

Some Programs for Reduction of Environmental Pollution in Slovenia

PART I: Prevention/Reduction of Industrial Atmospheric Pollution

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Abstract

Some actions towards reduction of atmospheric, aquatic and terrestrial environment pollution with dangerous substances, emitted from various sources, especially industrial and municipal, on the national level of Slovenia are presented and critically discussed. National-level environmental prevention actions have been initiated mainly after integration of Slovenia into EU and transposition of the European environmental legislation into our law system. Industry contributes significantly to the overall pollution of the environment, especially in the form of emissions to atmosphere, water and soil, thus participating to the related global and regional environmental problems as well as affecting many local situations. Regarding protection of the atmosphere, primary concern has been devoted to the emission reduction of acid rain and greenhouse gases, volatile organic compounds, persistent organic pollutants and dust particles.

Keywords: atmospheric pollution prevention, acid rain gases, greenhouse gases emission.

1. Introduction

Over last few decades the United Nations have developed and agreed an extensive system of international documents (conventions, agreements, agendas and protocols) in order to involve and oblige their member countries for comprehensive protection of global environment against pollution and devastation. The European Union promptly followed the development by issuing over 70 directives and hundreds of related sub-documents (regulations, decisions, guidelines and recommendations) to be implemented in the former as well as in the new member states. The main subjects of concern are global warming, stratospheric ozone layer depletion, troposphere photochemical pollution, chemisation of soils and oceans, noise and radiation, which all affect human health, biodiversity and abiotic environmental quality. As an important source of environment pollution, industrial activities are faced with severe restrictions, often more than other polluting sectors of economy. The restrictions stimulate implementation of sound technical and organizational measures for sustainable development of individual sectors as well as whole society. One part of restrictions represents environmental protection legislation; another part is technical, by means of clean technology implementation

(also called “best available techniques” - BAT). Both are primarily preventive oriented. European Union has (often in accordance with international conventions) also developed instruments to stimulate design and implementation of efficient, yet rational, integrated environmental protection systems. This is the task also for the new EU countries, which are very much behind the current state of the art in older member states.

The paper presents some preparative steps towards reduction of environmental pollution (especially of atmosphere and – in the second part- surface waters) from Slovenian process industries, as a reflection to the requirements of international agreements and EU directives. This may be of interest also for other candidate countries in the region, on the way of their technical and political integration into EU.

2. Reduction of the Industrial Atmospheric Pollution

2.1 Principal air pollutants

This area is generally controlled by so-called CLRTAP convention, one of the earliest international documents on the field of air pollution prevention (1979).¹ It covers very broad range of principal pollutants such as acidic gases (SO₂, NO_x), toxic gases (carbon monoxide),

ozone depleting and greenhouse gases (volatile organic compounds – VOC, CO₂, N₂O, CH₄), persistent organic pollutants (POPs), heavy metals (Cd, Hg, Pb and others), eutrofication gases (NH₃), dust particles and others. Each of them is a subject of special protocol to the convention, which specifies obligations of assigned countries for emission reduction. One of obligations of each country is also to monitor and report the related data, emission reduction plans and programs to EEA (European Environmental Agency). In the absence of measured data, annually emitted quantities of emissions may also be estimated, using so-called CORINAIR method.² Emission factors for the noted parameters are given for 11 most polluting groups of activities: 1. Combustion in energy and transformation industries; 2. Non-industrial combustion plants, 3. Combustion in manufacturing industry, 4. Production processes, 5. Extraction and distribution of fossil fuels, 6. Solvent and other product use, 7. Road transport, 8. Other mobile sources and machinery, 9. Waste treatment and disposal, 10. Agriculture, 11. Other sources and sinks. The main industrial contributors of air pollution may be found in groups 3, 4 and 6.

EU Directive 2001/81/EC³ has tightened the national obligations by defining ceiling limits of emission for each pollutant that must be met by 2010. By this means countries are forced to improve their environmental footprints mainly through pollution prevention measures, e.g. by forcing implementation of clean technologies (processes, using BAT), as required by the IPPC directive.⁴ Data on the total and industrially-generated air emissions of most important air pollutants in the year 2000 in Slovenia, together with the national ceiling values are presented in Table 1.⁵

Table 1. Emission data of selected air pollutants in Slovenia (year 2004)

pollutant	emission (t/a)	trend	emitted from industry		national ceiling value (t/a)
			(t/a)	(%)	
SO ₂	54,000	fast decline	~10,000	10.4	27,000
NO _x	57,000	steady	~3,000	4.5	45,000
CO	82,000	steady	~1,000	1.5	-
NM VOC*	46,000	steady	~4,000	10.0	40,000
H.M. [#]	40	fast decline	~7	17.5	-
POPs	23	increasing	-	-	-

*non-methane volatile organic compounds

[#] heavy metals, primarily Pb, Cd and Hg

Most of the principal air pollutants are exceeding the national ceiling values. The main emission sources are energy production and energy consumption sectors of economy. As can be seen, industrial contribution is relatively small, the largest share represent emissions of heavy metals. In the national environmental

protection action plan industry is not among those primarily addressed to make significant reduction, though introduction of BAT always give corresponding energy savings and emission reduction. Actions such as dust emission prevention in the course of BAT implementation are oriented primarily to metallurgical and metal treatment industries. Indirectly, however, industry is also responsible for the atmospheric pollution of acid rain gases in proportion to its share in overall energy consumption.

2.2 Emission of greenhouse gases

Countries, which have signed the Kyoto protocol to the UN Convention on Climate Change⁶, are bound to prepare national inventories and programs for reduction of greenhouse gases (GHG). The required rate of reduction is 8% below the level from 1986, by end of the first control period 2008-2012. Emission reduction of the GHG, including CO₂ and CFC/HFCs from industrial sources is one of obligations, though industry is responsible only for a minor fraction. The main burden for reduction thus remains on power production and consumption (including traffic) and agriculture, which together contribute about 90% of GHG emissions. The rest is shared by industry and waste management sector. In the latter, however, there is also some indirect contribution of industrial biodegradable waste (especially from food and pharmaceutical industries), which is being disposed of in unstable form on sanitary landfills, ultimately generating methane. Separate collection and composting of biodegradable waste is not yet a common practice. One tone of biodegradable waste yields between 200 and 400 Nm³ of landfill gas, containing approx. 60% methane, second most important GHG. Its relative greenhouse potential factor is as much as 18.25 in relation to CO₂.

The national inventory of GHG was made by estimation, using the IPCC guidelines, which enable prediction of GHG in the main contributing sectors.⁷ Emission data for the last 20 years are shown in Table 2.⁸

Overall contribution of industrial sector to GHG emission in the year 2004 was only 5.7%, with a decreasing trend. The main source of industrial GHG emissions is the application of organic chemicals, rather than production, so that chemical industry is not much involved. Trend shows marked increase of HFC emission in the last period, which calls for urgent action, though the absolute quantities from industry are small. The only specific industrial contribution to emission of GHG are fluoro-chloro- organic compounds (freons and halons), of which 90% origins from this sector, with corresponding effect to stratospheric ozone depletion. Their emissions were limited or even forbidden by Montreal Protocol (1989) to Vienna Convention (1985) and implemented during last two decades.

Table 2: Some data from the Slovene national inventory of greenhouse gases

Source of pollution	Total emissions (Gg CO ₂ eq. or %)				Emission index
	1986 Gg CO ₂ eq.	1996 Gg CO ₂ eq.	2004 Gg CO ₂ eq. %		2004/1986 (/)
Power production	15,221	15,471	16,177	80.3	1.06
Industry+solvent use	1,368	1,121	1,276	6.3	0.93
Agriculture	2,597	2,305	1,885	9.3	0.73
Waste management	996	1,145	823	4.1	0.83
Other	-	-	(-5,644) [#]	-	-
Total:	20,181	20,042	20,161	100	0.999
Type of GHG	Emissions, 2004 Gg CO ₂ eq. %		From industry Gg CO ₂ eq. %		2004/1986
CO ₂	16,524	82.0	934		-
CH ₄	1,958	9.7	0.3		-
N ₂ O	1,444	7.2	0.0		-
CFC & HFC*, SF ₆	235	1.1	202.5		-
Total:	20,161	100	1,136.8	5.7	0.89

[#] sinks in land use and forestry; *chlorofluorocarbons and fluorohydrocarbons

2.2.1 The GHG pollution reduction programs

National committee on climate change is responsible for preparation of the national GHG inventory and the national pollution reduction program, and also for its execution.⁹ The GHG emission inventory and the complementary emission reduction programs represent first step towards fulfillment of national obligations with respect to the requirements of noted international conventions as well as European environmental legislation. They are documented in the form of the national action program. It defines policies and measures in order to:

- reduce emission of harmful gases to the atmosphere by various means (technical, economic and legislative instruments) as a key objective
- adaptation of industry to environmental standards
- foster implementation of clean technologies and BAT techniques
- stimulate use of alternative, primarily renewable, resources e.g. bio fuels
- increase of efficient resource utilisation (loss prevention, emission and waste minimisation etc.) and productivity in industry.

Slovenia has recently (2006) been warned by the EU Commission on missing the planned interim emission reduction targets.

2.3 Volatile organic compounds

Volatile organic compounds (VOCs), beside acidic gases and greenhouse gases, represent the third

group of contemporary most important atmospheric pollutants, responsible - among above mentioned global effects - for local and regional generation of troposphere ozone. VOC is defined as any organic compound, having at 20°C a vapour pressure above 10 Pa. This limit value is very low, so that practically all liquid organic compounds and many solid ones must be considered. When considering their effect other than on climate change, methane contribution has not been taken into account.

Direct and indirect emissions of volatile organic compounds into environment (mainly into the air) from all anthropogenic sources are regulated by so-called VOC directive.¹⁰ It sets obligation of existing and new installations above the threshold capacity in 19 activities, which refer to its propositions. In fact the CORINAIR classification was further differentiated by splitting some groups into subgroups, thus defining the sources more precisely. Chemical industry is not directly addressed however manufacturers of coating preparations, varnishes, inks, adhesives, pharmaceutical products, wood preservatives, rubber industry, plastic lamination etc. are included.

The processes/installations above threshold must prepare and perform a solvent management plan. It is based on solvent mass balance. It includes all input streams (fresh and recycled solvent), and all possible output streams (in products, by-products, wastewaters, wastes and emissions), as shown in figure 2. Monitoring and annual reporting of VOC management is also part of their obligations.

On the national level, over 47 Gg (000 tons) of solvents were used and about 6.5 Gg emitted to the atmosphere in the year 2002. Participation of individual sectors in consumption and pollution is shown in figure 3. By far the biggest consumer of VOC (72%) is the paint and varnish industry (activity No. 16), follows the pharmaceutical industry (12%, activity No.19), whereas all other sectors contribute the rest 15%. Contributions to overall emission are more evenly distributed among the sectors, wood impregnation being the largest (23%).

The set limit values fulfill only 15% of companies, bound to the VOC directive, whereas for 5% emitters the situation is not clear (lack of data to make a satisfactory balance). All the rest violate the directive obligations. The total quantity of VOC emitted to atmosphere exceeds the limit value for about 50%. All violating emitters are asked to develop a pollution reduction program in order to reach limit values by the prescribed time horizon 2010.

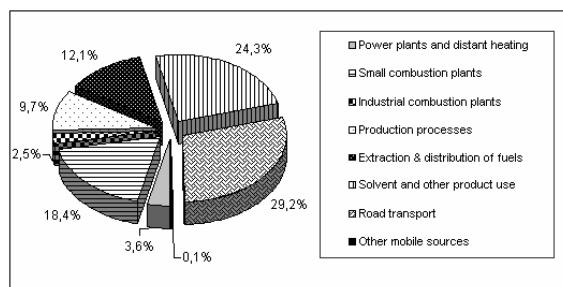


Figure 1. Contributions of various sectors to emission of VOCs in Slovenia

2.3.1 Emission reduction measures

These may be divided into two groups:

- *Primary measures*, aiming to emission prevention, which include minimization of solvent content in preparations, introduction of powder- or water-

base paints, more efficient paint applications and use of solvents, loss prevention, good manufacturing practice etc.

- *Secondary measures* (end-of-pipe), which are used once the emissions have already been generated. They mainly include conventional types of VOC emission treatment, being regenerative (condensation, adsorption, absorbers/washers) or destructive (incineration, biofilters, chemical degradation).

Implementation costs of best-practiced remedial measures, required to meet emission limit values, may be estimated by means of guiding document, prepared by EGTEI.¹¹ EGTEI is a UNECE/CLRTAP Expert Group which aims at improving knowledge on emission reduction costs through a database that has been established particularly for the purpose of producing cost curves as a modeling input. By offering techno-economic data, EGTEI contributes to the revision of the 1999 Gothenburg Protocol to abate acidification, eutrophication and ground-level ozone and of the 1998 Aarhus Protocol on heavy metals and persistent organic pollutants. Besides, it also contributes to the Clean Air for Europe (CAFE) program to protect against significant negative effects of air pollution on human health. Average investment and operating costs are given for reference types of established equipment in three size classes. Costs, taken into account are: R&D cost to develop new types of preparations, which use less solvent, investments for new application machines, energy costs and raw material costs.

Primarily the preventive methods are presented, followed by selected end-of-pipe methods.

Costs of remediation actions were calculated for all emitting sectors in extent, as needed to meet the limit values. Emission reductions already achieved

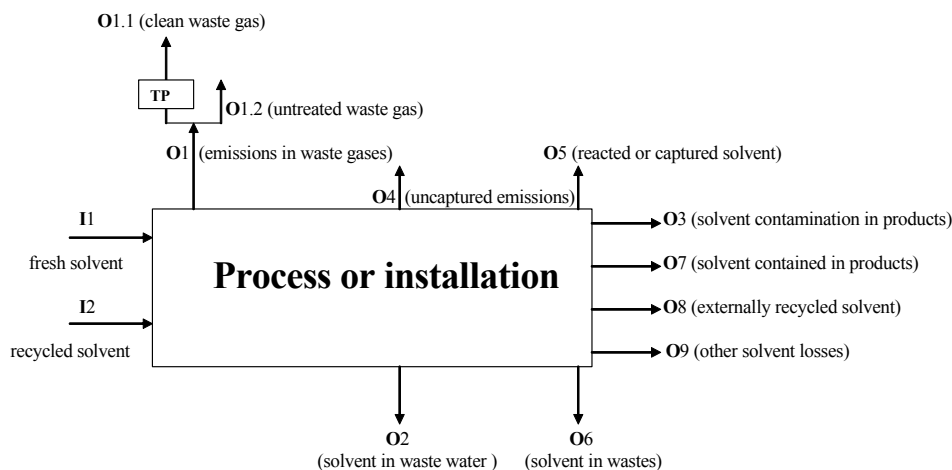


Figure 2: Components of the VOC mass balance

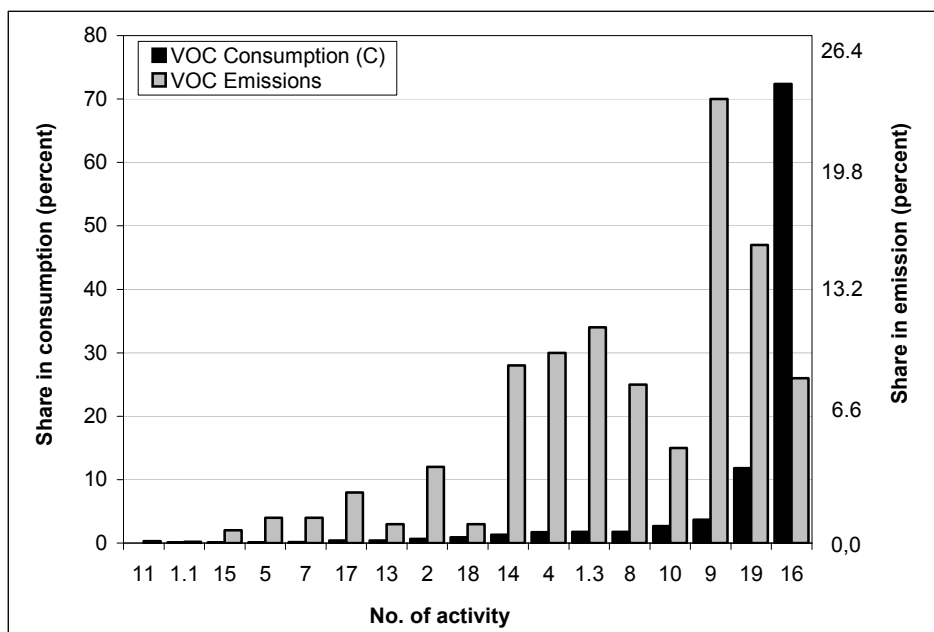


Figure 3. National consumption/emission balance of VOC in/from various sectors

were taken into account. Only few sectors are within the limits so they are exempted from the related investments. The largest investments are needed in the car industry (55%), followed by printing and pharmaceutical industries, wood impregnation and cleaning activities. They together represent 96% of all costs. Overall implementation cost of the remedial actions, calculated on the basis of data from 2003, is about 150 million Euros.¹²

Follow-up: The basic VOC directive 1999/13/EC has been recently supplemented by the directive 2004/42/EC, which limits the content of VOC in some retail products as paints, lacquers, varnishes and adhesives¹⁰.

Directive on national emission ceilings for certain atmospheric pollutants (so-called NEC directive)³, sets emission limits and loads of acidic, entrophic and ground-level ozone precursor pollutants (SO_x , NO_x , NH_3 , VOC) in order to improve the protection for each member country in the Community, to be attained by 2010.

3. Conclusions

Some actions towards reduction of atmospheric pollution with principal air pollutants like acid-rain gases, greenhouse gases and volatile organic compounds on the national level of Slovenia are presented. The main driver is new, pollution reduction oriented legislation. Special attention was devoted to industrial sources (especially from chemical and pharmaceutical

industry) as one of the main potential contributors. Surprisingly however, the actual shares of industrial pollution were found relatively small for all three noted groups of pollutants:

- 1 – 17.5% for emission of various principal air pollutants,
- 8% for emission of greenhouse gases, and
- 10% for total emission of volatile organic compounds.

This means that due attention has to be paid to other sectors of economy, responsible for the main part of these types of air pollution. It is often quite difficult to achieve, due to lack of tradition for sound and comprehensive environmental protection in some sectors like agriculture and municipal services. Limited capacity in knowledge, educated and skilled staff and tradition have been recognized as more critical factors than availability of technical solutions and investment capital, required for the task execution.

4. References

1. UN Convention on Long Range Transport of Air Pollutants (CLRTAP), Geneva, 1979, and pending protocols (e.g. Draft guidance documents on control techniques and economic instruments to the protocol to abate acidification, eutrophication and ground-level ozone (Gothenburg Protocol), European Commission, 1999).

2. CORINAIR (CORe INventory of AIR emissions): The atmospheric emission inventory for Europe, The guidebook, **1999**; Default Emission Factors Handbook, **1992**.
3. EU Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants, **2001**.
4. EU Directive 96/61/EC concerning integrated pollution prevention and control and pending reference documents (BREF) on best available techniques (BAT) in certain industrial processes, e.g. Reference Document on the Best Available Techniques in Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector, Integrated Pollution Prevention and Control (IPPC), European Commission, European IPPC Bureau, Institute of prospective technologies, Seville, Spain, **1996** and **2003**, resp.
5. Ministry of the Environment and Spatial Planning, Republic of Slovenia, National Environmental Report, **2000**.
6. Kyoto Protocol (**1995**) to Rio's Convention on Climate Changes (**1992**) and State report to the Conference of contracting countries on Framework Convention on Climate Change, Republic of Slovenia, Ministry of the Environment and Spatial Planning, Republic of Slovenia, Central Data Repository, **2006**.
7. Greenhouse Gas Inventories, Reference Manual, Intergovernmental Panel on Climate Change (IPCC) Guidelines for national GHG Inventories, UNEP/WMO, OECD/IEA, **1997**.
8. Republic of Slovenia, Environmental Agency, National GHG Inventory Report, EIONET SI, **2006**.
9. First national report to the framework convention on climate change, Ministry of the Environment and Spatial Planning, Republic of Slovenia, **2002** (in Slovene).
10. EU Directive 1999/13/EC (and 2004/42/EC) on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations, **1999, 2004**.
11. http://www.citepa.org/forums/egtei/egtei_index.htm Final Background Documents (for individual VOC abatement activities), EGTEI, CITEPA, Paris, (accessed: June **2003**).
12. V.Grilc, A.Jazbinšek: Measures for reduction of emissions of volatile organic compounds from industry, KI-DP-2293, National Institute of Chemistry, Ljubljana, **2003** (in Slovene).

Povzetek

Prikazane so nekatere aktivnosti na področju zmanjševanja onesnaževanja zraka na teritoriju Republike Slovenije, povzročenih iz industrijskih in drugih dejavnosti, s ciljem doseganja emisijskih in imisijskih zahtev nove zakonodaje in okoljevarstvenih standardov EU. Glavna pozornost je posvečena plinom kislega dežja, toplogrednim plinom in hlapnim organskim snovem.