Proposal for a
European Guidance for the use of the R1 energy efficiency formula for incineration facilities dedicated to the processing of Municipal Solid Waste according to
(Waste Framework Directive 2008//98/EC, Annex II, R1-formula)

(Version 29.07.2010)

This guidance serves the purpose to make the calculation of the R1 factor transparent and to ensure a harmonized application of the R1-formula. It constitutes a technical document.

1. Introduction

The energy efficiency formula, for simplicity referred to as the R1-formula, determines whether or not a Municipal Solid Waste Incinerator (MSWI) is a recovery operation in respect of R1.

In this context it is important to note, that "recovery" means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy (Art 3 (15) of Directive 2008/98/EC hereinafter referred to as (WFD).

The non-exhaustive list presented in Annex II of the WFD defines R1 as recovery operations "*Use principally as a fuel or other means to generate energy*". This includes incineration facilities dedicated to the processing of Municipal Solid Waste (MSW) 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:

$$\text{Energy efficiency} = \frac{E_p - (E_f + E_i)}{0.97 * (E_w + E_f)}$$

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 fuel contributing to the production of steam (GJ/year)*
Ew *means annual energy contained in the treated waste calculated using the 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*

In addition, Annex II of the WFD highlights that this formula shall be applied in accordance with the Reference Document on Best Available Techniques for Waste Incineration (BREF WI).

These new provisions were introduced by the new Waste Framework Directive in order to promote the use of waste to generate energy in waste incinerators with high energy efficiency and encourage innovation in waste incineration. The practical impact will have to be monitored in future and the R1 formula will have to be revised, if necessary to keep it up-dated with the technological progress.

For historical development of the formula and association to the Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration, from August 2006 (BREF WI) see Annex 1.

The following abbreviations for pertinent legislation are used in this document:

Legislation/Guidance	Abbreviation
Directive 2008/98/EC	WFD
Directive on the incineration of waste 2000/76/EC	WID
Directive concerning integrated pollution prevention and control 2008/1/EC	***IPPC Directive***
Regulation (EC) No 1013/2006	WSR
Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration, from August 2006.	BREF WI

For reasons of better readability the document specifies major topics in specific thematic areas in shaded boxes and summarises the major elements of guidance in boxes at the end of each chapter.

2. The Scope of the Energy Efficiency Formula

The scope of the formula comprises aspects such as the types of facility and of waste eligible for the application of the R1 status and to be considered in the calculation of the energy efficiency.

- *Facilities dedicated to the incineration of municipal waste (MSWI)*

Annex II of the WFD clearly restricts the scope of the formula to "Incineration facilities dedicated to the processing of Municipal Solid Waste (MSW)". Hence installations shall correspond to IPPC category 5.2. "Installations for the incineration of municipal waste (household waste and similar commercial, industrial and institutional wastes)". Plants dedicated to co-incineration or incineration plants dedicated to hazardous waste, hospital waste, sewage sludge or industrial waste are thus excluded from the scope of the formula.

The decisive parameter for the potential inclusion of a incineration plant in the scope of the formula shall be the classification of the plant in the permit. This permit as a minimum has to be in line with the **Directive on the incineration of waste 2000/76/EC (WID)** and if falling under the scope of the Directive **concerning integrated pollution prevention and control 2008/1/EC (IPPC)** take into account the provisions of the BREF document on Waste Incineration. As a mandatory prerequisite the facility shall have the technical design and capability to incinerate mixed municipal solid waste.

In case an incineration plant has two separate lines (one for hazardous waste and one for MSW) only the line for MSW can apply for the R1 status.

Waste incinerators dedicated to the incineration of municipal waste are waste incinerators which have the permit and are technically designed for the incineration of mixed municipal waste.

- *Waste acceptable in a MSWI plant*

Waste incinerators dedicated to the incineration of municipal waste are waste incinerators which have the permit and are technically designed for the incineration of mixed municipal waste, as classified in WID article 3(3)[1]. The WID however, does not explicitly exclude other waste streams, even not hazardous waste. It only stipulates in its article 4(4) that the permit granted by the competent authority for an incineration plant shall, lists explicitly the categories of waste which may be treated, according at least the categories of waste set up in the European Waste Catalogue (EWC), if possible and that it has to be compliant with water and air protection, IPPC and landfill legislation.

[1] "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, but excluding fractions indicated in the Annex to Decision 94/3/EC (4) under heading 20 01 that are collected separately at source and excluding the other wastes indicated under heading 20 02 (garden and park wastes (including cemetery waste) of that Annex. "Mixed municipal waste" in the meaning of the WID would thus include heading 20 03 02 (waste from markets), 20 03 03 (street-cleaning residues), 20 03 04 (septic tank sludge), 20 03 06 (waste from sewage cleaning), 20 03 07 (bulky waste) and 20 03 99 (municipal wastes not otherwise specified).

As the plant permit according to **Directive on the incineration of waste 2000/76/EC (WID)** and, if applicable, to the **Directive concerning integrated pollution prevention and control 2008/1/EC (IPPC)** including the BREF document on Waste Incineration is the decisive parameter for the scope of the formula, wastes covered by the permits shall be acceptable. For the application of the R1 classification it therefore is not relevant, whether or not the permit of a facility classified as MSWI allows accepting also other wastes, including hazardous waste.

The decisive criterion for the ability to apply for R1 status being the plant permit and the technical ability of the installation to incinerate mixed MSW (see chapter above), the competent authorities shall take into consideration this principle when specifying the list of acceptable wastes. In addition authorisation of any waste input except of mixed municipal solid waste (EWC 200301) shall be in line with the waste hierarchy principle[2] (according to Art.4 of WFD).

In practice the waste input into a MWI is made of different mixed and heterogeneous fractions, which are blended before feeding the hopper in order to optimize the combustion process. The share between mixed municipal waste and other waste which is actually incinerated in the facility is not relevant for the applicability of the R1 formula. The calculation of the R1 formula is done of the waste in the composition which is actually incinerated in a facility, not only on the part of the waste which is classified as municipal waste or mixed municipal waste.

All waste which is treated by a waste incinerator meeting the R1 threshold is to be regarded as waste which is submitted to a recovery operation regardless the calorific value of the waste, the amount of harmful substances contained or whether the waste has been mixed.[3]

As the WI Directive is the most relevant legislation for MSWI, it shall be made clear that "dedicated to the processing of Municipal Solid Waste (MSW)" puts the major focus on mixed household waste and similar waste, as defined in the Waste Incineration Directive (Art 3(3).

Other wastes may be acceptable if the waste fulfils certain criteria (comparable with municipal/commercial waste) and as long as specified in the permit of the MSWI.

The calculation of the R1 efficiency is based on the actual waste mix incinerated. As the goal is to recover the energy available in a given waste as efficiently as possible and not to receive waste with the highest possible NCV, an exclusion of single waste streams based on the NCV of waste would not *be relevant.*

- *The impact of the new waste hierarchy on waste treatment in R1 facilities*

The fact that a waste treated in an R1-facility is to be regarded as recovered has to be distinguished from the question whether the recovery of a certain waste in such a facility is to be seen as the waste

[2] Including and in the meaning of Recitals (7), (28), (29)

[3] The Court of Justice of the European Union decided in its ruling on the recovery of waste as fuels in cement kilns (ECJ C-228/00, para 47) that the treatment of waste meeting the requirements of the recovery of waste must be classified as a recovery operation, without the need to take into consideration criteria such as the calorific value of the waste, the amount of harmful substances contained in the incinerated waste or whether or not the waste has been mixed.

management option with the best environmental outcome considering the waste hierarchy and taking into account life-cycle thinking (Art 4 WFD).

Certain waste streams like paper, glass, plastic, metal recycling can be used with higher resource efficiency when they are separately collected from other municipal wastes and recycled. To a certain extent this applies to separately collected bio-waste which is submitted to biological treatment as well (http://ec.europa.eu/environment/waste/compost/pdf/com_biowaste.pdf).

According to Article 4(2) WFD Member States should encourage those waste management options that deliver the best overall environmental outcome. For waste streams where recycling is the preferable option this should include appropriate measures, such as the introduction of separate collection schemes and other measures supporting recycling, implementing recycling targets and avoiding overcapacities for waste incinerators in waste management plans. National legislation on recycling of certain waste streams might be another option.

Hazardous waste is usually treated in the most appropriate way in incinerators specifically dedicated to the treatment of hazardous waste. The R1 formula does not apply to those incinerators since the thresholds have been developed on the basis of the energy efficiency performance of municipal waste incinerators. Hazardous waste incinerators usually produce less energy because they use more energy to destroy harmful substances in waste in a thermal treatment with higher temperatures. Therefore the treatment of certain hazardous wastes ensures a higher efficiency in the elimination of the hazardous properties.

Even if a hazardous waste incinerator might not be classified as a recovery operation the disposal of hazardous waste in such an installation might have a better environmental outcome than the treatment in a municipal waste incinerator with a permit to accept certain hazardous waste and a deviation from the waste hierarchy for the treatment of hazardous waste would be justified in these cases.

The waste hierarchy principle[4] *(according to Art.4 of WFD) has to be complied with.* This applies namely for *waste streams like paper, glass, plastic, metal and separately collected bio-waste for which recycling should be considered as preferred option.*

According to Article 4(2) WFD Member States should encourage those waste management options that deliver the best overall environmental outcome taking into account life-cycle thinking. This shall apply namely for hazardous waste where disposal in dedicated incinerators for hazardous waste, might be considered preferable to recovery in MSWI.

3. System Boundaries for application of the R1-formula

The definition of system boundaries has considerable implications for the calculation of the energy efficiency, because it affects the energy streams to be calculated as Ei, Ef and Ew, thus influencing the R1 factor.

[4] Including and in the meaning of Recitals (7), (28), (29)

Directive 2008/98/EC does not contain a definition of the compounds of an “incineration facility”. Hence definitions in other relevant laws and guidance shall apply. In this context it is important to differentiate between “waste incineration installation” according the IPPC Directive 2008/1/EC and “incineration facility” according to the Waste Incineration Directive 2000/76/EC (WID).

The boundaries of a **“waste incineration installation” according the IPPC Directive 2008/1/EC** are defined by the limits of the operator’s permit. “Installation“ according to Art. 2(3) of the consolidated IPPC Directive (2008/1/EC) means a stationary technical unit where one or more activities listed in Annex I of this directive are carried out, and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution. Depending on local conditions, the “waste incineration installation” (IPPC) may simply include an “incineration facility” (WID) and its offices or other additional processes/activities, such as: - ash processing, recovery of metals from ash, on site manufacture of products from those recovered materials, - other waste treatment processes, such as a sorting facility, an aerobic and/or anaerobic digestion facility, a station for waste collection vehicles maintenance, etc. - other activities such as sewage sludge treatment, … - a classic boiler (fired with classical fuels), a complex process such as a combined cycle with gas turbine, an industrial complex.

The **“incineration facility” according to the WID** includes in general the waste feed to the oven(s), the waste incineration oven(s), the boiler(s), and the incineration flue gas cleaning system and, often, energy transformation and recovery equipments such as heat exchangers feeding a District Heating (DH) or cooling network and/or a Turbine Generator (TG) set.

The system boundaries for the calculation of the R1 factor are incineration oven(s), the boiler(s), and the incineration flue gas cleaning system and, often, energy transformation and recovery equipments such as heat exchangers feeding a District Heating (DH) or cooling network and/or a Turbine Generator (TG), see Annex 2.

Note: In order to assure correct calculation of the R1-formula, measurement points have to be established at the system boundaries. A basic illustration of system boundaries and energy flows is provided in Annex 1 to this document.

- *Flue gas treatment and turbine*

In line with the description in the related BREF Document (Annex 10.4.1, figure 10.14), the R1 system boundaries shall comprise only the essential parts of the incineration and energy recovery process. This includes the combustion chamber and boiler, flue gas treatment, energy transformation and recovery equipments such as heat exchangers and turbine generator set as well as all electrical systems (e.g. pumps, motors, fans, compressors, trace heating, control systems etc.) and heat consuming systems needed for their proper functioning.

Note: The inclusion of the flue gas cleaning system gives the incentive to use also lower temperature heat, which otherwise would be wasted.

The inclusion of the turbine into the R1 system boundaries is underpinned by the WID requesting combined heat and power recovery from waste to the extent possible. (For more details see BREF Document).

- *Pre-treatment, post-treatment, conventional boiler and combined processes*

Pre-treatment **shall not be included** in the R1 system boundary. This is justified by the fact, that pre-treatment is typically not included in the permit of the installation and is not an essential part of the incineration process; it is not included in the plant efficiency (Pl_{ef}) calculation formula BREF document and apart from mixing the waste and crushing or shredding the bulky ones, in general is not essential for the incineration process in MSWI. Furthermore it is listed as separate recovery operation (R12) in Annex II to the WFD. R 12 can include preliminary waste treatment operations prior to recovery including pre-processing such as, dismantling, sorting, crushing, compacting, pelletizing, drying, shredding, conditioning, repackaging, separating, blending or mixing.

A similar approach applies to bottom ash (post-)treatment, which also is not considered in the WI BREF Document and classified in Annex II to the WFD as R4/R5 operation.

Classic boilers or combined processes (e.g. if the incinerator is coupled with a gas turbine) using conventional fuels included in the installation, if any, as well are not to be included in the R1 system boundaries, even if they are connected to the incineration facility.

- *Processes outside the scope of the incineration facility permit*

It is important to note that the "R1-formula system" cannot be extended outside the "incineration facility" nor the "installation" as defined by the permit, and that installations outside the responsibility of the operator are to be excluded from R1 system boundaries in particular because the operator has no authority there.

The stationary technical unit used in the definition of the "incineration plant" (according to article 3(4) Reg. EC (No) 2000/76) dedicated to the thermal treatment of wastes with recovery of the combustion heat generated, as specified in the corresponding WID permit, shall be the decisive factor as regards inclusion or exclusion of scope of a turbine for generation of electricity and their consideration in the calculation of the R1 efficiency.

Therefore Turbine Generator sets outside the boundary limits of the permit are excluded of the 'R1-formula system' as well as classic boilers or combined processes (e.g. if the incinerator is coupled with a gas turbine) using conventional fuels even if included on the same site.

Existing plant permits may not be changed to include/exclude electricity production in order to reach R1 classification without corresponding plant modification.

4. The Energy Flows/Single Factors of the Energy Efficiency Formula

Ew, Ef, Ei and Eexp have always to be defined as energy flow at the system boundaries. In this context Ew, Ef and Ei constitute the input to the system, whereas the output from the system to third parties and/or the grid is Eexp.

Ep as another important factor of the R1 formula is not related to system boundaries but is clearly defined by means of the formula itself.

It is important to emphasise that the R1 formula does not cover all energy flows that have to be counted for a full energy balance for the system and that the R1 formula is not calculating the boiler efficiency but is considering the part recovered and utilized from the energy generated at the boiler.

A compilation of examples of energy flows allocated to the different parameter is provided in Annex 3a.

- *Equivalence factors*

Equivalence factors as specified in the calculation formula apply to electricity and heat not regarding whether produced, imported, self-consumed or taken back into the system as return flow or backflow. No equivalence factor applies for fuels (fuel-oil, gas …), i.e. the factor is 1.

Electricity is to be multiplied with the equivalence factor of 2.6. The equivalence factor for heat (steam or hot water) is 1.1.

The equivalence factors for electricity and heat generation are directly taken over from the BREF WI can be explained as follows:

the factor 2.6 for electricity is based on an average European coefficient of coal plants with 38%, which means an energy demand of 2,6 kWh for the production of one kWh of electricity.

The factor 1.1 for generated heat is based on an average European coefficient of heat plants of 91%.

The factors of 1.1 and 2.6 are to be applied independently whether the energy is used outside or inside the R1 system boundary.

Ep

Annex II of the WFD defines Ep as "annual energy produced as heat or electricity". It is calculated with energy in the form of electricity [...] and heat produced for commercial use [...].

"Produced" in this context is to be interpreted as "produced and utilized" in the meaning of "the part of the generated energy [that] is recovered and used (see ECJ ruling C-228/00), the part of the [energy] produced by the combustion [that] is reclaimed (see ECJ ruling C-458/00) or "recovery of energy from waste" as stipulated in chapter 3.5.4 p. 194 ff of the WI BREF Document or BREF document (page 597). This is not restricted to the exported energy as in the "plant efficiency potential" or "Output from the incineration facility" (Pl_{ef})[5] described in chapter 3.5.6 of the BREF, titled "data comparing energy required by, and output from, the installation".

In the BREF document (page 597) is the formula given for the total specific electricity produced in correlation to the quantity of waste incinerated; *Ne sp prod = (Oe exp + Ee circ*[6]*)/ m.*

This means that per quantity of waste the produced electricity is the sum of the total exported electricity and the circulated electricity divided by the quantity of waste. When this formula is applied for the total waste incinerated it transforms to: *Oe sp prod = Oe exp + Ee circ.*

The same sort of formula is in the BREF document given for produced heat. By combining the electricity produced and heat produced the total energy produced can be calculated. This can be written as: *Oprod = Oexp + Ecirc* or Ep = exported + circulated energy.

This interpretation is confirmed by the Commission non-paper on the energy efficiency draft, issued during the negotiations of the WFD in European Parliament and Council, stating that "some operators suggest changing the meaning of Ep from gross amount of energy from the turbine/generator (the actual meaning in COM(2005)667) to the amount of energy actually exported to the grid".

Ep thus includes the energy (heat and electricity) recovered from the waste which is exported outside the R1 system boundary to third parties or to other uses within the installation. as well as the energy which is used inside the R1 system boundary, including emission reduction measures by means of flue gas treatment and other essentially related purposes(See annexes 1 and 2))

Note: To be counted as Ep a commercial use needs to be given for heat. Exported heat shall only be counted in Ep if the operator can prove commercial use by means of valid contracts with third parties. Internal heat consumption (within the permit boundaries) shall also be regarded as commercial use, as it directly replaces primary energy which otherwise .would have to be purchased (opportunity cost principle) All internal uses have to be documented in the calculation form as prove of utilisation.

In order to avoid double counting:

- The heat used in the incineration facility to generate electricity being counted as produced electricity cannot be counted as produced heat.

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$$Pl\ ef = \left(\frac{Oexp - (Ef + Eimp)}{(Ef + Eimp + Ecirc)}\right)$$

6 Ecirc is circulated energy, energy that is produced and then circulated so that it is used in the installation.

- The electricity generated by a third party using the steam from the Incineration facility is not to be counted as electricity but only as produced heat.

- *Transport losses, inefficient use by third parties and transformation of heat into electricity by third parties.*

Ep is the energy produced by the incineration facility. The fact that energy is either used inefficiently by third parties shall not be taken into account and shall have no effect on the R1 energy efficiency formula. The same applies in the case of energy losses due to transport of heat energy.

- *Backflows and return flows of generated energies*

Backflows and return flows are energy flows (e.g. steam or warm water) that come back from the air or water cooled condensers as condensation water, from internal heat exchangers or from external customers in a closed circuit, e.g. from district heating or a power plant. Although, strictly speaking not a “backflow”, fresh feed water added as make up to compensate the blow down and water losses, shall be counted with backflows.

Backflows from internal or external sources shall be deducted from Ep as they directly lower the rate of energy recovery from waste.

- **Ef**

Ef is defined as *annual energy input to the system from fuels contributing to the production of steam (GJ/year)*.

Ef includes only fuels. Fuels are “combustible non waste substances” (e.g. diesel, natural gas) compliant with the Fuel Quality Directive 2009/30/EC, used for start-up and shutdown of the incineration process, fuels to maintain required temperatures > 850°C by using auxiliary burners.

Note that the energy of all waste, including RDF/SRF (Refuse Derived Fuel), etc. or waste (exhaust) gas is to be counted within Ew and not within Ef. This shall apply also for waste oil, although exclusively used in a burner, due to its definition as waste and the fact that it can only be used when the legally required incineration temperature has been reached.

In start-up the period where fuel contributes to the production of steam (counting as Ef), starts when the steam generator is connected to the steam grid and lasts until the legal minimum flue gas temperature (required by the legislation and or the permit) is reached. In shut down it lasts until the steam generator is disconnected from the grid.

- **Ei**

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

Ei consists of electricity, other kinds of imported non fuel energy such as steam and hot water, and of the amounts of fuel used during start-up and shut down processes (before connecting / after disconnecting to steam grid, (i.e. that part which is not counted as Ef), the energy for the re-heating of the flue-gas for catalysts or after the flue gas cleaning systems (e.g. with gas or oil) as well as other energies imported for the use of the "incineration facility" plant, which are not used for steam production are to be counted in Ei.

Avoid double counting: The condensate (or cold water) from the condensers or backflows returned from the export of steam (or hot water) are not counted in Ei, but are to be deducted from Ep.

Circulating heat and electricity for own uses of the incineration plant are part of Ep and are not to be counted in Ei.

This aspect gives an incentive to incineration facilities to make use of own energy produced (namely heat) and avoids that sophisticated flue gas treatment used to minimize air emissions (e.g. NOx) would have a negative impact on the ability to reach the R1 efficiency.

In this context it has to be taken into consideration that own energy consumption of an incineration facilities is limited by process design and that own energy consumption as well as minimum annual energy exports are clearly specified in the Waste Incineration BREF Document in BATs 61, 62, 63, 66b and 68, which shall be taken into consideration and reflected in the corresponding plant permits. (The limitations for internal use and minimum export requirements set in the BATs *are listed in Annex 3b).*

- *Distinction between Ef and Ei*

Distinction between Ef and Ei has in theory to be made for fuel used by the burner for start up and shut down. The consumption at the burner during start-up and shut down periods is roughly 50% without steam being produced (Ei) and 50 % with steam production (Ef).

Although specified separately in the calculation formula, in practice there is in general no need to make a distinction in imported fuel consumption between Ef and Ei, because the numerator of the R1-formula requests the sum Ef + Ei . This corresponds to the totally imported energy, for which data are readily available for operators.

The routine measurements performed by operators give direct access on the one hand to Ew + Ef and on the other to Ef + Ei which are the terms addressed by the R1-formula.

- **Ew**

Annex II of the WFD defines Ew as: "…annual energy contained in the treated waste calculated using the net calorific value of the waste (GJ/year)".

This comprises all types of waste acceptable at the MSWI plant as defined in IPPC and WID (see scope of the formula). This includes secondary fuels derived from waste as long as not having reached a legal end-of-waste status.

- *Determination of the energy input (Ew and Ef) and of the net caloric value (NCV) of the waste*

Ew has to be calculated for waste entering the R1 system boundary, which means after pre-treatment, if in place.

Analysis of individual waste samples is not a feasible determination method, because the amount of the waste to be sampled and the frequency of sampling for a reliable outcome would be too high.

The best method for the determination of the energy content of the waste or the NCV is a calculation with proofed process data over longer time periods (energy balance).

The method relies on a European standard, which is developed, for the specific case of Waste-to-Energy incinerators, in relevant reference documents [78]. These documents describe the detailed procedure for the Acceptance Test which is performed once in the course of the tests on completion of the plant and during which the efficiency of the boiler is determined.

The principle of the methods is to use an energy balance on the furnace and the boiler considered together as a calorimeter9. The energy inputs equal the energy outputs plus the energy losses (in flue gas, in bottom ash, by convection and radiation). The main energy outputs are measured during the comprehensive "Acceptance test" at the beginning of the life of the incineration facility (e.g. steam flow) and the small ones are assessed. The boiler efficiency gives the ratio between the energy output and the overall energy input.

For calculation and measurement details see annex 4 to this document.

The energy coming from the waste (Ew) is then obtained by deducting from the total energy input, the energy of the fuels contributing to the production of steam/hot water (Ef) used over the same period of time.

The average NCV (net calorific value) of the waste is obtained by dividing this waste energy input by the waste flow entering the incineration oven over the corresponding period of time. Ew is equal to the product of the NCV by the waste flow.

Alternatively the NCV formula given in the BREF document (chapter 2.4.2.1 and Annex 10.4.2)

NCV = (1.133 * (mst waste/mwaste) * cst x + 0.008 * Tb)/1.085 [GJ/Mg(tonne) waste] can be used.

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[7]'Acceptance Testing of Waste Incineration Plants with Grate Firing System' Guideline Edition 04/2000 by FDBR. Available from FDBR in German and in English.

[8] 'Acceptance Testing of Waste Incineration Plants with Grate Firing System' Guideline Edition 04/2000 by FDBR. Available from FDBR in German and in English.

[9] The boundary limits of the system here (furnace and boiler) are different (narrower) than the R1 boundary limits considered in the other parts of the R1 guideline document

In order to provide best results and reliability both alternative calculations shall be used for cross-checking.

Although specified separately in the calculation formula, in practice there is in general no need to specifically determine Ew and NCV, because the denominator of the R1-formula requests the sum of Ew + Ef, which corresponds to the total energy input to the boiler which is directly calculated by the method using the boiler as a calorimeter (see above).

5. Qualification Procedure and Monitoring of Compliance

It is important to note that the European Commission is not in the position to request harmonization of the procedures for the qualification procedure to apply for R1 classification, nor of the procedures for the monitoring of compliance with the classification.

Nevertheless a common definition for the terms that are used in the description of the R1-formula in Annex II (see below) and a clarification on how the factors can be calculated seems to be beneficiary and shall be addressed in this document. Statements in this chapter are recommendations for an appropriate and harmonized procedure. Implementation and enforcement of monitoring however will remain the full responsibility of Member States.

The procedures for classification of municipal waste incineration facilities as either 'Recovery operation' or 'Disposal operation' have to assure sufficient legal and planning security for operators.

In this context it has to be taken into consideration that energy efficiency is largely depending on the technical design of the facility and will only change to a limited extent during operation.

The status of a facility should be known before the waste is treated and, even, a long enough time before in order to comply with the stipulations of waste management contracts.

- *Applicable factor for classification as R1 operation*

According to Annex II of the WFD 2008/98/EC incineration facilities dedicated to the processing of Municipal Solid Waste (MSW) can be classified as R1 recovery operation 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*

In this context the meaning of "installations in operation and permitted" as mentioned above shall include installations that have a permit and are in operation before January 2009.

The factor of 0.65 applies exclusively for installations permitted after 31 December 2008. It does not apply for existing plants with a modification in the kettle, boiler or flue gas cleaning after 31

December 2008. Existing plants shall have the possibility to reach the threshold by amendment of their efficiency.

It shall be highlighted that a continuous incentive for further improvement shall be given by a regular review and adaptation of the threshold values for R1 classification as such.

- *Existing plants*

For existing plants "Installations in operation" the R1 factor shall be determined on the basis of practical annual performance data of the plant (see R1 calculation procedures below.)

A facility operating less than three years or having undergone constructive or contractual amendments concerning the energy efficiency has to be considered like a new facility.

- *New plants*

For new plants the R1 status shall initially be granted on the basis of the planning or construction specifications, considering the energy supply contracts and by determination of the general efficiency of the facility from an energetic view. This shall be achieved by means a comprehensive "acceptance test", determining the boiler efficiency made after commissioning, followed by a calculation on operational data made after one year in normal operation conditions on the basis of annual data.

- *R1 calculation procedures*

According to Annex II the energy efficiency of the incineration facility is to be based on annual figures for energy production and energy consumption of the plant. This shall be understood as real practical performance and not as a theoretical maximized value, not taking into considerations periods of lower efficiency.

The calculation therefore shall be based on regular operation (including revisions) of the whole facility. The regular operation includes the imperfect supply of electricity and heat because of lower demand.

The acquisition of data is made over a complete year. This is not necessarily a calendar year (i.e. the measuring period does not necessarily start on the 1st of January). The instruments and control equipment of the plant are maintained and controlled by the operator. Some data can be directly taken from a counter as a sum. For instance, fuel consumption, electricity produced. Some data require continuous computation and integration; For instance, the energy of steam flows.

Calculation of plant performance data and therewith of the R1 factor is associated with uncertainties which shall be calculated according to the standards for guaranteed performance[10] . Therefore plant operators when applying for R1 classification are recommended to assure that a sufficient safety margin can be kept on longer terms between the plant efficiency and the R1 threshold.

[10] In EN 12952-15 standard, Section 10.5.3, formula 10.5-6
In FDBR guideline, § 7.3.1, formulas 7.3.1-1, 7.3.1-2 and 7.3.1-3, pp. 32-33/50, English version.

The R1 criterion shall be regarded as satisfied on the condition that: R1 calculated (with measured, assessed and corrected data) minus overall uncertainty ≥ R1 threshold where 'R1 threshold' value is 0.6 for existing plants and 0.65 for new plants.

Calculation of the R1 factor on the basis of annual input and output data shall follow the exemplary calculation format provided in Annex 5.

- *R1 calculation procedures for multiple incineration lines*

Multiple incineration lines can be seen as multiple facilities, and can apply separately for the R1 status when the line(s) operate independently or the flows of each part of the plant can be clearly distinguished and calculated separately.

- *Approval of R1 calculation and allocation of R1 status*

There are two different possibilities for initial calculation of the R1-factor.

- Calculation by the plant operator (with external quality control)
- Calculation by an external certified expert or an expert from competent authorities.

The factor shall be either calculated or verified by an independent third person before it is presented to the competent authority of the EU-member state by the operator of the respective facility or the competent authority shall receive the calculation sheet and can carry on controls to make sure the R1 formula is properly used. The competent authority can also request further information or independent control measurements if needed.

The allocation of the R1 status shall not be based on the result of one climatically favourable year. In consequence the plant operator shall demonstrate to its competent authority that the R1 threshold was met over the past three years, using the mean value over the whole period ("gliding average" using two digits after point) as result, if the classification shall be achieved with an existing plant. This procedure shall not apply if relevant procedural changes have been performed during this period. In that case the procedure for new plants shall be performed.

The R1 status of the plant shall be formally confirmed by the competent authority on the basis of the data required to calculate the R1 value and the R1 value calculated provided by the plant operators. When the calculated R1 value is above or equal to the threshold, the competent authority issues a certificate within three months attesting that the plant complies with the R1-formula condition.

- *Revision of monitoring results/ verification of R1 status*

The calculation of the R1-factor and the statement of keeping the energy efficiency have to be presented on the basis of data of the preceding year (annual performance data as indicated above). The R1 classification of a municipal waste incinerator will be confirmed by the competent authority to the operator for the running year.

The operator shall annually report on the performance of its plant by means of a reporting form similar to the one presented in annex 5. This calculation shall be based on routine operator`s monitoring results and covers the quantities of waste incinerated, electricity generated, heat used outside the incinerator facility. For the additional energy flows lump sum data based on the previous R1-formula calculation of the plant might be used. The reporting shall be integrated into the reporting under Art 12(2)[11] of the WI Directive.

Due to the fact that major features of an incineration plant do not change over time, the operator`s report including annual monitoring results completed by an information on any structural changes occurred in the plant during the past year (e.g. technical modification, change of customers, etc.) allows the competent authority to achieve a routine validation and to check if a new acceptance test (see procedures for new installations) is necessary. If not, the installation can keep its R1/D10 status.

A new comprehensive acceptance test and recalculation is to be repeated after maximum 10 years or in case of a substantial change of the basic conditions (modification on boiler, turbine generator, heat supply contract, possibly the flue gas cleaning system) on which the first verification was based. If necessary, or in case of doubts, the authorities have the right to send inspectors or to ask for any additional calculations/measurements they need.

- *Transitional periods, new application*

It should be noted, that it is in the responsibility of the operator of the plant to provide for sufficient certainty concerning a consistent achievement of the R1 threshold even in case of modified circumstances. Thus, an operator should aim at keeping the energy efficiency well above the R1 threshold in order to be able to compensate for a modification in the conditions of operation. However, in case, the E-parameter change due to circumstances which cannot be influenced by the plant operator (e.g. the loss of industrial heat consumer, unexpected climatic conditions, break downs or other outage periods) and the R1 threshold cannot be met in the annual reporting, the status of the plant will not be withdrawn immediately.

In such cases the plant operator may – on the basis of the annual performance over the past three years – give a justified statement why the threshold could not be met. The plant operator will then be authorized by means of derogation to adjust/remediate the efficiency ratio to comply with the thresholds again until the annual reporting deadline in the following year.

When a plant cannot reach the R1 status or loses it – due to not being able to meet the threshold in two subsequent reporting years - the operator can try again to get the R1 status by applying for new test, after documentation of procedural changes or changed energy supply contracts.

[11] an annual report to be provided by the operator to the competent authority on the functioning and monitoring of the plant shall be made available to the public. This report shall, as a minimum requirement, give an account of the running of the process and the emissions into air and water compared with the emission standards in this Directive.

- *Communication on R1 status in the context of transboundary shipment*

The operator of a MSWI plant with R1 classification has to communicate the status of his plant to his clients by means of appropriate documentation (official certificate). In case of doubts, the competent authority can be asked for confirmation by other involved authorities and potential economic partners. A valid permit is a prerequisite for transboundary movement. The procedural requirements of the waste shipment regulation should apply for R1 MSWI as for any other facility.

Annex 1: The R1 calculation formula

The Formula in the WFD is related to the plant efficiency formula (Pl ef) in the **"Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration, from August 2006** (hereinafter referred to as BREF Document), *Annex 10.4.5* as described hereinafter.

$$Pl\ ef = (Oexp - (Ef + E\ imp))/(Ef + E\ imp + E\ circ)$$

all figures as equivalents in accordance to BREF, Chapter 3.5.6
Ef = annual energy input to the system by fuels with steam production (GJ/y)
E imp = annual imported energy (Note: energy from the treated waste (Ew) is not included)
E circ = annual energy circulated
Oexp = annual exported energy (combined total of heat plus electricity as equivalents)

"If the result is higher than 1: This shows that the plant minus imported energy with steam production is exporting (BREF) or producing (ECJ **C-228/00)** more energy than that which is required to operate the total waste incineration process"

According to the BREF document all amounts of energy (Ep, Ef, Ei, and Ew) are declared in GJ/a or MWh/a and equivalent values are used for heat and electricity in accordance to BREF, Chapter 3.5.6. Primary fuels are put into account without equivalent value (i.e. with a factor of 1), because no conversion of energy is connected with it.

The R1-formula can be deduced from the energy calculation formulas presented in BREF WI (Annex 10.4.4) as follows:

The denominator of the boiler efficiency by heat/steam production in correlation to the total heat/steam producing energy input - taking into account energy losses due to bottom ash and radiation or to remaining carbon content in the residues, which can technically not be avoided (factor 0.97). (BREF WI Annexes 10.4.4, page 599)

$$\eta b(97\%) = \left(\frac{Eh\ st\ boiler}{0.97 * (Ef + Ew)}\right) * 100\%$$

was used to derive the denominator of the R1-formula "0.97 * (Ef + Ew)".

The numerator of the R1 energy efficiency formula is related to the numerator of the boiler efficiency (Eh st boiler). However, instead of the total thermal energy (Eh/st boiler) generated by the boiler, only the energy (heat and or electricity) factually recovered - or in other words produced and utilized –from the waste, as the sum of the energy exported to third parties and the energy used within the installation forms the calculation basis for Ep . The numerator of the R1 energy efficiency formula can also be deduced from the numerator of the plant efficiency (Pl ef) formula Pl ef = Oexp – (Ef + Eimp). In contrast to Pl ef however, the recovery efficiency of an incineration plant according to the Formula in Annex II to the new WFD is based on the energy in terms of heat and electricity factually utilized from the energy generated at the boiler (Oprod) and on the energy exported from the plant (Oexp). (For standardization purpose, the marking Oprod was changed to Ep and Eimp to Ei).

Energy efficiency = Oprod - (Ef + Eimp) =>Ep - (Ef + Ei).

That means that the energy efficiency formula in the new WFD corresponds to the "recovery of energy from waste" as stipulated in chapter 3.5.4.1 and 3.5.4.2 (Tables 3.40 to 3.43) p. 195/196 of the WI BREF and not to the plant efficiency potential as described in chapter 3.5.6 titled "data comparing energy required by, and output from, the installation".

The calculated R1-factor gives the relation between:

(a) the energy recovered from the waste (exported energy plus internally used energy) minus the imported energy, and

(b) the energy from waste plus other imported energy used for steam production

ANNEX 2: System Boundaries of R1-formula

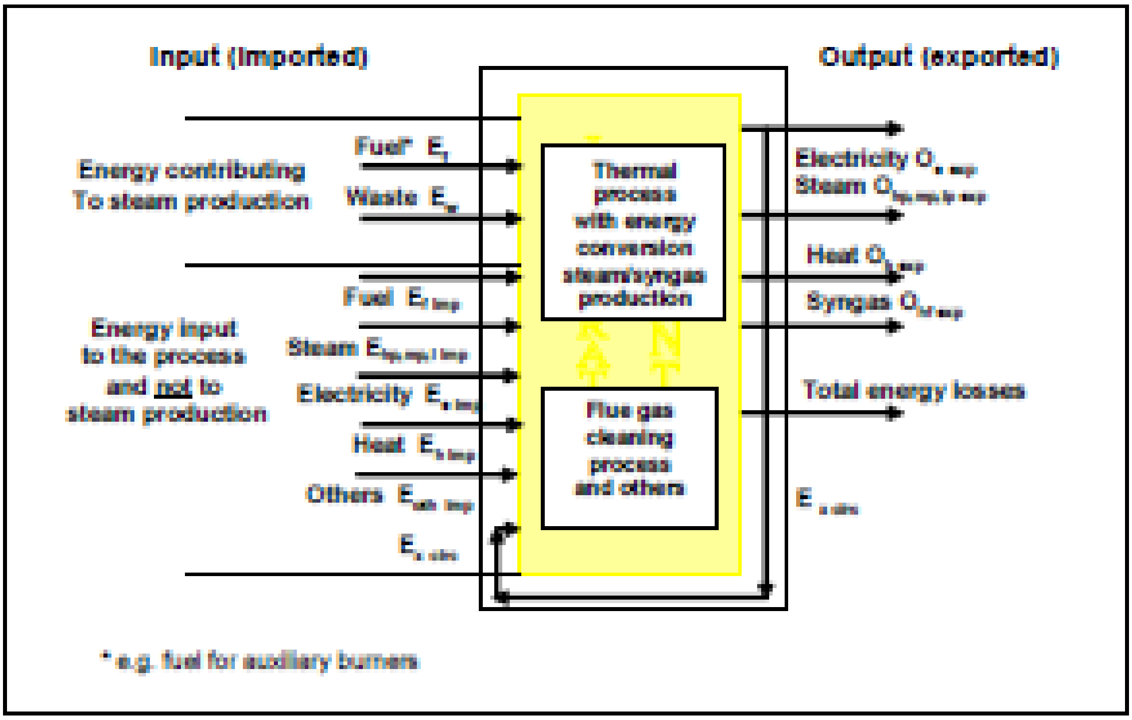

Figure 1: Energy efficiency system boundary according to BREF WI (Figure 10.14)

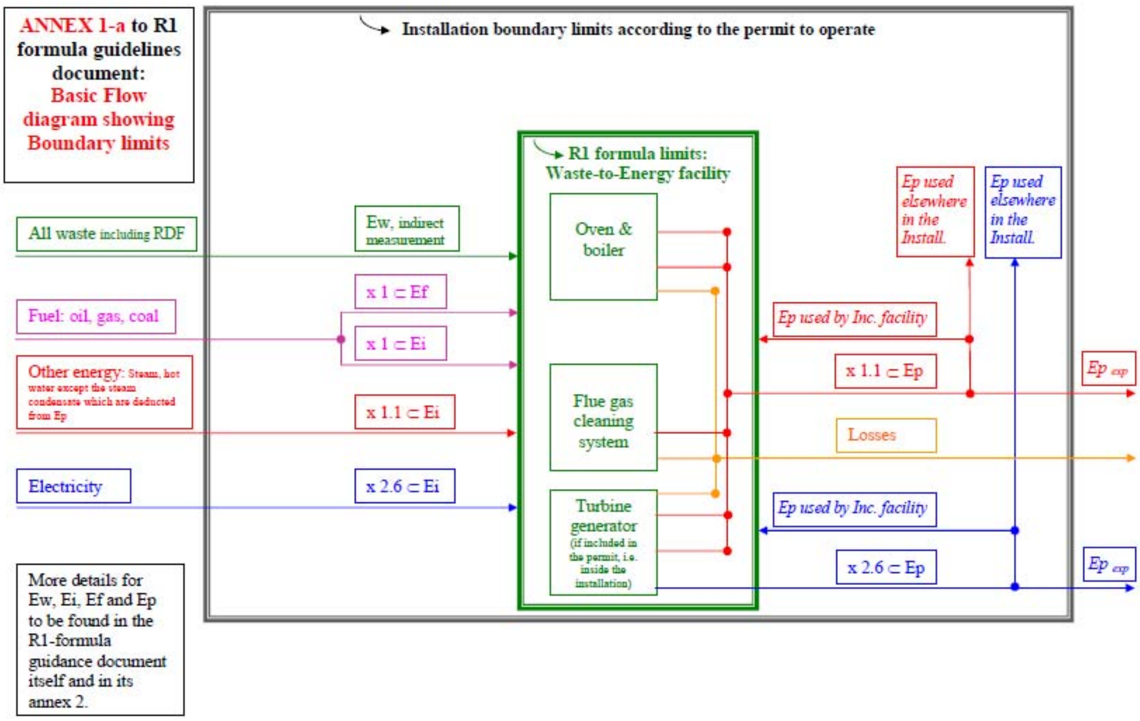

Figure 2: Distinction between R1 system boundary and permit boundary for MSWI
(Source: CEWEP-ESWET-FEAD Proposal for a Guideline for the use of the R1 energy efficiency formula for incineration facilities dedicated to the processing of Municipal Solid Waste (Waste Framework Directive 2008/98/EC, Annex II, R1-formula), 30 Nov 2009.

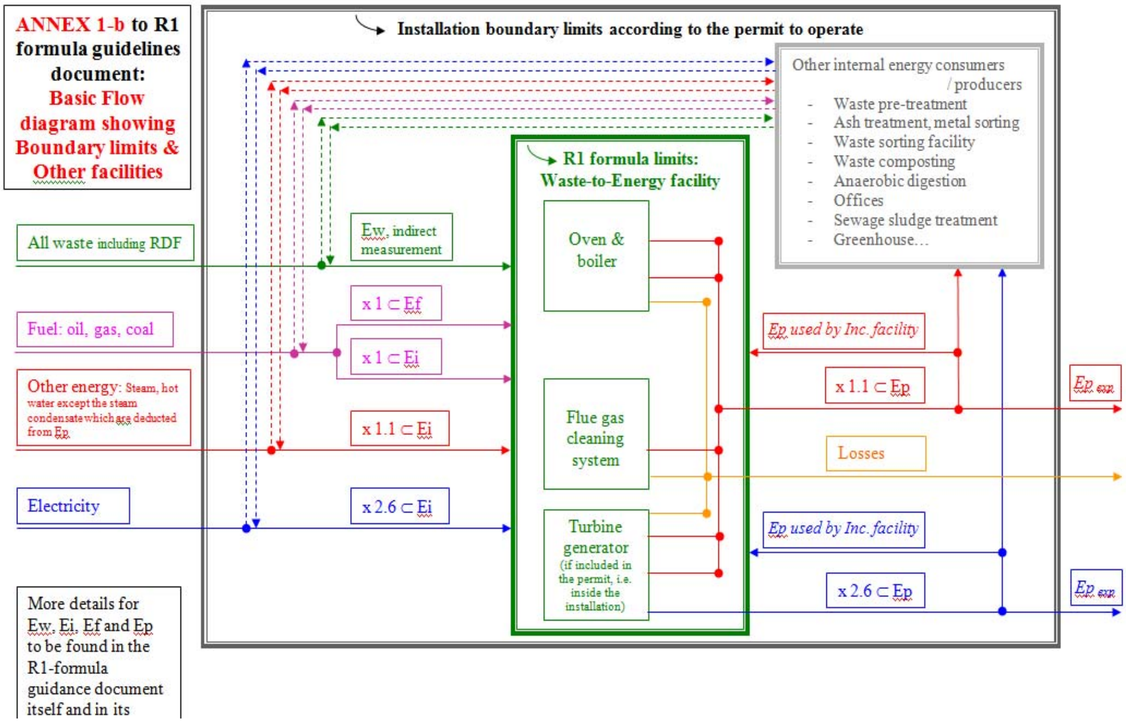

Figure 3: Other internal uses excluded from the R1 system boundary

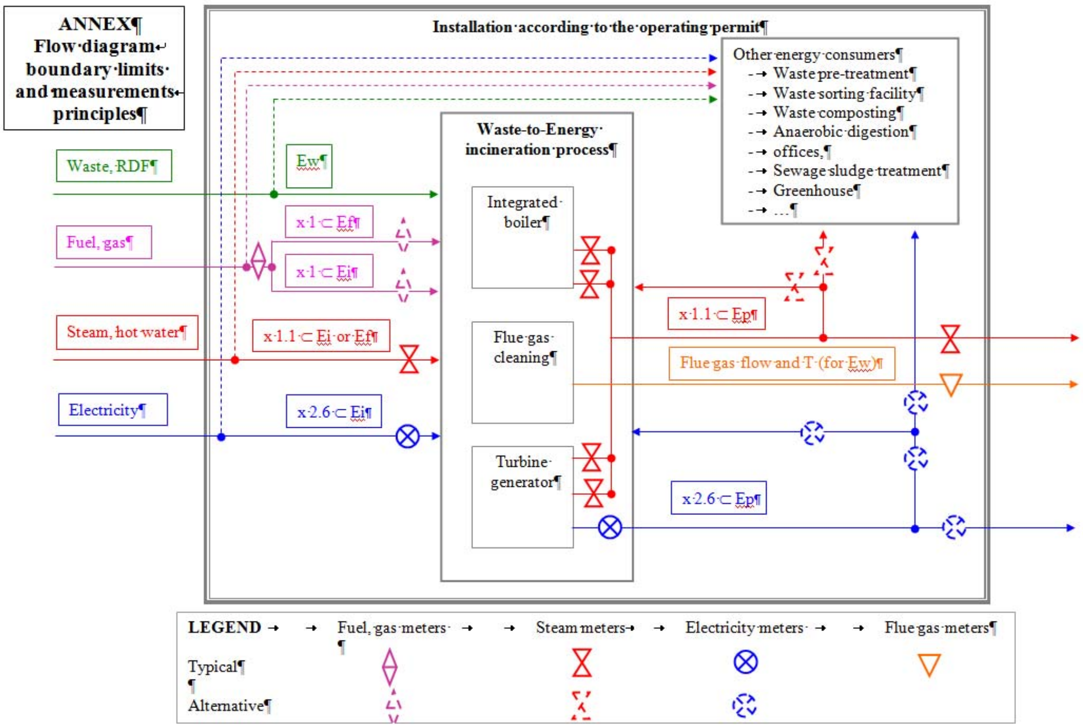

Figure 4: Position of measurement devices to determine energy flows relevant for the R1 calculation

Annex 3a): Energy to be counted in Ep, Ef and Ei

E_p	E_f	E_i
• Electricity produced (self use and delivery*) • District heating produced (self use and delivery*) • Process steam produced (self use and delivery*) • Other types of heating (local heat, mobile heat accumulator) • Incineration facility self use as electricity, steam/heat are e.g. - Energy used for evaporation or injection e.g. NH_4OH injection with steam, water for cleaning purpose or waste water from wet scrubbing - Energy used for soot blowers - Steam driven devices such as pumps, compressors, vacuum pumps - Energy used for pre-heating of the combustion air - Energy used for pre-heating of feed water - Energy used for heating of water-steam cycle system such as re-heating of the condensate from the air cooled condenser - Energy used for steam trace heating - Electricity used for all electrical systems (pumps, motors, fans, compressors, trace heating, control systems etc.), buildings and infrastructure (e.g. illumination, air conditioning etc.) - Energy used for re-heating of flue-gas (before catalytic reactor, after scrubber, before fabric filter) - Use of condensing energy from the steam in the flue gas - Heat for concentration process (salt concentration, spray drier) - Energy used for Apparatus, silos and buildings heating incl. warm water feed (administration, social buildings, other constructions)	• Support combustion with fuels for maintaining the minimal temperature/ incineration conditions • Start-up process with fuels starting when the steam generator is connected to the grid (usage of steam) • Shut-down process with fuels until decoupling of the steam generator with the grid (usage of steam)	• Support combustion with fuels in the start-up- and shut-down processes without connection of steam generator with the grid. • Imported energy for re-heating of the flue gases, e.g. with in pipe burner? (oil, gas) before catalytic reactor (SCR) or scrubber • Import of electricity (e.g. plants without turbine)

* Energy "self use and delivery" means the energy used by the incineration facility and the energy delivered inside the installation to other users as well as the energy delivered outside of the installation.

Annex 3b) Relevant BAT to limit self demand and determine export minimums

Specific BAT for municipal waste incineration

In addition to the generic measures given in Section 5.1, for municipal waste incineration BAT is in general considered to be:

61. the location of new installations so that the use of CHP and/or the heat and/or steam utilisation can be maximised, so as to generally exceed an overall total energy export level of 1.9 MWh/tonne of MSW (ref. Table 3.42), based on an average NCV of 2.9 MWh/tone (ref. Table 2.11)

62. in situations where less than 1.9 MWh/tonne of MSW (based on an average NCV of 2.9 MWh /tonne) can be exported, the greater of:

a. the generation of an annual average of 0.4 – 0.65 MWh electricity/tonne of MSW (based on an average NCV of 2.9 MWh/tonne (ref. Table 2.11) processed (ref. Table 3.40), with additional heat/steam supply as far as practicable in the local circumstances, or

b. the generation of at least the same amount of electricity from the waste as the annual average electricity demand of the entire installation, including (where used) on-site waste pretreatment and on-site residue treatment operations (ref. Table 3.48)

63. to reduce average installation electrical demand (excluding pretreatment or residue treatment) to be generally below 0.15 MWh/tonne of MSW processed (ref. Table 3.47 and section 4.3.6) based on an average NCV of 2.9 MWh/tonne of MSW (ref. Table 2.11)

5.3 Specific BAT for pretreated or selected municipal waste incineration

for pretreated or selected municipal waste (including municipal refuse derived fuels) incineration BAT is in general considered to be:

66. at new and existing installations, the generation of the greater of:

a. an annual average of generally at least 0.6 – 1.0 MWh electricity/tonne of waste (based on an average NCV of 4.2 MWh/tonne), or

b. the annual average electricity demand of the entire installation, including (where used) on-site waste pretreatment and on-site residue treatment operations

67. the location of new installations so that:

a. as well as the 0.6 – 1.0 MWhe/ tonne of electricity generated, the heat and/or steam can also be utilised for CHP, so that in general an additional thermal export level of 0.5 – 1.25 MWh/tonne of waste (ref. section 3.5.4.3) can be achieved (based on an average NCV of 4.2 MWh/tonne), or

b. where electricity is not generated, a thermal export level of 3 MWh/tonne of waste can be achieved (based on an average NCV of 4.2 MWh/tonne)

68. to reduce installation energy demand and to achieve an average installation electrical demand (excluding pretreatment or residue treatment) to generally below 0.2 MWh/tonne of waste processed (ref. Table 3.47 and section 4.3.6) based on an average NCV of 4.2 MWh/tonne of waste.

ANNEX 4: Determination of the Energy input (Ew + Ef) without calculation of NCV

The ratio between the energy output and the energy input is the boiler efficiency and therefore :

Ew + Ef = [(Energy of steam – Energy of feedwater) / boiler efficiency] – Energy of combustion air

Physical quantities required and related instruments

- Steam flow and enthalpy (Flow meter, Pressure, Temperature) at boiler outlet (usual location; can be adapted if more favourable location elsewhere).
- Steam flows and enthalpy (F, P, T) extracted before the main steam flow meter if any, e.g. from the drum if the unit consuming it is external to the 'calorimetric system' boundary limits and if these flows cannot be calculated from design data parameters or lump sum values be agreed.
- Feedwater flow and enthalpy (Flowmeter if flow not calculated, Temperature), usually at economizer inlet.
- Sensible heat of primary and secondary combustion air. This can be taken from the Acceptance Test or a lump sum value agreed, typically 7 to 8% of (Ew + Ef) if primary and secondary air is pre-heated and 5 % if only primary air is pre-heated. If not possible: Flow meter, Temperature after pre-heating.

Physical quantities measurement

- The physical quantities which are not re-calculated from other data nor taken as lump sum values are usually measured continuously.
- The corresponding energy flows can be calculated continuously by local counters or the plant CS (Control System) and averaged over the period of testing.

ANNEX 5: Example and calculation form for the determination of the R1 energy efficiency factor

			Reporting year		
	Type of energy	**unit**	**amount [Mg(tonne)]**	**NCV [kJ/kg]**	**energy E_x [MWh]**
1.1	amount of incinerated waste (without 1.2 and 1.3)		701.182	10.264	1.999.148
1.2	e.g. amount of incinerated sewage sludge		0		0
1.3	e.g. amount used activated carbon incinerated		0		0
1	**E_w: energy input to the system by waste**	**MWh**			**1.999.148**
2.1	$E_{f\,1}$: amount of light fuel oil for start up (after connection with the steam grid)	litre	335.834	42.000	3.370
2.2	$E_{f\,2}$: amount of light fuel oil for keeping the incineration temperature	litre	323.193	42.000	3.243
2.3	$E_{f\,3}$: amount of natural gas for start up and keeping incineration temperature	Nm^3			0
2	**S E_f: energy input by imported energy <u>with</u> steam production**	**MWh**			**6.612**
3.1	$E_{i\,1}$: amount of light fuel oil for start up/shut down (no connection with the steam grid)	litre	111.945	42.000	1.123
3.2	Ei 2: e.g. natural gas for heating up of flue gas temperature for SCR	Nm^3	0		0
3.3	$E_{i\,3}$: imported electricity (multiplied with the equivalence factor 2.6)		0		0
3.4	$E_{i\,4:}$ imported heat (multiplied with the equivalence factor 1.1)		0		0
3	**S E_i: energy input by imported energy <u>without</u> steam production**	**MWh**			**1.123**
4.1	$Ep_{el\ internal\ used}$: electricity produced and internally used for the incineration process	MWh	-		82.807
4.2	$Ep_{el\ exported}$: electricity delivered to a third party	MWh	-		339.982
4	**S $Ep_{el\ produced} = Ep_{el\ internal\ used} + Ep_{el\ exported}$**	**MWh**			**422.789**
5.1	$Ep_{heat\ exp.1}$: steam delivered to a third party without backflow as condensate		11.750	3.023	9.867
5.2	$Ep_{heat\ exp.2}$: district heat delivered to a third party with backflow as condensate (hot water)				71.445

			Reporting year		
	Type of energy	unit	amount [Mg(tonne)]	NCV [kJ/kg]	energy E_x [MWh]
5	**S $Ep_{heat\ exported}$ = $Ep_{heat\ exp.1}$ + $Ep_{heat\ exp.2}$**	**MWh**			**81.312**
6.1	$Ep_{heat\ int.used1}$: for steam driven turbo pumps for boiler water, backflow as steam		42.831	397	4.723
6.2	$Ep_{heat\ int.used2}$: for heating up of flue gas with steam, backflow as condensate		120.404	2.225	74.416
6.3	$Ep_{heat\ int.used3}$: for heating up combustion air with steam, backflow as condensate		66.225	2.606	47.940
6.4	$Ep_{heat\ int.used4}$: for concentration of liquid APC residues with steam, backflow as condensate		23.863	2.730	18.097
6.5	$Ep_{heat\ int.used5}$: for soot blowing <u>without</u> backflow as steam or condensate		38.026	2.918	30.822
6.6	$Ep_{heat\ int.used6}$: for deaeration and heating up of condensate, input as boiler (feed) water		211.343	2.499	146.679
6.7	$Ep_{heat\ int.used7}$: for heating purposes of buildings/instruments/silos, backflow as condensate		23.638	2.490	16.351
6.8	$Ep_{heat\ int.used8}$: for deaeration-demineralization with condensate as boiler water input		21.972	2.699	16.475
6.9	$Ep_{heat\ int.used9}$: for NH_4OH (water) injection <u>without</u> backflow as steam or condensate		10.517	2.918	8.525
6	**S $Ep_{heat\ int.used}$ = S $Ep_{heat\ int.used1-9}$**	**MWh**			**364.027**
	R1 = (Ep - (Ef + Ei)) / (0.97 * (Ew + Ef))	[-]			
	Ep = 2.6*(S $Ep_{el\ int.used}$+S $Ep_{el\ exported}$) + 1.1*(S $Ep_{heat\ int.used}$+S $Ep_{heat\ exported}$)	**MWh**	**1.589.124**		
	R1 = ((2.6*(422,789) + 1.1*(445,339)) - (6,612+1,123))/(0.97*(1,999,148+6,612)	[-]	**0,81**		

Remarks:

to 2.1 Amount of light fuel oil (ρ_{lfoil} = 0,86 kg/litre) during start up/shut down <u>with</u> steam production, determined from the light fuel oil demand during the relevant time period: connected to the steam grid but yet without release of waste into the furnace.

to 2.2 Amount of light fuel oil (ρ_{lfoil} = 0,86 kg/litre) <u>with</u> steam production, during the relevant time period: keeping incineration temperature.

to 3.1 Determined as difference out of total light fuel oil demand minus demand by 2.1 and 2.2.

to 5.1 In this example there is no backflow of condensate, therefore difference of enthalpy equal to the enthalpy of middle pressure (mp) steam (advice: in case of backflow of condensate Dc is the difference out of enthalpy from delivered steam minus enthalpy of condensate).

to 5.2 Amount of district heat determined from the quantity of transported hot water (deviation concerning the steam quantity about 3%).
to 6.1 Steam driven turbo pumps for boiler water using high pressure (hp) steam, decompressing to low pressure (lp) steam; Δc = 397 kJ/kg.
to 6.2 Heat exchangers for heating up flue gas are operated with middle (mp) pressure steam (13 bar). Depending on the fouling of the heat exchangers and throughput, so that the steam pressure is in the range of 9-12 bar. Only the difference of enthalpy, that means the enthalpy of mp steam (as average 10 bar) with backflow of the condensate into the condensate collecting tank (3.2 bar) and therefore on energy losses are taken into account (in the condensate collecting tank decompression to lp steam, which goes into the lp steam net).
to 6.3 Heat exchangers for combustion air are fed with mp steam and are operated at about 1 bar. The condensate goes back into the condensate collecting tank (100°C), therefore Δc = 3,023 - 100 *4,18 = 2,606 kJ/kg .
to 6.4 Liquid APC residues are treated with mp steam, condensate at 70°C flows back into the boiler (feed) water tank.
to 6.5 Hp steam used for soot blowing with an energy demand of Δc = 3,211 - 293 = 2,918 kJ/kg. Amount of energy used for soot blowing taking part in the hp steam production was neglected.
to 6.6 For deaeration and heating up of condensate for boiler (feed) water reason lp steam with 2,783 kJ/kg is used which commutes in this process steam to boiler water with a temperature of 122°C (2.1 bar). Incoming temperature of the different mixed condensates is about 68°C.
to 6.7 Heating of buildings e.g. administration, boiler houses and other sectors of the WtE plant as well as preparation of warm water for sanitary demand is processed by heat exchangers with lp steam. Backflow of condensate at about 70°C.
to 6.8 Temperature of fresh water from the demineralization installation about 20°C.
to 6.9 NH_4OH injection with hp steam.

(Source: Draft Guidance for the determination of the energy efficiency factor R1 (Waste Framework Directive 2000/98/EC, Annex II, R1-formula elaborated by ITAD in coordination with the German Environment Ministry and the Environment Agency, May 2009)