Appendix G1: Dioxorb Properties

CHEMICAL DATA SHEET

Walhalla-Dioxorb® 854

WALHALLA KALK

Adsorbent for purifying flue gases composed of two clay minerals for the removal of dioxines and furanes.

Chemical analysis:

Loss of ignition			12.0 - 15.0	%
Carbon dioxide	3.0 - 5.0	%		
Water (105 °C)	3.0 - 5.0	%		
CaO			9.0 - 11.0	%
MgO			2.5 - 3.5	%
SiO_2			46.0 - 49.0	%
Fe_2O_3			5.0 - 7.0	%
Al_2O_3			17.0 - 20.0	%
SO_3			2.0 - 3.0	%

Physical properties:

Bulk density according to EN 459-2	about 0.7	kg/dm^3

Riddle analysis:

Residue on test riddle according to DIN ISO 3310	0.1 mm	4 - 7	%
	0.063 mm	10 - 14	%

Walhalla-Dioxorb® reacts absorptive and adsorptive with PCDD/F and heavy metals.

The specified numbers are averages without right to title.

Safety Data Sheet = Walhalla-Dioxorb® - dangerousgroup no. 1.

Date: June 19, 2007

Appendix G2: Excerpt from Waste Framework Directive

D 14 Repackaging prior to submission to any of the operations numbered D 1 to D 13

D 15 Storage pending any of the operations numbered D 1 to D 14 (excluding temporary storage, pending collection, on the site where the waste is produced) ***

* This operation is prohibited by EU legislation and international conventions.

** If there is no other D code appropriate, this can include preliminary operations prior to disposal including pre-processing such as, inter alia, sorting, crushing, compacting, pelletising, drying, shredding, conditioning or separating prior to submission to any of the operations numbered D1 to D12.

*** Temporary storage means preliminary storage according to point (10) of Article 3.

ANNEX II

Recovery operations

R 1 Use principally as a fuel or other means to generate energy*

R 2 Solvent reclamation/regeneration

R 3 Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes) **

R 4 Recycling/reclamation of metals and metal compounds

R 5 Recycling/reclamation of other inorganic materials ***

R 6 Regeneration of acids or bases

R 7 Recovery of components used for pollution abatement

R 8 Recovery of components from catalysts

R 9 Oil re-refining or other reuses of oil

R 10 Land treatment resulting in benefit to agriculture or ecological improvement

R 11 Use of waste obtained from any of the operations numbered R 1 to R 10

R 12 Exchange of waste for submission to any of the operations numbered R 1 to R 11 ****

R 13 Storage of waste pending any of the operations numbered R 1 to R 12 (excluding temporary storage, pending collection, on the site where the waste is produced) *****

* This includes incineration facilities dedicated to the processing of municipal solid waste only where their energy efficiency is equal to or above:

0. 60 for installations in operation and permitted in accordance with applicable Community legislation before 1 January 2009,
0. 65 for installations permitted after 31 December 2008,
   using the following formula:
   Energy efficiency = (Ep -(Ef + Ei)) / (0.97 x? (Ew + Ef))
   In which:

Ep means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1 (GJ/year)

Ef means annual energy input to the system from fuels contributing to the production of steam (GJ/year)

Ew means annual energy contained in the treated waste calculated using the lower net calorific value of the waste (GJ/year)

Ei means annual energy imported excluding Ew and Ef (GJ/year)

0.97 is a factor accounting for energy losses due to bottom ash and radiation.

This formula shall be applied in accordance with the reference document on Best Available Techniques for waste incineration.

** This includes gasification and pyrolisis using the components as chemicals.

*** This includes soil cleaning resulting in recovery of the soil and recycling of inorganic construction materials.

**** If there is no other R code appropriate, this can include preliminary operations prior to recovery including pre-processing such as, inter alia, dismantling, sorting, crushing, compacting, pelletising, drying, shredding, conditioning, repackaging, separating, blending or mixing prior to submission to any of the operations numbered R1 to R11.

***** Temporary storage means preliminary storage according to point (10) of Article 3.

ANNEX III

Properties of waste which render it hazardous

H 1 "Explosive": substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.

H 2 "Oxidizing": substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.

H 3-A "Highly flammable"

— liquid substances and preparations having a flash point below 21 ºC (including extremely flammable liquids), or

Appendix G3: Annex 10.4 of BREF Document on Waste Incineration

10.4 Energy calculation methodology and example calculation

Data appear in this document that was calculated and compiled by members of the *Energy sub-group of the TWG (ESG)*. This annexe provides the calculation method that was developed and used by some of the members of this sub-group when compiling the data shown. It should be noted that there exist various methods for the calculation of energy efficiency, however it is anticipated that the provision of the method developed and used by the TWG sub-group may help reader to understand the basis for the figures derived by energy sub-group work.

10.4.1 General explanations of terms and system boundary of the energy calculation

For the purposes of the BREF the calculation was restricted to the waste "incineration site". The diagram below summarises the system inputs and outputs used by the BREF ESG:

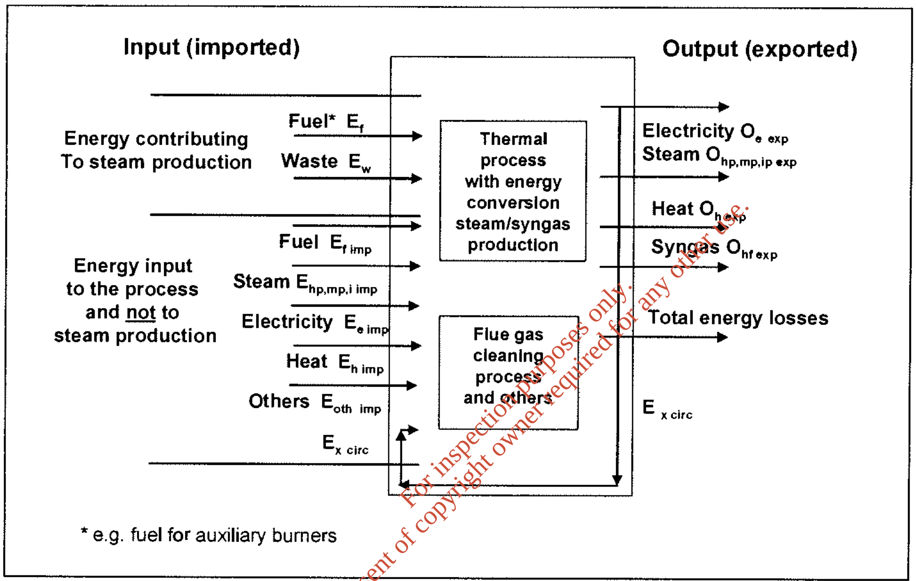

Figure 10.14: Summary of the energy system inputs and outputs used by BREF ESG

The main energy flows in waste incinerators can be summarised as:

a) Energy inputs (imported)

- only the energy input that is imported for the incineration process itself is included (see also d below). This will include, for example, the energy required for operation of a bulky waste shredder
- energy required to operate, for example, a full RDF plant (whether on site or not) is (for the purposes of this calculation) outside the system boundary and should not be included in the calculation (however it should be noted that this may be very significant if a wider life cycle boundary calculation is attempted)
- do not include energy required for waste collection, transportation and external pretreatment that is not necessary for the incineration process
- other energy imported to the site is included as an input e.g. electricity, natural gas for flue-gas reheating and/or oil for auxiliary burners, as long as they are partly or totally used to cover the energy needed in the incineration process.

b) Energy conversion

This is the energy from wastes/fuels that is converted in the incinerator to another form (e.g. steam or syngas) for export or circulation.

c) Energy outputs (exported)

- only the actual amount of energy exported is included (i.e. the gross production minus the energy circulated and consumed as losses to run the process itself)
- auxiliary on-site energy usage such as lighting and heating for offices should only be taken into account in the efficiency calculation if these figures are available and if a very precise balance is wanted. Otherwise this influence is considered small and can be neglected
- where energy is used on-site for another process (e.g. drying of sewage sludge or for running a district heating) this is counted as an output (export).

d) Circulated energy as energy losses (for explanation see figure above)

This is the energy that is generated by the process (e.g. steam/heat/electricity) that is then used in the process itself. This energy is not considered to count as a system input because it has not been imported from outside the system boundary. However, it is considered important that such circulation (if it is providing for energy losses) should be identified (as they substitute for imported energy) and should therefore be included in the check-list.

10.4.2 Example of NCV calculation used by energy sub-group

The data required for the calculation are generally available to incineration plant and are either measured or calculated from dimensioning figures such as steam parameters.

Method to calculate NCV of incinerated mono- and mixed waste

$$c = (1.133 \times (m_{st\,w}/m) \times c_{st\,x} + 0.008 \times T_b)/1.085 \text{ (GJ/tonne)}$$

c = lower (net) calorific value (NCV) of the incinerated waste with mst w /m ≥ 1 (GJ/tonne)

$$m_{st\,w} = m_{st\,x} - (m_f \times (c_f/c_{st\,x}) \times \eta_b)$$

$m_{st\,w}$ = amount of the produced steam out of waste in the corresponding time period to $m_{st\,x}$ e.g. per year (tonne/y)
$m_{st\,x}$ =total amount of the produced steam in a defined time period e.g. per year (tonne/y)
m_f =amount of fuel with steam production (see E_f in checklist) in the corresponding time period to $m_{st\,x}$ e.g. per year (tonne/y)
m =amount of incinerated waste (see E_w in checklist) in a defined time period to $m_{st\,x}$ e.g. per year (tonne/y)
$c_{st\,x}$ = net enthalpy of steam (enthalpy of steam minus enthalpy of boiler water) (GJ/tonne) see e.g. VDI Steam Tables in general constant for every single plant
c_f = net calorific value of fuel with steam production see table 1 (GJ/tonne)
T_b = temperature of flue-gas after boiler (at 4 – 12 % O_2 in flue-gas) (°C)
0.008 = spec. energy content in flue-gas (GJ/tonne x °C)
1.133 and 1.085 = constant figures by regression equation
ηb = efficiency of heat exchange (as approach 0.80)

Reference:

The basic equation for the calculation of NCV is taken from:
"Technology of Waste Incineration in Theory and Practice (Verbrennungstechnik von Abfällen in Theorie und Praxis)", 1995 ed. by Reimann, D.O.; Hämmerli, H;. and
VDI "Steam Tables", 1968 ed. by Schmidt,E.

Example NCV calculation for an average MSW:

Steam parameters 40 bar, 400 °C,	$C_{st\ hp}$	= 3.217 GJ/tonne
boiler water 3.2 bar, 135 °C	$C_{st\ bw}$	= 0.565 GJ/tonne
(constant for this W-t-E plant)	$C_{st\ x}$	= 2.652 GJ/tonne

$m_{st\ hp}$ = 404623 (tonne of HP steam)
m_f = 95.875 (tonne of fuel) (light oil)
C_f = 42.73 GJ/tonne
η_b = efficiency of heat exchange (as approach 0.80)

$m_{st\ w}$ = $m_{st\ hp}$ - (m_f x ($c_f/c_{st\ x}$) x 0.80)
= 404623 - (95.875 (tonne)x (42.73/ 2.652) x 0.80) = 404623 - 1236 = 403387 (tonne)
m = 126692 tonne of mixed municipal solid waste (MSW)
T_b = 220 °C (at 6 – 11 % O_2 in flue-gas)
C = (1.133 x ($m_{st\ w}$/m x $c_{st\ x}$) + 0.008 x T_b)/1.085
C = (1.133 x (403387/126692) x 2.652) + 0.008 x 220)/ 1.085 = (9.567 +1.760)/1.085

NCV = C = 10440 GJ/ tonne = 2900 MWh/tonne as average of mixed MSW

10.4.3 Basic operational data for three examples of the energy calculation

Annual basic operational data and figures may be collected using check-list shown below.

The check-list shown includes the data for the example of CHP production and export. Instead of generating an individual list for operational basic data of a plant the use of a standard checklist will deliver higher accuracy and reduce the risk of forgetting data to be taken into account for the energy calculation method.

Questionnaire/check-list	Accounting Period	Example calculation
Name of the plant:	Plant W-t-E with CHP production	

Scope of the energy balance: W-t-E plant only

INFORMATION TO BE PROVIDED FOR ENERGY CALCULATION AS BASIS FOR PLANT-EFFICIENCIES AND ENERGY RESULTS. THE YELLOW FIELDS SHOULD BE FILLED OUT WITH THE RELEVANT DATA FOR THE PLANT AS ACCURATE AS POSSIBLE:

Basic data

Name of plant	Example of calculation of combined heat and power recovery in accordance to BREF
Name of company	(2. draft) chapter 3.5.4.3
Address	
Contact person	
Telephone	
Fax	
E-mail	

Energy input from waste for E_w

Amount of all kind of waste incinerated, irrespective of type and composition	Total amount of waste incinerated	126692 [Mg](t)	E_w
Of which, waste for energetic recovery is included		0 [Mg](t)	

Imported energy with steam-/heatproduction E_f — **amount** (only one colum to be filled out)

Imported energy contributing to steam-/heat production, e.g. for auxiliary burners, start-up and shut-down proportionately[1], etc.	Natural gas		NCV [GJ/10³ Nm³]	0,0 [MWh]	0,000 [1000 Nm³]	E_f
	Digestion gas		NCV [GJ/10³ Nm³]	0,0 [MWh]	0,000 [1000 Nm³]	E_f
	Light fuel oil	42,730	Hu [GJ/Mg]	0,0 [m³]	95,9 [Mg](t)	E_f
	Heavy fuel oil		NCV [GJ/Mg]	0,0 [m³]	0,0 [Mg](t)	E_f
	Other oils		NCV [GJ/Mg]	0,0 [m³]	0,0 [Mg](t)	E_f
	Browncoal, Torf		NCV [GJ/Mg]		0,0 [Mg](t)	E_f
	Hard coal, Coke		NCV [GJ/Mg]		0,0 [Mg](t)	E_f
	Wood		NCV [GJ/Mg]		0,0 [Mg](t)	E_f
	RDF/SRF		NCV [GJ/Mg]		0,0 [Mg](t)	E_f
	Others		NCV [GJ/Mg]		0,0 [Mg](t)	E_f
	Hot water, district heat				0 [MWhh]	E_f

[1] If this cannot be determined exactly, 50% with and 50% without steam generation can be assumed in the case of minor use of auxiliary fuel and 70% with and 30% without steam production in the case of **Increased** use of auxiliary fuel

Imported energy without steam-/energy production $E_{x\ imp}$ — **amount** (only one colum to be filled out)

Imported energy not contributing to steam-/heat production, e.g. for flue gas treatment, start-up and shut-down proportionately[1], etc.	Natural gas		NCV [GJ/10³ Nm³]	0,0 [MWh]	[1000 Nm³]	$E_{f\ imp}$
	Digestion gas		NCV [GJ/10³ Nm³]	0,0 [MWh]	[1000 Nm³]	$E_{f\ imp}$
	Methane		NCV [GJ/Mg]	0,0 [MWh]	[1000 Nm³]	$E_{f\ imp}$
	Light fuel oil	42,730	Hu [GJ/Mg]	0,0 [m³]	95,9 [Mg](t)	$E_{f\ imp}$
	Heavy fuel oil		NCV [GJ/Mg]	0,0 [m³]	0,000 [Mg]	$E_{f\ imp}$
	Gasoil, other oils		NCV [GJ/Mg]	0,0 [m³]	0,000 [Mg]	$E_{f\ imp}$
	Electricity				180,0 [MWhe]	$E_{e\ imp}$
	Hot water, district heat				0,000 [MWhh]	$E_{h\ imp}$
	Steam hp,mp,lp	Steamquantity			0,000 [Mg](t)	$E_{st\ hp,mp,lp\ imp}$
		Steamparameters		[bar], [°C]		
		Boilerwater/condensate		[°C]		
	Steam hp,mp,lp	Steamquantity			0,000 [Mg](t)	$E_{st\ hp,mp,lp\ imp}$
		Steamparameters		[bar], [°C]		
		Boilerwater/condensate		[°C]		
	alternative: Steam in MWh$_h$/a				0 [MWhh]	$E_{st\ hp,mp,lp\ imp}$
	Others		NCV [GJ/Mg]		0,000 [Mg](t)	$E_{other\ imp}$

Table 10.97: Energy efficiency calculation data checklist 1

Circulated energy $E_{x\,circ}$

			Total energy $E_{x\,circ}$ * amount	Demand and losses out of $E_{x\,circ}$ **	
Self produced energy used in the process as circulated energy. For BREF/EUGH energy efficiency numbers and self demand only the energy losses (demand) are taken into account.	Electricity		17520,0 [MWhe]	17520,0 [MWhe]	$E_{e\,circ}$
	Steam hp,mp,lp	Steam quantity[2]	32458 [Mg](t)	32458 [Mg](t)	$E_{st\,hp,mp,lp\,circ}$
		Steam parameters	[bar], [°C]	40 bar, 400 °C	
		Boiler water/condensate	[°C]	135 °C	
	Steam hp,mp,lp	Steam quantity[3]	68000 [Mg](t)	6800 [Mg](t)	$E_{st\,hp,mp,lp\,circ}$
		Steam parameters	[bar], [°C]	40 bar, 400 °C	
		Boiler water/condensate	[°C]	0 °C	
	Steam hp,mp,lp	Steamquantity[4]	0 [Mg](t)	0 [Mg](t)	$E_{st\,hp,mp,lp\,circ}$
		Steam parameters	[bar], [°C]		
		Steam backflow	[°C]		
	alternative: Steam in MWh_h/a		0 [MWhh]	0 [MWhh]	$E_{st\,hp,mp,lp\,circ}$
	Hot water, district heat[5]		3760 [MWhh]	3760 [MWhh]	$E_{h\,circ}$
	Others		NCV [GJ/Mg]	0,000 [Mg](t)	$E_{other\,circ}$

* The total circulated energy should be filled in this column ($E_{x\,circ}$ total)

** Only the part of the total circulated energy from *, witch is used to cover the total losses/demand of the process. These losses can reach as a maximum E_x circulated but are in general by far lower. For self control the information under [2-6] are necessary.

[2-6] to find out not only the consumption but even the real losses of the process it is necessary to distinguish between self produced energy which is circulated and only used for the purpose of covering energy losses e.g. heating up flua gas before chimney or SCR system without influencing the steam/heat production and used energy for mixed purposes of covering energy losses plus influencing/ increasing the steam/heat production by circulation of this energy e.g. for heating up of the combustion air in the combustion chamber or boiler water/ condensate as well as partially for cleaning up the boiler with steam. To take this fact into account the use of the circulated energy should be described in the following lines under # [2-6] in a short version and it's distribution in quantity of the total corresponding consumption too e.g. for heating up flue gas or heating up boiler water, to avoid misinterpretation.

Short wording of the consumed circulated energy and quantity of it's corresponding total amount:

[2] Consumption for heating up flue gases before SCR = 32458 Mg/a
[3] HP-steam for sootblowing 10 % of 68000 Mg/a = 6800 Mg/a
[4]
[5] Heating of plant buildings = 3760 MWhh
[6]

If multiple uae of the consumed circulated energy is happening e.g. in more than one stage please indicate this too

Exported energy $O_{x\,exp}$

				amount	
Exported energy	Electricity			31730,0 [MWhe]	$O_{e\,exp}$
	Steam hp,mp,lp	Steam quantity		0,000 [Mg](t)	$O_{st\,hp,mp,lp\,exp}$
		Steam parameters	[bar], [°C]		
		Boiler water/condensate	[°C]		
	Steam hp,mp,lp	Steam quantity		0,000 [Mg](t)	$O_{st\,hp,mp,lp\,exp}$
		Steam parameters	[bar], [°C]		
		Boiler water/condensate	[°C]		
	Steam hp,mp,lp	Steamquantity		0,000 [Mg](t)	$O_{st\,hp,mp,lp\,exp}$
		Steam parameters	[bar], [°C]		
		Boiler water/condensate	[°C]		
	Steam hp,mp,lp	Steam quantity		0,000 [Mg](t)	$O_{st\,hp,mp,lp\,exp}$
		Steam parameters	[bar], [°C]		
		Boiler water/condensate	[°C]		
	Heat Alternative: Hot water, district heat in MWh_h	Hot water quantity		0,000 [Mg](t)	$O_{h\,exp}$
		Hot water effluent	[°C]		
		Hot water backflow	[°C]		
	alternative: Steam in MWh_h/a			0 [MWhh]	$O_{st\,hp,mp,lp\,exp}$
	Hot water, district heat		0,000 [MWhh]	137375,000 [MWhh]	$O_{h\,exp}$
	Others		NCV [GJ/Mg]	0,000 [Mg](t)	$O_{other\,exp}$

Table 10.98: Energy efficiency calculation data checklist 2

Thermal output/ calorific value/ O_2-content

Total thermal output of the entire plant	54,0 [MW]
Average net calorific value (NCV) of the waste, estimated by operator	no Info
Average net calorific value (NCV) of the waste, calculated by operator	10,440 [GJ/Mg]
Average net calorific value (NCV) of the waste acc. to formula by BREF/BAT	10,439 [GJ/Mg]
Boiler efficiency	83,0 [%]
O_2-content of the raw gas (after boiler) as dry	8,0 [%]
O_2 content after stack of the clean gas as dry	8,5 [%]

Steam/ hot water production

Produced steam/hot water out of boiler or wherever useable steam/ heat is produced during the total incineration process e.g. by heat pumps SCR with heat recovery, additional Eco`s in the thermal waste treatment	Steam hp,mp,lp after boiler	steam quantity		404623 [Mg](t)
		steam parameters	[bar], [°C]	40 bar/400 °C
		condensate backflow	[°C]	135°C
	Steam hp,mp,lp elsewhere	steam quantity		0,000 [Mg](t)
		steam parameters	[bar], [°C]	
		condensate backflow	[°C]	
	Steam	alternative: Steam produced in MWh_h/a		0 [MWhh]
	Hot water after boiler	hot water quantity		0,000 [Mg](t)
		hot water effluent	[°C]	
		hot water backflow	[°C]	
	Hot water elsewhere	hot water quantity		0,000 [Mg](t)
		hot water effluent	[°C]	
		hot water backflow	[°C]	
	Hot water, district heat			0,000 [MWhh]

Flue gas/ Clean gas

Flue gas temperature after boiler (corresponding to the point of previous data for steam or hot water production)		220 [°C]
Volume flow of clean gas (under standard conditions, dry)	3 lines	96603 [Nm³/h]
Volume flow of clean gas as annual total for the entire plant (under standard conditions, dry)	3 lines	655000000 [Nm³/a]
Flue gas temperature after chimney		120 [°C]

Table 10.99: Energy efficiency calculation data checklist 3

10.4.4 Energy calculation formulas with basic operational data for three examples of the energy calculation

The annual basic operational figures and data are the basis for the calculation of specific energy results and percentage efficiencies.

For the purpose of aggregation of data relating to the consumption/production/export of different sources of energy, reference has been made to GJ. However, more commonly electrical energy is reported as MWh_e, and steam, heat and hot water as $MWh_{h/st}$, therefore the examples are calculated with this unit.

To enable the comparison between different incineration plants in an easy and reliable way, simple formulas are adopted, all based on annual balances. Where used, international equivalency factors have been considered for energy conversions to obtain energy balances.

Method 1: Net annual specific (i.e. per tonne of waste treated) energy needed for and recovered by the installation, expressed as absolute and equivalent energy figures (N), in correlation to the quantity of incinerated waste (investigation period one year)

The specific value for the amount of energy produced, exported or needed per tonne of waste input is obtained simply by dividing the annual data by the waste throughput. The result delivers specific information for the considered plant because the NCV of waste itself is not taken into account.

This technique uses annual totals to calculate separate figures for:

- total specific energy demand of the entire plant per tonne of waste input Nop sp
- total specific electrical energy production/export per tonne of waste input Ne sp prod/exp
- total specific heat and steam production/export per tonne of waste input Nh/st sp prod/exp
- total specific electrical energy and heat/steam production/export of the entire plant
- per tonne of waste input Ne+h/st sp prod/exp

Method 2: Percentage yield (η)
This method calculates the overall percentage of energy needed for and recovered by the installation in relation to the steam producing energy inputs from the waste, as well as other energy inputs (e.g. support fuels) i.e. in relation to the total energy input into the plant.

Because the energy content of the waste input is included, an advantage of this method is that comparison is possible between incineration plants, independent of the waste type. This calculation method is widespread and the results are generally well understood. If the NCV of the waste is not known, it can be obtained from knowledge of the produced steam.

In this method, separate efficiency values are calculated for electricity and heat production/consumption using absolute figures as well as energy equivalents. These figures may be added together to give a total efficiency figure.

This technique uses annual totals for the entire plant to calculate separate figures for:

- percentage of energy demand of the entire plant in relation to the total energy input $\eta_{op\ sp}$
- percentage of electrical energy production/export in relation to the total energy input $\eta_{e\ sp\ prod/exp}$
- percentage of heat and steam production/export in relation to the total energy input $\eta_{h/st\ sp\ prod/exp}$
- percentage of electrical energy and heat/steam production/export of in relation to the total energy input $\eta_{e+h/st\ sp\ prod/exp}$

The basic equations are:

a) in absolute figures
In this case all data even for electricity and heat must be counted not as equivalents but as measured figures e.g. MWh_e and MWH_h or in GJ_e and GJ_h all others with their energy content

b) in equivalent figures
Here all data for electricity and heat must be counted as equivalents e.g. $MWh_{e\ equ}$ and $MWH_{h\ equ}$ all others with their energy content

Specific energy demand of the entire plant in correlation to the quantity of waste incinerated:
$$N_{op\ sp} = (E_f + E_{x\ imp} + E_{x\ circ}) / m$$
a) as $MWh_{op\ abs}$/t (of waste) or $GJ_{op\ abs}$/t (of waste)
b) as $MWh_{op\ equ}$/t (of waste) or $GJ_{op\ equ}$/t (of waste)

Examples for specific energy demand in relation to the basis data of table 1 in section 3 and Chapter 3.5.5 of the BREF

a) plant with only electricity production (in absolute) $N_{op\ sp}$ = (1138+ 1318 + 51269)/ 126692 = 0.424MWh abs/t
b) plant with only electricity production (in equivalent) $N_{op\ sp}$ = (1138+ 1612 + 80226)/ 126692 =0.655MWh equ/t

a) plant with only heat/steam production (in absolute) $N_{op\ sp}$ = (1138+18838 +33749)/ 126692 = 0.424 MWh abs/t
b) plant with only heat/steam production (in equivalent) $N_{op\ sp}$ = (1138+47717 +34121)/ 126692 = 0.655 MWh equ/t

a) plant with CHP (in absolute) $N_{op\ sp}$ = (1138+ 1318 + 51269)/ 126692 = 0.424 MWh abs/t
b) plant with CHP (in equivalent) $N_{op\ sp}$ = (1138+ 1612 + 80226)/ 126692 = 0.655 MWh equ/t

Percentage of total specific energy demand of the entire plant in correlation to the total energy input

$$\eta_{op\ abs} = ((E_f + E_{x\ imp} + E_{x\ circ})/(E_f + E_{x\ imp} + E_w)) \times 100\ \{\%\}$$

Examples for percentages of energy demand in connection with the basis data of table 1 in section 3.

a) plant with only electricity production (in absolute) $\eta_{op\ abs}$ = ((1138+ 1318 + 51269)/ (1138+ 1318+367406))*100 = 14.5 (%)
b) plant with only electricity production (in equivalent) $\eta_{op\ equ}$ = (1138+ 1612 + 80226)/ (1138+ 1612+367406))*100 = 22.4 (%)

a) plant with only heat/steam production (in absolute) $\eta_{op\ abs}$ = (1138+18838 +33749)/ (1138+ 1318+367406))*100 = 13.9 (%)
b) plant with only heat/steam production (in equivalent) $\eta_{op\ equ}$ = (1138+47717 +34121)/ (1138+ 1612+367406))*100 = 19.9(%)

a) plant with CHP (in absolute) $\eta_{op\ abs}$ = (1138+ 1318 + 51269)/ (1138+ 1318+367406))*100 = 14.5 (%)
b) plant with CHP (in equivalent) $\eta_{op\ equ}$ = (1138+ 1612 + 80226)/ (1138+ 1612+367406))*100 = 22.4 (%)

Total specific electricity produced in correlation to the quantity of waste incinerated:

$$N_{e\ sp\ prod} = (O_{e\ exp} + E_{e\ circ})/\ m$$

Total specific electricity exported in correlation to the quantity of waste incinerated:

$$N_{e\ sp\ exp} = (O_{e\ exp})/\ m$$

a) as $MWh_{op\ abs}$/t (of waste) or $GJ_{op\ abs}$/t (of waste)
b) as $MWh_{op\ equ}$/t (of waste) or $GJ_{op\ equ}$/t (of waste)

Examples for specific electricity produced and exported:

a) plant with only electricity production (in absolute) $N_{e\ sp\ prod}$ = (17520+50800)/ 126692 = 0.539 MWh_e abs/t
$N_{e\ exp}$ = (50800)/ 126692 = 0.401 MWh_e abs/t
b) plant with only electricity production (in equivalent) $N_{e\ sp\ prod}$ = ((17520 +50800)*2.6316)/ 126692 =1.419 MWh_e equ/t
$N_{e\ exp}$ = (50800*2.6316)/ 126692 = 1.055 MWh_e equ /t

a) plant with only heat/steam production (in absolute) $N_{e\ sp\ prod}$ = (0)/ 126692 =0.0 MWh_e abs/t
$N_{e\ exp}$ = (0)/ 126692 =0.0 MWh_e abs/t
b) plant with only heat/steam production (in equivalent) $N_{e\ sp\ prod}$ = (0)/ 126692 =0.0 MWh_e equ /t
$N_{e\ exp}$ = (0)/ 126692 =0.0 MWh_e equ /t

a) plant with CHP (in absolute) $N_{e\ sp\ prod}$ = (17520+31730)/ 126692 =0.389 MWh_e abs/t
$N_{e\ exp}$ = (31730)/ 126692 =0.250 MWh_e abs/t
b) plant with CHP (in equivalent) $N_{e\ sp\ prod}$ = ((17520 +31730)*2.6316)/ 126692=1.023 MWh_e equ /t
$N_{e\ exp}$ = (31730*2.6316)/ 126692 =0.659 MWh_e equ /t

Percentage of total electricity produced and exported in correlation to the total energy input:

$$\eta_{e\ abs} = ((O_e + E_{e\ circ})/(E_f + E_{x\ imp} + E_w)) \times 100\ \{\%\}$$

Examples for percentages of electricity produced and exported:

a) plant with only electricity production (in absolute) $\eta_{e\ abs\ prod}$ = (17520+50800)/ (1138+ 1318+367406))*100 =18.5 (%)
$\eta_{e\ abs\ exp}$ = (50800)/ (1138+ 1318+367406)*100 =13.7 (%)
b) plant with only electricity production (in equivalent) $\eta_{e\ equ\ prod}$ = ((17520 +50800)*2.6316)/ (1138+ 1612+367406))*100 =48.6 (%)
$\eta_{e\ equ\ exp}$ = (50800*2.6316)/ (1138+ 1612+367406))*100 =36.1 (%)

a) plant with only heat/steam production (in absolute) $\eta_{e\ abs\ prod}$ = (0)/ (1138+ 1318+367406))*100 =0 (%)
$\eta_{e\ abs\ exp}$ = (0)/ (1138+ 1318+367406))*100 = (%)
b) plant with only heat/steam production (in equivalent) $\eta_{e\ equ\ prod}$ = (0)/ (1138+ 1612+367406))*100 =0 (%)
$\eta_{e\ equ\ exp}$ = (0)/ (1138+ 1612+367406))*100 =0 (%)

a) plant with CHP (in absolute) $\eta_{e\ abs\ prod}$ = (17520+31730)/ (1138+ 1318+367406))*100 =13.3 (%)
$\eta_{e\ abs\ exp}$ = (31730)/ (1138+ 1318+367406))*100 =8.8 (%)

b) plant with CHP (in equivalent) $\eta_{e\ equ\ prod}$ = ((17520 +31730)*2.6316)/ (1138+ 1612+367406))*100 = 35.0 (%)
$\eta_{e\ equ\ exp}$ = (31730*2.6316)/ (1138+ 1612+367406))*100 = 22.6 (%)

Total specific heat/steam produced in correlation to the quantity of waste incinerated:

$$N_{h/st\ sp\ prod} = (O_{h/st\ exp} + E_{h/st\ circ}) / m$$

Total specific heat/steam exported in correlation to the quantity of waste incinerated:

$$N_{h/st\ sp\ exp} = (O_{h/st\ exp}) / m$$

a) as $MWh_{op\ abs}$/t (of waste) or $GJ_{op\ abs}$/t (of waste)
b) as $MWh_{op\ equ}$/t (of waste) or $GJ_{op\ equ}$/t (of waste))

Examples for specific heat/steam produced and exported:

a) plant with only electricity production (in absolute)	Nh/st sp prod = (33749+0)/ 12669	=0.266 MWhh/st abs/t
	Nh/st exp = (0)/ 126692	=0.0 MWhh/st abs/t
b) plant with only electricity production (in equivalent)	Nh/st sp prod = (34121+0)/ 126692	=0.269 MWhh/st equ/t
	Nh/st exp = (0)/ 126692	=0.0 MWhh/st equ /t
a) plant with only heat/steam production (in absolute)	Nh/st sp prod = (33749+242443)/ 126692	=2.180 MWhh/st abs/t
	Nh/st exp = (242443)/ 126692	=1.914 MWhh/st abs/t
b) plant with only heat/steam production(in equivalent)	Nh/st sp prod = (34121+242443)/ 126692	=2.183 MWhh/st equ /t
	Nh/st exp = (242443)/ 126692	=1.914 MWhh/st equ /t
a) plant with CHP (in absolute)	Nh/st sp prod = (33749+137375)/ 126692	=1.351 MWhh/st abs/t
	Nh/st exp = (137375)/ 126692	=1.084 MWhh/st abs/t
b) plant with CHP (in equivalent)	Nh/st sp prod = (34121+150961)/ 126692	=1.461 MWhh/st equ /t
	Nh/st e exp = (150961)/ 126692	=1.192 MWhh/st equ /t

Percentage of total heat/steam produced and exported in correlation to the total energy input:

$$\eta_{h/st\ abs} = ((O_{h/st} + E_{h/st\ circ}) / (E_f + E_{x\ imp} + E_w)) \times 100\ \{\%\}$$

Examples for percentages of heat/steam produced and exported:

a) plant with only electricity production (in absolute)	ηh/st abs prod = (33749+0)/ (1138+ 1318+367406))*100	=18.5 (%)
	ηh/st abs exp= (0)/ (1138+ 1318+367406)*100	=13.7 (%)
b) plant with only electricity production (in equivalent)	ηh/st equ prod = (34121+0)/ (1138+ 1612+367406))*100	= 48.6 (%)
	ηh/st equ exp = (0)/ (1138+ 1612+367406))*100	= 36.1 (%)
a) plant with only heat/steam production (in absolute)	ηh/st abs prod = (33749+242443)/ (1138+ 1318+367406))*100	=71.3 (%)
	ηh/st abs exp = (242443)/ (1138+ 1318+367406))*100	=62.6 (%)
b) plant with only heat/steam production (in equivalent)	ηh/st equ prod = (34121+242443)/ (1138+ 1612+367406))*100	=66.4(%)
	ηh/st equ exp = (242443)/ (1138+ 1612+367406))*100	=58.2 (%)
a) plant with CHP (in absolute)	ηh/st abs prod = (33749+137375)/ (1138+ 1318+367406))*100	=9.1 (%)
	ηh/st abs exp = (131730)/ (1138+ 1318+367406))*100	=0.0 (%)
b) plant with CHP (in equivalent)	ηh/st equ prod = (34121+150961)/ (1138+ 1612+367406))*100	=9.2 (%)
	ηh/st equ exp = (150961)/ (1138+ 1612+367406))*100	=0.0 (%)

Total specific electricity and heat/steam produced in correlation to the quantity of waste incinerated:

$$N_{e+h/st\ sp\ prod} = N_{e\ sp\ prod} + N_{h/st\ sp\ prod}$$

Total specific electricity and heat/steam exported in correlation to the quantity of waste incinerated:

$$N_{e+h/st\ sp\ exp} = N_{e\ sp\ exp} + N_{h/st\ sp\ exp}$$

a) as $MWh_{op\ abs}$/t (of waste) or $GJ_{op\ abs}$/t (of waste)
b) as $MWh_{op\ equ}$/t (of waste) or $GJ_{op\ equ}$/t (of waste)

Examples for specific heat/steam produced and exported:

a) plant with only electricity production (in absolute)	Ne+h/st sp prod = 0.539 + 0.266	=0.805MWhe+h/st abs/t
	Ne+h /st exp = 0.401 + 0	=0.401MWhe+h /st abs/t
b) plant with only electricity production (in equivalent)	Ne+h /st sp prod = 1.419 + 0.269	=1.688 MWhe+h /st equ/t
	Ne+h /st exp = 1.055 + 0	=1.055 MWhe+h /st equ /t
a) plant with only heat/steam production (in absolute)	Ne+h /st sp prod = 0 + 2.180	=2.180 MWhe+h /st abs/t
	Ne+h /st exp = 0 + 1.914	=1.914 MWhe+h /st abs/t
b) plant with only heat/steam production (in equivalent)	Ne+h /st sp prod = 0 + 2.183	=2.183 MWhe+h /st equ /t
	Ne+h /st exp = 0 + 1.914	=1.914 MWhe+h /st equ /t
a) plant with CHP (in absolute)	Ne+h /st sp prod = 0.389 + 1.351	=1.740 MWhe+h /st abs/t
	Ne+h /st exp = 0.250 + 1.084	=1.334 MWhe+h /st abs/t
b) plant with CHP(in equivalent	Ne+h /st sp prod = 1.023 + 1.461	=2.484 MWhe+h /st equ /t
	Ne+h /st e exp = 0.659 + 1.192	=1.851 MWhe+h /st equ /t

Percentage of total electricity and heat/steam produced and exported in correlation to the total energy input:

$$\eta_{e+h/st\ abs} = \eta_{e\ abs} + \eta_{h/st\ abs}\ \{\%\}$$

$$\eta_{e+h/st\ equ} = \eta_{e\ equ} + \eta_{h/st\ equ}\ \{\%\}$$

Examples for percentages of heat/steam produced and exported:

a) plant with only electricity production (in absolute)	ηe+h/st abs prod = 18.5 + 9.1	= 27.6 (%)
	ηe+h/st abs exp = 13.7 + 0	=13.7 (%)
b) plant with only electricity production (in equivalent)	ηe+h/st equ prod = 48.6 + 9.2	= 57.8 (%)
	ηe+h/st equ = 36.1 + 0	= 36.1 (%)
a) plant with only heat/steam production (in absolute)	ηe+h/st abs prod = 0 + 71.3	= 71.3 (%)
	ηe+h/st abs exp = 0 + 62.6	= 62.6 (%)
b) plant with only heat/steam production (in equivalent)	ηe+h/st equ prod = 0 + 66.4	= 66.4(%)
	ηe+h/st equ exp = 0 + 58.2	= 58.2 (%)
a) plant with CHP (in absolute)	ηe+h/st abs prod = 13.3 + 46.3	= 59.6 (%)
	ηe+h/st abs exp = 8.6 + 37.1	= 5.7 (%)
b) plant with CHP (in equivalent)	ηe+h/st equ prod = 35.0 + 50.0	= 85.0 (%)
	ηe+h/st equ exp = 22.6 +40.8	= 63.3 (%)

Boiler efficiency by heat/steam production in absolute figures in correlation to the total heat/steam producing energy input:

$$\eta b = (Eh/st\ \ boiler/(Ef + Ew))x\ 100\ \{\%\}$$

or because by losses of energy in the bottom ash, boiler dewatering and radiation estimated only 97 % released heat out of the furnace into the boiler

$$\eta_{b\ (97\ \%)} = (E_{h/st\ \ boiler}/0.97x(E_f + E_w))x\ 100\ \{\%\}$$

Examples for boiler efficiency by heat/steam production in absolute figures in correlation to the total heat/steam producing energy input:

$\eta_b = (E_{h/st\ \ boiler}/(Ef + Ew))x\ 100$	= (289207/(1138 + 367407))*100	= 80.9 (%)
ηb (97 %) = (Eh/st boiler/0.97x(Ef + Ew))x 100	= (289207/(0.97*(1138 + 367407)))*100	= 83.4 (%)

10.4.5 Equations to calculate the plant efficiency (Pl ef)

Annual basic operational figures and data are the basis for the calculation of the plant efficiency figures for the 3 examples given here. Both calculations provide a figure for the total efficiency of a plant (Pl ef) but with different correlation.

The exported (sold) energy minus the net part of imported energy is divided by the total energy demand for the waste incineration process, including flue-gas cleaning, generation of heat and electricity etc.

Because the calculation does nearly not take into account the energy content in the waste, it only allows efficiency comparison of incinerators processing similar wastes.

$$Pl_{ef} = (O_{exp} - (E_f + E_{imp}))/(E_f + E_{imp} + E_{circ})$$

all figures as equivalents in accordance to BREF, Chapter 3.5.6

E_f = *annual energy input to the system by fuels with steam production (GJ/y)*
E_{imp} = *annual imported energy (Note: energy from the treated waste (E_w) is not included)*
E_{circ} = *annual energy circulated*
O_{exp} = *annual exported energy (combined total of heat plus electricity as equivalents)*

For the calculation of Pl_{ef} the figures of section 3, enclosure 2 and 3 are used:

plant with only electricity (13.7 % abs) export (in equivalent)
Pl_{ef} = (133685 - (1138+1612))/(1138+1612+80226) = **1.58**

plant with only heat/steam (steam 62.6 % abs) export (in equivalent)
Pl_{ef} = (242443 - (1138+47717))/(1138+47717+34121) = **2.33**

plant with CHP (H= 37.1 % abs and P= 8.6 % abs) export (in equivalent)
Pl_{ef} = (234462 - (1138+1612))/(1138+1612+80226) = **2.79**

If the resulting figure is 0 or <0:

This means that no energy is exported (BREF) or produced (ECJ) but some imported energy is needed. This could be because no energy is recovered or because the energy that is recovered is consumed by the waste incineration process itself and not available for export and further more some imported energy is necessary.

If the result is higher than 1:

This shows that the plant minus imported energy with steam production is exporting (BREF) or producing (ECJ) more energy than that which is required to operate the total waste incineration process.

This calculation does not require knowledge of the energy content of the waste. However, the result will be influenced by the waste energy content, and it can be expected that wastes with a higher energy content can result in greater energy exports, and hence higher values of Pl_{ef}.

Appendix G4: Spreadsheet of Calculations

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Determination of the R1-Factor in accordance to the Draft of the Waste Framework Directive (WFD) (status Dec. 2005)

WtE plant Meath-Ireland — Part A

calculation period 1 hour, estimated annual operation hours 8000- 8200 h/a

#	description	identification in R1 formula	data	unit	remarks and basis of calculation
1	calculation period		1	hour	
2	total input of waste		26.67	ton	planning data
3	heat value of waste (NCV)		9.35	GJ/ton	planning data
4	energy input by waste	Ew	249.3645	GJ	2*3
5		Ew	69.3	MWh	2*3/3,6
6	energy demand of primary fuels (imported) **steam/WW producing** e.g. for start up and shut down		1.17740741	GJ	planning data
7			0.327	MWh	6/3,6
8	energy demand of primary fuels (imported) **not steam/WW producing** e.g. for start up and shut down, heating up of flue gases (fabric filter, SCR) and boiler for heating up purposes		0.41427298	GJ	Planungsdaten
9			0.115	MWh	8/3,6
10	energy demand of **imported electricity**		0.288	GJ	planning data
11			0.0800	MWh	10/3,6
12	exported electricity		14.720	MWh	planning data
13	selfdemand of produced electricity		2.480	MWh	planning data
14	exported heat/steam/WW		0.000	MWh	planning data
15	selfdemand of produced steam/heat/WW e.g. for heating of plant buildings, sootblowing, SNCR injection, heating up of combustion air and/or flue gases, evaporation of scrubber wastewater		2.667	MWh	planning data

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Determination of the R1-Factor in accordance to the Draft of the Waste Framework Directive (WFD) (status Dec. 2005)

WtE plant Meath-Ireland — Part B

calculation period 1 hour, estimated annual operation hours 8000- 8200 h/a

#	description	identification in R1 formula	data	unit	remarks and basis of calculation
16	equivalence factor for electricity		2.6	[-]	given for R1-calculation by WFD
17	equivalence factor for heat/steam/WW		1.1	[-]	given for R1-calculation by WFD
18	0,97 factor for taking into account losses of energy e.g. by bottom ash, blow down water, radiation of heat, organic content in residues and so on		0.97	[-]	given for R1-calculation by WFD
19	energy demand of primary fuels (imported) **steam/WW producing** as equivalent	Ef	0.360	Mwhequ	17*7
20	energy demand of primary fuels (imported) **not steam/WW producing** as equivalent	Ei	0.127	Mwhequ	17*9
21	imported electricity demand as equivalent (not steam/WW producing)	Ei	0.208	Mwhequ	16*11
22	sum of imported energy **not steam/WW producing** as equivalent	Σ Ei	0.335	Mwhequ	20+21
23	exported electricity as equivalent	Ep	38.272	Mwhequ	16*12
24	selfdemand of produced electricity as equivalent	Ep	6.448	Mwhequ	16*13
25	exported heat/steam/WW as equivalent	Ep	0.000	Mwhequ	17*14
26	selfdemand of produced steam/heat/WW as equivalent	Ep	2.934	Mwhequ	17*15
27	sum of utilized energy as equivalent	Σ Ep	47.65	Mwhequ	SUM (23:26)
28	sum of utilized energy minus total imported energy as equivalent (as numerator of the R1 equation)	Σ Ep-(Ef+Σ Ei)	46.959	Mwhequ	27-19-22
29	0,97 out of the sum of delivered energy by waste (equivalent=1) minus steam/WW producing energy as equivalent (as denominator of the R1 equation)	0,97*(Ew+Ef)	67.539	Mwhequ	18*(5+19)
30	**R1-Factor in accordance to the Draft of the Waste Framework Directive (WFD) (status Dec. 2005)**	(Σ Ep-(Ef+Σ Ei))/(0,97*(Ew+Ef))	**0.695**	[-]	28 : 29

Appendix G5: Example of Awareness Campaign Posters

Energy Efficiency

LIGHTING TIPS

Did you know lighting accounts for about 45% of the electricity usage in a commercial building:

Lighting an empty office overnight wastes enough energy to heat water for 1,000 cups of coffee.

What can you do?

1 The Off Switch

Turn lights off when leaving a room or area. When leaving for lunch or meetings switch off desk lamps and office lights.

2 Good Housekeeping

Dirty reflectors and louvers reduce light output by 20%. To ensure optimum efficiency, clean reflectors, windows and roof-lights.

3 Hours of Use

Make sure that full lighting is not being used unnecessarily outside of normal business hours.

4 Office Set Up

Is the office layout making the most of natural light?

5 Task Lighting

Where possible use individual task lighting in preference to increasing illumination over a large area.

6 Light Bulbs

Make sure that the light bulbs in your office are the most energy efficient with longer lifespans and lower maintenance costs.

Contact us if you have any new ideas

- Talk to your manager
- Take your idea to the next Sphere Meeting
- Use the QESH suggestion box
- E-mail info@indaver.ie

Save the trees—only print this message if absolutely necessary

Energy Efficiency

HEATING TIPS

Did you know heating and air conditioning accounts for about 25% of the electricity usage in a commercial building:

Reducing the temperature in a room by just 1°C can cut the heating bill by as much as 10%.

What can you do?

1 Optimum settings

Air conditioning and heating controls should not be set so that they conflict with each other. Otherwise, heating and cooling will take place at the same time and waste energy. Ideally, set heating at 19°C and air conditioning at 24°C. Make sure that the two systems cannot work at the same time.

2 Thermostats and Timers (Wall mounted heaters)

Set wall-mounted heaters on timer. Check that timers are set to the minimum period and ensure room thermostats and radiator controls are on minimum settings.

3 The off switch (Office Equipment)

It costs nothing to switch office equipment off. Office equipment generates heat. If possible locate heat-generating equipment such as photocopiers, away from air-conditioned spaces. Where this is not possible, locate them in areas where they are well ventilated and cannot build up heat. Office equipment can add significantly to your electricity bill, not only in running costs, but also in air conditioning.

4 Occupied areas

Ensure that only occupied areas are heated and that heating is reduced during non-working hours, such as bank holidays or weekends.

Contact us if you have any new ideas

- Talk to your manager
- Take your idea to the next Sphere Meeting
- Use the QESH suggestion box
- E-mail info@indaver.ie

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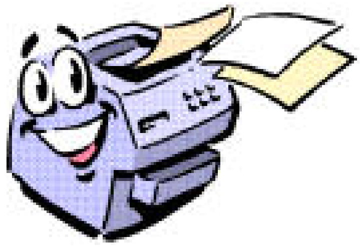
Energy Efficiency

OFFICE EQUIPMENT TIPS

Did you know that a photocopier left on overnight wastes enough energy to photocopy 5,300 A4 sheets?

A PC monitor left switched on overnight wastes enough energy to laser print 800 A4 copies.



What can you do?

1 Switch off

Make sure all office equipment is switched off overnight. Switch off your screen at lunchtime - the screen on a personal computer uses as much energy as all of its other components.

2 Standby mode

Standby is not switched off!! Even on standby a photocopier consumes as much as 200 watts per day. If you see a light on a machine switch if off.

3 Only switch on when needed

Don't switch on appliances unless you are ready to start using them. Photocopiers and printers don't need to be switched on immediately in the morning. Get into the habit of switching on only when needed.

Contact us if you have any new ideas

- Talk to your manager
- Take your idea to the next Sphere Meeting
- Use the QESH suggestion box
- E-mail info@indaver.ie

Save the trees—only print this message if absolutely necessary