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

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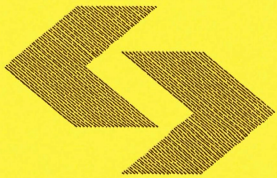

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GESAPU

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

Assessing of greenhouse gas emissions makes no sense without the analysis of uncertainty of the results obtained. In the inventory of greenhouse gas emissions, as the uncertainty, we take a value that indicates a lack of certainty in the inventory components caused by random factors (for instance, the uncertainty of the inventory process, emissions sources, and lack of transparency, etc). The uncertainties in the estimates of greenhouse gas emissions may arise due to the lack of knowledge about the emission processes, but can also be caused by errors in the collection of statistical data, the lack of representativeness, etc.

To model the uncertainty of the estimates of greenhouse gas emissions, the statistical data from (GUS, 2012) and the values of their uncertainties from Polish National Inventory Report (NIR, 2011) were used. In the industrial sector, there are a few emission source categories comparative to energy sector, and the uncertainties of emission factors are relatively low (an average of 5-10%, in extreme cases of 20-100%). The values of emission factors together with their uncertainties for some categories of emission sources were used from official sites of industrial enterprises, whenever available. In most cases such parameters are however unavailable, thus we used the IPCC methodology for the investigation of the uncertainty of parameters which were needed, using the Monte-Carlo method.

The uncertainties of the main parameters of greenhouse gas emission processes for the most important industrial plants in Poland with their coordinates are presented below, in *Tables 6.1 – 6.13*, and *Figures 6.1 – 6.2*:

- uncertainty of the main parameters of greenhouse gas emission processes for the ammonia production plants (*Table 6.1*);
- uncertainty of the main parameters of greenhouse gas emission processes for the nitric acid production plants (*Table 6.2*);
- uncertainty of the main parameters of greenhouse gas emission processes for the carbon black production plant (*Table 6.3*);
- uncertainty of the main parameters of greenhouse gas emission processes for the caprolactam production plants (*Table 6.4*);
- uncertainty of the main parameters of greenhouse gas emission processes for the calcium carbide production plant (*Table 6.5*);
- uncertainty of the main parameters of greenhouse gas emission processes for the ethylene production plant (*Table 6.6*);

- uncertainty of the main parameters of greenhouse gas emission processes from steel production in the electric arc furnaces (*Table 6.7*);
- uncertainty of the main parameters of greenhouse gas emission processes from steel production in the blast furnaces (*Table 6.8*);
- comparison of the results of spatial inventory of GHG emissions from steel production, and the statistical results calculated for the received uncertainties (*Table 6.9*);
- the results of investigation of uncertainties for the most steel producing plants (*Table 6.10*);
- uncertainty of the main parameters of greenhouse gas emission processes for the cement production plants (*Table 6.11*);
- uncertainty of the main parameters of greenhouse gas emission processes for the glass production plants in Poland (*Table 6.12*);
- comparison of the results of spatial inventory of GHG emissions from cement production, and the statistical results, taking into account uncertainty (*Table 6.13*);
- a diagram with comparison of the results of statistical approach (modeling) and spatial inventory of greenhouse gas emissions for most steel producers in Poland (*Figure 6.1*);
- a diagram with comparison of the results of statistical approach (modeling) and spatial inventory of greenhouse gas emissions for the cement production plants in Poland (*Figure 6.2*).

Table 6.1. Uncertainty of the main parameters of greenhouse gas emission processes on ammonia production plants in Poland (2010).

Id	Name	Capacity, [Gg/year]	Production [Gg/year]	Activity data uncertainty, [%]	CO_2 emission factor, [Mg_{CO2}/Mg]	CO_2 emission factor uncertainty lower, [%]	CO_2 emission factor uncertainty upper, [%]	CH_4 emission factor, [Mg_{CH4}/Mg]	CH_4 emission factor uncertainty, lower, [%]	CH_4 emission factor uncertainty upper, [%]
1	Anwil S.A.	520,0	504,2	5,00	1,75911	5,00	5,00	0,0049	20,00	20,00
2	Zakłady Chemiczne Police S.A.	250,0	242,4	5,00	1,75911	5,00	5,00	0,0049	20,00	20,00
3	ZAK S.A.	182,5	176,9	5,00	1,75911	5,00	5,00	0,0049	20,00	20,00
4	Zakłady Azotowe Puławy S.A.	978,2	948,4	5,00	1,75911	5,00	5,00	0,0049	20,00	20,00
5	Zakłady Azotowe w Tarnowie-Mościcach S.A.	193,5	187,6	5,00	1,75911	5,00	5,00	0,0049	20,00	20,00

Table 6.2. Uncertainty of the main parameters of greenhouse gas emission processes for the nitric acid production plants in Poland (2010).

Id	Name	Capacity, [Gg/year]	Production, [Gg/year]	Activity data uncertainty, [%]	N_2O emission factor, [Mg_{N2O}/Mg]	N_2O emission factor uncertainty, lower, [%]	N_2O emission factor uncertainty, upper, [%]
1	Zakłady Azotowe w Tarnowie-Mościcach S.A.	277,6	296,80	2,00	0,00175	30,00	30,00
2	ZAK S.A.	174,9	187,02	2,00	0,00105	30,00	30,00
3	Zakłady Azotowe Puławy S.A.	891,0	952,75	2,00	0,00140	30,00	30,00
4	Anwil S.A.	722,7	772,79	2,00	0,00120	30,00	30,00

Table 6.3. Uncertainty of the main parameters of greenhouse gas emission processes for the carbon black production plant in Poland (2010).

Id	Name	Production, [Gg/year]	Activity data uncertainty, [%]	CH_4 emission factor, [Mg_{CH4}/Mg]	CH_4 emission factor uncertainty, lower, [%]	CH_4 emission factor uncertainty, upper, [%]
1	Carbon Black Polska Sp. z o.o.	32,56	5,00	0,011	20,00	20,00

Table 6.4. Uncertainty of the main parameters of greenhouse gas emission processes for the caprolactam production plants in Poland (2010).

Id	Name	Capacity, [Gg/year]	Production, [Gg/year]	Activity data uncertainty, [%]	N_2O emission factor, [Mg_{N2O}/Mg]	N_2O emission factor uncertainty, lower, [%]	N_2O emission factor uncertainty, upper, [%]
1	Zakłady Azotowe Puławy S.A.	70	71,49	5,00	0,00474	20,00	20,00
2	Zakłady Azotowe w Tarnowie-Mościcach S.A.	86	87,82	5,00	0,00474	20,00	20,00

Table 6.5. Uncertainty of the main parameters of greenhouse gas emission processes for the calcium carbide production plant in Poland (2010).

Id	Name	Capacity, [Gg/year]	Production, [Gg/year]	Activity data uncertainty, [%]	CO_2 emission factor, [Mg_{CO2}/Mg]	CO_2 emission factor uncertainty, lower, [%]	CO_2 emission factor uncertainty, upper, [%]
1	Huta Łaziska S.A.	1,2	1,15	5	2,19	5	5

Table 6.6. Uncertainty of the main parameters of greenhouse gas emission processes for the ethylene production plant in Poland (2010).

Id	Name	Capacity, [Gg/year]	Production, [Gg/year]	Activity data uncertainty, [%]	CO_2 emission factor, [Mg_{CO2}/Mg]	CO_2 emission factor uncertainty, lower, [%]	CO_2 emission factor uncertainty, upper, [%]	CH_4 emission factor, [Mg_{CH4}/Mg]	CH_4 emission factor uncertainty, lower, [%]	CH_4 emission factor uncertainty, upper, [%]
1	Polski Koncern Naftowy Orlen S.A.	700	501,801	5,00	0,0003	5,00	5,00	0,001	20,00	20,00

Table 6.7. Uncertainty of the main parameters of greenhouse gas emission processes from steel production in the electric arc furnaces in Poland (2010).

Id	Name	Steel production [Gg/year]	Activity data uncertainty, [%]	CO_2 emission factor, [Mg_{CO2}/Mg]	CO_2 emission factor uncertainty lower, [%]	CO_2 emission factor uncertainty upper, [%]	CH_4 emission factor, [Mg_{CH4}/Mg]	CH_4 emission factor uncertainty lower, [%]	CH_4 emission factor uncertainty, upper, [%]
1	CMC Zawiercie S.A.	1576,16	5,00	0,084652	10,00	10,00	0,00012	20,00	20,00
2	CELSA „Huta Ostrowiec" Sp. z o.o.	969,95	5,00	0,084652	10,00	10,00	0,00012	20,00	20,00
3	Huta Stali Częstochowa Sp. z o.o.	848,70	5,00	0,084652	10,00	10,00	0,00012	20,00	20,00
4	HSW Huta Stali Jakościowych Sp. z o.o.	484,97	5,00	0,084652	10,00	10,00	0,00012	20,00	20,00
5	FERROSTAL Łabędy Sp. z o.o.	40,01	5,00	0,084652	10,00	10,00	0,00012	20,00	20,00
6	Huta LW Sp z o.o.	40,01	5,00	0,084652	10,00	10,00	0,00012	20,00	20,00
7	Huta Batory S.A.	40,01	5,00	0,084652	10,00	10,00	0,00012	20,00	20,00

Table 6.8. Uncertainty of the main parameters of greenhouse gas emission processes from steel production in the blast furnaces in Poland (2010).

Id	Name	Production, [Gg/year]	Activity data uncertainty, [%]	CO_2 emission factor, [Mg_{CO2}/Mg]	CO_2 emission factor uncertainty, lower, [%]	CO_2 emission factor uncertainty, upper, [%]	CH_4 emission factor, [Mg_{CH4}/Mg]	CH_4 emission factor uncertainty, lower, [%]	CH_4 emission factor uncertainty, upper, [%]
1	Arcelor Mittal Poland S.A. Dąbrowa Górnicza	2628,08	5,00	0,11306	10,00	10,00	0,000001	20,00	20,00
2	Arcelor Mittal Poland S.A. Kraków	1366,57	5,00	0,11306	10,00	10,00	0,000001	20,00	20,00

Table 6.9. Comparison of the results of spatial inventory of GHG emissions from steel production and the statistical analysis, taking into account uncertainty (2010).

Id	Name	Region	X	Y	Spatial inventory results, CO_2 eqv, [Gg]	Statistical values, CO_2 eqv, [Gg]	Difference, [%]
1	CMC Zawiercie S.A.	24	19,45798	50,48848	102,06	101,62	-0,004
2	CELSA „Huta Ostrowiec" Sp. z o.o.	26	21,42733	50,94490	62,81	63,15	0,005
3	Huta Stali Częstochowa Sp. z o.o.	24	19,17097	50,78710	54,95	55,31	0,007
4	HSW Huta Stali Jakościowych Sp. z o.o.	18	22,04443	50,55613	37,59	38,26	0,018
5	FERROSTAL Łabędy Sp. z o.o.	24	18,61348	50,36242	33,17	32,47	-0,021
6	Huta LW Sp z o.o.	14	20,92783	52,29263	31,4	30,83	-0,018
7	Huta Batory S.A.	24	18,94221	50,27245	28,75	29,68	0,032
8	Arcelor Mittal Poland S.A. Dąbrowa Górnicza	24	19,28403	50,33666	297,35	295,17	-0,007
9	Arcelor Mittal Poland S.A. Kraków	12	20,08180	50,07006	154,62	155,93	0,008

Table 6.10. Investigation of uncertainty for most steel producers (2010).

Name	Uncertainties [%]			
	CO_2	CH_4	N_2O	Total
CMC Zawiercie S.A.(1)	-11,81:+12,42	-20,8: +21,6	-23,02: +27,51	-11,51: +12,34
CELSA „Huta Ostrowiec" Sp. z o.o. (2)	-11,94: +12,53	-20,6: +21,3	-23,25: +27,68	-11,62: +12,45
Huta Stali Częstochowa Sp. z o.o. (3)	-11,79: +12,48	-20,73: +21,42	-23,36: +27,57	-11,67: +12,28
HSW Huta Stali Jakościowych Sp. z o.o. (4)	-11,81: +12,56	-20,86: +21,36	-23,31: +27,65	-11,70: +12,33
FERROSTAL Łabędy Sp. z o.o. (5)	-11,97: +12,49	-20,79: +21,70	-23,06: +27,66	-11,71: +12,28
Huta LW Sp z o.o. (6)	-11,95: +12,67	-21,09: +21,60	-23,17: +27,55	-11,69: +12,26
Huta Batory S.A. (7)	-11,99: +12,52	-20,66: +21,29	-23,24: +27,75	-11,78: +12,14
Arcelor Mittal Poland S.A. Dąbrowa Górnicza (8)	-11,89: +12,54	-21,04: +21,48	-23,14: +27,42	-11,84: +12,48
Arcelor Mittal Poland S.A. Kraków (9)	-11,98: +12,63	-19,3: +21,3	-16,71: +18,62	-11,83: +12,56
Total	-5,56: +5,65	-8,82: +9,00	-16,55: +19,04	-5,48: +5,60

Table 6.11. Uncertainty of the main parameters of greenhouse gas emission processes for cement production plants in Poland (2010).

№	company	plant	cement capacity, [Gg/year]	cement production totally [Gg/year]	clinker production totally [Gg/year]	clinker production separately, [Gg/year]
1	HeidelbergCement	Cementownia Górażdże	4000	3710	2440	2400
2	HeidelbergCement	Ekocem Sp. z o.o.	1400			0
3	Lafarge	Cementownia Małogoszcz	2000	3290	2430	1215
4	Lafarge	Cementownia Kujawy	2000			1215
5	CRH	Grupa Ożarów	2900	2660	2210	1144,4
6	CRH	Cementownia Rejowiec	2700			1065,6
7	Cemex	Cementownia Chełm	2000	2110	1820	1137,5
8	Cemex	Cementownia Rudniki	1200			682,5
9	Dyckerhoff	Dyckerhoff Polska Sp. z o.o.	1600	1390	1050	1050
10	Polen Cement	Cementownia Warta	2200	1350	1320	1320
11	Miebach	Cementownia Odra	750	730	350	350
12	Mapei	Górka Cement	100	50	50	50
13	Polska Energetyka Holding SA	Cementownia Nowa Huta	200	270	80	80

Table 6.11. (Continuation). Uncertainty of the main parameters of greenhouse gas emission processes for cement production plants in Poland (2010).

№	plant	activity data uncertainty, [%]	CO_2 emission factor for the clinker, [Mg_{CO2}/Mg]	CO_2 emission factor uncertainty, lower, [%]	CO_2 emission factor uncertainty, upper, [%]	Correction factor for the cement kiln dust (CF CKD)	CF CKD uncertainty, [%]
1	Cementownia Górażdże	2	0,512	15	15	1,02	10
2	Ekocem Sp. z o.o.	2	0,512	15	15	1,02	10
3	Cementownia Małogoszcz	2	0,520	15	15	1,02	10
4	Cementownia Kujawy	2	0,520	15	15	1,02	10
5	Grupa Ożarów	2	0,529	15	15	1,02	10
6	Cementownia Rejowiec	2	0,529	15	15	1,02	10
7	Cementownia Chełm	2	0,529	15	15	1,02	10
8	Cementownia Rudniki	2	0,529	15	15	1,02	10
9	Dyckerhoff Polska Sp. z o.o.	2	0,529	15	15	1,02	10
10	Cementownia Warta	2	0,529	15	15	1,02	10
11	Cementownia Odra	2	0,529	15	15	1,02	10
12	Górka Cement	2	0,529	15	15	1,02	10
13	Cementownia Nowa Huta	2	0,529	15	15	1,02	10

Table 6.12. Uncertainty of the main parameters of greenhouse gas emission processes for glass producers in Poland (2010).

№	company	glass production [Gg/year]	activity data uncertainty, [%]	CO_2 emission factor for glass, [Mg_{CO2}/Mg]	CO_2 emission factor uncertainty, lower, [%]	CO_2 emission factor uncertainty, upper, [%]	cullet ratio in glass,[%]	cullet ratio uncertainty, [%]
1	Owens-Illinois Polska S.A.	288,29	5	0,21	10	10	45	15
2	Owens-Illinois Polska S.A.	288,29	5	0,21	10	10	45	15
3	Ardagh Glass Gostyń S.A.	183,59	5	0,21	10	10	45	15
4	Ardagh Glass Ujście S.A.	124,78	5	0,21	10	10	45	15
5	Huta Szkła Warta S.A.	91,80	5	0,21	10	10	45	15
6	Stolzle Częstochowa S.A.	91,80	5	0,21	10	10	45	15
7	Huta Szkła „Jedlice" S.A.	53,07	5	0,21	10	10	45	15
8	Ardagh Glass Wyszków S.A.	53,07	5	0,21	10	10	45	15
9	Huta Szkła WYMIARKI S.A.	38,73	5	0,21	10	10	45	15
10	Huta Szkła SŁAWA S.P.	53,07	5	0,21	10	10	45	15
11	Vitrosilicon S.A.	53,07	5	0,21	10	10	45	15
12	HUTA SZKŁA "CZECHY" S.A.	37,29	5	0,21	10	10	45	15
13	Saint-Gobain Glass Polska Sp. Z o.o.	272,10	5	0,21	10	10	25	2
14	Pilkington Polska Sp. z o.o.	272,10	5	0,21	10	10	15	2
15	Guardian Industries Poland Sp. z o.o.	272,10	5	0,21	10	10	25	2

Table 6.12 (Continuation). Uncertainty of the main parameters of greenhouse gas emission processes for glass producers in Poland (2010).

№	company	glass production [Gg/year]	activity data uncertainty, [%]	CO_2 emission factor for glass, [Mg_{CO_2}/Mg]	CO_2 emission factor uncertainty, lower, [%]	CO_2 emission factor uncertainty, upper, [%]	cullet ratio in glass,[%]	cullet ratio uncertainty, [%]
16	Euroglas Polska Sp. z.o.o	272,10	5	0,21	10	10	20	2
17	Huta Szkła Gospodarczego Irena S.A.	15,00	5	0,10	10	10	40	15
18	Huta Szkła Kryształowego Violetta S.A.	15,00	5	0,10	10	10	40	15
19	Huta Szkła Kryształowego „Julia"	15,00	5	0,10	10	10	40	15
20	Huta Szkła Kryształowego „Beata"	15,00	5	0,10	10	10	40	15
21	Sudety Crystal Works Sp. z o.o.	15,00	5	0,10	10	10	40	15
22	Part-Glass Krosno Sp. z o.o.	15,00	5	0,10	10	10	40	15
23	MAKORA Krośnieńska Huta Szkła S.A.	15,00	5	0,10	10	10	40	15
24	Huta Szkła Artystycznego i Gospodarczego "Fistek Glass"	15,00	5	0,10	10	10	40	15
25	HUTA SZKŁA "GLOSS"	15,00	5	0,10	10	10	40	15
26	Huta Szkła Zawiercie Sp. z o.o.	15,00	5	0,10	10	10	40	15
27	SCHOTT Poland Sp. z o. o.	5,81	5	0,10	10	10	40	15
28	Philips Lighting Poland S.A.	5,81	5	0,20	10	10	55	15
29	Thomson Multimedia Polska Sp. z o.o.	5,81	5	0,13	10	10	45	15
30	KROSGLASS S.A.	79,58	5	0,19	10	10	7,5	15

Table 6.13. Comparison of the results of spatial inventory of GHG emissions from cement production and the statistical analysis, taking into account uncertainty (2010).

№	company	plant	X	Y	Spatial inventory results, CO_2 eqv, [Gg]	Statistical values, CO_2 eqv, [Gg]	CO_2 uncertainties [%]
1	HeidelbergCement	Cementownia Górażdże	19,45798	50,48848	1253,38	1253,90	-17,48: +18,61
2	Lafarge	Cementownia Małogoszcz	19,17097	50,78710	644,44	643,15	-17,35: +18,60
3	Lafarge	Cementownia Kujawy	22,04443	50,55613	644,44	640,52	-17,81: +18,90
4	CRH	Grupa Ożarów	18,61348	50,36242	617,50	616,89	-17,74: +18,96
5	CRH	Cementownia Rejowiec	20,92783	52,29263	574,98	576,20	-17,93: +18,78
6	Cemex	Cementownia Chełm	18,94221	50,27245	613,77	613,96	-17,71: +18,72
7	Cemex	Cementownia Rudniki	19,28403	50,33666	368,26	368,23	-17,36: +18,68
8	Dyckerhoff	Dyckerhoff Polska Sp. z o.o.	20,54966	50,81883	566,56	567,21	-17,59: +18,70
9	Polen Cement	Cementownia Warta	18,92203	51,10392	712,25	713,18	-17,00: +18,34
10	Miebach	Cementownia Odra	17,9143	50,68043	188,85	189,03	-17,77: +18,51
11	Mapei	Górka Cement	19,45588	50,17531	26,98	25,97	-17,92: +18,64
12	Polska Energetyka Holding SA	Cementownia Nowa Huta	20,11509	50,07629	43,17	42,10	-17,76: +18,59

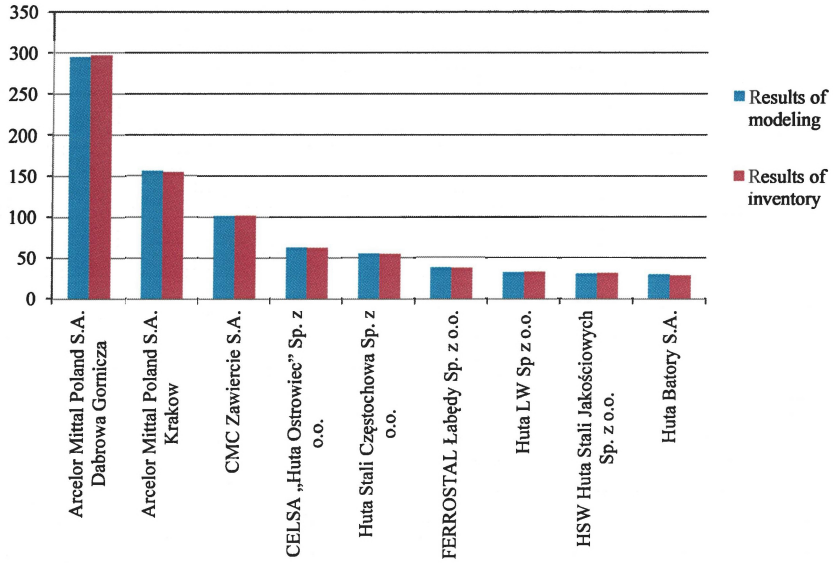

Figure 6.1. Comparison of the results of statistical approach (modeling) and spatial inventory of greenhouse gas emission for most steel producers in Poland (Gg, logarithmic scale, 2010)

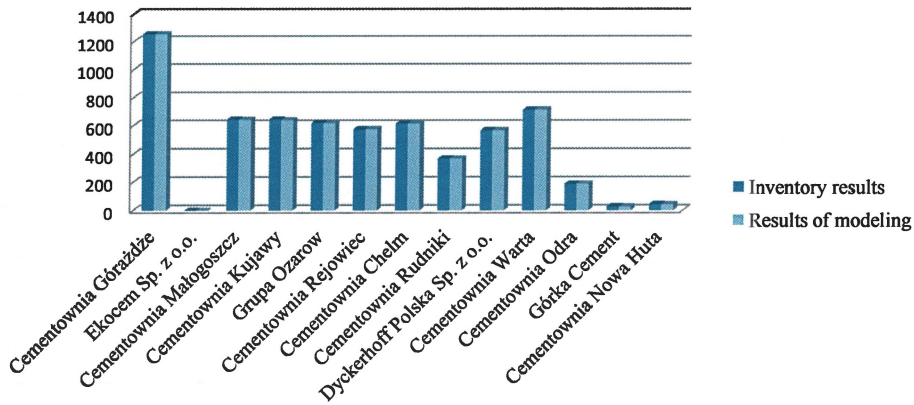

Figure 6.2. Comparison of the results of statistical approach (modeling) and spatial inventory of greenhouse gas emission for cement production plants in Poland (Gg, logarithmic scale, 2010)

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