Programme for gradual reduction of emissions of certain polluting substances at the level of the Republic of Macedonia

Skopje, May 2012

Content

1. Introduction

1.1 Programme goals

The Programme for gradual reduction of emissions of certain polluting substances at the level of the Republic of Macedonia (hereinafter: Programme) with reduction projections ranging from 2010 to 2020 is prepared in compliance with the requirements of international agreements and transposed EU regulations stated in the next chapter.

The Programme is fully compliant with the implementation of the requirements of CLRTAP (Convention on Long-Range Transboundary Air Pollution) of 1979 and its eight Protocols.

The main Programme requirements concern reduction of air emissions relative to **emission ceilings for certain atmospheric pollutants** in accordance with Directive 32001L0081 that has been already transposed in the legislation of the Republic of Macedonia through the Rulebook on the quantities of emission ceilings for pollutants in order to establish projections for a given period of time concerning reduction of pollutants' emission quantities at annual level (hereinafter: Rulebook on ceilings quantities) and Directive 32001L0080 on Large |Combustion Sources, also transposed in the legislation of the Republic of Macedonia through the Rulebook on the limit values of permissible emission levels and types of pollutants in waste gases and vapors released from stationary sources into the air (hereinafter: Rulebook on ELV). The Law on Ambient Air Quality and the Decree determining combustion plants that should undertake measures for ambient air protection against pollution specify the requirement for stationary sources, namely plants to adhere to prescribed emission limit values (ELV) and prepare plans for emission quantity reduction by 2020.

The Programme covers the following polluting substances:

- SO_2 – sulphur dioxide;
- NO_x – nitrogen oxides as nitrogen dioxide;
- NH_3 – ammonia;
- VOC – volatile organic compounds;
- TSP – total suspended particulates;
- CO – carbon monoxide;

The goal of the Programme is to identify the measures for reduction of emissions of the listed pollutants by key sources in order to prevent excess in the emission ceilings at annual level for 2010 and the levels by 2020.

The Programme establishes the basis for reporting to the above mentioned Convention on Long-Range Transboundary Air Pollution concerning reduction of pollution in the period from 2010 to 2020 in accordance with the Protocol to abate acidification, eutrophication and ground-level ozone (Gothenburg Protocol), adopted in our country by way of the Law on Ratification of the Protocol to abate acidification, eutrophication and ground-level ozone. Also, the Programme establishes the basis for reporting in accordance with the requirements of Directive 32001L0081, which as stated above have been transposed in the Rulebook on the emission ceilings.

Apart from abatement measures, the Programme presents the trends in emissions from 2001 to 2009, as well as projections for abatement of the quantities of emissions for the above listed pollutants.

The Programme is in accordance with all relevant documents, such as the National plan for ambient air protection [1], Strategy for energy development in the Republic of Macedonia by 2030 [2], Strategic environmental assessment of the Strategy [3], Strategy for promotion of energy efficiency in the Republic of Macedonia by 2020 [4], Baseline study on renewable energy sources in the Republic of Macedonia [5], National strategy for transport [6] and other relevant documents.

2. Multilateral agreements, legislation of the Republic of Macedonia and transposed EU regulations of relevance for the Programme

2.1 Multilateral agreements

The main international document upon which actions towards improvement of the quality of air by way of emissions reducing is the Convention on Long-Range Transboundary Air Pollution, the Convention on Long-Range Transboundary Air Pollution, adopted in Geneva, November 1979, was ratified by the Law on Ratification published in the Official Journal of SFRY 11/1988. Republic of Macedonia adopted the Convention by way of succession from former Yugoslavia, i.e. according to the documents of the MEPP, it ratified and adopted it on 17.11.1991. Under the National Programme for Approximation of the European Acquis, all eight Protocols to the Convention were ratified in the course of 2010. The Table below shows an overview of the Laws on Protocols' ratification.

Table 1. Overview of Protocols to CLRTAP

Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution concerning long-term funding of the Programme for cooperation in monitoring and assessment of the long-range transmission of pollutants in the air in Europe (EMEP)	Official Gazette of RM no. 24/10 of 19.02.2010
Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution to control nitrogen oxides emissions or their transboundary transmission	Official Gazette of RM no. 24/10 of 19.02.2010
Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution concerning further sulphur emissions reduction	Official Gazette of RM no. 24/10 of 19.02.2010
Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution to control emissions of volatile organic compounds or their transboundary transmission	Official Gazette of RM no. 24/10 of 19.02.2010
Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution concerning reduction of sulphur emissions or their transboundary transmission by at least 30 percents	Official Gazette of RM no. 24/10 of 19.02.2010
Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants	Official Gazette of RM no. 135/2010 of 08.10.2010
Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals	Official Gazette of RM no. 135/2010 of 08.10.2010
Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution to abate acidification, eutrophication and ground-level ozone - Gothenburg Protocol	Official Gazette of RM no. 135/2010 of 08.10.2010

2.1.1 Gothernburg Protocol

The Protocol to the Convention on Long-Range Transboundary Air Pollution to abate acidification, eutrophication and ground-level ozone, known as Gothenburg Protocol, establishes the obligation to prepare Programme for emission reduction. The Protocol is aimed at reducing the emissions of nitrogen oxides, sulphur dioxide, volatile organic compounds and ammonia caused by human activities, for which there is probability to be related to adverse effects on human health, natural ecosystems, materials and crops, due to acidification, eutrophication or increased concentration of ground-level ozone as a result of long-range transboundary air transmission, and provide to the extent possible, long-term and gradual approach, taking into account the advancement in scientific knowledge, in preventing the exceeding of atmospheric loads and concentrations of pollutants.

This Protocol entered into force in the Republic of Macedonia in January 2011. The National Action Plan for Ratification [7] was prepared for the purpose of implementing its requirements, listing the competent institutions, timescale and manner of the requirements fulfillment.

The obligation under the Protocol that the signatory countries establish their national upper emission limits – ceilings, has been fulfilled by the Republic of Macedonia. The upper emission limits – ceilings for the said pollutants are prescribed in the Rulebook on upper emission limits-ceilings. Here, it should be mentioned that the values of the emission ceilings were adopted by the inter-ministerial working group, while taking into account the reported emissions.

Review of the Protocol is underway, to cover the establishment of projections of the specified pollutants from 2010 to 2020 or specification of emissions that should be reached by 2020.

The Protocol specifies stricter limit values for specific sources of emissions and requires application of the best available techniques (BATs) for the purpose of emission reduction. Also, the Protocol suggests emission reduction for volatile organic compounds related to application of dyes and aerosols, while in the sector of agriculture it suggests implementation of adequate measures to reduce ammonia emissions. Guidelines to the Protocol suggest many techniques and economic instruments for emission reduction in the relevant sectors.

2.2 Transposed EU Directives

In accordance with the National Programme for EU Acquis Adoption, the following specific directives are of relevance for the National Programme for air emission reduction:

- Directive 32008L0001 on integrated pollution prevention and control;
- Directive 32001L0080 on the limitation of emissions of certain pollutants into the air from large combustion plants;
- Directive 32001L0081 on national emission ceilings for certain atmospheric pollutants;
- Directive 31999L0013 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations;
- Directive 32004L0042 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products and amending Directive 31999L0013;
- Directive 31994L0063 on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations;
- Directive 319990032 relating to the reduction of sulphur content of certain liquid fuels and amending Directive 31993L0012;
- Directive 31997L0068 relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery;
- Directive 31998L0070 relating to the quality of petrol and diesel fuels and amending directives 32000L0071, 32003L0017;
- Directive 32009L0028 on the use of energy from renewable sources

2.2.1 Directive 32008L001 on integrated pollution prevention and control

The goal of this Directive is to achieve integrated pollution prevention and control (IPPC) as resulting from individual activities. Parties are obliged to undertake all necessary measures as guarantee that competent authorities will secure that installations operate in such a manner that all appropriate measures have been undertaken to prevent pollution, primarily through application of BATs, without causing any significant pollution during their operation, avoid waste generation, secure efficient energy use, undertake all necessary measures to prevent incidents and limit their effects.

In the context of the above, integrated approach is applied in IPPC permitting through full coordination of the conditions and procedures for the permit issuance.

All issued and amended permits have to contain details of decrees concerning protection of air, water and soil, as specified in this Directive.

The permit has to specify the limit values for pollutants discharging into water, air and soil. Where adequate, limit values may be supplemented or replaced by equivalent parameters or technical measures.

Limit values of discharges and equivalent parameters and technical measures shall be based on BATs, taking into account technical characteristics of the subject installation, its geographical position and local environmental conditions. The permit shall contain certain requirements concerning monitoring of discharges, to specify the measuring methodology and frequency, procedure for assessment and obligation for data reporting to the competent authority necessary to carry out the permit compliance checks.

The permit shall contain measures related to conditions that differ from normal operating conditions.

In case the environmental quality standard requires stricter requirements compared to those that can be achieved by way of application of BAT, the permit shall specifically require additional measures without exemption of other measures that could be undertaken to comply with the environmental quality standard.

States shall undertake all necessary measures to secure that no significant modification in the installation operation planned by the operator shall be performed without permit issued in accordance with this Directive. The application for permit and the decision of the competent authority have to cover those parts of the installation and those aspects that could be affected by the modification.

The Directive requires primarily observation of the conditions set in the permit, inspection in data and public participation in permitting procedure, as well as information exchange.

Installations by category of activity that are necessarily subject of such requirements include:

- Energy
- Metal production and processing
- Mineral industry
- Chemical industry
- Waste treatment
- Other activities

Requirements of this Directive have been transposed into the national legislation and IPPC system has been established. Actually, the Inventory of installations that are subject to IPPC system has been developed. All identified installations should be issued A or B integrated permits for adjustment with adjustment plan (this is transitional phase that should be completed by 2014). A- integrated permits for adjustment with adjustment plan are under the responsibility of the MEPP and by the end of 2007 all 127 installations submitted applications; so far 28 IPPC permits and permits for adjustment with adjustment plan have been issued. B- integrated permits are under the responsibility of the units of local self-government (LSGUs). These processes of IPPC permitting are still underway.

2.2.2 Directive on national emission ceilings – 32001L0081 for certain pollutants ("NEC Directive")

The National emission ceilings Directive (NEC Directive) defines emission ceilings for SO_2, NO_2, VOC and NH_3 for EU Member States to be achieved by 2010. Besides, this Directive also prescribes elaboration of emission projections and development of National Programme for their gradual reduction. Republic of Macedonia, as a candidate country for EU membership, should approximate its national legislation with the one of the EU. Therefore, this Directive has been fully transposed into the following national regulations: The Law on Ambient Air Quality, Rulebook on methodology of inventory and establishment of the levels of pollutant emissions into atmosphere in tons per year for all types of activities, as well as other data reported to European Monitoring and Evaluation Programme (EMEP) and Rulebook on emission ceilings.

Emission ceilings for SO_2, NO_x, VOC and NH_3 to be achieved by 2010 in the Republic of Macedonia, as specified in Annex 1 of the Rulebook on emission ceilings, are as follows:

Table 2. Emission ceilings for SO_2, NO_x, VOC and NH_3 for 2010

SO_2 kilotons	**NO_x** kilotons	**VOC** kilotons	**NH_3** kilotons
130	39	30	17

The set quantities of emission ceilings for the specified pollutants have been determined on the basis of analysis of data of specified pollutants emissions reported to UNECE – CLRTAP for the period 2002-2008, which means that no simulation models were used in their determination for 2010. Consequently, it is possible that certain omission or uncertainty occur while determining projections for emission reduction for the period 2010-2020.

The requirement regarding preparation of Programme for gradual emission reduction for sulphur dioxide (SO_2), nitrogen oxides (NOx), ammonia (NH_3), and volatile organic compounds (VOC) is contained in Article 23 of the amendment of the Law on Ambient Air Quality adopted in 2010. This Article requires adoption of this Programme at the level of the Republic of Macedonia for the period 2010 to 2020.

It should be noted that this Directive has been fully transposed into the national legislation and the implementation of this Programme will provide its full implementation.

2.2.3 Directive 32001L0080 on the limitation of emissions of certain pollutants into the air from large combustion plants ("LCP Directive")

Directive 2001/80/EC or Large combustion plants Directive (LCP Directive) with designed capacity equal to and above 50 MW, regardless of whether solid, liquid or gaseous fuel is used, was adopted for the purpose of achieving reduction in annual pollutant emissions for sulphur dioxide, nitrogen oxides and dust from combustion plants and establishment of ELV for existing and new installations.

The Directive defines the installations as existing or new depending on the time of installation putting into operation and IPPC permit.

The above division into new and existing installations also defines the ELV for the specified pollutants. Furthermore, two ways of achieving the emission reduction are specified for existing installations, namely through observation of ELV and through the programme for emission reduction or implementation of measures envisaged in the programme, by which overall reduction on annual level is achieved for the quantities of SO_2, NO_X, total suspended particulates, ammonia and volatile organic compounds.

As already mentioned, articles of the Directive regulating ELV for existing and new installations have been transposed into the Rulebook on ELV.

The manners of measuring and calculating the emissions prescribed in the Directive as ISO (International Standard Organization) and CEN (European Committee for Standardization) standards are regulated by the Rulebook on emission measurements, being taken over by way of endorsement method as Macedonian – MK standards.

Reduction of emissions of sulphur dioxide, nitrogen oxides and total suspended particulates from large combustion plants (LCP) and gas turbines is set as legal obligation in Article 47 of the Law on Ambient Air Quality. Based on the said article, Decree determining combustion plants required to undertake measures for ambient air protection was adopted, to transpose part of Directive 32001L0080. Under the Decree, these installations (installations with a capacity above 50 MW) are obliged to prepare a Plan for undertaking measures for air protection, which will specify the actions for emission reduction and timescales for achievement for the given plant. It should be underlined that each LCP prepares individual plan for reduction. The prepared plans of the LCPs are part of the Programme.

2.3. Overview of the legislation in the Republic of Macedonia

This Chapter presents the legislation in our country of relevance for the Programme.

- Law on Environment, (Official Gazette of RM no. 53/05, 81/05, 24/07, 159/08 and 83/09, 48/10, 128/10, 51/11);
- Law on Ambient Air Quality, (Official Gazette of RM no. 67/04, 92/07, 35/10, 47/11);
- Decree determining the activities of installations subject to integrated environmental permit or adjustment permit with adjustment plan and schedule for applications for issuance of adjustment permit with adjustment plan, (Official Gazette of RM no. 89/05);
- Rulebook on the procedure for A-integrated environmental permitting, (Official Gazette of RM no. 04/06);
- Rulebook on the procedure for B-integrated environmental permitting, (Official Gazette of RM no. 04/06);
- Rulebook on the procedure for issuance of adjustment permit with adjustment plan, (Official Gazette of RM no. 04/06);
- Rulebook on detailed conditions to be fulfilled by the members of the scientific and technical Committee concerning the best available techniques, (Official Gazette of RM no. 71/06);
- Decree on the level of the compensation paid by operators of installations performing activities that are subject to adjustment permit with adjustment plan, (Official Gazette of RM no. 117/07);
- Decree on the level of the compensation paid by operators of installations performing activities that are subject to B-integrated environmental permit, (Official Gazette of RM no. 117/07);
- Rulebook on the limit values of permissible levels of emissions and types of polluting substances in waste gases and vapors released from stationary sources into the air, (Official Gazette of RM no. 141/2010);
- Rulebook on the methods, manners and methodology of measuring the air emissions from stationary sources, (Official Gazette of RM no. 11/2012);
- Decree on the limit values of the levels and types of polluting substances in the ambient air and alert thresholds, deadlines for limit values achievement, margins of tolerance for the limit values, target values and long-term targets, (Official Gazette of RM no. 50/05);
- Rulebook on criteria, methods and procedures for ambient air quality assessment, (Official Gazette of RM no. 82/2006);
- Rulebook on the methodology for inventory and establishment of the levels of polluting substances emission into the atmosphere in tons per year concerning all types of activities, as well as other data to be submitted to the European Monitoring and Evaluation Programme (EMEP), (Official Gazette of RM no. 142/07);
- Rulebook on the quantities of pollutant emission ceilings in order to determine projections for a given time period concerning reduction of the quantities of pollutant emissions on annual level (Official Gazette of RM no. 2/10);
- Law on Waste Management, (Official Gazette of RM no. 68/04, 71/04, 107/07, 102/08, 134/08);
- Strategy for Waste Management of the Republic of Macedonia (2008-2020), (Official Gazette of RM no. 39/08);
- National Waste Management Plan (2009-2015) of the Republic of Macedonia, (Official Gazette of RM no. 77/09);
- Rulebook on the emission limit values during waste burning and combustion and the conditions and manner of operation of installations for burning and combustion (Official Gazette of RM no. 123/2009);
- Law on Forests, (Official Gazette of RM no.47/97);
- Rulebook on the quality of liquid fuels (Official Gazette of RM no. 88/2007, 91/2007, 97/2007, 105/2007, 157/2007, 15/2008, 78/2008, 156/2008 and 81/2009);
- Law on Agriculture and Rural Development (Official Gazette of RM no. 134/2007);

- Law on Agricultural Activity Performance (Official Gazette of RM no. 11/02 and 89/08);
- National Strategy with Action Plan for Organic Agriculture of the Republic of Macedonia, August 2007;
- Law on Livestock Breeding (Official Gazette of RM no.7/2008);
- National programme for livestock breeding for the period 2000 - 2009;
- National Strategy for Agriculture and Rural Development 2007-2013;
- Law on Fertilizers (Official Gazette of RM no. 110/07, 20/09);
- Rulebook on inorganic fertilizers (Official Gazette of RM no. 96 of 31.07.2009);
- Rulebook on the procedure and documentation for recording and the content of the records on imported fertilizers, Official Gazette of RM no. 96 of 31.07.2009);
- Code of Good Agriculture and Hygiene Practice (Official Gazette of RM no. 112/10)
- Common Plan for Livestock Breeding for the period 2011-2020 (Official Gazette of RM no. 43/2011)
- Law on Energy (Official Gazette of RM no. 16/2011, 136/2011)
- Rulebook on energy balances and energy statistics (Official Gazette of RM no.138/2011)

3. Trend in pollutant emissions in the period 2001 – 2009

Emissions of SO_2, NOx, NH_3, VOC, CO and TSP in the period 2001 - 2009 are presented in this Chapter.

Trends have been determined on the basis of emission quantities processed on the basis of the methodology of SNAP (Selected Nomenclature of Air Pollution), which derives from EMEP/CORINAIR (Core Inventory for Air Pollution) Programme. SNAP is divided into sectors by activities as shown in Table 3.

Table 3. SNAP sectors

SNAP sector	Name
01	Combustion in thermal power plants, district heating plants and refinery
02	Heating boilers in non-industrial plants and small (household) fireplaces
03	Combustion processes in industrial production
04	Production processes
05	Extraction and distribution of fossil fuels and geothermal energy
06	Use of s olvents and other products
07	Road transport
08	Other mobile sources and machinery
09	Waste treatment and disposal
10	Agriculture
11	Other sources

The methodology identifies the key categories of sources for individual pollutants, by using the Guidelines of EMEP/EEA (European Environmantal Agency) concerning inventory of air pollutants of 2009 [8], and IPCC (Intergovernmental Panel on Climate Change) Guidelines for good practices and uncertainties management [9].

Other analyses recommended in case of uncertainties assessment were used as well.

Analysis of key sources in the Republic of Macedonia includes pollutants that induce acidification and eutrophication (SO_2, NO_X, VOC, NH_3). Trends for the period 2001 - 2009 are presented adequately for each pollutant.

3.1. Sulphur dioxide (SO_2)

The quantities of sulphur dioxide - SO_2 emission in the Republic of Macedonia, from 85 to 90% of the total emissions, result from combustion of fossil fuels for electricity production in coal fired thermal power plants (TPPs REK Bitola and REK Oslomej) and heating energy production. Emission trend indicates that the quantities of SO_2 from 2002 to 2004 had reduced, from 2004 to 2009 had even trend with minor changes of reduction or increase as shown in Table 4 and Figure 1, respectively. Greatest contribution to SO_2 emission originates from electricity and heating energy production (SNAP 01 and 02), followed by industrial processes using or combusting fuels (SNAP 03), and lower share goes to sectors of road transport (SNAP 07) and other machinery (SNAP 08).

Table 4: Quantities of sulphur dioxide emissions from 2001 to 2009 based on SNAP sectors

Sulphur dioxide - SO_2 [kt]									
SNAP sector	2001	2002	2003	2004	2005	2006	2007	2008	2009
SNAP 01	92.4	92.4	92.4	91.86	90.19	90.19	84.58	97.53	96.57
SNAP 02	5.03	5.03	12.51	1.06	1.08	1.08	1.01	1.10	1.10
SNAP 03	0.4	0.1	3.66	6.45	7.93	7.93	12.95	13.57	13.57
SNAP 04	3.1	32.75	33.06	0.36	0.36	0.36	0.21	0.30	0.02
SNAP 06	35.1	35.1	7.7	0.00	0.00	0.00	0.00	0.00	0.00
SNAP 07	0.5	0.5	1	0.77	0.80	0.80	1.00	0.78	0.78
SNAP 08				0.25	0.27	0.27	0.33	0.29	0.29
Total	136.530	165.880	150.330	100.756	100.629	100.629	100.074	113.569	112.329

Figure 1 shows the trend in the quantity of SO_2 emissions in the considered period, while the ceiling for this pollutant for 2010 under the Rulebook on emission ceilings is 130 kt. The quantities of emissions from 2004 to 2009 did not exceed the ceiling, and it is notable that emissions were lower for 2008 and 2009 by 16.4 kt, and 17.7 kt, respectively, relative to ceiling

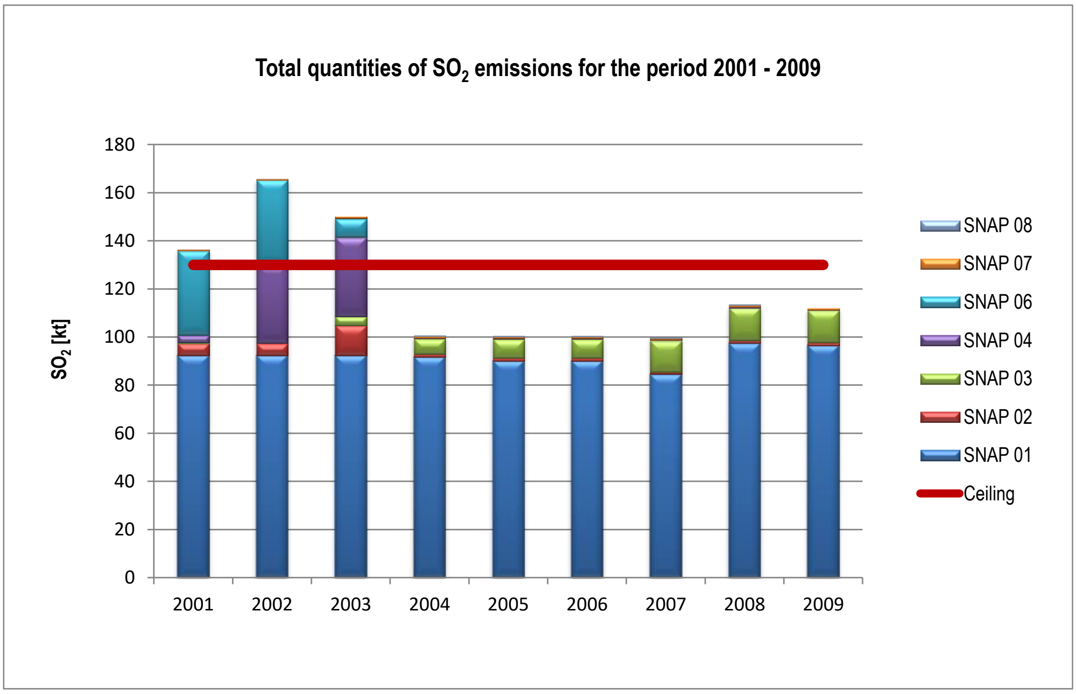

Figure 1. Total quantities of SO_2 emissions for the period 2001 - 2009

Figure 2 shows consumption of coal (lignite) for electricity production in the period 2004-2009 which is the main source of SO_2 emission.

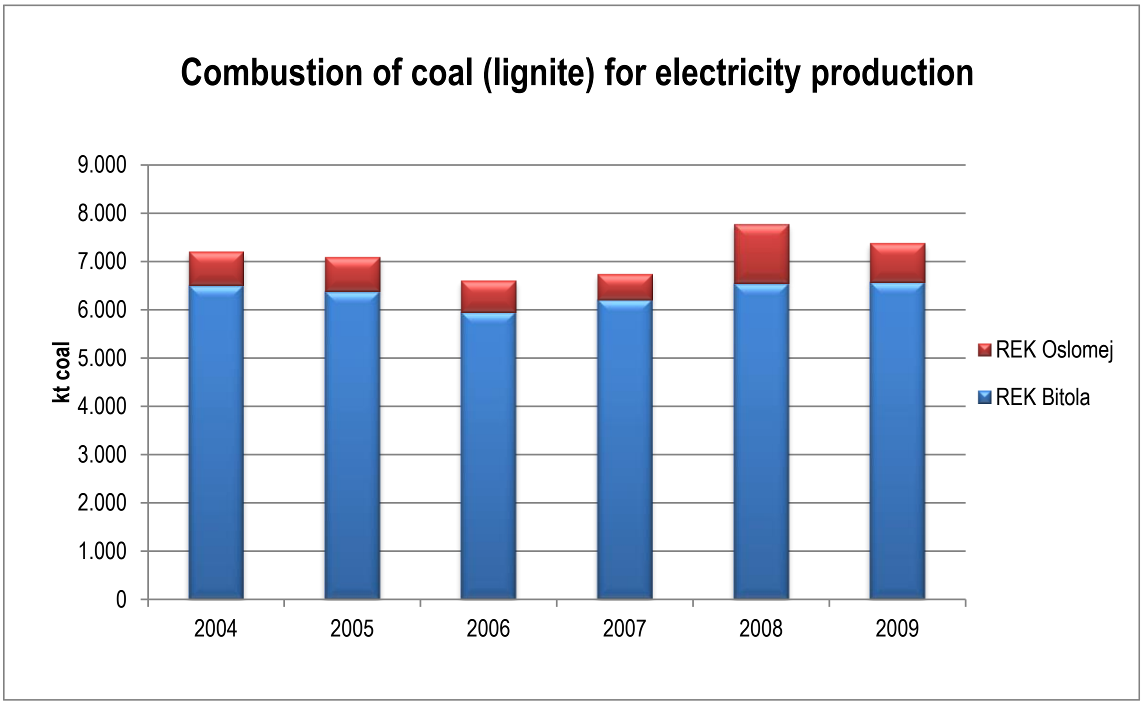

Figure 2. Combustion of coal (lignite) for electricity production

3.2. Nitrogen oxides (NO_x)

The main sources of NO_x emissions are combustion processes in electricity production resulting from coal combustion, as well as road transport together with other mobile sources. These emissions are distributed evenly, i.e. SNAP 01 contributes around 40%, and SNAP 07 and 08 around 35%. Other emissions originate from industrial production, sector with combustion processes (SNAP 03) and sector for production without combustion processes (SNAP 04). Emission quantities for the period 2001 to 2009 by SNAP sectors are presented in Table 5.

Table 5: Quantities of NOx emissions from 2001 to 2009 based on SNAP sectors

Nitrogen oxides - NOx [kt]									
SNAP sector	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
SNAP 01	14.70	14.70	14.70	13.10	12.89	12.89	12.22	13.96	13.96
SNAP 02	2.41	2.41	1.83	1.50	1.51	1.51	1.45	1.50	1.50
SNAP 03	0.10	0.50	3.06	2.74	3.33	3.33	4.39	4.46	4.46
SNAP 04	0.50	5.60	5.91	4.93	4.96	4.96	2.68	4.63	0.48
SNAP 07	11.30	11.30	22.00	9.20	9.67	9.67	11.60	9.71	9.71
SNAP 08	0.00	0.00	0.00	2.07	2.20	2.20	2.67	2.36	2.36
Total	**29.010**	**34.510**	**47.500**	**33.736**	**34.723**	**34.723**	**35.190**	**36.834**	**32.680**

Figure 3 shows the trend in the quantities of NO_x emissions in the analyzed period. Under the Rulebook on emission ceilings, the ceiling applicable for this pollutant for 2010 was 39 kt. Emission quantities from 2004 to 2009 did not exceed the ceiling value and were lower by around 4 kt at an average. In 2009, emission quantities were lower by 6.5 kt relative to ceiling, which resulted mainly from the non-operation of industrial facility Jugohrom Ferroalloys DOO.

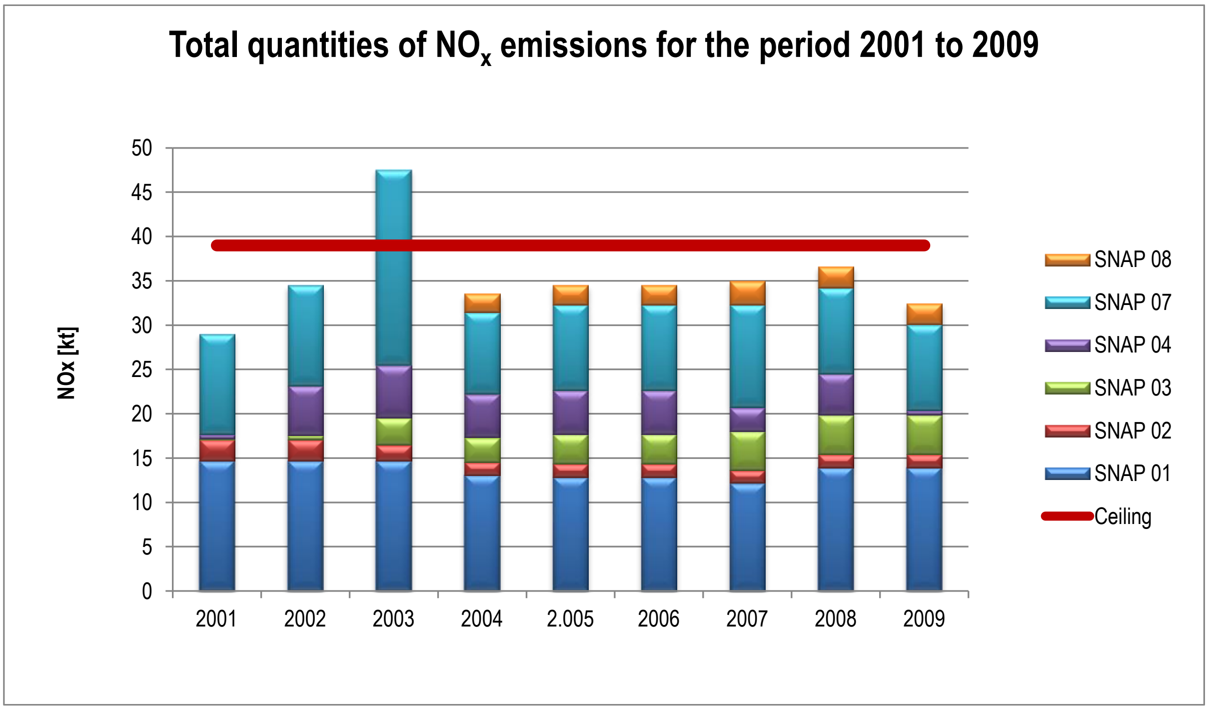

Figure 3: Total quantities of NO_x emissions for the period 2001 to 2009

3.3. Volatile organic compounds (VOC)

Emissions of volatile organic compounds are mainly result of mobile sources (SNAP 07 and 08), followed by emissions from solvents and other products use (SNAP 06) and other emissions resulting from wood burning in the subsector – households (SNAP 020205, small combustion fireplaces – furnaces, hearths, stoves and other, where incomplete combustion occurs). Table 6 shows the quantities of emissions for the period 2004 to 2009 by SNAP sectors.

Table 6: Total quantities of VOC emissions in the period 2004 to 2009 by SNAP sectors

Volatile organic compounds - VOC [kt]									
SNAP sector	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
SNAP 01				1.69	1.66	1.64	1.55	1.76	1.76
SNAP 02				3.51	3.51	3.49	3.49	3.51	3.49
SNAP 03				0.21	0.20	0.19	0.25	0.27	0.27
SNAP 04				1.11	1.15	1.15	1.15	0.95	0.96
SNAP 05				0.42	0.42	0.41	0.42	0.42	0.42
SNAP 06				8.48	8.32	8.31	8.32	9.01	8.99
SNAP 07				8.82	8.99	9.00	10.05	10.83	10.70
SNAP 08				0.97	0.97	0.97	1.10	1.08	1.08
Total				**25.22**	**25.21**	**25.16**	**26.34**	**27.82**	**27.65**

Figure 4 shows the trend in VOC emissions in the period 2004 to 2009. Under the Rulebook on ceilings, the ceiling concerning this pollutant for 2010 was 30 kilo tones. During 2007, 2008 and 2009, there was increase in the quantities of volatile organic compound emissions by around 10% resulting from increased consumption of fuel in road transport.

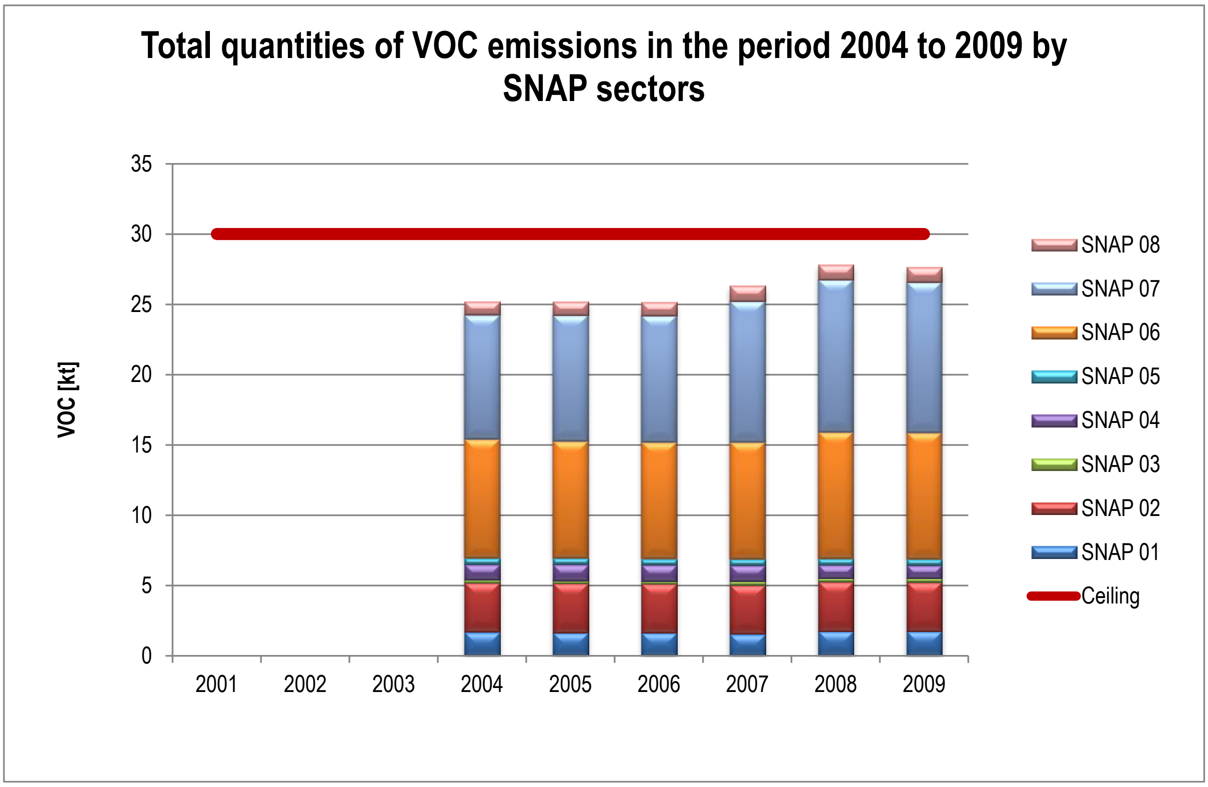

Figure 4: Total quantities of VOC emissions in the period 2004 to 2009 by SNAP sectors

3.4. Ammonia (NH_3)

The biggest source of ammonia emissions is the sector of agriculture, i.e. SNAP 10 (Cattle, pigs and poultry management). Table 7 shows emissions from this sector for each of the sources in livestock breeding.

Table 7: Total quantities of NH_3 emissions for the period 2004 to 2009 by sources in livestock breeding

Ammonia - NH_3 [kt]									
SNAP 10	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cattle				4.87	4.82	4.85	4.71	4.55	4.60
Pigs				1.08	1.06	1.07	1.04	1.00	1.01
Poultry				0.87	0.86	0.87	0.84	0.82	0.82
Other animals				0.56	0.56	0.56	0.54	0.53	0.53
Total				**7.38**	**7.30**	**7.34**	**7.14**	**6.90**	**6.97**

Ammonia emissions originating from cattle have highest share with 66%, then pigs with 15%, poultry with 12% and other animals with 8%.

Figure 5 shows the trend in NH_3 emissions in the period 2004 to 2009. According to the Rulebook on emission ceilings, the ceiling applicable for this pollutant for 2010 was 17 kt. The quantities of emission for this period did not exceed the ceiling, being lower by around 10 kt at an average. During the last years of the analyzed period, there was minor decline in NH_3 emissions, resulting from small drop in the number of cattle.

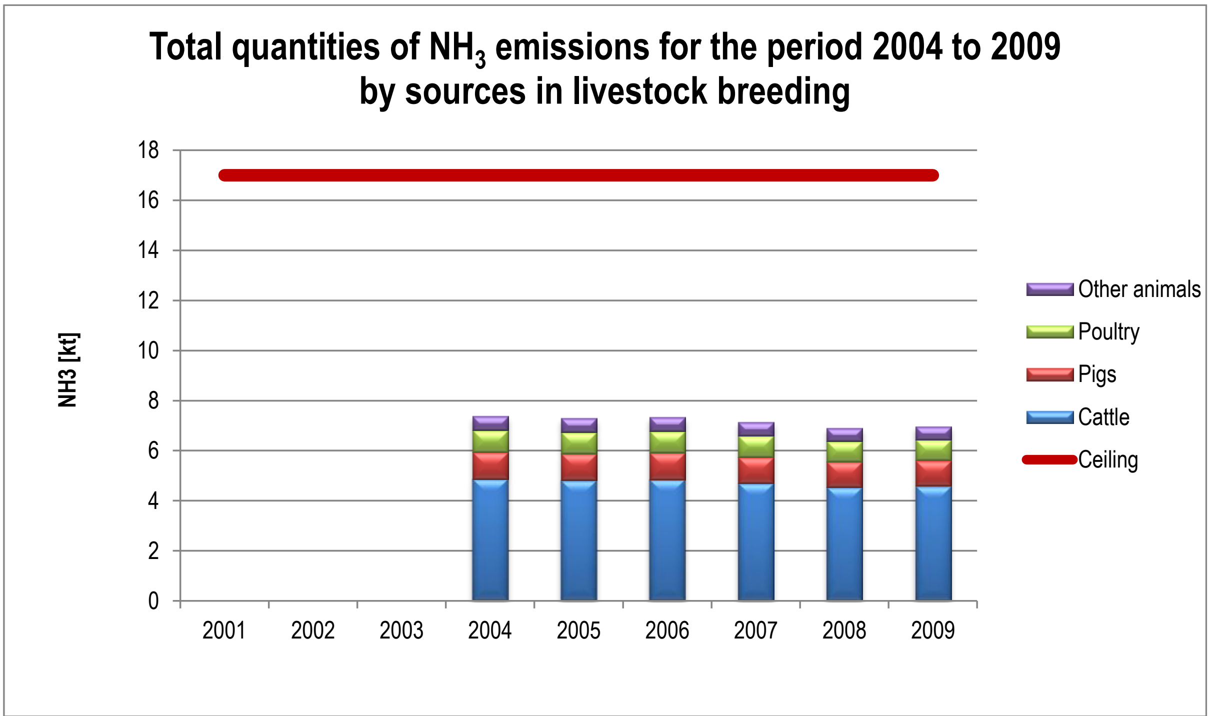

Figure 5: Total quantities of NH_3 emissions for the period 2004 to 2009 by sources in livestock breeding

3.5. Carbon monoxide (CO)

Emissions of CO originate mainly from mobile sources (SNAP 07 and 08), while the rest of emission quantities come from fuels combustion in energy production (SNAP 01, 02 and 03) and production technological processes (SNAP 04). Table 8 shows emission quantities for the period 2001 to 2009 rbased on SNAP sectors.

Table 8: Total quantities of CO emission in the period 2001 to 2009 by SNAP sectors

Carbon monoxide - CO [kt]									
SNAP sector	2001	2002	2003	2004	2005	2006	2007	2008	2009
SNAP 01	2.50	2.50	2.50	0.38	0.39	0.37	0.40	0.44	0.44
SNAP 02	2.80	2.80	29.01	41.44	41.45	43.18	41.39	41.43	41.48
SNAP 03	2.00	1.90	2.80	0.55	0.87	0.87	1.99	1.92	1.92
SNAP 04	3.30	8.60	9.70	9.00	9.05	9.05	4.86	7.83	0.20

SNAP 05				0.55	0.54	0.52	0.51	0.55	0.54
SNAP 06	18.20	18.20	18.20						
SNAP 07	47.30	47.30	76.30	40.93	41.66	41.43	46.48	43.41	43.40
SNAP 08				2.02	2.07	2.07	2.29	2.25	2.27
Total	**76.10**	**81.30**	**138.51**	**94.89**	**96.03**	**97.49**	**97.91**	**97.83**	**90.25**

Figure 6 shows the trend of CO emissions in the period 2001 to 2009. Quantities of emissions from 2004 to 2009 were without significant change, except in 2009 when reduction of around 8% was recorded as a result of non-operation of the industrial complex Jugohrom Ferroalloys DOO.

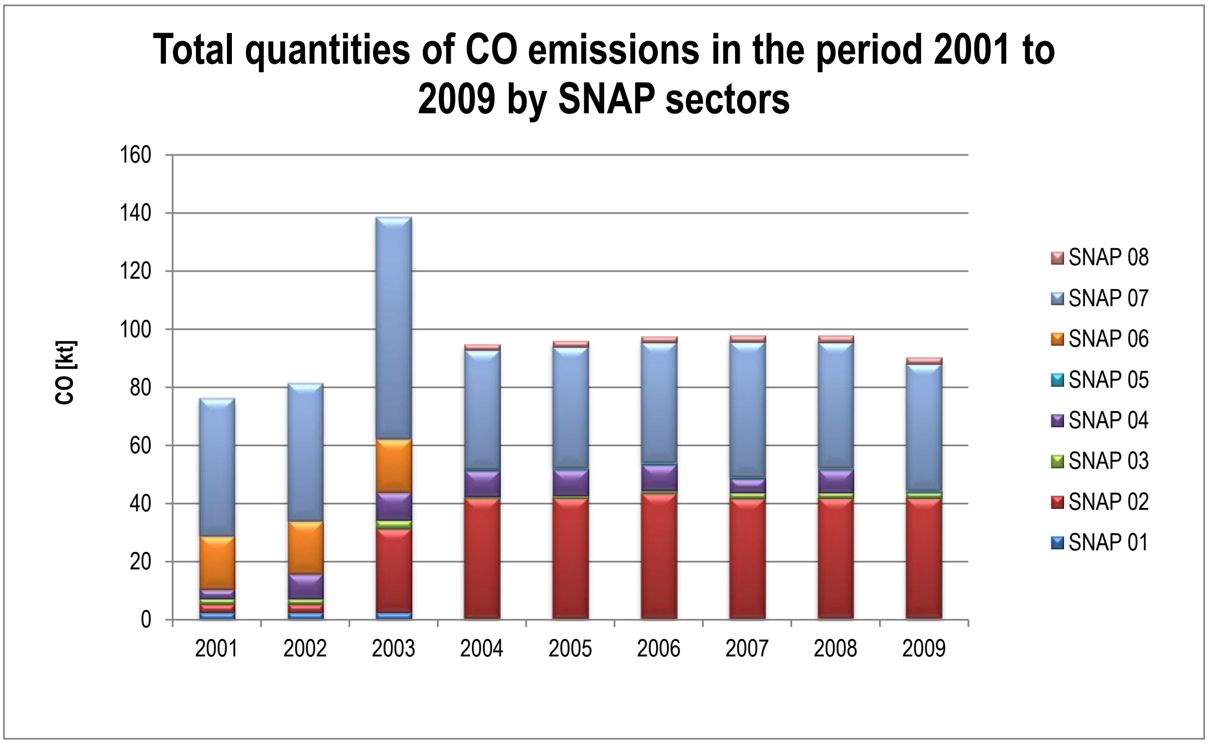

Figure 6: Total quantities of CO emissions in the period 2001 to 2009 by SNAP sectors

Table 9 presents key sectors of carbon monoxide for 2008.

Table 9. Key sectors of carbon monoxide for 2008

Code	Key sector	kt	%
1A3b	Road transport	43.406	44.4%
1A4b	Residential:Stationary plants, households and gardening (mobile)	42.641	43.6%
2C2	Production of ferro-alloys	7.635	7.8%
1A2b	Combustion plants in production and construction industry: non-ferrous metals	1.616	1.7%
1B1a	Fugitive emissions from solid fuels: Excavation of coal and management	0.552	0.6%
1A4cii	Agriculture/Forestry/Fishery: Vehicles outside public roads and other machinery	0.442	0.5%
1A2fi	Combustion plants in production and construction industry: Other	0.353	0.4%
1A1a	Public energy and heating plants	0.328	0.3%
1A4ai	Commercial/Institutional: Stationary	0.261	0.3%
2C1	Production of iron and steel	0.196	0.2%

1A2a	Combustion plants in production and construction industry: iron and steel	0.154	0.2%
1A1b	Oil refining	0.113	0.1%
1A3ai	International transport	0.088	0.1%

3.6. Total suspended particulates (TSP)

The highest share in the emissions of total suspended particulates – TSP in the Republic of Macedonia belongs to the sector of production processes (SNAP 04). The share is variable and depends on the intensity of installations' operation during the year, taking into account the processes in metallurgy (Skopski Leguri, Feni Industry, Jugohrom Ferrous Alloys DOO, Makstil). Table 10 shows quantities of emissions for the period 2003 to 2009 by SNAP sectors.

Table 10. Total quantities of TSP in the period 2003 to 2009 by SNAP sectors

Total suspended particulates - TSP [kt]									
SNAP sector	2001	2002	2003	2004	2005	2006	2007	2008	2009
SNAP 01			0.00	4.67	4.59	4.09	4.28	4.82	4.82
SNAP 02			0.88	1.53	1.54	1.54	1.53	1.54	1.54
SNAP 03			13.20	1.21	1.82	1.82	4.19	4.01	4.01
SNAP 04			2.08	22.28	22.45	22.45	13.56	16.76	0.59
SNAP 08			0.00	0.22	0.24	0.24	0.30	0.26	0.26
Total			16.16	29.92	30.63	30.13	23.86	27.38	11.21

Figure 7 shows the trend in TSP emissions in the period 2003 to 2009. It is notable that there are visible oscillations in relation to annual emission quantities, which confirms the above conclusion concerning metallurgical processes, i.e. their operation. This is also the case in 2009 when emission reduction of more than 55% was recorded, resulting mainly from non-operation of the industrial complex Jugohrom Ferroalloys DOO.

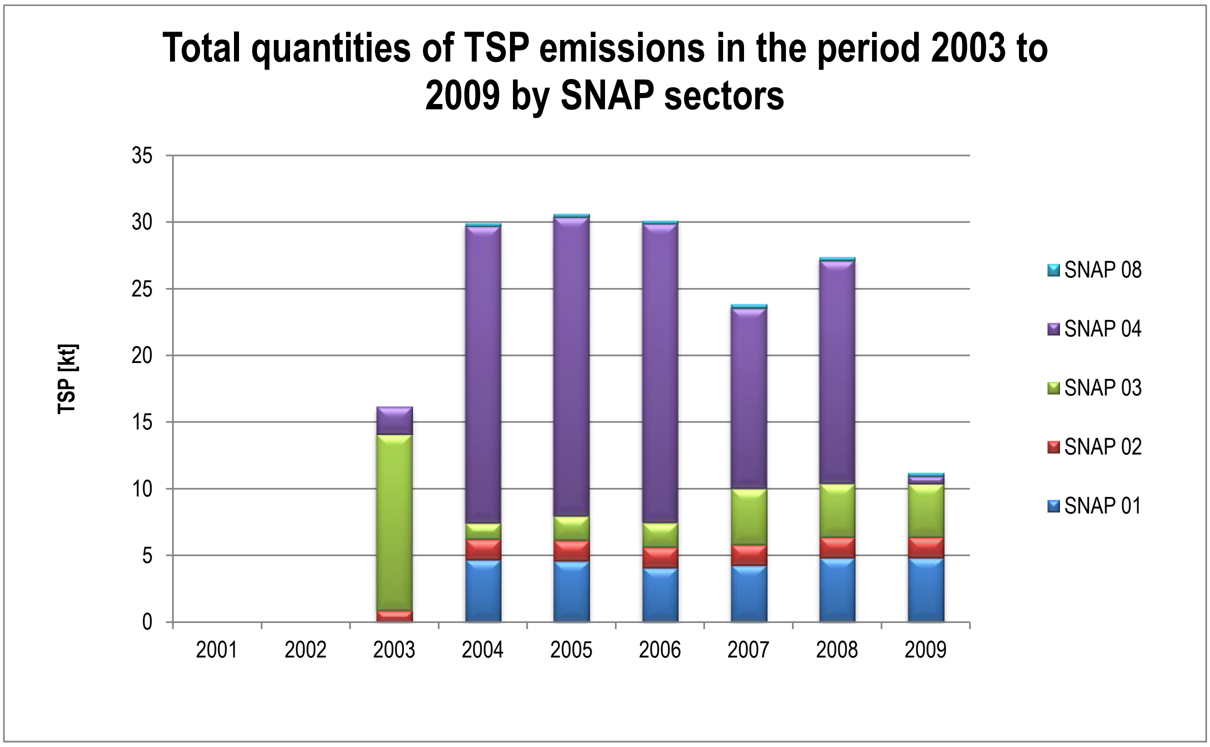

Figure 7. Total quantities of TSP emissions in the period 2003 to 2009 by SNAP sectors

Table 11 presents the key sectors for TSP in 2008, showing that 59% of TSP originate from production in metallurgy, while 33.8% from heat and electricity production and fuel combustion in production industry.

Table 11. Key sectors for total suspended particulates for 2008

Code	Key sectors	kt	%
2C2	Production of ferro-alloys	16.167	59.0%
1A1a	Public energy and heating plants	4.745	17.3%
1A2b	Combustion plants in production and construction industry: non-ferrous metals	3.087	11.3%
1A4b	Residential:Stationary plants, households and gardening (mobile)	1.431	5.2%
1A2a	Combustion plants in production and construction industry: iron and steel	0.852	3.1%
2A6	Roads asphalting	0.294	1.1%
2A1	Cement production	0.197	0.7%
1A4cii	Agriculture/Forestry/Fishery: Vehicles outside public roads and other machinery	0.162	0.6%
1A2fi	Combustion plants in production and construction industry: Other	0.146	0.5%
1A4ai	Commercial/Institutional: Stationary	0.107	0.4%
2C1	Production of iron and steel	0.097	0.4%
1A1b	Oil refining	0.073	0.3%
1A3c	Railroads	0.020	0.1%

4. Projection of emissions for the pollutants SO_2, NO_X, NH_3, and VOC from 2010 to 2020

4.1 Introduction

Projections of emissions are important tools in designing of strategies for emission reduction, aimed at achieving emission reductions in future. Projections are defined in the frames of given scenarios of social trends (population development, land use, GDP (Gross Domestic Product), transport and economic sectors like agriculture, energy, industry, etc.).

Reduction of the quantities of emissions in the air in accordance with the measures for their reduction should be allocated in a time and spatial frame and the efficiency of the wide spectrum of measures to be undertaken at present and in future should be evaluated.

Emission reduction is carried out as gradual reduction in emissions of the pollutants sulphur dioxide - SO_2, nitrogen oxides - NOx, ammonia - NH_3 and volatile organic compounds - VOC. Emission reduction is carried out through implementation of adequate measures by which certain projected values should be achieved for the quantities of the specified pollutants for 2010, 2015 and 2020, respectively. Values of emission ceilings for 2010 are specified in accordance with the Rulebook on emission ceilings.

The following elements were used in the preparation of projections for specified pollutants:

- Existing strategies and current plans for reduction;
- Applicable legislation;
- Strategies and policies “under preparation";
- (Future) social trends;
- Baseline scenario;

Current plans for reduction have been defined as policy determined intention to achieve specific national emission reduction targets or their ceilings as defined in the different protocols to UNECE/CLRTAP.

Applicable legislation is defined as national (and/or within EU) legal regulations in force by a given agreed date.

Policies “under preparation” are those proposed national and international legal and regulatory measures that are expected to be adopted within a short period.

Future social trends are expected future trends of the most important and relevant activities that have impact on the size of emission quantities of pollutants in the air for a specified source and pollution. These are the main activities assumed to be driving forces behind emissions of a specific sector, for example consumption of energy in a sector, steel production, etc.

Configuration of these trends is often called **"scenario"** (e.g. energy scenario) and therefore, in this Chapter, terms “future social trend” and “scenario” are used as synonyms.

Baseline (emission) scenarios are defined as combination of assumptions for the future social trends and existing legislation. For the baseline scenario, it is important that assumptions and simplifications are clear and explicit in the preparation of emission projection. This scenario does not induce fundamental variations in socio-economic development and in the implementation of the current legislation (national and international regulations). Therefore, this scenario is also sometimes called “business as usual” scenario.

4.2 Definition of scenarios

There are scenarios using projection of air pollutants emission reductions from 2010 to 2020 where those cause acidification and eutrophication, as well as emissions from large combustion plants (LCPs) and transport. These methodology and terminology are in line with UNECE, namely EMEP Protocol and CLRTAP Guidelines.

Scenarios are most often defined as combination of existing and assumed future social trends (industry, energy, GDP, etc.) and existing legislation.

Baseline scenario (BS)

Determination of projections under the **baseline scenario** or business as usual scenario means that determination of emission projections takes into account all policies and measures planned by the year selected as baseline year. The baseline scenario is usually a framework and starting point for each emission projection. It is important that in case of preparation of emission projections under the baseline scenario, official documents, applicable legislation and year of fulfillment of individual emission reduction measures are used.

Baseline scenario - BS or business as usual scenario takes the specified quantities of pollutants presented by the SNAP nomenclature of activities for the emissions in 2008, in accordance with CORINAIR methodology, reported to CLRTAP. These are presented in more detail in the Informative Inventory Report for 2008 on the Republic of Macedonia [10] - IIR (Informative Inventory Report). At this point, we should mention that these values have been obtained without application of reduction measures and their determination has been based on existing documents, applicable legislation and other data in the period of inventory taking.

The baseline scenario involves identification of the key sources of individual pollutants (presented in IIR for 2008 on the Republic of Macedonia), use of available environmental plans and programmes, programmes for country development, identification and observation of future possible activities aimed at reducing the emissions of pollutants into the air.

By way of using data on emissions from IIR for 2008, showing total quantities of pollutants in all SNAP sectors and share of individual sectors, we obtain the key sectors, i.e. sectors with highest share for individual pollutants.

Shares of emissions of sulphur dioxide -SO_2, nitrogen oxides-NOx, volatile organic compounds -VOC and ammonia-NH_3 by key sectors are presented in the text below.

Determination of projections for 2010, 2015 and 2020, respectively, under the baseline scenario, is mostly based on energy sector (combustion of fuels, energy production), which includes activities under SNAP sectors 01, 02,03, 05, 07 and 08. Given the fact that the greatest consumption of energy takes place in the mentioned sectors, broadcasting of projections in this Programme is based on data contained in the Strategy for Energy Development in the Republic of Macedonia by 2030 [2], Energy Balance of the Republic of Macedonia for the period 2012 to 2016 [11], Strategic Environmental Assessment of Strategy [3], Strategy for Energy Efficiency Promotion in the Republic of Macedonia by 2020 [4], Baseline Study on Renewable Energy Sources in the Republic of Macedonia [5], National Strategy for Transport [6] and other documents on energy sector.

Projections under the baseline scenario for pollutants from production processes related to use of volatile organic compounds - VOC, as well as ammonia from agricultural sector, depend on several aspects which in our case have not been sufficiently explored or available. Official data from the State Statistical Office or other competent institutions is limited in size in order to broadcast with greater certainty the quantities of these pollutants by 2020. This means that, for the purposes of development of this Programme, projections of volatile organic compounds and ammonia will be made on the basis of use of documents available to us.

First mitigation scenario – (FMS)

The scenario of application of measures for emission reductions towards determination of quantities of pollutant emissions in the air involves certain existing, defined, and adopted, as well as future policies and measures for emissions reduction. These include economic and energy projections and impacts of envisaged policies and measures in order to establish their primary goal, i.e. whether they will result in reduction of emissions into the air or not.

The First mitigation scenario is based on data contained in the Strategy for Energy Development in the Republic of Macedonia by 2030 [2], Energy Balance of the Republic of Macedonia for the period 2012 to 2016 [11], Strategic Environmental Assessment of Strategy [3], Strategy for Energy Efficiency Promotion in the Republic of Macedonia by 2020 [4], Baseline Study on Renewable Energy Sources in the Republic of Macedonia [5], National Strategy for Transport [6] and other documents on energy sector.

Projections under the first mitigation scenario from production processes associated with the use of volatile organic compounds - VOC, as well as ammonia from agricultural sector, depend on several aspects which in our case have not been sufficiently explored or available. This means that, for the purposes of development of this Programme, projections of volatile organic compounds and ammonia will be made on the basis of use of the documents: Code of good agriculture and hygiene practice and Common basic programme for livestock breeding) for the period 2011-2020.

Second mitigation scenario – (SMS)

The Second mitigation scenario is a reflection of expected results of emissions if the planned policies and measures of realistic chances are adopted and implemented within the timeframe of the period for which emission reductions are projected (2020). This scenario is based on planned, but still not adopted policies and measures, broadcasts for further actions to be included for the purpose of emissions reduction.

At this moment, due to lack of data and impossibility to use broadcasting models, the second mitigation scenario will not be used for determination of projections for 2015 and 2020, respectively.

4.3 Energy

Considering the fact that projections of pollutants quantities for the period from 2010 to 2020 will be to a great extent based on data on energy sector, the text below will briefly describe the energy sector of the Republic of Macedonia.

Energy sector contributes highest percentage (around 85 to 90%) in to ambient air pollution in the Republic of Macedonia.

In the period preceding 2010, documents were prepared in the energy sector where measures for efficiency were defined, and this offers the possibility to project both energy demand and consumption by 2020.

Energy infrastructure of the Republic of Macedonia enables exploitation of domestic primary energy, import and export of primary energy, processing of primary energy and final energy production, as well as energy transport and distribution. Energy infrastructure consists of sectors for coal, oil and oil products, natural gas, electricity productionт sector and heat production sector.

Projections of polutant emissions under the scenario for development of the energy system based solely on coal indicate average annual growth rate of 3.6% in the period 2008-2020, while in case of analysis of environmentally mitigated scenarios (introduction of co-generation gas plants, reduction in electricity consumption and increased use of renewable energy sources), the average annual growth rate for the period 2008-2020 will drop to 1.4%.

At the same time, measures are required to improve energy efficiency in production, transmission, distribution and consumption of energy, especially electricity, maximum utilization of renewable energy sources and as high as possible exploitation of natural gas.

In the context of the above, protection of the environment should be taken into account. In energy sector, this assumes action primarily through energy efficiency, renewable energy sources, selection of environment friendly energy resources and technologies, legislation and monitoring, education and public awareness, as well as promotion of positive examples.

Electric energy sector

Structure of electric energy system of Macedonia consists of:

- Hydro power plants with designed capacity of 580 MW;
- Thermal power plants on lignite with total designed capacity of 800 MW and crude oil with a capacity of 210 MW;
- Electricity transmission system, long distance transmission line with a voltage of 400 kV (594 km), 220 kV (103 km), and 110 kV (1480 km).
- Electricity distribution system. Distribution network consists of 150 km with a voltage of 110 kV, 1000 km of 35 kV, 720 km of 20 kV, 8900 km of 10 kV and 11600 km of 0.4 kV.

Operation of the Electric Energy Company (EEC) of Macedonia is managed by four entities, namely: AD ELEM - Skopje (Electric power plants of Macedonia) in state ownership, Joint Stock Company for electricity production and supply – AD MEPSO – Skopje (Macedonian electricity transmission system operator) in state ownership, operator of electricity transmission system of Macedonia - Joint Stock Company for electricity transmission and management of electric energy system of Macedonia Distribution Company EVN Macedonia AD and AD “TEC Negotino” in state ownership, Joint Stock Company for electricity production.

Heating facilities producing heat are mainly based on crude oil combustion and partially gas fuels. This causes air pollution with SO_2, NOx, TSP and CO, which has direct negative impact on the environment, as well as with gases (CO_2, CH_4, N_2O) with global negative impact through greenhouse effect.

IN most cases, SO_2 emission from electricity and heat production exceeds the ELV. This is due to combustion of low calorific coal in thermal power plants and combustion of crude oil in central heating plants.

Sector for oil and oil products

Capacity of OKTA Refinery and oil pipeline OKTA – Thessaloniki port satisfies the demand for oil products of the country in full, though the refinery requires modernization primarily for more efficient protection of the environment and improvement of performance efficiency.

Republic of Macedonia has Refinery for biodiesel fuel production, which under the license issued by the Regulatory Energy Commission has a capacity of 20 thousand tons per year, owned by Makpetrol company. Company BIODI-COM from Vasilevo also has license for biodiesel fuel production with a capacity of 400 t per year. Non-refined oil of rape seeds is used for biodiesel fuel production. At this stage, non-refined oil is imported.

Compared to countries in our surrounding, the Republic of Macedonia has a low number of petrol stations which are unevenly distributed on its territory. Petrol stations are owned by several companies, more prominent among which are Makpetrol, OKTA and Lukoil Macedonia. Besides sale of fuels at petrol stations, companies are also involved in wholesale trade in oil products.

Sector for natural gas

Republic of Macedonia is connected to only one main gas pipeline. The whole quantity of natural gas is imported from Russia through the gas pipeline which enters the country at Deve Bair on the border with Bulgaria and extends through Kriva Palanka, Kratovo and Kumanovo to Skopje. The national gas pipeline has a capacity of 800 million Nm^3 on annual basis with a possibility for increase to 1200 million Nm^3 per year. In this phase of the development of the gasification in the Republic of Macedonia, the primary distribution network has already been built in Kumanovo and Strumica, to which around ten consumers have been connected, while secondary distribution network is under development. In practical terms, distribution network enabling massive use of natural gas in households does not exist.

Sector for heat

At present, heat production in the Republic of Macedonia is mostly carried out in boilers fired on liquid oil products, natural gas and coal. Major part of them is old and has low performance coefficient.

The overall heat consume connected to heating systems at the threshold of a building is around 630 MW. The largest heating system is the one operated by Toplifikacija AD Skopje, to which around 550 MW are connected. Around 80 MW are connected to several smaller size systems, only two of which are outside Skopje. Under such rate of connection, it may be concluded that around 10% of users in the country are connected to central heating systems.

Renewable energy sources

From among renewable energy sources, hydropower is primarily used in the Republic of Macedonia (for electricity production), as well as biomass (mostly wood mass for heat generation in households), geothermal energy (mostly for greenhouses heating) and solar power to a modest extent (for hot water in households and for electricity production).

Energy Balance of the Republic of Macedonia

Energy Balance is indicative planning document and it presents the demand for total quantities of energy and for individual energy types, and possibilities for their supply through production in domestic facilities and import, for the period 2012 to 2016.

Energy Balance of the Republic of Macedonia for the period 2012 to 2016 (hereinafter: Energy Balance) has been developed in accordance with the Law on Energy and Rulebook on energy balances and energy statistics.

Energy balance to meet the estimated demand is prepared for each energy type. On the basis on data on individual balances, final consumption has been calculated, as well as demands for primary energy to secure the final consumption.

Consumption of final energy and energy resources from 2008 to 2011

Final energy consumption in the period 2008 to 2011 noted slight increase of 2.1%. Increase in consumption relative to 2010) is notable with all energy types and energy resources, except oil derivatives, where reduction in consumption has been recorded. With reference to the quantities planned in the Energy Balance for 2011, it is notable that the total final consumption realized in 2011 is by 12.7% lower than the planned one, so that reduction occurs with all energy types relative to planned quantities, except geothermal energy where consumption is higher than the planned one. The greatest impact on the lower total final consumption comes from deviations in oil derivatives (19.7%), electricity (5.1%) and lignite and coal (26.9%).

The highest share in final consumption belongs to electricity (between 37.9% and 41.1%) and oil derivatives (between 36.7% and 42.6%), whiles all other energy forms have total share within the range from 19.5% to 22.2%.

Consumption of primary energy and energy resources from 2008 to 2011

With regard to the consumption of primary energy in the period 2008 to 2011, there was slight increase in 2011 (following decrease in 2009 and 2010), by 1.0% higher than in 2008. In relation to 2008, increase in primary energy has been noted with electricity (14.5%), coals (1.7%), natural gas (14.7%), fire wood (1.8%) and geothermal energy (18.7%). There is a decline in raw oil and oil derivatives (7.2%) and coke (4.1%).

Consumption of primary energy in 2011 is by 5.6% higher than the consumption in 2010. Increase in the consumption of primary energy was recorded with natural gas (15.4%), geothermal energy (14.9%), lignite and coal (14.4%), electricity (6.7%), coke (3.2%) and fire wood (0.9%). Reduction is recorded only with raw oil and oil derivatives of 8.7%.

Lower consumption of primary energy than the planned one is recorded with natural gas (68.0%) due to lower production of electricity by TETO Skopje, which is under trial operation, then with raw oil and oil derivatives (15.3%), coke (14.1%), fire wood (11.1%) and lignite and coal (1.6%). On the other side, there is increase with electricity and geothermal energy compared to plans by 45.8% and 35.6%, respectively.

In the period 2008 to 2011, coal (from 46.1% to 49.9%) and raw oil and derivatives (from 25.3% to 31.9%) had dominant share in primary energy. Other forms of energy contributed 19.0% to 24.7%. In the period 2008 to 2011, the share of domestic sources in the total demand for primary energy was in the range from 56.9% to 58.8%, while in the same period the net import ranged from 41.2% to 43.1%.

Consumption of final energy and energy resources from 2012 to 2016

Final energy consumption for the period 2012 to 2016 has a trend of increase by 2016 relative to 2011, with an average annual rate of 2.2 % per year, so that in 2012 consumption is higher compared to 2011 by 3.9%. In 2012, there is increase for all energy types and energy resources, with the highest increase expected for natural gas (10.1%) and oil derivatives (6.9%), while the increase for other types is below 5%.

By 2016, all energy types are expected to note constant increase, with the highest average increase for natural gas (4.9 %/year), while this increase for other energy forms is mainly lower than 3%, except for coke (3.2 %/year). The increase in the consumption of natural gas is to the greatest extent due to extension of natural gas distribution systems in Kumanovo and Strumica and the increase with these systems reaches 23.5%/year. Apart from this, significant increase in the consumption of natural gas is expected in future for electricity production (and heat energy production) with the entry into operation of TETO Skopje.

The structure of the final energy consumption will not variate significantly. The highest share belongs to electricity (from 40.2% to 41.0%) and oil derivatives (from 36.9% to 37.8%), while all other energy forms will contribute within the range from 21.5% to 22.1%).

Consumption of primary energy and energy resources from 2012 to 2016

The demand for primary energy to meet the final consumption in the period 2012 to 2016 will grow throughout the period with the average rate (relative to 2011) of 2.3%/year. The highest increase is expected for natural gas

(29.1%/year), while the increase for other energy forms is lower than 3.2%/year, while electricity is expected to note reduction with an average rate of 2.7%/year. This increase in the demand for natural gas is due to increased consumption in TETO Skopje and distribution consumers in Kumanovo and Strumica.

Primary energy in 2012 will be higher compared to 2011 by 7.5%. This increase results from the increase for natural gas, raw oil and oil derivatives of 7.9%, geothermal energy of 3.8%, coke of 3.2%, fire wood, lignite and coal (0.2%), while electricity will undergo reduction by 35.9%.

As a result of the increase in the consumption of natural gas as of 2012, the share of all other energy forms will decrease. However, the highest share in primary energy will remain to belong to solid fuels (lignite and coal) within the range of 45.0% to 46.8%, followed by raw oil and derivatives with a share of 24.7% to 25.4% and natural gas (from 12.2% to 12.6%). Other energy forms have a total share ranging from 15.5% to 17.8%.

Increased consumption of natural gas after 2012 (compared to previous period) will have impact on the structure of primary energy sources.

Due to the above, net import of primary energy forms will grow from 41.5% in 2011 to 46.2% in 2016.

Data from strategic documents listed in part 4.3 Energy was used to determine projections of emissions of specified pollutants under the baseline scenario and first mitigation scenario.

4.4 Projections for sulphur dioxide emissions

4.4.1 Emissions of sulphur dioxide under the baseline scenario (BS)

In order to determine projections for annual quantities of sulphur dioxide emissions for 2010, 2015 and 2020, respectively, with assumptions taken as baseline scenario, we will first present the overview of the distribution of SO_2 emissions in the Republic of Macedonia by key sectors.

The key sectors for sulphur dioxide emissions are the sectors public energy and heating plants with 85.2% and combustion plants in production and construction industry: iron and steel with 10.5%. These emissions of SO_2 result from combustion of fossil fuels in electricity production by thermal power plants fired on coal (REK Bitola and REK Oslomej) that lack desulphurization plants. Apart from these, there are also emissions originating from combustion of liquid fuels from heat production and processes in industrial production, iron and steel and construction. Other annual quantities of emissions with around 4.3 % result mainly from combustion processes in the remained industrial production and household fireplaces, oil refining, and minor part from combustion of liquid fuels in mobile sources. For this fact exactly, the energy sector has been elaborated in more detail. The goal is to identify emissions of SO_2 and undertake measures for their reduction.

Table 12. Key sectors for sulphur dioxide - SO_2 for 2008

Code	Key sectors	kt	%
1A1a	Public energy and heating plants	96.715	85.2%
1A2a	Combustion plants in production and construction industry: iron and steel	11.872	10.5%
1A2b	Combustion plants in production and construction industry: non-ferrous metals	1.571	1.4%
1A4ai	Commercial/Institutional: Stationary	0.842	0.7%
1A1b	Oil refining	0.814	0.7%
1A3b	Road transport	0.779	0.7%
2C2	Production of ferro-alloys	0.281	0.2%
1A4b	Residential:Stationary plants, households and gardening (мобилни)	0.262	0.2%
1A2fi	Combustion plants in production and construction industry: Other	0.203	0.2%
1A4cii	Agriculture/Forestry/Fishery: Vehicles outside public roads and other machinery	0.168	0.1%

1A3c	Railroads	0.026	0.0%
2C1	Production of iron and steel	0.023	0.0%
1A3ai	International air transport	0.013	0.0%

As already mentioned, development of the baseline scenario while elaborating the projections under this document was based on the baseline scenario from the Strategy for Energy Development [2]. Under it, the demand for energy will be growing by 2020 with average annual rate of 2.6%, but the share of renewable energy sources (RES) will also grow, as will the use of natural gas. This results in expected reductions in the quantities of SO_2 after 2015. The sector for electric and heat energy production, where the share of RES and natural gas is the highest, has been taken to calculate and estimate the reductions in the quantities of SO_2 by 2020, taking into account that the highest share of SO_2 emissions originates from that sector.

In the period 2010 to 2020, for which quantities of sulphur dioxide emissions are broadcasted and projected, under the baseline scenario, the highest rate of increase related to energy production is expected with solar energy, amounting around 14.5%, followed by natural gas with 7.8%, geothermal energy with 9.7% and oil products together with biofuels with 3.1%. The rate of increase for electricity is 2.5%. The lowest rates of increase are broadcasted for coal of 1.6%, heat 1.2% and biomass for combustion - 0.7%.

During the analyzed period, the share of oil products increases, while the share of electricity decreases from 34% to 33%. By this, coal will reduce its share by one percentage. The share of natural gas of 2% will rise by nearly 4%, and the share of geothermal and solar power will increase, too.

Based on the above data, projections of the quantities of emissions result in reduced emissions of SO_2 by 2020. The obtained values, quantities of emissions, have slight increase by 2015, to start dropping by 2020. Table 13 and Figure 8 show projected quantities of SO_2 emissions under the baseline scenario and ceiling.

Table 13. Total quantities of SO_2 emissions under the baseline scenario and ceiling

year	2010	2015	2020	National ceiling
SO_2 [kt]	**115.14**	**130.3**	**99.22**	**130**

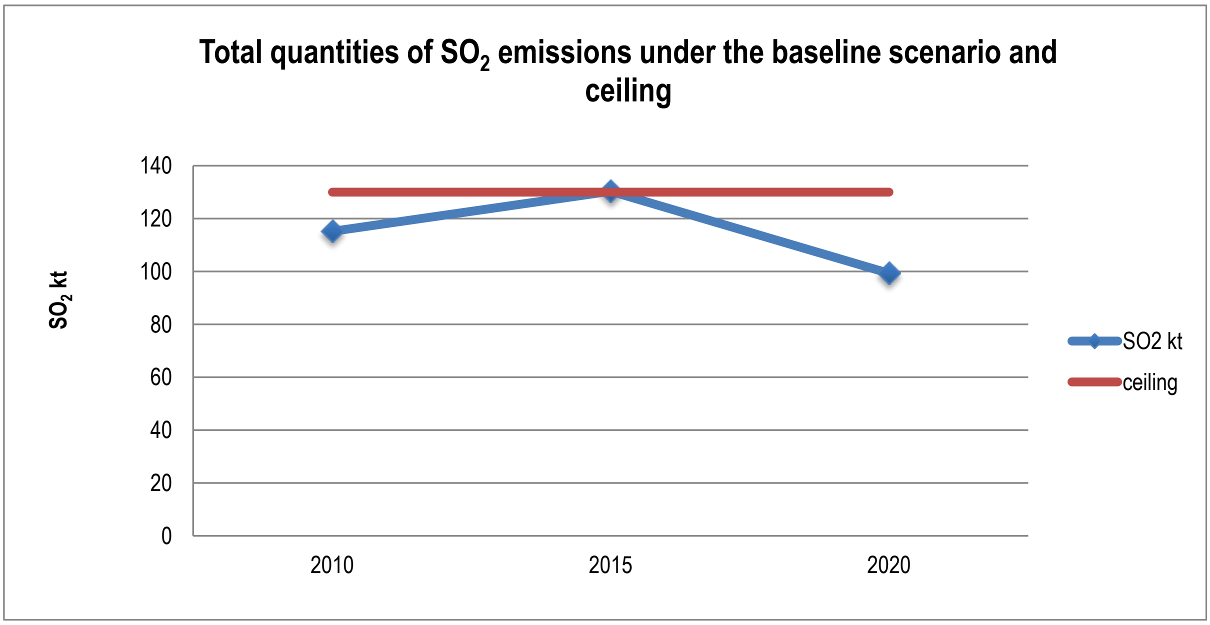

Figure 8. Total quantities of SO_2 emissions under the baseline scenario and ceiling

4.4.2 Emissions of sulphur dioxide under the first mitigation scenario – (FMS)

Under the first mitigation scenario, determination of the quantities of sulphur dioxide emissions in the air is carried out by way of using certain existing, defined, adopted and further policies and measures for emissions reduction by 2020. These include economic and energy projections and impacts of envisaged policies and measures regarding reduction of SO_2 emissions and protection of the environment. Analysis is performed to establish their primary goal, i.e. whether they will result in reduction of emissions into air or not.

Based on the above, it is evident that the reduction of sulphur dioxide emissions in the area of energy through undertaking measures for reduction of pollution from energy resources will result in significant reductions in the quantities of sulphur dioxide emissions.

Therefore, the first mitigation scenario (FMS) includes measures for energy efficiency by which the demands for energy resources will grow with an average annual rate of 2.16% by 2020. Annex 1 describes the basic measures for energy efficiency.

Improvement in energy diversity in supply with primary energy has been envisaged by 2020. Coal together with oil and oil products will reduce their share by 2020, while the share of natural gas will grow from 2.4% in 2006 to 16% in 2020, while the share of renewable energy sources in the total primary energy in the same period will increase from 11.5% to 13.3%.

The highest rate in growth is again noted with solar energy of 17.8%, followed by geothermal energy with 11.7% and natural gas with 10%.

The first mitigation scenario with measures based on energy efficiency includes to the greatest extent oil products, electricity production, as well as increased level of use of biomass, natural gas, geothermal energy and solar energy.

Under this scenario, natural gas will increase its share to the detriment of oil products, and the share of solar and geothermal energy will increase compared to the baseline scenario.

During the analyzed period, 80% of electricity production originate from thermal power plants fired on coal and 20% from renewable sources.

Measures for reduction of the quantities of sulphur dioxide emissions are defined in the part of Annex 3 concerning the use of BATs in previously listed sectors.

Table 14 and Figure 9 present projected quantities of SO_2 emissions under the first mitigation scenario and the ceiling. Emission quantities have slight increase by 2015 of around 12.94 kt, to start falling by 2020 by 43 kt. This is due to the application of energy efficiency measures that are reflected especially after 2015 in reduced emissions of SO_2 by 2020.

Table 14. Total quantities of SO_2 emissions under the mitigation scenario with energy efficiency measures

year	2010	2015	2020	National ceiling
SO_2 [kt]	**114.76**	**127.7**	**84.63**	**130**

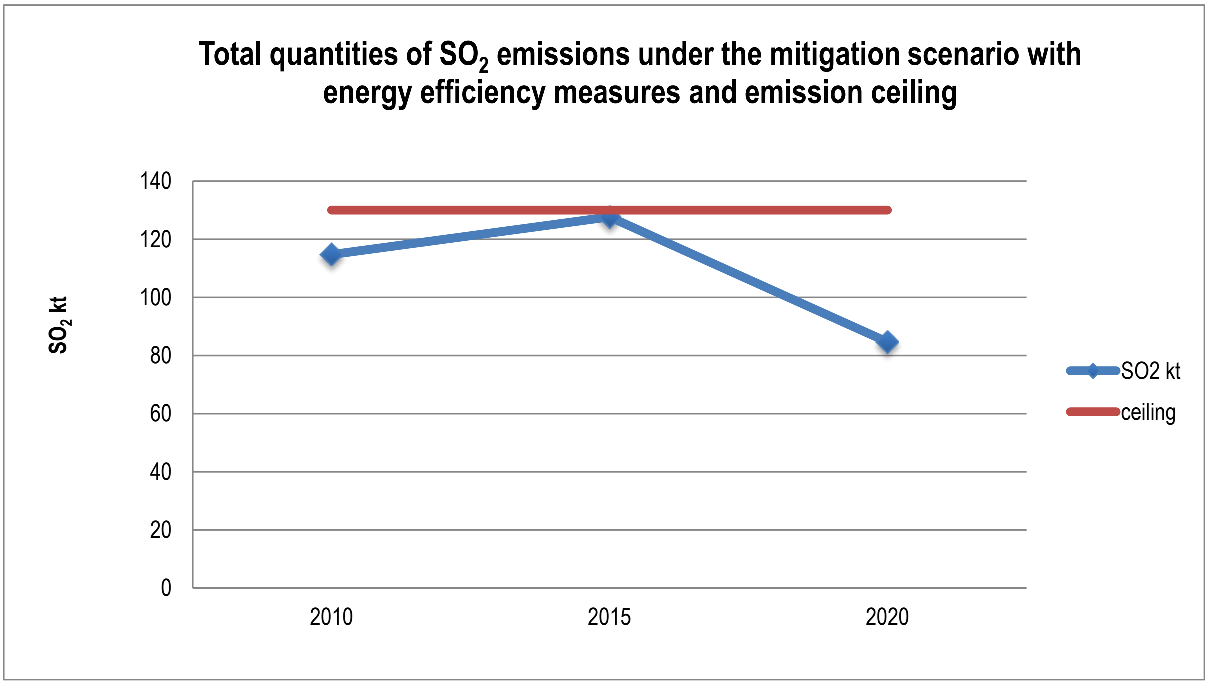

Figure 9. Total quantities of SO_2 emissions under the mitigation scenario with energy efficiency measures and emission ceiling

4.4.3 Emissions of sulphur dioxide under the scenario with use of models

Total quantities of SO_2 emission for the period 2005-2020 have been obtained on the basis of the baseline scenario by application of the GAINS model (Greenhouse Gas and Air Pollution Interactions and Synergies)[12], created by IIASA (International Institute for Applied Systems Analysis). This model examines the relation between the control of local and regional air pollution and transfer of greenhouse gas emissions at global level. GAINS is applied in 43 countries in Europe, including Russia. This model takes into account the emissions of the main pollutants, including SO_2. Data on the total quantities of SO_2 emissions presented in the next Table was taken over from the Report of CIAM (Centre for Integrated Assessment Modelling)[13].

We should also note that determination of the projections for SO_2 emissions from energy, for the Republic of Macedonia, is based mainly on the model PRIMES 2008, which covers the energy sector in full. Under the model, ways of presentation are used, i.e. “bottom-up” (engineering, explicit technological choices) and “top-down” (micro-economy, consistent economic decisions). The model uses different modules for each demand and decision. Decentralized decisions forming demand and supply of certain energy products, establishment of balance between demand and supply with electricity counted by energy article, trade in gas or electricity within EU and beyond EU, taxes, trading permits, subsidies and certificates are taken into account. The basis of the model are markets related by submodels to sectors for electricity demand and production and fuel supply. The model covers the period from 2000 to 2030, given the fact that it is fully calibrated with the data of EUROSTAT for the period 1990 to 2005, while projections start from 2010 [14]. Obtained results for SO_2 through application of the mentioned models are presented in Table 15.

Table 15. Total quantities of SO_2 emissions under the scenario with use of models

year	2005	2010	2015	2020	National ceiling
SO_2 [kt]	**99.72**	**112.85**	**93.59**	**15.22**	**130**

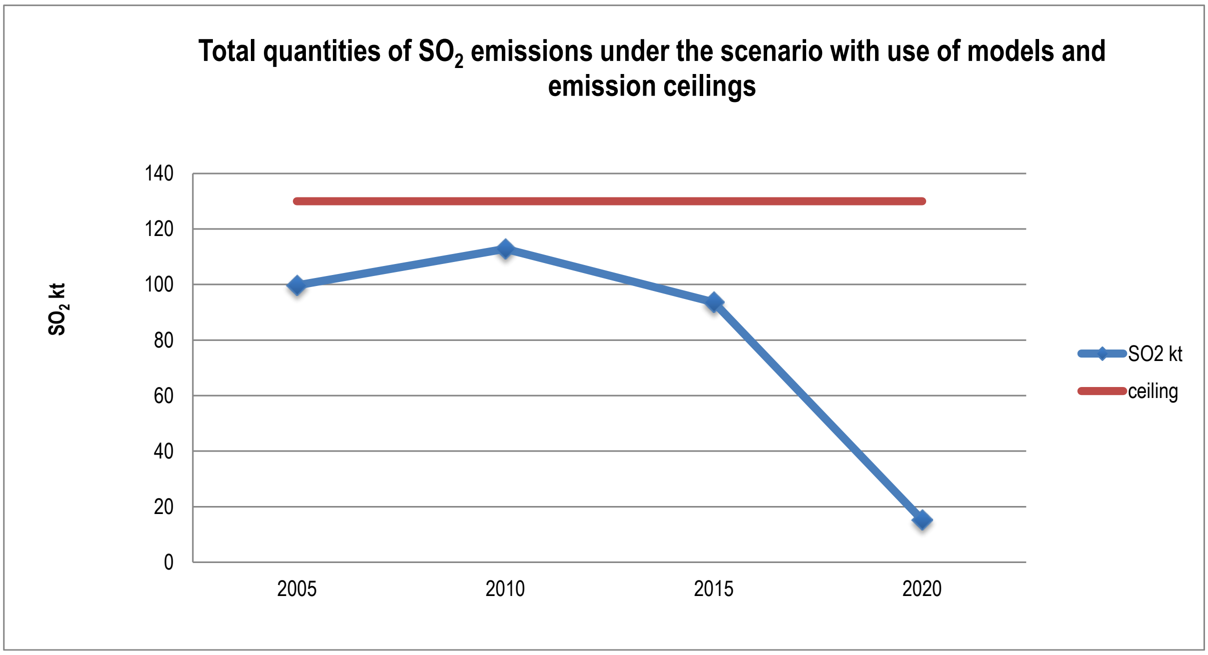

Figure 10. Total quantities of SO_2 emissions under the scenario with use of models and emission ceilings

4.4.4 Conclusion

The above presented scenarios are in compliance and in line with the strategic documents in the area of energy, as there are relevant documents in the domain of energy available at this moment. Based on this, further projections and broadcasts of the quantities of SO_2 emissions for 2015 and 2020 by application of measures for emission reduction will be based on energy production and consumption (electricity, liquid and gaseous fuels, bio-fuels, renewable sources).

As supplement to scenarios, we have taken partially available data from production and industrial processes, oil refining, agriculture and transport. Apart from this, we had to accept certain approximations and develop, from among all data available through integrated approach, the broadcasts for emission quantities, i.e. way towards their reduction by 2020.

Having reviewed the data obtained on projected quantities of sulphur dioxide emissions from 2010 to 2020, and taking into account that the implementation of the envisaged activities depends on different factors, we made comparison of data in Table 16.

Table 16 and Figure 11 show quantities of SO_2 emissions under the three scenarios and emission ceiling, including comparison between them.

Table 16. Total quantities of sulphur dioxide emissions by comparison of the three scenarios

year	2005	2010	2015	2020	National ceiling
SO_2 [kt] - BS		**115.1383**	**130.2684**	**99.21763**	**130**
SO_2 [kt] - FMS		**114.7563**	**127.6971**	**84.62121**	**130**
SO_2 [kt] - Model	**99.72**	**112.85**	**93.59**	**15.22**	**130**

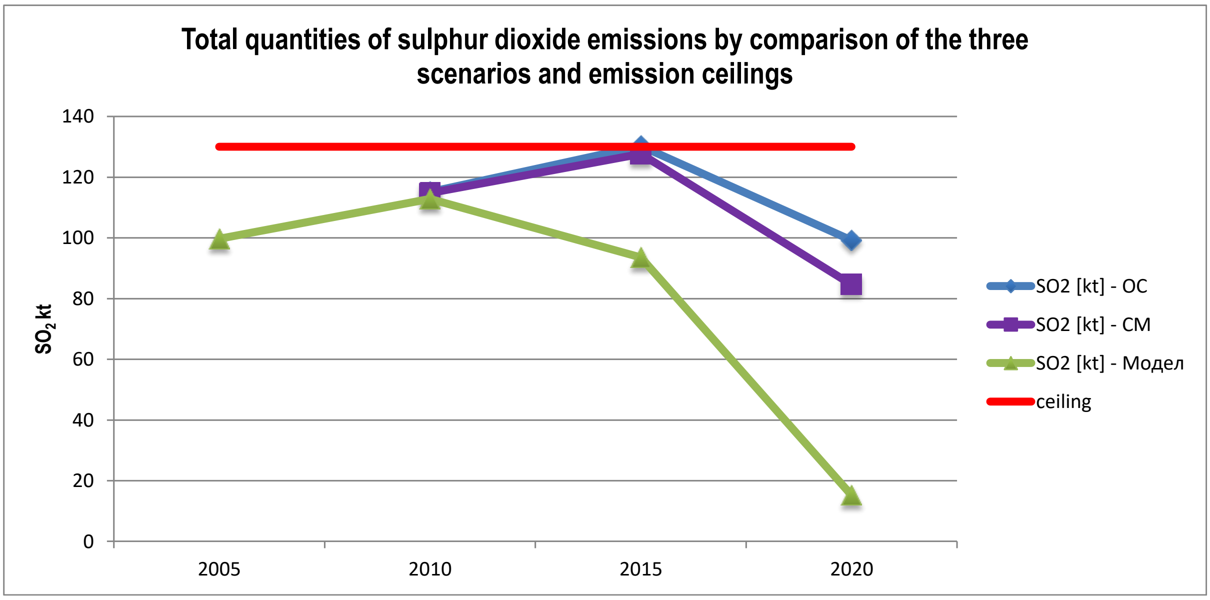

Figure 11. Total quantities of sulphur dioxide emissions by comparison of the three scenarios

Projections indicate that the trend of reduction of sulphur dioxide emissions for 2010 under the baseline scenario relative to first mitigation scenario is 0.04%, while baseline scenario compared to scenario using broadcasting models results in sulphur dioxide emission reduction of 2%.

For 2015, projections indicate that the reduction of the quantities of sulphur dioxide emissions under the baseline scenario compared to first mitigation scenario is 2%, while baseline scenario compared to scenario using broadcasting models results in sulphur dioxide emission reduction of 28.2%.

The trend of reduction of the quantities of sulphur dioxide emissions, according to projected quantities for 2020 under the baseline scenario relative to first mitigation scenario is 14.7%, while baseline scenario compared to scenario using broadcasting models results in sulphur dioxide emission reduction of 84.7%.

Projected values of the quantities of emissions under the baseline scenario compared to the first mitigation scenario indicate that, from 2010 towards 2020, the percentage of reduction in the quantities of sulfur dioxide emissions increases from 0.04 % to 14.7%, which suggests that it is realistic to achieve it through application of the proposed measures. With reference to scenario developed through use of broadcasting models, the percentage of reduction in the quantities of sulphur dioxide emissions from 2010 to 2020 of 84.7%, considering the production of energy planned by 2020, as well as use of fuels in other sectors, it seems to be too ambitious due to the fact that its implementation is conditioned by huge financial resources.

The above presented analysis is in line with data according to which it is planned that the production of electricity from thermal power plants fired on coal will amount 42%–51% by 2020, depending on the scenario, from natural gas and renewable energy sources 24%–28%, respectively and from thermal power plant fired on crude oil 2%–3%.

It should be pointed out that in the course of the analyzed period from 2010 to 2015, there are values of sulphur dioxide emissions close to the emission ceiling amounting 130 kilo tons per year, adopted on the basis of the Directive on emission ceiling for certain pollutants (32001L0081), while these quantities have great trend of reduction by 2020. This is most probably due to the fact that sulphur dioxide emissions projected under the baseline scenario and under the scenario involving energy efficiency measures assume implementation of the documents already adopted and documents to be adopted and finalization of projects in this area by 2020. Further reduction of sulphur dioxide emissions to reach values close to those of emissions envisaged by use of models requires as a measure application of recommended BATs in the sectors for energy production, reorganization of electricity production with higher share of 20% for renewable energy sources and modernization of industrial and production processes. Annex 3 describes BATs that should be used in the analyzed sectors.

4.5. Projections for nitrogen oxides emissions

4.5.1 Emissions of nitrogen oxides under the baseline scenario (BS)

In order to determine projections for annual quantities of nitrogen oxide emissions for 2010, 2015 and 2020, respectively, under the baseline scenario, we will first present the overview of the distribution of NOx emissions in the Republic of Macedonia by key sectors.

The key sectors (presented by SNAP methodology) with the greatest contribution to the quantity of nitrogen oxide emissions are the sectors for public energy (production of electricity and heat energy) with 37.2%, processes in production and construction industry: iron and steel with 11.3% and transport with 26.5%. These emissions of NOx result from combustion of fossil fuels in electricity production by thermal power plants fired on coal (REK Bitola and REK Oslomej) that do not use additives to reduce these emissions. Apart from these, there are also emissions originating from combustion of liquid fuels from heat production and processes in industrial production, iron and steel and construction. Other quantities of emissions result mainly from combustion processes in the remained industrial production, household fireplaces and oil refining.

Table 17. Key sectors for nitrogen oxides – NO_x for 2008

Code	Key sectors	k	%
1A1a	Public energy and heating plants	13.672	37.3%
1A3b	Road transport	9.711	26.5%
2C2	Production of ferro-alloys	4.154	11.3%
1A2fi	Combustion plants in production and construction industry: Other	2.338	6.4%
1A2a	Combustion plants in production and construction industry: iron and steel	1.579	4.3%
1A4cii	Agriculture/Forestry/Fishery: Vehicles outside public roads and other machinery	1.413	3.9%
1A4b	Residential:Stationary plants, households and gardening (mobile)	1.209	3.3%
1A2b	Combustion plants in production and construction industry: non-ferrous metals	1.176	3.2%
2B5a	Other: chemical industry	0.346	0.9%
1A4ai	Commercial/Institutional: Stationary	0.290	0.8%
1A1b	Oil refining	0.287	0.8%
1A3c	Railroads	0.174	0.5%
1A3ai	International air transport	0.135	0.4%
2C1	Production of iron and steel	0.132	0.4%

With regard to emissions from traffic, statistical data on the total number of vehicles is presented in Table 18 and the trend of growth by 2009 on Figure 12.

Table 18. Number of vehicles in the Republic of Macedonia

	2006	2007	2008	2009
Total	278864	287222	308494	332363

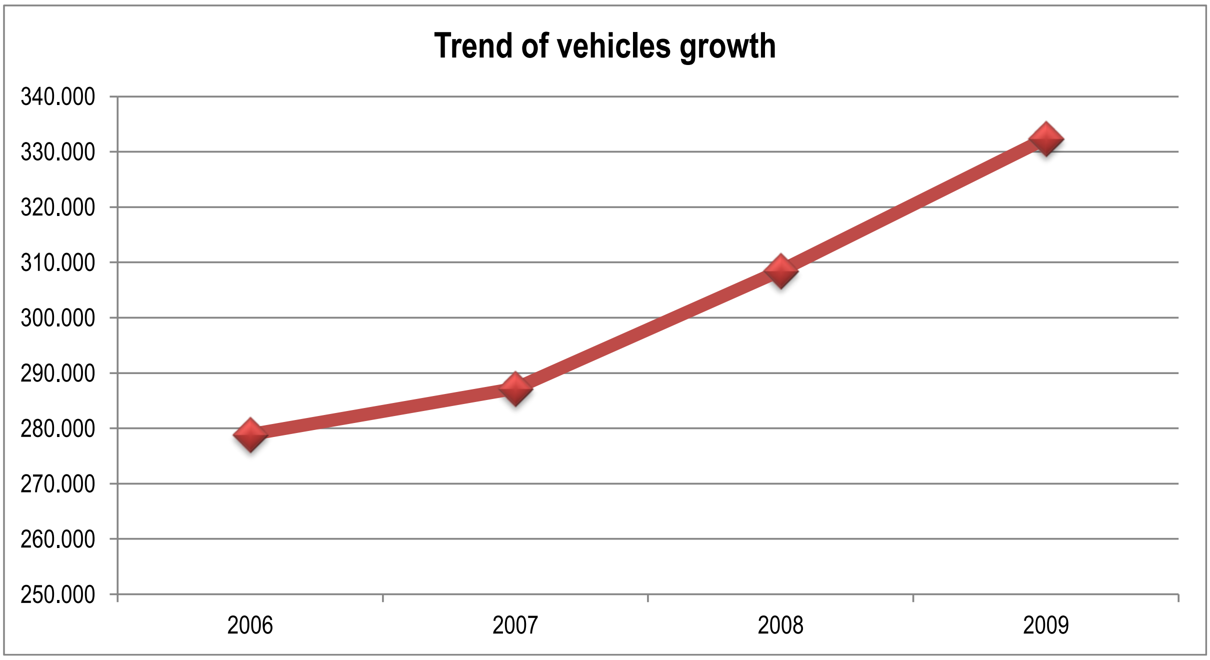

Figure 12. Trend of vehicles growth from 2006 to 2009

The growth of vehicles from 2006 to 2009 was 16% and to the most part concerned passenger vehicles. (Statistical Yearbook of the Republic of Macedonia for 2011 [16])

Table 19 and Figure 13 show total quantities of NO_x emissions under the baseline scenario and emission ceiling. According to this data, projections for emission quantities indicate reduction in NO_x emissions by 2020. Values obtained on the quantities of emissions indicate slight increase by 2015, after which reduction is expected by 2020.

Table 19. Total quantities of NO_x emissions under the baseline scenario and emission ceiling

year	2010	2015	2020	National emission ceiling
NOx [kt]	**33.27**	**37.65**	**28.67**	**39**

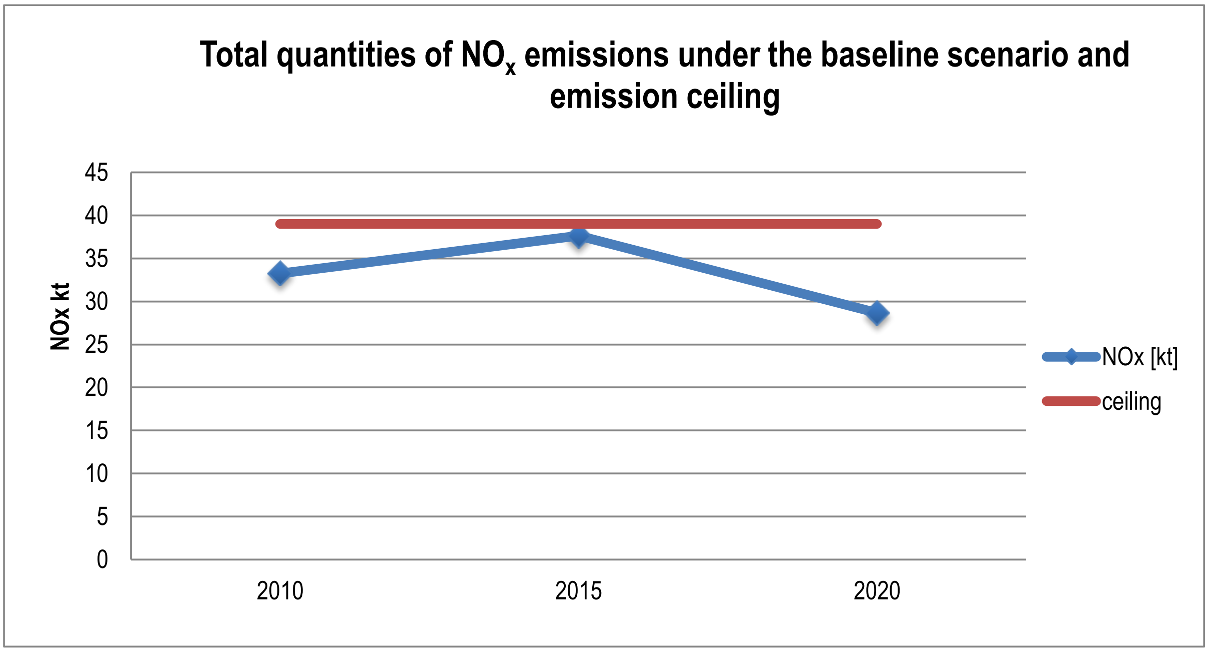

Figure 13. Total quantities of NO_x emissions under the baseline scenario and emission ceiling

Emissions of nitrogen oxides from heat and electricity production under the baseline scenario are in line with data presented in strategic documents in the area of energy. Analysis of these emissions is shown in the section on the baseline scenario for sulphur dioxide.

Emissions from transport sector are also relevant for this part, resulting from liquid fuels in vehicles, use of liquid fuels in construction industry, alloys and steel production.

The baseline scenario for the transport sector assumes establishment of stable economic growth and recovery the trend in the rate of motorization as of 2010. Under the baseline scenario, the rate of motorization in 2020 will reach the value of around 260 per 1000 inhabitants.

The structure of vehicles by the type of fuel they use is broadcasted on the basis of the analysis of the annual number of new vehicles sold in the Republic of Macedonia and possibility for renewal of vehicle fleet, as well as on the basis of broadcasts for fuel, performance and attractiveness of individual vehicle types. The set scenario of the vehicle structure by the type of fuel is in accordance with the National Strategy for Transport [6], where the goals of sustainable environment include the need for use of cleaner fuels and alternative vehicles. According to this broadcast, the percentage of vehicles with petrol engines will drop from the current 73% to around 63% in 2020 (average reduction rate of 0.67% per year). The percentage of vehicles with diesel engines will increase from the current 23% to around 28.6% in 2020 (average annual growth rate of 0.33%), while the percentage of vehicles with combination petrol-gas will increase from 3.6% to around 8.5% (average annual growth rate of 0.34%).

Under this scenario, it is assumed that the current distribution of 88% passenger cars,10% commercial vehicles and 2% motorcycles will remain unchanged throughout the broadcasting period.

Under the baseline scenario, relatively slow renewal of the vehicle fleet of only around 3.5% relative to the whole vehicle fleet is assumed.

4.5.2 Emissions of nitrogen oxides under the first mitigation scenario - (FMS)

Under the scenario assuming implementation of the measures listed in Annex 1 of this document, presented mostly as basic measures for energy efficiency, there is a trend of decline in the quantities of nitrogen oxides emissions. This is especially a result of projects that are carried out or will be initiated upon 2013 to last up to 2020.

There has been also a scenario for slow growth in the transport sector. The scenario of “slow growth” assumes recovery of the trend in the rate of motorization as of 2013.

Under this scenario of “slow growth”, it is envisaged that the number of vehicles will rise to 225 vehicles per 1000 inhabitants.

The total consumption of oil products in 2020 for the transport under the slow growth scenario will be by 13% lower broadcasted consumption in the same year under the baseline scenario. Consumption of oil products in the transport in 2020 will be by 63% higher than the one in 2007.

Measures for reduction of the quantities of NO_x emissions are also presented in the part on the use BATs on NO_x in sectors listed above.

Table 20 and Figure 14 present total quantities of NO_x emissions under the first mitigation scenario and emission ceiling. Quantities of NO_x by 2015 remain at almost the same level and then it will start to fall by 2020 by 9.36 kt.

Table 20. Total quantities of NO_x emissions under the first mitigation scenario

year	2010	2015	2020	National emission ceiling
NOx [kt]	**33.16**	**33.7**	**23.8**	**39**

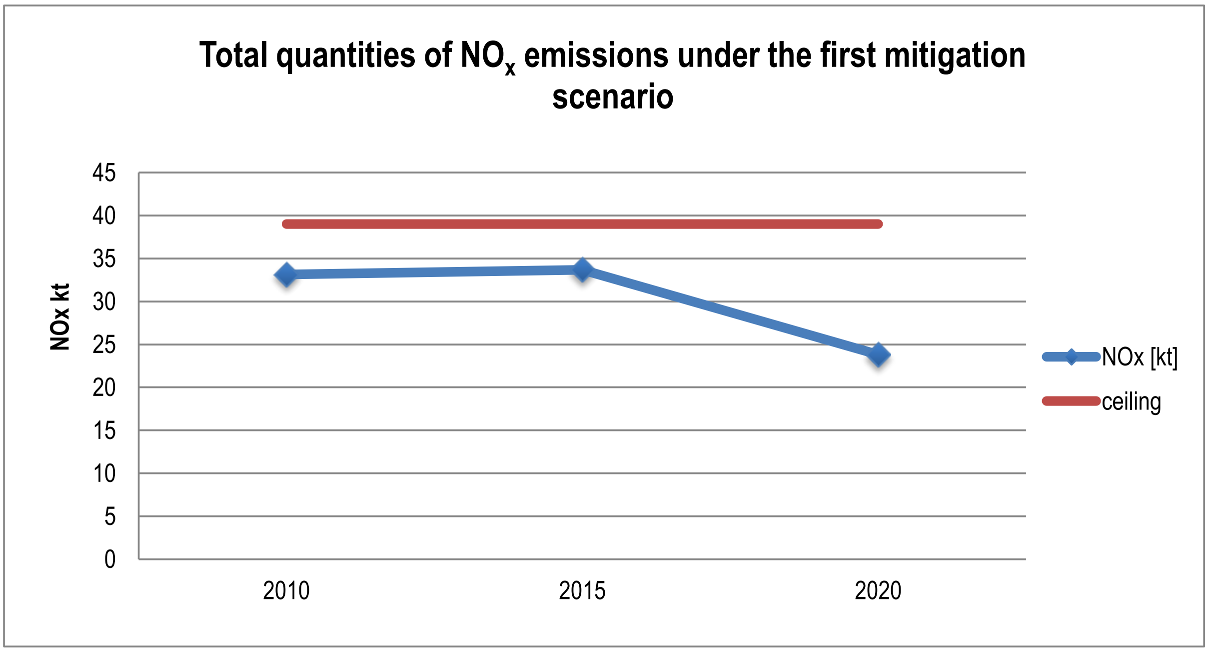

Figure 14. Total quantities of NO_x emissions under the first mitigation scenario

4.5.3 Emissions of nitrogen oxides by use of models

As in the case of SO_2, quantities of NO_x emissions for the period 2005-2020 have been obtained under the baseline scenario with application of GAINS model (see chapter 4.4.3). Data on the total quantities of NO_x emissions presented in Table 20 have been taken over from the Report of CIAM [13].

Table 21 and Figure 15 show total quantities of NOx emissions under the scenario based on use of models and emission ceiling.

Table 21. Total quantities of NO_x emissions under the scenario with use of models

year	2005	2010	2015	2020	National emission ceiling
NOx [kt]	**31.93**	**33.85**	**28.39**	**20.84**	**39**

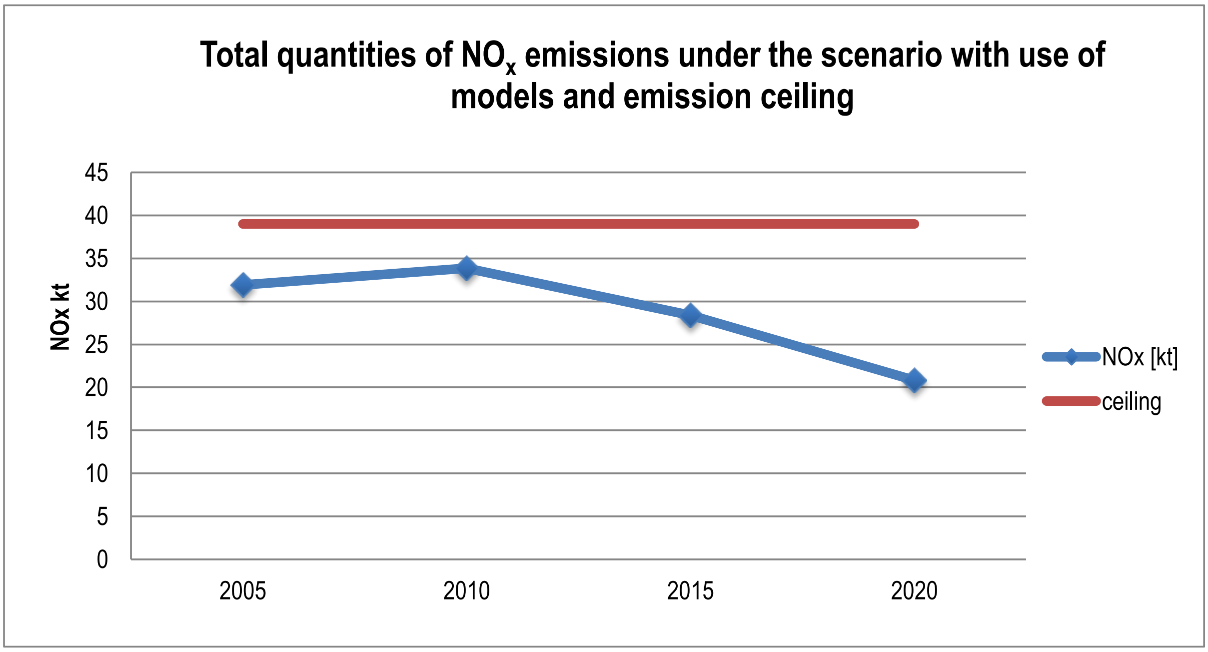

Figure 15. Total quantities of NO_x emissions under the scenario with use of models

4.5.4 Conclusion

Projections and broadcasts of the quantities of NO_x emissions for 2010, 2015 and 2020, respectively through application of measures for emission reductions are based on energy resources (electricity, liquid and gaseous fuels, bio-fuels, renewable sources).

Besides the above described measures, use of available data on transport has played an important role in the definition of scenarios. Also, projection of NO_x quantities has relied on the above listed strategies and documents as in the case of sulphur dioxide.

Table 22 and Figure 16 show quantities of NO_x emissions under the three scenarios and emission ceiling and comparison among them has been made.

Table 22. Total quantities of NO_x emissions – comparison of the three scenarios

year	2005	2010	2015	2020	National emission ceiling
NO_x [kt] - OC		**33.27**	**37.64**	**28.67**	**39**
NO_x [kt] - CM		**33.16**	**33.7**	**23.8**	**39**
NO_x [kt] - Model	**31.93**	**33.85**	**28.39**	**20.84**	**39**

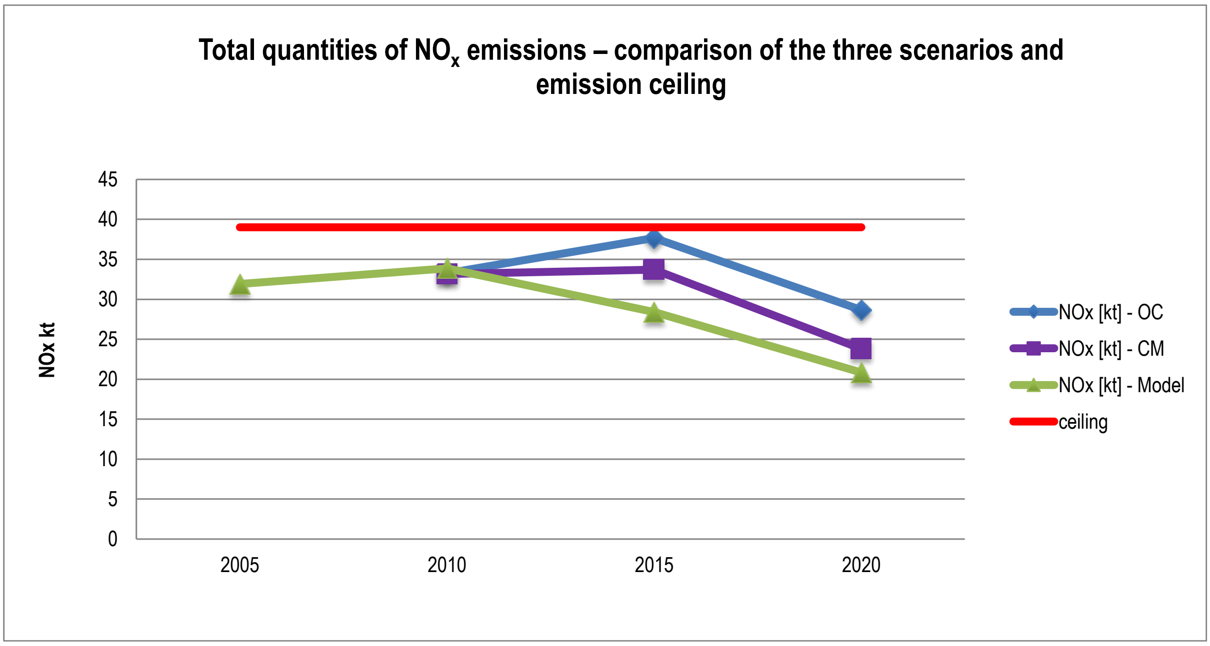

Figure 16. Total quantities of NO_x emissions – comparison of the three scenarios

According to the presented broadcasts, there is a trend of reduction of nitrogen oxide emissions for 2010 under the baseline scenario relative to first mitigation scenario by 0.4%, while baseline scenario compared to scenario using broadcasting models results in increased emissions of nitrogen oxides by 1.7%.

Projections indicate that there is a trend of reduction in the quantities of nitrogen oxide emissions for 2015 under the baseline scenario relative to first mitigation scenario of 10.5%, while baseline scenario compared to scenario using broadcasting models results in nitrogen oxide emissions reduction of 24.6%.

The trend of reduction of the quantities of nitrogen oxide emissions for 2020 under the baseline scenario relative to first mitigation scenario is 16.9%, while baseline scenario compared to scenario using broadcasting models results in nitrogen oxide emissions reduction of 27.3%.

According to the presented quantities of nitrogen oxide emissions under the baseline scenario from 2010 to 2020, there is a trend of reduction in emissions by 13.7%, while under the first mitigation scenario, the reduction in nitrogen oxide emissions for the same period is 28.3%. Under the scenario involving use of broadcasting models, the achieved reduction is 38.4% of the quantities of nitrogen oxide emissions.

It should be underlined that the ceiling of 39 kilo tons per year, adopted under the Rulebook on emission ceilings, is not exceeded throughout the analyzed period.

4.6 Projections of emissions of volatile organic compounds (VOC)

4.6.1 Emissions of volatile organic compounds (VOC) under the baseline scenario (BS)

Emissions of volatile organic compounds – VOC by key sources indicate that they originate mostly from mobile sources (fuels combustion and evaporation) and contribute 39.6% to total emission, 27.4% originate from evaporations in printing industry,15% from households related sources, 6.2 % from evaporations in heat energy production and around 11.8% from other sources.

The trend in emission quantities from 2007 to 2009 shows increase in VOC emissions by around 10% resulting from the increase in the consumption of fuel in road transport.

Under the Rulebook on emission ceilings, the ceiling for VOC is 30 kt. According to presented trends, the emission ceiling has not been exceeded in any case.

Table 23. Key sectors of volatile organic compounds (VOC) for 2008

Code	Key sectors	k	%
1A3b	Road transport	10.829	38.9%
3D1	Printing	7.615	27.4%
1A4b	Residential:Stationary plants, households and gardening (mobile)	4.182	15.0%
1A1a	Public energy and heating plants	1.739	6.2%
3A3	Other: application of protection (protective layer)	1.151	4.1%
2D2	Food and beverages	0.859	3.1%
1B2av	Distribution of oil products	0.425	1.5%
1A2a	Combustion plants in production and construction industry: iron and steel	0.227	0.8%
1A4cii	Agriculture/Forestry/Fishery: Vehicles outside public roads and other machinery	0.201	0.7%
3C	Chemical products	0.149	0.5%
1A2fi	Combustion plants in production and construction industry: Other	0.136	0.5%
3D3	Use of other products	0.091	0.3%
1A4ai	Commercial/Institutional: Stationary	0.084	0.3%
2C1	Production of iron and steel	0.063	0.2%
2B5a	Other chemical industry	0.027	0.1%
1A1b	Oil refining	0.024	0.1%

It was difficult to provide exact data for the analysis of the quantities of volatile organic compounds (VOC) in the period from 2010 to 2020 in accordance with the baseline scenario in several sectors (distribution of fuels, VOCs using and releasing industry) and the Strategy for Energy Development [2] and other above mentioned documents were used for the purpose. Also, with regard to the use and quantities of fuels in transport, the analysis presented in the previous chapter (projections for nitrogen oxides) was used. All these analyses were in accordance with the calculations specified in the EMEP/CORINAIR Rulebook. Under this methodology, emissions of VOCs from use of organic solvents and evaporation in oil derivatives transfer stations in particular were determined by way of applying this methodology.

Baseline scenario for VOCs from the transport sector assumes return of the trend in the rate of motorization starting from 2010. Under the baseline scenario, the rate of motorization in 2020 will achieve value of around 260 vehicles per 1000 inhabitants.

Table 24 and Figure 17 show the broadcasted quantities of volatile organic compounds – VOC emissions under the baseline scenario from 2010 to 2020.

Table 24. Total quantities of volatile organic compounds (VOC) emissions under the baseline scenario

year	2010	2015	2020	National emission ceiling
VOC [kt]	**28.37**	**32.25**	**36.67**	**30**

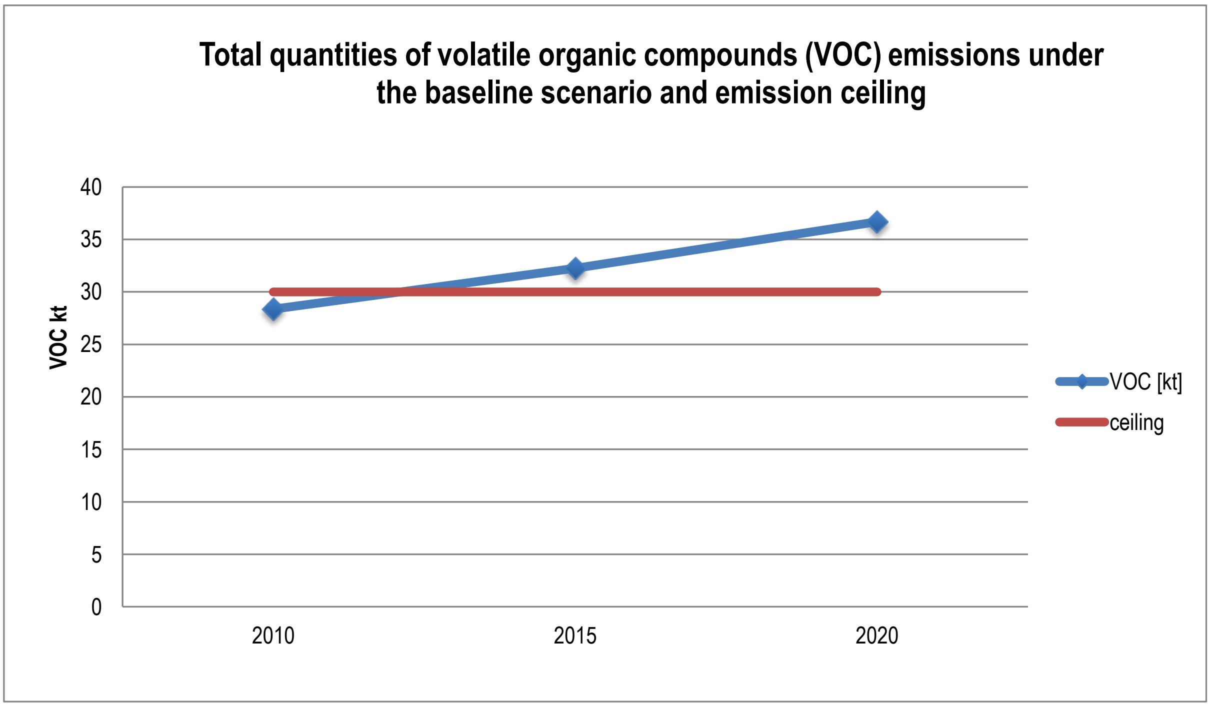

Figure 17. Total quantities of volatile organic compounds (VOC) emissions under the baseline scenario

4.6.2 Emissions of volatile organic compounds (VOC) under the first mitigation scenario

In the projections of the quantities of volatile organic compounds from 2010 to 2020 by use of emission reduction measures, we have taken into account the projections of the quantities of liquid fuels by sectors of energy production, for the consumption of fuels in transport, estimates of fuels evaporation in the course of their transport and distribution, evaporations in transfer stations and petrol stations, as well as projections of the growth in the number of vehicles under the slow growth model**.**

The "slow growth" scenario assumes return to the trend of motorization rate as of 2013.

Under this "slow growth" scenario, it is envisaged that the number of vehicles will increase by 225 vehicles per 1000 inhabitants.

Table 25 and Figure 18 show the broadcasted quantities of volatile organic compounds (VOC) emissions under the first mitigation scenario for the period from 2010 to 2020.

Table 25. Total quantities of volatile organic compounds (VOC) emissions under the first mitigation scenario

year	2010	2015	2020	National emission ceiling
VOC [kt]	**28.26**	**31.22**	**31.66**	**30**

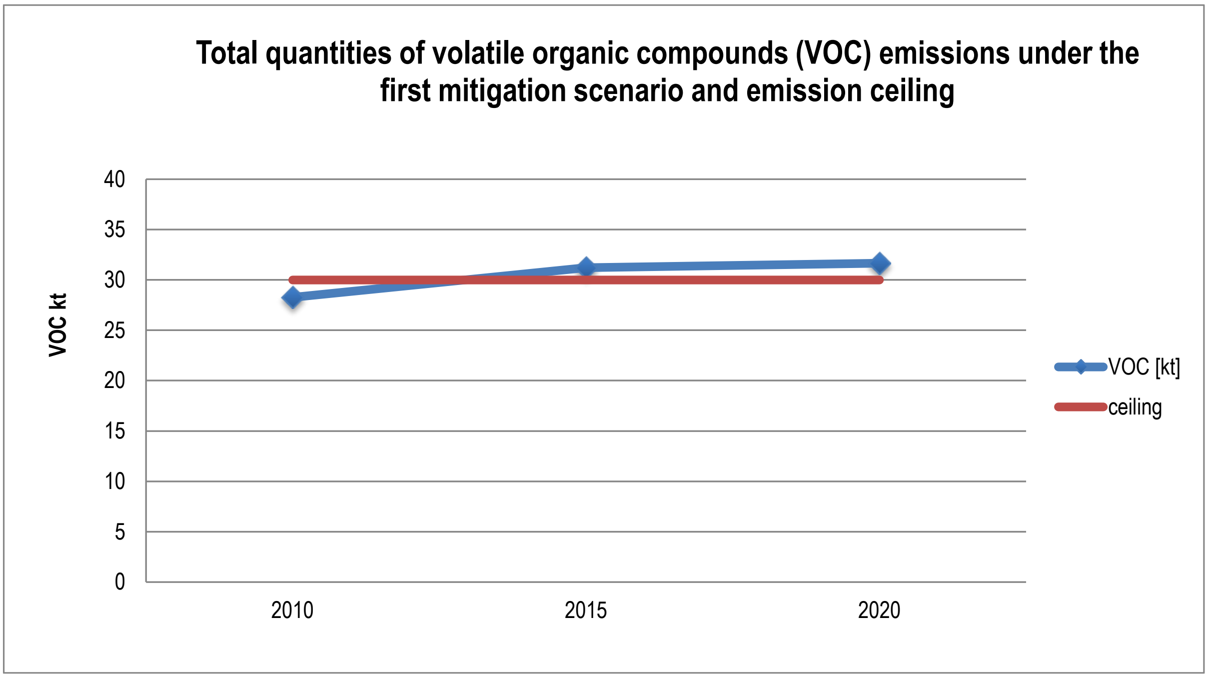

Figure 18. Total quantities of volatile organic compounds (VOC) emissions under the first mitigation scenario

4.6.3 Emissions of volatile organic compounds (VOC) under the scenario with use of models

Quantities of volatile organic compounds emissions for the period 2005-2020 have been obtained on the basis of the baseline scenario with application of the GAINS model (see chapter 4.4.3). Data on the total quantities of VOC emissions presented in Table 25 is taken over from the Report of CIAM [13].

Table 26 and Figure 19 show broadcasted quantities of volatile organic compounds (VOC) emission under the scenario with use of models, for the period from 2010 to 2020.

Table 26. Total quantities of volatile organic compounds (VOC) emissions under the scenario with use of models

year	2005	2010	2015	2020	National emission ceiling
VOC [kt]	22.64	19.98	16.79	15.29	**30**

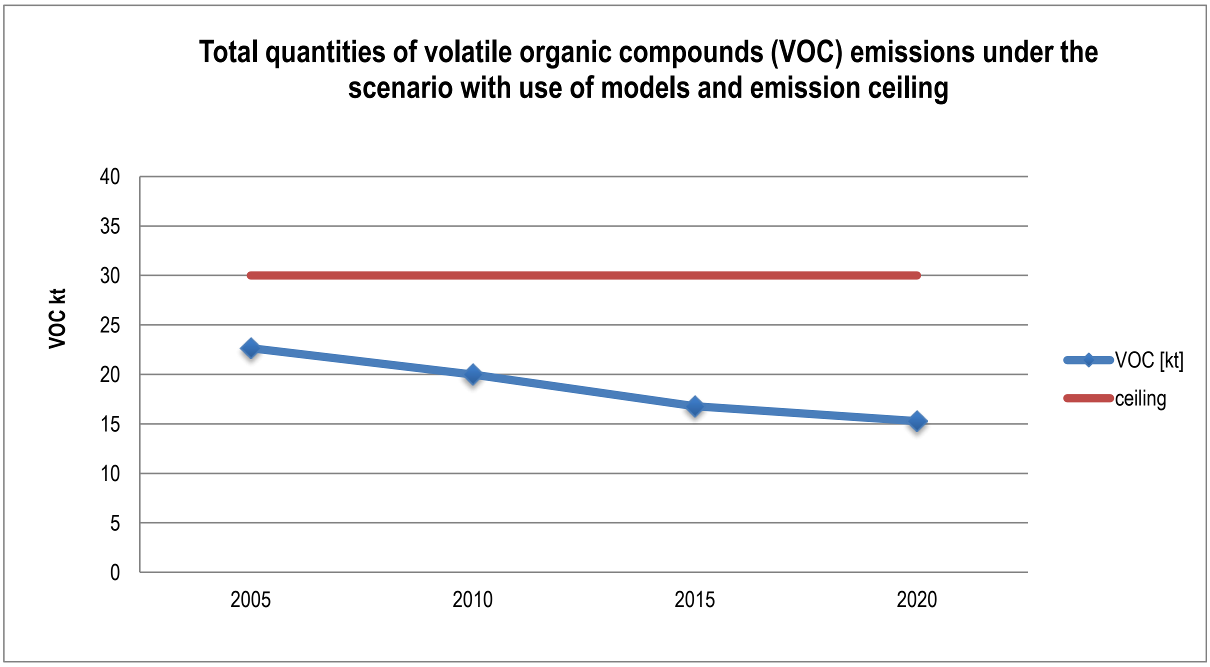

Figure 19. Total quantities of volatile organic compounds (VOC) emissions under the scenario with use of models

4.6.4 Conclusion

The scenario with measures for VOC quantities reduction includes energy production, fugitive emissions, road transport and from stationary sources, as well as the sector of organic solvents application.

Directive 31999L0013, besides ELVs and thresholds of exceeding of given VOCs, also provides a scheme for their reduction. It should be mentioned that this part of the Directive has not been transposed in the Republic of Macedonia yet and VOCs reduction scheme has not been prepared.

Measures for VOC emissions reduction are also presented in the part on the use of BATs in the above listed sectors.

With regard to certain processes lacking relevant data on VOCs, and where we thus were not able to use rates of activities and emission factors to calculate or estimate the quantities of emissions, we have taken into account data of international organizations - International Institute for Applied Systems Analysis (IIASA), based on which by way of use of relevant scientific internationally recognized models (GAINS, PRIMES 2008, CAPRI) we determined the quantities of emissions.

Table 27 and Figure 20 show the broadcasted quantities of volatile organic compounds (VOC) emissions through comparison among the three scenarios for the period from 2010 to 2020.

Table 27. Total quantities of VOC emissions- comparison among the three scenarios

year	2005	2010	2015	2020	National emission ceiling
VOC [kt] - OC		**28.37**	**32.25**	**36.67**	**30**
VOC [kt] - CM		**28.26**	**31.22**	**31.66**	**30**
VOC [kt] - Model	**22.64**	**19.98**	**16.79**	**15.29**	**30**

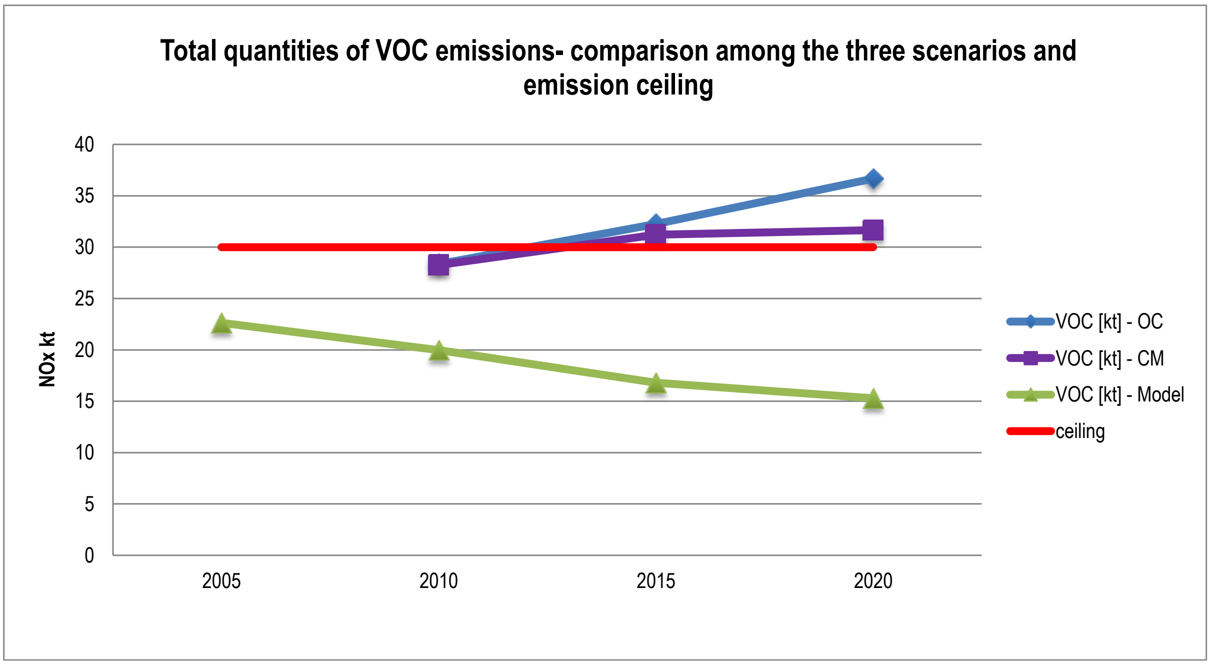

Figure 20. Total quantities of VOC emissions- comparison among the three scenarios

According to the presented broadcasts, there is a trend of reduction in the quantities of VOC emissions for 2010 under the baseline scenario relative to first mitigation scenario by 0.4%, while baseline scenario compared to scenario using broadcasting models results in VOC emissions reduction by 29.6%.

Projections indicate that there is a trend of reduction in the quantities of VOCs emissions for 2015 under the baseline scenario relative to first mitigation scenario of 3.2%, while baseline scenario compared to scenario using broadcasting models results in VOC emissions reduction of 48 %.

Also, projections indicate a trend of reduction of the quantities of VOC emissions for 2020 under the baseline scenario relative to first mitigation scenario by 13.7%, while baseline scenario compared to scenario using broadcasting models results in VOC emissions reduction of 58.3%.

According to the presented quantities of VOC emissions under the baseline scenario from 2010 to 2020, there is a trend of increase in the emissions of these pollutants by 29.2%, while under the first mitigation scenario, there is increase in VOC emissions for the same period by 12%. This indicates that application of reduction measures for VOC will in any case result in quantity reduction compared to the status under the baseline scenario. Under the scenario involving use of broadcasting models, the achieved reduction is 33.5% of the quantities of VOC emissions.

Throughout the analyzed period, there is no excess over the emission ceiling of 30 kt per year, adopted in accordance with the Directive on emission ceilings for certain pollutants (32001L0081) both under the baseline scenario and under the first mitigation scenario, as shown in diagrams above.

Annex 1 describes measures for VOC emissions reduction, while Annex 3 presents the relevant BATs.

4.7 Projections for ammonia emissions

4.7.1 Emissions of ammonia under the baseline scenario

Emissions of ammonia into the air originate mainly from agricultural sector, with the segment of milky cows contributing 44.4% and other cattle breeding 21.1%, pigs 14.4%, laying hens 11.7% and sheep and horses 7.5%.

The trend of NH_3 emissions in the period from 2004 to 2009 did not exceed the emission ceiling for this pollutant for 2010 the value being set at 17 kt per year. During the last two years of the analyzed period, there was insignificant decline in emissions resulting from reduced number of cattle and sheep.

Table 28. Key sectors for ammonia - NH_3

Code	Key sectors	kt	%
4B1a	Milky cows	3.117	44.4%
4B1b	Other cattle (non-milky cows)	1.483	21.1%
4B8	Pigs	1.015	14.4%
4B9a	Laying hens	0.824	11.7%
4B3	Sheep	0.376	5.3%
4B6	Horses	0.155	2.2%
1A4b	Residential:Stationary plants, households and gardening (mobile)	0.050	0.7%

Identification of ammonia emissions is carried out on the basis of the methodology specified in the EMEP/CORINAIR Rulebook [8], in line with the Convention on Long-Range Transboundary Air Pollution, as well as official data of the State Statistical Office.

Calculation of emissions under the baseline scenario relies upon emissions in 2008 and correcting coefficient has been derived from coefficients of ammonia emissions reduction or increase in line with the trends in the period 2005 to 2009. The reason for this approach is that there were insignificant variations in ammonia emissions in the period 2005 to 2009.

Final and accurate determination of projections for ammonia quantities also require elaboration of the adopted Common Basic Cattle Breeding Programme (CBCBP) and the Code of Good Agricultural and Hygiene Practice, adopted in the course of this document elaboration. It was not possible to use the measures for improved cattle breeding contained in it to define the scenario for ammonia projections for the period from 2010 to 2020 by application of reduction measures.

Table 29 and Figure 21 show quantities of ammonia emissions under the baseline scenario.

Table 29. Total quantities of ammonia emissions under the baseline scenario

year	2010	2015	2020	National emission ceiling
NH_3 [kt]	**9.87**	**10.24**	**9.25**	**17**

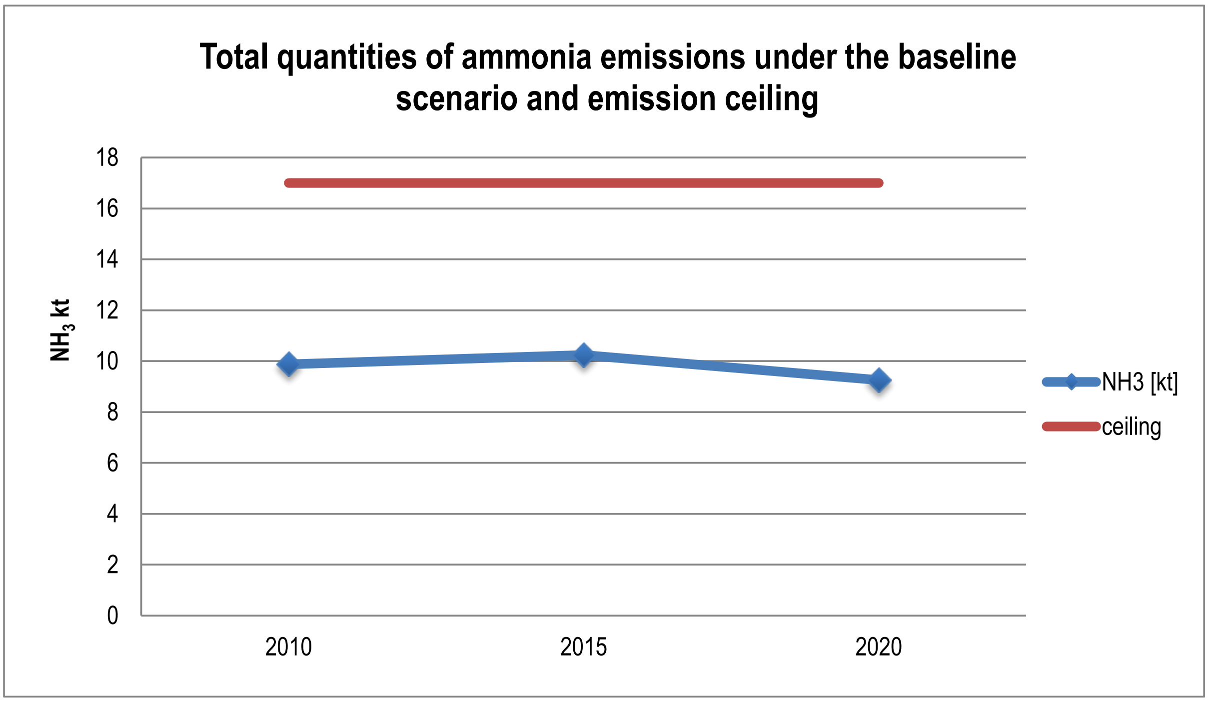

Figure 21. Total quantities of ammonia emissions under the baseline scenario

4.7.2 Emissions of ammonia under the scenario with use of models

As in the case of determining the quantities of previous core pollutants, GAINS model (see chapter 4.4.3) was also used with regard to the quantities of ammonia emissions. Data presented in Table 29 was taken over from the Report of CIAM [13]. However, in the case of ammonia, the CAPRI model (Common Agricultural Policy Regionalised Impact) was applied to determine emissions from agriculture.

The said economic model was developed by the European Commission, being applicable for a decade. It has been based on scientific quantitative analysis, related to legislation in the area of agriculture and it is used to assess the effects of the application of legislation in the areas of agriculture, trade in products, markets, benefits and environment, as well as for scientific research purposes. This global economic model is focused on EU Member States, Norway, Turkey and West Balkan countries [15]. Total quantities of ammonia emissions for the period 2000-2020 under the scenario with use of models are shown on Table 30 and Figure 22.

Table 30. Total quantities of ammonia emissions under the scenario with use of models

year	2005	2010	2015	2020	National emission ceiling
NH_3 [kt]	**8.5**	**8.94**	**9.13**	**8.94**	**17**

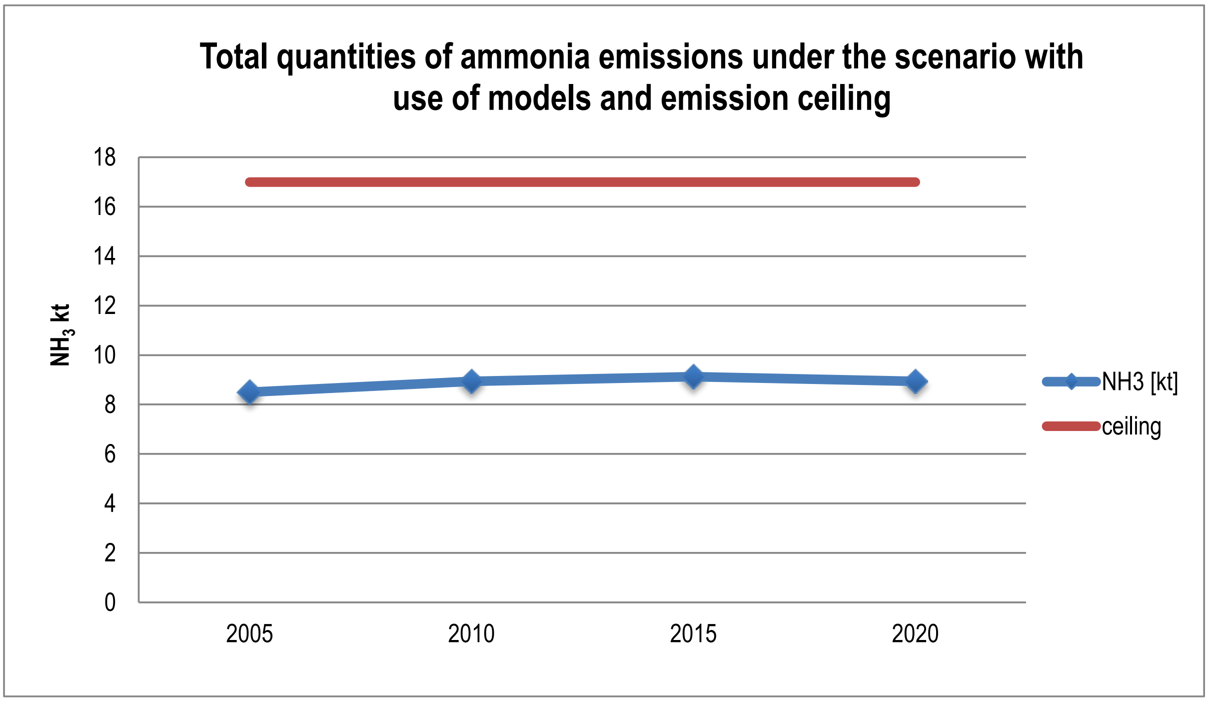

Figure 22. Total quantities of ammonia emissions under the scenario with use of models

4.7.3 Conclusion

Very rapid changes in legislation concerning cattle breeding are expected in the period 2011 to 2014, as it is approximated with the one of the EU and common market. This period should be used to increase the number of cattle and total production (CBCBP 2011-2020).

In the period by 2019, increased number of cattle per farmer is expected, as well as increased production per cow, but also gradual stagnation or reduction in the total number of cattle for meat and milk.

We should also point out that identification of ammonia from agricultural sector (breeding of cattle, sheep, goats, poultry, etc.) should be in line with the Code of Good Agricultural and Hygiene Practice and CBCBP for the period 2011-2020.

As already mentioned, due to the lack of data availability concerning the quantity of used fertilizers, projections of ammonia for the coming period by 2020 have not been elaborated for this segment.

Measures that should be implemented for the purpose of ammonia emission reduction include application of the BATs presented in Annex 3.

Table 31 and Figure 23 show total quantities of ammonia emissions by comparison of the two scenarios.

Table 31. Total quantities of ammonia emissions by comparison of the two scenarios

year	2005	2010	2015	2020	National emission ceiling
NH_3 [kt] - OC		**9.87**	**10.24**	**9.25**	**17**
NH_3 [kt] - Model	**8.5**	**8.94**	**9.13**	**8.94**	**17**

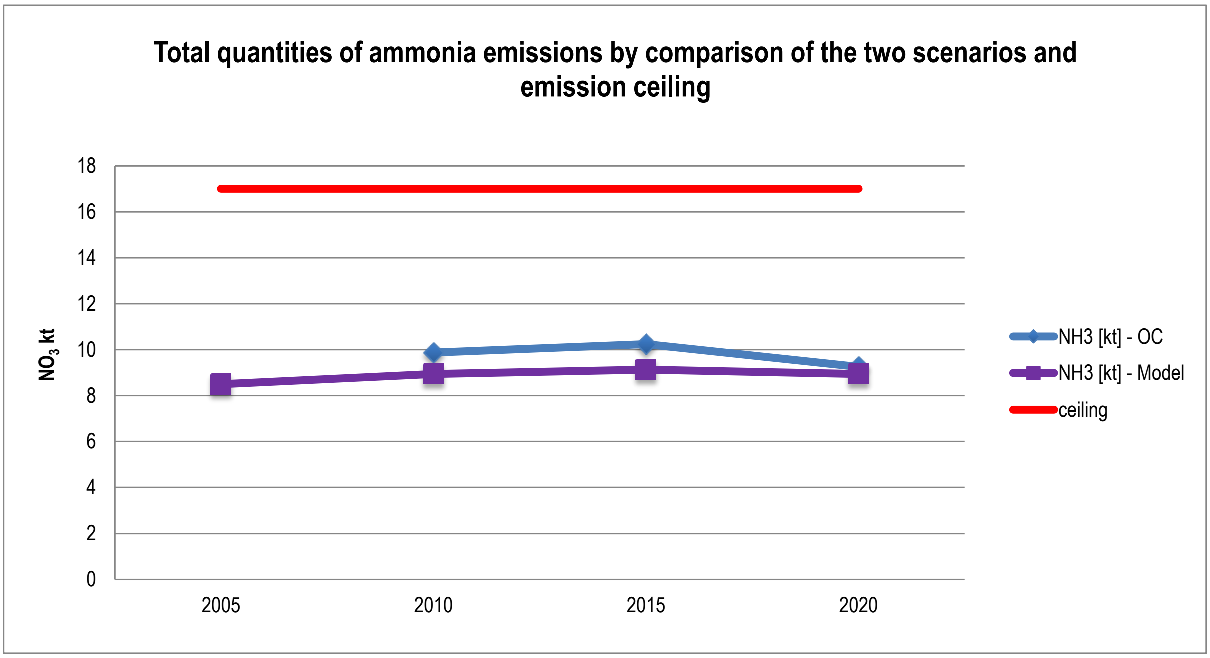

Figure 23. Total quantities of ammonia emissions by comparison of the two scenarios

With reference to ammonia emission projections for the period 2010 to 2020, it is a general assessment that under both scenarios quantities grow by 2015, though not by high percentage, and then fall by 2020 also by low percentage. Increase by 2015 is due to the fact that the relevant legislation in this area is expected to be prepared and introduced for enforcement upon 2014, which should contribute to further reduction of ammonia emissions.

Based on data processed for the purposes of this document. We may conclude that the increase in the quantities of ammonia emissions under the baseline scenario in the period from 2010 to 2015 is 3.7%, to fall by 6.3% until 2020 compared to 2010.

In relation to the scenario obtained by use of models, in the period from 2010 to 2015, there is increase in the ammonia quantities by 2.1%, i.e. quantities of 2010 will be retained.

It is evident that the quantities determined under the baseline scenario and under the scenario involving use of models are close in value, being much lower than the specified emission ceiling for ammonia for 2010 which is 17 kt per year. This indicates the fact that it is necessary to re-assess the quantities of ammonia emissions, as well as the value of the emission ceiling for ammonia for 2010. It is necessary to carry out further comprehensive analysis of all ammonia releases in order to identify its more probable quantities and projections, using the documents Code of Good Agricultural and Hygiene Practice and CBCBP for the period 2011-2020.

5. Large combustion plants

5.1 Large combustion plants required to undertake measures for ambient air protection against pollution

Under the Decree determining combustion plants required to undertake measures for ambient air protection, installations with a capacity above 50 MW are obliged to prepare a Plan for undertaking measures for air protection, to define actions for emission reduction and timeframe for their achievement by the given installation. It should be pointed out that each LCP installation prepares separate plan for emission reduction. Plans prepared by LCPs are part of the Programme.

The purpose of the adoption of the plan is that combustion plants reduce emissions of pollutants into the air in the period from 2010 to 2020. In the context of LCP's operation, we need to mention that the integrated environmental permits and adjustment permits with adjustment plans (IPPC) define the obligations of LCPs, applicable both for the new and existing ones. The more prominent obligations include measures for emission reduction, which are at the same time basis for the issuance of the IPPC permit. Besides these conditions, LCPs are also obliged to adhere to ELV specified in the Rulebook on ELVs. The IPPC permit may specify stricter ELVs as well, as well as ELVs for other pollutants if identified to be released into the air.

Taking into account the current state of these plants, significant financial resources are needed for their reconstruction, as well as specification of deadline for achieving compliance through adjustment plans of IPPC permits and thus extension of the validity of integrated environmental permit. This has in turn induced the necessity to request EU to allow for adaptation period and postponed compliance with certain requirements imposed by Directive 32001L0081. This period of adaptation and postponing can be requested from EU under the condition that the country has presented arguments and justified the reasons for which it is not able to fulfill the requirements.

The Plan for measures undertaking contains the basic technical data on the installation, such as general data, quantities of emission on annual level, contribution to national emission ceilings, type of fuel, capacity of the installation, number of operating hours, annual emissions of SO_2, NO_x and TSP, emissions of SO_2 prior to the commencement of desulphurization, rate of desulphurization and total annual flow. The Plan also includes measures for emission reduction such as substitute of fuel, modification and improvement in the management of incineration and combustion processes, introduction of new devices for emission reduction, timeframe for the Plan implementation, estimate of funds for its implementation, cost-benefit analysis, etc.

Under the Decree, each identified LCP should submit a plan to the competent authority (MEPP), where individual plans should be elaborated and adjusted to the effects on the overall pollution at national level, contribution to national emission ceilings, compliance with ELVs and aggregate the required financial resources for the plans implementation.

Difficulties in the preparation of the plan may occur due to certain provisions that are not defined or are partially described in Directive on large combustion plan (32001L0080). Thus, for example, application of ELVs for existing and new LCPs connected to joint outlet, is one of those. Additional requirements for LCPs, which are not regulated sufficiently in the Rulebook on ELV and Decree on the Plan for LCPs concern determination of input capacity.

The input capacity of each device, according to which ELV is specified, amounts equally as the total capacity of all devices connected to one outlet. In case some of the devices is out of operation during the analyzed period, then the capacity of the outlet changes and consequently ELV changes as well.

At the level of the Republic of Macedonia, total of 15 LCPs with designed capacity above 50 MW have been identified as obliged to prepare a Plan for undertaking measures for air protection and these are listed in the next Table.

Table 32. LCPs in the Republic of Macedonia with a total designed capacity above 50 MW

Name of facility	Designed capacity [MW]
REK Bitola	675
REK Oslomej	125
TPP Negotino	210
Toplifikacija Zapad	183
Toplifikacija Istok	293
Refinery Okta	290

Teteks	64
Cement plant Usje	136
Feni Industry	50
Greenhouses Hamzali	51
Greenhouses Anska Reka	84
Sugar factory “4 Noemvri” AD	54.0
ELEM-Energetika	105
Archelor Mital	64.3
TE-TO AD Skopje	480

Table 33 shows the current state and general profile of 9 LCPs, as well as quantities of emission of the pollutants for these LCPs for the period 2006 to 2011 with broadcasts by 2011 to 2015.

Table 33. General profile of existing operational large combustion plants

Name of the plant	Process	Type of fuel	Capacity (MW)	Aaot* from 2006 to 2010 (hours) where relevant	Aaot* from 2011 to 2015 (hours) where relevant
Refinery Okta	Process plants	Multi-fuel (Crude oil, firing gas)****	102.6	7136	5088
	Energy	Multi-fuel (Crude oil, firing gas)	188	3196	1550
Total			**290.6**		
Teteks Тетово	Boiler K104	Coal	22	2319	2319
	Boiler K 1374	Coal	19.7	1473	2012
	Boiler SPH 16	Crude oil	21.6	283	112
Total			**63.3**		
TPP Oslomej	Ferroconcrete stack	Coal	125	6220	6600
Archelor Mital	Annealing furnaces	Natural gas	30	4800	4800
	DZDG Galvanization line	Natural gas	9.3	7200	7200
	OC Plasticization line	Natural gas	25	7200	7200
Total			**64.3**		
Toplifikacija	ISTOK	Crude oil and Natural gas	293.93	1757	1917
	ZAPAD	Crude oil	182.91	1653	1740
Total			**476.84**		
REK Bitola	Block 1 and 2	Coal	450	7304	8160
	Block 3	Coal	225	7477	6480
Total			**675**		
TPP Negotino	Steam Boiler P-56	Heating oil Crude oil	210	1626	6500
TE-TO	Energy	Gas	480	0	8300
ELEM Energetika	Steam Boiler G-32	Natural gas and Crude oil (as alternative)	105	8.000	8.000

* Average annual operational time – Aaot

***** (Option for desulphurization rate) FGD (fuel gas desulfurization) Installation put into operation before 2001.

Tables included in Annex 2 present the profiles of already identified LCPs, as well as necessary data concerning emissions reduction by 2015. More specifically, listed data concern:

- Type of the process;
- Average operational hours from 2006 to 2010;
- Average operational hours from 2011 to 2015 - planned;
- Average flow from 2006 to 2010;
- Average flow from 2011 to 2015 - planned;
- Quantities of emission on annual level based on specified emission limit values;

- Average annual emissions from 2006 to 2010;
- Annual emissions for 2010; and
- Average annual emissions from average operational hours from 2011 to 2015 – planned.

The Table shows annual emissions for sulphur dioxide, nitrogen oxides and suspended particulate matters (dust).

Presented data shows clearly that individual LCPs listed in the Table, according to their plans for operation both from 2006 to 2010 and from 2011 to 2015, manifest variable quantities of emissions.

The quantities of emissions for both periods for which they are presented (average annual emissions from 2006 to 2010 and average annual emissions from 2011 to 2015) are much higher compared to annual emissions obtained according to emission limit values. This indicates that even with the planned measures for reduction, the facilities for electricity production (REK Bitola and REK Oslomej), will not achieve any significant reduction in annual emissions of the specified pollutants by 2015.

Table 34 and Figure 24 show contribution to the overall emissions from individual pollutants for each installation.

Table 34. Contribution to total emissions from individual pollutants for each installation

	SO_2				NOx				TSP			
Name of the plant	Aaue *** from 2006 to 2010 of SO_2	Share of each installation in SO_2 emissions	AE** of SO_2 in 2010 (t/year)	SO_2 2011-2015 with changed operational hours (t/year)	Aaue *** from 2006 to 2010 of NOx	Share of each installation in Nox emissions	AE** на NOx во 2010 (t/year)	NOx 2011-2015 with changed operational hours (t/year)	Aaue *** from 2006 to 2010 of TSP	Share of each installation in TSP emissions	AE** of TSP in 2010 (t/year)	TSP 2011-2015 with changed operational hours (t/year)
Refinery Okta	2634.62	3.20%	1097.10	663.10	509.23	2.48%	499.80	321.40	49.03	0.50%	29.90	21.32
Teteks Тетово	12.10	0.01%	11.23	14.47	4.60	0.02%	3.49	3.94	1.62	0.02%	0.95	0.95
Oslomej	14164.50	17.19%	15697.00	16655.98	2255.50	10.98%	2687.00	2851.16	2081.25	21.26%	1763.00	1870.71
Archelor Mital	46.06	0.06%	14.80	14.80	34.90	0.17%	85.71	85.71	0.00	0.00%	0.00	0.00
Toplifikacija	2126.94	2.58%	287.86	303.01	642.51	3.13%	197.59	210.70	0.00	0.00%	0.00	0.00
REK Bitola	51877.81	62.96%	59372.59	60409.62	14562.29	70.88%	16404.58	16846.34	7279.17	74.37%	6291.85	6428.06
TPP Negotino	11486.00	13.94%	0.00	0.00	1967.00	9.57%	0.00	0.00	317.00	3.24%	0.00	0.00
TE TO	0.00	0.00%	0.00	0.00	0	0	0	563.20	0	0	0	59.70
ELEM Energetika	55.00	0.07%	0.00	0.00	5.75	0.03%	11.95	11.95	0.00	0.00%	0.00	0.00
Total	**82403.03**	**100.00%**	**76480.58**	**78060.98**	**20544.98**	**100.00%**	**20453.32**	**20894.40**	**9787.77**	**100.00%**	**8145.40**	**8380.73**

* Average annual operational time – Aaot

** Annual emissions – AE

*** Average annual unreduced emissions - Aaue

**** Average annual waste gas flow - Aawgf

***** (Option for desulphurization rate) FGD Installation put into operation before 2001

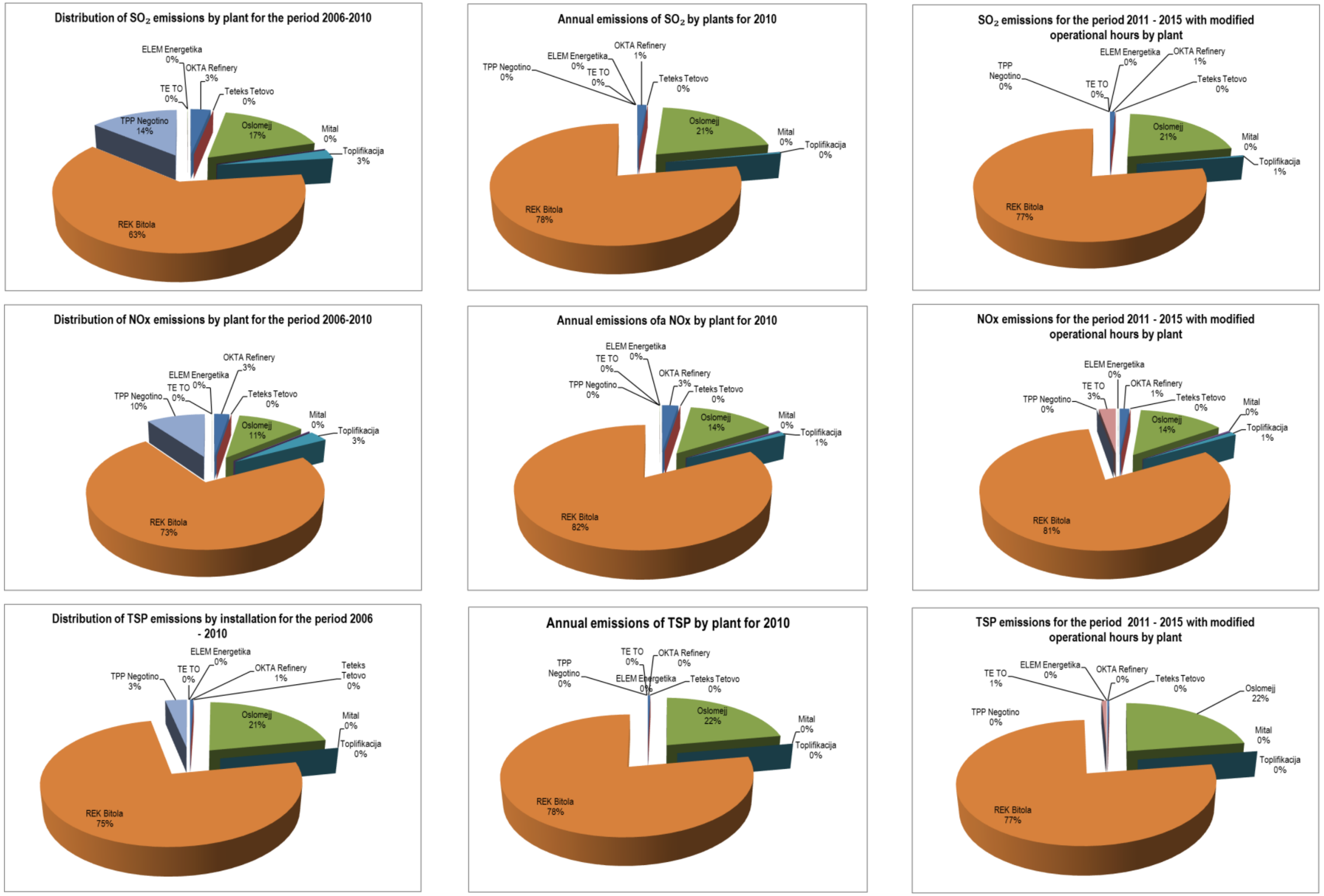

Figure 24. Contribution to total emissions from individual pollutants for each plant

The overview of the quantities of SO_2 emissions clearly shows that there is decrease in emissions from 2006 to 2011 compared to 2010 by 7.2 %, but the next broadcasts by 2015 note increase of the quantities for 2015 compared with 2010 by 2.1%. It is also evident that the highest percentage of the quantities of annual sulphur dioxide emissions originate from REK Bitola and REK Oslomej. This is also in line with the scenarios for SO_2 emissions reduction according to which there is increase in total quantities on annual level by 2015, and then they begin to reduce by 2020.

With regard to the quantities of nitrogen oxides emission presented in the Table, it is obvious that there are no significant difference throughout the presented period and the level is almost the same from 2006 to 2015. This is in line with the quantities presented in the baseline scenario and first mitigation scenario by 2015, while the implementation of measures is reflected by 2020 in nitrogen oxides emission reduction. The greatest contribution to the quantities of nitrogen oxides emission during the whole analyzed period originates from the operation of REK Bitola and REK Oslomej.

The quantities of total suspended particulate (dust) emissions were reducing from 2006 to 2011 compared to 2010 by 16.8 %, but the next broadcasts by 2015 note increase of the quantities for 2015 compared with 2010 by 2.9%. The highest percentage of the quantities of total suspended particulate emissions throughout the analyzed period originate from REK Bitola and REK Oslomej.

It should be mentioned that not all identified LCPs delivered data and thus the analyses has not been made on the total number, which means that the above shown values will change. Changes and corrections will be made on the occasion of the preparation of the Plan for mitigation measures undertaking to protect the ambient air in plants with a capacity above 50 MW.

5.2. Analysis of the contribution of each individual LCP to the quantities for SO_2 and NO_X emission ceilings

In order to determine contribution of each LCP to emission ceilings (see Table 2) and undertake measures for reduction of emission quantities for the specified pollutants, analysis has been made of the LCPs that have delivered data, and the results thus obtained are presented in Table 36.

Table 36. Contribution by each plant to ceiling for SO_2 and NOx

Contribution by each plant to emission ceiling		
	SO_2 in 2010	**NOx in 2010**
Refinery	0,84%	1,28%
Teteks	0,01%	0,01%
REK Oslomej	12,07%	6,89%
Arcelor Mital	0,01%	0,22%
Toplifikacija	0,22%	0,51%
REK Bitola	45,67%	42,06%
TPP Negotino	0	0,00%
TE-TO	0	1,44%
ELEM Energetika	0	0,03%
Other sources	27,58%	30,79%
Remaining to ceiling	13,59%	16,76%
	100,00%	100,00%

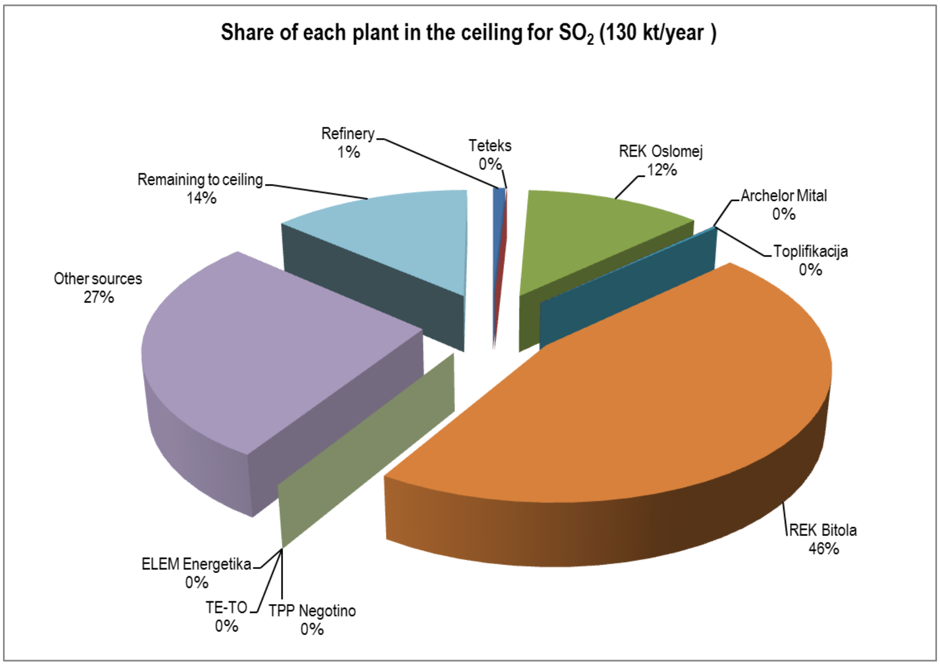

Figure 25. Share of each plant in the ceiling for SO_2

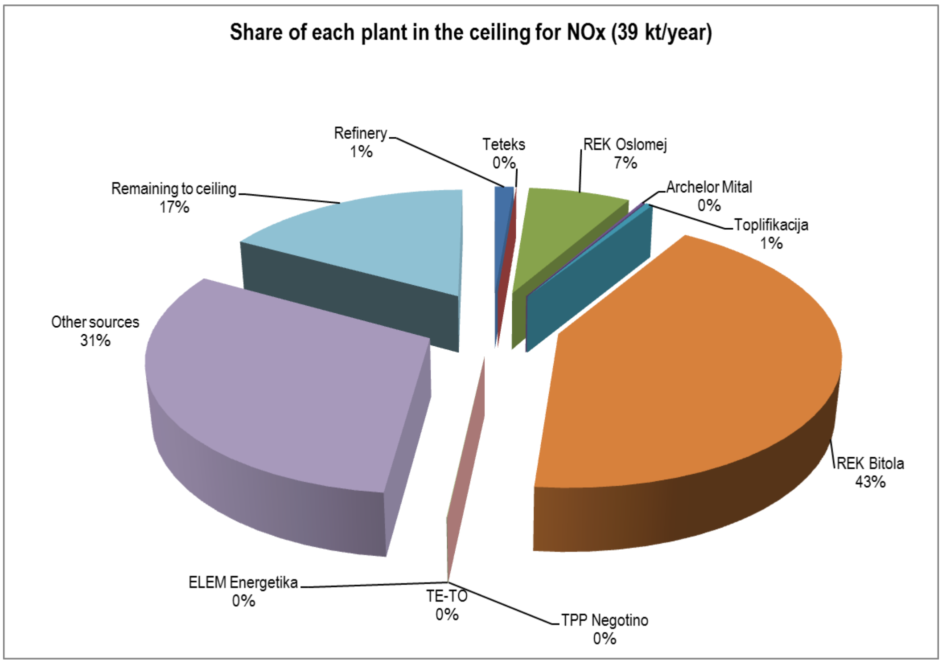

Figure 26. Share of each plant in the ceiling for NO_X

It should be underlined that each LCP prepares specific Plan for undertaking measures for ambient air protection, i.e. plan for emissions reduction. Individual plans are parts of the overall Plan. Plan for undertaking measures for ambient air protection will specify the actions for emissions reduction and the timeframe for compliance of the given plant. Emission reduction from the respective LCPs will mean that those should be deducted from the share in the emission ceiling at national level for the given pollutant. This in turn means that the reductions in the emissions of individual pollutants from certain LCP will reduce not only the share in total emissions at national level, but also the emission ceiling. Under this mechanism, it will not be possible a LCP to reduce emissions while another one to increase them, while the emission ceilings remain unchanged, but the percentage of emission ceilings reduction will be followed by corresponding reduced quantities of pollutants emission.

6. Estimate of financial resources for the Plan implementation

6.1. Introduction

In circumstances of transition towards a new economic system and relatively novel ambient of operation in the Republic of Macedonia, it seems that the issue of environment degradation has been ignored in a way.

It is a generally known fact that significant reduction in environmental pollution occurred during the first years of the transitional process. It was a side effect of the decline in production activity, but also a consequence from the initiated processes of the overall economic restructuring. With the passing of the transitional process, additional reasons for reduction in environmental pollution were the introduction of new modern legislation on the relevant matter, gradual steps towards implementation of effective protection policies and increased investments with environmental prefix.

6.2. Use of economic instruments in environmental protection

From the beginning of the transition towards market oriented economy, there have been great expectations for expansion of the role of economic instruments in environmental protection policy. The great advantage of economic instruments lies in incorporation of issues related to environmental pollution directly into the context of the developments performed on the market. The efficiency of economic instruments is due to flexibility provided to polluters, which is much greater than the one potentially offered by other related instruments of environmental policy. In the context of the above, possibilities for saving depend on:

- varying ability for technological and consumption modifications;
- cost sensitivity of producers or consumers;
- difference in marginal costs for different options (opportunities).

Compensations (taxes) for environmental protection are collected directly from polluters. Therefore, they represent application of the “polluter pays principle” (PPP). On the other side, these instruments increase public revenues and it is therefore important to determine whether their primary goal is to create revenues or perform the tasks of environmental protection.

The policy of environmental protection is important for successful performance of economic instruments. The criterion of economic efficiency requires uniform rates of pollution burdens to correspond with the margins of environmental degradation associated with the common pollution.

Compensations for preservation of the quality of environment in post-socialist countries were accepted and adapted to new conditions that emerged with political and economic transition. Compensations for emissions and related penalties for non-adherence to standards note greatest application, and production compensations have been established as from recently. Tax differentiation is present in the consumption of lead relative to unleaded petrol, while schemes of deposits re-funding are the most intensively applied in the case of glass bottles use.

As far as the application of the integrated pollution prevention and control system (IPPC) is concerned, through integrated environmental permitting, one may say that the potential for such permits has already been recognized, though practical implementation is in its initial stage.

6.3. Overview, analysis and scenario of socio-economic indicators (GDP) as basis for the influence of economy on the quality of ambient air

Gross Domestic Product is the basic measure of economic activity in a country, measuring the value of the total final products produced in the country for a period of one year. The text below is a short presentation and analysis of the GDP trend from 2000 to 2009 (see table 37).

Table 37. GDP trend from 2000 to 2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP (% of growth)	4.5	-4.5	0.9	2.8	4.6	4.4	5.0	6.1	5.0	- 0.9
GDP per capita (EUR)	1.921	1.886	1.978	2.081	2.185	2.363	2.564	2.919	3.283	3.253

Source: State Statistical Office of the Republic of Macedonia, National Bank of the Republic of Macedonia.

Continuous trend of economic growth in the Republic of Macedonia, with its peak in 2000 (with real GDP growth of 4.5%) was terminated in 2001. Deteriorated safety in the country and aggravated operational conditions induced reduction of the overall economic activity and weakening of macroeconomic performances.

Nevertheless, macroeconomic policy implemented in 2002 contributed to economy consolidation, improvement of macroeconomic performances and continuation of structural reforms resulting in GDP real growth rate of 0.9. In this way, the national economy returned to the zone of positive real growth rates of GDP.

Positive trend in GDP real growth rates of the Macedonian economy continued in the period 2003 to 2008 as well, reaching historically highest rate of real growth in 2007 (GDP real growth rate of 6.1%). However, in 2008, instead of continuation of the trend of significant GDP growth, lower real growth was achieved compared to 2007 (GDP growth of 5% in 2008), as a result from the occurrence of the world financial crisis.

The wave of stresses in global finances in September 2008 also meant deepening of economic crisis in developed economies and significant decline in external demand for Macedonian export, with articulated effects in the last months of the year.

Negative effects of the global financial and economic crisis on the national economy caused reduction in domestic economic activity in 2009. The first effects were visible even in the last quarter of 2008 with slowing down in the annual growth, while in the course of 2009 GDP experienced real drop of 0.9%. Negative achievements were notable from the beginning of the year, and the economy recorded its strongest fall during the third quarter, while the first positive annual changes were recorded during the last quarter of 2009. Yet, the positive fact was that Macedonian economy in 2009 proved to be relatively more resistant compared to other economies in the world, where the fall in economic activity was significantly bigger (NBRM: Annual Reports, 2000-2009).

Similar trend was also noted with GDP developments per capita (see Table 37).

In absence of adequate reliable quantitative methods for macroeconomic broadcasting and planning of future development of the national economy, projections of future GDP growth rates have been based on the following information: projections of the Ministry of Finance presented in the Pre-Accession Economic Programme 2012-2014, as well as projections for the future growth of neighbouring economies (important commercial partners) and projections for the growth in EU Member States. According to these assumptions, GDP growth in 2015 and 2020 could reach 6%, and 7%, respectively (Table38).

Table 38. GDP achieved in 2010 and GDP projected in 2015 and 2020

	2010	2015	2020
GDP (% of growth)	1.8	6.0	7.0

Source: State Statistical Office of the Republic of Macedonia, own projections

Macroeconomic projection at medium and long run is further aggravated by the great uncertainty in global economic trends, which to a great extent derive from events related to debt crisis in the Euro-zone, i.e. high uncertainty related to duration and depth of debt crisis. Thus, further aggravation of economic conditions in the Euro-zone would result in bigger slowing down of external demand, reduction in export and production in the country and vice-versa.

The main factors that can contribute significantly to the future development of Macedonian economy (mainly related to the rate of achievement of EU integration) include:

- *Faster economic growth through improved competitiveness.* The Republic of Macedonia should proceed with the implementation of sound macroeconomic policies, measures for improvement of business climate and status of infrastructure, as well as increased investments in education, including also university level of education.

- *Achievement of inclusive growth through strengthened opportunities for employment and social welfare.* Permanent improvements of active policies are required on labour market, as well as for the programmes for social welfare and aid.
- *Green growth through sustainable use of resources.* Investments in clean and efficient energy are necessary, as well as greater support to analysis development, in order to design and implement measures of the economic policy towards achievement of the green growth and mitigation of the effects of climate change on the national economy.

6.4. Estimate of financial resources required for implementation of measures and activities of the plan

The estimate of financial aspects, measures and activities for harmful emissions reduction takes the quantification of measures differentiated by their financial cost-effectiveness as starting point. In this context, distinction is made between measures requiring low, medium or high level of costs necessary for their implementation. Nevertheless, the basic characteristic under our circumstances is the shortage of financial resources to implement the appropriate measures. This is further burdened by often inadequate communication between individual ministries and state authorities, which creates administrative barriers. Finally, "there are many cases where the main constraints are the lack of expertise and opposition to new technologies, including also the low level of awareness of and interest in their application, even for settling vital energy problems... In some of the measures, serious constraints are also posed by the different interests of the stakeholders, because there is high number of independent decision-makers whose goals are difficult to adjust." [28] Convergence of different interests of decision makers under market conditions can be accomplished through development of appropriate economic strategy. Only in that way, we may expect change in the behavior of the stakeholders, but also change in the criteria by which they are led in the process of deciding on issues related to energy or harmful gases emission.

Projection of financial resources (costs) for emission reduction is based on the RAINS model, developed by IIASA. Within this model, time horizon of 15-20 years is taken into consideration. Projection of costs, i.e. financial expenditures is certainly very difficult and complex task, given the fact that technological changes (that cannot be foreseen) occur meantime, as well as changes in the structure of individual energy resources consumption. Therefore, long-term economic prognoses are most often limited to aggregated level of economic activity (national economy), and rarely at sector level. This approach has been actually used in this Study. Projections of costs concern the level of the entire economy for individual harmful gases. On one side, uncertainties that may derive from the changes individual sectors are made relative on one side, but this level of aggregation does not allow sufficient level of relevance of the prognosis itself, on the other. Anyhow, estimates of the total sums of costs for harmful gases reduction are presented at the level of the national economy and should as such serve as momentum for further investigations.

The main intention of the costs evaluation is to identify the values of resources that need to be allocated by the society for harmful emissions reduction. "In practice, these values are approximated through estimate of costs at production level, and not through prices faced by consumers… Of course, there will be certain transfers of money that will have impact on the distribution of income or competitiveness of the entity, but these phenomena should be exempted from analysis. Also, any kind of taxes added to production costs should be ignored similarly as transfers." [31]

In the frames of the model, the applied methodology divides parameters into general and country specific. General parameters refer to interest rate (i.e. discount factor), while specific data to certain type of technology (life cycle, depreciation rate, maintenance costs, etc.). In this context, the amount of costs is determined on the basis of present prices (in some cases, on the bases of data on 2010), using discount factor of 6%. Country specific parameters refer to average size and depreciation of installations in a given sector, prices of electricity and labour on the respective national market, prices of material input in the specific country, etc. Also, "…all indirect costs, like effects on the prices of energy resources, trade balance, employment and benefits obtained as a result of reduced damage on ecosystems, are exempted from the evaluation." [30] In our case, the analysis focuses exceptionally on the level of the national economy and does not reach the level of individual sectors.

We made comparative analysis of energy consumption relative to GDP or so called energy intensity indicator relative to one of the countries in the region – Republic of Croatia.

Based on the above, Republic of Macedonia belongs to the group of high energy intensive countries, i.e. high energy consumption. The first decade of the 21st century has been characterized by falling trend in energy intensity at global level, which is due to "increased efficiency in the use of energy, increased substitution of costly fuels and use of more cost-effective and renewable energy sources". [27] Industry in Macedonia is responsible for 33.8% of final energy consumption, and at the same time it contributes around 20 % to GDP generation. This reflects the high energy intensity in industrial sector, which is higher than the average. Nevertheless, "comparison of the situation in Macedonian industry with other European countries indicates energy intensity in this sector and the fact that Macedonia has insignificantly better performance than the average of the countries that are not members of OECD." [4]

Namely, in 2003 Macedonia recorded energy consumption relative to GDP (TPES/per 000 US$ PPP, i.e. ton oil equivalent) of 0.20. On the other side, consumption of total energy per capita in Macedonia (2004) was 1.282 kg toe (ton oil equivalent). As far as consumption of electricity per capita is concerned, in Macedonia, in 2004 it was 2.799 kwh per capita. Namely, 31.7% of the total energy consumption in Macedonia is attributed to industry, followed by households and road transport with 30.6% and 21.9% respectively.

Taking all the above into account, the required amount of financial resources for reduction of a ton of harmful emissions can be taken by a certain dose of reservation.

6.4.1. Estimate of financial resources for implementation of measures and activities for sulphur dioxide emissions reduction

The estimate of costs for SO_2 emissions reduction under the three scenarios is based on present prices (more specifically, on data for 2010), by use of discount factor of 6%. There is no distinction made in the amount of unit cost per kt SO_2, between individual scenarios. Relatively high amount of costs for 2020 derives from high potential for reduction (obtained as a result of differences in emissions projected for 2015 and 2020) on one side, and as a result of use of assumed interest (discount) factor, on the other. Their settlement to present value (PV) would make relative the amount of the cost for the value of the discount factor conformed with time interval (5 or 10 years).

Table 39. Total cost for SO_2 emissions reduction

Year	2005	2010	Reduction potential ($SO_{2\ 2010}$-$SO_{2\ 2015}$)	Cost (financial resources) – ($SO_{2\ 2010}$-$SO_{2\ 2015}$) – in mil.EUR	2015	Reduction potential ($SO_{2\ 2015}$-$SO_{2\ 2020}$)	Cost (financial resources) – ($SO_{2\ 2015}$-$SO_{2\ 2020}$) - in mil.EUR	2020	National ceiling
SO_2 [kt] – BS		115.1383	-15.1301	-	130.2684	31.06077	1266.3	99.21763	130
SO_2 [kt] – FMS		114.7563	-12.9408	-	127.6971	43.07589	1919.3	84.62121	130
SO_2 [kt] – Model	99.72	112.85	19.26	381.4	93.59	78.37	3195.2	15.22	130

6.4.2 Estimate of financial resources for implementation of measures and activities for nitrogen oxide emissions reduction

The estimate of financial resources required for nitrogen oxide emissions reduction takes into account the key sectors by SNAP methodology that have greatest contributions to the total emission of nitrogen oxides. Specificity of NOx emissions in Macedonia is reflected in the fact that they are to the greatest extent a result of fossil fuels combustion for electricity production in coal fired thermal power plants (REK Bitola and REK Oslomej), as well as emissions from the combustion of liquid fuels for heat production and processes in industry.

As far as transport sector is concerned, the starting point is the fact that in the middle of the previous decade, the number of passenger motor vehicles in Macedonia was around 124 vehicles per 1000 inhabitants (the share of passenger in the total number of motor vehicles was around 80-90%), while under the baseline scenario the rate of motorization in 2020 should reach the level of around 260 vehicles per 1000 inhabitants. Here, we should not neglect the crises that occurred around the middle of the first decade of the 21st century affecting the car industry at global level, as well as amended regulations on used vehicles import in Macedonia.

Projection of costs has been made again by use of RAINS model and Nitrogen oxides emission abatement cost curves settled within it. [29] The estimate of total costs refers to 2010 while taking into account the current legislation as starting point. This assumes ranking of all options for emission control that are available, according to their cost effectiveness. Initial emissions and control costs include measures that have been already covered by the current legislation. Cost curves analyze the remained potential for emission control.

Through this approach, several abatement cost curves have been obtained, fed by specific parameters for Macedonia, namely: both for stationary sources of emission and mobile sources of emissions (such that use petrol or diesel fuel). Taking the aggregation of emissions projected under the three scenarios as starting basis, use of the three curves was not adequate and thus the curve for stationary sources was basically used. Results obtained are presented in Table 40.

Table 40. Total cost for NOx emissions reduction

Year	2005	2010	Reduction potential (NOx_{2010}-NOx_{2015})	Cost (financial resources) – (NOx_{2010}-NOx_{2015}) – in mil.EUR	2015	Reduction potential (NOx_{2015}-NOx_{2020})	Cost (financial resources) – (NOx_{2015}-NOx_{2020}) - in mil.EUR	2020	National emission ceiling
NO_x [kt] – BS		33.27	-4.37	-	37.64	8.97	48.19	28.67	39
NO_x [kt] – FMS		33.16	-0.54	-	33.7	9.9	53.19	23.8	39
NO_x [kt] - Model	31.93	33.85	5.46	21.92	28.39	7.55	40.56	20.84	39

The estimate of the total costs for NOx emission reduction will be more complete if we take into account current and planned projects in energy sector, by which NOx emissions are reduced and generate reductions in carbon dioxide as additional effect (Annex 1). Based on current and planned project, total NOx for the period 2010 to 2014 will be reduced by 9.528 kt, while the planned amount of investments reaches the sum of 1.346.280.000 EUR (under the current prices).

6.4.3. Estimate of financial resources for implementation of measures and activities for volatile organic compound emissions reduction

Projection of the required financial resources for volatile organic compound emissions reduction is very complex task given the fact that projected emissions are presented in general, and not broken down amounts. Thus, the estimates can only be indirect. "Implementation of directives on large combustion plants, IPPC, waste incineration, volatile organic compounds, quality of fuels, non-road vehicles, etc., will result in emissions reduction. However, it is not certain whether this reduction associated with the future growth will be sufficient to achieve the future emission ceilings or other reduction activities will need to be implemented as well... The estimated capital and operational costs for this sector are subject to significant uncertainties.“ [26]

As far as the costs for the IPPC system implementation are concerned, those have been estimated at approximately 572 million EUR in investments and 39 million EUR annual operational costs to be covered by industry (investment and operational costs for the systems for mitigation of harmful effects of processes), Ministry of Environment and Physical Planning and Units of the local self-government (costs for training, administrative costs and costs for the employees). [7] On the other side, strengthened management of the quality of environment, ambient air in this case, requires "...overall costs, capital of almost 8 million EUR and operational gradually growing costs of almost 8.4 million EUR per year. These seem to be relatively low, but this results from the fact that most of the technical measures that will improve the quality of the air in Macedonia are attributed to the sector Industrial pollution control, especially Large Combustion Plants Directive and IPPC Directive... These costs might be lower than the real ones...“ [26]

6.4.4. Estimate of financial resources for implementation of measures and activities for ammonia emissions reduction

The estimate of the financial resources (costs) for ammonia emissions reduction is based on parameters contained in the RAINS ammonia module. [20] Specific function of costs derived in the context of the given model relates to 2010. Based on it, the estimates of the required resources have been made. No distinction is made between baseline scenario and first mitigation scenario. Simply, the estimate of costs has been left to generate the difference in the level of costs.

Table 41. - Total cost for ammonia emissions reduction

Year	2005	2010	Reduction potential ($NH_{3\,2010}$- $NH_{3\,2015}$)	Cost (financial resources) – ($NH_{3\,2010}$- $NH_{3\,2015}$) – in mil.EUR	2015	Reduction potential ($NH_{3\,2015}$- $NH_{3\,2020}$)	Cost (financial resources) – ($NH_{3\,2015}$- $NH_{3\,2020}$) - in mil.EUR	2020	National emission ceiling
NH_3 [kt] – BS		9.87	-0.37	-	10.24	0.99	17.65	9.25	17
NH_3 [kt] – Model	8.5	8.94	-0.19	-	9.13	0.19	3.39	8.94	17

Data presented in Table 41 lead to the conclusion that the absolute amount of financial resources for the application of ammonia reduction measures in the period from 2015 to 2020 is by far lower than the amounts required to reduce the emissions of SO_2 and NOx. The relevance of projected amounts is further supported by two relevant examples. Namely, total investments in six pig farms (in Veles, Shtip, Vinica, Sv.Nikole, Berovo and Tetovo) for reduction of harmful emissions of gases in the period 2010-2012 have been estimated at 1.097.200 US$, with parallel operational costs of 117.600 US$ at annual level. At the same time, total investments in nine landfills (in Skopje-Drisla, Veles, Shtip, Vinica, Strumica, Gostivar, Kumanovo, Bitola and Kochani) to reduce harmful gas emissions in the period 2009-2014 were estimated at 3.760.806 US$, with parallel operational costs of around 452.000 US$ on annual level.

Nevertheless, the analysis of costs for ammonia emissions reduction involves the fact that there are still many uncertainties in the case of Macedonia. Namely, in Macedonia, “emissions of methane and ammonia have not been analyzed in detail... where those originate from inadequate storage and use of manure and fertilizers of animal origin in regions with significant number of livestock breeding farms”. [7] On the top of this, in our country, “there is no continuous process of environmental monitoring and consequently there is shortage of relevant environmental data related to agriculture (soil, water, biodiversity, ecological areas). There is certainly lack of data on agriculture at the level of farm as well (introduction of FADN – Farm accounting data network is in its initial phase of establishment). This situation narrows to a certain degree the field of research freedom, though this does not jeopardize the feasibility of projected costs.

6.4.5. Projections of emissions of sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia under individual scenarios per capita

The analysis of the estimated overall emissions of individual harmful matters will attain additional relevance if estimates of emissions are presented per capita, i.e. disaggregated with the estimates of the total population in Macedonia for specific years. On 31.12.2010, the total number of registered population in Macedonia was 2.057.284 inhabitants. Projections of the total number of inhabitants in 2015 and 2020 are 2.026.551 and 2.022.092 inhabitants, respectively.[32]

Projected emissions per capita are presented below, expressed in kilograms.

Table 42. Projected emissions of sulphur dioxide under the three scenarios per capita (in kg)

Year	2010	2015	2020	National emission ceiling per capita		
				2010	2015	2020
SO_2 [kg] - BS	55.97	64.28	49.07	63.19	64.15	64.29
SO_2 [kg] - FMS	55.78	65.01	41.85			
SO_2 [kg] - Model	54.85	46.18	7.53			

Table 43. Projected emissions of nitrogen oxides under the three scenarios per capita (in kg)

Year	2010	2015	2020	National emission ceiling per capita		
				2010	2015	2020
NO_x [kg] – BS	16.17	18.57	14.18	18.96	19.24	19.29
NO_x [kg] - FMS	16.12	16.63	11.77			
NO_x [kg] - Model	16.45	14.01	10.31			

Table 44. Projected emissions of volatile organic compounds under the three scenarios per capita (in kg)

Year	2010	2015	2020	National emission ceiling per capita		
				2010	2015	2020
VOC [kg] – BS	13.79	15.91	18.13	14.58	14.80	14.84
VOC [kg] - FMS	13.74	15.40	15.66			
VOC [kg] – Model	9.71	8.28	7.56			

Table 45. Projected emissions of ammonia under the three scenarios per capita (in kg)

Year	2010	2015	2020	National emission ceiling per capita		
				2010	2015	2020
NH_3 [kg] - BS	4.80	5.05	4.57	8.26	8.39	8.41
NH_3 [kg] - Model	4.34	4.50	4.42			

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Annex 1

Measures for pollutant emissions reduction

No.	Measure definition	Timeframe	Activity	Comment
1.	Use of desulfurization equipment (scrubbers)	2020	Elimination of sulphur from gas prior to its final release into the air in accordance with the requirements of the LCP Directive 32001L0081	Law on Ambient Air Quality Decree on large combustion plants undertaking measures for air protection Rulebook on ELV Plan for undertaking measures for air protection against LCP BATs introduction
2.	Use of catalytic converters to reduce NO_x emissions	2020	Reduction of NO_x emissions in accordance with the requirements of the LCP Directive 32001L0081	Law on Ambient Air Quality Decree on large combustion plants undertaking measures for air protection Rulebook on ELV Plan for undertaking measures for air protection against LCP BATs introduction
3.	Use of electrostatic precipitators to reduce the emissions of suspended particulate matters		Reduction of suspended particulate matters emissions in accordance with the requirements of the LCP Directive 32001L0081	Law on Ambient Air Quality Decree on large combustion plants that undertake measures for air protection Rulebook on ELV Plan for undertaking measures for air protection against LCP BATs introduction
4.	Generation of biomass during coal combustion as partial substitute for fuel	2020	Reduction in the quantities of pollutant emissions	Plan for undertaking measures for air protection against LCP
5.	Substitute and reduction in the use of crude oil and diesel with biodiesel firing fuel	2020	Reduction in the quantities of pollutant emissions	Plan for undertaking measures for air protection against LCP
6.	Greater utilization of biomass and biogas as energy resource		Reduction in the quantities of pollutant emissions	
7.	Use and higher share of natural gas in all sectors, especially households, industry and heat production		Reduction in the quantities of pollutant emissions	
8.	Increase in the use of renewable energy sources		Achievement of energy efficiency	Mitigation of harmful environmental effects of fuels causing large pollution
9.	Provision of energy efficiency in energy production, transmission and use	2020	Reduction in the net consumption of final energy consumption 20%	Introduction of higher rate of energy utilization
			Generation of renewable energy sources by 20%	Inclusion of renewable energy sources in production and energy utilization.

				Construction of capacity for RES based production.
			Reduction of pollutant emissions in the air by 20%	This is in line with the target for 20% reduction of greenhouse gas emissions, through use of energy efficient systems for energy production and consumption
10.	Application of energy efficiency in residential sector		Investments in residential sector by specified time and financial schedule	25% of investments are expected in the sector for increased use of energy from renewable sources, for new boilers for individual district heating, new highly efficient furnaces for firing wood
			Improvement of energy efficiency in urban areas	Signing of Memorandum of Understanding for energy efficiency by network of mayors
11.	Application of energy efficiency in commercial and service sectors		Higher growth rate may be expected in hotel management industry as relevant for energy consumption	Energy consumption in this sector is compose mainly of electricity with a share of 43% in consumption and oil products (heating oil, so called D2 fuel and TNG) with almost 42 %
12.	Efficient energy use in industrial sector		Improvement and reconstruction of processes of production, equipment and systems for process control.	Introduction of IPPC system and integrated environmental permitting BATs introduction Clean Development Mechanism - CDM
13.	Energy savings in transport sector		More intensive use of public transport through promotion of vehicles with less environmental pollution, improvement in fuel quality, as well as introduction of biofuels on the market	
14.	Regular inspection supervision in the process of oil refining			Law on Ambient Air Quality Decree on large combustion plants undertaking measures for air protection Rulebook on ELV Plan for undertaking measures for air protection against LCP Rulebook on the measurement of emission from stationary sources
15.	Direction of excess firing gas		Efficient combustion of combusting torch for fast mixing of exhaust gases in atmosphere	
16.	Distribution of oil products in the systems that do not release emissions		Improvement of technical characteristics of the systems for liquid fuels transport and transfer	Rulebook on technical conditions for fuel transfer stations

17.	Use of energy efficiency improved techniques in dyes application		Elaboration of plans for VOCs use, improvement of application processes	Rulebook on ELV Rulebook on the measurement of emission from stationary sources Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution on the control of volatile organic compounds emission or their transboundary transfer
18.	Increase in water based dyes production		Use of dyes based on water as solvent	Rulebook on ELV Rulebook on the measurement of emission from stationary sources Law on the Ratification of the Protocol to 1979 Convention on Long-Range Transboundary Air Pollution to control emissions of volatile organic compounds or their transboundary transmission
19.	Manure management		Sustainable use of manure	Code on good agricultural and hygiene practice (Official Gazette of RM no. 112/10) Guide on achievement of the principles of good agricultural and hygiene practice (Official Gazette of RM no. 138/10) Practical brochure on Waste Management by the standards of good agricultural practice and technical instruction on products for plant protection and agricultural waste Rulebook on the rules of good agricultural practice in fertilizers use (Official Gazette of RM no. 68/11)
20.	Mineral fertilizers management		Sustainable use of mineral resources	
21.	Sustainable cattle management and breeding	2020	Common basic programme for livestock breeding	Law on Livestock Breeding (Official Gazette of RM no. 7/2008 and 116/2010) Rulebook on the scale of genetic reserves, as well as the manner and procedure of reserves provision and maintenance (Official Gazette of RM no. 151/2010) Rulebook on the manner of trading in native breeds and/or lines, the form and the content of the application for recognition of new native breeds and or lines and the form, content and manner of register keeping (Official Gazette of RM no. 151/2010) Rulebook on the manner of performing monitoring of biological diversity in livestock breeding (Official Gazette of RM no. 151/2010) Rulebook on detailed conditions for performing individual public service of biological diversity conservation in livestock breeding and preservation of cattle genetic

				reserves (Official Gazette of RM no. 151/2010) Programme for biological diversity in livestock breeding (Official Gazette of RM no. 144/2010) Common Plan for Livestock Breeding (CBCBP) for the period 2011-2020, (Official Gazette of RM no. 43/2011)

Projects in the area of energy for pollutant emissions reduction

Completed activities				
No.	**Measure definition**	**Timeframe**	**Activity**	**Comment**
1.	Modernization of subsidiary Energetika (Energy), A.D. ELEM	2009	Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 30MW. Increase of electricity production from domestic sources and reduction of electricity import by around 160GWh per year. Increase of thermal power production by around 200GWh per year. Significant reduction of pollution by use of natural gas in production process.	Co-generation regime has been introduced and turbo-generators produce combined electricity and heat. Natural gas is used as driving fuel instead of crude oil that used to be used for heat production only. Own investment of 3.5 million EUR
2.	Project TE-TO Construction of plant for combined electricity and heat production in Skopje	2011	Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 220MW. Increase of electricity production from domestic sources and reduction of electricity import by around 1850GWh per year. Increase of thermal power production by around 350GWh per year. Significant reduction of pollution by use of natural gas in production process.	Electric power system of the Republic of Macedonia has obtained new, contemporary and technologically modern production facility owned by Sintezgroup from Moscow, Russia and AD Toplifikacija from Skopje, with ownership structure of 70% to 30% to the benefit of Sintezgroup from Moscow, Russia. Implementation of the whole project was 167 million EUR worth, 70% of which was credit based indebt in LBB Bank from Germany and 30% own funds. Production process uses natural gas as driving fuel.
3.	Project KOGEL. Construction of plant for combined electricity and heat production in Skopje	2009	Increase of electricity production from domestic sources and reduction of electricity import by around 30,4MW. Increase of electricity production from domestic sources and reduction of electricity import by 150 to 220GWh per year.	

			Increase of thermal power production by around 30 to 70GWh per year. Significant reduction of pollution by use of natural gas in production process.	
Current projects				
4.	Modernization of REK Bitola.	2014	Extension of operational lifetime of REK Bitola by additional 120 000 operational hours. Increase of designed capacity of REK Bitola by additional 8.32 MW per block or around 25MW in total. Increase of electricity production from domestic sources and reduction of electricity import by around 160-200GWh per year. Reduction of environmental pollution by 134688t/ per year less CO_2, 258t/ per year less NOx.	The whole process of modernization of REK Bitola is planned for implementation in two phases. The first phase includes modernization and automation of turbo aggregates (turbines and generators) of the three blocks. The second phase includes modernization and automation of boiler of the three blocks. A.D. ELEM's own investment in an amount of 55.9 million EUR
5.	Rehabilitation of six hydro-power plants	2013	Increase of designed capacity of the six hydro power plants by additional 18.31MW. Increase of electricity production from domestic sources and reduction of electricity import by around 50GWh per year. Reduction of environmental pollution by 45750t/ per year less CO_2, 88t/ per year less NOx. Increase of energy efficiency and use of renewable energy sources for electricity production.	This project involves rehabilitation of six hydro power plants owned by A.D. ELEM, namely: HPP Globochica, HPP Tikvesh, HPP Vrutok, HPP Raven, HPP Vrben and HPP Shpilje. The first phase of this project was completed in the period 1998 to 2005, and the implementation of the second phase expected to be completed by 2013 is underway. A.D. ELEM's own investment in an amount of 31.88 million EUR.
Planned projects				
6.	Construction of wind power plants park - Bogdanci	2013	Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 50MW. Increase of electricity production from domestic sources and reduction of electricity import by around 100GWh per year. Reduction of environmental pollution by 91500t/per year less CO_2, 173t/per year less NOx. Increase of energy efficiency and use of renewable energy sources for electricity production.	This project is divided into two phases. The first phase of the implementation will have wind turbines installed with a capacity of 37MW, and wind turbines with a capacity of 13MW will be installed in additionally in the second phase.

				Total investment for the implementation of this project is 55.5 million EUR.
7.	Project Lukovo Pole	2016	Increase of electricity production from domestic sources and reduction of electricity import by around 159GWh per year. Reduction of environmental pollution by 145485t/per year помалку CO_2, 275t/per year помалку NO_x. Increase of energy efficiency and use of renewable energy sources for electricity production.	This Project assumes construction of new accumulation Lukovo Pole, construction of water supply canal in a length of around 20 km – by intake of the Korab's waters and construction of small hydro power plant Crn Kamen. Total investment for Lukovo Pole development has been estimated at 62 million EUR.
8.	Project Boshkov Most	2016	Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 68MW. Increase of electricity production from domestic sources and reduction of electricity import by around 120GWh per year. Reduction of environmental pollution by 109800t/per year помалку CO_2, 207t/per year помалку NOx. Increase of energy efficiency and use of renewable energy sources for electricity production.	This Project assumes construction of new accumulation Boshkov Most. The total investment for its implementation has been assessed at 86 million EUR.
9.	Project solar power plant in the mine Suvodol near Bitola		Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 50MW. Increase of electricity production from domestic sources and reduction of electricity import by around 104GWh per year. Reduction of environmental pollution by 94000t/per year less CO_2, 179t/per year less NOx. Increase of energy efficiency and use of renewable energy sources for electricity production.	This Project assumes construction of new solar power plant. By early 2013, Feasibility Study on solar power plant development will be elaborated. The development of the solar power plant will cost up to 225 million EUR.
10.	Project small hydro power plants		Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 250MW. Increase of electricity production from domestic sources and reduction of electricity import by around 1200GWh per year. Reduction of environmental pollution by 1098000t/per year less CO_2, 4296t/per year less NOx. Increase of energy efficiency and use of renewable energy sources for electricity production. Direct so called "Greenfield" investment.	This project assumes construction of 400 small power plants throughout the territory of the Republic of Macedonia Investments have been estimated at 62 million EUR.
11.	Project Chebren and Galishte		Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 530MW. Increase of electricity production from domestic sources and reduction of electricity import by around 1100GWh per year.	This project assumes selection of a company – concessionaire which will together with A.D. ELEM construct the hydro power

			Reduction of environmental pollution by 1006500t/per year less CO_2, 3938t/per year less NOx. Increase of energy efficiency and use of renewable energy sources for electricity production. Direct so called "Greenfield" investment.	plants Chebren and Galishte. The total investment has been estimated at around 700 million EUR.
12.	Project Sv.Petka	2012	Increase of designed capacity of electricity production plants in the Republic of Macedonia by around 36.4MW. Increase of electricity production from domestic sources and reduction of electricity import by around 66GWh per year. Reduction of environmental pollution by 59654t/per year less CO2, 114t/ per year less NOx. Increase of energy efficiency and use of renewable energy sources for electricity production.	This project assumes construction of a new hydro power plant. HPP Sv. Petka (former Matka 2) on the river of Treska. Total investment amounts around 68 million EUR.

Annex 2 Profile of large combustion plants in the Republic of Macedonia

Name of the plant	Process	Fuel type	OPERATIONAL HOURS		FLOW	
			Aaot* from 2006 to 2010 (hours)	Aaot* from 2011 to 2015 (hours)	Aawgf **** from 2006 to 2010 (million Nm^3 p.a)	Aawgf **** from 2011 to 2015 (million Nm^3 p.a)
Refinery Okta	Process plants	Multi fuel (Crude oil, firing gas)****	7136	5088	540.18	385.15
	Energy	Multi fuel (Crude oil, firing gas)	3196	1550	245.96	119.29
Total					**786.14**	**504.44**
Teteks Тетово	Boiler K104	Coal	2319	2319	58.88	58.88
	Boiler K 1374	Coal	1473	2012	33.33	45.52
	Boiler SPH 16	Crude oil	283	112	1.82	0.72
Total					**94.03**	**105.12**
TPP Oslomej	Reinforced concrete stack	Coal	6,220	6,600	**4109.32**	**4360.37**
Archelor Mital	Annealing furnaces	Natural gas	4800	4800	92.38	92.38
	JDG Galvanization line	Natural gas	7200	7200	19.49	19.49
	OC Plasticization line	Natural gas	7200	7200	182.20	182.20
Total					**294.07**	**294.07**
Toplifikacija	ISTOK	Crude oil and natural gas	1757	1917	629.20	686.50
	ZAPAD	Crude oil	1653	1740	279.30	294.00
Total					**908.50**	**980.50**
REK Bitola	Block 1 and 2	Coal	7304	8160	15810.27	17663.17
	Block 3	Coal	7477	6480	7925.80	6868.96
Total					**23736.07**	**24532.13**
TPP Negotino	Steam boiler P-56	Burning oil Crude oil	**1626**	**6,500**	**979.00**	**3913.59**
TE-TO	Energy	Gas	**0**	**8300**	**0**	**13317.00**
ELEM Energetika	Steam boiler G-32	Natural gas and crude oil (as alternative)	**8000**	**8000**	**169.78**	**169.78**

* Average annual operational time – Aaot, ** Annual emissions – AE, *** Average annual unreduced emissions - Aaue, **** Average annual waste gas flow - Aawgf – ***** (Option for desulphurization rate) FGD Installation put into operation before 2001.

Name of the plant	Process	Fuel type	SO_2				
			ELV for SO_2 by Rulebook (mg/Nm3)	Permissible quantities of SO_2 with ELV (t/year) with Aawgf**** from 2006 - 2010	Aaue*** from 2006 to 2010 of SO_2	AE** of SO_2 in 2010 (t/year)	SO_2 2011-2015 with modified operational hours (t/year)
Refinery Okta	Process plants	Multi fuel (Crude oil, firing gas)****	1625	877.79	2194.32	574.60	409.69

	Energy	Multi fuel (Crude oil, firing gas)	1700	418.14	440.30	522.50	253.40
Total				**1295.93**	**2634.62**	**1097.10**	**663.10**
Teteks Тетово	Boiler K104	Coal	2000	117.76	1.16	0.68	0.68
	Boiler K 1374	Coal		66.65	9.91	9.91	13.54
	Boiler SPH 16	Crude oil	1700	3.09	1.03	0.64	0.25
Total				**187.51**	**12.10**	**11.23**	**14.47**
TPP Oslomej	Reinforced concrete stack	Coal	1900	**7807.71**	**14164.50**	**15697.00**	**16655.98**
Archelor Mital	Annealing furnaces	Natural gas	100	9.24	0.59	0.51	0.51
	JDG Galvanization line	Natural gas	100	1.95	34.17	4.46	4.46
	OC Plasticization line	Natural gas	100	18.22	11.30	9.83	9.83
Total				**29.41**	**46.06**	**14.80**	**14.80**
Toplifikacija	ISTOK	Crude oil and natural gas	1700	22.02	1464.23	0.00	0.00
	ZAPAD	Crude oil	1700	474.81	662.71	287.86	303.01
Total				**496.83**	**2126.94**	**287.86**	**303.01**
REK Bitola	Block 1 and 2	Coal	**500**	7905.14	31722.04	35738.68	39927.11
	Block 3	Coal	1400	11096.12	20155.77	23633.91	20482.51
Total				**19001.26**	**51877.81**	**59372.59**	**60409.62**
TPP Negotino	Steam boiler P-56	Burning oil Crude oil	**1700**	**1664.30**	**11486.00**	**0.00**	**0.00**
TE-TO	Energy	Gas	**10**	**133.17**	**0.00**	**0.00**	**0.00**
ELEM Energetika	Steam boiler G-32	Natural gas and crude oil (as alternative)	**35**	**1.70**	**55.00**	**0.00**	**0.00**
TOTAL				**30617.81**	**82403.03**	**76480.58**	**78060.98**

Name of the plant	Processes	Fuel type	**NO_X**				
			ELV for NOx by Rulebook (mg/Nm³)	Permissible quantities of NOx with ELV (t/year) with Aawgf **** from 2006 - 2010	Aaue*** from 2006 to 2010 of NOx	AE** of NOx in 2010 (t/year)	NOx2011-2015 with modified operational hours (t/year)
Refinery Okta	Process plants	Multi fuel (Crude oil, firing gas)****	575	310.60	360.91	346.50	247.06
	Energy	Multi fuel (Crude oil, firing gas)	571	140.44	148.32	153.30	74.35
Total			0	**451.05**	**509.23**	**499.80**	**321.40**
Teteks Тетово	Boiler K104	Coal	500	29.44	2.09	1.22	1.22
	Boiler K 1374	Coal		16.66	1.87	1.87	2.55
	Boiler SPH 16	Crude oil	600	1.09	0.64	0.40	0.16
Total				**47.20**	4.60	**3.49**	**3.94**
TPP Oslomej	Reinforced concrete stack	Coal	600	**2465.59**	**2255.50**	**2687.00**	**2851.16**

Archelor Mital	Annealing furnaces	Natural gas	400	36.95	7.78	6.76	6.76
	JDG Galvanization line	Natural gas	400	7.80	6.56	21.14	21.14
	OC Plasticization line	Natural gas	400	72.88	20.56	57.81	57.81
Total				**117.63**	**34.90**	**85.71**	**85.71**
Toplifikacija	ISTOK	Crude oil and natural gas	300	188.76	486.05	70.53	76.95
	ZAPAD	Crude oil	600	167.58	156.46	127.06	133.75
Total				**356.34**	**642.51**	**197.59**	**210.70**
REK Bitola	Block 1 and 2	Coal	600	9486.16	9399.34	10494.15	11724.02
	Block 3	Coal	600	4755.48	5162.95	5910.43	5122.32
Total				**14241.64**	**14562.29**	**16404.58**	**16846.34**
TPP Negotino	Steam boiler P-56	Burning oil Crude oil	600	**587.40**	**1967.00**	**0.00**	**0.00**
TE-TO	Energy	Gas	75	**998.78**	**0**	**0**	**563.20**
ELEM Energetika	Steam boiler G-32	Natural gas and crude oil (as alternative)	300	**50.93**	**5.75**	**11.95**	**11.95**
TOTAL				**19316.55**	**20539.23**	**20453.32**	**20882.45**

Name of the plant	**Processes**	**Fuel type**	**TSP**				
			ELV for TSP by Rulebook (mg/Nm3)	Permissible quantities of dust with ELV (t/year) with Aawgf **** from 2006 - 2010	Aaue*** from 2006 to 2010 of TSP	AE** of TSP in 2010 (t/year)	TSP 2011-2015 with modified operational hours (t/year)
Refinery Okta	Process plants	Multi fuel (Crude oil, firing gas)****	50	27.01	49.03	29.90	21.32
	Energy	Multi fuel (Crude oil, firing gas)	50	12.30	0.00	0.00	0.00
Total				**39.31**	**49.03**	**29.90**	**21.32**
Teteks Тetovo	Boiler K104	Coal	50	2.94	1.62	0.95	0.95
	Boiler K 1374	Coal		1.67	0.00	0.00	0.00
	Boiler SPH 16	Crude oil	100	0.18	0.00	0.00	0.00
Total				**4.79**	**1.62**	**0.95**	**0.95**
TPP Oslomej	Reinforced concrete stack	Coal	100	**410.93**	**2081.25**	**1763.00**	**1870.71**
Archelor Mital	Annealing furnaces	Natural gas	20	1.85	0.00	0.00	0.00
	JDG Galvanization line	Natural gas	10	0.19	0.00	0.00	0.00
	OC Plasticization line	Natural gas	20	3.64	0.00	0.00	0.00
Total				**5.69**	**0.00**	**0.00**	**0.00**
Toplifikacija	ISTOK	Crude oil and natural gas	50	31.46	0.00	0.00	0.00
	ZAPAD	Crude oil	50	13.97	0.00	0.00	0.00
Total				**45.43**	**0.00**	**0.00**	**0.00**

REK Bitola	Block 1 and 2	Coal	100	1581.03	4836.36	3892.32	4348.48
	Block 3	Coal	100	792.58	2442.81	2399.53	2079.57
Total				**2373.61**	**7279.17**	**6291.85**	**6428.06**
TPP Negotino	Steam boiler P-56	Burning oil Crude oil	50	**48.95**	**317.00**	**0.00**	**0.00**
TE-TO	Energy	Gas	5	**66.59**	**0**	**0**	**59.70**
ELEM Energetika	Steam boiler G-32	Natural gas and crude oil (as alternative)	5	**0.85**	**0.00**	**0.00**	**0.00**
TOTAL				**2996.13**	**9787.77**	**8145.40**	**8380.73**

Annex 3

Overview of BATs for pollutant emission control from new and existing plants, including sources in agriculture

The applied measures and techniques have to be the best available techniques (BATs). Based on BAT, the Protocol sets the binding requirements in a form of emission limit values (ELV) for stationary and mobile sources, as well as standards for fuel and deadlines for their application.

In order to fulfill the obligations under the Programme, overview of the Best Available Techniques (BATs) for pollutants emission control is presented hereunder, together with the analysis of their application in the Republic of Macedonia and overview of sources of data on the relevant activities.

- Best Available Techniques (BATs) - means the most effective and advanced stage in the development of activities and methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, to reduce emissions and the negative impact on the environment as a whole.

- Techniques - include the technology used and the way in which the installation is designed, maintained, operated, and the termination of installations.

- Available techniques - mean the methods developed within the range enabling application in the relevant industrial sector, under economic and technical cost effective conditions, with full account taken of the costs and benefits, irrespective of whether the techniques are used, or developed and/or produced in the frames of the activity, provided that they are reasonably affordable to the operator.

- Best - means those techniques which are the most effective in achieving a high general level of protection of the environment as a whole.

1. BAT for sulfur dioxide (SO_2)

Combustion processes are the main source of anthropogenic emissions of sulfur dioxide from stationary sources. Based on EMEP / CORINAIR 90, the main stationary sources include:

a) Thermal power facilities and industrial plants for energy transformations:
- Combustion plants;
- Stationary internal combustion engines;

b) Non-industrial plants:
- Combustion plants in service sector;
- Combustion plants in households;

c) Industrial heating and boiler plants:
- Combustion plants and process furnaces;
- Processes (e.g. metallurgical processes – grinding, sintering, etc.);
- Paper production;

d) Production processes (specific organic processes of synthesis, metallic surfaces treatment);

e) Extraction and distribution of fossil fuels;

f) Waste treatment and disposal (e.g. thermal treatment of hazardous waste)

General methods for sulfur dioxide emissions reduction include:

a) Energy management measures:
- Energy saving – energy efficiency (improvement of energy effectiveness) of the process, secondary production and/or demand-side management (DSM) usually results in sulfur dioxide emission reduction,
- Energy combination – generally, sulfur dioxide emission can be reduced by increased share of energy sources with non-combustion processes (e.g. hydro power, wind, sun, nuclear power, etc.). Here, other environmental impacts should be identified as well.

b) Technological measures:

i. Fuel substitute (instead of solid fuel with high sulfur content – substitute with solid fuel and/or liquid fuel with low sulfur content or substitute with gas).
   - This results in reduction of SO_2 emissions, but with certain limitations, such as: availability of fuel with low sulfur content and ability of existing boilers to use various fuels.

ii. Fuel treatment
   - Desulfurization of liquid fuels (light and medium light distillates) is state-of-the-art of technology,
   - Desulfurization of heavy oil distillates is technically feasible, but we should at the same time bear in mind the characteristics of crude oil,
   - Desulfurization of heavy residues from atmospheric distillation is not practiced,
   - Processing of crude oil with lower sulfur content is recommendable,
   - hydrocracking (HGK) and technologies of full transformation refinery for deep conversion) combine high sulfur retention with increased produce of light products (petrol, diesel and oil). However, production costs are very high.

iii. Additional combustion technologies

   - Improved thermal efficiency and reduced sulfur dioxide emission: fluidized bed combustion (FBC), including: bubbling fluidized bed combustion (BFBC) circulating fluidized bed combustion (CFBC) and pressurized fluidized bed combustion (PFBC); Integrated Gasification Coal Combined (IGCC) plant and Combined Cycle Gas Turbine (CCGT) plant,
   - Combustion in fluidized bed is technology for hard and brown coal combustion, but it can also use other solid wastes like coke, refuse, peat bog, wood. Emissions can be reduced by integrated control of combustion through adding fluidized bed material,
   - IGCC process includes coal gasification and energy production in gas and steam turbine combined cycle.

iv. Modifications of processes and combustion
   - Injection of additives into the combustion unit; however, the experience has shown that the above leads to reduced thermal capacity. Ca/S ratio is high, while sulfur removal is low. Removal of byproducts is a problem, too. Therefore, this measure can be used as temporary measure in smaller installations.

v. Processes of flue gases desulfurization
   - These processes remove the already occurred sulfur oxides and are secondary measures. The state-of-the-art technology for flue gases treatment is based on sulfur removal by wet, dry or semi-dry catalytic chemical processes.

Table 1: Emission of sulfur oxides after the application of secondary measures in the process of combustion

	Uncontrolled emissions		Injection of additives		Wet flue gases treatment)[1]		Dry spray adsorption)[2]	
Efficiency of removal (%)			Up to 80		95		Up to 90	
Energy efficiency (kW_{el}/ $10^3 m^3$/h)			0.1-1		6-10		3-6	
Total designed capacity (ECE Eur) (MW_{th})					194.000		16.000	
Type of byproduct			Mixture of Ca-salts and flying ash		Gypsum (sludge/ wastewater)		Mixture $CaSO_3 x 1/2 H_2O$ and flying ash	
Specific investments (costs ECU (1990) / Kw_{el})			20-50		60-250		50-220	
	mg/m^3)[3]	g/kWh_{el}	mg/m^3)[c]	g/kWh_{el}	mg/m^3)[c]	g/kWh_{el}	mg/m^3)[c]	g/kWh_{el}
Hard coal)[4]	1.000-10.000	3.5-35	200-2.000	0.7-7	<400	<1.4	<400	<1.4
					(<200. 1% S)	<0.7	(<200. 1% S)	<0.7
Brown coal)[d]	1.000-20.000	4.2-84	200-4000	0.85 - 16.8	<400	<1.7	<400	<1.7
					(<200. 1% S)	<0.8	(<200. 1% S)	<0.8
Heavy burning oil)[d]	1.000 - 10.000	2.8-28	400-4000	1.1-11	<400	<1.1	<400	<1.1
					(<200. 1% S)	<0.6	(<200. 1% S)	<0.6

	Flue gas treatment with ammonia	**Wellman Lord**	**Active coal)[a]**	**Combined catalytic)[a]**
Efficiency of removal (%)	до 90	95	95	95
Energy efficiency ($kW_{el}/10^3 m^3$/h)	3-10	10-15	4-8	2
Total designed capacity (ICE Eur) (MWth)	200	2.000	700	1.300
Type of byproduct	Ammonia based fertilizer	Elemental S Sulfuric acid (99 vol.%)	Elemental S Sulfuric acid (99 vol.%)	Sulfuric acid (70wt.%)
Specific investments (costs ECU (1990) / Kw_{el})	230-270)[5]	200-300)[e])[6]	280-320)[e])[f]	3202-350)[e])[f]

)[1] For fuel with high sulfur content, removal efficiency should be adjusted. The above depends on specificities of the process. Availability of these processes is 95%.
)[2]Limited application for fuels with high sulfur content.
)[3]Emission in mg/m^3 (STP), dry 6% oxygen for solid fuels, 3% oxygen for liquid fuels.
)[4]Conversion factor depends on the properties of fuel, specific volume of flammable gas and thermal efficiency of boiler (conversion factors (m^3/kWh_{el}, thermal efficiency: 36%), used for: coal-3,5; brown coal-4,20, crude oil-2.80).
)[5]Specific investment costs have been obtained on the basis of low number of installations.
)[6] Specific investment costs include the process of denitrification.

	mg/m^3)[c]	g/kWh$_{el}$	mg/m^3)[c]	g/kWh$_{el}$	mg/m^3)[c]	g/kWh$_{el}$	mg/m^3)[c]	g/kWh$_{el}$
Hard coal)[d]	<400	<1.4	<400	<1.4	<400	<1.4	<400	<1.4
	(<200 .1% S)	<0.7	(<200. 1% S)	<0.7	(<200. 1% S)	<0.7	(<200. 1% S)	<0.7
Brown coal)[d]	<400	<1.7	<400	<1.7	<400	<1.7	<400	<1.7
	(<200 . 1% S)	<0.8	(<200. 1% S)	<0.8	(<200. 1% S)	<0.8	(<200. 1% S)	<0.8
Heavy burning oil)[d]	<400	<1.1	<400	<1.1	<400	<1.1	<400	<1.1
	(<200 . 1% S)	<0.6	(<200. 1% S)	<0.6	(<200. 1% S)	<0.6	(<200. 1% S)	<0.6

Techniques for SO_2 emission control in other sectors

Techniques for control related to thermal power plants can also be applied in the industrial sector (Table 2).

Application of SO_2 emission reduction techniques in industrial sector depends on specificity and constraints of the process itself within the analyzed sector. The most significant sources of SO_2 and adequate reduction measures are presented in Table 2.

In sources listed in Table 2, the process of integrated measures, including raw materials substitute (if required, combined with process specific treatment of flue-combusted gases) can be used to achieve the most effective SO_2 emission reductions.

Table 2: Sources of SO_2 emission and adequate measures for its reduction

Source	Measure
Nonferrous sulfide calcination	Wet suphuric acid catalytic process (WSA)
Cellulose production (Kraft)	Different process integrated measures

2. BATs for Nitrogen oxides (NOx)

Technical Annex includes techniques for NO_2 emissions control from stationary sources.

Categories of stationary sources for which BAT measures are proposed are the following:

- Combustion plants (combustion plants, gas turbines and stationary internal combustion engines)
- Refineries
- Metal production and processing (plants for metal ores crushing and sintering; plants for raw iron and steel manufacturing (primary and secondary casting) including continuous casting; plant for iron (ferrous) metals processing (hot rolling)
- Cement production plants
- Plants for thermal waste treatment (infective waste)

Measures for NO_2 emission control and reduction from stationary sources are divided into: primary, secondary (so called “add-on” or “end-of-pipe“) and technological measures. The list of available measures which can also combine is given here under:

a) More efficient technologies for NO_2 emissions control;
b) Energy management (efficient and rational energy use);
c) Adequate design of combustion device;

d) Improvement of combustion technology;
e) Combustion modification (primary measures);
f) New concepts of combustion technologies;
g) Flue gases treatment (secondary measures);
h) Good governance (e.g. good maintenance, good control).

Technological measures

Use of “cleaner” fuels and rational energy consumption will result in reduced emissions of NO_2. Given the fact that the use of “cleaner” fuels is regulated on national energy grounds and depends to a great extent on the circumstances in the country and current policy, it is limited by this sole fact. On the other side, reduction in energy consumption in many production processes can achieve significant reductions in NO_2 emissions through energy management such as: energy saving, change in technology and energy demand management by consumers. The costs for implementation of energy management can be lower relative to costs for additional energy supply. Treatment of fuels to eliminate nitrogen is not a commercial option, but increased application of hydro process in refineries will also result in reduced content of nitrogen in the final product.

Primary and secondary measures

In order to achieve more efficient reduction in NO_2, apart from energy management measures, it is also necessary to consider combination of technical options (fuel substitute, other combustion technologies, modification of combustion processes and fuel gases treatment). To identify the best combinations for combustion modifications and flue gases treatment, assessment specific for the considered plant is required.

Modifications in production process and combustion process are applied to reduce the formation of NO_2 during combustion. Modifications include control of air flow, temperature of flame, air-fuel ratio, etc. Certain options are typical for existing installations upgrading; other are typical for new installations, but also applicable in existing installation upgrading. Efficiency and applicability can be subject to certain limitations. These measures are often used individually or in combination:
a) Low Excess Air combustion (LEA);
b) Reduced Air Preheat (RAP) – applicable only for existing installations;
c) Burners re-distribution - Burner-Out-Of-service (BOOS) and Biased-Burner-Firing (BBF); applicable only for existing installations;
d) Low NOx Burner (LNB);
e) Flue Gas Recirculation (FGR);
f) Over Fire Air combustion (OFA) or air-staging;
g) In-Furnace NOx Reduction or Reburning (IFNR);
h) Water/steam injection and lean/premixed combustion – only for internal combustion engines.

The measure of gradual fuel supply (reburning) is highly developed and applicable for all fuels. Its advantages include compatibility with other primary NO_2 measures, simple integration, use of standard fuels (light and heavy oils, gas); additives are not required as reduction means, and thus there is minor demand for additional energy.

Emissions of NO_2 can also be reduced by application of fluidized bed combustion technology. This technology is applicable for wide spectrum of fuels (coal, biomass, heavy residues, etc.). Owing to lower temperatures at combustion (around 850°C) and air staging, this technology achieves low emission of NO_2 and can be used mostly without secondary measures. Oxycombustion is also one of the ways for NO_2 emissions reduction – industrial application of this technology has so far however been limited to glass production.

Adjustment (modification) of the process of combustion concerns mainly the structure of boilers and burners. Newer combustion devices include burners with low NOx emission (LNB) and over fire air (OFA) combustion. The last generation of LNB combine air-staging and fuel in the very structure of burners.

Contact processes, like cement production, are subject to numerous limitations in order to obtain the desired product quality, such as the requirement for high temperature of combustion and equal temperature distribution.

Typical combustion modifications applied in these processes include: staged combustion, low NOx burners (LNB), flue gas recirculation and process optimization (e.g. precalcination in furnaces with cement production process).

The process of Selective Catalytic Reduction (SCR) is the most frequently found and most affordable process of fuel gas treatment with high efficiency in NO_2 removal. SCR process usually uses ammonia or urea as reduction agent, though pure water-free ammonia stored under pressure is most frequently used. This process is applicable with small combustion devices and de-NOx technology has been recognized for combustion in boilers and certain industrial processes, such as:

a) Cement production (tested only in pilot projects);
b) Processes of oil industry;
c) Thermal treatment / incineration of hazardous waste (usually in rotary furnaces);
d) Thermal treatment / incineration of infective and other special waste in non-industrial or industrial combustion plants (rotary furnaces, pyrolysis plants, fluidized bed combustion of industrial waste such as sludge, heavy residues, etc.), but also with smaller devices (<10MW_{th})

The process of Selective Non-Catalytic Reduction (SNCR) is applicable with medium size combustion plants with medium content of NO_2 in untreated gas. The SNCR process itself can achieve 30-70% reduction in NO_2 emissions. Combined with the primary measure for flue gas recirculation, it is attractive and reliable technology for moderate removal of NO_2 (50 - 80%), especially with small combustion plants and industrial processes.

Other technologies for fuel gas treatment include processes for combined NO_2/SO_2 removal.

Specific measures for individual activities

Specific measures for individual activities are shown in Tables 3 to 6.

Table 3: Measures for control of NO_2 with NO_2 concentrations achievable with their application (combustion plants)

Emission source	Combination of emission control measures	Achievable concentrations in treated gas (Mg/Nm^3)
Small combustion plants 10-10 MW_{th} ; Medium combustion plants 10-50 MW_{th}		
Combustion plants with Dry Battom Boiler (DBB); Fuel: coal (> 10MW_{th})	Primary measures (PM)	400-600
Combustion plant; Fuel: light oil	PM	150-300
Combustion plant; Fuel: heavy oil (crude oil)	PM	300-600
Combustion plant; Fuel: natural gas	PM	50-150
Circulating fluidized bed combustion; Fuels: coal, biomass, etc.	Without additional measures	150-300
Bubbling fluidized bed combustion (BFBC); Fuels: coal, biomass, oil, sediments, etc.	Without additional measures	200-400
Combustion plant in industry; Fuel: process gas	PM	100-300
Big combustion plants of > 50 MWth		
Combustion plants with Dry Battom Boiler (DBB);	PM	300-600
	PM and SCR	80-150

Fuel: coal		
Combustion plants Fuel: crude oil	PM (without fuel staging (reburning)	250-500
	PM (with fuel staging (reburning)	Primary measures (PM)
Combustion plants; Fuel: natural gas	PM and SCR	60-150
	PM	50-200
Combustion device with Wet Bottom Boiler (WBB); Fuel: coal	PM and SCR("tail end " SCR position)	≤150
	PM and SNCR	≤200
Pressurized fluidized bed combustion Fuel: coal	Without additional measures	150-200
	SCR and/or SNCR	≤100
Circulating fluidized bed combustion; Fuels: coal, biomass, etc.	Without additional measures	150-300
	SNCR	100-200
Bubbling fluidized bed combustion; Fuels: coal, biomass, oil, sediments, etc.	Without additional measures	200-400
	SNCR	130-200
Combustion plant In industry; Fuel: process gas	PM	100-300
	PM and SNCR	100-200
Gas turbines		
Simple cycle, combined cycle, cogeneration (prior to additional combustion), mechanical drive		
Fuel: natural gas	PM	50-150
	SCR	10-50
Fuel: Diesel or process gas	Control by washing	100-200
	SCR	20-100
Integrated Gasification Coal Combined (IGCC) plant		
Fuel: coal or heavy oil	Injection of nitrogen and steam	50-100
Internal combustion engines		
Spark plug firing (Otto) engines, 4 - stroke		
„Oldrich burn“	SNCR (three-component catalyst	350
Improved “lean“ combustion	Without measures	350-550
	SCR	100
Compression firing engines (Diesel)		
Fuel: Heavy oil	SCR	400-1000
	Fuel gas recirculation and SCR	200-500
Fuel: Diesel	SCR	360-500
	Fuel gas recirculation and SCR	180-240

Table 4: Measures for control of NO_2 with NO_2 concentrations achievable with their application (refineries)

Emission source	Combination of emission control measures	Achievable concentrations in treated gas (Mg/Nm^3)
Process furnace; Fuel: oil coke	Primary measures (PM)	≤200
Process furnace; Fuel: heavy oil	PM	250-600
Process furnace;	PM	50-200

Fuel: natural gas		
Process furnace; Fuel: process gas	PM	100-300
FCC	SCR	100-200

Table 5: Measures for control of NO_2 with NO_2 concentrations achievable with their application (sinter plants and reheating furnaces – process in iron and steel industry)

Emission source	Combination of emission control measures	Achievable concentrations in treated gas (Mg/Nm^3)
Sinter plant		
Mobile screen; Fuel: coke breeze(byproduct in coke production process)	Fuel gas recirculation	300-400
	SCR	100-120
Reheating furnace		
Fuel: gas from blast furnace	Low-NOx burners (LNB)	≤390
Fuel: coke gas, heavy oil	Low-NOx burners (LNB)	≤1100
Fuel: natural gas, oil	Low-NOx burners (LNB)	≤250

Table 6: Measures for control of NO_2 with NO_2 concentrations achievable with their application (cement production)

Emission source	Combination of emission control measures	Achievable concentrations in treated gas (Mg/Nm^3)
Dry process with preheater/precalcinator		
Fuel: coal	Flame cooling, Low-NOx burners (LNB) or staged combustion	500)[7]
	Low-NOx burners (LNB) and SNCR	200-500
	Low-NOx burners (LNB) and SCR	100-200

3. BATs for Volatile Organic Compounds (VOCs)

Technical Annex includes stationary sources listed in Table 7.

Table 7: Stationary sources of VOCs emission considered in the Technical Annex of Gothenburg Protocol

Stationary sources
1. Combustion in households (<300 kWth)
2. Refineries
3. Extraction and distribution of fossil fuels
4. Manufacturing of organic chemical products
5. Adhesive coating (including wood and plastic lamination)
6. Coating processes (metal and plastic surface of passenger cars, trucks, truck cabins, buses or wooden surfaces)
7. Application of coatings (on metal, plastic and wooden surfaces) and dyes in construction industry and households
8. Coating of metals in electronic industry
9. Dry cleaning
10. Manufacturing of coatings, dyes, varnishes and adhesives
11. Manufacturing of pharmaceutical products
12. Printing industry
13. Surface cleaning

)[7]In combination with primary measures (PM)

14. Vegetable oil and animal fat production
15. Impregnation of wooden surfaces
16. Use of solvents in households
17. Manufacturing of baking and confectionery products
18 Manufacturing of beer (including production of malt)
19. Manufacturing of distilled alcoholic beverages

While planning measures or technologies for stationary sources releasing VOCs, as well as other pollutants such as SO_2, NO_2, NH_3, CO_2, heavy metals, particles, POPs, it is useful to consider such measures and technologies in combination with other possible techniques for other pollutants control, in order to enhance the effect of environmental impact elimination and reduction.

There are available and applicable measures for VOC emissions prevention and control for almost all stationary sources. There are primary, secondary (so called "add-on" or “end-of-pipe”) and structural measures that can be applied both for existing and new plants.

The list of available measures, with a possibility for combination, is presented here beneath:

a) More effective technologies for VOC control in terms of maintenance of equipment, better sequestration of flue gases and optimization of process conditions in general;

b) Substitute of VOCs, such as: use of solvents/products with low content of organic components or solvents free of organic components (such as water based dyes and coatings) and/or process modification;

c) Reduction of emissions through use of the best management practices, such as good maintenance, improved programme for supervision and maintenance, changes in processes, such as closed circulation devices, improved sealing of storage containers or structural changes such as dislocation of activity to a site where VOC emission reduction is more efficient (e.g. pre-coating of certain products);

d) Recycling and/or recovery of VOC through control of technologies, such as: condensation, adsorption, absorption and membrane processes (pre-process application). Another option is heat (energy) recovery from VOCs. It is recommendable to re-use the organic components at the point of their first use, unless complex admixtures are used. These complex admixtures are better treated outside the places of their original use, but in such cases emission can result from distribution, handling, transport and storage;

e) Destruction/removal of VOCs is carried out by control of technologies, such as: thermal treatment, catalytic combustion or biological treatment. During thermal treatment, heat regeneration is recommended in order to prevent further pollution. Other common procedure for destruction of non-halogenated VOCs is to use collected flue gases of VOCs as secondary air or as fuel in the existing energy transformation unit.

Secondary measures for VOC emissions reduction include:

a) Adsorption: VOCs are removed from flue gases by process of adsorption upon which they are desorbed into highly concentrated flue gases, which are then treated so that solvent is regenerated (concentrate) or burnt with energy recovery, if this is feasible within the process of production;

b) Absorption is mainly used in chemical, pharmaceutical and mineral fertilizers industries, where it is recommendable due to existing infrastructure;

c) Thermal treatment: standard technology, safe, reliable and efficient method for removal of wide range of VOCs (except for halogenated hydrocarbons) applied in most of the processes. Apart from this, it enables regeneration of useful thermal energy and is thus very cost-effective;

d) Catalytic thermal treatment: reliable, recognized and widely applicable method for removal of VOCs (both halogenated and non-halogenated), including odours. It is especially attractive in cases where possibilities for use of regenerated heat are limited, and considering the fact that the solvent regeneration techniques are expensive;

e) Condensation: further treatment is required where two or more components need to be regenerated. Where only one component is to be condensated, then the product is pure; however, most of the cases require additional processes for gas treatment in order to comply with the required emission limit values. Classical condensation is intended for solvents with low evaporation pressure;

f) Membrane technology (permeation): it is usually used for flue gases upgrading prior to the next process. This technology is under development;

g) Bio-filtration: it is applied successfully for removal of odours, but also for VOCs emission reduction. For technical and economic reasons, bio-filtration is applied whenever regeneration of flue gases components is not attractive or concentration of VOCs in flue gases is very low;

The choice of individual techniques for VOC gases control will depend on various parameters, including: concentration of VOCs in flue gas, volume flow of the gas, composition of VOCs in the flue gas, etc. Therefore, the most adequate technique should be selected considering the conditions of the analyzed process.

The overall efficiency of secondary measures for reduction of VOCs emissions resulting from the application of organic solvents in plants depends to a great extent on the efficiency of VOC flue gases sequestration. This refers especially to processes in which fugitive emissions exist.

Measures specified for individual activities

Measures for VOC emissions reduction specific for each activity are shown in Tables 8 to 21.

Table 8: Sources of emissions and measures for VOCs control with achievable emission factors for combustion plants

Source of emission	Combination of control measures	Achievable emission factor [g/GJ heat capacity][8]
Combustion plants of ≤ 120 kW_{th}		
Fuel: hard coal	Replacement of old combustion plant with new	40
Fuel: brown coal	Replacement of old combustion plant with new	76
Fuel: coke	Replacement of old combustion plant with new	44
Fuel: biomass (wood)	Old combustion plant with accumulative feeder	around 1.250
	New combustion plant with accumulative feeder	350
Fuel: burning oil	Replacement of old combustion plant and/or replacement of old burner with new	1.5
Fuel: natural gas	Replacement of old combustion plant and/or replacement of old burner with new	3
Combustion plants of >120 kW_{th}<300 kW_{th}		
Fuel: hard coal, brown coal, coke	Replacement of old combustion plant with new	6

[8]There are great differences in emissions depending on: capacity of such combustion devices (15 kW, 120 kW); operation under full or partial load; construction (heat exchanger, furnace/manual or automatic feeding).

Fuel: wood, wood coal, peat	Replacement of old combustion plant with new	16
Fuel: burning oil, natural gas	Replacement of old combustion plant with new	1

Table 9: Sources of emissions and measures for VOCs control with achievable emission factors for refineries

Source of emission	Combination of control measures	Achievable VOCs emission factor
– **Processes in refineries**	– Strict control of fugitive emissions (semi-annual and periodical supervision, repair and replacement of shafts for aeration, sampling points) – Control of the area for wastewater collection and treatment – Burning of non-sprinkling emissions from “blow-down“ systems and systems for gas collection in the torch – Destruction (burning, bio-filtration) or regeneration (adsorption of active coal, absorption) of sprinkling emissions	20-60 (g/ton raw material)
Tank with fixed cover		
Low steam pressure (0 <p <10 kPa),	Replacement of fixed cover with internal floating one	1 - 3 g/t stored
High steam pressure (p> 10 kPa),	Replacement of fixed cover with internal floating one	10-40 g/t stored
	Balancing of steams and regeneration	150-160 g/t stored
Tank with externally floating cover		
Low steam pressure (0 <p <10 kPa),	Improvement of performance procedure, improvement of sealing and secondary sealing, controlled sealing of cover and light colour of tank	0,5-2 g/t stored
High steam pressure (p> 10 kPa),	Improvement of performance procedure, improvement of sealing and secondary sealing, controlled sealing of cover and light colour of tank	5-25 g/t stored
Tank with internal floating cover		
Low steam pressure (0 <p <10 kPa),	Improvement of performance procedure, improvement of sealing and secondary sealing, controlled sealing of cover and light colour of tank	1 - 3 g/t stored
High steam pressure (p> 10 kPa),	Improvement of performance procedure, improvement of sealing and secondary sealing, controlled sealing of cover and light colour of tank	10-40 g/t stored

p = steam pressure

Table 11: Sources of emissions and measures for VOCs control with achievable emission factors for fossil fuels distribution

Source of emission	Combination of control measures	Achievable VOCs emission factor
Handling and storage (liquid fuels of fossil origin, except petrol)		
Storage of products with low steam pressure in tanks with fixed cover	System for steams balancing and improvement of supervision and maintenance	80 (g/ton fuels)
Storage of products with high steam pressure and crude oil in tanks with external floating cover	System for steams balancing and improvement of supervision and maintenance	10 (g/ton fuels)
Refinery dispatching stations (petrol)		

Railway cisterns filling in	Techniques of submerged filling from top and system for steams return and regeneration	75 (g/ton petrol)
Road cisterns filling in	Techniques of submerged filling from bottom and system for steams return and regeneration	60 (g/ton excavated crude oil)
Transport and storage (petrol)		
Gradual filling of road cisterns	Tank with fixed cover upgraded with internal floating cover or white coloured tank with floating cover	700 (g/ ton petrol)
	System for steams balancing between tank, connecting unit and unit for steams regeneration at combustion in thermal oxidation unit	300-400 (g/ ton petrol)
Petrol stations		
Petrol stations without VOCs removal systems	Incorporation of I and II degree of control	200 (g/ ton petrol)
Petrol stations with incorporated I degree of VOCs steams control	Incorporation of II degree of control	200 (g/ ton petrol)
Gas pipeline		
Joint pipes		
Small diameter and pressure of $p<0.075$ hPa	Reduced number of flanges, shafts, etc. and improved supervision and handling	400 (g/year/km)
Medium diameter and pressure of $0.075<p<7$ hPa	Reduced number of flanges, shafts, etc. and improved supervision and handling	4 (g/year/km)
Big diameter and pressure of $2<p<2$ hPa	Reduced number of flanges, shafts, etc. and improved supervision and handling	20 (g/year/km)
Welded pipes		
Small diameter and pressure of $p<0.075$ hPa	Improved supervision and handling	0.4 (g/year/km)
Medium diameter and pressure of $0.075<p<7$ hPa	Improved supervision and handling	0.004 (g/year/km)
Big diameter and pressure of $2<p<2$ hPa	Improved supervision and handling	0.2 (g/year/km)

Table 12: Sources of emissions and measures for VOCs control with achievable emission factors for adhesive coating (including wood and plastic lamination)

Source of emission	Combination of control measures	Achievable VOCs emission factor
Manual application, Adhesives with 50% solvents	Gradual transfer from adhesives with high solvents content to adhesives with low solvents content and thermal treatment or catalytic incineration when adhesives with high solvent content are used	40 g/kg adhesives
Manual application, Adhesives with 75% solvents Adhesives with 25% solvents	Gradual transfer from adhesives with high solvents content to adhesives with low solvents content and thermal treatment or catalytic incineration when adhesives with high solvent content are used	70 g/kg adhesives
Footwear industry	Use of hot softened adhesive for top leather and adhesives based on solvents for soles sticking	275 g/kg adhesives
Automated application	Gradual transfer from adhesives with high solvents content to adhesives with low solvents content and thermal treatment or catalytic incineration when adhesives with high solvent content are used	40 g/kg adhesives
Wood and plastic lamination	Transfer to water based adhesives	160 g/kg adhesives

Table 24: Sources of emissions and measures for VOCs control with achievable emission factors for coating processes (buses and trailers and wooden surfaces)

Source of emission	Combination of control measures	Achievable VOCs emission factor
Manufacturing of vehicles		
Manufacturing of buses and trailers	Transfer to water based coating and basic dyes)[a] and incineration in dry furnace	70g/m^2 coated buses
Coating of wooden surfaces		
All plants	Transfer to coating with medium solvent content)[9] and improved process of coating application, good management and thermal treatment of flue gas	4 g/m^{2}coated wooden surfaces
	Transfer to coating with low solvent content)[10] and improved process of coating application, good management and thermal treatment of flue gas	3 g/m^2 coated wooden surfaces

Table 13: Sources of emissions and measures for VOCs control with achievable emission factors for use of dyes in construction industry

Source of emission	**Combination of control measures**	**Achievable VOCs emission factor**
Use of dyes in construction industry	Transfer to coating with low solvent content	40g/kg dye

Table 14: Sources of emissions and measures for VOCs control with achievable emission factors for manufacturing of pharmaceutical products

Source of emission	**Combination of control measures**	**Achievable VOCs emission factor**
All plants	Transfer from halogenated and non-halogenated solvents to water based solvents and catalytic incineration or thermal treatment of flue gas or adsorption with active coal	90.000g/staff/ year

Table 15: Sources of emissions and measures for VOCs control with achievable emission factors for printing industry

Source of emission	**Combination of control measures**	**Achievable VOCs emission factor**
Flexography and copper gravure in packaging sector		
All plants	Transfer to water based printing varnishes (with solvent content of 10 mas%) and catalytic incineration or thermal treatment of flue gas or adsorption with active coal	50 g/kg undiluted printing varnish
Newspapers printing (coldsetoffset)		
Moistening, cleaning	Reduced consumption of isopropanole for moistening and cleaning with cooking oil based products	40 g/kg printing varnish
Printing of magazines (heatsetoffset)		
Solvents consumption >15 tons/year	Printing varnish without solvents (radial hardening) and reduced consumption of isopropanol intended for impregnation and use of cooking oil based products	40 g/kg printing varnish
Copper gravure in publishing sector		
All plants	Adsorption with active coal (depending on efficiency of fugitive emissions sequestration)	375 g/kg undiluted printing varnish
	Transfer to water based printing varnishes (with solvent content of 10 mas%) and adsorption with active coal	55 g/kg undiluted printing varnish

)[9] Coating with medium solvent content contains 20% organic solvents
)[10] Coating with low solvent content contains 5% organic solvents

	(depending on efficiency of fugitive emissions sequestration)	
Screen printing		
Small and large plants	Transfer to water based printing varnishes and catalytic incineration or thermal treatment of flue gas or biofiltration	25 g/kg printing varnish
	Transfer to UV-drying (hardening) of printing varnish	0 g/kg printing varnish

Table 16: Sources of emissions and measures for VOCs control with achievable emission factors for vegetable oil and animal fat production

Source of emission	Combination of control measures	Achievable VOCs emission factor
Extraction of oil from seeds; Charging or continuous process	Optimization of processes and Schumacher type of dissolvation (dissolvenizer) - toasting-drying-cooling and condensation or adsorption and biofiltration	0,85 g/kg processed seed)[11]

Table 17: Sources of emissions and measures for VOCs control with achievable emission factors for impregnation of wooden surfaces

Source of emission	Combination of control measures	Achievable VOCs emission factor
Small plants with solvent consumption <25 tons / year	Improvement of dye application techniques and drying plant enclosing	3500 g/m³ treated wooden surface
Large plants with solvent consumption ≥25 tons / year	Improvement of dye application techniques and drying plant enclosing and thermal treatment of flue gases	900 g/m³ treated wooden surface
All plants	Transfer to process with boron salt and boron steam	0 g/m³ treated wooden surface

Table 18: Sources of emissions and measures for VOCs control with achievable emission factors for households

Source of emission	Combination of control measures
Use of adhesives, products for vehicles maintenance, cleaning products, products for leather and furniture maintenance, creosote, pesticides and cosmetic preparations	Transfer to products without or with low content of solvents (water based solvents), inorganic propellants and reduction of packaging volume

Table 19: Sources of emissions and measures for VOCs control with achievable emission factors for manufacturing of baking and confectionery products

Source of emission	Combination of control measures	Achievable VOCs emission factor
Rotary or industrial production of baking or confectionery products	Removal of flue gases during fermentation and baking with burning or biofiltration	200 g/ton baking and confectionery products
Chain of baking or confectionery shops	Removal of flue gases during fermentation with biofiltration	400 g/ ton baking and confectionery products

Table 20: Sources of emissions and measures for VOCs control with achievable emission factors for beer production

Source of emission	Combination of control measures	Achievable VOCs emission factor
Production of beer with a capacity of ≥1000m³/year		
Brewery	Biofiltration of emissions in the process of malt production from wheat and CO_2 regeneration during fermentation	4g/m³ beer

Table 21: Sources of emissions and measures for VOCs control with achievable emission factors for manufacturing of distilled alcoholic beverages

)[11]Seeds include rape, sunflower seed and soya beams

Source of emission	Combination of control measures	Achievable VOCs emission factor
Manufacturing of distilled alcoholic beverages with capacity of ≥30m³/year		
Process of distillation involving fermentation and distillation	Burning of ethanol from the process of fermentation	80 g/m³ product
Process of distillation involving fermentation, distillation and malt production	Process of distillation involving fermentation, distillation and malt production	1.400 g/m³ product
Process of distillation involving fermentation, distillation and malt production and ripe (during several years)	Process of distillation involving fermentation, distillation and malt production	16.000 g/m³ product

4. BATs for ammonia (NH_3)

Technical annex considers the measures for reduction of ammonia emissions from agriculture and other stationary sources. Agriculture is the main source of ammonia emissions, mainly from animal excreta in animal housing: during storage, processing and application of organic manure on soil; from intestinal secretions during cattle grazing. Emissions also occur during soil fertilization with mineral nitrogen fertilizers. Emissions can be reduced from all these sources, but they can also be reduced through, for example, adaptation of fodder, to result in generation of less nitrogen in the cattle intestinal secretion and consequently lower amounts of generated ammonia.

The BATs are presented in correlation with the following chapters:
- Good agricultural practice;
- Techniques of soil fertilization with manure;
- Balancing of nitrogen and crops rotation;
- Techniques for manures storage;
- Animal housing facilities;
- Feeding technology and other measures;
- Stationary sources that are not from agricultural sector.

Techniques are grouped into three categories:
- Techniques in category 1: are well explored, considered practical and quantitative data on their efficiency in ammonia emission reduction is available (at least at experimental level);
- Techniques in category 2: promising, but the research carried out so far is inappropriate or it will always be difficult to measure their efficiency;
- Techniques in category 3: have proven inefficient or not applied in practice. These techniques cannot be BATs.

Measures for ammonia emissions reduction in various phases of manure lifecycle and handling are inter-related and in combination with measures)[12] the achieved emission reductions cannot be summed up in a simple way. Emission control during manure storage, handling and application on soil is of particular importance as releases of NH_3 emissions into the air are the most present inn these phases. Avoided reduction of emissions in the mentioned phases of the production process will result in irreversible loss of most of the benefits from the removal during the increment in livestock breeding facilities and storage facilities for manure.

Good agricultural practice

)[12]Effectiveness of combined measures is established by recommended standards of GOBALGAP, ISO, etc. (Explanation: Efficiency of measures is established by simple analysis "major – minor –mast – recommendations", as well as “Control points and storage criteria”.)

The goal of the Code of Good Agricultural Practice is to protect soil, water (ground waters), air and animal wellbeing against NH_3 emissions in agricultural production. Application of measures includes simple and complex procedures having financial and environmental requirements, and has proved to have effect of reduction in NH_3 emissions in the air. Measures should be specified with reference to the state of the environment, the area of production influence, technological recommendations for hygiene maintenance during animals breeding, feeding and watering, including the possibility for manure removal by way of balancing the nitrogen, crops rotation, and other elements of energy efficiency during the performance of operational activities on the farm.

Combination of the proposed measures achieves optimum results in energy efficiency, reduction of harmful emissions as environmental protection, while economic entities acquire the right to environmental permit, incentive for production, crediting and improvement of performance by utilization of EU funds.

Techniques of soil fertilization with manure (solid and liquid)

Reference method for organic manure incorporation in the soil without BAT application is defined as ammonia emission from unspecified solid and liquid manures evenly spread on the soil surface and without fast incorporation in soil. These are defined more precisely in the Code of good agricultural practice and Rulebook on the manner of good agricultural practice implementation, i.e. hygiene practice.

Techniques in category 1

Techniques in category 1 include use of equipment intended to reduce manure treated area and incorporation of liquid and solid organic manures in land.

Techniques in category 1 include:

- Linear dispersion of liquid manure by watering pipes;
- Linear dispersion of liquid manure by sprinklers;
- Induction – open notch;
- Induction – closed notch;
- Injection of liquid and solid manures from soil surface into soil within several hours.

Techniques in category 2

- Acceleration of the rate of manure injection into soil;
- Selection of manure application time;
- Induction under pressure;
- Adding liquid manures into irrigation water.

Techniques in category 3

• Manures acidification;
• Other additives.

Techniques for manure storage

Presently, there are no proven techniques for reduction of ammonia emissions from stored manure. With regard to keeping the dry manure from poultry for a longer period, BAT assumes securing the area with impermeable flooring and sufficient ventilation of manure to keep it dry and prevent additional ammonia loss.

Reference technique. Basis for calculation of the efficiency of measures for elimination of emissions from the storage area of the same type, without roofing or without “crust” on the top. Table 22 presents overview of measures for ammonia emission reduction from liquid manures and efficiency of emission reduction.

Techniques in category 1

The best demonstrated and the most practical emission reduction technique during liquid manure storage is store covering with solid roof or shade cover. Plastic foils (floating cover) are suitable for small lagoons with connected soil. Liquid manure storage bags on farms (e.g. <150 fattening pigs) also represent emission reduction system.

Table 22: Measures for elimination of ammonia emissions during liquid manure storage (from cattle and pigs)

Measures for elimination	Emission reduction [%][13]	Applicability
Solid cover, roof or shade cover (category 1.)	80	Tanks made of bricks or steel. Could prove unsuitable for existing stores
Plastic foils)[14] (floating cover) (category 1.)	60	Small lagoons connected to soil
Plastic foils)[b] (floating cover) (category 2.)	60	Small lagoons connected to soil and tanks made of bricks or steel. Management and other factors may limit the applicability of this technique
"Primitive technique" floating cover (e.g. straw, peat bog, LECA, etc.) (category 2.)	40	Tanks and silos made of bricks or steel. Probably most practical for lagoons connected to soil. Not suitable if the material used causes problems
Natural crust (floating cover) (category 2.)	35-50	Only for manure with high portion of solid matter. Not suitable for farms where frequent mixing and crust breaking is required due to frequent manure sprinkling
Replacement of lagoons with covered or high uncovered (H>3m) tanks (category 1.)	30-60	Only for new structures or planned reconstructions with high tanks
Storage bags (category 1.)	100	Large bags for big farms

Animal breeding facilities

Animal breeding facilities include different structural solutions depending on climate conditions and technological requirements of investors. Ammonia emissions from buildings will be reduced if the contact area of air with the exposed liquid and solid manure is reduced.

Reference technique

The level of achieved limit value for ammonia emission reduction is significantly increased in contemporary designed animal breeding facilities)[15].

Facilities for milking cows and cattle

Techniques for ammonia emissions reduction in big cattle facilities apply one or several of the following principles:

- Semi-open facilities with individual and deep-bedding, as well as inclined plates for urine adsorption,
- Closed facilities with individual bedding,
- System for mechanical hygiene maintenance with regular removal of liquid and solid phase of manure,
- Reduced area of the opening of the screen floor and contact of the standing surface with air

)[13]emission reduction is expressed relative to emissions from uncovered tanks/silos for liquid manure storage.

[14]Foils can be made of plastic, cloth or another adequate material.

)[15]Facilities are designed in line with technical and technological recommendations contained in the Code of good agricultural practice and applied BAT measures related to intensive agricultural production.

– Reduced temperature of solid manure.

Facilities for pigs breeding

Reference technique. Emissions from pigs breeding facilities with low positioned storage pit is taken as reference technique, although this technique has been banned in certain countries due to health safety of pigs.

Techniques for ammonia emissions reduction in pigs breeding facilities apply the following principles:

- Reduction of the area covered by manure which releases ammonia (solid flooring, area under liquid manure in canals);
- More frequent removal of manure from lower positioned beddings to external storage area;
- Additional treatment, such an aeration, to obtain washable liquid;
- Cooling of manure surface;
- Modification of chemical and physical properties of manure, such as increased pH value;
- Areas that are smooth and easy to maintain;
- Treatment of flue air with acid based scrubbers or biofilters.

Facilities for poultry

Facilities for laying hens

There are two systems of housing structures for laying hens:

• Battery system – traditional structure, so called deep bedding (roost) where manure falls in a hole beneath the roost and remains there for up to several years. This is a system with highest emissions in intensive laying hens breeding and therefore it is considered as reference system.

• Cage systems and free-range (deep litter and Aviary)

Facilities for young chicken

Traditionally, chickens are kept in structures with solid flooring fully covered with manure, taken as reference system (not BAT). In order to prevent ammonia emission, it is important to maintain the manure as dry as possible. Content of dry matter and ammonia emissions depend, *inter alia,* on:

- Composition of drinking water;
- Duration of reproductive period;
- Animals density and weight;
- Use of air conditioning systems;
- Use of floor insulation;
- Fodder.

Table 23: Reduction of ammonia emissions from different poultry housing relative to reference system

Code	Housing type	Emission reduction [%]
Laying hens		
Cage system		
1	Cage system with open storage of manure beneath cages, without ventilation (reference system, not BAT)[16]	0

)[16]Reference system and all other percentages of ammonia emission reduction from other techniques are based on: 0.083 kg NH_3/year x place

2	Cage system with open storage of manure beneath cages, with ventilation (it is conditionally a BAT; e.g. this system is BAT for warmer areas)	30
3	Manure removal by conveyor belts positioned beneath cages, in enclosed stores	58-76
4	Vertical multi-storey cages with manure conveying belts and improved drying	55
5	Vertical multi-storey cages with manure conveying belts and rapid efficient drying	60
6	Vertical multi-storey cages with manure conveying belts and improved efficient drying	70-88
7	Vertical multi-storey cages with manure conveying belts and internal and external drying tunnels	80
Free-range system		
1	Deep bedding system (litter) (Reference system, not a BAT)[17]	0
2	Deep bedding with efficient manure drying	60
3	Deep bedding with perforated floor and efficient manure drying	65
4	Alternative housing system (Aviary)	71
Young chicken		
1	Traditional	Reference
2	Storey floor with intensive manure drying (category 2.)	94
3	Storey auxiliary sides, intensive manure drying (category 2.)	94
4	Perforated floor with efficient manure drying (category 2.)	82
5	“Combideck” system (category 2.)	44

Strategy for feeding and other measures

Strategy for feeding

Measures applied in the domain of animal feeding, by which the amount of albumen is reduced, will also reduce secretion of N, and thus the need for implementing measures in animal housing facilities and in manure management. The management of the amount of nutrients in animal fodder is aimed at selecting appropriate feeding in accordance with the requirements of animals in their different phases and so the amount of emitted N is reduced.

Reference technique. Measures that may reduce the emissions of NH_3 through common strategy for feeding will depend on the current animal feeding practice. It is generally taken that reduction of 1 kg nitrogen in animal excrets will result in reduced emissions of ammonia ranging between 0.3 and 0.5 kilograms of N.

Feeding strategy for intensive pigs breeding

The feeding strategy for pigs breeding includes the phases of feeding, diet prescription based on easily achievable/affordable nutrients that may be supplemented with diets based on amino acids with low protein content.

Feeding phase (different fodder composition for different age groups) offers cost effective way of reduction of N excreted by pigs and applicable within short period of time. Multi-phase feeding depends on automated computer managed equipment.

Quantity of raw proteins (albumen)

Other measures

Mineral fertilizers

Urea is mineral fertilizer the use of which involves the greatest loss of nitrogen as ammonia.

)[17] Reference system and all other percentages of ammonia emission reduction from other techniques are based on: 0.315 kg NH_3/year x place

Grazing

Manure treatment

This measures has potential, but it has not been explored yet and due to existing uncertainties it is ranked as technique in category 2 or category 3.

Composting of solid and liquid manures with salt adding. Experimental data is very different, some showing even increased gas emissions.

Controlled processes of deinitrification in liquid manure: pilot plants have indicated that the control of deinitrification (switching between aerobic and anaerobic conditions) may reduce ammonia emissions by way of converting ammonia into nitrogen gas. This requires special reactor.

Use of fertilizers outside agricultural sector)[18]

Using of fertilizers outside agricultural sector results in reduction of ammonia emissions in agricultural sector. An example which has already been applied in certain countries includes burning of poultry manure and use of horse excrement and poultry manure in mushroom cultivation.

Additional substances (additives) in fodder and manures

Numerous additives have been proposed for ammonia reduction. Most of them are aimed at reducing the content of ammonia or pH values through chemical or physical processes. Their efficiency in ammonia emissions reduction depends on how good will they achieve the objective and the segment of management in which they will be applied. Those have been ranked as techniques in category 3.

Stationary sources not from agricultural sector

Production of inorganic nitrogen fertilizers, urea and ammonia

Installations for nitrogen fertilizers production include manufacturing of ammonia, urea, ammonium sulphate, ammonium nitrate and/or ammonium sulphate nitrate. Nitrogen acid is used in the process, which is also manufactured within the site of the plant.

Additional techniques of emission control, apart from scrubber, cyclone and filter that are constituent parts of production facilities, are generally not needed. The lowest value of ammonia emissions of 50 mg NH_3/m^3 can be achieved by increased regeneration of the product and reduced emissions into air, and proper maintenance and control of operational conditions.

Production of NPK mineral fertilizers (by nitro phosphate way or acids mixing) results in emission of 0.3 kg NH_3 / ton produced NPK and 0.01 kg NH_3/ ton NPK (expressed as N).

Emissions of ammonia from urea production are presented by outlets: column for regeneration with absorption (0.1-0.5 kg NH_3 / t produced urea), absorption column for concentration (0.1-0.2 kg NH_3 per ton produced urea), "prilling" urea (0.5-2.2 kg NH_3 / t produced urea), granulation (0.2-0.7 kg NH_3 / t produced urea). The outlet from the "prilling" process is also a source of urea dust (0.5-2.2 kg particulates / t produced urea), as well as granulator (0.1-0.5 kg particles / t produced urea).

)[18]protection measure is in experimental phase, and the ratio between demand and production is high