Energy Efficiency in Energy Crop Digestion

Based on an Evaluation of 41 Austrian Full Scale Biogas Plants

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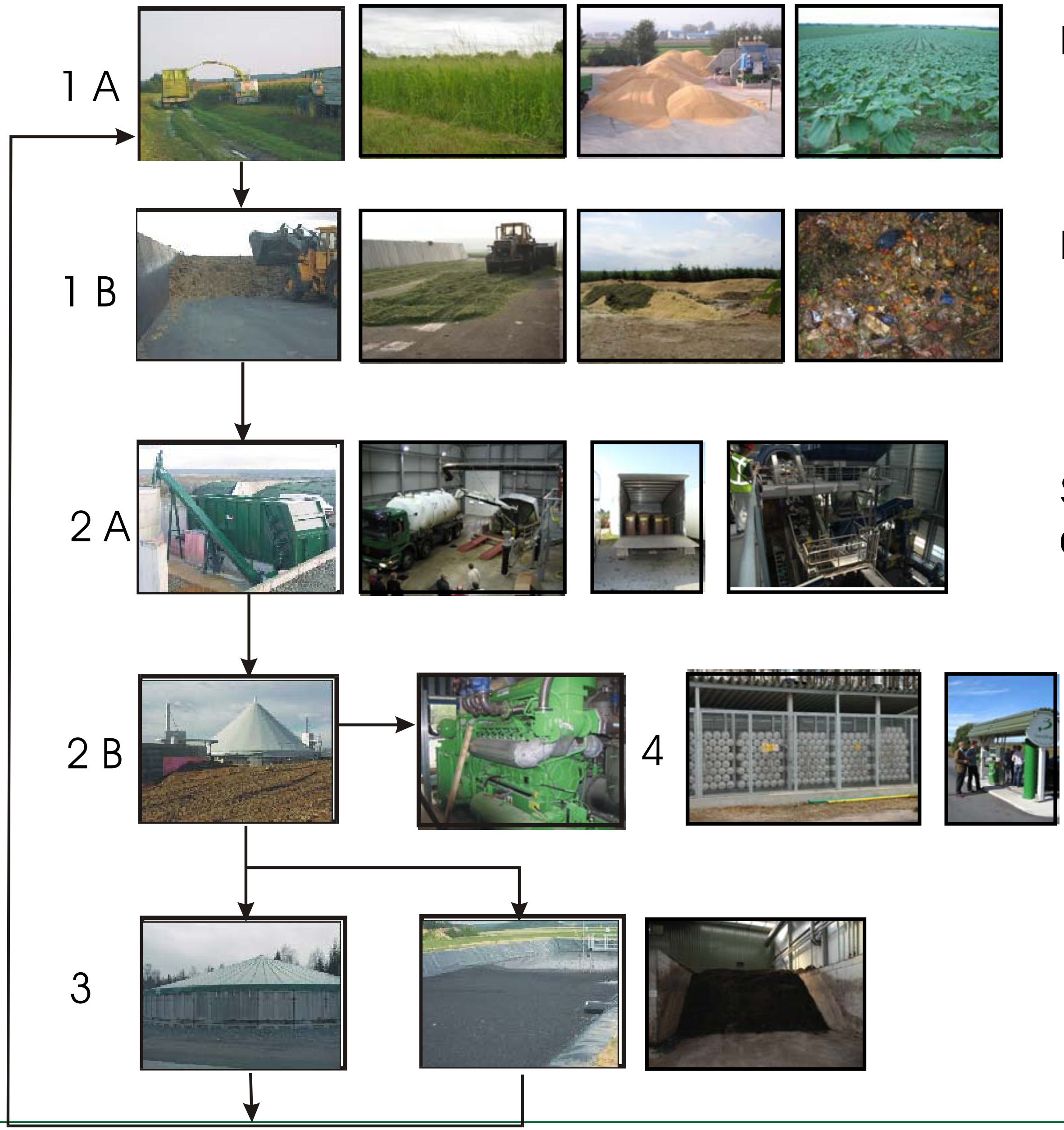


Renewable raw materials

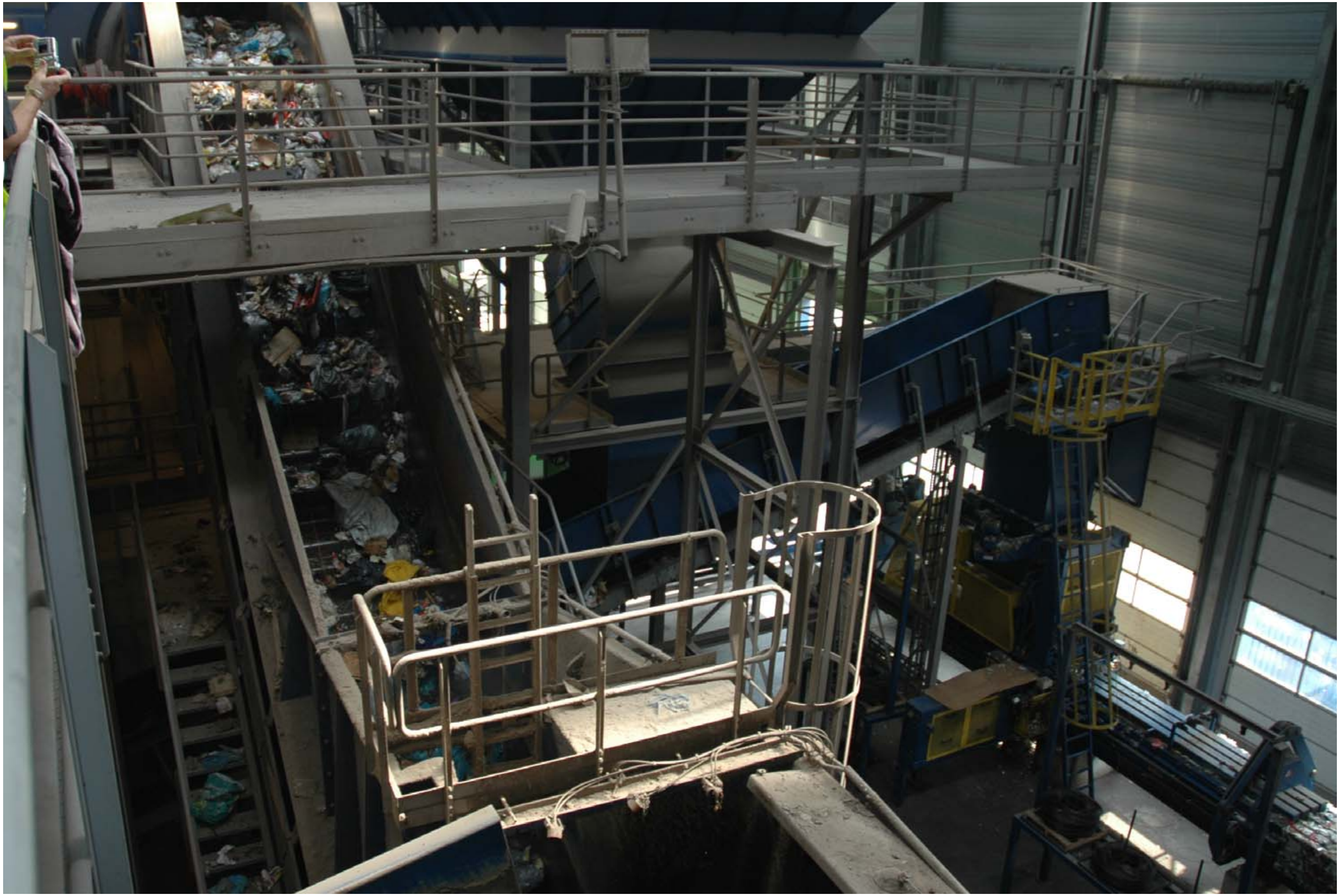
Bio-waste, by-products

Substrate preparation & dosage into digesters

Biogas use for power generation and /or upgrading to fuel

Use of digestate as fertilzer and/or compost


CLAAS




Samson
3235


thöni

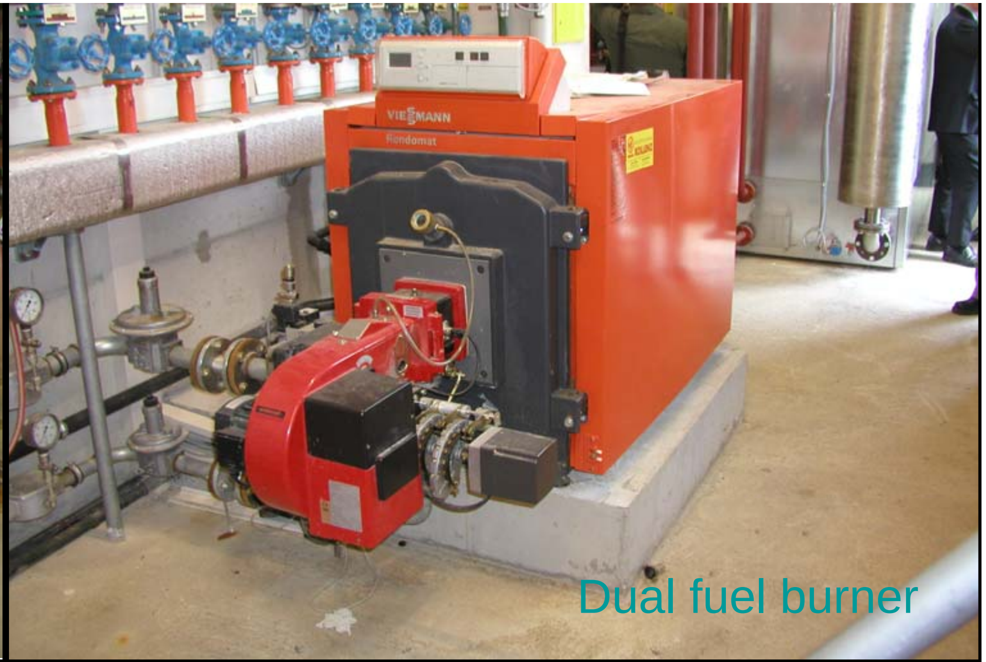
IEA Bioenergy

IFA TULLN

BOKU

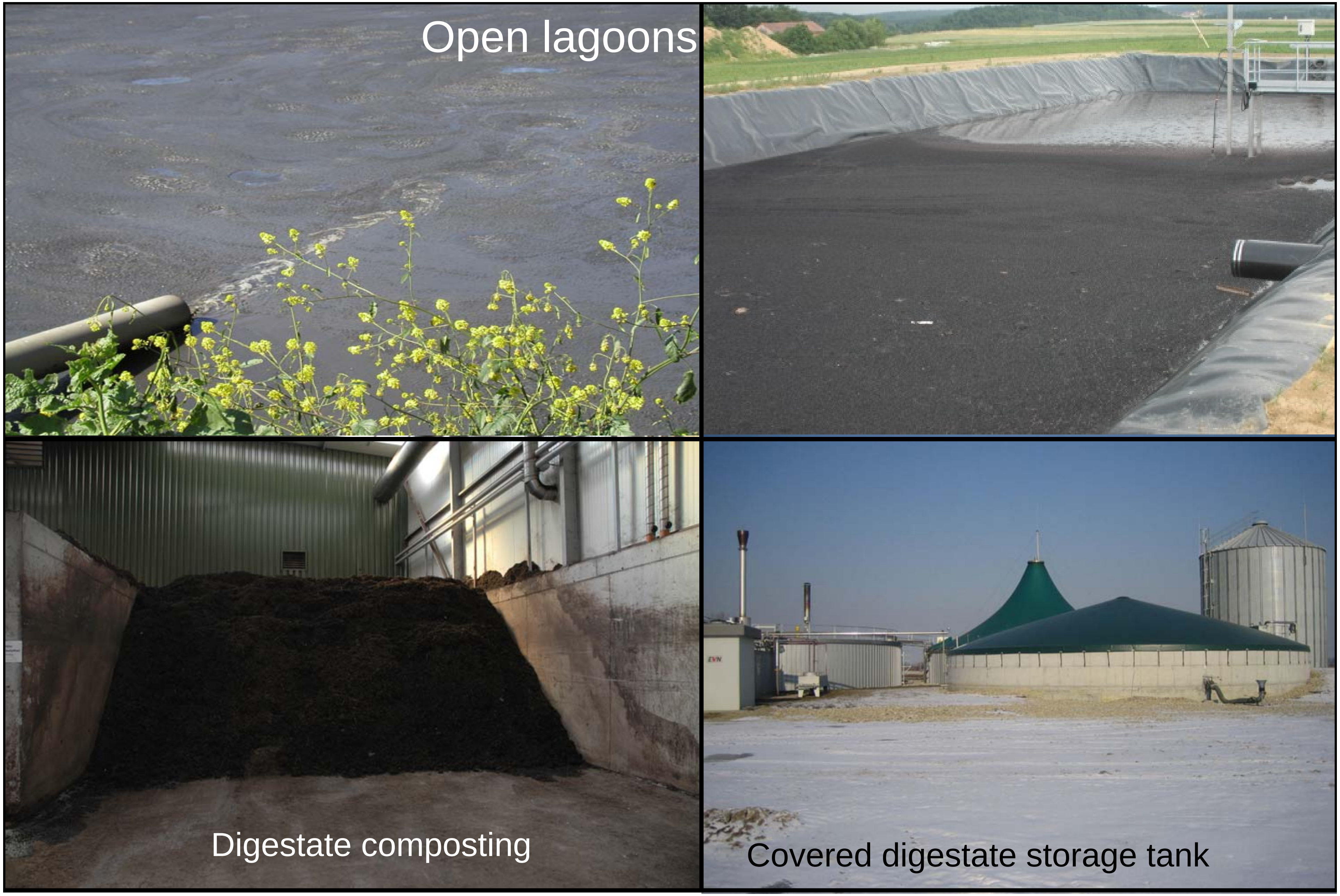

GE Jenbacher


CHP


Dual fuel burner

Biogas train Linköping (Photo: Svensk Biogas)

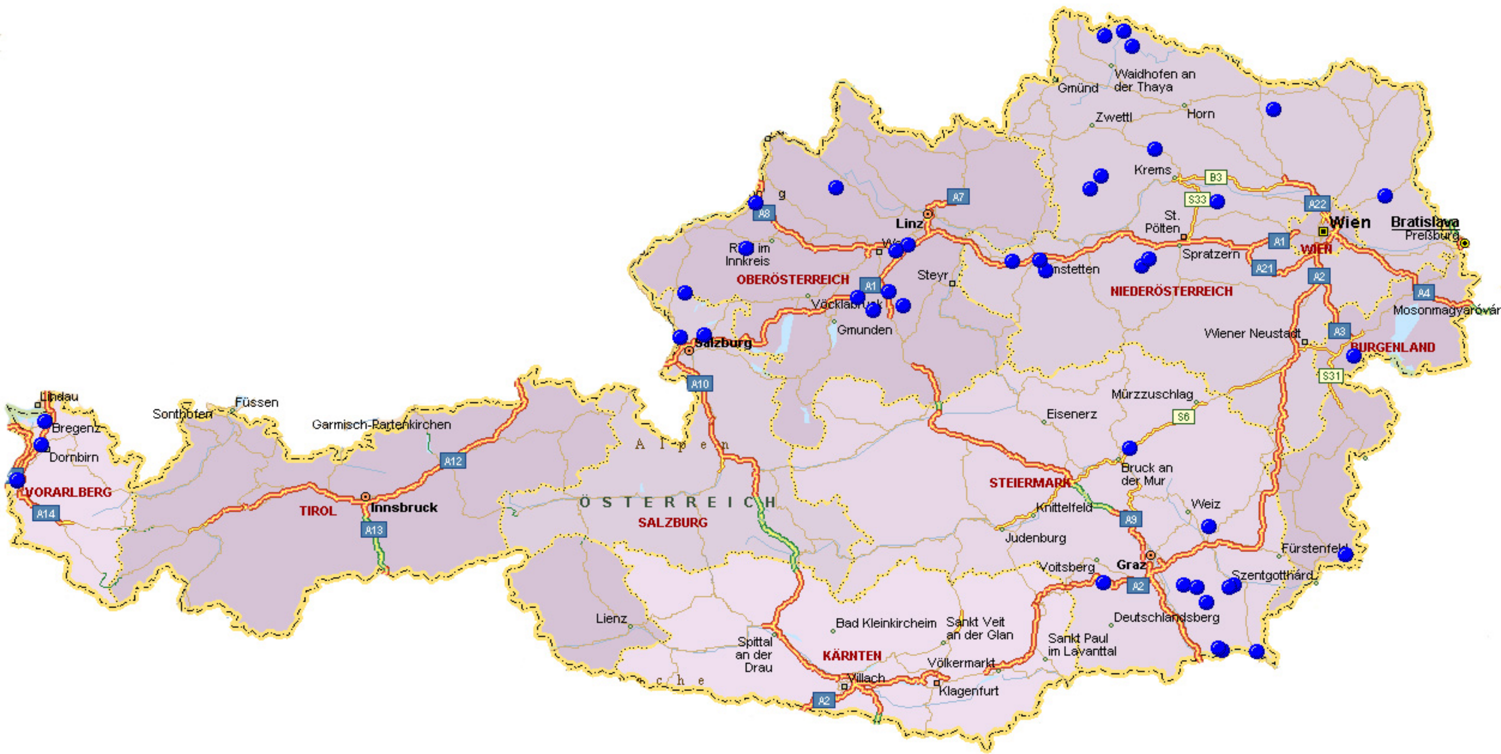
Biogas refuelling station Linköping (Photo SGC)


Open lagoons
Digestate composting
Covered digestate storage tank

Development of an evaluation system for biogas plants

„Ecolabel Biogas"

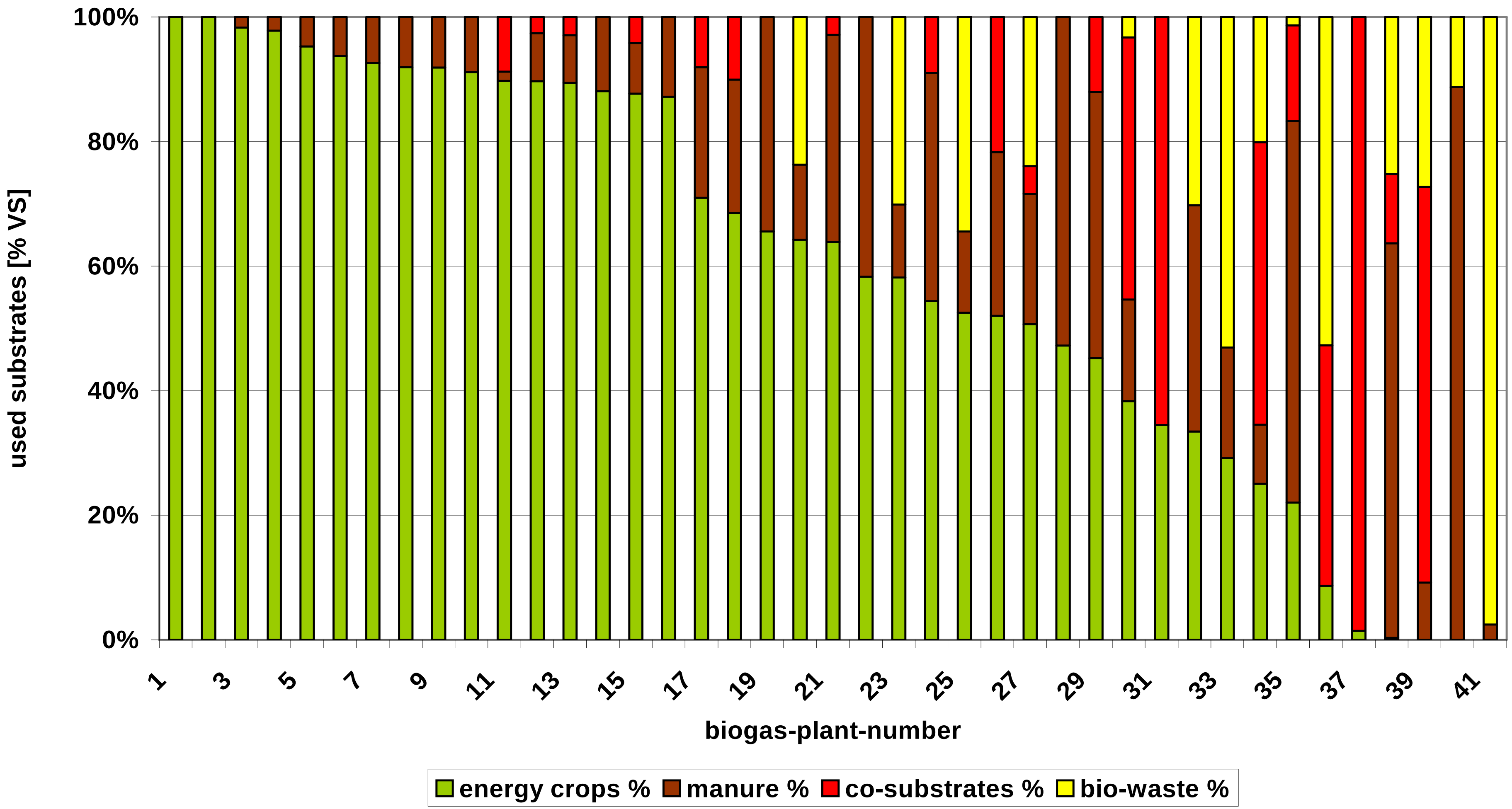
(BMVIT EdZ Project-No 807742)



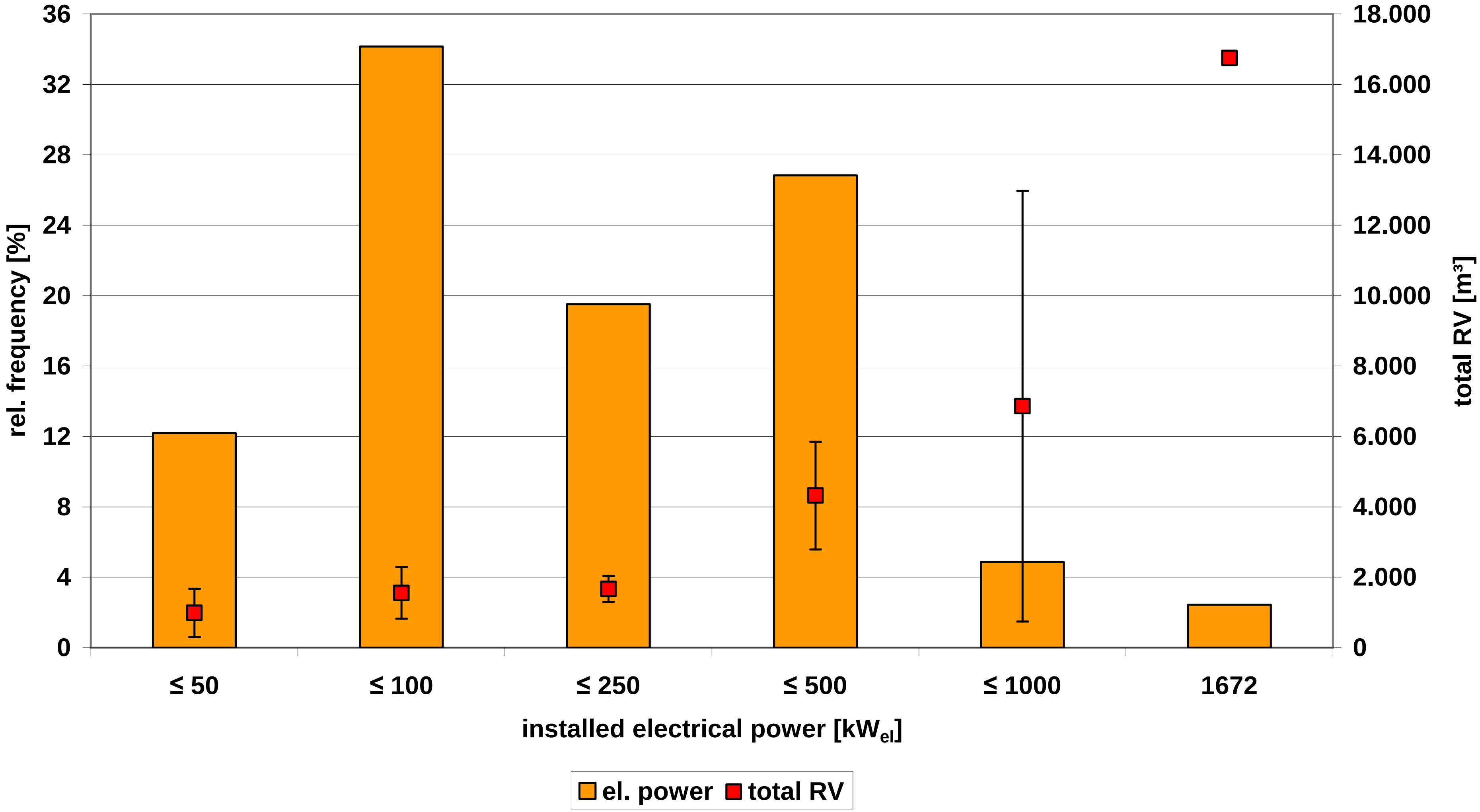
Parameters used in efficiency evaluation of biogas plants

General functional description	Measurable process conditions	Calculable variables
SUBSTRATE		
Quality / quantity Transport Storage Pretreatment Costs	COD[1] TKN[2], NH_4-N TS[3], VSS[4]	t / year Costs/year
DIGESTER		
Startup Investment costs Subsidies Annual costs Process steps Substrate dosage Digester type Digester equipment Digester mixing	T, Self heating pH, VFA[5], COD, TS, VSS TKN, NH_4-N Process energy demand Sludge recirculation	Residence time Hydraulic loading VSS degradation Biogas yield
DIGESTATE		
Storage type / cover Treatment / Dewatering Use	pH, COD, TS, VSS VFA, TKN, NH_4-N CH_4-formation Hygienic status	t / year
BIOGAS		
Gas holder Upgrading Quantity /utilisation	CH_4, H_2S	Calorific value Electrical efficiency Degree of utilisation of heat
PERSONNEL EXPENDITURE		
SALES REVENUES / OVERALL ECONOMICS		

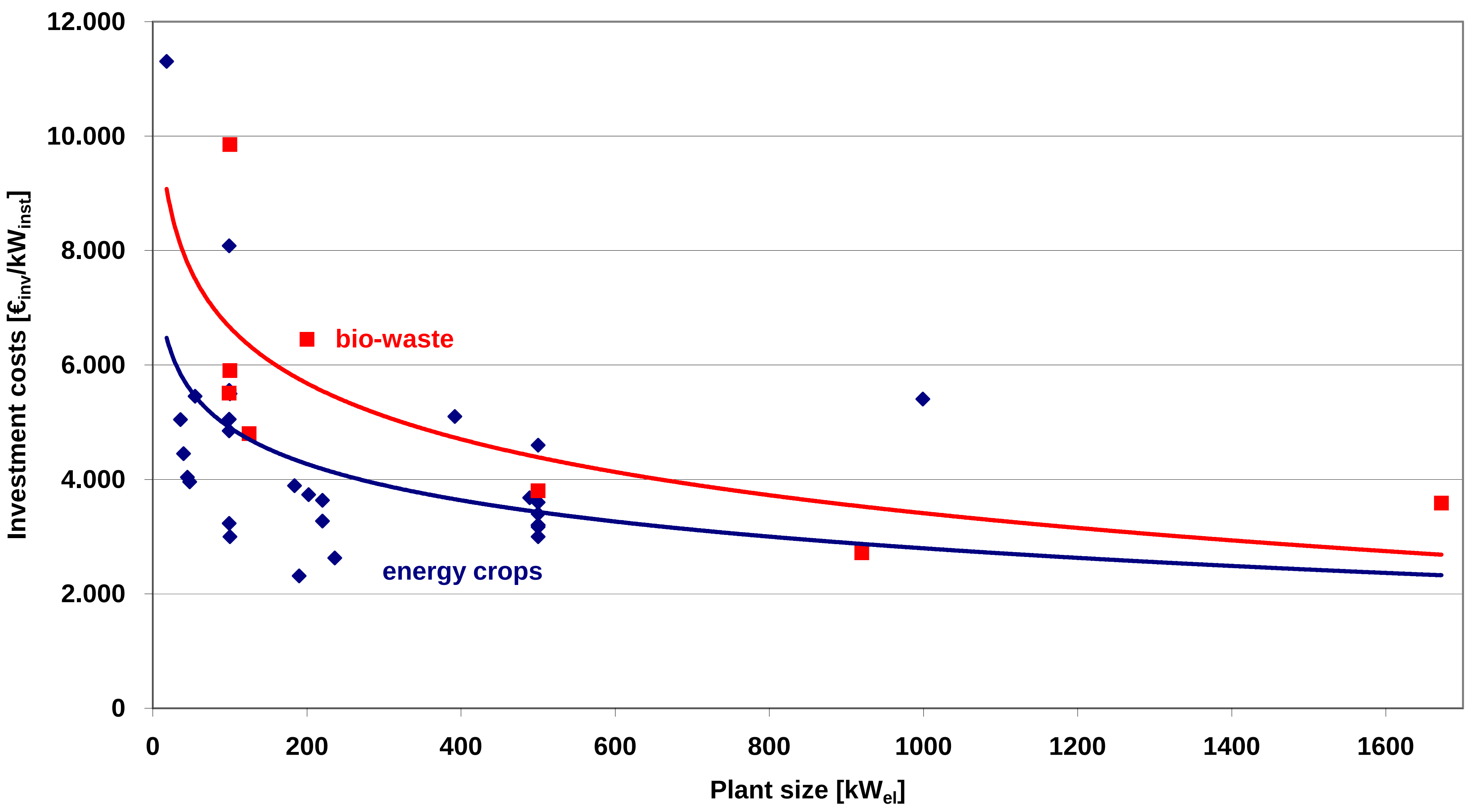
Used substrates (% VS)



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



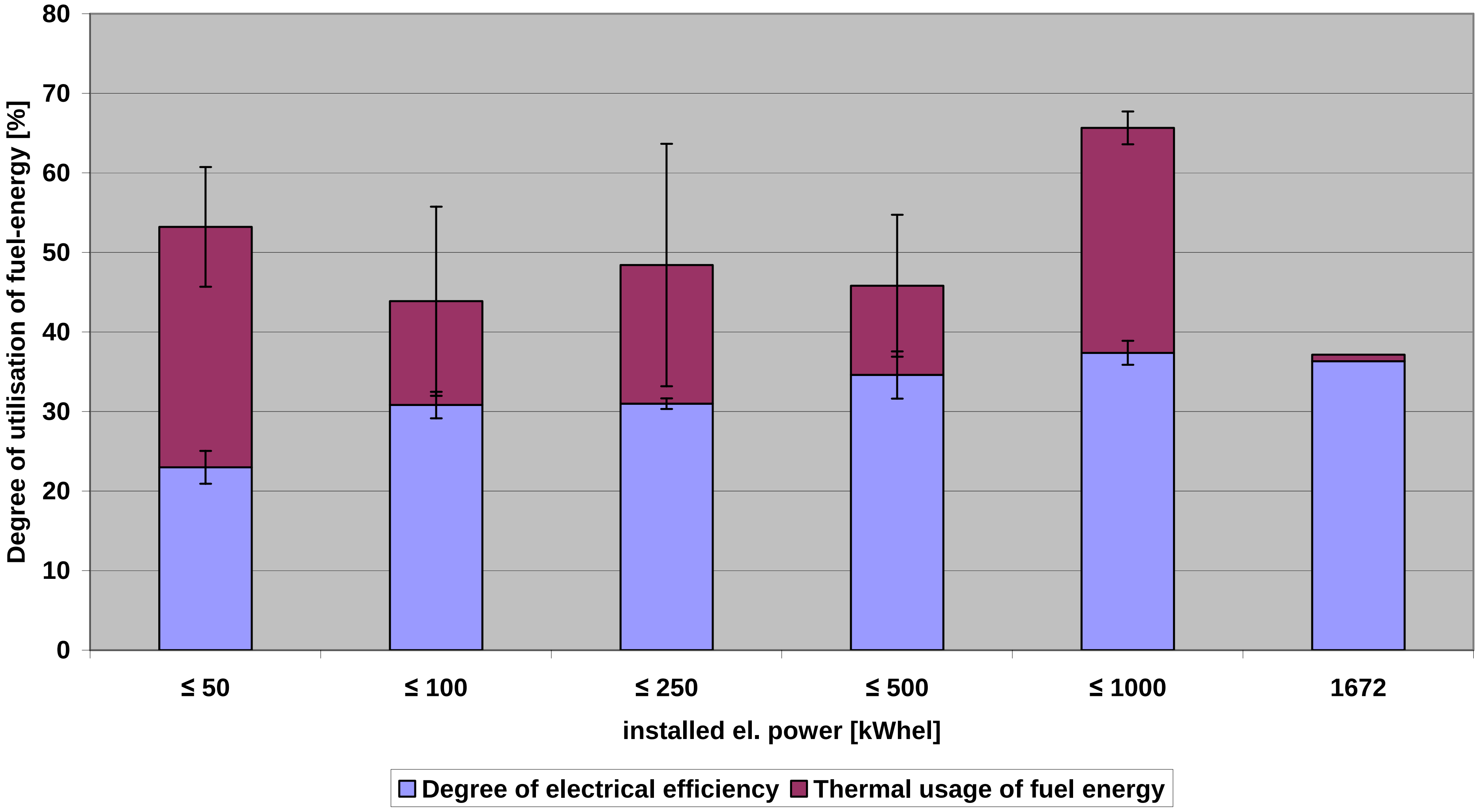
Investvestment costs



Energy Efficiency

- Electrical Efficiency
- Thermal Efficiency
- Energy Balance (Output : Input)
  (5 selected biogas plants)

Utilisation of fuel energy



Cultivation
Fertilizer

Pestizides
Transport

Ensilage
Silo cover

Dosage

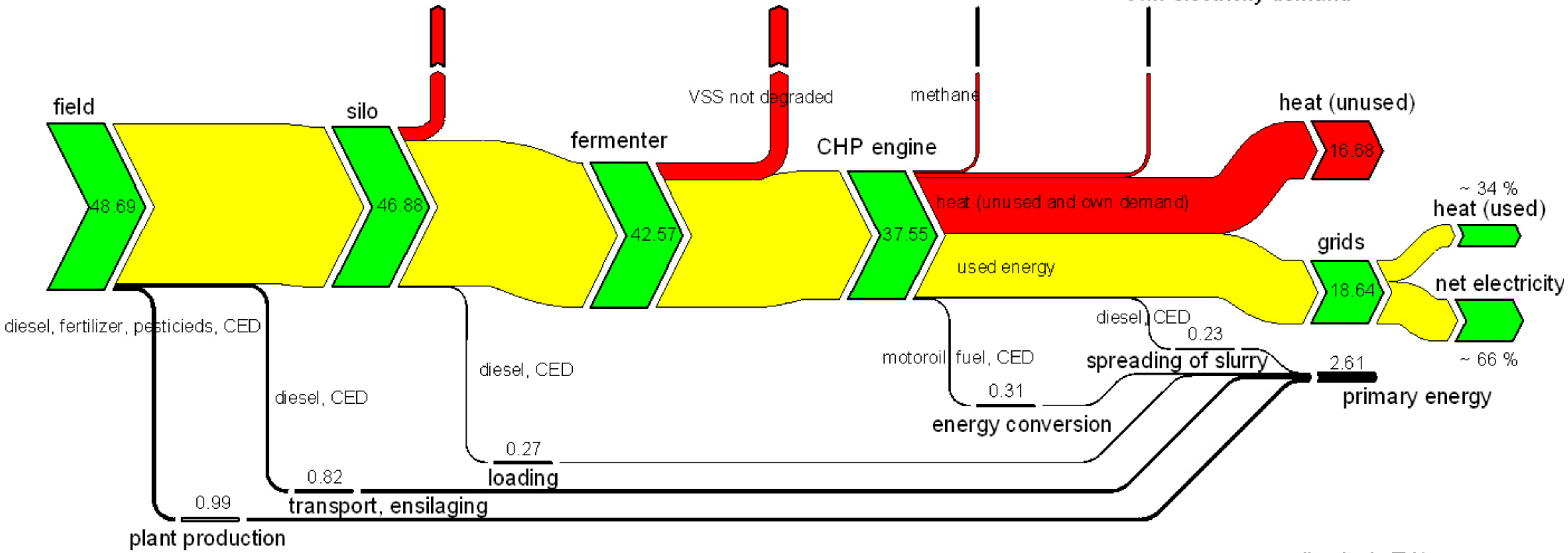
Process energy-demand

On-site power
Motor oil demand
Methane losses

Digestate use

Plant 1	Plant 2	Plant 3	Plant 4	Plant 5
Maize & other plants, agricult. by- pro-ducts, manure No use of synthetic fertilizer 2-step plant 500 kW_{el}	Only renewable biomass (Maize, grass), no manure Synthetic fertilizer appl. (base fertilising) 2-step plant 500 kW_{el}	Oil seed residues, Fat trap contents, waste from food & feedstuff industry; waste food, beet sugar by-products; renewable biomass on occasion 2-step plant 1.672 kW_{el}	Mainly manure (62 % cattle- and pig manure) Food leftovers and potato slops; 2-step plant 200 kW_{el} (ignition oil applied in CHP)	Conventional manure treatment (90 % pig manure and chicken litter), small amounts of fat trap contents Gas displacement system with hydraulic mixing 18 kW_{el} (η CHP only 22 %)

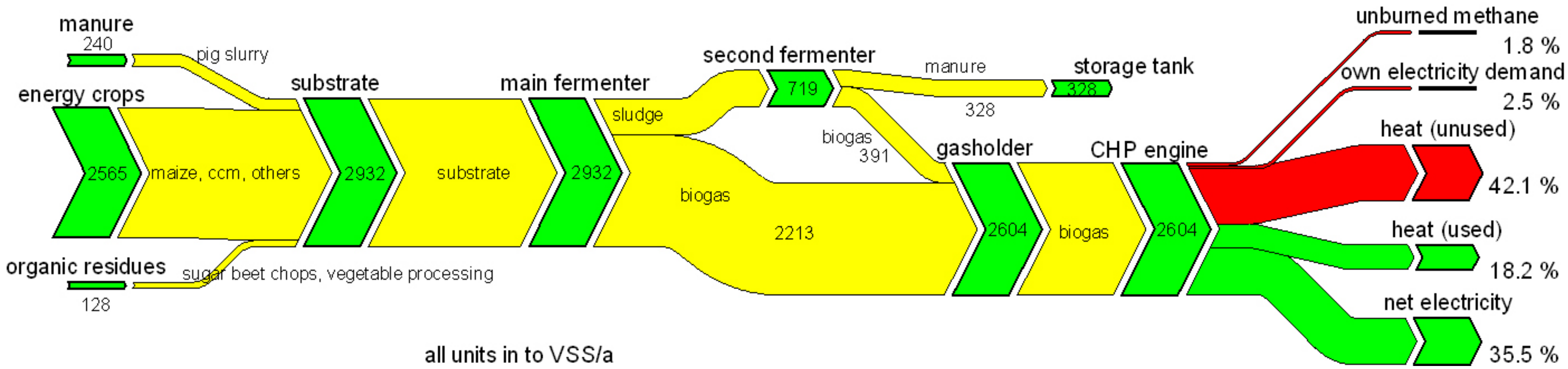
Energy flow during energy crop production-, digestion- and energy use



all units in TJ/a

CED – Cumulative Energy Demand

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



	Plant 1		Plant 2		Plant 3		Plant 4		Plant 5	
	Maize & agric. By-products, manure No synth. fertilzer, 2-step plant, 500 kW_{el}		Maize, Clover grass, no manure, Synthetic fertilizer, 2-step plant, 500 kW_{el}		Biowaste, Renewable raw materials on occasion 2-step plant, 1.672 kW_{el}		manure (60%), Food leftovers, Destill. slops 2-step plant 200 kW_{el} (Ignition oil in CHP)		Manure (90%), Fat trap contents; 18 kW_{el} (η CHP only 22 %)	
	Input	**CED**	**Input**	**CED**	**Input**	**CED**	**Input**	**CED**	**Input**	**CED**
O:I *Power/Heat*	*17.8*	*8.1*	*14.7*	*6.7*	*20.9*	*9.9*	*2.4*	*1.1*	*30.9*	*14.7*
O:I *Power*	*11.7*	*5.4*	*10.5*	*4.8*	*20.9*	*9.9*	*2.1*	*1*	*14*	*6.7*
O:I Power/Heat	18.7	8.6	14.7	6.7	8.7	4.1	2.5	1.2	34.4	16.5
O:I Power	12.4	5.7	10.5	4.8	8.7	4.1	2.2	1.1	15.7	7.5

O:I-ratio severely influenced by the degree of heat use

O:I-ratio severely influenced through transport energy demand

O:I-ratio severely influenced through use of ignition oil

Favour-able O:I-ratio in manure digestion

Comparative < Output : Input > - Efficiencies of Bioenergies

Plant oil*	3.2
Biodiesel*	3.9
Ethanol*	1.25-2
BtL*	7.9
Hydrogen*	4
Biogas*	2.7
Own measurements (including CED)**	
Plant 1 (Renewables & agric. by-products)	**8.6**
Plant 2 (Renewables)	**6.7**
Plant 3 (bio-waste, partly. renewables)	**4.1**
Plant 4 (manure, Co-substr., ignition oil CHP)	**1.2**
Plant 5 (manure)	**16.5**

*) Data source: FNR (2006); **) Cumulative Energy Demand

Conclusion

- **Energy balance (Output : Input) in Biogas production is favourable compared to other bio-energies (e.g. ethanol)**
- **Favourable Energy efficiency achievable even in manure- or bio-waste digestion**
- **Considerable potential for AD efficiency improvement**
  e.g. Heat use, Degradation efficiency, Reliable process technology…

Thank you for your attention!

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