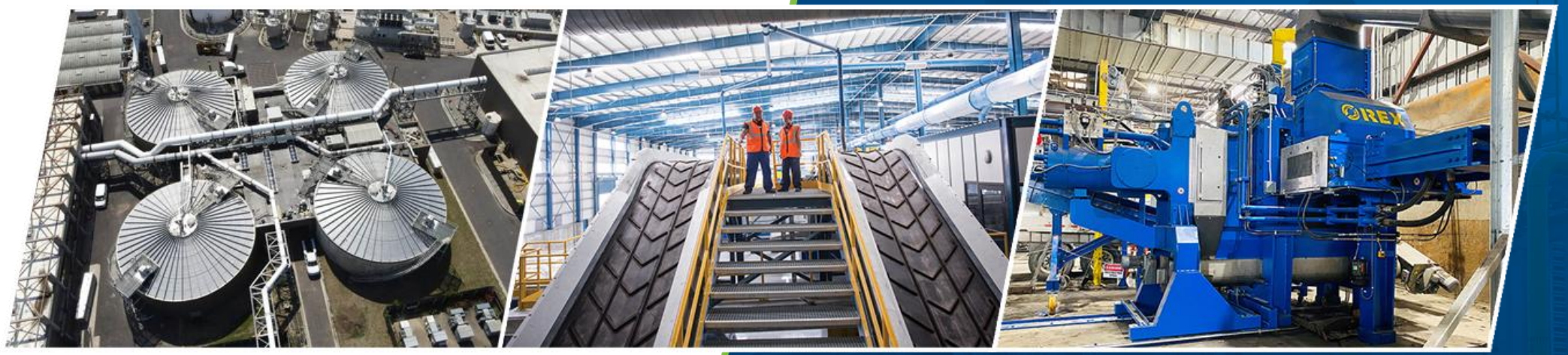
Turning Agricultural Residues into Renewable Gas: Practical Pathways for Ontario Farmers



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From Waste to Value: The Anaergia Opportunity

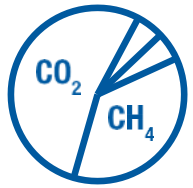
Of the 1.1°C by which humans have warmed the earth, 0.5°C is due to methane emissions*

WASTES

GLOBAL METHANE EMISSIONS IN 2018.

24.9 B

TONS OF CO_2E_6 EQUIVALENT



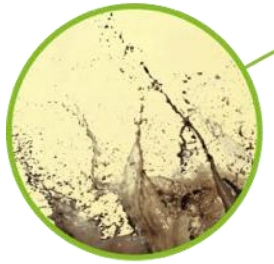
METHANE RETAINS

84X

MORE HEAT THAN CO_2

Source-Separated Organics & Organic Fraction of Municipal Solid Waste**

WHERE WE OPERATE



BIOSOLIDS

AGRICULTURAL & FOOD PROCESSING

MSW

What We Pioneered

Anaergia builds on more than 30 years of expertise in the circular bioeconomy. Today we deliver patented technology solutions that reduce methane emissions by diverting organic waste from landfills and transforming it into carbon-negative renewable natural gas (RNG), clean water, and organic fertilizer that restores soil health. With a portfolio of over 250 patents, we deliver scalable infrastructure that advances climate goals and circular economy outcomes

DIVERTED **WASTES** = RENEWABLE **FUEL** + CLEAN **WATER** + ORGANIC **FERTILIZER**

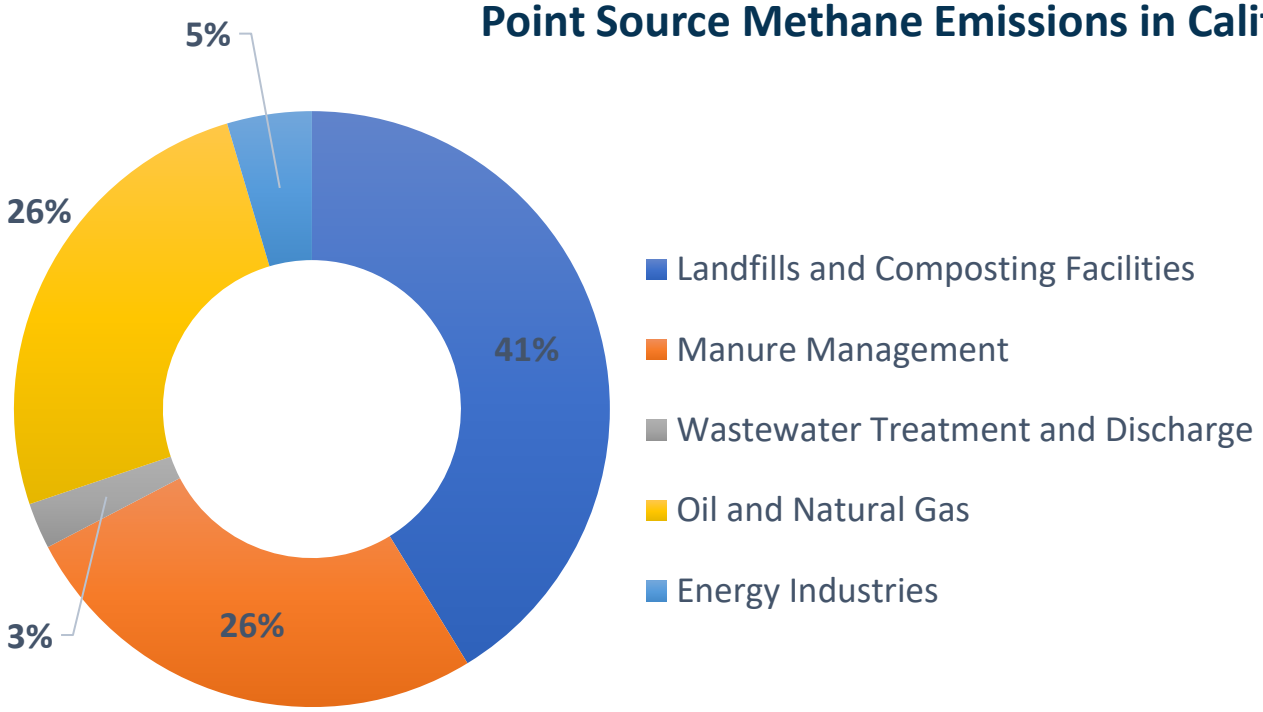
** Typically, more contaminated and requires preprocessing before digestion

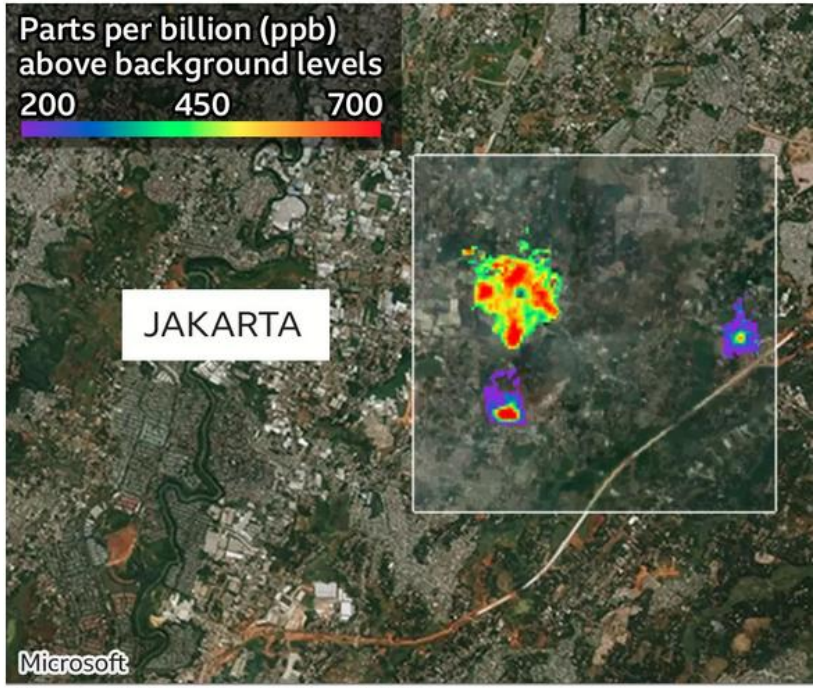
*https://www.eea.europa.eu/publications/methane-emissions-in-the-eu

The Role of Waste in Global Warming

Organic waste is a major contributor to worldwide GHG emissions.

Point Source Methane Emissions in California[1]





Source: GHGSat Inc, 24 Nov 2020

In California and other US states, waste management, wastewater, and manure represent about ***two-thirds of all point-source methane emissions***[1]

(1) Duren, Riley M. et al. "California's Methane Super Emitters." Nature 575 (2019): 180-184

What we do

Our mission is to accelerate the world's clean energy transition by transforming waste into renewable fuel, clean water and fertilizer

DIVERTED
WASTE

=

RENEWABLE
FUEL

+

CLEAN
WATER

+

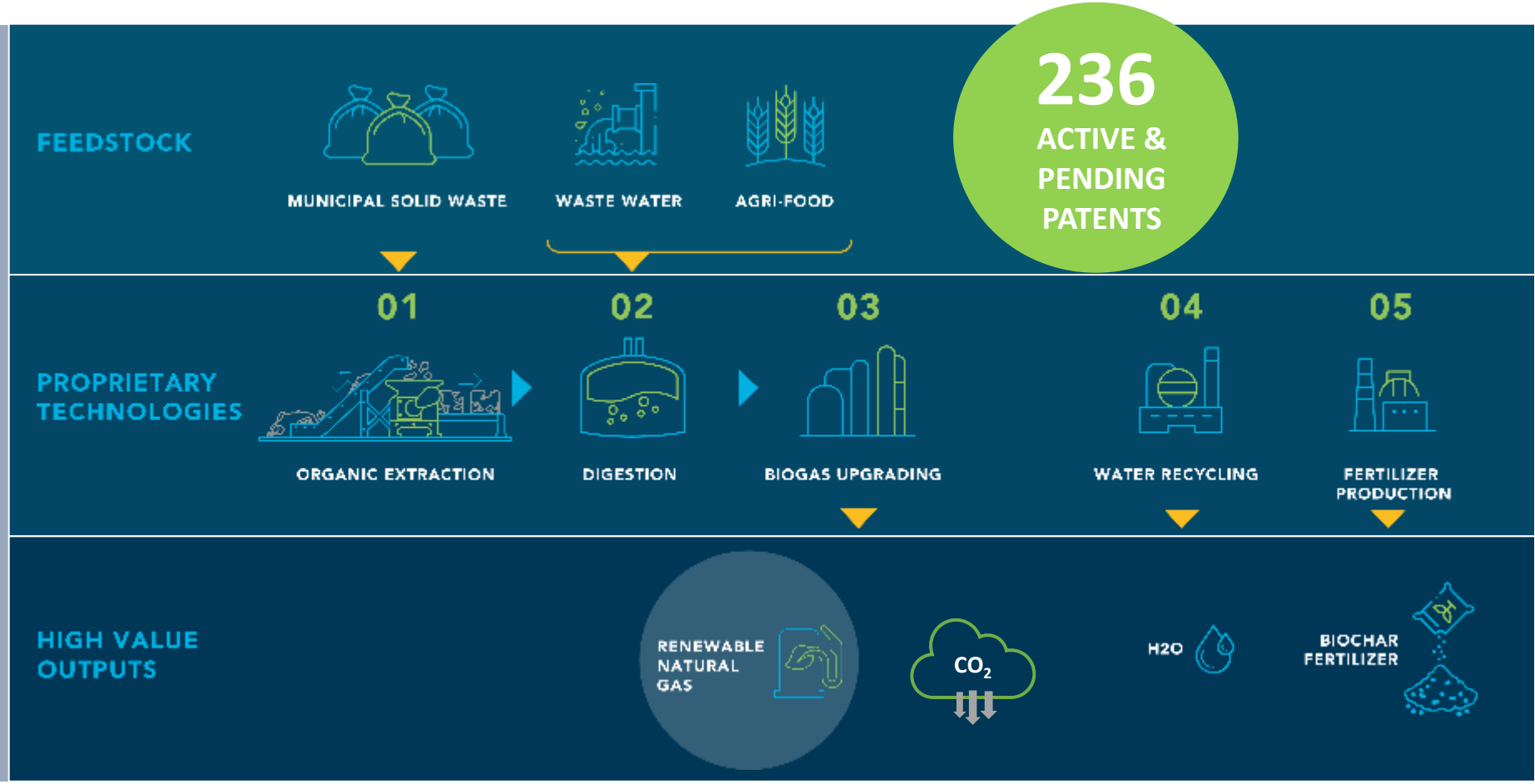
ORGANIC
FERTILIZER

What we offer

Anaergia created **a set of technologies** that provide complete and cost-effective solutions for converting waste to value.

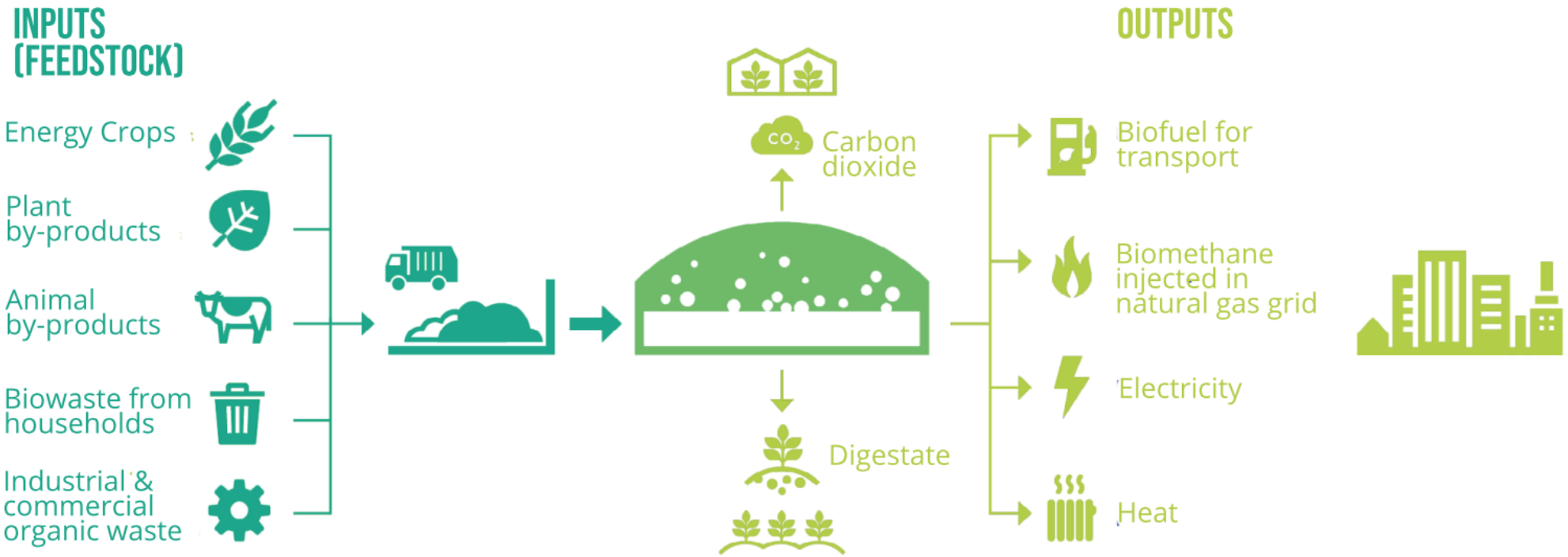
Anaergia Advantage

- OREX™ technology processes unsorted municipal solid waste (MSW) to extract clean organics
- Omnivore® anaerobic digester requires 60% less capex and increases capacity of existing systems by 300%
- Our agricultural digester references span 30 years globally



How would you explain anaerobic digestion to a 5th grader?

"Anaerobic digestion is a process where microorganisms break down biodegradable materials, like food waste, in the absence of oxygen. This process produces a gas called biogas, which can be used as a source of clean energy. It also produces a nutrient-rich substance called compost, which can be used as fertilizer for plants. So, in simple terms, anaerobic digestion is a way of turning waste into useful things like energy and fertilizer." – ChatGPT by OpenAI



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Why Anaerobic Digestion?

Most organics waste are suitable for anaerobic digestion

- Manure & Agricultural residues (i.e., straw, stover, spoiled crops)
- Second cropping and purpose grown biomass (energy crops)
- Agri-food processing waste (i.e., slaughterhouse, bakeries, breweries)
- Source Separated Organics
- Wastewater treatment sludge

Decentralized Energy Production

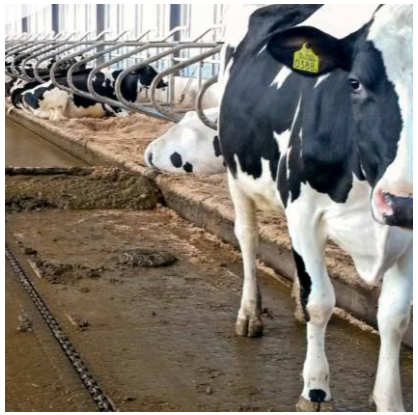
- Electricity & Heat (domestic heating)
- RNG or biomethane (plus CO2 recovery possible)

Nutrient Recovery and Circular Economy

- Digestion makes the nutrients more available and offsets synthetic fertilizer
- Increases the recycling of nutrients

For Society

- Creates high-quality jobs in the local value chain
- Reduction of odour and pathogens from manure and food waste
- Reduction of greenhouse gas emissions



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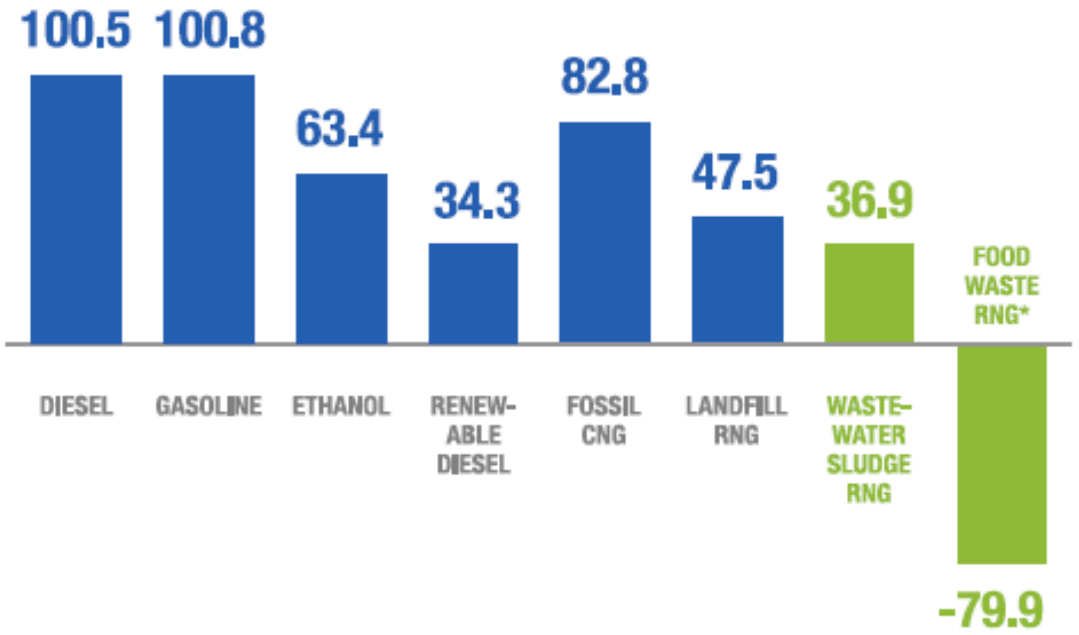
RNG: A Ready-to-Use, Carbon-Negative Gas

RNG is an immediate solution for carbon-negative gas

Average Carbon Intensity Score Awarded to Transportation Fuels in 2022 (gCO_2e/MJ)[(1)]



By preventing fugitive methane emissions, RNG derived from food waste and agricultural waste streams can have a negative CI

"Unlike hydrogen, biomethane is indistinguishable from natural gas and so can be used without the need for any changes in transmission and distribution infrastructure."

– International Energy Agency[(2)]

(1) California Air Resources Board. LCFS Pathway Certified Carbon Intensities. 10 March 2022
(2) International Energy Agency. "Outlook for Biogas and Biomethane." 2020. iea.org

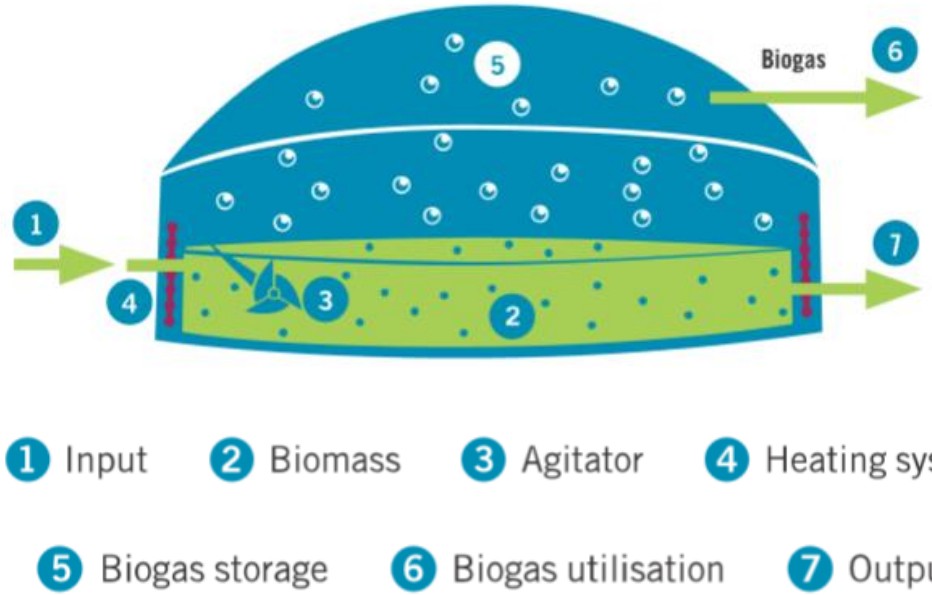
High Rate CSTR (Continuous Stirred Tank Reactor)

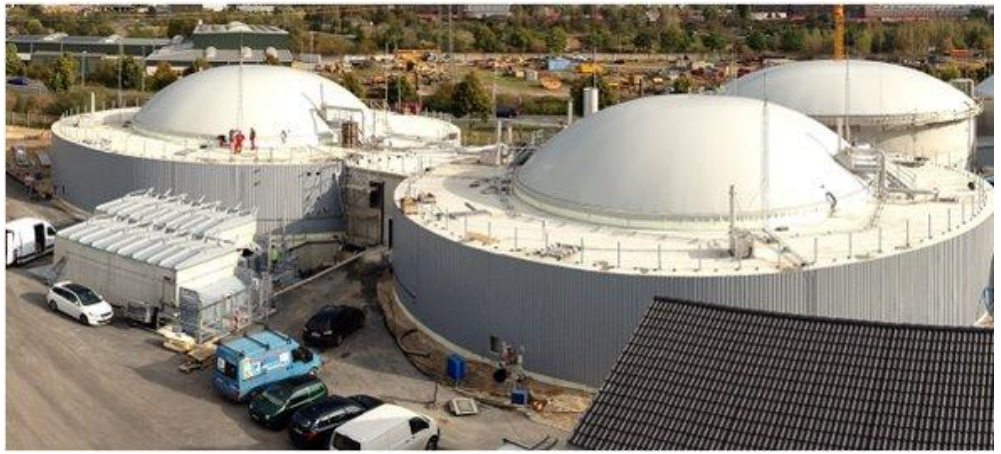
Advantages:

- Highest Volatile Solids Reduction (VSR) → availability of nutrients for bacteria and homogeneous conditions
- Most common, proven technology
- Simple but robust, wide range of feedstock
- Almost any plant size possible
- Cheaper than other digester types

Disadvantages:

- Floating of contamination and Sedimentation of grit if not removed before
- Tank content must be liquid
- Dilution necessary for some feedstock (increasing tank volumes and digestate amount)
- Mechanical mixers inside tank





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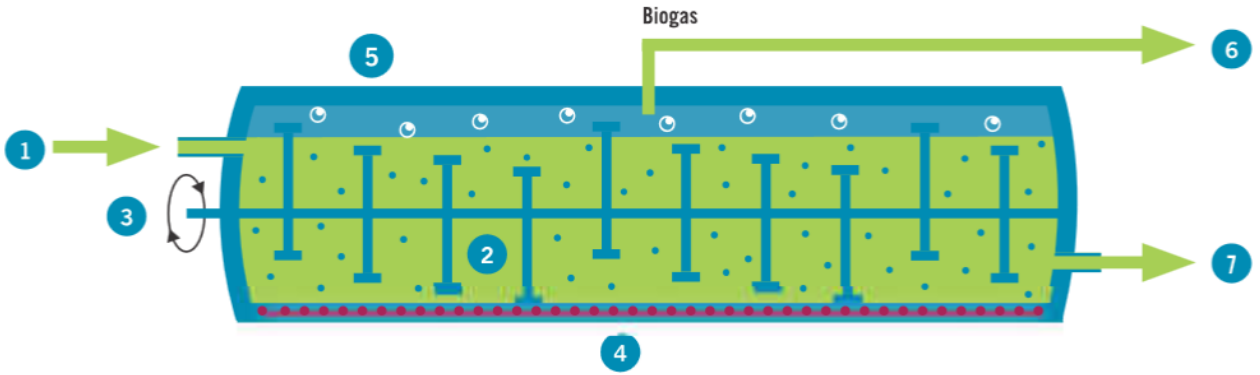
High Solids Plug Flow Digester

Advantages:

- High reactor load is possible
- No dilution required
- Robust system, less impacted by grit and contaminants
    - Only to a certain extent. But once concentration of contaminants or level of sediments too high, system gets blocked
- In many cases HRT is considered fix

Disadvantages:

- Lower VSR because of typically bigger particle size of infeed and less homogeneous conditions
- Are generally more expensive to build
- Reactor volume is limited (typically <2,000m³)



1. Input
2. Biomass
3. Agitator
4. Heating system
5. Biogas storage
6. Biogas utilisation
7. Output

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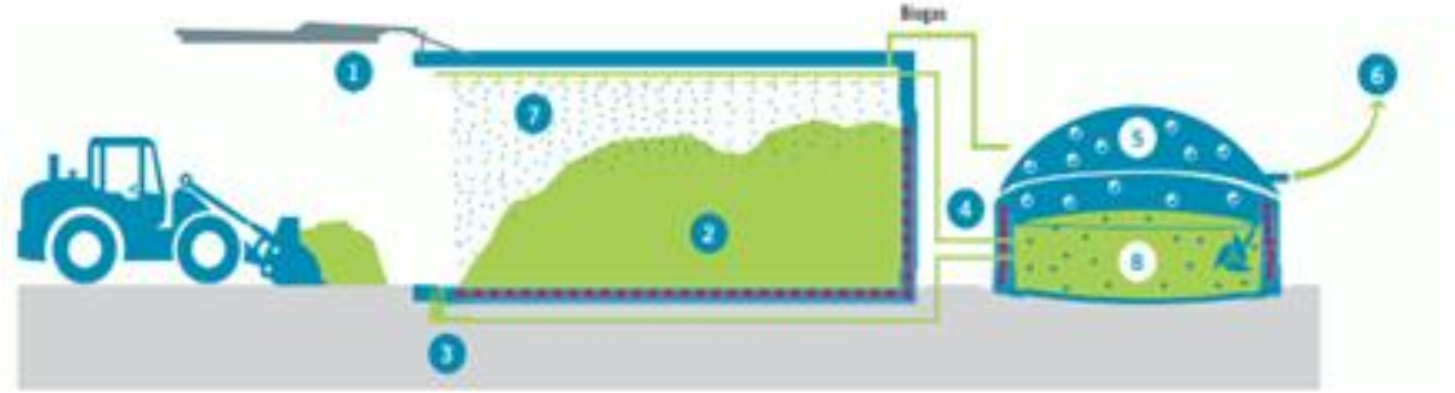
Batch Dry Fermentation – Garage Style

Advantages:

- No dilution required
- Robust system, less impacted by grit and contaminants
- HRT is fix
- Cheap in terms of CAPEX
- Suitable for green waste and compostable papers and cardboard from MSW

Disadvantages:

- Low VSR because of big particle size and less homogeneous conditions
- Significant labour involved in operation
- Odour emissions during exchange of material
- Only suitable for dry material (municipal solid waste fines, cannot be used for agricultural waste)



1. Gastight door
2. Biomass
3. Drainage system for percolation liquid
4. Heating system
5. Biogas storage
6. Biogas utilisation
7. Percolation liquid distribution
8. Percolation liquid storage tank

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Lagoon Digester

Advantages:

- Very cheap
- Low technology solution: typically, no mixing and no heating installed
- Big volumes are possible

Disadvantages:

- Low VSR, due to unmixed and uncontrolled conditions
- Only low TS possible, dilution required for off-farm feedstocks
- Mixing is difficult
- Not suitable for cold climates (Canada need not apply)

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What are the Feedstocks?

Manure & Harvested Crops

Co-mingled Food & Yard Waste

Clean & Packaged Food Waste

Contaminated SSO

MSW

Lower Contamination

Higher Contamination

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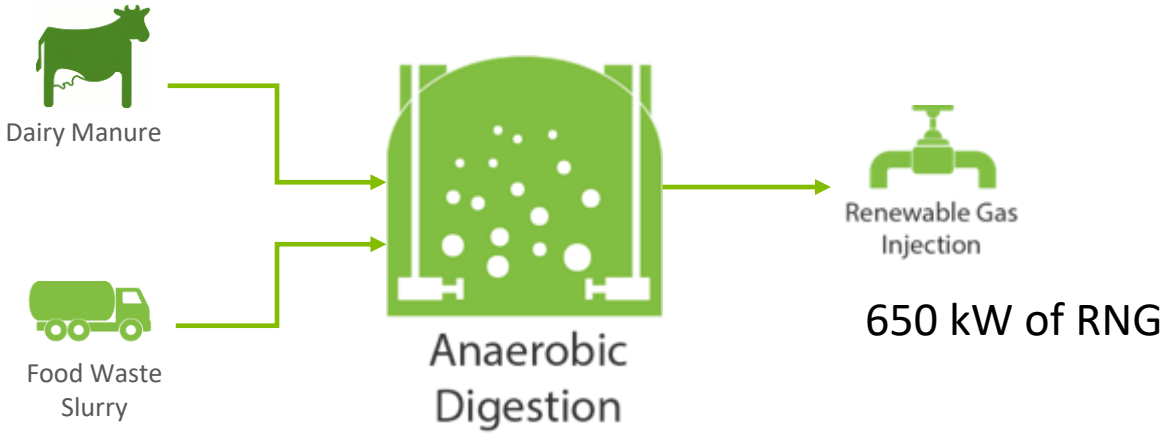
Advantages of External Food Waste for on-farm AD



- 500 Dairy Cow herd (10,000 tpy manure) can produce 170,000 cubic meters per year of RNG
- Additional 10,000 tpy of food waste slurry brings this to 740,000 cubic meters per year of RNG
- 5 x more biogas produced
- 2.5 x more Nitrogen
- 3.5 x more Phosphorous
- Returning nutrients to the soil

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What is Source Separated Organics?

- Source Separated Organics (SSO) are curbside collected organics from single family and multi-family residents institutionalized to lower the organic content of municipal solid waste (black bag garbage)
- Their composition will depend on the region as well as the acceptable organic waste approved by the municipality – these may include food scraps, peels, soiled paper products, animal waste, diapers/sanitary products, plastic film bin liners…to name only a few

	Italian SSO*	Singaporean SSO*	American SSO*	Canadian SSO*
Typical Photo				
Total Solids (TS %)	30%	15%	35%	30%
Contamination	10%	5%	30%	20%

* For representative purposes, each municipality will differ

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Examples of Pre-Treatment Technologies


Organics Pre-Processing Equipment

- Pulping of SSO and MSW fines (**~5 companies in space** incl. BTA, SchuBio, Lohse)
- Grinding or milling SSO and ICI with Hammer Mill, Paddle Mill or Turbo Cyclone (**~25 companies in this space and growing** incl. Anaergia, Scott's Turbo, Smicon, Suez Re:Sep 2.0, Tiger, DODA)
- Continuous screw press of SSO and ICI (**~5 companies in space** incl. Doppstadt, Mavitec, AKUPRESS)
- Organics extrusion press (**~3 companies in space** incl. Anaergia, Fitec, Kusters)

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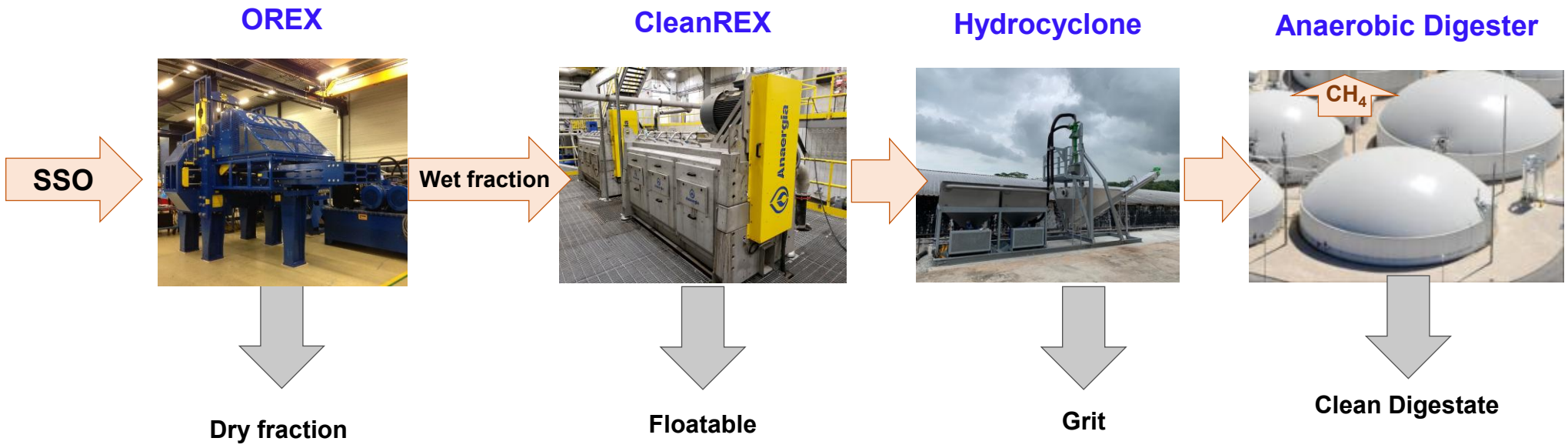
An Example of Processing SSO for Anaerobic Digestion

- Typically, SSO must undergo a multi-step process to remove the contaminants and fast settling inorganic solids (i.e., grit, glass, stones) before it can be sent to anaerobic digestion



CLEAN ORGANIC FEEDSTOCK GENERATES CLEAN FERTILIZER FOR REUSE

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Processing SSO for Anaerobic Digestion

Polished Pulp Recovered from SSO (wet basis)*		
Total solids (%)		12%
Total volatile solids (%)		10%
Polished Pulp (dry basis)		
Parameter		Measured Value (%)
Overs (>2mm)	Plant Fibers/Paper	4.36
	Glass	0.00
	Stone	0.00
	Metal	0.00
	Plastic	0.19
	Unidentified	0.28
Unders (<2 mm)		95.17%

- With proper treatment, a very clean polished pulp can be established (virtually free of plastic)
- The SSO pulp generates methane yields of >500Nm3/MT VS with CH4 content of 65%
- For comparison, Dairy manure typically yields 275Nm3/MT VS with CH4 content of 55%
- Managing SSO pulp is typically done in highly specialized facilities which include pre-processing and dewatering + wastewater treatment post anaerobic digestion

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Concentration of Plastic in Digestate Solids is a Risk

- Digestion will multiply the plastic contamination by 5X in the final digestate

- More pre-treatment in the start will ensure less plastic arrives in digester but can effect the organics recovery
- Post AD polishing can remove the last pieces of small plastic (termed confetti) and also the undigested fibres

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Quality of Digestate from Clean SSO Pulp

- With clean pulps produced from SSO, digestate is virtually free of plastics, glass, metal and foreign contaminants
- Nutrient values are improved in particular Nitrogen and Potassium

SSO Cake dewatered by Centrifuge (wet basis)		
Total solids (%)		32%
Total volatile solids (%)		16%
SSO Cake (dry basis)		
Parameter		Measured Value (%)
Overs (>2mm)	Plant Fibers/Paper	0.37
	Glass	0.00
	Stone	0.02
	Metal	0.00
	Plastic	0.16
	Unidentified	0.02
Unders (<2 mm)		99.42

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Fertilizer & Compost Regulations

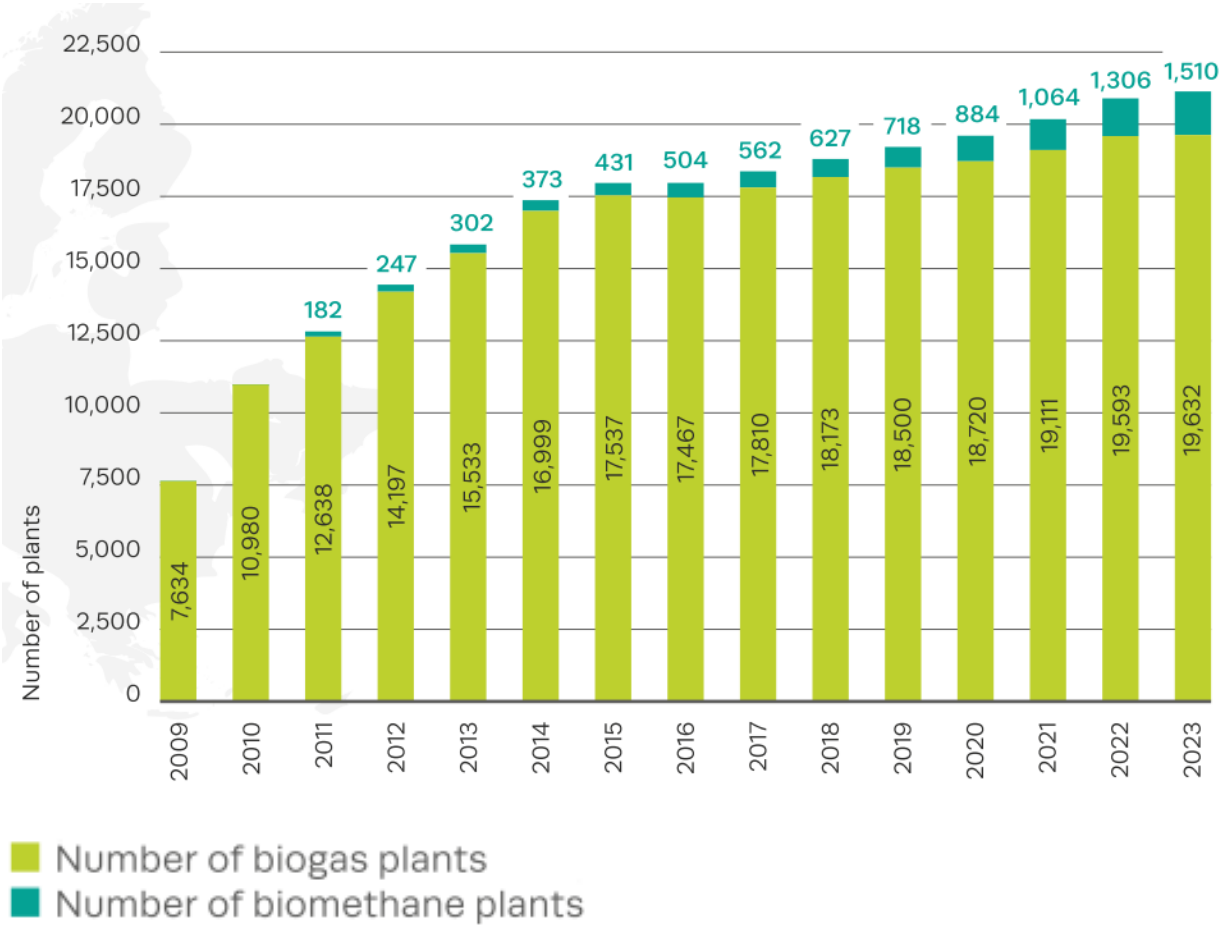
Contaminants degrade the quality of digestate, limiting its use for land application

Physical Contamination Standard	CalRecycle Compost Standard	Ontario, AA Compost	German Fertilizer Ordinance	Danish legislation for Biopulp prior to AD	EU	Austria
Foreign Debris	>4 mm, <0.5% TS basis	>3mm not exceeded < 1.0 %TS basis Plastics 0.5% and no objects > 25mm	>2mm, <0.4% TS basis	>2mm, <0.5% TS basis	>2mm, <0.5%TS basis	>2mm, <0.5%TS
Plastic	>4mm, <20% of foreign debris		>2mm, 0.1% TS basis	>2mm, <0.15% TS basis		>2mm,<0.2% TS basis

*Information form Christine Polo & Joerg Blischke presentation, CWEA conference 2019, CA, USA.

Total Biogas and Biomethane Plants in Europe

- Europe has already proven that biogas can scale. Today there are **more than 20,000 biogas and biomethane plants operating across Europe**.
- The sector experienced **rapid expansion from 2009 to 2014**, followed by **steady continued growth through 2023** as the market matured.
- In **2023, European biogas produced 234 TWh of energy**, equivalent to **about 6.7% of total EU natural gas consumption**.
- And importantly, **biomethane is now the fastest-growing segment**, reaching **52 TWh in 2023**, reflecting accelerating investment in renewable gas.
- Germany remains the **largest producer in Europe**, generating roughly **100 TWh of biogas and biomethane in 2023**, demonstrating the scale achievable once supportive policy and markets align.
- And importantly, this transition is already happening in Europe. **In Denmark, biomethane production reached the equivalent of about 37.5% of the country's gas consumption in 2024**, demonstrating that renewable gas can become a major component of a national gas system.



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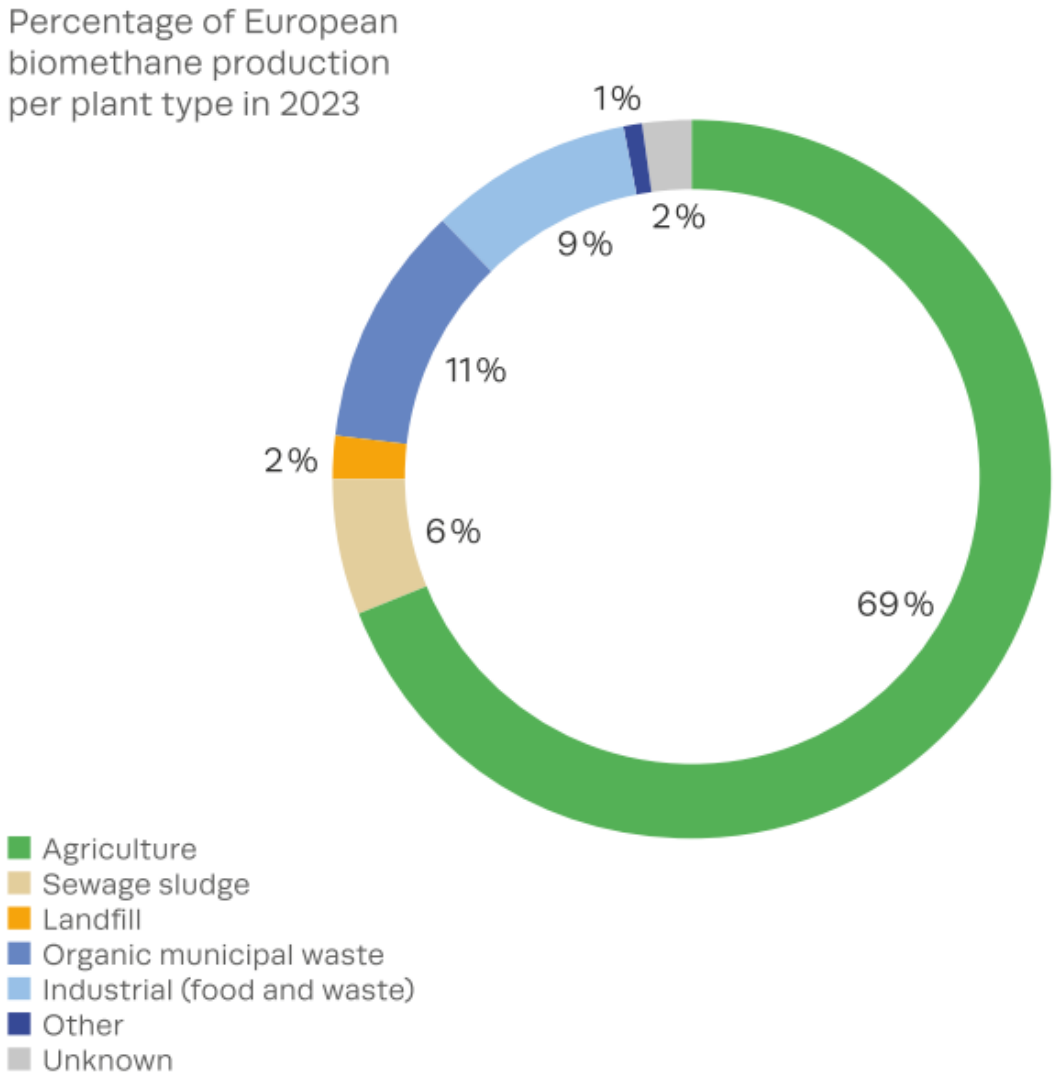
Europe Biogas was Built with Farmers

European Biogas Was Built on Agricultural Feedstocks

- European biogas development has been **primarily driven by agriculture**, with **~69% of production originating from agricultural plants**.
- Early project deployment relied heavily on **energy crops alongside agricultural residues such as manure and straw** to establish reliable feedstock supply.
- Other feedstocks — including **landfill gas, sewage sludge, organic municipal waste, and industrial residues** — represent smaller shares of the European biogas mix.
- New projects are increasingly incorporating **residues, organic wastes, and sequential cropping**, but **agriculture remains the backbone of the sector and a key beneficiary of future renewable gas growth**.



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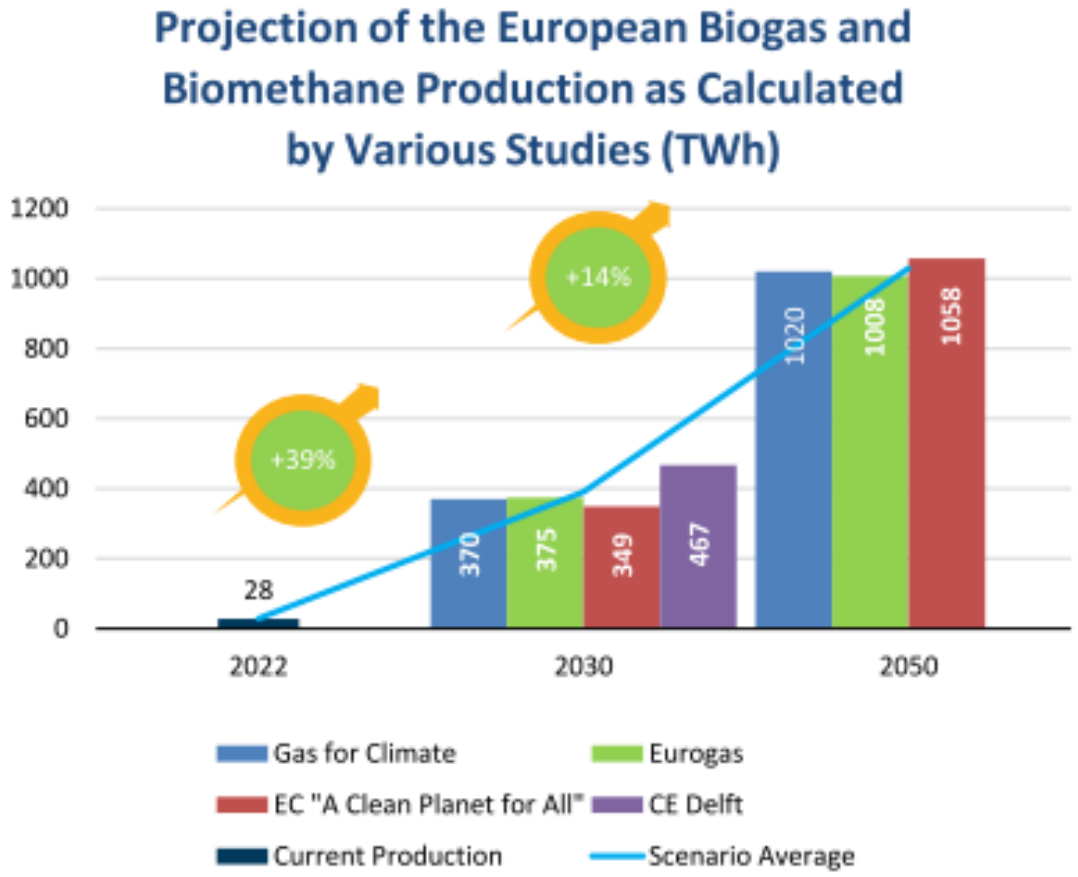
Europe Biomethane has a Strong Outlook

- European biomethane production converges between several reports by 2050
- Growth is forecasted to be 39% CAGR up to 2030 and subsequently 14% CAGR up to 2050
- Production is projected to increase 13-fold from 95 million MMBtu to 1.3 billion MMBtu between 2022 and 2030



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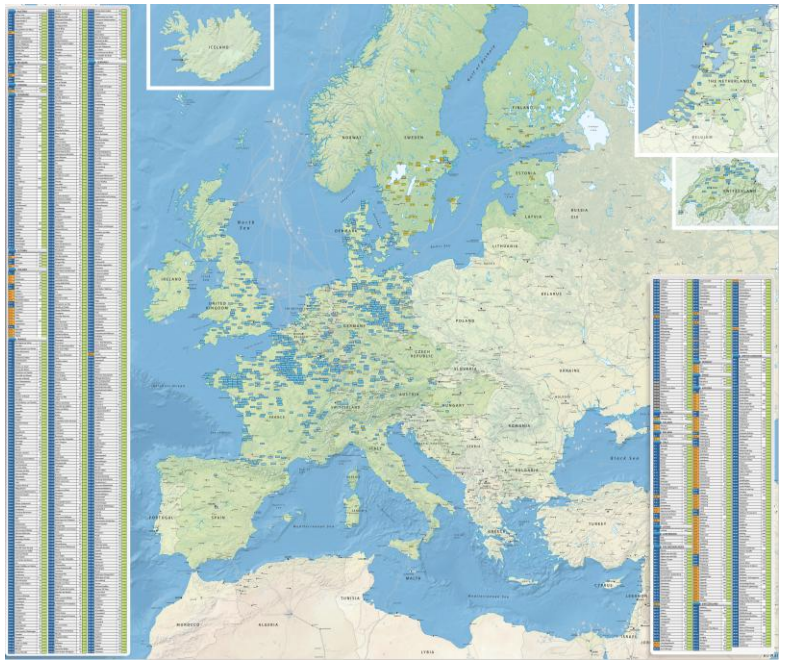
Europe Targeting Diversifying their Natural Gas Supply

The Plan:

- REPowerEU was drafted in response to geopolitical conflict in Europe with the aim to make Europe independent from Russian fossil fuels well before 2030
- Energy savings, clean energy production and energy supplies diversification
- The targets have increased:
  - 45% of renewable energy in the final energy mix
  - 35 bcm (1.3 billion MMBtu) annual production of biomethane by 2030
- €210 billion of investment will be needed to totally stop fossil fuels from Russia by 2027



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Röblingen – Germany

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Röblingen – Germany

TIMELINE

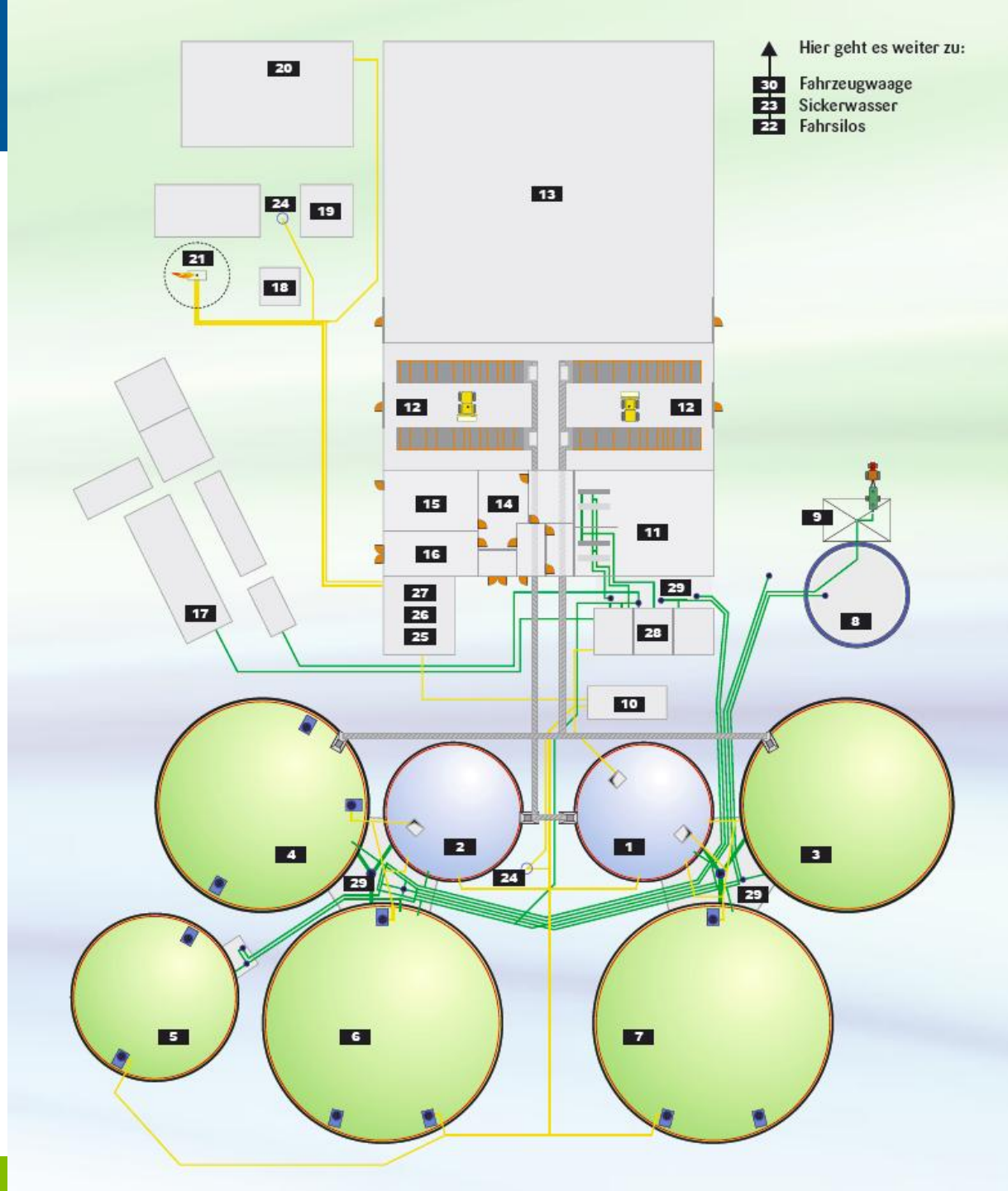
- Approval planning in 2010
- Detail Engineering in end of 2010, finished in March 2011
- Construction for stage 1 was done in 8 month (80% of the plant)
- Commissioning was taken in December 2011
- Construction for stage 2 ends in June 2012
- Commissioning for stage 2 was taken in November 2012

SUBSTRATES (100% ON-FARM)

- Chicken manure (liquid) = 23,000 t/y
- Cow manure = 20,000 t/y
- Pig manure = 18,000 t/y
- Corn silage = 23,000 t/y
- Whole crop silage = 8,700 t/y

ENERGY OUTPUT

- 900 kW Electrical
  - 750 Canadian Homes electrical requirements
- 6,000,000 Nm^3/year RNG (210,415 MMBtu/yr)
  - 5,000 Canadian Homes heating requirements



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Röblingen – Germany

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Röblingen – Germany

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Röblingen – Germany

Moara – Romania

INPUT
- Slaughterhouse waste = 20,000 t/y
- Wet commercial waste = 25,000 t/y (90% organic)
- Maize silage = 10,000 t/y

PROCESS
- Pretreatment: grinders & macerator; hammermill
- 2 primary AD; 1 secondary AD
- External biogas holder
- Pasteurizers
- 2 x 1.4MW CHPs
- FSP Screw Press

OUTPUT
- Digestate (solid fraction) to external composting plant
- Digestate (liquid fraction) to farmland
- 2.7 MW of electricity

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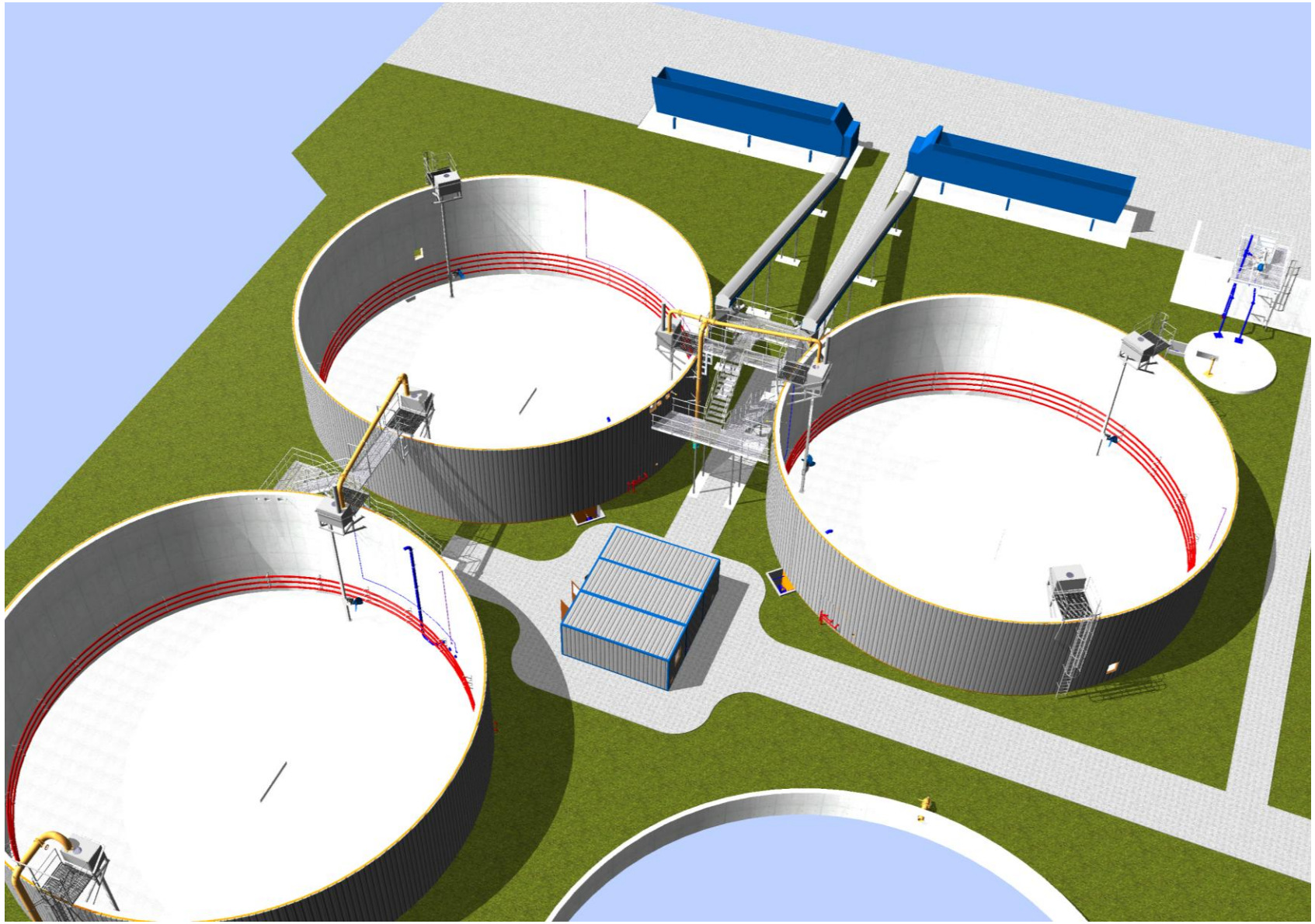
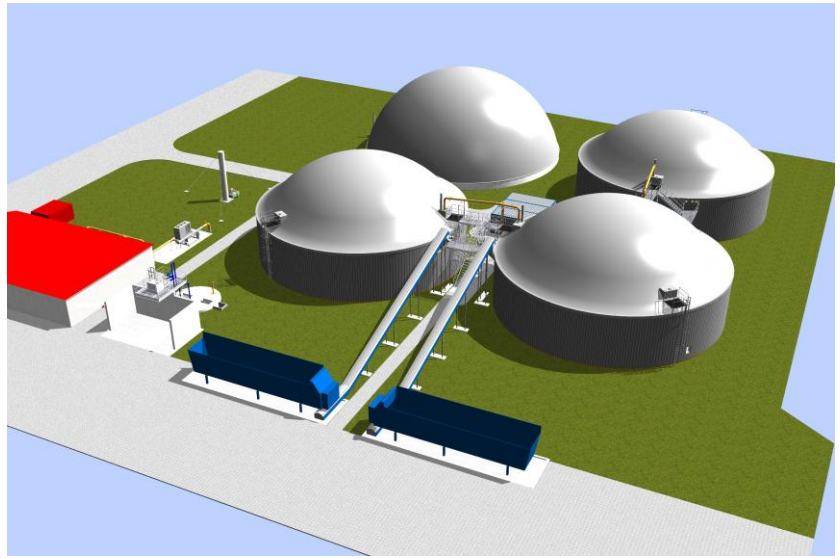
Moara – Romania





Modern Manure Management Facility in Japan

Okayama Biogas Plant

90,800 tpy
Of liquid and solid Manure

1.2 MW Power
Of renewable electricity

Integrated design by Anaergia

Variable Organic Waste Streams into Renewable Energy

BIOGAS PLANT SZARVAS

Substrates:

Organic Waste, Manure, Crops, Municipal Sludge, Slaughterhouse and agricultural waste to Energy

Power:

4.2 MW_{EL}

World's first wastewater plant where 100% of the feed becomes a commercial product and excess energy is exported thanks to Anaergia technology

The Sterling Natural Resources Center

3.0 MW
Of renewable Electricity

8,000,000
GPD of recycled water

~2,000
TPY of fertilizer

Globally Acclaimed Wastewater Facility

Flexible Deployment within existing wastewater infrastructure is highly replicable

GLOBAL WATER INTELLIGENCE

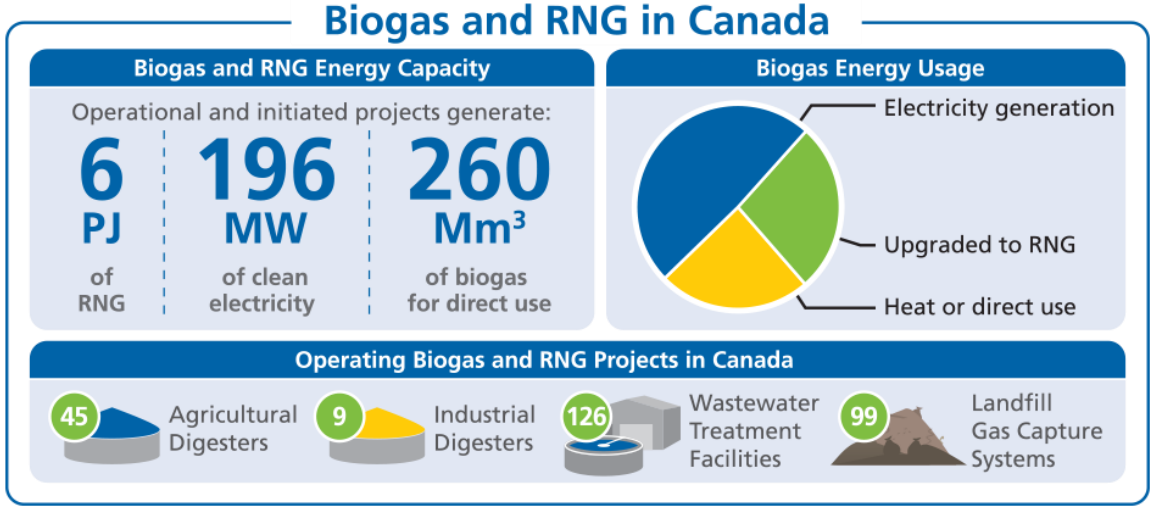
320,000

MMBtu per year of RNG

Canada's Current Biogas Scene

Canadian Biogas Association Reports a Healthy Biogas Market

- Many of the Canadian biogas plants are located on family farms and co-digest manure and off-farm organics from grocery stores and restaurants
- Key locations are Ontario (56%), Quebec (14%) and BC (12%)



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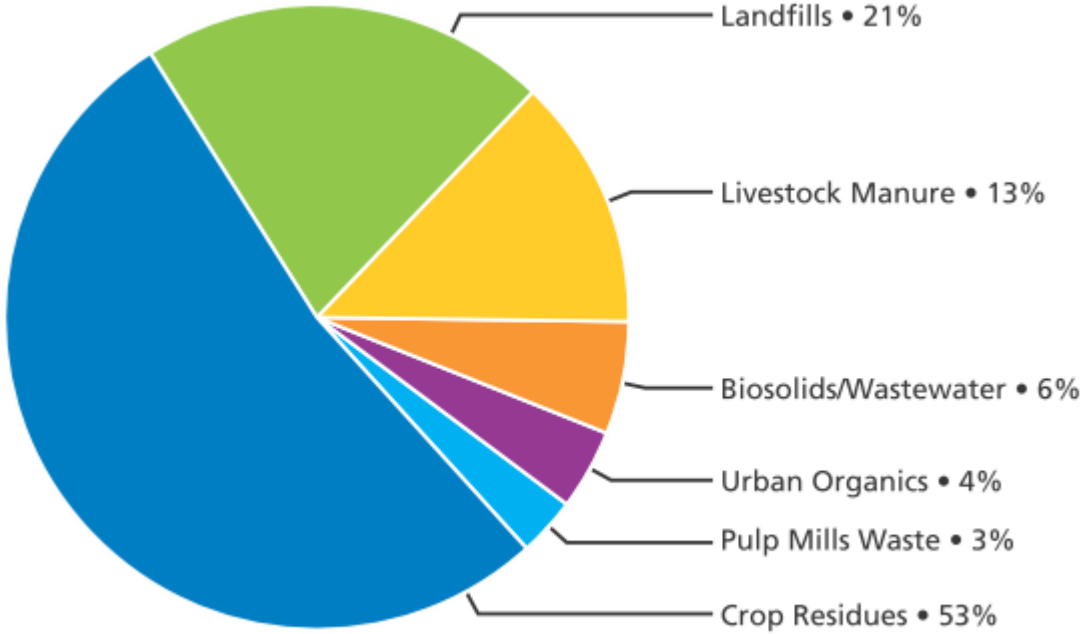
Canada's Market Outlook

Canada's Capacity Remains Untapped

- 155 PJ of biogas energy from RNG is realistically available (around 3,000,000 million Canadian homes consumption)
- Even larger if energy crops and purpose grown biomass is included
- We are currently only utilizing 13% of the potential with existing biogas assets
- The major opportunity is for on-farm AD with supplementation from off-farm organics



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The Time for Canadian AD Projects is Now

Canadian regulation, utility procurement, and customer demand are improving the business case for Canadian RNG projects.

Stronger Policy Support for Canadian RNG Projects

- Canada's **Clean Fuel Regulations (CFR)** have created an active compliance credit market for lower-carbon fuels.
- **Biogas and RNG supplied for use in Canada can create CFR credits**, creating a new revenue opportunity for qualifying projects.
- **NRCan's Clean Fuels Fund** remains an important source of federal support for new clean fuel production capacity and project de-risking.

Utility and Customer Demand Continue to Grow

- In British Columbia, policy and utility programs continue to support expanded RNG procurement and customer adoption.
- In Québec, Énergir has a regulatory RNG delivery obligation that rises to **10% by 2030–2031**.
- Utilities and commercial customers can lower lifecycle emissions using existing gas infrastructure by contracting for RNG.

FORTIS BC™

- **Up to 15% Renewable Natural Gas supply by 2030 under the B.C. Renewable Gas Program**

énergir

- **Québec regulatory mandate reaching 10% RNG distribution by 2030**

ENBRIDGE®

- **Investing across North America to scale RNG supply with net-zero operations by 2050**

nationalgrid

- **Committed to net-zero greenhouse gas emissions by 2050, including expansion of renewable gas solutions**

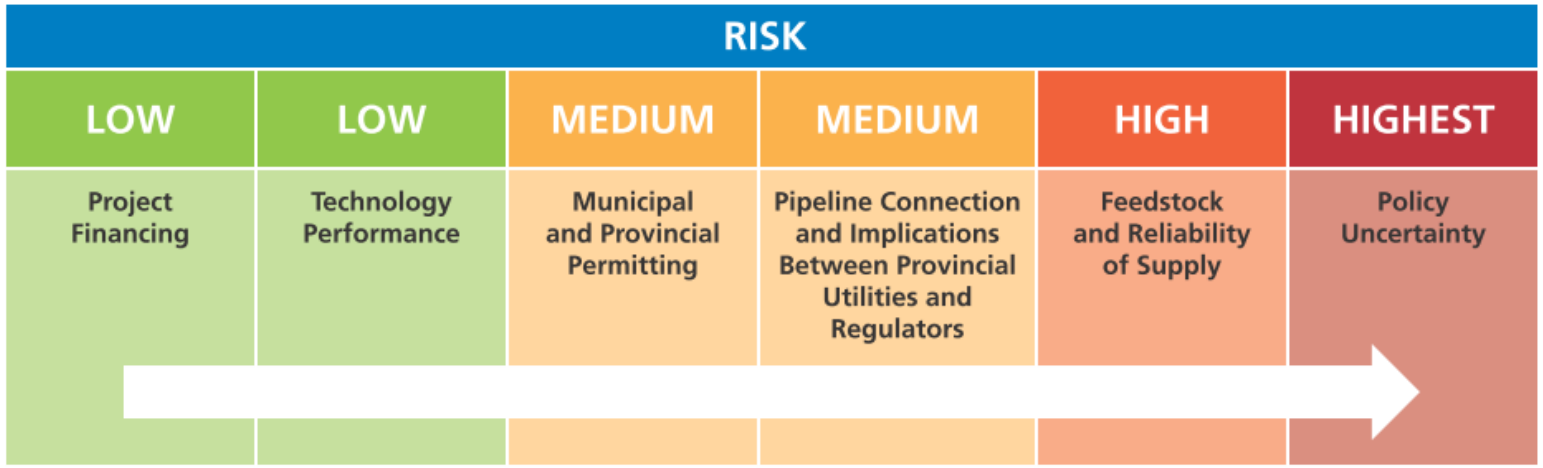
SoCalGas™

- **Targeting 20% Renewable Natural Gas in core gas supply by 2030**

DUKE ENERGY®

- **Net-zero methane emissions by 2030 and net-zero energy system by 2050, including renewable gas**

Canada's Barriers to Growth



Risks can be mitigated to grow the market

- High capital cost and long-term operational costs
- Connecting to Natural Gas pipelines is a challenge (estimate $1 million / km)
- Feedstock competition for the "low hanging fruit"
- Lack of funding to support the market growth
- Undefined policy – which was so critical to spurring the growth of farm based digesters in Europe

Anaergia