Optimizing Environmental Performance of Cleaning Equipment by Life Cycle Assessment

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Introduction

Most cleaning equipment requires energy to operate efficiently. The more efficiency, the more energy and larger equipment size is needed. In a life cycle perspective there is an optimum, where the incremental increase of impacts from energy production and from equipment construction and demolition equals the incremental decrease of impacts from increasing cleaning efficiency (figure 1).

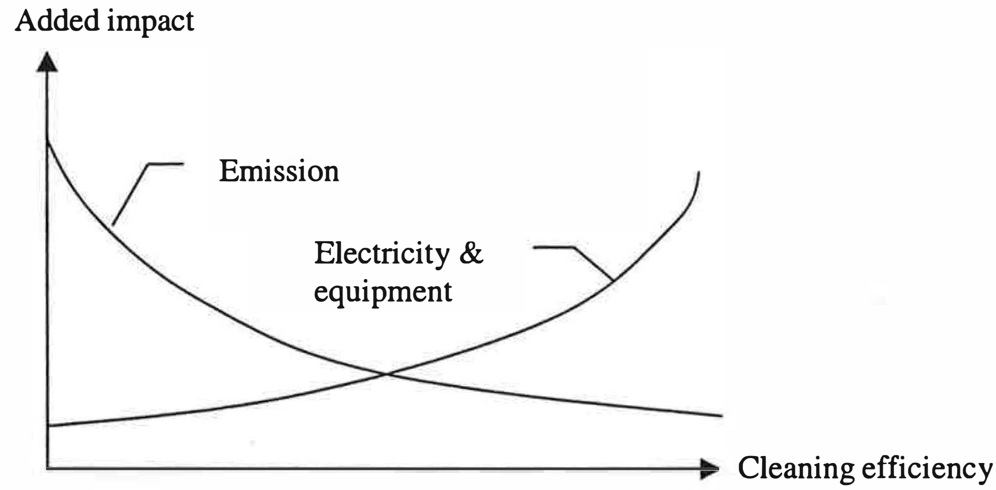

Figure 1. Optimisation of environmental performance of cleaning equipment.

In order to be able to optimise environmental performance, we need to weight different impacts to a common number. In Life Cycle Assessment (LCA) terminology, this is called weighting.

In order to make weighting possible we need to express environmental impacts via indicators that can be compared to some reference or valued. In LCA terminology these are called impact category indicators. Impact category indicators may be chosen early or late in a cause-effect chain, but existing weighting methods today either use emissions or transformed emissions and compare with emission goals or use monetary valuation of damages.

Some of the weighting methods used today are listed in table 1.

Table 1. Core characteristics of the four weighting methods presented and applied by Bengtsson (2000).

	Ecoscarcity 97 Brand et al. (1998)	**EDIP** Hauschild and Wenzel (1998)	**Ecoindicator 99** Goedkoop & Spriensmaa (1999)	**EPS 2000d** Steen, (1999)
Impact category indicators	Transformed emissions (partly)	Transformed emissions	Damages	Damages
Value source	Swiss policy targets	Danish policy targets	Panel repre-senting different perspectives	Society's willingness to pay to avoid damages
Geographical scope	Switzerland	Denmark	Europe	World
Parameters handled:				
- Emissions	Yes	Yes	Yes	Yes
- Resources	Energy only	Yes	Yes	Yes
- Work environment	No	Yes	No	No

The different methods have derived weighting indices to be used directly on the emissions or resource flows (table 2).

Table 2 Weighting indices used for obtaining weighting results directly from inventory data. (1) Indices are given per kg of emission or resource if nothing else is stated.

Emission or resource	BUWAL 97	EDIP**	EI99	EI99	EI99	EPS2000
			H, A	E, E	I, I	
Coal in ground	*	1 E-05/kg	5.99 E-03	6.87 E-02	0	0.0498
Oil in ground	*	3.9 E-05/kg	1.4 E-01	1.14 E-01	0	0.506
CO	NA	2.35 E-03	NA	5.79 E-03	NA	0.331
CH_4	4.4/g	4.12 E-03	4.7 E-02	3.5 E-02	8.1 E-02	2.72
NMVOC	32/g	VOC 0.036	1.36E-02	1.01 E-02	2.19 E-02	2.14
CO_2	0.2/g	1.49 E-04	2.97 E-02	2.22 E-02	4.97 E-02	0.108
N_2O	62/g	0.06	2.1	1.4	1.6	38.3
NOx	67/g	0.015	1.39	1.26	0.34	2.13
SOx	SO_2 53/g	0.01	0.66	0.53	0.77	3.27
BOD	NA	NA	NA	NA	NA	0.00201
COD	5.9/g	NA	NA	NA	NA	0.00101
N-tot	69/g	0.018	NA	NA	NA	-0.381
P-tot	2000/g	0.13	NA	NA	NA	0.055

* 1.0 /MJ Primary energy ** Resources and emissions are evaluated separately in the original EDIP method.

Trade-off Between Emission Reduction and Electric Power Consumption

As a first approximation the trade off between emission reduction and electric power consumption will be studied for a few substances using the weighting factors in table 3. A European average electricity mix is assumed to be used.

The maximum power consumption allowed per kg of SO_x ,NO_x and PM_{10} is shown in figure 2. Typical values for average power consumption are in the magnitude of 0.5 kJ/m^3 gas cleaned for cyclones and a spray scrubbers, 1 kJ/m^3 for a baghouse filter and 1-10 for venturi scrubbers. This means that the cleaning of gases with particles may be beneficial down to the mg/m^3 level for dust and to the 10 mg/m^3 level for SO_x and NO_x.

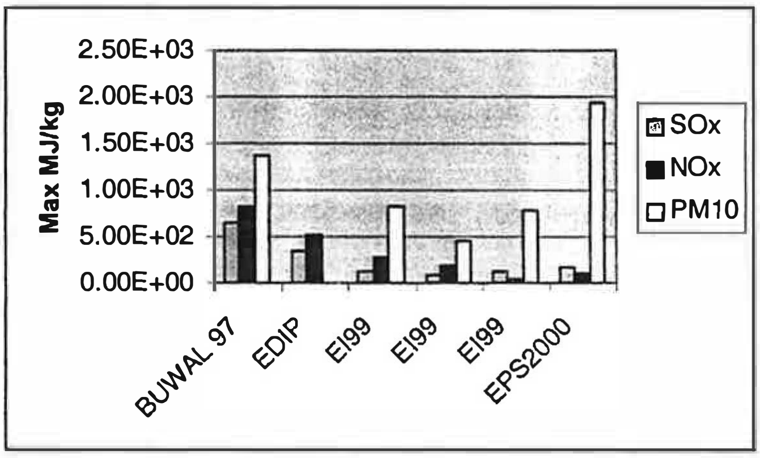

Figure 2. Maximum electric power consumption per kg of separated SO_x ,NO_x and PM_{10} in gas cleaning equipment for an overall environmental improvement

When Does Equipment Construction and Demolition Contribute Significantly to the Overall Impact?

Emissions and use of resources for manufacturing of hot rolled steel sheet is typically as shown in table 3.

Table 3. Emissions and use of resources for manufacturing of 1 kg hotrolled steel

Substance	Amount, kg/kg steel
coal use	0.37
oil use	0.1175
CO	0.00042
CO2	1.72
NOx	0.004355
SOx	0.008805
Fe_ore	1
PM_{10}	0.001

Using the same type of calculations as for figure 2, the amount of steel per kg of separated substance can be estimated (figure 3). The results show that the plant construction and demolition seldom will be a problem as long as normal steel is used.

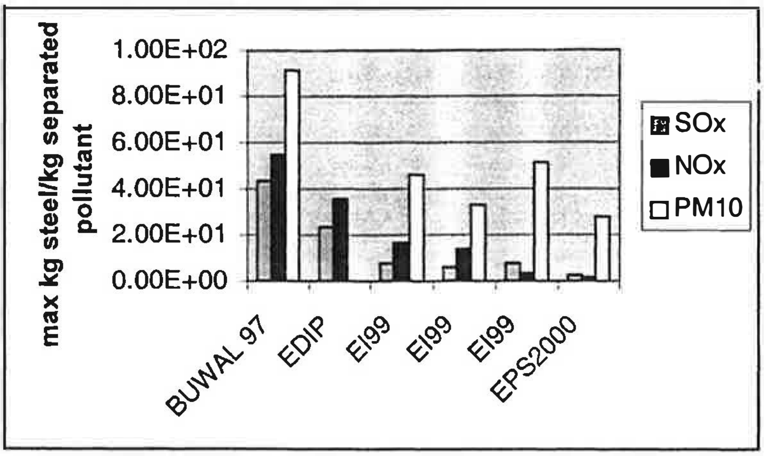

Figure 3. Maximum steel consumption per kg of separated SO_x, NO_x and PM_{10} in gas cleaning equipment for an overall environmental improvement.

Conlusions

Under normal circumstances, gas cleaning efficiencies may be rather high without violating an overall environmental improvement of the technical system including electricity generation. The dimensioning factor is power consumption during the use phase, while the construction and demolition of the equipment is of less significance.

References

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