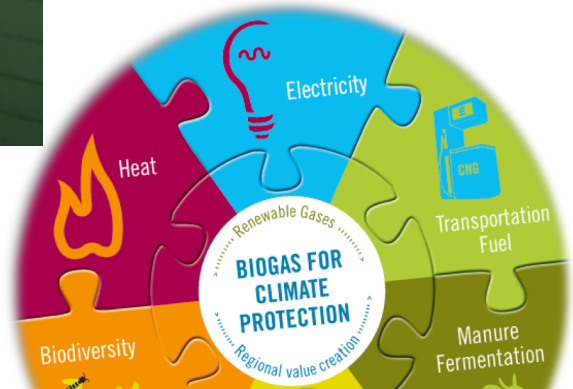
UABIO / FvB Webinar
19 May 2023

Fachverband BIOGAS
German Biogas Association
Association Allemande du Biogaz
Asociación Alemana de Biogás
www.biogas.org

German and European Biogas Markets
Status · Uses · Legal Framework · Success Cases

www.euref.de



Dirk Bonse

Head of Department “Renewable Gases“ · Fachverband Biogas e.V.
German Biogas Association

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Agenda

Who we are

On current occasion: Biomethane potential EU & Germany

Technological options for biomethane production (Overview)

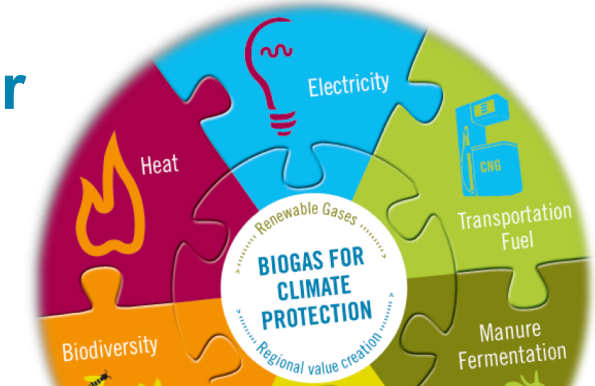
EU- and nationwide legal framework

Business concepts

Biomethane as a fuel

Conclusion and outlook

Additional Information: Technological options for biomethane production (details)



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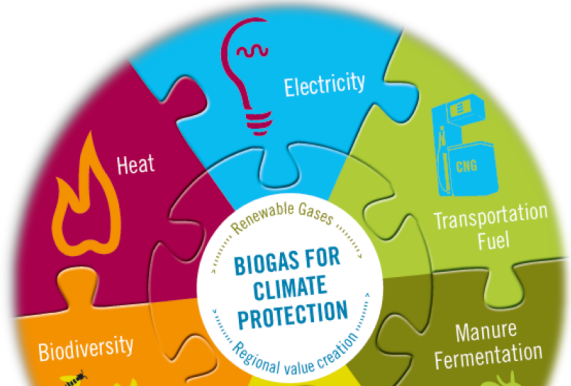
Who we are



The German Biogas Association: Profile

Fachverband BIOGAS

4,700+ members

- Plant operators
- Manufacturers
- Research Institutes
- Public Authorities
- Consultants
- Dedicated Individuals
- … and you?

Berlin Office

Freising Headquarter

40+ employees

Member of

EBA European Biogas Association

BEE

Germany's general association for all renewables

BBE

WORLD BIOENERGY ASSOCIATION

Our Goals:

Establishing biogas as an important component for climate protection

- Definition of legal frameworks and guidelines
- Information exchange, knowledge transfer
- Advocating on EU-, national and regional levels

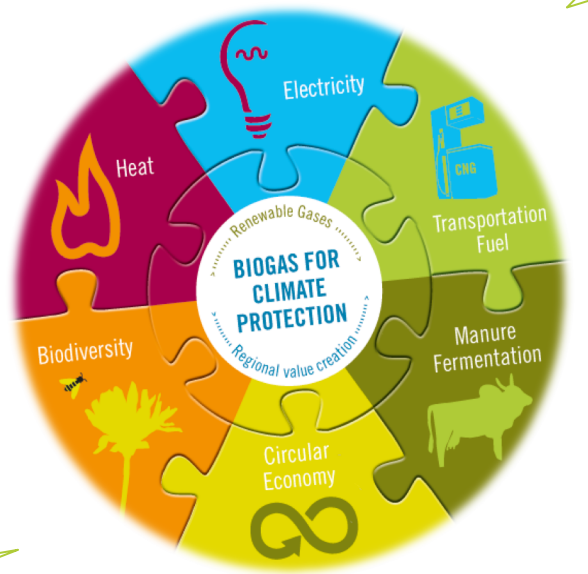
The German Biogas Association: Our departments

Fachverband BIOGAS

Energy
law, distribution,
trade / licensing

Member
services

Policy
Advocating



International
affairs

Permitting
procedures

Agriculture

Waste
Fertilisers
Hygiene

Manufacturers
& technology

Trainings &
safety

The German Biogas Association: Scope of works

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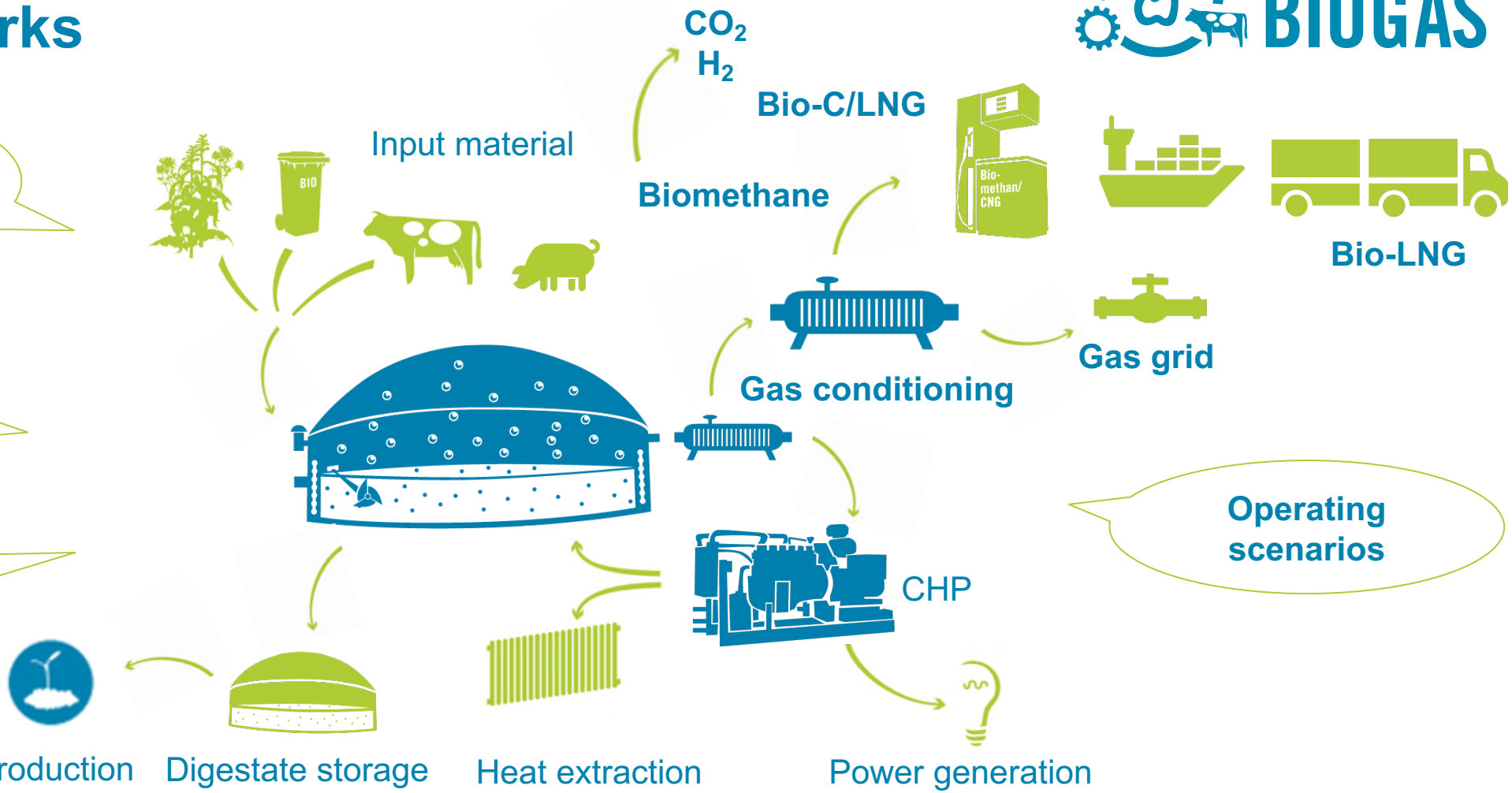
Monitoring of directives and laws

Technological options

Knowledge transfer



Operating scenarios

Market screenings

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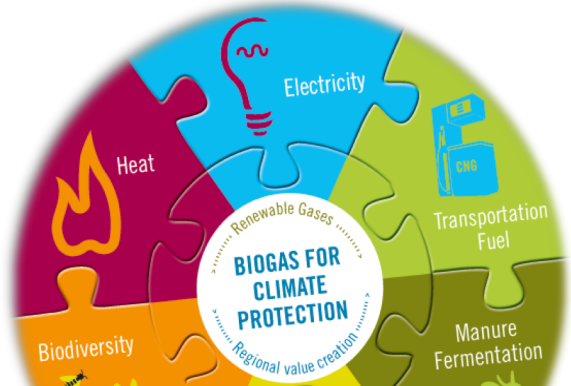
On current occasion: Biomethane potential EU & Germany



On current occasion:

REPowerEU – EU-wide biomethane potential

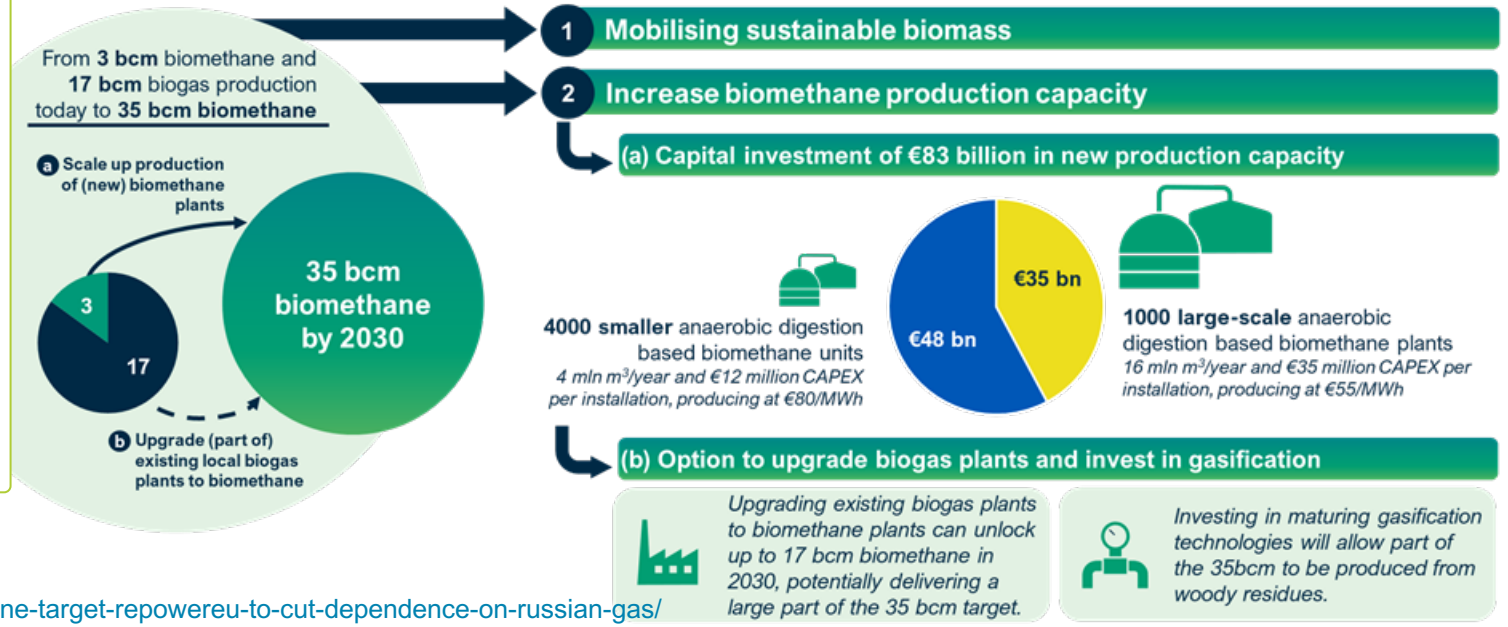
20 % of current imports from Russia

Fachverband BIOGAS

w/o additional farmland use

EBA European Biogas Association

- **08. March 2022:**
  - **Goal:**
    - **35 billion cubic meters of biomethane to be produced by 2030**
    - Adoption of the requirement formulated by EBA and 30 other organisations to make 350 TWh available.



https://www.europeanbiogas.eu/commission-announces-groundbreaking-biomethane-target-repowereu-to-cut-dependence-on-russian-gas/

- **Abolition of the maximum rated output (capping of production capacity)**
- **More flexibility in substrate use**
- **Less bureaucratic hurdles and faster decisions on permits**

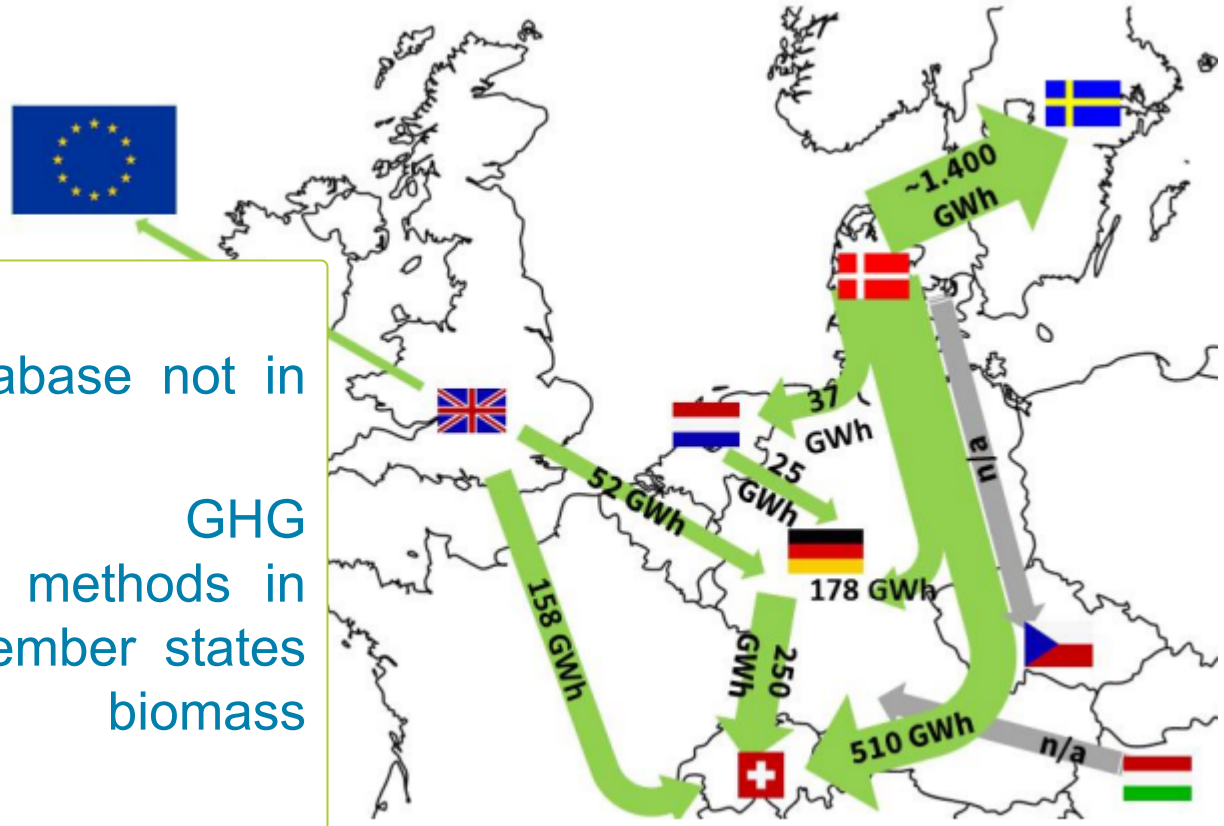
On current occasion:
REPowerEU – Biomethane Industrial Partnership (BIP)

- European Commission and industry leaders launch Biomethane Industrial Partnership to support the 35 bcm target
- Consisting of companies, industry associations, academia, society organisations
- Goals: Identification of barriers, legal frameworks (permitting), best practices, recommendations to EU Commission

https://bip-europe.eu/

Trade volumes 2020

International biomethane transfers 2020 without transfers < 10 GWh



Branchenbarometer Biomethan – dena 2021

Issues

- Union Database not in place
- Differing GHG accounting methods in the EU member states (national biomass codes)
- Effort Sharing Regulation and other measures not yet in place

- **By trade of certificates of origin**
- Recognition of biomethane from abroad in the ETS from/to countries with similar certification schemes – or no regulation
- More than half of Danish biomethane certificates marketed abroad
- Export from Denmark into Sweden triggered by CO2 and energy tax exemption

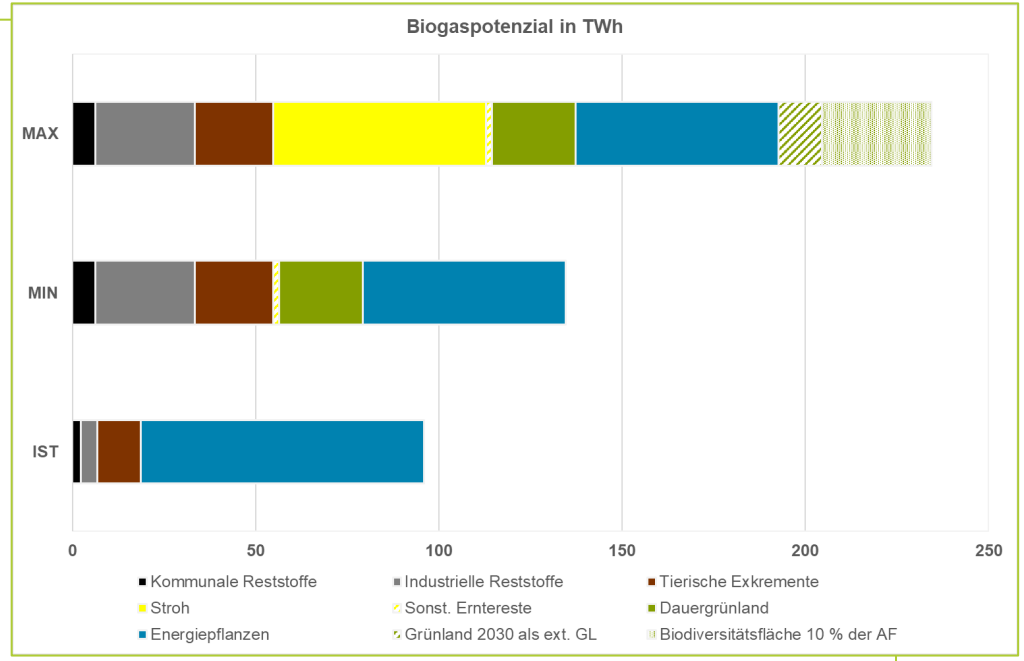
On current occasion:
German-wide biomethane potential

(i) Waste, Residuals & By-Products: **56-115 TWh**

- Municipal residues: 6,3 TWh
- Industrial residues: 27,1 TWh
- Manure (wet/dry): 21,4 TWh
- Straw: 0 - 58,1 TWh
- Other agri-residues: 1,7 TWh

(ii) Conventional & alternative energy crops: 55 TWh

(iii) Permanent grassland outcrop: 23 TWh



(iv) extensively used grassland outcrop (up to 1,2 Mio. ha in 2030): 0-22 TWh

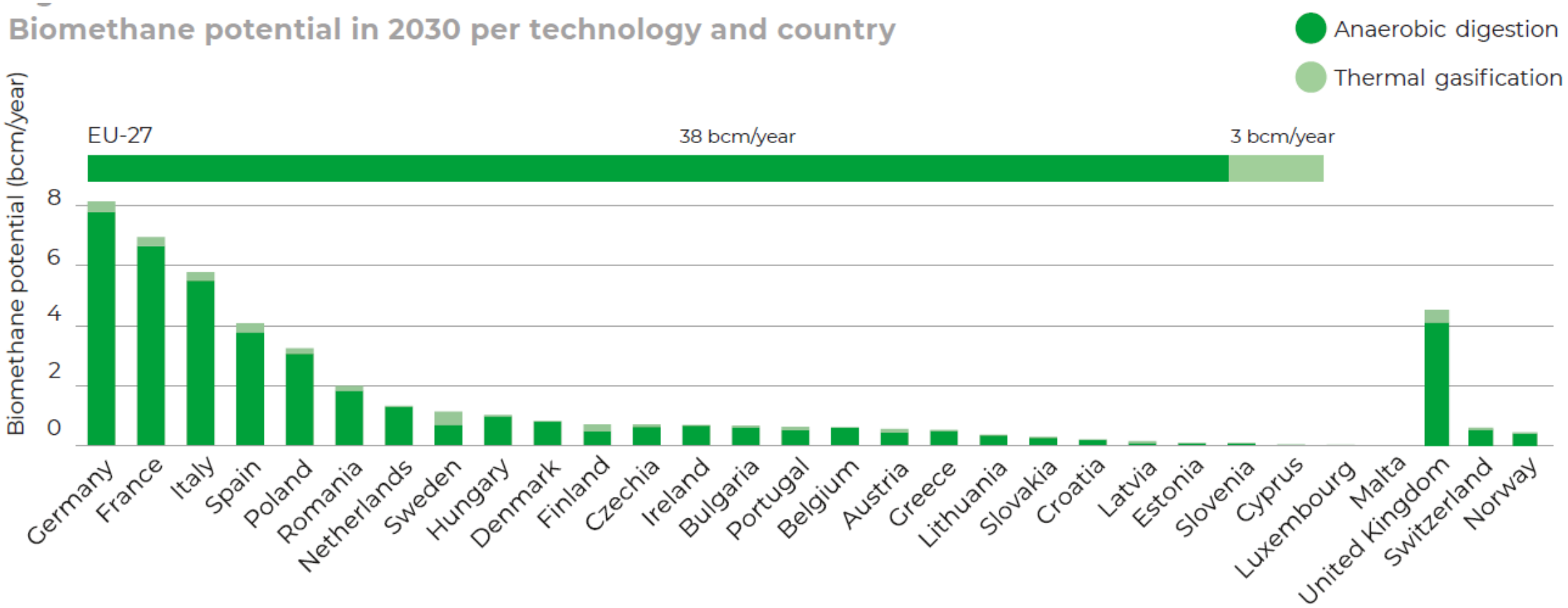
(v) Biodiversity areas (up to 1 Mio. ha wild and flowering plants in 2030): 0 - 30 TWh

=> up to 234 TWh (thereof approx. 95 TWh developed)

=> Corresponds to approx. 42% of today's natural gas imports from Russia

Sources: FvB
Abfälle, Reststoffe, Nebenprodukte, Energiepflanzen und Aufwuchs von Dauergrünland nach DVGW (2019), Ermittlung des Gesamtpotenzials erneuerbarer Gase zur Einspeisung ins deutsche Gasnetz.

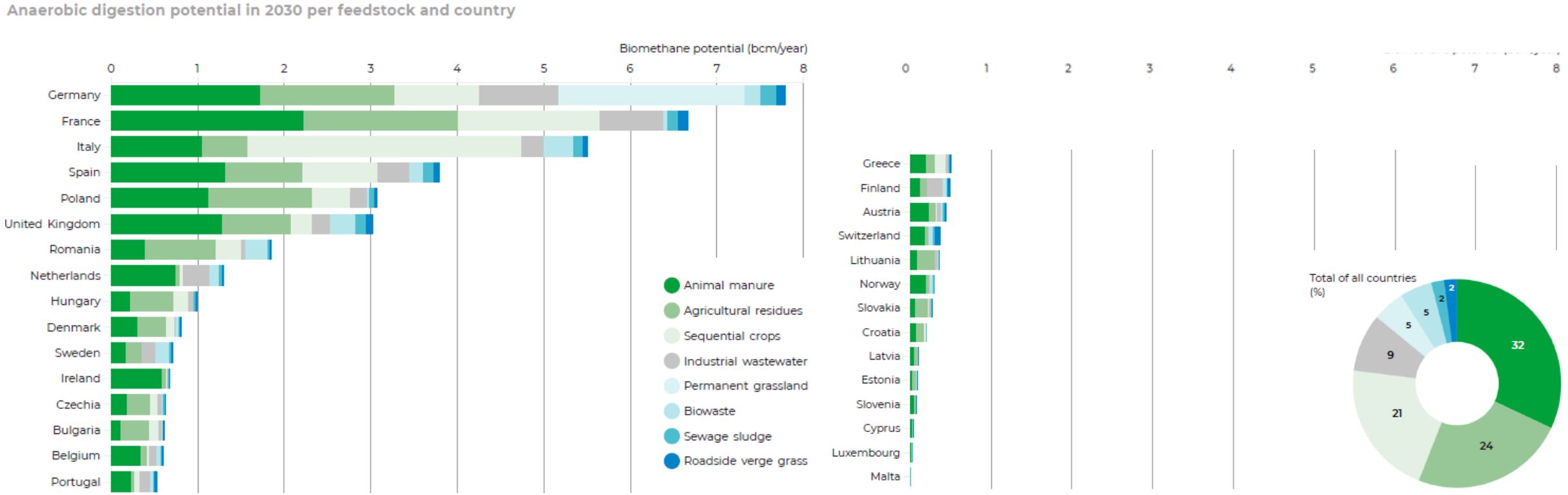
On current occasion:
European wide biomethane potential 2030



Guidehouse Netherlands B.V (Publisher) [July 2022]: Biomethane production potentials in the EU. A Gas for Climate Report. [p. 3.]

https://gasforclimate2050.eu/wp-content/uploads/2022/10/Guidehouse_GfC_report_design_final_v3.pdf

On current occasion:
European wide biomethane potential 2030



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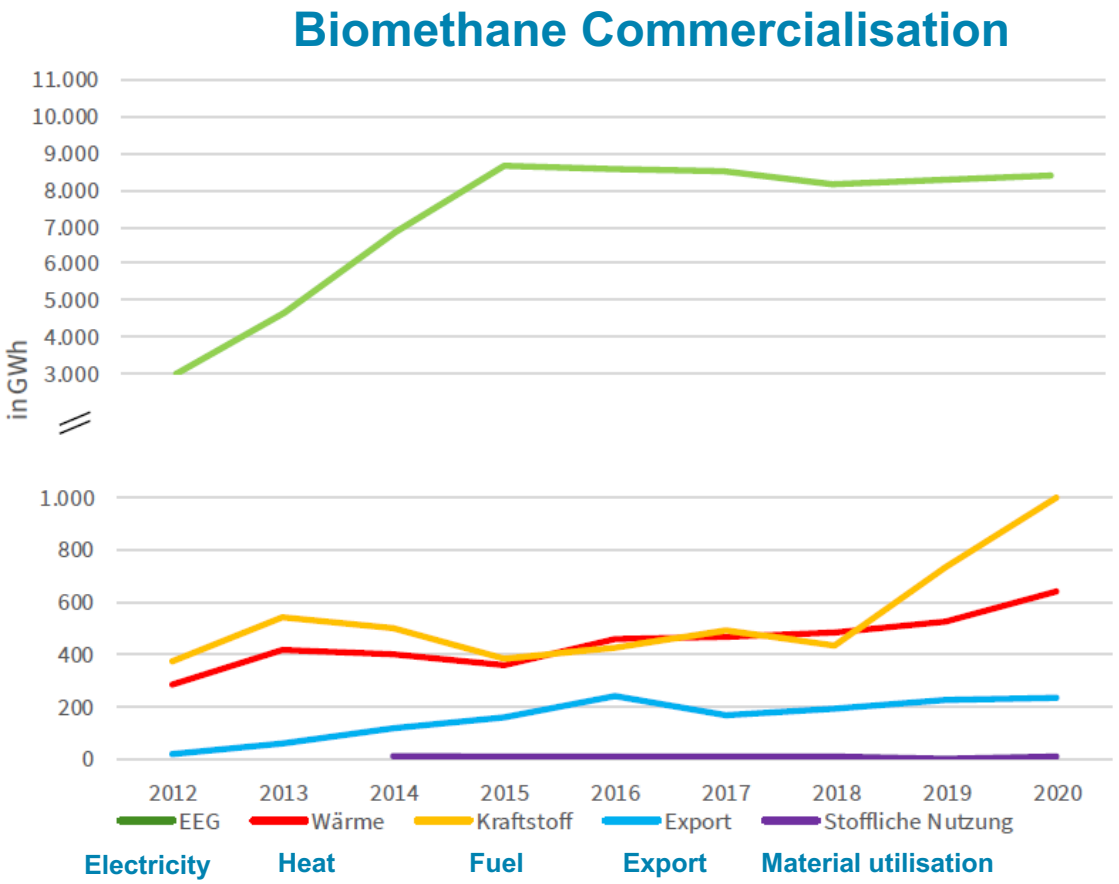
https://gasforclimate2050.eu/wp-content/uploads/2022/10/Guidehouse_GfC_report_design_final_v3.pdf

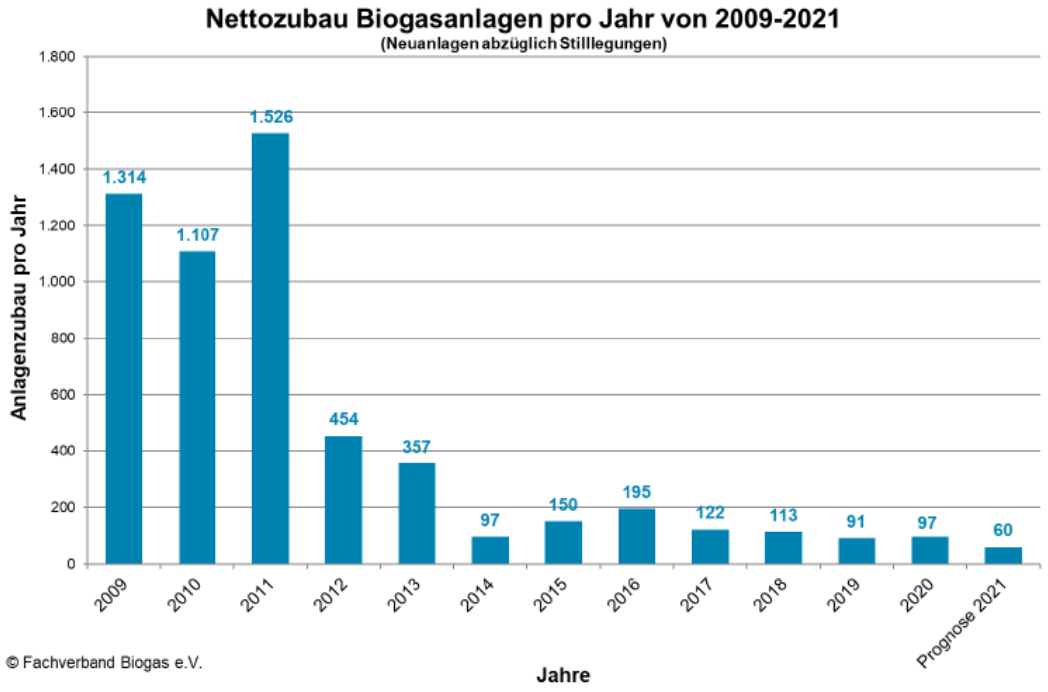
How much biomethane ends up in Germany's Biomethane Sector?

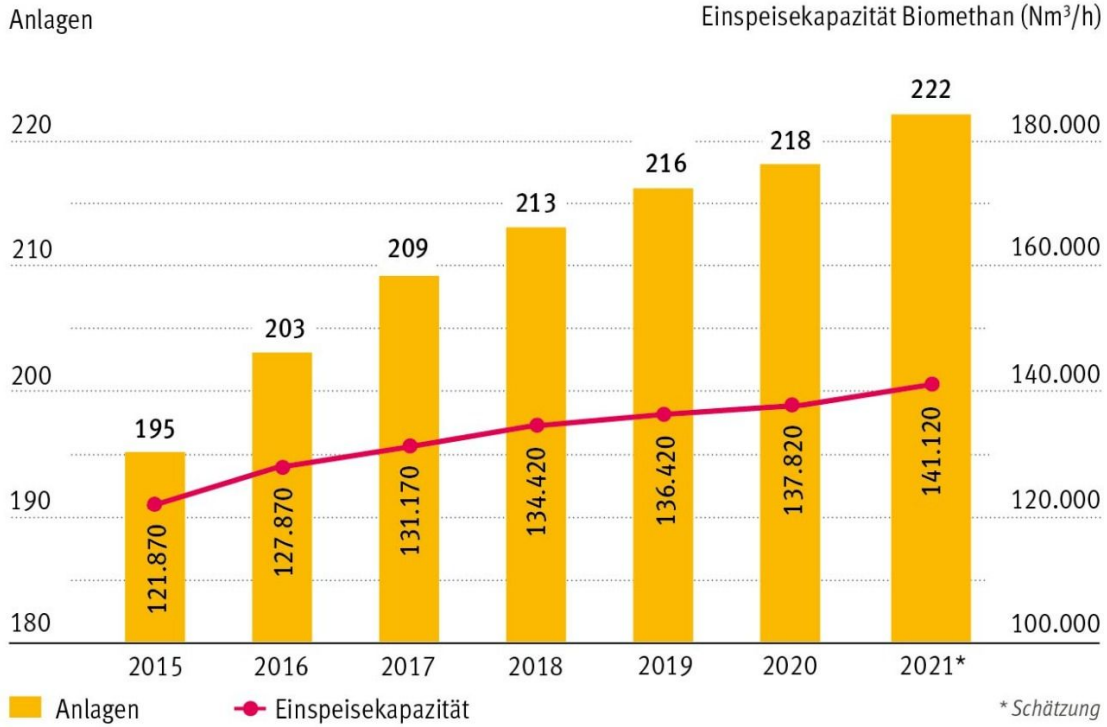


Year	Biomethane Feed-in [GWh]	Thereof fuel utilisation [GWh]
2020	9,847	1,000
2019	9,823	700
2018	10,108	389
2017	9,893	380
2016	9,318	379

Source: dena Branchenbarometer Biomethan 2021

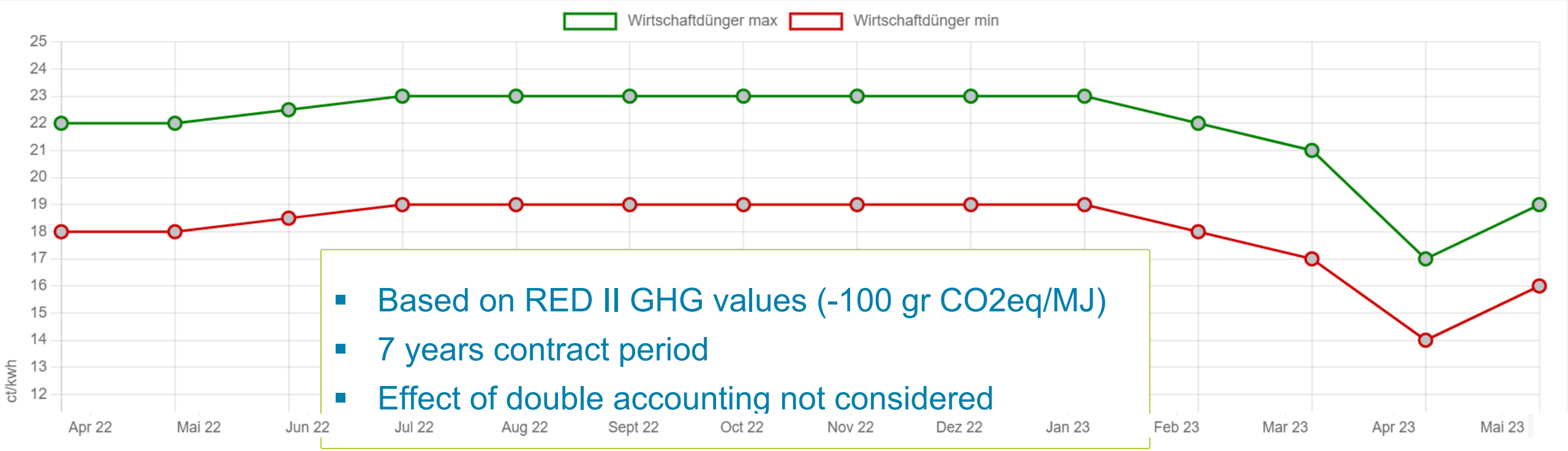
How much biomethane ends up in Germany's Biomethane Sector?





Installation capacity strongly decreasing – yet biomethane production increasing.
Older plants are upgrading to other uses than just electricity production from biogas.

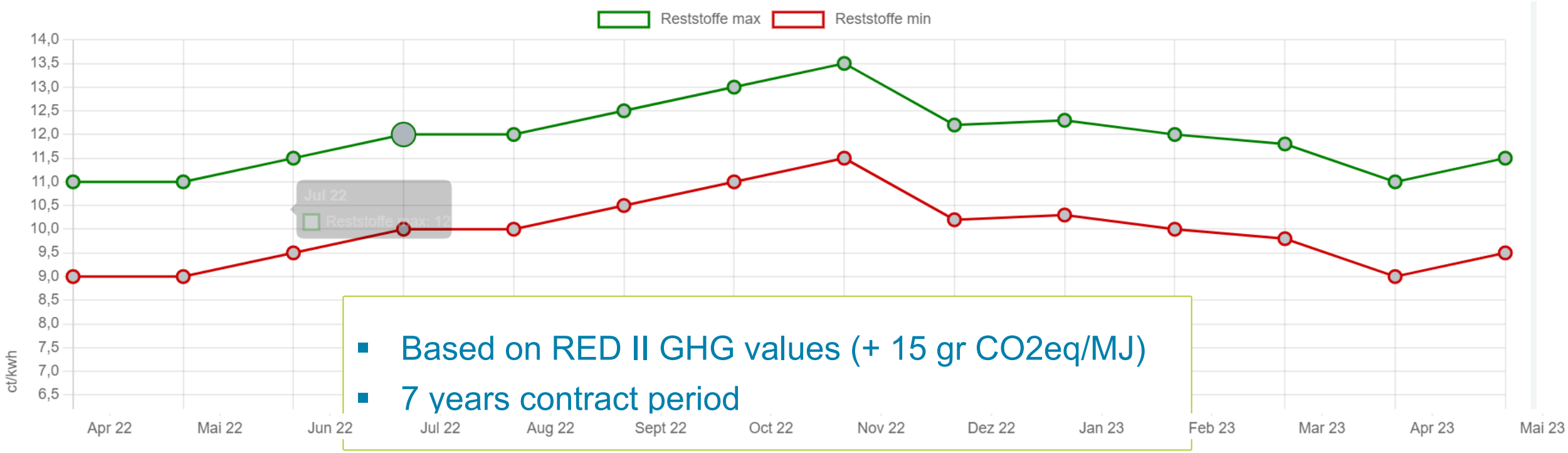
Pricing Biomethane in Germany
Min/Max Market Prices for Manure



- Based on RED II GHG values (-100 gr CO2eq/MJ)
- 7 years contract period
- Effect of double accounting not considered

https://agriportance.com/biomethan-preisticker/

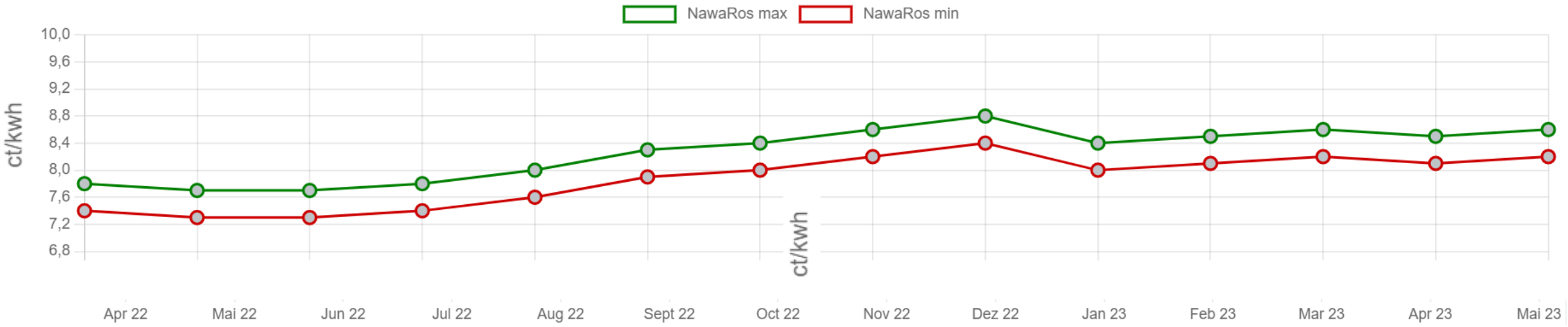
Pricing Biomethane in Germany
Min/Max Market Prices for Residues from 2023



- Based on RED II GHG values (+ 15 gr CO2eq/MJ)
- 7 years contract period

https://agriportance.com/biomethan-preisticker/

Pricing Biomethane in Germany
Min/Max Market Prices for ren. Raw Materials from 2023



- Based on feed-in tariff – predominately biomethane CHPs
- 7 years contract period

https://agriportance.com/biomethan-preisticker/

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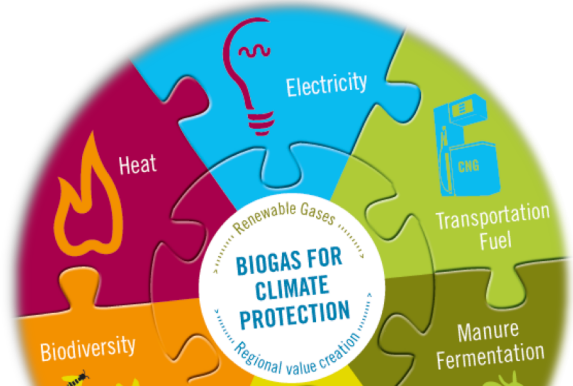
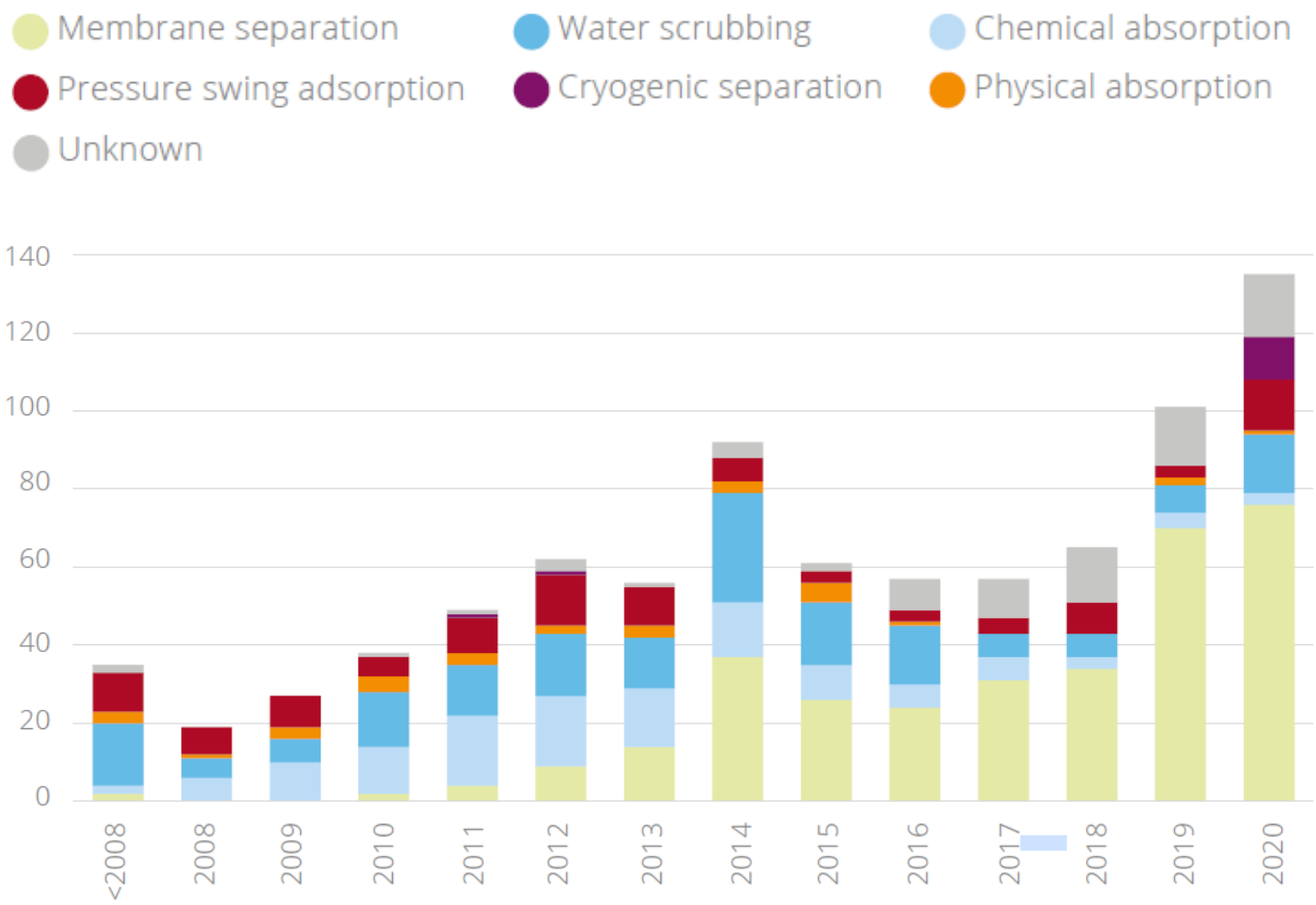
Technological options for biomethane production (Overview)



Technological options for biomethane production – from raw biogas to biomethane

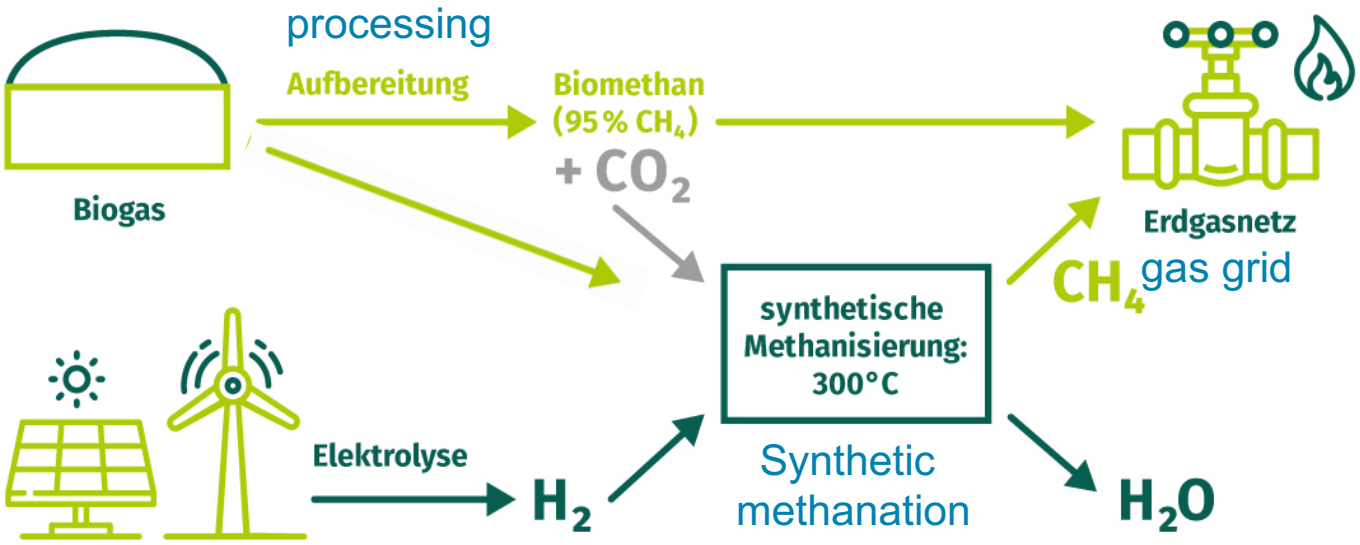
- **Why?**
  - Adaptation of the gas quality to the natural gas network (L- or H-gas)
  - Increase methane content of biogas (55 % - 98 %)

- **How?**
  - Drying
  - CO_2- removal (and use)
  - Coarse and fine desulfurisation
  - Odorising



EBA Statistical Report 2021: Number of new biomethane plants in EU per upgrading technology

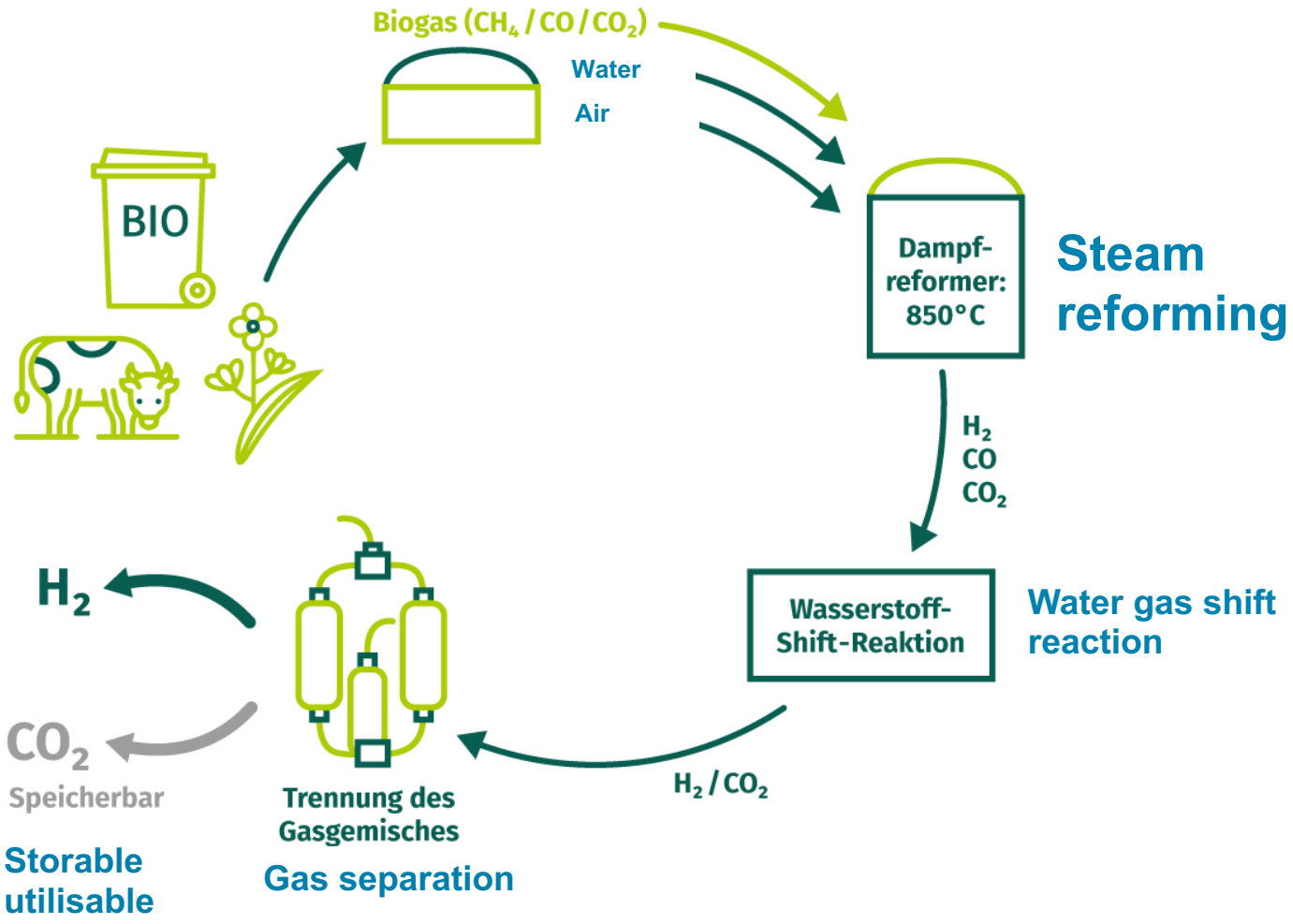
Technological options for biomethane production - direct & biological methanation



Methanation potential:
Approx. doubling potential for biomethane (234 TWh -> **435 TWh**)

- **Direct methanation**
  - Raw biogas is mixed with hydrogen in the fermenter
  - Alternative: biologic methanation, e.g., "dark fermentation" and certain bacterial strains produce a methane/hydrogen mixture
  - Interaction of CO_2 and methane in the raw biogas increase of the methane content.

Technological options for biomethane production - Hydrogen generation



- **Biogas steam reforming**
  - "classic steam reforming" with biogas instead of natural gas
  - Separation of hydrogen and carbon
  - Water gas shift reaction reduces carbon monoxide with water vapor to further hydrogen
  - Heat supply through partial combustion of raw biogas

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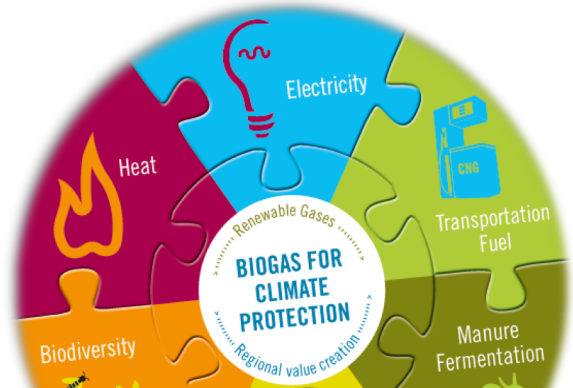
EU- and nationwide legal framework



Legal Framework

- **Overall framework: “Fit for 55 Packet”**
  - Target: GHG emissions reduction by 55% until 2030, climate neutral by 2050
  - Presentation on 14.07.2021, currently under revision
  - Reformed or new directives and regulations of the European Commission relating to EU climate policy

Clean Energy GHG Emissions

- **RED II Revision (RED III)**
- Energy Efficiency Directive (EED)

CO_2/GHG Taxation

- ETD (Energy Taxation Directive)
- LULUCF (Land Use, Land Use Change and Forestry)
- ETS
- Effort Sharing Regulation
- Carbon Border Adjustment Mechanism

Transport

- DAFI (Revised Alternative Fuels Infrastructure Directive), **CVD**
- FuelEU Maritime Initiative
- ReFuelEU Aviation Initiative

RED II: Emissions from biomethane as fuel
Business opportunities by GHG trading

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Default values in RED II for GHG Emissions (fossil comparator 94 g $CO_{2äq}$/MJ)

Substrate	g CO_{2eq}/MJ
Manure	-100
Biogenic waste	14
80 % manure + 20 % maize	-12

Disaggregated values along the process chain

Disaggregated default values for biogas for the production of electricity

Biomass fuel production system		Technology	TYPICAL VALUE [g CO_2eq/MJ]					DEFAULT VALUE [g CO_2eq/MJ]				
			Cultivation	Processing	Non-CO_2 emissions from the fuel in use	Transport	Manure credits	Cultivation	Processing	Non-CO_2 emissions from the fuel in use	Transport	Manure credits
Wet manure (1)	case 1	Open digestate	0,0	69,6	8,9	0,8	– 107,3	0,0	97,4	12,5	0,8	– 107,3
		Close digestate	0,0	0,0	8,9	0,8	– 97,6	0,0	0,0	12,5	0,8	– 97,6
	case 2	Open digestate	0,0	74,1	8,9	0,8	– 107,3	0,0	103,7	12,5	0,8	– 107,3
		Close digestate	0,0	4,2	8,9	0,8	– 97,6	0,0	5,9	12,5	0,8	– 97,6
	case 3	Open digestate	0,0	83,2	8,9	0,9	– 120,7	0,0	116,4	12,5	0,9	– 120,7
		Close digestate	0,0	4,6	8,9	0,8	– 108,5	0,0	6,4	12,5	0,8	– 108,5

EUROPEAN UNION

THE EUROPEAN PARLIAMENT — THE COUNCIL

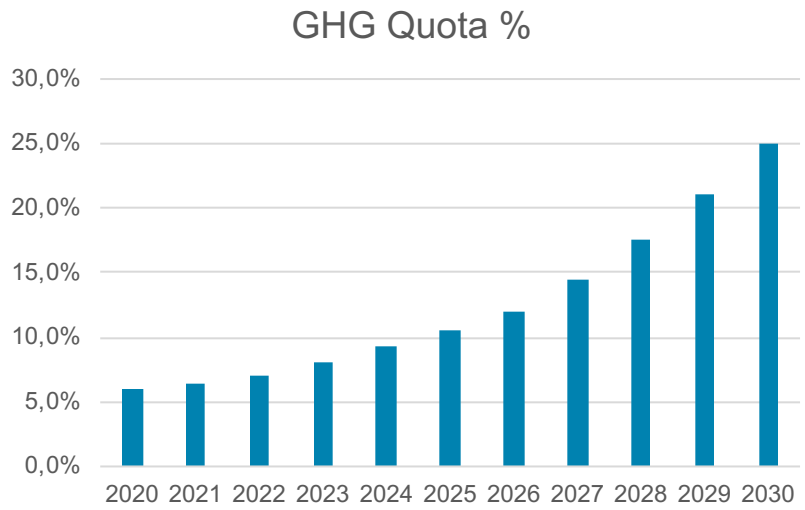
Brussels, 21 November 2018
(OR. en)

VTypical and default values for biomethane — 2016/0382 (COD) — PE-CONS 48/18

Biomethane production system	Technological option	Greenhouse gas emissions – typical value (g CO_2eq/MJ)	Greenhouse gas emissions – default value (g CO_2eq/MJ)
Biomethane from wet manure	Open digestate, no off-gas combustion[1]	-20	22
	Open digestate, off-gas combustion[2]	-35	1
	Close digestate, no off-gas combustion	-88	-79
	Close digestate, off-gas combustion	-103	-100
Biomethane from maize whole plant	Open digestate, no off-gas combustion	58	73
	Open digestate, off-gas combustion	43	52
	Close digestate, no off-gas combustion	41	51
	Close digestate, off-gas combustion	26	30
Biomethane from biowaste	Open digestate, no off-gas combustion	51	71
	Open digestate, off-gas combustion	36	50
	Close digestate, no off-gas combustion	25	35
	Close digestate, off-gas combustion	10	14

Relevance of the RED and the GHG balance in Germany's transport sector

- GHG quota replaces energy quota since 2015
  - since 2015 : 3.5 % GHG reduction
  - since 2017 : 4.0 % GHG reduction
  - since 2020 : 6.0 % GHG reduction



- **Everyone who distributes fuel must prove quota fulfilment!**

Year	Minimum for energy purposes, double credit for amounts above the minimum	2022	2023	2024	2025	2026 2027	2028 2029	2030
Advanced biofuels quotas (RED II Annex IX Part A)		0.2 %	0.3 %	0.4 %	0.7 %	1.0 %	1.7 %	2.6 %

- Biomethane as fuel can be used to fulfill quotas
  - **Non-compliance is penalised: 0.47 €/kg CO_2 = 600 €/t CO_2**
- **Double accounting of GHG Quota by over-fulfilling subquota confirmed in RED III – Member States can follow their own regulations**

RED II Revision (RED III)

ITRE

Committee on Industry, Research and Energy

- **Higher Renewable Nenergy Goals**: ~~40~~45 % until 2030
- **Generally higher goals**
  - **Buildings sector:** EU target of at least 49 % share of RE in buildings in 2030
  - **Heating and cooling in industry: Annual increase in RE use by** ~~1,1~~1,9 %-points in this sector
  - **Heating and cooling sector as a whole:** member states to increase RE use by ~~1,1~~2,3 %-points; if waste heat is used, the target increases to ~~1,5~~2,8 %-points
  - **District heating sector:** annual increase in RE heating/cooling and waste heating/cooling by ~~2,1~~2,3 %-points compared to 2020
  - **Transport sector: new:** assessed against GHG reductions of ~~13~~16 % by 2030; if a state chooses not to exhaust biofuels from food and feed up to the 7% limit, the contribution to RE target achievement is correspondingly less.
  - **Increased sub-quota for advanced biofuels and biogas:** 0.2% in 2022, 1% in 2025, and 2.2% in 2030; share of renewable fuels of non-biological origin to be 2.6% in 2028~~30~~ 2,6 %, in 2030 min. 5.7 %

What does this mean?

Food and feed plants
- Corn as the main crop
- Cereals(-GPS) as the main crop
- Oil crops as the main crop
- Sugarbeet as main crop

Not a food and feed crop:
- Corn straw (= waste)
- Cereal (-GPS) as catch crop/cover crop (e.g. green rye).
- General second crop that does not trigger land requirements.

Non food plant with cellulose content:
- Residues from food and feed crops (straw, husks, pods)
- Grass-type energy crops (ryegrass, switchgrass, miscanthus).
- Clover grass (especially in organic farming)

42. „zellulosehaltiges Non-Food-Material“ Rohstoffe, die überwiegend aus Zellulose und Hemizellulose bestehen und einen niedrigeren Lignin-Gehalt als lignozellulosehaltiges Material haben; es umfasst Reststoffe von Nahrungs- und Futtermittelpflanzen wie Stroh, Spelzen, Hülsen und Schalen, grasartige Energiepflanzen mit niedrigem Stärkegehalt wie Weidelgras, Rutenhirse, Miscanthus, und Pfahlrohr, Zwischenfrüchte vor und nach Hauptkulturen, Untersaaten, industrielle Reststoffe, einschließlich Nahrungs- und Futtermittelpflanzen nach Extraktion von Pflanzenölen, Zucker, Stärken und Protein, sowie Material aus Bioabfall; als Untersaaten und Deckpflanzen werden vorübergehend angebaute Weiden mit Gras-Klee-Mischungen mit einem niedrigen Stärkegehalt bezeichnet, die zur Fütterung von Vieh sowie dazu dienen, die Bodenfruchtbarkeit im Interesse höherer Ernteerträge bei den Ackerhauptkulturen zu verbessern;

Quelle: EU 2018

Sustainability in RED III

- **Threshold value for gas generation plants: Plants with an average methane flow rate of more than** ~~200~~500 m³ Methaneequivalent/h must prove sustainability
- **threshold value of 2 MW** remains: Member States may choose a lower threshold than the 2 MW or the ~~200~~500m³
- **Union Database** serves as proof of sustainability criteria and GHG savings of liquid and gaseous biofuels and combustibles as well as recycled carbon fuels; recording of all usage paths and quantities

ENVI **Committee** on the **Environment**, Public Health and Food Safety

Text proposed by the Commission ENVI	*Amendment* ITRE
(d) at least *70* % for electricity, heating and cooling production from biomass fuels used in installations until 31 December 2025, and at least *80* % from 1 January 2026.;	(d) at least *60* % for electricity, heating and cooling production from biomass fuels used in installations *starting operation from 1 January 2021* until 31 December 2025, and at least *70 % for installations starting operation* from 1 January 2026.;

Quelle: EP ITRE 2022

- **Demonstration of GHG savings from plants starting operation between 2021 and 2025 70%, from 2026 80% also from existing biomass plants.**

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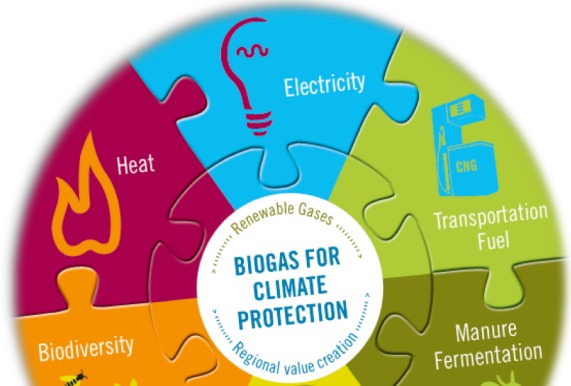
Business Concepts



Operator and business model concepts

- **Acceptance of raw biogas or biomethane by traders or distributors**
  - Low internal efforts
  - Market price dependence

- **Own yard gas station**
  - For internal and/or public use
  - Bio-LNG more expensive to produce
  - GHG Emissions trading possible for distributors to end-users

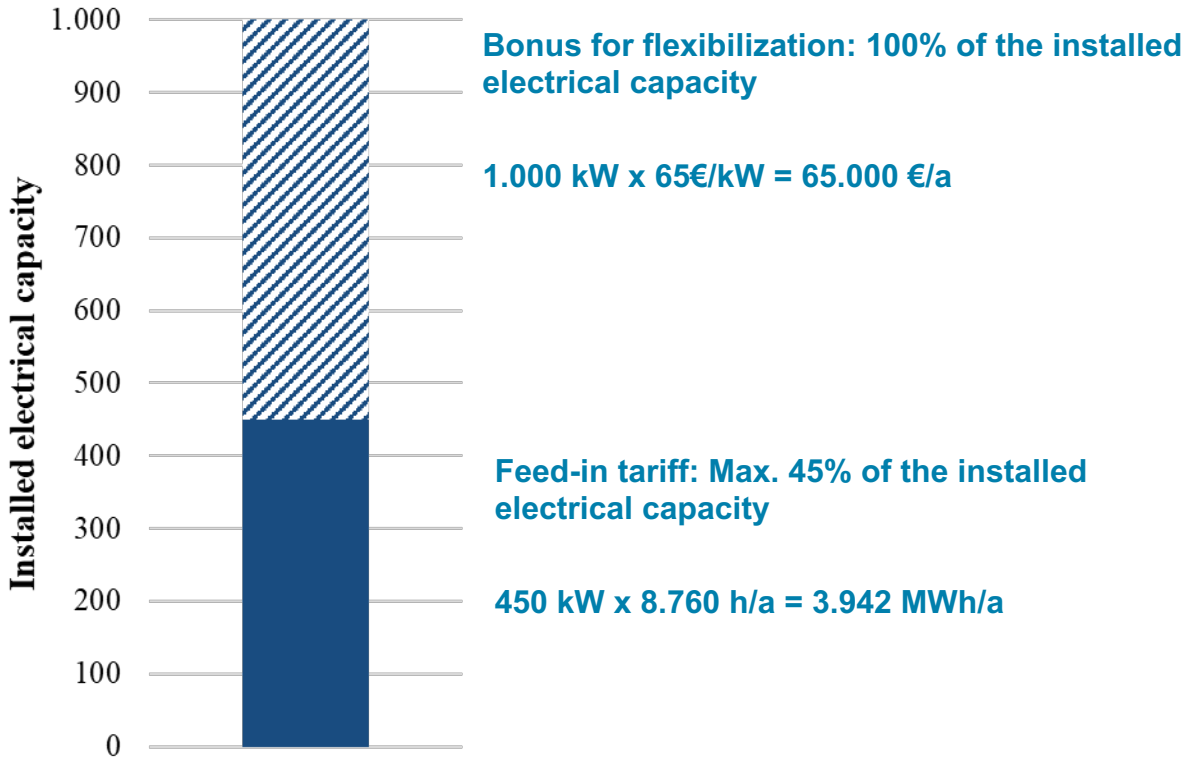
- **Feed-in to gas grid**
  - Moderate preparation effort
  - Purchase agreement with a dealer or gas station operator

    → In balance sheet terms, the operator extracts 100 % biomethane

- **Pooling of biogas/-methane plants**
  - Merger of several plant operators:
    - Central processing into bio-methane
    - Central processing to bio-C/LNG

Operator and business model concepts
Electricity sales

- 45% of the electricity production of the installed electrical power can receive a subsidy
- Feed-in tariffs
  - New plants - **16,28 Cent/kWh (2022)**
  - Existing plants – **18,22 Cent/kWh (2022)**
  - Bonus for flexibilization – **65 €/kW (installed)**
    - Covers only costs for additional CHPs, gas-storage, grid-connection,…
  - Feed-in tariffs = Maximum bidding price
  - Real tariffs are results of tendering rounds



Small Manure Processing Plants

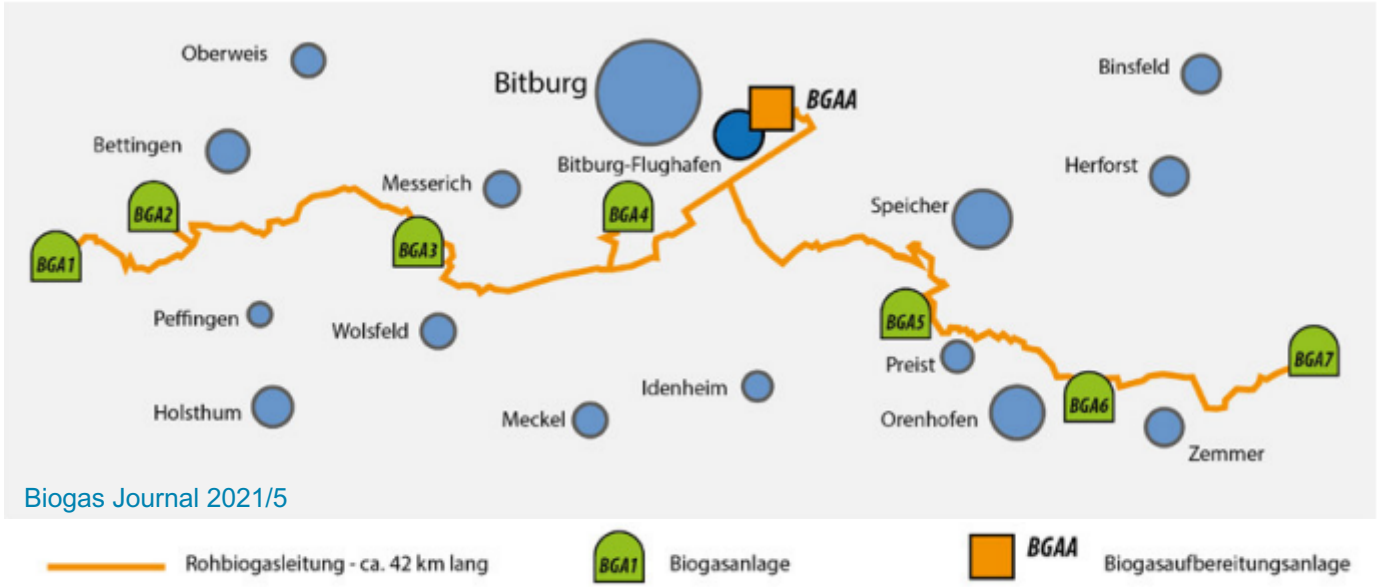
- **Example**
  - New installation 190 kWel
  - approx. 1,500 fattening bulls and calves as well as ren. raw materials
  - Despite high heat demand, enough energy for farm and residential buildings

- **New in EEG 2023:**
  - **Electricity from small manure plants**
  - **Proportion of liquid manure in the input mix at least 80%**
  - **Special feed-in tariff: output < 75 kW = 22 cents/kWh + electric output**
  - **75 - 150 kW = 19 cents/kWh**

Operator and business model concepts

Clustering of biogas plants – Example Bitburg/GER

Wikimedia Commons



Biogas Journal 2021/5

- Municipal utilities Trier: Distribution and sales structures
- Goals:
  - Regional added value
  - Secure and affordable energy supply
- Integration of green hydrogen production
- Individual CHP operation still possible

Eckdaten des Projektes	
Biogaslieferanten	Aktuell 7 Biogasanlagen mit bis zu 900 Nm^3/h Rohgasvolumen.
Biogassammelleitung	DN 125 ... 250, 42 km lang.
Fassungsvermögen Biogasspeicher	5.300 m^3
Aufbereitungstechnologie	Druckwechsel-Adsoptionsverfahren (PSA)
Aufbereitungskapazität	1.800 Nm^3/h Rohgas – 1.000 Nm^3/h Biomethan

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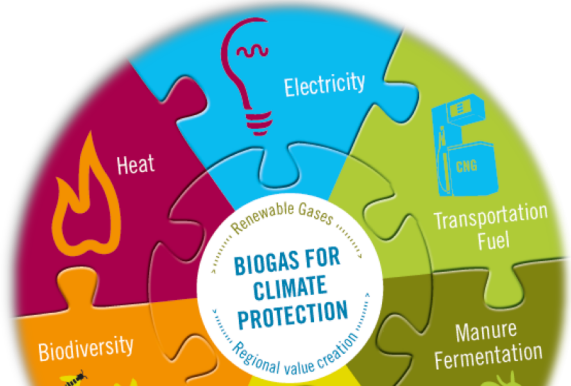
Biomethane as a fuel



Biomethane as a Fuel

- **Bio-CNG**
  - Compressed biomethane
  - For passenger cars and light vans

Possibly no market anymore by 2035:
Ban of all internal combustion engines in planning

- **Bio-LNG**
  - Liquefied Biomethane
  - primarily for heavy goods traffic and maritime or inland waterway traffic

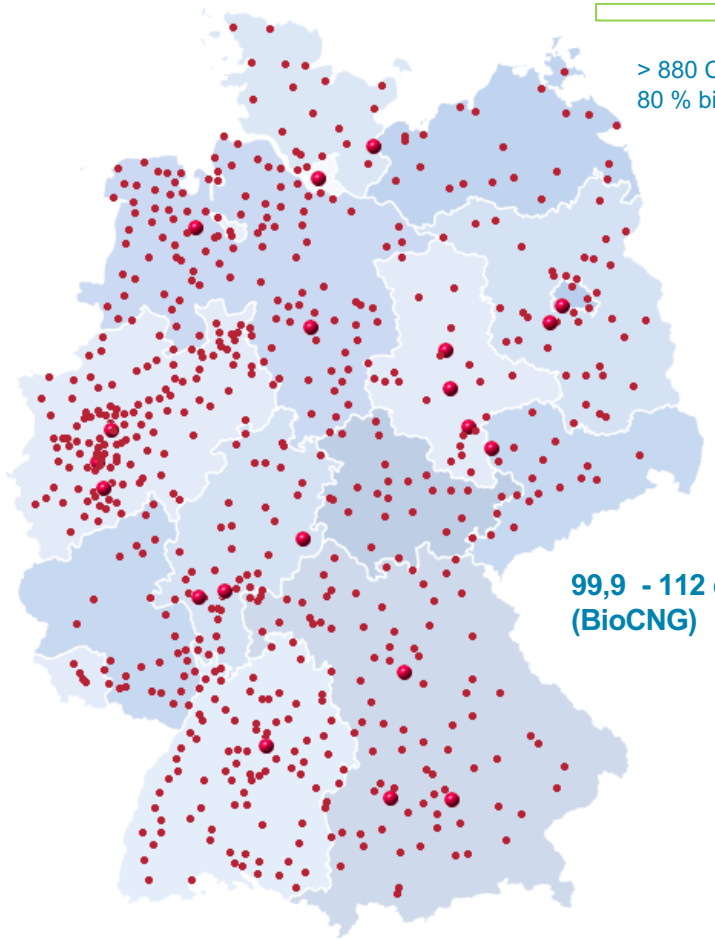
- **Decision making criteria**
  - Local offtakers (own consumption, vehicle fleets, public access)
  - CAPEX & OPEX
  - Incentives, tax exceptions
  - Long-term outlook (legal framework)

Good chances of being recognised as a climate-neutral fuel

Status Quo „alternative fuels“

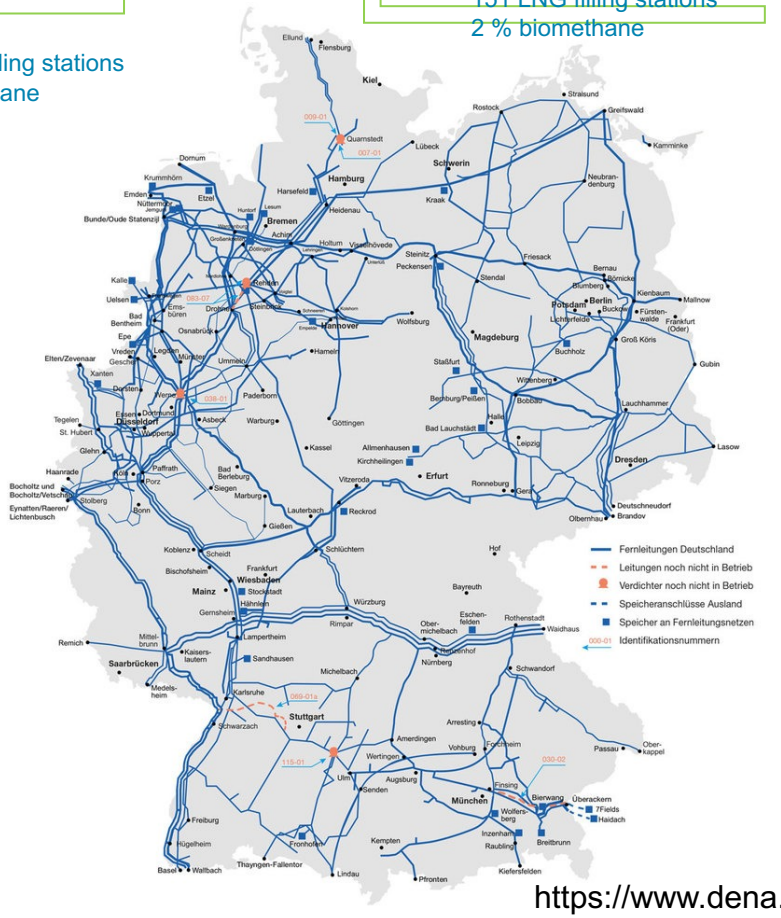
Gas Grid in Comparison with CNG und LNG Fuelling Stations

> 880 CNG filling stations
> 80 % biomethane



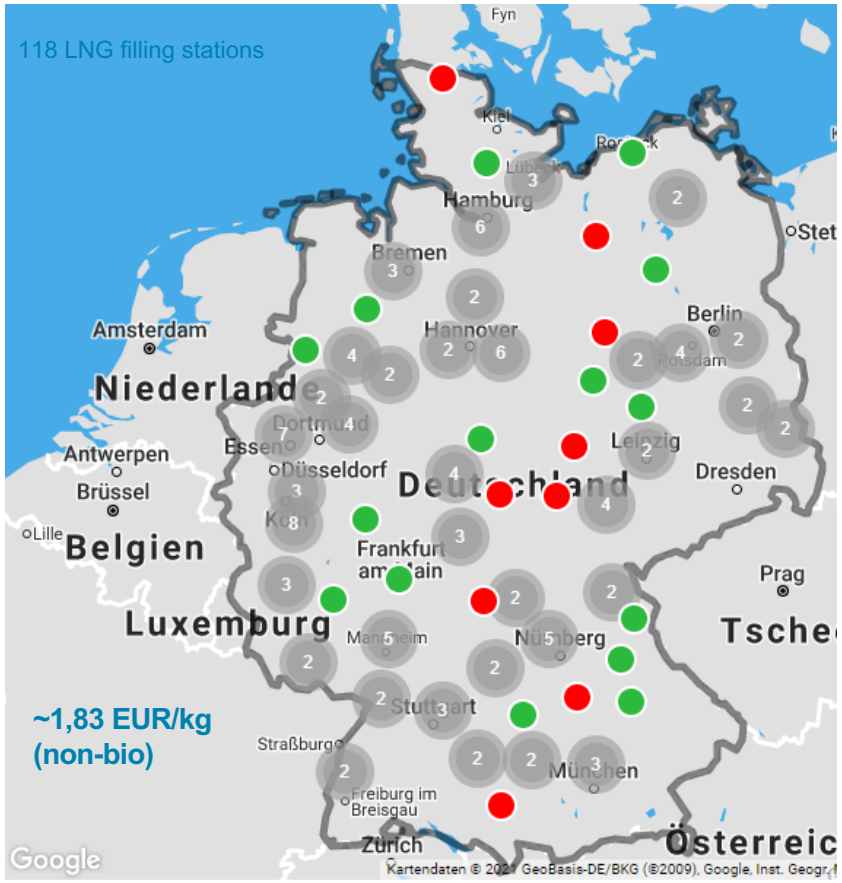
99,9 - 112 ct/kg
(BioCNG)

151 LNG filling stations
2 % biomethane



Das deutsche Gas-Fernleitungsnetz im Überblick; Stand Februar 2017
© Fernleitungsnetzbetreiber

118 LNG filling stations



~1,83 EUR/kg
(non-bio)

https://www.dena.de/themen-projekte/projekte/mobilitaet/lng-taskforce-und-initiative-erdgasmobilitaet/

Status

In Planung In Betrieb

https://www.gas24.de/cms/291-0-erdgastankstellen-uebersicht-deutschland.html

https://gwf-gas.de/maerkte-und-unternehmen/orangegas-fuehrt-bundesweit-einheitliche-preise-fuer-bio-cng-ein/

Legal framework
Alternative Fuels Infrastructure Regulation

DIRECTIVE 2014/94/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 22 October 2014

on the deployment of alternative fuels infrastructure

(45) LNG, including liquefied biomethane, might also offer a cost-efficient technology allowing heavy-duty vehicles to meet the stringent pollutant emission limits of Euro VI standards as referred to in Regulation (EC) No 595/2009 of the European Parliament and of the Council (3).

(48) An appropriate number of LNG and CNG refuelling points accessible to the public should be put in place by 31 December 2025, at least along the TEN-T Core Network existing at that date and, after that date, on the other parts of the TEN-T Core Network where these are made accessible to vehicles.

(58) In the application of this Directive, the Commission should consult relevant expert groups, including at least the European Expert Group on Future Transport Fuels, consisting of experts from industry and civil society, as well as the Joint Expert Group on Transport & Environment, which brings together experts from the Member States.

"The increased deployment and use of renewable and low-carbon fuels must go hand in hand with the creation of a comprehensive network of recharging and refuelling infrastructure based on a geographically fair manner to enable the widespread uptake of low- and zero-emission vehicles in all transport modes"

Proposal for the revision of the AFIR

Example Bio-CNG gas station grid

- **Biogas plant in Northern Germany**
  - Supplies 14 gas stations (partly self-owned) – “as balance”
  - Clients are logistics vehicle fleets, mobile care services, public transport, individuals – in a local context

- **Trade with THG quota**
  - Offtakers such as companies with a high CO_2 footprint
  - 2-3 times higher revenues as the earnings from the gas station itself

Bio-CNG gas station operator

PA
Price & Quantity

Additional earning
(GHG trade)

Quota subjected company
(e.g., mineral oil company)

H. Seide FvB

Example Bio-LNG gas station for transport fleet

- **Pilot project**
  - Shell
  - EDEKA Hannover-Minden (Lower Saxony)
  - IVECO

- **Goals**
  - Vehicle fleet conversion
  - 100 % Bio-LNG from 2023 onwards

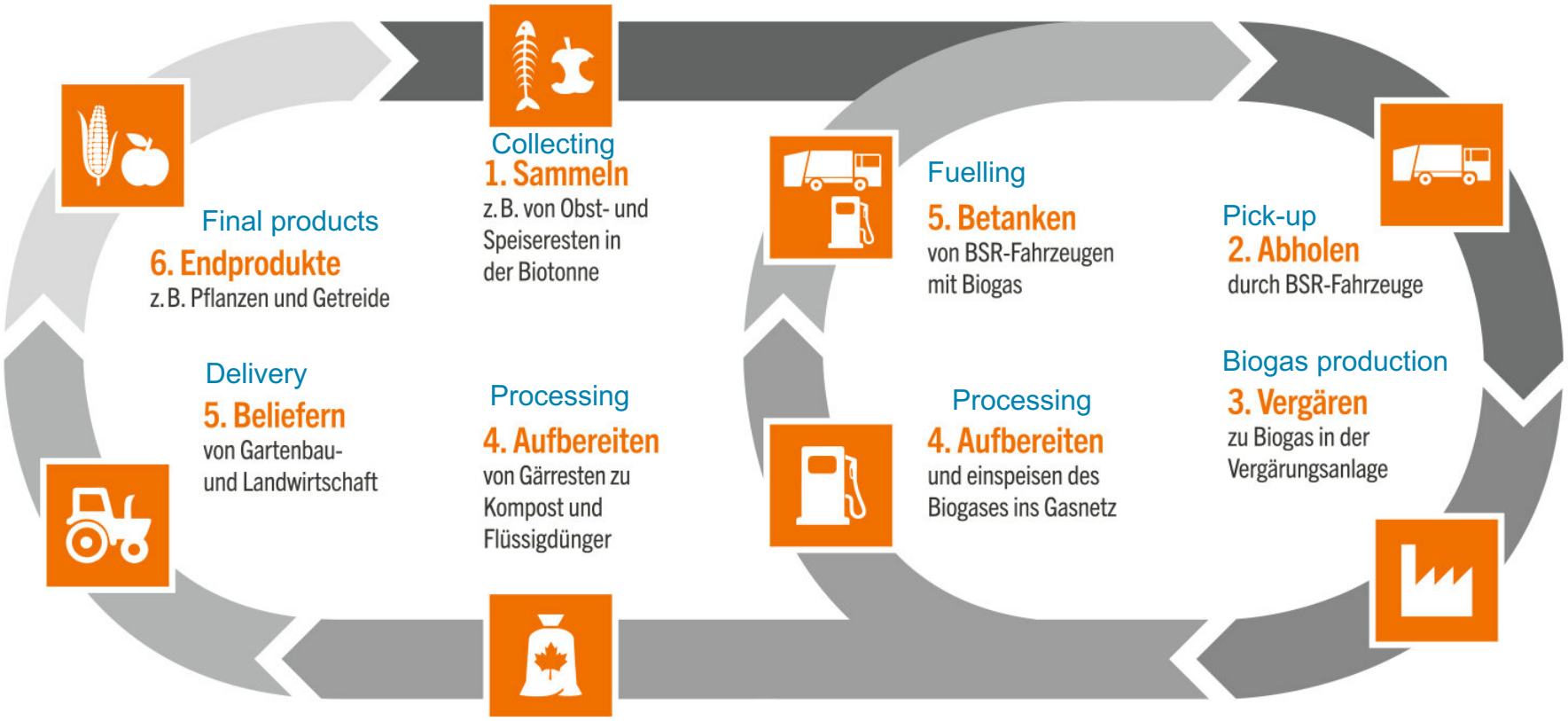
Source: gas24.de (Shell, EDAKA Minden)

- **Key data tractor unit**
  - Two 540 l tanks

  → up to 1.600 km range

https://www.gas24.de/cms/603-0-edeka-stellt-mit-shell-und-iveco-auf-bio-lng-fuer-lkw-transporte-um.html?article_id=603&clang=0

Example Bio-CNG from biogenic waste for garbage trucks



- **Local waste handling provider BSR**
- Biogenic household waste
- 160 garbage trucks run on CNG – half of the fleet

https://www.bsr.de/biogasanlage-22250.php

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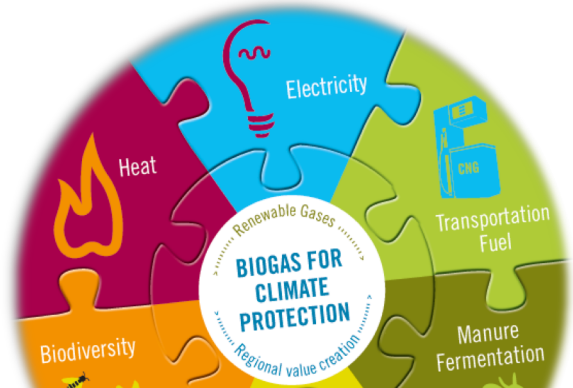
Conclusion and outlook



Conclusion and outlook

- Implementation of RED II by 2021 offers opportunities for biogas/biomethane, especially for renewable gases from manure, biogenic waste, straw, etc.
- Revision of Fit for 55 package, RD II->III, CVD
- Further development also depends on the design of the political framework
  - Extension of toll exemption (CO_2 component expected)
  - Promotion of vehicles & fleet conversion
  - Energy tax and trade regulations, also EU-wide
- Biomethane is in direct competition with other options
  – hence the options need to be technology neutral and utilised where applicable now

  → Well to wheel vs tailpipe approach

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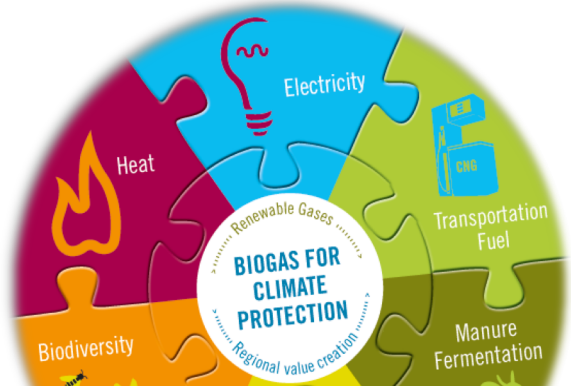
Technological options for biomethane production

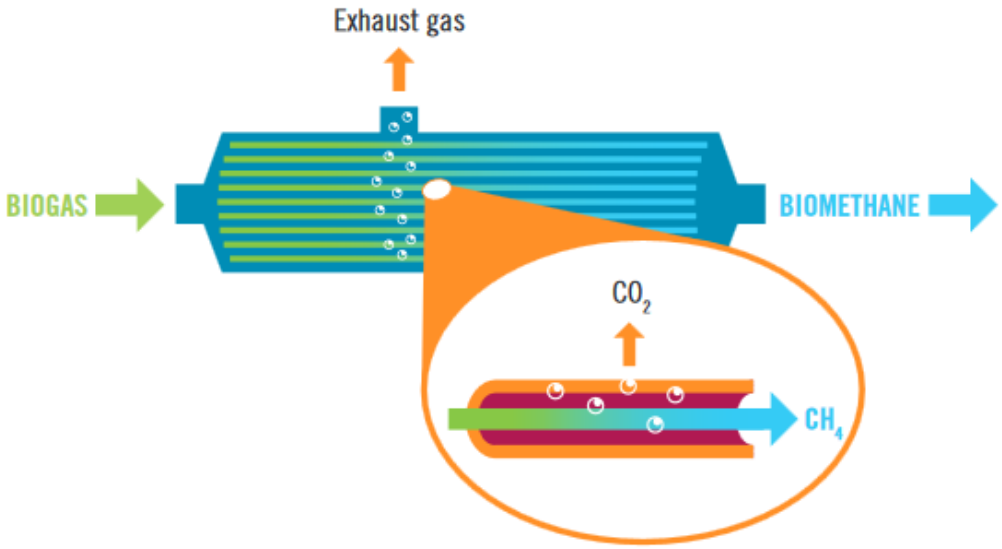


Biomethane Production

Processing Technologies – Membrane Separation

Characteristics

- Based on the principle of the different permeability velocities of the various gases: CO2 has a permeability 20 times higher than CH4.
- Pressure of 7 - 20 bar to accelerate the process.
- Therefore, no additional compression required for gas grid injectionTube bundle interconnection in two- or three-stage cascades → Increase in purity



Biomethane Production

Processing Technologies – Membrane Separation

Advantages

- Few moving parts
- Robust construction
- Modular design possible (for future extensions)
- Can be adapted to smaller volume flows

Disadvantages

- Methane loss to be observed
- Lean gas burner is advisable or required
- Electricity demand between 0.18 - 0.33 kWh per m³ biogas
- Increasing importance in recent years

Biomethane Production

Processing Technologies – Physical or Chemical Scrubbing

- Different solubility of gas components in different liquids: CO_2 dissolves better in water than CH_4.
- Most important influencing variables:
  - Properties of the solvents used
  - Solubility of gas components
- Differentiation between physical and chemical scrubbing:
  - **Physical Scrubbing**
    - physical solubility of the gas components in a wash solution without chemical reaction.
  - **Chemical Scrubbing**
    - Some gases (CO_2 and H_2S) react reversibly with the scrubbing liquid: mixture of water and additives such as MEA, DEA, MDEA (amines), etc.

Biomethane Production

Processing Technologies – Physical and Chemical Scrubbing

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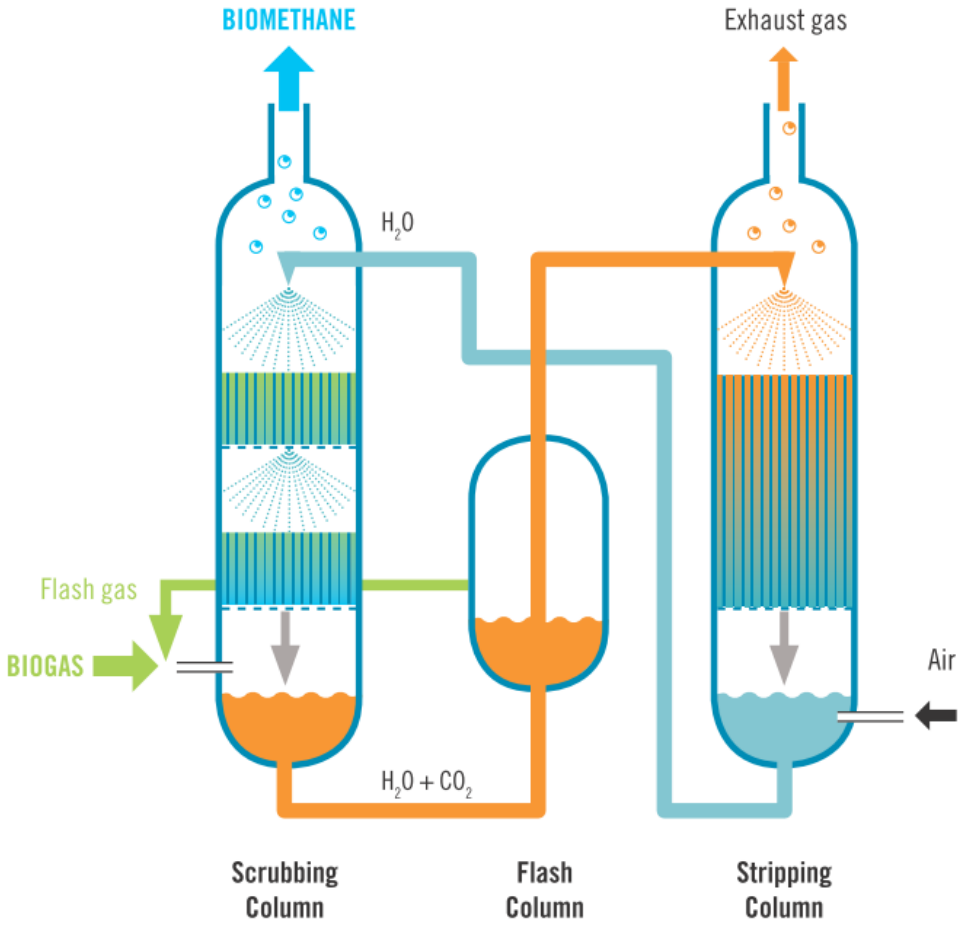
Physical Scrubbing:

- Pressure: 4 to 10 bar
- Water is sprayed from the top and the biogas is fed from the bottom of the scrubbing column to the top.
- CO2 dissolves in the water, CH4 remains in the gas.
- The purified gas is extracted at the top of the scrubbing column. The water containing CO2 is collected at the bottom of the column and regenerated in a two-stage process.
- For chemical scrubbing, a solvent (mostly amine-based) instead of water is used.



Biomethane Production

Processing Technologies – Physical Scrubbing

Advantages

- Technically mature process: widely used for years
- Water is an environmentally friendly and cost-effective solvent
- external heat source not necessary: excess heat can be used elsewhere

Disadvantages

- Pressure requirement between 4 and 10 bar
- Power requirement between 0.2 and 0.3 kWh/Nm³ biogas
- Methane losses between 1 and 4 %.
- Water is less selective than other solvents

Biomethane Production

Processing Technologies – Chemical Scrubbing

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Advantages

- Allows higher solubility and higher loading of the scrubbing liquid
- Less surface area required: smaller installation area
- Product gas is dried by a hydrophobic scrubbing solution

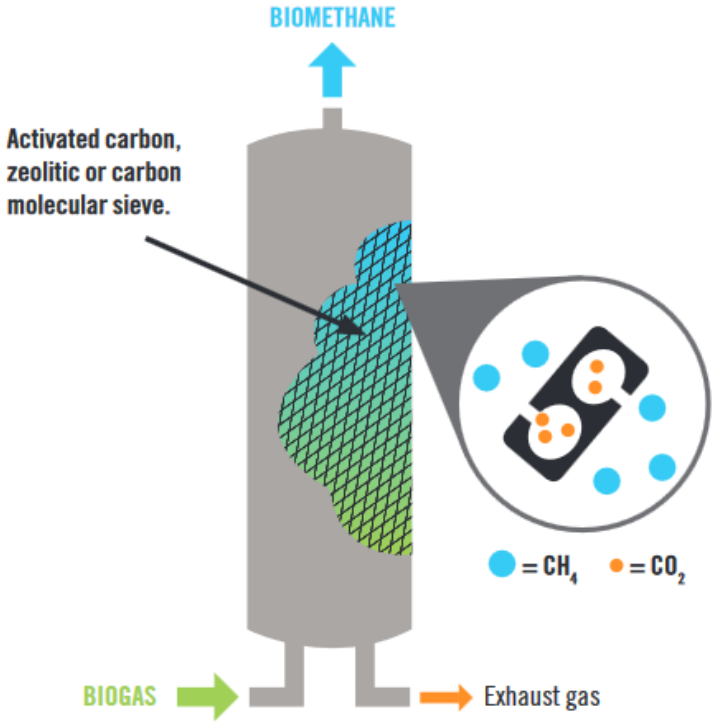
Disadvantages

- Heat is required for the regeneration of the scrubbing liquid.
- Solvent must not be released into the environment
- Methane losses relatively low – observation required
- Electricity requirement

Biomethane Production

Processing Technologies – Pressure Swing Adsorbtion

- **Principle**
  - different gas components are attracted (adsorbed) to certain surfaces to different degrees or penetrate the pores of the material to different degrees In principle, adsorption is higher at higher pressure and lower temperatures.
- **Process Steps**
  - Compression of the pre-cleaned biogas
  - Cooling: Smaller CO2 molecules accumulate to a much greater extent than CH4 molecules.
  - The biomethane is released through the column head. Depressurization inside the column : CO2 dissolves from the surfaces, returns to the gas phase and is vented.



Biomethane Production

Processing Technologies – Pressure Swing Adsorbtion

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Advantages

- Many reference plants and many years of operating experience
- No solvents are used
- No heat is required for regeneration

Disadvantages

- High mechanical stress on the plant due to the high speed of filling, pressurization and unloading of the column.
- Energy demand
- Methane losses
- Lean gas burner required

Biomethane Production

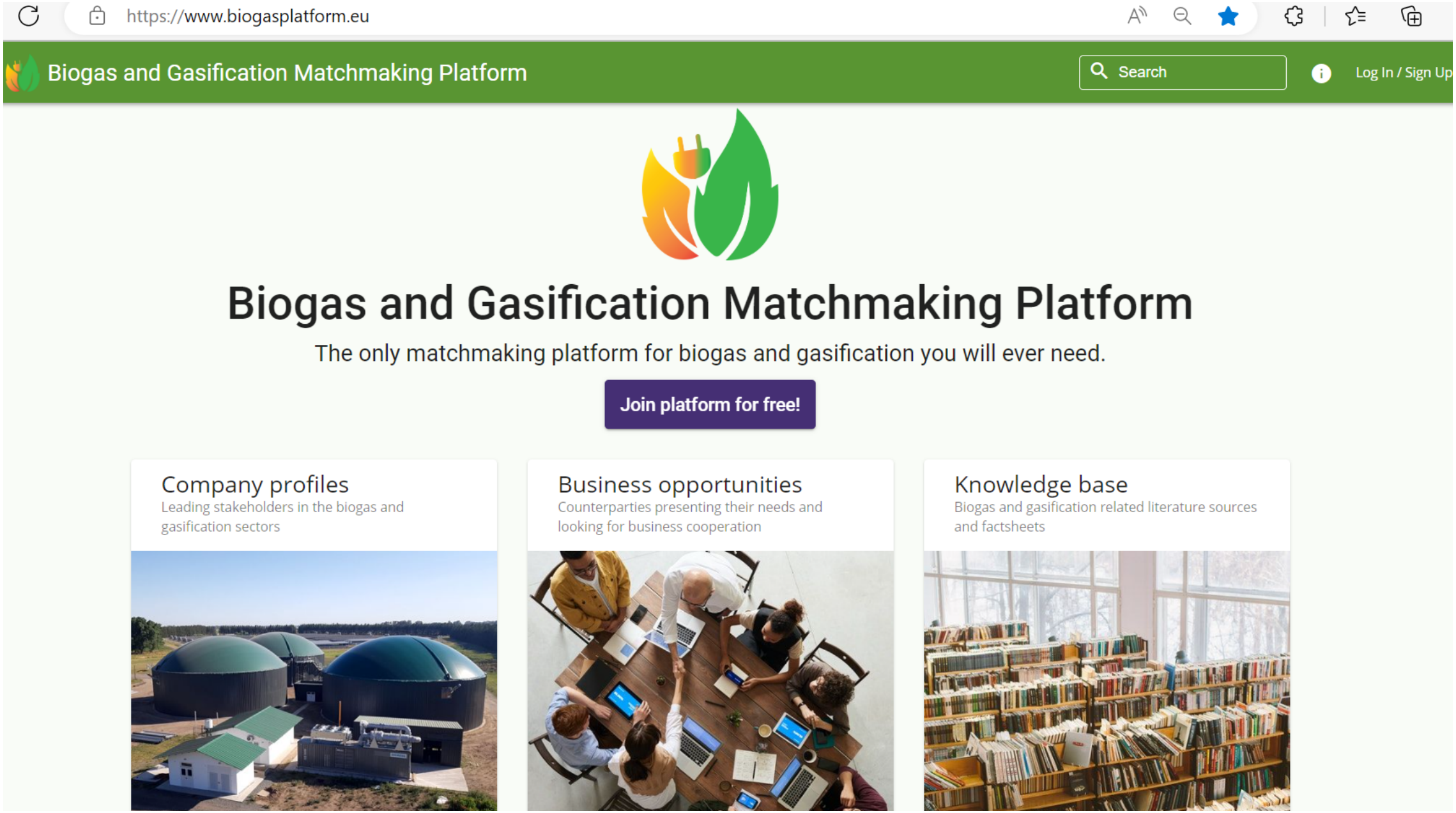
Processing Technologies – Cryogenic Separation

- Based on the fact that gases condense or re-sublimate at low temperatures or high pressure.
- Strong compression of the biogas to 65-80 bar (condensation points).
- Additional separation of water and H_2S by condensate separator.
- Partial liquid CH_4 is produced, which is marketed as LNG in regions without connection to the gas grid or as a fuel.

- Very clean separation of the gases
- High purity CO2 for further use

Quelle: Pentair Haffmanns (2017)

- Extremely energy-intensive
- Still few installations and providers



Dirk Bonse
19.05.2023

[Biogas and Gasification Matchmaking Platform (biogasplatform.eu)]

Our Biogas Know-How Series

Dirk Bonse
19.05.2023

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Thank you for your attention!

Any questions or comments?

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