

Workshop “ENERGY CROPS & BIOGAS”

Utrecht, 22 September 2005



Results and bottle necks of energy crop digestion plants

- Required process technology innovations -

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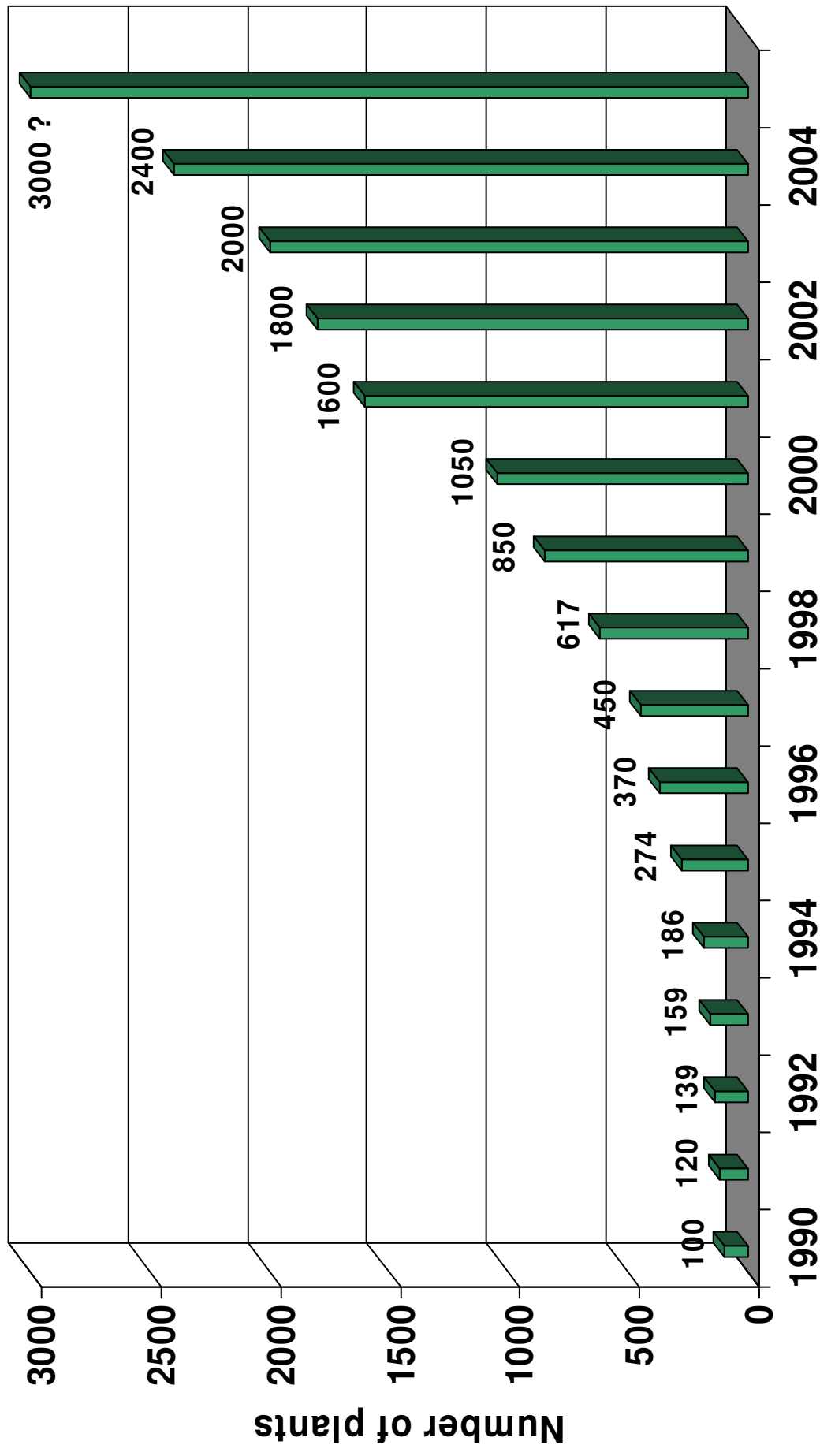
Outline

- **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**

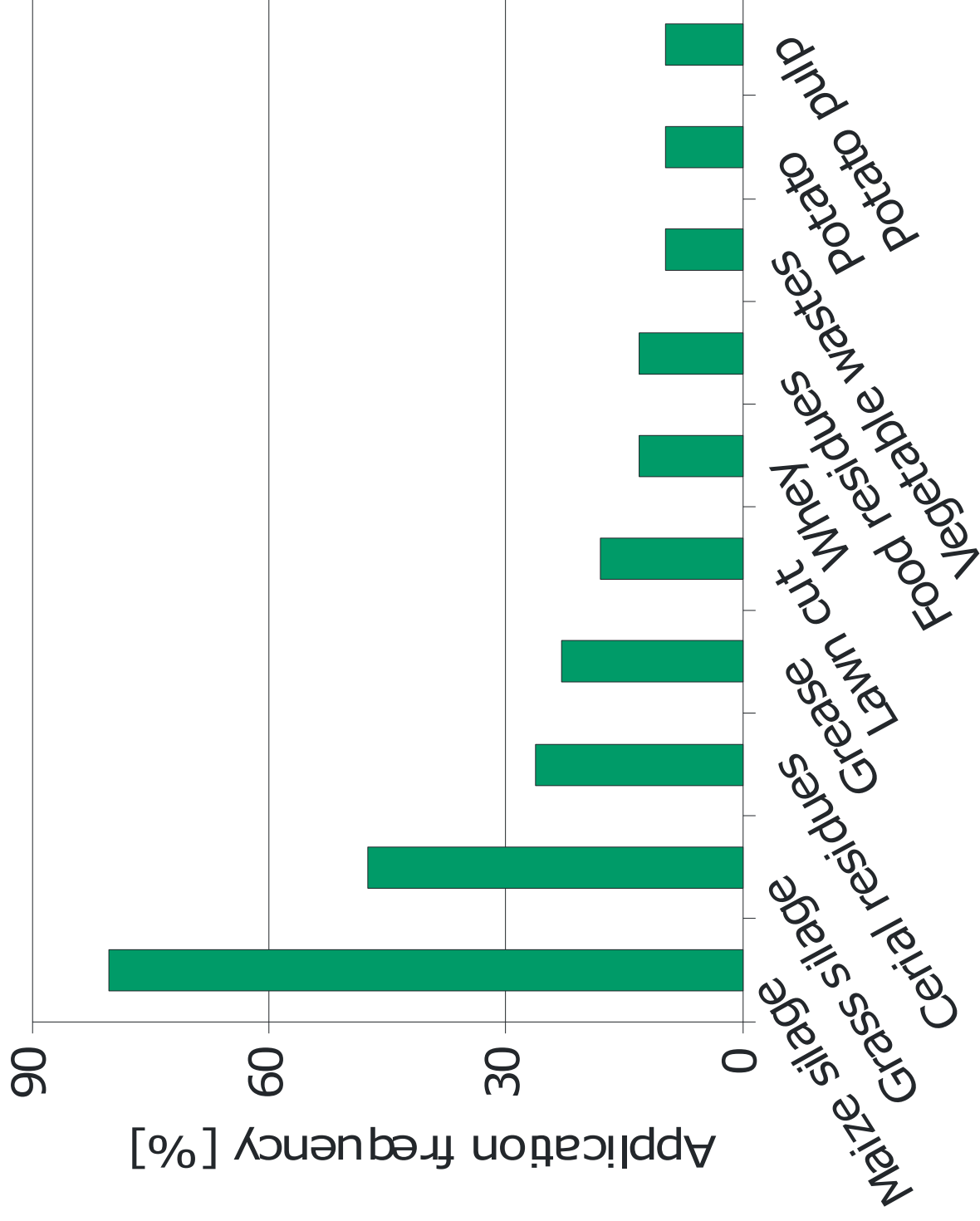
Renewable Energy Sources Act (2005)

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

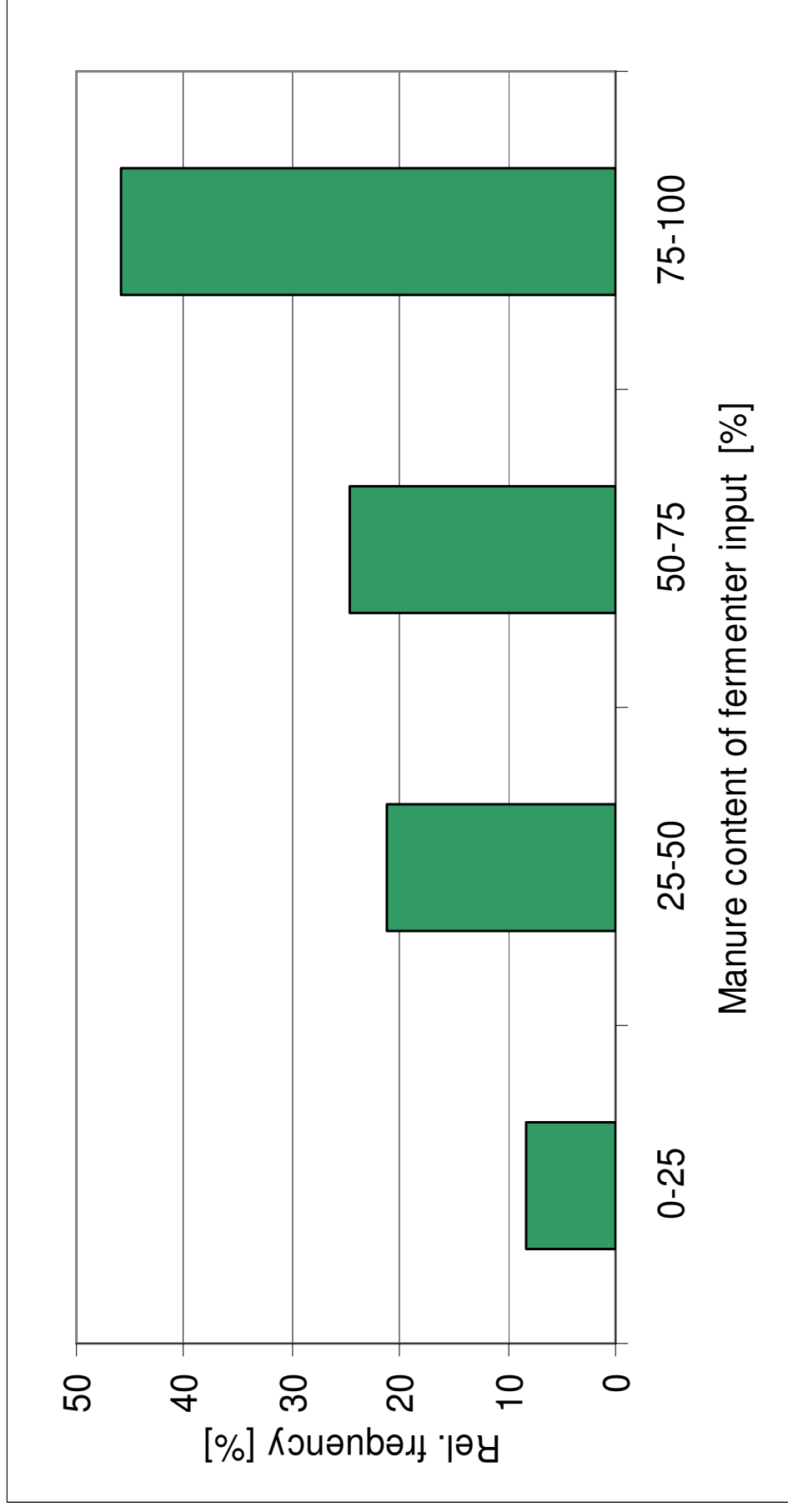
Biogas plants in Germany



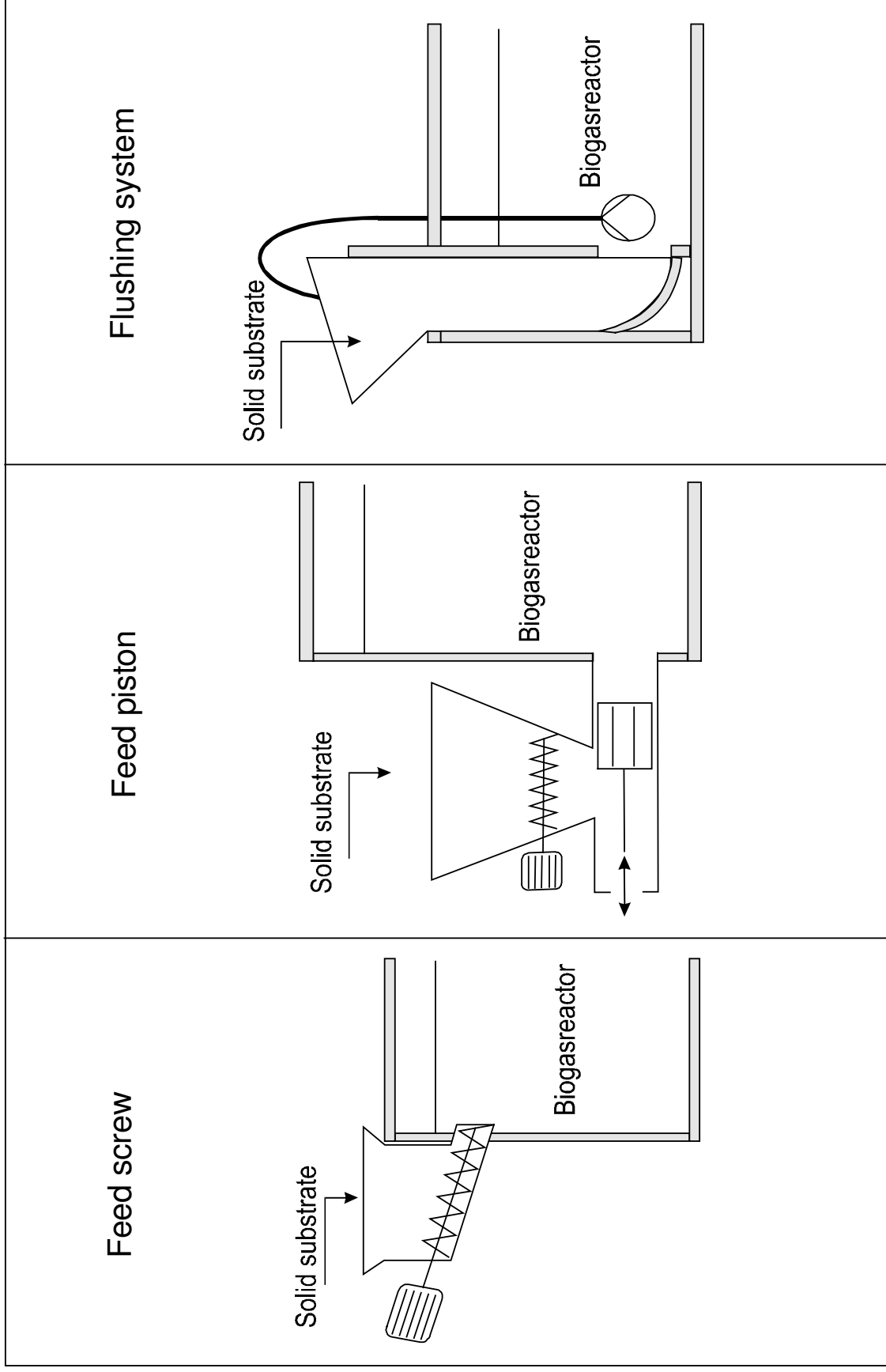
Application frequency of substrates



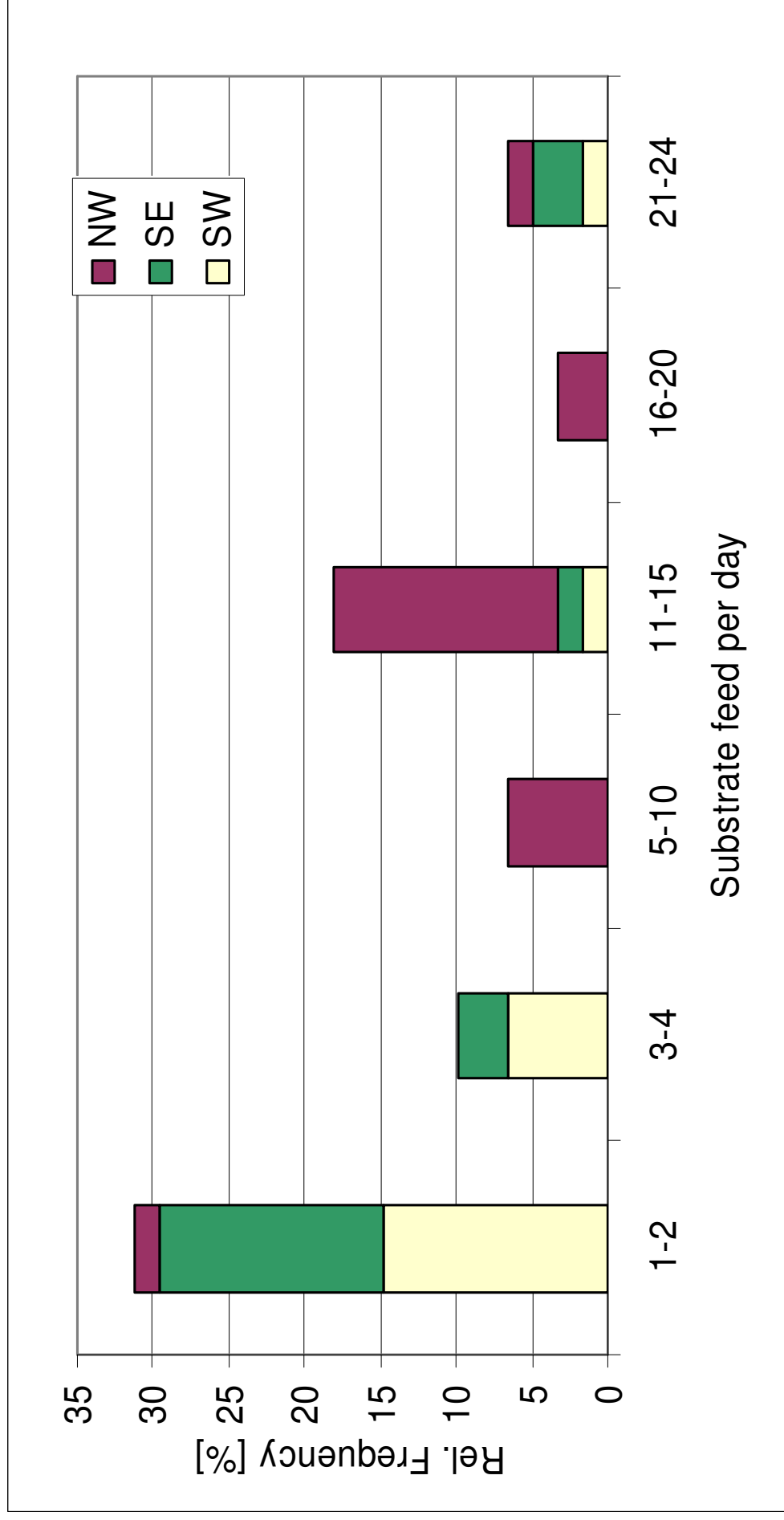
Manure content of fermenter input



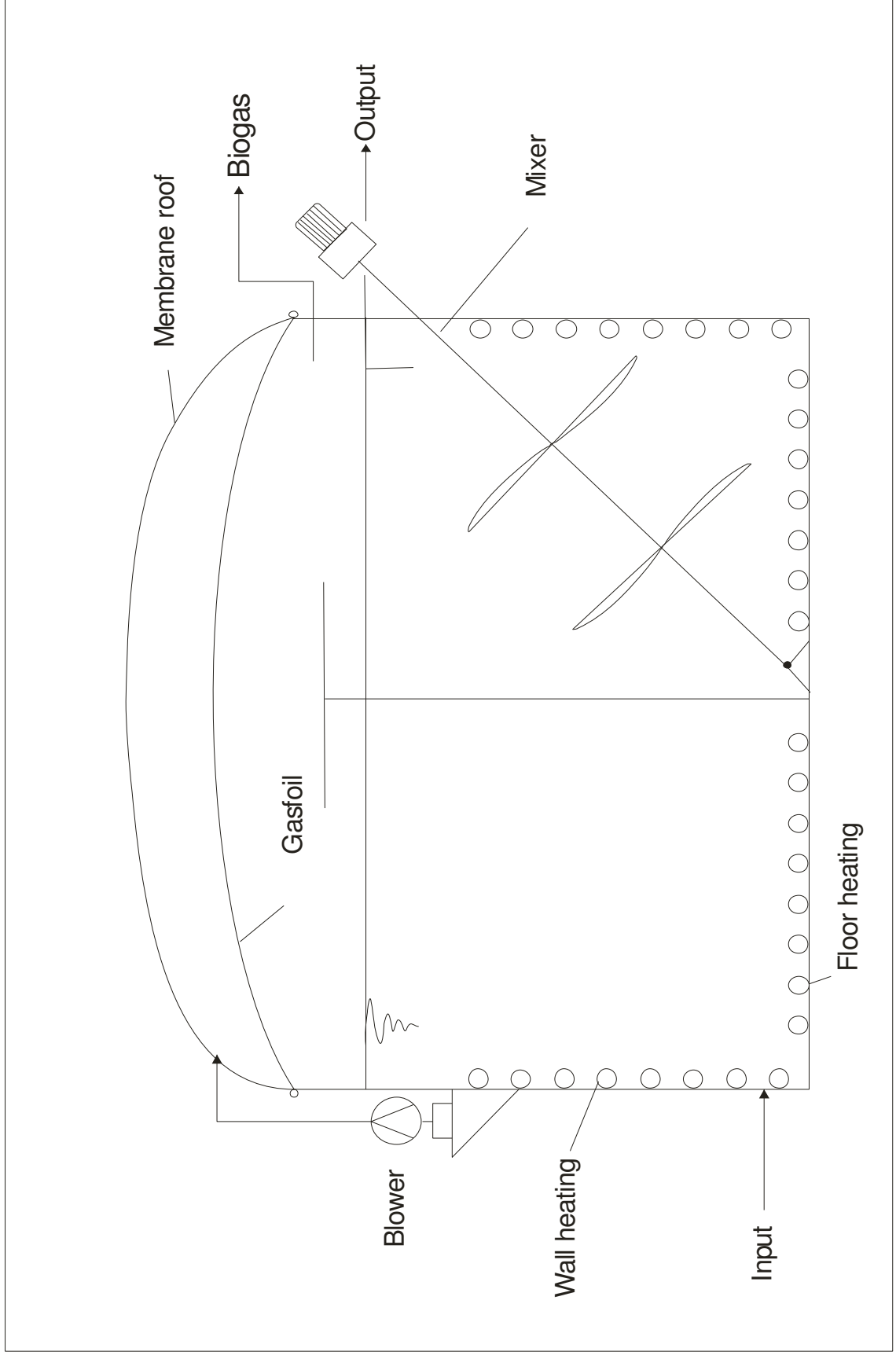
Direct-feeding systems for solids



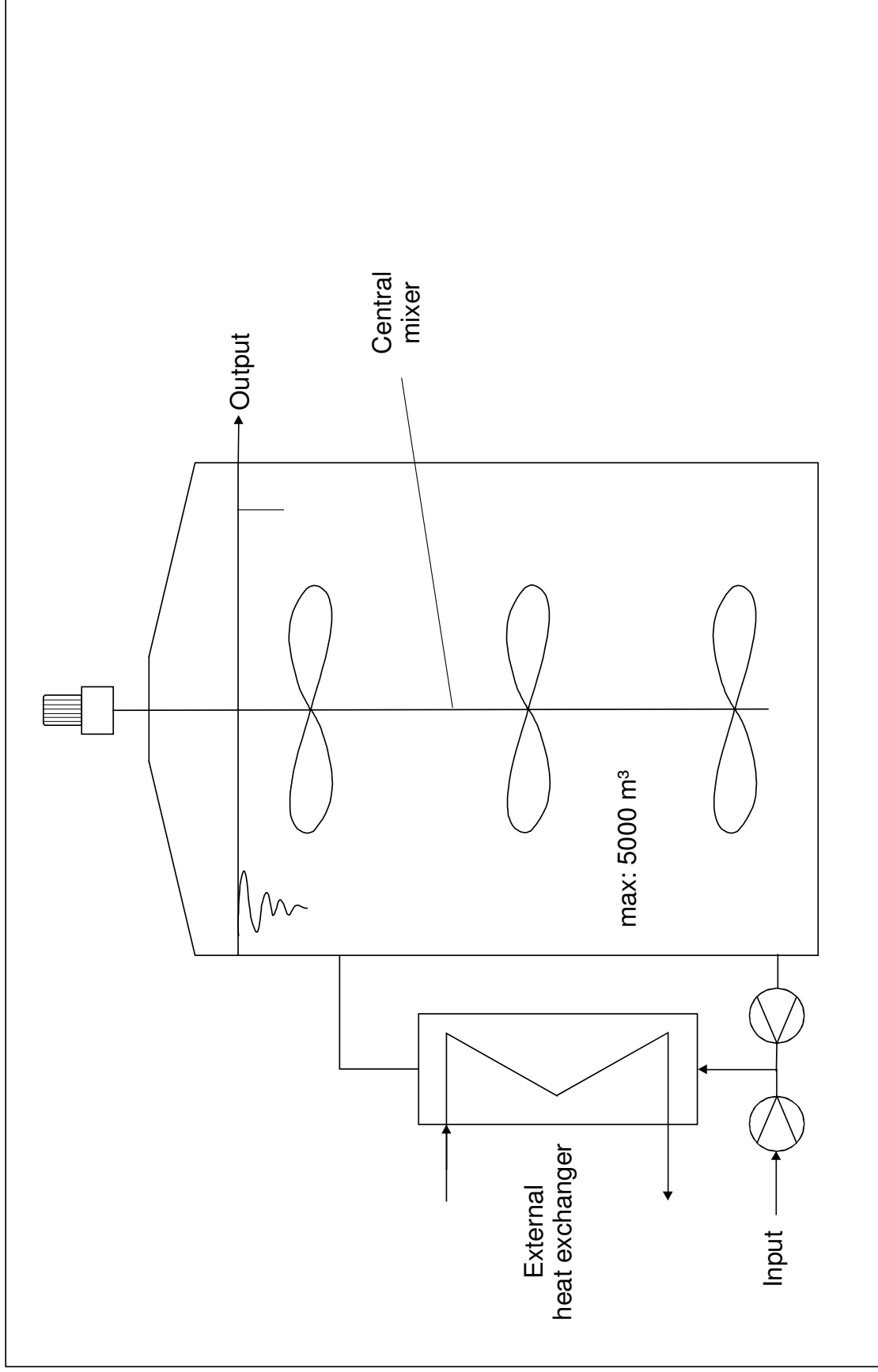
Substrate feed per day



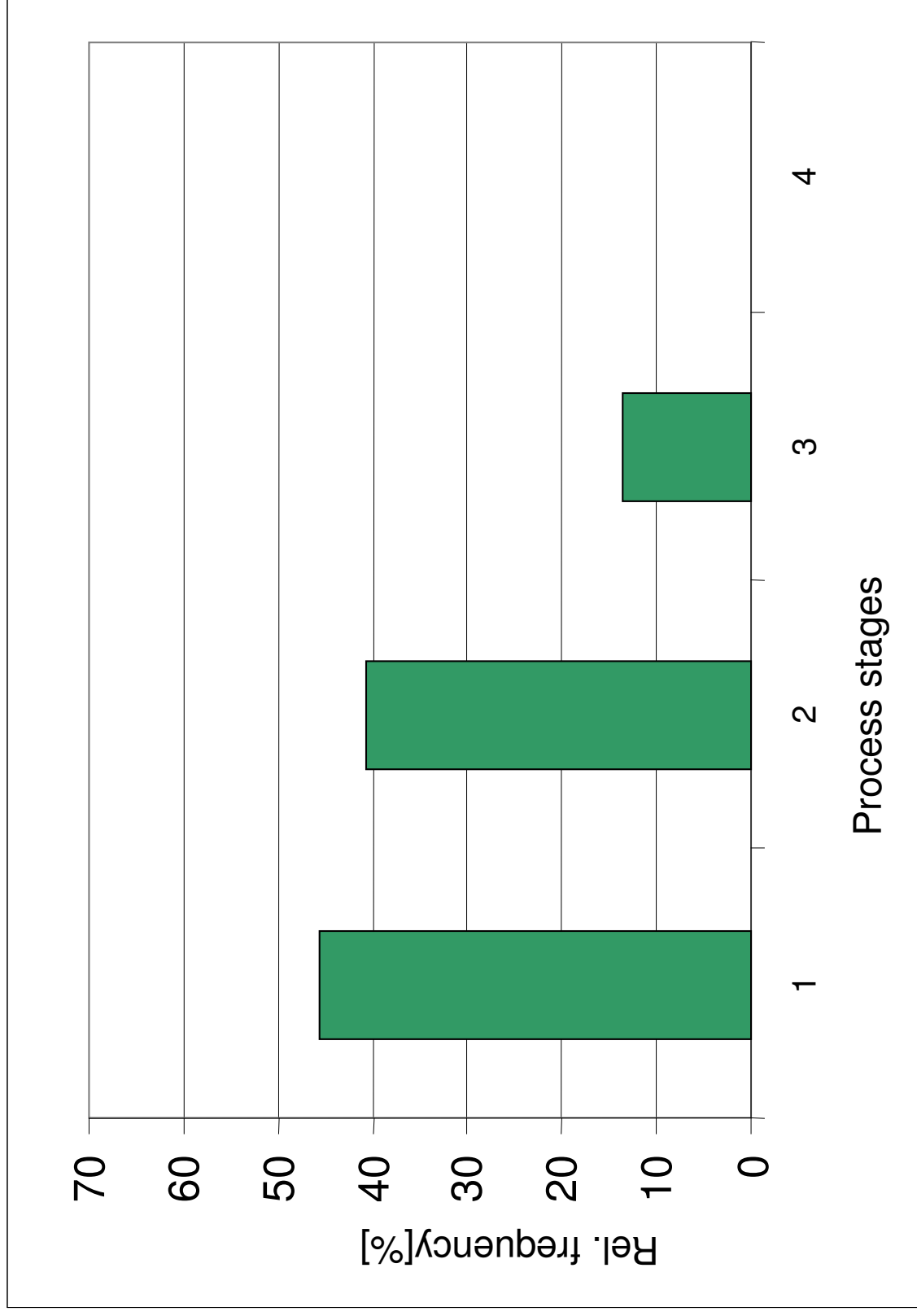
Digester with double membrane roof



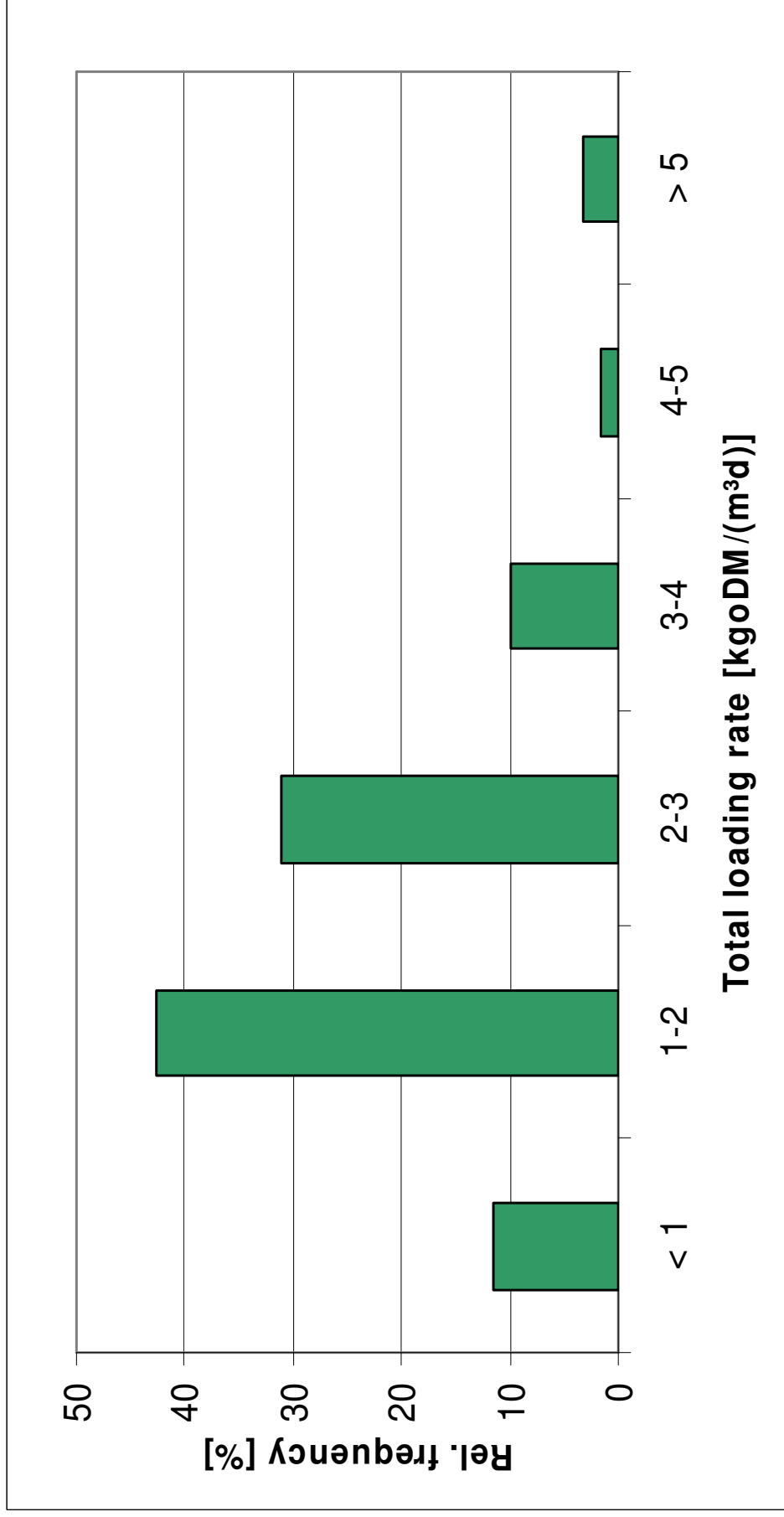
Upright large-scale digester



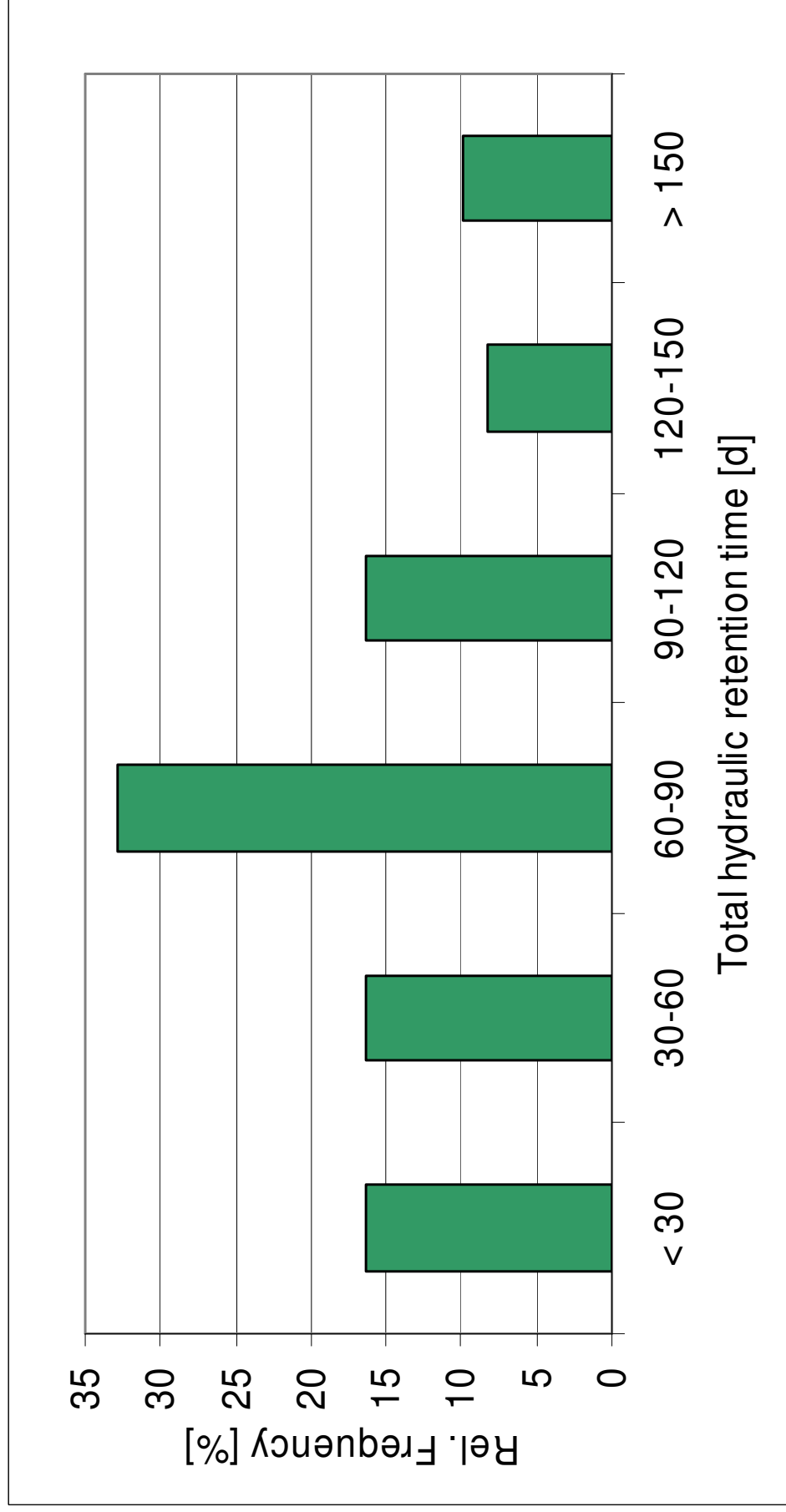
Number of process stages



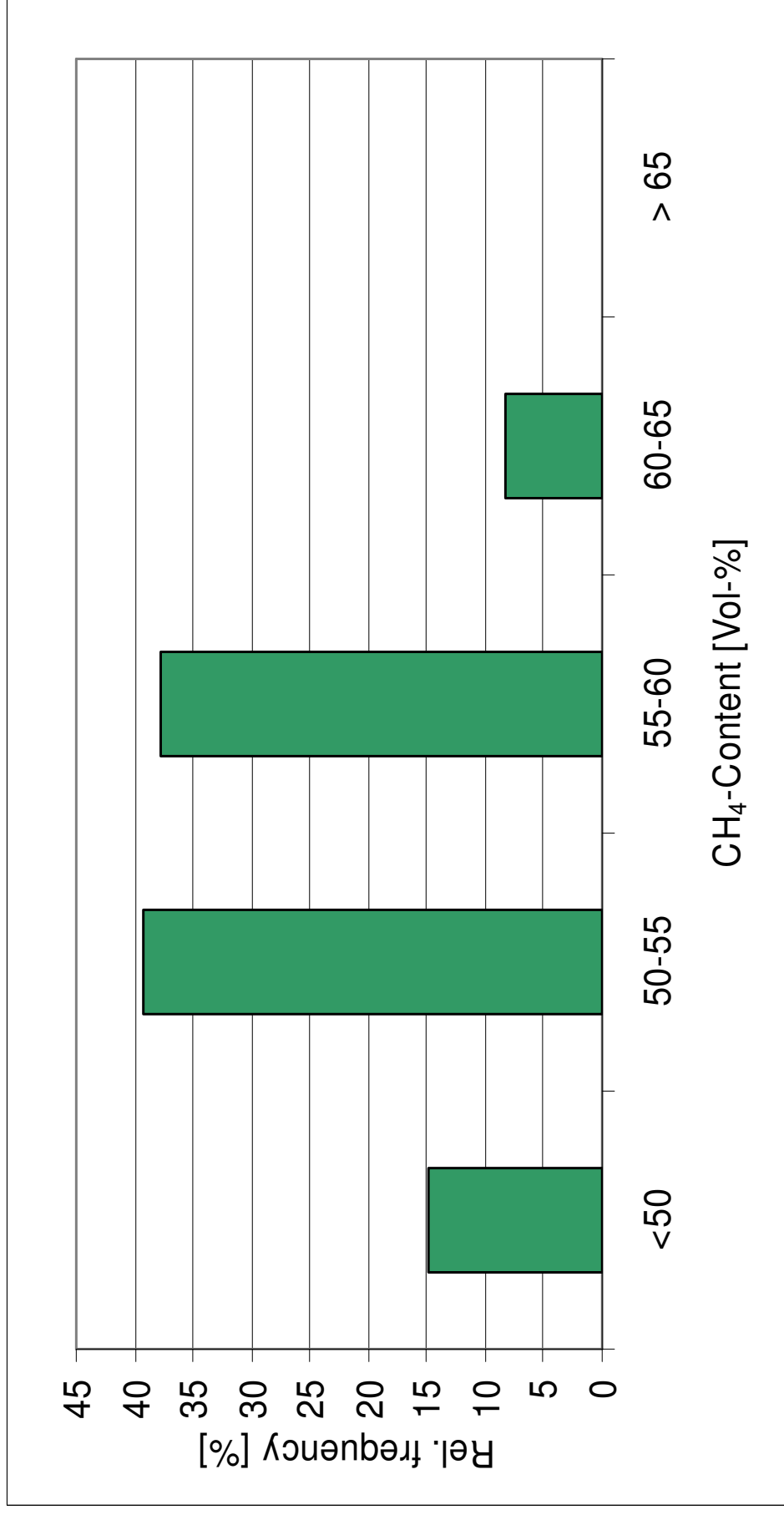
Organic loading rate



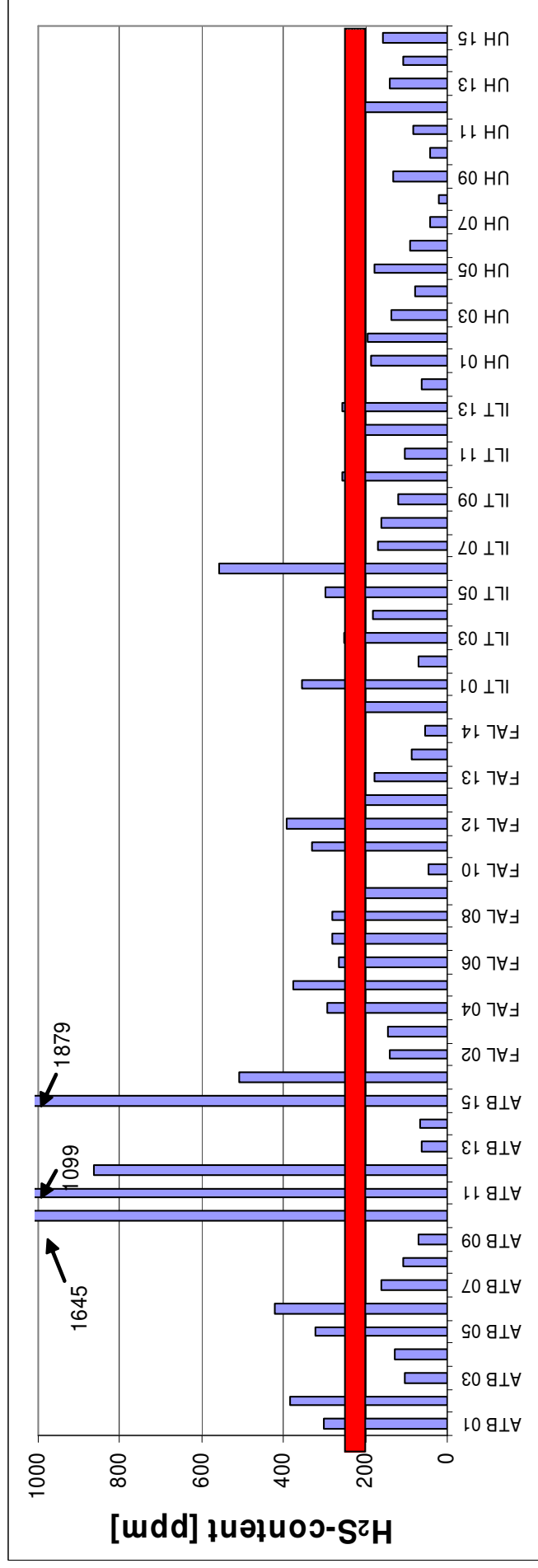
Typical retention time of biogas plants



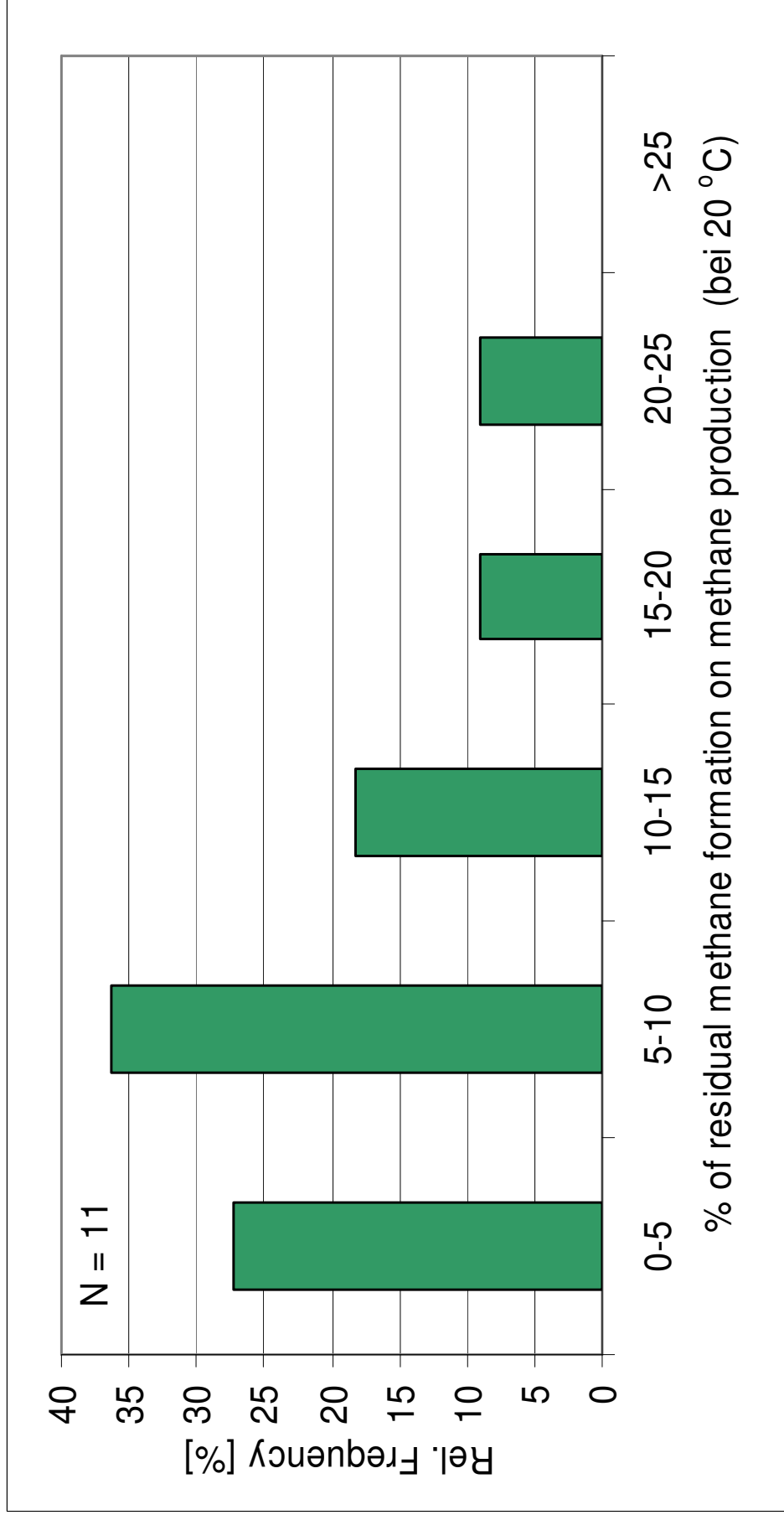
Methane content of biogas



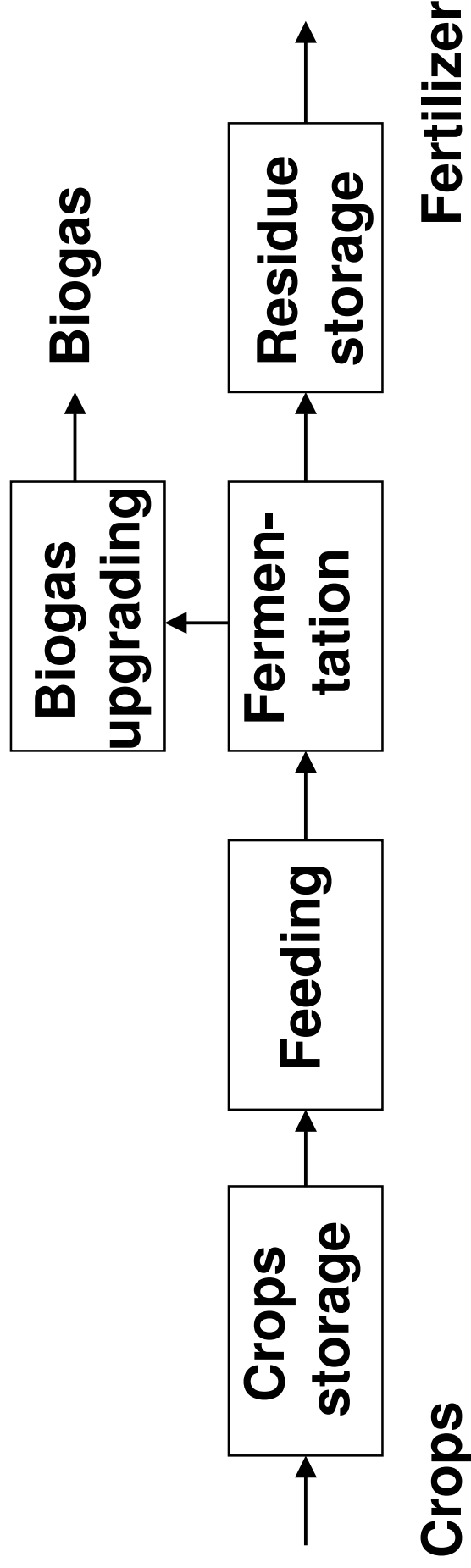
H₂S-content after desulphurization



Residual methane potential of digester residues



Process steps with typical bottle necks



Storage and substrate pre-treatment

Bottle neck	Effect
<p>Non optimized formation of organic acids by ensiling</p>	<ul style="list-style-type: none">▪ Energy losses during ensiling and storage▪ Increased risk for inhibition of the methanogenic process
<p>Mold formation during ensiling and storage of energy crops</p>	<ul style="list-style-type: none">▪ Inhibit the methanogenic activity
<p>Insufficient disintegration of energy crops</p>	<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">▪ Reduced process stability▪ Reduced biogas yield▪ H₂S-peaks in biogas
Mixing of silage and process water in an external open tank	<ul style="list-style-type: none">▪ Energy losses by methane emissions▪ High energy demand for mixing
Direct solids feeding by screw conveyor, piston and flushing systems	<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">-Reduced biogas yield-Clogging of the overflow pipe-Danger for the function of the whole process
Accumulation of biogas in the fermenter digestate	<ul style="list-style-type: none">-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	<ul style="list-style-type: none">-Reduced biogas yield-Incomplete degradation of the substrate

Fermenter and storage tank (2)

Bottle neck	Effect
Long hydraulic retention time	<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">▪ Stable mesophilic temperature conditions cannot be achieved▪ Process failure due to the reduced microbial activity above 42 °C
Open digestate storage tanks	<ul style="list-style-type: none">▪ Uncontrolled methane emissions (climate effect)

Biogas upgrading

Bottle neck	Effect
Insufficient biological desulphurization	<ul style="list-style-type: none">▪ Reduced lifespan of the CHP
Feeding of surplus air to the fermenter for biological desulphurization	<ul style="list-style-type: none">▪ Reduction of the ignitability of the gas due to the low CH₄-content of biogas
Incomplete drying of biogas	<p>Formation of condensate can disturb:</p> <ul style="list-style-type: none">▪ The transportation of biogas▪ All measuring devices in the gas main▪ The function of the CHP

Sizing of Equipment

Bottle neck	Effect
<p>Reliable dates of the biogas yield of energy crops</p>	<p>Insufficient adaptation of fermenter and CHP-capacity which result in:</p> <ul style="list-style-type: none">▪ Reduced electrical efficiency of CHP▪ Increased pollutant emission from CHP▪ Intermittent operation of CHP
<p>Reliable dates concerning the degradation capacity of the H₂S-oxidizing bacteria</p>	<ul style="list-style-type: none">▪ The efficiency of H₂S 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!

