Debunking Efficient Recovery

The Performance of EU Incineration Facilities

Report
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Equanimator Ltd for Zero Waste Europe

Contents

Introduction

This report aims to shed light on the irrelevance of the R1 energy efficiency formula (R1- formula), and give evidence in support of its removal. The evidence focuses on the arguments in respect of:

- The rationale for the R1 formula;
- The efficiency of other forms of power and heat generation;
- The efficiency of energy generation by incineration facilities;
- The performance of energy recovery installations as regards climate change.

In a previous report, we challenge the legitimacy of the distinction made in the *Waste Framework Directive (Directive 2008/98/EC)* ('the WFD') between incinerators to be regarded as 'disposal' and incinerators which may be regarded as 'recovery' installations on the basis of their meeting the R1 criterion in *Annex II of Directive 2008/98/EC*. Our recommendation was as follows: [1]

> *Remove the R1 formula in Annex II of the WFD so that municipal waste incineration is no longer able to be classified as 'recovery'.* This is important since much of the legislation urges an unwarranted preference for 'other recovery' (that is, non-material) over and above landfill, *even if the waste is subject to 'treatment'*, as we proposed it should be defined elsewhere in the same report. *The easiest way to address this is to remove the formula, which has lost relevance in respect of the resources that might be displaced by incinerators in the context of a decarbonising energy system in the EU;*

This report adds further weight to that argument. We start with briefly summarising the establishment of the R1 formula.

[1] Equanimator, *Rethinking the EU Landfill Target*, Zero Waste Europe, October 2021.

The R1 Formula

In 2003, two European Court of Justice (ECJ) rulings clarified that the incineration of waste constitutes recovery only if its main objective is to generate energy, replacing the use of other materials that would have had to be used to fulfil that function, and thereby conserving natural resources.

Where that was not the case (if the main objective was the treatment of waste, for example), then incineration could not be defined as recovery, but would be defined as disposal.

The European Commission summarised the situation as follows:

> *In recent jurisprudence the European Court of Justice developed a criterion for distinguishing between waste recovery and waste disposal. According to the Court, a waste treatment operation is to be classified as recovery when the fundamental objective of the operation is that the waste substitutes the use of primary resources. The Court has notably concluded that filling a mine with waste could be a recovery operation if the waste is used in replacement of primary resources that would have otherwise been used for the purpose of filling the mine. This could for instance be the case when, for the purpose of stabilising land a mine must be filled. The Court also concluded that use of waste as a fuel in a cement kiln is recovery when excess heat is generated and this heat is used in the process. In contrast, the Court decided that incineration in a dedicated municipal waste incinerator has for primary objective to dispose of the waste. The Court added that, in the cases analysed, this classification as disposal operation would not be changed if, as a secondary effect of the process, energy is generated and used.*

In the WFD of 2008, the European Commission then saw fit to set out a basis for establishing a performance criterion that would allow an incinerator to be defined as 'recovery' as opposed to 'disposal'. The ECJ ruling, however, did not seem to allow for such a performance threshold to determine whether a facility was a recovery one or not.

This criterion – the R1 criterion - was based on work that had been undertaken in the context of the development of a *Best Available Techniques Reference Document for Waste Incineration* (BREF), which sought to elaborate a measure of energy efficiency:[2]

[2] European Commission, *Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration*, August 2006

In order to enable a comparison of energy performance between waste incinerators, it is necessary to ensure that these comparisons are made in a consistent way. In particular it is necessary to standardise:

- *assessment boundaries i.e. what parts of the process are included/excluded?*
- *calculation methods*
- *how to deal with different energy inputs and outputs e.g. heat, steam, electricity, primary fuels, re-circulation of energy produced by the plant, etc.*

The sections that follow describe the typical inputs and outputs seen at many waste incinerators.

The BREF document elaborated further on a calculation approach in Section 3.5.1. It suggested that the production of electricity and heat at incinerators might require a means to render them 'equivalent' as sources of energy. Hence:

Simple addition of the electrical and heat outputs can create difficulties when considering the relative efficiencies of installations that produce different quantities of these energy flows. The use of equivalence factors can allow consideration of the relative value of these commodities i.e. it can allow consideration of the value of the energy production that the recovered energy displaces. The equivalence factors assigned will be dependent upon the energy mix that the energy recovered at the incineration installation replaces. Where equivalence factors have been used in this document, a note of the factor used is included (see also Section 3.5.3 regarding equivalence factors). An example an energy efficiency calculation is given in appendix 10.4.

This method was developed by members of a sub-group of the TWG [i.e. the Technical Working Group], *and was used to provide some of the summary survey data reported in this chapter.*

The equivalence factors for heat and energy were set out in Tabulated form (see Table 2). These were explained as follows:

Taking account of the energy form, requires the comparison of different units of measurement i.e. MWh, MWh_e (electricity), MWh_{th} (thermal energy). The following table gives conversion factors (for externally generated sources) assuming an average of 38 % for electrical conversion efficiency (i.e. 1MWh = 0.38 MWh_e), and 91 % for external heat generation (i.e. 1MWh = 0.91MW_{th}):

This seems to reflect assumptions regarding alternative sources of generation and their respective energy efficiencies (see below for the explanation given in Guidance from the European Commission).

Table 2: Energy equivalence conversion factors, (European Commission, 2020)

FROM:	MULTIPLY BY:			
To:	GJ	MWh	MWhe	MWhth
GJ	1	0.2778	0.1056	0.2528
MWh	3.6	1	0.3800	0.9100
MWhe	9.4737	2.6316	1	-
MWhth	3.9560	1.0989	-	1
Gcal	4.1868	1.163	0.4421	1.0583

Elsewhere, a different rationale for the use of the same conversion factor was given:

> *To allow addition of heat and electricity to provide a single efficiency measure, a factor of 2.6316 is applied to electrical efficiencies. This factor takes account of the unavoidable losses of electrical energy production and allows processes producing different balances of heat and power to be compared (and hence averaged) with greater meaning.*

The BREF note included a formula for determining 'plant efficiency' which incorporated the above conversion factors. More detail, as well as some worked examples, were provided in Annex 10.4 of the same document.

The same document identified the following as Best Available Techniques (BAT) for Municipal Waste:

> *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/tonne (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[3], 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)*

Footnote 8 indicated that: *'The direct use of heat/steam (export and/or self consumption) will reduce electricity generation, and therefore serving a heat demand may mean that less than 0.4 MWh el/tonne waste is generated.'*

It was clear, therefore, that the BREF note was indicating minimum levels of performance in respect of energy generation by municipal waste incinerators. The lower end of the range specified for electricity generation, however, was far from consistent with the requirement in the *Waste Incineration Directive* (WID) that facilities demonstrate that the heat generated during the incineration or co-incineration process is '*recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating*'[8]

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[3] As the WID was at the time – this has since then been subsumed within the *Industrial Emissions Directive 2010/75/EU).*

This sentiment is repeated in Article 6(6). That requirement was set as a condition for an operator to obtain a permit, without which it should not have been issued with a permit to operate at all. The BREF's suggestion that a facility could demonstrate BAT by generating electricity at an efficiency of 14% (0.4MWh of electricity per tonne of waste with average NCV of 2.9MWh/tonne) with '*additional heat/steam supply as far as practicable in the local circumstances'* (it being possible, implicitly, that this could be zero) was far too generous.

Nonetheless, in the WFD, it was deemed relevant to use the Industrial Emissions Directive (IED) formula not as the basis for determining whether a facility should be issued with a permit (or was in breach of the terms of the permit it had been granted), but as a basis for distinguishing between whether an incinerator should be defined as 'recovery' or 'disposal. The formula emerged as follows:

> *(*) This includes incineration facilities dedicated to the processing of municipal solid waste only where their energy efficiency is equal to or above:*
>
> *— 0,60 for installations in operation and permitted in accordance with applicable Community legislation before 1 January 2009,*
>
> *— 0,65 for installations permitted after 31 December 2008,*
>
> *using the following formula:*
>
> *Energy efficiency = (Ep – (Ef + Ei))/(0,97 × (Ew + Ef))*
>
> *In which:*
>
> *Ep means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2,6 and heat produced for commercial use multiplied by 1,1 (GJ/year)*
>
> *Ef means annual energy input to the system from fuels contributing to the production of steam (GJ/year)*
>
> *Ew means annual energy contained in the treated waste calculated using the net calorific value of the waste (GJ/year)*
>
> *Ei means annual energy imported excluding Ew and Ef (GJ/year)*
>
> *0,97 is a factor accounting for energy losses due to bottom ash and radiation.*
>
> *This formula shall be applied in accordance with the reference document on Best Available Techniques for waste incineration.*

Under these conditions, it is possible to establish what sorts of efficiency would be required from facilities generating either only electricity, or only heat. Of course, the criterion admits of facilities operating in combined heat and power mode, but the electricity and heat calculations set some limits in terms of facilities operating with only one or other form of heat delivered. These calculations are shown in Table 3 and Table 4 as the R1 formula would apply to facilities developed from 2009 onwards.

Table 3: Minimum (net) Efficiency of Electricity generation required to Meet R1 Threshold

R1 Efficiency Threshold	0.65	0.65	0.65
Gross Electricity Production as % Energy in Waste	22.9%	23.0%	23.1%
Electricity factor	2.6	2.6	2.6
Ef + Ei	0.0055	0.009	0.0110
Heat generated and used in plant	0.04	0.04	0.04
Energy in Waste	1	1	1
Energy Imported (as % energy in waste)	*0.05*	*0.1*	*0.15*
Bottom ash factor	0.97	0.97	0.97
(0,97 × (Ew + Ef))	0.973	0.974	0.975
Estimated Electricity generation (gross) as kWh per tonne input (at 10GJ/tonne)	636	639	642
Estimated Electricity generation (net) as kWh per tonne input (at 10GJ/tonne)	525	528	531
Estimated Electricity generation (net) as % Energy in Waste	19.1%	19.2%	19.3%

Table 4: Minimum (net) Efficiency of Heat generation required to Meet R1 Threshold

R1 Efficiency Threshold	0.65
Gross heat Produced for Commercial Use as % Energy in Waste	58.6%
Heat factor	1.1
Ef + Ei	
Energy in Waste	1
Energy Imported (as % energy in waste)	*0.0044*
Bottom ash factor	0.97
(0,97 × (Ew + Ef))	0.974
Estimated heat generation (gross) as kWh per tonne input (at 10GJ/tonne)	1,628
Estimated heat production (net) as kWh per tonne input (at 10GJ/tonne)	1,368
Estimated heat production (net) as % Energy in Waste	49.2%

The tables above show how the target gross efficiency required to meet the R1 criterion increases as the energy imported increases (as a percentage of the energy in the waste). For electricity generating facilities, this is likely to be a relatively small fraction of the total, so gross efficiencies of around 23%, giving net figures of the order 19% would potentially meet the criterion. The corresponding figures for heat only facilities would be of the order 59%, and 49%, respectively.

Note that the required efficiency for heat seems to be lower than what the IED was proposing for BAT for new installations located '*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.*' The IED proposal for electricity generation, on the other hand, seems weak by comparison. This does, though, add further to the confusion regarding the R1 threshold and its relationship to BAT (and the IED). For heat only facilities, the R1 threshold corresponds to BAT, which would imply that if a facility could be given a permit, it would always meet the R1 threshold (the one implied the other). The same is not true for electricity generating facilities. For these, the BAT threshold was set rather low, allowing for facilities with a low efficiency to be permitted. Furthermore, this would have limited the incentive to seek users of heat (or cooling) as opposed to exporting electricity into existing distribution networks.

Notwithstanding these points, the R1 criterion was rendered somewhat easier to meet for facilities in hotter countries by virtue of amendments made in *Amending Directive EU Directive 2015/1127*. The main rationale for the Directive seemed to be to ensure that the R1 threshold could be met more easily in countries with warmer climates by introducing a climate correction factor (CCF).

The energy efficiency formula value will be multiplied by a climate correction factor (CCF) as shown below:

> *1. CCF for installations in operation and permitted in accordance with applicable Union legislation before 1 September 2015.*
>
> *CCF = 1 if HDD >= 3 350*
>
> *CCF = 1,25 if HDD <= 2 150*
>
> *CCF = – (0,25/1 200) × HDD + 1,698 when 2 150 < HDD < 3 350*
>
> *2. 2. CCF for installations permitted after 31 August 2015 and for installations under 1 after 31 December 2029:*
>
> *CCF = 1 if HDD >= 3 350*
>
> *CCF = 1,12 if HDD <= 2 150*
>
> *CCF = – (0,12/1 200) × HDD + 1,335 when 2 150 < HDD < 3 350*
>
> *(The resulting value of CCF will be rounded at three decimal places).*

The value of HDD (Heating Degree Days) should be taken as the average of annual HDD values for the incineration facility location, calculated for a period of 20 consecutive years before the year for which CCF is calculated. For the calculation of the value of HDD the following method established by Eurostat should be applied: HDD is equal to (18 °C – Tm) × d if Tm is lower than or equal to 15 °C (heating threshold) and is nil if Tm is greater than 15 °C; where Tm is the mean (Tmin + Tmax)/2 outdoor temperature over a period of d days. Calculations are to be executed on a daily basis (d = 1), added up to a year.

If one considers what the IED requires – in terms of heat recovery – then it seems highly questionable to have a threshold for R1 that is easy to meet more or less everywhere. If there is any point at all to the distinction between 'disposal' and 'recovery' on efficiency grounds, it ought to be that some facilities cannot meet the R1 criterion, even where they recover heat '*as far as practicable*.' The rationale motivating the amendment seemed destined to erode the scope of the distinction.

The effect of the Amending Directive was – for hotter regions of the EU – to reduce the threshold value from 0.6 to 0.54 for older facilities granted a permit prior to 2008, and from 0.65 to 0.58 for new facilities. We estimate that this had the effect of reducing the threshold requirement for electricity export from 19% or so (see Table 3) to around 16.5%.

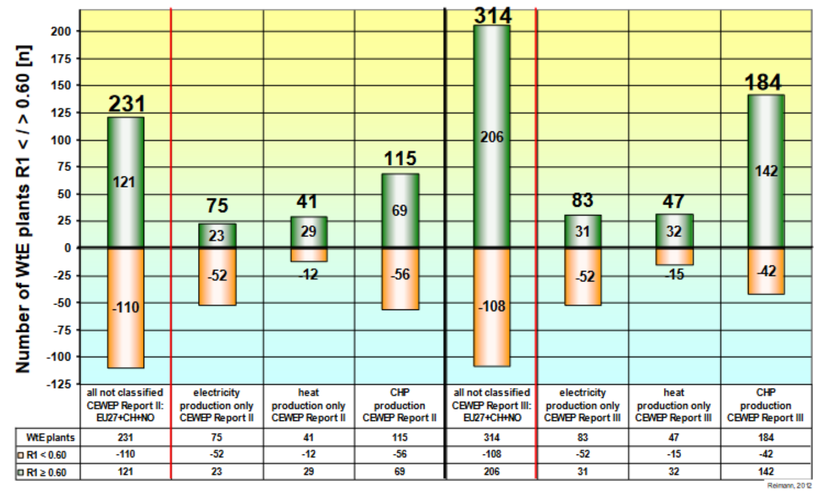
How Difficult is it to Meet the R1 Threshold?

Data reported by CEWEP

In the period shortly after the initial R1 criterion was established in 2008, CEWEP, the trade body representing energy from waste facilities, conducted studies in relation to a range of incineration facilities, seeking to understand whether they met the R1 criterion or not. The third of these studies was published in December 2012, and assessed facilities' performance between 2007 and 2010[4] Given that most of the facilities were permitted before December 31 2008, the lower threshold (0.6) was used as the basis for assessing whether the criterion was met or not.

The summary results, assessed alongside the facilities reviewed in a previous report, are shown in Figure 1. It shows that prior to the *Amending Directive*, around two-thirds of all facilities investigated were compliant. Some of these, it should be noted, appear to have had abysmal performance figures, as illustrated by Figure 2. Relevant directives had specified the requirement to recover heat 'as far as practicable' since 1999. Having facilities claiming to be doing so, but achieving such poor performance, might suggest one or more of the following: a) they were very old, b) they were not being well regulated, or c) the data submitted were in error. The fact that an electricity only facility was delivering only 75kWh of electricity per tonne of waste suggests a failure of one or other type.

Figure 1: Comparison of R1 factors of investigated European WtE plants divided into all, electricity only, heat only and Combined Heat and Power (CHP) production in the CEWEP Energy Reports II and III, Reimann(2012)



[4] Dieter O. Reimann , *CEWEP Energy Report III: (Status 2007-2010), Results of Specific Data for Energy, R1 Plant Efficiency Factor and NCV of 314 European Waste-to-Energy (WtE) Plants*, CEWEP, December 2012.

Table 5: Specific energy recovery rates for MSW in absolute and percentages as weighted-averages for the total WtE plants and divided into the categories type of energy recovery, size (throughput) and European geographical region (Status 2007-2010), Reimann (2012)

type of energy recovery depending on different classifications	unit	all investigated WtE plants	type of energy recovery of a plant			size (throughput) of a plant			geographical European region of a plant		
			electricity production only	heat production only	CHP production	< 100,000 Mg MSW/a	100,000 to 250,000 Mg MSW/a	> 250,000 Mg MSW/a	South-Western Europe	Central Europe	Northern Europe
number of plants included	n	314	83	47	184	118	124	72	55	188	71
total throughput of plants	mio Mg/a	59.44	12.98	5.67	40.78	7.06	19.80	32.57	8.73	40.52	10.19
Total specific energy input (incl. import) as weighted averages	MWh abs. / Mg total(Ew+Ef+Ei)	2.894	2.690	2.980	2.965	2.810	2.874	2.907	2.718	2.830	3.281
Specific electricity produced (Ep) as weighted averages	MWh el abs. /Mg total	0.431	0.581	0.000	0.444	0.341	0.426	0.454	0.570	0.419	0.362
	% of Mg total	14.89	21.6	0.0	15.0	12.1	14.8	15.6	21.0	14.8	11.0
Specific heat produced (Ep) as weighted averages	MWh th abs. /Mg total	1.001	0.122	2.301	1.101	0.951	0.921	1.061	0.328	0.800	2.381
	% of Mg total	34.59	4.5	77.2	37.1	33.8	32.1	36.5	12.1	28.3	72.6
total specific thermal recovery rate as heat + electricity (Ep) as weighted averages	MWh th+el abs. /Mg total	1.432	0.703	2.301	1.545	1.292	1.347	1.515	0.898	1.219	2.743
	% of Mg total	49.48	26.1	77.2	52.1	46.0	46.9	52.1	33.0	43.1	83.6

Figure 2: R1 factor calculated as individual R1 values as non-weighted average for 314 European WtE plants: 71 from Northern Europe, 188 from Central Europe and 55 from South-Western Europe (Status 2007-2010), Reimann, 2012

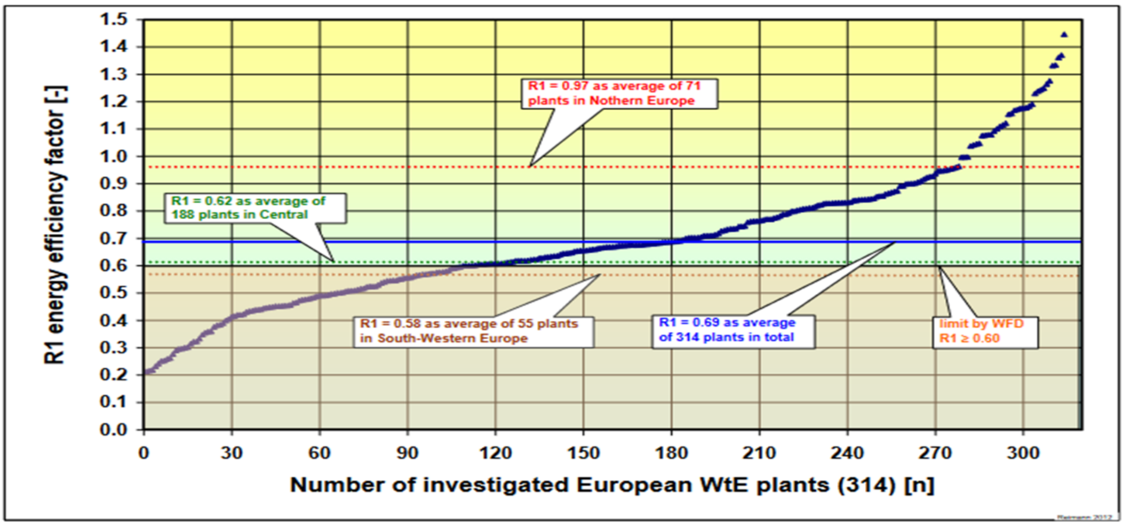


Table 6: Specific production of electricity and heat as sum out of exported plus self used recovered energy as min and max values as well as weighted averages in absolute MWh abs /Mg MSW and as percentages (%) of the total energy input from MSW plus imported energy for all 314 WtE plants and divided according to the type of energy recovery in this Report (Status 2007-2010), Reimann, 2012

specific heat and electricity produced and used depending on different classifications	unit	all investigated WtE plants	type of energy recovery of a plant		
			electricity production only	heat production only	CHP production
number of plants included	n	314	83	47	184
total throughput of plants	mio Mg/a	59.44	12.98	5.67	40.78
Total specific energy input (incl. import) as weighted averages	MWh input total abs. / Mg MSW	2.894	2.690	2.980	2.965
Specific electricity exported (Ep) as weighted averages	MWhel abs. /Mg MSW	0.336	0.476	0.000	0.338
	min / max MWhel abs. /Mg MSW	0.0 - 0.899	0.075 - 0.873	0.0	0.007 - 0.899
	% of MWhth input	11.61	17.70	0.00	11.40
Specific electricity self used (Ep)[1] as weighted averages	MWhel abs. /Mg MSW	0.095	0.105	0.000	0.106
	min / max MWhel abs. /Mg MSW	0.0 - 0.286	0.0 - 0.251	0.0	0.0 - 0.286
	% of MWhth input	3.28	3.90	0.00	3.58
Specific electricity produced (Ep) as weighted averages	MWhel abs. /Mg MSW	0.431	0.581	0.000	0.444
	% of MWhth input	14.90	21.6	0.0	15.0
Specific heat exported (Ep) as weighted averages	MWhth abs. /Mg MSW	0.849	0.000	2.154	0.938
	min / max MWhth abs. /Mg MSW	0.0 - 3.333	0.0	0.520 - 3.333	0.004 - 3.267
	% of MWhth input	29.34	0.00	72.28	31.64
Specific heat self used (Ep)[1] as weighted averages	MWhth abs. /Mg MSW	0.152	0.122	0.146	0.163
	min / max MWhth abs. /Mg MSW	0.014 - 0.389	0.014 - 0.389	0.014 - 0.350	0.020 - 0.387
	% of MWhth input	5.25	4.54	4.90	5.50
Specific heat produced (Ep) as weighted averages	MWhth abs. /Mg MSW	1.001	0.122	2.300	1.101
	% of MWhth input	34.59	4.54	77.18	37.13
Σ Specific heat and el produced (Ep) as weighted averages	MWhth+el abs. /Mg MSW	1.432	0.703	2.300	1.545
	% of MWhth input	49.5	26.1	77.2	52.1

The report's summary observations regarding the performance of facilities against the R1 criterion are worth repeating:

- *Very low results in general with R1 < 0.60 are found in small sized plants (throughput < 100,000Mg/a), located in South-Western Europe producing electricity only;*
- *For plants producing electricity only it is very difficult to meet R1 as only 37.3% meet R1 ≥ 0.60;*
- *The highest R1 results are related to large sized plants (throughput >250,000Mg/a), located in Northern Europe with CHP production;*
- *In the Energy Report II, 52% of all investigated WtE plants met R1 ≥ 0.60, whereas in this Report, although the assessment criteria are more stringent according to the final version of the R1 Guidelines, 65.6% of the WtE plants now meet R1 ≥ 0.60 primarily due to the optimization carried out by the plants that participated in the Energy Report II.*

The amount of MSW being recovered in the 206 investigated European WtE plants reaching R1 ≥ 0.60 is 46.39 mio Mg MSW/a equivalent to 78.1% of the corresponding 59.4 mio Mg MSW investigated from this Report.

[...] The R1 energy efficiency results do not include the R1 "climate factor" (R1cl), which is currently discussed at the EU level. If a R1cl factor would be adopted, it would increase the R1 level for the plants in South-Western Europe and some plants in Central Europe, but its ultimate influence cannot yet be predicted.

The comments highlight that facilities generating electricity only in Southwest Europe, where heat recovery has been less common, partly because of climatic conditions, were more likely to fail the criterion. However, we must note that '*For plants producing electricity only it is very difficult to meet R1*', is not demonstrated by only reporting the performance of extant facilities. The facilities could simply be operating at low levels of efficiency. As we showed above, the required efficiency of electricity generation is not especially high, even to meet the higher 0.65 threshold for facilities permitted post 2008.

The comments regarding the application of the climate factor are also interesting. They do, indeed, suggest that the intention was to help facilities in warmer climates – especially those operating in electricity only mode – to meet the R1 criterion. The presumption seems to have been that it should be relatively unchallenging for all facilities to meet the criterion.

Evidence from EU Data

The R1 criterion exists only for '*incineration facilities dedicated to the processing of municipal solid waste*.' Some evidence of the extent to which this is readily achieved (or otherwise) can be gleaned from data reported for municipal waste across the EU. 2020 Eurostat data reveal (with some caveats related to the nature of the data and the apparent need for estimation) that of the 61 million tonnes of municipal waste sent for some form of incineration in the EU, less than 2% (just over a million tonnes) was sent to facilities that failed to meet the R1 criterion (see Table 7).

Such a low figure suggests that the R1 criterion has become meaningless. It no longer serves (if indeed it ever did, not least once the climate correction factor was included) to distinguish between facilities that perform relatively well, and those that perform relatively poorly. For all intents and purposes, there is no municipal waste that is sent to a facility defined as 'D10 disposal'.

Table 7: Municipal Waste Sent for Incineration (D10 and R1) Shown Alongside Quantity Sent for D10 Incineration Only

	Disposal - incineration (D10) and recovery - energy recovery (R1)		**Disposal - incineration (D10)**	
European Union - 27 countries (from 2020)	61,153	s	1,116	s
Belgium	4,130	b	0	b
Bulgaria	103	s	0	s
Czechia	740		5	
Denmark	2,536	p	0	
Germany	16,133	s	616	s
Estonia	218		0	
Ireland	881	s	0	s

Greece	:		:	
Spain	2,487	e	0	e
France	11,653	e	52	e
Croatia	3		0	
Italy	5,615		158	
Cyprus	8		0	
Latvia	24		0	
Lithuania	349		0	
Luxembourg	215	s	0	s
Hungary	470		4	
Malta	0.014		0.014	
Netherlands	3,878		84	
Austria	2,652	b	7	b
Poland	2,823		166	
Portugal	962		0	
Romania	291		0	
Slovenia	134	e	21	
Slovakia	188		0	
Finland	1,908		3	
Sweden	2,680	be	0	e

Notes:
be *break in time series, estimated*
b *break in time series*
e *estimated*
p *provisional*
s *Eurostat estimate*
Source: Eurostat waste database

Efficiency of Energy Generation

In this Section we compare the efficiency of conversion of energy in fossil fuels into electricity. We then consider the same in respect of waste.

Efficiency of Energy Generation from Fossil-fuels

Efficiency of electricity generation of combined cycle gas turbines (CCGT) and coal fired power stations are reported in the UK by the Department of Business, Energy and Industrial Strategy[5] In 2021, relative to gross calorific value (GCV), efficiencies were 49.9% for CCGT and 33.4% for coal-fired generation. Relative to Net Calorific Value (NCV), the efficiencies are estimated at 55.5% and 35.1%, respectively. The same source indicates that for CHP schemes, the efficiency in 2020 was estimated at 69.1 per cent for qualifying electricity and heat. This compares with 48.5 per cent when taking into account qualifying electricity only, in line with the overall electricity efficiency for combined cycle gas turbines, which accounts for half of all UK CHP schemes.[6]

These figures are not untypical of gas- and coal-fired electricity generating systems. A study by Ecofys estimated efficiencies of generation over the period 1990 to 2016 for a range of countries, including Germany, France and Nordic countries (and UK).[7] The figures for coal and for gas are shown in Figure 3 and Figure 4, whilst Figure 5 shows how the weighted average efficiencies for all the countries studied have changed over the period. All the figures in the study are quoted for gross generation and relative to net calorific value. They suggest an upper end performance for coal-fired generation of just over 40%, and around 55% for gas. Individual facilities may have performance exceeding these values, since these figures represent country-wide averages.

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[5] UK Government, *Digest of United Kingdom Energy Statistics (DUKES) 2021: dataset*. See: https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2021.

[6] Department of Business, Energy and Industrial Strategy, *Digest of UK Energy Statistics: Annual data for UK, 2020*. See: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1060151/DUKES_2021_Chapters_1_to_7.pdf

[7] Ecofys, *International comparison of fossil power efficiency and CO_2 intensity - Update 2018*. September 2018. See: https://guidehouse.com/-/media/www/site/downloads/energy/2018/intl-comparison-of-fossil-power-efficiency--co2-in.pdf

In the USA, in 2019, natural gas-fuelled power plants converted 45% of energy input into net generation of electricity. The equivalent figure for coal was 32%.[8]

Figure 3: Average efficiency of coal-fired power production from 1990 to 2016 for analysed countries, [Ecofys (2018)]

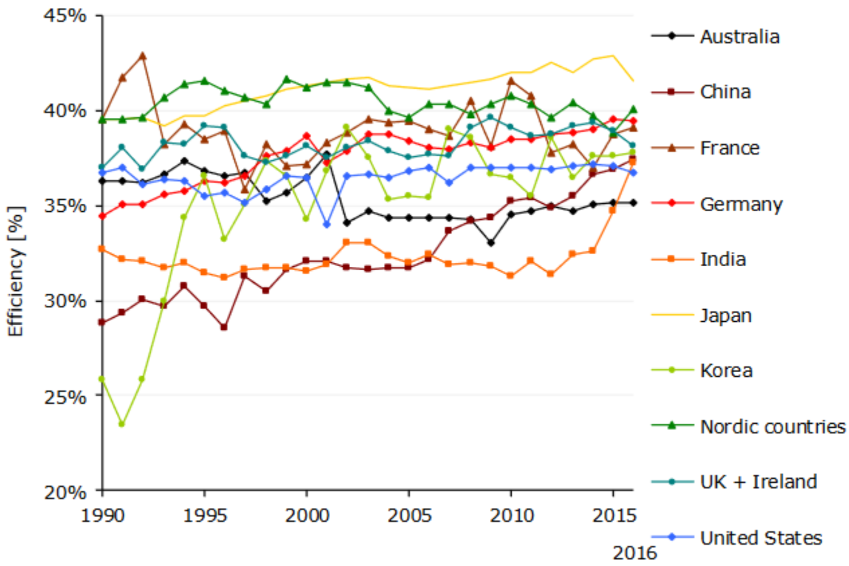
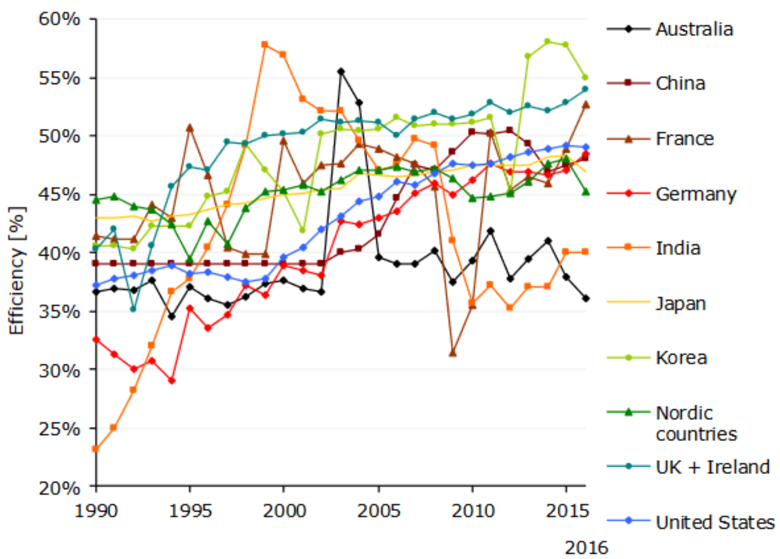
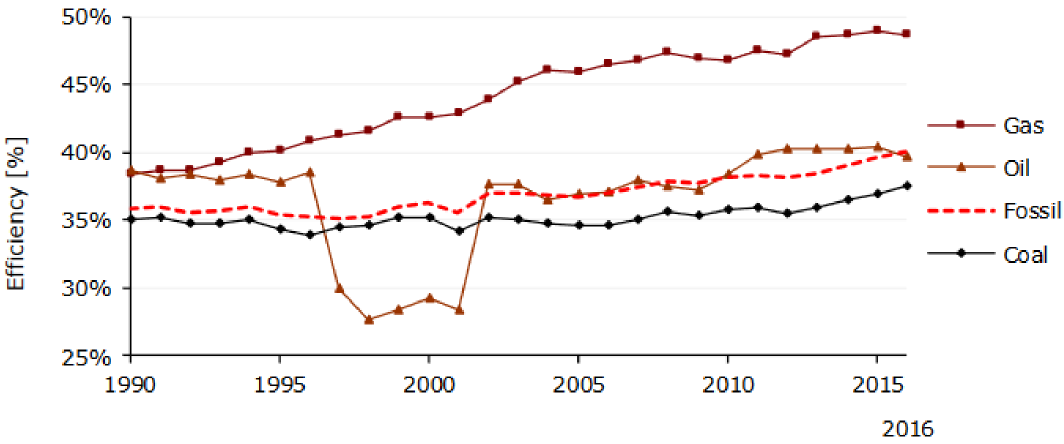


Figure 4: Average efficiency of gas-fired power production from 1990 to 2016 for analysed countries, [Ecofys (2018)]



[8] U.S. Energy Information Administration, "More than 60% of energy used for electricity generation is lost in conversion", July 2020. See: https://www.eia.gov/todayinenergy/detail.php?id=44436 (Accessed January 2023).

Figure 5: Average weighted efficiencies of all countries and regions at the scope of this study (%),Ecofys (2018)



Country-specific Data – Efficiency of Energy Generation from Waste

In the following Section, we estimate efficiencies of generation of energy from waste for Member States which incinerate a significant share of the waste incinerated across the EU. Many of these are countries where there is a relatively strong focus on electricity generation, or cogeneration, rather than on provision of heat. The exception is Sweden, though Germany lies – among the Member States we have included – in between the extremes of 'mainly heat' and 'mainly electricity' generation.

Germany

In Germany, we have used data from ITAD to calculate the efficiencies of generation for the whole fleet of facilities. In the aggregate, it appears that the efficiency of electricity generation was, overall, 14.3% (gross) or 10.9% (net), and for heat, the figure for exported heat / steam was 34% (see Table 8).

Table 8: Efficiencies of Energy Generation for German Incinerators, ITAD, 2022

		Efficiency Calculation
Energy Input (GJ)	259,920.00	
Energy Input (GWh)	72,200	
District Heating export (GWh)	11,180.00	15.5%
Process steam (GWh)	13,390.00	18.5%
Total Heat / Steam Export (GWh)	24,570.00	34.0%
Total electricity generation (gross)	10,350.00	14.3%
Electricity export (net)	7,900.00	10.9%

France

In 2020, French incineration facilities treated 14.57 million tonnes of waste. Using data from ADEME, we have estimated the efficiency of energy generation (gross, and net) for a given net calorific value of waste for the different facilities, key figures for which are shown in Table 9.

Table 9: Energy Generated at Household Waste Incineration Facilities in France, 2020, ADEME 2022

<table>
<tr><th>Type of Energy Generated</th><th>Number of Household Waste Incineration Plants</th><th>Quantity of waste received (kt)6</th><th>Amount of energy consumed by plants (MWh)</th><th>Quantity of energy sold (MWh)</th></tr>
<tr><td>Electrical</td><td>17</td><td>1,634</td><td>145,962</td><td>637,510</td></tr>
<tr><td>Thermal</td><td>15</td><td>724</td><td>133,884</td><td>889,155</td></tr>
<tr><td>Cogeneration</td><td>84</td><td>12,123</td><td></td><td></td></tr>
<tr><td colspan="3">Of which, electrical</td><td>964,271</td><td>2,571,933</td></tr>
<tr><td colspan="3">Of which, thermal</td><td>1,969,476</td><td>7,972,010</td></tr>
<tr><td colspan="3">Without valorisation of energy</td><td>2</td><td>53</td></tr>
<tr><td colspan="3"></td><td>Electrical</td><td>Thermal</td></tr>
<tr><td colspan="3">Total energy produced (GWh)</td><td>4,320</td><td>10,965</td></tr>
</table>

If one assumes the typical NCV of 2.9 MWh tonne (equivalent to around 10.4 GJ/tonne), then the efficiencies equate to:

Electricity only: 16.5% gross, 13.5% net

Heat only: 48.7% gross, 42.3% net

Cogeneration: 10.1% electricity and 28.3% heat (gross) and 7.3% electricity and 22.7% heat (net)

Total: 10.3% electricity and 26.1% heat (gross) and 7.6% electricity and 21.1% heat (net)

The efficiencies are slightly higher if one assumes a lower input NCV of waste of 2.64 MWh/tonne (equivalent to around 9.5 GJ/tonne)

Electricity only: 18.2% gross, 14.8% net

Heat only: 53.5% gross, 46.5% net

Cogeneration: 11.1% electricity and 31.1% heat (gross) and 8.0% electricity and 24.9% heat (net)

Total: 11.3% electricity and 28.7% heat (gross) and 8.4% electricity and 23.2% heat (net)

Italy

As for Italy, we have taken data regarding waste treatment and energy generation, and used different assumptions regarding net calorific value (NCV) of waste being treated.

Table 10: Waste Incineration Facilities: Treatment of Waste and Energy Recovered, 2020, ADEME 2022

Waste treated (tonnes)	NCV waste (GWh/tonne)	Total energy in waste (GWh, NCV)	Electricity (MWhe)	Heat (MWh$_t$)	kWhe/kg	kWht/kg
3,001,018	2.9	8,702,952.2	2,061,939	2,344,475	0.69	0.78
3,241,493	2.9	9,400,329.7	2,467,641		0.76	
6,242,511	**2.9**	18,103,281.9	**4,529,581**	**2,344,475**	**0.73**	**0.38**

The efficiencies calculated for the NCV of 2.9MWh per tonne are:

Electricity only: 26.3%

Combined heat and power: 23.7% electricity, 26.9% heat

Total: 25.0% electricity and 13.0% heat.

It is not clear whether the figures for electricity generation (or heat) are given 'gross' or 'net': we suspect that they may be quoted 'gross'. It is possible also that average NCVs for residual waste are higher than we have assumed here, so that our estimated efficiencies are higher than would be the case if wastes with higher NCV were being treated. The relatively intensive approach to separate collection of kitchen waste in many parts of Italy may, for example, lead to slightly elevated calorific values of waste being incinerated (relative to other EU countries with significant incineration capacity).

Netherlands

A report for the Netherlands indicates that in 2019, 7.39 million tonnes of waste were treated at incineration facilities. The same report noted energy production, gross, from these facilities. [9]

Table 11: Gross energy produced by waste incineration, 2015-2019.

	2015	2016	2017	2018	2019
Gross electricity production (GWh)	3,651	3,761	3,688	4,204	4,009
Delivered heat (PJ)	21.3	22.5	23.5	14.9	15.7
Total (PJ)	**34.4**	**36.0**	**36.8**	**30.0**	**30.2**

[9] Rijkswaterstaat (2021) Afvalverwerking in Nederland: gegevens 2019, report of the Werkgroep Afvalregistratie. – Utrecht: Rijkswaterstaat, August 2021.

Using the rightmost column, and assuming an NCV of 10 MJ/kg (footnotes to a Table in the report indicate that capacity has been estimated at different NCVs for waste, these ranging from 7.5 to 12.5 MJ/kg), then efficiencies can be estimated as follows for the overall fleet:

- Electricity (gross): 19.5%
- Heat (exported): 21.2%

Given these figures, and the differentials between 'gross' and 'net' efficiencies in the Member States already examined, we would expect net electricity generation to be of the order 16%.

Spain

For Spain, we use data from 2019 from MITECO. [10] Assuming a net calorific value of 10MJ/kg, then based on 2.44 million tonnes incinerated in 2019, and power generation of 1,628 GWh, then we estimate the efficiency of generation to be 24.1%. We assume this is 'gross' rather than net. If correct, the net efficiency might be of the order 20%.

United Kingdom

Analysis in 2017 by Tolvik of data relating to the Net Calorific Value of waste (from a variety of sources, some of which was under confidentiality) suggested that the average NCV for Residual waste collected by local authorities was 8.87MJ/Kg and for Residual Waste from commercial and industrial premises, it was 11.01 MJ/Kg. [11] Based on 2021 data, 77% of waste treated by incinerators was deemed to result from local authority collections, whilst the remainder (23%) originated from commerce (and industry). Most UK facilities operate in 'electricity only' mode. Based on Tolvik's calculations, the average NCV of waste incinerated would be 9.36 MJ/kg or 2.6 MWh/tonne. From the Tolvik report for 2021, UK figures for generation and efficiency are:

Net power export	0.584 MWh/tonne; efficiency 22.5%; and
Heat export	0.125 MWh/tonne; efficiency 4.8%.

Sweden

Of the Member States incinerating most waste, Sweden is the one most clearly focused on heat provision. For Sweden, we have used figures from the Afvall Sverige report of 2021. These do not indicate the NCV of respective waste streams and, in Sweden, much of the waste incinerated is from businesses and not classified as 'municipal' in the report.

[10] MITECO, *Memoria Anual de Generación y Gestión de Residuos: Residuos de Competencia Municipal. 2019*, 2020. See: https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/publicaciones/memoriaanual2019generacionygestionresiduosrescompetenciamunicipal_tcm30-534462.pdf

[11] Tolvik Consulting, *UK Energy from Waste Statistics – 2021*, May 2022. See: https://www.tolvik.com/wp-content/uploads/2022/05/Tolvik-UK-EfW-Statistics-2021_Published-May-2022.pdf

The efficiency calculations are sensitive to the assumptions regarding NCVs of waste being treated, and the high share of business waste in the mix of wastes incinerated makes it difficult to be certain of the calorific value of the input waste in this case.

In Table 12 below, we use figures of 10MJ/kg and 12MJ/kg, respectively, for municipal and business waste. This delivers high efficiencies of 85.7% for heat, and 11.9% for electricity. These seem barely plausible, although the use of condensation technology can allow for extraction of heat over and above the 100% figure as measured using net calorific values (as opposed to gross calorific values). The differences between net and gross calorific values is likely to be proportionately higher at lower NCV figures (where GCV may be 15% or higher than NCV).

Table 12: Electricity and Heat Production from Swedish Incineration and Estimated Efficiency, Avfall Sverige, 2021

	2020	NCV (GJ/tonne)	Energy in Waste (GWh/tonne)
Municipal waste	2,240,990	10	6,224,972
Business waste	4,646,980	12	15,489,933
Total	**6,887,970**		**21,714,906**

Production (MWh)			Efficiency of production
Heating	18,607,670		85.7%
Electricity	2,593,970		11.9%
Total	**21,201,640**		

An alternative calculation was performed using NCV figures reported for samples of waste taken from three facilities whose proportion of commercial waste was similar to that for all Sweden.[12] For samples taken at the Goteborg facility, the NCV is especially high (averaging 18MJ/kg – these may have been calculated as opposed to being based on direct measurement), but taking a simple (unweighted) average, then the average NCV of the samples was 13.9 MJ/kg. If this NCV is used for all waste incinerated in Sweden, the efficiencies of generation of electricity and heat fall to 70.0 and 9.8% respectively.

Whichever figure is accepted, they indicate much higher efficiencies for heat generation in facilities which are, to a large extent, oriented towards provision of district heating, than for power generation in facilities which are either dedicated to electricity production, or largely oriented to power production, though these latter facilities also export some heat.

[12] Avfall Sverige, Determination of the fossil carbon content in combustible municipal solid waste in Sweden, Rapport U2012:05, 2012. Note these figures are somewhat dated now. The data used were taken from the samples reported for Renova (Sävenäs CHP waste combustion plant), Umeå Energi and Borås Energi och Miljö (since the details regarding the samples indicated a significant share of commercial waste in the sample, as per the total reported for Sweden)

Further Observations

When waste is incinerated to generate electricity, the efficiency of the process is limited. It is challenging to achieve high efficiencies of electricity production in this way, and the upper end efficiency of production (gross) is in the mid-20s percent, with the upper end net efficiency being in the low 20's percent. Individual facilities can achieve better performance, and higher efficiencies might be more likely to be found at larger installations. Both the gross and net figures are expressed relative to the net calorific value of the input waste (they would be lower when expressed relative to gross calorific values). This can be compared with the main sources of fossil fuel power generation, which achieve generation efficiencies of the order upper 30's percent in the case of coal, and the mid-50's for gas, expressed relative to net calorific value of the fuels combusted.

Where waste is used to generate heat, the efficiencies obtained are generally much higher, and very high efficiencies can be achieved for export of heat. In this case, efficiencies are comparable with those of other fuels, and different sources of heat may feed into the same networks. There is a separate question to be asked as to the extent to which exported heat displaces other sources of heat at all times, and the nature of the sources being displaced. Yet it is clear that high efficiencies can be obtained only where the focus is on heat generation, or on cogeneration of heat and power. Though, in the latter case the 'penalty' associated with seeking to generate significant electricity for export can be significant in respect of a then lower heat export.

In Member States such as Sweden, Denmark, Finland, and to a proportionately lesser extent, Germany, district heating networks provide the basis for delivering heat derived from waste (and other fuels) into a heat network, whilst process steam can be delivered to other users. Heat networks are not trivial investments, and some of those in place in Nordic countries have been in function for many years already. However, there are some concerns emerging in Sweden that the existence of district heating networks might weaken the importance of improving thermal efficiency of buildings through, for example, choice of fabric in buildings. [13] There is a concern that this could, in turn, 'lock-in' municipalities to the use of waste for district heating, and reduce the emphasis on reducing and recycling that waste.

For installations yet to be built, focusing on electricity generation for the next twenty years or so seems unlikely to be productive, both because the efficiency of export of electricity is likely to be low, and because the background sources of power are likely to continue to decarbonize over the coming years.

[13] Equanimator, *Incineration and residues in the EU: quantities and fates*, September 2022.

Focusing on heat generation raises the question as to how best to do this in order to avoid lock-in, and to seek to maximise the associated carbon benefits. Here, the nature of the intended end-users becomes important:

1. If the intention is to supply new-build housing, then the question might reasonably asked as to what environmental benefits are generated from this. For new-build houses, focusing on design of the buildings and considering the use of supporting low carbon / renewable heating systems might be at least as environmentally beneficial as installing a new district heating network and supplying the housing with heat from waste incineration.
2. If the intention is to supply extant industry with heat, then the longevity of the end use application might be questioned (not least if the industrial user is under pressure to further decarbonize its source of heating); and
3. If the intention is to install a new heat network to supply existing housing, then the installation costs may be prohibitive given the need to both install the network and retrofit existing homes with infrastructure to make use of the heat delivered. Once again, the longevity of the commitment, given the desire to decarbonize heat, might suggest that the costs of the network installation (not to mention the incinerator) have to be recovered over a shorter time period than might be desirable.

None of these are especially compelling investment propositions in the context of a climate crisis, unless the waste used to generate heat can be 'de-fossilised' and / or the carbon dioxide emitted can be captured (and used).[14]

The comparative impacts, in terms of greenhouse gas emissions, can best be considered by de-composing the generation of energy from different fuels into two stages:

- What are the greenhouse gas emissions from each fuel, or waste, per unit of energy contained within it?
- What is the efficiency with which the energy generating process converts the energy in the fuel, or waste, into deliverable energy?

[14] On reducing fossil carbon content, sorting plastics from leftover mixed waste can help in this regard (see: D. Hogg,The case for sorting recyclables prior to landfill and incineration, Reloop, June 2022). On carbon capture and storage, opinions vary as to the likely viability and technological feasibility of this as a means of (more-or-less) complete CO_2 removal. Some reports highlight the energy penalty of doing this: it might be argued that, at least on environmental grounds, important as the energy penalty may be, the removal of the CO_2 justifies that penalty (especially if the energy is internally generated), as long as the resulting (non-CO_2) air emissions are not such as to give rise to major health problems.

Combining the two enables us to appreciate the greenhouse gas emissions associated with generating electricity or heat. In Table 13 below, we conduct this analysis for electricity. In Table 14, we do the same for heat. Where waste is concerned, we assume that one tonne of CO_2 is emitted from incinerating one tonne of waste of NCV 10GJ/ tonne, and that half of the CO_2 is of fossil origin, and half is of non-fossil origin. Table 13 and Table 14 both show (column [A]) that where non-fossil CO_2 is omitted, the CO_2e emissions per GJ of energy in the feedstock are lowest for waste, these being marginally below emissions per GJ of energy contained in natural gas[15] But in Table 13, the relative efficiencies of generation (column [B]) are such that the emissions of CO_2e per kWh of electricity generated from natural gas are around half those from waste (column [D]). In Table 14, we omit coal and compare the situation of a high efficiency district heating system with a modern gas boiler. Since the relative efficiencies of conversion to heat are similar, the figures for the emissions of greenhouse gases, expressed in CO_2e, are similar for natural gas and for waste, as long as non-fossil CO_2 emissions from waste are ignored.

Table 13: Basic Estimation of CO_2 intensity of Electricity Delivered by Incineration, and Gas- and Coal-fired Generation, Based on Carbon Content of Energy Source, and Generation Efficiency

	kg CO_2e per GJ (NCV) [A]	Efficiency of generation (relative to NCV) [B]	kg CO_2e per GJ delivered [C]	kg CO_2 per kWh electricity delivered [D]
Natural Gas	56.4	55%	102.5	0.369
Coal	93.6	35%	267.5	0.963
Waste, excl. biogenic CO_2	50.0	25%	200.0	0.720
Waste, incl. biogenic CO_2	100.0	25%	400.0	1.440

Table 14: Basic Estimation of CO_2 intensity of Heat Delivered from Incineration and Gas-fired Boilers Based on Carbon Content of Energy Source, and Generation Efficiency

	kg CO_2e per GJ (NCV)	Efficiency of generation (relative to NCV)	kg CO_2e per GJ delivered	kg CO_2 per kWh heat delivered
Natural Gas	56.4	95%	59.3	0.214
Waste, excl. biogenic CO_2	50.0	90%	55.6	0.200
Waste, incl. biogenic CO_2	100.0	90%	111.1	0.400

As soon as one factors in emissions of CO2 from non-fossil sources, then waste appears as big a source of greenhouse gas emissions – per unit of energy content – as coal (column [A]). The emissions of CO2e per unit of electricity are well above those for coal, and almost four times those from natural gas. For heat, the emissions of CO2e per kWh delivered are around double those from boilers fired by natural gas.

[15] Figures for natural gas and coal were taken from the UK Government GHG Conversion Factors for Company Reporting, downloadable from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022 (the CO_2/kWh (NCV basis) figures were multiplied by 1000/3.6 to give figures in CO_2/ GJ).

It should be noted that the above analysis likely understates the current greenhouse gas emissions associated with extracting coal and natural gas in the first place. These 'upstream emissions' will be influenced by the source of the coal or natural gas used. These emissions are – belatedly – attracting attention because where methane is concerned, addressing any losses can help reduce concentrations in the atmosphere, and the associated contribution to temperature change, over the relatively short-term.

Summary

The R1 criterion, which was established to help draw a distinction between 'recovery' and 'disposal,' fails to make a meaningful distinction between facilities that were deemed worthy of a permit – which would have to demonstrate recovery of heat '*as far as practicable*' - and facilities which achieved a relatively high performance in terms of energy efficiency. EU statistics reveal that 98% of municipal waste which is incinerated in the EU is incinerated in facilities classified as 'recovery'. For all intents and purposes, the efficiency threshold set under R1 is one which is far too easily met. The effect of *Amending Directive 2015/1127* in introducing a climate correction factor helped to narrow the distinction, but in truth, the criterion was always set in such a way that even newer facilities could achieve recovery status with a gross efficiency of just around 23%, equivalent to a net efficiency of around 19%. Thus, climate correction factors allow for the R1 criterion to be met at even lower efficiencies.

Nonetheless, efficiencies of existing incineration facilities, at the aggregate national level, are relatively low in those Member States where the focus is more on generation of electricity than heat - Table 15 summarises the figures for different Member States which were derived earlier in this report and shows that estimated efficiencies (based on assumed NCV values as shown in the Table) are generally low for electricity only facilities. At the aggregate level, they rarely sum to more than 40% gross, even if one assumes that heat and electricity should be given equivalent status (which is unclear). [16]

Table 15: Summary of Efficiency of Energy generation from Incineration, National Level Figures [17]

		Elec only		Heat only		Cogen				Total			
	NCV assumption (GJ/tonne)					Elec		Heat		Elec		Heat	
		Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
Germany	(given)									14.3%	10.9%	34%	
France	10.4	16.5%	13.5%	48.7%	42.3%	10.1%	7.3%	28.3%	22.7%	10.3%	7.6%	26.1%	21.1%
	9.5	18.2%	14.8%	53.5%	46.5%	11.0%	8.4%	31.1%	23.2%	11.3%	8.4%	28.7%	23.2%
Italy	10.4	26.3%				23.7%		26.9%		25.0%		13.0%	
Netherlands	10.0									19.5%		21.2%	
Spain	10.0	24.1%											
UK	(given @9.4)										22.5%		5.0%
Sweden	MSW=10.0; C&I=12.0									11.9%		85.0%	
	13.9									9.8%		70.0%	

[16] It should be noted that the Member States shown in the Figure are six of the top seven Member States in terms of the amount of municipal waste incinerated, as well as the UK (which would lie between France and Italy in the Table if ranked by quantity). Sweden incinerated slightly more than Spain in the year of reporting, but is shown separately as the Member State which is a) incinerating a large quantity of waste, and b) focussed mainly on use of incineration for heat generation.

[17] Where there are two rows for a given Member State, this reflects discussion in the Main Report regarding the net calorific value (NCV) of waste used in estimations of the efficiency of generation in a given Member State. Where this has not been made clear, analysis has been undertaken using more than one figure for the NCV

The weighting for electricity in the calculation – of 2.6 – was justified in the underlying BREF document through reference to a 38% average efficiency of conversion into electricity (presumably from fossil fuels). In reality, conversion efficiencies are now much higher: in 2018, the EEA noted '*Between 2005 and 2016, the efficiency of public conventional thermal power plants in the EU increased from 47 % to almost 50 %.*' [22] Efficiencies of electricity generation from waste, on the other hand, are in the mid-20's in the best cases. This compares with figures of around 35% for coal-fired generation, and 55% for CCGT.

Incineration is frequently considered a low carbon, sometimes even renewable (even if only partially), source of energy. It is neither. Especially when generating electricity only, typical efficiencies of generation compare poorly with those of coal fired electricity generating plant, and even worse when compared with combined cycle gas turbines. Even though (if one excludes the non-fossil CO_2 from the analysis) the greenhouse gas emissions per unit of energy content are relatively low for waste, the low generation efficiency of incineration leads to greenhouse gas emissions per unit of electricity being almost double those associated with natural gas generation. The situation is somewhat better, comparatively, as regards heat generation, but even here, performance is no better than that of domestic gas fired boilers. The situation worsens – the emissions effectively double, both for electricity and for gas – when emissions of non-fossil CO_2 from waste incineration are considered.

These comparisons are somewhat backward looking. As we look forward, especially at new-build housing or commercial properties, the counterfactual source of heat is increasingly unlikely to be gas as urban planners seek lower carbon sources of space heating and hot water, such as heat pumps. Suitable use of building fabric will minimise demand for space heating, whilst heat pumps are likely to increase the extent to which they supply the balance.

In previous work, we indicated that there is a compelling logic for abandoning the distinction between D10 and R1 incineration. We argued the point on the basis of the flawed rationale for making the distinction in the first place, and on the basis of the relative merits of 'landfill' and 'incineration' under current, and likely future, circumstances. We argued that sending leftover mixed waste directly either to incineration or landfill should no longer be considered acceptable in a world threatened by runaway climate change.

The analysis in this report strengthens the argument for abandoning the now meaningless distinction between D10 and R1 incineration. The R1 formula was badged as an 'energy efficiency' formula, but the formula has been amended such that it no longer promotes this goal. It covers facilities whose efficiency of generation of power (when operating to generate only power) is around half the average efficiency of EU gas fired power generation, and which generate electricity at twice the carbon intensity of gas fired power stations, as well as facilities which, when generating heat only, deliver heat at roughly the same carbon intensity as a gas-fired boiler.

[22] U.S. Energy Information Administration, "More than 60% of energy used for electricity generation is lost in conversion", July 2020. See: https://www.eia.gov/todayinenergy/detail.php?id=44436 (Accessed January 2023).

Zero Waste Europe is the European network of communities, local leaders, experts, and change agents working towards the elimination of waste in our society. We advocate for sustainable systems and the redesign of our relationship with resources, to accelerate a just transition towards zero waste for the benefit of people and the planet.

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