volume 05 | 2018

# BIOGAS DIRECTORY

INTERNATIONAL CLEAN ENERGY & SUSTAINABILITY NETWORK
ICESN

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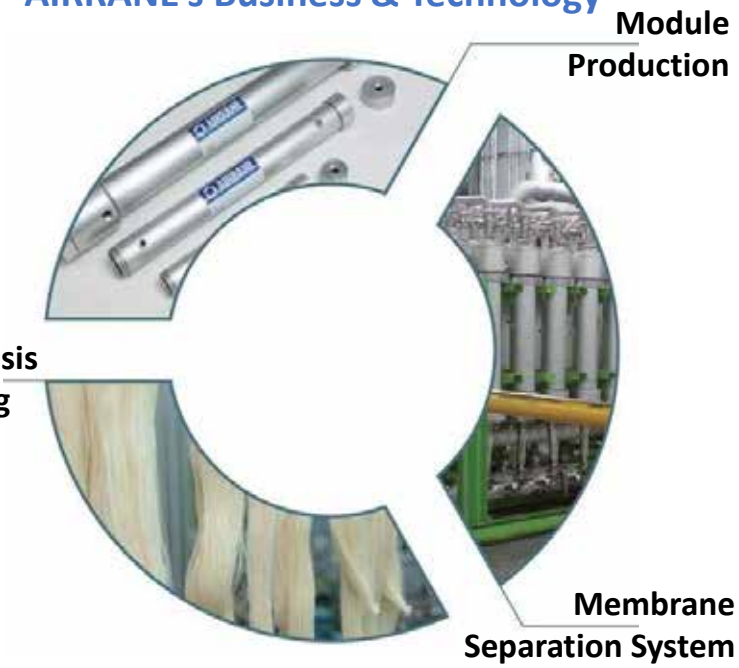
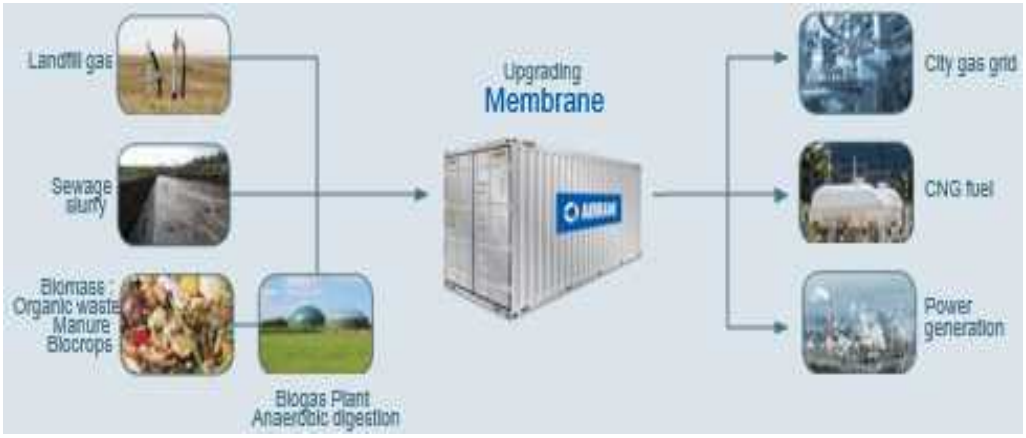



## Industries & Applications

- **Biogas Upgrading:** biogas(from food waste, manure), landfill gas, sewage slurry
- **Nitrogen Generation:** fuel tank inerting (OBIGGS), chemical processing
- **Power:** $CO_2$ Capture, $O_2$ generation for oxyfuel combustion, $H_2$ purification
- **Microelectronics:** IPA/HF recycling, $O_2/CO_2/N_2$ controlling for DI water
- **Food & Beverage:** controlled atmosphere, Nitrogen coffee/beer
- **Healthcare & Air Quality Control:** membrane dryer, mobile oxygen concentrator
- **Oil & Gas:** $N_2/CO_2/H_2S$ removal for natural gas, recovery of monomer/solvent

## Biogas Upgraging




## Membrane Benefits

- **Simple & Reliable Design**
- **Economic Solution**
- **Environmental Benefits**
- **Flexible Application**
- **Improved Safety**

*Landfill*

By -

# DIVERTING WASTE FROM LANDFILLS

A behind the scenes insight into projects that actually solve waste handling issues.

**[Intro]**
In Colombo, the capital of Sri Lanka, a serious effort is being made to eliminate waste going to landfills. Meet one of the key technology suppliers of the project, Xergi A/S, which is supplying the organic waste handling facility there which is a complete biological processing plant.

**[Start]**
Sri Lanka is a fast expanding economy. With a population of 21 million, it is currently experiencing a booming interest among tourists. And who can blame them? The country offers beautiful beaches, culture, nature and wild life experiences. Waste handling, however, has not been one of the country's strong points – until recently.

As this is the case for many countries in the region, waste was not treated and ended up in ever increasing mountains of waste at the landfills in the outskirts of the cities.

## Food waste collection

The first steps towards sustainable waste handling were taken a long time before the biogas and waste handling project was commenced. In 2016, source separation of waste in the suburbs of Colombo was made mandatory. Now, it is compulsory for all households, hotels, restaurants etc. in all of Colombo and its larger suburbs to segregate the organic waste from the inorganic waste.

However, still most of the waste ended up in landfills, so the government facilitated the development of an end-of-the-pipe solution, offering the waste stream - previously going into landfills - to private investors in a tender process for them to make the optimum exploitation of the resources in the waste stream, and make the necessary investments to do so.

This was the foundation for a far more environmentally friendly waste solution,

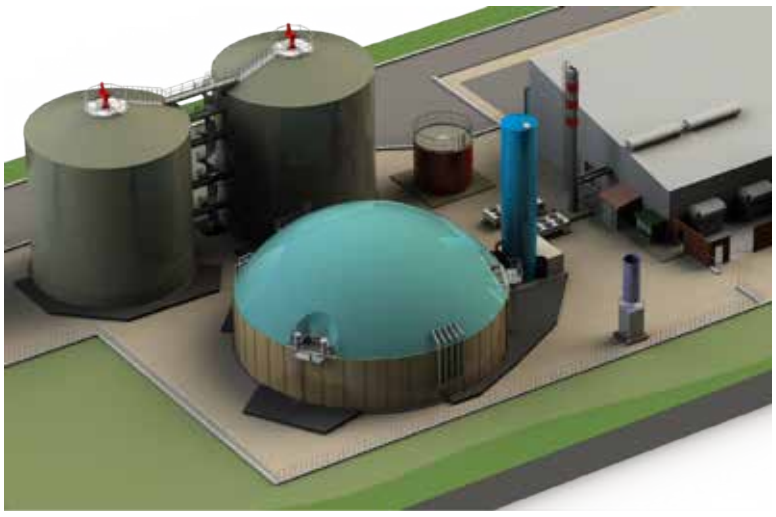
*Xergi biogas plant, example*

where organic waste could be utilized for renewable energy production and recovery of nutrients as fertilizer.

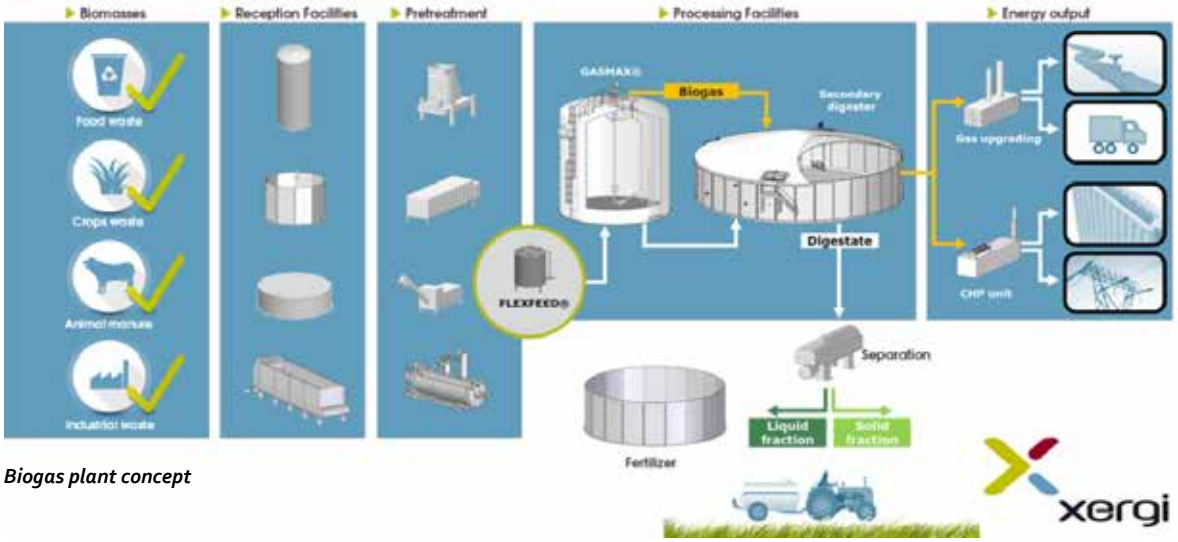
## Integrated waste handling facility

The Thumbovila Karadiyana integrated biogas and incineration project is located in the southern outskirts of Colombo. It is currently under construction, and will handle 500 tonnes of solid waste per day once it is in commercial operation. The project will add significantly to the ever increasing demand for energy in Colombo with an electrical export to the grid of 10 MW per hour, sufficient to supply electricity for approximately 40,000 Sri Lanka households.

The key technology supplier, Xergi A/S from Denmark has been part of the project from the beginning and is known for its leading technology for anaerobic digestion of food waste and other organic waste to produce biogas. Xergi is supplying a solution, where the organic fraction of the waste will be utilized to generate renewable electricity to the grid. Furthermore, the anaerobic digestion will not destroy the valuable nutrients in the food waste, such as phosphorus and nitrogen, but will make these nutrients available as a fertilizer for growing of new crops.



***Sketch, Thumbovila Karadiyana waste management***




*Biogas plant concept*

Executive Director/CTO for the project developer, Fairway Waste Management (Pvt.) Ltd., Dr. Pasad Kulatunga says; "The Thumbovila Karadiyana project marks the beginning of a new sustainable way of solid waste handling in Sri Lanka. This project will set the future standards for sustainable and environmentally friendly solid waste handling in this region."

## Environmentally sustainable solution

Fairway Waste Management has chosen a solution, where utilizing the solid waste stream includes some of the most advanced technologies for generating energy and for making a project with a green footprint. Among these are the advanced anaerobic digestion technology from Xergi for handling of the organic solid waste, incineration technology of non-organic residual fraction, and integration of fresh liquid waste-water (leachate) from the incineration plant into the biogas plant.

Diverting waste from the landfill will not only preserve an ecologically sensitive area, it will stop ground water pollution, prevent further methane emissions into the atmosphere from the landfill, protect the wildlife, stop dust and odour pollution and prevent spread of diseases through biological vectors e.g. birds and rodents from the landfill. Importantly the biogas plant that will also treat slaughterhouse waste, which will allow the health authorities to control stray dog population, and thereby turn around the current increase in prevalence of rabies around the landfill.

The two technologies for handling the organic and the inorganic waste are key in making a sustainable integrated waste handling project. The inorganic waste can be utilized much better in the incineration plant when the wet organic fraction is treated separately, and choosing an experienced technology provider such as Xergi for handling the organic fraction makes a bankable solution.

## Future trend for food waste handling

The integrated biogas and waste handling project in Sri Lanka is very much in line with the developments in the waste handling industry in other parts of the world, according to Jørgen Ballermann, CEO of Xergi: "Food waste is a core focus area for Xergi, where efficient and high performing biogas plants will extract renewable energy, while returning the nutrients to the soil to contribute to making waste handling a part of the circular economy."

The utilization of food waste for anaerobic digestion is not a new, unproven technology. Xergi already processes large quantities of food waste at its plants in UK, France, Denmark and Sweden among others. BD

xergi
excellence in biogas

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# BACTERIA UTILISE CHICKEN MANURE BETTER

By employing a preliminary biological phase upstream of the biogas plant, a Finnish company removes nitrogen from the biogas raw materials, thus increasing the gas production in this way.

**BIOGAS.** Up until now it has not been possible to effectively use manure and droppings from poultry farms for biogas production. Roughly 2.1 billion tonnes are produced globally every year - and this amount is increasing. Only a small portion of this can be used for the production of biogas. The reason for this is the high nitrogen content in the residual materials that is converted to ammoniac (NH3) and which prevents the production of biogas.

The Finnish company Ductor in Helsinki has now developed a process to remove the nitrogen from the manure and slurry before the actual production of biogas is begun with. The process entails the nitrogen compounds undergoing further processing in order that the fertilizer ammonium sulphate forms.

This involves fermenting the manure and slurry using a mixture of bacteria specifically bred for this purpose before the actual biogas production is started. The mixture of bacteria consists of approximately 20 different microbial species and it works in the temperature range from 50 to 55 °Celsius, explained Ilkka Virkajärvi, Chief Developer at Ductor during a visit to view the pilot plant. The plant is located near Turku, which is 100 kilometres north-west of Helsinki, on the grounds of an agricultural college. A chemical method to remove the nitrogen would require pressures of up to eight bar and temperatures of in excess of 100 °Celsius, reaction conditions that would be too expensive to actually put into practice, explained Virkajärvi.

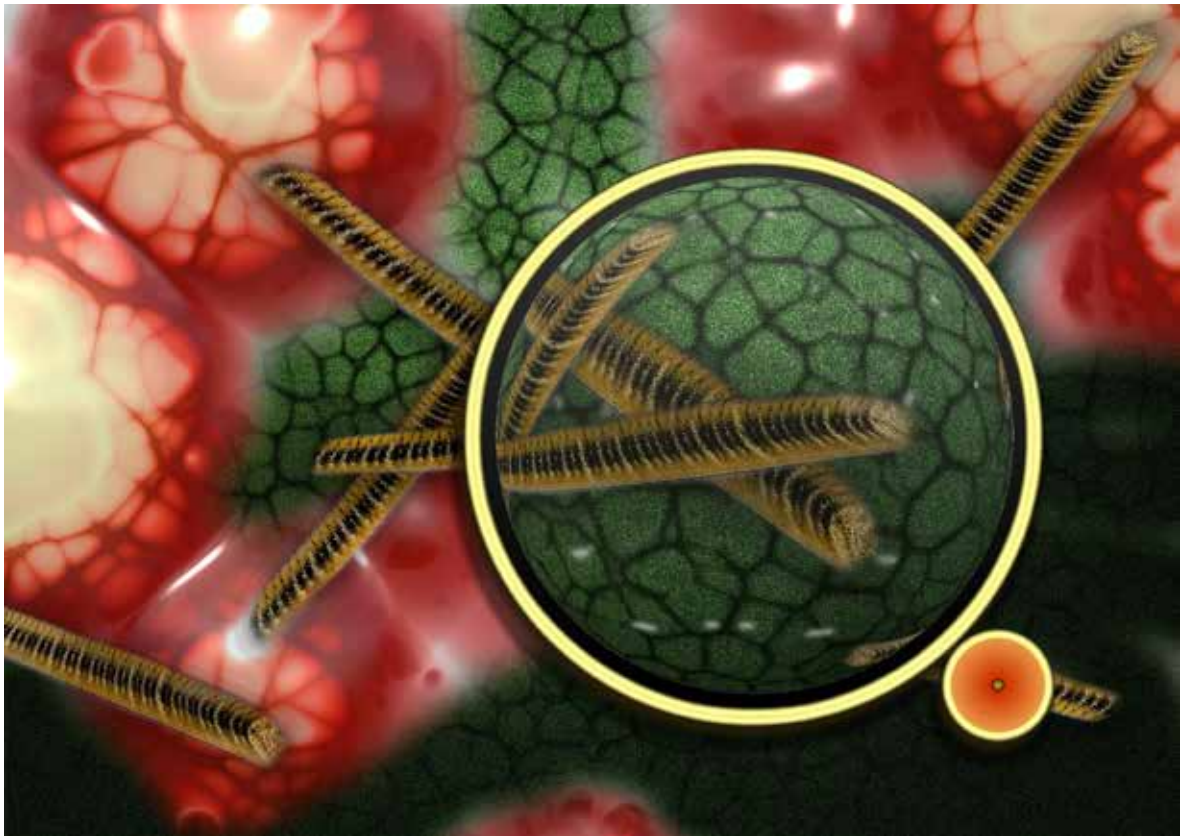
This biological process, which has meanwhile been patented, involves the nitrogen first being converted into ammonium (NH4+). This can then be combined with sulphur to allow the fertilizer ammonium sulphate to be created. The process allows approximately 80 kg of ammonium sulphate and 400 kg of phosphate fertilizer to be won from every tonne of poultry manure.

Once the nitrogen has been removed from the process, the production of biogas can begin. Virkajärvi is also not just interested in an improved yield, but also in a further aspect: The system allows Ductor to put the nitrogen into a cycle. What is applied to the field as fertilizer returns to where the poultry are housed in the food chain, and from there back onto the field.

### The building blocks for a closed-loop utilisation

The developers have delivered a technology to form the cornerstone for a closed- loop utilisation that the Finish Environment Minister Kimmo Tiilikainen in Finland would like to see implemented. By 2045 Finland should be a climate neutral country, he explained to German journalists in Helsinki. This will furthermore entail reducing the amount of nutrients that are washed from Finish soils into the sea, as well as playing a pioneering role in biotechnology and the use of renewable energies. The production of biogas has an important role to play in his plans because it makes it possible to utilise biomass instead of just depositing it in nature, emphasised Tiilikainen.

And the Environment Minister's vision does not end there, he also sees the



possibility of reducing emissions generated by motor vehicles. The fastest way of reducing the burden on the environment caused by motor vehicles is to convert renewable sources of energy into fuel. At least with respect to gas, this technology already exists. Electrical mobility still has a long way to go in terms of its development before it will be economical viable and suitable for the mass market. Despite the technical advantages, natural-gas powered vehicles are still not so easy to sell, admitted Tiilikainen.

### In contact with interested parties outside Finland

The solutions developed in Finland in order to realise a closed-loop cycle are not meant to be used only in Finland, the country also wants to export them. And Tiilikainen certainly has the interest of Ductor when it comes to this. Particularly because the company is also on the search for foreign customers.

One of the countries being looked at is Germany, and particularly Lower Saxony where there are a large number of poultry farms. The Managing Director of Ductor's German subsidiary Aarre Viiala is already in contact with around 50 interested parties. According to his calculations, the biogas plant would have to produce upwards of 500 kW of electrical power before the system would be economically viable. An initial plant is planned for Emsland: Viala will begin with construction once the planning permission has been granted.

With this system for utilising nitrogen, the Finns are hoping to increase the economic viability of biogas production. Although Viala calculates that the amortisation period for the additional processing phase is around ten years, the operator can use the cheaper poultry manure in the plant instead of the more expensive corn silage.

According to Ductor the technology can also use other waste materials from poultry farming, such as feathers for example. The arable land that would otherwise have to be used to grow the corn and other crops could be used in another way without the production of biogas needing to be curtailed in any way. BD

By: Armin Muller

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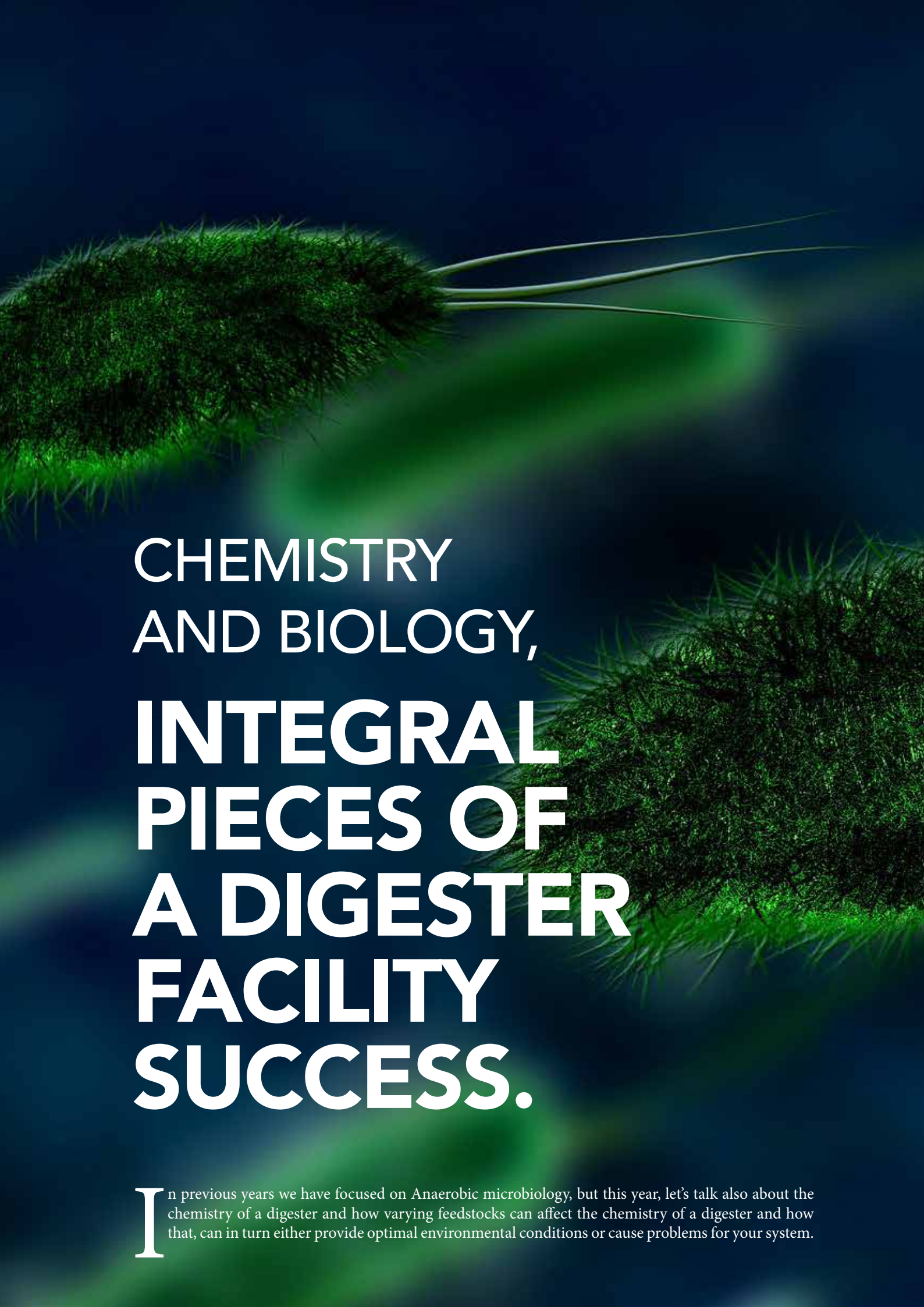

# CHEMISTRY AND BIOLOGY, INTEGRAL PIECES OF A DIGESTER FACILITY SUCCESS.

In previous years we have focused on Anaerobic microbiology, but this year, let's talk also about the chemistry of a digester and how varying feedstocks can affect the chemistry of a digester and how that, can in turn either provide optimal environmental conditions or cause problems for your system.

| | mg/l | mg/l | mg/l |
|---|---|---|---|
| **Mineral** | **Optimal Level** | **Inhibitory level** | **Toxic Level** |
| **$NH^4$** | 200 | 1500 | 3000 |
| **$NH^3$** | n/a | n/a | 50 |
| **Chromium** | n/a | 5 | 1000 |
| **Cadmium** | n/a | 20 | 1000 |
| **Arsenic** | n/a | n/a | 0.5 |
| **Calcium** | 150 | 2500 | 8000 |
| **Magnesium** | 125 | 1000 | 3000 |
| **Potassium** | 300 | 2500 | 12000 |
| **Sodium** | 150 | 3500 | 8000 |
| **Cobalt** | 0.45 | n/a | 70 |
| **Iron** | 3.5 | 5 | n/a |
| **Lead** | n/a | n/a | 600 |
| **Sulfide** | n/a | n/a | 50 |
| **Acetaldehyde** | n/a | n/a | 350 |
| **Nickel** | 2 | 60 | 250 |
| **ZnCl** | 2 | 40 | n/a |
| **$CuCl^2$** | n/a | 10 | 40 |

With all digesters, there is a fine line between operational success and operational failure. A slight change in chemistry or environmental conditions can cause everything to collapse. Even the slightest shift in temperature can be the difference between 100% methane potential generation and 30% methane generation.

Archaea, in particular methanogens, those responsible for creating methane gas from the feedstocks we feed in, have strange appetites, from needing micronutrients like Cobalt, or nickel, to even specific temperature zones like 98 degrees for some methanospherillium and 103 degrees Fahrenheit for some methanosarcina (two species common in dairy manure, one in Jersey cows, and the other in Holstein cows.) The difference here in temperature can make the difference between 100% capacity or just 60% capacity! Running a Jersey dairy cow base digester at 103, reduces the methane production and likewise running a Holstein dairy Cow based digester at 98 will do the same.

Meanwhile missing the point on a specific chemical compound can reduce the output by 60%, and having too much can reduce production by 95% or more!

Below is a chart that we put together of various minerals and nutrients and where most


common optimal performances or required mineral levels are, as well as levels in which we start to see reductions in methane production.

Please remember that all biology is very unique and this chart is for general purposes only. Some methanogens are very nitrogen tolerant, others are very comfortable operating in highly toxic environments.

pH is another very delicate component of the chemistry balance. We always try to aim to be in a range of pH, usually 6.8 to 7.8 is the desired range where most methanogens work best. We can occasionally find methanogens that work well outside these parameters, but those are considered exceptions to the rule and not the standard.

There are many other chemistry factors in which we look at ranges such as Fatty Acids and Alkalinity, which help us learn to manage our biological systems.

Once we have these systems in check and have a stable chemistry we find that the biology will adjust to your needs with more prevalent archaea (methanogens) and bacteria populations that will accomplish the desired tasks of converting organic matter to methane gas.

One thing we often judge a digesters success by, is the ability to convert or destroy volatile solids, the problem with this measuring standard, is that a healthy digester creates volatile solids while destroying other volatile solids, as it breaks down more complex carbon molecules converting them into food sources for our methanogenic populations. As such, do not be surprised if you find yourself never getting the desired volatiles destruction rate in your digester, yet finding yourself producing good levels of gas.

A good system might just act that way. The best standard to date, that we have found in the lab for testing digester efficiencies is by testing organic carbon before and after and using that as a measuring stick. You can also cross examine those results by looking at the concentration of nutrients like Nitrogen, Phosphorous and Potassium. As the carbon component degrades into gas, these minerals cannot break down in the same gaseous form with the biogas, and so will begin concentrating in the digester and you should see your TN% (Total Nitrogen, not TKN), TP%. And TK% should all increase by a set percentage. As your digester becomes more efficient at breaking down carbon, you will see these nutrients increase similarly, this in turn increases your bottom line and your profitability. BD

By: Will Charlton

DIGESTER DOC

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## Biogas capture & conveying

Continental Industrie Biogas blowers are used in 2 Biogas processes:

- Anaerobic digestion plant: The blower receives the Biogas from the anaerobic digester and boosts the gas either to a flare for combustion or to a process plant where it is cleaned/desulphurized and dewatered for further conversion in electricity and heat or for upgrading process.

- Landfill site: The blower extracts the Biogas from the landfill site by creating a vacuum in the Landfill gas extraction wells. The blower produces a positive discharge pressure for the onward transport of the Biogas to further processing units like flaring system, energy generation (CHP) or upgrading process.

The durability of the Centrifugal Blowers, their specific sealing system "biogas type", and their performance characteristics, are all well suited to these applications requiring operation over a wide volumetric flow range.

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Category 3 G according to the Atex 94/9/CE directive, usable in zone 2.

ATEX

## Gas Boosters

Safety requirements for equipment in hazardous areas ask for special blowers. Continental Industrie offers ATEX blowers for EX-zones 1 and 2 for the landfill and biogas.

# TECHNOLOGIES AND EQUIPMENT FOR BIOGAS DRYING/WATER VAPOR REMOVAL

## Introduction

Biogas production has grown exponentially in recent years and the future looks promising. It is regarded as the main replacement for natural gas, both as fuel for vehicles or for injection into the natural gas network.

Biogas, is the gas produced by the anaerobic (oxygen-free) decomposition of organic matter, is amongst the different energy types that have their origin in biomass. It is mainly composed by methane (CH4), which it is who gives, the characteristic of combustible gas.

Therefore, biogas from landfills, biodigester and wastewater treatment plants (WWTPs) is a valuable material to produce energy, biofuels and chemical products, such as hydrogen and methanol.

From a technical point of view, biogas is a multi-component mixture of gases, with a basic composition (CH4, CO2, H2, O2, N2, water vapor, etc.) and several harmful components (NH3, siloxanes, hydrocarbons both halogenated and heavy hydrocarbons, H2S, etc.)

Its composition is closely related with the type

of material to feed, the technology used for its production and the type of digestion process selected.

Biogas is a dirty gas that needs to undergo cleaning for its use as biofuel or as raw material to produce other products. One of its components that must be removed is water vapor due to the different problems that this component can cause in the biogas line and in the equipment involved with this kind of installation.

When biogas comes out of the bioreactor, it is a saturated gas in water vapor given the vapor-liquid equilibrium.

The water vapor content depends on the working temperature and pressure inside of bioreactor. For example, it is estimated that with an output biogas temperature of 35 ºC, the water vapor content is of around 35 g/Nm3

Generally, the absolute humidity of biogas fluctuates between 2.5 to 4 % for mesophilic processes at room temperature. This water vapor is part of the biogas composition and for that reason when water vapor is removed from the biogas stream, it is being upgraded at the same time.

On the other hand, the condensate being produced by this water vapor is an acid condensate due to the presence of H2S and CO2 in the biogas.

## Why is necessary to remove water vapor from biogas.

1. To avoid problems with operation of the CHP system as water vapor decreases the energy performance.
2. To avoid problems of possible clogging in the biogas line or the formation of frozen water.
3. To avoid corrosion on the equipment and machines involved in its transport and moving.

## What are the techniques for removing water vapor from biogas?

Many separation/removal techniques can be applied to reduce moisture content, for example, adsorption on silica gel or dehumidification with glycol. Nonetheless, cooling and condensation are two biogas cleaning techniques which, in combination, offer very useful benefits.

The main aim is to reduce moisture and to remove, insofar as possible, components such as halogenated and heavy hydrocarbons, as well as, siloxanes (mainly type D), depending on the operating temperature of the cooling system.

*Figure 1. . Biogas drying system/water vapor removal facility developed by Energy & Waste S.l group. Vertical position of the heat exchanger. Located in Albufera WWTP-Valencia Spain.*

*Figure 2. Biogas drying system/water vapor removal facility developed by Energy & Waste S.l group. Vertical position of the heat exchanger with heat recover system. Located in Alcala Oeste WWTP-Madrid Spain.*

*Nomenclatures*
*AV Average value*

*Table 1. Biogas composition before and after of water removal system (drying step) and the (%) of increase and decrease of the main components.*

| Components | Biogas without water removal (%) | Biogas with water removal (%) | Decrease/ Increase |
|---|---|---|---|
| CH4 (Av) | 59,86 | 62,1 | 3,74 |
| CO2(AV) | 31,76 | 33,95 | 6,90 |
| Absolute humidity | 3,56 | 0,3 | 91,57 |

## What kinds of biogas drying equipment there are in the market currently?

A biogas drying/water vapor removal facility based on cooling and condensation normally has the following elements:

1. Heat exchanger, generally shell and tube type
2. Condenser with demister or without it.
3. Chiller.
4. Pipe and Fittings.

**Figure 1** shows a biogas drying/water vapor removal facility developed by Energy & Waste S.l group. This equipment has the following parts. Condensate pot, heat exchanger in vertical position, chiller unit and condensate tank with droplet separator (demister). The demister can be located inside of the equipment or on the outside itself.

Some biogas drying facilities are equipped with an energy recovery unit/economizer for minimizing energy consumption required for the operation. This equipment allows reducing the operating costs, given that it requires a less powerful chiller.

The use of economizers depends on many factors, including the flow of biogas to be treated, biogas stream temperature and the purpose of the facility.

**Figure 2** shows a biogas drying facility, with energy recovery unit, developed by Energy & Waste S.l group, for reducing moisture and, to some extent, removing siloxanes and hydrogen sulfide (H2S). The figure shows the different equipment of the technology. The facility has a Condensate pot, heat exchanger in vertical position with condensate tank, this tank has a demister on the inside, a chiller unit and an energy recovery unit.

There are currently two basic types of biogas drying facilities on the market, depending on the position of the heat exchanger unit. Facilities with a horizontal arrangement and facilities with a vertical arrangement.

Since the year 2000, Energy & Waste group has been developing the vertical biogas drying facility as result of its R&D work, which offers the following benefits:

a) It takes up less space for mounting and installation.
b) The condensates removal is enhanced
c) Lower probability of water freezing in pipes when operating at low temperatures or in cooled seasons
d) Better heat transfer rates.
e) More efficient water vapor and dangerous components removal

## What effect produce water vapor removing on the biogas stream?

The **table 1**. Shows biogas composition before and after being passed through the water removal system and how to increase and decrease its main components, that is, water vapor, CH4 and CO2 in Alcala Oeste WWTP when the sludge digester running at 38 ºC degree and the biogas has reached a dewpoint of 2 ºC in the drying facility.

Because of the biogas stream dewatering there is an increase in both CH4 and CO2 due to the removal of water content. This result allows for increase of the calorific value of biogas and at the same time improvement of engine operation.

The results in **table 1** show how necessary is the biogas drying and the benefits it brings to the biogas stream. BD

By: Joaquin Reina

Energy & Waste Engineering, S.L.


# Don't Waste The Waste – Efficient Biogas Upgrading

## Practice Examples For Biomethane Production Worldwide

*Biogas is an eco-friendly energy source that is becoming increasingly important in today's energy supply. It can be used to generate power or heat or as a fuel. To produce fuel an upgrading and puri cation process is required and in the past a stable reliable technology has been a challenge. Today, however, innovative highly selective polymer membranes from Evonik convert raw biogas simply and e ciently into highly pure bio- methane conserving valuable resources.*


**In our modern** society, decisions are increasingly being influenced by ecological considerations. Industry and business are also reacting to the trend towards sustainability and o ering more and more "eco" products. And green energy is following the same track. According to the Renewables Global Status Report (GSR) 2016, renewable energies today account for about 19,2% of global energy consumption; by the year 2050, this gure could rise to more than 50 %, as predicted in a scenario of the World Climate Council in its Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN). With the major energy producers focusing mainly on wind, water and sun, biogas as an alternative energy source appears to have been somewhat over shadowed – quite unjusti ably, because it is a highly effcient energy source and an important component of decentralized supply structures.

Biogas is produced by fermentation of biomass, an organic substance consisting of, for example, plants, liquid manure, or e uent sludge. But in addition to the methane energy source, raw biogas also contains carbon dioxide ($CO^2$) and other trace gases. Because $CO^2$ is not combustible, it lowers the caloric value of the gas and must therefore be separated out.

Evonik Industries has developed a technology for cost and energy-effcient separation of $CO^2$. What appears at rst sight to be a bunch of spaghetti strands or a paint brush is in fact a bundle of highly selective mem- branes made up of multiple cylindrical polymer hollow bres. These are used in the new hollow bre membrane modules of SEPURAN® Green. The membranes are made from an internally developed high performance polymer with very high temperature and pressure resistance. This plastic gives the membrane the property of distinguishing particularly e ectively between methane and $CO^2$, allowing the raw gas to be purified to more than 99% methane.

Since the quality of the methane is equal to pipeline natural gas it can be injected into the gas grid for multiple applications. To generate heat or as raw material in industrial processes would be the main applications. Another purpose and unfortunately still underdeveloped and not popular in our society is using the puri ed methane as fuel replacement. Two variants are known – CNG and LNG. Either you go for the compressed way for short haul distances on roads or one step further in order to ease storage and transport and liquefy the methane as solution

for long haul distances for transports on roads and water. Either way the transport sector can be revolutionized by using biomethane instead of fossil fuels. Besides decarbonizing the atmosphere also NOx pollution coming from Diesel powered vehicles will be avoided and improves air quality and therefore individual health and well-being.

It needs to be understood that biogas is not just anaerobic digestion of energy crops and it is also a lot more than just the source of electrical power and heat generation. Biomethane is THE carbon neutral source, can replace fossil based fuels, can reduce carbon footprints and leads the way to decarbonize our society and ultimately will signi cantly slow down the climate change. And if this is not enough already also the purified $CO^2$ can be used as second product in industrial applica- tions in greenhouses to grow vegetables and plants or as dry ice and even as additive in food and beverages.

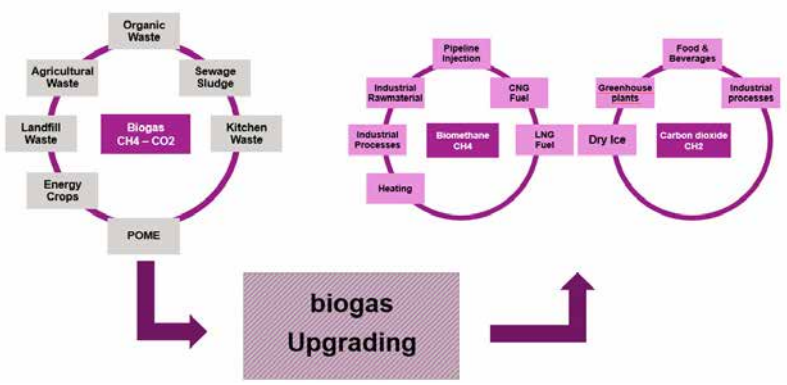


*Figure 1. Biogas to biomethane*

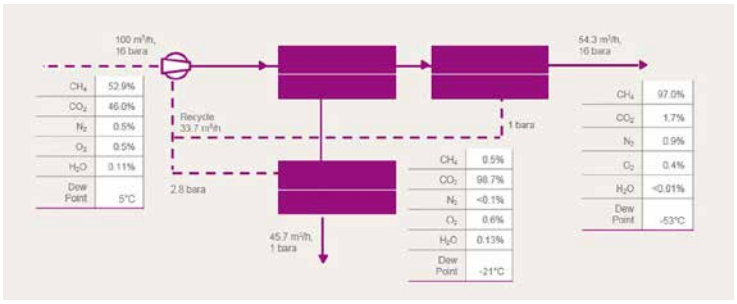


*Figure 2. Evonik patented process 3-stage membrane, one compressor – low recycle stream – high yields and low power consumption*

## Global Potential Of Biogas And Biomethane

The global potential of biogas and biomethane is undeniable immense. Considering the substrates which are available around the globe like agricultural waste originated from dairy or meat production farms. Municipal waste originated and collected in some countries still stored in landfill locations and in more developed countries collected and treated in incineration plants. Kitchen waste with leftovers from households and restaurants. Waste water and sewage sludge treated in respective plants or more regional specific substrates like palm oil mill e uents (POME) coming from the palm oil industry primarily in Malaysia and Indonesia or sugar cane vinasse in sugar and ethanol industry in Brazil.

All those mentioned substrates can be treated in an anaerobic digestions process and raw biogas is the result of microbes at work. The biogas upgrading technology has experienced major improvement over the past five years. In other words the technology got less expensive, the investment is more a ordable and makes a larger number of projects economically feasible. Also the operational costs have been drastically reduced and the yields have been optimised so that an upgrading plant using SEPURAN® Green gas separation membranes can run significantly more efficient than other technologies. Plus Evonik has patented a 3-stage membrane process which is exclusively available to a selected group of OEM partners and only those partners may use the respective design. This setup and design can achieve high yields of methane production and can comply with strict environmental regulations regarding possible methane slip during production and the plant can run with highest e ciency also regarding electrical power consumption. So the e cient and a ordable upgrading technology can bridge the gap from available substrate and anaerobic digestion towards the bene cial product and o take of biomethane.

What else is needed in order to establish sustainability and decarbonization.

Mainly three things:

- governments and authorities need to provide a framework of standards and rules
- benefits regarding taxes or other incentives need to be established in order to emphasize a sustainable business development
- entrepreneurship and individual motivation of companies and individuals seizing business opportunities, exploring new markets and becoming a front runner for decarbonizing the civilisation.

## Challenges And Development

A framework of rules and standards is essential for any development. Unfortunately in many regions of the world production and o take questions around biome- thane have not been established yet. Simple issues like product qualities or safety standards are to be settled and as good as possible harmonized in order for multiple projects to start up.

To replace easy accessible and available fossil based fuels and natural gas means in the first place additional effort or in other words more operational cost, less profit margins and maybe less competitiveness. Authorities have to acknowledge that industries can be one of the main drivers to change our way of doing things. However the climate saving targets established at the UN Climate Change Conference in Paris in 2015. However, so far only a few countries have been the frontrunners to promote the production and use of biomethane. Switzerland, Denmark or the UK provide a respective supportive business environment. The industry has already been and still is in the process of signi cant development in those countries.

In other countries, however, where protection of environment and sustainability and resource conservation has minor meaning and is less common, the development is only at its beginning.

## Projects

A few lighthouse projects nevertheless have been realised also in those countries. EnviTec Biogas AG has recently commissioned one of the rst and largest biogas upgrading projects using SEPURAN® Green membranes. Their integrated turnkey solution branded as EnviThan is now operational in China. In Penglai, Shandong Province chicken manure is converted to biogas and ultimately upgraded to 2000 $Nm^3/h$ biomethane. The biomethane coming from the upgrading plant with 13,5 bar is then compressed to 200 bar and stored in CNG (compressend natural biogas) trailers. Those trailers are regularly transferred to Yantai a nearby Chinese city on the east coast with nearly 7 Mio inhabitants. The CNG is reloaded at local lling stations in order to provide fuel for gas powered vehicles.

Most common in China are Taxis but also private cars run on gas instead of petrol or diesel.

The potential for similar projects is undisputed – biogas coming from agricultural waste to be upgraded to biomethane and used as vehicle fuel with the unstoppable need for mobility in the fast developing Chinese society contains potential for vast GHG savings and business opportunities. BD

Volker Wehber
Evonik Resource Efficiency GmbH

EVONIK INDUSTRIES

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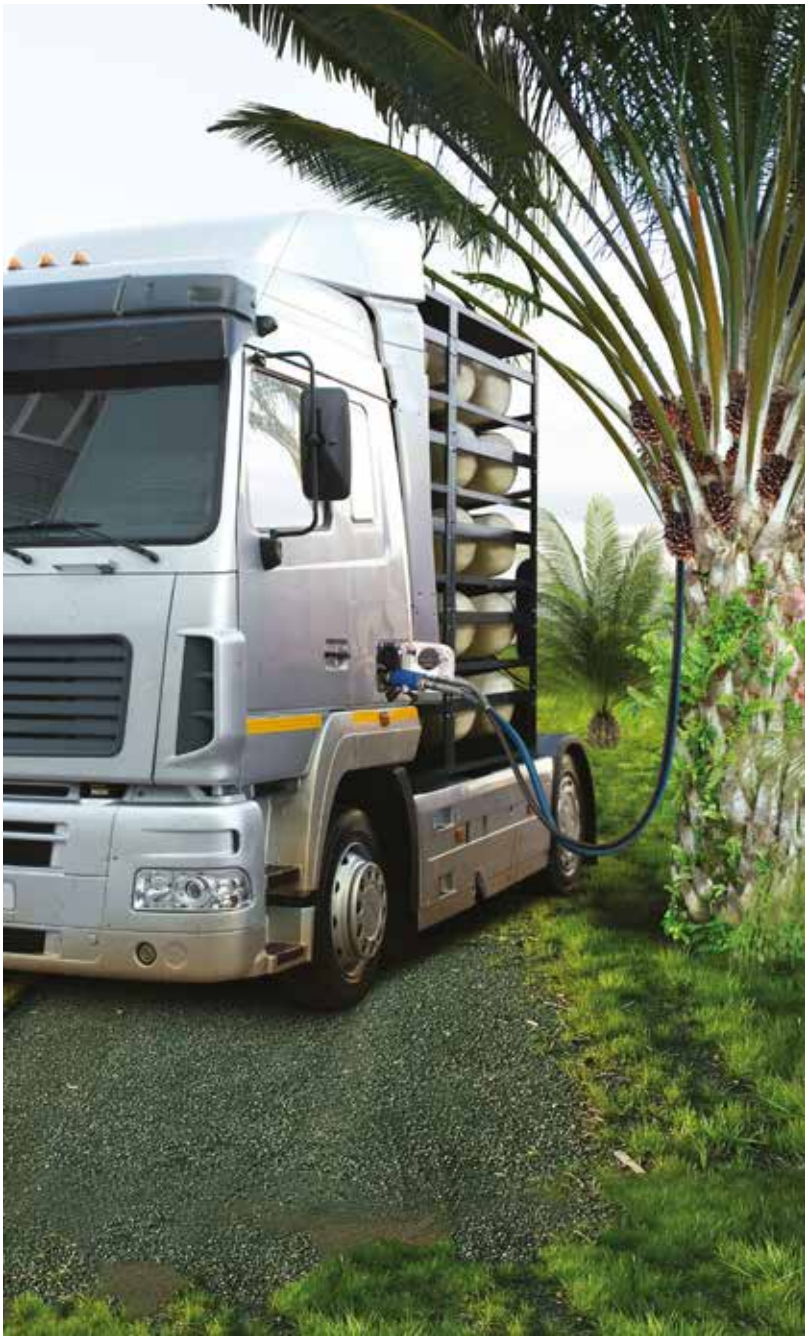

**SEPURAN® Green membranes have the highest $CO_2/CH_4$ selectivity and are therefore a superior technology for biogas upgrading. SEPURAN® Green enables the production of high purity biomethane which can be used to replace fossil fuel such as diesel, natural gas and etc..**

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# 3 BIG POINTS BEFORE JUMPING OFF THE CLIFF INTO POME2BIOGAS

*Key points: Palm Oil Mill Industry in Malaysia and Indonesia, Power Electricity Sale to the Grid, Biogas, Project Development & Investment.*

**Pome2Biogas** (POME stands for Palm Oil Mill Effluent) seems to have brought a fresh air into the Palm Oil Mill Industry, after battling with low Palm Oil Prices since 2014. This time, putting the investor's interests in the spotlight, since the results suggest that this type of energy is not just trendy and catchy but profitable as well. Actually, Pome2Biogas is a great and accessible opportunity to a vast market of small and medium investors (2 – 10 M USD) willing to capitalize juicy projects with high returns in short and mid-term. Nonetheless, there are some grey areas normally overlooked by the rush of the market and the pressure of securing a good project. Hereunder, I present three typical points ignored or taken carelessly during project planning: Business & Scope, Technology Provider, and Location.

These three points may cause a whole lot of unforeseen failures, misunderstandings, delays, and bottom line - lower returns or even no return of the investment.

## Business & Scope

These days there are many Project Developers (PD) and Investors (PD&I) doing their maths and are ready to jump off the cliff into Pome2Biogas (Pome2Electricity) in Malaysia and Indonesia. Although the numbers make sense, and great returns may be expected, most people are forgetting that these projects are in the midst of an environmental liability on the Mill side. I don't want to rain on anyone's parade, but PD&I cannot turn a blind eye on this subject, just justifying the financial opportunity because at the end of the day, it depends upon the entire lifespan of the Biogas Power Plant itself.

Most PD&I think the right way is to receive the POME as a zero-cost feedstock while Mills avoid investing in a mandatory facility and therefore are able to focus on their core business. It seems very logical but not practical though. The Pome2Electricity potential is just a part of the entire POME treatment required before any Mill can run legally in these two nations. Here lies the tricky part, and I wonder looking ahead in the case of legal disputes for discharge compliance which, part is liable and must be held accountable?

Pome2Electricity has its core "factory" in a biological sensitive system which must be fed and operated with care. That being said, in the case the mill has no interest whatsoever in the Biogas Plant or POME treatment for that matter, the mill may discharge any kind of effluent, for instance: excessive oily POME, ashes, chemicals applied during maintenance, etc. Under those circumstances, the Biogas Factory will suffer from instability with the inability to produce biogas and electricity, and naturally no revenues.

In such instances, the PD&I might choose to create a Special Purpose Vehicle (SPV) which includes, on one hand, the PD&I and the Operator party and on the other hand the Mill or feedstock provider. It will require a feedstock supply contract which ensures that the POME fulfils the requirements of the SPV at any given time. The task may seem daunting for a small capital but no one will like to take any chances otherwise.

## Technology Provider (TP)

PD&I that are rushing and in haste, are drawn to search for, quickly and easily, a Technology Provider in a Tender Process which is often times their biggest mistake. Naivety doesn't exclude someone from liability.

Furthermore, I dare to say that Tenders in Pome2Electricity with serious commitments with the grid are the kiss of death. When one wants to develop a project and invest in it, one must do his due diligence with the TP instead of calling a Tender with a serious lack of experience & knowledge, and neither a clear picture of what is desired and/or required. I don't think I've seen the gamut of Tenders in this Industry in Southeast Asia, but

I've seen enough to warn all those newcomers out there.

My biggest piece of advice is to do a comprehensive due diligence, seeking out TP's capabilities, track-records, experienced staff, real showcases, specialties, strengths & weaknesses, and last but not least comparing apples with apples. Thus, PD&I can enjoy a great piece of mind during execution (avoiding undesired surprises) and for the years to come with their investment.

## Location

People tend to believe that last points are of less importance, however, this is not the case in Pome2Biogas. The location will determine, to a greater extent the profitability of the project. It seems obvious, though, it is one of the trickiest parts of the analysis. Let me flesh it out.

Beyond a shadow of a doubt, Indonesia represents the biggest potential in the region with regards to Pome2Electricity; nonetheless, if the PD&I are not acquainted with PLN policies, sooner rather than later, they will find themselves on a slippery slope towards bankruptcy. PLN determines the Feed-In-Tariff (FiT) for the different islands in Indonesia; however, they change their mind quite often putting a huge spoke in PD&I's wheel. If the PD&I are resolved to thrive in Pome2Electricity, it is very likely the following opportunity to seize in their minds will be Malaysia, but…

As compared with Indonesia (more than 20 FiT for Pome2Electricity which may fluctuate easily), Malaysia only has three regions to compare: Peninsular Malaysia, Sabah, and Sarawak. Peninsular Malaysia and Sabah are running under a pretty straight-forward capacity FiT scheme: up to 4 MW, between 4 MW and 10 MW and between 10 MW and 30 MW; whereas Sarawak runs under an independent and, apparently, so far is not feasible. Despite the fact of having a clear scheme, the PD&I still have a long way to go before securing something interesting enough due to the good coverage of the electrical network plus bureaucratic challenges.

I don't intend to prevent people to make investments and to venture into new territories, but for the sake of this beautiful Industry, please do your homework with diligence. Serious players in this Industry want to play the game long term rather than getting some flawed projects which are going nowhere. For the new faces, you are more than welcome, if you guys are serious and want to work hard - many beautiful rewards lie ahead. If the PD&I learn to do it well, the model can be replicated as many times as your capital allows it.

Oh, I almost forgot my last advice, if you're a foreign group, please look desperately for a local and reliable partner. BD

By Juan J. Gil

EnviTec Biogas

*370 m³ gas to grid plant near Oxford, UK*

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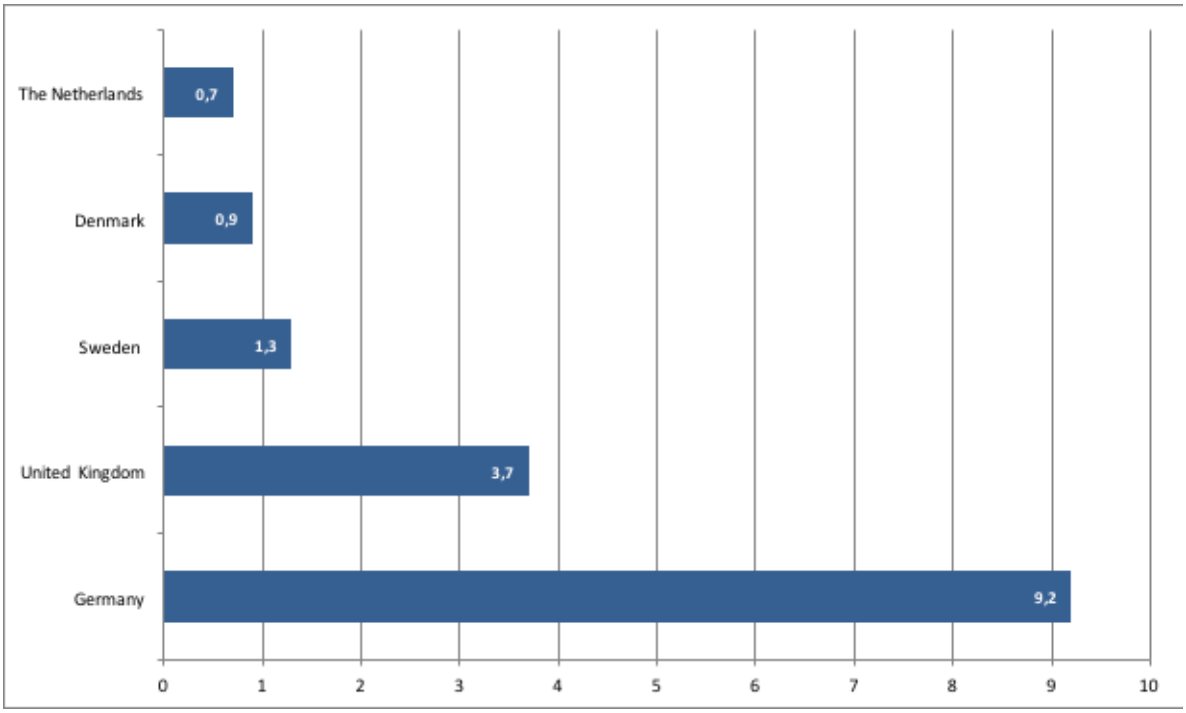
# GERMAN BIOMETHANE BRANCH:

## CURRENT DEVELOPMENTS AND TRENDS

*Figure 1 – Five biggest biomethane producers in Europe in 2016, TWh [2, 3]*




**The biomethane,** as an all-rounder, has gained importance in the German energy mix. Its broad variety of applications makes the biomethane usage interesting in power generation, heat sector and transport. Therefore, the ability of storage and transport of the biomethane in different states is an added advantage. Its direct injection into gas pipelines, compression to the bioCNG or its liquefaction to bioLNG opens up new markets for this renewable energy carrier. Thus, a broad number of stakeholders, among others operators of combined heat and power generation units (CHP), domestic gas and heat users, industrial and retailing companies interesting in greening their products, transportation companies, can profit by its usage. Biomethane enables a significant reduction of emissions especially in the local environment; it encourages the development of renewables and integrates agricultural, energy and transportation sectors into the regional economies. In this regard, the support of biomethane as a sustainable and promising energy solution shall be an important task of politics and business in the next decades.

According to statistics, the number of the biomethane plants in Germany remains growing despite the cuts of the state funding over the last years. The current number of the biomethane plants is 197, which is four units more compared to 2016 [1]. However, the increasing amount of the biomethane injected into the gas grid shows not only the growth of plants number but also a significant improvement of the plants' performance. In the last years, the injected value of the biomethane has been increasing by more than 10%: from 688 million cubic meters in 2014 to 774 million cubic meters in 2015 and 856 million cubic meters in 2016 or 9.2 TWh expressed in the energy units. This biomethane amount covered about 1% of the annual national gas demand [2]. The European data shows the total number of the biomethane plants which was 503 and the amount of produced biomethane equals 17.3 TWh, both in December 2016. According to these numbers, German biomethane market is the biggest one in Europe, see **Figure 1.**

In case of the biogas plants with CHP as a biogas consumer, when the 20 years period of participation in the power market expires, the plant operator has to decide whether to remain on the power market by undertaking investments into the equipment or to decide to upgrade biogas to biomethane. The model of participating in

the balancing energy tenders, where CHP can flexibly run and, by that, compensate the production peaks in the national power grid system, seems to be applicable not for every biogas plant operator.

Apart from the well-established path by converting biomethane to power, another interesting approach is the enforcement of the biomethane usage in the domestic heating, which has been established in Baden-Wuerttemberg, a federal state with one of the Germany's largest population. According to the legislation in force, up to 10% of the heating energy in the households must be provided by biomethane when boilers are in use [4]. The main aim of this is to reduce the GHG-emissions in Baden-Wuerttemberg by 90% in 2050 as compared to 1990. This example shows the commitment of the government to apply biomethane as a strong instrument for the environmental protection.

The transportation sector is gaining a significant focus amongst the biomethane producers. Due to the well-established filling infrastructure and the mature engine technology, the usage of the bioCNG will be practiced by both private individuals and fleets operators of delivery trucks, municipal vehicles, buses and other vehicles with relatively short range. At the moment, there are 857 CNG filling stations in Germany [5], whereby almost 200 of them provide pure biomethane [6]. Due to its bigger energy density, bioLNG could provide more range. This makes bioLNG attractive to long haul vehicles and vessels.

With almost 500,000 km of gas network, there are still many spots remaining, which do not have a proper connection to the gas supply, mostly in the countryside, which makes the biogas plant operators consider to avoid pipeline connecting costs and sell the produced biogas in the non-pipeline way through so called court filling stations. Compression and, with regard to the additional costs, even liquefaction of biomethane turn out to be a good alternative for many biogas plant operators. Having no connection to the gas network, they have to be integrated into the regional transportation sector. Hereby, local operators of fleets such as regional acting delivery services and freight transport, taxi businesses, public bus companies seem to be the best option for the biomethane retail on that kind of filling stations. The fleets of the agricultural companies situated locally could improve the utilization capacity of the station.

The European legislation followed by the other sovereign legislation, facilitates the usage of biofuels of the second generation, which includes also biomethane. In the current version of the Proposal for a directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources the share of the advanced biofuels in the fuel market should be 3.6% by 2030. This obliges the fuel companies to include in their portfolios advanced biofuels to avoid penalties.

On the other end of the biomethane supply chain, end-users try to include advanced fuels and biomethane amongst them to make "green" their own energy demand and, by that, to reduce the CO2-footprint of the products. Furthermore, the social acceptance of the products produced with relatively low CO2 intensity should not be underestimated. Some German manufacturers have been already integrating biomethane in their value chain.

The German Biogas Association is actively working to support the members and stakeholders through providing information on new approaches, policies and education. Diversification of the market for biomethane ensures the future of the biogas branch and each of its players, enables the emission impact reduction in different sectors of the economy and increase the competitiveness of the innovative companies, using the biomethane, and their products.

**Sources:**


*[1] The German Biogas Association, the own data, 2017,*

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# GREEN GRASS TO GAS
## G2 TO G2

What can the impacts be, when biogas energy crops are introduced at a farm? The evaluation process is a complex task due to the major effects of change that crop rotation has on the cultivation system. Thus, it is difficult to generalize, introduction of different crops on different land types will result in different impacts. To meet future sustainability criteria for biofuel systems based on energy crops on farmland, it will be crucial to demonstrate supply systems with minor effects on current food production.

One potentially interesting strategy could be to improve the soil productivity, and thereby food crop yields, through dedicated and integrated food and energy crop rotations. The hypothesis behind this study was that the introduction of ley crops as bioenergy crops on intensively cultivated land could be a case where positive synergies can be achieved due to the positive impact on soil organic matter content and reduced soil compaction. In a case where the market possibilities are small for ley as fodder, the ley would be used for biogas production, generating a bio-fertilizer that could be returned to arable land. The use of arable land for purposes other than for food/feed production can then be balanced against the benefits of reduced GHG emissions and soil improvement.

This makes grass an excellent energy crop due to its long persistence of high yields

accompanied by low energy inputs. Approximately 40% of world agricultural land is under grass. Animal herds have decreased and will continue to do so thereby allowing grass fields to proliferate. Cross compliance does not encourage the conversion of permanent pastureland to arable land; thus, the world has, and will continue to have increased quantities of excess grassland.

Therefore, grass must be considered a significant source of biomass. Current grass species and cultivation practices are favorable for anaerobic digestion (AD), which is a mature technology. Upgrading biogas to BioCNG, injecting into the gas grids, or supplying directly to the industrial clients or replacing the vehicular fuel leads to an effective bioenergy system complete with distribution to all rural as well as urban areas.

## Grass in BioCNG and Animal Systems:

Agronomists and progressive farmers require the cultivation of high productive grass species for high productive pastures, which allow them to receive the full range of benefits from its various uses. This is true for the use of grass and grass silage along with animal feed as a feedstock to produce BioCNG. The attention on different perennial grasses, as energy crops, mainly in the USA and Europe, was accelerated when it was realised that they offer good energy balance along with several environmental advantages.

Species, varieties and seed mixtures should clearly be chosen to suit the purposes for which the sward is to be used and as well as the environment that it will be used in. The physiology of grasses considering, for example, their photosynthetic (PS) pathway, i.e. C-3 (cool or temperate) versus C-4 (warm or tropical) grasses, imposes environmental specificity and, hence, differences in their productivity and BioCNG yield.

The main characteristic of cool compared with warm grasses is that affect their productivity are that the former fix carbon dioxide (CO2) in a cooler environment, i.e. they respond to nitrogen fertilizer early in the spring, whereas in warm seasons their growth rates are reduced. In contrast, warm species require less nitrogen to achieve the same light-saturated assimilation rate, leading to higher photosynthetic nitrogen use efficiency. This means that they are more efficient at gathering carbon dioxide in warm environments and are more tolerant at water stress conditions. However, productivity of animals (i.e. meat, milk, wool) consuming mostly forage is directly related to the quality of the forage and the amount consumed.

## Grass to BioCNG:

Life-cycle assessment is one of the most appropriate methodologies for the evaluation of the environmental burdens associated with biofuel production as it allows the identification of opportunities for environmental improvement and is widely used for evaluation of sustainability of biofuel production. The analysis takes into consideration the energy and emissions (both direct and indirect) associated with all stages of production of silage and BioCNG. This facilitates comparison of systems if the boundary conditions are the same. The functional unit is defined as cubic metres (m3) of BioCNG per year and the environmental impacts are expressed as grams carbon dioxide equivalent (CO2e) per megajoule energy replaced. This is important; the analysis is a field-to-wheel system rather than a field-to-tank system. The vehicle operating on gaseous transport fuel is assumed to have efficiency (MJ/km) 16% - 20%

less than a diesel vehicle. This thus reduces the efficiency of the whole process. Emissions associated with the manufacture of machinery are not included as per the EU Renewable Energy Directive. The global warming potential (GWP) for carbon dioxide, nitrogen dioxide and methane is 1 kg CO2, 296 kg CO2 and 23 kg CO2, respectively.

### Types of Grass:

Grass quality is vital for good operation of the digester. It is therefore important to realize that there is a substantial difference between the qualities of grass coming from urban areas, rural areas as well as roadsides, and grass coming from nature management or natural fields. Grass from nature management or natural fields are mowed for biodiversity purposes once or twice a year – based on their availability as well as necessity whereas grass from the management of roadsides and urban/rural areas is cut only when needed. Second, nature conservation areas are often ideal for recovering biomass compatible with biogas systems because the grasslands are larger and there is no contamination reducing the need for additional cleaning. However, taking into account the danger of contamination with inert material, fields with a lot of molehills, wooden vegetation and rocks should be mown very carefully. Grass from urban/rural areas and roadside grasses are also suitable for biogas systems, but litter should be removed prior to mowing. It might furthermore be advisable to exclude roadside grass with a high risk of pollution. These elements should all be taken into consideration when choosing the mowing location as this will reduce the costs further down the value chain. From a biogas project perspective, grass from landscape management/ fields where the food crops are not grown are the most interesting because the grasslands are larger and there is no physical contamination such as litter or non biodegradable wastes. It is also likely that these areas are easier to mow with less sand contamination, resulting in lower logistic cost which is a very important factor from feasibility point of view.

### Primary treatment and cleaning:

Because of the associated cost, cleaning of grass as a primary treatment for the biogas plant should be avoided. Most of the contaminations can be avoided if the best operational practices are followed. Even though it can be tempting for a digester to accept lower quality biomass, due to the favorable tipping fee (if offered) or more biogas generation, caution is required and a good quality control and/or additional pre-treatment is a must. Again there are different types of pre treatments for different kinds of available grasses based on the solid as well as lignocelluloses content. Indeed, cleaning of the material is essential to avoid problems like clogging or physical damage to pipelines and machinery. A cleaning step can be done either to remove larger inert material or smaller inert material like sand/silt. The approach is slightly different but the bottom line is that both fractions should be removed to avoid mechanical problems. The removal of bulky material (e.g. plastic bags, cans, bottles) can be obtained through a drum sieve while sand is often removed by washing or sedimentation or sand separators. Primary hydrolysis tanks like any other kind of storage tank prior to the main digestion tank can help in the removal of sand. After a while the sand will settle under gravitational influence after which it can be removed from the bottom of the tank easily. In biogas plants, primary treatment is applied specifically to increase biogas production. Most techniques aim at increasing the contact surface and reducing

fiber lengths, so that the biomass can be digested faster. In addition, the primary treatment can also lead to a reduction of the grass length, decreasing the chances of technical problems in the digester. In most existing biogas plants adapted machinery and additional primary treatments steps will be necessary in order to successfully digest grass. Especially for wet type digesters with a continuous operation an infrastructural reorganization is needed in order to be able to receive large quantities of grass.

If the grass particles are too long to be fed to the digester, a silage feeder can cut the grass and automatically screw the grass into the biogas digester. This is only possible for small amounts of grass. Because of the fibrous nature, regular feed pumps sometimes have difficulties pumping liquid slurry with grass. By using a vacuum pump technology this can be avoided, because there are no moving parts inside the pump. Another advantage is that one pump can take care of all pumping actions, pumping different feed stocks from different locations into the digester and pumping liquid slurry from the digester. Primary treatment technologies aim at changing the characteristics of the biomass and/or at increasing the accessibility to the degradable biomass for microbial enzymes. They are subdivided in a number of categories.

A biological pre-treatment uses natural processes to preserve the biomass and/or to ameliorate the chemical composition. In this case enzymes, microorganisms or small organic acids are added. Enzymes (like cellulase and amylase) can be added to break down cellulose, hemicellulose and starch respectively. In addition, the growth of bacteria and fungi can be inhibited directly by adding organic acids to the silo. An addition of nutrients, like molasses or soluble carbohydrates, can induce increased acidity thanks to the conversion of sugars to organic acids.

In a chemical pre-treatment inorganic products like mineral acids or alkali are added. They are used mainly to break down the lignin-components so that more biodegradable biomass becomes available to the microorganisms in the biogas plants. Ensiling is a storage technique that can be considered as a combination of both a chemical and biological pre-treatment.

Additives can be used, usually when the physical parameters of the biomass are not suited for ensiling. Additives are used to increase the efficiency of the ensiling process, but also to prepare the biomass for AD and eventually stimulate fermentation, help the degradation of fibers, inhibit bacteria, etc. In fact, microorganisms such as Lactobacillus spp. are usually added to stimulate lactic acid production leading to:

- The prevention of dry matter losses, and
- Better degradation of fibers.
- The faster increase of the acidity,
- The inhibition of dangerous bacteria,

When the grass is ensiled it is protected from water and oxygen intrusion, more complex molecules are broken down into components that are easier to degrade for the biogas digester microbiology and hydrolysis is facilitated, which in turn accelerates digestion and increases methane production. In short: ensiling is used to make optimal use of the biogas potential of the grass in case it cannot be digested fresh. Despite having a high potential for digestion, grass remains a low value product. Hence, adding enzymes or chemical products can be too expensive. A physical pre-treatment aims at reduction of the particle size. Size reduction takes place when biomass is shredded, heated, washed or exposed to ultrasonic waves. The before mentioned physical stimuli can be combined in a so called "primary treatment train". For removing soil in the grass a washing step can be introduced. This was tested in many plants across the world and is a quite proven and much simpler step. The technical results were promising, but the economics again need to be considered more deeply.

By mixing input biomass and recirculated slurry in a primary hydrolysis tank, biomass is homogenized before it is fed to the digester. Typical for a primary hydrolysis tank is a short retention time and low pH, as this helps break down the lignocelluloses structure of the grass.

Extrusion is a particular combination of mechanical and thermal treatment. It reduces the particle size and dissolves the chemical bonds between cellulose and lignin, resulting in a better biodegradability of the grass. Moreover, since extrusion reduces the grass particle size, it will achieve better mixing in the reactor and avoid potential clogging problems and scum layers in the digester. However, this technology is expensive and it is not clear if these advantages compensate the costs. Energy consumption is estimated at 18 - 22 kWh/ ton of raw material. In general, smaller particles (except for impurities like sand) reduce

problems with pumping, clogging and mixing. Mainly in wet AD, these technical problems can be brought to a minimum if the grass size is reduced sufficiently (particle sizes of 2 cm or less).

## Storage

Grass is preferably digested fresh. However, as the mowing works in landscape management tend to be done in a limited time window, it can be advantageous for a digester to ensile the grass cuttings. Ensiling is a technique to store grass for longer periods of time from few days to months, while preserving the grass biogas potential. This is done by airtight storage of the grass under a cover made from inert material. To make good silage the dry matter content of the grass should be between 23 and 37 %. The grass length should be <2 cm; in a wet biogas systems smaller particle sizes are preferred. The particle size of the grass should be reduced prior to storage/ ensilaging to increase compaction of the grass and avoid oxygen entering the silage.

After the biomass is compacted, it must be covered. It is advised that a bunker silo be used. This is a horizontal silo or trench silo with concrete floor and walls. Storing the grass cuttings in the open or just using a regular cover should be avoided to ensure more gas production at the later stage. In most cases the silo will be located at the biogas project site. This allows the biogas plant operator to control the grass quality before it is ensilaged. Other possibilities include silo bags or plastic bales; this last technique is more costly and labour intensive than the others, but might be useful when handling small amounts of biomass. The same applies for the silo bag, however this technique was developed more recently and some adjustments may have to be made for handling grass.

Well-built silos do not leach and carbon losses are limited.

As stated earlier, it is best to process grass in the digester as soon (as fresh) as possible since contact with oxygen initiates undesirable microbial activity resulting in loss of biogas potential. Therefore, if large quantities of grass are delivered, the process of ensiling should start immediately or within 48 hours after mowing. This should be taken into account when grass from several smaller fields need to be brought together. Ensiled biomass should be digested at a steady pace after opening. For a bunker silo at least one meter of the silo should be fed each day. Opened silage can lose up to 25 % of its biogas potential in 5 days.

## Digester Type:

The impact of the particle size and the necessity of a pre-treatment step are influenced by the type

of digester. When working with a "wet digester" it is important to reduce the size of grass and avoid inert material in the input, as this could lead to technical failures. These types of digesters work with a dry matter content of about 10 -12% (or lower) resulting in the fact that grass should be co-digested with a more liquid type of biomass to achieve the desired dry matter content. On the other hand, in "dry digesters", or garage-box like static digesters, grass can be used without primary treatment: e.g. the possible contamination is not an issue, although smaller particle sizes yield a better biogas production in dry digesters as well. In dry or garage type digesters, grass at 30-35% dry matter content can also be used without primary treatment. Nevertheless it is advised to always perform a co-digestion with a more easily degradable biomass (e.g. energy crops) in the case of dry digestion. This is to assure that the Anaerobic process evolves in a smooth way with an optimization of biogas production.

## Biogas Potential:

Under optimal conditions, grass originating from areas with 2 to 4 (or more) cuts per year, are characterized by a high biogas potential: typical yields are in the range of 450 to 600 m3/ ton dry matter with methane content around 53 -57%. On the other hand, grass mowed only once per year shows high lignin content and a relatively low biogas potential, around 200-350 m3/ton dry matter. When considering the expected dry matter content of the grass, these values correspond to a biogas yield in the range 80 – 150 m3 of biogas per ton of fresh material, a value which equals half of the typical 200 m3 biogas obtained from 1 ton of maize silage. For an easy comparison one can state that 2-3 tons of poor grass silage will produce the same amount of biogas as one ton of maize silage. In literature, there are various and multiple reviews that compare biogas production potential from grass residues originating from different land use types, different periods of harvest (and 'cuts') and different methods for preservation. Based on literature investigation and my own research, the energy potential is situated in the broad range of 200-600 Nm3 biogas per dry matter and approximately 100-300 Nm3 methane per ton dry matter. Taking into account an average dry weight of 25-35% and the energy content of methane being 8-10 kWh/Nm3 this can be further converted to a potential of 250-1,000 kWh gross energy yield (total burning value) per ton of fresh weight biomass.

## Conclusions:

Selection of the proper digester design for grass to biogas production is an important management decision that merits further investigation. For the wet continuous two-stage system, all designs have potential for biogas of grass silage. Nevertheless, comparisons for treating similar quantities of grass silage under similar loading rates and characteristics to evaluate optimal digestion configuration are required. These systems can be further optimized for better and continuous biogas production, based on changing their filling regimes and co-digestion patterns. There is a need to compare the potential of various pretreatment options (including pressure, thermal, enzymatic and chemical pretreatments) for increased efficiency. Upgrading of biogas comprises the removal of carbon dioxide, hydrogen

sulphide and other possible pollutants from biogas. Out of all the available processes, the PSA system may be the simplest processes to operate because of the use of special chemicals or equipment is not necessary. Also, the latest developed PSA systems with methane enrichment units provide maximum purity (up to 99% CH4) with very minimal cost. The technology is evolving and better results are achieved compared to the old designs and the data. The produced BioCNG can either be used directly on-site as a transport fuel or, after industrial fuel replacement, or can also be injected in the grids may be used off-site where better energy efficiencies and financial returns may be achieved.

The digestion of grass can be an economic sound alternative for other feed stocks such as maize, manure or other feed stocks. High quality grass can have a high biogas potential and for many regions in Europe, money will be given if you digest grass residues. When good quality grass is digested, the profitability of your plant can increase. However, when bad quality grass ends up in the digester problems can arise. Grass contaminated with sand, stones, plastics or grass which is rotten, should not enter digesters. Good agreements with the supplier of the grass are of utmost importance. During ensiling it was shown that additives did not increase the BGP a lot. When ensiling, the BGP decreases with 10-20 % compared to fresh grass when done properly. When done badly up to 50 % of the BGP can be lost. Even though they can be more expensive, dry digesters have advantages compared to wet digesters: since floating layers cannot occur, shredding is of lower importance, solid waste materials cannot settle to the bottom and inert material cannot cause problems to the mixing system. A wet digester can digest grass without technical problems as long as <20 % of the input is grass.

**Recommendations:**

Employ a tariff scheme for upgraded biogas: At present, there is a tariff structure for electricity from biomass. It is suggested that the utilization of biogas is better employed when upgraded to biogas and used as either a source of heat or as a vehicular fuel. There is no tariff scheme for these end uses. The German biogas system allows a bonus for grid injection of upgraded biogas and use at a different site. Support for vehicular fuel is of particular importance as BioCNG is allowed a double credit for renewable energy in transport targets.

Develop, promote and regulate the BioCNG market: The sale of BioCNG as a vehicular fuel in many countries has been found to be profitable, offering higher returns than heat or electricity. The development of BioCNG as a vehicular fuel in other countries has generally been based on an existing CNG market, and the development of CNG is often based on the introduction of CNG to captive fleets (e.g. buses, waste collection Lorries, taxis) followed by private cars. The CNG market requires support through regulation and incentives from government. For example, a target of CNG vehicles could be introduced to mirror the target of 10% of all vehicles to be electric powered by 2020. Other examples include grant-aiding CNG service stations and mandating of public transport fleets to incorporate a certain percentage of CNG vehicles by specified dates. BD

**Srinivas Kasulla**
*Waste to Energy Expert*

SINCE 1984

BELGIUM | COLOMBIA | INDONESIA | MALAYSIA

# Integrated management
## of organic matter

**BIOGAS | COMPOSTING | FERTI-IRRIGATION**

Biotec manages organic matter and in particular the by-product of tropical agro-industries. Our objective is to protect the environment while generating renewable energy (biogas) and ensuring sustainable agricultural practices.
We implement projects and operate plants to achieve the hightest level of satisfaction of our customers.

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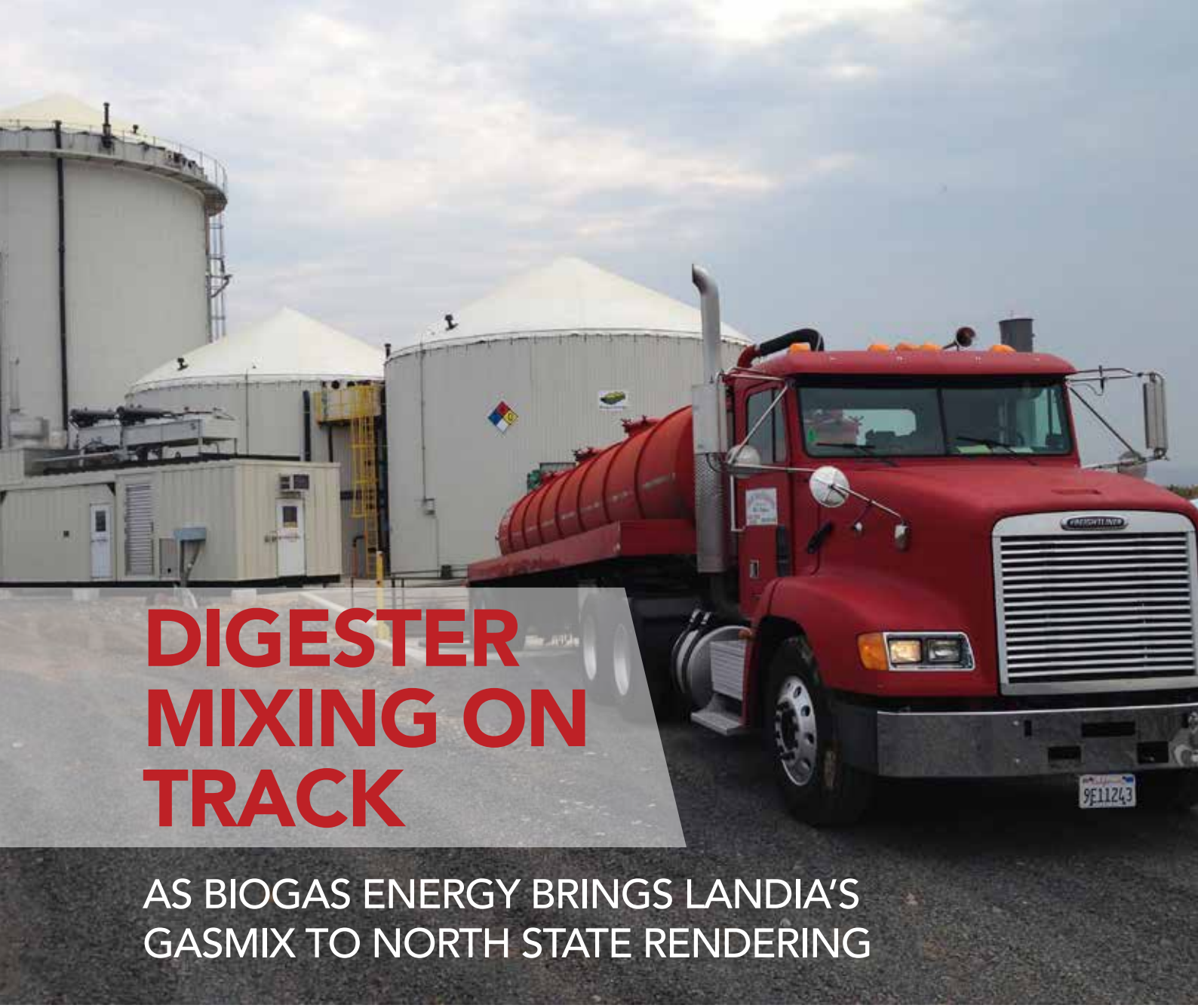

# DIGESTER MIXING ON TRACK

## AS BIOGAS ENERGY BRINGS LANDIA'S GASMIX TO NORTH STATE RENDERING

**The rendering** business is not known for its glamour or its cutting edge technology, but in North America's first project of its kind, that's all about to change for an industry that is positioned for growth.

Biogas Energy have built an anaerobic digestion (AD) facility at North State Rendering in Oroville, California that is already paying dividends, with uninterrupted biogas generating electricity, fuelling trucks and running boilers. The economics seriously stack up – not to mention the massive reduction in carbon footprint.

"For a rendering plant, biogas is a natural fit", says Brian Gannon of Biogas Energy. "North State Rendering were looking for ways to cut costs, secure new waste supply contracts, and improve wastewater treatment, so creating their own on-site biogas facility was a wise move. Fuel and energy are a significant operational cost for the business, so investing in technology that eliminates electricity bills, slashes diesel costs and reduces natural gas imports all makes sense. Modifying the anaerobic digestion process to integrate with a rendering plant took some fine tuning, including a very positive modification to the digester's mixing system, but now, we see how we got it right".

### Waste Reception and Pre-processing

Grease trap waste and food waste from kitchens, restaurants, and food manufacturers is expensive to render, so by diverting this material to the digester, North State Rendering reduces costs and frees up rendering capacity for higher-value materials.

The waste reception equipment prepares high-solids feedstocks for the digester, whilst a grease trap reception system separates out contaminants such as plastic and metals.

With this flexible reception facility configuration, the digester can process a wide variety of materials, from food and yard waste to high-liquid grease trap material. Wastewater from the rendering process is also added to the mix. North State Rendering can also add dead stock to the digester during warmer months when rendering can become problematic due to extreme degradation of the material.

**Anaerobic Digester Tanks**

From the reception area, the material is pumped into twotanks (40' diameter by 24' high), where the first acid-forming phase of the biogas production process takes place.

These heated tanks contain bacteria that break down the material and prepare it for the main digester tank, which stands 64' tall. When the material is ready, it is pumped into the main digester where biogas-producing bacteria get to work.

Brian Gannon continued: "We had been using submersible propeller mixers inside our main digester, but with our re-design of the tank, we switched to a new system that meets all of our needs. One of the main issues with submersible digester mixing systems is that the equipment is inside the tank, which from a maintenance point of view is a nightmare. The downtime caused by having to open the digester to lift the mixers out for repairs and maintenance caused serious process interruptions and safety issues.

"We now have a Landia digester mixing system, which is mounted externally, so maintenance is much easier. Even during commissioning when the AD biology was at a delicate stage, we were able to carry out some tweaks without any interruption whatsoever to the biogas production process. With submersible mixers we would have had to start over again, which would have been very expensive and used up a ton of manpower".

In addition to its ease of maintenance, Brian also points to the Landia (patent-pending) GasMix System being able to agitate the entire digester tank (especially one 64-feet high!), whereas other units often cannot prevent a crust from forming on the top level of the tank's contents.

"The anaerobic digestion facility is designed to process a very wide range of feedstock", he said, "so its pumps and mixers have to cope. The Landia chopper pumps, which form part of the GasMix system, are absolute troopers. They just keep on working. We wouldn't be achieving what we are now without them".

Comprising two 30-HP chopper pumps and a self-aspirating system that reduces solids to produce more methane in a much shorter time period, Landia's GasMix (designed specifically for AD/biogas) is easy to regulate and also offers significant energy savings because it only has to run for a maximum of 30 per cent of the installed capacity.

Brian also explained that the anaerobic digester is not only producing biogas, but processing wastewater to improve water quality. The bacteria creating biogas digest is the material that causes elevated COD in wastewater. Hence, the digester also acts as a small wastewater treatment plant, improving the quality of wastewater and enabling reductions in discharge fees.

"We generate enough electricity to power the entire North State Rendering plant," added Brian. "Heat from the generator is also used to heat the digesters, so we're able to optimize energy efficiency".

**Energy and Fuel Production**

Biogas Energy estimates that North State Rendering

will reduce diesel costs by 75% by introducing a gas-cleaning skid to create a pipeline-quality biomethane that is then compressed in a CNG fueling station.

As the biogas-to-CNG upgrade system produces pipeline-quality natural gas, producers can inject the gas into the pipeline to sell to other customers. Finally, any surplus biogas is fed to a boiler at the rendering plant to reduce the need to purchase natural gas. With a diverse use for the biogas, North State Rendering will maximize revenue and hedge against price increases in electricity, diesel, and natural gas.

### Sources of Facility Funding

For its new anaerobic digester, North State Rendering was able to take advantage of grants from the California Energy Commission's Alternative and Renewable Fuel Vehicle Technology Program.

State and federal inducements can also include tax incentives, sales tax exemption, grants for renewable energy project and truck conversion costs, and incentivized electricity production pricing.

Brian Gannon concluded: "Renderers have a big head-start over other companies trying to develop new waste-to-energy facilities. Unlike newcomers, renderers already have the necessary permits in place to process waste material. They also have the trucks to collect waste, and the energy consumption that biogas facilities can help fuel.

"As energy and fuel prices climb and wastewater discharge fees escalate, waste processors can turn waste into an asset. For Biogas Energy, our experience at North State Rendering and the introduction of Landia's GasMix digester mixing system means that we can help our clients generate renewable energy with a system that maximizes production while facilitating operations and maintenance". BD

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# BIOENERGY INTERNATIONAL

## WHENEVER AND WHEREVER BIOENERGY IS DISCUSSED

Bioenergy International is an English language subscription-based trade publication focused on the biomass-to-energy value chain; solid, liquid or gas. From a holistic viewpoint it includes biomass production and collection systems, biomass refining and processing technologies, biomass storage and transportation systems and biomass utilisation technologies.

Bioenergy International has seven (7) regular issues a year and one "Pellets Special" issue which includes the "World of Pellets" poster. Each issue is packed with hands-on coverage from the field, forest, laboratory, project, plant, event or process. Editorial priority is given to "doers" from around the world providing an insight into the what, where, when, who, why and how.


We invite you to join us in shaping the unwritten chapters ahead.

Founded in 2001 and in print ever since, Bioenergy International is based in Stockholm, Sweden and is owned by SBSAB, a wholly-owned subsidiary of the Swedish Bioenergy Association, Svebio.

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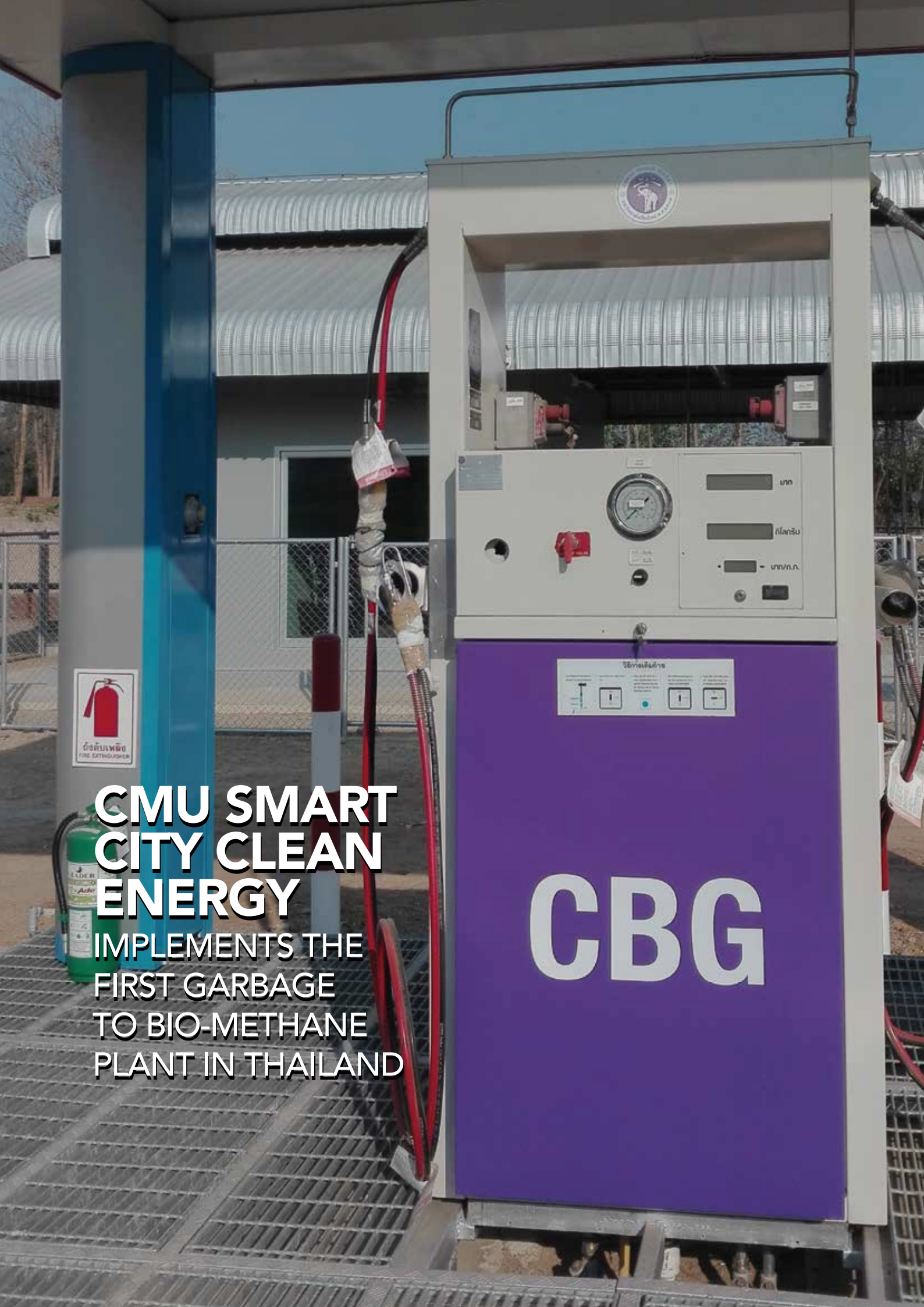


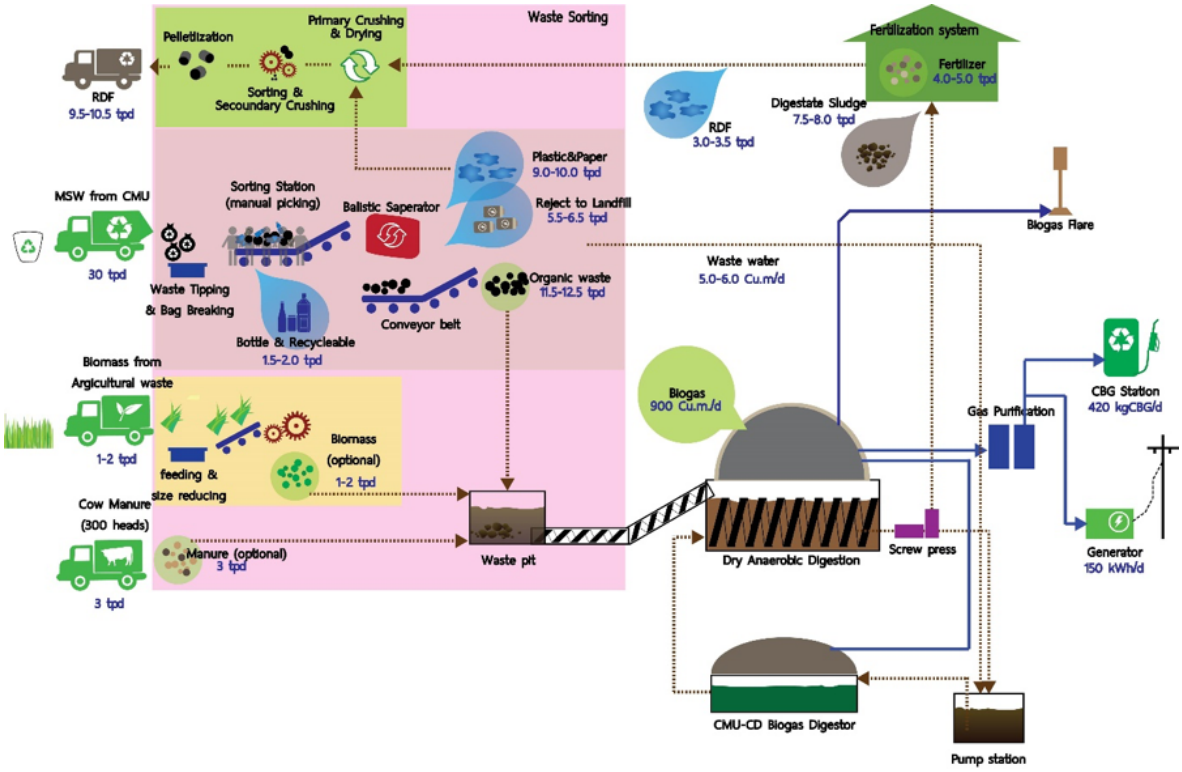

# CMU SMART CITY CLEAN ENERGY

## IMPLEMENTS THE FIRST GARBAGE TO BIO-METHANE PLANT IN THAILAND


**Chiang Mai University** is one of the most advanced research universities in Thailand and is highly recognized in the field of renewable energy and environmental studies. Operating for CMU, the Energy Research and Development Institute Nakornping (ERDI) has helped set up the CMU smart city initiative program which has won the top 7 best smart city designs which was awarded by the Thailand Ministry of Energy in 2017. While the smart city theme is extensively practiced in a broad spectrum and scale all over the world, the CMU smart city program has focused its attention on smart energy and environment.

The CMU Smart City Clean Energy initiative sets up targets in several aspects including energy, environment and education. One essential milestone is to educate CMU graduates on sustainability cognizance and the further shifting social paradigm to ensure a sustainable future. Many measures have been performed to educate, demonstrate and familiarize students and employees with a sustainable living routine.

In South East Asia, even though recycling has been broadly practiced, proper garbage sorting at the household level is still not the best and thus collected household waste normally ends up in incinerators or landfills. Many valuable materials can still be recovered from collected waste making a sorting facility required. In 2017, as a part of the "CMU Smart City Clean Energy" initiative, Chiang Mai University implemented a CMU Garbage / Biomass management facility located in Mae Hea district in Chiang Mai. The facility consists of 3 major components: small scale garbage sorting, anaerobic organic dry + wet fermentation and a vehicle grade bio-methane upgrading system as illustrated in Figure 1. The main mission of this facility is to experiment and demonstrate a suitable solution to manage and utilize municipal waste in Thailand and South East Asia. The plant design and integration was




completed by ERDI-CMU and a construction contract was awarded to Chiang Mai Rimdoi Public Company limited (CRD) in March 2017. Construction and installation was completed and commissioned in January 2018.

The sorting equipment is supplied through a project partner, Sanwa New Energy, China. The system has two main components; a semi-manual picking station and an automatic ballistic separator. The analysis results show that unsorted MSW input contains 40% organic waste; 40% combustibles (paper, garment, rubber etc.) and 20% (glass, metals, sand, mortar etc.) by mass. The throughput of sorting equipment can achieve approximately 35% organic (55% humidity); 20% recycled (including bottle, glass and metal); 20% RDF (combustible) and 20% rejected inert (to landfills). An approximate mass balance of 30 tons per day MSW input is demonstrated in Figure 2.The sorting efficiency is expected to increase since source separation schemes will also be strictly implemented in CMU city from mid-2018.

The separated organic part is then fed through an organic shredder to ensure size reduction before feeding into a main dry anaerobic digester with a total solid content of above 15%. An additional CMU plug-flow type concrete lagoon wet digester is also installed to treat liquid effluent of additional waste water from a nearby facility. The wet digester also serves as inoculum storage for a dry

fermenter and the active sludge is routinely fed to stabilize the dry fermentation process. The design value of biogas yield from dry fermentation is expected in the range of 80 – 100 m3 BG/kg of sorted organic waste as per the CMU in-house research result.

Biogas produced from the facility is expected to be in the range of 800 – 1,200 m3 per day from 20-30 tons MSW input operating at 10 hours per day. The available biogas is pre-treated in a biological scrubber and evaporative dryer before separately fed to a 50 kW biogas genset and a 500 kg/day bio-methane upgrading system. The upgrading system is a CMU in-house design membrane separation system. The bio-methane (87-90% CH4 content) quality conforms to the Thailand natural gas for vehicle (NGV) standards governed by the ministry of energy. The compressed bio-methane (CBG) is utilized to fuel 4 public buses for inter-campus transport and


2 garbage collection pickup trucks.

As a part of CMU smart city initiative, the genset can be controlled by the campus power management center to function as backups and demand peak cut support. This implementation is projected to achieve more than 5,000 tons CO2 equivalent emission reduction per annum. Nonetheless, this CMU implementation is always open for site visits with training courses available to help convey the essential aspects in MSW management throughout the region for continued development of a sustainable future. BD

By: Dr Pruk Aggarangsi
ERDI

# BIOGAS –

## HOW THIS COMMON BUT UNDEREXPLORED COOKING FUEL IS CHANGING LIVES IN AFRICA

**The potential** of biogas in Africa is huge. You'll surely learn a lot of interesting stuff about this amazing fuel of the future.

Recent studies estimate that over 80 percent of African households (especially in rural areas) still depend on firewood and charcoal for cooking their daily meals.

For those who can afford it, kerosene (also known as paraffin) and cooking gas are the next best options. However, due to rapid deforestation in many parts of Africa, firewood and charcoal are becoming increasingly scarce.

The rising prices of kerosene and cooking gas make them less affordable every day. If this trend continues in the future, many people on our continent may be unable to afford fuels to cook their food.

In this article, you will learn about biogas; what it is and how it's produced. You will also understand why it has such a huge potential in Africa and how entrepreneurs like you can take advantage of it.

### Biogas. What exactly is it?

Biogas refers to a mixture of gases produced by the decay or fermentation of organic waste (like sewage, kitchen waste, animal manure, food scraps and

plant material).

When all of this organic waste is allowed to decay in the absence of oxygen, methane, carbon dioxide and some other gases are produced. Methane is the most important of all the produced gases because it is a very valuable fuel. Methane is a popular natural gas that is used for heating, lighting and cooking purposes in the home.

We produce (and waste) large volumes of biogas everyday without even knowing it.

Every time you flush the toilet after use or wash kitchen dirt down the sink, you are wasting the valuable raw materials needed to produce biogas. All that waste probably ends up in an underground sewage pit where (sometimes) biogas is produced and wasted to the atmosphere.

This gas could have been channeled back into the kitchen and used to cook food and boil water. This gas could have saved you hundreds of dollars spent every year on charcoal, firewood, kerosene and cooking gas.

As you will find out later in this article, a household of six people (father, mother and four children) can produce enough biogas to last for up to 3 hours of cooking everyday!

Biogas is a clean, effective and cheaper alternative to all the expensive and environment-unfriendly fuels we use today.

Africa is still quite new to the concept of biogas. The Asians (especially in India, Bangladesh, Pakistan and Vietnam) have been using biogas for more than 50 years now. Over 2 million households in India use biogas as fuel for cooking and heating. In Bangladesh and Pakistan, the number is in the hundreds of thousands.

By producing fuel from their own waste, many poor families in Asia have cut down the amount of money they spend on cooking fuel (which can amount to thousands of dollars in a single year.

However, all hope is not lost for Africa yet. Like a few other revolutionary solutions (such as solar power), biogas is making considerable progress in some parts of Africa. Kenya, Ethiopia, Uganda and South Africa are some of the countries on the continent with a growing rate of biogas use.

With the concerted efforts of governments, NGOs and International Development Organisations, more countries on our continent will embrace biogas.

## How is biogas produced?

Today, there are several different techniques for producing biogas and several models and designs of biogas machines and plants now exist. Nevertheless, the concept remains simple and the same.

The heart of any biogas system or production arrangement is known as a biodigester (or simply a 'digester').

A digester is a sealed and airtight tank or container (usually made of concrete or plastic) that behaves like the stomach of a human being. It collects waste (raw materials) and 'digests' it with the help of billions of bacteria.

Like I mentioned above, for biogas to be produced, this digestion must happen in the absence of oxygen (scientifically known as 'anaerobic digestion'). The valuable byproduct of this digestion process is methane, the cooking gas that we so desperately need.

The methane gas that is produced usually rises and builds up at the top of the digester. A gas pipe is attached to the top of the digester to carry the produced gas back into the house (usually the kitchen) where it is used as fuel for cooking and heating.

The images below provide a visual representation of biogas production and how it works.

Other parts of a biogas system include a feeder pipe, through which the waste materials (from the toilet, kitchen and other sources) enter the digester. There is also an overflow pipe or tank that ensures that the pressure inside the digester remains within safe limits.

Human beings have a similar overflow mechanism. Remember what happens when the gas pressure inside your stomach reaches a high level? What happens? You fart or you belch! Whether or not it smells is a totally different matter. *Laughing*

The final other interesting part of a biogas plant is an outlet or collection pipe for the solid and liquid residue that is left behind after the digestion process.

This residue (also known as 'slurry') is commonly referred to as a 'biofertilizer' because it is very rich in nitrogen and phosphorus which makes it a good manure/fertilizer for your garden or small farm.

Biogas production has a long-life span. A small-scale biogas production plant in your backyard can last for up to 20 years and will require little maintenance during its life time.

How much does it cost to build one? It depends.

A biogas plant that is made of plastic is likely to cost less than one made of stone, sand, iron rods and cement. Labour

costs may be the other significant cost to consider after the cost of materials.

When the biogas plant is built and in place, it requires no running expenses. It's the only machine or plant on earth you will ever own without spending a dime on fuel. That's because your guts will provide the fuel!

### Why is there a huge potential for biogas in Africa?

The economic and health benefits of biogas to African consumers is huge. Sometimes, I'm surprised that biogas hasn't taken a foothold on our continent given its very immense potential.

As is our tradition on Smallstarter, it is important that we take a look at some of the reasons why biogas has such a lucrative prospect on our continent.

### #1 – There is a growing demand for sustainable, cheaper and cleaner fuels in Africa

People in developing regions like Africa spend a huge chunk of their money and time on cooking fuel. The high demand for firewood and charcoal has led to the rapid decline of Africa's forest resources.

Wood and kerosene also produce a lot of unhealthy smoke when they burn in kitchen stoves and lanterns. This is leading to a rise in the incidence of deaths and sicknesses resulting from inhaling harmful substances.

The short video below gives an interesting account of how biogas is transforming the daily lives of ordinary people in Ethiopia. Just fifty years ago, more than half of Ethiopia was covered by forests. Today, just about 3 percent of its forests remain due to intensive logging for firewood.

In a country where nearly 90 percent of its people cook with firewood, it may only be a matter of time before all the forests disappear. Fortunately, biogas is coming to the rescue. Rather than spend the little money they have on firewood, ordinary Ethiopians now use dung produced by their cattle to produce cooking fuel.

With the looming threats of climate change and global warming, there is a growing demand for sustainable fuels which cause little harm to our health and environment. In addition to these threats is the rising cost of wood, kerosene and other traditional fuels.

Biogas provides a more sustainable, cleaner and cheaper option for most Africans. By using 'worthless' resources like rotten food, kitchen waste and human/animal waste, ordinary people can produce the valuable fuel they need to cook food and produce lighting.

### #2 Africa has a suitable environment for biogas

Available evidence shows that the microbial activity and chemical reactions required to produce biogas performs best above certain temperatures (usually above 15 degrees Centigrade).

As a result, people in temperate and cold regions of the world may need to provide additional heating during winter (and other cold periods) to produce biogas. This possibility makes it difficult to justify biogas production in these areas.

Like in India and other parts of Asia where biogas has worked so well, Africa's average temperatures are within a range that is most suitable for microbial activities that produce biogas. Our continent's tropical climate makes biogas production

economically interesting and viable.

In addition to the climate, there is a readily available supply of organic matter (human and animal waste) which provides fuel for biogas systems.

### The 'Little Green Monster': An African biogas success story

A group of forward-thinking entrepreneurs in South Africa have developed an interesting domestic biogas production plant for households and small scale users.

The product, branded as the "Little Green Monster" is designed to 'eat organic waste and breathe fire.'

Wally Weber, one of the engineers who developed this brilliant product says its aim is to "help South African communities to reduce their energy bills, reduce their carbon footprints and limit wastegoing into landfill sites "in a responsible and positive manner."

As you will discover in the video below, the system can produce up to 500 litres of biogas in a day (for an average household of six people). This is equal to a total energy content of 7 kWh (units) per day which is enough to heat up a water heater to produce enough hot water for two people to have a 10-minute shower or cook food for up to 3-4 hours in a day.

The product was launched in April 2013 and is manufactured by Pioneer Plastics Energy, a South African company. It is designed to fit into the existing sewage system of a house and requires little intervention.

The Little Green Monster retails at over $1,000 in South Africa. This is a product that shows a lot of promise and I strongly believe similar designs and innovations will come up across Africa in the not too distant future.

To find out more about the Little Green Monster product and how it works, visit the company website at: http://www.pioneerplasticsenergy.co.za/pioneer-biogas-digesters

### How can you make money from biogas in Africa?

The upside business potential for biogas in Africa is huge. Like solar energy which has turned Tanzania's Patrick Ngowi into a millionaire, biogas has the potential to make lots of money in Africa if you can get it right. It's something totally new and different.

So, how can interested African entrepreneurs make money from biogas? Let's take a quick look at three interesting options that come to my mind.

#### #1 Installation of biogas systems

One of the main reasons why biogas hasn't caught on in Africa (compared to Asia) is that there is very little and limited technical capacity. Although some of the common biogas systems have simple designs, it still requires knowledge and skill to successfully install a biogas system that works.

You will need to have a working knowledge of the basic biology and chemistry involved in biogas production. Some construction knowledge is also involved because installing these systems usually involves plumbing, piping and other structural work.

Let's imagine for a moment that you now have the skill and knowledge required to install biogas systems. Every household in your community will surely want one after they learn that it is cheaper and cleaner than all the other expensive (and dirty) fuels.

You can start your own small biogas construction and installation company that installs these systems for a fee.

#### #2 Training & Consultancy

Like I mentioned in the last point, the technical skills and knowledge required for producing biogas are lacking in many parts of Africa. You can use your skills and knowledge to empower other people to build and install biogas systems for themselves and for others.

You could partner with a government agency, an NGO or a company looking to sponsor training programs for youths as part of its community development initiatives and programs.

#### #3 Sales of biogas appliances and equipment

At the moment, there aren't a lot of biogas appliances and equipment in the market. As the adoption of biogas grows, the demand for these products will grow too. Meters, gauges, pipes, biogas stoves and even full biogas digester units like the Little Green Monster will be in demand.

### Who are the best customers for biogas?

Now that you recognize the business potentials of biogas, who would be interested in installing biogas systems?

The customers you should look out for presently generate a lot of organic waste and spend a lot of money on cooking fuels.

Schools (boarding schools

and university hostels), prisons, hospitals, and populated residential buildings are strong potential customers. Households that keep livestock (such as pigs and cattle) are also very good targets.

These sets of customers will find enormous value in installing biogas systems.

Another interesting group of potential customers are Governments (local and national), NGOs, and International Donors/ Development Organisations. These organisations are usually interested in projects that promote green technology, sustainability, social and economic development, especially in Africa.

If you find a community that will benefit tremendously from biogas, you could approach any of these organisations with a well-developed proposal to sponsor your project/initiatives.

The Africa Biogas Partnership Programme (ABPP) is one of the most active supporters of biogas on the continent. It is a partnership between two NGOs (Hivos and SNV). ABPP supports national programmes on domestic biogas in five African countries.

The programme aims at constructing over 100,000 biogas plants in Ethiopia, Kenya, Tanzania, Uganda, and Burkina Faso. It plans to provide access to a sustainable source of energy for over half a million people by the year 2017. You can visit the ABPP website at: http://africabiogas.org/

## Learning Resources

Information, knowledge and skill will be critical to your success if you plan to exploit the lucrative potentials of biogas.

I have identified a couple of useful (and free) information you can start with. Use the things you learn to dig deeper and do some more research. You never might guess what interesting opportunities and perspectives you may stumble on.

Here they are:

- Introduction to Biogas Plant Construction. This interesting manual was written as part of a training program for biogas technicians in Kenya. The program was jointly sponsored by the European Union and the Kenyan government. It provides a detailed understanding of biogas, and the design, construction, operation and maintenance aspects of biogas plants. It is written in simple and clear language. You would enjoy it.
- Biogas Training Material for the Improved VacVina Model. VACVINA is one of many biogas technologies that exist in the world today. It was introduced in 1998 by The Center for Community Research and Development (CCRD) in Vietnam. This training material contains information about the design for this model.

We should be excited about the potentials of biogas in Africa

Biogas is an interesting energy source that will play a very critical role in our continent's future. It is also a timely business opportunity for African entrepreneurs.

I hope that the information in this article will be useful as you consider opportunities for biogas around you. I believe that the opportunity and information we have shared with you in this article can be taken further by your creativity and energy. BD

**John-Paul Iwuoha**
*Author, Impact Entrepreneur, Business Strategist, Founder of* **Smallstarter Africa**

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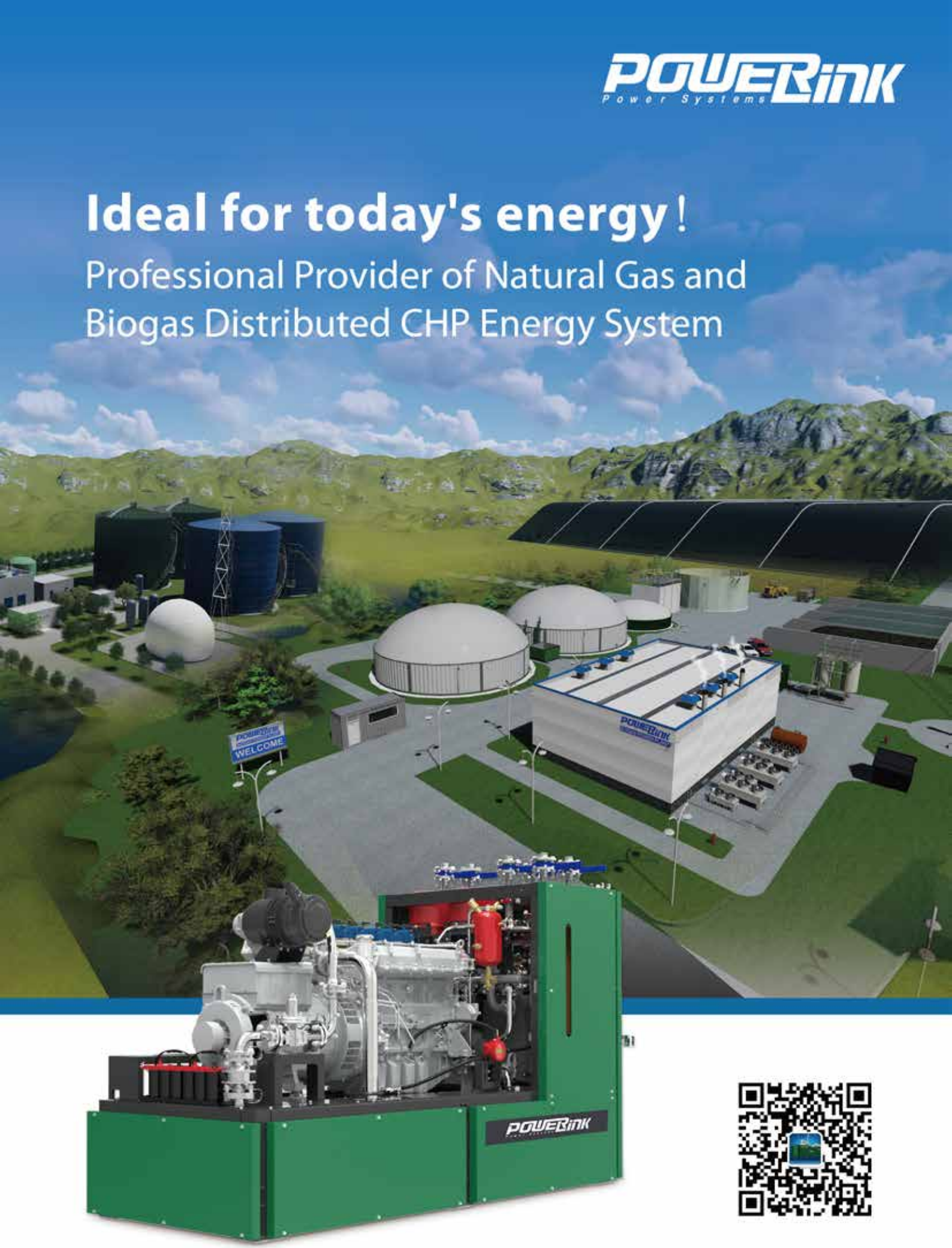


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# BIOGAS DIRECTORY

# ALPHABETICAL LIST

# ALPHABETICAL LIST

# ANAEROBIC DIGESTION

COMPANY LIST

## AEV Energy Gmbh

T : +49 172 / 801 40 54
E : info@aev-energy.de
W : www.aev-energy.de

Products/Services: Biogas, Waste to Energy, Power Generation, Electricity Production
Countries covered: Europe, Asia, Iran
Category: Anaerobic Digestion

## Alternative Energy Corporation

T : +65 9029 3990
E : mark@altencos.com
W : www.altencos.com

Products/Services: Environmental: Waste to sustainable
energy products
Countries covered: Southeast Asia
Category: Anaerobic Digestion

## Asia Biogas

T : +66 2651 9900
E : info@asiabiogas.com
W : www.asiabiogas.com

Products/Services: Asia Biogas designs, constructs, finances and operates clean energy projects
Countries covered: Southeast Asia
Category: Anaerobic Digestion | Power Generation | Consultant

## Bilgeri Environtec Gmbh

T : +43 5578 77005 0
E : info@environtec.at
W : www.biogas-plant.com

Products/Services: Gas Purification, Storage, & Combustion, Gas Flares, Gas Holders, Feenter Equipment
Countries coveed: Worldwide
Category: Anaerobic Digestion

## Binder Instrumentation Pte Ltd

T : +65 6562 7638
E : binder.engrg@pacific.net.sg
W : http://www.binder-engineering.com

Products/Services: COMBIMASS - Biogas analysis & gas flow systemst
Countries covered: Europe, Middle East, Southeast Asia, Mexico, Venezuela
Category: Anerobic Digestion

## Biodome Asia

T : +603 5880 6704
E : enquiries@biodome-asia.com
W : www.biodome-asia.com

Products/Services: Coated, Bolted Steel Tanks for Anaerobic Digestion & Biodom Double Membrane Gas Storage
Countries covered: Southeast Asia, Asia-Pacific
Category: Anaerobic Digestion

## Dimasa Groupo

T : +34 93 835 9104
E :info@dimasagroupo.com
W : www.dimasagroup.com

**Products/Services:**
Treatment (Cleaning & Condition), Upgrading of Biogas

**About:**
The international holding Dimasa Group, based on Barcelona (Spain), a subsidiary in Puebla (Mexico) and a large commercial network in South America, has more than 30 years of experience in designing and manufacturing tanks and equipment in Fiberglass Reinforced Polyester (GRP). The constancy of the preservation of the environment of the founders and new additions, have made specialist in the treatment of Water, Waste and Biogas. The business line of biogas have 3 different technologies: Biogas Cleaning and Conditioning, Biogas Pumping and Burning Plant, and Biogas Enrichment (upgrading); and 1 objective: energetic valorization of the biogas of the residues.

**Countries covered:** Worldwide

**Category:** Anerobic Digestion | Biomethane Upgrading

## Biogasmart

T : +39 0372 080585
E : info@biogasmart.com
W : www.biogasmart.com

Products/Services: Storage, Blowers, Compressors, Gas Treatment, Pumps & Mixers, Air Treatment
Countries covered: Italy, France, Germany, Denmark, South Korea, Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading

## Biogas Equity 2 Inc

T : +65 9283 9555
E : mikemuller@biogas2.com
W : www.biogas2.com

Products/Services: Waste conversion based on newest patented German Technology, AD, gasification
Countries covered: North America
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## Biotec International Asia

T : +603 5880 4100
E : asia@biotec-net
W : www.bio-tec.net

Products/Services: Design, build and operate biogas plants especially in Palm Oil Mills
Countries covered: Malaysia, Indonesia
Category: Anerobic Digestion

## Biowatt Development Ltd

T : +44 845 838 0735
E : solutions.hub@biowatt.co.uk
W : www.biowatt.uk.com

Products/Services:Project development, engineering and funding
Countries covered: UK
Category: Anaerobic Digestion | Consultants

## Cabot Norit Singapore Pte. Ltd.

T : +65 6631 9392
E : angela.tok@cabotcorp.com
W : www.cabotcorp.com

Products/Services: World's largest producer of activated carbon and related service
Countries covered: Singapore, Malaysia, Thailand, Philippines, Indonesia, Myanmar, Vietnam, Cambodia, Australia, New Zealand, Papua New Guinea
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## CEICO Consulting Pte Ltd

T : +91 9844 1723 53
E : gerard@ceico.com
W : www.ceico.in

Products/Services: Consulting, engineering and implementation of biogas on a turkey basis
Countries covered: India, Nepal, Sri Lanka
Category: Anaerobic Digestion | Biomethane Upgrading

## Beijing Yingherui Environmental Technology Co.,Ltd

T : +86 010 884 674 81
E : yhrwmm@126.com
W : www.yhri.cn

**Products/Services:**
Design, Supply and installation of Anaerobic Digestor

**About:**
Beijing Yingherui Environmental Technology Co., Ltd(YHR) established in 2005, dedicated in researching and developing of Anaerobic Digestion technologies and equipment manufacturing.
YHR is a Top-level provider of the comprehensive solution for organic waste treatment in China.
We developed our patent technologies for biogas industry, including semi-aerobic hydrolysis for fibrous substrate, ABDP technology for low TS substrate etc. which have been widely applied in China AD plants. YHR is the earliest bolted Glass-fused-to-steel tank manufacturing factory in China. Up to now, we have delivered over 6,000 GFS tanks worldwide in biogas & wastewater treatment.

**Countries covered:** Worldwide

**Category:** Anaerobic Digestion | Consultant

## CIMC Enric

T : +86 552 307 3687
E : edllchaustin@163.com
W : www.enricgroup.com

Products/Services:Anaerobic digestion, methane gas desulphurisation, decarburation, EPC Project management, modularization, stadardization and intelleginization in methane gas engineering
Countries covered: North America, Europe, South America, Central Asia, Southeast Asia, Russia, Australia, China, Thailand, India
Category: Anaerobic Digestion | Biomethane Upgrading | Gas Distribution | Consultants

## Digester Doc

T : 208-731-3234
E : will@digesterdoc.com
W : www.digesterdoc.com

Products/Services: Laboratory services, consulting and optimization testing services
Countries covered: Worldwide
Category: Anaerobic Digestion

## Enpro Envirotech Pty Ltd

T : +61 415351012
E : will@digesterdoc.com
W : www.digesterdoc.com

Products/Services: Feasibility, design, drawging, consultancy, training, troubleshooting, resource recovery
Countries covered: Australia, Pacific Island, China, India, Indonesia
Category: Anaerobic Digestion | Biomethane Upgrading | Consultants

## Enviroequip Sales & Rentals

T : +603 7987 8386
E : jayantk@enproenvirotech.com
W : www.enproenvirotech.com

Products/Services: Gas analysers for biogas, landfill gas
Countries covered: Southeast Asia, India, Pakistan, Middle East
Category: Anaerobic Digestion | Miscellaneous

## Geotech

T : +44 1926 338 111
E : sales@geotech.co.uk
W : www.geotechuk.com

Products/Services: Fixed and portable gas analyzers, suppliers for biogas applications world wide
Countries covered: Worldwide
Category: Anaerobic Digestion

## Hangzhou Energy & Envionmental Engineering Co. Ltd.

T : +86571 8604 1861-8704
E : heee-gm@163.com
W : www.heee-biogas.com

Products/Services:Process design, equipment supply
Countries covered:
China, Bangladesh, Thailand, Kazakhstan
Categories: Anaerobic Digestion

## Hycura

T : 1 888 406 9670
E : info@hycura.com
W : www.hycura.com

Products/Services:
Microbe granulation technology for increased production of bio-gases
Countries covered: USA, Canada
Category: Anaerobic Digestion

## KIS (Knowledge Integration Services) Group

T : +603 2615 7237
E : contact@kisgroup.net
W : www.kisgroup.net

Products/Services: ZPHBTM POME Treatment Technology
Countries covered: India, Idonesia, Singapore, Colombia
Category: Anaerobic Digestion

## Konzen Clean Energy

T : +603 2161 8987
E : info@konzencleanenergy.com
W : www.konzencleanenergy.com

Products/Services: Water and wastewater treatment plant, anaerobic system, biogas plant
Countries covered: Malaysia, China
Category: Anaerobic Digestion

## Mailhem Engineers

T : +91 20 2565 0047
E : info@mailhem.com
W : www.mailhem.com

Products/Services: Solid & liquid organic waste treatment projects on turnkey basis
Countries covered: India, Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## Maverick Biomethane Projects Pvt Ltd

T : +91 265 234 3010
E : info@maverickbiomethane.com
W : www.maverickbiomethane.com

Products/Services:
Green waste to energy, BG2CNG, anaerobic digestion
Countries covered: UAE, Tanzania, Kenya, Congo, India, Mauritius
Category: Anaerobic Digestion | Biomethane Upgrading | Gas Distribution

## MT Energie Gmbh

T : +49 4281 9845 0
E : info@mt-energie.com
W : www.mt-energie.com

Products/Services: Biogas plant, bogas upgrading plant, biogas plant components, technical and biological support
Countries covered: UK, US, Germany, Europe
Category: Anaerobic Digestion | Biomethane Upgrading

## Oiltek Nova Bioenergy Sdn Bhd

T : +603 55428 288
E : lester@oiltek.com.my
W : www.oiltek.com.my

Products/Services: "Our technology is proven successfully in POME application since 28 years ago. "
Countries covered: Worldwide
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Gas Distribution

## Pure Energy LLC

T : 435 659 3541
E : info@peg-ibr.com
W : www.pureenergygroupllc.com

Products/Services:
PEG offers advanced scalable AD technology for waste to energy conversion
Countries covered: USA, Europe, Asia
Category: Anaerobic Digestion

## Spectrum Renewable Energy Private Limited

T : +91 40 23281918
E : drrao@srel.in
W : www.srel.in

Products/Services:
Anaerobic Digestion
Countries covered: ASIA & USA
Category: Anaerobic Digestion

## SP Multitech Renewable Energy

T : +603 5882 5595
E : info@spmultitech.com
W : www.spmultitech.com

Products/Services:
Biogas technology and equipment, design and construction of biogas plants
Countries covered: Malaysia
Category: Anaerobic Digestion

## Q2 Engineering

T : +603 7665 3788
E : Q2@Q2 .com.my
W : www.q2.com.my

Products/Services: Design, build, investment, technology provider for bogas and landfill gas
Countries covered: Malaysia, Indonesia, West Africa, Ivory Coast
Category: Anaerobic Digestion

## Tech Infinity Engineering

T : +603 7726 3231
E : info@techinfinity.my
W : www.techinfinity.my

Products/Services: Complete biogas value chain provider
Countries covered: Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Gas Distribution

## Teck Guan

T : +6016 826 9852
E : douglas@teckguan.com
W : www.teckguan.com

Products/Services: A 10 year experience jumpstart for maximum production from POME
Countries covered: Malaysia
Category: Anaerobic Digestion

## True Eco

T : +6011-2627 8823,
E : elainewong@true-eco.com
W : www.true-eco.com

Products/Services: On-going training, maintenance, service support, continuous system monitoring, process research and analysis
Countries covered: Worldwide
Category: Anaerobic Digestion, Power Generation, Consultants

## TT Renewable Sdn Bhd

T : 012-6226615 / 03-27110888
E : ssales@tenagatiub.com.my
W : N.A

Products/Services: System Integrator & Technology Provider For Biogas To Power Plant
Countries covered: Malaysia
Category: Anaerobic Digestion, Biomethane Upgrading, Power Generation, Consultants

## Vivam Solid Waste Management Pvt. Ltd.

T : 9423781306
E : contact@vivamgroup.co.in / Nirmala@vivamgroup.co.in
W : www.vivamgroup.co.in

Products/Services: Waste management consultancy, Turnkey supply erection and commissioning of Biogas and compost plant of capacity 1 kg to 1000 tons per day
Countries covered: India
Category: Anaerobic Digestion |Biomethane Upgrading | Power Generation | Consultants

## Veolia Water Solutions

T : +65 6549 1556
E : michel.otten@veoliawater.com
W : www.veoliawaterst-sea.com

Products/Services: Biothane product line including promethane and a leading solution for POME
Countries covered: Worldwide
Category: Anaerobic Digestion

## WCM Power Sdn Bhd

T : 03 6148 3726
E : enquiry@wcmgroup.my
W : www.vwcmgroup.my

Products/Services: EPCC/BOOT/AD & Biogas Consulting
Countries covered: Malaysia, Indonesia, West Africa, Latin America
Category: Anaerobic Digestion, Power Generation, Consultants

## Xeon Waste Managers

T : +91 9004 689601
E : srinivas@xeonwm.com
W : www.xeonwm.com

Products/Services: Energy Bin, enzymes and cultures for anaerobic digestion and biogas plants
Countries covered: India, Sri Lanka, Pakistan, Europe, Bangladesh, USA, UK
Category: Anaerobic Digestion |Biomethane Upgrading | Consultants | Miscellaneous

## Xergi

T : +45 2076 3381
E : olet@xergi.com
W : www.xergi.com

Products/Services: Waste Management, Design and build large scale biogas plant
Countries covered: Japan, Korea, China, ailand, Vietnam, Malaysia, Singapore, Philippines, Indonesia, Europe, Africa, North America, and others. North America
Category: Anaerobic Digestion

# BIOMETHANE UPGRADING

COMPANY LIST

## Air Liquide Advanced Business & Technologies Asia

T : +86 21 8035 5000
E : atc.contact@airliquide.com
W : www.energies.airliquide.com

Products/Services: Technologies & Equipment for Biogas Upgrading, Bio NG handling & Liquefying
Countries covered: Asian Pacific Countries
Category: Biomethane Upgrading

## Bauer Gmbh

T : +43/ 3142/ 200-0
E : bauer@bauer-at.com
W : www.bauer-at.com

Products/Services: Press screw separators, eccentric screw pumps, submersible pumps, submersibe mixers, biodos automatic feed system, slurry tankers
Countries covered: North America, Russia, Australia, Slovakia, Ukraine, Hungary, Brazil, Poland, Romania, Asia
Category: Biomethane Upgrading | Gas Distribution

## Biogasmart

T : +39 0372 080585
E : info@biogasmart.com
W : www.biogasmart.com

Products/Services: Storage, Blowers, Compressors, Gas Treatment, Pumps & Mixers, Air Treatment
Countries covered: Italy, France, Germany, Denmark, South Korea, Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading

## Biogas Equity 2 Inc

T : +65 9283 9555
E : mikemuller@biogas2.com
W : www.biogas2.com

Products/Services: Waste conversion based on newest patented German Technology, AD, gasification
Countries covered: North America
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## Bireme Group Pte Ltd

T : +65 6748 7988
E : adrian.bek@biremegroup.com
W : www.biremegroup.com

Products/Services: Natural gas/Biogas dryer/ purification, On-site N2/O2 generators, Compressed Air Turn-key solutions.
Countries covered: Australia, Singapore, Indonesia, Malaysia, Philippines, Thailand, Pakistan, Kazakhstan, and Uzbekistan
Category: Biomethane Upgrading

## Cabot Norit Singapore Pte. Ltd.

T : +65 6631 9392
E : angela.tok@cabotcorp.com
W : www.cabotcorp.com

Products/Services: World's largest producer of activated carbon and related service
Countries covered: Singapore, Malaysia, Thailand, Philippines, Indonesia, Myanmar, Vietnam, Cambodia, Australia, New Zealand, Papua New Guinea
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

# AIRRANE

T : +82 43 715 6580
E : inquiry@airrane.com
W : www.airrane.com

**Products/Services:**
Gas Separation Membrane

**About:**
Membrane separation process, of of the separation process for bio-methane, uses membrane to selectively flow specific substances through and separate gas, which uses polymer membrane is commonly used for removal carbon dioxide in biogas. Airrane Co., Ltd. is developing membrane module and process using hollow fiber which can purify bio-methane to high purity.

**Countries covered:** Worldwide

**Category:** Biomethane Upgrading

## Carbotech

T : +49 (201) 50709-300
E : mail@carbotech.info
W : www.carbotech.info/en.html

Products/Services: Innovative and comprehensive solutions in the field of gas separation
Countries covered: Germany, Sweden
Category: Biomethane Upgrading | Power Generation

## CEICO Consulting Pte Ltd

T : +91 9844 1723 53
E : gerard@ceico.com
W : www.ceico.in

Products/Services: Consulting, engineering and implementation of biogas on a turkey basis
Countries covered: India, Nepal, Sri Lanka
Category: Anaerobic Digestion | Biomethane Upgrading

## CIMC Enric

T : +86 552 307 3687
E : edllchaustin@163.com
W : www.enricgroup.com

Products/Services: Anaerobic digestion, methane gas desulphurisation, decarburation, EPC Project management, modularization, stadardization and intelleginization in methane gas engineering
Countries covered: North America, Europe, South America, Central Asia, Southeast Asia, Russia, Australia, China, Thailand, India
Category: Anaerobic Digestion | Biomethane Upgrading | Gas Distribution | Consultants

## Climate Energy

T : +603 5115 0118
E : ching@climateenergy.net
W : N.A

Products/Services: Solutions provider in gas handling and utilization of downstream biogas plant including power generation, hear recovery and gas purficiation (bio-methane)
Countries covered: Malaysia
Category: Biomethane Upgrading | Power Generation

## DMT Environmental Techlonogy

T : +31 513 63 6709
E : Moverbosch@dmt-et.nl
W : www.dmt-et.com

Products/Services: High efficient biogas upgrading technology and desulphurisation systems
Countries covered: USA, Canada, Europe, Asia - Malaysia
Category: Biomethane Upgrading | Consultants

## Energy & Waste S.I

T : +34930019877
E : ewtech@ewtech-ing.com
W : www.ewtech-ing.com

Products/Services: Biogas dryer, Biogas Cleaning, Biogas upgrading, Foam removal, Gravel filter, Particle filter
Countries covered: South America, Spain
Category: Biomethane Upgrading

# TRUE ECO SDN BHD

T : +601126278823
E : askme@true-eco.com
W : www.true-eco.com

**Products/Services:**
Consulting, engineering, construction and operation management of anaerobic digestion system and biogas plant

**About:**
It is people that deliver projects. Leveraging on technical know-how and plant operation experience, our team work closely with you to assist you in designing and configuring operator-friendly solutions that tailored to support your specific wastewater and biogas goals. Our comprehensive engineering service range offers: project feasibility assessment, technical design and procurement, project construction, operation and maintenance, process improvement and technical training. With the drive to reduce downtime and cost pressure, we benefit our clients by optimizing cost and improving operational reliability. We are committed to assist you in your wastewater and biogas ventures. Contact us today.

**Countries covered:** Malaysia, South East Asia

**Category:** Anaerobic Digestion, Biomethane Upgrading, Power Generation, Consultants

## Enpro Envirotech Pty Ltd

T : +61 415351012
E : will@digesterdoc.com
W : www.digesterdoc.com

Products/Services: Feasibility, design, drawging, consultancy, training, troubleshooting, resource recovery
Countries covered: Australia, Pacific Island, China, India, Indonesia
Category: Anaerobic Digestion | Biomethane Upgrading | Consultants

## Envitec Biogas AG

T : +49 2574 8888 0
E : info@envitec-biogas.com
W : www.envitec-biogas.com

Products/Services: Biogas and biogas upgrading plants
Countries covered:
Over 20 countries in Asia, Europe and North America
Category: Anaerobic Digestion | Biomethane Upgrading

## Evonik Malaysia

T : +603 2268 7878
E : micheal.yeong@evonik.com
W : www.evonik.com

Products/Services: Biomethane upgrading, membrane solutions
Countries covered: Malaysia
Category: Biomethane Upgrading

## Greenlane Technologies Ltd

T : +64 9571 0687
E : salesnz@greenlanebiogas.com
W : www.greenlanebiogas.com

Products/Services: Biogas upgrading, gas compression and biogas conditioning & Dehydration Systems.
Countries covered: Asia & Australia
Category: Biomethane Upgrading

## Kwangshin

T : 603-6201-7435
E : ykmin88@everchem.com.my
W : www.kwangshin.com

Products/Services: Gas compressors, bottling, gas turbine for biogas upgrading and CNG fueling
Countries covered: Malaysia, South Korea, USA
Category: Biomethane Upgrading

## Mailhem Engineers

T : +91 20 2565 0047
E : info@mailhem.com
W : www.mailhem.com

Products/Services: Solid & liquid organic waste treatment projects on turnkey basis.
Countries covered: India, Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## Maverick Biomethane Projects Pvt Ltd

T : +91 265 234 3010
E : info@maverickbiomethane.com
W : www.maverickbiomethane.com

Products/Services: Green waste to energy, BG2CNG, anaerobic digestion
Countries covered: UAE, Tanzania, Kenya, Congo, India, Mauritius
Category: Anaerobic Digestion | Biomethane Upgrading | Gas Distribution

## MT Energie Gmbh

T : +49 4281 9845 0
E : info@mt-energie.com
W : www.mt-energie.com

Products/Services:
Biogas plant, bogas upgrading plant, biogas plant components, technical and biological support
Countries covered: UK, US, Germany, Europe
Category: Anaerobic Digestion | Biomethane Upgrading

## Neuman & Esser South East Asia

T : +66 38 923700
E : info@neuman-esser.co.th
W : www.neuman-esser.de

Products/Services: Reciprocating compressor systems, parts and services
Countries covered: Southeast Asia, Taiwan, South Korea, Australia, New Zealand
Category: Biomethane Upgrading | Miscellaneous

## Oiltek Nova Bioenergy Sdn Bhd

T : +603 55428 288
E : lester@oiltek.com.my
W : www.oiltek.com.my

Products/Services: "Our technology is proven successfully in POME application since 28 years ago. "
Countries covered: Worldwide
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Gas Distribution

## One Gasmaster Sdn Bhd

T : +603 78850202
E : sales@onegasmaster.com
W : www.onegasmaster.com

Products/Services: Bio-Gas Analyser System solution provider
Countries covered: Malaysia
Category: Biomethane Upgrading | Consultants | Miscellaneous

## Recuperma Gmbh

T : +49 2305 54886 - 0
E : info@recuperma.de
W : www.recuperma.com

Products/Services: Universal disintegrator: UzBio, Substrate preparation, increasing gas recovery
Countries covered: Germany
Category: Biomethane Upgrading | Miscellaneous

## SAFE S.p.A.

T : +39 051 687 82251
E : info@safegas.it
W : www.safegas.it

Products/Services: Gas compressors, bio-methane upgrading, gas transportation & distribution solutions
Countries covered: Worldwide
Category: Biomethane Upgrading | Gas Distribution

## Samapi Group

T : +41 91 9306395
E : remfer@samapigroup.com
W : www.samapigroup.com

Products/Services: Gas compression, Bio-methane treatment
Countries covered: Worldwide
Category: Biomethane Upgrading | Power Generation | Gas Distribution

## Taiyo Nippon Sanso

T : +65 6265 9355
E : shleong@nox.com.sg
W : www.tn-sanso.co.jp.en

Products/Services: Industrial gas solutions, air separation and gas handling
Countries covered: US, China, Taiwan, Korea, Singapore, Vietnam, Philippines, Malaysia, Indonesia, India
Category: Biomethane Upgrading

## Tech Infinity Engineering

T : +603 7726 3231
E : info@techinfinity.my
W : www.techinfinity.my

Products/Services: Complete biogas value chain provider
Countries covered: Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Gas Distribution

## True Eco

T : +6011-2627 8823,
E : elainewong@true-eco.com
W : www.true-eco.com

Products/Services: On-going training, maintenance, service support, continuous system monitoring, process research and analysis
Countries covered: Worldwide
Category: Anaerobic Digestion, Power Generation, Consultants

## TT Renewable Sdn Bhd

T : 012-6226615 / 03-27110888
E : ssales@tenagatiub.com.my
W : N.A

Products/Services:
System Integrator & Technology Provider For Biogas To Power Plant
Countries covered: Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Consultants

## Vivam Solid Waste Management Pvt. Ltd.

T : 9423781306
E : contact@vivamgroup.co.in / Nirmala@vivamgroup.co.in
W : www.vivamgroup.co.in

Products/Services: Waste management consultancy, Turnkey supply erection and commissioning of Biogas and compost plant of capacity 1 kg to 1000 tons per day
Countries covered: India
Category: Anaerobic Digestion |Biomethane Upgrading | Power Generation | Consultants

## Xebec Inc

T : +001 450 979 8700
E : sales@xebecinc.com
W : www.xebecinc.com

Products/Services: Biogas Upgrading Plants
Countries covered: Worldwide
Category: Biomethane Upgrading

## Xeon Waste Managers

T : +91 9004 689601
E : srinivas@xeonwm.com
W : www.xeonwm.com

Products/Services: Energy Bin, enzymes and cultures for anaerobic digestion and biogas plants
Countries covered: India, Sri Lanka, Pakistan, Europe, Bangladesh, USA, UK
Category: Anaerobic Digestion |Biomethane Upgrading | Consultants | Miscellaneous

# POWER GENERATION

COMPANY LIST

## Asia Biogas

T : +66 2651 9900
E : info@asiabiogas.com
W : www.asiabiogas.com

Products/Services: Asia Biogas designs, constructs, finances and operates clean energy projects
Countries covered: Southeast Asia
Category: Anaerobic Digestion | Power Generation | Consultant

## Biogas Equity 2 Inc

T : +65 9283 9555
E : mikemuller@biogas2.com
W : www.biogas2.com

Products/Services: Waste conversion based on newest patented German Technology, AD, gasification
Countries covered: North America
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## Cabot Norit Singapore Pte. Ltd.

T : +65 6631 9392
E : angela.tok@cabotcorp.com
W : www.cabotcorp.com

Products/Services: World's largest producer of activated carbon and related service
Countries covered: Singapore, Malaysia, Thailand, Philippines, Indonesia, Myanmar, Vietnam, Cambodia, Australia, New Zealand, Papua New Guinea
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## Carbotech

T : +49 (201) 50709-300
E : mail@carbotech.info
W : www.carbotech.info/en.html

Products/Services: Innovative and comprehensive solutions in the field of gas separation
Countries covered: Germany, Sweden
Category: Biomethane Upgrading | Power Generation

## Caterpillar Asia

T: +65 9154 3697
E: johncylee@cat.com
W: www.catgaspower.com

Products/Services: Gas engine generator systems for power generation and heat utilization
Countries covered: Worldwide
Category: Power Generation

## Climate Energy

T : +603 5115 0118
E : ching@climateenergy.net
W : N.A

Products/Services: Solutions provider in gas handling and utilization of downstream biogas plant including power generation, hear recovery and gas purficiation (bio-methane)
Countries covered: Malaysia
Category: Biomethane Upgrading | Power Generation

# KPSR CONSTRUCTION

T : +60 18 2795 013
E : kpsr-biogas@outlook.com
W : www.kpsr-biogas.com

**Products/Services:**
Design and consulting services for industrial anaerobic digestion and biogas treatment

**About:**
KPSR Construction are biogas project specialists - this is all we do. We provide a niche service where our client's project needs are the focus of a complete customised design. We are professional engineers who understand the technical issues leading to reliable operation. Our projects are efficient, effective, straightforward to operate, and meet all reasonable investment criteria. Designed for a SE Asian context, our projects are adapted to each site and can be implemented in remote locations. Typical feed-stocks are palm oil, cassava waste, distillery waste and feedlot waste. Solids are able to be included. Typical project size is 2 – 4 MWe.

**Countries covered:** Global

**Category:** Anaerobic Digestion, Biomethane Upgrading, Power Generation, Consultants

## Dresser-Rand

T : +34 943 8651 82
E : guascor@guascor.com
W : www.dresser-rand.com

Products/Services: Bioenergy (Biogas from biodigestion, sewage, landfill) & Energy efficiency (co-generation - trigeneration)
Countries covered: Worldwide
Category: Power Generation

## Fornovogas

T : +39 0521 1553844
E : info@fornovogas.it
W : www.fornovogas.it/en/

Products/Services: Complete solutions for worldwide gas compression
Countries covered: Complete solutions for worldwide gas compression
Category: Power Generation | Gas Distribution

## Impact Bienergy

T : +1 315 434 1100
E : srirup.k@impactbioenergy.com
W : www. impactbioenergy.com

Products/Services: We manufacture portable bioenergy systems that convert organic waste materials into energy and biofertilizer
Countries covered: USA, Philippines
Category: Power Generation | Consultants | Miscellaneous

## Libertine FPE Limited

T : +44 7740 488 130
E : sam.cockerill@libertine.co.uk
W : www.lbertine.co.uk

Products/Services:
1-100kW power generation, CHP and waste heat recovery technology
Countries covered: Asia, South America
Category: Power Generation

## Mailhem Engineers

T : +91 20 2565 0047
E : info@mailhem.com
W : www.mailhem.com

Products/Services: Solid & liquid organic waste treatment projects on turnkey basis
Countries covered: India, Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation

## Metro Machinery Co.

T : +66 2742 8000
E : somkiat.chos@metrocat.com
W : www.metrocat.com

Products/Services: Sells and services the complete caterpillar gas line of products
Countries covered: Thailand
Category: Power Generation

# SOLMAX BIOENERGY

T : 603-33753600 | Ext: 305/309
E : jtan@solmaxbioenergy.com
W : www.solmaxbioenergy.com

**Products/Services:**
Invest and Operate for Biogas Power Plants from Organic Waste

**About:**
Solmax is a global environmental solution provider with its headquarters in Canada. In line with Solmax's mission "Protect, Create and Optimize", Solmax BioEnergy focuses on protecting the environment while generating renewable energy from organic waste. Benefiting from 35 years of experience of its parent company in environmental protection, Solmax BioEnergy puts its expertise to the organic waste treatment industry by acting as a BOOT (Build, Own, Operate & Transfer) investor. In conjunction with its sister unit that has already innovated within this industry by introducing the BioCoverPro geomembrane to contain biogas generated from organic waste water, Solmax BioEnergy is offering great technical expertise, solid financial standing and an innovative spirit to this growing industry.

**Countries covered:** Global

**Category:** Power Generation

## MTU Asia Pte Ltd

T : +65 6860 9703
E : desmod.kho@mtu-online.com
W : www.mtuonsiteenergy.com

Products/Services: MTU onsite energy power genset (gas, diesel, biogas)
Countries covered: Worldwide
Category: Power Generation

## Multico Enviro

T : +603 7960 4898
E : inquiry@multico.com.my
W : www.multico.com.my

Products/Services: Pre-engineering design, electrical and mechaical works and project management for clean opwer generation
Countries covered: Malaysia, Thailand, Philippines, Taiwan, Maynmar, Indonesia, Cambodia, Laos
Category: Power Generation | Consultants

## Oiltek Nova Bioenergy

Sdn Bhd
T : +603 55428 288
E : lester@oiltek.com.my
W : www.oiltek.com.my

Products/Services: "Our technology is proven successfully in POME application since 28 years ago. "
Countries covered: Worldwide
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Gas Distribution

## OPRA Turbines

T : +65 9851 8279
E : n.htwee@opraturbines.com
W : www.opraturbines.com

Products/Services: Gas turbine generators
Countries covered: UAE, Netherlands, Russia, Singapore, US
Category: Power Generation

## PT Asia Biogas Indonesia

T : +62 21 5296 0370
E : adhi.erlangga@asiabiogas.co.id
W : www.asiabiogas.com

Products/Services:
Biogas & biomass plant designer for both thermal and electricity generation
Countries covered: Thailand, Indonesia, Singapore
Category: Power Generation

## Samapi Group

T : +41 91 9306395
E : remfer@samapigroup.com
W : www.samapigroup.com

Products/Services: Gas compression, Bio-methane treatment
Countries covered: Worldwide
Category: Biomethane Upgrading | Power Generation | Gas Distribution

## Sime Darby Industrial

T : +86 510 8663 2086
E : ng.chun.hoong@simedarby.com
W : www.simedarby.com

Products/Services: Caterpillar palm oil biogas, agriculture biogas, landfill and sewage gas generators
Countries covered: Malaysia, Singapore, Australia, PNG
Category: Power Generation

## Shuangliang Eco-Energy System Co. Ltd.

T : +86 510 8663 2086 / 8822
E : ktsales@shuangliang.com
W : www.shuangliang.com

Products/Services: Co-gen, Tri-gen system with LiBr absorption chiller/heat pump
Countries covered: China, Thailand
Category: Power Generation

## Tech Infinity Engineering

T : +603 7726 3231
E : info@techinfinity.my
W : www.techinfinity.my

Products/Services: Complete biogas value chain provider
Countries covered: Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation |Gas Distribution

## True Eco

T : +6011-2627 8823,
E : elainewong@true-eco.com
W : www.true-eco.com

Products/Services: Consulting, Engineering, Construction and operation management of anaerobic dygestion system and biogas plant
Countries covered: Worldwide
Category: Anaerobic Digestion | Power Generation | Consultants

## TT Renewable Sdn Bhd

T : 012-6226615 / 03-27110888
E : ssales@tenagatiub.com.my
W : N.A

Products/Services: System Integrator & Technology Provider For Biogas To Power Plant
Countries covered: Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Consultants

## Vivam Solid Waste Management Pvt. Ltd.

T : 9423781306
E : contact@vivamgroup.co.in / Nirmala@vivamgroup.co.in
W : www.vivamgroup.co.in

Products/Services: Waste management consultancy, Turnkey supply erection and commissioning of Biogas and compost plant of capacity 1 kg to 1000 tons per day
Countries covered: India
Category: Anaerobic Digestion |Biomethane Upgrading | Power Generation | Consultants

## WCM Power Sdn Bhd

T : 03 6148 3726
E : enquiry@wcmgroup.my
W : www.vwcmgroup.my

Products/Services: EPCC/BOOT/AD & Biogas Consulting
Countries covered: Malaysia, Indonesia, West Africa, Latin America
Category: Anaerobic Digestion | Power Generation | Consultants

# GAS DISTRIBUTION

COMPANY LIST

## Bauer Gmbh
T : +43/ 3142/ 200-0
E : bauer@bauer-at.com
W : www.bauer-at.com

Products/Services: Press screw separators, eccentrc screw pumps, submersible pumps, submersibe mixers, biodos automatic feed system, slurry tankers
Countries covered: North America, Russia, Australia, Slovakia, Ukraine, Hungary, Brazil, Poland, Romania, Asia
Category: Biomethane Upgrading | Gas Distribution

## CIMC Enric
T : +86 552 307 3687
E : edllchaustin@163.com
W : www.enricgroup.com

Products/Services: Anaerobic digestion, methane gas desulphurisation, decarburation, EPC Project management, modularization, stadardization and intelleginization in methane gas engineering
Countries covered: North America, Europe, South America, Central Asia, Southeast Asia, Russia, Australia, China, Thailand, India
Category: Anaerobic Digestion | Biomethane Upgrading | Gas Distribution | Consultants

## Continental Industrie
T : (+34) 934 96 10 80
E : andrea@keyways-int.com
W : www.continental-industrie.com

Products/Services: Multi Stage Centrifugal Blowers, Single Stage Turbo Compressor, Gas Boosters
Countries covered: Worldwide
Category: Gas Distribution | Miscellaneous

## Environtec
T : + 43 5578 77005-0
E : info@environtec.at
W : www.biogas-plant.com

Products/Services: Waste air cleaning, Gas treatment, Gas Storage, Gas recovery
Countries covered: Worldwide
Category: Gas Distribution | Miscellaneous

## Fornovogas
T : +39 0521 1553844
E : info@fornovogas.it
W : www.fornovogas.it/en/

Products/Services: Complete solutions for worldwide gas compression
Countries covered: Worldwide
Category: Power Generation | Gas Distribution

## Gas Malaysia
T : 03 - 5192 3000
E : enquiries@gasmalaysia.com
W : www.gasmalaysia.com

Products/Services: Gas distribution
Countries covered: Malaysia
Category: Gas Distribution

## Maverick Biomethane Projects Pvt Ltd
T : +91 265 234 3010
E : info@maverickbiomethane.com
W : www.maverickbiomethane.com

Products/Services: Green waste to energy, BG2CNG, anaerobic digestion
Countries covered: UAE, Tanzania, Kenya, Congo, India, Mauritius
Category: Anaerobic Digestion | Biomethane Upgrading | Gas Distribution

## Oiltek Nova Bioenergy Sdn Bhd
T : +603 55428 288
E : lester@oiltek.com.my
W : www.oiltek.com.my

Products/Services: "Our technology is proven successfully in POME application since 28 years ago. "
Countries covered: Worldwide
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Gas Distribution

## PT Natgas Indonesia
T : +62 8136 436 6041
E : shleong@nox.cm.sg
W : N.A

Products/Services: Specialize in CNG gas equipment and piping
Countries covered: Indonesia
Category: Gas Distribution

## Samapi Group
T : +41 91 9306395
E : remfer@samapigroup.com
W : www.samapigroup.com

Products/Services: Gas compression, Bio-methane treatment
Countries covered: Worldwide
Category: Biomethane Upgrading | Power Generation | Gas Distribution

## SAFE S.p.A.

T : +39 051 687 82251
E : info@safegas.it
W : www.safegas.it

Products/Services: Gas compressors, bio-methane upgrading, gas transportation & distribution solutions
Countries covered: Worldwide
Category: Biomethane Upgrading | Gas Distribution

## Tech Infinity Engineering

T : +603 7726 3231
E : info@techinfinity.my
W : www.techinfinity.my

Products/Services: Complete biogas value chain provider
Countries covered: Malaysia
Category: Anaerobic Digestion | Biomethane Upgrading | Power Generation | Gas Distribution

## Vivam Solid Waste Management Pvt. Ltd.

T : 9423781306
E : contact@vivamgroup.co.in / Nirmala@vivamgroup.co.in
W : www.vivamgroup.co.in

Products/Services: Waste management consultancy, Turnkey supply erection and commissioning of Biogas and compost plant of capacity 1 kg to 1000 tons per day
Countries covered: India
Category: Anaerobic Digestion |Biomethane Upgrading | Power Generation | Gas Distribution | Consultants

# CONSULTANTS

COMPANY LIST

## ADI Systems Asia Pacific

T : 0064 951 0240
E : asiapacific@adi.ca
W : www.adisysteminc.com

Products/Services: Specialists in wastewater treatment and waste-to-energy systems design
Countries covered: Asia-Pacific Region
Category: Consultants

## Asia Biogas

T : +66 2651 9900
E : info@asiabiogas.com
W : www.asiabiogas.com

Products/Services: Asia Biogas designs, constructs, finances and operates clean energy projects
Countries covered: Southeast Asia
Category: Anaerobic Digestion | Power Generation | Consultant

## Biowatt Development Ltd

T : +44 845 838 0735
E : solutions.hub@biowatt.co.uk
W : www.biowatt.uk.com

Products/Services: Project development, engineering and funding
Countries covered: UK
Category: Anaerobic Digestion | Consultants

## BTS Biogas

T : +39 0454 85 42 05;
E : R.Salmaso@bts-biogas.com
W : www.bts-biogas.com

Products/ Services: BTS Biogas is the largest provider of biogas plants in Italy and is a pioneer in this sector. The core expertise of the company is in planning, production, and commnstructing the plants.
Countries: Italy, UK, Germany, France, Czech Republic, Portugal, Romania, Japan, South Korea
Category: Consultants

## CIMC Enric

T : +86 552 307 3687
E : edllchaustin@163.com
W : www.enricgroup.com

Products/Services: Anaerobic digestion, methane gas desulphurisation, decarburation, EPC Project management, modularization, stadardization and intelleginization in methane gas engineering
Countries covered: North America, Europe, South America, Central Asia, Southeast Asia, Russia, Australia, China, Thailand, India
Category: Anaerobic Digestion | Biomethane Upgrading | Gas Distribution | Consultants

# DMT ENVIROMENTAL TECHNOLOGY

T : +31 513 63 6709
E : Moverbosch@dmt-et.nl
W : www.dmt-et.com

**Products/Services:**
Biogas Upgrading, Gas Desulphurisation, Water Treatment

**About:**
ManDMT Environmental Technology is the expert and global leader in biogas upgrading technology. Focusing on the Palm Oil Industry, DMT delivers desulphurization and upgrading technology specifically for biogas from Palm Oil Mill Effluent in order to create value from waste. Its proven, profitable, sustainable and easy to use.
DMT Environmental Technology is a fast growing company that specializes in helping companies to contribute to the environment in a sustainable and profitable way. The techniques we implement solve environmental issues. With over more than 28 years of experience, DMT is reliable partner and market leader in the field of biogas upgrading. DMT has won several awards on innovation and technology as well as several growth awards.

**Countries covered:** Worldwide

**Category:** Biomethane Upgrading, Consultants

## Enpro Envirotech Pty Ltd

T : +61 415351012
E : will@digesterdoc.com
W : www.digesterdoc.com

Products/Services: Feasibility, design, drawging, consultancy, training, troubleshooting, resource recovery
Countries covered: Australia, Pacific Island, China, India, Indonesia
Category: Anaerobic Digestion | Biomethane Upgrading | Consultants

## Genpower Carbon Solutions

T : +603 7863 0826
E : Martha.fernandez@bunge.com
W : N.A

Products/Services: Waste to energy project development, biogas POA inclusion & carbon finance
Countries covered: Malaysia
Category: Consultants

## Green Access Sdn Bhd

T : +603 7620 7929
E : green.access.my@gmail.com
W : N.A

Products/Services: Commercialization of an integrated microbial based POME treatment system (PTS)
Countries covered: Malaysia
Category: Consultants

## Impact Biogas

T : +1 315 434 1100
E : chingyu.yeung@inficon.com
W : www. impactbioenergy.com

Products/Services: We manufacture portable bioenergy systems that convert organic waste materials into energy and biofertilizer
Countries covered: USA, Philippines
Category: Power Generation | Consultants | Miscellaneous

## Multico Enviro

T : +603 7960 4898
E : inquiry@multico.com.my
W : www.multico.com.my

Products/Services: Pre-engineering design, electrical and mechaical works and project management for clean opwer generation
Countries covered: Malaysia, Thailand, Philippines, Taiwan, Maynmar, Indonesia, Cambodia, Laos
Category: Power Generation | Consultants

## MV Technologies

T : +1 303 277 1625
E : info@mvseer.com
W : www.mvseer.com

Products/Services: Engineered hydrogen sulfide (H2S Removal), methane gas desulphurization, odor control
Countries covered: USA, UK, Asia-Pacific, EU
Category: Consultants | Miscellaneous

## SEBIGAS

T : 0039 0331 1817 711
E : sales@sebigas.com
W : www.sebigas.com

**Products/Services:**
Tailored plants, to suit customer requirement and technology and engineering as technology provider

**About:**
SEBIGAS, a division of EXERGY S.p.A., sub-holding of maccaferri Industrial Group is specialized in the design, construction and management of biogas power plant. SEBIGAS offers INTEGRATED SOLUTIONS for the widest-ranging demands of the market. Financial strength, technological exoertise and flexibility execution with a focus on research and development in biology and engineerring fields are the strengths that characterise SEBIGAS products. SEBGIAS operates and EPC CONTRACTOR for the construction of turnkey plants ad provider technology and engineering in the role of TECHNOLOGY PROVIDER.

**Countries covered:** Italy, Thailand, Brazil

**Category:** Anaerobic Digestion, Consultants

## One Gasmaster Sdn Bhd

T : +603 78850202
E : sales@onegasmaster.com
W : www.onegasmaster.com

Products/Services: Bio-Gas Analyser System solution provider
Countries covered: Malaysia
Category: Biomethane Upgrading | Consultants | Miscellaneous

## PlanET Biogastechnik GmbH

T : 0049 2564 3950126
E : sales@planet-biogas.com
W : en.planet-biogas.com

Products/Services: Engineering, Material Supply, Installation, Service
Countries covered:
North America, Several European Countries, Australia, Southeast Asia, China, Japan
Category: Consultants | Miscellaneous

## P&S Design Co.

T : +662 3120 165
E : paiboon@psbiogas.com
W : www.psbiogas.com

Products/Services: Environmental & energy engineering expert consultant
Countries covered: Thailand
Category: Consultants

## Redmore Environmental Ltd

T : 0161 706 0075
E : info@red-env.co.uk
W : www.red-env.co.uk

Products/Services:
Environmental assessments in support of planning or permitting applications
Countries covered: UK
Category: Consultants

## Reex Capital Asia

T : +65 6818 9710
E : yanis.boudjouher@reexasia.com
W : www.reexasia.com

Products/Services: Capital raising (equity and debt), development strategy via M&A, and J, due diligence, feasiility studies and advisory
Countries covered: Asia
Category: Consultants

## True Eco

T : +6011-2627 8823,
E : elainewong@true-eco.com
W : www.true-eco.com

Products/Services: Consulting, Engineering, Construction and operation management of anaerobic dygestion system and biogas plant
Countries covered: Worldwide
Category: Anaerobic Digestion | Power Generation | Consultants

## Vivam Solid Waste Management Pvt. Ltd.

T : 9423781306
E : contact@vivamgroup.co.in / Nirmala@vivamgroup.co.in
W : www.vivamgroup.co.in

Products/Services: Waste management consultancy, Turnkey supply erection and commissioning of Biogas and compost plant of capacity 1 kg to 1000 tons per day
Countries covered: India
Category: Anaerobic Digestion |Biomethane Upgrading | Power Generation | Gas Distribution | Consultants

## WCM Power Sdn Bhd

T : 03 6148 3726
E : enquiry@wcmgroup.my
W : www.vwcmgroup.my

Products/Services: EPCC/BOOT/AD & Biogas Consulting
Countries covered: Malaysia, Indonesia, West Africa, Latin America
Category: Anaerobic Digestion, Power Generation, Consultants

## Xeon Waste Managers

T : +91 9004 689601
E : srinivas@xeonwm.com
W : www.xeonwm.com

Products/Services: Energy Bin, enzymes and cultures for anaerobic digestion and biogas plants
Countries covered: India, Sri Lanka, Pakistan, Europe, Bangladesh, USA, UK
Category: Anaerobic Digestion |Biomethane Upgrading | Consultants | Miscellaneous

# MISCELLANEOUS

COMPANY LIST

## Addinol Lube Oil

T : +49 172/801 40 54
E : info@ave-energy.de
W : www.aev-energy.de

Products/Services: Biogas, Waste to Energy, Energy Production, Electricity Production
Countries covered: Europe, China, Australia
Category: Miscellaneous

## Biogen (UK) Ltd

T : +441 1234 827210
E : info@biogen.co.uk
W : www.biogen.co.uk

Products/Services: Anaerobic Digeston Design Specialists, Design, Building & Operation of Plants
Countries covered: UK
Category: Miscellaneous

## Biotech Alliance International Sdn Bhd

T : +60 8241 4837
E : bioall@myjaring.net
W : N.A

Products/Services: BAIGUS advanced furrow composting system which provides a wide range of decomposing microbes and soil enrichment microbes namely nitorgen fixers, phosphorous stabilising agents, mycorrhiza, zinc holders and trichoderma
Countries covered: Malaysia
Category: Miscellaneous

## Braunschweiger Flammenfilter Gmbh (Protego)

T : +49 5307 809 0
E : office@protego.de
W : www.protego.com

Products/Services:Pressure and vacuum relieve valves, Flame Arrester, Gauge catch
Countries covered: Germany
Category: Miscellaneous

## Clean Energy Advisors Pte Ltd

T : +66 87 809 7556
E : jsiteur@clean-energy-advisors.com
W : www.clean-energy-advisors.com

Products/Services: Biogas training, Financial report planning, Consultancy
Countries covered: US
Category: Miscellaneous

## Continental Industrie

T : (+34) 934 96 10 80
E : andrea@keyways-int.com
W : www.continental-industrie.com

Products/Services: Multi Stage Centrifugal Blowers, Single Stage Turbo Compressor, Gas Boosters
Countries covered: Worldwide
Category: Gas Distribution | Miscellaneous

# HUBEI CUBIC-RUIYI INSTRUMENT CO., LTD

T : 0086-27-81628831
E : info@gasanalyzer.com.cn
W : www.gasanalyzer.com.cn

湖北锐意自控系统有限公司
Hubei Cubic-Ruiyi Instrument Co.,Ltd.

**About:**
Hubei Cubic-Ruiyi Instrument Co., Ltd was established in 2010 and located at "Optical vally, Wuhan" in China, a hi-tech enterprise specializing in development, production and sales for gas analyzer, systems, ultrasonic gas flow meter, monitoring solution of networking industry. Based on the core sensor technology of infrared (NDIR), ultrasonic and laser Raman with independent intellectual property, Cubic-Ruiyi has successfully developed world leading ultrasonic gas flowmeter and energy conservation&emission reduction instruments like biogas analyzer, flue gas analyzer, syngas analyzer, emission gas analyzer and so on. Which has been widely used in electric power, steel, nonferrous metals, coal chemical, petrochemical, waste incineration, anaerobic digestion, motor vehicles and engine testing, oil and gas exploration, comprehensive utilization of coal-bed methane, air separation, energy saving and environmental protection departments, research institutions and civilian use and so on. Our products are well sold throughout China and have exported to 74 countries worldwide.

**Countries covered:** Indonesia, Thaialnd, Malaysia, Philippines, Singapore, Vietnam, India, Italy, Belgium, Bulgaria, Mexica, Brazil

**Category:** Miscellaneous

## Elmac Technologies Ltd
T : +44 1352 717600
E : sales@elmactechnologies.com
W : www.elmactechnologies.com

Products/Services: Flame arresters, pressure vacuum relief, valves, emergency relief vents, gauge hatches, man-ways, vents, tank blanketing valves, bursting discs
Countries covered: UK, Suth Africa, China
Category: Miscellaneous

## Environtec
T : + 43 5578 77005-0
E : info@environtec.at
W : www.biogas-plant.com

Products/Services: Waste air cleaning, Gas treatment, Gas Storage, Gas recovery
Countries covered: Worldwide
Category: Gas Distribution | Miscellaneous

## Enviroequip Sales & Rentals
T : +603 7987 8386
E : enquiry@enviroequip.com.my
W : www.enviroequip.com.my

Products/Services: Gas analysers for biogas, landfill gas
Countries covered: Southeast Asia, India, Pakistan, Middle East
Category: Anaerobic Digestion | Miscellaneous

## Flex Energy Inc.
T : +65 8488 9118
E : vincen.lim@flexenergy.com
W : www.flexenergy.com

Products/Services: Micro gas turbine generator
Countries covered: International
Category: Miscellaneous

## Hermann Sewerin Gmbh
T : +49 5241 934-0
E : sales@sewerin.com
W : www.sewerin.com

Products/Services: Gas leak detection, gas warning and measuring devices, gas odorisation
Countries covered: Germany
Category: Miscellaneous

## Impact Bienergy
T : +1 315 434 1100
E : srirup.k@impactbioenergy.com
W : www. impactbioenergy.com

Products/Services: We manufacture portable bioenergy systems that convert organic waste materials into energy and biofertilizer
Countries covered: USA, Philippines
Category: Power Generation | Consultants | Miscellaneous

## Inficon
T: +1 315 434 1100
E: info@impactbioenergy.com
W: www.inficon.com

Products/Services: Rapid Biogas BTU and methane, CO, CO2 and nitrogen concentration in seconds
Countries covered: Germany, France, Italy, Austria, Switzerland, Sweden, US
Category: Miscellaneous

## Kassbohrer Gelandefahrzeug AG
T : +497932 900-0
E : info@pistenbully.com
W : www.pistenbully.com

Products/Services: Pistenbully 300 greentech all-terrain vehicle for difficult terrain
Countries covered: Germany, France, Italy, Austria, Switzerland, Sweden, US
Category: Miscellaneous

## Luxfer Gas Cylinders
T : + 44 115 98 03800
E : customerservice@luxfer.net
W : www.luxferaf.com

Products/Services: Lightweight high pressure composite cylinders and roof mounted systems for shuttle buses
Countries covered: United states, Australia, China, Canada, Germany
Category: Miscellaneous

## Moseb Engineering
T : +603 8073 3625
E : info.my@mosebengineering.com
W : www.mvseer.com

Products/Services: Flow Meters, Pressure, temperature and analytical measurement instruments
Countries covered: Malaysia
Category: Miscellaneous

## MV Technologies
T : +1 303 277 1625
E : info@mvseer.com
W : www.mvseer.com

Products/Services: Engineered hydrogen sulfide (H2S Removal), methane gas desulphurization, odor control
Countries covered: USA, UK, Asia-Pacific, EU
Category: Consultants | Miscellaneous

## Mvance Engineering Sdn Bhd

T : +606-2633339
E : mvancesb@yahoo.com
W : www.m-vance.com

Products/Services: Supply of material, fabrication, installation and commissioning of various plants as well as machineries
Countries covered: Malaysia
Category: Miscellaneous

## Netzsch

T : +603 7843 6883
E : info.nmk@netzsch.com
info.nji@netzsch.com
info.ntb@netzsch.com
W : www.netzsch.com

Products/Services: Pumps, macerators, spare parts
Countries covered: Worldwide
Category: Miscellaneous

## Neuman & Esser South East Asia

T : +66 38 923700
E : info@neuman-esser.co.th
W : www.neuman-esser.de

Products/Services: Reciprocating compressor systems, parts and services
Countries covered: Southeast Asia, Taiwan, South Korea, Australia, New Zealand
Category: Biomethane Upgrading | Miscellaneous

## One Gasmaster Sdn Bhd

T : +603 78850202
E : sales@onegasmaster.com
W : www.onegasmaster.com

Products/Services: Bio-Gas Analyser System solution provider
Countries covered: Malaysia
Category: Biomethane Upgrading | Consultants | Miscellaneous

## PlanET Biogastechnik GmbH

T : 0049 2564 3950126
E : sales@planet-biogas.com
W : en.planet-biogas.com

Products/Services: Engineering, Material Supply, Installation, Service
Countries covered:
North America, Several European Countries, Australia, Southeast Asia, China, Japan
Category: Consultants | Miscellaneous

## Recuperma Gmbh

T : +49 2305 54886 - 0
E : info@recuperma.de
W : www.recuperma.com

Products/Services: Universal disintegrator: UzBio, Substrate preparation, increasing gas recovery
Countries covered: Germany
Category: Biomethane Upgrading | Miscellaneous

## TUV Nord Malaysia Sdn Bhd

T : +603 8023 2124
E : robert.cheong@tuv-nord.com
W : www.tuv-nord.com

Products/Services: Inspection, testing and certification
Countries covered: Malaysia
Category: Miscellaneous

## Union Instruments GmbH

T : +49 721 680 3810
E : info@union-instruments.com
W : www.union-instruments.com

Products/Services: Devices and Systems for gas analysis in the process industry
Countries covered: Worldwide
Category: Miscellaneous

## Wuhan Cubic Optoelectronics Co., Ltd

T : 0086-27-81628827
E : wei.ye@gassensor.com.cn
W : www.gassensor.com.cn

Products/Services: Gas Analyzer /Gas sensor /Flow meter
Countries Covered: USA, India, South Korea, Thailand,Italy, Belgium ,France,Brazil and Argentina
Category: Miscellaneous

## Zuwa Zumpe Germany

T : +49 8682 8934
E : export@zuwa.de
W : www.zuwa.de

Products/Services: Pumps for Biogas Plants
Countries covered: Germany
Category: Miscellaneous

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Replace Diesel /LPG/Gas used in Plantation / Mill with Bottled GREEN PALM GAS™ (BIO CNG)


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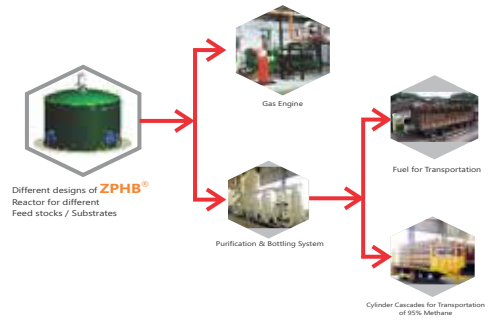


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