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Research Report

**Proposals of effective ways for
uncertainty reduction in the Polish
greenhouse gas inventory system**

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Geoinformation technologies, spatio-temporal approaches, and full carbon account for improving accuracy of GHG inventories

Deliverable 1.4. Proposals of effective ways for uncertainty reduction in the Polish greenhouse gas inventory system

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5. Main components of uncertainty reduction on the basis of spatial inventory and modeling of greenhouse gas emissions in Poland: households

The greenhouse gas emission coefficients from burning fossil fuels depend on the fuel type and its chemical characteristics (e.g. the fuel carbon content) that, may vary by region. The burning technology in the residential sector (households) does not differ much in different settlements, therefore, there is no spatial effect in the emission factors. During the combustion process not all the fuel carbon oxidize-less than 1% of the carbon escapes oxidation. The default emission factors recommended by IPCC are derived on the assumption of full oxidation and may be used only if representative country-specific factors are not available.

In Poland the national CO₂ emission factors are available only for coal combustion. Since the chemical composition of the same type of fuel for different countries does not differ significantly, for other fuel types we used the emission factors recommended by international experts (the IPCC Guidelines). In general, the uncertainty of CO₂ emission factor from fuel combustion is small when comparing with other greenhouse gases, because the emission of this gas is mainly dependent on the carbon content of the fuel (which is quite easy to identify). The uncertainty of CO₂ emission factor is symmetric (the normal distribution is assumed).

Emission factors for CH₄ and N₂O strongly depend on the burning technology. Therefore, the uncertainty for these gases is high. But as the technology does not vary in the residential sector by regions, the default or country-specific values (if available) may be used.

The uncertainty analysis was conducted using the Monte Carlo method for processes of burning coal, natural gas, and liquid gas on regional level in Poland for carbon oxide, methane, and nitrous oxide (Table 5.1 – Table 5.12). The uncertainties of CO₂, CH₄, and N₂O from burning coal, natural gas, and liquid gas are presented in Figures 5.1 – 5.3, and the total uncertainty in Poland is presented in Figure 5.4 and in Table 5.13. In these tables and figures the term ‘Statistical values’ means the emission, calculated taking into account the uncertainty (with the use of the Monte-Carlo method).

Table 5.1. Uncertainty of CO₂ emissions from burning coal in the residential sector in Poland.

Voivodeship	Coal, [thousands ton], 2010	CO ₂ emissions (Mg)		Uncertainty	
		Statistical values	Spatial inventories		
Dolnośląskie	775	2090890,17	1847326,3	-20,80%	21,99%
Kujawsko-pomorskie	576	1554027,84	1373951,2	-20,63%	21,60%
Lubelskie	649	1750970,29	1549779,9	-20,67%	21,72%
Lubuskie	188	507213,64	449138,8	-20,68%	21,97%
Łódzkie	838	2260864,92	1999468,5	-20,56%	22,09%
Małopolskie	895	2414664,95	2138076,1	-20,88%	22,07%
Mazowieckie	1306	3523518,73	3118072,9	-20,62%	22,07%
Opolskie	295	795913,27	705097,4	-20,42%	22,18%
Podkarpackie	561	1513548,19	1338938,3	-20,90%	21,71%
Podlaskie	248	669091,33	591758,1	-20,69%	22,05%
Pomorskie	393	1060282,96	938691,5	-20,70%	21,88%
Śląskie	1448	3906619,32	3455212,2	-20,50%	22,14%
Świętokrzyskie	366	987453,06	873954,8	-20,67%	21,94%
Warmińsko-Mazurskie	266	717661,84	634652,9	-20,80%	22,02%
Wielkopolskie	848	2287876,98	2025151	-20,59%	22,44%
Zachodniopomorskie	248	669086,86	591942,6	-20,74%	21,98%
Poland total	9900	26709684,35	23627668,3	-20,66%	22,06%

Table 5.2. Uncertainty of CH₄ emissions from burning coal in the residential sector in Poland.

Voivodeship	Coal, [thousands ton], 2010	CH ₄ emissions (Mg)		Uncertainty	
		Statistical values	Spatial inventories		
Dolnośląskie	775	6701,57	5930,182	-40,10%	54,77%
Kujawsko-pomorskie	576	4980,86	4403,818	-39,91%	54,75%
Lubelskie	649	5612,08	4967,301	-39,90%	55,61%
Lubuskie	188	1625,68	1440,393	-39,90%	54,81%
Łódzkie	838	7246,36	6393,702	-39,80%	54,75%
Małopolskie	895	7739,31	6828,545	-39,89%	54,69%
Mazowieckie	1306	11293,33	9976,374	-39,83%	55,18%
Opolskie	295	2551	2265,012	-40,37%	56,11%
Podkarpackie	561	4851,12	4302,827	-40,10%	55,85%
Podlaskie	248	2144,52	1896,26	-40,34%	55,00%
Pomorskie	393	3398,34	3001,554	-40,09%	55,09%
Śląskie	1448	12521,22	11100,39	-39,56%	54,95%
Świętokrzyskie	366	3164,91	2800,11	-39,83%	55,81%
Warmińsko-Mazurskie	266	2300,2	2039,379	-39,84%	54,10%
Wielkopolskie	848	7332,94	6476,776	-39,93%	56,36%
Zachodniopomorskie	248	2144,51	1897,233	-40,21%	55,11%
Poland total	9900	83057	75899,194	-39,97%	55,40%

Table 5.3. Uncertainty of N₂O emissions from burning coal in the residential sector in Poland.

Voivodeship	Coal, [thousands ton], 2010	N ₂ O emissions (Mg)		Uncertainty	
		Statistical values	Spatial inventories		
Dolnośląskie	775	33,5079	29,65781	-47,00%	68,99%
Kujawsko-pomorskie	576	24,9043	22,00008	-46,58%	69,21%
Lubelskie	649	28,0604	24,88752	-46,98%	70,88%
Lubuskie	188	8,12842	7,205483	-47,09%	69,59%
Łódzkie	838	36,2318	32,11669	-46,79%	70,28%
Małopolskie	895	38,6966	34,1933	-46,46%	69,93%
Mazowieckie	1306	56,4666	50,00859	-46,34%	70,06%
Opolskie	295	12,755	11,28102	-46,64%	70,00%
Podkarpackie	561	24,2556	21,45449	-46,82%	69,53%
Podlaskie	248	10,7226	9,490687	-47,22%	68,12%
Pomorskie	393	16,9917	15,03658	-47,30%	70,04%
Śląskie	1448	62,6061	55,46137	-47,00%	69,63%
Świętokrzyskie	366	15,8246	13,99896	-46,78%	69,06%
Warmińsko-Mazurskie	266	11,501	10,1905	-46,53%	71,12%
Wielkopolskie	848	36,6647	32,51695	-46,84%	69,31%
Zachodniopomorskie	248	10,7225	9,454746	-46,71%	68,39%
Poland total	9900	428,04	378,7147	-47,12%	69,54%

Table 5.4. Uncertainty of greenhouse gas emissions from burning coal in the residential sector in Poland.

Voivodeship	Coal, [thousands ton]	GHG emissions in CO ₂ -eq (Gg)		Uncertainty	
		Statistical values	Spatial inventories		
Dolnośląskie	775	2 242,01	2 007,01	-20,79%	21,81%
Kujawsko-pomorskie	576	1 666,35	1 493,72	-20,83%	22,29%
Lubelskie	649	1 877,52	1 684,03	-20,58%	21,43%
Lubuskie	188	543,87	487,37	-20,71%	21,86%
Łódzkie	838	2 424,27	2 173,49	-20,95%	21,94%
Małopolskie	895	2 589,19	2 307,66	-20,28%	22,32%
Mazowieckie	1306	3 778,18	3 382,48	-20,33%	22,17%
Opolskie	295	853,44	761,35	-20,81%	22,19%
Podkarpackie	561	1 622,94	1 453,47	-19,98%	22,04%
Podlaskie	248	717,45	640,88	-20,96%	22,25%
Pomorskie	393	1 136,92	1 017,64	-20,69%	22,42%
Śląskie	1448	4 188,97	3 753,50	-21,25%	22,53%
Świętokrzyskie	366	1 058,82	947,37	-20,62%	21,45%
Warmińsko-Mazurskie	266	769,53	687,29	-20,37%	22,89%
Wielkopolskie	848	2 453,23	2 193,10	-21,27%	22,69%
Zachodniopomorskie	248	717,45	642,78	-21,26%	22,24%
Poland total	9900	28 640,14	25 590,61	-21,25%	21,99%

Table 5.5. Uncertainty of CO₂ emissions from burning natural gas in the residential sector in Poland.

Voivodeship	Natural gas	CO ₂ emissions (Mg)		Uncertainty	
	[TJ], 2010	Statistical values	Spatial inventories		
Dolnośląskie	12498	697 641,51	697 829,50	-7,16%	7,10%
Kujawsko-pomorskie	5033	280 942,36	280 857,30	-7,07%	7,19%
Lubelskie	5905	329 617,90	329 619,00	-7,07%	7,05%
Lubuskie	3875	216 302,56	216 363,70	-7,19%	7,12%
Łódzkie	5628	314 155,43	314 088,50	-7,14%	7,13%
Małopolskie	15536	867 220,16	867 259,30	-7,20%	7,12%
Mazowieckie	29645	1 654 785,65	1 655 094,10	-7,06%	7,16%
Opolskie	2576	143 792,19	143 818,30	-7,14%	7,29%
Podkarpackie	9234	515 442,55	515 500,20	-7,06%	6,97%
Podlaskie	1665	92 940,32	92 949,50	-7,18%	7,23%
Pomorskie	8244	460 179,57	460 317,30	-7,15%	7,13%
Śląskie	17518	977 855,39	977 844,70	-7,14%	7,05%
Świętokrzyskie	3012	168 130,76	168 110,30	-7,09%	7,17%
Warmińsko-Mazurskie	3408	190 234,59	190 157,50	-6,98%	7,10%
Wielkopolskie	15324	855 387,26	854 877,70	-6,95%	7,13%
Zachodniopomorskie	9326	520 575,53	520 543,00	-7,05%	7,18%
Poland total	148427	8 285 203,73	8 285 247,40	-7,00%	7,05%

Table 5.6. Uncertainty of CH₄ emissions from burning natural gas in the residential sector in Poland.

Voivodeship	Natural gas	CH ₄ emissions (Mg)		Uncertainty	
	[TJ], 2010	Statistical values	Spatial inventories		
Dolnośląskie	12498	62,49	62,57	-36,71%	49,43%
Kujawsko-pomorskie	5033	25,17	25,21	-36,92%	49,27%
Lubelskie	5905	29,53	29,47	-36,47%	48,53%
Lubuskie	3875	19,38	19,39	-36,81%	49,12%
Łódzkie	5628	28,14	28,13	-36,91%	49,16%
Małopolskie	15536	77,68	77,65	-36,83%	49,55%
Mazowieckie	29645	148,23	148,04	-36,35%	48,97%
Opolskie	2576	12,88	12,87	-36,54%	49,06%
Podkarpackie	9234	46,17	46,16	-36,66%	50,22%
Podlaskie	1665	8,33	8,33	-36,49%	48,38%
Pomorskie	8244	41,22	41,31	-36,32%	49,06%
Śląskie	17518	87,59	87,57	-36,96%	48,70%
Świętokrzyskie	3012	15,06	15,06	-36,94%	48,89%
Warmińsko-Mazurskie	3408	17,04	17,05	-36,42%	48,76%
Wielkopolskie	15324	76,62	76,65	-36,63%	47,94%
Zachodniopomorskie	9326	46,63	46,63	-37,08%	49,49%
Poland total	148427	742,14	741,69	-36,88%	50,32%

Table 5.7. Uncertainty of N₂O emissions from burning natural gas in the residential sector in Poland.

Voivodeship	Natural gas	N ₂ O emissions (Mg)		Uncertainty	
	[TJ], 2010	Statistical values	Spatial inventories		
Dolnośląskie	12498	12,50	12,50	-44,36%	63,64%
Kujawsko-pomorskie	5033	5,03	5,05	-44,06%	63,86%
Lubelskie	5905	5,91	5,91	-44,39%	63,37%
Lubuskie	3875	3,88	3,89	-44,34%	65,61%
Łódzkie	5628	5,63	5,64	-44,64%	65,04%
Małopolskie	15536	15,54	15,53	-44,69%	63,92%
Mazowieckie	29645	29,65	29,67	-44,42%	64,04%
Opolskie	2576	2,58	2,58	-43,77%	64,53%
Podkarpackie	9234	9,23	9,25	-44,99%	65,02%
Podlaskie	1665	1,67	1,66	-44,26%	64,25%
Pomorskie	8244	8,24	8,22	-44,02%	63,40%
Śląskie	17518	17,52	17,53	-44,31%	65,02%
Świętokrzyskie	3012	3,01	3,02	-44,38%	64,61%
Warmińsko-Mazurskie	3408	3,41	3,40	-43,67%	64,70%
Wielkopolskie	15324	15,32	15,32	-44,75%	64,75%
Zachodniopomorskie	9326	9,33	9,31	-44,19%	63,60%
Poland total	148427	148,43	148,72	-44,61%	63,50%

Table 5.8. Uncertainty of greenhouse gas emissions from burning natural gas in the residential sector in Poland.

Voivodeship	Natural gas	GHG emissions in CO ₂ -eq (Gg)		Uncertainty	
	[TJ], 2010	Statistical values	Spatial inventories		
Dolnośląskie	12498	699,34	703,15	-7,38%	7,18%
Kujawsko-pomorskie	5033	281,63	282,98	-6,87%	6,71%
Lubelskie	5905	330,42	332,16	-7,11%	7,36%
Lubuskie	3875	216,83	217,91	-7,36%	7,15%
Łódzkie	5628	314,92	316,47	-7,18%	7,16%
Małopolskie	15536	869,33	873,78	-6,99%	7,14%
Mazowieckie	29645	1658,82	1 666,00	-6,94%	6,89%
Opolskie	2576	144,14	144,91	-6,87%	7,06%
Podkarpackie	9234	516,70	519,30	-7,23%	7,26%
Podlaskie	1665	93,17	93,68	-6,92%	7,21%
Pomorskie	8244	461,30	463,70	-7,07%	7,14%
Śląskie	17518	980,24	984,85	-7,21%	7,13%
Świętokrzyskie	3012	168,54	169,53	-6,74%	7,26%
Warmińsko-Mazurskie	3408	190,70	191,56	-6,89%	7,25%
Wielkopolskie	15324	857,47	862,19	-7,07%	6,87%
Zachodniopomorskie	9326	521,84	524,27	-7,06%	7,30%
Poland total	148427	8305,39	8 345,40	-6,93%	7,07%

Table 5.9. Uncertainty of CO₂ emissions from burning liquid gas in the residential sector in Poland.

Voivodeship	Liquid gas	CO ₂ emissions (Mg)		Uncertainty	
	[thousands ton], 2010	Statistical values	Spatial inventories		
Dolnośląskie	26	76 804,21	76 783,12	-17,91%	18,92%
Kujawsko-pomorskie	26	76 805,52	76 830,79	-17,84%	18,64%
Lubelskie	32	94 529,21	94 476,93	-17,77%	18,55%
Lubuskie	11	32 494,35	32 497,50	-17,82%	18,94%
Łódzkie	42	124 068,36	124 050,41	-17,61%	18,49%
Małopolskie	25	73 850,97	73 816,87	-17,76%	18,62%
Mazowieckie	59	174 288,01	174 423,24	-17,80%	18,63%
Opolskie	14	41 357,33	41 346,46	-17,72%	18,91%
Podkarpackie	9	26 586,31	26 598,69	-17,82%	18,53%
Podlaskie	24	70 896,59	70 911,22	-18,02%	18,55%
Pomorskie	25	73 850,44	73 831,72	-17,84%	18,58%
Śląskie	46	135 885,08	135 905,92	-17,65%	18,82%
Świętokrzyskie	20	59 080,86	59 139,65	-17,93%	18,50%
Warmińsko-Mazurskie	24	70 897,60	70 945,12	-17,79%	18,55%
Wielkopolskie	41	121 116,53	121 156,01	-18,02%	18,77%
Zachodniopomorskie	16	47 264,08	47 216,43	-17,88%	18,47%
Poland total	440	1 299 775,45	1 299 897,63	-17,66%	18,79%

Table 5.10. Uncertainty of CH₄ emissions from burning liquid gas in the residential sector in Poland.

Voivodeship	Liquid gas	CH ₄ emissions (Mg)		Uncertainty	
	[thousands ton], 2010	Statistical values	Spatial inventories		
Dolnośląskie	26	1,62	1,62	-38,84%	53,12%
Kujawsko-pomorskie	26	1,62	1,63	-39,26%	54,30%
Lubelskie	32	2,00	2,00	-39,00%	53,63%
Lubuskie	11	0,69	0,69	-39,26%	52,74%
Łódzkie	42	2,62	2,63	-38,95%	53,21%
Małopolskie	25	1,56	1,56	-38,88%	53,63%
Mazowieckie	59	3,68	3,68	-38,52%	52,49%
Opolskie	14	0,87	0,87	-38,83%	53,18%
Podkarpackie	9	0,56	0,56	-39,28%	53,23%
Podlaskie	24	1,50	1,50	-39,57%	53,22%
Pomorskie	25	1,56	1,56	-38,86%	52,10%
Śląskie	46	2,87	2,88	-39,80%	54,19%
Świętokrzyskie	20	1,25	1,25	-38,92%	53,44%
Warmińsko-Mazurskie	24	1,50	1,50	-38,88%	53,48%
Wielkopolskie	41	2,56	2,57	-39,28%	53,08%
Zachodniopomorskie	16	1,00	1,00	-39,23%	53,22%
Poland total	440	27,47	27,52	-39,18%	53,07%

Table 5.11. Uncertainty of N₂O emissions from burning liquid gas in the residential sector in Poland.

Voivodeship	Liquid gas	N ₂ O emissions (Mg)		Uncertainty	
	[thousands ton], 2010	Statistical values	Spatial inventories		
Dolnośląskie	26	8,12	8,13	-46,43%	70,32%
Kujawsko-pomorskie	26	8,12	8,11	-45,82%	67,23%
Lubelskie	32	9,99	10,01	-46,02%	68,70%
Lubuskie	11	3,43	3,43	-45,98%	65,94%
Łódzkie	42	13,11	13,14	-46,27%	67,72%
Małopolskie	25	7,81	7,77	-45,99%	68,47%
Mazowieckie	59	18,42	18,39	-46,11%	67,79%
Opolskie	14	4,37	4,38	-45,70%	68,20%
Podkarpackie	9	2,81	2,82	-46,10%	67,82%
Podlaskie	24	7,49	7,50	-46,11%	67,58%
Pomorskie	25	7,80	7,77	-46,17%	66,85%
Śląskie	46	14,36	14,39	-46,24%	68,46%
Świętokrzyskie	20	6,24	6,25	-46,27%	68,29%
Warmińsko-Mazurskie	24	7,49	7,50	-46,56%	68,20%
Wielkopolskie	41	12,80	12,79	-45,80%	67,16%
Zachodniopomorskie	16	5,00	5,00	-46,57%	67,56%
Poland total	440	137,37	137,97	-45,87%	67,54%

Table 5.12. Uncertainty of greenhouse gas emissions from burning liquid gas in the residential sector in Poland.

Voivodeship	Liquid gas, [thousands ton]	GHG emissions in CO ₂ -eq (Gg)		Uncertainty	
		Statistical values	Spatial inventories		
Dolnośląskie	26	76,97	79,34	-17,99%	18,75%
Kujawsko-pomorskie	26	76,97	79,34	-18,36%	18,85%
Lubelskie	32	94,74	97,58	-17,92%	18,60%
Lubuskie	11	32,57	33,54	-17,59%	18,17%
Łódzkie	42	124,34	127,82	-17,48%	18,35%
Małopolskie	25	74,01	76,16	-18,08%	18,48%
Mazowieckie	59	174,67	180,05	-17,88%	18,82%
Opolskie	14	41,45	42,63	-17,80%	18,39%
Podkarpackie	9	26,64	27,44	-17,78%	18,43%
Podlaskie	24	71,05	73,27	-17,81%	18,71%
Pomorskie	25	74,01	76,37	-18,17%	18,73%
Śląskie	46	136,18	140,19	-17,67%	18,84%
Świętokrzyskie	20	59,21	61,02	-17,95%	19,08%
Warmińsko-Mazurskie	24	71,05	73,14	-17,67%	18,47%
Wielkopolskie	41	121,38	124,87	-17,86%	19,06%
Zachodniopomorskie	16	47,37	48,83	-17,57%	18,64%
Poland total	440	1 302,61	1 341,14	-17,65%	18,84%

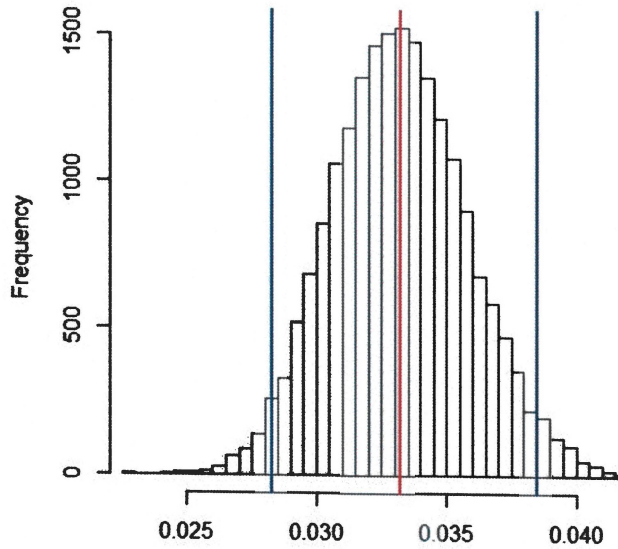


Figure 5.1. Uncertainty of CO₂ emissions from burning coal, natural gas, and liquid gas in Poland (2010, Gg * 10⁶)

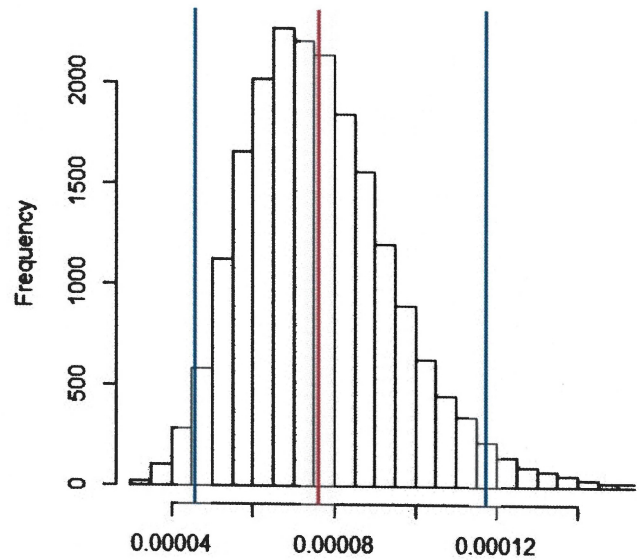


Figure 5.2. Uncertainty of CH₄ emissions from burning coal, natural gas, and liquid gas in Poland (2010, Gg * 10⁶)

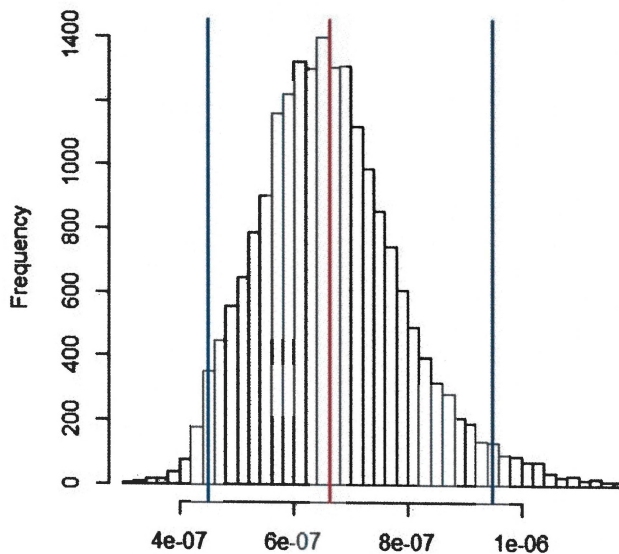


Figure 5.3. Uncertainty of N₂O emissions from burning coal, natural gas, and liquid gas in Poland (2010, Gg * 10⁶)

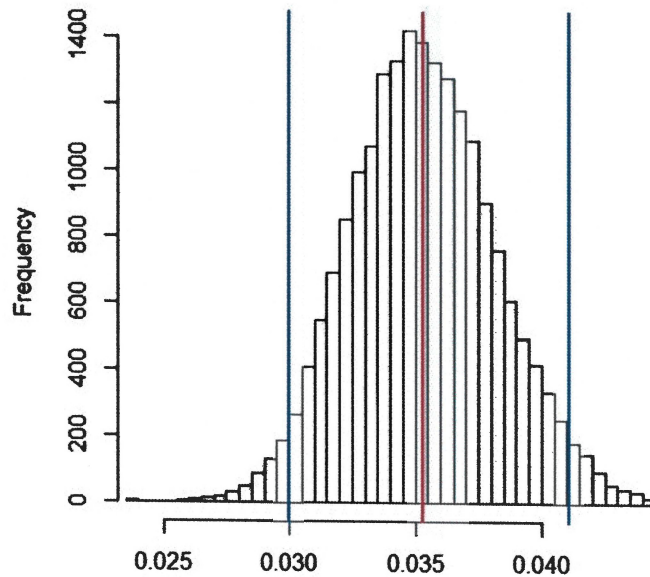


Figure 5.4. Uncertainty of greenhouse gas emissions from burning coal, natural gas, and liquid gas in Poland (2010, Gg * 10⁶)

Table 5.13. Uncertainty of greenhouse gas emissions from burning coal, natural gas, and liquid gas in Poland (2010).

GHGs	Uncertainty			
	CO ₂	CH ₄	N ₂ O	Total
GHG emissions (Gg)	33219,05	76,45	0,664	35328,22
Uncertainty	-14.79% ... +15.98%	-39.77% ... +53.83%	-32.16% ... +43.22%	-15.11% ... +16.39%

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