Raport Badawczy
Research Report

RB/12/2014

Information technology for spatial greenhouse gas emission inventory ready to use for any part of Poland, and any time period

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Warszawa 2014

D 1.3

Version 1
Date 30.10.2012
Author LPNU, SRI
Dissemination level PP
Document reference D 1.3

GESAPU

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

Deliverable 1.3. Information technology for spatial greenhouse gas emission inventory ready to use for any part of Poland, and any time period

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Delivery Date: M38

Project Duration 24 June 2010 – 23 June 2014 (48 Months)
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This project is supported by funding by the European Commission: FP7-PEOPLE-2009-IRSES, Project n° 247645.

Project: #247645. Call: FP7-PEOPLE-2009-IRSES, Marie Curie Actions—International Research Staff Exchange Scheme (IRSES).

Work package 1. Spatially resolved greenhouse gas inventory for Poland

Deliverable 1.3.Information technology for spatial greenhouse gas emission inventory ready to use for any part of Poland, and any time period

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4. Geoinformation technology for spatial GHG inventory: Industrial sector

According to the IPCC methodology industrial processes sector is one of the main considerable sectors for greenhouse gas emission reduction. The GHG emissions in this sector are caused by chemical or physical transformations of materials during manufacturing of industrial products. Major GHG emissions source categories are the cement production, lime production, iron and steel industry, ammonia production, nitric acid production, consumption of hydrofluorocarbons (HFC) in refrigerating and air conditioning equipment, etc. Emissions in this sector account for about 7% of the total net emissions (National Inventory Submissions). The data on production of industrial products in Poland is available only on country level.

Carrying out the spatial GHG inventory at the level of every elementary object in the industrial sector consists of three main steps (*Figure4.1*):

- Import of statistical data;
- Disaggregation of statistical data on manufacturing of industrial products;
- Greenhouse gas emission estimation.

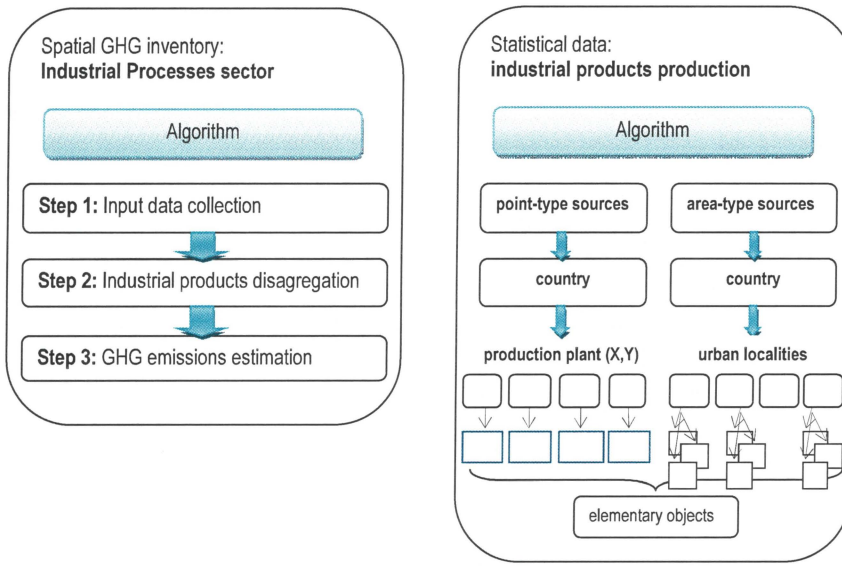


Figure 4.1. The algorithm of the spatial greenhouse gas emissions inventory in the industrial sector.

The information technology was created for realization of the developed methodology. The logical structure of thealgorithm is presented in *Figure4.2*. Each step of this methodology was implemented as a program module, using a geographic information system. Thus, the created information technology consists of three program modules: Ind1collection, Ind2disaggregation,and Ind3estimation:

(1) **Ind1collection**. All input data are given as digital maps, Excel tables (with the statistical data from GUS and separately with the data from main production plants in each emissions source category) and emission factors. There are point-type and area-type sources of the GHG emissions in the industrial sector. For instance, meat and bread production plants are assumed as area-type sources, that is why the population density map is used to prepare the georeferenced database with the elementary objects. We consider the area within which the population density is the same as the elementary object. The population map was created using raster data on population density disaggregated according to the Corine land cover 2000 (Gallego, 2010). The map was updated with the data for 2010. The data concerning the population in urban localities also are updated for 2010.

In the**Ind1collection** module the statistical data was imported from Excel tables. The data on production of main industrial products is available on country level. Information (location, production capacity, and geographic coordinates) about large production plants in each emissions source category was collected and saved as Excel tables, and then respective digital maps of production plants were built,using this information. The imported Excel tables contain the important statistical data which characterizes activities in the industrial sector and is essential for carrying out the greenhouse gas emission inventory.In particular, they contain:

- Characteristics of activity of industrial production plants in each source category with a link to the map of administrative units, for example, a cement production plant linked to municipality (*Table 4.1*);
- Greenhouse gas emission factors.

(2) **Ind2disaggregation.** The statistical data on the amount of industrial products are disaggregated from country level to the level of plants, proportionally to production capacities of large production plants from digital maps, which are built in previous module. In the case of area-type emissions source, when a lot of small plants are localized at a small part of territory,the statistical data are disaggregated from the level of the country or voivodeships to the level of urban localities proportionally to thepopulation density data.

(3) **Ind3stimation**. Using specialized geoinformation system, the estimates of greenhouse gas emission have been obtained. Firstly, we estimate the GHG emissions from each category of emissions sources in subsectors of the industrial sector due to the IPCC classification: Mineral products (number of categories – 7), Chemistry (9), Iron and Steel industry (9), Other production

(1), consumption of Halocarbons and SF6 (7). The values of emissions in this case depend on the disaggregated statistical data on production and respective specific emission factors, which characterize activity of individual enterprise and used production technologies. The emission factors vary by production plant. For instance, the results of modeling of the GHG emissions from nitric acid production plants are presented as table in *Figure4.3* and, additionally, illustrated ina built digital map for the category "Nitric acid production" of chemical industry in *Figure4.4*. In the result of overlayingthe digital map of elementary objects and the digital map of nitric acid production plants, we transferred the values of GHG emissions estimated on the level of plants to elementary objects proportionally to the sum of productions from the plants that, are within these objects.

Using the developed information technology, we carried out numerical experiments from GHG emissions estimation for 2010 on the base of respective statistical information on industrial products production in this year. As the result, we obtained the estimates of the greenhouse gas emissions at the level of elementary objects for 2010 for all categories in the industrial sector. The georeferenced database contains information about carbon dioxide, methane, and nitrous oxide emissions from main categories of human activity due to the IPCC methodology, as well as the estimates of greenhouse gas emissions fromindirect informations, for example, emissions of carbon monoxide, nitrous oxides, sulphur dioxide, non-methane volatile organic compounds from pulp-paper industry, and food industry. Total greenhouse gas emissions in CO_2-equivalent also are represented in georeferenced database with inventory results. Every elementary object from digital map is linked to the exact row of the georeferenced database, which contains information about greenhouse gas emissions in the industrial sector.

The georeferenced database contains the results of the spatial GHG emission inventory and consists of geographic elements and the table of attributes with activity data, disaggregated values on industrial products production, total GHG emissions, and emissions for each emissions source categories. Using the GIS-tools, the obtained results may be presented as thematic maps. The final georeferenced database is ready to use in further research.

As an example, we illustrated the results of the spatial GHG emissions inventory for elementary objects of one of the 16 regions (Silesian voivodeship - *Figure4.5*). The figure shows territorial distribution of CO_2 emissions from main industrial processes of cement, lime, glass, soda ash production and lime and dolomite use in one region. For displaying the results at elementary objects, the map of the municipalities of Silesian region wassplit ingrids of defined size (2x2 km).
For correct operation of the software the following tools areneeded:

- IBM-compatible PC;
- Windows Service Pack 2 / 2002/XP;
- MS Office (MS Excel 2003 +);
- GIS MapInfo 8,0 +;
- Module of IPCC methodologies for MSExcel.

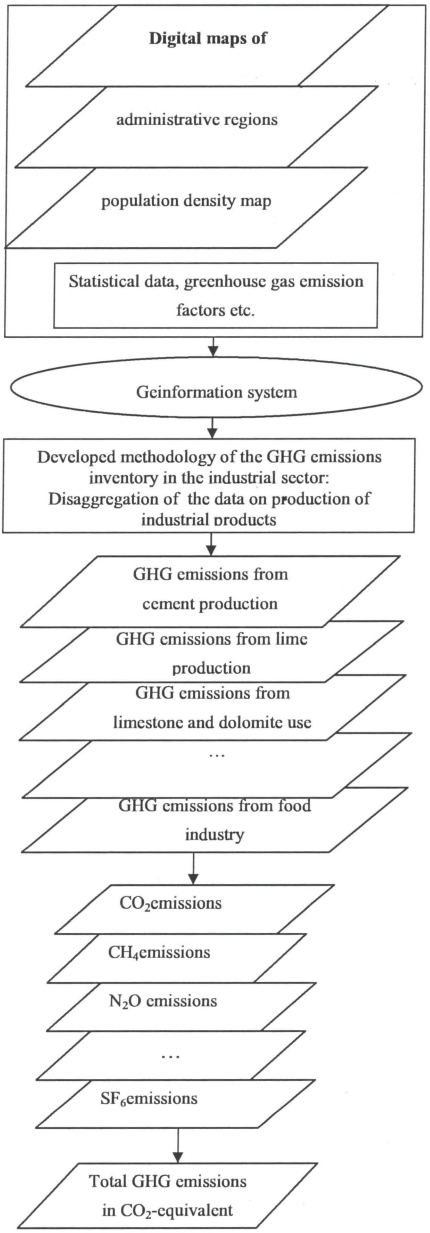


Figure 4.2. The logical structure of the software.

Table 4.1. Explanation of columns of the attribute table.

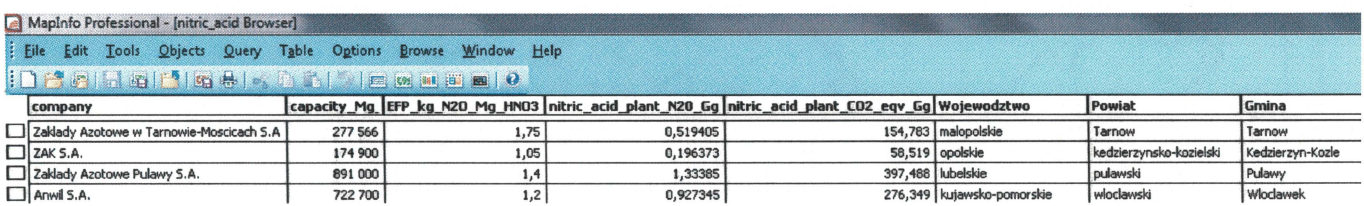
eo_2A1_CO2_Gg	CO_2 emissions from cement production (Mineral products)
eo_2A2_CO2_Gg	CO_2 emissions from lime production (Mineral products)
eo_2A3_CO2_Gg	CO_2 emissions from limestone and dolomite use (Mineral products)
eo_2A4_CO2_Gg	CO_2 emissions from soda ash production and use production (Mineral products)
eo_2A5_CO_Gg	CO emissions from asphalt roofing (production) (Mineral products)
eo_2A5_NMVOC_Gg	NMVOC emissions from asphalt roofing (production) (Mineral products)
eo_2A6_NMVOC_Gg	NMVOC emissions from road paving with asphalt (production) (Mineral products)
eo_2A7_CO2_Gg	CO_2 emissions from glass production (Mineral products)
eo_2B1_CO2_Gg	CO_2 emissions from ammonia production (Chemistry)
eo_2B1_CH4_Gg	CH_4 emissions from ammonia production (Chemistry)
eo_2B2_N2O_Gg	N_2O emissions from nitric acid production (Chemistry)
eo_2B4_CO2_Gg	CO_2 emissions from calcium carbide production (Chemistry)
eo_2B5a_N2O_Gg	N_2O emissions from caprolactam production (Chemistry)
eo_2B5b_CH4_Gg	CH_4 emissions from carbon black production (Chemistry)
eo_2B5c_CO2_Gg	CO_2 emissions from ethylene production (Chemistry)
eo_2B5c_CH4_Gg	CH_4 emissions from ethylene production (Chemistry)
eo_2B5d_CH4_Gg	CH_4 emissions from methanol production (Chemistry)
eo_2B5e_CH4_Gg	CH_4 emissions from styrene production (Chemistry)
eo_2C1a_CO2_Gg	CO_2 emissions from iron ore sinter production (Metal production)
eo_2C1a_CH4_Gg	CH_4 emissions from iron ore sinter production in sintering plants (Metal production)
eo_2C1c_CO2_Gg	CO_2 emissions from steel cast production in electric arc furnaces (Metal production)
eo_2C1d_CO2_Gg	CO_2 emissions from iron cast production (Metal production)
eo_2C1d_CH4_Gg	CH_4 emissions from iron cast production (Metal production)

eo_2C1e_CO2_Gg	CO_2 emissions from pig iron production in blast furnaces (Metal production)
eo_2C1e_CH4_Gg	CH_4 emissions from pig iron production in blast furnaces (Metal production)
eo_2C1e_N2O_Gg	N_2O emissions from pig iron production in blast furnaces (Metal production)
eo_2C1f_CO2_Gg	CO_2 emissions from steel production in basic oxygen furnaces (Metal production)
eo_2C1f_CH4_Gg	CH_4 emissions from steel production in basic oxygen furnaces (Metal production)
eo_2C1f_N2O_Gg	N_2O emissions from steel production in basic oxygen furnaces (Metal production)
eo_2C1g_CO2_Gg	CO_2 emissions from steel production in electric arc furnaces (Metal production)
eo_2C1g_CH4_Gg	CH_4 emissions from steel production in electric arc furnaces (Metal production)
eo_2C2_CO2_Gg	CO_2 emissions from ferroalloys production (Metal production)
eo_2C2_CH4_Gg	CH_4 emissions from ferroalloys production (Metal production)
eo_2C3_CO2_Gg	CO_2 emissions from aluminium production (Metal production)
eo_2C3_CF4_Gg	CF_4 emissions from aluminium production (Metal production)
eo_2C3_C2F6_Gg	C_2F_6 emissions from aluminium production (Metal production)
eo_2C5a_CO2_Gg	CO_2 emissions from zinc production (Metal production)
eo_2C5b_CO2_Gg	CO_2 emissions from lead production (Metal production)
eo_2D1a_CO2_Gg	CO_2 emissions from paper production
eo_2D1a_NOx_Gg	NOx emissions from paper production;
eo_2D1a_NMVOC_Gg	NMVOC emissions from paper production;
eo_2D1a_CO_Gg	CO emissions from paper production;
eo_2D1a_SO2_Gg	SO_2 emissions from paper production;
eo_2D1b_NOx_Gg	NOx emissions from pulp production;
eo_2D1b_NMVOC_Gg	NMVOC emissions from pulp production;
eo_2D1b_CO_Gg	CO emissions from pulp production;
eo_2D1b_SO2_Gg	SO_2 emissions from pulp production;
eo_2D2_NMVOC_Gg	NMVOC emissions from food and drink industry;

eo_HFCs_CO2eq_Gg	total HFC emissions in CO_2-equivalent
eo_PFCs_CO2eq_Gg	total PFC emissions in CO_2-equivalent
eo_SF6_CO2eq_Gg	total SF6 emissions in CO_2-equivalent
eo_total_CO2eq_Gg	total emissions in CO_2-equivalent in the industrial sector

Table 4.2. Geo-linking of cement production plants to municipalities.

Id teryt 2011	Company	plant	City	street	X	Y	capacity [Gg/year]
1605013	Heidelberg Cement	Cementownia Górażdże	Chorula	Cementowa 1,	17,9775	50,5272	3000
2465011	Heidelberg Cement	Ekocem Sp. z o.o.	Dąbrowa Górnicza	Rożdzieńskiego 14	19,2738	50,3557	1400
2602033	Lafarge	Cementownia Małogoszcz	Małogoszcz	Warszawska 110	20,2803	50,823	2000
419013	Lafarge	Cementownia Kujawy	Piechcin	88-192 Piechcin	21,6602	50,8937	2000
2606053	CRH	Grupa Ożarów	Ożarów	Kościuszki 85	18,0183	52,822	1300
603011	CRH	Cementownia Rejowiec	Rejowiec Fabryczny	Fabryczna 1	23,2299	51,1212	1300
662011	Cemex	Cementownia Chełm	Chełm	Fabryczna 6	23,5433	51,1373	1200
2404063	Cemex	Cementownia Rudniki	Rudniki	Mostowska 10	19,2047	50,885	1000
2604172	Dyckerhoff	Dyckerhoff Polska Sp. z o.o.	Sitkówka-Nowiny	Zakładowa 3	20,5497	50,8188	1400
1009013	Polen Cement	Cementownia Warta	Działoszyn	Przemysłowa 17	18,922	51,1039	1240
1661011	Miebach	Cementownia Odra	Opole	Budowlanych 9	17,9143	50,6804	750
1203053	Mapei	Górka Cement	Trzebinia	22 Lipca 58	19,4559	50,1753	100
1261011	Polska Energetyka Holding SA	Cementownia Nowa Huta	Kraków	Cementowa 2	20,1151	50,0763	200



company	capacity_Mg	EFP_kg_N2O_Mg_HNO3	nitric_acid_plant_N2O_Gg	nitric_acid_plant_CO2_eqv_Gg	Wojewodztwo	Powiat	Gmina
Zaklady Azotowe w Tarnowie-Moscicach S.A	277 566	1,75	0,519405	154,763	malopolskie	Tarnow	Tarnow
ZAK S.A.	174 900	1,05	0,196373	58,519	opolskie	kedzierzynsko-kozielski	Kedzierzyn-Kozle
Zaklady Azotowe Pulawy S.A.	891 000	1,4	1,33385	397,488	lubelskie	pulawski	Pulawy
Anwil S.A.	722 700	1,2	0,927345	276,349	kujawsko-pomorskie	wloclawski	Wloclawek

Figure 4.3. Georeferenced database of the results of the GHG inventory in the category "Nitric acid production".

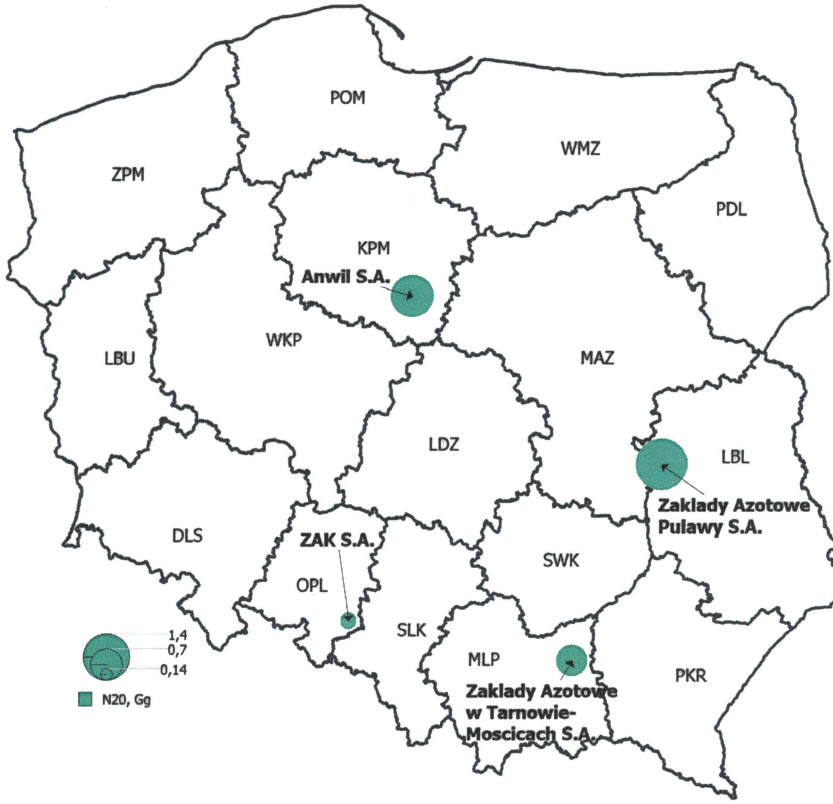


Figure 4.4. Territorial distribution of the main N_2O emissions sources in Poland (Gg, 2010 year).

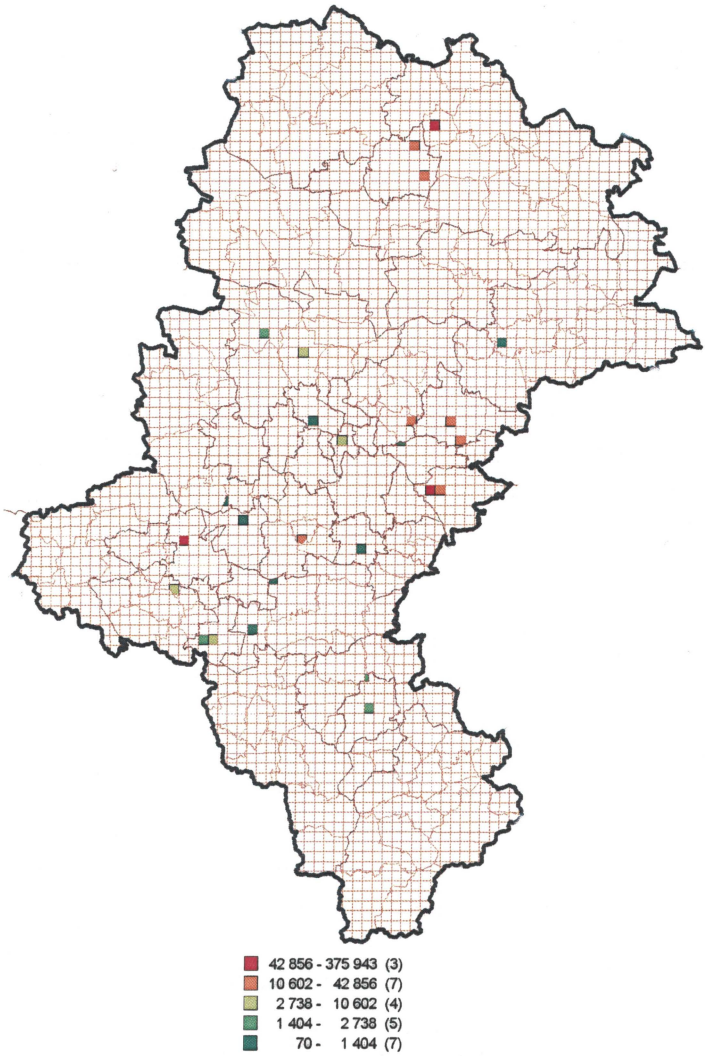


Figure 4.5. The results of the spatial CO_2 emissions inventory from minerals production at elementary objects in Silesian voivodeship of Poland (Mg, 2010).

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