

IN COLLABORATION WITH



BIOMETHANE WEBINAR

25 June 2025 Wednesday



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Task 37



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Ashish Kumar
Vice President IFGE, Vice
Chairman IFGE CBG Producer
Forum, & MD Verbio, India

Evolving Biomethane (CBG) Policy Framework in India:
Status-quo and Key Action Demand Areas

Supportive Biomethane Policies in
Countries

Renewable Gas Certificates for Biomethane

KEY TOPICS

Innovations in Biomethane: Insights from
Research Projects

Biomethane Certification Program:
Regulations and Standards



Ashish Kumar

Vice President IFGE, Vice Chairman IFGE CBG
Producer Forum, & MD Verbio, India

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BIO METHANE WEBINAR

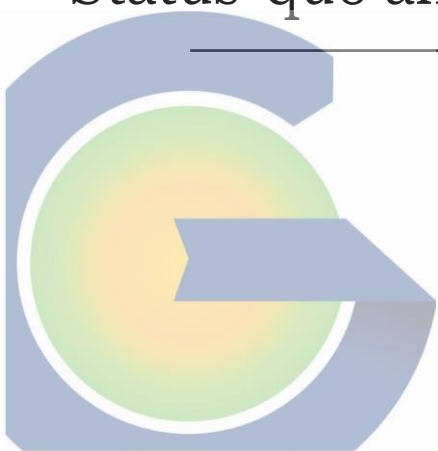
25 June 2025 Wednesday

SESSION TOPIC

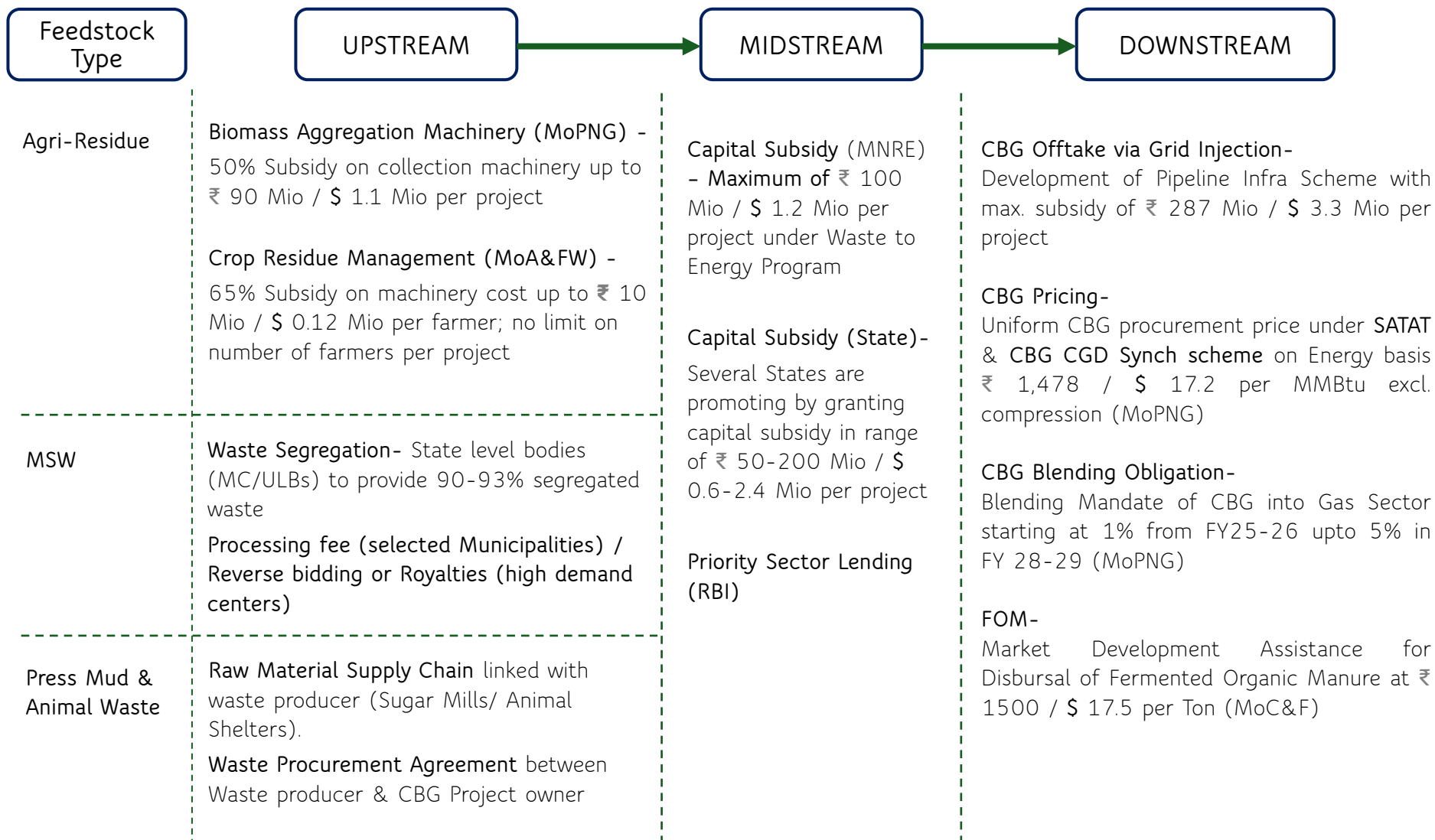
**Evolving Biomethane (CBG) Policy
Framework in India: Status-quo and
Key Action Demand Areas**

Evolving Biomethane (CBG) Policy Framework in India: Status-quo and Key Action Demand Areas

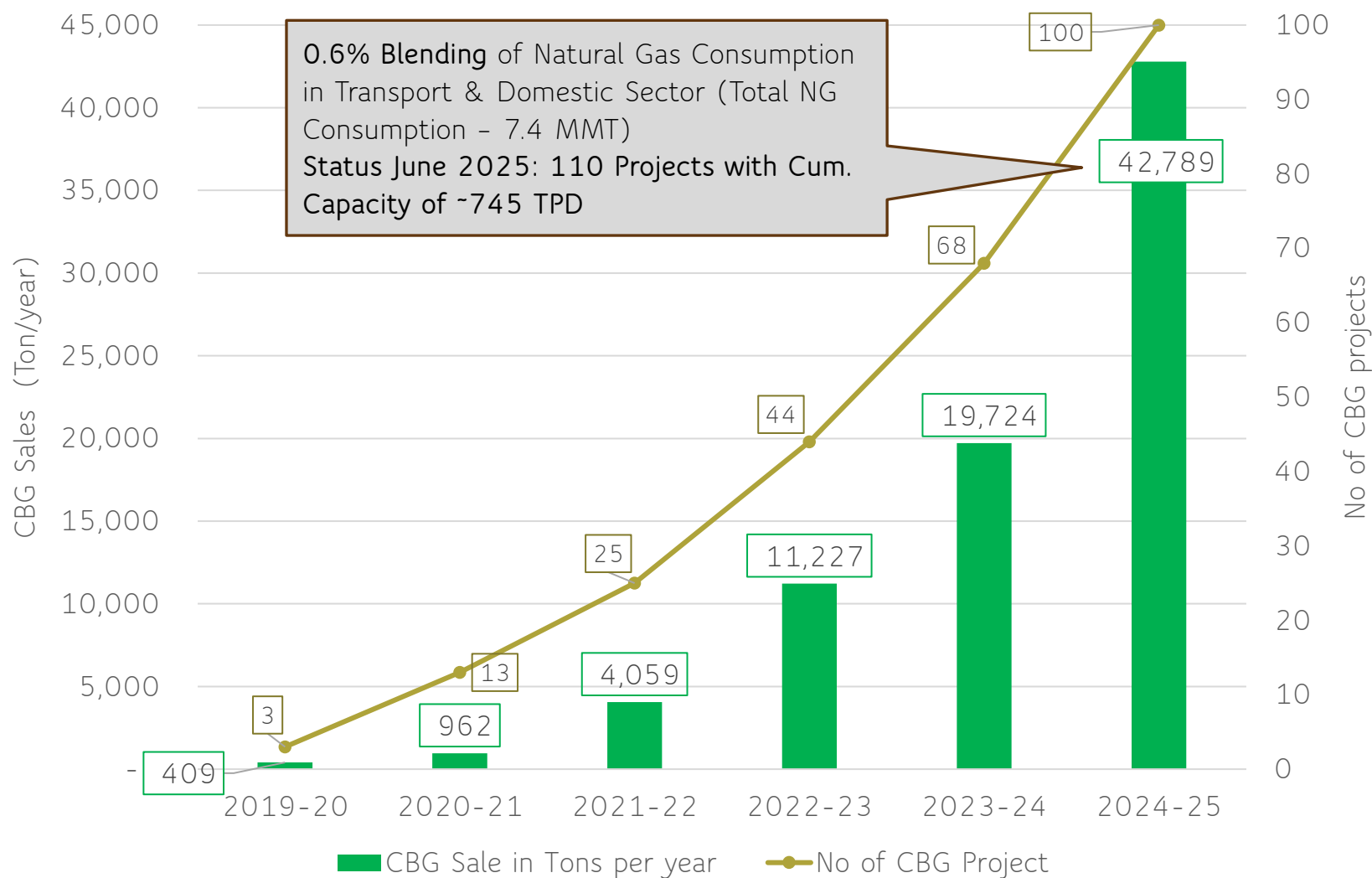
25 JUNE 2025



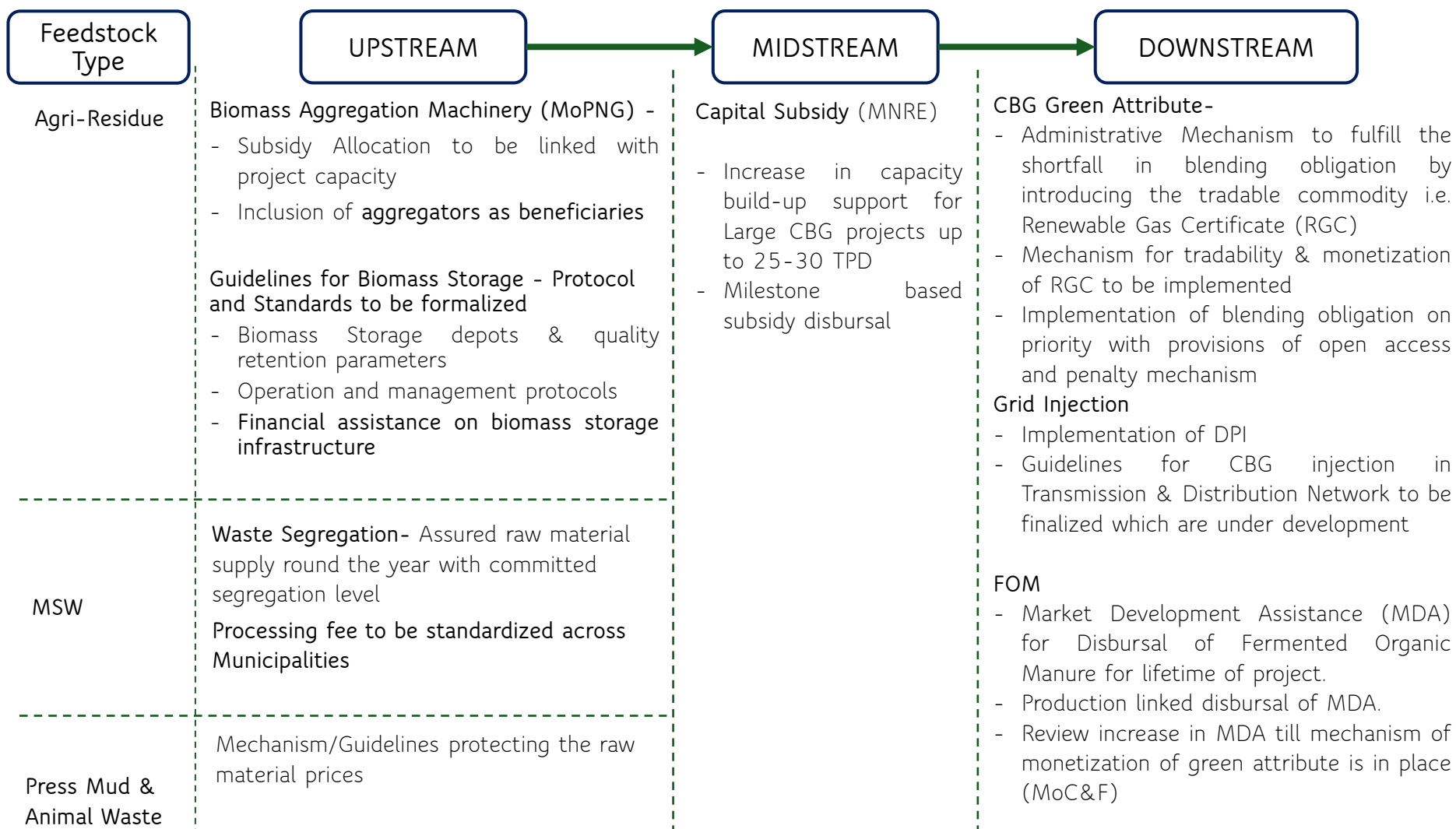
Overview of CBG Policies in India – Status-quo



CBG Projects & Volume Development 2019-24

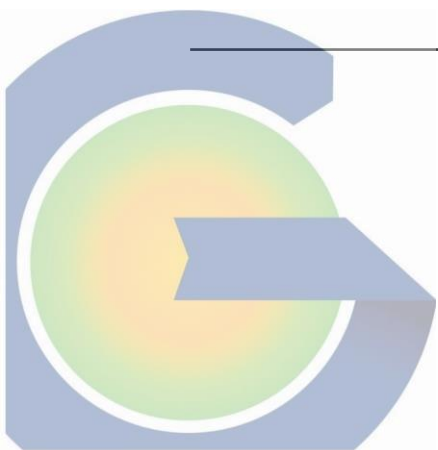


Overview of Key Action Demand Areas



Thanks for your time!!

MEMBERS
CBG PRODUCERS FORUM





Dr. Bernhard Drosig

Leader, IEA Bioenergy Task 37

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BIO METHANE WEBINAR

25 June 2025 Wednesday

SESSION TOPIC

Lessons for policymakers
from IEA Bioenergy Task 37
Collaboration Programme



IEA Bioenergy
Technology Collaboration Programme



IEA Bioenergy Technology Collaboration Programme Task 37 - Energy from Biogas

Bernhard Drosig
Task Leader

Lessons for policymakers from last work programme 2022-2024

The IEA Bioenergy Technology Collaboration Programme (TCP) is organised under the auspices of the International Energy Agency (IEA) but is functionally and legally autonomous. Views, findings and publications of the IEA Bioenergy TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

IEA Bioenergy TCP

Mission:

To increase knowledge and understanding of bioenergy systems in order to facilitate the deployment of:

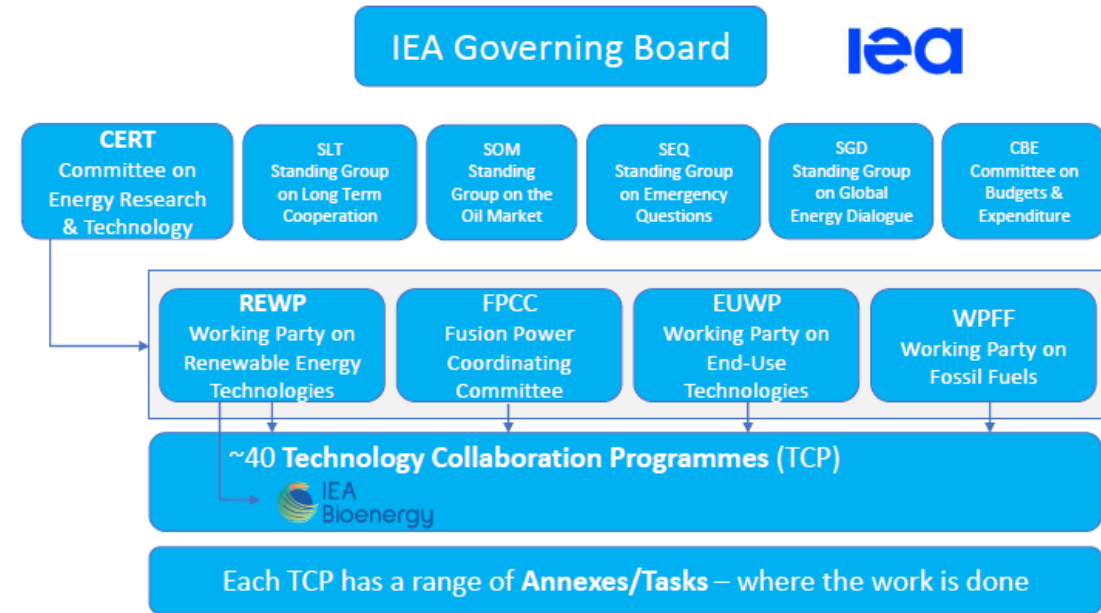
- **environmentally sound**
- **socially acceptable and**
- **cost-competitive bioenergy systems**

Key Role:

Independent collaborative body focused on delivering clear and verified information on bioenergy

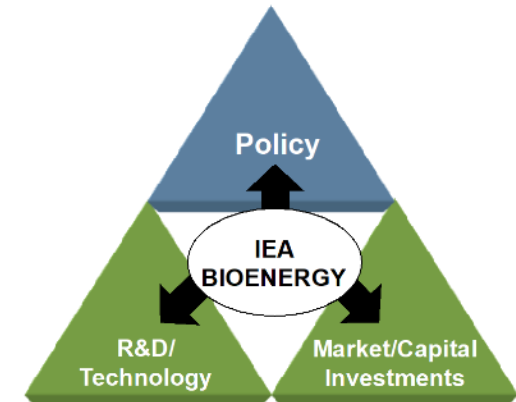
IEA Bioenergy TCP

Technology Collaboration Programme (TCP)
functioning within a framework created by the
International Energy Agency (IEA)

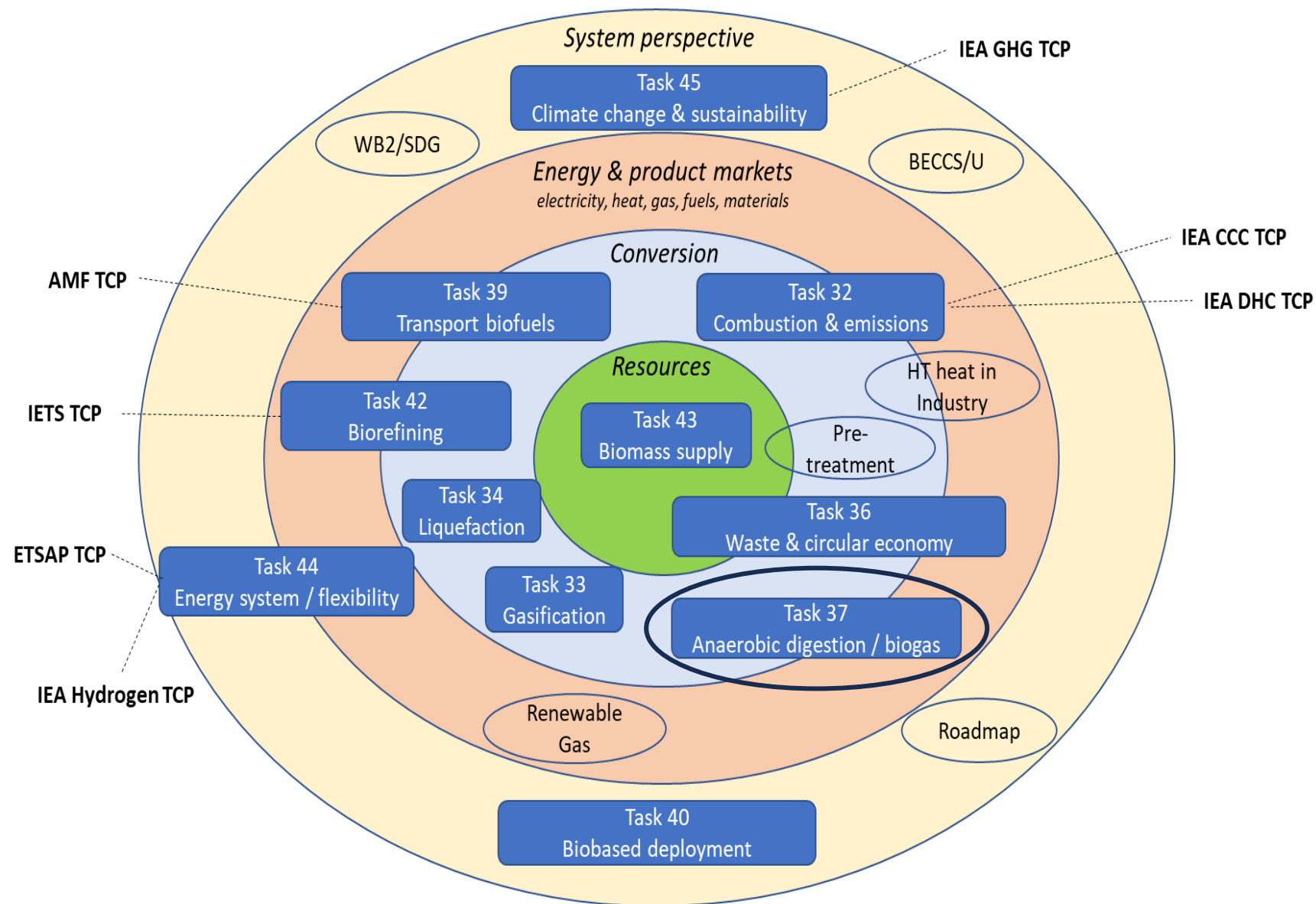


Work programme carried out through **Tasks** and **Special Projects**, covering the full value chain from feedstock to final energy product

26 members: 15 *European countries* + *EC, US, CND, BR, China, India, Japan, Korea, AUS, NZ, SAfr*



Activities/Tasks in IEA Bioenergy TCP

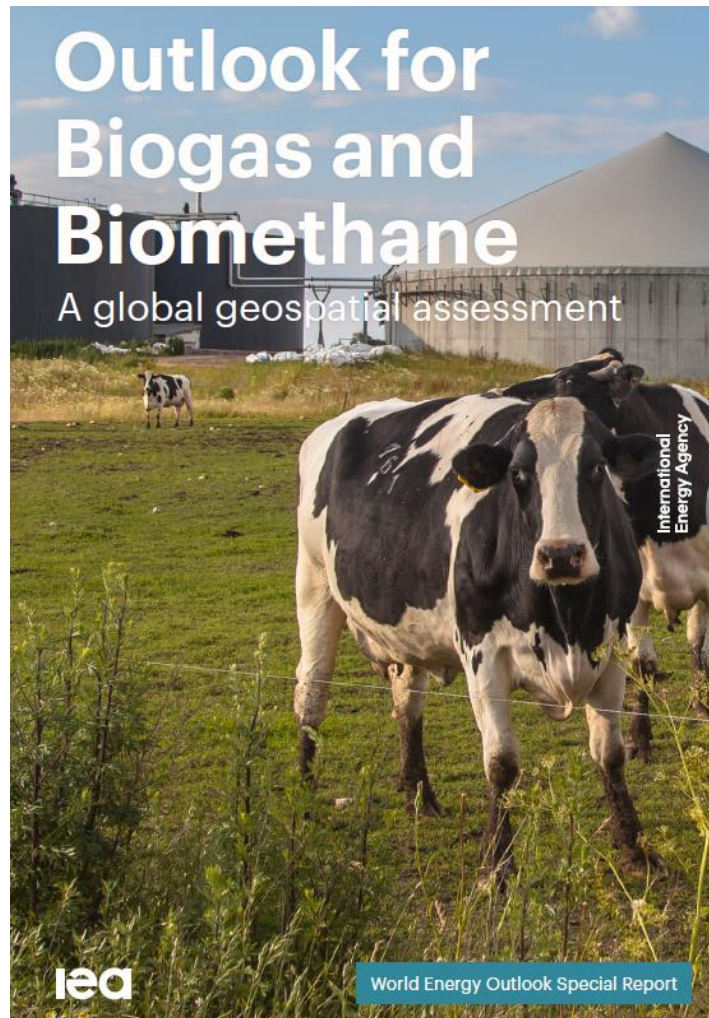


Task 37 Energy from Biogas -

17 Participating Countries in Triennium 2025-2027

- Austria
- Australia
- Brasil
- Canada
- Denmark
- European Commission
- Finland
- France
- Germany
- India
- Ireland
- Italy
- Netherlands
- Norway
- Sweden
- Switzerland
- UK

Messages in IEA headquarter biogas outlook report



“A relatively small share of the untapped potential for biogases is cost-competitive, but more can be unlocked if co-benefits are valued.”

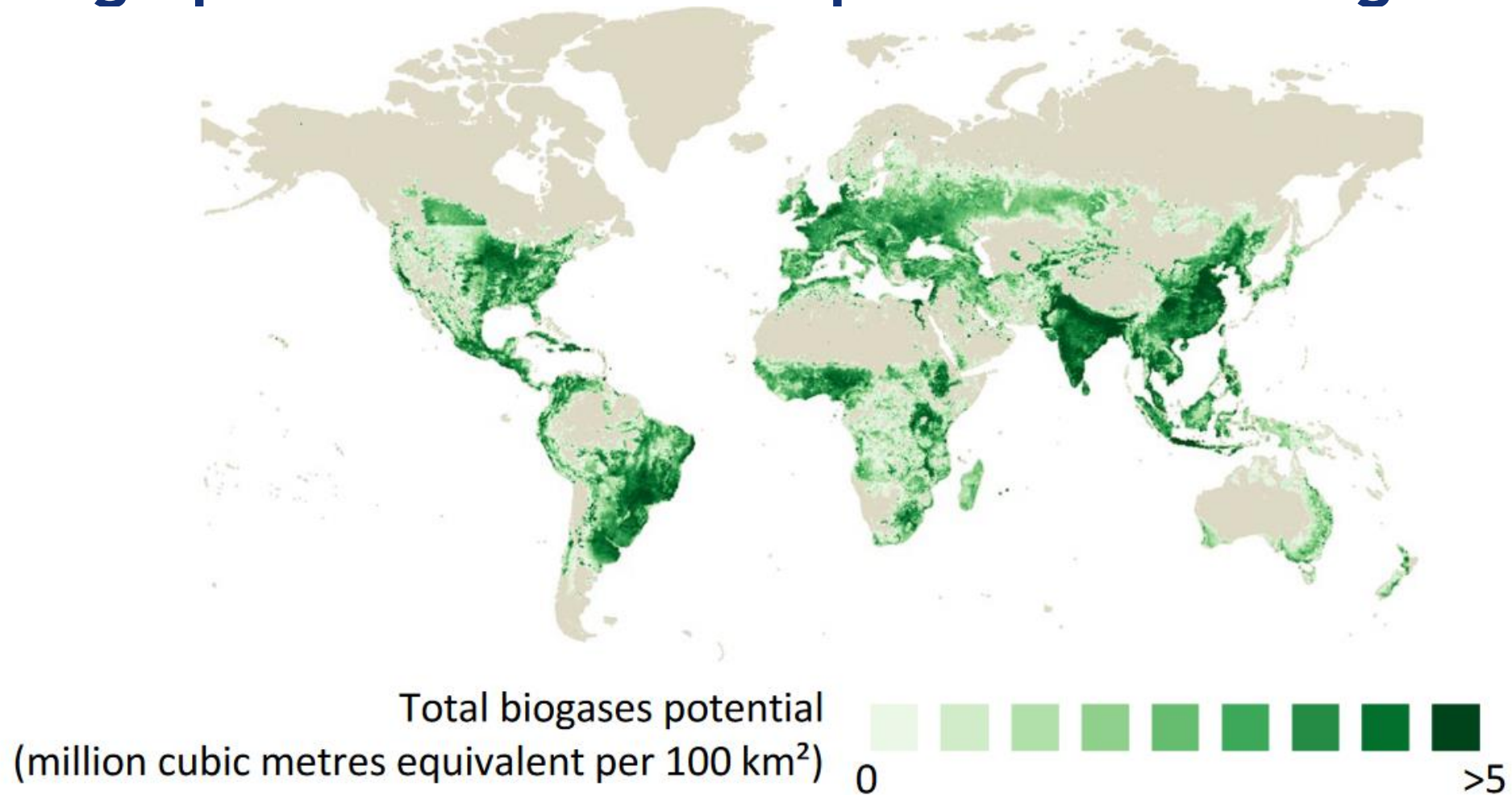
“The investment case for biogases is strongest when local economic development is a priority.”

“Logistical hurdles and complex permitting procedures have held back increases in biogases production in many countries.”

“Consistent and robust policy support is essential”

IEA – International Energy Agency (2025) Outlook for Biogas and Biomethane - A global geospatial assessment, <https://www.iea.org/reports/outlook-for-biogas-and-biomethane>

Geographic distribution of potential for biogases



IEA – International Energy Agency (2025) Outlook for Biogas and Biomethane - A global geospatial assessment
<https://www.iea.org/reports/outlook-for-biogas-and-biomethane>

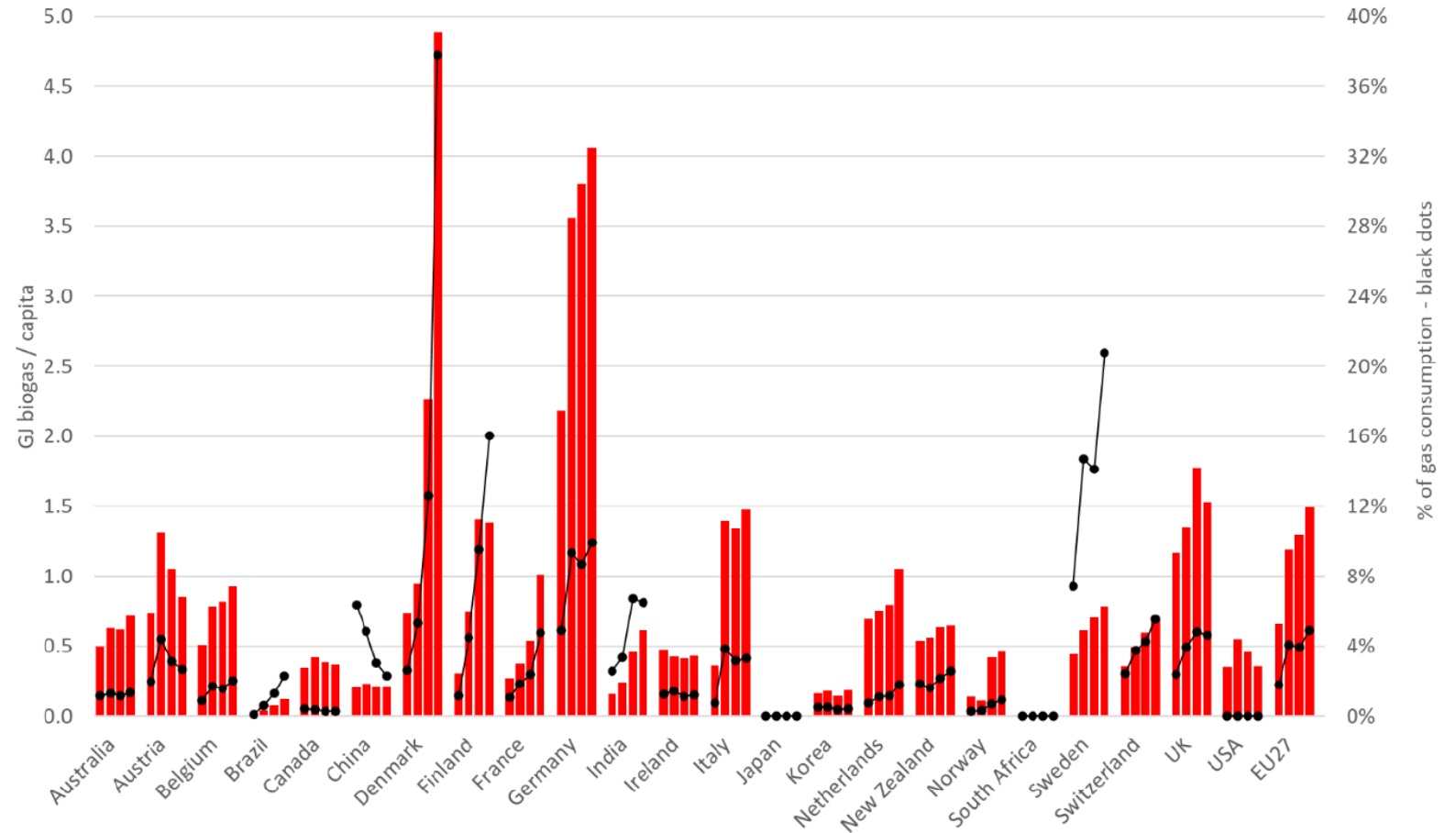
Biogas use in the IEA Bioenergy member countries



IEA Bioenergy: Countries' Report - update 2024

Implementation of bioenergy in the IEA Bioenergy member countries

IEA Bioenergy ExCo
December 2024



IEA Bioenergy: Countries' Report – update 2024 - Implementation of bioenergy in the IEA Bioenergy member countries (2024) https://www.ieabioenergy.com/wp-content/uploads/2025/01/CountriesReport2024_final.pdf

The role of biogas and biomethane in pathway to net zero



The role of biogas and biomethane in pathway to net zero

Biogas is produced as the main product of anaerobic digestion (AD) of wet biomass. Biogas can be used locally for heat purposes or for power and heat production (CHP); as an alternative, biogas can be upgraded to bio-methane to replace natural gas. As such, it is one of the means to reduce the consumption of fossil fuels and contribute to the transition towards a net zero energy system.

This position paper - developed by members of IEA Bioenergy Task 37 ("Energy from Biogas") - provides a holistic perspective on the roles of biogas and biomethane. The main conclusion is that biogas and biomethane have a range of options which can be employed in pathways to net zero. They provide sustainable flexible systems that play essential roles in circular economy, energy, and environmental systems.

PERSPECTIVES OF BIOGAS AND BIOMETHANE

Pathway to Net Zero

The pathway to net zero requires far more than provision of renewable electricity. We must employ renewable hydrocarbons in the form of liquid and gaseous fuels with minimum carbon intensity. Indeed, we must go beyond energy and employ renewable green hydrogen in the production of chemicals such as ammonia (NH_3) and methanol (CH_3OH), and for steel. When we produce biomethane (CH_4) or green hydrogen (H_2), we are in both cases producing renewable hydrogen molecules within a renewable gas. We need these renewable gases and renewable hydrocarbons for dispatchable electricity, for long term energy storage and for sectors where electricity has limited applications. These applications (termed the hard to abate sectors) include: heavy-duty, long-distance transport (trucks, ships and planes); high temperature industrial heat (food and beverage sector, steel production, glass production); agriculture (renewable fertiliser such as green ammonia and biofertiliser); and chemical production (such as methanol).

- The pathway to net zero requires far more than provision of renewable electricity
- Biomethane as replacement for natural gas - can be fed into existing gas infrastructure
- Biogas and biomethane systems are mature and multi-functional
- Biogas systems can contribute to energy security since the whole production chain can be set up and operated locally
- Biogas production can utilize a wide variety of organic feedstocks

The role of biogas and biomethane in pathway to net zero II

- Often the driver for biogas solution is reduction in fugitive emissions from waste
- Biogas systems provide the by-products digestate and carbon dioxide
- A detailed region-specific analysis of availability, costs and impact of specific feedstock utilization is recommended in order to ensure an effective and sustainable biogas sector
- Biomethane is cheaper than green hydrogen and is expected to remain so for some time in future
- Biogas and biomethane are sustainable flexible systems that play essential roles in circular economy, energy and environmental systems

https://task37.ieabioenergy.com/wp-content/uploads/sites/32/2023/05/2022_12_12-IEA_Bioenergy_position-paper_Final2.pdf

Sustainability effects associated with biogas solutions



Identification and assessment of sustainability effects associated with biogas solutions

-Literature review and perspectives from five countries

IEA Bioenergy: Task 37
March 2025



Technology Collaboration Programme
by IEA



“It is of utmost importance that decision-makers, including planners, developers and policymakers, and the public develop a comprehensive understanding of the broad system effects of biogas solutions and their highly cross-sectoral nature involving waste management, energy, industry and agriculture.

Unlike mono-functional systems which are easier to understand and manage, biogas solutions contribute to multiple sectors and sustainability goals, and require a great deal of cross-sectoral collaboration to create industrial-urban-rural symbiosis.”

Ammenberg J., Baier, U., Lyng, K-A., Nägele, H-J., Thual, J., Wellisch, M. (2025). Identification and assessment of sustainability effects related to biogas solutions - Literature review and perspectives from five countries. Ammenberg, J; Wellisch, M, Liebetrau, J. (Ed.) IEA Bioenergy Task 37, March 2025. ISBN 979-12-80907-62-2
<https://task37.ieabioenergy.com/technical-reports/identification-and-assessment-of-sustainability-effects-associated-with-biogas-solutions/>

Key externalities

Environment

- GHG impact (+/-)
- Change in soil health
- Impact on N pollution of water

Economy, society

- Improved energy security
- Organic waste processing costs
- Provision of biogenic CO₂
- Job Creation
- Contribution to resilience of agriculture

Agriculture

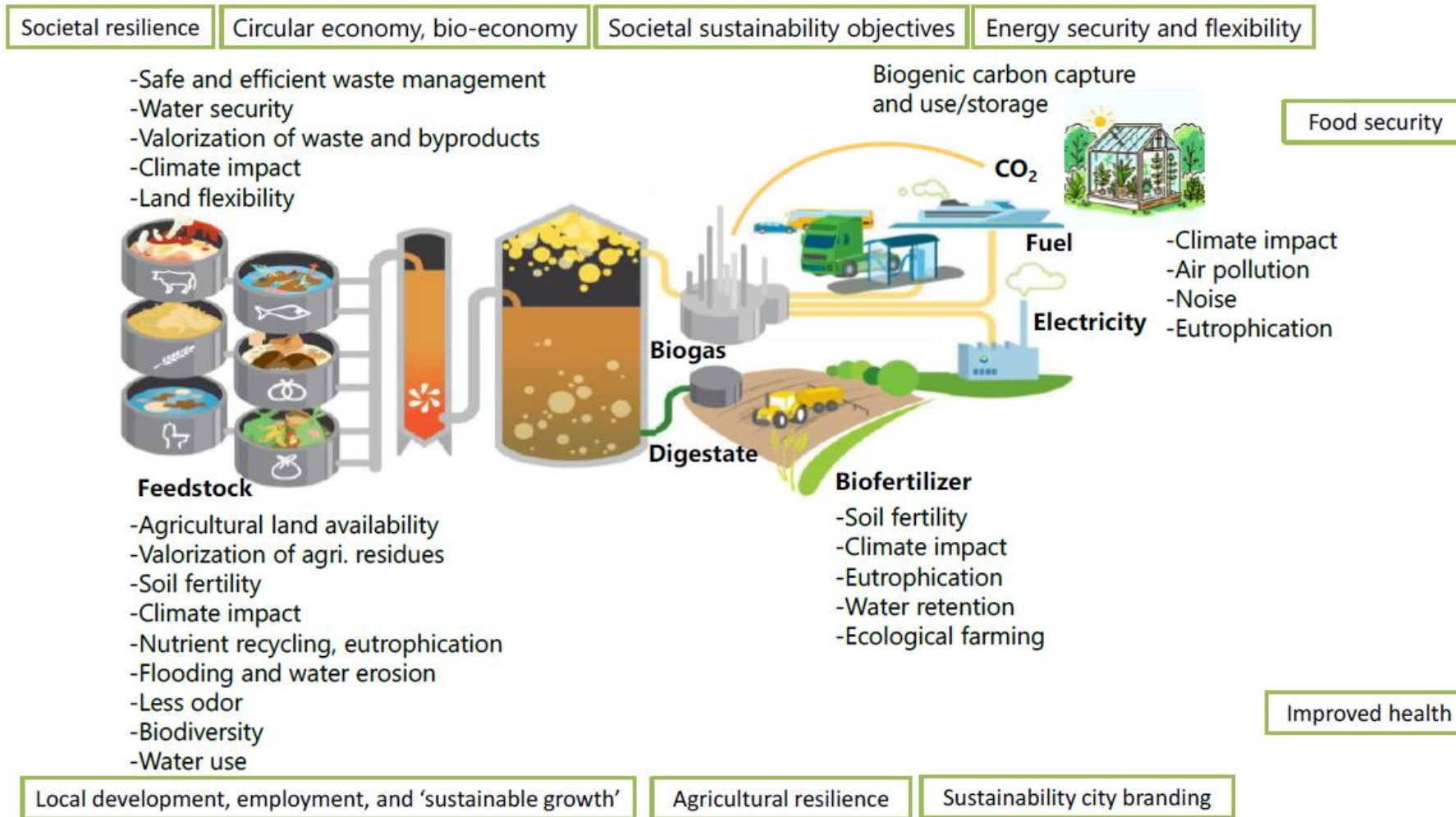
- Reduction in use of synthetic fertilizer
- Impact of intermediate crops

Energy

- Use of existing gas infrastructure
- Production of renewable energy - stable and storable
- Contribution to energy transition and regional circular economies
- Elimination of fossil fuel energy

The report highlights 53 sustainability effects of biogas solutions.

Valorising sustainability effects / co-benefits of biogas



<https://task37.ieabioenergy.com/technical-reports/identification-and-assessment-of-sustainability-effects-associated-with-biogas-solutions/>

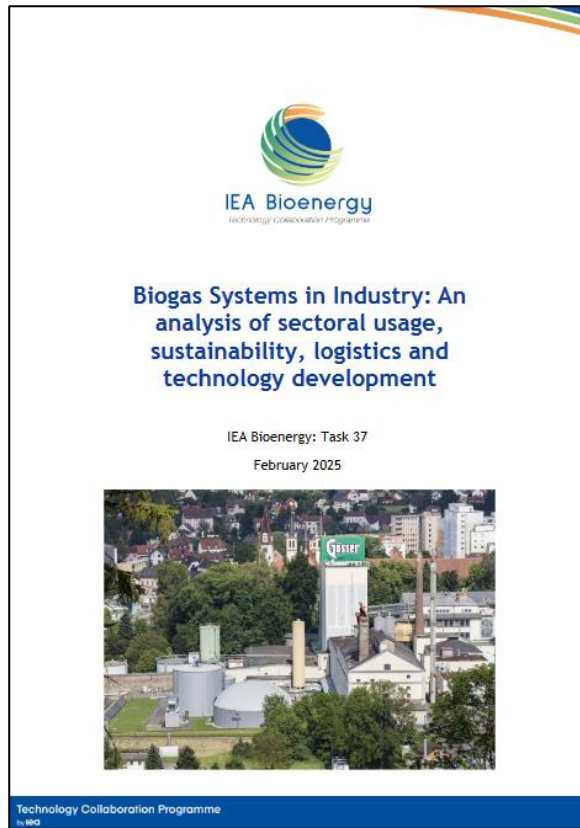
Promote More Holistic Understanding and Perspectives

- Use science-based, multi-criteria sustainability assessments to inform decisions on technical alternatives.
- Recognize the cross-sectoral benefits of biogas solutions in waste, wastewater, agriculture, energy, transport, and various industrial sectors.
- Encourage greater cross-sector collaboration, shared decision-making and support solutions that contribute to a circular economy. Include different sized solutions and solutions that are co-created with local communities.
- Shift the focus toward integrated strategies that combine multiple renewable technologies to deliver desired functions while addressing urgent sustainability challenges.

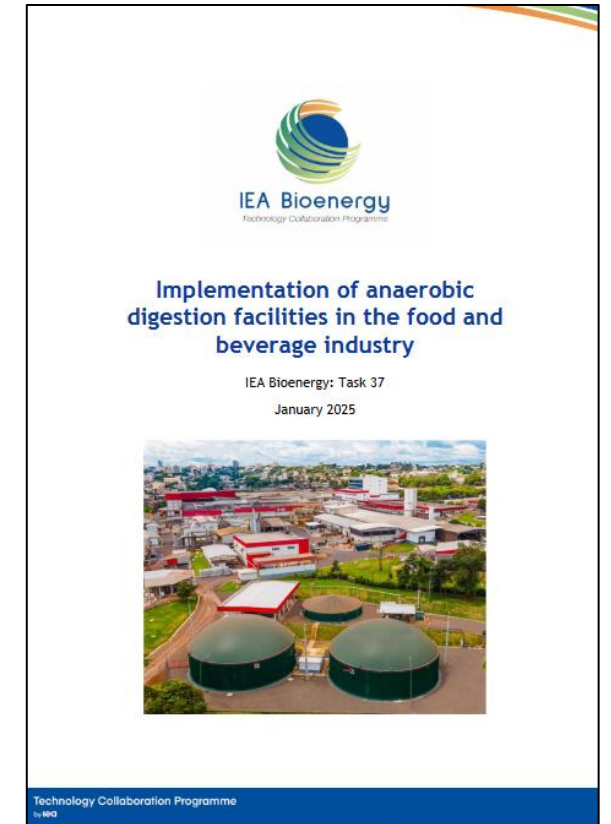
Adopt Coherent and Effective Policy Frameworks

- Harmonize lifecycle and value chain perspectives across relevant policies.
- Enable biogas value chain actors to capture the full societal value of their contributions.
- Remove regulatory and administrative barriers, such as restrictions on sustainable crop-based biogas and lengthy approval processes for mature technologies.
- Set clear targets for the production and use of biogas, biomethane, digestate/biofertilizers, and biogenic CO₂, and ensure the development of supporting infrastructure and access to land to make these targets achievable.
- Balance top-down strategies with local adaptability to facilitate effective and implementation.

Biogas and the producing industries



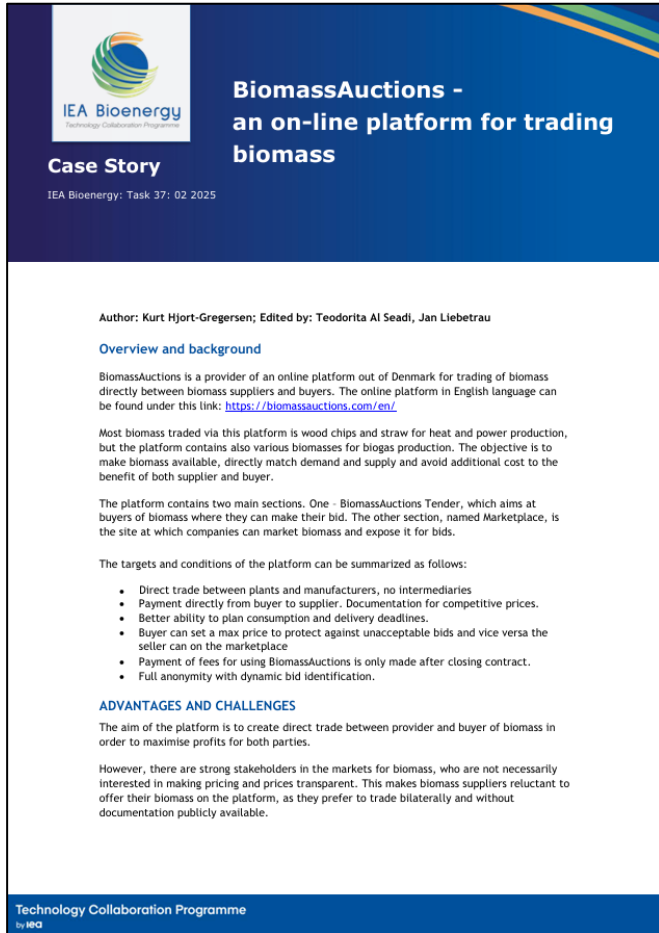
- Producing industries can address their Scope 1 and Scope 2 emissions by biogas / biomethane.
- The food and beverage industries have a vast range of byproducts and wastes which can be used as feedstocks onsite.



Wall, D.M., O'Shea, R. (2025) Biogas Systems in Industry: An analysis of sectoral usage, sustainability, logistics and technology development, Murphy, J.D. (Ed.) IEA Bioenergy Task 37, 2025:1.

Pesta G., Hanseemann E., Bochmann G., Drosch B., Gabauer W. (2025) Implementation of Anaerobic Digestion facilities in the Food and Beverage Industry. Liebetrau, J (Ed.) IEA Bioenergy Task 37, 2025, ISBN 979-12-80907-60-8

Case story - a Danish online platform for trading biomass

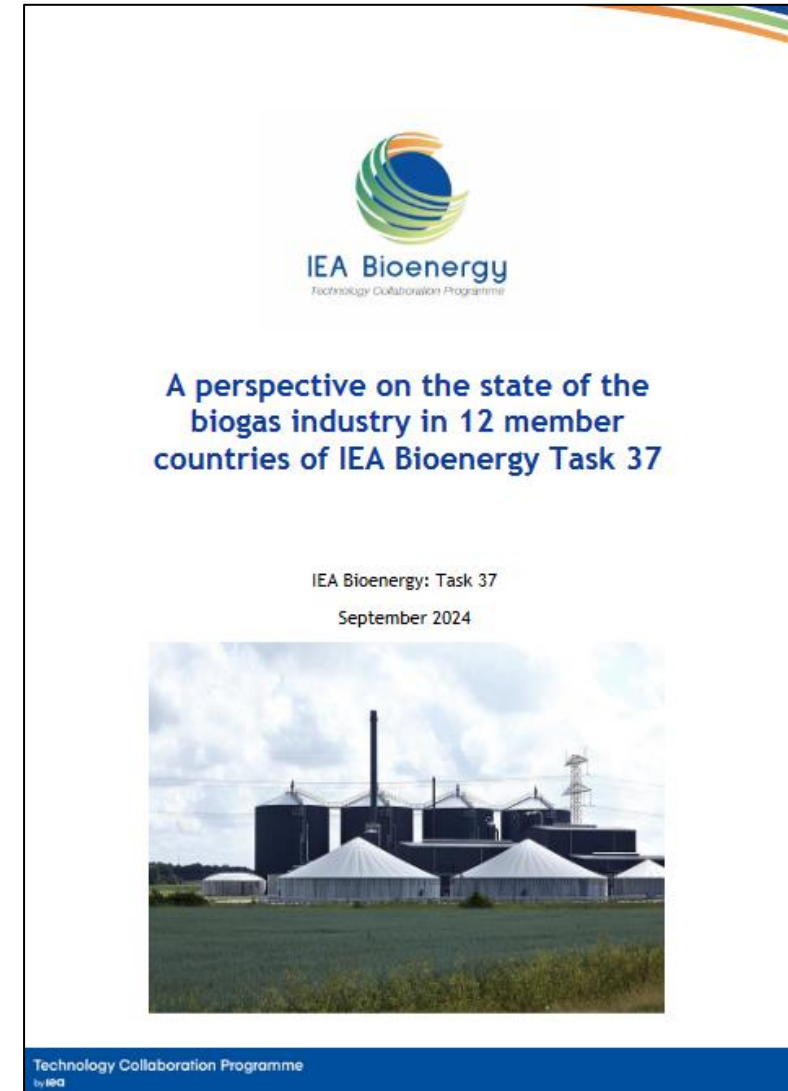
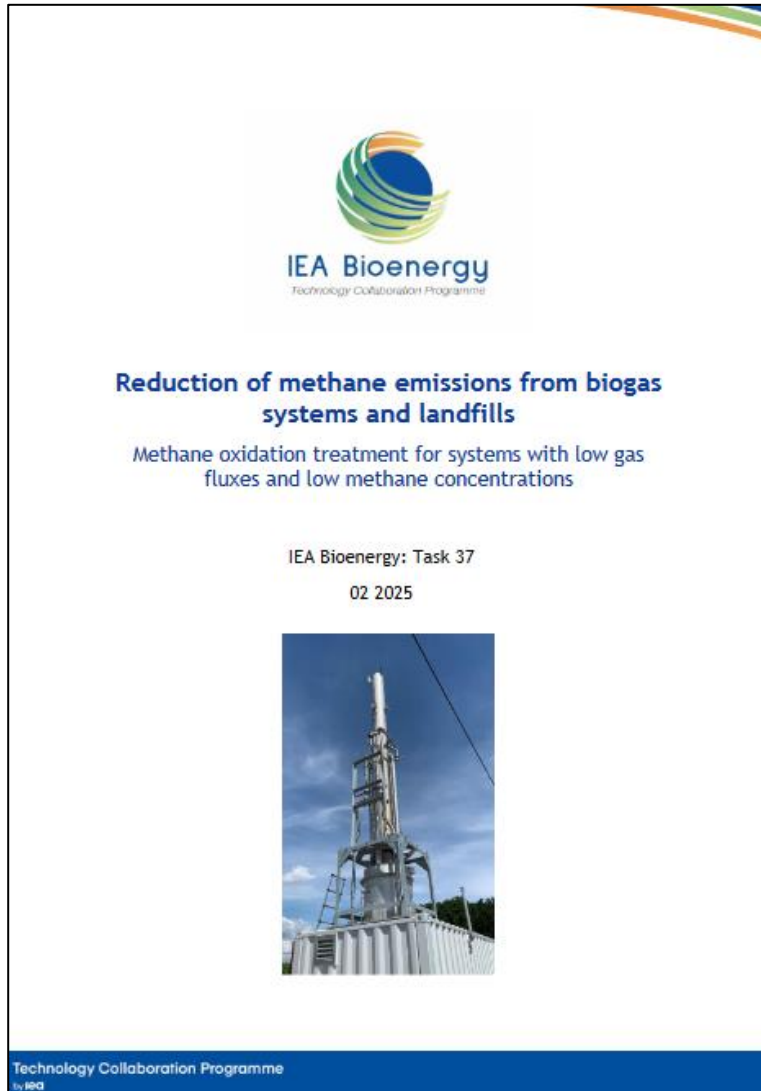


The targets and conditions of the platform:

- Direct trade between plants and manufacturers, no intermediaries
- Payment directly from buyer to supplier. documentation for competitive prices
- Better ability to plan consumption and delivery deadlines.
- Buyer can set a max price to protect against unacceptable bids and vice versa the seller can on the marketplace
- Payment of fees for using the platform is only made after closing contract
- Full anonymity with dynamic bid identification.

https://task37.ieabioenergy.com/wp-content/uploads/sites/32/2025/03/IEA-Bioenergy-case-story-BiomassAuctions_2025.pdf

Task 37 Energy from Biogas - Other reports



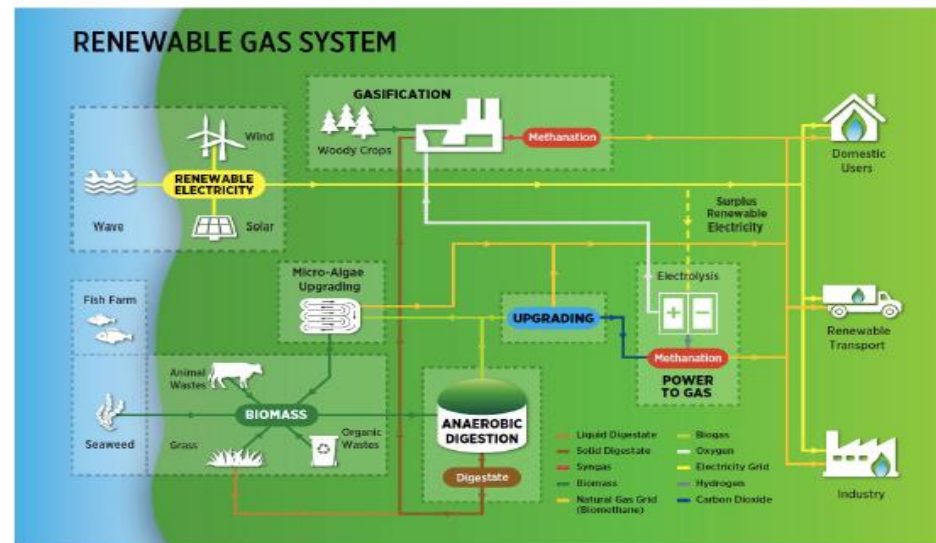
Topics of ongoing work programme 2025-2027

- Assessment of sustainability effects of biogas in a circular economy system
 - Field application of digestates in agricultural production: standards, regulations, policies, best practices and challenges
 - Monitoring microbial cultures in biogas plants
 - Economics and GHG marginal abatement costs
 - Small scale biogas systems - Home Biogas Systems
 - Biogas systems and synergies with E-fuel production
 - Case stories (2-4 pagers)
 - Country report summary
 - Intertask: BECCU/S, Synergies of bioenergy
 - Newsletter
- The diagram illustrates a 'RENEWABLE GAS SYSTEM' with the following components and flows:

 - Renewable Electricity Sources:** Wind, Wave, and Solar panels provide power to the system.
 - Biomass Sources:** Fish Farm, Seaweed, Grass, Animal Wastes, and Organic Wastes feed into the 'BIOMASS' stage.
 - Gasification:** Woody Crops feed into the 'GASIFICATION' stage, which produces 'Methanation' gas.
 - Anaerobic Digestion:** Biomass feeds into 'ANAEROBIC DIGESTION', which produces 'Digestate' and 'Biogas'.
 - Micro-Algae Upgrading:** Biogas from anaerobic digestion feeds into 'Micro-Algae Upgrading', which produces 'UPGRADING' gas.
 - Electrolysis:** Renewable electricity feeds into 'Electrolysis', which produces 'Hydrogen' and 'Oxygen'.
 - Power to Gas:** Hydrogen and CO₂ (from the upgrading stage) feed into 'POWER TO GAS', which produces 'Methanation' gas.
 - Final Outputs:** The system produces 'Surplus Renewable Electricity' and 'Methanation' gas, which are then distributed to 'Domestic Users', 'Renewable Transport', and 'Industry'.

Legend:

 - Orange line: Liquid Digestate
 - Green line: Solid Digestate
 - Red line: Syngas
 - Blue line: Biomass
 - Yellow line: Natural Gas Grid (Bioethane)
 - Light green line: Biogas
 - Dark green line: Oxygen
 - Light blue line: Electricity Grid
 - Dark blue line: Hydrogen
 - Dark red line: Carbon Dioxide
- All information is available under:
<https://task37.ieahbioenergy.com/>



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<https://task37.ieabioenergy.com/>

Task 37 Energy from Biogas

- Newsletter - <https://task37.ieabioenergy.com/newsletter.html>
- Country Reports - <https://task37.ieabioenergy.com/country-reports.html>
- Case Stories - <https://task37.ieabioenergy.com/case-stories.html>
- Webinars and Workshops - <https://task37.ieabioenergy.com/events/>
- Technical Reports - <https://task37.ieabioenergy.com/technical-brochures.html>

Thank you for your attention!

Contact IEA Bioenergy Task 37

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American Biogas Council

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BIO METHANE WEBINAR

25 June 2025 Wednesday

SESSION TOPIC

North America's RNG Ecosystem,
Case Studies, and Best Practices

North America's RNG Ecosystem Case Studies and Best Practices

Paul Greene

June 2025

GreeneTec Introduction

- First founding member of American Biogas Council in 2010 and first elected chair
- See:
 - www.greene-tec.com
 - www.biogas.tv
- Biogas RNG Advisory business since 2022

Biogas Markets

- Agriculture
 - Manures
 - Processing Waste (DAF Float, etc)
- Food Manufacturing Waste
- Landfill Gas
- Food Waste – Preconsumer, Grocery Store, Restaurants
- Municipal Wastewater Treatment
- Post Consumer Food Waste

Drivers

- A few USA states have landfill ban directives to keep organic waste out of landfills
 - Connecticut, Massachusetts, California, New York City
- Low Carbon Fuel Standards for Transportation
- SAF – Several states are creating tax credits
- Section 48 Investment Tax Credit created a big wave of projects in late 2024.
- Canadian Clean Fuel Regulation (CFR) is very good for both Canadian and American RNG.

Policy

- National Policy
 - RFS – RINS
- State Policy
 - CA LCFS
- Canada
 - CFR (Clean Fuel Regulation)



The future

- All eyes are on the upcoming 45Z Production Tax Credit
- People now building the projects that were registered in 2024 deploying the ITC
- Looking at new fuels like aviation fuels and Maritime

Renewable Fuel Standard

- Rewards RIN credits for food waste, manures, biosolids and landfill gas
 - D3 RINs (Cellulosic Biofuels) are trading at about \$33 per mmbtu
 - D5 RINs (Advanced Biofuels) are trading at about \$14 per mmbtu

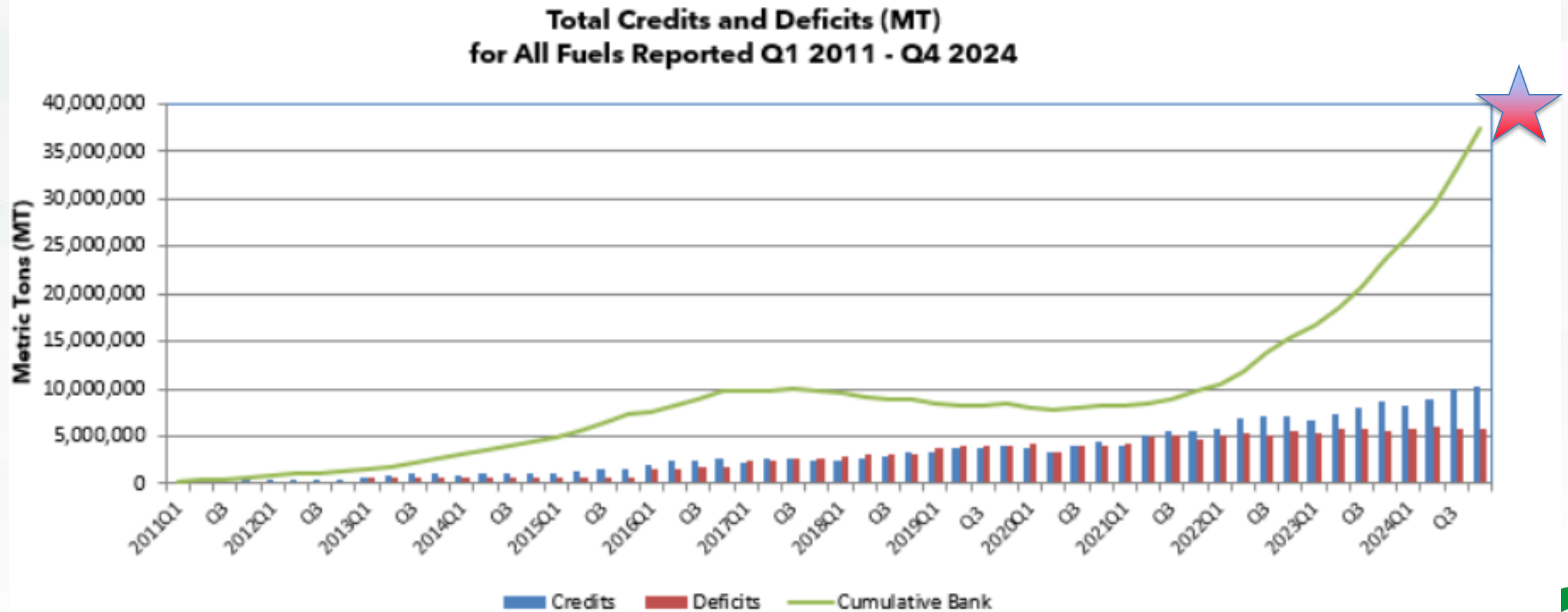
The 2025 Budget Battle

- The “Big Beautiful Bill”.
- Terminates
 - Section 45V for Hydrogen
- Section 45Z is a low carbon fuels tax credit.
 - Unclear if negative carbon intensity scoring will be allowed
 - A production tax credit now good until 2027 but looks like it will be extended to 2031
- Investment Tax Credit – Section 48 expired

Trends

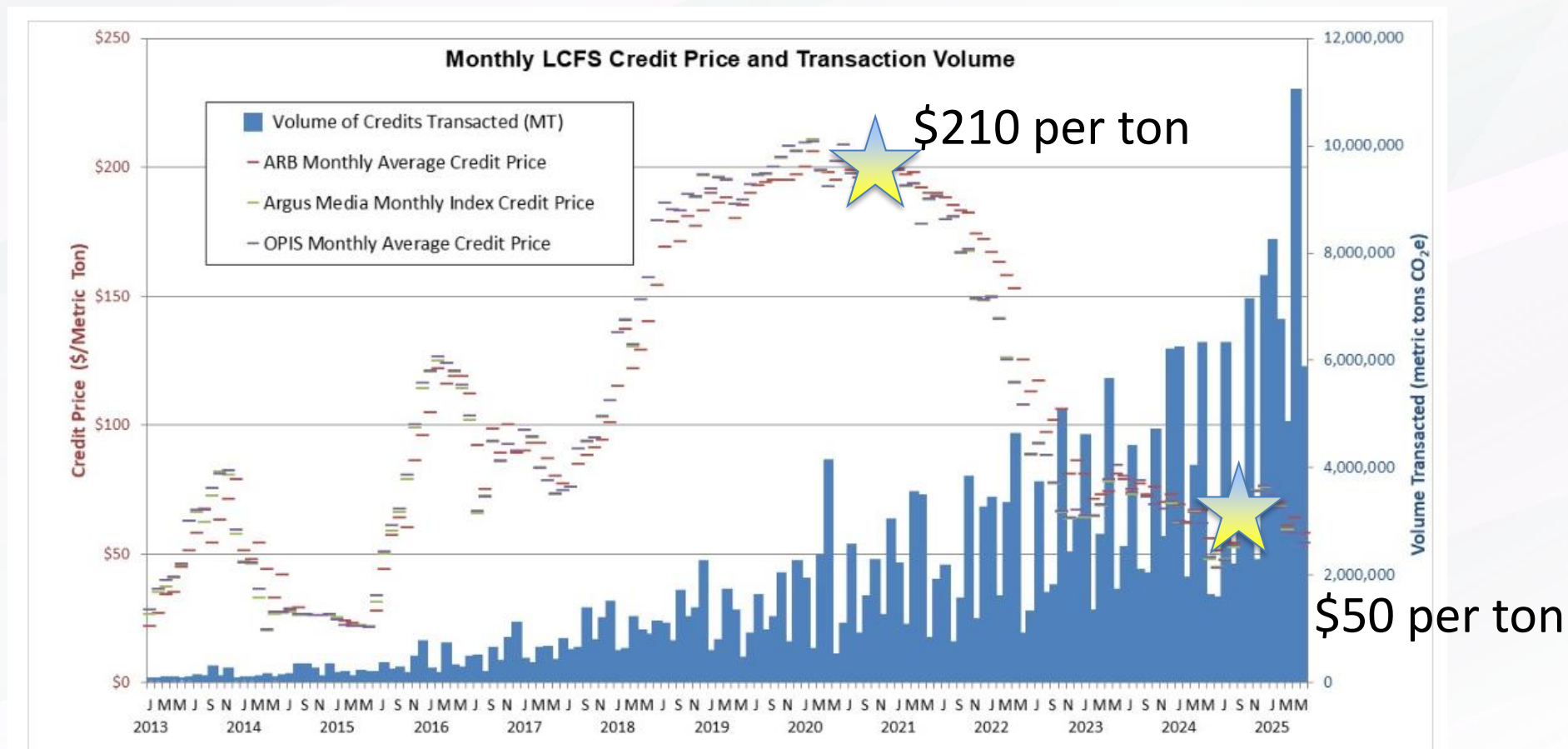
- California LCFS Prices – softened from \$100+ to \$45 per ton
 - CA LCFS was the catalyst for the USA boom in the RNG business from 2020 to 2023
- D3 RIN prices have softened to \$2.50 each
- Regulatory uncertainty

California carbon bank is full of credits the program is very popular



California LCFS Prices

have reached a new normal



Tax Code

- Section 48 ITC – Need to have “safe harbored” the project before 1/1/2025

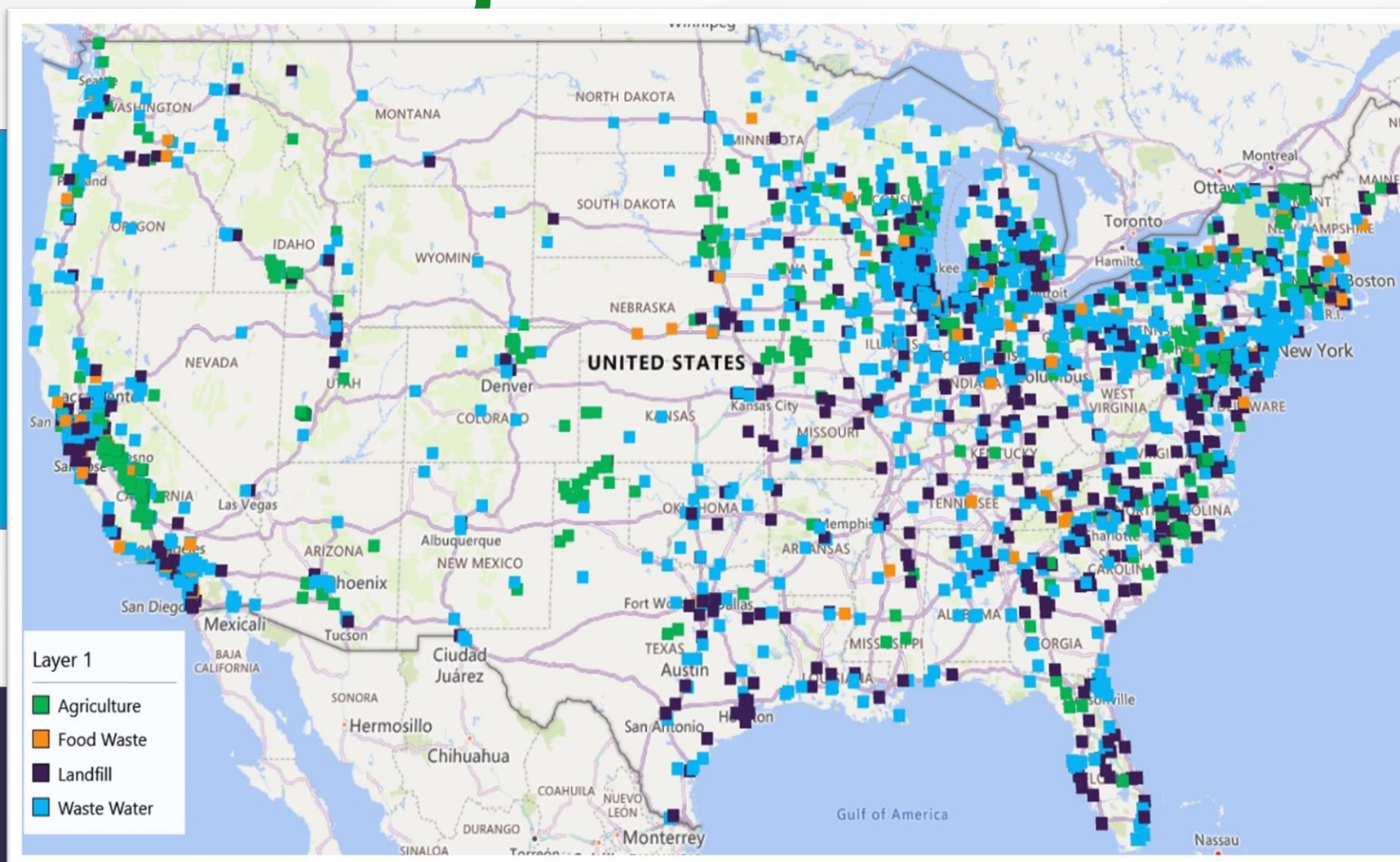
The U.S. Biogas Market

Operational Biogas Systems: 2,494

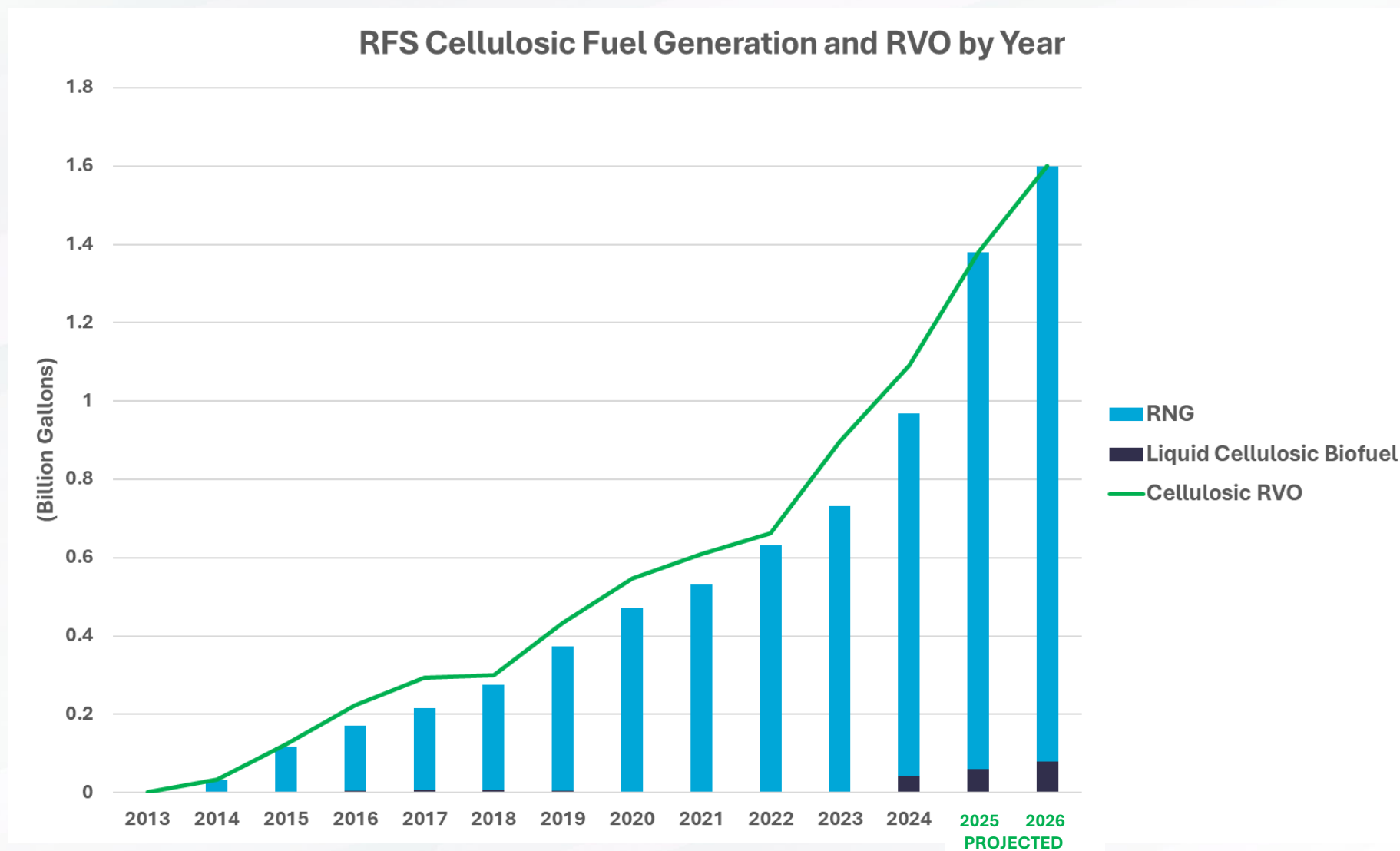
- 576 RNG
 - 1,400 Electricity
-
- 609 on Farm
 - 1,189 Wastewater
 - 113 Food Scrap
 - 583 at Landfills

Potential New Biogas Systems: 17,000

- 11,200 on Farms
- 3,750 Wastewater
- 1,370 Food Scrap
- 730 at Landfills

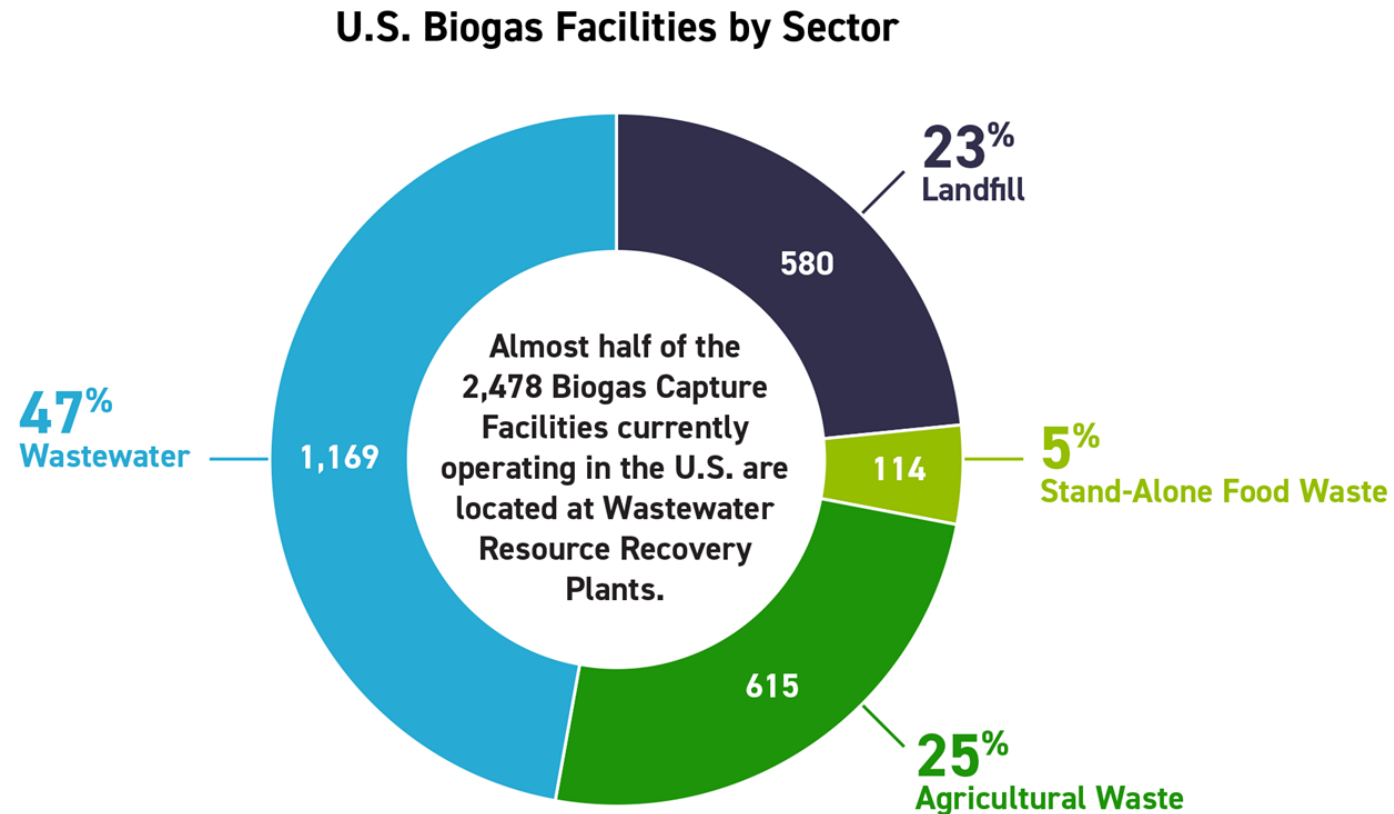


Growth of US Biogas Use in Transportation



April 2025

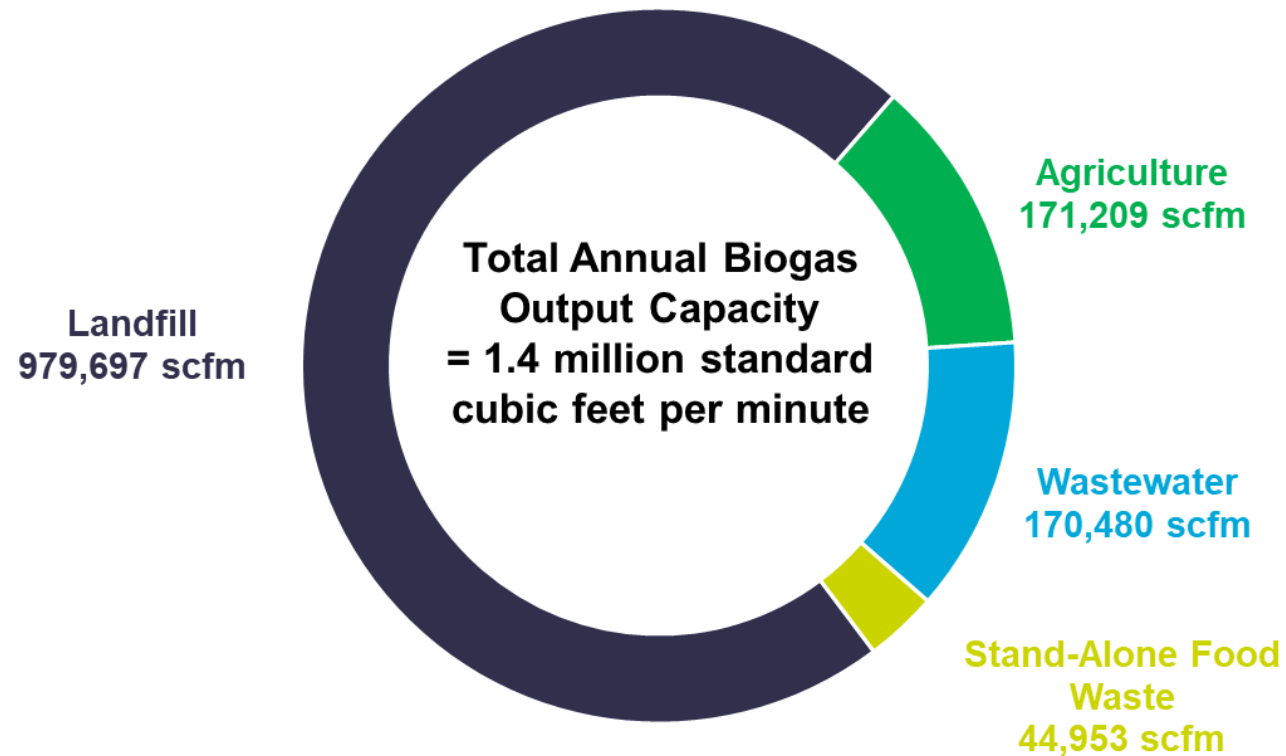
Biogas Systems In The U.S. By Feedstock Source, 2024



2024 Growth: 5.4%	
Landfill	+4.3%
Agriculture	+18.0%
Wastewater	+0.4%
Food Waste	+2.7%

U.S. Biogas Production Capacity (scfm)

Total U.S. Biogas Production Capacity at end of 2024



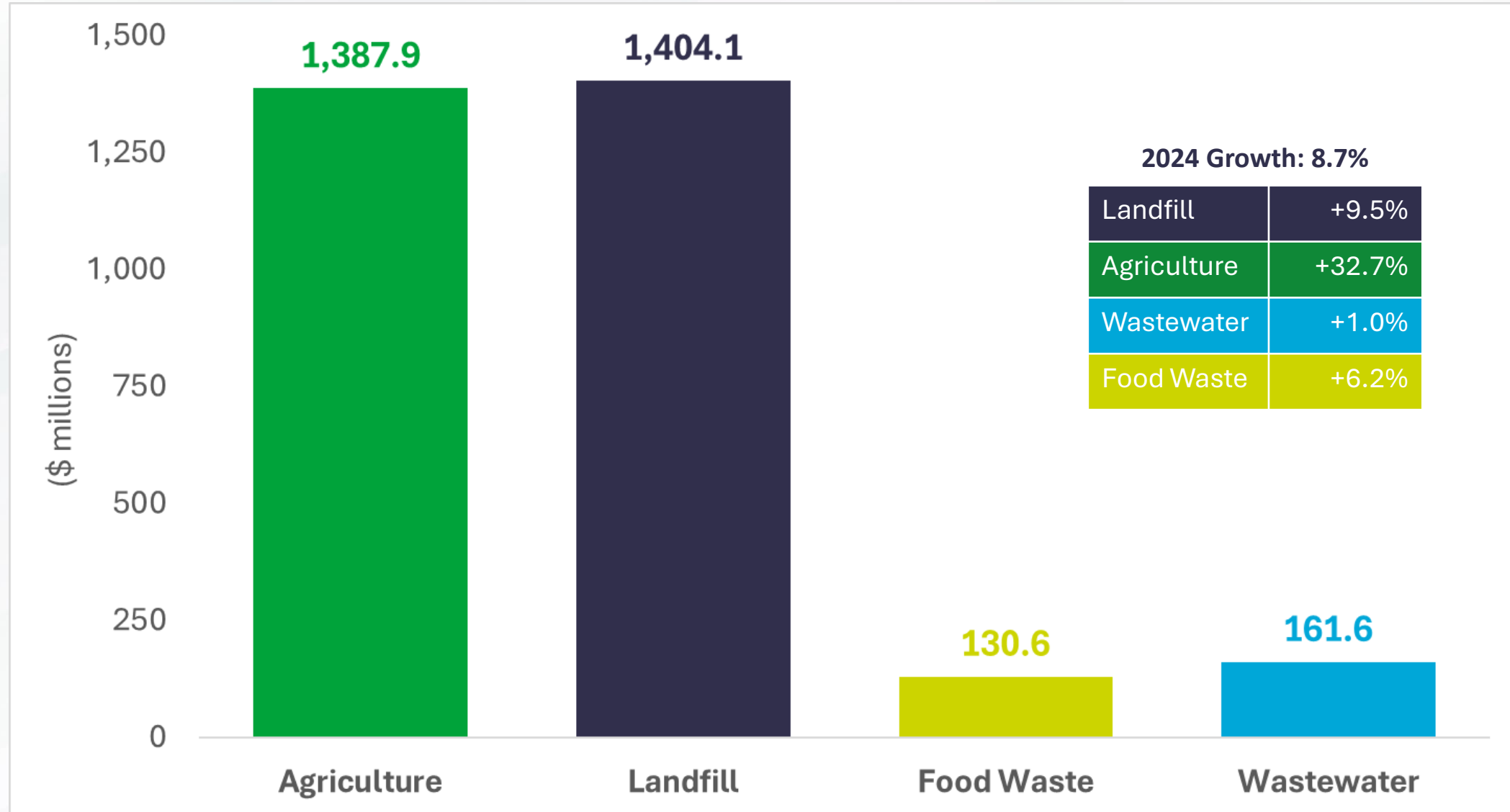
2024 Growth: 10.6%	
Landfill	+12.3%
Agriculture	+13.9%
Wastewater	+0.9%
Food Waste	+2.4%

Total U.S. Biogas Production Capacity, 2015-2024

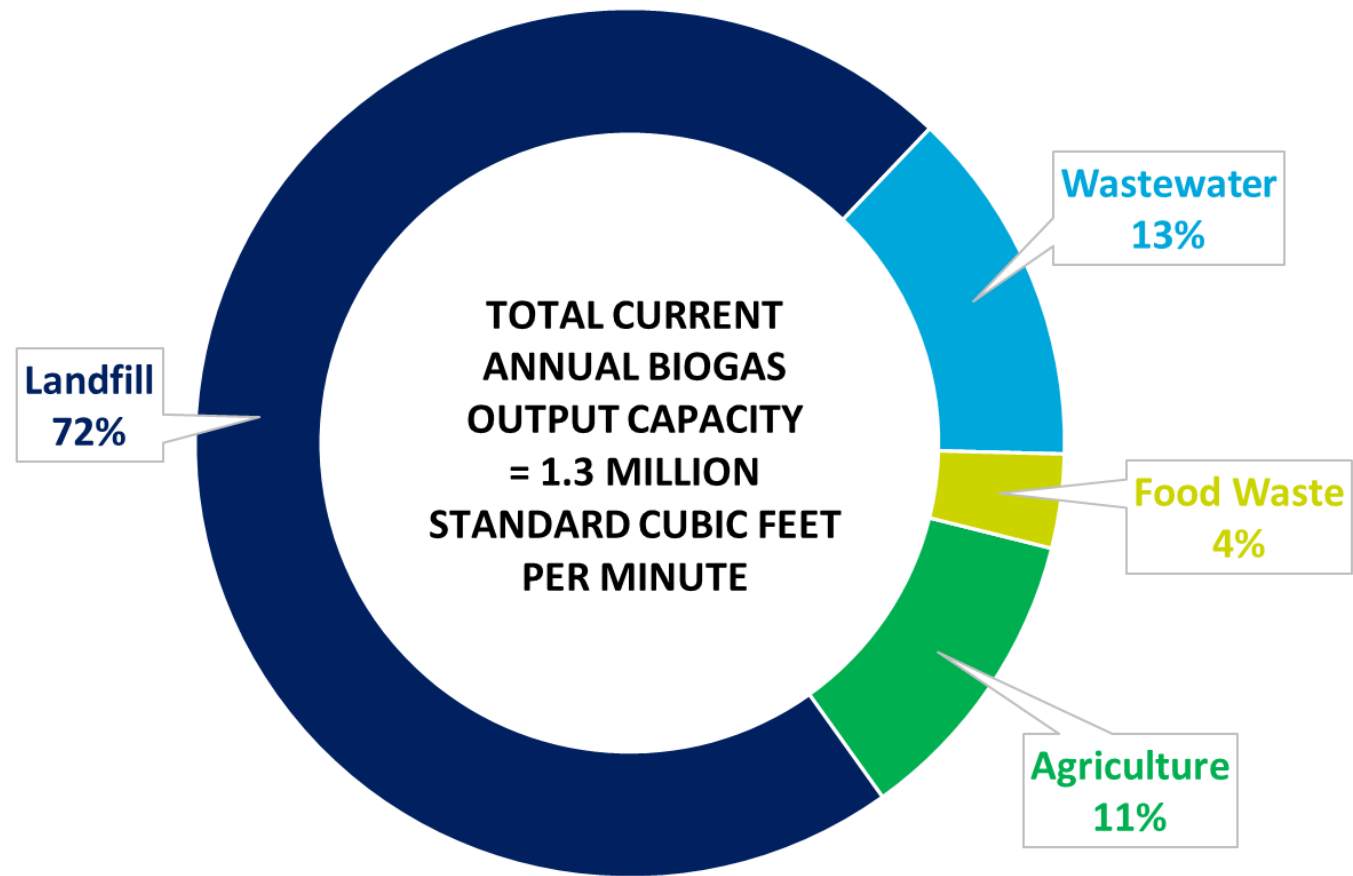


NOTE: Production is attributed to the year system went into operation.

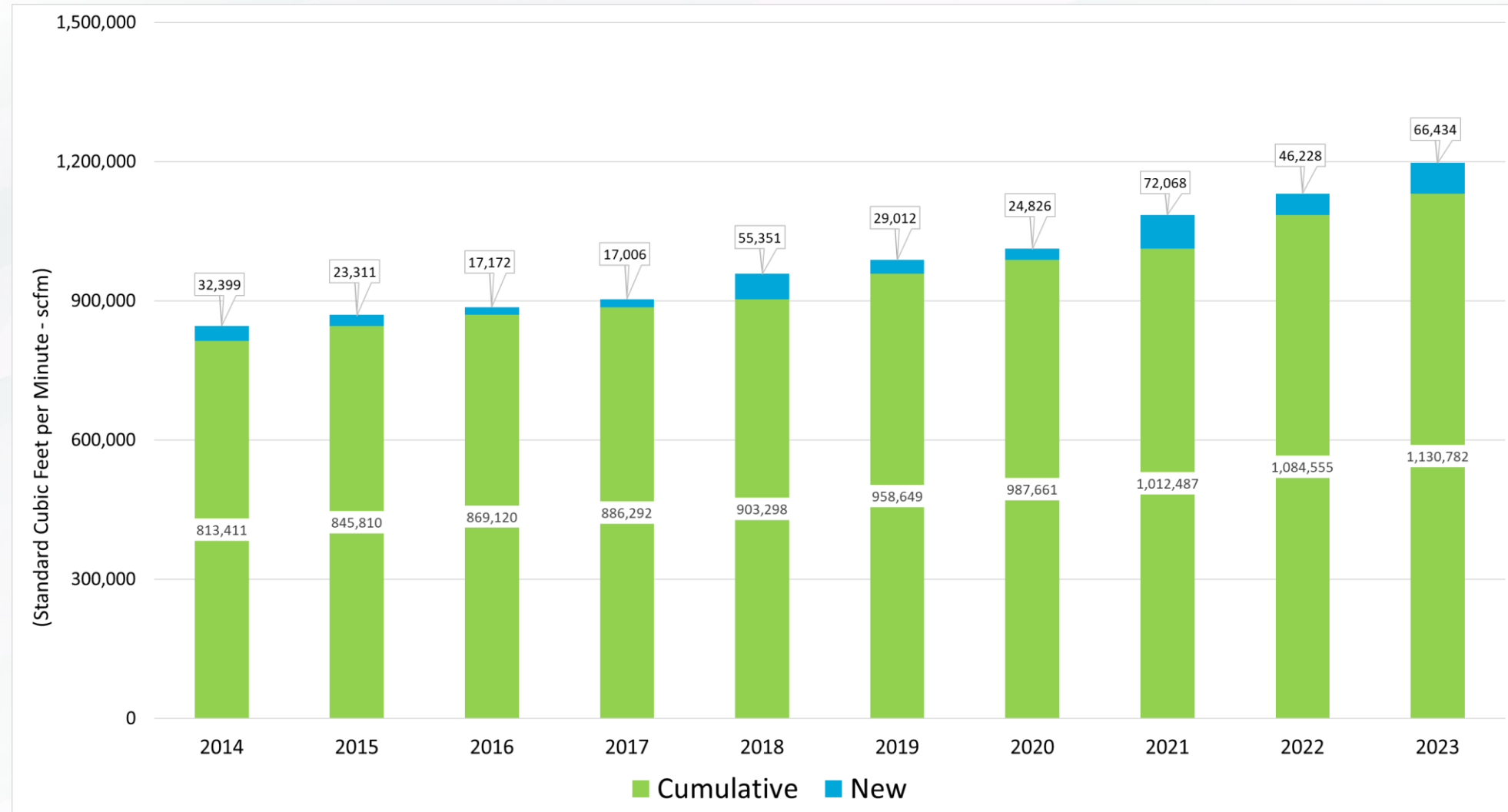
\$3B of Capital Came Online in 2024



Total U.S. Biogas Production Capacity

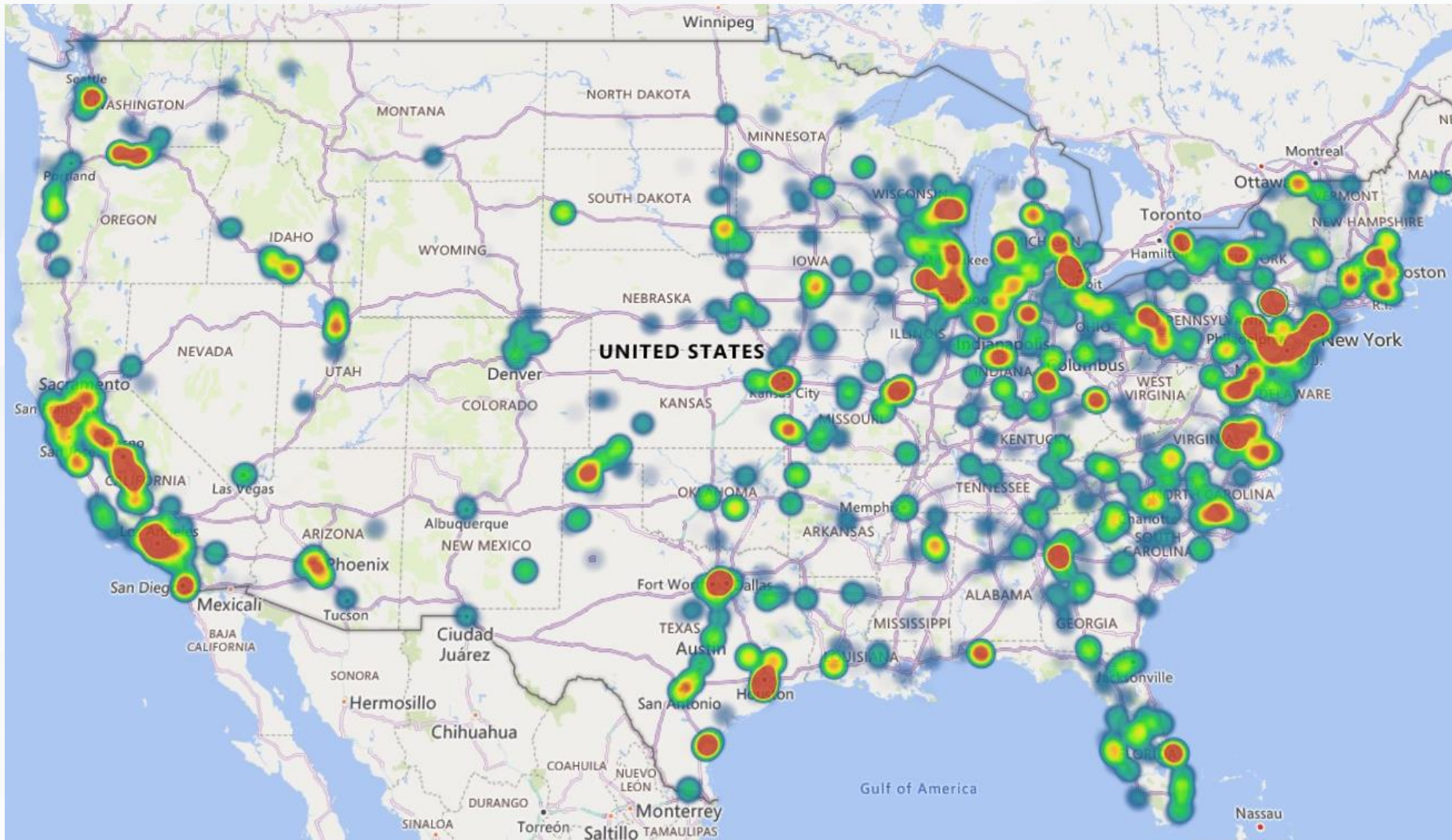


US Biogas Output, 2014-2023 (scfm)



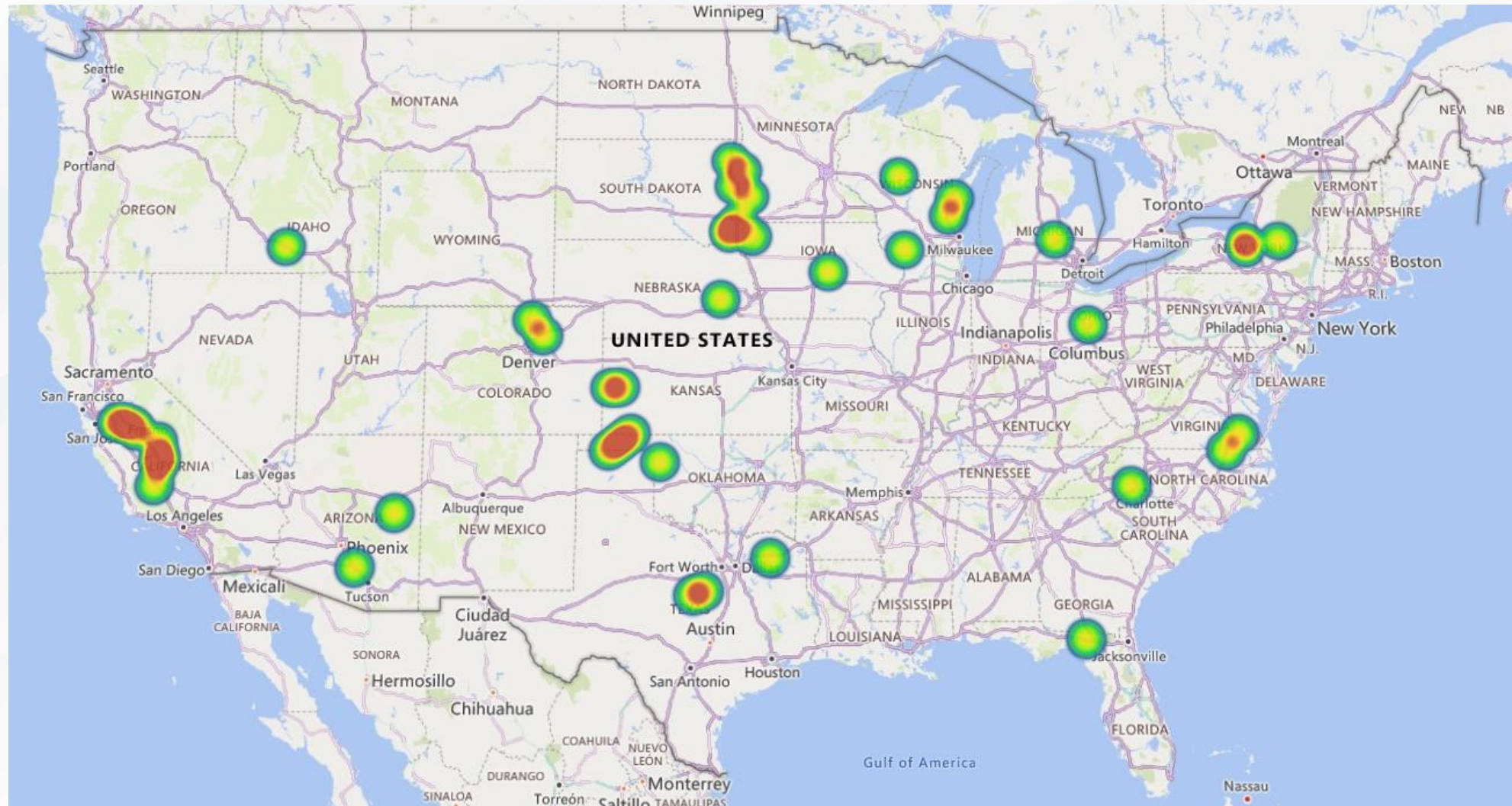
4/10/2024

U.S. Biogas Production

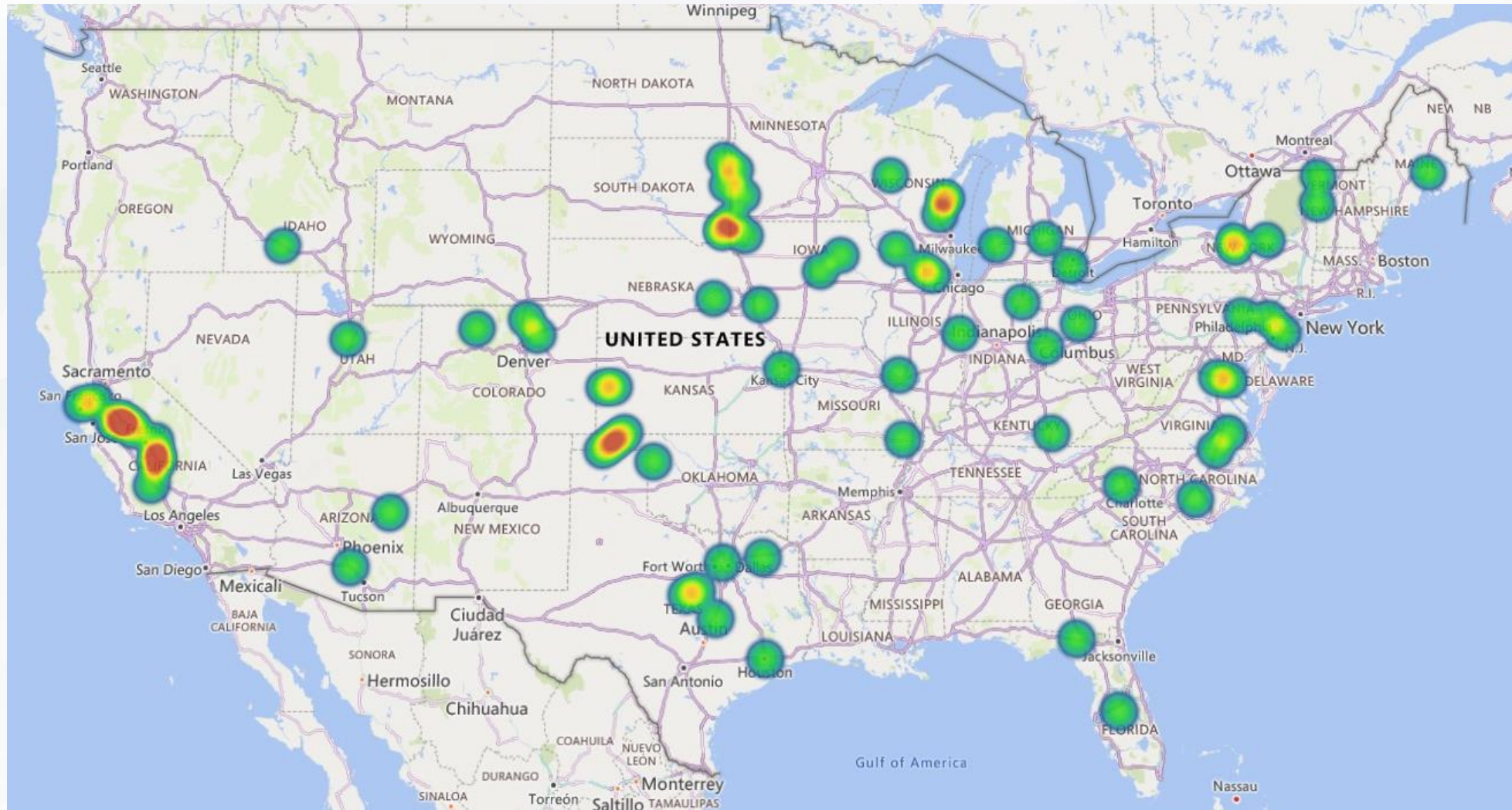


March 2025

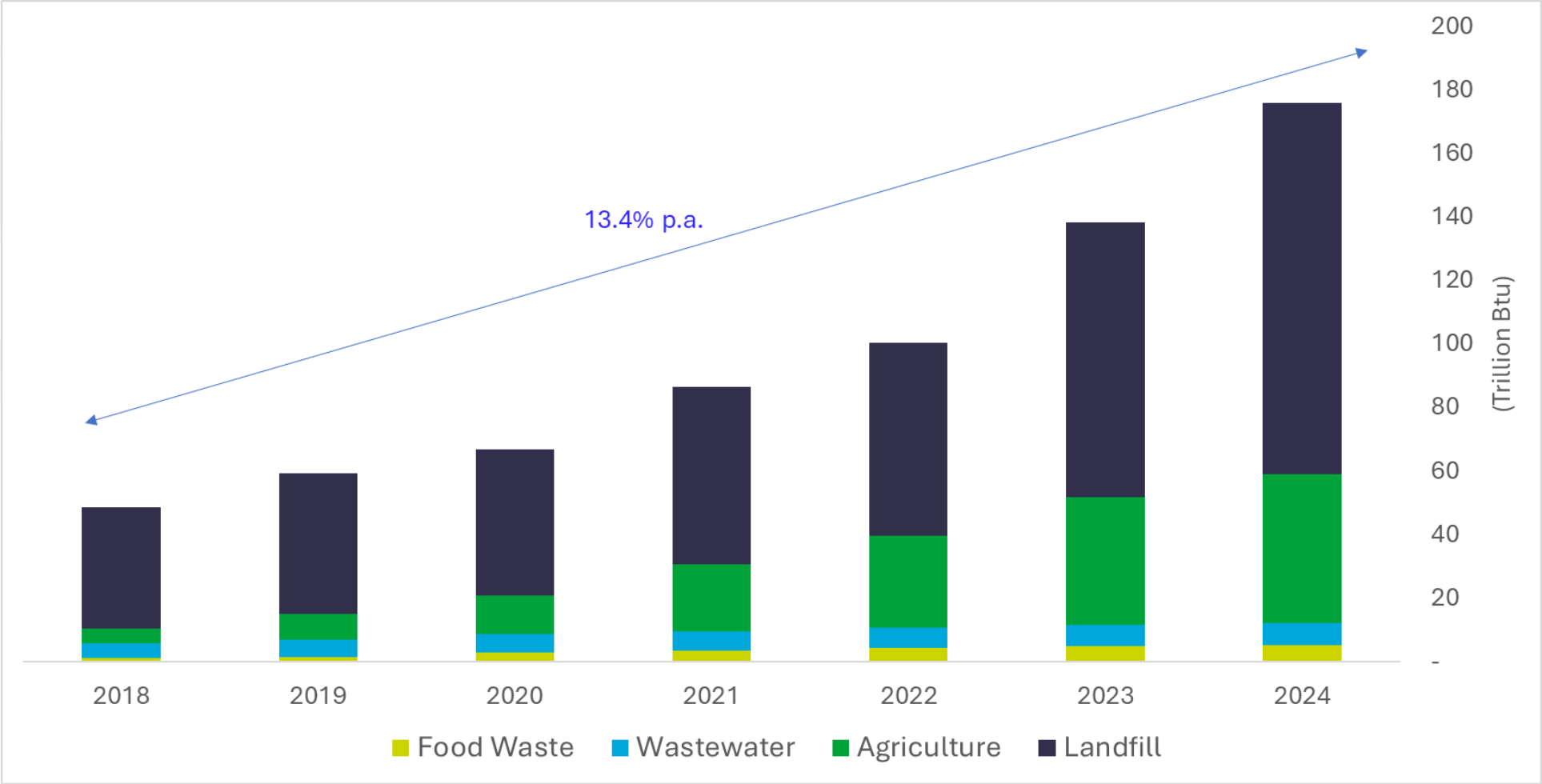
Main Centers of U.S. Biogas Production on Farms



New Biogas Production Capacity Added in 2024

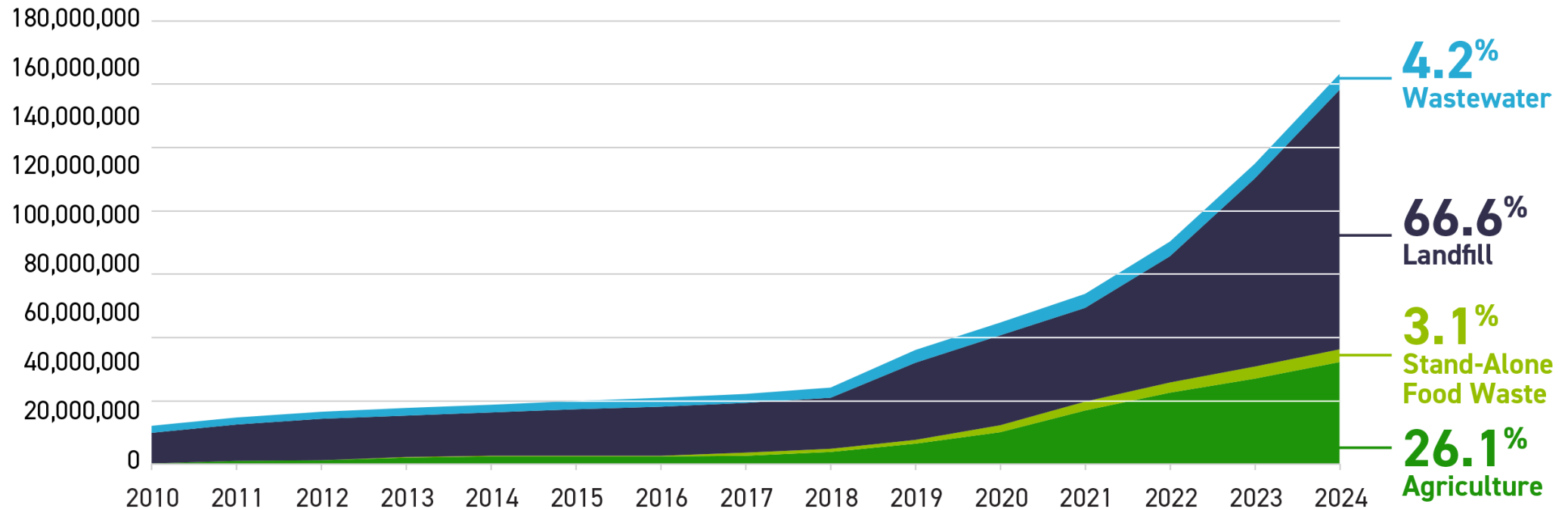


U.S. RNG Production by Feedstock, 2018-2024 (Trillion Btu)



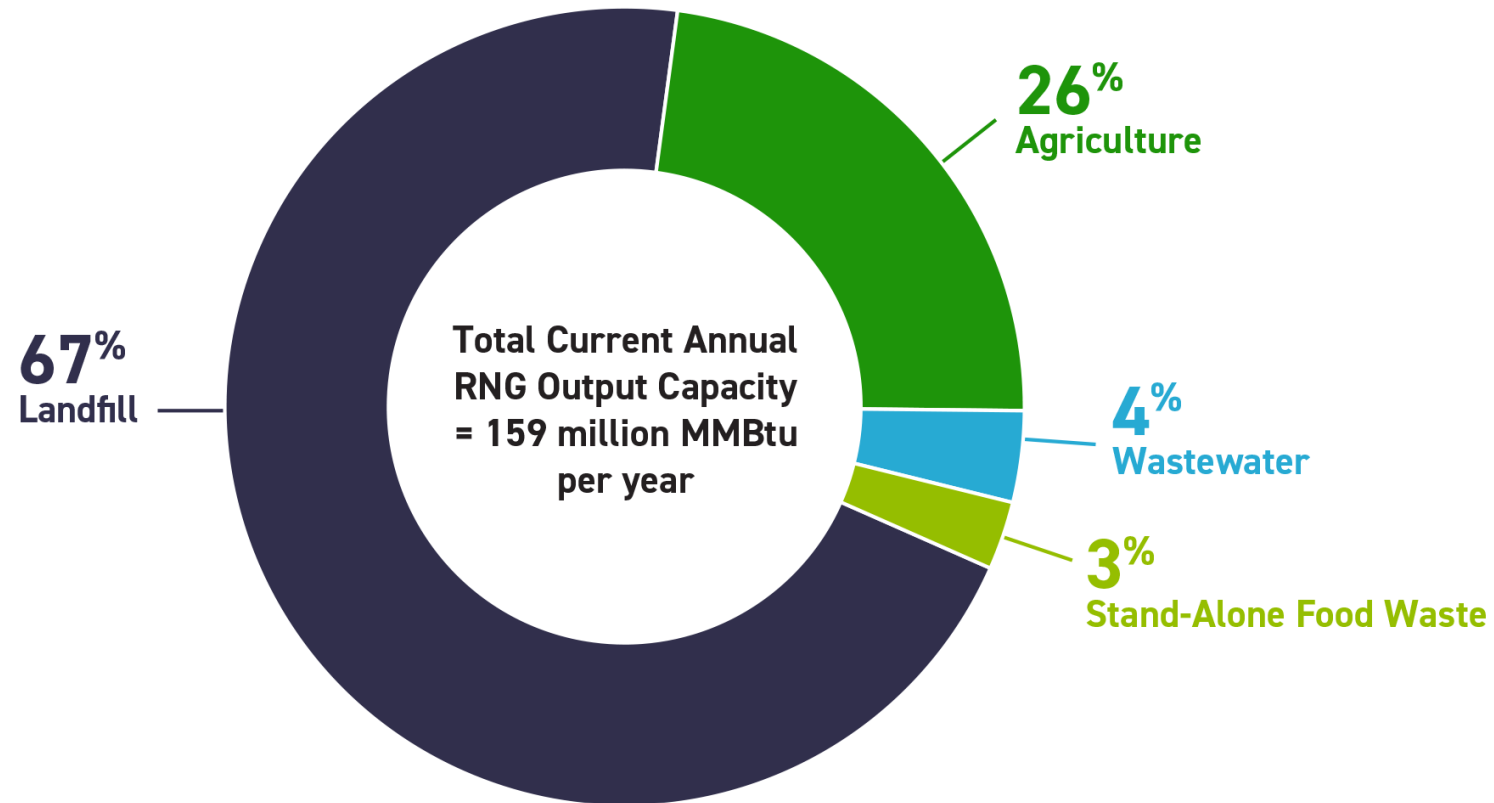
RNG Capacity 2010-2024

RNG Output Capacity by Sector, 2010-2024 (MMBtu)



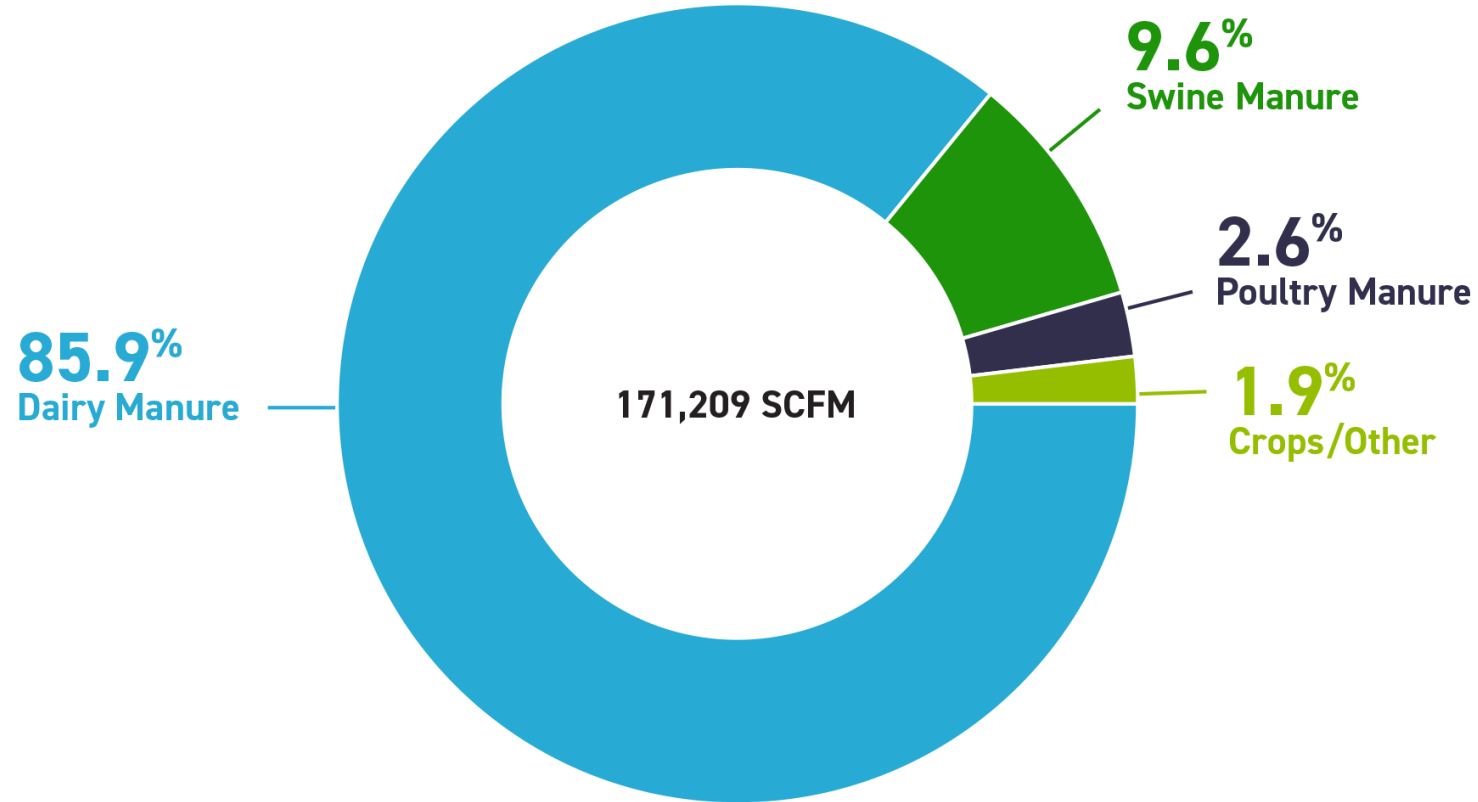
RNG Capacity by Sector

RNG Production Capacity at end of 2024, (MMBtu)

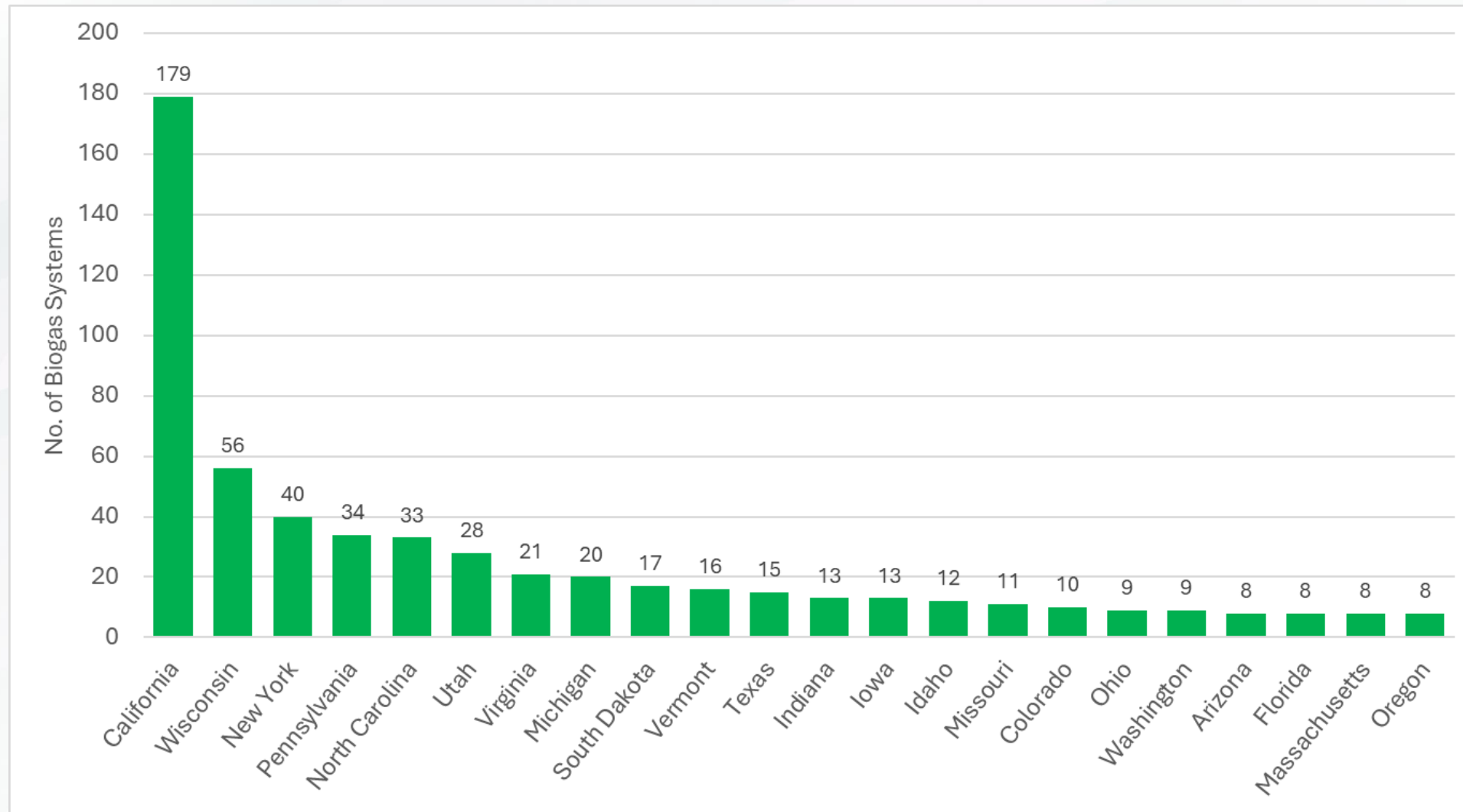


Farm-Based Biogas Capacity

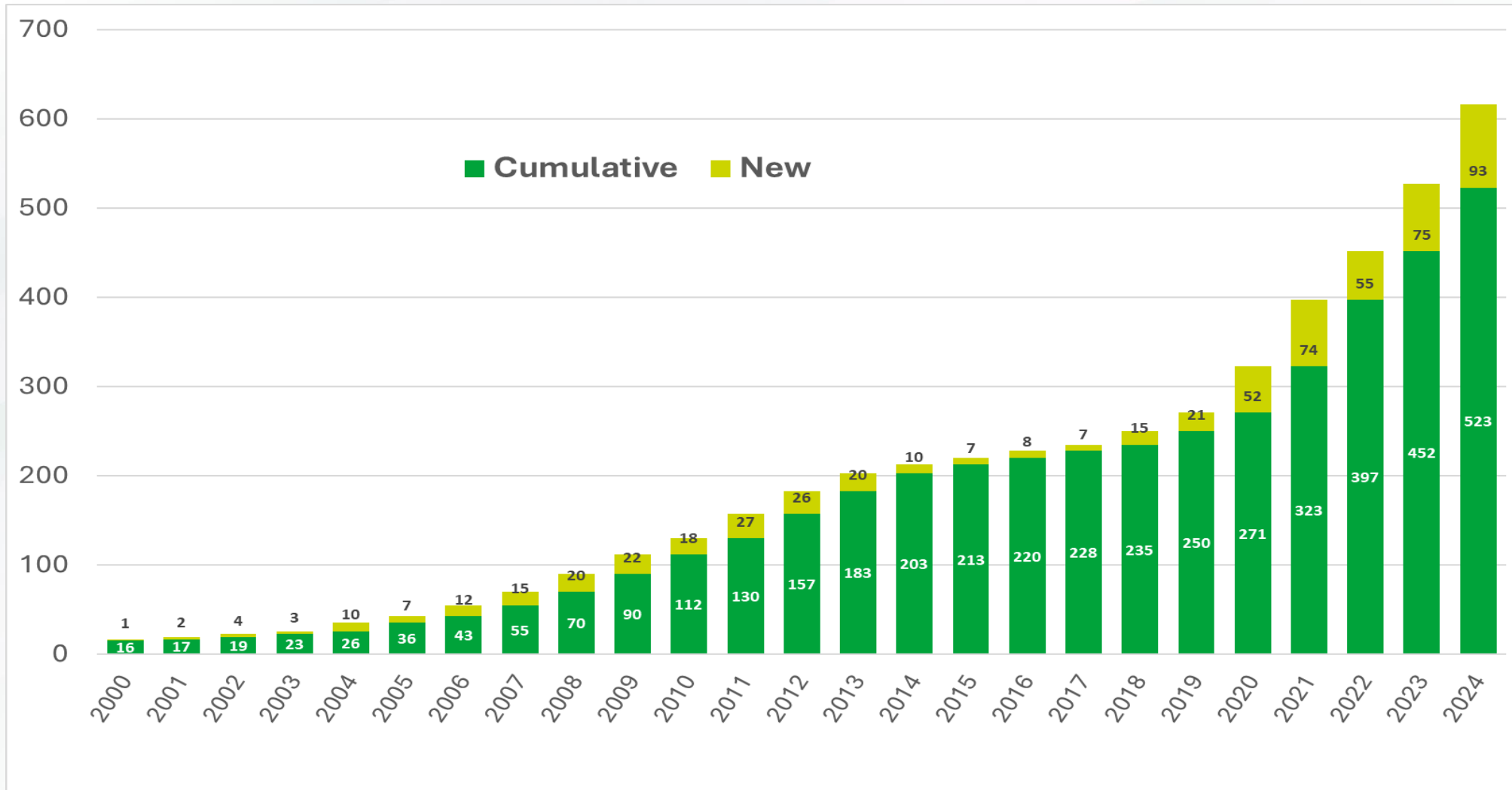
Farm-Based Biogas Production Capacity by Primary Feedstock at end of 2024



Operational On-Farm Biogas Systems by State, 2024

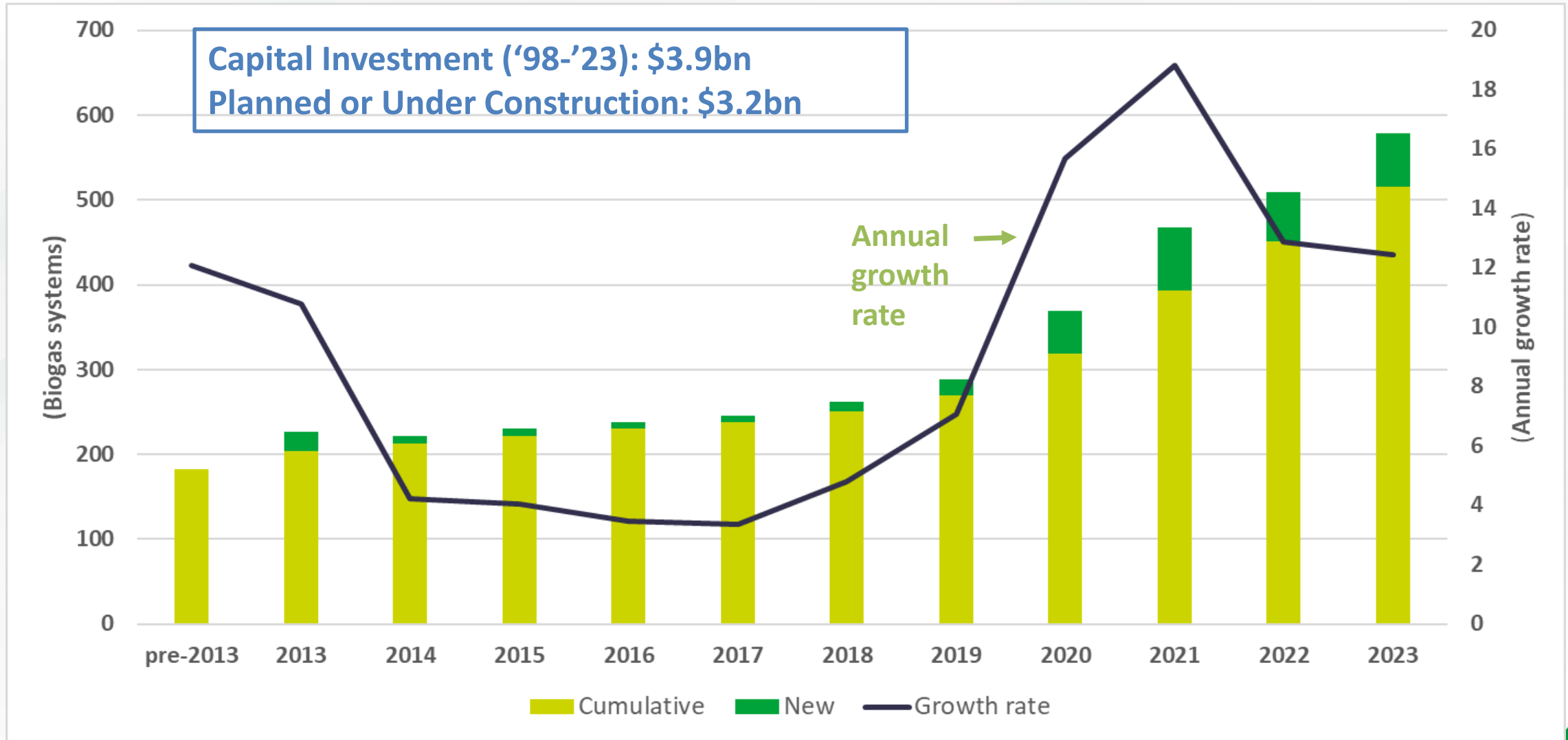


US Farm-based Biogas Systems, 2000-2024

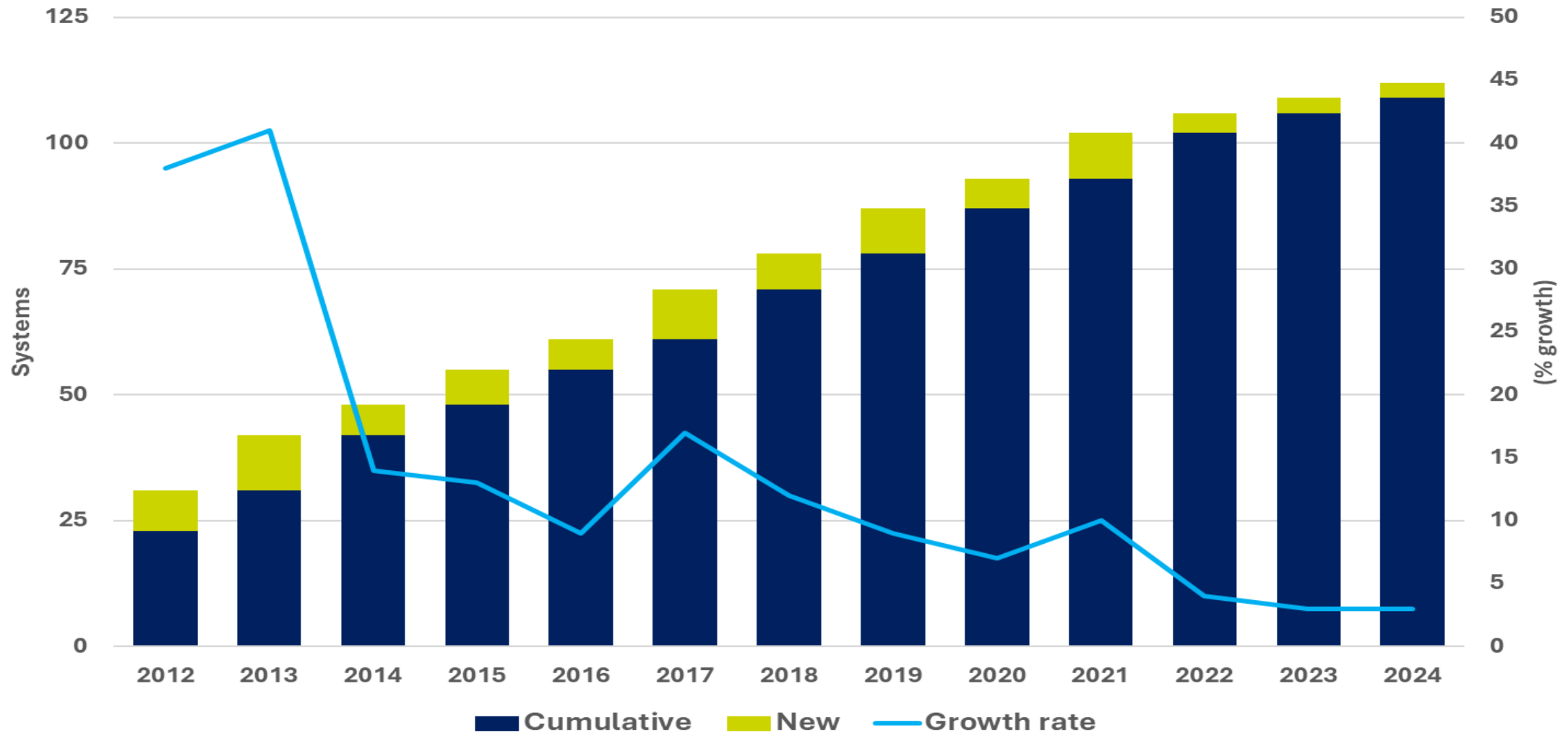


616 operational
farm-based biogas
systems in 2024

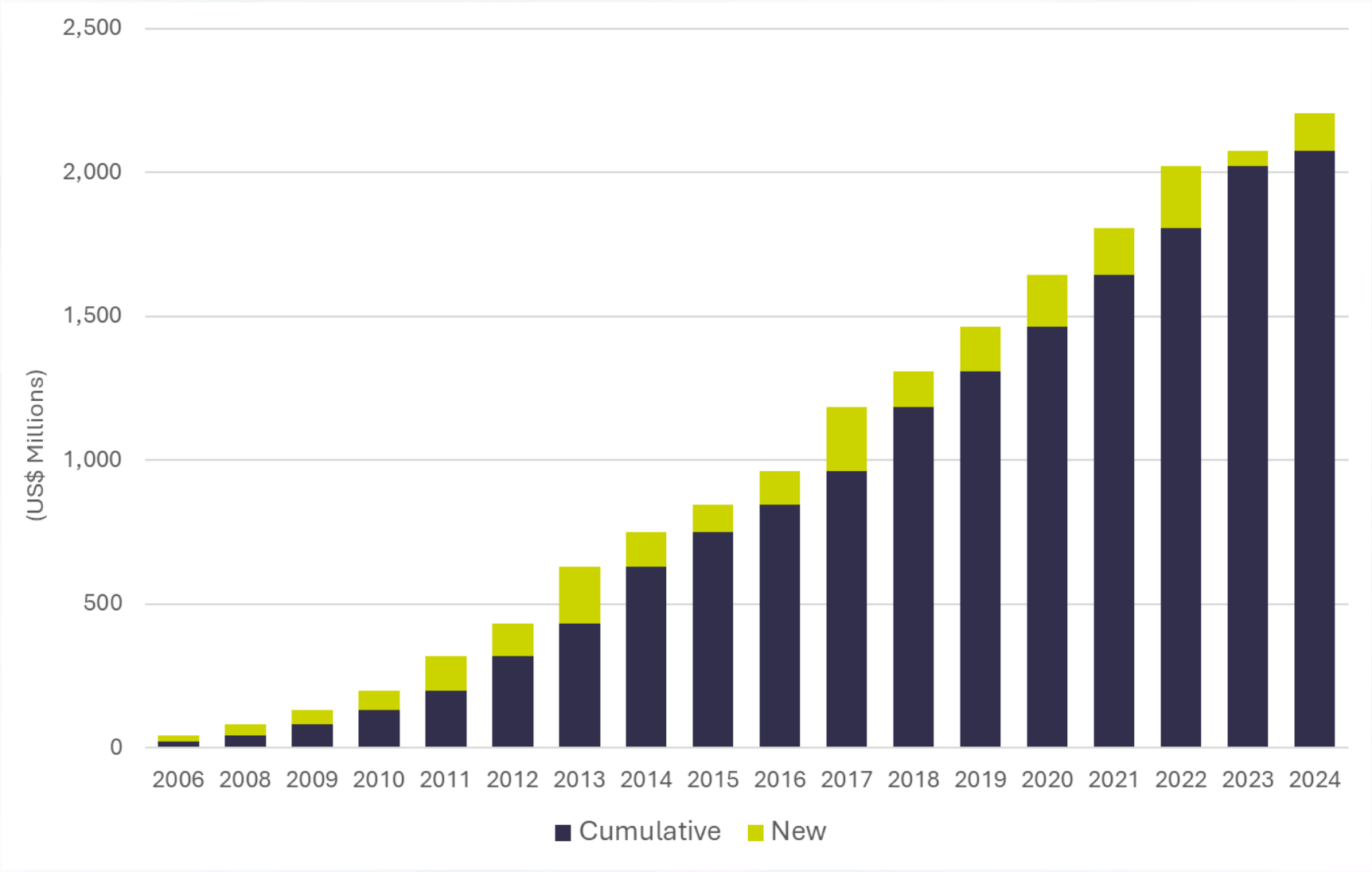
Farm-based Biogas Systems in the US



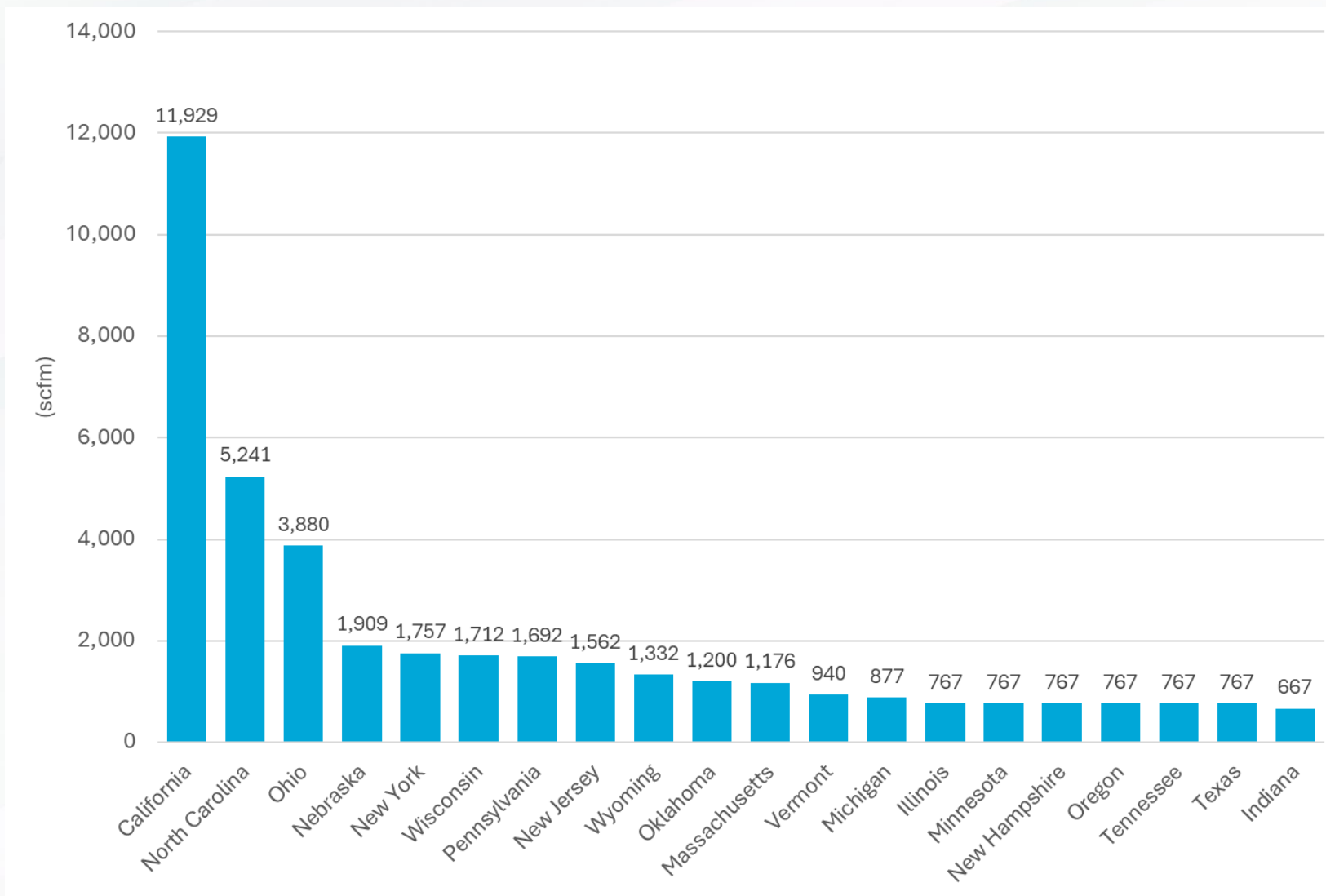
Stand-Alone Food Waste Biogas Systems, 2012-2024



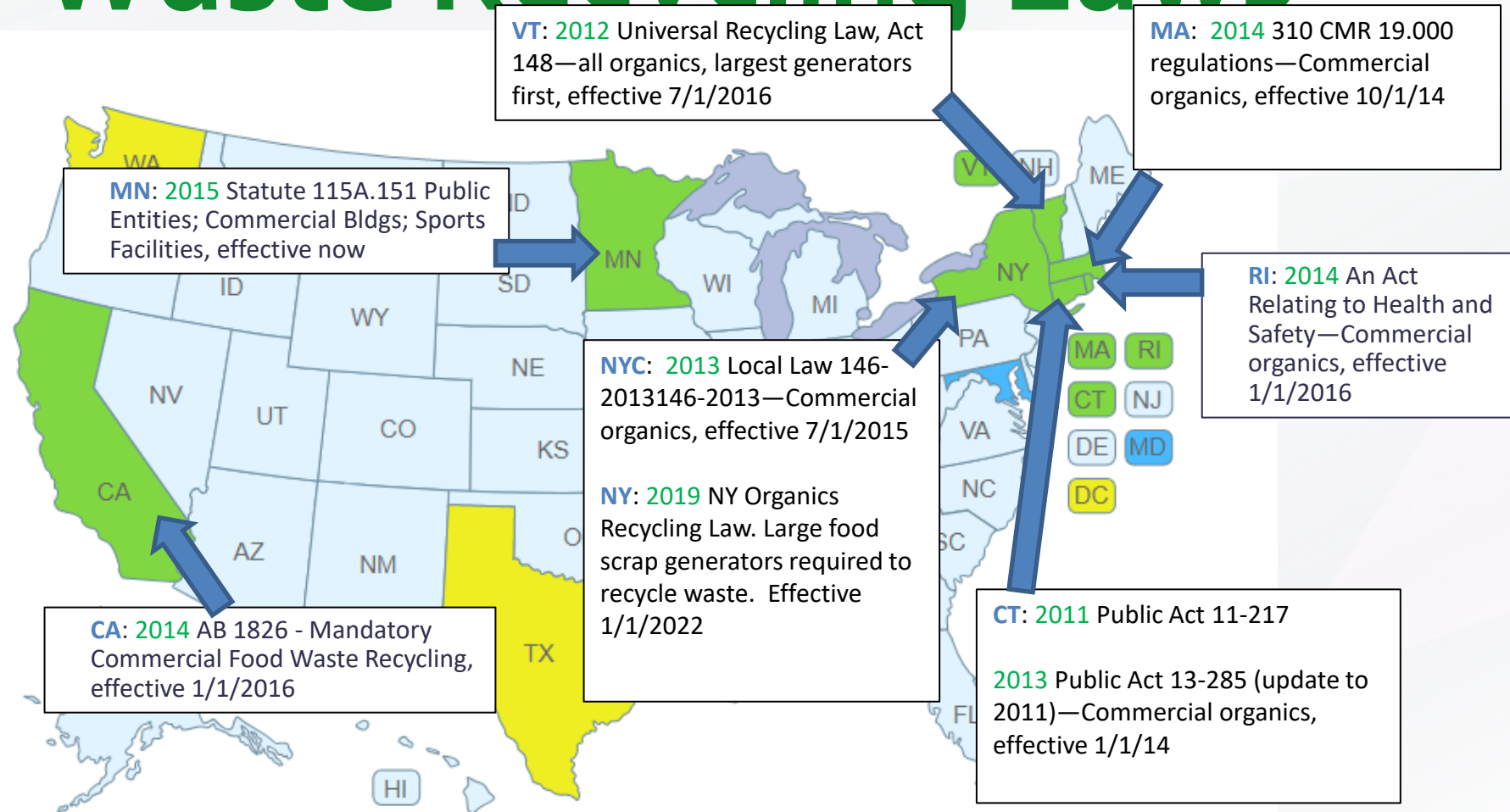
Capital Investment in Standalone Food Waste Biogas Systems



Total Biogas Production Capacity at Standalone Food Waste Facilities by Leading States, 2024



10 States Have Food Waste Recycling Laws



PROJECTS - USA



Green Era – Chicago, IL

100,000 tons per year
Of food waste from
Food manufacturing

200,000 mmbtu per year
Of RNG

Solids depackaging system



Synthica – Cincinnati Ohio

- 190,000 tons of food waste per year
- RNG into the natural gas pipeline



Dairy Farms, Iowa

USA – BIOSTREAM DEPLOYMENTS 11 SITES 19 UNITS



♦ Our Goal is to be the most
Reliable Upgrading Partner
for the Industry

- ♦ Technology
- ♦ Relationship

♦ lamram@ivysads.com

♦ prao@ivysads.com



Warsaw, North Carolina

Food Waste Digesters

Creation of RNG

45,000 m³ of digesters

Waste from processing of
Proteins (Hogs, chickens)



Jessup, Maryland

100,000 tons of food waste
Per year

190,000 mmbtu of RNG per year

Food waste from local food
Manufacturing

BTS Bioenergy



Gila Bend, Arizona

Dairy Manure Digesters

Creation of RNG

10,000 milking cows



San Bernardino, California

100,000 tons of food waste/ year

Creation of electricity from biogas

Extensive digestate treatment with
Reverse osmosis water filters



THANK YOU

PAUL GREENE

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01 518 951 5766



Alessandro Gardeman

Co-Founder, Brazilian Biogas Association and
Chairman of the Board of Directors at ABiogás

IN COLLABORATION WITH



BIO METHANE WEBINAR

25 June 2025 Wednesday

SESSION TOPIC

**Biomethane in Brazil: Supportive
Policies, Case Studies,
and Best Practices**



Associação Brasileira do Biogás

Global Biofuels Alliance (GBA) Webinar on Biomethane

Alessandro Gardemann

Chairman of the Board

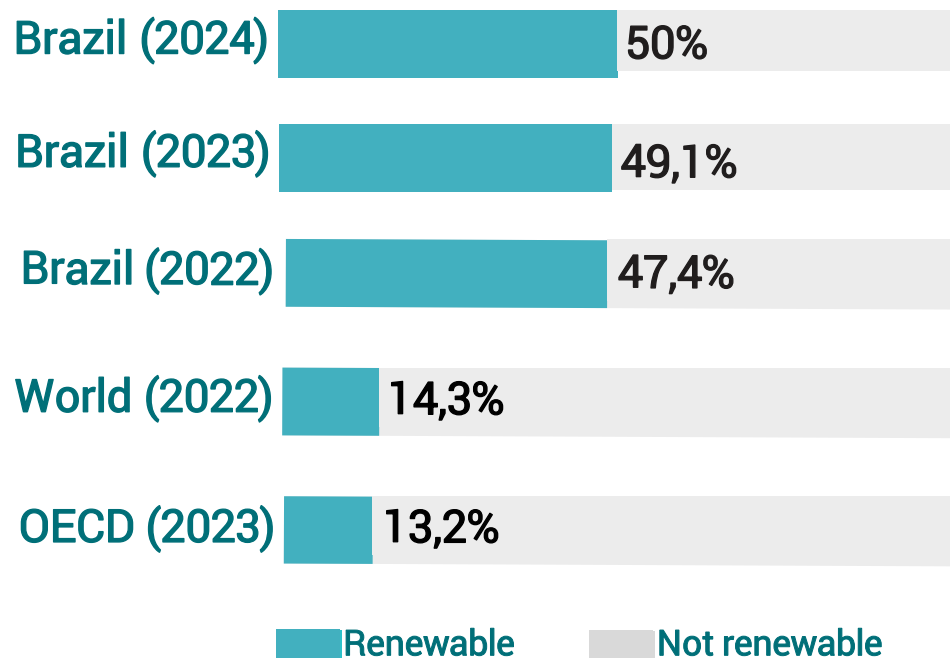
25/06/2025

ASSOCIATED COMPANIES

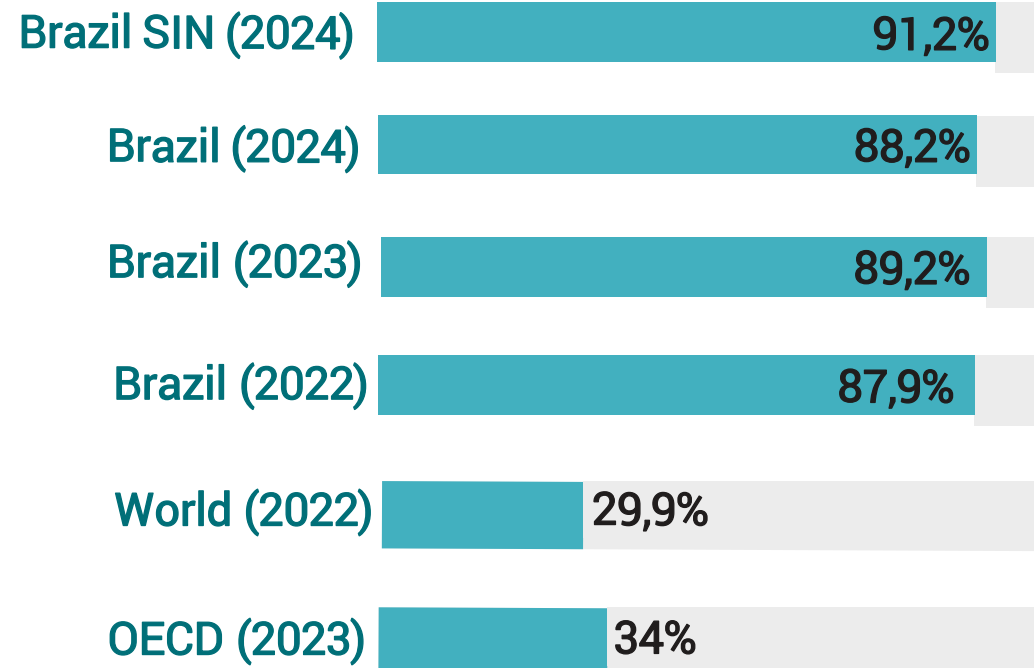


BRAZILIAN MATRIX

ENERGY MATRIX

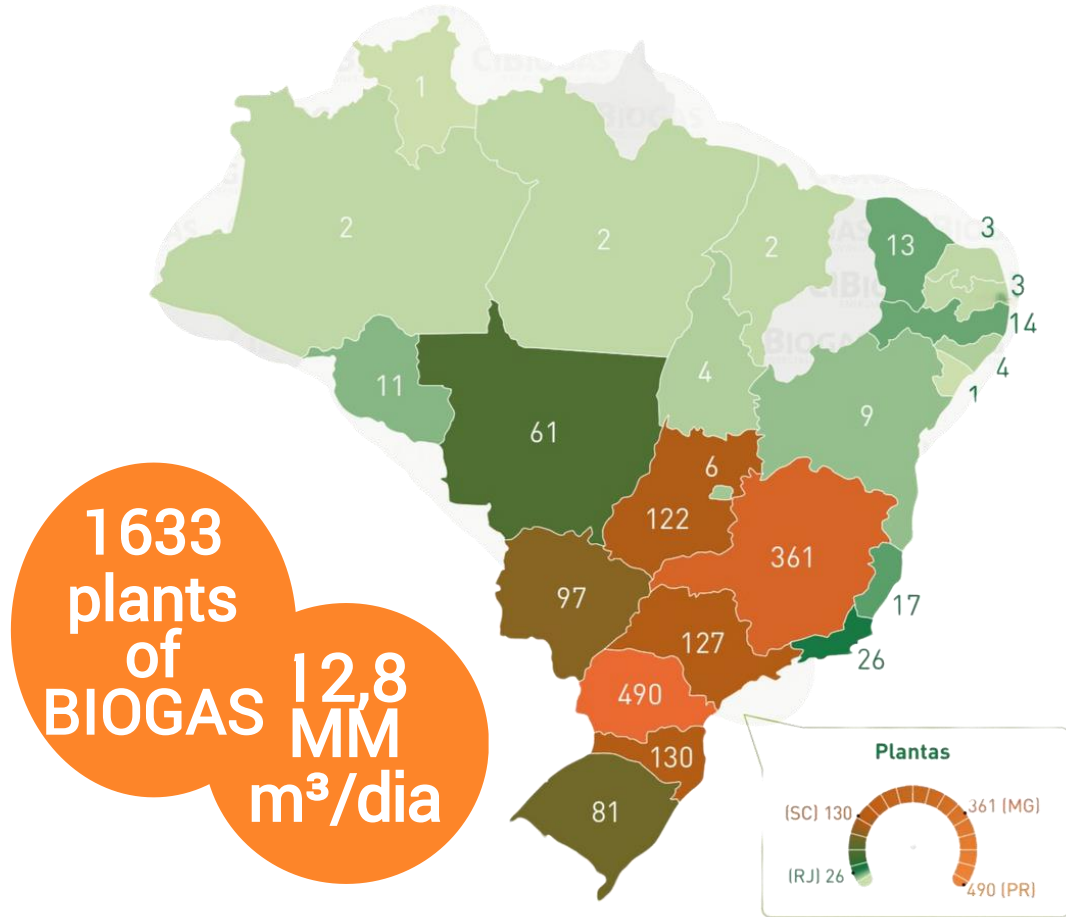


POWER MATRIX

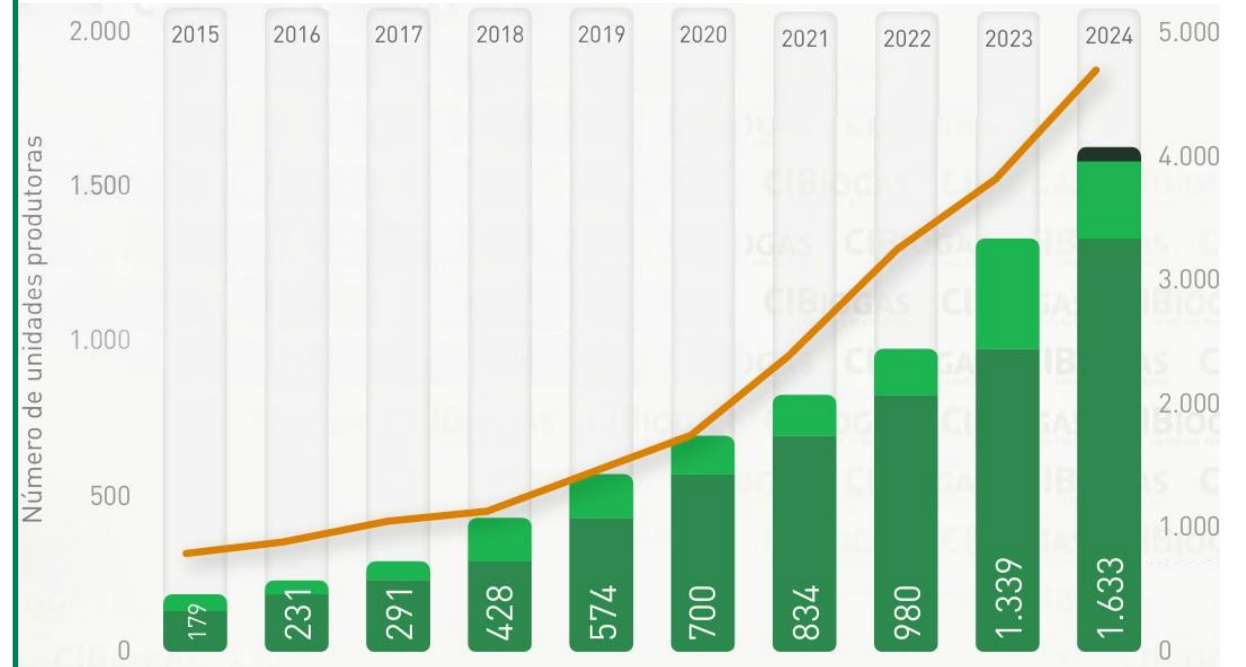


BIOGAS OVERVIEW

BIOGAS



SECTOR GROWTH BETWEEN 2015 AND 2024

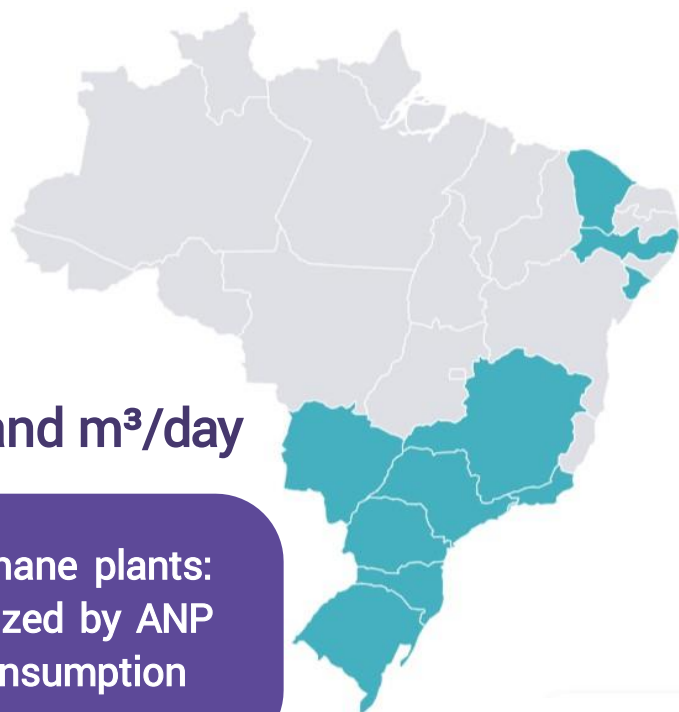


BIOMETHANE OVERVIEW

BIOMETHANE

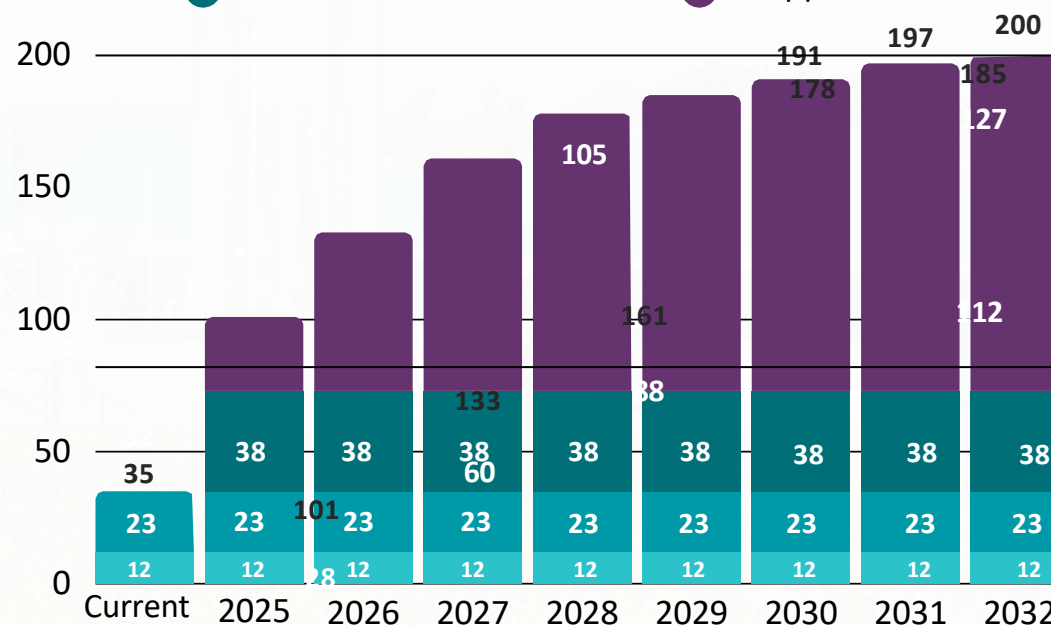
874 thousand m³/day

35 biomethane plants:
12 authorized by ANP
23 self-consumption



ESTIMATED GROWTH OF BIOMETHANE UNTIL 2032

- Authorized
- In operation (non-commercial)
- In Authorization Process
- Mapped Plants



3	7,92
2	MM ³ /D
3	7,60
1	MM ³ /D
3	7,34
0	MM ³ /D
2	7,07
9	MM ³ /D
2	6,73
8	MM ³ /D
6	
2	5,89
7	MM ³ /D
5	

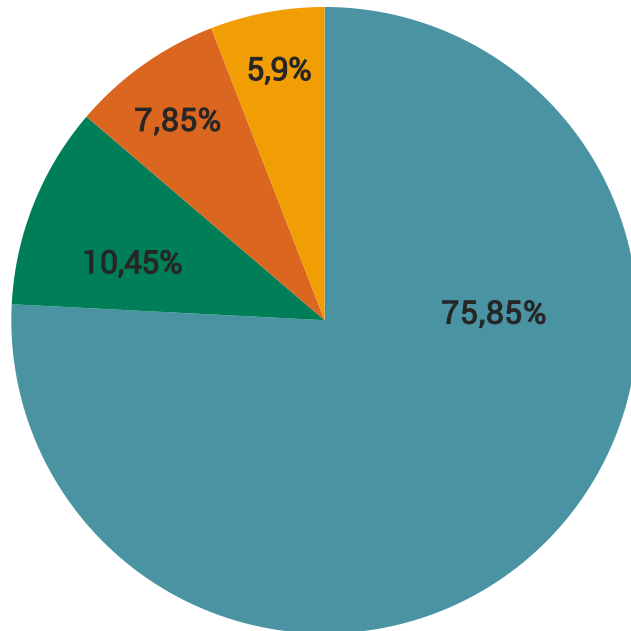
In Authorization Process



1 509 973 m³/day

SHORT-TERM POTENTIAL OF ABIOGAS

- Sugar-energy 26.48 million m³/day
- Animal protein 3.65 million m³/day
- Urban Solid Waste (MSW) 2.74 million m³/day
- Sanitary sewage 2.06 million m³/day



By 2030, biomethane
production could reach
34.9 million
m³/day

Source: ABiogás based on the Study for the Development of the Potential for Biogas and Biomethane in the State of São Paulo by FIESP, 2024.

Long-term
Biomethane potential
120 million m³/day

Brazil produces biogas exclusively from waste

Anaerobic digestion is a natural and sustainable process that transforms organic waste into renewable energy, using only waste materials and not relying on any energy crops.



SUGAR CANE
INDUSTRY



AGRICULTURE



ANIMAL MANURE



SANITATION

TRANSPORT

GÁS VERDE - URCA ENERGIA

Seropédica, RJ - Brazil



Substrate:
Landfill

Biomethane Volume:
120,000 m³/day

COMPANIES THAT USE BIOMETHANE IN THEIR FLEETS

Luft Logistics inicia testes com caminhão movido a GNV e biometano

Minerva apresenta que a bio metano e o gás, tecnologia também capaz a reduzir custos operacionais com combustíveis

Fonte: Luft Logistics



Bravo incorpora caminhões movidos a gás e inicia avaliação do biometano para redução da emissão de CO2



TransMaroni chega a 50 caminhões



Marfrig é mais uma grande empresa que investe em caminhão movido a gás



Loga aposta em caminhões movidos a Biometano para tornar frota mais sustentável





INDUSTRY

GEO BIO GAS&CARBON

Tamboara, PR - Brazil

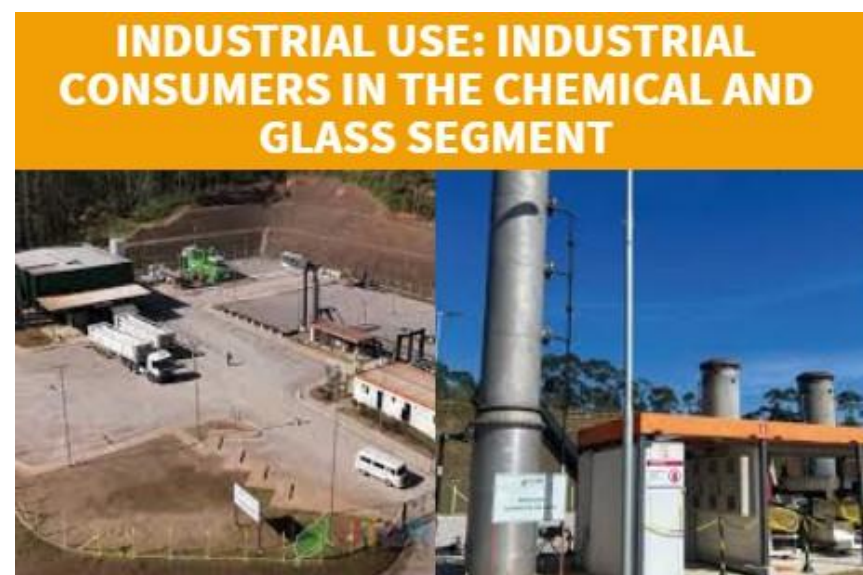


Substrate:
Agroindustry

Biogas Volume:
86,880 m³/day

ZEG BIOGÁS

São José dos Campos, SP - Brazil



Substrate:
Sanitation

Biogas Volume:
30,000 m³/day

CIRCULAR ECONOMY

BLEY ENERGIAS

Londrina, PR - Brasil

**CIRCULAR ECONOMY: TRANSPORT
OF MILK AND ANIMAL FEED**



Substrate:
Animal Manure

Biomehane Volume:
200 m³/day

ADECOAGRO

Ivinhema, MS - Brazil

**CIRCULAR ECONOMY: POWER GENERATION
AND TRANSPORTATION FUEL**



Substrate:
Sugar cane industry

Biomehane Volume:
6,600 m³/day

YARA FERTILIZANTES

Cubatão, SP - Brazil

**CIRCULAR ECONOMY: 5 THOUSAND
TONS/YEAR OF RENEWABLE AMMONIA**



Substrate:
Sugar cane industry

Biomehane Volume:
20,000 m³/day

FEDERAL REGULATORY INCENTIVES

FUELS OF THE FUTURE:

Creates of a decarbonization target that will be met through the mandatory purchase of biomethane by producers and importers of natural gas and creation of a certificate of guarantee of origin of biomethane. Decarbonization target of SAF.

MOVER:

Establishes that all government incentives must consider life cycle energy analysis when making policies to incentivize green mobility.

NATIONAL BIOFUELS POLICY - RENOVABIO:

Program that sets decarbonization goals for liquid fuel distributors, who need to acquire decarbonization credits(CBIOs) from biofuel producers.

PATEN:

Its objective is to facilitate access to credit for sustainable development projects. The program uses corporate tax credits with the federal government to finance initiatives related to the energy transition, including biogas and biomethane projects among its priority sectors.

HYDROGEN LEGAL FRAMEWORK AND INCENTIVES TO GREEN AND RENEWABLE HYDROGEN:

Regulates the production of hydrogen considered low-carbon and establishes a voluntary certification.

NEW GAS LAW:

Brought measures to opening the gas market in Brazil and establishes that biomethane that complies with ANP standardization must have equal regulatory treatment of natural gas.

NATIONAL POLICY FOR SOLID WASTE:

Established targets for improving the management of urban solid waste, including biogas production.

CARBON MARKET:

Established a regulated carbon market, creating mechanisms for the trading of carbon credits. This initiative aims to encourage the reduction of greenhouse gas emissions and promote investments in clean technologies, such as biogas and biomethane.

LAW No. 14,993/2024



Promotion of sustainable low-carbon mobility and the capture and geological storage of carbon dioxide.

National Program for Decarbonization of Natural Gas Producers and Importers and Incentive to Biomethane

GUIDELINES

I

Recognition of the use of biogas and biomethane to meet decarbonization goals.

II

Recognition of LCA as the best methodology for measuring the reduction of GHG emissions and the environmental benefits of technological routes.

GOALS

I

Stimulate the production and consumption of biomethane and biogas with projects in the production chain.

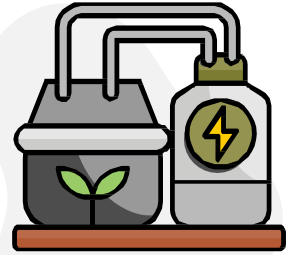
II

Encourage heavy vehicles, agricultural machinery and engine conversion to methane.

III

Promote infrastructure to connect biomethane plants to natural gas networks, with economic viability.

NATIONAL PROGRAM FOR DECARBONIZATION OF NATURAL GAS PRODUCERS AND IMPORTERS AND INCENTIVE OF BIOMETHANE



1

Decarbonization goal

CNPE defines the mandatory decarbonization target, from 1 to 10% from 2026.

DEFINITION OF THE VOLUME OF BIOMETHANE TO BE ACQUIRED

The ANP will define the volume of biomethane according to the percentage of the mandatory annual target for reducing greenhouse gas emissions in the natural gas market.

2

3

biomethane or cGOB

Natural gas producers and importers must prove decarbonization through the purchase or use of a minimum volume of biomethane or the acquisition of a Biomethane Origin Guarantee Certificate - CGOB.



cgoB marketing

The CGOB and biomethane acquired may be freely traded until their retirement by those who are interested in effectively decarbonizing, but may only be used to achieve objectives once.

4

5

cgoB negotiation

The Biomethane Origin Guarantee Certificate may be traded in organized markets, including at auctions.



CGOB REGULATION

The regulation will provide for the issuance, maturity, intermediation, custody, bookkeeping, negotiation and other aspects related to the CGOB.

6

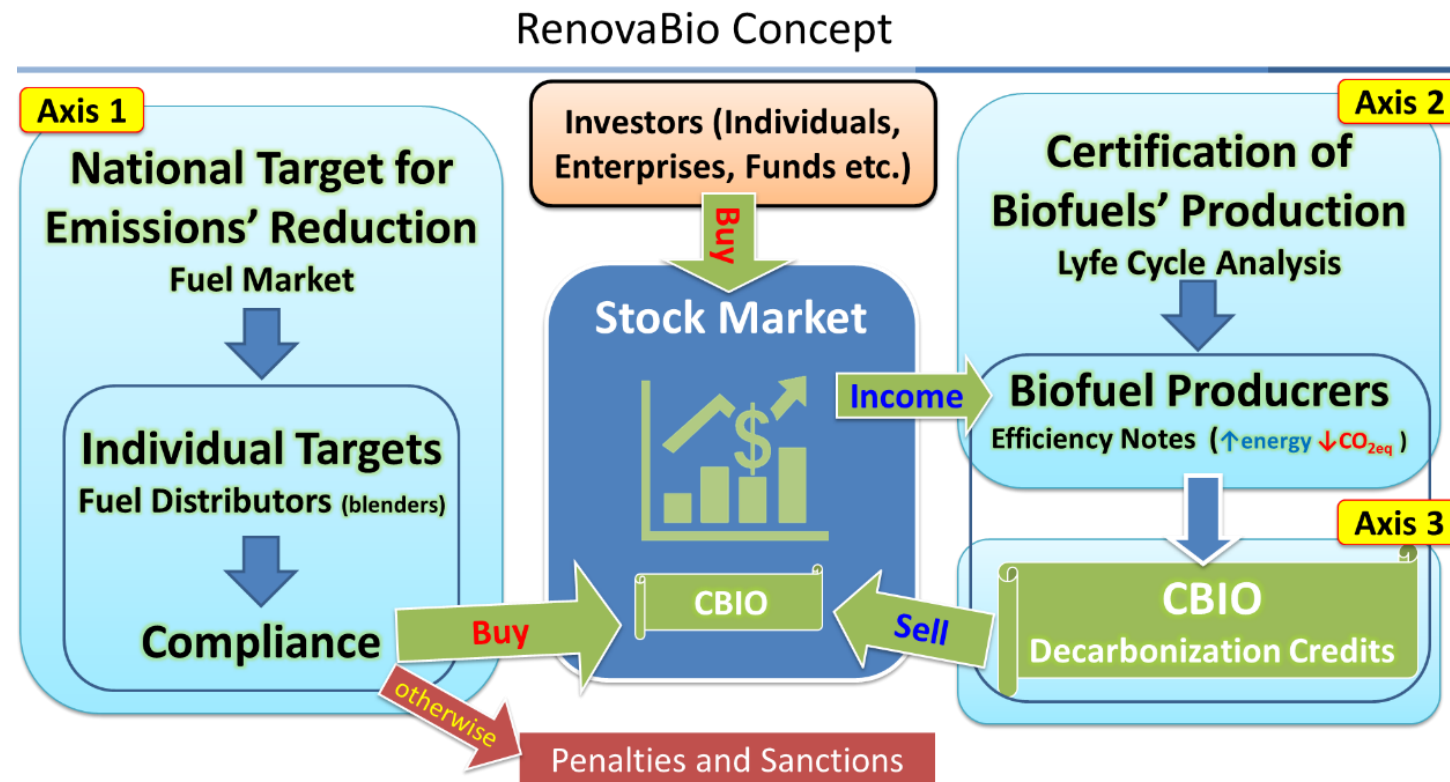


REGULATORY INCENTIVES

NATIONAL BIOFUELS POLICY - RENOVABIO: Program that sets decarbonization goals for liquid fuel distributors, who need to acquire decarbonization credits (CBIOs) from biofuel producers.

US\$ 19,30 (average value on April 12, 2024)

Since the beginning of RenovaBio, the prices of credits have ranged from US\$ 2,89 to US\$ 40,31



STATE REGULATORY INCENTIVES

GREEN SUPPLY CONTRACT:

Natural Gas distribution companies in the State of São Paulo may sign with consumers a contract that will provide biomethane to consumers, by charging an additional price.

PARANÁ RENEWABLE RURAL ENERGY - RENOVAPR:

Special financing conditions for renewable energy generation, including biogas and biomethane production.

SIMPLIFICATION OF ENVIRONMENT LICENSING BUREAUCRACY:

State of Paraná establishes different environmental licensing process according to the environment risk presented by different sizes and kinds of residues used in plants.

THE SUSTAINABLE CORRIDORS PROGRAM:

State incentives to adapt fuel stations to supply trucks with natural gas and biomethane and federal incentives for the substitution of diesel truck fleet to CNG and LNG motors.

BIOMETHANE MANDATORY MIXTURE:

State of Rio de Janeiro obliges natural gas distribution companies to have a 10% mixture of biomethane, but it sets a very low cap price for the acquisition of biomethane.

PUBLIC CALLS FOR BIOMETHANE PROCUREMENT:

In 2024, eight public calls for biomethane highlighted the sector's growth and its role in energy diversification. Initiatives in states like Alagoas, Bahia, Pernambuco, Paraná, São Paulo, and Mato Grosso do Sul are driving investment and regional integration.

TAX INCENTIVES

CONSTITUTIONAL AMENDMENT N° 123/2022

Established that taxation of biofuels and renewable hydrogen must be lower than the taxation of fossil fuels, to guarantee competitiveness.

SPECIAL REGIME OF INCENTIVES FOR INFRASTRUCTURE DEVELOPMENT (REIDI)

Reidi's tax incentive consists of suspending the incidence of contributions to PIS (1.65%) and COFINS (7.6%) on revenues arising from the acquisitions of good necessary to the construction of biogas and biomethane plants

REDUCTION OF ICMS (IVA) RATE FOR BIOGAS AND BIOMETHANE

Reduces tax rate on biogas and biomethane transactions to 12% in some states.

TAX REFORM

It simplifies taxes and strengthens the competitive advantage of biofuels, setting IBS and CBS rates at up to 60%, in relation to fossil fuels.

INCENTIVATED DEBENTURES AND BONDS

Tax reduction for renewable energy infrastructure companies that issue bonds and debentures.



ABiogás

Associação Brasileira do Biogás

Alessandro Gardemann

Chairman of the Board





Tim Hamers

Secretary General, European Renewable Gas
Registry (ERGaR)

IN COLLABORATION WITH



BIO METHANE WEBINAR

25 June 2025 Wednesday

SESSION TOPIC

Renewable Gas Certificates for
Biomethane

Global Biofuels Alliance knowledge webinar

*Renewable Gas Certificate for
biomethane*
25 June 2025

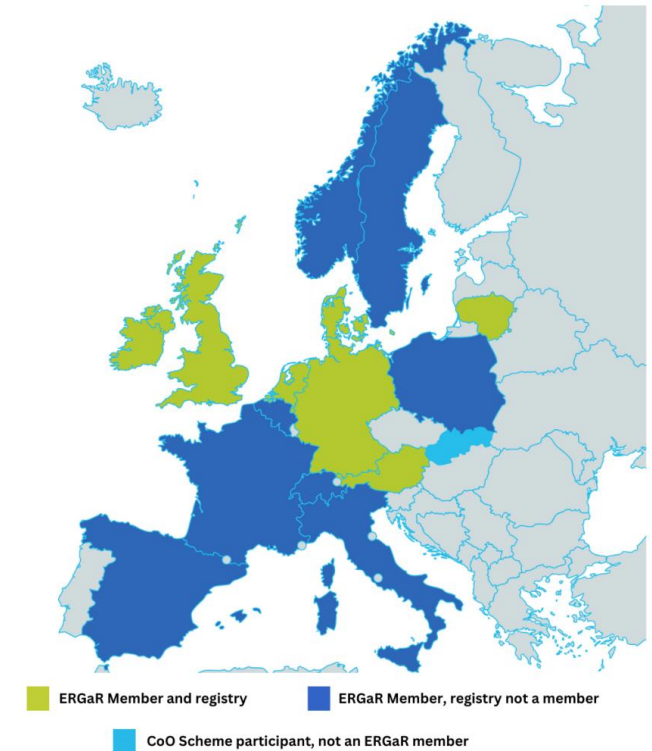


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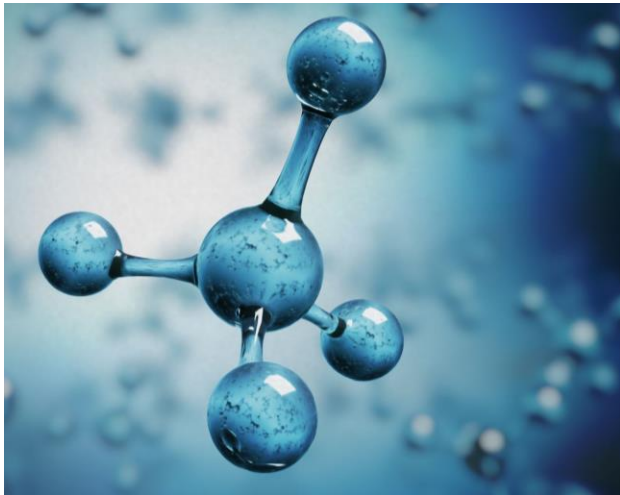
Introducing ERGaR

- ERGaR is the **European Renewable Gas Registry**
- What do we do?
 - Facilitate the cross-border transfers of renewable gas certificates (Certificates/Guarantees of Origin)
 - Provide a forum for the collaboration of renewable gas registries and market participants in Europe



Why certification?

Non-renewable methane from grid



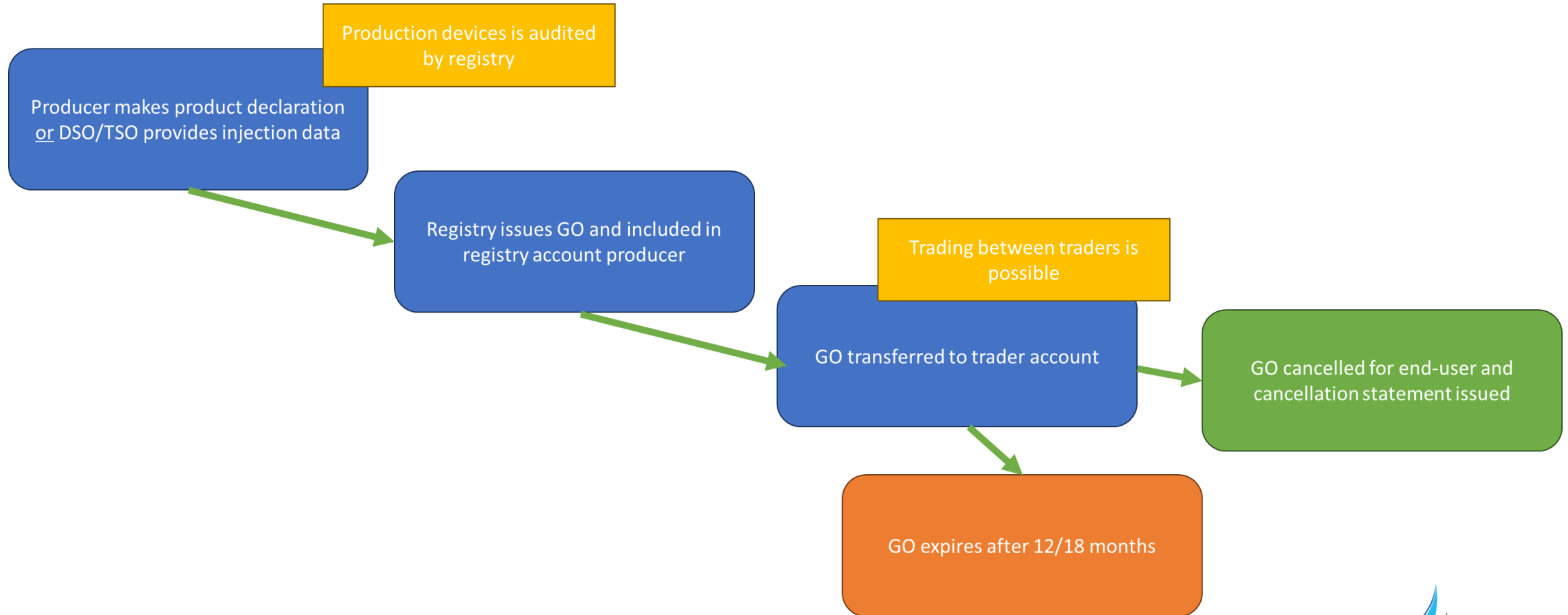
Biomethane from grid



Types of certificates

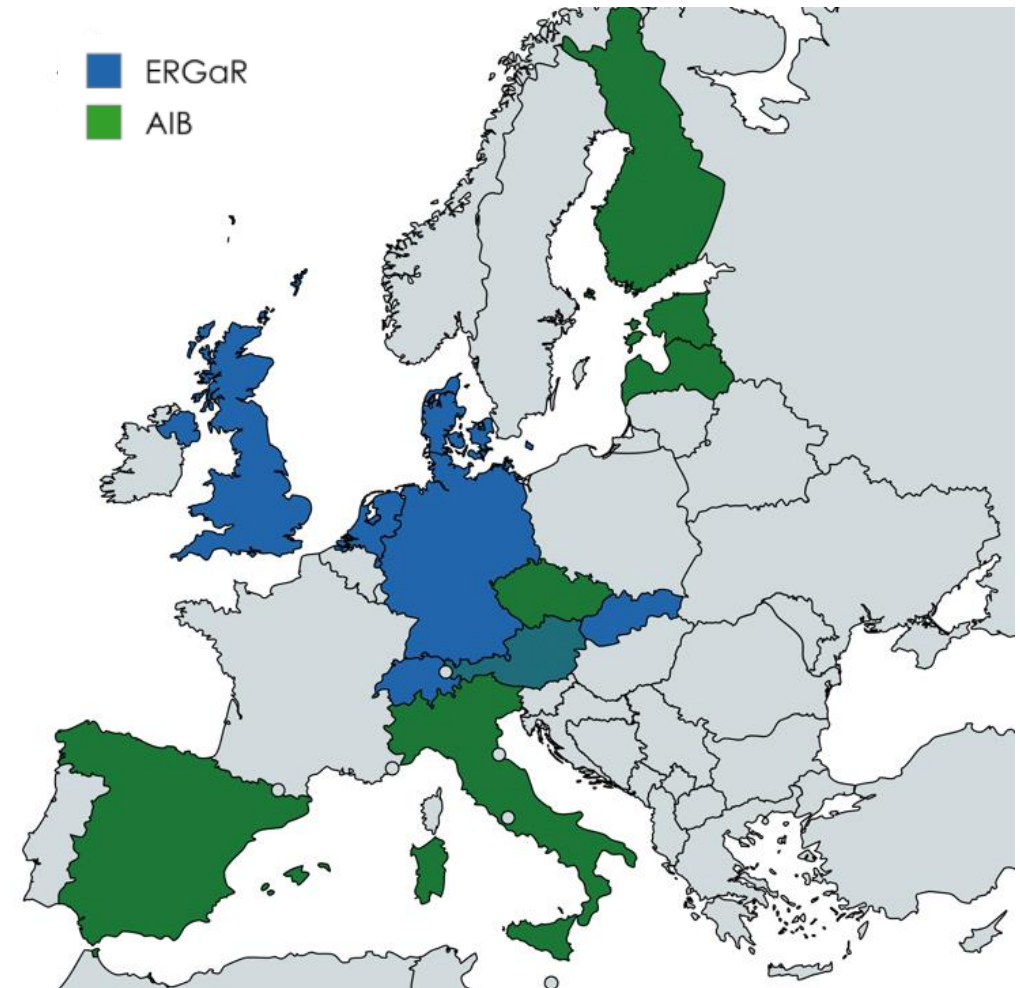
Key characteristics			
Certificates	Guarantee of Origin (GO)	Proof of Sustainability	Others (e.g. Certificate of Origin)
Legal basis	Art. 19 RED II	Art. 25-31 RED II	None, national legislation
Purpose	Consumer disclosure	Target counting	Renewable obligations, disclosure
Verification	EN 16325	Recognised voluntary schemes	National legislation
Issuing body	Government appointed	Sometimes national databases, none	Differs (e.g. dena)
System	Book & claim	Mass balancing	(Generally) book & claim

Guarantee of Origin – in practice



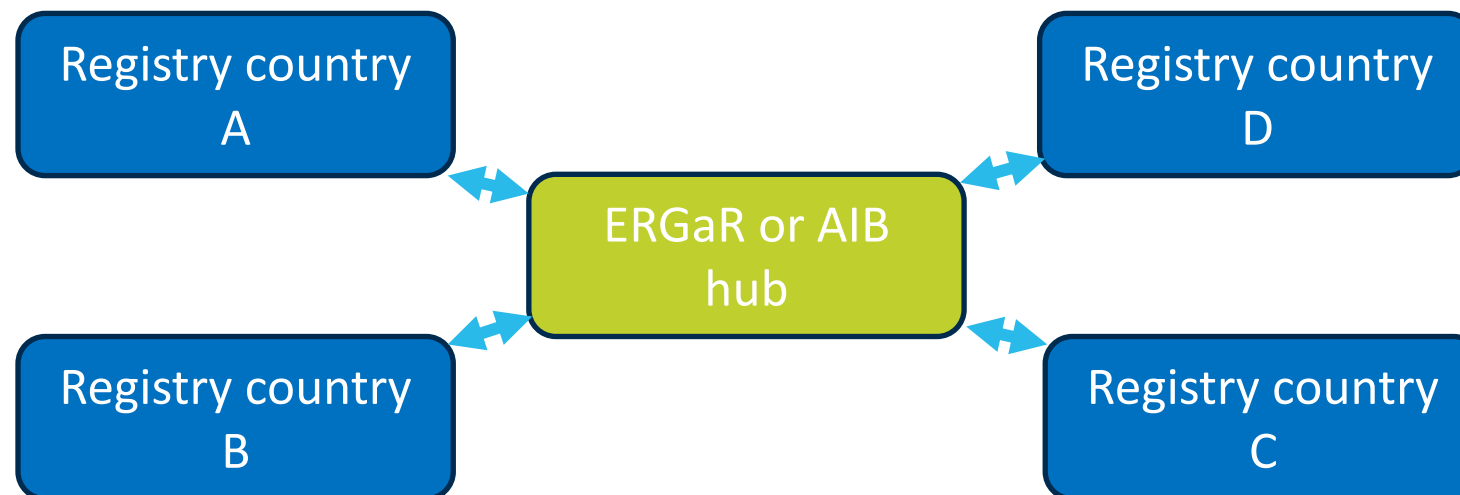
ERGaR CoO Scheme

- Launched in Q1 2021
- 7 system participants at the moment
 - Sometimes government approved (e.g. NL, DK, SK, CH) with a GO, sometimes not (e.g. DE, UK, AT) with a CoO

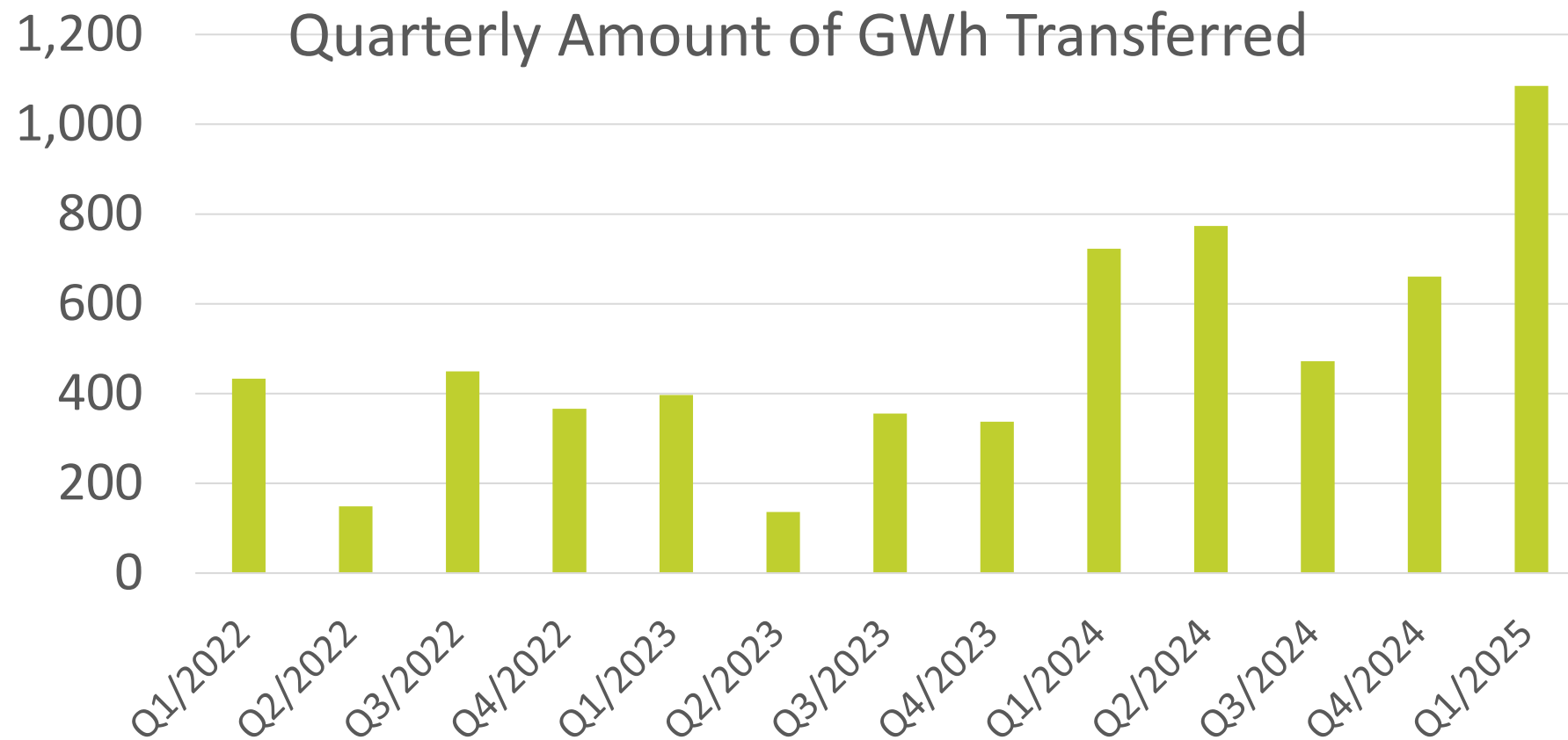


Cross-border trading GOs/COs

- Cross border trade via ERGaR or AIB for member countries
 - Easier with one centralised hub than bilateral agreements between all countries
 - Ongoing discussions on cooperation with AIB
 - AIB Gas Scheme members: Spain, Italy, Austria, Czech Republic, Latvia, Brussels & Finland



Statistics



Challenges cross-border GO trading

- No GO registry in each country
- Not all GO registries connected to same Hub
- Requires account in various GO registries

Proof of sustainability

- Document that confirms the production is sustainable according to RED II rules
- PDF document can be sent by email across all borders
 - No capacity bookings required on EU gas grid

Proof of Sustainability (PoS) for Biofuels and Bioliquids V4.2

For biofuels and bioliquids according to the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD), both amended through Directive (EU) 2015/1513

Unique Number of Sustainability Declaration:

Place and date of dispatch:

Date of issuance:

 **ISCC**
International Sustainability
to Carbon Certification
www.iscc-system.org

Supplier	Recipient
Name:	Name:
Address:	Address:
Certification System: ISCC EU	
Certificate Number:	Contract Number:

1. General information

Type of Product:

Type of Raw Material:

Additional Information (voluntary):

Country of Origin (of the raw material):

Quantity: ☐ m³ ☐ metric tons

Energy content (MJ): MJ

2. Sustainability criteria of the biomass according to Article 17 RED:

The raw material complies with the sustainability criteria according to Art. 17 (3), (4) and (5) RED¹ ☐ Yes ☐ No

The raw material meets the definition of waste or residue according to the RED, i.e. it was not intentionally produced and not intentionally modified, or contaminated, or discarded, to meet the definition of waste or residue² ☐ Yes ☐ No

3. Greenhouse Gas (GHG) Information

Total default value according to RED applied ☐ Yes ☐ No

E = Total GHG emissions from supply and use of the fuel (gCO₂eq/MJ) gCO₂eq/MJ

E = Ec + El + Ep + Etd + Eu - Esca - Eccc - Ecor - Eee = 0

GHG emission saving³:

0,0% (for biofuels 83,8 gCO₂eq/MJ) 0,0% (for heat production 77 gCO₂eq/MJ)

0,0% (for electricity production 91 gCO₂eq/MJ) 0,0% (for cogeneration 85 gCO₂eq/MJ)

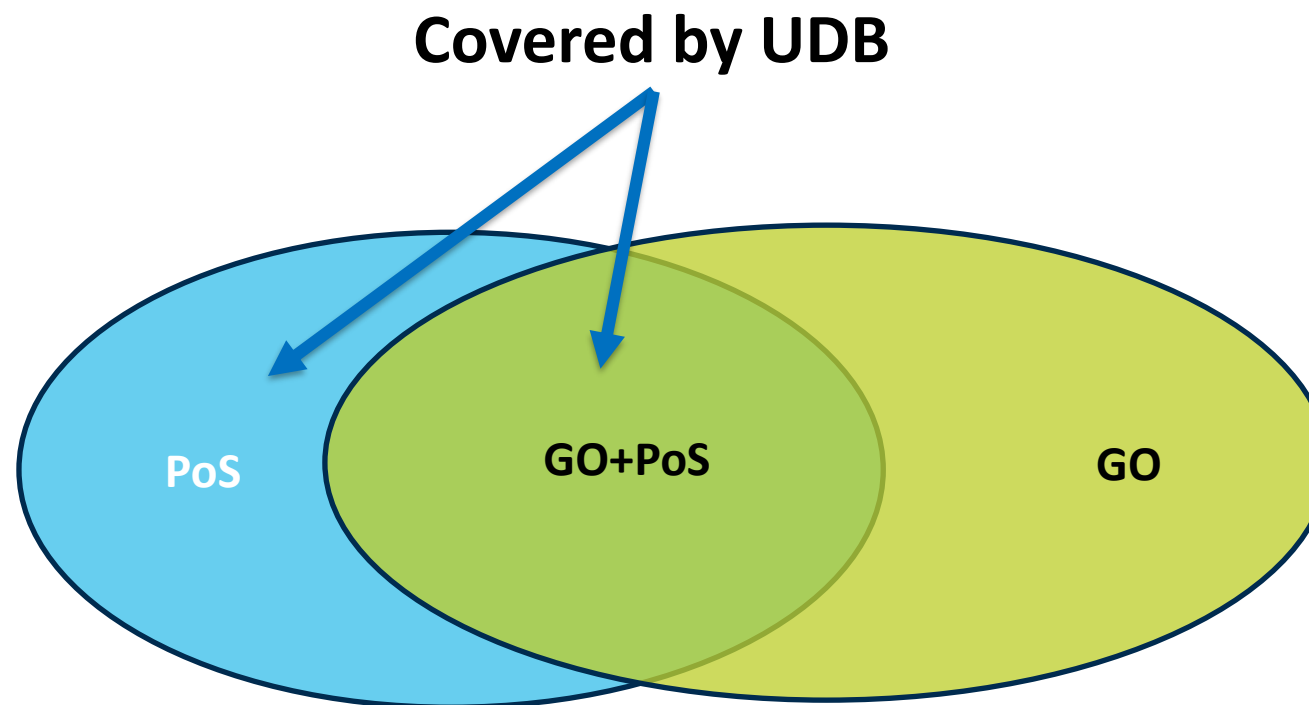
If the GHG emission savings are below 60%:
The installation where the final biofuel or bioliquid was produced started physical production of biofuels or bioliquids after 5 October 2015 ☐ Yes ☐ No

Not valid without ID number of the ISCC certificate above

Union Database

- New Union Database will replace current system of tracking and tracing ownership of PoS
 - Based on article 31a Renewable Energy Directive
 - Not a trading platform
 - Many questions still open -> **i.e. major disclaimer on presentation**

UDB scope



Impact UDB on cross-border trade

- More harmonized market for GO + PoS
- More clarity
- Problems with imports from 3rd countries

Biomethane markets

- Different use cases for biomethane (certificates)
 - Compliance markets
 - European Emission Trading Scheme (ETS)
 - Voluntary market

Biomethane compliance market

- Compliance markets (with PoS)
 - Transport sector
 - In each country based on EU Renewable Energy Directive
 - Blending obligations (e.g. Netherlands or France)
 - Certain percentage of methane/gas used needs to be biomethane
 - Starting to be implemented
 - Limits on using biomethane from abroad
 - German quotas (EEG, BeHG, etc)
 - Several types of quotas in Germany
 - Most commonly used is EEG to claim renewable energy production and increase expected for renewable heating

Biomethane ETS markets

- European Emission Trading Scheme allows use of sustainable biomethane
 - Biomethane with PoS considered zero-rated
 - According to EU guidance (MRR) PoS and GO should be used jointly to claim according to ETS
 - Differences in implementation in countries on where to send certificates or how to use subsidized biomethane
 - UDB should make this simpler

Biomethane voluntary markets

- Uncertainty on how biomethane can be used for voluntary market
 - Main guidance should come from GHG Protocol, but no clarity on how biomethane certificates can be used
 - Companies follow the GHG Protocol due to EU legislation or programme setting within SBTi
 - GHG Protocol guidance documents are currently being revised
 - Timeline: standard ready by end of 2028 with first document end of 2025
 - Depending on results GO and/or PoS can be used to reduce scope 1 and/or scope 3 emissions
 - Will have big impact on biomethane market

Biomethane support

- Biomethane market support mechanisms are different between European countries
- Support mostly needed and different in countries:
 - Investment support (e.g. Ireland)
 - Production support (e.g. France)
 - Quotas (e.g. Germany and soon Netherlands)
- Will impact price in each market with small differences in approach

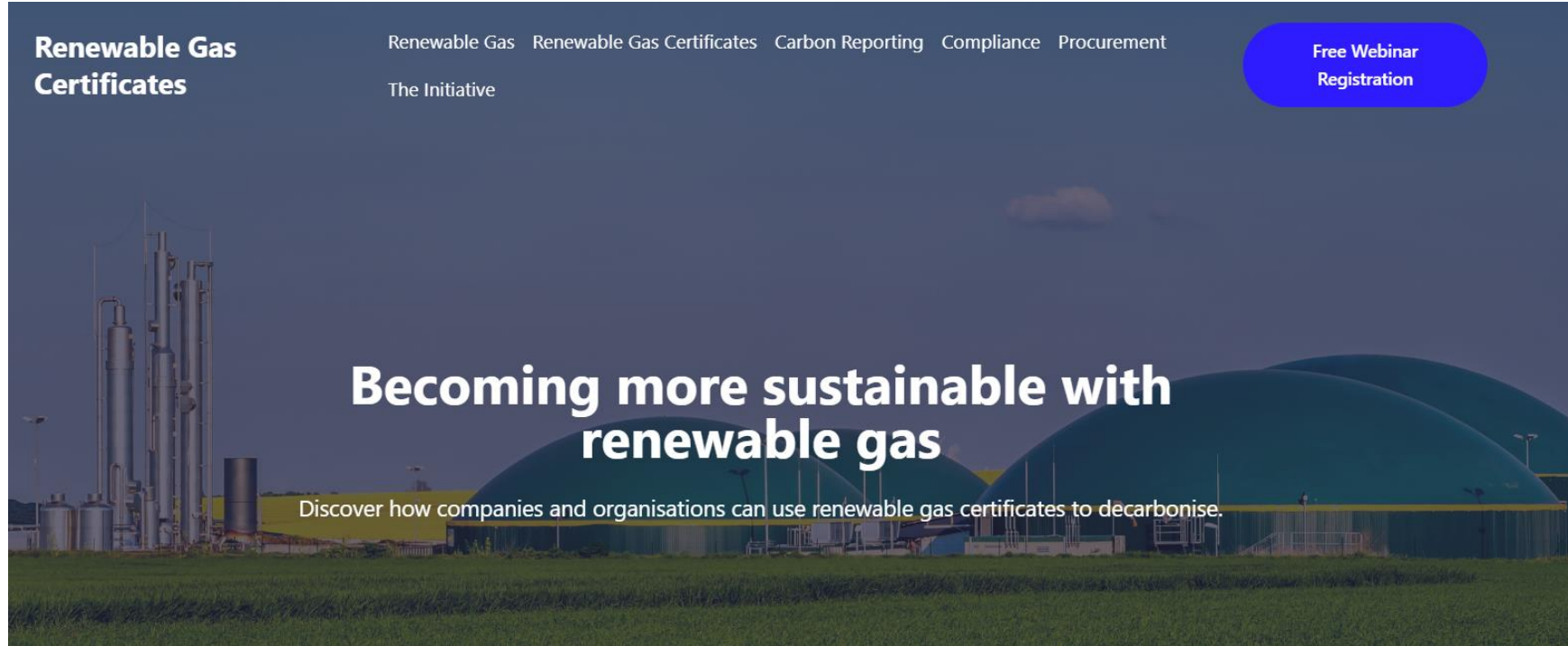
Biomethane price drivers

- Carbon intensity score (i.e. GHG emissions)
 - CI-score can be minimum threshold (e.g. German transport) or be part of total calculations (e.g. Dutch blending obligations)
 - Manure and other waste has lower CI score than crops
- Subsidised/unsubsidized biomethane
 - Depending on national rules subsidized biomethane cannot be used for transport market and/or ETS
- Guarantee of Origin – Proof of Sustainability
 - Biomethane that is considered sustainable with a PoS is higher in price
- Feedstock
 - Waste often higher price due to limitations on crop use to quality for subsidies or quotas in certain countries

Key developments expected coming years

- Continue trend of stable and significant growth
- Movement towards single European market
 - EU Union Database will create more harmonization and trust in system
 - More certificate registries connected
- Expected more voluntary demand
 - Revision GHG Protocol guides (hopefully) with more clarity on role biomethane
 - Increased interest from corporates
- Continued support systems with more attention to quotas and blending obligations

More information



www.renewablegascertificates.org

THANK YOU & STAY IN TOUCH WITH US!



<https://www.ergar.org/>



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IN COLLABORATION WITH



Dr. Archishman Bose
Professor, University College Cork (UCC)



Dr Richard O'Shea
Professor, University College Cork (UCC)

BIO METHANE WEBINAR

25 June 2025 Wednesday

SESSION TOPIC

**Innovations in Biomethane:
Insights from Research Projects**

Innovations in Biomethane: Insights from Recent Research Projects

Presenters: Dr Archishman Bose, Dr Richard O'Shea

The Biomethane Webinar
25th June 2025

HOST INSTITUTION



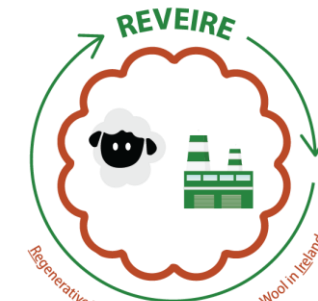
PARTNER INSTITUTIONS





Dr Richard O'Shea

- Lecturer in Sustainability in Enterprise, School of Engineering, UCC (2021- Present)
- PhD in Energy Engineering “Pathways to a biomethane industry in Ireland” (UCC, 2018)
- BE (Hons) in Energy Engineering (UCC, 2014)
- *Multiple Criteria Decision Analysis*
- *Decarbonization of industry, technoeconomic analysis*



ENTYRE
Mapping the Role of End-of-Life
Tyres for a Sustainable Circular
Economy in Ireland





Prof Jerry Murphy

Director: MaREI

Professor of Civil
Engineering



**Dr Archishman
Bose**

Bioenergy &
Biorefinery

Eli Lily Lecturer in
Process Engineering



Dr David Wall

Advanced Fuels &
Circular Economy

Senior Lecturer in
Transportation
Engineering



Dr Richard O Shea

Industrial Ecology

Lecturer in
Sustainability in
Enterprise



Dr Xue Ning



Dr Nathan Gray



Dr Deepa Sachan



Dr Soumitra Pati



Dr Yunfei Li



Dr Abdul Haq



Derek Casey



Rajas Shinde



Nikita Verma



M. Nabeel Haider



**Mohammadali
Babanejadi**



Asif Tanvir Bhuiya



Niloufar Hasanpour



Rohan Solanki



Hongkun Zhu



**Shaghayegh
Mojoodi**



Jun Ni



Matthew Carrol

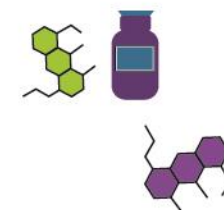


Dr Gaia Crestani

e-Fuels & e-Refineries



Refinery



Biofertilisers

Carboxylic Acids

Carbon Dioxide

Experimental Analysis



Circular Economy, Energy &
Environmental Systems

Waste Valorisation

Systems Modelling

Sustainable Technologies

Hydrogen

Methanol

Ammonia

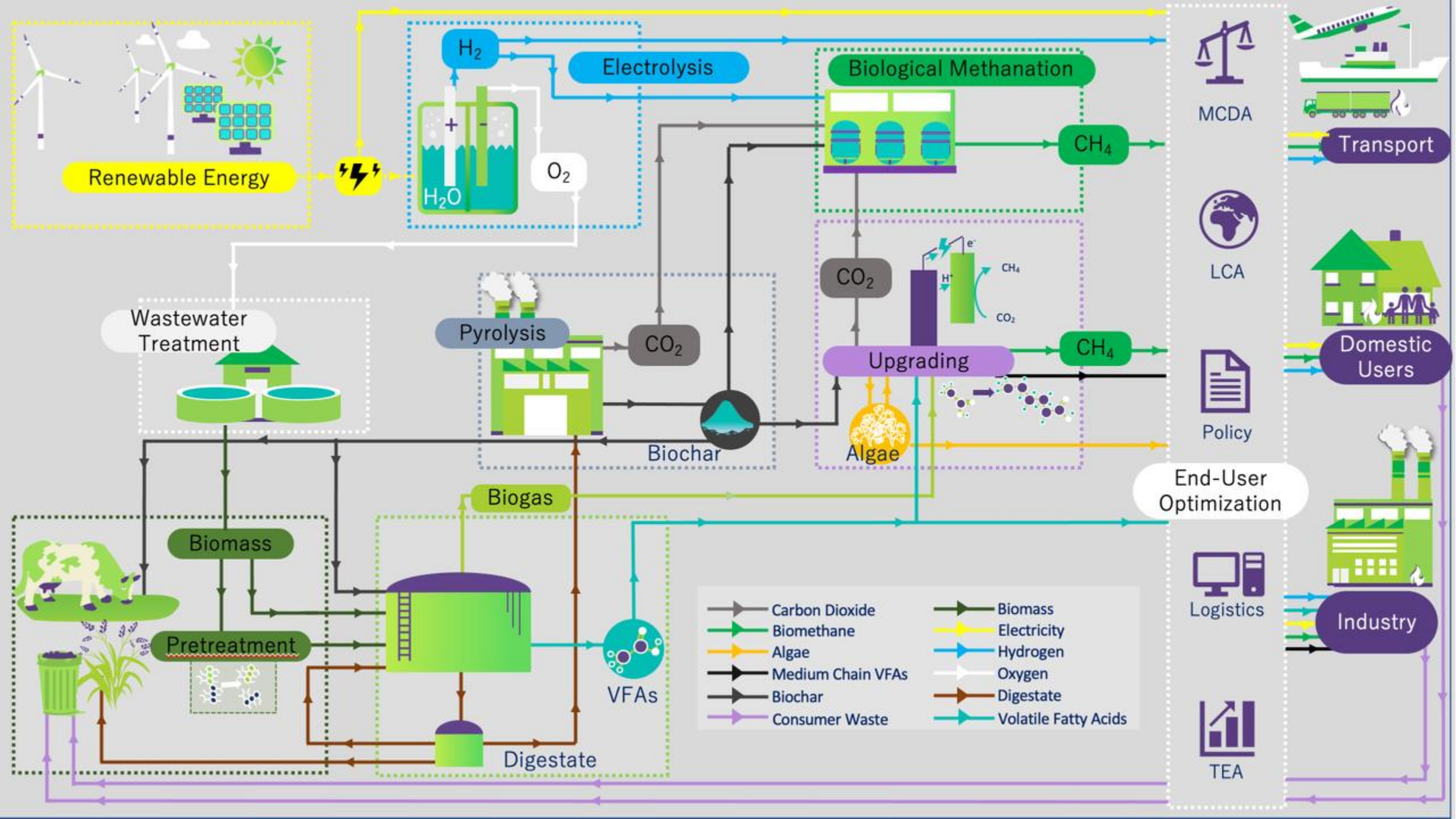
Methane

Fuels



Biofuels & Biorefineries







Prof Jerry Murphy



Dr David Wall



Dr Richen Lin



Dr Richard O Shea



Dr Xue Ning



Dr Donal O Ceileachair



Dr Jorge Diaz Huerta

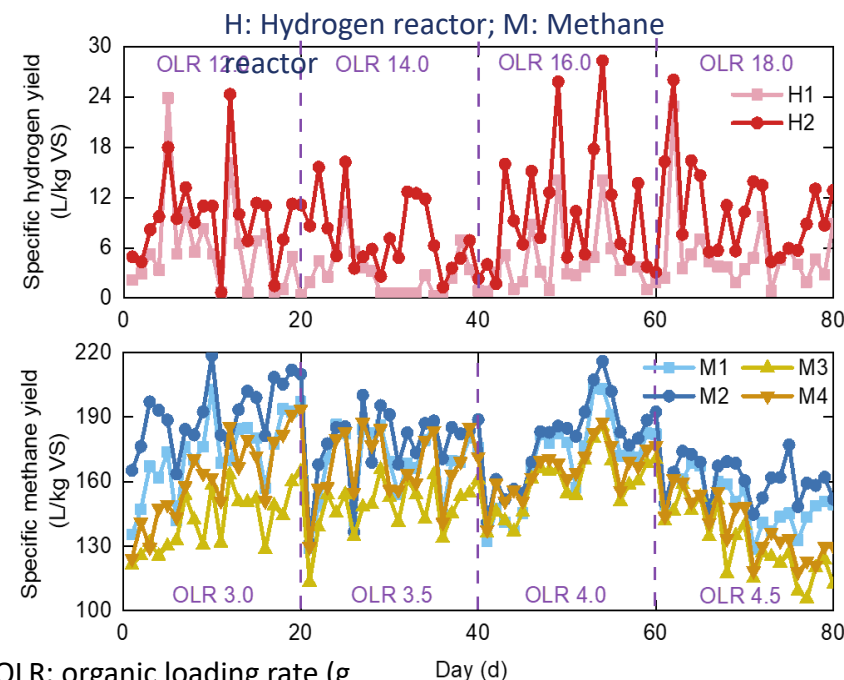
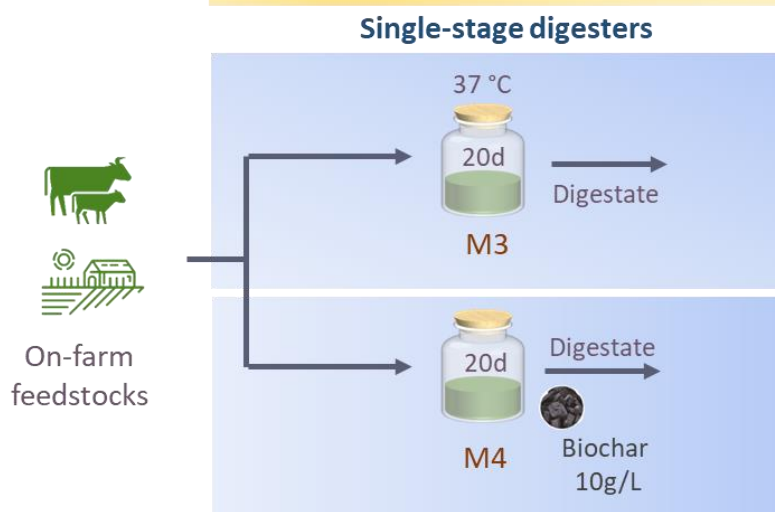
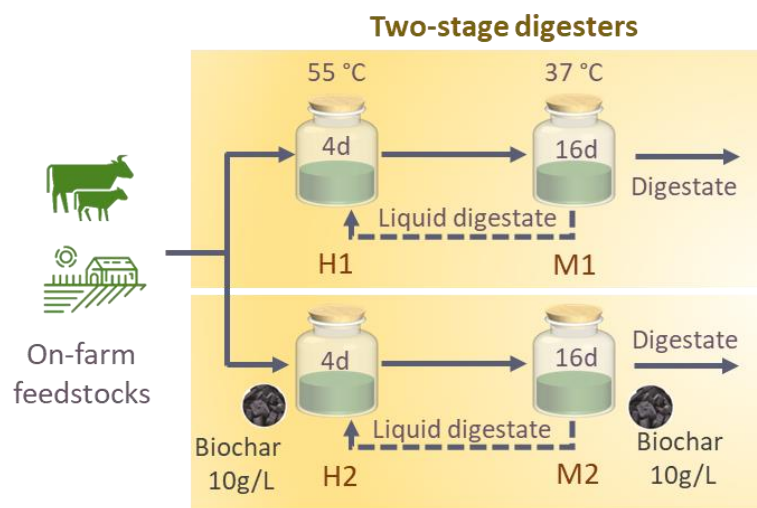
WP1: Enhance on-farm digestion efficiency through novel pre-treatments

WP2: Integration of electro-methanogenesis with anaerobic digestion to increase overall biomethane conversion

WP3: Optimising the logistics of on farm anaerobic digestion in Ireland

WP4: Techno-economic analysis of potential on-farm anaerobic digestion pathways

WP5: Management, communication, and dissemination



OLR: organic loading rate (g VS/L/day)

Biochar increased bio-hydrogen yield by 62% - 139% in two stage continuous digestion

Biochar increased biomethane yield by 3% in single stage continuous digestion, and 7% in two stage continuous digestion (OLR 4 kg VS/m³/day)

Journal of Cleaner Production
Volume 423, 15 October 2023, 138723

Improving biomethane production from biochar-supplemented two-stage anaerobic digestion of on-farm feedstocks

Xue Ning^{a,b}, Chen Deng^{a,b}, R. B. Daniel T. Hickey^{a,b}, Anna Hockley^{a,b}, Richard O'Shea^{a,b}, David M. Wall^{a,b}, Richen Lin^{a,b}, Jerry D. Murphy^{a,b}



Prof Jerry Murphy



Dr David Wall



Dr Richen Lin



Dr Richard O Shea



Dr Xue Ning



Dr Donal O Ceileachair



Dr Jorge Diaz Huerta

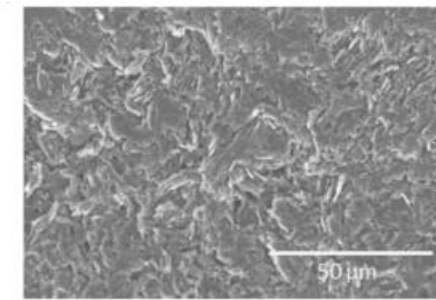
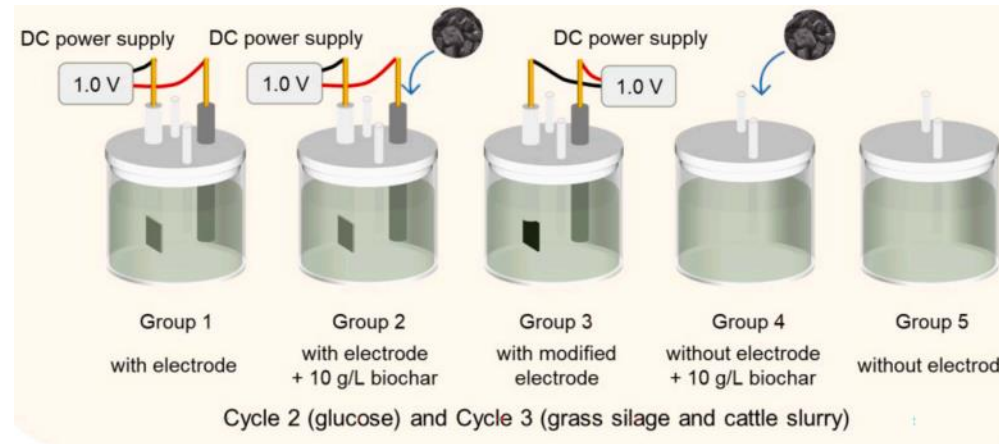
WP1: Enhance on-farm digestion efficiency through novel pre-treatments

WP2: Integration of electro-methanogenesis with anaerobic digestion to increase overall biomethane conversion

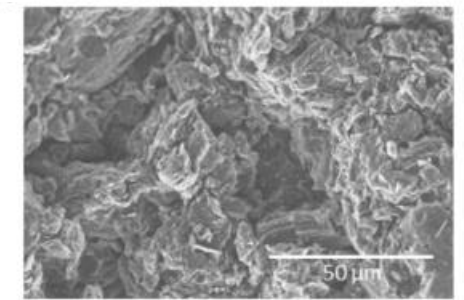
WP3: Optimising the logistics of on farm anaerobic digestion in Ireland

WP4: Techno-economic analysis of potential on-farm anaerobic digestion pathways

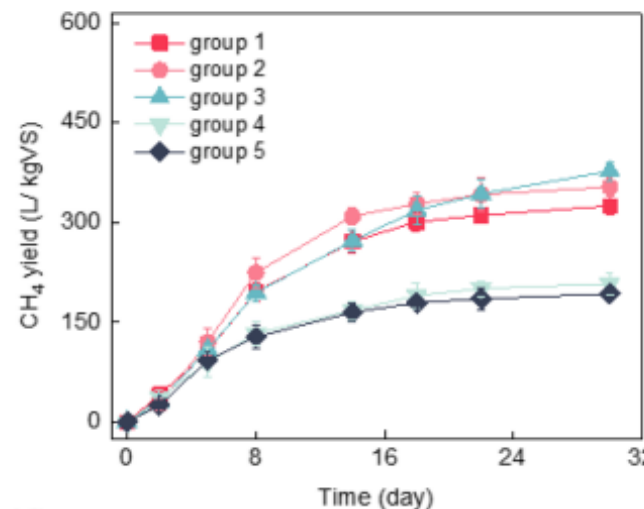
WP5: Management, communication, and dissemination



Pristine Electrode



Modified Electrode



Biochar increased biomethane yield by 7.9%

MEC-AD system increased methane yield by 96.8% and methane content by 32.5%

Proposed underlying cause: Increased VFA degradation on the anode and in-situ carbon conversion from CO_2 to CH_4 on the cathode

6.5 fold return on electrical energy input



Prof Jerry Murphy



Dr David Wall



Dr Richen Lin



Dr Richard O Shea



Dr Xue Ning



Dr Donal O Ceileachair



Dr Jorge Diaz Huerta

WP1: Enhance on-farm digestion efficiency through novel pre-treatments

WP2: Integration of electro-methanogenesis with anaerobic digestion to increase overall biomethane conversion

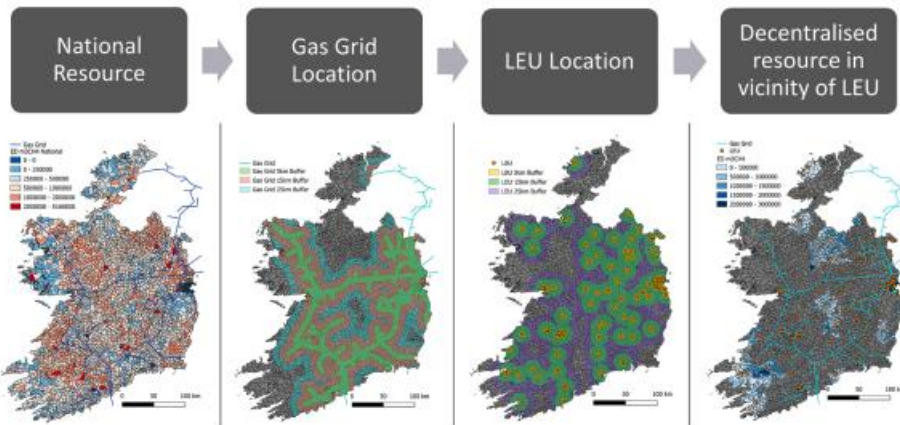
WP3: Optimising the logistics of on farm anaerobic digestion in Ireland

WP4: Techno-economic analysis of potential on-farm anaerobic digestion pathways

WP5: Management, communication, and dissemination



Alternative energy management strategies for large industry in non-gas-grid regions using on-farm biomethane

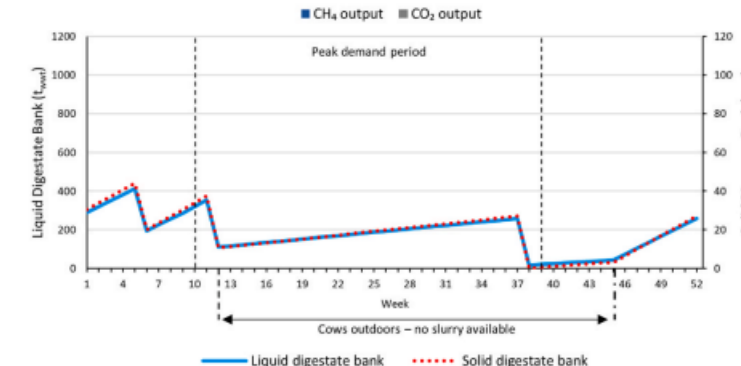
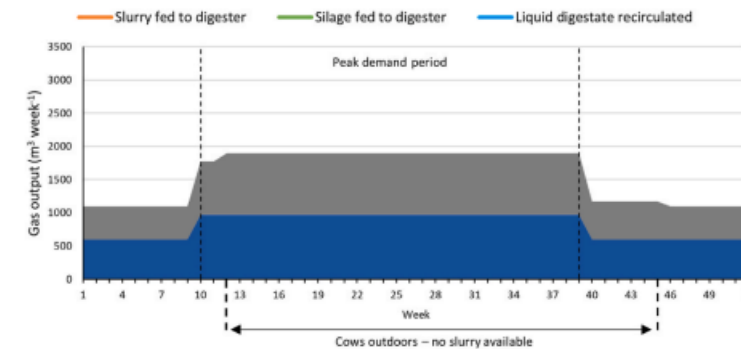
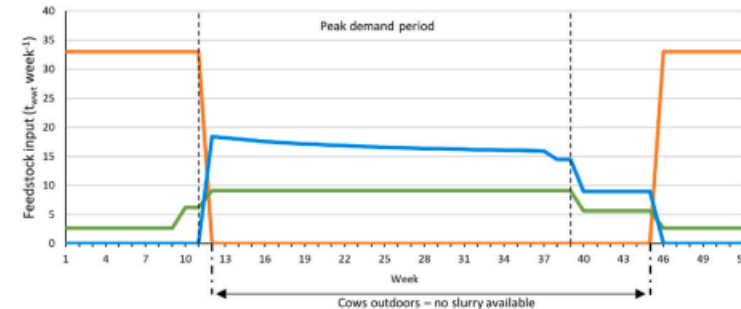


Total biomethane resource: ~67 PJ

Share of Total Resource (%)		Distance from Gas Grid (km)				
		5	10	15	20	25
Distance from Large Energy User (km)	25					11.19
	20				14.40	9.56
	15			17.31	12.28	7.87
	10		16.06	12.25	8.61	5.16
	5	9.72	7.42	5.69	3.91	2.42



The effect of seasonal biomass availability and energy demand on the operation of an on-farm biomethane plant



Supply: Zero-grazing, pasture based

Demand: Constant, Winter, Summer

- Seasonal manure availability may reduce output by 21%.
- Can reduce digester size by 6- 17%.
- If extra silage is used meeting the RED-III criteria becomes more difficult.
- Digestate recirculation is required if liquid manure is unavailable
- Seasonal gas demand may increase digester size by up to 30% compared to constant demand.



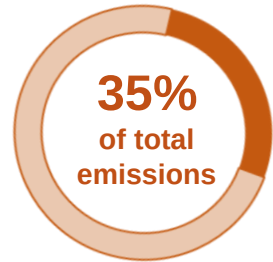
Dr David Wall



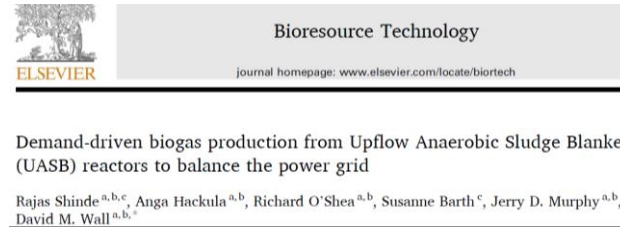
Dr Richard O Shea



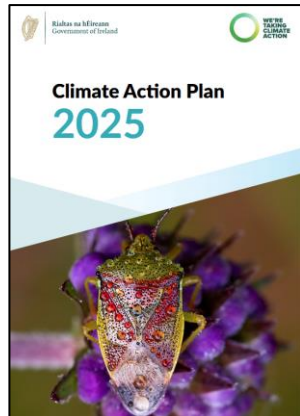
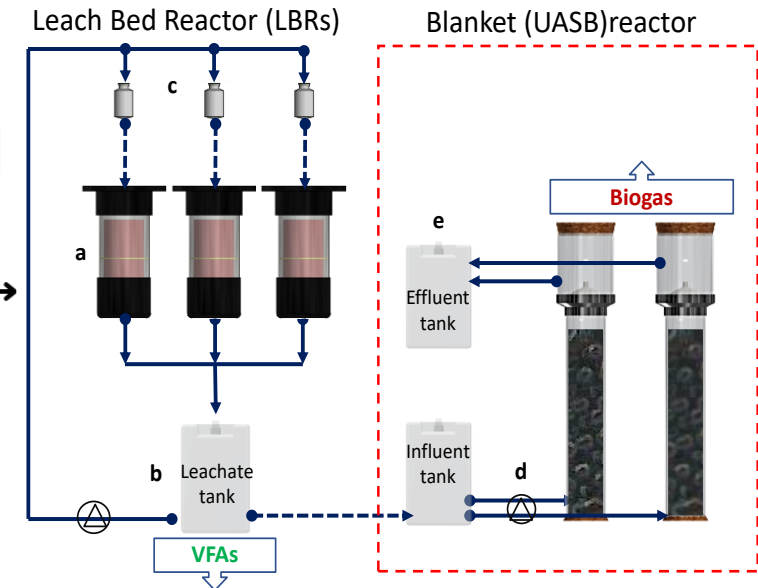
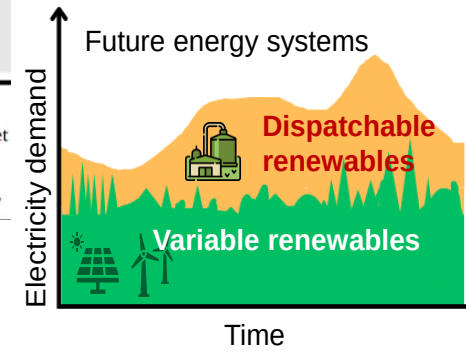
Rajas Shinde



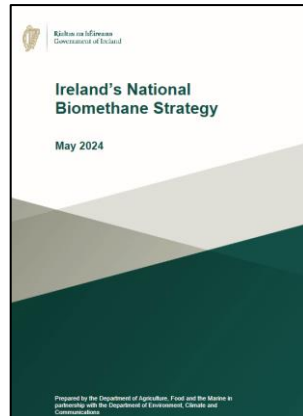
"A Dynamic Anaerobic Digestion-based Biorefinery Model to Enhance the Alternative Uses of Grass"



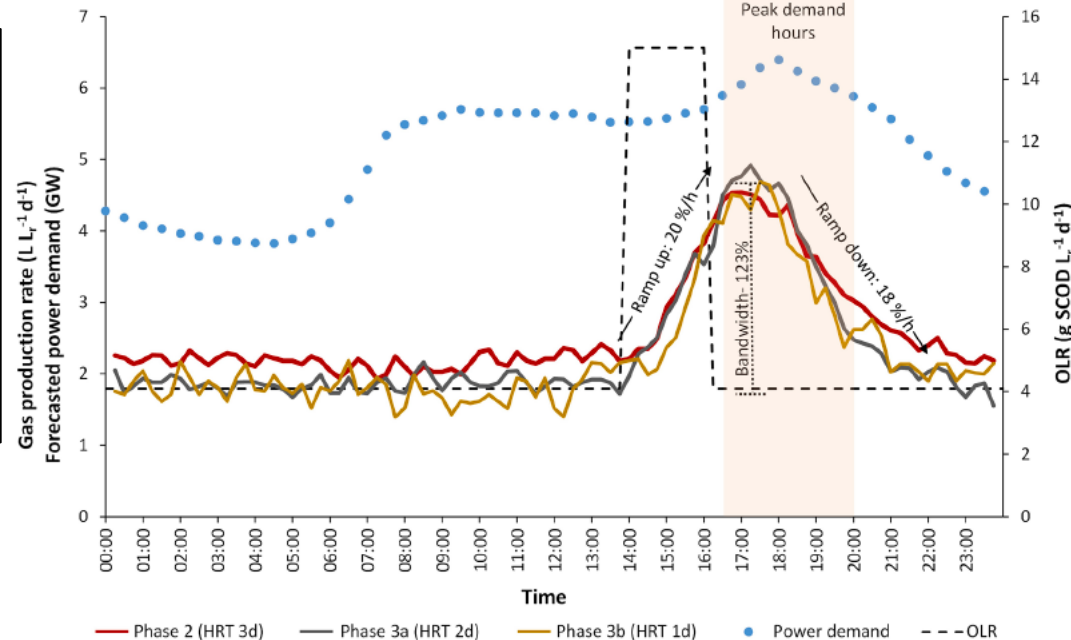
Peak OLR 2 hours before peak demand
20 %/hr ramp up
18 %/hr ramp down
123 %bandwidth
Biogas production aligned with peak electricity demand



25% reduction in agricultural emissions by 2030



5.7 TWh of biomethane by 2030



By-products: 10.3 kg per Original Litre Of Alcohol (OLA)



ACS
ENGINEERING

pubs.acs.org/engineeringau



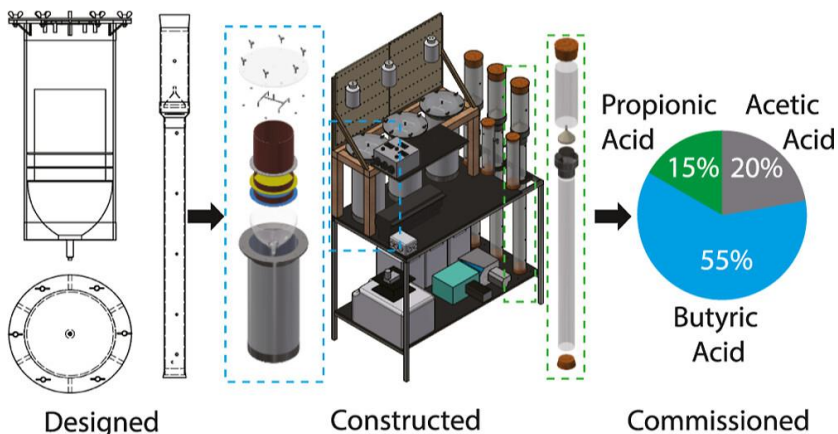
Article

Design, Construction, and Concept Validation of a Laboratory-Scale Two-phase Reactor to Valorize Whiskey Distillery By-products

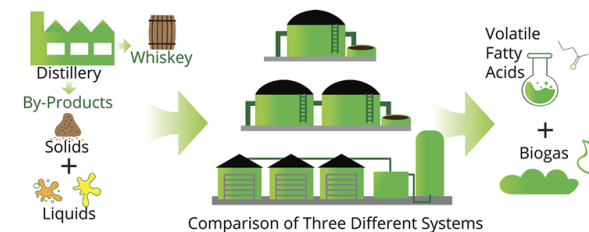
Anga Hackula, Richard O'Shea, Jerry D. Murphy, and David M. Wall*

Cite This: ACS Eng. Au 2023, 3, 224–234

Read Online



~60% of theoretical biogas output
~75% vol. methane content
~55% butyric acid
~20% acetic acid



Contents lists available at ScienceDirect
Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech



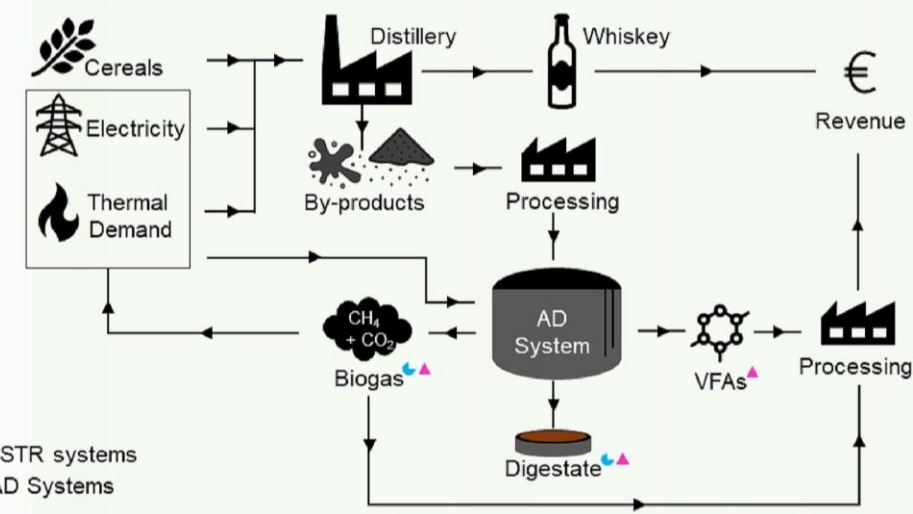
Two-phase anaerobic digestion for enhanced valorisation of whiskey distillery by-products

Anga Hackula^{a,b}, Rajas Shinde^{a,b,c}, Daniel Hickey^{a,b}, Richard O'Shea^{a,b}, Jerry D. Murphy^{a,b}, David M. Wall^{a,b}

Anaerobic
Digestion
Systems

Legend:

● : Traditional CSTR systems
▲ : Two-phase AD Systems



Similar methane yields between 3 systems assessed
Ability to replace 44% of distillery gas demand
Additional 0.14€/OLA

Prof Jerry Murphy

Dr David Wall

Dr Richard O Shea

Dr Anga Hackula



Prof Jerry Murphy



Dr Stephen Jackson



Dr Richard O Shea



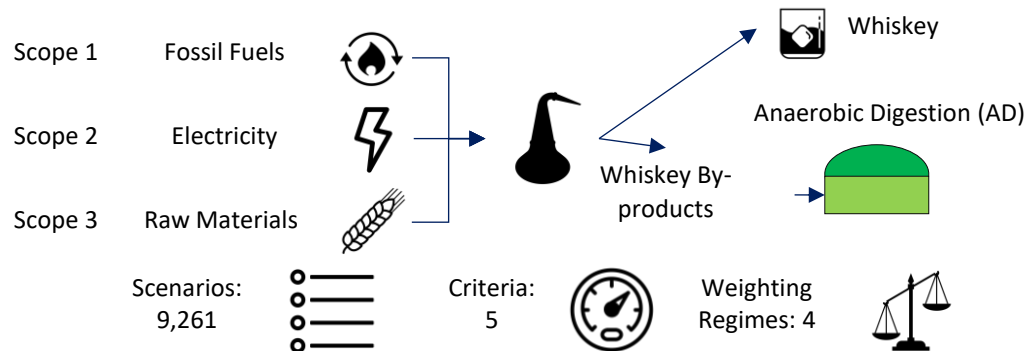
Dr Xihui Kang

Biofuel Research Journal 31 (2021) 1417-1432

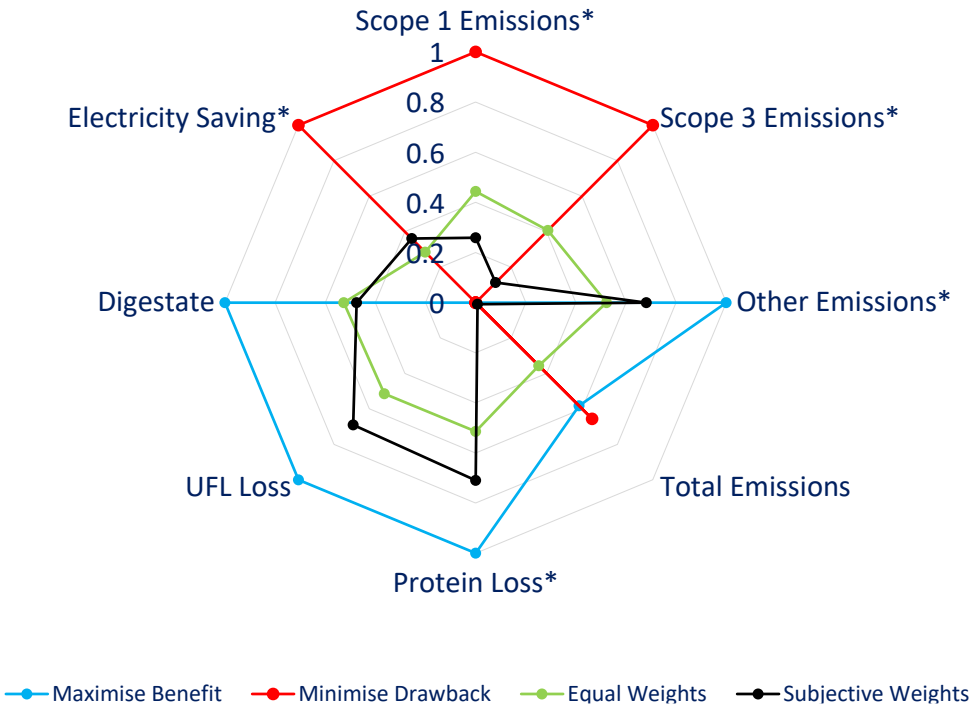


Original Research Paper

Distillery decarbonisation and anaerobic digestion: balancing benefits and drawbacks using a compromise programming approach



	Max benefit	Min drawback	Equal weights	Subjective weights
Draff (%)	100	0	50	100
Thick Stillage (%)	100	0	50	100
Thin Stillage (%)	100	0	55	0
Scope 1 Saving (%)	60	0	33	45
Scope 3 Saving (tCO ₂ eq)	11,389	0	6,748	10,105
Other emissions (ktCO ₂ eq)	38,641	0	20,165	26,315
Protein Loss (t)	13,554	0	6,974	9,618
Electricity Saving (MWh)	8,514	0	6,086	5,442



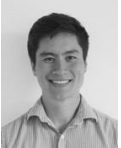
Decarbonizing whiskey production



Prof Jerry Murphy



Dr Stephen Jackson



Dr Richard O Shea



Dr Xihui Kang



Assessing decarbonisation pathways in the food and beverage sector: A multi-criteria decision analysis approach

Richard O'Shea^{a,b,*}, Richen Lin^c, David M. Wall^{a,b}, Jerry D. Murphy^{a,b}



Technologies:
5



Pathways:
21



Criteria:
5



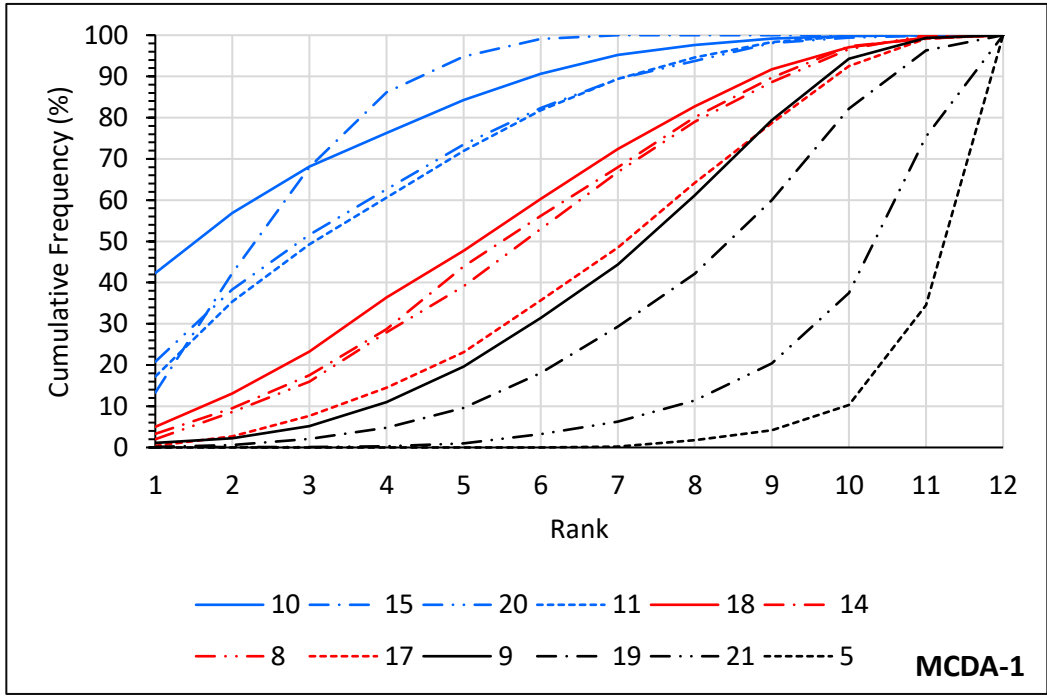
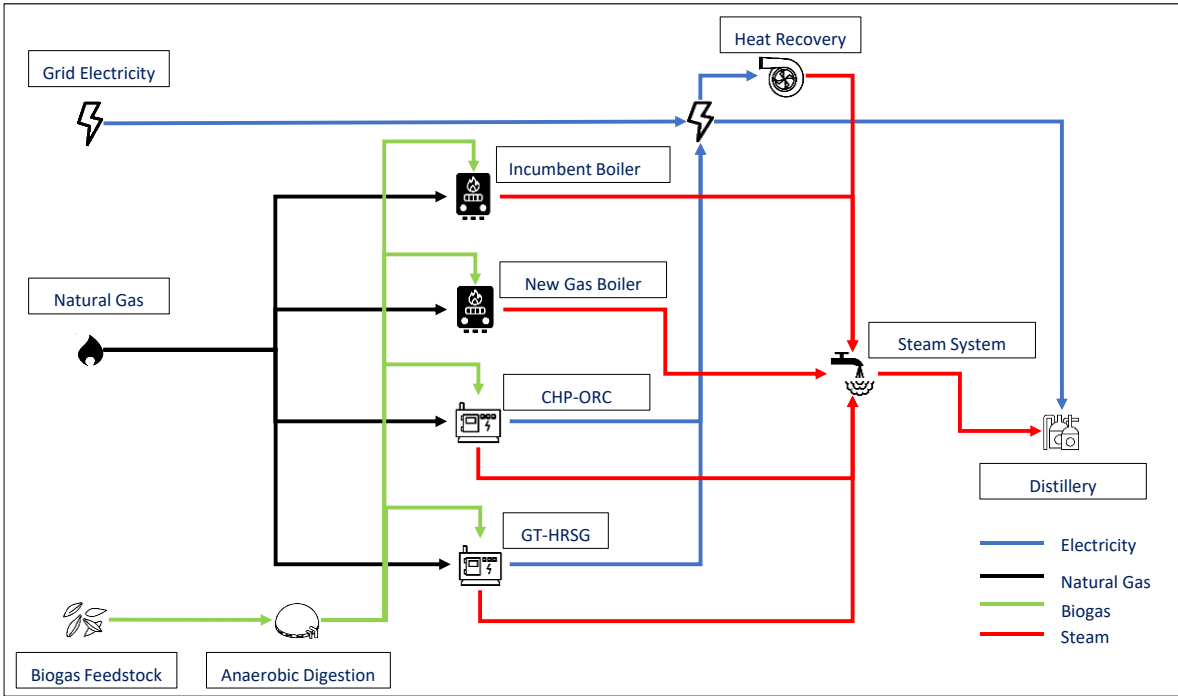
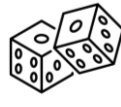
Weighting
Regimes:4



MCDAs Methods:
5



Monte Carlo
Simulations:
1,000

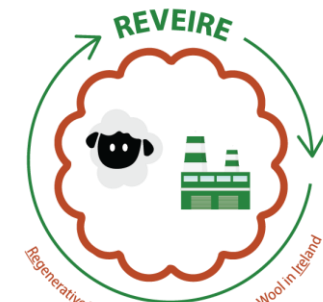


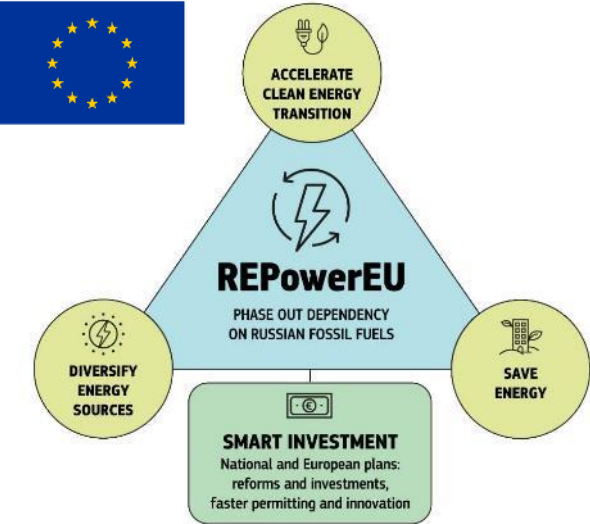
	Equal Weighting (MCDA-1)	Economic Only (MCDA-2)	Environment Only (MCDA-3)	Environment and Economy (MCDA-4)
Pathway	New Boiler & CHP-ORC & Heat Recovery	New Boiler & CHP-ORC & Heat Recovery	38kV & Heat Recovery & Biogas	New Boiler & CHP – ORC & Heat Recovery & Biogas
NPV (M€)	11.232	11.232	-15.398	-6.016
Project carbon saved (tCO ₂ eq)	342,383	342,383	780,365	765,188
LCOA (€/tCO ₂ eq)	-32.80	-32.80	19.73	7.86
Discounted payback (yr)	12.75	12.75	>20	>20
CAPEX/tCO ₂	1,524	1,524	480	932
Scope 1 emission reduction (%)	43	43	100	100



Dr Archishman Bose

- Eli Lilly Lecturer in Process and Chemical Engineering, UCC (2022)
- PhD in Engineering, focusing on Photosynthetic Biogas Upgrading, UCC (2022)
- MSc (Mechanical/Energy Engineering), KTH Royal Institute of Technology, Sweden and Politecnico di Torino, Italy (2018)
- BEng (Mechanical), Jadavpur University, Kolkata (2014)
- Program Director, MEngSc Pharmaceutical & Biopharmaceutical Engineering, UCC (2023)
- *Circular Bioeconomy and Industrial Symbiosis*
- *Process design and feasibility analyses* (technoeconomic analysis, life cycle assessment) with focus on biorefining





CLIMATE ACTION PLAN 2023
Changing Ireland for the Better



What is Sustainable Biomethane

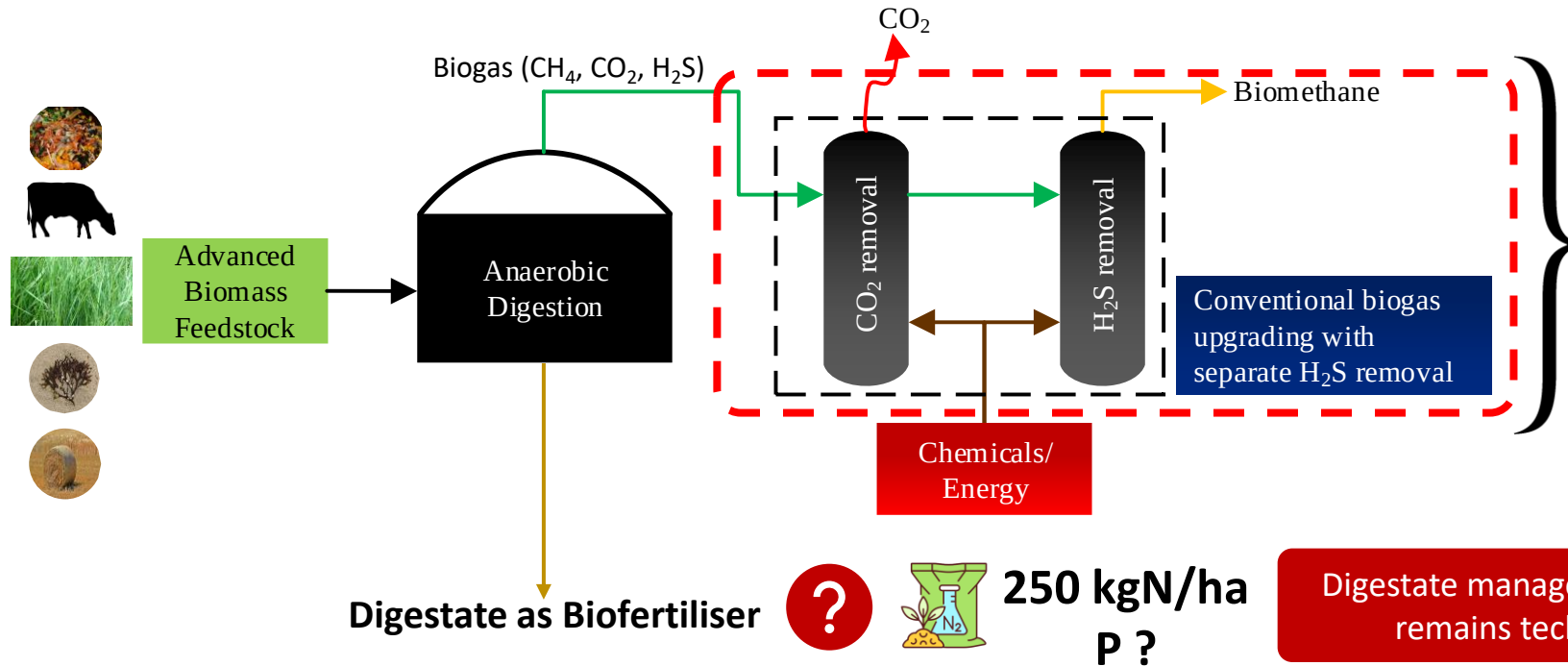


L 328/82 EN Official Journal of the European Union 21.12.2018

DIRECTIVES

DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 11 December 2018
on the promotion of the use of energy from renewable sources
(recast)
(Text with EEA relevance)

Advanced Anaerobic Digestion



Higher Cost & Energy

Problems of Scaling

Higher Marginal Abatement Costs

CO₂ released back into atmosphere

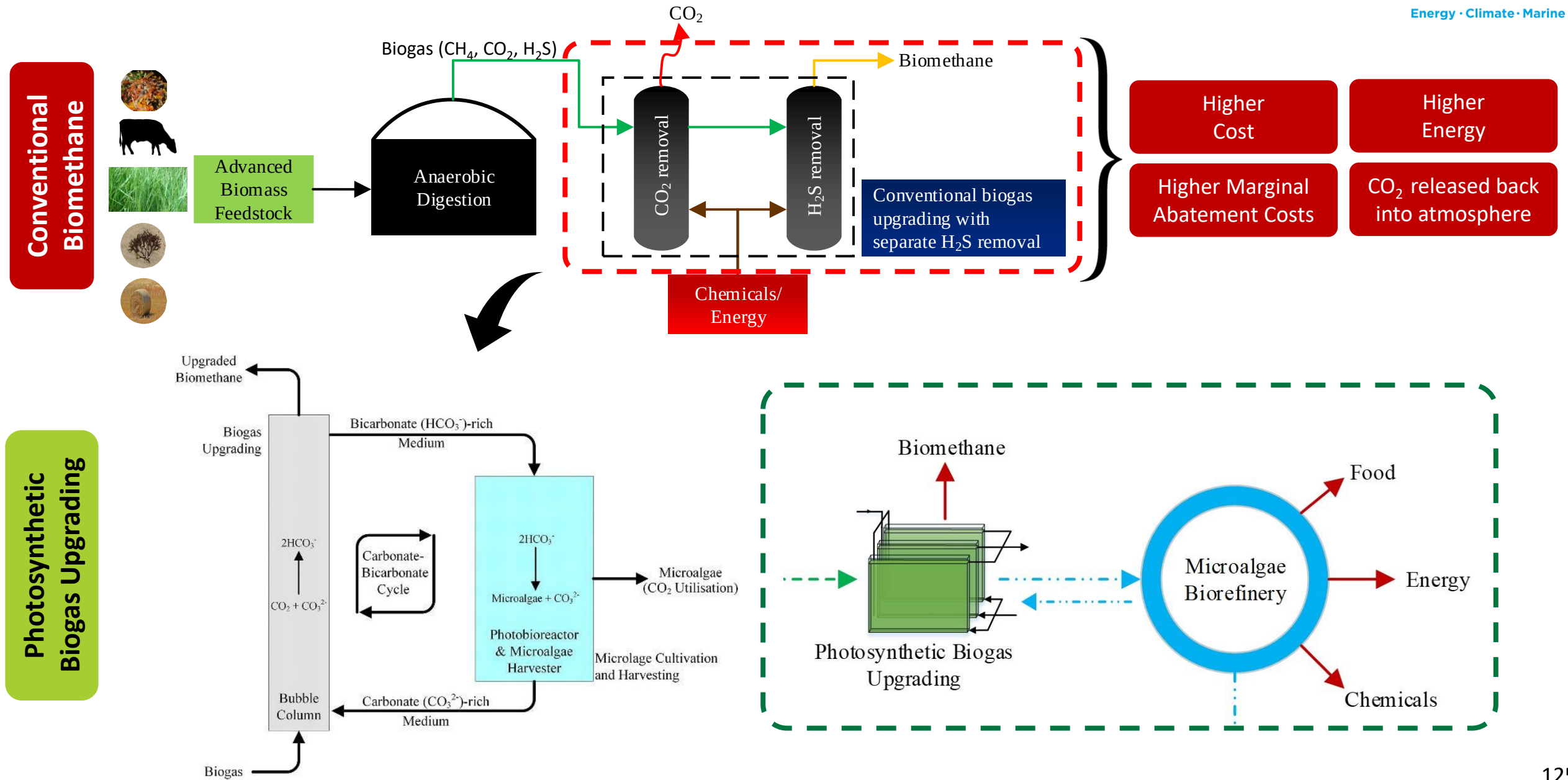
Digestate management and Land availability remains technological bottlenecks



Novel AD-Biorefineries

Need for more Sustainable Biogas Upgrading

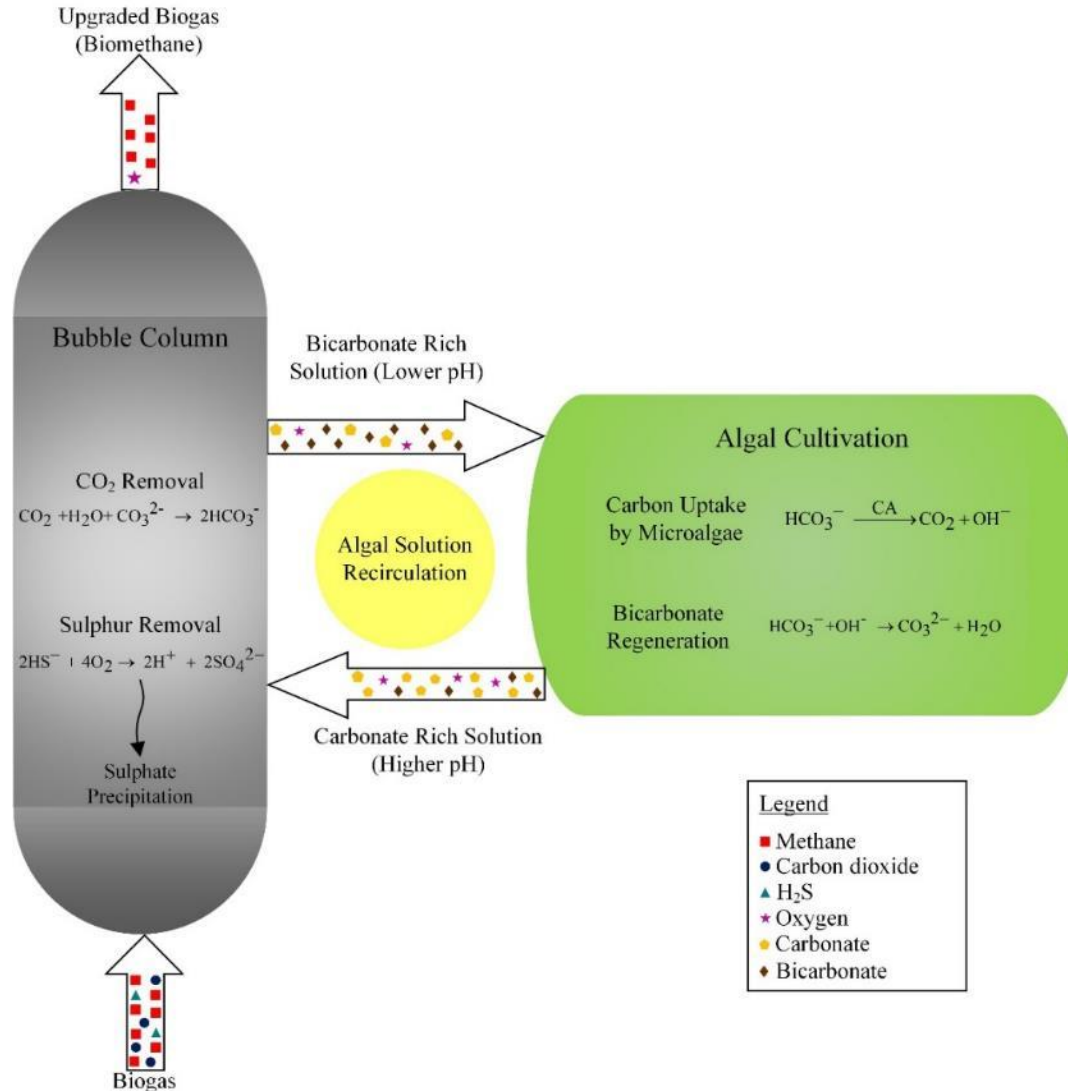
Need for alternative use of digestate



Novel Biogas Upgrading

Understanding the Process

Understanding the Process and its Opportunities



Research review paper

How to optimise photosynthetic biogas upgrading: a perspective on system design and microalgae selection

Archishman Bose^{a,b}, Richen Lin^{a,b,c}, Karthik Rajendran^{c,e}, Richard O'Shea^{a,b}, Ao Xia^d, Jerry D. Murphy^{a,b,e}

^a Environmental Research Institute, MaREI Centre, University College Cork, Cork, T23 XE10, Ireland

^b School of Engineering, University College Cork, Cork, Ireland

^c Department of Environmental Science, SEM University-AP, Amaravati, Andhra Pradesh 522 502, India

^d Key Laboratory of Low-grade Energy Utilization Technologies and Systems, Chongqing University, Chongqing 400044, China



Review

A perspective on novel cascading algal biomethane biorefinery systems

Archishman Bose^{a,b}, Richard O'Shea^{a,b,c,d}, Richen Lin^{a,b}, Jerry D. Murphy^{a,b}

Show more

<https://doi.org/10.1016/j.biortech.2020.123027>

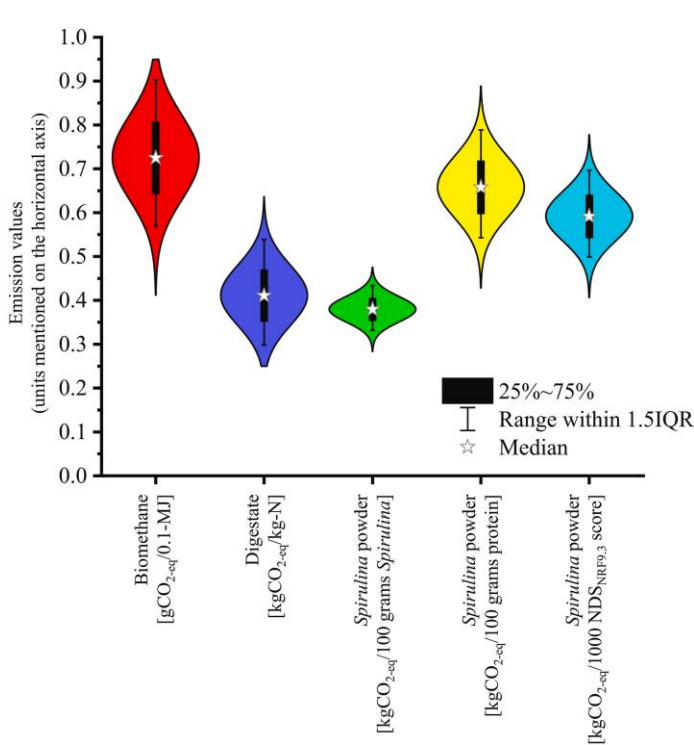
Get rights and content



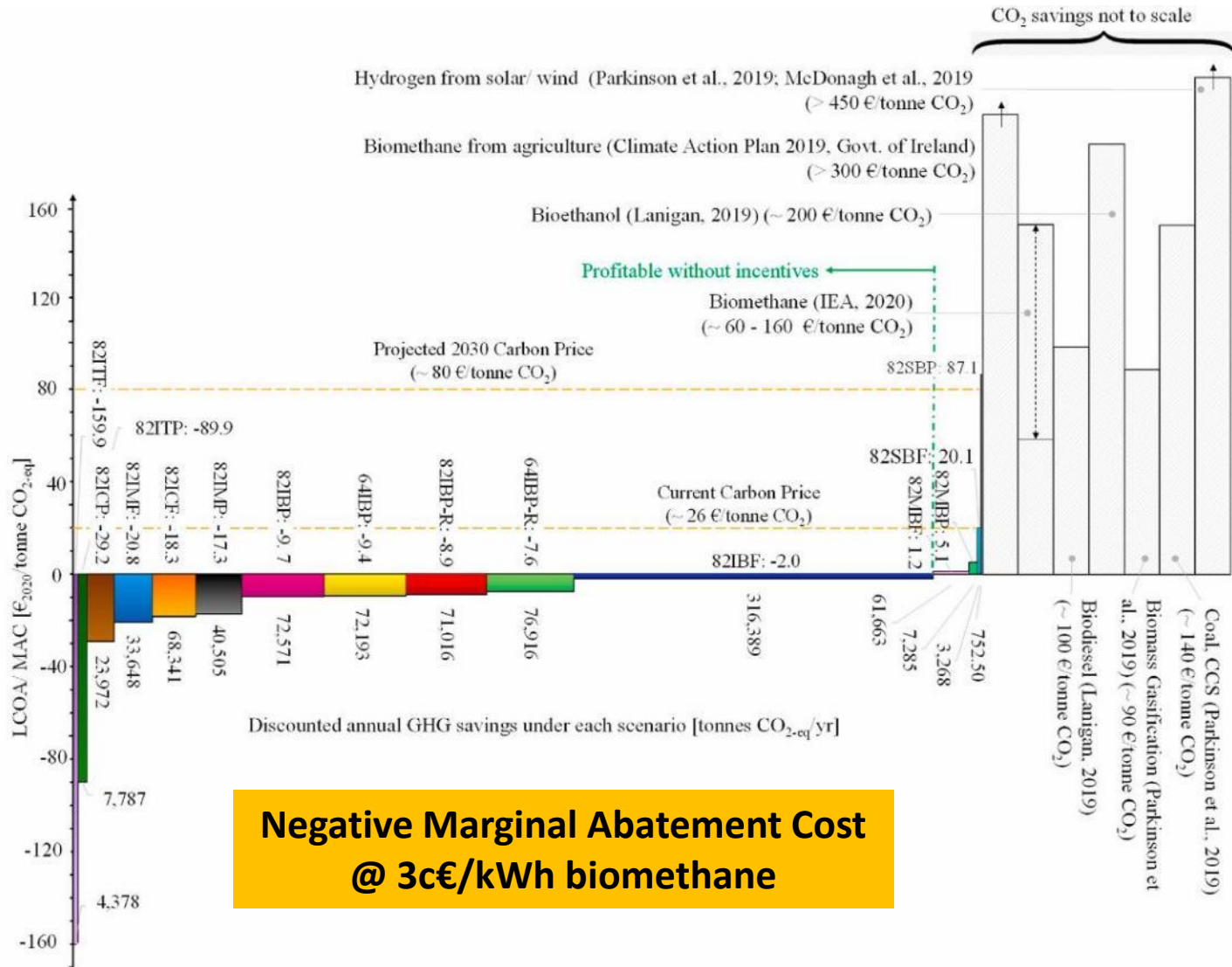
Optimisation and performance prediction of photosynthetic biogas upgrading using a bubble column

Archishman Bose^{a,b,c}, Richard O'Shea^{a,b,d}, Richen Lin^{a,b,d}, Jerry D. Murphy^{a,b,d}

Show more



**Biomethane @
< 10 gCO₂/MJ
(c. 90% emission reductio)**



**Negative Marginal Abatement Cost
@ 3c€/kWh biomethane**

4

Key Questions

?

How to optimise and scale-up the Bubble Column Reactor

?

Which local microalgae species is ideal in Ireland

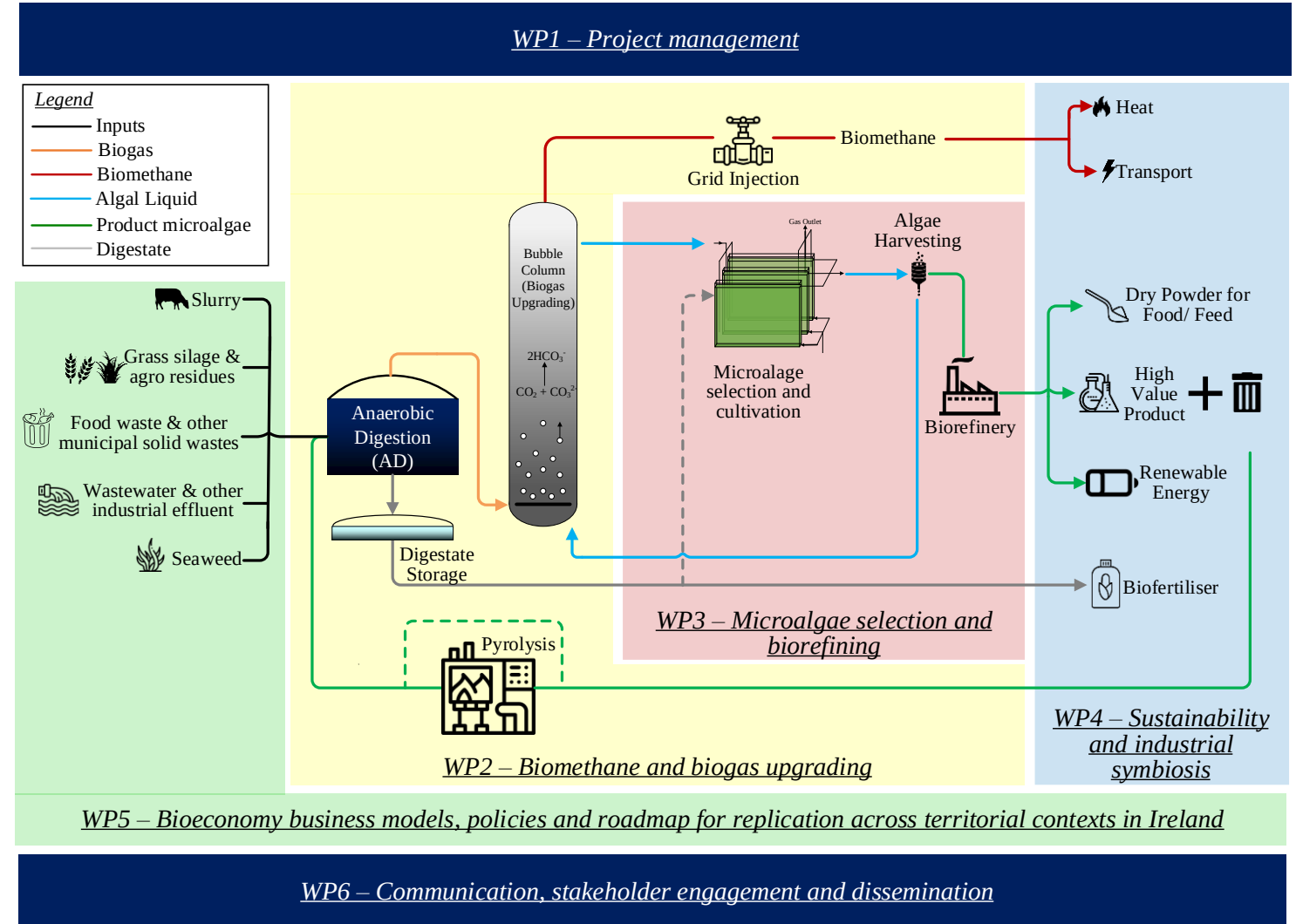
?

What product/ process configuration is optimal?

?

How to develop business models around this cascading process

Developing Cascading Biomethane Biochemicals and Biofertiliser Systems for a Circular Bioeconomy in Ireland (CABBBIE)





In practice (feasibility, acceptance, business models and scaleup)

Sustainability Assessments

NPV, IRR, E-ROI



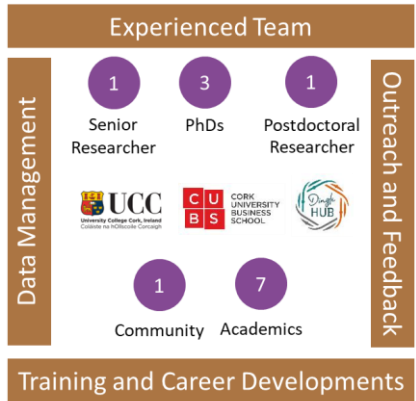
Multi Criteria Decision Analyses



Business Model Development

Demand Analysis
Financing Model
Ownership Model

Microalgae species selection



In the lab (deep science)

Scale-up via Piloting

Dissemination and Capacity Building

Policy and Roadmaps



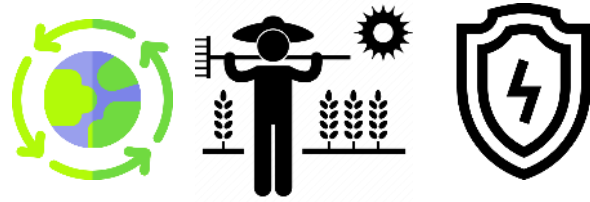
Biotechnology Advances
Volume 82, September 2025, 108581



Lab-scale optimisation

Selecting optimal algal strains for robust photosynthetic upgrading of biogas under temperate oceanic climates

Muhammad Nabeel Haider ^{a b}, Linda O'Higgins ^a, Richard O'Shea ^{a b}, Lorraine Archer ^c, David M. Wall ^{a b}, Nikita Verma ^{a b}, María del Rosario Rodero ^d, Muhammad Aamer Mehmood ^e, Jerry D. Murphy ^{a b}, Archishman Bose ^{a b} ✉



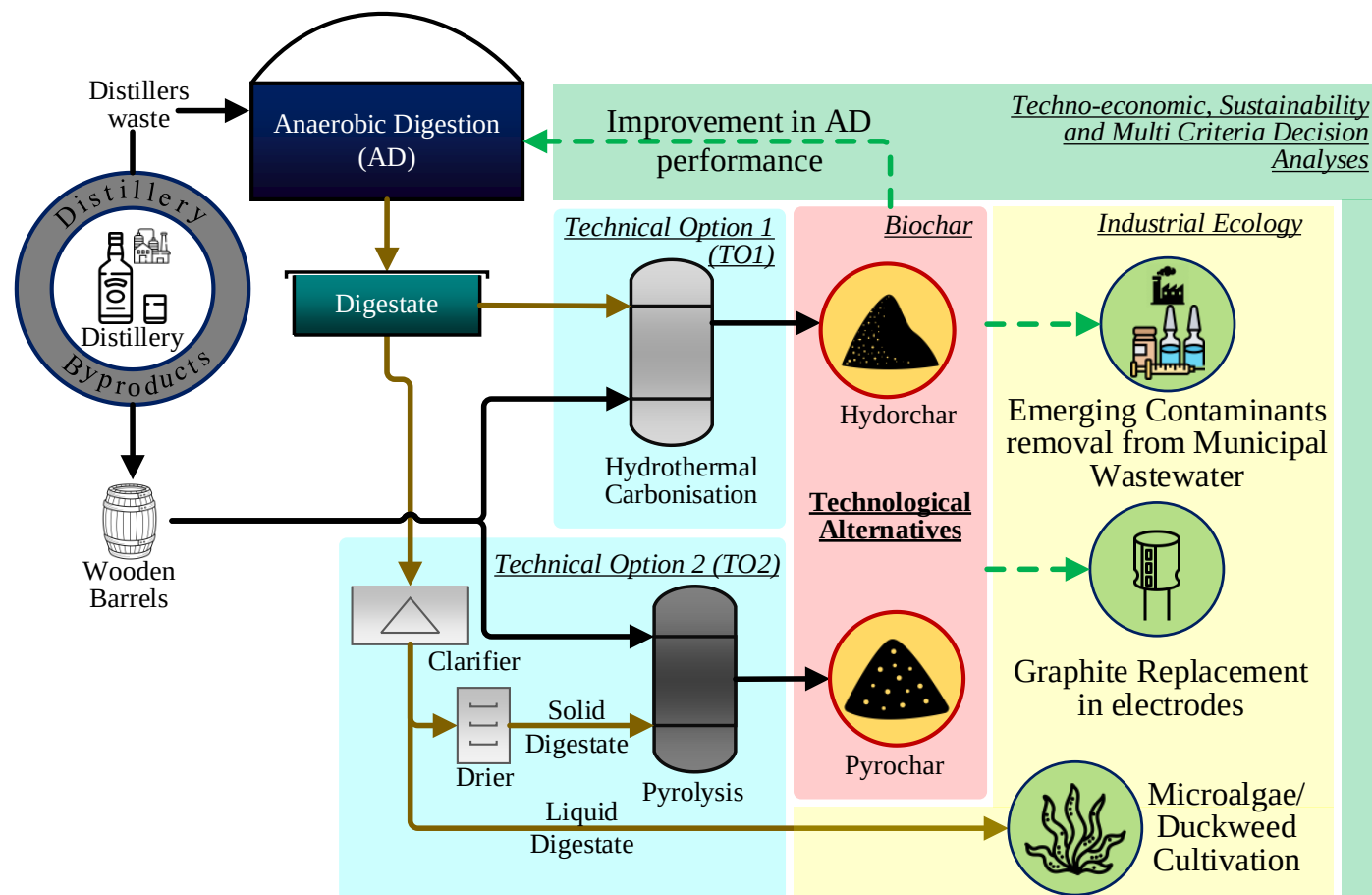


Digestate to Biochar



Engineered Organic Carbon-based
EMERGE
Functional Materials for Energy and Water

Engineered Organic Carbon-based Functional Materials for Energy and Water (EMERGE)



Distillery by-products
(consistent feedstock)



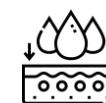
Anaerobic digestate ?



Biochar



Novel Adsorbent



Graphite Replacement





Dr Archishman Bose



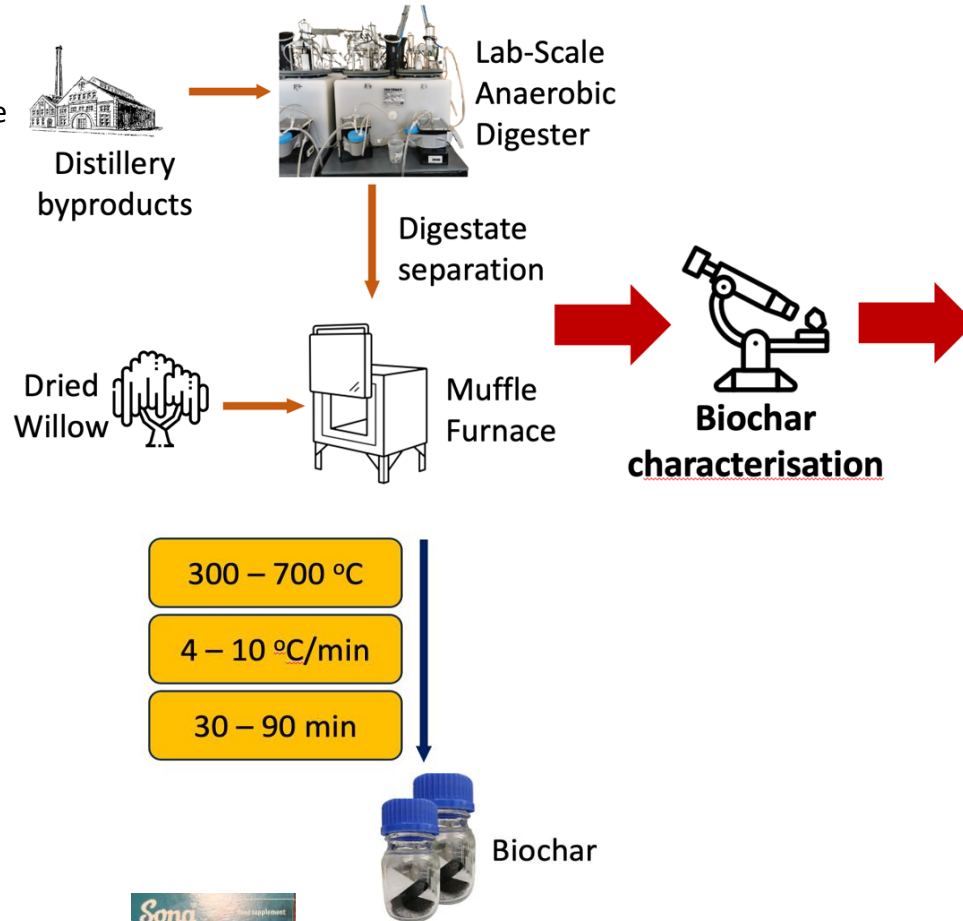
Dr Xue Ning



Dr Deepa Sachan

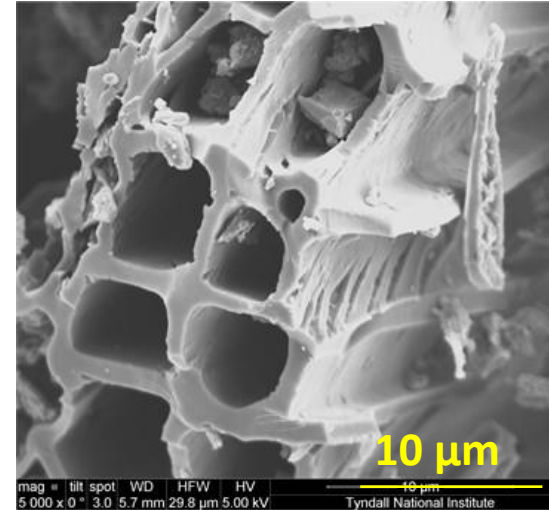


Prof Jerry Murphy
(mentor)



€16 for 12g = €1.333 M /t

Biochar at 700 °C, 90 mins



- ↑ BET surface area **54.4m²/g**
- ↑ High Conductivity **23.6 µS/cm**
- ↑ Surface Morphology & Functional Groups
- ! Large Variation within batches!

Acid-Treated Biochar

- ↗ BET Surface Area **391.5 m²/g (7-fold increase)**
- ↗ Conductivity **44.5 µS/cm g (2-fold increase)**
- ↗ Improved Consistency



Tube Furnace



Muffle Furnace



Microwave Digester



**Surface Area
Analyser**

Lab-scale
experiments

Characterisation of
biochar

Optimisation of
operations

Mapping Pathways
for Scale-up



**BET Surface Area and Pore
Volume Analyser**



FTIR



Scanning Electron Microscopy



Xray Diffractometry

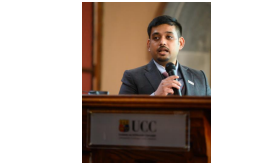


Raman Spectroscopy



**EDX (Energy-Dispersive X-
ray analysis)**

Can Biochar Remove Emerging Contaminants?



Dr Archishman Bose



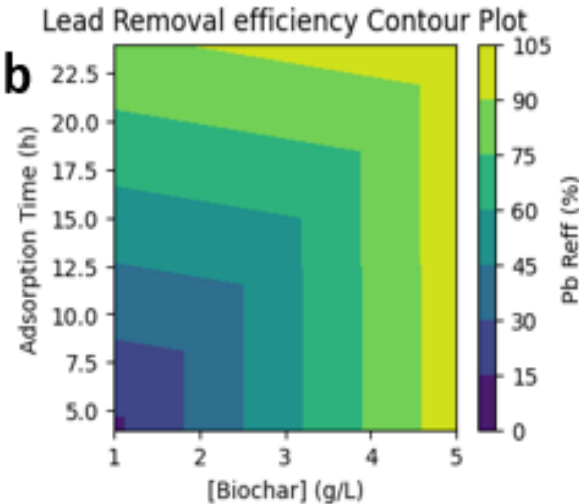
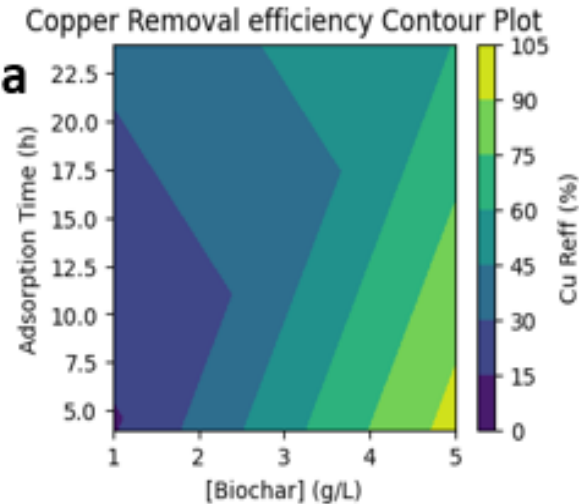
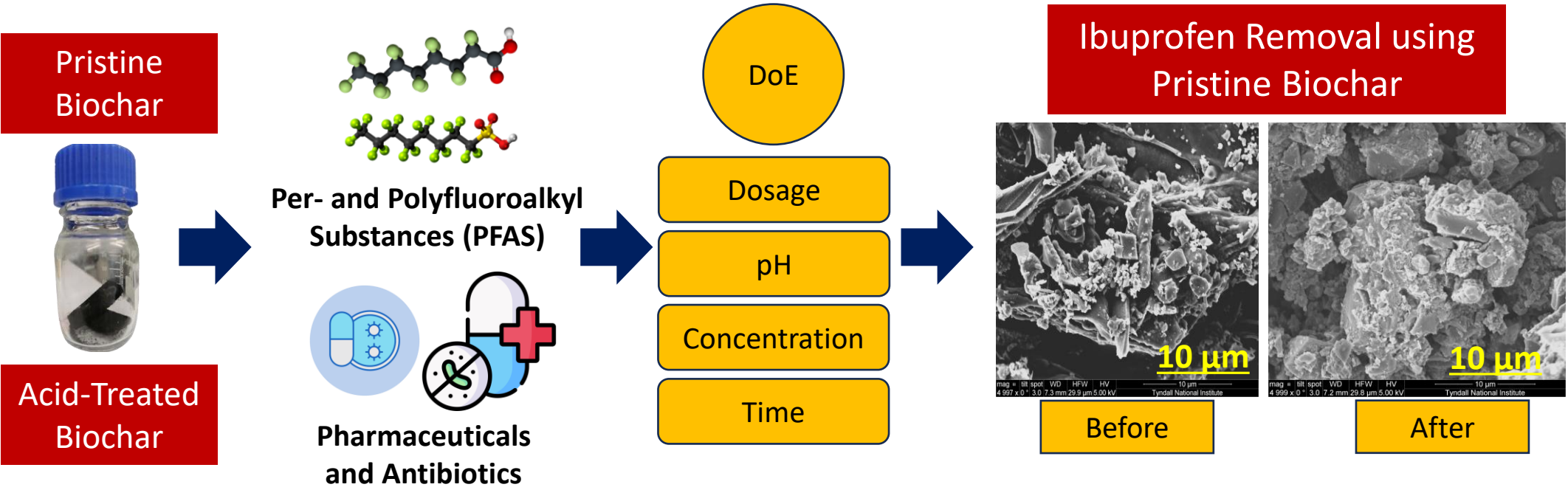
Dr Xue Ning



Dr Deepa Sachan

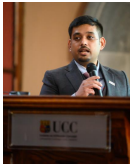


Prof Jerry Murphy
(mentor)





Dr Xue Ning



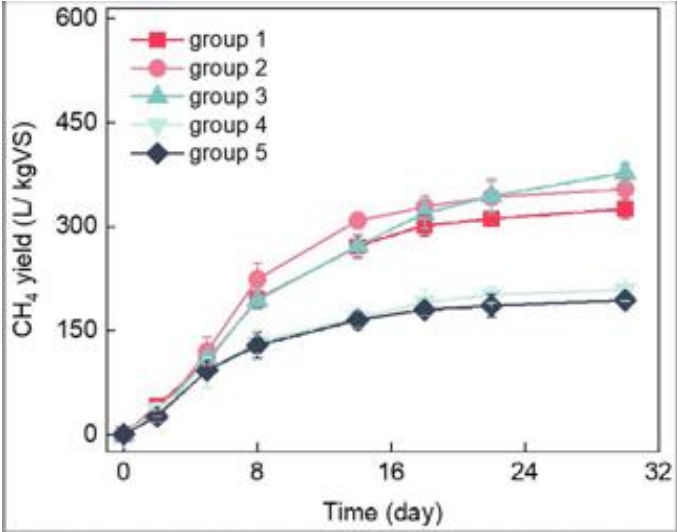
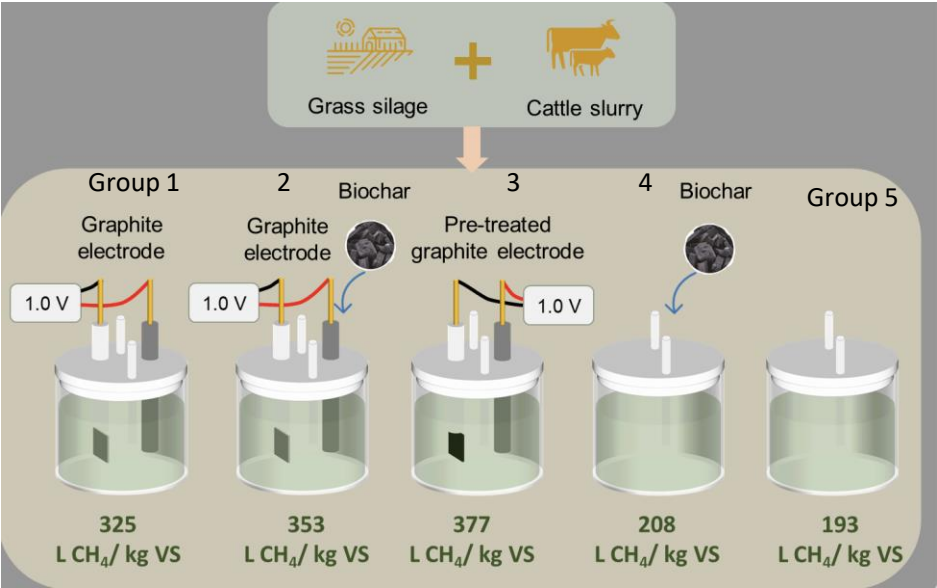
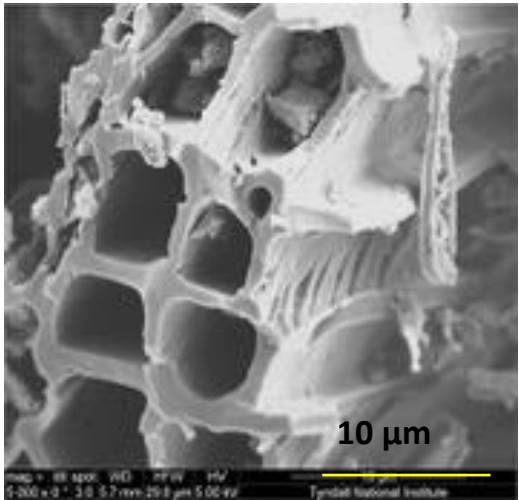
Dr Archishman Bose



Prof Jerry Murphy
(mentor)

Description: Minimising feedstocks to facilitate RePowerEU target of 35 bcm of biomethane by 2030

- (1) Two phase digestion with biochar electrodes to improve biomethane production.
- (2) Replacing graphite electrodes with biochar-based electrodes could improve sustainability of adding electrodes to AD.
- (3) The concept could be extended to microbial electrosynthesis for CO₂ valorisation



Improving biomethane production from biochar-supplemented two-stage anaerobic digestion of on-farm feedstocks

Xue Ning^{*,†}, Chen Deng^{*,†}, R. W. Daniel T. Hickey^{*,†}, Anna Hackula^{*,†}, Richard O'Shea^{*,†}, David M. Wall^{*,†}, Richan Lin^{*,†}, Jerry D. Murphy^{*,†}



Biochar facilitates biofuel production through batch single-stage and two-stage digestion of grass silage and cattle slurry

Xue Ning^{*,†}, Chen Deng^{*,†}, R. W. Daniel T. Hickey^{*,†}, Anna Hackula^{*,†}, Richard O'Shea^{*,†}, David M. Wall^{*,†}, Richan Lin^{*,†}, Jerry D. Murphy^{*,†}



Improving the efficiency of anaerobic digestion and optimising *in-situ* CO₂ bioconversion through the enhanced local electric field at the microbe-electrode interface

Xue Ning^{*,†}, Richan Lin^{*,†}, R. W. Daniel T. Hickey^{*,†}, Anna Hackula^{*,†}, Richard O'Shea^{*,†}, David M. Wall^{*,†}, Jerry D. Murphy^{*,†}

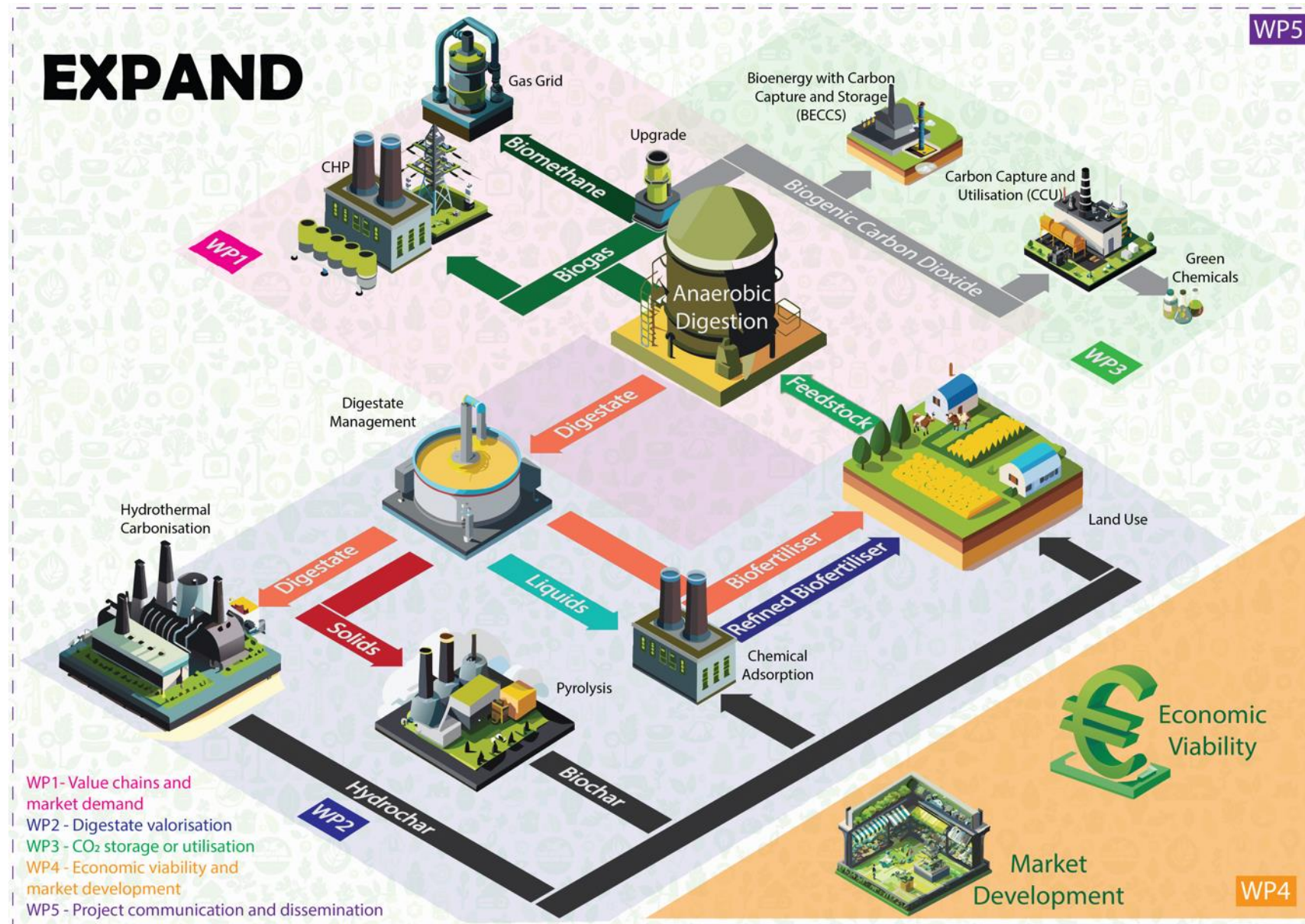
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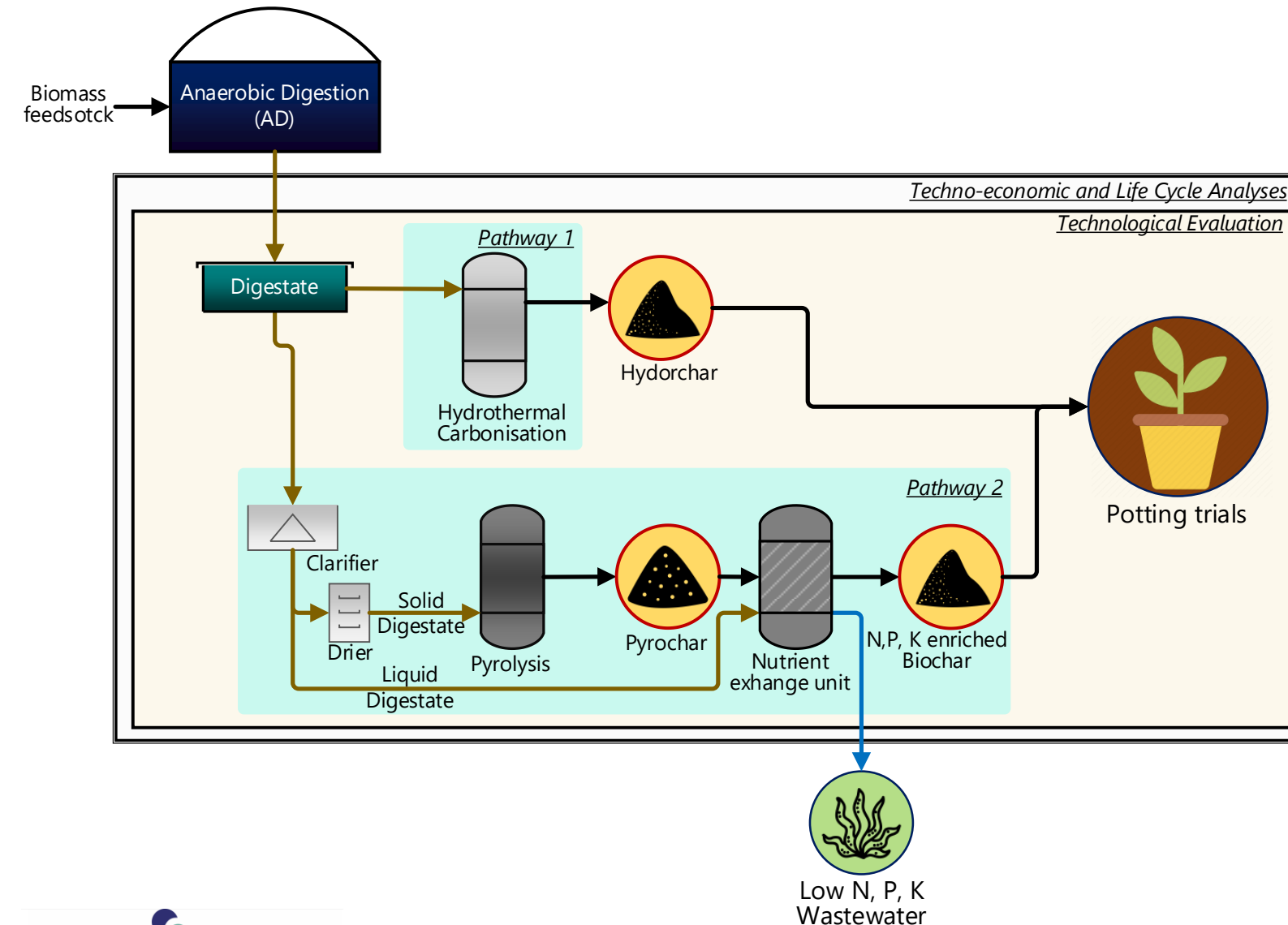
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Article
Microbe-electrode interactions on biocathodes are facilitated through tip-enhanced electric fields during CO₂-fed microbial electrosynthesis



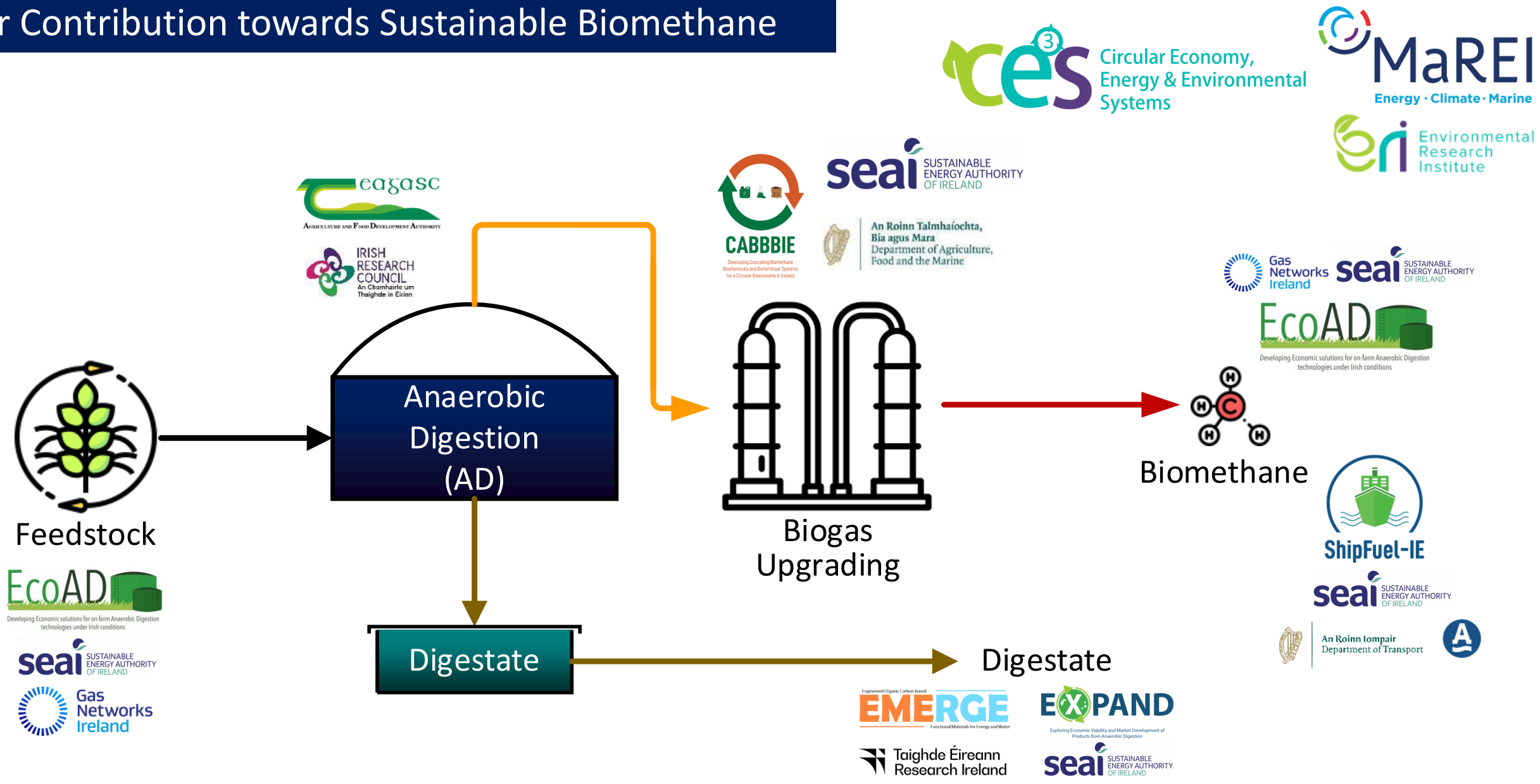
Exploring Economic Viability and Market Development of Products from Anaerobic Digestion





- 1 Assessment of **conventional digestate management options** focusing on digestate as a biofertiliser.
- 2 **Production of pyrochar and hydrochar** from digestate as a **soil amendment** and a **biofertiliser**.
- 3 **Nutrient adsorption capacity of pyrochar** from liquid digestate.
- 4 **Pot trials to assess grass growth yield** from different biochars.
- 5 **Techno-economic and lifecycle assessment** of biochar fertilisers v. direct land spreading of digestate

Our Contribution towards Sustainable Biomethane



Thank you

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HOST INSTITUTION



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Dr. Pradeep Monga

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IN COLLABORATION WITH



BIO METHANE WEBINAR

25 June 2025 Wednesday

SESSION TOPIC

Making Biogas Happen by 2030



WORLD BIOGAS
ASSOCIATION

#MakingBiogasHappen Programme

Webinar 26 June 2025

Dr Pradeep Monga

Senior Advisor and Policy Director

World Biogas Association

- ❑ Founded in 2016 by associations from the United Kingdom, the United States of America and Italy, together with 20 founding companies.
- ❑ It currently represents more than 100 organisations, including national associations, from around the world.
- ❑ WBA is an accredited member of the UNFCCC and REN21, an official partner of the CCAC (secretariat of the Global Methane Pledge) and the GMI, a founding member of the Global Biofuels Alliance (GBA), and an associate of the Global Bioenergy Partnership and the CTCN.
- ❑ WBA works closely with the IEA, UNIDO, FAO, the European Commission and C40 Cities, among others.
- ❑ Global association for the biogas, landfill gas and anaerobic digestion (AD) sectors, dedicated to facilitating the adoption of biogas globally.



WBA Vision and Mission

Our Evolving Vision



"A world where sustainable biogas is integral to climate, energy, agriculture, and waste solutions, with WBA as a definitive global voice in circular economy, member champion, and indispensable enabler"

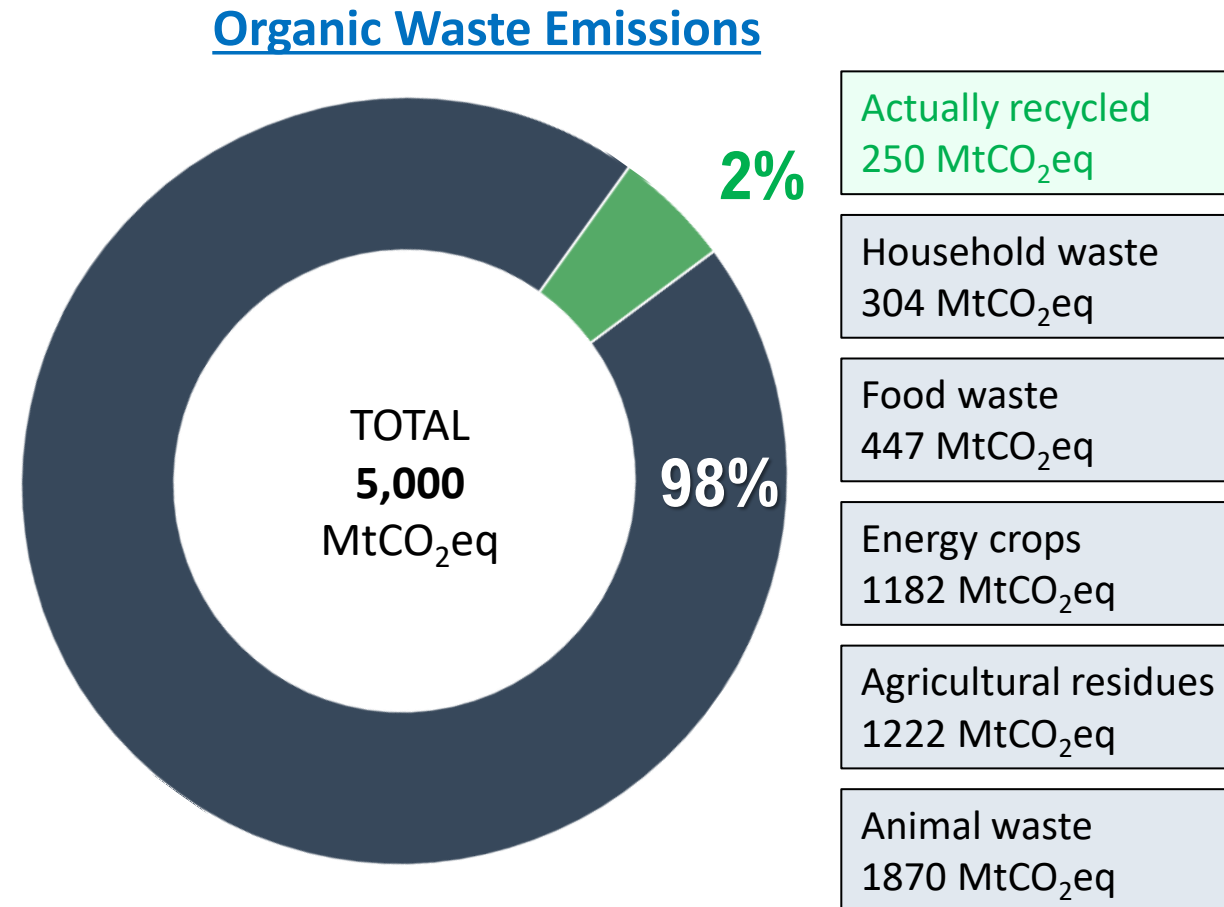


Our Mission

"WBA empowers the global biogas ecosystem, uniting members, nations, and industries to unlock biogas's full potential for a decarbonised, circular, and sustainable future"

Biogas, a circular economy waste to energy solution

- More than 105 billion tons of organic waste are produced worldwide annually. Not being recycled, they emit methane and other greenhouse gases – 98% are not recycled.
- Anaerobic digestion (AD) and biogas upgrading are recognised as one of the fastest, most cost-effective ways to reach net-zero.
- AD recycles organic waste, converting an environmental problem into a valuable solution, such as biogas, biomethane, bio-CO₂ and biofertilisers.
- By recycling available organic waste, it is possible to meet 50% of the Global Methane Pledge and reduce GHG emissions by 11% by 2030.
- Reduction of 5 billion tons of CO₂ equivalent



Global Biogas Market

- **40 billion cubic metres of natural gas equivalent (bcme) of Biogas is produced annually**, primarily for electricity and heat generation – IEA 2025
- **Upgrading Biogas to Biomethane for Transport Sector** is increasingly common, driven by efforts to decarbonise transport and ambitions for energy independence
- **10 billion cubic meters of Biomethane is produced globally**, equivalent to 0.2% of natural gas demand
- **Technological advancements** are increasing methane yields and recovery at biogas plants
- **Biogas, Biomethane and Bio-CO₂** are now seen as raw materials for producing hydrocarbons, sustainable aviation fuel (SAF), e-methane, e-methanol, bio-LPG and Renewable Dimethyl Ether (rDME)

Global Biogas Market

- **Investment in Biogas** is expected to surge, rising from the current USD 2 billion per year to **USD 15 billion annually by 2050**, underscoring the sector's increasing importance in the global energy transition.
- **Demand for Biogas and Biomethane** is projected to double between 2023 and 2035 under the IEA's Stated Policies Scenario.
- **Emissions-intensive industries**, gas networks, and big oil companies are turning to biogas and biomethane production as drop-in alternatives that require minimal changes to existing infrastructure, are reliable and mature technologies, and are attractive for rapid decarbonization at relatively low transition costs.
- **Governments and industry** are developing cooperative models, collection hubs and digital platforms to coordinate logistics for reliable feedstock availability for biogas projects.

Measures to scale up the Biomethane Market Globally

- **National Biomethane Production Targets:** Strategic instruments to guide the development of the sector, attract investment, and integrate biomethane into the energy matrix and fuel markets in a planned and sustainable manner.

1. The European Commission's RePowerEU plan aims to generate 35 billion cubic metres of Biomethane per year by 2030, reducing imports and increasing the European Union's energy storage capacity, while mobilising €37 billion in loans and subsidies.
2. India has set a mandate of 5% Biomethane in compressed and channelled natural gas by 2030.
3. As of 2026 in Brazil, at least 1% of the carbon dioxide (CO₂) emissions from fossil gas producers and importers must be abated through direct commercialisation or biomethane credits (CJOB).

Measures to scale up the Biomethane Market Globally

- **Linking to Emissions Trading System (ETS):** Market policies designed to control and reduce greenhouse gas (GHG) emissions cost-effectively.
 - The ETS is regulated by law and is compulsory for specific sectors (e.g., energy, industry, aviation, agriculture), unlike the voluntary system.
- **Providing initial Financial Assistance (CAPEX) to this fast-growing sector to have a level playing field like other renewables**

Examples

1. Ireland: *National Biomethane Strategy (2024)* provides subsidies of 20% of the CAPEX up to a maximum of € 5 million.

2. Italy: offers a subsidy of up to 40 % of the investment cost from the European Union's National Recovery and Resilience Plan (RRP).

Measures to scale up the Biomethane Market Globally

- **Recognise Anaerobic Digestion as a priority technology pathway for Waste Management.**

Examples

- 1. The Food Policy of the Municipality of Milan, which aims to reduce food waste, identifies anaerobic digestion and composting as priority methods for waste treatment.**
- 2. The Swedish city of Malmö has set among the objectives of its 2014 food policy the reduction of waste and the valorisation of organic waste to produce electricity and biomethane from biogas.**
- 3. Countries in Latin America (including Brazil) and the Caribbean have developed a joint roadmap for closing open dumps. Preventing landfills from forming reduces greenhouse gas emissions that enter the atmosphere and lowers risks to human health.**



The Biogas Sector still faces major challenges

- ❑ **Technical, operational and maintenance challenges**
 - ❑ Plants with low yield and environmental performance
 - ❑ Lack of information and qualification of operators
 - ❑ Lack of safety and standardisation
- ❑ **Policy, Regulatory, Standards, and Certification challenges for the market:**
 - ❑ Variations in regulations between councils and provinces,
 - ❑ Fragmented policies, agencies and ministries,
 - ❑ Delays in obtaining licences.
- ❑ **High CAPEX and limited financing options**

How can we construct hundreds of thousands of high-performance and reliable biogas plants, along with all the necessary infrastructure, within five years (by 2030)?

World Biogas Association

MakingBiogasHappen (#MBH) Programme



Phase 1

Global Biogas Regulatory Framework (GBRF) and Anaerobic Digestion Certification Scheme International (ADCS)

- **GBRF: 9 Pillars** - Recommendations for local and national governments to encourage regulatory harmonisation and investment in the use of best practices, policies, and technologies from around the world.
- **Certification and Standards: 11 Modules** - Best practices and safety measures for biogas plants through an international certification scheme and a biogas-tailored Life Cycle Assessment (LCA) methodology.



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#MakingBiogasHappen - Phase 1

Global Biogas Regulatory Framework

Now available at:

 www.globalbiogasframework.org

GLOBAL BIOGAS
REGULATORY
FRAMEWORK



Nine Pillars:

1. International and National Policy
2. Feedstock Policy
3. Biogas Utilisation
4. Digestate Policy
5. Gas Quality Regulations
6. Technical and Operational Quality Standards
7. Permitting Regulations
8. Planning Policy
9. Health, Safety and Environmental Protection

#MakingBiogasHappen - Phase 1

AD Certification Scheme International

Now available at:

 www.adcsinternational.org



Eleven modules:

1. Site information and understanding
2. Managing health and safety risk
3. Staff training
4. Process monitoring
5. Maintenance of the plant, kit and infrastructure
6. Procuring services
7. Managing environmental risks
8. Cross-contamination regulations compliance
9. Digestate management
10. Biomethane process
11. Life cycle assessment (LCA)



#MakingBiogasHappen Phase 2

- Dissemination & Outreach
- Adaptation & Integration



World Biogas Association

#MakingBiogasHappen Programme



Phase 2

Roll out at the national and sub-national levels

- **Outreach and Dissemination** of #MBH findings at national and subnational levels. Participation in bilateral events and meetings.
- **Adaptation:** Preparation of Biogas Action and Implementation Plans at the national, state or city level as required, by customising key elements of GBRF and ADCS International to the local biogas ecosystem.
- **Capacity Building:** Training and resources to develop local expertise in the biogas value chain. Dissemination of the best practice regulatory framework.
- **Standardisation:** Technology Benchmarking, Standards, ADCS Certification, and LCA adapted for biogas.

#MakingBiogasHappen - Phase 2

Way Forward

- WBA presence at Global Events for MBH dissemination and outreach
- Establishing partnerships with national, state, and local agencies to roll out MBH phase 2
- Finalizing MoUs with national and state governments: **Focus on Brazil and India**
- Customise key elements of GBRF and ADCS International to the national policies and programmes, aligning with climate targets and energy security, building upon ongoing activities
- Workshops on GBRF and ADCS International for policymakers and regulators, operators, and entrepreneurs.
- **Present the key elements of the #MBH Phase 2 at the global events: COP 30**



Signing of MoU on 5 June with the State Government of São Paulo on the Roll-out of #MBH Phase 2

#MakingBiogasHappen Programme

Key Deliverables

- 1. Rapid and adaptive growth of the Biogas Industry and Supply Chain**
- 2. Alignment with climate targets and ensuring business models**
- 3. National policies adapted to promote high Performing Biogas / Biomethane plants**
- 4. Standards and Certification with guarantees that regulations and safety measures are implemented**
- 5. Life Cycle Analysis methodology dedicated to Biogas Plants, with links to the carbon market**
- 6. Social acceptance and economic empowerment**
- 7. Fast, efficient and dedicated licensing processes for biogas/biomethane.**
- 8. Quality standards for the biogas industry**
- 9. Global linkages, identification of pioneering technologies, and correct design**
- 10. Linking Global Conventions, Protocols, and Alliances (GBA, GMH)**

**Mission
Biogas**

**Mission
Possible**



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Thank you!

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Thank you!

To know more or to register for GBA's webinar series,
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