

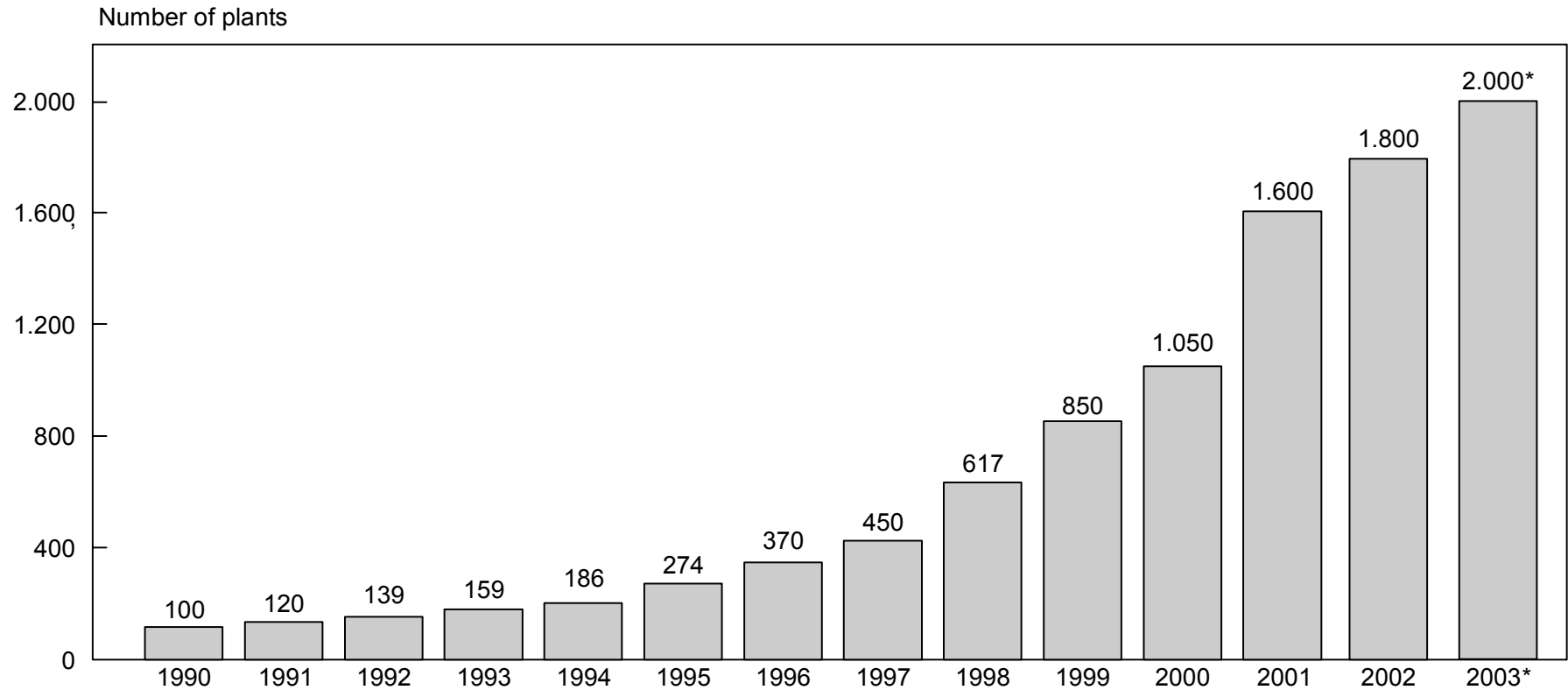
Biogas technologies in Germany - Feedstocks and Technology -

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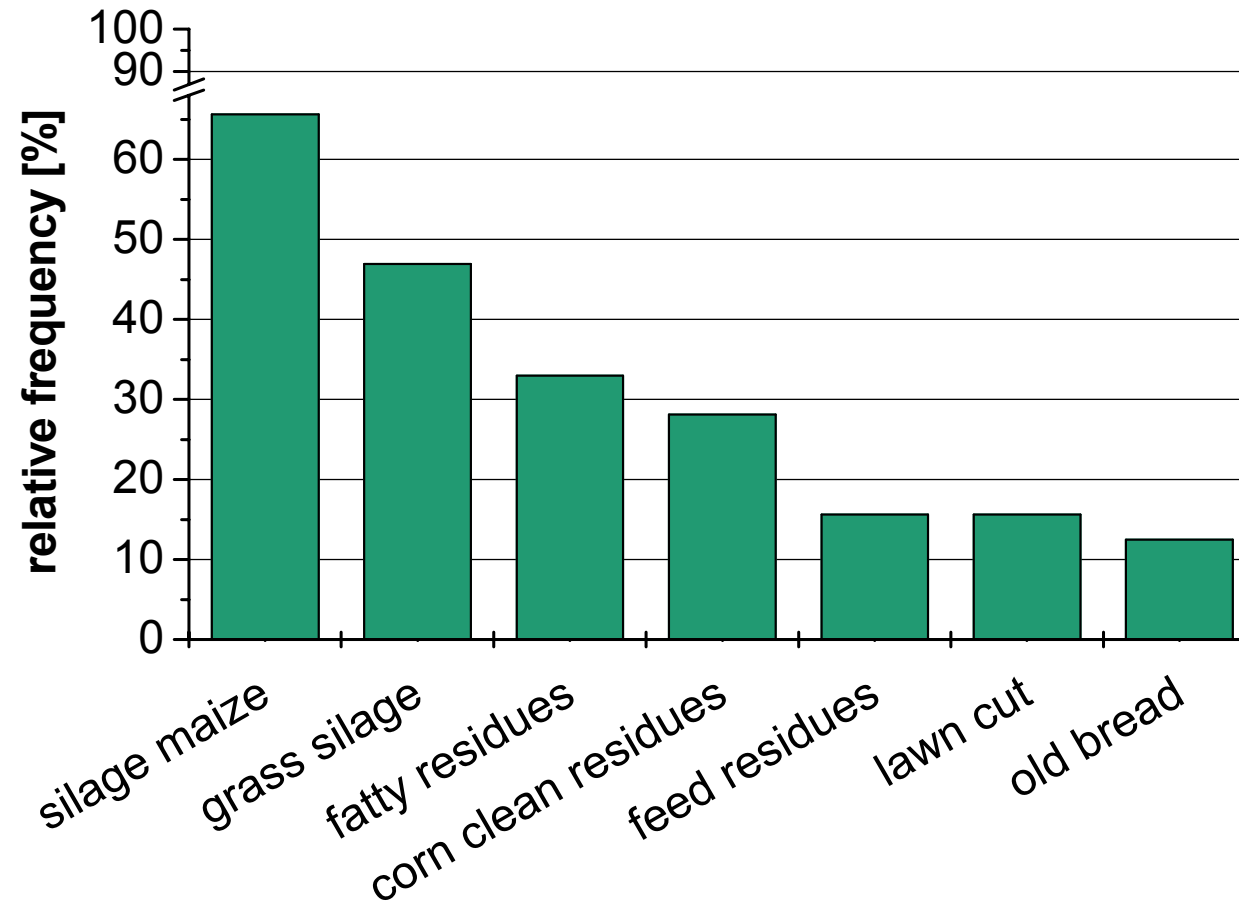
- **Substrates**
- **Fermentation technologies**
 - Wet fermentation
 - Dry Fermentation
- **Biogas utilisation**
 - Gas engines
 - Micro gas turbines
 - Fuel cells
- **Outlook**

Number of biogas plants in Germany

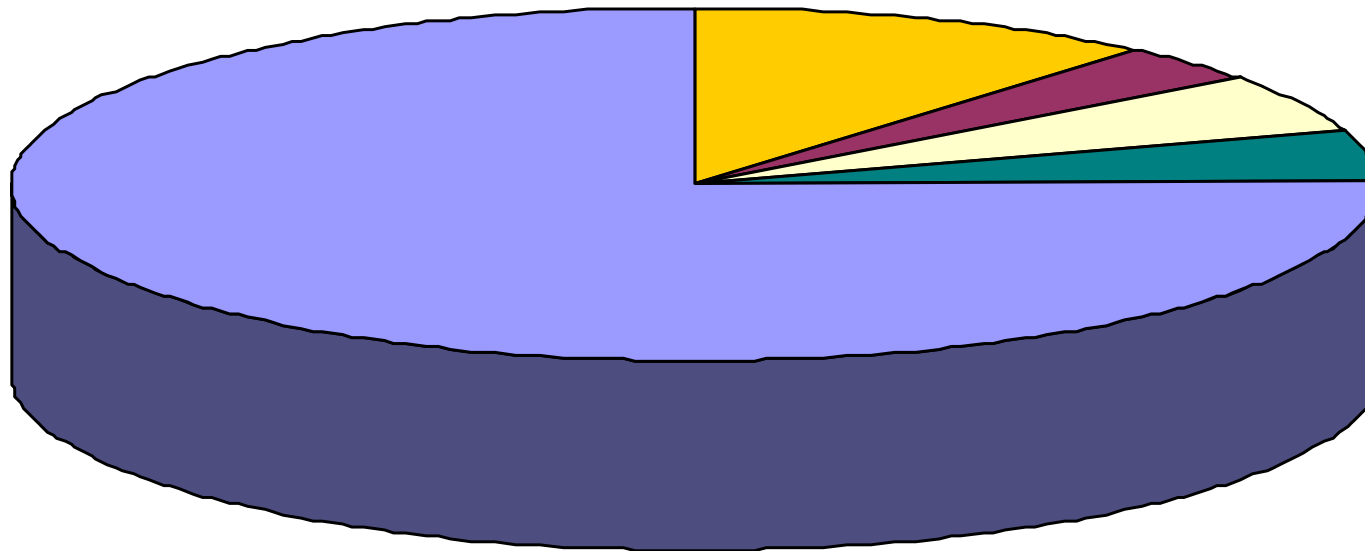


* estimated

Substrates in modern biogas plants



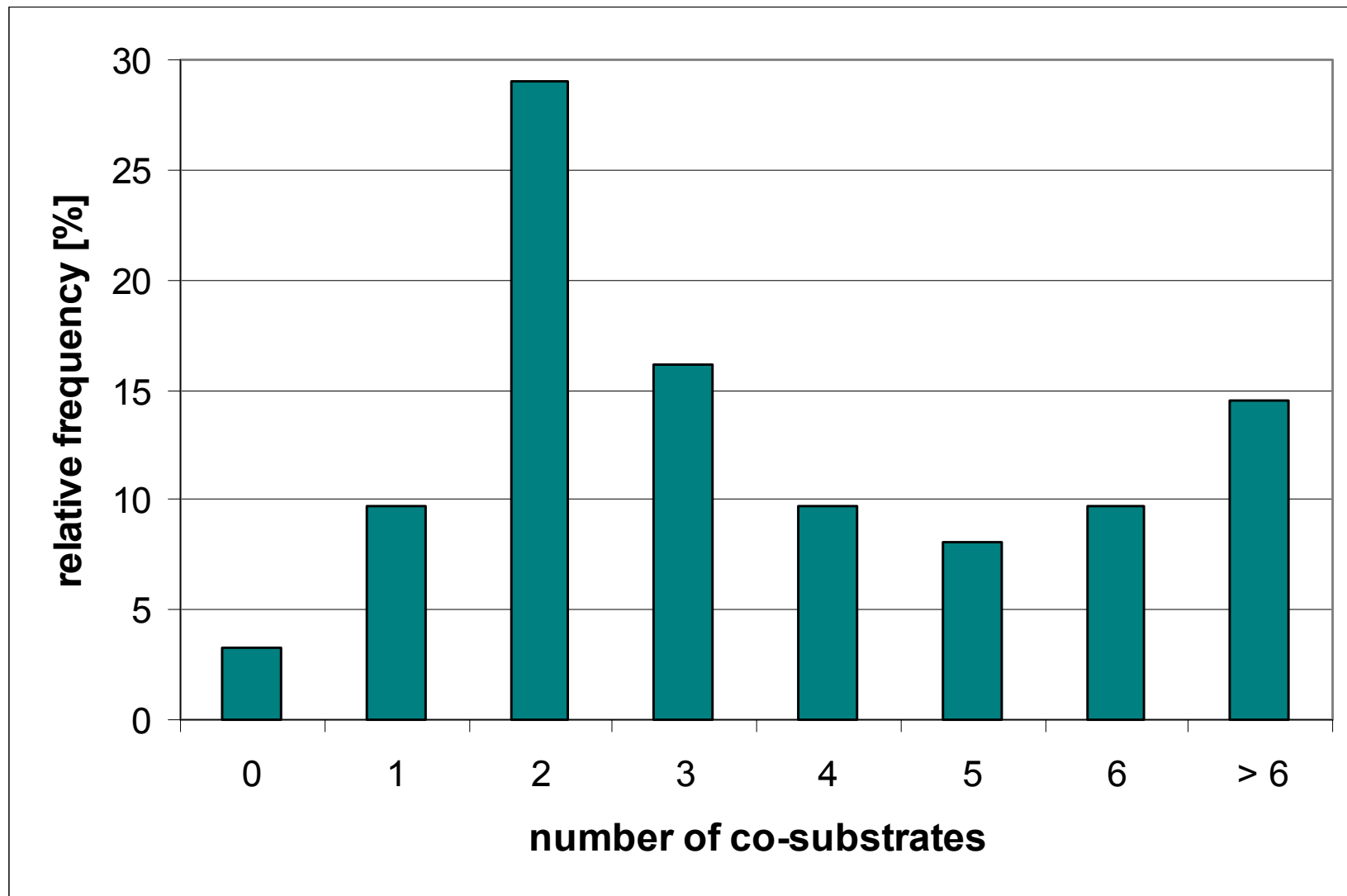
Average substrate composition



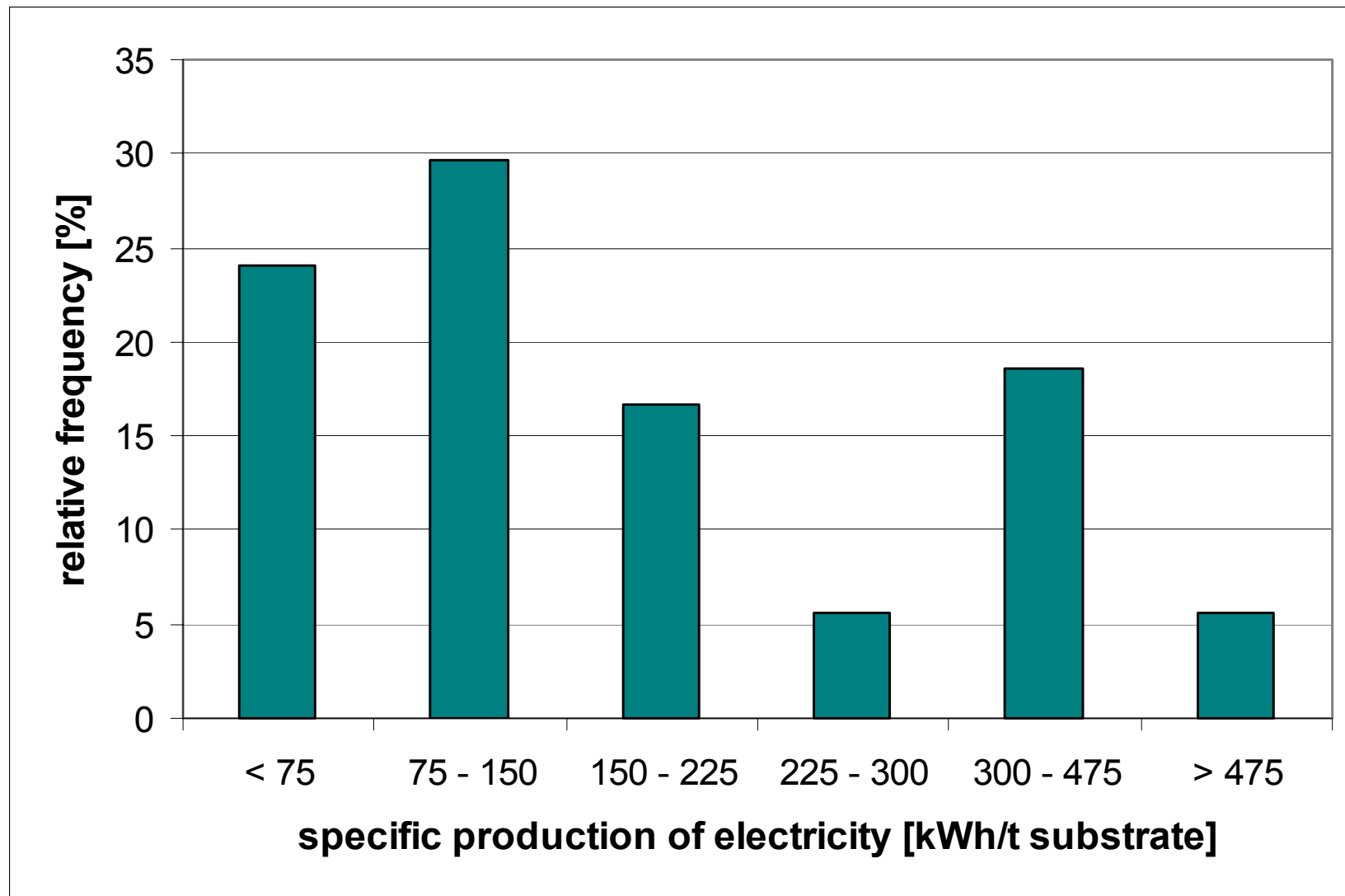
Ø: 6,0 t substrate per m³ and year

- | | |
|---------------|--------------|
| maize silage | grass silage |
| cereal wastes | fatty wastes |
| manure | |

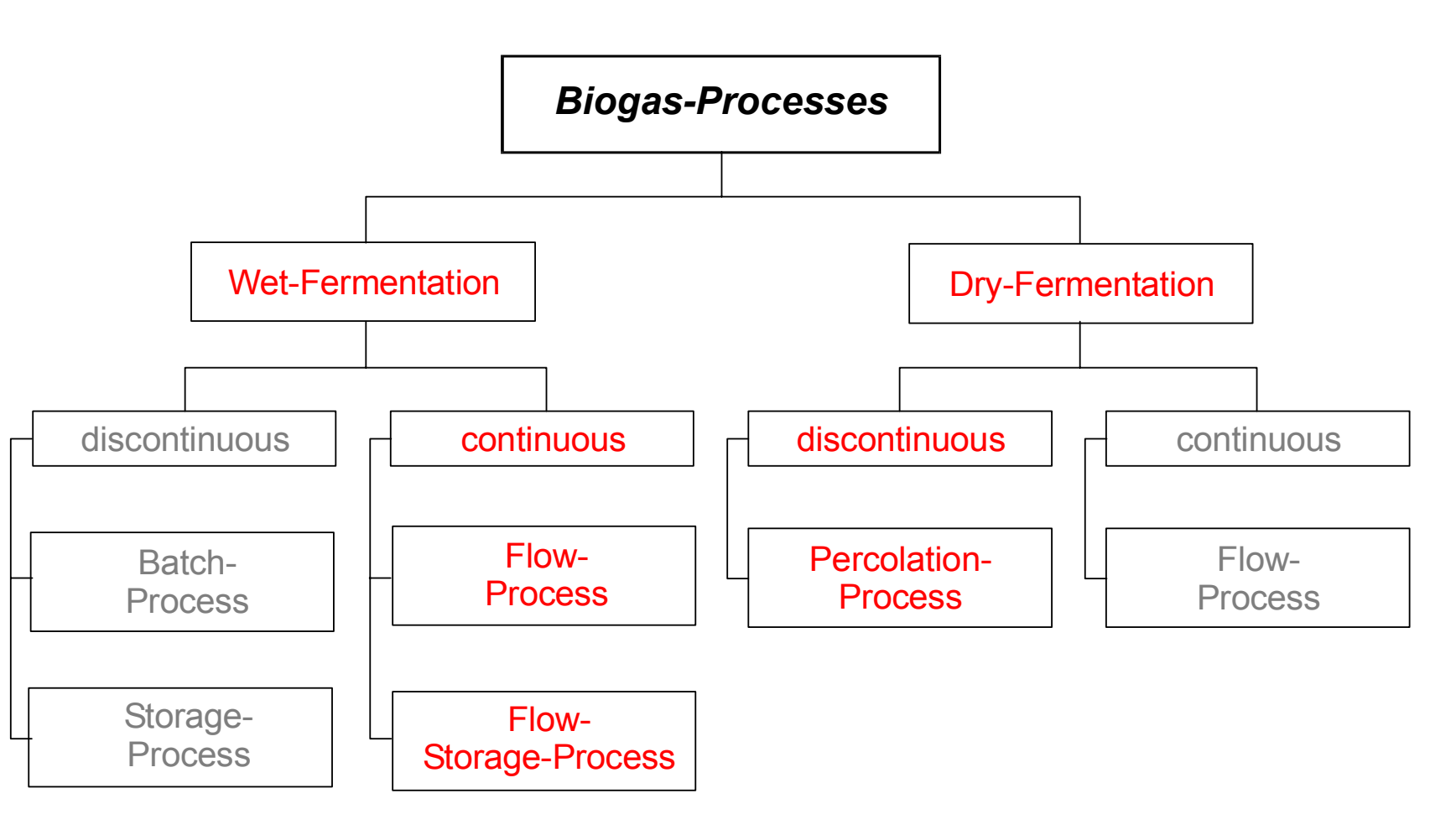
Number of applied co-substrates



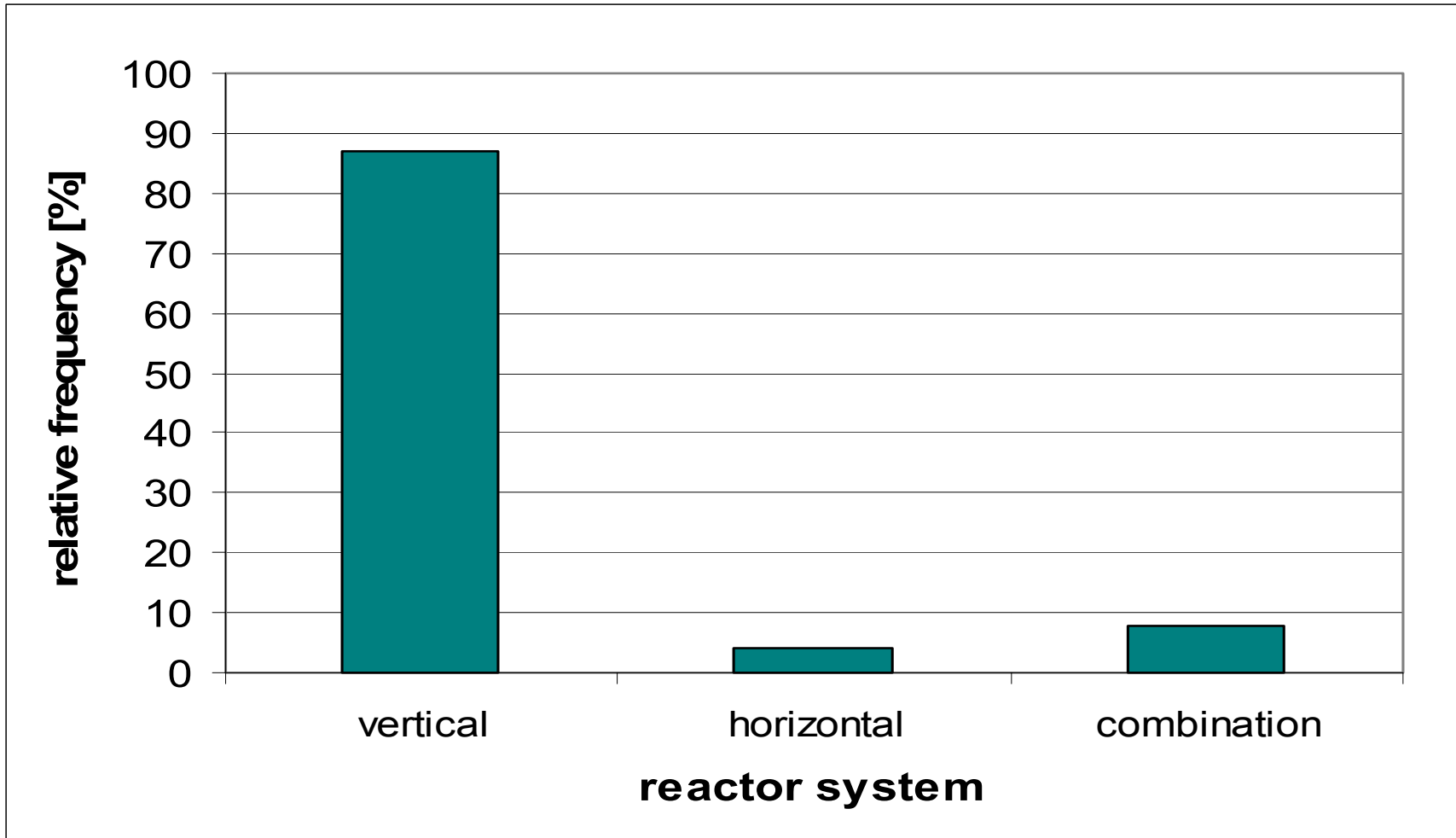
Specific energy yield from substrates



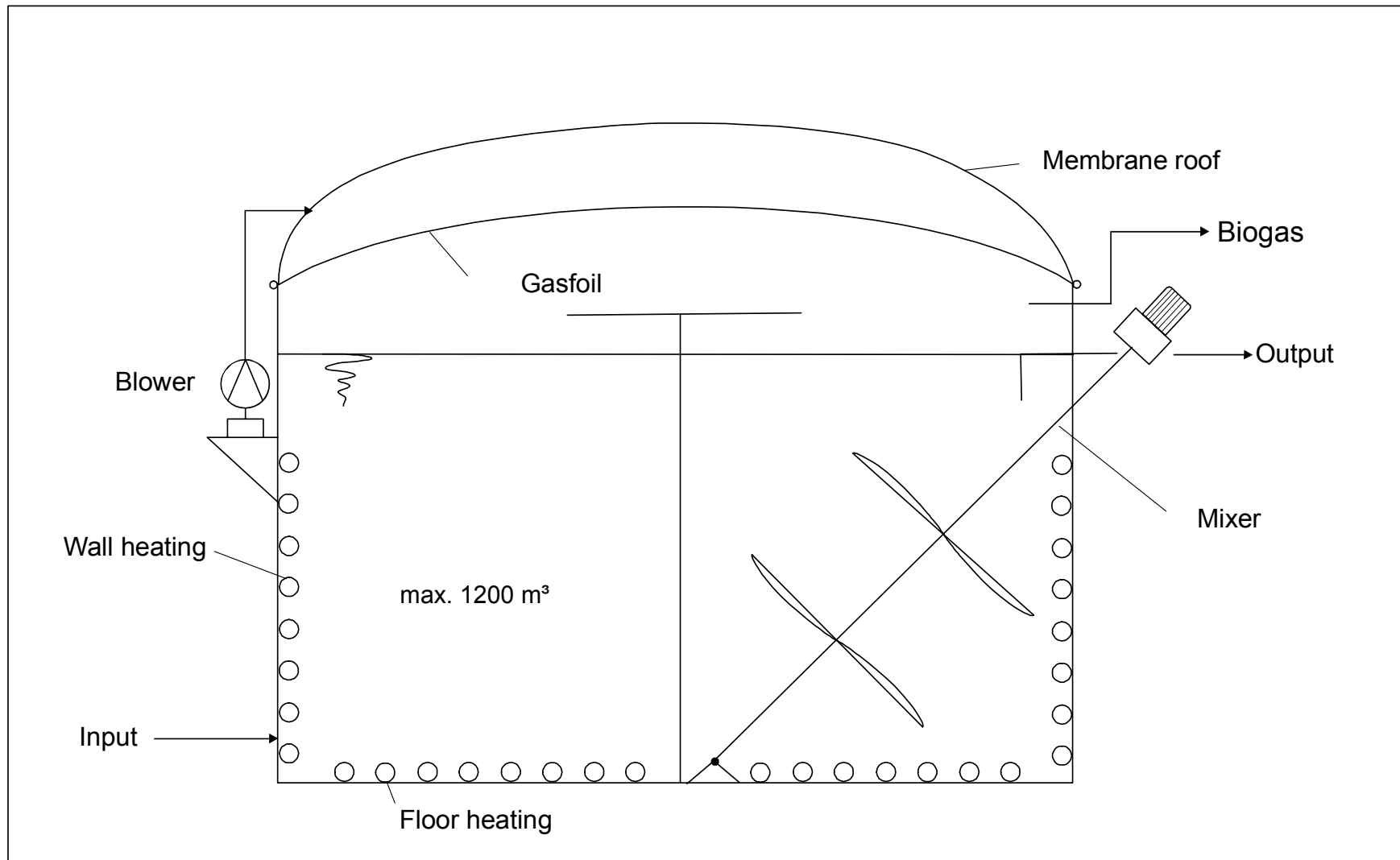
Process types in agriculture



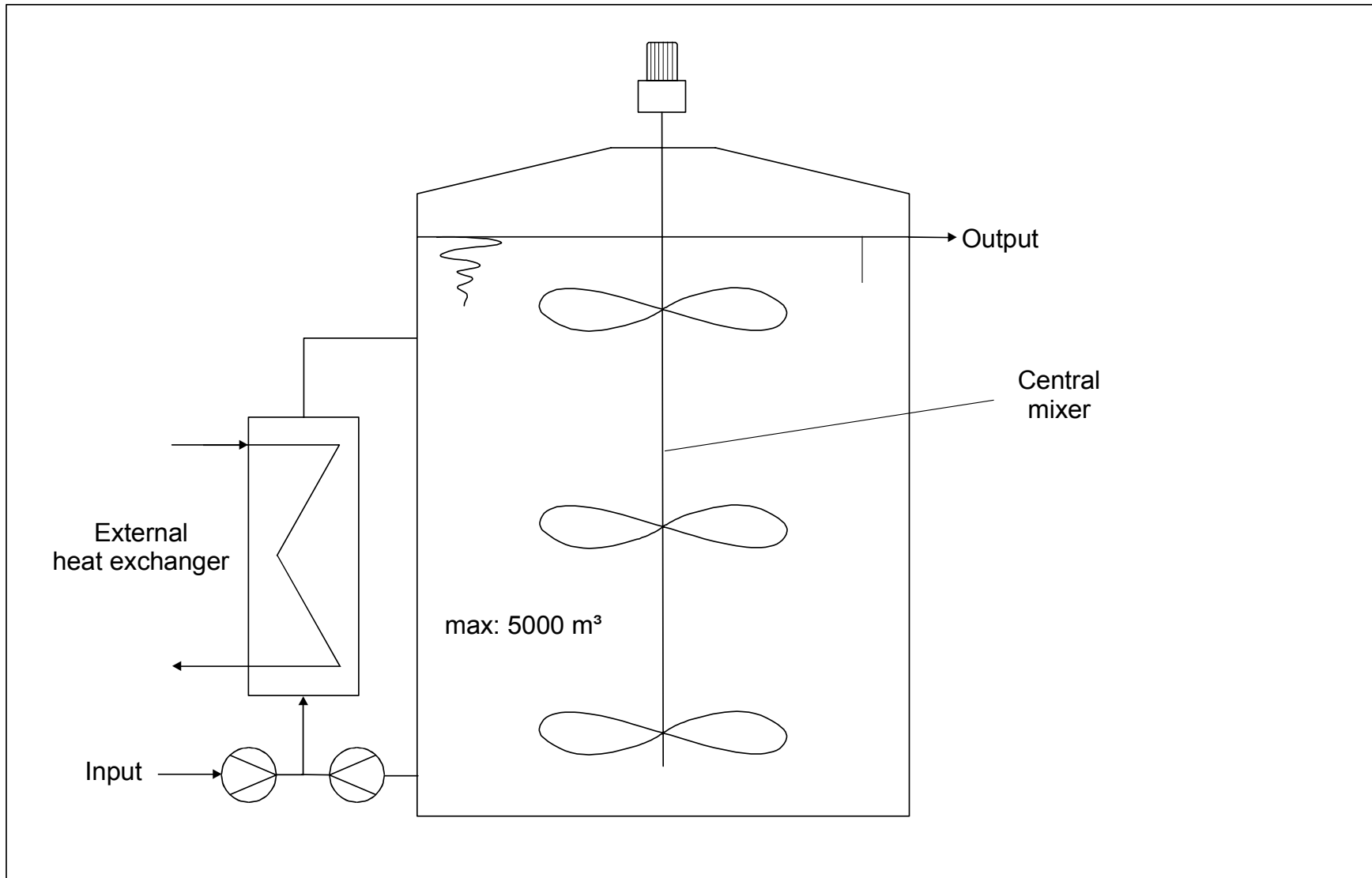
Used fermenter systems in agriculture



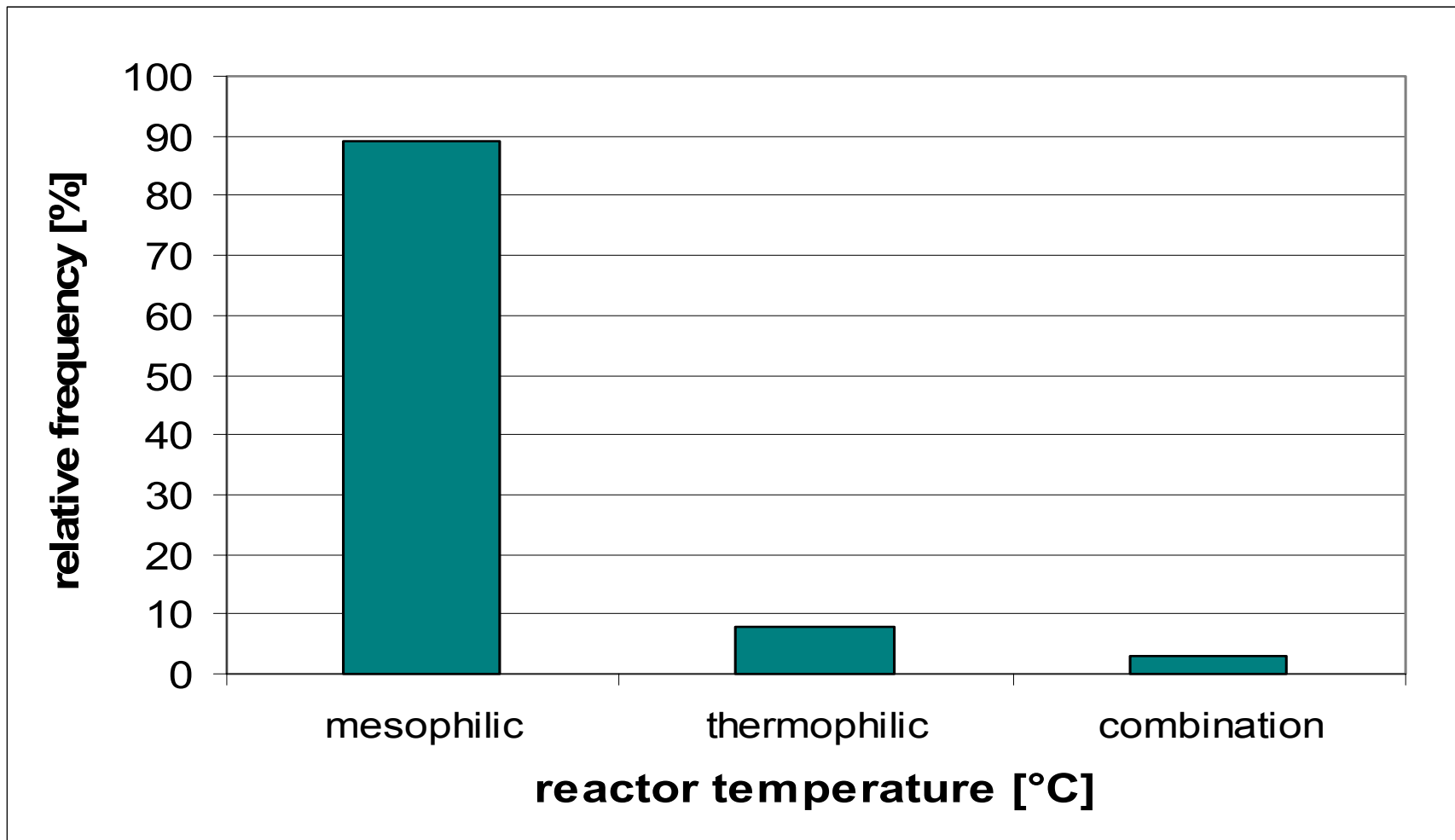
Digester with double membrane roof



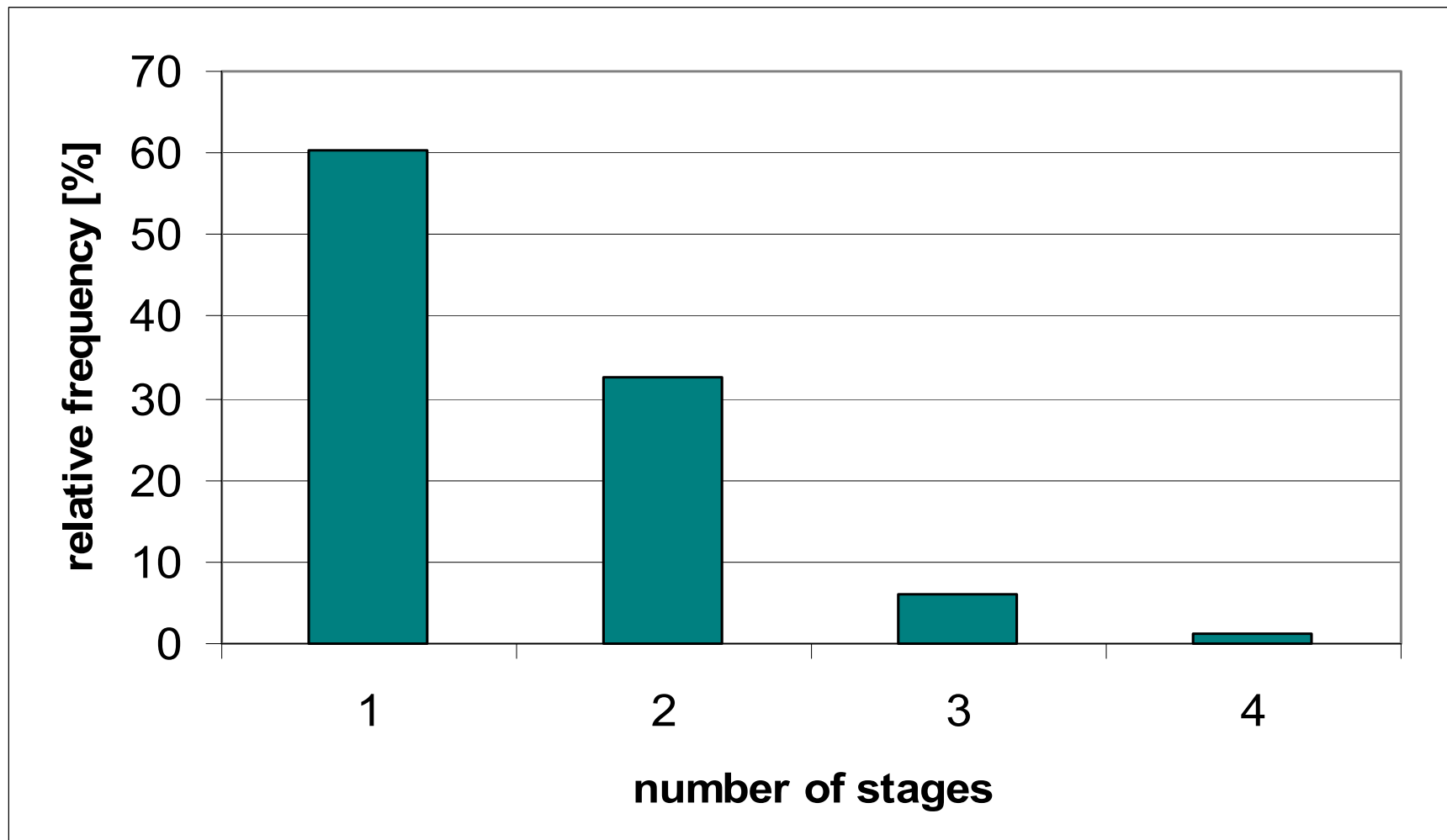
Upright large-scale digester



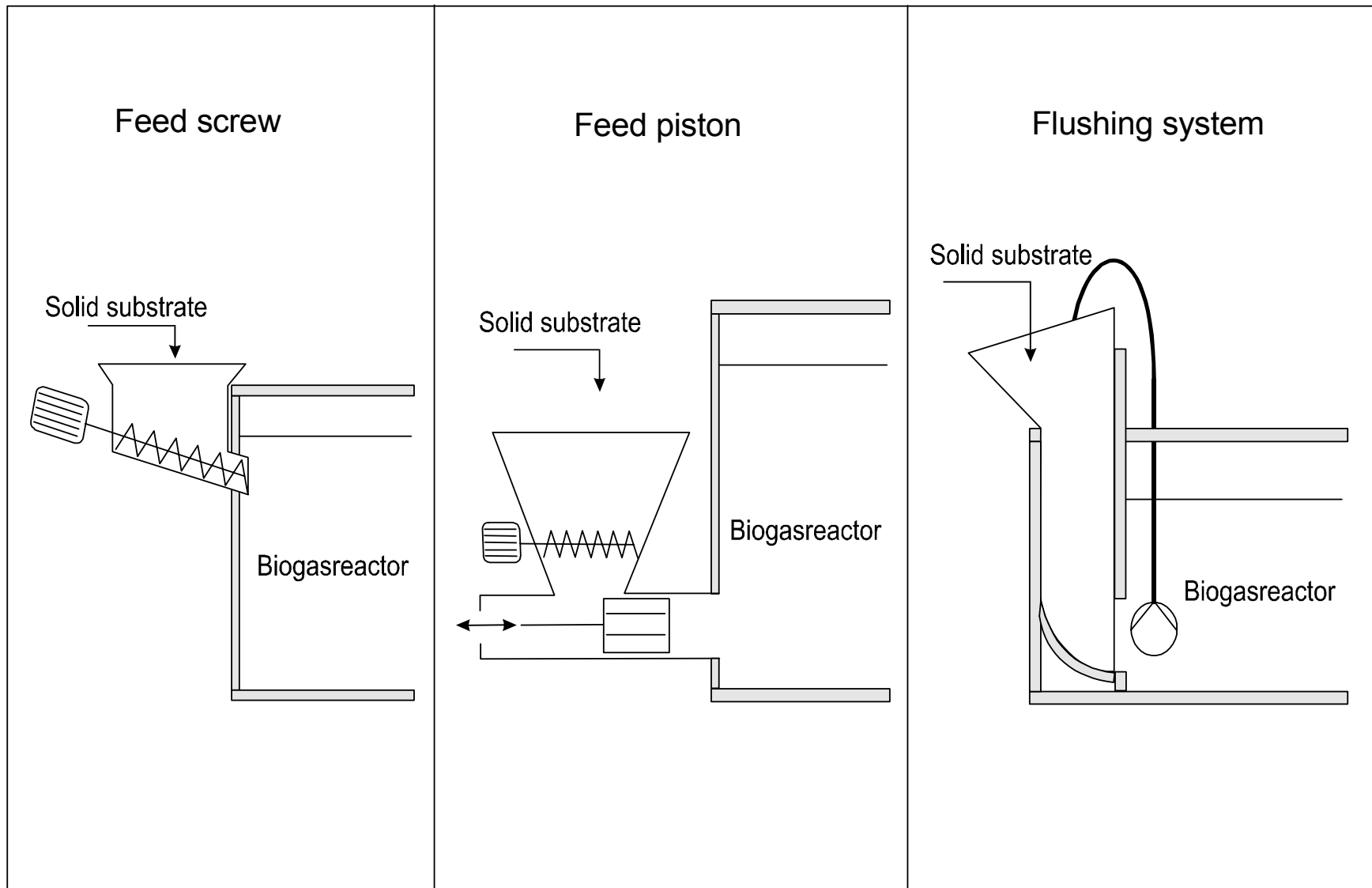
Common process temperature



Number of process stages



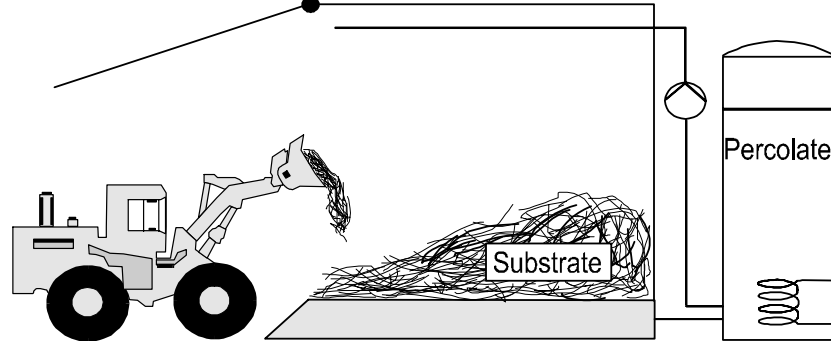
Direct-feeding systems for solids



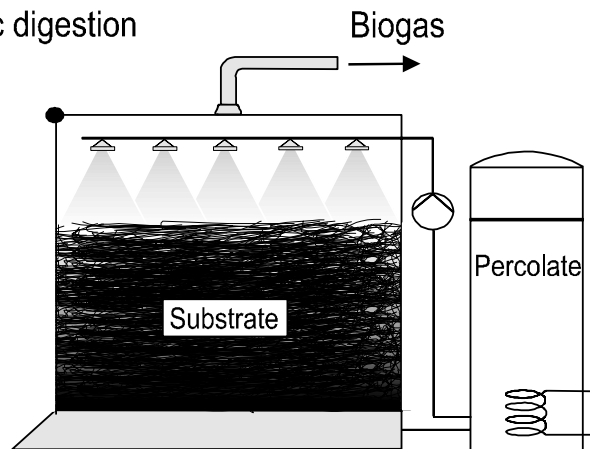
Dry-fermentation

Container process with percolation

Charge/Discharge

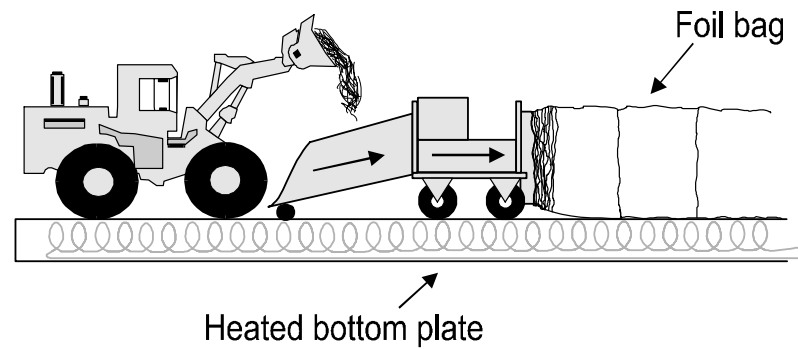


Anaerobic digestion

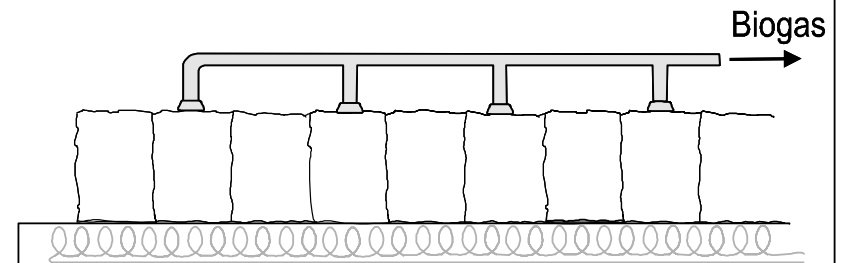


Bag process without percolation

Charge/Discharge



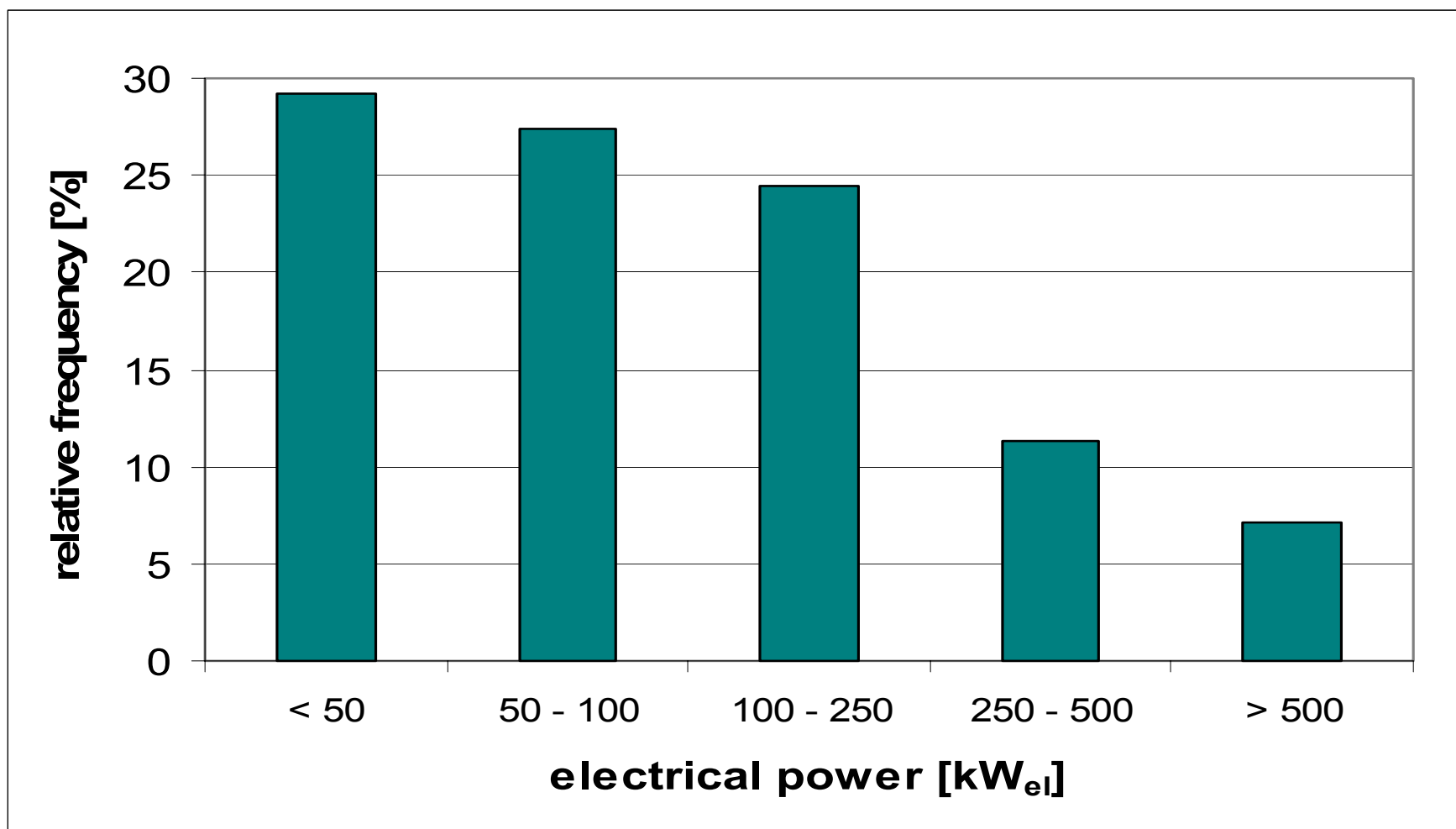
Anaerobic digestion



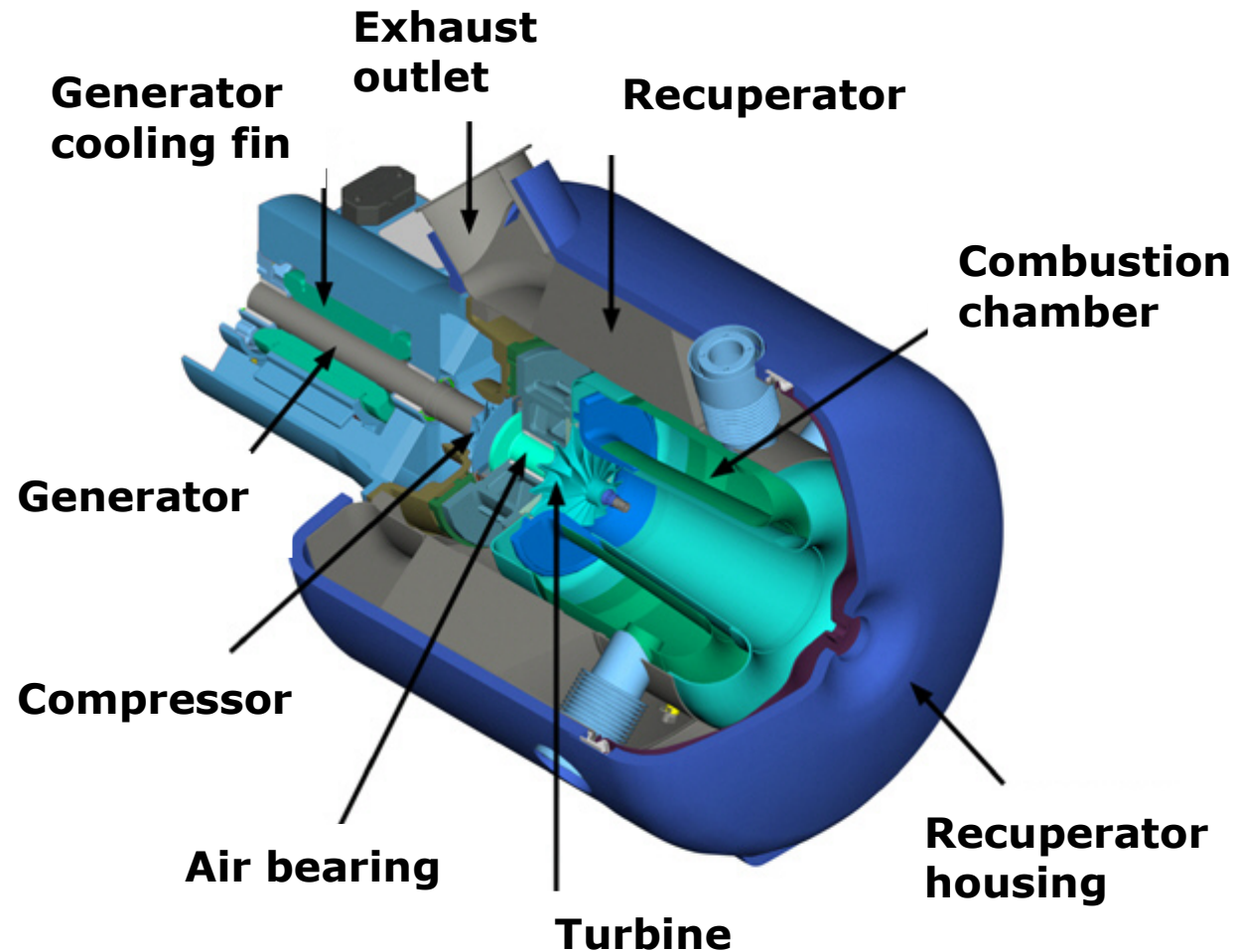
Features of biogas engines

Feature	Petrol engine Gas-Otto	Diesel engine Ingnition jet	Diesel engine Gas-Otto
Efficiency [%]	22 - 27	30 - 37	28 - 35
Lifespan	low	medium	high
Maintenance demand	high	high	low
Investment costs	low	medium	high
Power class [kW]	5 - 30	30 - 200	> 200

Electrical power of German biogas plants



Micro gas turbines (Capstone)



Fuel cell tests with biogas in Germany

- **GEW Köln AG, Köln**
 - PAFC (ONSI Corporation, USA), 200 kW
 - Sewage sludge digester gas
- **Farmatic/FAL, Nortorf/Braunschweig**
 - PEMFC (PSFU, D), 25-500 W
 - FAL-Biogas plant for manure treatment
- **Schmack Biogas AG, Schwandorf**
 - MCFC (MTU CFC Solutions, D), 300 W
 - Biogas plant Haimhausen

- The total biogas potential in Germany is about 24 Bill. m³/a, but only 5 % of the available organic substrates are used today for biogas production.
- More than 94 % of all biogas plants are operated with cofermentation, using cow and pig manure as basic substrate.
- Energy crops are used in more than 50 % of all modern biogas plants for cofermentation together with other organic wastes.
- Nearly all agricultural biogas plants are operated with wet-fermentation and only few pilot and demonstration plants are running with dry-fermentation
- Today biogas is used only in conventional combined heat and power plants (CHP), but in future upgraded biogas is used also as vehicle fuel and in fuel cells.
- For the complete utilization of the available organic substrates between 30,000 and 40,000 biogas plants are necessary in Germany.

Actual amendment of EEG (5.11.03)

Electric.capacity	Compensation paid for electricity [€-Cent/kWh]	
	Farm substrates	Non-farm organic wastes
< 150 KW	14,0	11,5
< 500 kW	12,4	9,9
< 5 MW	8,9	8,9
> 5 MW	8,4	8,4

The compensation is paid for maximum 15 years.

The compensation is increased by 1 Cent/kWh if fuel cells, micro gas turbines or stirling engines are used for electricity production.

Beginning from January 2005 the compensation is reduced by 2 % per year.