

# How food waste and digestate play an important part in the Danish biogas sector

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# DENMARK: BEER, BUTTER, BACON and...BIOENERGY!



**43.000 km<sup>2</sup> – 5,6 million people** – in a flat country with lakes and streams...and where the highest top (147meters!) is called “The Sky Mountain”

**High livestock density** – and related environmental challengers from...

- 35.000.000 pigs/year on 3200 farms
- 1.500.000 dairy cows on 1.000 farms

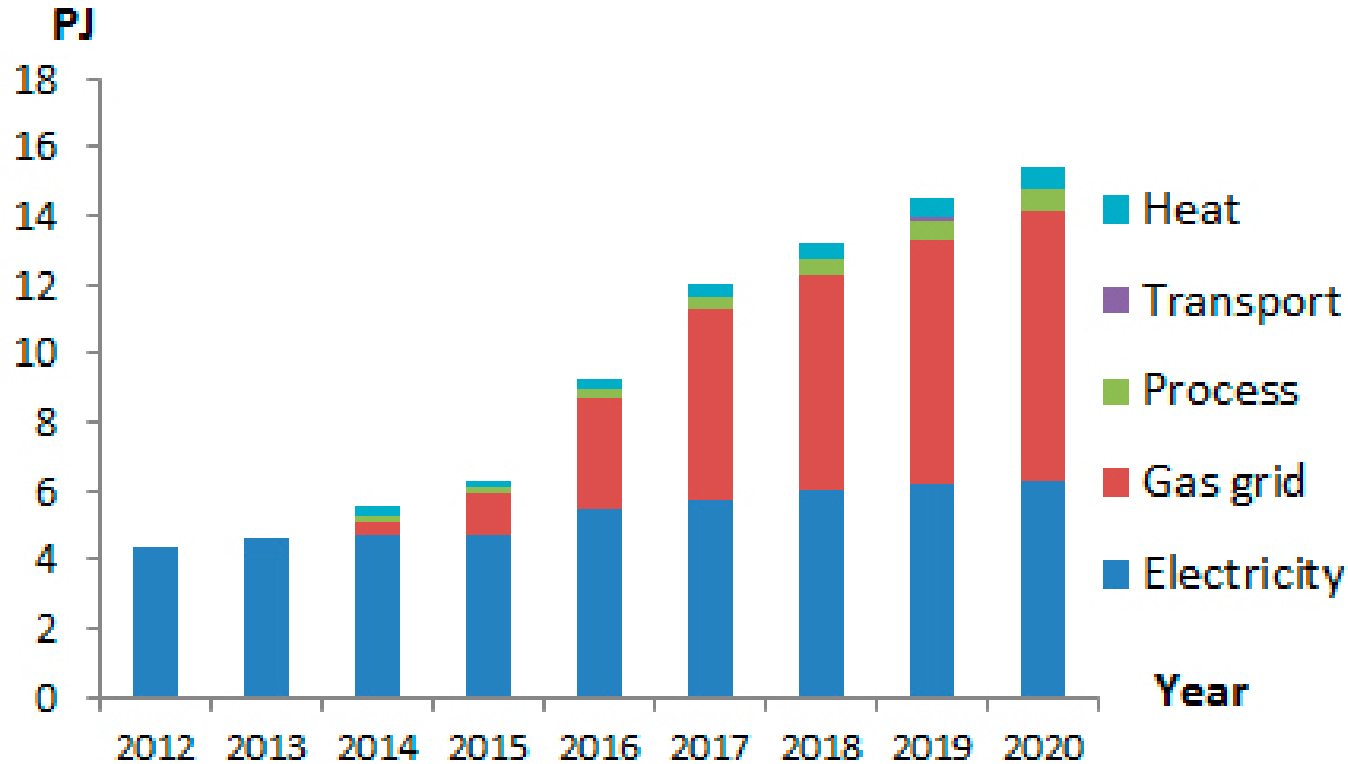
**Highly regulated + Ambitious goals** backed by all political parties:

- By 2050: 100% fossil free incl. climate neutral agrisector
- 70% GHG reduction in 2030 compared to 1990 (now 34%)
- 100% of all foodwaste to be recycled by 2023.

**Home to companies like** Danish Crown, Arla, Carlsberg, Danfoss, Grundfos, Vestas, LEGO, Siemens Wind Power, Maersk

# Denmark's Biogas Boom: From 5 to 20 PJ in 5 years

22% of gas used in Denmark is renewable natural gas. 30% in 2021 is expected



**Currently 166 biogas plants in Denmark**

56 waste water plants

6 industrial plants (food waste)

28 landfills (no more landfills are build)

27 agriculture co-op plants (increasing)

49 farm based plants

## **The Danish Biogas Model**

Large plants: 50.000-800.000 tons/annually

Cooperatives – owned by the biomass suppliers  
and gas company

Use of waste – not food!

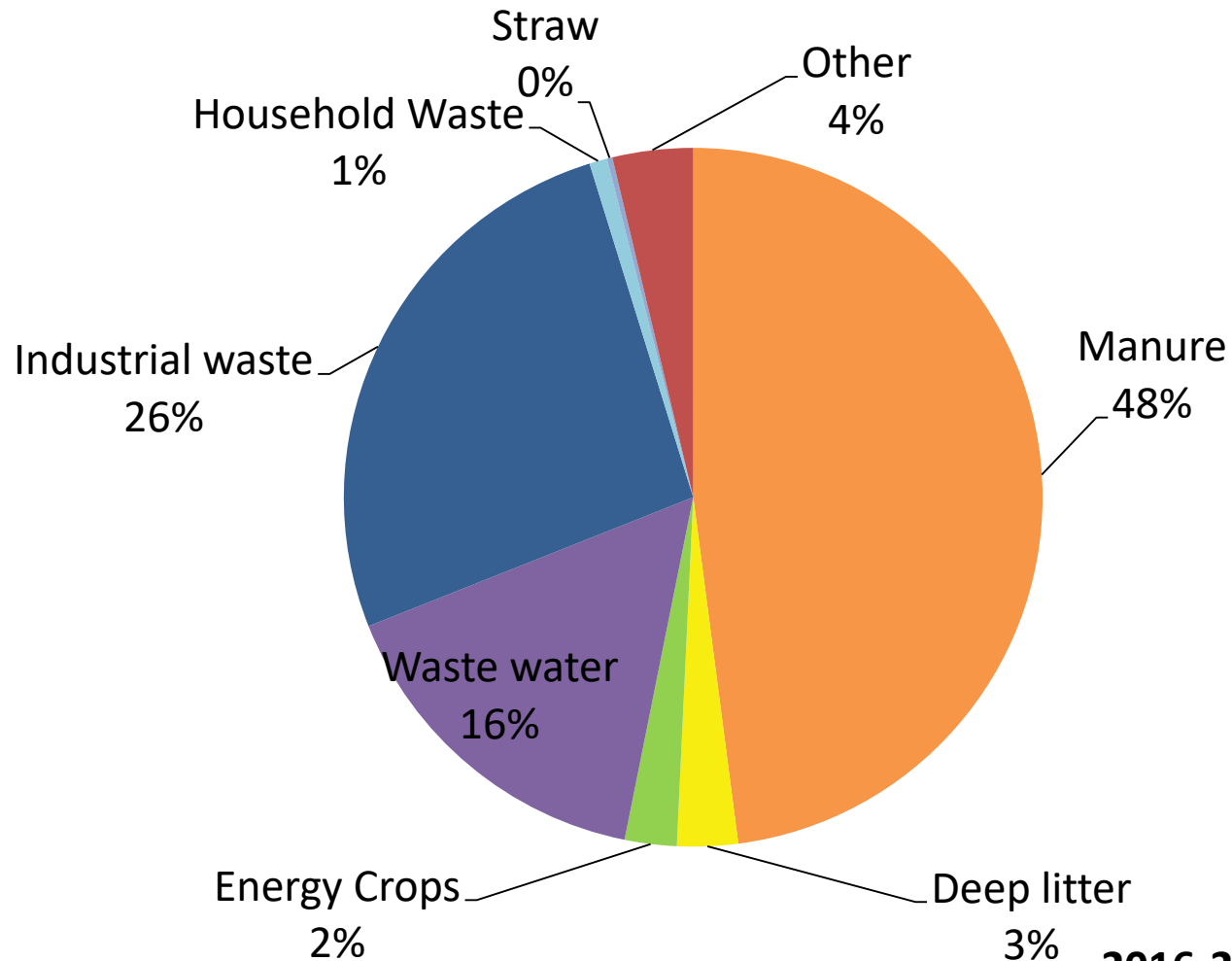
Environmental technology: Avoiding leaching  
and use of recycling nutrients

Gas upgrading to the grid

Thermophilic

# Denmark's Biogas Boom: Types of biomass used

Around 25% of livestock manure is degassed...



Type	Ton
Manure	5033745
Deep litter	295191
Energy Crops	252189
Waste water	1662229
Industrial waste	2753021
↑ Household waste	250000*
↑ Straw	26148
Other	391091
<b>Total</b>	<b>10500218</b>

2016-2017 numbers, DEA

\* 2020 estimate





## Waste pr capita in Denmark/year

700 kg non-organic

84 kg organic – difference in #people household

Estimated that 900.000 tons of organic household waste will be gathered by 2030.

## By 2023

Organic waste from households must be collected separately. Exceptions can be made if documented technical, economical or environmental aspects does not make it beneficial.

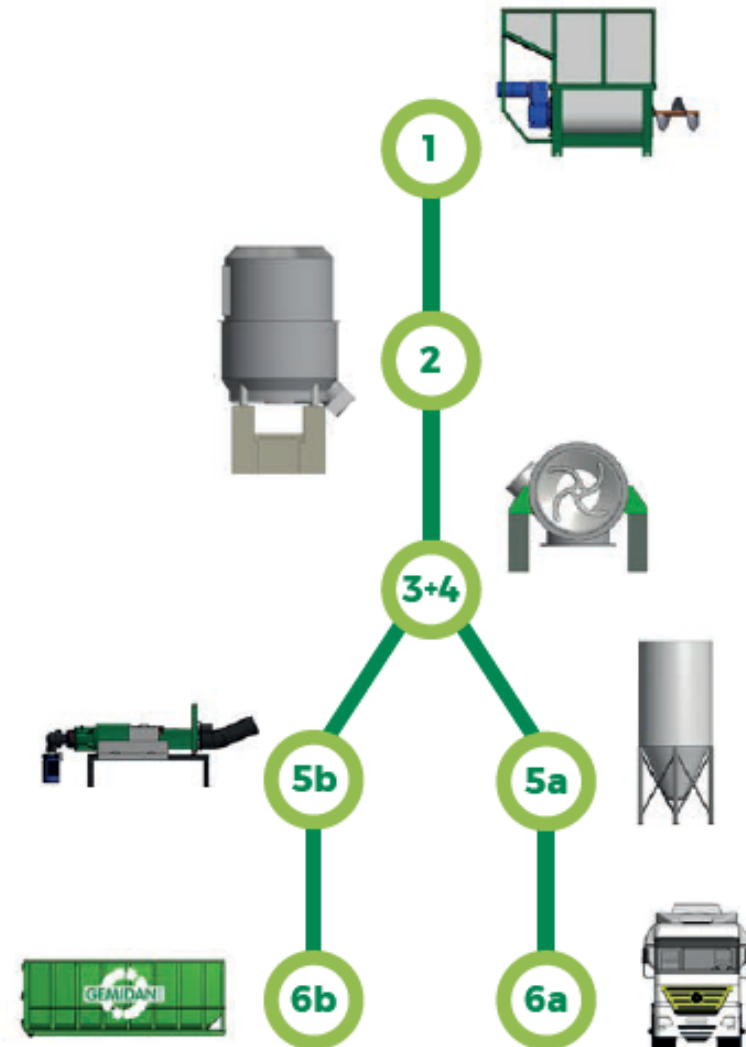
8 food waste pretreatment plants in operation incl one owned by a municipality, 3-4 more plants under way.

# Denmark's Biogas Boom: Unlocking the food waste potential

Organic waste diversion from land field can be done without contaminating soil



1. Feeding of organic waste
2. Pulping the waste
3. Separation of rejects post pulping
4. Cleaning of rejects for maximum utilization of organic potential
- 5a. Storing of pulp before delivery
- 6a. Transport of pulp
- 5b. Screw press dewatering of rejects
- 6b. Storing of rejects for reuse/incineration



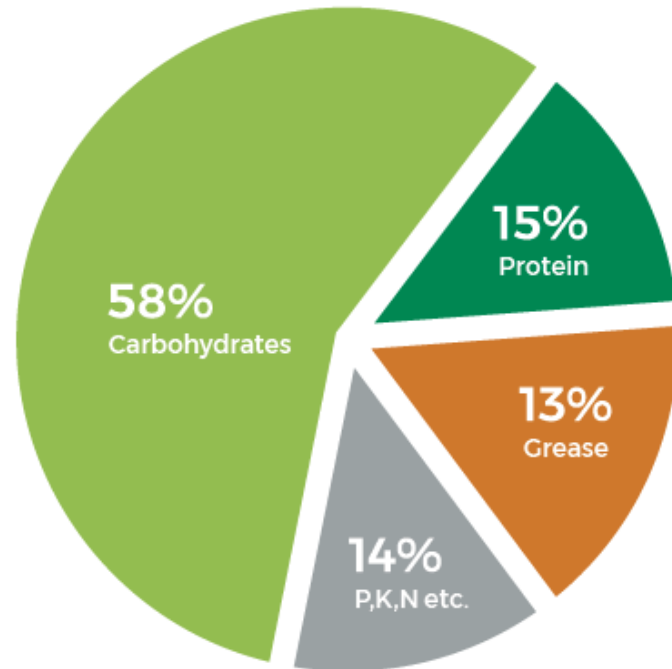
Currently three Gemidan Ecogi plants running in Denmark, one underway in Denmark and outside.

# Denmark's Biogas Boom: Unlocking the food waste potential

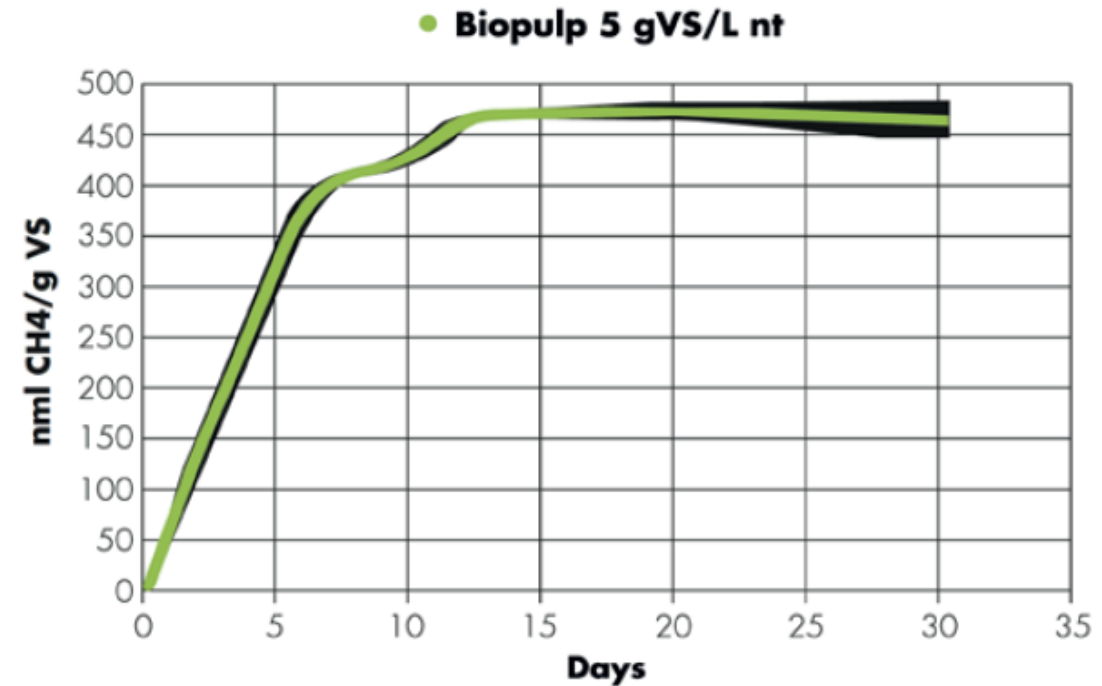
Organic waste diversion from land field can be done without contaminating soil



Composition of TS fraction for KOD



Gas yield



# Denmark's Biogas Boom: Unlocking the food waste potential

Organic waste diversion from land field can be done without contaminating soil

## Organic fraction for biogas digestate production



## Non-organic fraction/Reject

- Food waste from commercial kitchens, restaurants etc. 2-5%
- Organic waste from households 10-20%
- Package food waste 15-30%





# Quality Control

Regulation on monitoring biopulp from organic household waste and waste from service sector.

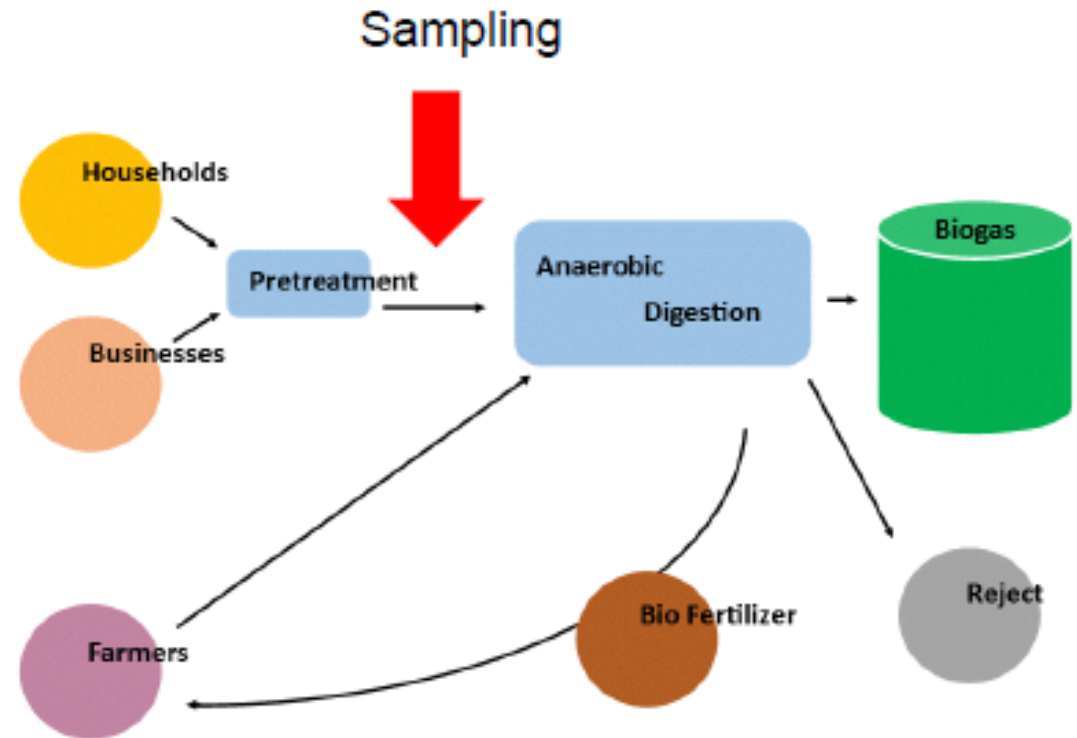
*Guidance on sampling for physical impurities in the pretreated biopulp of 24<sup>th</sup> July 2018.*

Daily sampling mixed to monthly sample.

Content limits:

Plastic, glass og composit materials, > 2 mm:  
0,5 weight % of dry matter

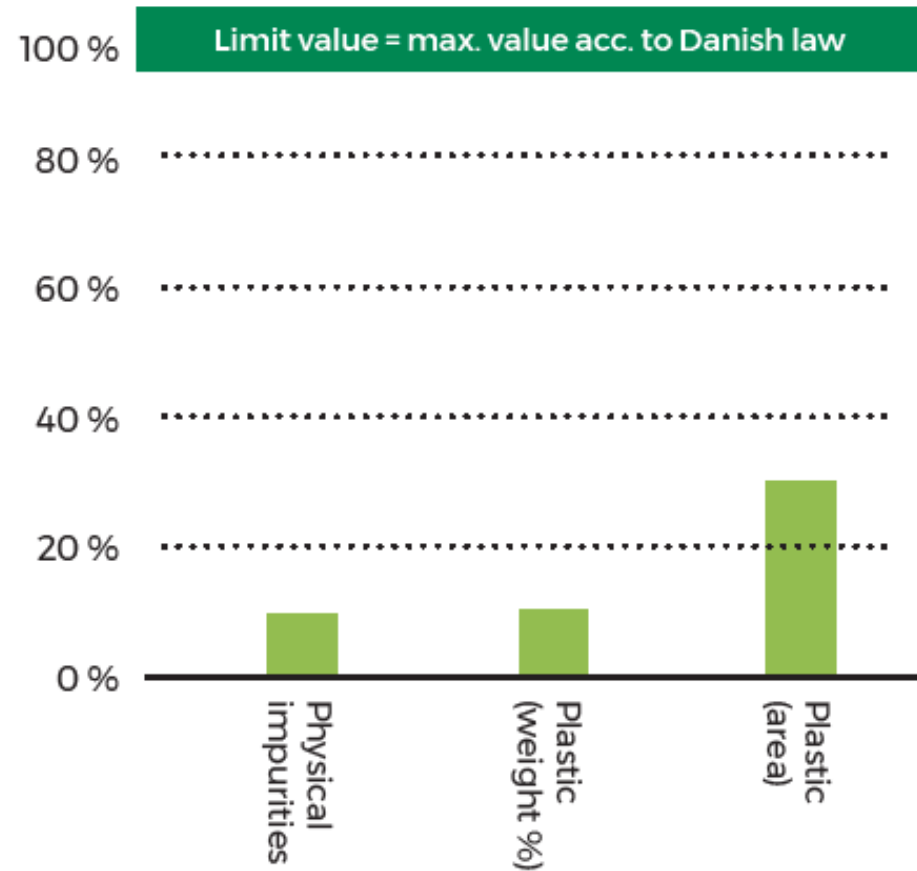
Plastic, > 2 mm: 0,15 weight % of dry matter  
& 1 cm<sup>2</sup> / % dry matter in 1 liter biopulp.



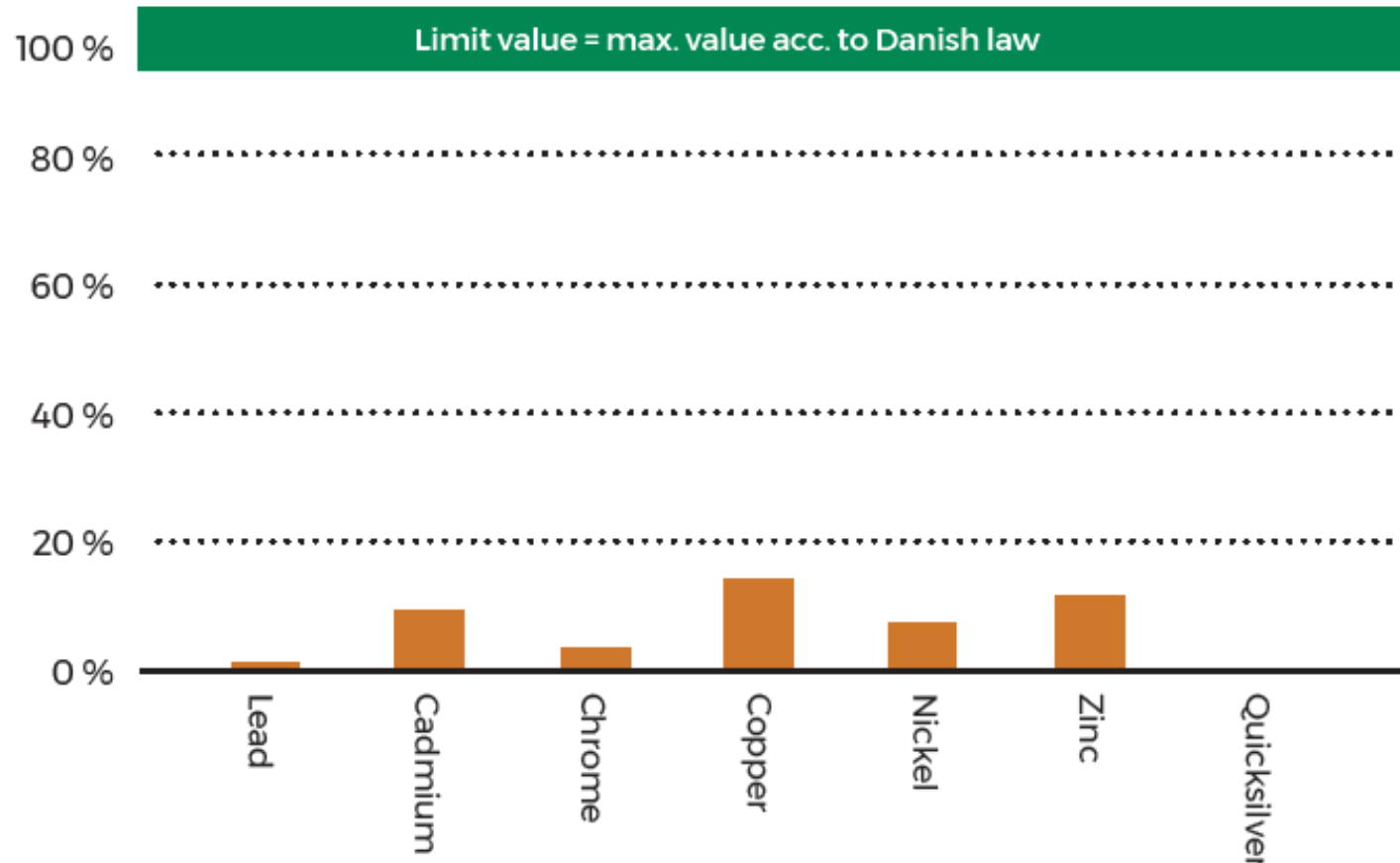
# Denmark's Biogas Boom: Unlocking the food waste potential

Organic waste diversion from land field can be done without contaminating soil

Impurities in pulp



Heavy metals







Less smell and leaching  
Less methane and laughing gas slip  
Jobs through local value chains

Higher availability of nutrients  
Increased recycling of nutrients  
Renewable and storable gas

**Externalities - total socioeconomic value of biogas in Denmark: 26 NZD/GJ**





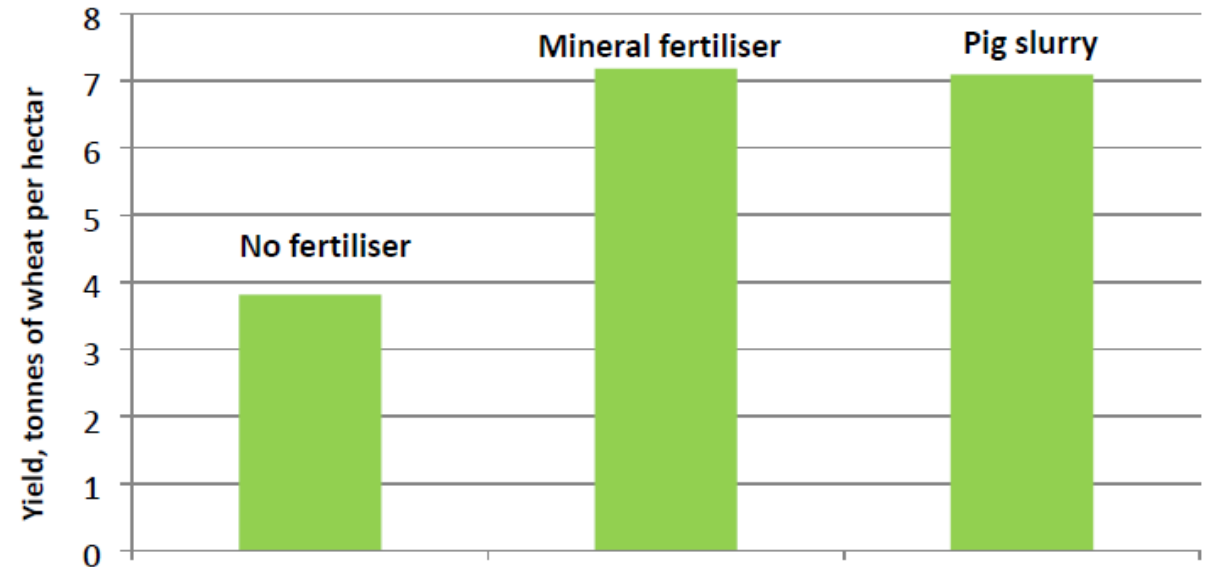
Grøn gas til vores kunder

nature  
energy



# Denmark's Biogas Boom: Application of liquid degassed biomass

New value chains - Imported mineral fertilizer vs. own produce?



**Soil injection or tow horses? Acidification?**

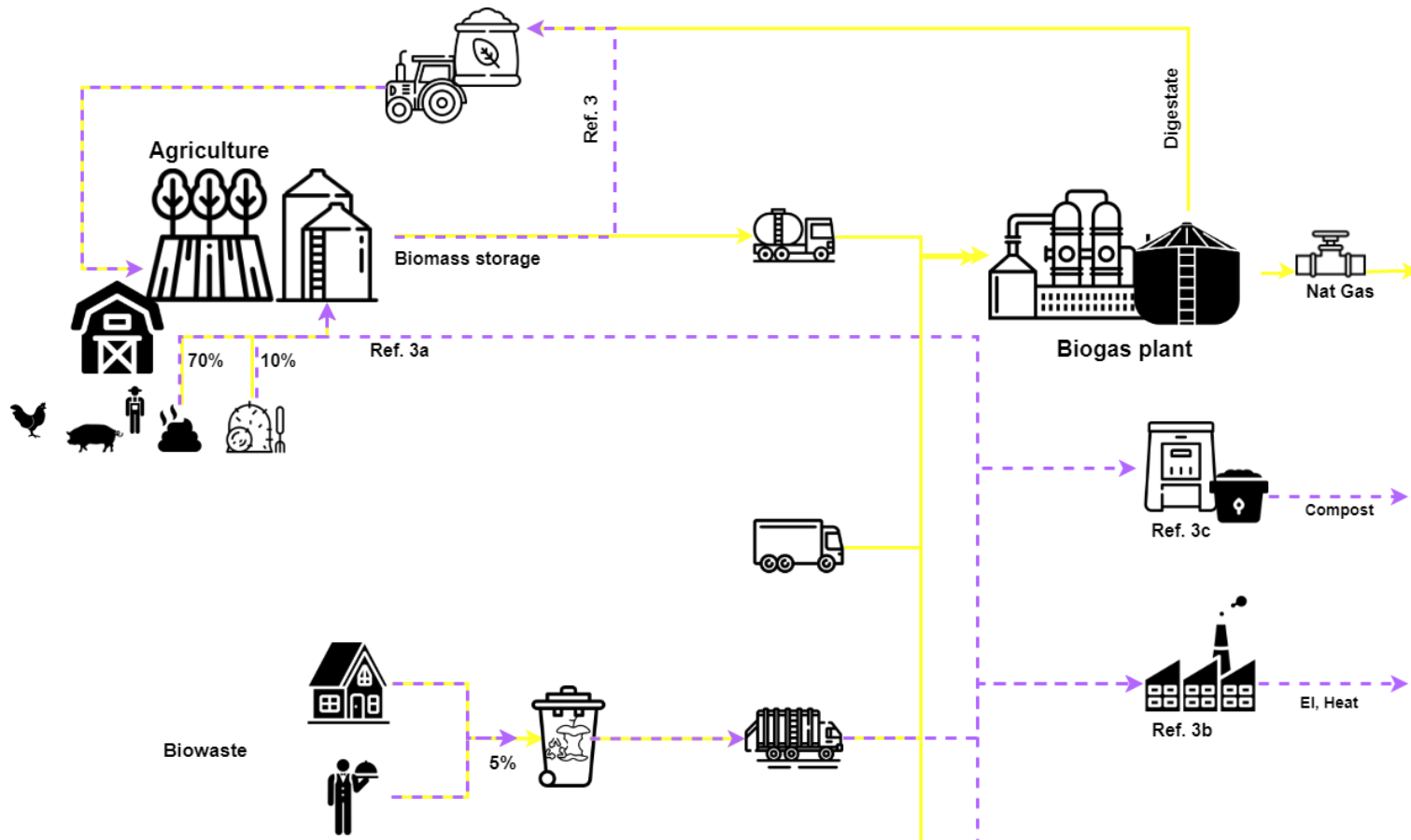
2/3 of all fertilizer used in Denmark is manurebased

**Esti. market value pr. kg fertilizer**

N: \$ 2.2 - P: \$ 6.0 - K: \$ 1.9 - S: \$ 1.2 - Mg: \$ 0.9

# Denmark's Biogas Boom: Environmental impact from biowaste

Putting numbers on the benefits of biogas – New Danish Energy Agency Report



## Biogas plant (plant model for the analysis)

- Centralized Biogas plants (numerous biomass suppliers)
- 45 day residence time under thermophilic operation.
- Transport distances: 4, 20, and 88 mil for transport of manure, straw/deep litter, and foodwaste respectively
- Post storage tanks: 20 day residence time at 20°C (68°F)
- Portion of Biogas used for process heat, rest for natural gas grid
- Reactor specification 8000m<sup>3</sup> CSTR

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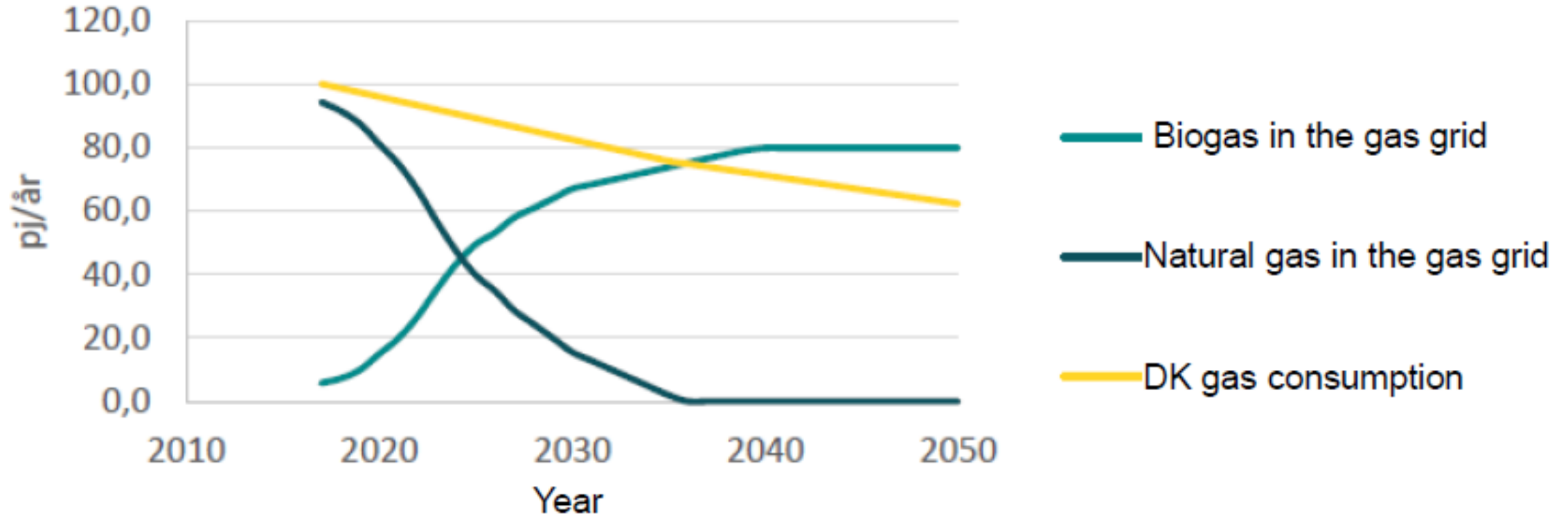
*Table 0.3. Effects on GHG emissions for five selected model biogas plants at 45 day retention time in the biogas reactor. The greenhouse gas (GHG) emissions include substitution of energy, emissions of methane and nitrous oxide, and changes in soil carbon storage for biogas digested slurry compared to a reference situation. The GHG effects are calculated on the basis of the biomasses used and on the basis of the produced gross energy. Positive effects represent reductions in emissions.*

Model biogas plant	GHG per ton biomass kg CO <sub>2</sub> -eq. ton <sup>-1</sup> biomass	GHG per unit of gross gas energy produced kg CO <sub>2</sub> -eq. GJ <sup>-1</sup> gross energy
M1a. Slurry + deep litter	66.8	77.5
M1b. Slurry + straw	105.5	52.9
M2. Slurry + deep litter + energy crop	67.7*	68.4*
M3. Slurry + deep litter + organic waste	65.3	52.7
M4. Grass-clover + slurry + deep litter + biowaste	99.5	54.7

\*: The GHG effects of energy crops does not include effects of changes in land use (iLUC).

# Denmark's Biogas Boom: Looking towards 4<sup>th</sup> and 5<sup>th</sup> gen.

Storable bioenergy with a positive environment impact





# 4<sup>th</sup> generation biogas: Power to gas – CO<sub>2</sub> + H<sub>2</sub> = CH<sub>4</sub>

Storable bioenergy with a positive environment impact

**92+**

completed/  
ongoing R&D&D  
projects since  
2004

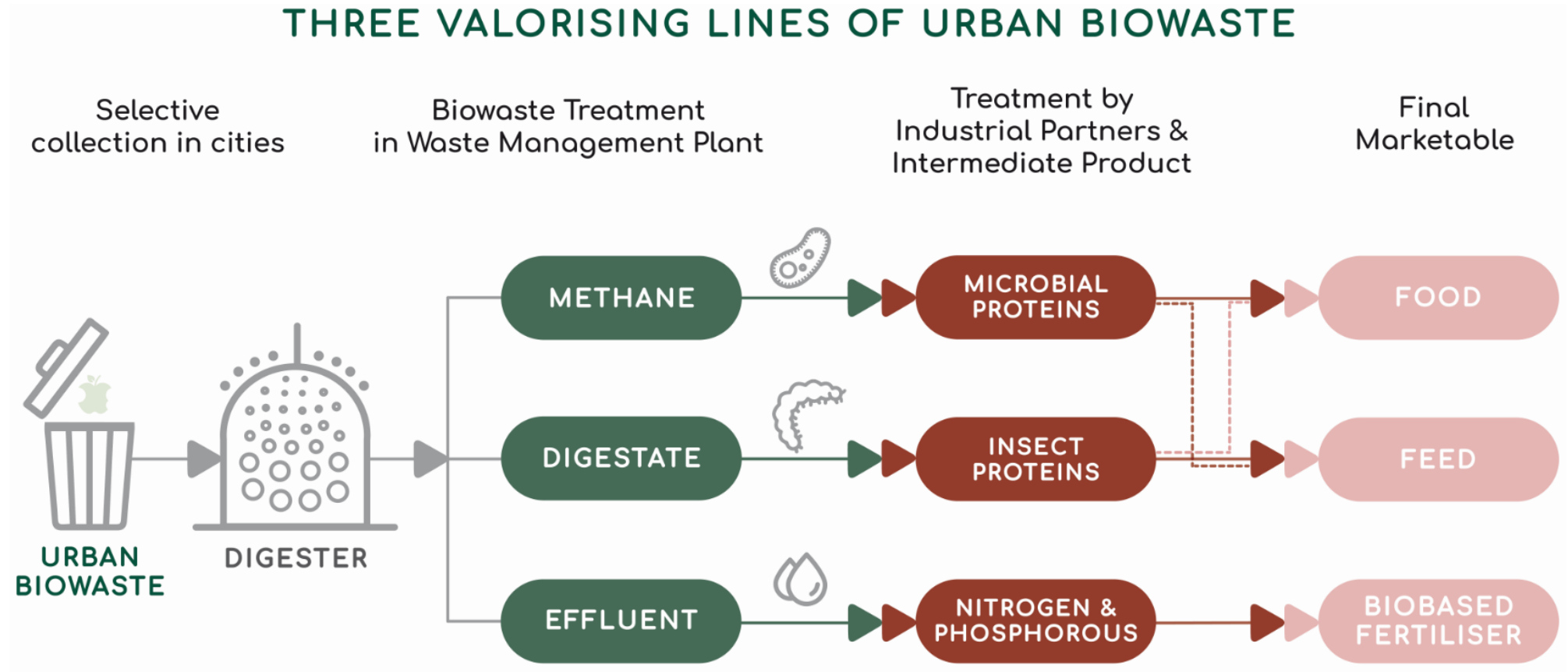
**\$248+**

million invested  
from private and  
public side

**1<sup>st</sup>**

fullscale P2X  
project (12MW)  
underway at  
GreenLab Skive

# 5<sup>th</sup> generation: Biogas to food and jet fuel



*“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No 818312”*



Horizon 2020  
European Union Funding  
for Research & Innovation

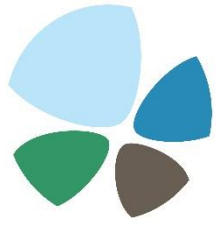
# Danish Biogas Alliance in Australia & New Zealand

The logo for Combigas features the word "Combigas" in a bold, sans-serif font. "Combi" is in black and "gas" is in green. A grey horizontal bar is positioned below the text.The logo for NIRAS consists of the word "NIRAS" in a bold, red, sans-serif font. A red flame-like graphic element is integrated into the letter "A".The logo for BIO GASCLEAN features the word "BIO" in large blue letters above "GASCLEAN" in smaller blue letters. A stylized green plant icon is positioned between the two words.The logo for GEMIDAN ECOGI features the word "GEMIDAN" in white letters on a green horizontal bar. The word "ECOGI" is written vertically in white on the right side of the bar. The bar is set against a circular green background with leaf motifs.

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