İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

INVESTIGATION OF AN EMISSION INVENTORY FOR TURKEY

M.Sc. Thesis by
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Programme: **Environmental Sciences and Engineering**

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TÜRKİYE İÇİN BİR EMİSYON ENVANTERİ GELİŞTİRİLMESİ

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CONTENT

ABBREVIATIONS

NOx	:	Oxides of Nitrogen
SO_2	:	Sulphur Dioxide
NH_3	:	Ammonia
VOC	:	Volatile Organic Compounds
PM_{10}	:	Fine Particulates, size 10 µm or less
NMVOC	:	Non methane volatile organic compounds
CH_4	:	Methane
CO	:	Carbon monoxide
POP	:	Persistent Organic Pollutant
EPA	:	Environmental Policy Agency
EF	:	Emission Factor
N_2O	:	Nitrous Oxide
PAH	:	Polycyclic Aromatic Hydrocarbons
TUIK	:	Turkish Statistical Institute
MoEF	:	Ministry of Environment and Forestry

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INVESTIGATION OF AN EMISSION INVENTORY FOR TURKEY

SUMMARY

Emission Inventories are important tools in order to set environmental policies on air quality and control. There are several international conventions that oblige the parties to submit emission inventories to the executive boards. Turkey is also a party to Long Range Air Pollution Convention, and United Nations Framework Convention on Climate Change which oblige Turkey to submit emission inventories to the executive boards of the conventions.

Objective of this study is to investigate an emission inventory for Turkey on the pollutants which cause eutrophication, acidification, and ground level ozone pollution. Sources which were assessed in the study are mobile sources, small combustion processes, large combustion plants, and the most important industrial processes. Biogenic emissions have not been calculated in the study.

Collection and assessment of the data was an important step of the study. Many different references have been used to calculate the activities and finally the emissions. Fuel consumption data is the base of the study although production capacities have been considered for industrial processes.

Results show that the highest pollution in share occurs in the major metropolitan cities in Turkey which are İstanbul, Ankara, İzmir. The other metropolitan cities Konya and Adana have relatively lower emissions than these provinces, but higher emissions than the other provinces. Also cities which have a thermal power plant has high SO_2 and PM_{10} emissions.

This study shows the relevant sectors for different pollutants which can be an important indicator to realize the most important sector causing air pollution and to define the abatement technologies for this sector. Also the fuel quality which consumed in Turkey has been assessed and can be an important beginning point for emission abatement.

TÜRKİYE İÇİN BİR EMİSYON ENVANTERİ GELİŞTİRİLMESİ

ÖZET

Emission envanteri hava kalitesi ve kontrolü üzerine belirlenecek çevre politikalarının belirlenmesinde önemli bir araçtır. Üye ülkeleri emisyon envanteri hazırlamakla yükümlü kılan birçok uluslararası sözleşme mevcuttur. Türkiye, kendisini emisyon envanteri hazırlamakla yükümlü kılan Uzun Menzilli Sınırlar Ötesi Hava Kirliliği Sözleşmesi ve Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi'ne taraftır.

Bu çalışmanın amacı, ötrofikasyon, asidifikasyon ve yer seviyesi ozon kirliliğine sebep olan kirleticileri esas alan bir emisyon envanterinin geliştirilmesidir. Çalışmada incelenen kaynaklar, mobil kaynaklar, yanma prosesleri, termik santraller ve çevresel olarak önem taşıyan endüstriyel faaliyetlerdir. Biyojenik emisyonlar çalışmaya dahil edilmemiştir.

Veri temini ve değerlendirilmesi çalışmanın önemli bir aşamasını oluşturmaktadır. Aktivitelerin ve emisyonların hesaplanmasında çok çeşitli referanslardan yararlanılmıştır. Yakıt tüketimi verisi çalışmanın temelini oluştururken, endüstriyel prosesler için üretim kapasitesi verisi kullanılmıştır.

Çalışmanın sonucunda, hava kirliliğinin yoğun olarak yaşandığı bölgeler Türkiye'nin büyükşehirlerinden İstanbul, Ankara, İzmir olarak belirlenmiştir. Diğer büyükşehirler Konya ve Adana İstanbul, Ankara ve İzmir'e oranla daha az emisyona sebep olurken diğer illere göre daha fazla emisyona sebep olmaktadır. Ayrıca termik santrallerin bulunduğu illerde diğer illere oranla daha yüksek SO_2 ve PM_{10} emisyonları hesaplanmıştır.

Bu çalışma kirliliğe neden olan önemli sektörlerin ve bu sektörde emisyonları azaltmak için gerekli teknolojilerin belirlenmesinde kullanılmak üzere farklı parametreler ile ilgili sektörleri belirlemektedir. Ayrıca, Türkiye'de kullanılan yakıt kalitesi de çalışmada değerlendirilmiştir ve emisyon azaltımı için önemli bir başlangıç noktası olarak kullanılabilir.

1. INTRODUCTION

1.1. Importance of the Study

Air pollution is a very important global problem which affects both environment and human health and should be solved by all countries which cause air pollution all over the world. The only way of solving this problem is first to quantify the pollution. An emission inventory can quantify the pollution of a region, country, continent or just the investigation area. It is the best way to collect and store the necessary data to estimate emissions. When data is available, it is easy to update the emission inventory. Moreover, the most important step of preparing an emission inventory is collecting and assessing of the data to produce a reliable emission inventory. There have been many different methodologies for emission inventories. Also many countries have their own model to calculate emissions and generate their emission inventory.

Turkey has air pollution problem for many years. It is a serious issue especially in metropolitan cities and industrial zones in Turkey. But air quality measurements are limited with only particulate matter and SO_2. Air pollution should be under control in order to provide better health conditions and a better air quality. Turkey is also a party to the Long Range Air Pollution Convention and has to submit annual emission inventories on SO_2, NO_x, NMVOC, CH_4, CO, NH_3, various heavy metals and POPs according to this convention.

Eutrophication, acidification, and ground level ozone pollution have been important problems and the main reason of these problems are SO_2, NOx, NMVOCs and NH_3. Because of these problems European Parliament decided to set limits on these emissions in order to decrease acidification, eutrophication and ground level ozone. EU member states has to submit emission inventories to show the progress of their air quality.

As Turkey is a party to the Long Range Air Pollution and also is candidate to the European Union, Turkey should also generate emission inventories which are subject to these conventions. It is also very important to monitor these pollutants in order to set limits and develop abatement technologies thus provide better air quality.

1.2. Objective and Scope

Objective of the study is to collect the necessary data and assess the data to generate an emission inventory for Turkey based on the pollutants which cause eutrophication, acidification, and ground level ozone pollution for 2003. These pollutants are SO_2, NOx, VOCs and NH_3. Since PM_{10} is an important conventional pollutant that significantly impact human health, it is also included in this study. Data of mobile sources, small combustion processes, large combustion plants, and the most important industrial processes have been collected when available. So that emission inventory is only based on anthropogenic sources. The available data has been assessed and this data has been used as the base of the study.

The importance of the study, objective and scope of the study have been mentioned in the first chapter.

Definition of the emission inventories, different emission inventory models and methodologies, sources of the emissions and categorization of the emission sources have been defined in the second chapter.

International requirements for emission inventories and the conventions which oblige the parties to the convention to submit emission inventories have been mentioned in the third chapter.

Data availability, emission calculation methodology, and results of these calculation for mobile sources, small combustion plants, large combustion plants and industrial processes have been given in the fourth chapter. This chapter also includes the assessment of the data, every step of calculation, and comparison of the results between every different source group. All calculations have been given in this chapter.

Uncertainty of the study which occurs because of the lack of data has been evaluated in the fifth chapter. Visualization of population and pollution has been given in the sixth chapter.

Results and recommendations have been given in the last chapter. ArcGIS has been used for the distribution.

2. EMISSION INVENTORIES

2.1. Emission

Emission is the term used to describe the gases and particles put into the air by a variety of sources, including factories, power plants, motor vehicles, airplanes and natural sources such as trees and vegetation (EPA, 2007). Emission can be also called as the physical transfer of material from one compartment of the world across a boundary into another compartment (Winiwarter and Schimak, 2004). Emissions can pose health risks and contribute to air pollution, global warming and the destruction of the ozone layer (EPA, 2007). Atmosphere scientist use the atmosphere as their reference system and the term emission to describe all flows into the atmosphere (Winiwarter and Schimak, 2004).

2.2. Emission Factor

An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant (EPA, 2007). Emission factors show the quantity of a pollutant by a unit production (Tünay and Alp, 1996). These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., kt/activity). Emissions from various sources of air pollution can be calculated by the emission factors. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i.e., a population average) (EPA, 2007).

2.3. Emission Estimation

The basic model for emission estimation is the product of at least two variables, such as an activity statistic and a typical average emission factor for the activity, or an emission measurement over a period of time and the number of such periods. In practice, the calculations tend to be more complicated but the principles remain the same (EMEP, 2003).

The general equation for emissions estimation is:

$$E = A \times EF \times (1-ER/100) \quad \textbf{(2.1)}$$

E = emissions

A = activity rate

EF = emission factor

ER = overall emission reduction efficiency, %

Flows from the anthroposphere affect atmosphere, water and soil. These flows may cause acidification, air quality degradation, global warming/climate change, damage and soiling of buildings and other structures, stratospheric ozone depletion, human and ecosystem exposure to hazardous substances (EMEP, 2003).

2.4. Emission Inventory

Emission inventories are the figures representing the amount of air pollutants emitted to the atmosphere from a zone (local, regional or global scales) during a specific period of time (past, present or future), due to anthropogenic or natural activities (Parra et al., 2006). An atmospheric emission inventory consists of the information of emission flows into the atmosphere. An emission inventory provides information on the economic sector, emission source, and spatial and temporal variability of the respective emission (Orthofer and Winiwarter, 1998). It is important to have emission data in order to monitor progress in air pollution, to identify possible emission reduction measures, to produce data for atmospheric models, to fulfill the international obligations (Theloke, 2005).

Quantitative information is also important to inform the policy makers and the public, to define environmental priorities and identify the activities and actors responsible for the problems, to set explicit objectives and constraints, to assess the potential environmental impacts and implications of different strategies and plans, to evaluate the environmental costs and benefits of different policies, to monitor policy action to ensure that it is having the desired effects (EMEP, 2003). An atmospheric emission inventory needs emission data with high temporal and spatial resolution (Theloke, 2005).

When the issue is identification of emission sources, estimates on potential emission control options, the required emission data is annual emission, which is disaggregated for sources and processes. When there is a need for development of efficient emission control options, the required emission data is annual emission and costs of measures and processes. If verification of atmospheric models that simulate transport and chemical transformation of pollutants is necessary, it is important to have accurate actual hourly emission for grid cells, differentiated for substance categories, emission source height. Future hourly emission for grid cells, for typical weather conditions, differentiated for substance categories, emission source altitude are necessary data for the applications such as future trend and possible developments of ambient concentrations of pollutants and to develop efficient emission control options (Friedrich, 2005).

Depending on the source sector and substances investigated, different approaches exist for determination of emissions, such as bottom-up approach and top-down approach. Detailed information of individual emission sources are collected and added to yield a regional total in bottom-up approach. This method allows integrating results from continuous emission monitoring which is available from few, but large emission sources. For the major part of the emitters, emission flows need to be calculated. In order to provide this, specific emission measurements from a similar activity and/or a different time period are used. Results from these emission measurements are related to a more generally available parameter typical for the activity such as energy consumption, production figures, mileage driven. These results will be normalized as an emission factor. Emissions are calculated by multiplying this emission factor and the value for activity (Winiwarter and Schimak, 2004).

The top-down approach applies this to a larger administrative area, where statistical data is more available. In this case emissions are first calculated for the total area, and only distributed within the area using surrogate information and downscaling methods.

Sector specific emission models may use additional background information to derive total emissions, beside the simple procedure of applying an emission factor. Approaches can differ between source sectors, and for subregions within the inventory domain. A wealth of background data is essential to establish an emission inventory. Thus, an appropriate software system is necessary to collect the relevant information in a database and to provide the relationship for the emission calculation (Winiwarter and Schimak, 2004).

There have been some examples of these application software systems such as, AURORA, emission inventory and dispersion modelling system from Milan, Italy, MESAP software used by UBA from Germany to compile national inventories for international reporting, GENEMIS approach to adapt emission data to atmospheric models, and the RAINS model integrating emissions and abatement costs into an enviro-economic assessment (Winiwarter and Schimak, 2004).

These systems have their own features, and the input data requirements correspond to specific availability of information. The database also contain some information which are not necessary to calculate emissions. But this information may be needed by a contract agency. As a result it may be difficult to transfer an emission inventory system created for a specific user to an application elsewhere (Winiwarter and Schimak, 2004).

The requirements for calculation of emission data are, the investigation are, spatial resolution, investigation period, and years of investigation. Investigation area could be regional, continental, or hemispherical/global. The spatial resolution may be chosen as for example 1x1 km, 30x30 km, 1ºx1º, or coordinates may be given for sources as large point sources. Investigation period may be chosen as a year or a time period. The base year, current updates and future scenario dates should be determined for the calculation. For point sources information for height of emissions, volume and temperature of the flue gas, and technical parameters of the emission source are necessary data. Also it is important to define the species that will be the base for the study (Theloke, 2005). Species may be classical pollutants, greenhouse gases etc.

Air pollutants are being emitted from a variety of sources, as anthropogenic and biogenic and natural emissions. Anthropogenic emissions includes power plants, refineries, incinerators, factories, domestic households, cars and other vehicles, animals and humans, fossil fuel extraction and production sites, offices and public buildings, distribution pipelines, fertilized land, land with biological decay (EMEP, 2003). Biogenic and natural emissions consist soil, vegetation, volcanoes and lightning.

Emission estimates are collected together into inventories or databases which usually also contain supporting data on the locations of the sources of emissions; emission measurements where available; emission factors; capacity, production or activity rates in the various source sectors; operating conditions; methods of measurement or estimation. Emission inventories may contain data on three types of source, such as point, area and line. All data may be on area basis, as region, country, sub region in inventories (EMEP, 2003).

An emission inventory should have the following features; transparency, which means that the third parties can understand and verify the calculations and results; consistency, which means that the time series can be comparable within the countries; comparability, which provides the international comparison of the data; completeness, which shows that all relevant sources and sinks are included in the emission inventory; accuracy, which provides quality assurance and management for the calculation process (Wirth & Theloke, 2006).

2.5. Atmospheric Emission Inventory Methodology

There have been several different emission inventory project depending on the origin of the developer country. These are the OECD Control of Major Air Pollutants (MAP) Project, the DGXI Inventory, the CORINE Programme and subsequent work by the European Environment Agency Task Force, the Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe (EMEP), the IPCC/OECD Greenhouse Gas Emissions Programme (EMEP, 2003).

2.5.1. OECD/MAP Project

The MAP Project was designed in 1990 by OECD. The aim of the project was to assess pollution by large scale photochemical oxidant episodes in Western Europe, and to evaluate the impact of emission control strategies for this episode. This project covered SO_2, NOx, VOC emissions caused by point and area sources. This sources were divided into nine source group as; mobile sources, power plants, non-industrial combustion, industry, organic solvent evaporation, waste treatment and disposal, Agriculture and food industry, nature, miscellaneous (EMEP, 2003).

2.5.2. The DGXI Inventory

The CEC Environment Directorate (DGXI) financed and emission inventory for EU12 member states in 1985. The aim of the DGXI Inventory was to collect necessary data on emissions for all relevant emission sources in order to provide a database for air pollution control studies. The inventory covered four pollutants SO_2, NOx, VOC and PM. Main source sector of the pollutants are utility power plant, industrial combustion plant, district heating, oil refineries and petrochemical plant, domestic heating, industrial processes, solvent use, transportation, Agriculture and nature (EMEP, 2003).

2.5.3. CORINE and the EEA Task Force

The program was called CORINE because of the Coordination d'Information Environnementale. It includes a project which collects data on emission into the air relevant to acid deposition. This project was called CORINAIR. This project started in 1985 with the objective of compiling a coordinated emission inventory. The CORINAIR 1985 Emission Inventory covers three pollutants SO_2, NOx, VOC. Main source sectors were recognized as combustion, oil refineries, industrial combustion, processes, solvent evaporation, road transportation, nature and miscellaneous. A source sector nomenclature (NAPSEA: Nomenclature for Air Pollution Socio Economic Activity, SNAP: Selected Nomenclature for Air Pollution), an emission factor handbook, and a computer software package were also developed with this project. The CORINAIR 1985 Inventory was developed in collaboration with the Member States, Eurostat, OECD, UNECE/EMEP, and completed in 1990.

A more developed nomenclature, SNAP90 has been produced with the new version. SNAP90 includes 260 activities, grouped into three level of sub sectors and 11 main sectors. Pollutants list extended to sulphur dioxide, oxides of nitrogen, non-methane volatile organic compounds, ammonia, carbon monoxide, methane, nitrous oxide and carbon dioxide. The main source sectors have been recognized as - Public power, cogeneration and district heating plants, commercial, institutional and residential combustion plants, industrial combustion, production processes, extraction and distribution of fossil fuels, solvent use, road transport, other mobile sources and machinery, waste treatment and disposal, Agriculture, nature (EMEP, 2003).

2.5.4. EMEP

EMEP (The Cooperative Program for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe) has arranged workshops on Emission Inventory Techniques. The aim was to develop guidelines for estimation and reporting of emission data for SOx, NOx, NMVOCs, CH_4, NH_3, and CO. The guideline recommends that emission data should be reported at least for major 11 sources. These sources were agreed with the CORINAIR Inventory Project.

2.5.5. The IPCC/OECD/IEA Program on National Greenhouse Gas Inventories

OECD had a workshop on greenhouse emission inventory methodology in 1991. IPCC adapted Work Program to IPCC Working Group 1 with support of OECD and IEA. This group recognized that method development effort should build on available data, provide an accessible method for all participant countries, allow more detailed methods, have better documentation to provide consistency and transparency. The Working Group has prepared Guidelines for National Greenhouse Gases in three volumes as reporting instructions, workbook and reference manual. The guidelines were revised through workshops and the latest version of the guideline has been published as "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories".

The revised guideline covers greenhouse gases, CO_2, CH_4, N_2O, HFCs,PFCs, SF_6; ozone precursors, NOx, CO, NMVOC. Furthermore information on SO_2, NH_3 and other greenhouse gases was also requested.

IPCC guidelines specifies the sources as energy (combustion and fugitive), industrial processes, solvent and other product use, agriculture, land use change and forestry, waste.

2.6. Sources of Air Pollutant Emissions

There have been many different segmentation of sources of air pollutant emissions according to many different atmospheric emission inventory methodology. In this study sources have been divided into four sector. These are mobile sources, small combustion plants, large combustion plants, and other industrial processes.

2.6.1. Mobile Sources

Mobile sources emissions are significant for emission inventories all over the world (Schifter et al., 2005). Vehicle emissions from road transport, railways, inland navigation, shipping or aviation are provided for sections along the line of the road, railway-track, sea-lane in some inventories (EMEP, 2003). Emissions from mobile sources may be included in line sources and area sources depending on the road section. Mobile sources on all road sections outside settlements are included in line sources and mobile sources on all streets inside settlements are included in area sources. In this study mobile sources were considered as mobile sources and were not divided into groups.

The general equation for emissions estimation is given by Formula 2.2 (Wirth & Theloke, 2006):

$$E_{ij} = EF_i \times A_j \qquad \textbf{(2.2)}$$

E_{ij} = emission of pollutant i in spatial unit j

A_j = activity level in spatial unit j

EF_i = emission factor for pollutant i

This formula can be given as (Wirth & Theloke, 2006) Formula 2.3 with the assumption of the activity is mileage for mobile sources.

$$E_{ij} = EF_{ij} \times M_j \qquad \textbf{(2.3)}$$

E_{ij} = emission (mass/year) of pollutant i from vehicle type j

EF_{ij} = emission factor (g/km) for pollutant i for vehicle type j

M_j = mileage (km/year) of vehicle type j

The activity which is mileage for mobile sources may be given as following formula (2.4):

Mj	= FCj / aFCj	**(2.4)**
Mj	= mileage (km/year) of vehicle type j	
aFCj	= average fuel consumption (g/km) per vehicle type j	
FCj	= fuel consumption (g/year) of vehicle type j	

There have been different models in order to estimate emissions from road traffic as line sources. The models that have been used for estimation of emissions caused by mobile sources are COPERT and HBEFA.

2.6.2. Small Combustion

Small combustion plants have thermal inputs lower than 1 MW in general. They are located in households/residential areas, small manufacturing sites/manufacturing industries, public facilities/buildings, commercial and public services (e.g. hospitals), agriculture (Wirth, 2006). They are also included in area sources and may be defined as all stationary sources excluding point sources (Wang et al., 2005). Type of fuels consumed in small combustion plants may be given as: Fuel oil, lignite, hard coal, natural gas, liquid natural gas (LNG), liquid petrol gas (LPG), biomass. There are different methods to estimate emissions from small combustion plants. These are bottom-up and top-down approach. The bottom-up approach is applicable if data is available for every different source. Otherwise top-down approach is applicable. If fuel consumption data on different regional scale is available then the top-down approach is applicable. Emission is calculated by the following formula (2.5).

E	=	EF x FC	**(2.5)**
E	=	Emission of air pollutant [tons per year]	
EF	=	Emission factor [kg air pollutant/ tons fuel per year]	
FC	=	Amount of fuel consumption (energy supply) [tons per year]	

There are several possible parameters for distribution of air pollutants on a smaller regional scale. These are population density, different regional fuel consumption, natural gas networks.

2.6.3 Point Sources

An individual plant or a large combustion plant is the subject of point sources. Capacity, operating conditions, location are important parameters for emission estimations. Point sources are considered as following source groups according to EMEP:

- Power plant with thermal input capacity >=300MW
- Refineries
- Sulphuric acid plant
- Nitric acid plant
- Integrated iron/steel with production capacity >3Mt/yr
- Paper pulp plant with production capacity > 100kt/yr
- Large vehicle paint plant with production capacity > 100000 vehicles/yr
- Airports with >100000 LTO cycles/yr
- Other plant emitting >=1000t/yr SO_2, NOx or VOC or >=300000t/yr CO_2

According to Theloke point sources may be considered as follows:

- Furnaces which has a capacity greater than 20 MWth
- Paint application with a capacity greater than 25 kg organic solvent used/h
- Printing with a capacity greater than 25 kg solvent used/h
- Degreasing with a capacity greater than 20 t solvent used/h
- Refineries
- Gasoline storage with a tank size greater than 10000 ton
- Deicing of aircraft, extraction of edible fat, and oil
- Major plants of organic chemistry (Theloke, 2005).

2.6.4 Other Sources

There are many different sources which are not included in mobile sources, small combustion plants and point sources chapters. However it is necessary to include all relevant emission sources in order to provide completeness of the emission inventory. Thus, industrial processes, which have significant emissions to human health are also included in the study. These are, iron and steel industry, crude oil refineries, cement indurty and pulp and paper industry. Emissions have been calculated by the activity data and emission factors which are specific for Turkey. Emission factors were taken from IIASA Rains online model.

2.7. Models for Emission Factors

2.7.1. COPERT III

COPERT is a computer model which estimates emissions of all regulated air pollutants (CO, NOx, VOC, PM) produced by different vehicle categories (passenger cars, light duty vehicles, heavy duty vehicles, mopeds and motorcycles) as well as CO_2 emissions on the basis of fuel consumption. Besides the software provides calculation for an extended list of non regulated pollutants, including CH_4, N_2O, NH_3, SO_2, heavy metals, PAHs and POPs and NMVOC emissions allocated to several individual species as well. Emission estimations are based on three different type of emissions as: Emissions produced during thermally stabilized engine operation (hot emissions), emissions occurring during engine start from ambient temperature (cold-start and warming-up effects) and NMVOC emissions due to fuel evaporation. The total emissions are calculated depending on the activity data provided by the user and speed-dependent emission factors calculated by the software.

The software application of COPERT methodology has been developed for the compilation of national inventories (i.e. NUTS 0) on a yearly basis. However, the methodology can also be used with a sufficient degree of certainty at a higher resolution too, i.e. for the compilation of urban emission inventories with a spatial resolution of 1x1 km^2 and a temporal resolution of 1 hour.

In order to calculate exhaust emissions from internal combustion engines used in off-road applications (agriculture, forestry, household, industry, waterways and railways) the user must use the separate module of COPERT III (COPERT, 2006). Figure 2.1 shows the model interface.

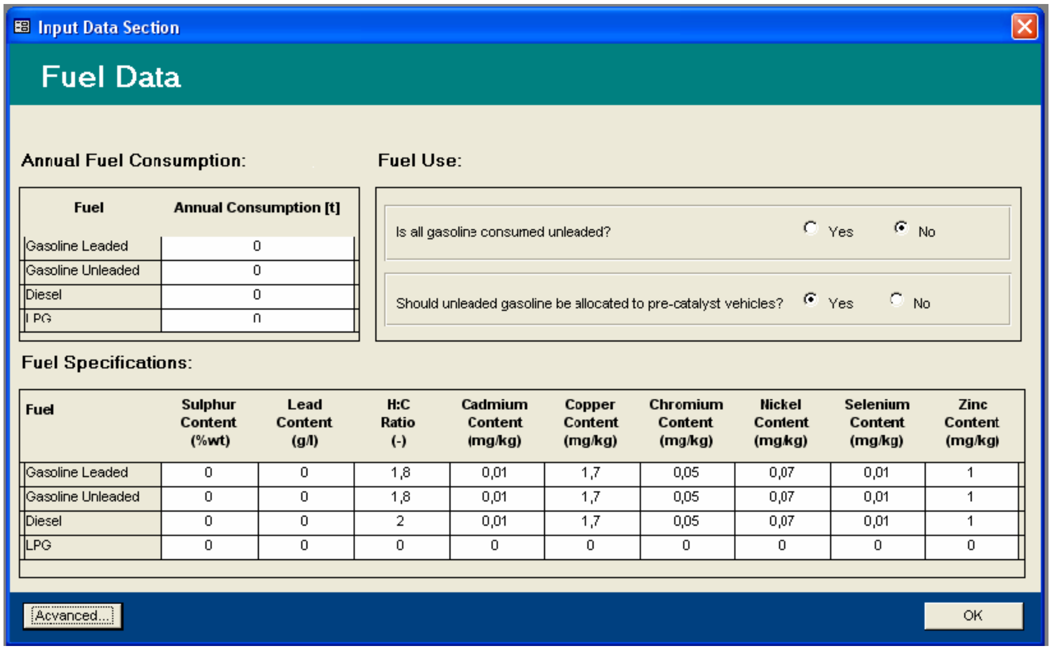


Figure 2.1. COPERT III

2.7.2. Handbook Emission Factors for Road Transport (HBEFA)

The handbook Emission Factors for Road Transport is a model which provides emission factors for different type of vehicles such as; passenger cars, light duty vehicles, heavy duty vehicles and motorcycles. Traffic situations are also considered in this model. The latest version is HBEFA 2.1 which is published in February 2004. The new thing on this version is the revised emission factors of the heavy duty vehicles. Also there were changes on the emission factor of the light duty vehicle. There are also new measurements for vehicle categories up to EURO-3. The new version of HBEFA includes data for Germany, Austria and Switzerland. The principal of the model has not changed. If somebody wants to get the hot emission factor then he also gets the cold start and evaporative emission factors. All relevant emission standards are covered in the model. New models and approaches were introduced and some definitions were adapted.

The handbook provides emission factors per traffic activity as in the earlier versions. Different levels of desegregation are as following:

- Type of emission: hot emissions, cold start emissions, evaporation (hot/warm soak, diurnal)
- Vehicle category: Passenger cars, light duty vehicles, buses, coaches, motorcycles

- Year and implicitly by varying fleet composition in the three countries (Germany, Austria, Switzerland)
- Pollutants: CO, HC, NOx, PM, several components of HC, CO_2, NH_3, N_2O
- Different traffic situations and different gradient classes: emission factors are being provided for several traffic situation and different gradient classes.

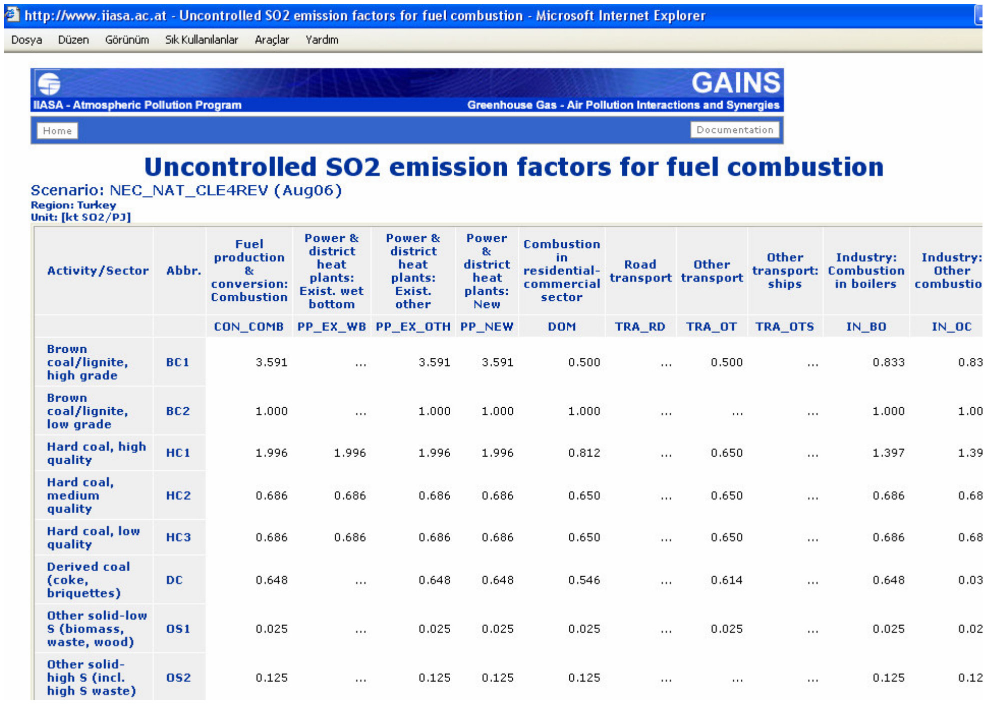
Cold start emission factors: Typical on temperature distributions and behavioral parameters, i.e. trip length distributions, driving patterns at cold start (HBEFA, 2007).

2.7.3. IIASA

International Institute for Applied Systems Analysis (IIASA) is a non-governmental research organization. It is located in Laxenburg, Austria and sponsored by its national member organizations in Africa, Asia, Europe, and North America. IIASA has scientific studies on environment, economy, technology. IIASA has helped many countries in reducing air pollution and better managing land, water and energy resources.

RAINS Europe Online Model

Rains Online model is a tool for analyzing strategies to reduce acidification, eutrophication and ground level ozone. Rains combines projections of future economic, Ağrıcultural, and energy development in 38 European countries, the present and future emissions of SO_2, NO_x, VOC and NH_3 resulting from these activities, the options for reducing emissions and the costs of these measures, the atmospheric dispersion characteristics of sulfur and nitrogen compounds and the formation of ground-level ozone, and the environmental sensitivities of ecosystems towards acidification, eutrophication, and ground-level ozone in order to develop cost effective emission control strategies in Europe.



http://www.iiasa.ac.at - Uncontrolled SO2 emission factors for fuel combustion - Microsoft Internet Explorer

Dosya Düzen Görünüm Sık Kullanılanlar Araçlar Yardım

GAINS

IIASA - Atmospheric Pollution Program

Greenhouse Gas - Air Pollution Interactions and Synergies

Home

Documentation

Uncontrolled SO2 emission factors for fuel combustion

Scenario: NEC_NAT_CLE4REV (Aug06)

Region: Turkey

Unit: [kt SO2/PJ]

Activity/Sector	Abbr.	Fuel production & conversion: Combustion	Power & district heat plants: Exist. wet bottom	Power & district heat plants: Exist. other	Power & district heat plants: New	Combustion in residential-commercial sector	Road transport	Other transport	Other transport: ships	Industry: Combustion in boilers	Industry: Other combustio
		CON_COMB	PP_EX_WB	PP_EX_OTH	PP_NEW	DOM	TRA_RD	TRA_OT	TRA_OTS	IN_BO	IN_OC
Brown coal/lignite, high grade	BC1	3.591	...	3.591	3.591	0.500	...	0.500	...	0.833	0.83
Brown coal/lignite, low grade	BC2	1.000	...	1.000	1.000	1.000	...	...	...	1.000	1.00
Hard coal, high quality	HC1	1.996	1.996	1.996	1.996	0.812	...	0.650	...	1.397	1.39
Hard coal, medium quality	HC2	0.686	0.686	0.686	0.686	0.650	...	0.650	...	0.686	0.68
Hard coal, low quality	HC3	0.686	0.686	0.686	0.686	0.650	...	0.650	...	0.686	0.68
Derived coal (coke, briquettes)	DC	0.648	...	0.648	0.648	0.546	...	0.614	...	0.648	0.03
Other solid-low S (biomass, waste, wood)	OS1	0.025	...	0.025	0.025	0.025	...	0.025	...	0.025	0.02
Other solid-high S (incl. high S waste)	OS2	0.125	...	0.125	0.125	0.125	...	...	...	0.125	0.12

Figure 2.2. Interface of IIASA Gains Online Model

The Regional Air Pollution Information and Simulation (RAINS) model has been developed by IIASA. Rains is a tool for the integrated tool for the integrated assessment of alternative strategies to reduce acid deposition in Europe and Asia (Alcamo et al. 1990). The RAINS Online 7.2 Model describes pathways of pollutans (sulfur dioxide, nitrogen oxides and ammonia) and monitor their impacts on acidification and eutrophication (Amaan et al. 1996). The structure of the model is shown in Figure 2.3.

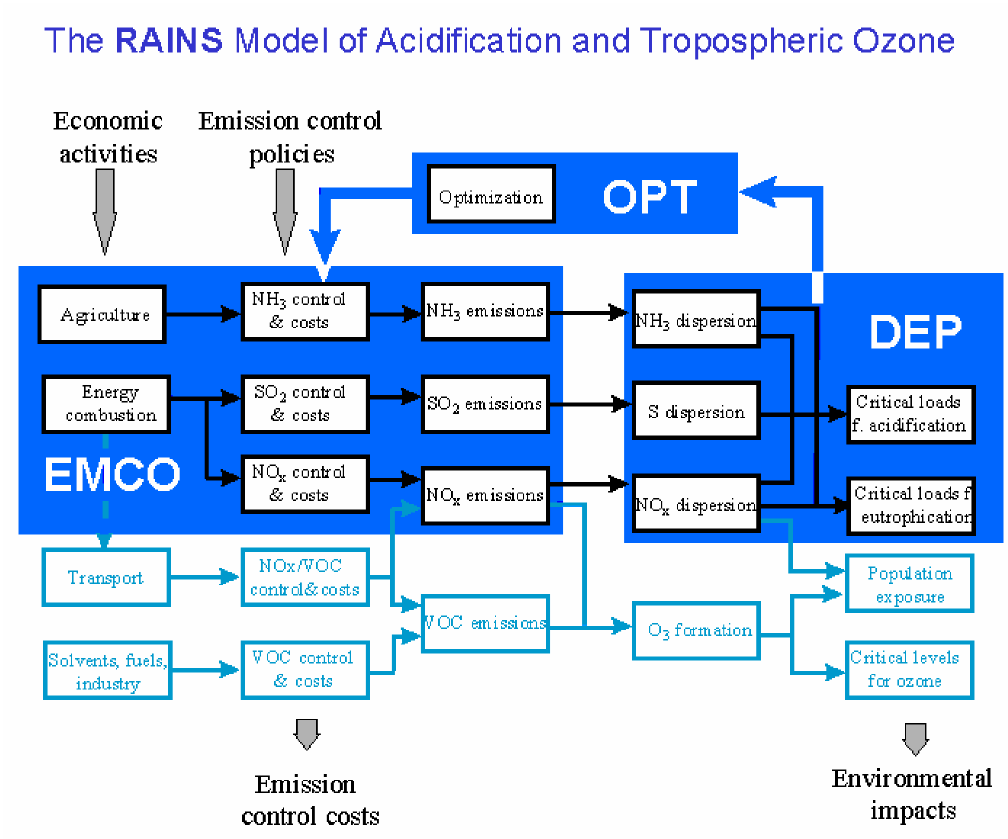


Figure 2.3. The Rains Model of Acidification and Tropospheric Ozone (IIASA, 2000)

The various sub-models are organized into three models. These are EMCO, DEP and OPT. EMCO is the emission cost module with parts for nitrogen oxides, sulphur dioxide and ammonia, DEP is the acid deposition and ecosystem impact module and OPT is the optimization module.

RAINS estimates emissions based on activity data, uncontrolled emission factors, the removal efficiency of emission control measures and the extent to which such measures are applied:

$$E_i = \sum_{j,k,m} E_{i,j,k,m} = \sum_{j,k,m} A_{i,j,k} ef_{i,j,k} (1 - eff_m) X_{i,j,k,m} \quad \textbf{(2.6)}$$

i,j,k,m : Country, sector, activity type, abatement technology;

Ei	:	Emissions in country i;
A	:	Activity (level) in a given sector, e.g. coal consumption in power plants
ef	:	Raw gas emission factor
effm	:	Reduction efficiency of the abatement option m
X	:	Actual implementation rate of the considered abatement, e.g., fraction of total coal used in power plants that are equipped with electrostatic precipitators.

3. INTERNATIONAL REQUIREMENTS FOR EMISSION INVENTORIES

There are several international conventions which oblige the parties to prepare and submit emission inventories to the executive boards of the conventions. Turkey is a party to Long Range Transboundary Air Pollution Convention and United Nations Framework Convention on Climate Change. But, not a party to Kyoto Protocol yet. As a candidate country to the European Union, Turkey also should be careful on National Emission Ceilings which will become as a limitation for Turkey during the acquisition of EU.

3.1. Long Range Air Pollution Convention

The Convention on Long Range Transboundary of Air Pollution (LRTAP) is the first international agreement concerning transboundary air pollution. It was opened for signature on 13 November 1979 in Geneva and was entered into force on 16 March 1983.

The parties of the convention are: Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzigovina, Bulgaria, Canada, Crotia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Holy See, Hungary, İçeland, Ireland, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Monaco, Netherlands, Norway, Poland, Poland, Portugal, Romania, Republic of Moldova, Russia, San Marino, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States, European Community.

By this convention, it has been recognized that one country should not harm the other country with its air pollution (Barton, 1997). Parties of the convention should report emission data to the Executive Body of the Convention. The Convention on Long Range Transboundary Air Pollution has been extended by five protocols:

- Protocol on Long Term Financing of the Cooperative Program for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe (EMEP), Geneva,1984
- Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 percent, Helsinki, 1985
- Protocol Concerning the control of Emissions of Nitrogen Oxides or their Transboundary Fluxes, Sofia, 1988
- Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes, Geneva, 1991
- Protocol on Further Reduction of Sulphur Emissions, Oslo, 1994
- Protocol on Heavy Metal and on Persistent Organic Pollutants, 1998
- Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, 1999

Parties should report annual national emissions of SO_2, NO_x, NMVOC, CH_4, CO, NH_3, various heavy metals and POPs (persistent organic polluters). Besides, parties should report emission data within grid elements to EMEP periodically. While parties generate their emission inventories, they should use EMEP/CORINAIR Atmospheric Emission Inventory Guidebook as the reference. Moreover parties use the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook to check that all the relevant are considered. Parties should determine and explain when another methodology has been used (EMEP, 2003).

3.2. United Nations Framework Convention on Climate Change (UNFCCC)

United Nations Framework Convention on Climate Change is an international agreement concerning the aim of reducing greenhouse gases in order to struggle global warming. It has been entered into force on 21 March 1994 (UNFCCC, 2006). The convention has no mandatory limits on greenhouse gases (CO2, CH4, N_2O, PFCs, HFCs, SF6).

UNFCCC has two annex list for the countries. Countries take place in the annex 1 and annex 2 of the convention according to their situation. Annex 1 consists countries that are undergoing the process of transition to market economy (UNFCCC, 1992), EU and OECD countries. Annex 2 consists the European Union and OECD countries as at 1992. As Turkey is a member of OECD, it took place in annex-1 and annex-2 of the convention. Countries in annex 2 are responsible to provide technological and financial support to the developing countries and decrease the greenhouse gas emissions level from year 2000 to 1990. Turkey was taken out from the annex 2 with its own demand, because of the different situation in comparison with the other countries in annex 2 in 2001. This amendment entered into force in 2002. Turkey became a party of the convention on 24 May 2004.

According to the convention "All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties." (Article 4, paragraph 1(a)).

As a party of the convention, Turkey also should develop its national emission inventory. Turkey has submitted the first greenhouse gases national emission inventory to the secretary of UNFCCC on 15 April 2006.

Kyoto Protocol

Kyoto Protocol is an amendment to UNFCCC which entered into force on 16 February 2005. This protocol sets mandatory limits to greenhouse gases, that necessitates the emissions between the years 2008-2012 should be 6-8% below 1990 emissions. There are three mechanisms to provide reduction in greenhouse gases emissions. These mechanisms are, clean development mechanism, joint implementation, and emissions trading.

Clean development mechanism provides the Annex 1 parties of the convention to implement projects in non annex 1 parties. These projects return as a certified emission reduction, which helps to meet their emission targets. Joint Implementation is also a project base mechanism that allows the party in Annex 1 to help to another party in annex 1 to reduce the emissions. This returns to the party as emission reduction units (ERU) which helps the party to meet the Kyoto targets. Emission trading allows the parties in annex 1 to transfer units from another party in annex 1

(UNFCCC, 2006). Annex 1 parties to the protocol are as following, Austria, Belgium, Bulgaria, Canada, Czech Republic, Denmark, Australia, Estonia, Finland, France, Germany, Greece, Hungary, İçeland, Ireland, Italy, Japan, Latvia, Liechtenstein, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Spain, Sweden, Switzerland, UK and North Ireland, USA.

3.3. Amended Council Decision 99/296/EC on a Monitoring Mechanism of Community CO_2 and other Greenhouse Gas Emissions

Council decision 93/389/EEC was adopted to help monitoring of CO_2 and other greenhouse gas emissions by European Community. It has been amended in 1999 by Council Decision 99/296/EC. This decision was aimed to stabilize CO_2 emissions by 2000 at the 1990 level. Member states should report their anthropogenic CO_2 emissions and removal for the previous year. Member states also should submit their emission inventory on Kyoto greenhouse gases (CO_2, CH_4, N_2O, PFCs, HFCs, SF_6) (EMEP, 2003).

3.4. National Emission Ceilings (NEC) Directive

NEC Directive which was adopted by European Parliament and Council of Ministers in 2001, sets national emission ceilings for four air pollutants, SO_2, NOx, VOCs and NH_3 that cause ground level ozone and acidification. This directive was improved both for human health and environment. The aim of the directive is to decrease acidifying, eutrophying and ozone levels in Europe. National Emission Ceilings for EU countries are given by Table 3.1. Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia are acceding countries that are also agree with NECs.

Table 3.1: National Emission Ceilings for EU25

Member State	SO_2 (kt/y)	NO_x (kt/y)	VOC (kt/y)	NH_3 (kt/y)
Austria	39	103	159	66
Belgium	99	176	139	74
Denmark	55	127	85	69
Finland	110	170	130	31
France	375	810	1 050	780
Germany	520	1 051	995	550
Greece	523	344	261	73
Ireland	42	65	55	116
Italy	475	990	1 159	419
Luxembourg	4	110	9	7
Netherlands	50	260	185	128
Portugal	160	250	180	90
Spain	746	847	662	353
Sweden	67	148	241	57
UK	585	1 167	1 200	297
EU-15	3 850	6 519	6 510	3 110
Cyprus	39	23	14	9
Czech Republic	265	286	220	80
Estonia	100	60	49	29
Hungary	500	198	137	90
Latvia	101	61	136	44
Lithuania	145	110	92	84
Malta	9	8	12	3
Poland	1 397	879	800	468
Slovakia	110	130	140	39
Slovenia	27	45	40	20
EU-25	6 543	8 319	8 150	3 976

EU Member states should submit national emission inventories and projections to the Commission for 2010. Besides, they have to prepare the emission inventories according to the directive.

4. EMISSION INVENTORY FOR TURKEY

Turkey is located between 36°- 42° North parallels and 26° - 45° East meridians. The land is situated between the Mediterranean Sea and the Black Sea. The area of the country including the lakes is 814.578 km^2. The country is divided into seven regions as Marmara, Aegean, Mediterranean, Central Anatolia, East Anatolia, Southeast Anatolia, and Black Sea Region. Turkey has 81 provinces and the capital of the country is Ankara. Major metropolitan cities in Turkey are İstanbul, Ankara, İzmir, Bursa, Konya and Adana (see Figure 4.1).

Figure: 4.1: Map of Turkey with respect to the provinces

The following source groups have been considered in this emission inventory study: Mobile Sources, Small Combustion Processes, Large Combustion Plants, Industrial Processes (Iron and Steel Industry, Crude Oil Refineries, Cement Plants, Pulp and Paper Industry) Agricultural and Solvent Use. The focused pollutants of the emission inventory are: NO_X, VOC, NH_3, SO_2, and PM_{10}. The first four pollutants are affected by the National Emissions Ceiling. These pollutants are responsible for acidification, eutrophication and ground level ozone pollution. PM_{10} is also an important pollutant that significantly impact human health. As the nearest actual year with sufficient data availability is 2003, the base year of the study has been chosen as this year.

4.1. Mobile Sources of Turkey

On road mobile sources in Turkey are passenger cars, pick up (light duty vehicles), minibuses, buses, trucks, and motorcycles. The definition of these vehicles can be given as following:

Passenger Car (PC) : A passenger car is a motorized vehicle which has at most seven seats excluding the driver seat, and is being used for the transportation of passengers.

Pickup (kamyonet): A pick up is a motorized light duty vehicle with a loaded weight not exceeding 3.5 tones, which is used for the transportation of goods.

Minibus: A minibus is a motorized vehicle which has 8-14 seats excluding the driver seat, and is being used for the transportation of passengers.

Bus: A bus is a motorized vehicle which has at least 15 seats excluding the driver seat, and is being used for transportation of passengers.

Truck : A truck is a motorized heavy duty vehicle which has a loaded weight over 3.5 tones and is being used for the transportation of goods.

Motorcycles : A motorcycle is a two wheeled motorized vehicle.

4.1.1. Data Availability of Mobile Sources in Turkey

Data availability is an important issue to generate an emission inventory. In order to calculate emissions, mileage values, vehicle stock, and vehicle technologies for the different vehicle types are needed. A major part of this work consisted therefore in the collection and assessment of data from various sources given as follows:

- Vehicle Stock : Vehicle stock data has been taken from the statistical studies of TUIK (Turkish Statistical Institute, 2003). Vehicle stock data is available for every province for every year and every month.
- Vehicle Technologies : The data for PC has been provided by ITU Department of Automotive. Data on the other vehicle types has been provided by Security General Directorate, 2004. This data is given for the different fuel technologies, e.g. amount of diesel fuel consuming pick up in Turkey.

- Mileage data : This data has been taken from the report of KGM (General Directorate of Highways, 2004). In this report mileage values from manual, automatic traffic counts and from estimates are available for every province in total, and per region distributed to the vehicle type. The regions are the special regions of General Directorate of Highways, which are sixteen in total.
- Fuel Consumption : Fuel Consumption data has been provided by Ministry of Environment and Forestry for 2003. It is available for Turkey and different sub sectors.

4.1.2. Methodology for Mobile Sources

The methodology of the emission calculation for mobile sources is given by the following chapter.

4.1.2.1. Vehicle Stock

Vehicle stock values for the year 2003 have been calculated by using the mean value of twelve months. Vehicle stock of İstanbul and Turkey is given by Table 4.1.

Table 4.1: Vehicle stock in İstanbul and in Turkey in 2003

	PC (number)	**Pick up (number)**	**Minibus (number)**	**Bus (number)**	**Truck (number)**	**Motorcycle (number)**
İstanbul	917666	153365	11175	15498	25304	32967
Turkey	4646841	915225	243101	121565	401148	1058415
share	20%	17%	5%	13%	6%	3%

Passenger Cars

75% of passenger cars in Turkey consume gasoline. Pre ECE, ECE 15 00 & 01, ECE 15 02, ECE 15 03, ECE 15 04, EURO I, EURO III are the different kind of emission abatement measures which are used in Turkey as gasoline consuming cars. The second important fuel being consumed by passenger cars is liquefied petroleum gas (LPG). LPG is the fuel, which was only being used for heating appliances. It is contents propane or butane or the mixture of these two gases. LPG is being used as a vehicle fuel since 1996 with the decision that is published in Official Gazette in Turkey. The highest number of consumer of LPG are commercial taxis.

According to the Statistics of TUIK, there are 4.646.841 passenger cars in 2003. 917.666 of those have been registered in İstanbul which represents 20% of the total passenger car stock of Turkey. The share of passenger car (PC) according to their fuel consumption in Turkey is given by Figure 4.2.

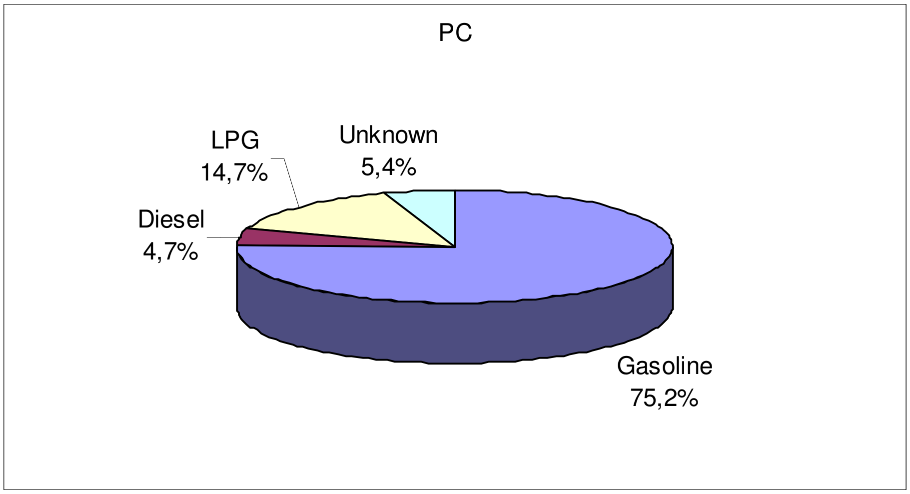


Figure 4.2: Share of PC in Turkey in 2003 according to the fuel consumption

Pick up (kamyonet)

75% of the pick ups which is a light duty vehicle consume diesel fuel. There are 915.225 pick up in Turkey in 2003 according to the statistics of TUIK. The share of pick ups according to their fuel consumption is given by Figure 4.3. There are 153.365 pick ups in İstanbul represents 17% of the total number for Turkey.

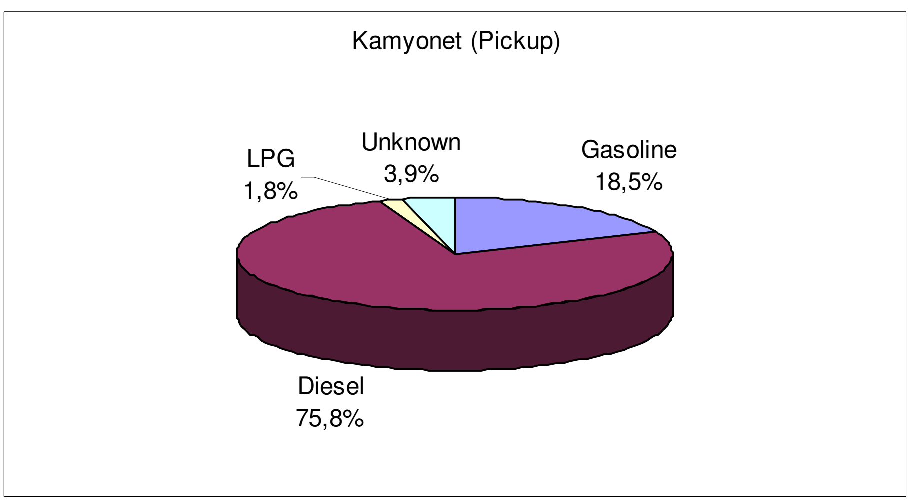


Figure 4.3: Share of pick up in Turkey in 2003 according to the fuel consumption

Minibus

86% of minibuses consume diesel fuel. There are 243.101 minibuses in Turkey in 2003. 11.175 of the total number have been registered in İstanbul. The share of minibuses according to their fuel consumption is given by Figure 4.4.

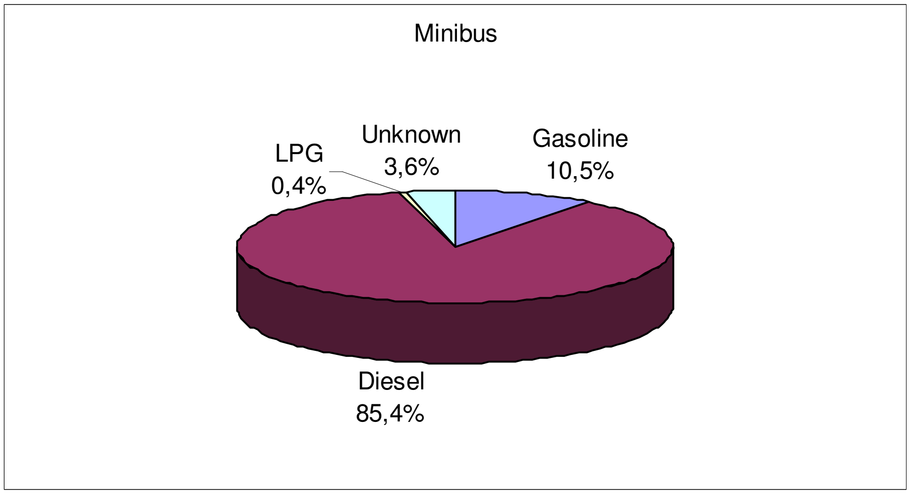


Figure 4.4: Share of minibuses in Turkey in 2003 according to the fuel consumption

Buses

88% of the buses in Turkey consume diesel fuel. There are 121.565 buses registered in Turkey in 2003. In İstanbul the number of registered buses is 15.498 (13%). The share of buses according to their fuel consumption in Turkey in 2003 is given by Figure 4.5.

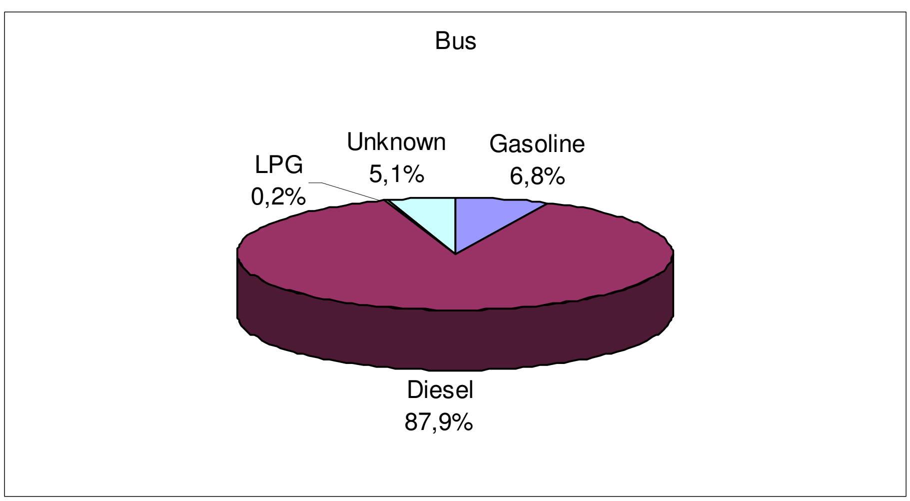


Figure 4.5: Share of buses in Turkey in 2003 according to the fuel consumption

Trucks

90% of the trucks in Turkey consume diesel fuel. 401.148 trucks registered in Turkey in 2003, and 25.304 of this number were registered to İstanbul province which forms 6% of the total number in Turkey. Trucks are mainly registered in the provinces that are called metropolitan cities and in provinces that are close to the border. The share of trucks according to their fuel consumption in Turkey in 2003 is given by Figure 4.6.

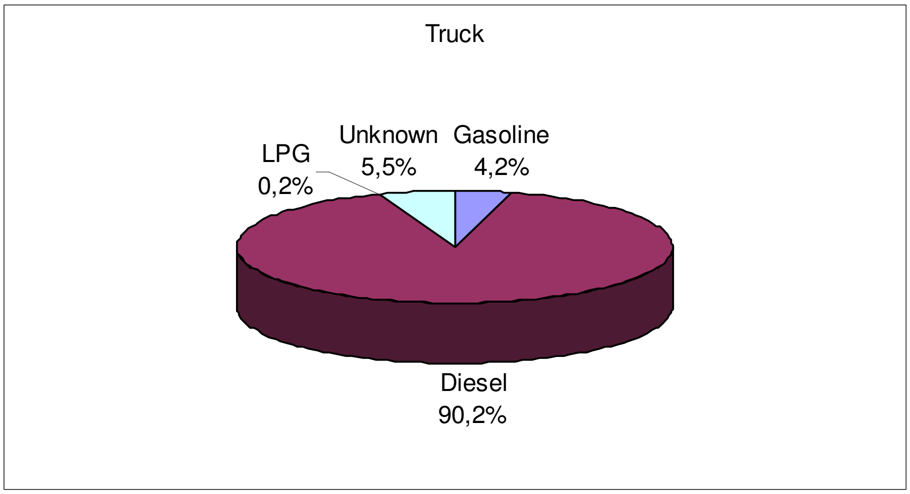


Figure 4.6: Share of trucks in Turkey in 2003 according to the fuel consumption

Motorcycles

Despite the available information that 95% of the motorcycles in Turkey consume gasoline fuel, it has been assumed that all the motorcycles in Turkey consume gasoline. 1.058.415 motorcycles were registered in Turkey in 2003 and 3% of this stock with a number 32.967 was registered in İstanbul. As there was no information available on the number of mopeds, all two wheelers are assumed to be motorcycles.

Comparing the vehicle fleet of İstanbul region and Turkey shows that passenger cars have the highest share 80% and 64% respectively (see Figure 4.7 and 4.8). In İstanbul pick ups have the second highest share, while for the whole of Turkey the share of motorcycles and pick ups is almost equal.

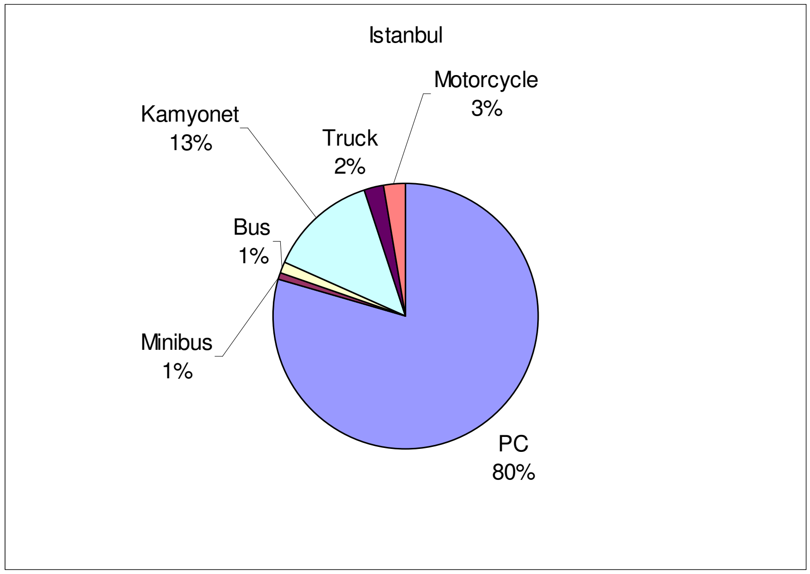


Figure 4.7: Distribution of the vehicles in İstanbul in 2003 (TUIK, 2003)

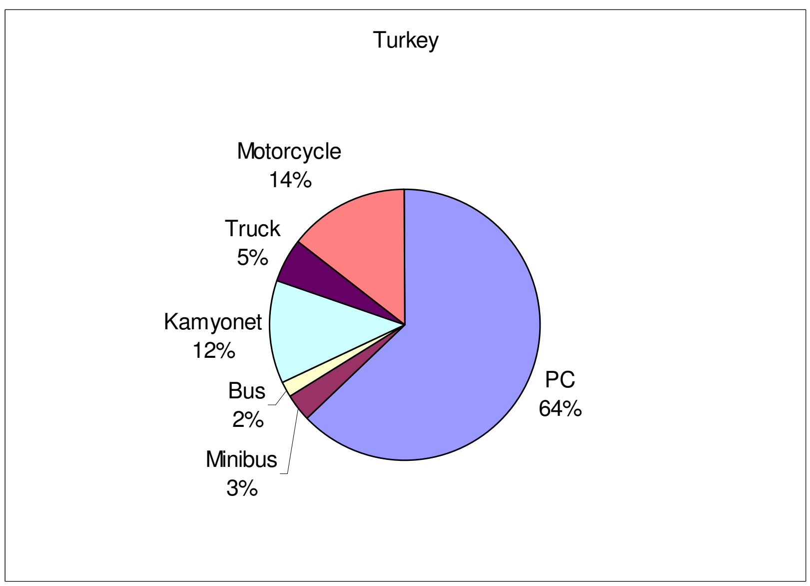


Figure 4.8: Distribution of the Vehicles in Turkey in 2003 (TUIK, 2003)

4.1.2.2. Vehicle Sub segments:

Vehicle numbers for different fuel types in 2003 are calculated by the ratio of statistical values of 2004 (Security General Directorate, 2004). According to the study of ITU Faculty of Mechanical Engineering, Automotive Department, PC group has been divided into four technology groups such as EURO III, EURO I, 15.04, uncontrolled. In order to provide the distribution of PC into different segments and for reasons of consistency with the COPERT emission factors, it has been assumed that the uncontrolled passenger car group is formed by the four sub segments PRE ECE, 15.00-01, 15.02, 15.03 with the same share. Since these values are calculated for whole Turkey, the ratio between the sub segment and total number of vehicles has been used for the calculation of sub segments of every province. The vehicle technology has been assumed as following:

- PC : PRE ECE, 15.00-01, 15.02, 15.03, 15.04, EURO I, EURO III (for Gasoline), Diesel (moderate control), LPG
- Pick up : Gasoline, Diesel, LPG
- Minibus : Gasoline, Diesel, LPG
- Bus : Gasoline, Diesel, LPG
- Truck : Gasoline, Diesel, LPG
- Motorcycle : Gasoline

4.1.2.3. Mileage

The base report that has been used for this phase is Traffic and Transportation Information 2004 which has been published by General Directorates of Highways. Values of 2004 have been converted into values for 2003 by the ratio between total mileage values for year 2003 and 2004. As the mileage has been reported according to provinces with a total number without specification of the type of vehicle, the ratio of total Turkey has been used for calculation of the mileage for different vehicle types. This ratio has been calculated by the information in the report of Highway Transportation Statistics 2004 published by General Directorate of Highways (Traffic and Transport Information, 2004).

According to the report (Traffic and Transportation Information, 2004), vehicles have been counted as car, medium goods vehicle, bus and truck. Cars include vehicles with a maximum of 3.5 tons loaded weight, medium goods vehicles (MGV) includes the vehicle with 3.5 – 10 tons weight. By taking into consideration this information, it has been assumed that cars include PC and pick up (LDV), and MGV include minibus.

Total mileage values which have been given in the report (Traffic and Transport Information, 2004) have been converted to the mileage value of each vehicle type.

This calculation has been done by formula 4.1:

Mj = (TMp x F) / VSj **(4.1)**

Mj	: Mileage per vehicle type j (km/year)
TMp	: Total mileage for specisific province (km/year)
F	: Factor for mileage according to the different vehicle types for Turkey
VSj	: Vehicle stock of vehicle type j

By this approach, the factor (F) was the same for every province. So the ratio for all the different vehicle types was the same for all provinces. Because of that, the results were not overall satisfying as it can be seen by the Figure 4.9. For example the province with the number 73 which is called Şırnak has a mileage value for passenger cars about 70.000 km/year-n. This mileage is not an acceptable value while the average mileage value for passenger car for whole Turkey is about 12.000 km/year-n. Also the province with number 34 which is called İstanbul has a mileage value for passenger cars about 2300 km/year-n, which is also not realistic.

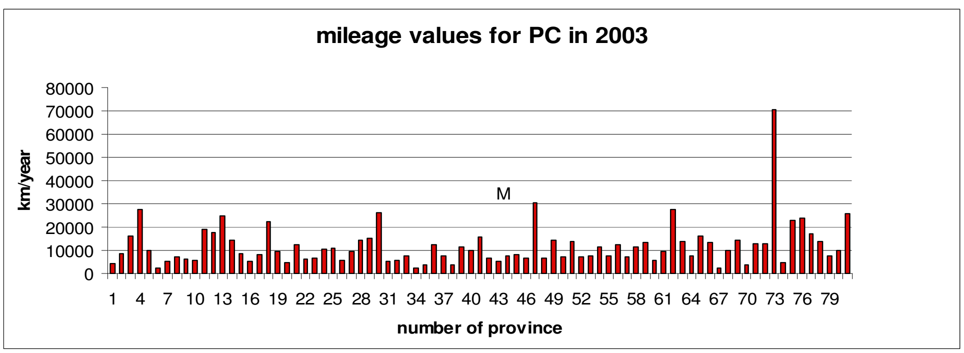


Figure 4.9: First approach for mileage calculation

Because of these reasons, an alternative approach was developed by calculating the mileage on base of fuel consumption data for Turkey. Fuel consumption data which is available for Turkey (MoEF, 2003) in total has been distributed with the ratio taken by another study (Oil Product Sales by Provinces in 2004) to the provinces. It was assumed that the ratio is the same for the base year of the study (2003) and the fuel consumption has been distributed to the provinces according to this ratio. Because of the high share of gasoline fuel for passenger cars, gasoline fuel usage was taken as the base for the mileage calculation. The formula is given as 4.2:

$$Mj = FCj / aFCj \quad \textbf{(4.2)}$$

Mj : Mileage (km/year) of vehicle type

aFCj : Average fuel consumption (g/km) per vehicle type j

FCj : Fuel consumption (g/year) of vehicle type j

(Wirth and Theloke, 2006)

As shown in Chapter 4.1.2.1, two different vehicle types use gasoline fuel in Turkey. These vehicle types are passenger cars and motorcycles. With the assumption of a motorcycle mileage of 5000 km/year, the mileage of passenger cars for every province has been calculated. This resulted in a mileage value of 21500 km/a for PC in İstanbul. The other provinces also have more appropriate values by this approach. Thus, the second approach (Formula 4.2) has been chosen for mileage calculation of passenger cars. Mileage values of the other vehicle types have been calculated by the first approach (Formula 4.1).

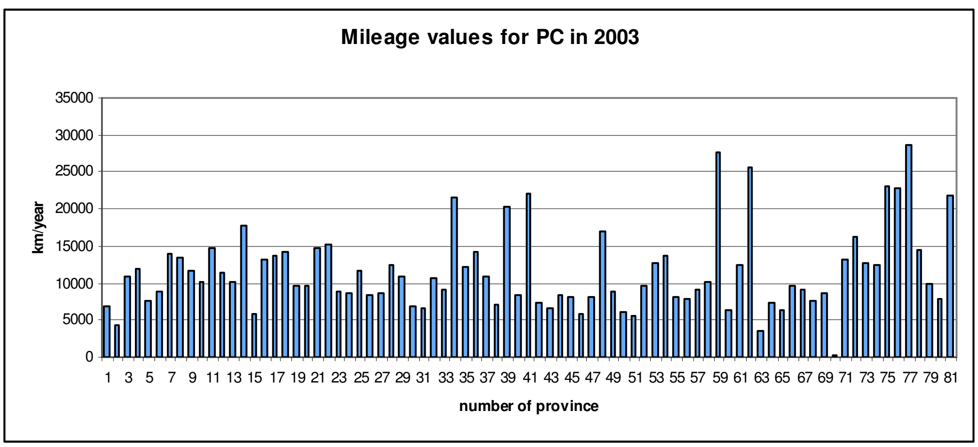


Figure 4.10. Second approach for mileage calculation

As it is seen in Figure 4.10, the range of mileage for PC is between 5000 and 25000 km/yr which is an acceptable value.

4.1.2.4. Emissions

Hot emissions, Evaporative VOC and Cold Start emissions have been calculated.

First Approach for Hot Emissions : In order to calculate annual hot emissions, COPERT III has been used. Emission Factors for NO_X, VOC, NH_3, PM have been produced by COPERT III according to the given data for Turkey. Emission factors for SO_2 has been taken from HBEFA 2.1. As COPERT III emission factors are speed dependant, a mean speed of 60 km/h has been selected for Turkey, as no further information on driving shares (urban, rural, highways) was available for the first approach.

Second Approach for Hot Emissions : A ratio between urban and rural population which was produced from "Year 2000 population census of Turkey" (TUIK, 2000). This ratio was used in order to distribute total mileage according to the provinces. With the ratio of urban and rural mileage, emission factors for 81 provinces have been produced by COPERT III.

Evaporative VOC Emissions : Evaporative VOC Emissions have been calculated with COPERT III per province for gasoline vehicles considering diurnal, hot soak and running losses.

Cold Excess Emissions : For cold excess emissions, emission factor for urban driving has been used. Cold start emissions exist in three driving conditions, but they are more obvious in urban driving (COPERT III, 2000). For that reason cold excess emissions have been calculated for three major metropolitan municipalities İstanbul, Ankara and İzmir. Cold excess emission factors are available for passenger cars and light duty vehicles in COPERT III.

Annual Emissions (Theloke and Wirth, 2006)

Hot Emissions have been calculated by the following formula:

$$Eij = EFij \times Mj \qquad \textbf{(4.3)}$$

Eij : emission of pollutant i from vehicle type j (mass/year)

EFij : emission factor for pollutant i for vehicle type j (g/km)

Mj : mileage of vehicle type j (km/year)

Evaporative VOC Emissions have been calculated by the formula 4.4:

$$E_{EVA,\ VOC;\ j} = 365 \times N_j \times (e^d + S + R) \qquad \textbf{(4.4)}$$

$E_{EVA, VOC;j}$	:VOC emissions due to evaporative losses caused by vehicle category j
N_j	: number of gasoline vehicles of category j,
e^d	: mean emission factor for diurnal losses
S	: emission factor for total soak losses
R	: running losses

(COPERT III, 2000)

4.1.3. Results

With the help of mentioned assumptions and methodology, NO_x, VOC, NH_3, SO_2 and PM_{10} emissions were calculated and will be presented in the following chapter.

4.1.3.1. NO_x Emissions

NO_x emissions are mainly caused by PRE ECE, 15.00-01, 15.02, 15.03, 15.04 passenger cars, gasoline fuel consuming light duty vehicles, diesel fuel using buses and diesel fuel consuming trucks (Table 4.1). Considering the emission factors, the most important source of NO_x emissions are heavy duty vehicles (bus, truck), but the vehicle stock of passenger cars is relatively high in comparison with the heavy duty vehicles (see Figures 4.8, 4.9). This causes at passenger cars are the most important source of NO_x. As it can be seen by Table 4.2 and Figure 4.11, NO_x emissions are caused mostly by passenger cars. The reason of that can be explained by two reasons. The first and most important reason is the high share of passenger cars.

Table 4.2 : NOx Emissions in Turkey in 2003

NOx	PC tons/yr	Pick up tons/yr	Minibus tons/yr	Bus tons/yr	Truck tons/yr	Motorcycles tons/yr	Total tons/yr
First approach	131392	13858	4165	21634	100269	727	272045
Second approach	102591	16848	7644	23923	135430	728	287164

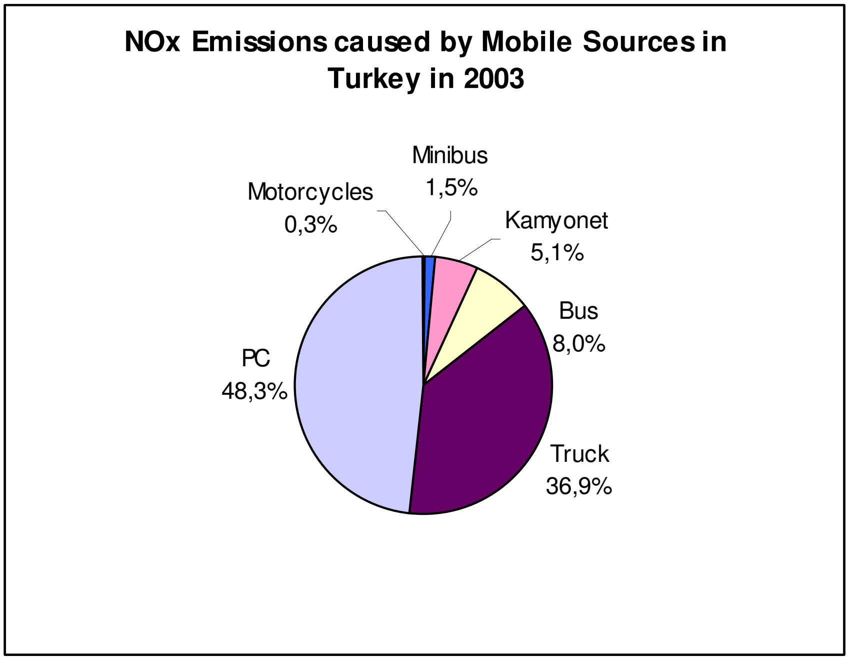


Figure 4.11: NOx Emissions caused by Mobile Sources in Turkey in 2003 (first approach)

As the characteristics of urban and rural driving are different a difference between the first and second approach occurred for vehicles. It can be seen that diesel consuming vehicles have higher NOx emission factors for urban driving where the gasoline consuming vehicles have lower NOx emission factor for urban driving.

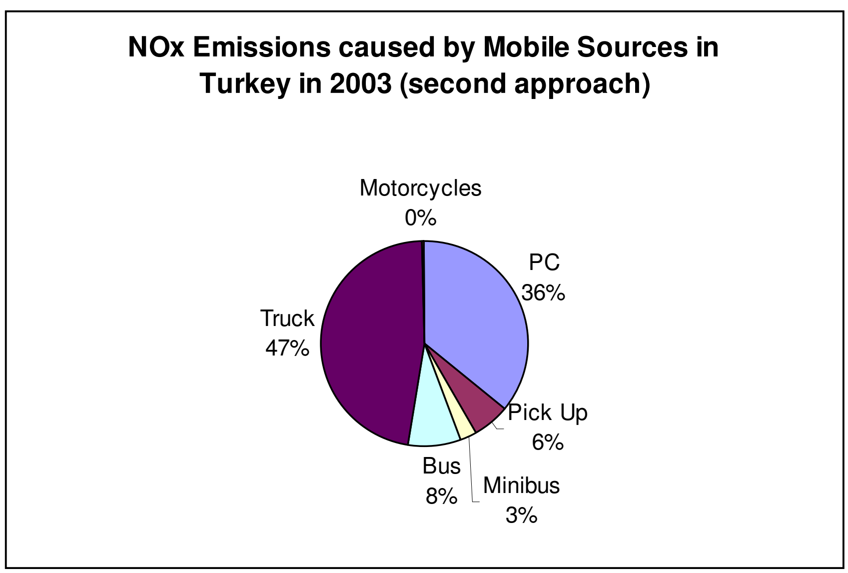


Figure 4.12: NOx Emissions caused by Mobile Sources in Turkey in 2003 (second approach)

4.1.3.2. VOC Emissions

VOC Emissions are also mainly caused by PRE ECE, 15.00-01, 15.02, 15.03, 15.04 passenger cars, gasoline consuming LDV, gasoline consuming buses and trucks and motorcycles. VOC emissions are mostly caused by gasoline fuel driven engines and because of this the most important sources are passenger cars in İstanbul with nearly 90% share (see Figure A.2). In Turkey the share is about 57%, as stock and mileage of passenger cars is relatively lower than in İstanbul. According to Figure 4.13, it can be seen that motorcycles are an important source for VOC Emissions. A study shows that, cars without catalytic converters and two cycle motorcycles emit 12 times more HC than cars with catalytic converters (Vasic and Weilenmann, 2006).

Table 4.3: VOC Emissions in İstanbul and Turkey in 2003

VOC	PC tons/yr	Pick up tons/yr	Minibus tons/yr	Bus tons/yr	Truck tons/yr	Motorcycles tons/yr	Total tons/yr
First Approach	63103	2735	699	3866	14366	25747	110516
Second Approach	126303	4423	1310	4944	24361	25762	187102

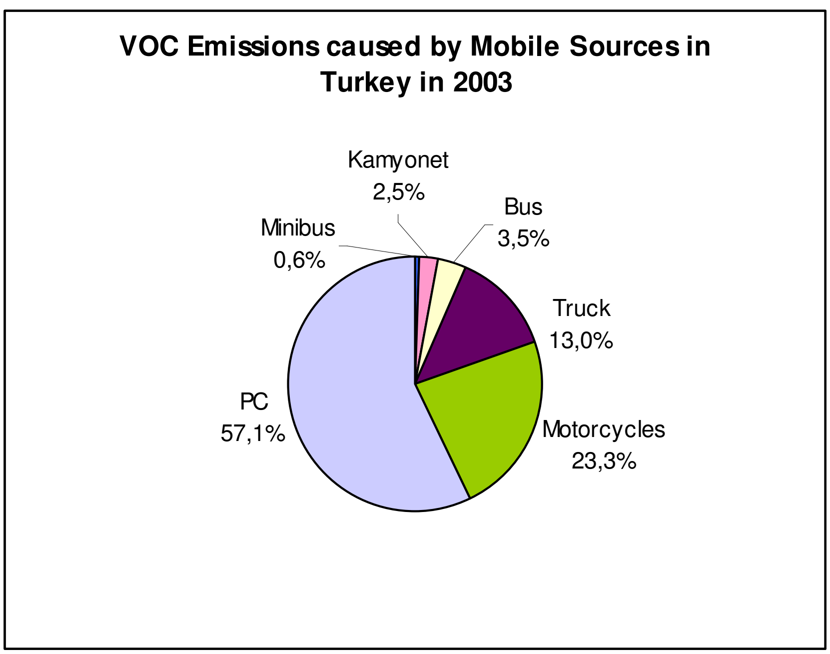


Figure 4.13: VOC Emissions caused by Mobile Sources in Turkey in 2003 (first approach)

VOC emission factors for urban driving is higher for every different type of engine. So that results for VOC emissions are higher in the second approach where urban driving shares are also included to the calculations (see Figure 4.13 and 4.14).

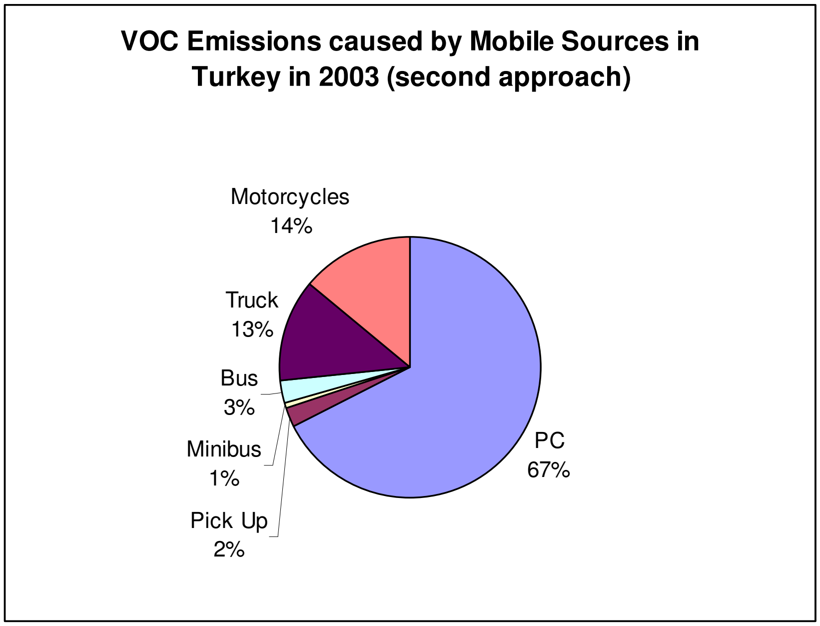


Figure 4.14: VOC Emissions caused by Mobile Sources in Turkey in 2003

4.1.3.3. NH_3 Emissions

NH_3 Emissions are not a main pollutant caused by mobile sources. But gasoline fuel consuming light duty vehicles and diesel fuel consuming heavy duty vehicles are more important in comparison with the other fuels that are being used in mobile sources.

Table 4.4: NH3 Emissions in İstanbul and Turkey in 2003

NH3	PC tons/yr	Pick up tons/yr	Minibus tons/yr	Bus tons/yr	Truck tons/yr	Motorcycles tons/yr	Total tons/yr
First Approach	230	2	0,3	0,4	2,3	0,3	236
Second Approach	678	12	4,0	7,7	33,0	10,6	745

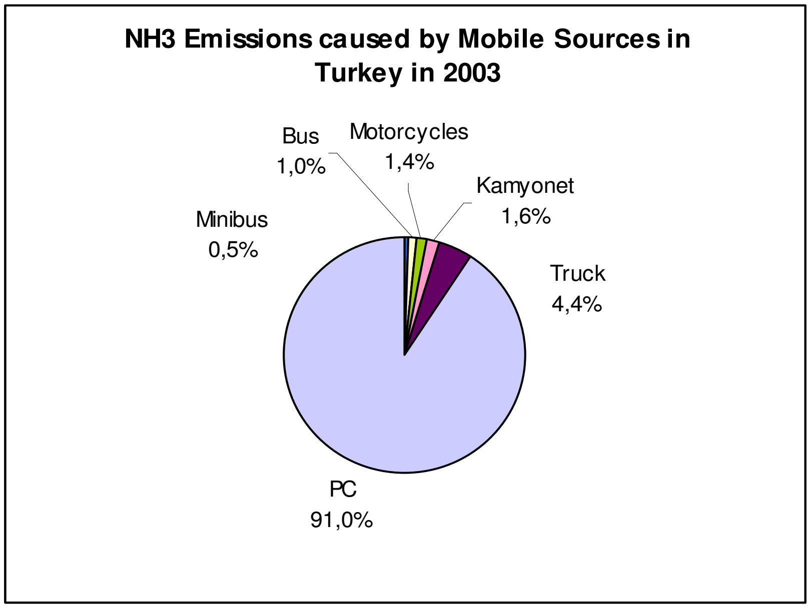


Figure 4.15: NH3 Emissions caused by Mobile Sources in Turkey in 2003 (first approach)

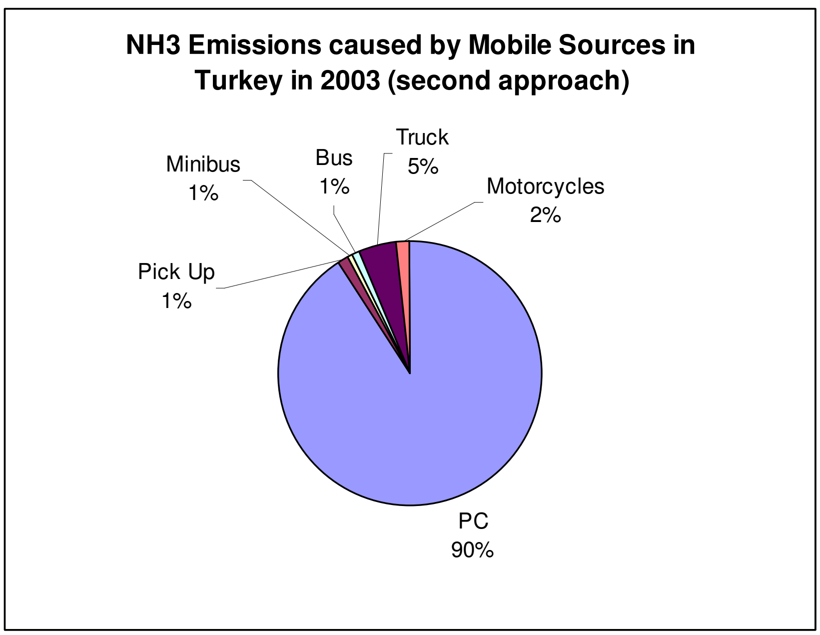


Figure 4.16: NH3 Emissions caused by Mobile Sources in Turkey in 2003 (second approach)

4.1.3.4. PM_{10} Emissions

Diesel fuel consuming vehicles are the main cause for PM_{10} emissions. For that reason the most important source of PM_{10} caused by mobile sources in İstanbul are pickup, buses, trucks. This can be explained by the higher number of pick ups in İstanbul region (Table 4.1). As it can be seen by Figure 4.17, the most important sources are trucks which form 51% of the total PM_{10} pollution caused by mobile sources in Turkey. The reason for this difference is the relatively high emission factor and high mileage of trucks.

Table 4.5: PM_{10} Emissions in İstanbul and Turkey in 2003

	PC	Pick up	Minibus	Bus	Truck	Motorcycles	Total
PM10	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**
First approach	1161	2498	967	1107	6311	227	12272
Second approach	2885	860	1648	1404	9551	233	16581

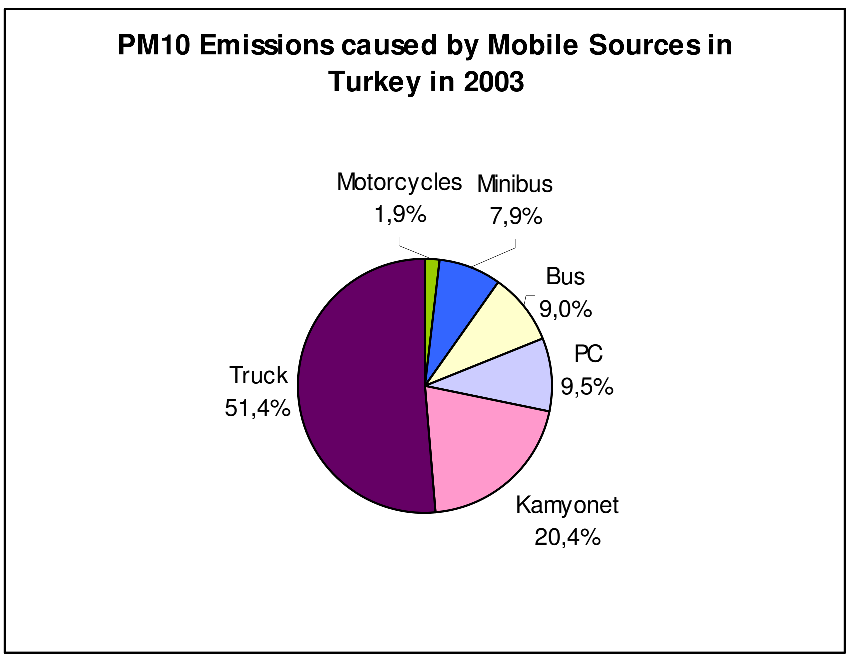


Figure 4.17: PM_{10} Emissions caused by Mobile Sources in Turkey in 2003 (first approach)

PM_{10} emission factors for urban driving is higher for every different type of engine. So that results for PM_{10} emissions are higher in the second approach where urban driving shares are also included to the calculations (see Figure 4.17, and 4.18).

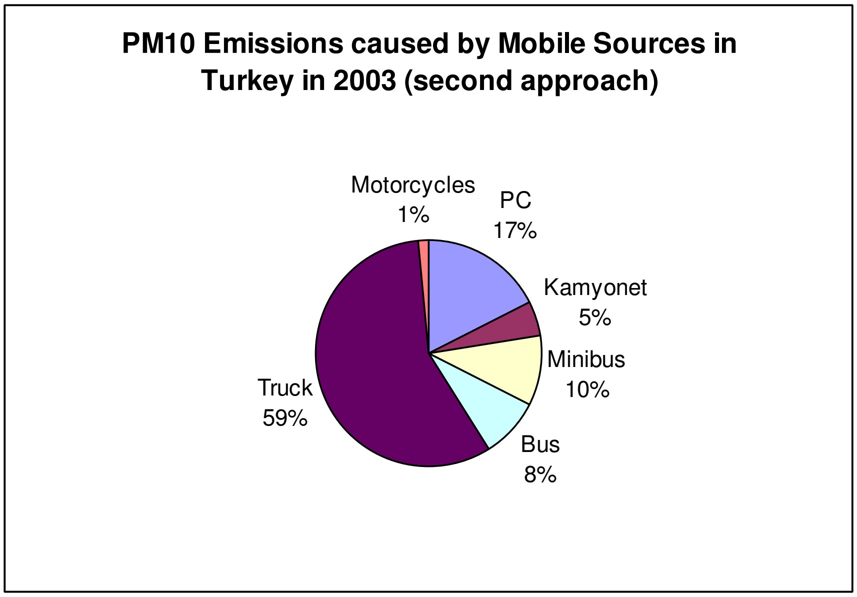


Figure 4.18: PM_{10} Emissions caused by Mobile Sources in Turkey in 2003 (second approach)

4.1.3.5. SO_2 Emissions

As SO_2 emissions are caused by sulphur content of fuel, diesel fuel consuming vehicles are the main reason for SO_2 emissions. For that reason, trucks are the most important sources for SO_2 pollution in Turkey, because the mileage and the emission factors of truck is higher than the other vehicles. Since buses are also diesel consuming vehicles, these are the second important source for SO_2 emissions (See Figure 4.19).

As it is shown by Figure 4.19, values of Turkey are more representative than İstanbul, where diesel fuel consuming vehicles are the most important source for SO_2 emissions.

Table 4.6: SO_2 Emissions in İstanbul and Turkey in 2003

SO2	PC tons/yr	Pick up tons/yr	Minibus tons/yr	Buses tons/yr	Trucks tons/yr	Motorcyles tons/yr	Total tons/yr
First approach	1396	1544	595	1902	10390	125	15951
Second approach	1884	1756	883	1874	10992	115	17503

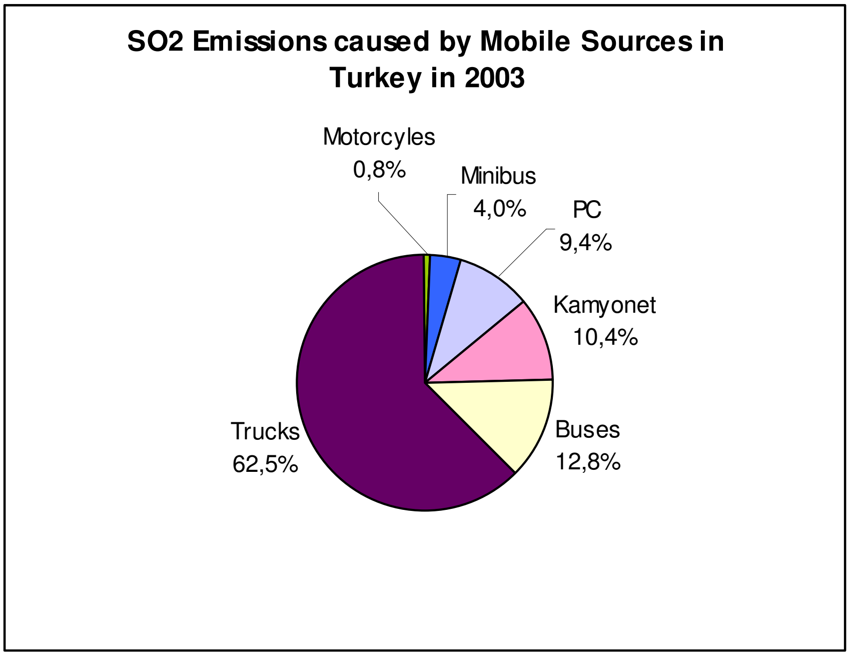


Figure 4.19: SO_2 Emissions caused by Mobile Sources in Turkey in 2003 (first approach)

SO_2 emission factors for urban driving is higher for every different type of engine. So that results for SO_2 emissions are higher in the second approach where urban driving shares are also included to the calculations.

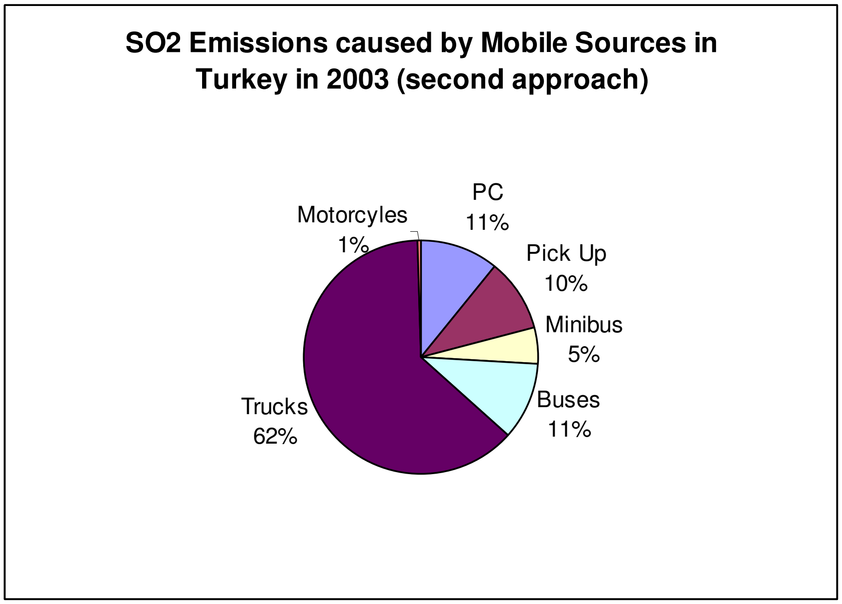


Figure 4.20: SO_2 Emissions caused by Mobile Sources in Turkey in 2003 (second approach)

4.1.3.6. Evaporative VOC Emissions

Evaporative VOC emissions can be calculated for gasoline fuel passenger cars, gasoline fuel light duty vehicles, motorcycles, but not for the gasoline fuel heavy duty vehicles because of the lack of the data (COPERT III, 2000). As it can be seen by the following table 4.4, evaporative emission ratio between İstanbul and Turkey for passenger cars is almost 20%. This result represents the passenger car ratio which is also 20%.

Table 4.7: Evaporative VOC Emissions for İstanbul and Turkey

Evaporative VOC Emissions	PC tons/yr	Pick up tons/yr	Motorcycle tons/yr	Minibus tons/yr
İstanbul	7498	319	141	13
Turkey	37970	1902	4514	287

4.1.3.7. Cold Excess Emissions

For cold excess emissions, emission factor for urban driving has been used. Cold start emissions exist in three driving conditions, but they are more obvious in urban driving (COPERT III, 2000). For that reason cold excess emissions have been calculated for three major metropolitan municipalities İstanbul, Ankara and İzmir.

Cold excess emission factors are available for passenger cars and light duty vehicles in COPERT III.

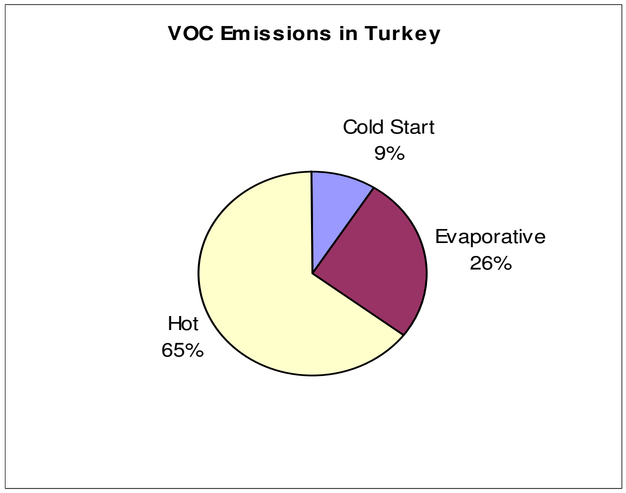


Figure 4.21: Cold start caused by Mobile Sources in Turkey in 2003

4.2. Small Combustion Processes of Turkey

Small Combustion Processes in Turkey can be distinguished as residential sector and industrial sector. Fuels that are being used for residential sector are coking coal, hard coal, lignite, briquette, liquefied petroleum gas (LPG), fuel oil, kerosene, natural gas, primary solid biomass, solar / geothermal energy, and electricity. Fuels that are being used in industrial sector are coking coal, hard coal, lignite, coke oven coke, coke oven gas, blast furnace gas, naphtha, liquefied petroleum gas, motor gasoline, gas/diesel, residual fuel oil, and natural gas.

4.2.1. Data Availability of Small Combustion Processes in Turkey

The following data has been collected in order to calculate emission of small combustion processes.

- Fuel Consumption : The most important data which is available for the calculations is fuel consumption data for Turkey. Values have been given for residential and industrial sector in Turkey as total number (MoEF, 2003).
- Population Density : In order to distribute the fuel consumption of residential sector to the provinces, "Population of Turkey for year 2000 Census" data has been used. This data has been taken from web site of Turkish Statistical Institute (TUIK, 2000).
- Number of Employees : In order to distribute the fuel consumption of industrial sector to the provinces, number of employee information has been used. This information has been taken from the web site of Turkey Association of Chambers and Stocks (TOBB, 2006). When the capacity of the industry is greater, fuel consumption and number of employees should be higher. For that reason, it is assumed that the ratio of employees according to the provinces represent the ratio of fuel consumption.
- Emission Factors : Emission factors have been taken from RAINS Online Model. These emission factors were calculated according to the countries. The model provides the user to choose the country and to find out the appropriate emission factor which is available according to the sectors and activities.

4.2.2. Methodology

The methodology of emission calculation for small combustion plants is described in the following chapter.

4.2.2.1. Fuel Consumption

Fuel types that are being used in Turkey in residential sector are given by Figure 4.22.

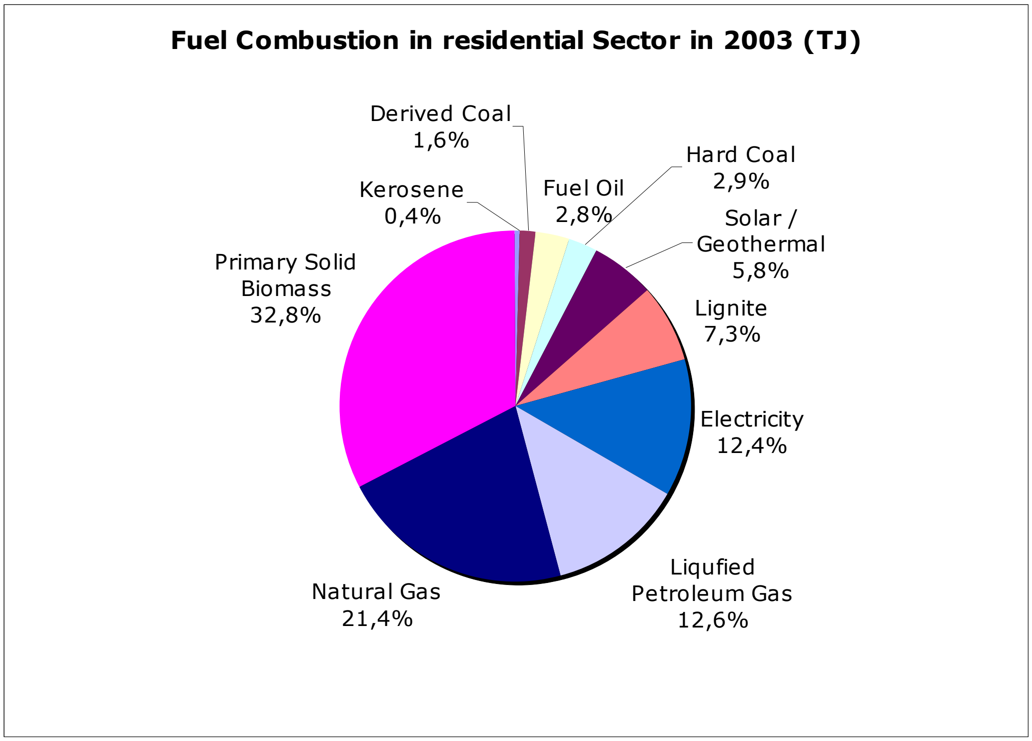


Figure 4.22: Fuel Consumption in Residential Sector in 2003 (MoEF, 2003)

As it is shown by Figure 4.22 primary solid biomass has the highest share with 33% of the total fuel consumption in Turkey in 2003. Natural gas has the second highest share for residential sector in Turkey. The high share of primary solid biomass can be explained by its usage in country sides of Turkey. Natural gas has been started to use both in residential and in commercial sector in Ankara in October 1988, and in industrial sector in August 1989, in İstanbul in January 1992, and in Bursa in 1992 (Botas, 2006). LPG consumption has the third highest share, which is used for ovens and catalytic stoves.

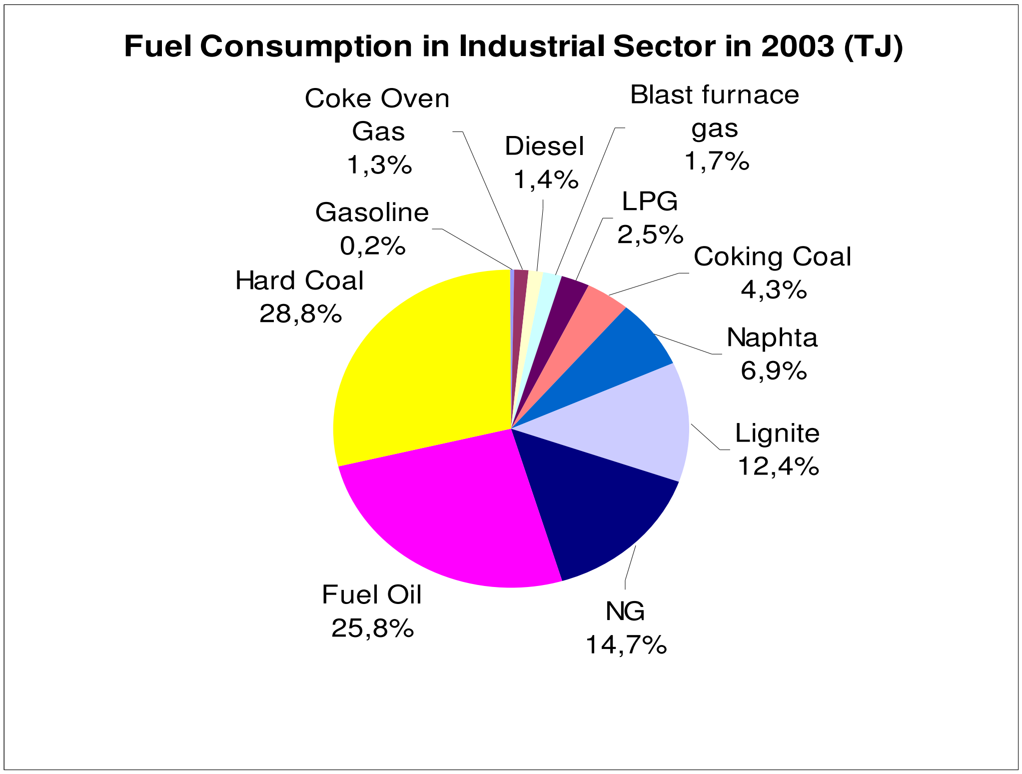


Figure 4.23: Fuel Consumption in Industrial Sector in 2003 (MoEF, 2003)

As it is shown by Figure 4.23 hard coal is the most consumed fuel source that is used in industries with comparison in TJ unit. The second highest share belongs to fuel oil with 25.8%. Following these fuels, natural gas and lignite consumption have the third and fourth highest share in industrial sector in 2003.

4.2.2.2. Distribution of Fuel Consumption

Fuel consumption has been distributed according to the residential sector and industrial sector by two indicators, which are population density and number of employees. Heating necessity in residential areas depends on the number of people living in that area. For this reason, fuel consumption has been distributed by the population density. Fuel consumption of a specific province has been calculated by Formula 4.5:

$$FC_P = FC_T \times Pd \quad \textbf{(4.5)}$$

FC_P : Fuel consumption of a specific province for residential sector

FC_T : Fuel consumption of Turkey in residential sector

Pd : Population density of the province

$Pd = P_P / P_T$ **(4.6)**

P_P : Population of the province

P_T : Population of Turkey

Fuel consumption of industrial sector has been distributed by the number of employee according to the provinces. It is assumed that industry with a greater production capacity needs more energy and also more employees. Therefore, it is assumed that there is a direct proportion between employee and energy consumption. For this reason, fuel consumption for industrial sector distributed to provinces by Formula 4.7.

$FC_P = FC_T \times Ed$ **(4.7)**

FC_P : Fuel consumption of a specific province for industrial sector

FC_T : Fuel consumption of Turkey in industrial sector

Ed : Employee density of the province

$Ed = E_P / E_T$ **(4.8)**

EP : Number of employee in the province

ET : Number of employee in Turkey

4.2.2.3. Emissions:

Emissions have been calculated by the following formula:

$E = F \times EF$

E: Emission of air pollutant (tone per year)

F: Amount of fuel consumption (tone per year)

EF : Emission Factor (kg air pollutant/ tons fuel per year)

(Wirth, 2006)

4.2.3. Results :

With the help of the assumptions and methodology, NOx, VOC, NH_3, SO_2 and PM_{10} emissions were calculated and presented in the following sector according to the residential and industrial sectors.

4.2.3.1. Residential Sector

NOx Emissions

NOx Emissions caused by residential sector are given by Figure 4.24. Although fuel oil and coal causes higher emission factors than primary solid biomass, the highest share belong to primary biomass with 38%. As it was shown in Figure 4.21 primary solid biomass is the most consumed fuel in residential sector in Turkey in 2003. Despite primary solid biomass was used 11 times more than fuel oil, NOx emission caused by primary solid biomass is 4.75 times of emission caused by fuel oil. The same explanation is valid for the natural gas. Because of the higher consumption of natural gas, it has more NOx emissions in comparison with lignite coal which has a higher emission factor than natural gas.

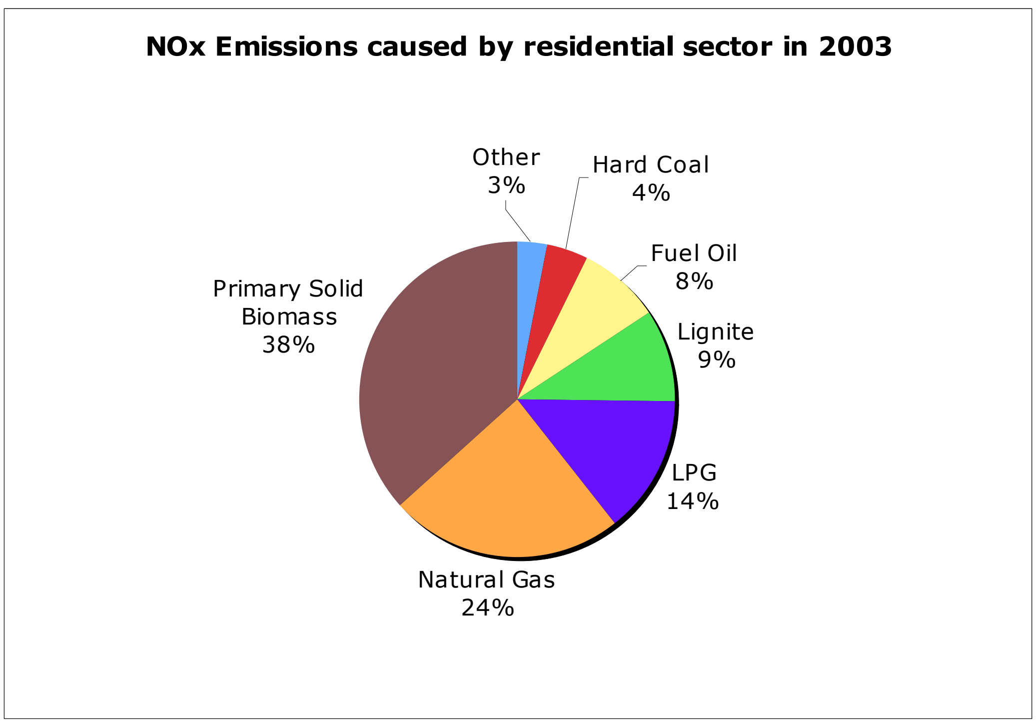


Figure 4.24: NOx Emissions caused by residential sector in Turkey in 2003

VOC Emissions

Although the major source of VOC Emissions for residential commercial sector is the coal and wood combustion (Klimont et al., 2000), both the consumption and the emission factor of primary solid biomass is higher than the other fuels. For this reason, the highest share of VOC emissions belongs to primary solid biomass as it is shown by Figure 4.25.

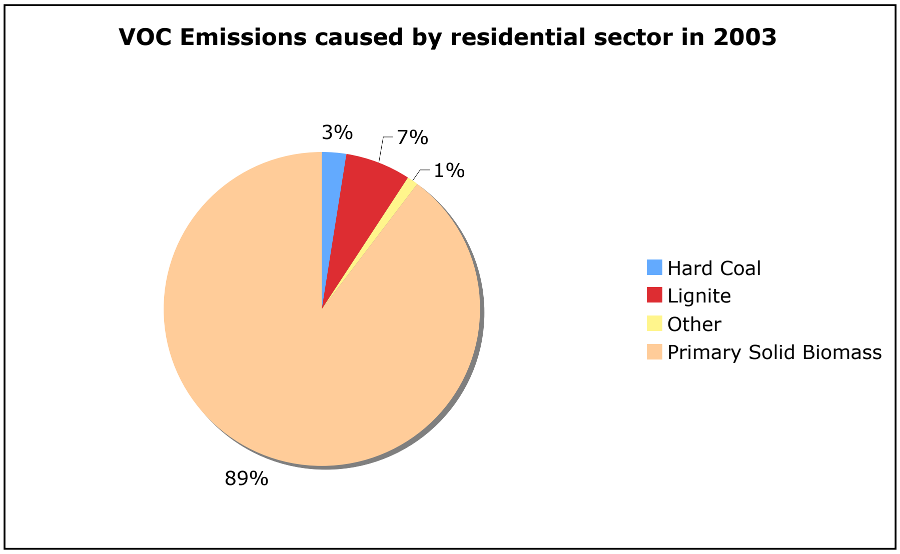


Figure 4.25 : VOC Emissions caused by residential sector in Turkey in 2003

NH_3 Emissions

As it is shown by Figure 4.26 NH_3 emissions mainly caused by primary solid biomass, lignite and hard coal. These fuels have nearly the same emission factors, although the energy density of the fuels are different. For this reason, fuel consumption comparison is valid for the comparison of NH_3 emissions. Besides, the most important part of the NH_3 emissions come out at the smoldering stage of combustion (Roe et al., 2004).

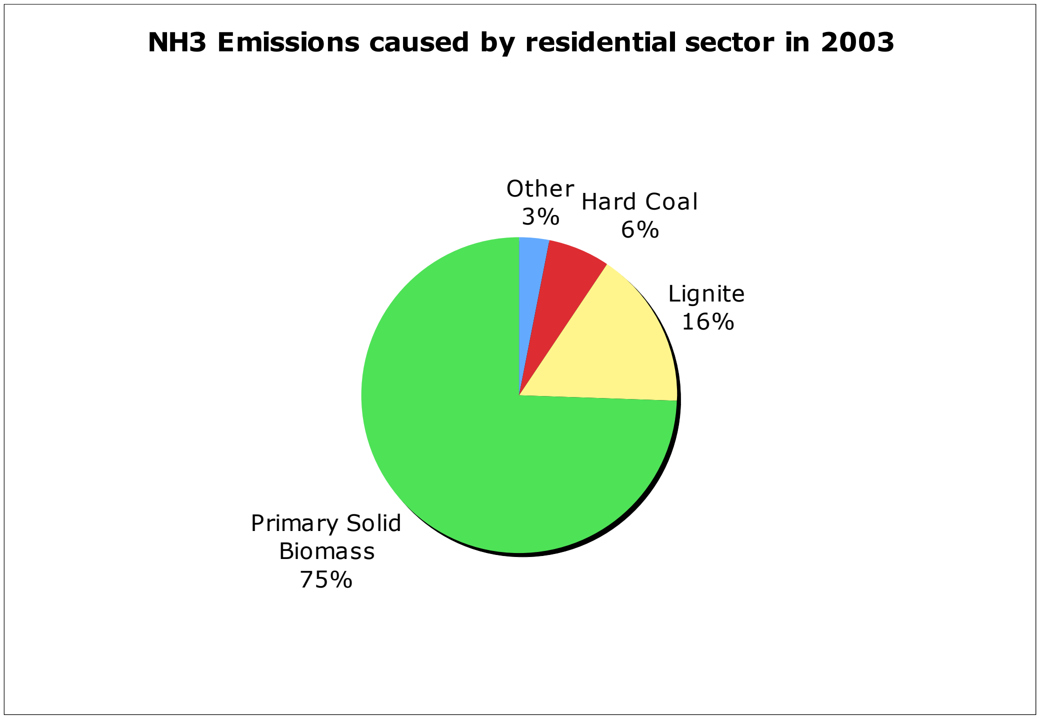


Figure 4.26: NH_3 Emissions caused by residential sector in Turkey in 2003

SO_2 Emissions

The main source of SO_2 emissions are fuel oil, lignite and hard coal. The reason of this mainly depends on the sulphur content of the fuel. Both residual fuel oil and coal have high sulphur content in Turkey. For this reason SO_2 emissions caused by coal and residual fuel oil is greater than the other fuels.

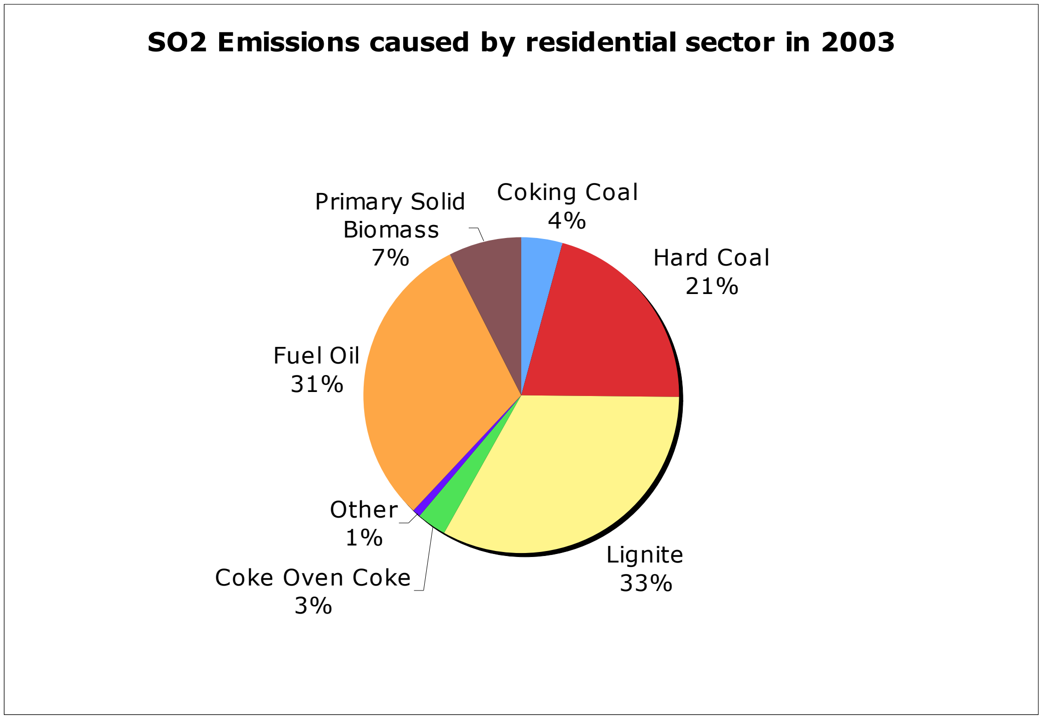


Figure 4.27 : SO_2 Emissions caused by residential sector in Turkey in 2003

PM_{10} Emissions

Although the PM_{10} emission factors of lignite and hard coal is higher, primary solid biomass is the most important source of residential PM_{10} emissions in residential sector in Turkey. Emissions due to lignite and hard coal follows the primary solid biomass with high shares in spite of the primary solid biomass consumption is four times of lignite consumption.

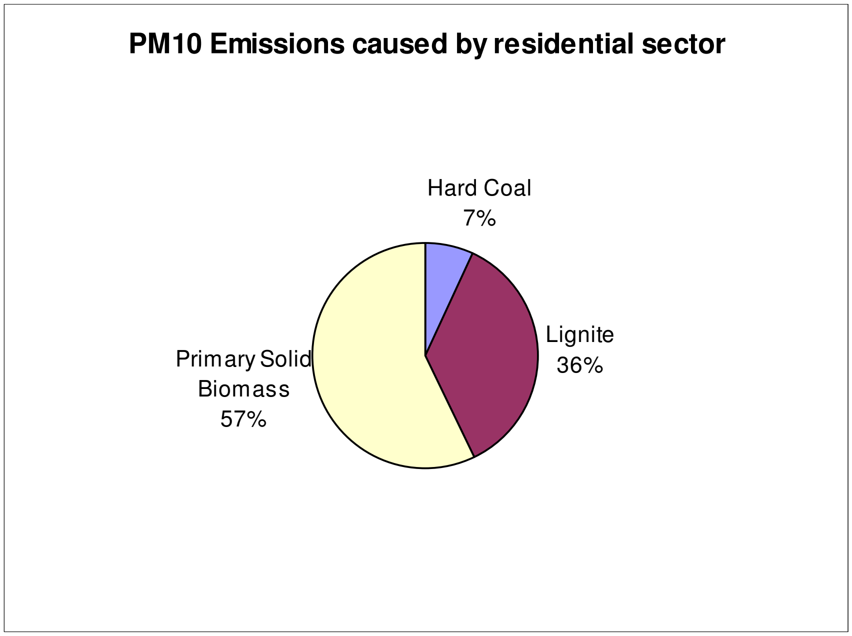


Figure 4.28: PM_{10} Emissions caused by residential sector

4.2.3.2. Industrial Sector

NOx Emissions

As it is shown by Figure 4.29, the most important sources of NOx emissions are hard coal and fuel oil, which also represents the main consumed process fuels in industrial sector. The main reason for this fact is the higher nitrogen content of fuel oil and hard coal in comparison with the other fuels. Thus, the formation of thermal NOx is affected by four factors: peak temperature, fuel nitrogen concentration, oxygen concentration, and time of exposure at peak temperature. Fuel nitrogen conversion is the more important NOx-forming mechanism in residual oil boilers. It can account for 50 percent of the total NOx emissions from residual oil firing. The percent conversion of fuel nitrogen to NOx varies greatly, however; typically from 20 to 90 percent of nitrogen in oil is converted to NOx.

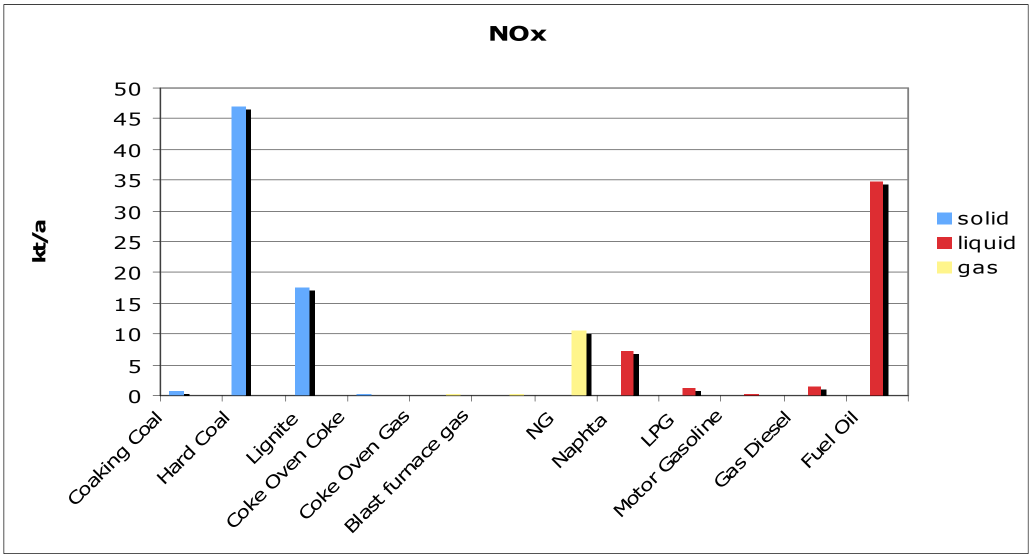


Figure 4.29 : NOx emissions caused by industrial sector

SO_2 Emissions

Similarly to NOx emissions, hard coal and fuel oil are the most important SO_2 emission sources in combustion processes in the industrial sector. Both the sulfur content and the consumption of hard coal and fuel oil is higher than other fuels. For this reason SO_2 emissions caused by this fuels are higher than caused by other fuels in industrial sector, as it is shown by Figure 4.30.

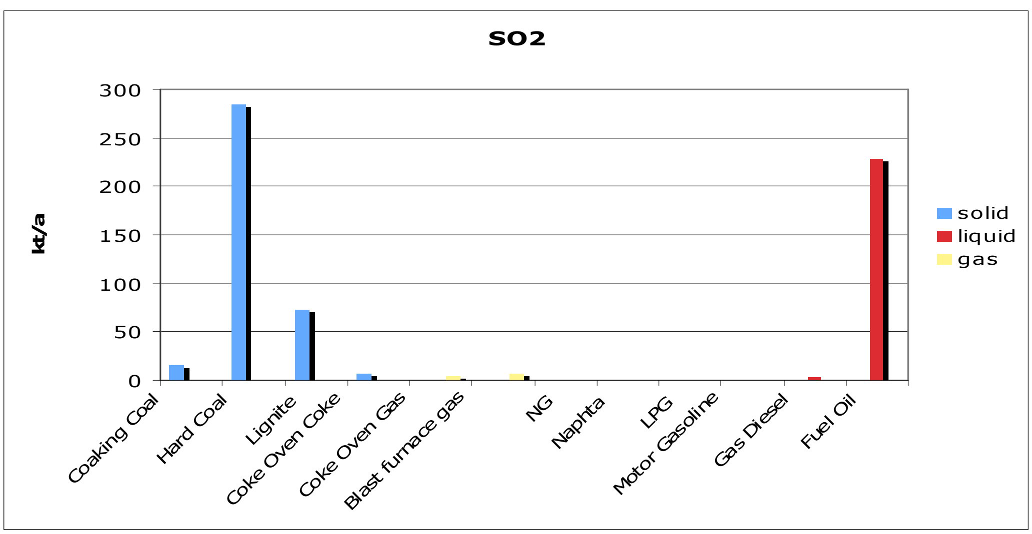


Figure 4.30: SO_2 Emissions caused by industrial sector

NH_3 Emissions

NH_3 emissions are mainly caused by residual fuel oil in industrial sector. This can be explained with the higher nitrogen ratio of fuel oil in comparison with coal. Although there are NH_3 emissions caused by industrial sector, the main source of NH_3 emissions are livestock and fertilizer use in Ağrıcultural activities.

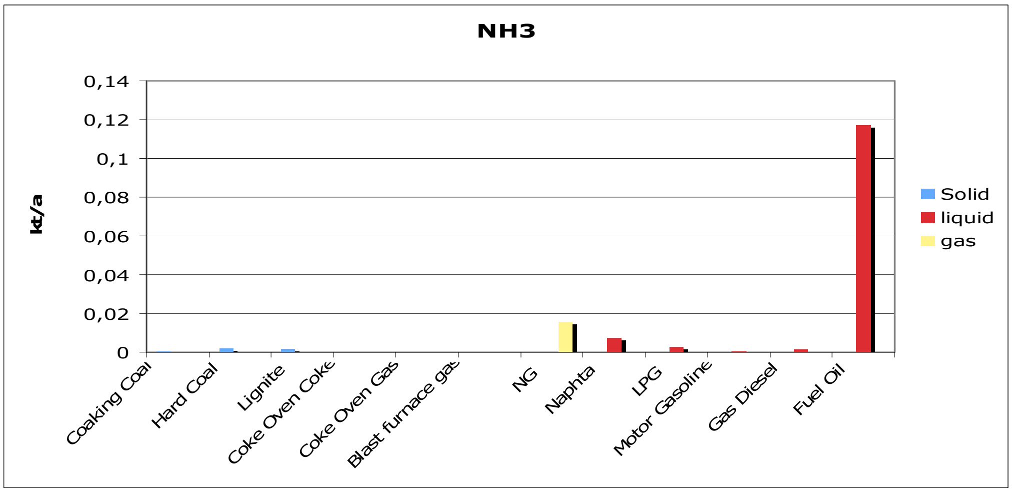


Figure 4.31: NH_3 Emissions caused by industrial sector

PM_{10} Emissions

PM_{10} Emissions are mainly caused by hard coal and lignite which are the most important source of particulate matter (PM_{10}) pollution. As coal is an ash forming fuel, it becomes the most important PM_{10} emission source. Although fuel oil has a high share of consumption, hard coal and lignite are the most important sources because of their ash forming structure.

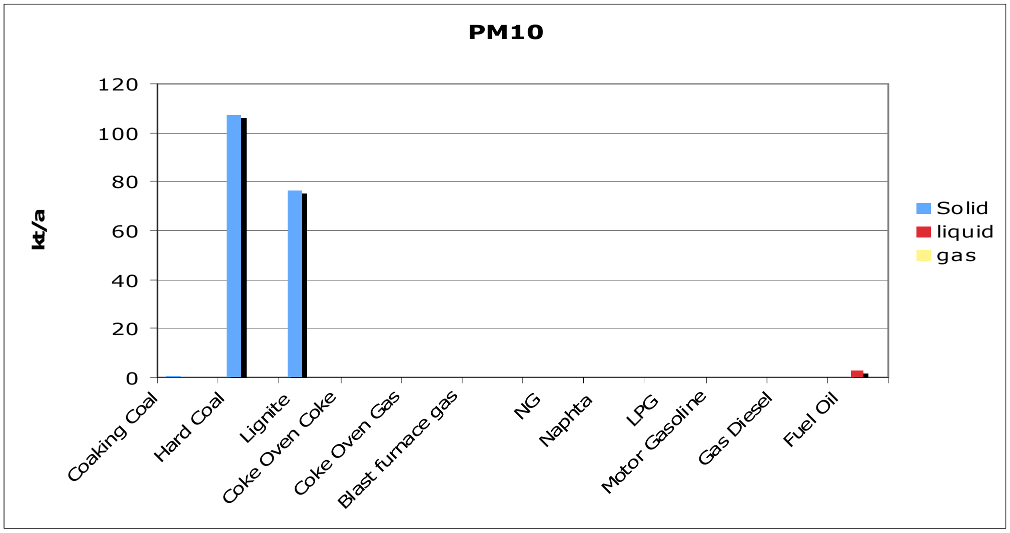


Figure 4.32: PM_{10} Emissions caused by industry

VOC Emissions

As it is shown by Figure 4.33 VOC emissions due to the coal species are relatively higher than from other fuel consumption. Emission factors for lignite and hard coal are higher than for residual fuel oil, but the energy density of fuel oil makes the emission amounts from this fuel as important as the emissions caused by hard coal consumption.

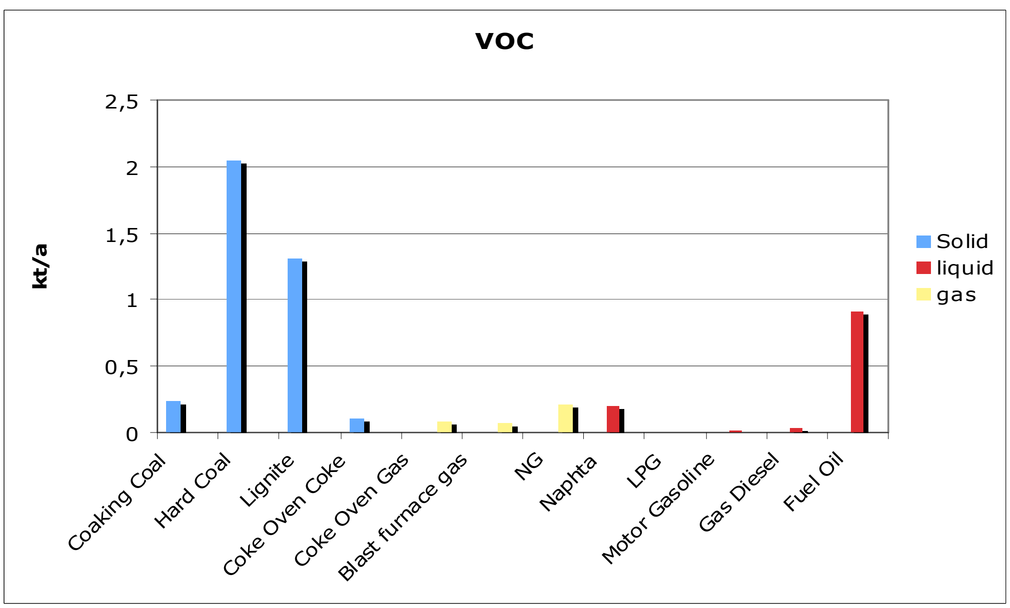


Figure 4.33: VOC Emissions caused by industry

4.3. Large Combustion Plants in Turkey

Large combustion plants are defined as combustion plants with a thermal output greater than 50 MW. Thermal power plants are located near the lignite basins which are mostly situated in the Aegean region in Turkey. The biggest lignite basin of Turkey which is called Elbistan is on the intersection of the Mediterranean, Central Anatolian and East Anatolian Regions. Afşin Elbistan Thermal Power Plant is located in this area with the highest production capacity as 8840 GWh. The second largest lignite basin of Turkey is Soma (Senguler, 2001) is situated in Manisa which is in the Aegean Region. Soma Thermal Power Plants are located on this region, which has eight units. Besides, production capacity of Soma Thermal Power Plant is 6725 GWh, which have the second highest production capacity.

4.3.1. Data Availability of Large Combustion Plants in Turkey

There are different data bases for calculation emissions from large combustion plants in Turkey. These databases are described as following:

- Production Characteristics of Power Plants: This data includes, installed capacity, production capacity, fuel quality, unit heat consumption, efficiency, province, region, fuel and sector information (EIE, 2006). This data is the base of the calculations for large combustion plants.
- Specific Information about the Thermal Power Plants: This data includes, information about production and specific information about power plant as gross production, net production, start up year, total installed capacity, number of units (EUAS, 2006).
- Emission Factors : Emission factors have been taken from RAINS Online Model.

4.3.2. Methodology for Large Combustion Plants

The methodology of emission calculation for large combustion plants is described in the following chapter.

4.3.2.1 Description of the Thermal Power Plants

By the help of information given by excel sheets (EIE, 2006), thermal power plant which has an installed capacity greater than 50 MW has been selected for the calculation. These thermal power plants are shown by Table 4.1.

Table 4.8: Thermal Power Plants in Turkey in 2003

Power Plant	Province	Region	Start up
Afşin-Elbistan	Kahramanmaraş	Southeast Anatolia	1984
Orhaneli	Bursa	Marmara	1992
Seyitömer	Kütahya	Aegean	1973
Tunçbilek	Kütahya	Aegean	1956
Kangal	Sivas	Central Anatolia	1991
Çatalağzı	Zonguldak	Black Sea	1989
Hopa	Artvin	Black Sea	1973
Ambarlı	İstanbul	Marmara	1967
Soma A	Manisa	Aegean	1981
Soma B	Manisa	Aegean	1981
Yatağan	Muğla	Aegean	1982
Kemerköy	Muğla	Aegean	1993
Yeniköy	Muğla	Aegean	1987
Çayırhan	Ankara	Central Anatolia	1988
Erdemir	Zonguldak	Black Sea	1964
Çolakoğlu	İstanbul	Marmara	1999
Aliağa Petkim	Izmır	Aegean	1975
İsdemir	Hatay	Mediterrean	1975

The main fuel of these power plants is lignite coal. The reason for lignite consumption in Thermal Power Plants can be explained by Figure 4.34. As it is shown, the highest production share belongs to lignite production in oil equivalent unit. Moreover, almost 85% of lignite is used in power plants in Turkey (Anac and Ersoy, 2002).

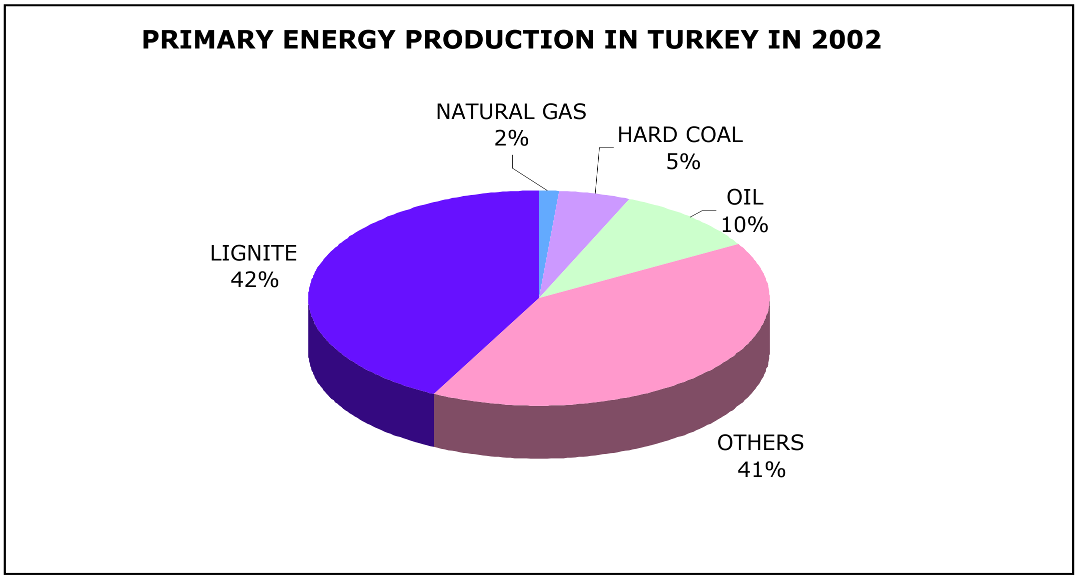


Figure 4.34: Primary Energy Production in Turkey in 2002 (TPAO, 2006)

As the main fuel of thermal power plants in Turkey is lignite, sulfur content of these lignite sources should be known. The sulfur content of lignite in Turkey changes between 1.5% and 5% and the mean sulphur content of lignite has been calculated as 3% on dry basis (Uzun and Özdoğan, 2003). According to many studies, sulphur content of lignite is about 1.3% in European countries. For example, the mean sulphur content of lignite changes between 0.8%-1.2% in Romania (Slevoaca), 1.3-1.7% in Greece (ExternE Greece, 1997), and 1.29% in Spain (ExternE Spain, 1997).

Thermal power plants are ranked according to their production capacity by Figure 4.35.

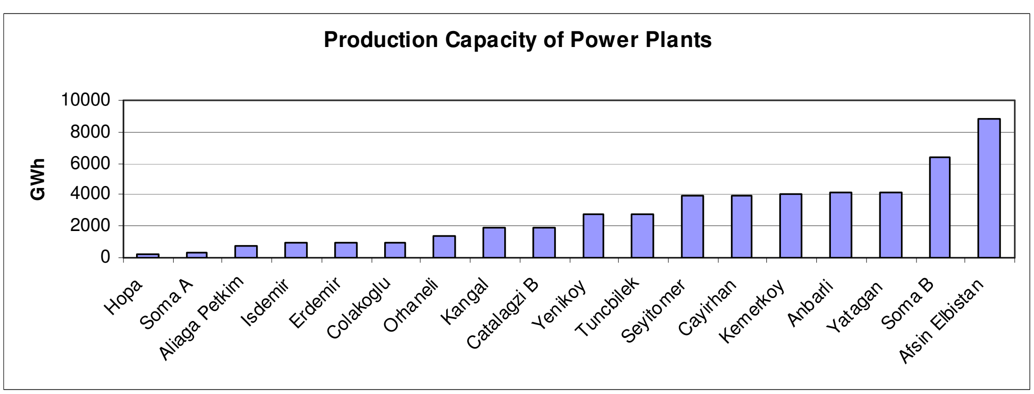


Figure 4.35: Production Capacity of Power Plants

4.3.2.2. Emissions:

Emissions have been calculated by the following formula:

E = F x EF (4.1)

E: Emission of air pollutant (tone per year)

F: Amount of fuel consumption (PJ)

EF : Emission Factor (t/PJ)

(Wirth, 2006)

4.3.3. Results

With the help of the information (EIE, 2006) and the emission factors of IIASA SO_2, PM_{10}, NO_x, VOC, NH_3 emissions have been calculated and will be presented in the following chapter.

4.3.3.1. SO_2 Emissions

The most important emissions caused by thermal power plants are SO_2 emissions. Besides, the most important cause of SO_2 emissions are lignite fired thermal power plants. SO_2 emissions caused by lignite power plants is shown by Figure 4.34. Because there is flue gas desulphurization (FGD) technology on Orhaneli, Yatağan, Kemerkoy, Yeniköy and Çayırhan Thermal Power Plants, it is seen that emissions of these thermal power plants are relatively lower than the other power plants which has no abetement technologies. For example, production capacity of Yatağan is greater than Seyitomer, nevertheless, SO_2 emissions of Seyitomer is higher than Yatağan.

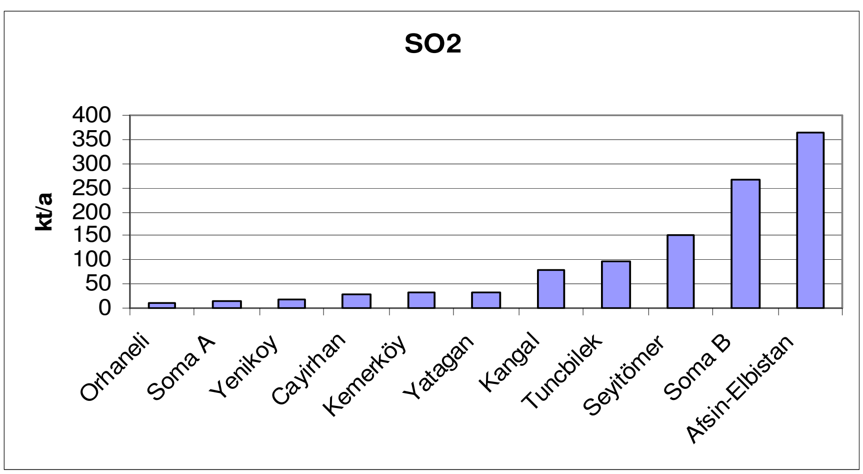


Figure 4.36: SO_2 Emissions caused by lignite fired power plants

As it is shown in Figure 4.36, the highest SO_2 emission is caused by Afşin Elbistan Thermal Power plant which is the biggest thermal power plant of Turkey. This power plant causes SO_2 emission of more than 350 kt/a. Soma B Thermal Power Plant follows Afşin Elbistan with a value over 250 kt/a SO_2 emissions. The most important necessity of these thermal power plant is flue gas desulphurization technology for SO_2 emission abatement.

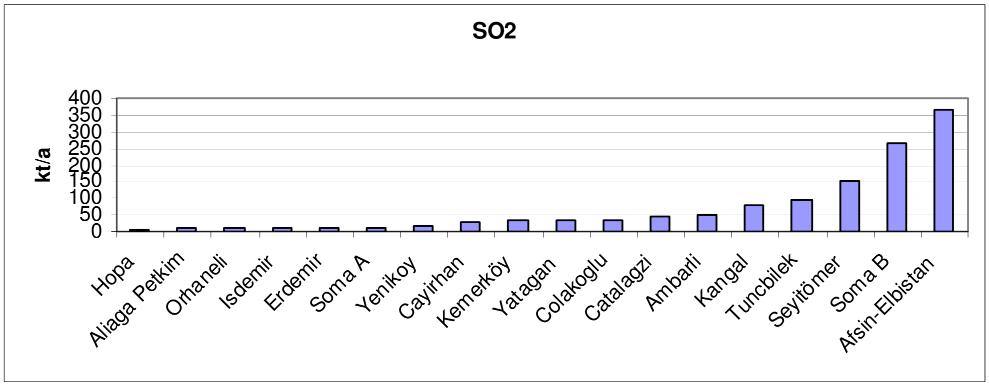


Figure 4.37 : SO_2 Emissions caused by thermal power plants

If the treatment plant does not work :

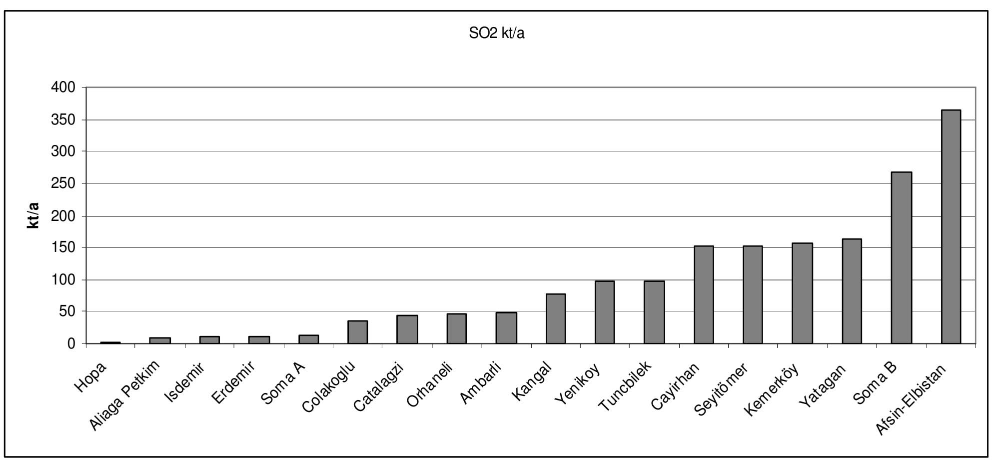


Figure 4.38 : SO_2 Emissions caused by thermal power plants

4.3.3.2. NOx Emissions

NOx emissions caused by the different thermal power plants is showed by Figure 4.39. According to this figure, Afşin Elbistan which has the highest production capacity causes NOx emissions of about 27.5 kt/a and the following thermal power plant Soma B caused emissions of about 20 kt/a. Circulating Bed Fluidized Bed

Combustion Technology (CFBC) is ideal for combustion of the coal which has a poor quality in Turkey (Senguler, 2001).

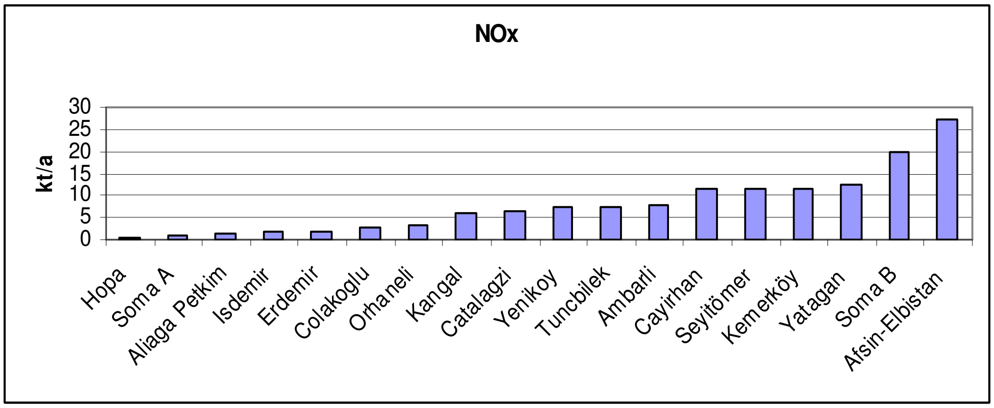


Figure 4.39: NOx Emissions caused by thermal power plants

4.3.3.3. PM_{10} Emissions if the treatment plant works

PM_{10} emissions caused by thermal power is given by Figure 4.40. As it is shown, PM_{10} is caused only by coal fired power plants because of the ash forming structure of coal. Afşin Elbistan Thermal Power Plant causes 33 kt/a PM_{10} emissions. The ranking is the same as the production capacities of these thermal power plants, with the difference of fuel consumption. Fuel oil fired thermal power plants have very low PM_{10} emissions in comparison with the lignite fired thermal power plants.

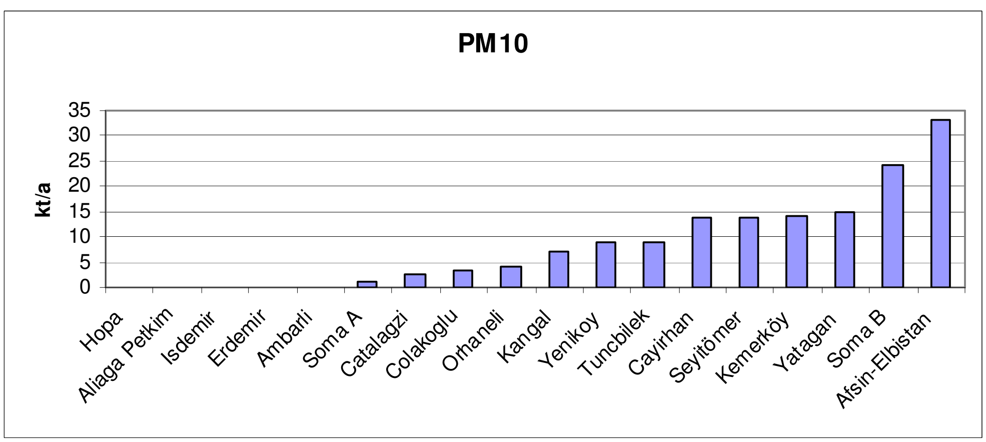


Figure 4.40: PM_{10} Emissions caused by thermal power plants

If the treatment plant does not work:

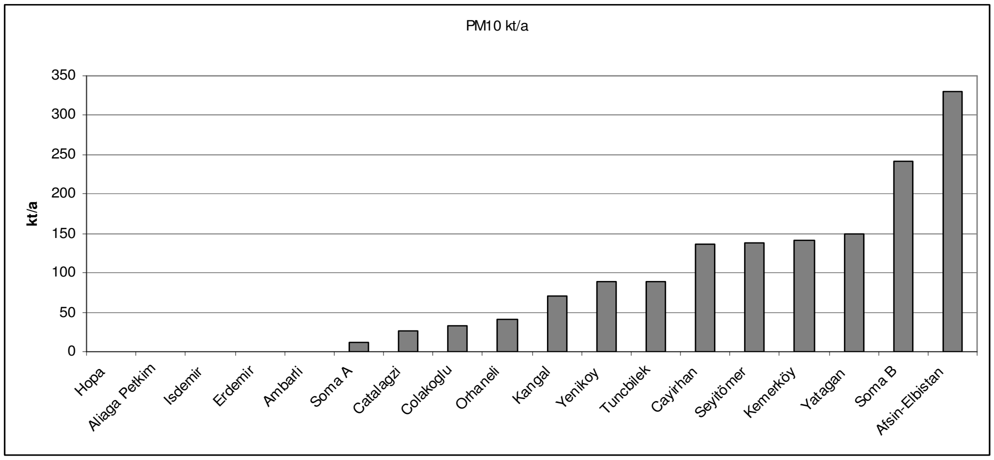


Figure 4.41: PM_{10} Emissions caused by thermal power plants

4.3.3.4. NH_3 Emissions

Despite, NH_3 emissions mainly caused by livestock and fertilizer application in Agriculture, power plants play a role on NH_3 emissions. Ambarlı Thermal Power Plant has NH_3 emissions of about 2 kt/a as it is shown by Figure 4.42. As this power plant is a fuel oil fired power plants emissions caused by Ambarlı is higher than comparable coal fired power plants. Although Hopa is a fuel oil fired power plant, it has low NH3 emissions in comparison with the other power plants because of its low energy consumption.

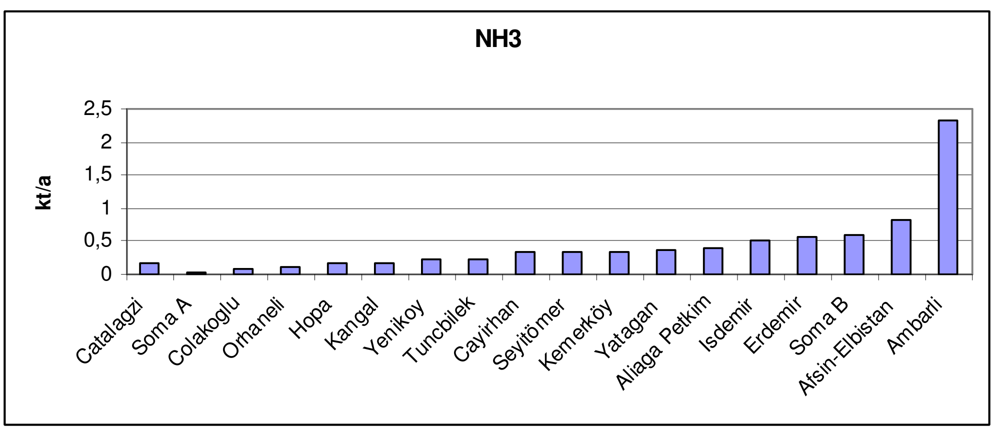


Figure 4.42: NH_3 Emissions caused by thermal power plants

4.3.3.5. VOC Emissions

Although VOC emissions mainly caused by solvent use and mobile sources, thermal power plants plays a minor role on VOC emissions. Afşin Elbistan Thermal Power Plant causes 1.5 kt/a VOC emissions and Soma Thermal Power Plant 1.1 kt/a VOC emissions. Emission factors for VOC from coal is higher than from fuel oil. Also production capacity of lignite fired thermal power plants are higher than fuel oil thermal power plants. This can explain the big difference between the coal fired and fuel oil fired thermal power plants.

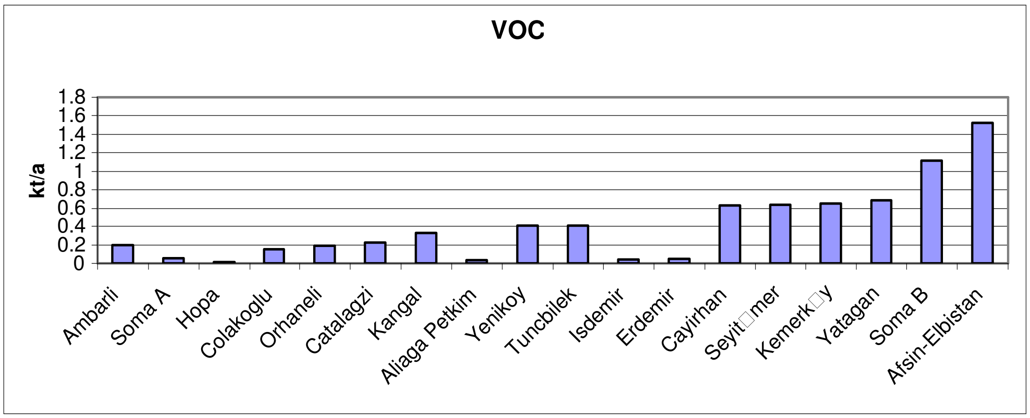


Figure 4.43: VOC Emissions caused by thermal power plants

4.4. Industrial Processes

Data availability, methodology for emission calculation and description about Iron and Steel Industry, Crude Oil Refineries, Cement Factories, and Pulp and Paper Plants in Turkey will be presented in this chapter.

4.4.1. Data Availability

Necessary data for activities (production) has been taken by a report which collects information about the different industries (MoEF, 2004). This report includes a specific chapter about the most significant processes which has a priority affect on environment. Emission factors have been taken by RAINS Model, which are given for production in activity units.

4.4.2. Methodology

The appropriate emission factors have been chosen (RAINS, 2004) and emissions have been calculated by Formula 4.10.

$$E = A \times EF \qquad \textbf{(4.10)}$$

E : Emission of air pollutant

A : Activity (kt)

EF : Emission factor of the pollutant (kt/mt)

4.4.3. Industries

The following industrial activities were considered.

4.4.3.1. Iron and Steel Industry

Iron and Steel Industry has been established in Turkey in 1930, which is an important factor for industrialization and development of the Turkish economy. The first integrated plant which is called Kardemir located in Karabük, started to operate in 1937 and the second integrated plant Erdemir located in Zonguldak started to operate in 1965 (TISPA, 2006). There are three integrated iron and steel plant and fifteen electrical arc iron and steel plants processing in Turkey at the end of 2000 (MoEF, 2004).

Production of electrical arc iron and steel plants were 9095 kt/a, and production of integrated iron and steel plant were 5228 kt/a in 2000 (TISPA, 2000). With the help of emission factors taken by RAINS model and the Formula (4.10), PM_{10} emissions have been calculated, and presented by Table 4.9.

When the emissions of integrated iron and steel plants and electrical arc iron and steel plants compared, it is seen that production per kt in integrated iron and steel plants cause greater emission than electrical arc iron and steel plants per kt. These values are shown by Table 4.9.

Table 4.9: Emissions from iron and steel industry

Production Technology	Production kt/a	PM_{10} kt/a	PM_{10} t/kt
Integrated Iron and Steel Plants	5228	11,5	2,2
Electrical Arc Iron and Steel Plants	9095	13,9	1,5

PM_{10} emission in iron and steel industry, occurs during the oxygen blow period, in basic oxygen furnace and during all the processes in electric arc iron and steel plants, however melting and refining processes are the most important sources (EPA, 1998).

4.4.3.2. Crude Oil Refineries

The first refinery in Turkey was established in Batman in 1950. There are five crude oil refineries in Turkey as at 2000. Four of these refineries belong to public sector, and one of them belongs to private sector. Diesel fuel, gasoline, fuel oil and naphtha are produced in these refineries. Processed crude oil is 24.200 kt/a in overall (MoEF, 2004).

SO_2, PM_{10}, NOx, VOC emissions are the significant emissions that have to be calculated due to the crude oil refineries. Fundamentally, the most important pollutant due to the crude oil refineries is VOC. It can occur in every different step of the production including processing, flaring, storage and waste water treatment. The shares of European VOC emissions from refineries in 1990 estimated by 0.9% in total VOC emissions despite 25% of the countries have not reported emissions from refineries (Klimont et al., 2000).

Activities during transportation and refuelling of petroleum are also important VOC sources (Friedrich, 2003). Processed crude oil and emissions from crude oil refineries have been given by Table 4.10. The main part of the emissions is caused by VOC emissions, as it is shown by the table.

Table 4.10: Emissions from crude oil refineries

	Processed Crude Oil	Emissions			
		SO2	NOx	PM10	VOC
Crude Oil Refineries	kt/year	kt/a	kt/a	kt/a	kt/a
	24.200	21,78	7,26	2,904	56,628

4.4.3.3. Cement Production

The first cement factory was established in İstanbul Darica, which had a 20.000 ton/a capacity. The second factory was started to operate in Ankara in 1926, and Kartal and Zeytinburnu in 1930. After 1950, a big increase was noticed in cement industry in Turkey (MoEF, 2004).

Production of cement has steps as raw material preparation, burning of the raw material to produce cement clinker, preparation of cement components and grinding of cement components steps, which are all important sources for PM emissions (Klimont et al., 2002). Cement production and calculated emissions due to cement industry according to the regions is shown by Table 4.12. It shows that PM_{10} emissions from cement industry has an important share in comparison with the other pollutants. Production capacities (TCMA, 2001) and calculated emissions are given by Table 4.11.

Table 4.11: Emissions from cement production process

	Production Capacity	Emission		
		SO2	NOx	PM10
Region	**kt/a**	**kt/a**	**kt/a**	**kt/a**
Marmara	20465	5,9	21,9	102,3
Aegean	7794	2,3	8,5	39,9
Mediterrenean	11935	2,9	10,8	50,5
Black Sea	7017	2,2	8,2	38,4
Central Anatolia	10972	3,3	12,1	56,4
East Anatolia	2270	0,9	3,4	15,9
Southeast Anatolia	4702	1,9	7,0	32,7

4.4.3.4. Pulp and Paper Industry

First pulp and paper facilities established in Yalova and Beykoz in 18th-19th century. Pulp and paper industry established following the proclamation of the republic. The first pulp and paper factory was established in İzmit with 12000 ton/a capacity in 1934. There are forty pulp and paper factories with a 1907 kt/a in Turkey in 2001. Production capacity and calculated emissions due to the pulp and paper industry is given by Table 4.12.

Table 4.12: Emissions from pulp and paper industry

Sector	Capacity ton/yr	SO_2 kt/yr
Public	702700	5,6
Private	1204386	9,6

Results

SO_2 emissions are mainly caused by crude oil refineries in comparison with the cement and pulp and paper industry. As a result of particulate matter control mechanisms, SO_2 emissions can also be reduced, because of the sulphur content of cement.

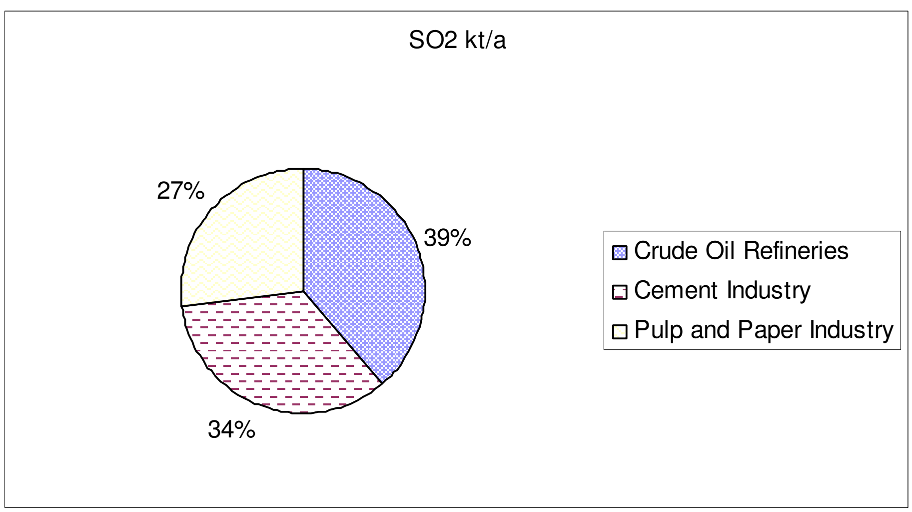


Figure 4.44 : SO_2 emissions according to the industrial processes

The most important industrial process causes PM_{10} emissions is the cement industry in Turkey. Although it is important to prevent the losses of cement, there are still important losses in every step of cement production. Iron and Steel Industry is also an important source of PM_{10} pollution, where the integrated iron and steel plants causes more pollution per kt.

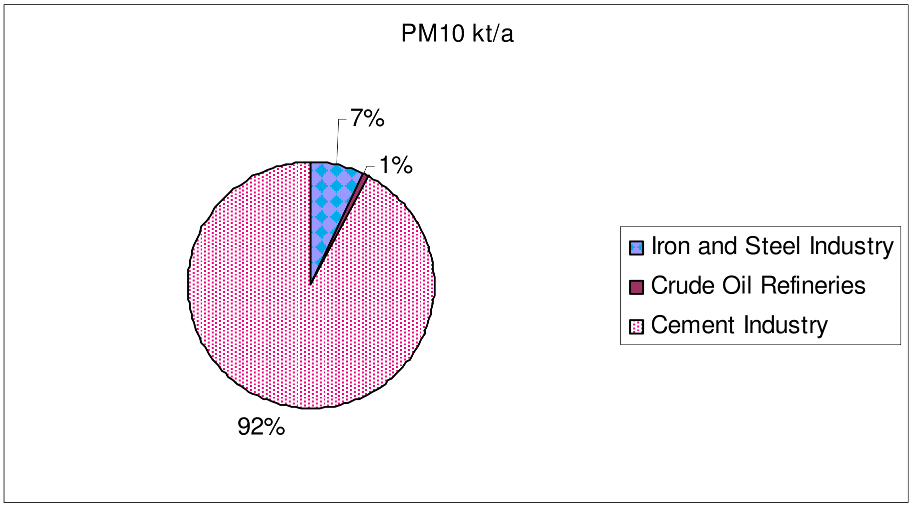


Figure 4.45: PM_{10} emissions according to the industrial processes

5. UNCERTAINTIES

With uncertainty analysis, it is possible to estimate emission data quality and change the data which causes high error. There have been many different methodology in order to estimate uncertainties. In this study error estimation was not used. Although, uncertainty analysis will be given by following chapters in terms of data quality.

5.1. Mobile Sources

In mobile sources section, calculations depend on vehicle stock, vehicle technologies mileage values, fuel consumption and emission factors. In fact emissions are also dependent on weight, gradient, level of maintenance and load.

Vehicle stock data has no issue while it is provided from Turkish Statistical Institute for year 2003. No ratio has been used to update the data. There is only one calculation in vehicle stock data. Because of this data was given per months, an average of the vehicle stock for each different vehicle type has been calculated.

There is no data on vehicle technologies in Turkey. So that there are many studies which are estimating the nearest value by assessing many different data. The most important study about vehicle technologies have been carried out by Mechanical Engineering Faculty, Automotive Department. This data has been assessed with assumptions of uncontrolled vehicles are distributed equally to the other technologies.

Mileage values has a huge role on estimating emissions. Two different method have been applied for mileage calculation. The first one is producing mileage values according to the report of General Directorate of Highways. The problem was that the mileage value for different provinces were not sorted according to the vehicle types. So that an error occurred by the distribution of total mileage to the provinces with the same factor which was produced for Turkey. After calculations it was seen that the mileage value for passenger car is very low with respect to the other countries. So that another approach was necessary. According to the second approach fuel consumption according to provinces data was used. This data was only for provinces.

In order to calculate emissions per vehicle type, distribution of fuel consumption according to the vehicle type is necessary. So an error comes because of the ratio that has been used for the distribution.

Emission factors were produced by using COPERT III. The problem occurred on this step was the necessity of urban/rural/highway distribution of roads. In fact road lengths have been provided by KGM, but it was not enough to distribute the activity, which is mileage for mobile sources, to the different road types. For that reason two different approach was used to calculate emissions from mobile sources. The first one is the assumption of 60 km/h, while the shares are not available. The second approach was produced according to the population density data which is provided by TUIK Population Census 2000. Urban and rural population density have been used to distribute the mileage to the different road types. So that this data is also an assessment of existng data.

5.2. Small Combustion Processes

In small combustion section, calculations depend on fuel consumption, and emission factors.

Fuel consumption data was provided by MoEF. But this data has the total value for Turkey. In order to distribute the total fuel consumption to the provinces a ratio had to be produced. So that two approaches was used for this distribution. For calculations of emissions from residential sector, population distribution was used with the approach of the more people the more fuel consumption. For industrial fuel consumption number of employees data has been used. The ratio of employees according to provinces was used to distribute the fuel consumption with the assumption of the more employee the the larger industry and the higher fuel consumption.

Emission factors were taken by IIASA Rains Model while there is no emission factors produced specific for Turkey. IIASA produces the emission factors with the information provided from countries. So that it is accepted that the emission factors from IIASA is acceptable for calculations.

5.3. Large Combustion Plants

Necessary data for emission calculations were production characteristics of power plants such as capacity, operating conditions, location. This data was provided from EIE (Administration of Electrical Works). Other specific information was provided by EUAS, which were production, net production, start up year, total installed capacity, number of units. While data is directly produced by the energy production administrations, it is accepted that it is the best available data for calculations.

Emission factors were used from IIASA and two different approach used for emission calculations which are with treatment and without treatment.

5.4. Industrial Processes

Necessary data for emission estimation for industrial processes are activity values and emission factors for selected industries. Activity values have been provided by MoEF, Turkey Environmental Atlas, which gives the production capacities according to the plants located in provinces. Emission factors were used from IIASA, which are specific for Turkey and has abated emission factors according to the removal efficiency.

6. VISUALIZATION

6.1. Visualization of Population

It is necessary to visualize the population distribution of Turkey in order to connect the link between the population and pollution. Figure 5.1 shows the population of Turkey according to the provinces. As it is determined in Chapter 4, major metropolitan cities in Turkey are İstanbul, Ankara, İzmir, Bursa, Konya and Adana. When emissions are examined, it is seen that there is a correlation between population number and emissions. The highest emissions are caused by the metropolitan provinces. Visualization was provided by ArcGIS.

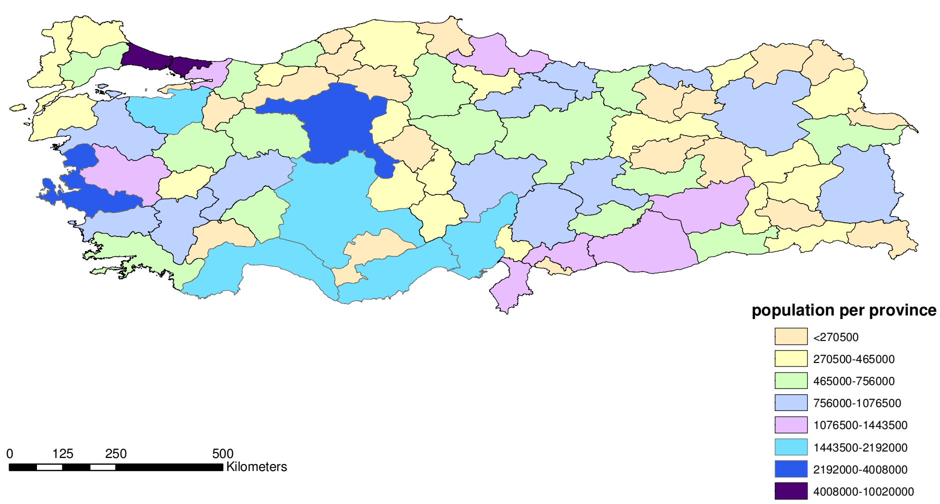


Figure 6.1. Population of Turkey according to the provinces

6.2. Visualization of NOx caused by Mobile Sources

The most important source affects NOx emissions is mobile sources. The distribution of NOx caused by mobile sources is given by Figure 5.2. According to this distribution it is seen that İstanbul has the highest emissions with respect to the other provinces. İzmir and Kocaeli have lower NOx emissions than İstanbul but higher emissions that the other provinces. NOx is mostly produced by gasoline consuming passenger cars and heavy duty vehicle, i.e passenger cars, bus and truck. İstanbul has the highest passenger car share in respect with the other provinces which is %20.

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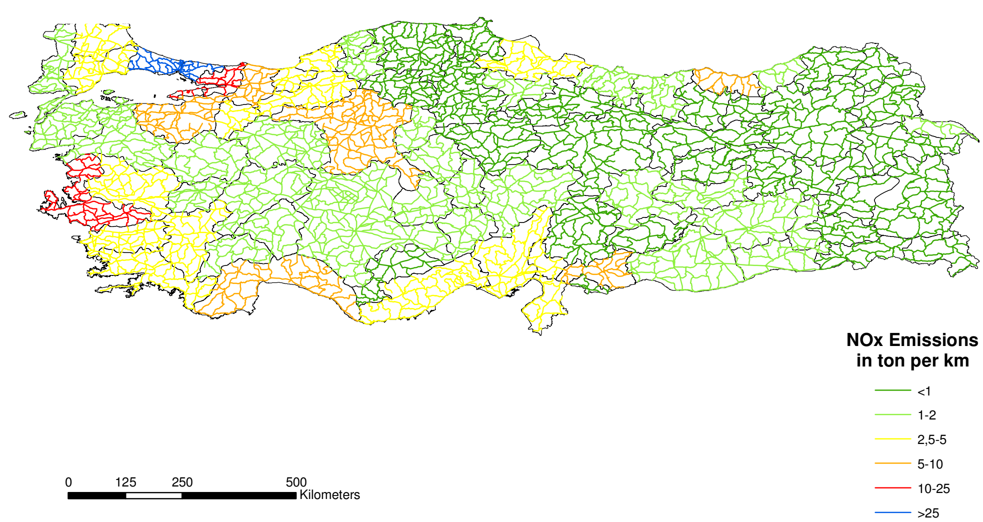

Figure 6.2. NOx emissions caused by mobile sources

6.3. Visualization of SO_2 Emissions

The most important source for SO_2 emissions are lignite fired thermal power plants. Thus Kahramanmaraş, Bursa, Kütahya, Sivas, Zonguldak, Artvin, İstanbul, Manisa, Muğla, Ankara, Zonguldak, Izmır, Hatay which have a thermal power plant, have higher SO_2 emissions with respect to the other provinces. Kahramanmaraş, Manisa and Muğla are the provinces which are affected at most. Afşin Elbistan lignite fired thermal power plant is located in Kahramanmaraş which ahs the highest energy production capacity. Soma lignite fired thermal power plant has the second highest production capacity. Thus Manisa has a high SO2 emission with respect to the other provinces. Muğla is also an important province which is affected by the lignite power plants. These power plants are Yatağan, Kemerkoy and Yeniköy.

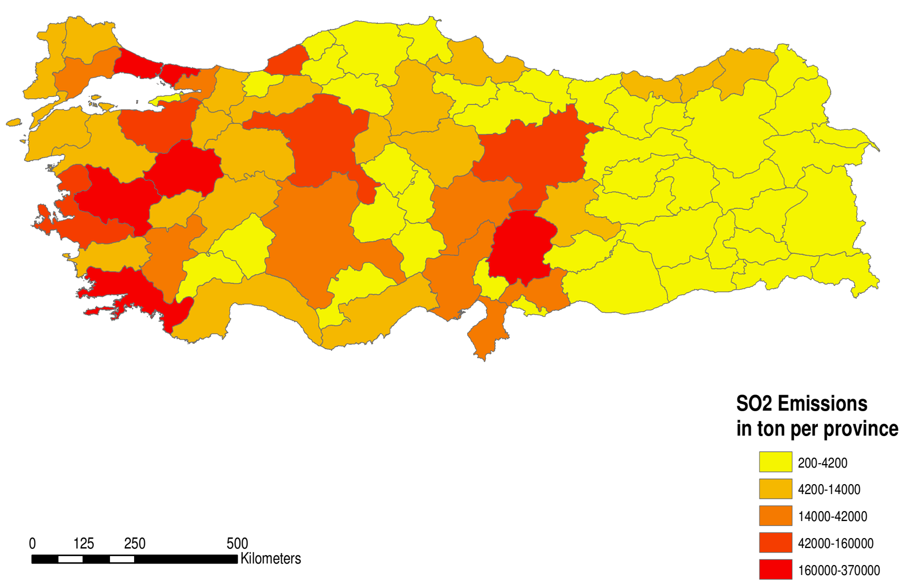

Figure 6.3. SO_2 emissions according to the provinces

6.4. Visualization of PM_{10} Emissions

The most important cause of PM_{10} emissions are ash forming fuels. So that, uncontrolled processes such as biomass (wood, etc) burning cause high amounts of PM_{10} emissions. Also cement processes cause high amount of PM_{10} with respect to the other industrial prosesses while there have been losses in every step of cement production. According to the Figure 6.4. it is seen that İstanbul, Ankara, Kütahya, Manisa, Muğla, Kahramanmaraş have higher PM_{10} emissions relative to the other provinces. Because there is lignite fire power plant or cement process located at these provinces.

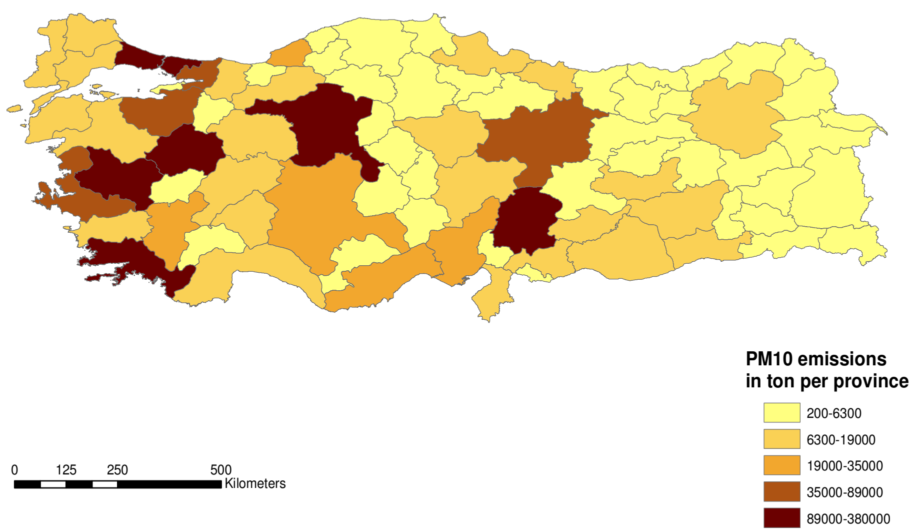

Figure 6.4. PM_{10} emissions according to the provinces

7. RESULTS AND DISCUSSION

In this section the most important emission that one source leads will be explained.

Mobile Sources

According to many studies the most important pollutant occurred due to mobile sources is NOx. With this study it is also proved that mobile sources are the most important NOx emitting sources while NOx form when fuel is burned at high temperatures, as in a combustion process. Besides the primary sources of NOx are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels.

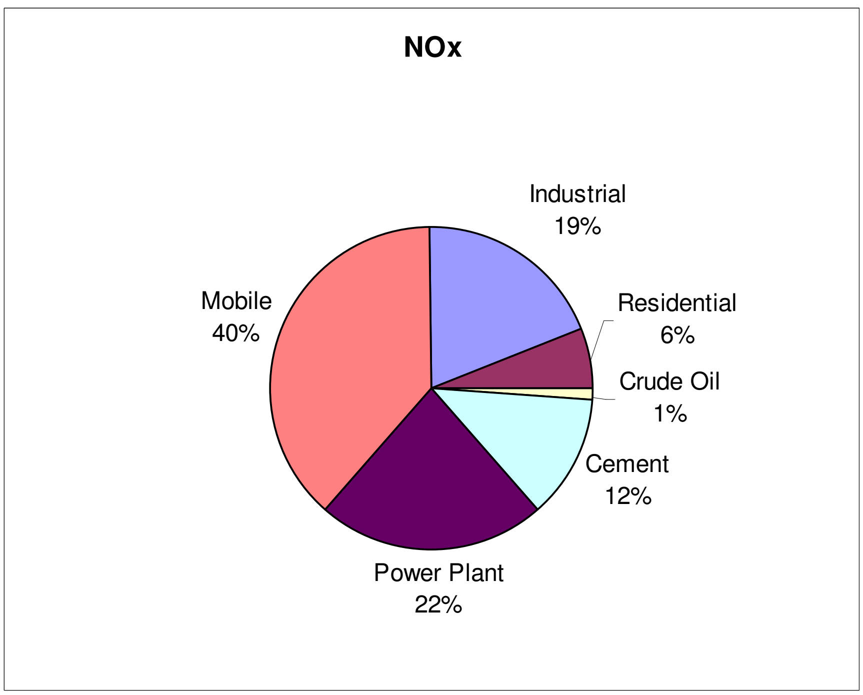

Figure 7.1. NOx Emissions according to the sectors

Small Combustion Processes

Small combustion plants may cause many different emissions as there is a wide variety of fuels that can be used for small combustion plants. The most important development occurred last year is the start of using natural gas. Natural gas has been started to be used both in residential and in commercial sector in Ankara in October 1988, and in industrial sector in August 1989, in İstanbul in January 1992, and in Bursa in 1992 (Botas, 2006). For that reason there was a decrease in SO_2 emissions in metropolitan cities in last years. Residential sector of small combustion may contribute to the PM_{10} emissions because of there is still cities in Turkey which use coal and biomass. As a result of using ash forming fuels PM_{10} emissions increase. In Turkey the most important reason of PM_{10} emissions is cement factories. Cement processes cause high amount of PM_{10} because of the losses occuring in every step of cement production. PM10 emission distribution according to the sectors is given by Figure 7.2.

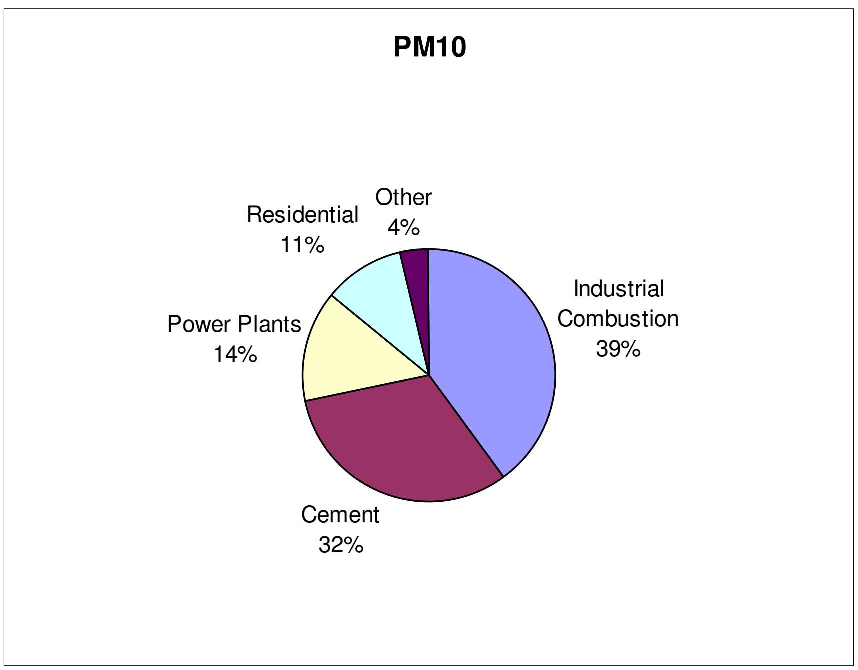

Figure 7.2. PM_{10} Emissions according to the sectors

Large Combustion Plants

Afşin Elbistan Thermal Power Plant has the highest production capacity as 8840 GWh. It also has the highest emissions due to its capacity. As the main fuel of thermal power plants in Turkey is lignite, sulfur content of these lignite sources should be known. The sulfur content of lignite in Turkey changes between 1.5% and 5% and the mean sulphur content of lignite has been calculated as 3% on dry basis (Uzun and Özdoğan, 2003). Because of the high sulphur content of lignite and lack of abatement technologies large combustion plants causes the highest SO_2 emissions.

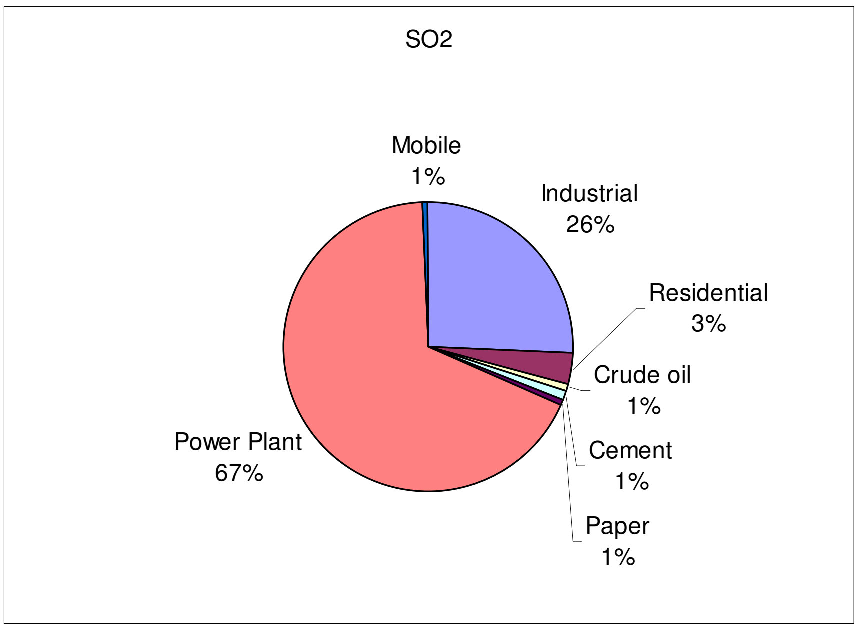

Figure 7.3. SO_2 Emissions according to the sectors

With this study emissions are estimated to monitor progress in air pollution, to identify possible emission reduction measures, to produce data for atmospheric models. Emissions are estimated within the approaches given in the fourth chapter and distributed to Turkey by ArcGIS.

In conclusion, this study shows that the most important step of generation of an emission inventory is data availability and the quality of the data. Data assessment is also a very important step of the study. So that it is necessary to produce better activity data for sectors such as mileage and vehicle technology for mobile sources, fuel consumption according to the provinces for small combustion processes, specific information such as coordinates of the power plant, height of the power plant stack height of the source, flue gas temperature, flue gas velocity or flow rate and cross sectional area of the source, for large combustion plants, in order to generate a complete and accurate emission inventory.

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APPENDIXES

A. GENERAL

Table A.1: Population of Turkey in 2000 (TUIK)

No	PROVINCES	POPULATION (N)	Ratio (Province/ Turkey) %
1	Adana	1849478	2,73
2	Adıyaman	623811	0,92
3	Afyon	812416	1,20
4	Ağrı	528744	0,78
5	Amasya	365231	0,54
6	Ankara	4007860	5,91
7	Antalya	1719751	2,54
8	Artvin	191934	0,28
9	Aydın	950757	1,40
10	Balıkesir	1076347	1,59
11	Bilecik	194326	0,29
12	Bingöl	253739	0,37
13	Bitlis	388678	0,57
14	Bolu	270654	0,40
15	Burdur	256803	0,38
16	Bursa	2125140	3,13
17	Çanakkale	464975	0,69
18	Çankırı	270355	0,40
19	Çorum	597065	0,88
20	Denizli	850029	1,25
21	Diyarbakır	1362708	2,01
22	Edirne	402606	0,59
23	Elazığ	569616	0,84
24	Erzincan	316841	0,47
25	Erzurum	937389	1,38
26	Eskişehir	706009	1,04
27	Gaziantep	1285249	1,90
28	Giresun	523819	0,77
29	Gümüşhane	186953	0,28
30	Hakkari	236581	0,35
31	Hatay	1253726	1,85
32	Isparta	513681	0,76
33	İçel	1651400	2,44
34	İstanbul	10018735	14,78
35	İzmir	3370866	4,97
36	Kars	325016	0,48
37	Kastamonu	375476	0,55
38	Kayseri	1060432	1,56
39	Kırklareli	328461	0,48
40	Kırşehir	253239	0,37
41	Kocaeli	1206085	1,78
42	Konya	2192166	3,23
43	Kütahya	656903	0,97
44	Malatya	853658	1,26
45	Manisa	1260169	1,86
46	Kahramanmaraş	1002384	1,48
47	Mardin	705098	1,04
48	Muğla	715328	1,05

No	PROVINCES	POPULATION (N)	Ratio (Province/ Turkey) %
49	Muş	453654	0,67
50	Nevşehir	309914	0,46
51	Niğde	348081	0,51
52	Ordu	887765	1,31
53	Rize	365938	0,54
54	Sakarya	756168	1,12
55	Samsun	1209137	1,78
56	Siirt	263676	0,39
57	Sinop	225574	0,33
58	Sivas	755091	1,11
59	Tekirdağ	623591	0,92
60	Tokat	828027	1,22
61	Trabzon	975137	1,44
62	Tunceli	93584	0,14
63	Şanlıurfa	1443422	2,13
64	Uşak	322313	0,48
65	Van	877524	1,29
66	Yozgat	682919	1,01
67	Zonguldak	615599	0,91
68	Aksaray	396084	0,58
69	Bayburt	97358	0,14
70	Karaman	243210	0,36
71	Kırıkkale	383508	0,57
72	Batman	456734	0,67
73	Şırnak	353197	0,52
74	Bartın	184178	0,27
75	Ardahan	133756	0,20
76	Iğdır	168634	0,25
77	Yalova	168593	0,25
78	Karabük	225102	0,33
79	Kilis	114724	0,17
80	Osmaniye	458782	0,68
81	Düzce	314266	0,46

Table A.2 : Number of Employees According to the Provinces (TUIK)

PROVINCES	EMPLOYEES	Percentage
	number	%
Adana	62281	2,35
Adıyaman	8474	0,32
Afyon	14634	0,55
Ağrı	1049	0,04
Amasya	6996	0,26
Ankara	137973	5,21
Antalya	25847	0,98
Artvin	4724	0,18
Aydın	24976	0,94
Balıkesir	26681	1,01
Bilecik	18543	0,70

Bingöl	597	0,02
Bitlis	489	0,02
Bolu	17777	0,67
Burdur	7073	0,27
Bursa	192445	7,27
Çanakkale	18625	0,70
Çankırı	4455	0,17
Çorum	14884	0,56
Denizli	92400	3,49
Diyarbakır	7763	0,29
Edirne	13401	0,51
Elazığ	6839	0,26
Erzincan	2591	0,10
Erzurum	7777	0,29
Eskişehir	43252	1,63
Gaziantep	67399	2,55
Giresun	7090	0,27
Gümüşhane	1314	0,05
Hakkari	458	0,02
Hatay	28921	1,09
Isparta	8476	0,32
İçel	29494	1,11
İstanbul	701492	26,49
İzmir	200388	7,57
Kars	2661	0,10
Kastamonu	6509	0,25
Kayseri	72292	2,73
Kırklareli	28123	1,06
Kırşehir	4189	0,16
Kocaeli	127168	4,80
Konya	76009	2,87
Kütahya	13486	0,51
Malatya	14123	0,53
Manisa	57686	2,18
Kahramanmaraş	23629	0,89
Mardin	3086	0,12
Muğla	8141	0,31
Muş	1903	0,07
Nevşehir	4561	0,17
Niğde	5666	0,21
Ordu	10765	0,41
Rize	33058	1,25
Sakarya	35377	1,34
Samsun	19067	0,72
Siirt	1156	0,04
Sinop	7125	0,27
Sivas	13658	0,52
Tekirdağ	111223	4,20
Tokat	10020	0,38
Trabzon	13481	0,51
Tunceli	306	0,01
Şanlıurfa	5854	0,22

Uşak	16995	0,64
Van	3754	0,14
Yozgat	10011	0,38
Zonguldak	26696	1,01
Aksaray	5740	0,22
Bayburt	425	0,02
Karaman	11192	0,42
Kırıkkale	8717	0,33
Batman	2766	0,10
Şırnak	408	0,02
Bartın	5200	0,20
Ardahan	128	0,00
Iğdır	388	0,01
Yalova	9097	0,34
Karabük	11985	0,45
Kilis	749	0,03
Osmaniye	3420	0,13
Düzce	12690	0,48
Toplam	2648261	100,00

B. MOBILE SOURCES

Table B.1: Vehicle Stock for 2003 (TUIK, 2003)

PROVINCES	PC	Minibus	Buses	Pick Up	Truck	Motorcycles
Adana	148832	6297	3221	29899	11558	65018
Adıyaman	15087	1396	244	2015	1785	4693
Afyon	34611	3330	1265	7089	6973	14429
Ağrı	4440	1066	175	668	1043	327
Amasya	20750	2323	444	4393	2795	5397
Ankara	681890	11932	12441	89101	29148	15186
Antalya	175658	7355	4813	46306	12881	93089
Artvin	8230	1929	332	2640	2243	424
Aydın	74030	9022	1162	16744	5445	40152
Balıkesir	98343	4874	3291	23262	8261	36544
Bilecik	11461	699	599	2682	1869	2567
Bingöl	2899	820	193	705	542	548
Bitlis	4761	900	159	941	1108	222
Bolu	27873	1839	1194	6290	4098	8052
Burdur	22747	795	623	3043	4062	12916
Bursa	188579	7315	6539	55339	13313	25043
Çanakkale	32494	1597	1182	7323	3303	16203
Çankırı	5711	579	261	1079	1271	2335
Çorum	28349	2375	735	4368	4199	11042
Denizli	79678	6777	2632	15623	5795	30087
Diyarbakır	17869	2462	601	5591	3196	4574
Edirne	28660	1545	1159	4525	2768	6956
Elazığ	23650	2302	701	5122	1884	5058
Erzincan	11764	1399	506	1721	1370	4977
Erzurum	23697	588	637	3112	1943	1039
Eskişehir	70791	1955	1829	12234	7084	14233
Gaziantep	66327	4658	1391	14504	6607	50156
Giresun	14899	6101	277	4703	2915	554
Gümüşhane	4346	1247	77	898	1357	313
Hakkari	1579	283	26	421	449	159
Hatay	74209	7496	1934	16623	6181	59854
Isparta	32602	1179	1030	6720	3140	15278
İçel	94777	2872	3136	27425	11974	53697
İstanbul	917666	11175	15498	153365	25304	32967
İzmir	351499	9820	9426	77612	18906	75988
Kars	6195	1404	520	997	1245	645
Kastamonu	22458	2363	629	3019	3985	3426
Kayseri	88989	4298	2226	15402	9325	9988
Kırklareli	22766	1198	904	3114	2412	5844
Kırşehir	13691	1302	358	1402	2019	2234
Kocaeli	82737	4125	4464	17993	7289	5189
Konya	125942	6193	3183	30205	21311	52917
Kütahya	45937	3891	1130	6877	4597	13021
Malatya	31555	3193	900	5642	3094	4716
Manisa	82083	6006	3537	20255	8584	65030
Kahramanmaraş	35977	4131	1394	5956	4044	16282
Mardin	8062	1814	252	1684	8384	1302
Muğla	77267	6479	1889	16781	4728	44893
Muş	3583	874	139	993	887	237

Nevşehir	18344	2331	492	4380	4713	4591
Niğde	13793	1038	589	3470	4068	7232
Ordu	26904	6896	601	5759	3686	1394
Rize	14359	3157	624	6560	3645	485
Sakarya	50779	2483	2291	14745	5731	6816
Samsun	68135	9110	1054	17532	6204	12432
Siirt	3431	533	116	1015	857	517
Sinop	11373	1512	332	1580	1618	1624
Sivas	26980	2587	687	3721	3116	3134
Tekirdağ	32621	2041	2193	6379	3167	4084
Tokat	29817	2897	1167	5281	3735	6496
Trabzon	32160	6343	1158	12235	4780	1007
Tunceli	1120	516	122	341	190	313
Şanlıurfa	38699	2836	823	4270	7972	22514
Uşak	23509	1296	596	3702	1836	9792
Van	15593	3195	345	3570	4217	1208
Yozgat	15655	2044	513	1712	3409	1295
Zonguldak	57922	4277	1991	10421	6289	3657
Aksaray	18494	964	568	2253	3902	5380
Bayburt	2728	451	189	423	540	183
Karaman	14954	1050	347	2863	1804	15429
Kırıkkale	12765	1210	486	1986	1355	2131
Batman	5843	1073	145	2044	678	876
Şırnak	1983	432	47	487	15229	311
Bartın	10203	1496	289	2206	958	785
Ardahan	1435	662	36	219	290	44
Iğdır	2594	373	409	619	4692	337
Yalova	9129	518	589	2557	775	488
Karabük	8978	850	289	1881	889	197
Kilis	2710	385	74	553	308	2702
Osmaniye	14817	1708	208	2997	827	4537
Düzce	11015	1261	939	3058	993	625
Total	4646841	243101	121565	915225	401148	1058415

Table B.2: Fuel Consumption according to the provinces (TPAO)

İller		Normal benzin	Süper benzin	K.Benzin	K.Benzin 98 oktan	TOTAL	Motorin
Provinces	LPG	Regular gasoline	Super gasoline	Unleaded gasoline	Unl.gasoline (RON 98)	Gasoline	Diesel oil
Adana	105801		17292	34035	5191	56518	231839
Adıyaman	24352		690	2770	190	3650	26453
Afyon	27913		5223	12212	1980	19415	112131
Ağrı	5033		347	2068	38	2453	23055
Aksaray	15865		1284	5314	660	7258	40351
Amasya	16802		2188	5419	424	8031	42351
Ankara	416986	26	53421	203013	25354	281814	1123643
Antalya	169511		36743	79436	9960	126139	371045
Ardahan	2385		81	1299	136	1516	7340
Artvin	5056		2154	2752	209	5115	17579
Aydın	48057		20046	21440	4016	45502	133693
Balıkesir	59099		18937	26289	5189	50415	189554

Bartın	32312		3012	2459	459	5930	19423
Batman	8930		660	3725	73	4458	31395
Bayburt	2377		35	1064	4	1103	7045
Bilecik	13769		3102	4046	913	8061	43055
Bingöl	5052		554	1021	24	1599	8016
Bitlis	4350		235	1952	68	2255	8827
Bolu	25936	22	5795	15909	1944	23670	99021
Burdur	17743		3135	4416	433	7984	44956
Bursa	118514		39311	65017	12485	116813	346588
Çanakkale	27317		9794	10758	1975	22527	87976
Çankırı	22038		900	2693	431	4024	22965
Çorum	62481		4042	9168	755	13965	121547
Denizli	52543		17091	18617	3493	39201	155714
Diyarbakır	26993		2053	9474	1226	12753	52422
Düzce	20737		3273	6833	938	11044	38865
Edirne	18094		7946	10746	2297	20989	71296
Elazığ	26229		3383	6183	846	10412	47915
Erzincan	9986		1632	3464	240	5336	39730
Erzurum	24480		1821	10381	517	12719	61238
Eskişehir	37604		12360	13029	4084	29473	128509
Gaziantep	115130		11434	18905	3197	33536	86663
Giresun	18593		2724	5300	448	8472	44934
Gümüşhane	3972		500	1582	144	2226	11769
Hakkari	2087		197	323		520	3241
Hatay	57299		11053	17695	2277	31025	117409
İçel	89986		18859	28204	99	47162	326638
Iğdır	2894		136	1423	1200	2759	3024
Isparta	22144		5318	7339	5496	18153	59148
İstanbul	809767	3579	167027	636460	98080	905146	1769834
İzmir	270933		64387	123407	19745	207539	651775
Kahramanmaraş	40811	12	2871	7919	961	11763	94825
Karabük	12296		2136	3231	627	5994	27835
Karaman	15625		1057	1289	143	2489	12338
Kars	6756		774	3225	137	4136	21161
Kastamonu	20264		4473	6190	1059	11722	53716
Kayseri	62754		5712	20459	3987	30158	191578
Kilis	3623		569	681	366	1616	2598
Kırıkkale	19143		1585	5074	1358	8017	36863
Kırklareli	17451	58	8503	13023	369	21953	67339
Kırşehir	11125	26	995	4469	62	5552	35671
Kocaeli	115608		20892	52037	10695	83624	331752
Konya	140738		14345	30976	4722	50043	306701
Kütahya	36304		6924	7454	1278	15656	129861
Malatya	37180		2763	8724	1074	12561	77551
Manisa	63270		18904	17581	3030	39515	216700
Mardin	9681		402	2645	151	3198	21026
Muğla	56415		25480	31254	9283	66017	172439
Muş	4400		309	1143	23	1475	7717
Nevşehir	16197		1716	3835	292	5843	41019
Niğde	31363		1300	3001	284	4585	36630
Ordu	29938		3010	8788	338	12136	59422
Osmaniye	22149		2445	3305	282	6032	29007

Rize	14236		2208	5844	318	8370	38689
Sakarya	56915		9776	20021	2863	32660	167697
Samsun	56955		6712	19144	1473	27329	156018
Siirt	4176		393	891	34	1318	7651
Sinop	9495		1772	2938	250	4960	18320
Sivas	27655		3892	8069	1031	12992	77654
Şanlıurfa	38311		1849	6807	729	9385	43087
Şirnak	30084		318	861	3	1182	19770
Tekirdağ	34948		14830	22486	4316	41632	149627
Tokat	23952		2871	6057	526	9454	65506
Trabzon	33408		3382	14135	788	18305	113974
Tunceli	2713		606	736	5	1347	5878
Uşak	14840		3996	4678	725	9399	37204
Van	12933		713	3855	193	4761	14845
Yalova	11149		2997	7636	1375	12008	38147
Yozgat	21527		1086	5723	265	7074	46445
Zonguldak	29156		9465	12881	2106	24452	81911
Toplam	4042694	3723	754206	1816705	274759	2849393	9886144

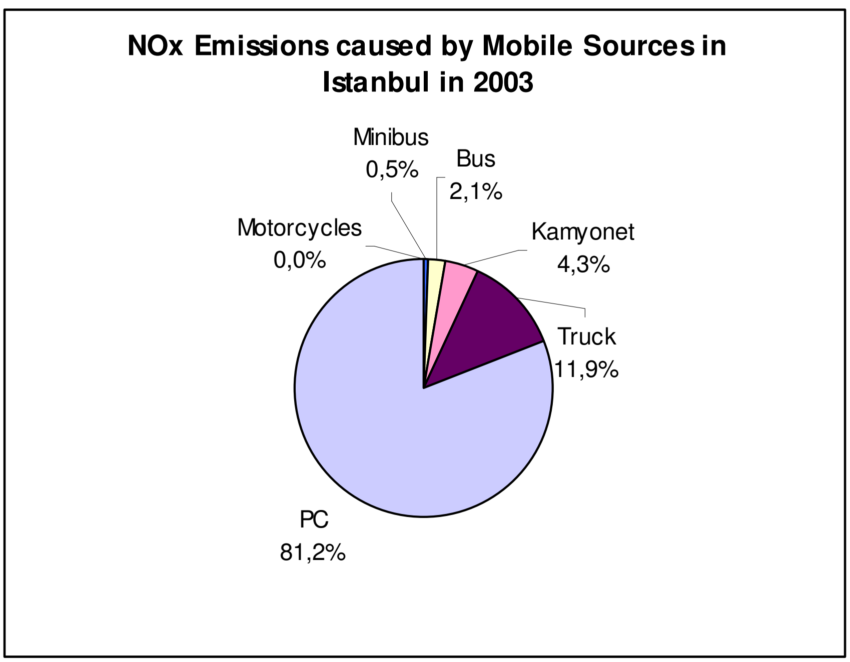

Figure B.1: NOx Emissions caused by Mobile Sources in İstanbul in 2003

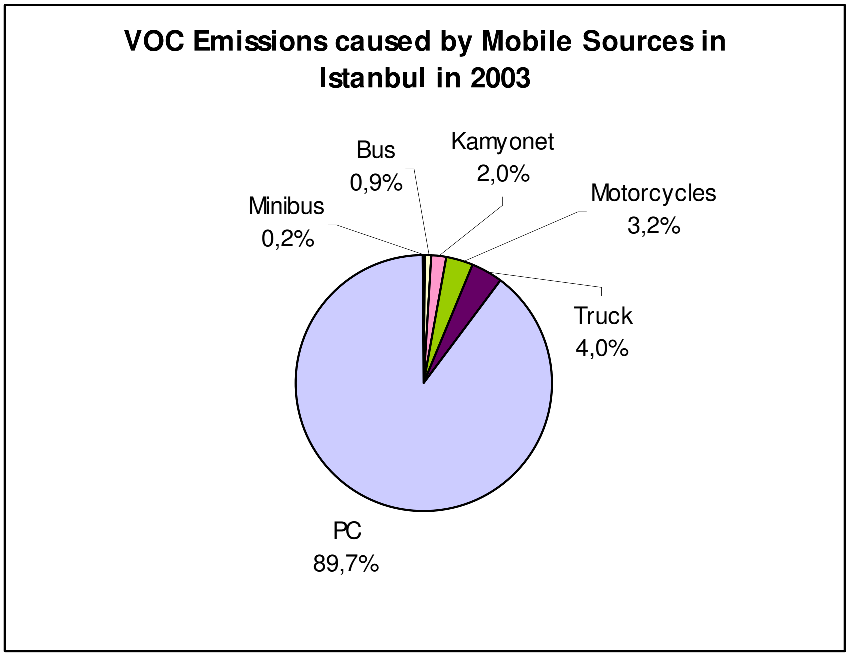

Figure B.2: VOC Emissions caused by Mobile Sources in İstanbul in 2003

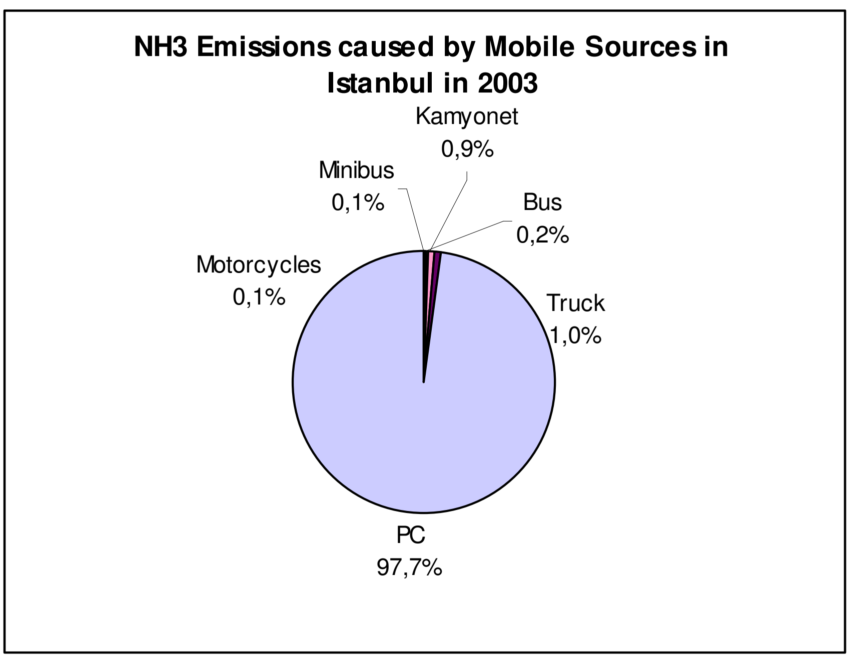

Figure B.3: NH_3 Emissions caused by Mobile Sources in İstanbul in 2003

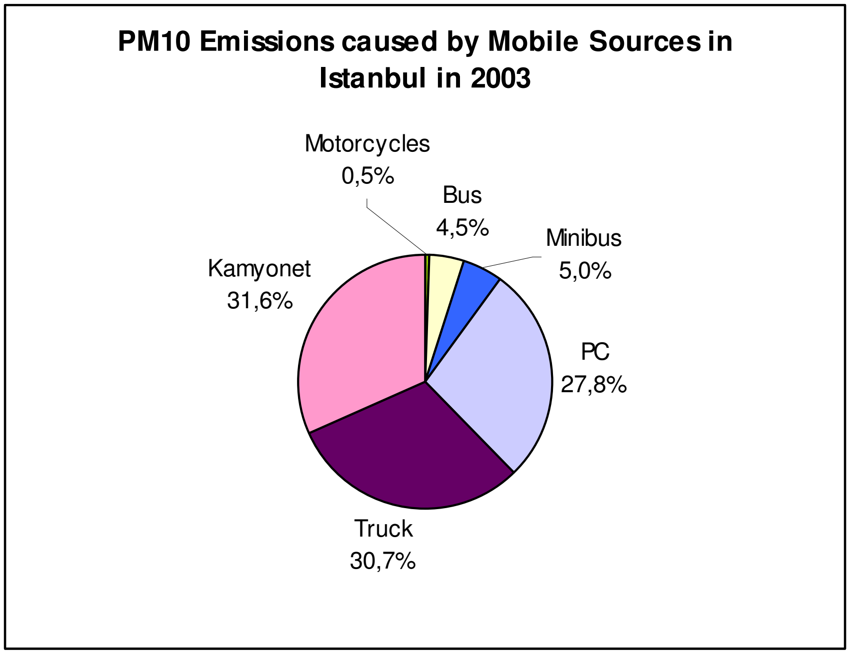

Figure B.4: PM_{10} Emissions caused by Mobile Sources in İstanbul in 2003

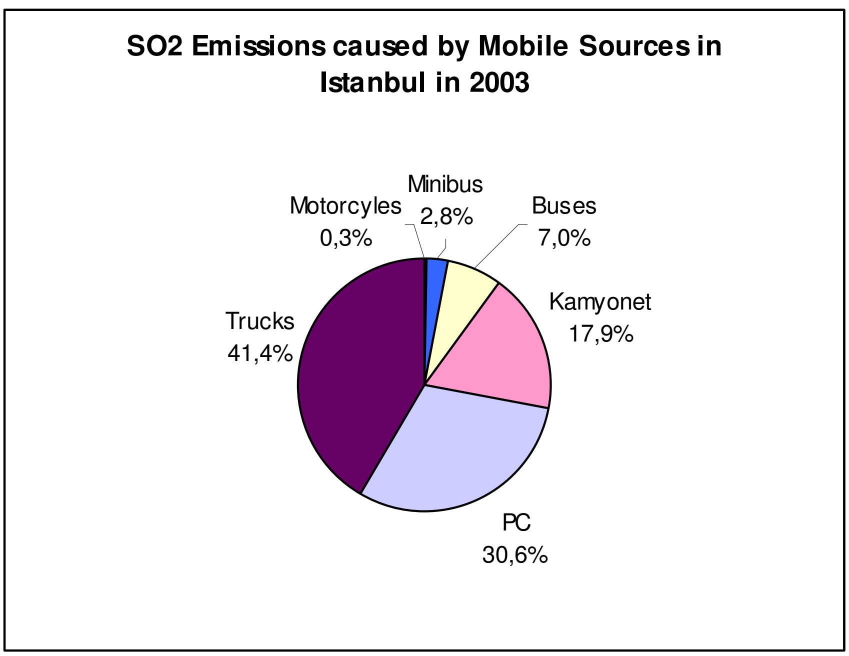

Figure B.5: SO_2 Emissions caused by Mobile Sources in İstanbul in 2003

Table B.3 : NOx Emissions of Mobile Sources

	PC	Pick Up	Minibus	Bus	Truck	Motorcycle	TOTAL
PROVINCES	**NOx**	**NOx**	**NOx**	**NOx**	**NOx**	**NOx**	**NOx**
	ton/year	**ton/year**	**ton/year**	**ton/year**	**tone/year**	**ton/year**	**ton/year**
Adana	2248,7	171,0	91,2	366,8	2056,5	44,7	4978,9
Adıyaman	141,8	23,8	18,0	72,4	405,7	3,2	664,9
Afyon	827,5	154,0	80,9	325,2	1823,4	9,9	3220,9
Ağrı	115,0	24,7	16,8	67,7	379,7	0,2	604,2
Amasya	346,3	58,3	29,8	119,8	671,9	3,7	1229,8
Ankara	13364,3	275,3	212,5	854,8	4792,8	10,4	19510,1
Antalya	5381,0	337,4	144,3	580,3	3254,0	64,0	9761,0
Artvin	241,5	24,8	9,1	36,6	205,3	0,3	517,6
Aydın	1895,3	137,4	66,5	267,3	1498,9	27,6	3893,0
Balıkesir	2155,3	174,4	81,3	327,1	1834,3	25,1	4597,6
Bilecik	367,4	68,5	32,2	129,6	726,6	1,8	1326,0
Bingöl	72,6	16,7	7,6	30,6	171,7	0,4	299,6
Bitlis	106,2	31,3	16,9	68,0	381,4	0,2	604,0
Bolu	1075,3	119,9	58,1	233,8	1310,8	5,5	2803,5
Burdur	291,7	34,4	26,0	104,7	587,2	8,9	1053,0
Bursa	5409,0	375,7	147,8	594,3	3332,2	17,2	9876,2
Çanakkale	963,9	78,5	38,1	153,2	859,0	11,1	2103,9
Çankırı	176,1	32,3	18,1	73,0	409,2	1,6	710,4
Çorum	590,6	55,8	37,3	149,9	840,7	7,6	1681,8
Denizli	1664,2	100,5	54,7	219,9	1233,0	20,7	3292,9
Diyarbakır	577,7	91,7	34,3	138,1	774,6	3,1	1619,7
Edirne	954,8	38,6	25,2	101,5	569,3	4,8	1694,2
Elazığ	462,5	46,5	23,3	93,7	525,6	3,5	1155,1
Erzincan	220,4	24,3	17,0	68,4	383,6	3,4	717,2
Erzurum	600,7	46,3	10,2	143,0	801,7	0,7	1602,5
Eskişehir	1309,6	92,9	56,2	226,1	1267,9	9,8	2962,5
Gaziantep	1253,7	183,9	91,4	367,7	2061,8	34,5	3993,0
Giresun	401,1	89,1	33,1	61,4	746,9	0,4	1332,0
Gümüşhane	104,2	18,3	9,5	17,1	214,9	0,2	364,3
Hakkari	23,7	14,8	6,3	5,7	141,7	0,1	192,3
Hatay	1066,2	116,4	56,7	228,2	1279,6	41,2	2788,2
Isparta	761,3	53,0	27,7	111,4	624,4	10,5	1588,2
İçel	1880,4	288,5	114,7	461,3	2586,7	36,9	5368,5
İstanbul	47069,4	2472,6	305,4	1228,4	6888,0	22,7	57986,5
İzmir	9390,8	406,7	200,6	807,0	4525,1	52,2	15382,5
Kars	193,2	16,3	10,5	42,2	236,7	0,4	499,4
Kastamonu	536,4	31,8	23,9	96,3	539,9	2,4	1230,7
Kayseri	1371,9	74,5	45,0	181,1	1015,7	6,9	2695,1
Kırklareli	1008,6	47,0	34,9	140,2	785,9	4,0	2020,6
Kırşehir	249,8	19,3	18,5	74,4	417,2	1,5	780,8
Kocaeli	3960,9	382,6	191,1	768,5	4309,4	3,6	9616,1
Konya	2023,5	275,3	127,0	510,7	2863,5	36,4	5836,4

Kütahya	657,7	47,0	32,2	129,5	726,3	9,0	1601,7
Malatya	567,6	56,6	33,3	133,8	750,4	3,2	1544,9
Manisa	1436,0	224,6	101,3	407,3	2283,6	44,7	4497,4
Kahramanmaraş	448,9	53,6	33,7	135,5	759,6	11,2	1442,4
Mardin	143,8	68,8	35,5	55,7	801,5	0,9	1106,3
Muğla	2842,9	147,4	73,7	296,4	1662,0	30,9	5053,3
Muş	68,9	19,4	8,0	32,0	179,5	0,2	307,9
Nevşehir	247,3	41,9	19,4	78,1	437,8	3,2	827,7
Niğde	168,8	63,5	28,2	113,4	636,0	5,0	1015,0
Ordu	570,4	54,8	27,8	111,6	625,9	1,0	1391,4
Rize	396,7	68,0	19,4	77,8	436,5	0,3	998,7
Sakarya	1513,6	228,0	90,4	363,6	2039,0	4,7	4239,3
Samsun	1219,7	181,3	79,0	317,9	1782,5	8,6	3589,0
Siirt	59,4	16,9	6,6	26,6	149,3	0,4	259,3
Sinop	225,8	15,4	11,3	45,4	254,7	1,1	553,7
Sivas	599,2	57,7	42,4	170,7	957,3	2,2	1829,4
Tekirdağ	950,8	114,6	62,5	251,5	1410,3	2,8	2792,6
Tokat	406,7	40,1	23,8	95,7	536,6	4,5	1107,3
Trabzon	867,9	157,9	51,1	205,6	1152,9	0,7	2436,2
Tunceli	31,1	12,7	4,9	19,5	109,6	0,2	177,9
Şanlıurfa	291,8	80,2	72,0	289,7	1624,6	15,5	2373,9
Uşak	381,1	37,7	24,7	99,4	557,4	6,7	1107,0
Van	219,2	77,1	36,9	148,6	833,2	0,8	1315,8
Yozgat	329,1	30,4	27,5	110,8	621,2	0,9	1119,9
Zonguldak	1143,3	36,2	21,2	85,2	478,0	2,5	1766,5
Aksaray	309,5	31,0	25,4	102,3	573,6	3,7	1045,4
Bayburt	51,4	8,0	5,3	21,4	120,0	0,1	206,3
Karaman	121,7	14,4	8,0	32,1	179,9	10,6	366,6
Kırıkkale	368,4	33,9	22,5	90,3	506,3	1,5	1022,7
Batman	207,0	35,2	12,1	48,7	273,3	0,6	576,9
Şırnak	54,3	7,9	7,5	10,5	472,1	0,2	552,5
Bartın	278,0	14,1	7,1	28,5	159,8	0,5	488,0
Ardahan	39,8	6,7	4,5	8,0	101,8	0,0	160,8
Iğdır	71,9	19,8	9,2	36,8	206,4	0,2	344,2
Yalova	341,9	59,0	24,1	96,8	542,9	0,3	1065,0
Karabük	285,1	35,4	18,2	73,3	411,2	0,1	823,4
Kilis	58,4	5,8	3,0	12,2	68,6	1,9	149,9
Osmaniye	256,7	39,7	21,1	46,0	475,1	3,1	841,7
Düzce	305,4	106,2	43,6	175,5	249,9	0,4	881,0
Total	131391,6	13857,6	4165,3	21634,1	100268,9	727,2	272044,8

Table B.4 : VOC Emissions of Mobile Sources

	PC	Pick Up	Minibus	Bus	Truck	Motorcycles	TOTAL
PROVINCES	VOC	VOC	VOC	VOC	VOC	VOC	VOC
	ton/year	ton/year	ton/year	ton/year	tone/year	ton/year	tone/year
Adana	1092,3	33,7	15,3	65,5	294,7	1582,5	3084,0
Adıyaman	68,9	4,7	3,0	12,9	58,1	114,2	261,9
Afyon	402,0	30,4	13,6	58,1	261,2	351,2	1116,5
Ağrı	55,9	4,9	2,8	12,1	54,4	8,0	138,0
Amasya	168,2	11,5	5,0	21,4	96,3	131,4	433,8
Ankara	6491,4	54,3	35,7	152,8	686,7	369,6	7790,4
Antalya	2613,7	66,6	24,2	103,7	466,2	2265,8	5540,2
Artvin	117,3	4,9	1,5	6,5	29,4	10,3	170,0
Aydın	920,6	27,1	11,2	47,8	214,8	977,3	2198,7
Balıkesir	1046,9	34,4	13,7	58,5	262,8	889,5	2305,7
Bilecik	178,5	13,5	5,4	23,2	104,1	62,5	387,1
Bingöl	35,3	3,3	1,3	5,5	24,6	13,3	83,3
Bitlis	51,6	6,2	2,8	12,2	54,6	5,4	132,8
Bolu	522,3	23,7	9,8	41,8	187,8	196,0	981,3
Burdur	141,7	6,8	4,4	18,7	84,1	314,4	570,1
Bursa	2627,3	74,1	24,8	106,2	477,4	609,6	3919,4
Çanakkale	468,2	15,5	6,4	27,4	123,1	394,4	1034,9
Çankırı	85,5	6,4	3,1	13,0	58,6	56,8	223,5
Çorum	286,9	11,0	6,3	26,8	120,4	268,8	720,1
Denizli	808,4	19,8	9,2	39,3	176,7	732,3	1785,6
Diyarbakır	280,6	18,1	5,8	24,7	111,0	111,3	551,5
Edirne	463,8	7,6	4,2	18,1	81,6	169,3	744,6
Elazığ	224,6	9,2	3,9	16,8	75,3	123,1	452,9
Erzincan	107,1	4,8	2,9	12,2	55,0	121,2	303,0
Erzurum	291,8	9,1	1,7	25,6	114,9	25,3	468,3
Eskişehir	636,1	18,3	9,4	40,4	181,7	346,4	1232,4
Gaziantep	609,0	36,3	15,4	65,7	295,4	1220,8	2242,5
Giresun	194,8	17,6	5,6	11,0	107,0	13,5	349,4
Gümüşhane	50,6	3,6	1,6	3,1	30,8	7,6	97,3
Hakkari	11,5	2,9	1,1	1,0	20,3	3,9	40,7
Hatay	517,9	23,0	9,5	40,8	183,3	1456,9	2231,3
Isparta	369,8	10,5	4,7	19,9	89,5	371,9	866,1
İçel	913,4	56,9	19,3	82,4	370,6	1307,0	2749,6
İstanbul	22145,8	487,9	51,3	219,5	986,9	802,4	24693,8
İzmir	4561,4	80,3	33,7	144,2	648,3	1849,6	7317,4
Kars	93,8	3,2	1,8	7,5	33,9	15,7	156,0
Kastamonu	260,6	6,3	4,0	17,2	77,4	83,4	448,8
Kayseri	666,4	14,7	7,6	32,4	145,5	243,1	1109,6
Kırklareli	489,9	9,3	5,9	25,1	112,6	142,2	784,9
Kırşehir	121,3	3,8	3,1	13,3	59,8	54,4	255,7
Kocaeli	1923,9	75,5	32,1	137,4	617,4	126,3	2912,6
Konya	982,9	54,3	21,3	91,3	410,3	1288,0	2848,0
Kütahya	319,4	9,3	5,4	23,2	104,1	316,9	778,3

Malatya	275,7	11,2	5,6	23,9	107,5	114,8	538,6
Manisa	697,5	44,3	17,0	72,8	327,2	1582,8	2741,6
Kahramanmaraş	218,0	10,6	5,7	24,2	108,8	396,3	763,6
Mardin	69,9	13,6	6,0	10,0	114,8	31,7	245,9
Muğla	1380,9	29,1	12,4	53,0	238,1	1092,7	2806,1
Muş	33,5	3,8	1,3	5,7	25,7	5,8	75,8
Nevşehir	120,1	8,3	3,3	14,0	62,7	111,8	320,1
Niğde	82,0	12,5	4,7	20,3	91,1	176,0	386,7
Ordu	277,0	10,8	4,7	20,0	89,7	33,9	436,1
Rize	192,7	13,4	3,3	13,9	62,5	11,8	297,6
Sakarya	735,2	45,0	15,2	65,0	292,1	165,9	1318,4
Samsun	592,4	35,8	13,3	56,8	255,4	302,6	1256,3
Siirt	28,9	3,3	1,1	4,8	21,4	12,6	72,0
Sinop	109,7	3,1	1,9	8,1	36,5	39,5	198,8
Sivas	291,0	11,4	7,1	30,5	137,2	76,3	553,5
Tekirdağ	461,9	22,6	10,5	45,0	202,1	99,4	841,4
Tokat	197,5	7,9	4,0	17,1	76,9	158,1	461,5
Trabzon	421,6	31,2	8,6	36,7	165,2	24,5	687,7
Tunceli	15,1	2,5	0,8	3,5	15,7	7,6	45,2
Şanlıurfa	141,8	15,8	12,1	51,8	232,8	548,0	1002,2
Uşak	185,1	7,4	4,2	17,8	79,9	238,3	532,6
Van	106,5	15,2	6,2	26,6	119,4	29,4	303,2
Yozgat	159,9	6,0	4,6	19,8	89,0	31,5	310,8
Zonguldak	555,3	7,2	3,6	15,2	68,5	89,0	738,8
Aksaray	150,3	6,1	4,3	18,3	82,2	131,0	392,1
Bayburt	25,0	1,6	0,9	3,8	17,2	4,5	52,9
Karaman	59,1	2,8	1,3	5,7	25,8	375,6	470,4
Kırıkkale	178,9	6,7	3,8	16,1	72,5	51,9	329,9
Batman	100,6	6,9	2,0	8,7	39,2	21,3	178,7
Şırnak	26,4	1,6	1,3	1,9	67,6	7,6	106,3
Bartın	135,0	2,8	1,2	5,1	22,9	19,1	186,1
Ardahan	19,3	1,3	0,8	1,4	14,6	1,1	38,5
Iğdır	34,9	3,9	1,5	6,6	29,6	8,2	84,7
Yalova	166,1	11,7	4,0	17,3	77,8	11,9	288,7
Karabük	138,5	7,0	3,1	13,1	58,9	4,8	225,4
Kilis	28,4	1,1	0,5	2,2	9,8	65,8	107,8
Osmaniye	124,7	7,8	3,5	8,2	68,1	110,4	322,8
Düzce	148,3	21,0	7,3	31,4	35,8	15,2	259,0
Total	63103,4	2734,6	699,2	3866,2	14365,8	25746,6	110515,8

Table B.5 : NH_3 Emissions of Mobile Sources

	PC	Pick Up	Minibus	BUS	Truck	Motorcycles	TOTAL
PROVINCES	**NH3**	**NH3**	**NH3**	**NH3**	**NH3**	**NH3**	**NH3**
	ton/year	**ton/year**	**ton/year**	**ton/year**	**tone/year**	**ton/year**	**tone/year**
Adana	11,9	0,2	0,1	0,1	0,7	0,7	13,6
Adıyaman	0,8	0,0	0,0	0,0	0,1	0,1	1,0
Afyon	4,4	0,1	0,1	0,1	0,6	0,1	5,5
Ağrı	0,6	0,0	0,0	0,0	0,1	0,0	0,8
Amasya	1,8	0,1	0,0	0,0	0,2	0,1	2,2
Ankara	71,0	0,2	0,2	0,3	1,6	0,2	73,4
Antalya	28,6	0,3	0,1	0,2	1,1	0,9	31,2
Artvin	1,3	0,0	0,0	0,0	0,1	0,0	1,4
Aydın	10,1	0,1	0,1	0,1	0,5	0,4	11,2
Balıkesir	11,4	0,2	0,1	0,1	0,6	0,4	12,8
Bilecik	2,0	0,1	0,0	0,1	0,2	0,0	2,4
Bingöl	0,4	0,0	0,0	0,0	0,1	0,0	0,5
Bitlis	0,6	0,0	0,0	0,0	0,1	0,0	0,8
Bolu	5,7	0,1	0,1	0,1	0,4	0,1	6,5
Burdur	1,6	0,0	0,0	0,0	0,2	0,1	2,0
Bursa	28,7	0,3	0,1	0,2	1,1	0,3	30,8
Çanakkale	5,1	0,1	0,0	0,1	0,3	0,2	5,7
Çankırı	0,9	0,0	0,0	0,0	0,1	0,0	1,2
Çorum	3,1	0,1	0,0	0,1	0,3	0,1	3,7
Denizli	8,8	0,1	0,1	0,1	0,4	0,3	9,8
Diyarbakır	3,1	0,1	0,0	0,1	0,3	0,1	3,5
Edirne	5,1	0,0	0,0	0,0	0,2	0,1	5,4
Elazığ	2,5	0,0	0,0	0,0	0,2	0,1	2,8
Erzincan	1,2	0,0	0,0	0,0	0,1	0,1	1,4
Erzurum	3,2	0,0	0,0	0,1	0,3	0,0	3,6
Eskişehir	7,0	0,1	0,1	0,1	0,4	0,1	7,7
Gaziantep	6,7	0,2	0,1	0,1	0,7	0,5	8,2
Giresun	2,1	0,1	0,0	0,0	0,3	0,0	2,5
Gümüşhane	0,6	0,0	0,0	0,0	0,1	0,0	0,7
Hakkari	0,1	0,0	0,0	0,0	0,1	0,0	0,2
Hatay	5,7	0,1	0,1	0,1	0,4	0,6	6,9
Isparta	4,0	0,1	0,0	0,0	0,2	0,2	4,5
İçel	10,0	0,3	0,1	0,2	0,9	0,5	11,9
İstanbul	230,1	2,2	0,3	0,4	2,3	0,3	235,6
İzmir	49,9	0,4	0,2	0,3	1,5	0,8	52,9
Kars	1,0	0,0	0,0	0,0	0,1	0,0	1,2
Kastamonu	2,9	0,0	0,0	0,0	0,2	0,0	3,1
Kayseri	7,3	0,1	0,0	0,1	0,3	0,1	7,9
Kırklareli	5,4	0,0	0,0	0,1	0,3	0,1	5,8
Kırşehir	1,3	0,0	0,0	0,0	0,1	0,0	1,6
Kocaeli	21,0	0,3	0,2	0,3	1,4	0,1	23,3
Konya	10,7	0,2	0,1	0,2	0,9	0,5	12,8
Kütahya	3,5	0,0	0,0	0,1	0,2	0,1	4,0

Malatya	3,0	0,1	0,0	0,1	0,3	0,1	3,4
Manisa	7,6	0,2	0,1	0,2	0,8	0,7	9,5
Kahramanmaraş	2,4	0,1	0,0	0,1	0,3	0,2	2,9
Mardin	0,8	0,1	0,0	0,0	0,3	0,0	1,2
Muğla	15,1	0,1	0,1	0,1	0,6	0,5	16,4
Muş	0,4	0,0	0,0	0,0	0,1	0,0	0,5
Nevşehir	1,3	0,0	0,0	0,0	0,1	0,1	1,6
Niğde	0,9	0,1	0,0	0,0	0,2	0,1	1,3
Ordu	3,0	0,1	0,0	0,0	0,2	0,0	3,4
Rize	2,1	0,1	0,0	0,0	0,1	0,0	2,4
Sakarya	8,0	0,2	0,1	0,1	0,7	0,1	9,2
Samsun	6,5	0,2	0,1	0,1	0,6	0,1	7,5
Siirt	0,3	0,0	0,0	0,0	0,1	0,0	0,4
Sinop	1,2	0,0	0,0	0,0	0,1	0,0	1,3
Sivas	3,2	0,1	0,0	0,1	0,3	0,0	3,7
Tekirdağ	5,1	0,1	0,1	0,1	0,5	0,0	5,8
Tokat	2,2	0,0	0,0	0,0	0,2	0,1	2,5
Trabzon	4,6	0,1	0,1	0,1	0,4	0,0	5,3
Tunceli	0,2	0,0	0,0	0,0	0,0	0,0	0,2
Şanlıurfa	1,6	0,1	0,1	0,1	0,5	0,2	2,6
Uşak	2,0	0,0	0,0	0,0	0,2	0,1	2,4
Van	1,2	0,1	0,0	0,1	0,3	0,0	1,6
Yozgat	1,8	0,0	0,0	0,0	0,2	0,0	2,1
Zonguldak	6,1	0,0	0,0	0,0	0,2	0,0	6,4
Aksaray	1,6	0,0	0,0	0,0	0,2	0,1	2,0
Bayburt	0,3	0,0	0,0	0,0	0,0	0,0	0,3
Karaman	0,7	0,0	0,0	0,0	0,1	0,2	0,9
Kırıkkale	2,0	0,0	0,0	0,0	0,2	0,0	2,2
Batman	1,1	0,0	0,0	0,0	0,1	0,0	1,3
Şırnak	0,3	0,0	0,0	0,0	0,2	0,0	0,5
Bartın	1,5	0,0	0,0	0,0	0,1	0,0	1,6
Ardahan	0,2	0,0	0,0	0,0	0,0	0,0	0,3
Iğdır	0,4	0,0	0,0	0,0	0,1	0,0	0,5
Yalova	1,8	0,1	0,0	0,0	0,2	0,0	2,1
Karabük	1,5	0,0	0,0	0,0	0,1	0,0	1,7
Kilis	0,3	0,0	0,0	0,0	0,0	0,0	0,4
Osmaniye	1,4	0,0	0,0	0,0	0,2	0,1	1,6
Düzce	1,6	0,1	0,0	0,1	0,1	0,0	1,9
Total	677,9	12,0	4,0	7,7	33,0	10,6	745,1

Table B.6 : SO_2 Emissions of Mobile Sources

	PC	Pick Up	Minibus	Buses	Trucks	Motorcycles	TOTAL
PROVINCES	**SO2**	**SO2**	**SO2**	**SO2**	**SO2**	**SO2**	**SO2**
	ton/year	ton/year	ton/year	ton/year	tone/year	ton/year	tone/year
Adana	24,7	19,1	13,0	32,2	190,2	7,7	286,8
Adıyaman	1,6	2,7	2,6	6,4	37,5	0,6	51,2
Afyon	9,1	17,2	11,5	28,6	168,7	1,7	236,7
Ağrı	1,3	2,8	2,4	6,0	35,1	0,0	47,5
Amasya	3,8	6,5	4,3	10,5	62,2	0,6	87,9
Ankara	146,5	30,7	30,3	75,1	443,3	1,8	727,7
Antalya	59,0	37,6	20,6	51,0	301,0	11,0	480,1
Artvin	2,7	2,8	1,3	3,2	19,0	0,1	29,0
Aydın	20,8	15,3	9,5	23,5	138,6	4,7	212,4
Balıkesir	23,6	19,4	11,6	28,8	169,7	4,3	257,4
Bilecik	4,0	7,6	4,6	11,4	67,2	0,3	95,2
Bingöl	0,8	1,9	1,1	2,7	15,9	0,1	22,4
Bitlis	1,2	3,5	2,4	6,0	35,3	0,0	48,4
Bolu	11,8	13,4	8,3	20,6	121,2	1,0	176,2
Burdur	3,2	3,8	3,7	9,2	54,3	1,5	75,8
Bursa	59,3	41,9	21,1	52,2	308,2	3,0	485,7
Çanakkale	10,6	8,8	5,4	13,5	79,5	1,9	119,6
Çankırı	1,9	3,6	2,6	6,4	37,9	0,3	52,7
Çorum	6,5	6,2	5,3	13,2	77,8	1,3	110,3
Denizli	18,2	11,2	7,8	19,3	114,0	3,6	174,2
Diyarbakır	6,3	10,2	4,9	12,1	71,7	0,5	105,8
Edirne	10,5	4,3	3,6	8,9	52,7	0,8	80,8
Elazığ	5,1	5,2	3,3	8,2	48,6	0,6	71,0
Erzincan	2,4	2,7	2,4	6,0	35,5	0,6	49,6
Erzurum	6,6	5,2	1,5	12,6	74,2	0,1	100,0
Eskişehir	14,4	10,4	8,0	19,9	117,3	1,7	171,6
Gaziantep	13,7	20,5	13,1	32,3	190,7	5,9	276,2
Giresun	4,4	9,9	4,7	5,4	69,1	0,1	93,6
Gümüşhane	1,1	2,0	1,4	1,5	19,9	0,0	26,0
Hakkari	0,3	1,7	0,9	0,5	13,1	0,0	16,4
Hatay	11,7	13,0	8,1	20,1	118,4	7,1	178,2
Isparta	8,3	5,9	4,0	9,8	57,8	1,8	87,6
İçel	20,6	32,2	16,4	40,6	239,3	6,3	355,3
İstanbul	471,7	275,5	43,6	108,0	637,1	3,9	1539,8
İzmir	102,9	45,3	28,6	71,0	418,5	9,0	675,4
Kars	2,1	1,8	1,5	3,7	21,9	0,1	31,1
Kastamonu	5,9	3,5	3,4	8,5	49,9	0,4	71,7
Kayseri	15,0	8,3	6,4	15,9	93,9	1,2	140,8
Kırklareli	11,1	5,2	5,0	12,3	72,7	0,7	107,0
Kırşehir	2,7	2,2	2,6	6,5	38,6	0,3	52,9
Kocaeli	43,4	42,6	27,3	67,6	398,6	0,6	580,1
Konya	22,2	30,7	18,1	44,9	264,9	6,2	387,0
Kütahya	7,2	5,2	4,6	11,4	67,2	1,5	97,2

Malatya	6,2	6,3	4,8	11,8	69,4	0,6	99,0
Manisa	15,7	25,0	14,5	35,8	211,2	7,7	309,9
Kahramanmaraş	4,9	6,0	4,8	11,9	70,3	1,9	99,8
Mardin	1,6	7,7	5,1	4,9	74,1	0,2	93,5
Muğla	31,2	16,4	10,5	26,1	153,7	5,3	243,2
Muş	0,8	2,2	1,1	2,8	16,6	0,0	23,5
Nevşehir	2,7	4,7	2,8	6,9	40,5	0,5	58,1
Niğde	1,9	7,1	4,0	10,0	58,8	0,9	82,6
Ordu	6,3	6,1	4,0	9,8	57,9	0,2	84,2
Rize	4,4	7,6	2,8	6,8	40,4	0,1	62,0
Sakarya	16,6	25,4	12,9	32,0	188,6	0,8	276,3
Samsun	13,4	20,2	11,3	28,0	164,9	1,5	239,1
Siirt	0,7	1,9	1,0	2,3	13,8	0,1	19,7
Sinop	2,5	1,7	1,6	4,0	23,6	0,2	33,6
Sivas	6,6	6,4	6,1	15,0	88,5	0,4	123,0
Tekirdağ	10,4	12,8	8,9	22,1	130,4	0,5	185,2
Tokat	4,5	4,5	3,4	8,4	49,6	0,8	71,1
Trabzon	9,5	17,6	7,3	18,1	106,6	0,1	159,2
Tunceli	0,3	1,4	0,7	1,7	10,1	0,0	14,3
Şanlıurfa	3,2	8,9	10,3	25,5	150,3	2,7	200,8
Uşak	4,2	4,2	3,5	8,7	51,6	1,2	73,4
Van	2,4	8,6	5,3	13,1	77,1	0,1	106,5
Yozgat	3,6	3,4	3,9	9,7	57,5	0,2	78,3
Zonguldak	12,5	4,0	3,0	7,5	44,2	0,4	71,7
Aksaray	3,4	3,5	3,6	9,0	53,1	0,6	73,2
Bayburt	0,6	0,9	0,8	1,9	11,1	0,0	15,2
Karaman	1,3	1,6	1,1	2,8	16,6	1,8	25,4
Kırıkkale	4,0	3,8	3,2	7,9	46,8	0,3	66,0
Batman	2,3	3,9	1,7	4,3	25,3	0,1	37,6
Şırnak	0,6	0,9	1,1	0,9	43,7	0,0	47,2
Bartın	3,1	1,6	1,0	2,5	14,8	0,1	23,0
Ardahan	0,4	0,8	0,6	0,7	9,4	0,0	12,0
Iğdır	0,8	2,2	1,3	3,2	19,1	0,0	26,7
Yalova	3,8	6,6	3,4	8,5	50,2	0,1	72,6
Karabük	3,1	3,9	2,6	6,5	38,0	0,0	54,2
Kilis	0,6	0,6	0,4	1,1	6,3	0,3	9,5
Osmaniye	2,8	4,4	3,0	4,0	43,9	0,5	58,8
Düzce	3,4	11,8	6,2	15,4	23,1	0,1	60,0
Total	1396,0	1544,2	594,6	1901,9	9274,2	124,7	14835,6

Table B.7 : Total Emissions of Mobile Sources

	PC	Kamyonet	Minibus	Bus	Truck	Motorcycles	Total
NOx	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**
İstanbul	47069	2473	305	1228	6888	23	57986
Turkey	131392	13858	4165	21634	100269	727	272045
	PC	**Kamyonet**	**Minibus**	**Bus**	**Truck**	**Motorcycles**	**Total**
VOC	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**
İstanbul	22146	488	51	220	987	802	24694
Turkey	63103	2735	699	3866	14366	25747	110516
	PC	**Kamyonet**	**Minibus**	**Bus**	**Truck**	**Motorcycles**	**Total**
NH3	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**
İstanbul	230	2	0	0	2	0	236
Turkey	678	12	4	8	33	11	745
	PC	**Kamyonet**	**Minibus**	**Bus**	**Truck**	**Motorcycles**	**Total**
SO2	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**
İstanbul	472	276	44	108	637	4	1540
Turkey	1396	1544	595	1902	9274	125	14836
	PC	**Kamyonet**	**Minibus**	**Bus**	**Truck**	**Motorcycles**	**Total**
PM10	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**	**tons/yr**
İstanbul	392	446	71	63	434	7	1413
Turkey	1161	2498	967	1107	6311	227	12272

Table B.8 : Emission Factors for Mobile Sources

	Emission Factors for kamyonet														
	NO x gasoline	**NO x diesel**	**NO x LPG**	**VOC gasoline**	**VOC diesel**	**VOC LPG**	**NH3 gasoline**	**NH3 diesel**	**NH3 LPG**	**SO2 gasoline**	**SO2 diesel**	SO2 LPG	PM gasoline	PM diesel	PM LPG
	g/km	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**
RURAL	3,02870	0,92700	2,47323	0,89060	0,10880	0,76182	0,00200	0,00100	0,00000	0,02386	0,18227	0,00000	0,02500	0,30000	0,00000
URBAN	2,31270	3,07180	1,80836	3,40420	0,16640	1,97045	0,00200	0,00100	0,00000	0,03850	0,36214	0,00000	0,02500	0,28146	0,00000
	Rural Emission Factor for Minibus g/km														
	NO x gasoline	**NO x diesel**	**NO x LPG**	**VOC gasoline**	**VOC diesel**	**VOC LPG**	**NH3 gasoline**	**NH3 Diesel**	**NH3 LPG**	**SO2 gasoline**	**SO2 diesel**	SO2 LPG	PM gasoline	PM diesel	PM LPG
	g/km	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**
RURAL	3,02870	0,92700	2,47323	0,89060	0,10880	0,76182	0,00200	0,00100	0,00000	0,02386	0,18227	0,00000	0,02500	0,30000	0,00000
URBAN	2,31270	3,07180	1,80836	3,40420	0,16640	1,97045	0,00200	0,00100	0,00000	0,03850	0,36214	0,00000	0,02500	0,28146	0,00000
	Emission Factor for bus g/km														
	NO x gasoline	**NO x diesel**	**NO x LPG**	**VOC gasoline**	**VOC diesel**	**VOC LPG**	**NH3 gasoline**	**NH3 diesel**	**NH 3 LPG**	**SO2 gasoline**	**SO2 diesel**	**SO2 LPG**	**PM gas**	**PM diesel**	**PM LPG**
	g/km	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**
RURAL	7,50000	8,26000	2,47323	5,50000	1,17049	0,76182	0,00200	0,00300	0,00100	0,05033	0,77128	0,00000	0,02500	0,45409	0,00000
URBAN	4,50000	17,62732	1,80836	7,00000	3,10153	1,97045	0,00200	0,00300	0,00100	0,05214	1,26275	0,00000	0,02500	1,02076	0,00000
	Emission factor for truck g/km														
	NO x gasoline	**NO x diesel**	**NO x LPG**	**VOC gasoline**	**VOC diesel**	**VOC LPG**	**NH3 gasoline**	**NH3 diesel**	**NH3 LPG**	**SO2 gasoline**	**SO2 diesel**	**SO2 LPG**	**PM gasoline**	**PM diesel**	**PM LPG**
	g/km	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**
RURAL	7,50000	9,06000	2,47000	5,50000	1,10462	0,76182	0,00200	0,00300	0,00100	0,05033	0,86638	0,00000	0,02500	0,59382	0,00000
URBAN	4,50000	17,63253	1,80836	7,00000	3,10153	1,97045	0,00200	0,00300	0,00100	0,05214	1,38240	0,00000	0,02500	1,29612	0,00000
	Emission Factors for motorcycle g/km														
	NO x gasoline	**NO x diesel**	**NO x LPG**	**VOC g**	**VOC d**	**VOC LPG**	**NH3 gasoline**	**NH3 diesel**	**NH3 LPG**	**SO2 gasoline**	**SO2 diesel**	**SO2 LPG**	**PM gasoline**	**PM diesel**	**PM LPG**
	g/km	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**	**g/km**
RURAL	0,13750	0,13750	0,13750	4,86800	4,86800	4,86800	0,00200	0,00200	0,00200	0,02357	0,02357	0,02357	0,04400	0,04400	0,04400
URBAN	0,13750	0,13750	0,13750	4,86800	4,86800	4,86800	0,00200	0,00200	0,00200	0,02062	0,02062	0,02062	0,04400	0,04400	0,04400

C: SMALL COMBUSTION

Table C.1: Fuel Consumption in Turkey in 2003

		COAL TYPE					OIL		
TYPE OF FUEL		**Coking Coal**	**Other Bit. Coal & Anthracite**	**Lignite/ Brown Coal**	**Coke Oven Coke**	**BKB Peat Briquettes**	**LPG**	**Kerosene**	**Residual Fuel Oil**
UNIT	%	**kt**	**kt**	**kt**	**kt**	**kt**	**kt**	**kt**	**kt**
TURKEY	**Ratio pop.**	**209**	**825**	**4244**	**159**	**47**	**2027**	**71**	**500**
Adana	2,73	5,70	22,50	115,76	4,34	1,28	55,29	1,94	13,64
Adıyaman	0,92	1,92	7,59	39,05	1,46	0,43	18,65	0,65	4,60
Afyon	1,20	2,50	9,89	50,85	1,91	0,56	24,29	0,85	5,99
Ağrı	0,78	1,63	6,43	33,10	1,24	0,37	15,81	0,55	3,90
Amasya	0,54	1,13	4,44	22,86	0,86	0,25	10,92	0,38	2,69
Ankara	5,91	12,35	48,77	250,86	9,40	2,78	119,82	4,20	29,55
Antalya	2,54	5,30	20,92	107,64	4,03	1,19	51,41	1,80	12,68
Artvin	0,28	0,59	2,34	12,01	0,45	0,13	5,74	0,20	1,42
Aydın	1,40	2,93	11,57	59,51	2,23	0,66	28,42	1,00	7,01
Balıkesir	1,59	3,32	13,10	67,37	2,52	0,75	32,18	1,13	7,94
Bilecik	0,29	0,60	2,36	12,16	0,46	0,13	5,81	0,20	1,43
Bingöl	0,37	0,78	3,09	15,88	0,60	0,18	7,59	0,27	1,87
Bitlis	0,57	1,20	4,73	24,33	0,91	0,27	11,62	0,41	2,87
Bolu	0,40	0,83	3,29	16,94	0,63	0,19	8,09	0,28	2,00
Burdur	0,38	0,79	3,12	16,07	0,60	0,18	7,68	0,27	1,89
Bursa	3,13	6,55	25,86	133,02	4,98	1,47	63,53	2,23	15,67
Çanakkale	0,69	1,43	5,66	29,10	1,09	0,32	13,90	0,49	3,43
Çankırı	0,40	0,83	3,29	16,92	0,63	0,19	8,08	0,28	1,99
Çorum	0,88	1,84	7,26	37,37	1,40	0,41	17,85	0,63	4,40
Denizli	1,25	2,62	10,34	53,21	1,99	0,59	25,41	0,89	6,27
Diyarbakır	2,01	4,20	16,58	85,29	3,20	0,94	40,74	1,43	10,05
Edirne	0,59	1,24	4,90	25,20	0,94	0,28	12,04	0,42	2,97
Elazığ	0,84	1,76	6,93	35,65	1,34	0,39	17,03	0,60	4,20
Erzincan	0,47	0,98	3,86	19,83	0,74	0,22	9,47	0,33	2,34
Erzurum	1,38	2,89	11,41	58,67	2,20	0,65	28,02	0,98	6,91
Eskişehir	1,04	2,18	8,59	44,19	1,66	0,49	21,11	0,74	5,21
Gaziantep	1,90	3,96	15,64	80,45	3,01	0,89	38,42	1,35	9,48
Giresun	0,77	1,61	6,37	32,79	1,23	0,36	15,66	0,55	3,86
Gümüşhane	0,28	0,58	2,27	11,70	0,44	0,13	5,59	0,20	1,38
Hakkari	0,35	0,73	2,88	14,81	0,55	0,16	7,07	0,25	1,74
Hatay	1,85	3,86	15,25	78,47	2,94	0,87	37,48	1,31	9,25
Isparta	0,76	1,58	6,25	32,15	1,20	0,36	15,36	0,54	3,79
İçel	2,44	5,09	20,09	103,36	3,87	1,14	49,37	1,73	12,18
İstanbul	14,78	30,88	121,90	627,10	23,49	6,94	299,51	10,49	73,88
İzmir	4,97	10,39	41,01	210,99	7,90	2,34	100,77	3,53	24,86
Kars	0,48	1,00	3,95	20,34	0,76	0,23	9,72	0,34	2,40
Kastamonu	0,55	1,16	4,57	23,50	0,88	0,26	11,22	0,39	2,77
Kayseri	1,56	3,27	12,90	66,37	2,49	0,74	31,70	1,11	7,82
Kırklareli	0,48	1,01	4,00	20,56	0,77	0,23	9,82	0,34	2,42
Kırşehir	0,37	0,78	3,08	15,85	0,59	0,18	7,57	0,27	1,87
Kocaeli	1,78	3,72	14,67	75,49	2,83	0,84	36,06	1,26	8,89
Kütahya	0,97	2,02	7,99	41,12	1,54	0,46	19,64	0,69	4,84
Malatya	1,26	2,63	10,39	53,43	2,00	0,59	25,52	0,89	6,30
Manisa	1,86	3,88	15,33	78,88	2,96	0,87	37,67	1,32	9,29

Kahramanmaraş	1,48	3,09	12,20	62,74	2,35	0,69	29,97	1,05	7,39
Mardin	1,04	2,17	8,58	44,13	1,65	0,49	21,08	0,74	5,20
Muğla	1,05	2,20	8,70	44,77	1,68	0,50	21,38	0,75	5,27
Muş	0,67	1,40	5,52	28,40	1,06	0,31	13,56	0,48	3,35
Nevşehir	0,46	0,96	3,77	19,40	0,73	0,21	9,26	0,32	2,29
Niğde	0,51	1,07	4,24	21,79	0,82	0,24	10,41	0,36	2,57
Ordu	1,31	2,74	10,80	55,57	2,08	0,62	26,54	0,93	6,55
Rize	0,54	1,13	4,45	22,90	0,86	0,25	10,94	0,38	2,70
Sakarya	1,12	2,33	9,20	47,33	1,77	0,52	22,61	0,79	5,58
Samsun	1,78	3,73	14,71	75,68	2,84	0,84	36,15	1,27	8,92
Siirt	0,39	0,81	3,21	16,50	0,62	0,18	7,88	0,28	1,94
Sinop	0,33	0,70	2,74	14,12	0,53	0,16	6,74	0,24	1,66
Sivas	1,11	2,33	9,19	47,26	1,77	0,52	22,57	0,79	5,57
Tekirdağ	0,92	1,92	7,59	39,03	1,46	0,43	18,64	0,65	4,60
Tokat	1,22	2,55	10,07	51,83	1,94	0,57	24,75	0,87	6,11
Trabzon	1,44	3,01	11,86	61,04	2,29	0,68	29,15	1,02	7,19
Tunceli	0,14	0,29	1,14	5,86	0,22	0,06	2,80	0,10	0,69
Şanlıurfa	2,13	4,45	17,56	90,35	3,38	1,00	43,15	1,51	10,64
Uşak	0,48	0,99	3,92	20,17	0,76	0,22	9,64	0,34	2,38
Van	1,29	2,70	10,68	54,93	2,06	0,61	26,23	0,92	6,47
Yozgat	1,01	2,11	8,31	42,75	1,60	0,47	20,42	0,72	5,04
Zonguldak	0,91	1,90	7,49	38,53	1,44	0,43	18,40	0,64	4,54
Aksaray	0,58	1,22	4,82	24,79	0,93	0,27	11,84	0,41	2,92
Bayburt	0,14	0,30	1,18	6,09	0,23	0,07	2,91	0,10	0,72
Karaman	0,36	0,75	2,96	15,22	0,57	0,17	7,27	0,25	1,79
Kırıkkale	0,57	1,18	4,67	24,00	0,90	0,27	11,46	0,40	2,83
Batman	0,67	1,41	5,56	28,59	1,07	0,32	13,65	0,48	3,37
Şırnak	0,52	1,09	4,30	22,11	0,83	0,24	10,56	0,37	2,60
Bartın	0,27	0,57	2,24	11,53	0,43	0,13	5,51	0,19	1,36
Ardahan	0,20	0,41	1,63	8,37	0,31	0,09	4,00	0,14	0,99
Iğdır	0,25	0,52	2,05	10,56	0,40	0,12	5,04	0,18	1,24
Yalova	0,25	0,52	2,05	10,55	0,40	0,12	5,04	0,18	1,24
Karabük	0,33	0,69	2,74	14,09	0,53	0,16	6,73	0,24	1,66
Kilis	0,17	0,35	1,40	7,18	0,27	0,08	3,43	0,12	0,85
Osmaniye	0,68	1,41	5,58	28,72	1,08	0,32	13,72	0,48	3,38
Düzce	0,46	0,97	3,82	19,67	0,74	0,22	9,39	0,33	2,32
TOTAL	100,00	209,00	825,00	4244,00	159,00	47,00	2027,00	71,00	500,00

Table C.2: Fuel Consumption in Turkey in 2003

TYPE OF FUEL		Natural Gas	Primary Solid Biomass	Geo Thermal	Solar Thermal	Electicity
UNIT	%	**TJ**	**PJ**	**PJ**	**PJ**	**GWh**
TURKEY	**Ratio pop.**	**156399**	**240,623**	**32,818**	**9,67**	**25195**
Adana	2,73	4266,07	6,56	0,90	0,26	687,24
Adıyaman	0,92	1438,91	2,21	0,30	0,09	231,80
Afyon	1,20	1873,95	2,88	0,39	0,12	301,88
Ağrı	0,78	1219,62	1,88	0,26	0,08	196,47
Amasya	0,54	842,46	1,30	0,18	0,05	135,71
Ankara	5,91	9244,68	14,22	1,94	0,57	1489,27
Antalya	2,54	3966,84	6,10	0,83	0,25	639,04
Artvin	0,28	442,72	0,68	0,09	0,03	71,32
Aydın	1,40	2193,05	3,37	0,46	0,14	353,29
Balıkesir	1,59	2482,74	3,82	0,52	0,15	399,96
Bilecik	0,29	448,24	0,69	0,09	0,03	72,21
Bingöl	0,37	585,28	0,90	0,12	0,04	94,29
Bitlis	0,57	896,54	1,38	0,19	0,06	144,43
Bolu	0,40	624,30	0,96	0,13	0,04	100,57
Burdur	0,38	592,35	0,91	0,12	0,04	95,42
Bursa	3,13	4901,93	7,54	1,03	0,30	789,67
Çanakkale	0,69	1072,53	1,65	0,23	0,07	172,78
Çankırı	0,40	623,61	0,96	0,13	0,04	100,46
Çorum	0,88	1377,21	2,12	0,29	0,09	221,86
Denizli	1,25	1960,71	3,02	0,41	0,12	315,86
Diyarbakır	2,01	3143,27	4,84	0,66	0,19	506,36
Edirne	0,59	928,67	1,43	0,19	0,06	149,60
Elazığ	0,84	1313,90	2,02	0,28	0,08	211,66
Erzincan	0,47	730,84	1,12	0,15	0,05	117,73
Erzurum	1,38	2162,22	3,33	0,45	0,13	348,32
Eskişehir	1,04	1628,51	2,51	0,34	0,10	262,34
Gaziantep	1,90	2964,60	4,56	0,62	0,18	477,58
Giresun	0,77	1208,26	1,86	0,25	0,07	194,64
Gümüşhane	0,28	431,23	0,66	0,09	0,03	69,47
Hakkari	0,35	545,71	0,84	0,11	0,03	87,91
Hatay	1,85	2891,89	4,45	0,61	0,18	465,87
Isparta	0,76	1184,88	1,82	0,25	0,07	190,88
İçel	2,44	3809,18	5,86	0,80	0,24	613,64
İstanbul	14,78	23109,58	35,55	4,85	1,43	3722,82
İzmir	4,97	7775,36	11,96	1,63	0,48	1252,57
Kars	0,48	749,69	1,15	0,16	0,05	120,77
Kastamonu	0,55	866,09	1,33	0,18	0,05	139,52
Kayseri	1,56	2446,03	3,76	0,51	0,15	394,04
Kırklareli	0,48	757,64	1,17	0,16	0,05	122,05
Kırşehir	0,37	584,13	0,90	0,12	0,04	94,10
Kocaeli	1,78	2782,00	4,28	0,58	0,17	448,16
Konya	3,23	5056,53	7,78	1,06	0,31	814,58
Kütahya	0,97	1515,24	2,33	0,32	0,09	244,10
Malatya	1,26	1969,08	3,03	0,41	0,12	317,21
Manisa	1,86	2906,75	4,47	0,61	0,18	468,26

TYPE OF FUEL		Natural Gas	Primary Solid Biomass	Geo Thermal	Solar Thermal	Electicity
Kahramanmaraş	1,48	2312,14	3,56	0,49	0,14	372,47
Mardin	1,04	1626,40	2,50	0,34	0,10	262,00
Muğla	1,05	1650,00	2,54	0,35	0,10	265,81
Muş	0,67	1046,41	1,61	0,22	0,06	168,57
Nevşehir	0,46	714,86	1,10	0,15	0,04	115,16
Niğde	0,51	802,90	1,24	0,17	0,05	129,34
Ordu	1,31	2047,75	3,15	0,43	0,13	329,88
Rize	0,54	844,09	1,30	0,18	0,05	135,98
Sakarya	1,12	1744,20	2,68	0,37	0,11	280,98
Samsun	1,78	2789,04	4,29	0,59	0,17	449,30
Siirt	0,39	608,20	0,94	0,13	0,04	97,98
Sinop	0,33	520,32	0,80	0,11	0,03	83,82
Sivas	1,11	1741,72	2,68	0,37	0,11	280,58
Tekirdağ	0,92	1438,40	2,21	0,30	0,09	231,72
Tokat	1,22	1909,96	2,94	0,40	0,12	307,68
Trabzon	1,44	2249,29	3,46	0,47	0,14	362,35
Tunceli	0,14	215,86	0,33	0,05	0,01	34,77
Şanlıurfa	2,13	3329,45	5,12	0,70	0,21	536,36
Uşak	0,48	743,46	1,14	0,16	0,05	119,77
Van	1,29	2024,13	3,11	0,42	0,13	326,08
Yozgat	1,01	1575,25	2,42	0,33	0,10	253,76
Zonguldak	0,91	1419,96	2,18	0,30	0,09	228,75
Aksaray	0,58	913,62	1,41	0,19	0,06	147,18
Bayburt	0,14	224,57	0,35	0,05	0,01	36,18
Karaman	0,36	561,00	0,86	0,12	0,03	90,37
Kırıkkale	0,57	884,61	1,36	0,19	0,05	142,51
Batman	0,67	1053,52	1,62	0,22	0,07	169,72
Şırnak	0,52	814,70	1,25	0,17	0,05	131,24
Bartın	0,27	424,83	0,65	0,09	0,03	68,44
Ardahan	0,20	308,53	0,47	0,06	0,02	49,70
Iğdır	0,25	388,98	0,60	0,08	0,02	62,66
Yalova	0,25	388,88	0,60	0,08	0,02	62,65
Karabük	0,33	519,23	0,80	0,11	0,03	83,64
Kilis	0,17	264,63	0,41	0,06	0,02	42,63
Osmaniye	0,68	1058,24	1,63	0,22	0,07	170,48
Düzce	0,46	724,90	1,12	0,15	0,04	116,78
TOTAL	100,00	156399,00	240,62	32,82	9,67	25195,00

D: LARGE COMBUSTION

Table D.1: Quality of power plants in Turkey

POWER PLANT	Fuel Quality (kcal/kg)	Unit Fuel Consumption (g/kWh)	Unit Heat Consum. kcal/kwh	Efficiency %	Fuel Consum. PJ
AFŞİN-ELBİSTAN	1239	2218	2748	31	102
ORHANELİ	2162	1034	2236	38	13
SEYİTÖMER	1715	1523	2612	33	43
TUÇBİLEK	2170	1080	2344	37	27
KANGAL	1267	2099	2659	32	22
ÇATALAĞZI-B	3400	800	2720	32	22
HOPA	9600	330	3168	27	3
ANBARLI	9600	241	2314	37	40
SOMA-A	3121	974	3040	28	4
SOMA-B	1824	1514	2762	31	74
YATAĞAN	2026	1318	2670	32	46
KEMERKÖY	1496	1693	2533	34	43
YENİKÖY	1544	1547	2389	36	27
ÇAYIRHAN	1977	1300	2570	33	42
ERDEMİR	8250	298	2460	35	10
ÇOLAKOĞLU	8250	298	2460	35	10
ALİAĞA PETKİM	9500	238	2260	38	7
İSDEMİR	9500	238	2260	38	9

POWER PLANT	Year	Fuel Type	PLACE		SECTOR	Number of Unit	Installed Capacity (MW)	Production Capacity (GWh)
			Province	Region				
AFŞİN-ELBİSTAN	1984	Lignite	K.MARAŞ	GDA	TEAŞ	4	1360	8840
ORHANELİ	1992	Lignite	BURSA	MAR	TEAŞ	1	210	1365
SEYİTÖMER	1973	Lignite	KÜTAHYA	EGE	TEAŞ	4	600	3900
TUÇBİLEK	1956	Lignite	KÜTAHYA	EGE	TEAŞ	5	429	2790
KANGAL	1991	Lignite	SİVAS	İÇ	TEAŞ	2	300	1950
ÇATALAĞZI-B	1989	Hard Coal	ZONGULDAK		TEAŞ	2	300	1950
HOPA	1973	Fuel Oil	ARTVİN		TEAŞ	2	50	200
ANBARLI	1967	Fuel Oil	İSTANBUL	MAR	TEAŞ	5	630	4100
SOMA-A	1981	Lignite	MANİSA	EGE	BAK	2	44	290
SOMA-B		Lignite	MANİSA	EGE	BAK	6	990	6435
YATAĞAN	1982	Lignite	MUĞLA	EGE	TEAŞ	3	630	4100
KEMERKÖY	1993	Lignite	MUĞLA	EGE	BAK	3	630	4095
YENİKÖY	1987	Lignite	MUĞLA	EGE	BAK	2	420	2730
ÇAYIRHAN	1988	Lignite	ANKARA	İÇ	TEAŞ	4	620	3922
ERDEMİR	1964		ZONGULDAK	KDEN	OTOPR		127	939
ÇOLAKOĞLU	1999	Coal	İSTANBUL	MAR	OTOPR		123,4	973
ALİAĞA PETKİM	1975	Fuel Oil	İZMİR	EGE	OTOPR		148	730
İSDEMİR	1975	Liquid Gas	HATAY	AKDENİZ	OTOPR		220	930

Table D.2: Fuel consumption of power plants in Turkey

POWER PLANT	Fuel Type	PLACE		Technology	Fuel Consum.
		Province	Region		PJ
AFŞİN-ELBİSTAN	Lignite	K.MARAŞ	GDANAD	PC	102
ORHANELİ	Lignite	BURSA	MAR	PC FGD	13
SEYİTÖMER	Lignite	KÜTAHYA	EGE	PC	43
TUNÇBİLEK	Lignite	KÜTAHYA	EGE	PC	27
KANGAL	Lignite	SİVAS	İÇ	PC	22
ÇATALAĞZI-B	Hard Coal	ZONGULDAK		PC	22
HOPA	Fuel Oil	ARTVİN			3
ANBARLI	Fuel Oil	İSTANBUL	MAR		40
SOMA-A	Lignite	MANİSA	EGE	PC	4
SOMA-B	Lignite	MANİSA	EGE	PC	74
YATAĞAN	Lignite	MUĞLA	EGE	PC FGD	46
KEMERKÖY	Lignite	MUĞLA	EGE	PC FGD	43
YENİKÖY	Lignite	MUĞLA	EGE	PC FGD	27
ÇAYIRHAN	Lignite	ANKARA	İÇ	PC FGD	42
ERDEMİR	Fuel Oil Gas	ZONGULDAK	KDEN		10
ÇOLAKOĞLU	Coal	İSTANBUL	MAR	CFB	10
ALİAĞA PETKİM	Fuel Oil	İZMİR	EGE		7
İSDEMİR	Liquid Gas	HATAY	AKDENİZ	Single drum	9

Table D.2: Emissions of power plants in Turkey

	Emission Factor					Emissions				
	SO2	NOx	PM10	NH3	VOC	SO2	NOx	PM10	NH3	VOC
POWER PLANT	kt SO2/PJ	kt Nox/PJ	kt PM10/PJ	kt NH3/PJ	kt VOC/PJ	kt	kt	kt	kt	kt
AFŞİN-ELBİSTAN	3,591	0,27	3,251	0,008	0,015	365,0	27,4	330,4	0,8	1,5
ORHANELİ	3,591	0,27	3,251	0,008	0,015	45,9	3,4	41,5	0,1	0,2
SEYİTÖMER	3,591	0,27	3,251	0,008	0,015	153,1	11,5	138,6	0,3	0,6
TUNÇBİLEK	3,591	0,27	3,251	0,008	0,015	98,2	7,4	88,9	0,2	0,4
KANGAL	3,591	0,27	3,251	0,008	0,015	77,9	5,9	70,5	0,2	0,3
ÇATALAĞZI-B	1,996	0,3	1,208	0,008	0,01	44,3	6,7	26,8	0,2	0,2
HOPA	1,25	0,2	0,01318	0,059	0,005	3,3	0,5	0,0	0,2	0,0
ANBARLI	1,25	0,2	0,01318	0,059	0,005	49,6	7,9	0,5	2,3	0,2
SOMA-A	3,591	0,27	3,251	0,008	0,015	13,3	1,0	12,0	0,0	0,1
SOMA-B	3,591	0,27	3,251	0,008	0,015	267,0	20,1	241,7	0,6	1,1
YATAĞAN	3,591	0,27	3,251	0,008	0,015	164,5	12,4	148,9	0,4	0,7
KEMERKÖY	3,591	0,27	3,251	0,008	0,015	155,8	11,7	141,1	0,3	0,7
YENİKÖY	3,591	0,27	3,251	0,008	0,015	98,0	7,4	88,7	0,2	0,4
ÇAYIRHAN	3,591	0,27	3,251	0,008	0,015	151,4	11,4	137,1	0,3	0,6
ERDEMİR	1,25	0,2	0,01318	0,059	0,005	12,1	1,9	0,1	0,6	0,0
ÇOLAKOĞLU	3,591	0,27	3,251	0,008	0,015	36,0	2,7	32,6	0,1	0,2
ALİAĞA PETKİM	1,25	0,2	0,01318	0,059	0,005	8,6	1,4	0,1	0,4	0,0
İSDEMİR	1,25	0,2	0,01318	0,059	0,005	11,0	1,8	0,1	0,5	0,0
TOTAL						1755,0	142,5	1499,8	7,8	7,4

E: INDUSTRIAL PROCESSES

Table E:1: Iron and Steel Industry

IRON AND STEEL INDUSTRY		Name	Province	Production	EF	Emissions	Abated Emissions by removal techn.efficiency
					PM10	PM10	
				kt/a	g/ton	kt	kt/a
Integrated Iron and Steel Plants	1	Eregli	Zonguldak	2388	14630	34,9	5,2
	2	Iskenderun	Iskenderun	1965	14630	28,7	4,3
	3	Karabük	Karabük	875	14630	12,8	1,9
Electrical Arc Iron and Steel Plants	4	Asil	Bursa	200	10179	2,0	0,3
	5	Aypas	Kocaeli	0	10179	0,0	0,0
	6	Cebitas	İzmir	417	10179	4,2	0,6
	7	Cemtas	Bursa	134	10179	1,4	0,2
	8	Çolakoğlu	Kocaeli	1570	10179	16,0	2,4
	9	Cukurova	İzmir	439	10179	4,5	0,7
	10	Diler	Kocaeli	263	10179	2,7	0,4
	11	Ege	İzmir	559	10179	5,7	0,9
	12	Ekinciler	Iskenderun	404	10179	4,1	0,6
	13	Habas	İzmir	1324	10179	13,5	2,0
	14	Icdas	İstanbul	1384	10179	14,1	2,1
	15	İzmir	İzmir	743	10179	7,6	1,1
	16	Kroman	Kocaeli	626	10179	6,4	1,0
	17	Metas	İzmir	0	10179	0,0	0,0
	18	MKEK	Kırıkkale	6	10179	0,1	0,0
	19	Sivas	Sivas	0	10179	0,0	0,0
	20	Tuber	İstanbul	0	10179	0,0	0,0
	21	Yazici	Iskenderun	824	10179	8,4	1,3
	22	Yesilyurt	Samsun	202	10179	2,1	0,3

Table E.2: Crude Oil Refineries

No	Name of refinery	Installed capacity	Processed Crude Oil	Capacity	EF				Emission			
					SO2	NOx	PM10	VOC	SO2	NOx	PM10	VOC
		kt/year	kt/year	%	kt/mton	kt/mton	kt/mton	kt/mt	kt	kt	kt	kt
1	Batman	1100	800	70,5	0,9	0,3	0,12	2,34	1	0	0	2
2	İzmir Aliağa	10000	10700	106,5	0,9	0,3	0,12	2,34	10	3	1	25
3	İzmit Yarimca	11500	6400	56	0,9	0,3	0,12	2,34	6	2	1	15
4	Kırıkkale Orta Anadolu	5000	3400	67,4	0,9	0,3	0,12	2,34	3	1	0	8
5	Tüpras Total	27600	21300	77	0,9	0,3	0,12	2,34	19	6	3	50
6	Atas Mersin	4400	2900	67	0,9	0,3	0,12	2,34	3	1	0	7
	TOTAL	32000	24200	75,6	0,9	0,3	0,12	2,34	22	7	3	57

Table E.3: Cement Industry

				Production	Capacity	EF		
NO	**Name**	**Region**	**Province**	**Capacity**	**usage**	**SO2**	**NOx**	**PM10**
				kt/yr	**%**	**kt/mton**	**kt/mton**	**kt/mton**
1	Akcimento	Marmara	İstanbul	3700	61,05	0,95	1,75	54,6
2	Balıkesir	Marmara	Balıkesir	450	61,05	0,95	1,75	54,6
3	Bursa	Marmara	Bursa	2603	61,05	0,95	1,75	54,6
4	Çanakkale	Marmara	Çanakkale	2000	61,05	0,95	1,75	54,6
5	Darica	Marmara	Kocaeli	2700	61,05	0,95	1,75	54,6
6	Lalapasa	Marmara	Edirne	1152	61,05	0,95	1,75	54,6
7	Nuh	Marmara	Kocaeli	3750	61,05	0,95	1,75	54,6
8	Trakya	Marmara	Kırklareli	2220	61,05	0,95	1,75	54,6
9	Anadolu	Marmara	İstanbul	700	61,05	0,95	1,75	54,6
10	Ikon	Marmara	Kocaeli	440	61,05	0,95	1,75	54,6
11	Marmara	Marmara	İstanbul	750	61,05	0,95	1,75	54,6
				20465		0,95	1,75	54,6
12	Baticim	Ege	İzmir	2200	62,48	0,95	1,75	54,6
13	Batisoke	Ege	Aydın	1194	62,48	0,95	1,75	54,6
14	Cimentas	Ege	İzmir	2050	62,48	0,95	1,75	54,6
15	Denizli	Ege	Denizli	2250	62,48	0,95	1,75	54,6
16	Bakircay	Ege	İzmir	100	62,48	0,95	1,75	54,6
				7794		0,95	1,75	54,6
17	Adana	Akdeniz	Adana	3643	51,71	0,95	1,75	54,6
18	Cimsa	Akdeniz	Mersin	3620	51,71	0,95	1,75	54,6
19	Goltas	Akdeniz	Isparta	2992	51,71	0,95	1,75	54,6
20	Adomad	Akdeniz	Antalya	500	51,71	0,95	1,75	54,6
21	Iskenderun	Akdeniz	Antakya	1000	51,71	0,95	1,75	54,6
22	Ozgur Beton	Akdeniz	Antalya	180	51,71	0,95	1,75	54,6
				11935		0,95	1,75	54,6
23	Bartın	Karadeniz	Bartın	350	66,85	0,95	1,75	54,6
24	Bolu	Karadeniz	Bolu	1800	66,85	0,95	1,75	54,6
25	Çorum	Karadeniz	Çorum	500	66,85	0,95	1,75	54,6
26	Ladik	Karadeniz	Samsun	900	66,85	0,95	1,75	54,6
27	Trabzon	Karadeniz	Trabzon	450	66,85	0,95	1,75	54,6
28	Unye	Karadeniz	Ordu	1700	66,85	0,95	1,75	54,6
29	Aytek	Karadeniz	Zonguldak	250	66,85	0,95	1,75	54,6
30	Eregli	Karadeniz	Zonguldak	210	66,85	0,95	1,75	54,6
31	Gümüşhane	Karadeniz	Gümüşhane	150	66,85	0,95	1,75	54,6
32	Karcimsa	Karadeniz	Karabük	258	66,85	0,95	1,75	54,6
33	Samsun	Karadeniz	Samsun	449	66,85	0,95	1,75	54,6
				7017		0,95	1,75	54,6
34	Afyon	Ic Anadolu	Afyon	640	62,79	0,95	1,75	54,6
35	Ankara	Ic Anadolu	Ankara	1610	62,79	0,95	1,75	54,6
36	Bastas	Ic Anadolu	Ankara	1740	62,79	0,95	1,75	54,6
37	Eskişehir	Ic Anadolu	Eskişehir	610	62,79	0,95	1,75	54,6
38	Konya	Ic Anadolu	Konya	2074	62,79	0,95	1,75	54,6
39	Niğde	Ic Anadolu	Niğde	917	62,79	0,95	1,75	54,6
40	Sivas	Ic Anadolu	Sivas	615	62,79	0,95	1,75	54,6
41	Yozgat	Ic Anadolu	Yozgat	800	62,79	0,95	1,75	54,6
42	Cim Kayseri	Ic Anadolu	Kayseri	666	62,79	0,95	1,75	54,6
43	Hasanoglan	Ic Anadolu	Ankara	500	62,79	0,95	1,75	54,6
44	Istas	Ic Anadolu	Ankara	300	62,79	0,95	1,75	54,6

				Production Capacity	Capacity usage	EF		
NO	**Name**	**Region**	**Province**			**SO2**	**NOx**	**PM10**
				kt/yr	**%**	**kt/mton**	**kt/mton**	**kt/mton**
46	Askale	Dogu Anadolu	Erzurum	750	85,43	0,95	1,75	54,6
47	Elazığ	Dogu Anadolu	Elazığ	900	85,43	0,95	1,75	54,6
48	Kars	Dogu Anadolu	Kars	400	85,43	0,95	1,75	54,6
49	Van	Dogu Anadolu	Van	220	85,43	0,95	1,75	54,6
				2270		0,95	1,75	54,6
50	Adıyaman	GD Anadolu	Adıyaman	900	84,83	0,95	1,75	54,6
51	Ergani	GD Anadolu	Diyarbakır	682	84,83	0,95	1,75	54,6
52	Gaziantep	GD Anadolu	Gaziantep	670	84,83	0,95	1,75	54,6
53	Kurtalan	GD Anadolu	Siirt	800	84,83	0,95	1,75	54,6
54	Mardin	GD Anadolu	Mardin	1020	84,83	0,95	1,75	54,6
55	Şanlıurfa	GD Anadolu	Şanlıurfa	630	84,83	0,95	1,75	54,6
				4702		0,95	1,75	54,6

Table E.3: Emissions of Cement Industry

			Emission			Abated Emmission by removal	
NO	**Name**	**Region**	**SO2**	**NOx**	**PM10**	**SO2**	**PM10**
			kt/a	**kt/a**	**kt/a**	**kt/a**	**kt/a**
1	Akcimento	Marmara	2,1	4,0	123,3	1,1	18,5
2	Balıkesir	Marmara	0,3	0,5	15,0	0,1	2,2
3	Bursa	Marmara	1,5	2,8	86,8	0,8	13,0
4	Çanakkale	Marmara	1,2	2,1	66,7	0,6	10,0
5	Darica	Marmara	1,6	2,9	90,0	0,8	13,5
6	Lalapasa	Marmara	0,7	1,2	38,4	0,3	5,8
7	Nuh	Marmara	2,2	4,0	125,0	1,1	18,7
8	Trakya	Marmara	1,3	2,4	74,0	0,6	11,1
9	Anadolu	Marmara	0,4	0,7	23,3	0,2	3,5
10	Ikon	Marmara	0,3	0,5	14,7	0,1	2,2
11	Marmara	Marmara	0,4	0,8	25,0	0,2	3,7
			11,9	21,9	682,1	5,9	102,3
12	Baticim	Ege	1,3	2,4	75,1	0,7	11,3
13	Batisoke	Ege	0,7	1,3	40,7	0,4	6,1
14	Cimentas	Ege	1,2	2,2	69,9	0,6	10,5
15	Denizli	Ege	1,3	2,5	76,8	0,7	11,5
16	Bakircay	Ege	0,1	0,1	3,4	0,0	0,5
			4,6	8,5	265,9	2,3	39,9
17	Adana	Akdeniz	1,8	3,3	102,9	0,9	15,4
18	Cimsa	Akdeniz	1,8	3,3	102,2	0,9	15,3
19	Goltas	Akdeniz	1,5	2,7	84,5	0,7	12,7
20	Adomad	Akdeniz	0,2	0,5	14,1	0,1	2,1
21	Iskenderun	Akdeniz	0,5	0,9	28,2	0,2	4,2
22	Ozgur Beton	Akdeniz	0,1	0,2	5,1	0,0	0,8
			5,9	10,8	337,0	2,9	50,5

23	Bartın	Karadeniz	0,2	0,4	12,8	0,1	1,9
24	Bolu	Karadeniz	1,1	2,1	65,7	0,6	9,9
25	Çorum	Karadeniz	0,3	0,6	18,3	0,2	2,7
26	Ladik	Karadeniz	0,6	1,1	32,9	0,3	4,9
27	Trabzon	Karadeniz	0,3	0,5	16,4	0,1	2,5
28	Unye	Karadeniz	1,1	2,0	62,1	0,5	9,3
29	Aytek	Karadeniz	0,2	0,3	9,1	0,1	1,4
30	Eregli	Karadeniz	0,1	0,2	7,7	0,1	1,1
31	Gümüşhane	Karadeniz	0,1	0,2	5,5	0,0	0,8
32	Karcimsa	Karadeniz	0,2	0,3	9,4	0,1	1,4
33	Samsun	Karadeniz	0,3	0,5	16,4	0,1	2,5
			4,5	8,2	256,1	2,2	38,4
34	Afyon	Ic Anadolu	0,4	0,7	21,9	0,2	3,3
35	Ankara	Ic Anadolu	1,0	1,8	55,2	0,5	8,3
36	Bastas	Ic Anadolu	1,0	1,9	59,7	0,5	8,9
37	Eskişehir	Ic Anadolu	0,4	0,7	20,9	0,2	3,1
38	Konya	Ic Anadolu	1,2	2,3	71,1	0,6	10,7
39	Niğde	Ic Anadolu	0,5	1,0	31,4	0,3	4,7
40	Sivas	Ic Anadolu	0,4	0,7	21,1	0,2	3,2
41	Yozgat	Ic Anadolu	0,5	0,9	27,4	0,2	4,1
42	Cim Kayseri	Ic Anadolu	0,4	0,7	22,8	0,2	3,4
43	Hasanoglan	Ic Anadolu	0,3	0,5	17,1	0,1	2,6
44	Istas	Ic Anadolu	0,2	0,3	10,3	0,1	1,5
45	Nevşehir	Ic Anadolu	0,3	0,5	17,1	0,1	2,6
			6,5	12,1	376,2	3,3	56,4
46	Askale	Dogu Anadolu	0,6	1,1	35,0	0,3	5,2
47	Elazığ	Dogu Anadolu	0,7	1,3	42,0	0,4	6,3
48	Kars	Dogu Anadolu	0,3	0,6	18,7	0,2	2,8
49	Van	Dogu Anadolu	0,2	0,3	10,3	0,1	1,5
			1,8	3,4	105,9	0,9	15,9
50	Adıyaman	GD Anadolu	0,7	1,3	41,7	0,4	6,3
51	Ergani	GD Anadolu	0,6	1,0	31,6	0,3	4,7
52	Gaziantep	GD Anadolu	0,5	1,0	31,0	0,3	4,7
53	Kurtalan	GD Anadolu	0,6	1,2	37,1	0,3	5,6
54	Mardin	GD Anadolu	0,8	1,5	47,2	0,4	7,1
55	Şanlıurfa	GD Anadolu	0,5	0,9	29,2	0,3	4,4
			3,8	7,0	217,8	1,9	32,7

Table E.4: Paper Industry

					EF	Emission	Emission
No	**Name**	**Province**	**Statute**	**Capacity**	**SO2**	**SO2**	**SO2**
				ton/yr	**kt/mton**	**kt/yr**	**t/yr**
1	SEKA	Afyon	Public	39000	8,0	0,3	312,0
2	SEKA	Mersin	Public	155000	8,0	1,2	1240,0
3	SEKA	Giresun	Public	82500	8,0	0,7	660,0
4	SEKA	Balıkesir	Public	100000	8,0	0,8	800,0
5	SEKA	Bolu	Public	46000	8,0	0,4	368,0
6	SEKA	Zonguldak	Public	75000	8,0	0,6	600,0
7	SEKA	Muğla	Public	75000	8,0	0,6	600,0
8	SEKA	İzmit	Public	120000	8,0	1,0	960,0
9	SEKA	Kastamonu	Public	10200	8,0	0,1	81,6
				702700	8,0	5,6	5621,6
1	Akasan	Adana	Private	30000	8,0	0,2	240,0
2	Viking	İzmir	Private	25000	8,0	0,2	200,0
3	Meteksan	Ankara	Private	29000	8,0	0,2	232,0
4	Marmara	Bilecik	Private	50000	8,0	0,4	400,0
5	Toprak	Bilecik	Private	62886	8,0	0,5	503,1
6	M. Karton	Tekirdağ	Private	90000	8,0	0,7	720,0
7	Copikas	Çorum	Private	14500	8,0	0,1	116,0
8	Dentas	Denizli	Private	24000	8,0	0,2	192,0
9	Olmuksa	Edirne	Private	55000	8,0	0,4	440,0
10	Tirekutsan	İzmir	Private	90000	8,0	0,7	720,0
11	Alkim	İzmir	Private	55000	8,0	0,4	440,0
12	Kmaras	Kahramanmaraş	Private	110000	8,0	0,9	880,0
13	Ipek	Karamursel	Private	35000	8,0	0,3	280,0
14	Kartonsan	İzmit	Private	155000	8,0	1,2	1240,0
15	Selkasan	Manisa	Private	55000	8,0	0,4	440,0
16	Meteksan	Tekirdağ	Private	24000	8,0	0,2	192,0
17	Parteks	Adana	Private	10000	8,0	0,1	80,0
18	Ozaltin	Adana	Private	5000	8,0	0,0	40,0
19	Trakya	Tekirdağ	Private	18000	8,0	0,1	144,0
20	Gürsoylar	Çorum	Private	30000	8,0	0,2	240,0
21	Korsel	Eskişehir	Private	6000	8,0	0,0	48,0
22	Cilkiz	Gaziantep	Private	4000	8,0	0,0	32,0
23	Halkali	İstanbul	Private	60000	8,0	0,5	480,0
24	Ucal	İstanbul	Private	13000	8,0	0,1	104,0
25	Mopak	İzmir	Private	36000	8,0	0,3	288,0
26	Ve-Ge	İzmir	Private	20000	8,0	0,2	160,0
27	Levent	İzmir	Private	7000	8,0	0,1	56,0
28	Urun	İzmir	Private	5000	8,0	0,0	40,0
29	Simka	Kayseri	Private	6000	8,0	0,0	48,0
30	Kombassan	Konya	Private	45000	8,0	0,4	360,0
31	Kombassan	Tekirdağ	Private	35000	8,0	0,3	280,0
				1204386		9,6	9635,1

CIRRICULUM VITAE

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