



# BIOGAS CALCULATION TOOL FOR THEORETICAL BIOMETHANE PRODUCTION

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Biogas calculation tool for theoretical biomethane production by Laavi *et al.*

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# CONTENT

- Biowaste as feedstock for biogas
- Motivation to build a biogas calculation tool
- Anaerobic digestion through Buswell-Boyle approach
- Case studies for small scale biowaste production
  - Manures (chicken, swine, beef feedlot, cattle/cow)
  - Agricultural waste
- Conclusions

# BIOWASTE AS FEEDSTOCK FOR BIOGAS

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- In Europe, 120 – 140 million tons biowaste annually
- Biowaste produces methane
  - If not captured, released to atmosphere
- If harvested, both methane and fertilizer can be produced
  - Biomethane can replace fossil fuel



# MOTIVATION TO BUILD A BIOGAS CALCULATION TOOL

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- Small to medium size biowaste producers often not involved in biogas production
  - Small volumes of biowaste production
  - Expensive and laborous feasibility studies in contrast to relatively low revenues
  - Joining a larger biowaste treatment plant may be complicated or have long distances

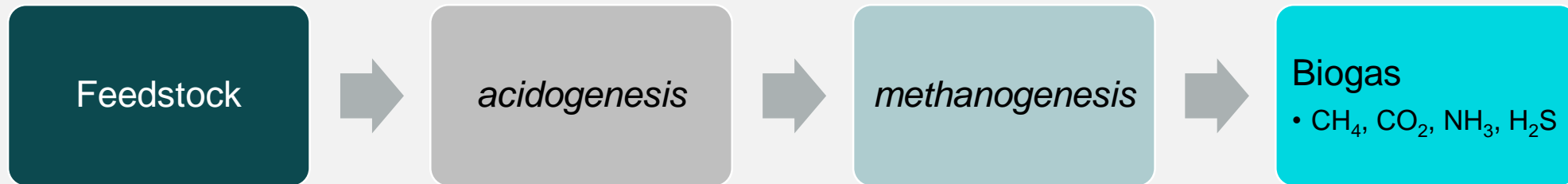


Need for a quick and easy tool for small to medium size biowaste producers to reduce methane emissions and increase biofuel production level

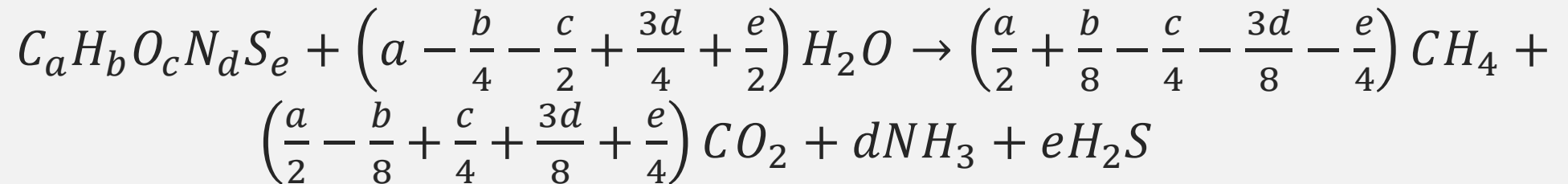
# ANAEROBIC DIGESTION THROUGH BUSWELL-BOYLE EQUATION

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- Biological degradation produces biogas with only four components: methane, carbon dioxide, ammonia, and hydrogen sulphide



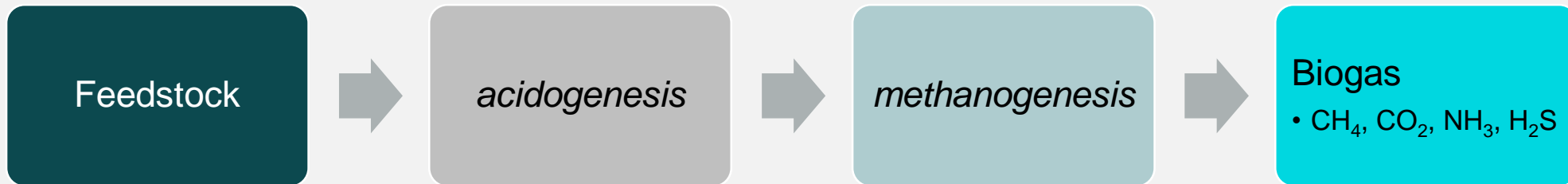
- Mathematical expression:



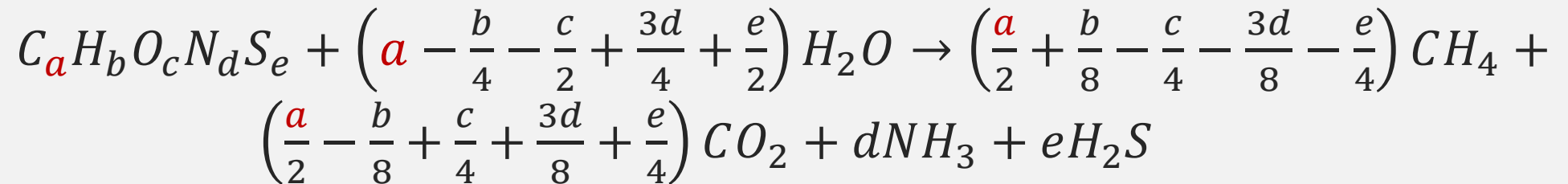


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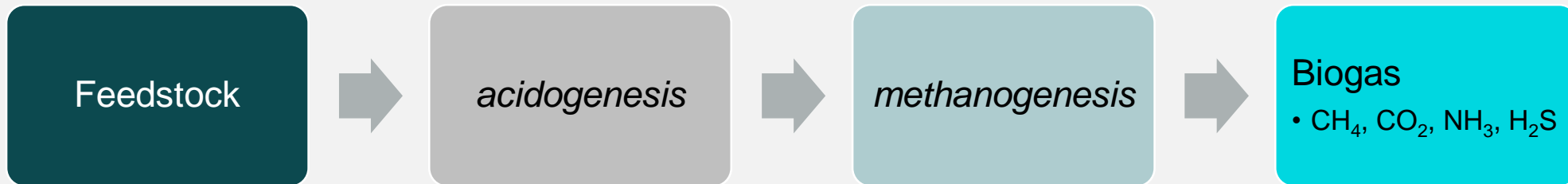


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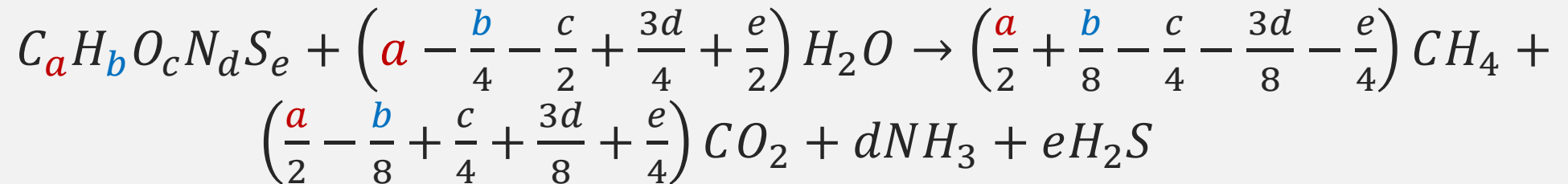


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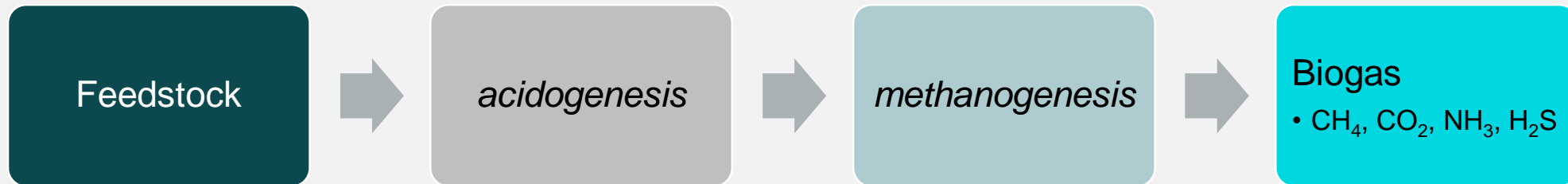


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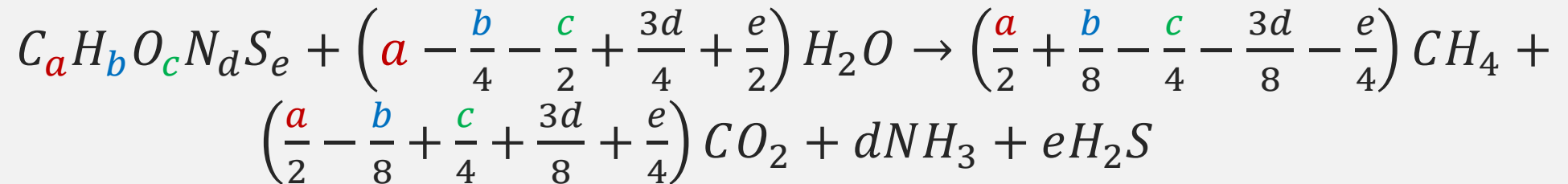


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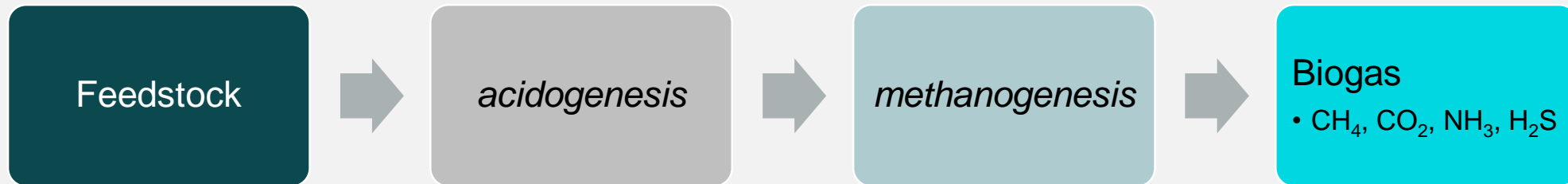


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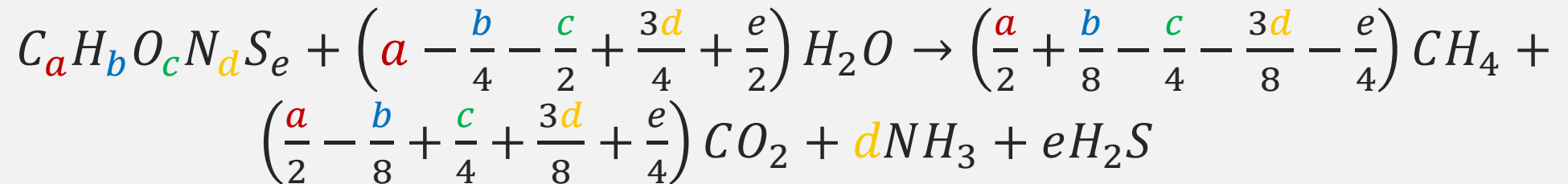


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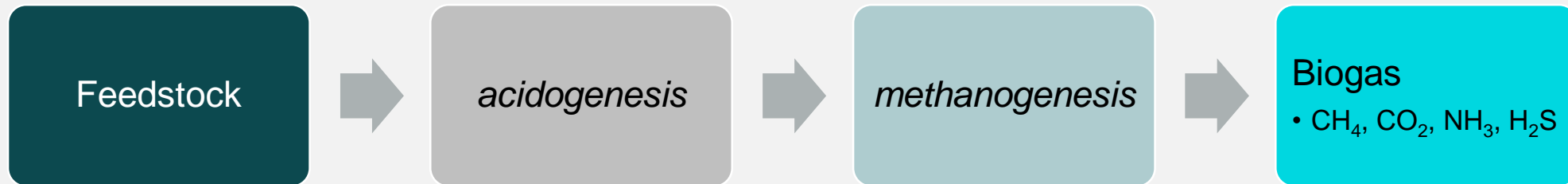


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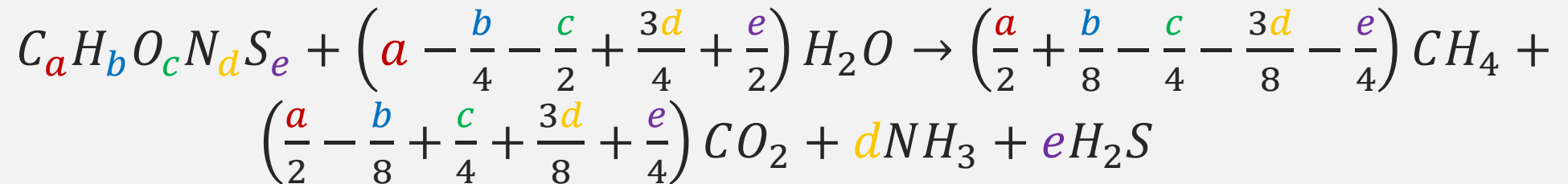


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- Mathematical expression:



# ANAEROBIC DIGESTION THROUGH BUSWELL-BOYLE EQUATION

- **GOOD:** Serves a quick and easy theoretical basis for the calculation of biogas production
  - Only elemental analysis required, inert fraction and moisture fraction
- **CHALLENGING:** Assumes 100% degradation
  - To avoid too optimistic yields, assessment of biodegradable factor and/or total conversion



**Development of database with degradation factors**

# CASE STUDIES

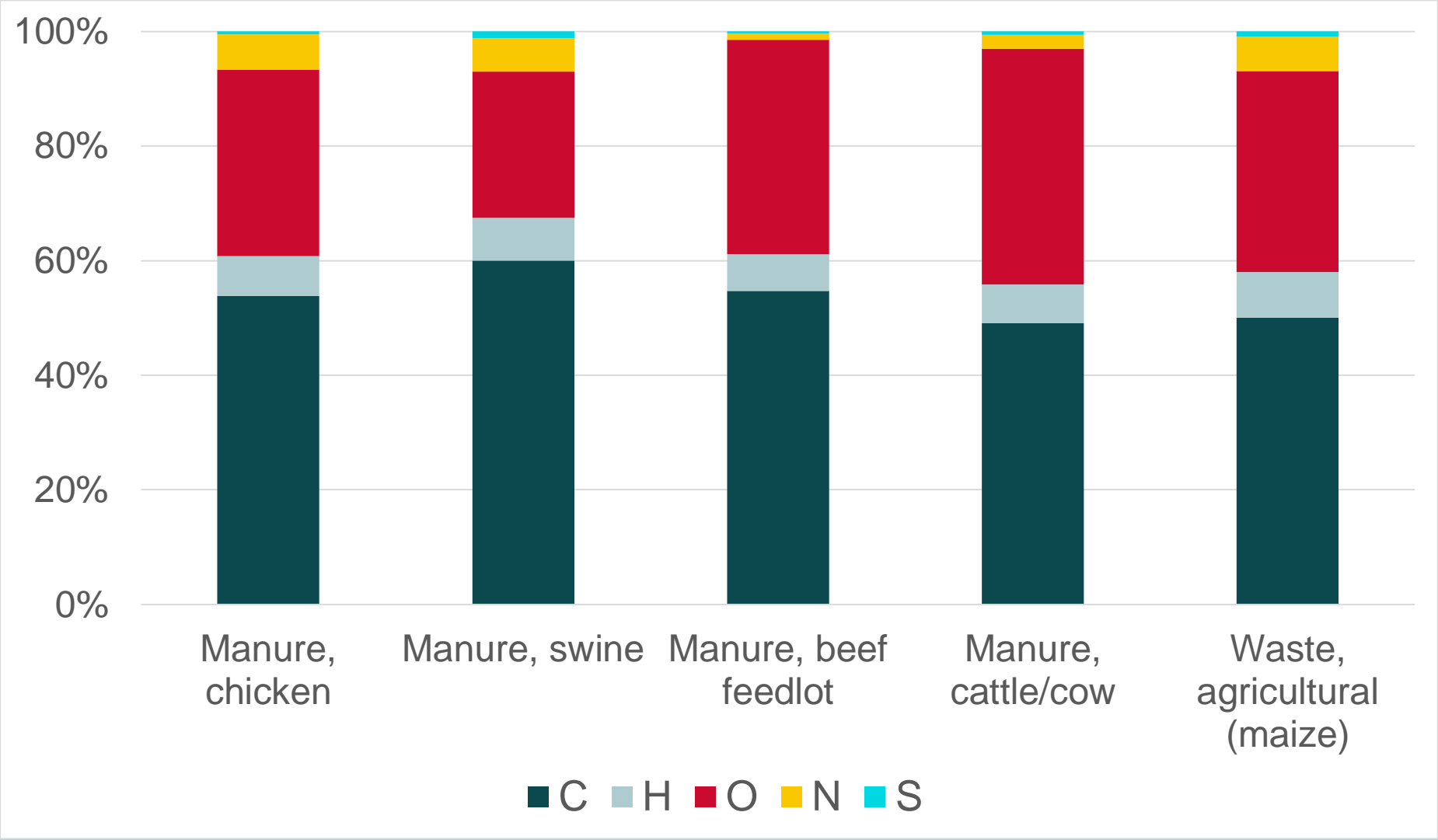
## Manures and agricultural waste

# CASE STUDIES FOR SMALL SCALE BIOWASTE PRODUCTION

	Quantity	Biowaste production	Biomethane production potential (BMP)
		$t_{VS}/a$	$m^3CH_4/t_{VS}$
<b>Manure, chicken</b>	1000 hens	11	263
<b>Manure, swine</b>	10 sows	6.24	413
<b>Manure, beef feedlot</b>	10 animals	11.0	300
<b>Manure, cattle/cow</b>	10 cows	23.9	255
<b>Waste, agricultural (maize)</b>	1 ha of area	6.68	288



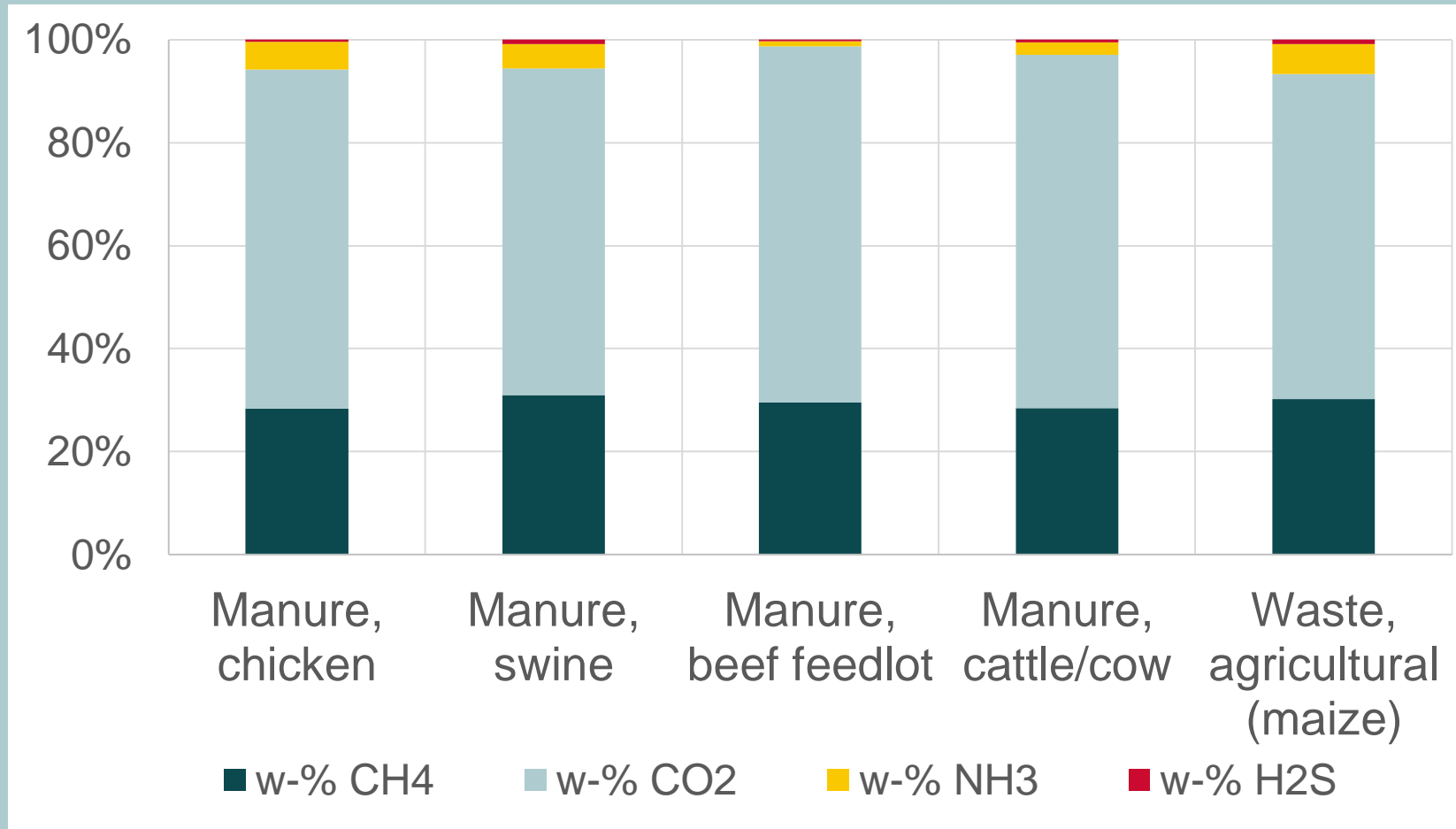
# CASE STUDY FEEDSTOCKS COMPOSITIONS (wt-%)



# FEEDSTOCK DEGRADATION FACTORS

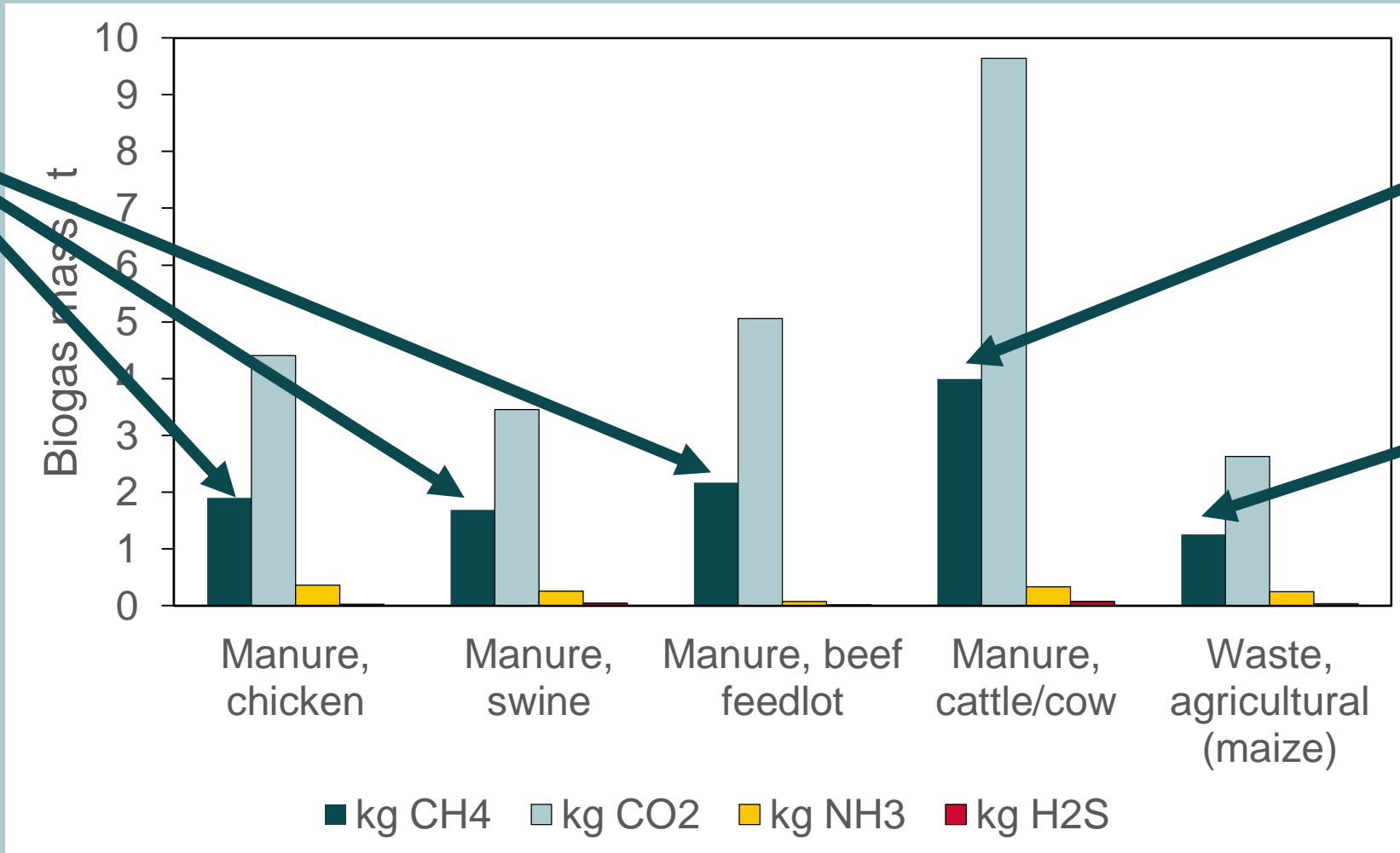


# CALCULATED BIOGAS COMPOSITION



# ANNUAL BIOGAS PRODUCTION(t/a)

1000 hens  
or 10  
swines or  
beef  
feedlot  
produce  
2 t<sub>CH<sub>4</sub></sub>/a



10 cows  
produce  
4 t<sub>CH<sub>4</sub></sub>/a

1 ha maize  
produces  
1 t<sub>CH<sub>4</sub></sub>/a

# CALCULATED BIOWASTE PRODUCTION

World wide experimental data requires correction factor for Finland

	<b>TBMP 100 %</b>	<b>TBMP with <math>f_d</math></b>	<b>BMP</b>	<b><math>f_{d,FI}</math></b>
	t/a	t/a	t/a	%
<b>Manure, chicken</b>	4.28	3.43	1.90	44.3
<b>Manure, swine</b>	2.87	2.29	1.69	59.0
<b>Manure, beef feedlot</b>	4.33	3.47	2.16	49.9
<b>Manure, cattle/cow</b>	8.31	4.32	4.00	48.1
<b>Waste, agricultural (maize)</b>	2.53	1.90	1.26	49.8

# CONCLUSIONS

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- Buswell-Boyle functions as a basis for a quick and easy tool
- Important to get small players in to replace fossil fuels with biofuels
- Small farms produce significant amounts of biomethane
  - With 10 cows several tons of biomethane annually
  - With 1 ha of area maize 1 ton biomethane annually
  - With 1000 hens or 10 swines/beef feedlot about 2 tons of biomethane
- Need for database to adjust theoretical biogas production to match the local biomethane production

# Thank you for your attention!



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