Biogas - Energy from anaerobic digestion

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Fachagentur Nachwachsende Rohstoffe e.V. (FNR)

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- Agency for Renewable Resources (FNR)
- Biogas production
- Utilisation of biogas
- Biogas in Germany
- Outlook and summary

- **Agency for Renewable Resources (FNR)**

Biogas production

Utilisation of biogas

Biogas in Germany

Outlook and summary

Fachagentur Nachwachsende Rohstoffe e.V. (FNR)

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Who we are: Central coordinating agency in the area of "Renewable Resources" in Germany

Founded: October 1993

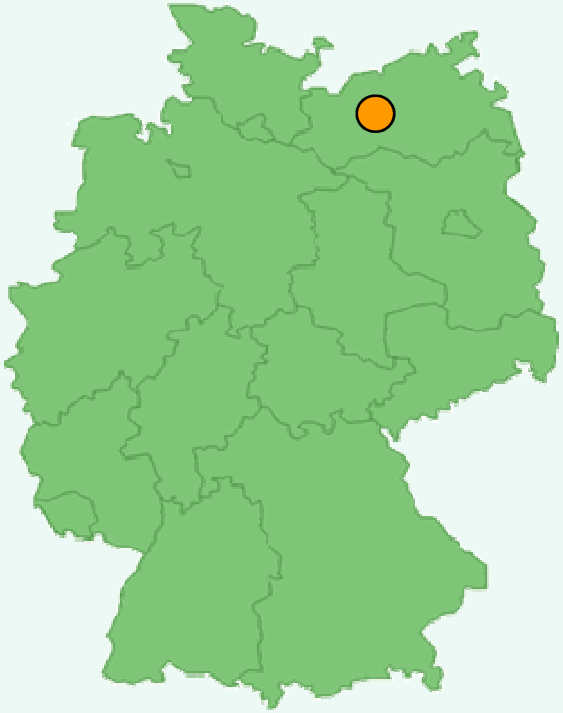
Location: Gülzow, Mecklenburg-Western Pomerania

Support: Federal Ministry of Food, Agriculture and Consumer Protection (BMELV)

Members: 66

Employees: 74

Legal status: Registered Association



FNR - Tasks and main fields of work

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Tasks

- Support research, development and demonstration projects (RTD Programme)
- Provide all stakeholders with information and advice
- Public Relations activities
- German contact point for EU activities

Main fields of work

- Renewable energies from biomass
- Materials / bio-degradable materials from renewable resources
- Building with renewable resources
- Lubricants from plant oils
- Bio-conversion technologies
- Consumer information

Aim: Support market introduction

R&D programme "Nachwachsende Rohstoffe" ("Renewable Resources")

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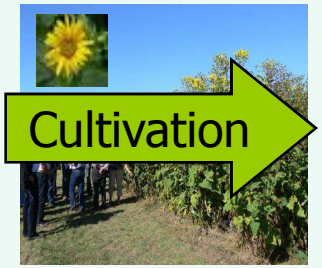
- Research, development and demonstration projects funded
- more than 2.000 projects funded as of today
- ~ 450 ongoing projects per year
- marketable products and technologies in the fields of
  - Bio-lubricants
  - Construction and insulation materials
  - (Raw) materials from renewable resources
  - Bioenergy

Project funding: Strategic approach - research and development along the process line

e.g.:
Energy beet, winter field bean, grasses



e.g.:
EVA 1&2 , ELKE

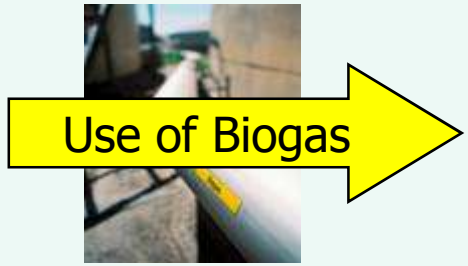
Cultivation of Silphium perfoliatum

(cup plant)

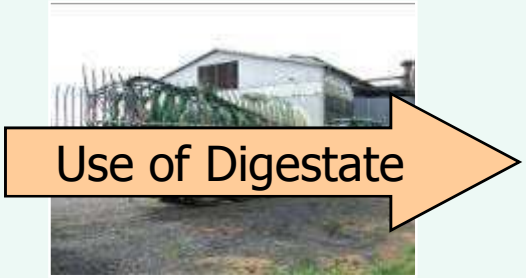
e.g.:
Intensification of anaerobic biomass degradation for methane production

Biogas Measurement Programme (BMPII)

e.g.:
Treatment of biogas with membrane technology



e.g.:
Investigations on phytosanitary risk



Agency for Renewable Resources (FNR)

- **Biogas production**

Utilisation of biogas

Biogas in Germany

Outlook and summary

Biogas

- produced from organic matter without oxygen
- in nature in swamps, bogs, ruminant stomach
- microbial decomposition
- technically in biogas (AD) plants
- biogas yield and methane content varies
- energy content: 1 m³ biogas = 5.0 - 7.5 kWh

  1 m³ methane = 9.97 kWh
- storeable, production do not depend on weather, daytime or season

Biogas II

- Reduce dependance on fossil energy sources
- Increasing independence from energy imports
- Reduction of green-house-gas emissions
- Utilisation of unused residues and wastes and regional available organic matter
- Saving of mineral fertiliser by using digestate
- No new infrastructure needed – power and gas already there
- Biogas production and utilization creates values and strengthens rural areas
- Added income for farmers, job creation
- Related activities in research and development will enhance the know-how and technology progress in Germany

Input substrates

- livestock excrements
  - slurry, manure
- energy crops
  - maize (corn), grass, grain, beets, sunflowers ...

- by-products from food- and feed industry
  - potatoe pulp, apple pomace, draff ...
- organic wastes and residues
  - biowaste, leftovers, expired food, slaughterhouse waste, landscaping material, lawn cuttings ...

Biomass use and requirements

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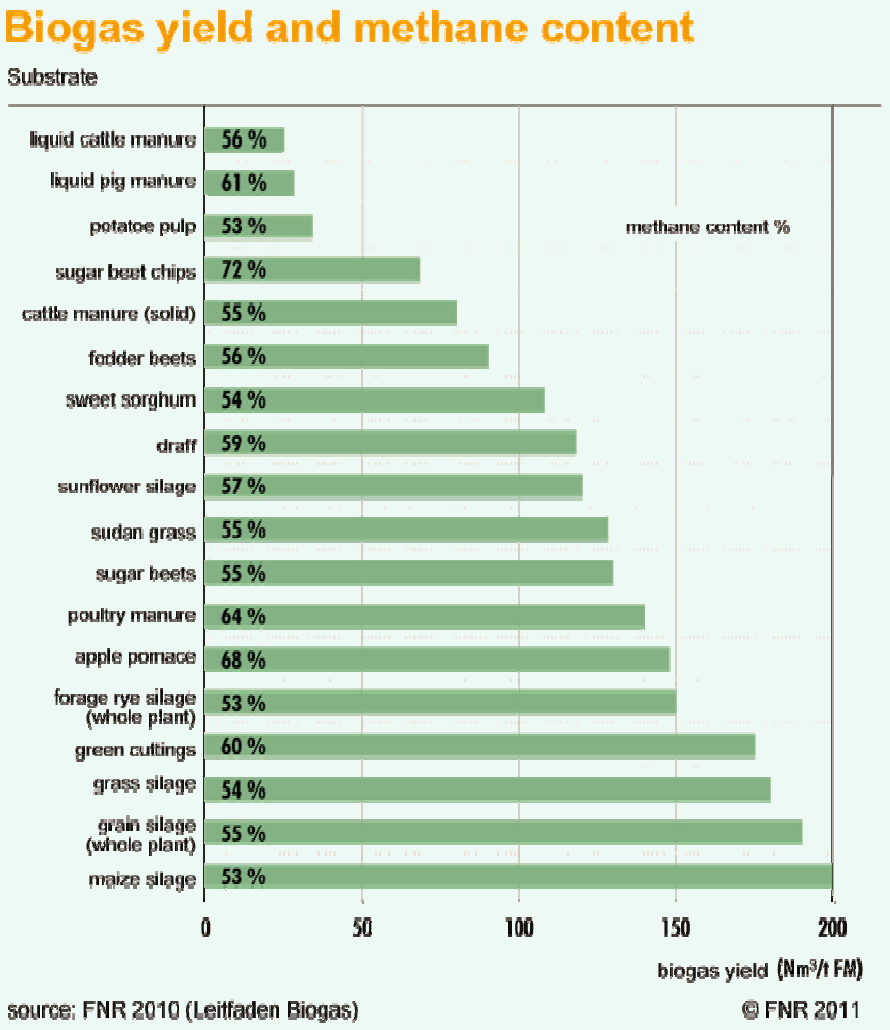
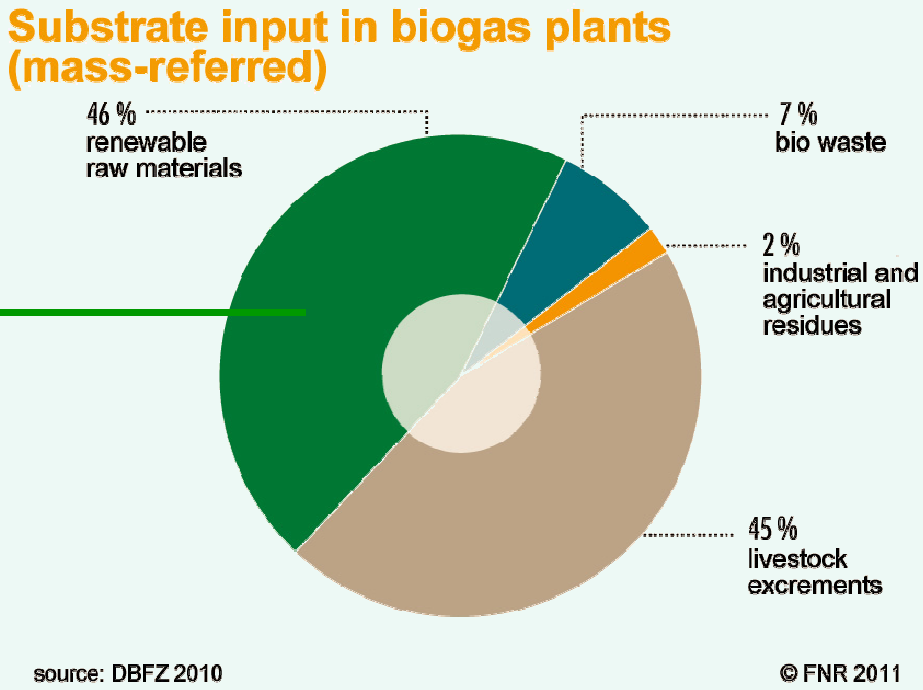
Important:

- local availability
- stable quantity over the year
- steady quality
- costs of production (per ha) / proceeds of disposal
- biogas yield (methane output per tone)
- opt. mixture with other substrates for digesting (pH-value, HRT,…)



Biogas substrates in Germany



Corn silage 76%	Grass silage 11%
Grain silage (whole plant) 7%	Grain 4%
Sugar beets 1%	others 1%

Source: operator survey 2010, DBFZ (2011)

Process technology

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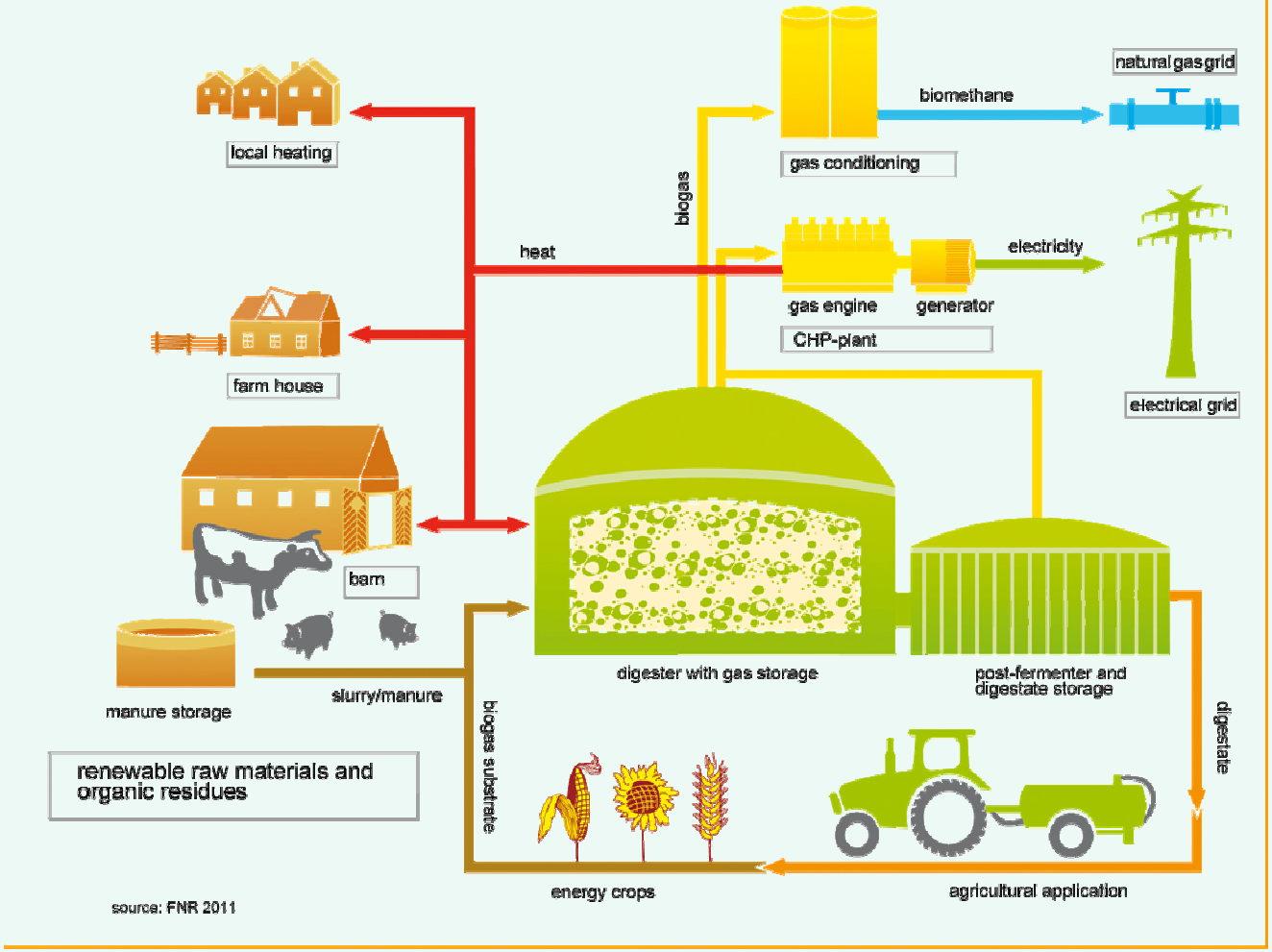
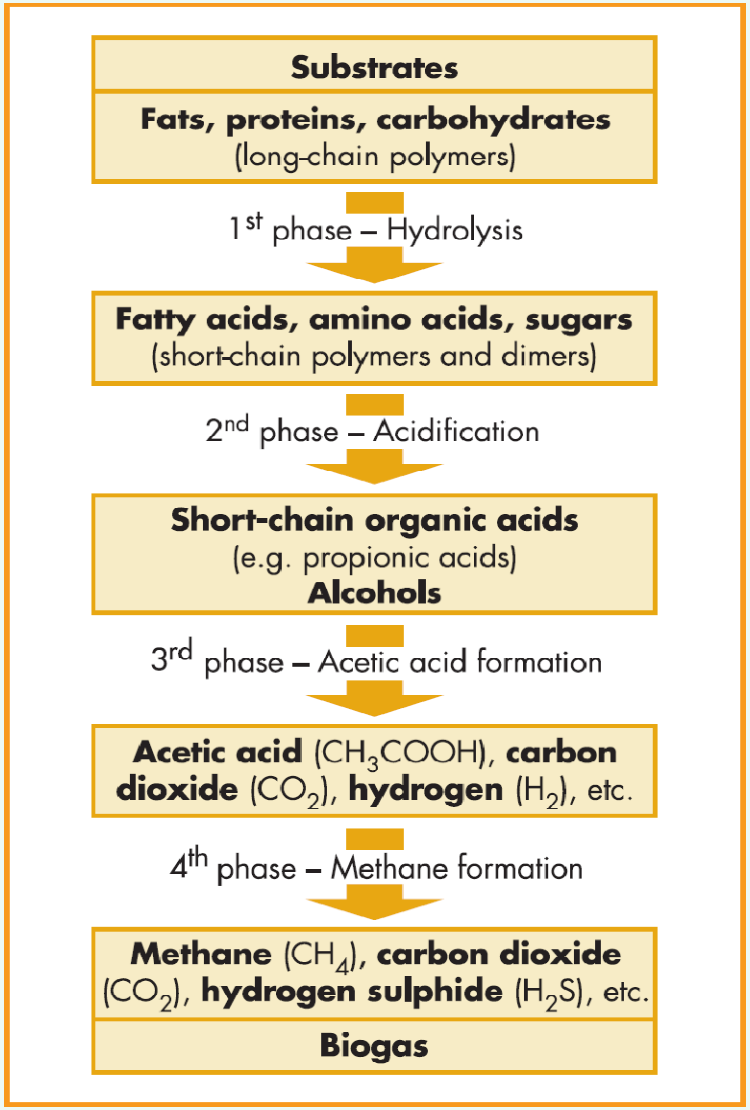
Scheme of a farm-based biogas plant



Fermentation process



Composition of biogas

methane (CH_4)	50-75%
carbon dioxide (CO_2)	25-45%
water (H_2O)	2- 7%
oxygen (O_2); nitrogen (N_2)	<2%
ammonia (NH_3); hydrogen sulphide (H_2S)	<1%
trace gases	<2%

Process conditions

- pH-value: hydrolysis: 4,5 – 6,3
  methane formation: 6,8 – 7,5
- anaerobic (oxygen-free)
- temperature: mesophilic: 32 - 42 °C
  thermophilic: 50 - 57 °C
- organic load [kg oDM/m³ d], hydraulic retention time [d]
- nutrients (C/N/P-ratio): 75:5:1 to 125:5:1
- Inhibitors

Methods of biogas production

Criteria	Distinctive feature
Dry matter content of input substrate	• wet fermentation • dry fermentation
Type of feeding	• discontinuously • quasi-continuously • continuously
Number of process phases	• single-phase • two-phase
Process temperature	• psychrophil • mesophil • thermophil

Dry matter content

Biogas technologies

Wet fermentation (liquid digester content)

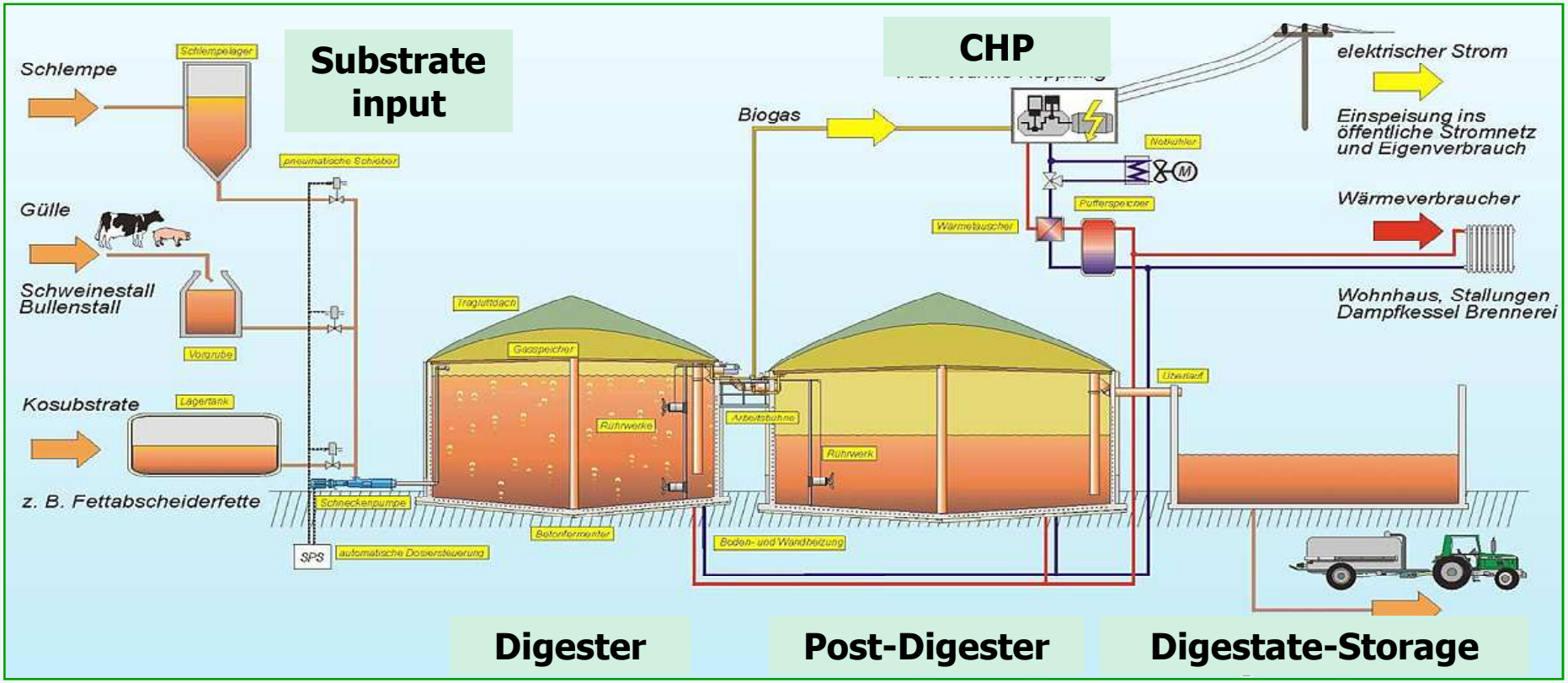
- dis-/ continuously operation
- for liquids, pasty and solid substrates (total solid max. 15 %)
- good substrate commingling

Dry fermentation (solid digester content)

- dis- / continuously operation
- only for stackable biomasses
- no homogenisation
- small reactor capacities
- Percolation needed

AD plant - wet fermenation

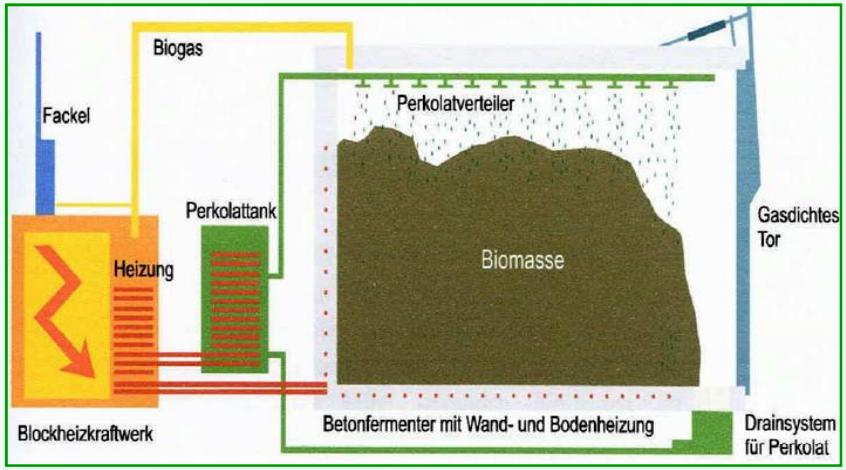
- Wet fermentation is the method of choice in Germany
- Substrates are mainly livestock excrements and energy crops



Source: Biogas Nord

Dry fermentation "percolation reactor"

- No need for liquid substrate (manure, whey etc.) as basic
- Suitable technology for farms without livestock
- Biomass is digested in its stackable, bulky form (no mixing needed)
- modular conception
- Retention time: 4-8 weeks
- Preferred in biowaste plants



Attention should be paid to…

- performance and efficiency of wet and dry fermentation methods are comparable
- temperature fluctuation in reactor will occur microbial strain changes:
  < 2°C / day (→ insulation and heating concept)
- sufficient supply of trace elements might be needed if no farm fertilizer are digested
- Organic load (how much oDM can fed into per digester volume and time) and HRT (average time interval substrate is kept inside digester)
- increased organic load reduces HRT, performance fall-off from 5 kg oDM/m³d possible
- feed in substrate in small portions several times (15 or 20+) a day

Agency for Renewable Resources (FNR)

Biogas production

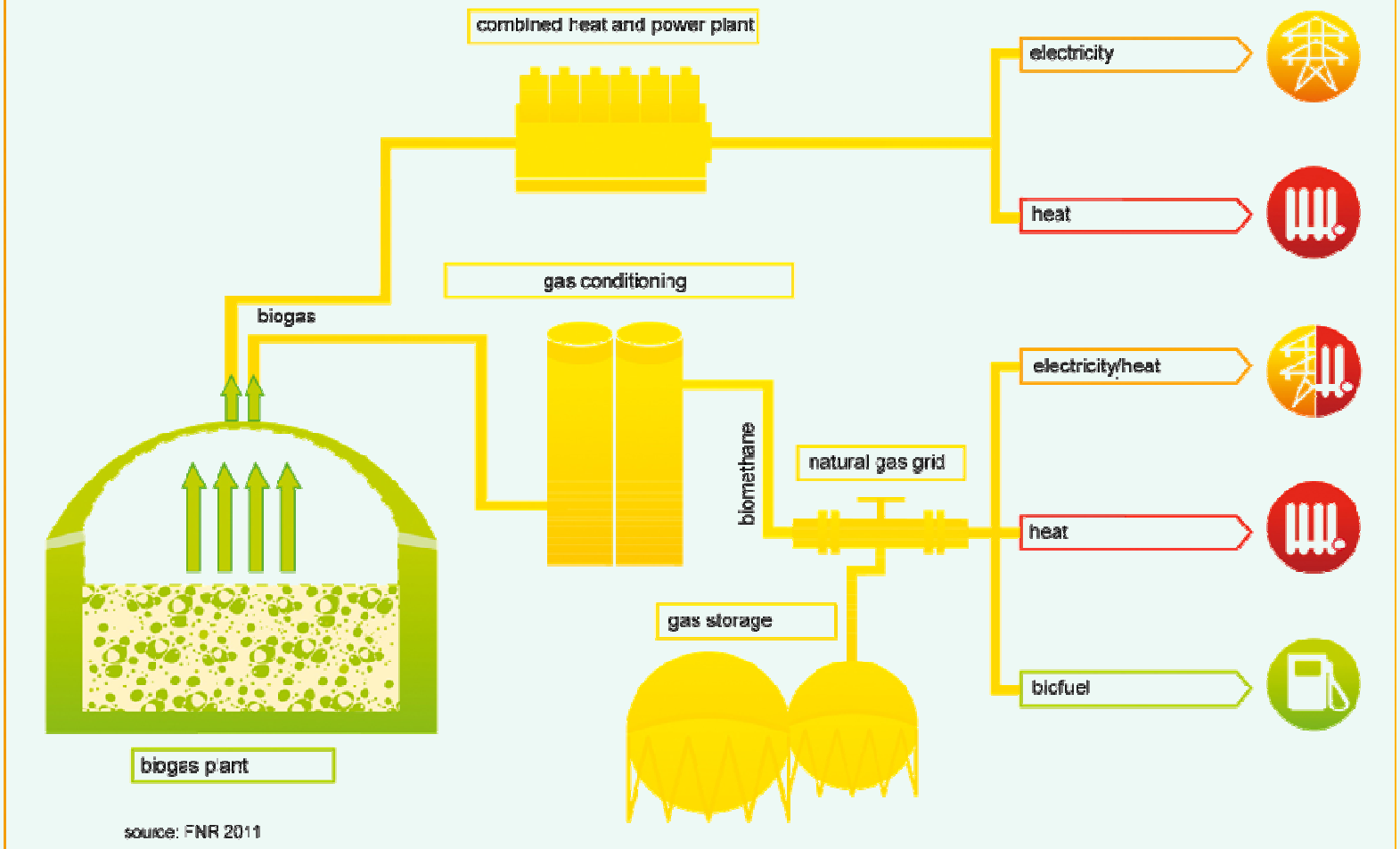
- **Utilisation of biogas**

Biogas in Germany

Outlook and summary

Possible utilisation

Various utilisation of biogas



Power and heat

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Decentralised CHP-plant

electricity

- Gas-Otto-engine
- Spark-Ignition-engine
- Fuel cell
- Micro turbine
- Stirling engine

heat

- ORC
- fermenter
- **external**
  - farm buildings
  - heat grid
    - residential
    - municipal
    - commercial
  - cooling

Biomethan and fuel

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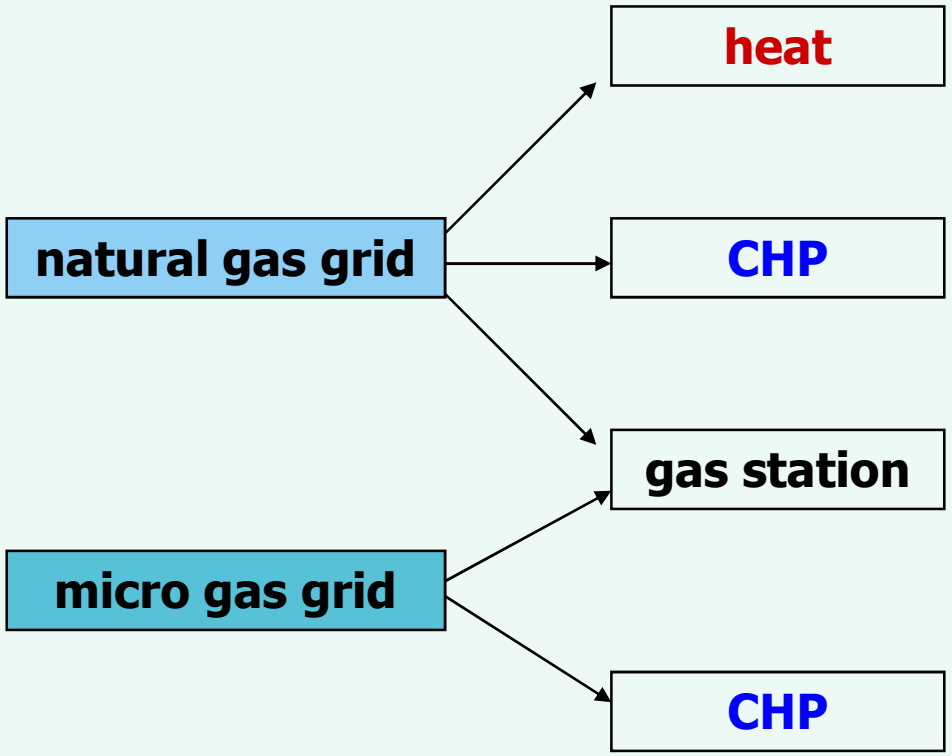
Steps in biogas upgrading

- organic matter
- biogas production
- raw biogas
- gas cleaning and conditioning
  desulphurisation
  drying
  removal of CO_2, O_2 and other trace gases
- pure biogas
- upgrading to natural gas quality
  odourisation
  gas mixture (if necessary)
  gas compression
- biomethane



Agency for Renewable Resources (FNR)

Biogas production

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Outlook and summary

Biogas plants and electrical capacity

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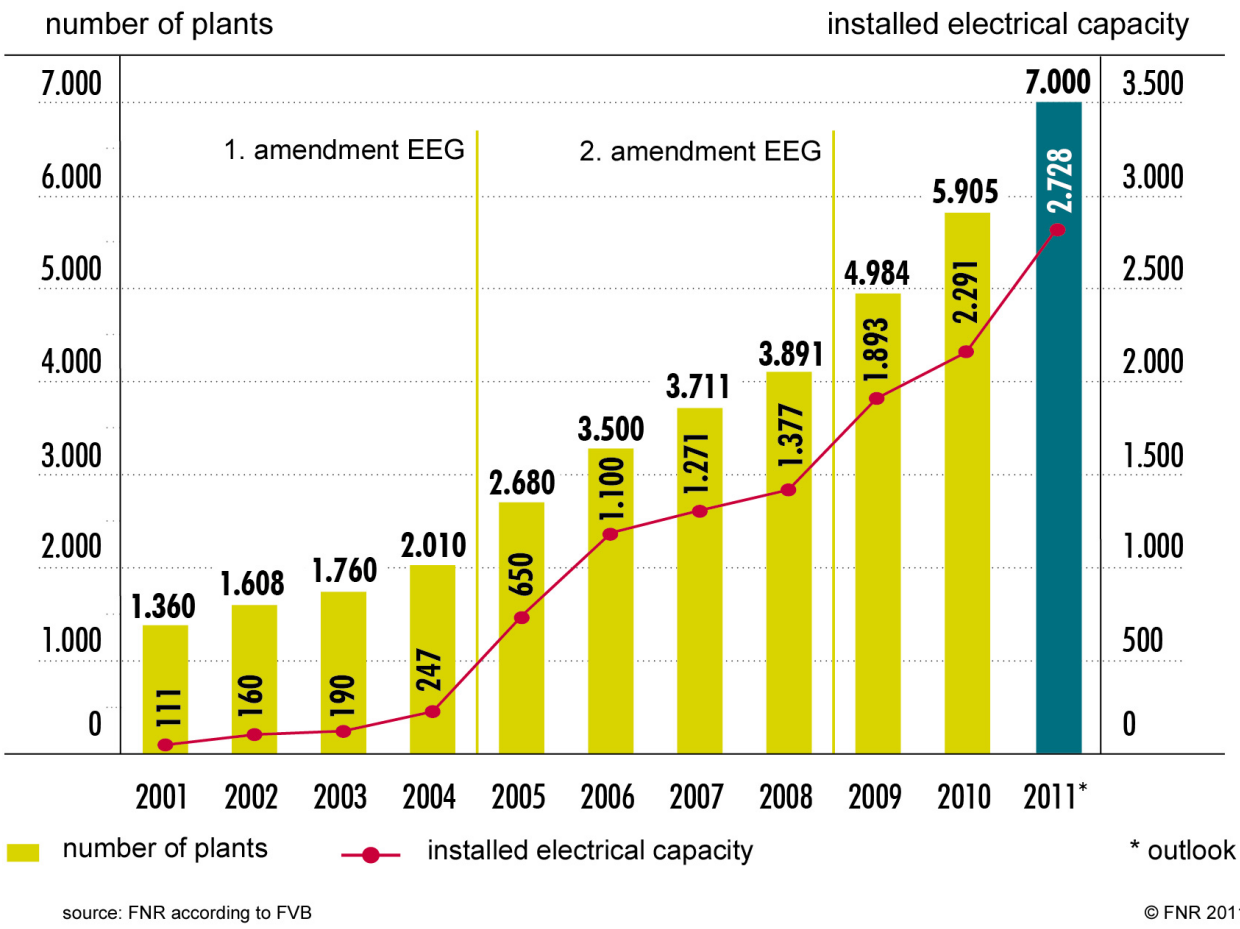
Development of biogas plants in Germany



source: FNR according to FVB

German biogas industry

State-of-the-art (2010)

- 5905 plants with 2291 MW_{el} performance
- 13.3 bill. kWh electricity from biogas,
  equals 12.9 % of electricity from renewable resources
  (electricity for 3.7 million households)
- 7.6 bill. kWh heat production from biogas,
  equals 6.6 % of heat from renewable resources
- Avoided GHG-emissions 7,517,000 tons
- Cultivation area of crops for biogas in 2010
  approx. 650,000 ha (2011: >800,000 ha)
- more than 30,000 jobs (direct)

Economic factors

- pre-investment calculation and ongoing calculation of profitability
- controlled construction and operation costs
- usage of slurry and manure; low cost by-products
- up-to-date maintenance and repair
- utilisation of surplus heat
- profitable use of digestate

Regulatory framework

- **Power production**
  The Renewable Energy Source Act (-> EEG)
- **Heat production**
  The Renewable Energy Source Heating Act (-> EEWärmeG)
- **Biomethane production**
  Acts and guidelines for feed in upgraded biogas into the natural gas grid - Gas Grid Access Ordinance (GasNZV) & Gas Grid Tariff Ordinance (GasNEV)
- **Governmental aid**
  - Incentive programme for renewable energy projects
  - Granting loans with low interest for RES projects
  - Promotion of investments in local heat and biogas pipelines (GAK)
  - Promotion of investments by the Agro-Investment-Programme (AFP) or by supporting programmes of the Federal States

Regulatory framework II

Construction and operation of biogasplants are regulated and guided by:

- **building regulations and planning law**
- **imission protection, water and conservation law**
- **waste and hygiene legislation**
- **fertiliser legislation**

and more (especially if by-products are used)

Renewable Energy Sources Act (EEG)

- first version 2000
- EEG, enacted by the government of Germany, promotes the development of renewable energy sources with a feed-in tariff scheme
- specific payment conditions for each type of RES for a period of twenty years (plus year of initial operation)
- actual version from 2009, newest version of the EEG will come into force 1st of January 2012
- power supply industry is compelled to connect the plants to the grid and to secure the feed in

EEG 2012

EEG tariff 2012
ct/kWh

		2012	2013
basic tariff			
	up to 150 kW_{el}	14,30	14,01
	150 - 500 kW_{el}	12,30	12,05
	500 kW - 5 MW_{el}	11,00	10,78
	5 - 20 MW_{el}	6,00	5,88
special tariff	up to 75 kW_{el}	25,00	24,50
substrate tariff			
input substrate class I	up to 500 kW_{el}	6/6	6/6
	500 - 750 kW_{el}	5/2,5	5/2,5
	750 kW - 5 MW_{el}	4/2,5	4/2,5
input substrate class II	up to 500 kW_{el}	8	8
	500 kW - 5 MW_{el}	8/6	8/6
gas upgrading bonus			
	up to 700 Nm^3	3,00	2,94
	700 - 1,000 Nm^3	2,00	1,96
	1,000 - 1,400 Nm^3	1,00	0,98
biowaste bonus			
	up to 500 kW_{el}	16,00	15,68
	500 kW - 20 MW_{el}	14,00	13,72

- Annual degression basic tariff and boni 2%
- Special tariff for small slurry plants
- Substrates are classified in 3 categories

  0: most by-products

  1: energy crops

  2: ecologic valuable substrates
- Minimum heat utilisation 60%
- Maximum corn and grain input 60%
- Direct marketing option

Problems

- food-or-fuel discussion
- increasing cultivation of corn

  (monoculture, price increase of farmland, problems for groundwater, biodiversity and landscape)
- Lack of acceptance: NIMBY

  (traffic, smell, danger of explosion, rising food prices…)
- Insufficient heat utilisation
- Inefficient plant operations

Agency for Renewable Resources (FNR)

Biogas production

Utilisation of biogas

Biogas in Germany

- **Outlook and summary**

Outlook

- biogas production will generate additional income possibilities for farmers
- plant location and substrate-optimised conceptual design is essential for a successful operation
- Trend:
  - construction of decentralised AD with lower performances and slurry usage
  - large biogas plants with upgrading units
- good potentials in Germany and the EU for biogas production
- efficiency and sustainability are the key elements for crop cultivation, biogas production and utilisation for the future
- Biogas can contribute an energetic potential of 503 PJ (including sewage and landfill gas) by 2020, in 2007 just 108 PJ used
- in spite of the achievements for RES, great efforts still has to be made to fulfil the set targets

Summary

- biogas production is a natural process, systematically done in biogas plants
- large variety of input materials
- whole process is technically proven; improvements still to come
- fermentation process consist of four stages
- raw biogas needs to be cleaned and upgraded
- various utilisation possible (electricity, heat, fuel)
- large amounts can be supplied by agriculture
- biogas production is subject to many laws and regulations
- development needs support (german EEG exemplary)


Thank you for your attention!
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