Performing Entire Life Cycle Inventory Analysis: Input-Output-Tables as Background Inventory Data for LCA

Torsten Marheineke

The need of background inventory data (’’BID’’)

„A product system should be modeled in such a manner that inputs and outputs at its boundaries are elementary flows“
/ISO 14041/

But:

- all upstream products for each process of a product system ?
- data for upstream processes resp. time / resources to collect these data ?
- use of cut-off criteria: restricts the efforts to be made performing an LCIA, but results in neglecting up- and downstream processes

Input-Output-Tables as BID for LCA

- Allows comparison of physical process and economic sector
- IOA provides LCIA of average products of the economic sectors
- Data of IOA are
    - applicable to each product or service
    - publicly available
    - periodically updated
- Imports are approximated by domestic production (as long as data on commodity exchange between economies are not available)
- Introduction of an additional sector „depreciation / capital goods“ takes into acocunt the use of capital goods

The structure of Input-Output-Tables

		demanding sector 1	...	n	*∑ intersectoral cons..*	*private consumption*	*public consumption*	*cap. goods - equip.*	*cap. goods - buildings*	*stock exchange*	*export*	*∑ final consumption*	*total consumption*
supplying sector	1	$x_{1,1}$	...	$x_{1,n}$	.	.	.	$d_{1,}$	$e_{1,}$	.	.	.	.
	.	.		.	.	.	.	.	.	.	.	.	.
	.	.		.	.	.	.	.	.	.	.	.	.
	.	.		.				.	.				
	n	$x_{n,1}$	...	$x_{n,n}$				d_n	e_n				
∑ intersect. demand.		...											
⋮													
depreciation		b_1	...	b_n									
⋮													
domestic production		q_1	...	q_n									
import		...											
total supply		...											

$X = (x_{i,j})$: matrix of intersectoral consumption

$\underline{b} = (b_j)$: vector of depreciation

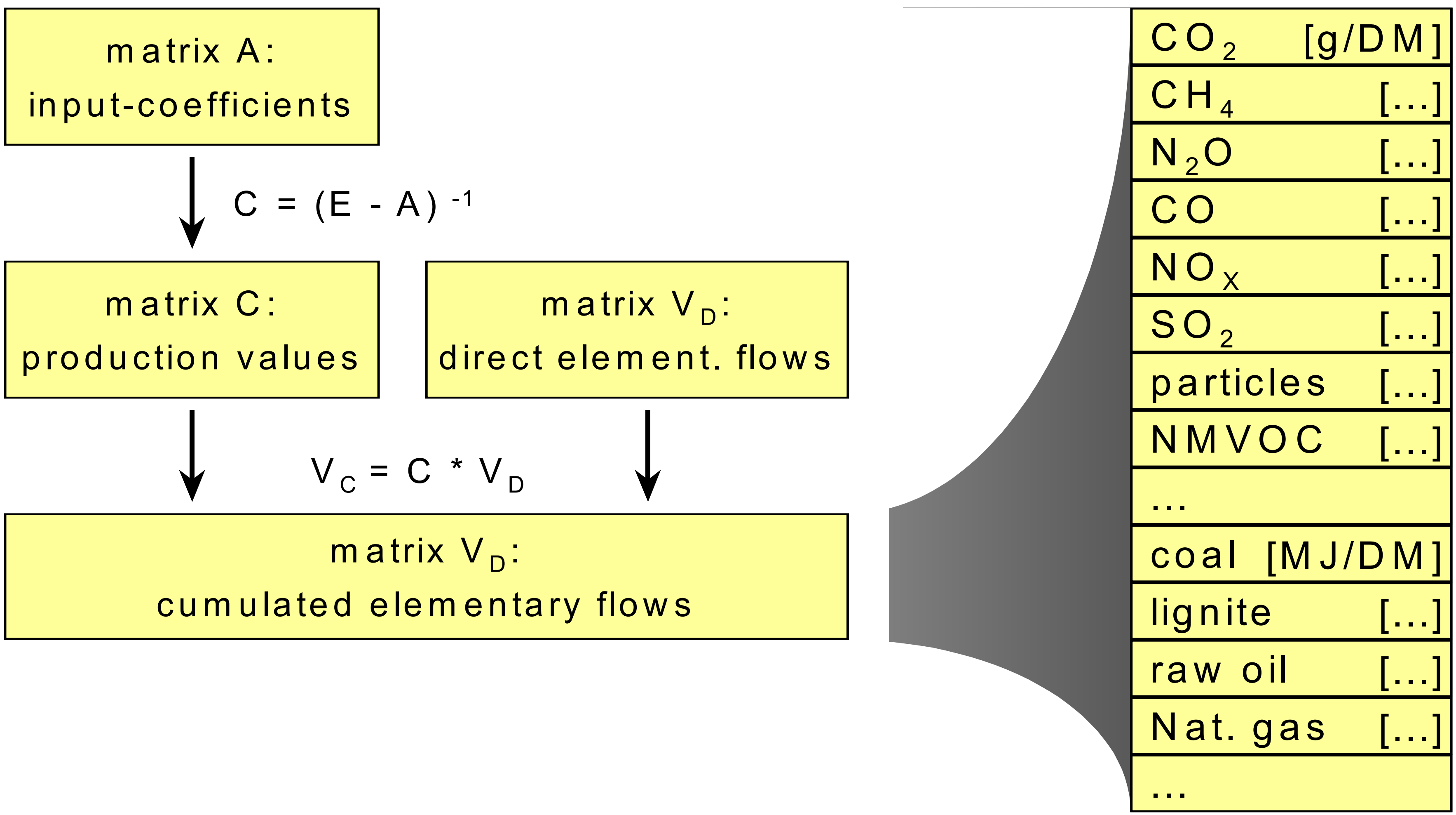
$\underline{q} = (q_j)$: vector of domestic production

$\underline{d} = (d_i)$: vector of domestic supply of movable capital goods (equipments)

$\underline{e} = (e_i)$: vector of domestic supply of non-movable capital goods (buildings)

Contact: info@m-m-p.com

Calculation of cumulated elementary flows for the sectors of an input-output-table



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The hybrid approach combining PCA and IOA

/Marheineke et. al., 1998/

1	Setting up the process chain (substance, mass end energy balance for each process)
2	Monetary balance for each process => Value of commodity inputs NOT covered by the process chain
3	Assignment of „not covered commodity inputs“ to economic sectors of the IOT and calculation of elementary flows with IOA

Monetary balance for each process of the process chain

Value of commodity inputs covered by the process chain

\+ Net value added of the economic activity

\+ Value of commodity inputs NOT covered by the process chain

= Value of the commodity output

$$V_{In,PCA} + T_{net} + V_{In,IOA} = V_{Out}$$

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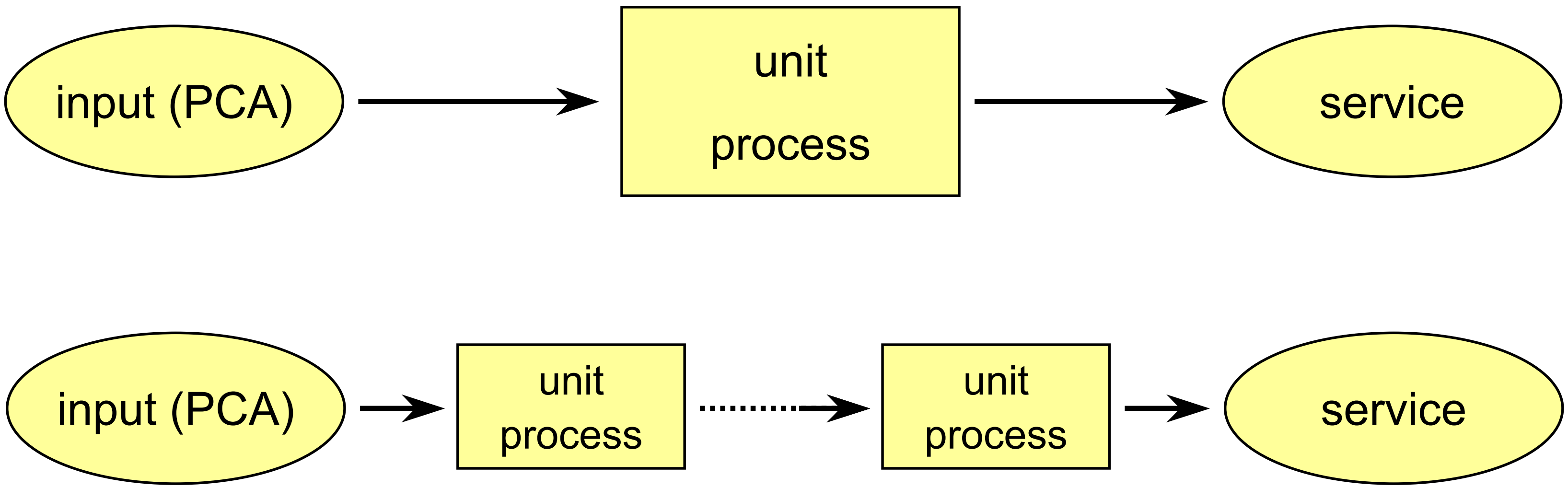
The result of using BID should not depend on the structure of the process chain !



$$\Rightarrow \quad T_{net} = f\,(V_{Out} - V_{In=,PCA})$$

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Assignment of „not covered commodity inputs“ to the economic sectors of the IOT

1.	$\underline{Y}_{D1} = A * \underline{Y}_{Out}$
2.	$y_{D,i}^* = 0$ if ▪ $y_{D1,i} < y_{In,PCA,i}$ or ▪ $y_{Out,i} <> 0$ or ▪ „additional information“ else $y_{D,i}^* = y_{D1,i} - y_{In,PCA,i}$
3.	$\underline{Y}_D = \frac{\lvert V_{In,IOA} \rvert}{\lvert V_D^* \rvert} * \underline{Y}_D^*$

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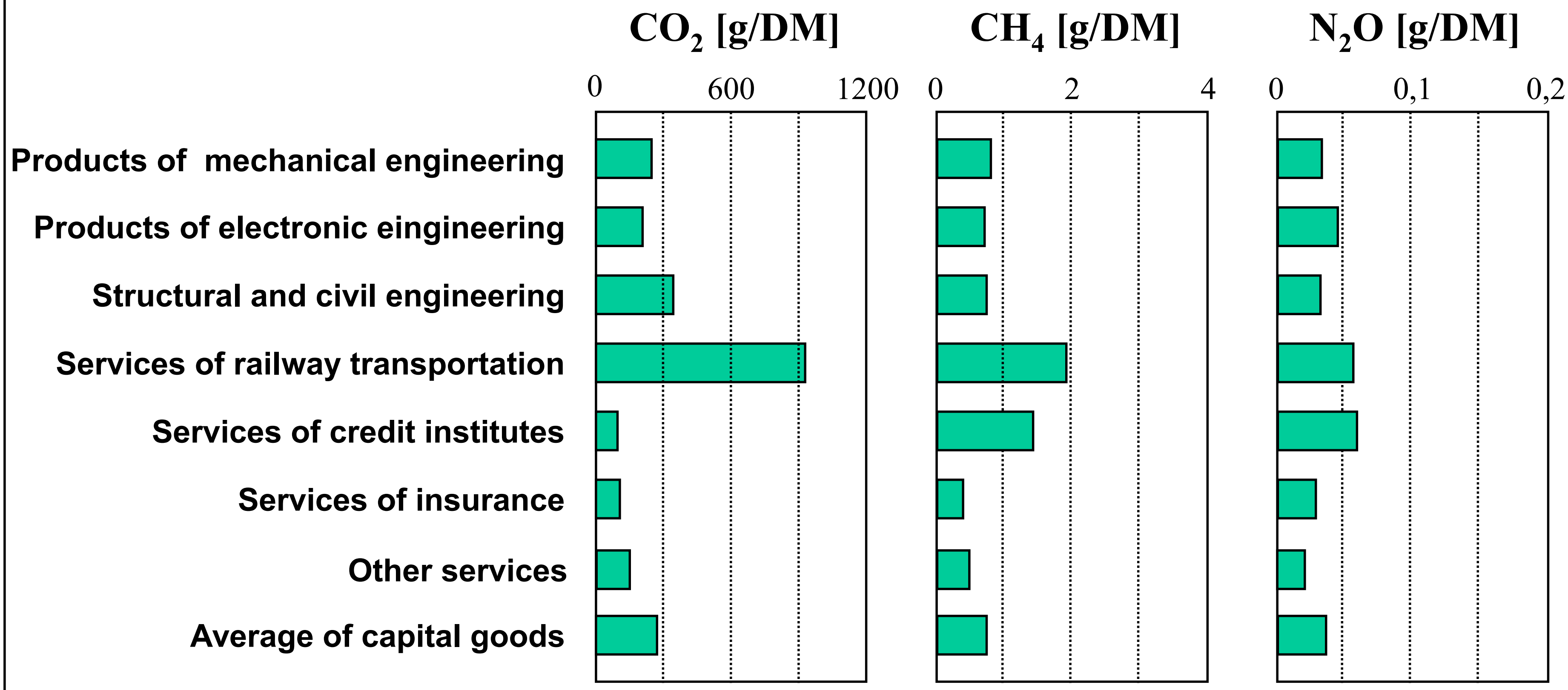
GHG-emissions for some average products of the German Input-Output-Table (1993)



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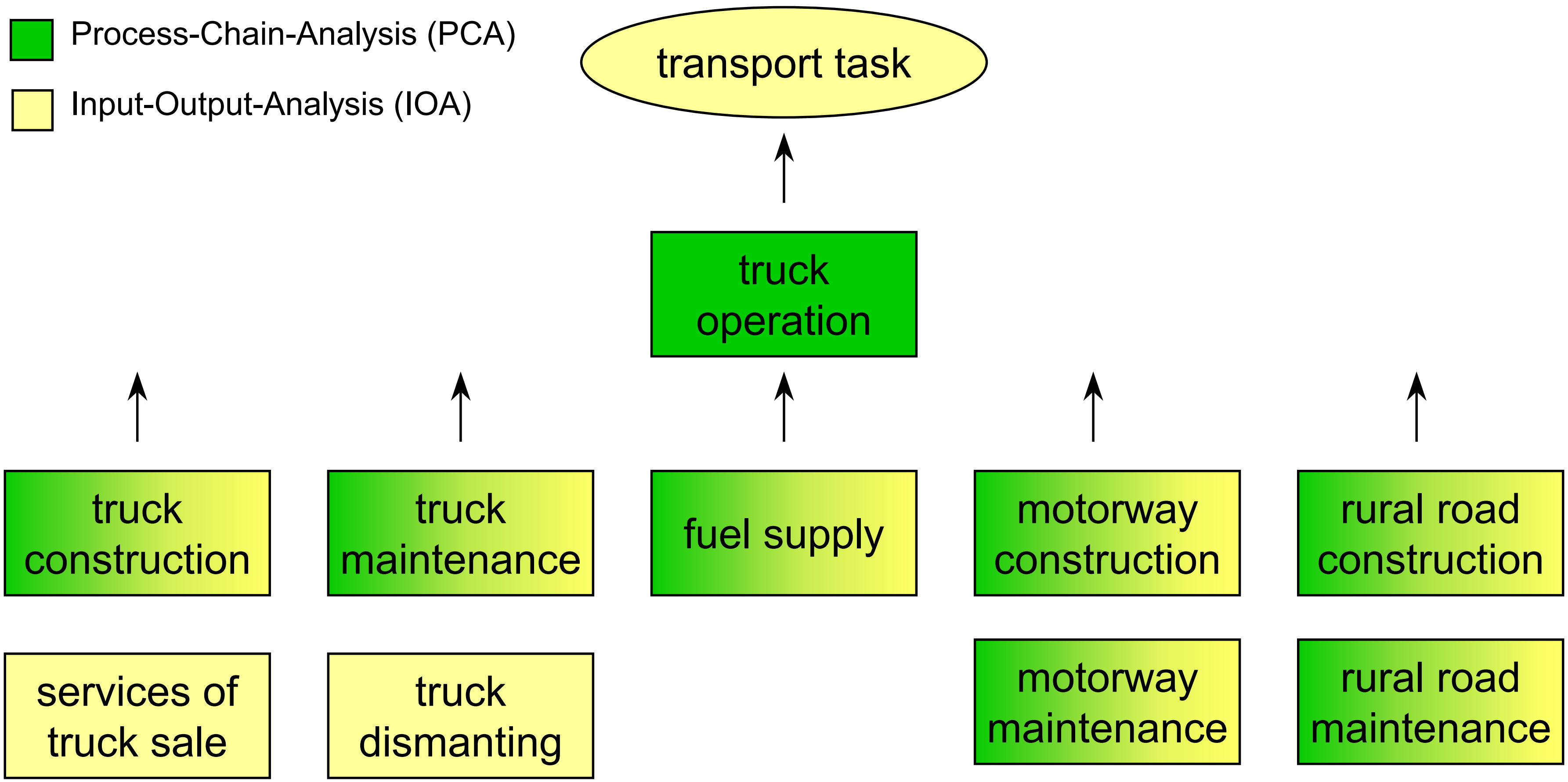
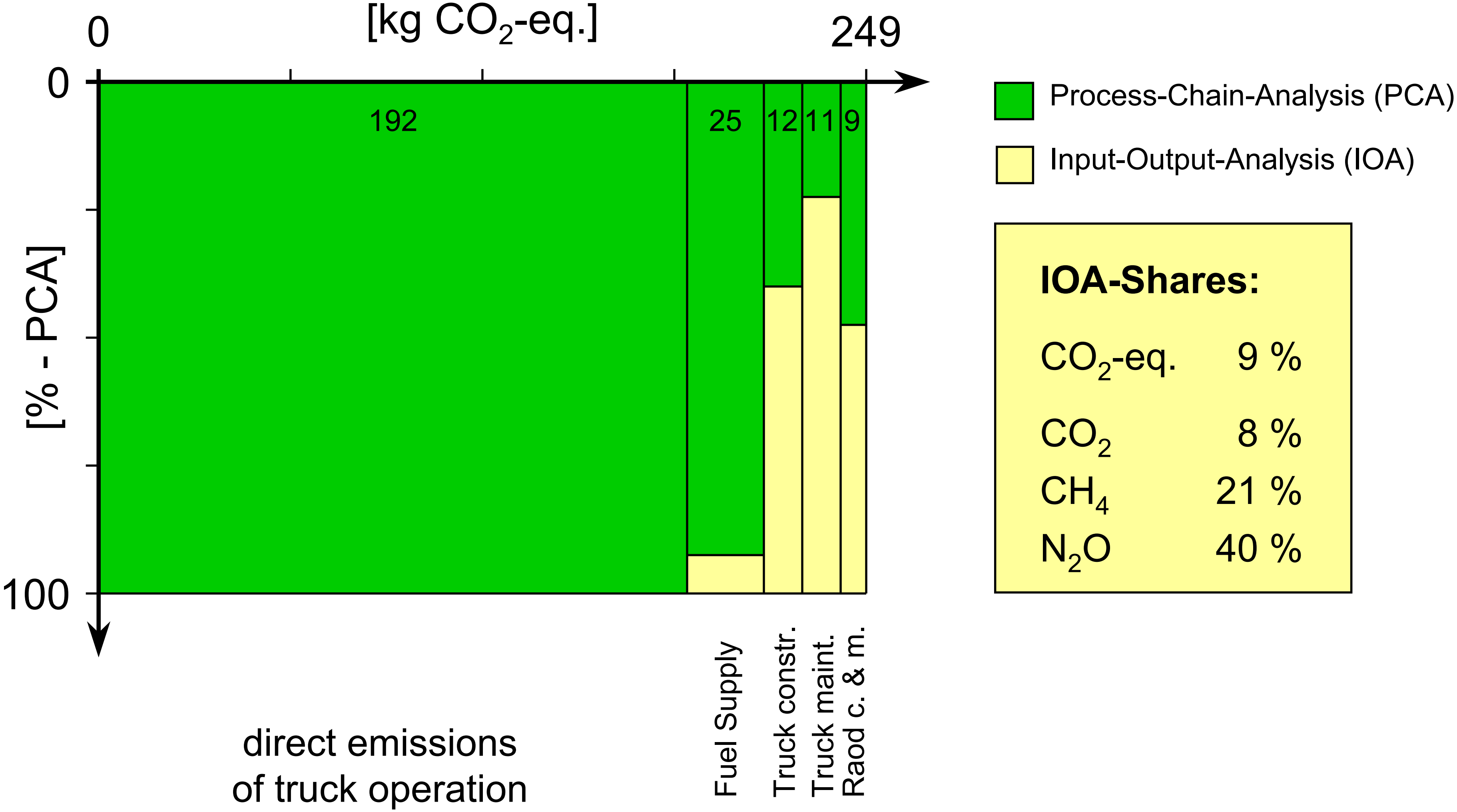
Elements of the product system for a freight transport task

(40t-truck, truckload 15t, distance 160 km)



Hybrid-Balance for the freight transport task



IOA-Shares:

CO_2-eq.	9 %
CO_2	8 %
CH_4	21 %
N_2O	40 %

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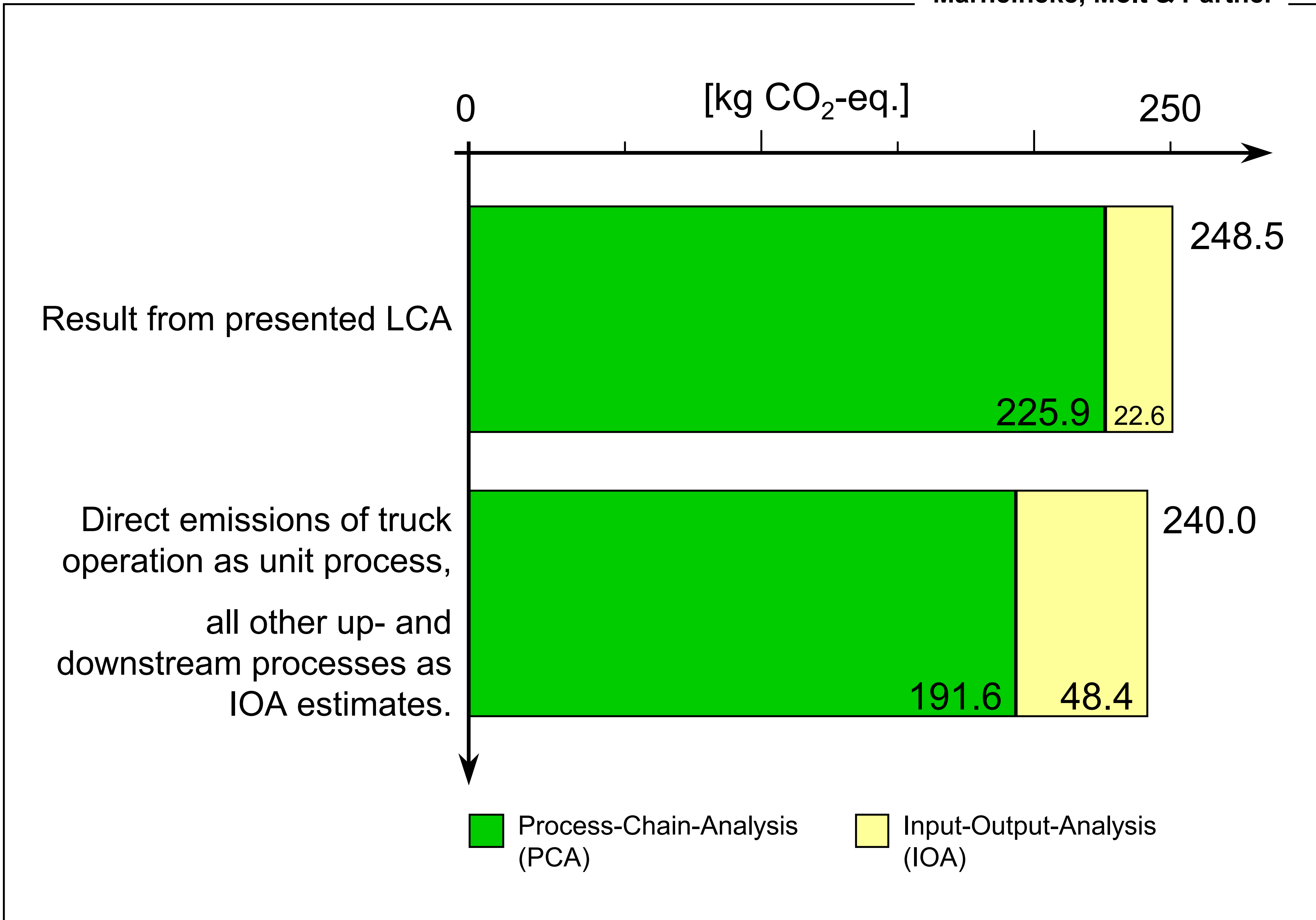

0
[kg CO_2-eq.]
250
Result from presented LCA
225.9
22.6
248.5
Direct emissions of truck operation as unit process,
all other up- and downstream processes as IOA estimates.
191.6
48.4
240.0
Process-Chain-Analysis (PCA)
Input-Output-Analysis (IOA)

Hybrid approach – easy to use !

Prerequisites:

- Input-Output-Table (IOT) and corresponding enviromental interventions
- Software with implemented hybrid functionality

Then, the additional effort in comparison to a „pure“ PCA is very limited. The additional information needed are:

- Monetary value of the output of each process
- Assigment of the output of each process to a sector of the IOT

References describing the Hybrid Approach

Marheineke, T.; Friedrich, R., Krewitt, W.: Application of a Hybrid-Approach to the Life Cycle Inventory Analysis of a Freight Transport Task.In.: SAE 1998 Transactions – Journal of Passenger Cars, Section 6 – Volume 107. Society of Automotive Engineers (SAE), Warrendale PA, USA

Marheineke, T., Stekeler, J.: Ein Hybrid-Ansatz zur ganzheiltichen Bilanzierung – Möglichkeiten und Grenzen am Beispiel einer Transportaufgabe im Verkehr. In: VDI-Bericht 1307, VDI-Verlag GmbH, Düsseldorf 1996

Contact

torsten.marheineke@m-m-p.com