

Hunting “Brown Zombies” to Reduce Industry’s Carbon Emissions

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Online Appendix

Table S1 – Installations and emissions covered by our analysis, by country

Country	2013				2019			
	Emissions		Installations		Emissions		Installations	
	Total	Covered (%)	Total	Covered (%)	Total	Covered (%)	Total	Covered (%)
Austria	21,855,225	99	154	90	23,157,386	98	151	87
Belgium	30,681,835	98	300	93	32,157,177	97	286	92
Bulgaria	5,241,022	98	86	90	7,222,159	99	70	96
Cyprus	1,192,030	0	8	0	1,169,290	0	5	0
Czechia	16,220,971	99	191	94	17,463,585	99	173	88
Denmark	5,715,282	37	100	87	5,926,715	34	95	87
Estonia	1,113,376	0	8	0	1,486,237	0	9	0
Spain	55,052,520	97	711	91	61,203,645	95	648	87
Finland	12,909,517	78	90	74	12,510,655	78	84	74
France	71,232,216	83	716	82	67,688,208	70	678	76
Germany	115,089,599	75	1,182	67	120,335,772	75	1,123	65
Greece	12,515,237	0	51	0	13,220,982	0	41	0
Croatia	3,812,780	0	38	0	4,835,357	0	38	0
Hungary	6,987,797	98	118	88	8,806,174	64	105	82
Ireland	2,129,148	81	28	36	2,188,852	67	31	26
Iceland	1,196,254	0	4	0	1,238,140	0	5	0
Italy	69,509,623	77	867	89	64,583,475	78	790	86
Liechtenstein	943	0	2	0	198	0	2	0
Lithuania	5,471,791	0	23	0	5,462,498	0	17	0
Luxembourg	1,118,429	100	12	100	1,386,988	19	13	38
Latvia	947,452	8	16	25	939,056	8	17	18
Netherlands	36,487,313	1	267	2	36,501,982	1	241	2
Norway	20,062,393	13	102	35	22,410,929	23	112	37
Poland	37,397,487	47	369	55	42,402,724	43	345	58
Portugal	10,111,887	98	187	94	11,065,709	98	160	93
Romania	16,514,413	92	133	88	16,500,732	97	116	88
Sweden	13,181,676	28	146	62	13,662,024	27	145	61
Slovenia	1,721,223	70	41	76	1,771,472	80	35	83
Slovakia	15,563,161	99	66	95	13,757,457	99	64	97
United Kingdom	63,227,493	71	539	81	58,565,468	68	518	80
TOTAL	654,260,093	70	6,555	75	669,621,046	68	6,117	73

Note: Total emissions include all emissions from stationary installations that cannot be attributed to an operator company with NACE 2-digit code above 33. Total installations refer to the number of installations that either belong to an operator company within the manufacturing industry (NACE 2-digit code above 33) or that cannot be attributed to an operator company. Installations with zero emissions are not counted. Covered refers to the emissions and installations covered in the analysis of Section 3.

Source: Authors' calculations based on EUTL and ORBIS data.

Table S2 – Installations and emissions covered by our analysis, by activity

Activity	2013				2019			
	Emissions		Installations		Emissions		Installations	
	Total	Covered (%)	Total	Covered (%)	Total	Covered (%)	Total	Covered (%)
Combustion	100,696,063	62	2,255	74	94,954,585	61	2,034	71
Refining	126,980,924	68	164	68	129,859,259	64	176	66
Coke	10,606,129	40	18	67	9,910,869	48	15	67
Metal ore	39,899,036	97	53	81	34,339,693	74	55	73
Iron or steel	72,153,374	68	228	75	68,642,619	65	206	71
Ferrous metals	27,893,211	80	307	74	33,264,783	79	291	69
Primary aluminium	4,498,394	43	39	59	7,867,301	62	37	54
Secondary aluminium	451,455	55	30	70	1,047,048	75	29	69
Non-ferrous metals	3,999,942	45	88	80	7,785,116	59	92	78
Cement clinker	118,666,488	74	312	82	118,528,738	72	299	83
Lime	29,031,262	83	247	73	28,287,310	84	238	72
Glass	18,438,969	84	378	82	17,958,598	81	357	81
Ceramics	10,505,361	72	1,084	77	14,314,078	74	958	76
Mineral wool	2,044,946	66	113	63	2,301,361	68	100	63
Gypsum or plasterboard	916,883	77	56	86	1,549,245	85	53	85
Pulp	9,195,416	85	243	84	8,160,963	83	232	80
Paper or cardboard	17,486,314	68	498	71	17,557,675	68	492	70
Carbon black	1,466,022	77	17	88	1,594,691	86	17	94
Nitric acid	3,311,579	75	32	88	5,984,892	81	32	81
Adipic acid	39,646	100	1	100	95,214	100	1	100
Glyoxal	10,482	0	1	0	10,099	0	1	0
Ammonia	13,608,671	23	27	56	16,493,689	38	25	52
Bulk chemicals	33,667,647	66	289	67	35,474,980	69	307	66
Hydrogen	5,626,732	52	38	63	8,035,520	65	31	65
Soda ash	1,701,090	58	14	57	3,549,132	43	13	46
Transport GHG	328	100	1	100	1,498	100	1	100
Other	1,363,726	99	22	91	2,052,091	92	25	76
TOTAL	654,260,090	70	6,555	75	669,621,047	68	6,117	73

Note: Activity refers to the activity id listed in Appendix 1. Total emissions include all emissions from stationary installations that cannot be attributed to an operator company with NACE 2-digit code above 33. Total installations refer to the number of installations that either belong to an operator company within the manufacturing industry (NACE 2-digit code above 33) or cannot be attributed to an operator company. Installations with zero emissions are not counted. Covered refers to the emissions and installations covered in the analysis of Section 3.

Source: Authors' calculations based on EUTL

Table S3 – Reallocation exercise away from “brown zombies” based on negative EBITDA with a carbon price of €100 and no free emission allowances

	Non-brown zombies					Brown zombies					Emission savings ⁽²⁾	
	# firms	Value added	Emissions	% free ⁽¹⁾	Intensity	# firms	Value added	Emissions	% free ⁽¹⁾	Intensity	Emissions	% total
Combustion	667	141,963	23,120,867	70	163	181	13,034	22,791,212	67	1,749	20,668,424	45
Refining	21	9,883	28,078,046	72	2,841	30	10,257	59,276,480	70	5,779	30,135,882	34
Coke	1	12	131,765	100	10,980	4	41	1,295,384	43	31,595	845,187	59
Metal ore	3	65	151,487	99	2,331	7	1,561	7,950,803	79	5,093	4,312,785	53
Iron or steel	73	4,847	6,492,719	82	1,340	41	5,625	73,088,653	88	12,994	65,553,776	82
Ferrous metals	76	5,403	4,408,176	74	816	53	4,250	5,129,165	80	1,207	1,661,694	17
Primary aluminium	5	1,114	2,577,761	80	2,314	7	773	2,608,318	87	3,374	819,620	16
Secondary aluminium	14	722	826,088	79	1,144	4	81	145,046	94	1,791	52,369	5
Non-ferrous metals	41	4,039	2,566,683	86	635	15	428	2,434,809	85	5,689	2,162,826	43
Cement clinker	4	38	48,485	92	1,276	85	4,892	90,615,811	91	18,523	84,374,008	93
Lime	6	200	479,861	99	2,399	62	1,438	16,840,342	83	11,711	13,390,142	77
Glass	141	6,176	9,518,097	77	1,541	54	1,849	5,202,713	81	2,814	2,353,140	16
Ceramics	201	4,762	6,822,784	83	1,433	182	1,017	4,070,802	85	4,003	2,613,689	24
Mineral wool	27	819	1,220,494	71	1,490	12	154	468,208	67	3,040	238,713	14
Gypsum or plasterboard	19	945	901,028	84	953	2	28	89,849	81	3,209	63,152	6
Pulp	102	4,947	3,770,438	70	762	21	416	870,616	69	2,093	553,555	12
Paper or cardboard	213	8,124	11,142,302	64	1,372	56	838	3,058,339	62	3,650	1,908,998	13
Carbon black	5	1,042	1,109,876	88	1,065	3	34	488,094	73	14,356	451,879	28
Nitric acid	6	291	796,721	100	2,738	2	118	743,760	90	6,303	420,691	27
Adipic acid	1	35	95,214	100	2,720	0						
Ammonia	0					9	779	10,841,371	83	13,917		
Bulk chemicals	93	8,124	14,314,089	82	1,762	22	1,910	11,607,075	79	6,077	8,241,749	32
Hydrogen	9	1,433	1,123,567	86	784	4	152	3,128,044	86	20,579	3,008,866	71
Soda ash	1	114	914,837	100	8,025	4	152	1,471,385	78	9,680	251,602	11
Other	4	107	192,083	100	1,795	5	111	331,521	76	2,987	132,257	25
Oil and gas	65	14,634	11,042,439	43	755	47	1,943	14,437,336	76	7,430	12,971,198	51
TOTAL	1,798	219,839	131,845,907	73	600	912	51,881 19,1 ⁽³⁾	338,985,136 72,0 ⁽³⁾	82	6,534	257,186,202	55

⁽¹⁾ Percentage of emissions covered by free allowances.

⁽²⁾ Emission savings (in tCO₂-eq, % of total emissions) if the bottom 20% most emission-intensive firms would produce the same output, but with the average intensity of the 80% least intensive firms.

⁽³⁾ Represents the share in the percentage of value added or emissions of the 20% most emission-intensive firms in the value added or emissions of all firms.

Notes: Figures for 2019. Value added in € millions, emissions in tCO₂-eq, emission intensity tCO₂-eq per € million value added. A brown zombie is defined as a firm that ceteris paribus has a negative cash flow (EBITDA) if the carbon price were €100 in 2019. Based on an EU ETS price of €20/tonne CO₂, for each payable emission €80 is deducted from the 2019 EBITDA and €100 is deducted for each free emission.

Source: Authors' calculations based on EUTL and ORBIS data.

Table S4 – Reallocation exercise away from the 100 most emitting firms

	2,379 least emitting firms				100 most emitting firms				Emission savings ⁽¹⁾	
	# firms	Value added	Emissions	Intensity	# firms	Value added	Emissions	Intensity	Emissions	% total
Combustion	774	168,613	34,017,252	202	6	898	10,879,256	12,115	10,698,087	24
Refining	25	5,869	7,394,143	1,260	25	19,445	72,964,191	3,752	48,466,132	60
Coke	5	57	1,427,149	25,038	0	0	0		0	0
Metal ore	10	503	576,237	1,146	2	1,144	7,619,543	6,660	6,308,976	77
Iron or steel	90	5,345	9,500,574	1,777	14	4,941	73,517,032	14,879	64,734,556	78
Ferrous metals	108	7,772	5,163,592	664	3	617	5,239,963	8,493	4,830,038	46
Primary aluminium	10	1,109	3,687,641	3,325	1	700	1,225,079	1,750	-1,102,557	-22
Secondary aluminium	16	768	889,902	1,159	0	0	0		0	0
Non-ferrous metals	53	4,286	4,352,129	1,015	0	0	0		0	0
Cement clinker	52	1,762	22,441,498	12,736	28	3,562	62,715,693	17,607	17,348,714	20
Lime	62	1,232	10,893,811	8,842	3	255	6,141,233	24,083	3,886,427	23
Glass	172	7,747	14,343,495	1,851	0	0	0		0	0
Ceramics	349	5,647	9,947,027	1,761	0	0	0		0	0
Mineral wool	37	1,180	1,755,455	1,488	0	0	0		0	0
Gypsum or plasterboard	24	1,176	1,189,971	1,012	0	0	0		0	0
Pulp	110	7,677	5,561,813	724	0	0	0		0	0
Paper or cardboard	240	8,782	12,275,980	1,398	1	368	1,094,164	2,973	579,753	4
Carbon black	8	1,087	1,597,970	1,470	0	0	0		0	0
Nitric acid	8	543	1,650,386	3,039	0	0	0		0	0
Adipic acid	1	35	95,214	2,720	0	0	0		0	0
Ammonia	4	307	3,032,267	9,877	5	457	7,809,105	17,088	3,295,275	30
Bulk chemicals	98	6,924	11,872,053	1,715	6	2,779	13,565,736	4,882	8,800,797	35
Hydrogen	12	1,521	2,841,768	1,868	1	43	1,409,842	32,787	1,329,503	31
Soda ash	5	295	2,386,222	8,089	0	0	0		0	0
Other	10	366	1,070,930	2,926	0	0	0		0	0
Oil and gas	96	9,794	11,146,520	1,138	5	4,101	8,671,840	2,115	4,004,505	20
TOTAL	2,379	250,397	181,110,999	98,240	100	39,310 13,6% ⁽²⁾	272,852,677 60,1% ⁽²⁾	149,184	173,180,206	38%

⁽¹⁾ Emission savings (in tCO₂-eq, % of total emissions) if the 100 most emitting firms would produce the same output, but with the average intensity of the 2,379 least emitting firms.

⁽²⁾ Represents the share in the percentage of value added or emissions of the 100 most emitting firms in the value added or emissions of all firms.

Notes: Figures for 2019. Value added in € millions, emissions in tCO₂-eq, emission intensity tCO₂-eq per € million value added.

Source: Authors' calculations based on EUTL and ORBIS data.