European Commission

Innovative biomethane for REPowerEU

A PROJECTS INFO PACK BY CORDIS

Research and Innovation

CONTENTS

FOREWORD

"Biomethane is essential for the EU to achieve its energy autonomy and climate neutrality fast and in a cost-effective way. Research and innovation is key to advancing novel and competitive biomethane solutions to boost its share in the EU energy mix by 2030 and 2050 and help reach Europe's ambitious goals for a green and secure energy transition."

Marc Lemaître
Director-General,
Directorate-General for Research and Innovation

Biomethane is a renewable gas that can substitute fossil natural gas in all of today's applications, using the existing gas infrastructure. It can be used in power plants to generate electricity, in industrial plants to meet the demand for electricity and heat, in buildings for heating, in transport as fuel, in chemical processes as feedstock and for energy storage as an energy carrier for hydrogen. It can therefore displace and reduce natural gas imports, while accelerating the green energy transition and contributing to the European Green Deal's climate and energy targets for 2030 and beyond.

For this reason, REPowerEU names biomethane as a priority for diversifying the EU gas supplies and aims to double its targeted production levels by 2030. This will bolster Europe's energy security and speed up its independence from fossil coal, oil and natural gas.

Biomethane today is commercially produced in small quantities by upgrading biogas. However, to reach the ambitious EU targets in a cost-competitive way and diversify our energy mix, in particular in the gas-consuming sectors, we need to develop and demonstrate advanced technologies for the efficient production of biomethane. This is where research and innovation has a key role to play in making the gas supply cleaner, more secure, reliable and competitive.

The EU's research and innovation framework programmes Horizon 2020 and Horizon Europe have continuously supported novel, sustainable and circular biomethane technologies and their market uptake with EU public funds. In this specially commissioned Projects Info Pack, you will discover 15 selected projects on innovative biomethane that are contributing to boosting its production and place in the EU energy market.

EDITORIAL

Europe's energy security is under pressure from rising costs, climate change, domestic and international energy policy, and conflict. Biomethane – natural gas produced from renewable sources such as municipal and agricultural waste – offers a reliable, drop-in fuel that can meet the energy needs of citizens. This Projects Info Pack showcases the research being carried out to grow Europe's biomethane industry, boosting energy security and helping to deliver on the EU's ambitions for a competitive, low-carbon economy.

Events in the past year affecting the supply of Europe's gas imports have made clear the need for the EU to diversify its energy portfolio.

REPowerEU is the European Commission's plan to erase Europe's dependence on Russian fossil fuels by 2030 by increasing European biomethane production tenfold, to 35 billion cubic metres annually of a sustainable, cheaper and locally produced renewable alternative. The projects in this Pack showcase the advanced technologies that will help deliver on this objective.

For more than a decade, the Directorate-General for Research and Innovation has been supporting projects working towards this goal of increased biomethane production, funded through the Horizon 2020 and Horizon Europe programmes.

In Chapter I (page 9), you will find some of the earliest projects featured in this Pack. They are coordination support actions that focus on market uptake measures – addressing the barriers to a larger biomethane industry. These include the **Bin2Grid**, **BiogasAction**, **BIOSURF** and **ISABEL** projects, as well as **REGATRACE** which built an efficient and trusted system to accelerate cross-border biomethane trading.

Chapter II (page 15) focuses on innovation for sustainability, circularity and the future, through circular, net zero carbon emissions production of renewable gas. The **NET-Fuels** project turns agricultural residues into drop-in renewable gas, while **FlexSNG** is helping broaden the various feedstocks that such gasification technology can accept. The **PRODIGIO** project aims to make industrial microalgae production more reliable. Both

CRONUS and **DESIRED** examine the potential to create synthetic fuels from atmospheric carbon, and **CarbonNeutralLNG** examines how to efficiently convert biomethane into liquified gas for the transport sector.

In Chapter III (page 29), you will find projects dedicated to upscaling innovative production, demonstrating a portfolio of technologies for sustainable, secure and competitive production of renewable gas. These include the **HYFUELUP** project's work on gasifying wood waste, work by **METHAREN** converting intermittent renewable electricity into reliable fuel, and new biomethane technologies developed by **SEMPRE-BIO** and **BIOMETHAVERSE**.

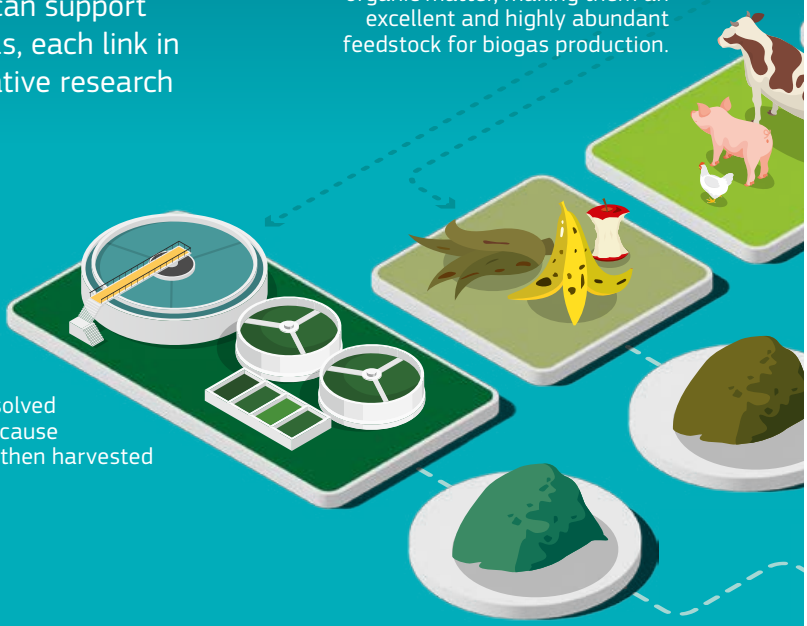
Together, these projects reflect the broad coalition of researchers across Europe contributing to the implementation of REPowerEU's Biomethane action plan, and to Europe's continued climate and energy security.

Fuelling innovation

Biomethane is a renewable fuel derived from multiple sources and delivered directly to a wide range of consumers. From increasing the supply of feedstocks through improved municipal waste programmes and utilisation of marginal lands, to the development of advanced materials and technologies that can support economical synthesis of sustainable biofuels, each link in this web presents an opportunity for innovative research to increase biomethane production.

Organic matter

Household food and paper waste, farmland residues, and animal manure from meat, egg and dairy production are all waste products high in organic matter, making them an excellent and highly abundant feedstock for biogas production.

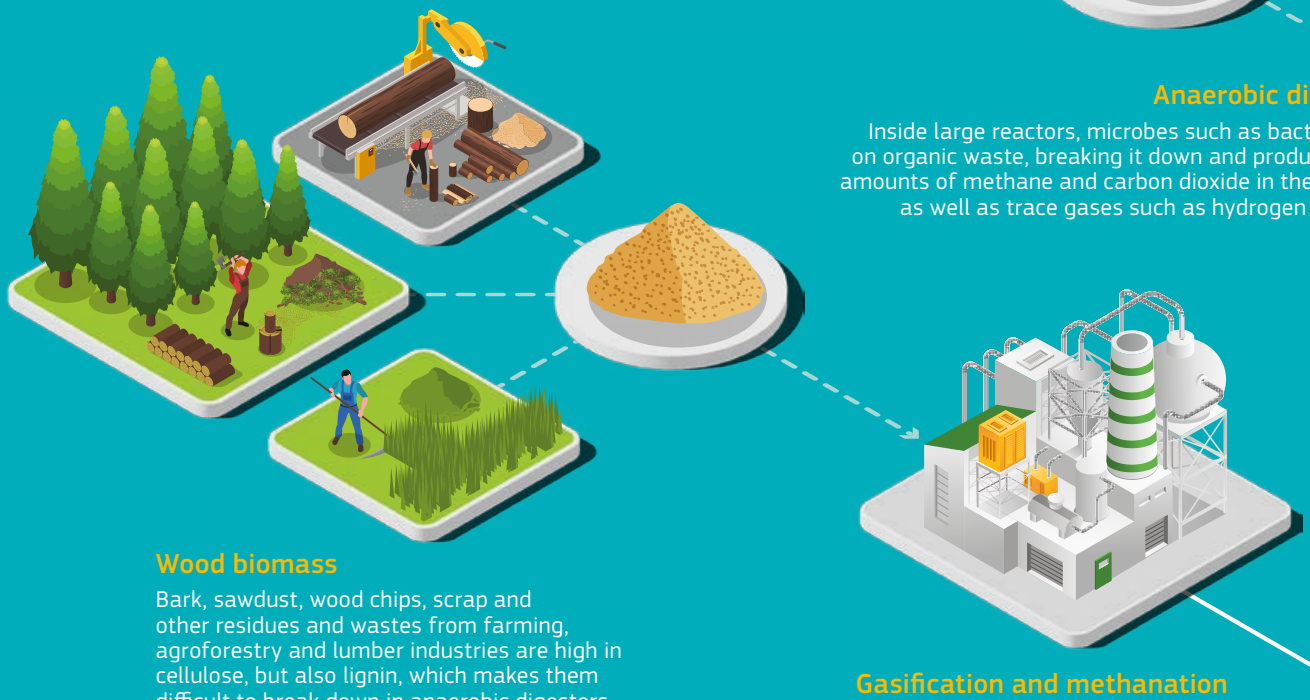


Waste waters

During their treatment, industrial and residential waste waters are stored in large ponds that encourage the growth of algae, to remove dissolved nutrients that would otherwise cause harmful pollution. This algae is then harvested and used as a feedstock.

Anaerobic digestion

Inside large reactors, microbes such as bacteria feed on organic waste, breaking it down and producing high amounts of methane and carbon dioxide in the process, as well as trace gases such as hydrogen sulphide.



Wood biomass

Bark, sawdust, wood chips, scrap and other residues and wastes from farming, agroforestry and lumber industries are high in cellulose, but also lignin, which makes them difficult to break down in anaerobic digesters.

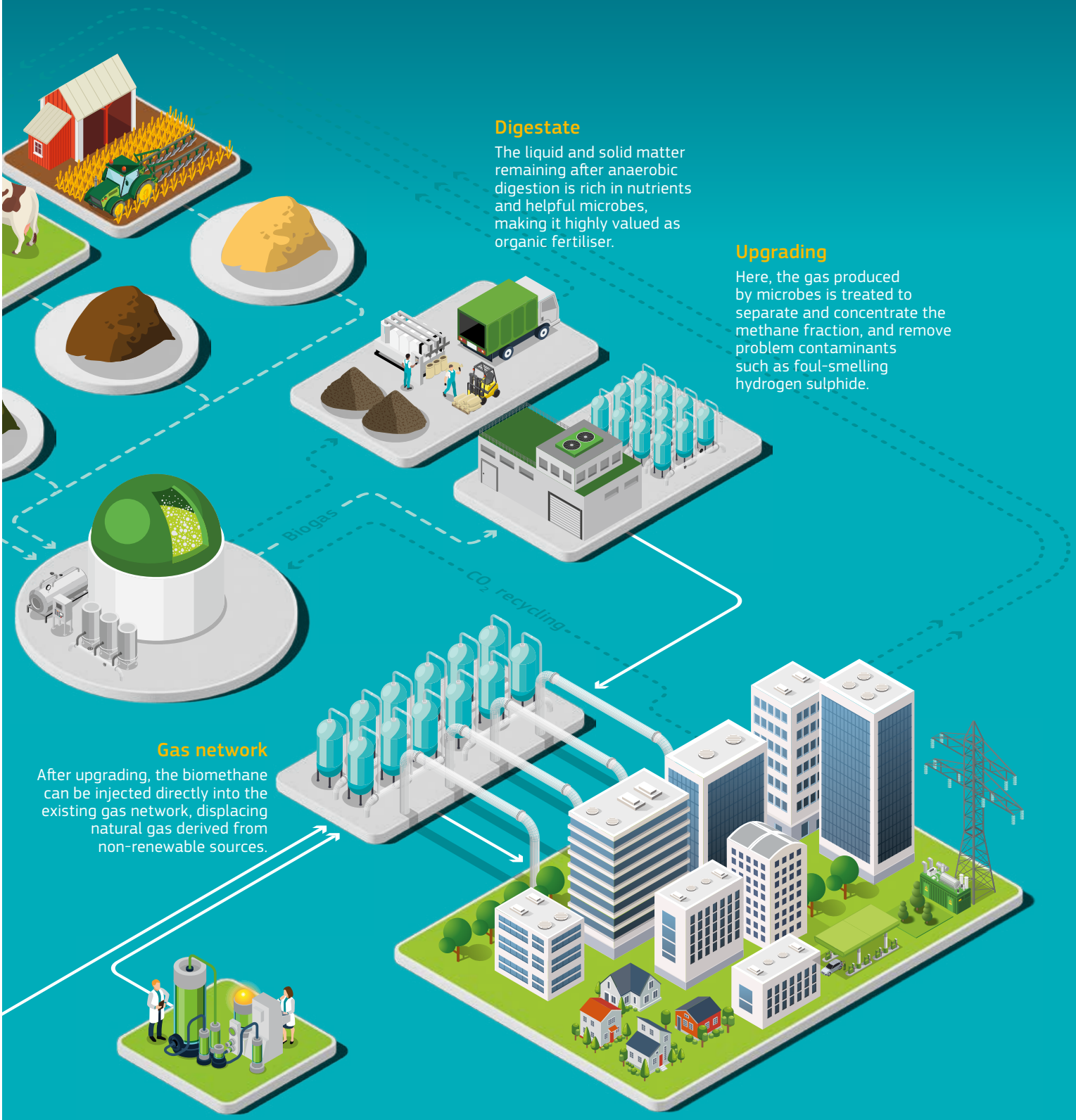
Gasification and methanation

Using high temperatures and controlled inputs of oxygen and steam, woody wastes are chemically broken down, releasing nitrogen, carbon monoxide, hydrogen and carbon dioxide. These gases can then be converted into methane. The leftover ash, called biochar, can be used to condition farm soils while sequestrating carbon.

Wastes / Feedstock

Biomethane

Recycle



Digestate

The liquid and solid matter remaining after anaerobic digestion is rich in nutrients and helpful microbes, making it highly valued as organic fertiliser.

Upgrading

Here, the gas produced by microbes is treated to separate and concentrate the methane fraction, and remove problem contaminants such as foul-smelling hydrogen sulphide.

Gas network

After upgrading, the biomethane can be injected directly into the existing gas network, displacing natural gas derived from non-renewable sources.

Artificial photosynthesis

Water and atmospheric carbon dioxide represent the most abundant and widely available source of ingredients needed to make methane. By harnessing renewable energy such as solar, the gas can be efficiently synthesised anywhere in the world.

Consumption

To the consumer, biomethane is indistinguishable from fossil fuel gases, supplying the chemical energy needed for transport, industrial applications, heating and cooking.

Ending Europe's reliance on fossil fuel imports

REPowerEU aims to rapidly reduce the EU's dependence on Russian fossil fuels by accelerating the transition to clean energy. It puts forward a Biomethane action plan with the objective of increasing the production of biomethane in the EU to 35 billion cubic metres per year to replace 20 % of Russian natural gas imports. It is one of a raft of overlapping policies supporting the development of biomethane.

The EU has been supporting research and innovation in biomethane under the Horizon 2020 and Horizon Europe programmes for development and demonstration of innovative biomethane technologies and market uptake measures. Biomethane is also an essential part of the SET-Plan Action 8: Bioenergy and Renewable Fuels for Sustainable Transport.

This impact can be further accelerated through the new European innovation agenda and the EU's new ERA for Research and Innovation for creating necessary research and innovation skills.

The European Green Deal will transform the EU's economy towards a sustainable future and climate neutrality by 2050 through the 'Fit for 55' package of legislation which includes actions on renewable energy with specific targets for advanced biofuels and biogas set in the Revision of the Renewable Energy Directive II.

The Green Deal industrial plan for the net-zero age through the Net Zero Industry Act will provide a more supportive environment for the scaling up of the EU's manufacturing capacity for net zero technologies including biomethane.

MARKET UPTAKE MEASURES

Delivering the future

Increasing biomethane production in the EU is not solely a technological challenge.

"To increase the biomethane share in the EU gas market, we need to understand non-technological barriers to deploying production technologies, for example regulatory, financing and social, and develop appropriate market uptake measures and mechanisms to overcome them."

Maria Georgiadou, Senior Expert at the Directorate-General for Research and Innovation

Here follow four EU-funded projects that highlight the multiple ways in which researchers are bringing clean, renewable domestic energy to market.

Bin2Grid: Turning unexploited food waste into biomethane supplied through local filling stations network

Over 88 million tonnes of food are thrown away in the EU every year. The Bin2Grid project promoted the collection of food waste, and its conversion to biogas and upgrading into biomethane, supplying stations in Zagreb, Skopje, Malaga and Paris.

To bridge the gaps between waste management and renewable energy production, the project investigated technologies related to biowaste separation and treatment, biogas production and upgrading, and economic tools to boost profitability of the concept.

Project dates:
1 January 2015 – 31 December 2017

Coordinated by:
Zagrebacki Holding in Croatia

Funded under:
Horizon 2020-ENERGY

CORDIS factsheet:
cordis.europa.eu/project/id/646560

Total budget:
EUR 709 468

EU contribution:
EUR 709 468

BiogasAction: Promotion of sustainable biogas production in EU

The BiogasAction project developed the European biogas sector across 14 European regions by focusing on the removal of non-technical barriers to widespread production from manure and other organic waste.

As well as a comprehensive biomethane market web portal, the project created a guidance document for investors on financing biogas and biomethane projects, and advice for policymakers and local authorities on improving national framework conditions for biogas and biomethane deployment.

Project dates:
1 January 2016 – 31 December 2018

Coordinated by:
Energy Consulting Network in Denmark

Funded under:
Horizon 2020-ENERGY

CORDIS factsheet:
cordis.europa.eu/project/id/691755

Total budget:
EUR 1 999 885

EU contribution:
EUR 1 999 885

BIOSURF: BIOmethane as SUstainable and Renewable Fuel

By harmonising biomethane registration, labelling, and certification, we can streamline cross-border trade in biomethane. The BIOSURF project extended national registries of biogas injection to the whole of Europe, enabling movements of biomethane through the European natural gas infrastructure.

It also developed a calculation to quantify the greenhouse gas emissions of biomethane that is compliant with both the RED framework and the EU Emissions Trading System.

Project dates:
1 January 2015 – 31 December 2017

Coordinated by:
Institute of Studies for the Integration of Systems (I.S.I.S), Cooperative Society in Italy

Funded under:
Horizon 2020-ENERGY

CORDIS factsheet:
cordis.europa.eu/project/id/646533

Project website:
biosurf.eu/en_GB

Total budget:
EUR 1 872 912

EU contribution:
EUR 1 872 912

ISABEL: Triggering Sustainable Biogas Energy Communities through Social Innovation

Sustainable biogas technologies have been slow in catching up with community energy developments.

Founded on the principles of Social Innovation, the ISABEL project carried out work in Germany, Greece and the United Kingdom to pave the way for the transition from traditional supply chains to community ownership, allowing citizens to take full advantage of the ample societal benefits of local community-driven biogas systems.

Project dates:
1 January 2016 – 31 December 2018

Coordinated by:
Q-Plan International Advisors in Greece

Funded under:
Horizon 2020-ENERGY

CORDIS factsheet:
cordis.europa.eu/project/id/691752

Total budget:
EUR 1 897 437

EU contribution:
EUR 1 897 437

"A reliable EU Guarantees of Origin system will contribute to the boost of the biomethane market."

Stefano Proietti, REGATRACE project coordinator

PROJECT ID CARD

Full name: REnewable GAs TRAde Centre in Europe

Project dates: 1 June 2019 – 30 November 2022

Coordinated by: Institute of Studies for the Integration of Systems (I.S.I.S.), Cooperative Society in Italy

Funded under: Horizon 2020-ENERGY

CORDIS factsheet: cordis.europa.eu/project/id/857796

Project website: regatrace.eu

Total budget: EUR 3 306 658

EU contribution: EUR 3 000 485

REGATRACE

Opening the portal to Europe's biomethane trade

Through the creation of an efficient and trusted trade system, an EU-funded project has increased uptake in Europe's growing biomethane market.

A sustainable energy source that can be transported across the existing natural gas transport system, biomethane can make Europe's energy grid greener and more independent. Doing this will require increased use of the European common biomethane market, which will also enable investments and promote cross-border trade.

The EU-funded REGATRACE project created an efficient trade system based on the issuing and trading of biomethane gas certificates. These provide Guarantees of Origin (GoO) and Proof of Sustainability (PoS) for biomethane and other renewable gases.

"This strongly contributed to the uptake of the European common biomethane market," says Stefano Proietti, senior researcher at ISINNOVA in Italy, and REGATRACE project coordinator. "A significant help was also provided by the comprehensive set of the project's actions at country level," he adds.

REGATRACE paved the way for national GoO issuing bodies for biomethane. Some of the existing biomethane registries were also connected to the platform for the European Renewable Gas Registry (ERGaR) Certificates of Origin (CoO) Scheme. The AIB Hub will also facilitate standardised cross-registry transfer of gas GoOs.

"A reliable EU Guarantees of Origin system will contribute to the boost of the biomethane market, thanks to traceability, transparency and certification of biomethane production," Proietti says.

In the first three quarters of 2022, transfers between Austria, Denmark, Germany, the Netherlands, Sweden and the United Kingdom resulted in a total transfer volume of approximately 4 300 GWh.

Cross-border transfers of biomethane certificates between other European countries are still relatively low, Proietti notes. Yet based on these data and observations, the volume of cross-border transfers of biomethane certificates will total approximately 6 000 GWh in 2022 – double that of 2020.

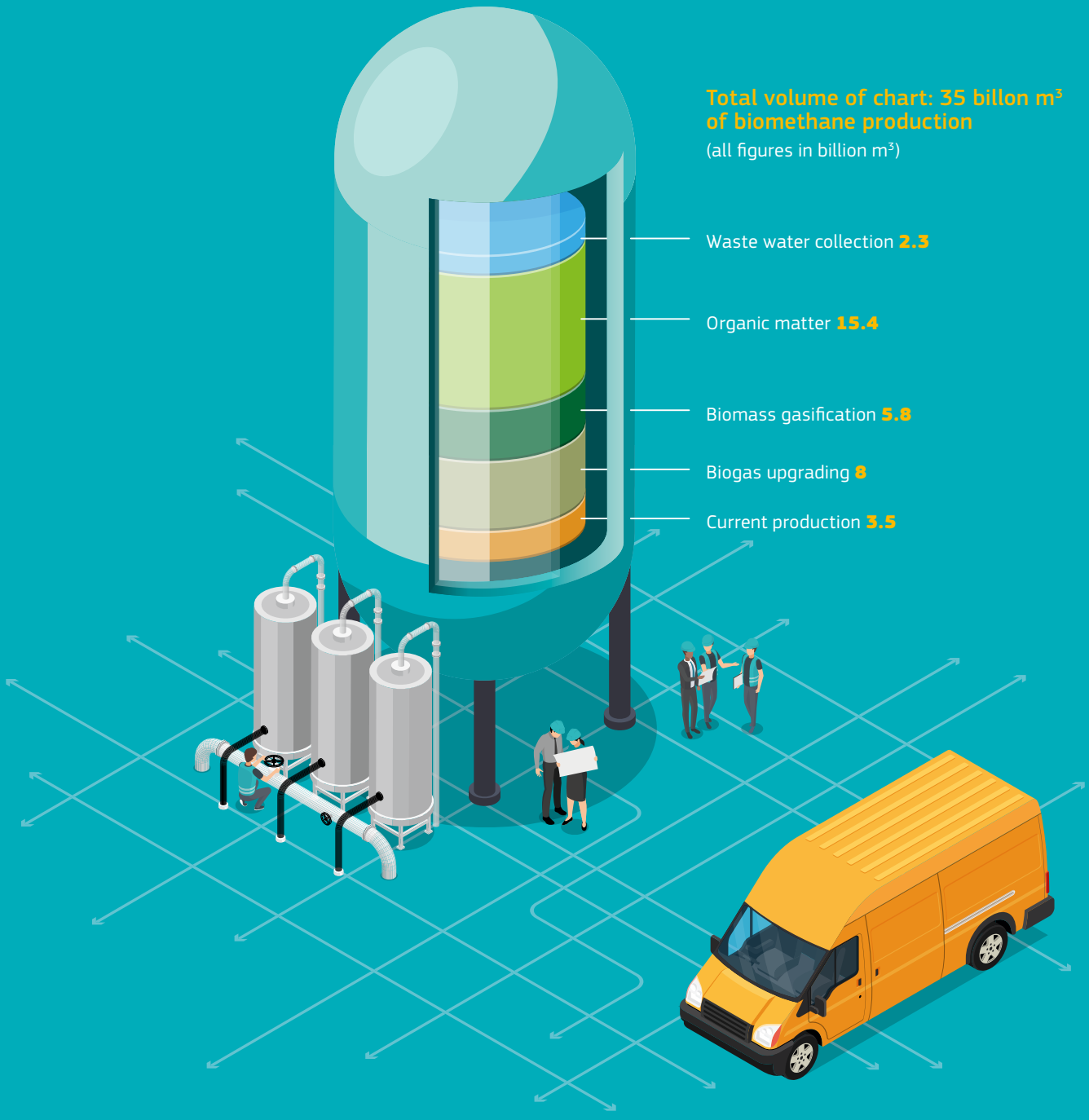
The work contributes essentially to the hydrogen and decarbonised gas markets package for the creation of a European-wide market for renewable and low-carbon gases.

Future work in this area will pave the way for national strategies and energy and climate plans integrating sustainable biogas and biomethane production.

"The guidance will also assist project developers in planning and realising biomethane investment projects," notes Proietti. "All of this will strongly contribute to the REPowerEU Plan," he adds.

Filling the tank

The REPowerEU initiative has set an ambitious target for Europe's biomethane industry, seeking to increase domestic production to 35 billion cubic metres (bcm) by 2030, reducing dependence on foreign imports of fossil fuels. This tenfold increase over current production will draw from a range of sources. Upgrading all existing biogas facilities to produce biomethane is expected to contribute 8 bcm, while the remainder is generated from increasing the collection and processing of feedstocks such as woody biomass, organic matter and waste water. Innovative technologies will shape the exact contribution of each element to the 2030 target: improvements to gasification technology, for example, could relieve demand for organic material and therefore pressure on farmland.



Source data: Directorate-General for Research and Innovation, European Commission

INNOVATION FOR SUSTAINABILITY, CIRCULARITY AND THE FUTURE

"The carbon will be sequestered for a hundred years or more."

Andrea Contin, NET-Fuels project coordinator

PROJECT ID CARD

Full name: Increasing biomass conversion efficiency to carbon-negative sustainable biofuels by combination of thermal and bio-electrochemical processes

Project dates: 1 November 2022 – 31 October 2026

Coordinated by: University of Bologna in Italy

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101083780

Project website: netfuelsproject.org

Total budget: EUR 4 501 739

EU contribution: EUR 4 501 739

NET-Fuels

Turning biomass wastes into a viable carbon-negative fuel

Can agricultural waste be transformed into biofuel at scale, via a carbon-negative process? The NET-Fuels project aims to find out.

Fossil fuels still dominate our economy and power most of our cars, airplanes and heavy goods vehicles. If Europe is to fully make the transition towards greener transportation – and a greener economy overall – then cost-effective carbon-neutral alternatives need to be found.

To this end, the EU-funded NET-Fuels project is investigating whether biofuels produced from low-value agricultural residues could hold the key. The initiative, led by Andrea Contin from the University of Bologna in Italy, is developing a novel method of treating agricultural waste at high temperatures without oxygen. This produces a charcoal-like biochar, an oil similar to biodiesel, and a mixture of hydrogen and carbon monoxide called syngas.

“Plants and crops take carbon out from the atmosphere as they grow,” explains Contin. “The biochar produced in this process retains this carbon. This can then be used in the soil, where the carbon will be sequestered for a hundred years or more.” Contin says this will enable the NET-Fuels process to be carbon-negative.

In the second phase of production, the volatile syngas is separated from hydrogen and combusted with pure oxygen. The resultant CO_2 is then mixed with the hydrogen and converted into methane by bacteria. “A key aim of ours is to see if we can produce methane this way, from CO_2 and hydrogen,” adds Contin. “This will be a challenge, as bacteria are sensitive even to small levels of contaminants. This has only been tested in labs up until now.”

If successful, the NET-Fuels project could represent a significant step forward in the production of economically viable and carbon-negative biomethane. The hope is that the process will create a new revenue stream for agricultural businesses, sequester CO_2 in soil efficiently while fertilising it, and produce biomethane in sufficient quantities.

“We will certainly be looking at the economic potential of this process,” says Contin. “This is one piece of a much larger puzzle.” The project also plans to set up a certification system for carbon sequestration to create an attractive market for biochar production.

"We are developing and validating a more cost-effective, feedstock-flexible concept for producing biomethane."

Sanna Tuomi, FlexSNG project coordinator

PROJECT ID CARD

Full name: Flexible Production of Synthetic Natural Gas and Biochar via Gasification of Biomass and Waste Feedstocks

Project dates: 1 June 2021 – 31 May 2024

Coordinated by: VTT Technical Research Centre in Finland

Funded under: Horizon 2020-ENERGY

CORDIS factsheet: cordis.europa.eu/project/id/101022432

Project website: flexsng.eu

Total budget: EUR 4 478 190

EU contribution: EUR 4 230 810

FlexSNG

Generating high-quality biomethane from low-quality residues

A flexible, cost-effective means of producing biomethane, biochar and heat from a wide array of feedstock could help Europe to transition away from fossil fuels and increase its energy autonomy.

Presently, the anaerobic digesters used to produce biomethane can only accept certain organic wastes and energy crops. But more advanced biomass-to-synthetic natural gas (SNG) concepts, based on biomass gasification, are often highly complex, and require high upfront investment costs.

"The FlexSNG project was launched to address these challenges," explains project coordinator Sanna Tuomi from VTT in Finland. "We are developing and validating a more cost-effective, feedstock-flexible concept for producing biomethane, biochar and heat."

The FlexSNG concept combines gasification with simplified gas cleaning, methanation and low-cost oxygen production. The project has set a target of reducing biomethane production costs by 30 % compared to state-of-the-art concepts based on steam/oxygen-blown gasification.

Through feedstock supply chain modelling and optimisation, the team also aims to cut feedstock supply costs by 20 %. "The preliminary piloting phase has been completed," continues Tuomi. "Biochar samples produced have been found to be suitable for combustion, and could have other end use applications such as construction material additive or soil amendment."

In parallel with the development of the gasification process, oxygen transport membranes, which will be used as a low-cost solution to supply oxygen to this process, have been successfully tested.

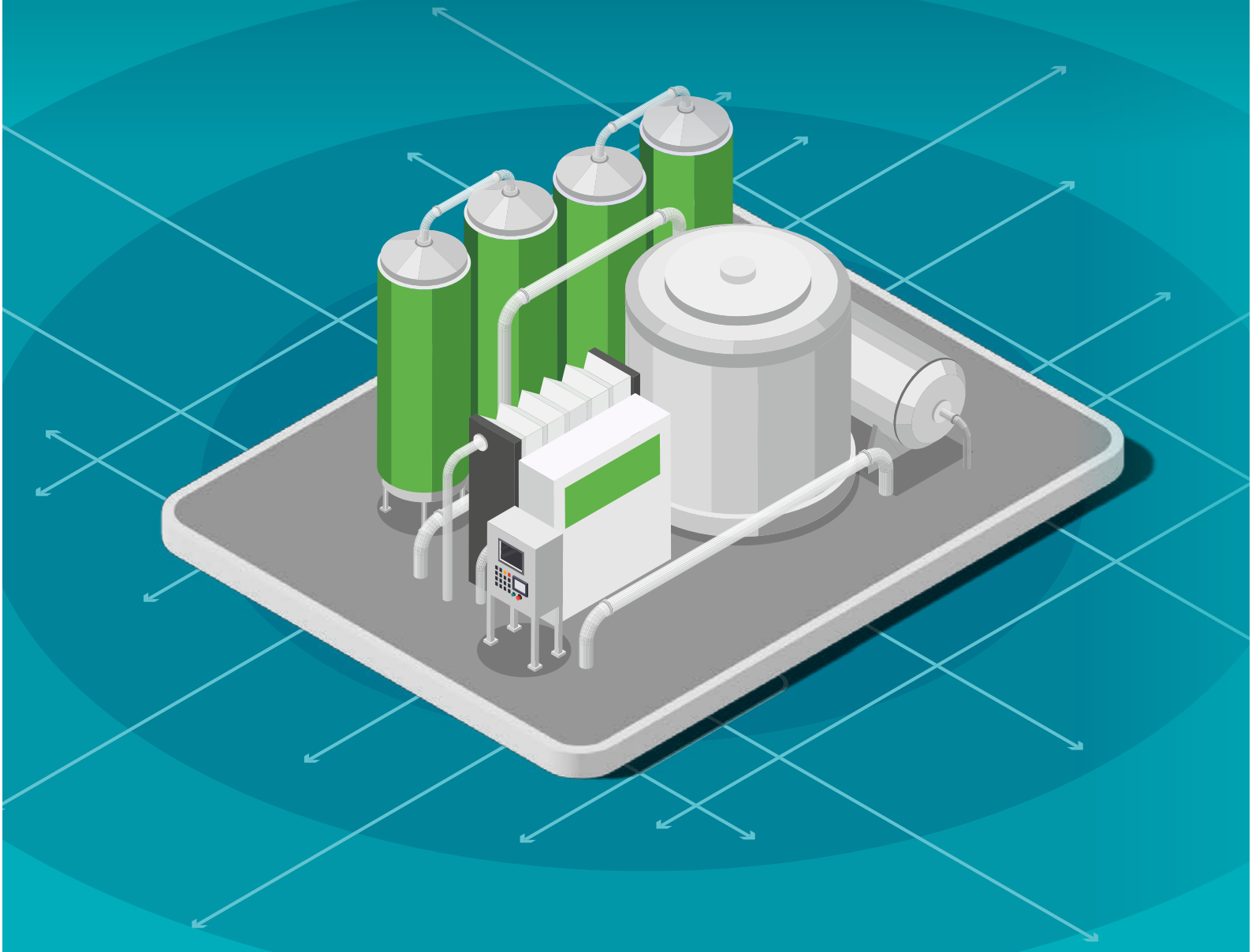
"The experimental work performed so far has created a good basis for our upcoming validation runs," says Tuomi. "The whole concept – from gasification up to final gas cleaning – will now be verified with woody residues, agricultural residues and waste feedstocks."

Tuomi and her team are confident that they will be able to show how the FlexSNG concept could be a viable alternative for producing biomethane alongside biochar and heat. After this has been successfully achieved, the hope is to follow up immediately with demonstration projects at the industrial scale.

"The industrial implementation of this FlexSNG technology will help to support the decarbonisation of the transport and energy sectors, as well as the overall transition towards a low-carbon economy," adds Tuomi.

"The scientific knowledge derived from PRODIGIO will increase the performance of bioreactors, and the entire production chain from microalgae to biogas."

Pedro Cermeño, PRODIGIO project coordinator



PROJECT ID CARD

Full name: Developing early-warning systems for improved microalgae PROduction and anaerobic DIGestIOn

Project dates: 1 January 2021 – 31 December 2023

Coordinated by: Spanish National Research Council in Spain

Funded under: Horizon 2020-ENERGY

CORDIS factsheet: cordis.europa.eu/project/id/101007006

Project website: prodigio-project.eu

Total budget: EUR 2 452 941

EU contribution: EUR 2 452 941

PRODIGIO

Growing sustainable biogas in Europe with microalgae

Large-scale biogas production from microscopic organisms is challenging, particularly as living systems can become unstable and die off. The EU-funded PRODIGIO project seeks tools to predict these breakdowns.

Microalgae have been considered a promising source of biogas energy for over 60 years. Developing this technology further could help alleviate some of Europe's energy dependence on foreign fuels and help to create a greener future.

Large-scale microalgae production is challenging, as these systems are composed of very diverse microbial communities. Anaerobic digestion is a natural biomass degradation process also carried out by microbe communities. Both of these processes are susceptible to failure.

"Combining microalgae production with anaerobic digestion provides a truly sustainable source of renewable biogas for the future but, as with microalgae production, biogas conversion yields are far from optimal," explains Pedro Cermeño, senior researcher at the Institute of Marine Sciences (ICM) of the Spanish National Research Council (CSIC) in Spain, and PRODIGIO project coordinator.

Through the EU-funded PRODIGIO project, a consortium of researchers are aiming to set up a scientific knowledge base for the development of a system failure prediction technology. This will help improve the performance of both microalgae biomass production and biomass to biogas conversion systems.

"Anticipating the collapse of ecological systems is crucial for the timely implementation of preventive and mitigation measures that ensure bioprocess stability over time," adds Cermeño. "The knowledge gained in PRODIGIO is allowing us to develop early warning signals, thus improving our ability to predict when systems are approaching a tipping point."

PRODIGIO consists of two lines of research: on photobioreactors for microalgae biomass production, and anaerobic reactors for conversion of biomass into biogas. Experiments so far have succeeded in inducing the collapse of microalgal cultures and anaerobic communities, and are allowing the team to explore the mechanisms underlying system failure.

"The scientific knowledge derived from PRODIGIO will increase the performance of bioreactors, both for the production of microalgae biomass and for the conversion of biomass into biogas," says Cermeño. "This new knowledge, once converted into technology, is expected to move the entire production chain from microalgae to biogas efficiently towards its theoretical maximum."

"The project aims to significantly advance the current state of the art in biofuel production and the capture, utilisation and storage of biogenic effluent gases."

Dimitris Malamis, CRONUS project coordinator

PROJECT ID CARD

Full name: Capture and Reuse Of biogenic gases for Negative-emission - sustainable biofUelS

Project dates: 1 December 2022 – 31 August 2026

Coordinated by: National Technical University of Athens in Greece

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101084405

Total budget: EUR 4 390 895

EU contribution: EUR 4 390 895

CRONUS

Towards carbon-negative, sustainable, secure and competitive biofuels

Using a process called carbon capture, utilisation and storage, the EU-funded CRONUS project aims to achieve an annual production rate of over 10 million litres of carbon-negative biofuels.

If Europe is to meet its twin goals of carbon neutrality and energy sovereignty, it must kick its dependence on fossil fuels. One way to get there is through biofuels. With the support of the EU-funded CRONUS project, Dimitris Malamis, an environmental engineer at the National Technical University of Athens, is leading an effort to increase the efficiency of clean, sustainable, secure and competitive biofuels through the methanation of effluent gases. "The project aims to significantly advance the current state of the art in biofuel production and the capture, utilisation and storage of biogenic effluent gases while also promoting sustainable innovation," explains Malamis.

At the heart of the CRONUS solution is carbon capture, utilisation and storage (CUS) – techniques that capture biogenic carbon dioxide at the point of its release and then either reuse it or store it underground thus creating negative emissions. "Implementing carbon CUS into the production of biofuels can help limit global warming and contribute to the phasing out of fossil fuels and the decarbonisation of the EU economy," adds Malamis.

To this end, the project intends to develop and test new integrated and sustainable technological solutions for highly efficient biogenic effluent gas CUS within the biofuels value chain. "These tests will provide actionable information on how the technologies should be optimised and identify any risks or potential sustainability hotspots," remarks Malamis.

The project will then upscale the most promising technologies into functional prototypes that will be implemented and further tested in actual biofuel production plants. The end goal is to achieve an annual production rate of over 10 million litres of carbon-negative biofuels within five years of the project's end.

"Although we are in the very early stages, I am confident that CRONUS will help accelerate the green transition and contribute to creating a sustainable, secure and competitive energy supply for Europe," concludes Malamis.

"If successful, this project will help Europe achieve its ambitious climate targets while also reducing its dependence on fossil carbon-sourced energy."

Angela Dibenedetto, DESIRED project coordinator

PROJECT ID CARD

Full name: Direct co-processing of CO2 and water to sustainable multicarbon energy products in novel photocatalytic reactor

Project dates: 1 November 2022 – 31 October 2026

Coordinated by: National Interuniversity Consortium for Chemical Reactivity and Catalysis in Italy

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101083355

Project website: desired-project.eu

Total budget: EUR 3 058 752

EU contribution: EUR 3 058 752

DESIRED

Making solar-based liquid fuels a reality

The EU-funded DESIRED project aims to use solar energy to turn carbon dioxide and water recovered from the atmosphere into sustainable fuel.

Despite global action to address climate change, over 80 % of the world's energy still comes from fossil carbon sources such as coal, oil and natural gas. When these sources are turned into the fuels used to power industry and transportation, they account for over 40 % of all greenhouse gas emissions.

The good news is that there are alternatives with the potential to drastically reduce carbon emissions. Direct solar fuels are produced using solar power to convert CO_2 and water into biomethane and more complex hydrocarbon fuels. However, significant improvement in the photocatalysts and reactor technology is required before this can happen.

Enter the EU-funded DESIRED project. "Our goal is to develop the technology and processes needed to recover CO_2 and water from the atmosphere and, using solar energy, produce liquid fuels," says Angela Dibenedetto, a professor at the University of Bari Aldo Moro in Italy, and DESIRED project coordinator.

According to Dibenedetto, the project focuses on developing a solar-based drop-in or replacement fuel that can fill the gap between fossil carbon-based fuels and alternatives. "For some sectors, such as commercial aviation, the direct shift to electric batteries or hydrogen is simply not an option," she explains. "These are the sectors we aim to serve by providing a clean equivalent to today's liquid fuels."

Although still in its infancy, the DESIRED system will produce C1 and C2+ solar fuels through the direct coprocessing of CO_2 and water. This coprocessing will be done via a recyclable hybrid photo-electrocatalyst, supported on either frustules or zeolites, and housed within an innovative photoreactor.

The seven European partners involved in the DESIRED project are also studying the economic feasibility, environmental benefits and social acceptability of the proposed solution. Based on the outcome of this initial assessment, the system will be further developed for modelling and simulation.

"If successful, this project will help Europe achieve its ambitious climate targets while also reducing its dependence on fossil carbon-sourced energy," concludes Dibenedetto.

"The goal of this process is to completely make use of the green carbon found in biomass."

Jürgen Karl, CarbonNeutralLNG project coordinator

PROJECT ID CARD

Full name: Truly Carbon Neutral electricity enhanced Synthesis of Liquefied Natural Gas (LNG) from biomass

Project dates: 1 November 2022 – 31 October 2025

Coordinated by: Friedrich-Alexander University Erlangen-Nuremberg in Germany

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101084066

Project website: carbonneutrallng.eu

Total budget: EUR 3 306 160

EU contribution: EUR 3 306 160

CarbonNeutralLNG

Turning biomass into green liquid natural gas

The EU-funded CarbonNeutralLNG project aims to position liquid natural gas as a sustainable, carbon-neutral alternative to fossil fuels.

While the electrification of the mobility sector has the potential to cut transport-related emissions in half, it does have its limitations. For example, heavy-duty, long-distance transport, such as maritime and aviation, will require fuel with high energy densities – such as liquified natural gas (LNG).

Although LNG traditionally comes from fossil fuels, recent research has begun developing so-called 'GreenLNG', or liquid natural gas made from renewable resources such as biomass. While the process chain for producing such renewable LNG has advanced considerably, it is still plagued by significant carbon losses and high costs – both of which have hampered its uptake.

"GreenLNG is crucial for a carbon-neutral transport sector and can play a key role in decarbonising the EU's energy demand," says Jürgen Karl, chair of energy process engineering at Friedrich-Alexander University.

With the support of the EU-funded CarbonNeutralLNG project, Karl is working to make GreenLNG a viable option for long-haul, heavy-duty transport. "One of the first things we aim to do is reduce the carbon losses associated with producing LNG from methane," he explains.

To do this, project researchers plan to use a sorption-enhanced electrically heated steam gasifier capable of providing both the syngas needed for chemical catalytic methanation and pure CO_2 that can be converted into methane. "The goal of this process is to completely make use of the green carbon found in biomass," adds Karl.

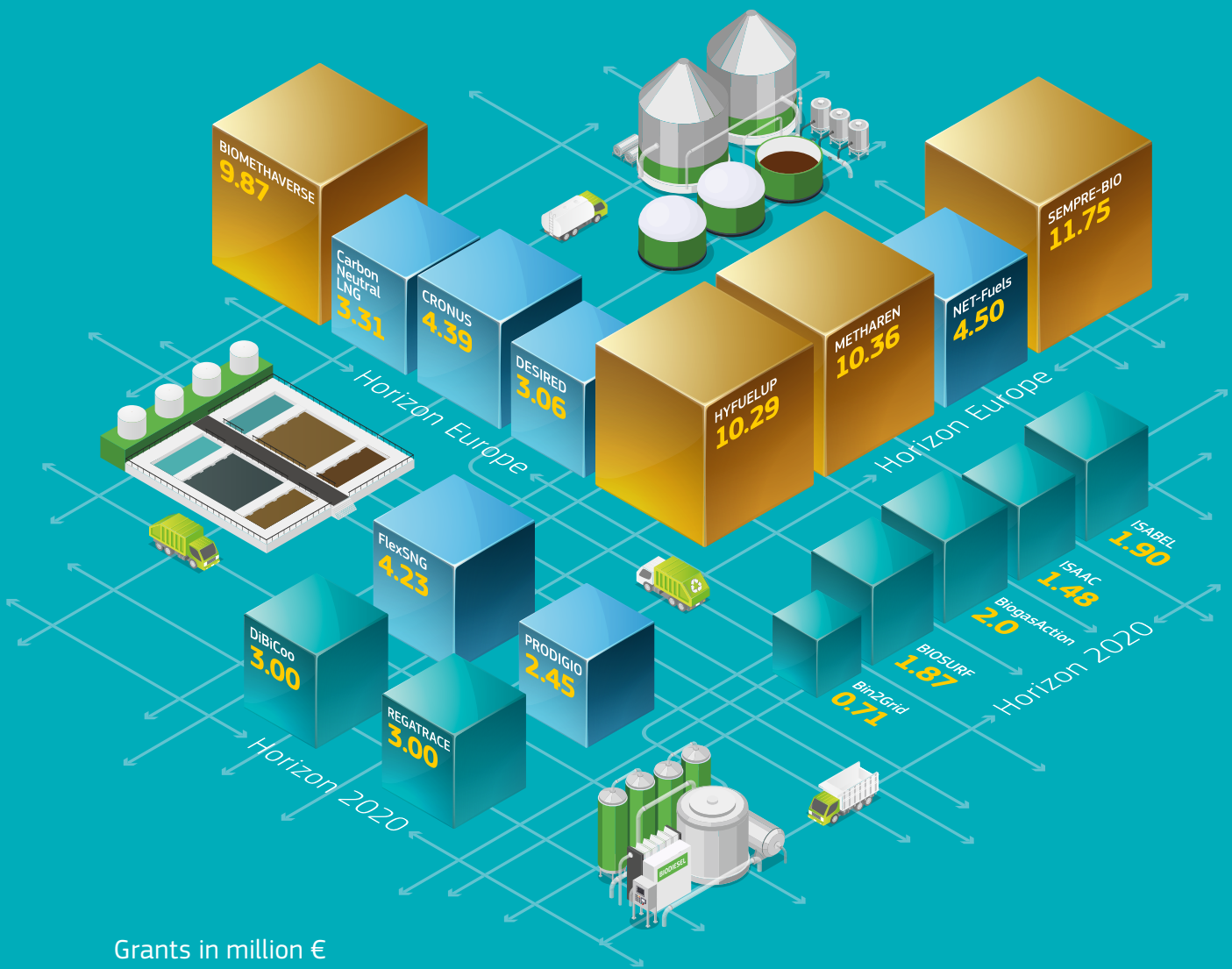
Karl says the new process will feature efficient monitoring systems and will be optimised using artificial intelligence and machine learning algorithms. It will also be backed by policy recommendations for implementing such processes across Europe.

"Developing an efficient and cost-effective alternative to the current use of fossil fuels in the transport sector is of high strategic importance," concludes Karl. "Feasible GreenLNG process chains such as those proposed by the CarbonNeutralLNG project will open the door to exploring new energy sources and help decrease our dependence on fossil fuels."

Investing in a greener future

Through the Horizon 2020 and Horizon Europe programmes, the EU has invested tens of millions of euros in targeted research to grow Europe's biomethane industry over the last decade. The 17 projects below represent more than €75 m of EU funding, distributed across more than 180 research organisations, public bodies, and SMEs. These grants were awarded through three mutually synergistic streams: Research and Innovation Actions (relating to exploratory scientific research and prototype development), Innovation Actions (relating to demonstrating, large-scale product validation and market replication), and Coordination and Support Actions (relating to accompanying and market uptake measures).

Through investments such as these, Horizon Europe works to strengthen the impact of research and innovation, boosts European competitiveness and growth, and helps deliver on ambitious targets for climate, energy and the economy in line with the European Green Deal and the REPowerEU priorities.



Grants in million €

Coordination and Support Actions
Research and Innovation Actions
Innovation Actions

Source data: cordis.europa.eu

UPSCALING INNOVATIVE PRODUCTION

"We are confident that it is possible to produce 100 % renewable natural gas at competitive costs."

Gonçalo Lourinho, HYFUELUP project coordinator

PROJECT ID CARD

Full name: Hybrid Biomethane Production from Integrated Biomass Conversion

Project dates: 1 November 2022 – 31 October 2026

Coordinated by: BIOREF Collaborative Laboratory for Biorefineries in Portugal

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101084148

Project website: hyfuelup.eu

Total budget: EUR 11 573 443

EU contribution: EUR 10 294 334

HYFUELUP

Greening transport through locally sourced plant waste

Adapting gasification technology to utilise a wide range of woody wastes could lower the cost of biomethane, helping Europe to decarbonise the energy and transport sectors and cut reliance on fossil fuel imports.

New technology to produce renewable natural gas from biowaste is being pioneered by the EU-funded HYFUELUP project. The biomethane produced will be used as liquid fuel to decarbonise long-distance road freight transport and maritime transportation.

"We recognised the need for waste diversification in biomethane production," explains project coordinator Gonçalo Lourinho from the BIOREF Collaborative Laboratory for Biorefineries in Portugal. "This is critical for increasing production levels, and decarbonising Europe's gas supply."

To achieve this, the HYFUELUP project is developing innovative technologies that are more adaptable to the use of diverse local renewable resources. These could include crop residues, lignocellulosic residues and other low-cost biogenic wastes.

The core technologies involved – advanced gasification and methanation – have already been developed, and the focus now is on scaling them up. These will then be tested and optimised, before a demonstration plant in Portugal is constructed.

"This plant will provide evidence of the new value chain for biomethane production we are proposing," says Lourinho. "This stage of the project will also be accompanied by an initial feedstock assessment, and a sustainability analysis of the produced biomethane. The aim here is to explore the potential and viable future market uptake of the HYFUELUP solution."

Lourinho believes that the HYFUELUP project is already well on track to meet its goal of deploying an economically viable biomethane demonstration plant in 2026. If successful, the technology could then be replicated in other European countries.

Indeed, Lourinho sees this as an essential element of building a competitive and sustainable energy system, with a significantly reduced dependency on imported natural gas. The project will also encourage increased sustainability in the transport sector, and create a market for locally sourced biowaste to be used as feedstock.

"We are confident that it is possible to produce 100 % renewable natural gas at competitive costs and with greater efficiency in terms of carbon utilisation," he adds. "And this will be achieved through using different low-cost biomass waste mixtures."

"Our aim is to enable the constant production of biomethane even when renewable power production drops."

Xavier Millerand, METHAREN project manager

PROJECT ID CARD

Full name: Innovative bioMETHAne system integration boosting production while managing Renewable energies intermittency

Project dates: 1 November 2022 – 31 October 2027

Coordinated by: T.EN in the Netherlands

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101084288

Total budget: EUR 13 962 947

EU contribution: EUR 10 361 053

METHAREN

Turning renewable electricity into reliable fuel

Researchers are developing an innovative, circular biomethane production system that could help unleash the full potential of renewable energy.

Hydrogen produced from renewable power sources could be used to turn biogenic CO_2 into biomethane. To be fully viable however, this process needs to be scalable, reliable and affordable. What's more, any efficient production system needs to overcome the challenge of intermittency when it comes to renewable energy sources.

This is where the EU-funded METHAREN project comes in.

Researchers plan to develop a means of managing this intermittency without the need for energy storage devices. Instead, they will directly bridge renewable power production to the gas grid, while simultaneously maximising conversion efficiency.

"This will be achieved through integrating and installing a combination of technologies," explains project manager Xavier Millerand from Technip Energies, based in France. "Our aim is to enable the constant production of biomethane even when renewable power production drops."

The METHAREN project will develop an innovative integrated system consisting of a biowaste gasification system, a solid oxide electrolyser and a methanation system. The system will reuse water and oxygen, as well as heat, to maximise efficiency and sustainability.

"Another key aspect is being able to directly and continuously convert renewably sourced electricity into gas, without the need for storage," adds Millerand. "This is a critical differentiating point."

Following initial engineering studies, the project will develop and fine-tune these technologies. "In particular, the high-temperature electrolyser envisaged by the project team needs to gain in technical maturity," says Millerand. These technologies will then be integrated into an existing biogas unit in northern Italy. The process will be validated by running the pilot unit, with a view to upscaling and eventual commercialisation.

The project team is confident that this pioneering process will deliver cost and production efficiencies for biogas plants. Already, at least 30 other sites with replication potential have been identified. "The ultimate goal is to provide Europe with the technology it needs to significantly ramp up biomethane production," notes Millerand. "We believe that this project will demonstrate a viable way of achieving this."

"Once the technologies are developed to the point of commercialisation, they can greatly help meet the REPowerEU targets for biomethane production."

Oriol Casal, SEMPRE-BIO project coordinator

PROJECT ID CARD

Full name: SEcuring doMestic PRoduction of cost-Effective BIOmethane

Project dates: 1 November 2022 – 30 April 2026

Coordinated by: Cetaqua – Water Technology Centre in Spain

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101084297

Project website: sempre-bio.com

Total budget: EUR 11 753 080

EU contribution: EUR 9 926 448

SEMPRE-BIO

Boosting Europe's biomethane production

New biomethane technologies will help Europe wean itself off Russia's fossil fuels. An EU-funded project is helping transform these ideas into reality through European Biomethane Innovation Ecosystems.

The EU-funded SEMPRE-BIO project aims to diversify the portfolio of technologies for biomethane production, while also lowering their costs. A range of innovative new biomethane technologies could give Europe new, clean sources of energy.

"There are several technological partners who will scale up their technologies and develop them to the gates of full-scale implementation," explains Oriol Casal, senior R&D project manager at Cetaqua – Water Technology Centre in Spain, and SEMPRE-BIO coordinator.

Some of the technologies under development include biological methanation of biogas and CO_2, syngas methanation, small-scale and decentralised cryogenic upgrading and PEM electrolysis. These will be developed in three case studies in Belgium, France and Spain.

The aim is not just to build and operate demonstration plants for these technologies. The SEMPRE-BIO consortium is also establishing European Biomethane Innovation Ecosystems, or EBIEs, which will foster growing communities along the entire biomethane chain, including key actors such as gas utility companies, municipalities and research centres.

These will generate new, shared technical expertise, and speed the development of large-scale and cheaper biomethane technologies. Businesses will also be able to better source their potential customers, which will further work to speed uptake.

The various biomethane projects are collaborating to prepare policy recommendations, which will maximise production and uptake of biomethane under the REPowerEU plan.

The EBIEs are currently being developed, and case studies will be carried out through 2023 and early 2024, with full operation expected by mid 2024.

"Once the technologies are developed to the point of commercialisation, they can greatly help meet the REPowerEU targets for biomethane production," says Casal. The project is developing this potential on three fronts: synthetic biomethane, non-digestible feedstock and small-scale decentralised biogas plants.

"We want to express our most sincere gratitude for the funding and this chance at paving the European biomethane outlook of the future," Casal adds.

"The costs of producing biomethane with renewable energy or hydrogen should be comparable to the costs of other renewable technologies."

Stefano Proietti, BIOMETHAVERSE project coordinator

PROJECT ID CARD

Full name: Demonstrating and Connecting Production Innovations in the BIOMETHAne uniVERSE

Project dates: 1 October 2022 – 31 March 2027

Coordinated by: Institute of Studies for the Integration of Systems (I.S.I.S), Cooperative Society in Italy

Funded under: HORIZON.2.5 – Climate, Energy and Mobility

CORDIS factsheet: cordis.europa.eu/project/id/101084200

Project website: biomethaverse.eu

Total budget: EUR 11 489 961

EU contribution: EUR 9 871 768

BIOMETHAVERSE

New technologies for cost-efficient biomethane production

The coordinator of the BIOMETHAVERSE project is confident innovative developments can reduce the cost of producing biomethane by almost half.

Biomethane, a renewable natural gas made from decaying organic matter, such as food, agricultural and animal waste, could play a key role in achieving Europe's ambitious climate and energy objectives. However, in order for this to happen, new technologies are needed to efficiently produce it.

The EU-funded BIOMETHAVERSE project hopes to achieve this. "The project aims to diversify the technology basis for biomethane production in Europe, increase its cost-effectiveness and contribute to the investment in and uptake of the biomethane market," says Stefano Proietti, senior researcher at ISINNOVA, the project's lead partner.

The project looks to address some of the main hurdles to creating a biomethane ecosystem, including the costs of producing it. "The costs of producing biomethane with renewable energy or hydrogen should be comparable to the costs of long-term energy storage or other renewable technologies," notes Proietti.

The project also aims to advocate the creation of policies and incentive schemes that support biomethane production. For example, some of the planned technologies will convert excess electricity into biomethane, while others will leverage existing gas grids for its storage and transport.

According to Proietti, the project will involve a combination of innovative technologies, in-depth research into new feedstocks and careful market analysis. "Demonstrator replicability, market penetration and policy are all at the heart of the BIOMETHAVERSE project, as are cross-site learning, upscaling, sustainability and the circular economy," he adds.

Although very much a work in progress, Proietti is confident that the project will succeed in reducing the costs of producing biomethane by as much as 44 % and will enable an estimated 66 % increase in biomethane production by 2030. Not only will this significantly reduce greenhouse gas emissions, it will also create an estimated 294 000 jobs.

"The successful implementation and adoption of our biomethane technologies will decrease Europe's energy costs, reduce our dependency on fossil fuels and help us achieve our Green Deal objectives," concludes Proietti.

Glossary

Anaerobic digestion is a sequence of processes by which microorganisms break down biodegradable material such as biomass in the absence of oxygen to produce biogas.

Artificial photosynthesis is a chemical process that uses sunlight to drive the conversion of carbon dioxide and water into carbohydrates (such as food) or hydrocarbons (such as fuels) and oxygen.

Biochar is a charcoal produced during the biomass gasification process. It can be added to soil as a means of removing carbon dioxide from the atmosphere.

Biogas is a mixture of methane, carbon dioxide and trace gases produced by the microbial decomposition (fermentation) of organic wastes.

Biomass describes low-grade vegetation, residues and wastes, and animal waste typically used for fuel.

Biomethane is chemically identical to natural gas, but produced sustainably from renewable sources such as biomass.

Bioreactors are the large apparatus in which biomass is fermented to produce biogas.

Carbon-negative biofuel production is the use of techniques that capture biomass-based carbon dioxide at the point of its release and store it underground, e.g. as biochar, thus creating negative emissions.

Cryogenic means at very low temperatures.

Direct solar fuels are renewable synthetic fuels made by directly converting solar energy into chemical energy.

An **energy carrier** is a compound capable of storing energy from an external energy source, so it can be transferred and released later when needed.

Fermentation is a metabolic process in which bacteria, yeasts or other microorganisms chemically break down an organic substance, typically generating carbon dioxide and heat.

Gasification is an industrial process that uses high temperatures and controlled amounts of air and steam to convert carbon-rich substances such as coal and biomass into syngas.

Intermittent renewable electricity describes technologies such as solar and wind power that cannot provide a constant supply.

Methanation is the conversion of carbon monoxide and carbon dioxide into methane by the addition of hydrogen.

Microalgae are microscopic, single-celled algae that may exist independently or in colonies.

Photocatalysis is the acceleration of a chemical reaction by light.

Photoelectrocatalysis uses direct sunlight in the presence of a catalyst to split water into hydrogen and oxygen.

Polymer electrolyte membrane (PEM) electrolysis is the separation of water into hydrogen and oxygen using electricity, performed across a solid electrolyte.

A **solid oxide electrolyser** is a fuel cell that electrolyses water (and/or carbon dioxide) using a ceramic electrolyte to produce hydrogen gas (and/or carbon monoxide) and oxygen.

Syngas is synthetic gas consisting mainly of carbon monoxide, hydrogen and carbon dioxide.

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RESULTS PACK ON RENEWABLE FUELS

Transportation fuels are among the largest sources of greenhouse gas (GHG) emissions in the EU. This CORDIS Results Pack showcases 15 EU-funded projects that are introducing renewable fuel technologies to support the clean energy transition in the transport sector and help the EU's energy independence in line with the European Green Deal and REPowerEU.

Check out the Pack here:
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