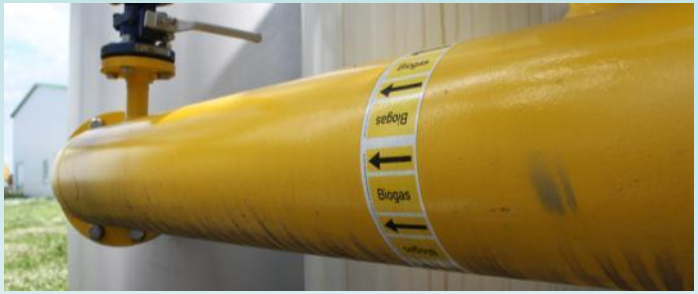
Digestión Anaerobia en Biorefinerias
Anaerobic Digestion in Biorefineries

2nd SMIBIO Workshop

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

30 May 2017, Manizales, Colombia

Dominik Rutz
WIP Renewable Energies
Sylvensteinstr. 2
81369 München

Biogas Projects by WIP

11 years EU funded market support biogas projects implemented by WIP 2007-2017

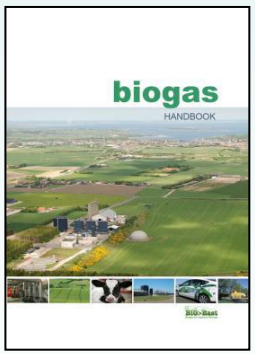
www.big-east.eu: Training courses for farmers and decision makers (WIP coordinator)

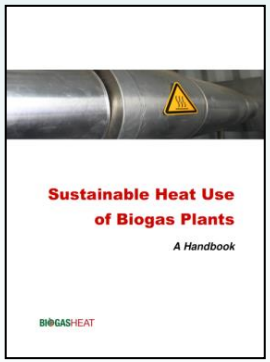
www.biogasin.org: Removing financial and administrative barriers

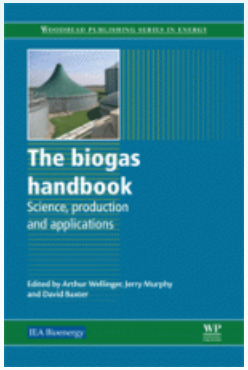
www.urbanbiogas.eu: Municipal waste-to-biomethane concepts (WIP coordinator)

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

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







Where we are

Germany

Bavaria

Munich

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1. Renewable Energies in Germany
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Current policy developments

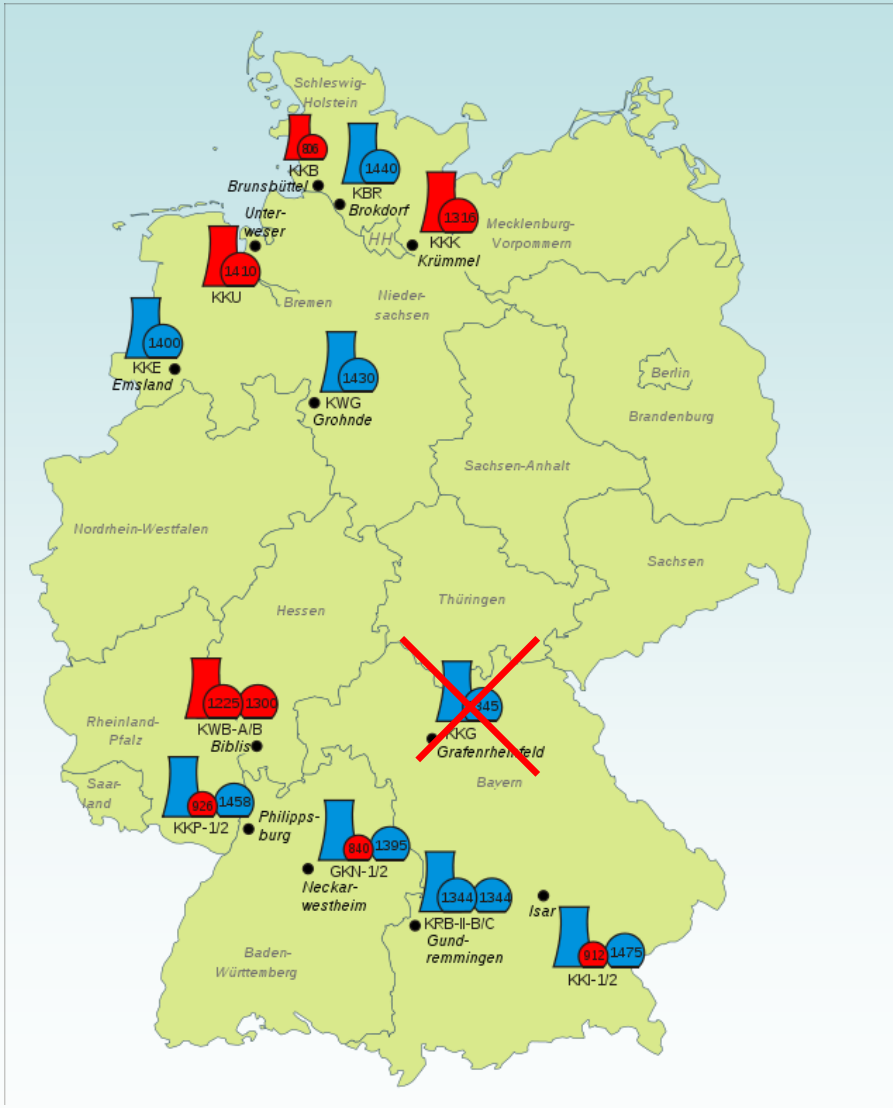
- The disaster of the nuclear power station in 2011 in **Fukishima**, Japan, let to a drastically change in German Energy policies.
- The „**energy transition**“ from fossil-nuclear based energy system towards a renewable energy system was decided.
- This transition is regarded by many other states as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

All will be shut down by 2022!



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

German Targets on Climate Change

Dialogue process for the Climate Action Pl

"In Germany, we want to commit to ssions reduction pathway with a final t 80 to 95 percent **lower greenhouse gas e is compared to 1990** by 2050. We will augme arget with concrete measures, draw ough a broad participatory process (Cli ction Plan)."

We need **100%** renewable energies TODAY!!!

Coalition agreement between the CDU, CSU and SPD , 18th legislative period
http://www.klimaschutzplan2050.de/en/

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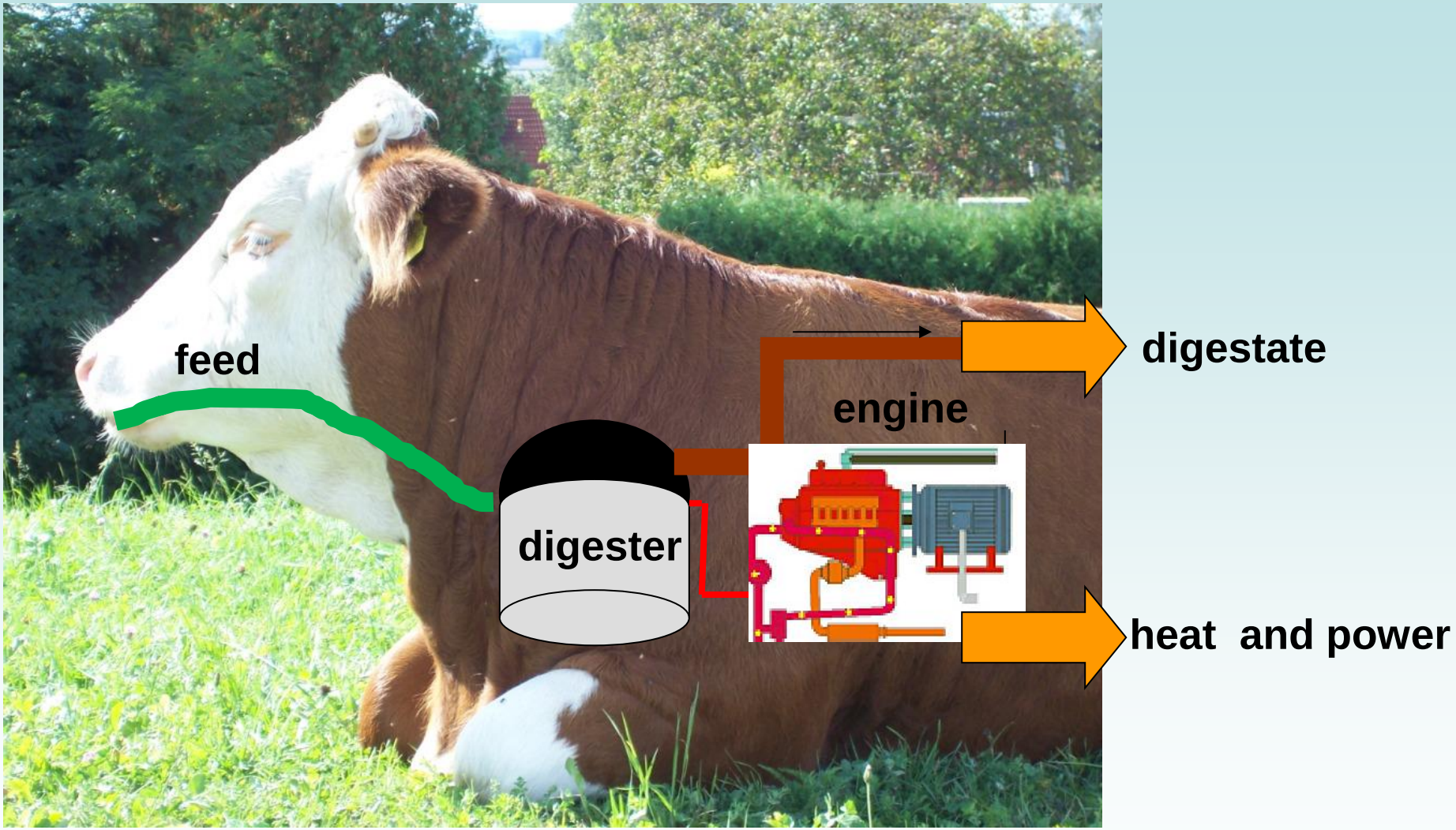
„Natural“ biogas plants…

Picture sources: © Dominik Rutz

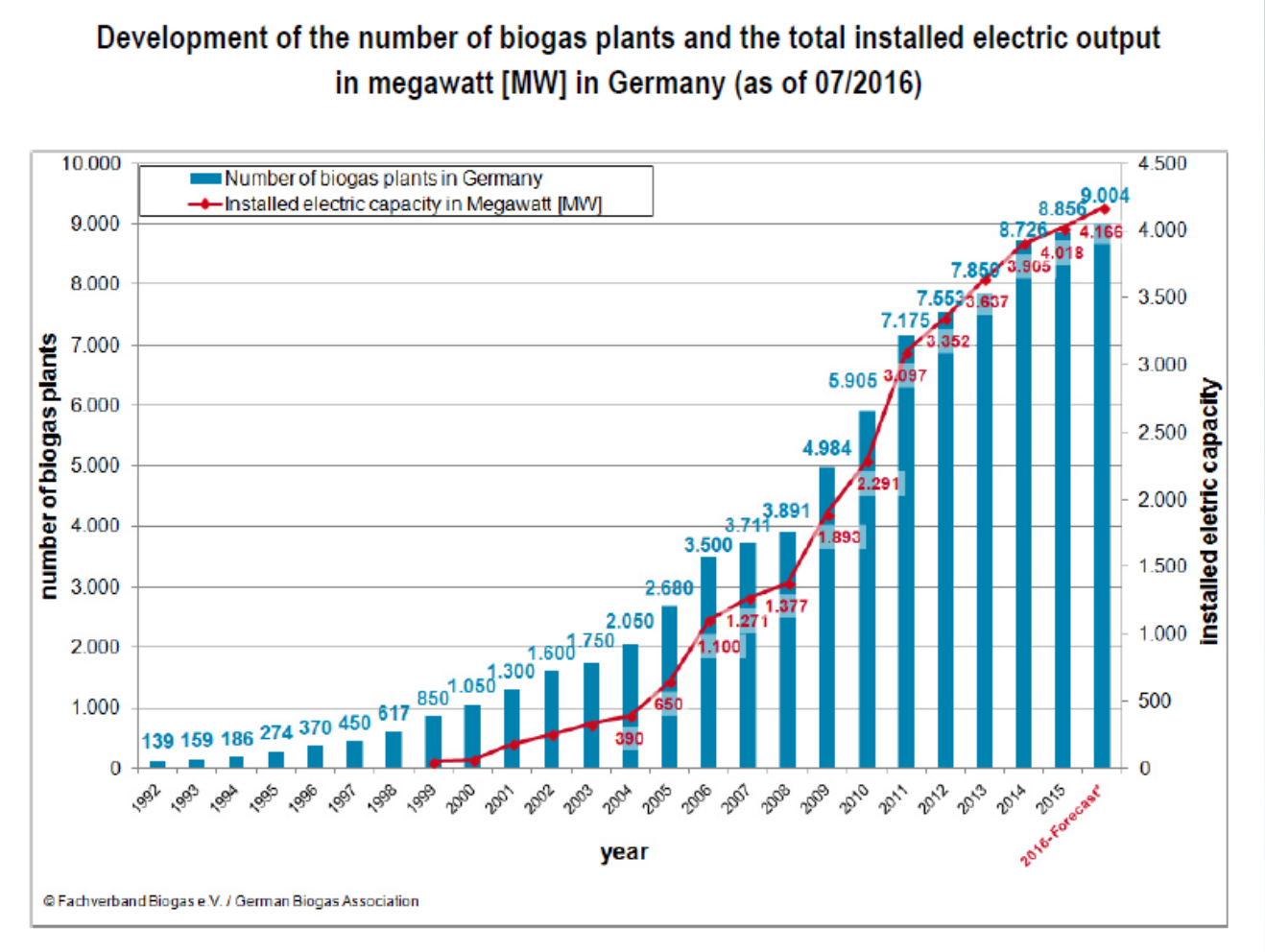
The biogas principle – like a concrete cow



Picture sources: © Dominik Rutz

Biogas plants and capacity in Germany

(Status: 07/2016)



The future is however uncertain

→ Many German companies are looking for other markets!

Source: http://www.biogas.org/edcom/webfvb.nsf/id/DE_Branchenzahlen/$file/15-11-19_Biogasindustryfigures_2014-2015_english.pdf

Biogas statistics

Biogas sector statistics in Germany at a glance

(as of 07/2016)

	2014*	2015*	Forecast 2016**
Number of biogas plants (biogas plants with biomethane injection)	8.726 (167)	8.856 (183)	9.004 (193)
Installed electric capcity 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_2 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

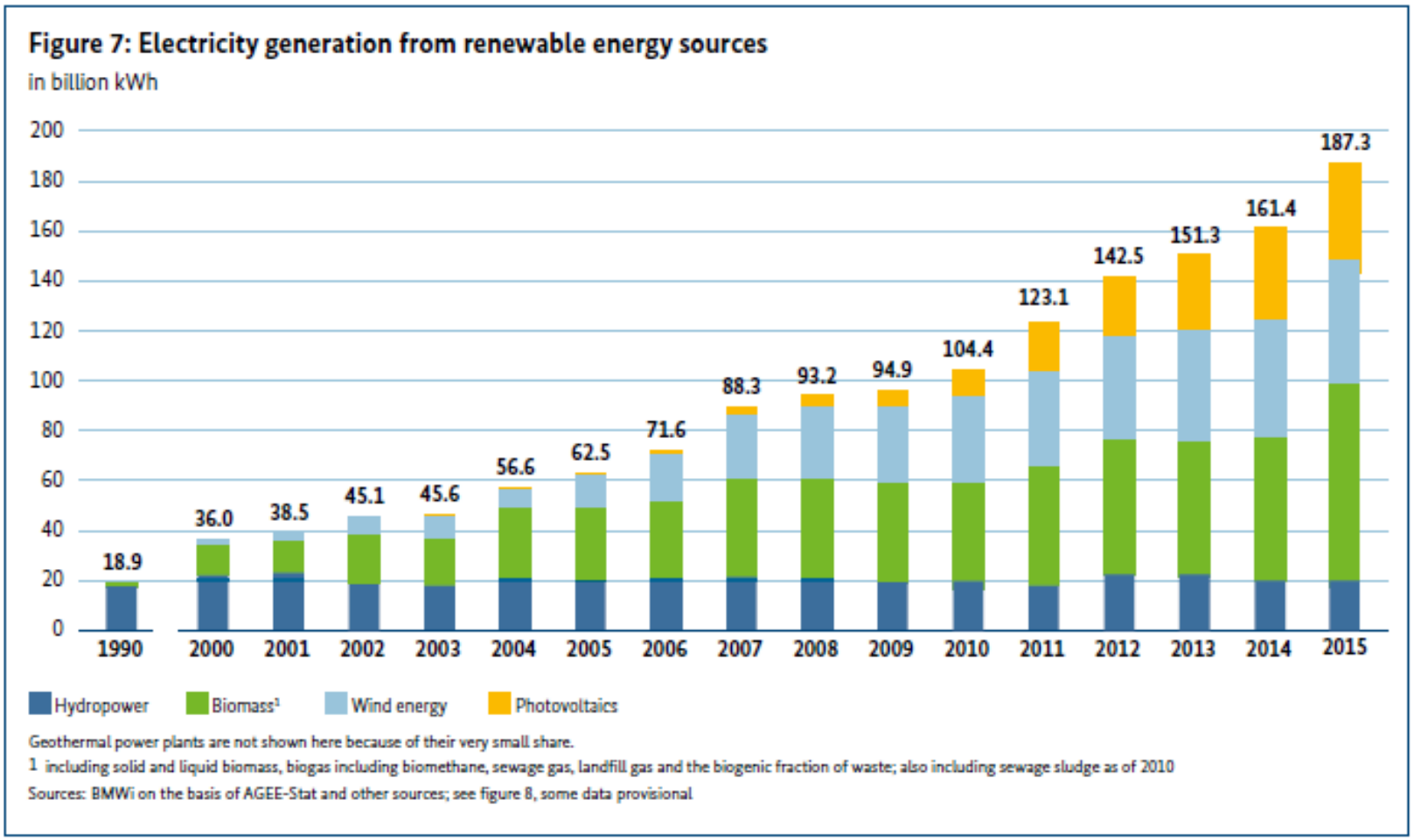
© Fachverband Biogas e.V. / German Biogas Association

* Own extrapolation based on country data / plant register BNetzA

** Based on a expert survey / plant register BNetzA

Source: http://www.biogas.org/edcom/webfvb.nsf/id/DE_Branchenzahlen/$file/15-11-19_Biogasindustryfigures_2014-2015_english.pdf

RE Electricity in Germany



Source: http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/development-of-renewable-energy-sources-in-germany-2015.pdf?__blob=publicationFile&v=9

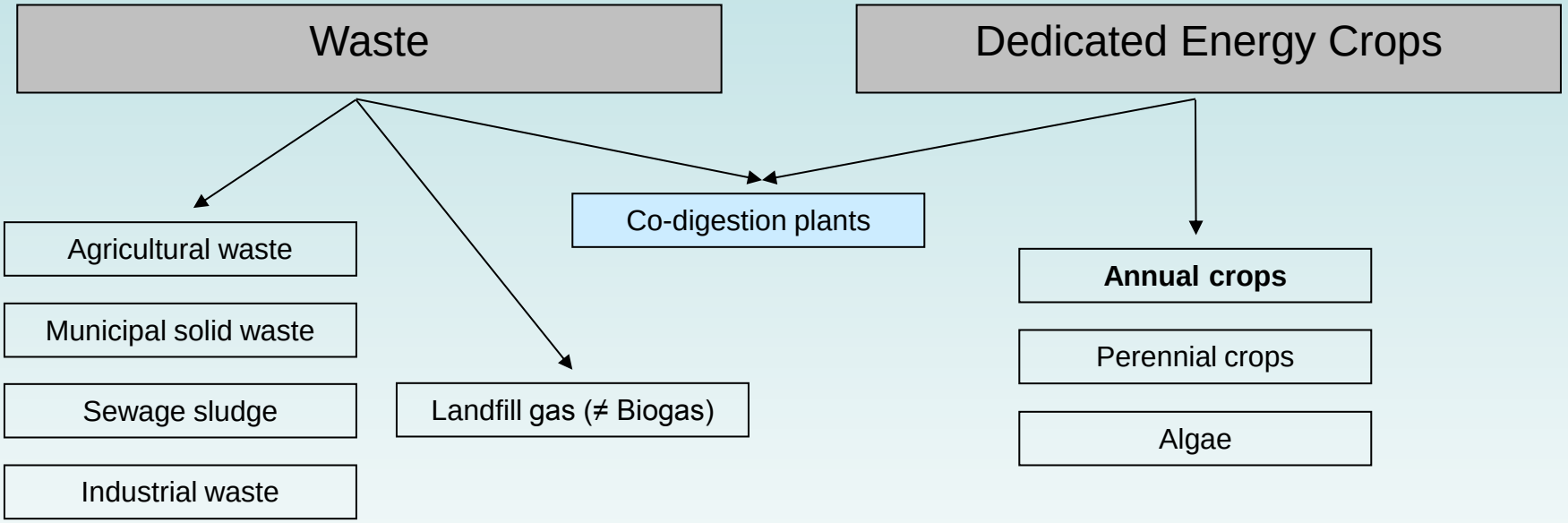
Reasons for this biogas development?

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“

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

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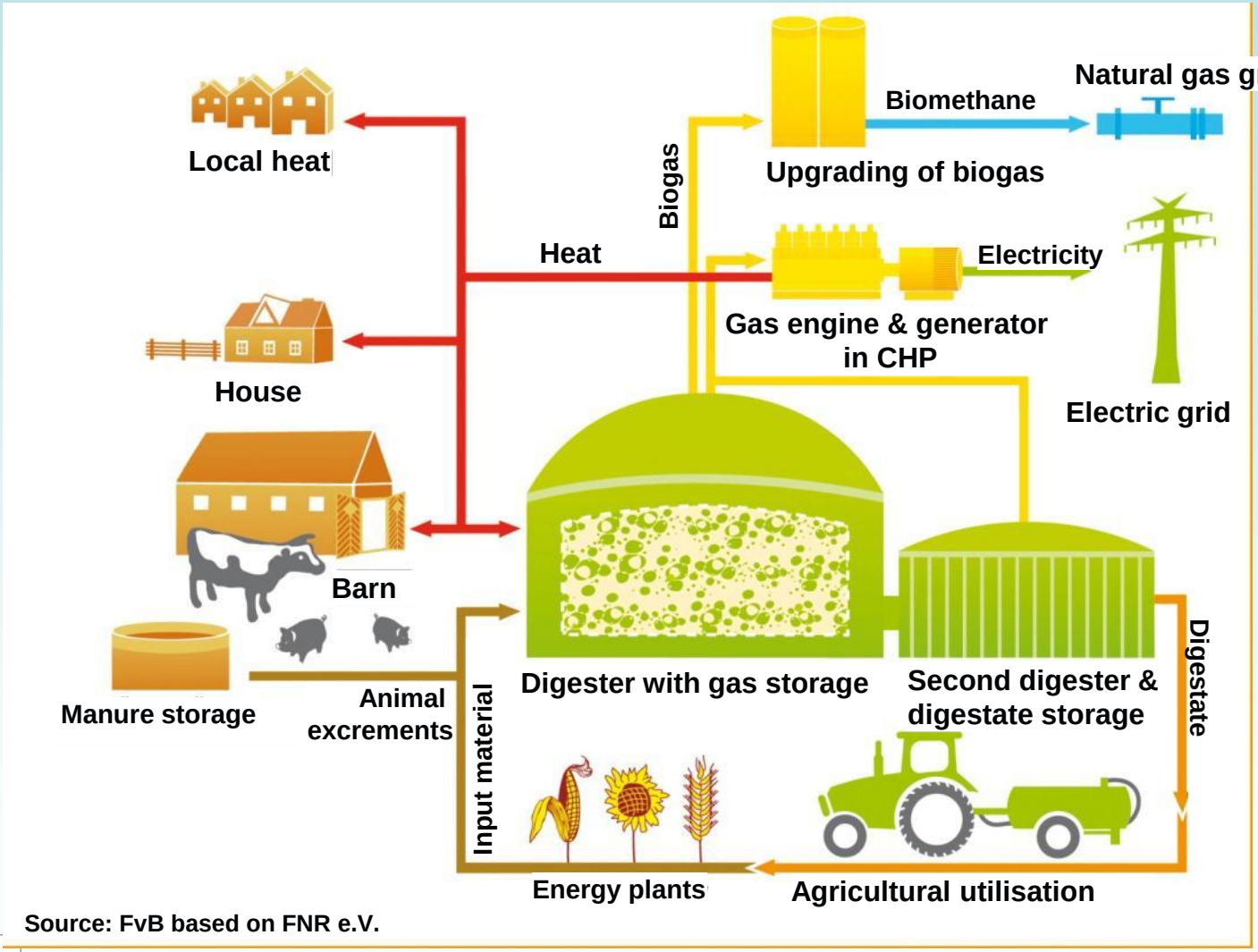
Scheme of an agricultural biogas plant
- Anaerobic Digestion (AD) -



Source: FvB based on FNR e.V.

Definition: Biogas

Biogas plant
(Bavaria)

Biogas plant
(Bavaria)

Typical biogas plant in Bavaria/Germany

CHP unit
(Bavaria)

Concrete fermenter construction
(Bavaria)

Biogas plant
(Bavaria)

Picture sources: © Dominik Rutz

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

Silages shall be covered!

Picture sources: © Dominik Rutz

Feedstock storage needs logistics!

Picture sources: © Dominik Rutz

Harvest of grass for silage

Picture sources: © Dominik Rutz

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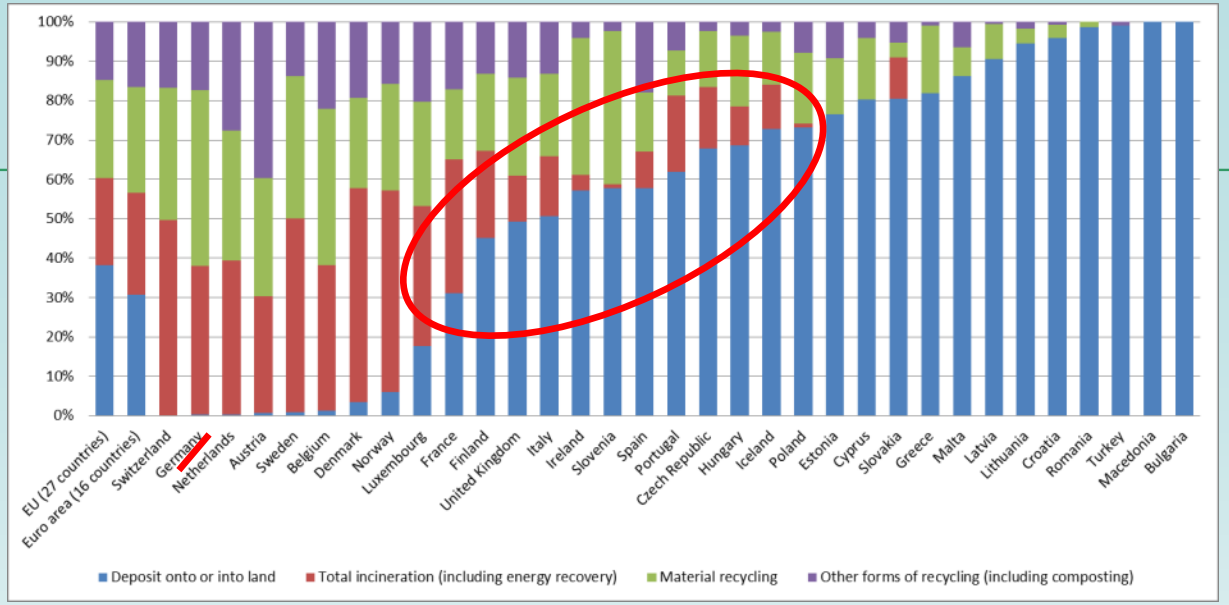
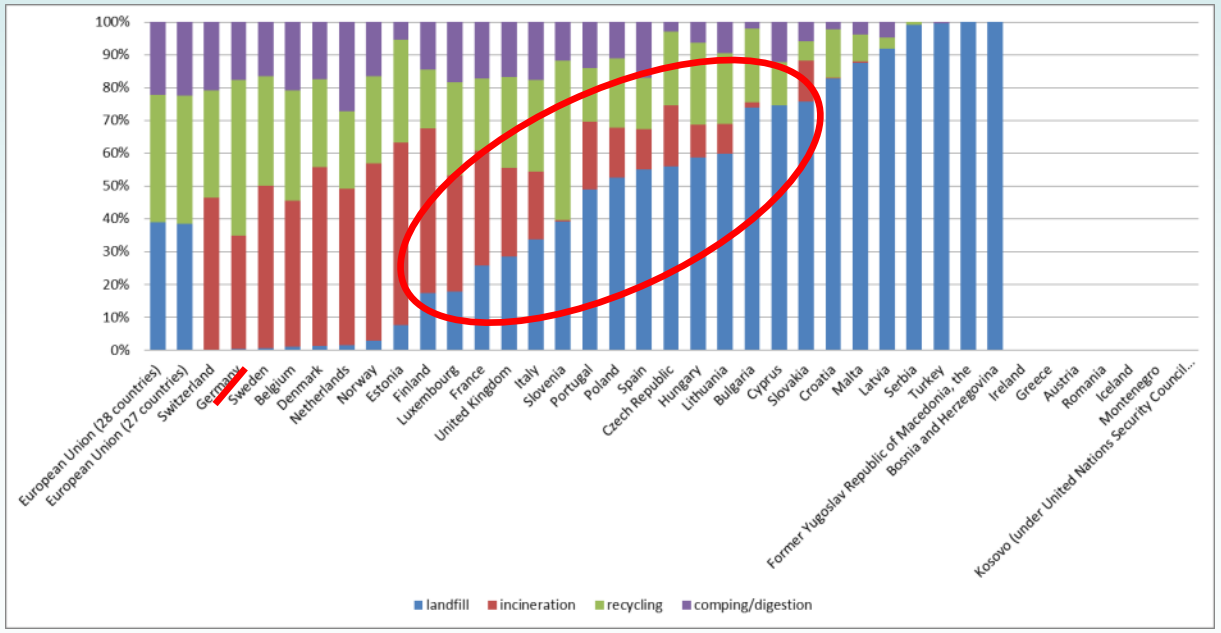
Waste treatement
in the EU
in 2010 and 2014

Landfilling
decreases!



2010



2014

Data source: EuroStat; Some data (e.g. incineration in EU and Euro area) were not yet available!

Definition: Landfill gas ≠ biogas

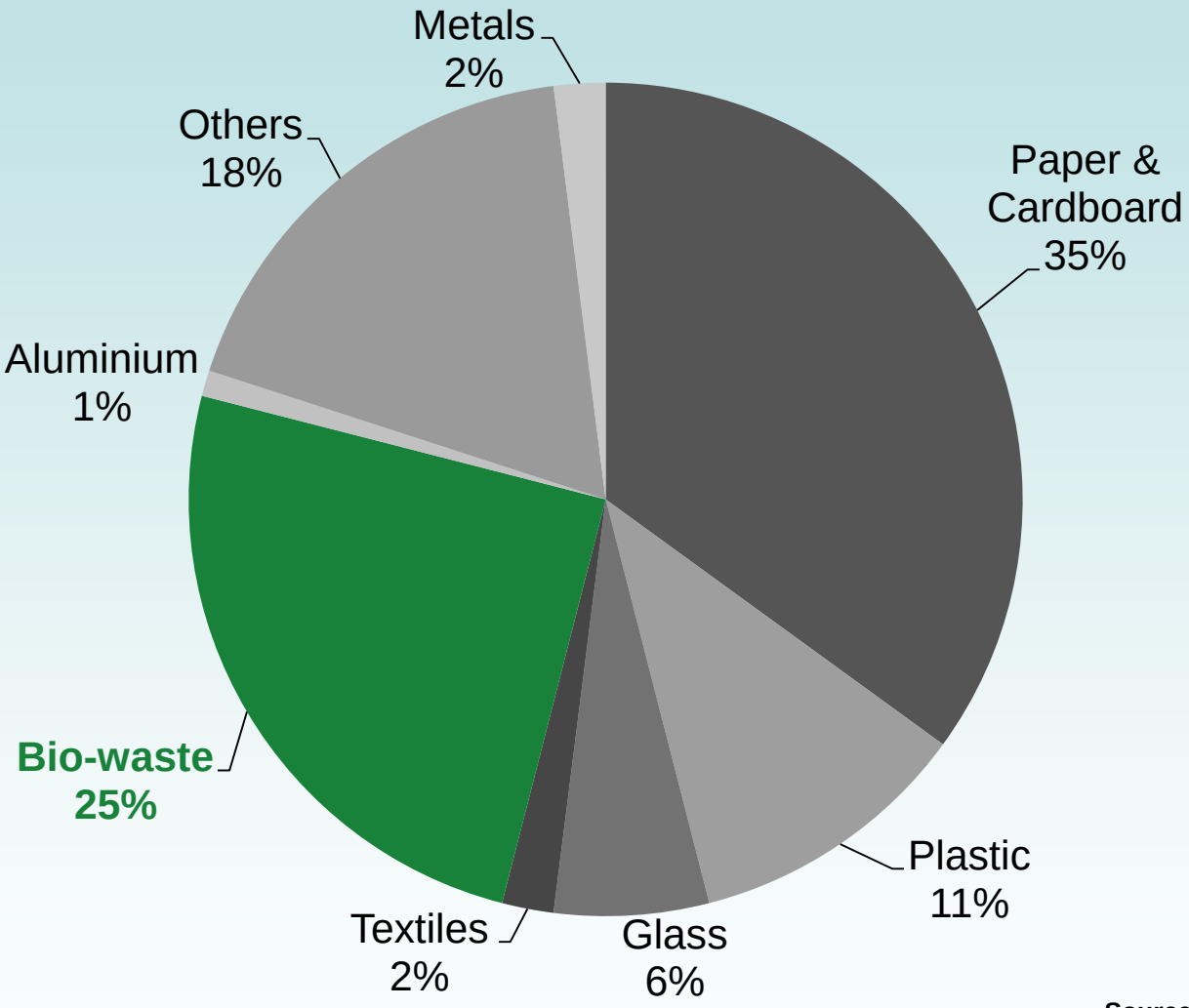
Gas recovery of landfill site
(Zagreb, Croatia)

Landfill site
(Zagreb, Croatia)

Landfill site
(Valmiera, Latvia)

Picture sources: © Dominik Rutz

Typical composition of MSW



Source: Dominik Rutz, WIP
Data: EUROSTAT, 2009

Waste-to-Biogas/Biomethane

Organic fraction of MSW
(Bavaria)

Valuable digestate
(Bavaria)

Different bins for waste collection
(Bavaria)

WtB biogas plant
(Bavaria)

Catering waste
(Bavaria)

Expired food waste
(Bavaria)

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

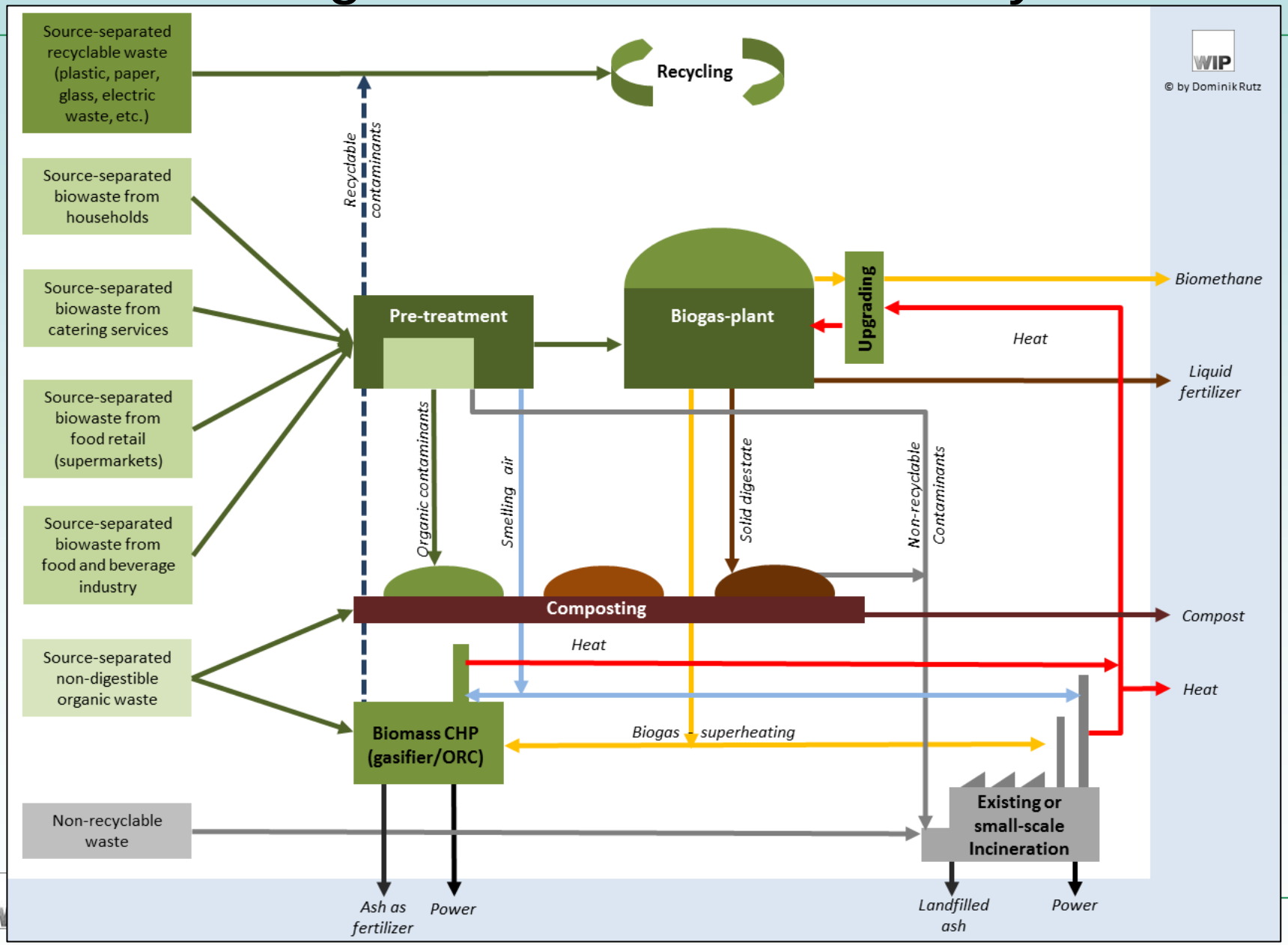
+ High energetic output

+ High-value end-product: closed nutrient cycle

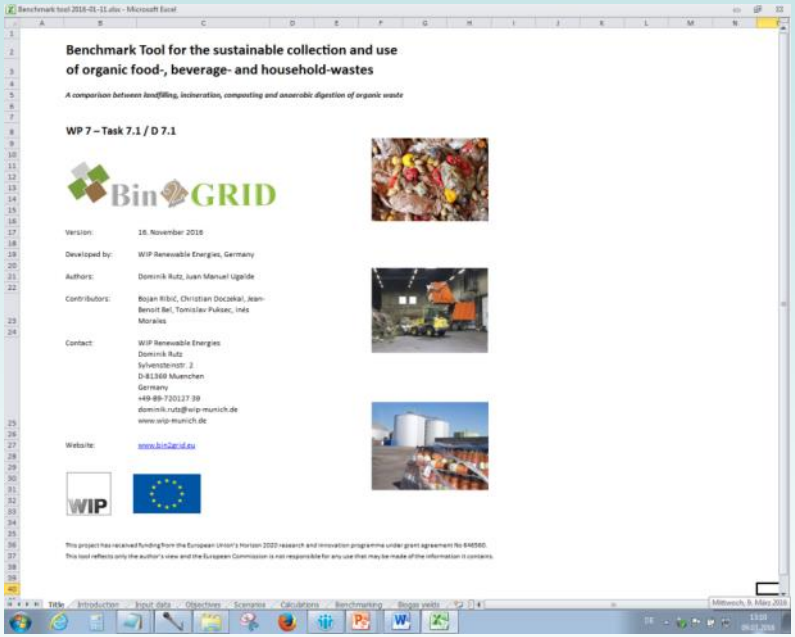
+ Opportunity to produce transport fuels

→ Still needs non-technical support

Integrated Biowaste Refinery



Bin2Grid Benchmark Tool



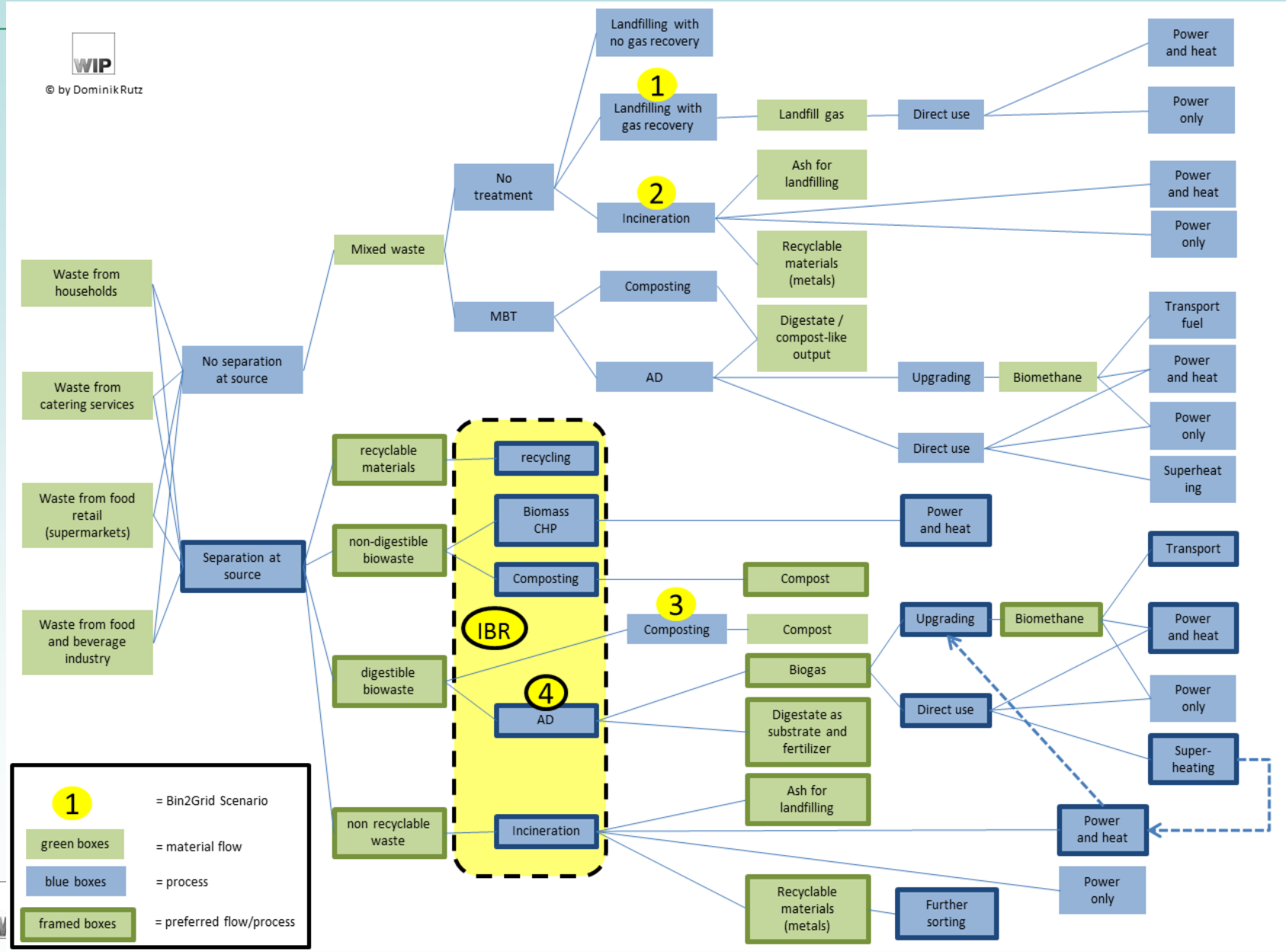
- Excel-based tool
- Comparison between AD, composting, incineration, landfilling
- **Is available for free at www.bin2grid.eu**

Objectives

1. Reduction of total waste generation
2. Improvement of overall recycling rates
3. Valorisation of the energy content of organic waste
4. Increase of secure energy supply
5. Reduction of GHG emissions
6. Recycling of nutrients (phosphor)
7. Creation of jobs
8. Reduction of implementation time

AD = Anaerobic digestion
GHG = Greenhouse gases

Bin2Grid Benchmark Scenarios



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**

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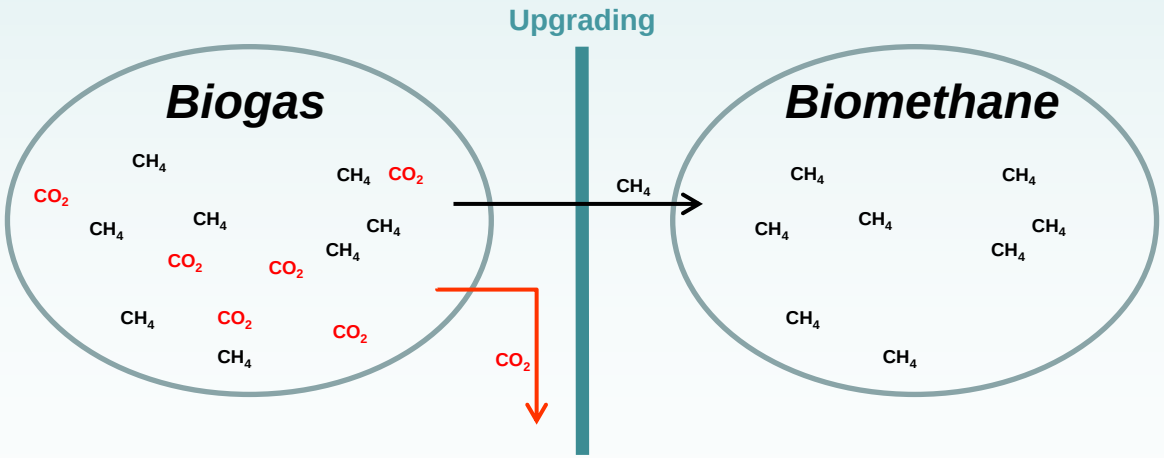
Biomethane

- 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)

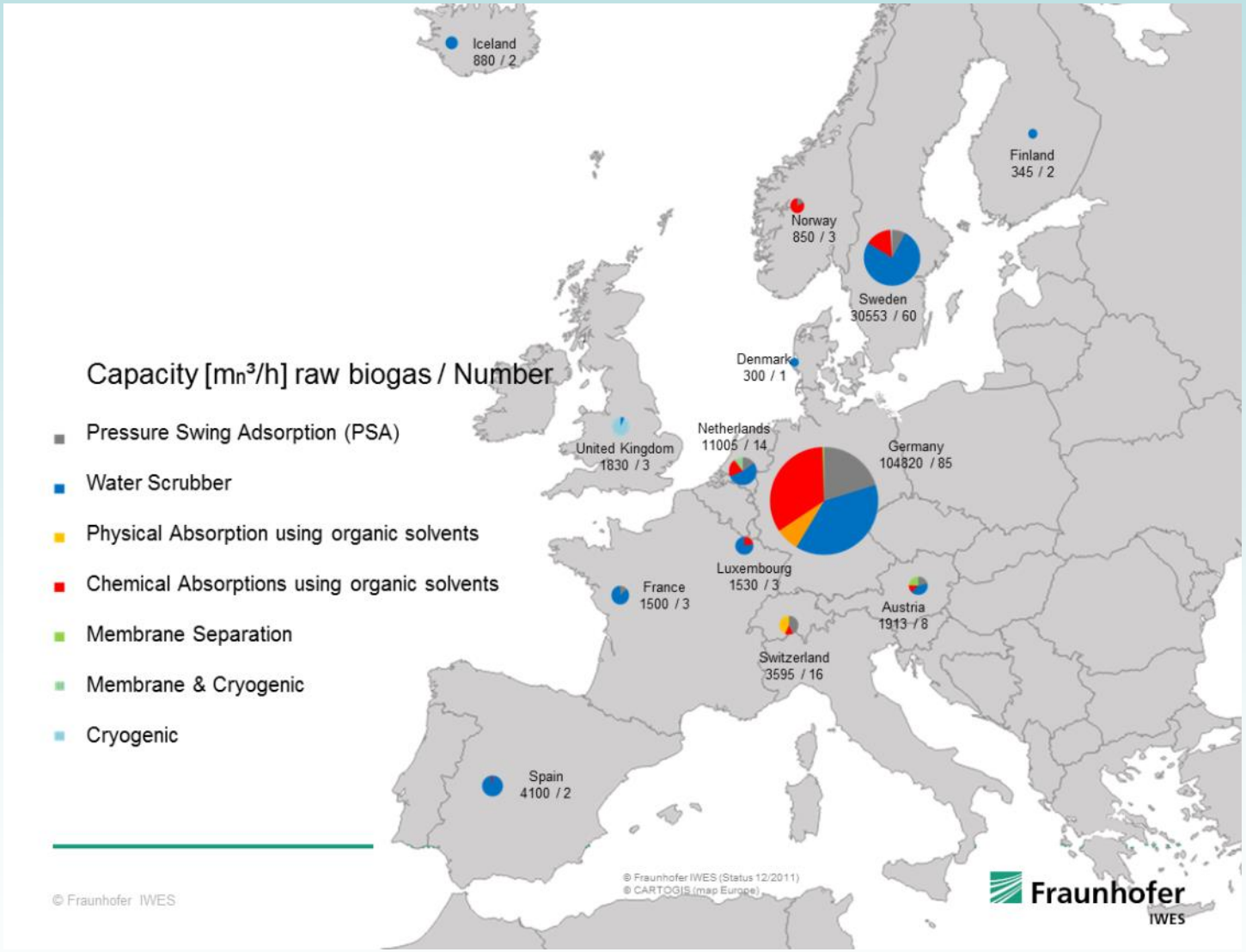
Biomethane injection
(Bavaria)

Pressure swing adsorption (PSA)
(Bavaria)

Biomethane filling station
(Austria)

Picture sources: © Dominik Rutz

Biomethane upgrading plants in Europe



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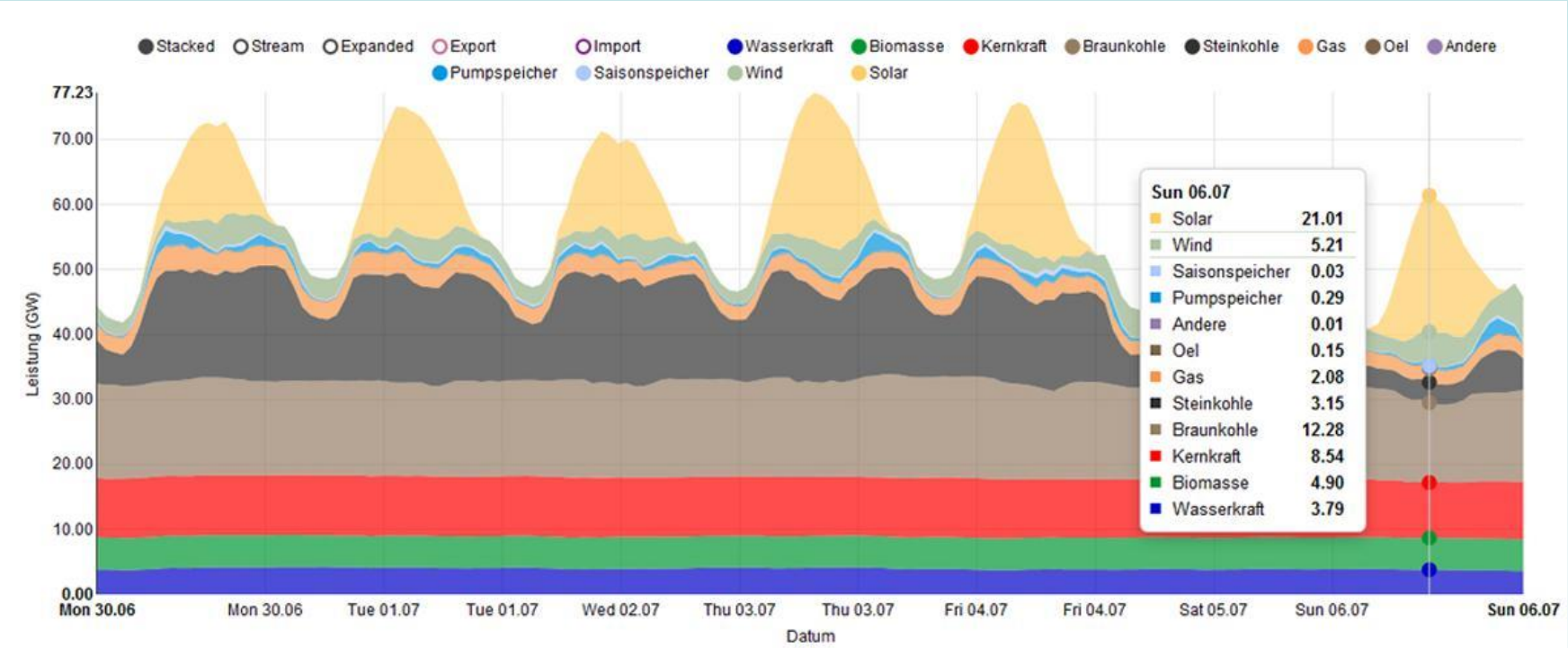
Electricity production in Germany in week 27/2014

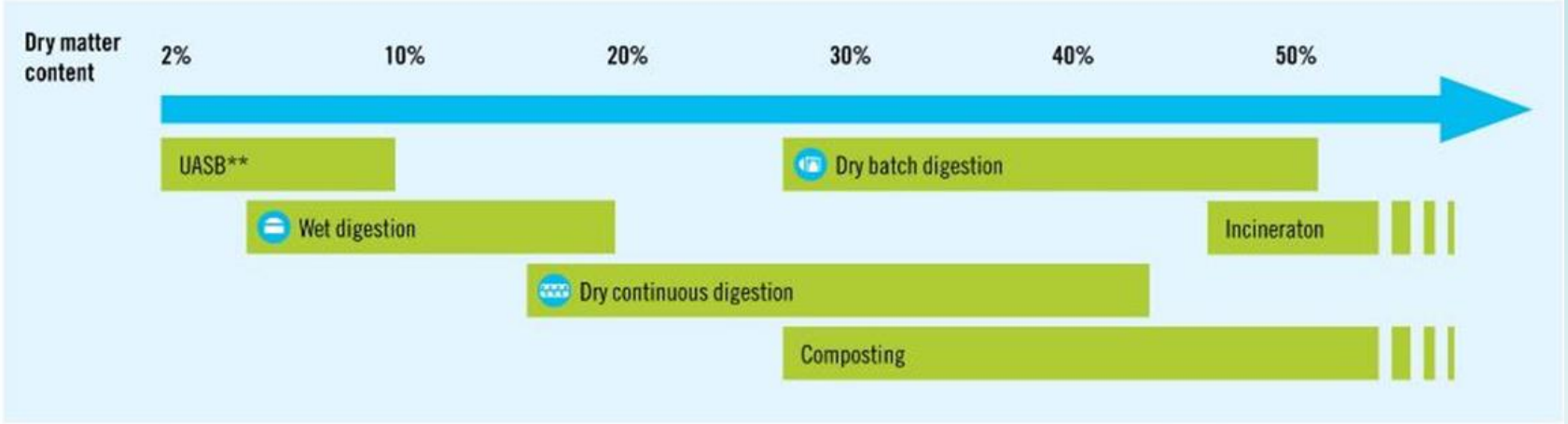


Source: http://www.bine.info/themen/erneuerbare-energien/photovoltaik/news/datenbank-zeigt-leistung-der-erneuerbaren/ © Fraunhofer ISE

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
- 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**

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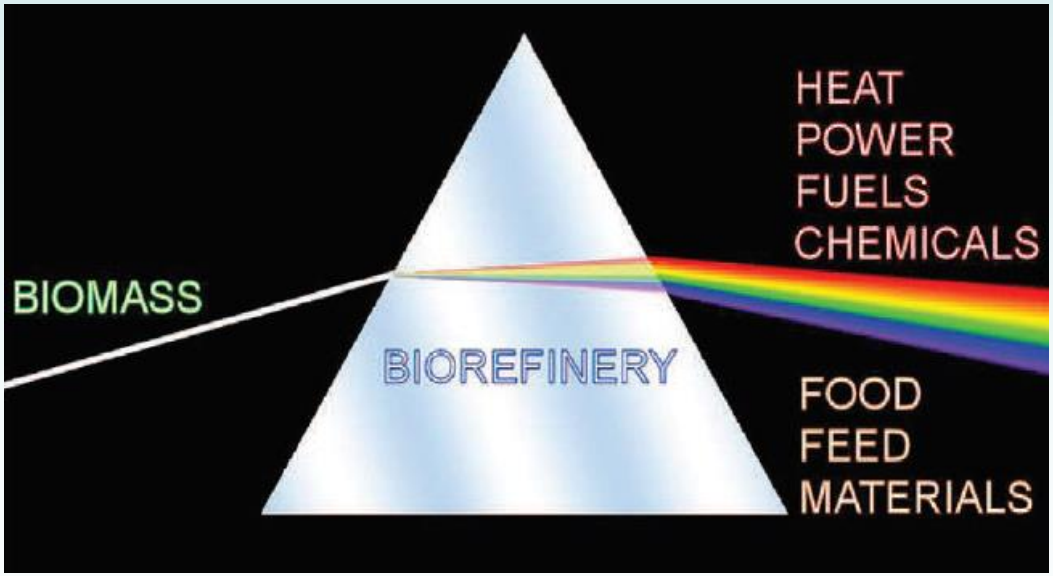
How is „biorefinery“ defined?

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

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

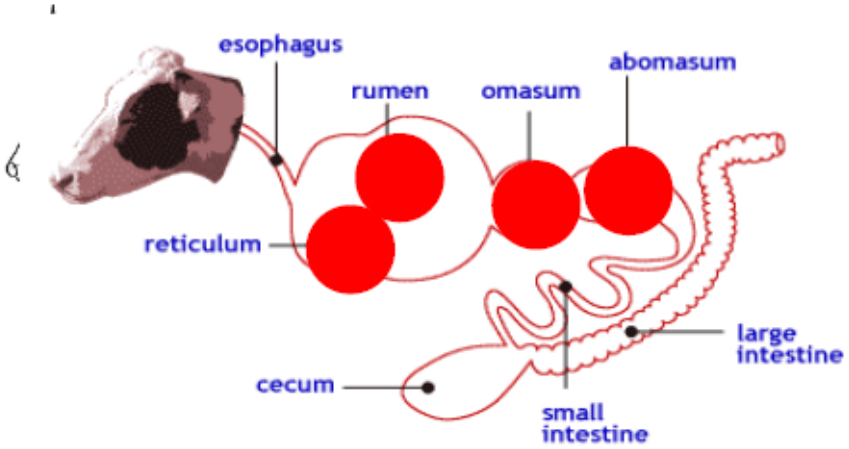
high fiber

Example 2

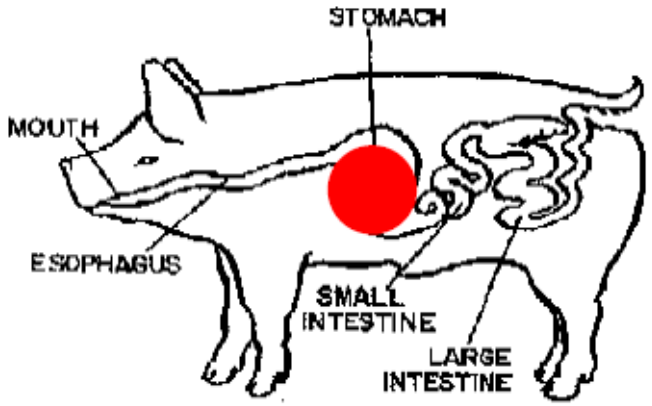
SLP – Imitating the Bovine Digestion System

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!

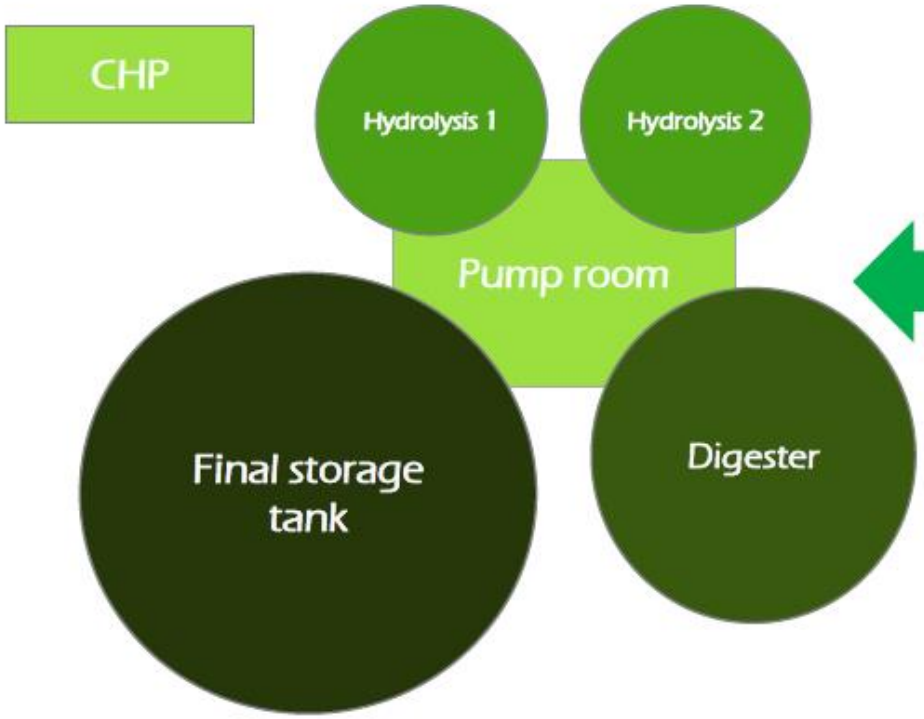
Example 2

AD Plant of the 2nd Generation

Digestion - 2-stage Biology with Upstream Batch-Hydrolysis

SNOWLEOPARD

Basic layout



Example 3: Modular/Movable small-scale biogas plant

- BiogasTiger – biogas plant manufacturer in Germany
- Innovation: „Movable“ small-scale biogas plant in containers
- www.biogastiger.de
- PPP Project Germany -Ecuador

Example 3: Modular/Movable small-scale biogas plant

- PPP Project Germany –Ecuador
- „Aprovechamiento de resíduos orgánicos con tecnología de biogas – Potenciales y desarrollo de competencias en el Ecuador“
- (09/2016 – 04/2018)
- Objective: Training courses and capacity building on biogas from wastes in Ecuador
- More Info: www.fickertwinterling.de, www.biogastiger.de

Example 4: 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 **8,000** 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 perfect stand-alone technology and even better for the inclusion in a Biorefinery**

Thank You!

Dominik Rutz

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www.urbanbiogas.eu

www.biogasheat.org

www.big-east.eu

www.biogasin.org

www.globalbiopact.eu

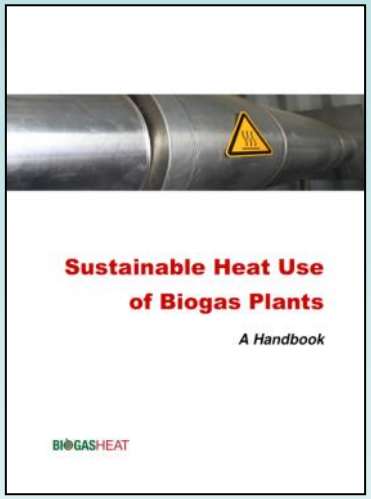
www.biotrade2020plus.eu

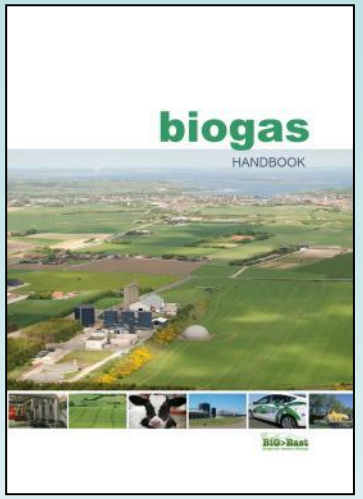
www.srcplus.eu

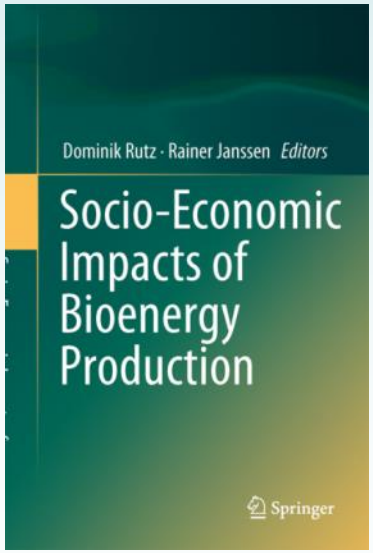
www.corejetfuel.eu

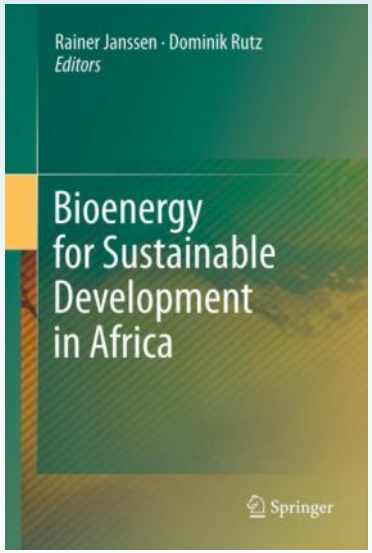
www.bin2grid.eu

www.wip-munich.de









Thank You!

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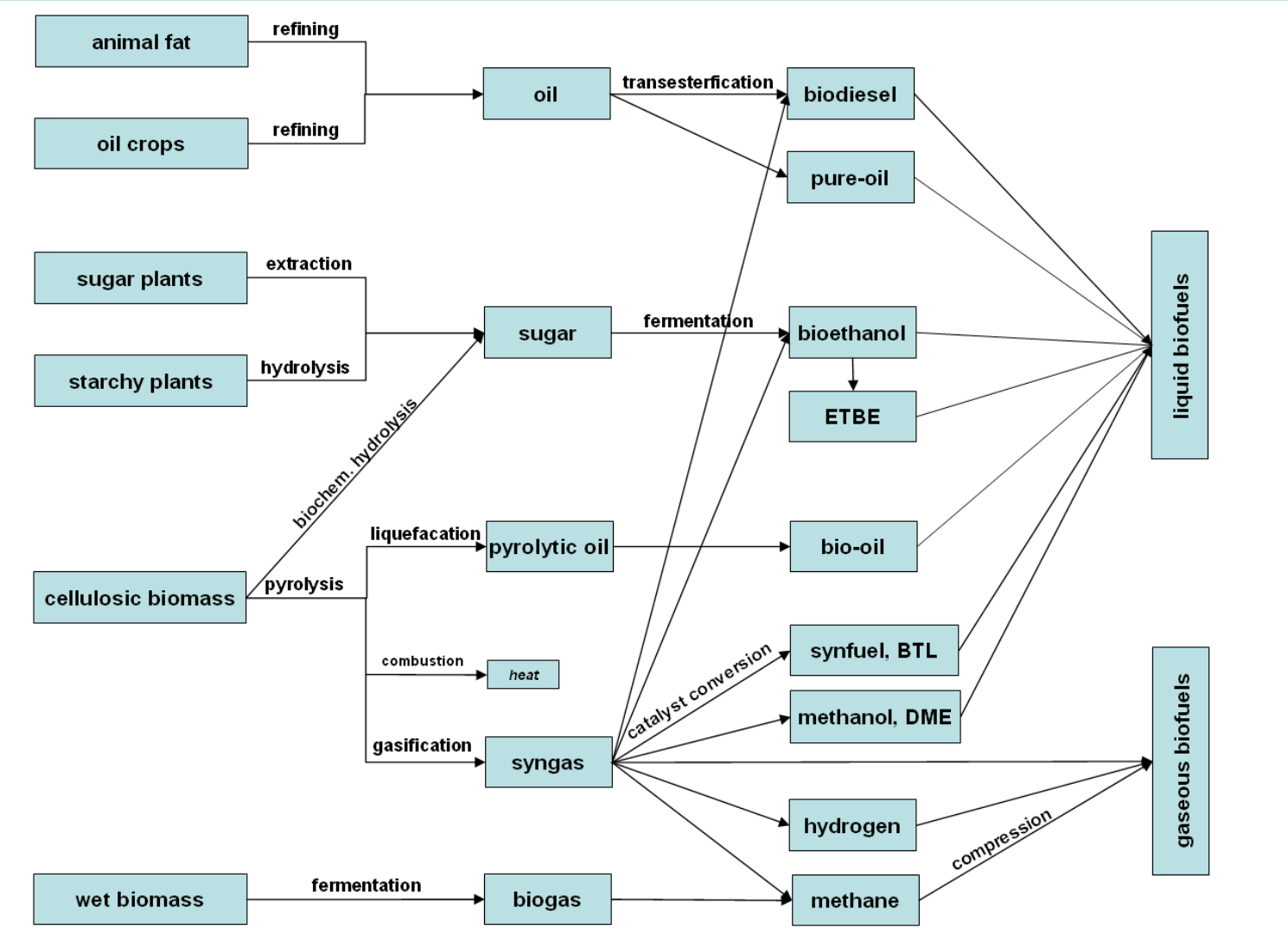
Overview Biofuels: Pathways



Definition: Biofuels (Examples)

Rapeseed for
pure plant oil or biodiesel
(Bavaria)

Sugar beet for ethanol
(Bavaria)

Pure plant oil
filling station
(Bavaria)

Straw for 2nd generation
ethanol
(Bavaria)

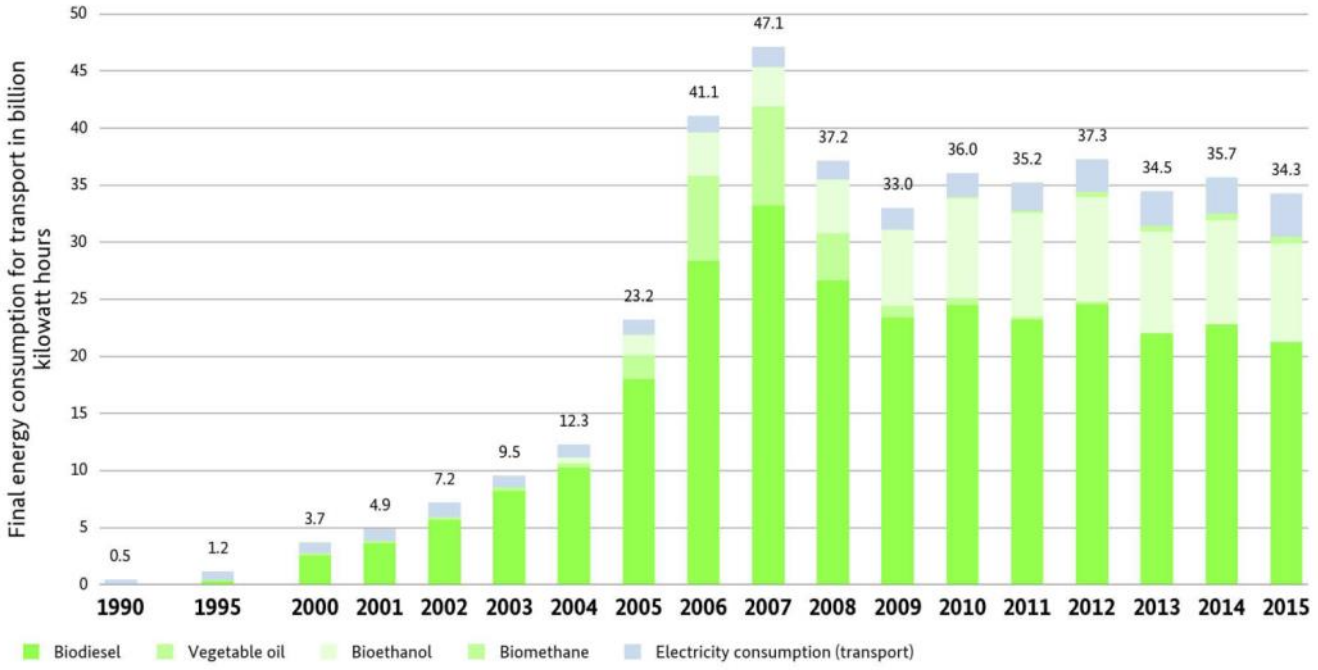
Biomethane
filling station
(Bavaria)

Biofuels in Germany

Federal Ministry
for Economic Affairs
and Energy

AGEE Stat
Arbeitsgruppe Erneuerbare Energien - Statistik

Development of final energy consumption in transport from renewable energy sources in Germany



BMWi based on Working Group on Renewable Energy-Statistics (AGEE-Stat); as at February 2016; all figures provisional

2nd generation ethanol demo plant

- **Location**: Straubing, Bavaria
- **Start of operation**: July 2012
- **Feedstock**: straw
- 4,000 t biomass converted into 1,000 t ethanol
- **Operator**: CLARIANT (http://www.clariant.de/C12576710018E579/vwWebPagesByID/FCF7D4059D4DC077C1257AD20052DB27)

Source: https://www.biotechnologie.de/BIO/Navigation/DE/root,did=153156.html