Biomethane Department

CALL FOR PROJECTS

OBJECT: ELECTROMETHANOGENESIS AS A NEW WAY OF PRODUCING BIOMETHANE

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- **AUTHORS :**

SOLENE FERREIRA: SOLENE.FERREIRA@EXTERNE.GRDF.FR
LEO BENICHOU: LEO.BENICHOU@GRDF.FR

- **RECIPIENTS : START-UPS, COMPANIES OR GROUPS OF COMPANIES, BIOMETHANE PRODUCERS, RESEARCH CENTERS/LABORATORIES, UNIVERSITIES**

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INTRODUCTION

Presentation of GRDF

GRDF is the main gas distributor in France and in Europe. It designs, builds, operates, and maintains the gas distribution network in France in accordance with the law, the public service contract with the State and the concession contracts signed with local authorities.

GRDF delivers gas to customers on behalf of all suppliers on the French market, guaranteeing each of them and renewable gas producers free and non-discriminatory access to the distribution network. The company develops the network with a dual objective of economic balance and equal access to the gas network. Through all its missions and at the heart of its industrial activity, GRDF ensures the safety of goods and people.

Daily, GRDF carries out the following missions:

- Design, build, maintain and operate more than 200,000 km of gas distribution network under concession
- Transporting gas on behalf of suppliers, with complete impartiality
- Distribute gas safely to its 11 million customers
- Promote the use of gas and the profitable development of the network and gas energy
- Support and connect renewable gas producers to the distribution network in a non-discriminatory manner

As the benchmark player for gas energy, an energy that has its place in the energy transition, GRDF is strongly committed to this development. By anchoring gas as a vector for the transition, by strengthening links with local authorities, and by making network modernization a priority, GRDF is at the heart of change management.

Electromethanogenesis

In addition to its support for the development of anaerobic digestion (AD), GRDF wishes to support the emergence of new renewable gases in France and at international level.

In France, the ADEME's objective for 2050[1] is to have a gas system based 100% on renewable gas (the level of final demand in 2050 for network gas would be around 300 TWh). However, AD alone will not be able to meet all the final demand. One of the levers to reach 100% renewable energy according to ADEME and the « Negawatt 2022 » scenarios is to produce gas from electricity (or « power-to-gas »), beyond a simple tool to make the electricity system more flexible, and to make renewable electricity a full-fledged source of energy for gas uses. Power-to-gas is expected to supply about 140 TWh by 2050.

[1] https://transitions2050.ademe.fr/cooperations-territoriales

- ELECTROMETHANOGENESIS

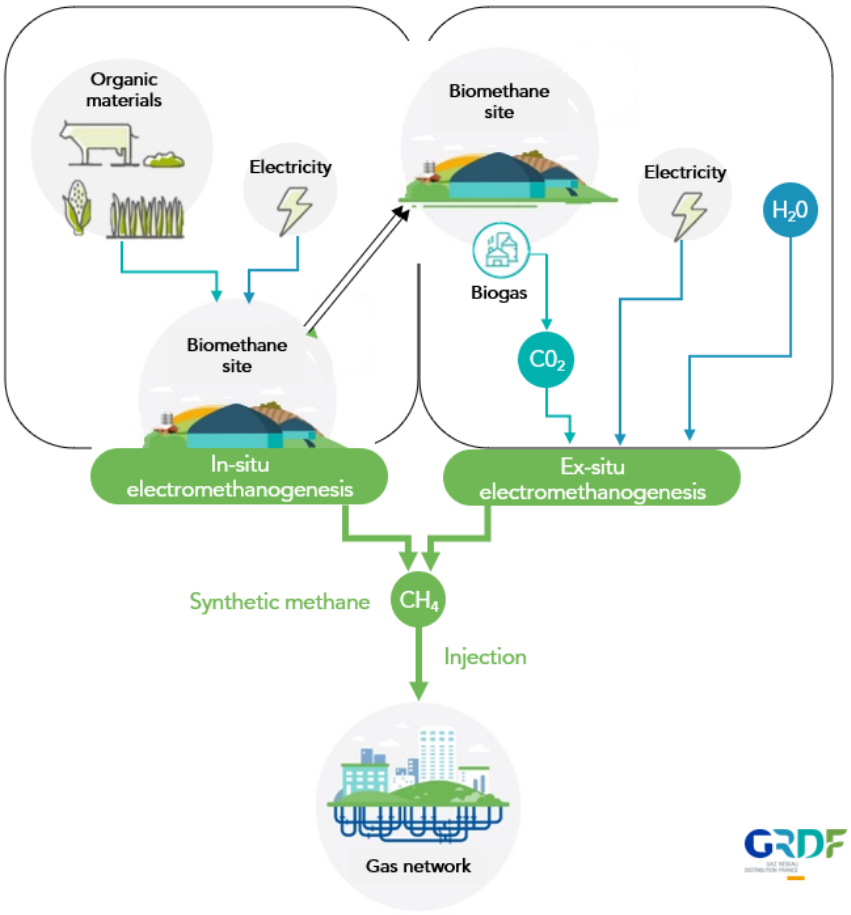
Electromethanogenesis, a promising technology, is interesting for anaerobic digestion. The principle consists in applying directly to the methanogenic micro-organisms a low voltage electric current to provide electrons to these micro-organisms. The micro-organisms present in the reactor can then lead to the reduction of CO_2 into CH_4 inside the digester, which allows to improve the quality of the biogas with a lower concentration of CO_2. This solution using the coupling between biochemical and electrochemical reactions could thus reduce the need for biogas treatment and the associated costs.

The use of biogenic CO_2[2] from anaerobic digestion sites and "green" electricity makes it possible to produce "green" synthetic methane, i.e renewable and with a low GHG impact.

Another interesting application is the upgrading and power-to-gas approach where the use of surplus renewable energy would allow the production of methane by a single system (as opposed to the coupling of electrolysis and methanation) without the need of hydrogen injection. The purification of biogas allows to reduce the remaining CO_2 by obtaining a high purity methane.

The integration of electromethanogenesis would thus improve the economic and environmental balance of the production and injection of biomethane into the networks and would reinforce the principle of local and circular economy inherent to methanization.

[2] Biogenic carbon (and by extension biogenic CO_2 or bioCO_2) is the carbon fixed by the plant during its growth (photosynthesis) from CO_2 in the air. Thus, when this CO_2 is released during the biogas purification stage, the overall balance is zero and therefore neutral for climate change.



PRESENTATION OF THE CALL FOR PROJECTS

In line with its mission to support and promote biomethane injection, GRDF is mobilizing its R&D resources to help make biomethane more competitive. Increasing the methane concentration in raw biogas, reducing biogas upgrading requirements, and recovering biogenic CO_2 are important levers for developing the biomethane sector and making it more competitive than natural gas.

Scope of the CFP

This call for projects is addressed to companies, start-ups, researchers and specialists in the field of electromethanogenesis and bioelectrochemical systems, research centers, universities and academic centers, industrialists, or other aggregators, having the will to improve economically and environmentally the AD units through electromethanogenesis.

The objectives of this call for projects are:

- explore the possible synergies between AD and electromethanogenesis (increase of methane concentration in raw biogas, decrease of biogas purification requirements, …)

- to encourage the implementation and maturation **(TRL[3] gain) of innovations** of electromethanogenesis;

This call for projects covers a perimeter composed of four distinct axes. The respondent will formulate a response on at least one of these axes:

- **Optimization of electrodes:**

Some technical and economical barriers concerning the electrodes used in the electromethanogenesis process have been identified. First of all, the arrangement and the nature of the electrodes used is one of the main concerns towards an optimization of the bioelectrochemical processes. For example, the distance separating these electrodes must be as small as possible to minimize the electrical energy losses brought to the system (overvoltage). On the other hand, since the CO_2 reduction reactions take place in contact with these same electrodes, the contact surface with the digestate must be as large as possible, which generally leads to the choice of structured electrodes with the largest possible developed surface. Finally, the choice of the material constituting the anode and/or the cathode as well as the method used for the inoculation (creation of the electroactive biofilm) can prove to be an important factor of optimization to facilitate the electronic exchanges with the biological medium on the one hand, and on the other hand, to limit the parasitic reactions (limiting the yield of the reaction by creating a passivation layer) and the degradation of the electrodes (corrosion and/or physical damage due to the non-homogeneous nature of the substrate). Thus, the system configuration can strongly impact the technical and economical performance of the technology.

In order to optimize the process, and to maximize the coulombic efficiency[4] of the reactions taking place in the electromethanogenesis reactors, GRDF wishes to study various forms of electrodes by testing several materials and configurations. The characteristics sought for the electrode materials will be specified. The objective is to focus on the overall methane production performance of such systems. Economic performance will also be addressed.

- **Batch/ continuous modelling:**

The electromethanogenesis technologies developed today are on a laboratory scale. Due to the small size of the reactors, the feeding mode used for the demonstrators is a batch feeding. In order to facilitate the scaling up of a pilot plant, GRDF wishes to model these electromethanogenesis systems using a continuous digestate feed. Thus, the different reactor configurations that can be used for electromethanogenesis can be compared, notably on the basis of the fluid dynamics which can be influenced by various parameters such as the effect of stirring, the reactor configuration, the location of the electrodes or the nature of the digestate used. The generated modelling results should allow to better anticipate the performances of the different types of electromethanogenesis reactors according to the chosen conditions. The parameters envisaged can be specified and detailed in the application file submitted.

- **Technical and economic evaluation:**

In order to accelerate the scaling of electromethanogenesis innovations, GRDF wishes to carry out a technico-economic assessment with a view to industrial-scale deployment. The difficulty to evaluate the technology, and the small amount of technical information available will force

[3] Technology Readiness Level
[4] Coulombic efficiency: molar quantity of electrons consumed to produce one mole of CH_4

to approach the estimation by considering the evaluation of the singular equipments as well as the uncertainties related to the low technological maturity of the process and to the classes of hypothesis considered according to the upgrading phases.

- **Ex-situ electromethanogenesis and upgrading:**

Another interesting application of electromethanogenesis is the power-to-gas approach. This approach at the interface between electrolysis and biological methanation presents several operational advantages such as the possibility to get over the logistics related to the management of hydrogen flows, or the possibility to use directly the biogas flow generated by the digester. This application of electromethanogenesis can be particularly interesting to upgrade the biogas produced and thus maximize the biomethane production of an anaerobic digestion unit while reducing the costs associated with the removal of CO_2 from the biogas. In order to improve the competitiveness of these still underdeveloped applications, it is necessary to optimize the operation and performance of these technologies. Different components of the power-to-gas approach can be studied (performance of different prototypes, study of biofilms or other bioelectrochemical approaches, growth of microorganisms and their performance, etc.). GRDF may also select a proof of concept or a laboratory pilot (TRL 3 to 5).

The aim of this call for proposals is to accelerate the scaling up and the arrival on the market of electromethanogenesis solutions adapted to the context of AD installations.

All the initiatives seeking to allow an economic and environmental improvement of the methanization units through the production pathway of electromethanogenesis, on all or part of the bricks of the technology, will be studied by the selection panel. *(See selection criteria)*

Calendar

The schedule envisaged is as follows:

- Application deadline: September 1 to November 1, 2022
- Selection panel: November 28, 2022
- Announcement of the winner: End of November 2022
- Desired start of production T0: December 2022 - early 2023
- End of the test campaign: T0 + 6 months minimum

REQUIREMENTS

Selection criteria

The following criteria will be assessed in the application to determine the winner(s). They are not mandatory unless explicitly stated in the table.

Depending on the relevance of the responses to this call for proposals, GRDF reserves the right to award at least one of the different areas proposed to the potential respondent.

Criteria for participation

Overall quality of response (REQUIRED)	GRDF's CFP are intended to be simple and effective. However, the quality of the presentation of the information and the application document, as well as the completeness of the file will be evaluated
Experience of the actors in electromethanogenesis (REQUIRED)	Demonstrate that the applicant and his partners have experience and know-how in the activity he wishes to develop within the framework of an electromethanogenesis development project
Scope of the projects (REQUIRED)	This CFP targets projects led by biomethane producers and associated actors. Synergies with methanization are strongly valued
Level of maturity (REQUIRED)	The degree of maturity and the gain in technological development enabled by the project (in terms of TRL scale) presented are selection criteria
Economic gain	The project brings an economic gain to the methanization unit, favoring the competitiveness of biomethane
Environmental gain	The project is part of the approach to reduce the impact on the climate by reducing the GHG[5] balance

The criteria for participation are:

- The applicant can be a company, a public institute/laboratory, university/research centers;

  In the case of a consortium, the principles of the consortium agreement will be specified in the application file: role, competencies, responsibilities, cost-sharing.

- The candidate must be active in electromethanogenesis and bioelectrochemical systems for more than 1 year and must be able to justify industrial work and/or research. These elements must be justified in the application, through a presentation of the latest achievements (research projects, patent, thesis, work, presentations, etc.) ;

- The technological maturity level of the proposed solution (TRL) must be at least 3.

[5] Greenhouse Gas

CONTRACTUALIZATION MODALITIES

Winner of the CFP

One or more winners will be selected by GRDF.

GRDF's contributions to the project are:

- Provisional financial participation of GRDF in the demonstration projects, up to 40 000€, at GRDF's discretion ;
- Technical support on GRDF's field of expertise and on the compatibility of the gas produced with GRDF's operated networks ;
- If necessary, identification of a methanization site in France, preferable connected to the GRDF network for the installation of a demonstrator

Counterparts to GRDF's involvement in the demonstration project

The counterparts to GRDF's involvement in the demonstration project will be defined before the launch of the experiment in the partnership contract binding the various stakeholders.

As a partner in the project, GRDF will have access to at least the following Results:

- Deliverables
- Results of the test campaign to produce synthetic methane by the electromethanogenesis route

GRDF will keep during the experimentation, as well as once closed, a license to use the results, free of charge, without any time limit, allowing it to freely use the Results for its own needs.

The project leader will retain full ownership of the demonstrator, its previous knowledge and the knowledge acquired.

EXPECTED CONTENT OF THE APPLICATION

A file (to be uploaded in the form on page 2) including at least

- Elements of appreciation on the above-mentioned selection criteria;
- Presentation of the project actors;
- Presentation of the project;

EXPECTED CONTENT OF THE APPLICATION - ELECTROMETHANOGENESIS

- Organization of the project: budget, schedule, deliverables, contractual terms; if the answer integrates several axes of the mentioned perimeter, a dimensioning of the costs axis by axis is expected ;
- Expectations / needs of the candidate towards GRDF.

Any element allowing to assess the application regarding the criteria mentioned in the paragraph "Selection criteria" is welcome.

The answers will be made on the platform https://innovation.grdf.fr/ by filling in the requested information and providing an application file as an attachment. The filing of the form will specify:

- Contact point
- The project or your activity + upload application file
- How you knew the CFP

Pay attention to the banner displayed during the validation of your form, it confirms the good reception of your file by GRDF.

Electromethanogenesis project holders, don't wait any longer to apply!