Technical Challenges in Biogas/Biomethane Plants for Production of Biofuels

Torsten Fischer and Smilja Latinovic

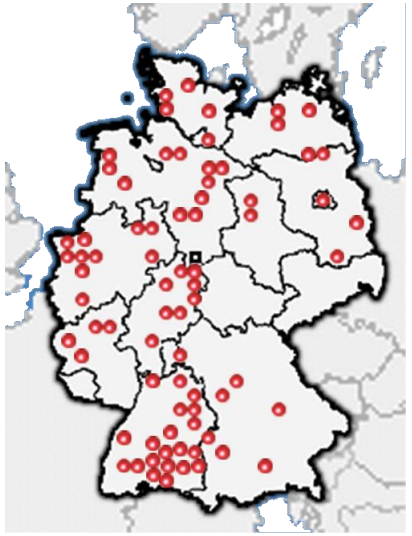
Krieg & Fischer Ingenieure GmbH
Bertha-von-Suttner-Strasse 9, D-37085 Göttingen, Germany
Tel.: ++49 551 900 363-0, Fax: ++49 551 900 363-29
Fischer@KriegFischer.de
www.KriegFischer.de

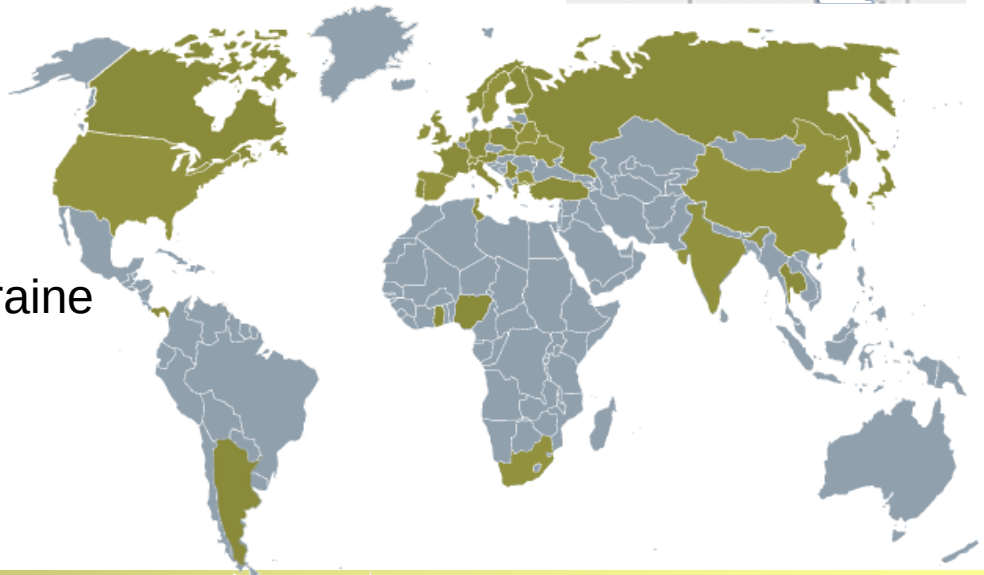
Amsterdam
November 30th, 2022

Krieg & Fischer Ingenieure GmbH

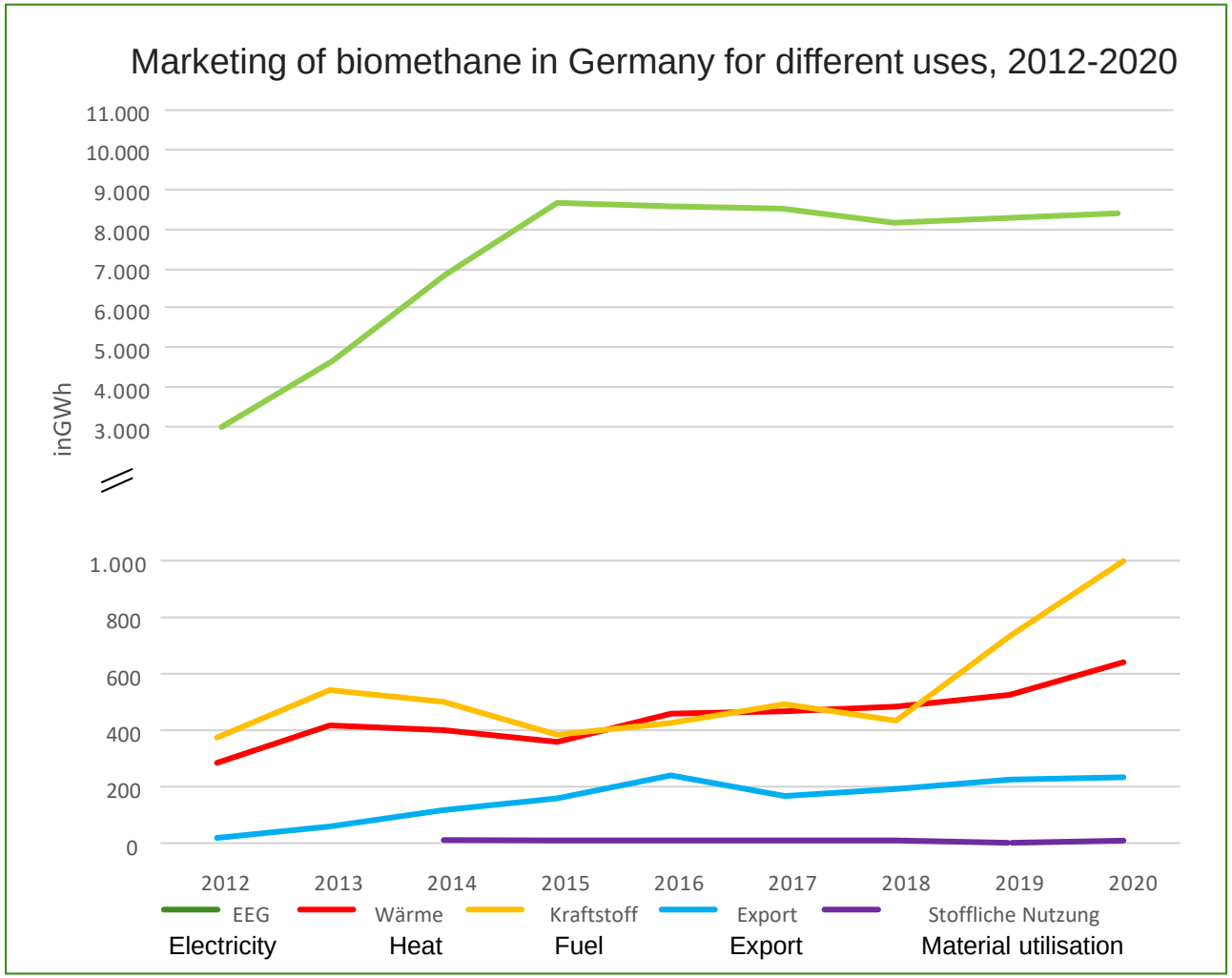
Engineering Office, specialized in Design and Engineering of Biogas Plants

Foundation:	1999
Team:	25
Experience:	> 35 Years
References:	ca. 200 Biogas Plants
in:	Germany, Japan, Netherlands, Austria, Switzerland, Lithuania, Italy, Slovakia, Canada, USA, Spain, France, Ireland, Russia, India, China, Argentina and Ukraine
Partner in:	Japan, Canada, Bulgaria, Poland, Italy, Spain and Ukraine





Biomethane use in Germany



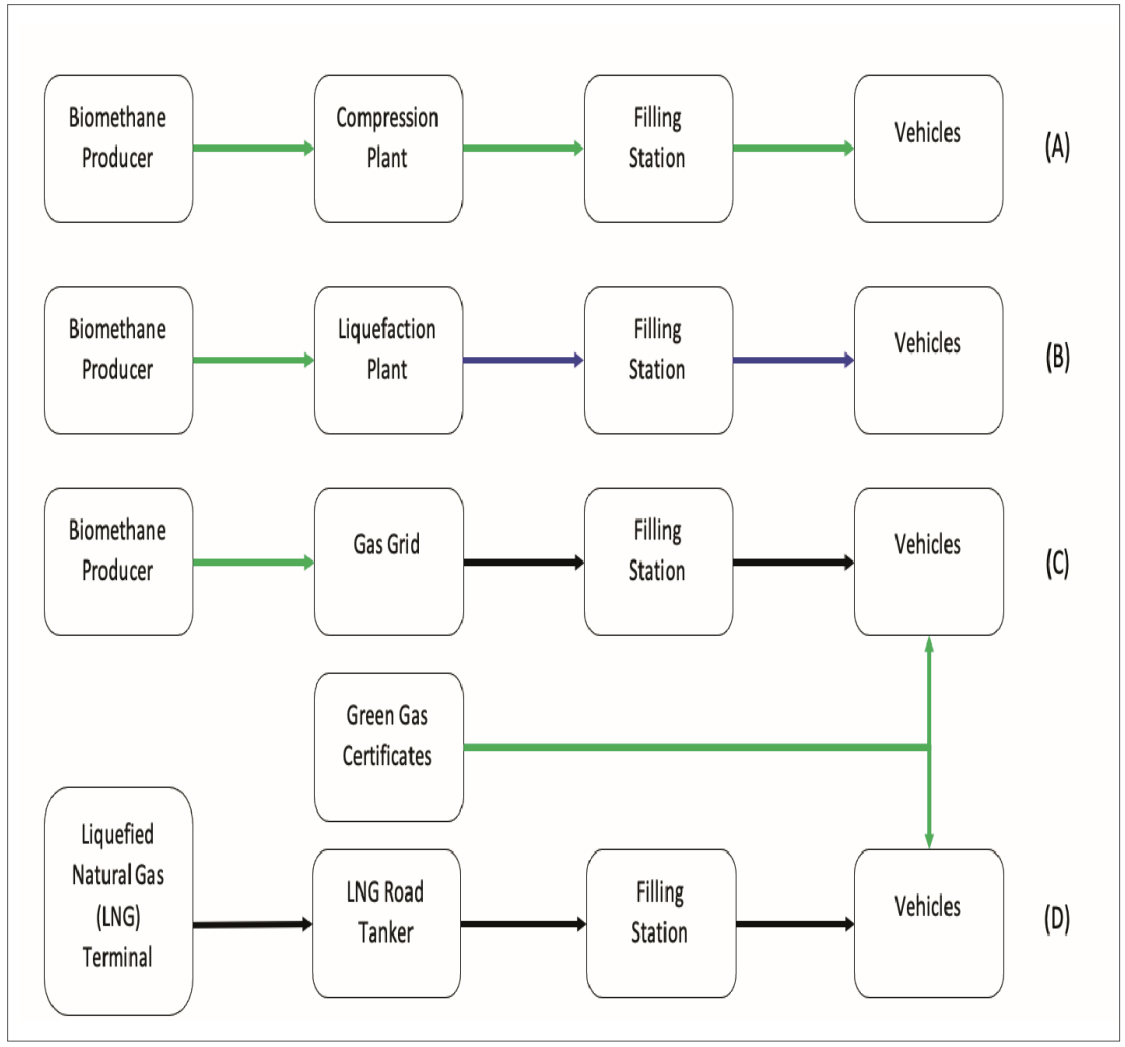
Source: Branchenbarometer Biomethan 2021, Deutsche Energie-Agentur GmbH

Biomethane in Germany's transport sector

Year	Biomethane Feed-in [GWh]	Thereof fuel utilization [GWh]
2020	9,847	1,000
2019	9,823	700
2018	10,108	389
2017	9,893	380
2016	9,318	379

Source: Fachverband Biogas e.V.

Biomethane as vehicle fuel - supply chains to filling stations



Source: IEA Bioenergy 2021

Direct connection to biomethane producer, compressed biomethane (Bio-CNG).

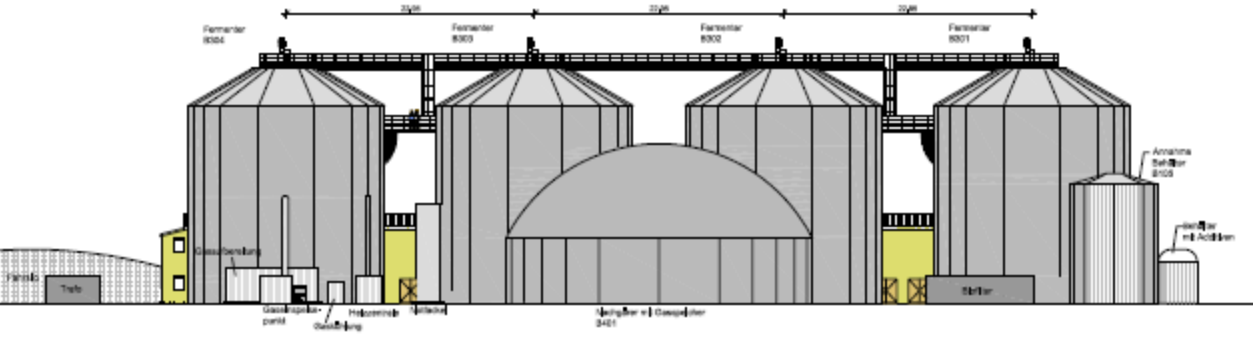
- Used for passenger cars and light vans

Direct connection to biomethane producer, liquefied biomethane (Bio-LNG).

- Primarily used for heavy goods traffic and maritime or inland waterway traffic

Compressed biomethane via gas grid and green gas certificates.

Dinteloord, The Netherlands



- Built: 2011
- Substrate: sugar beet ends, sugar beet leafs, sugar beet, vegetable waste 114,000 t/a
- Digester: 4 x 4,480 m³ steel tank
- Upgrading of 1,750 m³/h biogas to 990 m³/h methane

Source: Cosun Beet

Krieg & Fischer Ingenieure GmbH

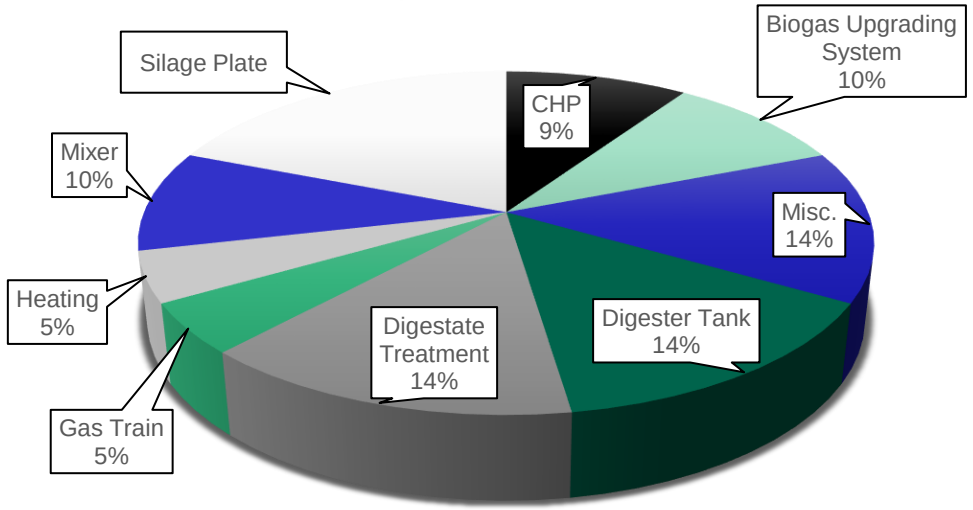
Technical Challenges in Biogas/Biomethane Plants for Production of Biofuels

Evaluation of expert reports 2010 - 2022

Basis of this Investigation:

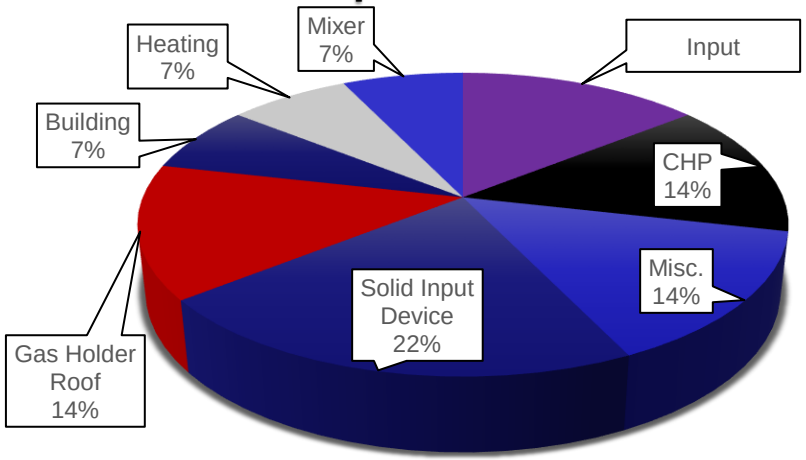
- Krieg & Fischer expert reports written in the past 12 years or so.
- Court cases, Insurance cases, private orders.
- Germany, Austria, Netherlands, USA, Japan, France.
- Result: 220 expert reports.

Topics in 2015

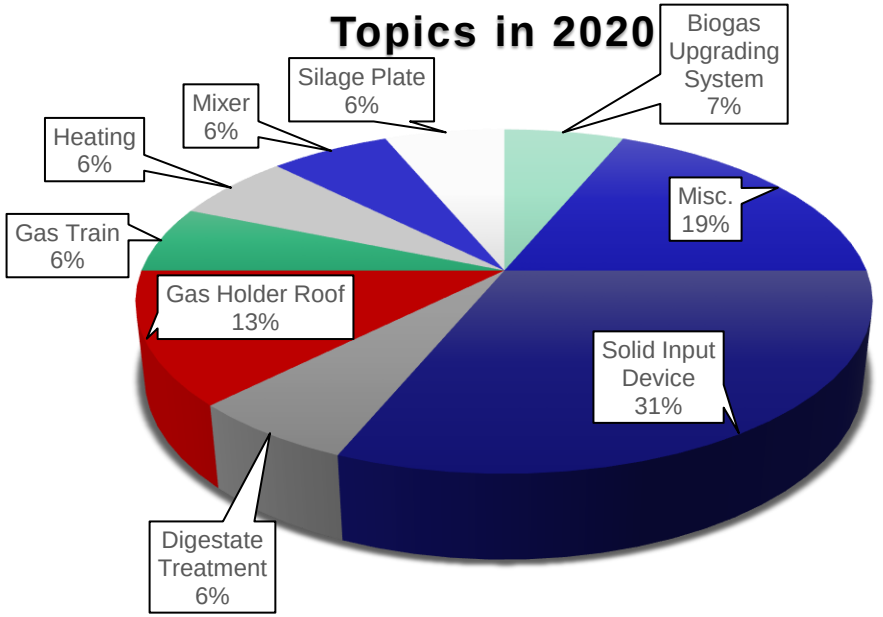


Krieg & Fischer Ingenieure GmbH

Topics in 2010



Topics in 2020



Biogas plant with biogas upgrading unit and biomethane production, built in 2011.

Accident: 2017
Insurance Case
Burning RTO

Photo by Operator

RTO
(Regenerative Thermal Oxidizer)

- Exhaust gas treatment (behind the biogas upgrading unit)
- Combustion device
- Input: The CO2-stream behind the biogas upgrading unit (including CH4, VOCs, etc.) → aim: minimising methane emissions.
- Output: CO2, H2O (99+ %)

Biogas plant with biogas upgrading unit and biomethane production, built in 2011.

Accident: 2017
Insurance Case
Burning RTO

Photo by Operator

Krieg & Fischer Ingenieure GmbH

Firefighters at work

Photo by Operator

Krieg & Fischer Ingenieure GmbH

Firefighters found an oil-type kind of sludge inside the RTO

Krieg & Fischer Ingenieure GmbH

Biogas Upgrading

Reason for accident:

- No proper documentation of the biogas treatment, the biogas upgrading unit incl. RTO.
- Wrongly/badly designed desulphurisation system upfront the biogas upgrading unit.
  → accumulation of elementary sulphur in all the upgrading unit.
- Service contract for maintenance for the biogas upgrading unit. Poorly educated staff on site → calling the maintenance company in case something looked wrong.

- Direct reason: Solvent from the biogas upgrading unit entered the RTO accidentally. Due to the very hot environment a fire started.
- Indirect reason: badly maintained peripherical equipment → defect ball valve / dirty sludge tank / blocked outlet / inoperable electrical contact.

Krieg & Fischer Ingenieure GmbH

Inoperable Ball valve as indirect reason for the accident

Lessons learned
Conclusion Biogas Upgrading Units:

- Biogas Upgrading unit: High availability – compared to CHP.
- Between 2015 and 2020 about 7-10% of the investigated accidents (by Krieg & Fischer) are linked to biogas upgrading. Less though in the past couple of years.
- RTO requirements new in Germany in 2010. (Only two accidents with RTO known by Krieg & Fischer).

- Proper documentation needed.
- Clear structure/organization/responsibility for maintenance service required.
- Ongoing education of staff needed. Again and again.
- Inoperable ball valve created accidental costs of less than € 10,000 for repair and about € 100.000 for stop of operation.

In case somebody is interested in more cases:

Bioenergy accident investigation

Torsten Fischer of Krieg + Fischer Ingenieure discusses a legal investigation related to the deficiencies of a digestate dryer at a German biogas plant

First-person sleuthing: investigating a digestate dryer

Torsten Fischer, founder and managing director at Krieg + Fischer Ingenieure, has been an expert legal witness for more than 10 years covering 120 cases

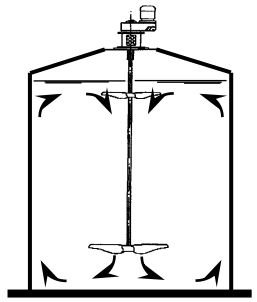
My reaction

Dryers are always difficult; this is no easy job.

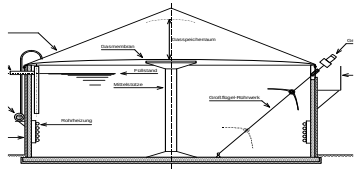
The job

Fermenter and plant types

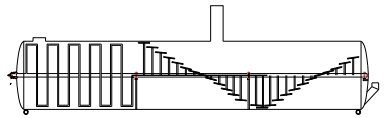
- High Fermenter, central agitator



- Flat Fermenter, side mounted agitators



- Horizontal Fermenter, reel agitator



- Others and combinations

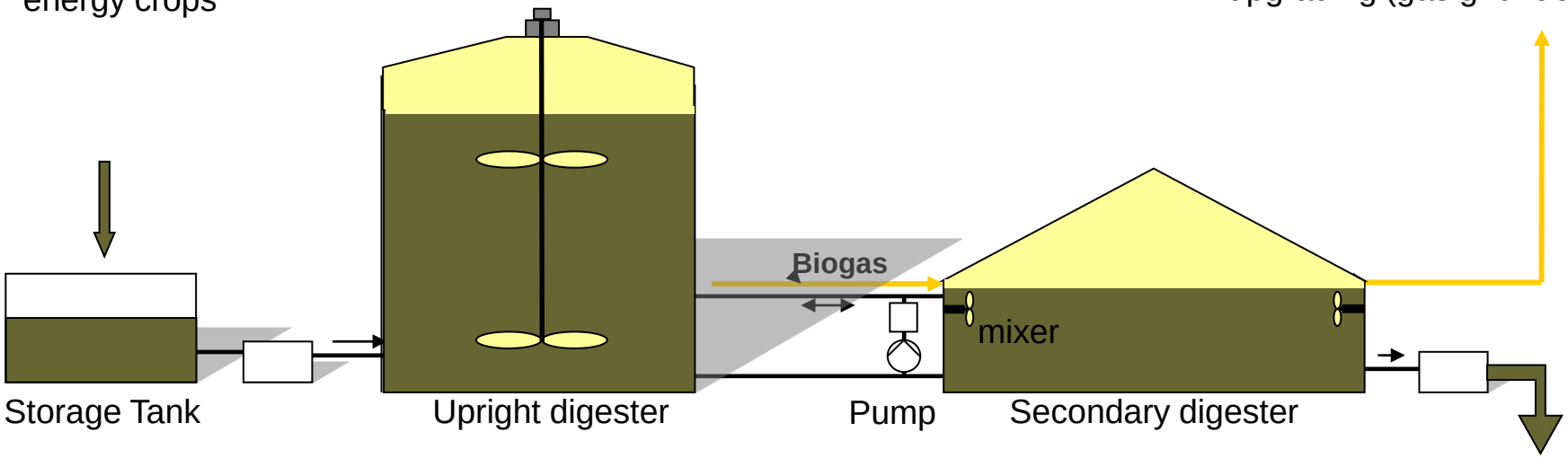
Biogas concept with upright digester

Substrate

manure
organic waste
energy crops

mixer

Gas utilization
→CHP (power, heat)
→direct use (heating, cooking, light)
→upgrading (gas grid fuel, fuel cell**)**



Input device
→piston pump, screw etc. (solids)
→pump (fluids)

Heat exchanger

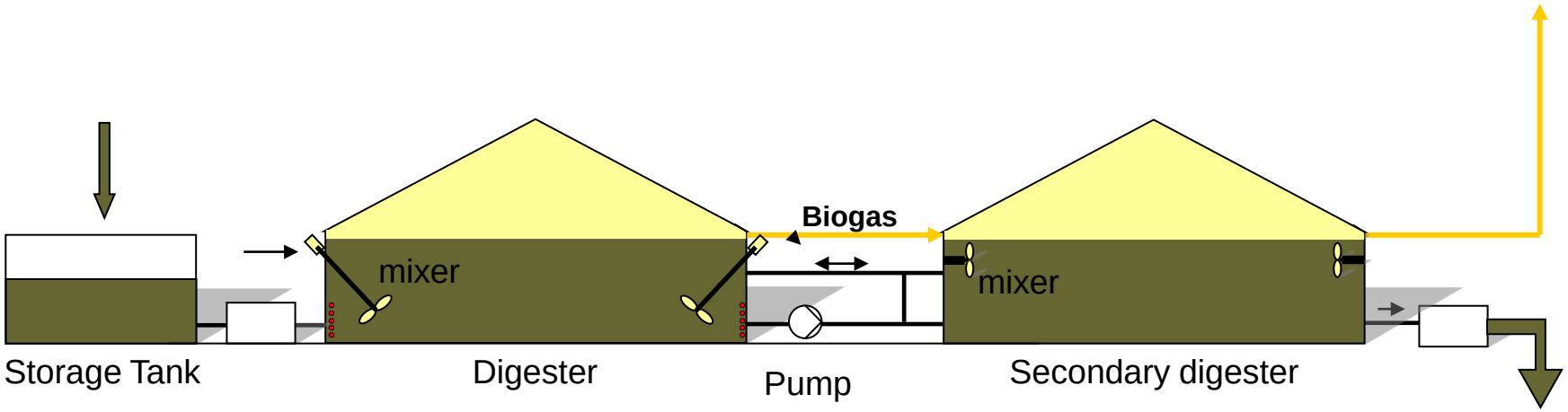
Digested substrate
→storage and use as fertilizer
→treatment

Biogas concept with flat digester

Substrate

manure
organic waste
energy crops

Gas utilization
→CHP (power, heat)
→direct use (heating, cooking, light)
→upgrading (gas grid fuel, fuel cell**)**



Input device
→piston pump, screw etc. (solids)
→pump (fluids)

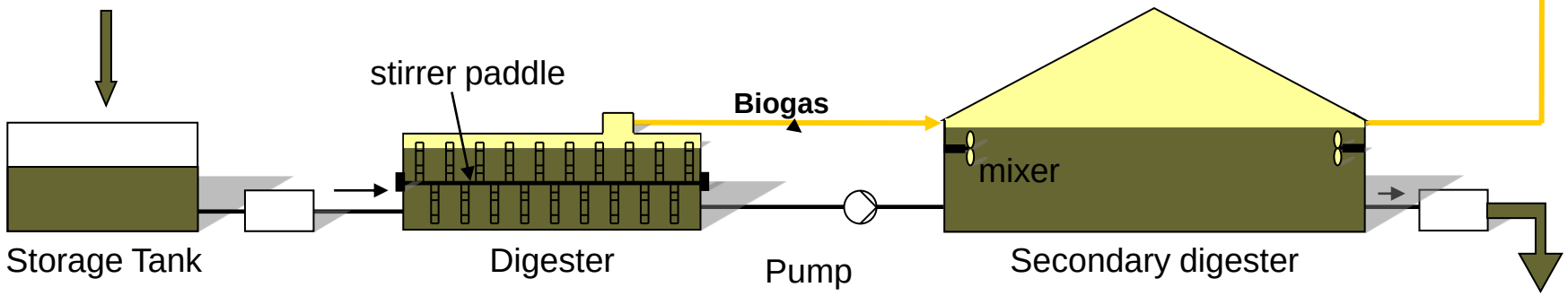
Digested substrate
→storage and
use as fertilizer
→treatment

Biogas concept with a horizontal digester

Substrate

manure
organic waste
energy crops

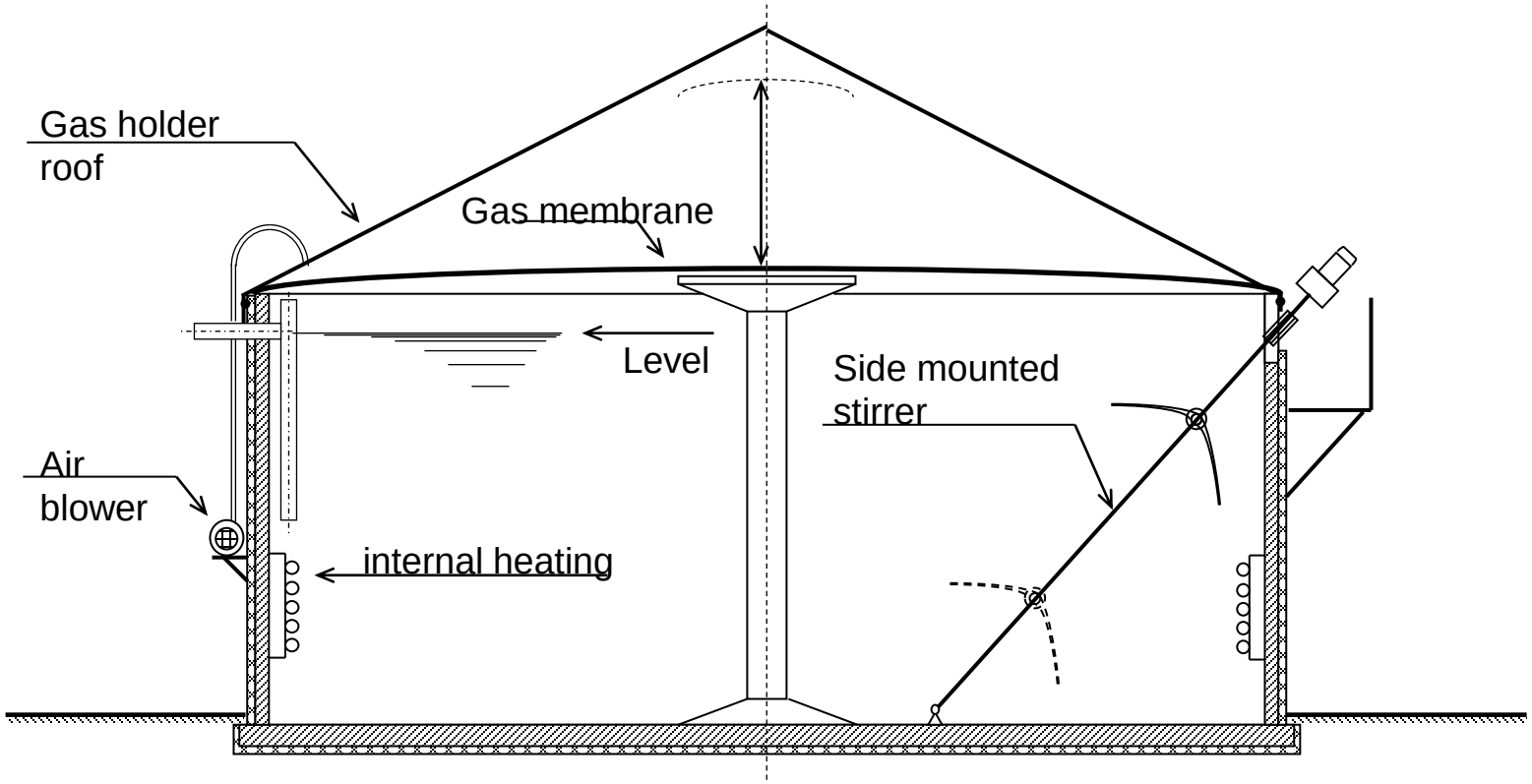
Gas utilization
→CHP (power, heat)
→direct use (heating, cooking, light)
→upgrading (gas grid fuel, fuel cell**)**



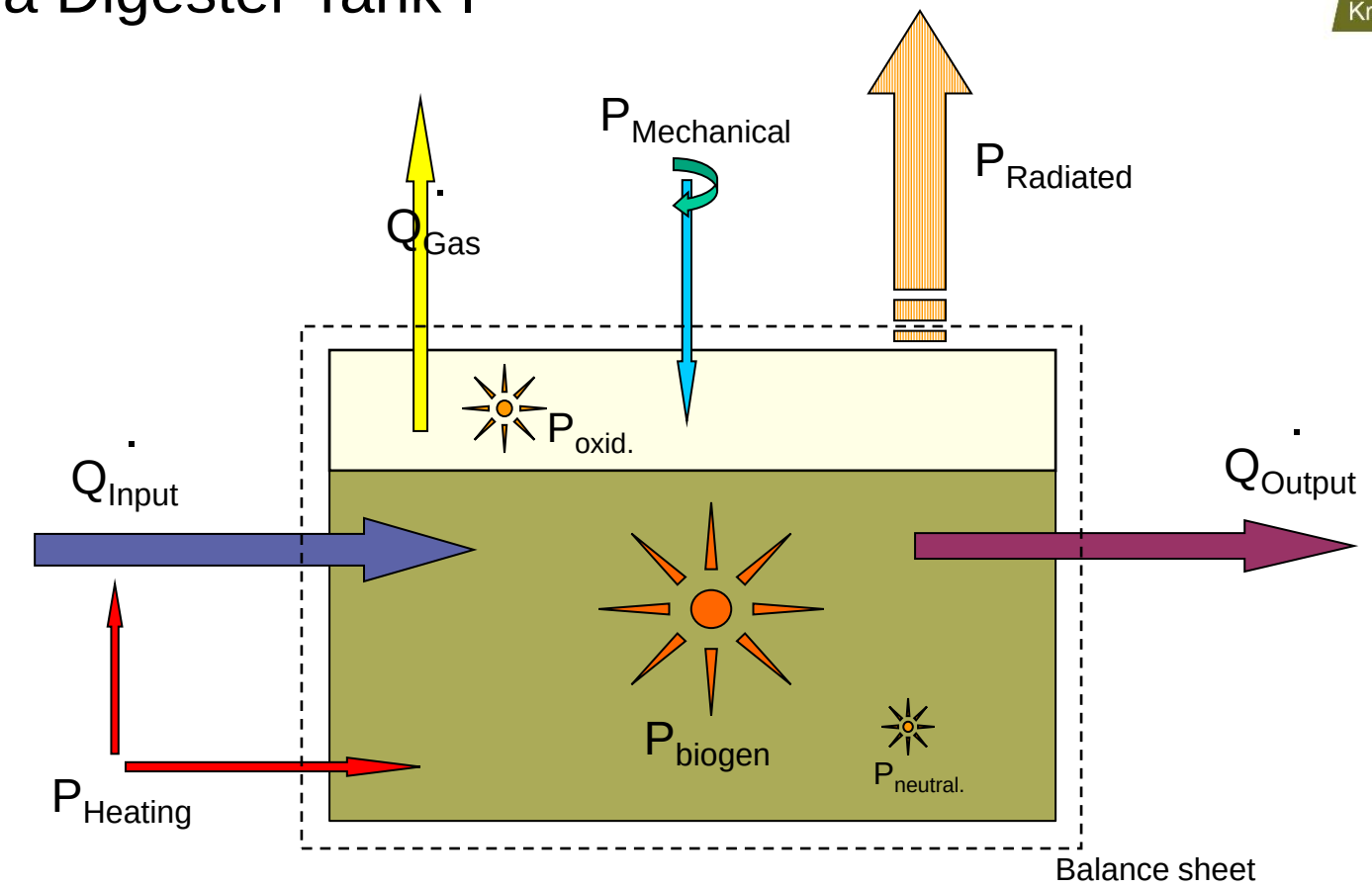
Input device
→piston pump, screw etc. (solids)

Digested substrate
→storage and
use as fertilizer
→treatment

Flat Digester Tank



Heat balance of a Digester Tank I



For constant Temperature:

Inflowing Heat+ generated Heat + outflowing Heat = 0

(note sign)

Heat balance of a Digester Tank II

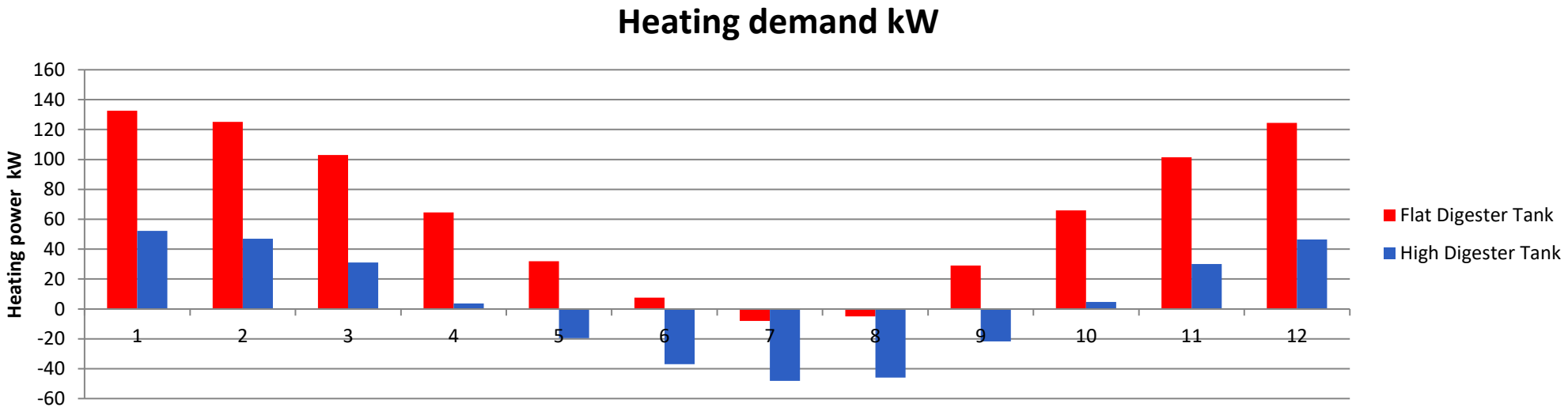
For constant Temperature:

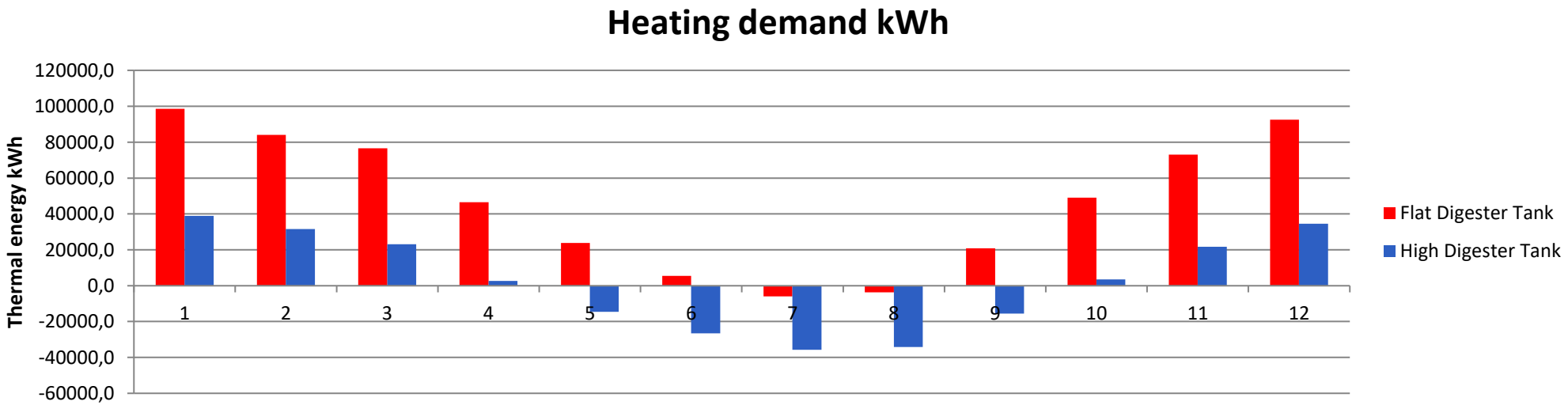
Inflowing Heat+ generated Heat + outflowing Heat = 0

(note sign)

$$\dot{Q}_{Input} + \dot{Q}_{Heating} + \dot{Q}_{mech} + \dot{Q}_{biogen} + \dot{Q}_{Enschw.} + \dot{Q}_{neutra} + \dot{Q}_{loss} + \dot{Q}_{Einstrahl} + \dot{Q}_{Gas} = 0$$

Heat losses in two different digester tank systems (a principle overview)





Heat Losses by Source
(Top 3 most important losses)

Flat Digester Tank	[kWh]	High Digester Tank	[kWh]
Output Substrate*	303,000	Output Substrate*	107,000
Roof (gas holder roof)	138,000	Output Biogas	34,000
Output Biogas	96,000	Wall (insulated)	10,000
Result (all heat losses): required thermal energy	571,000		156,000
Difference:	415,000		

Assuming costs (only) about 10 €ct/kWh this ends up with about € 40,000 per year.

*Output Substrate: calculated external energy - biologically produced energy

Comparison of different types of digester tanks

Digesters with gas holder roofs on top are not well-suited for biogas plants with biogas upgrading

- heat losses
- costs

in comparison to high upright or horizontal digester tanks (fully insulated tanks)

Technical Challenges in Biogas/Biomethane Plants for Production of Biofuels

Torsten Fischer and Smilja Latinovic

Krieg & Fischer Ingenieure GmbH
Bertha-von-Suttner-Strasse 9, D-37085 Göttingen, Germany
Tel.: ++49 551 900 363-0, Fax: ++49 551 900 363-29
Fischer@KriegFischer.de
www.KriegFischer.de

Amsterdam
November 30th, 2022