

EXPERIENCES FROM LARGE SCALE USE OF CROPS FOR BIOGAS PRODUCTION

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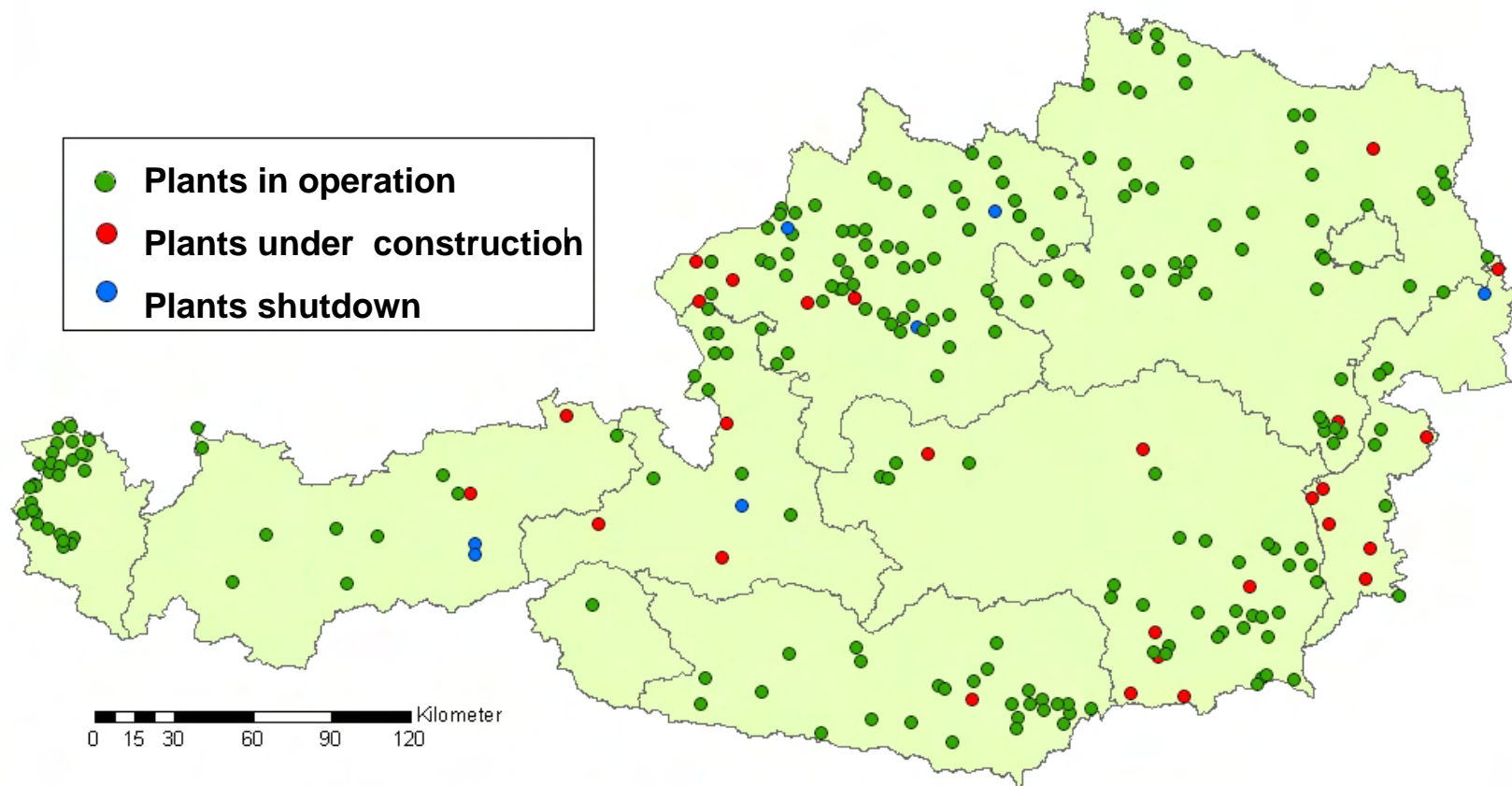
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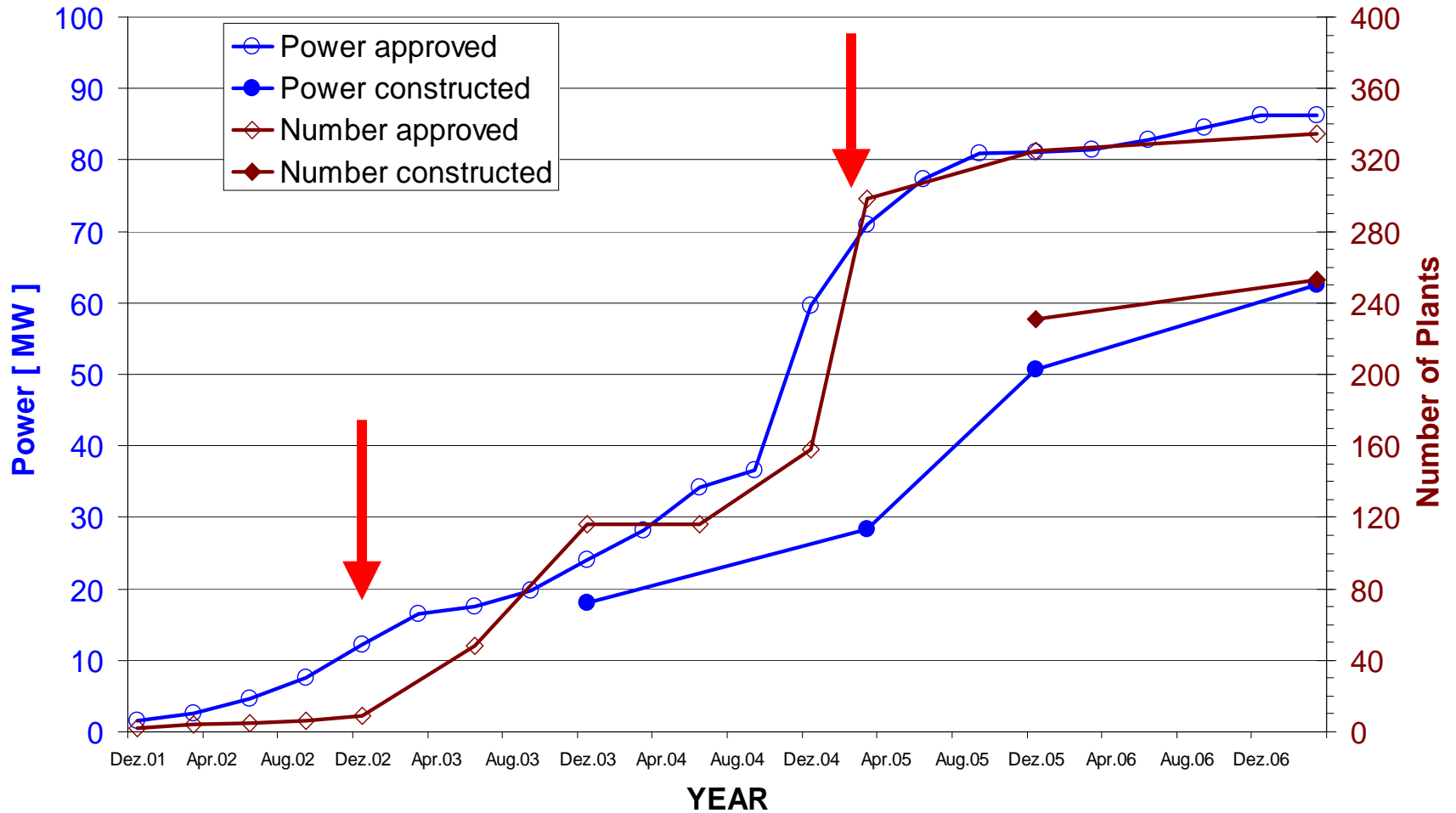
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- **Current status of biogas progress in Austria**
- **Process technology of energy crop digestion**
- **A representative full scale example**
- **Biogas plant monitoring & evaluation in Austria**
- **Economics estimation of biogas production**

Approximately 350 Agricultural biogas plants in Austria



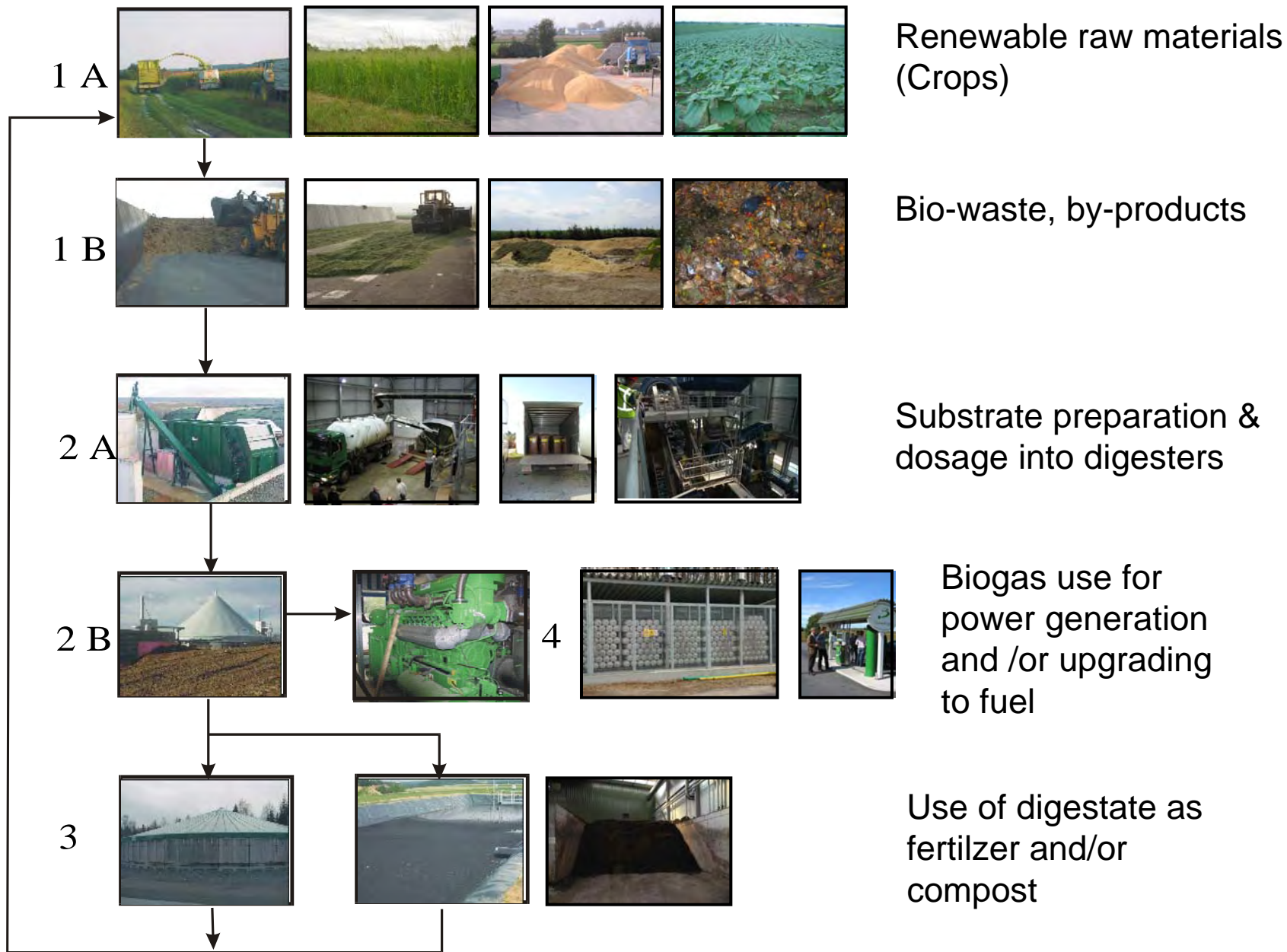
Biogas Plants in Austria Data: e-control Austria



Austrian Tariff for Green Electricity from Biogas

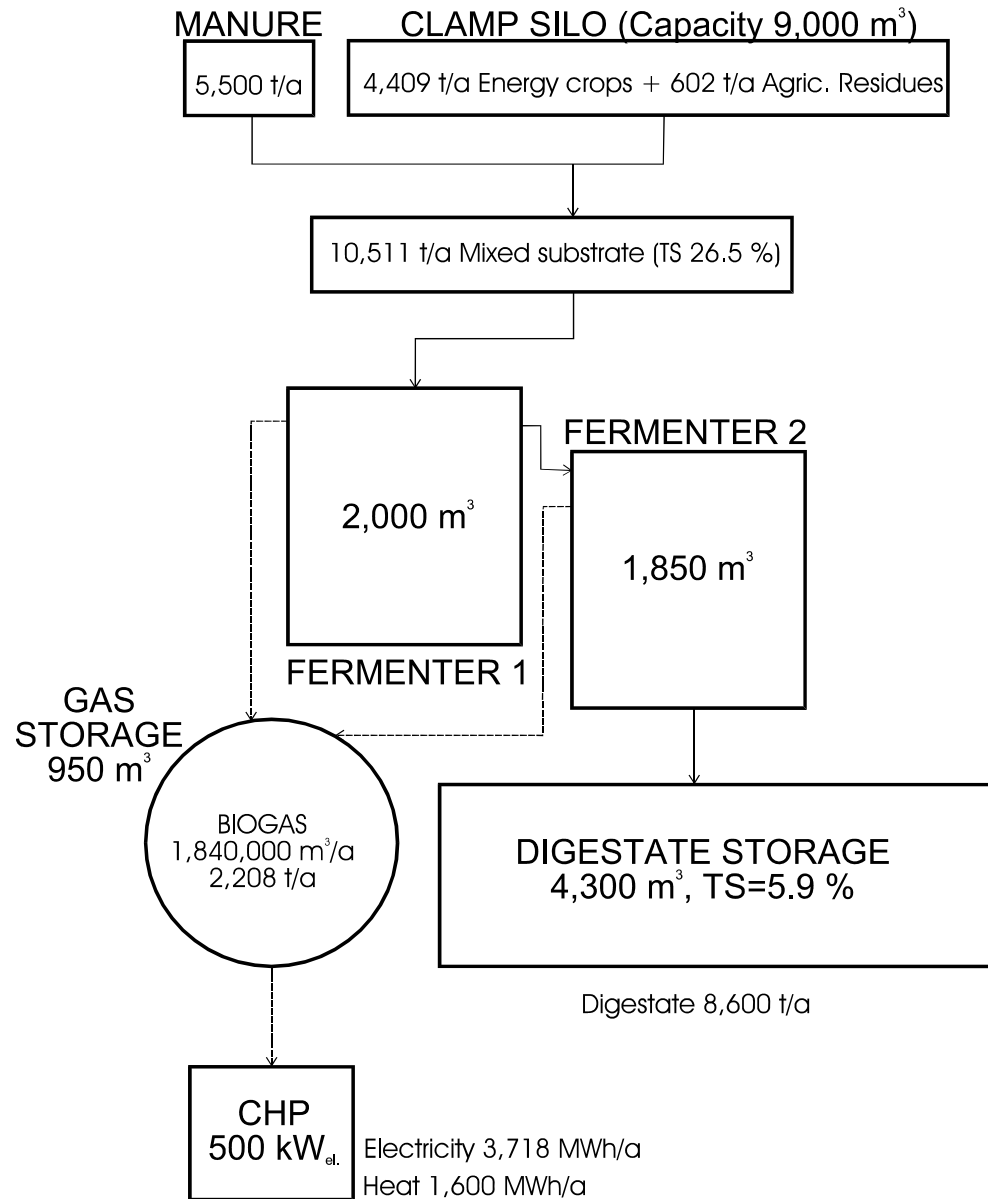


	BGBL II 508/2002	BGBI II 401/2006	BGBI II 401/2007	BGBI II 59/2008	BGBI I 114/2008
	2002-2004	2006	2007	2008	2008
	[Cent/kWh]	[Cent/kWh]	[Cent/kWh]	[Cent/kWh]	[Cent/kWh]
≤100 kW	16,50	17,00	16,95	16,94	+ 4,00
>100 - 250 kW	14,50	15,20	15,15	15,14	+ 4,00
>250 - 500 kW	12,50	14,10	14,00	13,99	+ 4,00
>500 kW - 1MW	12,50	12,60	12,40	12,39	+ 4,00
>1 MW	10,30	11,50	11,30	11,29	+ 4,00
Landfill Gas	6,00	4,10	4,05	4,04	
Gas WWTP	3,00	6,00	5,95	5,94	
min. Utilization		60%	60%	60%	
Co-Substrates	-25%	-30%	-30%	-30%	
Limit		30% of € 17 Mio/a			
Guarantee	13 Year	10 Year Year 11: 75% Year 12: 50% Year 13-24: Market Price	10 Year Year 11: 75% Year 12: 50% Year 13-24: Market Price	15 Year	2008 only



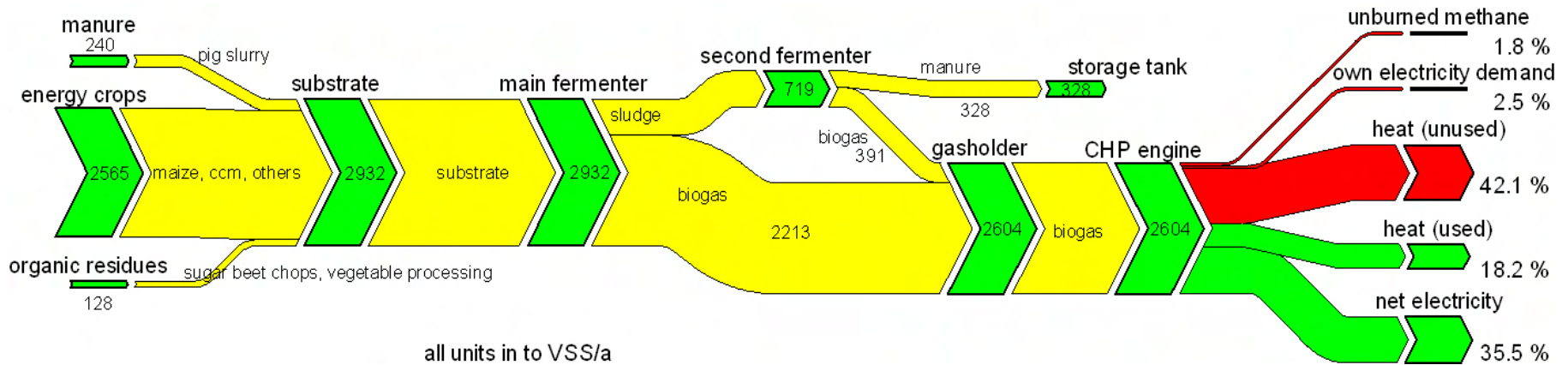
Representative example of an 500 kW_{el.} „Energy Crop“ Co-digestion plant





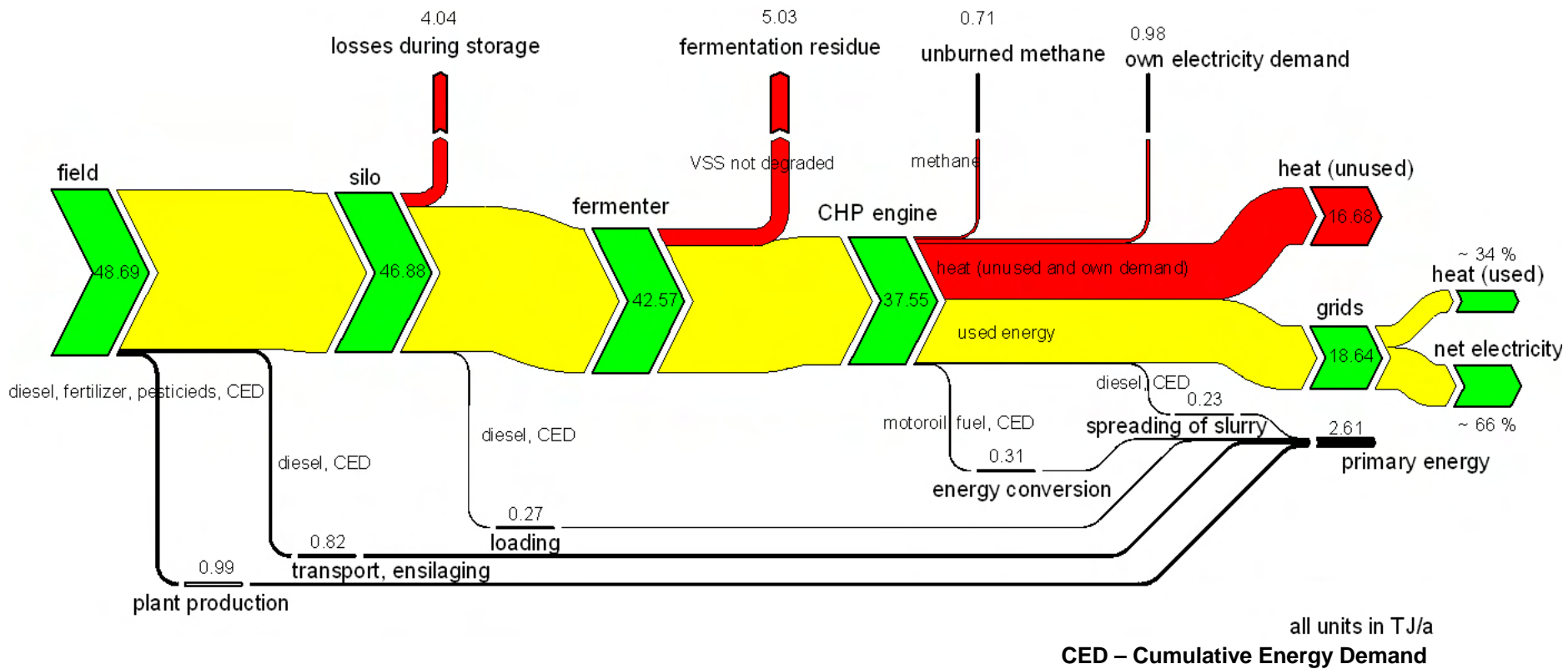


Mass flow (VS) during energy crop production-, digestion- and energy use





Energy flow during energy crop production-, digestion- and energy use



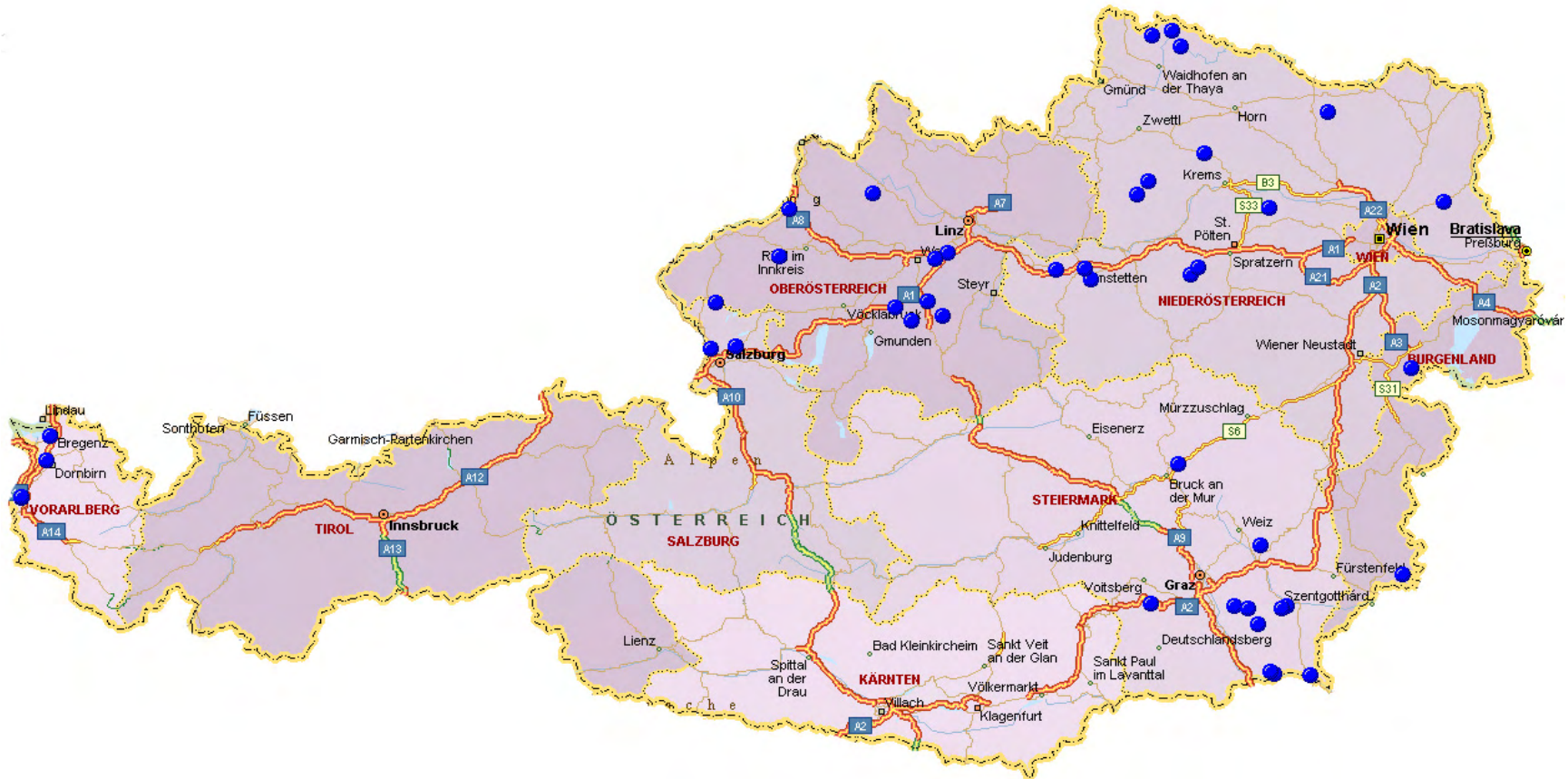
Biogas plant monitoring & evaluation

2004 – 2006: 23 % of all existing Austrian biogas plants investigated

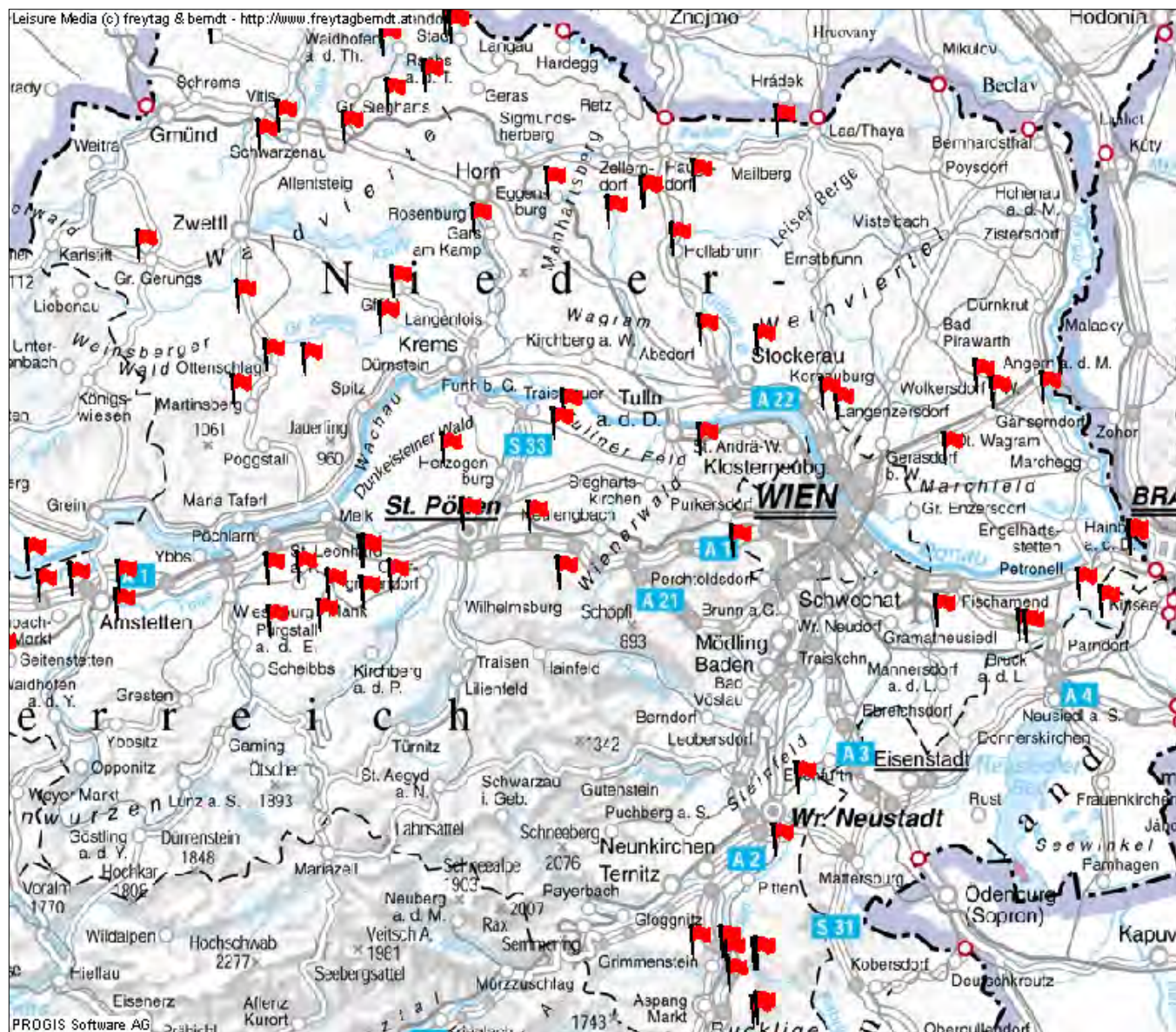
2007 – 2008: Monitoring of 78 biogas plants in province Lower Austria

Representative sampling in 41 biogas plants

23 % of all existing biogas plants in 2004 investigated
(produce 43 % of overall biogas electricity supplied in Austria)



Repeated Monitoring of 78 biogas plants in Lower Austria in 2007

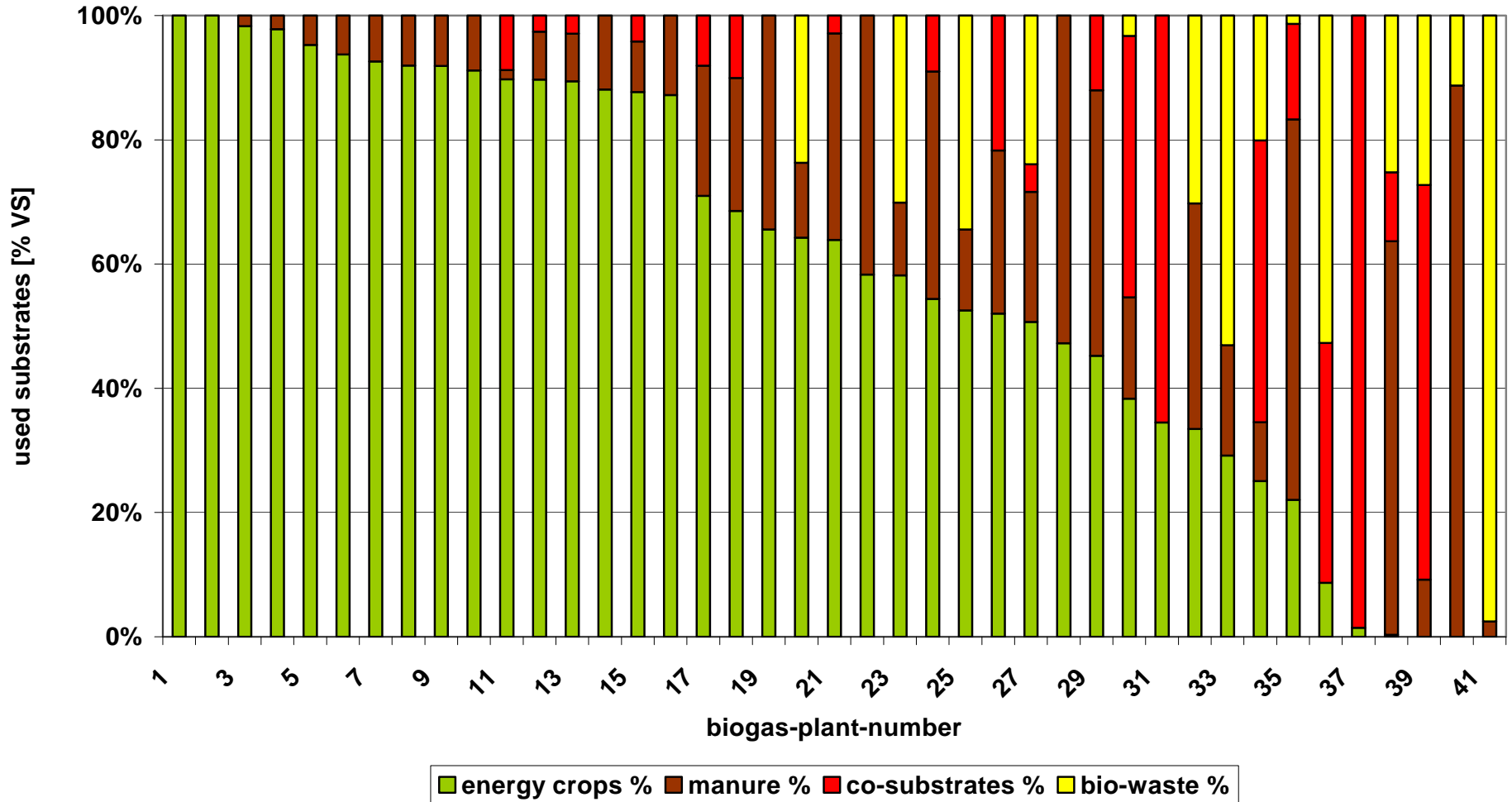


Operational parameters of 41 full scale energy crop digestion plants in Austria

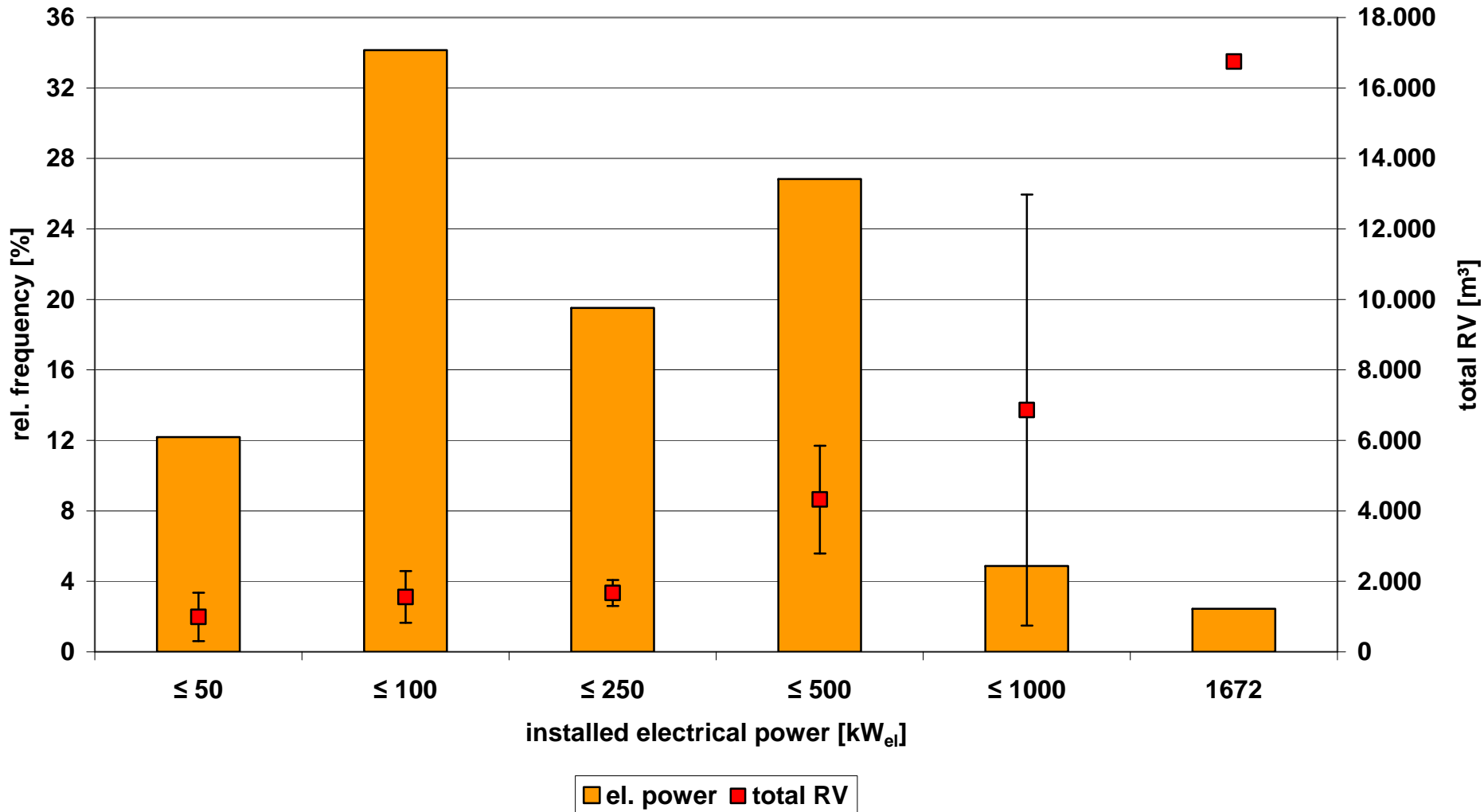
Parameter	Unit	Median	min.	max.
Amount of processed substrate	$t_{\text{Substrate}}/\text{d}$	13.2	0.8	58.9
Hydraulic retention time (days)	$\text{m}^3_{\text{RV}}/(t_{\text{Substrate}}/\text{d})$	131	44	483
Organic load (dry substance)	$\text{kg}_{\text{VS}}/(\text{m}^3_{\text{RV}}\cdot\text{d})$	3.59	1.04	7.97
COD load	$\text{kg}_{\text{COD}}/(\text{m}^3_{\text{RV}}\cdot\text{d})$	5.64	1.62	11.95
Amount of VS dosed	t_{VS}/d	2.34	0.33	13.78
Biogas generation per day	$\text{Nm}^3_{\text{biogas}}/\text{d}$	1,461	233	10.115
Biogas productivity	$\text{Nm}^3_{\text{biogas}}/(\text{m}^3_{\text{RV}}\cdot\text{d})$	0.96	0.22	2.17
Carbon degradation	%	82.8	61.5	96.8
Average biogas yield	$\text{Nm}^3_{\text{biogas}}/\text{kg}_{\text{VS}}$	0.662	0.511	0.878
Methane content in biogas	%	54.8	49.7	67.0
Electrical efficiency	%	31.3	20.7	39.2
Use of heat (related to total input energy $H_{u, \text{biogas}}$)	%	16.5	0.0	42.6
Annual use efficiency (related to total input energy $H_{u, \text{biogas}}$)	%	47.3	30.5	72.3

RV: Reactor volume; $H_{u, \text{biogas}}$: Net calorific value of biogas; VS: Organic matter

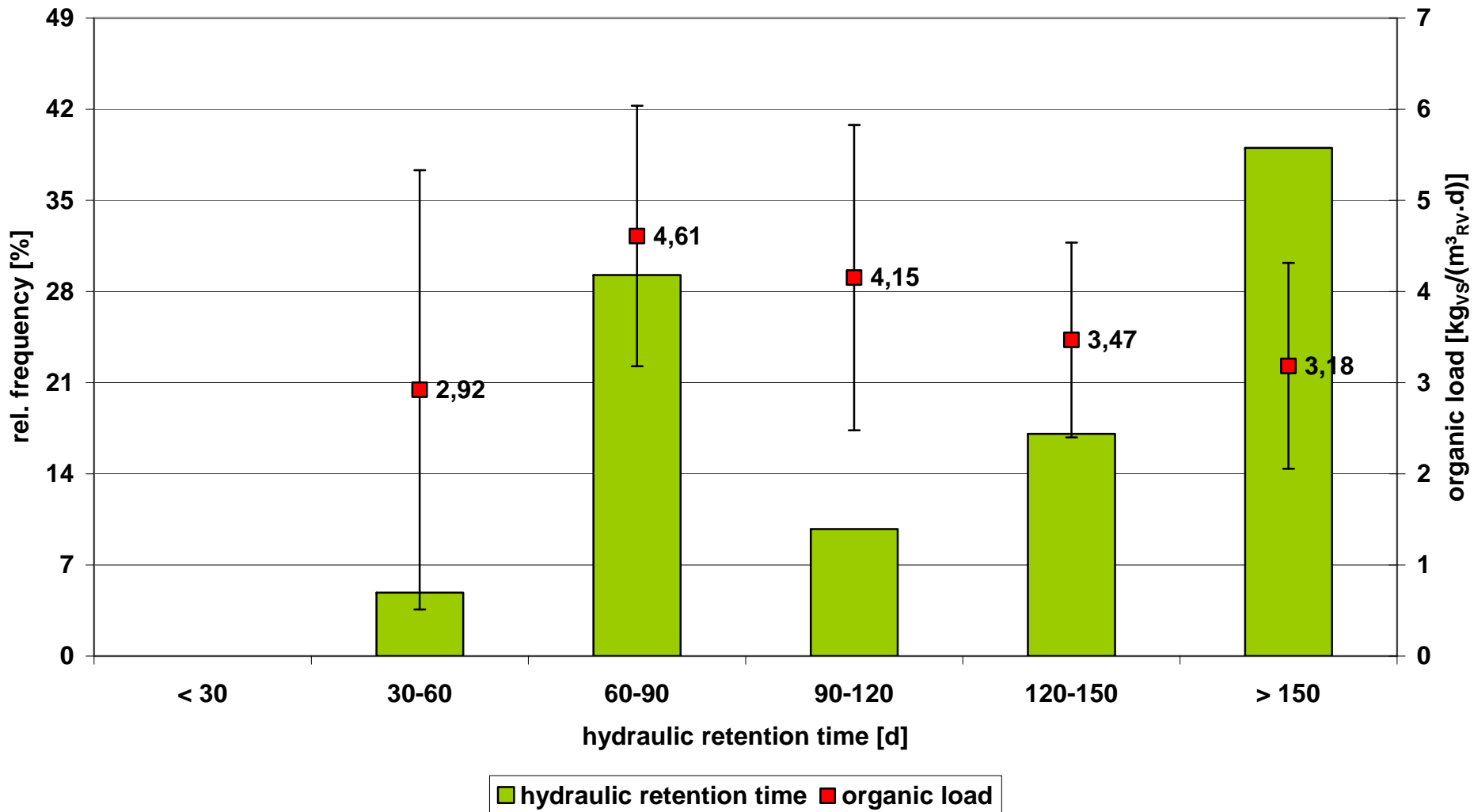
Used substrates (% VS)



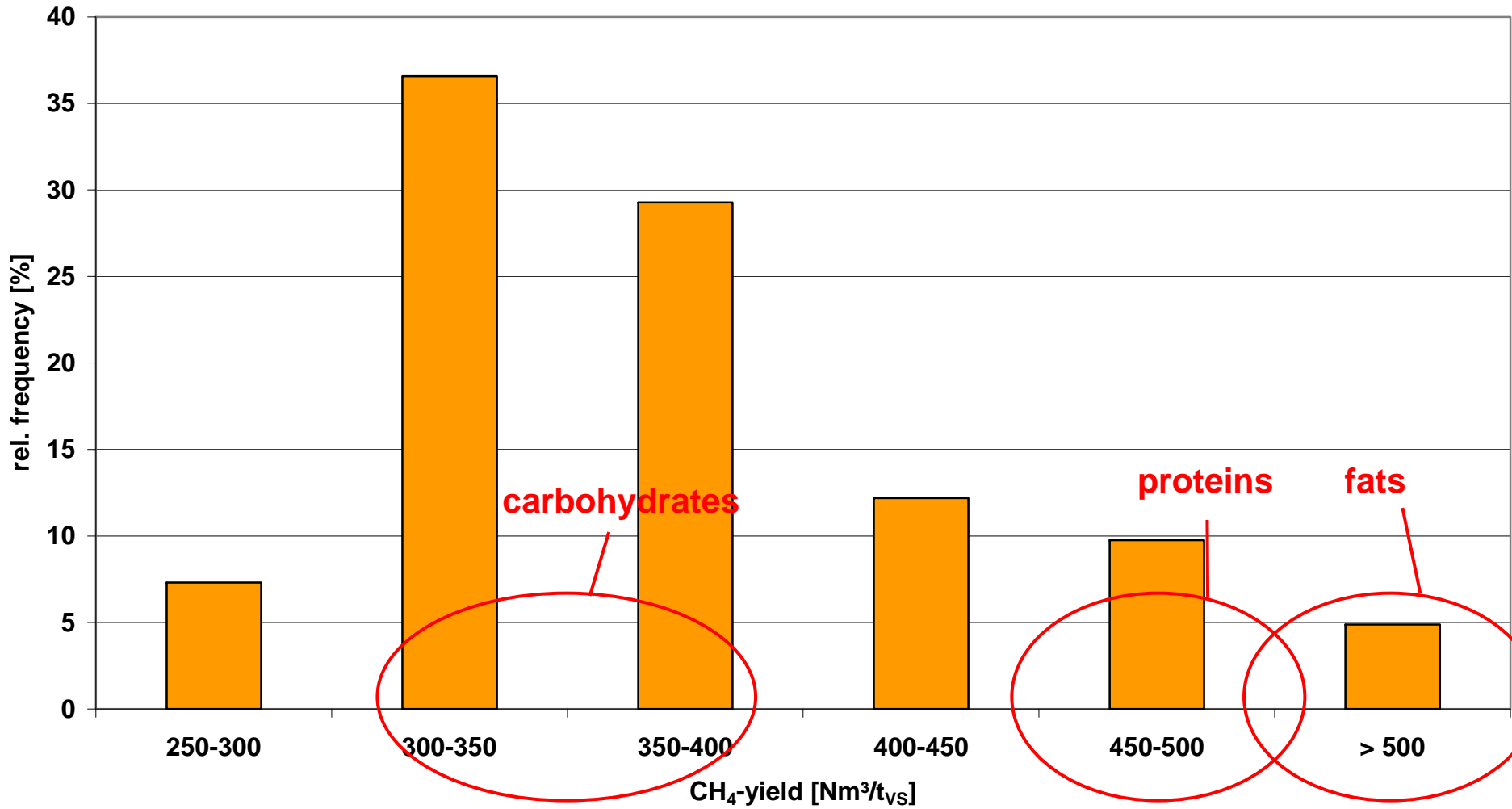
Plant size (kW_{el}) and reactor volume (RV)



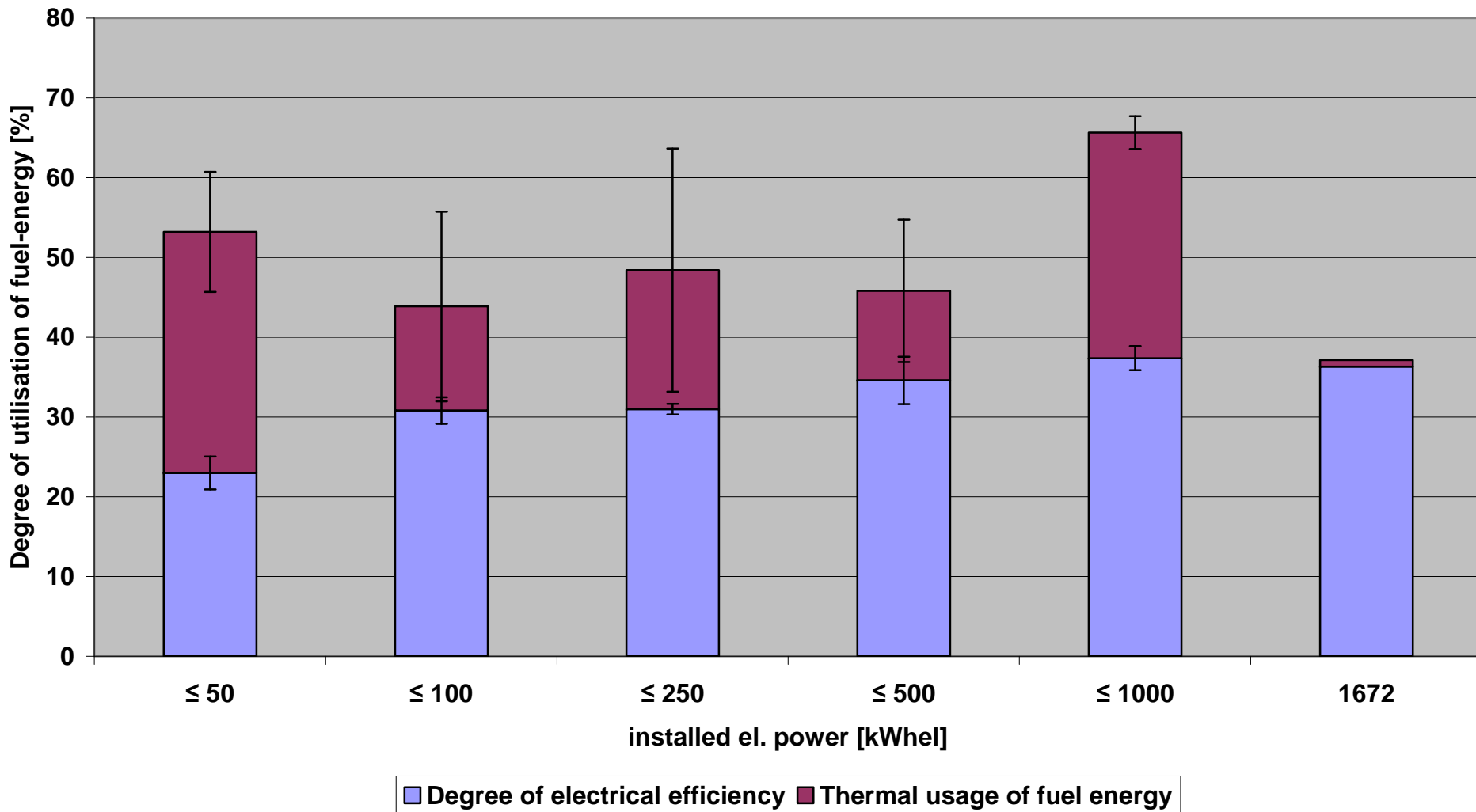
Hydraulic retention time and organic load



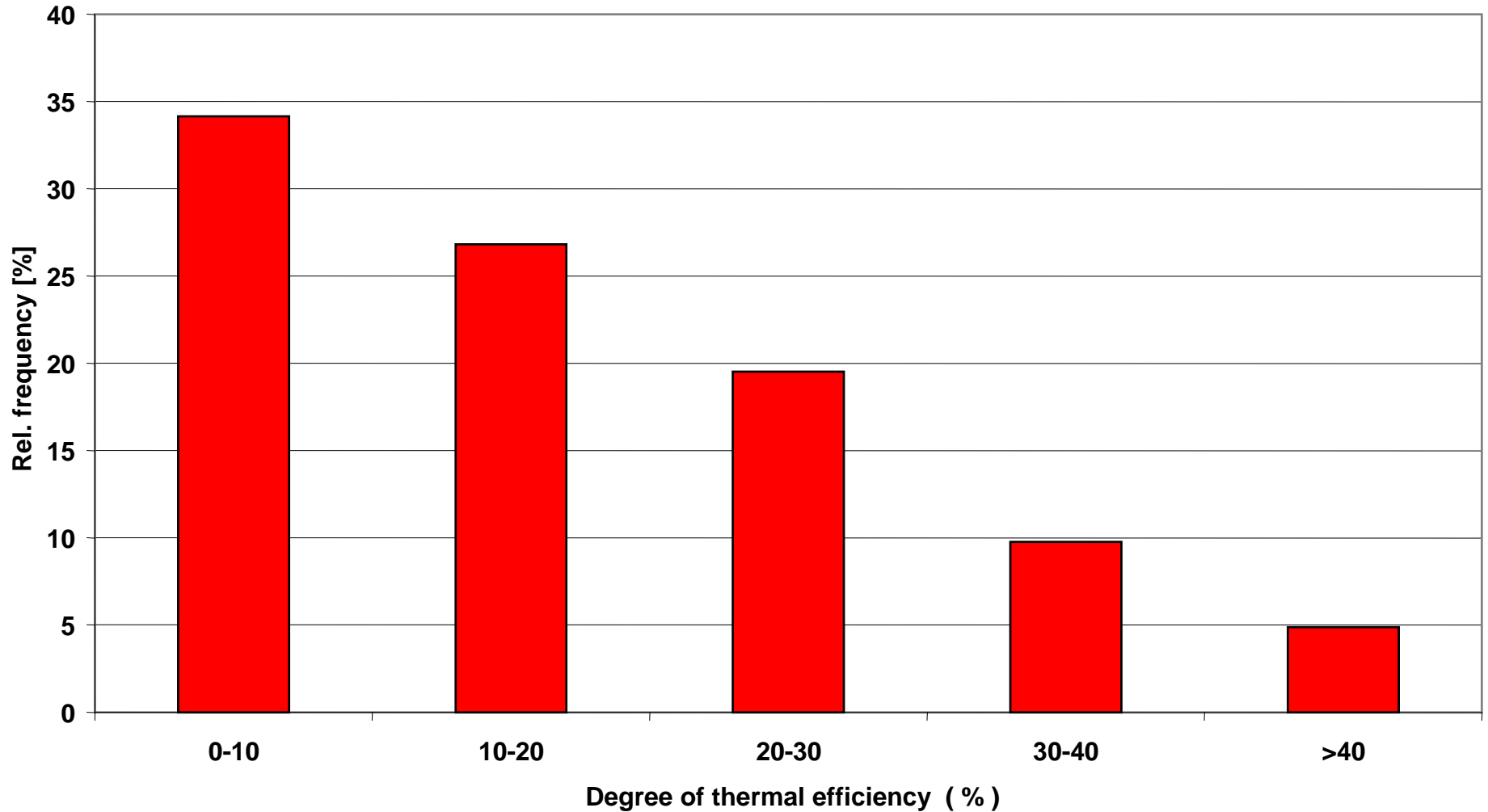
Methane-yield [VS]



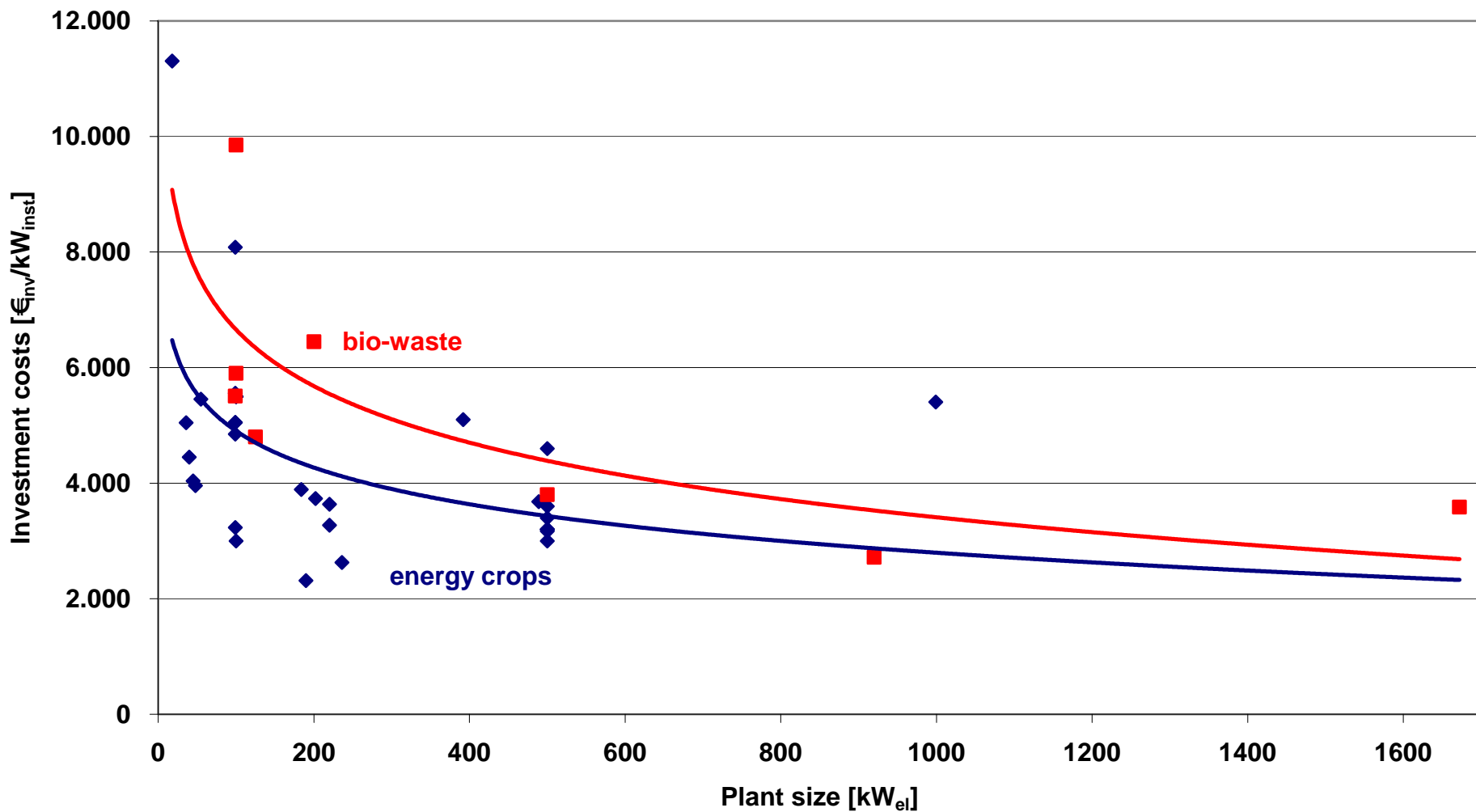
Utilisation of fuel energy



Degree of thermal efficiency



Investment costs



Profitableness?

Multiple influential factors!

Investment costs: 2,000-4,000 €/kWh

Raw material costs: 60-190 €/t maize

Plant performance (efficiency): 30-72%

Subsidies (building, capital, energy)

Energy price (gas, power, heat, fuel)

Energy crop digestion plant 500 kW_{el.} – Economics estimation

3,979 t maize (corn, 30 % H₂O) / year
1,800,000 m³ biogas (50 % CH₄) / year
3,718 MWh/a power
1,600 MWh/a heat
5,318 MWh/a total energy used

	Case 1	Case 2
Investment costs (€)	2,000,000	2,000,000
Amortisation (13 years)	153,850	153,850
Raw material costs	278,530	736,115
<u>Other costs</u>	<u>43,238</u>	<u>43,238</u>
Total costs (€/ year)	475,618	933,203
<u>Revenue (€/ year)</u>	<u>595,616</u>	<u>595,616</u>
Profit / Loss (€/ year)	+119,998	-337,587

Austrian biogas trade monitor

- **50 % of all Austrian biogas plants suffered on economic losses in 2008**
- **Most plants depend on external substrates (crops)**
- **Every third owner considered a shutdown of the plant in 2008**
- **60 % of all owners would not invest again in biogas plants**
- **Most plants have just a poor or even missing concept for heat use**
- **Only a small minority of the plants considers biogas upgrading**
- **40 % of the plants use uncovered digestate storage tanks / lagoons**
- **20 % of all plants use open substrate storage**

Conclusions

- **An objective status of the technical performance of Austrian energy crop digestion plants is available**
- **Experiences can prevent wrong economic decisions and technological development**
- **Considerable potential for AD efficiency improvement e.g. Heat use, Overall efficiency, Reliable process technology...**
- **Critical interdependency of process economics on raw material costs and subsidies on energy prices**

Thank you for your attention!

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