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AIR POLLUTION FROM INDUSTRIAL SOURCES AND THE AIR POLLUTION ASSESSMENT PROGRAM: THE CASE STUDY OF THESSALONIKI

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Abstract. The Air Pollution Assessment Program (A.P.A.P.) for the Greater Area of Thessaloniki (G.A.Th.) is inscribed. The methodology of statements concerning air pollution from industrial sources is presented, air pollutant emission data are given and conclusions are referred. Finally, the participation of each group of sources (industry, heating, traffic) in the air pollution in Thessaloniki is estimated and an air pollution reduction scheme is resulted.

Keywords: air, pollutant, emission, reduction, source, participation.

GENERAL

Thessaloniki, being the second highly populated city in Greece (nearly 1 mil. people), also has high concentration of industrial activities. There is a great variety of industrial production, as all main industrial activities take place. These activities are responsible for a significant percentage of air pollution in the Greater Area of Thessaloniki (G.A.Th.). The Organisation of Thessaloniki has initiated a significant number of statements concerning air pollution caused by all main industrial sources, as part of an Air Pollution Assessment Program (A.P.A.P.) for the G.A.Th. (Fig. 1).

The basic aims of the A.P.A.P. were:

– to write down the air pollution sources in the G.A.Th.;

– to compute the air pollutant emission amounts in order to estimate the air pollution level in the G.A.Th.;

– to propose an air pollution reduction scheme which could be immediately applied in order that the atmospheric environment parameters in the G.A.Th. should be improved, as well as to propose a total air protection policy which should be based on development aims[1].

Air pollutant emissions caused by all main air pollution sources were estimated, firstly including industry, external urban combustion sources (mainly domestic heating) and traffic. As main pollutants were considered to be sulphur dioxide, nitrogen oxides, carbon monoxide, hydrocarbons and other V.O.Cs, as well as solid particles (mainly dust and carbon ash).

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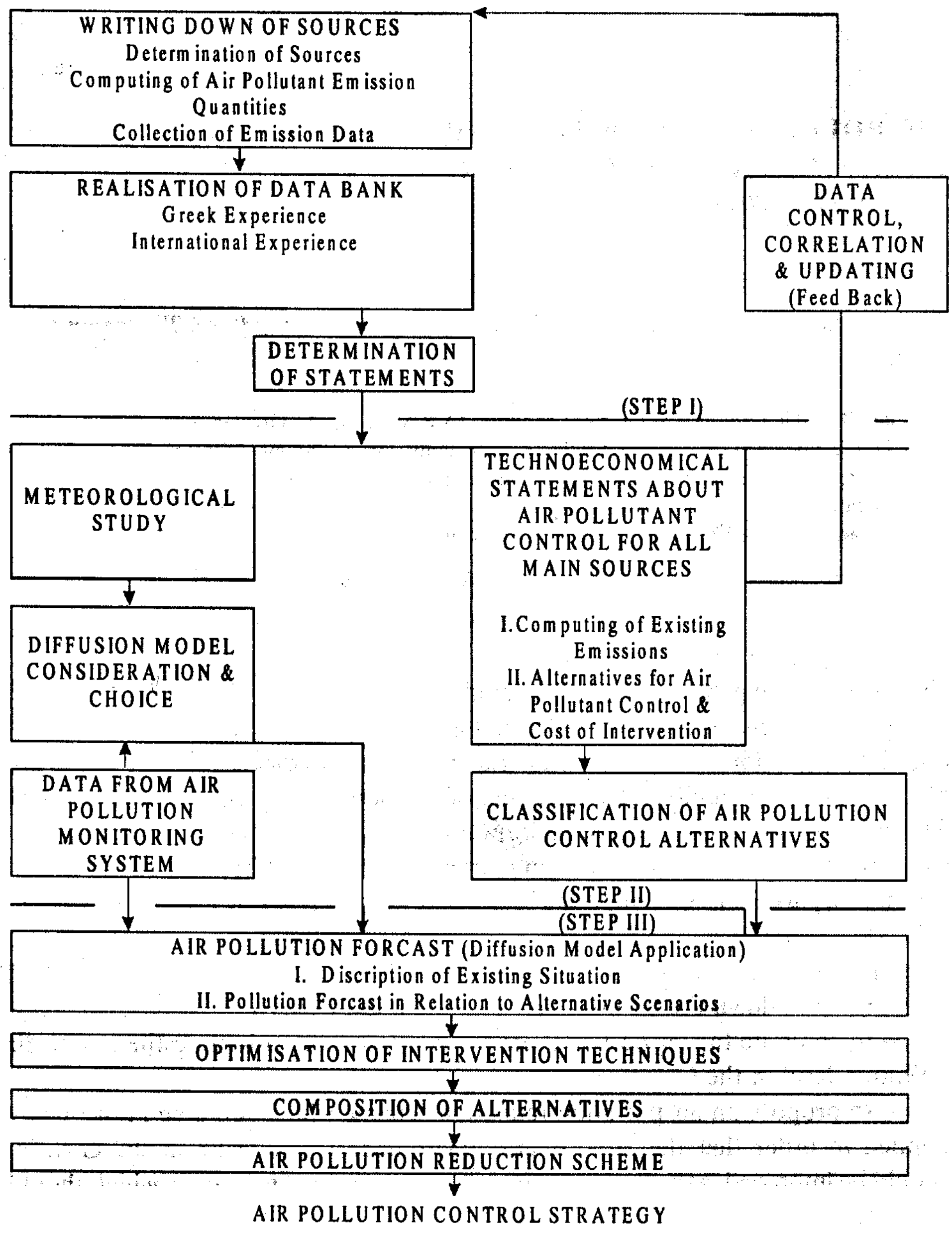

Fig. 1. Air pollution assessment program[1]

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The existing air pollution levels, representing the air quality indicator, were evaluated in relation to the emissions from each different pollution source.

As to the industrial sources, a list of various industrial activities was produced, including industrial combustion as a different activity. All important data concerning each industrial installation were taken into account, including used materials and projects, production height for the previous five years of operation, etc. Then air pollutant emissions for all main pollutants were estimated by means of emission factors, which could be found in Greek and international bibliography (Matrix 1)[2,3].

Next step was the introduction of a number of scenarios of alternative air pollution control techniques for each industrial installation and the estimation of air pollutant emissions after each scenario had been realised[5], as well as money needed. The methodology, which was used, was cost-benefit analysis for each alternative. A list of cost-benefit indicators for all alternatives concerning each installation separately was produced. Results were summarised for each industrial process. Then, the optimum alternative – with the smallest value of cost-benefit indicator – was chosen for each installation, considered as the initially acceptable choice. Finally, new air pollutant emissions were estimated for each pollutant separetely, suggesting that the optimum alternative for each industry had been applied. In special circumstances, the alternative producing the highest efficiency indicator of pollution reduction was chosen, no matter of money needed. This could be considered to be necessary in the case of high toxicity pollutants emitted or high pollution parameter values measured in the atmosphere, excessing the air quality standards determined by law[1,2].

The solutions proposed were generally the following ones – or a combination of them:

- installation of new air pollution control equipment, such as: ventilation systems, wet scrubbers, absorption towers, fiber filters, etc.;
- technical improvement of existing equipment;
- adjustment, maintenance and efficiency control of this equipment combined to emission monitoring systems installed;
- optimisation of materials used and processes taking place as well (the so-called clean technologies, etc.);
- special buildings or other constructions which could reduce the pollutant diffusion from open air storing, material transfer systems, crushing machines, vehicle traffic whithin the industrial sites, etc.

The statement about the external urban combustion sources was based on the values (1988-1990) of two-year emissions from heating combusters resulted by the control of their operation. In the same time the domestic heating processes being in use (central heating or other) were written down. Such sources were also considered to be the combustion systems in bread-baking installations and hot water

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Matrix 1. Air pollutant emissions from industrial activities in the G.A.Th. (tn/yr)[4]

	POLLUTANT / INDUSTRIAL ACTIVITY	Solid Particles			SO_2			NO_x	
		1989	1993	(1)	1989	1993	(1)	1989	1993
1	Petroleum Refining	(20) (260)	(20) (260)	(20) (260)	(2) 15672	(2) 7180	(2) 3860	619	619
2	Chemical-Petrochemical Production	-	-	-	-	-	-	(4) 63	(4) 20
3	Acid, Fertilizer & C.F.C. Production	(2) 1,960	(2) 1,960	(2) 800	(2) 5,400	(2) 3,030	(2) 1,150	(2) 830	(2) 830
4	Iron & Steel Production	370	(5) 150	150	-	-	-	-	-
5	Cement Manufacturing	2,270	(6) 870	260	200	200	200	1.200	1.200
6	Electrolytic Manganium Dioxide Production	(7) 24+	(7) 24+	20	363	363	363	-	-
7	Ceramic Clay Manufacturing	3,390	(8) 3,065	170	800	800	800	72	72
8	Pesticide-Insecticide Production (9)	-	-	-	-	-	-	-	-
9	Rubber Production	-	-	-	-	-	-	-	-
10	Feed & Grain Mills - Corn Syrup Production	570	570	30	-	-	-	-	-
11	Wood Processing	-	-	-	-	-	-	-	-
12	Asbestos Products	(11) 2.7	(11) 2.7	(11) 1.3	-	-	-	-	-
13	Tobacco Processing	2,470	2,470	400	-	-	-	-	-
14	Limestone Calcination (Kilns)	(12) 400	(12) 400	(12) 400	-	-	-	-	-
15	Asphaltic Concrete Plants	11.5	11.5	3	-	-	-	-	-
16	Concrete Batching	8,580	8,580	170	-	-	-	-	-
17	Stone Quarrying & Processing	7,000	7,000	370	-	-	-	-	-
18	Secondary Lead Smelting	(13) 252	(13) 252	(13) 12	-	-	-	-	-
19	Secondary Iron Smelting	(14) 150	(14) 150	(14) 150	-	-	-	-	-
20	Stone Mineral Processing	(15) 3,030	(15) 3,030	(15) 1,210	-	-	-	-	-
21	Metal Surface Coating, Painting & Varnishing	700	(16) 700	50	-	-	-	-	-
22	Storage, Transfer & Marketing of Petroleum Liquids	-	-	-	-	-	-	-	-
23	Industrial Combustion (18)	(20) (450)	(20) (450)	(20) (450)	9218	9218	9218	1033	1033
	TOTAL	31994	30043	4906	30490	20791	17748	3817	3774

	CO			V.O.Cs			Ash		
(1)	1989	1993	(1)	1989	1993	(1)	1989	1993	(1)
-	66	66	-	(3) 2330	(3) 2330+	(3) 1700+	260	260	-
50	(4) 15.7	(4) 4.7	1	(4) 718	(4) 679.5	235	-	-	-
(2) 830	2.47	2.47	-	0.67	0.67	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	53	53	-	0.31	0.31	-	-	-	-
-	0.002	0.002	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	(10) -	(10) -	(10) -	-	-	-
-	-	-	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	700	(16) 758	100	-	-	-
-	-	-	-	2,572	(17) 2572+	1,965+	-	-	-
-	100	100	-	24.1	24.1	24.1	450	450	-
-	237	226	-	• 6345	(19) 6383+	4024+	710	710	-

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Notes on Matrix 1:

(1) Values in the 3rd column are those that are waited to be after the most available intervention on each pollution source has taken place;

(2) These values represent the average of pollutant emissions, the real ones varying among a minimum and a maximum value;

(3) These values also concern the emissions that come from the marine loading area and not those that will result from the increase of storing quantities into the industrial area;

(4) It is waited that V.O.C. emissions will be decreased to 382t/yr, after PVC process improvement. In addition to that, the decrease of NO_x, CO and V.O.C. emissions from 1989 to 1993 is owed to the pause of NH_3 processing;

(5) This value represents emissions after an appropriate fiber filter has been used, considering that maximum efficiency has been achieved;

(6) This value represents solid particle emissions after a clinker storing house has been constructed;

(7) These values do not include solid particle emissions from raw material transferring (e.g. road dust) that are going to be erased after an intervention on open air storage system;

(8) This emission reduction is exclusively owed to an appropriate intervention on the dust diffusion sources of a single industrial installation;

(9) These pollutant emissions have not been quantified, as they are toxic ones, so they are to be totally erased;

(10) A V.O.C. identification and quantification scheme is proposed;

(11) These solid particle emissions include asbestos fiber emissions of 150 kg/yr before and 0.45 kg/yr after an intervention for pollution reduction;

(12) Proposals are related to combustion improvement methods;

(13) These values correspond to lead particle emissions of 152 t/yr before and 2t/yr after the installation of pollution reduction equipment;

(14) Removal of relative industrial activities is proposed;

(15) In addition to installing pollution reduction equipment, removal of this industrial activity away of the G.A.Th. is proposed;

(16) In the meanwhile, new industrial installations have been constructed, so a V.O.C. emission increase has taken place;

(17) Real V.O.C. emissions have already been increased because new storing tanks have been installed, but this increase has not been estimated yet;

(18) These values have been estimated suggesting that fuel combusters operate under optimum operation conditions, that is not usually true, so real emissions are higher than those presented into the Matrix (1);

(19) These values include 981 t/yr V.O.C. emissions, that have been estimated and presented above as part of relative emissions from petroleum refining;

(20) These values represent carbon ash emissions from relative activities.

production for hospitals, hotels and swimming-pools. It should be mentioned that only 25% of central heating installations had got good operation indicators for all measured parameters as well as 25.5% of hospital boilers, 30% of hotel boilers and 67.7% of public swimming-pool boilers[6]. A heating installation control scheme has been applied for the recent three years in some neighbourhoods of the G.A.Th. and new data has been derived. Emissions from domestic heating installations during 1993 were estimated by the author, using fuel consumption data and emission factors, suggesting that good operation conditions had been achieved, which is not true for most of the combusters controlled, as it is obvious in Matrix 2 data[5].

Air pollution control techniques for urban combustion sources mainly include good operation control of combustion systems, as well as keeping the public award about the obligation of adjusting and maintaining them. At the same time, changing the heating model, e.g. using natural gas, as well as widening the environment protection law and other specific legal regulations are proposed.

Computing annual traffic emissions during 1993 all over the G.A.Th. (Matrix 2) was based on CORINAIR/COPERT '90 data[7] and was done by the author specifying the existing data of the Laboratory of Applied Thermodynamic of Thessaloniki University for the whole Thessaloniki Prefecture Region[8]. Matrix 3 shows the distribution of the number of vehicles for each vehicle category, as well as the distance covered, movement speed and traffic percentages in different regions (urban, regional and highway). Traffic emissions during 1990 had already been computed, using the same methodology as that mentioned above, and a vehicle emission control scheme and available traffic regulations had been proposed[3].

Conclusions from all these statements – air pollutant emissions from industry, urban combustion sources (domestic heating) and traffic – were combined to percentile participation of each group of sources in total air pollution emissions in Thessaloniki. Matrix 2 and Fig. 2 summarise annual air pollutant emissions in the G.A.Th.[4] It is obvious that industry is almost exclusively "responsible" for SO_2 and solid particle emissions; at the same time its participation in NO_x and V.O.Cs emissions is also important. Traffic is almost exclusively responsible for CO emissions and NO_x, V.O.Cs and carbon ash emissions from traffic are important as well. Domestic heating lightly participates in SO_2 and NO_x annual emissions, entirely emitted during winter time (November-April).

The conclusions mentioned above result to applying available techniques in order to reduce air pollution from each group of sources, that mainly means reduction of:

- solid particle emissions caused by industry;
- SO_2 emissions caused by industrial processes (fertilizer production, petroleum refining, fuel combustion) and external urban sources (mainly domestic heating);
- CO, H_xC_y, NO_x and Pb emissions caused by diesel vehicles;
- carbon ash emissions caused by industry, diesel vehicles and domestic heating as well;
- special toxic substances caused by specific processes (pesticide-insecticide production, lead, copper, aluminum or iron secondary smelting, metal surface coating, painting and varnishing, etc.).

It is obvious that the cost of air pollution reduction is occasionally negative (e.g. combustion sources), as optimisation of combustion efficiency results to the reduction of fuel consumption.

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Matrix 2. Annual Air Pollutant Emissions in the G.A.Th. (1993)[4]

Pollutant / source	Solid particles		Carbon Ash		SO_2		NO_x		CO		V.O.Cs	
	kt	%	kt	%	kt	%	kt	%	kt	%	kt	%
Industry	30.04	96.3	0.71	38.0	20.79	89.4	3.77	32.2	0.23	0.3	6.38+[1]	32.9
Heating [2]	(0.20)	0.6	0.20	10.7	1.96	8.4	0.89	7.6	0.60	0.7	0.30	1.6
Traffic [3]	(0.96)	3.1	0.96	51.3	0.50	2.2	7.04	60.2	83.47	99.0	12.73	65.5
Total	**31.20**	**100.0**	**1.87**	**100.0**	**23.25**	**100.0**	**11.70**	**100.0**	**84.30**	**100.0**	**19.41**	**100.0**

Notes on Matrix 2:

(1) V.O.C. emissions are in fact higher because some V.O.C. emissions have not been taken into account (e.g. those from rubber processing, new petroleum liquid tanks, mobil varnishing, building processing, etc.);

(2) a – these emissions have been counted suggesting that the annual increase of diesel consumption for heating purposes is 10% after 1989 (the last period for which there is enough consumption data for the whole G.A.Th. region), b – carbon ash emissions are referred as solid particle emissions as well;

(3) It is suggested that during the years 1990-1993 the emission decrease because of technical improvements on vehicle equipment is equal to the emission increase because of the increase of the number of vehicles in the G.A.Th., as well as there has not been any other change of the other vehicle category technical characteristics.

Matrix 3. Input data for COPERT Program (Thessaloniki, 1990)[7]

Vehicle category	Number of vehicles	Annual distance covered (km)	Percent of traffic (%)			Velocity (km/h)		
			U	R	H	U	R	H
1.Vehicles <2.5t								
Benzin <1.4t	163 854	11 500	66	17	17	19	60	90
Benzin 1.4-2.0t	23 464	11 500	66	17	17	19	60	90
Benzin >2.0t	4 198	11 500	66	17	17	19	60	90
Diesel	2 167	100 000	92	4	4	19	60	90
L.P.G.	264	100 000	92	4	4	19	60	90
2. Light Lorries								
Benzin	46 887	11 500	66	17	17			
Diesel	474	17 000	66	17	17			
3. Vehicles >3.5t								
Diesel 3.5-16t	8 944	30 000	58	21	21			
Diesel >16t	5 129	50 000	14	43	43			
4. Bicycles								
<50cc	60 000	6 000	100	0	0			
>50cc/2stroke	5 520	9 000	67	20	13			
>50cc/4stroke	21 390	9 000	67	20	13			

Fuel Consumption: Benzin: 258 kt; Diesel: 150 kt; L.P.G.: 2 kt

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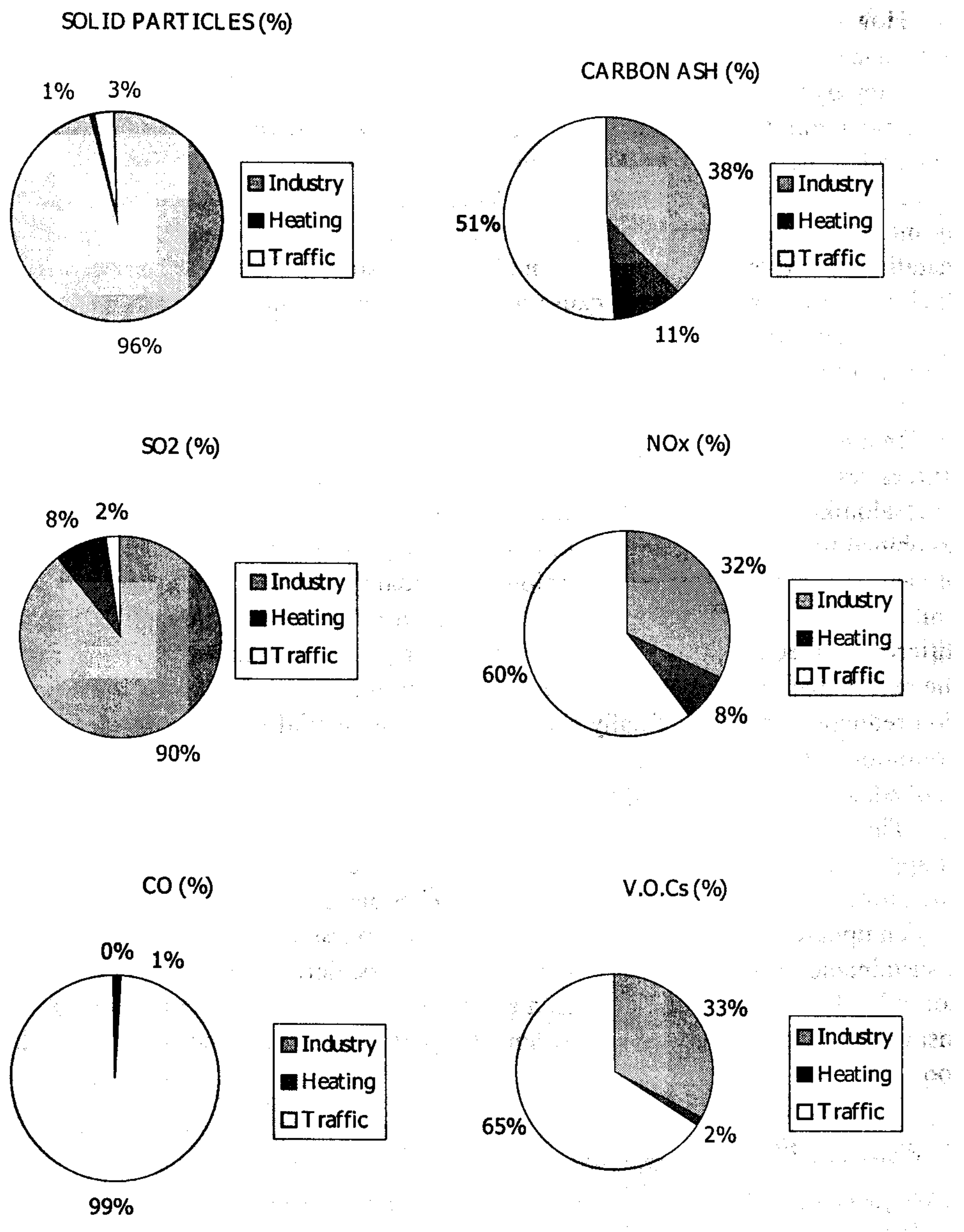

Fig. 2. Annual air pollutant emissions in the G. A. Th. (1993)[4]

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However, the standards of the Best Available Technology – Not Entailing Excessive Cost (B.A.T.-N.E.E.C.) are to be applied in existing industrial installations step by step, according to the Greek Environment Protection Law and other national regulations which specify European Union Directives, such as that conserning the Environmental Impact Assessment (E.I.A.) process[9-12].

In other cases, it is not possible that an efficient pollution reduction be achieved by means of a not excessive cost intervention, so, changing the site of process installation and realising a new regional planning strategy, seems to be necessary. Such processes are those that cause toxic substance emissions or high solid particle emissions (e.g. mineral processing, stone quarrying and processing, asphaltic plants, etc.). Usually, there is need for process optimisation and installation of pollution control equipment as well.

In addition to the statements about pollution sources, a number of university studies resulted to the meteorological simulation of atmospheric environment of Thessaloniki, as well as air pollution diffusion models. These studies are to be combined to the existing air pollution monitoring system in order the real impact of each group of sources on Thessaloniki air quality is found out. Finally, an air pollution reduction scheme is decided for each different pollutant, including a different degree of intervention on different air pollution sources, depending on the real impact of each source on the air pollution of Thessaloniki. An air pollution reduction scheme is finally chosen for each industrial project, considered as optimum in real circumstances. The most available scheme is also chosen to be applied, so that traffic and domestic heating emissions be controlled.

The mentioned scheme is to be repeated from time to time in order the results of applied techniques are evaluated, in relation to the air pollution control success and money spent, and possibly readjustment takes place (feed back process). That's why an updated data bank including air pollutant emission values is necessary. So, a sustainable air pollution control strategy could be derived, as well as priorities could be determined. Nevertheless, a staff of specialists having the knowledge to insure the realisation of this environmental protection scheme could be trained, too[1].

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