

Annex 2. Detailed discussion of methodology and data for estimating CO₂ emissions from fossil fuel combustion

Methods:

CO₂ emissions from fuel combustion are in general calculated by using the methodology of the IPCC 1996 Guidelines. Different tiers (T1, T2 and T3) have been applied for different fuels according to the CO₂ EF used (default - D, country specific - CS or plant specific - PS).

$$Emissions_{fuel} = Fuel\ Consumption_{fuel} \times CO_2\ Emission\ Factor_{fuel} \times Oxidation\ Factor_{fuel}$$

Both, country specific and IPCC default CO₂ emission factors are used in GHG emission calculations. Since 2004, Estonia has developed country specific emission factors for the main domestic fuel- oil shale. There are two different carbon emission factors for oil shale according to the combustion technology: CO₂ for pulverized combustion of oil shale is - 28.85 tC/TJ and CEF for oil shale combustion in circulating fluidised bed – 26.94 tC/TJ. There are also country specific carbon emission factors developed for shale oil (a liquid fuel made by thermal processing of oil shale) and for oil shale gases (by products of the oil shale thermal processing and have a different quality depending from technology used): semi-coke gas and generator gas (this two gases have different calorific value and carbon emission factor).

In order to improve the accuracy of the inventory, some of the CO₂ factors were checked and updated for the 2010 inventory. In previous submissions for calculation of CO₂ emission from natural gas, sod and milled peat and peat briquettes combustion, IPCC default values were used. In the 2010 submission Estonia used Finnish country specific emission factors, because the fuels are similar. For motor gasoline and diesel oil Lithuanian country specific CO₂ emission factors are used, whereas Estonia imports almost all motor fuels from Lithuania.

The Estonia's list of fuels, net calorific values by fuel and used CO₂ emission factors are included in the table A.1.

Table A.1 CO₂ emission factors from fossil Fuel ncombustion, oxidation factors and net calorific values by fuel

Fuels	NCV average	Unit	CEF tC/TJ	CO ₂ EF CO ₂ /TJ	Oxidation factor	Source
Liquid fuels						
LPG (Liquefied Petrol Gas)	45.53	GJ/t	17.2	63.1	0.99	D, IPCC 2006 ¹
Gasoline	43.99	GJ/t	19.91	73	0.99	CS, LT (Lithuania)
Jet Kerosene	43.0	GJ/t	19.5	71.5	0.99	D, IPCC 2006
Aviation Gasoline	43.0	GJ/t	19.5	71.5	0.99	D, IPCC 2006
Gasoil (light fuel oil)	42.26	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania)
Gasoil (for non-road use)	42.26	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania)
Shale Oil	39.22	GJ/t	21.1	77.4	0.99	CS, MoE 2006 ²

¹ 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

² Method for determining the amount of carbon dioxide discharged into the atmosphere. The Regulation of the Minister of the Environment. State Gazette No 22, 11.2006, 85, 1546 (in Estonian).

Fuels	NCV average	Unit	CEF tC/TJ	CO ₂ EF CO ₂ /TJ	Oxidation factor	Source
Diesel Oil	42.26	GJ/t	20.2	74.1	0.99	CS, LT (Lithuania)
Residual Fuel Oil (heavy fuel oil)	40.15	GJ/t	21.1	77.4	0.99	D, IPCC 2006
Recycled Waste Oil		GJ/t	20.2	74	1	PS, Kunda Nordic Cement
Solid fuels						
Coal	27.2	GJ/t	26.8	98.3	0.98	D, IPCC 2006
Coke Oven Coke	29.3	GJ/t	29.18	107.0	0.98	D, IPCC 2006
Oil Shale _{PC} *	8.87	GJ/t	27.85	102.1	0.98	CS, MoE 2006
Oil Shale _{FBC} **	8.87	GJ/t	26.94	98.8	0.98	CS, MoE 2006
Milled Peat	8.7 – 12.0	GJ/t	28.9	106.0	0.98	CS, FI (Finland)
Sod Peat	8.7 – 12.0	GJ/t	27.82	102.0	0.98	CS, FI (Finland)
Peat Briquette	16.0	GJ/t	26.45	97.0	0.98	CS, FI (Finland)
Oil Shale Semi-coke	8.78	GJ/1000 m ³	15.45	56.7	0.995	CS, Martins, A., 2007 ³
Oil Shale Generator Gas	3.52	GJ/1000 m ³		126.4	0.995	CS, Martins, A., 2007
Other Fossil based Waste (MSW)		GJ/t	21.8	80.0	1	PS, Kunda Nordic Cement
Plastic Waste		GJ/t	20.5	75	1	PS, Kunda Nordic Cement
Gaseous fuels						
Natural Gas	33.6	GJ/1000 m ³	15.3		0.995	CS, FI (Finland)
Biomass fuels						
Solid Biomass (firewood, bark, chips, sawdust, pellets and briquettes, etc)	6.13 – 16.92	GJ/m ³ s	29.9		0.98	D, IPCC 2006
Black Liquors	10	GJ/t	29.9	109.6	0.98	D, IPCC1996 ⁴
Biogas (landfill gas and biogas from wastewater treatment)	19.73	GJ/1000 m ³	14.89	56.1	0.995	D, IPCC2006

* Oil Shale PC – pulverised combustion of oil shale

** Oil Shale FBC – fluidised bed combustion of oil shale

*** D - IPCC default value; CS – country specific, PS – plant specific

Activity data.

Activity data for GHG emission calculations from fuel combustion are collected from several data sources. The main fuel consumption data by fuel types and final consumption sectors, including sub-sectors are received from the Energy Department of the Statistics Estonia. Those data are available in the electronic database of the Statistics Estonian www.stat.ee. Some detailed data (i.e. technology specific oil shale and semi-coke gas consumption in Narva power plants and shale oil production by the Narva Shale Oil Plant) are obtained from the energy company Eesti Energia AS. Some road transport data are obtained from Estonian Environment Information Centre and Waste fuel data from the cement factory AS Kunda Nordic Cement. In the Chapter 3.2 of the NIR 201

³ Martins, A., 2007: Research of Ants Martins, Tallinn University of Technology (not published).

⁴ IPCC. (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Intergovernmental Panel on Climate Change. Meteorological Office. Bracknell. United Kingdom.

Emissions From Fuel Combustion activity data are given by main fuel groups: solid, liquide, gaseous fuels and biomass and in some cases also other fuels. In the tables A.2 activity data are presented by fuels in PJ-s.

Table A.2 Fuel combustion by fuel, PJ

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Solid fuels	241.00	220.24	180.44	136.19	143.44	133.57	138.02	134.77	118.13	109.49	111.38	108.94	105.52	123.55	124.02	118.03	111.46	137.74	130.12
Oil Shale	218.86	200.83	165.45	125.72	133.26	120.86	124.80	122.93	109.92	103.31	103.36	99.46	96.97	114.18	115.99	110.25	103.12	126.25	118.50
Peat	1.81	1.13	1.17	1.12	1.22	1.81	2.32	2.20	1.86	1.45	1.37	1.77	1.97	1.94	1.75	1.60	1.79	2.21	1.85
Peat Briquette	3.59	3.34	2.61	2.03	1.58	2.15	2.00	1.10	0.55	0.51	0.47	0.27	0.30	0.33	0.24	0.21	0.19	0.21	0.27
Coal	9.29	9.00	5.71	2.93	2.19	2.50	2.80	2.41	1.83	1.95	2.29	2.96	1.61	1.19	1.56	1.50	1.89	3.54	3.48
Oil shale gas	7.04	5.62	5.42	4.30	5.15	6.22	6.07	6.12	3.93	2.24	3.83	4.35	4.64	5.90	4.47	4.46	4.46	5.53	6.00
Coke	0.41	0.32	0.09	0.08	0.05	0.03	0.03	0.02	0.03	0.03	0.05	0.13	0.03	0.02	0.01	0.01	0.01	0.00	0.01
Liquid fuels	121.83	110.96	61.57	59.76	58.29	46.79	49.91	48.53	48.34	43.74	36.13	42.18	43.30	42.24	42.33	42.44	42.77	44.78	41.29
Heavy fuel oil	67.84	61.69	26.86	28.66	23.40	14.41	15.72	13.05	13.52	10.98	3.75	3.34	2.38	1.21	0.67	0.51	0.23	0.27	0.20
Light fuel oil	5.05	3.69	1.60	0.86	0.73	0.97	1.69	1.96	2.23	2.69	3.21	4.88	4.73	4.70	4.34	4.00	2.56	2.89	2.37
Motor gasoline	22.84	20.26	9.85	9.97	12.46	10.72	12.07	13.14	12.68	12.04	12.15	14.42	13.37	13.00	12.40	12.47	13.53	14.20	14.11
Diesel Oil	24.44	23.77	14.40	13.35	14.30	12.99	14.20	14.12	15.13	12.66	12.43	14.18	17.70	18.23	19.52	20.39	22.23	24.05	21.29
Shale oil	0.00	0.00	8.37	6.57	6.90	7.35	5.86	5.87	4.37	5.01	4.24	4.97	4.83	4.78	5.09	4.73	3.95	3.02	2.94
LPG	1.58	1.47	0.48	0.31	0.47	0.32	0.33	0.35	0.38	0.32	0.33	0.36	0.27	0.29	0.29	0.31	0.27	0.34	0.35
Aviation gasoline	0.08	0.08	0.03	0.04	0.03	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03
Gaseous fuels	43.46	44.21	26.39	13.46	16.54	19.37	21.93	21.23	19.88	19.44	23.51	25.64	23.81	25.109	27.94	28.54	28.97	28.99	27.43
Natural gas	43.46	44.21	26.39	13.46	16.54	19.37	21.93	21.23	19.88	19.44	23.51	25.64	23.81	25.11	27.94	28.54	28.97	28.99	27.43
Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01	0.13	0.35	0.39	0.47	0.51	0.55	0.61	0.56
MSW, etc	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.01	0.13	0.35	0.39	0.47	0.51	0.55	0.61	0.56
Biomass	8630	8471	7817	7.64	12.54	20.35	24.28	24.78	21.12	21.27	21.43	22.56	22.89	23.99	24.88	24.45	21.87	24.77	26.58
Solid biomass	8 366	8 207	7 553	7.37	12.25	20.00	23.22	24.27	20.71	20.51	20.63	21.75	21.72	22.72	23.63	22.92	20.25	23.11	25.08
Black liquor	8.63	8.47	7.82	7.64	12.54	20.35	24.28	24.78	21.12	21.27	21.43	22.56	22.89	23.99	24.88	24.45	21.87	24.77	26.58
Biogas	8.37	8.21	7.55	7.37	12.25	20.00	23.22	24.27	20.71	20.51	20.63	21.75	21.72	22.72	23.63	22.92	20.25	23.11	25.08

Table A.3 CO₂ emissions from fuel combustion, Tg

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Solid fuels	35.40	32.49	23.78	18.51	19.25	17.57	18.31	17.84	16.20	15.00	14.73	15.06	14.72	16.57	16.58	15.93	15.31	18.18	16.79
Oil Shale	23.89	21.76	17.72	13.28	13.98	13.01	13.39	13.06	11.51	10.69	10.77	10.54	10.20	12.05	11.90	11.21	10.54	13.26	12.21
Peat	21.60	19.77	16.16	12.19	12.89	11.65	12.00	11.80	10.66	10.07	9.95	9.57	9.31	11.05	11.08	10.42	9.70	12.07	11.03
Peat Briquette	0.19	0.12	0.12	0.12	0.13	0.19	0.23	0.22	0.19	0.15	0.14	0.18	0.20	0.20	0.18	0.16	0.18	0.23	0.19
Coal	0.34	0.31	0.25	0.19	0.15	0.20	0.19	0.10	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.03
Oil shale gas	0.89	0.86	0.55	0.28	0.21	0.24	0.27	0.23	0.17	0.19	0.22	0.28	0.15	0.11	0.15	0.14	0.18	0.34	0.33
Coke	0.84	0.66	0.64	0.50	0.60	0.73	0.70	0.70	0.44	0.23	0.42	0.47	0.50	0.66	0.47	0.46	0.46	0.60	0.63
Liquid fuels	0.04	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Heavy fuel oil	9.13	8.31	4.62	4.49	4.36	3.49	3.72	3.61	3.59	3.25	2.67	3.11	3.19	3.11	3.12	3.12	3.14	3.29	3.03
Light fuel oil	5.20	4.72	2.06	2.20	1.79	1.10	1.20	1.00	1.04	0.84	0.29	0.26	0.18	0.09	0.05	0.04	0.02	0.02	0.02
Motor gasoline	0.37	0.27	0.12	0.06	0.05	0.07	0.12	0.14	0.16	0.20	0.24	0.36	0.35	0.34	0.32	0.29	0.19	0.21	0.17
Diesel Oil	1.67	1.48	0.72	0.73	0.91	0.78	0.88	0.96	0.93	0.88	0.89	1.05	0.98	0.95	0.90	0.91	0.99	1.04	1.03
Shale oil	1.79	1.74	1.06	0.98	1.05	0.95	1.04	1.04	1.11	0.93	0.91	1.04	1.30	1.34	1.43	1.50	1.63	1.76	1.56
LPG	0.00	0.00	0.64	0.50	0.53	0.56	0.45	0.45	0.34	0.38	0.33	0.38	0.37	0.37	0.39	0.36	0.30	0.23	0.23
Aviation gasoline	0.10	0.09	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Gaseous fuels	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas	2.38	2.42	1.44	0.73	0.91	1.06	1.20	1.16	1.09	1.06	1.29	1.40	1.30	1.38	1.53	1.56	1.59	1.59	1.50
Other	2.38	2.42	1.44	0.73	0.91	1.06	1.20	1.16	1.09	1.06	1.29	1.40	1.30	1.38	1.53	1.56	1.59	1.59	1.50
MSW. etc	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.04	0.04	0.04	0.04	0.03

