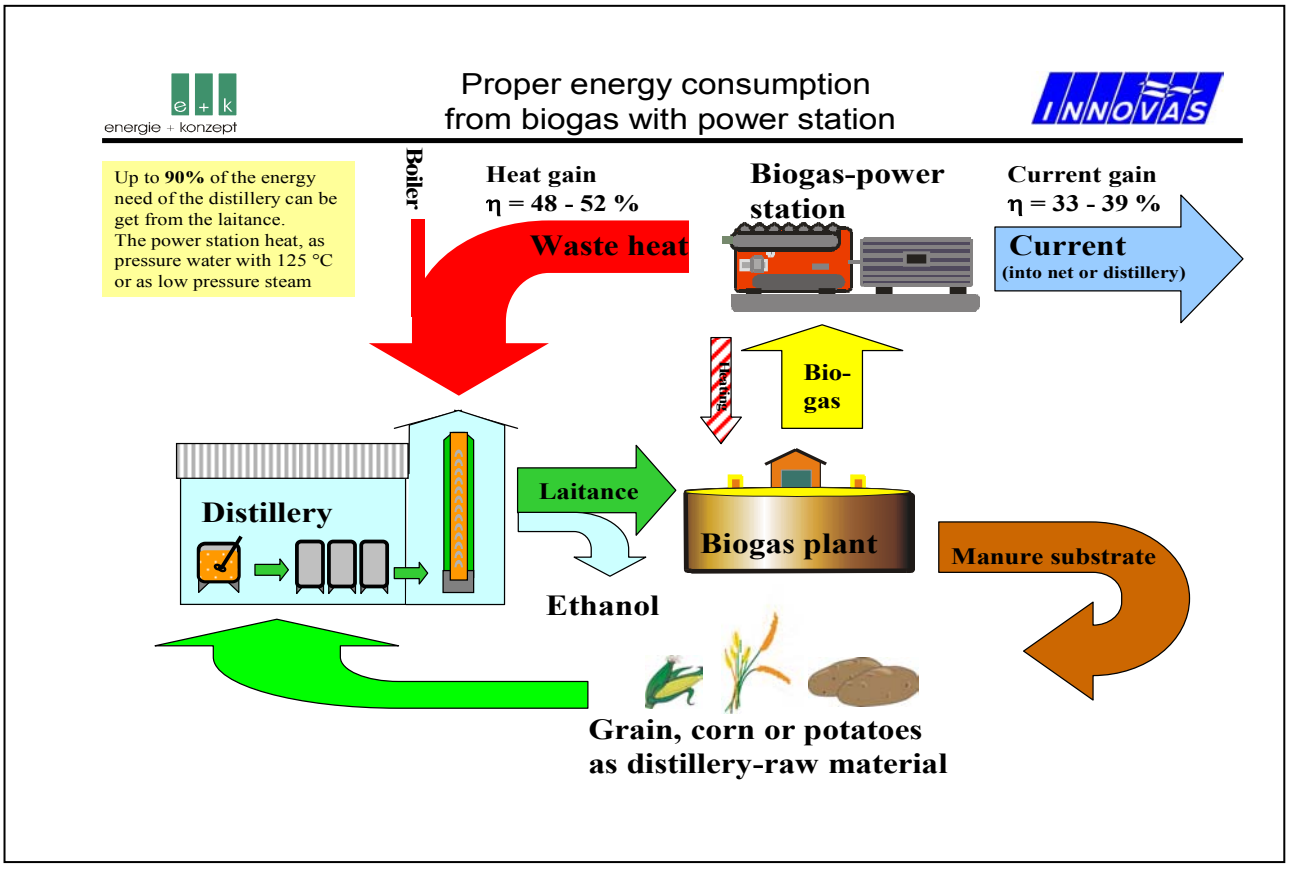
Distillery and biogas

Introduction

Biogas plant are successfully established in distilleries for many years. Biogas plants for distillery laitance are technically high developed and also work excellent with laitance from mono-substrate. The anaerobic fermentation is a natural process and the participated micro-organism are one of the oldest creatures on our earth. We are not able to change these processes fundamentally but support it positively. Following the regulations of the nature we get high-efficient and plants without problems.

The energy generation from laitance is an interesting alternative to the usual feed processing especially if the feeding market doesn't afford enough profit.



Principle graph of the proper energy supply of a distillery

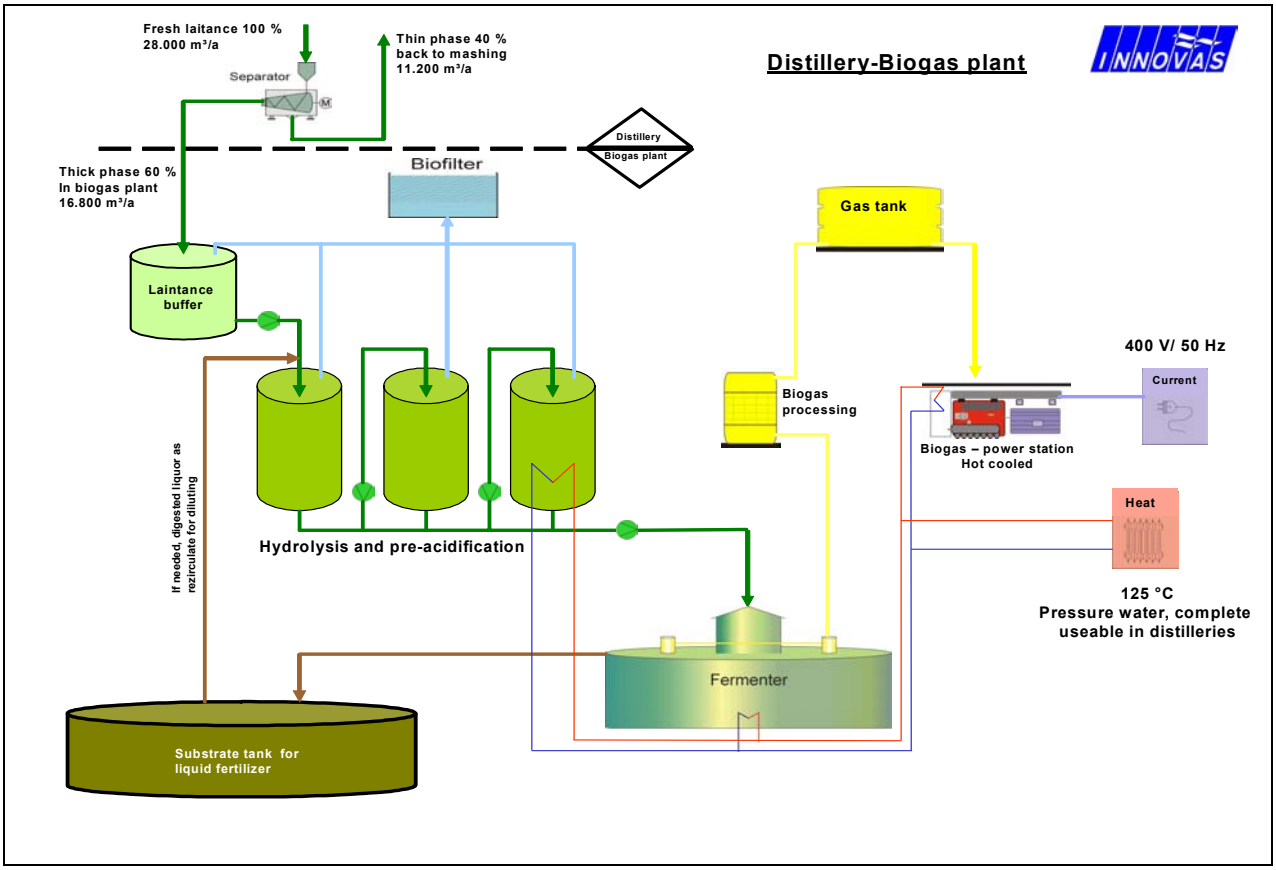
The renewable energy generation also from laitance is clearly valorised and appreciated by different bonus especially because of the new law about the priority of renewable energy (EEG). With these new regulations of the EEG the economical situation of biogas plants in distilleries was much more improved.

Therefore and because of the distillery branch which is actually in a state of change we have developed a plant concept which as an indispensable part will see that an agricultural distillery can be able to produce bio-ethanol for the fuel sector to market prices.

Plant concept

Our concept starts from the consideration that in Germany approx. 50-60 distilleries have a company size to process 6 m³ mash per hour. It was also assumed that the distillery works in two shifts, 6 days a week and 50 weeks per year. The concept of an enlarged distillery was detailed presented and published for example by Mr. Dr. Senn from the University Hohenheim, so that it can be disregarded here a detailed explanation. Only the fort he biogas production important facts are here explained.

In 300 production days a minimum of 28.000 hl raw alcohol per year are produced. Approx. 28.000 t/a of laitance arise with this. The laitance is separated in the distillery and ca. 40 % is moved back to the mash. Ca. 16.800 t/a of ca. 11 % TS concentrated laitance remain for the biogas plant.



Scheme in principle of a biogas production from laitance

Energy potential

For the calculation of the generatable biogas quantity it is assumed that in the future, especially in Bavaria, mainly corn laitance will be fermented. Of course the biogas plant will also work excellent with grain or potato laitance. The real biogas quantity will be naturally different according to the grain type and laitance consistence.

For the clarification of the connections here is some theory of the biogas production.

In general the substance groups of the fats, proteins and carbohydrates are useful for the biogas production while lignin is not anaerobe degradable. Therefore it is not possible to get biogas from a crude fibre which has a stabile lignin shell.

The gas formation and the content of CH_4 (gas quality) depends also from the material composition. Knowing the composition it is possible to calculate the theoretical generatable biogas quantity and its CH_4 and CO_2 content with the help of the Buswell-Formula. As a matter of convenience we have tabulated the possible gas and methane formation.

Constituent / Basic substance	stoichiometrical biogas yield (Litre Biogas / kg OTS)	ca. methane content in biogas (% in Biogas)
Fats	1.400 l/kg (1,4 m³/kg)	80 .. 90 %
Proteins	600 .. 900 l/kg (0,6 .. 0,9 m³/kg)	75 .. 80 %
Carbohydrates	700 .. 800 l/kg (0,7 .. 0,8 m³/kg)	50 .. 60 %

Table 1 – Gas yield from added organic

Concerning the laitance the biogas quantity and so the generatable amount of energy can be rated with these figures and with the known composition of the biogas.
To get a neutral comparison we have taken the composition of the following described laitance type from the „DLG-Feeding value tables“.
To make the different laintance type comparable the TS-content was determined uniform to 7.0 %, although the TS content can vary from 5.5 to 12 % according to the used distilling process.

Type of laintance	TS/OTS (%)	Raw fat (g/kg TS)	Proteins (g/kg TS)	Carbohydr. (g/kg TS)	Basic fibre (g/kg TS)	specif. gas production rate (m³/kgOTS)	Biogas per 1 m³ laitance (m³/m³)
Potato laitance	7,0 / 85 %	17 g	285 g	451 g	106 g	0,60 m³/kg	36 m³
Wheat	7,0 / 88 %	67 g	362 g	416 g	97 g	0,65 m³/kg	38 m³
Rye	7,0 / 88 %	54 g	431 g	406 g	56 g	0,68 m³/kg	40 m³
Corn	7,0 / 94 %	82 g	297 g	466 g	104 g	0,70 m³/kg	45 m³

Table 2 - typical biogas yields from laitance

These gas yields can only be obtained with a two-step high-performance biogas plant, whose process steps are carefully adjusted. Simple, one-step biogas plants with the usual feeding and stirring technology will never achieve such decomposition rates and gas yields from laitance.

Now we are coming to our model calculation of a 28.000 hl distillery.

assumed laitance quantity (separated quantity)	16.800 t/a 48 t/d

(Notice: contrary to the distillery the biogas plant is fed constantly. The laitance quantity is divided on 7 days a week. So we get 350 operation days a year.)

assumed laitance composition	11 % TS, of it 89,5 % OTS ca. 4.885 kg OTS/d
digestion tank volume	1.700 m³
tank load in fermenter	2,92 kg OTS / m³ x d
specific gas generation rate (with haircut)	600 litre Biogas / kg OTS
generatable biogas	ca. 2.950 m³/d ca. 1.032.500 m³/a
biogas quality	> 70 % CH_4
primary energy quantity in biogas	ca. 20.500kWh$_{prim.}$/d ca. 7.190.000kWh$_{prim.}$/a

Energy use

With the reorganization of the law about the priority of renewable energy some essential improvements of the feeding prices also for distilleries have been the result.
Beside the graduated basic tariffs an additional bonus for combined heat and power and for renewable resources is paid. Laitance from agricultural distilleries is considered as renewable resource according to the EEG.

Current tariff acc. to new EEG	11,5 ct.€/kWh until 150 kW 9,9 ct.€/kWh over 150 kW 10,6 ct.€/kWh mixed price
plus renewable resource bonus	6,0 ct.€/kWh
plus combined heat and power bonus	2,0 ct.€/kWh

(Particular a distillery has very good conditions for the combined heat and power bonus, because the biogas plant has in principle no need of specific heat. The laitance is at the disposal in a warm state.

Total of possible feeding tariff	18,6 ct.€/kWh

The aforementioned tariff calculation refers to the first year of the effective date of the EEG. Plants which are set to work later, the feeding remuneration is reduced by 1.5 % each.

To use the waste heat of the power station also in the distillery a so called hot cooled power station is established. The heat is as pressure water with 125 °C at these aggregates at the disposal.

With an annual performance of 8.000 operating hours a power station can be run with 330 kW.

Power station performance electrical	330	kW
Efficiency $\eta_{electr.}$	36	%
generatable current	ca. 7.380	$kWh_{electr./}d$
	ca. 2.583.000	$kWh_{electr./}a$

Possible profit from current sale (with use of all bonus) **ca. 480.000 €/a**

Power station performance thermal	470	kW
Efficiency $\eta_{therm.}$	52	%
generatable heat energy	ca. 10.660	$kWh_{therm./}d$
	ca. 3.731.000	$kWh_{therm./}a$

Total of generatable heat energy (at a heating oil price of 0,35 €/l)	ca. 130.500	€/a
at a two shift operation of the distillery only 60 % can be used effectively in the distillery value	ca. 78.000	€/a
theoretical value of the unused heat energy	ca. 52.000	€/a

(Regardless of this the proportionate combined heat and power bonus is spared!)

That's why it should be thought about run the distillery also 24 hours and 350 days a year. A biogas storage for 10 hours would also be possible, but this means increased local requirements and higher investment costs.

Proper energy consumption, operating costs

The proper energy consumption of the laitance biogas plant is relative low.

Proper current consumption of the biogas plant	ca. 200.000	$kWh_{electr./}a$
with 10 ct.€/kWh calculated,	ca. 20.000	€/a

The heat energy demand can be disregarded if the laitance with a temperature of 40-50 °C can be provided.

The personnel application for the operation of a laitance biogas plant is because of the possible degree of automation very low. We calculate with 2 hours a day for the monitoring. These monitoring tasks are done by the distillery staff.

Proportionate personnel costs 700 h/a, à 20,- €/h	ca. 14.000	€/a
Maintenance costs and repair reserves	ca. 50.000	€/a
several resources, analytic etc.	ca. 5.000	€/a

The capital costs for credits and the depreciation of the plant must be added.

Costs for the supply of the laitance and fort he disposal of the fermentation rests have not been taken into consideration, because these costs are part of the raw material production of the distillery.

Use of the fermentation rests

The fermentation rest from the biogas plants reused as high-quality liquid fertilizer in the companies of the raw material suppliers.

as fertilizer is at disposal	ca. 15.300 t/a
with	ca.2 % TS

The balancing of the fertilizer ingredients (fertilizer value) was disregarded because in this concept the fermentation rest shall be moved back to the ground from where the raw material was harvested and these nutrients extracted.

Investment costs

If the biogas plant is planned and built as a single plant the following investment costs could arise:

Laitance treatment, hydrolysis etc.	ca.	284.000 €
Fermenter, 1.700 m³ digestion tank	ca.	193.000 €
Biogas treatment, storage etc.	ca.	173.000 €
Substrate discharge, storage for 130 days	ca.	132.000 €
Biofilter	ca.	21.000 €
Control engineering electrics	ca.	50.000 €
Power station, incl. current and heat retention	ca.	250.000 €
Buildings, company and protection buildings (easy construction)	ca.	125.000 €
Erection, commissioning etc.	ca.	29.000 €
additional costs, contingencies	ca.	86.000 €
Planning costs	ca.	132.000 €
Total investment for biogas plant (single planning)	ca.	1.475.000 €

If it is possible to build more plants (e.g. 30) in a short time the costs could be reduced by 15 % because of rationalization effects.

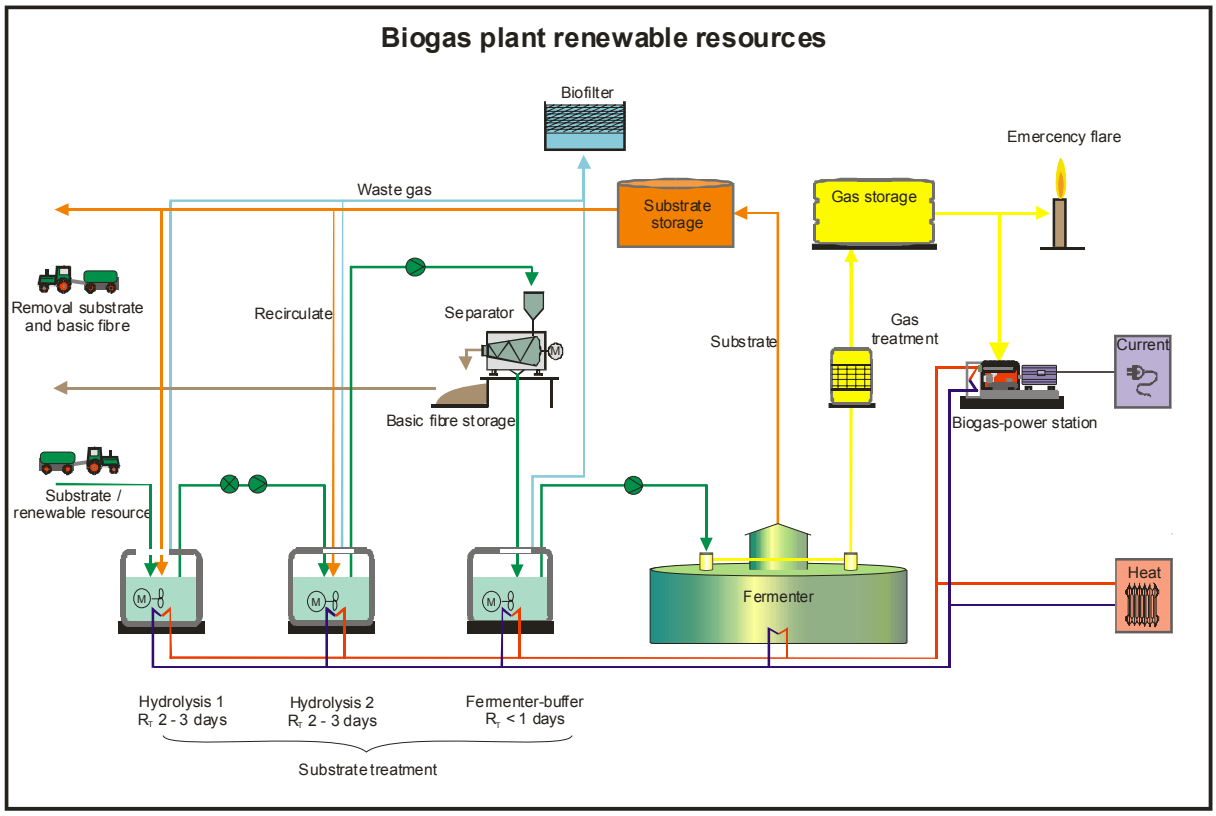
It must also be clear that a well-behaving organisation of the execution of contracts must be developed.

As a matter of convenience, in our concept presentation we calculate with a cost reduction of estimated 10 % and round upward or downward to full 1.000 €.

Laitance treatment, hydrolysis etc.	ca.	256.000 €
Fermenter, 1.700 m³ digestion tank	ca.	173.000 €
Biogas treatment, storage etc.	ca.	156.000 €
Substrate discharge, storage for 130 days	ca.	119.000 €
Biofilter	ca.	18.000 €
Control engineering electrics	ca.	45.000 €
Power station, incl. current and heat retention	ca.	225.000 €
Buildings (easy construction)	ca.	113.000 €
Erection, commissioning etc..	ca.	26.000 €
additional costs, contingencies	ca.	74.000 €
Planning costs for standard plant, allocated to 30 plants	ca.	8.000 €
individual construction support and project management	ca.	35.000 €
Total investment for standardized biogas plant	**ca.**	**1.248.000 €**

Comparison with fermentation of corn silage

Interesting is a comparison of similar biogas plants, which are fed for example with corn silage.



Principle graph of the biogas production from laitance

The layout citeria is the maximum tank load of 3.0 kgOTS/m³*d, or 4.900 kg of organic substance (OTS) per day.

To produce ca. 1.032.500 m³ of biogas, you need ca. 5.500 - 5.700 t of corn silage (end of the maturity of paste, ca. 35 % TS).

If we assume an average yield of 50 t/ha, an acreage of at least 110 ha is necessary.

The biogas from corn silage has a worse quality than biogas from corn laitance. You can calculate with a methane content of ca. 65 % CH_4.

This means a primary energy quantity in the biogas of	ca. 19.175	$kWh_{prim.}$/d
	ca. 6.711.250	$kWh_{prim.}$/a
With the same power station and the same efficiency is generatable	ca. 6.900	$kWh_{electr.}$/d
	ca. 2.415.000	$kWh_{electr.}$/a

possible current sale from corn silage **ca. 400.890 €/a**
(basic tariff 10,6 ct.€/kWh, + 6,0 ct.€/kWh renewable resource bonus, without combined heat and power bonus)

At a single standing biogas plant for renewable resources it must be considered that higher operation costs will arise than with a laitance plant.

The investment costs will be higher by 80.000 – 150.000 e because of additional treatment technology and additional driving silo.

The proper energy consumption is higher because of the necessary treatment	ca. 300.000	$kWh_{electr.}$/a
with 10 ct.€/kWh calculated	ca. 30.000	€/a

At least 20 % of the generatable heat must be calculated for the proper heat consumption. However we calculate in our model without additional heat use.

The personnel application for the operation of a renewable resources biogas plant is clearly higher than in a distillery biogas plant. We must calculate with 4 hours fort he feeding, substrate treatment, monitoring etc. Additional personnel must be engaged.

Particular personnel costs 1.400 h/a, à 20,- €/h	ca. 28.000	€/a
Maintenance costs, repair reserves, resources, analytic (like distillery plant)	ca. 55.000	€/a

Last but not least the raw material provision must be calculated. If we assume a production price of 20,- €/t, the raw material costs will be ca. 110.000 €/a

Result

If we compare the economy of a renewable resource biogas plant with a laitance plant of a distillery it will be ascertained that the added value of a distillery plant will be 4-5 times higher than from a simple renewable resource plant.

Finally because of the higher incomes from the current sale the lower profits from the sale of bio-ethanol can be compensated and thus the distillery is capable to work.

Altogether a biogas plant in combination with a distillery can also achieve a positive amount of coverage fort he company as a single planned plant.
Amortization times under 4 – 5 years are at this point possible because of improved feeding tariffs.

For renewable resources plants it must be noted that despite the improved feeding tariffs a secured economy can only be achieved if also the heat arising from the electricity formation is used convenient and profitable. The second fact is the optimization of the entire raw material production and the provision logistics.

INNOVAS Innovative Energie- und Umwelttechnik
Anselm Gleixner und Stefan Reitberger GbR
Margot-Kalinke-Str. 9, D-80939 München
Phone: 089 - 16 78 39 73, Fax: 089 - 16 78 39 75
E-Mail: info@innovas.com
URL: http//www.innovas.com

DGE GmbH
Dr.-Ing. Günther Engineering GmbH
Hufelandstr. 33, D-06886 Wittenberg
Phone: +49-3491-661841, Fax: +49-3491-661842
E-Mail: dge-info@t-online.de
www.dge-wittenberg.de