D6.3 | Long-terms visions and roadmaps

Deliverable:	Long-terms visions and roadmaps
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Executive Summary

This document defines a shared **strategic vision** and a **roadmap** in the Target countries (BE, ES, IE, IT, LT, PL, and CZ) and in Supported ones (EL, EE, FI, LV, UA, and SI), with the aim to promote the market development of biomethane.

To this purpose, **4 Participatory workshops** were planned in each Target and Supported country, where different key national stakeholders have been involved in the drafting of visions and roadmaps.

The deliverable defines the **key concepts** (visions and roadmaps), provides **guidelines** for the workshops to be undertaken and the identification of the appropriate stakeholders, and includes the **visions** and the **roadmaps** for each country.

The comparative analysis allowed to identify **commonalities** and **specific features** of the different countries:

- Some countries are **already producing biomethane** (BE, EE, FI, IT, and ES), while others **not yet** (CZ, EL, IE, LV, LT, PL, SI, and UA).
- **Common** and **specific barriers** were identified: **low profitability** of biogas/biomethane production, **technical and administrative constraints**; lack of a **common quality standard** and of **cross-border certificate trade**; lack of **guarantee of origin system**; availability of **low-cost fossil fuels** and differential cost with natural gas; lack of a **stable and long-term** regulatory and legal framework; lack of long-term **incentive schemes**; no natural gas **infrastructure for transport** and lack or limited number of **methane vehicles**.
- **Common** and **specific drivers** were identified: **closing nutrient loops**, interest in **advancing nutrients**, improving soil management, need of **biofertilizers** in the market; carbon neutrality **targets**, national **self-sufficiency** of energy, vitality of the **rural areas**; large or increasing number of **filling stations**; biomethane as **solution for multiple domains**, i.e., agriculture, environment, agriculture, transport, employment.
- **Common** and **specific features of roadmaps** were identified: implementation of several **incentives schemes**; setting up a **GoO** and **certification system**; appropriate **legislation** on waste management, nutrient recycling and on energy; **technical and regulatory framework** for the connection to the medium and low-pressure networks; **supply network** with distinct biomethane distribution points; develop/adapt **gas distribution networks** to inject biomethane and also methane/hydrogen mixtures; improving **access to the grid**; adjusting the **electricity grid operation**; strong role of **public procurement policies**; **increased research** on innovative technologies; **integration** with the energy systems, especially where electrification is not possible.

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REGATRACE in a nutshell

REGATRACE (**RE**newable **GA**s **TRA**de **C**entre in **E**urope) aims to create an efficient trade system based on issuing and trading biomethane/renewable gas certificates/Guarantees of Origin (GO) with exclusion of double sale.
This objective will be achieved through the following founding pillars:

- European biomethane/renewable gases GO system
- Set-up of national GO issuing bodies
- Integration of GO from different renewable gas technologies with electric and hydrogen GO systems
- Integrated assessment and sustainable feedstock mobilisation strategies and technology synergies
- Support for biomethane market uptake
- Transferability of results beyond the project's countries.

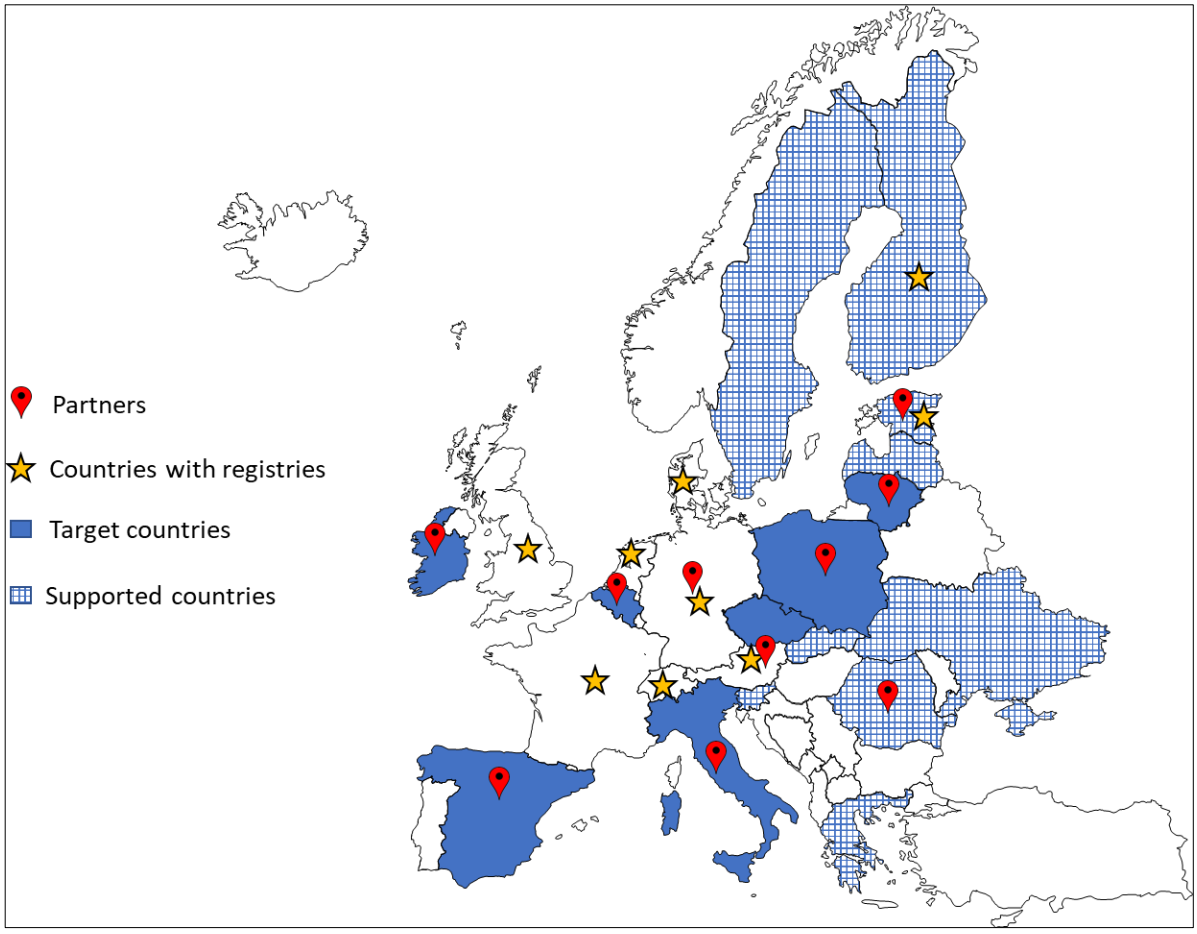

Figure 1: REGATRACE countries and partners

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Introduction

This deliverable is the main outcome of task 6.2 (**Support for national strategic visions and roadmaps**) in WP6 (**Support for biomethane market uptake**), whose objective is to promote the market development of renewable gases through the definition of a shared **strategic vision** and a **roadmap** in the Target countries (BE, ES, IE, IT, LT, PL, and CZ) and in Supported ones (EL, EE, FI, LV, UA, and SI).[1]

To this purpose, it was planned to organise **4 Participatory workshops** in each Target and Supported country, where different key national stakeholders have been involved in the drafting of visions and roadmaps.

ISINNOVA, as leader of task 6.2, defined and provided a dedicated conceptual and practical framework for shaping the activities, supporting the set-up of the Biomethane Working Groups (BWG), and providing guidance on the strategic planning process.

This report consists of three different sections.

Section 1 defines the key concepts (visions and roadmaps) and lists the activities to undertake, namely the participatory workshops in each country mentioned above.

Section 2 provides guidelines for the effective set-up of the Biomethane Working Groups (BWG). It includes:

- the identification and selection of the appropriate stakeholders.
- stakeholders' mapping.

Section 3 reports the visions and the roadmaps drafted by each country in accordance with the participatory process of workshops.

Section 4 contains a comparative analysis of the visions and roadmaps in the different countries, with conclusions on commonalities and specific features in order to pave the way for further developments of the strategic plans and actions to increase biomethane production and use in the coming months and years.

[1] Target countries are involved also in the set-up of registries (WP3), while supported ones focus only on the biomethane market uptake (WP6).

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1. Concepts and activities of the participatory process

This section defines the key concepts of the participatory process and describe the activities that were undertaken, namely the participatory workshops for the definition of the strategic visions and roadmaps.

A **vision** is intended as a qualitative description of a desired future that serves to guide the definition of targets and objectives as ground to prepare actions to reach them.

The definition of a vision for biomethane include, as orientating indications, at least the following information:

- Background.
- Vision objectives and temporal scale.
- Targets.
- Strengths and weaknesses.
- Challenges and opportunities.
- Barriers and drivers.
- Risks.
- How to reach objectives and targets.

A **roadmap** is intended as a reference document that defines the organisation of the work, identifies specific activities to be undertaken, and sets a schedule, responsibilities and the necessary resources to reach the above-mentioned targets and objectives elaborated within the vision.

The definition of a roadmap for biomethane include, as orientating indications, at least the following information:

- Introduction.
- Departing point.
- Objectives.
- Expected results.
- Integration and synergies with other existing policies.
- Organisation and division of roles.
- Tasks and timetable.
- Budget and resources.
- Monitoring.

The process of visioning and **road mapping** adopted in REGATRACE consisted of **4 Participatory workshops** to organise in own language in every Target and Supported country.

A number of key national stakeholders was identified and involved in dedicated **Biomethane Working Groups (BWG)**, whose function was meant as strictly operational and only reserved to stakeholders identified (indicatively between 10 and 20 ones).

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Should in any country have already existed similar working groups and/or strategies comparable to those indicated above, the activities within REGATRACE aimed to confirm, consolidate and eventually enlarge what previously created.
In each country, the partners and the EBAs linked third parties (LTPs) responsible for the activities within this task were:

- **Belgium**: Biogas-E (EBA LTP), with support of Fluxys (project partner).
- **Czech Republic**: CzBA (project partner).
- **Estonia**: EBAMTU (EBA LTP), with support of Elering (project partner).
- **Finland**: FBA (EBA LTP).
- **Greece**: HABIO (EBA LTP).
- **Italy**: CIB (project partner).
- **Ireland**: RGFI (project partner).
- **Lithuania**: Amber (project partner).
- **Latvia**: LBA (EBA LTP).
- **Poland**: UPEBI (project partner).
- **Slovenia**: CCIS-CAFÉ (EBA LTP).
- **Spain**: AEBIG (EBA LTP), with support of Nedgia (project partner).
- **Ukraine**: UABIO (EBA LTP).

Homogeneous and standard contents and information was provided for the organization of the participatory process with the aim to achieve comparable results within the framework of the project.
The **4 participatory workshops** were generally structured as follow:

Workshop	Purpose	Indicative Timing
Kick-off WS: Vision	Presentation of REGATRACE project and the mapping on the state of play of renewable gases market in Europe (D6.1) with the aim to fill eventual gaps and to collect inputs for the definition of the long-term strategic **vision**.	Between March 2020 and December 2020
2nd WS: Roadmap	Presentation, discussion and consolidation of the draft strategic long-term vision with stakeholders, while collecting also first ideas and inputs for the definition of the national **roadmap.**	Between February and October 2021
3rd WS: Guidance for feasibility analysis	Presentation of the national **roadmaps** and presentation of the draft Guidance on feasibility analysis created in task 6.3 to collect inputs for the preparation of the country tailored guidance.	Between October 2020 and March 2021
4th WS: Final results and lesson learned	Summing up the entire process with results achieved and presentation of the **country tailored guidance for feasibility analysis** (D6.4).	Between April and June 2022

The indicated timing of the different workshops was conceived in a way to proceed compactly, within a certain time window, for each round of them, to allow smooth and homogeneous progress. Unfortunately, the explosion of COVID-19 partly affected the calendar above, with the effect to dilute those events over time (the duration of the project was also extended from 36 to 42 months), and

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according to the different needs of REGATRACE countries, that in some cases, had to organize online or hybrid workshops to guarantee the participation of all the key parties.
By the way, this inconvenient didn't impact on the effectiveness and the results of the process (detailed timing of the workshops in each county is reported in **Annex II**).

Finally, a conclusive event was planned (to be held in **September 2022**) to gather all responsible entities of Target and Supported countries to share and exchange results and lessons from the participatory process.

After each round of workshops in all the different countries, ISINNOVA suggested a detailed set of objectives to the BWG leaders to consolidate what initially planned, taking into account the outcomes of the workshops in the previous round. This set of objectives was then discussed by the BWG leaders, in accordance with their specific requirements to achieve a common agreement on the workshops' goals.

To guarantee a homogeneous approach among countries in every workshop and every round of them, ISINNOVA provided a general structure of the agenda that was then properly adjusted according to the specific needs of the different countries.

The entire participatory process was submitted to a specific assessment analysis: after the identification and the involvement of key national stakeholders in dedicated Biomethane Working Groups, the **level of cooperation internally perceived** by them was assumed as a key indicator.

To this purpose, a specific methodology for estimating the perceived level of cooperation among the members of the Biomethane Working Groups was created, with the general assumption that a high level of cooperation in the group could positively influence the entire participatory process.

To best assess the level of cooperation, six indicators were defined:
1) Leadership
2) Balanced Team
3) Clear Division of Responsibility
4) Overall level of commitment perceived
5) Transparency / Communication
6) Compliance between individual and collective objectives.

The level of cooperation can be quantified by combining these 6 factors. The more they are successful (assigning a score for each of them), the higher is the cooperation level.

After the Kick-off meeting, the members of each Biomethane Working Group established in the target and supported countries were asked to answer a short questionnaire in order to define, as a baseline, the state of play and their expectations in terms of current relationship and future collaboration. As soon as the 4th and final workshops will be held (i.e., **after the finalisation of the present document**), an ex-post assessment, through another specific questionnaire, will allow to assess if those expectations are met and why this happened.

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Besides measuring the success of the visioning and road mapping process, this analysis helps to investigate on potential barriers that might have hindered these activities. The results of this assessment will be reported in Deliverable D7.2 (**Final Evaluation Report**), to be submitted in **October 2022**.

A comprehensive summary of workshops, outcomes and deliverables of WP6 is shown in Figure 2 below.

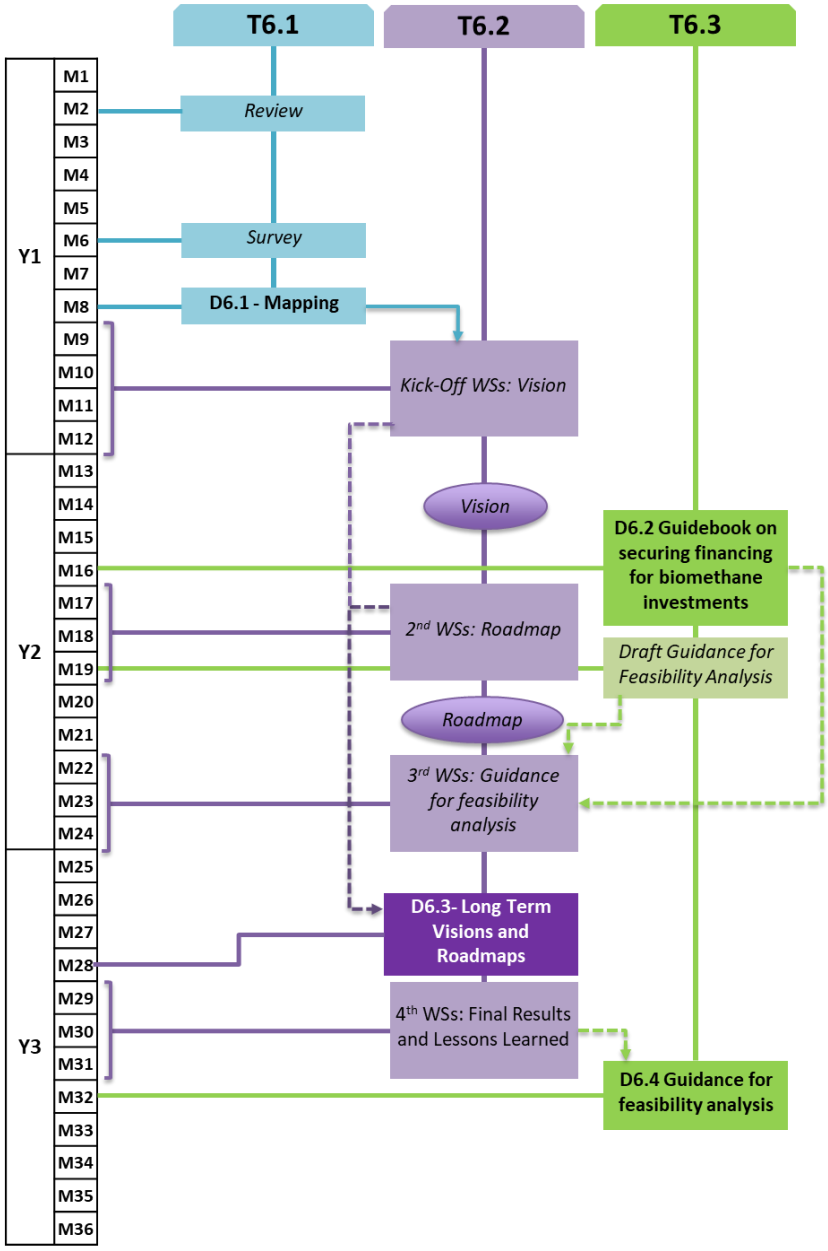

Figure 2: Structure of WP6 activities

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2. Set-up of the biomethane working groups

This section contains suggested procedures and practices to proceed with an appropriate identification of the stakeholders involved in the BWG. By the way, each leader of the BWG could adjust it according to eventual country requirements, specificities, and contexts.

2.1 Preparation of the procedure for the identification of stakeholders

The preparation of the procedure for the organization and constitution of the biomethane working groups was considered as one of the most crucial parameters for the success of this activity.

The first step included the specification of the necessary definitions. More in details, as stakeholder, it could be considered everyone having specific knowledge about the examined project or initiative. The stakeholders have a relation and are motivated by the specific project or initiative aiming at their improvement and their successful implementation.

The involvement of the stakeholders can be either direct with their contribution to the fulfillment of the target or indirect with the provision of information regarding the project or the initiative.

The stakeholders' management procedure can be considered as a planned procedure in order to engage stakeholders effectively targeting to the improvement or success of the project or the initiative.

The stakeholders' management procedure can be characterized as efficient in the case that it combines both of the necessary planning and communication initiatives. To this direction, it is crucial to identify and plan the most cost-effective stakeholders' engagement activities, which can lead to the maximization of the triggered impacts on the defined strategy and operations.

In the beginning, it was vital to realize and clarify the objectives of the stakeholders' engagement. The entity responsible of the activities should set the objective and the level of ambition during the establishment of this procedure. This can be achieved taking into consideration any available best practice and lesson learnt in order to establish the objectives more efficiently. It is vital to specify the reasons and the targets regarding the engagement of the stakeholders. The clear understanding of what is being evaluated facilitate all the procedure of the stakeholders' engagement.

A thorough and in-depth understanding of the project or the initiative was meant to reassure that the planned procedure involved a wide range of stakeholders' perspectives and experiences. This procedure required the precise specification of the priorities in engaging stakeholders at this phase, while the establishment of the scope and objectives of this stakeholder's engagement led to the specification of the necessary boundaries.

Finally, it was important to initially identify the stakeholders' motivations in order to facilitate their involvement in this procedure. As well as to examine and understand the potential stakeholders' expectations and motivations, because this could be proved crucial for their final participation and effective contribution.

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2.2 Stakeholders' mapping

The second step to set up a BWG was the stakeholders' mapping. It led to a list of stakeholders integrating the most important perspectives of the analysis. The stakeholders' mapping consisted of the following three phases:

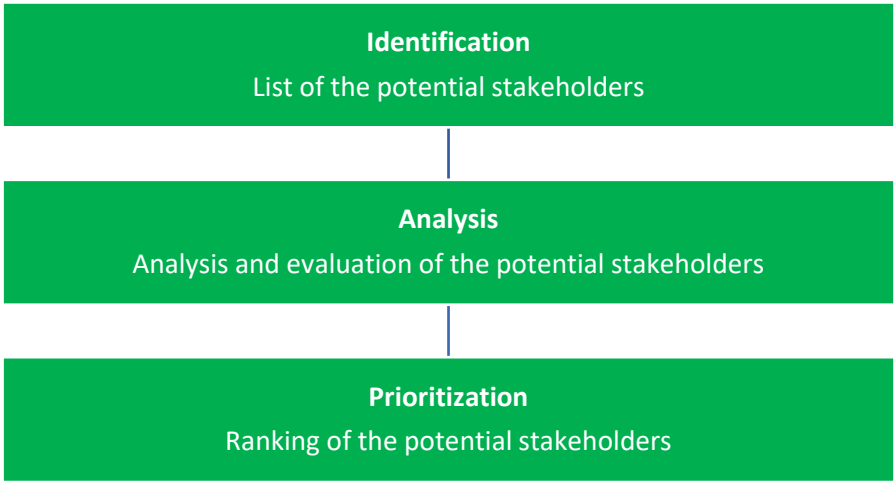

Figure 3: The implemented phases of the procedure for the stakeholders' mapping

2.2.1 Identification

The first task of stakeholders' mapping was the preliminary identification of the stakeholders. The already clarified description of the project or the initiative helped the implementation of this task including the established targets. These goals contributed to the effective depiction of the required characteristics of the stakeholders and the identification of which types of stakeholders are required.

It was important to realize that stakeholders should have specific roles during their engagement. Therefore, an initial categorization could be performed according to their roles and the level of involvement. The role was crucial because some stakeholders' roles are more influential and significant than others.

An initial identification of the stakeholders could be performed taking into account the following classification of the stakeholders:

- The stakeholders, who absolutely agree, participate actively and have a direct relation with the examined project or initiative.
- The stakeholders, who agree but do not have a direct relation with the examined project or initiative.
- The stakeholders, who do not have a specific opinion about the success or failure of the examined project or initiative.
- The stakeholders, who hinder the successful implementation of the examined project or initiative.

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The stakeholders were identified from all the potential stakeholders' groups. Indicatively, the initial list of stakeholders may include the following groups:

- Central government authorities
- Regional government authorities
- Local government authorities
- Energy authorities
- Transmission System Operators (TSOs)
- Distribution System Operators (DSOs)
- Energy Suppliers
- Universities
- Research centers & institutions
- NGO
- Consultancy firms
- Regional development & financing parties
- Standardization bodies
- Agricultural associations
- Technical & trade associations
- Experts (incl. sellers & installers)
- Media
- Consumers associations

A crucial point was the fact that the procedure of the stakeholders' mapping was a dynamic procedure, and it could lead to the continuous changes of the selected stakeholders.
Some indicative questions, which could help for the successful identification of the stakeholders were the following:

- Do the stakeholders have significant expertise in the relative field of the examined project or initiative?
- Do the stakeholders represent diverse perspectives and/or experiences?
- Can the stakeholders raise crucial questions contributing to the improvement and success of the examined project or initiative?
- Are the stakeholders responsible for the implementation of examined project or initiative?
- Do the stakeholders have the power to influence the current status of implementation?
- Do the stakeholders want to benefit the project or initiative in order to reach the predefined goals?
- Can the stakeholders be considered as proponents of evaluation and are capable of supporting the implementation of examined project or initiative?
- Can the stakeholders delay or stop the examined project or initiative?
- Can the stakeholders be excluded from the potential engagement?
- Does the official decision-making authority be included into the selected stakeholders?
- Do the stakeholders have the power to implement the agreed solution?
- Can the stakeholders be affected by the outcome of the project or the initiative?

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The definition of the above-mentioned questions may enhance significantly the procedure for the effective identification of the participating stakeholders.

Some recommendations for the identification of the stakeholders could include:

- ✓ To take into account any potential best practices and lessons learnt from past and ongoing engagement procedures in your country.
- ✓ To try to be open-minded and to consider potential stakeholders taking into consideration the evolution of the energy sector in the near future, the identification of new markets and technologies, the adoption of new regulations and legislations etc.
- ✓ To reassure a wide variety of stakeholders having in mind the objectives of the examined project or initiative. The centrality of the stakeholders in the project or the initiative is essential. It is important not to select only decision-makers, but the aim is a balanced selection of representatives including societal organizations, public bodies, private sector representatives, scientific experts etc.
- ✓ To think strategically and politically about the selected stakeholders so as to avoid problems during the constitution of the working groups. It is important to keep in mind that a single group might have specific interests and expectations, while several groups might have completely different. Try to avoid a situation with many stakeholders who care about some interests and expectations and a limited number who care about other ones. It will be difficult to balance these contradictory interests and expectations.

2.2.2 Analysing

After the step of the stakeholders' identification, characteristics and profiles were analyzed in order to select the most appropriate of them for the constitution of the BWG.

It was important to have in mind that different stakeholders may have completely different levels of interest and influence for the examined project or initiative. Nevertheless, as previously mentioned, the stakeholders should represent a mix of perspectives, experiences and roles relative to the project or initiative.

Within this framework, a procedure for the effective selection of stakeholders was developed through the establishment of specific criteria.

The stakeholders' engagement matrix provided an overview of the most crucial characteristics for each potential stakeholder separately. The profile of the potential stakeholders could help to map and assess them taking into account the most important features.

The proposed approach targets to the qualitative assessment of specific stakeholders' components such as their degree of expertise, their willingness for participation and the overall impact, which was expected to be triggered by their involvement.

The selected criteria, which must be evaluated, are described briefly below.

I. **Capacity**: Evaluate the resource capacity of each stakeholder taking into consideration their knowledge, expertise and technical capabilities.

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II. **Willingness**: Evaluate stakeholders' availability and willingness for participation.
III. **Power**: Evaluate stakeholders' role into the decision-making procedure, which is essential for the elaboration of visions and roadmaps for biomethane.
IV. **Influence**: Evaluate the number and the quality of stakeholders' connections, which can influence all the involved parties during the elaboration of visions and roadmaps for biomethane.
V. **Necessity**: Evaluate stakeholders' necessity for inclusion or exclusion from this engagement procedure.

All the above criteria were assessed utilizing the following scale:

1: Low, 2: Medium, 3: High

It should be mentioned that additional criteria could be added for analysis taking into consideration the characteristics of each country and the peculiarities of the energy sector.

2.2.3 Prioritizing

The final step of the stakeholders' mapping was the prioritization process, which aims at the sorting of the identified and analyzed stakeholders.

The total score of a stakeholder "i" can be calculated from the following equation:

$$\text{Total Score}_{i} = \text{Score}_{i,\text{Capacity}} + \text{Score}_{i,\text{Willingness}} + \text{Score}_{i,\text{Power}} + \text{Score}_{i,\text{Influence}} + \text{Score}_{i,\text{Necessity}}$$

The evaluation of the stakeholders can be performed according to the following classification criteria:

1. If the score is higher than 10 then the specific stakeholder can be characterized as "Very important stakeholder".

2. If the score is between 6 and 10 then the specific stakeholder can be characterized "Important stakeholder".

3. If the score is lower than 6 then the specific stakeholder can be characterized "Non-important stakeholder".

For example, if a stakeholder has been evaluated with the following scores:
$\text{Score}_{\text{Capacity}} = 2$, $\text{Score}_{\text{Willingness}} = 2$, $\text{Score}_{\text{Power}} = 3$, $\text{Score}_{\text{Influence}} = 3$, $\text{Score}_{\text{Necessity}} = 1$,
then, the total score can be calculated with the following equation: $2 + 2 + 3 + 3 + 1 = 11$.

Therefore, taking into consideration the above classification criteria, the stakeholder will be assessed as *"Very Important Stakeholder"*.

It was important to select the most effective stakeholders according to the established criteria.
After the prioritization of the stakeholders, leaders of BWG could examine the obtained ranking and assess if the relevant stakeholders are capable of achieving the objectives of the examined project or initiative.

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Finally, **it was important to keep this part of the procedure as confidential**, because stakeholders could be discomposed if they are aware that their respective scores do not result in high-priority-stakeholders in comparison with other ones.

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3. Visions and Roadmaps

This section contains the visions and roadmaps drafted by all target and supported countries according with the participatory workshops.

3.1 Belgium 

3.1.1 Vision

Belgium has a well-developed biogas sector, with **189** active installations in 2020 and a total production of **2.7 TWh** of biogas[2], most of it being burned in local CHPs for the production of electricity. This biogas is mainly produced from agricultural waste (including manure) and industrial waste streams. In contrast to neighboring countries, the upgrading of biogas to biomethane is a fairly new development. The first Flemish biomethane plant (80 m^3/h injection capacity) started injecting biomethane in the gas grid at the end of 2018.
Due to favorable developments in the subsidy scheme for biomethane production and valorization in Wallonia, several new biomethane projects were planned. The inauguration of the first Walloon biomethane plant took place in December 2020. This plant has a significantly higher production capacity (600 m^3/h) than the one in Flanders, marking the first large-scale biomethane plant in Belgium. By the end of 2021 **six biomethane plants** were fully operational, two in Flanders and four in Wallonia, for a production of **150 GWh/y**.

With current biomethane projects in pipeline by 2025 more than **1 TWh** could be produced. Moreover, as the support mechanism for biogas CHP mainly in Flanders is fading out by 2025, about **1.4 TWh** of existing biogas production could be converted to biomethane injection.[3]
Recent studies indicate a production potential of **15.6 TWh** of biomethane in Belgium.[4] Agricultural (waste) streams are responsible for the largest fraction of the potential, but they are currently underused.

Today, the cost differential between natural gas and biomethane is one of the major **barriers** for investments in biomethane projects. A solid **support mechanism** is essential to boost the production of biomethane in Belgium. Other barriers are the public image of anaerobic digestion, the limited potential of raw materials and the administrative burden for plant operators.

The sustainability aspect is one of the main **drivers** for the further market development of biomethane in Belgium. Hard to electrify sectors and processes, such as heavy industry or long-distance transport, are important opportunities for the biomethane market, as these could maximise the added value of biomethane compared to other renewable sources. The high abatement potential of GHG emissions makes biomethane an interesting energy source regarding the Belgian climate and energy targets. Besides, anaerobic digestion has a crucial role to play in a more circular economy: closing nutrient loops, valorising waste streams, improving soil management and providing local employment.

[2] EBA statistical report 2020, European Biogas Association, 2021
[3] Biogas-E study 2022 on fade support for biogas in Flanders
[4] Quelle place pour la biométhane injectable en Belgique?, Gas.be, 2019

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In general, clear targets for biomethane are still lacking in the regulatory framework for renewable energy and climate, creating a mismatch between the (limited) potential of biomethane and the Belgian targets. Together with a **fair support mechanism**, such targets could accelerate the development of the biomethane market in Belgium.

In Belgium, the production of renewable energy is a regional affair. The three regions (Flanders, Brussels and Wallonia) are therefore, to a large extend, responsible for the targets and support schemes regarding biomethane production. A constructive dialogue between the federal and regional level, with focus on the potential, the preferred use of biomethane and the best way to stimulate the production, is an essential **first step** to create a long-term strategy for biomethane development.
A **next step** is to link the production of biomethane to the policies on GHG emission targets, biofuels, agricultural development and circular economy. The recognition of the potential of biomethane with regard to the climate targets on policy level will be beneficial for social acceptance. A strong long-term strategy, together with clear targets and objectives, will provide the industry with a solid guideline to work towards a future-proof biomethane sector.
A **third step** is to promote research and innovation in biomethane and anaerobic digestion. Belgium is home to some of the best universities in Europe in the field of biotechnology. This expertise and knowledge should be used to further optimise the biomethane sector, and develop new valorisation methods for biomethane and other by-products such as digestate, nutrient recuperation, CO_2, etc.

3.1.2 Roadmap

Medium Term (2030)

Biomethane should be **integrated with the energy system**. Biomethane is a valuable addition to the (renewable) energy portfolio in Belgium. It has unique characteristics compared to other renewable sources: it is compatible with the existing gas grid, it can be stored for longer periods without loss of energy, and it is available independent of meteorological conditions. In order to fully exploit the added value of biomethane to the Belgian energy system, it is important to have detailed numbers on the production potential and possible development trajectory. A **study on biomethane potential** is needed to define the possible contribution and the costs of biomethane to the energy system. An initial study was performed in 2019 by Valbiom (commissioned by Gas.be), showing a realistic feedstock potential for biomethane **15.6TWh**. In 2021 and 2022 the greengasplatform.be (Gas.be, Valbiom, Biogas-E) performed a 'deep dive study on biomethane in Belgium' with Climact delivering a GHG model for Biomethane and showing that if 11 TWh could be produced by 2030 this would result in a CO_2 reduction of 2 mio-ton per year in Belgium. Early 2022 Valbiom for Wallonia and Biogas-E developed a detailed mapping of the feedstock and the most adequate digester (technically and cost-wise) for each of the regions.

Next, **the preferred use of biomethane** should be defined to ensure stable market development. A first step could be to align the Flemish strategy for biomethane with the Walloon one and stimulate the greening of existing fossil CHP's with biomethane. A broader set of criteria must then be defined to ensure the socially and environmentally responsible use of biomethane, rather than focusing on one application. This allows the biomethane market to grow within the boundaries of these criteria. A

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trustworthy and fully functioning **certification system** is essential for the trading and use of biomethane, especially with a deeper integration of the electricity and gas system.

The results of the potential study and the preferred use of biomethane should be **integrated in the National Energy and Climate Plan of Belgium (NECP)**. Future revisions create the opportunity to include biomethane as a fully-fledged part of the energy transition.

Fossil transport fuels should be replaced with biomethane. The use of biomethane as a biofuel is the most promising for the heavy transport and maritime sector. In this respect as from beginning 2021 BioLNG (certified under ISCC) can be sourced for transport purposes at the Zeebrugge LNG Terminal. This BioLNG is destined mainly for heavy duty truck in north-west Europe. Still in most of the countries where this BioLNG is delivered, it cannot account for the renewable obligation of the fuel suppliers due to issues in national legislation even though it complies with the RED II. In Belgium as from 2022 bioCNG and bioLNG can be registered as an advanced biofuel and is already accountable for the 6% GHG reduction obligation of the FQD. By 2023, when the RED II will also be transposed in the Belgian federal law, bioCNG and bioLNG should also be accountable for the renewable transport fuel targets. However, there are no additional incentives for the use of bio-CNG or bio-LNG, despite the great potential to lower the emission of the transport sector. Moreover, the NECP does not specify the transition to a cleaner and greener heavy transport and maritime sector. Creating a **clear long-term vision and legislative incentives** is essential to promote the use of biomethane in the transport sector.

Also, on European level the emissions of transport fuels are calculated using the tailpipe measurement approach, ignoring the Well-to-Tank benefits associated with biomethane. Therefore, a **Well-to-Wheel evaluation** is necessary to compare the impact of different transport solutions towards GHG emissions. Alongside a more favourable legislation, **a strong effort by the transport fuel sector to promote and supply biomethane** will send a powerful message to users, as well as policy makers.

GHG emission reduction of the production process should be optimised. Research within the REGATRACE project has shown that the perceived value of biomethane is related to its GHG abatement potential.[5] Biomethane with a low or negative carbon footprint therefore has a higher potential for further market development. In addition, reducing the GHG impact of the product and production process will have a positive effect on the public image of biomethane. A transparent calculation method to **quantify the carbon footprint** is essential to **monitor, optimise and communicate the status of current and future biomethane production** and its environmental impact.
Since more than 80% of the biomethane potential in Belgium is related to agricultural (waste including manure) streams[6], an efficient supply chain from the farm to the biomethane plant benefits both parties: reducing GHG emissions upstream and ensuring sufficient biomethane production, lowering the need for fossil fuels.
The support system needs to be reformed to an **operational support that rewards the contributions of biomethane to the reduction of GHG emissions**. As a result, biomethane producers will be encouraged

[5] 'Importance of different aspects of renewable gas for consumers' from 'D6.1| Mapping the state of play of renewable gases in Europe'
[6] 'Potentieel voor injecteerbaar biomethaan in België', study performed by Valbiom in commission of gas.be, 2020

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to maximise their positive environmental impact. The focus of the support system will shift from production to climate impact.

Positive externalities of biomethane should be recognised. Biomethane is mostly valued as a renewable energy carrier. Although the benefits of anaerobic digestion and biomethane are diverse, they are currently not recognised. Anaerobic digestion is a corner stone for a more circular (bio)economy: upcycling waste streams, recovering nutrients, water and carbon, reducing emissions etc. The recognition of these externalities is essential to **assess the real value of this technology to our society**.

Long-Term (2050)

Production of high value molecules and products (with shift from energy source to chemical feedstock), as Belgium, and especially the port of Antwerp, is one of the most important chemical clusters in Europe. Like any other industry, they face the challenge of decarbonisation in the coming decades. Biomethane is an interesting alternative for the current use of natural gas or its derivatives in the chemical industry. It can be used as a building block for organic molecules and chemical products. These pathways have a potentially higher socio-economic impact than their use as an energy source. It is important to **identify and demonstrate the potential pathways for biomethane in the chemical and biobased industry**. Further scientific research is essential to create new production processes and incorporate biomethane as **renewable chemical feedstocks**. Thus, in the long-term, there will be a different role for biomethane, as, in the meanwhile, its contribution as an energy source will decrease with the further penetration of wind and PV power and technologies, such as heat pumps or geothermal installations. It is also the responsibility of the chemical industry to invest in greener production processes and to consider the possible role of biomethane. Currently, the willingness to pay (WTP) of the chemical industry is too low. **Legislative incentives** or **targets** could help to **increase the WTP** and the use of biomethane as an alternative for natural gas. A higher WTP could result in a transition from natural gas to renewable gas, even by 2030.

Backbone for bioeconomy: anaerobic digestion can be seen as an enabler for a more circular economy, with **integration with the agricultural system**. Waste streams from the bioeconomy are converted to a multi-purpose methane molecule, while nutrients, carbon, water and even CO_2 can be recovered. Today, these are considered by-products, but their role in the future bioeconomy can be important: providing alternatives for chemical fertilizers, restocking the carbon in our soils and supplying green CO_2 for industry and horticulture. In the coming years, new markets and technologies for the recovery of these by-products will develop further. It is important that the **legislation stimulates a more circular economy by paving the way for these biobased products**: new product regulations, adapted fertilizers rules, etc., so technological evolutions can be fully exploited.

3.2 Czech Republic 

3.2.1 Vision

The Czech Republic is, with its biogas production of **6.6 TWh** per year (**0.66 MWh** per capita per year), one of the top countries producing biogas in Europe. Large share of production comes from agricultural

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substrates (dedicated biomass), which is not compliant with current sustainability trends and EU Directive RED II. Also, the biogas is currently used for CHP production, while heat is often wasted making the efficacy of the biogas production questionable. The biogas field therefore needs to be modernised and transformed towards further waste usage and better energy usage, where biomethane should play a major role.
At the moment, **biomethane production is practically non-existent** in the Czech Republic, with the exception of one biogas plant and one wastewater treatment plant (**pilot projects**).

The main reason for the Czech Republic's lagging behind in the development of biomethane is **legislative barriers**. Until 2021, there was no legislation that would define, regulate and support biomethane. The State Energy Concept (adopted in 2015) does not once mention biomethane. Obsolete decrees regulating natural gas industry made it very difficult and sometimes impossible to inject biomethane into the gas network. In November 2019, the Czech Republic's National Energy and Climate Plan brought biomethane into the frame and highlighted its benefits when used in the field of heat industry and transport.

Currently the main **driver** for biomethane deployment in the Czech Republic would be a demand from petroleum producers using biomethane for joint reporting of emissions savings under the Air Pollution Control Act. Therefore, the main opportunity is to supply the biomethane to these companies and other corporate customers who are deploying their green strategies as well as export the biomethane to other EU member states.

The requirements for the quality of biomethane, the conditions for its measurement and injection into the gas grid were regulated in 2021 by the issuance of a new Decree No. 78/2021 Coll. After the adoption of the Act on Supported Energy Sources (Act on RES) in September 2021, biomethane promotion, certification and Guarantees of Origin issuing will be possible from 2023. However, the implementing legislation is still under development. And, also, the **removal of technical barriers** (especially the required value of combustion heat) remains a crucial point.

The new Act on RES brings an obligation to ensure a minimum amount of advanced biomethane in natural gas for transport purposes:
a) **0.5%** from 1st January 2023, approximately 8 GWh
b) **2%** from 1st January 2025, approximately 41 GWh
c) **40%** from 1st January 2030, approximately 1,620 GWh[7].
The biomethane from energy crops is expected to be consumed mainly in the heating and cooling sector as mentioned in the Czech Republic's National Energy and Climate Plan.

3.2.2 Roadmap

Short term (2022 – 2023)

Creating a **stable regulatory framework** is important to ensure the investors will be interested to participate in the biomethane market.

[7] based on the predictions of the natural gas consumption in the transport sector by Energy Market Operator (OTE)

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The Czech Republic has a well-developed biogas market, although the majority of biogas production originates from agricultural biomass including energy crops. Therefore, some infrastructure is already in place, and it appears only smart to use it and transform it to biomethane production which on the other hand also brings some **challenges** – both **technological** and **financial**. The potential for transformation of the current biogas plants is analysed in order to propose targeted measures for the implementation of the transition of biogas plants to biomethane production and compile a set of legislative and technical requirements that would enable the production and injection of biomethane into the network.

The new Act on RES (165/2012 Coll.) – in force since 1st January 2022 – brings operation support for biomethane in form of Green Bonus and since 1st January 2023 also introduces Guarantees of Origin (GoO) not only for electricity but also combined heat and power production as well as biomethane, hydrogen and heat from RES.

Implementing legislation has to be created though. This action is mainly under the responsibility of the Ministry of Industry and Trade as the GoO issuing body is OTE (Operator of the Energy Market) that is a subsidiary company of the MIT. Works on the legislation are already underway.

In order to ensure that there is sufficient amount of sustainable biomass that could be used in AD sites producing advanced biomethane, the **waste management legislation** should be stricter when it comes to biodegradable waste collection and treatment. In the Czech Republic there is an exemption granted by Decree no. 273/2001, Coll. until 2030 that allows landfilling of biodegradable waste if it is part of municipal waste. Any exception allowing to landfill bio-waste should be ended in all cases and biodegradable waste biomass should be treated as a valuable resource as it is.

The Czech Republic will also support the biomethane production sites by introducing an **obligation to purchase** of the production pipeline connecting the biomethane plant to the national natural gas grid by the distribution system operator from the manufacturer of biomethane – under the condition that there would be a public tender for the contractor of the construction of the pipeline. ERO (Energy Regulatory Office) will also define a support for remote biomethane filling stations (in the case the biomethane grid injection will not be feasible) but not in the form of GoO.

Medium Term (2024-2030)

When the legislation is clear and settled, growth in biomethane sector is expected. It is mainly large cities such as Prague, Brno and other settlements that are planning to build new biomethane plants. The reason for building these plants is an interest in reducing the production of mixed municipal waste (MMW), to which the municipality is pushed by the new waste law. A very effective way of reducing MMW is the **separate collection** of biodegradable waste and kitchen waste from households, the collection of biowaste from restaurants and canteens and the collection of expired food. These wastes will no longer end up in landfills, but as a material for biomethane production.

Wastewater treatment plants (WWTP) with anaerobic sludge stabilization will switch to biomethane production about five years earlier than biogas plants due to the end of operational support for electricity generation.

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Specialized industrial biogas plants will produce biomethane from waste and by-products that will arise in the production of food, animal feed or in the processing of vegetable and animal oils and fats.

The biggest challenge for the future is definitely to set the right conditions for the **conversion** of agricultural biogas plants that produce electricity into modern sources that will process more waste and produce biomethane from biogas.

Long Term (after 2030)

The future development will be highly dependent on the **EU legislation** as the Czech government does not act in this field as a stakeholder but rather as a follower. Recognizing that biomethane is an environmentally friendly renewable fuel will become an integral part of the Czech as well as EU's energy mix in the future and will, among other things, make a significant contribution to the EU's raw material and energy security.

Nevertheless, the **bio-waste processing to biomethane** should become key since the exemption for landfilling bio-waste expires in 2030 and we should experience further development in this field. On the other hand, there might still be problems with bio-waste availability if considering the fact that, with advanced material technologies, the biodegradable waste might in the future also become a highly demanded source for other fields (e.g., production of bioplastics and other organic materials with higher added value).
Also, the high costs vs. benefits of renewables have to be considered with a view of a risk of upcoming energy poverty in the EU which would definitely shatter economic stability of the EU and its citizens.

It is therefore important to ensure sustainable deployment of any renewable always keeping in mind the aim to secure a stable energy mix and smart use of resources with biomethane production and use being seen as not just a target but a possible solution.

3.3 Estonia 

3.3.1 Vision

The preparation of the Estonian Energy Development Plan (ENNMAK 2030) confirmed a large amount of unused biogas as potential renewable energy source. In addition to existing biogas boiler houses and for power plants producing heat and electricity, biomethane produced from biogas may be an important input in increasing the use of renewable energy in transport. There is need for an additional biogas resource to meet the renewable energy target in the transport sector.
Part of the ENMAK 2030 development process with macroeconomic analyses was realised. The results indicated that annual up-take of biomethane up all potential at 2050 creates add values to GDP 71-589 M €; GDP increases 72 to 549 € per capita; up to new **6,000** jobs are created.
In addition to energy management measures, the objectives of biogas development in agriculture and waste management have been consolidated in the National Energy and Climate Plan (REKK 2030).

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In 2021, there were **11** biogas plant and **2** biomethane plants, with **16,974 MWh** of biogas and **152,352 MWh** of biomethane, of which **55,567 MWh** was produced from sewage sludge, **61,081 MWh** from animal manure, **24,978 MWh** from food industry residues, **5,897 MWh** from biowaste and **4,829 MWh** from other biomasses.
In 2020, Elering issued 97,408 (MWh or approx. 9.7 million Nm^3) gas origin certificates to biomethane producers, of which 54,184 MWh for sewage sludge and 43,224 MWh for biomethane produced from animal manure, biomass, bio-waste and food industry residues.
27% of Estonia's territory is arable land and about 7% is natural grassland. There is forest land 51.4%, the utilized agricultural area is 983,000 hectares. About 250,000 cattle are raised in Estonia, 300,000 pigs and 70,000 sheep and goats. All agriculture is a potential raw material for biogas production - slurry / manure from livestock, biomass crops and grassland.

In 2015, the Estonian Development Fund estimated the production potential of Estonian biomethane at approx. **4.5 TWh**. This large number includes 80% herbaceous biomass from arable land as a raw material, which for various reasons, the raw material for biomethane production may not be preferred.
In addition to its role in energy, biomethane is also useful in solving the problem of agricultural waste: its production reduces waste in an environmentally friendly way, while reducing the climate impact of agriculture. The maximum benefit is derived from biomethane when using raw manure, slurry, food waste (e.g., whey), spoiled animal feed (thus preventing significant greenhouse gas emissions from the agricultural sector) or landfill gas.
The total potential of raw materials in Estonia is sufficient to produce about **1 - 1.3 TWh of biomethane per year**. In total the optimal for the production of such volumes is about 20–30 biomethane production plants scattered all over Estonia.[8]
Consequently, the Energy Roadmap envisages the development of biogas / biomethane production and expansion potential of 1-1.3 TWh per year for the period 2022-2031. Field of application during the period 2021-2040 will change, being in the first half of the period certainly mainly transport-oriented, but in the second half of the period, and especially at the end of the period, biogas / biomethane will be used not only for land transport but also for maritime transport and as an alternative to controlling peak loads for electricity generation.[9]

The **strength** of the Estonian biogas sector is the importance of the field in shaping energy management policy in the preparation and adoption of ENMAK 2030 during mid-2020-s. The support of the EU Structural Funds in promoting the use of biomethane in transport in the previous support period was 1 of the four priority areas of the energy sector. Within the framework of this, a bus purchase support and investment support for the construction of CNG filling stations have been developed and are currently being implemented. Biomethane producers will be supported from CO_2 quota sales funds until the end of 2023. The short-term nature of the measures can be considered a weakness, as the payback periods of energy management projects are usually longer than 3-5 years.

The **challenge** for the biogas sector is to increase consumption in transport. Despite increasing, however, it could be even greater in heavy transport, especially in order to achieve a significant change. The use of

[8] ENERGIA TEEKAART 2021-2031-204, TalTech, Rohetiiger Energia-teekaart-17122021.pdf (rohetiiger.ee), p 33.
[9] ENERGIA TEEKAART 2021-2031-204, TalTech, Rohetiiger Energia-teekaart-17122021.pdf (rohetiiger.ee), p 34.

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biogas and biomethane in innovative fuel cells can also be considered a challenge, which creates preconditions for small-scale biogas production and consumption in places where other solutions are not cost-effective. Technological development also creates opportunities, if small amount biomethane can be liquefied at economically reasonable costs, it also creates many times greater prospects for liquefied biomethane consumption (trains, ships). Cross-border international trade in biomethane (both molecule and certificate of origin) creates preconditions for profitable production of biomethane post-2023 (after the end of subsidies). The Baltic Connector has already made it possible to establish a common gas market area between Estonia, Latvia, and Finland. With the completion of the GIPL[10], this opportunity will be extended to the whole of Europe.

The **driving** factors are the relatively well-developed network of CNG filling stations, the increased number of methane buses, trucks and cars, the effective support for the price-premium of biomethane, support for the construction of filling stations and the purchase of buses. Also, the creation of a single gas market between Estonia, Latvia, and Finland.

Today, the lack of a common biomethane quality standard, conditions for the injection of biomethane into the natural gas network and cross-border biomethane certificate trade is an **obstacle** to international trade of biomethane. The technology is hampered by the very high purchase price of solid oxide fuel cells using biogas and the lack of market-based small-scale biomethane liquefaction technologies.

Significant **risks** in the development of the biogas sector are difficult to predict. At the end of the biomethane price-premium support, one of the risks is that the price of the biomethane certificate is too low for the producer, which may not ensure the enough profitability of new projects. However, given the general trends in the EU green-turn and circular economy and the potential use of biomethane in SOFC fuel cells, green hydrogen production, participation in international cross-border trade, demand and affordability are expected to create growth rather than decline in biomethane production and consumption.

3.3.2 Roadmap

The role of biomethane must increase significantly in 2030, with the goal to produce **100 million Nm^3 or 1 TWh** of biomethane per year. The target is **15,000** units for methane cars, **1,500** for heavy goods vehicles (buses and lorries), and **50** for methane filling stations.

The Estonian Biogas Association makes the following proposals to policy makers:

- Supporting the use of biogas in pilot projects for the **use of solid oxide fuel cells (SOFCs)**, in particular for small-scale installations at source. The heat and electricity generated in the SOFC can be used on site, including in autonomous areas without mains electricity, not to mention district heating (from the first quarter of 2024).
- As a measure to implement the EU Green Deal, extend the **eligibility period of support** for biomethane producers for the development of the biomethane market until 2030 or adopt a new similar regulation (from the first quarter of 2024).

[10] Gas Interconnection between Poland and Lihtuania.

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- To **exempt and differentiate 40% - 80% of heavy goods vehicles** consuming methane fuel from road tolls in Estonia on the basis of EURO classes (from the first quarter of 2023).
- To introduce **purchase aid** for the use of local gas vehicles in Estonia (renewal of the local truck fleet from EUROIII to EUROVI on the example of Germany (from the first quarter of 2023).
- **Business tax rebate** for biomethane consumption.
- Use of more environmentally friendly rolling stock when **purchasing public services** (setting an example in the implementation of the Clean Vehicles Directive) - so-called green procurements in road construction, where the consumption of methane fuel provides additional points in the evaluation of tenders (from the third quarter of 2022).
- Continue to give **preference to methane-powered buses in public transport procurement** and to build **methane filling stations** in areas where this is not available for public transport today (by the end of 2022).
- Active participation in the development of an **international quality standard for biomethane** that takes into account the specificities of biomethane production. Also create preconditions for cross-border trade in biomethane, including certificates of origin (from the first quarter of 2024).
- To create opportunities for the partial **replacement of natural gas with biomethane, synthesis gas or hydrogen** in the production of heat (necessary legislative changes in the first and third quarters of 2022 and implementation in 2022/2023).
- To establish a functioning **incentive scheme** for the sorting of municipal and agricultural waste in all municipalities in order to divert all bio-waste to biomethane plants; and composting and fertilizer production (set-up of the mechanism in 2022, implementation in the first quarter of 2023).
- To allow the use of vehicles of **higher weight and length** in Estonian road transport: in order to remain competitive with neighboring countries, at least up to 25.25 m, but consider allowing, for example, trains up to 34.50 m with a maximum weight of 76 tonnes (implementation in the 3rd quarter of 2022).

In order to achieve the desired goals of reducing the environmental impact, ensuring security of supply and optimizing the added value, the investments costs were calculated at 168 M € during 2022-2025; 168 M € during 2026-2030; 34 M € during 2031-2035 (for a total of 368 M €). The aggregate results of the added-value calculation for biomethane are 109 M € by 2031 and 156 M € by 2040. Activity Coefficient for Biofuels - biomethane is 0.54.

Investments in biomethane production have been assessed by Estonian biomethane production developers and the starting point is 11 million euros per production unit with an annual production volume of 3 million m^3 (approx. 28 GWh). The cost of the investment is expected to increase by 2% per year. The growth of biomethane production units will take place until the expected optimal production volume is reached, i.e., 108 M m^3 or 1,000 GWh per year.

3.4 Finland

3.4.1 Vision

In 2020, biogas production was **767 GWh** and biomethane production was **109 GWh.** About **100 GWh** were fed into the grid. Biogas production was **239 GWh** in wastewater treatment plants, **190 GWh** in

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landfills and **323 GWh** in co-treatment plants. The farms produced only **17 GWh** of biogas. Most of the the biomethane was produced at co-treatment plans. The number of biogas-producing reactor plants, and in particular co-digestion plants, is growing. There is big potential, particularly in agri-biomass based biogas and biomethane production, but the growth has not yet realized. Instead, the amount of gas generated in landfills is declining. In 2019, **95.4 GWh** of biogas certificates were issued.

The **vision** of the Finnish biogas and biomethane sector is to be competitive and vital and being strongly integrated into the modern energy system and network. Besides that, the sector holds a strong foothold in national the nutrient recycling activities.
In order to stay on track and to reach its potential, the Finnish sector sets the production target of **4 TWh** to be reached by 2030. Most of the biogas would be upgraded to biomethane; so that the biogas sector could serve the growing demand in sustainable and clean energy from the transport and industry sectors. The new biogas production would be based specifically on the utilization of agricultural-based by-products, but new technologies and feeds would also play a role (e.g., gasification). For 2035, **6 - 15 TWh** was envisaged for biogas and biomethane production.
The demand for biogas and biomethane could be **4 - 11 TWh** in Finland in 2030. A significant part of the demand would be for biomethane, of which heavy vehicles could consume **2.5 - 4 TWh**, passenger cars **0.5 - 1 TWh**, buses **0.5 TWh**, industry **0.5 - 4 TWh** and ships **0.85 - 4 TWh**. It was estimated that **0.4 - 2 TWh** of biogas would be consumed in heat and electricity production.
The biogas production has been quite stable in the past 10 years, but the production and consumption of biomethane have increased in the past few years Finland, but a larger growth leap has yet to be taken. The Finnish biogas and biomethane sectors have potential in terms of both the availability of raw materials and the demand – the Finnish market for biogas, biomethane and synthetic gas can be considering as emerging and promising.

Opportunities for the Finnish sector are created by many factors, such as carbon neutrality targets, interests in advancing national self-sufficiency of energy and nutrients and the vitality of the rural areas, and emission reduction targets for transport and agriculture. The nutrient recycling offers also wide ranges of business opportunities for the sector. There is also a strong political will to develop and invest in the national biogas and biomethane sector.

The low profitability of biogas and biomethane production is **challenging** the sector, as the end-product markets (both energy and recycled nutrient products) are still developing. The availability of low-cost fossil fuels is also considered to slow down the development of the industry. Well-designed and targeted policy instrument can fasten the development: the profitability can be improved with subsidies, and demand for end-products can be increased with various incentives. Incentive schemes should be made more predictable and long-term to encourage for new investments.

In order to reach the objectives and targets, there is a need for having **better dialogue** between different stakeholders (producers, users, decision makers, official and other). There is big number of different stakeholders, as the biogas and biomethane sector is strongly involved in different sectors such as energy production, agriculture, transportation and waste management. It is not only about energy production but it also an excellent way to recycle nutrients.

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Moreover, there is a need for **defining long term actions**; hence an official national biogas and biomethane production target for **2030** and long-term national incentive package are urgently needed. The targets and actions agreed together would create confidence in the industry's growth potential for the current players and for newcomers.

The Finnish biogas sector has already started the journey to call for long term actions by launching a Biogas 2030 statement in August 2020. The statement was signed by six Finnish energy and circular economy linked associations that are the Finnish Biocycle and Biogas Association, the Bioenergy Association of Finland, the Finnish Federation of Agricultural and Forestry Producers MTK, Finnish Clean Energy Association, and Finnish Gas Association. More information about Biokaasu2030 statement can be found at the www.biokaasu2030.fi. Things have already progressed, as finally in September 2021, the Finnish Government agreed to have a national biogas and biomethane production target of **4 TWh** in 2030.

3.4.2 Roadmap

Actions should be taken in three-time windows: **2021-2023**, **2024-2030** and **2030-2035**. For the start, it is important to ensure the availability of biomethane for users, in which the increased production volumes of biogas/biomethane and the number of gas filling play important roles. This requires public investment money through the 2020s. Later the development of new market mechanisms, such as GoO-system, becomes also important. Between 2025-2030, the demand for biomethane in shipping and industries should be strengthen. The role of digestate is becoming more vital year after year, because it can improve the economics of biogas plants remarkably. Through the 2020s, there is a need to improve market conditions of recycled nutrients and fertilizers needs, namely by increasing the supply of a good quality products and finding right incentives to raise up the demand side. Detailed actions are reported below.

Measures at 2021-2023

- To improve the **availability of biogas** and **biomethane** (e.g., distribution, obligation, bio-LNG).
- Expansion of the bio-CNG and bio-LNG **distribution network** (e.g., investment aid for stations; containers need to recognized better in the aid policy).
- To modify the European **CO_2 standard** for vehicles.
- To increase in **procurement** aid level for CBG / LBG trucks.
- To have specific actions for different types of institutions: e.g., advice and information on new financing solutions and company models (company / co-operative / outsourced operator / subcontractor models).
- To provide **financial incentives** for industrial gas investments.
- To make use of **innovation** clusters, **interdisciplinary** innovations.
- Evaluation of the introduction of **new instruments** (e.g., obligations).
- To fasten the role of **public procurement** / municipalities as market initiators / openers.
- To fasten the regulatory framework for **nutrient recycling** (e.g., obligations, rights, incentives).
- The CAP27-system supports **nutrient recycling**.

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Measures at 2024-2030

- To improve the **availability** of biogas and biomethane (e.g., through new GoO and sustainability certificates).
- To modify **procurement aid** of heavy-duty vehicles by setting obligation to use biomethane in the early years.
- To increase the demand for biomethane in **shipping**.
- To increase the demand for biomethane in **industrial use**.
- To develop the market for **recycled nutrient** products and support in production of new products.
- To have a **financial incentive** for the use of recycled nutrients.
- To utilize **dry fraction** made from reject as a growing medium, especially by the public sector.

Measures at 2030-2035

Ensure that biogas and biomethane have a role to play in the energy integration and in the processes that cannot be electrified before 2040:

- As the price of coal (or CO_2 emission allowances) rises, the **demand** for biogas will increase as well. and, thus, also the production.
- The world is electrifying; biogas can still have good opportunities even if the price of electricity rises.
- Adjusting the electricity grid is necessary in any case, biogas can have a role in **storing** the renewable energy.

3.5 Greece 

3.5.1 Vision

Biogas production in Greece started in the early 2000s and until 2010 the Greek biogas sector was dominated by landfills and Wastewater Treatment Plants (WWTP) with annual biogas production of 59 and 484 GWh, respectively.[11] In the period 2011-2020, the first biogas plants were constructed from agricultural feedstocks, the number of which reached about 50 by the end of the decade. During this period, apart from the construction of new plants, there was an increase in the production of existing plants, growth trends that continue in the new decade. In 2020, Greece produced **1,126 GWh of biogas** from which 428 GWh of electricity[12] were generated in plants with a total installed electricity capacity of approximately 90 MWe. Currently, **no biomethane production** takes place.

The growth rate of the installed capacity of biomass power generation in the previous decade was not sufficient to achieve the goal of the National Energy and climate plan (NECP), falling short by 57% from the target in terms of installed electrical capacity (90MWe vs 210 MWe).
There is a lack of an existing regulatory framework and subsidy scheme for biomethane as a final energy product. In the NECP drafted for the decade 2020-2030, the policy on the contribution of bioenergy to

[11] The production of biogas and biomethane is expressed in energy units of fuel, and the production of electricity in units of electricity. The conversion factor between the energy and electricity factor for evaluating production capacity is 0.38.
[12] Similarly.

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energy production continues to focus on electricity generation, proposing the following development (Table 1). However, bioenergy use in other sectors (transport, heating/cooling) is not foreseen in the current NECP, except for the indirect use of biogenic electricity through e-mobility and heat pumps.

Table 1: Bioenergy production prediction (NECP 2019)

	2020	2022	2025	2027	2030
Annual production [GWhe]	400	500	800	1,000	1,600
Installed capacity (MWe)	90	112	180	225	360
Share of bioenergy in the total electricity generation from RES (%)	2.26	2.17	2.81	3.10	4.2

In order to reach its potential, the new NREAP has set an electricity generation target of **1,600 GWh** from biogas by 2030. Most of the biogas would be upgraded to biomethane, so that the biogas sector could serve the growing demand in sustainable and clean energy from the transport and industry sectors.
The quantitative targets for the penetration of biomethane to replace partially the natural gas are related to the long-term vision of the plan for 2050 leading to climate neutrality. The reference is to the long-term strategy for 2050 (MS-50)[13], and among the various scenarios, scenario NC1.5 is selected, which refers to the new energy carriers (New Energy Carriers for 1.5^0C). The total consumption of fuel gases (both fossil and renewable) is presented in Table 2 below:

Table 2: Development of renewable gas production in the period 2020 - 2050.

	2020	2030	2040	2050
Annual consumption [TWh]	58	64	36	42
Share of renewable gases in the annual consumption	0	25	50	100
Annual production of renewable gases [TWh]	0	16	18	42

Therefore, the long-term vision is to enable the annual energy production of renewable gases equal to **42 TWh** in 2050, with a (hypothetical) development of the share of renewable gases from 0 to 100%, between 2020 and 2050.

Opportunities for the Greek biogas sector are created by many factors such as carbon neutrality targets, lignite phase-out, low-carbon-intensity energy system, decentralization of energy schemes, and interests in advancing nutrients and the vitality of the rural areas. Nutrient recycling offers also wide ranges of business opportunities for the biogas sector.
In view of the forthcoming extension of the Emissions Trading System (EU ETS) into the maritime sector, a special interesting opportunity is seen in the **development of decentralised Bio-LNG production** for the supply of small and medium sized vessels with zero-emission fuel, while the same infrastructure can also support Bio-LNG supply for the heavy road transportation.
Biomethane produced, upgraded and purified according to the national specifications can be injected to the grid. The existing **Greek gas distribution infrastructure can support** the biomethane injection, since:

[13] https://ypen.gov.gr/wp-content/uploads/2020/11/lts_gr_el.pdf

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a) it is located close to the agricultural areas; b) it has high-capacity potential (operating at 16 bar and 4 bar); c) it is constructed with PE and steel, so it ensures the adaptability with biomethane injection; d) it has zero leaks.

However, a **strong political framework** needs to be established in Greece so that the national biogas sector will be developed. The **low profitability** of biogas production impedes the development of the sector, as the end-product markets (both energy and recycled nutrient products) are still undeveloped and the demand for renewable gas is uncertain. Policy instruments promote certain practices to reduce greenhouse gas emissions (e.g., electric cars) other than renewable gas, setting a considerable economic risk when investing on an industrial scale.
The Greek government has also established a Hydrogen Committee in order to promote the policy issues covering the renewable gas production sector (including biomethane production) besides hydrogen production.
In order to reach the objectives and targets above, there is a need for having a **fruitful dialogue** between different stakeholders (producers, users, decision-makers, official and other). There is a big number of different stakeholders, as the biogas sector is strongly involved in different sectors, such as energy production, agriculture, transportation, and waste management. Collaboration between biogas producers and industry as final users should be reinforced. Technology developments, legal, regulatory, and network development efforts should go hand in hand in order to achieve efficient and timely decarbonization of the gas sector.

3.5.2 Roadmap

To achieve targets indicated above different timeframes were defined (in 2030 and 2050).

Medium-term (2030)

Based on data provided in Table 2 above, the target for the renewable gases production is about **16 TWh** for 2030. The share of biomethane can be set at 50% of the total for 2030, i.e., **8 TWh**. The rest share can be covered by hydrogen produced via electrolysis. This quantity exceeds by 100% the prediction of NECP for electricity from Biomass - Biogas.
To the extent that the NECP's estimate of available biomass suitable for anaerobic digestion is reliable, it will be necessary to use biomass suitable for gasification for the production of **4 additional TWh** and/or to increase digestible biomass with new feedstocks that in the past they have not taken into consideration for the estimation of the targets either due to cost or due to their exclusion based on sustainability criteria (RED).

The measures - actions that will be needed to achieve this goal are:

- Development of a biomethane production certification system through **Guarantees of Origin**.
- Development of a **legislative** biomethane production support framework with stronger incentives than those currently in place for electricity generation, so that new producers shift to biomethane.
- Production **support tariffs** to apply to self-consumption of biomethane production (prosumers).
- Incentives for **retrofitting** of Biogas plant for electricity production to biomethane production plants after the completion of 10 years from the entry into force of the first electricity generation contract.

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- **Incentives** for the creation of fleets of vehicles (road and fixed track) and ships using compressed or liquefied Biomethane. Similar incentives with those applied in e-mobility should be given.
- Development of the **technical and regulatory framework** for the connection to the medium and low-pressure networks in cooperation with the distribution network operators.
- Development of **a supply network** with distinct biomethane distribution points in compressed or liquefied form in collaboration with the operators of refuelling stations of vehicles and ships.
- Incentives for the development of supply chains for **residual biomass** with the participation of the agricultural production, distribution and processing sectors.
- Incentives for the cultivation of **energy crops** with respect to the sustainability criteria of the Renewable Energy Directive (RED II-III).

The role of the main stakeholders is summarized below:

- **DAPEEP** is the manager of Renewable Energy Sources and Guarantees of Origin (GoO) and manages the RES and the High Efficiency Cogeneration of the National Interconnected System, as well as the Power Supplies that have been supplied by CHP and RES. It is the auctioneer of pollutant rights in Greece. DAPEEP will implement the **biomethane production certification system** through Guarantees of Origin.
- The Hellenic Gas Transmission System Operator (**DESFA**) S.A. is responsible for the operation, management, utilization and development of the National Natural Gas System and its interconnections, in a technically sound and economically efficient way, in order to best serve its users with safety, reliability and adequacy. DESFA will define the **specification of the biomethane to be injected in grid** according to ENEN 16723-1:2016 (Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network - Part 1: Specifications for biomethane for injection in the natural gas network)
- **DEDA** owns, develops, operates and maintains the gas distribution networks, ensuring the economical, reliable, safe and uninterrupted energy supply. In addition, DEDA is responsible to interconnect the producer with the natural gas network and control the gas quality before injected into the grid. In biomethane market, DEDA will implement the **connection of all biomethane producers to the natural gas grid**, while they will be responsible for the monitoring of biomethane specifications.
- **Biogas producers** are the operators of the biogas plants (agricultural, landfill and sewage sludge sector). Biogas producers will invest on the upgrading of the produced biogas to biomethane via the application of different technologies like water scrubbing, pressure swing adsorption, chemical scrubbing, physical scrubbing, and membrane separation.
- Regulatory Authority for Energy (**RAE**) and **Hellenic Ministry of Environment and Energy** will define and apply the **legislative framework**, including the feed-in tariff mechanism for promotion of biomethane market
- Finally, a **biomethane aggregator entity** is foreseen to be involved in the biomethane market, in order to be an intermediate entity for providing certain biomethane amounts to DEDA from the biomethane producers.

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Long-term (2050)

The target for biomethane production can be set at 30% of the total for 2050, i.e., **12 TWh**. The rest **30 TWh** (being the estimated share of power and industry in the total consumption of Natural Gas) could be produced by green hydrogen, be transported via HP pipelines, and be utilized mainly for electricity production and in the industry.

Part of the hydrogen production could merge with the Biomethane one, serving indirectly the sectors where Biomethane would develop as the prime replacement of Natural Gas, i.e., the sectors of Transport and Heating and Cooling. Combining the use of Hydrogen (in mixture or in CH_4 molecules - after methanation of CO_2) with Biomethane, would allow utilization of NG infrastructure for its direct green equivalent for a seamless transition in the sectors currently served by NG (excluding power production).

The measures - actions that will be needed to achieve this goal, among others, are:

- Allow the use of Green Hydrogen as feedstock to the AD and Gasification processes.
- Develop / adapt gas distribution networks to operate on Methane / Hydrogen mixtures.
- Exclude the gas-powered ICEs from the general ban.
- Further develop CNG / LNG refuelling infrastructure for road, rail, sea transportation means.
- Encourage / incentivise installation of Biomethane production close to the served gas distribution networks and refuelling stations / terminals by offsetting feedstock - digestate logistics cost with the reduction in gas transportation – pipeline injection costs.
- Generalizing the EU-ETS to all types of transportation and/or establishing alternative means of GHG reduction related support.

Those measure are additional to those listed for the Medium – term period and their application may start already in the decade 2020 – 30. In any case, with the exception of the measures relevant to Green Hydrogen (where production of low-cost Hydrogen at small scales is likely to be mature towards the end of the decade), the others would provide the means of better exploiting the Biomethane production.

3.6 Ireland

3.6.1 Vision

In 2021 Ireland had **31** biogas plant for a production of **482 GWh** and **one** demonstration central facility injected **4,972 MWh** of biomethane into the grid. The projection for 2022 is approximately **21,285 MWh** of biomethane production and injected into the grid. By the way, Ireland lags behind other EU countries in **not having an established biomethane industry**. This has meant that work to establish a trading environment has been concurrent with the work of Renewable Gas Forum Ireland and industry consumers to develop the integrated business case and achieve stakeholder and government recognition of, and policy and legislative support for, biomethane and bio-fertiliser production.

Ireland is particularly suited to agricultural feedstock-based AD biomethane and bio-fertiliser production because 80% of its land is pasturelands, with a strong dairy industry and ready availability of sustainable forage (silage) and slurry feedstock.

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Gas Networks Ireland, as the gas authority in Ireland, has implemented and now operates the **Renewable Gas Registry Scheme** and they are also responsible for Ireland's gas pipeline network – one of the most modern in Europe. It provides confidence, certainty and assurances to gas consumers, in validating and verifying, in a fully accountable and transparent manner, that biomethane is sustainably produced.
A series of reports have been commissioned since 2019 by RGFI and for and on behalf of industry such as Project Clover industry sectoral collaboration, informed by professional, independent advisory services from KPMG. They provide independent analyses of science-based targets, full economic assessment and cost benefit analysis, in compliance with the Public Spending Code, using reliable and trusted independent information and data.
Recent research from the government agricultural research agency, Teagasc, and Devenish Nutrition, shows how a move to mixed species sward pastures can further the sustainability of energy value and environmental benefits of the agricultural feedstock, with only 2% of land required for sustainable feedstock supply and 735,000 Ha of permanent pasture lands available for use to grow sustainable agri-feedstock to supply an indigenous and sustainable AD biomethane industry.
Momentum is gathering in Ireland to embrace sustainable indigenous biomethane and bio-fertiliser production and use, to help meet decarbonisation targets, within a new policy and legislative framework and with strong consumer support from key market segments of manufacturing, processing (thermal demand) and transport (heavy goods vehicles).
The legally binding framework is provided through Irelands' Climate Action Bill (Climate Action and Low Carbon Development (Amendment) Bill 2021), which also establishes carbon budgeting and structures and processes to support Ireland's transition to Net Zero by no later than 2050 and with a reduction in GHG emissions 51% by 2030.

The Government of Ireland Climate Action Plan, published in October 2021, includes biomethane for the first time. A core measure in the Climate Action Plan is to work with the agriculture and waste sector to contribute sustainable agricultural feedstocks in the production of **1.6 TWh** per annum of indigenous, sustainably produced biomethane, for injection into the gas grid by 2030, representing about 3% of natural gas supply. Section 16.3.2 of the Plan states that this will abate c. 0.1-0.2 $MtCO_2$ eq per annum for the agriculture sector and will displace 0.4 $MtCO_2$eq per annum for the energy.
Industry have welcomed the Climate Action Plan's commitment to pursue opportunities for the production of further levels of biomethane above 1.6 TWh, building on the output of the forthcoming National Heat Study and Land Use Review. Their ambition is to develop at least 125 x 20GWh AD plants by 2030 generating a minimum of **2.5 TWh** of renewable gas per annum, representing 15% of industrial and commercial gas usage, and displacing around 0.7Mt CO_2 per annum. However, in the first instance industry will focus on developing a number of 20 MW plants that can be used to develop proof of concept to further work and development on commercialising digestate and soil carbon sequestration (Carbon Farming).
This approach would, at the same time, provide farmers with a diverse, reliable income stream, support the development of a circular, rural bioeconomy with opportunities to diversify into renewable energy, bio-fertiliser production, and support the commercial sustainability and competitiveness of the Irish food and drinks industry. It is projected to create **3,000** sustainable jobs across rural Ireland.

The main **barriers** and **obstacles** can be summarised as follows:

- Lack of a Renewable Heat Obligation to bridge the funding gap.

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- Need to adjust the GBER exemption threshold to allow capital funding required and related structure/mechanism to support the establishment of a mature biomethane industry.
- Lack of understanding of the benefit of AD biomethane to the environment, energy security, storage and pricing and the circular bioeconomy.

The main **drivers** and **opportunities** can be summarised as follows:

- Implementation of RHO in 2023.
- Develop a National Biomethane Strategy.
- the national and international imperative to address climate change by decarbonising.
- Project Clover agri-food industry led collaboration, working in consultation with Government and farmers to decarbonise their thermal processes and support zero carbon farming.
- The need to develop indigenous, secure energy supplies, storage and pricing and the implementation of the REPowerEU plan, aligned with capital grants for AD biomethane plants.
- The need to support farmers and regenerative agriculture and to sustain diverse farm incomes.
- Research and innovation on:
  - ✓ sustainable agri feedstock AD biomethane and biofertiliser sustainability
  - ✓ available feedstock and the potential for multi spp swards
  - ✓ food and energy production systems
  - ✓ the business case and commercial feasibility studies for sustainable Agri feedstock AD biomethane, biofertilisers and Carbon Farming Initiative and related products
- Development of Teagasc Grange Centre of Excellence for AD biomethane.
- RGFI as a National Co-ordination and design authority and its role in representing its members, developing collaborations and knowledge exchange.

3.6.2 Roadmap

To achieve targets indicated above different timeframes were defined (in 2030 and 2050).

Medium-term (2030)

- The announcement of a Renewable Heat Fuel **Obligation scheme** in 2022, with implementation by 2023, and a biomethane **target of 11% by 2030**.
- **Government support** with match capital funding of 50% for a scheme which would support further the full potential to commercialise bio-fertilisers and soil carbon sequestration by 2021-2023 and capital funding to support full roll out to 2030.
- **Consultation** with industry on the optimum economic structure for a national carbon farming initiative.
- Facilitating **cross border trade of renewable gases** and **Guarantees of Origin**.
- **Research, knowledge and information transfer** especially in relation to co-products such as bio-fertilisers and soil carbon sequestration.
- Greater **public awareness** of the opportunity to decarbonise and the associated environmental benefits.
- Factoring of biomethane into the **following policies and plans**:
  - ✓ Renewable Heat Obligation Scheme and ongoing liaison with industry

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- ✓ Annual Review of the Climate Action Plan, Sectoral Climate Action Plans to be produced from 2022 and 5 yearly Local Authority Climate Plans
- ✓ National Biomethane Strategy – proposed new policy action
- ✓ Renewable Energy Directive Article 23 – RHO implementation by 2023
- ✓ Draft Circular Economy Bill to be published
- ✓ Circular Economy Strategy
- ✓ Waste Action Plan for a Circular Economy updated
- ✓ Bio-economy Action Plan
- ✓ Land Use Review, currently underway, to be followed by Diversification Reviews for income and land use for farmers Just Transition Fund
- ✓ National Heat Study
- ✓ Recovery and Resilience Plan
- ✓ National Adaptation Framework produced in Jan 2018 will be reviewed in 2022.
- ✓ Refresh of Regional Development Plans up to 2024
- ✓ New national strategy for Research and Innovation
- ✓ EU taxonomy will come into force in 2022/23 to support the financial system to direct essential investments into climate action
- ✓ Sustainable Finance Ireland.
- ✓ EU Strategy for Sustainable Finance.

Long-term (2050)

By 2030, Ireland will have an established **AD biomethane** and **bio-fertiliser industry** focussed on reducing GHG emissions in industry, agriculture and transport, as part of the circular bioeconomy and supporting regenerative agriculture. Bio-fertilisers, produced from the digestate, will be an organic fertiliser that replaces the artificial fertilisers and will satisfy the requirements of different crops and regenerate soils. Having an indigenous supply of biomethane, also lowers reliance on imported fossil fuels, strengthens energy security and supply, can lead to the potential to pursue other revenue streams such as biogenic CO_2, bio actives and other bio products.

In the coming years, **new innovative technologies**, commercialising and monetising of by products, developing new markets and technologies for the recovery of these by-products will develop further. Their role in the future bioeconomy and socio-economic benefits will be important: providing alternatives for chemical fertilizers, restocking the carbon in our soils and supplying green CO_2 for industry and horticulture.

It is important that the legi**slation, regulatory environment and licensing** stimulates, activates and supports a more circular bio economy by paving the way for these bio-based products: new product regulations, adapted fertilisers rules, etc.

The cost of renewable electricity is expected to **stabilise** in the coming years with a maturing market and reducing production costs of PV-installations, wind turbines and batteries. Biomethane will be used for applications where there is no other economic, competitive, scalable and effective alternative for thermal processes used in the manufacturing and processing sector.

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3.7 Italy 

3.7.1 Vision

During the last 10 years the biogas sector in Italy went through radical changes. The years 2008-2012 were characterized by a rapid growth of biogas plants' amount. The sector grew considerably, exceeding **1,000** plants with an installed capacity around 900 MWel, thanks to a feed in tariff *("tariffa onnicomprensiva")* that guaranteed really interesting subsidies (0.28 €/KWh) for the production of renewable electric energy.
From January 2013 to December 2017, the Italian biogas support scheme substantially changed and was considered less profitable by the investors. Compared to the past, the subsidies have decreased and have been extended from 15 to 20 years and related to the size of the plant (the smaller the biogas plant is, the higher is the subsidy) and to the feedstock (the more by-products or organic waste you use, the higher is the subsidy). They also introduced a ranking system for the new biogas plants ("registry") and a special bonus for the enhancement of the thermal energy and for the reduction of the nitrogen content in the digestate.
At the end of 2017 in Italy there were **1,555** operating plants, with a total installed capacity of **1,345 MWel**, making Italy the second biogas market in Europe after Germany and the fourth in the word after Germany, China and USA.

In Italy presently there are only few biomethane plants in production, despite excellent starting conditions as important **drivers**, i.e., large number of biogas plants and natural gas vehicles, extension of the natural gas grids), namely:

- Around 1,900 biogas plants.
- More than 1 M of CNG and LNG vehicles.
- Around 1,500 CNG and LNG filling stations.
- Around 40,000 km of transmission grid and around 250,000 km of distribution grid.

At the end of October 2020, **22 biomethane production plants** were in operation in Italy, with a total capacity of approximately **20,000 m^3/hour** and **168 million m^3 per year**, calculated considering the functioning of the plant of **8,400 hours** per year.
Of the twenty-two plants in production, only **5**, equal to 23% of the total, are fed with agricultural by products. Most (**14**) use OFMSW as a matrix, **2** agro-industrial waste, while **1** plant is fed by the sludge of a civil wastewater purifier. By evaluating the contribution of the different matrices not on the basis of the number of plants on the expected production (cubic meters of biomethane per hour), the agricultural by-products allow to obtain only 11.7% of the total biomethane against 75.4% of the OFMSW.
Also, it is worth noting the entry into operation of the first two liquefaction plants, with 1,400 and 2,000 tons of liquefied biomethane.
In February 2022, there were **28 plants** producing **284 million m^3** per year (no details available on feedstock used).

The main **barriers** can be summarised as follows:

- excessive bureaucracy slowing down authorisations for new biomethane plants (especially those fuelled by OFMSW, but there are also cases involving agricultural plants).

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- distance of many farms interested in biomethane production (with a new plant or by converting an existing biogas plant) from the natural gas transport network. This results in very long connection times and high connection costs (> 1 M€).
- NIMBY effect for both OFMSW and agricultural plants. There is still strong opposition to the construction of new anaerobic digesters for the production of renewable electricity or biomethane.
- Lack of a durable incentive financing scheme, which does not facilitate long-term investments.
- Discrepancies at the regulatory level between the biomethane decree and the decree that regulates the agronomic use of digestate: some agro-industrial by-products (e.g., bread and pasta processing waste) can be used to produce biomethane but, if used, create problems in the management of digestate (an amendment that should solve the problem is in progress for approval).

At the beginning of 2018 the Italian government published a decree (Decree 02 March 2018) encouraging the production of biomethane and that should give a strong boost to this sector, with a target of **1.1 billion cubic meters biomethane per year**. The duration of the Decree of 02 March 2018 is expected to be extended by at least one year (from December 2022 to December 2023).
Italy has historically supported, with its Feed-in-Tariff-based support scheme for electricity generation from renewables, biogas development, having in 2020 a **~25 TWh/year** production **(~1,900** plants).
However, the current Electricity generation support is coming to an end for the plants built before the end of 2012, and rather than introducing a new incentive, Italian Government intends to operate a shift by facilitating the conversion of existing biogas plants to biomethane plants.
In addition, with the 2018 Decree, Italian Government has engaged efforts to develop biomethane production, reaching a **0.3 billion m^3/year** production, with 30 operational plants.
After having supported and, partially, developed biomethane production for road transportation, through the CIC ("*Certificati di Immissione in Consumo di biocarburanti*", certificate of release for consumption of biofuels) scheme set up by the 2018 Decree, Italian Government is presently intending to pursue efforts by developing non-transport biomethane usage, with a new support scheme.
CIC's scheme has participated to Biomethane development for Road Transportation, with a current production of **0.35 billion m^3/year** and an expected production of **0.6 - 0.7 billion m^3/year** by the end of 2022 that which will make it possible to replace 60-70% of the fossil natural gas generally used to power the approximately 1,050,000 Italian natural gas vehicles. In the already approved Italian PNRR (National Plan of Recovery and Resilience), **1.91 billion €** have been allocated to reach **4 billion m^3/year** by 2026.
A **new support scheme** for biomethane production, based on feed-in-tariffs and premiums granted to Biomethane producers, is expected to be published in 2022. It will extend eligible biomethane end-use sectors, including other sectors than transport, such as industrial or residential. Probably, the bioLNG will continue to receive subsidies to be used in the transport sector due to the increase in consumption by heavy duty vehicles. The use of biomethane in the maritime shipping sector could also be encouraged.
By 2030, Italy could achieve a production of **6.5 billion m^3** of biomethane per year from agricultural and agro-industrial biomass for various purposes (electricity, transport, industrial applications), increasing the competitiveness and economic and environmental sustainability of farms.
The contribution of the Organic Fraction Municipal Solid Waste (OFMSW) and other sectors (sewage plants, landfill) could be equal to **1.5 billion billion m^3** of biomethane per year.

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3.7.2 Roadmap

In order to achieve the targets indicated above, the pillars for the development of the Italian agricultural biomethane potential are:

- **Limited use of first crops**, in line with the specific characteristics of Italian agriculture. It is estimated a trend towards a reduction in the relative agricultural surface area compared to that currently used (less than 200,000 ha, 3% of the Italian UAA in arable land), in any case reduced and lower than the surface area once allocated to set aside, and a greater attention to the peculiarities of individual territorial contexts. The possibility of allocating part of the farm area to sustainable crops for biogas allows to preserve the crop rotation for food and also to enhance the value of those soils that are difficult to manage due to soil type, structural lack of organic matter and / or adverse seasonal climatic trends.
- **Increasing the use of second crops**, taking into account the peculiarities of the production chains in different parts of the country and the amount of irrigated or irrigable UAA, on an area not exceeding 10-12% of the Italian UAA used for arable crops.
- **Growing use of livestock manure in anaerobic digestion**, an almost obliged path to drastically reduce the overall impact of Italian livestock farming and at the same time increase the efficiency of organic fertilization and soil fertility. By 2030, it is estimated that at least 65% of the livestock manure produced today will be sent to biogas.
- **Growing use of agricultural residues and agro-industrial by-products** of high quality and managed in a virtuous way according to the principles of circular economy. Depending on the peculiarities of the individual flows in relation to their quality and their valorisation in the food chain, it is estimated that between 10 and 70% of the total available will be sent to biogas. As for crop residues, their removal from the soil is balanced with the return of digestate to the soil (with a better humification index).

Measures at 2022

In **2022** the expected measures - actions that will be needed to achieve the goals above are:

- March 2022: **revision of application procedures** of the Decree 02 March 2018 by GSE (state company to promote sustainable energy), with introduction of biomethane use for maritime transport.
- By summer 2022: **new Italian biomethane subsidies scheme**. It will introduce:
  - ✓ a new support schemes for biomethane production based on Feed-in-Tariffs & Premiums granted to producers.
  - ✓ Different tariffs granted depending on defined criteria (such as the size of the plant, feedstock origins, etc.).
  - ✓ Tender-based system (twice a year).
  - ✓ New end uses as well as transport ones.
- By summer 2022: **GSE application procedures** of the new Italian biomethane decree. The document will contain all the definitions (e.g., gas network, entry into operation, biomethane producer, etc.), the possible configurations of the biomethane plant (e.g., injection into the natural gas grid, liquefaction, etc.), the methods of assigning incentives, etc.
- By the end of 2022: **publication of tenders** for access to the new biomethane decree. To benefit from the subsidies provided for by the new decree, the companies interested in producing biomethane will have to participate in a tender. Forecast of 2 tenders / year.

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- By the end of 2022: **UNI 11567** technical standard revision. Revision of environmental sustainability criteria for the production of biomethane. Expected 2 different reference values (percentage of reduction of GHG emissions): one for biomethane used in the transport sector, one for biomethane for other uses.
- By the end of 2022: updating the regulation relating to **digestate** and **zootechnical** effluents.The decree (concerning both biogas and biomethane) will introduce an update regarding the use of digestate in agriculture also taking into account the feedstocks that can be used to produce biomethane.
- By the end of 2022: **decree FER2**. The decree (concerning biogas) will introduce **incentives** to geothermal, offshore wind farms, biomass, biogas and solar thermodynamic. To produce electricity from biogas, probably, the maximum size will be < 300 KWel.

Measures in the period 2023-2026

- To promote the **injection of biomethane** into the distribution network (as, for example, happens in France), also through the new construction of pipelines 5-10 km long in order to facilitate access to the gas network by isolated biogas plants.
- To facilitate the **access** of biomethane to the natural gas transport network also by introducing the "gas reverse flow" in the distribution grids.
- To **modify** the European CO_2 **standard** for vehicles.
- To increase **aid level** for CBG / LBG trucks through, for example, the reduction of motorway tolls and through economic subsidies for the purchase of trucks.
- To provide **financial incentives** for industrial gas investments.
- To provide a **support mechanism** for electricity production in existing biogas plants which will soon end the incentive period, and that cannot easily converted into biomethane plants.
- To introduce **incentives** to convert agricultural tractors and other engine-powered machinery from diesel to biomethane.
- To **simplify** the **authorization** process for biomethane plants and shorten their timing.
- To facilitate the **transfer** of specific know-how to the agricultural sector.

Measures in the period 2027-2030

- To publish a new **support scheme** for biomethane and renewable gas production.
- To encourage the production of biomethane through the **Power to Gas** process which uses the biogenic CO_2 by existing biomethane plants.
- To introduction **alternative biomasses** (e.g., microalgae) for the production of biogas and biomethane.
- To promote the use of **biogenic CO_2** in industrial processes.
- To increase the demand for biomethane in **shipments** and **industrial** use through specific incentives for end-users.
- To introduce the **obligation** to use **livestock manure** in anaerobic digestion in order to reduce the emissions of GHG in the agricultural sector.
- To introduce **agri-environmental incentives** that help to increase organic matter in the soil through the use of digestate.

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3.8 Latvia

3.8.1 Vision

Latvia has high biogas installed electric capacity per 1 million of population, generated in **58 biogas plants**, build during 2009-2015. However, there has been a steady slow-down in development: the 2011-2013 NREAP targets were comfortably exceeded; the 2014 and 2015 targets were just met; and since 2016 Latvia has lagged further and further behind its goals. 5 biogas plants during this period were shut down after they lost their FiT on administrative grounds. Already in the last 8 years (since 2012) no biogas plant building permission was issued. The biogas production in 2019 reached **298.4 GWh**, while **no biomethane production** currently exists yet.

The biggest **challenge** is the lack of natural gas infrastructure for transport and of vehicles. The low profitability of biogas production is challenging for the sector, as the end- product markets are still developing. The new targeted policy instruments should be developed more actively to reach climate goals until 2025 and developing biomethane production sector and demand for end products.

One of the best **opportunities** is the use of biomethane as a biofuel in the heavy transport and maritime sectors. The number of LNG lorries on the European road network has grown rapidly over the last decade and the first gas-powered vessels have been developed. However, Latvia does not have specific targets for the use of bio-CNG or bio-LNG, despite its great potential to reduce emissions from the transport sector. Furthermore, the Latvian National Energy and Climate Plan (NECP) does not envisage a shift towards a cleaner and greener heavy transport and maritime sector.
The **opportunity** of **integrating energy and agricultural system** will rely on the following aspects:

- The close interaction between the agricultural sector and biomethane plants needs to be encouraged. Efficient transport of raw materials from farms to biomethane plants is important to reduce GHG emissions on farms and maximize biomethane production. Biofertilizer produced from digestate will be adapted to the requirements of different crops and soils.
- The cost of renewable electricity will decrease in the coming years due to lower production costs for photovoltaic installations, wind turbines and batteries. Biomethane will be used for difficult-to-electrification applications, such as high-temperature processes or long-term storage, or when other renewable sources are not available, such as in adverse weather conditions.
- With the growing importance of the bioeconomy, anaerobic digestion will be important for closing the gaps in the circular economy by recycling organic waste streams from various biological products and for obtaining useful products such as biomethane and biofertilizer. The evaluation of biomethane is a much-needed first step in increasing the role of anaerobic digestion in our circular economy.

The Latvian Biogas Association calls for a **0.68 TWh** biomethane production capacity by **2030**, based on current and future production capacity.
To take full advantage of the added value of biomethane in the Latvian energy system, it is important to obtain detailed figures on the production potential and possible development trajectory. A study on

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potential is also needed to determine the potential contribution and costs of biomethane to the energy system.

3.8.2 Roadmap

To achieve targets indicated above different timeframes were defined (in 2030 and 2050).

Medium-term (2030)

In the medium- term, to achieve the capacity indicated above, the following actions are needed:

- Strengthen the role of **public procurement/local governments** as market initiators in the development of the biomethane market.
- Strengthen the **legal framework** for nutrient recovery (e.g., by responsibilities, rights, incentives).
- Improve the **availability** of biogas and biomethane in the transport sector (e.g., through guarantees of origin and sustainability certificates).
- Modify the **procurement support** for vehicles in the heavy transport and municipal public transport sectors, establishing the obligation to use biogas in the first years.
- Increase the demand for biomethane for **industrial use**.

Long-term (2050)

In the long-term, actions for increasing biomethane production and use will be:

- Many of the existing biogas plants will **switch** from on-site biogas valorisation cogeneration plant for modernization and biomethane production.
- The current level of production corresponds to only 30% of the production potential. It must be ensured that more agricultural waste streams, such as manure, food residues or crop residues, are valorised by **increasing biomethane production**.
- Biomethane will increasingly be used as a **transport fuel**, especially for heavy goods vehicles and maritime transport, and will thus replace fossil fuels.
- As GHG reduction targets become more stringent, the impact of biomethane as a product on **GHG reduction** will become more important than its renewable value. The sales price of biomethane will be determined based on the product's emission reduction potential.
- This transition can be accelerated by reforming **operating support systems** and rewarding the contribution of biomethane to reducing GHG emissions.

3.9 Lithuania 

3.9.1 Vision

In Lithuania there are **41 biogas plants**, with a heat capacity of **9.5 MW** and electricity capacity of **33.4 MW**. Annual electricity produced from biogas amounts around **140 GWh**. Biogas is produced from agricultural wastes, from sewage, from landfill gas, biowaste and industrial waste.

There is **no biomethane production** in Lithuania, but with changes in support policy and additional investments, these biogas plants could be adapted for biomethane production and new facilities could be built. First biomethane plants connected to gas transmission system will start to operate in 2023.

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A biomethane sector as competitive and integrated into renewable energy system, that ensures the sustainable implementation of the national climate change plan and creates value to the country's economy. It is based on:

- the sustainable implementation of the national climate change plan, with **1 TWh** produced biomethane in Lithuania in 2030.
- the creation of value to the country's economy through **new jobs, capital return, taxes paid, know-how exports**.
- the **integration** into European **GOs exchange system**.

The **strong aspects** of the sector are:

- Well-developed gas transportation infrastructure;
- Experience in biogas production;
- Supply potential (sufficient quantity of raw materials from the agricultural sector and waste sector);
- Demand potential in the Lithuanian transport sector.

The **weaknesses** of the sector are:

- Biomethane production on commercial terms is non-redeemable.
- Significant investment is required for biomethane production plants (for biogas quality improvement installations, connection to gas networks, etc.).
- There are no biomethane production facilities connected to gas network and no experiences.
- No effective investment support.
- There are no local producers of biogas plants equipment.
- There is no sufficient gas filling infrastructure for vehicles.
- There is no centralized coordination of the biogas / biomethane sector development at institutional level.

The **opportunities** of the sector are:

- The need to supply the transport sector with biofuels (especially 2nd generation biofuels).
- Value creation for other sectors (waste management, organic fertilizers, including CO_2 use in the longer term methanization using Power to Gas technologies).
- Development of biomethane production and export of biomethane technologies as contribution to strengthen the Lithuanian economy (export of know-how).
- Sector development (new jobs, return on capital, value added development of a circular economy).
- Export opportunities at regional and European level (via European GOs).
- Contribution to the reduction of energy imports and to reduce energy dependence on energy supplies from third countries.
- Enforcement of obligations under EU legislation (RES quotas especially in the transport sector).
- High potential to reduce methane / CO_2 emissions from agriculture sector.

The **threats** of the sector are:

- Inefficient and unbalanced support scheme.
- Incentives are segmented, targeting only small facilities (economies of scale not achieved).

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In order to reach the objectives and targets above, there is a need for having **better dialogue** between different stakeholders (producers, users, decision makers, official and other). Effective and balanced support schemes should be implemented on national level. Integration into European GO exchange scheme is foreseen to have a big impact on national biomethane production increase.
The main national biomethane demand potential is foreseen in the transport sector with ambitious national targets for 2030.

3.9.2 Roadmap

The stakeholders playing a role in the achievements of the vision are:

- **Consumers** (transport, industry, energy sector): they ensure competition in the biomethane market and access to biomethane.
- **Producers/Suppliers**: they ensure ability to sell biomethane in a simple and flexible manner and under competitive price.
- **Decision makers/institutions**: they ensure sustainable implementation of the Climate change plan.
- **Society**: it reduces the impact on climate change and create long-term added value for the country's economy.

Actions to implement the vision are listed below with indication of stakeholders influencing its achievement.

- By **2021** actions of decision makers/institutions led to: Alternative Fuel Law and by-laws has been adopted; 15 million € has been dedicated for the construction of biomethane production facilities and the purchase of biomethane fuelled vehicles under the Climate change program.
- By **2022:**
  - Producers/Suppliers:
    - Possibility for emissions reductions have been made through the use of biomethane GOs (Commission Implementing Regulation (EU) 2020/2085, Art. 1 (7) (b)).
    - Fuel statistics unit system that enables use of renewable fuel in transport sector becomes operational.
    - National GO registry IT system upgraded.
    - Potential connection points for biomethane production facilities to the gas transmission system have been identified and made public.
    - Funds from Economic Recovery and Resilience Fund approved to biomethane production facilities (EUR 22.21 million) for 2021-2026.
    - CEN EN16325 comes into force.
    - Ability for GOs with proof of sustainability certificates cross border exchange under bilateral agreements.
  - Decision makers/institutions:
    - List of bio-based feedstocks for production of second-generation (including the production of advanced biofuels) biofuels approved.
    - The funds from Climate change program approved for the purchase of alternative fuel vehicles and for the installation of refuelling infrastructure (approximately EUR 10 - 20 million allocated annually).

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- By **2023**:
  - Producers/Suppliers (Biomethane production of **184 GWh**):
    - Liquefied biomethane integration into fuel statistic unit system.
    - Off grid produced biomethane integration into fuel statistic unit system.
    - First biomethane producer connected to gas transportation system.
  - Decision makers/institutions:
    - The Sustainable Mobility Fund for the long-term implementation of sustainable mobility measures and other related measures is launched to finance its implementation.
    - Increased fees for non-hazardous waste disposal in landfills up to 50 - 70 Eur / ton.
- By **2024**:
  - Producers/Suppliers (Biomethane production of **230 GWh**):
    - The possibility for market participants to exchange GOs with sustainability certificates with EU countries is ensured.
    - Facilitated biomethane construction planning, connection to gas networks and land easements processes.
- By **2025**:
    - Producers/Suppliers (Biomethane production of **288 GWh**): opportunities have been created for the injection of off-grid biomethane into gas transportation systems.
- By **2026**:
  - Producers/Suppliers (Biomethane production of **360 GWh**): Biomethane transportation tariff discounts apply.
  - Decision makers/institutions: Union database fully operating.
- By **2030**:
  - Producers/Suppliers (Biomethane production of **950 GWh**):
    - 34 road transport fleets are equipped with compressed and liquefied gas filling stations.
    - 3,750 buses or trucks using 50% biomethane.
    - Not more than 5% of all waste shall be disposed in landfills.
    - 50% livestock waste is used for the production of biomethane.

3.10 Poland

3.10.1 Vision

At the end of 2020, there were **338 biogas installations** in Poland with total installed electric capacity of **255.69 MWh**, of which **116** were agricultural biogas plants with total installed electric capacity of **117.80 MWh**. In 2020 agricultural biogas plants produced **325.24 million m^3** of biogas. It was used to produce **689.12 GWh** of electricity.

Due to the lack of appropriate infrastructure for biogas upgrading and the lack of a comprehensive support system, the direction of biomethane use has **not been implemented** at the moment.

In 2030, **0.7** to **1 billion m^3** of biomethane (as an advanced fuel produced from the raw materials listed in Appendix 1 to the Act on bio-components and liquid biofuels) in transport could be produced, as part of the implementation of RED II targets applicable as bioCNG, bioLNG and component for bio-hydrogen production. More specifically:

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- **2030** targets:
- **10%** biomethane share in the gaseous fuels market, with a 100 biomethane installations.
- **2050** targets:
- **30%** share of biomethane in the gaseous fuels market, with 300 biomethane installations.

Among the factors affecting the development of the biogas and biomethane sector in Poland, the EU climate and energy policy should be mentioned as main one, directly impacting the necessity to look for low-carbon energy carriers.
Poland's Energy Policy until 2040 (**PEP2040**) indicates that demand for petroleum products will increase in the coming years (also due to new applications), but a large part of the increased demand will be covered by the use of biofuels and alternative fuels, as well as electromobility. In this context, the importance of biogas produced from waste materials as an energy carrier in transport has been underlined in PEP2040 due to its high potential in terms of greenhouse gas emission reduction, as well as its role in a circular economy.

Key barriers limiting the possibility of biogas and biomethane market development include:
- Lack of a stable and long-term regulatory and legal framework, which makes investment in the development of biogas units less economically attractive.
- Lack of a support system.
- Difficulties in gaining public funding for investments in biomethane plants.
- Practical obstacles for biomethane plants connection to gas distribution grids (lack of grid or its insufficient capacity).
- Limited number of natural gas/biomethane vehicles.

Drivers influencing the development of the sector are:
- EU and national climate and energy policy.
- Access to biogas-to-biomethane upgrading facilities on the Polish market.
- Increased public awareness of the properties of biofuels, alternative and advanced fuels.
- Benefits connected with the use of biofuels.
- Subsidies for research.
- Work in the field of improving the exploitation of vehicles and transport means.
- Improvement of infrastructure (filling stations).
- Legal changes encouraging the dissemination of environment-friendly solutions in transport.

3.10.2 Roadmap

To achieve goals defined in the vision, **cooperation among all market participants** is needed, i.e., the regulator, ministries, politicians, state-owned companies, system operators, energy companies, local governments, and consumers, as well as entities interested in the production of biomethane. An indicator of this cooperation, as well as the integration of the biogas industry, was the signing in **November 2021** by the representatives of the government administration and the stakeholders of the biogas and biomethane sector of the "**Agreement on cooperation for the development of the biogas and biomethane sector**". Its purpose is to support the development of the biogas and biomethane sectors in

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Poland. The signed document will help to maximize the so-called local content, i.e., the participation of Polish entrepreneurs and technologies in the supply chain for the construction and operation of domestic biogas plants and biomethane plants, as well as market development and the widespread use of biogas and biomethane in the economy. The sectoral agreement was initiated by the Ministry of Climate and Environment with the "Letter of intent on establishing a partnership for the development of the biogas and biomethane sector and the conclusion of a sectoral agreement", signed in 2020. This event made it possible to start intensive cooperation between entities interested in the construction and development of this sector in Poland.
Different groups of stakeholders have different tasks to be performed: some tasks rely on politicians, others on companies (transmission and distribution network operators, manufacturers, suppliers of equipment, etc.), and others on consumers / recipients. The main proposed tasks will be broken down into production, transmission / marketing, and use / users - consumers.

Action plan: Actions should be taken in three timeframes: **2022-2025** (short-term), **2025-2030** (medium-term) and **2030-2050** (long-term).

At the beginning, it is crucial to **start the production of biomethane** in Poland and to ensure the availability of biomethane to end users using this fuel for energy purposes. This requires the introduction of **legal regulations** as soon as possible and the provision of **public funds** to support investments in the production and use of biomethane and other green gases.
In addition, it is proposed in the first period to promote the production of renewable gas in areas with a high availability of raw materials (where there is a well-developed agri-food industry or waste treatment and composting plants - with measures supporting consumption on site - in vehicle fleets, heating or in industry) or injection into natural gas networks, where technically possible and economically viable.
Presently, there is no biomethane production in Poland. However, the country has a large raw material potential resulting mainly from the well- developed agri-food industry, that is the main supplier of the raw material, especially in the form of waste and residues, for biogas plants. In addition, activating the society towards the correct, selective collection of the biodegradable fraction of municipal waste, using, for example, models already used in Scandinavia for years, may additionally affect the rapid and intensive activation of the market.
Due to the fact that the biogas value chain is characterized by a high degree of technological maturity, market uptake can be quick. In order to support this development in the short term, it is considered necessary to appreciate the renewable origin of biogas by setting up a **guarantee of origin system** that allows consumers and businesses to distinguish its added value from natural gas and guarantees appropriate sustainability standards.
The **management of digestate** from year to year is becoming more and more important, as it can significantly improve the economics of biomethane plants.

In the **following years**, the demand for biomethane in transport and in industry should increase.

Production
Main tasks will be: creating a market; increasing social acceptance; developing technologies.

Companies

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- Biomethane producers and technology suppliers: they should strive to significantly **reduce the cost** of biomethane production. A local supply chain should be built and developed in Polish conditions.
- Farmers, biomethane producers, research units dealing with **agriculture**: increasing financial outlays for research and development works aimed at continuous improvement of biogas production technology. The search for innovative production methods, such as, for example, BiogasDoneRight® - a method that proposes sequential cultivation systems, which not only makes it possible to scale up the sustainable production of biomethane but can also generate additional benefits, such as increased employment in rural areas, security of energy supply and more sustainable agricultural production. Currently, *BiogasDoneRight*® is mainly used in Italy and tested in France and Germany. In order for this concept to be disseminated across the EU, cultivation trials in different Member States are necessary. Farmers and biogas producers can take the lead, supported by agricultural institutes and universities.

Institutional organisms

- National actions: **Fair support** for renewable gases. Ensure that the benefits of renewable gas are taken into account in a harmonized way as renewable energy included in national incentive schemes, e.g., by facilitating grid connection and tariff discounts for introducing green gas into the transmission grid.
- Local governments: promotion of **good practices** based on the experience of other regions, implementation of projects combining the implementation of municipal management tasks: waste management, low-emission public transport, circular economy, education to increase social acceptance.

Transfer/Trade/Transport

- Improving **access** to the grid: quality of injected biomethane / green gas; connection costs (possibility of co-financing connection costs).
- Allowing TSOs to **increase production** more easily.
- Enabling cross-border trade:
  - introduction of the **guarantee of origin system**.
  - establishment of the **European register** of guarantees of origin.
  - creation of a European **green gas trading platform**.

Users

Building and developing the **demand** for green gas, including biomethane, in different sectors: energy, heating (e.g., heating of buildings), transportation (including heavy transport and shipping, and maritime transport), and industry.

Enterprises

Industry consciously decides to use renewable gas. More and more companies are taking responsibility for the fight against climate change. More than 400 large multinationals have committed to reducing their companies' emissions in line with the required reductions to meet the Paris Agreement target. The modernization of the EU ETS after 2021 is likely to increase **investments** in low-carbon production technologies and energy efficiency in industry.

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Financing

Work is currently underway to prepare financial support under the Cohesion Policy for 2021-2027. As part of the national program European Funds for Infrastructure, Climate, Environment 2021-2027 (FEnIKS 2021-2027), **comprehensive support** for the development of the biogas and biomethane sector is also planned - from production, storage, transport and use for energy production.

3.11 Slovenia

3.11.1 Vision

In 2021 there were **24 biogas plants** producing 24 biogas plants **87.928 MWh.** Currently, there is **no biomethane production** In Slovenia, nor any financial support to promote it.

National energy and environmental plan (NEPN, 2020) anticipates **10% of methane** and **hydrogen** of renewable source in transmission and distribution pipeline systems that reduce use of fossil fuels and decrease dependency of fuel imports.

The renewable energy promotion act has been applicable from 2021 and regulates important areas regarding biomethane production as: certificates of origin, register of certificate, etc. In December of 2021 a new law for gas supply has passed is valid from end of January 2022: it regulates many areas and provides also legal basis for undertaking of biomethane to natural- gas-pipeline systems.

The Slovenian biogas sector has potential in terms of both the availability of raw materials and the demand for biogas.

Opportunities for the Slovenian biogas sector are created by many factors such as carbon neutrality targets, interests in advancing national self-sufficiency of energy and nutrients and the vitality of the rural areas, and emission reduction targets for transport and agriculture. The nutrient recycling offers also wide ranges of business opportunities for the biogas sector. There is also a strong political will to develop and invest in the national biogas sector.

Well-designed and targeted policy instrument can fasten the development: the **profitability** can be improved with **subsidies** and demand for end-products can be increased with various **incentives**. **Incentive schemes** should be made more predictable and long-term to encourage for new investments.

To reach the objectives and targets there is a need for having **better dialogue** between different stakeholders (producers, users, decision makers, official and other). There is big number of different stakeholders, as the biogas sector is strongly involved in different sectors such as energy production, agriculture, transport and waste management. Biogas is not only about energy production but it also an excellent way to recycle nutrients.

3.11.2 Roadmap

To achieve targets indicated above different timeframes were defined (in 2025, 2030 and 2050).

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Short-term (2025)

Based on new legislation some additional steps are needed for successfully implementation of real biomethane production.
The CAP (Common Agricultural Policy) provides for **subsidies** for agricultural biogas plants not for industrial biogas plant (waste and other biodegradable waste).
Reducing time for **obtaining permits** for the production of biomethane, which are extremely time-consuming and take several years.
As subsidies have not yet been set at national level (per investment or unit of biomethane produced), there is currently a **high risk** for investors to invest and thus long payback periods. The own price of biomethane production has been higher than the price of natural gas in recent years. Investors are expecting financial incentives for the production of gaseous fuels such as biomethane, as defined by the National law on promoting the use of renewable energy sources (ZSROVE), which would improve the profitability of biomethane production projects.

Concerning the **register of certificates**, an appropriate procedure and platform for transparent issuing and treatment with certificates of origin have to be prepared and harmonize it with other EU countries. Harmonization is crucial for free market and raise of attraction for production and demand. For biomethane, this will provide a specific system of guarantees of origin.

Concerning the **financial support scheme**, a new study has to be prepared to evaluate and recommend the type and amount of financial support for successfully develop the biomethane market. Several studies about biogas and biomethane production in Slovenia were prepared in the past. It has to be evaluated existing financial mechanisms (grants and subsidies) in other countries. The study should evaluate mechanisms of countries with similar level of biomethane market development, similar biogas/biomethane potential, agricultural status, etc. Scenarios of different biomethane-market-development phases have to be researched. An appropriate financial scheme adoption over the years until 2050 has to be prepared for every scenario.
The Ministry for Infrastructure is preparing a proposal for a **support scheme** in which biomethane will be included. The first draft of the proposal is expected to be prepared by the summer of 2022, which will be reviewed by the European Commission, followed by the Energy Agency tender, which will last approximately one year.

Regarding some bad experiences of **local residents** at beginning of biogas plants operation (mainly due to smell), intensive actions and measures have to be planned to educate and make people aware about benefit of biomethane economy and diminish its bad reputation and NIMBY effects.

Medium-term (2030)

Biogas plant upgrade is the fastest way to trigger the biomethane production. From technical point of view, this requires upgrade with conditioning systems for elimination of CO_2, VOC, H_2S, water and other undesired components. Biomethane in the end use enable higher efficiency of energy transformations, minimal primary energy loss and preservation of maximal exergy in comparison to burning of biogas in cogeneration of electricity and heat units (CHP). All existing biogas plants should produce biomethane until 2030.

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Currently natural gas flow enters into Slovenia at the border of neighbour countries Austria and Italia. In few years **transmission pipeline system** will be connected also with Hungarian and Croatian pipeline systems that will additionally ensure flow of gas towards Slovenia. However, existing transmission and distribution natural gas pipeline systems has been designed for top-down principle of gas supply. Actually, due to new source points, the natural gas pipeline systems has to be adapted to ensure gas flow in opposite direction than usually flows. Pipeline networks will have to be expanded towards biogas plants. Additionally, new regulating and measuring stations, odorization units and compact compress stations will be necessary for effective biomethane transport. Gas pipeline operators will have to prepare a plan of pipeline system adoption in order to accept maximal quantities of biomethane. After the confirmation of the plan by national regulator of gas market, the operator will take measures to realize the plan.

Biogas/biomethane plants has to be additionally equipped with **liquefaction units** where connection to gas pipeline system is not applicable or is not feasible. Liquefied biomethane (liquefied biomethane ~ liquefied natural gas LNG) should be transported by train or by trucks to the points of demand (i.e., LNG filling stations).

In Slovenia is still some **unexploited potential** of biogas and biomethane production, e.g., regarding the waste-water-treatment plants and composting plants. There is also additional potential of biomethane purification at landfills. Small-scale potential represents farms where biogas plants are currently very rare. Small farms should create communities for joint production of biogas and biomethane.

Current legislation about **waste management** is rigorous about digestate treatment. It is necessary to redefine waste politics and simplify bureaucratic procedures that decrease effectivity and attraction of potential investors.

3.12 Spain 

3.12.1 Vision

Currently, there are around **210** biogas plants in Spain, of which sewage-based are the most numerous. Spain's total biogas production in 2019 roughly amounted to **8,100 GWh**.
There are currently **4** biomethane plants in Spain injecting into the gas grid. Spain's total biomethane production in 2021 amounted to **100 GWh**.

The coming years will be important for the development of the Spanish biomethane sector, as all the sector is asking to the Spanish government for approving support mechanisms for renewable gas and its injection into the gas grid.
The potential of the Spain's biomethane production is **122 TWh** (according to a report published by the European Commission "Impact of the use of the biomethane and hydrogen potential on trans-European

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infrastructure"[14]). It must be highlighted that it is now greater due to new waste recovery technologies and new sources of biogas (e.g., use of rice straw as a substrate).
The Spanish biogas/biomethane sector target is to reach the following annual biomethane productions/consumptions:

- By **2030**: **10%** biomethane over gas consumption (around **30 TWh** of biomethane)
- By **2050**: **100%** biomethane over gas consumption (around **250 TWh** of biomethane)

Mandatory targets should be fixed with a progressive annual compliance: starting targets for 2023 and publishing targets every 2 years with annual detail; a minimum penalty fee of €100/MWh for non-compliance with the target, updated every 2 years with annual detail.

The main **barriers** to the development of the biogas/biomethane market are:

- Lack of stable regulatory framework, lack of waste management policies, lack of guarantee of origin system, no traceability for virtual blending, and no traceability for biofuel, leading to investment difficulties.
- Need for greater intensity of coordination to integrate the solutions that biogas/biomethane brings to the problems of Environment + Agriculture + Livestock + Demographic challenge of depopulation.
- Shortage of biogas plants which could be converted to biomethane plants.

The main **opportunities** that should be promoted for the development of the biogas/biomethane market in are:

- Focus on positive externalities: biomethane is much more than an energy solution, it is a solution for the Environment + Agriculture + Livestock + Demographic challenge of depopulation.
- Integrated transposition of REDII.
- Regulate the establishment of the "Polluter Pays Principle" through the implementation of "win-win" mechanisms that accelerate its development.
- Re-evaluate the potential of the IDAE 2018 report: it is now greater due to new waste recovery technologies and new sources of biogas (e.g., use of rice straw as a substrate).
- Need of biofertilizers in the market.
- Growing problem of livestock manure.

The main **strategies** for the development of the biogas/biomethane market in Spain are as follows:

- A legal positioning and legal certainty for the development of projects, including a system of Guarantees of Origin.
- A system of economic and fiscal incentives for the development of projects, as, for example, the system in France with development of investment incentive mechanisms: FiT, FiP, tax benefits, etc.
- Stimulate investments in biomethane production plants, especially for small installations (French model).
- CAPEX aid for the connection of biomethane plants to the grid and recognition of investment for the reinforcement of gas infrastructures for the connection of biomethane plants.
- Consumption incentive system with quotas for gas traders: increasing percentages over time.
- More focus on marketing to companies (primary, secondary and tertiary sector), and less on marketing to households (domestic consumption).

[14] https://op.europa.eu/en/publication-detail/-/publication/10e93b15-8b56-11ea-812f-01aa75ed71a1/

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- Incentives for the end consumer: subsidies (commercial), tax advantages (domestic), etc.
- Need to set targets for production/management of waste solutions at national level: political decisions with commitment.
- To revisit the Waste Hierarchy within the EC Directive on Waste Disposal.
- To re-evaluate the potential of the IDAE 2018 report: it is now greater due to new waste recovery technologies and new sources of biogas (e.g., use of rice straw as a substrate).
- Proposal for Circular Economy cooperation.
- Need to open a specific Declaration of Interest for the biomethane sector.
- To consider all plant outputs ensuring the use of digestate as biofertiliser and develop the concept of biorefinery = Bioproducts from AD.
- To promote a common framework for cooperation and dialogue between stakeholders: producers, investors, traders, final consumers.

3.12.2 Roadmap

To achieve goals defined in the vision strategies were drafted according to different timeframes (2022-2023, 2024-2030 and 2030-2035).

Main strategies 2022-2023

- To establish a reasonably **stable regulatory framework** and long-term foresight to attract investment and foster both supply and demand side; in agreement with the European Green Deal commitment and with the European priorities identified in the recent Gas Package.
- To establish a system **of financial and fiscal incentives** for the development of projects (France system is a successful example: CAPEX, FiT, FiP, tax benefits, etc.).
- To urgently implement a system of **guarantees of origin**, including information on compliance with sustainability criteria and reduction of greenhouse gas emissions in the production process of biogas, where appropriate.
- To set increasing **annual targets** (similar to the increasing targets in other sectors), with focus on the area of marketing for final consumption, as well as producer + network operator + marketing.
- To implement appropriate policies to make better use of energy potential for the producers:
  - Prioritization of biomethane **injection** into the grid: solving production/consumption coincidence problems, contributing to the democratisation of the use of renewable gas for all sectors (domestic, commercial, industrial, transport, etc.) and optimising the means of transport of renewable energy to the end user.
  - Adopting other solutions where the grid is not accessible.
  - Producer's **investments** in the infrastructure for connecting biomethane plants to the grid:
    - **Specified percentage** will be facilitated with CAPEX aid as recognition of investment for the reinforcement of gas infrastructures.
    - Another **specified percentage** will be facilitated with standards of paid care with annual instalments to the grid operator.
- Active and involved role of the Public Administration:
  - **Interministerial Roundtable**, including Ministry of Ecological Transition, Agriculture, Livestock, etc. and relevant intersectorial stakeholders, in order to establish a more fruitful collaboration.

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- **Municipalities**:
  - **obligation** to valorize all municipal waste into biomethane. And in the case of waste-water treatment plants, obligation to implement strategies avoiding to sending biogas to flare, aligned with current strategy trends.
  - obligation to use the **digestate** as biofertilizer, including a simplified harmonisation of its management/use in municipalities with the adaptation of best practices to optimise the quality of digestate
- Enhancing the environmental understanding of the biomethanisation in the **waste recovery**, as a preliminary process to composting system, optimizing energy available in organics fractions.
- Assessing **environmental value** (which includes economic value), even prioritising it over assessing economic value alone (e.g., waste and other regulations).
- One-stop management: **standardized and equal procedures** in all Regional Public Administrations, simplifying the administrative burden of projects and establishing reduced response times by the Administration in the delivery of authorisations and permits (updating of knowledge).

- To regulate the establishment of the "**Polluter Pays Principle**" through:
  - Implementation of "**win-win**" mechanisms to accelerate its development.
  - **Penalties** for not valorising organic residues (prioritising biomethane production).
  - Biofertilizers quotas for fertilizer producers, X% Nitrogen content, X% Phosphorus content.

Main strategies 2024-2030

- Application of the economic values of **positive externalities** of biomethane.
- To establish a reasonably stable regulatory framework, including clarification of the use of digestate as a biofertiliser:
  - From a legislative point of view, the MAM Order 304/2002 of 8 February, Valorisation Operations and LER Codes, allows **digestate** to go down the route of direct application operation by Valorisation Operation R10, direct application for soil improvement.
  - Additionally, a key reference document is "End of Waste for Composts and Digestate" from the JRC of DG ENV of 2014, basis also for the Fertiliser Regulation EC Regulation 2019/1009 of 5 June. In the CMCs - Component Material Categories 4 and 5 are digestate for the purpose of being authorised components of **fertilisers**.
  - To enable the capacity to provide **organic amendment to soils**: for greater legal certainty, the legal regime for the end of waste status applicable to digestate should be clarified. Encourage rotational crops (sequential crops).
- Need for **research** of the evolution of the gas market, with intersectoral participation: producers, traders, consumers, Administration, Technology Centres, etc.).
- Establishment of **awards** for plants with best practices (in waste management, in operation, in biofertiliser management, etc.), whose "visualisation" will help to promote, encourage, and develop the sector in Spain.
- To fasten the regulatory framework for **nutrient recycling**: obligations, rights, financial incentives for the use of recycled nutrients.
- As the price of CO_2 rights rises, the **demand** for biomethane will increase.

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Main strategies 2030-2035

- GHG diffuse emission sectors analysis: **global monitoring** and updating of this sector.
- Energy market analysis: **monitoring** and updating this market in order to position the role of biomethane. According to the different expected scenarios, the role of biomethane will be crucial.

3.13 Ukraine

3.13.1 Vision

Biogas production in Ukraine is stimulated by feed-in-tariff (green tariff) for electricity produced from biogas. Almost all Ukrainian biogas plants produce electricity with successive national power grid delivery so far.

The average annual growth of the biogas sector was **70%** in 2017-2020. If at the end of 2017 the total installed capacity of biogas plants was **29 MWe**, then at the end of 2020 it was already **103 MWe**. During this time period annual electricity production increased from **93.5** to **471.5 GWh** (from around **130 million m^3**). About 30% of electricity was produced from landfill gas (LFG) at municipal solid waste (MSW) landfills and waste dumps. The rest 70% of electricity produced by agricultural biogas plants.

In 2021 there were **30 agricultural biogas plants** under operation in Ukraine, but **no biomethane production**. The individual projects ranged from **125 kWe to 12 MWe** of installled capacity. Some of the small projects produce electricity without green tariff, two projects produce only heat for own industry needs. At the same time there were 26 LFG recovery systems, all of them with electricity production with total installed capacity of **30 MWe**.

Despite the limited number of implemented agricultural biogas plants, their technical scope covers a wide range of industries and different types of feedstock. Ukrainian biogas plants are implemented at pig, cattle, and chicken farms, at sugar plants, breweries, and food production enterprises, using a broad diversity of raw materials such as pig and cattle manure, chicken litter, maize and sugar sorghum silage, sugar beet pulp and molasses, food treatment waste and industry waste water.

Current Ukraine's Energy Strategy sets an ambitious goal of achieving **11 Mtoe of biomass, biofuels and waste** in the total supply of primary energy in 2035. It corresponds to **11.5%** of the total primary energy supply. Biogas and especially biomethane will play important role in this development.

First stimulation of biomethane production was approved with amendment to the Law of Ukraine "On Alternative energy sources" at the end of 2021. Experts estimate that the total biogas production could reach **1.6 bcm** in 2030. The significant part of that biogas could be upgraded to biomethane. Total biomethane production could be **1.0 bcm** in 2030. It is expected that biomethane could partly (0.2 bcm) be exported to the EU. The rest could be utilized locally for combined heat and electricity generation in CHP units (0.5 bcm), heating and industry applications (0.23 bcm) and for transportation purpose (0.08 bcm). In such a way biogas sector could serve the growing demand in sustainable and clean energy from the transport and industry sectors.

The long-term goal includes the launch and considerable growth of the production of biomethane by 2050. Total biogas and biomethane production could be at the level of **6.0 bcm** by that date. Only 25% of total amount (1.5 bcm) may be used as raw biogas for combined heat and electricity production. The

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rest of biogas could be upgraded to biomethane. It is expected that biomethane will still be important as export product (2.3 bcm) to the EU. The rest could be utilized for local purpose.

It should be noted that according to the company "Naftogaz of Ukraine", the total consumption of natural gas in Ukraine was 29.8 bcm in 2019, of which 14.3 bcm (48%) were imported.[15] Therefore, the maximum possible exploitation of the available biogas/biomethane potential is one of the tools of ensuring the **country's energy security**.

These short- and long-term goals were developed by Ukrainian Bioenergy Association and need to be further discussed among all interested parties including Ukrainian profile Ministries, State Agencies, natural gas systems operators and private businesses.
The new biogas production would be based in particular on the utilization of agricultural by-products, but new technologies and feeds would also play a role. They may include thermal gasification of lignocellulose originated from agriculture and forest and implementation of the power-to-gas process. In energy systems with large share of renewable energy sources excess electricity could be used to produce hydrogen by electrolysis of water followed by its methanization with carbon dioxide from the biogas upgrading process.

Ukraine has the **necessary prerequisites and opportunities** for a significant increase in the production of biogas and biomethane. Feedstock for biogas production can be agricultural residues (primary residues such as straw, secondary residues such as spent grain in beer production, sugar beet pulp, manure), energy crops (maize silage), as well as MSW and some other types of biomasses.
The Ukrainian natural gas transportation system (GTS) is internationally connected and potentially enabling biomethane and other renewable gases physical or virtual delivery from Ukraine to Western Europe. However, there is a downward trend in the transit of natural gas to Europe by Ukrainian GTS. Ensuring the maximal possible load of the Ukrainian GTS with natural gas of own production and alternative renewable gases is urgent.
Moreover, Ukraine has the largest area of agricultural land in Europe, one of the highest agricultural areas per capita and developed agriculture industry.
Using biomethane as a motor fuel is an excellent opportunity for agricultural producers to obtain own energy source by means of waste and secondary products of their own production. There is a long-term tradition to use compressed natural gas (CNG) as a motor fuel for buses and heavy vehicles In Ukraine. More than **CNG 200,000 vehicles** existed, and the country offered a reasonably good network with about **300 CNG filling stations** distributed all over the country. The use of biomethane for public transportation can significantly improve air pollution in large cities. Biomethane should be used not only by road transportation, but also by maritime and rail transportation, not only in compressed (CBG), but also in liquefied (LBG) form.
Ukrainian biogas sector should be strongly integrated into the modern energy system and network. Besides that, the sector should hold a strong foothold in national nutrient recycling activities and participate in the archiving of the national target of greenhouse gases emission reduction.
The Ukrainian biogas sector has potential in terms of both the availability of raw materials and the demand for biogas. The Ukrainian biogas market can be considering as emerging and promising.

[15] *https://www.naftogaz.com/*

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Despite biogas production and consumption have rapidly increased in Ukraine during the last years, further development is not clear due to **limited attractiveness of green tariff for electricity**. So far, biomethane production is **not competitive** with natural gas market price and need support in Ukraine similarly to all over the world. The low profitability of biogas production is **challenging** the sector. The **availability** of **low-cost fossil fuels** is also considered to slow down the development of the biogas industry.

Opportunities for the Ukrainian biogas sector are created by many factors such as carbon neutrality targets, interests in advancing national self-sufficiency of energy and the vitality of the rural areas, and emission reduction targets for transport and agriculture. The nutrient recycling offers also wide ranges of business opportunities for the biogas sector.
Well-designed and targeted policy instrument can fasten the development. Profitability can be improved with subsidies and other means of support. Demand for end-products can also be increased with various incentives. These schemes should be made more predictable and long-term to encourage for new investments.
Using the capabilities of the Ukrainian GTS connected to European GTSs and, in the long term, virtual export to the EU market, could improve the economic attractiveness of biomethane production in Ukraine. Development of the Ukrainian Register for biomethane production and utilization and cooperation with similar Registries of EU countries is the potential possibility to exchange the biomethane Guaranty (certificates) of Origin (GoO) with other countries.
In order to reach the objectives and targets there is a need for having **better dialogue** between different stakeholders (producers, users, decision makers, official and other). There is big number of different stakeholders as the biogas sector is strongly involved in different sectors such as energy production, agriculture, transportation, and waste management. Biogas is not only about energy production but it also an excellent way to recycle nutrients.
Moreover, there is a need for defining **long-term actions**. An official national biogas production target for 2035 and long-term national incentive package are urgently demanded. The targets and actions agreed together would create confidence in the industry's growth potential for the current players and for newcomers.

3.13.2 Roadmap

To achieve targets indicated above different timeframes were defined (in 2022, 2030 and 2050).

Short-Term (2022)

The short term-actions (2022) include:

- Development and submission to the Cabinet of Ministers of Ukraine of the **draft Law** on amendments to the Law of Ukraine “On Alternative energy sources” to stimulate production of biomethane. The responsible bodies for this action are State agency for energy efficiency (SAEE) and Ministry of Energy. This law amendment was submitted by the Cabinet of Ministers of Ukraine to the Verkhovna Rada of Ukraine and approved in the 4th quarter of 2021.
- Development and submission to the Cabinet of Ministers of Ukraine the **draft Procedure** of the functioning of the **Register of biomethane** production and consumption. The Procedure should be

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adopted by the Resolution of the Cabinet of Ministers of Ukraine. Expected result is a launch of the Register of biomethane production and consumption.

- Start of implementation of the system of **guarantees of origin**, including information on compliance with sustainability criteria and reduction of greenhouse gas emissions in the production process of biogas, where appropriate.

Medium term (2030)

The optimal way of biomethane production and utilisation should be defined to ensure market development. A trustworthy and fully functioning **certification system** is essential for the trading and use of biomethane, especially with a deeper integration of the electricity and gas system. The results of the preferred use of biomethane should be integrated in the National Energy Strategy.

The medium-term actions may include:

- Creating a **mid-term target and legislative incentives** to promote the use of biomethane in the transport sector.
- Fastening the regulatory framework for **nutrient recycling** (e.g., obligations, rights, incentives). Development the market for recycled nutrient products and support in production of new products.
- Adjusting the **electricity grid operation** by increasing the role of biogas for electrical load regulation.
- Introduction of **separate collection** of the biodegradable fraction of municipal waste with subsequent biogas production.
- Development and adaptation of **Roadmap** for bioenergy development including biomethane until 2050 and Action Plan until at least 2035.

Long term (2050)

The long-term actions may include:

- Adaptation of Ukrainian gas system for use of **biomethane** and optionally **hydrogen**.
- Expansion of the **bio-CNG** and **bio-LNG distribution network**.
- Creating **legislation** to promote the use of biomethane as efficient factor of circular economy implementation (including new product regulations, adapted fertilizers rules, etc).
- Creating **legislative incentives** to promote the use of biomethane for chemical industry.
- Joining of Ukraine to **European biomethane trading system**, thus creating new market opportunities.

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4. Comparative analysis and conclusions

The role played by biomethane in the **clean energy transition** in the frame of the European Green Deal is increasingly important.

After the invasion of Ukraine by Russia, EC published the Communication "EPowerEU: Joint European action for more affordable, secure and sustainable energy" [16]: currently the new ambitious goal for biomethane is to double the objective of Fit for 55, leading to the production of **35 billion cubic metres (bcm) per year by 2030**.

To do so, EC will ask Member States to consider, in their CAP strategic plans, channelling funds to biomethane produced from sustainable biomass sources, including in particular agricultural wastes and residues.

By Summer 2022, the Commission will publish a **REPower Plan**, in cooperation with Member States. This will strongly affect present NECPs (National Energy and Climate Plans) and will also impact on visions and roadmaps so far developed by the different countries included in the previous chapter of this documents, with possible acceleration of measures and actions so far envisaged and/or planning of new ones.

A **comparative analysis** of the visions and roadmaps of the Target countries (BE, ES, IE, IT, LT, PL, and CZ) and Supported countries (EL, EE, FI, LV, UA, and SI) is made according to some aspects identified during their drafting, i.e., current production of biomethane (and biogas), barriers, drivers, and main actions in the future years (a detailed table is reported in **Annex I**).

The comparative analysis allowed to identify **commonalities** and **specific features** as a basis to feed the debate and the further developments of the strategic plans and actions in the different countries for increasing biomethane production and use in Europe in the coming months and years.

They can be summarized as follows.

Some countries are **already producing biomethane** (BE, EE, FI, IE, IT, and ES), while others **not yet** (CZ, EL, LV, LT, PL, SI, and UA).

Common and **specific barriers** were identified as follows:

- **Low profitability** of biogas/biomethane production (FI, EL, LV, LT, SI, UA):
- **Technical and administrative constraints**, lack of a **common quality standard** and of **cross-border certificate trade**, lack of **guarantee of origin system** (BE, CZ, EE, ES, IT).
- Availability of **low-cost fossil fuels** and differential cost with natural gas (BE, FI, UA).
- Lack of a **stable and long-term** regulatory and legal framework (PL, ES, EL, CZ).
- Lack of long-term **incentive schemes** (IT, PL, SI, UA).

[16] Communication from the Commission to the European Parliament, the European Council, the Council, The European Economic and Social Committee and the Committee of the Regions, REPowerEU: Joint European Action for more affordable, secure and sustainable energy, COM(2022) 108 final, 8.3.2022

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- No natural gas **infrastructure for transport** and lack or limited number of **methane vehicles** (LV, LT, PL).
- No effective **investment support** and lack of **public funding for investments** in biomethane plants (LT, PL).
- No biomethane production facilities connected to gas network and **obstacles** for biomethane plants connection to gas distribution grids (IT, LT, PL).
- **NIMBY** effect; limited potential of raw materials (BE, IT).
- **High purchase price** of solid oxide fuel cells; lack of small-scale liquefaction technologies (EE).
- No **local producers** of biogas plants equipment; no centralized coordination of the biogas/biomethane sector development at institutional level (LT).
- **Regulatory discrepancies** between biomethane and the agronomic use of digestate (IT).
- Lack of **waste management policies**, shortage of biogas plants which could be **converted** to biomethane plants (ES).
- Lack of a Renewable Heat **Obligation** for the funding gap, need to adjust the **GBER exemption** threshold to allow capital funding required and related **structure/mechanism** to develop the biomethane industry (IE).

Common and **specific drivers** were identified as follows:

- **Closing nutrient loops**, interest in **advancing nutrients**, improving soil management, need of **biofertilizers** in the market (BE, FI, EL, ES, IE, SI, UA).
- Carbon neutrality **targets**, national **self-sufficiency** of energy, vitality of the **rural areas** (FI, EL, IE, SI, UA).
- Large or increasing number of **filling stations** (EE, IT, PL).
- Biomethane as **solution for multiple domains**, i.e., agriculture, environment, agriculture, transport, employment (BE, LV, ES).
- Strong **political will** to develop and invest in the sector (FI, SI).
- Large or increasing number of **gas vehicles** (EE, IT).
- Supply **potential demand** and **potential** in the transport sector (IE, LT).
- Broad extension of the **natural gas grids** (IT, LT).
- **Decentralization** of energy schemes and integration of biomethane into the energy system (EL, LV).
- Valorising **waste streams** and **livestock manure** (BE, ES).
- **EU and national climate and energy policies** (CZ, PL).
- Large number of **biogas plants** (IT).
- **Effective support** for the price-premium of biomethane, for the construction of filling stations and for the purchase of buses (EE).
- Increased **public awareness** of the properties of biofuels, alternative and advanced fuels; **subsidies** for research; **legal changes** encouraging the dissemination of environment-friendly solutions in transport (PL).
- **Connection** to European GTSs for possible export to EU market (UA).

Common and **specific features of roadmaps** were identified as follows:

- Implementation of several **incentives schemes**, e.g., exemption and differentiation of road tolls for heavy goods vehicles, business tax rebate for biomethane consumption, incentives for sorting of

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municipal and agricultural waste, purchase aid for the use of gas vehicles, financial incentives for biomethane production investments, financial incentives for the use of recycled nutrients, support tariffs to apply to self-consumption of biomethane production (prosumers), incentives for retrofitting of Biogas plants to biomethane, incentives for the production of biomethane vehicles fleets and ships, incentives for the development of supply chains for residual biomass from agriculture, incentives for the cultivation of energy crops complying with sustainability criteria, financial support for a scheme to commercialise bio-fertilisers, bio-based and chemicals, funds from Economic Recovery and Resilience Fund for biomethane facilities, tariff discounts for biomethane transport, incentive schemes for grid connection and tariff discounts (EE, FI, EL, IE, IT, LT, PL, SI, ES, UA).

- Setting up a **GoO** and **certification system** to recognize renewable and sustainable features, and also enabling European cross border trade of renewable gases (FI, EL, IE, LT, LV, PL, SI, ES, UA).
- Appropriate **legislation** on waste management, nutrient recycling and on energy, e.g., separate collection of biowaste, increased fees for non-hazardous waste disposal in landfills, 50% of livestock waste for production of biomethane, obligation to use livestock manure in anaerobic digestion, increased use of digestate as fertiliser (BE, CZ, FI, IT, LV, LT, SI, ES, UA).
- **Technical and regulatory framework** for the connection to the medium and low-pressure networks in cooperation with the distribution network operators; **supply network** with distinct biomethane distribution points in cooperation with the operators of refuelling stations of vehicles and ships; develop/adapt **gas distribution networks** to inject biomethane and also methane/hydrogen mixtures; improving **access to the grid**, with defined quality of injected biomethane/green gas; adjusting the **electricity grid operation** by increasing the role of biogas for electrical load regulation (EL, EE, IT, LT, PL, SI, UA).
- Strong role of **public procurement policies**, in particular from local governments, e.g., use of more environmentally friendly rolling stock when purchasing public services, preference to methane buses in public procurements and to build methane filling stations, obligation quota for vehicles in the heavy transport and municipal public transport sectors (CZ, EE, FI, LV)
- **Increased research** on innovative technologies, with a specific focus on co-products such as bio-fertilisers and soil carbon sequestration, alternatives for chemical fertilizers, restocking the carbon in soils and supplying green CO_2 for industry and horticulture, integration between agriculture and biomethane (FI, IE, IT, PL, ES).
- **Integration** with the energy systems, especially where electrification is not possible (BE, FI, IE).
- Simplifying and accelerating **authorisations and permits** to build biomethane plants (SI, ES, IT).
- **Education and awareness** about benefit of biomethane economy to reduce its bad reputation and NIMBY effects (SI, ES).

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Annex I: Summary table of visions and roadmaps

Country	Vision	Roadmap
Belgium	- **Current production**: **2.7 TWh** of biogas and **150 GWh** of biomethane. - **Target**: **1.4 TWh** at 2025 and **15.6 TWh** at 2030; - **Barriers**: differential cost with natural gas; NIMBY effect; limited potential of raw materials; administrative burden for operators. - **Drivers**: closing nutrient loops; valorising waste streams; improving soil management; providing local employment; solution for hard to electrify sectors and processes.	**2030** - **Integration** with the energy system. - **Replacement** of fossil transport fuels with biomethane. - **Optimisation** of the GHG emission reduction of the production process. **2050** - Production of high value molecules and products (with **shift from energy source to chemical feedstock**). - Appropriate legislation for **bioeconomy** and **circular economy.**
Czech Republic	- **Current production**: **6.6 TWh** of biogas and **none** of biomethane. - **Target**: **41 GWh** at 2025 and **1,620 GWh** at 2030 - **Barriers**: technical barriers and missing implementing legislation. - **Drivers**: the demand from petroleum producers using biomethane for emissions savings under the Air Pollution Control Act.	**2022-2023** - Implementing **legislation** on energy. - Waste **legislation**. - **Obligation** to purchase biomethane. **2024-2030** - Separate collection of biowaste. - Switch of wastewater treatment plants to biomethane. **After 2030** Further development of bio-waste processing (**for bio-based and chemicals**).
Estonia	- **Current production**: **16,974 MWh** of biogas and **152,352 MWh** of biomethane. - **Target**: **1 TWh** at 2030; - **Barriers**: lack of a common quality standard and of cross-border certificate trade; high purchase price of solid oxide fuel cells; lack of small-scale liquefaction technologies. - **Drivers**: relatively well-developed network of CNG filling stations, the increased number of methane buses, trucks and cars, the effective support for the price-premium of biomethane,	**2022-2024** - Support the use of biogas in pilot projects for the **use of solid oxide fuel cells (SOFCs)** - Extend the **eligibility period of support** for biomethane producers. - To **exempt and differentiate** heavy goods vehicles from road tolls. - To introduce **purchase aid** for the use of local gas vehicles in Estonia. - **Business tax rebate** for biomethane consumption. - Use of more environmentally friendly rolling stock when **purchasing public services.** - **Preference to methane buses in public procurements** and to build **methane filling stations.** - Support **international quality standards** for biomethane. - **Incentive scheme** for the sorting of municipal and agricultural waste.

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	for the construction of filling stations and for the purchase of buses.	
Finland	- **Current production**: **797 GWh** of biogas and **109 GWh** of biomethane. - **Target**: **4 TWh** at 2030; **6-15 TWh** at 2035. - **Barriers**: low profitability of biomethane production; availability of low-cost fossil fuels. - **Drivers**: carbon neutrality targets, national self-sufficiency of energy and nutrients; the vitality of the rural areas; strong political will to develop and invest in the sector.	**2021-2023** - Increased **availability** of biomethane (e.g., distribution, obligation, bio-LNG). - Increased **procurement** aid level for CBG / LBG trucks. - **Financial incentives** for industrial gas investments. - To make use of **innovation** clusters, **interdisciplinary** innovations. - Role of **public procurement**/municipalities as market initiators/openers. - Regulatory framework for **nutrient recycling** (e.g., obligations, rights, incentives). **2024-2030** - Increased **availability** of biomethane (e.g., through new GoO and sustainability certificates). - To modify **procurement aid** of heavy-duty vehicles with obligation to use biomethane. - Increased demand for biomethane in **shipping** and in **industrial use** - Market for **recycled nutrient** products and for new products. - **Financial incentive** for the use of recycled nutrients. - To use **dry fraction** made from reject, especially by the public sector. **2030-2035** **Integration** with the energy systems, where electrification is not possible.
Greece	- **Current production**: **1,126 GWh** of biogas and **none** of biomethane. - **Target**: **16 TWh** at 2030, **18 TWh** at 2040 and **42 TWh** at 2050. - **Barriers**: need for legislative framework and institutional dialogue; low profitability of biogas production. - **Drivers**: carbon neutrality targets, lignite phase-out, low-carbon-intensity energy system, decentralization of energy schemes, interest in advancing nutrients and the vitality of the rural areas.	**2030** - Biomethane certification system through **Guarantees of Origin**. - **Legislative** support framework with incentives schemes. - **Support tariffs** to apply to self-consumption of biomethane production (prosumers). - Incentives for **retrofitting** of Biogas plant for electricity production to biomethane. - **Incentives** for the creation of biomethane vehicles fleets and ships. - **Technical and regulatory framework** for the connection to the medium and low-pressure networks. - **A supply network** with distinct biomethane distribution points. - **Incentives** for the development of supply chains for **residual biomass**. - **Incentives** for **energy crops** with respect to the sustainability criteria of the RED II-III. **2050** - Allow the use of **Green Hydrogen** as feedstock to the AD and Gasification processes. - Develop/adapt **gas distribution networks** to operate on Methane/Hydrogen mixtures. - Exclude the gas-powered ICEs from the general **ban**. - Further develop **CNG/LNG refuelling infrastructure** for road, rail, sea transportation means.

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Ireland	- **Current production**: **482 GWh** of biogas and **4,972 MWh** of biomethane - **Target**: **1.6 TWh** at 2030. - **Barriers**: Lack of a Renewable Heat Obligation for the funding gap, need to adjust the GBER exemption threshold to allow capital funding required and related structure/mechanism to develop the biomethane industry. - **Drivers**: potential and capacity for a sustainable biomethane industry; strong demand of biomethane for thermal demand in manufacturing and processing; need to decarbonize agriculture, thermal demand, and transport; mandatory decarbonization targets, commercial sustainability, and competitiveness; energy security, storage and pricing.	**2030** - Introduction of a Renewable Heat Fuel **Obligation scheme**. - **Government support** with capital funding of 50% for a scheme to commercialise bio-fertilisers and soil carbon sequestration. - **Consultating** with industry to optimise the economic structure for a carbon farming initiative. - Facilitating **cross border trade of renewable gases** and **Guarantees of Origin**. - **Research, knowledge and information transfer** especially in relation to co-products such as bio-fertilisers and soil carbon sequestration. - Greater **public awareness** of benefits and opportunities to decarbonise. **2050** - An established **biomethane** and **bio-fertiliser industry** focussed on reducing GHG emissions and to lowers reliance on imported fossil fuels, strengthens energy security and supply. - **New innovative technologies** to develop alternatives for chemical fertilizers, restocking the carbon in soils and supplying green CO_2 for industry and horticulture. - Use of biomethane where there is **no other competitive and effective alternative** for thermal processes in the manufacturing and processing sector.
Italy	- **Current production**: **25 TWh** of biogas and **168 mcm** of biomethane. - **Target**: **4 bcm** at 2026. - **Barriers**: excessive bureaucracy for authorisations; distance of farms interested in biomethane production from the natural gas transport network; NIMBY effect; lack of a long-term incentive scheme; regulatory discrepancies between biomethane and the agronomic use of digestate. - **Drivers**: excellent starting conditions i.e., large number of biogas plants, filling stations and natural gas vehicles, extension of the gas grids.	**2022** - **Revision of application procedures**, with introduction of biomethane use for maritime transport. - **New Italian biomethane subsidies scheme** and **GSE application procedures.** - **Publication of tenders** for access to the new biomethane decree. - **UNI 11567** technical standard revision. - Updating the regulation relating to **digestate** and **zootechnical** effluents. - **Decree FER2** will introduce **incentives** to geothermal, offshore wind farms, biomass, biogas and solar thermodynamic. **2023-2026** - To facilitate the **injection of biomethane** into the grid, namely by **isolated biogas plants**. - To facilitate the **access** of biomethane to the grid also by introducing the "gas reverse flow". - To increase **support** for CBG / LBG trucks use and purchase. - To provide **financial incentives** for industrial gas investments. - **Support mechanism** for existing biogas plants that cannot easily converted to biomethane. - To introduce **incentives** to convert agricultural tractors from diesel to biomethane. - To simplify the **authorization process** for biomethane plants and shorten their timing. **2027-2030** - A new **support scheme** for biomethane and renewable gas production.

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		- To encourage the production of biomethane through the **Power to Gas process.** - To use **alternative biomasses** (e.g., microalgae) for the production of biogas and biomethane. - To promote the use of **biogenic CO_2** in industrial processes. - To increase the demand for biomethane in **shipments** and **industrial use** with specific incentives. - To introduce the **obligation** to use livestock manure in anaerobic digestion. - Agri-environmental **incentives** to increase organic matter in the soil through the use of digestate.
Latvia	- **Current production**: **298.4 GWh** of biogas and **none** of biomethane. - **Target**: **0.68 TWh** at 2030. - **Barriers**: lack vehicles and of natural gas infrastructure for transport; low profitability of biogas production. - **Drivers**: integration of biomethane into the energy system; replacement of fossil transport fuels.	**2030** - Strengthen the role of **public procurement/local governments** to boost the biomethane market. - Strengthen the **legal framework** for nutrient recovery (e.g., by responsibilities, rights, incentives). - Improve the **availability** of biogas and biomethane in the transport sector (e.g., through guarantees of origin and sustainability certificates). - Modify the **procurement support** for vehicles in the heavy transport and municipal public transport sectors, establishing the obligation to use biogas in the first years. - Increase the demand for biomethane for **industrial use**.
Lithuania	- **Current production**: **140 GWh** of biogas and **none** of biomethane. - **Target**: **1 TWh** at 2030. - **Barriers**: low profitability of biomethane production; no biomethane production facilities connected to gas network; no effective investment support; no local producers of biogas plants equipment; no sufficient gas filling infrastructure for vehicles; no centralized coordination of the biogas/biomethane sector development at institutional level. - **Drivers**: well-developed gas transportation infrastructure; supply potential; demand potential in the transport sector.	**2022-2025** - Emissions reductions through the use of **biomethane GOs** - **Fuel statistics unit system** enabling the use of renewable fuel in transport sector. - National **GO registry IT system** upgraded. - **Connection points** for biomethane production facilities to the gas transmission system. - Approval of **funds** from Economic Recovery and Resilience Fund for biomethane facilities. - **CEN EN16325** comes into force. - Ability for GOs with proof of **sustainability certificates cross border** exchanges. - List of **bio-based feedstocks** for production of second-generation biofuels. - **Funds** for the purchase of alternative fuel vehicles and for the refuelling infrastructure. - **Liquefied biomethane integration** into fuel statistic unit system. - **Off grid produced biomethane** integration into fuel statistic unit system. - First biomethane producer **connected** to gas transportation system. - **Increased fees** for non-hazardous waste disposal in landfills up to 50 - 70 Eur / ton. - **Injection** of off-grid biomethane into gas transportation systems. **2026-2030** - Biomethane transportation **tariff discounts** apply. - 34 road transport fleets are equipped with compressed and liquefied gas filling stations. - 3,750 buses or trucks using **50% biomethane**.

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		- Not more than **5% of all waste** shall be disposed in landfills. - **50% livestock waste** is used for the production of biomethane.
Poland	- **Current production**: **325.24 mcm** of biogas and **none** of biomethane. - **Target**: **0.7 to 1 bcm** at 2030. - **Barriers**: Lack of a stable and long-term regulatory and legal framework; lack of a support system; lack of public funding for investments in biomethane plants; obstacles for biomethane plants connection to gas distribution grids; limited number of natural gas/biomethane vehicles. - **Drivers**: EU and national climate and energy policy; access to upgrading facilities on the market; increased public awareness of the properties of renewable fuels; subsidies for research; improvement of filling stations.	**2022-2025** - L**egal regulations** and provision of **public funds** to support investments in the production and use of biomethane and other green gases. - **Promoting** renewable gas in areas with a high availability of raw materials or injection into natural gas networks, where technically possible and economically viable. - Setting up a **guarantee of origin system**. - Increased importance of **digestate** to improve the economics of biomethane plants. **2025-2050** - To **reduce the costs** of biomethane production. - Increasing **research** to **integrate** agriculture and biomethane technologies. - national **incentive schemes** for grid connection and tariff discounts. - **Good practices** by local authorities in waste management, low-emission public transport, circular economy, education to increase social acceptance. - Improving **access to the grid**: quality of injected green gas; co-financing of connection costs. - **Enabling cross-border trade** (with GoO, European register, and green gas trading platform).
Slovenia	- **Current production**: **87.928 MWh** of biogas and **none** of biomethane. - **Target**: **10%** of biomethane at 2030. - **Barriers**: low profitability of biogas production; lack of incentives schemes for long-term investments. - **Drivers**: carbon neutrality targets, national self-sufficiency of energy and nutrients; the vitality of the rural areas; strong political will to develop and invest in the sector.	**2025** - **Subsidies** for industrial biogas plants (waste and other biodegradable waste). - Reducing time for **obtaining permits** to build biomethane plants. - **Financial incentives** for the production of gaseous fuels such as biomethane. - Procedures and platform for transparent issuing and treatment with **certificates of origin**. - Education and awareness of local residents about benefit of biomethane economy and diminish its bad reputation and **NIMBY effects**. **2030** - All existing biogas plants should produce biomethane. - Adaptation of the **transmission pipeline system** to ensure biomethane injection, with new regulating and measuring stations, odorization units and compact compress stations. - Adding of **liquefaction units** to biomethane plants and increase or LNG/LBG filling stations. - Exploit **potential** of waste-water-treatment plants and landfills for biomethane production. - Redefine current legislation about **waste management** to increase digestate treatment.
Spain	- **Current production**: **8,100 GWh** of biogas and **100 GWh** of biomethane. - **Target**: **30 TWh** at 2030 and **250 TWh** at 2050.	**2022-2023** - **Stable regulatory framework** to attract investment and foster both supply and demand side. - **Financial and fiscal incentives** for the development of biomethane projects.

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	- **Barriers**: Lack of stable regulatory framework, lack of waste management policies, lack of guarantee of origin system, no traceability for virtual blending, and no traceability for biofuel, leading to investment difficulties; shortage of biogas plants which could be converted to biomethane plants. - **Drivers**: focus on positive externalities; implementing the "Polluter Pays Principle"; need of biofertilizers in the market; growing interest to solve the problem of livestock manure.	- Define a European system of **guarantees of biomethane origin.** - To set increasing **annual targets** for biomethane production. - Prioritization of biomethane **injection** into the grid or other solutions where it is not accessible. - **Obligation** for municipalities to valorize all municipal waste and wastewater sludge into biomethane, and to use the **digestate** as biofertilizer. - **Standardized and equal procedures** in all Regional Public Administrations, simplifying and accelerating authorisations and permits. **2024-2030** - Application of the economic values of **positive externalities** of biomethane. - **Clarification** of the use of **digestate** as a biofertiliser. - Need for **research** of the evolution of the gas market. - **Awards** for plants with best practices (in waste management, in operation, in biofertiliser management, etc.) and their "visualisation" to promote, encourage, and develop the sector. - Regulatory framework for **nutrient recycling**: obligations, rights, and financial incentives. **2030-2035** - GHG diffuse emission sectors analysis: **global monitoring** and updating of this sector. - Energy market analysis: **monitoring** and updating this market to position the role of biomethane.
Ukraine	- **Current production**: **130 mcm** of biogas and **none** of biomethane. - **Target**: **1 bcm** at 2030 and **6 bcm** at 2050. - **Barriers**: limited attractiveness of green tariff for electricity; low profitability compared to natural gas price; lack of financial and subsidies schemes. - **Drivers**: carbon neutrality targets; national self-sufficiency of energy; vitality of the rural areas; emission reduction targets for transport and agriculture; nutrient recycling; connection to European GTSs for possible export to EU market.	**2022** - **Amendments** to the Law on Alternative energy sources to stimulate production of biomethane. - **Draft Procedure** of the functioning of the **Register of biomethane** production and consumption. - Start of implementation of the system of **guarantees of biomethane origin.** **2030** - **Mid-term targets and incentives** to promote the use of biomethane in the transport sector. - Fastening the regulatory framework for **nutrient recycling** (e.g., obligations, rights, incentives). - Adjusting the **electricity grid operation** with increased role of biogas for electrical load regulation. - Introduction of **separate collection** of municipal biowaste with subsequent biogas production. - Development of **Roadmap** for bioenergy including biomethane until 2035 and 2050. **2050** - Adaptation of Ukrainian gas system for use of **biomethane** and optionally **hydrogen**. - Expansion of the **bio-CNG** and **bio-LNG distribution network**. - Creating **legislation** to promote the use of biomethane as efficient factor of circular economy implementation (including new product regulations, adapted fertilizers rules, etc). - Creating **legislative incentives** to promote the use of biomethane for chemical industry. - Joining **European biomethane trading system**, thus creating new market opportunities.

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Annex II: Timing of the participatory workshops

The **3 workshops** in each target and supported country were held as follows in the different countries.

Kick-off Workshop: Vision

- ✓ Belgium: 12/10/2020
- ✓ Czech Republic: 01/10/2020
- ✓ Estonia: 30/11/2020
- ✓ Finland: 10/03/2020
- ✓ Greece: 16/11/2020
- ✓ Ireland: 23/04/2021
- ✓ Italy: 27/10/2020
- ✓ Lithuania: 21/10/2020
- ✓ Latvia: 24/09/2020
- ✓ Poland: 02/10/2020
- ✓ Slovenia: 23/10/2020
- ✓ Spain: 9-16-23/3/2020
- ✓ Ukraine: 23/10/2020

Second Workshop: Roadmap

- ✓ Belgium: 11/03/2021
- ✓ Czech Republic: 03/05/2021
- ✓ Estonia: 26/04/2021
- ✓ Finland: 16/02/2021
- ✓ Greece: 28/09/2021
- ✓ Ireland: 29/09/2021
- ✓ Italy: 17/11/2020
- ✓ Lithuania: 25/05/2021
- ✓ Latvia: 09/06/2021
- ✓ Poland: 24/06/2021
- ✓ Slovenia: 29/06/2021
- ✓ Spain: 7-14/10/2021
- ✓ Ukraine: 30/06/2021

Third Workshop: Guidance for feasibility analysis

- ✓ Belgium: 02/12/2021
- ✓ Czech Republic: 07/10/2021
- ✓ Estonia: 29/11/2021
- ✓ Finland: 18/10/2021
- ✓ Greece: 22/12/2021
- ✓ Ireland: 15/12/2021
- ✓ Italy: 05/03/2022
- ✓ Lithuania: 14/12/2021
- ✓ Latvia: 09/02/2022
- ✓ Poland: 28/01/2022
- ✓ Slovenia: 21-22/03/2022
- ✓ Spain: 17/01/2022
- ✓ Ukraine: 20/12/2021

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Razali, R., Anwar, F., 2011. Selecting the right stakeholders for requirements elicitation: A systematic approach. Journal of Theoretical and Applied Information Technology.

RES H/C SPREAD, Deliverable 3.4: Methodological and procedural approach for the organization and implementation of the workshops.

RES H/C SPREAD, Deliverable 3.1: Recommendations for the establishment of the Country Governance Committees.

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