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MODEL STRATEGY FOR REDUCTION OF AMMONIA EMISSIONS EXAMPLE OF THE REPUBLIC OF BELARUS

S.V.Kakareka, A.V.Marchikhina, A.S.Pilipchuk

An important condition of enhancing effectiveness of the Convention on Long-range Transboundary Air Pollution is expanding the number of countries which ratified its protocols, particularly the latest ones – Protocol on Heavy Metals, Protocol on POPs and the Gothenburg Protocol. Considerable potential the expansion lies within the Eastern and South-eastern Europe, Caucasus and Central Asia. The Working Group on Strategies and Review carries out large-scale activities on determining benefits of the accession to the protocols and provides this information to the countries with the aim of raising interest to accession among the EECCA countries. One of activity areas is the development of a list of the most effective air pollution abatement measures. An example of such activity is evaluating potential reduction of sulfur, nitrogen oxides and suspended particles emissions by implementing certain emissions strategies carried out by the International Institute for Applied System Analysis (CIAM Report 1/2008) which permitted to evaluate to a first approximation the potential for emissions reduction by applying six groups of measures. The report of the Chairman of the 39th Task Force for Integrated Assessment Modeling (TFIAM) meeting points out the necessity of explicit references to the key emissions reduction measures in the Annexes to the Gothenburg Protocol.

The proposed Model Strategy is an attempt to analyze emissions reduction strategies (scenarios) for ammonia on example of the Republic of Belarus. The survey includes a brief overview of the main ammonia emissions sources in Belarus, information on common agricultural practices, description of the main emissions reduction scenarios, methodology for evaluating costs of ammonia reduction applying the GAINS model and the outcomes.

The current Model Strategy is a result of detailed analysis of the CIAM 1/2010 report which contained four alternative options of establishing environmental aims for consideration on the 47th session of the Working Group on Strategies and Review in August 2010th and of the amended report "Cost-effective Emission Reductions to Improve Air Quality in Europe in 2020 Scenarios for the Negotiations on the Revision of the Gothenburg Protocol under the Convention on Long-range Transboundary Air Pollution. Version 2.0, 28.03. 2011". In addition to the above mentioned documents four supplementary ammonia reduction scenarios were developed within the Model Strategy basing on the analysis of the main ammonia emission sources in Belarus.

In order to make the Model Strategy applicable for other countries one should fill Table 2 of the document (total ammonia emissions in a country by NFR categories) taking account of the data from chapter 1.2 and Table 1 (ammonia emission rates per unit in livestock breeding) and then based on the developed emission scenarios (not applied) evaluate ammonia reduction capacity of the country taking account of minimum unit rates indicated in the chapter "Key findings".

1. Levels and sources of ammonia emissions in Belarus

1.1 Inventory methodology for ammonia emissions

Ammonia belongs to substances incompletely accounted for by national statistics in Belarus. The reason is that the main ammonia emission contribution comes from agricultural processes and only a part of agricultural entities report on the emissions. Thereby the EMEP methodology and, in particular, the EMEP/EEA Air pollutant emission inventory guidebook (2009) is applied for ammonia emissions inventory preparation and compilation of national emission reports.

The calculation method applying unit emissions rates evaluates the following ammonia emission sources: fuel combustion in power generation and processing industry, non-industrial combustion plants, combustion in processing industry, road transport and other mobile sources, waste treatment and disposal, agriculture. Special attention is paid to selection and justification of unit ammonia emission values in animal breeding and crop production. Emissions from manufacturing industry and a number of other source categories are evaluated applying statistics data.

1.2 Ammonia emission factors

Technologies of animal breeding and crop production in Belarus

Analysis of animal breeding and crop production technologies was carried out using reference information, analytical reviews, regulatory documents, issued scientific information to select and justify ammonia emissions factors

(Справочно-нормативные ..., 1995; Механизация ..., 1997; Рекомендации по модернизации ..., 2005; Самосюк, 2005; Основные показатели ..., 2006; Республиканские нормы ..., 2007; Справочник..., 2007; Технологические комплексы ..., 2010 and other). It was also taken into account that approximately 90% of cattle, 70% of pigs and 80% of poultry population belong to agricultural enterprises.

Cattle breeding

Cattle-breeding enterprises of Belarus apply the following systems of livestock keeping: stall-fed, mixed grazing and stall-fed, and grazing. Stall-feeding is mostly applied for calves under 1 year. Stall-fed animals can be kept tied, free or in boxes. In Belarus farms the common system for cattle housing includes mostly (90-94% of livestock population) tied stall -housing.

There are three manure storage systems: liquid (at large-scale cattle-breeding entities), solid (on farms) and at pastures.

Mostly no-bedding housing is applied for dairy cattle, the manure in this case is removed mechanically – by longitudinal, transverse and inclined conveyors. Enterprises of beef stock farming (with livestock population above 3000 heads) apply year round free-stall slotted floor housing; at farms group stall free housing on replaceable bedding with mechanical manure removal as well as tied housing. For manure removal cattle feeding enterprises use gutter collection, recirculation and self-flowing systems.

In all hydro removal systems manure goes through slatted floor to canals and being removed out of the barn. In general solid manure storage is typical for cattle breeding in Belarus.

Swine breeding

Two systems are used for swine breeding: indoor and outdoor. The main herd is kept indoors: outdoor housing is supposed for boars, gestating sows and replacement pigs. No-bedding housing and manure hydro removal systems are applied. Bedding (straw, sawdust, peat) in swine stalls is used mostly in small and medium farms. In such farms manure is removed by manual and aerial trucks, conveyors, bulldozers. Large industrial farms and agricultural enterprises apply no-bedding housing; the manure mass enters manure canals and then is diluted with water and removed by different types of pumps.

Swine breeding enterprises apply two manure storage systems. The first one consists of separating solid and liquid fractions with subsequent outdoor storage in piles for solid manure and accumulation in reservoirs for liquid fraction. The second manure handling system includes manure storage in manure depository with natural sludge. Swine breeding enterprises store 45% of liquid manure and 55% of solid manure.

Poultry handling

There are four types of poultry production enterprises in Belarus divided according to their activities: egg production, broiler production, poultry breeding stations and poultry incubation enterprises. At egg production enterprises poultry is kept in single-level or multi-level battery cages. Two handling systems are applied for broilers: cage and open-floor housing. Open-floor housing in production houses means daily manure removal or removal after poultry slaughtering. Poultry dung is removed by scraper conveyors, bulldozers; also hydraulic conveyor and pneumatic systems are used.

Fertilizer deposition

In Belarus bedding (about 60%) and no-bedding (40%) manure is applied as fertilizer. No-bedding manure is divided into liquid (3-8% of dry matter), semi-liquid (8% and more dry matter) and manure wastewater (less than 3% dry matter). Liquid fraction is usually applied as fertilizer by sprinkling or using cistern-spreaders.

Bedding manure is applied mostly for autumn ploughing by agricultural processing machines and manure sprinkler systems. Liquid organic fertilizers are applied in autumn or spring for ploughing or cultivation as well as by plant growth and development stages.

Deposition of mineral fertilizers

In Belarus surface distribution of granular mineral fertilizers and liquid fertilizers is applied.

Ammonia emission factors for livestock handling (including all stages of manure processing) are provided in Table 1.

Table 1 – Ammonia emission factors in livestock handling

Livestock group	Description of source	Emission factor, kg per head per year
Dairy cattle	liquid storage	39,3
	solid storage	28,7
	disposal on pasture land	3,9
Other cattle (bulls, calves	liquid systems	13,4
	solid storage	9,2

Livestock group	Description of source	Emission factor, kg per head per year
and other cattle)	disposal on pasture land	2,0
Gestating sows	liquid systems	15,8
	solid storage	18,2
Other types of swine (boars, replacement pigs etc.)	liquid systems	6,7
	solid storage	6,5
Hens	cage housing	0,48
Broilers	open-floor housing	0,22
Hens	free grazing	0,32
Broilers	same	0,16
Horses	–	5,1
Sheep and goats	–	0,46

To estimate ammonia emissions from deposition of mineral nitric fertilizers the emission factor of 0,05 kg per 1 kg of nitric fertilizer in active substance was used (EMEP/EEA Air Pollutant ..., 2009; Klimont, 2004).

The following ammonia emission factors are applied for incomplete combustion of solid fuels: coal, peat – 10 g/t, firewood – 5 g/t.

To estimate ammonia emissions from urban wastewater processing the specific emission factor of 14,4 g of ammonia to 1 million liters of wastewater; in rural settlements 1,6 kg per person per year. To estimate emissions from waste disposal the unit emission rate 0,63 kg per person per year is taken.

1.3 Inventory outcomes

According to summary data for recent years (including statistical data for industrial processes) annual ammonia emissions in Belarus is 140-150 thous.tons (2008 – 146 thous.tons – table 2).

Table 2 – Total ammonia emissions in the Republic of Belarus by NFR categories (2008)

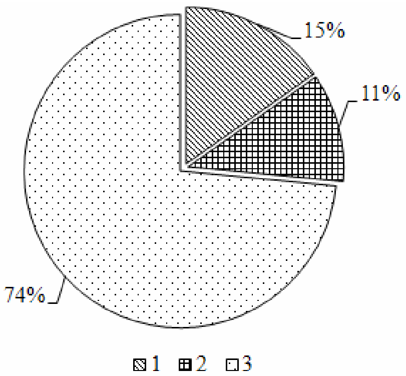
NFR source category	Source	Emissions thous. tons	Contribution to gross emissions %
1A1a	Public electricity and heat production	0,044	0,03

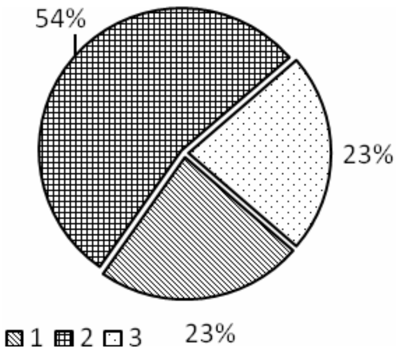
NFR source category	Source	Emissions thous. tons	Contribution to gross emissions %
1A2	Manufacturing industries and construction (Combustion in Manufacturing Industries, Construction and glass production)	0,023	0,02
1A3b	Road transport	0,016	0,01
1A3c	Railway transport	0,002	0,00
1A4a	Small combustion in Commercial/institutional sector	0,003	0,00
1A4b	Small combustion Combustion in Residential sector	0,019	0,01
1A4c	Non-road mobile sources and machinery Agriculture/forestry/fishery	0,005	0,00
1B2	Oil and natural gas	0,106	0,07
2A7b	Construction and demolition	0,005	0,00
2B	Chemical industry	4,74	3,23
2B1	Ammonia production	0,006	0,00
2B2	Nitric acid production	0,042	0,03
2C	Metal industry	0,097	0,07
2D	Other production industry	1,46	1,00
2D1	Pulp and paper	0,034	0,02
2D2	Food and beverage	1,427	0,97
2G	Other industrial processes	1,945	1,33

NFR source category	Source	Emissions thous. tons	Contribution to gross emissions %
4B	Manure management	101,74	69,3
4B1a	Dairy cattle	35,81	24,4
4B1b	Other cattle	32,14	21,9
4B3	Sheep and Goats	0,024	0,02
4B6	Horses	0,726	0,50
4B8	Pigs	23,33	15,9
4B9a	Poultry	9,713	6,62
4D1	Agricultural soils (mineral fertilization)	26,18	17,8
6A	Solid waste disposal on land	6,093	4,15
6B	Wastewater handling	4,037	2,75
6D	Other waste	0,255	0,17
	Total	**146,77**	100,0

Among main ammonia contributors are livestock handling activities (69% total emissions). Contribution of subcategories "Manure removal, storage and application as fertilizer: dairy cattle" and "Manure removal, storage and application as fertilizer: other cattle" into total ammonia emissions exceeds 45%. Other contributors are the subcategories "Manure removal, storage and application as fertilizer: pigs" – 16% and "Manure removal, storage and application as fertilizer: poultry" – 6,6%.

74% of ammonia emissions from cattle handling are caused by agricultural enterprises and 15% by private agricultural households. Ammonia contributions from large and medium entities (more than 1500 heads of livestock) are 11% of total emissions from cattle handling (Pic. 1 A).





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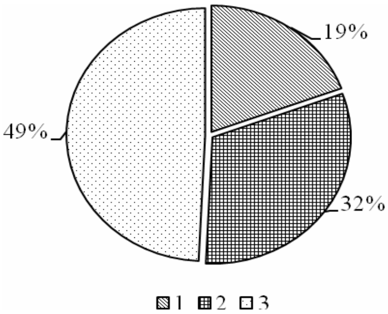


1 – private agricultural households;
2 – large and medium agricultural entities;
3 – small agricultural entities

C)

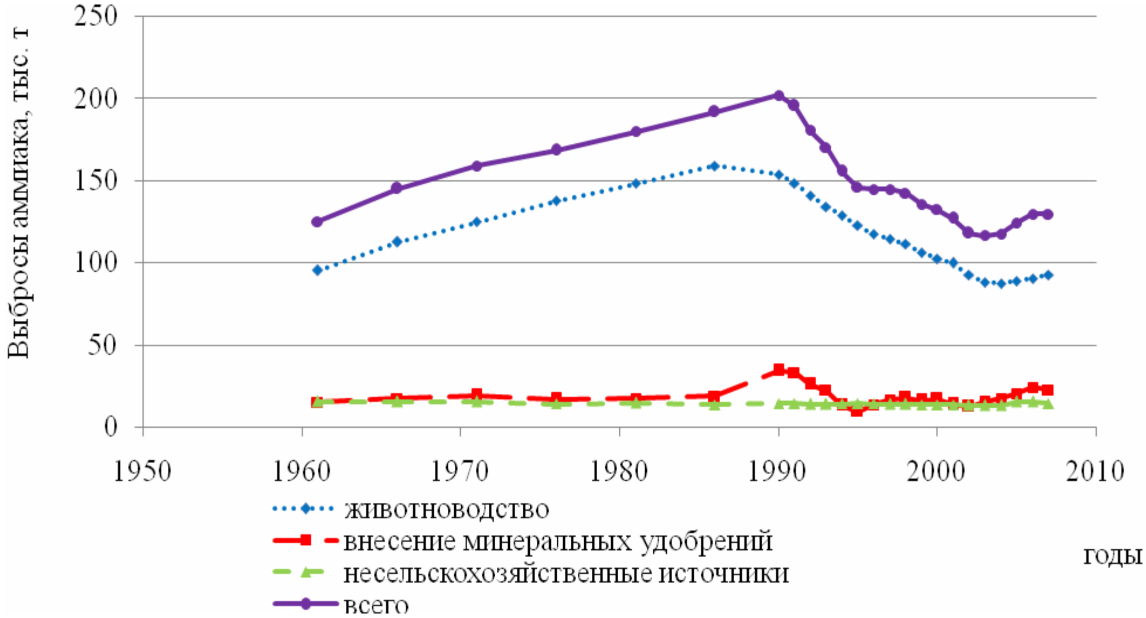
Picture 1 – Distribution of ammonia emissions from cattle (A), pigs (B), poultry (C) handling by types of sources

In swine handling more than 50% of ammonia emissions come from large and medium enterprises (more than 15000 pigs); small entities and private households contribute 23% each (Pic.1 B). 32% of ammonia emissions from poultry handling comes from large and middle size enterprises (with more than 500000 heads of poultry), 49% from small enterprises and 19% from agricultural households (Pic. C). The main contributor to the source "Other cattle" (sheep, goats, horses) is private households (62%). Crop husbandry activities (category "Mineral fertilization") contribute 17,8% of total ammonia emissions.

Ammonia emissions from non-agricultural sources in Belarus in 2008 are 18,9 thous. tons that is 13% of total emissions. 10,4 thous. tons of this amount refers to waste handling (residential waste removal, wastewater handling) and 4,7 thous. tons to chemical industry (production of nitric fertilizers, ammonia, nitric acid etc.).

Ammonia emissions were estimated for particular years from 1961 to 1990 and annually from 1991 to 2007. According to recent data ammonia emissions in Belarus from 1961 to 1990 were growing permanently, with reduction in 1990–

2001 and growth after 2001 (Pic.2). It should be pointed out that ammonia emissions curve for Belarus reflects the livestock population dynamics.



Picture 2 – Dynamic of gross ammonia emissions in Belarus

In general agricultural sources contribute more than 80% of atmospheric ammonia emissions. Thereafter only ammonia emission reduction from these sources will decrease significantly the national ammonia emissions.

2. Ammonia reduction scenarios in livestock breeding

Measures to reduce ammonia emissions in livestock handling can be divided into several groups:

– reduction of emissions from breeding and housing: improved housing system (use of bedding, aeration etc.), improved feeding (reduction of nitrogen, food supplements), purification of exhaust air from barns (installation of filters);
– reduction of emissions from manure storage: building of closed manure storages; litter treatment, manure pH reduction, urease activity reduction, new wastewater treatment methods;
– reduction of emissions from manure spreading on soil: fast ploughing after manure spreading, manure injection and proper manure application terms (Guidance Document…, 2007).

Values of ammonia emission reduction capacity in Belarus in case of implementing emission reduction activities in agriculture (in livestock handling primarily) and appropriate costs were estimated applying the GAINS model. Due to a number of existing alternatives and diversity of the activities the capacity for emissions reduction and appropriate costs were estimated for a consecutive series of ammonia reduction strategies (scenarios), depending on share of each sector covered by a group of measures.

Measures are grouped into 3 categories: of low, medium and high effectiveness including those applied in different stages: animal handling, manure storage and spreading on soil (table 3).

Table 3 – Groups of ammonia reduction measures

Group of measures	Example
Low efficiency	band application of manure, composting in clamps, rows etc.
Medium efficiency	manure isolation within 12 hours after application, simple beddings (straw, peat, bark, bead fillers etc.)
High efficiency	fast application of solid manure, liquid fertilizers injection, hard lid of manure storage reservoir etc.

In total emissions and costs were estimated for 9 emission reduction scenarios including "without measures" scenario (without implementing emissions reduction measures). Scenarios 1 and 2 include implementation of low efficiency measures at two stages of livestock production: manure storage and deposition of manure fertilizers (table 4). Scenarios 3 and 4 for these stages include implementation of high efficiency measures. The scenarios differ by the share of livestock population covered by the measures: 10% for scenarios 1 and 3, 25% for scenarios 2 and 4.

Table 4 – Characteristics of ammonia reduction scenarios 0 – 6

<table>
<tr><th>Scenario</th><th>Measures</th><th>Share of livestock production covered by a measure, %</th></tr>
<tr><td>0</td><td>without measures</td><td>100</td></tr>
<tr><td>1</td><td rowspan="2">low efficiency measures implemented in manure storage and manure fertilization</td><td>10</td></tr>
<tr><td>2</td><td>25</td></tr>
<tr><td>3</td><td rowspan="2">high efficiency measures implemented in manure storage and manure fertilization</td><td>10</td></tr>
<tr><td>4</td><td>25</td></tr>
<tr><td>5</td><td rowspan="2">high efficiency measures implemented in livestock handling, manure storage and manure fertilization</td><td>50</td></tr>
<tr><td>6</td><td>100</td></tr>
</table>

Scenarios 5 and 6 include maximum efficiency measures applied by the GAINS model for all stages of livestock production. Dairy cattle handling: manure storage in closed reservoirs, low-emission fertilization. Other cattle: improved housing, low-emission fertilization. Swine handling: application of bio-filters, manure storage in closed reservoirs, low-emission fertilization. Poultry handling: improved feeding, application of biofilters, manure storage in closed reservoirs, low-emission fertilization.

The scenarios differ by average share of livestock population covered with the measures: for 5 scenario – 50%, for 6 – 100%. For estimating an "average" scenario of implementing ammonia reduction measures scenarios 7 and 8 are applied in which to one part of livestock population the measures are applied at the stage of incorporating manure into soil, to other part at the stage of manure storage and deposition to soil, to the third part– at the stage of livestock handling (tables 5-6).

Table 5 – Characteristics of ammonia reduction scenario 7

Type of livestock	Manure removal system	Description of measures	Share of livestock production embraced by a measure, %
Cattle, swines	liquid	manure storage in closed reservoirs	20
		low-emission fertilization	60
		improved housing	20
	solid	low-emission fertilization	100
Poultry	-	biofiltration	50
		low-emission fertilization	10
		improved housing	20
Other livestock	-	low-emission fertilization	100

Table 6 – Characteristics of ammonia reduction scenario 8

Type of livestock	Manure removal system	Description of measures	Share of livestock production embraced by a measure, %

Type of livestock	Manure removal system	Description of measures	Share of livestock production embraced by a measure, %
Cattle	liquid	manure storage in closed reservoirs and low emissions fertilization methods	20
		low emissions fertilization methods	80
	solid	low emissions fertilization methods	100
Swines	liquid	biofilter, manure storage in closed reservoirs and low emissions fertilization methods	20
		low-emission fertilization methods	80
	solid	low-emission fertilization methods	100
Poultry	-	biofilter	30
		biofilter, manure storage in closed reservoirs and low-emission fertilization methods	20
		low-emission fertilization methods	50
Other livestock	-	low-emission fertilization methods	100

Estimation of ammonia emission reduction costs is based on capital and operating costs rates provided in the GAINS guidelines *(Klimont et al, 2004 and other)*. To estimate the costs of housing improvements as an ammonia reduction measure besides coefficients of investment functions (cif) and coefficients of investment functions (civ) quantity of fuel used for heating (Qg), price of fuel (cg) and energy consumption per unit *(*Qe*)* are accounted for.

For estimating costs of ammonia reduction in manure storage (building of closed manure reservoirs) only the following common parameters are used: coefficients of investment functions (cif and civ), exploitation rate (lt) and fixed percentage of investments for calculating annual costs of maintenance and operation (fk).

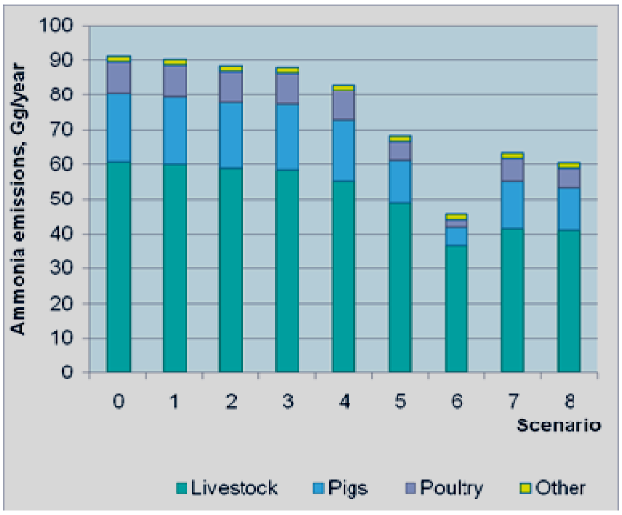
In the GAINS model fixed and variable costs are used as parameters for estimating ammonia reduction costs in application of organic fertilizers. Manure incorporation into plow lands (parameters cfma and cvma are used) and manure spreading in grazing lands should be distinguished (cfmg and cfmg).

3. Outcomes

Analysis of outcomes showed that maximum technically accessible ammonia reduction in livestock production (scenario 6 – all livestock products are produced implementing all potential ammonia emission measures) is 45,5 thous. tons i.e. 35% (table 7 picture 3). Ammonia emissions are expected to be 84,3 thous. tons per year with annual costs 347 mln. Euro. Unit costs will be rather high reaching annual 7.6 thous. Euro per ton of ammonia reduction.

Table 7 – Costs of ammonia reduction for different emissions reduction scenarios (implemented measures) (with respect to emissions in 2005)

Scenario	Costs, mln. Euro/y	Emission reduction, thous.t/y	Costs of emission reduction per unit, thous.Euro/t	Percentage of emission reduction by 2005, %	Percentage of emission reduction by 2008, %	Emissions remaining by 2005, thous.t/year
0	-	-	-			129,8
1	12	1	12,0	0,8	0,7	128,8
2	30	2,6	11,5	2,0	1,8	127,2
3	14,9	3,3	4,5	2,5	2,2	126,5
4	37,3	8,2	4,5	6,3	5,6	121,6
5	173,6	22,8	7,6	17,6	15,5	107,0
6	347,1	45,5	7,6	35,1	31,0	84,3
7	106,6	27,9	3,8	21,5	19,0	101,9
8	102,0	30,81	3,3	23,7	21,0	98,99



Picture 3 – Ammonia reduction capacity in different livestock production sectors

Implementation of scenarios 1, 2, 3 with related costs of 12-30 mln. Euro does not allow for notable ammonia reduction, showing differences with "without measures" scenario within 1-3% while unit costs per 1 ton reduction of ammonia will be the highest reaching 12 thous. Euro per year.

Key outcomes:

Implementation of scenarios 7 and 8 will decrease ammonia emissions by 20-23% with annual cost of 102-107 mln. Euro. These scenarios have the lowest unit costs of 3.3-3.8 thous. Euro per 1 ton of ammonia reduction.

4. Conclusions

Provisional costs estimation for different scenarios showed that technically accessible ammonia reduction by reducing emission in livestock handling can reach 23%. However necessary expenses on air protection measures will reach 100 mln. Euro per year that is twice as high as net average annual air protection expenses in Belarus. The fact should be taken into account that in Belarus air protection expenses for agriculture still constitute an insignificant part of the total air protection budget.

Accounting for the information above as well as the specificity of ammonia reduction measures most of which are primary, a significant ammonia reduction can be achieved by carrying out the following parallel activities:

- carrying out a EU-supported assessment projects in livestock production sector for a 8-year period with annual expenses 100 mln. Euro (implementation period can be reduced by providing total funds of 800 mln. Euro);

- elaborating a strategy for transition to best available technologies with their stage-by-stage implementation during 15-year period with annual foreign investments of not less than 50 mln. Euro directed to renewable energy sources (primarily, biogas facilities).

Implementation of emission reduction activities can start from investments into cattle breeding enterprises with more than 720 conditional heads of livestock, swine breeding enterprises with more than 6000 conditional heads of livestock and poultry breeding entities with more than 90000 conditional heads of livestock. For this purpose the experience of joint implementation of the Kyoto Protocol projects for greenhouse gases reduction can be used.

References

Мальчихина А.В. Антропогенные источники выбросов аммиака в окружающую среду Беларуси: выявление, оценка и прогноз /Автореф дисс. на соис. уч. степени канд.геогр. наук. Минск, 2010. – 23 с.

Механизация животноводства / В.К. Гриб [и др.]. – Минск: Ураджай, 1997. – 640 с.

Проект руководящих документов по методам ограничения выбросов и экономическим инструментам к Протоколу о борьбе с подкислением, эвтрофикацией и приземным озоном/EB.AIR/1999/2. 132 р.

Рекомендации по модернизации систем управления технологическими процессами в свиноводстве / Министерство сельского хозяйства и продовольствия Республики Беларусь, УО «Белорусский государственный аграрный технический университет» Кафедра автоматизированных систем управления производством. – Минск: БАТУ, 2005. – 45 с.

Республиканские нормы технологического проектирования новых, реконструкции и технического перевооружения животноводческих объектов: утв. приказом М-ва сельского хозяйства и продовольствия Респ. Беларусь 30.12.2006. № 514. // Нац. реестр правовых актов Респ. Беларусь. – 2007. – 8/15889.

Самосюк В.Н. Состояние и перспективы технического переоснащения отраслей свиноводства в Беларуси и России с учетом экологических требований / В.Г. Самосюк, В.Н. Дашков, В.Н. Гутман // Journal of Research and Application in Agricultural Engineering. – 2005. – Vol. 53. – P. 71–74.

Справочник агрохимика / В.В. Лапа [и др.]; под ред. В. В. Лапа. – Минск: Белорус. наука, 2007. – 389 с.

Справочно-нормативные материалы по животноводству. – Жодино, 1995. – 43 с.

Технологические комплексы машин и оборудования для производства молока и говядины // Научно-практический центр национальной академии наук Беларуси по механизации сельского хозяйства 2010 г. [Электронный ресурс]. – 2010. – Режим доступа: http://belagromech.basnet.by/research/machines/milk. – Дата доступа: 17.06.2010.

EMEP/EEA air Pollutant Emission Inventory Guidebook 2009. Technical Guidance to Prepare National Emission Inventories EEA // EEA [Electronic resource]. – Copenhagen, 2009. – Mode of access: http://www.eea.europa.eu/themes/air/emep-eea-air-pollutant-emission-inventory-guidebook/emep. – Date of Access: 20.04.2010.

Environmental Health Criteria 54: Ammonia // Geneva, World Health Organization [Electronic resource]. – 1986. – Mode of access: http://www.inchem.org/documents/ehc/ehc/ehc54.htm. – Date of access: 22.02.2005.

Global Estimates of Gaseous Emissions of NH_3, NO and N_2O from Agricultural Land / International Fertilizer Industry Association Food and Agriculture Organization of the United Nations. – Rome, 2001. – 106 p.

Guidance Document on Control Techniques for Preventing and Abating Emissions of Ammonia. ECE/EB.AIR/WG.5/2007/13 / Economic and Social Council. – Geneva, 2007. – 35 p

Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution / Economic Commission for Europe. – Geneva, 2008. – 18 p.

Klimont, Z. Modeling of Emissions of Air Pollutants and Greenhouse Gases from Agricultural Sources in Europe / Z. Klimont, C. Brink. – Luxenburg: IIASA, 2004. – 69 p.

Officially Reported Emission Data // EMEP [Electronic resource]. – 2000. – Mode of access: http://www.ceip.at/emission-data-webdab/emissions-as-reported-by-parties. – Date of access: 12.05.2009.

Scenarios of SO_2, NO_x, and PM emissions in the non-EU countries up to 2020. Background Paper for the 41st Session of the Working Group on Strategies and Review of the Convention on Long-range Transboundary Air Pollution. Geneva, April 14-17, 2008. CIAM Report 1/2008. 30 p.