BIOENERGY
Germany

The BioEnergy Group

The BIOENERGY GROUP is a leading supplier of intelligent plant solutions. We are a team of specialists dedicated to biogas technology. We develop, produce, repair and automate biogas equipment and components, including complete plants.

We are specialized in the construction and optimization of biogas plants. On-site installation and 24/7 technical support are, of course, part of our comprehensive customer service.

BIOENERGY GERMANY - machinery and plant construction Co., Ltd. (Thailand) and BioEnergie gruenes Deutschland GmbH (Germany)

Both sister companies, as part of the BIOENERGY GROUP, combine not only 15 years of experience in the design, manufacturing and operation of biogas plants worldwide but also the know-how from the biological support of more than 300 biogas plants worldwide.

In Thailand, BIOENERGY GERMANY is responsible for:

- project development, engineering and plant design
- plant construction
- optimization of existing plants
- plant operation and operation support
- service and maintenance
- biological maintenance
- plant monitoring and controlling
- coordination between available projects and investors

The experience we have gained in completing projects around the world has shown one thing in particular: For sustainable biogas projects, it is extremely important to be in close contact with the local communities and their people. We have developed a system concept that is not only characterized by the use of reliable German technology, but also bears a high degree of responsibility for the sustainable economic success of every BIOENERGY GERMANY project.

Our key to success: Efficiency and sustainability as well as social and ecological responsibility.

Many Companies One Team

The steadily growing BIOENERGY GROUP combines several companies which operate in various sectors.

Each company in the group focuses on its own expertise within the area of biogas and renewable energy. The close cooperation among the companies results in perfect synergies and the generation of unique solutions.

BIOENERGIE Deutschland

BIOGAS:

- turnkey biogas systems
- optimization of existing plants
- 20/80 model, BTO, BOT, BOO
- delivery of components
- plant management
- service & maintenance
- control room monitoring (24/7)
- biological (laboratory) services
- control systems and automation

OTHER SERVICES:

- consulting
- accounting
- finance management
- financing
- investment

BIOENERGY Germany machinery and plant construction Co., Ltd.

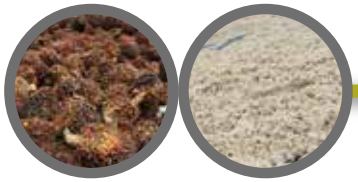
M-TEAM! BIOGAS SERVICE GMBH

IBUG

AS Germany GmbH

Feedstock

industrial waste and by-products



slurry and waste water

energy crops

agricultural waste

MSF-OF

PRE-
TRETMENT

FEEDING-SYSTEM

BIOGAS REACTORS

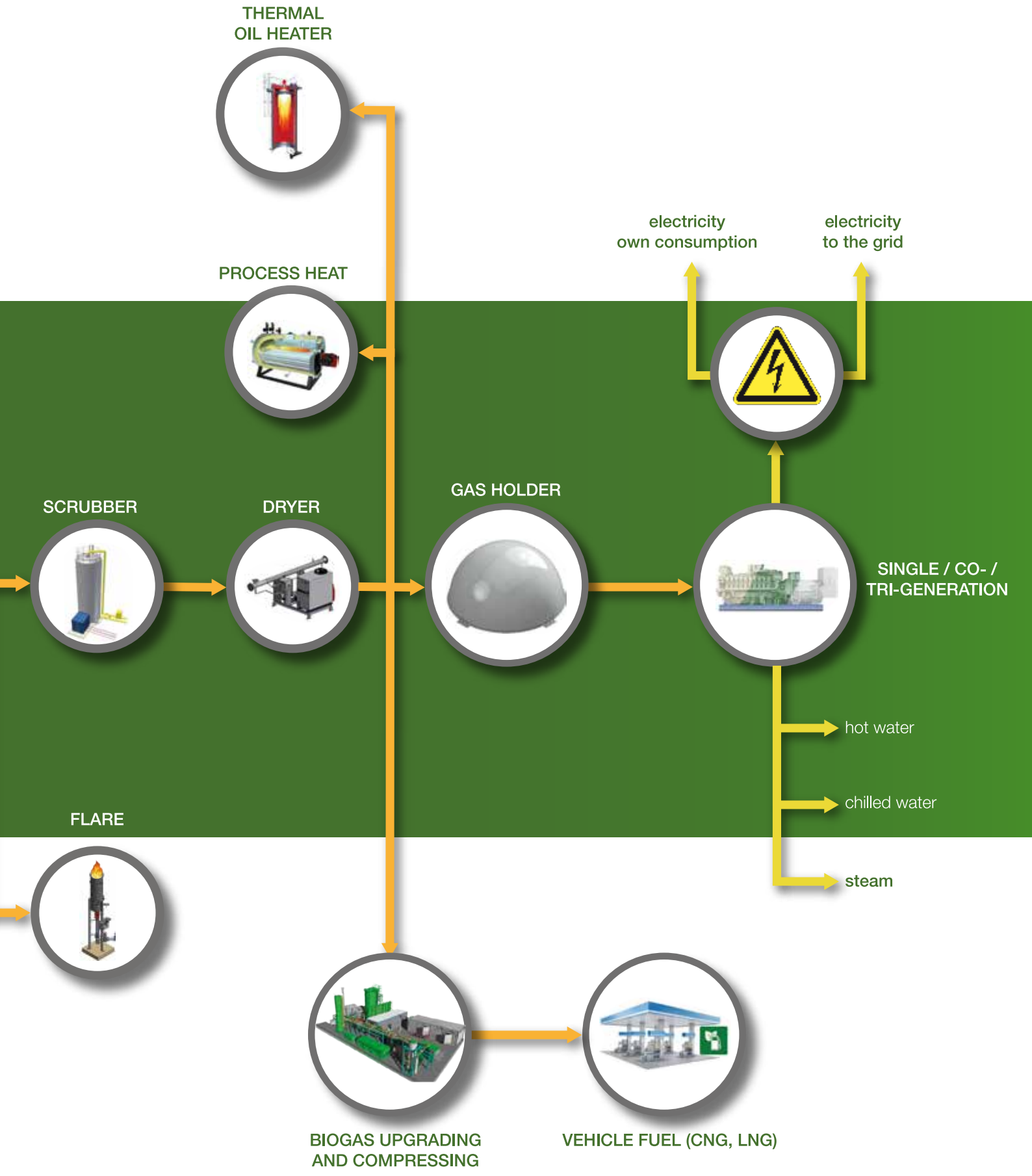
meso-/thermophilic
optimal design depending on feedstock

DIGESTATE

LIQUID-/
SOLID-
SEPARATION

liquid fertilizer
or recycle

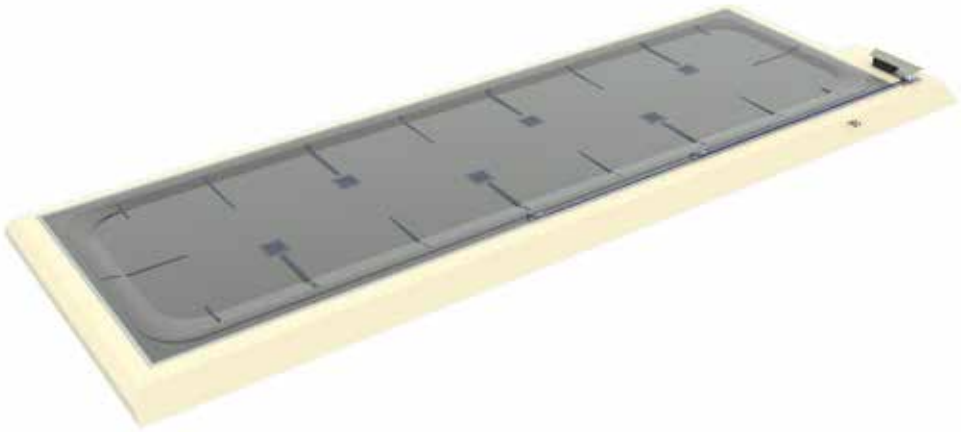
solid
fertilizer


THERMAL
OIL HEATER
PROCESS HEAT
electricity
own consumption
electricity
to the grid
SCRUBBER
DRYER
GAS HOLDER
SINGLE / CO- /
TRI-GENERATION
hot water
chilled water
steam
FLARE
BIOGAS UPGRADING
AND COMPRESSING
VEHICLE FUEL (CNG, LNG)

Lagoon 4.0™ highly efficient for South Ea

HIGHLY EFFICIENT BIOGAS PLANTS - ADAPTED TO LOCAL CONDITIONS

Current lagoon systems have low efficiency and are dangerous. However, there is a lot of wastewater, which is why a lagoon system is cost effective. Accordingly, we have combined the advantages of a lagoon and the advantages of a CSTR and have developed a fully automated CSLR (Continuously Stirred Lagoon Reactor) with a floating roof.



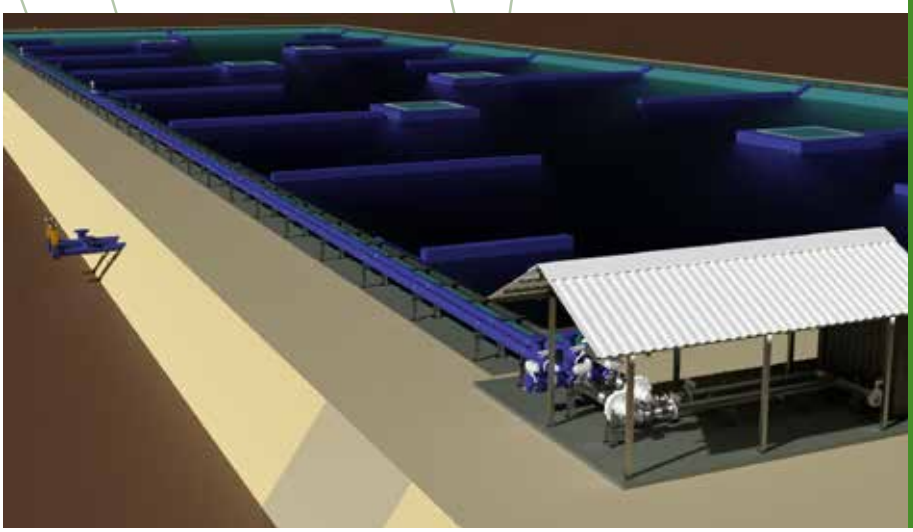
PROBLEMS WITH CURRENT SYSTEMS THAT ARE ALL SOLVED BY LAGOON 4.0™

- **forming of lakes:** reduction of gas volume, limited gas movement, increased risk of leaking
- **gas leaking:** safety problem, environmental problem, loss of gas
- **liquid leaking:** environmental problem, gas production under bottom liner, significant damage
- **no or insufficient mixing:** reduced plant efficiency, reduced gas production, floating and sinking layer
- **floating and sinking layers:** reduced gas production, damage to equipment
- **dangerous/low safety:** high risk for people, environment and investment

ast Asia

FULLY AUTOMATED FEEDING AND MIXING SYSTEMS

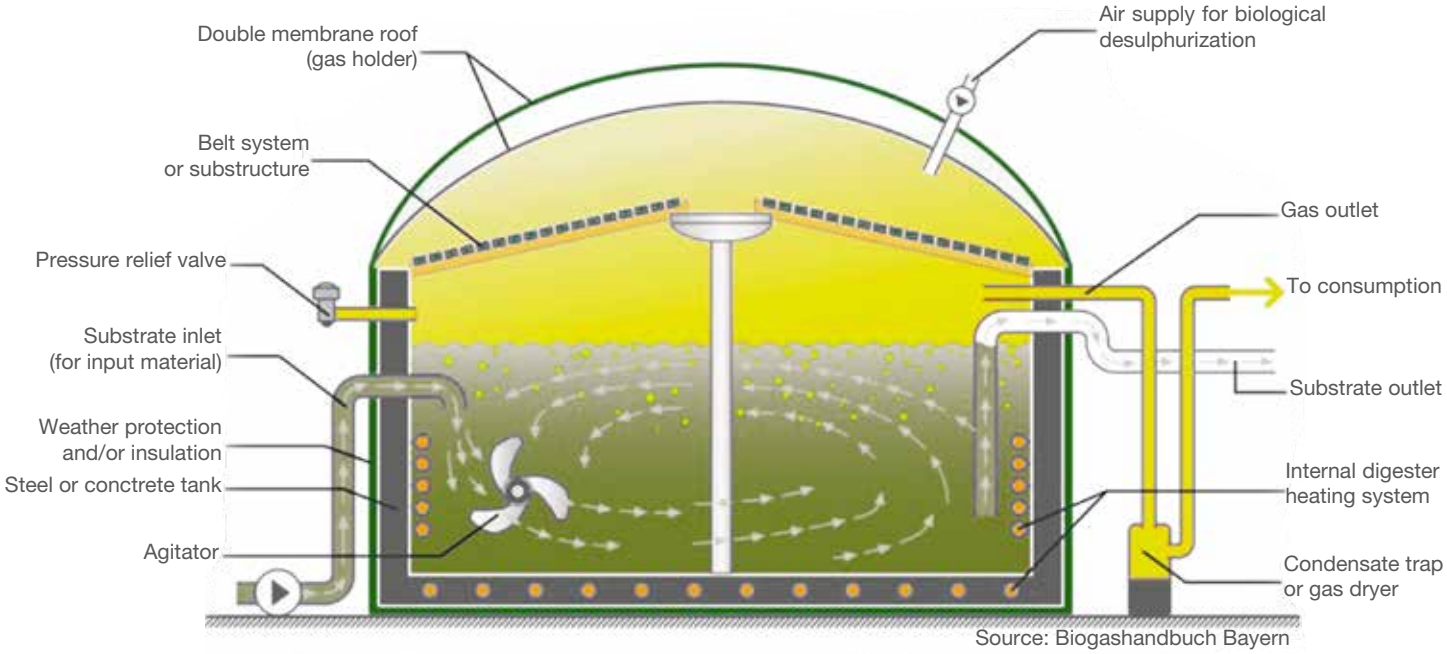
- low energy demand
- fully automated, monitored and controlled
- perfect feeding and mixing intervals
- long service life equipment
- easy maintenance by service hatch (no interruption of the process)
- no liner penetration, no leaking, no clogging



HIGHER GAS PRODUCTION DUE TO THE ROBUST AND EFFICIENT TECHNOLOGY OF LAGOON 4.0™

- **flat floating roof:** highest safety, no formation of lakes, no leaking
- **complete mixing:** the entire lagoon can be mixed by using submersible mixers
- **fully automated** with controlling and monitoring by iCoSy software
- **smooth plant operation**
- **less interruptions**
- **easy trouble shooting**
- **best support for plant operator**

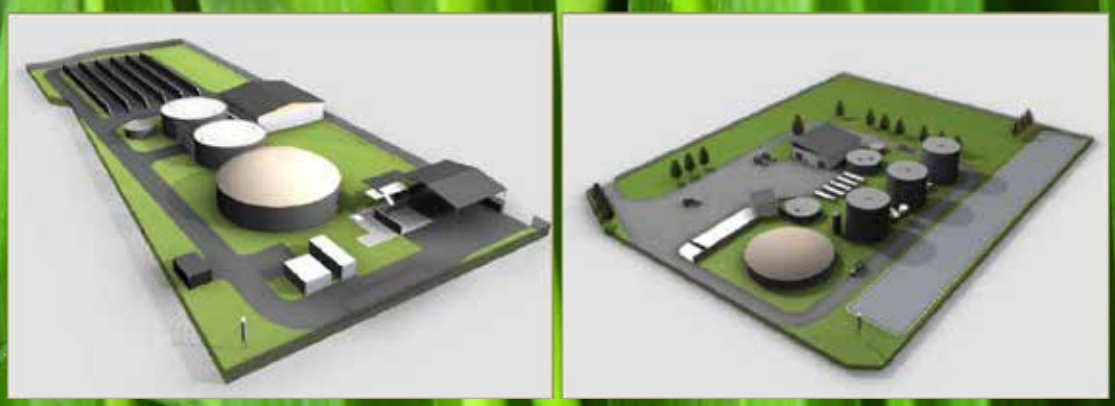
CSTR Technology



Source: Biogashandbuch Bayern

- most commonly used digester technology
- dry matter of feedstock can range from 1% up to 100%
- accepts a wide range of feedstock

- simple and robust technology
- controlled thermophilic and mesophilic process is possible
- fully automated plant operation



Overview of feedstock

INDUSTRIAL BY-PRODUCTS	ORGANIC AND AGRICULTURAL WASTES	ENERGY CROPS
cassava pulp	organic fraction of municipal solid waste (OF-MSW)	napier grass
waste water	sewage sludge	sweet sorghum
raw glycerin	kitchen waste	maize / corn
vinasses / molasses / bagasses	manure & slurry	sunflower
POME / EFB	rice straw	sugar cane
POM decanter cake	crop residues	cassava root
fruit processing waste	green waste	oilseed rape
slaughterhouse waste	market waste	grass in general
and many more ...	and many more...	and many more...

Biogas from MSW-OF

THE HIGH ORGANIC CONTENT OF MUNICIPAL SOLID WASTE IN LOW- AND MIDDLE-INCOME COUNTRIES (UP TO 60%) CAUSES NUMEROUS PROBLEMS IN THE HANDLING AND DISPOSAL OF THE WASTE.

By reintroducing recyclables into value chains, the use of biogas technology that uses waste as feedstock promotes a circular economy. The advantages are twofold: energy is recovered and the nutrient cycle is closed.

A huge variety of organic waste and residues are suitable for use as feedstock for biogas production.

The only requirement is that it consists of organic material that can be anaerobically degraded by the microorganisms inside the digester. Among other things, the water content and degradability of the feedstock are particularly important factors to consider when it comes to choosing the right technology:

- wet continuous digestion
  (continuously stirred tank and hydraulic reactors)
- dry continuous digestion
  (horizontal or vertical plug flow reactors)
- dry batch digestion
  (garage and percolation systems)

Feedstock preparation

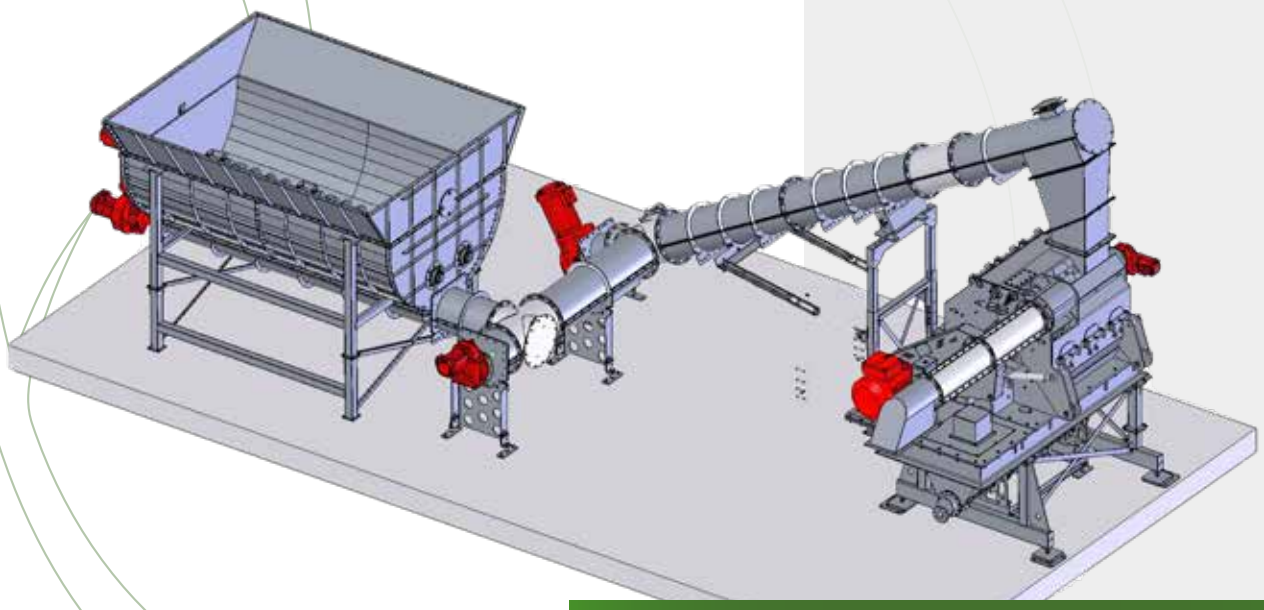
TO ENSURE THAT OPERATING CONDITIONS REMAIN STABLE AND PRODUCE THE BEST POSSIBLE BIOGAS YIELDS, IT IS ESSENTIAL TO USE AN OPTIMAL WASTE MIXTURE IN THE DIGESTER.

Different feedstock preparation technologies can be applied, with different approaches used depending on whether the feedstock is wet or dry.

The first stage in the process usually involves reducing particle size and creating a more homogenous material. This can be achieved by using

- screwcutting
- milling
- drumming or
- shredding machines

Techniques for extracting organic material from packaging include breaking glass with presses or opening plastic sacks with cutters.



SEPARATION SHREDDER SYSTEM

Feeding Systems

SOLIDS DOSING COMPACT SYSTEM

- 2 break-up rollers with exchangeable tools
- 13 m³ to 35 m³
- reliable dosing
- precise balance of loading and volume by a weighing- and an optional filling detection
- surfaces coming into contact with the product are made of stainless steel 1.4301
- conveyance via direct load, overhead spiral conveyor or connection to a liquid feeding system

SOLIDS DOSING - WALKING / PUSHING FLOOR

- adapts to the product due to pusher plate or walking floor system
- 30 m³ to 250 m³
- optimum utilization of storage container space
- low energy demand and tough design
- safe and reliable function
- can be easily expanded due to modular design
- integrated weighing system
- made of normal or stainless steel

SOLIDS DOSING AND LIQUID FEEDING

Solid dosing systems can be combined with liquid feeding systems, which come with perfect premixing and easy transport to the digester.

Double membrane cover & external gas holder

1 Outer membrane	4 Middle mast	7 Filling level measurement	10 Non-return valve
2 Inner membrane	5 Anchoring	8 Air support blower	11 Safety valve
3 Brace system	6 Inspection window	9 Pressure-regulating valve	

- low cost gas storage with high quality
- installed thousands of times
- nearly no maintenance
- 1⁄4, 1⁄2, 3⁄4 - sphere
- flat and rectangular shapes are also possible
- long service life
- high tightness (impermeability)
- high safety
- possibility of bio. desulphurization
- installation on top of a tank or directly on the ground

Mixing Systems

PHANTOM 1000

- most efficient agitator for biogas applications
- turbulence generation combined with high thrust
- prevents floating layers and sink layers
- propeller diameter: 1.0 m

PHANTOM 1400

- hybrid mixer for flexible use: flow accelerator and turbulence generator
- high thrust for a global flow
- low energy consumption
- propeller diameter: 1.4 m

PHANTOM 2500

- extremely low energy consumption due to large propellers and slow rotation speed
- bacteria-friendly global flow in the digester
- propeller diameter: 2.5 m

For the toughest conditions

TYPHOON 650

- generates strong turbulences
- small but powerful
- excellent for use in residue storage
- three-bladed propeller for operation even at low fill levels
- propeller diameter: 0.65 m

LONGSHAFT AGITATORS

- high efficiency agitator system
- low energy consumption
- propeller diameter: 1.0 m, 1.4 m, 1.6 m and 2.5 m
- installation in different heights, up to 10 m under filling level
- motor and gear outside the tank
- easy maintenance without interruption of the process

Plant Equipment

PUMPS

- manufacturer independent
- different technologies e.g. rotary lobe pump, cavity pump or mono pump, submersible pump
- easy and little maintenance

GAS BLOWER

- low energy consumption
- nearly maintenance-free
- highly efficient

GAS CHILLER / DRYER

- best gas quality for the reliable
- operation of CHP plants
- high quality material for long service life
- fully automated system or simplified for manual operation

GAS ANALYSER

- fully automated detection and logging of gas quality parameter
- CO_2, CH_4, H_2S, O_2
- with special µ-pulse system for high H_2S loads up to 50,000 ppm and a long sensor lifetime

HEATING SYSTEM

- corrugated stainless steel pipes
- fully automated and accurate temperature control
- highest possible heat exchange
- no calcification, no welding, no leakages

BIOGAS FLARES

- fully automated
- integrated gas blower
- for each gas flow
- made in stainless steel (SS304, 1.4301 or similar)
- open flare and covered flare are possible

Technical buildings machinery & control

TECHNICAL BUILDING (CONTAINERIZED) - MECHANICAL SECTION

The mechanical section of the technical building is the heart of the biogas plant.
Incl.

- compressor for compressed air supply (dry and filtered)
- automated gate valve system for total plant as proposed
- heating circuit distribution system (for heat supply of the CSTR and others)
- air supply for desulphurization in the CSTR gas phase
- fully automated substrate distributer system
- central pump station
- space for LP-blower

TECHNICAL BUILDING (CONTAINERIZED) - CONTROL SECTION

The control section of the technical building is the brain of the biogas plant.
Incl.

- air conditioned and insulated control room
- switching cabinet for the biogas plant
- power supply cabinet for the biogas plant
- plant control system for the biogas plant
- PC station with plant operation software iCoSy (SCADA/plant visualization and operation)
- Implementation of BOP equipment fully automated gas analyzer

CONTAINER ON DEMAND

technical containers | tool containers | laboratory containers | chp containers | customised containers

Plant control system iCoSy

TO REACH A HIGH LEVEL OF AUTOMATION,

BioEnergy Group installs a large number of sensors throughout the plant, such as filling level sensors, pressure sensors, flow meters, radar sensors, etc. At the same time, the biogas software has been programmed for easy and smooth plant operation and troubleshooting.

iBUG - are our experts for plant control systems, software and electrical planning for biogas plants. Our control software automates the processes within your biogas plant or production, ensuring maximum efficiency.
The modernization and conversion of the system software is carried out safely and quickly by our well-trained programmers so that the ongoing operation of your system does not have to be interrupted.

- user-friendly and intuitive design
- diagrams illustrate plant parameters
- extremely high degree of automation
- reduced energy consumption through integrated energy management system
- access via remote and APP for tablet and smartphone
- real time data access and automatic storage in online data base

Monitoring & controlling via 24/7 control room

THE BIOENERGY GROUP SERVICE TEAM IS AVAILABLE 24 HOURS A DAY, 7 DAYS A WEEK IN OUR CONTROL ROOMS, LOCATED IN GERMANY AND THAILAND.

Here, a team of technicians and engineers offer round the clock plant control surveillance.

The control room guarantees optimum servicing of the biogas plant at any time. In our control room we have the ability to log into the system of any biogas plant: Simply put, we see what the operator sees and can actively assist the operator in resolving any problems. This saves valuable time and money.

In the event of malfunctions or emergencies the BIOENERGY team is available at short notice and ensures quick troubleshooting.

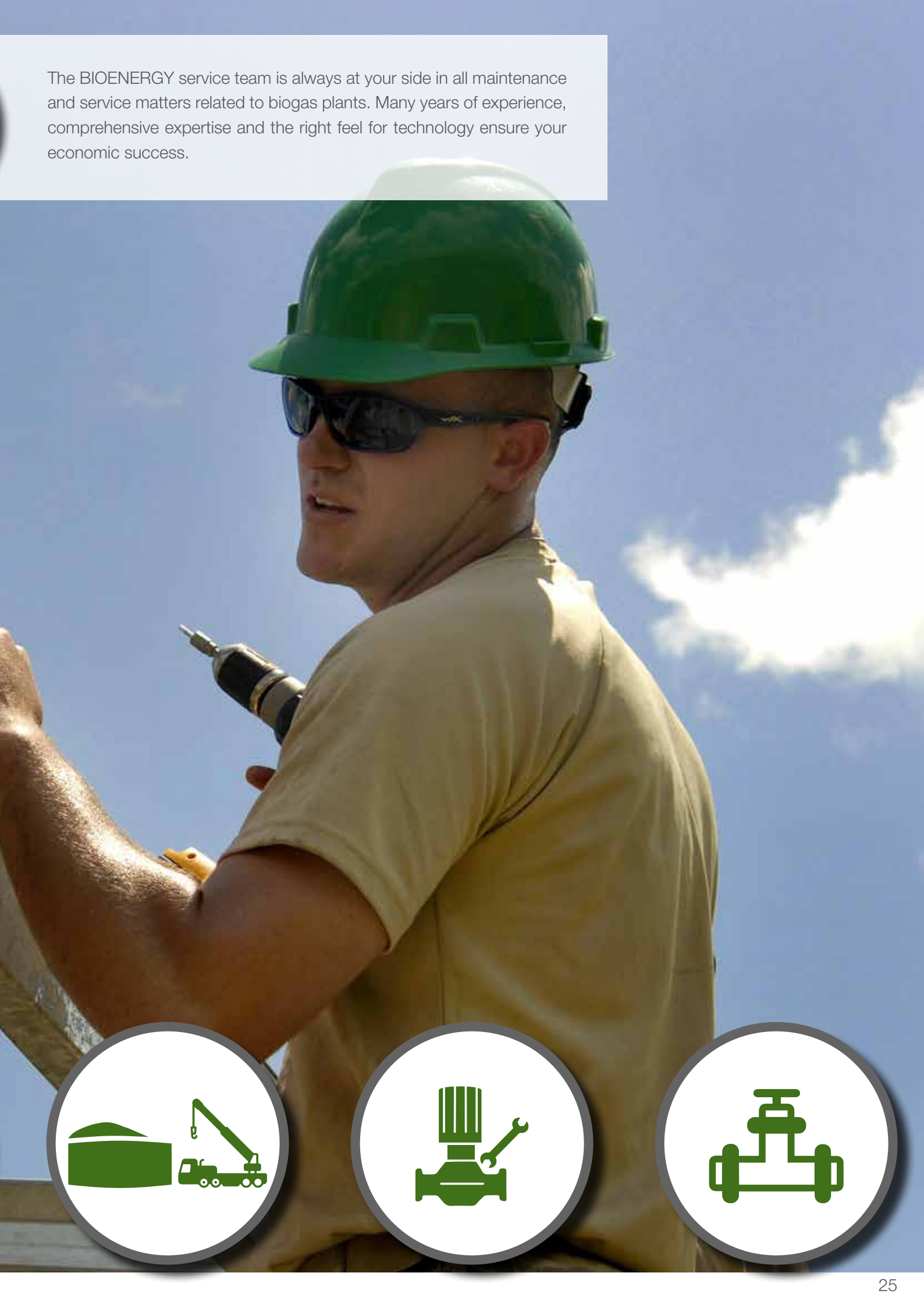
- A team of technicians offer 24/7 plant control surveillance.
- Additionally, we analyze plant system failure reports and give advice on how to resolve them.
- In case a problem can not be solved online or by the plant operator, the BIOENERGY GERMANY service & maintenance team is available 24 hours a day, 7 days a week to travel to the biogas plant and resolve the problem.
- Part of our monitoring and control service is the preparation of weekly, monthly and annual status and efficiency reports for you and your shareholders. Our compact and professional reports, focused on the important data and numbers, are available in English, German and in the Thai language.

Service and maintenance

ONE OF THE KEY FACTORS OF SUCCESS IS THE CONTINUOUS SERVICE AND MAINTENANCE OF THE PLANT COMPONENTS.

The BIOENERGY GROUP establishes a service structure in every country where it is active to guarantee fast, reliable maintenance and service.

The BIOENERGY service team is always at your side in all maintenance and service matters related to biogas plants. Many years of experience, comprehensive expertise and the right feel for technology ensure your economic success.



Liquid / Solid Separation

THE LIQUID-/SOLID-SEPARATION UNIT IS SUITABLE FOR A WIDE RANGE OF APPLICATIONS SUCH AS LIQUID-/SOLID SEPARATION OF CSTR DIGESTATE, WASTEWATER FROM FACTORIES OR WASTE WATER IN FRONT OF UASB REACTORS.

The separation unit was designed for continuous operation, and more than 250 units have been installed. The separation unit can be adapted for each case and amount of influent or effluent from 1 m^3/h up to several hundred m^3/h.

Different screen sizes available:
0.1 mm – 1.5 mm.

Reduction of more than 99.5% of solids > chosen screen sizeput

ADVANTAGES:

- easy regulation of the solid content
- high throughput rates
- fully automated operating software
- continuous operation possible
- easy maintenance
- low operating costs
- suitable for each flow by modular installation

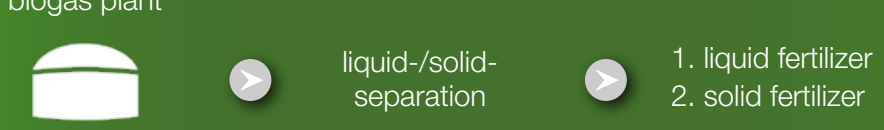
INDUSTRIES:

- starch/cassava industry
- ethanol industry
- food production
- palm oil industry
- biogas plants
- and many more …

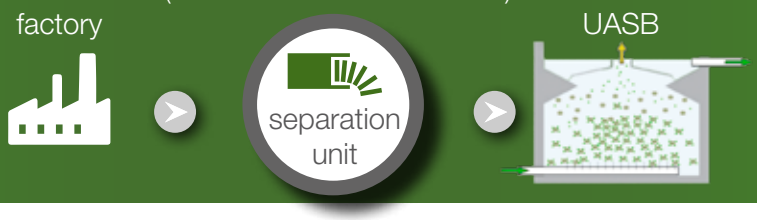
EXAMPLE OF USE

The separation unit is suitable for a wide range of applications to separate wastewater, effluents or influents into solid and liquid fractions.
In this way, in most cases the unit can replace sedimentation ponds, clarifiers and filters. In other cases, the size of sediment ponds, clarifiers and filters can be reduced, and the efficiency can be increased with the addition of a liquid / solid separation unit.

LIQUID-/SOLID-SEPARATION FOR DIGESTATE OF A CSTR BIOGAS PLANT



UASB PRE-TREATMENT WITH LIQUID-/SOLID-SEPARATION UNIT (REPLACING A CLARIFIER)



Biogas laboratory in Thailand (Korat)

FOR BIOGAS PLANTS, ONE ESSENTIAL KEY FACTOR OF SUCCESS IS THE KNOW-HOW AS WELL AS CONTINUOUS MONITORING AND CONTROLLING OF THE PROCESS BIOLOGY. TO SERVE OUR CUSTOMERS, WE OPERATE A LABORATORY IN KORAT, THAILAND, SPECIALIZED IN BIOGAS PROCESS BIOLOGY.

The laboratory enables us to determine the composition of the feedstock to be applied and to determine accurate details of the gas yield to be expected. Furthermore, the laboratory is an essential element for the biological maintenance of the biogas plant in operation.

OUR HIGHLY SPECIALIZED STANDARD ANALYSIS:

- pH-value, electrical conductivity
- VFA/TAC (volatile fatty acids and total alkalinity)
- DM and oDM (dry matter and organic dry matter)
- N_{total} and NH_4-N
- acetic acid equivalent and fatty acid spectrum
- gas yield test and inhibition test
- micro-, trace and macro nutrient requirements
- BOD and COD
- on-site gas quality analysis

BENEFITS OF LABORATORY SUPPORT:

- safe and fast start up
- safe plant operation
- smooth gas production without interruption
- continuously high methane content
- higher gas yield
- extended life of plant equipment

HIGH AND RELIABLE REVENUE THROUGH HIGHLY EFFICIENT PLANT OPERATION

Gas yield test and inhibition test

BOTH TESTS ARE BASED ON THE INTERNATIONAL STANDARD VDI 4630 TO MEASURE THE REAL GAS POTENTIAL OF AN INPUT MATERIAL AS WELL AS THE INHIBITION POTENTIAL OF DIFFICULT INPUT MATERIALS SUCH AS THE ORGANIC FRACTION OF MSW (OFMSW).

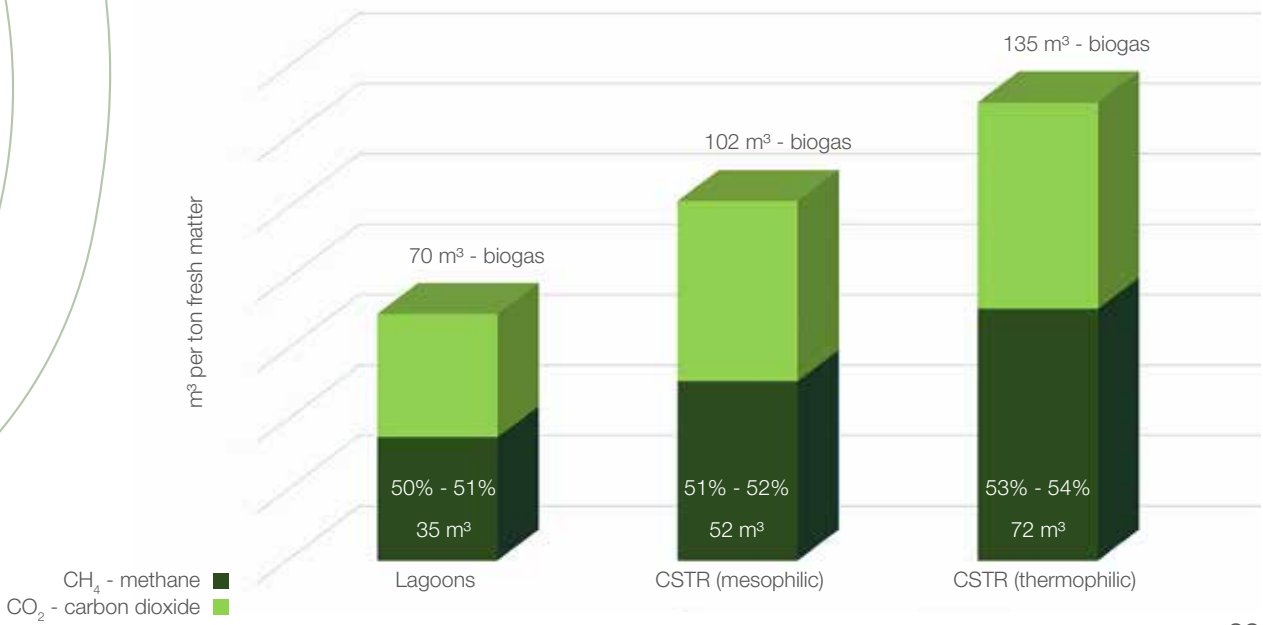
The gas yield test (also known as BMP – bio methane potential) includes:

- gas quality (CH_4, CO_2, H_2S, O_2)
- gas yield (total and per time)
- dry matter content, organic dry matter content and COD

GAS YIELD TEST – VDI 4630

- more than 9,500 biogas plants were designed based on VDI 4630
- >450 different input materials analyzed by our laboratory
- high accuracy by low cost
- testing time approx. 30 days
- perfect base for technical and financial design
- testing of each kind of feed-stock is possible

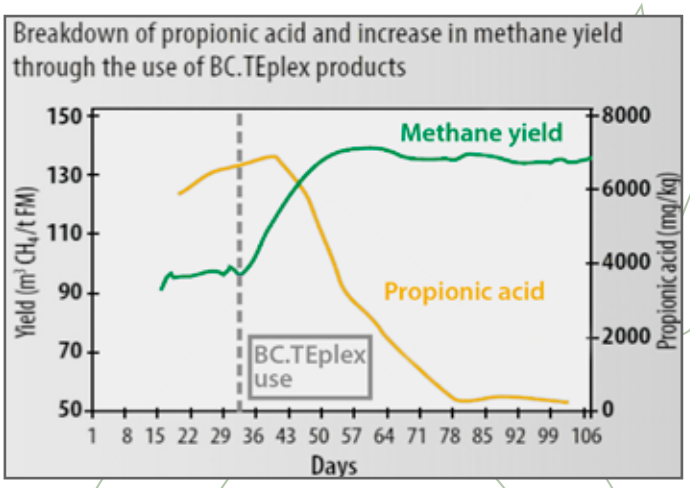
BIOGAS AND METHANE PRODUCTION PER TON OF FRESH NAPIER GRASS

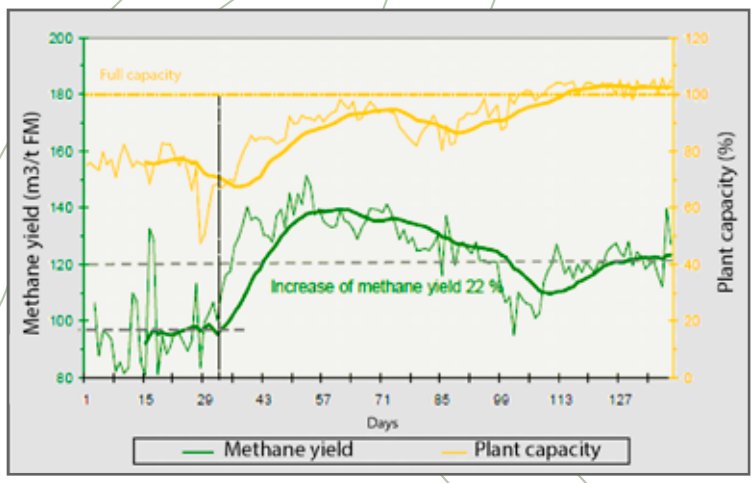


Biological maintenance additives

LAW OF THE MINIMUM (SPRENGEL/LIEBIG):
"THE GROWTH OF ORGANISMS IS LIMITED BY THE NUTRIENT IN SHORTEST SUPPLY"

The microorganisms involved in the biogas process need a wide variety of nutrients. Some of them are needed in very small amounts (micro and trace elements). Different microorganisms need different Nutrients.





TRACE ELEMENTS

Often the feed does not contain all the trace elements needed by all the different microorganisms involved in the biogas process. As a consequence, the microorganisms can not grow at their optimum speed and the conversion of feed into biogas is slow.

The lack of trace elements causes increasing VFA, decreasing gas quality, an unstable biogas process, foam, low biogas yield, process failure, economical losses.

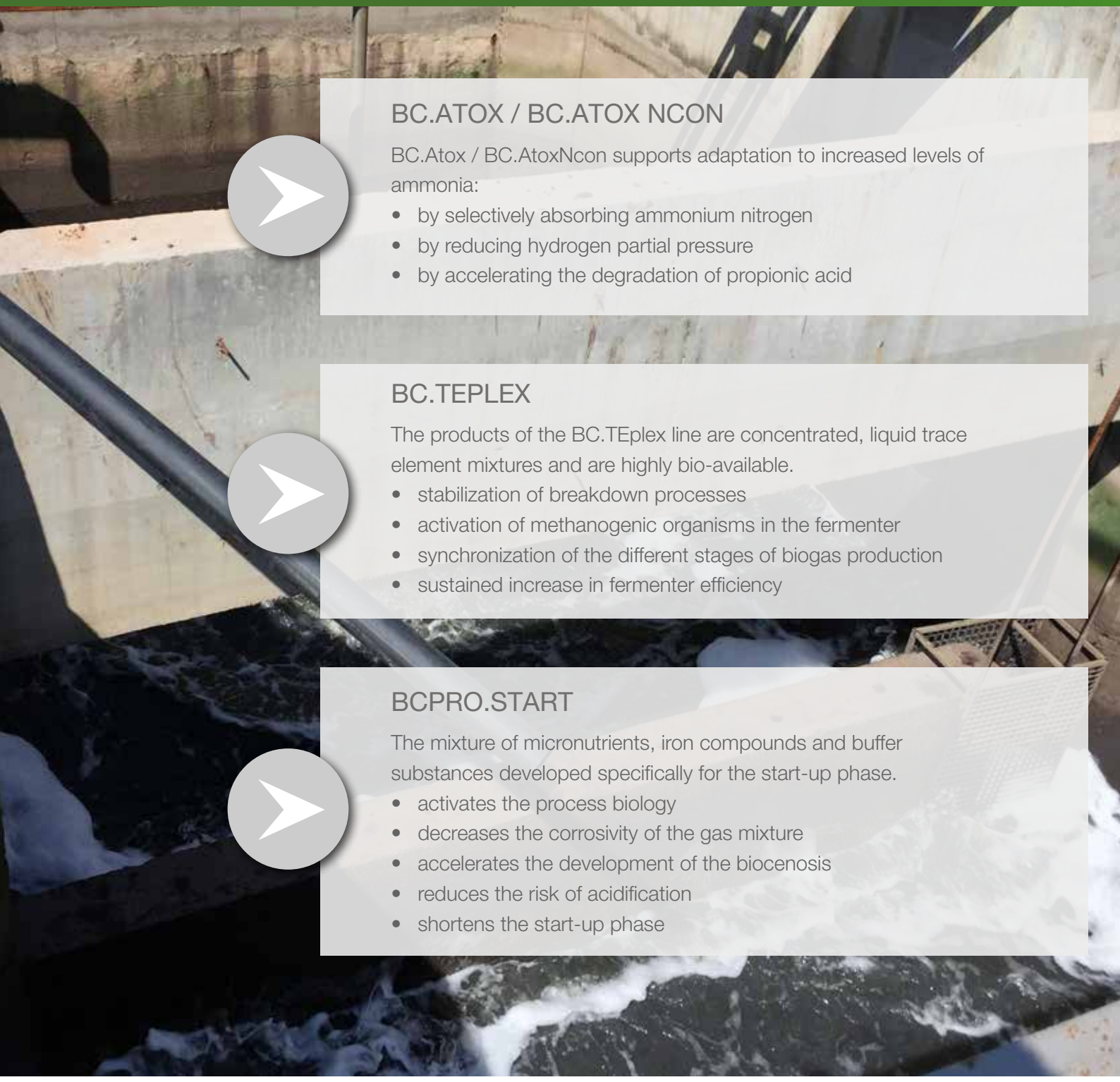
SCHAUMANN BioEnergy

BioEnergy Germany is the exclusive partner of Schaumann BioEnergy in Thailand.

Trace elements, nutrients & micronutrients

OUR PARTNER SCHAUMANN BIOENERGY GMBH IS THE LEADING SUPPLIER OF ADDITIVES FOR BIOGAS PLANTS AND WASTEWATER TREATMENTS.

We offer solutions for every type of plant and feedstock to optimize the biological processes and increase the gas production while reducing costs of operation.



BC.ATOX / BC.ATOX NCON

BC.Atox / BC.AtoxNcon supports adaptation to increased levels of ammonia:

- by selectively absorbing ammonium nitrogen
- by reducing hydrogen partial pressure
- by accelerating the degradation of propionic acid

BC.TEPLEX

The products of the BC.TEplex line are concentrated, liquid trace element mixtures and are highly bio-available.

- stabilization of breakdown processes
- activation of methanogenic organisms in the fermenter
- synchronization of the different stages of biogas production
- sustained increase in fermenter efficiency

BCPRO.START

The mixture of micronutrients, iron compounds and buffer substances developed specifically for the start-up phase.

- activates the process biology
- decreases the corrosivity of the gas mixture
- accelerates the development of the biocenosis
- reduces the risk of acidification
- shortens the start-up phase

Financing by the BioEnergy Group

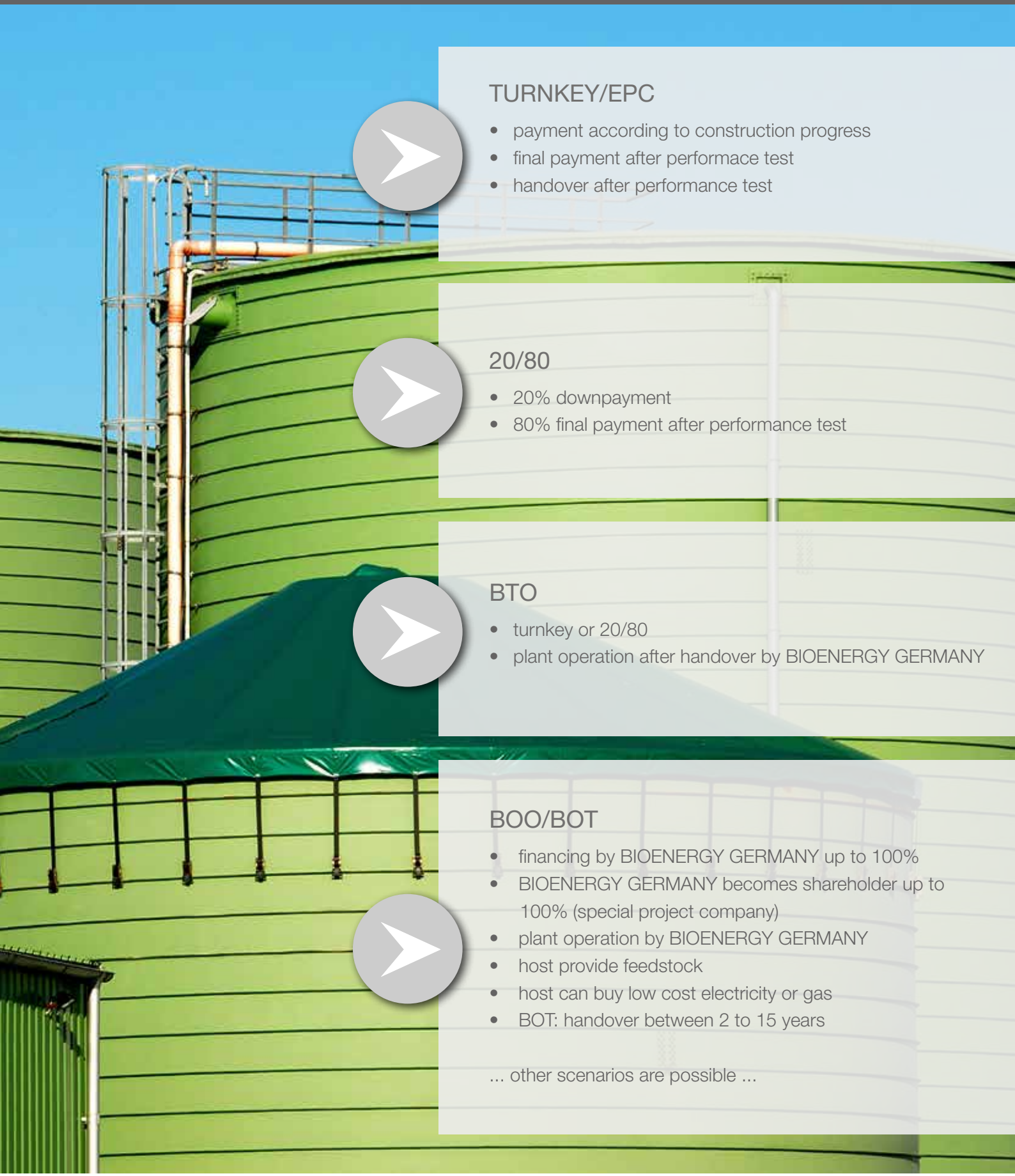
THE BIOENERGY GROUP OFFERS CONSULTING SERVICES TO PRIVATE INVESTORS WHO WANT TO INVEST IN RENEWABLE ENERGY PROJECTS, IN PARTICULAR BIOGAS.

The BioEnergy Group brings projects and investors together and analyzes the project with a feasibility study and risk assessment. With the BioEnergy Group financing concept, several biogas plants have been financed and built during the last years. The financial concept is flexible and can be adapted to the requirements of each project.

KEY FACTORS AND ESSENTIAL REQUIREMENTS

- ensuring feedstock supply
- ensuring revenue through (electricity, heat, cold, biogas, CBG, LPG) sales and/or utilization.
- leasing of the project land plots
- correct choice of technology
- maintenance friendly plant design
- continuous service and maintenance
- 24/7 monitoring and controlling of the process
- continuous “biological maintenance” and biological support
- plant operation only by experienced or well trained experts

Installation and operation models



TURNKEY/EPC

- payment according to construction progress
- final payment after performace test
- handover after performance test

20/80

- 20% downpayment
- 80% final payment after performance test

BTO

- turnkey or 20/80
- plant operation after handover by BIOENERGY GERMANY

BOO/BOT

- financing by BIOENERGY GERMANY up to 100%
- BIOENERGY GERMANY becomes shareholder up to 100% (special project company)
- plant operation by BIOENERGY GERMANY
- host provide feedstock
- host can buy low cost electricity or gas
- BOT: handover between 2 to 15 years

... other scenarios are possible ...

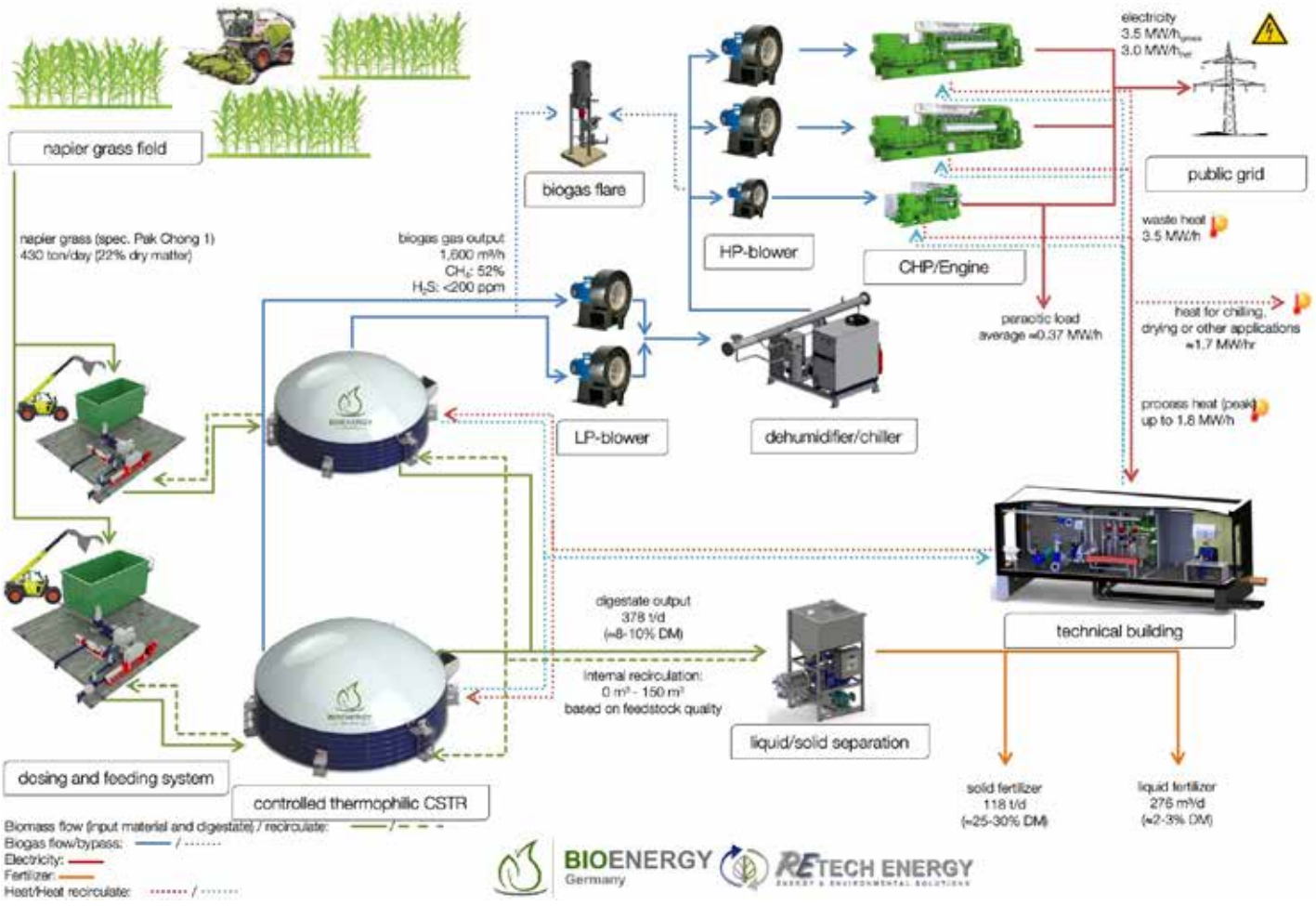
ENERGY FOR ALL
Thailand

- highly efficient CSTR biogas plants for different kinds of Napier Grass
  on example: Pack Chong 1, Kiew Siam, Raak Kaew
- all sizes available
- involved in research, project development, energy saving plant solutions

BIOGAS PLANT WITH CONCRETE TANKS

BIOGAS PLANT WITH GFS TANKS

FROM HARVEST TO THE GRID: 3.5 MW_{gross} based on Napier Grass Pack Chong 1



Selected references*

COMPLETE BIOGAS PLANTS

DELIVERY, INSTALLATION AND INTEGRATION OF A GAS DRYER/CHILLER

DELIVERY, INSTALLATION AND INTEGRATION OF AN EXTERNAL DOUBLE MEMBRANE GAS HOLDER

* detailed reference list on request only

CONTROLSYSTEM AND SOFTWARE FOR PLANT OPTIMIZATION - INSTALLED IN A TECHNICAL CONTAINER

PUMP CONTAINER FOR TWO PUMPS OF A LIQUID FEEDING SYSTEM INCL. CONTAINER VENTILATION SYSTEM, DRAINAGE SYSTEM, LIFTING DEVICE

SOFTWARE DEVELOPMENT AND INTUITIVE VISUALIZATION FOR BIOGAS PLANTS

SUMMARY OF BENEFITS

- BIOENERGY GERMANY is familiar with local requirements in EUROPE and SOUTH EAST ASIA (located in Thailand (Korat) and Germany)
- well established German technology adapted to local conditions (Thailand and South East Asia)
- service and maintenance team for all of our products - in Thailand and Germany
- high specialized laboratory service (located in Thailand and Germany)
- experience from the biological support of more than 300 biogas plants worldwide
- in-depth knowledge of the local feedstock
- 24/7 plant operation, management and monitoring in Thailand and Germany
- different plant models and financing (turnkey, BTO, 20/80, BOT, BOO)
- highest process efficiency (higher and reliable gas production)
- combination of international and local sources
- best price-performance ratio of biogas plants
- BIOENERGY GROUP has more than 15 years of experience in plant manufacturing and operation

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