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Business Unit:	Integrity
In Association with	bio Intelligence Service
Report Title:	**Sustainable Industrial Policy – Building on the Eco-design Directive – Energy-Using Products Group Analysis / 2** **Lot 4: Industrial and Laboratory Furnaces and Ovens – Appendices**
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Client:	**European Commission, DG Enterprise**
Client Reference:	ENTR-2009-35 Contract SI2.549003
Report Number:	2012-0230
Project Number:	
Report Version:	**FINAL Report Appendices**

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11 September 2012

Ref. 043122753 Draft Task 1-5 Rep final

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Appendix A - EU Member State data

The following tables include data for section 2 (PRODCOM Eurostat data).

Table 1. Number and value of exports, imports and production of furnace burners for liquid fuel by Member State, 2008

Country	Exports		Imports		Production	
	Volume (Number of units)	Value (€m)	Volume (Number of units)	Value (€m)	Volume (Number of units)	Value (€m)
Austria	1 581	1.6	4 614	2.7	n/a	0.0
Belgium	3 276	0.5	38 139	11.6	n/a	0.0
Bulgaria	19	0.2	12 971	1.3	n/a	0.0
Croatia	n/a	0.0	n/a	0.0	0	0.0
Czech Republic	1 620	1.8	2 072	0.5	n/a	0.0
Denmark	2 205	0.5	19 511	7.7	0	0.0
Estonia	10	0.0	372	0.2	0	0.0
Finland	2 167	9.9	1 977	1.5	11 578	19.3
France	139 793	29.0	94 190	12.7	NA	0.0
Germany	103 939	74.0	40 185	17.3	147 935	129.4
Greece	1 242	0.3	91 523	10.1	0	0.0
Hungary	0	0.0	17 122	0.3	0	0.0
Iceland	n/a	0.0	n/a	0.0	0	0.0
Ireland	71	0.0	60 650	7.4	n/a	0.0
Italy	589 430	75.2	29 486	3.5	700 318	131.6
Latvia	79	0.0	11 529	0.2	0	0.0
Lithuania	163	0.2	554	0.3	0	0.0
Luxemburg	502	0.2	2 485	0.9	0	0.0
Malta	0	0.0	18	0.0	0	0.0
Netherlands	94 445	7.5	30 053	5.6	NA	19.0
Norway	n/a	0.0	n/a	0.0	0	0.0
Poland	351	1.7	4277	2.0	n/a	0.0
Portugal	140	0.1	82 548	1.1	0	0.0
Romania	266	1.1	8 299	2.4	0	0.0
Slovakia	33	0.0	1 512	0.1	0	0.0
Slovenia	1 186	0.8	5 524	1.7	0	0.0
Spain	29 737	2.2	538 142	15.8	2 847	5.0
Sweden	74 083	16.0	5 065	2.2	n/a	0.0
UK	51 738	12.8	141 485	18.1	13 545	6.1
EU-27 total	**587 487**	**122.4**	**124 745**	**10.7**	**1 153 836**	**392.6**

Table 2. Apparent consumption of furnace burners for liquid fuel by Member State, 2008

Country	Volume (number of units)
Austria	-
Belgium	-
Bulgaria	-
Croatia	0
Czech Republic	-
Denmark	17,306
Estonia	362
Finland	11,388
France	-
Germany	84,181
Greece	90,281
Hungary	17,122
Iceland	0
Ireland	-
Italy	140,374
Latvia	11,450
Lithuania	391
Luxemburg	1,983
Malta	18
Netherlands	-
Norway	0
Poland	-
Portugal	82,408
Romania	8,033
Slovakia	1,479
Slovenia	4,338
Spain	511,252
Sweden	-
UK	103,292
EU-27 total	**691,094**

Table 3. Production of furnace burners for solid fuel or gas (including combination burners) by Member State, 2008

Country	Volume (number of units)	Value (€m)
Austria	n/a	n/a
Belgium	n/a	n/a
Bulgaria	n/a	n/a
Croatia	0	0.0
Czech Republic	2,838	8.1
Denmark	0	0.0
Estonia	0	0.0
Finland	2,026	15.7
France	n/a	n/a
Germany	95,735	224.8
Greece	0	0.0
Hungary	n/a	n/a
Iceland	0	0.0
Ireland	n/a	n/a
Italy	53,480,833	186.6
Latvia	0	0.0
Lithuania	414	0.0
Luxemburg	0	0.0
Malta	0	0.0
Netherlands	n/a	85.5
Norway	0	0.0
Poland	137,757	2.3
Portugal	3,610	2.5
Romania	n/a	n/a
Slovakia	n/a	n/a
Slovenia	0	0.0
Spain	1,767	14.1
Sweden	2,997	7.9
UK	26,933	72.4
EU-27 total	**53,962,732**	**705.5**

Table 4. Production of electric bakery and biscuit ovens by Member State, 2008

Country	Volume (number of units)	Value (€m)
Austria	n/a	n/a
Belgium	0	0.0
Bulgaria	n/a	1.0
Croatia	n/a	n/a
Czech Republic	n/a	n/a
Denmark	0	0.0
Estonia	n/a	n/a
Finland	0	0.0
France	3,980	25.8
Germany	22,410	85.6
Greece	n/a	n/a
Hungary	0	0.0
Iceland	0	0.0
Ireland	0	0.0
Italy	69,388	57.3
Latvia	0	0.0
Lithuania	0	0.0
Luxemburg	0	0.0
Malta	0	0.0
Netherlands	0	0.0
Norway	n/a	n/a
Poland	n/a	0.6
Portugal	n/a	n/a
Romania	0	0.0
Slovakia	0	0.0
Slovenia	0	0.0
Spain	12,619	38.4
Sweden	2,279	16.8
UK	0	0.0
EU-25 total	**112,718**	**241.3**
EU-27 total	**113,118**	**242.3**

Table 5. Production of non-electric bakery and biscuit ovens by Member State, 2008

Country	Volume (number of units)	Value (€m)
Austria	0	0.0
Belgium	0	0.0
Bulgaria	12	0.9
Croatia	n/a	n/a
Czech Republic	n/a	n/a
Denmark	393	1.7
Estonia	0	0.0
Finland	0	0.0
France	4,601	39.6
Germany	n/a	n/a
Greece	n/a	n/a
Hungary	n/a	n/a
Iceland	0	0.0
Ireland	0	0.0
Italy	15,880	99.1
Latvia	0	0.0
Lithuania	0	0.0
Luxemburg	0	0.0
Malta	0	0.0
Netherlands	n/a	n/a
Norway	0	0.0
Poland	n/a	n/a
Portugal	453	5.5
Romania	0	0.0
Slovakia	0	0.0
Slovenia	n/a	n/a
Spain	4,405	17.3
Sweden	n/a	n/a
UK	95	9.8
EU-25 total	**28,290**	**266.4**
EU-27 total	**28,302**	**267.3**

Table 6. Volume and value of exports, imports and production of non-electric industrial or laboratory furnaces and ovens by Member State, 2008

	Exports		Imports		Production	
Country	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)
Austria	1,611	8.1	3,054	16.4	n/a	n/a
Belgium	667	5.4	1,711	12.8	0	0.0
Bulgaria	0	0.0	932	5.5	94	0.4
Croatia	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	1,740	11.0	863	8.4	832	8.0
Denmark	785	13.2	1,671	1.9	0	3.2
Estonia	2	0.0	95	0.7	7	0.0
Finland	1,786	19.3	196	2.6	0	0.0
France	3,251	37.5	1,810	14.6	9	172.7
Germany	8,419	96.2	2,014	17.9	n/a	n/a
Greece	42	0.2	372	3.1	n/a	n/a
Hungary	1,998	9.3	2,177	27.7	n/a	n/a
Iceland	n/a	n/a	n/a	n/a	0	0.0
Ireland	11	0.2	18	0.3	n/a	n/a
Italy	45,812	251.2	1,515	8.6	23,913	164.2
Latvia	172	0.7	199	1.0	0	0.0
Lithuania	25	0.2	53	0.7	0	n/a
Luxemburg	0	0.0	17	0.3	0	0.0
Malta	1	0.0	27	0.1	0	0.0
Netherlands	1,043	10.0	776	11.4	n/a	n/a
Norway	n/a	n/a	n/a	n/a	n/a	n/a
Poland	3,887	13.9	2,674	14.1	n/a	4.0
Portugal	794	2.8	746	18.4	341	1.4
Romania	84	0.3	3,158	18.3	n/a	n/a
Slovakia	10	0.1	128	0.9	0	0.0
Slovenia	348	3.8	100	1.0	n/a	n/a
Spain	4,232	18.6	3,757	24.4	4,021	24.1
Sweden	688	16.1	239	3.8	44,933	14.5
UK	3,760	28.5	1,363	9.6	n/a	29.0
EU-25 total	**58,908**	**390.1**	**4,730**	**33.5**	**145,122**	**742.7**
EU-27 total	**56,641**	**379.8**	**5,121**	**35.7**	**145,242**	**744.2**

Table 7. Volume and value of exports, imports and production of resistance heated industrial or laboratory furnaces and ovens by Member State, 2008

Country	Exports		Imports		Production	
	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)
Austria	913	34	340	10	n/a	n/a
Belgium	317	9	385	9	0	0
Bulgaria	53	0	72	2	n/a	n/a
Croatia	n/a	n/a	n/a	n/a	0	0
Czech Republic	1,147	14	275	4	428	11
Denmark	713	9	110	3	0	10
Estonia	19	0	28	1	0	0
Finland	154	3	310	6	n/a	0
France	349	13	1,321	22	572	60
Germany	10,349	349	1,505	32	13,385	463
Greece	18	0	44	1	0	0
Hungary	0	0	289	4	n/a	n/a
Iceland	n/a	n/a	n/a	n/a	0	0
Ireland	2	0	26	1	0	0
Italy	2,734	42	397	12	4,744	64
Latvia	5	0	8	0	0	0
Lithuania	322	4	25	1	304	4
Luxemburg	0	0	55	1	0	0
Malta	0	0	5	0	0	0
Netherlands	377	14	89	3	n/a	n/a
Norway	n/a	n/a	n/a	n/a	0	0
Poland	693	10	375	6	n/a	n/a
Portugal	40	0	69	1	12	1
Romania	275	1	404	6	n/a	n/a
Slovakia	3	3	33	2	0	0
Slovenia	188	2	169	3	n/a	n/a
Spain	807	11	706	13	458	14
Sweden	929	13	208	4	538	12
UK	610	18	788	13	n/a	19
EU-25 total	**13,406**	**390**	**3,054**	**51**	**31,781**	**810**
EU-27 total	**13,563**	**388**	**3,153**	**53**	**31,805**	**811**

Table 8. Volume and value of exports, imports and production of electrical induction industrial or laboratory furnaces and ovens by Member State, 2008

Country	Exports		Imports		Production	
	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)
Austria	35.5	1.3	289.6	6.1	0.0	0.0
Belgium	26.0	0.2	119.3	1.5	n/a	n/a
Bulgaria	25.9	0.5	12.9	0.1	0.0	0.0
Croatia	n/a	n/a	n/a	n/a	0.0	0.0
Czech Republic	158.9	1.7	292.3	3.3	641.6	7.1
Denmark	12.6	0.2	3.2	0.1	0.0	0.0
Estonia	4.7	0.0	2.2	0.0	0.0	0.0
Finland	19.4	0.4	63.2	2.9	0.0	0.0
France	163.4	8.3	540.5	8.8	n/a	n/a
Germany	3,671.5	69.2	377.4	8.8	5,851.2	124.9
Greece	0.0	0.0	9.9	0.2	0.0	0.0
Hungary	0.0	0.0	23.5	0.8	0.0	0.0
Iceland	n/a	n/a	n/a	n/a	0.0	0.0
Ireland	1.5	0.0	5.6	0.2	0.0	0.0
Italy	1,232.8	33.9	533.1	6.5	1,879.4	48.5
Latvia	0.0	0.0	3.3	0.1	0.0	0.0
Lithuania	0.8	0.1	2.0	0.1	1.0	0.0
Luxemburg	0.0	0.0	0.0	0.0	0.0	0.0
Malta	0.0	0.0	0.9	0.0	0.0	0.0
Netherlands	35.1	3.0	6.3	1.1	0.0	0.0
Norway	n/a	n/a	n/a	n/a	0.0	0.0
Poland	2.1	0.0	486.1	7.3	311.0	3.3
Portugal	0.0	0.0	8.2	0.4	0.6	0.1
Romania	24.0	0.5	61.2	1.7	0.0	0.0
Slovakia	83.7	1.2	10.3	0.8	0.0	0.0
Slovenia	134.6	1.8	65.7	1.1	0.0	0.0
Spain	198.7	3.7	85.2	2.2	192.9	10.3
Sweden	326.3	8.3	34.8	1.5	0.0	0.0
UK	2,360.9	34.3	62.6	1.6	n/a	n/a
EU-25 total	**5,684.1**	**104.2**	**644.8**	**10.4**	**10,189.4**	**255.4**
EU-27 total	**5,495.3**	**99.9**	**649.5**	**10.7**	**10,189.4**	**255.4**

Table 9. Volume and value of exports, imports and production of electrical industrial/laboratory furnaces/ovens, induction/dielectric heating equipment by Member State, 2008

	Exports		Imports		Production	
Country	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)
Austria	1,150.2	29.8	467.4	12.4	n/a	n/a
Belgium	688.9	13.9	632.7	14.4	0.0	0.0
Bulgaria	42.6	0.8	113.9	1.1	0.0	0.0
Croatia	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	153.6	2.9	327.9	15.4	1,001.4	6.5
Denmark	418.0	5.3	199.4	7.0	0.1	1.9
Estonia	31.5	0.5	17.9	0.4	112.7	2.1
Finland	25.3	1.3	473.7	9.4	n/a	1.5
France	1,077.3	31.6	870.0	20.4	6.1	23.8
Germany	6,106.0	216.5	1,990.3	50.0	5,735.3	193.8
Greece	32.5	0.1	80.5	1.8	0.0	0.0
Hungary	51.7	0.1	151.1	3.5	0.0	0.0
Iceland	n/a	n/a	n/a	n/a	0.0	0.0
Ireland	39.0	3.5	36.0	1.4	0.0	0.0
Italy	3,859.2	62.3	1,268.9	27.6	9,476.1	76.7
Latvia	4.8	0.2	24.1	0.7	0.0	0.0
Lithuania	24.8	0.6	69.7	1.0	0.0	0.0
Luxemburg	4.3	0.2	12.0	0.1	0.0	0.0
Malta	0.8	0.1	12.0	0.1	0.0	0.0
Netherlands	644.1	20.7	460.9	14.6	n/a	n/a
Norway	n/a	n/a	n/a	n/a	0.0	0.0
Poland	1,734.9	23.8	431.8	11.3	4,364.0	54.8
Portugal	91.1	1.0	131.9	2.5	1,358.9	3.4
Romania	28.8	0.2	314.0	6.5	0.0	0.0
Slovakia	13.7	0.2	33.9	0.9	0.0	0.0
Slovenia	14.8	0.7	555.2	7.7	n/a	n/a
Spain	1,659.3	17.7	739.8	17.6	n/a	n/a
Sweden	103.1	5.3	529.5	15.4	n/a	n/a
UK	1,917.1	52.7	2,705.7	28.4	n/a	25.0
EU-25 total	**12,952.5**	**309.1**	**6,209.0**	**103.8**	**27,149.4**	**480.0**
EU-27 total	**12,792.4**	**305.5**	**6,276.1**	**103.8**	**27,149.4**	**480.0**

Table 10. Volume and value of exports, imports and production of electric infra-red radiation ovens by Member State, 2008

Country	Exports		Imports		Production	
	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)	Volume (tonnes)	Value (€m)
Austria	0.5	0.0	1.9	0.1	0.0	0.0
Belgium	3.4	0.2	47.2	0.2	0.0	0.0
Bulgaria	31.7	0.5	0.5	0.0	0.0	0.0
Croatia	n/a	n/a	n/a	n/a	0.0	0.0
Czech Republic	0.0	0.0	4.9	0.2	0.0	0.0
Denmark	0.6	0.0	0.0	0.0	0.0	0.0
Estonia	0.1	0.0	0.3	0.0	0.0	0.0
Finland	1.3	0.1	2.5	0.2	0.0	0.0
France	15.7	2.0	223.9	2.3	n/a	3.1
Germany	39.1	5.0	46.2	1.4	n/a	n/a
Greece	0.0	0.0	30.0	1.9	n/a	n/a
Hungary	0.0	0.0	3.1	0.0	0.0	0.0
Iceland	n/a	n/a	n/a	n/a	0.0	0.0
Ireland	0.1	0.0	1.8	0.1	0.0	0.0
Italy	107.9	1.5	8.4	0.5	445.6	4.7
Latvia	0.3	0.0	12.0	0.1	0.0	0.0
Lithuania	7.1	0.1	0.8	0.0	0.0	0.0
Luxemburg	0.0	0.0	7.0	0.1	0.0	0.0
Malta	n/a	n/a	n/a	n/a	0.0	0.0
Netherlands	22.2	0.8	57.5	1.7	n/a	n/a
Norway	n/a	n/a	n/a	n/a	0.0	0.0
Poland	0.9	0.0	41.9	0.5	0.0	0.0
Portugal	0.1	0.0	18.3	0.3	0.0	0.0
Romania	0.0	0.0	39.3	0.5	0.0	0.0
Slovakia	0.1	0.0	0.0	0.0	0.0	0.0
Slovenia	0.4	0.0	1.6	0.0	0.0	0.0
Spain	41.6	0.5	106.5	0.8	n/a	n/a
Sweden	3.6	0.4	6.7	0.1	0.0	0.0
UK	274.5	1.6	75.2	1.2	0.0	0.0
EU-25 total	**434.9**	**7.7**	**156.4**	**4.6**	**1,000.0**	**16.3**
EU-27 total	**434.2**	**7.6**	**157.4**	**4.7**	**1,000.0**	**16.3**

The following tables include Member State data for Task 2**Error! Reference source not found.**

Table 11. The evolution of electricity rates between mid-2007 and mid-2009 for customers (500-2000 MWh) in EU-27[1] (all taxes included)

Member State	**Rate [€/kWh]**			
	2008S1	**2008S2**	**2009S1**	**2009S2**
Austria	0.1276	0.1286	:	:
Belgium	0.1293	:	0.1344	:
Bulgaria	0.0675	0.0782	0.0777	0.0767
Cyprus	0.1638	0.2075	0.1360	0.1715
Czech Republic	0.1318	0.1335	0.1271	0.1335
Denmark	0.2113	0.2240	0.2067	0.2136
Estonia	0.0669	0.0711	0.0759	0.0774
Finland	0.0781	0.0822	0.0841	0.0833
France	0.0778	0.0736	0.0865	0.0784
Germany	0.1410	0.1428	0.1505	0.1515
Greece	0.0941	0.1006	0.1037	0.1020
Hungary	0.1371	0.1461	0.1487	0.1554
Ireland	0.1489	0.1604	0.1364	0.1327
Italy	0.1584	0.1685	0.1824	0.1581
Latvia	0.0779	0.0940	0.1085	0.1082
Lithuania	0.0978	0.0990	0.1099	0.0954
Luxembourg	0.1035	0.1038	0.1227	0.1228
Malta	0.1282	0.1700	0.1581	0.1356
Netherlands	0.1180	0.1220	0.1340	0.1320
Poland	0.1075	0.1110	0.1100	0.1139
Portugal	0.0939	0.0946	0.0984	0.0989
Romania	0.1057	0.1134	0.0970	0.0990
Slovakia	0.1368	0.1534	0.1693	0.1670
Slovenia	0.1118	0.1182	0.1342	0.1155
Spain	0.1108	0.1238	0.1338	0.1299
Sweden	0.0866	0.0965	0.0832	0.0861
United Kingdom	0.1147	0.1279	0.1283	0.1164
European Union 27	**0.1194**	**0.1253**	**0.1305**	**0.1253**

[1] Eurostat (2010), "Electricity - industrial consumers - half-yearly prices - New methodology from 2007 onwards".

Table 12. Electricity rates in the first semester of 2009 according to taxes breakdown in EU-27[2] for average industrial consumers (500 – 2000MWh)

Member State	Rate [€/kWh]		
	Without taxes	Without VAT	All taxes included
Austria	:	:	:
Belgium	:	:	:
Bulgaria	0.0634	0.0639	0.0767
Czech Republic	0.1110	0.1122	0.1335
Denmark	0.0793	0.0927	0.2136
Germany	0.0958	0.1134	0.1515
Estonia	0.0575	0.0645	0.0774
Ireland	0.1170	0.1175	0.1327
Greece	0.0853	0.0936	0.1020
Spain	0.1066	0.1120	0.1299
France	0.0599	0.0656	0.0784
Italy	:	0.1370	0.1581
Cyprus	0.1472	0.1494	0.1715
Latvia	0.0893	0.0893	0.1082
Lithuania	0.0790	0.0790	0.0954
Luxembourg	0.1118	0.1158	0.1228
Hungary	0.1276	0.1297	0.1554
Malta	0.1291	0.1291	0.1356
Netherlands	0.0930	0.1110	0.1320
Poland	0.0886	0.0933	0.1139
Portugal	0.0932	0.0944	0.0989
Romania	0.0828	0.0828	0.0990
Slovenia	0.0921	0.0962	0.1155
Slovakia	0.1396	0.1403	0.1670
Finland	0.0656	0.0683	0.0833
Sweden	0.0684	0.0689	0.0861
United Kingdom	0.0973	0.1012	0.1164
European Union 27	**0.0913**	**0.1026**	**0.1253**

[2] Eurostat, http://nui.epp.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Table 13. Natural gas rates (including taxes) for consumers in the consumption band IC (1000-10000 GJ), between 2008 and 2009 in EU-27[3] (taxes included)

Member States	Rate [€/GJ]			
	2008S1	2008S2	2009S1	2009S2
Austria	:	:	:	:
Belgium	11.0600	13.0400	10.9000	10.1400
Bulgaria	6.8565	8.9120	10.4919	7.1480
Czech Republic	10.5608	13.0291	11.0608	8.9957
Denmark	:	21.1262	19.2852	16.9414
Germany	14.7600	16.4300	14.2600	11.4400
Estonia	8.2263	10.3394	8.8481	7.6630
Ireland	12.4800	12.2000	10.2800	8.0800
Spain	8.8640	10.4800	10.0944	8.7328
France	10.9300	12.8440	11.8700	10.3400
Italy	10.2710	12.4510	12.1880	8.6160
Latvia	9.3343	12.9890	13.1531	9.3030
Lithuania	10.3688	14.3275	10.3029	9.0917
Luxembourg	11.1400	12.0400	11.9200	10.6500
Hungary	11.6241	14.0565	12.3662	9.7429
Netherlands	11.4400	12.6580	12.6610	12.3630
Poland	10.2049	11.3883	9.4335	10.1955
Portugal	9.1250	9.6740	10.3000	7.5851
Romania	9.2700	9.2396	7.7146	7.0551
Slovenia	12.1400	15.1900	14.5500	11.5400
Slovakia	10.6105	15.6186	13.4510	10.6020
Finland	9.7000	11.4000	10.4000	9.7000
Sweden	17.9508	18.3688	13.7191	15.7882
United Kingdom	9.0719	10.2074	9.5994	6.6988
European Union 27	**11.0670**	**12.8311**	**11.7462**	**9.6012**

[3] Eurostat (2009), "Environment and Energy, Data in focus, 49/2009".

Table 14. Natural gas tax rates for consumers in the range 1000-10000 GJ, between 2008 and 2009 in EU-27[4]

Member States	Rate [€/GJ]		
	Without taxes	Without VAT	All taxes included
Austria	:	:	:
Belgium	8.0700	8.5000	10.1400
Bulgaria	5.9566	5.9566	7.1480
Czech Republic	7.2294	7.5594	8.9957
Denmark	5.4546	13.5558	16.9414
Germany	8.4900	9.6100	11.4400
Estonia	5.7699	6.3861	7.6630
Ireland	7.3100	7.3100	8.0800
Spain	7.5283	7.5283	8.7328
France	8.5000	8.8000	10.3400
Italy	7.4080	7.8330	8.6160
Latvia	7.6863	7.6863	9.3030
Lithuania	7.5535	7.5535	9.0917
Luxembourg	9.9600	10.0300	10.6500
Hungary	7.5155	7.7943	9.7429
Netherlands	8.7680	10.3890	12.3630
Poland	8.3585	8.3585	10.1955
Portugal	7.2239	7.2239	7.5851
Romania	3.8725	5.9288	7.0551
Slovenia	8.8300	9.6100	11.5400
Slovakia	8.7260	8.9090	10.6020
Finland	7.4000	8.0000	9.7000
Sweden	10.8785	12.6113	15.7882
UK	5.5279	5.8206	6.6988
European Union 27	**7.5557**	**8.2166**	**9.6012**

[4] Eurostat (2009), "Environment and Energy, Data in focus, 49/2009".

Table 15. Coal prices without VAT in 18 Member States, in June 2005[5]

State	Coal price (€/GJ)
Austria	12.68
Belgium	N.A
Czech Rep.	1.29
Denmark	20.80
Estonia	3.31
Finland	N.A.
France	15.03
Germany	9.23
Greece	N.A.
Hungary	3.88
Ireland	12.59
Latvia	1.75
Netherlands	N.A.
Poland	3.49
Portugal	N.A.
Slovakia	4.49
Spain	N.A.
Sweden	N.A.
EU average	**8.05**

[5] E. Alakangas et al. (2007) Biomass fuel trade in Europe, Summary Report. Eubionet II.

Table 16. EU-27 interest rates[6]

State	2006	2007	2008
Austria	3.79%	4.29%	4.27%
Belgium	3.81%	4.33%	4.42%
Bulgaria	4.18%	4.54%	5.38%
Cyprus	4.13%	4.48%	4.60%
Czech Republic	3.80%	4.30%	4.63%
Denmark	3.81%	4.29%	4.30%
Estonia	5.01%	6.09%	8.16%
Finland	3.78%	4.29%	4.30%
France	3.80%	4.30%	4.24%
Germany	3.76%	4.22%	4.00%
Greece	4.07%	4.50%	4.81%
Hungary	7.12%	6.74%	8.24%
Ireland	3.77%	4.31%	4.53%
Italy	4.05%	4.49%	4.69%
Latvia	4.13%	5.28%	6.43%
Lithuania	4.08%	4.55%	5.61%
Luxembourg	3.91%	4.56%	4.61%
Malta	4.32%	4.72%	4.81%
Netherlands	3.78%	4.29%	4.23%
Poland	5.23%	5.48%	6.07%
Portugal	3.91%	4.43%	4.53%
Romania	7.23%	7.13%	7.70%
Slovakia	4.41%	4.49%	4.72%
Slovenia	3.85%	4.53%	4.61%
Spain	3.78%	4.31%	4.37%
Sweden	3.70%	4.17%	3.90%
UK	4.38%	5.06%	4.51%
EU 27	**4.08%**	**4.57%**	**4.55%**

[6] Eurostat, Interest Rates, Long-term interest rates, Maastricht criterion interest rates, EMU convergence criterion series - Annual data, accessed 26 November 2009.

Table 17. EU-27 annual inflation rates (%)[7]

State	2006	2007	2008
Austria	1.70	2.20	3.20
Belgium	2.30	1.80	4.50
Bulgaria	7.40	7.60	12.00
Cyprus	2.20	2.20	4.40
Czech Republic	2.10	3.00	6.30
Denmark	1.90	1.70	3.60
Estonia	4.40	6.70	10.60
Finland	1.30	1.60	3.90
France	1.90	1.60	3.20
Germany	1.80	2.30	2.80
Greece	3.30	3.00	4.20
Hungary	4.00	7.90	6.00
Ireland	2.70	2.90	3.10
Italy	2.20	2.00	3.50
Latvia	6.60	10.10	15.30
Lithuania	3.80	5.80	11.10
Luxembourg	3.00	2.70	4.10
Malta	2.60	0.70	4.70
Netherlands	1.70	1.60	2.20
Poland	1.30	2.60	4.20
Portugal	3.00	2.40	2.70
Romania	6.60	4.90	7.90
Slovakia	4.30	1.90	3.90
Slovenia	2.50	3.80	5.50
Spain	3.60	2.80	4.10
Sweden	1.50	1.70	3.30
UK	2.30	2.30	3.60
EU 27	**2.30**	**2.40**	**3.70**

[7] Eurostat, Prices, Harmonised indices of consumer prices (HICP), HICP (2005=100) - Annual Data (average index and rate of change), accessed 27 November 2009.

Appendix B – Calculations of types of furnaces and ovens

Proportions by energy source and batch / continuous of large-size furnaces and ovens sold in the EU

Sector	Proportion Electric	Proportion fossil fuel	Proportion batch	Proportion continuous
Furnaces				
Cement		100%		100%
Lime		100%		100%
Steel production except electric arc		100%		100%
Electric arc (steel)	100%		100%	
Container glass melting		100%		100%
Flat glass melting	<5%	>95%		100%
Glass wool & domestic		100%		100%
Other glass		100%		
Brick & roof tile		100%		100%
Ceramic tiles & sanitary ware,		100%		100%
Other ceramic		100%		
Oil refinery		100%		100%
Large heat treatment		100%	92%	8%
Steel re-heating		100%		100%
Metal smelting and melting	5%	95%	50%	50%
Ovens				
Brick & roof tile		100%	40%	60%
Ceramic tiles & sanitary ware,		100%		100%
Bakery - bread		100%		100%
Bakery biscuits		100%		100%

Small and medium size industrial

Data by energy source

Small & Medium Industrial	Sales	Proportion Electric	Proportion fossil fuel	Number sales electric	Number sales gas
Belt furnace, steel screw heat treatment	100		100.0%	0	100
Non-ferrous heat treatment / air	500	80.0%	20.0%	400	100
Non-ferrous heat treatment / vacuum	500	100.0%		500	0
Non-ferrous heat treatment / induction	500	100.0%		500	0
Crucible melting	500	30.0%	70.0%	150	350
Rotary melting	40		100.0%	0	40
Bakery ovens (rack & deck) - industrial	50000	40.0%	60.0%	20000	30000
Medium multipurpose Ovens & Furnaces	500	80.0%	20.0%	400	100
Smaller multi-purpose ovens and furnaces	15000	95.0%	5.0%	14250	750
PCB reflow ovens	286	100.0%		286	0
Continuous furnaces (electronics, solar, etc.)	90	100.0%		90	0
Total				**36576**	**31440**
Total excluding bakery				**16576**	**1440**

Results: Including bakery ovens, 54% are electrically heated

Excluding bakery ovens, 92% are electrically heated

Batch / continuous ratio

Small & Medium Industrial	Sales	Proportion batch	Proportion continuous	Number sales batch	Number sales continuous
Belt furnace, steel screw heat treatment	100		100.0%	0	100
Non-ferrous heat treatment / air	500	50.0%	50.0%	250	250
Non-ferrous heat treatment / vacuum	500	100.0%		500	0
Non-ferrous heat treatment / induction	500	100.0%		500	0
Crucible melting	500	100.0%		500	0
Rotary melting	40	100.0%		40	0
Bakery ovens (rack & deck) - industrial	50000	100.0%		50000	0
Medium multipurpose Ovens & Furnaces	500	95.0%	5.0%	475	25
Smaller multi-purpose ovens and furnaces	15000	95.0%	5.0%	14250	750
PCB reflow ovens	286		100.0%	0	286
Continuous furnaces (electronics, solar, etc.)	90		100.0%	0	90
Grain dryer	2000	67.0%	33.0%	1340	660
Total				**67855**	**2161**
Total without bakery				**17855**	**2161**

Results: Including bakery ovens, 98% are batch, 2% are continuous

Excluding bakery ovens, 91.1% are batch, 8.9% are continuous

Oven (<450°) : Furnace (>450°C) ratio

Small & Medium Industrial	Sales	Ovens <450°C	Furnaces >450°C	Number ovens sold/y	Number furnaces sold/y
Belt furnace, steel screw heat treatment	100	0.0%	100.0%	0	100
Non-ferrous heat treatment / air	500	0.0%	100.0%	0	500
Non-ferrous heat treatment / vacuum	500	0.0%	100.0%	0	500
Non-ferrous heat treatment / induction	500	0.0%	100.0%	0	500
Crucible melting	500	0.0%	100.0%	0	500
Rotary melting	40	0.0%	100.0%	0	40
Bakery ovens (rack & deck) - industrial	50000	100.0%	0.0%	50000	0
Medium multipurpose Ovens & Furnaces	500	51.0%	49.0%	255	245
Smaller multi-purpose ovens and furnaces	15000	60.0%	40.0%	9000	6000
PCB reflow ovens	286	100.0%	0.0%	286	0
Continuous furnaces (electronics, solar, etc.)	90	0.0%	100.0%	0	90
Grain dryer	2000	100.0%	0.0%	2000	0
Total				**61541**	**8475**
Total without bakery				**11541**	**8475**

Results:

Including bakery ovens, 87.5% are ovens, 12.5% furnaces

Excluding bakery ovens, 58% are ovens, 42% furnaces.

Average power rating (kW)

Small & Medium Industrial	Sales	Average power rating electric KW	Average power rating gas KW	Number sales electric	Number sales gas	total kW elec	total kW gas
Belt furnace, steel screw heat treatment	100	0	1000	0	100	0	100000
Non-ferrous heat treatment / air	500	50	200	400	100	20000	20000
Non-ferrous heat treatment / vacuum	500	300		500	0	150000	0
Non-ferrous heat treatment / induction	500	300		500	0	150000	0
Crucible melting	500	50	200	150	350	7500	70000
Rotary melting	40	0	2000	0	40	0	80000
Bakery ovens (rack & deck) - industrial	50000	50	100	20000	30000	1000000	3000000
Medium multipurpose Ovens & Furnaces	500	96.7	204.8	400	100	38680	20480
Smaller multi-purpose ovens and furnaces	15000	50	100	14250	750	712500	75000
PCB reflow ovens	286	40		286	0	11440	0
Continuous furnaces (electronics, solar, etc.)	90	80	0	90	0	7200	0
Grain dryer	2000	0	1000	0	2000		2000000
Totals				36576	33440	2097320	5365480
Totals without bakery				**16576**	**3440**	1097320	2365480
Average kW						**57.3**	**160.5**
Average without bakery						**66.2**	**687.6**

Results:

Including bakery ovens, average electric power rating = 57.3 kW, gas power rating = 160.5 kW

Excluding bakery ovens, average electric power rating = 66.2 kW, gas power rating = 688 kW

Appendix C - First screening of the volume of sales and trade, environmental impact and potential for improvement of the products

EU Sales

There are no published accurate sales data for ovens and furnaces including from PRODCOM Eurostat. PRODCOM has data missing for many types of furnace and oven, and for some types sales are included with data for other types of equipment. The only PRODCOM data available for 2008 are:

Table 18. Oven and furnace sales data available from PRODCOM Eurostat data

PRODCOM category	PRODCOM data
Non-electric furnaces and ovens for the roasting, melting or other heat-treatment of ores, pyrites or of metals	7300 manufactured and sold
Electric bakery and biscuit ovens	113,118 manufactured /sold. This total probably includes commercial catering ovens which are covered by Lot study 22
Bakery ovens, including biscuit ovens, non-electric	28,300 manufactured /sold. This total probably includes commercial catering ovens which are covered by Lot study 22

There are also several PRODCOM categories with weight data only. As ovens and furnace weight varies considerably, this data cannot be used to calculate numbers sold.

PRODCOM category "'Non-domestic equipment for cooking or heating food (excluding non-electric tunnel ovens, non-electric bakery ovens, non-electric percolators)" had 988,000 manufactured / sold most of which are commercial catering products outside the scope of this study. This figure is surprisingly high even for commercial catering and may be incorrect.

Potential for energy efficiency savings

Significant energy savings that reduce global greenhouse gas emissions have already been achieved by changes to oven and furnace design and further improvements are possible. Large decreases in energy consumption and hazardous emissions can be achieved by replacement of old inefficient furnaces located in the EU by new more efficient designs If these are located at the same site this will clearly result in a beneficial reduction in EU emissions as well as globally. Energy emissions can also potentially be reduced by an estimated 10% (opinion of CECOF and others) by further improvements to new furnace design. However, if changes in legislation cause manufacturers to relocate production outside the EU, this would appear to reduce the emissions from within the EU but there is no benefit globally unless the new plant is more energy efficient. Furthermore, the EU has little influence over production processes carried out outside the EU, even for the production of goods placed on the EU market. Many products consumed in the EU are manufactured using ovens and furnaces outside the EU and the energy consumed is not included in the EU's carbon emission totals. Several EU furnace and oven manufacturers have said that furnaces and ovens built in some countries have lower design specifications that would be required in EU and so are cheaper to install but use more energy.

Some products manufactured using ovens and furnaces are usually made locally to where they are used whereas in some sectors, manufacturing has relocated to locations outside EU, for example:

- Most cement is used in the EU Member State where it is made because it is heavy so transport costs are high and also it is a relatively unstable material which deteriorates if it becomes wet.
- Glass containers and sheet are relatively heavy and fragile so most is made and consumed within Member States. CPIV data shows that only 1.9% of container glass and 5.9% of flat glass used in EU are imported into EU although 38.5% of tableware is imported[8].
- Bricks and roof tiles are heavy and so are not transported large distances whereas ceramic tiles are lighter and so are transported larger distances with most being made in Italy and Spain. Most tableware for use within EU was made in EU until the 1990s but large quantities are now made in Asia.
- The EU is fairly self-sufficient in steel although some low grades are imported and high grade steels are exported. Steel is heavy and so expensive to ship over large distances so for example, if there is excess capacity in EU and insufficient in India, it is more economical in the long-term to build a new plant in India.
- The EU had at one time a very large electronics industry which uses solder reflow ovens and other types of oven and furnace. However, most consumer and some commercial electrical equipment is now manufactured in Asia.

Of course labour costs, grants and local restrictions on process plant also influence where new installations are constructed. Many fabricated goods such as consumer electronics and household appliances are manufactured outside the EU from materials such as steel that is produced in furnaces that are also located outside the EU. The EU does not include in total EU emissions data the carbon emissions that result from imported manufactured goods although the quantities of CO_2 are large. Furnaces and ovens located outside the EU that are used to make these products are not regulated by EU legislation and in some countries have inferior energy efficiency to new EU plant.

One publication[9] claims that currently only 40% of energy, on average, is used in furnaces and that 60% is lost. Energy efficient recuperative and regenerative burners can reduce consumption considerably but there are technical limitations so that these recover only 5 – 30% of energy in exhaust gases, although in some cases larger reductions in energy consumption are possible[10]. For example, hot gases from furnaces can be used for pre-heating or drying materials and so very energy efficient processes can be installed. The potential for energy efficiency improvements will be discussed in more detail in tasks 4, 5 and 6 but an initial estimate is made here.

[8] http://www.cpivglass.be/main.html

[9] US Patent application US 2008/0014537 A1, A. Atreya, 12 July 2007.

[10] Energy Efficient Crucible Furnaces, Institute of Cast Metal Engineers, http://www.icme.org.uk/news.asp?ID=114

Ovens and furnaces for manufacturing processes

Research sponsored by the IHEA (Industrial Heating Equipment Association) and the US Department of Energy estimated in 2001 that it is possible to reduce the energy consumption of existing industrial process heating, which is primarily ovens and furnaces, by 5 – 25% and this should be possible within 10 years[11]. This however, is the difference between older less energy efficient processes that were already in use with new more efficient furnaces and ovens and so is a larger improvement potential than the difference between new standard designs and new BAT designs which is the eco-design improvement potential used for this study.

Energy is lost through three main areas: through insulation, by ventilation and by water cooling. There are many scientific publications describing techniques to improve the energy efficiency of ovens and furnaces and many oven and furnace manufacturers advertise energy efficiency as an important benefit of some of their products. Clearly there is potential for energy savings in this sector but quantification is not straightforward. Estimates can be made for some sectors from data published in IPPC BREFs but this is limited to the largest installations only. The IPPC Energy Efficiency BREF describes several design options that its defines as BAT (e.g. regenerative burners), however, it states that these may cost more than the price of the energy saved (this depends on the payback period) and so some new furnaces and ovens are not as efficient as is technically feasible. It is possible that further energy savings beyond those already being adopted by industry are achievable. Discussions with furnace manufacturers and users of furnaces indicate that for the larger furnaces at least, energy efficient designs using BAT are available on the EU market but these are more expensive than standard designs but this varies between industry sectors. Most EU users expect a return on investments in less than two years (stakeholders have informed us that periods of as little as 6 months and as long as three years are used for purchase decisions) and so if the additional cost of energy savings features has a longer payback time than this, these may not be used, even though the furnace may be used for over 20 years, during which time, the more energy efficient design would cost less overall. This indicates that there is a potential for energy savings when comparing furnaces and ovens that users are willing to install (or for which they are able to secure investment) and the most energy efficient designs that are available. Various methods described below have been used to attempt to estimate the potential for energy savings although, without data from manufacturers, this will not be very accurate.

> Industrial total energy consumption in the EU is estimated by JRC[12] to be 316.9Mtoe (million tonnes oil equivalent) which according to the IEA converter[13] is 3685 TWh (this converts the oil equivalent figure to energy as TWh). In the USA, 17% of industrial energy is used for process heating whereas the figure for Germany is 32%[14] although CECOF estimate ~40%. Using the 32% figure for EU, the total energy used by thermal processes, which are mostly

[11] "Roadmap for Process Heating Technology. Priority Research & Development Goals and Near-Term Non-Research Goals To Improve Industrial Process Heating", Capital Surini Group International, Inc. and Energetics, Incorporated, 16 March 2001.

[12] "Electricity Consumption and Efficiency Trends in European Union - Status Report 2009", Paolo BERTOLDI and Bogdan ATANASIU, Joint Research Centre.

[13] IEA unit converter, http://www.iea.org/stats/unit.asp

[14] H. Egger "Efficient use and recuperation of energy within a state of the art commercial heat treatment facility" Heat Processing, issue 4 2008, p269

various types of furnace and oven would be 1179 TWh. This figure includes steel and cement production which together accounts for 48% of industrial CO_2 emissions[15] in the EU. Therefore to obtain a figure for all industry except for these two largest energy consumers (steel and cement), 52% of 1179 = 613 TWh energy is used by ovens and furnaces in the EU (excluding steel and cement). The IHEA estimate is applicable to furnaces in the USA and would imply if applicable in the EU that potential energy savings of 5 – 25%, exist which would be equivalent to 31 - 153 TWh/year. This is only a rough estimate but shows that large energy consumption decreases are technically feasible.

CECOF and others have estimated for the EU which uses different technology to the USA that a 10% reduction, on average is achievable by using the best available technology for all new furnaces and ovens. Using the above figures, this gives an improvement potential of 118 TWh including cement and steel and 61 TWh excluding these two sectors.

Significant reductions in energy consumption have already been made by several industry sectors that use furnaces including steel and cement but there is a very large stock of old inefficient furnaces and ovens in the EU. The aim of this study is to determine the potential energy savings that could be achieved by using the best available technology instead of average energy efficiency new furnaces and ovens, not the potential savings from replacement of old existing stock with average new furnaces although this would be very large. Opinions within the furnace and oven industry vary with some sectors claiming that new furnaces are the best available technology and so could not be more efficient whereas others point out that users have financial constraints so if the cost of energy efficiency innovations is not paid for within a relatively short time period, these designs are not selected. As explained above, if the added cost has a payback period of more than the number of years defined by the manufacturers' senior management (most commonly two years), many EU furnace users say that they will not fund or be able to secure the funding for these more expensive design options even though the furnaces will be used for up to 20 years or longer (although the reasons for making investment decisions are complex). If a longer payback period were used, the more energy efficient option would be cheaper overall. Furnace manufacturers endeavour to make their products as energy efficient as possible but are constrained by the willingness or ability of their customers to pay for the best design options. Financial issues are discussed in more detail in task 7.

In general, new designs of the largest furnaces that use the most energy including steel production (blast furnaces, etc.), cement kilns, float glass, etc. will use the best available technology but they may not always be as energy efficient as possible due to the cost of some features. Medium and small size furnaces may also not be as energy efficient as possible due to cost constraints and sometimes due to a lack of expertise by users and so there will be a difference in energy consumption between different designs. One example relates to the type of gas burner used. Recuperative burners use pre-heated air and so consume about 15 - 20% less energy than similar burners fed with cold air[16]. It is possible for users to buy new metal melting furnaces either with standard burners or with recuperative burners, the latter being more expensive but considerably more energy efficient.

[15] Technical report No 04/2009, "Annual European Community greenhouse gas inventory 1990 – 2007 and inventory report 2009. Submission to the UNFCCC Secretariat", 27 May 2009, European Environment Agency.

[16] There are several furnace manufacturers that offer metal melting furnaces with either standard or recuperative burners including Morgan Metal Melting Systems www.morganmms.com

There are many other energy efficient design innovations being offered which users could choose to purchase and these will be discussed in detail in tasks 5 and 6. One that is used only in larger furnaces is the regenerative burner. These are now standard in the largest glass melting furnaces but optional in many other types of furnace. They are relatively expensive to install and may also add to maintenance costs, but they can give very significant energy consumption reduction; typically ~40% less energy or better is possible when compared to standard burners. However the cost of replacement of a recuperative system with a regenerative system can be several million Euros (one example quotes $3.7 million[17]) and is discussed in section **Error! Reference source not found.**.

The potential energy saving in other sectors varies depending on the types of oven and furnace that are available and suitable for the specific processes, all of which are different.

Cement production

WBCSD (World Business Council for Sustainable Development) and IEA (International Energy Agency) have produced a roadmap for reductions in global warming emissions from cement products until 2050[18]. Carbon emission reductions are planned from several aspects of cement production:

- Thermal energy consumption decrease from an average of 3.7 GJ/tonne clinker to an average of 3.2 GJ/tonne clinker by 2050. The reduction by 2020 will be ~3.6 GJ/tonne clinker
- Electrical energy use – efficiency savings of up to 10% by 2050 although savings by 2020 will be more modest
- Use of bio-fuels – decreases use of fossil fuels (this may not reduce energy consumption but will reduce fossil CO_2 emissions, however supplies of sustainable bio-fuels are limited).
- Reduction of the proportion of clinker (made in the rotary furnace) in cement from currently ~79% to ~72% – reduces energy required per tonne of cement
- CO_2 capture – potentially could make cement production and use a net absorber of atmospheric CO2 although the carbon capture process will consume additional electrical energy
- Phasing out less efficient processes. The most efficient kilns produce cement with ~3.4GJ/tonne of clinker whereas the least efficient consume ~4.4 GJ/tonne of clinker.

There is also research[18] into alternative types of cement that may produce benefits such as magnesium silicate based materials (Novacem). When this is calcined, no CO_2 is emitted unlike from limestone but the cement made from this feedstock absorbs CO_2 when it sets so that potentially this type of cement could be a net consumer of CO_2.

[17] Hughes P., Sebestyen A., High Temperature Air Combustion (HiTAC) for Industrial Applications, Asia-Pacific Partnership Steel Task Force, 13 Jan 2009, www.asiapacificpartnership.org/pdf/Steel/6th_meeting/High_Temperature_Air_Combustion_(HiTAC)_for_Industrial_Applications.pdf

[18] Cement Technology Roadmap 2009, Carbon emissions reductions up to 2050, http://www.wbcsd.org/includes/getTarget.asp?type=d&id=MzY3NDM

The potential energy saving that should be achievable by using the most energy efficient kiln designs (excluding use of bio-fuels and other measures) can be calculated:

- World cement production in 2006 = 2559 Mtonnes, EU produces ~10% = 256 Mtonnes.
- WBCSD and IEA estimate that thermal energy efficiency can reduce energy consumption from 3.9GJ/tonne to 3.6 GJ/tonne in 2020 and 3.2 GJ/tonne in 2050, i.e. a reduction of 0.3 GJ/tonne by 2020 and 0.7GJ/tonne by 2050. This would be equivalent to 84 kWh / tonne clinker by 2020 and 195 kWh /tonne clinker by 2050. The best EU cement production installations already meet the 3.2 GJ/tonne target and so improvements will be made mainly by replacing and refurbishing older kilns.
- The estimated potential thermal energy saving in EU from energy efficiency measures in cement production in EU (current production about 256 million tonnes in EU, assuming no increase in production) by 2020 could be 21.3 TWh/year and by 2050 could be 50TWh/year. This is without other changes that would give further reductions in energy consumption and is mainly as a result of replacement of old by new kilns.
- The German cement industry trade association VDZ claim that German cement kilns have an energy efficiency of ~70%[19] which is high for a rotary furnace. Achieving further energy efficiency savings will be difficult although some may be possible.

Very significant energy saving may be achievable by 2020 and 2050 if the industry plan is followed and one of EU's largest cement manufacturers "Lafarge" recently reported it had met its CO_2 emission reduction target[20]. All new plant should be built and existing plant should be refurbished utilising the best available technology. The cement industry should achieve its aims because of the industry plan to reduce carbon emissions, but also to comply with the IPPC directive and importantly to gain the reductions in cost from using less energy and emitting less CO_2 from fossil carbon.

Further benefits from carbon capture and storage are possible but this would incur a net cost with no financial benefit to the kiln operator (unless this is from ETS). Energy savings are being made but some will occur only when existing plant is refurbished or replaced as this requires considerable investment. New cement kilns should be BAT as defined by the IPPC BREF guidance but cement kilns have long lives between refurbishment or replacement and so further reductions in the EU's annual energy consumption would occur if the rate of refurbishment or replacement of kilns could be accelerated.

[19] http://www.vdz-online.de/fileadmin/gruppen/vdz/3LiteraturRecherche/UmweltundRessourcen/Umweltdaten/Umweltdaten2008_e_WEB.pdf

[20] http://www.lafarge.com/wps/portal/6_2_1-CADet?WCM_GLOBAL_CONTEXT=/wps/wcm/connect/Lafarge.com/AllPR/2010/PR100329b/MainEN

Steel production

The steel production industry is in some ways a special case because it is very unlikely that new iron and steel production plant will be installed in the EU. Existing coke ovens and blast furnaces will be refurbished but no new plant is likely to be installed except for arc furnaces used for scrap recycling.

Japanese research indicated in 2008 that EU steel manufacture could reduce energy consumption by ~16% whereas the difference in energy efficiency between the average EU steel installation and the best is 7.2% (based on IPPC BREF data). It is important to note that these efficiency improvement estimates are for steel production installations which include blast furnace, BOF, holding furnaces, heat treatment, etc.

The draft IPPC BREF for steel states that in 2004, EU steel production used on average 19.4GJ/tonne whereas the best EU plant used 18GJ/t which is 1.4GJ/tonne less. As EU production of steel is 206 million tonnes, this indicates an energy saving of 80 TWh, calculated as follows (although this includes some old for new replacement);

206 million tonnes @ 1.4 GJ/tonne = 288 million GJ/year.

The conversion factor for MJ to TWh is 3.6GJ= 1MWh

So 288 million GJ/3.6 = 80 million MWh = 80 TWh

In fact efficiencies are already being made and this predicted saving should eventually be made in EU without intervention. The energy efficiency technology is not solely Japanese and much was developed in the EU but Japan was the first to modify its steel industry, possibly because of the Japanese policy of planning much further into the future than European industry. Longer payback periods appear to be more acceptable in Japan than in the EU. In the EU, modifications are made only when existing plant is due for refurbishment which is typically every 25 years. It could therefore take many years to accomplish these efficiency savings unless the process can be accelerated. However if EU plant are closed and steel imported from inefficient plant located outside the EU, there would be no reduction in global greenhouse gas emissions or even an increase in global emissions.

According to one steel production furnace manufacturer, the cost of blast furnace refurbishment is from €10 – 100 million. The best energy efficiency would be achieved by investment of the higher amount (€100 million) whereas this usually requires increased borrowing. It also has the longest payback time, which may not always be acceptable to EU steel manufacturers without financial incentives from EU governments (discussed in task 7).

These estimates do not take into account the potential for newer steel processes such as direct reduction. Opinions on whether direct reduction / electric arc furnace (EAF) is more energy efficient than blast furnace / basic oxygen furnace (BOF) vary. One report claims that this can give a potential reduction in CO_2 emissions of ~20%[21]. Direct reduction eliminates the need for coke ovens but the product needs to be melted in an electric arc furnace (EAF) instead of being treated in a basic oxygen furnace (BOF). The BOF is a net energy generator but EAF consumes electrical energy so the

[21] Draft IPPC reference to BAT for the production of iron and steel, July 2009.

comparison of the blast furnace and direct reduction routes are not straightforward. One publication suggests that the combination of Direct Reduction with EAF could reduce total CO2 emissions per tonne of steel from 1557 kg CO2 / tonne of hot rolled steel from a blast furnace / BOF to only 1080 kg CO2 /tonne from direct reduction / EAF representing a reduction of 30%[22]. However another publication indicates that direct reduction / EAF uses more energy than blast furnace /BOF[23]. It is not clear whether these new technologies would give energy efficiencies in the EU as they rely on the availability of large quantities of natural gas which has a limited supply in the EU.

Ceramics

Manufacturers and trade associations have provided some useful market data. The manufacture of bricks, tiles and other ceramics uses large quantities of energy. Energy efficiency has significantly improved, by up to 50%, since the 1980s due to improved insulation[24] and the reuse of hot cooling air and combustion gases for drying, for gas burners and for pre-heating materials. However, at least one manufacturer has indicated that further 10% improvements would be possible if users were willing to pay more for new furnaces. A study carried out to establish benchmarks for the EU Emissions Trading Scheme (ETS) found that the energy consumption of brick kilns varies considerably depending on the type of kiln. Hoffman kilns use 573 kWh/tonne whereas tunnel kilns use 658 kWh/tonne[25]. This difference is however very deceptive as Hoffman kilns are very old and not particularly energy efficient whereas new tunnel kilns can be very efficient. The main reason for this difference is the clay's composition. Clay types that are used to make bricks in UK Hoffman kilns contain high organic content and so the old chamber kilns that are used for these types of clay require much less heat energy for firing bricks (benchmark = 245 kWh/tonne) but this is due to the energy provided by the combustion of the organic material within the clay in addition to the energy from gas burners. If the brick kilns are considered in terms of the total CO_2 emissions, Hoffman kilns would have relatively high CO2 emissions in comparison with modern tunnel kilns. Ceramic tiles and porcelain are made in roller kilns which can be energy efficient if designed with good insulation and re-use of recovered heat. For many types of ceramics, new technology such as microwave assisted heating, especially for drying, could further provide opportunities for further reductions in energy consumption. There are also options for other changes that could reduce energy consumption such as design (e.g. less supporting kiln furniture is needed for a "rustic" appearance), choice of raw material (clay composition – high $CaCO_3$ content and high moisture content increase energy consumption although transporting clays further increases energy consumption for transport), etc. Many of these issues are not furnace-related and so outside the scope of this study but technical design issues are discussed in task 5.

[22] P. E. Duarte et al. "Energiron Direct Reduction Technology".

[23] "Energy use and carbon dioxide emissions in the steel sector in key developing countries" April 2001 http://ies.lbl.gov/iespubs/46987.pdf

[24] David Shemanski, Managing Director of Measham Brick Quarry, Hanson and Jane Anderson, Principal Consultant at BRE, Watford interviewed on "You and Yours", BBC Radio 4, Dec 2009.

[25] Study carried out by Enviros Consulting for UKDTI 2006, http://www.berr.gov.uk/files/file33274.pdf

Glass

Glass sheet (e.g. windows) and containers (e.g. bottles) manufacture consumes very large amounts of energy. One glass melting furnace producing ~500 tonnes glass per day will consume ~360GWh annually at a cost for energy of €3 – 4 million. There are 58 flat glass installations in EU so total energy consumption for this process step alone only for glass sheet is 21 TWh/year (container glass consumes far more). One glass manufacturer has provided information that research has indicated that energy efficiencies of up to 5% (i.e. 1 TWh p.a. for flat glass melting) may be achievable but the cost would incur a payback of over 7 years and so due to limits on capital availability, this manufacturer stated that this investment would not be adopted and all other EU glass manufacturers have the same policies.

Medium size industrial furnaces and ovens

EU manufacturers of medium-size industrial furnaces and ovens report that there is increasing competition from Asian manufacturers. These Asian products have inferior energy efficiency and are cheaper. One manufacturer also claimed that some Chinese furnaces do not meet the specifications claimed by the manufacturers. Significant improvement potential is therefore likely and could be >10%.

Laboratory furnaces and ovens

There is no published sales data for the numbers of laboratory ovens and furnaces sold in the EU available but useful information has been provided by several manufacturers, some of whom have provided their own confidential sales figures and others estimates for total EU sales. Estimated total EU sales data appear to be consistent with manufacturers own sales figures. In this sector, it is uncommon for manufacturers to measure energy consumption or energy efficiency and no standard test method is available. However some manufacturers measure the energy to maintain ovens and furnaces at their maximum rated temperature (or at a temperature 100°C below the maximum rated temperature) which gives an indication of the variation in performance. Energy consumption of autoclaves and incubators is easier to quantify as these are used in standard ways, i.e. autoclaves use predefined thermal profiles and incubators are on continuously. Laboratory ovens and furnaces are used in many different ways from continuously to only very occasional uses. Several manufacturers have indicated the improvement potential that might be possible although further improvements may be possible but only with very large price increases. Data supplied by manufacturers has been included in Table 19.

Sector estimates

A semi-quantitative matrix for industrial and laboratory furnaces and ovens has been developed (and is being refined during this study).

The improvement potential depends on what is assumed to be business as usual (BAU). Two extreme definitions could be used:

- Industry takes no action to improve energy efficiency

- All new and refurbished furnaces and ovens include the best available technology for energy efficiency.

In reality, BAU will be somewhere between the two. Some industry sectors such as the cement industry have ambitious plans to reduce energy consumption whereas others incorporate energy efficiency modifications only if a financial saving, often in the short term (< 3 years), can be demonstrated. Technically, according to various industry and some independent sources, there appears to be little potential for improvement in the energy efficiency of new and recently refurbished furnaces used to make steel, cement and lime. For other large furnaces the potential is about 10% and for medium size furnaces more than 10%.

Energy costs are largest with the biggest furnaces and so the trend is that energy efficiency is considered as a higher priority for the largest energy consumers and least for small laboratory ovens and furnaces. New and refurbished furnaces for steel production, cement kilns, float glass furnaces, etc. will usually use BAT although not necessarily every energy saving modification possible due to cost. Installers of medium size furnaces do not always adopt the most energy efficient design and they claim this is due to a relatively long payback period and the high investment cost.

In order to determine predicted improvement potential, BAU has been assumed to be what industry sectors will do with no action taken by the EU. This assumes that industry sectors will follow energy consumption reduction improvement plans where these have been agreed such as by the cement industry or the most energy efficient designs will always be used such as for waste to energy incinerators. For other types of furnaces however, BAU assumes that energy efficiency improvements will be limited by financial restrictions.

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Table 19. Sales, stock energy consumption and estimated improvement potential for main industry sectors. EU improvement potential is total stock energy consumption x improvement potential

Oven / furnace sector	Sales 2009 new units	Stock 2009 units*	Average primary energy consumption (MWh/Yr)	Total stock energy consumption (TWh/Yr)*	Improvement potential (by 2020)	Estimated EU energy savings TWh (replacement / refurbishment of all stock)
Cement kiln (4)	2/yr (1 – 2 refurb / yr)	377	735,000	277	0 - 5%	0 – 14
Lime kilns (3,4)	~1.2 new/yr (1 refurb. / yr)	~600	50,000	30	0%	0
Steel production (1 – 3)	no new (~10 refurbished/yr)	538	Many types of furnace used	435	0 – 7.2%	~30 (new for old refurbishment of stock only)
Glass – total (1, 2)	>60 large plus many more smaller furnaces	628 (of >20t/day 2005) Total >787	Many types and sizes	64	Up to 20%	0 – 12.8
Container glass (1, 2)	20 – 30 new / yr (~17 refurb / yr)	~300	53,000 (melters)	40	5%?	2.0
Flat glass (1, 2)	3 – 4 melting refurbished	58	1,000 – 360,000	22	5%?	1.1
Ceramics total (most 2)	>40	10,000		113	20%	0 – 22.6
Brick, ceramic tile and sanitaryware (2)	20 brick and roof tiles (natural clay), 20 ceramic tiles + sanitary-ware (refined clay)	7000	22,200	74	10%	7.4
Oil refining (1,2?)	~45	1800[26]	Not known	329 – 1050		

[26] "Description and Characterisation of the Ceramic Fibres Industry of the EU", Environmental Resource Management 1995

Oven / furnace sector	Sales 2009 new units	Stock 2009 units*	Average primary energy consumption (MWh/Yr)	Total stock energy consumption (TWh/Yr)*	Improvement potential (by 2020)	Estimated EU energy savings TWh (replacement / refurbishment of all stock)
Incinerators WtE** (3)	~10	903[27]	5,500	5	0%	0
Metal smelting & melting – large size (1, 3, 4)	~10	Cu 20 sites, Al 130 sites, Zn 27 sites & Lead 39 sites (~400 furnaces in total)	17,500	Scrap Al = ~3 Cu total = ~ 15 Others ?	20 – 40% (for melting)	Al = 0.6 – 1.2 Cu = ~ 3
Bakery (2) – excludes other food ovens	40	1200	17,000	2.3 TWh (bread only)	~10%	2.3
Large metals heating	180	3500	20,000 – 50,000	10	5 - 10%	0.5 - 1
Mainly Small / medium-size industrial below						
Medium size ovens (1, 2)	500	50,000	75	3.7	10 - 20%	~ 0.6
All types of small & medium furnaces & ovens (including heat treatment) (1, 2)	15,000	300,000	Ovens = 75 Furnaces = 270	42 – electricity (105 primary energy)	10 – 20%	4 – 8 electricity 10 – 20 primary energy
Metals heat treatment (1, 2)	~1500 (500 each of induction, vacuum and thermal)	37,500 (assumes average 25 year life)	~800 MWh/y	22	~10%	1.1
Electronics (2)	400	30,000	~150 MWh/y	4.8	0 - 10	0.24 electricity = 0.6 primary energy

[27] ISWA report "Energy-from-Waste Statistics - State-of-the-Art-Report" 5th Edition August 2006, data for 2005 including Norway and Switzerland. 903 line at 427 installations

Oven / furnace sector	Sales 2009 new units	Stock 2009 units*	Average primary energy consumption (MWh/Yr)	Total stock energy consumption (TWh/Yr)*	Improvement potential (by 2020)	Estimated EU energy savings TWh (replacement / refurbishment of all stock)
Other incinerators (1)	100	1000	200 – 500 MWh/y	0.2 – 0.5	0	0
Rack ovens (small bakery) (data from Lot 22 Eco-design study)	7500	75,000	Electric (primary) = 180 Gas = 84	37.5	10%	3.75
Laboratory (1 mainly)	49,000	765,000	17	13	10 – 20%	1.3 – 2.6
Medical sterilizers (1)	10,000	100,000	2.52	0.25	5%	0.01 (electricity)
Laboratory analysis instruments (1 mainly)	17,000	170,000	3.6	0.62	<5%	<0.5
Totals (estimated from incomplete data)	100,000	1,000,000	-	1200 - ~1400	10 – 20%	~100

* Estimated from data in IPPC BREFs.
** WtE – waste to energy incinerators only; excludes the large number of waste incinerators with no energy recovery.
The method used for calculating improvement potential for large furnaces and ovens in Table 21 is given in Table 20.

Table 20. Method used for calculating improvement potential

Sector	Calculation method assuming	2020 improvement potential
Cement kiln	Data from Cembureau shows that there was an increase of 14 cement installations between 2005 and 2008 in EU and all were dry kilns with pre-heaters and pre-calciners. There was a decrease of 7 installations of other types indicating that these older kiln types were replaced by new energy efficient kilns. This means that there were 7 new and 7 refurbished kilns assuming 1 kiln per installation which will not always be correct – on average there are 1.6 kilns / installation – actual numbers may be more than 7 + 7 over 3 years	The biggest improvement potential is from replacement of old by new. However, the potential for improving new kilns is likely to be very small, probably less than 5%.
Lime kilns	New furnace numbers data from EuLA	Due to the very high energy cost (40% of production costs) and the innovative design of modern lime kilns, no further improvement seems likely.
Steel production furnaces	One new steel production plant installed in the last 10 years in EU and no new plant likely in EU. There are ~90 blast furnace / BOS facilities which are refurbished every 10 – 25 years so at least 9/year will be blast furnaces. Industry information is that there are ~10 refurbishment projects for steel production furnaces annually in EU.	Improvement potential due mainly to refurbishment. Due to restrictions on capital, all possible energy saving modifications are not always adopted so improvement potential of <u>up to</u> 7.2% has been estimated.
Glass – total	Sales data available only for furnaces in the 787 installations covered by IPPC. There are many more smaller installations with medium-size and small furnaces and most installations have > 1 furnace	
Container glass	EU production in 2007 was 22 million tonnes and a medium size furnace would produce 87,500 tonnes / year so there are about 250 container glass stock in EU. Time between refurbishment is ~15 years so 25/15 = 17 per year. 22 million tonnes produced with an average consumption = 8.7GJ/tonne although only 75% of this is furnace energy.	170 of 250 (68%) replaced by 2020. So based on estimated improvement potential of 5%, energy saved by 2020 – 40TWh x 5% x 68% = 1.36TWh/year. Improvement potential could be >5% if feedstock pre-heating is feasible
Flat glass	3 – 4 glass melter rebuilds per year, which was calculated from stock of 58 having a life of ~15 years between rebuilds. New plant less common. (There are also lehrs, and other furnaces used) 9.37 million tonnes produced with an average energy consumption of 7.5 GJ/tonne although only 83% is furnace energy (data from one manufacture indicates usage is 18 (average of 14 – 22) TWh / year for flat glass melting plus energy for subsequent process steps so total is ~22 TWh/y).	30 – 40 of 58 (~60%) replaced by 2020. So based on improvement potential of 5%, energy saved by 2020 = 22TWh x 5% x 60% = 0.66TWh/year (5% figure supplied by flat glass manufacturer and is probably a conservative estimate). Improvement potential could be >5% if feedstock pre-heating is feasible
Ceramics total	The Carbon Trust claims that the ceramic and glass industries could reduce energy consumption by 20%. This refers to replacement of existing furnaces not the difference between standard new and BAT new furnaces.	Use of hotter preheated air for burners would save at least 10% energy. Recovered heat use for drying could also give savings

Sector	Calculation method assuming	2020 improvement potential
Brick, ceramic tile and sanitaryware	Sales and stock data from Actimac for kilns. Assume at least one drying oven per kiln but energy saving mainly from kilns (ovens use waste heat from kilns) Manufacturers estimate that furnaces could be 10% more efficient than currently produced	Stock = 3300. Typical life = ~25 years so 130 should be replaced per year so 40% would be replaced by 2020. Energy saved = 74TWh x 10% x 40% = 2.96TWh/year by 2020 (7.4TWh / year by 2050)
Oil refining	Refineries consume on average 9% of the energy of crude oil processed but not all is used in furnaces. Assume that oil refinery furnaces are replaced after 40 years life	Difficult to consider "furnaces" separately from the oil refinery as a whole
Incinerators WtE**	The principal energy source for waste to energy incinerators is the waste materials feedstock. Electricity is used to operate the equipment such as for air pumps, controllers, hygiene etc but there is a net surplus of electricity generated. Electrical energy consumed is 0.1MWh / tonne waste. ~20% of EU municipal waste = ~ 50 million tonnes / year is incinerated by 903 incinerators. So 1 average incinerator consumes 55,000 tonnes waste / year at 0.1MWh/tonne = 5,500MWh/year. 50 million tonnes waste x 0.1MWh/tonne = 5TWh/yr (stock energy consumption)	No improvement potential as these are designed to generate as much power as possible and heat is also utilised
Hazardous waste incinerators	Data provided by stakeholder	Apart from energy to heat up, as waste combustion is exothermic, heat input is required only to the afterburner which destroys toxic emissions. Heat recovery possible from flue gases but cannot be used by furnace.
Metal smelting & melting	Aluminium – Calculated from 4.1 million tonnes recycled in Western Europe in 2003 (data from www.eaa.net) and IPPC draft BREF guidance, non-ferrous metals industries 2009, table 4.21. Copper – energy consumption estimated from data in IPPC BREF (quantity produced and energy consumed per tonne) 2009 stocks: Numbers of sites from 2009 draft BREF. For copper each site will have at least one primary smelter and one fire refining furnace. Most aluminium sites are secondary furnaces, may be more than one furnace per site. Zinc each of 15 primary sites has one roaster and there are 12 secondary sites with at least one furnace. 9 primary lead smelting furnaces and about 30 sites with at least one secondary refining furnace. There will also be many more smaller furnaces	This sector includes very wide variety of furnaces, some having a small improvement potential (electric ~10%) and some (gas) as much as 40%.
Large steel re-heating	Sales estimate obtained from two stakeholders (but different values). Stock assumes30 -40 years life, energy consumption based on visit to several installations in Germany and from one stakeholder	Biggest heat loss is in flue gases at >20%. 5% energy saving if 25% of flue gas heat can be recovered and re-used.

Sector	Calculation method assuming	2020 improvement potential
Food	IPPC BREF states typical energy consumption = 0.125 – 0.167 kWh/kg bakery products and in 1999, the EU15 produced 10.6 million tonnes. Assume 15 million tonnes in 2010 for EU27. Oven energy consumption data, oven stock and sales data estimated from data supplied by bread manufacturer	Stakeholder claims potential for reducing energy consumption of very large ovens is low although more research may identify solutions to heat recovery issues.
Medium size ovens and furnaces	Ovens data from one manufacturer, total estimated sales from one large manufacturer's sales. Stock assumes total EU stock level does not change and average life 20 years. Annual energy consumption assumes: consumption = half electricity ratings (from Nabertherm's brochure) of mid-size electric oven (25KW) or furnace (90KW) in use 12 hours per day, 5 days / week and 50 weeks per year (some will be gas but electricity only assumed for calculation). Assume stock of 100,000 furnaces and 200,000 ovens in the EU. Primary energy is 2.5 x electricity TWh. Estimate of sales of 15,000 appears reasonable although PRODCOM figure for non-electric furnaces for metals is ~7000 EU production per annum. This category also includes electrical for metals as well as furnaces and ovens for other applications.	Potential energy saving for electrically heated ovens and furnaces estimated at ~10% and these are the majority of the mid-size ovens and furnaces. Energy saving potential of gas heated is much higher (>30%)
Metals heat treatment	Medium-size furnaces used for non-ferrous and ferrous. Three types of process, vacuum (electric heating), induction (electric) and thermal (electric and gas, batch or continuous) annual sales estimated by stakeholder, stock is 25 times sales assuming average life is 25 years.	Varies depending on process type. Improvement potential of induction and vacuum is fairly small whereas thermal processes have a higher potential.
Electronics	Sales numbers believed to be small	Improvement potential for semiconductor production very low (from Japanese manufacturer), others small (~5%) – electric heat and have good insulation (authors personal experience)
Laboratory	Energy consumption estimates for laboratory ovens and furnaces assumes oven / furnace assumption is 3x no-load constant temperature consumption so on average 4KWh and on 50% of time	

Table 21. Stock, sales, energy consumption and improvement potential of laboratory furnaces and ovens

Type	Stock	2008 Sales	Typical use (hours / day & days / year)	Average energy consumption *	Annual stock energy consumption TWh/yr	Improvement potential %	Improvement potential TWh/yr (assumes all stock replaced)
Lab Oven	400,000	25,000	5000 hours / year	1.6 KW x 3 = 4.8 4.8 x 5000 = 24 MWh	9.6	10 – 20%	1 – 2
Lab Furnace	140,000	9,000	1000 hours / year	1.2 KW x 3 = 3.6 3.6 x 1000 = 3.6 MWh	0.5	10 – 20%	0.05 – 0.1
Incubator	225,000	15,000	Continuous = 8760 h / y	0.07 KW x 2 = 0.14 0.14 x 8760 = 1.2 MWh	0.27	5%	0.014
Analytical instruments	170,000 (10 times 2007 sales)	17,000 (2007 sales)	2000 hours / yr	3.6 MWh	0.62	5%	0.03
Lab sterilizer	Total estimated at 100,000 Lab steam sterilizers = 10,000	Total estimated at 7000 Lab steam sterilizers = 580	Lab = 2000 hours / year	Lab = 2.52 MWh (from manufacturer)	Lab = 0.025 Total (if all use 2.5 MWh/yr) = 0.25	5%	0.01

The actual energy consumption of laboratory ovens and furnaces is not known and so has been estimated as follows: First multiply the energy consumption to maintain the maximum temperature when empty of the most popular size by 1.2 because the average size is slightly larger than the most popular size (which is one of the smallest sizes). The average annual energy consumption is calculated by multiplying the energy consumption of the average empty oven by 3 to calculate actual energy consumption to include the energy needed to heat up the oven / furnace and its contents. The hourly consumption is multiplied by the number of hours per year for annual consumption. For incubators, it is estimated that the 70 watt model is the average size and energy consumption is double the empty incubator consumption as the mass of petri dishes etc. is less than the typical mass of materials heated in ovens, i.e. consumption is 2 x 70 = 140 watts.

