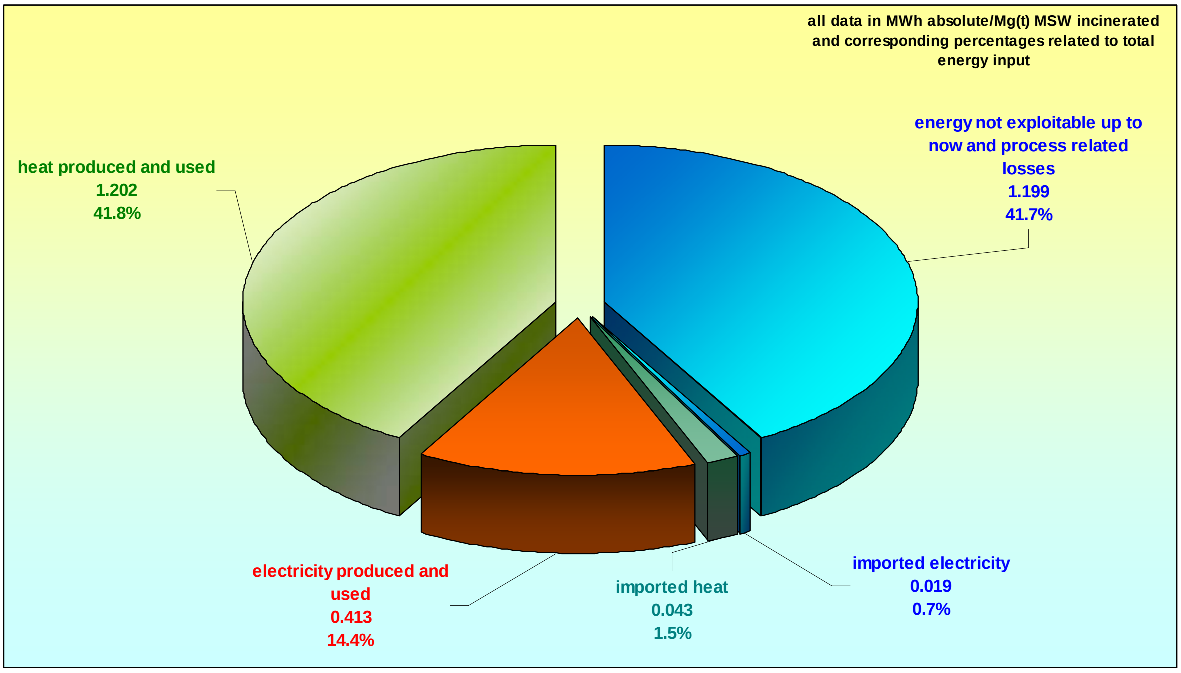
CEWEP Energy Report II
(Status 2004-2007)

Results of Specific Data for Energy, R1 Plant Efficiency factor and Net Calorific Value (NCV) of 231 European WtE Plants



by

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Content

1. Executive summary

Continuing the work started with its first CEWEP Energy Report on 97 European Waste-to-Energy (WtE) plants referring to the operation years 2001-2004, CEWEP now publishes a second CEWEP Energy Report on 231 European WtE plants referring to the operation years 2004-2007.

The calculations were made assuming the same hypotheses as made in the first CEWEP Energy Report which was used as a reference when the Commission set the thresholds of the R1 formula in its proposal for the Waste Framework Directive. The formula used in the first report was slightly different from the one which is now in the Waste Framework Directive 2008/98/EC, but the results are quite comparable between the 2 reports in this respect.

However, the number of plants investigated has nearly tripled in this second report with a greater number of small plants and many plants from the South and the West part of EU and consequently this led to somewhat different results.

Energy data from 231 European WtE plants operated by CEWEP members from 16 countries of Europe (15 EU countries + CH) were collected and used for this report. The mixed municipal waste (MSW) incinerated by these investigated plants amounts to 45 million Mg/year in EU 27 and 45.5 million Mg/y (EU 27 + CH). These amounts represent a share of 76% of the incinerated MSW in EU 27 in 2006 and 71.5% of the incinerated MSW in EU 27+CH+NO during the same year.

The main objective of this report was to calculate the key figures Ep, Ew, Ef and Ei as basis for the R1 efficiency factor of these 231 installations according to the formula given in Annex II of the Waste Framework Directive 2008/98/EC and to determine whether they are Recovery operation (R1) or Disposal operation (D10). The criterion given in the Directive is R ≥ 0.60 for existing plants and ≥ 0.65 for plants permitted after 31/12/2008.

For the total of the 231 investigated European WtE plants, the R1 efficiency factor (calculated with the equivalence factors as given by the Directive) is 0.75 (0.04 min and 1.41 max) on average and therefore well exceeding the value of ≥ 0.60. The R1 efficiency factor of 169 WtE plants (73.2%) out of the total 231 investigated European plants is also well over 0.60.

The second task of the report was to check the possible effects of the main parameters of the energy efficiency performance of the plants as it is reflected by the R1 formula, with a view to gathering useful information for the guidance which the European Commission may elaborate as additional general conditions for the determination of R1.

With respect to the influencing parameters, the results of the investigation clearly show strong correlations between the values of R1 and the kind of energy recovery, the size of the plant and the European geographical location, respectively.

Type (kind) of energy recovery:
WtE plants “only electricity” producing are achieving the lowest R1 factor of 0.64 as a non-weighted average so that only 46 plants (61.3%) out of 75 are reaching R1 ≥ 0.60. Although WtE plants “only heat” producing are achieving a R1 factor of 0.72, only 25 plants (61.0%) out of 41 are reaching R1 ≥ 0.60. In this case, the import of the total electricity to treat the waste plays an important negative role. WtE plants “CHP” producing get the highest R1 factor of 0.84 as a non-weighted average so that 98 plants (85.2%) out of 115 are reaching R1 ≥ 0.60.

Size (throughput) of the plant:
As expected, small sized WtE plants (< 100,000 Mg/a) are getting the lowest R1 factor of 0.68 as a non-weighted average, so that only 50 plants (54.3%) out of 92 are reaching R1 ≥ 0.60. Middle sized WtE plants (100,000 – 250,000 Mg/a) are better with the R1 factor of 0.77 as a non-weighted average, so that 60 (77.9%) out of 77 plants are reaching R1 ≥ 0.60. Large sized WtE plants (> 250,000 Mg/a) are achieving the highest R1 factor of 0.85 as a non-weighted average so that 59 plants (95.2%) out of 62 are reaching R1 ≥ 0.60.

Plant location (with respect to the European geographical region):
As expected, plants in South-West Europe achieve the lowest R1 factor of 0.61 as a non-weighted average, so that only 24 plants (40.7%) out of 59 are reaching R1 ≥ 0.60. Plants in Central (Middle) Europe are getting a higher R1 factor of 0.74 as a non-weighted average, so that 114 plants (80.9%) out of 141 are reaching R1 ≥ 0.60.
Plants in North Europe have by far the highest R1 factor of 1.10 as non-weighted average, so that all of the 31 plants (100%) are reaching R1 ≥ 0.60.

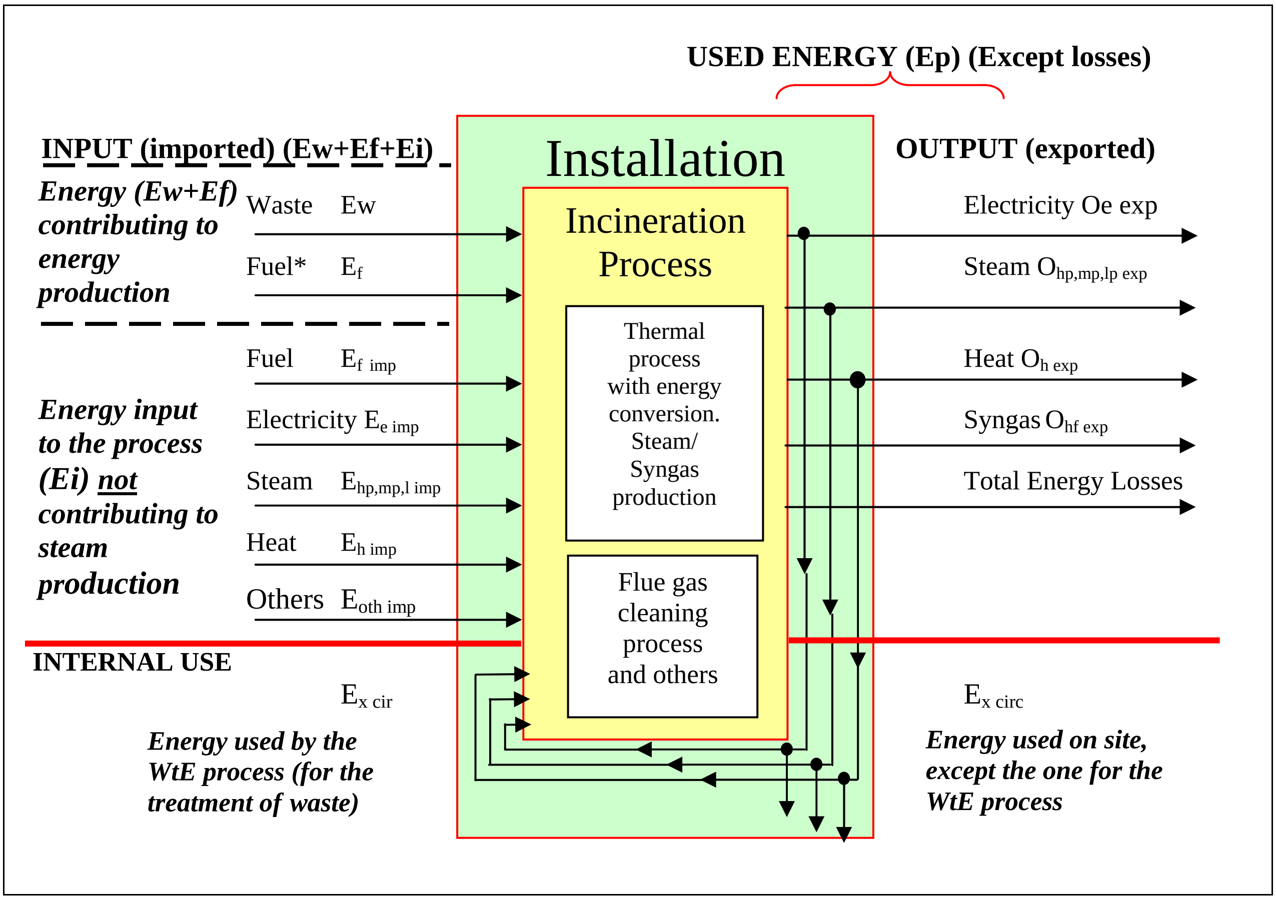
These results corroborate the statements of the BREF Waste Incineration.

2. Introduction

Waste-to-Energy (WtE) plants generate electricity and heat through the thermal treatment of mixed municipal waste (MSW). In a few EU Member States, WtE plants have temporarily been classified as disposal facilities, not taking into account the energy they produce and export, their contribution to the national energy supply, to resources saving (primary fuels saving) and the corresponding reduction of emissions of CO_2 (greenhouse gases, climate relevance).

The situation has been restored and clarified by the Waste Framework Directive (WFD) 2008/98/EC [1] because it includes in ANNEX II a calculation formula to determine when a waste incineration installation is a recovery operation (R1) or not. If not meeting the fixed R1 efficiency criteria, the installation will be classified as disposal operation (D10). The formula is checking the recovery of energy from waste and its utilisation on the basis of the 1st law of thermodynamics which is that energy output must correspond with the energy input. This formula is very similar to the one which was already known (draft of the Waste Framework Directive) at the time of the first CEWEP report on energy efficiency (Status 2001-2004) [2].

Diagram 1: Summary of the system inputs and outputs on the basis of the BREF WI Best Available Technique REFerence Document Waste Incineration



* Fuel for auxiliary burners

3. General

In order to determine the current and future situation concerning energy data for the European WtE plants, a computer program applying the formula laid down in the Directive 2008/98/EC (WFD) was developed.

This program is connected with a databank which includes energy data of hundreds of WtE plants provided by CEWEP members who answered an installation checklist (**Appendix A** in updated version) and a minimized energy questionnaire (**Appendix B**) which were developed and used in particular for the CEWEP Energy Report II (status 2004-2007).

The **equivalence factors** for energy given with the R1 formula have been used[1].

All **weighted and non-weighted averages**[2] are based on the specific energy data of each of the 231 individual WtE plants included in this report.

To avoid the possibility of misinterpretation of the results in this report, the following energy is taken into account:

- the electricity produced as the sum of exported electricity and electricity used for the thermal treatment of waste,
- the heat produced and used as the sum of heat exported and heat used for the thermal treatment of waste, (Heat for the thermal treatment of waste (demand) is including e.g. heating the combustion air, the steam demand to soot blowers, flue gas reheating, pipe heating, building heating as well as 100% of the energy for heating up the boiler water from around 70°C up to the boiler water end temperature),
- the imported energy as electricity and heat needed to run the incineration process.

4. Amount of MSW investigated and incinerated

Energy data from 231 European WtE plants from 16 European countries (15 EU countries + CH) is the basis for this CEWEP Energy Report II for the time period 2004-2007[3]. The amount of mixed municipal waste (MSW)[4] being incinerated and investigated was summarised from the filled out checklists accounting for 45,007,742 Mg/a (throughput EU 27) and 45,518,189 Mg/a (throughput EU 27 + CH). These amounts represent a share of 76% (of MSW incinerated in the 17 countries with incinerators in EU 27) and 71.5% (of MSW incinerated in 19 countries with incinerators in EU 27+CH+NO) respectively of the total amount of incinerated MSW in Europe (2006) as shown in Diagram 2.

Annual amount of MSW incinerated and investigated in the report:
For this 4 years period, each plant is only taken into account once with its most recent data even if several annual energy calculations have been carried out during this time period[5].

2004:	20 WtE plants	4,365,068 Mg	9.6%
2005:	0 WtE plants	0 Mg	0.0%
2006:	111 WtE plants	16,527,214 Mg	36.3%
2007:	100 WtE plants	24,625,907 Mg	54.1%
total 2004-2007:	**231** WtE plants	**45,518,189 Mg**	**100.0%**

[1] Equivalence factors are used for the comparison of different kinds of energies produced by a WtE plant on the basis of the efficiencies of other thermal energy generators using primary fuels which, according to the BREF WI [1e] are, for electricity generation in power plants as overall European average 38% and for district heating and steam producing plants, as European average 91%.
The equivalence factors for energy given in Annex II of the WFD [1] have been used in the formula for the determination of the R1 energy recovery efficiency factor.
The equivalence factors for energy produced (export plus energy used for the treatment of the waste) are 2.6 for electricity and 1.1 for heat.
Relating to BREF WI [1b] the equivalence factors for Ef and Ei as primary fuels are 1.0 and for Ei as district heat or hot water/steam 1.1 and as electricity 2.6.
In order to differentiate the values, it is specified in the text or the titles if they include the equivalence factor (equ) or not (abs.).

[2] Weighted averages are used in this report for the comparison of all kinds of energy production, e.g for NCV:
$(\Sigma\,(\text{MSW throughput}_{\text{individual}} * \text{NCV}_{\text{individual}})_n) / (\Sigma\,(\text{MSW throughput}_{\text{individual}})_n) = \text{NCV}_{\text{weighted average}}$.
Non weighted averages are used for min. and max. results as well as for the averages of the R1-efficiency factor according to WFD.

[3] The information from 9 plants (in addition to the 231 already mentioned) have not been taken into account because of biogas combustion, co-combustion with wood chips, peat or natural gas, gasification by pyrolysis, no energy recovery or even no boiler because this would have distorted the comparability of the CEWEP Energy Report II (status 2004-2007).

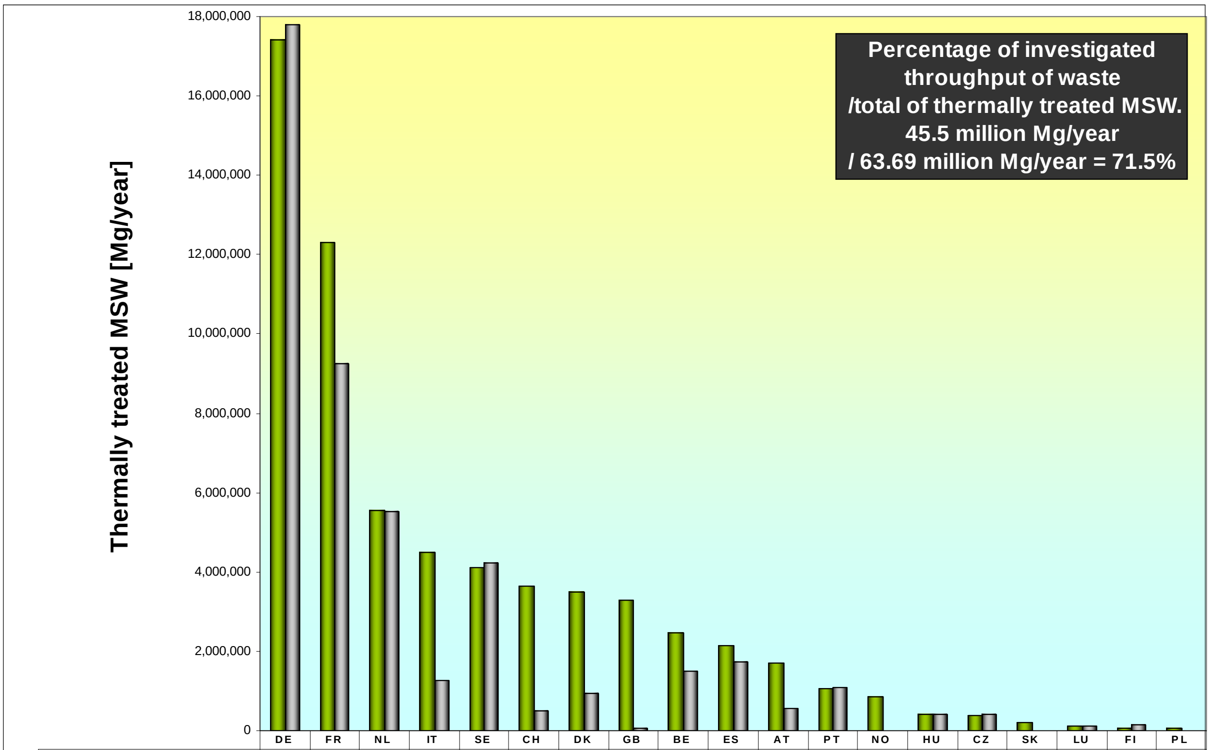
[4] Mixed municipal waste means waste from households as well as commercial, industrial and institutional waste, which, because of its nature and composition is similar to waste from households (although its NCV might be different). In some cases, high calorific waste is added to the MSW incinerated.

[5] Because the investigated plants had delivered data as asked for in the questionnaires mentioned above for the time period 2004 to 2007, some did not update old data to 2007 figures.

45,518,189 Mg/year has been taken into account as the basis for the determination of the energy results in this report for EU 27 + CH including **45,007,742 Mg/year** from EU 27. These amounts are compared below with the figures for the total waste throughput by incineration in **2006** and with data available at that time gathered by CEWEP, listed under "CEWEP: EUROPE - Thermally Treated MSW 2006" including relevant references [4] and the percentages represented as follows:

	Total incinerated 2006	Investigated 2004-2007	% investigated
EU 27:	59.20 million Mg/year	45.01 million Mg/year	76.0%
EU 27 + CH + NO:	63.69 million Mg/year	45.52 million Mg/year	71.5%

Diagram 2: Thermally treated mixed municipal waste (MSW)[1)] in Waste-to-Energy (WtE) plants as total in 2006[2)] compared with the throughput of the 231 investigated WtE plants included in the CEWEP Energy Report II (status 2004-2007)



	DE	FR	NL	IT	SE	CH	DK	GB	BE	ES	AT	PT	NO	HU	CZ	SK	LU	FI	PL
Total MSW incinerated in 2006	17,403,8	12,300,0	5,541,79	4,500,0	4,099,8	3,640,2	3,489,0	3,284,0	2,462,61	2,136,27	1,700,00	1,067,95	849,755	405,317	392,878	194,010	125,000	49,000	48,500
MSW in CEWEP Report 2004-2007	17,804,9	9,254,4	5,527,5	1,254,82	4,220,0	510,447	935,466	46,087	1,505,91	1,725,65	561,272	1,079,90	0	405,317	412,752	0	123,650	150,000	0

1) mixed municipal waste (MSW) means waste from households as well as commercial, industrial and institutional waste, which, because of its nature and composition is similar to waste from households

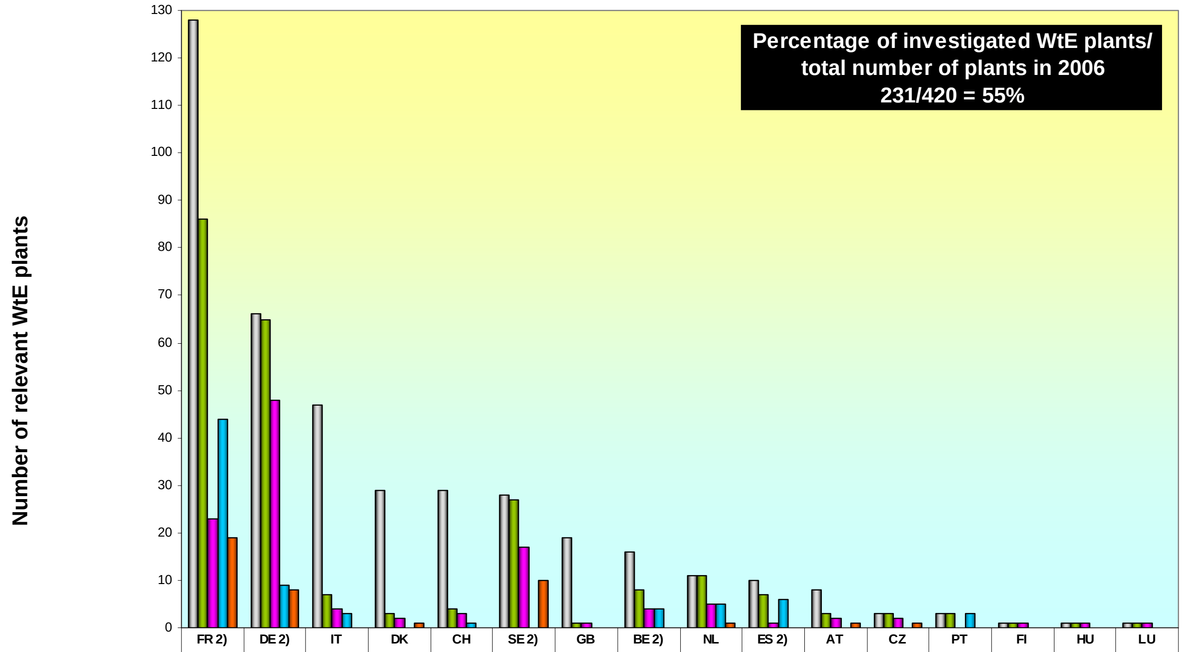
2) Data gathered by CEWEP, listed under "CEWEP: EUROPE - Thermally Treated MSW 2006" including relevant references

4.1 Number of WtE plants investigated

The number of 231 WtE plants included in this report represents 61.4% (from 15 EU countries of the EU 27) and 55.0% (from 16 countries of the EU 27+CH+NO) respectively of the total 420 European WtE plants in the 19 European countries in 2006. Because no data was provided or available about the WtE plants existing in Poland, Slovakia and Norway they are not included in Diagram 3.

	Total relevant plants 2006	Investigated	% of total
EU 27:	370 WtE plants	227 WtE plants	61.4%
EU 27 + CH + NO:	420 WtE plants	231 WtE plants	55.0%

Diagram 3: Number of existing European Waste-to-Energy (WtE) plants as total in 2006 compared with the 231 investigated WtE plants and distinction of the type of energy recovery included in the CEWEP Energy Report II (status 2004-2007)



	FR 2)	DE 2)	IT	DK	CH	SE 2)	GB	BE 2)	NL	ES 2)	AT	CZ	PT	FI	HU	LU
existing in 2006	128	66	47	29	29	28	19	16	11	10	8	3	3	1	1	1
investigated in 2004-2007	86	65	7	3	4	27	1	8	11	7	3	3	3	1	1	1
producing CHP	23	48	4	2	3	17	1	4	5	1	2	2	0	1	1	1
producing only electricity	44	9	3	0	1	0	0	4	5	6	0	0	3	0	0	0
producing only heat	19	8	0	1	0	10	0	0	1	0	1	1	0	0	0	0

[1)] Data gathered by CEWEP, listed under "CEWEP: EUROPE - Thermally Treated MSW 2006" including relevant references

[2)] 11 plants have been discarded (1 plant BE (biogas), 1 plant SE (co-combustion with wood chips and peat), 7 plants FR (no energy recovery or boiler), 1 plant ES (co-combustion with gas), 1 plant DE (pyrolysis)) have not been taken into account because this would distort the generality of the CEWEP energy report II.

Diagram 3 also shows the geographical distribution (by countries) of the 3 categories of plants according to the way the energy is used:

- In Scandinavia and Eastern Europe the energy is used as 'heat only' or 'CHP'.
- In Germany CHP plants are the majority, but some plants generate 'electricity only'. In Belgium, the Netherlands and Italy the number of CHP plants is nearly equal to the number of 'electricity only' plants.
- In France, Spain and Portugal the 'electricity only' plants are by far the most frequent.

5. Objective of the CEWEP Energy Report II (status 2004-2007)

Beside the general energy results (such as Net Calorific Value (NCV), energy production as heat and/or electricity, R1 efficiency factor) for the

- **total of 231 investigated WtE plants without any further classification,**

this CEWEP Energy Report II also contains answers to 3 additional decisive questions in view to identify correlations between their energy data and the following parameters:

- **type(kind) of energy recovery**
  3 categories: only electricity, only heat, CHP production,
- **size (throughput) of the plant**
  3 categories: <100,000, 100,000-250,000, >250,000 Mg MSW/a,
- **geographical location of the plant**
  3 categories: North Europe (DK, FI, SE)**, Central (Middle) Europe** (AT, BE, CH, CZ, DE, North-Western part of FR, GB, HU, LU, NL)**, South-West Europe** (ES, remaining part of FR, IT, PT)

In this report all investigated WtE plants exporting steam only are included in the group of "only heat producing" without considering the purpose how the steam is used by the customers.

6. NCV of MSW (Ew) of all investigated 231 WtE plants

The weighted average of Net Calorific Value (NCV) over the total amount being incinerated in the 231 WtE plants, calculated according to BREF WI [3a], is 2.814 MWh/Mg MSW or 10.129 GJ/Mg MSW, whereas MSW includes in some cases wastes with a higher calorific value. This NCV is only slightly higher than the value of 9.987 GJ/Mg found in the first CEWEP Energy Report for the time period 2001-2004 [2].

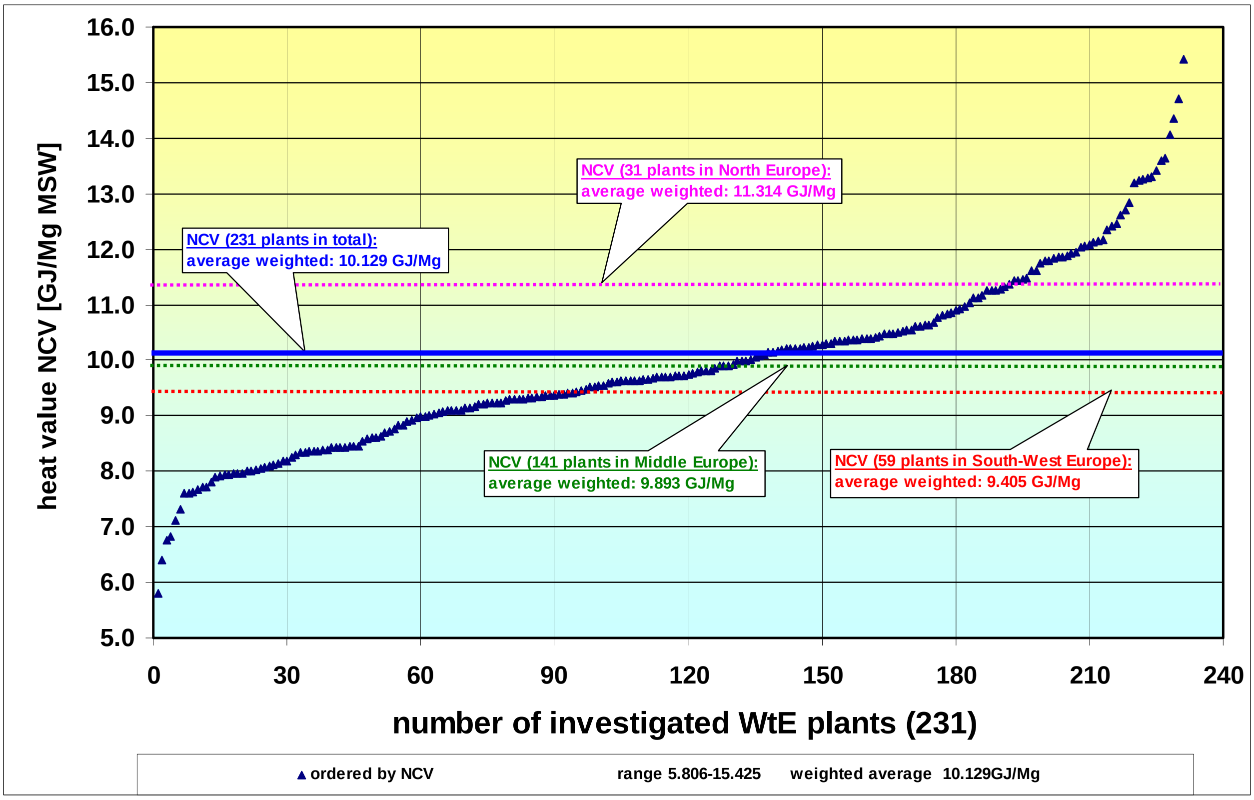


Figure 1: Net Calorific Value (NCV) - calculated by using the BREF WI NCV-formula [3a] as individual NCV values and weighted averages for 231 European WtE plants as well as weighted averages of 31 WtE plants from North Europe, 141 WtE plants from Central (Middle) Europe and 59 WtE plants from South-West Europe (status 2004-2007)

The energy questionnaires did not provide information that explains the wide range of NCV.

One of the main reasons for the relatively high range of the individual NCVs from the plants investigated may be the influence of greater amounts of high calorific fractions (e.g. bulky, trade, industrial and commercial waste, spoiled wrapping or waste wood) in the waste to be incinerated in a plant.

For the lower results, a high content of green waste, sewage sludge co-incineration, waste water and water content e.g. in rainy seasons may be the reason.

Accuracy of the results from the measuring devices used may be another reason and should be checked e.g. by comparing the quantity of boiler water with the corresponding result of the steam/heat quantity.

6.1 NCV of MSW (Ew) of all investigated 231 WtE plants and classified into categories in the CEWEP Energy Report II (status 2004-2007)

The following Table 1 shows the results for NCV (Ew) classified in 3 categories for each of the 3 following parameters: the type (kind) of energy recovery, the size and the geographical location of the plants.

Table 1: NCV as weighted averages of MSW for the total WtE plants classified into the categories type of energy recovery, size (throughput) and European geographical region in the CEWEP Energy Report II (status 2004-2007)

relevant NCV depending on different classifications	unit	all investi-gated WtE plants	kind of energy recovery of a plant (weighted averages)			size (throughput) of a plant (weighted averages)			geographical European region of a plant (weighted averages)		
			only electricity production	only heat production	CHP production	< 100,000 Mg/year	100,000 to 250,000 Mg/year	> 250,000 Mg/year	South-West Europe	Middle Europe	North Europe
number of plants included	n	231	75	41	115	92	77	62	59	141	31
total throughput of plants	million Mg/a	45.52	12.72	4.57	28.23	5.34	12.77	27.41	8.08	32.13	5.31
Net calorific value of MSW	GJ/Mg MSW	10.129	9.446	10.498	10.321	9.967	9.914	10.202	9.405	9.895	11.314
	GJ/Mg MSW	5.81-15.44	5.81-13.19	7.60-15.45	6.76-13.14	5.81-15.44	6.40-13.19	8.00-14.36	6.82-15.43	5.81-12.71	9.32-14.36
	MWh/Mg MSW	2.814	2.624	2.916	2.867	2.769	2.754	2.834	2.613	2.749	3.143

Table 1 shows that the average NCV of plants producing only electricity is lower than that of plants generating heat only or CHP.

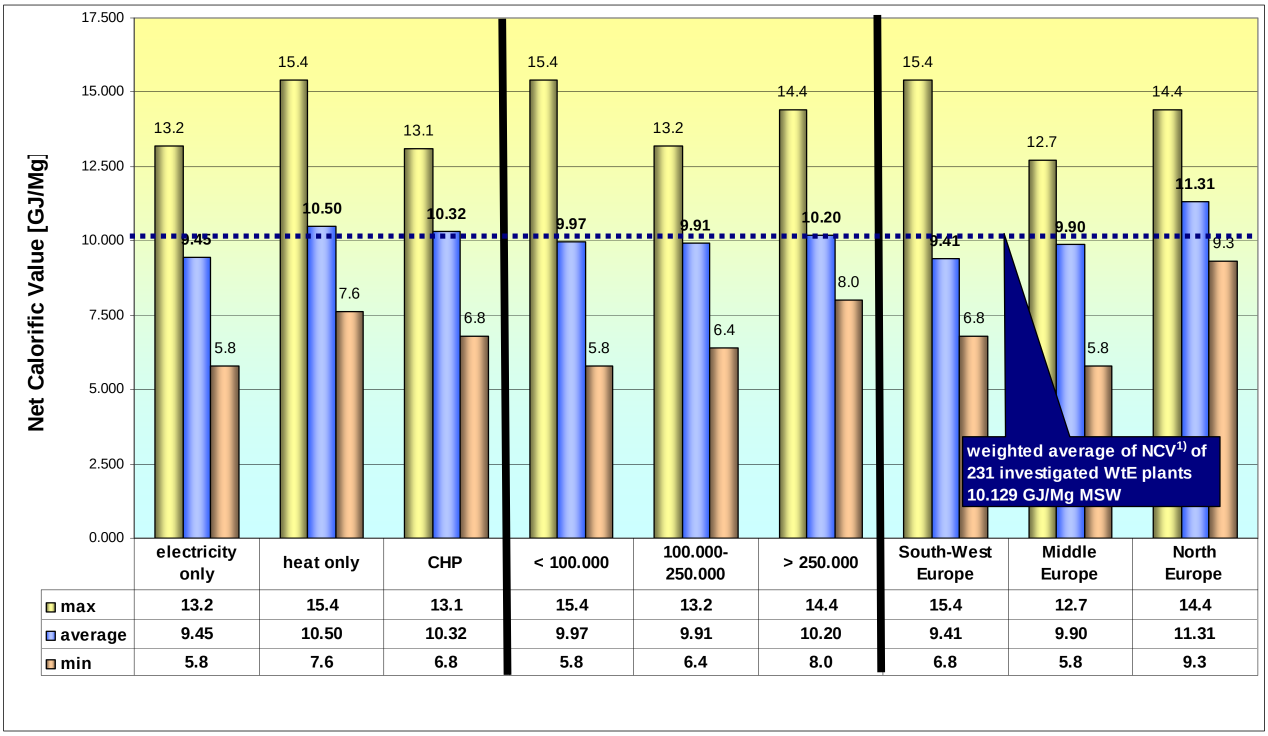
The most important difference is due to geographical location.

The lowest weighted average NCV is found in WtE plants in South-West Europe.

The highest weighted average NCV is related to North Europe where the energy from waste is mainly used for heating purposes with the aim to substitute primary fuels, which would otherwise be imported and therefore in general a higher NCV of the waste is obtained e.g. by adding waste wood chips or higher calorific waste fractions to the waste. Most of these plants from North Europe are producing only heat or CHP.

The weighted averages of NCV depending on the type of energy recovery, size and geographical location of a plant are, except in North Europe in a range between 9.4 and 10.5 GJ/Mg MSW. More important are the individual NCVs of the plants, which have a very wide range between 5.8 and 15.4 GJ/Mg MSW and by this are influencing extremely the energy data of a plant.

Diagram 4: NCV calculated by NCV formula in BREF WI of 231 investigated WtE plants divided into categories according to the type (kind) of energy recovery, the size (throughput) and the European geographical region as min., max. values and non weighted averages in the CEWEP Energy Report II (status 2004-2007)



1) NVC calculation by BREF WI will be validated in future CEWEP energy reports by updated checklist

7. Specific demand of imported energy as heat and electricity (Ef+Ei)

The total energy input into a WtE plant includes the energy from the waste (Ew), and often additional energy such as electricity and/or (primary) fuels (Ef and Ei(th+el)), which is/are imported in order to run a proper incineration process in accordance with the regulations and sometimes to increase the energy input or the calorific value of the waste.

Because the R1 formula [1] takes the imported energy into consideration, it is necessary to make a distinction between Ef and Ei.

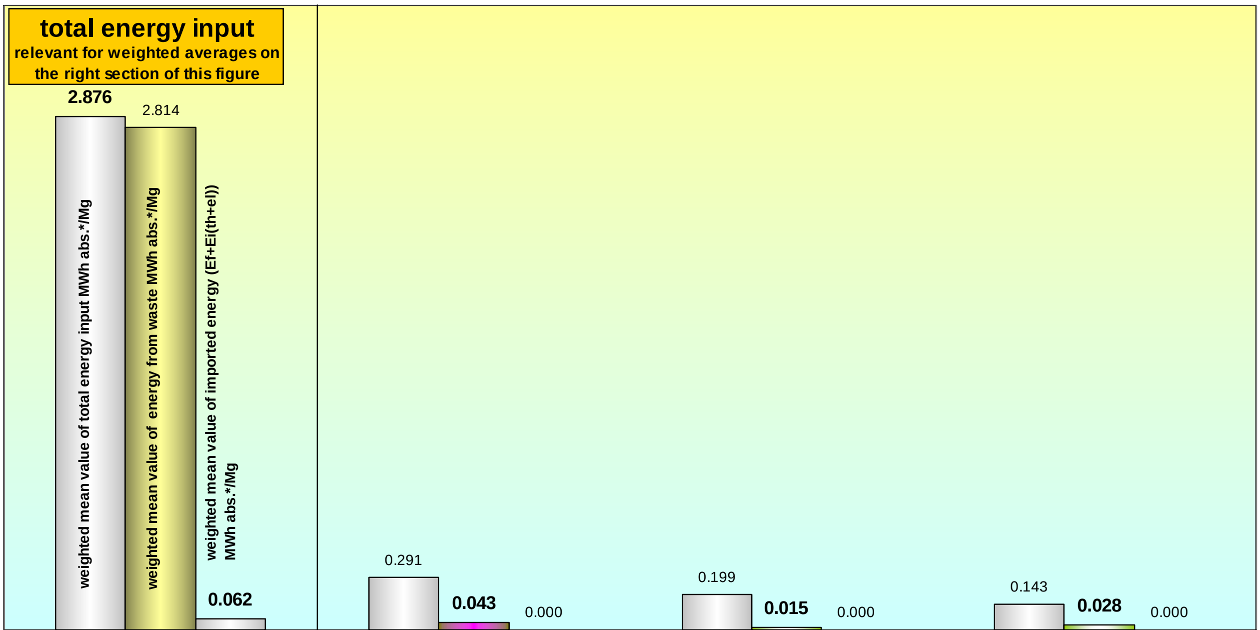
The imported energy with steam production (or hot water) is Ef, whereas the imported energy without steam producing is Ei.

Examples of imported energy with steam production (Ef) are the fuel for start up (second phase, when steam is produced), fuel for keeping temperature > 850 °C by using auxiliary burners or fuels for increasing the energy input (by addition of coal, unpolluted wood etc.).

Examples of imported energy without steam production (Ei) are imported electricity, fuel for re-heating flue gases before a SCR process or fuel for start up situations (first phase before steam is produced and connected with the grid).

The additional imported energy (Ef, Ei(th) and Ei(el)) is based mostly on measured data, and if data are not available, on theoretical and practical assessments of consumption as e.g. in the CEWEP Energy Report (status 2001-2004) [2].

The weighted averages of the total energy input as shown in the left section of Figure 2 and 3 are the basis to which the weighted averages on the right section in Figure 2 and 3 are correlated.

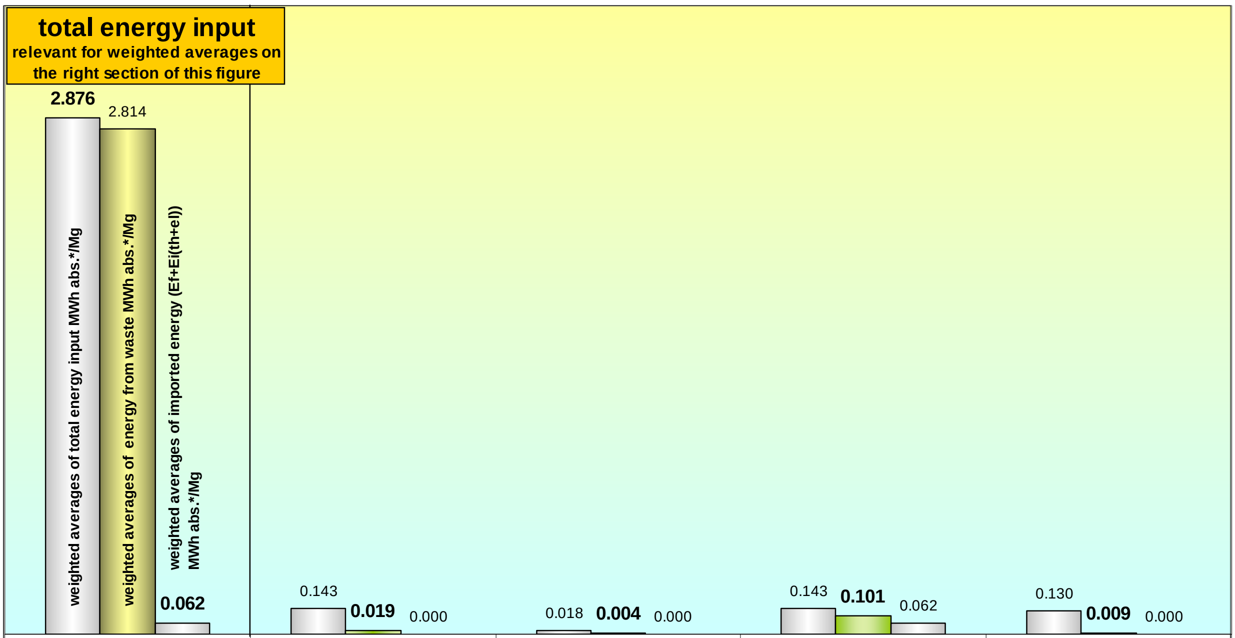


	weighted averages of total energy input (Ew + Ef + Ei(th+el)) MWh abs.*/Mg MSW	imported energy as heat (Ef + Ei(th)) MWh abs.*/Mg MSW	imported heat steam producing (Ef) MWh abs.*/Mg MSW	imported heat not steam producing (Ei(th)) MWh abs.*/Mg MSW
max:	2.876	0.291	0.199	0.143
weighted average:	2.814	0.043	0.015	0.028
min:	0.062	0.0 (no enforced stop in reference year)	0.0 (no enforced stop in reference year)	0.0 (no enforced stop in reference year)

abs.* = absolute (real figures without equivalence factors)   Ei(th) = imported heat not steam producing

Figure 2: Specific demand for energy imported as heat contributing to steam production (Ef) and non-steam production (Ei(th)) as max. - weighted averages - min. values in MWh abs./Mg MSW for the 231 investigated European WtE plants (status 2004-2007)

A distinction is necessary between WtE plants producing only heat and plants producing only electricity and/or CHP. If only heat is produced the total electricity demand has to be imported, which is as weighted average 0.101 MWh/Mg waste and by this 10 or rather 20 times higher than for a plant only producing electricity and/or CHP.



weighted averages of total energy input (Ew+Ef+Ei(th+el)) MWh abs.*/Mg MSW	imp. electricity not steam prod. (Ei(el)) from 231 plants MWh abs.*/Mg MSW	imp. electricity not steam prod. (Ei(el)) from 75 plants only el. producing MWh abs.*/Mg MSW	imp. electricity not steam prod. (Ei(el)) from 41 plants only heat producing MWh abs.*/Mg MSW	imp. electricity not steam prod. (Ei(el)) from 115 plants CHP*** producing MWh abs.*/Mg MSW
2.876	max: 0.143	0.018	0.143	0.130
2.814	weighted averages: 0.019	0.004	0.101	0.009
0.062	min**: 0.0 (no stop in reference year)	0.0 (no stop in reference year)	0.062	0.0 (no stop in reference year)

abs.* = absolute (real figures without equivalence factors)
min** = WtE plants with no interruption in the reference year
Ei(th) = imported heat not steam producing
Ei(el) = imported electricity not steam producing
CHP*** = Combined Heat and Power production

Figure 3: Specific demand for energy imported as electricity (Ei(el)) as max. - weighted averages - min. values in MWh abs./Mg MSW for the 231 investigated European WtE plants (status 2004-2007)

For this reason, the weighted average of imported electricity which is 0.019 MWh/Mg MSW for all WtE plants cannot be considered as representative as such, but only for the whole of the 231 investigated WtE plants

The total additional imported energy demand, 0.062 MWh/Mg, (Ef + Ei(th+el)) is about 2.2% of the total energy input (2.876 MWh/Mg MSW) with about 1.5% as heat (Ef + Ei(th) and 0.7% as electricity (Ei(el)).

The ratio between the imported heat with steam production (Ef) and the non-steam producing one is currently about 1 : 2 (0.028/0.015 = 1.9). Taking in addition into account the imported electricity (Ei(el) it is about 1 : 3 (0.028+0.019) / 0.015 = 3.1).

The demand for imported energy Ei(th) is significantly reduced in WtE plants which use self produced heat (e.g. steam) instead of primary fuel for flue gas re-heating before the SCR process.

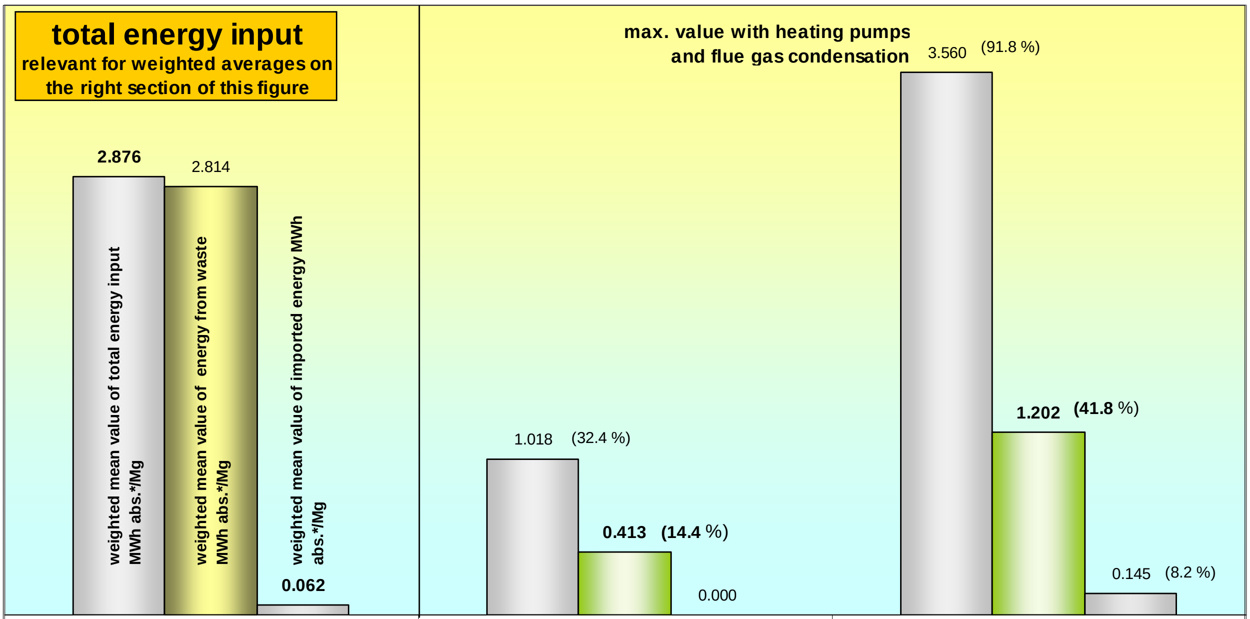
Specified data concerning the energy demand of imported energy depending on type (kind) of energy recovery, size and European geographical region are summarized in Table 2.

8. Energy input and produced as electricity and heat of all investigated 231 WtE plants in the CEWEP Energy Report II (status 2004-2007)

The following Figures 4 and 5 and Table 2 show the results of the production of electricity and heat including the energy used to treat the waste.

Heat used to treat the waste is for example heat for heating up boiler water from around 70°C up to the boiler water end temperature, heating up combustion air, heating up of flue gases (e.g. before fabric filter or SCR), use as steam for soot blowing, for injection purposes (e.g. NH4OH for SNCR), for steam driven turbo pumps, compressors, blowers, use for treatment of liquid residues from Air Pollution Control (APC), for heating of building, silos, pipes etc.

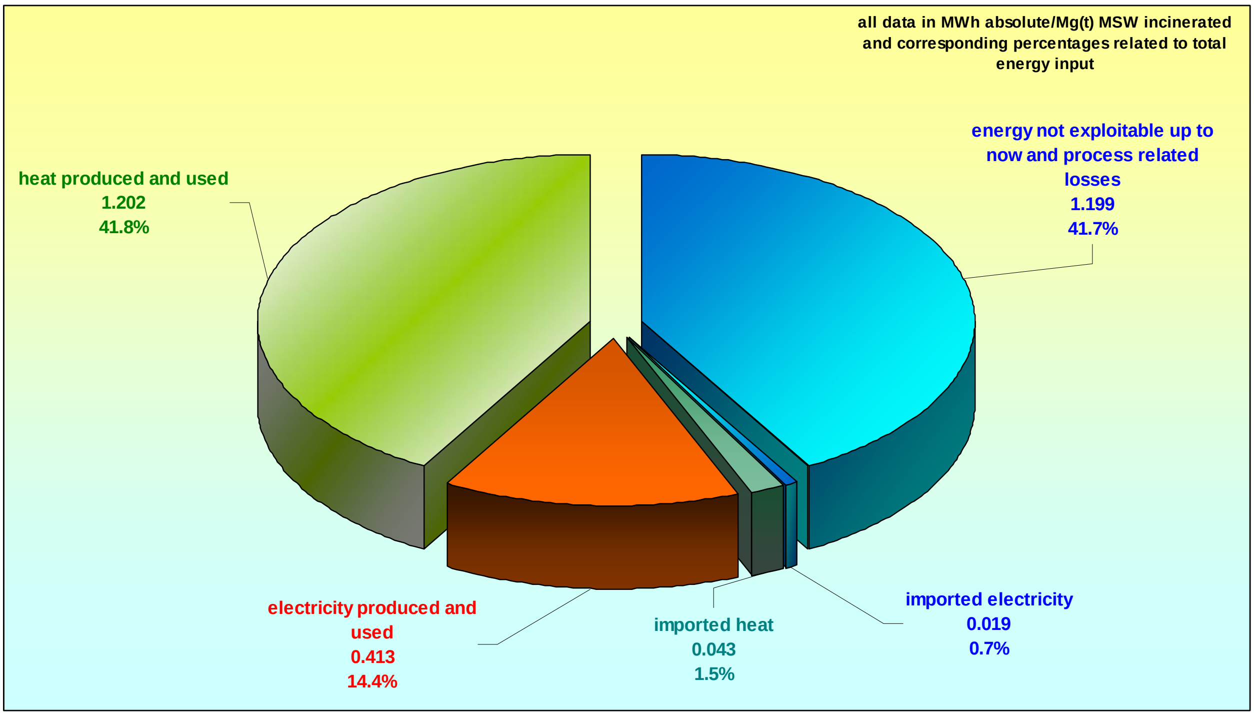
The heat used to treat the waste is most often not measured, but can be calculated from other operational data and on the basis of experience.



weighted averages of total energy input (Ew + Ef + Ei(th+el)) MWh abs.*/Mg MSW		produced electricity (Ep) MWh abs.*/Mg MSW	produced heat (Ep) MWh abs.*/Mg MSW
2.876	max:	1.018	3.560
2.814	weighted average:	0.413	1.202
0.062	min**:	0.000	0.145

abs.* = absolute (real figures without equivalence factors)
min** = 0,000 mean no production of electricity
Ei(th) = imported heat not steam producing
Ei(el) = imported electricity not steam producing

Figure 4: Specific produced and used electricity and heat as max. - weighted averages - min. values in absolute values Mg abs./Mg MSW and in percentages of total energy input for 231 investigated European WtE plants (status 2004-2007)



WtE plants	231 CEWEP plants	period of energy balance	2004-2007
total amount of waste incinerated	45,518,189 Mg(t)	total recovery efficiency in absolute in % of total energy input	56.2
NCV by BREF formula for the total waste	2.814 MWh/Mg	total recovery efficiency in equivalent in % of total energy input	83.4
Total energy input (including imported energy)	2.876 MWh abs/Mg	R1 recovery factor in accordance to the draft of WFD case 1) [-]	0.75
		heat produced (exported and self used) equ = 1,1	

Figure 5: Pie chart of the total energy input (waste + imported energy) in MWh abs. /Mg MSW its percentages % subdivided into the production and import of electricity and heat as well as losses and recovered but not used energy of the 231 investigated European CEWEP WtE plants (status 2004-2007)

Produced electricity is generally measured and includes the electricity used to treat the waste.

For better appreciation of the rate of produced energy, the total energy input consisting of energy from MSW plus imported energy is shown on the left section of Figure 4 and in the upper part of Table 2.

The energy results are also shown in percentages (%) of the total energy input.

Beside the basic data on energy input Figure 4 shows the specific produced and used energy as electricity and heat which are related to the corresponding throughput of a plant in MWh/Mg MSW. The more significant percentages, which are related to the energy input by waste in MWh /MWh input, have also been determined and are presented as weighted averages and min. and max. values in Figure 4 and 5 as well as in Table 2.

8.1 Energy produced and used (Ep) as heat and electricity of all investigated 231 WtE plants and classified according to the different categories: type (kind) of energy recovery, size (throughput) and European geographical region in the CEWEP Energy Report II (status 2004-2007)

The following Table 2 shows decisive differences in the energy produced and used (Ep) as heat and electricity depending on the kind of energy recovery, the size and the geographical location of the plant. All data are in absolute values (without equivalence factors).

Table 2: Specific production and import of electricity and heat for all 231 WtE plants classified according to the kind of energy recovery, the size (throughput) and the geographical location as weighted averages in MWh abs./Mg and percentages (%) of total energy input in the CEWEP Energy Report II (status 2004-2007)

Energy produced and used (Ep) and imported energy (Ef + Ei) as heat and electricity according to all and to different classifications	unit	all investi-gated WtE plants	kind of energy recovery of a plant (weighted averages)			size (throughput) of a plant (weighted averages)			geographical European region of a plant (weighted averages)		
			only electricity production	only heat production	CHP production	< 100,000 Mg/year	100,000 to 250,000 Mg/year	> 250,000 Mg/year	South-West Europe	Middle Europe	North Europe
number of plants included	n	231	75	41	115	92	77	62	59	141	31
total throughput of plants	million Mg/a	45.52	12.72	4.57	28.23	5.34	12.77	27.41	8.08	32.13	5.31
Total specific energy input (incl. import) as weighted averages	MWh abs. /Mg	2.876	2.664	3.056	2.922	2.845	2.810	2.886	2.670	2.805	3.483
Specific electricity produced (Ep) as weighted averages	MWh abs. /Mg	0.413	0.551	0.000	0.416	0.305	0.386	0.445	0.441	0.418	0.334
	% of total specific energy input	*14.4*	*20.7*	*0.0*	*14.2*	*10.7*	*13.7*	*15.4*	*16.5*	*14.9*	*9.6*
Specific heat produced and used (Ep) as weighted averages	MWh abs. /Mg	1.202	0.400	2.486	1.341	1.098	1.059	1.273	0.582	1.067	2.889
	% of total specific energy input	*41.8*	*15.0*	*81.3*	*45.9*	*38.6*	*37.7*	*44.1*	*21.8*	*38.0*	*82.9*
Specific energy imported (Ef+Ei) as weighted averages	MWh abs. /Mg	0.062	0.040	0.141	0.055	0.076	0.056	0.053	0.058	0.066	0.048
	% of total specific energy input	*2.2*	*1.5*	*4.6*	*1.9*	*2.7*	*2.0*	*1.8*	*2.2*	*2.4*	*1.4*

The evaluation of the results in Table 2, which are the basis for the determination of the R1 efficiency factor, can be summarized as follows:

The results for the total investigated 231 plants without classification with an electricity production of 14.4% and heat production of 41.8% are weighted averages and therefore can only be used for general information This is for example relevant for the determination of the total electricity and heat production by the investigated plants and/or to assess it for all existing and even all future plants in Europe. They can be used as basis for the comparison with the results of future energy reports to show possible changes of energy recovery rates.

The produced energy can be specified as weighted averages as follows, depending on the:

Type (kind) of energy recovery

As to be expected, WtE plants "only electricity" producing are getting the highest rate of electricity production (20.7%) but the lowest rate of heat recovery (15%) which is the heat used to treat the waste; WtE plants "only heat" producing are generating the highest rate of heat (as weighted average 81.3%) but no electricity and therefore must import the total electricity to treat the waste. The extremely high efficiency (81.3%) of WtE plants only heat producing is plausible and means that roughly all the produced steam of these plants is used because it corresponds to a typical boiler efficiency of a WtE plant. Furthermore these results are reached primarily by WtE plants in North Europe; WtE plants "CHP" producing are in between exporting electricity (14.2%) and heat (45.9%).

Size (throughput) of a plant

Small sized WtE plants <100,000 Mg/a achieve the lowest rate of electricity production (10.7%) and a rate of heat recovery of 38.6%; middle sized WtE plants 100,000 – 250,000 Mg/a have a higher rate of electricity production (13.7%) and a rate of heat recovery similar to small sized plants (37.7%); **Large sized WtE plants >250,000 Mg/a are achieving not only the highest rate of electricity production (15.4%) but also the highest rate of heat recovery (44.1%).**

Location of a plant in a European geographical region:

Plants in South-West Europe are achieving by far the lowest rate of heat recovery (21.8%) and because of that the highest rate of electricity production (16.5%); plants in Central (Middle) Europe are reaching a lower rate of electricity production (14.9%) but a better rate of heat recovery (38.0%); as already well known **plants in North Europe are getting a rate of electricity production (9.6%), which is similar to the rate of small sized plants but the best data for heat recovery which results in the highest rate of heat recovery (82.9%)** because of optimal climate conditions for high heat demand.

The imported energy is in all categories at a similar low level between 1.5-2.7% of the corresponding energy input except in the case of WtE plants "only heat" producing which import the electricity they need to treat the waste (4.6%)).

9. Total annual energy production and demand

The total annual energy production and demand of imported energy in absolute figures of the 231 investigated plants as shown in Table 3 is based on the specific weighted averages from Chapter 8.1, Table 2 and Chapter 7 of this report. The total amount of MSW incinerated in Europe as in Chapter 4 is taken into account.

Table 3: Annual energy production and demand by the European WtE plants (status 2006), based on the results (weighted averages) of this CEWEP Energy Report II (status 2004-2007)

kind of energy	investigated plants related to EU 27	investigated plants related to EU 27+CH	EU 27 (extrapolated)	EU 27+CH+NO (extrapolated)
	45.01 million Mg/year	45.52 million Mg/year	59.2 million Mg/year	63.69 million Mg/year
	MWh abs./year	MWh abs./year	MWh abs./year	MWh abs./year
heat produced	54,102,020	54,715,040	71,158,400	76,555,380
electricity produced	18,589,130	18,799,760	24,449,600	26,303,970
heat imported	1,935,430	1,957,360	2,545,600	2,738,670
electricity imported	855,190	864,880	1,124,800	1,210,110

The results of the 231 plants investigated in this report, extrapolated to the 420 European WtE plants (status 2004-2007) show that about 77 TWh/year are produced and used as heat.

Furthermore, about 26 TWh/year are produced as electricity.

The ratio between produced (used) heat to produced electricity is hereby 3 to 1.

10. R1 recovery efficiency factor according to WFD

The R1 efficiency factor is a non-dimensional figure, based on the 1st law of thermodynamics (energy input = energy output) combined with integrated political objectives (minimisation demand of primary fuels).

To avoid any ambiguity in the interpretation of the efficiencies in this report, only the formula indicated in the WFD to determine the R1 status (recovery operation) is used. The R1 recovery efficiency formula is always calculated with the equivalence factors given in Annex II of the WFD.

The energy data results from Chapter 8, Table 2 (excluded data for all investigated WtE plants).

In the WFD formula, the R1 threshold value for a WtE plant to be classified as a recovery operation is:

- **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

The WFD formula to calculate the ‘efficiency’ factor R1 is:

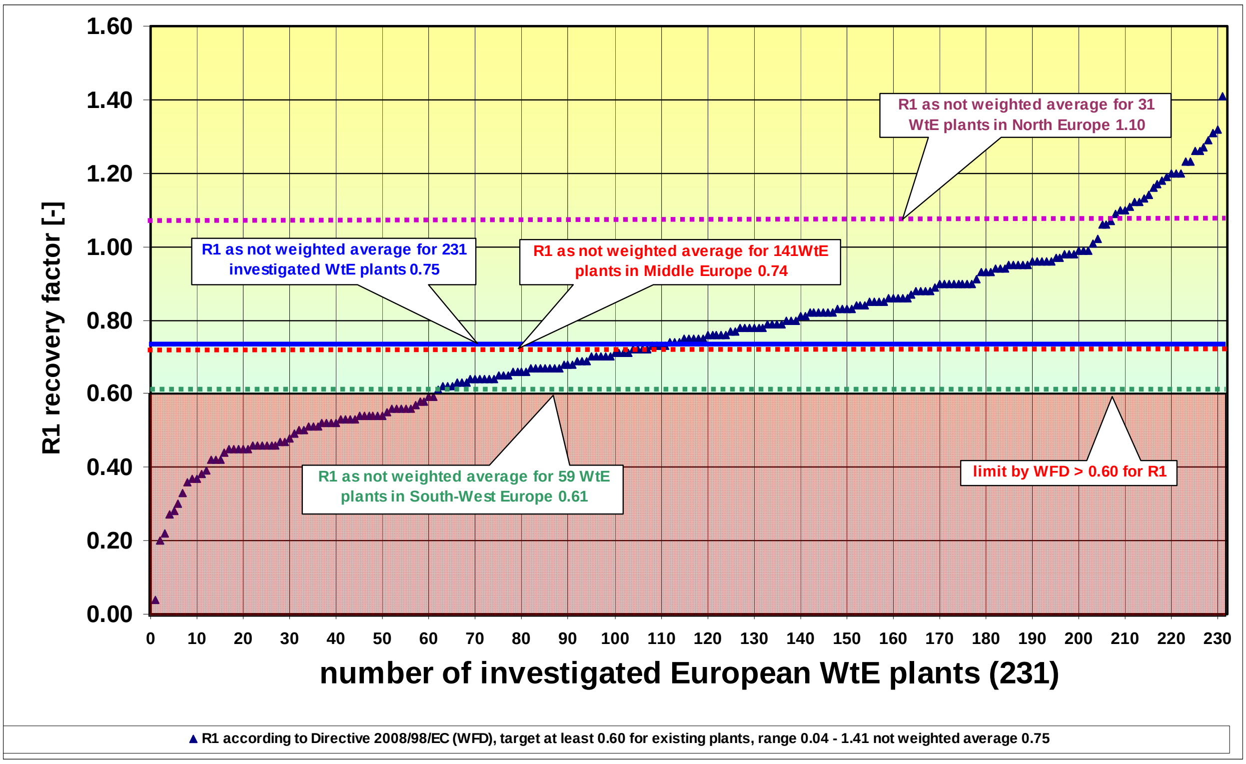
- **(Ep-(Ef+Ei))/(0,97*(Ew+Ef))**

where Ep is the produced energy (produced electricity and heat including electricity and heat used to treat the waste) with an equivalence factor of 2.6 for electricity and of 1.1 for heat produced for commercial use. According to BREF WI [3] the equivalence factors for Ef and Ei as primary fuels are 1.0, for Ei as district heat or hot water/steam 1.1 and as electricity 2.6.

If, as laid down in BREF WI, the heat used to treat the waste as part of Ep would have to be determined with an equivalence factor of 1.0 (and not with 1.1 as in this report) the following results of the R1 efficiency factors would decrease in the range of 0.00 – 0.03 as average 0.015 (1.9%).

The results in this report are quite well comparable to those in the CEWEP Energy Report I (status 2001-2004) [2], although the formula and the equivalence factors used in this first report were slightly different to the ones in the Directive 2008/98/EC (WFD) [1] (used in the present report) which at that time was not finalized. In the time period of this report (2004 to 2007) also the number of investigated plants has more than doubled and further locations of plants were added. By taking into account 86 French plants with many of them smaller sized than the average in North and Middle Europe and often equipped with simpler flue gas cleaning systems, the overall results have changed. The massive input of French plants has therefore influenced in some cases the results in this report.

10.1 R1 results of all plants as individual and non weighted averages



1) Calculation in accordance to the Directive 2008/98/EC (WFD) [2], ANNEX II, with equivalence factors for energy produced (export and self use) are for electricity 1M Whel = 2.6 M Whel equ and for heat 1M Whth = 11M Whth equ.

Figure 6: R1 efficiency factor calculated by using the BREF WI NCV-formula [1c] as individual NCV values and weighted average for 231 European WtE plants as well as weighted averages of 31 WtE plants from North Europe, 141 WtE plants from Central (Middle) Europe and 59 WtE plants from South-West Europe (status 2004-2007)

For the **total of 231 investigated European WtE plants without classification** (Figure 6) the R1 efficiency factor (calculated with the equivalence factors as mentioned above) is:
0.75[6] (0.04 min.-1.41 max.) as non weighted average and therefore ≥ 0.60.
169 plants (73.2%) out of the total 231 investigated European WtE plants are reaching ≥ 0.60.

10.2 R1 efficiency factor as averages for the 231 WtE plants and WtE plants classified into the categories type (kind) of energy recovery, sizes (throughput) and European geographical region in the CEWEP Energy Report II (status 2004-2007)

Table 4: R1 efficiency factors for all 231 WtE plants and plants classified according to the type (kind) of energy recovery, the size (throughput) and the geographical location as min., non weighted averages and max. values with the number of plants reaching/not reaching R1 = 0.60 in the CEWEP Energy Report (status 2004-2007)

R1 depending on different classifications	unit	all investi-gated WtE plants	kind of energy recovery of a plant			size (throughput) of a plant			geographical European region of a plant		
			only electricity production	only heat production	CHP production	< 100,000 Mg/year	100,000 to 250,000 Mg/year	> 250,000 Mg/year	South-West Europe	Middle Europe	North Europe
number of plants included	n	231	75	41	115	92	77	62	59	141	31
total throughput of plants	million Mg/a	45.52	12.72	4.57	28.23	5.34	12.77	27.41	8.08	32.13	5.31
R1 result (averages not weighted)	[-]	0.75	0.64	0.72	0.84	0.68	0.77	0.85	0.61	0.74	1.10
R1 result (min-max)	[-]	0.04-1.41	0.12-0.98	0.04-1.29	0.30-1.41	0.04-1.20	0.12-1.41	0.47-1.31	0.12-1.12	0.04-1.29	0.88-1.41
number of plants: R1 at least 0.60	n *(%)*	169 *(73.2)*	46 *(61.3)*	25 *(61.0)*	98 *(85.2)*	50 *(54.3)*	60 *(77.9)*	59 *(95.2)*	24 *(40.7)*	114 *(80.9)*	31 *(100)*
number of plants: R1 under 0.60	n *(%)*	62 *(26.8)*	29 *(38.7)*	16 *(39.0)*	17 *(14.8)*	42 *(45.7)*	17 *(22.1)*	3 *(4.8)*	35 *(59.3)*	27 *(19.1)*	0 *(0)*

The evaluation of the results in Table 4 for R1 shows, as could be expected, a tendency which is similar to the results of Table 2 but, due to the equivalence factors, the influence of produced electricity is increased.

The R1 results of the 3 investigated categories as non-weighted averages can be summarized as follows:

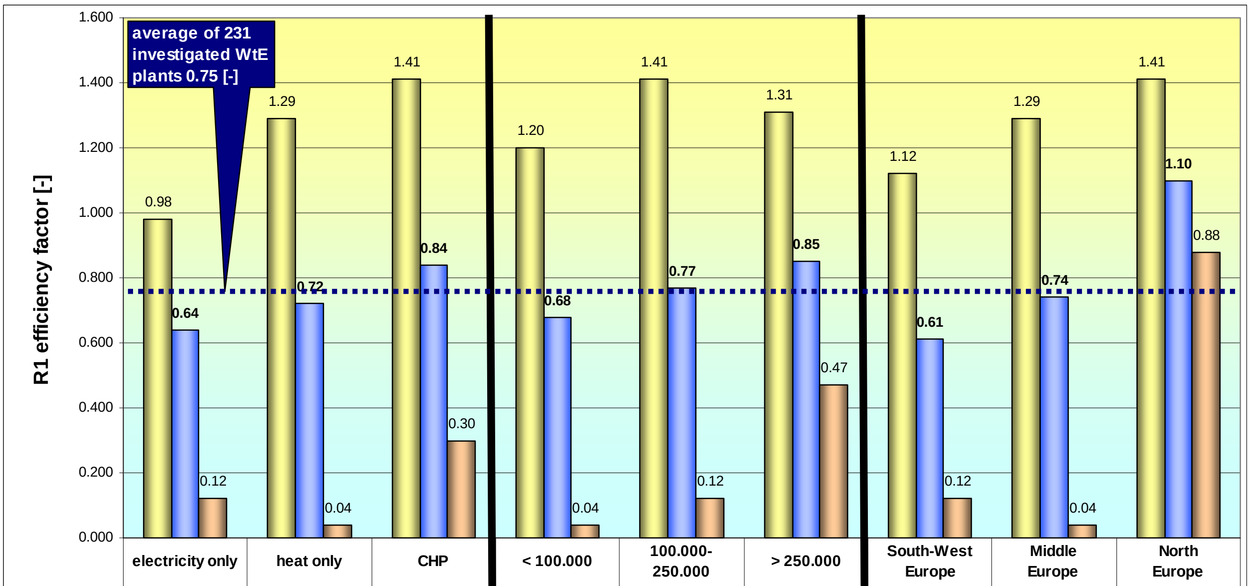
Type (kind) of energy recovery
WtE plants "only electricity" producing are achieving the lowest R1 factor of 0.64 as a non-weighted average so that only 46 plants (61.3%) out of 75 are reaching R1 ≥ 0.60.
Although **WtE plants "only heat" producing** are achieving a R1 factor of 0.72, only 25 plants (61.0%) out of 41 are reaching R1 ≥ 0.60. In this case, the import of the total electricity to treat the waste plays an important negative role.
WtE plants "CHP" producing get the highest R1 factor of 0.84 as a non-weighted average so that 98 plants (85.2%) out of 115 are reaching R1 ≥ 0.60.

Size (throughput) of the plant
As expected, **small sized WtE plants (< 100,000 Mg/a) are getting the lowest R1 factor** of 0.68 as a non-weighted average, so that only 50 plants (54.3%) out of 92 are reaching R1 ≥ 0.60.
Middle sized WtE plants (100,000 – 250,000 Mg/a) are better with the R1 factor of 0.77 as a non-weighted average, so that 60 (77.9%) out of 77 plants are reaching R1 ≥ 0.60.
Large sized WtE plants (> 250,000 Mg/a) are achieving the highest R1 factor of 0.85 as a non-weighted average so that 59 plants (95.2%) out of 62 are reaching R1 ≥ 0.60.

Plant location (in a European geographical region)
As expected, **plants in South-West Europe achieve the lowest R1 factor** of 0.61 as a non-weighted average, so that only 24 plants (40.7%) out of 59 are reaching R1 ≥ 0.60.
Plants in Central (Middle) Europe are getting a higher R1 factor of 0.74 as a non-weighted average, so that 114 plants (80.9%) out of 141 are reaching R1 ≥ 0.60.
Plants in North Europe have by far the highest R1 factor of 1.10 as non-weighted average, so that all of the 31 plants (100%) are reaching R1 ≥ 0.60.

[6] A calculation of R1 using the specific weighted averages for heat and electricity produced from Table 3 for all investigated plants would result in a far higher R1 efficiency factor (in a range, similar to the R1 result of CHP producing plants), because these weighted averages are single results and do not correlate to each other.

Diagram 5: R1 energy efficiency factors[1)] calculated according to the Directive 2008/98/EC (WFD) of 231 investigated WtE plants divided into different categories according to the type (kind) of energy recovery, the size (throughput) and the geographical location as min., max. values and non weighted averages in the CEWEP Energy Report II (status 2004-2007)



	electricity only	heat only	CHP	< 100.000	100.000-250.000	> 250.000	South-West Europe	Middle Europe	North Europe
max	0.98	1.29	1.41	1.20	1.41	1.31	1.12	1.29	1.41
average	0.64	0.72	0.84	0.68	0.77	0.85	0.61	0.74	1.10
min	0.12	0.04	0.30	0.04	0.12	0.47	0.12	0.04	0.88

[1)] R1calculation in accordance to the Directive 2008/98/EC (WFD), Annex II, with equivalence factors: for electricity produced and imported 1MWh el = 2.6 MWhel equ; for heat produced and commercially used 1MWh th = 11MWhthe equ and according to BREF WI for imported fuel 1MWh fuel = 10 MW fuel equ. The heat used by the plant to treat the waste includes all uses of steam, particularly steam to the deaerator and to the air heater.

It is evident as shown in Figure 6 and Diagram 5 that for small sized plants, only producing electricity and located in South-West Europe with R1 averages between 0.61-0.68 it is very difficult to reach R1=0.60.

Middle sized plants in Central (Middle) Europe producing heat respectively CHP have a better basis to reach R1=0.60 with R1 averages between 0.72-0.77(0.84).

Highest R1 factors >> 0.60 are reachable in large sized plants in North Europe which are CHP producing with R1 averages between 0.84-1.10.

In conclusion, the results of the investigation clearly show strong correlations between the values of R1 and the type of energy recovery, the size of the plant and the geographical location respectively. These results corroborate the statements of the BREF WI[7, 8, 9]

11. Optimisation possibilities to increase the energy utilisation and efficiency

The first condition for optimisation is to have reliable measurements, in particular on steam flow and other flows and to get a good appraisal of the uncertainty of the data.

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[7] Regarding the type of energy recovered, the BREF WI says for instance, p. 286, last par.: "In terms of optimising the energy recovery, reducing the technical risk and reducing costs, heat supply is favourable where this is possible. However this still depends on the local conditions, and significantly on the respective sale prices of electricity and heat. If a (substantial) part of the heat cannot be used, then CHP might well be the right solution. If no heat can be sold, then good practice is generally to use the available energy to create electricity."

[8] Concerning size, the BREF WI states for instance, p. 286, 2nd par.: "Higher relative treatment costs at smaller plants and the lack of economy of scale tend to lead to a lower availability of capital for investment in the most sophisticated energy recovery techniques. This, in turn, means that lower efficiencies can be expected at smaller installations e.g. municipal waste incinerators below 100 K tonnes/yr throughput." See also table 4.17, p. 293 of the BREF WI

[9] On location, the BREF WI says for instance, p. 281, 2nd bullet from the end: "Plants that export steam as a base load can achieve higher annual supply and hence export more of the recovered heat than those with variable output options, who will need to cool away some heat during low demand periods."

11.1 Optimisation concerning type (kind) of energy recovery

For existing and new plants the following 4 issues have been identified as having influence on the energy production and its utilisation, while necessary or additional investment or operation costs must be taken into account, whereas the optimization of existing installations, when possible, usually requires extremely high expenditure.

- Increase in heat utilisation as steam, district heat or district cool (medium to very high investment); by far the most effective mean but not possible everywhere since it depends e.g. essentially on the presence of customers for heat, and the length of the heat (cooling) demand period (climate zone) and the local energy market conditions (prices).
- Increase in electricity production (medium to high investment; possible increase in maintenance costs); not possible for every plant (e.g. often no optimal equipment available for small plants/units).
- Optimisation of thermal process (low to medium investment); low to medium effect.
- Optimisation of the plant consumption in recovered and primary energy (low to medium investment); low to medium effect as many existing plants have already been refurbished when they had to comply with the Waste Incineration Directive.

Already from the outset of new installations or rebuilding, the energy demand for maximum operational efficiency and high efficient flue gas cleaning systems with low energy demand should be taken into account. In this case later optimisation measures and extra costs can be minimised.

It is recommended that the authorities involved in decision making on the location of new WtE plants take a proactive approach in searching for sites which have the possibility to supply a large proportion of the energy from WtE in the form of heat, i.e. either in the form of steam to adjacent industry or in the form of heat for district heating & cooling networks.
The type of the energy recovery of an existing and new or rebuilt plant as important parameter for R1 may sometimes be influenced by the operator of a plant.

11.2 Optimisation concerning size of a plant

An optimisation of the size of a plant is in general only an option for new installations or rebuilding, because this depends e.g. on the density and concentration of the population in a region, distances and type of transport, amount and quality (type and NCV) of waste which may or will be delivered to the plant, the capacity of nearby located existing plants with their available (free) capacities, market prices for waste to be treated and for recovered energies, the acceptance by the people, the permit of the local authorities etc..

The size of an existing plant, an important parameter for R1, cannot be influenced by the operator of a plant. This is only an option for the planning of new installations or rebuilding of plants. It is usually more difficult for small size plants to reach R1 ≥ 0.60 than for medium and large sized plants.

11.3 Optimisation concerning the location of a plant in a European geographical region

The location of a plant in a European geographical region (climate zone), the most important parameter for R1, can neither be influenced by the operator of a plant nor by the designer of new installations or rebuilding of plants.

Therefore WtE plants in South-West Europe are at an extremely high disadvantage in comparison to WtE plants in North Europe and even, but less, to WtE plants in Central (Middle) Europe to reach R1 ≥ 0.60.

Final remarks

I would like to thank all members of the CEWEP Energy Working Group for their constructive assistance, and primarily the national WtE associations and all individual operators of WtE plants for the delivered data. Only with this information was it possible for the CEWEP Energy Report II (status 2004 -2007) to be realised.

References

[1] Directive 2008/98/EC of the European Parliament and of the Council "on waste and repealing certain Directives" Annex II, 19 November (2008)

[2] Confederation of European Waste to Energy Plants (CEWEP) „CEWEP Energy Report (Status 2001-2004)" see http://www.cewep.eu/studies/climate-protection/art230,223.html, by D. O. Reimann, Bamberg, Germany, October 2005/ updated July (2006)

[3] BREF/BAT Waste Incineration (WI) for Integrated Pollution Prevention and Control (IPPC), "Reference Document on the Best Available Techniques for Waste Incineration", EUROPEAN COMMISSION, EIPPC Bureau Sevilla, August (2006), http://eippcb.jrc.es/pages/FActivities.htm

[3a] BREF - formula for NCV: Chapter 2, article 2.4.2, pg. 83-84

Appendix A

CEWEP updated energy checklist

Appendix A contains the energy checklist as basis for the calculation of the energy demand of a WtE plant.

Checklist for determination of NCV, CO_2 emissions and R1-efficiency factors of the W-t-E plants associated with CEWEP by overall approaches

Name of the plant:		linie(n): 1 to ...

General information

Name of the plant	
Name of company	
Address	
Contact person	
Telephone	
Fax	
E-mail	

Please take note of the following remark:
It is sufficient, if only the relevant datalines of the plant will be answered with "yes" by deleting "no". All for the plant not relevant datalines should be left with "yes/no" or "yes" should be deleted.

Specific information	comments	answers		
Are the following information applicable for the whole plant		yes	no	
if no: is it only applicable for one or more lines with < 30% of the total steam production	if not, please fill out additional checklists for all different systems (lines)		yes	no
if no: is it only applicable for one or more lines with > 30% - 60% of the total steam production			yes	no
if no: is it only applicable for one or more lines with > 60% of the total steam production			yes	no
Co-incineration of wet sewage sludge(< 30% DS)		yes	no	
Co-incineration of dry sewage sludge(> 30% in general >70% DS)		yes	no	
Demand of primary (imported) fuels for start up/shut down operations		yes	no	
Demand of primary (imported) fuels primarily used for keeping combustion temperature > 850°C		yes	no	
Demand of primary (imported) fuels primarily used for heating up flue gases (e.g. before SCR cat)		yes	no	
Wet scrubber for flue gas cleaning (wastewater free)		yes	no	
Wet scrubber for flue gas cleaning (with wastewater effluent)		yes	no	
Dry flue gas cleaning system		yes	no	
Sem-dry (sem-wet) flue gas cleaning system		yes	no	
ESP for dedusting		yes	no	
Fabric filter for dedusting		yes	no	
Water cooled grade with energy recovery (e.g. heating up primary air or boiler feed water)		yes	no	
SCR wth internal heating up of flue gases by gas/gas heat exchanger		yes	no	1) 2)
SCR cat at an operation temperature >300°C			yes	no
SCR cat at an operation temperature 220°C-300°C			yes	no
SCR cat at an operation temperature < 220°C			yes	no

1) or 2): Only if an answer is "yes" than please **delete** always in the corresponding, green highlighted cell behind the **not relevant figure** either 1) or 2); whereas 1) is relevant for steam or hot water extracted **before the steam measuring device after boiler** and 2) is relevant for steam or hot water extracted after the steam measuring device after boiler (e.g. before heat exchanger, before or out of the turbine)

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Continued on page 2

Name of the plant:		linie(n): 1 to …			
Please take note of the following remark: It is sufficient, if only the relevant datalines of the plant will be answered with "yes" by deleting "no". All for the plant not relevant datalines should be left with "yes/no" or "yes" should be deleted.					
Specific information	comments	answers			
SNCR NH4OH injection in combination with high pressure (HP)-steam		yes	no	1) 2)	
SNCR NH4OH injection in combination with medium(MP)-or low pressure(LP)-steam		yes	no	1) 2)	
SNCR NH4OH injection in combination with water		yes	no		
Heating up of primary air with steam or hot water		yes	no	1) 2)	
Primary air: part of the total combustion air: > 50%			yes	no	
Primary air: part of the total combustion air: < 50%			yes	no	
Heating up of secondary or tertiary air with steam or hot water		yes	no	1) 2)	
Use of recirculation gas		yes	no		
Sootblowing with high pressure (HP)-steam		yes	no	1) 2)	
Sootblowing with medium(MP)pressure steam		yes	no	1) 2)	
Water addition before or into the boiler e.g. for cleaning or cooling purpose		yes	no		
Turbo pump, turbo blower or turbo compressor driven with steam		yes	no	1) 2)	
Treatment of residues with steam or hot water e.g. evaporation of scrubber water, recovery of Cl		yes	no	1) 2)	
Extraction of steam or hot water out of the boiler without a measuring device		yes	no		
Heating for buildings of the plant with steam or hot water		yes	no	1) 2)	
Steam for heating up boiler water		yes	no	1) 2)	
Use of heat to heat up e.g. boiler water or combustion air out of the flue gas by temperature reduction		yes	no		
Use of heat by temperature reduction and condensation of steam out of the flue gas to heat up e.g. boiler water or combustion air		yes	no		
Others, not listed up before, as continues important steam or hot water demand		yes	no	1) 2)	
1) or 2): Only if an answer is "yes" than please **delete** always in the corresponding, green highlighted cell behind the **not relevant figure** either 1) or 2); whereas 1) is relevant for steam or hot water extracted **before the steam measuring device after boiler** and 2) is relevant for steam or hot water extracted after the steam measuring device after boiler (e.g. before heat exchanger, before or out of the turbine)				Reimann status 2009	

Appendix B

CEWEP energy questionnaire

Appendix B the energy questionnaire as basis for the calculation of the NCV, and R1 formula of a WtE plant.

Annual CEWEP Questionnaire on Energy related Data

General

Basic data

Country:	
Plant:	
Website:	

Responsible contact person

Name:			
Street:		Number:	
Postal Code:		City:	
Telephone:		Fax:	
E-Mail:			

Input of waste and primary fuels

Reference year:		year
Number of lines:		number

Waste

Total amount of waste incinerated:		[Mg/a]
included in the total amount mixed municipal waste:		[Mg/a]
included in the total amount industrial, trade and other wastes:		[Mg/a]
included in the total amount sewage sludge:		[Mg/a]

Imported primary fuels and electricity

light or heavy oil in m^3:	as delivered		m^3/a
or light or heavy oil in Mg:			[Mg/a]
natural gas in Nm^3:	as delivered		1000 Nm^3/a
or natural gas in MWh:			MWh/a
other primary fuels:			MWh/a
electricity:			MWh/a

Energy generation and use

Total amount of generated steam or hot water

Amount (mass) of produced steam or hot water through the boiler:		[Mg/a]
Temperature of the incoming bioler water for steam/hot water generation:		[°C]
Pressure of the produced steam:		[bar]
Temperature of the produced steam or hot water :		[°C]
Average temperature of flue gas after boiler (or fluegas condensation):		[°C]

Heat / steam utilization

Amount of exported heat as district heat or steam:		[MWh/a]
Amount of exported heat as steam (if not included in H/53):		[GJ/a]

Electricity generation and installed electric performance

Installed generator performance in total:		[MW]
Amount of produced electricity:		[MWh/a]
Amount of exported electricity:		[MWh/a]

CO_2 emission

Continuous measuring of CO2 (also non-gauged results):		Yes
		No
If yes, please state concentration:		[Vol.-%]