sEEnergies

QUANTIFICATION OF SYNERGIES BETWEEN ENERGY EFFICIENCY FIRST PRINCIPLE AND RENEWABLE ENERGY SYSTEMS

D3.5 Data set with Energy Efficiency potentials on top of the frozen efficiency scenario

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Executive Summary

Because it is not possible to include the entire dataset in this report, we only include the Energy Efficiency potentials for Austria. Table 1 shows the material production projections in the period 2015-2050 and Tables 2 and 3 the Fuel and Electricity demand, respectively, in the Frozen Efficiency scenario. Table 4 shows the Energy Efficiency potentials in 2030 per energy saving technology/measure and per industrial sub-sector and Table 5 shows the Energy Efficiency potentials for 2050. The full dataset, showing the savings potentials for all EU27 (and UK) countries, is available upon request to the project coordinator.

The data reported in this deliverable will be used in the development of the IndustryPLAN model. In Tables 4 and 5 the Energy Efficiency potentials, the associated investment costs and the change in operation and maintenance costs (O&M) are reported per technology/measure to calculate the Cost of Conserved Energy (CCE) that will be used in IndustryPLAN for the construction of the cost-supply curves.

Cost-supply curves are a useful tool, used to present the cost-effective as well as the technical energy savings potentials. To construct the curves, the most important energy efficiency measures/technologies, commercially available today, are identified and ranked from low to high, based on their CCE. The cost-supply curves show, in the y-axis, the CCE, and in the x-axis, the cumulative energy savings. The CCE can be determined using Eq. (1):

$$CCE = \frac{Annualized\ Investment\ Cost + Annual\ O\&M\ costs}{Annual\ energy\ savings} \quad (1)$$

Where the $Annualized\ Investment\ Cost$ is calculated from Eq. (2):

$$Annualized\ Investment\ Cost = Investment\ Cost \cdot \frac{d}{(1-(1+d)^{-n})} \quad (2)$$

Where d is the discount rate (%) and n the technical lifetime in years of the energy efficiency technology. In this database we calculated the CCE for three different discount rates; 15%, 10% and 5%. The costs are reported in € (2015).

A detailed description of the methodology and assumptions will become available in deliverable D **3.6: Energy Efficiency potentials on top of reference scenario,** that will be submitted as a report at the end of November 2020.

Table 1. Production projections in Austria per industrial sub-sector (ktonnes) - Frozen Efficiency Scenario

Industrial sub-sector	Product	2015	2020	2025	2030	2035	2040	2045	2050
Chemicals	Carbon black	-	-	-	-	-	-	-	-
Chemicals	Ethylene	412	431	441	449	461	461	461	461
Chemicals	Methanol	-	-	-	-	-	-	-	-
Chemicals	Ammonia	486	494	502	511	512	513	514	516
Chemicals	Soda ash	-	-	-	-	-	-	-	-
Iron and steel	BF/BOF steel	7,020	8,143	7,785	7,441	7,497	7,552	7,608	7,665
Iron and steel	Pig iron	5,805	6,734	6,584	6,437	6,485	6,533	6,582	6,630
Iron and steel	Rolled steel	7,601	8,817	8,063	7,373	7,079	6,798	6,527	6,267
Iron and steel	EAF steel	667	774	740	707	712	718	723	728
Iron and steel	Coke oven	2,673	3,101	3,032	2,964	2,986	3,008	3,031	3,053
Foundries	Ferrous metals casting	146	169	161	154	155	157	158	159
Non-ferrous metals	Aluminium primary	-	-	-	-	-	-	-	-
Non-ferrous metals	Aluminium secondary	88	95	95	96	96	97	97	97
Foundries	Nonferrous metals casting	141	146	149	152	152	152	152	152
Non-metallic minerals	Cement	4,700	4,981	5,278	5,593	5,628	5,662	5,698	5,733
Non-metallic minerals	Flat glass	-	-	-	-	-	-	-	-
Non-metallic minerals	Container glass	310	313	315	318	309	301	292	284
Paper and pulp	Paper	4,965	5,262	5,315	5,368	5,394	5,421	5,448	5,475
Paper and pulp	Tissue paper	138	138	136	137	138	139	140	140
Paper and pulp	Graphic paper	2,732	2,780	2,667	2,694	2,761	2,830	2,901	2,974
Paper and pulp	Board and packag. Paper	1,921	2,037	2,057	2,077	2,088	2,140	2,194	2,249
Paper and pulp	Chemical pulp	1,004	1,074	1,095	1,139	1,182	1,227	1,273	1,321
Paper and pulp	Mechanical pulp	358	328	311	318	330	342	355	368
Paper and pulp	Recovered fibre pulp	2,035	2,179	2,222	2,265	2,351	2,439	2,531	2,626

Table 2 Final fuel consumption projections in Austria (TJ)

Industrial sub-sector	Product	2015	2020	2025	2030	2035	2040	2045	2050
Chemicals	Carbon black	-	-	-	-	-	-	-	-
Chemicals	Ethylene	14,803	15,460	15,820	16,103	16,542	16,542	16,542	16,542
Chemicals	Methanol	-	-	-	-	-	-	-	-
Chemicals	Ammonia	5,496	5,586	5,677	5,770	5,785	5,799	5,814	5,828
Chemicals	Soda ash	-	-	-	-	-	-	-	-
Chemicals	Rest of chemicals	6,572	6,814	6,960	7,082	7,228	7,233	7,238	7,242
Iron and steel	BF/BOF steel	351	407	389	372	375	378	380	383
Iron and steel	Pig iron	67,338	78,116	76,375	74,673	75,227	75,785	76,347	76,913
Iron and steel	Rolled steel	8,027	9,311	8,514	7,786	7,476	7,178	6,892	6,618
Iron and steel	EAF steel	334	387	370	354	356	359	361	364
Iron and steel	Coke oven	4,277	4,961	4,851	4,743	4,778	4,813	4,849	4,885
Foundries	Ferrous metals casting	1,000	1,160	1,109	1,060	1,068	1,076	1,084	1,092
Iron and steel	Rest of iron and steel	8,959	11,114	10,791	10,483	10,517	10,554	10,592	10,632
Non-ferrous metals	Aluminium primary	-	-	-	-	-	-	-	-
Non-ferrous metals	Aluminium secondary	286	308	310	311	313	314	315	317
Foundries	Nonferrous metals casting	733	762	777	793	793	793	793	793
Non-ferrous metals	Rest of non-ferrous metals	3,091	3,247	3,297	3,348	3,352	3,356	3,361	3,365
Non-metallic minerals	Cement	12,272	13,004	13,781	14,603	14,694	14,785	14,876	14,968
Non-metallic minerals	Flat glass	-	-	-	-	-	-	-	-
Non-metallic minerals	Container glass	1,438	1,451	1,463	1,476	1,435	1,395	1,357	1,319
Non-metallic minerals	Rest of non-metallic minerals	16,198	17,045	18,069	19,157	19,212	19,268	19,325	19,383
Paper and pulp	Tissue paper	1,002	998	988	998	1,003	1,008	1,013	1,018
Paper and pulp	Graphic paper	20,762	21,127	20,271	20,472	20,985	21,511	22,050	22,603
Paper and pulp	Board and packag. Paper	9,799	10,387	10,490	10,594	10,647	10,914	11,187	11,468
Paper and pulp	Chemical pulp	12,695	13,591	13,858	14,412	14,954	15,517	16,101	16,707
Paper and pulp	Mechanical pulp	720	660	626	638	662	687	713	740
Paper and pulp	Recovered fibre pulp	1,099	1,177	1,200	1,223	1,269	1,317	1,367	1,418
Paper and pulp	Rest of pulp and paper	29,672	30,872	30,545	31,129	31,891	32,814	33,765	34,745
Others	Others	91,965	99,486	104,193	106,791	114,561	124,836	132,323	142,463

Table 3 Final electricity consumption projections in Austria (TJ)

Industrial sub-sector	Product	2015	2020	2025	2030	2035	2040	2045	2050
Chemicals	Carbon black	-	-	-	-	-	-	-	-
Chemicals	Ethylene	-	-	-	-	-	-	-	-
Chemicals	Methanol	-	-	-	-	-	-	-	-
Chemicals	Ammonia	243	247	251	255	256	257	257	258
Chemicals	Soda ash	-	-	-	-	-	-	-	-
Chemicals	Rest of chemicals	15,734	15,992	16,254	16,521	16,562	16,603	16,644	16,686
Iron and steel	BF/BOF steel	562	651	623	595	600	604	609	613
Iron and steel	Pig iron	3,483	4,040	3,950	3,862	3,891	3,920	3,949	3,978
Iron and steel	Rolled steel	3,344	3,880	3,548	3,244	3,115	2,991	2,872	2,757
Iron and steel	EAF steel	1,201	1,393	1,331	1,273	1,282	1,292	1,301	1,311
Iron and steel	Coke oven	267	310	303	296	299	301	303	305
Foundries	Ferrous metals casting	16	18	17	16	17	17	17	17
Iron and steel	Rest of iron and steel	318	369	351	333	330	327	325	322
Non-ferrous metals	Aluminium primary	-	-	-	-	-	-	-	-
Non-ferrous metals	Aluminium secondary	-	-	-	-	-	-	-	-
Foundries	Nonferrous metals casting	84	88	90	91	91	91	91	91
Non-ferrous metals	Rest of non-ferrous metals	3,448	3,585	3,656	3,729	3,729	3,729	3,729	3,729
Non-metallic minerals	Cement	1,963	2,080	2,204	2,336	2,350	2,365	2,379	2,394
Non-metallic minerals	Flat glass	-	-	-	-	-	-	-	-
Non-metallic minerals	Container glass	62	63	63	64	62	60	58	57
Non-metallic minerals	Rest of non-metallic minerals	4,599	4,861	5,151	5,459	5,485	5,512	5,539	5,567
Paper and pulp	Tissue paper	251	250	248	250	251	253	254	255
Paper and pulp	Graphic paper	5,737	5,838	5,601	5,657	5,799	5,944	6,093	6,246
Paper and pulp	Board and packag. Paper	2,882	3,055	3,085	3,116	3,131	3,210	3,290	3,373
Paper and pulp	Chemical pulp	2,308	2,471	2,520	2,620	2,719	2,821	2,928	3,038
Paper and pulp	Mechanical pulp	2,835	2,602	2,467	2,515	2,610	2,708	2,810	2,916
Paper and pulp	Recovered fibre pulp	1,913	2,048	2,088	2,129	2,209	2,293	2,379	2,468
Paper and pulp	Rest of pulp and paper	357	364	358	365	374	386	397	410
Others	Others	39,379	42,365	43,224	43,871	46,240	48,844	50,886	53,665

Table 4 Industrial Energy Efficiency potentials per technology in 2030 in Austria

												Annualized Investment Cost in € (2015)/tonne			Cost of Conserved Energy (/GJ-saved)		
Industrial Subsector	Product	Measures/Technologies	2050 Implementation Rate %	Fuel savings (GJ/tonne product)	Electricity savings (GJ/tonne product)	2050 Fuel Savings Potential (TJ)	2050 Electricity Savings Potential (TJ)	2050 Total Energy Savings Potential (PJ)	Investment Cost in € (2015)/tonne	Change in O&M Costs in € (2015)/tonne	Technical lifetime (years)	Total Investment million € (2015)	15%	10%	5%	15%	10%	5%
Non-metallic min	Cement	Improved Raw Mill Blending	40%	0.01	0.01	33	16	0.0	4.0	0.0	20	8.9	0.6	0.5	0.3	29.3	21.5	14.7
Non-metallic min	Cement	Use of High-Pressure Roller Presses	40%	0.00	0.05	0	115	0.1	10.8	0.0	20	24.1	1.7	1.3	0.9	33.5	24.6	16.8
Non-metallic min	Cement	High Efficiency Classifiers	30%	0.00	0.01	0	23	0.0	4.4	0.0	20	7.4	0.7	0.5	0.4	51.7	38.0	26.0
Non-metallic min	Cement	Raw Meal Process Control	30%	0.00	0.00	0	7	0.0	0.1	0.1	20	0.2	0.0	0.0	0.0	23.4	22.3	21.3
Non-metallic min	Cement	Energy Management and Control Systems	15%	0.12	0.00	105	4	0.1	0.3	0.0	10	0.3	0.1	0.1	0.0	0.5	0.4	0.3
Non-metallic min	Cement	Kiln Combustion System Improvements	5%	0.26	0.00	73	0	0.1	0.8	0.0	30	0.2	0.1	0.1	0.1	0.5	0.4	0.2
Non-metallic min	Cement	Indirect Firing	5%	0.13	0.00	36	0	0.0	9.6	0.0	20	2.7	1.5	1.1	0.8	11.8	8.7	5.9
Non-metallic min	Cement	Oxygen Enrichment technology	5%	0.11	-0.06	29	-16	0.0	6.2	0.0	20	1.7	1.0	0.7	0.5	20.7	15.2	10.4
Non-metallic min	Cement	Preheater Shell Heat Loss Reduction	5%	0.26	0.00	73	0	0.1	0.4	0.0	5	0.1	0.1	0.1	0.1	0.4	0.4	0.3
Non-metallic min	Cement	Conversion to Grate Cooler	15%	0.23	-0.01	191	-10	0.2	14.6	0.1	30	12.2	2.2	1.5	0.9	10.7	7.6	4.8
Non-metallic min	Cement	Optimize Grate Cooler	30%	0.07	0.00	123	-6	0.1	1.7	0.1	30	2.8	0.3	0.2	0.1	5.0	3.9	3.0
Non-metallic min	Cement	Low-Pressure Drop Suspension Preheaters	20%	0.00	0.01	0	7	0.0	5.9	0.0	30	6.7	0.9	0.6	0.4	141.8	98.7	60.6
Non-metallic min	Cement	Heat Recovery for Power Generation (ORC)	58%	0.00	0.04	0	123	0.1	20.0	1.0	20	64.9	3.2	2.3	1.6	109.7	87.3	67.6
Non-metallic min	Cement	Increase Preheater Stages (from 5 to6)	8%	0.09	0.00	39	-1	0.0	11.2	0.0	30	5.0	1.7	1.2	0.7	20.1	14.1	8.7
Non-metallic min	Cement	Addition of Precalciner or Upgrade	17%	0.42	0.00	387	0	0.4	93.2	-1.2	40	86.1	14.0	9.5	5.4	30.7	20.0	10.2
Non-metallic min	Cement	Conversion of Long Dry Kiln to Preheater Precalciner	3%	0.83	0.00	117	0	0.1	93.2	0.0	40	13.0	14.0	9.5	5.4	16.8	11.4	6.5
Non-metallic min	Cement	Blended Cement (70% BFS)	14%	1.32	-0.06	1061	-48	1.0	6.2	0.0	30	5.0	1.0	0.7	0.4	0.7	0.5	0.3
Non-metallic min	Cement	Use of Fly Ash, Blast Furnace Slag in Clinker (15% substitution)	2%	0.18	0.00	20	0	0.0	2.5	0.0	30	0.3	0.4	0.3	0.2	2.2	1.5	0.9
Non-metallic min	Cement	Biomass and Waste	11%	-0.15	-0.01	-92	-3	-0.1	4.3	0.0	30	2.7	0.7	0.5	0.3	-4.2	-2.9	-1.8
Non-metallic min	Cement	Energy Management and Process Control	20%	0.00	0.02	0	22	0.0	0.6	0.0	10	0.6	0.1	0.1	0.1	5.5	4.5	3.6
Non-metallic min	Cement	Replace ball mills with VRMs	35%	0.00	0.05	0	105	0.1	17.3	0.2	20	33.9	2.8	2.0	1.4	54.9	41.2	29.1
Non-metallic min	Cement	High-Efficiency Classifiers	30%	0.00	0.02	0	26	0.0	2.7	0.0	20	4.6	0.4	0.3	0.2	28.4	20.9	14.3
Non-metallic min	Cement	High efficiency motors	30%	0.00	0.01	0	23	0.0	0.4	0.0	10	0.6	0.1	0.1	0.0	5.3	4.3	3.5
Non-metallic min	Cement	Adjustable speed drives	40%	0.00	0.02	0	50	0.1	0.2	0.0	10	0.4	0.0	0.0	0.0	1.7	1.4	1.1
Non-metallic min	Container glass	Batch preheating	20%	0.32	0.00	20	0	0.0	19.6	0.0	20	1.2	3.1	2.3	1.6	9.7	7.1	4.9
Non-metallic min	Container glass	Increase of cullets	27%	1.20	0.00	103	0	0.1	28.0	0.8	20	2.4	4.5	3.3	2.2	4.4	3.4	2.6
Non-metallic min	Container glass	Low Nox burners_container glass	21%	0.26	0.00	17	0	0.0	2.6	0.0	20	0.2	0.4	0.3	0.2	1.6	1.2	0.8
Non-metallic min	Container glass	Optimized burning_container glass	39%	0.52	0.00	65	0	0.1	10.0	0.0	20	1.2	1.6	1.2	0.8	3.1	2.3	1.5
Non-metallic min	Container glass	Fast response_container glass	18%	0.45	0.07	26	4	0.0	10.0	0.0	10	0.6	2.0	1.6	1.3	3.8	3.1	2.5
Non-metallic min	Container glass	Process Control-Software and Image based control_container glass	30%	0.23	0.00	22	0	0.0	2.5	0.0	10	0.2	0.5	0.4	0.3	2.2	1.8	1.4
Non-metallic min	Flat glass	Waste heat recovery- el. Generation	5%	0.00	0.26	0	0	0.0	10.0	0.0	20	0.0	1.6	1.2	0.8	0.0	0.0	0.0
Non-metallic min	Flat glass	Low Nox burners_flat glass	21%	0.38	0.00	0	0	0.0	2.6	0.0	20	0.0	0.4	0.3	0.2	0.0	0.0	0.0
Non-metallic min	Flat glass	Optimized burning_flat glass	41%	0.95	0.00	0	0	0.0	10.0	0.0	20	0.0	1.6	1.2	0.8	0.0	0.0	0.0
Non-metallic min	Flat glass	Fast response_flat glass	18%	0.86	-0.09	0	0	0.0	10.0	0.0	10	0.0	2.0	1.6	1.3	0.0	0.0	0.0
Non-metallic min	Flat glass	Process Control-Software and Image based control_flat glass	30%	0.44	0.00	0	0	0.0	2.5	0.0	10	0.0	0.5	0.4	0.3	0.0	0.0	0.0
Iron and steel	Coke oven	Coke dry quenching	3%	1.42	0.00	127	0	0.1	43.6	0.0	18	3.9	7.1	5.3	3.7	5.0	3.7	2.6
Iron and steel	Coke oven	Programmed heating in coke oven	50%	0.16	0.00	237	0	0.2	0.2	0.0	10	0.3	0.0	0.0	0.0	0.3	0.2	0.2
Iron and steel	Coke oven	Variable speed drive on coke oven gas compressors	50%	0.01	0.00	15	0	0.0	0.3	0.0	15	0.5	0.1	0.0	0.0	6.0	4.6	3.4
Iron and steel	Coke oven	Coal moisture control	50%	0.33	0.00	489	0	0.5	6.5	0.0	10	9.6	1.3	1.1	0.8	3.9	3.2	2.6
Iron and steel	pig iron	Top gas recycling	9%	1.23	0.00	710	0	0.7	87.2	0.0	20	50.5	13.9	10.2	7.0	11.4	8.4	5.7
Iron and steel	pig iron	Waste heat recovery blast furnace slag	43%	0.35	0.00	969	0	1.0	54.5	0.0	20	150.9	8.7	6.4	4.4	24.9	18.3	12.5
Iron and steel	pig iron	Top gas recovery turbine	21%	0.00	0.10	0	129	0.1	3.3	0.5	15	4.4	0.6	0.4	0.3	11.4	10.0	8.8
Iron and steel	pig iron	Moisture Removing Blowing Technique in Blast Furnace	65%	0.23	0.00	962	0	1.0	2.0	0.0	15	8.5	0.3	0.3	0.2	1.5	1.2	0.8
Iron and steel	pig iron	Injection of pulverized coal in BF	45%	0.64	0.00	1854	0	1.9	5.4	1.6	20	15.8	0.9	0.6	0.4	3.8	3.4	3.1
Iron and steel	pig iron	Injection of natural gas in BF	50%	0.32	0.00	1030	0	1.0	5.2	0.3	20	16.9	0.8	0.6	0.4	3.6	2.9	2.3
Iron and steel	pig iron	Injection of oil in BF	50%	0.48	0.00	1545	0	1.5	9.9	-2.2	20	31.9	1.6	1.2	0.8	-1.2	-2.1	-2.9
Iron and steel	pig iron	Injection of plastic waste in BF	50%	0.16	0.00	515	0	0.5	5.4	1.6	20	17.5	0.9	0.6	0.4	15.2	13.7	12.5
Iron and steel	pig iron	Injection of coke oven gas in BF	50%	0.32	0.05	1030	161	1.2	5.2	0.0	20	16.9	0.8	0.6	0.4	2.3	1.7	1.1
Iron and steel	pig iron	Cogeneration (for the use of untapped coke oven gas, blast furnace ga	20%	0.23	0.00	296	0	0.3	2.8	0.0	20	3.7	0.5	0.3	0.2	2.0	1.5	1.0
Iron and steel	pig iron	Recovery of blast furnace gas	3%	0.09	0.00	14	0	0.0	1.3	0.0	15	0.2	0.2	0.2	0.1	2.4	1.8	1.4
Iron and steel	pig iron	Improved hot blast stove control	30%	0.32	0.00	618	0	0.6	0.3	0.0	5	0.7	0.1	0.1	0.1	0.3	0.3	0.3
Iron and steel	pig iron	Improved blast furnace control	25%	0.32	0.00	515	0	0.5	0.6	0.0	5	0.9	0.2	0.2	0.1	0.5	0.5	0.4
Iron and steel	BF/BOF steel	Recovery of BOF and sensible heat	40%	0.56	0.00	1667	0	1.7	25.6	0.0	10	76.3	5.1	4.2	3.3	9.1	7.4	5.9
Iron and steel	EAF steel	Scrap preheating	25%	0.15	0.37	27	65	0.1	17.4	0.0	30	3.1	2.7	1.9	1.1	5.1	3.6	2.2
Iron and steel	EAF steel	Converting the furnace operation to ultra-high power (UHP) (Increasin	45%	0.11	0.00	35	0	0.0	9.7	0.0	15	3.1	1.7	1.3	0.9	15.0	11.6	8.5
Iron and steel	EAF steel	Improving process control in EAF	40%	0.24	0.09	68	25	0.1	1.4	-0.9	10	0.4	0.3	0.2	0.2	-1.9	-2.0	-2.2
Iron and steel	Rolled Steel	Recuperative or regenerative burner	30%	0.56	0.00	1239	0	1.2	2.9	0.0	10	6.4	0.6	0.5	0.4	1.0	0.8	0.7
Iron and steel	Rolled Steel	Endless Hot Rolling of Steel Sheets	8%	0.36	0.00	223	0	0.2	7.3	0.0	20	4.5	1.2	0.9	0.6	3.3	2.4	1.6
Iron and steel	Rolled Steel	Process control in hot rolling	30%	0.30	0.00	664	0	0.7	0.8	0.0	10	1.8	0.2	0.1	0.1	0.5	0.4	0.4
Iron and steel	BF/BOF steel	Integration of casting and rolling (thin slab strip casting)	65%	0.73	0.00	3531	0	3.5	6.9	0.0	20	33.4	1.1	0.8	0.6	1.5	1.1	0.8
Iron and steel	pig iron	Variable speed drives for flue gas control, pumps, fans in integrated st	15%	0.00	0.03	0	29	0.0	1.5	0.0	10	1.5	0.3	0.2	0.2	10.1	8.2	6.5
Iron and steel	pig iron	Energy monitoring and management systems	25%	0.08	0.01	129	16	0.1	0.2	0.0	5	0.3	0.1	0.0	0.0	0.6	0.5	0.4
Non-ferrous meta	Aluminium prim	Inert Anodes	5%	0.00	3.60	0	0.00	0.0	86.0	0.0	20	0.0	13.7	10.1	6.9	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Wetted Cathode	5%	0.00	7.34	0	0.00	0.0	524.0	0.0	20	0.0	83.7	61.5	42.0	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	PFPB	10%	0.00	2.80	0	0.00	0.0	2342.3	0.0	20	0.0	374.2	275.1	188.0	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Optimization electrolysis control	20%	0.00	3.60	0	0.00	0.0	188.1	-65.0	5	0.0	56.1	49.6	43.4	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Optimization cell design	20%	0.00	2.52	0	0.00	0.0	236.1	0.0	6	0.0	62.4	54.2	46.5	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Lower the electrolysis temperature	5%	0.00	4.50	0	0.00	0.0	0.0	75.0	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-ferrous meta	Aluminium seco	Regenerative or recuperative burner	35%	2.04	0.00	68	0.00	0.1	14.3	0.4	20	0.5	2.3	1.7	1.1	1.3	1.0	0.8

Industrial Subsector	Product	Measures/Technologies	2050 Implementation Rate %	Fuel savings (GJ/tonne product)	Electricity savings (GJ/tonne product)	2050 Fuel Savings Potential (TJ)	2050 Electricity Savings Potential (TJ)	2050 Total Energy Savings Potential (PJ)	Investment Cost in € (2015)/tonne	Change in O&M Costs in € (2015)/tonne	Technical lifetime (years)	Total Investment million € (2015)	15%	10%	5%	15%	10%	5%
Non-ferrous meta	Aluminium seco	New decoating equipment	15%	0.36	0.00	5	0.00	0.0	40.0	40.0	10	0.6	8.0	6.5	5.2	132.3	128.3	124.6
Non-ferrous meta	Nonferrous met	Improved process scheduling	39%	1.80	0.00	107	0.00	0.1	18.0	0.0	20	1.1	2.9	2.1	1.4	1.6	1.2	0.8
Non-ferrous meta	Nonferrous met	Regenerative or recuperative burner	35%	2.04	0.00	109	0.00	0.1	14.3	0.4	20	0.8	2.3	1.7	1.1	1.3	1.0	0.8
Non-ferrous meta	Nonferrous met	Liquid metal as feedstock	20%	3.60	0.00	110	0.00	0.1	18.0	0.0	20	0.5	2.9	2.1	1.4	0.8	0.6	0.4
Pulp and paper	Chemical pulp	Black liquor gasification	9%	0.00	2.00	0	205	0.2	508.4	5.4	20	52.1	81.2	59.7	40.8	43.3	32.6	23.1
Pulp and paper	Mechanical pulp	Heat recovery (TMP, GW)	5%	3.48	0.00	55	0	0.1	41.4	0.0	20	0.7	6.6	4.9	3.3	1.9	1.4	1.0
Pulp and paper	Mechanical pulp	High efficiency grinding GW	46%	0.00	2.59	0	379	0.4	407.3	0.0	5	59.5	121.5	107.5	94.1	46.9	41.5	36.3
Pulp and paper	Mechanical pulp	Enzymatic pre-treatment	14%	0.00	1.86	0	80	0.1	501.2	3.2	15	21.5	85.7	65.9	48.3	47.8	37.1	27.7
Pulp and paper	Mechanical pulp	Efficient refiner and pretreatment (TMP)	13%	0.00	1.55	0	62	0.1	121.9	0.0	20	4.8	19.5	14.3	9.8	12.5	9.2	6.3
Pulp and paper	Recovered fibre	High consistency pulping	45%	0.00	0.20	0	204	0.2	2.8	0.0	20	2.8	0.4	0.3	0.2	2.2	1.6	1.1
Pulp and paper	Recovered fibre	Efficient screening	48%	0.00	0.65	0	699	0.7	6.4	0.0	20	6.8	1.0	0.7	0.5	1.6	1.1	0.8
Pulp and paper	Recovered fibre	Heat recovery from bleaching	48%	0.30	0.00	323	0	0.3	1.5	0.0	20	1.6	0.2	0.2	0.1	0.8	0.6	0.4
Pulp and paper	Recovered fibre	De-Inking flotation optimization	70%	0.00	0.50	0	793	0.8	1.0	0.0	15	1.6	0.2	0.1	0.1	0.4	0.3	0.2
Pulp and paper	Recovered fibre	Efficient disperser	52%	0.00	0.22	0	257	0.3	1.3	0.0	15	1.5	0.2	0.2	0.1	1.0	0.8	0.6
Pulp and paper	Paper	Efficient refiners	18%	0.00	0.12	0	114	0.1	16.4	0.0	20	15.8	2.6	1.9	1.3	22.2	16.3	11.1
Pulp and paper	Paper	Optimization of refining	50%	0.00	0.08	0	201	0.2	0.7	0.0	20	2.0	0.1	0.1	0.1	1.6	1.2	0.8
Pulp and paper	Paper	Chemical modification of fibres	9%	0.19	0.16	89	79	0.2	16.6	3.5	20	8.0	2.6	1.9	1.3	17.5	15.5	13.7
Pulp and paper	Paper	Steambox	2%	0.18	0.00	19	0	0.0	4.6	0.0	15	0.5	0.8	0.6	0.4	4.3	3.3	2.4
Pulp and paper	Paper	Shoepress	6%	0.48	0.00	155	0	0.2	31.7	0.0	20	10.2	5.1	3.7	2.5	10.6	7.8	5.3
Pulp and paper	Paper	New drying techniques	6%	0.67	0.00	215	0	0.2	91.4	0.0	20	29.5	14.6	10.7	7.3	21.9	16.1	11.0
Pulp and paper	Paper	Heat recovery and integration	18%	1.07	0.00	1034	0	1.0	16.0	0.0	20	15.4	2.5	1.9	1.3	2.4	1.8	1.2
Chemicals	Ethylene	Advanced furnace materials	30%	1.69	0.00	227	0.0	0.2	2.1	0.0	20	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Chemicals	Ethylene	Improving compression and separation section	18%	1.00	0.00	81	0.0	0.1	0.6	0.0	20	0.0	0.1	0.1	0.0	0.1	0.1	0.0
Chemicals	Ethylene	Integration of a gas turbine	12%	2.64	0.00	142	0.0	0.1	58.0	0.0	20	3.1	9.3	6.8	4.7	3.5	2.6	1.8
Chemicals	Ethylene	Improved compressors	8%	0.78	0.00	28	0.0	0.0	22.3	0.0	20	0.8	3.6	2.6	1.8	4.5	3.3	2.3
Chemicals	Ethylene	Utilization of flare gas	9%	2.00	0.00	81	0.0	0.1	60.0	0.0	20	2.4	9.6	7.0	4.8	4.8	3.5	2.4
Chemicals	Ethylene	Modern control system, ethylene	9%	1.46	0.00	59	0.0	0.1	29.0	0.0	10	1.2	5.8	4.7	3.8	4.0	3.2	2.6
Chemicals	Soda ash	Integrated design and operation	25%	1.98	0.14	0	0.0	0.0	40.0	0.0	20	0.0	6.4	4.7	3.2	0.0	0.0	0.0
Chemicals	Soda ash	Vertical shaft kiln for the production of concentrated CO2 gas and reac	20%	0.30	0.00	0	0.0	0.0	16.0	0.0	20	0.0	2.6	1.9	1.3	0.0	0.0	0.0
Chemicals	Soda ash	Heat integration	15%	1.00	0.00	0	0.0	0.0	20.0	0.0	20	0.0	3.2	2.3	1.6	0.0	0.0	0.0
Chemicals	Soda ash	Modern control system_soda ash	16%	0.40	0.04	0	0.0	0.0	10.0	0.0	10	0.0	2.0	1.6	1.3	0.0	0.0	0.0
Chemicals	Soda ash	Usage of CHP, soda ash	27%	1.80	0.00	0	0.0	0.0	36.0	0.0	30	0.0	5.5	3.8	2.3	0.0	0.0	0.0
Chemicals	Soda ash	Efficiency package	23%	1.00	0.04	0	0.0	0.0	22.0	0.0	20	0.0	3.5	2.6	1.8	0.0	0.0	0.0
Chemicals	Soda ash	Usage of more pure feed	27%	0.30	0.00	0	0.0	0.0	1.0	0.0	10	0.0	0.2	0.2	0.1	0.0	0.0	0.0
Chemicals	Carbon black	Usage of CHP, carbon black	10%	6.48	0.00	0	0.0	0.0	130.0	0.0	20	0.0	20.8	15.3	10.4	0.0	0.0	0.0
Chemicals	Carbon black	Modern control system, carbon black	8%	6.48	0.20	0	0.0	0.0	139.0	0.0	10	0.0	27.7	22.6	18.0	0.0	0.0	0.0
Chemicals	Carbon black	Optimization of black carbon separation	14%	6.48	0.25	0	0.0	0.0	142.0	0.0	20	0.0	22.7	16.7	11.4	0.0	0.0	0.0
Chemicals	Methanol	Efficiency package, synthesis gas section	21%	1.78	0.08	0	0.0	0.0	39.0	0.0	20	0.0	6.2	4.6	3.1	0.0	0.0	0.0
Chemicals	Methanol	Efficiency package, methanol synthesis section	27%	1.09	0.04	0	0.0	0.0	24.0	0.0	20	0.0	3.8	2.8	1.9	0.0	0.0	0.0
Chemicals	Ammonia	Improved CO2 removal section	20%	1.00	0.00	102	0.0	0.1	15.0	0.0	20	1.5	2.4	1.8	1.2	2.4	1.8	1.2
Chemicals	Ammonia	Indirect cooling of the ammonia synthesis reactor	20%	0.60	0.00	61	0.0	0.1	7.1	0.0	20	0.7	1.1	0.8	0.6	1.9	1.4	1.0
Chemicals	Ammonia	Increasing the air preheat with waste heat	20%	0.90	0.00	92	0.0	0.1	7.4	0.0	20	0.8	1.2	0.9	0.6	1.3	1.0	0.7
Chemicals	Ammonia	Hydrogen recovery (such as PSA)	20%	0.80	0.00	82	0.0	0.1	2.0	0.0	20	0.2	0.3	0.2	0.2	0.4	0.3	0.2
Chemicals	Ammonia	pre-reforming	20%	2.29	0.00	234	0.0	0.2	16.4	0.0	20	1.7	2.6	1.9	1.3	1.1	0.8	0.6
Chemicals	Ammonia	Advanced process control	30%	0.70	0.00	107	0.0	0.1	6.0	0.0	10	0.9	1.2	1.0	0.8	1.7	1.4	1.1

Table 5 Industrial Energy Efficiency potentials per technology in 2050 in Austria

												Annualized Investment Cost in € (2015)/tonne			Cost of Conserved Energy (/GJ-saved)		
Industrial Subsector	Product	Measures/Technologies	2050 Implementation Rate %	Fuel savings (GJ/tonne product)	Electricity savings (GJ/tonne product)	2050 Fuel Savings Potential (TJ)	2050 Electricity Savings Potential (TJ)	2050 Total Energy Savings Potential (PJ)	Investment Cost in € (2015)/tonne	Change in O&M Costs in € (2015)/tonne	Technical lifetime (years)	Total Investment million € (2015)	15%	10%	5%	15%	10%	5%
Non-metallic min	Cement	Improved Raw Mill Blending	70%	0.01	0.01	59	28	0.1	4.0	0.0	20	15.9	0.6	0.5	0.3	29.3	21.5	14.7
Non-metallic min	Cement	Use of High-Pressure Roller Presses	70%	0.00	0.05	0	206	0.2	10.8	0.0	20	43.2	1.7	1.3	0.9	33.5	24.6	16.8
Non-metallic min	Cement	High Efficiency Classifiers	50%	0.00	0.01	0	39	0.0	4.4	0.0	20	12.7	0.7	0.5	0.4	51.7	38.0	26.0
Non-metallic min	Cement	Raw Meal Process Control	50%	0.00	0.00	0	12	0.0	0.1	0.1	20	0.3	0.0	0.0	0.0	23.4	22.3	21.3
Non-metallic min	Cement	Energy Management and Control Systems	20%	0.12	0.00	143	5	0.1	0.3	0.0	10	0.4	0.1	0.1	0.0	0.5	0.4	0.3
Non-metallic min	Cement	Kiln Combustion System Improvements	5%	0.26	0.00	75	0	0.1	0.8	0.0	30	0.2	0.1	0.1	0.1	0.5	0.4	0.2
Non-metallic min	Cement	Indirect Firing	5%	0.13	0.00	37	0	0.0	9.6	0.0	20	2.7	1.5	1.1	0.8	11.8	8.7	5.9
Non-metallic min	Cement	Oxygen Enrichment technology	5%	0.11	-0.06	30	-16	0.0	6.2	0.0	20	1.8	1.0	0.7	0.5	20.7	15.2	10.4
Non-metallic min	Cement	Preheater Shell Heat Loss Reduction	5%	0.26	0.00	75	0	0.1	0.4	0.0	5	0.1	0.1	0.1	0.1	0.4	0.4	0.3
Non-metallic min	Cement	Conversion to Grate Cooler	20%	0.23	-0.01	262	-13	0.2	14.6	0.1	30	16.7	2.2	1.5	0.9	10.7	7.6	4.8
Non-metallic min	Cement	Optimize Grate Cooler	30%	0.07	0.00	126	-6	0.1	1.7	0.1	30	2.9	0.3	0.2	0.1	5.0	3.9	3.0
Non-metallic min	Cement	Low-Pressure Drop Suspension Preheaters	25%	0.00	0.01	0	9	0.0	5.9	0.0	30	8.5	0.9	0.6	0.4	141.8	98.7	60.6
Non-metallic min	Cement	Heat Recovery for Power Generation (ORC)	100%	0.00	0.04	0	217	0.2	20.0	1.0	20	114.7	3.2	2.3	1.6	109.7	87.3	67.6
Non-metallic min	Cement	Increase Preheater Stages (from 5 to6)	10%	0.09	0.00	50	-1	0.0	11.2	0.0	30	6.4	1.7	1.2	0.7	20.1	14.1	8.7
Non-metallic min	Cement	Addition of Precalciner or Upgrade	33%	0.42	0.00	794	0	0.8	93.2	-1.2	40	176.4	14.0	9.5	5.4	30.7	20.0	10.2
Non-metallic min	Cement	Conversion of Long Dry Kiln to Preheater Precalciner	5%	0.83	0.00	239	0	0.2	93.2	0.0	40	26.7	14.0	9.5	5.4	16.8	11.4	6.5
Non-metallic min	Cement	Blended Cement (70% BFS)	100%	1.32	-0.06	7588	-341	7.2	6.2	0.0	30	35.8	1.0	0.7	0.4	0.7	0.5	0.3
Non-metallic min	Cement	Use of Fly Ash, Blast Furnace Slag in Clinker (15% substitution)	92%	0.18	0.00	923	-12	0.9	2.5	0.0	30	13.2	0.4	0.3	0.2	2.2	1.5	0.9
Non-metallic min	Cement	Biomass and Waste	22%	-0.15	-0.01	-189	-7	-0.2	4.3	0.0	30	5.5	0.7	0.5	0.3	-4.2	-2.9	-1.8
Non-metallic min	Cement	Energy Management and Process Control	20%	0.00	0.02	0	23	0.0	0.6	0.0	10	0.6	0.1	0.1	0.1	5.5	4.5	3.6
Non-metallic min	Cement	Replace ball mills with VRMs	68%	0.00	0.05	0	208	0.2	17.3	0.2	20	67.5	2.8	2.0	1.4	54.9	41.2	29.1
Non-metallic min	Cement	High-Efficiency Classifiers	30%	0.00	0.02	0	26	0.0	2.7	0.0	20	4.7	0.4	0.3	0.2	28.4	20.9	14.3
Non-metallic min	Cement	High efficiency motors	50%	0.00	0.01	0	40	0.0	0.4	0.0	10	1.1	0.1	0.1	0.0	5.3	4.3	3.5
Non-metallic min	Cement	Adjustable speed drives	60%	0.00	0.02	0	77	0.1	0.2	0.0	10	0.7	0.0	0.0	0.0	1.7	1.4	1.1
Non-metallic min	Container glass	Batch preheating	38%	0.32	0.00	35	0	0.0	19.6	0.0	20	2.1	3.1	2.3	1.6	9.7	7.1	4.9
Non-metallic min	Container glass	Increase of cullets	30%	1.20	0.00	102	0	0.1	28.0	0.8	20	2.4	4.5	3.3	2.2	4.4	3.4	2.6
Non-metallic min	Container glass	Low Nox burners_container glass	37%	0.26	0.00	27	0	0.0	2.6	0.0	20	0.3	0.4	0.3	0.2	1.6	1.2	0.8
Non-metallic min	Container glass	Optimized burning_container glass	65%	0.52	0.00	96	0	0.1	10.0	0.0	20	1.8	1.6	1.2	0.8	3.1	2.3	1.5
Non-metallic min	Container glass	Fast response_container glass	48%	0.45	0.07	61	10	0.1	10.0	0.0	10	1.4	2.0	1.6	1.3	3.8	3.1	2.5
Non-metallic min	Container glass	Process Control-Software and Image based control_container glass	50%	0.23	0.00	33	0	0.0	2.5	0.0	10	0.4	0.5	0.4	0.3	2.2	1.8	1.4
Non-metallic min	Flat glass	Waste heat recovery- el. Generation	25%	0.00	0.26	0	0	0.0	10.0	0.0	20	0.0	1.6	1.2	0.8	0.0	0.0	0.0
Non-metallic min	Flat glass	Low Nox burners_flat glass	37%	0.38	0.00	0	0	0.0	2.6	0.0	20	0.0	0.4	0.3	0.2	0.0	0.0	0.0
Non-metallic min	Flat glass	Optimized burning_flat glass	66%	0.95	0.00	0	0	0.0	10.0	0.0	20	0.0	1.6	1.2	0.8	0.0	0.0	0.0
Non-metallic min	Flat glass	Fast response_flat glass	48%	0.86	-0.09	0	0	0.0	10.0	0.0	10	0.0	2.0	1.6	1.3	0.0	0.0	0.0
Non-metallic min	Flat glass	Process Control-Software and Image based control_flat glass	50%	0.44	0.00	0	0	0.0	2.5	0.0	10	0.0	0.5	0.4	0.3	0.0	0.0	0.0
Iron and steel	Coke oven	Coke dry quenching	100%	1.42	0.00	4348	0	4.3	43.6	0.0	18	133.1	7.1	5.3	3.7	5.0	3.7	2.6
Iron and steel	Coke oven	Programmed heating in coke oven	70%	0.16	0.00	342	0	0.3	0.2	0.0	10	0.5	0.0	0.0	0.0	0.3	0.2	0.2
Iron and steel	Coke oven	Variable speed drive on coke oven gas compressors	70%	0.01	0.00	21	0	0.0	0.3	0.0	15	0.7	0.1	0.0	0.0	6.0	4.6	3.4
Iron and steel	Coke oven	Coal moisture control	70%	0.33	0.00	705	0	0.7	6.5	0.0	10	13.9	1.3	1.1	0.8	3.9	3.2	2.6
Iron and steel	pig iron	Top gas recycling	99%	1.23	0.00	8048	0	8.0	87.2	0.0	20	572.4	13.9	10.2	7.0	11.4	8.4	5.7
Iron and steel	pig iron	Waste heat recovery blast furnace slag	80%	0.35	0.00	1857	0	1.9	54.5	0.0	20	289.1	8.7	6.4	4.4	24.9	18.3	12.5
Iron and steel	pig iron	Top gas recovery turbine	29%	0.00	0.10	0	183	0.2	3.3	0.5	15	6.3	0.6	0.4	0.3	11.4	10.0	8.8
Iron and steel	pig iron	Moisture Removing Blowing Technique in Blast Furnace	75%	0.23	0.00	1144	0	1.1	2.0	0.0	15	10.1	0.3	0.3	0.2	1.5	1.2	0.8
Iron and steel	pig iron	Injection of pulverized coal in BF	95%	0.64	0.00	4031	0	4.0	5.4	1.6	20	34.3	0.9	0.6	0.4	3.8	3.4	3.1
Iron and steel	pig iron	Injection of natural gas in BF	100%	0.32	0.00	2122	0	2.1	5.2	0.3	20	34.8	0.8	0.6	0.4	3.6	2.9	2.3
Iron and steel	pig iron	Injection of oil in BF	100%	0.48	0.00	3183	0	3.2	9.9	-2.2	20	65.8	1.6	1.2	0.8	-1.2	-2.1	-2.9
Iron and steel	pig iron	Injection of plastic waste in BF	100%	0.16	0.00	1061	0	1.1	5.4	1.6	20	36.1	0.9	0.6	0.4	15.2	13.7	12.5
Iron and steel	pig iron	Injection of coke oven gas in BF	100%	0.32	0.05	2122	332	2.5	5.2	0.0	20	34.8	0.8	0.6	0.4	2.3	1.7	1.1
Iron and steel	pig iron	Cogeneration (for the use of untapped coke oven gas, blast furnace ga	50%	0.23	0.00	763	0	0.8	2.8	0.0	20	9.4	0.5	0.3	0.2	2.0	1.5	1.0
Iron and steel	pig iron	Recovery of blast furnace gas	5%	0.09	0.00	30	0	0.0	1.3	0.0	15	0.4	0.2	0.2	0.1	2.4	1.8	1.4
Iron and steel	pig iron	Improved hot blast stove control	45%	0.32	0.00	955	0	1.0	0.3	0.0	5	1.0	0.1	0.1	0.1	0.3	0.3	0.3
Iron and steel	pig iron	Improved blast furnace control	50%	0.32	0.00	1061	0	1.1	0.6	0.0	5	1.9	0.2	0.2	0.1	0.5	0.5	0.4
Iron and steel	BF/BOF steel	Recovery of BOF and sensible heat	50%	0.56	0.00	2146	0	2.1	25.6	0.0	10	98.2	5.1	4.2	3.3	9.1	7.4	5.9
Iron and steel	EAF steel	Scrap preheating	70%	0.15	0.37	76	189	0.3	17.4	0.0	30	8.9	2.7	1.9	1.1	5.1	3.6	2.2
Iron and steel	EAF steel	Converting the furnace operation to ultra-high power (UHP) (Increasin	70%	0.11	0.00	56	0	0.1	9.7	0.0	15	4.9	1.7	1.3	0.9	15.0	11.6	8.5
Iron and steel	EAF steel	Improving process control in EAF	50%	0.24	0.09	87	33	0.1	1.4	-0.9	10	0.5	0.3	0.2	0.2	-1.9	-2.0	-2.2
Iron and steel	Rolled Steel	Recuperative or regenerative burner	36%	0.56	0.00	1263	0	1.3	2.9	0.0	10	6.5	0.6	0.5	0.4	1.0	0.8	0.7
Iron and steel	Rolled Steel	Endless Hot Rolling of Steel Sheets	11%	0.36	0.00	257	0	0.3	7.3	0.0	20	5.2	1.2	0.9	0.6	3.3	2.4	1.6
Iron and steel	Rolled Steel	Process control in hot rolling	42%	0.30	0.00	790	0	0.8	0.8	0.0	10	2.2	0.2	0.1	0.1	0.5	0.4	0.4
Iron and steel	BF/BOF steel	Integration of casting and rolling (thin slab strip casting)	75%	0.73	0.00	4196	0	4.2	6.9	0.0	20	39.7	1.1	0.8	0.6	1.5	1.1	0.8
Iron and steel	pig iron	Variable speed drives for flue gas control, pumps, fans in integrated st	15%	0.00	0.03	0	30	0.0	1.5	0.0	10	1.5	0.3	0.2	0.2	10.1	8.2	6.5
Iron and steel	pig iron	Energy monitoring and management systems	50%	0.08	0.01	257	32	0.3	0.2	0.0	5	0.6	0.1	0.0	0.0	0.6	0.5	0.5
Non-ferrous meta	Aluminium prim	Inert Anodes	90%	0.00	3.60	0	0.00	0.0	86.0	0.0	20	0.0	13.7	10.1	6.9	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Wetted Cathode	90%	0.00	7.34	0	0.00	0.0	524.0	0.0	20	0.0	83.7	61.5	42.0	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	PFPB	10%	0.00	2.80	0	0.00	0.0	2342.3	0.0	20	0.0	374.2	275.1	188.0	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Optimization electrolysis control	30%	0.00	3.60	0	0.00	0.0	188.1	-65.0	5	0.0	56.1	49.6	43.4	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Optimization cell design	30%	0.00	2.52	0	0.00	0.0	236.1	0.0	6	0.0	62.4	54.2	46.5	0.0	0.0	0.0
Non-ferrous meta	Aluminium prim	Lower the electrolysis temperature	100%	0.00	4.50	0	0.00	0.0	0.0	75.0	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-ferrous meta	Aluminium seco	Regenerative or recuperative burner	60%	2.04	0.00	117	0.00	0.1	14.3	0.4	20	0.8	2.3	1.7	1.1	1.3	1.0	0.8

Industrial Subsector	Product	Measures/Technologies	2050 Implementation Rate %	Fuel savings (GJ/tonne product)	Electricity savings (GJ/tonne product)	2050 Fuel Savings Potential (TJ)	2050 Electricity Savings Potential (TJ)	2050 Total Energy Savings Potential (PJ)	Investment Cost in € (2015)/tonne	Change in O&M Costs in € (2015)/tonne	Technical lifetime (years)	Total Investment million € (2015)	15%	10%	5%	15%	10%	5%
Non-ferrous meta	Aluminium seco	New decoating equipment	60%	0.36	0.00	21	0.00	0.0	40.0	40.0	10	2.3	8.0	6.5	5.2	134.7	130.6	126.9
Non-ferrous meta	Nonferrous met	Improved process scheduling	40%	1.80	0.00	110	0.00	0.1	18.0	0.0	20	1.1	2.9	2.1	1.4	1.6	1.2	0.8
Non-ferrous meta	Nonferrous met	Regenerative or recuperative burner	60%	2.04	0.00	186	0.00	0.2	14.3	0.4	20	1.3	2.3	1.7	1.1	1.3	1.0	0.8
Non-ferrous meta	Nonferrous met	Liquid metal as feedstock	45%	3.60	0.00	247	0.00	0.2	18.0	0.0	20	1.2	2.9	2.1	1.4	0.8	0.6	0.4
Pulp and paper	Chemical pulp	Black liquor gasification	79%	0.00	2.00	0	2087	2.1	508.4	5.4	20	530.5	81.2	59.7	40.8	43.3	32.6	23.1
Pulp and paper	Mechanical pulp	Heat recovery (TMP, GW)	5%	3.48	0.00	64	0	0.1	41.4	0.0	20	0.8	6.6	4.9	3.3	1.9	1.4	1.0
Pulp and paper	Mechanical pulp	High efficiency grinding GW	100%	0.00	2.59	0	954	1.0	407.3	0.0	5	150.0	121.5	107.5	94.1	46.9	41.5	36.3
Pulp and paper	Mechanical pulp	Enzymatic pre-treatment	80%	0.00	1.86	0	548	0.5	501.2	3.2	15	147.6	85.7	65.9	48.3	47.8	37.1	27.7
Pulp and paper	Mechanical pulp	Efficient refiner and pretreatment (TMP)	65%	0.00	1.55	0	371	0.4	121.9	0.0	20	29.2	19.5	14.3	9.8	12.5	9.2	6.3
Pulp and paper	Recovered fibre	High consistency pulping	60%	0.00	0.20	0	315	0.3	2.8	0.0	20	4.4	0.4	0.3	0.2	2.2	1.6	1.1
Pulp and paper	Recovered fibre	Efficient screening	70%	0.00	0.65	0	1195	1.2	6.4	0.0	20	11.7	1.0	0.7	0.5	1.6	1.1	0.8
Pulp and paper	Recovered fibre	Heat recovery from bleaching	70%	0.30	0.00	551	0	0.6	1.5	0.0	20	2.8	0.2	0.2	0.1	0.8	0.6	0.4
Pulp and paper	Recovered fibre	De-Inking flotation optimization	100%	0.00	0.50	0	1313	1.3	1.0	0.0	15	2.7	0.2	0.1	0.1	0.4	0.3	0.2
Pulp and paper	Recovered fibre	Efficient disperser	60%	0.00	0.22	0	347	0.3	1.3	0.0	15	2.0	0.2	0.2	0.1	1.0	0.8	0.6
Pulp and paper	Paper	Efficient refiners	23%	0.00	0.12	0	149	0.1	16.4	0.0	20	20.6	2.6	1.9	1.3	22.2	16.3	11.1
Pulp and paper	Paper	Optimization of refining	60%	0.00	0.08	0	246	0.2	0.7	0.0	20	2.4	0.1	0.1	0.1	1.6	1.2	0.8
Pulp and paper	Paper	Chemical modification of fibres	80%	0.19	0.16	810	718	1.5	16.6	3.5	20	72.6	2.6	1.9	1.3	17.5	15.5	13.7
Pulp and paper	Paper	Steambox	5%	0.18	0.00	49	0	0.0	4.6	0.0	15	1.2	0.8	0.6	0.4	4.3	3.3	2.4
Pulp and paper	Paper	Shoepress	10%	0.48	0.00	263	0	0.3	31.7	0.0	20	17.4	5.1	3.7	2.5	10.6	7.8	5.3
Pulp and paper	Paper	New drying techniques	96%	0.67	0.00	3506	0	3.5	91.4	0.0	20	480.7	14.6	10.7	7.3	21.9	16.1	11.0
Pulp and paper	Paper	Heat recovery and integration	32%	1.07	0.00	1875	0	1.9	16.0	0.0	20	28.0	2.5	1.9	1.3	2.4	1.8	1.2
Chemicals	Ethylene	Advanced furnace materials	55%	1.69	0.00	428	0.0	0.4	2.1	0.0	20	0.5	0.3	0.2	0.2	0.2	0.1	0.1
Chemicals	Ethylene	Improving compression and separation section	28%	1.00	0.00	129	0.0	0.1	0.6	0.0	20	0.1	0.1	0.1	0.0	0.1	0.1	0.0
Chemicals	Ethylene	Integration of a gas turbine	15%	2.64	0.00	182	0.0	0.2	58.0	0.0	20	4.0	9.3	6.8	4.7	3.5	2.6	1.8
Chemicals	Ethylene	Improved compressors	10%	0.78	0.00	36	0.0	0.0	22.3	0.0	20	1.0	3.6	2.6	1.8	4.5	3.3	2.3
Chemicals	Ethylene	Utilization of flare gas	10%	2.00	0.00	92	0.0	0.1	60.0	0.0	20	2.8	9.6	7.0	4.8	4.8	3.5	2.4
Chemicals	Ethylene	Modern control system, ethylene	10%	1.46	0.00	67	0.0	0.1	29.0	0.0	10	1.3	5.8	4.7	3.8	4.0	3.2	2.6
Chemicals	Soda ash	Integrated design and operation	40%	1.98	0.14	0	0.0	0.0	40.0	0.0	20	0.0	6.4	4.7	3.2	0.0	0.0	0.0
Chemicals	Soda ash	Vertical shaft kiln for the production of concentrated CO2 gas and reac	30%	0.30	0.00	0	0.0	0.0	16.0	0.0	20	0.0	2.6	1.9	1.3	0.0	0.0	0.0
Chemicals	Soda ash	Heat integration	19%	1.00	0.00	0	0.0	0.0	20.0	0.0	20	0.0	3.2	2.3	1.6	0.0	0.0	0.0
Chemicals	Soda ash	Modern control system_soda ash	19%	0.40	0.04	0	0.0	0.0	10.0	0.0	10	0.0	2.0	1.6	1.3	0.0	0.0	0.0
Chemicals	Soda ash	Usage of CHP, soda ash	30%	1.80	0.00	0	0.0	0.0	36.0	0.0	30	0.0	5.5	3.8	2.3	0.0	0.0	0.0
Chemicals	Soda ash	Efficiency package	29%	1.00	0.04	0	0.0	0.0	22.0	0.0	20	0.0	3.5	2.6	1.8	0.0	0.0	0.0
Chemicals	Soda ash	Usage of more pure feed	30%	0.30	0.00	0	0.0	0.0	1.0	0.0	10	0.0	0.2	0.2	0.1	0.0	0.0	0.0
Chemicals	Carbon black	Usage of CHP, carbon black	10%	6.48	0.00	0	0.0	0.0	130.0	0.0	20	0.0	20.8	15.3	10.4	0.0	0.0	0.0
Chemicals	Carbon black	Modern control system, carbon black	14%	6.48	0.20	0	0.0	0.0	139.0	0.0	10	0.0	27.7	22.6	18.0	0.0	0.0	0.0
Chemicals	Carbon black	Optimization of black carbon separation	23%	6.48	0.25	0	0.0	0.0	142.0	0.0	20	0.0	22.7	16.7	11.4	0.0	0.0	0.0
Chemicals	Methanol	Efficiency package, synthesis gas section	30%	1.78	0.08	0	0.0	0.0	39.0	0.0	20	0.0	6.2	4.6	3.1	0.0	0.0	0.0
Chemicals	Methanol	Efficiency package, methanol synthesis section	37%	1.09	0.04	0	0.0	0.0	24.0	0.0	20	0.0	3.8	2.8	1.9	0.0	0.0	0.0
Chemicals	Ammonia	Improved CO2 removal section	31%	1.00	0.00	160	0.0	0.2	15.0	0.0	20	2.4	2.4	1.8	1.2	2.4	1.8	1.2
Chemicals	Ammonia	Indirect cooling of the ammonia synthesis reactor	31%	0.60	0.00	96	0.0	0.1	7.1	0.0	20	1.1	1.1	0.8	0.6	1.9	1.4	1.0
Chemicals	Ammonia	Increasing the air preheat with waste heat	31%	0.90	0.00	144	0.0	0.1	7.4	0.0	20	1.2	1.2	0.9	0.6	1.3	1.0	0.7
Chemicals	Ammonia	Hydrogen recovery (such as PSA)	31%	0.80	0.00	128	0.0	0.1	2.0	0.0	20	0.3	0.3	0.2	0.2	0.4	0.3	0.2
Chemicals	Ammonia	pre-reforming	31%	2.29	0.00	366	0.0	0.4	16.4	0.0	20	2.6	2.6	1.9	1.3	1.1	0.8	0.6
Chemicals	Ammonia	Advanced process control	55%	0.70	0.00	199	0.0	0.2	6.0	0.0	10	1.7	1.2	1.0	0.8	1.7	1.4	1.1