Uncertainty analysis of GHG spatial inventory from the industrial activity: A case study for Poland

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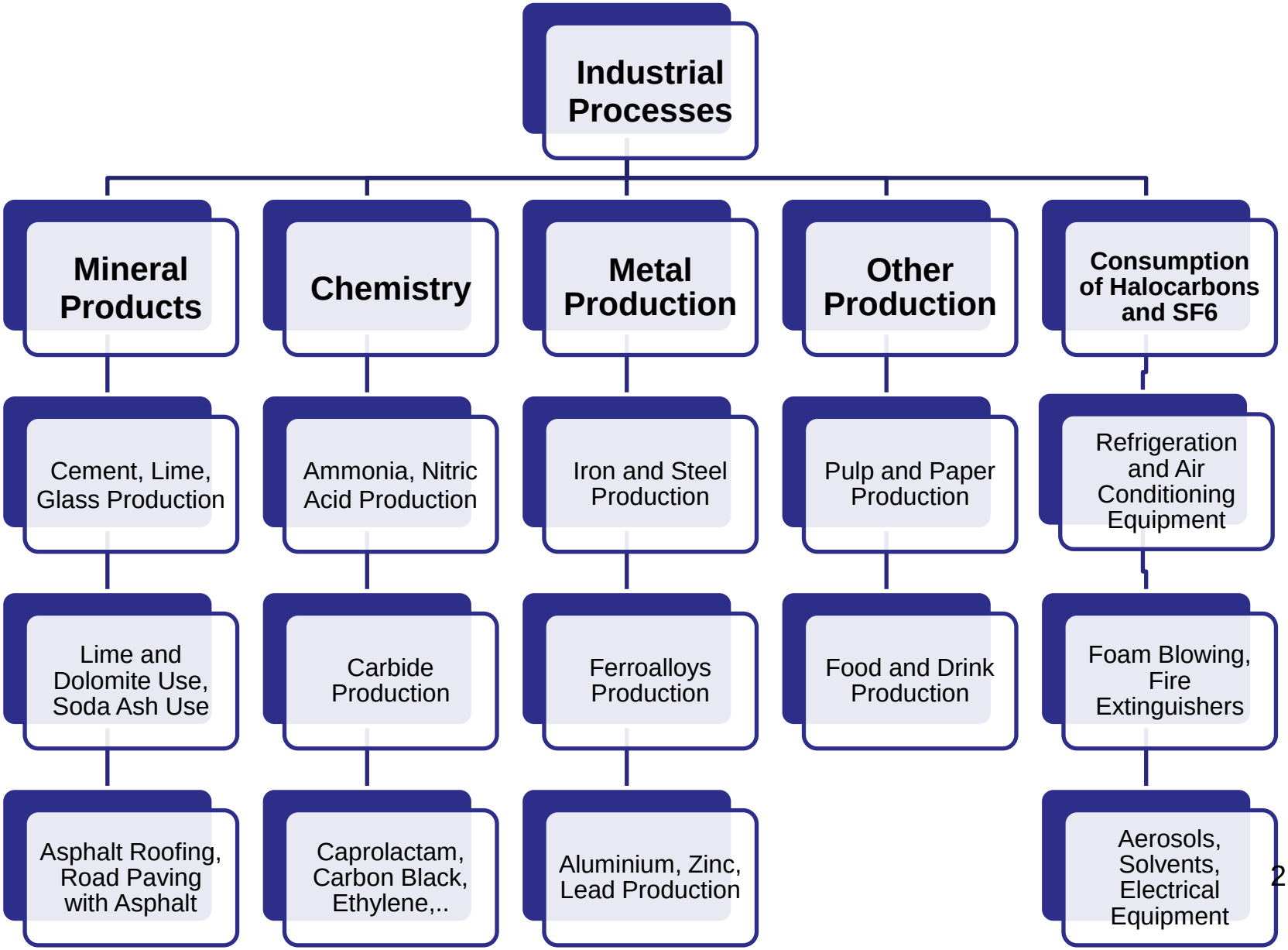
Structure of GHG inventory reporting due to IPCC Industrial Processes sector



Industrial Processes sector

Sources of input data

1. Production capacities/outcomes

- ✓ Central Statistical Office, Local Data Bank - http://stat.gov.pl;
- ✓ official web sites of enterprises ;
- ✓ annual reports on GHG inventory (NIR).

2. Emission factors

- ✓ individual enterprises;
- ✓ NIR 2010-2013;
- ✓ IPCC 1996/2006 methodology.

3. Digital maps

- ✓ Google Earth coordinates -> map of production facilities;
- ✓ GDP 2009 map -> population density map 2 x 2 km;
- ✓ Map of municipalities + grid 2 x2 km -> map of elementary areas.

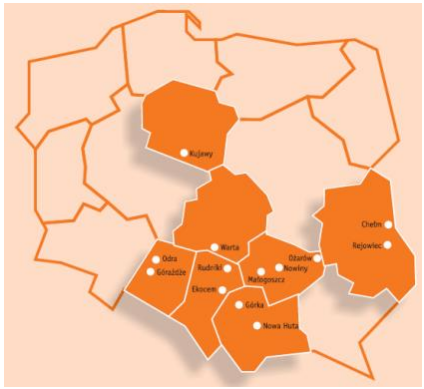
Maps of emission sources

Point-type sources:

Cement,
Ammonia,
Paper,
…

Activity data
(country)

Polish Cement Association:
Addreses

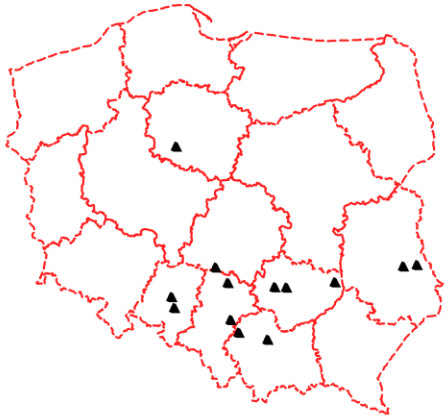


validation

Google Earth
geographic coordinates

International Cement Review:

Capacity 1
Capacity 2
…
Capacity *N*



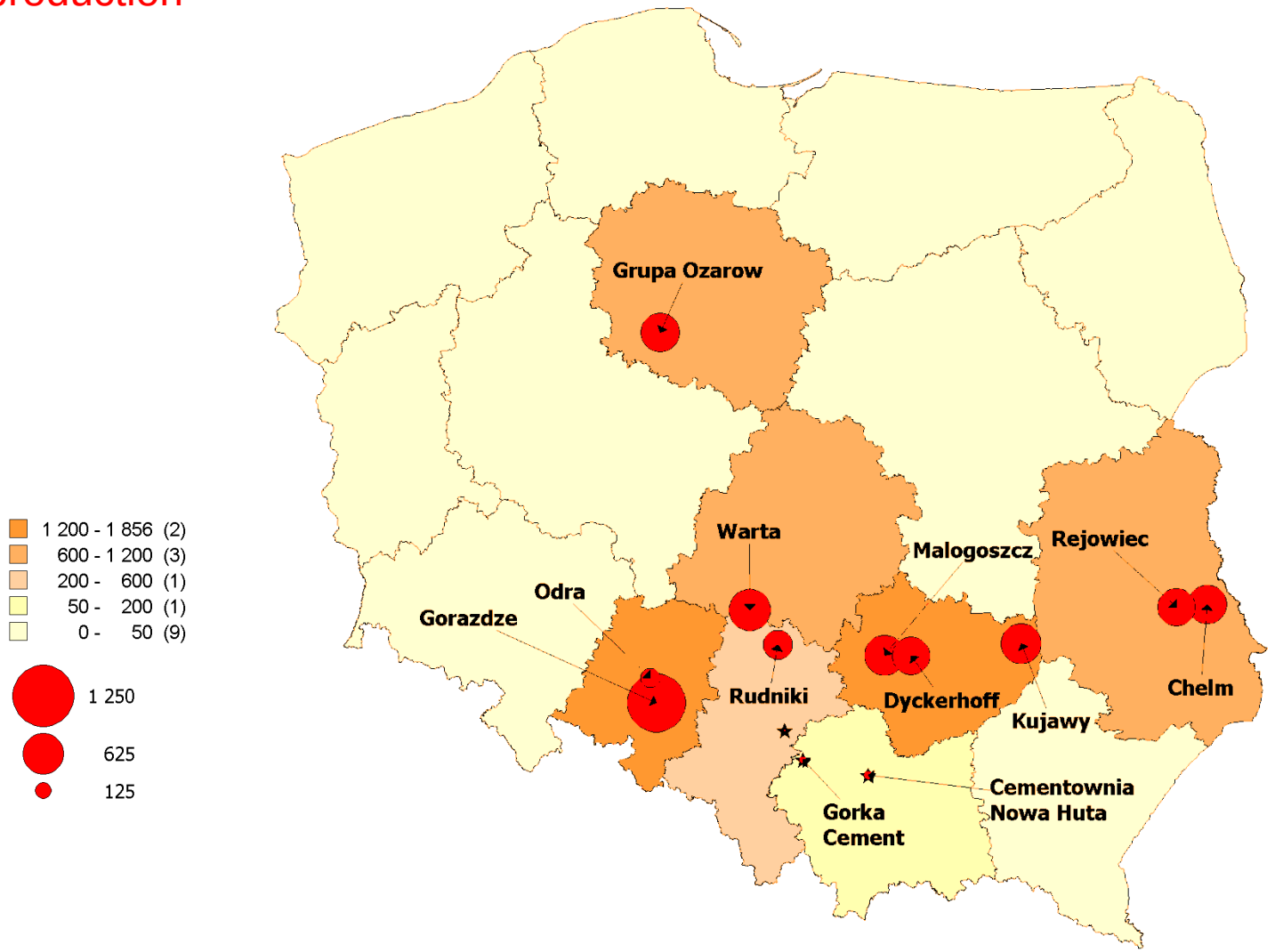
MapInfo

!

Large cement production plants

Inventory results

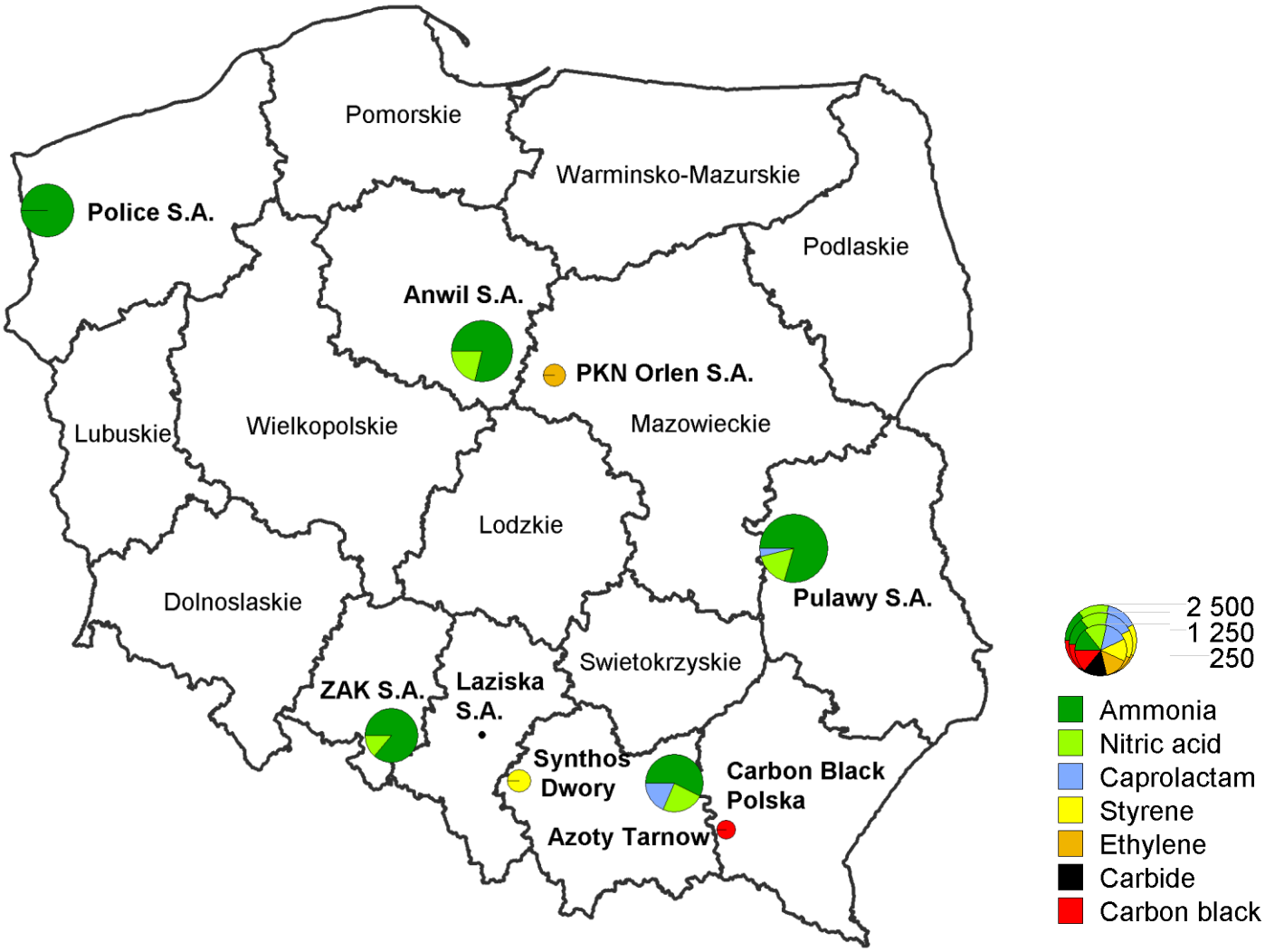
Category 2.A.1:
Cement production



CO_2 Emissions (plants, Gg, 2010)

Inventory results

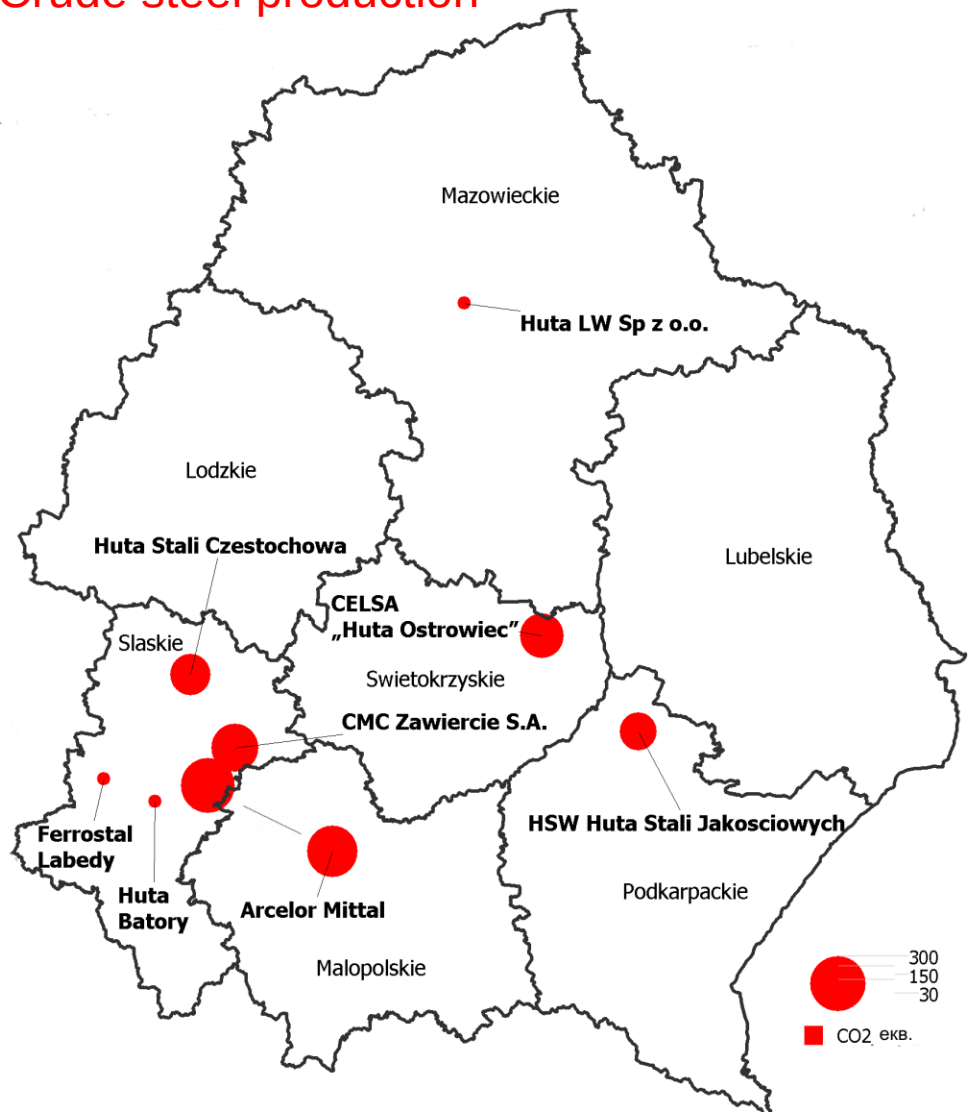
Subsector 2.B:
Chemistry



CO_2 eqv. emissions from chemicals production (plants, Gg, 2010)

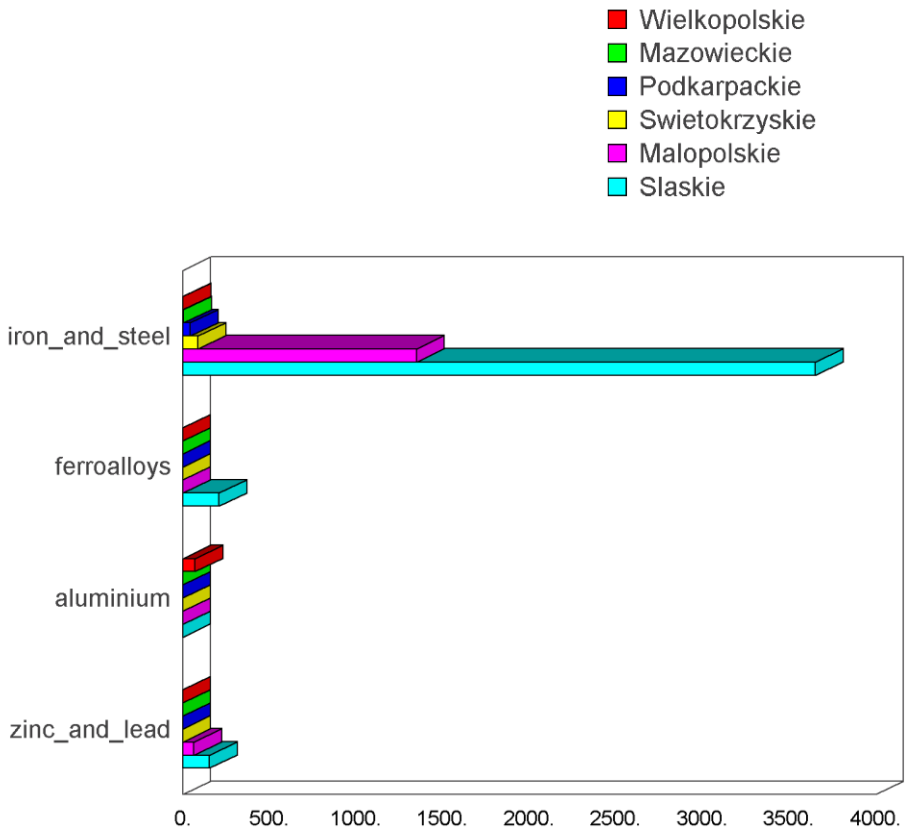
Inventory results

Category 2.C.1:
Crude steel production



CO_2 eqv. emissions (plants, Gg, 2010)

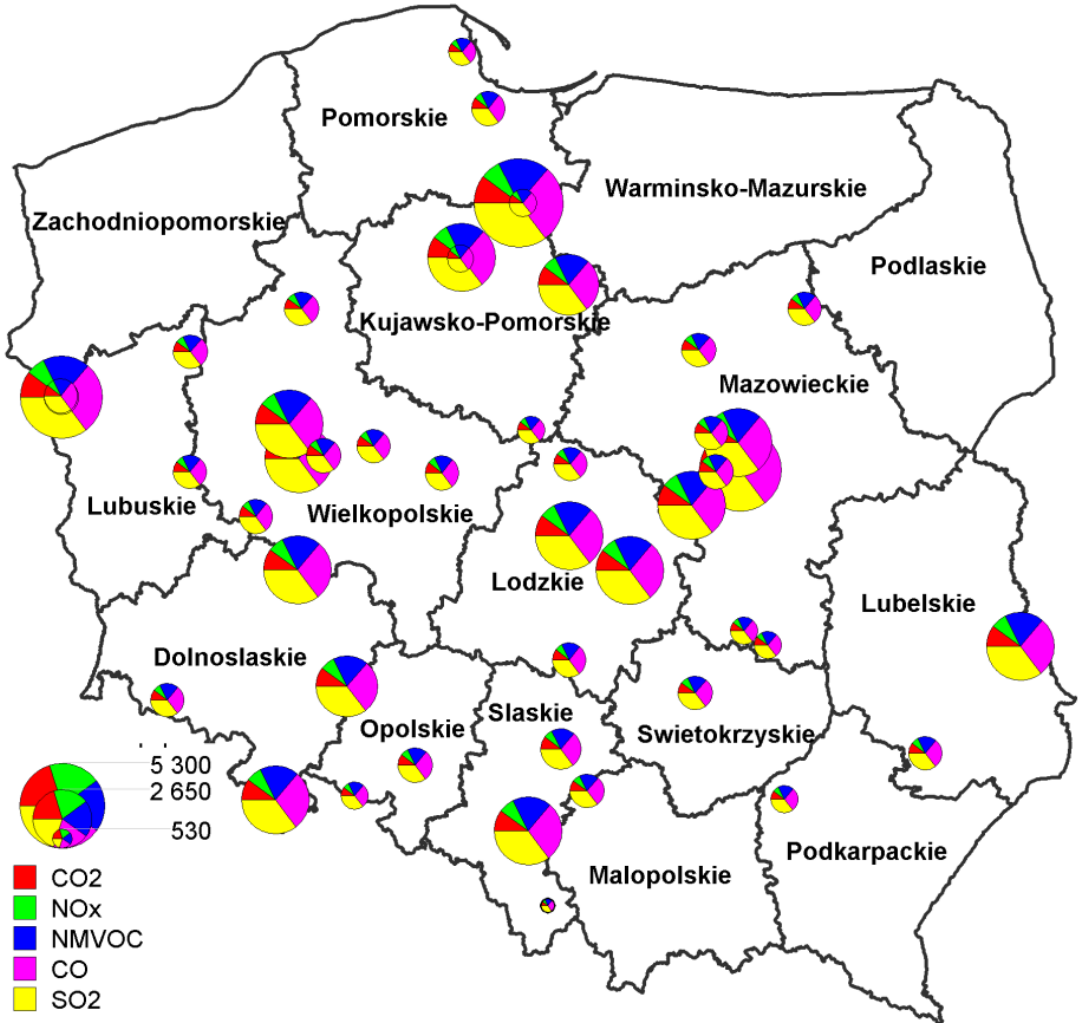
Subsector 2.C:
Metal production



CO_2 eqv. emissions (voivodeships, Gg, 2010) :

Inventory results

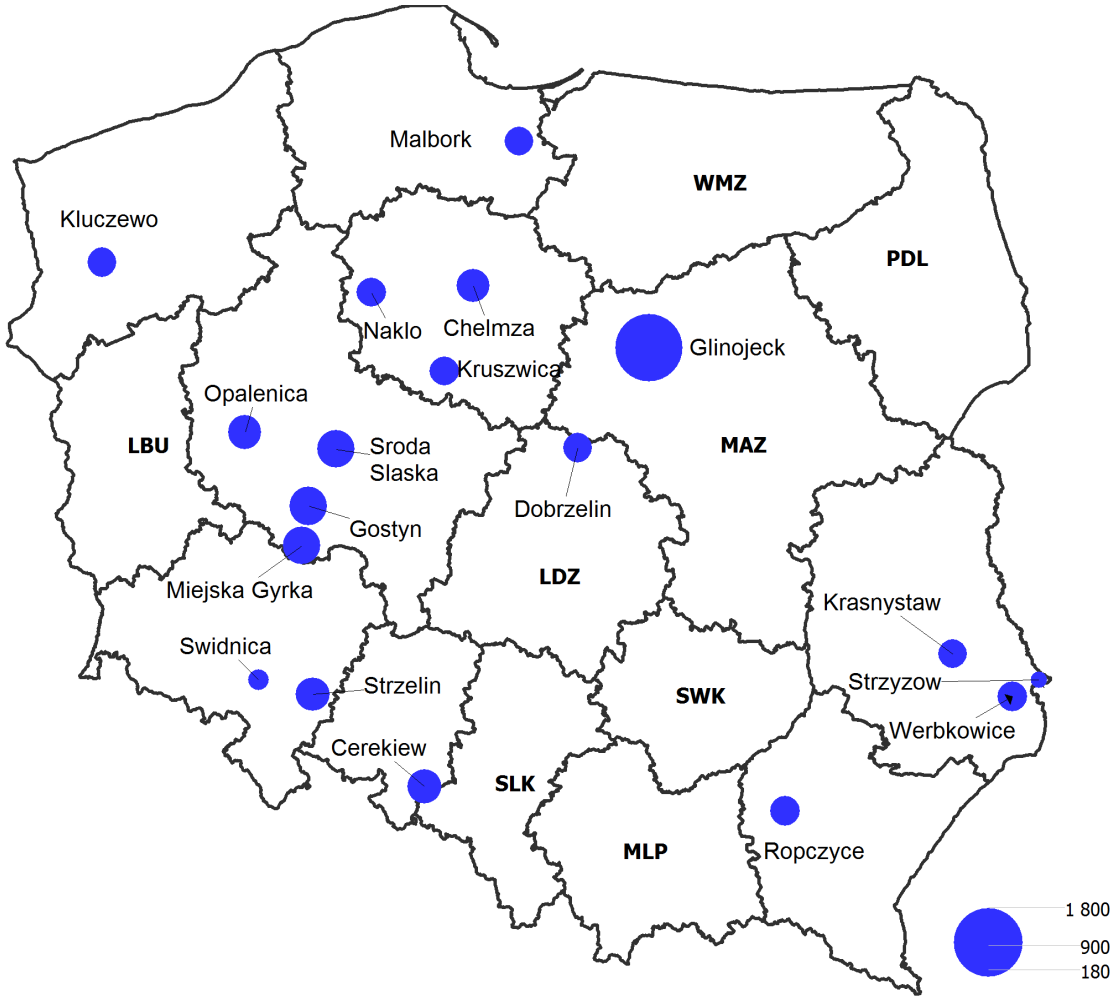
Category 2.D.1: Paper production



GHG Emissions by type of gas (plants, Mg, 2010)

Inventory results

Category 2.D.2: Food production (sugar)



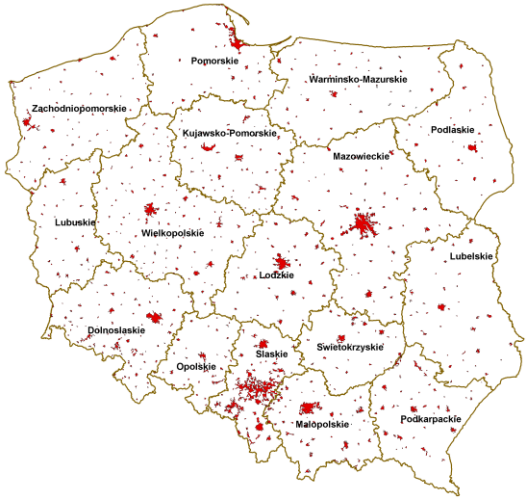
NMVOC Emissions (plants, Mg, 2010)

Maps of emission sources

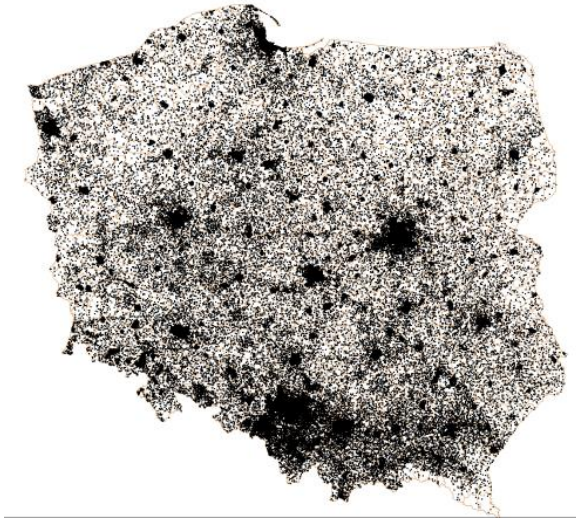
Area-type sources:

Meat,
Bread,
Fish,
…

Map of urban localities:



Population density map:



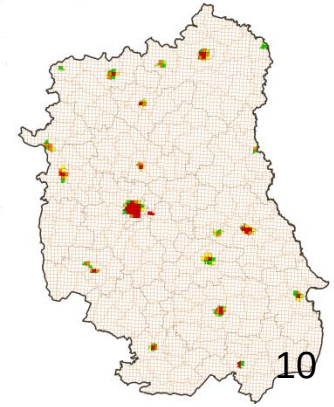
! Large meat production plants

Activity data
voivodeship – plants

city 1, population 1
city 2, population 2
…
city N, population N

MapInfo

grid



Formulas for disaggregation:
meat production, industrial sector

- ✓ the output of meat products in the city:

$$D_{\text{meat,small}}\left(S_{n_{urb,s}}^{urb,R_{1,n1}}\right)=\frac{1}{P\left(R_{1,n_1}\right)}\cdot\left[D_{\text{meat}}\left(R_{1,n_1}\right)-\sum_{n_p=1}^{N_{\text{meat}}^{R_{1,n1}}} D_{\text{meat}}\left(\xi_{\text{meat},n_p}^{R_{1,n1}}\right)\right]\cdot P\left(S_{n_{urb,s}}^{urb,R_{1,n1}}\right),$$

$P\left(R_{1,n_1}\right)$: population in the voivodeship;

$D_{\text{meat}}\left(R_{1,n_1}\right)$: outcomes in the voivodeship;

$D_{\text{meat}}\left(\xi_{\text{meat},n_p}^{R_{1,n1}}\right)$: outcomes obtained by all large plants in the voivodeship;

$P\left(S_{n_{urb,s}}^{urb,R_{1,n1}}\right)$: population in the city.

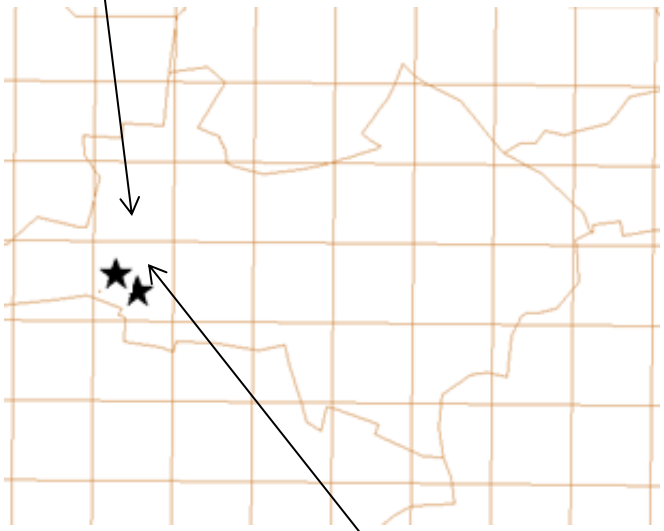
- ✓ fraction of population in the elementary area of the city:

$$c\left(\delta_n, S_{n_{urb,s}}^{urb,R_{1,n1}}\right)=\frac{d\left(\delta_n\right)\cdot area\left(S_{n_{urb,s}}^{urb,R_{1,n1}}\cap\delta_n\right)}{P\left(S_{n_{urb,s}}^{urb,R_{1,n1}}\right)},$$

Formulas for emission estimation:
meat production, industrial sector

- ✓ **none large meat production plant is within**

$$(1)\ E_{Meat}^{NMVOC}(\delta_m) = \left[D\left(S_{n_{urb,s}}^{urb} \right) - \sum_{n_p=1}^{N_{meat,p}} D\left(\xi_{Meat,n_p} \right) \right] \times K_{Meat}^{NMVOC}(\delta_m) \times c\left(\delta_m, S_{n_{urb,s}}^{urb} \right),$$

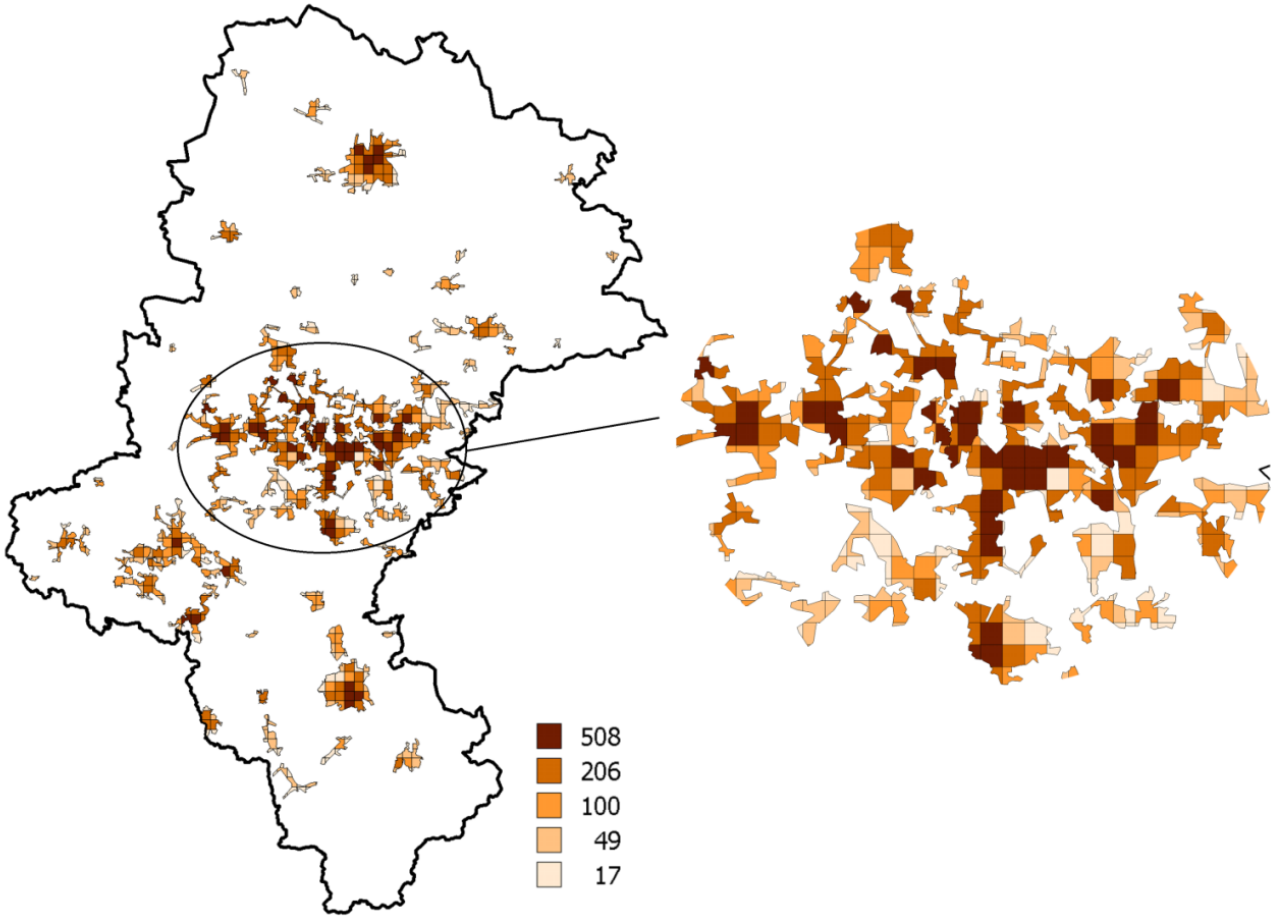


- ✓ **several large plants are within**

$$(2)\ E_{Meat}^{NMVOC}(\delta_m) = {}^{(1)}E_{Meat}^{NMVOC}(\delta_m) + \sum_{n_p=1}^{N_{meat,p}} \left[D\left(\xi_{Meat,n_p} \right) \times K_{Meat}^{NMVOC}\left(\xi_{Meat,n_p} \right) \right],$$

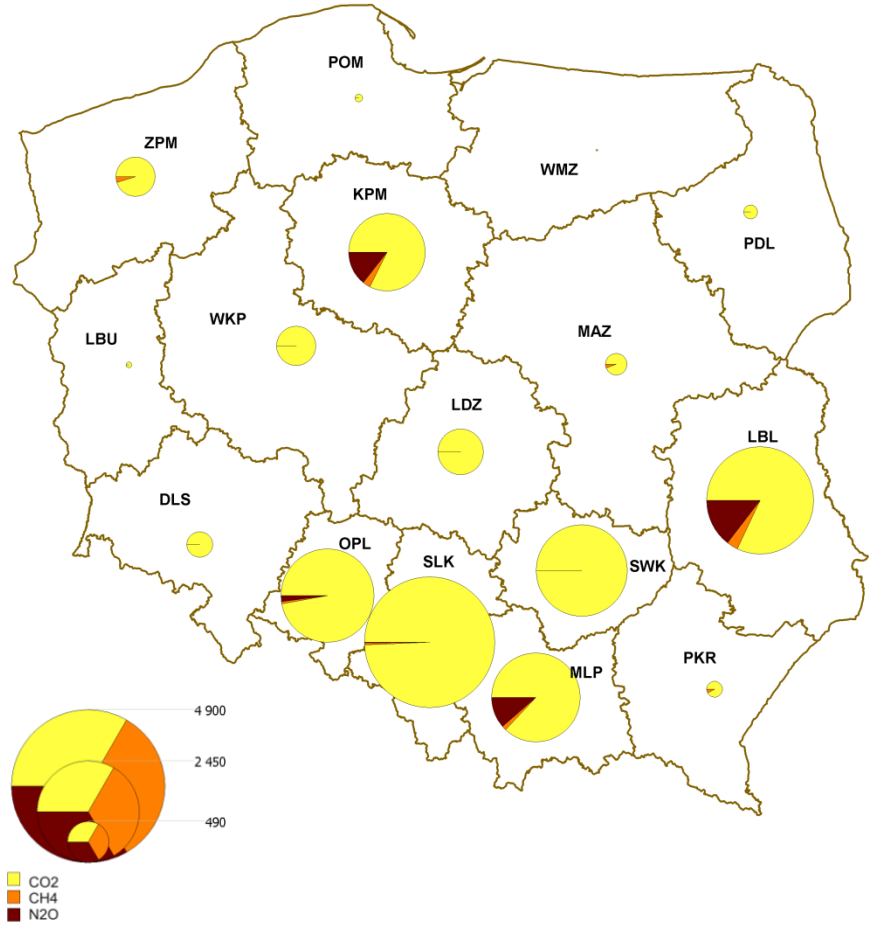
Inventory results

Category: Meat production

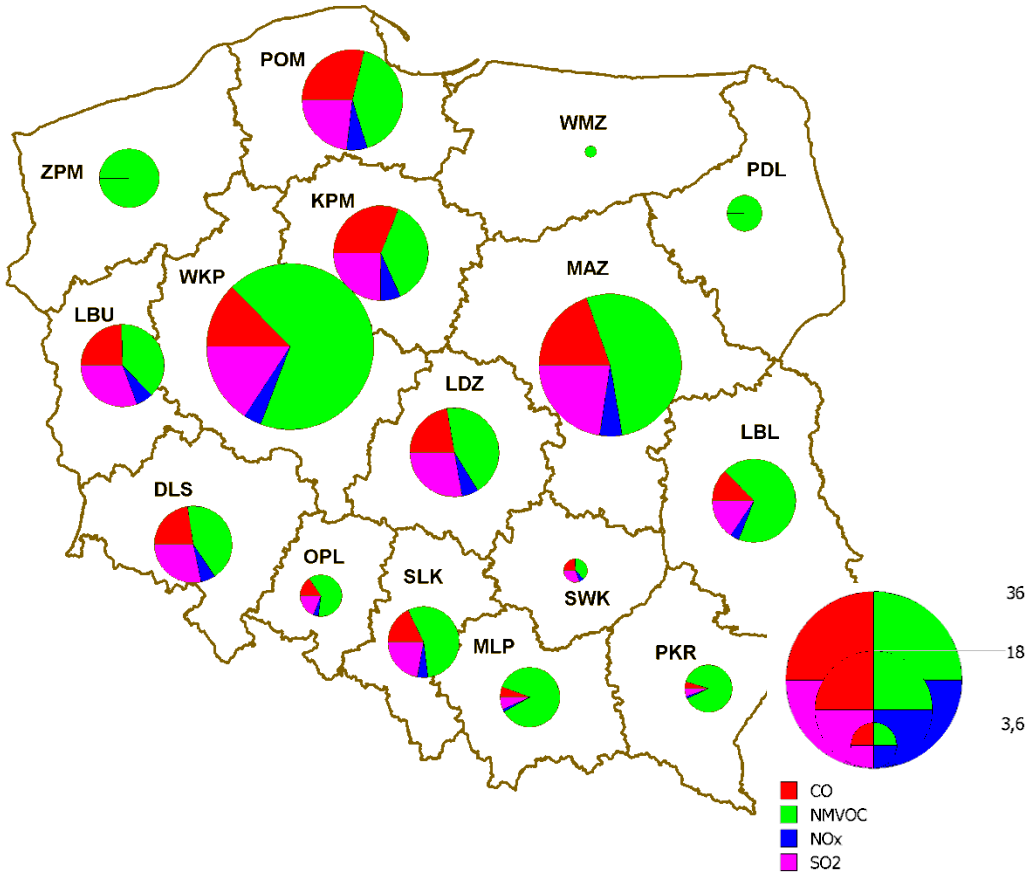


NMVOC Emissions (grid 2 x 2 km, kg/km^2, 2010)

Inventory results (all categories)



Direct emissions in CO_2 equivalent
(voivodeships, Gg, 2010)



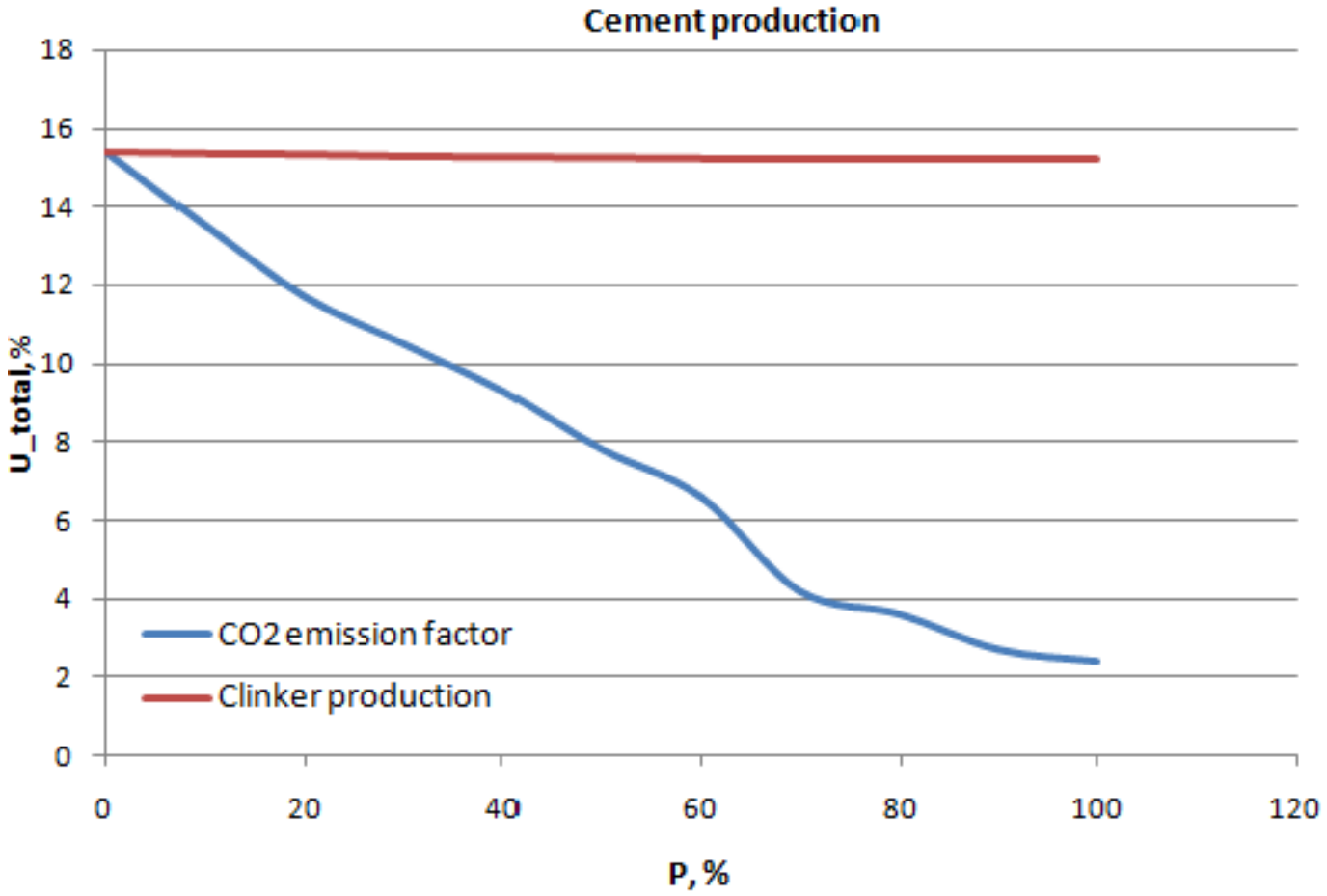
Indirect emissions by type of gas
(voivodeships, Gg, 2010)

Input data for uncertainty analysis and results

Statistical data (5%, normal) Emission coefficients (15%, normal)

№	Name of plant	Volumes of clinker produced, 10^3 tons/ year	CO_2 emission factor, t_{CO2}/t	CO_2 emission, 10^3 tons	Uncertainty range (lower), %	Uncertainty range (upper), %
1	Cementownia Górażdże	2400	0,512	1228,82	-15,569	15,979
2	Cementownia Małogoszcz	1215	0,52	631,78	-15,655	15,981
3	Cementownia Kujawy	1215	0,52	631,82	-15,646	15,985
4	Grupa Ozarów	1144,4	0,529	605,38	-15,663	15,993
5	Cementownia Rejowiec	1065,6	0,529	563,72	-15,655	15,986
6	Cementownia Chełm	1137,5	0,529	601,73	-15,650	15,981
7	Cementownia Rudniki	682,5	0,529	361,02	-15,643	15,982
8	Dyckerhoff Polska	1050	0,529	555,43	-15,643	15,975
9	Cementownia Warta	1320	0,529	698,25	-15,659	15,989
10	Cementownia Odra	350	0,529	185,15	-15,653	15,982
11	Górka Cement	50	0,529	26,43	-15,654	15,986
12	Cementownia Nowa Huta	80	0,529	42,36	-15,652	15,978

Sensitivity analysis



Dependence of uncertainty of GHG inventory in cement production from decreasing uncertainty of input data into ***P*** percents

Thank You for Attention!

Verification of results

	Gg, 2010														
	NIR							Spatial inventory							
	CO2	CH4	N2O	HFCs, CO2 eqv	PFCs, CO2 eqv	SF6	CO2 eqv	CO2	CH4	N2O	HFCs, CO2 eqv	PFCs, CO2 eqv	SF6	CO2 eqv	%
Industrial Processes	**19648,8**	**12,88**	**3,79**	**7442,3**	**56,13**	**0,00154**	**28629,4**	**19305,9**	**12,88**	**3,78**	**7442,2**	**56,08**	**0,0014**	**28284,9**	**1,2**
A. Mineral Products	10152,9						10152,9	9878,4						9878,4	2,7
B. Chemistry	3622,9	11,44	3,74				5023,7	3881,9	11,44	3,73				5279,4	5,1
C. Metal production	5536,8	1,44	0,05		42,64	0,00018	5628,2	5537,1	1,44	0,046		42,04		5628,8	0,1
D. Other Production	8,6						8,6	8,6						8,6	0,0
F. Consumption of Halocarbons and SF6				7442,3	13,49	0,00136	7488,5				7442,2	14,04	0,0014	7489,9	0,1

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