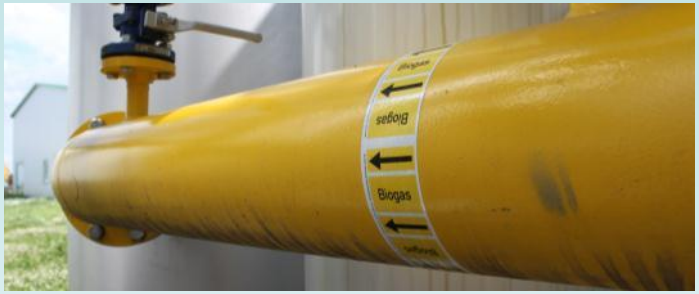
Die Rolle von Biogasanlagen in Bioraffinerien

Anaerobic Digestion in Biorefineries

Digestión Anaerobia en Biorefinerias



4th SMIBIO Workshop

Small-scale Biorefineries for Rural Development in Latin America and Europe

4 July 2018, Straubing, Germany

Dominik Rutz, Rainer Janssen, Ingo Ball
WIP Renewable Energies
Sylvensteinstr. 2
81369 München

Biogas Projects by WIP

12 years EU funded market support biogas projects implemented by WIP 2007-2018

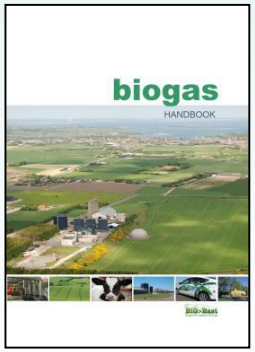
www.big-east.eu: Training courses for farmers and decision makers (WIP coordinator)

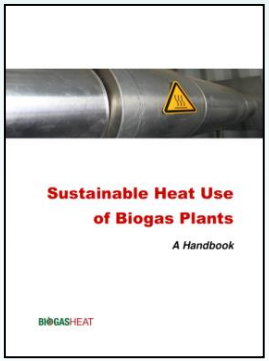
www.biogasin.org: Removing financial and administrative barriers

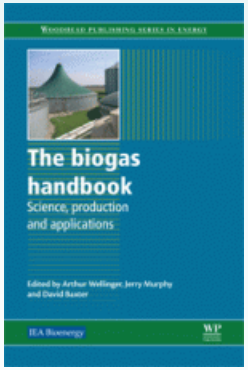
www.urbanbiogas.eu: Municipal waste-to-biomethane concepts (WIP coordinator)

www.biogasheat.org: Using the waste heat from AD plants

www.bin2grid.eu: Waste from food & beverage industry for biomethane







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Current policy developments

- The accident in 2011 in **Fukishima**, Japan, let to a drastically change in German Energy policies.
- The „**energy transition**“ from fossil-nuclear based energy system towards a renewable energy system was decided.
- This transition is regarded by many other states as „**experiment**“

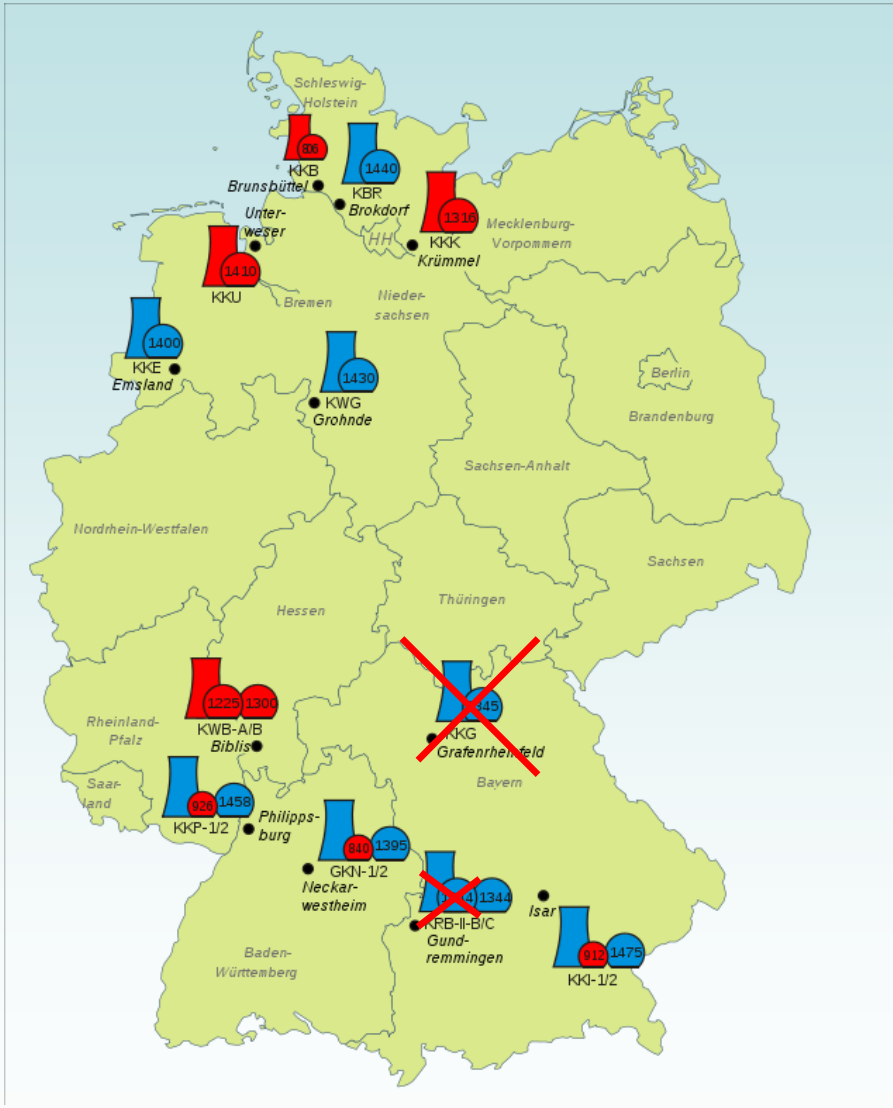
- However, the main focus of the energy transition is on **power production**. Efficiency and heating is less discussed!
- The government reduced the speed of renewable energies growth considerably

Nuclear Power!

Nine (in red) of the seventeen operating reactors in Germany were permanently shut down following the March 2011 Fukushima nuclear disaster.

Currently, 7 reactors are in operation

All will be shut down by December 2022!



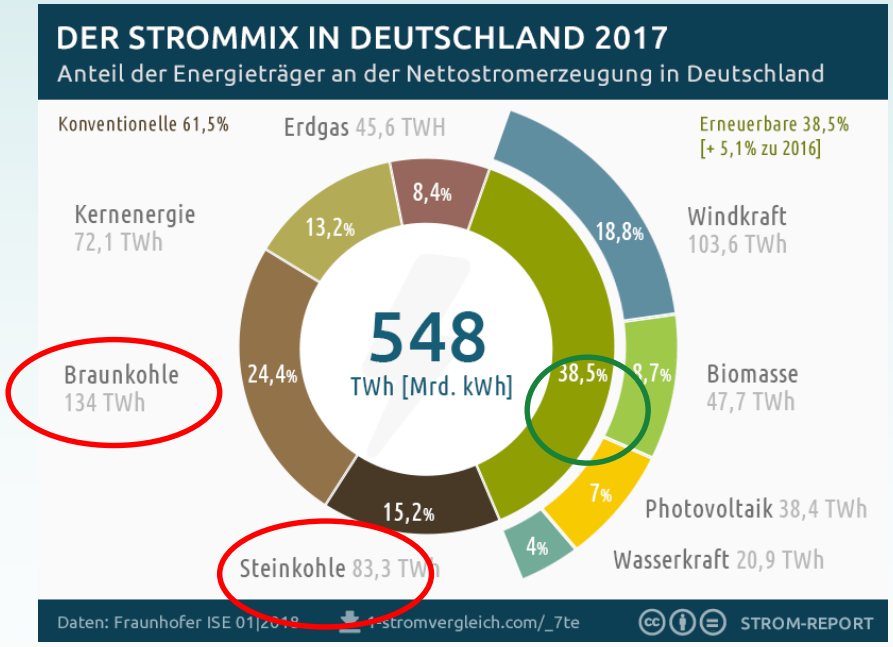
Source: http://en.wikipedia.org/wiki/Nuclear_power_in_Germany

Coal

- ~ 40 % power generation in Germany is from coal!
- Germany is lignite producer No 1 worldwide!

- „Coal-Commission“ (Kohlekommission) was set-up in June 2018
- Shall elaborate the transition of coal phase-out

- Much critizism!



https://1-stromvergleich.com/strom-report/strommix/#strommix-2017-deutschland

Only little focus in the public debate about…

- Fossil fuels in the heating sector
- Energy efficency
- Fossil ressources for materials/products

→ biorefineries

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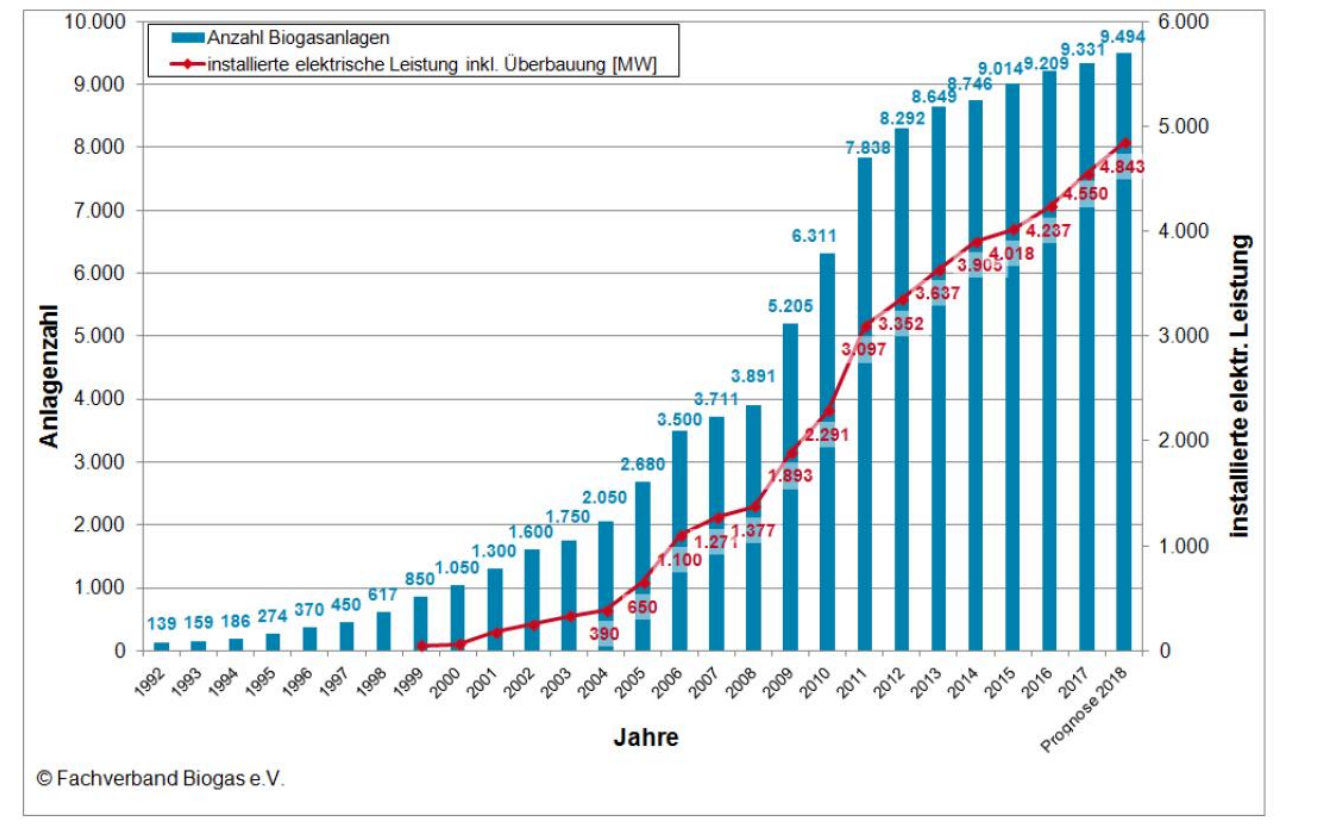
Biogas plants and capacity in Germany

(Status: 07/2016)

Development of the number of biogas plants and the total installed electric output in megawatt [MW] in Germany (as of 05/2018)



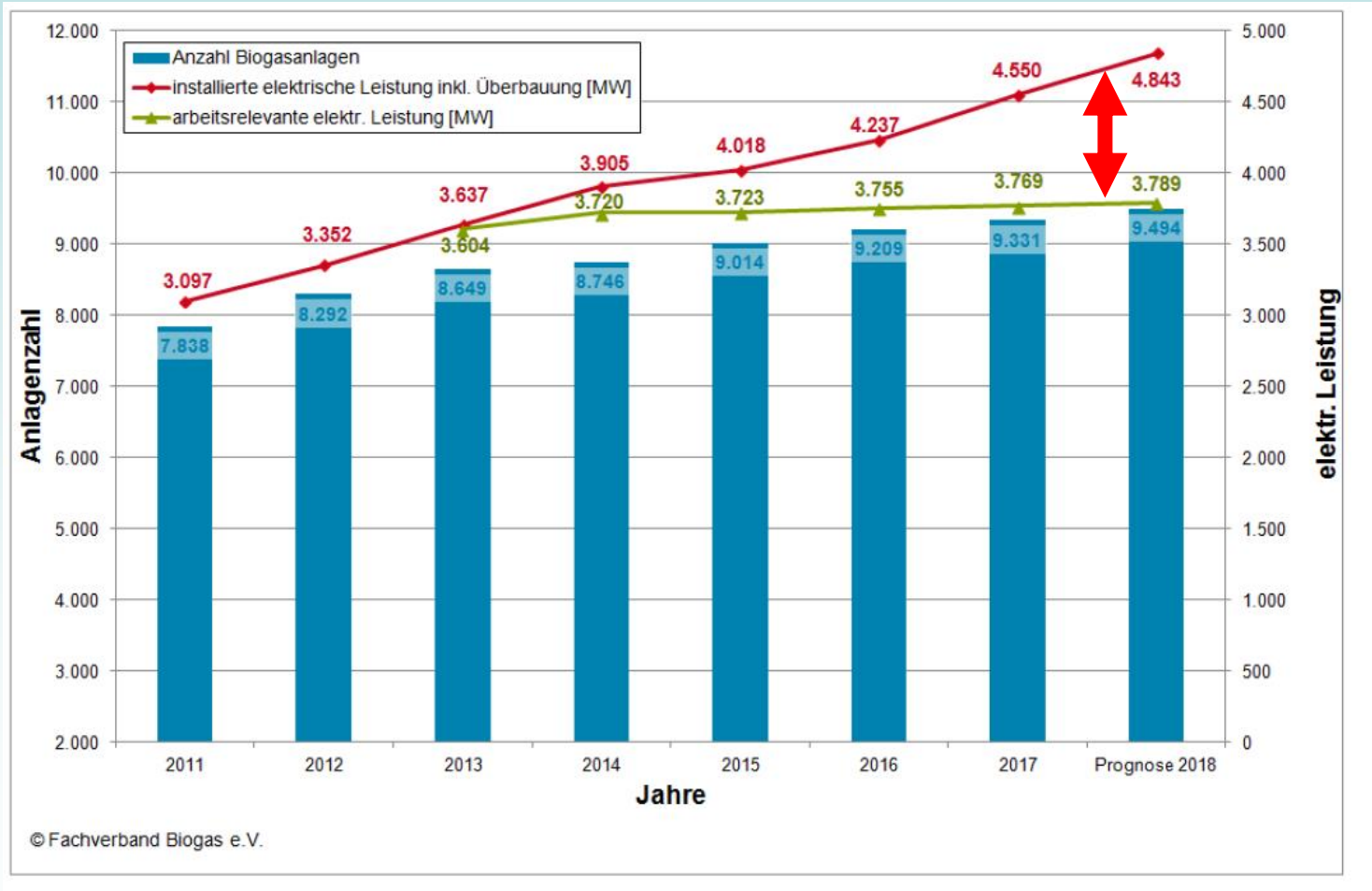
The future is however uncertain

→ Many German companies are looking for other markets!

Source: https://www.biogas.org/edcom/webfvb.nsf/id/de_branchenzahlen

Biogas statistics

Development of the number of biogas plants and the total installed electric capacity and working capacity in megawatt [MW] in Germany (as of 05/2018)



Source: https://www.biogas.org/edcom/webfvb.nsf/id/de_branchenzahlen

Reasons for this biogas development?

The rapid development of the biogas sector in Germany is caused by the following facts:

- Historically, biogas plants were set-up to close nutrient cycles & to treat wastes in **organic agriculture**

- The support of biogas plants through the German Feed-in power feed-in-tariff system was a huge **agricultural support scheme** -> „energy farmer“

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Classification of biogas plants

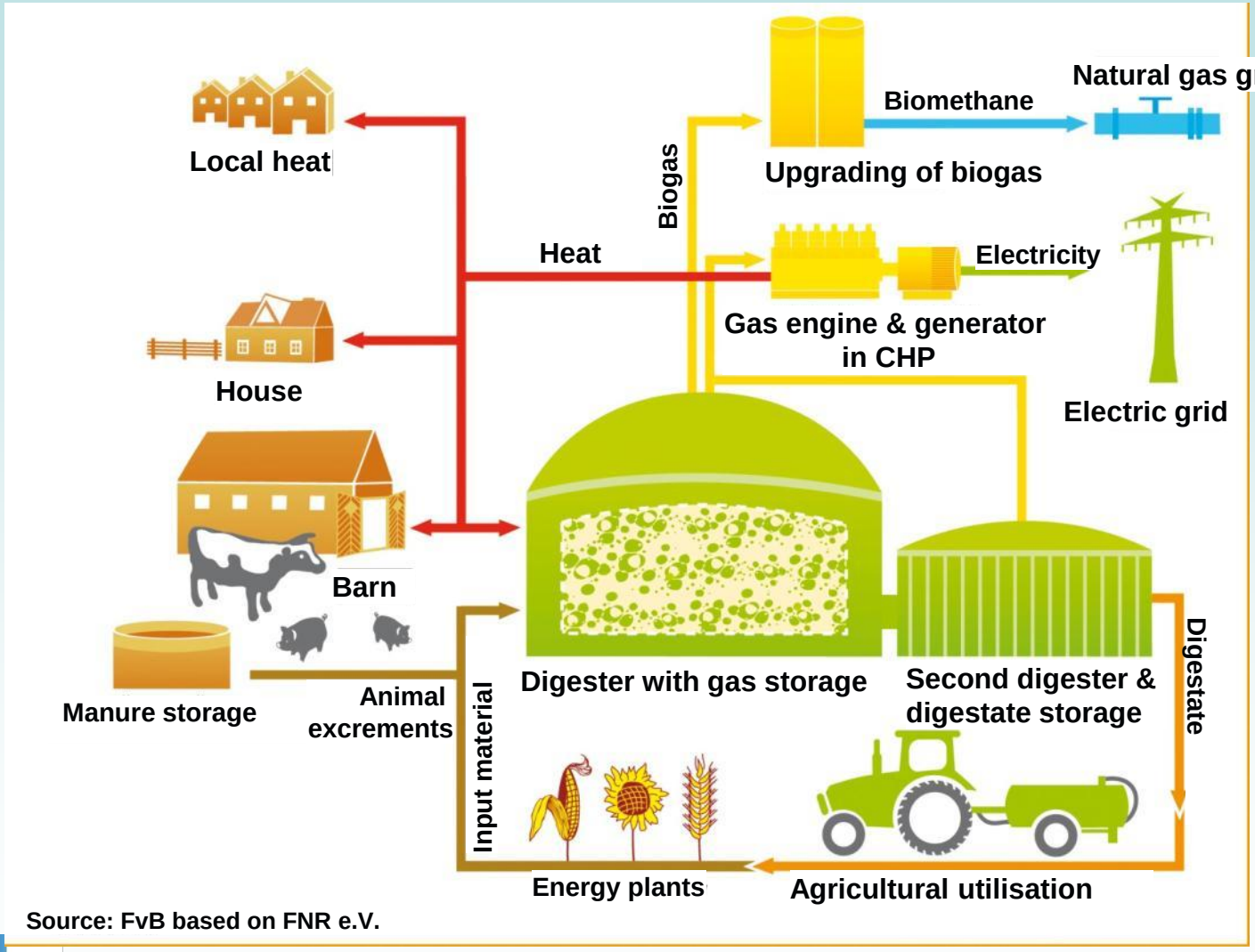
- **Objective**: household level, agricultural, industrial
- **Size of the plant**: household-, small-, medium-, large scale

- **Moisture level of substrate**: Wet or dry fermentation
- **Process stages**: Single or multi stage process
- **Material flow**: Continuous or discontinuous process

- **Process temperature**:
  Psychrophilic (25°C), Mesophilic (37-42°C), Thermophilic (50-60°C)

- **Biogas use**:
  cooking & lighting, combined heat and power (CHP), biomethane, chemicals (?)

Scheme of an agricultural biogas plant
- Anaerobic Digestion (AD) -

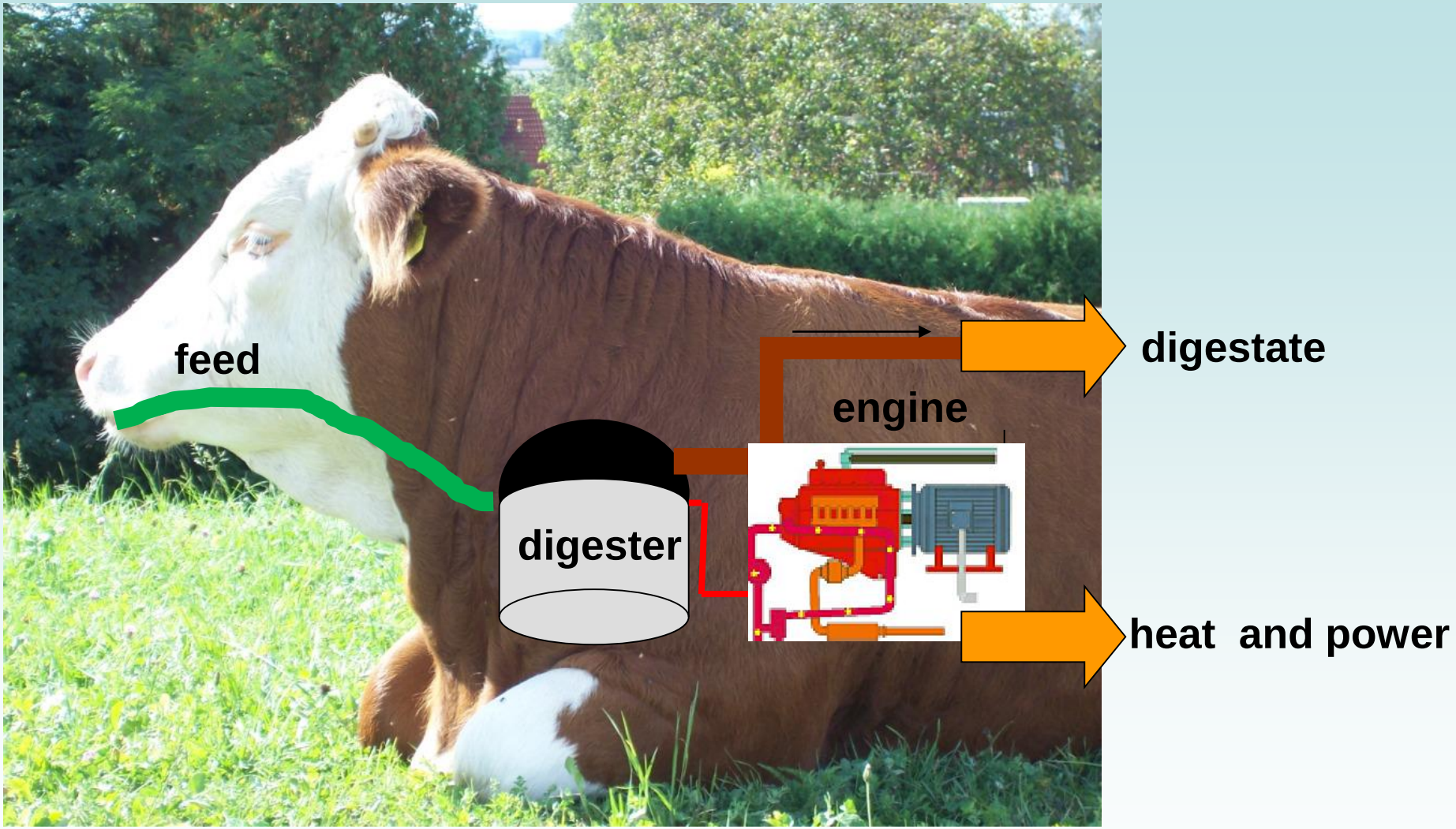


Source: FvB based on FNR e.V.

„Natural“ biogas plants…

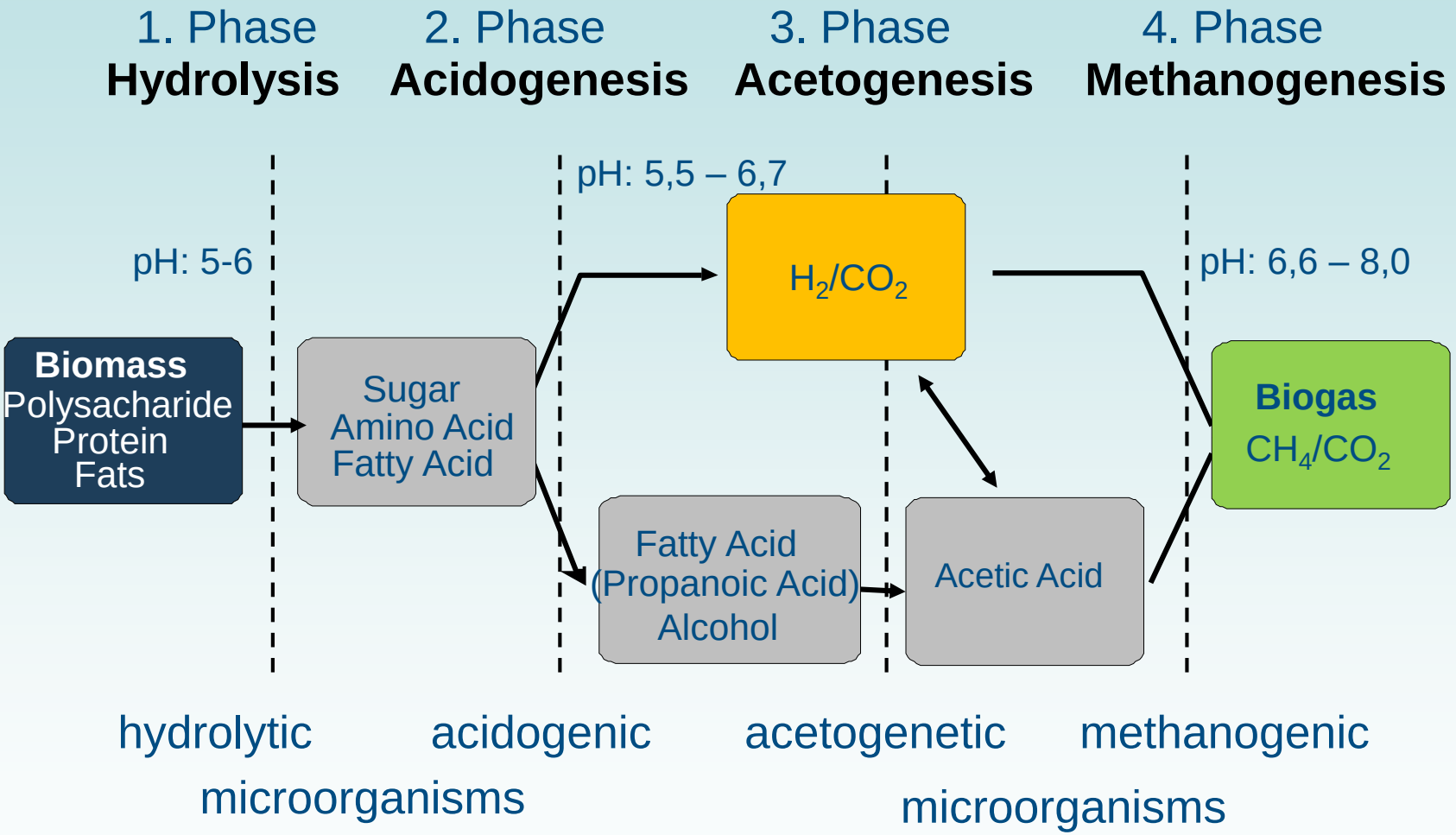
Picture sources: © Dominik Rutz

The biogas principle – like a concrete cow



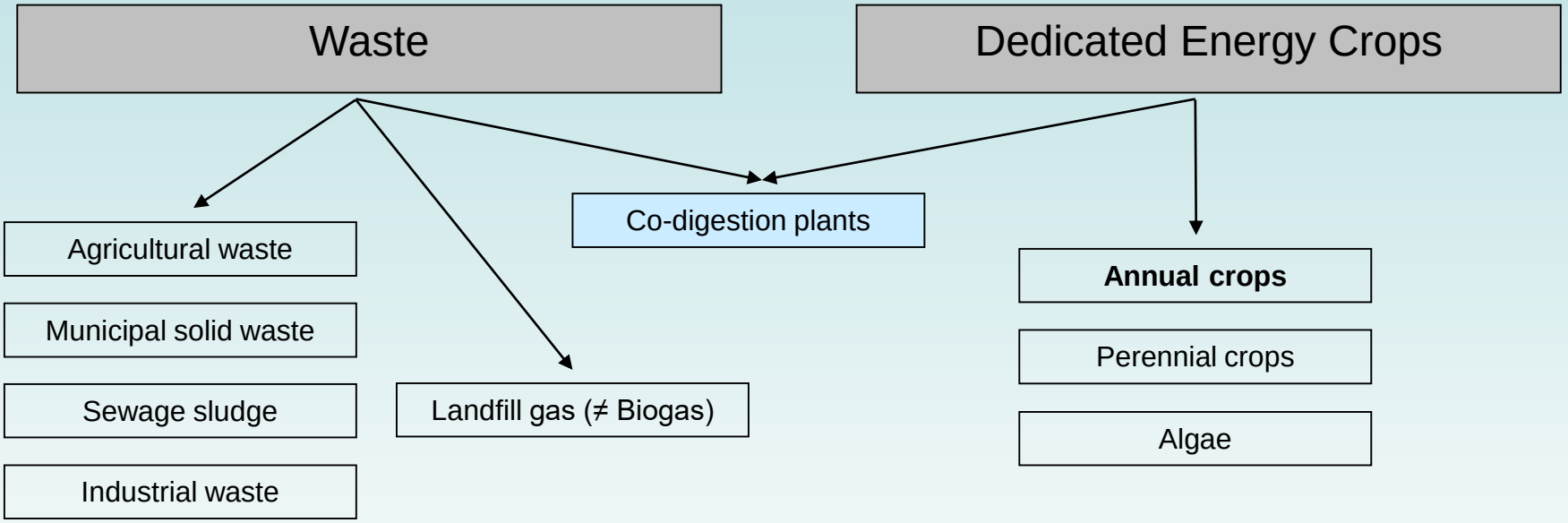
Picture sources: © Dominik Rutz

Process steps of anaerobic digestion



Source: Clemens Findeisen, German Biogas Association

Biogas Feedstock Classification



Methane yields of different feedstock

Attention:

These are average numbers!!
Real numbers may differ!!

The more details you know about your foreseen feedstock, the better you can estimate your revenues!

Feedstock	CH_4 yield [m^3/t fresh feedstock]	Feedstock	CH_4 yield [m^3/t fresh feedstock]
Frying oil and fats	562	Potato peels	66
Glycerine	421	Press cake from sugar production	64
Casein	392	Sugar beet shavings	64
Lactose	378	Legumes (whole crop)	63
Skimmed milk dry	363	Spent grains (fresh/pressed)	61
Baking waste	344	Potato pulp from starch production	61
Grain maize	324	Medical and spice plants (rejected)	58
Cereal grain kernels	320	Food leftovers	57
Rapeseed cake	317	Cut flowers (rejected)	55
Whey, low sugar, dry	298	Fodder beet	52
Rapeseed meal	274	Small beet pieces (from sugar processing)	50
Cereal waste	272	Sugar beet leaf with sugar beet parts	46
Bran	270	Rennet whey	44
Old bread	254	Flotation fats	43
Waste from cereal processing	254	Green cuttings from private/public gardens and park maintenance	43
Corn cob mix (CCM)	242	Grass from roadways maintenance	43
Grain dust	172	Acid whey	42
Molasses from beet sugar production	166	Vegetables (rejected)	40
Cobs, husks, kernels of corn	148	Fodder beet leaf	38
Corn (whole crop)	106	Skimmed milk fresh	33
Cereals (whole crop)	103	Contents of rumen	33
Grass including ley grass	100	Buttermilk fresh	32
Potatoes	92	Potato haulm	30
Potatoes (rejected)	92	Guts (pigs)	27
Curd cheese	92	Waste from vegetable processing	26
Lactose molasses	91	Cereal vinasse except from alcohol production	22
Animal blood	83	Acid whey fresh	20
Flotation sludge	81	Cereal vinasse from alcohol production	18
Sorghum (whole crop)	80	Potato vinasse except from alcohol production	18
Sudan grass	80	Fresh sweet whey	18
Ryegrass	79	Whey	18
Sugar beet	75	Potato vinasse from alcohol production	17
Forage rye (whole crop)	72	Grease separator contents	15
Milk	70	Water from potato starch production	11

Source: BMU 2012 / Handbook – Sustainable Heat use of Biogas Plants; Rutz, 2012

Typical biogas plant in Bavaria/Germany

CHP unit
(Bavaria)

Concrete fermenter construction
(Bavaria)

Biogas plant
(Bavaria)

Typical biogas plant in Bavaria/Germany

- Average Size: ~500 kWel
- Biogas use: electricity
- Feedstock: mainly corn silage, but also manure, waste, etc.

Corn silage & digestate tractor
(Bavaria)

Mize/corn field
(Bavaria)

Corn silage preparation

Picture sources: © Dominik Rutz

Corn silage

Picture sources: © Dominik Rutz

Feedstock storage needs logistics!

Picture sources: © Dominik Rutz

Harvest of grass for silage

Picture sources: © Dominik Rutz

Treatment Methods for Bio-waste





Landfill

- Reduction necessary to comply with Directive 2006/12/EC
- Landfill gas could be energetically used, but energy output is low
- No use of nutrients is possible

Incineration Plant

+ Energetic use
- "waste heat" is often un-used
- No use of nutrients is possible
- High investment costs and other barriers for new plants
- Long transport ways due to centralised plants

Household Composting

+ Common practice in many cases
+ High-value end-product: closed nutrient cycle
+ No sophisticated logistics needed
- No energetic output
- Not all waste is suitable for private composts
- Not possible in urban areas

Industrial Composting

+ Common practice in many cases
+ High-value end-product: closed nutrient cycle
- No energetic output

Anaerobic Digestion

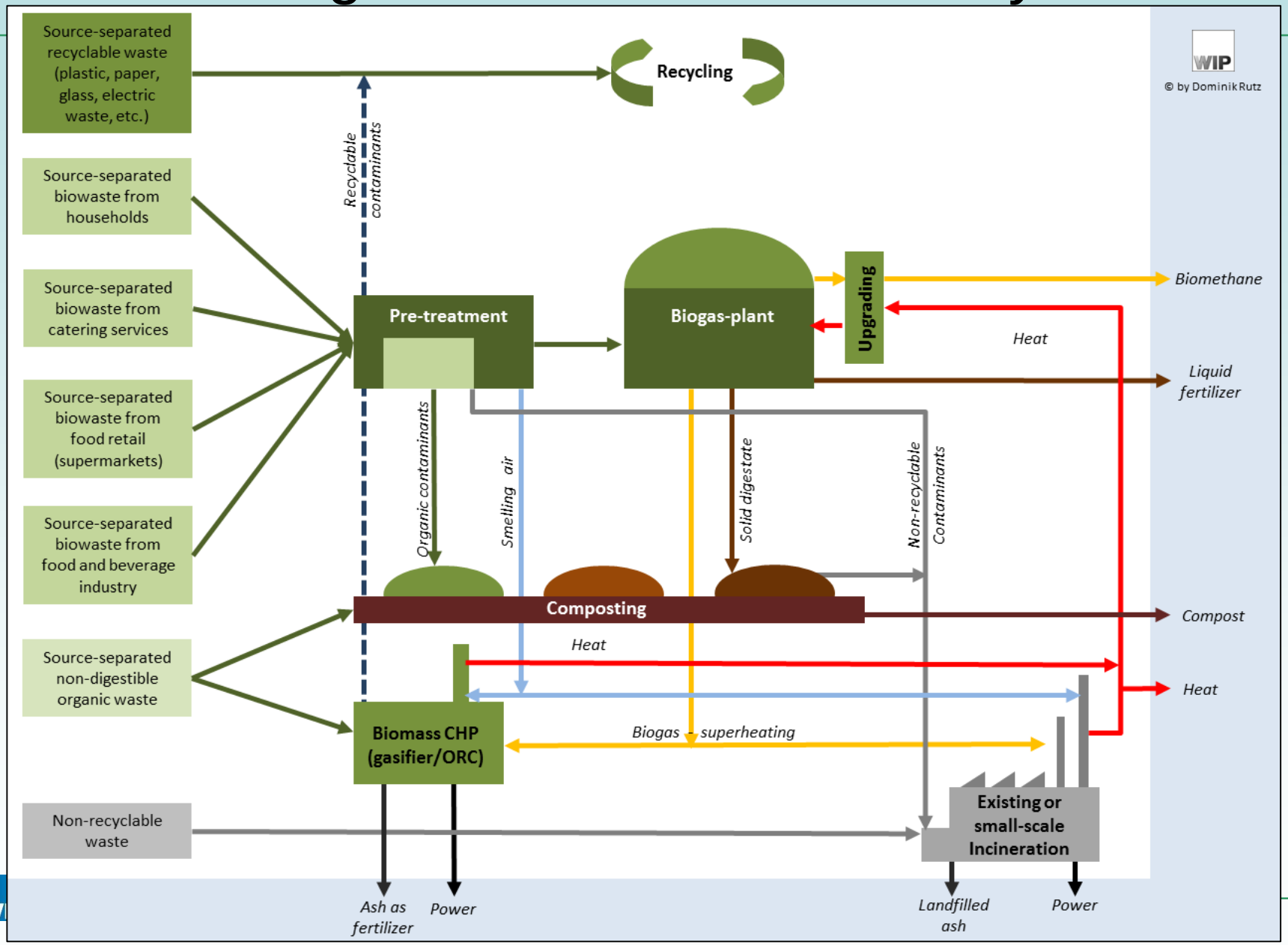
+ High energetic output

+ High-value end-product: closed nutrient cycle

+ Opportunity to produce transport fuels

→ Still needs non-technical support

Integrated Biowaste Refinery



Revenues from waste treatment plants

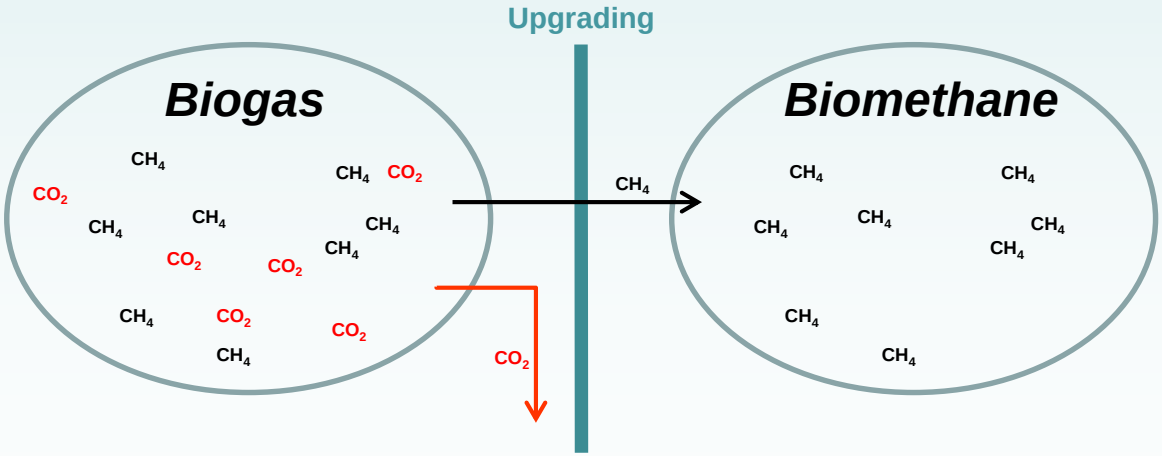
- Revenues from waste treatment plants are gained from:
  - Tipping fees
  - Energy production
  - Digestate sale

- Often, the main revenues of „waste“-biogas plants is from the

  -> **tipping fees**

Biomethane

- Biogas usually has a methane (CH_4) content of 50-60%
- Various upgrading technologies exist (membrane, amine scrubbing, water scrubbing, PSA, etc.)
- Biogas can be upgraded to biomethane of >95% CH_4 content
- Same properties as natural gas



Biomethane

Upgrading unit
(Bavaria)

Biomethane injection
(Bavaria)

Pressure swing adsorption (PSA)
(Bavaria)

Biomethane filling station
(Austria)

Picture sources: © Dominik Rutz

Technology is mature!

For **all** value chain steps,
from feedstock collection to biomethane utilisation,
technologies are **mature** and **availabe**!

>15,000 biogas plants in Europe!
>290 bimethane plants in Europe!
>750 biogas plants for biowaste in Europe

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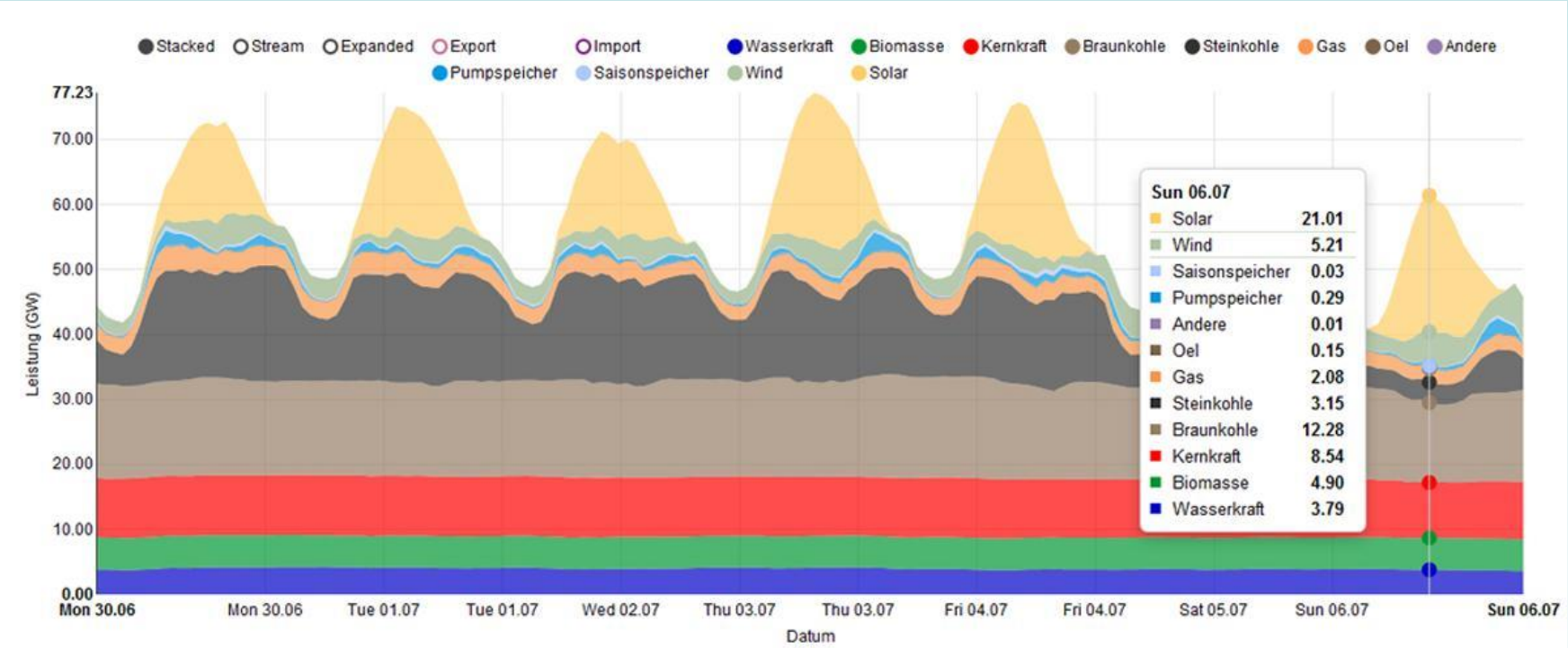
Electricity production in Germany in week 27/2014

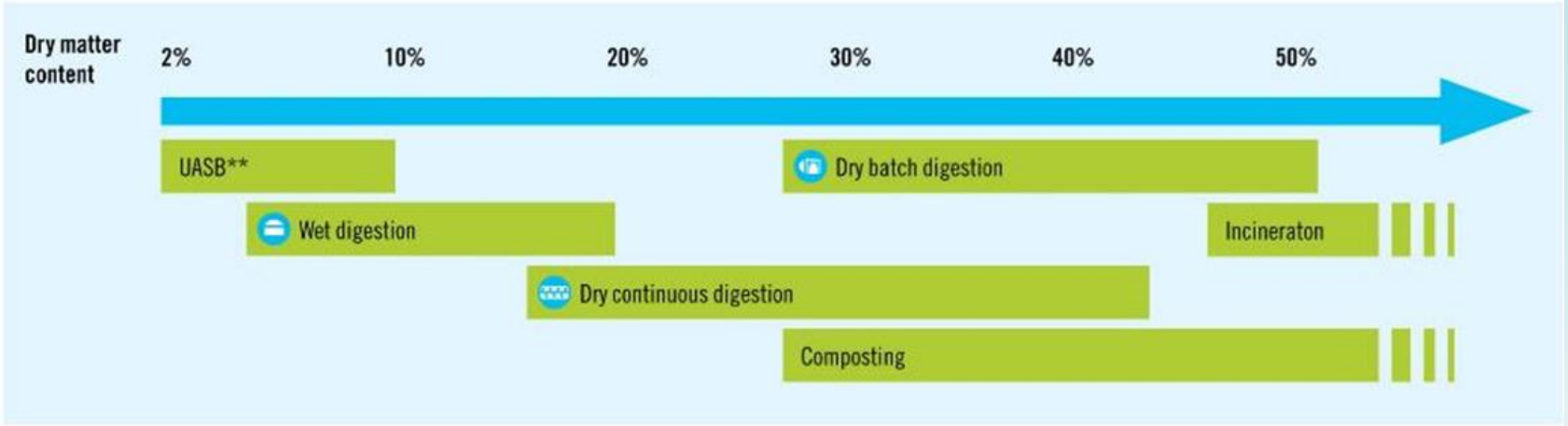


Source: http://www.bine.info/themen/erneuerbare-energien/photovoltaik/news/datenbank-zeigt-leistung-der-erneuerbaren/ © Fraunhofer ISE

Digester technologies

Fachverband BIOGAS

Overview of technologies depending on dry matter content for the possible operating mode*



** Mostly every feedstock can be diluted to the needed dry matter content of each digester technology.*

*** UASB: Upflow anaerobic sludge blanket technology is a form of anaerobic digestion designed for materials with high water content (e.g. sewage sludge). UASB reactors are installed for waste or process water treatment.*

Why Biogas / Anaerobic Digestion?

- **Wet** / in-homogenous material can be treated
- **Waste** treatment method
- Approved and **mature** technology
- Recycling of nutrients as **fertilizer** (digestate)
- Biogas can be produced at **any scale**!
- Biogas can **balance the power grid**
- Biogas contributes to „**sector coupling**“ (power, heat, transport)

→ **AD can be one part of a modern biorefinery**

Objective of a biogas plant: comparison to photovoltaics

- If the „only“ objective is power generation, other systems (e.g. **photovoltaics**) are much simpler, cheaper, less risky!

- Main **advantages** of biogas systems :
  - **Wet** / in-homogenous wastes can be treated
  - Recycling of nutrients as **fertilizer** (digestate)
  - Biogas can be produced at **any scale**!
  - **Local** revenue generation
  - **Continuous** job creation during the lifetime of the biogas system
  - Multiple use of biogas (e.g. also for chemicals)

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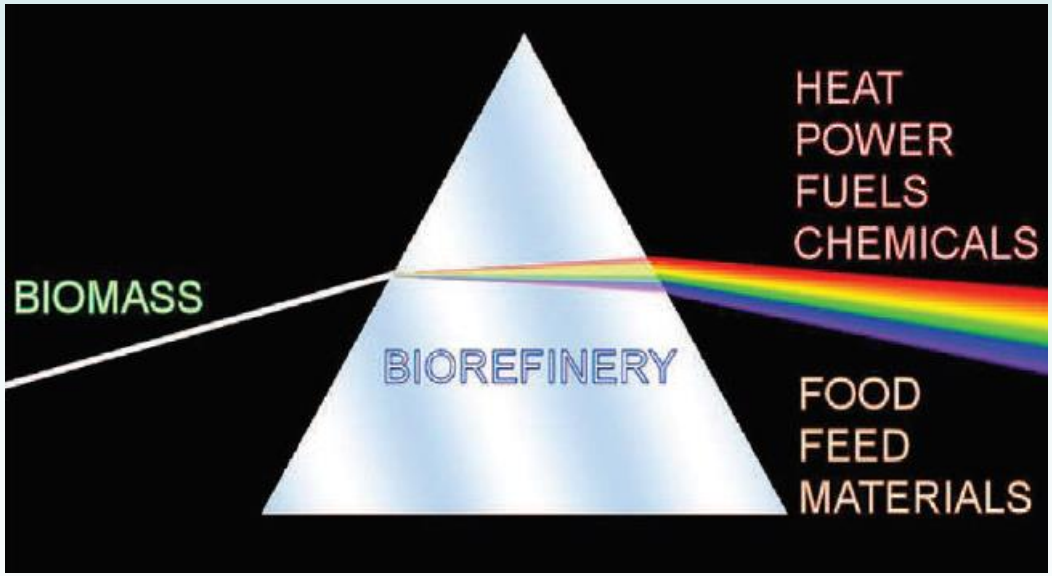
How is „biorefinery“ defined?

IEA Bioenergy Task 42 Definition:

“Biorefinery is the sustainable processing of biomass into a spectrum of marketable products and energy.”



Source: http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/3/7/5/cf7aa6b6-2140-46f2-b4ca-455f5c3eb547_de%20Jong%202015%20Biorefinery%20Concepts%20in%20Comparison%20to%20Petrochemical%20Refineries%20Book%20Chapter.pdf

Biogas in biorefineries

Biogas/AD can …

- **treat waste streams** in a biorefinery
- **provide heat and power** in a biorefinery
- **provide chemicals** (e.g. CH_4; H_2; etc.) in a biorefinery

Key question:

- **Location of the biogas plant:** close to feedstock and/or close to the biorefinery, industries, logistics?
- **Logistics**: minimizing transport of large volumes (feedstock, digestate)

→ These aspects may be very different for a biorefinery AD plant than for an agricultural biogas plant

Example 1: Small- Scale Biogas-Refinery in Bavaria: Hotel/Farm Weßner Hof

Wastes from:
- Farm
- Slaughterhouse
- Restaurant/hotel
- distillery

Energy:
- Biogas
- PV

Products:
- Food
- Brandy
- Fertilizer

Example 2: Medium sized biogas plants: digestion of ligno-cellulose rich material

- 2-stage AD technology from SnowLeopard in Germany
- www.snow-leopard-projects.com

Example 2: Medium sized biogas plants: digestion of ligno-cellulose rich material

The Right Feed for

SNOWLEOPARD

low fiber

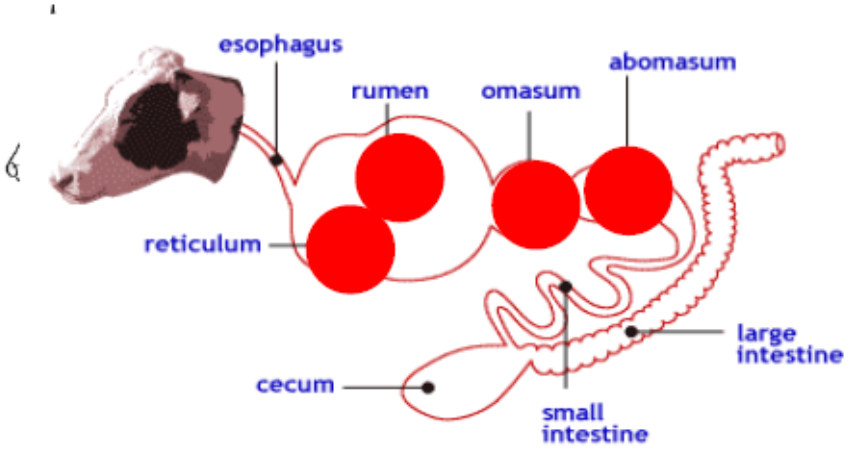
high fiber

Example 2

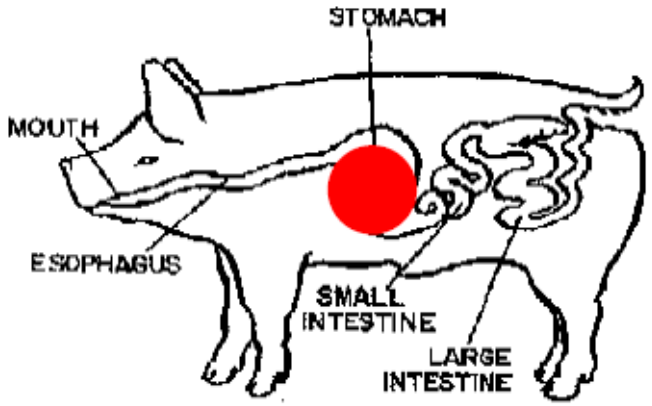
SLP – Imitating the Bovine Digestion System

SNOWLEOPARD

Cattle have 4 stomachs
- and can digest cellulose



Pigs have only 1 stomach
- and can only digest starch, protein and fat



Cellulose is most common and cheapest biomass worldwide!
The aim is to ferment cellulose!

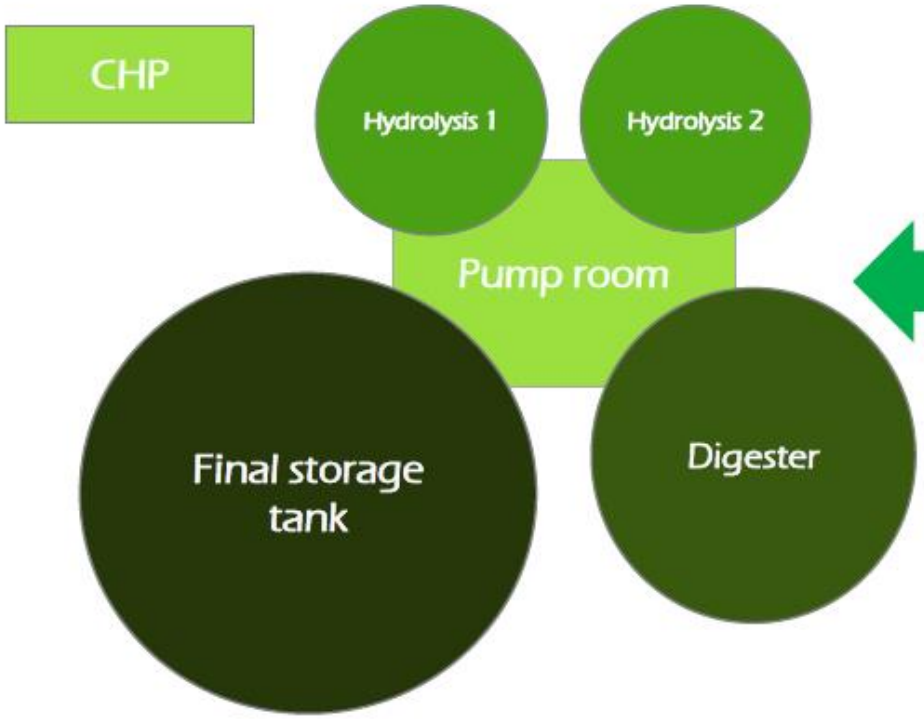
Example 2

AD Plant of the 2nd Generation

Digestion - 2-stage Biology with Upstream Batch-Hydrolysis

SNOWLEOPARD

Basic layout



Example 3: Large scale biogas / ethanol refinery

- Biomethane from straw and from residues from ethanol/biodiesel production
- Locatd at a crude oil refinery
- VERBIO produces per year:
  - 470.000 t biodiesel
  - 260.000 t bioethanol
  - 600 GWh biomethane

verbio
Biofuel and Technology

“DE BIOh Verbiostraw “Project:
Production of biomethane from 100% straw

- VERBIO production site in Schwedt/Oder, Germany
- Technology: mono fermentation of straw (biomethane equal to natural gas made of 100% straw)
- Plant capacity (final stage 2019): 16.5 MW (136 GWh/a)
- Feedstock (final stage 2019): 40,000 tons of straw p.a.

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Conclusion

- Bioenergy development in Germany is largely influenced by **German and European legislation**
- The path for the complete **energy transition** has been prepared (for electricity, efficiency and heat still need to be pushed!)
- Biogas is an important technology in Germany with more than **9,000** AD plants
- Many **companies** (SMEs) were set up to provide technologies
- As the political framework for biomass use is getting less favourable in Germany, companies have to look for **export markets**

- **Biogas/AD is a very good stand-alone technology and even better for the inclusion in a Biorefinery**

Thank You!

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