

Appendix 6 – Energy Efficiency Calculations

Section 1: Energy Efficiency calculation at projected MSW calorific value (11.3 Mj/kg) in 2021.

Section 2: Energy Efficiency calculation at existing MSW calorific value (8.8 Mj/kg) assuming no change in waste characteristics.

Section 3: Energy Efficiency calculation assuming 50% adoption of FOGO MSW calorific value (12.3 Mj/kg)

Section 1: Energy Efficiency calculation at projected MSW calorific value (11.3 Mj/kg) in 2021.

	Type of energy	Unit	Reporting Year			
			Amount	NCV KJ/kg	Energy Ex GJ/a	
	Hours operation per year		8,000			
1	Amount of gasified waste (without 1.2 and 1.3)	t/a	200,000	11,300	2,260,000	600 tpd waste
1	Amount of incinerated sewage sludge	t/a	0			
1	Amount activated carbon incinerated	t/a	0			
1	Other	t/a	0			
1	Ew: energy input to the system by waste				2,260,000	
2	Ef 1: amount of light fuel oil for start up	Litre/a	10,600	35,900	381	KJ/Litre
2	Ef 2: amount of light fuel oil for keeping the gasification temperature	Litre/a	0			
2	Ef 3: amount of natural gas for start up and keeping gasification temperature	Nm3/a	0			
2	Ef 4: amount of wood for start-up	t/a	120	12,500	1,500	6 gasifiers 2 starts/year x 10t per start
2	Ef 5: amount of wood for keeping the gasification temperature	t/a	0			
2	S Ef: energy input by imported energy <u>with</u> steam production				1,881	
3	Ei 1: amount of light fuel oil for start up/shut down (no connection with the steam grid)		0			
3	Ei 2: e.g. natural gas for heating up of flue gas temperature for SCR and start up/shut down		0			
3	Ei 3: imported electricity (multiplied with the equivalence factor 2.6)		0			
3	Ei 4: imported heat (multiplied with the equivalence factor 1.1)		0			
3	S Ei: energy input by imported energy <u>without</u> steam production				0	
4	Epel internal used: electricity produced and internally used for the gasification process	kW	2,100		60,480	
4	Epel exported: electricity delivered to a third party	kW	15,140		436,032	
4	S Epel produced = Epel internal used + Epel exported				496,512	
5	Epheat exp.1: steam delivered to a third party without backflow as condensate		0			
5	Epheat exp.2: district heat delivered to a third party with backflow as condensate (hot water)		0			
5	S Epheat exported = Epheat exp.1 + Epheat exp.2					
6	Epheat int.used-1: for steam driven turbo pumps for boiler water, backflow as steam	t/a	0			
6	Epheat int.used-2: for heating up of flue gas with steam, backflow as condensate	t/a	24,000	2,380	57,120	
6	Epheat int.used-4: for concentration of liquid APC residues with steam, backflow as condensate	t/a	0			
6	Epheat int.used-5: for soot blowing without backflow as steam or condensate	t/a	900	2,918	2,626	
7	Epheat int.used-7: for heating purposes of buildings/instruments/silos, backflow as condensate	t/a	10,000	2,380	23,800	
7	Epheat int.used-8: for deaeration- demineralization with condensate as boiler water input	t/a	86,400	2,699	233,194	
7	Epheat int.used-9: for NH ₄ OH (water) injection without backflow as steam or condensate	t/a	0			
6	S Epheat int.used = S Epheat int.used (1-9)				316,740	
	R1 = (Ep - (Ef + Ei)) / (0.97 * (Ew + Ef))				0.746	
	Ep = 2.6*(S Epel int.used+S Epel exported) + 1.1*(S Epheat int.used+S Epheat exported)				1,639,345	

(Source: Based on 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).

Section 2: Energy Efficiency calculation at existing MSW calorific value (8.8 Mj/kg) assuming no change in waste characteristics.

	Type of energy	Unit	Reporting Year			
			Amount	NCV KJ/kg	Energy Ex GJ/a	
	Hours operation per year		8,000			
1	Amount of gasified waste (without 1.2 and 1.3)	t/a	200,000	8,800	1,760,000	600 tpd waste
1	Amount of incinerated sewage sludge	t/a	0			
1	Amount activated carbon incinerated	t/a	0			
1	Other	t/a	0			
1	Ew: energy input to the system by waste				1,760,000	
2	Ef 1: amount of light fuel oil for start up	Litre/a	10,600	35,900	381	KJ/Litre
2	Ef 2: amount of light fuel oil for keeping the gasification temperature	Litre/a	0			
2	Ef 3: amount of natural gas for start up and keeping gasification temperature	Nm3/a	0			
2	Ef 4: amount of wood for start-up	t/a	120	12,500	1,500	6 gasifiers 2 starts/year x 10t per start
2	Ef 5: amount of wood for keeping the gasification temperature	t/a	0			
2	S Ef: energy input by imported energy <u>with</u> steam production				1,881	
3	Ei 1: amount of light fuel oil for start up/shut down (no connection with the steam grid)		0			
3	Ei 2: e.g. natural gas for heating up of flue gas temperature for SCR and start up/shut down		0			
3	Ei 3: imported electricity (multiplied with the equivalence factor 2.6)		0			
3	Ei 4: imported heat (multiplied with the equivalence factor 1.1)		0			
3	S Ei: energy input by imported energy <u>without</u> steam production				0	
4	Epel internal used: electricity produced and internally used for the gasification process	kW	1,800		51,840	
4	Epel exported: electricity delivered to a third party	kW	11,628		334,886	
4	S Epel produced = Epel internal used + Epel exported				386,726	
5	Epheat exp.1: steam delivered to a third party without backflow as condensate		0			
5	Epheat exp.2: district heat delivered to a third party with backflow as condensate (hot water)		0			
5	S Epheat exported = Epheat exp.1 + Epheat exp.2					
6	Epheat int.used-1: for steam driven turbo pumps for boiler water, backflow as steam	t/a	0			
6	Epheat int.used-2: for heating up of flue gas with steam, backflow as condensate	t/a	20,000	2,380	47,600	
6	Epheat int.used-4: for concentration of liquid APC residues with steam, backflow as condensate	t/a	0			
6	Epheat int.used-5: for soot blowing without backflow as steam or condensate	t/a	900	2,918	2,626	
7	Epheat int.used-7: for heating purposes of buildings/instruments/silos, backflow as condensate	t/a	10,000	2,380	23,800	
7	Epheat int.used-8: for deaeration- demineralization with condensate as boiler water input	t/a	67,184	2,699	181,330	
7	Epheat int.used-9: for NH ₄ OH (water) injection without backflow as steam or condensate	t/a	0			
6	S Epheat int.used = S Epheat int.used (1-9)				255,356	
	R1 = (Ep - (Ef + Ei)) / (0.97 * (Ew + Ef))				0.752	
	Ep = 2.6*(S Epel int.used+S Epel exported) + 1.1*(S Epheat int.used+S Epheat exported)				1,286,380	

(Source: Based on 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).

**Section 3: Energy Efficiency calculation assuming 50% adoption of
FOGO MSW calorific value (12.3 MJ/kg)**

	Type of energy	Unit	Reporting Year			
			Amount	NCV KJ/kg	Energy Ex GJ/a	
	Hours operation per year		8,000			
1.1	Amount of gasified waste (without 1.2 and 1.3)	t/a	200,000	12,300	2,460,000	600 tpd waste
1.2	Amount of incinerated sewage sludge	t/a	0			
1.3	Amount activated carbon incinerated	t/a	0			
1.4	Other	t/a	0			
1.0	Ew: energy input to the system by waste				2,460,000	
2.1	Ef 1: amount of light fuel oil for start up	Litre/a	10,600	35,900	381	KJ/Litre
2.2	Ef 2: amount of light fuel oil for keeping the gasification temperature	Litre/a	0			
2.3	Ef 3: amount of natural gas for start up and keeping gasification temperature	Nm3/a	0			
	Ef 4: amount of wood for start-up	t/a	120	12,500	1,500	6 gasifiers 2 starts/year x 10t per start
	Ef 5: amount of wood for keeping the gasification temperature	t/a	0			
2.0	S Ef: energy input by imported energy <u>with</u> steam production				1,881	
3.1	Ei 1: amount of light fuel oil for start up/shut down (no connection with the steam grid)		0			
3.2	Ei 2: e.g. natural gas for heating up of flue gas temperature for SCR and start up/shut down		0			
3.3	Ei 3: imported electricity (multiplied with the equivalence factor 2.6)		0			
3.4	Ei 4: imported heat (multiplied with the equivalence factor 1.1)		0			
3.0	S Ei: energy input by imported energy <u>without</u> steam production				0	
4.1	Epel internal used: electricity produced and internally used for the gasification process	kW	2,800		80,640	
4.2	Epel exported: electricity delivered to a third party	kW	15,966		459,821	
4.0	S Epel produced = Epel internal used + Epel exported				540,461	
5.1	Epheat exp.1: steam delivered to a third party without backflow as condensate		0			
5.2	Epheat exp.2: district heat delivered to a third party with backflow as condensate (hot water)		0			
5.0	S Epheat exported = Epheat exp.1 + Epheat exp.2					
6.1	Epheat int.used-1: for steam driven turbo pumps for boiler water, backflow as steam	t/a	0			
6.2	Epheat int.used-2: for heating up of flue gas with steam, backflow as condensate	t/a	20,000	2,380	47,600	
6.3	Epheat int.used-4: for concentration of liquid APC residues with steam, backflow as condensate	t/a	0			
6.4	Epheat int.used-5: for soot blowing without backflow as steam or condensate	t/a	900	2,918	2,626	
6.5	Epheat int.used-7: for heating purposes of buildings/instruments/silos, backflow as condensate	t/a	10,000	2,380	23,800	
6.6	Epheat int.used-8: for deaeration- demineralization with condensate as boiler water input	t/a	93,856	2,699	253,317	
6.7	Epheat int.used-9: for NH ₄ OH (water) injection without backflow as steam or condensate	t/a	0			
6.0	S Epheat int.used = S Epheat int.used (1-9)				327,344	
	R1 = (Ep - (Ef + Ei)) / (0.97 * (Ew + Ef))				0.738	
	Ep = 2.6*(S Epel int.used+S Epel exported) + 1.1*(S Epheat int.used+S Epheat exported)				1,765,276	

(Source: Based on 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).