Workshop “ENERGY CROPS & BIOGAS”

Utrecht, 22 September 2005

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Results and bottle necks of energy crop digestion plants - Required process technology innovations -

P. Weiland

Federal Agricultural Research Centre (FAL)
Braunschweig / Germany

Outline

- Introduction
- Actual situation in Germany
- Results from evaluation of 60 biogas plants
- Bottle necks of crop digestion plants
- Technologies for process optimization
- Summary and outlook

Renewable Energy Sources Act (2005)

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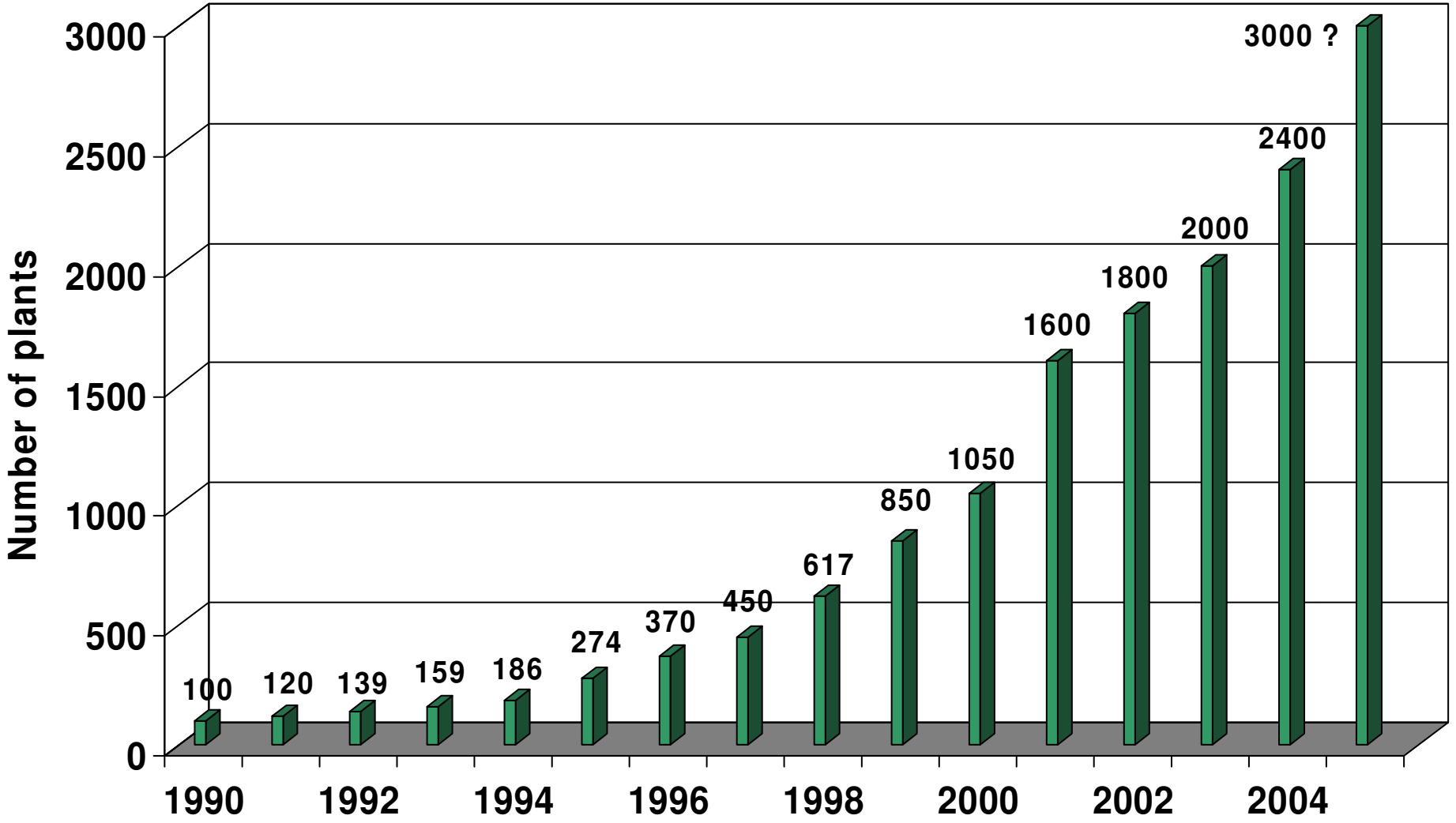
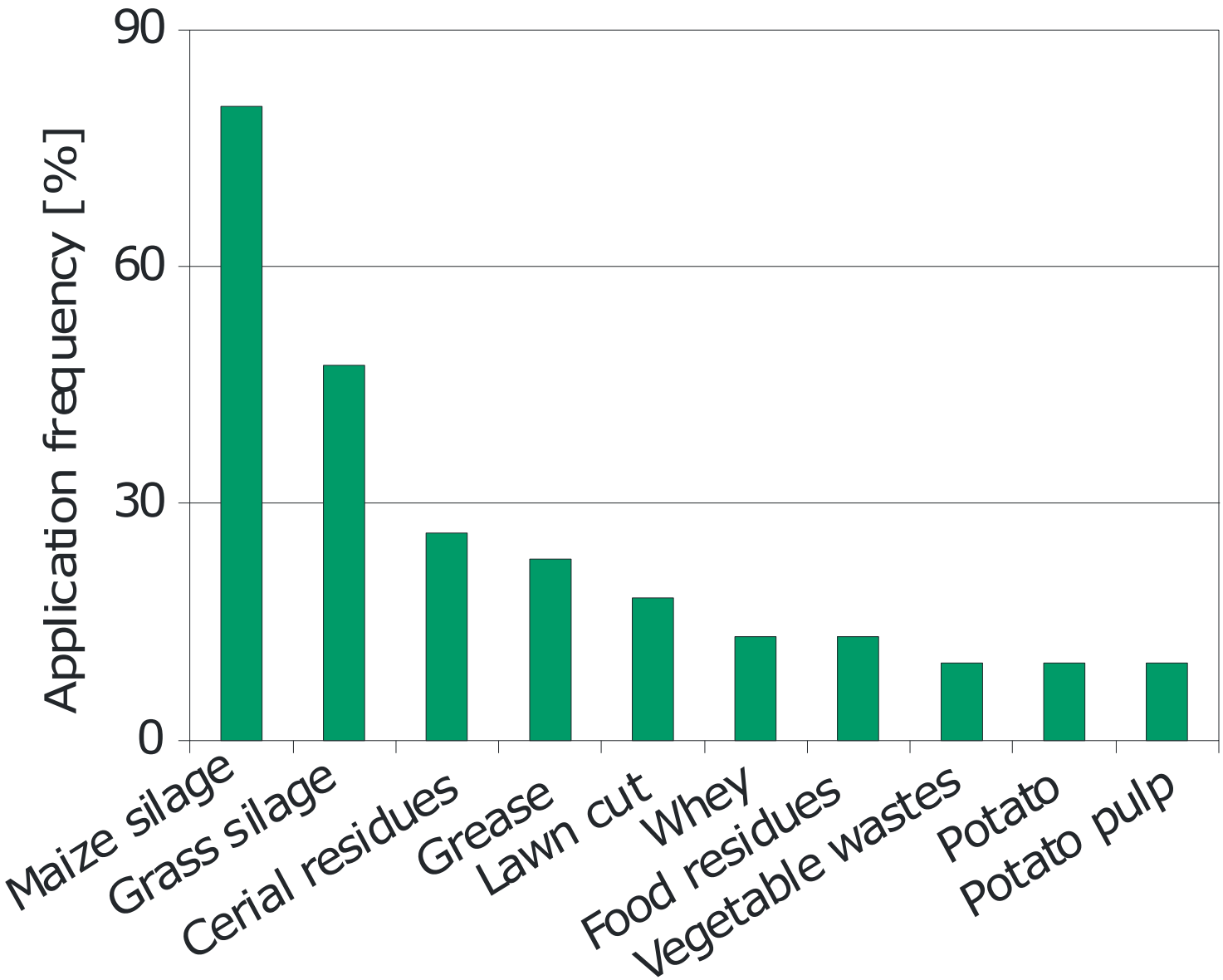
Electrical Capacity [kW]	Compensation Paid for Electricity [Cent/kWh$_{el}$]	Bonus Paid for Biomass [Cent/kWh$_{el}$]
150	11.33	6.0
150 – 500	9.75	6.0
500-5,000	8.77	4.0
CHP-Bonus: 2 Cent/kWh$_{el}$ for external heat utilization		
Technology-Bonus: 2 Cent/kWh$_{el}$ (e.g. dry-fermentation)		

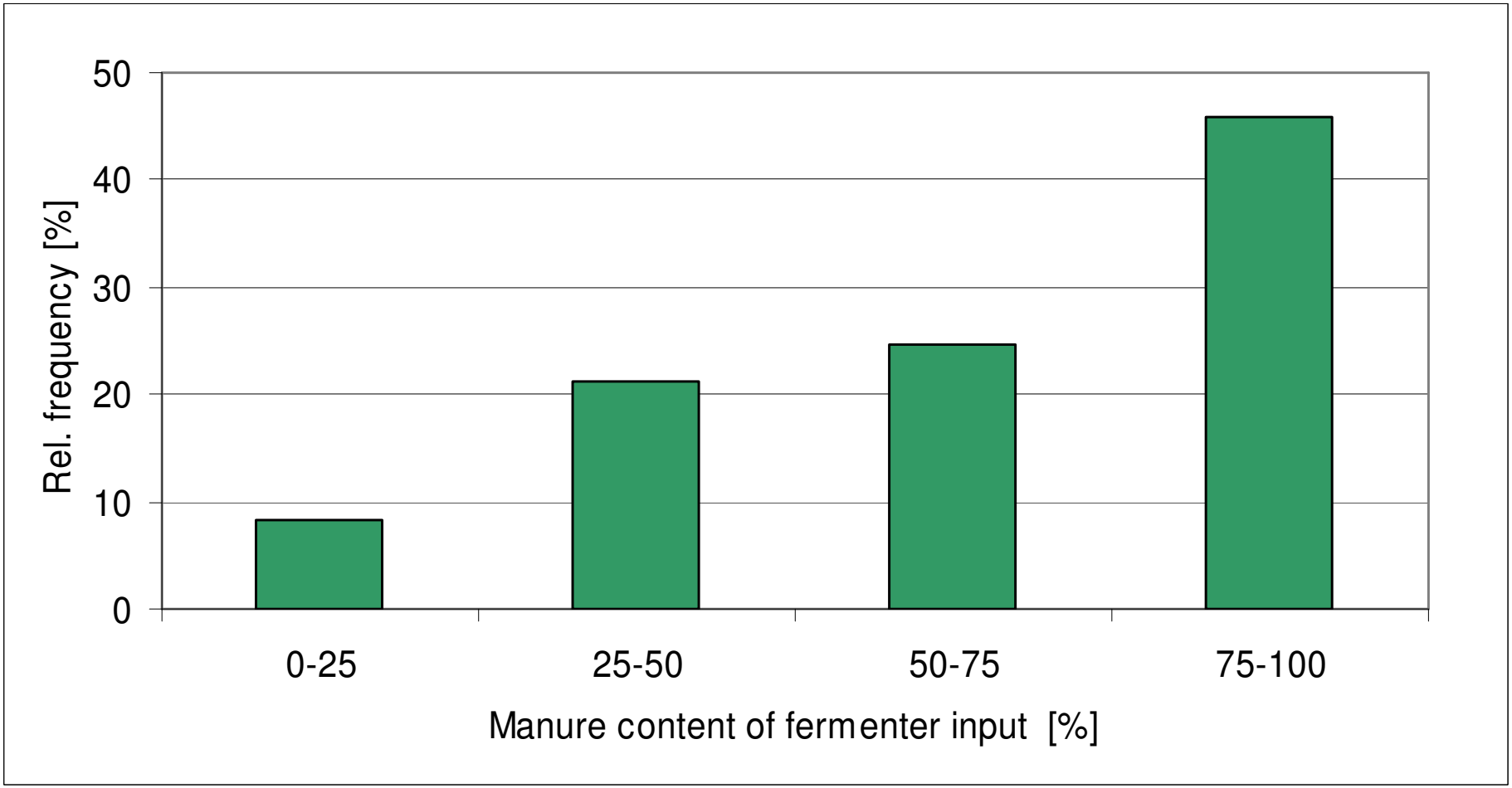
Biogas plants in Germany



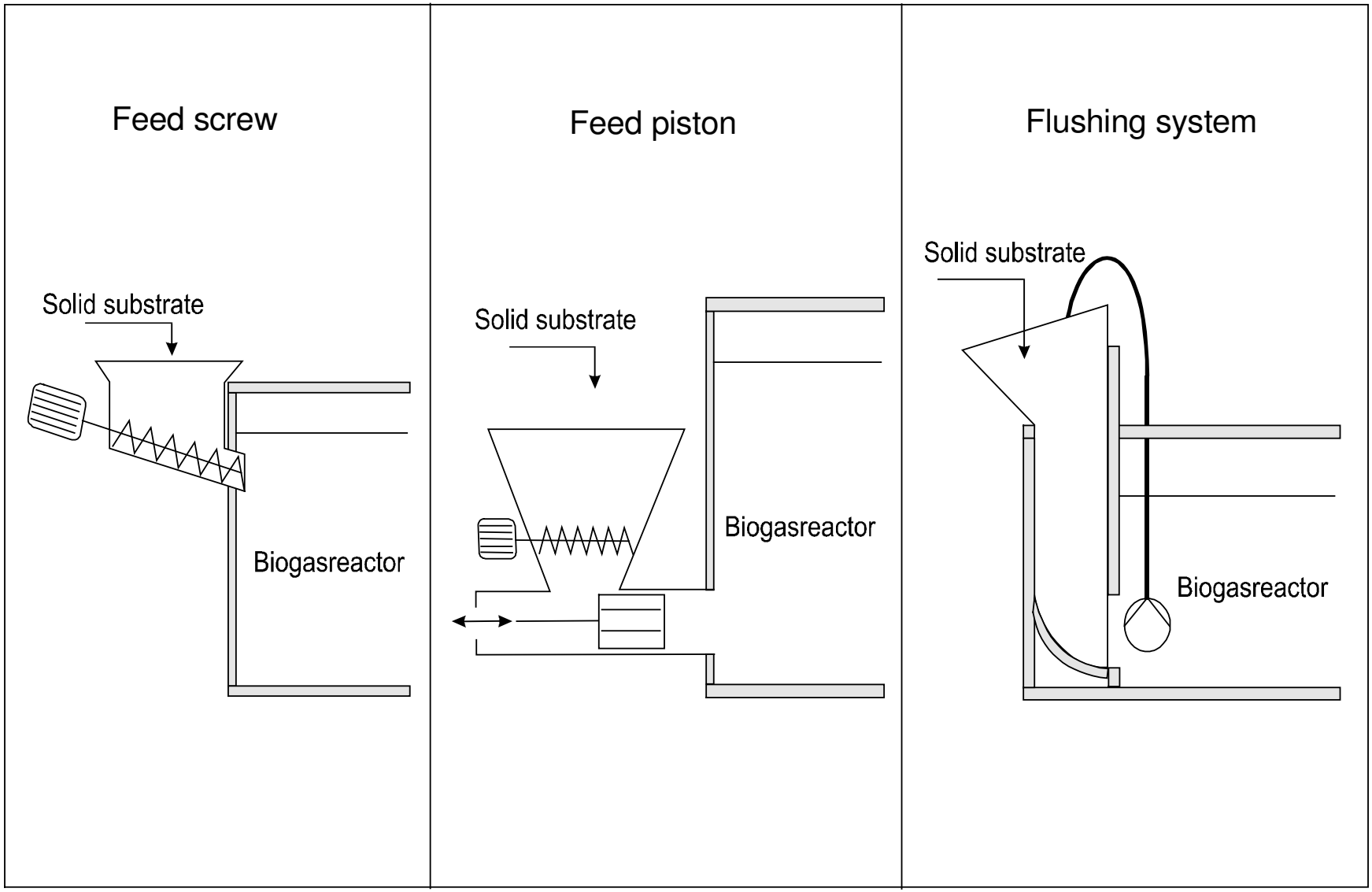
Application frequency of substrates



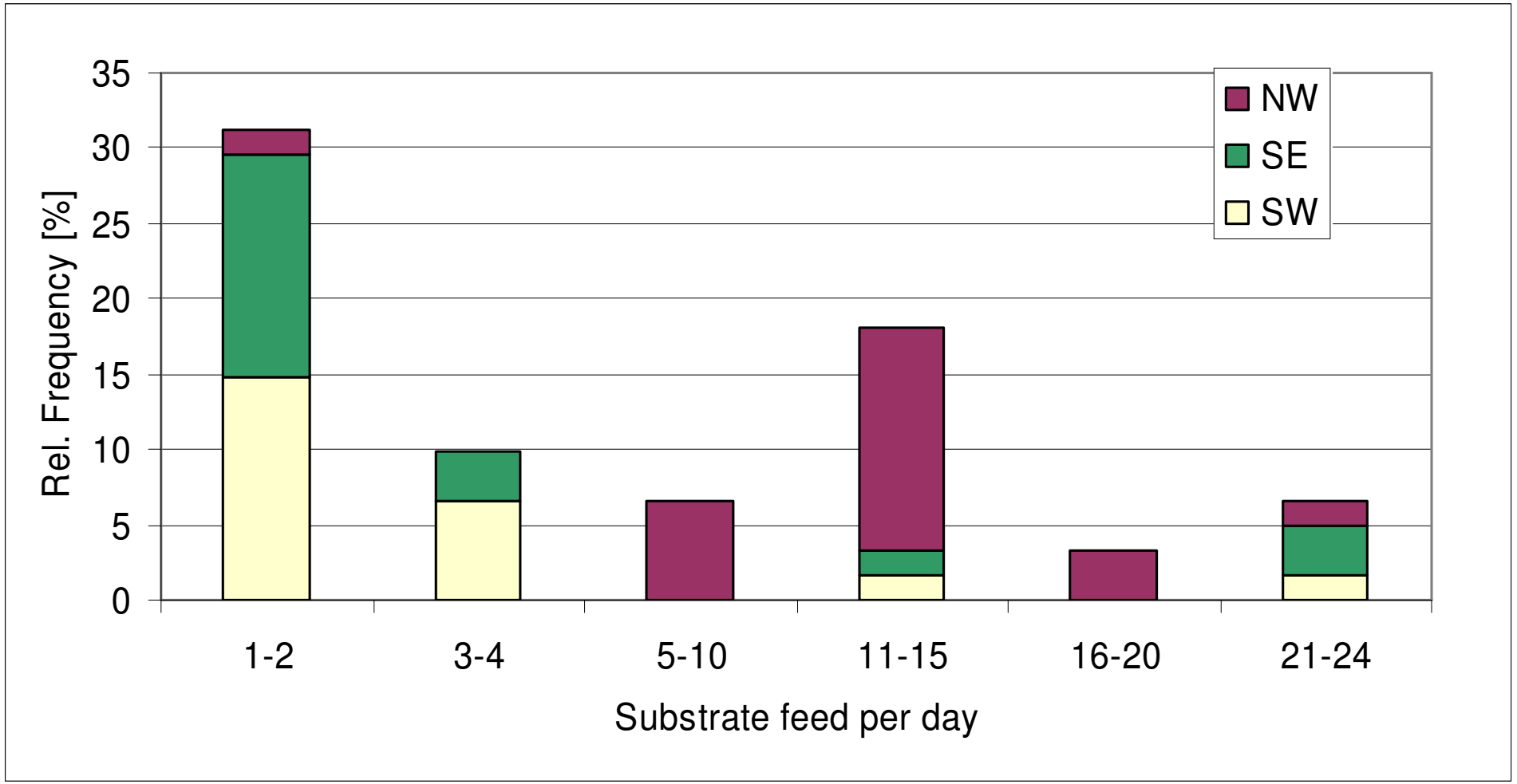
Manure content of fermenter input



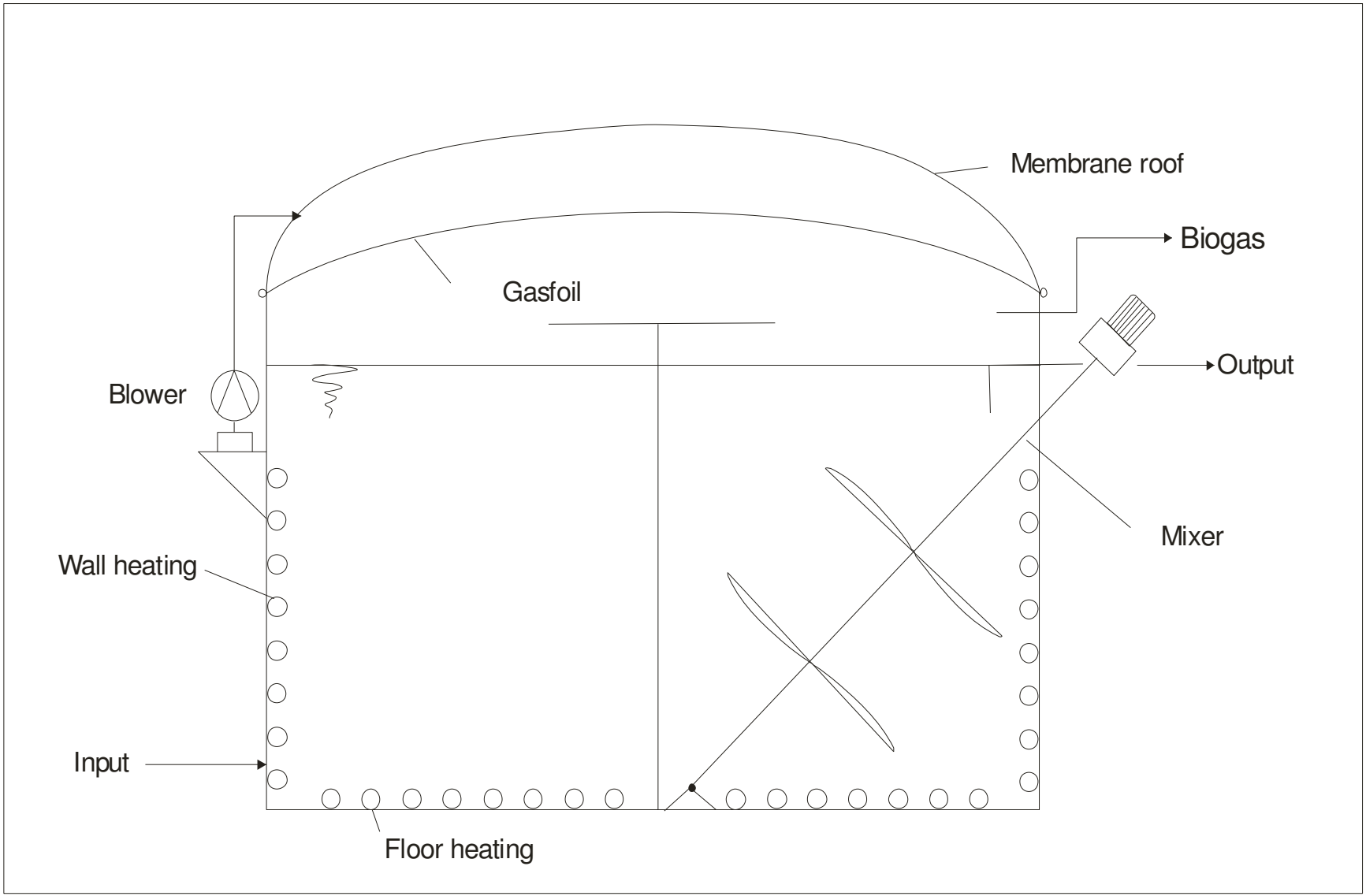
Direct-feeding systems for solids



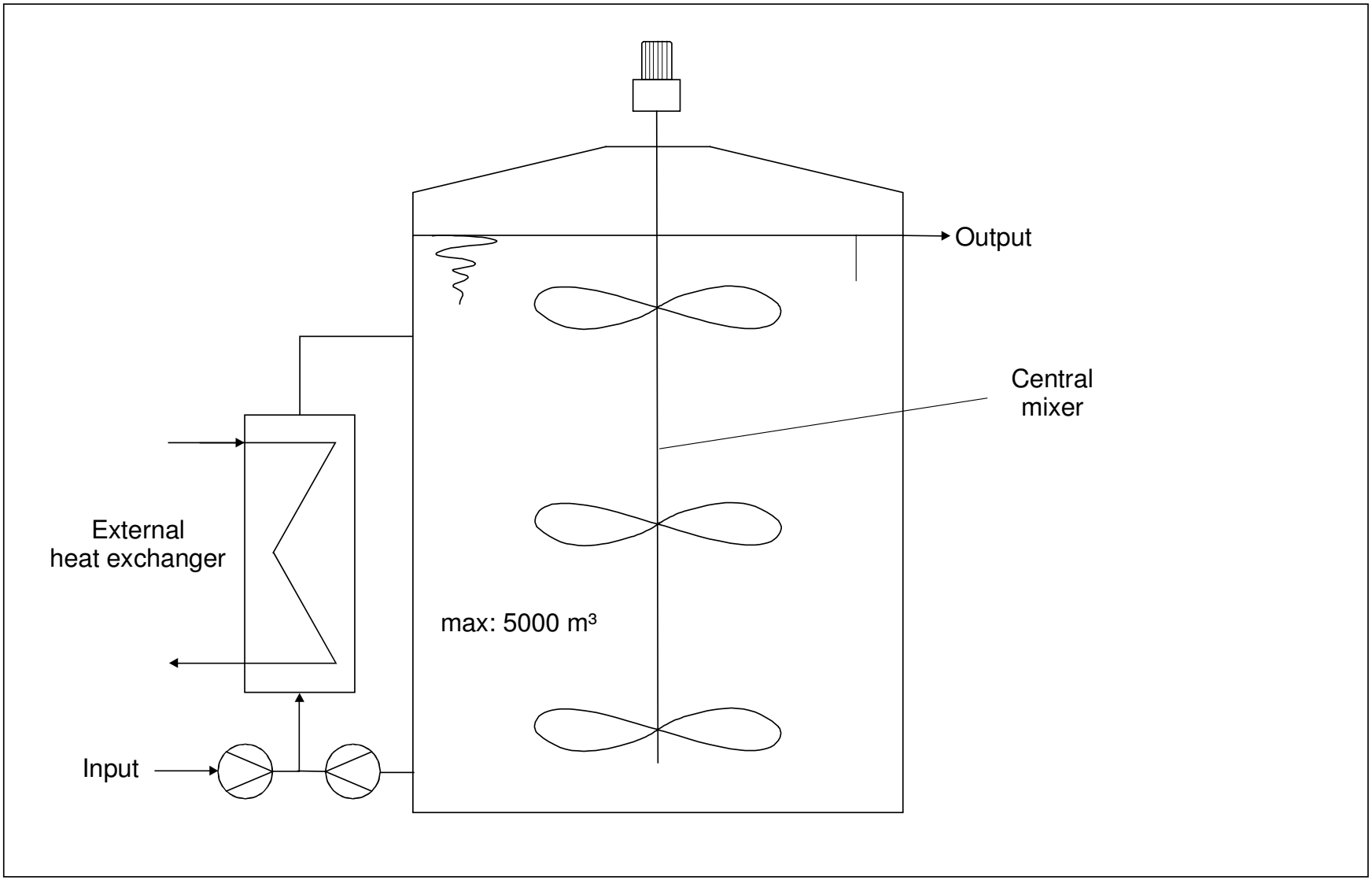
Substrate feed per day



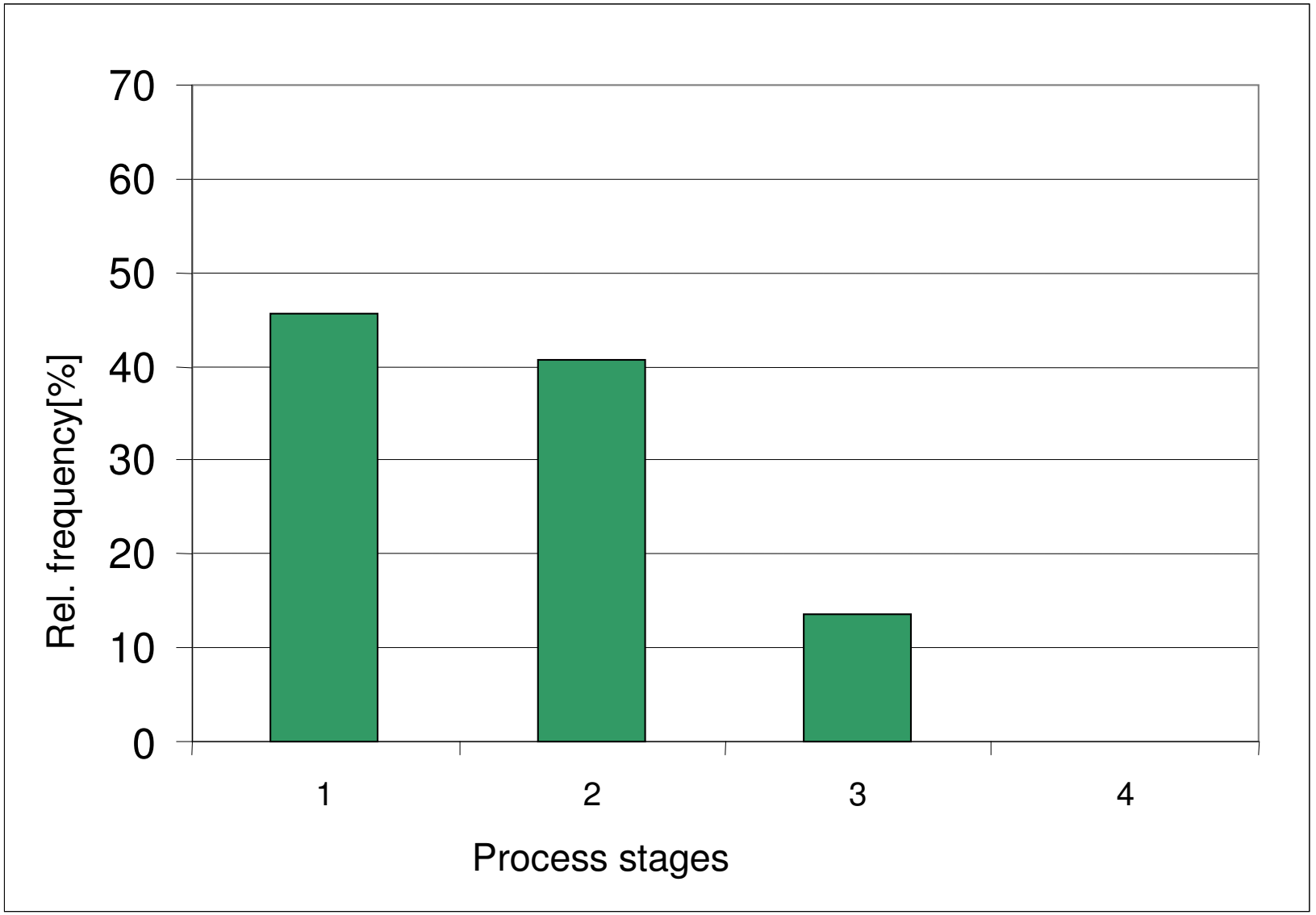
Digester with double membrane roof



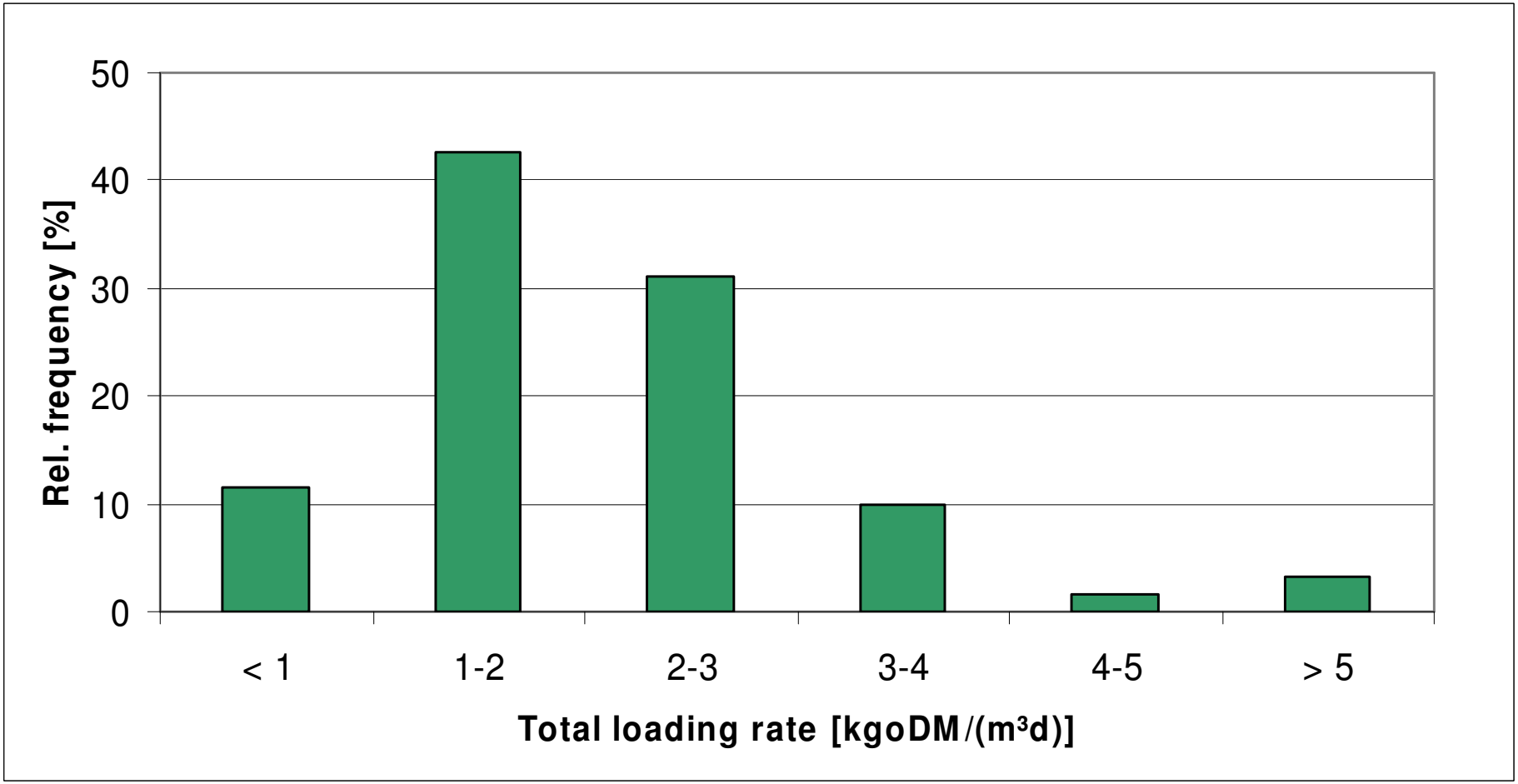
Upright large-scale digester



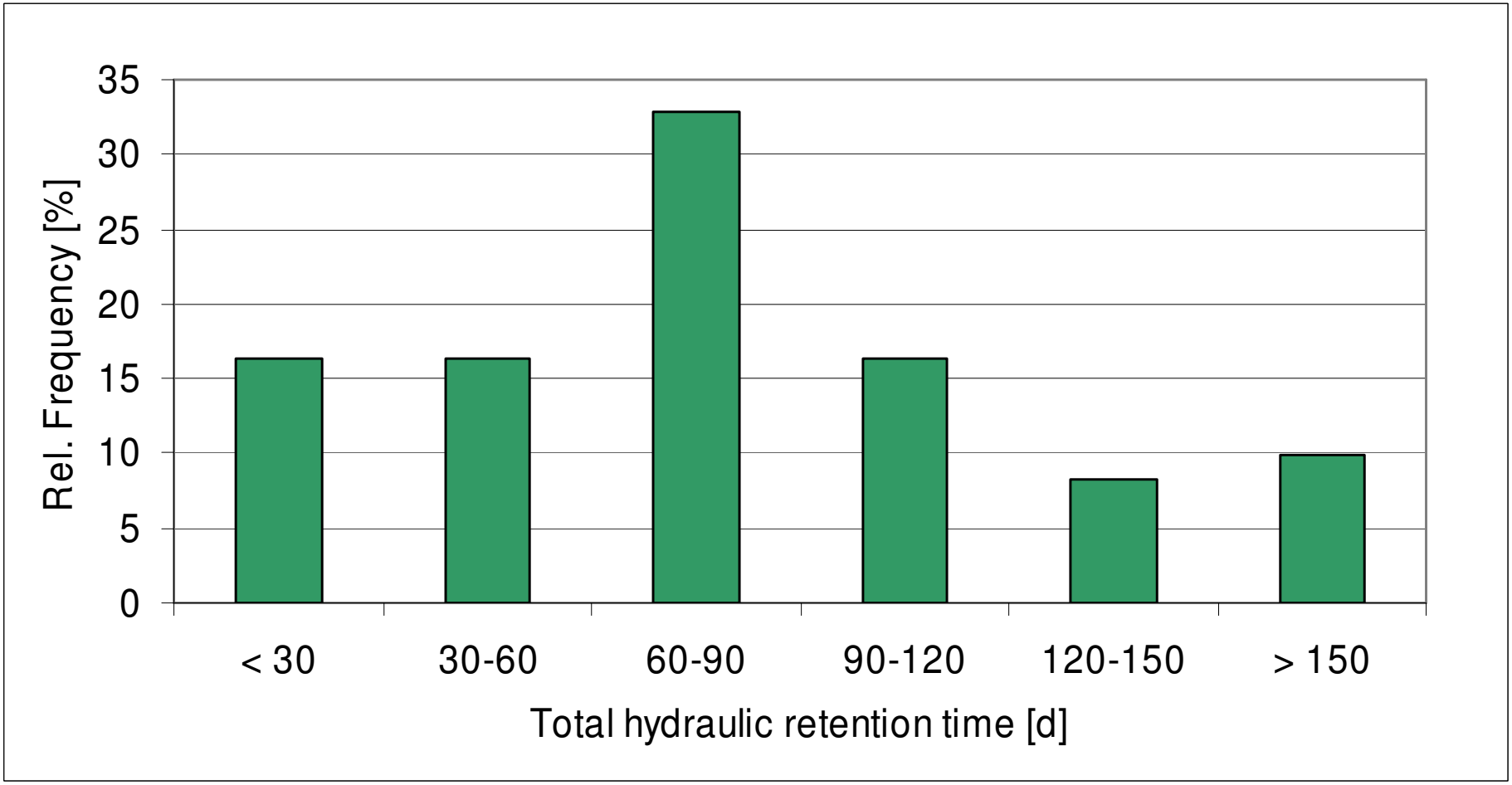
Number of process stages



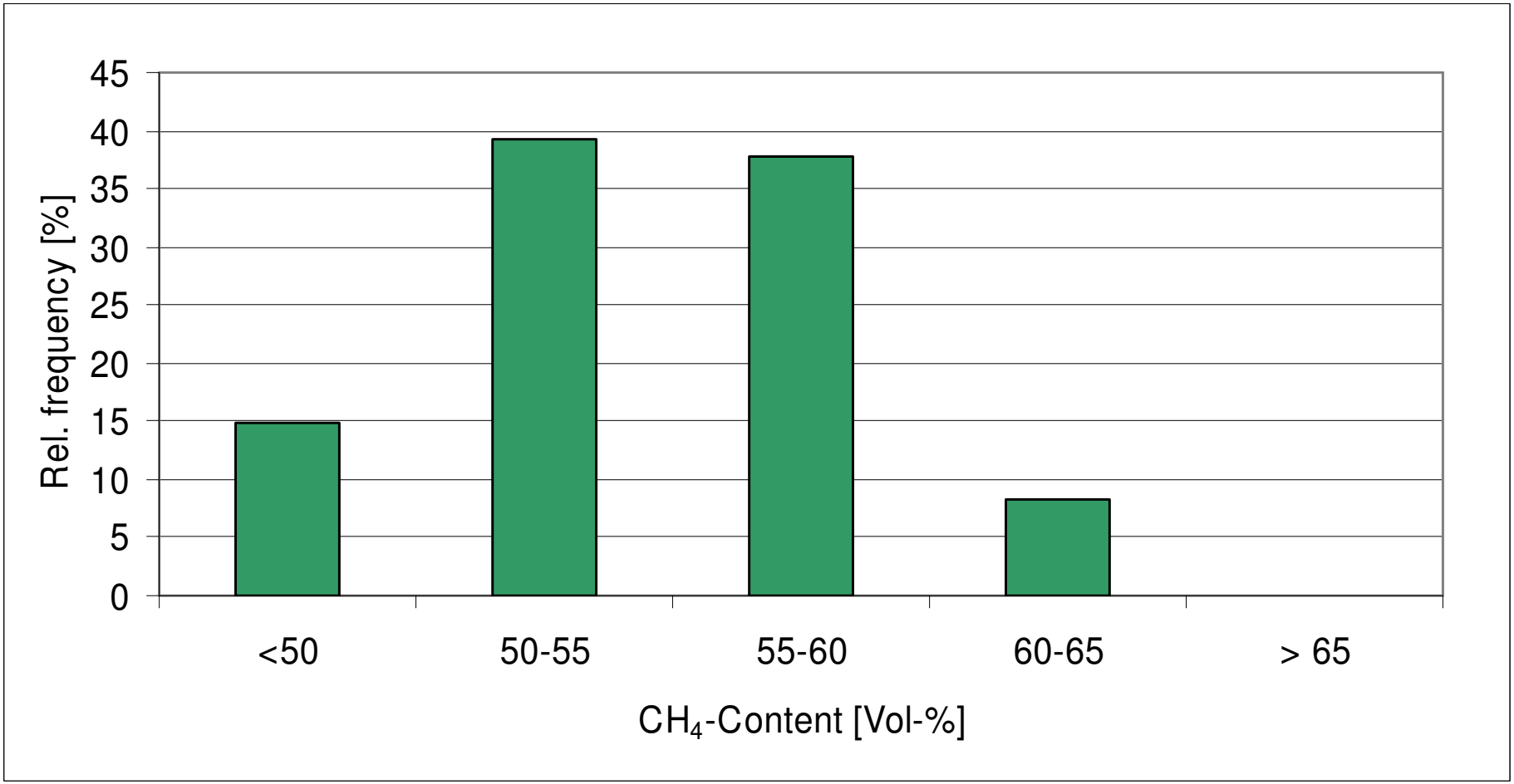
Organic loading rate



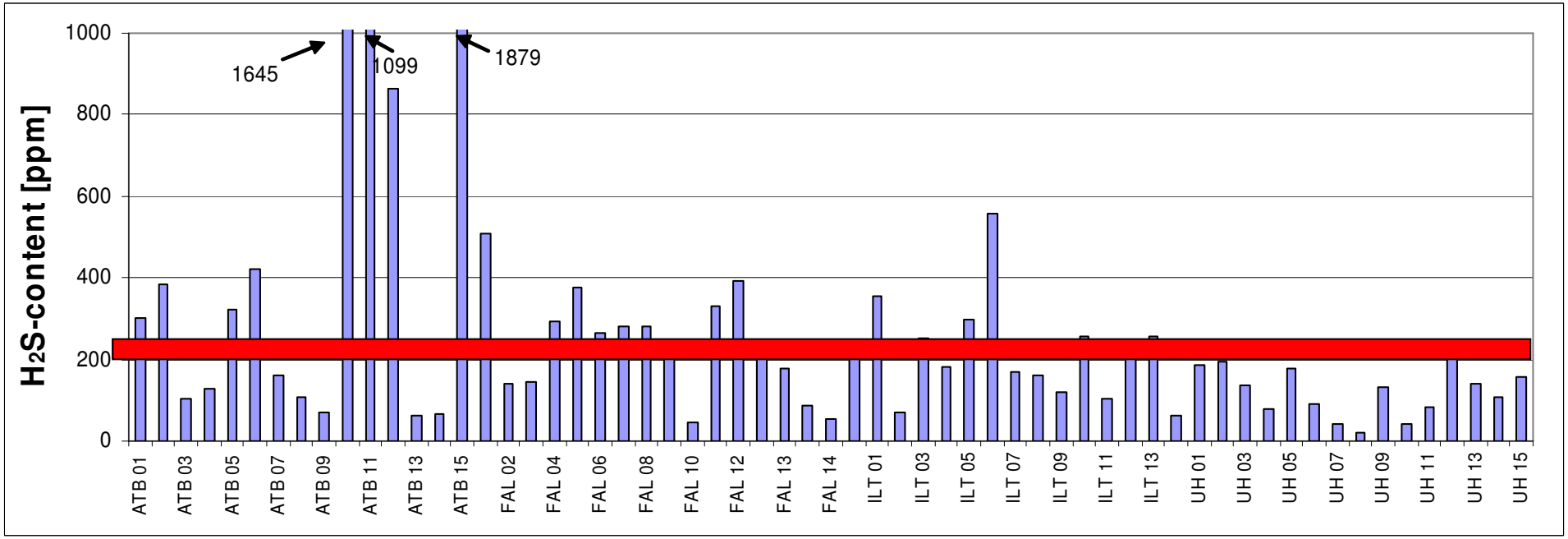
Typical retention time of biogas plants



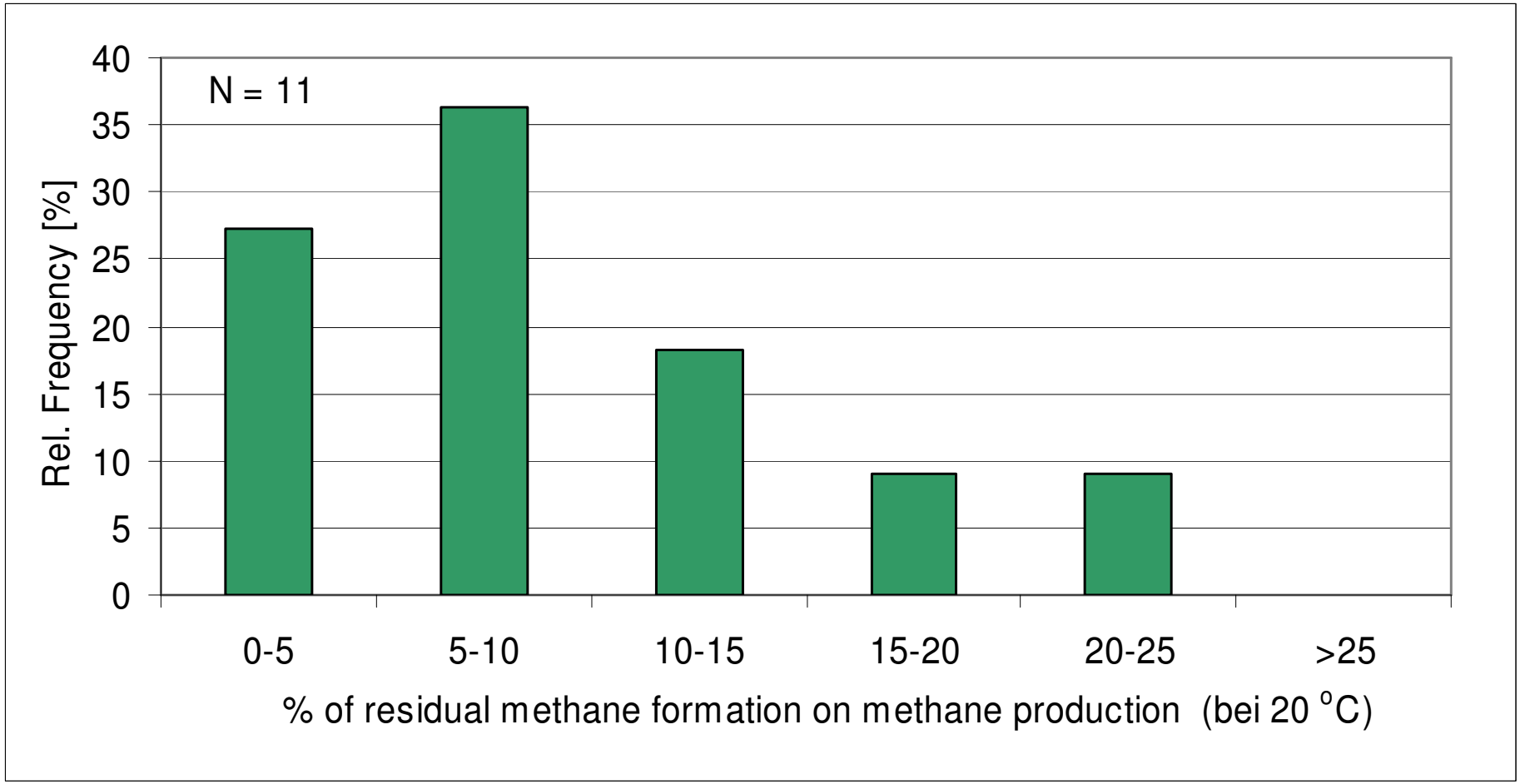
Methane content of biogas



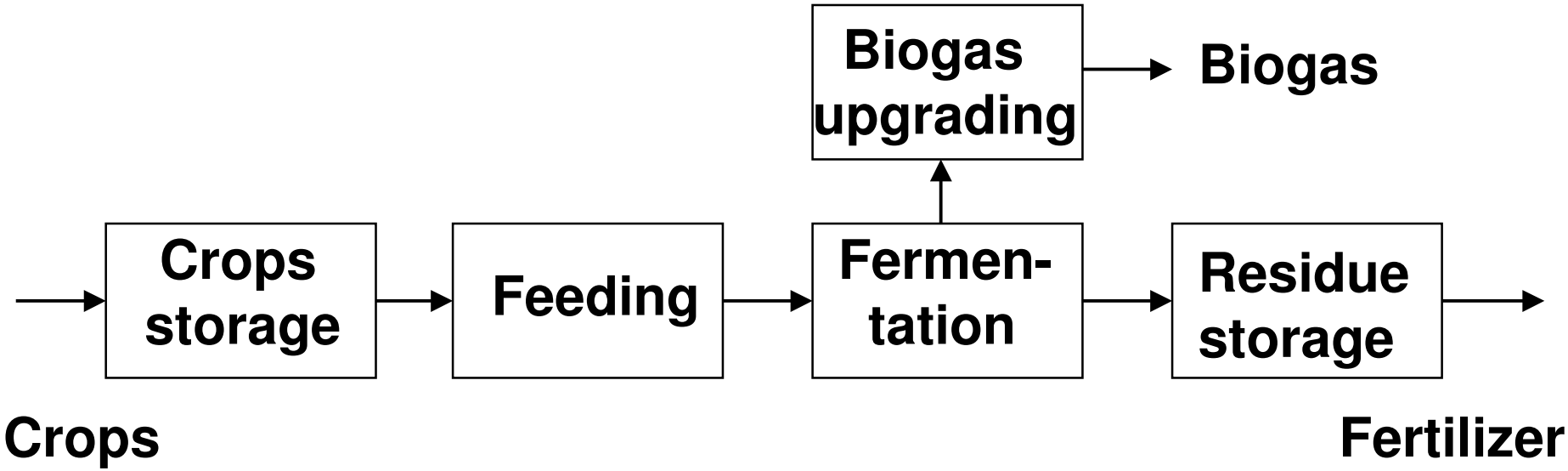
H_2S-content after desulphurization



Residual methane potential of digester residues



Process steps with typical bottle necks



Storage and substrate pre-treatment

Bottle neck	Effect
Non optimized formation of organic acids by ensiling	▪Energy losses during ensiling and storage ▪Increased risk for inhibition of the methanogenic process
Mold formation during ensiling and storage of energy crops	▪Inhibit the methanogenic activity
Insufficient disintegration of energy crops	▪Reduced anaerobic degradation rate ▪Risk for scum formation in fermenter ▪Bad handling properties of the substrate

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Solids feeding

Bottle neck	Effect
Discontinuously feeding of few charges per day	▪Reduced process stability ▪Reduced biogas yield ▪H_2S-peaks in biogas
Mixing of silage and process water in an external open tank	▪Energy losses by methane emissions ▪High energy demand for mixing
Direct solids feeding by screw conveyor, piston and flushing systems	▪Risk for blockage for screw conveyor diameter < 300 mm ▪Piston systems compacts long fiber crops ▪Flushing systems cannot be applied for crops of low density

Fermenter and storage tank (1)

Bottle neck	Effect
Scum formation	▪Reduced biogas yield ▪Clogging of the overflow pipe ▪Danger for the function of the whole process
Accumulation of biogas in the fermenter digestate	▪Reduction of the gas storage capacity in the top of fermenter ▪Fermenter can be operated only at reduced loading ▪Risk for clogging of the gas pipe
Short circuit flow of substrate	▪Reduced biogas yield ▪Incomplete degradation of the substrate

Fermenter and storage tank (2)

Bottle neck	Effect
Long hydraulic retention time	▪Large reactor volumes ▪Low specific methane productivity ▪High energy input per ton of substrate for heating and mixing
Formation of biogenic heat by mono-fermentation of energy crops	▪Stable mesophilic temperature conditions cannot be achieved ▪Process failure due to the reduced microbial activity above 42 °C
Open digestate storage tanks	▪Uncontrolled methane emissions (climate effect)

Biogas upgrading

Bottle neck	Effect
Insufficient biological desulphurization	▪ Reduced lifespan of the CHP
Feeding of surplus air to the fermenter for biological desulphurization	▪Reduction of the ignitability of the gas due to the low CH_4-content of biogas
Incomplete drying of biogas	Formation of condensate can disturb: ▪The transportation of biogas ▪All measuring devices in the gas main ▪The function of the CHP

Sizing of Equipment

Bottle neck	Effect
Reliable dates of the biogas yield of energy crops	Insufficient adaptation of fermenter and CHP-capacity which result in: ▪Reduced electrical efficiency of CHP ▪Increased pollutant emission from CHP ▪Intermittent operation of CHP
Reliable dates concerning the degradation capacity of the H_2S-oxidizing bacteria	▪The efficiency of H_2S reduction cannot be calculated exactly resulting in over- or undersized installations.

Summary and outlook

- The results have shown that all important agricultural crops can be used for biogas production.
- For increasing the process efficiency and reliability the whole process chain has to be optimized.
- All process units must be adapted on the specific properties of energy crops.
- Few experiences are available from plants with mono-fermentation of energy crops.
- The missing stabilizing effect of manure makes a better process control necessary.

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Many thanks for your attention!