
European Biogas Conference
27 OCTOBER 2021
CIRCULAR SOLUTIONS & INNOVATIONS
EBA
European Biogas Association
26–27 October 2021, Brussels

EBA Conference – 27 October

Opening speech

DIMITRI KOUFOS

European Bank for Reconstruction and Development

EBA
European Biogas Association

26–27 October 2021, Brussels

KD

EBA Conference – 27 October

Opening speech

PIERRE BASCOU

Director of DG AGRI D ‘Sustainability and income support’, European Commission

EBA European Biogas Association

26–27 October 2021, Brussels

SESSION 3: BIOGAS CIRCULARITY

Moderated by TV & Radio presenter Sasha Twining

European Biogas Conference
26-27 October 2021

Emilio Folli, Consorzio Italiano Biogas

Adam Nowak, European Young Farmers Organisation

Vasileios Diamantis, Democritus University of Thrace

Thomas Manheim, DUCTOR

Joanna Post, UNFCCC

EBA Conference – 27 October

What is the main contribution of biogas to the circular economy?

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Farming for Future

Emilio Folli

Dr Agrarian Sciences & Technologies, Consorzio Italiano Biogas

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FARMING FOR FUTURE: BIOGAS AND ENERGY TRANSITION

EMILIO FOLLI
CIB - CONSORZIO ITALIANO BIOGAS

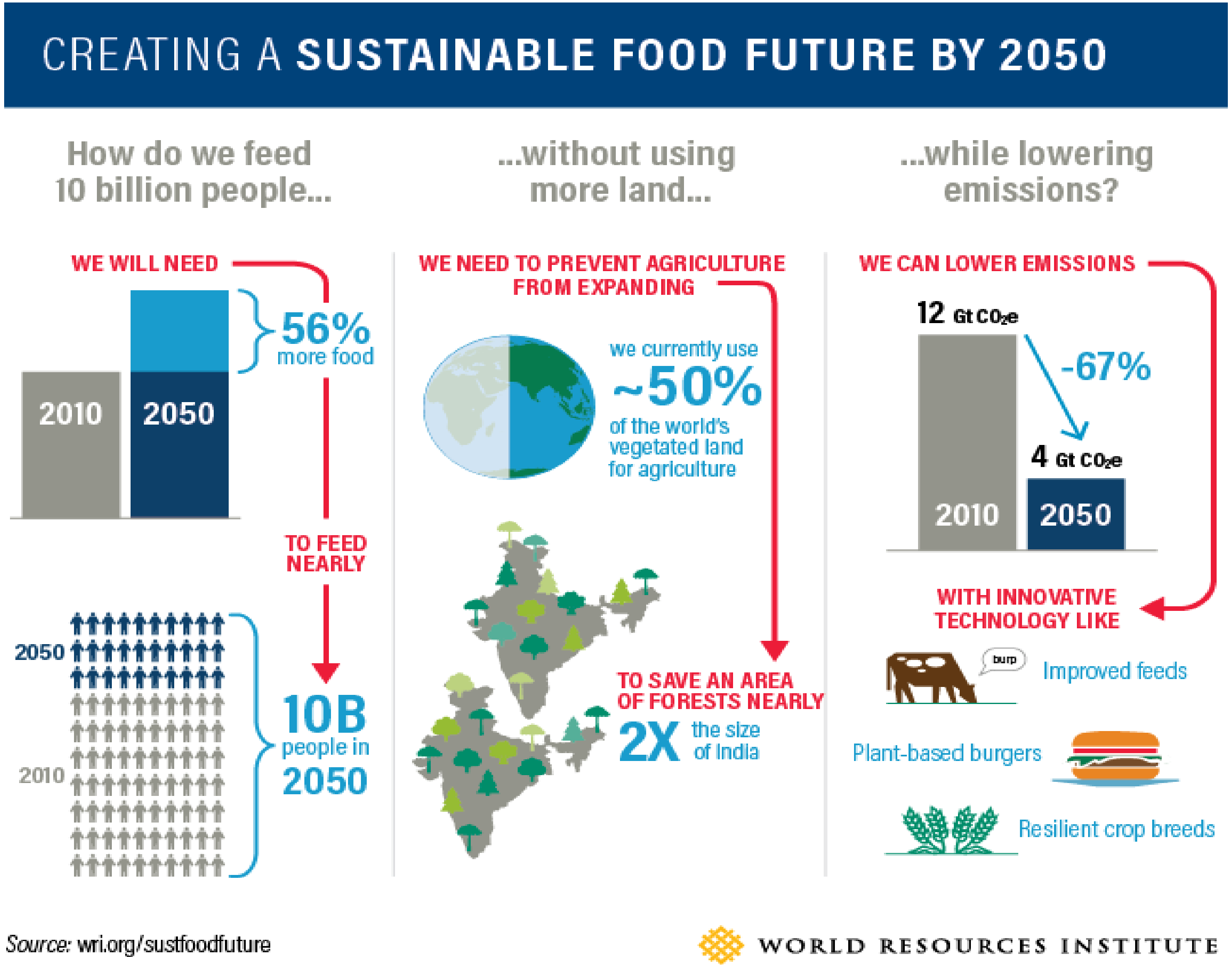
10 ACTIONS TO FARM THE FUTURE

THE CONTRIBUTION OF BIOGAS DONE RIGHT FOR THE AGRO-ECOLOGICAL CONVERSION OF ITALIAN AGRICULTURE

FARMING FOR FUTURE

www.farmingforfuture.it

THE GLOBAL CONTEXT

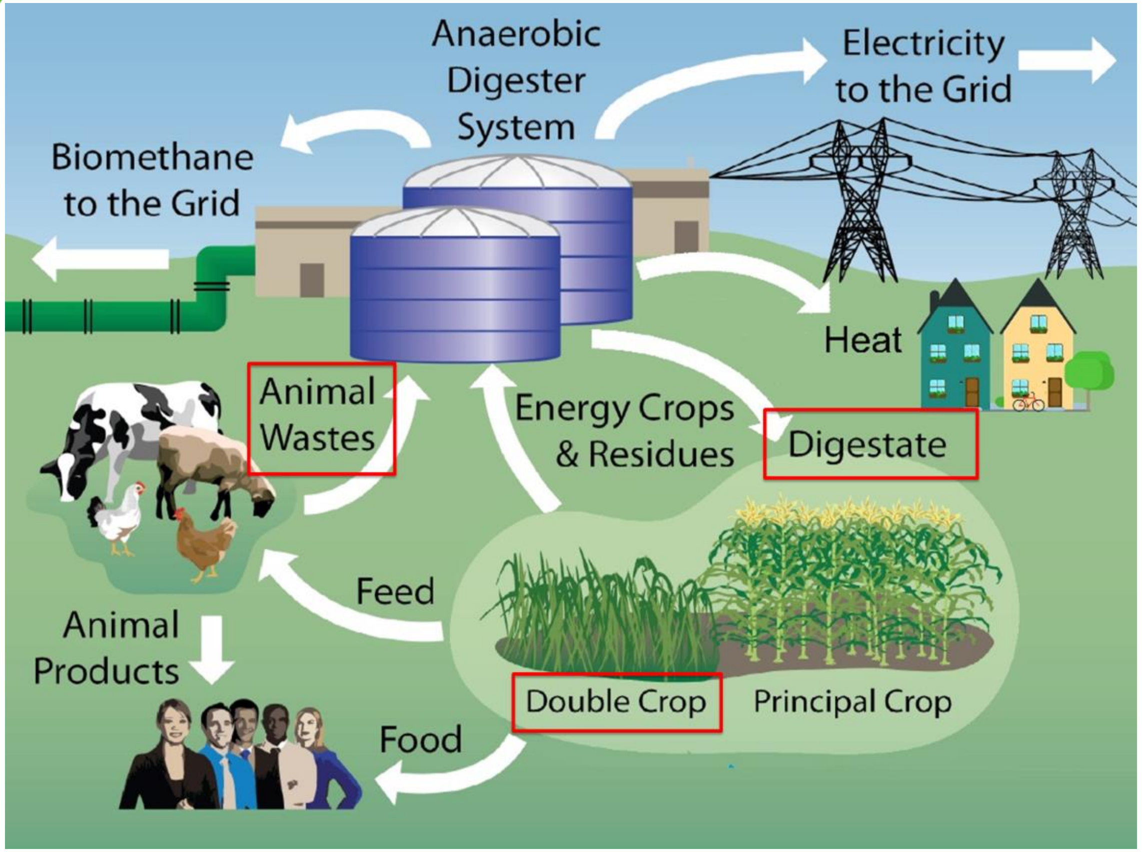


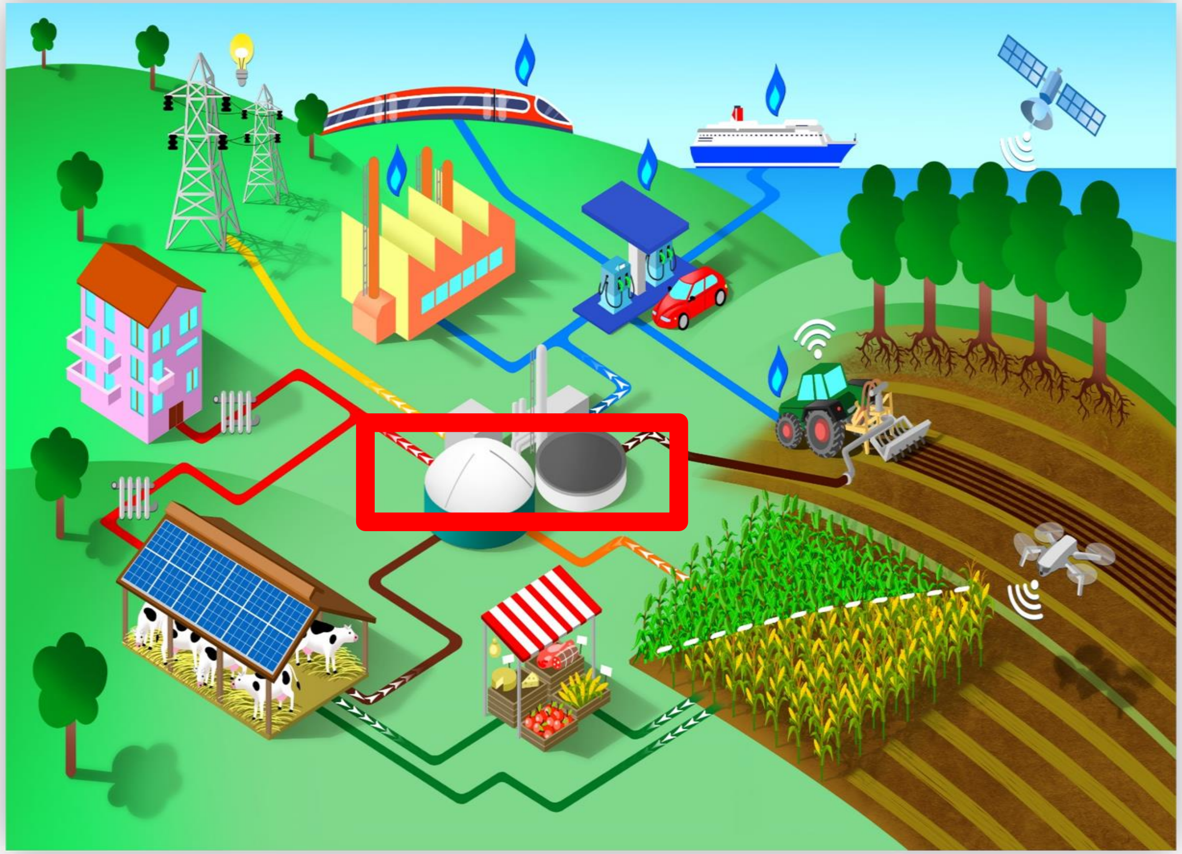
AGRICULTURE, ANIMAL PRODUCTION, EMISSIONS

Do we really need to reduce livestock operations by 50% to reduce ammonia and greenhouse gas emissions by 50%? Or are there techniques and technologies available that can reduce emissions while preserving livestock, capital, and jobs?

How can we do more organic farming, reduce inputs, increase soil fertility, but at the same time produce more food?

FROM BIOGASFATTOBENE® TO……. FARMING FOR FUTURE!!!!





FARMING FOR FUTURE. 10 ACTIONS TO FARM THE FUTURE

1. RENEWABLE ENERGY IN AGRICULTURE
REPLACE FOSSIL FUELS WITH RENEWABLE ENERGY SOURCES TO REDUCE POLLUTION AND EMISSIONS

2. FARM 4.0
ADOPT ADVANCED AGRICULTURAL AND ANIMAL FARMING TECHNOLOGY TO CALIBRARE THE NECESSARY RESOURCES FOR CROPS AND ANIMAL FARMS

3. MANAGEMENT OF ANIMAL MANURE
USE ANIMAL MANURE AND AGRICULTURAL BYPRODUCTS IN ANAEROBIC DIGESTION TO REDUCE EMISSIONS AND PRODUCE RENEWABLE BIOENERGY

4. ORGANIC FERITILISATION
USE ORGANIC FERTILISER (DIGESTATE) TO RETURN NUTRIENTS TO THE SOIL AND REDUCE THE USE OF CHEMICAL FERTILISERS

5. INNOVATIVE FARMING PROCESSES
ADOPT ADVANCED SOIL TILLAGE AND ORGANIC FERTILISATION TECHNIQUES TO REDUCE EMISSIONS FROM SOILS

6. ANIMAL QUALITY AND WELFARE
IMPLEMENT ADVANCED AGRICULTURAL AND ZOOTECHNICAL TECHNIQUES TO IMPROVE THE QUALITY AND WELFARE OF LIVESTOCK FARMS

10. BIOGAS AND OTHER RENEWABLE GASES
PRODUCE METHANE AND HYDROGEN RENEWABLE FROM AGRICULTURAL BIOGAS

9. PRODUCTION AND USE OF BIOMATERIALS
DEVELOP AND USE ORGANIC, NATURAL AND RENEWABLE MATERIALS

8. AGROFORESTRY
INTEGRATE TREES IN CULTIVATED FIELDS TO INCREASE PHOTOSYNTHESIS AND ORGANIC MATTER IN SOILS

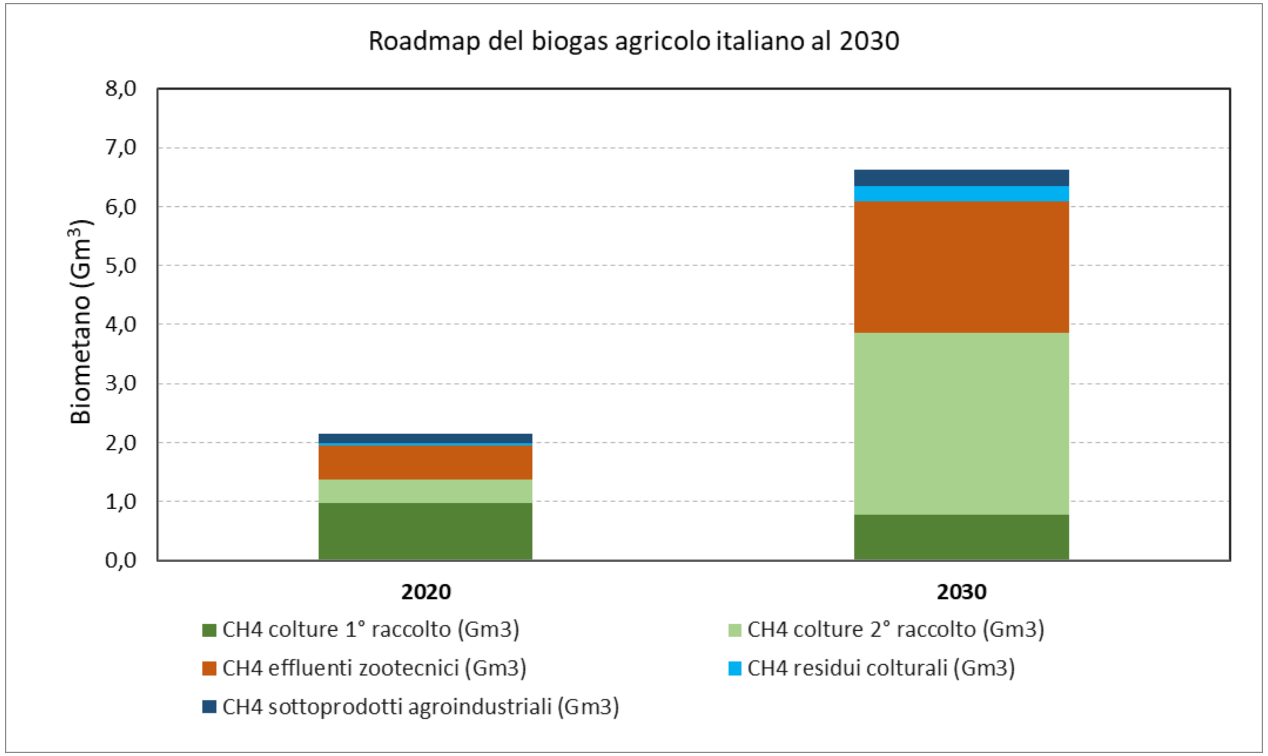
7. INCREASED SOIL FERTILITY
ADOPT DOUBLE CROPS TO INCREASE CO_2 CAPTURE AND SOIL FERTILITY

FARMING FOR FUTURE

ITALIAN AGRICULTURAL BIOGAS ROADMAP TO 2030

6.5 billion m3 of BioCH4 by 2030 for various uses

- **Limited use of first harvest crops**: up to a maximum of 200,000 ha.
- **Increasing use of second-harvest crops** (no more than 10-12% of the Italian UAA devoted to arable crops);
- **Increasing use of livestock manure**: 65% of current production;
- **Growing use of agricultural residues and agro-industrial by-products**: variable quotas from 10 to 70% of the total available.



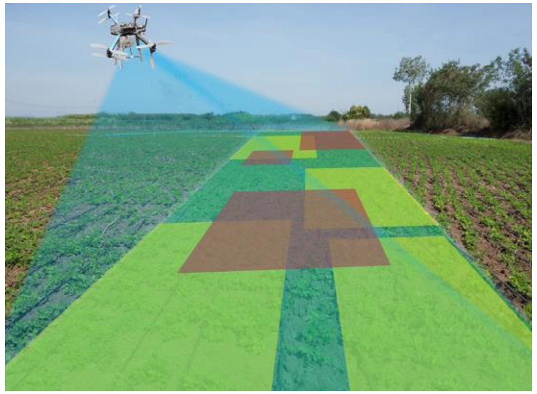
By 2030 6.5 billion m3 of "sustainable" BioCH4 according to RED II criteria (65-70% GHG savings compared to FFC for all uses)

ACTION 1 - RENEWABLE ENERGY IN AGRICULTURE

- Electrification to reduce diesel consumption per unit of end product
- Electricity from **cogeneration with heat enhancement**
- **Biomethane mechanization** (also bioLNG)
- Use of biomethane in **all uses** that are difficult to electrify

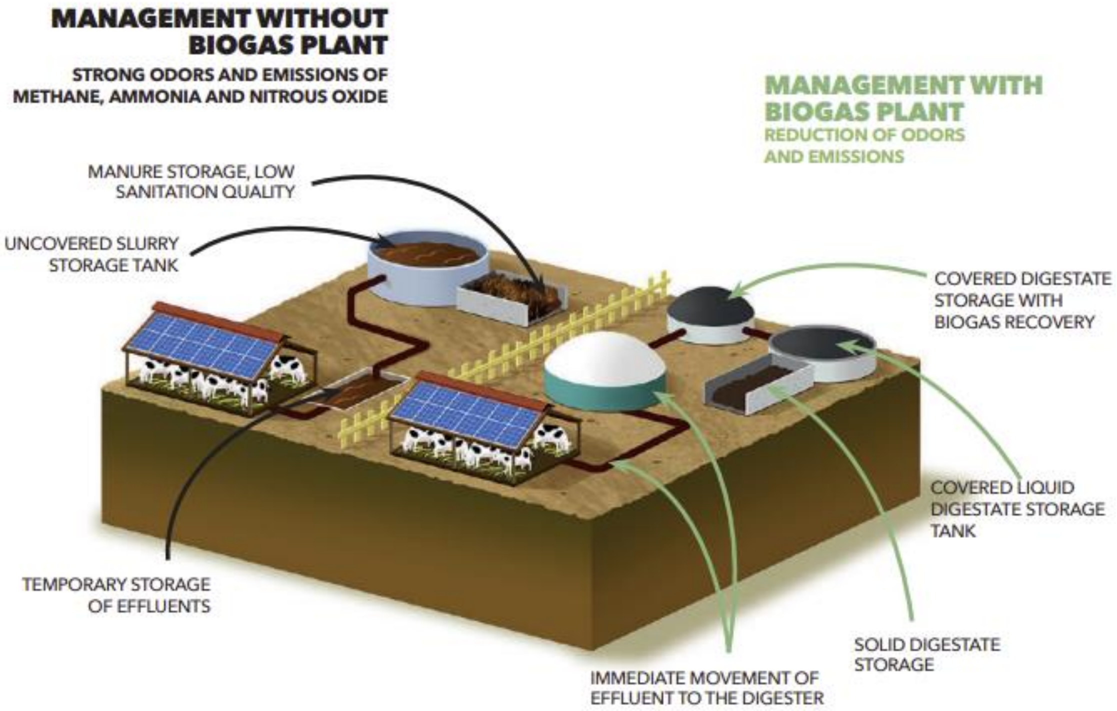
ACTION 2 – FARM 4.0

- **Spreading Precision Agriculture, Agriculture 4.0 and Animal Husbandry 4.0, Robotics, IoT**
- **Reduction of energy** used per unit of product (at least 10-15%)processing times (up to 35%) overall consumption of inputs per unit of product (water, seeds, fertilizers and pesticides).
- **Increase in production yields** (7-15% for cereals and industrial; 10-15% of milk production). Reduction in production costs (estimated to average 10-15%)
- **Carbon footprint per unit of product** (produce more with less).



ACTION 3 - MANAGEMENT OF LIVESTOCK EFFLUENT

- **Livestock manure** to biogas: 65% total
- **Immediate start** to digester (improved animal welfare)
- **Covered storage** with biogas recovery for the first 30 days (essential for sustainability)
- **Decentralized storage capacity** (distribution at the most suitable times)
- **Digestate, organic fertilizer** with well-defined and optimized agronomic characteristics



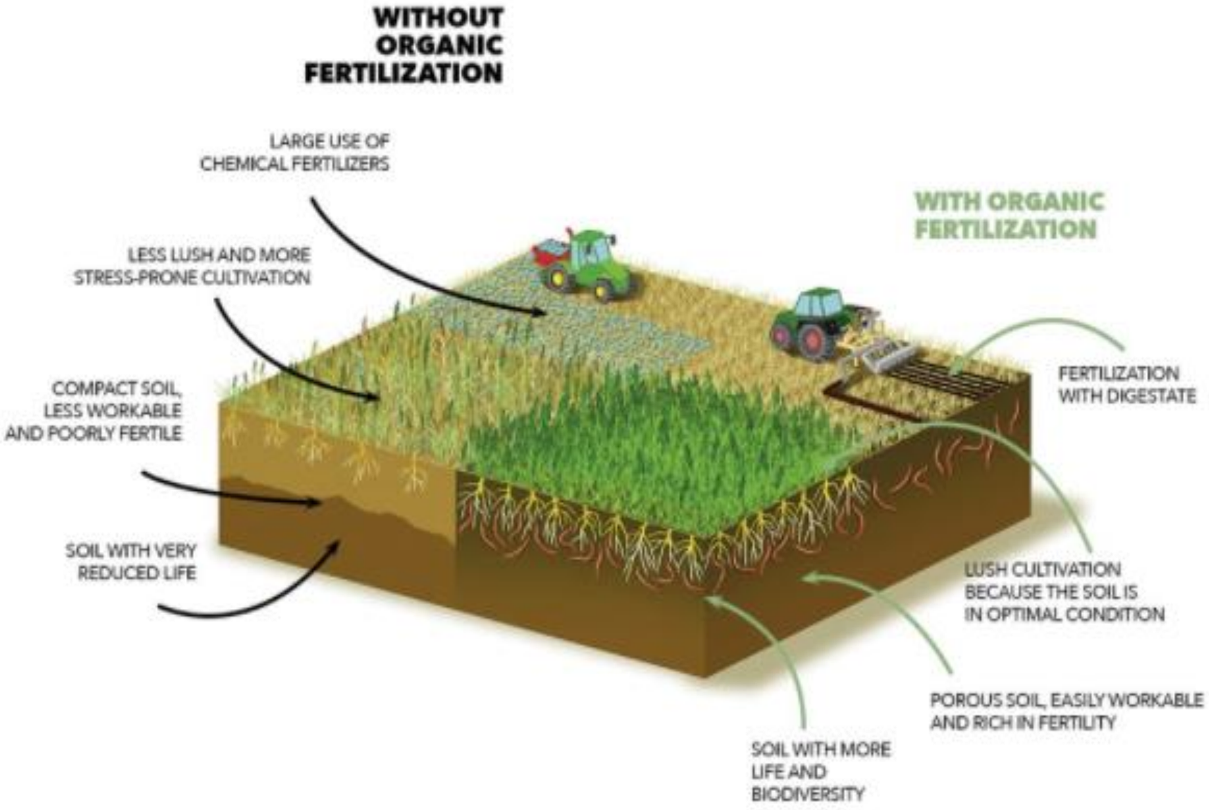
ACTION 4 - ORGANIC FERTILIZATION WITH DIGESTATE

❖ **Know the characteristics of digestate:**

- Contains stable organic matter, with a C/N ratio similar to soils (8 to 14). In the soil it promotes the formation of stable humus (higher humification index than other matrices. For example, crop residues that can induce "nitrogen starvation");
- has the same overall supply of nutrients as the input matrices (it supplies not only N, but also P and K), but as far as nitrogen is concerned, in a form that is more easily assimilated by the crops;

❖ **Optimize the distribution** phase in the field

❖ **Use of high efficiency and low emissivity systems** (net increase in recovery of distributed nitrogen, reduction of NH3 emissions).

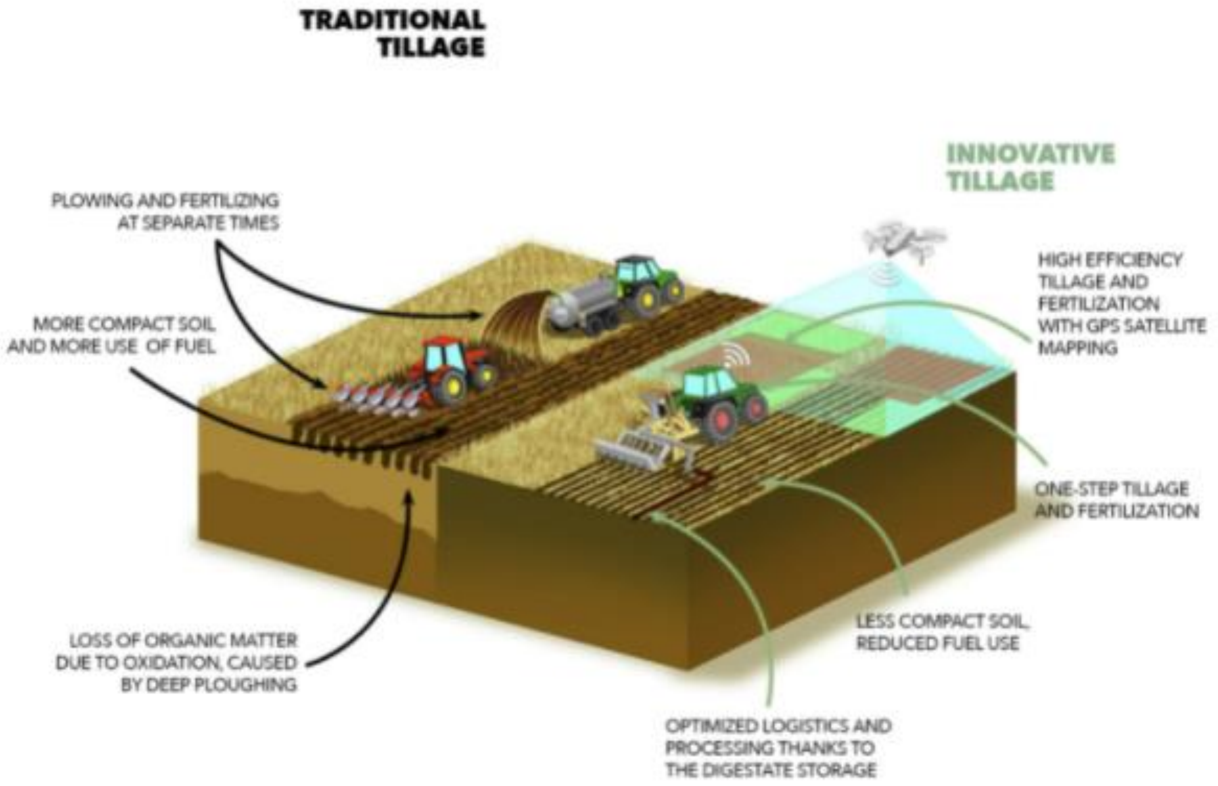


Replaceable chemical fertilizers from 1 m3 of digestate

Digestato	Equivalente concime chimico
Sostanza organica (SO) 39 kg/t	Assente
Azoto totale (N) 4 kg/t	8,69 kg Urea
Fosforo (P) 2 kg/t	5,26 kg Perfosfato Triplo
Potassio (K) 4,25 kg/t	9,04 kg Solfato potassico

ACTION 5 - INNOVATIVE AGRONOMIC OPERATIONS

- **Reduced tillage techniques**: reduced tillage depth, strip tillage, no tillage, no-till seeding;
- **Distribution techniques** in the field of digestate with **high efficiency** of distributed nitrogen and low emissions into the atmosphere: distribution close to the ground, immediate burial, distribution in coverage, fertigation with clarified and micro-filtered digestate;
- **Separation of the digestate transport phase from the distribution phase** (decentralized storage, underground transport networks);

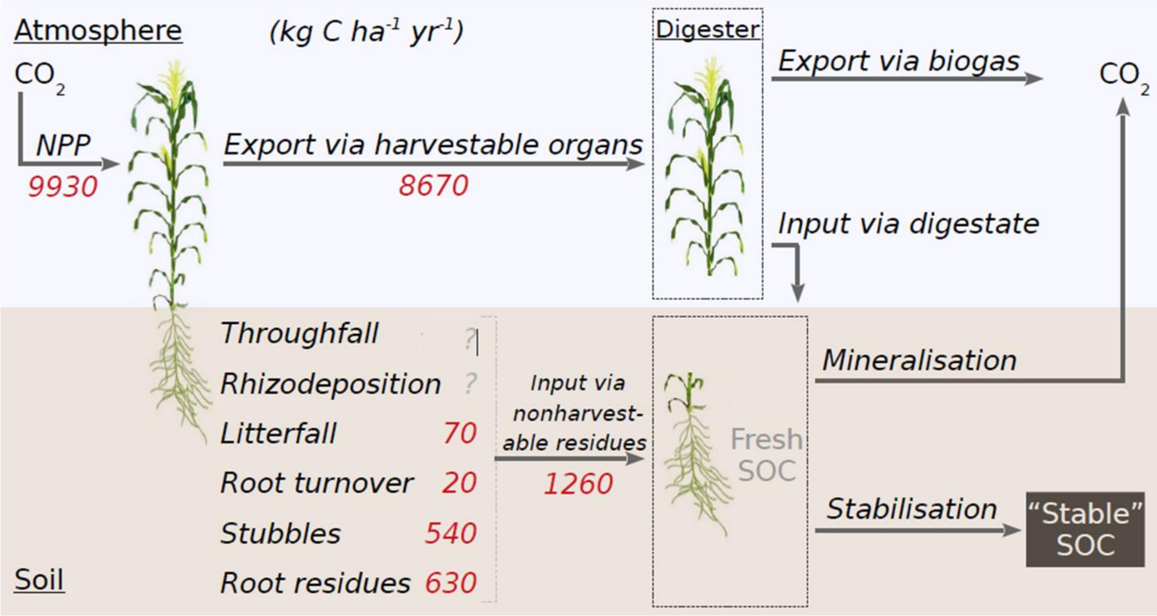


INNOVATIVE TECHNIQUES FOR THE DISTRIBUTION OF DIGESTATES

For more on this topic check out the webinair on action 

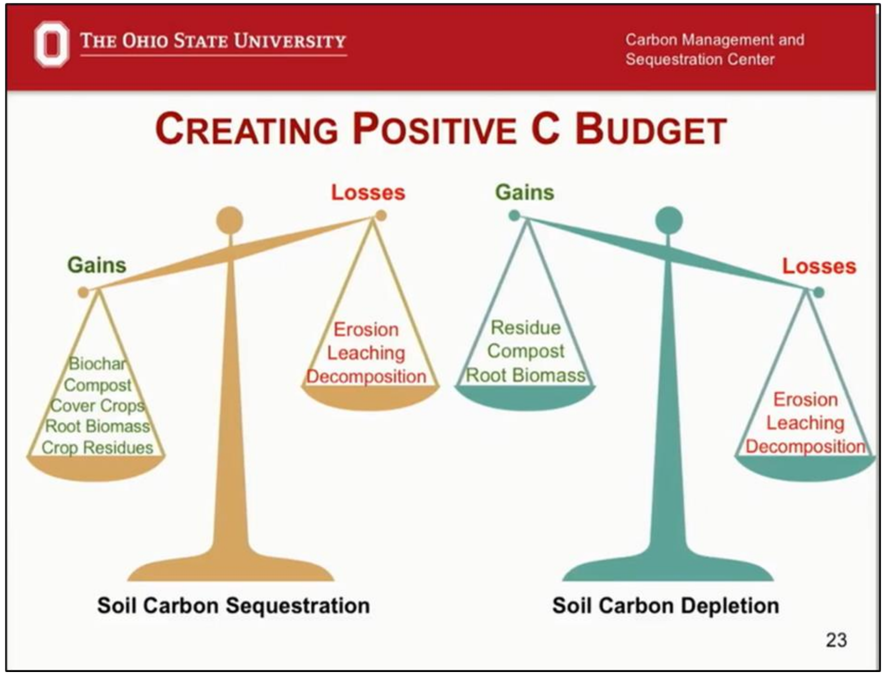
OUR AGRONOMIC TECHNIQUE FOR THE DISTRIBUTION AND TILLAGE

ACTION 7 - INCREASE SOIL FERTILITY

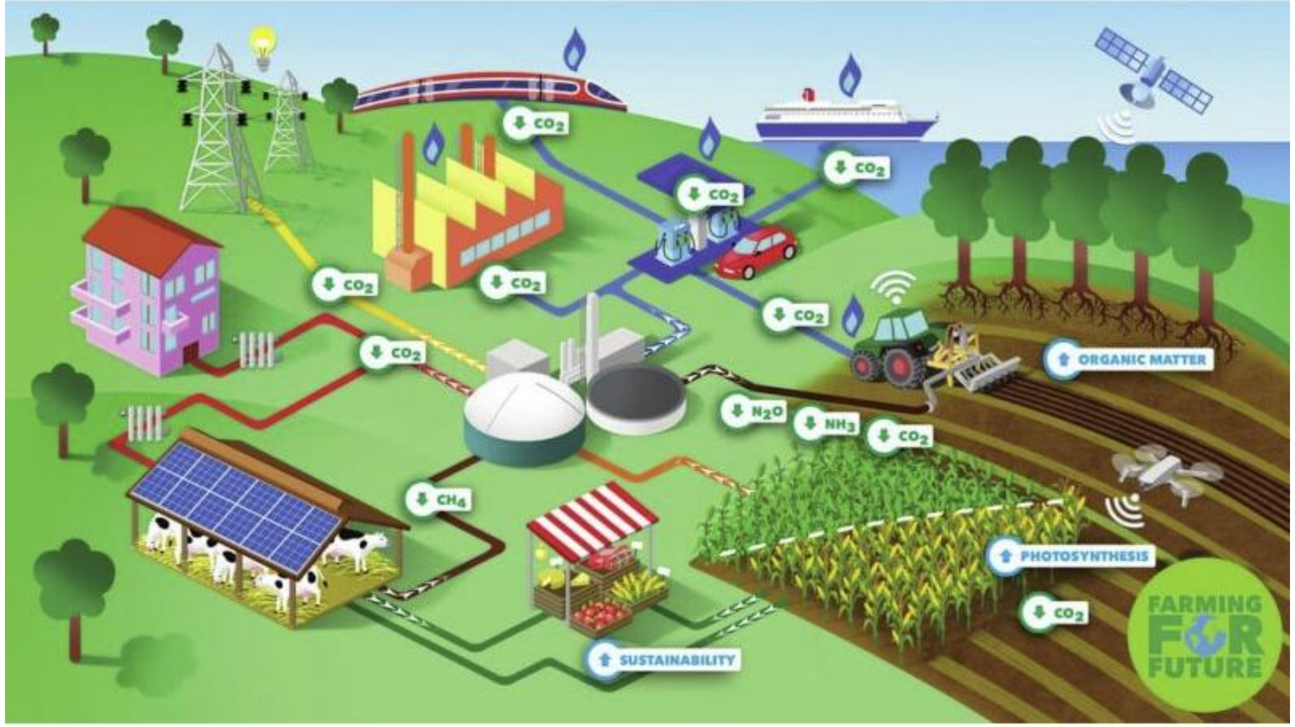


- ❖ Regular organic fertilization with digestate with calibrated dosages distributed with high-efficiency methods (appropriate distribution times and sites)
- ❖ Increase the area devoted to intercropping or double cropping, including nitrogen-fixing crops in the crop rotation:

- ✓ Less erosion, less leaching, increased biodiversity
- ✓ Increased amount of CO2 removed from the atmosphere per hectare(5-10 t of CO2 less per intensification of photosynthesis)
- ✓ Additional production of roots, characterized by a particularly stable organic substance
- ✓ Additional amount of digestate for organic fertilization, instead of green manure (avoiding "nitrogen starvation").



THE POTENTIAL TO REDUCE GHG EMISSIONS BY 2030



10 ACTIONS + BIOGAS DONERIGHT® =

-32%
OF DIRECT EMISSIONS FROM AGRICULTURE

EQUAL TO -12,400 KTON CO2/YEAR

-6%
OF EMISSIONS AVOIDED OVERALL FROM FUEL USE FOSSIL

EQUAL TO -19,000 KTON CO2/YEAR

-31.400 KTON CO_2/YEAR
IN ATMOSPHERE

EQUAL TO THE EMISSIONS OF 18.5 MILLION OF CARS,
50% OF THE ITALIAN CAR FLEET*.

* AVERAGE CAR EMISSIONS 145 GCO2/KM WITH A DISTANCE TRAVELLED OF 11,500 KM/YEAR


"Essentially, all life depends upon the soil.
There can be no life without soil and no soil without
life; they have evolved together."
Charles E. Kellogg


EBA Conference – 27 October
Supporting Europe's next generation of farmers
ADAM NOWAK
European Young Farmers Organisation
EBA
European Biogas Association
26–27 October 2021, Brussels

EUROPEAN COUNCIL OF YOUNG FARMERS
CEJA
CONSEIL EUROPÉEN DES JEUNES AGRICULTEURS

The voice of the next generation of EU farmers

SUPPORTING EUROPE'S NEXT GENERATION OF FARMERS

CEJA

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The voice of the next generation of EU farmers

YOUNG FARMERS' CALL FOR CLIMATE ACTION

The voice of the next generation of EU farmers

ADAPTATION

The voice of the next generation of EU farmers

EMISSIONS REDUCTION

The voice of the next generation of EU farmers

CARBON SEQUESTRATION

CEJA

European Council of Young Farmers

The voice of the next generation of EU farmers

ENERGY & BIO-ECONOMY

The voice of the next generation of EU farmers

SOURCE OF INCOME FOR FARMERS

The voice of the next generation of EU farmers

LIMITING AMOUNT OF MINERAL FERTILIZERS

The voice of the next generation of EU farmers

AGRICULTURAL BIOGAS PLANTS AS BEST TECHNIQUE FOR THE TREATMENT OF ANIMAL EXCREMENTS

The voice of the next generation of EU farmers

REDUCE ODOR EMISSIONS AND WASTE MANAGEMENT

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LIMITATION OF METHANE EMISSIONS TO THE ATMOSPHERE

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INCREASING THE NUMBER OF LOCAL JOBS „GREEN JOBS”

CEJA

The voice of the next generation of EU farmers

NOW IS THE HIGH TIME TO MOVE TO THE GREEN SIDE OF THE FORCE!

CEJA

The voice of the next generation of EU farmers

ABOUT CEJA

The European Council of Young Farmers, was founded in Rome in 1958 when young farmers' organisations from the six initial Member States of the European Coal and Steel Community (ECSC) set up a "Comité d'Entente".

The organisation's main aim is to represent the interests of young farmers to EU institutions and stakeholders. CEJA's membership is composed of 32 national organisations and one associate member.

It stands for around two million young farmers across 22 Member States, the United Kingdom and Serbia.

EBA Conference – 27 October

Giving water its value in the circular economy

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26–27 October 2021, Brussels

Giving water its value in the circular economy

Vasileios Diamantis[1*], Maxime Remy[2], Marco Giacomazzi[3], Mieke Decorte[3], Christian Kuijlaars[4], Raúl Muñoz[5], Marta Gandiglio[6], Harmen Dekker[3]

[1]*Hellenic Association of Biogas Producers (HABIO), Athens, Greece*

[2]*PAQUES B.V., Netherlands*

[3]*European Biogas Association (EBA), Brussels, Belgium*

[4]*BIOTHANE - VEOLIA Water Technologies – Anaerobic Technology Center, Netherlands*

[5]*Institute of Sustainable Processes-University of Valladolid, Spain*

[6]*Department of Energy-Politecnico di Torino, Italy*

EU long-term decarbonization strategy

Consumption of biogas(es) at EU

2021 **18 bcm**

19 000 AD facilities

→

2050 **95 bcm**

+ 40 000 AD facilities

	Biogas production potential (bcm)
Sewage sludge	3
Industrial wastewaters	14
Food wastes	16
Manures	20
lignocellulosic residues	??
Renewable H_2	??

Industrial wastewater

Beverage Industry

Dairy Industry

Ethanol industry

Pulp & paper

Biodiesel industry

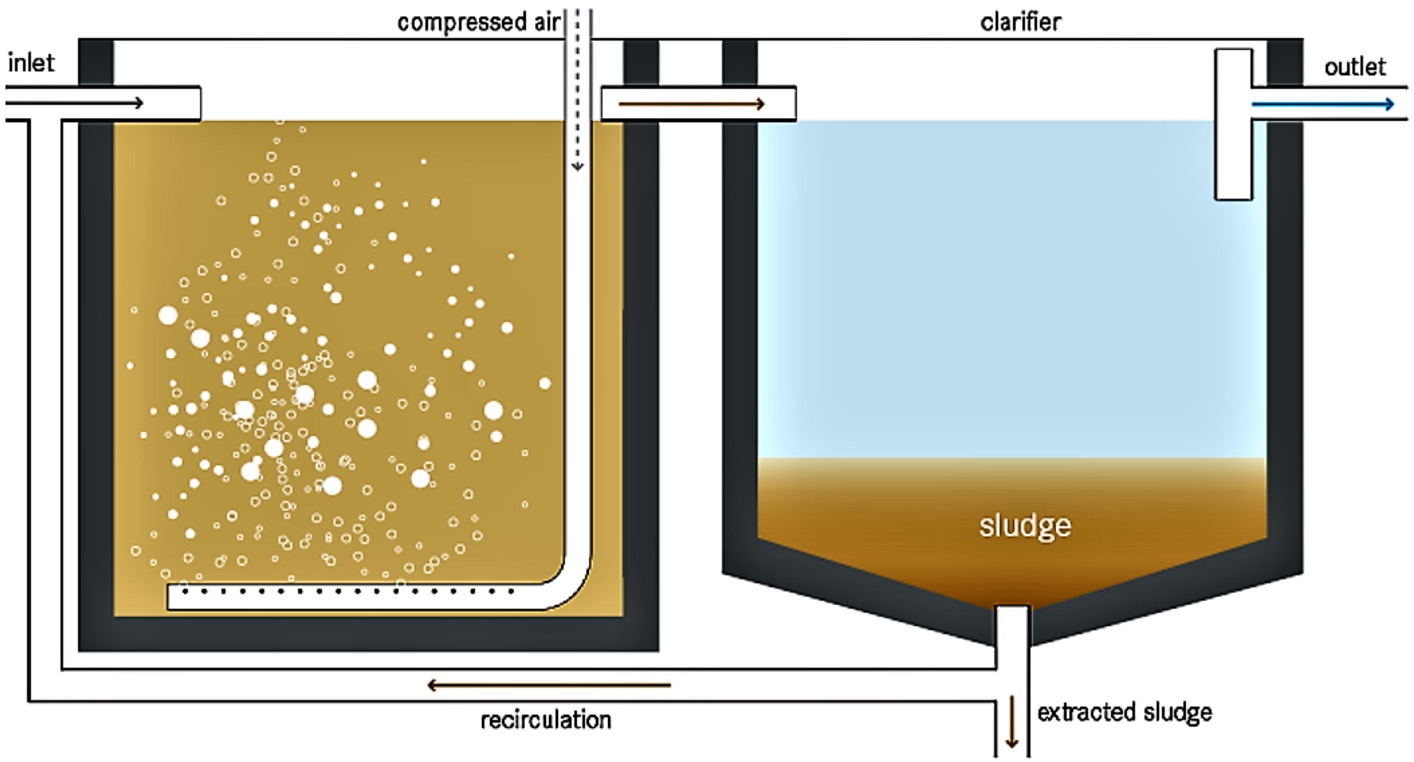
Fruit & vegetable

Meat industry

Vegetable oils

Industrial wastewater treatment

- Activated sludge process



Act. Sludge Metrics

Energy consumption

~ 1 kWh / kg COD

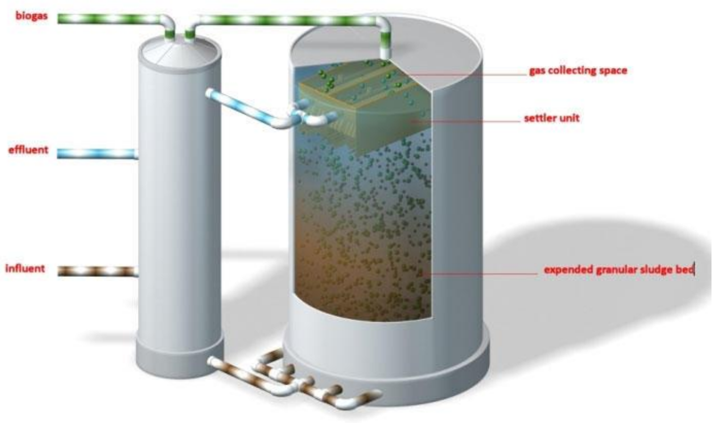
Sludge production

~ 0.4 kg VS / kg COD

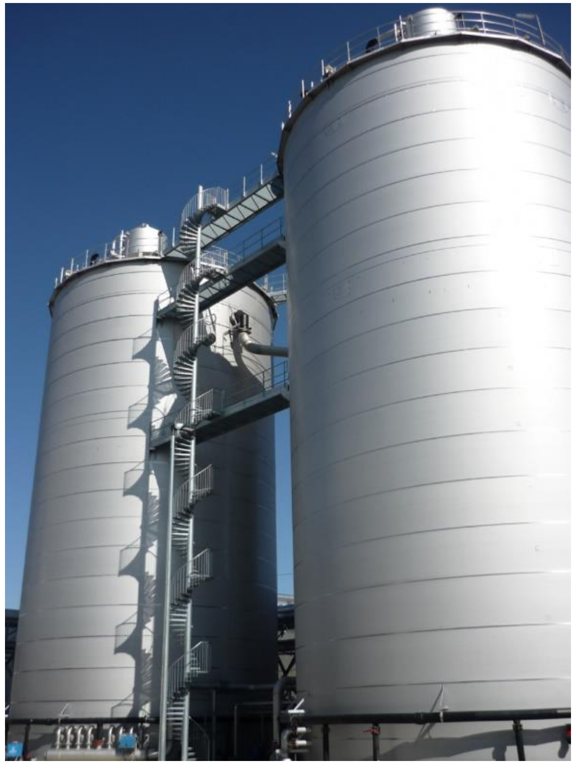
Take home message: Industrial wastewater treatment requires 40 TWh electricity and produces 17 mil tn DM excess sludge annually at EU level

Industrial wastewater anaerobic treatment

- Anaerobic granular sludge bioreactors
- Suitable for wastewater treatment (solids and lipids-free)
- Hydraulic residence time (0.5-1 d)
- Biogas production rate (up to 6-7 m^3/m^3d)



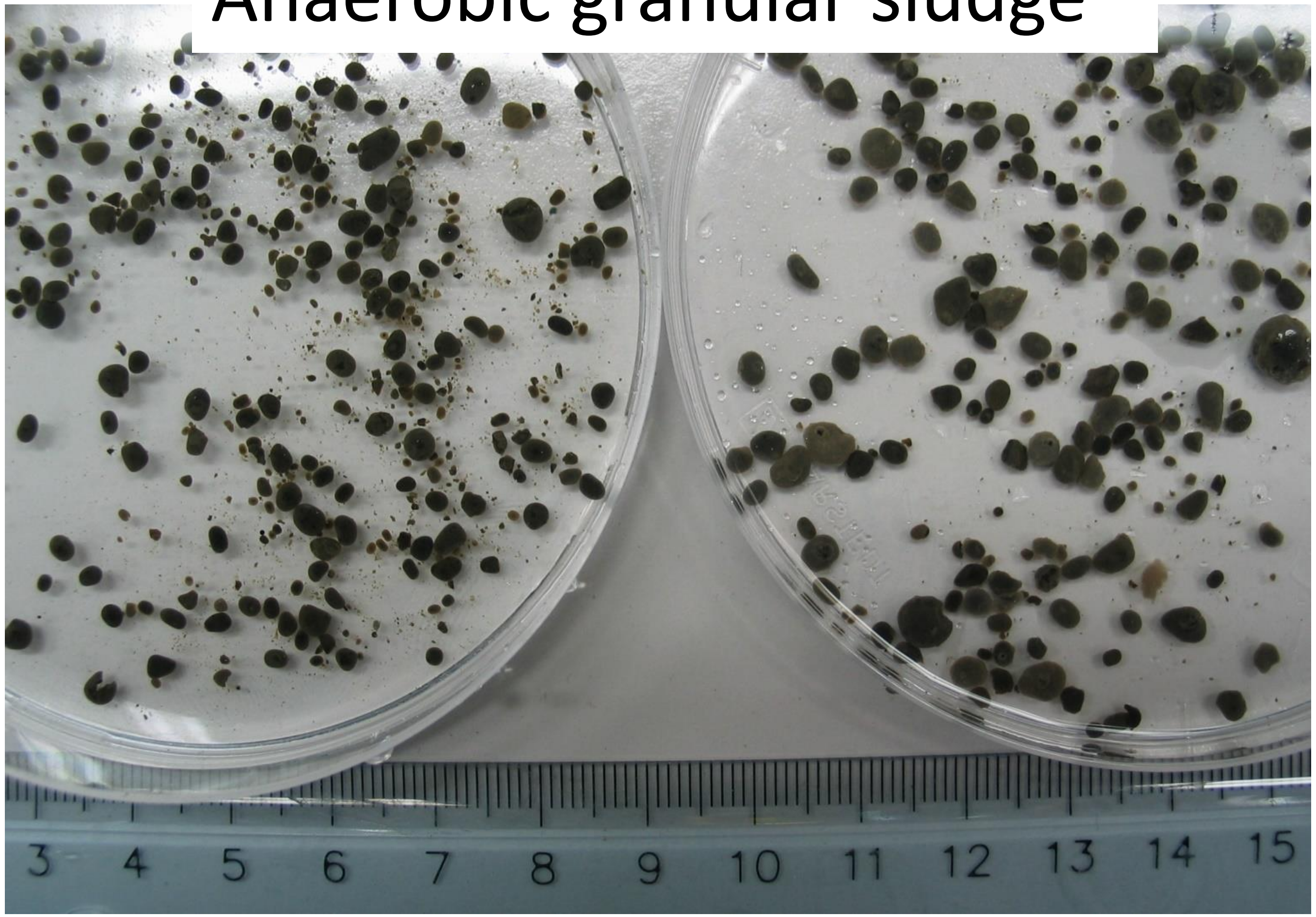
Source: Biothane Veolia



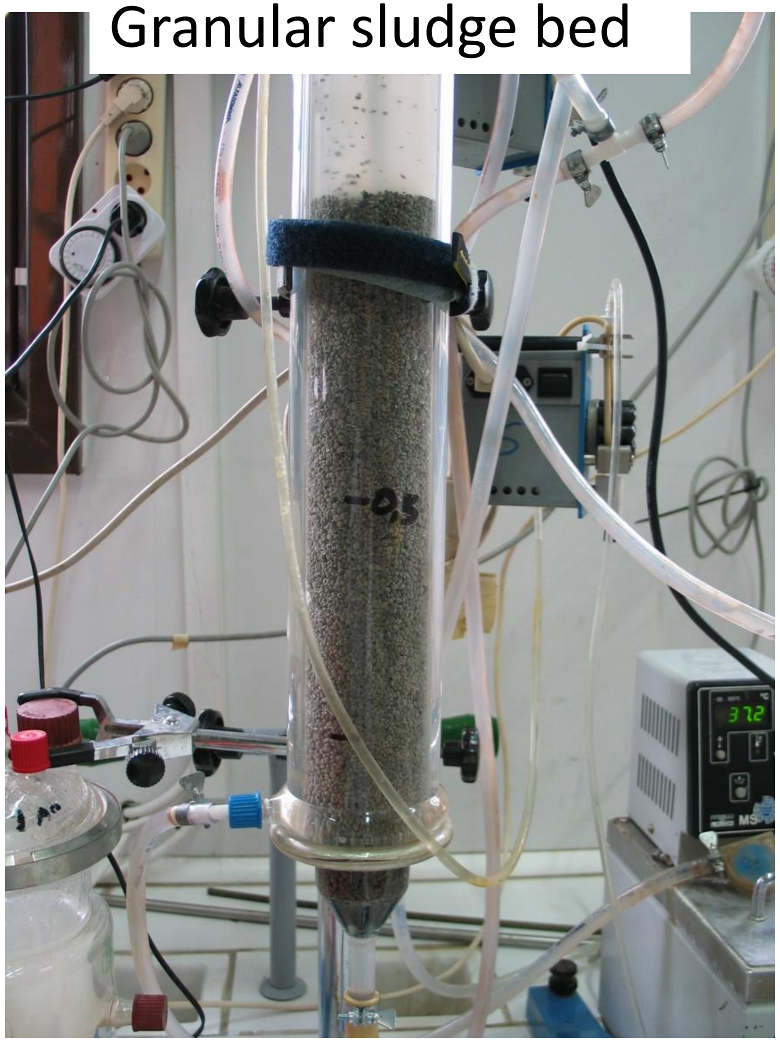
Source: Paques

Industrial wastewater anaerobic treatment

Anaerobic granular sludge



Granular sludge bed



Major outcomes of the EBA working group

- **+ 14 bcm (CH_4)** from industrial wastewater treatment
- **– 30 TWh electricity consumption** from activated sludge
- - **10 mil tn DM excess sludge** from activated sludge
- \+ **7 bil € CAPEX** at EU level (@ full capacity)
- \+ **20 000 Job positions** at EU level (@ full capacity)

Major outcomes of the EBA working group

Market penetration limited to <10% of EU SMEs

Large number of **small** and medium SMEs

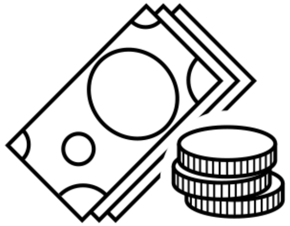
High specific CAPEX (€/m^3) for small size AD facilities

SMEs invest in front-end rather back-end technologies

Concluding remarks

- To enhance penetration of anaerobic digestion technologies for industrial wastewater treatment we need:

Financial incentives



Environmental legislation

Social awareness

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Use of digestate as biofertiliser

THOMAS MANHEIM
Head of Agronomy, Advocacy and Regulatory Affairs, DUCTOR

EBA
European Biogas Association

26–27 October 2021, Brussels

DUCTOR AG

Use of digestate as bio-fertilizer: Entering the era of circular economy

European Biogas Conference 2021, 27th October 2021

Dr. Thomas Mannheim

RECOVERY OF NUTRIENTS: ENTERING THE AGE OF SUSTAINABILITY

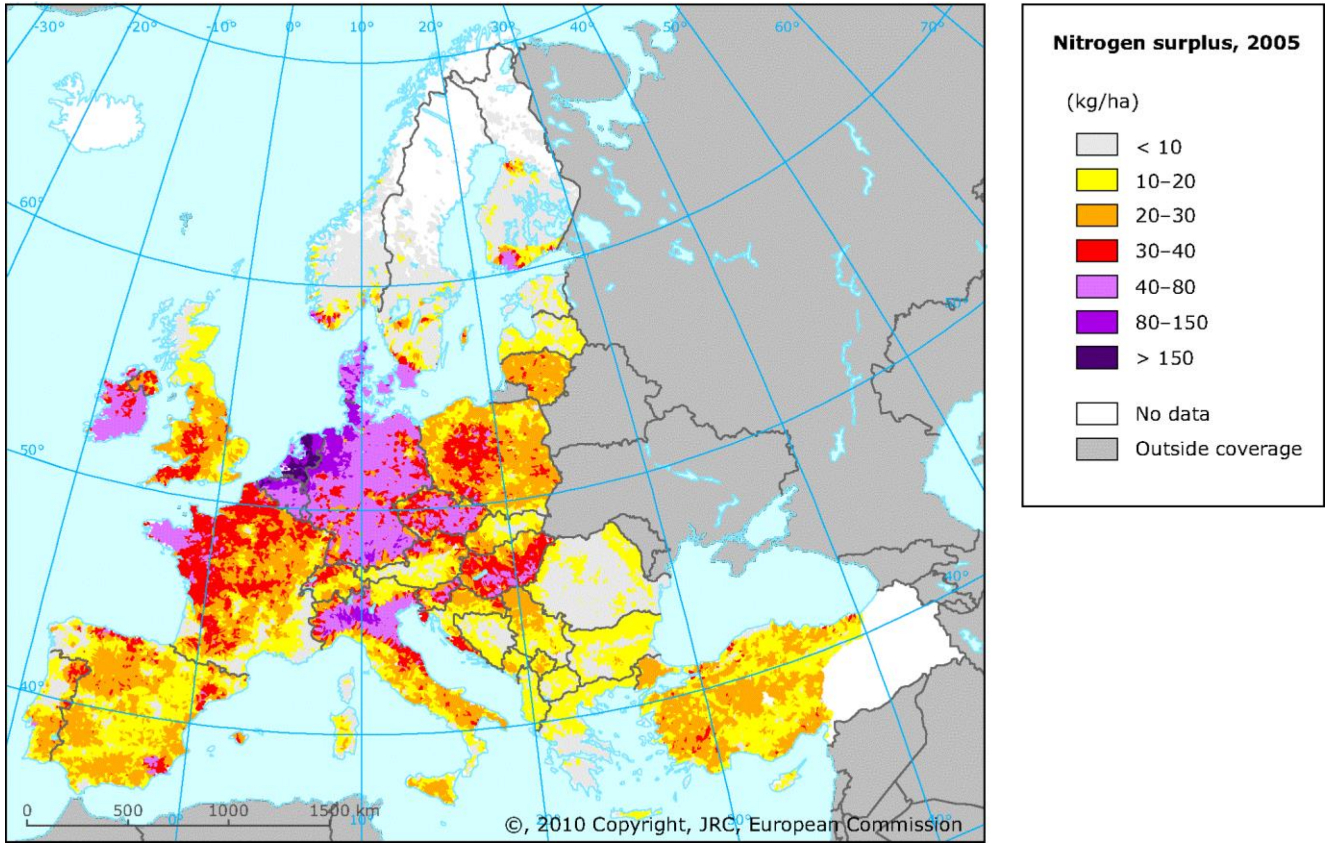
adapted from Galloway et al, 2016

EU MANURE WASTE HANDLING IS MADE MORE DIFFICULT
- CONCENTRATED ANIMAL HUSBANDRY CHALLENGES SUPPORT DUCTOR'S SOLUTIONS

- Out of the about 8 bn tons of manure being generated in Europe per year, 8 countries generate about 80%

- Between 3 and 5 Mt of N and P are currently not being effectively recovered for agricultural use. This quantity represent 20-30 percent of mineral fertilizer consumption in Europe.

- Stringent rules relates to storage and application



Ductor’s sustainable solution “pulled and pushed” from two sides

There is a “demand pull” from consumers and a “Solution Push” from legislators

Consumers and Society

- Different consumers demand different solutions. Food Security vs. Top segment buying behaviors, focusing Healthy, Safe and Sustainable organic products

Chemical Fertilizers

- The production of synthetic fertilizer brings 700 Mio tons of CO_2 and the intercontinental trade of fertilizers has a high transportation footprint
- 1 ton CH_4 as feedstock brings 2 tons CO_2 from Ammonia production, vs. world average of 6 tons

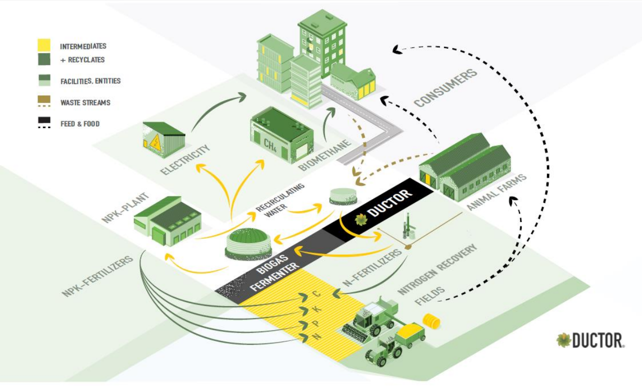
Manure Handling

- Direct Manure handling is a problem child bringing low Nutrient Use Efficiency, high ammonia volatilization, eutrophication, methane slip & high N_2O emissions.
- Application and storage challenges

THE DUCTOR WAY

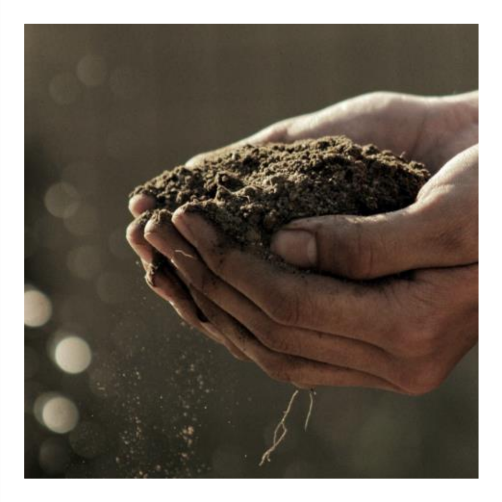
Circular Approach

> The Ductor Model



Holistic Agronomy

> Feeding soil and plants



Climate Positivity

> Carbon negative production

CLOSE UP ON DIGESTATE
- THE MAIN PRODUCT OF ANAEROBIC DIGESTION

Sustainability in agriculture means:

- Satisfaction of current and future demands of food production without undermining soil fertility and the natural resource base
- Considering energy consumption, use efficency of inputs and land, recycling of nutrients, effects on ecosystems, water bodies, and climate.

Anaerobic digestion as a solution:

- Option for stabilization of biogenic wastes.
- Enabeling the sanitation.
- Enabling the use of digestate as a CO_2e negative fertilizer.
- Producing energy from wastes.

With the inclusion of the fertilizer aspect, anaerobic digestion has the potential to become a core technology for sustainable agriculture.

THE WAY FROM MANURE TO FERTILIZER

Processing step	Purpose	Effect on substrate versus manure
AD-Process	Renewable Energy production (heat/electricity or biomethane)	Reduction of organic substance, increase of ammonium, reduction of Corg, rise of pH from neutral to about pH 8, lower viscosity, partial precipitation of P2O5 to less soluble forms
Separation	Separation of liquid and solid streams.	Liquid stream: Contains soluble nutrient like ammonium, potassium, but also chlorine and sodium. Low viscosity. Solid stream: Contains P_2O_5, residual Corg (non soluble fraction), other precipitated salts, Nitrogen in organically bound form (not immediately plant available). Can be further processed as organic NPK fertilizer after drying and pelletizing, or for further aerobic treatment (composting). High P_2O_5 content limits application.
Nitrogen recovery	Concentration of ammonium in liquid stream, neutralization with acids (mainly sulfuric acid). Production of a marketable liquid N+S fertilizer	Ammonium sulfate liquid with about 8 % nitrogen and 9 % sulfur (S) content. Mineral nitrogen fertilizer derived from processed manure or similar biological wastes. Meets RENURE criteria and can replace Haber-Bosch nitrogen. Ready for targeted application with 100 % MFE. Downside: Cost for chemical inputs for stripping exceed market price for ASL. New technologies for nitrogen recovery offer promising low-cost options.
P_2O_5 precipitation and separation	Removal of P2O5 for balanced nutrient content	Low-nutrient (N+P)+K organic fertzilizer (or soil improver) can further processed for maintenance of soil fertility (stable organic substance with supportive nutrients). Precipitated P_2O_5 (as struvite or similar) can replace mined phosphate. Downside: Solubility and plant availabilty limits market access, physical conditioning challenging (napplication on farm side). Economically useful?
K_2O filter	Recovery of K_2O	K_2O in Liquid phase free of N and P_2O_5 can be spilled to farmland directly or can be recoverd by ultra-filtration. K_2O recovery is not often used, as the recovery rate is low in contrast to the costs for invests, maintanance and energy. No or only low-cost marktability.

DIGESTATE VERSUS INPUT: CHANGES AND EFFECTS

NITROGEN: HIGHER AVAILABILITY, HIGHER RISK FOR LOSSES

- Transformation of organic N to mineral N (NH_4^+)
- Higher NUE in the year of application possible.
- But: More sensitive to potential losses (leaching, gaseous emissions) if not applied respecting 4R rules.

ORGANIC C: CONTRIBUTION TO SOIL ORGANIC MATTER

No negative effects of digestate on long-term humic substance content of soils versus untreated (Reinhold et al, 1991, Thompson et al. 2013)
C_{org} application of rapidly available C_{org} reduced. Remaining C_{org} more stable.
Reduced C:N ratio.

PHOSPHORUS: AVIALABILITY STRONGLY DEPENDING ON PROCESS

- Shift to higher pH leads to partical precipitation of short term available water soluble phosphate to Ca-phosphates and Mg-phosphates (struvite).
- This effect can be used for phosphate separation. Struvite can be marketed as biobased P fertilizer.
- Preliminary acidification leads to high P solubility, which can be used for incresed struvite precipitation
- Additives added to the AD fermenter have huge effects on phosphate availability: iron or aluminum salts (e.g. desulfurification) lead to precipitation of unsoluble Fe-P- or Al-P salts.

POTASSIUM: NO INFLUENCE

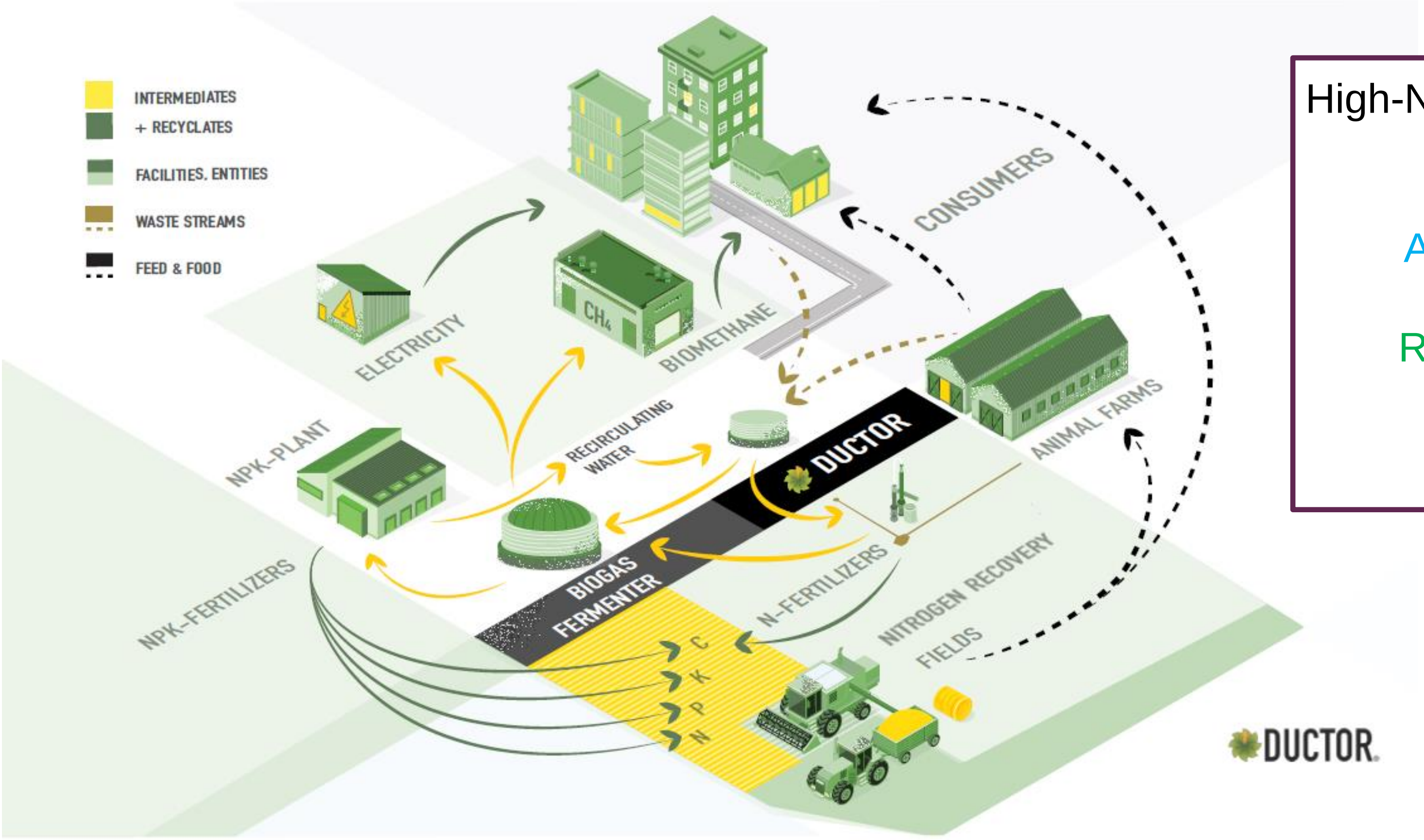
- AD does not infuence K^+ solubility (remians in water soluble form). Expemtion: Part of it can be included to struvite.

PH: SHIFT TO HIGHER PH

- CO_2 emission leads to pH increase:

$$HCO_3 + H+ \rightleftarrows H_2O + CO_2(sol) \rightleftarrows CO_2(gas)\uparrow$$
$$NH_4^+ \rightleftarrows H+ + NH3(sol) \rightleftarrows NH_3(gas)\uparrow$$

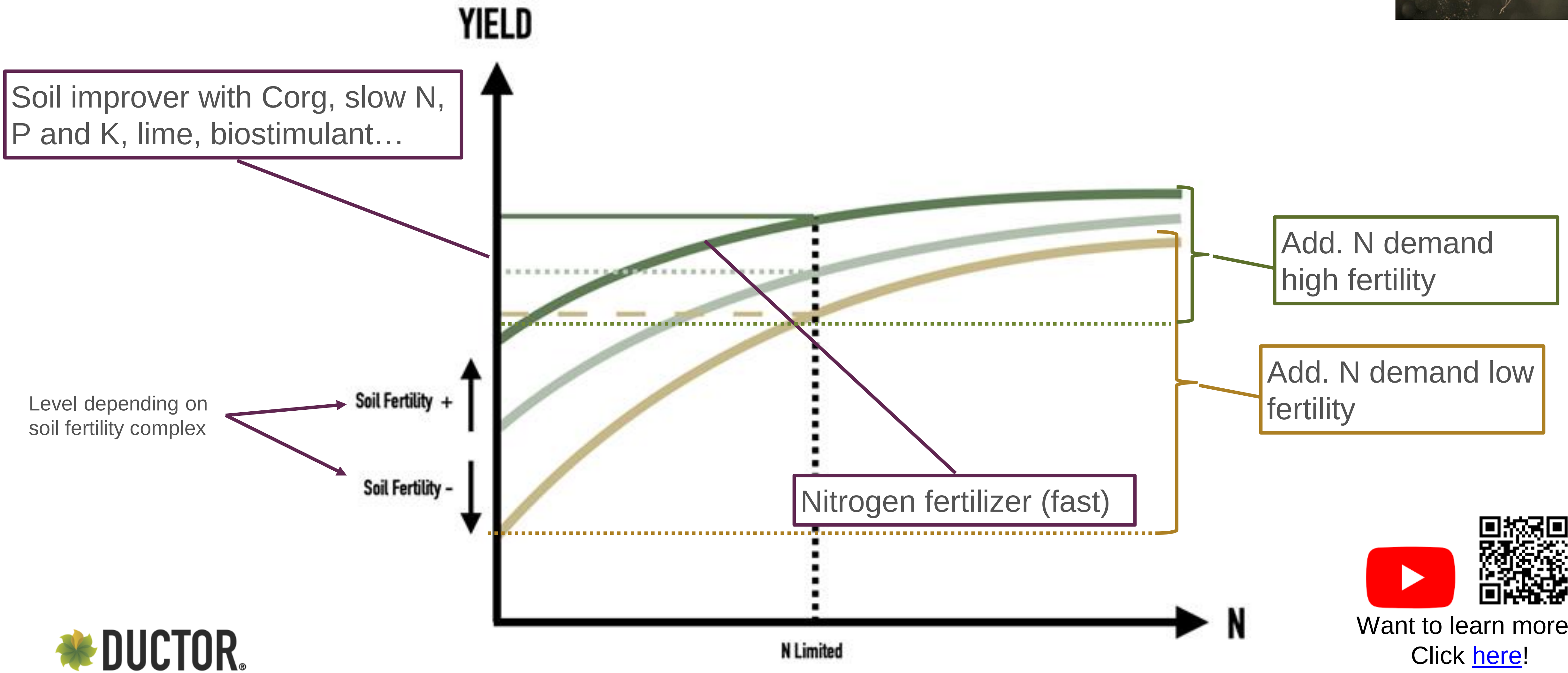
DUCTOR'S CIRCULAR MODEL



High-N Animal-By-Products (replacing energy crops)
Hydrolization and separation of N
recovered liquid N fertilizer
AD-Process with de-nitrogenized feedstock
Renewable energy
Recovered organic NPK fertilizer or soil improver

DUCTOR®

HOLISTIC AGRONOMY – OUR STORY



DUCTOR®

Want to learn more? Click here!

CLIMATE POSITIVITY – CASE STUDY

Ductor’s fertilizers save GHG emissions in two ways:

1. Replacement of fossil fuels and electricity by renewable energy:

Ductor professional LCA in cooperation with First Climate, following all international guidelines, enables the calculation and certification of the GHG footprint of all Ductor’s operations.

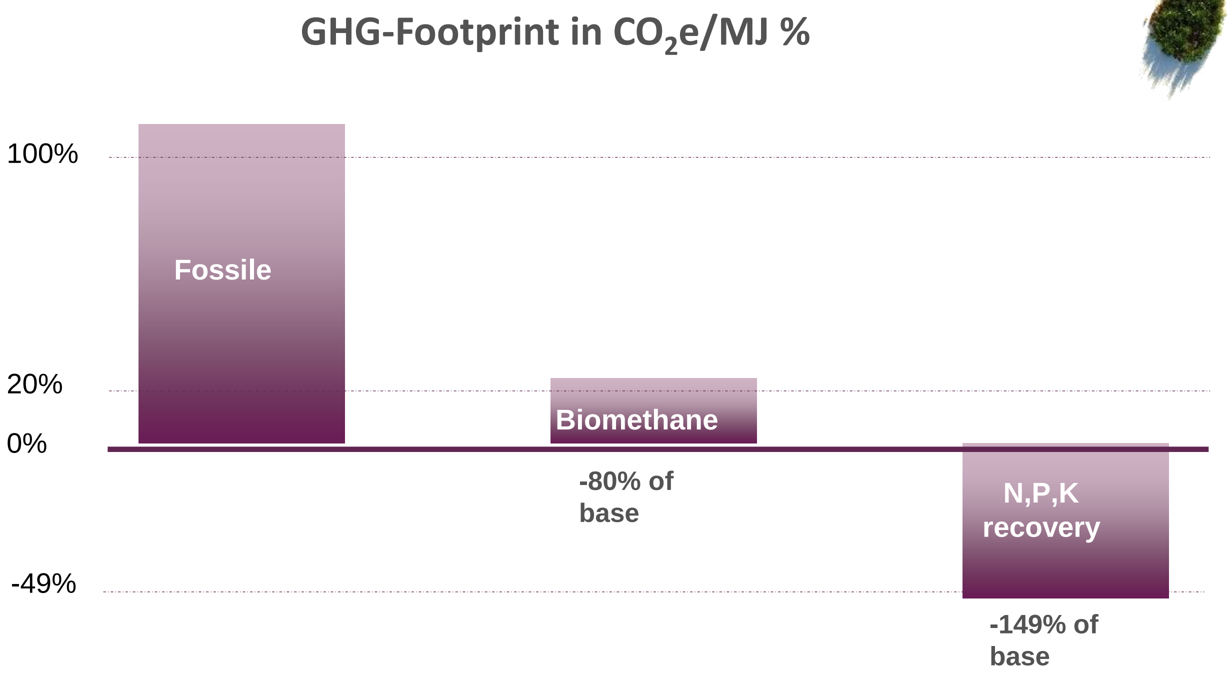
Pilot scenario shows that the GHG footprint with Ductor’s biomethane vs. con. LNG is reduced by up to 80 %.

2. Replacement of mineral fertilizers by recycled organic based fertilizers:

Major GHG emissions from agriculture derives from nitrogen fertilization. 2 % of the total GHG emissions are caused by the ammonia synthesis of Haber-Bosch. By replacing synthetic nitrogen by Ductor recovered nitrogen, GHG emissions per unit nitrogen applied is reduced by up to 83 % according to Cool Farm Tool standard calculation: Per kg $N+P_2O_5+K_2O$, about 7 kg CO_2 eq emissions are avoided.

3. (not included): Effect on land use change:

Farmland can be used for other purposes than energy crop production.



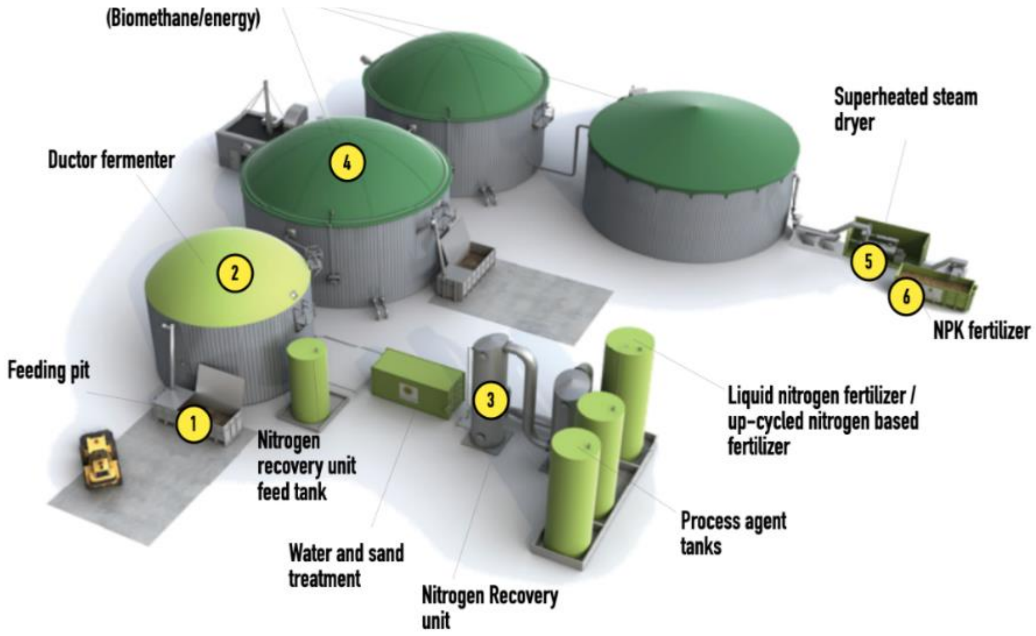
Consolidated effect of energy and nutrient recovery:

Related to energy consumption Ductor’s technology reduces the GHG footprint **in total by - 149 % versus fossil base (100 %)** , resulting in **- 80 % by biomethane**, and additionally **-69 % by mineral fertilizer replacement.**

DUCTOR®
Source: Ductor

DESIGN OF TYPICAL DUCTOR PLANT

Product from biogas	Quantity	Unit
Electricity, total production	4 500	MWh
Electricity, net production	3 600	MWh
Heat, total production	4 700	MWh
Product from digestate		
Wet digestate (DM30%)	9 000	Ton / a
Products from Nitrogen		
Ammonium sulphate (38 %	1 400	Ton / a



Ductor plant at Haren, Germany (add on)
Silage corn of about 200 ha are replaced by chicken litter with Ductor's technology

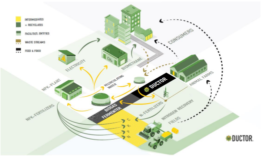
ORGANIC DERIVED FERTILIZERS FOR ORGANIC FARMING?

Approval for the use as input in organic farming in California (CDFA certified since August 2021 under NOP)

REGISTERED
cdfa
ORGANIC INPUT MATERIAL

DUCTOR®

CONCLUSION



1. **Multi-level sustainable value-creation** through handling of agricultural wastes streams such as manure, slurry and other organic wastes high in nitrogen.
2. Stable fertilizer and soil improving **products** as well as **energy** are obtained from organic resources.
3. Nitrogen can be applied safely and in a targeted manner, allowing **compliance with RENURE**.
4. **Release of agricultural land** previously occupied by energy crop production (e.g., maize) can be used alternatively now, allowing **economical improvement** for farms. **The exchange rate is ~ 1:1.**
5. Production is **carbon negative**.
6. Recovered liquid nitrogen produced by Ductor's process is **approved for OF in California by CDFA**

→ With the inclusion of the fertilizer aspect, anaerobic digestion has the potential to become a core technology for sustainable agriculture.

THANK YOU!

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DIGESTATE VERSUS INPUT: CHANGES AND EFFECTS (1)

NITROGEN

- Conversion from organic bound nitrogen to ammonia nitrogen.
- Higher share of direct available of nitrogen: Specific yield effect in the year of application depends directly on NH^{4+}-content and close C:N ratio.
- Must be applied on demand, otherwise higher risk of leaching/emission. Higher pH + highe ammonium content = higher risk of ammonia emissions. Lower viscosity = higher infiltration rates = less ammonia emissions. Incorporation in soils = lower NH_3-emissions, but might rise N_2O emissions (emission swapping).
- Further treatment: Solid/liquid separation:
- Separation of ammonium from residual organic matter.
- Stripping of ammonia for further concentration: Meeting JRC renure requirements in C:N ratio and residual N_{org} content: mineral N:TN ratio ≥ 90% or a TOC:TN ratio ≤ 3.
- Plan: Can be exempted from 170 kg p.a. limitation on organic nitrogen in Nitrate Directive 91/676/EWG (170 kg /ha limit).

ORGANIC C: Conversion of fatty acids and carbohydrates to CO_2 and CH_4.

- Up to 90 % of C_{org} converted, depending on composition.
- Lignin and parts od cellulose are not decomposed --- contribution to soil humic substance
- Hemicellulose, fatty acids: complete decomposition
- Proteins: Complete decomposition, N is hydrolysed to NH_4^+
- No negative effects of digestate on long-term humic substance content of soils versus untreated (Reinhold et al, 1991, Thompson et al. 2013)
- C_{org} application of rapidly available C_{org} reduced. Remaining C_{org} more stable.

DIGESTATE VERSUS INPUT: CHANGES AND EFFECTS (2)

C:N RATIO

- In case if ammoniacal nitrogen was recovered: Solid phase = NPK fertilizer or soil improver?
- Ideal C:N ratio: 9 – 13:1 (meets natural C:N ratio of soils)

PHOSPHORUS

- Shift to higher pH leads to partical precipitation of short term available water soluble phosphate to Ca-phosphates and Mg-phosphates (struvite).
- This effect can be used for phosphate separation. Struvite can be marketed as biobased P fertilizer.
- Preliminary acidification leads to high P solubility, which can be used for incresed struvite precipitation
- Additives added to the AD fermenter have huge effects on phosphate availability: iron or aluminum salts (e.g. desulfurification) lead to precipitation of unsoluble Fe-P- or Al-P salts.

POTASSIUM

AD does not infuence K^+ solubility (remians in water soluble form). Expemtion: Part of it can be included to struvite.

PH:

CO_2 emission leads to pH increase:

$$HCO_3 + H+ \rightleftarrows H_2O + CO_2(sol) \rightleftarrows CO_2(gas)\uparrow$$
$$NH_4^+ \rightleftarrows H+ + NH3(sol) \rightleftarrows NH_3(gas)\uparrow$$

REGULATORY CHALLENGES - RENURE

How does RENURE affect fertilization practices?

RENURE= Report, published by the Joint Research Centre (JRC) of the European Commission on "technical proposals for the safe use of processed manure above the threshold established for Nitrate Vulnerable Zones by the Nitrates Directive (91/676/EEC)".

→ Aims to reduce adverse environmental effects caused by manure handling and increasing agronomic efficiency.

How can Ductor's technology help to achieve this goal?

Ductor's technology, based on biological and physical processes, separates the nutrient streams contained in regular farmyard manure into a liquid nitrogen phase and a solid phase. By that organic nitrogen can be used in a targeted manner, comparable to a mineral fertilizer.

→ Original JRC publication to be found here!

DUCTOR®

MARKET SIZE ORGANIC DERIVED FERTILIZERS

- Total Manure production 1.4 BMt, 7.8% processed
- 6.5-7 MMt of organic processed products
- 70% of sales is in solids, 30% in liquids
- Total value Euro 1.8 billion in 2017, Euro 3.5 billion in 2026 i.e. **average annual growth of 8-9%**
- Total estimated **pelletized** sales around 1.67 MMt
- Total estimated **pelletized** capacity around 2.2 MMt. Average capacity per fty: 25-50K Mt. Over 60+ producers
- Most producers are at full capacity due to (spot) based export opportunities (ME + AP)
- Conservative anticipated EU sales **pelletized products** 2026/2027 2.6 MMt

Production Capacity Europe			EU Sales		Outside EU Sales
	Mt * 1000	%	Mt * 1000	%	Mt * 1000
Spain	664	*64%*	431	*36%*	233
Italy	540	*78%*	416	*22%*	124
France	399	*91%*	354	*9%*	46
Belgium	150	*45%*	63	*55%*	87
The Netherlands	155	*67%*	85	*33%*	70
Germany	105	*100%*	105	*0%*	0
Poland	85	*100%*	85	*0%*	0
UK	50	*90%*	45	*10%*	5
Scandinavia	80	*100%*	80	*0%*	0
Baltics	11	*100%*	11	*0%*	0
Total	***2,239***		***1,674***		***565***

EBA Conference – 27 October

The value of carbon removals

JOANNA POST

Programme Officer, UNFCCC

EBA
European Biogas Association

26–27 October 2021, Brussels

SESSION 3: BIOGAS CIRCULARITY

PANEL DISCUSSION

European Biogas Conference
26-27 October 2021

Emilio Folli, Consorzio Italiano Biogas

Adam Nowak, European Young Farmers Organisation

Vasileios Diamantis, Democritus University of Thrace

Thomas Manheim, DUCTOR

CLOSING SESSION: FUTURE OF BIOGAS

Moderated by TV & Radio presenter Sasha Twining

European Biogas Conference
26-27 October 2021

Philipp Lukas, Future Biogas

Madeleine Alphen, Pyrogasification Club at ATEE

Harmen Dekker, European Biogas Association

Steve Jones, BayoTech

EBA Conference – 27 October

CO2 valorisation in biomethane production

PHILIPP LUKAS
Chief Executive Officer, Future Biogas

EBA
European Biogas Association

26–27 October 2021, Brussels

EBA Conference – 27 October

Looking into the market readiness of gasification technologies

MADELEINE ALPHEN

General Delegate of the Pyrogasification Club, ATEE

European Biogas Association

26–27 October 2021, Brussels

atee Club Pyrogazéification
ASSOCIATION TECHNIQUE ENERGIE ENVIRONNEMENT

Closing session: future of biogas

Looking into the market readiness of gasification technologies

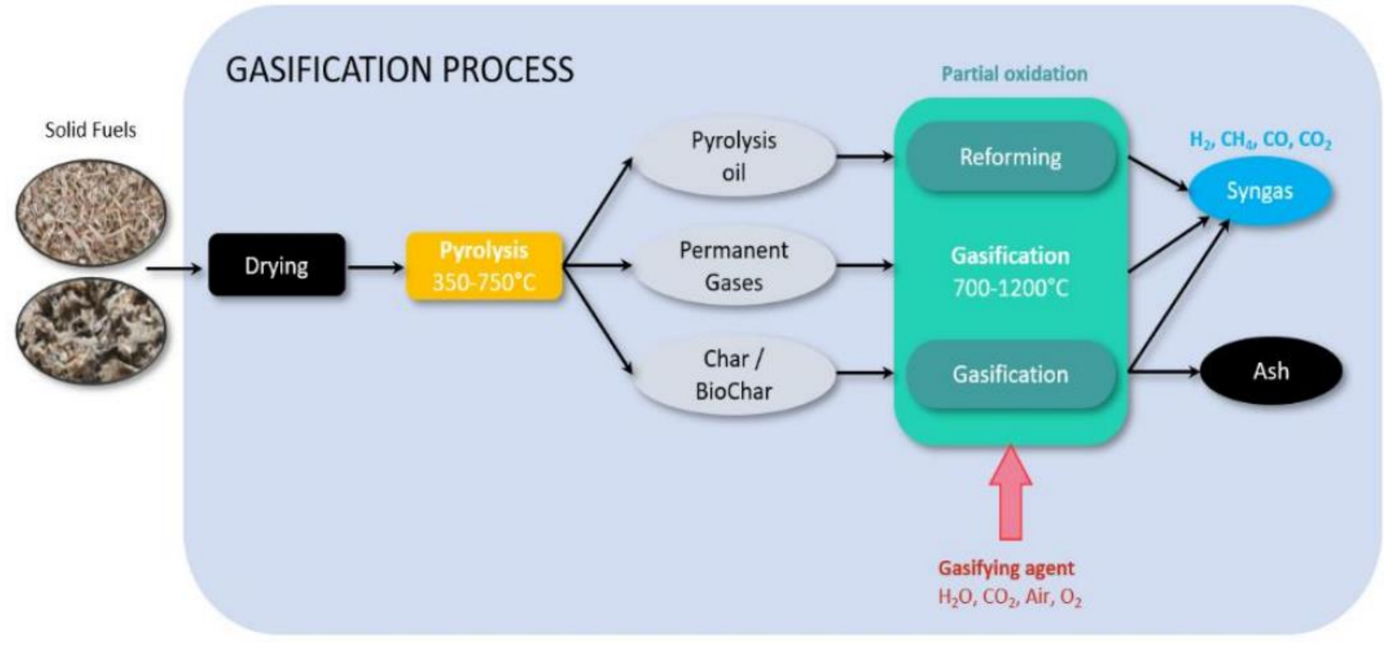
EBA CONFERENCE 2021

Madeleine ALPHEN

General Delegate of the French Pyrogasification Club

TECHNICAL ASSOCIATION FOR ENERGY AND ENVIRONMENT (ATEE)

What is gasification?



1. **PYROLYSIS** is a **thermal treatment** of which, in the absence of oxygen, transforms soli carbonaceous materials into a gaseous phase (synthesis gas or syngas), a liquid phase (oil) and a solid phase (char).

2. **GASIFICATION** is a pyrolysis followed by a process of **transforming non-gaseous phases** into syngas by adding a small amount of air, oxygen, CO2 or water vapor.

Syngas can be used in various applications including:

- Direct and local use of the gas for **high-T° heating**
- Use in gas engines for **CHP generation**
- Use as an **educt for several chemical synthesis** like Fischer-Tropsch, Synthetic Natural Gas, Hydrogen or Methanol

atee ASSOCIATION TECHNIQUE ENERGIE ENVIRONNEMENT Club Pyrogazéification

A wide range of eligible feedstock

Solid biomass, biogenic waste, non-recyclable waste (SRF, plastics, used tires, etc.)


Woody biomass / Forest chips


Crop residues (straw)


Green waste


Polluted wood


Furniture waste
waste wood


Grape marc / Olive pomace


Solid Recovered Fuel (SRF)
plastics, wood, foam and textile

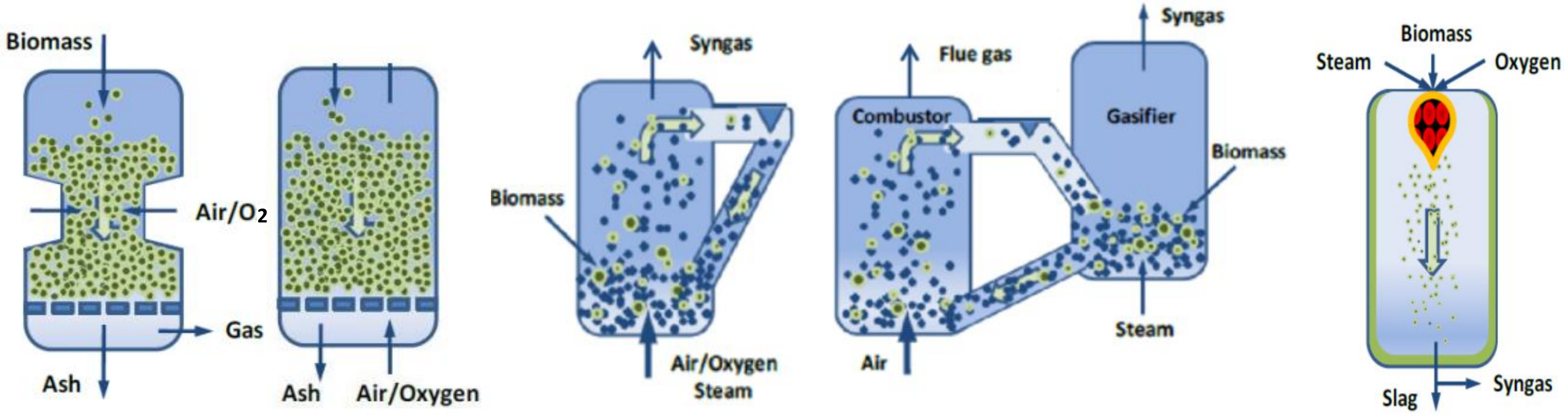

Non-recyclable / polluted plastics


Digestate from anaerobic digestion

Gasification technologies

Different types of gasification reactors are commonly used in today's market.
They offer a modular range of capacity from kW to GW and for various types of feedstock.

Most common types of reactor:



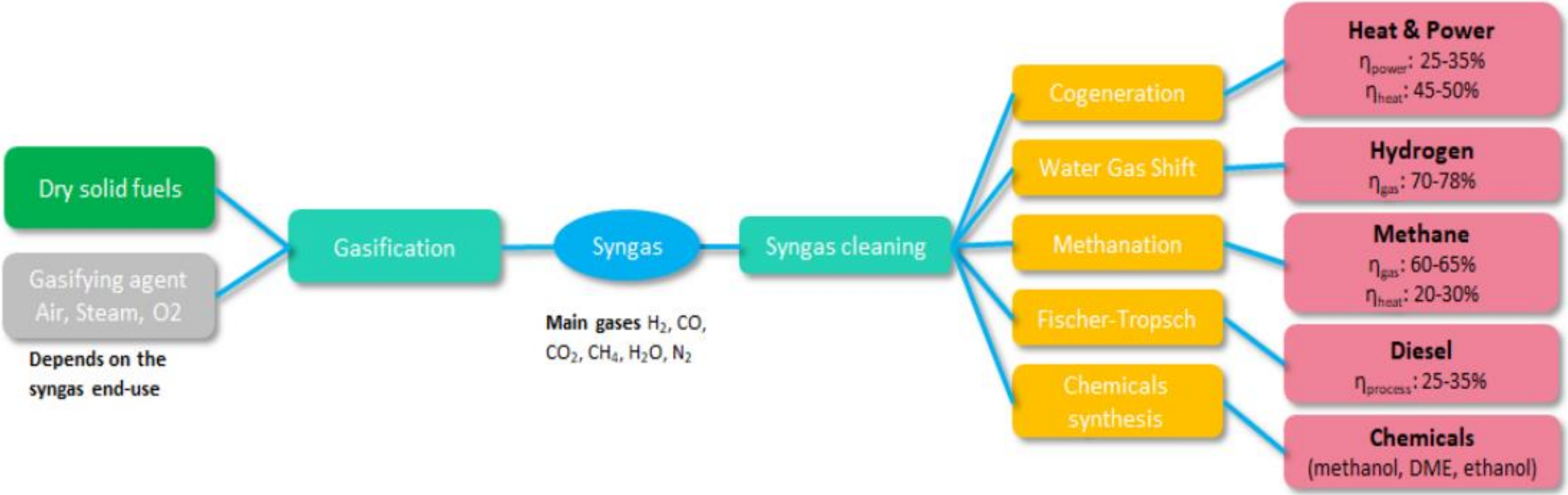
Fixed bed
updraft, downdraft, twin fire and fixed-floating bed

Fluidized bed
bubbling, circulating

Dual fluidized bed

Entrained flow

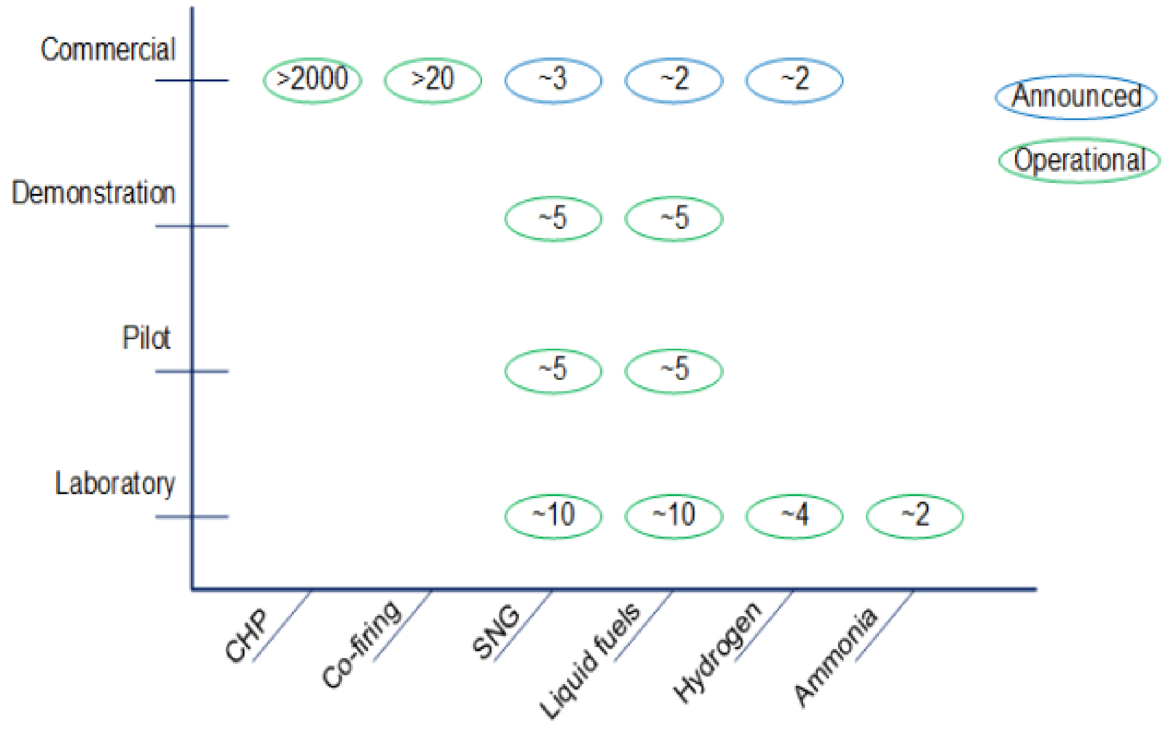
Various applications of the produced syngas…



Biochar valorisation pathways:

- Uses for biochars are mainly found in **agriculture** (feed amendment, stable bedding, slurry stabilization or directly in soils)
- New applications are being developed in **building materials** (concrete or asphalt), in **plastics** or in **high-tech** (to replace fossil resources).
- Carbon sink: as long as the biochars are not thermally used, the **carbon is conserved** over hundreds to thousands of years.

Existing gasification facilities worldwide



1. The **production of power and heat (CHP)** as well as **co-firing** are **very well-established** technologies:

> 2000 operating CHP units

from a few 10 kWe to several MWe

2. There are **far fewer plants which produce synthetic biofuels and biochemicals** but **lots of new projects** are currently being developed.

Since the end of the 20th century…

→ Awareness regarding climate change

→ New interest towards biomass and waste gasification for CHP and molecules synthesis (fuels, renewable gas and chemical molecules)

Project exemple

BioTfuel Project – Dunkerque, France

Objective: to develop, demonstrate and commercialize a full B-XtL chain

- Process chain validated and optimized on a **wide range** of biomass
- **End to end solution**: From R&D to market / From biomass to final products

CURRENT STATUS:

- Commissioning and start up completed
- Demonstration and technology optimisation completed
- On the way to **commercialization**:

> *Axens (on behalf of consortium): single licensor for the complete B-XtL chain*
>
> *A performance guarantee for the complete chain:*
>
> - *For processes and catalysts*
> - *From biomass to final products*
>
> *A full scope of services from studies to unit start-up and follow-up*

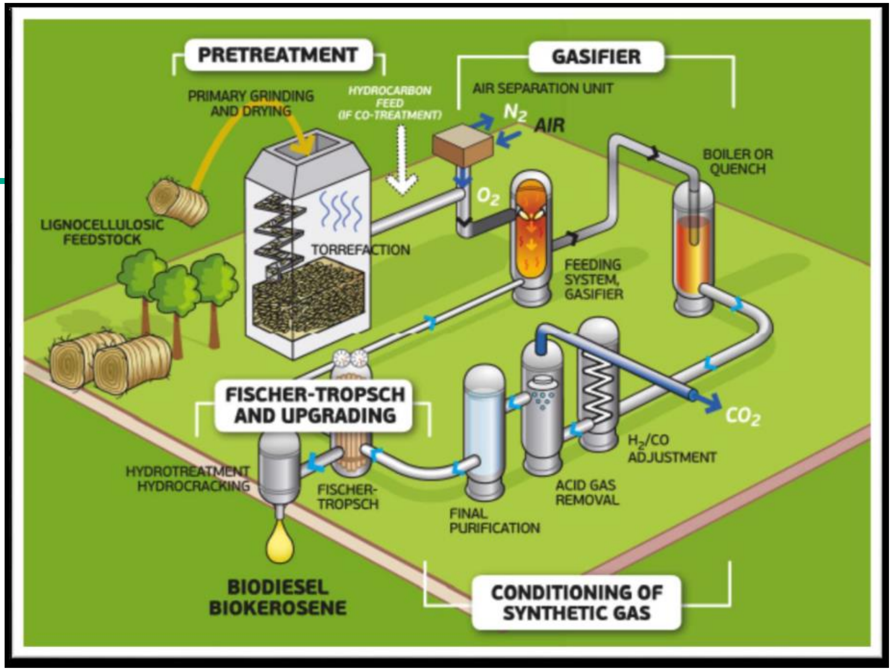


Photo: Bionext

Project exemple

GAYA Project – Dunkerque, France

Objective: to demonstrate the feasibility of the production of 2nd generation bioCH4

- A 10-year R&D program
- Demonstration platform covering the **entire production chain**

FEEDSTOCK:

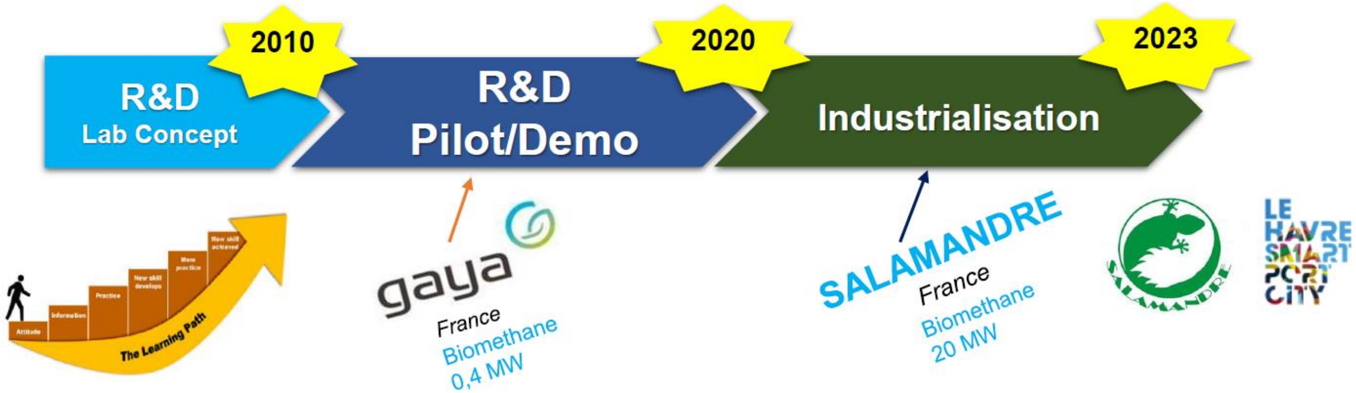
- woody biomass
- non-recyclable waste (Solid Recovered Fuel)

OUTPUT:

- biomethane 0,4 MW (demo)

STATUS:

- Oct. 2017: platform inauguration
- Nov. 2018: 1st production of purified synthesis gas from biomass
- Nov.2019: 1st production of biomethane from woody biomass
- Nov. 2020: 1st production of biomethane from SRF



What future for gasification?
Market readiness and industrialization potentials

WHAT POTENTIALS?

- A **decentralized approach** based on the needs of the territories
- A **new outlet for waste recovery** while respecting the treatment hierarchy
- A **decarbonisation solution**: energy-intensive industries, heat / electricity, networks, mobility
- A tool for **energy independence** in Europe

WHERE ARE WE NOW?

- **Growing interest** from regional stakeholders (communities, industrialists, etc.)
  A versatile solution that can be adapted to various local circumstances
- **Industrial maturity levels or close** depending on the inputs and outlets targeted
- A European **know-how** and many **emerging projects:**
  Projects adapted to the scales and needs of the territories
  Existing demonstrators for the production of synthetic methane, hydrogen and (bio) fuels

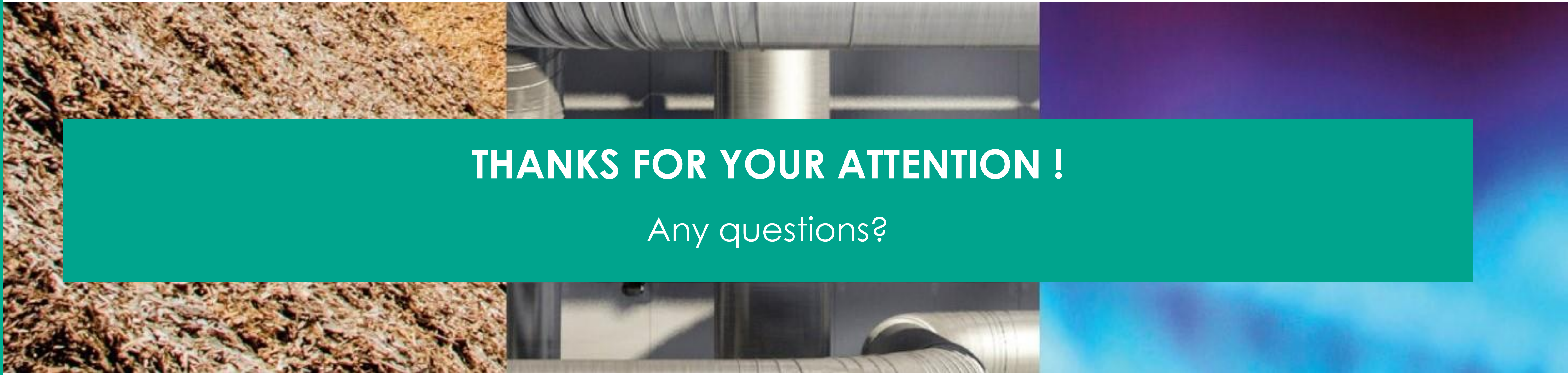
WHAT ARE THE STAKEHOLDERS' EXPECTATIONS?

- **Regulations adapted** to the scale and life of the projects
- **Recognition and support from public authorities** to launch the first commercial units for the production of synthetic methane, hydrogen and biofuels by gasification of biomass and waste

Photo: Leroux&Lotz

atee Club Pyrogazéification

ASSOCIATION TECHNIQUE ENERGIE ENVIRONNEMENT



Contact information:

Madeleine ALPHEN – m.alphen@atee.fr

https://atee.fr/energies-renouvelables/club-pyrogazeification

EBA Conference – 27 October

Showcasing cutting-edge renewable gas technologies

HARMEN DEKKER

Director, EBA

EBA
European Biogas Association

26-27 October 2021, Brussels

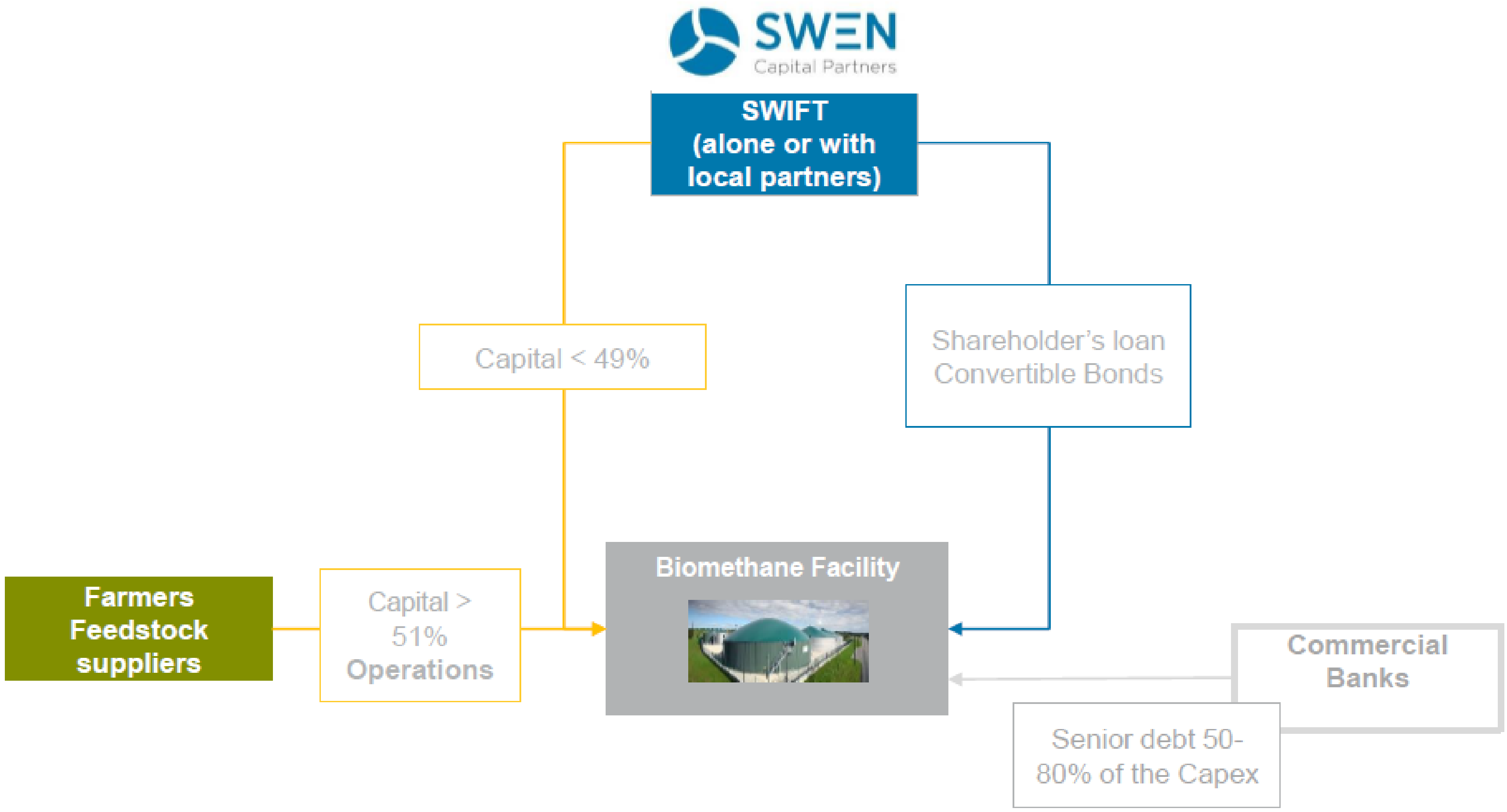
European Biogas
Association

SHOWCASING CUTTTING-EDGE RENEWABLE TECHNOLOGIES

Harmen Dekker
Director

- Enablers
- Improvements
- New Products
- Measurements

Typical financing of biomethane facility



Tailored solutions for specific foam origins and different feedstocks

Solutions	Agricultural	Industrial	M-E Evaporaors
EROL MET 610	☑	☑	☑
EROL MET 1500		☑	
EROL MET 1900		☑	☑
EROL MET 1950	☑	☑	
EROL MET 2800	☑	☑	☑
EROL MET 3200	☑		

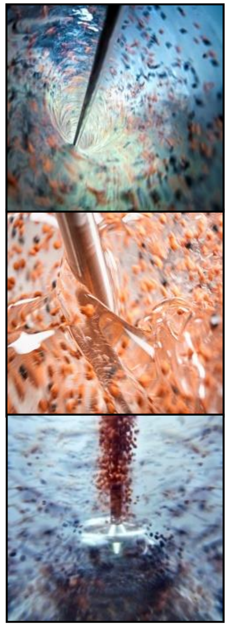

25L Keg

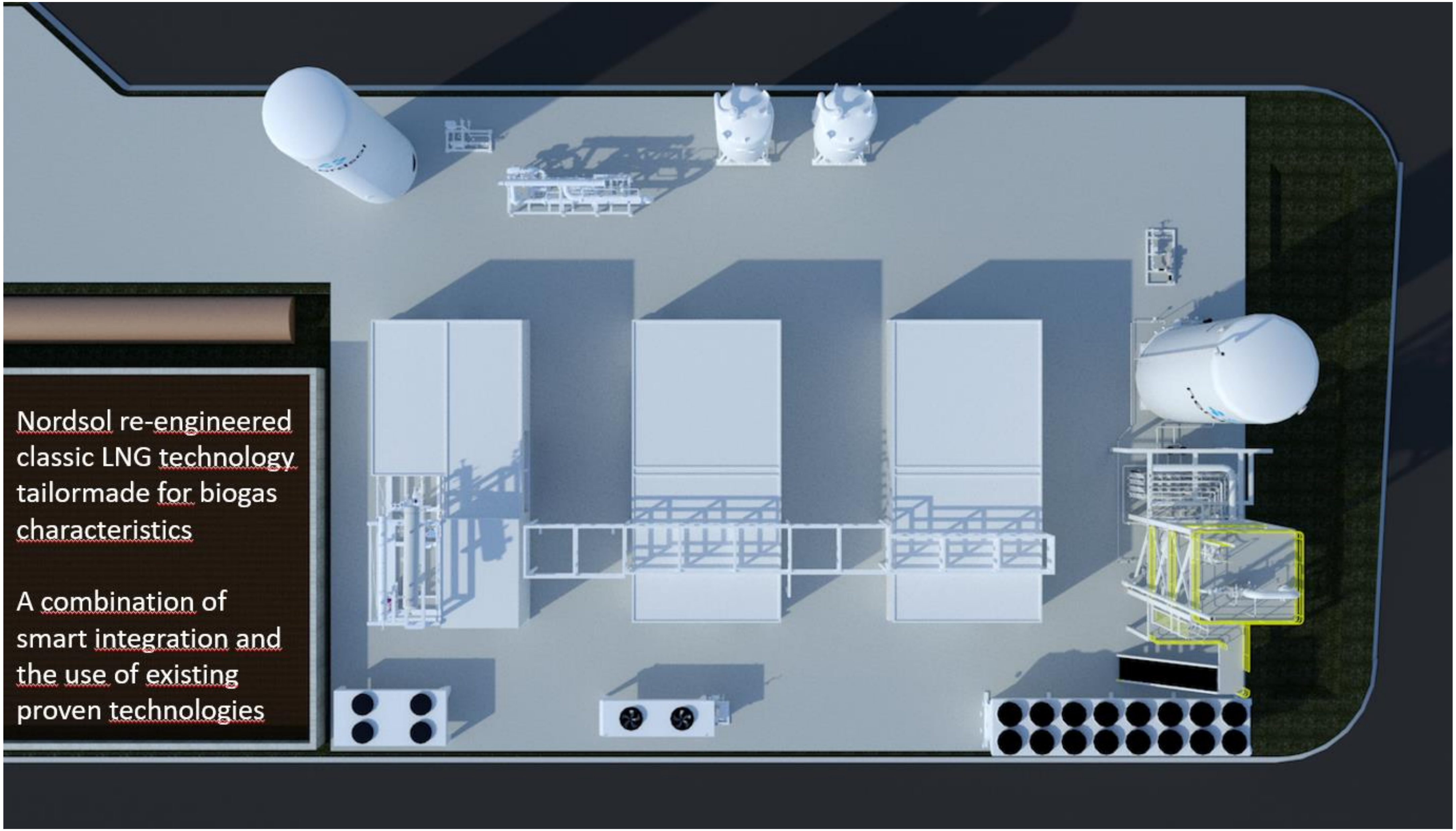

220L Drum


1000L IBC


Multi-effect evaporators


Welcome to our
competence
centre
Tailor made
mixing solutions
Knowledge
We know your product and offer our expertise
to optimize your production process
Innovation
We act on the market's requirements, continuously
improving and innovating
Equipment
We supply robust, reliable, and durable equipment
for optimal TCO
Support
We assist you during installation & commissioning
and provide 24/7 after-sales services
jongia
mixing technology





nordsol

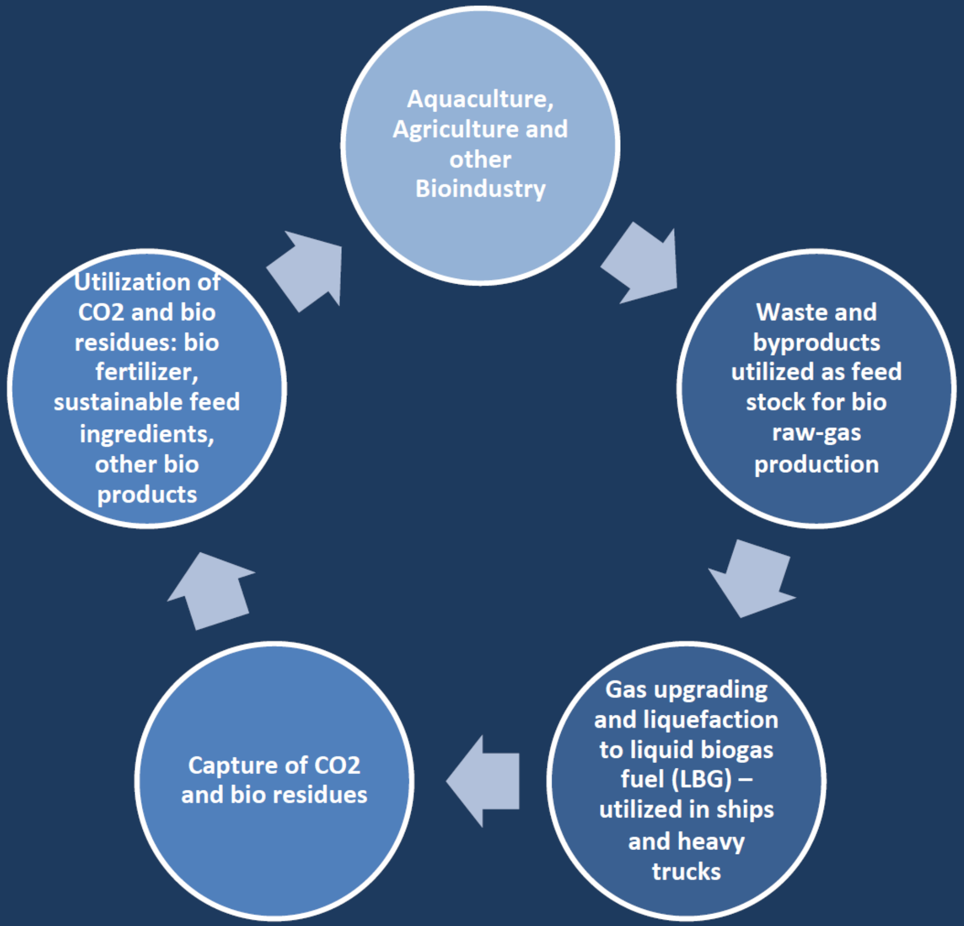
The future is liquid.

How we fit in the global picture

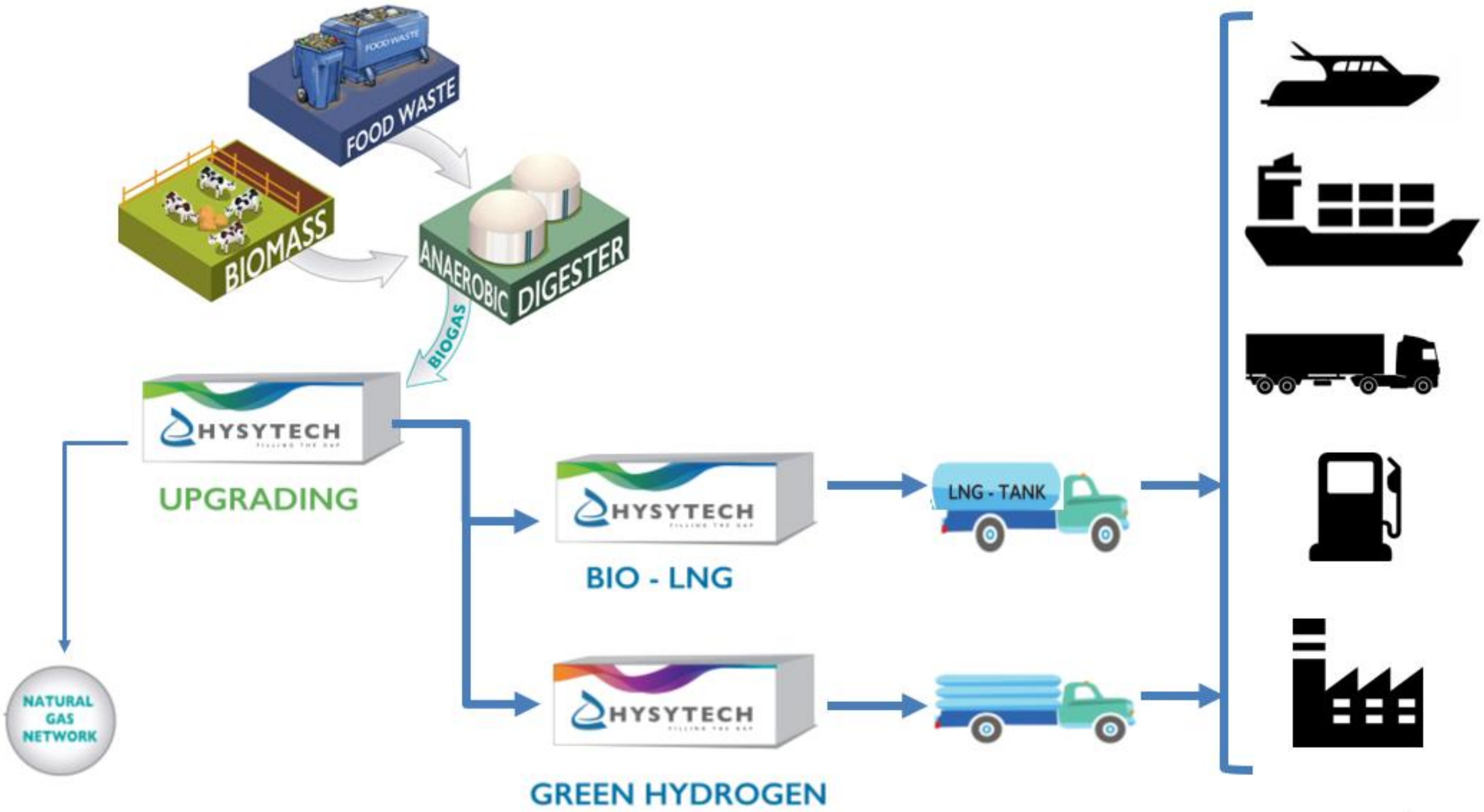
Biokraft – circular bioeconomy innovation power

Innovation R&D efforts, productification:

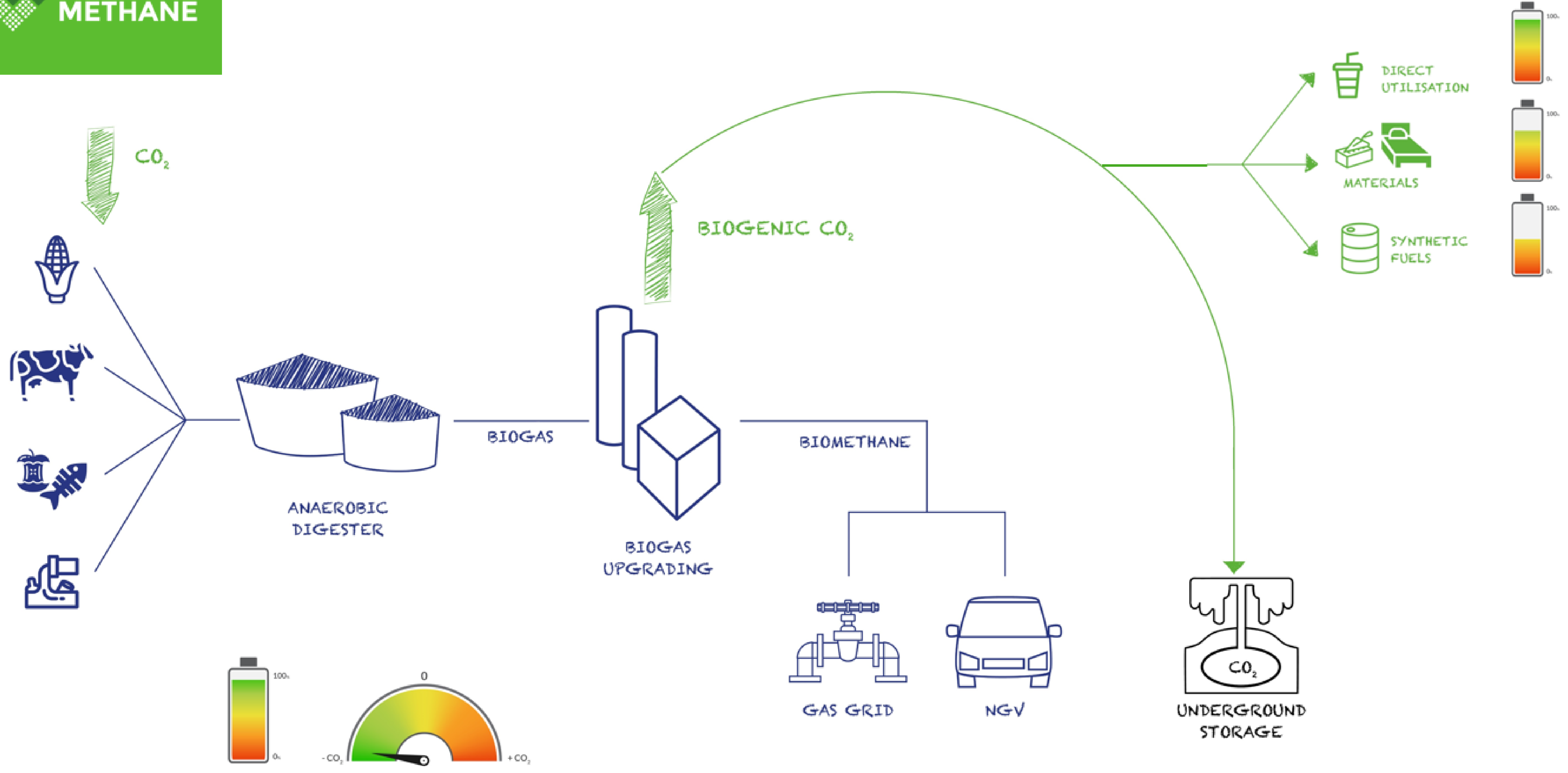
- ***JETFUEL***
- ***Digitalization***
- ***Bio fertilizer***
- ***e-LBG***
- ***Sustainable feed ingredients***
- ***"GREEN", "SUSTAINABLE" (the new taxonomy will change things)***

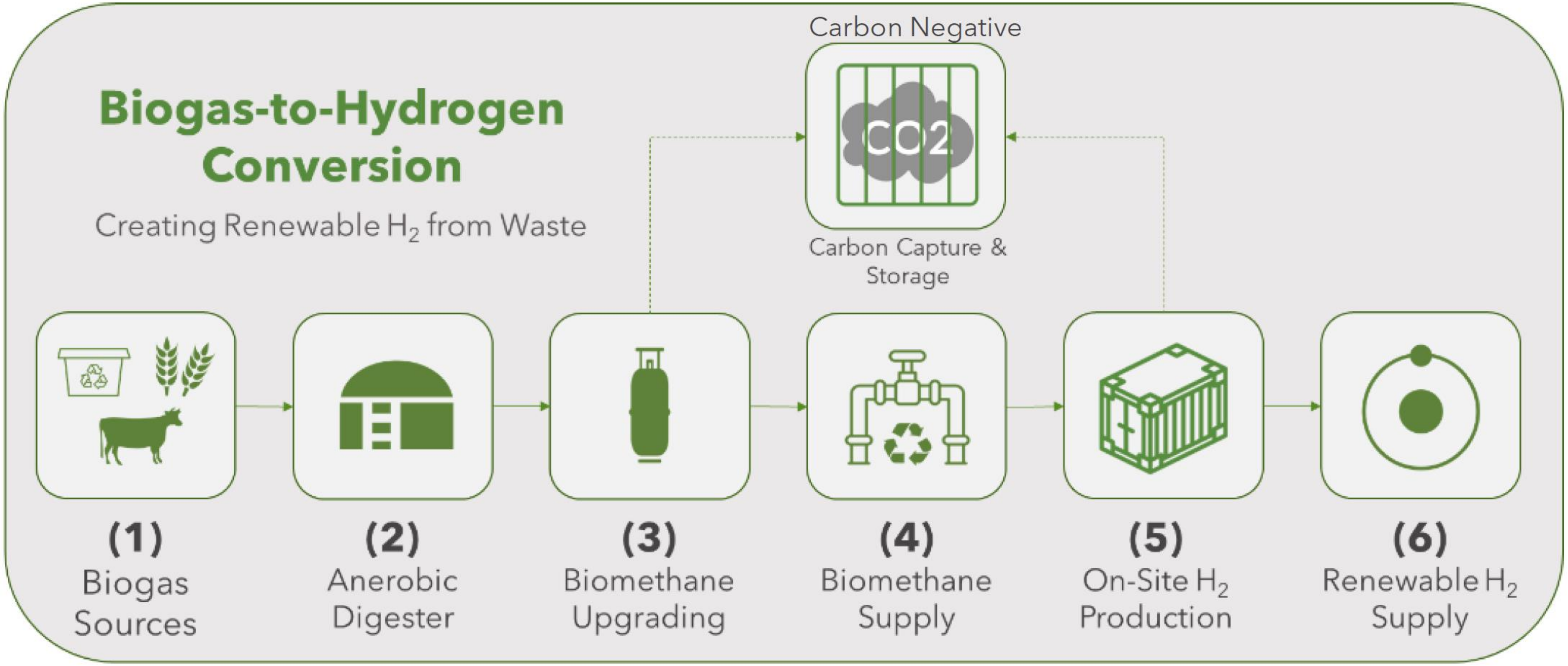


• Biogas value chain as biofuel

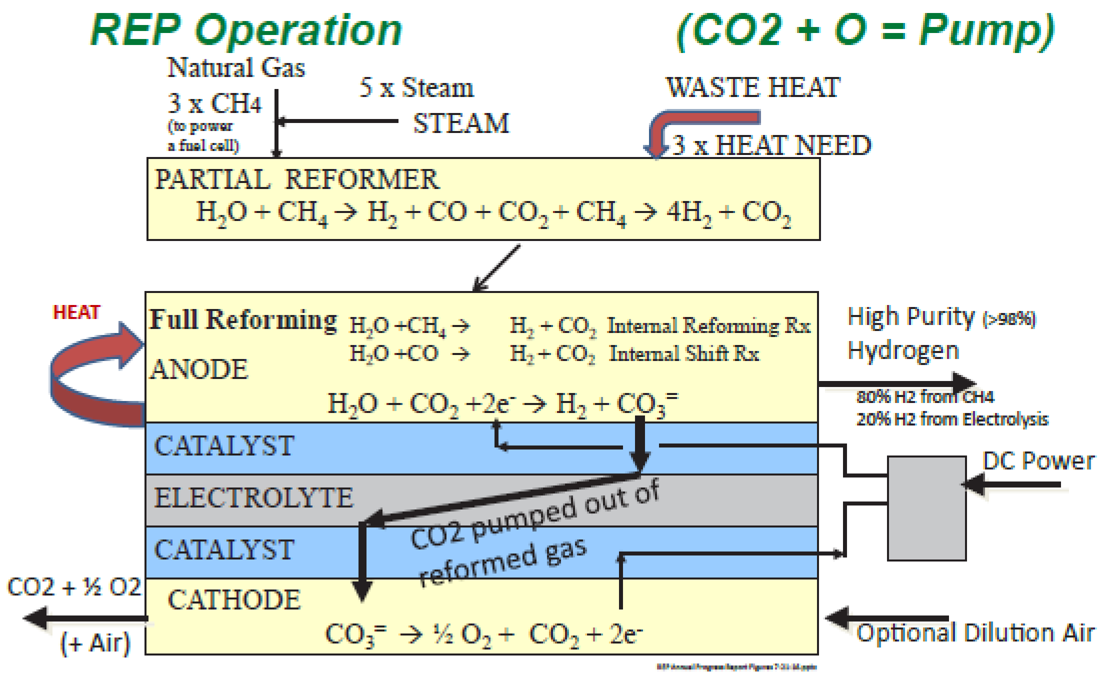


Biomethane production pathway with CCS




Biogas-to-Hydrogen Conversion
Creating Renewable H_2 from Waste
Carbon Negative
CO2
Carbon Capture & Storage
(1) Biogas Sources
(2) Anerobic Digester
(3) Biomethane Upgrading
(4) Biomethane Supply
(5) On-Site H_2 Production
(6) Renewable H_2 Supply

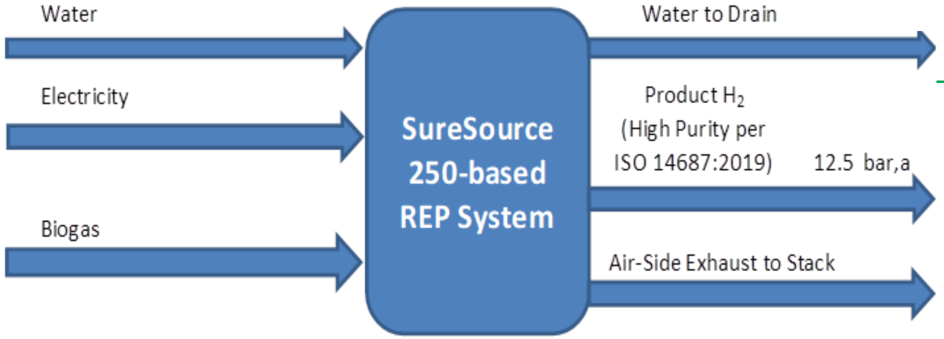
REP – Reforming Electrolysis Purification

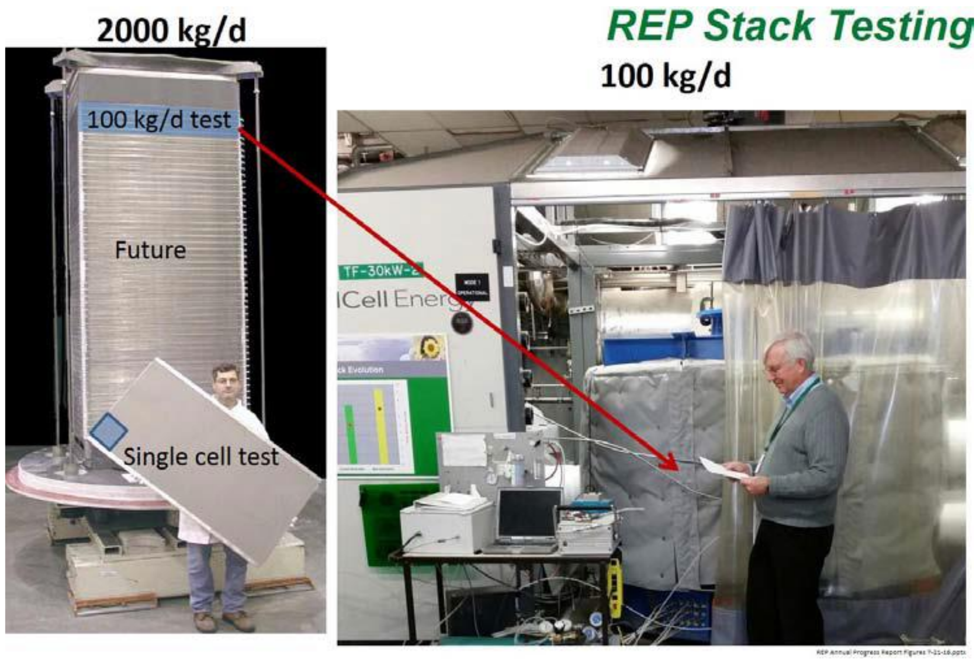


10 x H2 per cell generated, external heat source is needed

Rx - Reaction; DC - Direct current

FIGURE 1. Operation of Reforming-Electrolyzer-Purifier (REP)



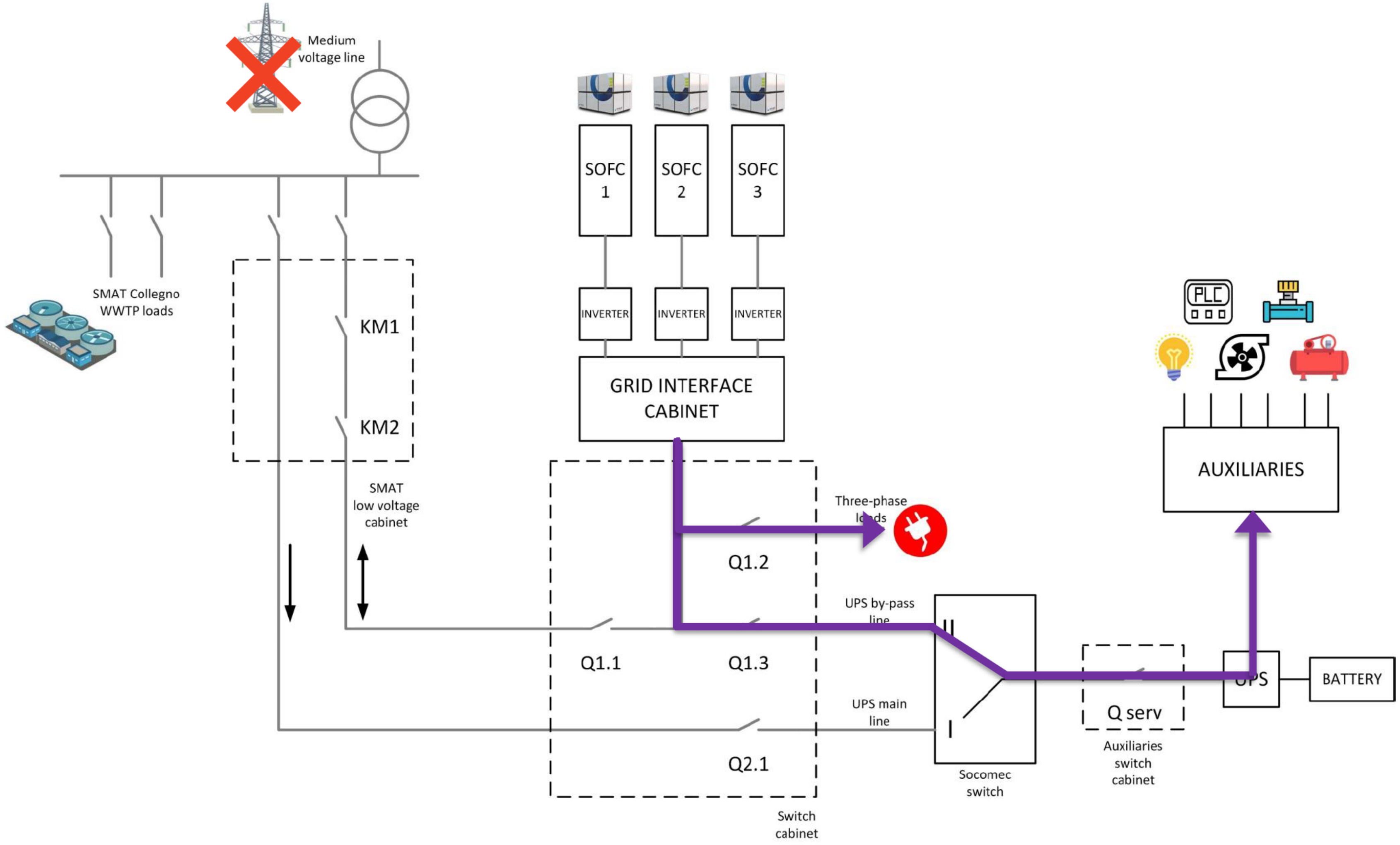


System tested and operated at the lab. We are ready for the first demo plant in the field

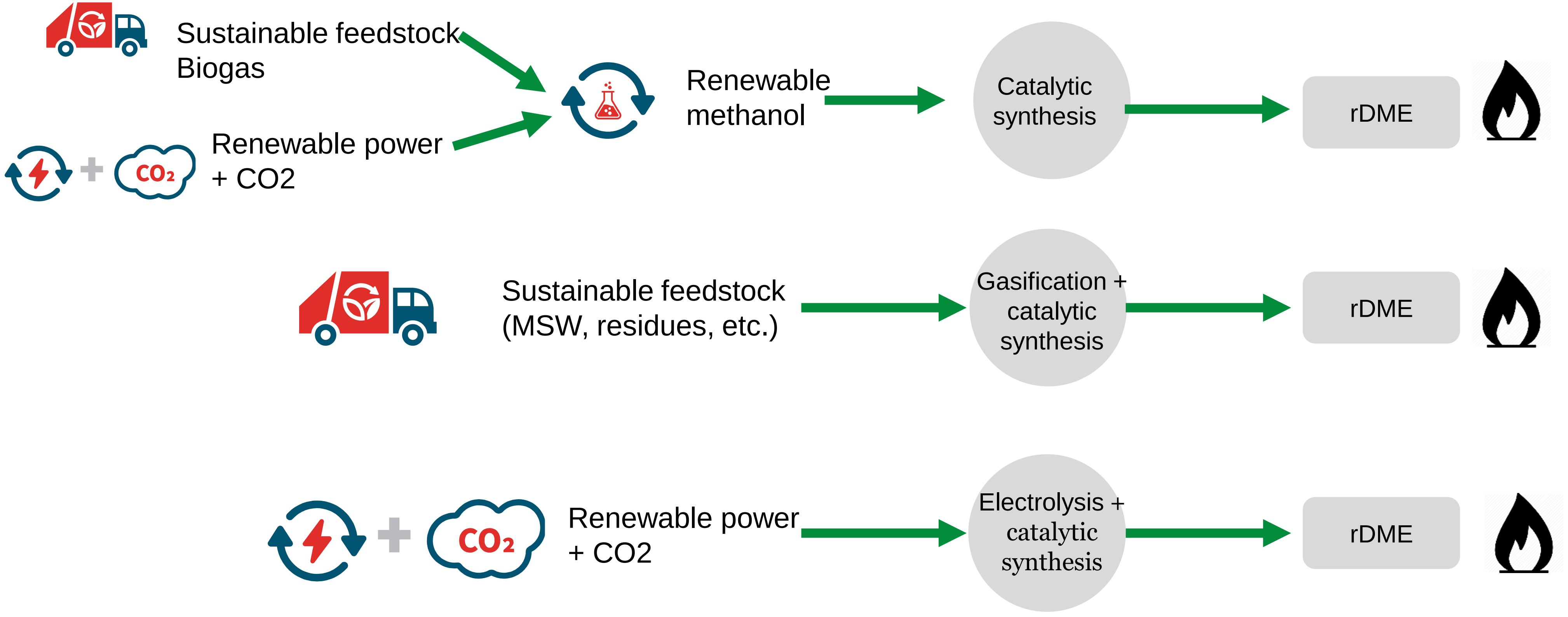
SOFC:

Highest efficiency in energy recovery from biogas 50-56%

ISLAND MODE

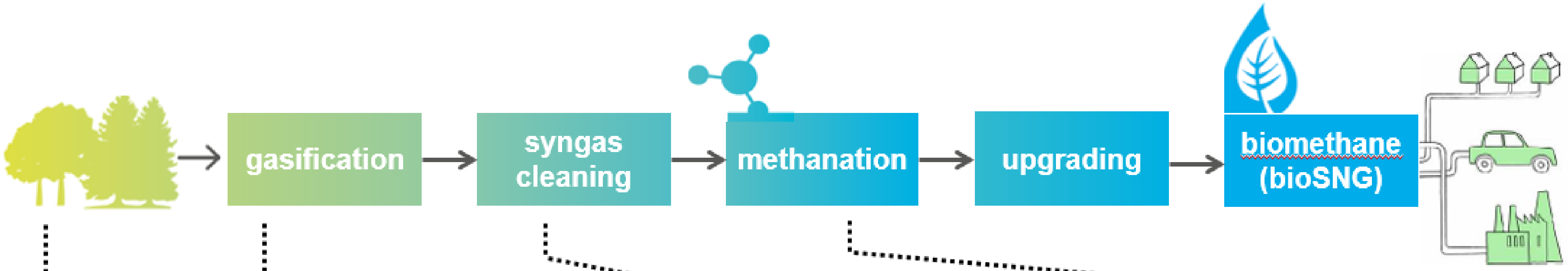


rDME Production Pathways



SHV ENERGY

GAYA Project has been built to address different challenges (techno, economic and environmental) all along the process chain



Flexibility in biomass procurement

Process improvement:
- efficiency,
- syngas quality,
- availability

Technological combinations to:
- lower CAPEX and OPEX
- reduce environmental impacts

- Definition and validation of an innovative process (economically suitable)
- Process integration

Virtual tour on the GAYA platform

A REVOLUTION IN BIOGAS AND OFFGAS MEASUREMENT
The Vaisala MGP260 family

The world's first optical in situ devices measuring directly in demanding biogas process environments.

Superior measurement stability and accuracy

In situ

Real-time

Wet basis

Ex certified

No sampling lines, pumps or moisture removal needed

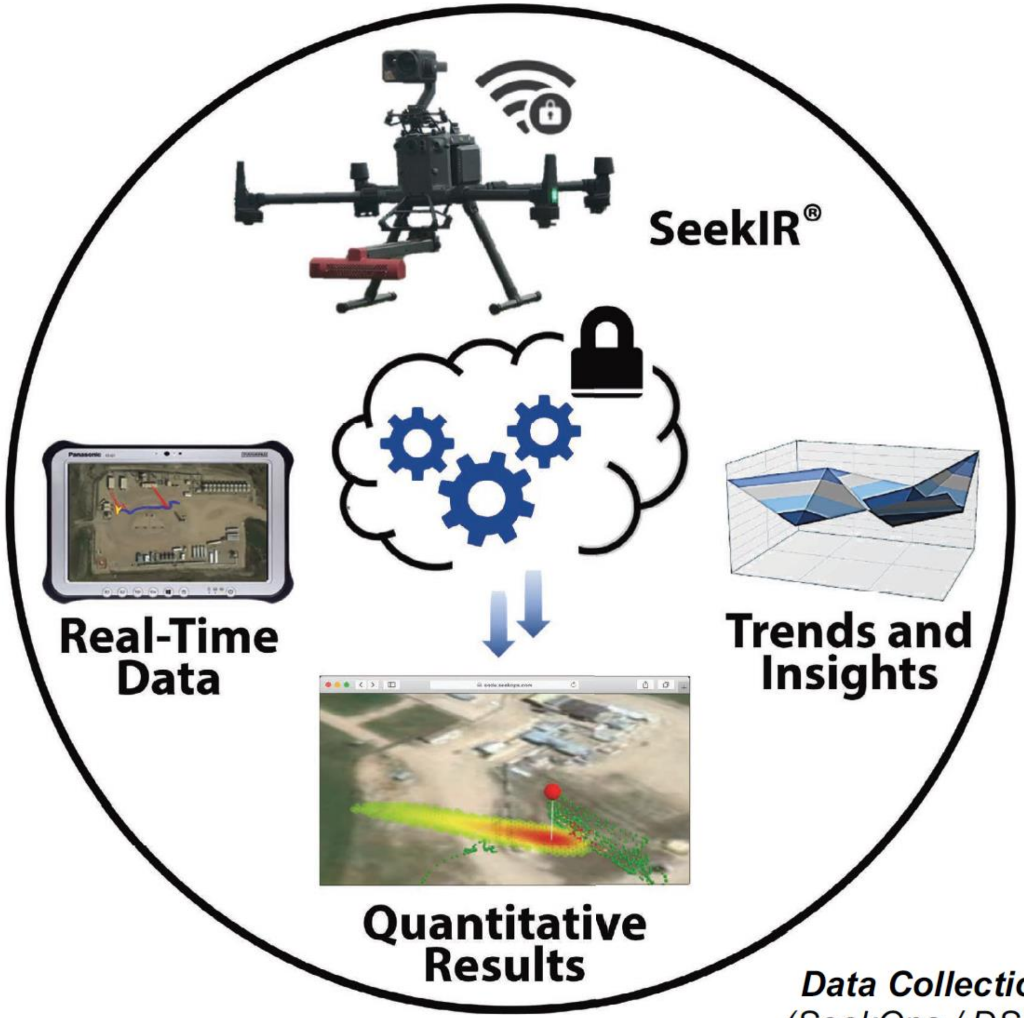
MGP261 for raw biogas
- 3-in-1: methane, carbon dioxide and humidity
- Process control

MGP262 for offgas
- 2-in-1: low methane and high carbon dioxide
- Emission and process control

VAISALA

SeekOps Solution – Summary

	ONSHORE
Sensor	**SeekIR® Drone Multirotor**
Industries & Verticals	 **Energy**  **Biogas**  **Waste Mgmt.**
Services Territory	• North America • Middle East • Europe
Future	• European **Biogas** Inspections • BVLOS operations



Data Collection
(SeekOps / DSPs)

ble

you

EBA
European Biogas
Association

EBA Conference – 27 October

Fueling the Hydrogen Revolution with Renewable Natural Gas

STEVE JONES

Senior Vice President, BayoTech

EBA
European Biogas Association

26–27 October 2021, Brussels

Waste to hydrogen: using biomethane to produce renewable hydrogen for heavy duty transport

For more information contact:

Steve Jones
Senior Vice President
BayoTech
steve.jones@bayotech.co.uk

bayotech.us

Oct.2021

BayoTech

Our highly efficient model of local production & distribution hubs makes hydrogen more affordable, sustainable and accessible.

Low-cost, low-carbon hydrogen, supplied reliably when and where you need it.

BayoTech makes hydrogen easy.

BayoTech

Private company established in 2001

90+ employees

Headquartered in New Mexico

18,000 sq ft Center of Excellence for product development

Additional facilities in Oklahoma, California & Texas

Strong product manufacturing partners

Strong technology portfolio

A growing portfolio of IP patents and licenses combined with in house research and development, trade secrets, experience and know-how gives BayoTech a competitive advantage

A full-service hydrogen supplier

Offering localized production, transport, storage, fueling and power solutions

Strong investor partnerships

Top financial and strategic partners are investors in BayoTech: Newlight Partners, Nutrien, Cottonwood Technology Fund, Sun Mountain Capital, Fortistar, Caterpillar, The Yield Lab

BayoTech

Hydrogen Fuel Cell Fleets

The performance of diesel, with zero-emissions at the tailpipe

Rapid Refueling

Can be refueled in less than 10 minutes

Extended Range

Up to 300 miles between refueling

All Weather

Consistent power delivery during the duty cycle, in heat and cold

All Terrain

Excel on hilly routes or steep terrain

Payload Capability

Minimal impact on payload capability

BayoTech

Centralized Supply Model is Poorly Suited for Distributed Demand

Established application
Users are located near hydrogen plants

Sources: Shell, Bloomberg, Hydrogen Council

Delivered Hydrogen
<$4/kg

H2

Centralized Production
$1–$3/kg

High volume industrial use

Pipeline
$0.05/kg H2
$1MM/mile to build
Limited hydrogen pipeline network

Emerging applications
Users are distributed and in more urban areas

H2

Centralized Production
$1–$3/kg

High Volume Sales
$8 - 14/kg

Industrial User

Low Volume Sales
$12 - 20/kg

H2

Refueling Station

Key Challenges to Adoption

Higher Cost from Transportation
Hydrogen's low volumetric energy density makes it inefficient to transport long distances

Higher Carbon Intensity
Truck trailers and liquification process have 2-4x carbon intensity compared to pipeline

Supply Reliability
Customers receiving excess hydrogen from a central plant are the first to lose service

BayoTech

Hydrogen Hubs Provide Solutions to Ease Adoption

Current Challenges to Adoption

Current system is **designed to serve large co-located customers**

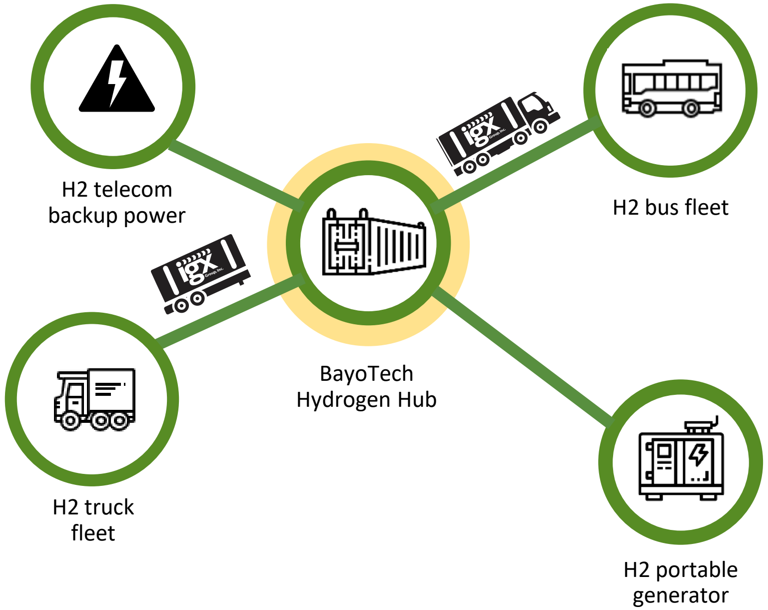
Long distance transportation is carbon intensive and expensive

Lack of scalable infrastructure for emerging applications

Supply to growth markets is **unreliable**

BayoTech Solutions

Designed to support the **full hydrogen ecosystem**, allowing customers to embrace low carbon energy transition without large commitments



Hydrogen from RNG
Why and How?

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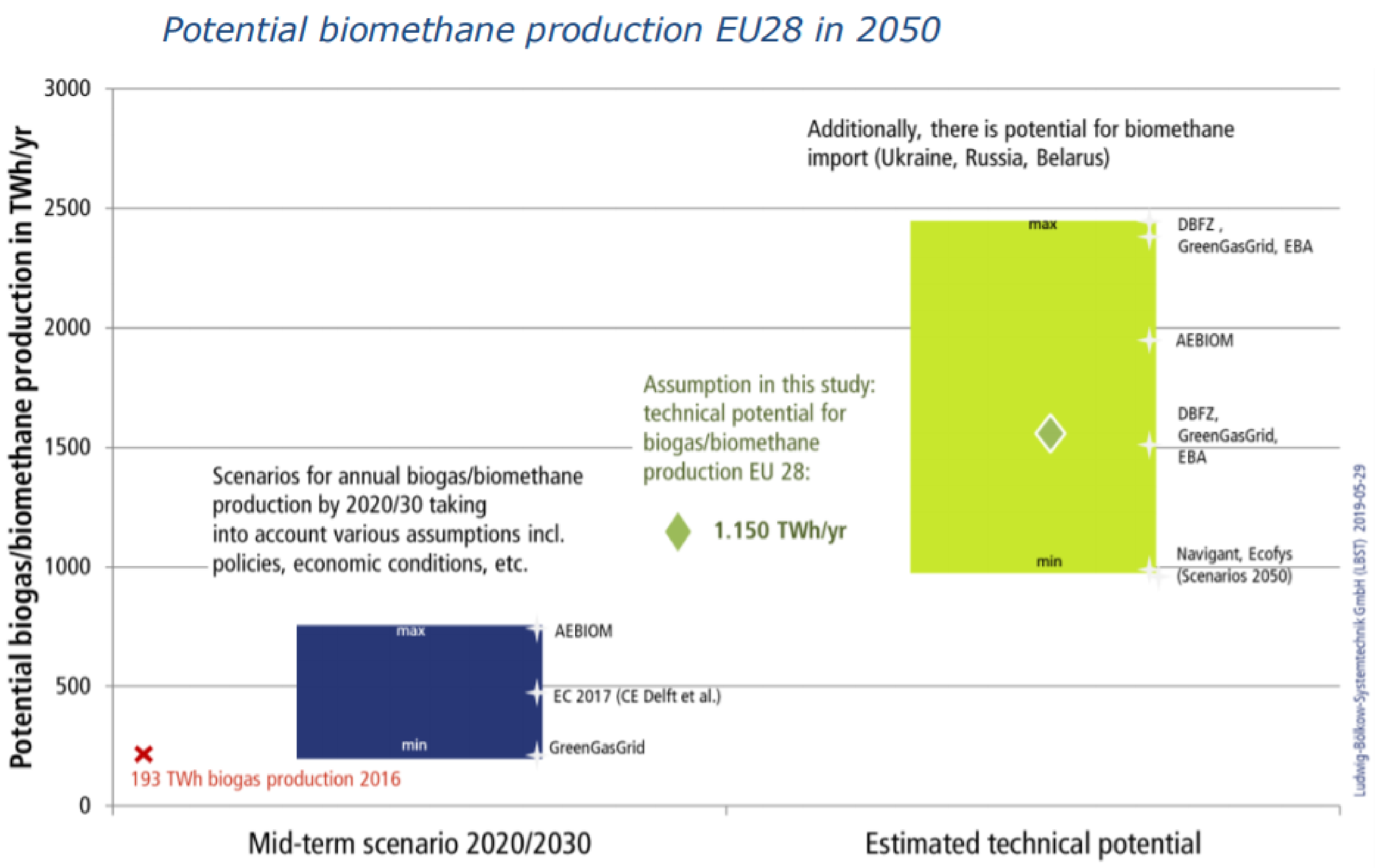
European Biomethane Production Facilities in 2020

- 18 countries currently producing biomethane in Europe
- 729 active biomethane production facilities in Europe
- 232 production facilities in Germany, 131 in France & 80 in the UK
- Number of biomethane plants in Europe has increased by 51% in 2 years, from 483 in 2018 to 729 in 2020

Realizing the Potential

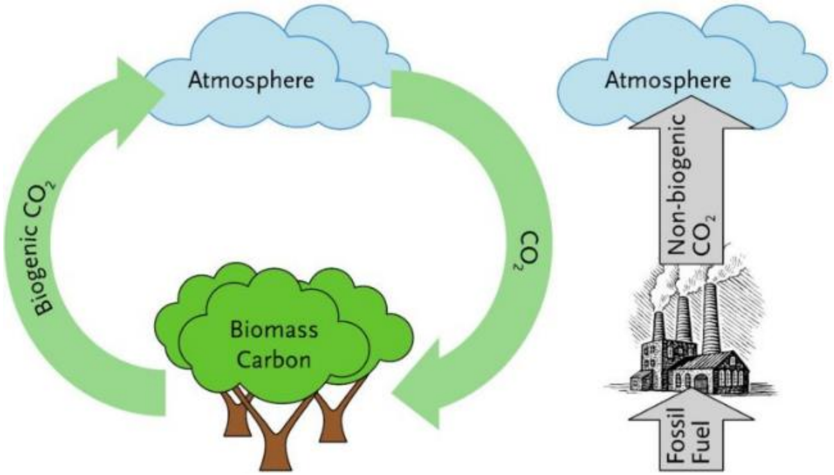
- The EU has significant biogas/biomethane production potential of between 1,150 and 2,500 TWh per year
- Biogas is regional – local waste for local use
- Also pipeline injection is possible allowing flexibility in geography



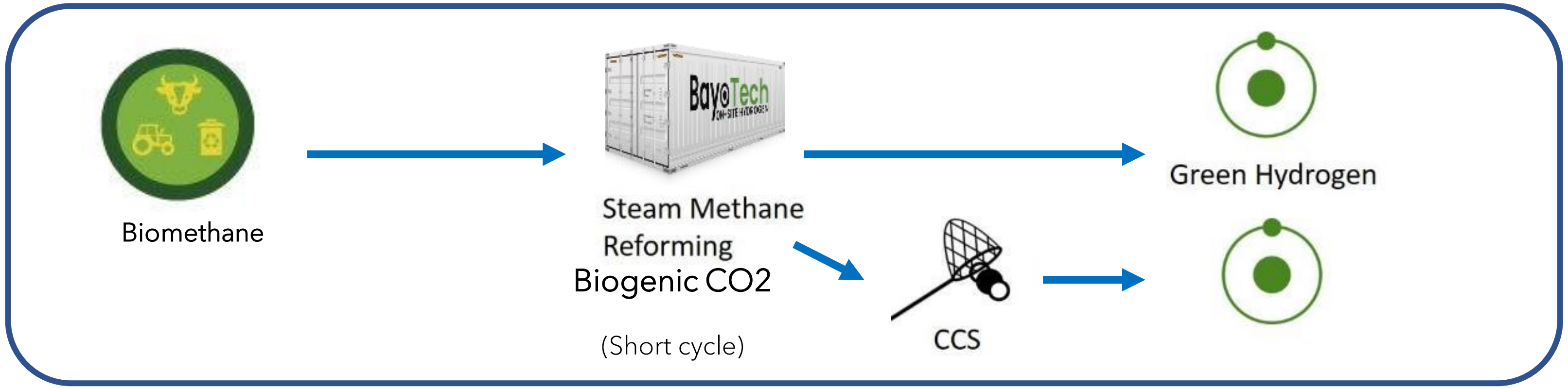
Source: Impact of the use of the biomethane and hydrogen potential on trans-European infrastructure, European Commission (2019)

Biogenic CO_2 – Net Zero

Burning/reforming biomass emits carbon that is part of the biogenic carbon cycle. Bioenergy combustion/reformation simply returns to the atmosphere the carbon that was absorbed as the plants grew.



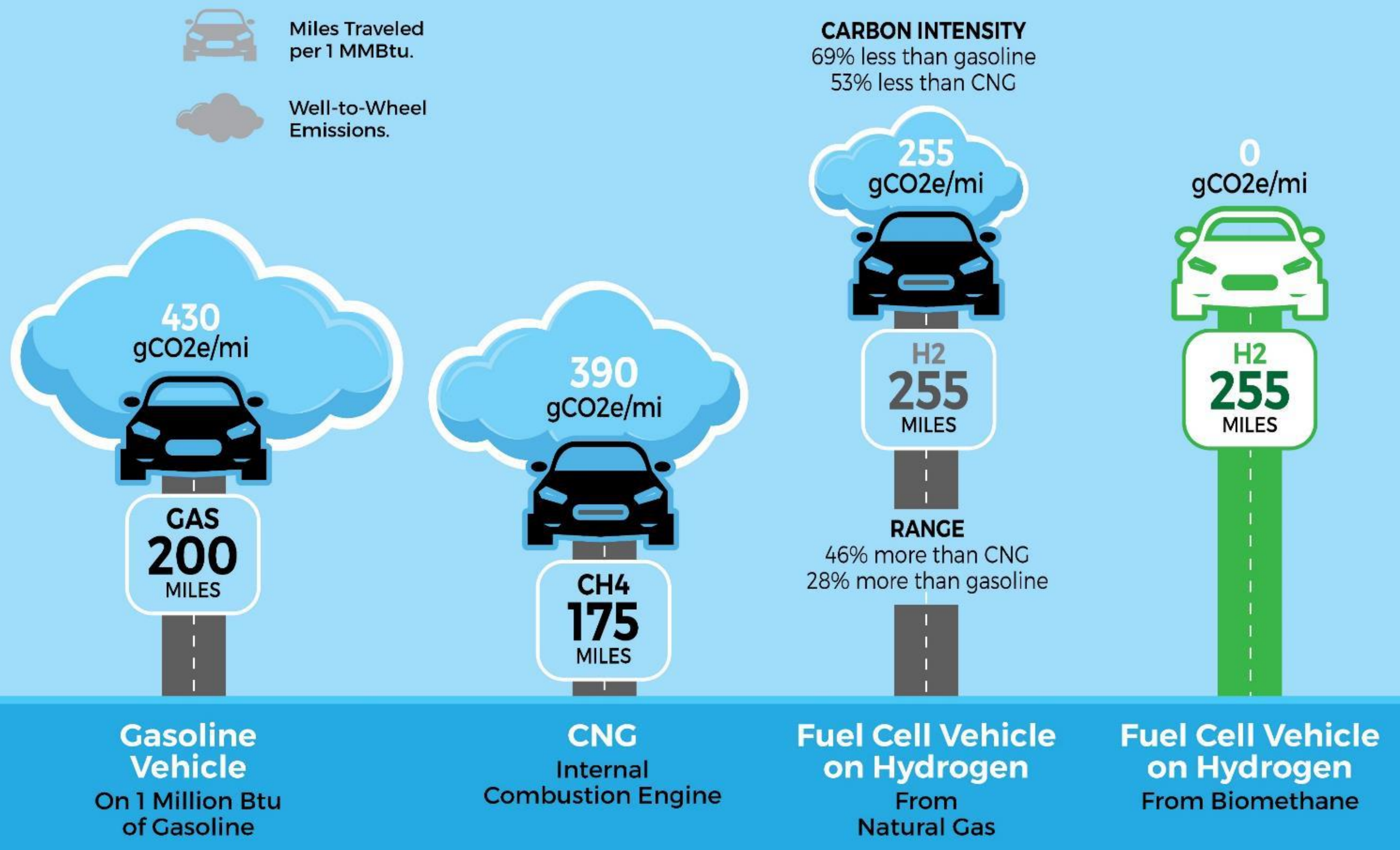
Burning fossil fuels releases carbon that has been locked up in the ground for millions of years. Fossil fuel use increases the total amount of carbon in the biosphere-atmosphere system.



Biomethane to hydrogen with CCS is the ONLY way to generate carbon <u>negative</u> hydrogen

Picture credit – IEA

HOW FAR CAN A CAR GO ON
1MMBTU of CNG or Gasoline?



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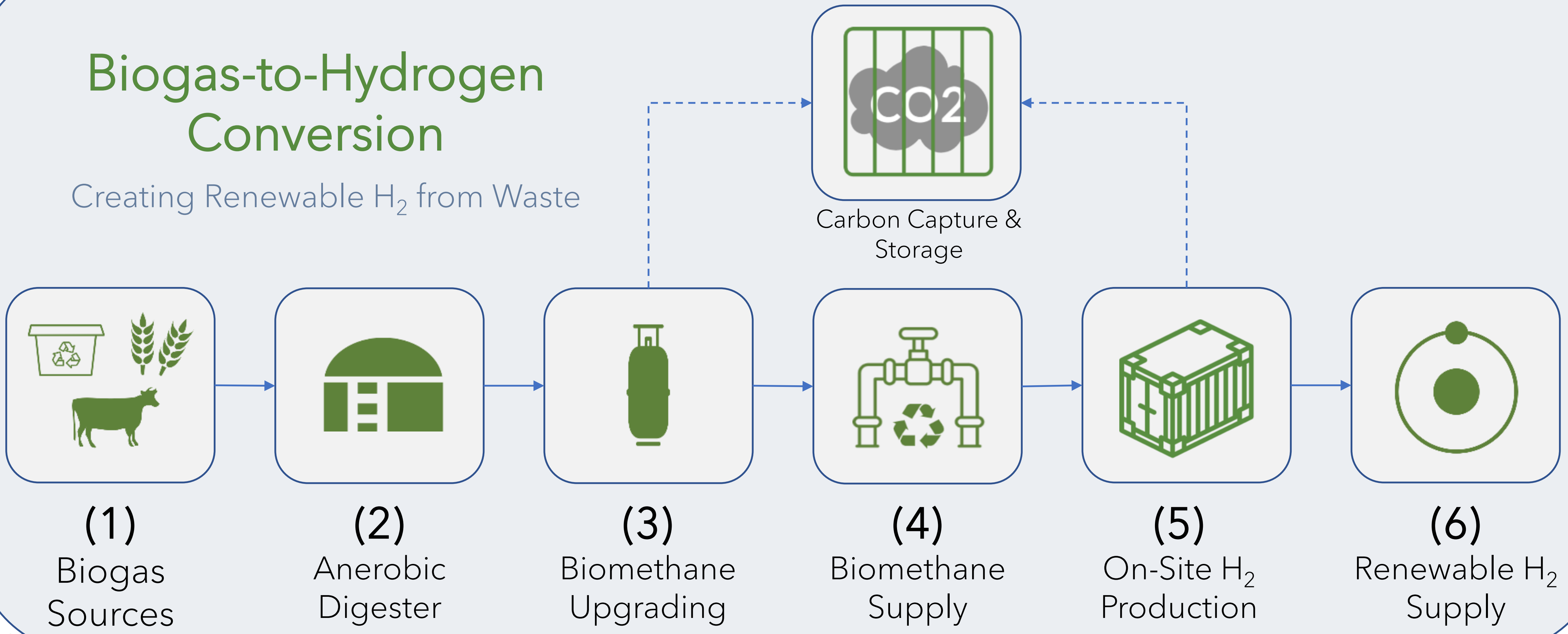
Biogas-to-Hydrogen Conversion

Creating Renewable H_2 from Waste



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Captured Fleet Benefits

- **Schedule planning** – Vehicles do a predefined route, planning is simplified
- **Return to base** – central base for maintenance, fuel and servicing, allow economies of scale to be realised
- **Local impact** – captured fleets usually effect the local environment directly. Improved air quality and lower GHG emissions
- **Consistent demand** – Vehicle fleet needs to keep working to minimize cost, low downtime is essential. Great for hydrogen
- **Lots are already RNG**– Infrastructure exists, pipelines and accounting mechanisms – leverage for hydrogen
- **Sustainability goals** – many fleet operators have emissions targets and sustainability goals, added incentive for ZEV

BayoTech

Hydrogen fueling solutions that grow with your fleet

BayoTech offers range of flexible, modular and scalable solutions to fuel your hydrogen buses & trucks.

Low-cost, low-carbon hydrogen made simple.

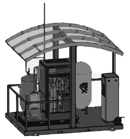
SHORT DEMO

Direct Fill / Wet Hose Fueling

Small, mobile trailer carrying 350 bar hydrogen cylinders for direct fueling of vehicles or equipment

Ideal temporary solution for **fueling demo vehicles**

5 to 100 kg/day



<5 VEHICLES

BayoStart

Hydrogen **stored, compressed and dispensed onsite** from skid-based dispenser

Fastest way to get hydrogen with little commitment

Small footprint, easy permitting

5-20 VEHICLES

BayoStorage

High pressure hydrogen **delivered and stored at your depot or HRS**

Ideal for depots with limited space or **existing dispensing infrastructure**

Trailers monitored and swapped as needed

> 20 VEHICLES

BayoGaaS Onsite

BayoTech owned **production plants sited at your depot**

Hydrogen is generated, stored, compressed and dispensed onsite

Lowest cost/kg option

600 to 1,000+ kg/day

BayoTech

- High-pressure, Type 3 cylinder-based gas transport and storage equipment
- BayoTech transports 3x more hydrogen per trip than traditional steel-tube trailers
- Higher payload means less frequent deliveries, lower transportation costs and fewer emissions
- Scalable pods for transport (up to 880kg of hydrogen at 350-500 bar)
- High-pressure dispensing capabilities

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Compression/Dispensing Skid

- Modular compression and dispensing skid for fast deployment of hydrogen vehicle fueling
- Suitable applications:
  - Buses, trucks, forklifts, port vehicles & marine vessels
- Designed for temporary fueling solution for pilot programs or small scale, permanent installations
- Low-cost, easy to deploy with minimal site improvements
- Flexible ownership options – lease or buy

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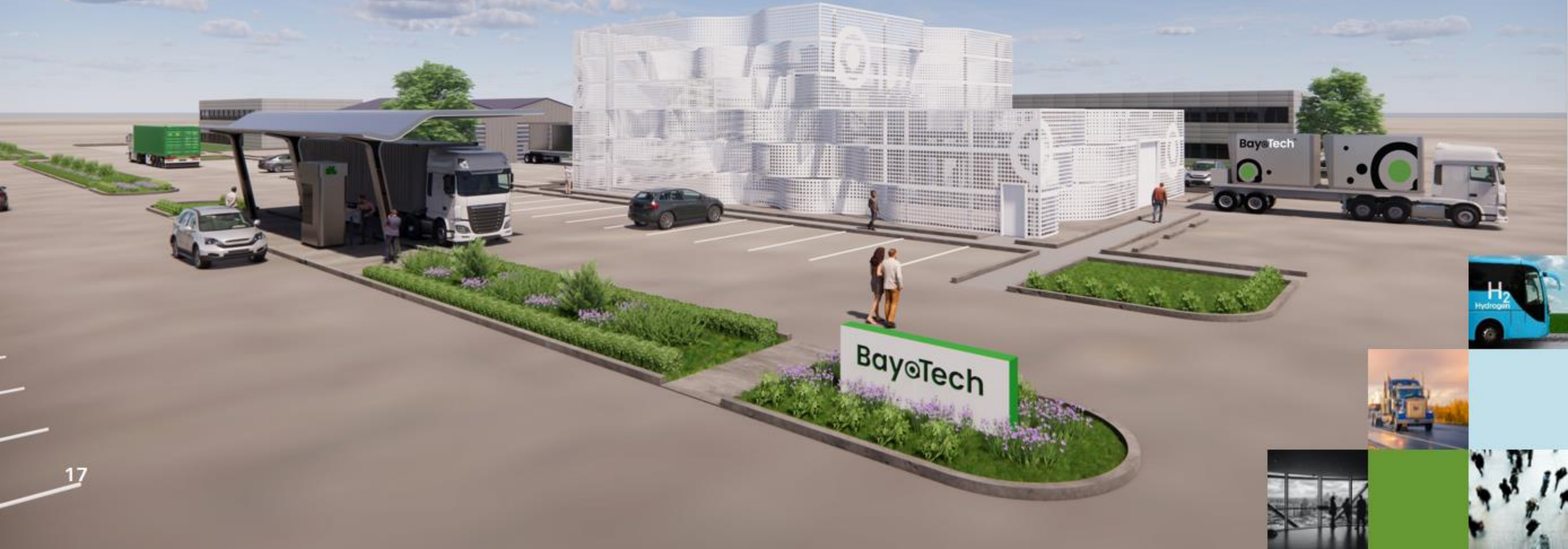
BayoTech™

BayoTech owned network of distributed hydrogen hubs produce **1 – 5 tons of hydrogen per day.**

Our patented reformer uses **20-30% less energy**, saving money and reducing carbon footprint.

High energy efficiency and avoided liquefaction and long-haul transportation result in **lower carbon emissions** than legacy technologies.

Can be paired with **renewable natural gas or carbon capture** for even lower carbon intensity.



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Sustainability Initiatives

High Efficiency Technology

Our proprietary design uses heat more efficiently for >80% production efficiency. This translates to less feedstock used and lower costs.

No Liquefaction, Less Transportation

Our hydrogen is produced closer to the point of use and transported in high-pressure, high-capacity storage trailers. Fewer truck trips, lower emissions.

Biogas as Feedstock

BayoTech's systems can use biomethane (RNG) derived from biogas as a feedstock, significantly reducing the carbon intensity of hydrogen production.

Carbon Capture

BayoTech partners with leaders in carbon capture technology that integrate with our hydrogen generation systems.

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Key Takeaways

- Hydrogen technology is ready now
- It is the best link between biomethane and zero emission vehicles
- Pipeline supply for biomethane – onsite production
- Biomethane to hydrogen is viable and effective
- It is the only way to create carbon negative hydrogen
- Captured fleets provide the perfect setting for RNG to hydrogen facilities
- BayoTech can deploy these systems today for low cost, low carbon hydrogen

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CLOSING SESSION: FUTURE OF BIOGAS

Question & Answer Session

European Biogas Conference
26-27 October 2021

Philipp Lukas, Future Biogas

Madeleine Alphen, Pyrogasification Club at ATEE

Harmen Dekker, European Biogas Association

Steve Jones, BayoTech

European Biogas Conference

Closing and wrap-up

SUSANNA PFLÜGER

Secretary General, European Biogas Association

EBA
European Biogas Association

26–27 October 2021, Brussels

European Biogas Conference

Closing and wrap-up

PHILIPP LUKAS

Board Member, European Biogas Association

EBA
European Biogas
Association

26–27 October 2021, Brussels


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