



Decentral concepts for biomethane as a fuel – a chance for existing biogas plants?

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Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. *Association for Technology and Construction in Agriculture*



- Institutionally funded by Federal Minister of Agriculture, Food and Regional Identity
- Business office in Darmstadt/Germany
- About 100 employees
- Partner in various international / national research projects and committees

Main mission:

**Knowledge transfer from research
and consulting to agriculture**



Our tasks



Focus of activities



Business Management



Emissions & climate protection



Energy



Horticulture



Livestock farming



Organic farming



Crop production



Site development &
immission control



Knowledge technologies

Providing information e.g. on biogas



Publications



Conferences



Web-applications



Information supply (online)

Information hub on business options for existing plants



www.zukunftbiogas.de



KTBL-Betriebsmodelle

[» mehr lesen](#)

Model
calculations



Machbarkeitsstudien

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Feasibility
studies



Konzeptbeschreibungen

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Concept
descriptions



Post-EEG-Rechner Biogas

[» mehr lesen](#)

Online
application

The BIOKRAFT project

Renewable fuel supply as a business segment for agricultural biogas plants

- Funded by:



Bundesministerium
für Landwirtschaft, Ernährung
und Heimat



- Project consortium:



Institut für Biogas
Kreislaufwirtschaft & Energie

- Additional partners:



- Target group:

Agricultural biogas plants, consultants, policy

Why biomethane as a fuel?

2000 First “EEG” - Erneuerbare Energien Gesetz (Renewable Energy Sources Act)
2000, 2004, 2009, 2012, 2014, 2017, 2021, 2023, 20??)
=> focusing on renewable electricity
=> granting fixed feed-in tariffs for 20 years

Many of the existing biogas plants touch to the end of their first EEG period and must decide whether or how to continue.

Current EEG conditions are much less attractive than their old conditions, need far more complex concepts and high investment to adapt the “old-fashioned” plants: profitability is in question!

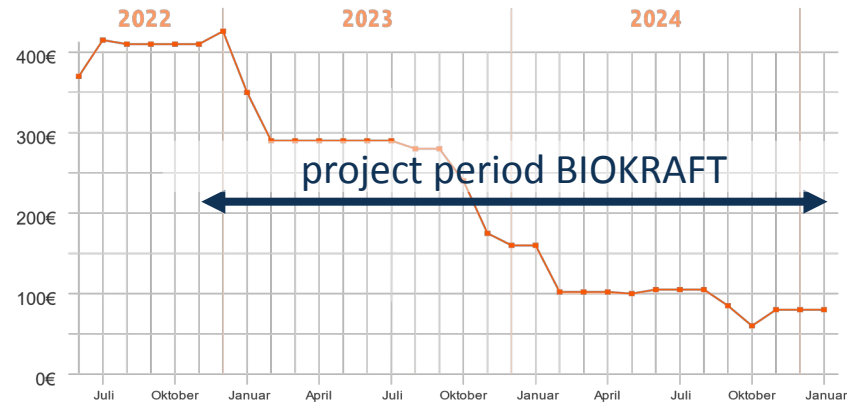
2018 Renewable Energies Directive, RED II: inclusion of gaseous biomass
=> minimum requirements for GHG reduction by power/heat/cooling/fuels from biogas
high GHG credits for animal manure; advanced biofuels allowing for double counting
DE: participation in GHG certificate trading in transport sector (“THG-Quote”)

=> Biofuel production as an interesting option for continued operation after first EEG period („post EEG“)
especially for biogas plants with high shares of animal manure

Proposal BIOKRAFT (FNR), project start 11/2021

GHG quota: price development 2022 – 2025

highest monthly GHG quota bonus

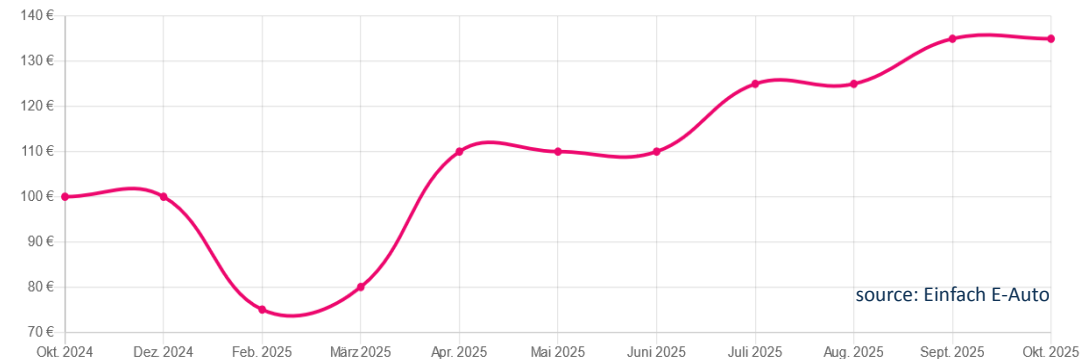


Die Daten stammen von den in unserem Vergleich gelisteten Anbietern im Zeitraum zwischen Juni 2022 und Januar 2025. Berücksichtigt wurden Fix-Prämien sowie Prämien mit einem garantierten Mindestbetrag.

Quelle: verivox.de

verivox

GHG quota: price development 10/2024 – 10/2025



source: Einfach E-Auto

And now??

=> BIOKRAFT manual

No answers! But providing decision support.

- political, legal and normative framework (EU, DE)
- technical principles of biofuel production from biogas (bioCNG/bioLNG)
- requirements concerning the operation of a biomethane fuel station, marketing and management
- necessary investments and costs
- identification and economic assessment of practice-oriented supply paths
- examples from practice

to be published by the end of 2025

online publication for download (pdf), free of charge



Survey among potential customers

Relevant factors for boosting biofuels: relevance and need for improvement



Profiles of existing biofuel concepts

BioCNG Anlage in Frohndorf, DE



© IBKE



© IBKE

BioLNG Anlage in Hof, DE



© Sterling Cryogenics B.V.



© Sterling Cryogenics B.V.

Tankstelle	
Kraftstoffart	BioCNG
Absatzmenge	
Betreiber	
Hersteller	
Jahr der Inbetriebnahme	
Zielgruppe / Betankungsoptionen	
Vermarktungsoption	
Anzahl Zapfsäulen	
Bezahlungssystem	
Aufstellungsort	
Biogasaufbereitung	
Aufbereitungskapazität	
Aufbereitungsverfahren	
Hersteller	
Gasnetzzugang	
Biogasanlage	
Angaben zu Substraten	
Biogasanlagengröße	400 kW _{el} aktuell BHKW 250 kW _{el}
Jahr der Inbetriebnahme	2012
Betreiber	Agra GmbH Frohndorf / Orlishausen

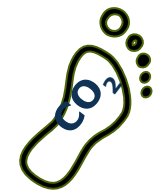
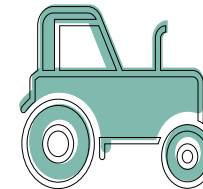
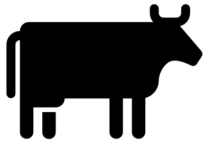
7 bioCNG / 4 bioLNG examples

- type of fuel
- marketed amount
- marketing concept
- operator / site / start of operation
- technical parameters of upgrading facility
- characteristics of biogas plant

Tankstelle	
Kraftstoffart	BioLNG
Absatzmenge	Monat
Betreiber	hBH Töpen www.dennree.de
Hersteller	25
Jahr der Inbetriebnahme	erner Fuhrpark
Zielgruppe / Betankungsoptionen	
Vermarktungsoption	on Verflüssigungsanlage durch Bio-
Anzahl Zapfsäulen	kette zum eigenen Standort (3er
Bezahlungssystem	cke mit Tankwagen); dort
Aufstellungsort	ene Tankstelle für eigene LNG-LKW
Biogasaufbereitung	
Aufbereitungskapazität	
Aufbereitungsverfahren	
Hersteller	genics B.V.
Gasnetzzugang	
Biogasanlage	
Angaben zu Substraten	zip
Biogasanlagengröße	genics B.V.
Jahr der Inbetriebnahme	gcryogenics.com
Betreiber	ftliche Abfälle (Gülle/Mist)
Biogasanlagengröße	aktuell 2 MW _{el}
Jahr der Inbetriebnahme	k.A.
Betreiber	BGA Bioenergie GmbH (Bayern)

Factors to be considered for biofuel concepts

- location of the biogas plant (BP)
- plant size
- available feedstocks: amounts and type (=> GHG quota!)
- land area under production, animal numbers, own vehicle pool
- process energy demand of the BP itself
- fuel type to produce (bioCNG vs. bioLNG)
- sales potential on site or at external site
- possibility to access the public gas grid
- need for off-gas treatment at the biogas upgrading facility (BUF)
- development of GHG quota prize



⇒ guidance to plant operators and consultants to identify and develop appropriate biofuel concepts for existing biogas plants after the end of EEG support

Model calculations for 3 general concepts

- Concept 1:

0 % AI

100 % "old school"

(MS-Excel)

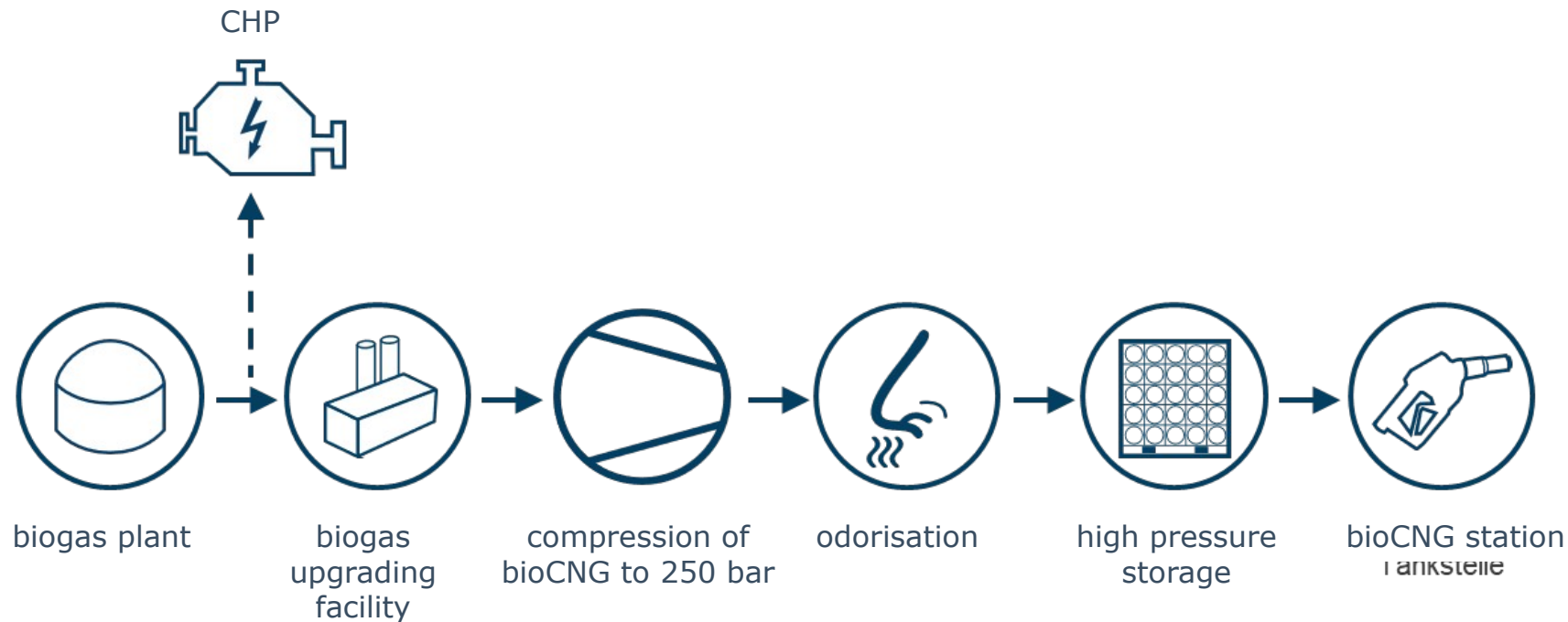
gas

biomethane transport with trucks („mobile bridge“)

Concept 1:

Fuel station at the plant site, without access to gas grid

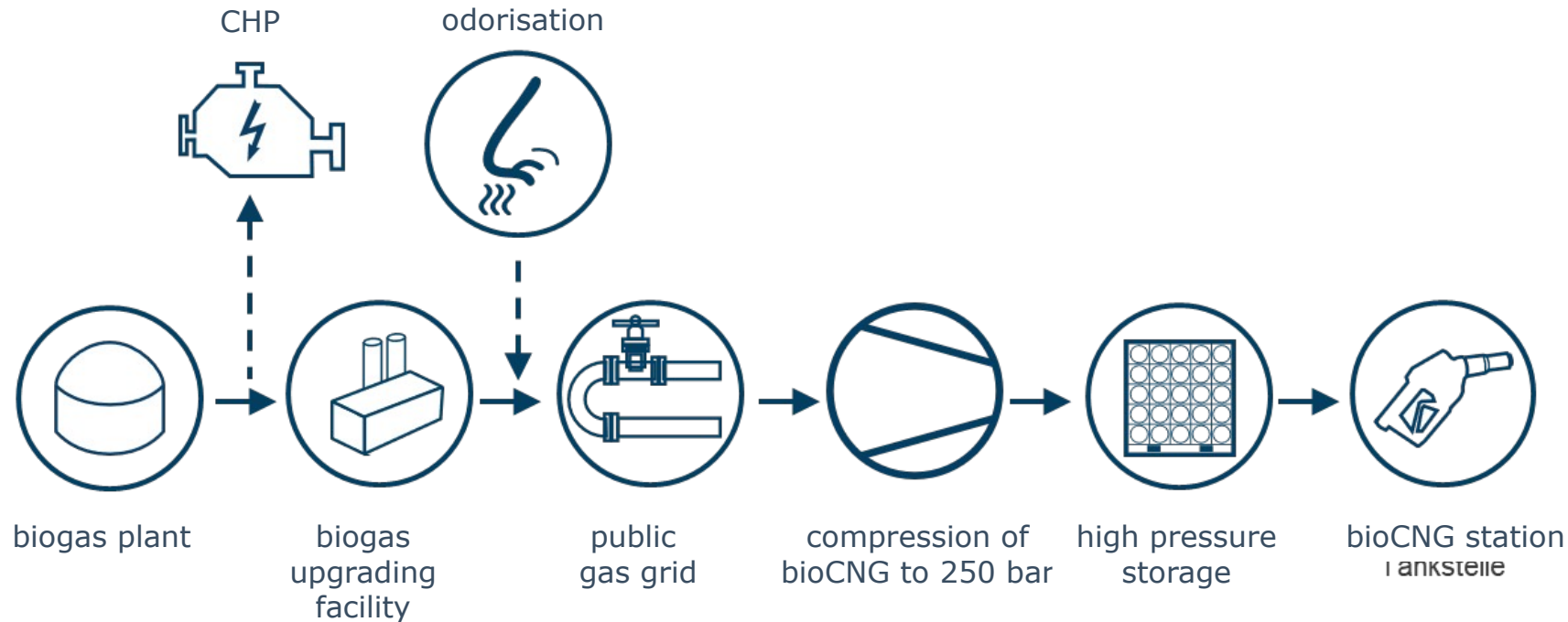
- option 1: on-site station only for own demand
farms with CNG vehicles – however limited „market“
- option 2: public station if nearby a transport nodal point or a company with truck pool



Concept 2:

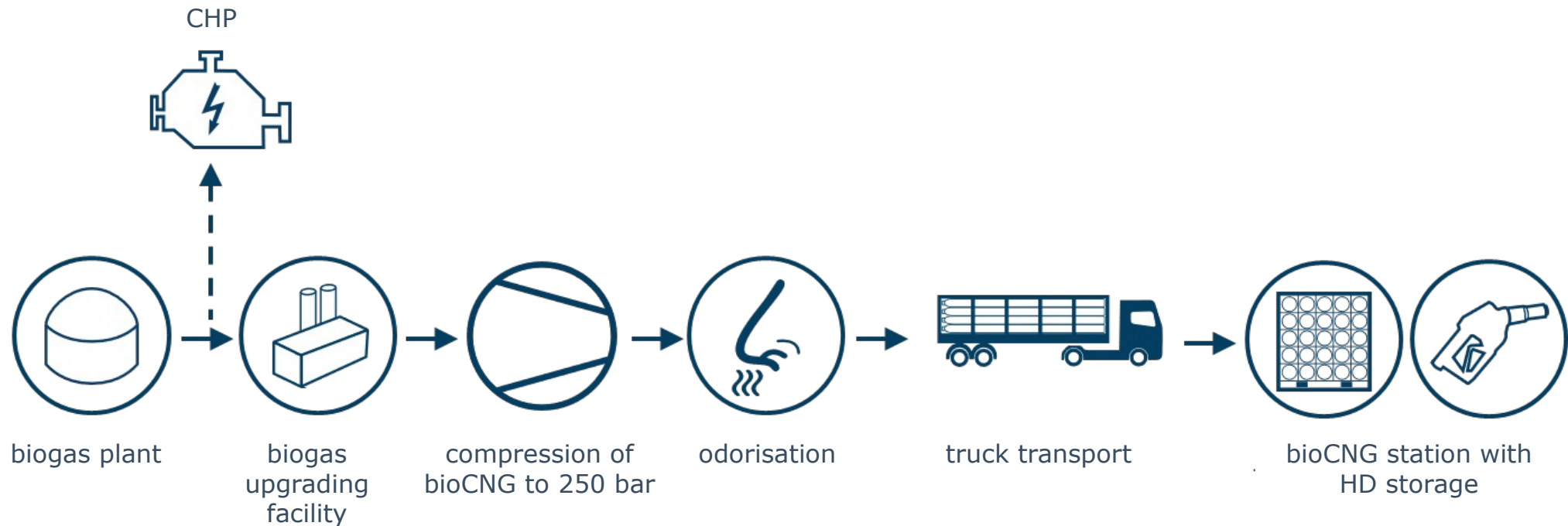
Fuel station separate from the plant site, transport: gas grid

- biomethane feed-in into the public gas grid
- virtual use on all biomethane fuel sites
- advantage: strategic choice of fuel station location
- BUF can be bigger than fuel marketing potential at the BP site



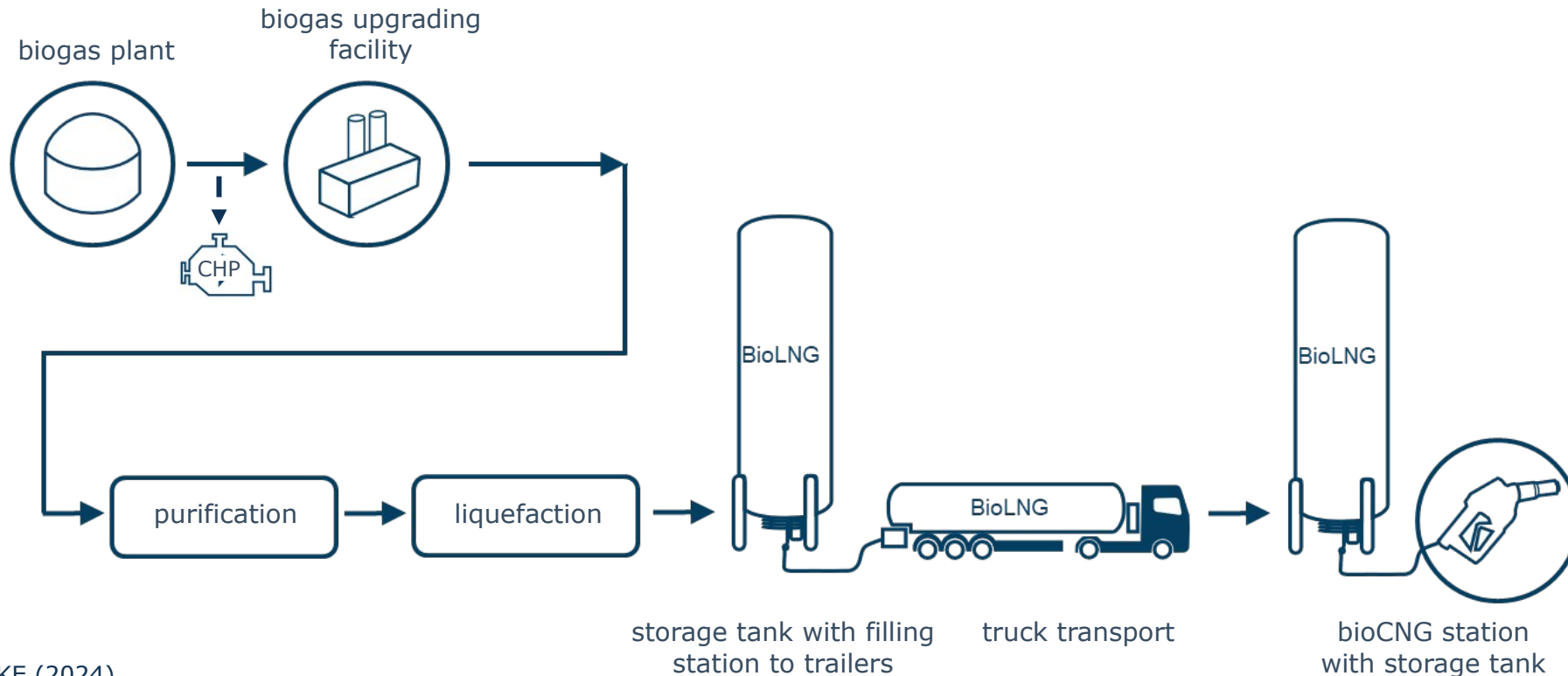
Concept 3 (bioCNG): Fuel station separate from the plant site, without access to gas grid, transport: trucks

- road transport (here: bioCNG)
- for BP sites without gas grid access and low on-site marketing potential
- advantage: strategic choice of fuel station location
- HOWEVER: additional costs and GHG emissions due to road transport



Concept 3 (bioLNG): Fuel station separate from the plant site, without access to gas grid, transport: trucks

- road transport (here: bioLNG)
- for BP sites without gas grid access and low on-site marketing potential
- advantage: strategic choice of fuel station location
- HOWEVER: additional costs and GHG emissions due to road transport



Assumptions I

- 10 years of continued operation of retrofitted biogas plant after first period of EEG
(=> results are mean values of 10 a)
- heat supply with on-site CHP; electricity supply as well if sufficient, otherwise power purchase
- sale of surplus power and heat if existing (keep existing heat concepts running!)
- CHP service life 60.000 h, in flex-mode max. 20 a (two starts per day)
- animal manure: available at the plant site => no feedstock or transport costs
- feedstock processing due to solid manure and maize straw utilization
- biogas upgrading with membrane technology (three-phased):
 - methane slip 0.7 %
 - methane content in product gas 97 %
 - off-gas treatment if necessary
- reference scenario: base model plants with maximum rated power of 200, 500 und 1000 kW_{el}
- data basis: KTBL data base completed by recent market surveys



Assumptions II

- technical equipment: reinvestment according to respective service life
- price index for investments, feedstocks, operating supplies, heat revenues
- 10 % planning and approval costs on expansion investment
- no fixed costs for existing buildings, no land costs
- inflation and deconstruction not considered
- in case of power feed-in: flexibility bonus 65 €/kW_{inst} and award price from biomass auction 17.44 Ct/kWh_{el}
- additional revenues due to flexible operation from 1.61 bis 2.39 Ct/kWh_{el}, depending on flexibility factor
- interest rate: 3 %
- fuel prices: 1.23 kg/kg (no differentiation CNG / LNG)
- THG quota* 150 €/t CO₂
- factor for double counting for advanced biofuels: 1.85
- biomethane price:
 - 15 Ct/kWh (H_{s,n}) for manure based biomethane*
 - 9.5 Ct/kWh (H_{s,n}) for energy crop based biomethane*
 - 10.6 Ct/kWh (H_{s,n}) for residue based biomethane**

* Prices are market projections for an operation of 10 years starting from 2025.

** From „Branchenbarometer-Biomethan 2024“

Feedstock availability – animal manure

- high GHG quota credits for biofuels from animal manure (+ “advanced” biofuels)
- but** high animal numbers necessary for large fuel amounts :

500 m³_N raw biogas per livestock unit (LU) and year

=> 100 m³/h upgrading capacity BUF = 25 t bioCNG/month = 1.750 LU

CNG-Bereitstellungsmenge an Zapfsäule					3 t/month (micro)	7 t/month (small)	13 t/month (middle)	50 t/month (big)
PKW	Tank volume	15,0	kg / filling	fillings / day	6,7	15,6	28,9	111,1
	Fuel demand	3,9	kg/100 km	km / day	2.564	5.983	11.111	42.735
LKW 12t	Annahme Tankvolumen:	72,0	kg/Betankung	Tankvorgänge/Tag	1,4	3,2	6,0	23,1
	Annahme Kraftstoffverbrauch:	15,0	kg/100 km	km/Tag	667	1.556	2.889	11.111
Traktor	Annahme Tankvolumen:	79,0	kg/Betankung	Tankvorgänge/Tag	1,3	3,0	5,5	21,1
	Annahme Kraftstoffverbrauch:	15,8	kg/Betriebsstunde	Betriebsstunde/Tag	6	15	27	105
LKW 40t	Annahme Tankvolumen:	130,0	kg/Betankung	Tankvorgänge/Tag	0,8	1,8	3,3	12,8
	Annahme Kraftstoffverbrauch:	25,3	kg/100 km	km/Tag	396	924	1.716	6.601

=> small-scale solutions necessary for fuel concepts on agricultural biogas plants!

=> economies of scale leading to high specific costs per kg / kWh_(H₂,N) biomethane fuel

Reference situation: base model plants in continued operation with flexible power generation

Technical adjustments:

initial concept in 1st EEG period:
on-site power generation



- adjustment transformer station and gas conditioning
- expansion of gas storage capacity with external storage
- incorporation of heat buffer storage (35% external heat utilization)

	200 kW _{el} (80 / 20)	500 kW _{el} (75 / 25)	1.000 kW _{el} (50 / 50)	1.000 kW _{el} (AM) (75 / 25)
Feedstocks	80% animal manure 20% energy crops	75% animal manure 10% residues 15% energy crops	50% animal manure 10% residues 40% energy crops	75% animal manure 10% residues 15% energy crops
CHP (base model)				
CHP 1	250 kW _{el}	550 kW _{el}	1100 kW _{el}	1100 kW _{el}
CHP 2	250 kW _{el}	550 kW _{el}	1150 kW _{el}	1150 kW _{el}
sum	500 kW_{el}	1100 kW_{el}	2250 kW_{el}	2250 kW_{el}
Flexibility factor	2.5	2.3	2.2	2.2
raw gas production m _N ³ /h	96	228	442	442

(80 / 20): relationship animal manure / coferments

animal manure (AM): cattle slurry, cattle solid manure; residues: maize straw; energy crops: cereal, maize, gras and silphia silage (maize silage: max. 15%)

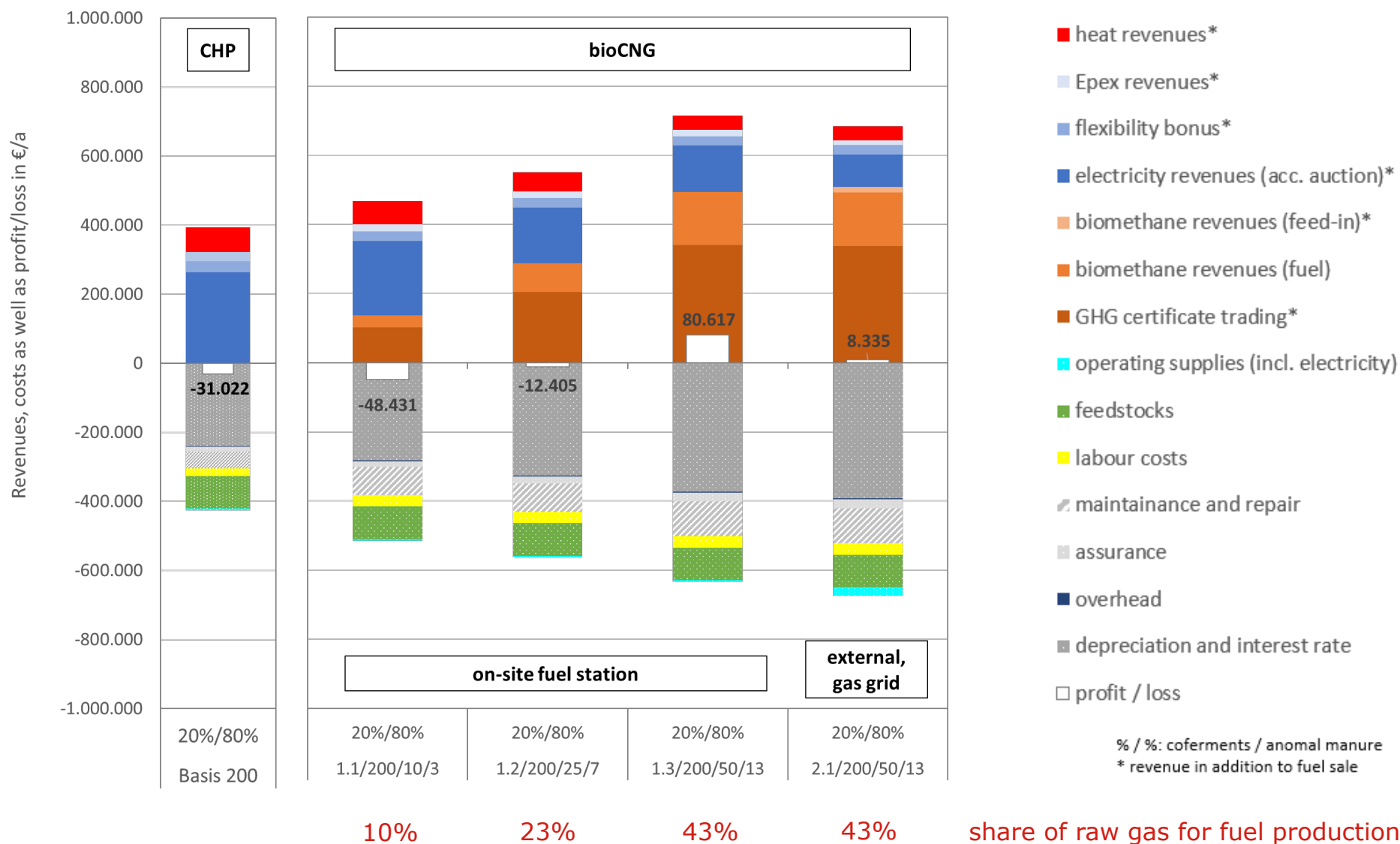
13 plant models - combining concepts, sales and model plants

Concepts and paths		maximum rated output, kW _{el}	maximum upgrading capacity BUF, Nm³/h Rohbiogas	sales volume*, t/month	fuel type	raw gas supply to BUF, Nm³/h % raw gas production	flex factor
Concept 1: fuel station at biogas plant site							
1	1.1	200	10	3 micro	CNG	9,5 9,9%	2.4
	1.2		25	7 small		22 23%	2.8
	1.3		50	13 middle		41 43%	3.7
	1.4 a)	500	190	50		161 71%	2.4
	1.4 b)	1000a	190	50		163 37%	2.4
Concept 2: fuel station separate from BP site: biomethane transport via to gas grid							
2	2.1	200	50	13 middle	CNG	41 43%	3.9
	2.2 a)	500	190	50		161 71%	3.7
	2.2 b)	1000a	190	50		182 41%	2.6
Concept 3: fuel station separate from BP site; no access to gas grid; “mobile bridge” (trucks)							
3	3.1 a)	500	190	50	CNG	161 71%	3.7
	3.1 b)	1000a	190	50		163 37%	2.4
	3.2 a)	500	190	50	LNG	162 71%	3.8
	3.2 b)	1000a	190	50		163 37%	2.4
	3.3	1000b	390	100		324 74%	4.2

BUF: biogas upgrading facility

* biomethane production only from animal manure and residues

Annual costs and revenue for model plant 200 kW_{el}

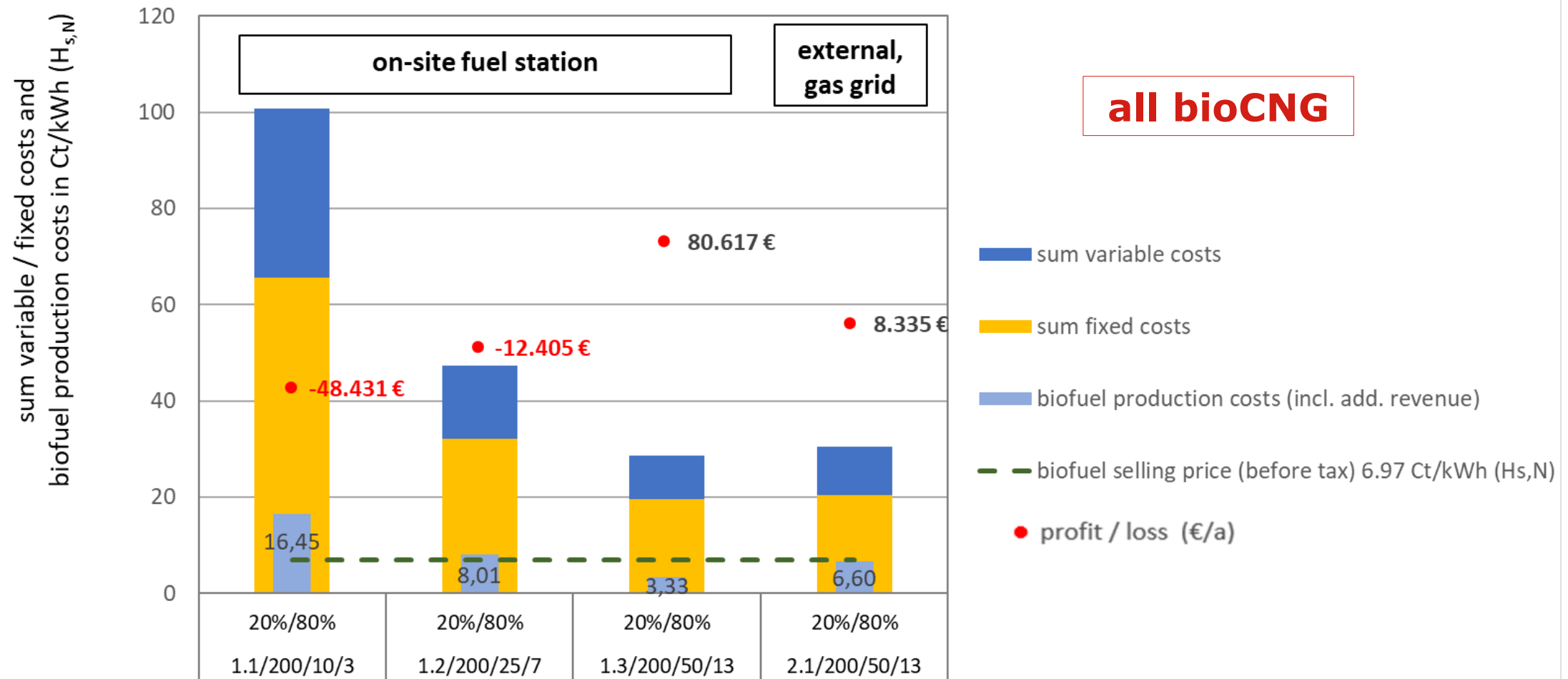


10-year average!

NOTE: German number notation in table (comma instead of point for decimals, point as thousands separator).

Specific fuel costs for model plant 200 kW_{el}

all bioCNG



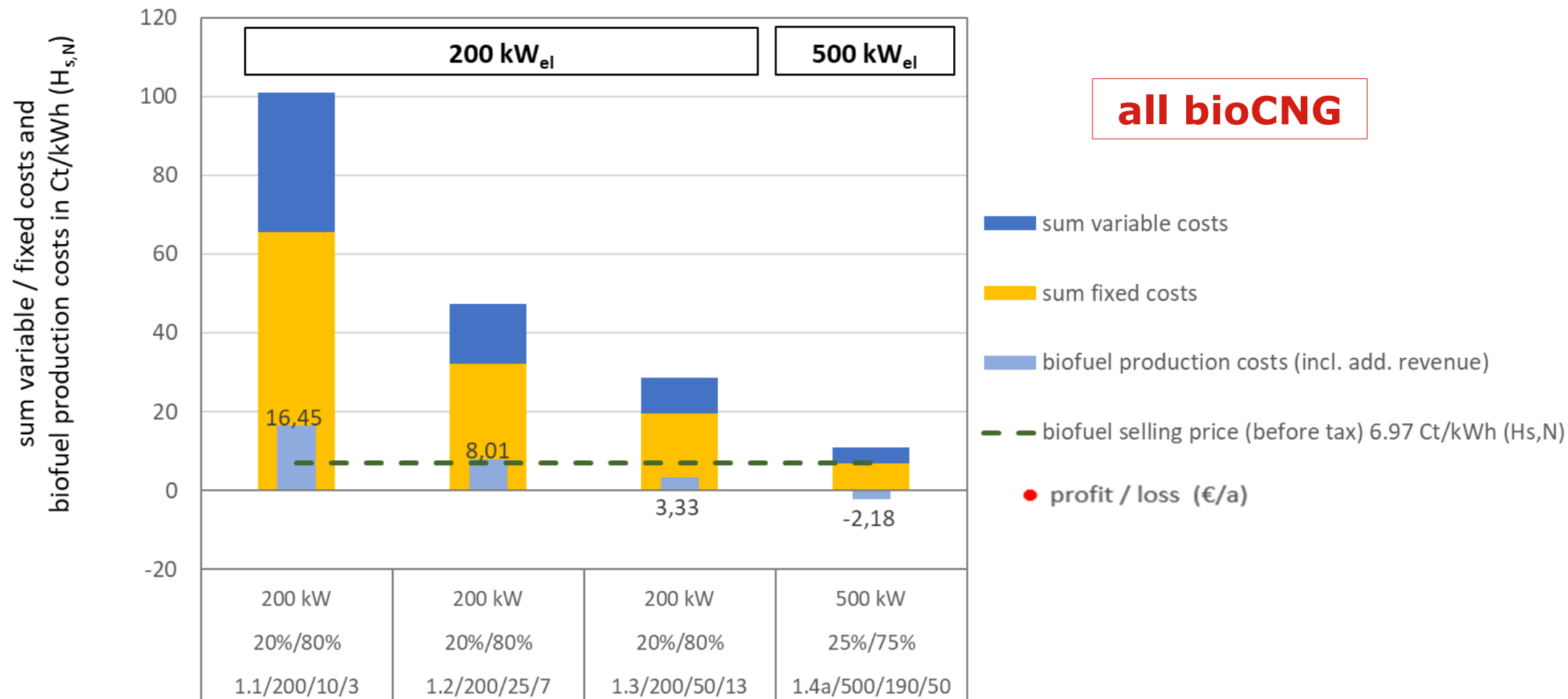
20%/80%: coferments/ animal manure

additional revenue: electricity, flex bonus, EPEX, heat; biomethane feed-in (concept 2), GHG certificate trade

NOTE: German number notation in table (comma instead of point for decimals, point as thousands separator).

Economies of scale: Concept 1 – fuel station on site

all bioCNG



20%/80%: coferments/ animal manure

additional revenue: electricity, heat, flex bonus, EPEX (if electricity/heat surplus); biomethane feed-in, GHG certificate trade

NOTE: German number notation in table (comma instead of point for decimals, point as thousands separator).

Summary – with focus on model calculation

- RED II / III is creating significant incentives for enhanced use of animal manure in biogas plants.
- Investment demand for integrating a fuel concept in the „post EEG“ period is higher than for continued operation with optimised power/heat production by 27 to 73%.
- Profitability is reached especially for plants $\geq 500 \text{ kW}_{\text{el}}$ equivalent and a sales volume of 50 tons per month.
- However, without revenue from GHG quota trading none of the described paths would be profitable – despite optimistic starting conditions.
- Small-scale fuel solutions are cost intensive and could not yield a profit under the conditions described for the smallest considered biogas plant ($200 \text{ kW}_{\text{el}}$).

- There is no single, universal solution for all plants.
- Operators need to carefully evaluate their individual conditions and marketing possibilities. Small plants should consider cluster solutions to benefit of economies of scale.
- Think outside of the usual box!
=> bioCO₂, methanisation / reversible electrolysis
- Look out of your window!
=> local / regional opportunities
- Keep in mind: energy and general system transformation
 - fade-out of gas grids
 - communal heat planning
 - bioeconomy
 - ...

**This will not be the last time
you must change / adapt your
plant concept!**

Thanks to

● our project partners in the consortium



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Thank you for your attention!



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