Determination of the biogenic fraction in waste: Balance method

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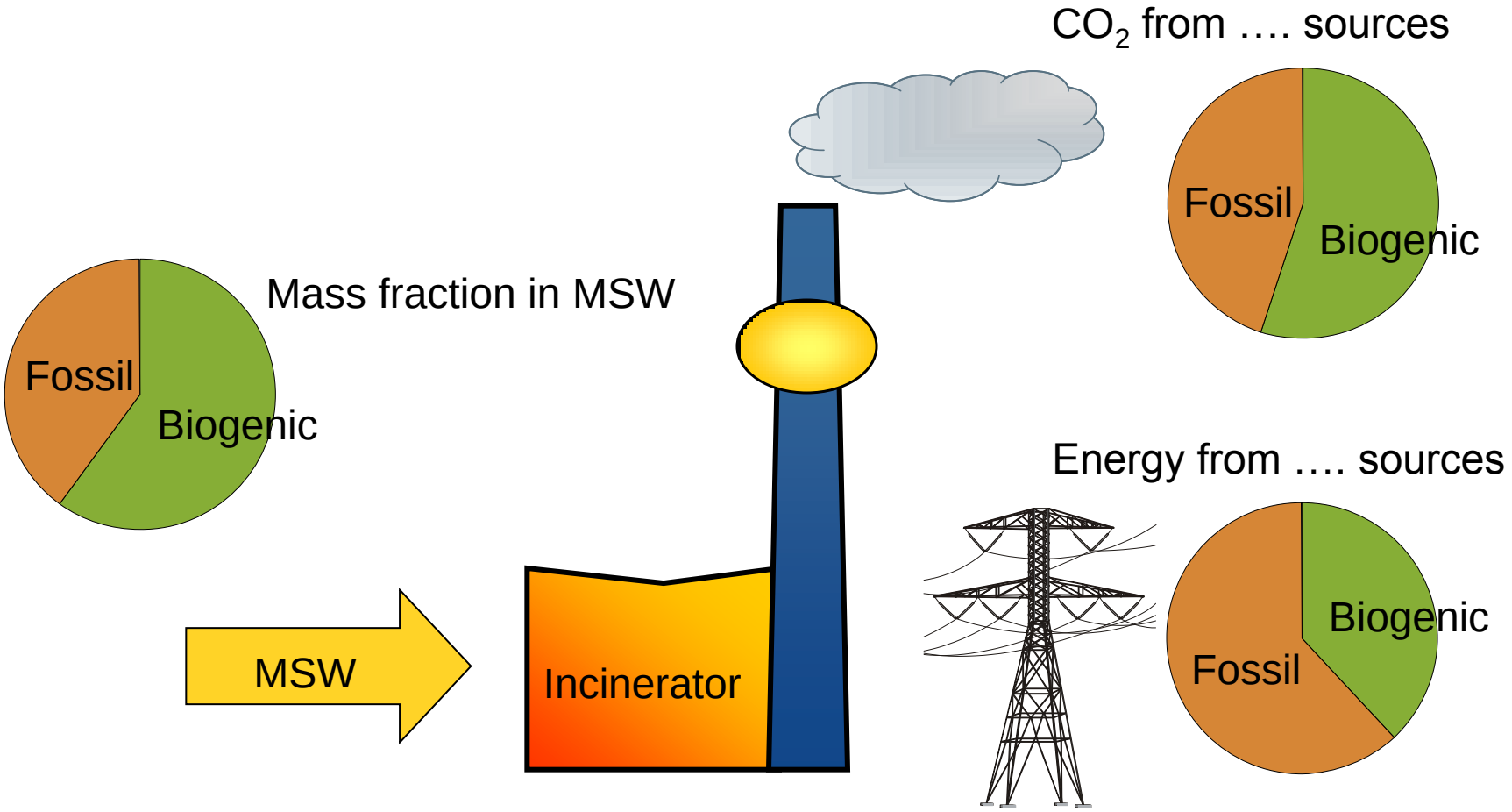
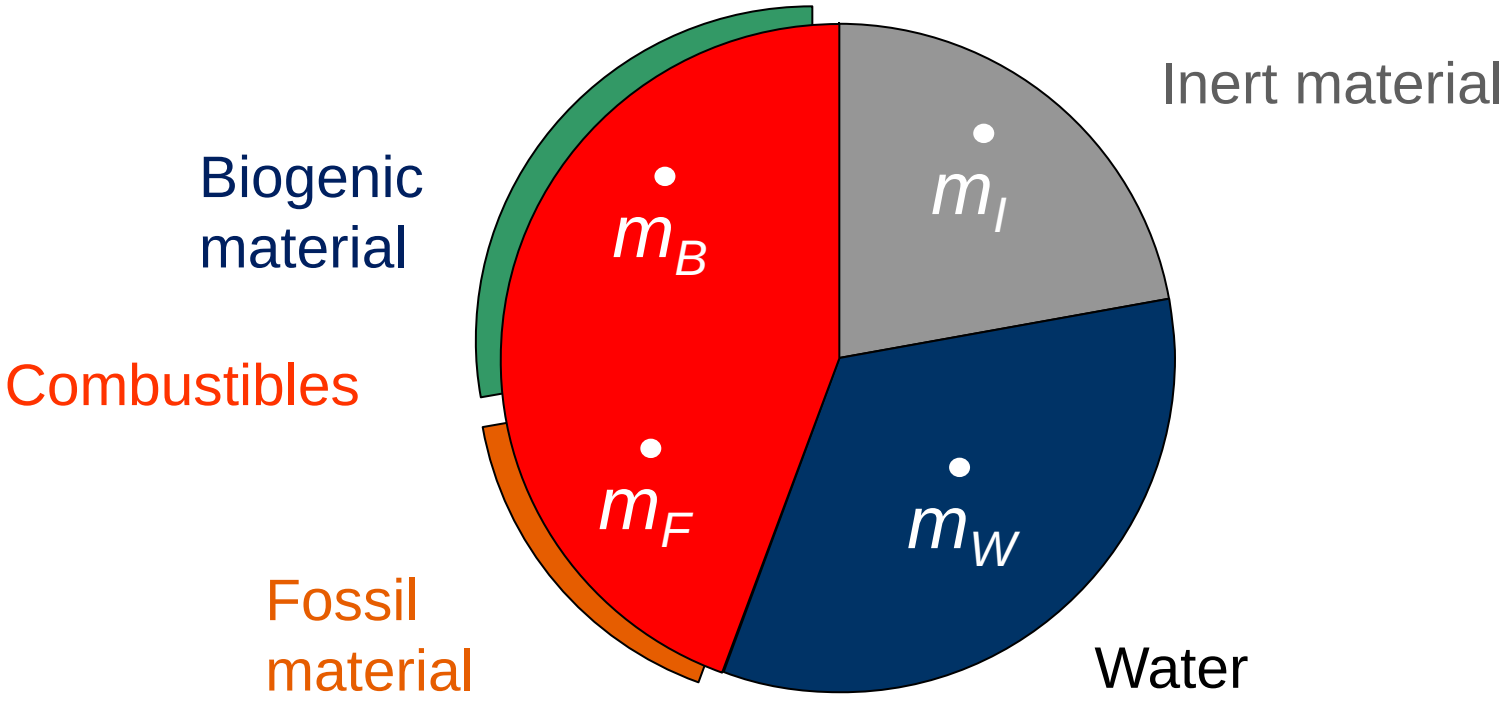
The problem to be solved



Balance Method: Concept

1. Theoretical split up of waste into 4 „material groups“ biogenic, fossil, inert and water

Balance Method: Concept



Fellner et al., 2007

Balance Method: Concept

1. Theoretical split up of waste into 4 „material groups“ biogenic, fossil, inert and water

2. Chemical composition of the material groups biogenic and fossil (content of C, H, O, N, S and Cl)

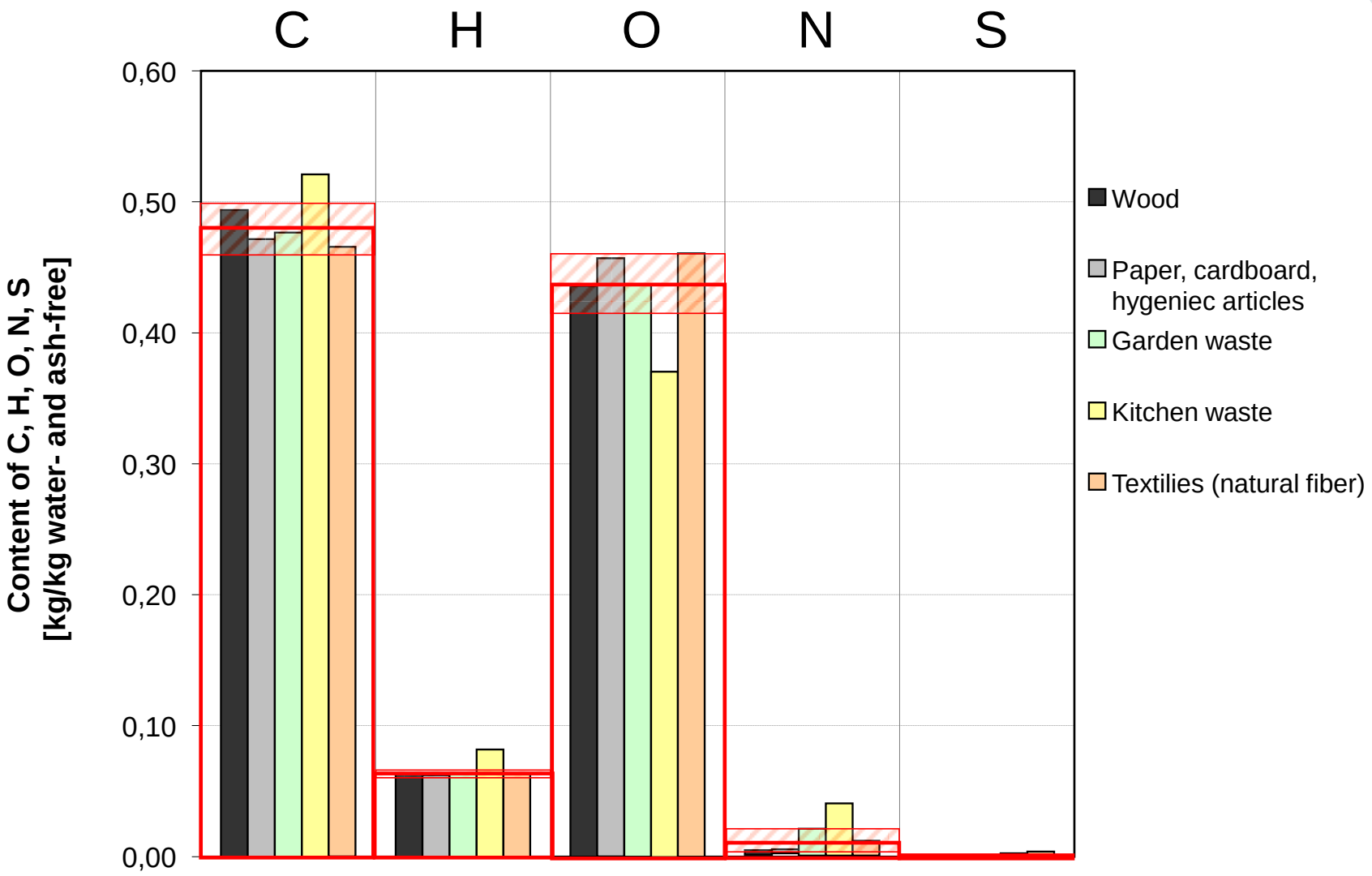
Required Input Data

Tab.: Chemical Composition of Biogenic and Fossil Matter

Material group	C-content		H-content		O-content		N-content		S-content		Cl-content	
	[g/kg moisture-and-ash-free]											
	av.	*sd*	**av.**	*sd*	**av.**	*sd*	**av.**	*sd*	**av.**	*sd*	**av.**	*sd*
Biogenic matter	**483**	10	**65**	*0,8*	**441**	*10*	**8**	*3*	**1,2**	*0,3*	**-**	-
Fossil matter	**768**	20	**109**	*7*	**88**	*22*	**13**	*5*	**3**	*1,1*	**19**	*15*

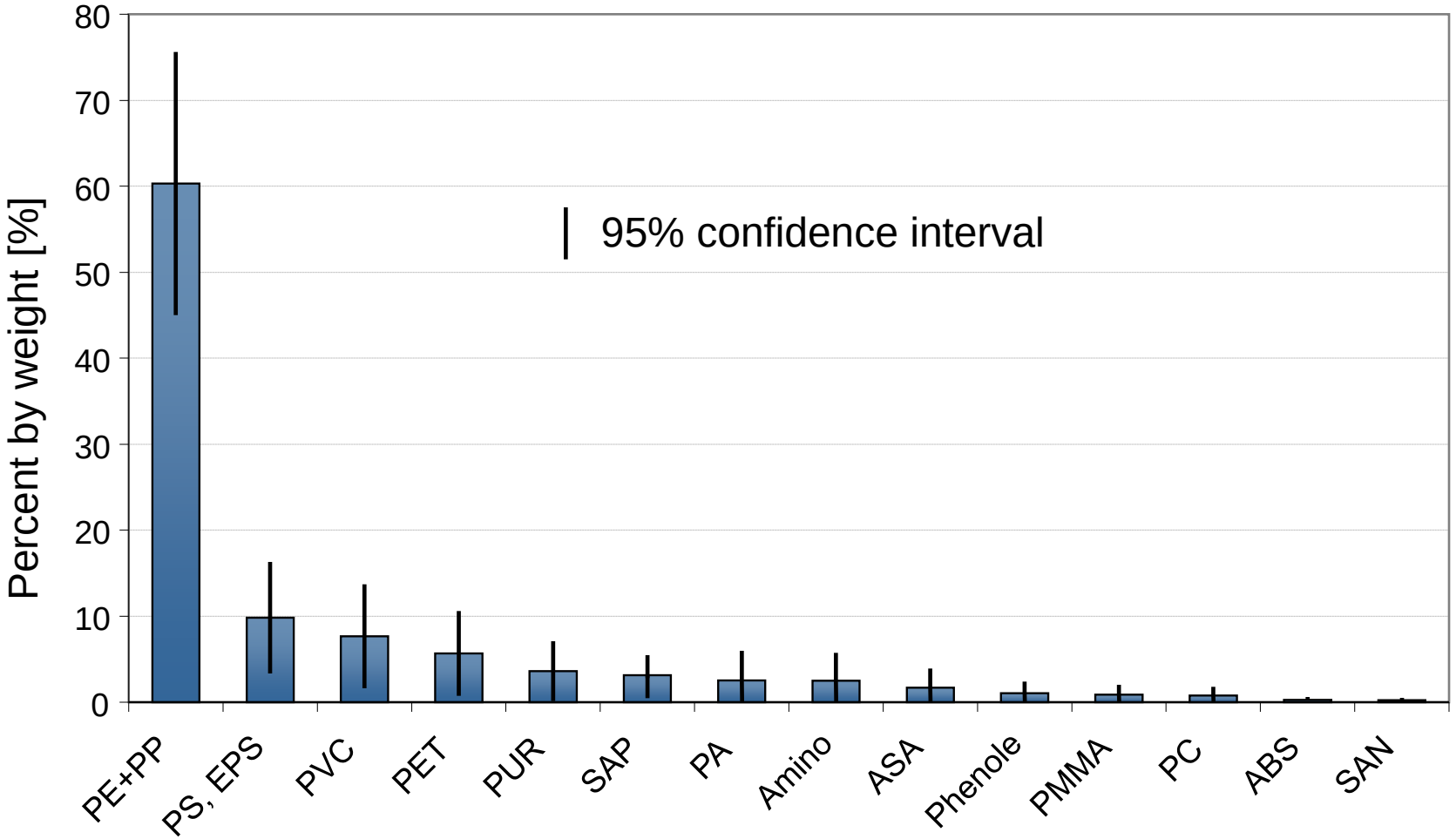
Fellner et al., 2007

Chemical Composition of Biomass



IEA Bioenergy Task 36, Nov. 15-16 2012, Vienna
Balance Method by Rechberger & Fellner

Composition of plastic fraction in MSW



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Balance Method: Concept

1. Theoretical split up of waste into 4 „material groups“ biogenic, fossil, inert and water

2. Chemical composition of the material groups biogenic and fossil (content of C, H, O, N, S and Cl)

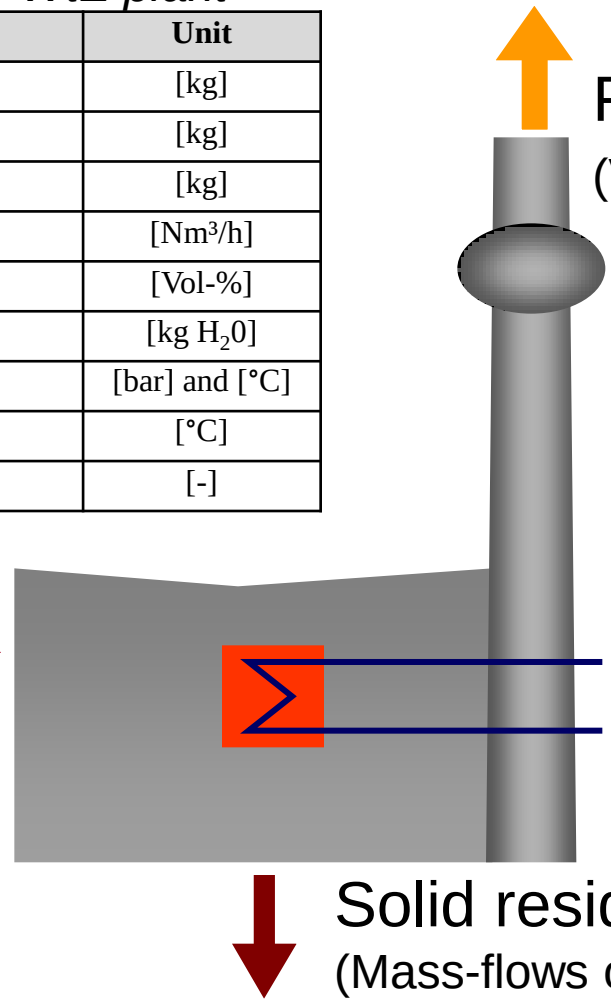
3. Theoretical balance equations (including mass fractions of material groups (unknowns) and their chemical composition)

4. Comparison of theoretical balance equations with measured operating data from the incineration plant

Required operating data

Required operating data of WtE plant

parameter	Unit
waste amount	[kg]
amount of sewage sludge	[kg]
amount of solid residues	[kg]
volume of flue gas	[Nm³/h]
O_2 and CO_2 content in the flue gas	[Vol-%]
steam production	[kg H_20]
steam pressure and temperature	[bar] and [°C]
temperature of the feed water	[°C]
boiler efficiency	[-]



Flue gas
(Volume, O_2, CO_2)

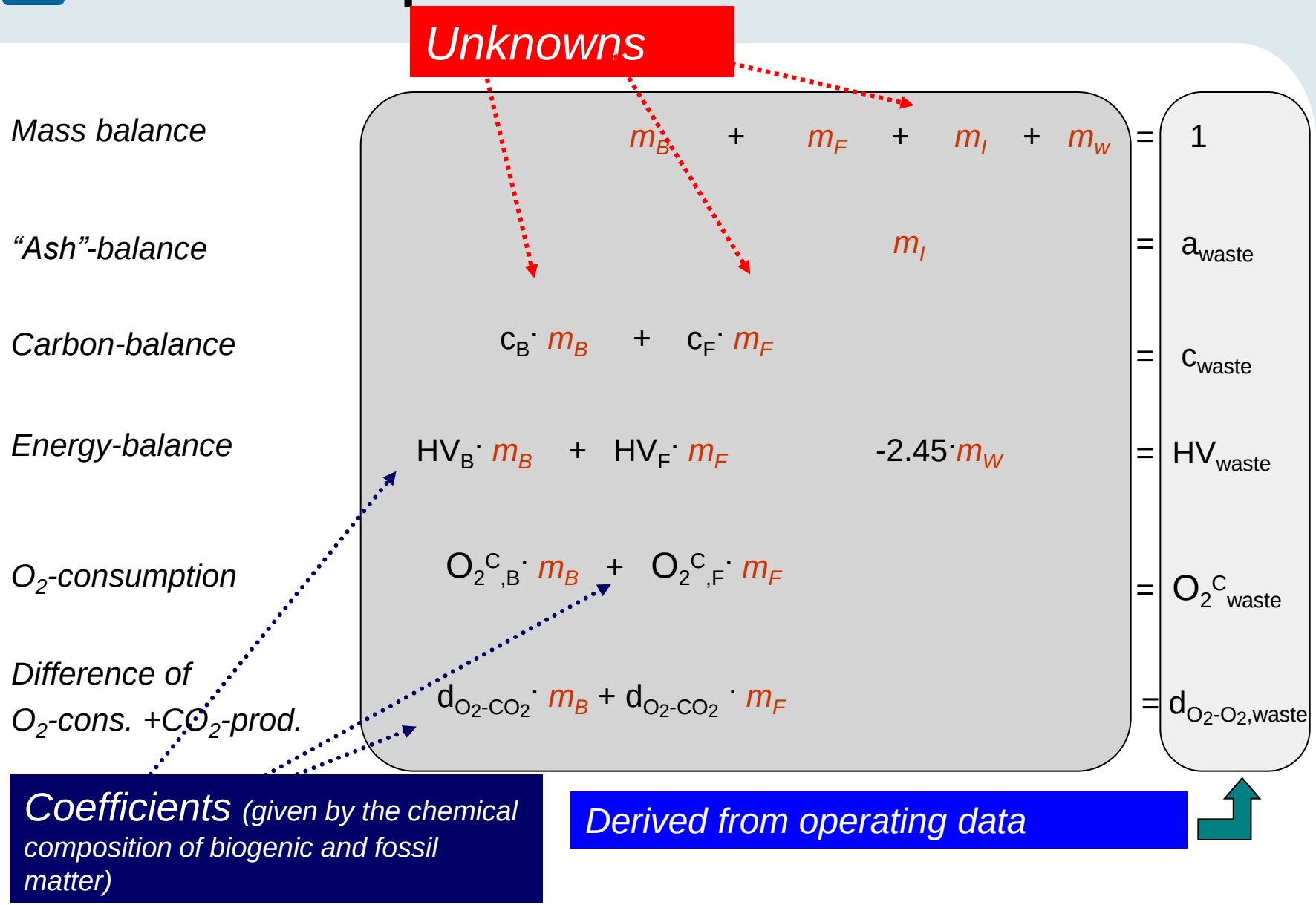
Waste
(Mass-flow)

Auxiliary fuels
(Fuel oil, natural gas)
(Mass-flow)

Steam boiler
(Steam production, pressure, temperature, boiler efficiency)

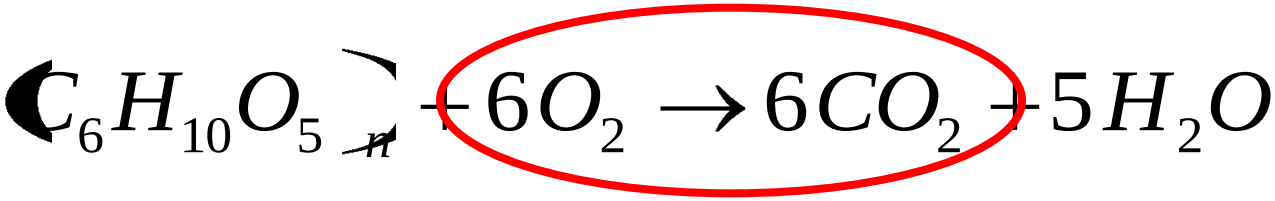
Solid residues
(Mass-flows of bottom ash, fly-ash, filter cake, iron-scrap)

Balance Equations



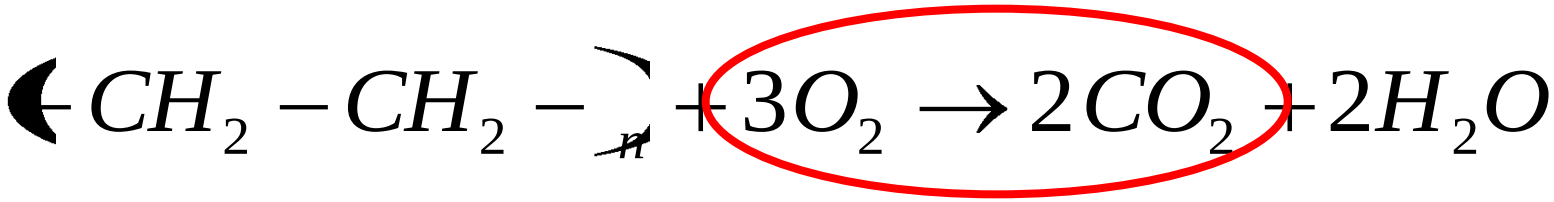
O_2 Consumption vs. CO_2 Production

Biomass (cellulose)



O_2-consumption = CO_2-production

Plastics (polyethylene)



O_2-consumption > CO_2-production

Difference between O_2 Consumption and CO_2 Production

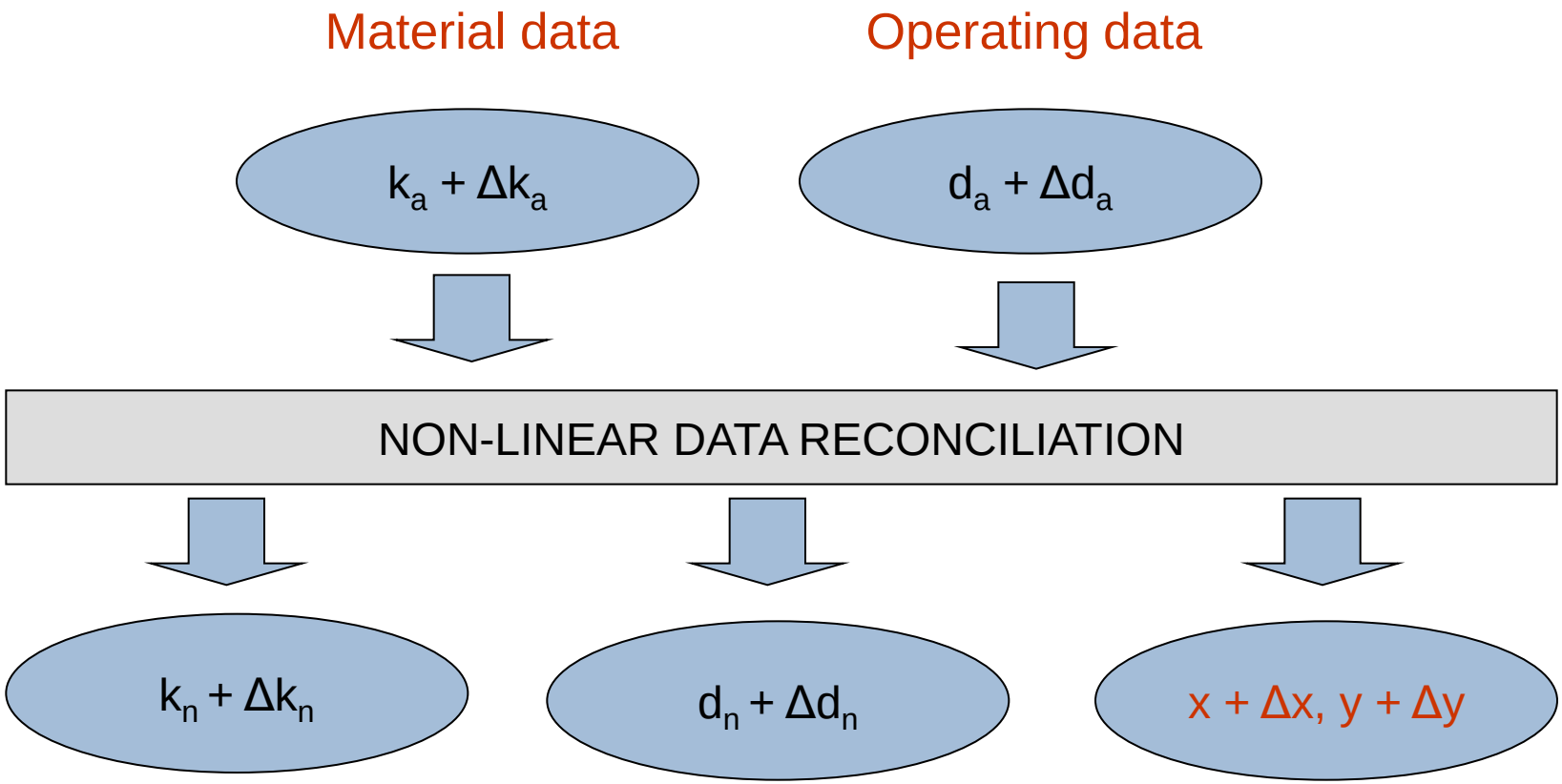
$$\dot{m}_B \cdot \left(\frac{c_{H_B}}{4 \cdot M_H} - \frac{c_{O_B}}{2 \cdot M_O} + \frac{c_{N_B}}{2 \cdot M_N} + \frac{c_{S_B}}{M_S} \right) \cdot 10^3 +$$

$$+ \dot{m}_F \cdot \left(\frac{c_{H_F} - \frac{c_{Cl_F}}{M_{Cl}}}{4 \cdot M_H} - \frac{c_{O_F}}{2 \cdot M_O} + \frac{c_{N_F}}{2 \cdot M_N} + \frac{c_{S_F}}{M_S} \right) \cdot 10^3 = d_{O_2-CO_2} =$$

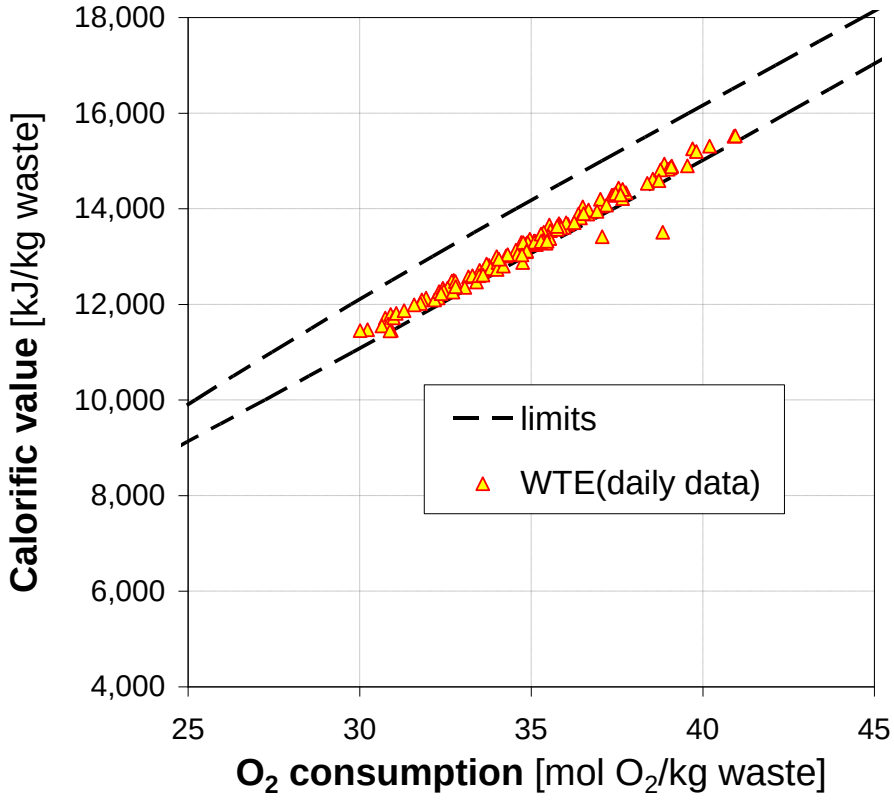
$$= \frac{\frac{\dot{V}_{flue\ gas}}{10^3} \cdot \left(c_{O_{2,a}} + c_{CO_{2,a}} \cdot \left(\frac{100 - c_{O_{2,fg}} - c_{CO_{2,fg}}}{100 - c_{O_{2,a}} - c_{CO_{2,a}}} \right) - c_{O_{2,fg}} + c_{CO_{2,fg}} \right) \cdot \frac{1}{100} \cdot \frac{1}{V_m}}{\dot{M}_{waste}}$$

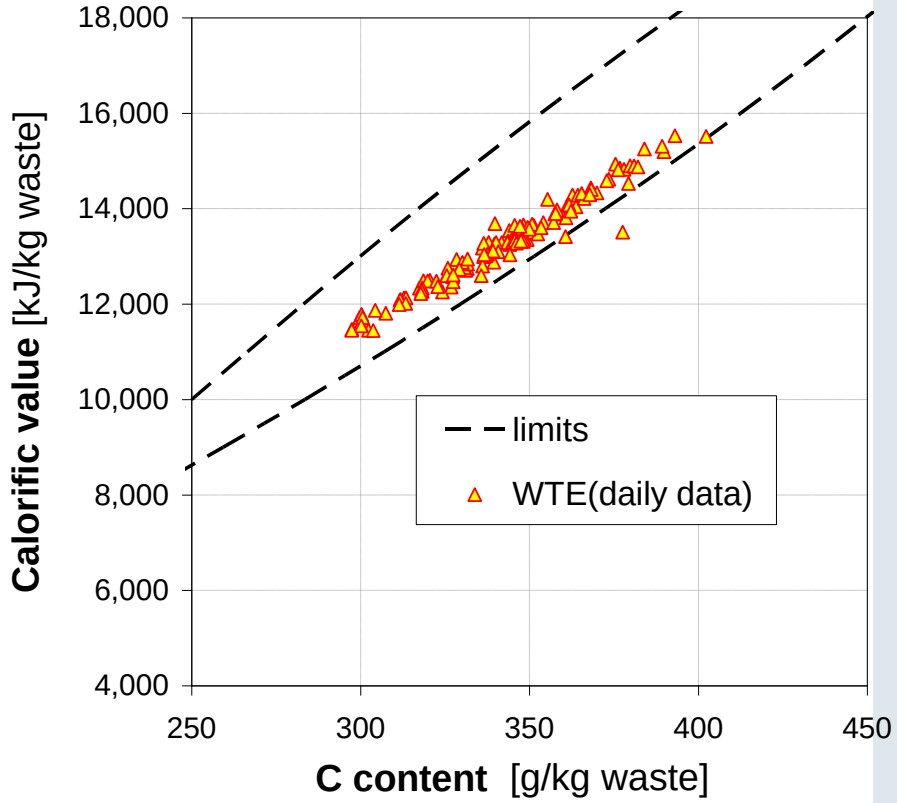
Fellner et al., 2007

Solution of non-linear over-determined system of equations



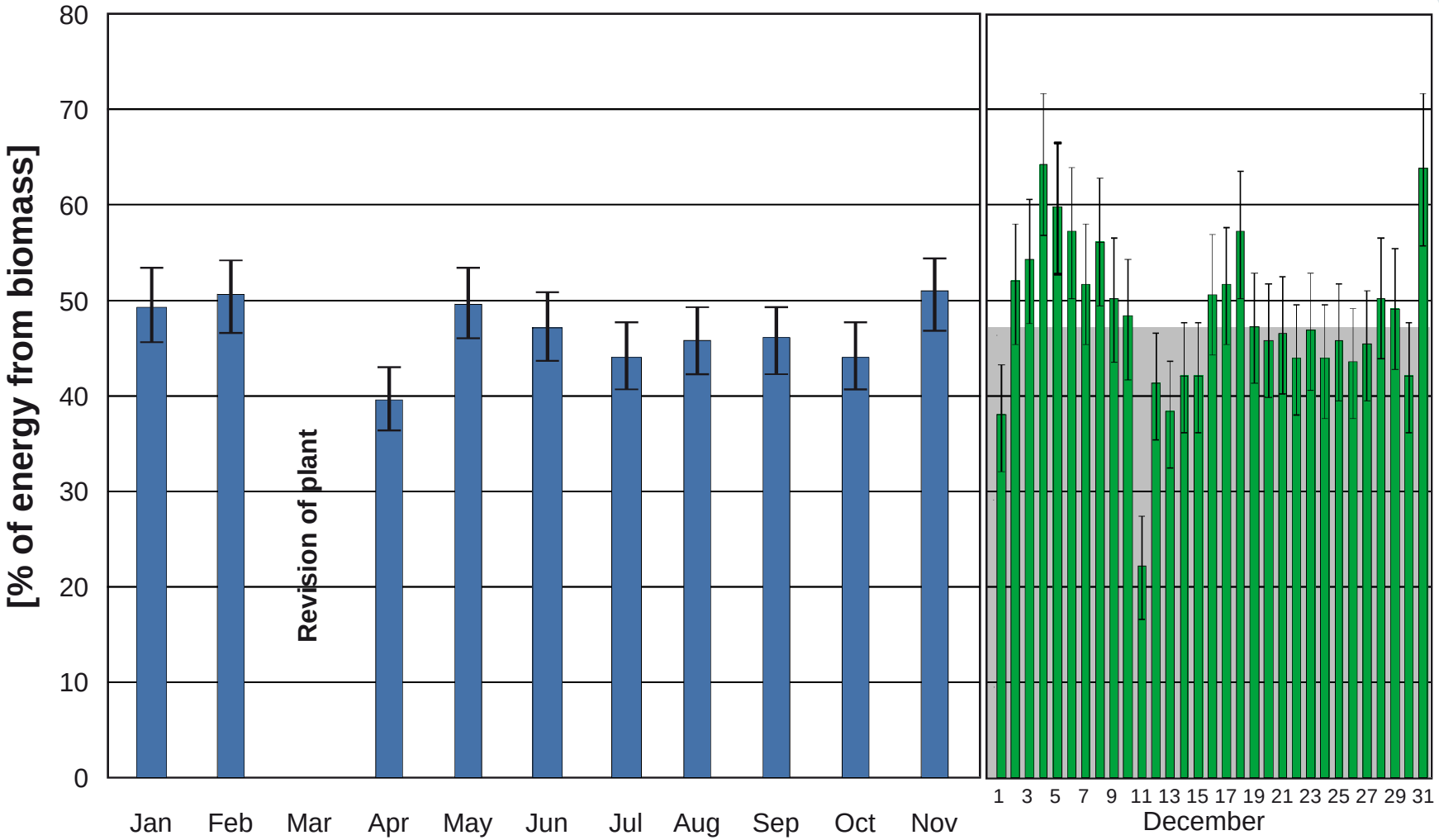
Plausibility check of operating data



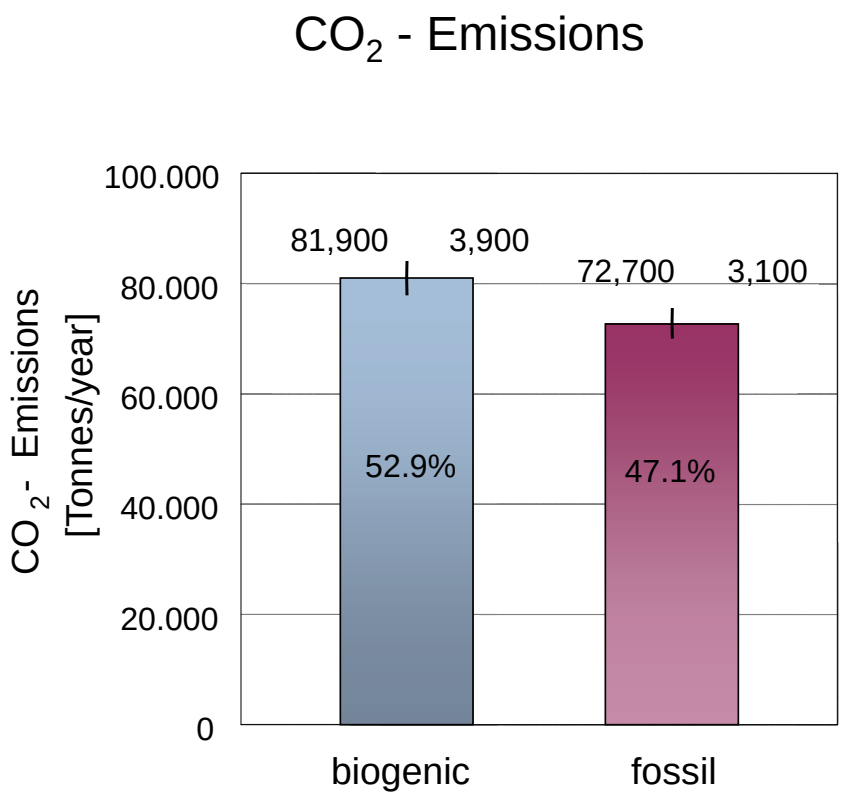


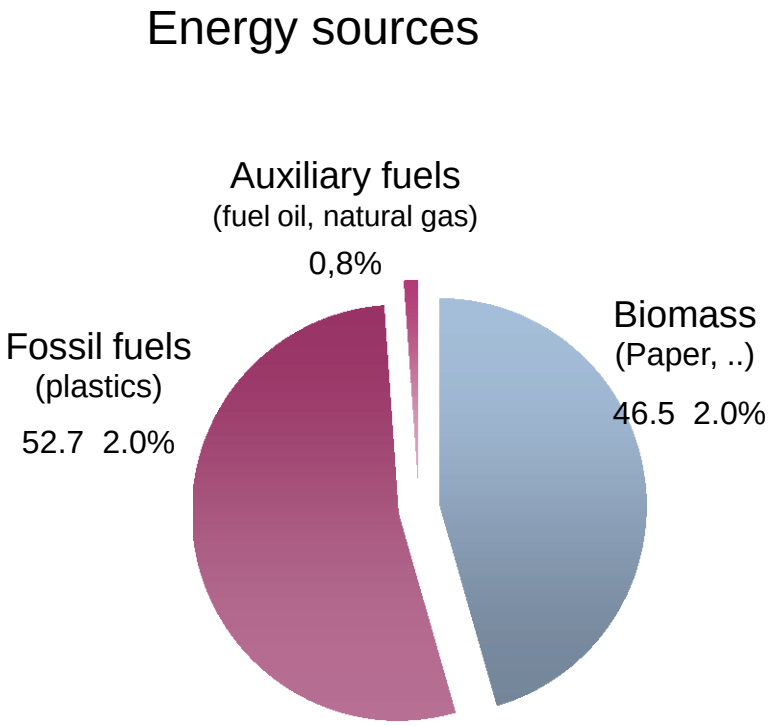
Fellner et al., 2007

Annual result of balance method



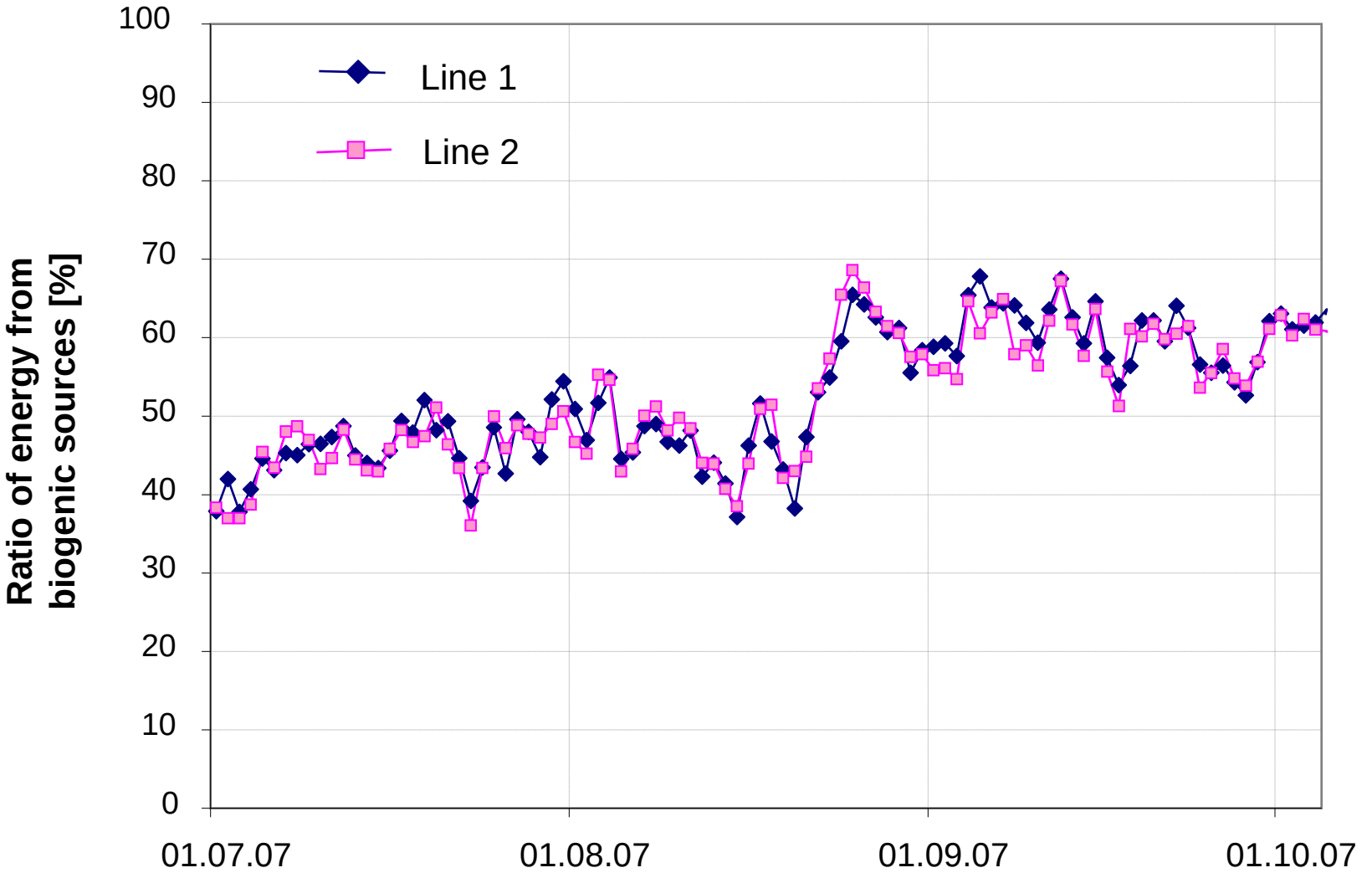
Results (annual values)





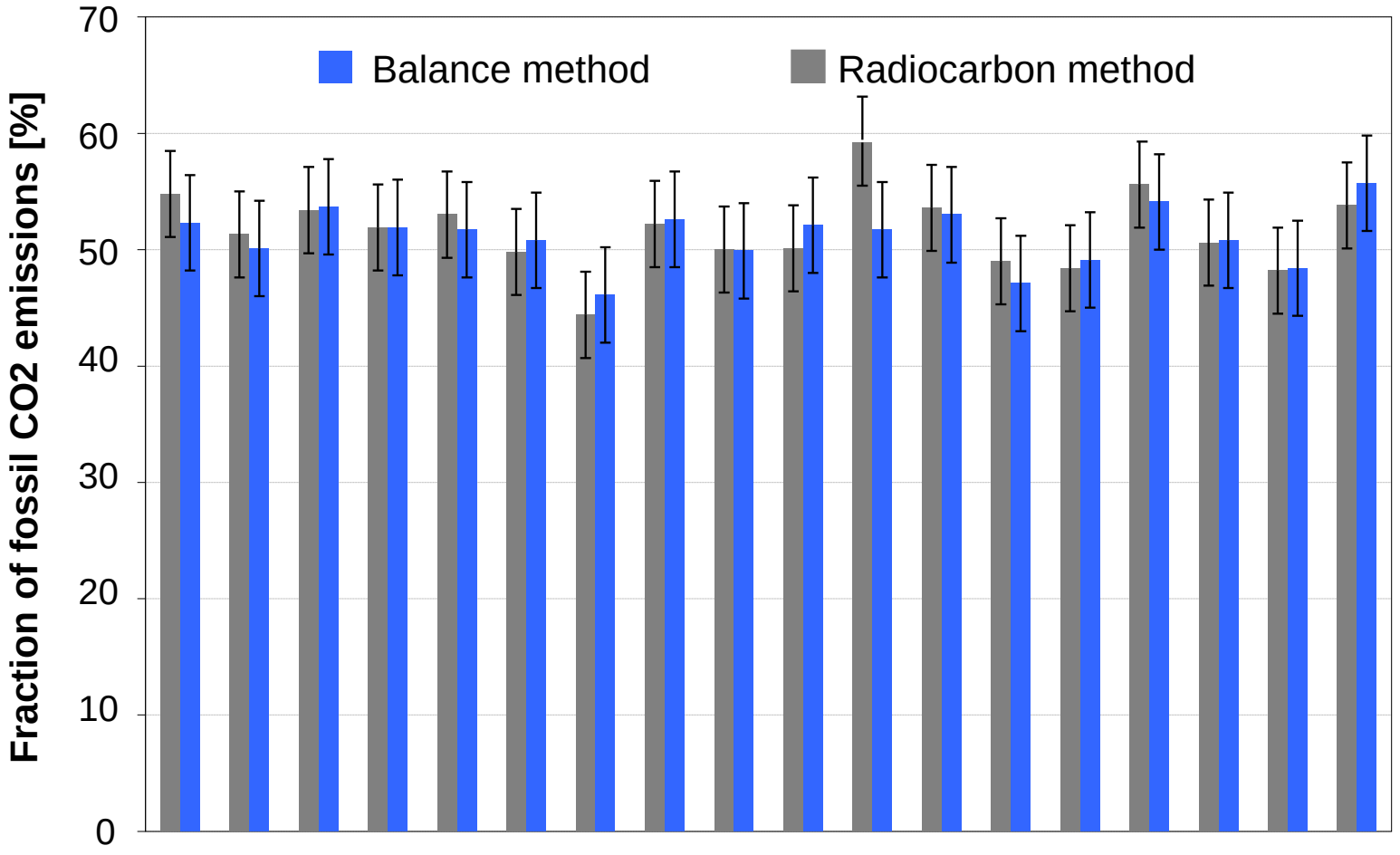
Fellner et al., 2007

Results: two combustion lines



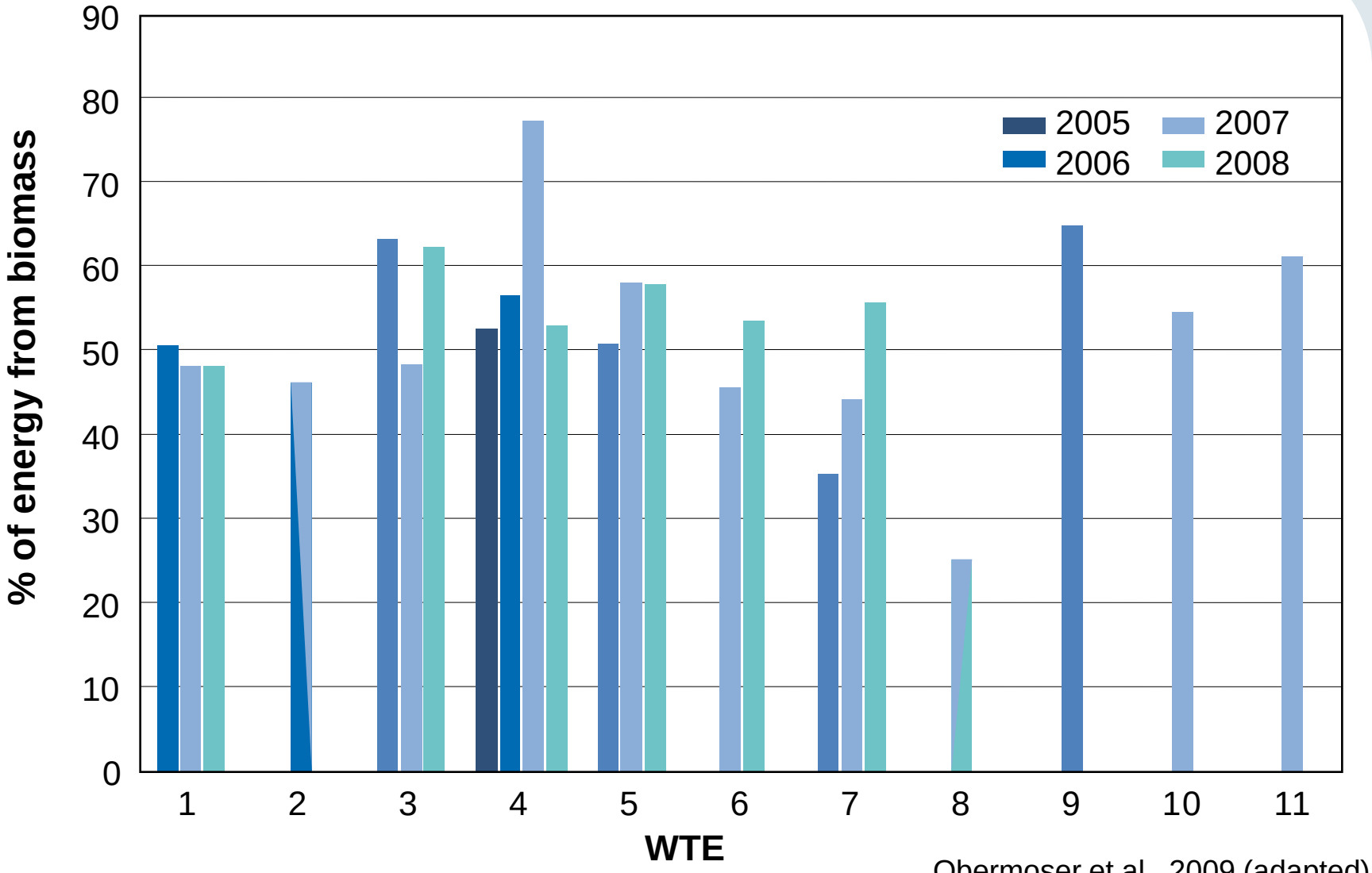
Obermoser et al., 2009

Comparison with radiocarbon method



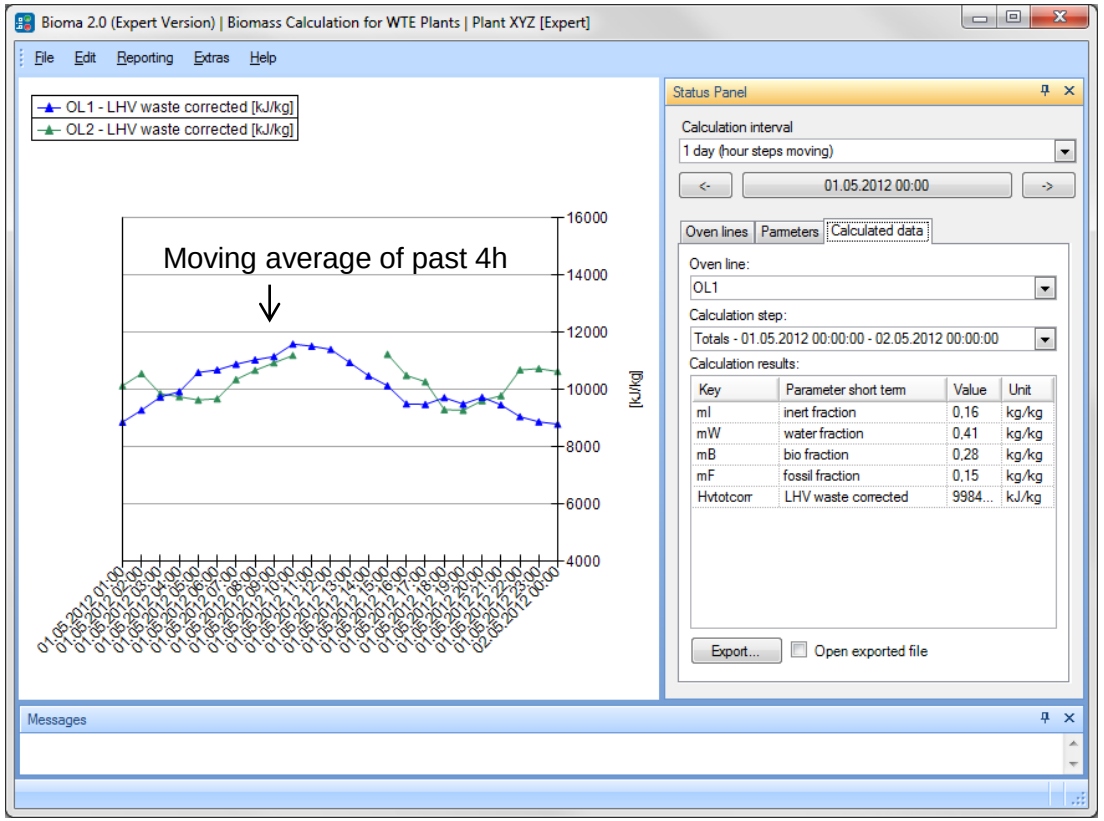
Mohn et al., 2008

There is no typical factor for green energy



Obermoser et al., 2009 (adapted)

Software for routine operation



Summary

Routine operation at 3 Austrian WtE plants (4-5 years)

- high precision (σ < 4 % relative)
- low costs
- additional benefits

Trial runs at 8 WtE plants

Successful validation with radiocarbon method

Software BIOMA for routine application available

No need to apply uncertain fixed rates

References

Fellner, J., Cencic, O., Rechberger, H., A new method to determine the ratio of electricity production from fossil and biogenic sources in waste-to-energy plants. *Environmental Science and Technology*, **2007**, Vol 41, No. 7, 2579-2586.

Mohn, J., Szidat, S., Fellner J., Rechberger, H., Quartier, R., Buchmann, B., Emmenegger, L., Determination of biogenic and fossil CO_2 emitted by waste incineration based on $^{14}CO_2$ and mass balances, *Bioresource Technology*, 99, **2008**, 6471-6479.

Obermoser, M., Fellner, J., Rechberger, H., Determination of reliable CO2 emission factors for waste-to-energy plants, *Waste Management and Research*, 27, **2009**, 907-913.

Fellner, J., Cencic, O., Zellinger, G., Rechberger, H. Long term analysis of the biomass content in the feed of a waste-to-energy plant with oxygen-enriched combustion air. *Waste Management and Research*, **2011**, Vol.29, 3-12.