MINISTRY OF FOREIGN AFFAIRS
OF DENMARK
The Trade Council

INNOVATIVE DANISH BIOGAS & WASTE SOLUTIONS

2022

WASTE, RECYCLING AND BIOGAS ADVISORY

ABOUT WBA

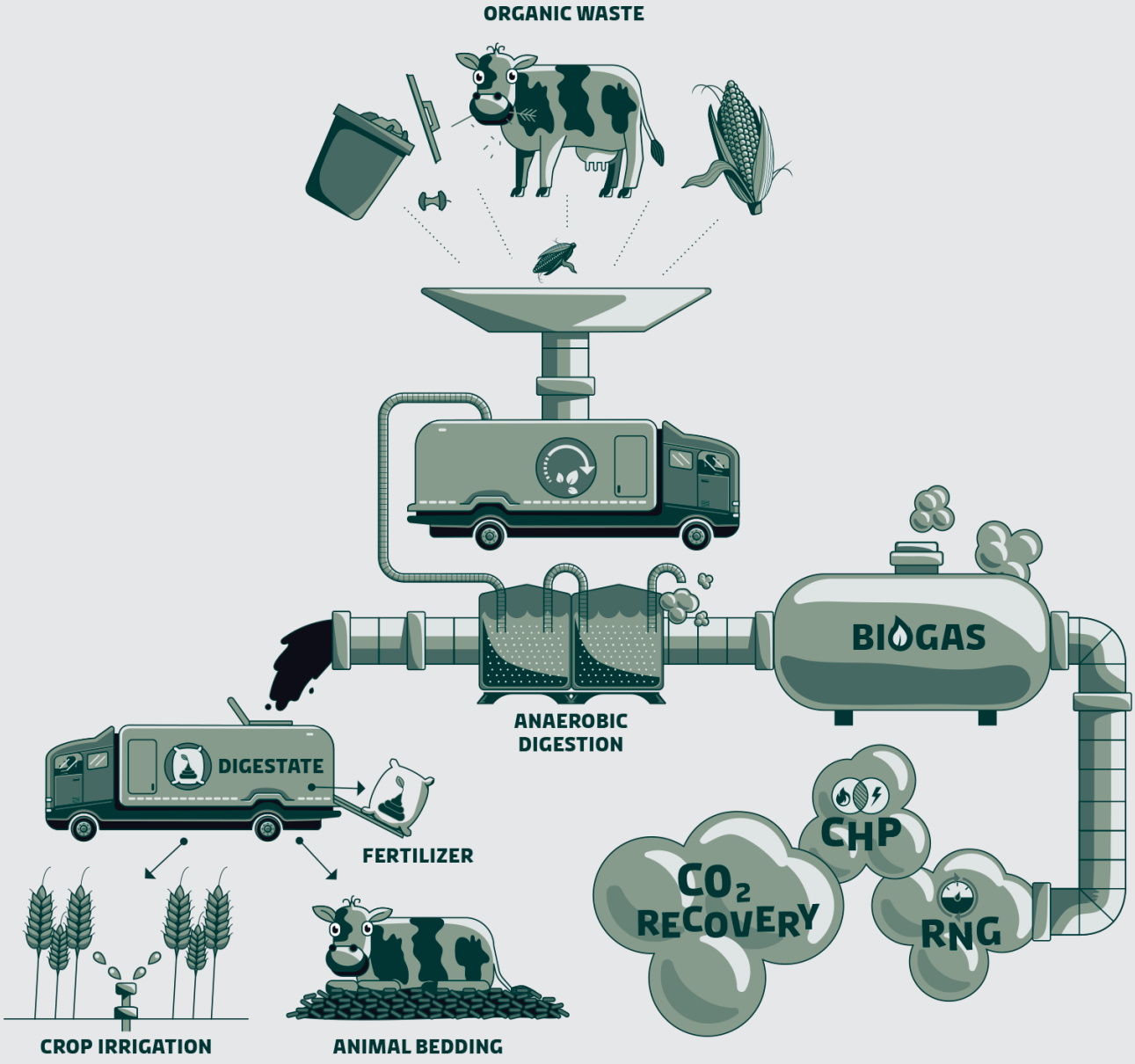
The Waste & Biogas Advisory (WBA) is a dedicated sector platform that offers specialized knowledge on key aspects of the biogas value chain. The WBA group consists of industry experts with a deep commitment to advance biogas and innovative waste management solutions in North America.

The estimated market potential for biogas plants with livestock operations, water resource recovery facilities, food waste digesters and landfills in the U.S. and Canada totals more than 12,000 projects according to recent studies. The US alone generates more than 250 million tons of municipal solid waste every year, with an estimated 60 million tons of food waste is loss or wasted annually. Livestock manure from billions of cattle, chickens, and pigs must be managed each year and is another key source of methane emissions. Wastewater from more than 400 million American and Canadian citizens must be managed daily. Biogas plants turn these organic wastes into a resource by capturing the methane to generate renewable energy and convert nutrients into rich fertilizer. The North American biogas industry has many prospects, but needs commercially proven, cost-effective solutions in order to address key barriers for growth.

The WBA aims to facilitate solutions sharing between Danish biogas companies and their counterparts in the U.S. to help unlock commercial opportunities and accelerate sustainable waste management projects, including biogas. Through alliance-based collaboration, WBA acts as a full solutions provider to the U.S. market covering key competencies for biogas production including pre-treatment of organics, project development and investment, design, engineering and construction, gas conditioning, and nutrient recovery.

DENMARK AND BIOGAS

Biogas plants have existed in Denmark since the 1970s to manage nutrients and reduce the environmental footprint of livestock farms. In 2012, Denmark more formally committed to the growth of the biogas industry when it became a political priority and part of the National Government's strategy for a fossil-free energy supply by 2050. Feed-in tariffs and investment tax credits significantly matured the industry, greatly increased the number of large-scale centralized projects and spurred innovation in areas like digester design & operation, ownership models, renewable natural gas (RNG), CO_2 recovery, Power2Gas, and nutrient recovery.

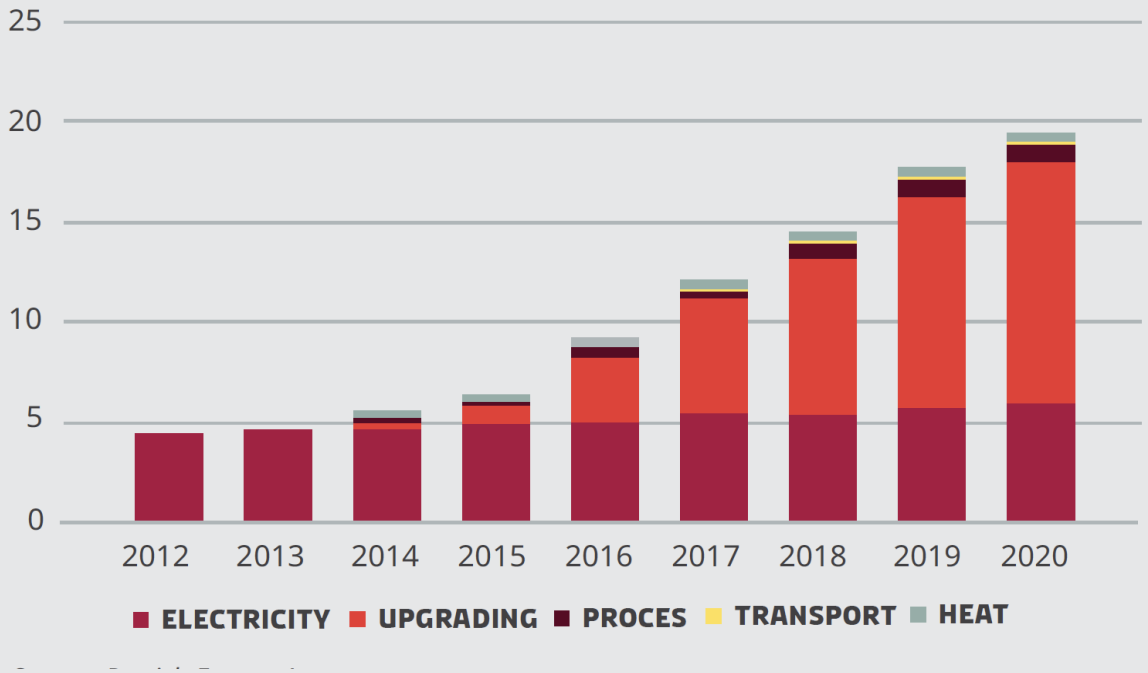


Source: WBA, the Danish Biogas Model

IN 2020, 20 PERCENT OF THE DANISH GAS GRID WAS RENEWABLE NATURAL GAS (RNG)

The Danish biogas industry has experienced incredible growth in production since 2012. In 2020, biogas production reached almost 20 Peta Joule, a more than 400 percent increase in production since 2012 - of which renewable natural gas (RNG) experienced the most growth. This has been driven primarily by the growth of large, centralized co-digestion biogas plants to treat animal manure, food waste and ag residuals.

Recent and expected biogas production and use in Denmark, 2012-2020 (PJ)



Source: Danish Energy Agency

Another significant development is the shift from onsite electric generation to upgrading and injection into the natural gas pipeline. In 2020, 20 percent of the grid came from bio-methane production, from primarily centralized plants that co-digest livestock waste with other organic feedstock materials. The percentage of RNG in the grid is expected to grow to more than 30% by 2023.

BY 2035, 100 PERCENT OF THE NATURAL GAS GRID IN DENMARK IS EXPECTED TO BE SOURCED ENTIRELY FROM RNG AND OTHER 'GREEN' GAS SOURCES

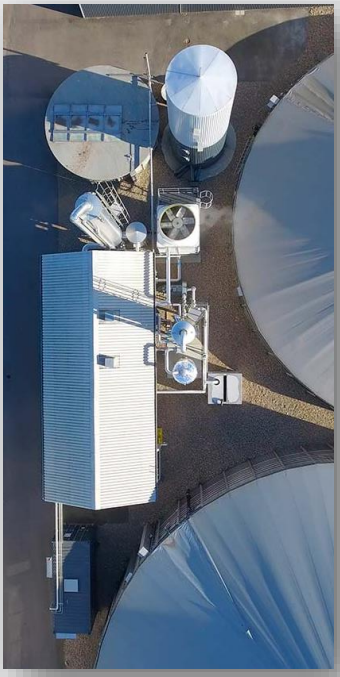
The Trade Council is an integrated part of the Ministry of Foreign Affairs of Denmark.

The Trade Council provides services with the purpose to foster commercial activities between Danish and foreign business communities. The services provided aim to increase the awareness of Danish core competencies and how these can benefit foreign markets.

For more information about Danish waste and biogas partner companies, please contact Cecilie Sorensen at cecsor@um.dk or Chris Voell at chrvoe@um.dk.

COMPETENCE DIRECTORY

Ammongas



AMMONGAS is an engineering company specialized in biogas upgrading to biomethane/renewable natural gas (RNG). Ammongas has developed an amine-based system for biogas upgrading that is the 'go to' solution in Denmark, with 20 plants of various sizes operating in the country. They have also supplied an equal number of installations throughout Europe and the world.

Compared to other technologies, the amine scrubber provides high methane purity and a methane recovery above 99.9 percent, meaning less than 0.1 percent methane slippage with the CO_2 stream.

The amine-based system also enables removal of H_2S 'downstream' of CO_2 removal, eliminating the need for expensive compression and pre-treatment of the raw biogas. The upgrading plants are designed as robust systems reducing service and maintenance costs.

www.ammongas.dk

BUSINESS CASE:

AMMONGAS

1 OPPORTUNITY

Upgraded biogas, RNG or biomethane, ensures an optimal utilisation of the raw biogas as it can be utilised in the natural gas grid, allowing for storage and flexibility for a number of energy needs. This means that it can be used when and where it is needed instead of being wasted. Upgraded biogas is also environmentally friendly, and can be used for green electricity or thermal, or fuel in cars, buses and trucks.

2 SOLUTION HIGHLIGHTS

Ammongas has developed an amine based system for removal of CO_2 in biogas, which is based on a proven, high-quality, cost efficient stripper-absorber concept. The system has its special advantage by working in a pressure less environment, thereby reducing investment costs and power consumption.

3 RESULTS

Ammongas is the 'go to' upgrading solution for biogas in Denmark, with 20 installations of various sizes operating. The system is remarkably effective and is able to **upgrade biogas into a >99 percent pure methane gas**, with a methane loss to the atmosphere below 0.1 percent. The excess heat from the system can be reused as 75 °C (167 °F) (or higher) water to central heating, pasteurization or heating of biogas reactors

BIOGASCLEAN is a world leader in biological desulfurization of biogas – with no use of chemicals. Biogasclean's experience is significant, with more than 280 installations across 40 countries – including 14 in North America, with additional systems being installed at dairy and meat processing digesters. Biogasclean's technology is deployed in many sectors including digesters treating agriculture residues, food waste, manure, and wastewater bio-solids, as well as landfill gas.

The technology is designed to handle any flow or H_2S concentration in the raw biogas and the system is fully automated yielding competitive OPEX for both CHP and RNG projects. Treated water from the process is used as liquid fertilizer in two out of three projects adding additional benefits to the project.

Biogasclean provides performance guarantees to all customers and is a strong partner in a biogas project.

Client:	**Hans Jørgensen & Søn**	**CO_2 flow:**	**600 m³/h 352 scfm**
End User:	**NGF Månsson**	**H_2S in:**	**7,500 ppm**
Sector:	**RNG to the grid**	**H_2S out:**	**50 ppm**
Location:	**Brande, DK**		
Year:	**2017**		

www.biogasclean.com

BUSINESS CASE:

BIOGASCLEAN

1 OPPORTUNITY

Hydrogen sulfide (H_2S) is a strongly odorous gas that can corrode digester and energy generation components and is a serious health and safety threat. It is often referred to as “sewer gas” and is particularly present in the wastewater and digester environments. Cost-effective solutions for H_2S removal are in high demand to minimize OPEX costs, reduce equipment failures, and eliminate nuisances like odor.

2 SOLUTION HIGHLIGHTS

Biogasclean’s systems can reduce H_2S concentration down to 50 ppm, after which the biogas can be used for electricity, heat or bio-methane generation. Most systems are designed for 3,000-5,000 ppm, but have installs treating 20,000 ppm. In combination with an amine scrubber, Biogasclean provides H_2S removal for the off-gas stream, yielding high methane recovery and low operating costs. Biogasclean offers tailored solutions for small and large-scale installations.

3 RESULTS

The patented QSR® technology makes it possible to periodically clean the packing media inside the tank. The Biogasclean system is installed at several RNG projects, the largest one producing 777 million scf per year of biomethane and **reducing H2S from 8000 ppm to 50 ppm in the off-gas**. Biogasclean’s venture into RNG offers **methane recovery up to 99.9 percent** when combined with an amine scrubber for upgrading.

GEMIDAN ECOGI A/S provides a pre-treatment system to capture the organic fraction from residential, commercial and industrial food waste sources. Their unique pre-treatment technology processes multiple organic waste streams and produces a high-quality 'biopulp' that can be delivered for anaerobic digestion and composting. This 99.9% biopulp can add significantly to energy generation and nutrient recovery efforts. There are four Ecogi facilities operating in Denmark, processing between 40,000 and 120,000 tons per year.

Ecogi's robust design warrants high tolerance towards harsh waste streams and can demonstrate low OPEX with a system that has a fully automated operation.

Ecogi is owned by the Gemidan Group, a leading Danish waste management company with 30 years of industry experience. Gemidan Ecogi is specialized in designing, delivering, operating and maintaining complete plants.

Analysed purity of products (17 percent dry matter)

	Test run 1%	Test run 2%	Test run 3%	Average %	Standard deviation %
Purity product all impurities (17% dry matter)	99.948	99.967	99.960	99.96	0.01
Purity mix plastics (17% dry matter)	99.992	99.995	99.996	99.996	0.002

Recovery based on expected methane yield in biogas plants.

Test rum	1	2	3
Washing water (particles < 3 mm) ton VS	0.0143	0.0182	0.0135
Organic material (particles > 3 mm) mm ton VS	0.1163	0.0707	0.0816
Organic ton VS in input	1.80	1.44	1.24
Loss of methane potential washing water m3 CH4	5.72	7.27	5.41
Loss of methane potential larger organics > 3 mm m3 CH4	23.26	14.14	16.32
Sum loss m3 CH4	28.98	21.41	21.73
m3 CH4	720.07	574.46	495.87
% recovery CH4	95.98	96.27	95.62

www.ecogi.dk

BUSINESS CASE:

GEMIDAN ECOGI

1 OPPORTUNITY

It is an increasing challenge for the biogas and compost industries to source high-value feedstock for anaerobic digestion. Gemidan Ecogi provides public and private solid waste agencies with an alternative to landfilling by sending organic waste streams to biogas plants for production of renewable energy and nutrient-rich fertilizer – or to composting operations for nutrient and solids recovery.

2 SOLUTION HIGHLIGHTS

Gemidan Ecogi has designed a technology that maximizes organic recovery and purity in the biopulp. Ecogi effectively removes paper, plastic, metal and glass contaminants from food waste sources. Gemidan Ecogi's solution focuses on maximum utilization and provides performance guarantees in all aspects, including power production, organic recovery, and capacity.

3 RESULTS

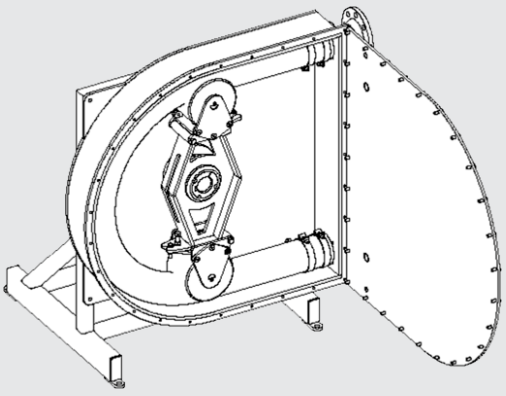
Gemidan Ecogi's solution has proven to **recover 95 percent of the organic matter** in the waste streams.

Continuous testing and documentation have resulted in high fineness in the bio-pulp achieving up to **99.9 percent purity**. This ensures that the substrate after composting or digestion can be applied on cropland as nutrient-rich fertilizer or soil amendment.

LSM • PUMPS USA Inc.

LSM PUMPS USA have been manufacturing peristaltic (hose) pumps since the 1990s and with great success in many industries – including biogas, food waste, meat rendering, fish production, & wastewater. With the ability to handle thick slurry and up to 80 percent solids and large particles, the pump is also very energy efficient due to the pump design. Compared to other hose pumps, the LSM pumps differentiate by the advantage of larger pump cases, meaning longer hoses and thereby more volume moved per revolution at lower speed resulting in longer lifespan of the gear and hose. Further, the special role of adjustment gives the hose optimal compression, lower level of friction, better lubrication, and lower power consumption. The internal rollers make start, stop and reverse motion a very smooth operation and will also extend the hose life significantly.

LSM has a number of installations in the US market, a strong distribution and support network established.



www.lsmpumps.com

BUSINESS CASE:

LSM PUMPS USA

1 OPPORTUNITY

Due to an uptime of only 80 hours and an increasing number of costly repairs of a conventional rotary lobe pump, K Agro, a biogas plant in Denmark, researched and approached the market for alternatives to pump their biomass at 14 percent solids - with larger fragments from, e.g., sugar beets. For the conventional rotary lube pumps, each repair's cost was estimated at $2,000 for parts alone, weekly repairs estimated to be 3 hours (~145 hours/year) and the downtime cost for total stop of production estimated at $1,000/hour.

2 SOLUTION HIGHLIGHTS

Two LSM 150 hose pumps were installed to solve K Agro's pumping challenges; avoiding downtime and securing a stable and reliable machine for their production. The maintenance of the LSM pumps is possible without dismounting the pump from the application and without the need of special training or tools.

3 RESULTS

K Agro has experienced an increased operating time and spare part expenses are cut by 2/3. The pump application is expected to last 8-10 months of runtime before the hose needs replacement, and the return on investment will be visible after just 7 months in operation, just based on spare parts – not taking lost production and working hours into the calculation.

nature energy

NATURE ENERGY is the world's first fully integrated renewable natural gas (RNG) company. Nature Energy is introducing a strong business model for building, owning and operating large-scale biogas plants, together with partners, providing superior solutions for anaerobic digestion systems. With the acquisition of Xergi, Nature Energy is a technology leader in advanced biogas solutions. Nature Energy has developed models for handling complex biomasses and is continuously enhancing options for high value products based on the organic waste materials. The current developments focus on reuse and comercialization of CO_2.

www.natureenergy.dk/en

BUSINESS CASE:
NATURE ENERGY

1
OPPORTUNITY

Without intelligent management of the organic waste, CO_2 emissions increase, water environment, and soil suffer from heavy nutrient loads and cause significant environmental problems. The biogas solutions from Nature Energy solve these issues, by utilizing waste as a resource in the biogas plants.

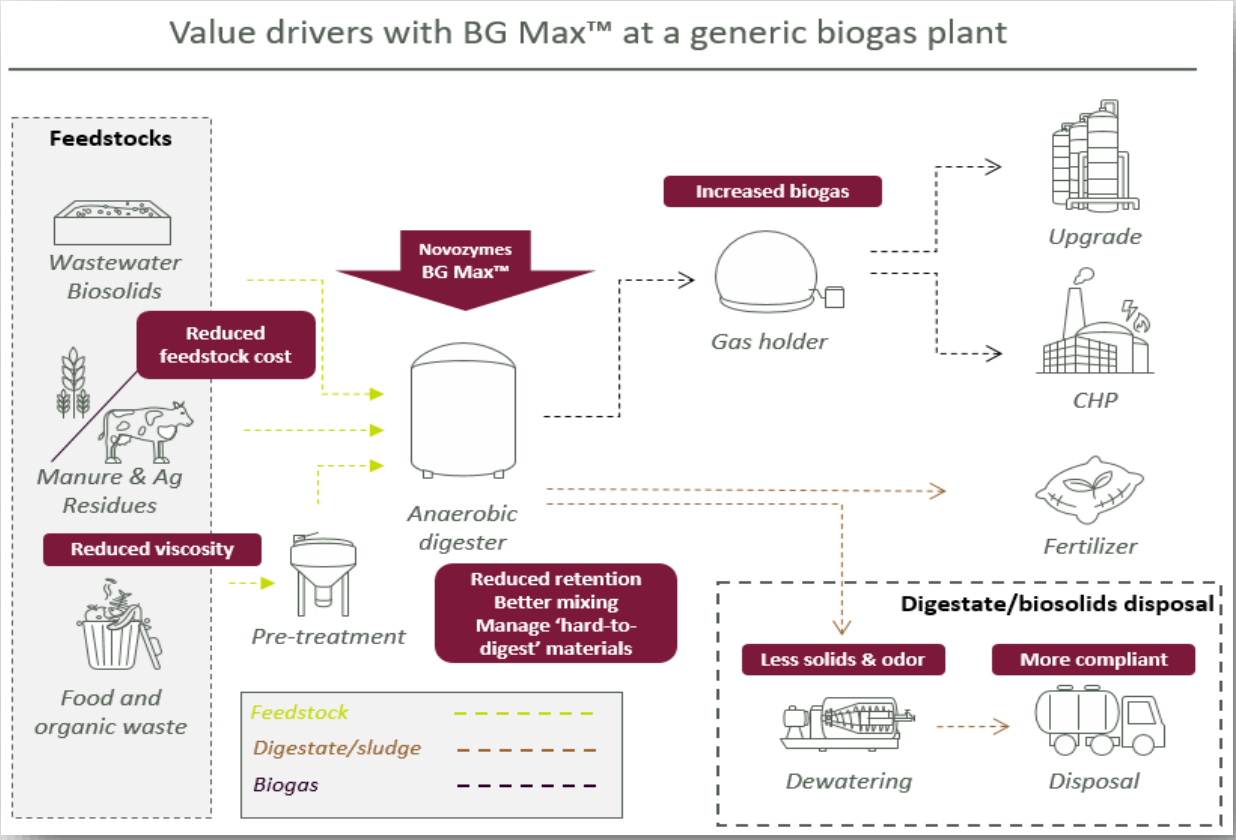
2
SOLUTION HIGHLIGHTS

Nature Energy designs, builds, owns, and operates anaerobic digester systems - producing nutrient rich organic fertilizer, and biomethane for gas-to-grid solutions. Many different types of organic waste material can be processed with its leading co-digestion technology. This provides a better management of waste streams and a high energy production. The plants are often based on a cooperative business mod-el, including local farmers and other stakeholder and partners.

3
RESULTS

Nature Energy has built more than 70 large-scale biogas plants, of which 9 biogas plants are of the build-own-operate concept. Nature Energy's strategy is focused on large-scale, industrial biogas plants. The largest facility is currently **producing 22 million cubic meters of biomethane** per year; **processing 700,000 metric ton of biomass** (manure, agricultural residuals, food waste); **providing fertilizer** to surrounding crop farmers.

novozymes®



Biological solutions from **NOVOZYMES** drive several values for biogas plants. As the world leader in biological solutions for industrial facilities, Novozymes offers tailor-made enzymatic blends for biogas plants based on substrate mix and operating conditions. Due to their extensive enzyme portfolio and long history in enzymatic process optimization, they can offer ideal solutions for anaerobic digesters that process residues from agriculture, municipal waste, food production, or wastewater, helping plants boost profitability by reducing feedstock costs and increasing biogas revenue.

Whether the biogas is produced from agricultural residues, food waste or wastewater biosolids, enzymes improve the hydrolysis in the digester, which is particularly helpful when processing 'hard to digest' substrates. Enzymes can also help prevent the formation of hard crusts within the digester. Novozymes has a strong presence in North America with more than 1,200 employees across eight states and two provinces. A smaller team is dedicated to the waste-to-energy sector, which includes a growing biogas industry.

BUSINESS CASE:

NOVOZYMES

https://biosolutions.novozymes.com/en/wastewater/biogas

1 OPPORTUNITY

With a growing focus on (advanced) organic waste management in North America, biological solutions from Novozymes can help plants seize both opportunities from new waste streams, and improve the profitability of existing operations.

2 SOLUTION HIGHLIGHTS

Biological solutions from Novozymes improve the conversion of organics into biogas. The primary benefits from enzyme use include:

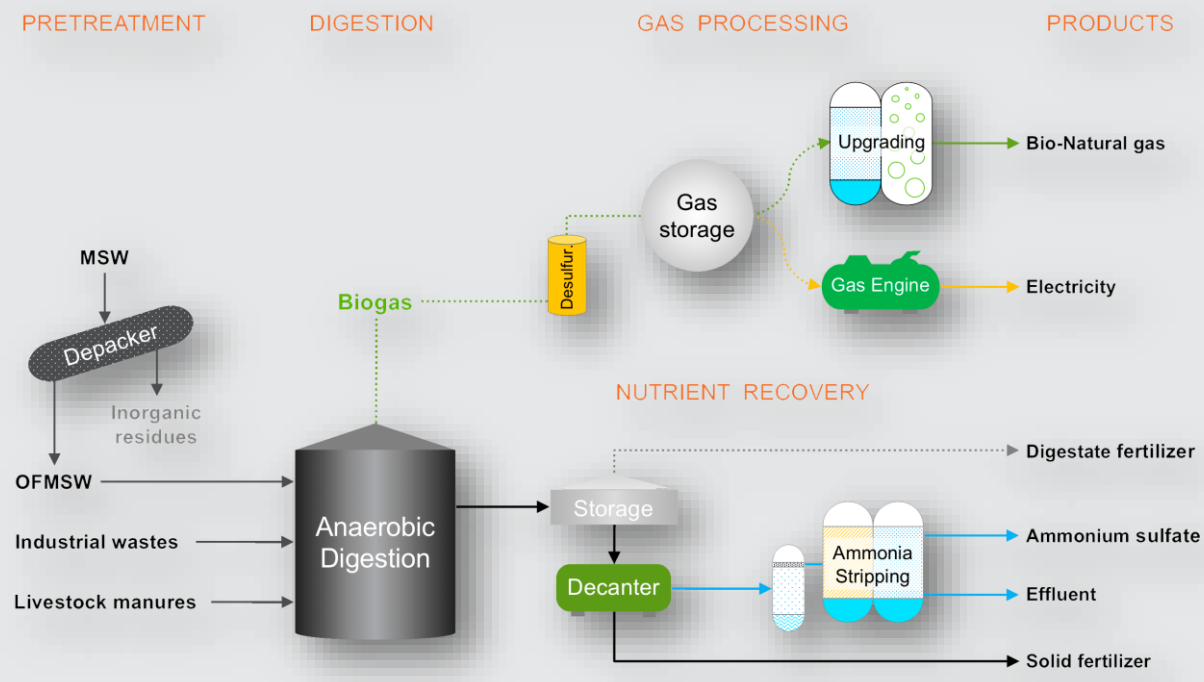
- More biogas production from manure, food waste & wastewater biosolids.
- Reduced solids for disposal.
- Improved processability of hard-to-digest feedstocks
- Ability to solubilize organic matter, which is especially valuable during food waste pre-treatment, where better separation and lower viscosity can increase plant processing capacity.

3 RESULTS

The use of enzymes in biogas plants is well-documented and is already an established industry in Western Europe. Target benefits of enzyme applications from Novozymes could include:

- **Up to 15% increase in biogas yield** (average across substrates)
- **Up to 10% solids reduction** (outlet from anaerobic digester)
- **Up to 30% COD reduction** (outlet from upstream anaerobic treatment)
- Better solubilization of organic matter, and DM increase of incoming waste of up to 5%
- **Recovery of up to 50% organic matter** from the reject stream

Renew energy



GENERAL PROCESS FLOW OF A BIOGAS PLANT

RENEW ENERGY has been designing and building anaerobic digester systems for more than 25 years in Denmark, Europe and the US. They are a leading engineering consulting company specialized in biogas, bio-refinery and nutrient recovery solutions. Renew Energy has provided analysis and engineering services to more than 10 biogas and bio-refinery plants, including Fair Oaks Farms in Indiana, the Fremont Community Digester in Michigan and most recently Trenton Biogas in New Jersey.

Renew Energy's philosophy is to design plants where energy consumption is minimized and biogas generation is maximized. They specialize in systems to co-digest animal manure, food waste, ag residuals & other hard to digest feedstocks.

Renew designs systems where operations are automated, nutrients and water are recovered, transport of feedstock and fertilizers are reduced, and odors are kept at an absolute minimum. Renew Energy collaborates closely with Danish solution suppliers.

Blaabjerg Plant, Denmark

Maansson Plant, Denmark

Trenton Biogas, New Jersey, USA

www.renewenergy.dk

BUSINESS CASE:

RENEW ENERGY

1 OPPORTUNITY

Anaerobic digestion offers an effective way to handle large amounts of organic waste (manure, food waste, agricultural residues), where energy-rich biogas and nutrient-rich digestate are produced. Optimization of the anaerobic digestion process for optimal biogas production and recovery of valuable digestate nutrients are key to the long-term success of a biogas plant.

2 SOLUTION HIGHLIGHTS

Renew Energy's solutions optimize the biogas production and recover the nutrients in the digestate. Examples include feedstock pretreatment prior to anaerobic digestion and co-digestion to increase the bio-methane yield; mechanical separation of digestate that allows the use of phosphorus in the solid fraction easy to transport; ammonia stripping controls ammonia odor and produces ammonium sulfate fertilizer.

3 RESULTS

Renew Energy has provided engineering consultancy to Trenton Biogas in the planning and construction of the first food waste digester in New Jersey. The plant is designed to treat 380 ton/day organic waste, producing 3 MW power, 12 tons/day of ammonium sulphate and 80 tons/day solid fertilizer. The Danish Export Credit Foundation provided loan guarantees and helped secure financing, which totalled $45 million USD.

Biogas Go Global (BGG) is a Triple Helix Partnership between the Danish Trade Council of North America Biogas Team, Food & Biocluster Denmark and the Danish Energy Agency. Funded by the Danish Industry Foundation, BGG facilitates knowledge transfer between Denmark and the U.S. on biogas production, organics recycling and nutrient recovery. The idea is to bridge the gap between project development, regulation and R&D with an aim to create partnerships that bring the biogas industry forward in both countries.

MINISTRY OF FOREIGN AFFAIRS OF DENMARK
The Trade Council

INDUSTRIENS FOND
FREMMER DANSK KONKURRENCEEVNE
The Danish Industry Foundation

Biogas Go Global

Biogas Go Global

Food & Bio Cluster Denmark

Danish Energy Agency

A TRIPLE-HELIX APPROACH

TOWARDS A GREEN FUTURE

ACADEMIA: Food and Bio Cluster Denmark and INBIOM - the Innovation Network for Biomass – identify areas of collaboration between Danish and U.S. universities and knowledge institu-tions and assist U.S. companies with corporate establishment in Denmark.

INDUSTRY: The Trade Council of Denmark is part of the Danish Ministry of Foreign Affairs. Through its Biogas Alliance, The Trade Council facilitates commercial opportunities between Danish and U.S. interests in the waste and biogas sector.

GOVERNMENT: The Danish Energy Agency is part of the Danish Ministry of Energy, Utilities and Climate and brings experience with regulatory drivers for bioenergy systems in front of U.S. policy makers and regulators at the federal, state and local levels to create government partnerships.

WBA TEAM

CHRISTOPHER VOELL
Head, Waste, Recycling and Biogas Advisory (WBA)
Embassy of Denmark, Washington, DC
+1 240-877-4745, chrvoe@um.dk
Chris has headed the WBA since 2019, helping to grow the Biogas Alliance and Biogas Go Global efforts. He has worked for non-profit, government and private organizations in the waste management, wastewater, livestock, and biogas energy sectors since 1986, most recently with the Climate Change Division of the U.S. Environmental Protection Agency and the Global Methane Initiative. His focus is on identifying strategic partnerships and business alliances with North American companies, NGOs and government agencies and helping to advance environmentally and economically sound waste management with Danish solutions.

CECILIE ENGELL SOERENSEN
Commercial Advisor, Waste, Recycling and Biogas Advisory
Embassy of Denmark, Washington, DC
+1 202-251-9555, cecsor@um.dk
Cecilie joined WBA Team in 2020 and since has led many efforts related to the US Biogas Alliance and Biogas Go Global. She has a background in international business development and worked on renewable energy projects and policy in the biogas and wind sectors while at the Embassy of Denmark in Chile. Her focus with WB&A is identifying biogas and waste project opportunities in North America and positioning Danish solutions for inclusion. Cecilie is also responsible for branding and promotion of Danish interests through SoMe and other outlets.

EMIN SLIJEPCEVIC
Jr. Commercial Advisor, Waste, Recycling and Biogas Advisory
Consulate General of Chicago, Chicago, IL
+1 312-566-3758, emisli@um.dk
Emin joins the Biogas Team after a successful internship at the Embassy of Denmark in Washington, DC supporting Trade Council priority areas across North America. Emin has more than two years of working experience within exports from his previous role at The Trade Council in the Danish MFA. In his new role, Emin will support both the Biogas and Wastewater Alliances from his office in Chicago, helping grow export potential for biogas in the on-farm and wastewater sectors in the Midwest

WASTE, RECYCLING AND BIOGAS ADVISORY

The Waste, Recycling and Biogas Advisory Webpage

THETRADECOUNCIL.DK
USA.UM.DK

The Trade Council of Denmark in North America – Energy and Environment

@wbatcdk

Embassy of Denmark
3200 Whitehaven Street, NW
Washington, D.C. 20008