Progress in integrated assessment modelling in Belarus

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IVL Swedish Environmental Research Institute

IAM framework in Belarus:

- National Academy of Sciences/Ministry of Natural Resources projects
- Swedish-Belarus project (coordinated by IVL)

Goals:

- IAM basis in Belarus strengthening for air legislation improvement and new air abatement programs elaboration;
- scientific provision of negotiations on LRTAP Protocols;
- support to LRTAP technical bodies in view of IAM application in EECCA etc.

Current status:

- Emphasis onto NOx.

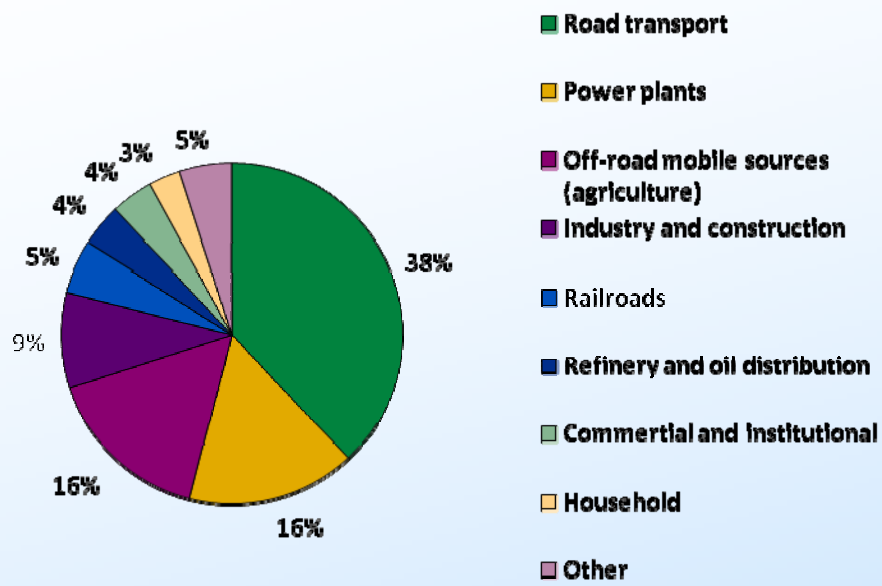
Current tasks:

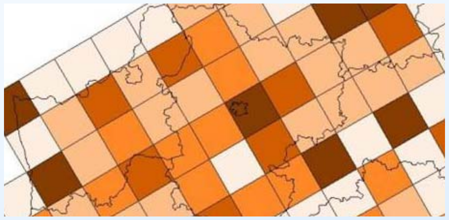
- analysis of emission abatement technologies for NOx, applicable in EECCA countries, with special emphasis on Belarus;
-comparative analysis of GAINS database on emission abatement technologies for NOx parameters, NOx EFs and abatement costs parameters in application to EECCA countries;
- analysis of CIAM NOx emission scenarios in relation to Belarus;
-preparation of the NOx emission reduction control strategy for Belarus;
- NOx emission reduction potential analysis;
- Impact assessment.

Included into presentation:

1. Introduction: NOx emission sources and levels, NOx content in flue gases as basis for EF estimation and control efficiency
2. Technologies of NOx control technologies applicable in EECCA
3. NOx emission factors and control parameters vs. GAINS
4. Sensitivity of GAINS NOx emission analysis
5. NOx emission scenarios for Belarus up to 2030
6. NOx emission reduction potential in Belarus and Gothenburg Protocol ceilings attainability
7. Conclusions and further steps

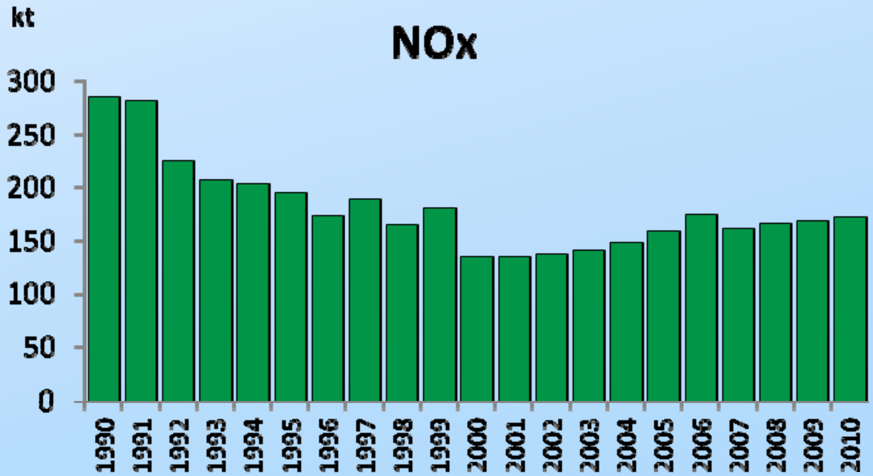
1. NOx emission sources in Belarus





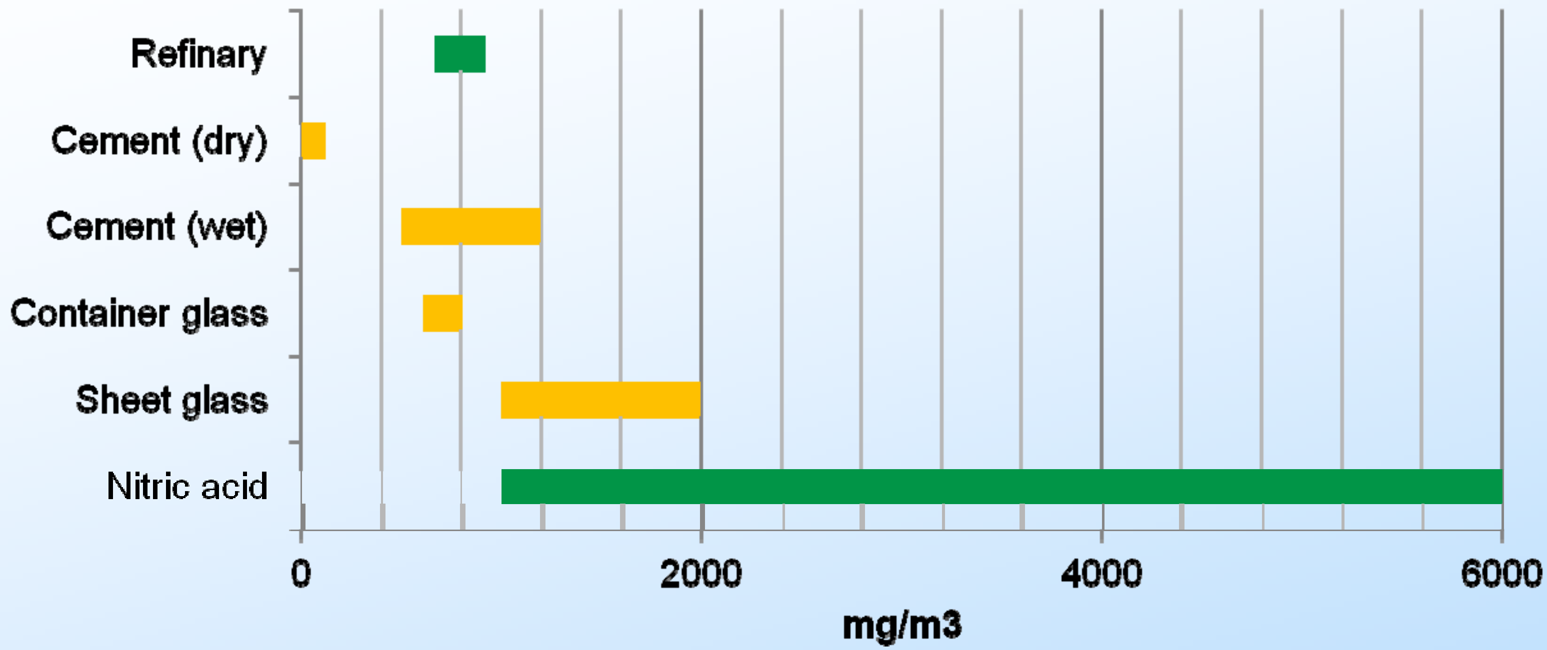
Spatial distribution of NOx emission

The total NOx emission in 2010 – 171.3 thous. t. Main sources: road transport (38 % total emission), stationary fuel combustion in different sectors (Agriculture/forest/ fishing -16%, Energy – 16%.



Trends of NOx emission in Belarus

NOx content in flue gases from technological processes



Main sources of NOx emission among technological processes:
•catalytic reforming and cracking (refinery);
•glass furnaces (up to 2000 mg/m^3 and more);
•clinker rotary kilns (wet process - 700-800 mg/m^3; dry process - 80-100 mg/m^3);
•production of nitrogen fertilizers (absorption towers for nitric acid production – up to 5000-6000 mg/m^3, primary reformer furnaces, tubular reformers, cyclone furnaces and reactors).

2. NOx control technologies

The most common technologies used for NOx emission reduction in EECCA and other countries

Belarus

- Two-stages combustion
- Flue gas recirculation
- Combination of flue gas recirculation and two-stages combustion

Russian Federation

- Flue gas recirculation
- Few-stages combustion
- Low emission burners

EC and USA

- Low emission burners
- Selective catalytic reduction
- Selective non-catalytic reduction
- Flue gas recirculation
- Staged combustion and air flow supply

3. NOx emission factors and control parameters in Belarus vs. GAINS

Abated NOx emission factors for power plants in GAINS, kt NOx/PJ

Sector/Technology	Fuel			
	BC2	GAS	HF	OS1
PP_EX_OTH		**0.203**	**0.27**	**0.195**
NOC		0.15	0.2	0.13
PHCCM				0.065
POGCM		0.053	0.07	
PP_EX_S	**0.365**			
NOC	0.27			
PBCCM	0.095			
PP_NEW		**0.05**	**0.1**	**0.065**
NOC		0.05	0.1	0.065

Aggregated NOx emission factors for power plants in Belarus vs. GAINS

	Emission factor, kt_NOx/PJ	
	GAINS	in Belarus (fact)
Interval	0.05-0.27	0.01-0.10
Most typical for Belarus: (PP_EX_OTH_GAS)	0.053 (combustion modification), 0.15 (without control)	0.05

GAINS control options for NOx and their parameters

Secondary (SCR, SNCR) control options not applied in energy sector and industry in Belarus.

Data on application of certain type of combustion modification and few-stages combustion is limited so it can be identified by emission factor value.

Fuel combustion

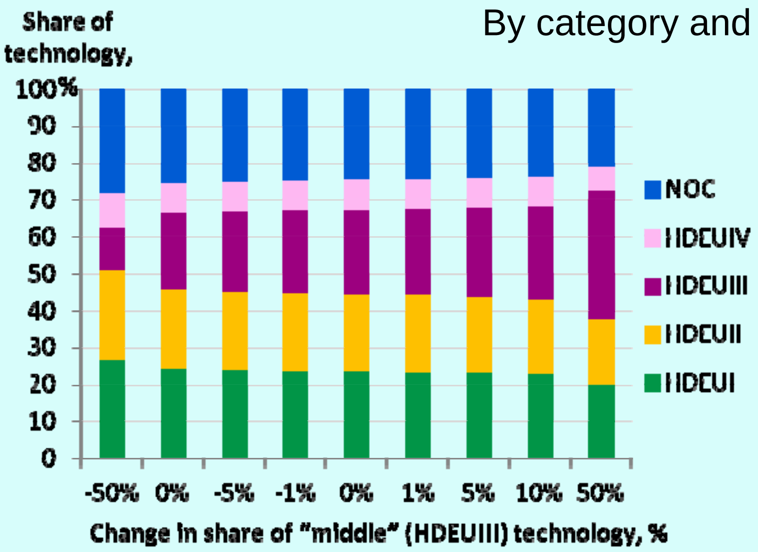
	Emission factor, kt NOx/GJ		
Sector	GAINS		Belarus
	NOC	CM (50-65% reduction)	
Combustion in industry	0.13	0.65	0.073-1.475

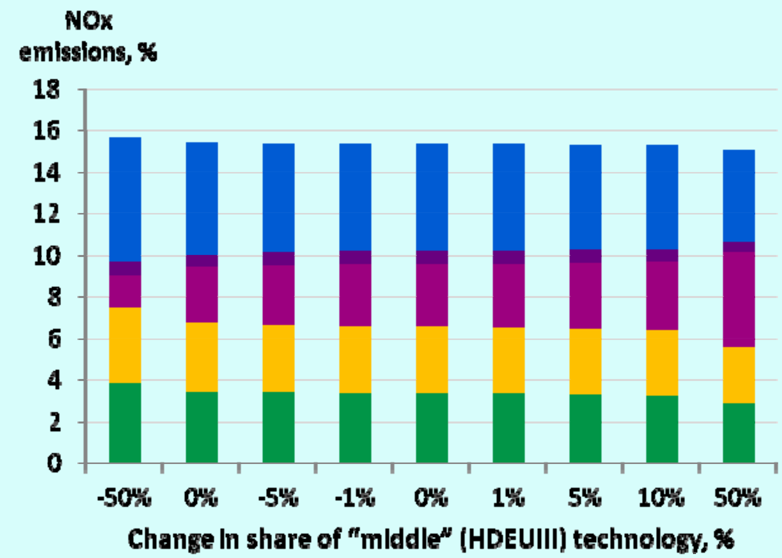
Technological processes

	Emission factor, kt NOx/unit				
Sector	**GAINS**				Belarus
	NOC	Stage 1 (40% reduction)	Stage 2 (60% reduction)	Stage 3 (80% reduction)	
Refinery	0.30	0.18	0.12	0.06	0.302
Cement	1.75	1.05	0.7	0.35	1.63
Glass	8.12	4.87	2.92	1.62	9.79

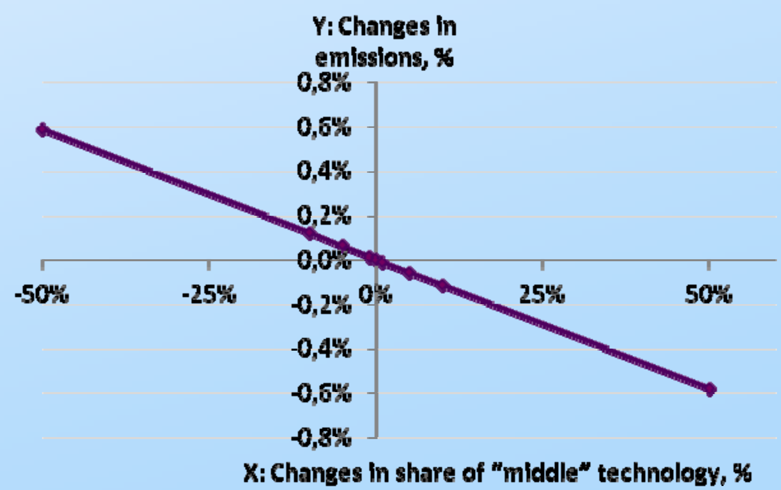
4. Sensitivity of GAINS NOx emission analysis

By category and activity (fuel)





Summary for sector



5. NOx emission scenarios for Belarus up to 2030

Scenarios scheme

Economic scenario	Energy structure	Control strategy		
		Base	Current legislation	Optimistic
Pessimistic	Base	Scenario 1		
Nominal	Base		Scenario 2	
Optimistic	Base		Scenario 5	Scenario 6
Planned	Base		Scenario 3	Scenario 4
	Local and Renewable energy sources		Scenario 7	Scenario 9
	Local and Renewable energy sources+ Atomic energy		Scenario 8	

Main attention – to base economic scenario.

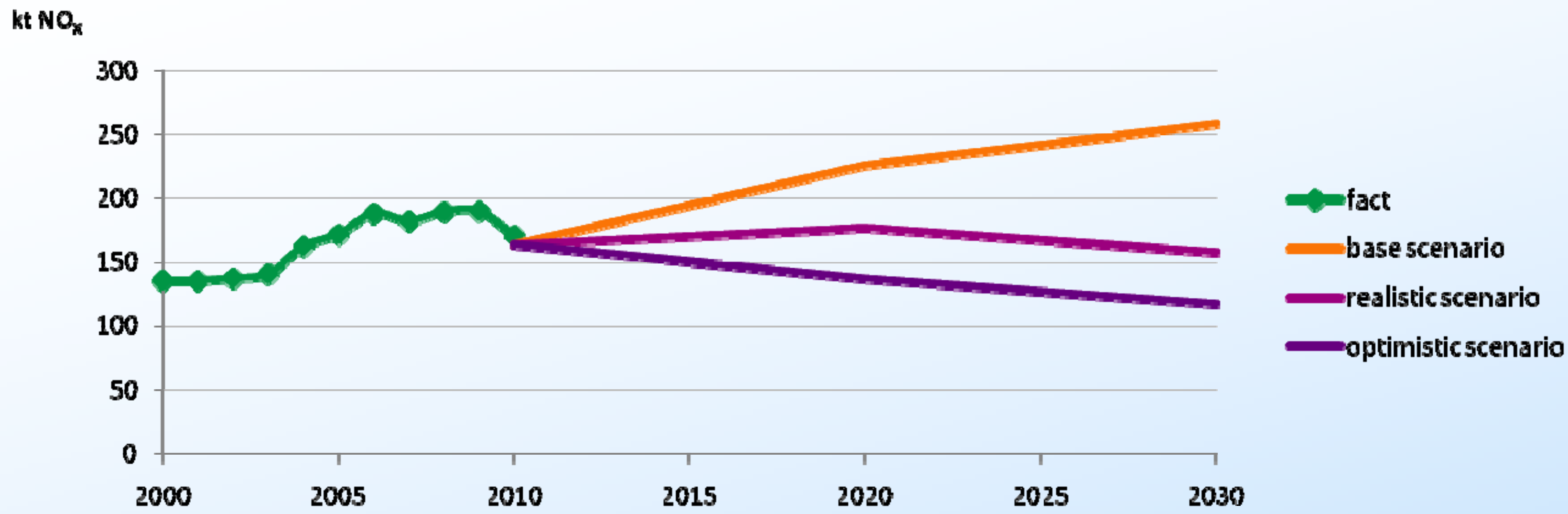
Control strategies for Nox vs. CIAM control strategies (for 2020)

Sector	Technology	INM Scenarios			CIAM Scenarios		
		Base	Realistic	Optimistic	Low*	Mid	High*
PR_CEM, PR_LIME, PR_OT_NFME	NSC_NOX	80	70	60	0	0	0
	PRNOX1	20	15	15	0	0	0
	PRNOX2	0	10	15	100	100	0
	PRNOX3	0	5	10	0	0	100
PR_SINT, PR_NIAC, PR_SUAC	NSC_NOX	0	0	0	0	0	0
	PRNOX1	80	70	60	0	0	0
	PRNOX2	0	0	0	0	0	0
	PRNOX3	20	30	40	100	100	100
PR_PIGI, PR_PULP, PR_REF	NSC_NOX	100	90	85	0	0	0
	PRNOX1	0	0	0	0	100	100
	PRNOX2	0	10	5	0	0	0
	PRNOX3	0	0	10	100	0	0
PR_GLASS	NSC_NOX	70	60	55	0	0	0
	PRNOX1	20	20	20	0	0	0
	PRNOX2	10	15	15	100	0	0
	PRNOX3	0	5	10	0	100	100

national control strategies in comparison with CIAM control strategies :

- more detailed;
- more varied;
- smoother;
- less optimistic.

NOx emission projection

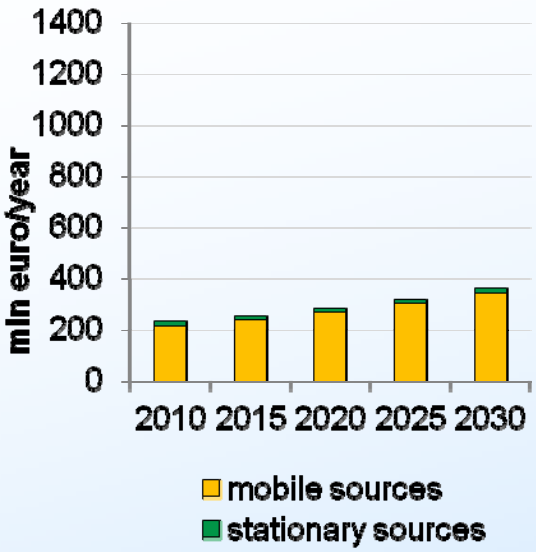


Three scenarios of NOx emission in Belarus were developed: base, 'realistic' and optimistic.

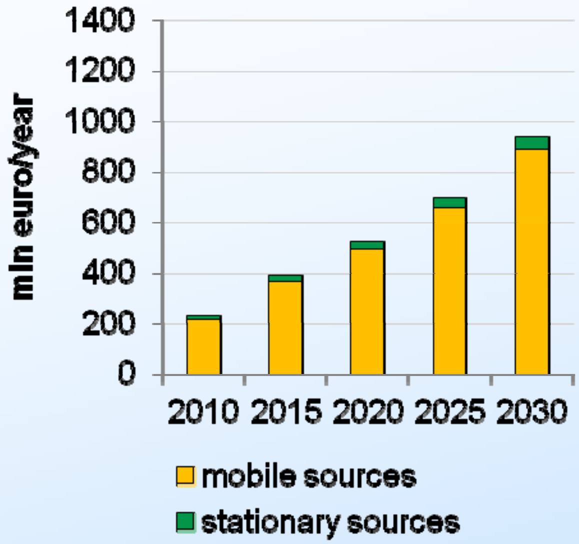
Base scenario: economic development according to national programs incl. atomic energy, no NOx additional emission reduction measures
Realistic scenario: economic development and NOx reduction technologies improvement according to national programs.
Optimistic scenario: economic development and best technology for NOx emission reduction

NOx emission in 2020 can be from 136 thous. t (optimistic scenario) to 225 thous.t (base scenario), in 2030 – from 117 to 258 thous.t.

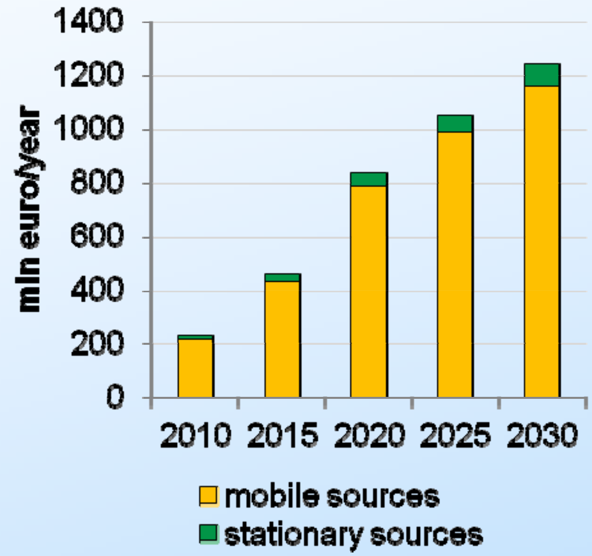
Cost of NOx emission reduction for different scenarios



base



realistic



optimistic

The cost of NOx emission reduction for base scenario will make up 278.5 mln. Euro in 2020 and 356 mln. Euro in 2030 (23 и 57% higher in compared to 2010).
The cost of NOx emission reduction for realistic scenario make up 519 mln. Euro in 2020 and 691 mln. Euro in 2030. The cost per tonne of NOx reduction – from 4.88 thous. euro in 2020 and in 5.75 thous. Euro in 2030 (current NO2 emission fee - 410 Euro/t).
The cost of NOx emission reduction for optimistic scenario is estimated in 830 mln euro in 2020 and 1238 mln euro in 2030. The cost per tonne of NOx reduction will be: 6.22 thous. Euro in 2020 and 6.25 thous. Euro in 2030.

6. NOx emission reduction potential and Gothenburg Protocol ceilings attainability

Goal: assessment of attainability of Gothenburg emission ceilings (25% reduction for NOx by 2020 compared to 2005 for Belarus)

NOx emission in Belarus in 2005 was 156.6 thous.t (from stationary sources - 58.5 thous.t; so the target value - 125.3 thous. t (43.8 thous. t. for stationary sources).

Methodology and data

Methodology:

- activity and NOx emission data collection by sectors;
- NOx emission factors assessment by sectors and their trends;
- costs parametrisation;
- projection of NOx emission for different economic scenario and combinations of control measures;
- optimisation, revealing of cost-effective sources for NOx emission reduction.

Data:

- statistical data on fuel used and NOx emission by detailed sectors;
- data on NOx control technology by sectors;
- national and branch program, plans for economic development.

Procedure

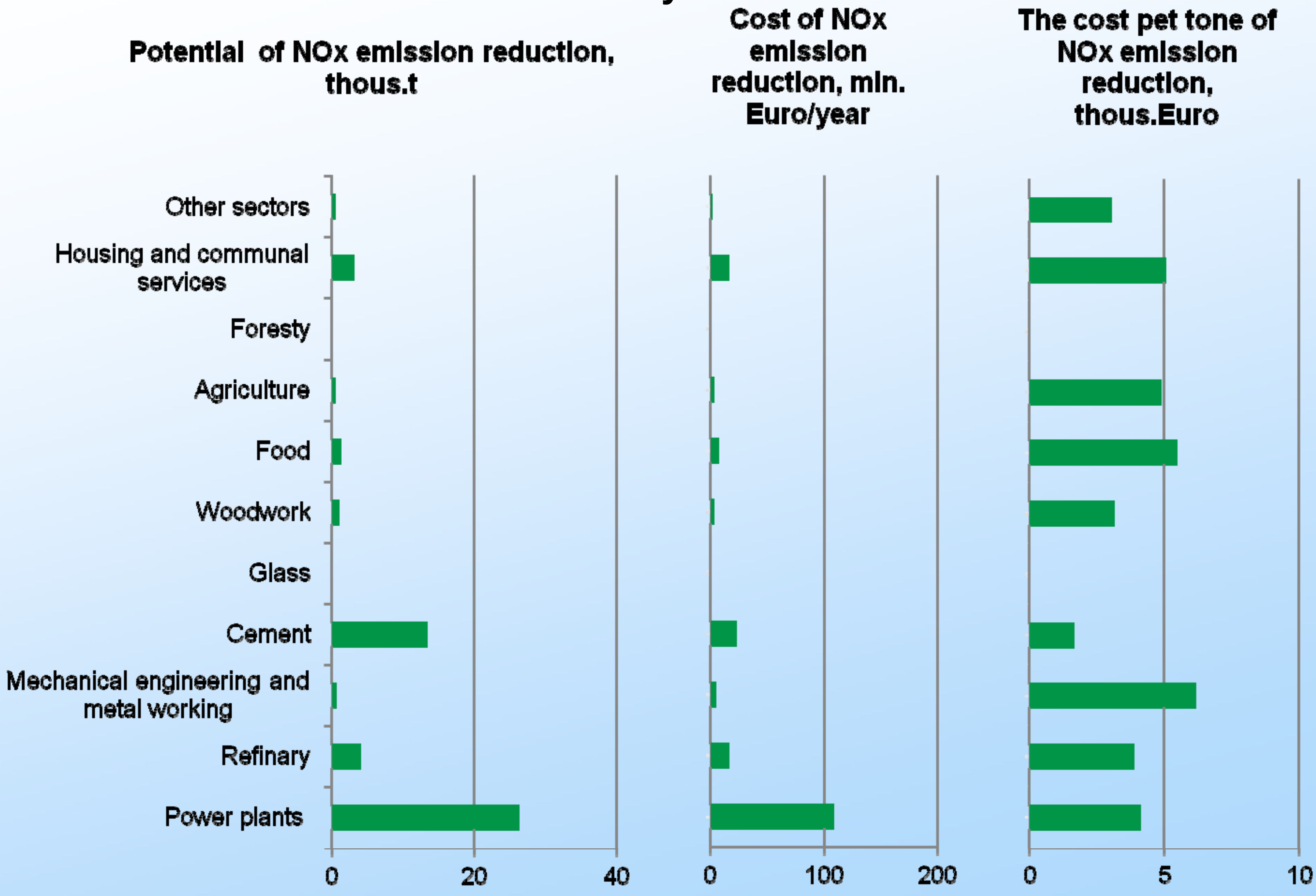
On the first step the potential of NOx emission reduction was assessed for every sectors taking into account the different economic scenario for the country and sectors. Possibility of NOx reduction with the most effective technology and actual emission factors were assessed. The cost for NOx reduction up to minimal level was estimated.

Additionally for the energy sector analysis of emission factors and their dependence from fuel was done; attainability of the best emission values for the large enterprises was calculated.

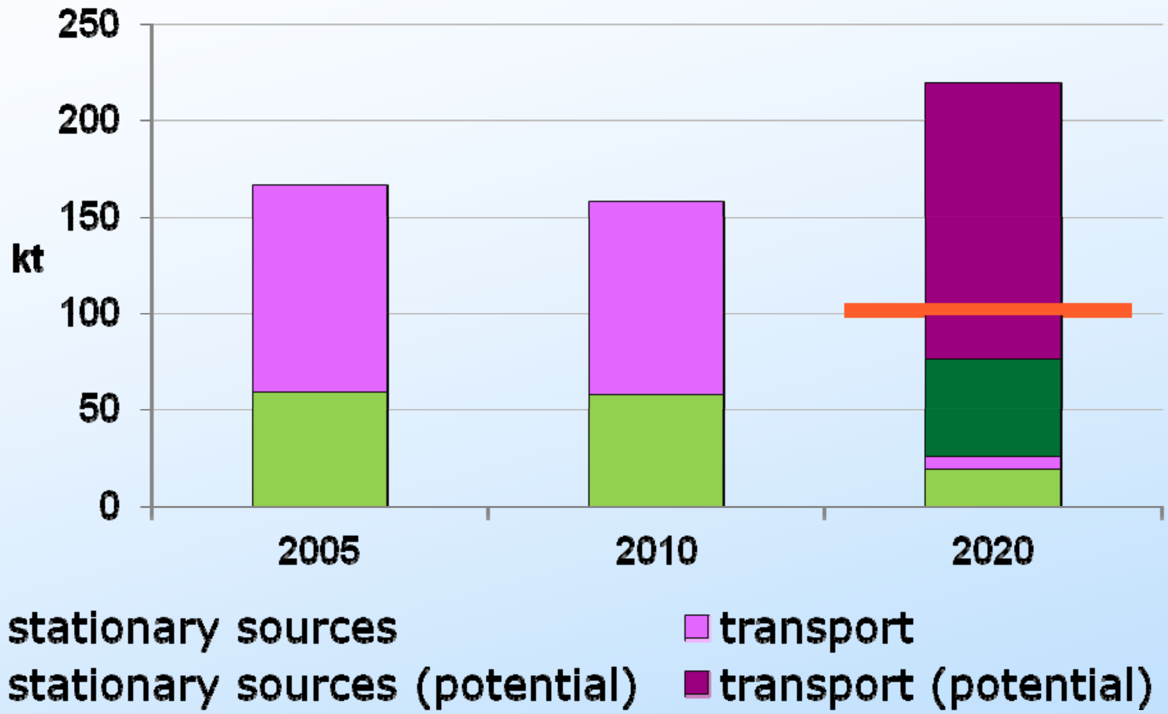
At the second step the target value for the key sectors were assessed taking into account the actual emissions. Possibility of target value achievement, the most applicable technology and cost of NOx reduction were analyzed.

At the third step NOx emission reduction potential and costs for different sectors was compared.

Potential of NOx emission reduction in main sectors and costs
Stationary sources



Total NOx emission by 2020 and reduction potential



The total cost of emission reduction to target value will make up 620,9 mln. euro/year, including 52.7 mln. Euro for stationary sources (without domestic sector) and 568.2 mln.Euro – for mobile sources.

The cost of NOx reduction per tonne vary from 0.56 to 20.4 thous. Euro.

Key sectors for NOx emission reduction and costs

Cost per tonne NO_x abated	NOx reduction potential: Low	NOx reduction potential: High
Low	• fuel combustion in cement industry; • fuel combustion in glass and porcelain industry	• processes in cement industry
High	• machine-building and metal working; • woodworking, pulp and paper industry • food industry; • agriculture;	• power plants; • oil refinery; • housing and communal services; • household sector; • transport

7. Conclusions and further steps

- Practical application of IAM results (emission reduction strategies etc);
- More attention to IAM model parameterisation: projected values and costs as well as abatement potential assessments are highly impacted by model parameters;
- GAINS application in line with other IAM models for verification etc.;
- More attention to abatement costs for transport: now looks frighteningly;
- Urban environment impact analysis;
- Multipollutant IAM incl. VOCs and GHG.

Thank you for your attention!