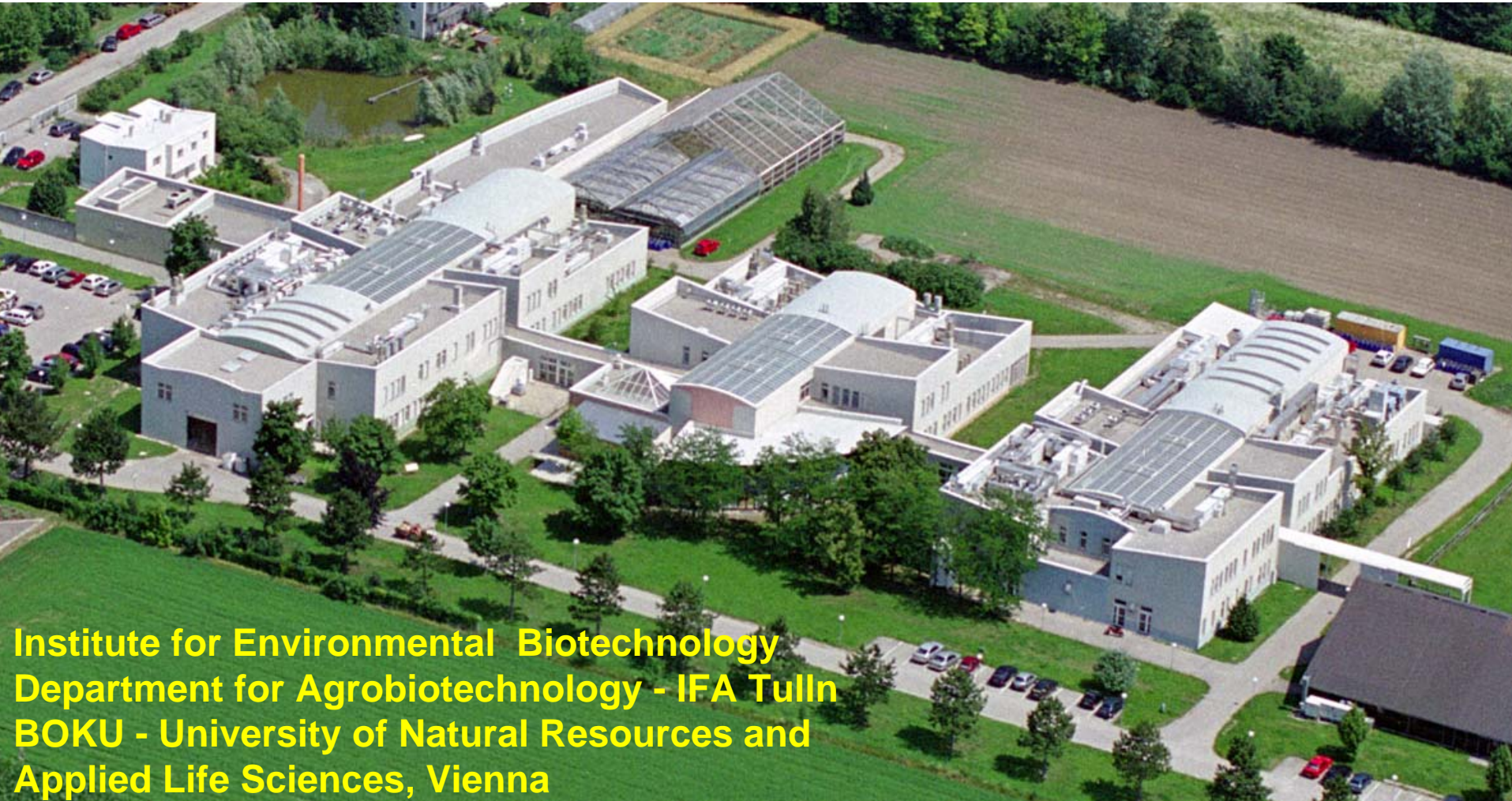


Country Update Austria - 2006

R. Braun 21. 4 .2006



**Institute for Environmental Biotechnology
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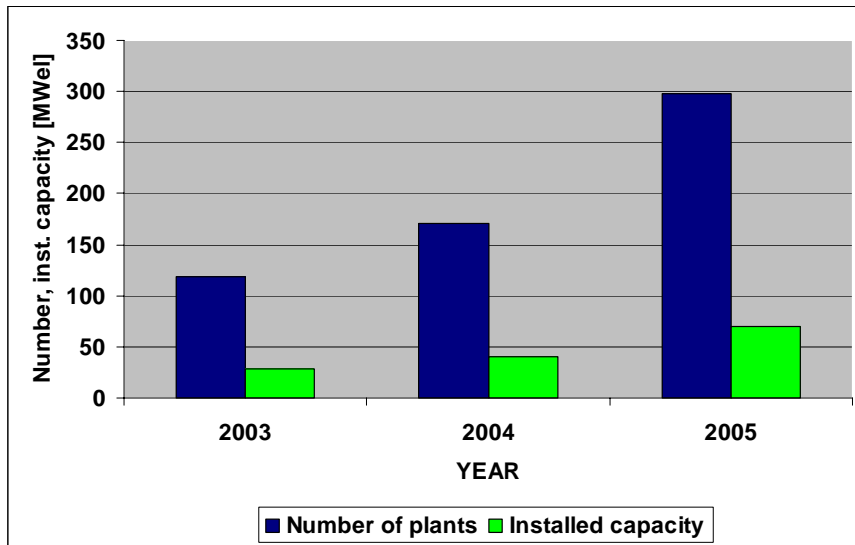


R. Braun

IEA Task 37 „Energy from Biogas and Landfill Gas“



Development of energy crop digestion in Austria



Austrian Eco Electricity Act (2002) Ökostromgesetz BGBl. I Nr. 2002/149

| Inst. capacity (kW) | Feed-in tariff (€ct./kWh)* |
|---------------------|----------------------------|
| < 100 | 16.5 |
| 100-500 | 14.5 |
| 500-1000 | 12.5 |
| > 1,000 | 10.3 |

*) 25 % reduction in case of co-digestion of defined co-substrates; consent must be achieved by end of 2004

Amendment of the „ÖKOSTROMGESETZ“ 200?

- Overall limit to subsidies for Eco-electricity tariffs
- No fixed tariffs for solar-, wind-, biomass- etc.
(call for tenders)
- Decreasing subsidies (- 5 % per year)
- Distribution of subsidies: 40% biomass, 30% biogas, 20% wind, 10% photovoltaic
- Guaranteed for 10 years (before 13 years)
- New Eco-energy company to be founded for administration

Biogas Plants in Austria - April 2006

| Source | Number of Plants | Mio m ³ Biogas per Year | % of Total Biogas |
|-----------------------------|---|------------------------------------|-------------------|
| Landfills | 62 Grey Waste - Landfill Gas Recov. Pl. | 45-100 | 21.3 |
| Sewage sludge | 134 Sewage sludge digesters | 75 - 100 | 25.8 |
| Agriculture ¹ | ~350 Biogas- u. Co-Fermentation Plants | 121 - 182 | 44.6 |
| Industry ¹ | 25 Anaerobic Wastewater Treatment Pl. | 9 - 14 | 3.4 |
| Municipalities ¹ | ~15 Biowaste Digestion Plants | 15 - 18 | 4.9 |
| TOTAL | | 265 - 414 | 100 |

1) Estimation

Renewable Energy Sources in Austria

(Statistics Austria, 2001)

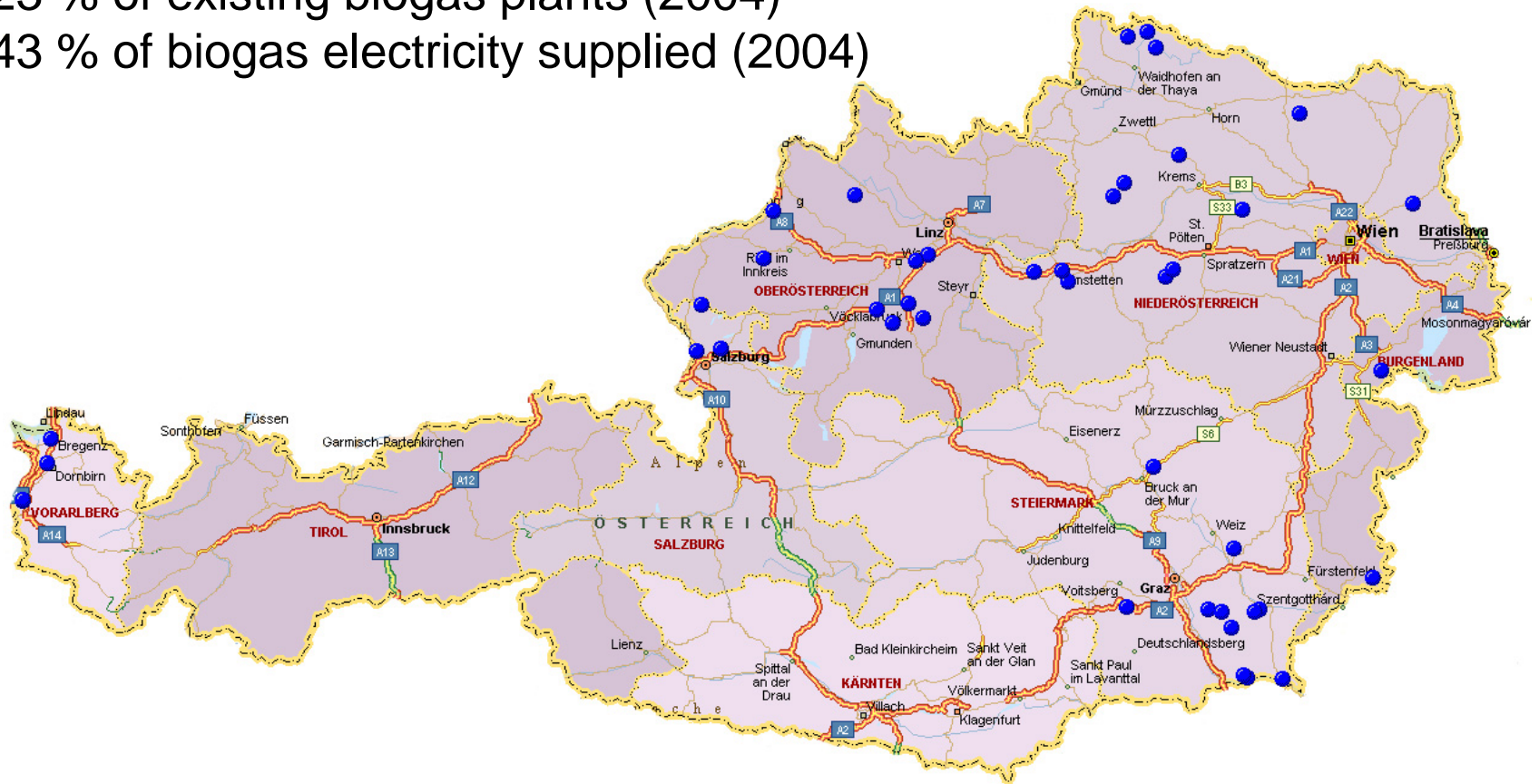
| | |
|-----------------------------------|--|
| Hydropower | 151 PJ \approx 11.6 % of PED ¹⁾ |
| Others | 142 PJ \approx 11 % of PED |
| Total PED in Austria | 1,290 PJ |
| OTHERS | |
| Firewood | 69.2 % |
| Industrial residual waste liquors | 15.6 % |
| Combustible waste | 7.3 % |
| Heat pump | 4.9 % |
| Biogas, sewage gas, landfill gas | 1.6 % |
| Straw | 1.0 % |
| Wind- & solar energy | 0.4 % |
| 100,0 % | |

¹⁾ Primary energy demand

Investigation of “Energy Crop” - Digestion Status in Austria by means of monitoring of a representative sample of 41 biogas plants

23 % of existing biogas plants (2004)

43 % of biogas electricity supplied (2004)



Parameters applied for evaluation of the biogas plants

| General functional description | Measurable process conditions | Calculable variables |
|---|--|---|
| SUBSTRATE | | |
| Quality / quantity Transport, Storage Pretreatment Costs | COD ¹ TKN ² , NH ₄ -N TS ³ , VS ⁴ | t / year Costs/year |
| DIGESTER | | |
| Startup Investment costs, Annual costs Subsidies Process steps, Substrate dosage Digester type Digester equipment Digester mixing | T, Self heating pH, VFA ⁵ , COD, TS, VS TKN, NH ₄ -N Process energy demand Sludge recirculation | Residence time Hydraulic loading VS degradation Biogas yield |
| DIGESTATE | | |
| Storage type / cover Treatment / Dewatering Use | pH, COD, TS, VS VFA, TKN, NH ₄ -N, CH ₄ -formation Hygienic status | t / year |
| BIOGAS | | |
| Quantity /utilisation Gas holder, Upgrading | CH ₄ , H ₂ S | Calorific value Electrical efficiency |
| PERSONNEL EXPENDITURE | | |
| SALES REVENUES / OVERALL ECONOMICS | | |
| ECOLOGICAL / SOCIO-ECONOMIC PERFORMANCE | | |

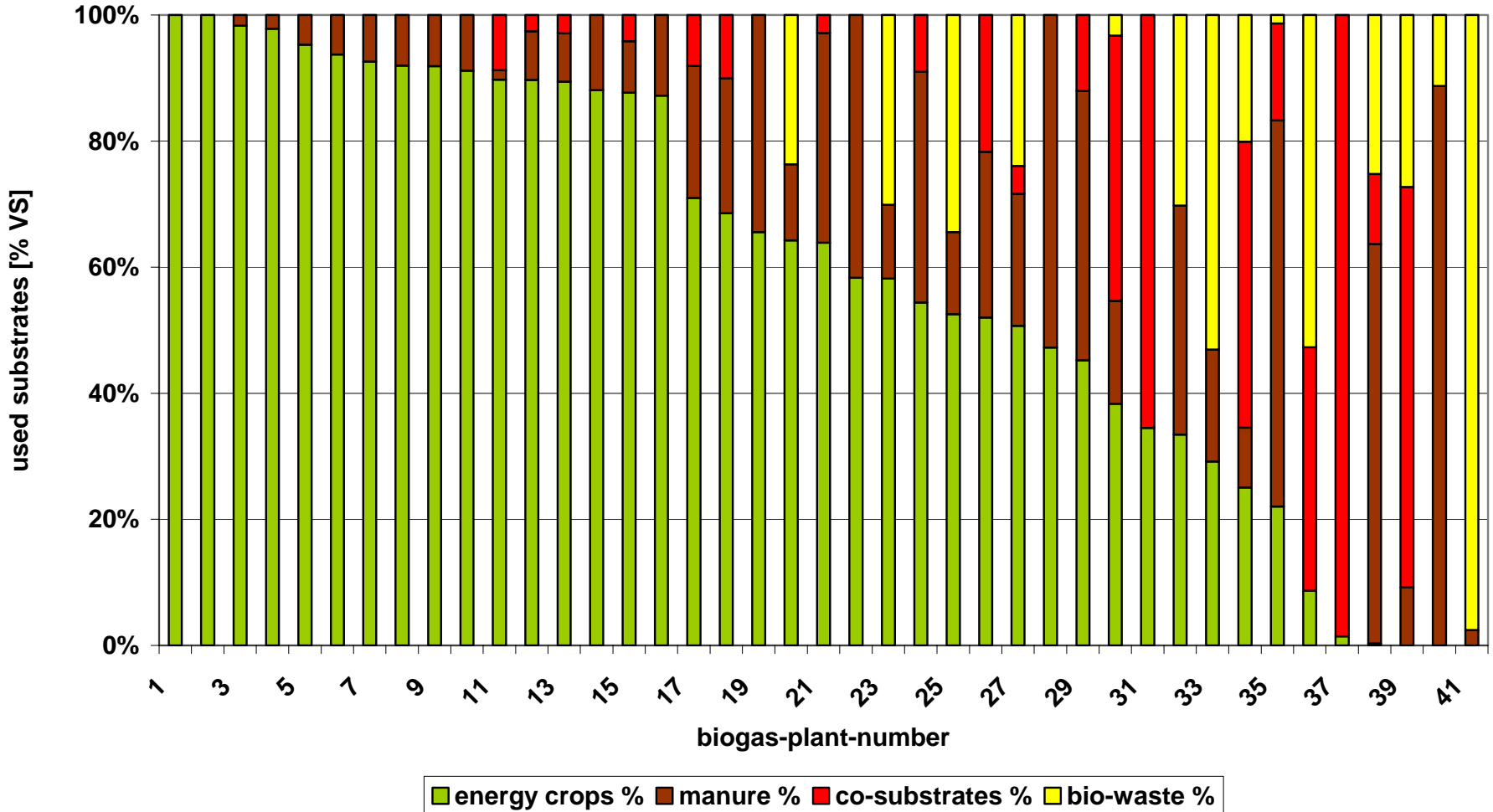
¹⁾ Chemical Oxygen Demand; ²⁾ Total Kjellidahl Nitrogen; ³⁾ Total Solids; ⁴⁾ Volatile Solids; ⁵⁾ Volatile Fatty Acids

Performance figures of the technical monitoring and benchmarking

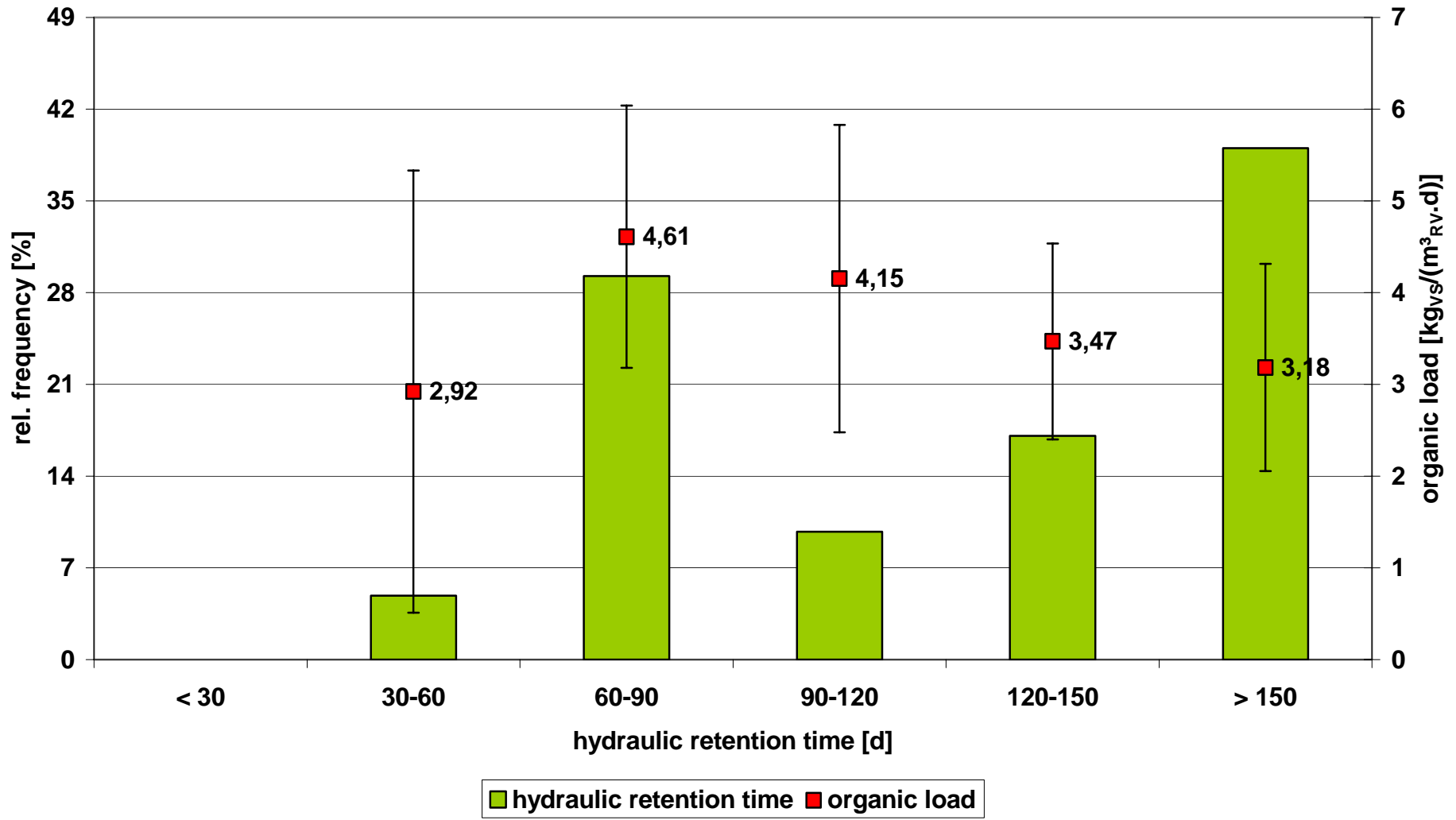
| Parameter | Unit | Median ¹ | min. | max. |
|---|---|---------------------|-------|--------|
| Amount of processed substrate | $t_{\text{Substrate}}/\text{d}$ | 13.2 | 0.8 | 58.9 |
| Hydraulic retention time | $\text{m}^3_{\text{RV}}/(t_{\text{Substrate}}/\text{d})$ | 131 | 44 | 483 |
| Organic load (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 | t_{VS}/d | 2.34 | 0.33 | 13.78 |
| Biogas generation | $\text{Nm}^3_{\text{biogas}}/\text{d}$ | 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 $H_{\text{u, biogas}}$) | % | 16.5 | 0.0 | 42.6 |
| Annual use efficiency (related to total input energy $H_{\text{u, biogas}}$) | % | 47.3 | 30.5 | 72.3 |

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

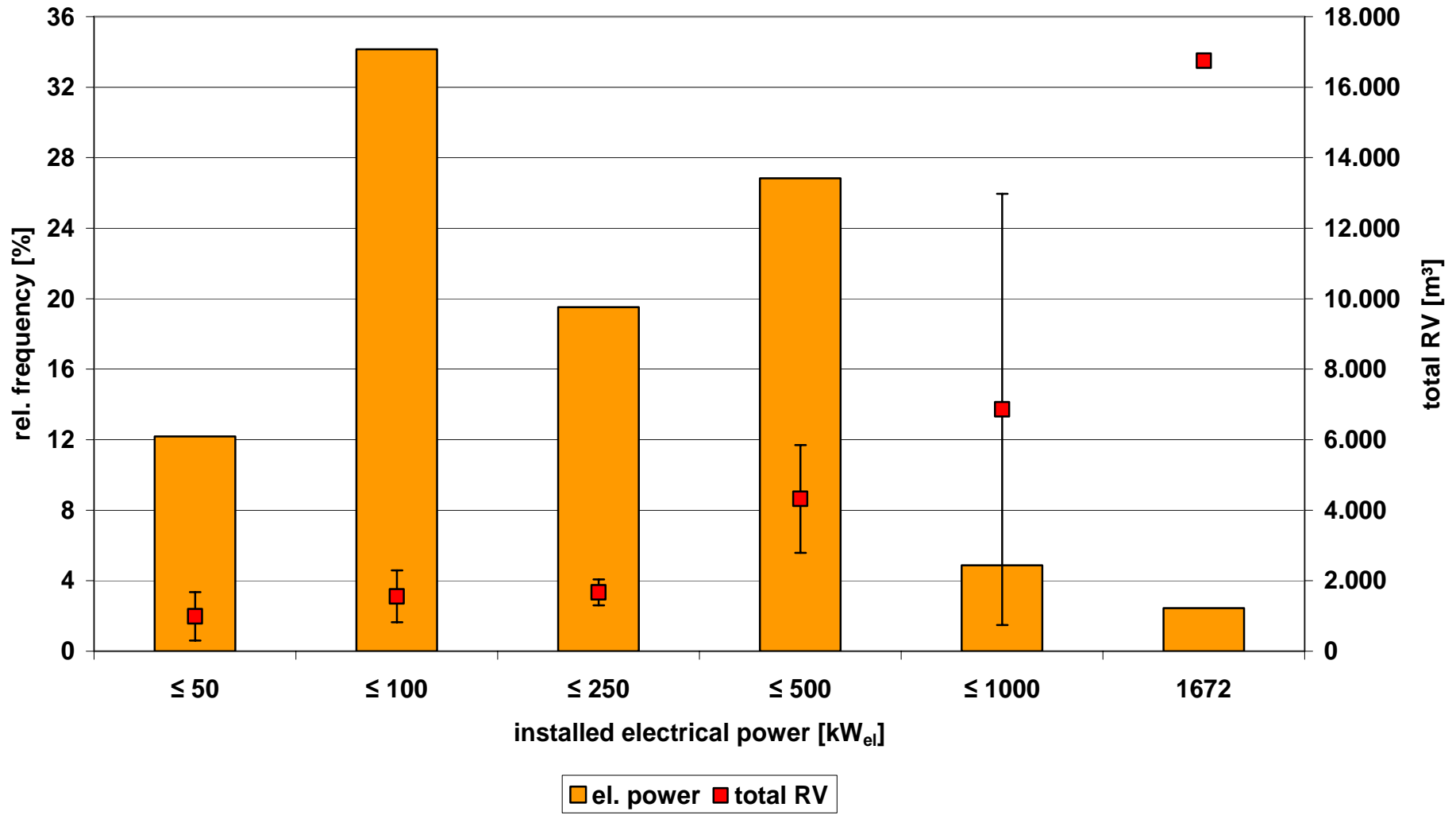
Used substrates (% VS)



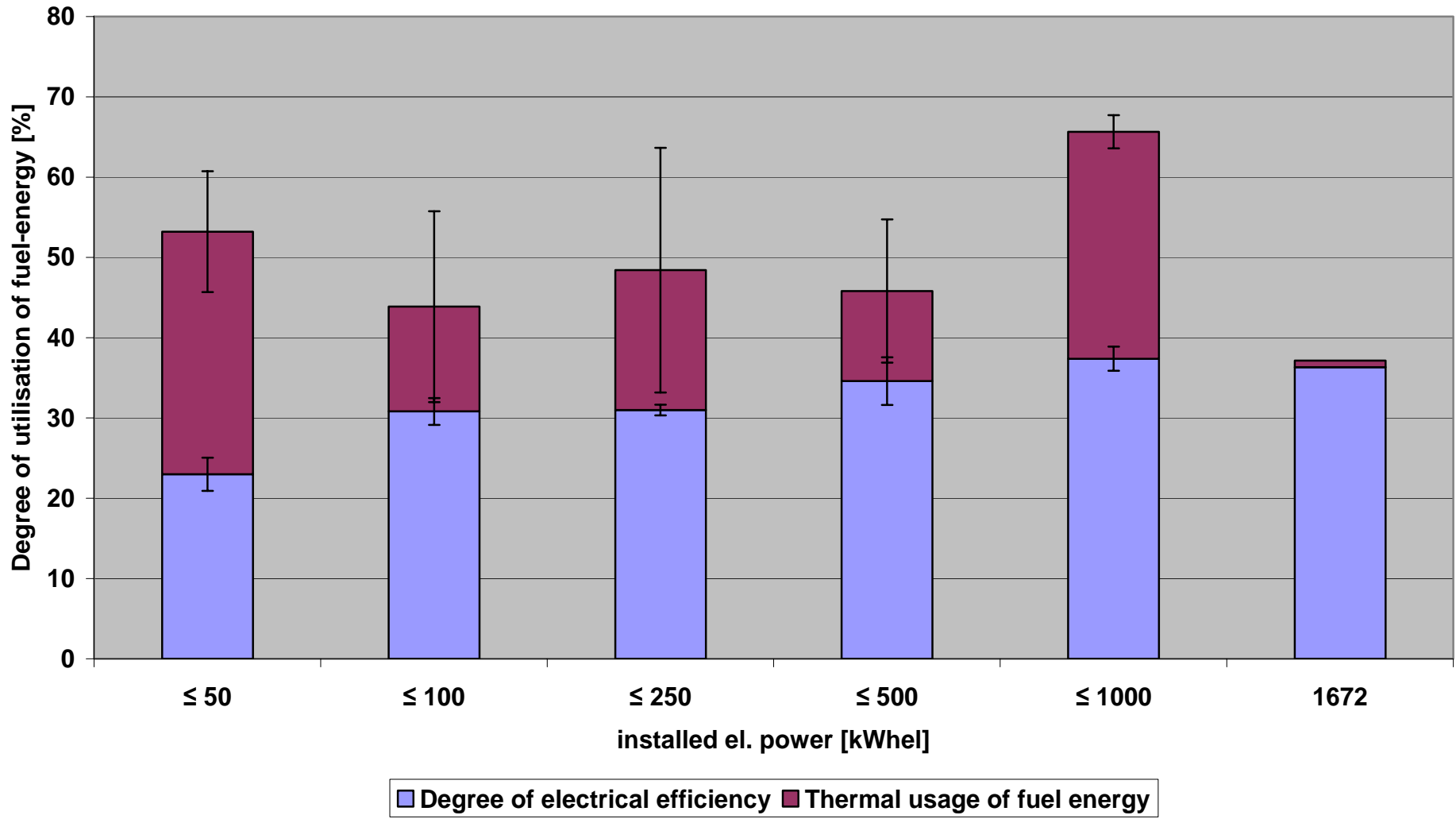
Hydraulic retention time and organic load



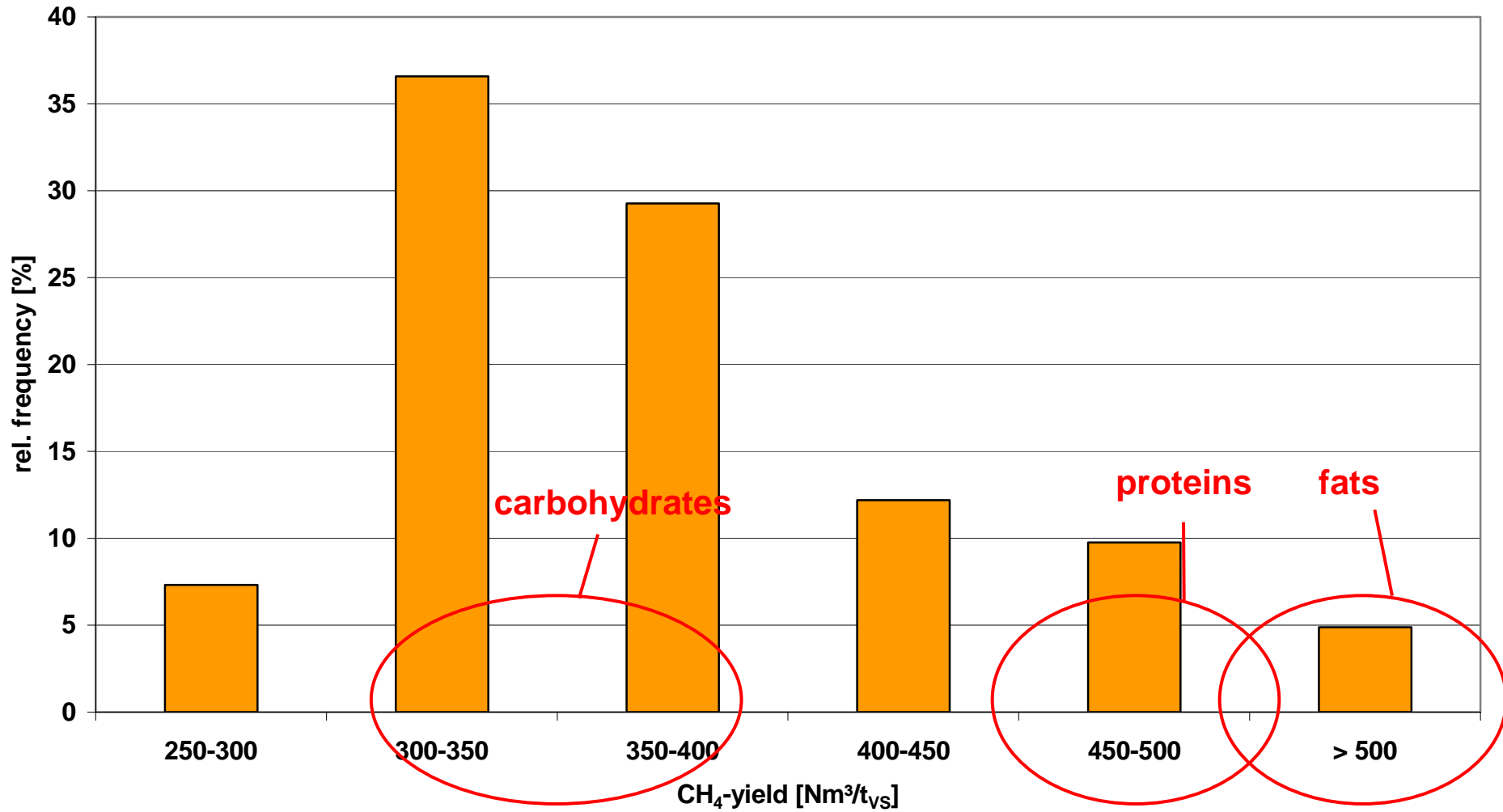
Plant size (kW_{el}) and reactor volume (RV)



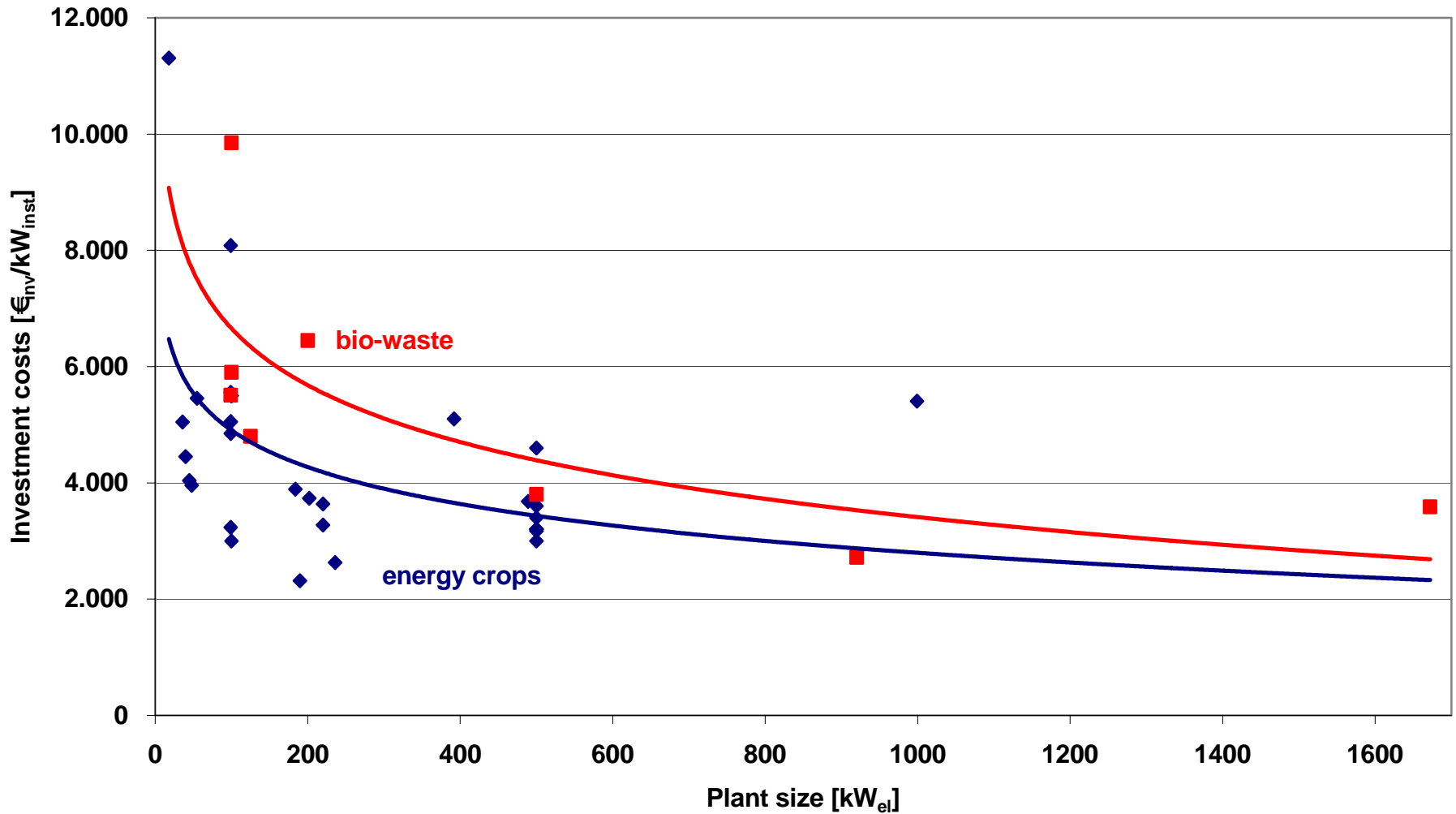
Utilisation of fuel energy



Methane-yield [VS]



Investment costs

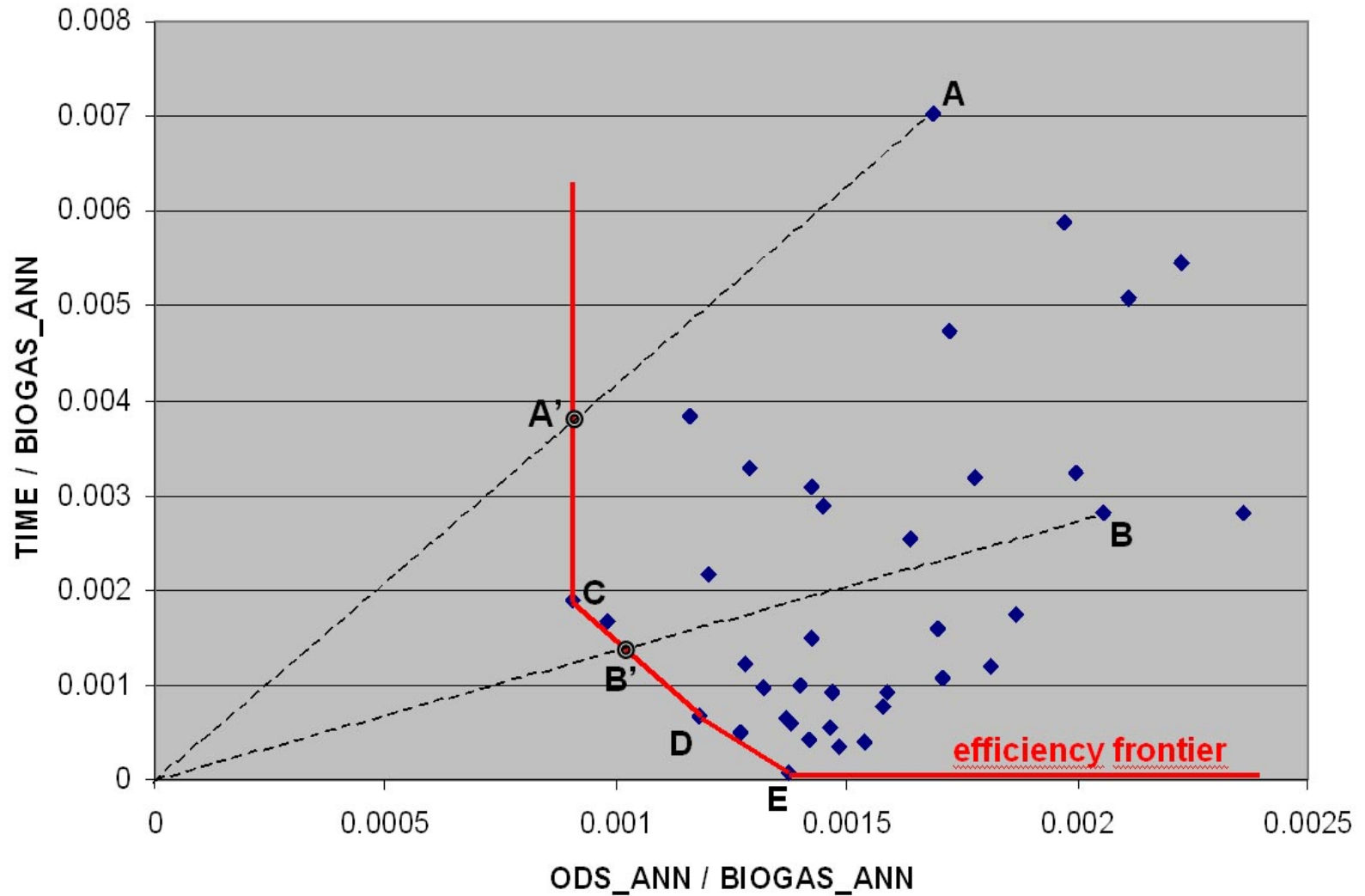


Benchmarking by means of Data Envelopment Analysis (DEA)

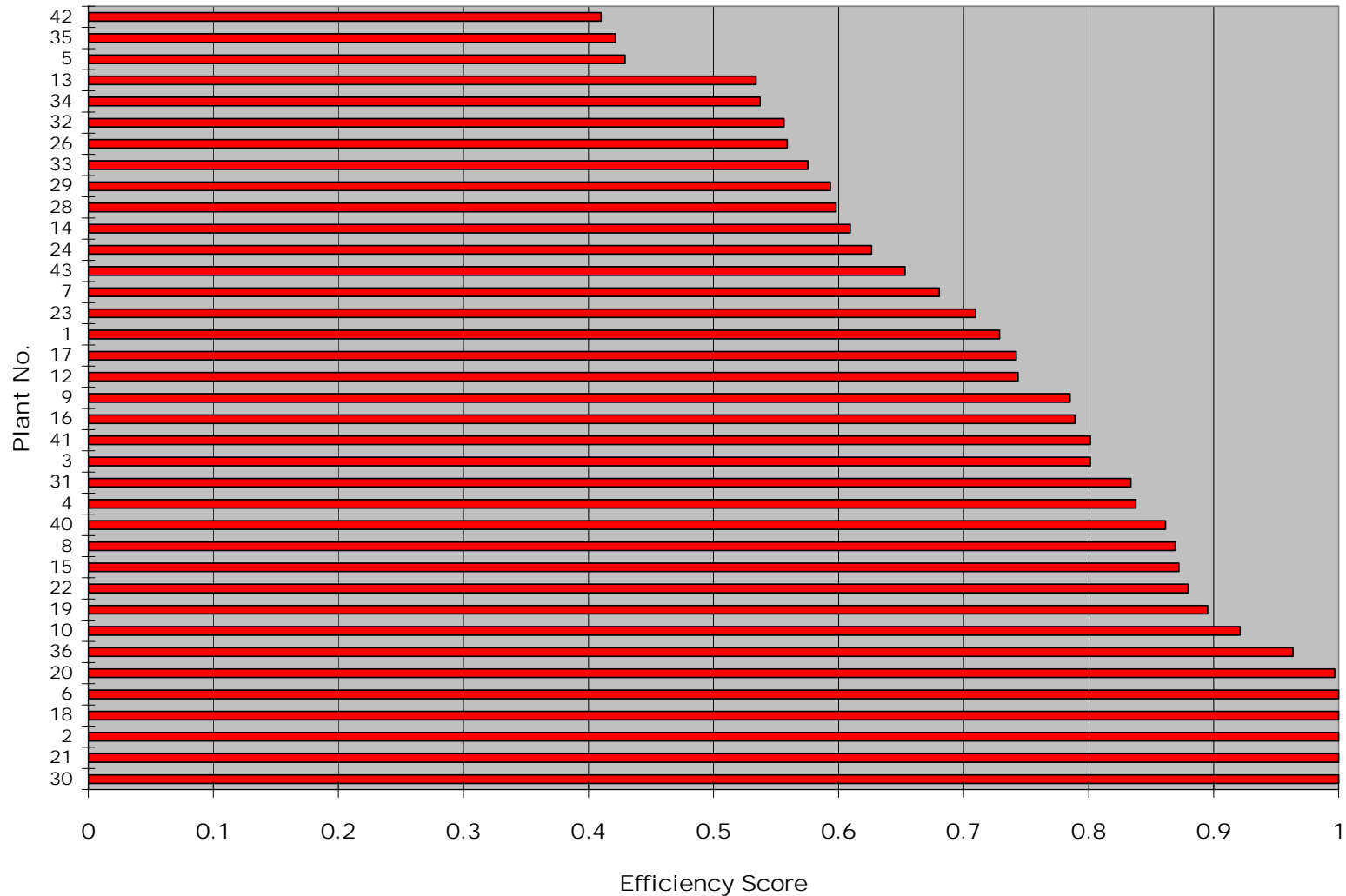
- Best practise benchmarking model
- Non-parametric linear programming tool
- Comparative efficiency measurement
- Production efficiency frontier



Efficiency frontier

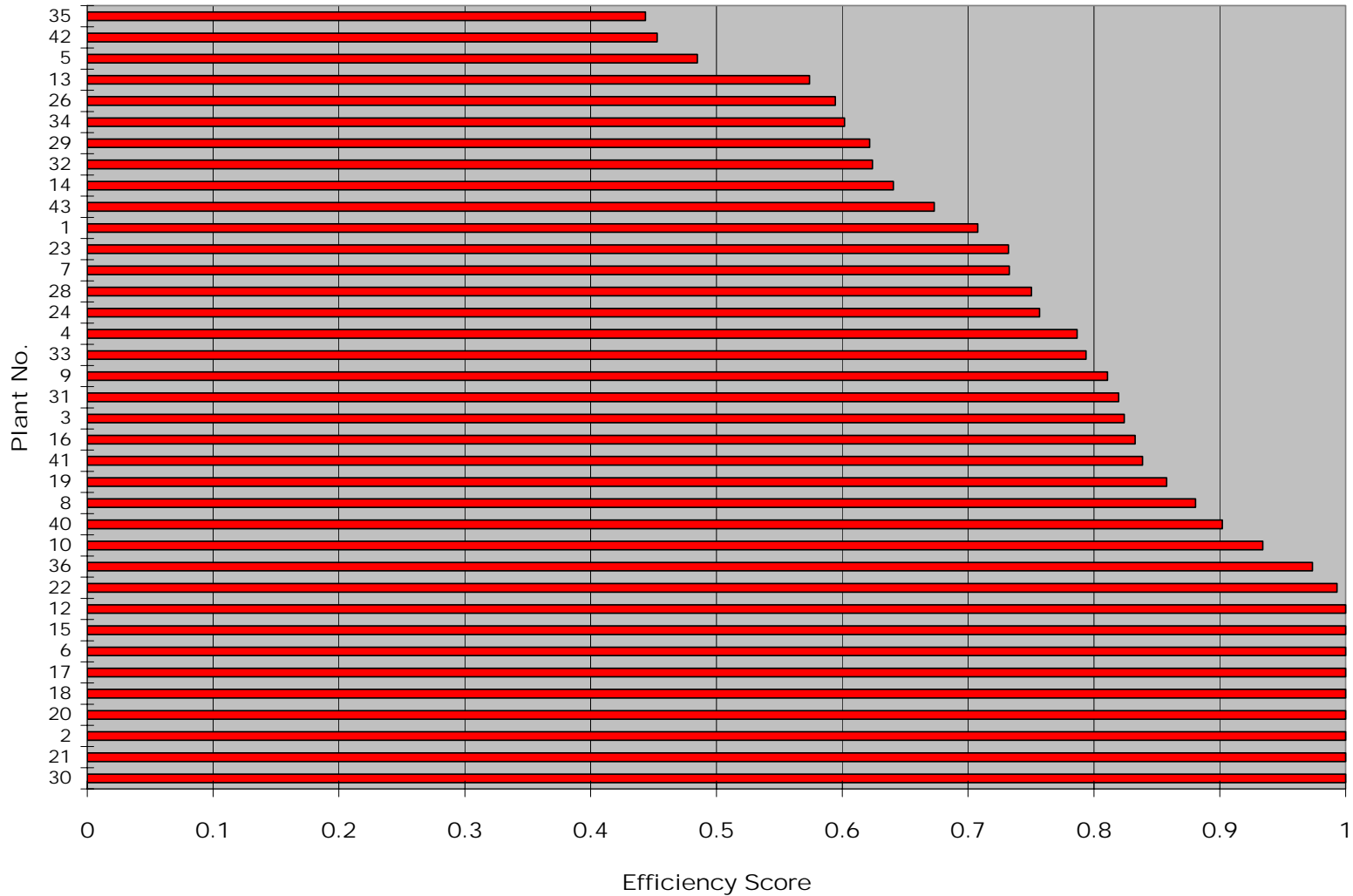


Relative efficiency I



(inputs used: amount of organic dry substance, time effort; outputs used: net electricity production and total heat production)

Relative efficiency II



(inputs used: organic dry substance and time effort; outputs used: electricity fed into the grid, total heat production)

CONCLUSIONS

- **Reasons for specifically good or poor performing digestion plants must be further investigated in detail**
- **Environmental- (ecologic) and socio-economic impacts of energy crop digestion must be thoroughly investigated and considered**
- **Experiences from best practice biogas plants can prevent poor technological development and wrong investment / subsidies decisions**

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