

# **Technical Solutions for Biogas Production in Germany**

## **Решение технических проблем при производстве биогаза в Германии**

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**Westphalian University Gelsenkirchen**  
**Westphalian Energy Institut**

- Historical overview – Germany
- Biogas from renewable resources
- Technical details
- Political and economic aspects
- Outlook for new concepts

Biogas production is historically established in **4 different fields**

## 1. Treatment of waste water sludge:

- here the better handling of the sludge was the driving force
- Co-fermentation was not practiced
- technology was developed in the waste water branch
- energetic benefits are by product

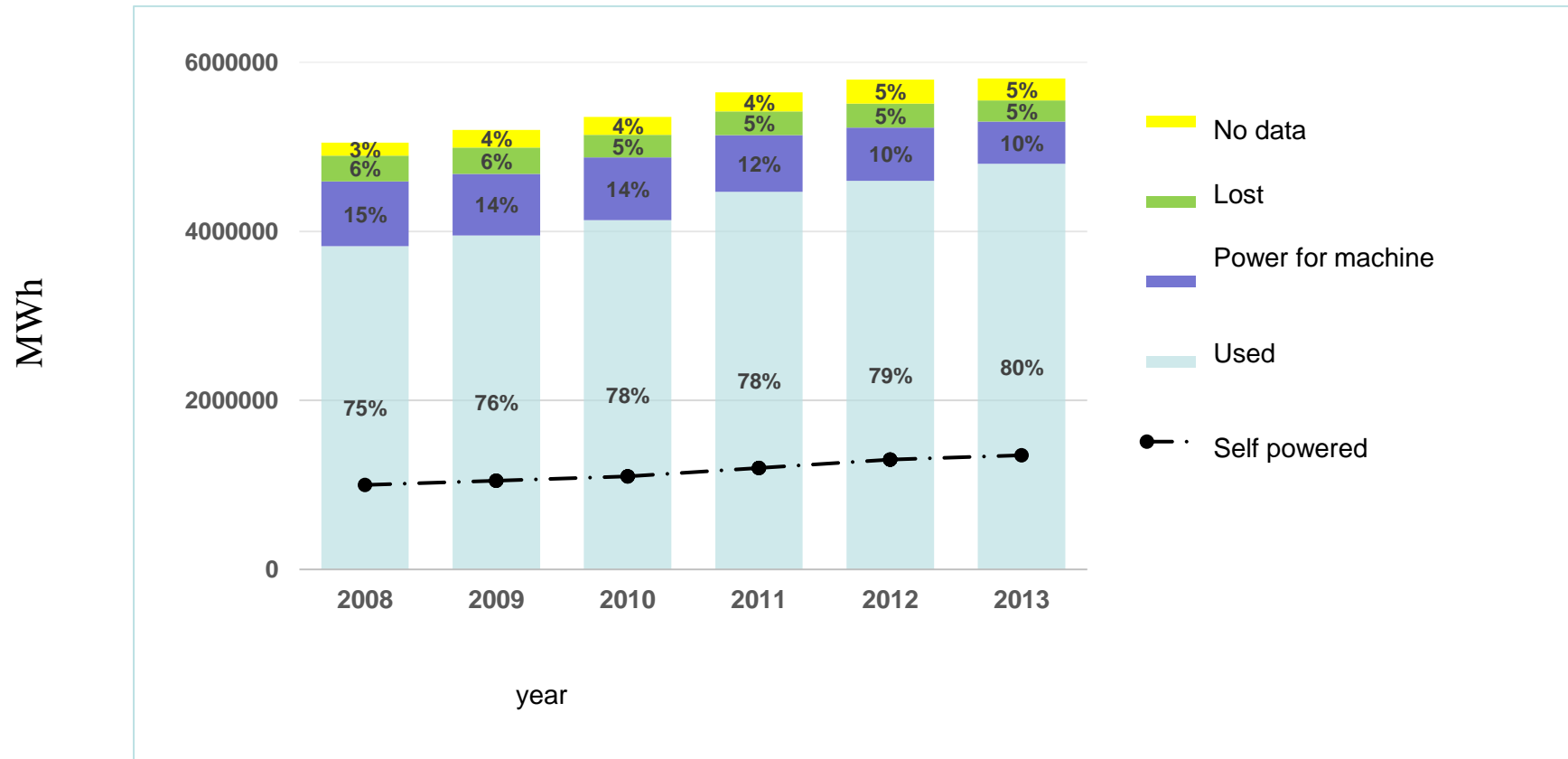


OSWALD  
SCHULZE  
Umwelttechnik

# Energy Production from Sewage Sludge



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## 2. Anaerobic treatment of waste water - from different industries ( specially food production )



WABAG UASB (Upflow Anaerobic Sludge Blanket)

## 3. anaerobic digestion of biodegradable municipal solid waste

- waste treatment
- energy use

**Input:**

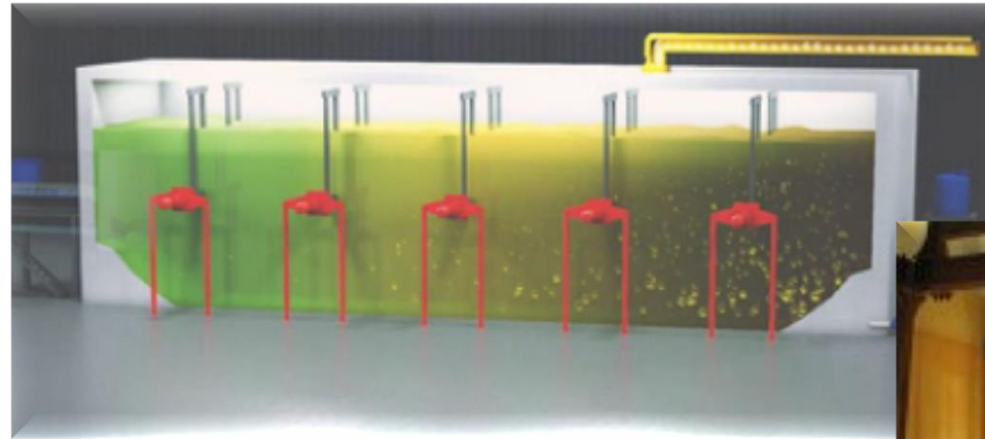
60 000 t/a organic waste

**Biogas production**

850 Nm<sup>3</sup>/h (5,5 MW)



***Sustainability price  
2016***



Strabag LARAN® Plug Flow Digester

## 4. Use of renewable primary resources

- running only for energetic use

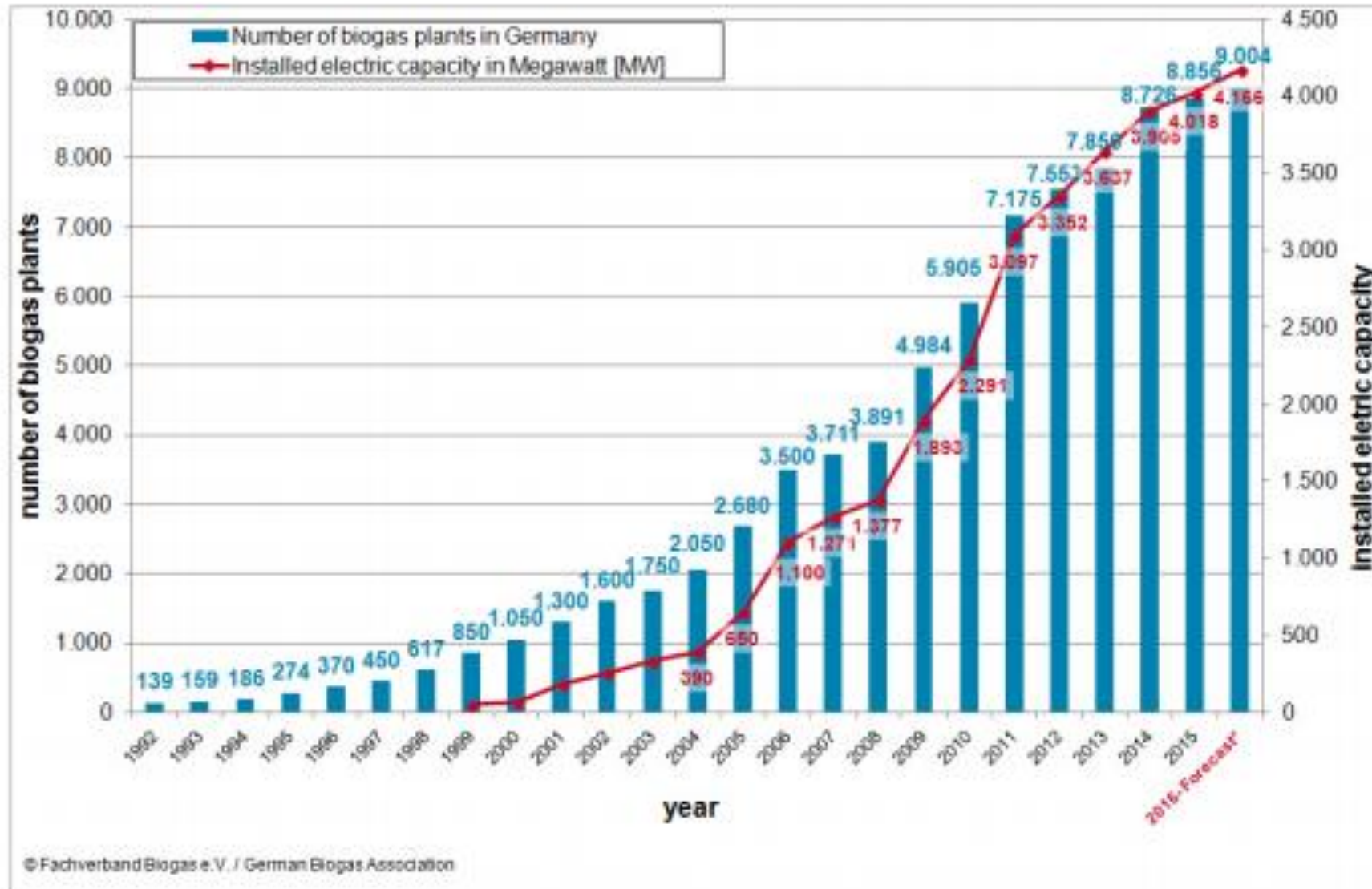
*These will be the focus of this presentation.*

## Statements:

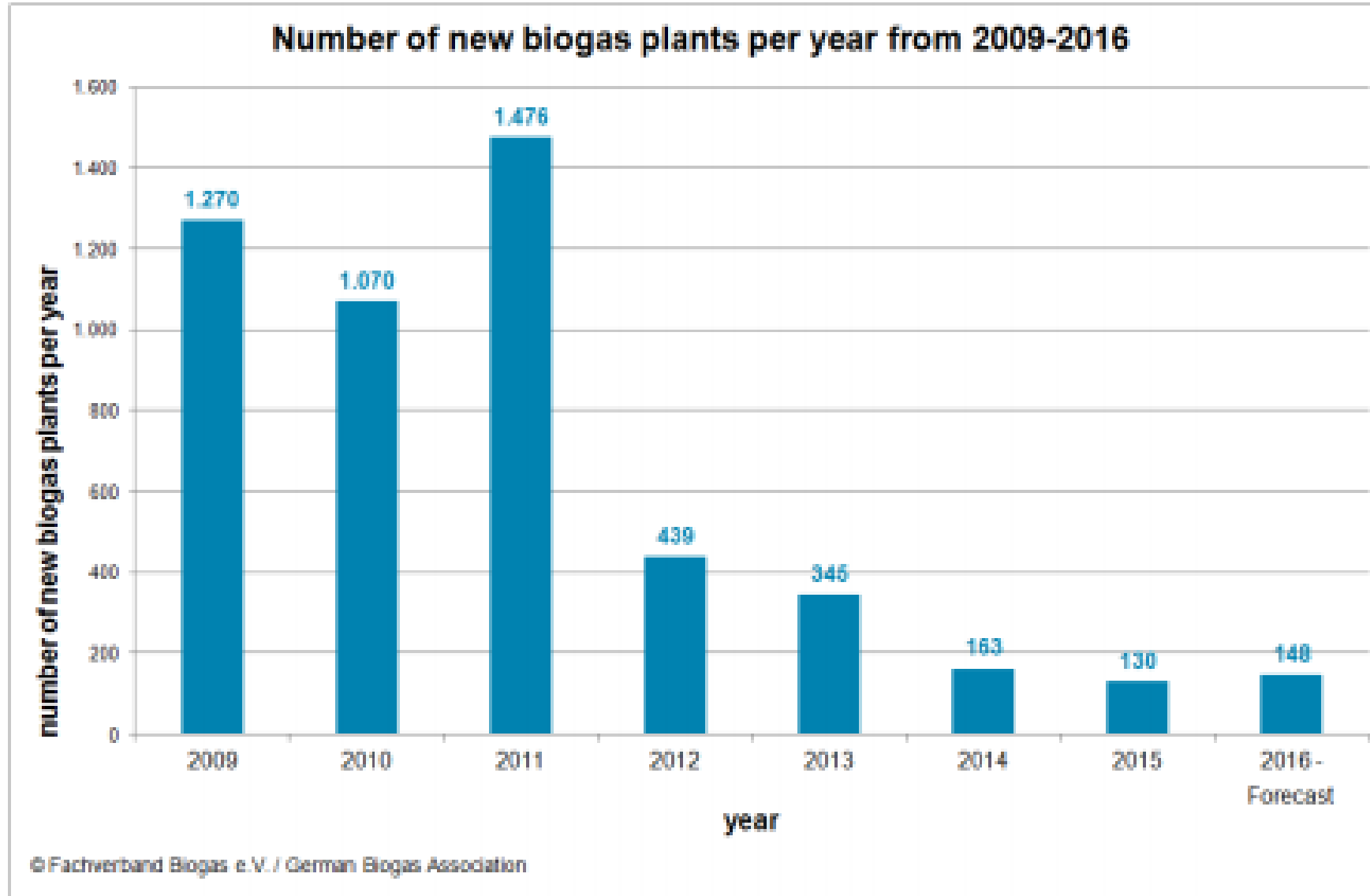
1. The intensive start of building biogas plants with renewable primary resources was caused by the law (renewable energy law EEG 2000)
2. Driving force was the attractive financial support for the produced electricity



# Number of Plants and Electric Capacity



# Actual Development



# Microbiological Process



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**Production  
Harvesting  
Storage**

**Pretreatment  
Feed input**

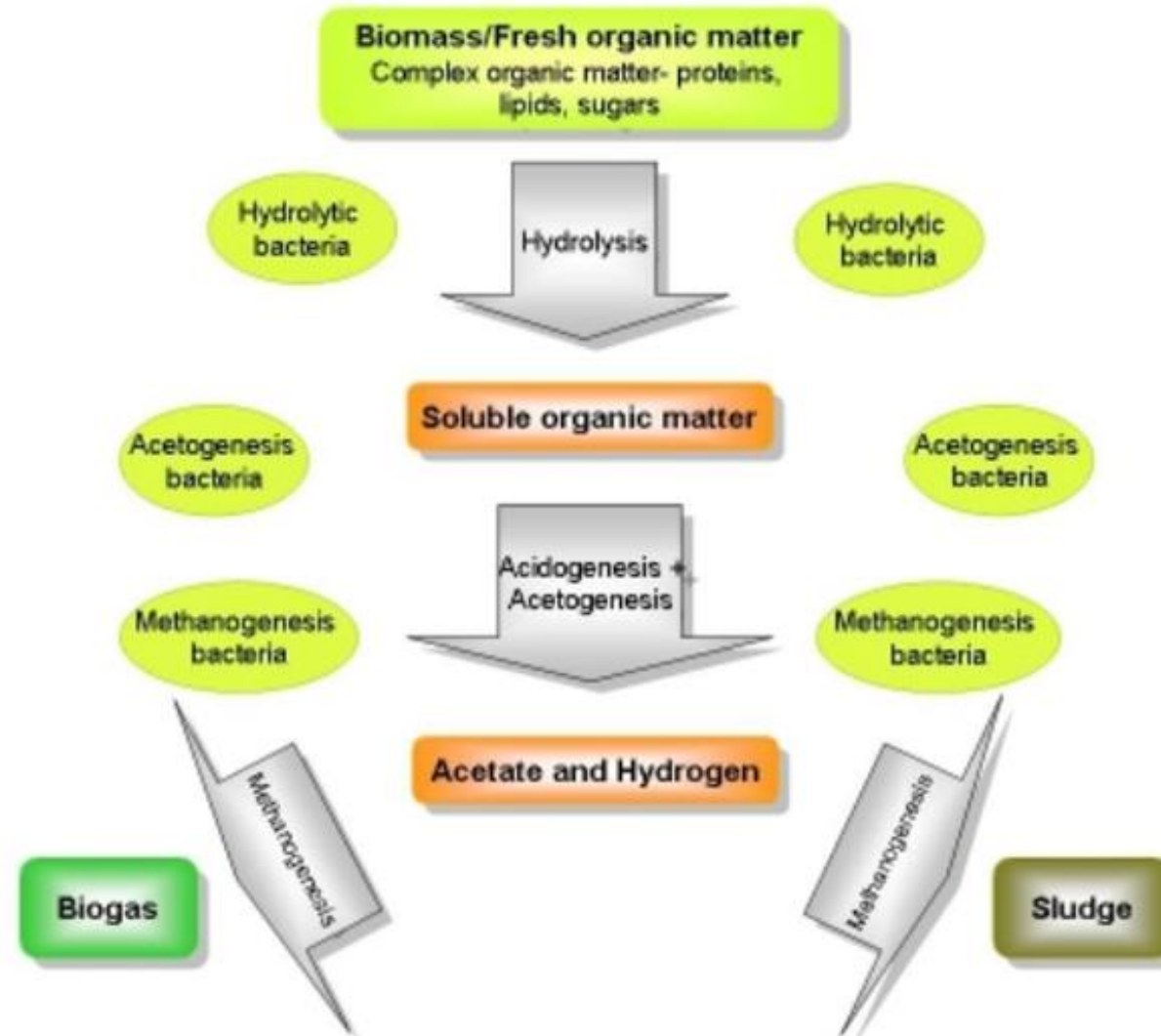
**Mixing**

**Gas  
Management**

**Temperature**

**Process control**

**Solids  
Management**



- Intensive research fields
- Competence and knowledge increase
- New companies and professions in these working areas

# Microbiological Process



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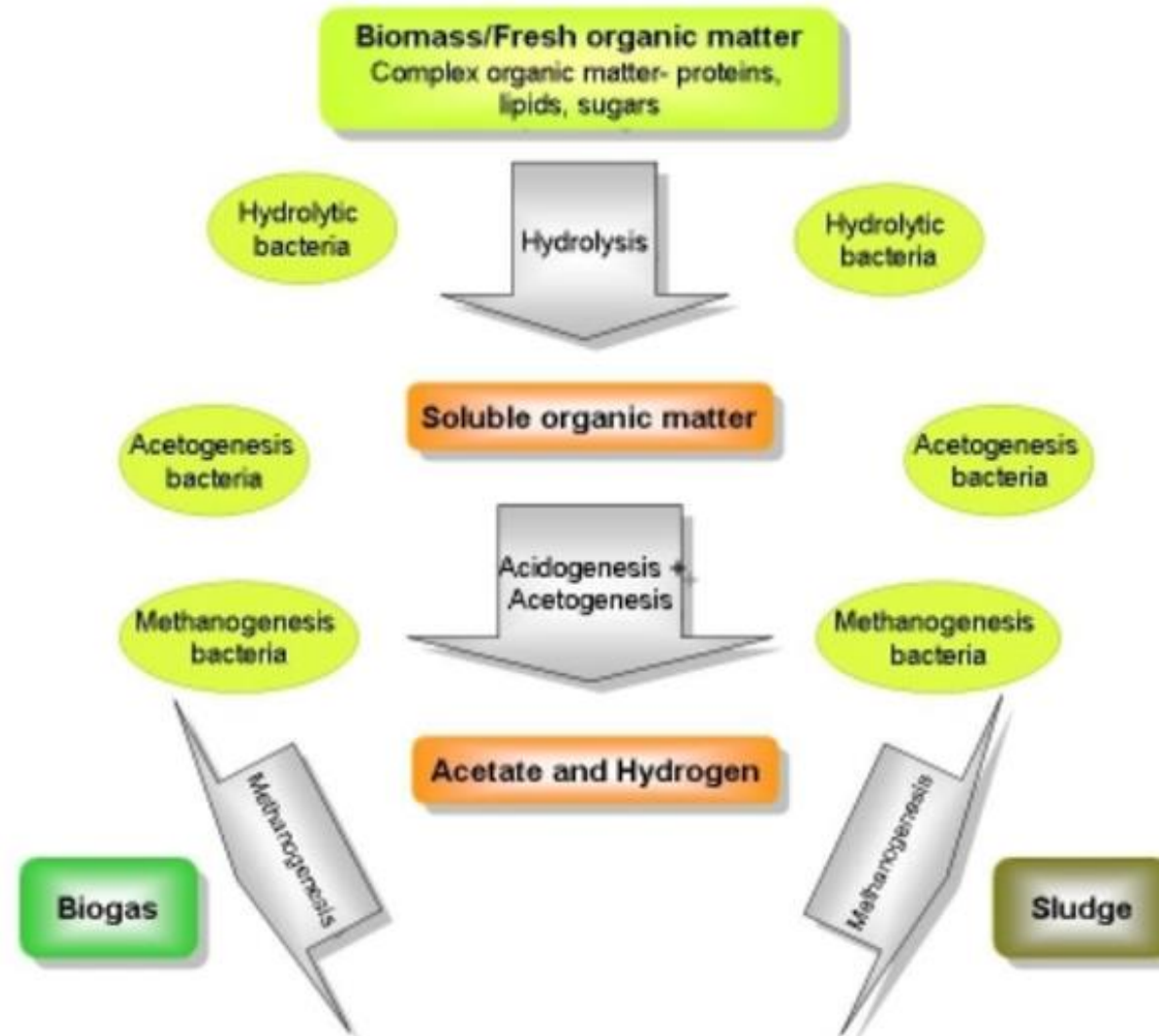
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# Biogas from Renewable Resources



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## **Feed:**

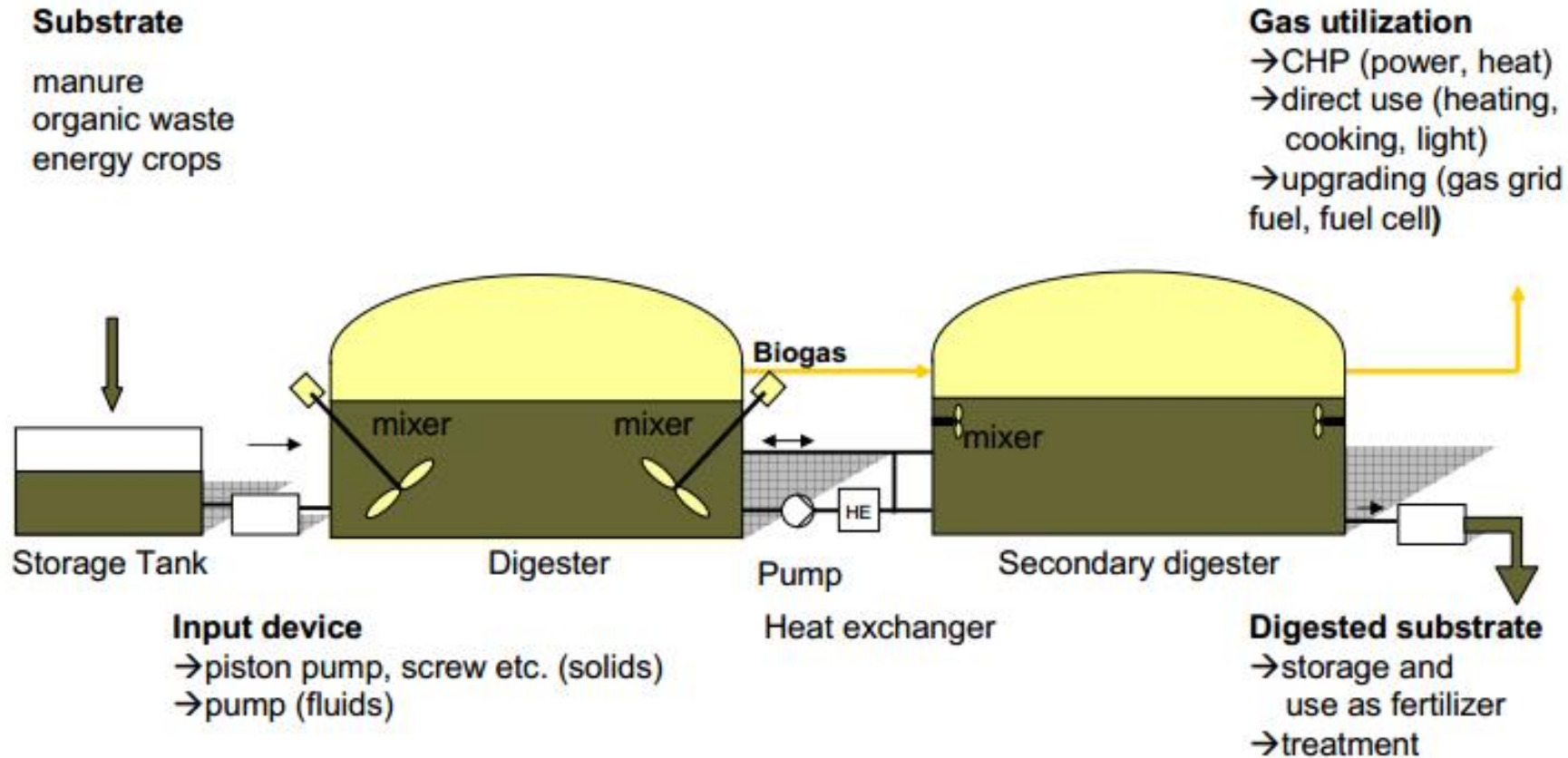
### Solid:

- different resources of organic matter

### Liquid:

- manure

# Agricultural Biogas Plant





# Biogas from renewable resources

## Substrates



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### Liquids

#### Farm fertilizer

- Cattle manure
- Pig manure
- Poultry manure
- Cattle dung
- Pig dung

### Solids

#### Agricultural ferments

- Corn silage
- Grass silage
- whole crop silage
- Hay





# Biomass Production



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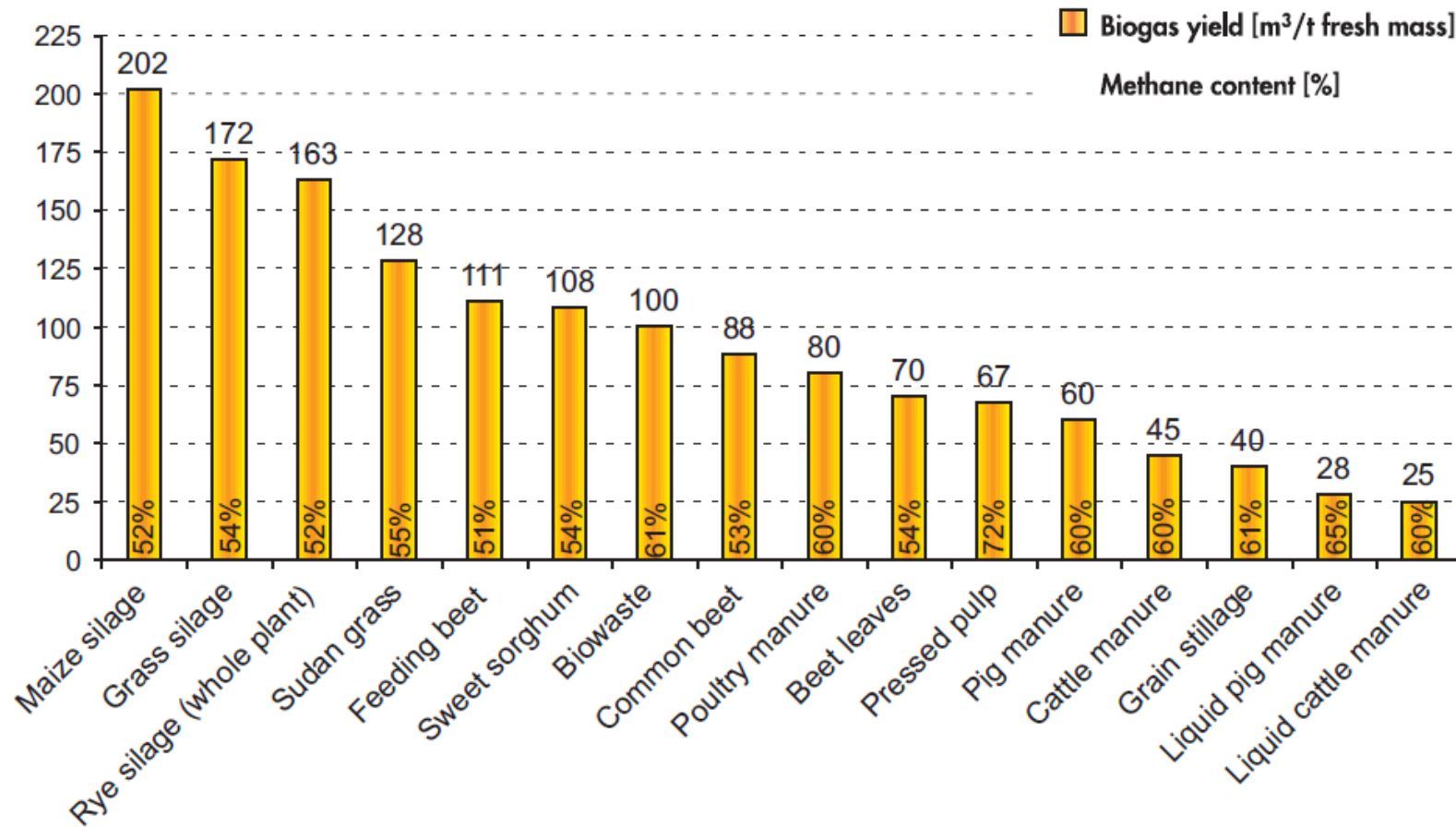
- harvesting and silage



# Energy Plants



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*FNR, 2006; Energiepflanzen, KTBL, 2006*

# Microbiological Process



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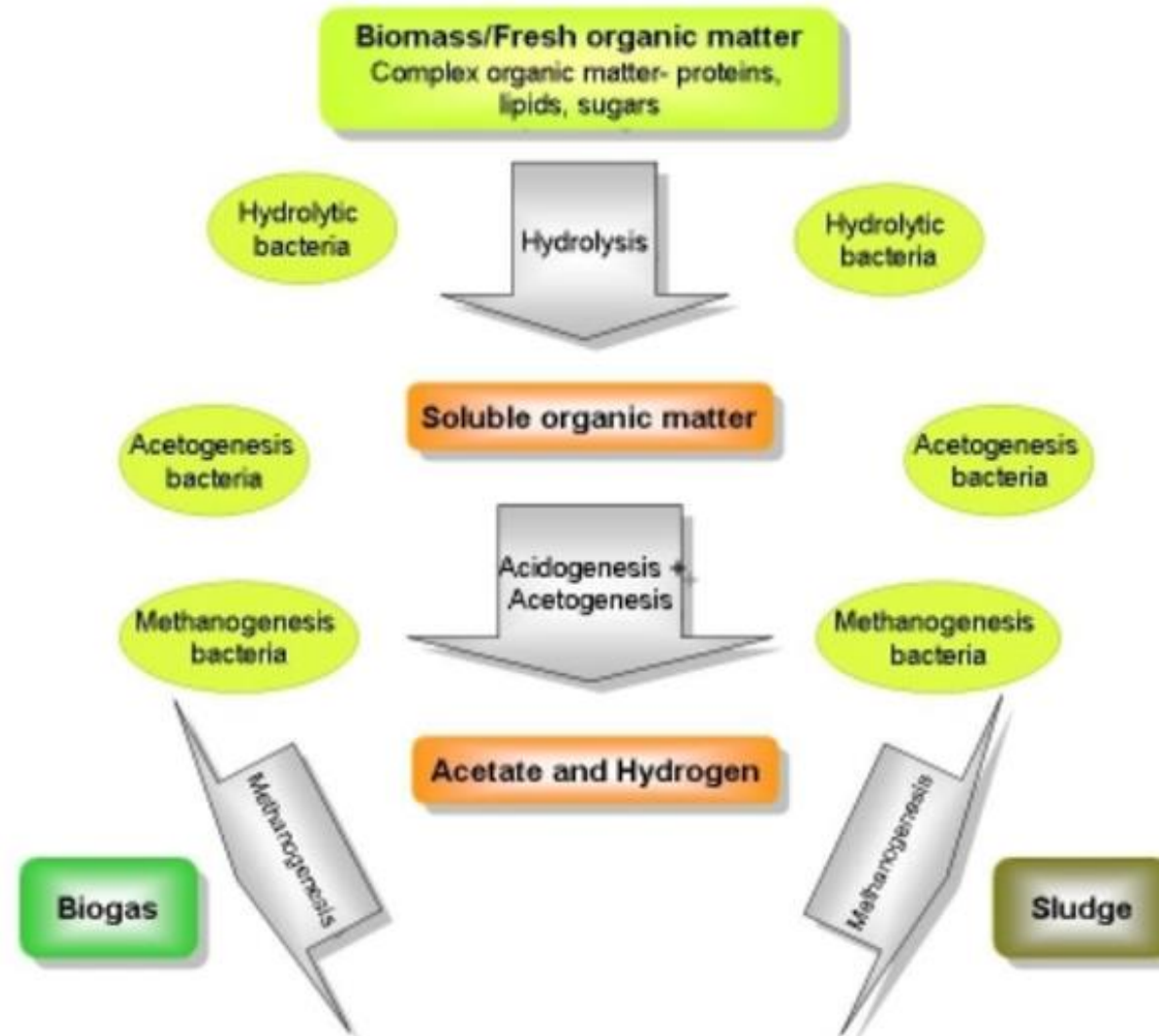
Mixing

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# Pre-treatment technologies

## Biochemical pre-treatments

- Microbial pre-treatments
- Enzymatic pre-treatments

## Chemical pre-treatments

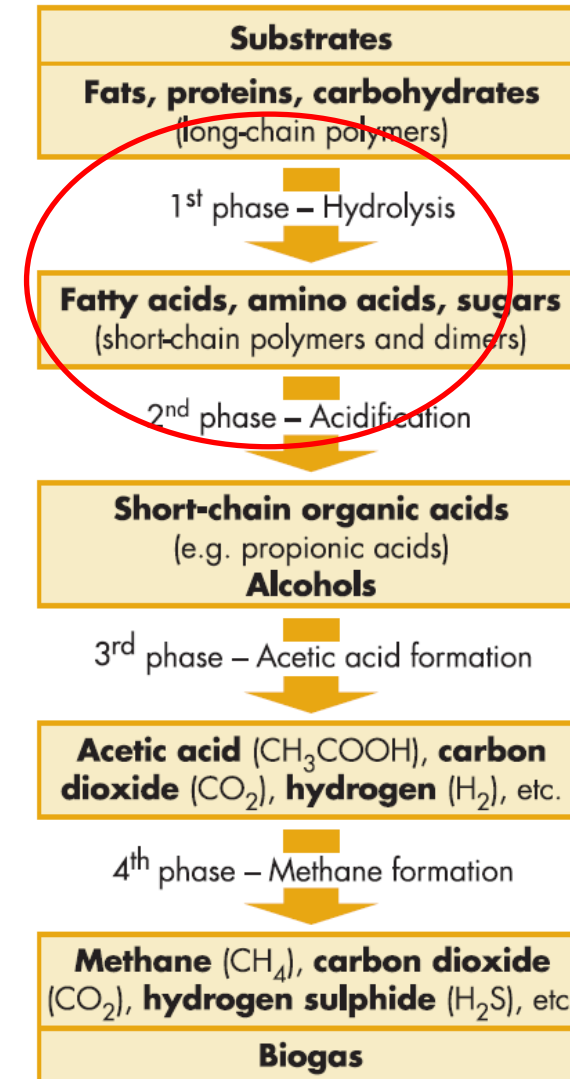
- Caustic pre-treatments
- Acid pre-treatments

## Physical pre-treatments

- Mechanical pre-treatments
- Thermal pre-treatments
- Ultrasonic pre-treatments

## Combined processes

- Thermal-chemical pre-treatments
- Thermo-mechanical pre-treatments





- Increase of methane production
- Process stability
- Shorter reaction time, better room yield



- invest
- energy demand



# Microbiological Process



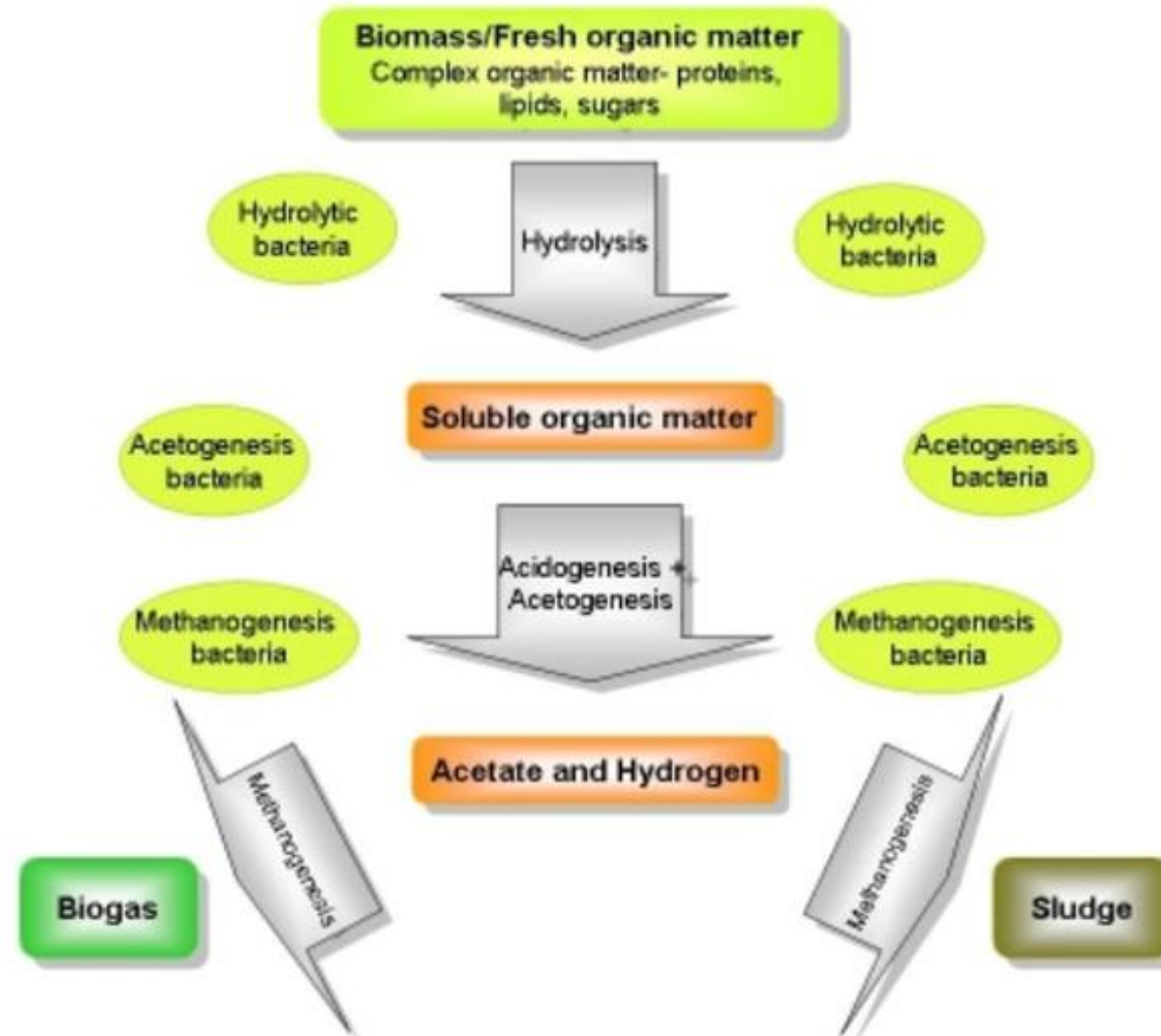
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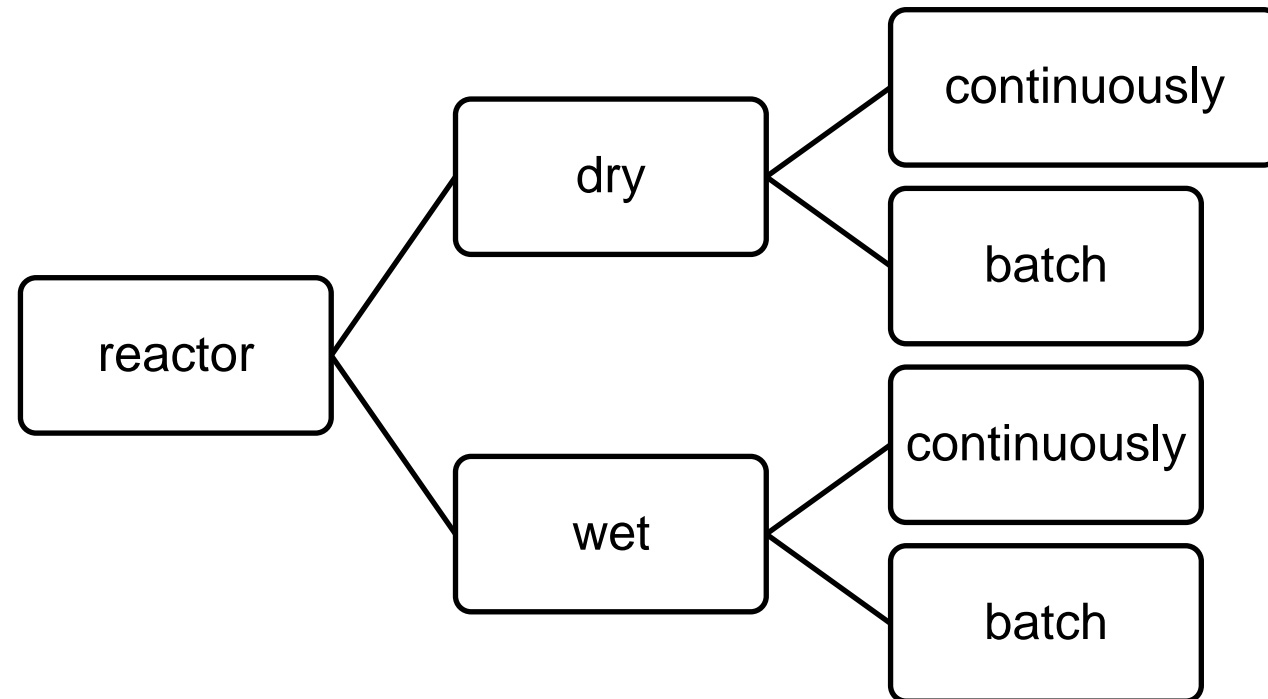


Temperature

Process control

Solids  
Management

- Dry : 20-40% Dry Mass (DM)
- Wet: < 15% DM
- Mesophil: 37 ° C
- Thermophil: 70° C



# Plant in Belgorod built by AD AGRO Systems



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**Electrical energy : for the local grid**

**3600 kW<sub>el</sub>**

**Since 2012 total 79,4 x 10<sup>6</sup> kWh**

**Feed:**

input:	
Meat leftovers	11.180 t/a
Gastric /intestinal contents	2.912 t/a
Fur and hairs	475 t/a
Corn silage	20.000 t/a
Sewage sludge	1.820 m³/a
Pig manure	400 m³/a
Water	26.000 m³/a
Sum	62.787 m³/a

Data from AD AGRO/  
AltEnergio



1. Harvesting and storage
2. Preparation and feeding
3. Fermenters
4. Gas handling
5. Energy use

# Microbiological Process



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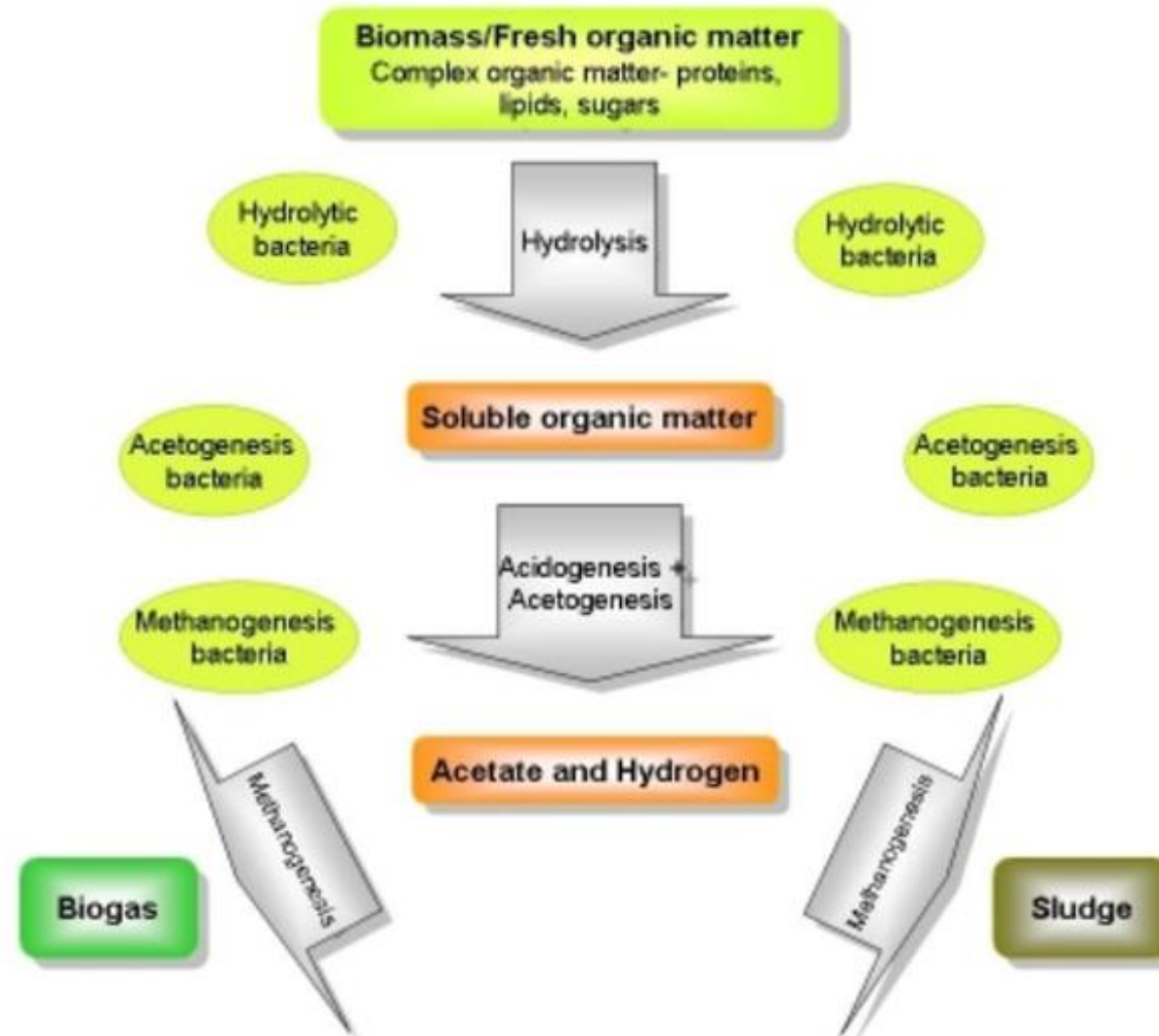
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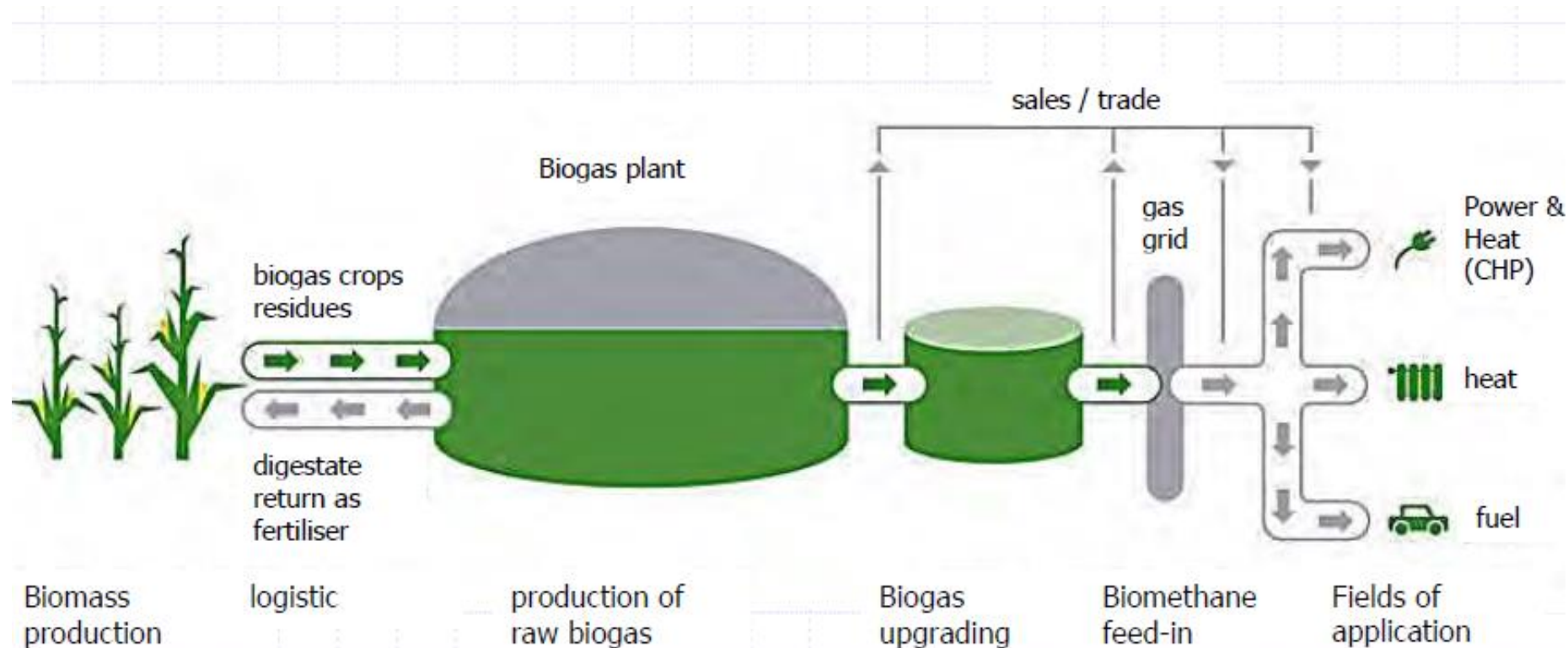
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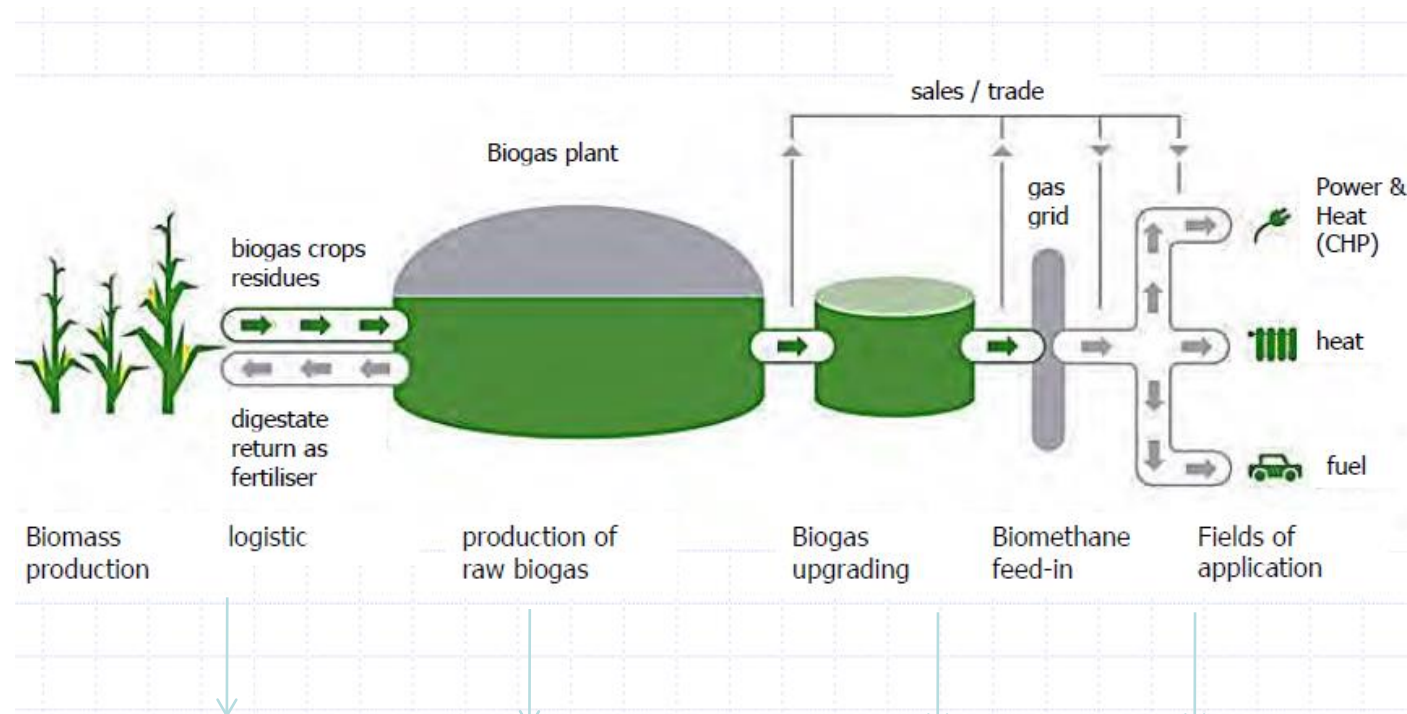


# Process Structure for Agricultural Plants



Source: dena, biogasregister 2011

# Process Control



DM , volume, mass  
electricity, heat

T, VOA /TIC,DM

gas volume  
content

engine  
hours

## **biogas plant 75 kW<sub>el</sub>**

- 3.300 t cow manure (165 dairy cows; at Ø 8,000 l milk production/a)
- 790 t corn silage (18 ha; at Ø 50 t FM/ha yield)

## **biogas plant 500 kW<sub>el</sub>**

- 2.200 t cow manure (110 dairy cows, at Ø 8,000 l milk production/a)
- 6.500 t of corn silage (148 ha; at Ø 50 t FM/ha yield) 1,100 t cereal-GPS (31 ha; at Ø 40 t FM/ha yield)
- 1.100 t silage from the permanent grassland (42 ha; at Ø 30 FM / ha yield)

Data from: FNR

# Microbiological Process



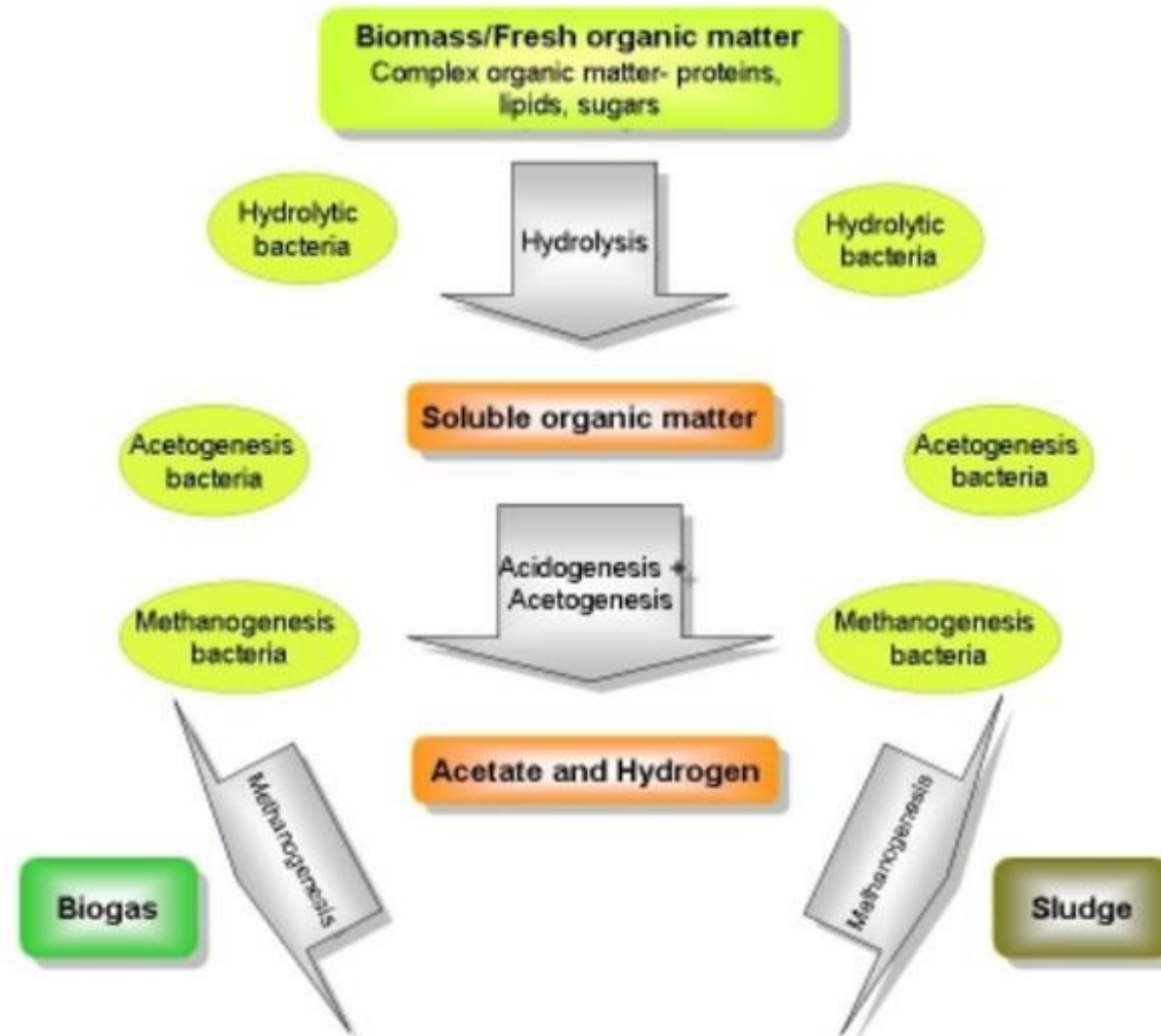
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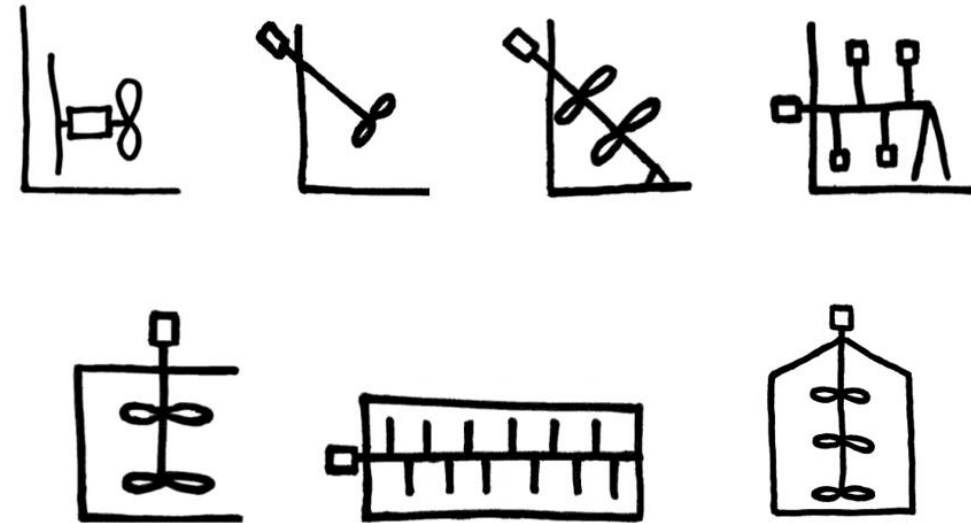
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# Mixing Concepts



**Development of a supplier branch**

# Microbiological Process



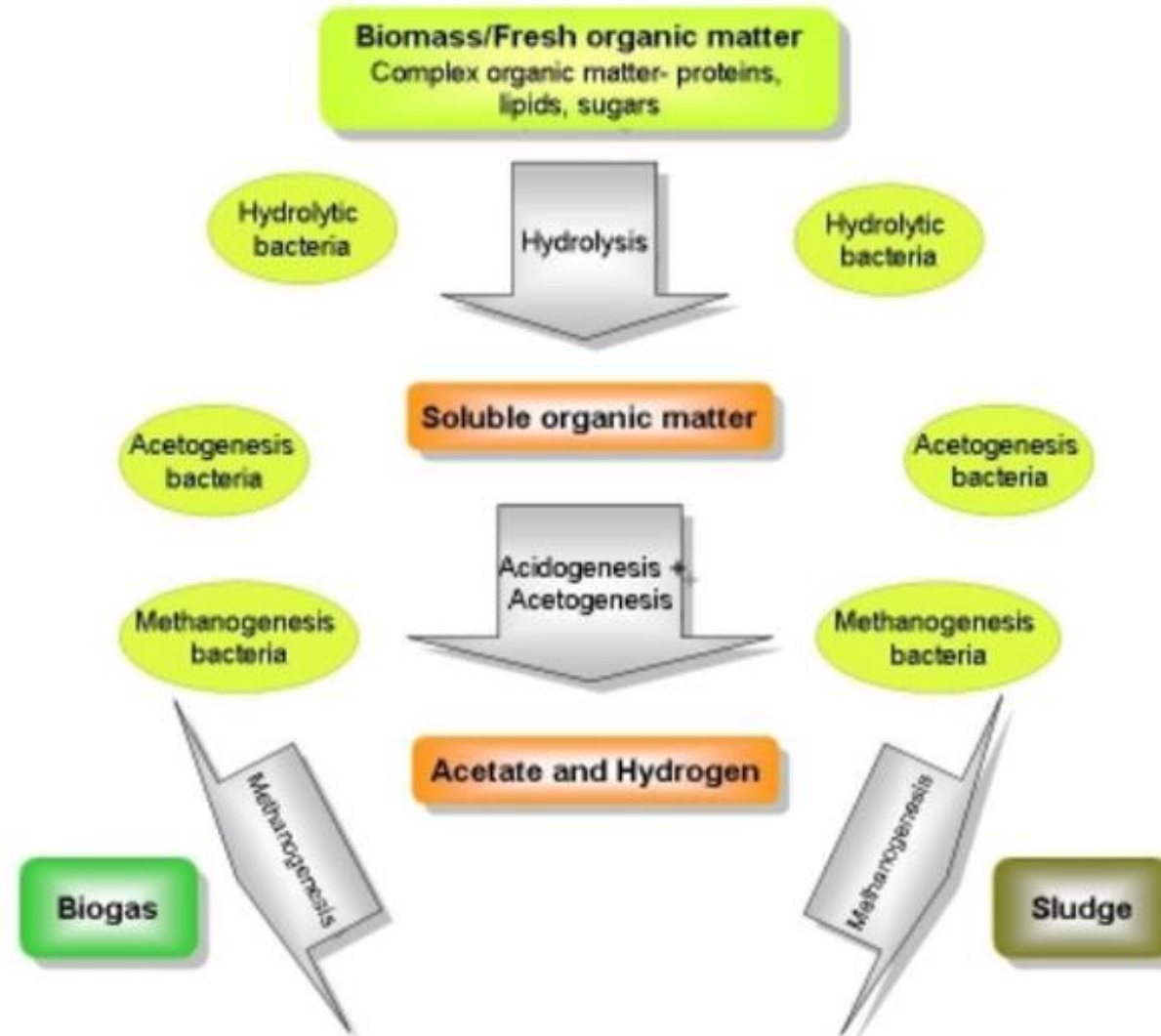
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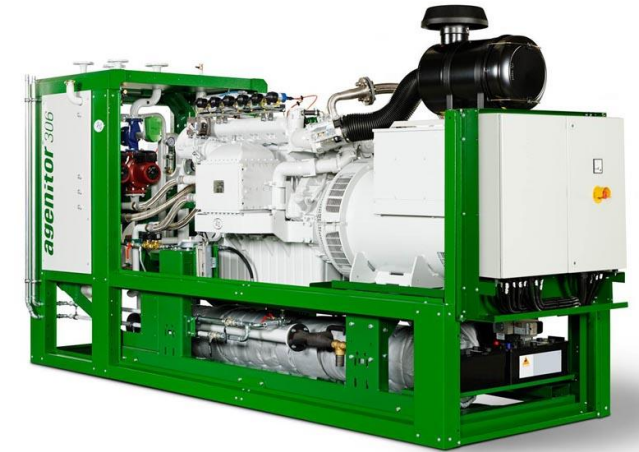
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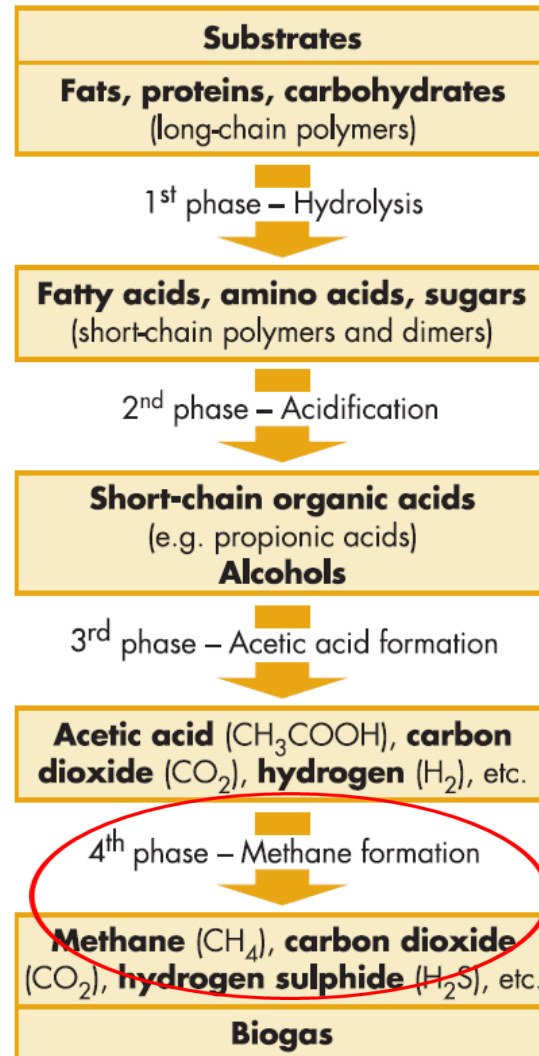
- Incineration

Combined Heat Power Engine ( CHP)  
with different motor concepts.....

- Upgrading for the gas grid



# Biogas – a Gas Mixture

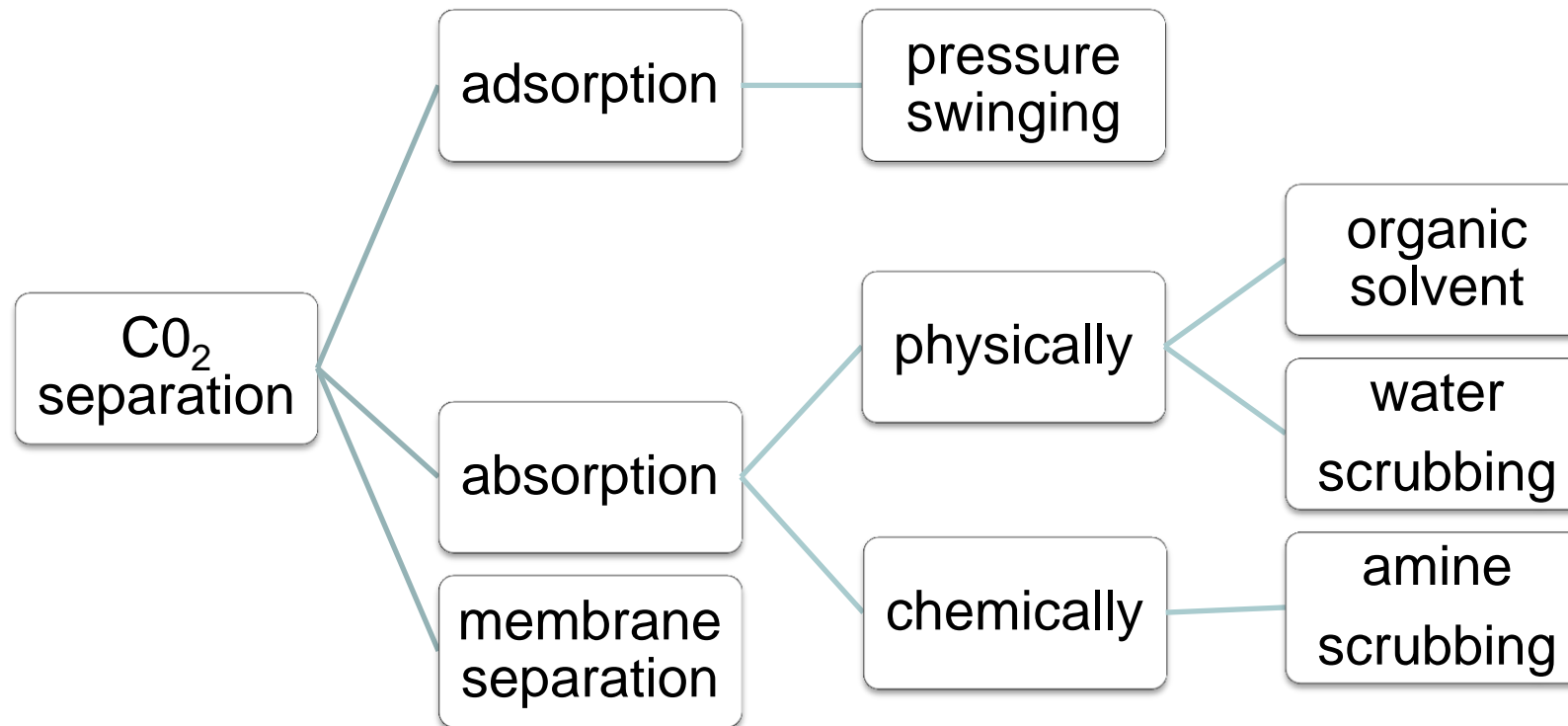


50 – 75 % methane (CH<sub>4</sub>)  
25 – 45 % carbon dioxide (CO<sub>2</sub>)  
2 – 7 % water (H<sub>2</sub>O)  
< 2 % oxygen (O<sub>2</sub>)  
< 2 % nitrogen (N<sub>2</sub>)  
< 1 % ammonia (NH<sub>3</sub>)  
< 1 % hydrogen sulphide (H<sub>2</sub>S).

# Biomethane - Upgrade of Biogas



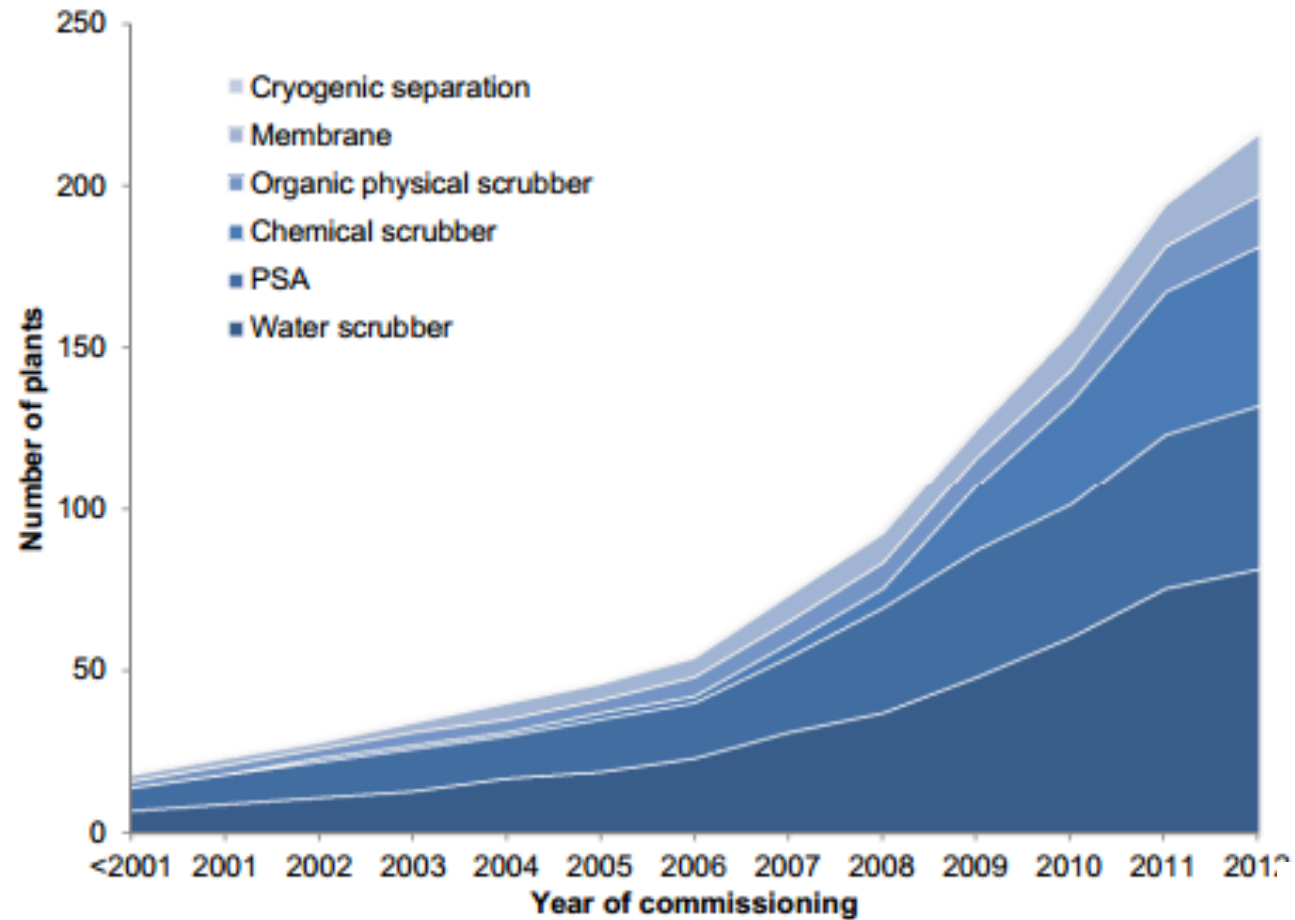
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# Biogas Upgrade in Europe



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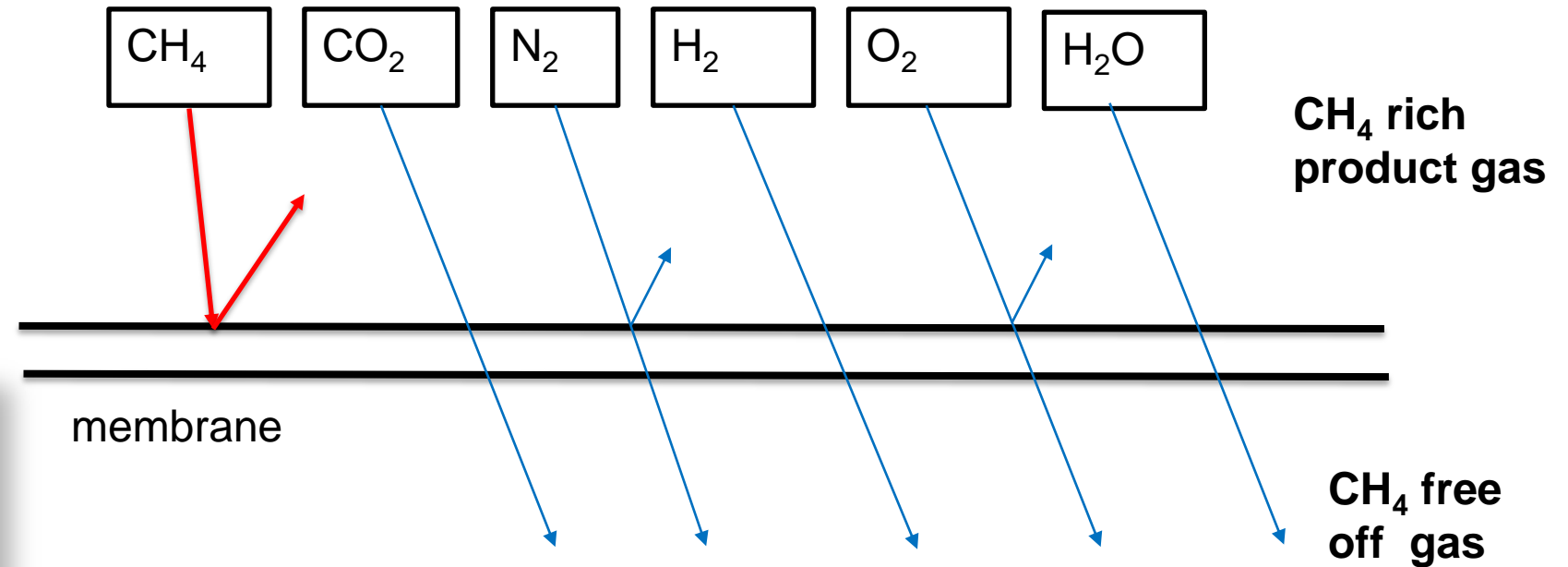


SGC Rapport 2013:270

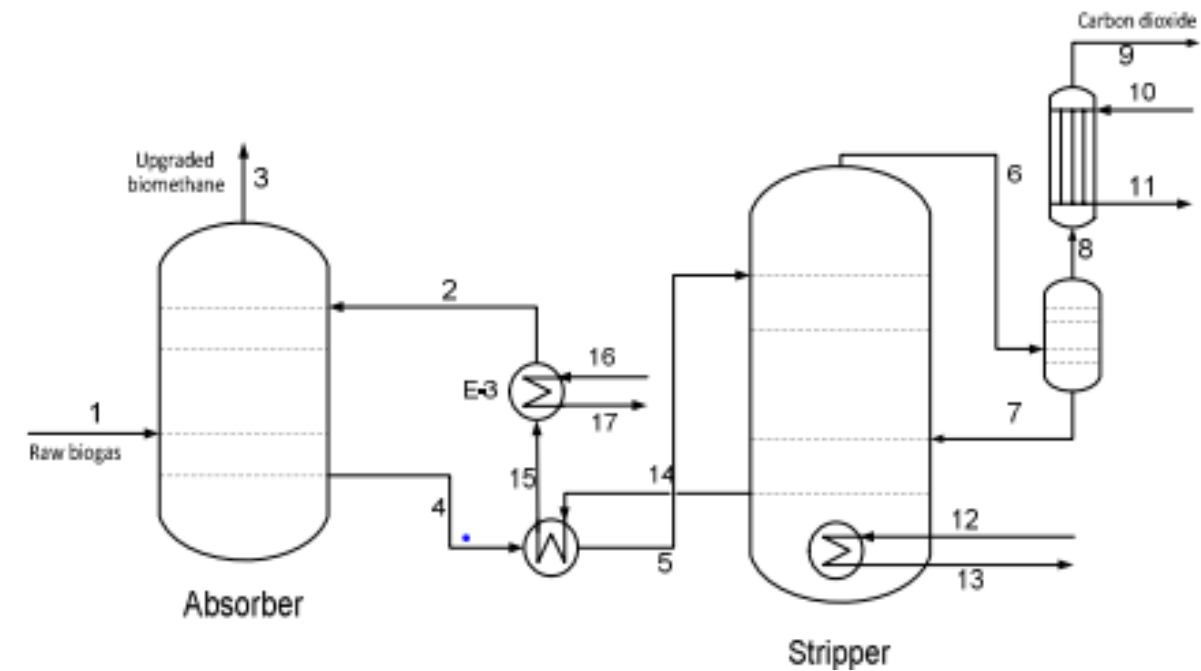
# Membrane Separation – Methane Enrichment



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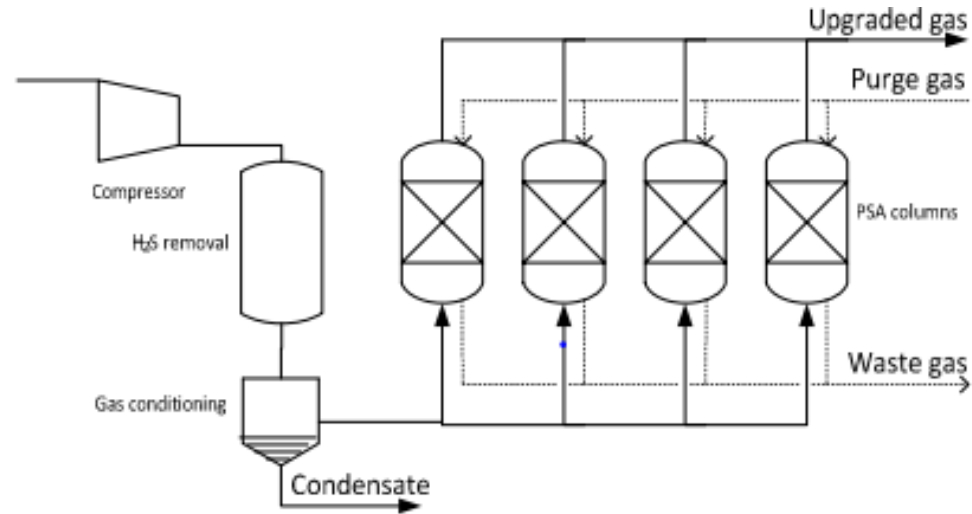


# Amine scrubbing





# Pressure Swinging Adsorption



Schmack  
biogas

# Biogas – “national links”



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<http://www.biogas.org/>

<http://biogas.fnr.de/>

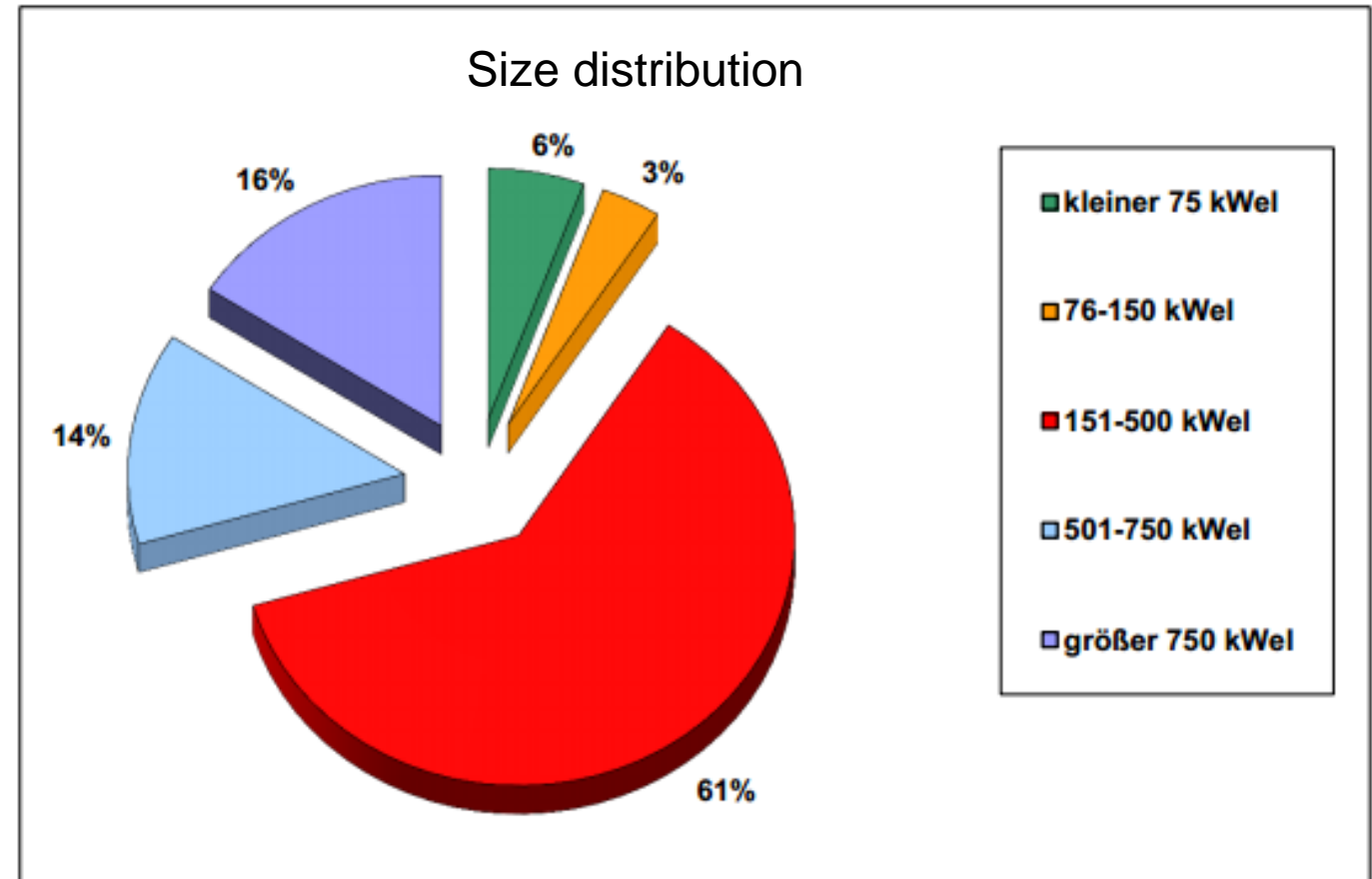
<http://www.biogas-forum-bayern.de>

<https://www.dbfz.de>

<https://www.carmen-ev.de>



- farmer/ owner driven
- energy companies
- new companies



# German Energy Law Compensation



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Dimensioning of power ( kW)	Compensation ( EU Cent/kWh)
$\leq 75$	23,73
- 150	13,66
- 500	11,78
- 5000	10,55
- 20.000	5,85

- Congresses and Workshops over the year > 10
- Documents for standards: for example VDI

ICS 27.190	VDI-RICHTLINIEN		Februar 2011 February 2011
• VEREIN DEUTSCHER INGENIEURE	Gütekriterien für Biogasanlagen  Quality criteria for biogas plants	VDI 4631  Ausg. deutsch/englisch Issue German/English	13

# Topics for the Discussion...



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- Economical developments
- Agricultural development
- Environmental influences

- Number of companies  
 $\geq 200$  *Small and medium sized* - *regional/ local*
- Number of employments
- Value chain in Germany... no imported products

# Biogas Statics



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	2014*	2015*	Forecast 2016**
Number of biogas plants (biogas plants with biomethane injection)	8.726 (167)	8.856 (183)	9.004 (193)
Installed electric capacity in MW	3.905	4.018	4.166
Gross electricity production in TWh per year	28,88	29,38	29,41
Housholds supplied with biogas-based electricity in millions	8,3	8,4	8,4
CO <sub>2</sub> reduction by biogas in million tons	18,7	19,0	19,1
Turnover in Germany in Euro	8,4 Billion	8,2 Billion	8,3 Billion
Jobs in the biogas sector	45.000	42.000	43.000

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\* Own extrapolation based on country data / plant register BNetzA

\*\* Based on a expert survey / plant register BNetzA



- 7% of the agricultural land in use for energy plants
- The price for land increased ...competition for food production
- Areas with intensive monoculture

- CO<sub>2</sub> Balance ( + or = 0 ? )
- Contamination of the water body
- Use of the residue from the fermentation / solids
- Land use

- new plants based on municipal organic waste and optimization of existing plants
- German companies & researchers go international
- role in the energy system is very important due to storability – for stabilizing the grid with renewable energy
- independence from international gas trade
- flexible use, few renewable alternatives in transport sector
- decentralized supply of gas... combination with H2 technology

# Решение технических проблем при производстве биогаза в Германии



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Vielen Dank für Ihre Aufmerksamkeit  
Большое спасибо за внимание