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(Kazakh Research Institute for Environment Monitoring and Climate)

KAZAKHSTANI GHG EMISSIONS INVENTORY FROM COAL MINING AND ROAD TRANSPORTATION

FINAL PROJECT REPORT

Almaty, July 2002

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Environment Monitoring and Climate
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CONTENTS

LIST OF ACRONYMS, ABBREVIATIONS, AND UNITS 5

INTRODUCTION 6

1 METHANE EMISSIONS INVENTORY IN COAL MINING 9

1.1 COAL PRODUCTION AND RESOURCES 9

1.1.1 Underground Coal Mining 10

1.1.2 Surface Mining 11

1.2 EMISSION ESTIMATION METHODOLOGY AND DATA SOURCES 11

1.2.1 Underground Mining 12

1.2.2 Surface Mining 13

1.2.3 Post-mining Emissions Assessment 14

1.3 METHANE EMISSIONS 14

1.4 UNCERTAINTY ASSESSMENT 15

1.5 RECOMMENDATIONS ON IMPROVEMENT OF THE METHANE INVENTORY IN COAL MINING 16

1.5.1 Underground coal mining 16

1.5.2 Surface coal mining 16

2 GHG EMISSIONS INVENTORY IN ROAD TRANSPORT IN ALMATY 17

2.1 ROAD TRANSPORTATION IN ALMATY 17

2.2 METHODOLOGY AND DATA SOURCES 20

2.2.1 CO_2 emission estimate 20

2.2.2 Non-CO_2 emission estimates (CH_4, N_2O, CO, NOx, NMVOC) 22

2.2.3 Data sources 22

2.2.4 Emission Factors 25

2.3 GHG EMISSIONS 26

2.3.1 Total GHG Emissions 26

2.3.2 Carbon Dioxide Emissions 29

2.3.3 Methane Emissions 30

2.3.4 Nitrous Oxide Emissions 31

2.3.5 Indirect Greenhouse Gases Emissions 32

2.4 UNCERTAINTY ASSESSMENT 34

2.4.1 Activity data uncertainty 35

2.4.2 Emission factors uncertainty and general uncertainties of N_2O, CH_4 and CO_2 estimates 36

2.4.3 Combined Uncertainty 36

2.5 RECOMMENDATIONS ON IMPROVEMENT OF THE GHG INVENTORY IN ROAD TRANSPORT 37

REFERENCE 39

LIST OF ACRONYMS, ABBREVIATIONS, AND UNITS

Acronyms and Abbreviations

GHG	Greenhouse Gas
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
RK	Republic of Kazakhstan
UNFCCC	United Nations Framework Convention on Climate Change
OJSC	Open Joint Stock Company
CJSC	Closed Joint Stock Company
CMM	Coal mining methane

Chemical Symbols

CH_4	methane
CO	Carbon monoxide
CO_2	Carbon dioxide
N_2O	Nitrous oxide
NMVOC	non-methane volatile organic compounds
NO_x	nitrogen oxides
SO_2	sulphur dioxide
LPG	liquid petroleum gas
CNG	compressed natural gas

Units

Gg	gigagram
mln m^3	million cubic meter
ths t	thousand tonne
TJ	terajoule
mln t	million metric tonne

INTRODUCTION

At the Seventh Session of the UNFCCC COP convened on 3 November 2001 it was agreed to comply with the request of Kazakhstan to amend the list of Annex I countries. According to this decision Kazakhstan will be an Annex I country after the Kyoto Protocol comes into force and is ratified by Kazakhstan. In this case Kazakhstan will have to create a national system for monitoring and reporting GHG emissions and sinks, which is an important condition of successful international cooperation for the abatement of global GHG emissions.

Kazakhstan's inventories have been conducted periodically under the support of several international grants. Since 2000 the Government of Kazakhstan, according to the decision of Interagency Commission to prepare inventories on the permanent basis, has provided limited funding to prepare an annual national GHG inventory. As a result, GHG inventories have been prepared for 1990, 1992, 1994, 1999 and 2000 by the Kazakh Research Institute of Environment Monitoring and climate (KazNIIMOSK) in cooperation with the specialists from several agencies and organizations. Additionally KazNIIMOSK collaborates with PNNL and the US EPA for improvement of the GHG inventory quality and development of national data collection system in Kazakhstan. In 1999-2000 the project on added an inventory of GHG emissions in the heat and power sector of Almaty region.

The major constraints to improve the quality of greenhouse gas inventories in Kazakhstan are imperfections in the data collection system, the use of IPCC default emission factors because national emission factors are not available, and the lack of national activity data. The GHG inventory can be improved by using regional or sector approaches. The first step in cooperation between KazNIIMOSK and PNNL was a regional project focused on inventorying GHG emissions from the heat/power and transportation sectors in the Almaty region applying a "bottom-up" approach.

The main outputs achieved by the regional project are listed below:

- ⇒ GHG emissions were estimated for heat and power producers using a "bottom-up" approach;
- ⇒ Recommendations for improving the statistical reporting tables, developed with specialists from the Agency for Statistics of the Republic of Kazakhstan, were adopted in 2002;
- ⇒ The net calorific values for fuels used in Kazakhstan, the carbon emission factors, and the average values for the fraction of oxidized carbon were calculated based on the reporting data provided by the heat and power enterprises in the Almaty region.

In the framework of this regional project, KazNIIMOSK and PNNL conducted a seminar on greenhouse gas emissions on April 17, 2001. The seminar was focused on developing a national inventory system for annual GHG emissions and sinks in the Republic of Kazakhstan. At the conclusion of the workshop and in discussions that followed, KazNIIMOSK, EPA and PNNL developed priorities for continuing improvements to the Kazakhstani inventory process. The priorities are based on the contribution of the key sources to the total GHG emissions in Kazakhstan and the ability to appreciably improve the estimates. The sectors selected for the current project were coal mining and road transportation.

The studies within the framework of the Kazakhstani GHG Emissions Inventory for Coal Mining and Road Transportation Project focused on defining the national emission factors and “bottom-up” methodologies, overcoming existing data gaps in national activity data, and decreasing uncertainties of GHG emissions from coal production and road transportation. In addition, steps were undertaken to establish an annual data collection system from these GHG

emission sources and to define responsibilities for the collection and management of activity data.

The main goals of this project are the following:

- To develop a high-quality bottom-up inventory of GHG emissions from coal mining and road transport as an important step in improving the inventory methodologies and accuracy;
- To prepare recommendations on a national GHG data collection system for the coal mining and transportation sectors in Kazakhstan.

The inventory focused on coal production in Kazakhstan and road transport in Almaty for 1990-2000. Almaty was selected for the GHG emission inventory in road transport because the city has experienced significant growth in private road transport and improving national road transport data first requires a solid understanding of the underlying trends. Given problems with data at the national level, a detailed look at transport on a smaller scale has the potential to provide information on trends and emission factors that can then be extrapolated to the national level.

The main results of the project are listed below:

⇒ GHG emissions were estimated from coal mining in Kazakhstan and road transportation in Almaty city for 1991–2000 using a "bottom-up" approach;

⇒ The statistical reporting forms used by the enterprises in coal mining and road transport were studied. Together with the specialists of the Agency for Statistics of RK, the Institute of Transportation, and the Road Police Department, recommendations for improving the reporting forms were elaborated.

⇒ Net calorific values, carbon emission factors, the fraction of carbon oxidised for four fuel types (gasoline, diesel, LPG and CNG), and the emission factors for non-CO_2 gases for the different types of vehicles were provided by "KazNIPIenergoprom";

⇒ Recommendations on a national GHG data collection system for both coal mining and road transport were prepared.

⇒ Directions for further studies were identified that accounted for their contribution to total GHG emissions, uncertainty of emissions estimates, and the possibilities for improving the quality of inventories.

During project implementation two workshops were devoted to the development of a GHG emissions inventory system in Kazakhstan. The topic of the first workshop, held in Karaganda city (January 2002), was the development of a national GHG inventory system in coal mining where the majority coal mining enterprises for underground mines are located. Experts from KazNIIMOSK organized this workshop in collaboration with the Karaganda branch of OJSC "Azimut Energy Services" and the Public Association "Methane Center." "Methane Center" was recently organized in Kazakhstan to coordinate projects addressed to coalbed and coalmine methane emissions reduction through methane utilization. The workshop on development of the national GHG inventory system in road transportation was held in February 2002 with the participation of specialists from the statistical agencies, transport research institutes, and road transportation enterprises of Almaty.

The goal of the workshops was to increase the awareness of participants about the global climate change problem and GHG inventory issues, and to assure their interest and involvement, as well as, participation in the development and improvement of a national data collection system in coal mining and road transportation. Discussions were on the following issues:

- ⇒ climate change;
- ⇒ position of Kazakhstan regarding the UN FCCC and Kyoto Protocol;
- ⇒ status of the work for fulfilling the UN FCCC commitments in Kazakhstan including the conduct of a GHG emissions inventory ;
- ⇒ application of the IPCC methodology to estimate GHG emissions from coal mining and road transportation;
- ⇒ information and data requirements needed to prepare a high-quality bottom-up GHG inventory in the coal mining industry and road transport.

The final report, based on the project results, contains two main parts:

“Methane emission inventory in coal mining in Kazakhstan,” ”GHG emissions inventory in road transport in Almaty”.

1 METHANE EMISSIONS INVENTORY IN COAL MINING

1.1 COAL PRODUCTION AND RESOURCES

Kazakhstan possesses about 3.3 % of total world economically recoverable reserves of coal – enough for 500 years of domestic consumption. Kazakhstan ranks 8th in the world and 3rd among CIS countries for coal production. Also, Kazakhstan maintains first place in the CIS for per capita coal production equal to 4.5 t, compared to 1/3 this amount in Russia and Ukraine.

Moreover Kazakhstan is among the top 10 coal exporters with 25.7 mln t or 4.5% of the total world coal exports in 2000. Domestically, coal accounts for 90% of energy consumed for power generation and 40-50% in the residential sector.

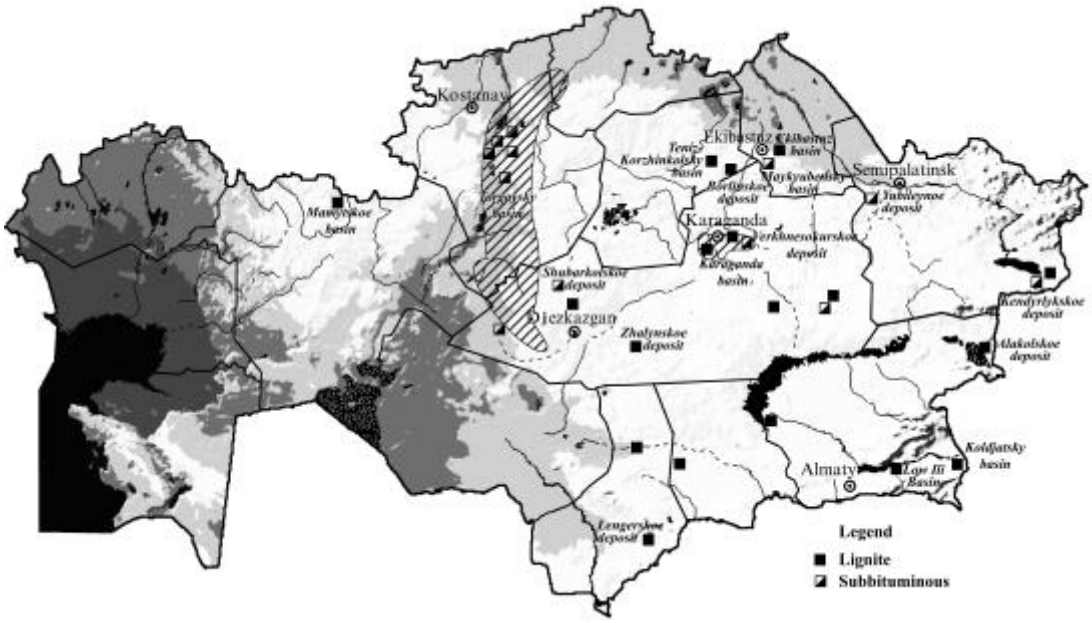
There are about 100 coal deposits in Kazakhstan with geological reserves estimated at 176.7 billion t. However only 40 of the deposits have been explored and the estimated production reserves amount to 34.1 billion tons. Coals in Kazakhstan are either sub-bituminous or lignite.

Ekibastuz, Kuuchekinsky and Borlinsky coal deposits are sub-bituminous of low quality (high ash, sulfur content, and low heat content). These are mainly used at power plants to produce electricity and heat.

The Shubarkol, Karaganda and Maykyuben coal deposits are of high quality use mainly as a fuel in industrial and residential sectors.

The largest coal basins, Karaganda and Ekibastuz, are responsible for about 95 % of the total coal production in Kazakhstan. The main coal deposits are located throughout the central part of the country, which is geographically convenient for coal transportation throughout the country (figure 1.1). However, transportation difficulties occur due to the low scale of development and carrying capacity of the railway system.

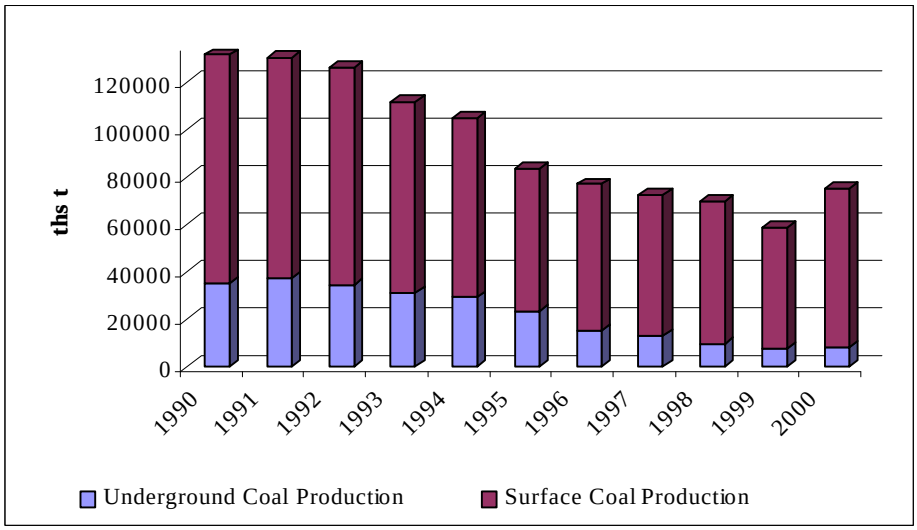
Figure 1.1: Large coal Deposits of Kazakhstan



Kazakhstan produces its coal from both surface and underground mines with overall production decreasing through the period 1990-2000. From 1990 through 1999 Kazakhstan experienced a steady decline in coal production from 131.4 mln t in 1990 to 58.2 mln t in 1999

attributed to the economic recession. However, production increased by about 30% from 1999 to 2000 in both surface and underground mines (see figure 1.2).

Figure 1.2: Dynamics of surface and underground coal mining in Kazakhstan



The share of total production from underground mines decreased steadily from about 27% to 11% in 1990 and 2000, respectively, in the total coal balance of the Republic, whereas production from surface mines rose by an offsetting amount.

Many coal-mining enterprises were closed or reorganized during 1995-1997, the period of privatization in coal mining industry. At present the key coal producing enterprises in Kazakhstan are:

- OJSC "Ispat-Karmet" (8 underground mines in the Karaganda basin)
- «Bogatyr Access Komir», Ltd (the Bogatyr and Severny surface mines in the Ekibastuz basin)
- OJSC "Eurasian Energy Corporation" (the Vostochny open pit mine in the Ekibastuz basin).

There are a number of smaller coal producing enterprises in Kazakhstan that include the OJSC "Borly" in the Borlinskoe deposit, the "Maykyuben-West" Joint Venture in the Maykyubensky basin, and the "KomirInvest" Ltd and "Transenergo" Ltd in the Karaganda basin.

1.1.1 Underground Coal Mining

Underground coal mines have always been dangerous, but industry in Kazakhstan must have coking coals that are produced only in underground mines.

Underground mining is present only in the Karaganda basin, which is the largest coal mining region in Kazakhstan. These coals have relatively high ash content and are difficult to wash. Coking coals are supplied to steel and iron sectors as well as to by-product coke plants in Kazakhstan, Russia, Ukraine and Georgia. In addition, these are mined for production of special coke that is supplied to enterprises in the phosphoric and ferroalloy industries.

Since 1990, there were 2 main stages in the lifecycle of Karaganda basin mines. In 1990 26 underground mines operated in Kazakhstan with many inefficient, unprofitable and, unpromising mines closed by 1995. During this period of production decreased from 35 to 23 mln t from 1990 and 1995. This is explained by insufficient financing to maintain

production from higher cost underground mines and the requirement for more complicated mining processes.

In 1996 15 mines were transferred to OJSC "Ispat-Karmet" and underwent reorganization and enlargement to stabilize production levels. At present in the Karaganda basin, 8 mines belong to the Coal Department of OJSC "Ispat-Karmet, and 4 mines belong to "KomirInvest" Ltd and "Transenergo" Ltd (two each). Of the 12 mines remaining, the 8 “Ipsat-Karmet” continue to operate and the 4 belonging to “KomirInvest” and “Transenergo” have nearly stopped production

1.1.2 Surface Mining

Surface coal mining in Kazakhstan occurs throughout the country and accounts for an increasing share of total coal production -- from 73% in 1990 to 89% in 2000. There are numerous coal basins in Kazakhstan suitable for surface mining, but only a few are currently exploited.

Ekibastuz basin is the center of the surface coal mining industry in Kazakhstan and has been exploited since 1955. The main deposit contains about 7 billion tons of coal with over 75 billion m^3 of methane embedded. Coal is produced at 3 open pit mines -- «Severny and «Bogatyr» owned by "Bogatyr Access Komir" Ltd since 1997, and «Vostochny» belonging to OJSC "Eurasian Energy Corporation". Ekibastuz coal is characterized by high content of ash, sulfur, and mineral gangu, and is used in power plants in Kazakhstan, Ural and West Siberia. The Ekibastuz basin open pit mines are the largest in Kazakhstan, responsible for 75-85% of the total surface coal production in the republic.

There are a number of small open pit coal mines located in different regions of Kazakhstan that account for the remaining 15-25% of surface coal production, these include:

Shubarcolskoe deposit is located in the southwest of Karaganda region. Exploration in this deposit is of high importance for large-scale production of high-quality coals by less expensive surface mining. At this time, only one open pit mine is operating and the low carrying capacity of the railway limits production from the Shubarkol deposit.

Borlinskoe deposit has been under exploitation since 1980. Conditions are favorable for the surface mining of the low-quality sub-bituminous coal, but the demand for this coal is rather limited as it is used only in the residential sector.

Kuuchekinskoe deposit is situated north of Karaganda city. Coal is mined from two open pits and the coals are of low quality.

Maykyubensky basin contains an open pit mine "Maykyubensky" with total planned production capacity of 25 mln t coal per year when fully developed.

Lowili deposit is located in the poorly developed region of southeast Kazakhstan. It contains a huge stratum of lignite coal with the largest seam in the central and northwest parts of deposit. The coal has high ash and low sulfur content.

1.2 EMISSION ESTIMATION METHODOLOGY AND DATA SOURCES

The general methodology for estimating Coal-Mining Methane (CMM) emissions is based on the equation as recommended by the IPCC Guidelines:

Total Emissions	=	Emissions from underground mining
		+ Emissions from surface mining
		+ Emissions from Post-mining activities
		- Utilized and/or flared methane

The Republican Agency for Statistics is the main data source for developing estimates of the GHG emissions from the various sectors of economic activity in Kazakhstan. However, additional data from the coal mining enterprises is required in order to develop a high-quality estimate of methane emissions from coal mining, storage, and transportation.

1.2.1 Underground Mining

Given the fact that the great share of fugitive methane (CH_4) emissions in Kazakhstan are emitted from underground mines, special attention was given to improving the inventory of CH_4.

Mines in the Karaganda basin are considered to be very "gassy" with a high probability of methane content. Coal is mined at the depth of 650-700 m and production of 1 ton of coal is accompanied by emission of about 33 m^3 methane to the mine. Thus special attention is paid to lower the methane content in the mines and provide for its utilization. Surface wells are widely used in the basin to provide degasification of the strata. The level of methane utilization is very low although some portion of methane is recovered and used as fuel for heating. About 10-12 mln m^3 is recovered and combusted in 3-4 boiler installations. In addition, a portion of methane emissions have been flared since 1999. For safety reasons methane emissions at mines are measured and recorded from ventilation and degasification systems.

The Tier III methodology of the Revised IPCC Guidelines (i.e. measured methane emissions from underground mines) was used to estimate CH_4 emissions. Experts from the Coal Department of "Ispat-Karmet" were contacted to obtain additional information for CMM (Coal Mining Methane) emissions on the basis of the IPCC Tier III method.

CMM emissions were estimated from active underground mines for the period 1990 through 2000, and not for mines that were deactivated. The following data were provided for the active mines (Table 1.1):

- underground coal production
- measured methane emissions from ventilation and degasification systems
- amount of methane utilized and/or flared

Total emissions from underground mines were estimated as the sum of the methane emissions measured from each mine's ventilation and degasification systems. The amount of methane utilized for internal purposes was then subtracted from the total to estimate the amount flared.

Table 1.1: Data used for methane emissions estimation from underground coal mining

Years	Total Coal Production, mln t	Underground Coal Production, mln t	Measured methane emissions, mln m^3		Methane utilized and/or flared, mln m^3
			Degasification	Ventilation	
1990	131.443	35.31	189.84	983.66	9.09
1991	130.382	36.91	200.83	914.75	11.16
1992	126.536	34.4	179.97	915.52	11.30
1993	111.880	31.1	162.96	957.82	13.25
1994	104.625	29.14	148.31	678.12	5.74
1995	83.355	23.3	115.8	671.37	6.10
1996	76.831	15.1	55.4	408.00	3.60
1997	72.586	12.9	48.2	347.45	4.03
1998	69.7149	9.2	42.6	303.45	10.7
1999	58.1992	7.3	27.2	227.32	11.6
2000	74.8724	8.2	41.0	286.23	12.5

1.2.2 Surface Mining

Surface mines are considered to be very gassy for open mining pattern and pose a very serious safety hazard for miners. Methane is removed by blowing air through the tunnels with roughly 70% of methane escaping to the atmosphere in the form of ventilation air. Though the concentrations of methane are less than 1%, this causes serious methane emissions because of the volume of gas not captured and utilized.

Methane emissions from open pit mines were estimated separately for big mines and the numerous small mines. The number of open pit mines is rather high and not all submitted the requested data. The Tier II methodology was applied to estimate the CH_4 emissions from the three largest open pit mines: "Bogatyr", "Vostochny" and "Severny". Experts from two key surface coal-producing enterprises, «Bogatyr Access Komir» Ltd and OJSC "Eurasian Energy Corporation," were contacted to obtain additional data (Table 1.2).

Table 1.2: Data used for methane emissions estimation from surface coal mining

Years	Coal Production at Severny open pit coalmine, mln t	Coal Production at Bogatyr open pit coalmine, mln t	Coal Production at Vostochny open pit coalmine, mln t	In-situ gas content for Bogatyr, m^3 CH_4/t
1990	15.0	37.0	20.9	9
1991	14.5	34.8	22.8	9
1992	13.9	32.7	21.7	9
1993	13.4	30.5	21.1	9
1994	12.9	28.3	19.3	9
1995	12.4	26.1	19.9	9
1996	11.8	24.0	17.0	9
1997	11.3	21.8	14.8	9.1
1998	15.1	21.4	10.9	8.6
1999	10.7	17.1	11.1	9.2
2000	12.7	23.1	16.0	9.2

Coal production data were obtained for 1990-2000 from the "Vostochny" mine and only for 1997-2000 for the two large open pit mines "Severny" and "Bogatyr". Coal production during the period of 1990-1996 was estimated basing on interpolation method for the latter two mines.

Data on in-situ gas content for these mines during the pre-privatization period of 1990-1996 were estimated as follows:

- According to expert judgment at the "Severny" mine, coal is produced in the methane-free strata (above 200 m) thus CH_4 emissions from this mine are negligible.
- Data on the in-situ gas content obtained for the "Bogatyr" open pit mine for 1997-2000 were applied as the in-situ gas content for the 1990-1996 period.The in-situ gas content of the “Vostochny” was assumed to be equal to that of "Bogatyr".

These two mines have a similar methane bearing capacity (about 8-12 m^3 per ton) as they are located in the same deposit close to each other and have similar coal characteristics and mining conditions.

Emission factors for the surrounding strata were estimated to be equal to 0, as the surrounding strata consists mostly of sand and rocks.

Methane emissions from the rest of the open pit coal mines were estimated using the Tier I methodology. Coal production from these mines was defined as the difference between total coal production in Kazakhstan minus the coal production by the "Ispat-Karmet" underground mines and by the "Bogatyr", "Vostochny" and "Severny" open pit mines. The emission factor was taken from the Revised IPCC Guidelines (Tier I).

1.2.3 Post-mining Emissions Assessment

Methane is also emitted from post-mining activities such as coal processing, storage, transportation, and utilization.

Estimates of post-mining emissions from underground mines were calculated by experts from "Ispat-Karmet" using a national emission factor equal to *1 m^3 of CH_4 per ton of coal mined*. This is in accordance with "Guidelines for designing of ventilation systems at coal mines" and "Handbook for designing of coal-mining buildings and processing plants with highly explosive and fire-risk conditions".

Based on expert opinion, post-mining emissions from surface mining were assumed to be negligible.

Currently, the estimates do not include emissions from abandoned coal mines because of data limitations.

1.3 METHANE EMISSIONS

Accounting for its high global warming potential, methane is the second most significant greenhouse gas following carbon dioxide, and coal mining contributes more than half of the total CH_4 emissions in Kazakhstan*.

Cumulative methane emissions from Kazakhstan coalmines are presented in Table 1.3. The total methane emissions in 2000 were estimated at 475.12 Gg, declining 60% since 1990 caused mainly by the economic recession.

Table 1.3: Total CH_4 Emissions in Kazakhstan for 1990-2000, Gg

Activity	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*
Underground mine Tier III	786.2	747.4	733.9	750.9	553.7	527.4	310.4	265.0	231.8	170.5	219.2
Surface mine Tier II	349.2	347.7	327.5	310.8	286.8	277.5	247.3	222.0	189.1	172.2	238.8
Surface mine Tier I	31.1	28.5	31.9	21.1	20.1	2.2	11.9	15.8	17.5	16.1	19.9
Post-mining activities	23.6	24.7	23.0	20.8	19.5	15.6	10.1	8.6	6.1	4.8	5.4
Methane utilized	6.0	7.4	7.5	8.8	3.8	4.0	2.4	2.7	7.1	7.7	8.3
Total Emitted	**1184.1**	**1141.0**	**1109.0**	**1094.9**	**876.4**	**818.7**	**577.4**	**508.9**	**437.5**	**355.9**	**475.1**

During 1990-1999 total methane emissions from coal mining and post-production activities decreased steadily at an average rate of 92 Gg/year from 1184.18 Gg to 355.98 Gg in 1990 and 1999, respectively. In 2000 methane emissions rose to between 1997 and 1998 levels of 475.12 Gg, mainly to an increase in coal production.

In 1990, the contributions of underground and surface mining were 68% and 32%, respectively. In 2000 these shares changed to 46% and 54%, respectively, mainly due to the

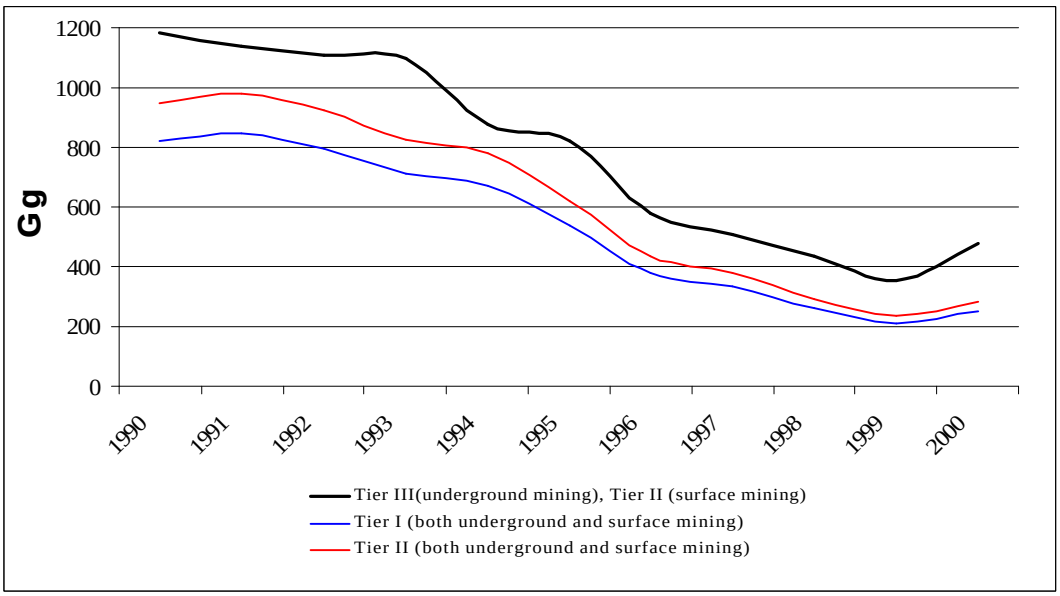
* Based on actual measurements from underground mines and activity data combined for surface mines.

reduction in underground coal mining, which decreased from 27% to 11% of total coal production during the period. Thus a slight change in production resulted in a significant change in methane emissions.

1.4 UNCERTAINTY ASSESSMENT

The purpose of this inventory to improve estimates of methane emissions from the coal mining sector by applying the more precise Tier III and Tier II methodologies where possible to reduce uncertainty. In previous studies the Tier I methodology was applied to estimate fugitive methane emissions in coal mining sector. Figure 1.3 shows the cumulative levels of methane emissions from 1990 through 2000 estimated for the three tiers.

Figure 1.3: Methane Emissions from Coal Mining in Kazakhstan for 1990-2000.



It is evident that general trends are similar under the three Tiers. The differences in emissions estimates can be attributed to the different methods of arriving at the total.

The results presented in Table 1.3 are a combination of both measured and calculated data:

- emissions estimation from underground mines were based upon actual measured data from ventilation and degasification systems, which have relatively high accuracy;
- data on methane utilized and/or flared from underground mines were also based upon measured data;
- emissions from surface mines were estimated on the basis of both the IPCC Tier I and Tier II methods, and thus have considerably more uncertainty compared to the estimates for underground mines;
- emissions from post-mining activities were estimated by utilizing the IPCC Tier II approach with a national emission factor and also carry higher level of uncertainty.
- The overall uncertainty is estimated to be ±20%.

The results of the project show that methane emissions were underestimated in previous inventories and that uncertainty is reduced by applying the Tier III and Tier II methodologies.

1.5 RECOMMENDATIONS ON IMPROVEMENT OF THE METHANE INVENTORY IN COAL MINING

1.5.1 Underground coal mining

The majority of coal mine methane in Kazakhstan is emitted to the atmosphere from underground mines. For safety reasons methane emissions are measured and recorded from ventilation and degasification systems. Moreover some of the methane recovered is used as fuel for energy purposes and the data are also recorded. Although emissions and use are recorded at the mine level by the coal mining enterprises, this information is not included in the statistical reporting tables. This lack of data prevents use of the UNFCCC Tier III methodology to estimate CMM emissions. Recommendations:

1. It is feasible to conduct the centralized annual data collection through the existing and authorized state body, the Republican Agency for Statistics;
2. It is necessary to develop and introduce new annual statistical reporting forms for the underground coal mining enterprises that contain the following information by every mine:

actual coal production, ths t	measured CH_4 emissions, mln m^3		methane utilized, mln m^3	methane flared, mln m^3
	degasification	ventilation		
1.	*2.*	*3.*	*4.*	*5.*

   2.1. Data in columns 2-5 might be processed in the ecological statistics department since they reflect ecological safety of production;
   2.2. The amount of methane utilized as combusted fuel also should be included in the fuel and energy balance as a separate item. At present, the amount of methane utilized are reported together with the amount of natural gas, which leads to the uncertainty in methane emissions estimation;
   2.3. The amount of methane flared instead of being emitted or utilized should also be reported separately;
3. It is sufficient that the Agency for Statistics provides aggregate oblast level data on underground coal production and amount of methane recovered.

1.5.2 Surface coal mining

Estimation of methane emissions from surface coal mining also requires that enterprises report additional data currently not requested by the Agency for Statistics.

Recommendations:

1. It is necessary that the Republican Agency for Statistics records annual coal production separately for surface and underground mines;
2. It is necessary that a body responsible for the national GHG Inventory develops and updates a database with the following information for each surface mine:

Open-cast	in-situ gas content (m^3/t)	emission factor for surrounding strata (m^3/t)	emission factor for coal production (m^3/t)
1.	*2.*	*3.*	*4.*

Note: column 4 is to be filled in when data in columns 2 and 3 are absent.

3. Since the data in columns 2-4 may vary by mine, aggregation is possible only in cases of equality.

2 GHG EMISSIONS INVENTORY IN ROAD TRANSPORT IN ALMATY

2.1 ROAD TRANSPORTATION IN ALMATY

Almaty, founded in 1854, is the largest city in Kazakhstan and was the nations capital from 1929 through 1995. In 1995 Astana became the new capital and Almaty was designated as the 'Southern Capital'. Almaty is located in the northern foothills of the Zhailiysky Alatau mountains at an altitude of 700 – 900 m. The city covers an area of 300 km^2 with a population of 1,139,900. In 2001, the most populated city with the density of 3799.7 people per square km. Moreover Almaty contributes the largest share of Kazakhstan's GDP (gross domestic product) at 16%.

Dynamics of road transport development in Almaty during 1990-2000

The total road fleet of Almaty amounts to 14.9% of the total fleet in Kazakhstan. Almaty occupies the first place in the number of passenger cars owned by the populace with 14.1 cars per hundred people in 2000. The statistical agencies in Kazakhstan report 4 main road fleet groups -- passenger cars, trucks, buses, and specialized vehicles (ambulances, fire-engines, truck cranes, and other). At the end of 1990 the total fleet in Almaty amounted to 86,850 vehicles, which increased to 190,990 vehicles by the end of 2000. Table 2.1 presents the structure of road transport in 1990 and 2000.

Table 2.1: Structure of road transport in 1990 and 2000 by vehicle type, %

Vehicle type	1990	2000
Passenger cars	65.5	87.2
Trucks	20.9	8.0
Buses	5.1	2.9
Specialized	8.4	2.0

In the 10 years, the total fleet grew by 119.9 % due mostly to privately owned vehicles (passenger cars, trucks, and buses). Figure 2.1 and table 2.2 show dynamics of the total road fleet registered in Almaty from 1990 through 2000.

Figure 2.1: Dynamics of the number of road vehicles in Almaty, 1990-2000.

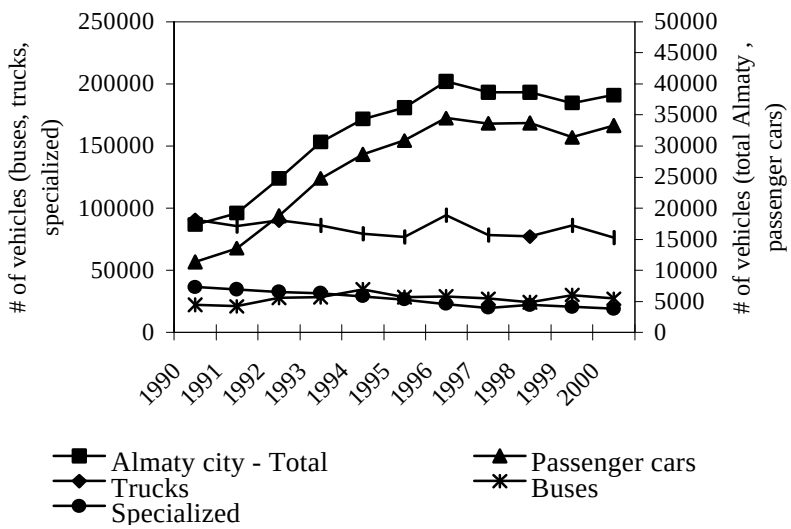


Table 2.2: Total number of vehicles in Almaty from 1990 through 2000

units

Vehicle type	1990	1991	1992	1993	1995	1996	1997	1998	2000
Trucks - Total	***18,132***	***17,115***	***18,010***	***17,231***	***15,386***	***18,885***	***15,711***	***15,444***	***15,280***
Gasoline	10,314	9,876	11,826	12,391	11,569	15,501	12,781	12,683	13,093
Diesel	4,009	3,826	3,681	3,232	2,968	2,890	2,398	2,508	2,122
LPG	2,687	2,522	1,921	1,226	629	359	421	161	56
CNG	1,122	891	582	382	220	135	111	92	9
Buses - Total	***4,467***	***4,250***	***5,544***	***5,681***	***5,721***	***5,792***	***5,470***	***4,897***	***5,476***
Gasoline	3,778	3,416	4,902	5,061	5,198	5,147	4,837	4,222	4,555
Diesel	156	585	517	545	505	628	616	668	916
LPG	235	174	95	48	17	17	16	5	3
CNG	298	75	30	27	1		1	2	1
Passenger cars - Total	***56,939***	***67,856***	***93,915***	***123,894***	***154,429***	***172,569***	***168,065***	***168,394***	***166,402***
Gasoline	56,939	67,856	93,915	123,894	154,139	172,538	168,065	168,313	166,272
Diesel								81	130
LPG					290	31			
CNG									
Specialized - Total	***7,307***	***6,949***	***6,568***	***6,371***	***5,319***	***4,611***	***4,005***	***4,408***	***3,824***
Gasoline					4,557	3,941	3,383	3,795	3230
Diesel					608	517	517	534	555
LPG					138	140	100	79	36
CNG					16	10	5		2
TOTAL	**86,845**	**96,170**	**124,037**	**153,177**	**180,855**	**201,857**	**193,251**	**193,143**	**190,982**

Source: Agency for Statistics

The total number of vehicles increased from 1990 to 1996 and then started to decrease slightly 1997. The number of trucks fluctuated during the period with a general declining trend, and in 2000 trucks amounted to 15,280 vehicles. The number of buses also fluctuated from year to year, exceeding the 1990 level except for 1991. The fleet of specialized vehicles decreased steadily from 7,307 vehicles in 1990 to 3,824 in 2000. The number of passenger cars determined the general trend of the development of the total road fleet in Almaty with rapid growth during 1990-1996 stabilizing at about 166,400 vehicles by 2000.

Structure of the total road fleet by types of fuel

The road vehicles use gasoline, diesel, liquid petroleum gas (LPG), and compressed natural gas (CNG) as fuel. The share of vehicles that consumed LPG and CNG is very small and declined during the period. In 1990 the shares of trucks, buses, and specialized vehicles that used CNG were 6.2%, 2.3%, and 3.6%, respectively. By 2000 the shares for trucks and specialized vehicles were 0.1% each and only one bus was registered that used CNG as fuel. In 1990 14.8% of trucks and 5.3% of buses used LPG and these shares decreased to 0.1% each by 2000.

During the period number of trucks that use diesel fuel decreased from 22% in 1990 to 14% in 2000, whereas the fleet of trucks that consumed gasoline increased from 57% in 1990 to 86% in 2000. At the same time, the number of buses fueled by diesel rose significantly from 4% to 17% during 1990-2000, especially last 4 years. The number of gasoline buses decreased, but not as much as those of trucks.

Structure of fleet by vehicle types

Most vehicles registered in Almaty were produced in CIS countries – 60.8%. Vehicles from other foreign countries (Japan, South Korea, USA, Western Europe) make up 43.3% of passenger car registrations, 30.4% of bus registrations, and 8.1% of truck registrations. The most popular brand foreign passenger cars in Kazakhstan are "Toyota".

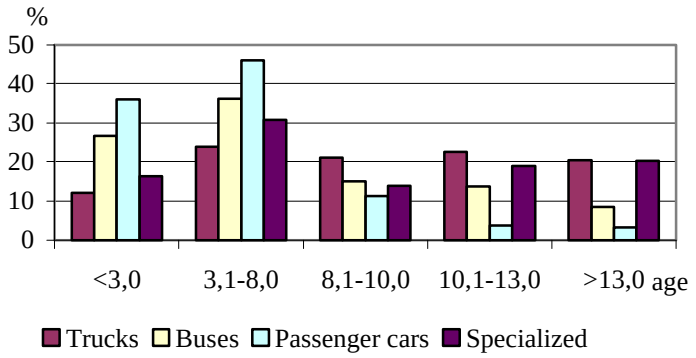
Structure of fleet by vehicle age

The Agency for Statistics keeps records of vehicle age only for non-privately owned vehicles, which comprised about 40% in 1990-91 and only 10.2% of total road vehicles in 2000. These road vehicles are divided into 5 age groups in the existing reporting:

- Less than 3 years;
- More than 3 – under 8 years;
- More than 8 – under 10 years;
- More than 10 – under 13 years;
- More than 13 years.

The data indicate that the age distribution of Almaty's road fleet through 1993 was about 70% of vehicles less than 8 years old, 11% between 8 and 10 years old, and about 19% of road fleet were 10 years and older. By 2000 the distribution changed such that only 54% of vehicles were under 8 years, 16% were between 8 and 10 years old, and about 30% were 10 years and older. Figure 2.2 shows the age structure of road vehicles in Almaty by type in 2000.

Figure 2.2: Age of road vehicles by type in Almaty, 2000



Structure of road fleet by type of ownership

Until 1992 only passenger cars were privately owned in Kazakhstan. As a result of privatization, small transportation enterprises have appeared which made it possible for people to privatize trucks and buses and to enter transportation businesses. In 2000, 89.9% of the total fleet in Almaty (trucks, buses, and passenger cars) were privately owned with private ownership accounting for 96.9% of passenger cars, and 50.4% and 47.3% of trucks and buses, respectively.

2.2 METHODOLOGY AND DATA SOURCES

Road transport emits significant amounts of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and several criteria pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), sulfur dioxide (SO_2), and particulate matter (PM), which contribute to local and regional air pollution.

This inventory contains estimates of both direct greenhouse gases (CO_2, CH_4, and N_2O) and indirect greenhouse gases (CO, NO_x, NMVOC, and SO_2). The IPCC methodology includes road transport into the "Energy" category of emissions sources and prescribes the Tier I, Tier II, and Tier III methods to estimate emissions. The Tier I – "top-down" approach – is based on the total fuel consumption, whereas the Tier II – "bottom-up" methodology – takes into account fuel type and vehicle type. The Tier III method utilizes a modeling approach to estimate emissions inventories.

If required data are available, IPCC Guidelines recommend using both Tier I and Tier II methodologies in parallel to develop estimates of CO_2 emissions. This provides a quality check of estimates as close results of CO_2 emissions estimates by the two approaches testifies to the reliability of activity data and calculations. This also allows a quality check of the estimated emissions of greenhouse gases other than CO_2.

In previous studies GHG emissions from road transport in Kazakhstan were estimated only by the Tier I methodology using emission factors provided in the IPCC Guidelines. Both the Tier I and Tier II methodologies were applied in this inventory.

CO_2 emissions from fuel combustion by road transport are calculated apart from other greenhouse gas emissions in this sector. CO_2 emissions can be accurately calculated on the basis of the amount and type of fuel combusted as well as its carbon content, as the fraction of carbon oxidized is nearly the same under different fuel combustion technologies. Emissions of greenhouse gases other than CO_2 are more complicated to estimate as they depend upon the vehicle type, fuel type, driving conditions, and emission control technology types.

2.2.1 CO_2 emission estimate

Tier I calculates CO_2 emissions for each fuel type on the basis of the following equation:

$$\textit{Total emissions} = S_j(FC_j * EF_j * FO_j * 44/12)$$

where **FC** – amount of fuel consumed (in energy units);

EF – emission factors;

FO – fraction of carbon oxidised;

j - fuel type;

44/12 – conversion to CO_2

Alternatively, Tier II estimates CO_2 emissions in two steps. The first step is to estimate consumption of every fuel type by vehicle types (passenger cars, trucks, buses, specialized vehicles) based on the equation below:

$$FCij = Nij\ Kij\ Eij$$

where **FC** – fuel consumption;

N – number of vehicles;

K – annual kilometers traveled per vehicle;

E – average fuel consumption (kg/1000 km or liter/100 km);

j – fuel type;

i – vehicle type (passenger cars, trucks, buses, specialized vehicles)

The total fleet was divided into groups presented in table 2.3 for more precise estimation of fuel consumed. After estimation of fuel consumption, vehicles were assigned to 4 different groups in accordance with the IPCC Guidelines (passenger cars, light-duty trucks and minibuses, buses, heavy-duty trucks).

Table 2.3: Fleet division by vehicle types and models

Vehicle type	*Production*	*Characteristics*			*IPCC vehicle types*
		engine volume, l	*seating capacity*	*carrying capacity, ton*	
passenger cars	*CIS countries*	V_h *<1.4*			*passenger cars*
		1.4< V_h *<2.0*			
		2.0< V_h			
	Japan, South Korea, USA, Western Europe	V_h *<1.4*			
		1.4< V_h *<2.0*			
		2.0< V_h			
buses	*CIS countries*		***n****<16*		*light-duty trucks and minibuses*
			16< ***n*** *<35*		*buses*
			35< ***n***		
	Japan, South Korea, USA, Western Europe		***n****<16*		*light-duty trucks and minibuses*
			16< ***n*** *<35*		*buses*
			35< ***n***		
trucks	*CIS countries*			***q****<1.5*	*light-duty trucks and minibuses*
				*1.5<****q****<5.0*	*heavy-duty trucks*
				*5.0<****q****<12*	
				*12<****q***	
	Japan, South Korea, USA, Western Europe				*light-duty trucks and minibuses*
					heavy-duty trucks

Source: Research Institute of Transport

The second step is to estimate total CO_2 emissions by multiplying fuel consumption by emission factor specific for fuel type and vehicle type.

$$\textit{Total emissions} = SiSj(FCij * EFij)$$

where **FC** – fuel consumption;

EF – emission factor;

j – fuel type;

i – vehicle type (passenger cars, trucks, buses, specialized vehicles)

2.2.2 Non-CO_2 emission estimates (CH_4, N_2O, CO, NOx, NMVOC)

The IPCC Tier I methodology prescribes estimation of non-CO_2 gases emissions on the basis of the equation below:

$$Emissions = Sj(FCj * EFj)$$

where **FC** – fuel consumption;

EF – emission factor;

j – fuel type.

The IPCC Tier II methodology allows two approaches for estimation of emissions: 1) on the basis of vehicle km traveled by technology type, and 2) on the basis of fuel consumption by technology type. Statistical data were sufficient to estimate emissions of greenhouse gases other than CO_2 through the second approach.

2.2.3 Data sources

The main sources of data for developing the inventories of GHGs in the road transport sector were the following:

- National Agency for Statistics ("Fuel and Energy balance of Kazakhstan", year-book of "Road Transport of Kazakhstan", which is developed on the basis of reporting data from all enterprises that own or rent vehicles)
- Road Police Department
- Transport Research Institute
- Kazakhstan Ministry of Transport and Communications

Table 2.4 provides the data that were used to develop the Tier I estimates of CO_2 and non-CO_2 emissions from road transport in Almaty.

Table 2.4: Main data for GHG emissions estimation from road transport (Tier I)

Fuel	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Area, thous. km^2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Population, thous. people					1114.7	1111.8	1117.7	1120.1	1129.3	1139.9
Gasoline consumption, TJ	155.665	127.388	93.602	62.587	64.26	45.519	37.545	40.065	37.451	83.888
Diesel consumption, TJ	56.85	83.454	39.854	29.685	38.971	33.428	84.979	28.885	25.779	102.498
CNG consumption, TJ	6.052	14.189	5.129	0.76	0.314	0.133	0.204	0.049	9.501	0.057
LPG consumption, TJ	23.019	14.182	8.395	5.425	2.103	1.738	1.036	0.748	8.203	1.36

Tables 2.5, 2.6 and 2.7 present input data for calculation of GHG emissions from road transport using the Tier II methodology. Average fuel consumption for different types of vehicles (passenger cars, trucks, buses, etc) is estimated by a methodology developed by the Research Institute of Transport. The data include vehicles that were in satisfactory working order and able to perform transportation services (aka good order vehicles), which therefore emitted greenhouse gases.

Table 2.5: Good-order vehicles by fuel types, 1990-2000

units

Vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline										
passenger cars	52,431	72,580	94,961	104,801	117,079	130,542	126,913	127,229	122,673	125,917
light-duty trucks and minibuses	3,483	4,144	4,408	4,207	4,181	4,431	4,875	5,161	5,894	6,340
heavy-duty buses	9,189	9,639	9,326	7,890	6,594	7,249	6,103	6,251	6,164	6,172
buses	2,246	2,709	2,813	2,499	2,078	1,664	1,721	1,694	1,921	2,112
Total	***67,349***	***89,072***	***111,508***	***119,397***	***129,932***	***143,886***	***139,612***	***140,335***	***136,652***	***140,541***
Diesel										
passenger cars	32	69	125	184	259	354	398	446	478	545
light-duty trucks and minibuses	146	173	188	209	276	336	366	355	379	419
heavy-duty buses	4,360	4,606	4,244	3,844	3,491	4,360	3,618	3,826	3,739	4,377
buses	133	162	180	212	311	373	422	379	374	381
Total	***4,671***	***5,010***	***4,737***	***4,449***	***4,337***	***5,423***	***4,804***	***5,006***	***4,970***	***5,722***
LPG&CNG										
passenger cars	1,435	1,037	844	542	324	69	69	17	13	61
light-duty trucks and minibuses	368	278	204	157	177	186	82	74	15	19
heavy-duty buses	3,083	2,448	1,591	983	658	429	184	162	47	95
buses	337	254	209	133	80	80	64	39	28	71
Total	***5,223***	***4,017***	***2,848***	***1,815***	***1,239***	***764***	***399***	***292***	***103***	***246***
TOTAL	**77,243**	**98,099**	**119,093**	**125,661**	**135,508**	**150,073**	**144,815**	**145,633**	**141,725**	**146,509**

Source: Research Institute of Transport; Road Police Department; Agency for Statistics.

Table 2.6: Average kilometers traveled by good-order vehicles for 1991-2000, 10^3 km/year

Vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Passenger cars										
CIS countries	13.9	13.7	13.7	14.2	15.2	17.0	19.8	22.6	24.8	25.6
Japan, South Korea, USA, Western Europe	15.0	14.7	14.7	15.2	16.3	18.2	21.2	24.2	26.7	27.5
Buses										
CIS countries	47.1	43.6	40.1	38.3	37.7	37.1	38.3	40.1	43.6	48.3
Japan, South Korea, USA, Western Europe	49.5	45.8	42.0	40.2	39.6	39.0	40.2	42.0	45.8	50.7
Trucks										
CIS countries										
<12.0 tons	44.9	35.6	27.1	21.5	17.8	15.9	15.9	18.7	24.3	33.7
>12.0 tons	73.9	58.5	44.6	35.4	29.2	26.2	26.2	30.8	40.0	55.4
Japan, South Korea, USA, Western Europe										
<12.0 tons	68.5	54.3	41.4	32.8	27.1	24.3	24.3	28.6	37.1	51.4
>12.0 tons	92.5	73.3	55.9	44.3	36.6	32.8	32.8	38.6	50.1	69.4

Source: Research Institute of Transport; Road Police Department; Agency for Statistics

Table 2.7: Average fuel consumption by good-order vehicles for 1991-2000, litres/100 km

Fuel type/Vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline										
Passenger cars										
Vh<1.4	8.12	8.12	8.12	8.12	8.12	8.12	8.12	8.12	8.12	8.12
1.4<Vh<2.0	9.65	9.65	9.65	9.65	9.65	9.65	9.65	9.65	9.65	9.65
2.0<Vh	13.22	13.22	13.22	13.22	13.22	13.22	13.22	13.22	13.22	13.22
Buses										
n<16	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
16<n<35	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9
35<n	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.4
Trucks										
q<1.5	16.2	16.2	16.1	16.1	16	15.8	16.3	16.6	16.3	16
1.5<q<5.0	31.8	31.8	31.8	31.7	31.1	30.8	32.1	33.1	32.3	31.2
5.0<q<12.0	45.4	45.5	45.3	45.2	43.7	42.7	46.3	48.9	46.8	43.9
12<q	55.0	55.0	54.8	54.8	53.1	52.1	55.9	58.7	56.4	53.3
Diesel										
Passenger cars										
Vh<1.4	7.16	7.16	7.16	7.16	7.16	7.16	7.16	7.16	7.16	7.16
1.4<Vh<2.0	7.16	7.16	7.16	7.16	7.16	7.16	7.16	7.16	7.16	7.16
2.0<Vh	9.79	9.79	9.79	9.79	9.79	9.79	9.79	9.79	9.79	9.79
Buses										
n<16	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
16<n<35	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2
35<n	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6
Trucks										
q<1.5	10.4	10.4	10.4	10.4	10.3	10.2	10.4	10.5	10.4	10.3
1.5<q<5.0	15.8	15.8	15.8	15.8	15.5	15.4	15.9	16.4	16	15.5
5.0<q<12.0	29.2	29.3	29.2	29.1	28.5	28.1	29.6	30.7	29.8	28.6
12<q	47.2	47.3	47.2	47.1	46.3	45.7	47.7	49.2	48	46.4
LPG&CNG										
Passenger cars	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Buses										
n<16	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
16<n<35	30	30	30	30	30	30	30	30	30	30
35<n	51	51	51	51	51	51	51	51	51	51
Trucks										
q<1.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
1.5<q	30	30	30	30	30	30	30	30	30	30

Source: Research Institute of Transport; Road Police Department; Agency for Statistics
Vh is engine volume; n is number of seats; q is net carrying capacity

2.2.4 Emission Factors

National emission factors for this inventory were calculated by experts from "KazNIPIenergoprom" and the Kazakh Research Designing Institute of Energy Industry.

Table 2.8 presents factors used to convert combusted fuel into CO_2 emissions (net calorific values, carbon emission factors, fraction of carbon oxidized). They were calculated for gasoline, diesel, LPG, and CNG using following information:

⇒ GOSTs of different fuel types (national standards);

⇒ statistical data;

⇒ data on several oil and gas deposits.

Table 2.8: Factors for CO_2 emissions estimation from road transport

Fuel type	Net calorific value, TJ/unit	Carbon emission factor, t C/TJ	Fraction of carbon oxidized
Gasoline	44.21	19.13	0.995
Diesel	43.02	19.98	0.995
LPG	47.17	17.91	0.99
CNG	34.25	15.03	0.995

Emission factors for non-CO_2 gases were calculated for different vehicle types and fuel types based on "Russian Guidelines for estimation of road transport emissions to be used in calculation of city air pollution". Division of the fleet by types of vehicles were made by experts from the Transport Research Institute that take into account recommendations from the IPCC Guidelines:

1. *Passenger cars* – vehicles with rated gross weight less than 3500 kg designed to carry 12 or fewer passengers;
2. *Light-duty trucks and minibuses* – vehicles with rated gross weight less than 3500 kg designed for transportation of cargo or up to 16 passengers or which are equipped with special features for off-road operation. They include most pickup trucks, passenger and cargo vans, four-wheel drive vehicles, and derivatives of these;
3. *Heavy-duty trucks* – manufacturer's gross vehicle weight rating exceeding 3500 kg. These include large pickups, vans and trucks using pickup and van chassis, as well as large heavy-duty trucks, which have gross vehicle weights more than 7 tons;
4. *Buses* – all buses except minibuses.

The road fleet was not divided by the emission control technology type as all vehicles were assumed to have no emissions controls. In support of this assumption, the share of vehicles equipped with emission control technologies is negligible. Additionally, these vehicles are currently not separately registered in statistics. Table 2.9 presents the calculated emission factors for non-CO_2 gases. N_2O emissions factors were taken from the IPCC Guidelines as default.

Table 2.9: Emission factors of non-CO_2 gases (CH_4, N_2O, CO, NO_x, NMVOC) for road transport

Units	Emission factor						
	NO_x	**CH_4**	**NMVOC**	**CO**	**N_2O**	**CO_2**	**SO_2**
Gasoline passenger cars							
g/km	1.80	0.023	2.1	19		291.56	0.187
g/kg of fuel	19.23	1.25	22.44	203		3115	2
g/MJ	0.439	0.006	0.512	4.636	0.1	71.13	0.046
Diesel passenger cars							
g/km	1.30	0.022	0.25	2		281.56	0.891
g/kg of fuel	14.59	1.25	2.81	22.4		3160	10
g/MJ	0.342	0.006	0.066	0.527	0.6	74.14	0.235
Light-duty gasoline trucks and minibuses							
g/km	2.90	0.047	11.5	69.4		583.13	0.374
g/kg of fuel	15.49	1.25	61.43	370.7		3115	2
g/MJ	0.354	0.006	1.403	8.466	0.1	71.13	0.046
Heavy-duty gasoline trucks							
g/km	5.20	0.05	13.4	75		627.98	0.403
g/kg of fuel	25.79	1.25	66.47	372.0		3115	2
g/MJ	0.589	0.006	1.518	8.496	0.1	71.13	0.046
Heavy-duty diesel trucks							
g/km	7.70	0.071	6	8.5		895.86	2.835
g/kg of fuel	27.16	1.25	21.16	30.0		3160	10
g/MJ	0.637	0.006	0.497	0.703	0.6	74.14	0.235
Heavy-duty LPG trucks							
g/km	2.6	0.047	1.3	39		414.43	0
g/kg of fuel	16.76	1.25	8.38	251.5		2672	0
g/MJ	0.345	0.006	0.173	5.179	0.6	55.04	0
Gasoline buses							
g/km	5.3	0.065	13.4	97.6		807.41	0.518
g/kg of fuel	20.45	1.25	51.70	376.5		3115	2
g/MJ	0.467	0.006	1.181	8.599	0.1	71.13	0.046
Diesel buses							
g/km	8	0.073	6.5	8.8		921.46	2.916
g/kg of fuel	27.43	1.25	22.29	30.2		3160	10
g/MJ	0.644	0.006	0.523	0.708	0.6	74.14	0.235

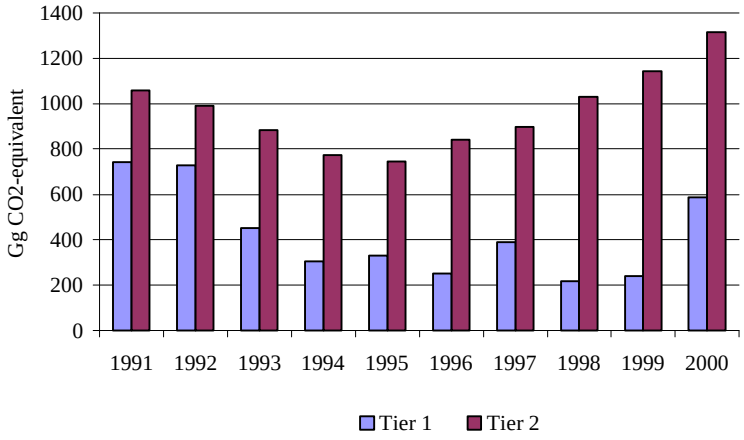
2.3 GHG EMISSIONS

2.3.1 Total GHG Emissions

Basied on estimations in 2001, total direct greenhouse gases emissions from road transport amounted to 1315.1 Gg of CO_2-equivalent including 1302.2 Gg of CO_2 emissions. Per capita

GHG emissions were 1.2 t of which 1.1 t were CO_2. Figure 2.3 shows the total direct greenhouse gases emissions from road transport (passenger cars, trucks, buses). Specialized vehicles were included into these categories according to technical characteristics.

Figure 2.3: Tier I & Tier II total direct greenhouse gases emissions, 1991-2000



Emissions were estimated on the basis of both "top-down" and "bottom-up" approaches. The difference between these two was 40.2% in 1991 and then increased up to 120.7% by 2000. This happened due to underestimation of fuel (mainly gasoline) in the fuel and energy balance prepared by Agency for Statistics. Because of the low quality and incomplete statistical data on fuel consumption, emissions estimation through the Tier II methodology is considered to be more reliable. For instance, according to Tier I estimations direct greenhouse gases emissions decreased by 21.2% through 1991-2000 despite the fact that the number of good-order vehicles increased by 89.7% during the period. Total direct greenhouse gases emissions estimated through the Tier II methodology increased by 24.2% through 1991-2000.

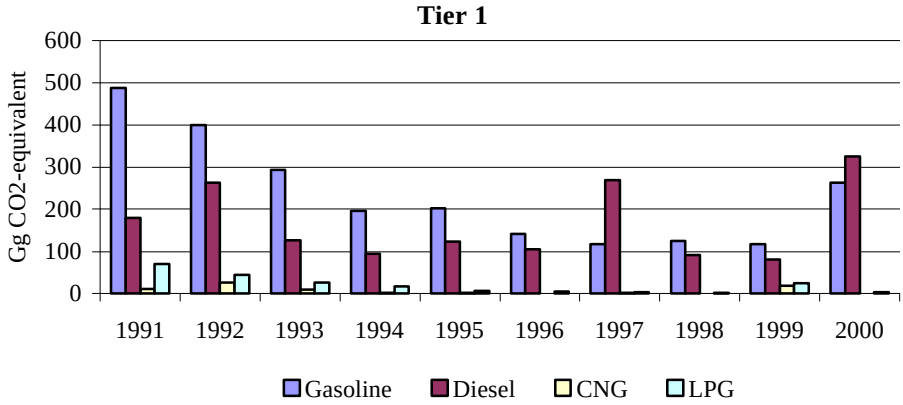
Table 2.10 below presents the dynamics and structure of total direct GHGs emissions for the road transport sector. The shares of three direct greenhouse gases stayed almost unchanged under both Tiers during the period with carbon dioxide accounting for more than 98% of total direct GHGs emissions, whereas the shares of methane and nitrous oxide amounted to 1.2% and 0.1%, respectively.

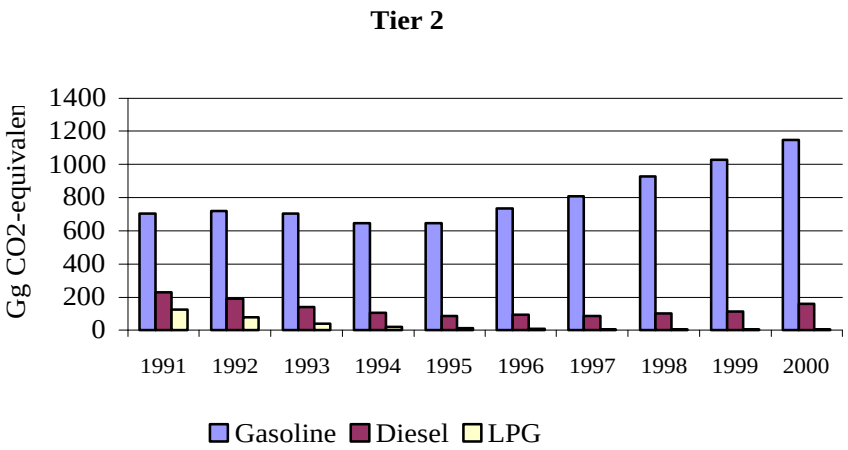
Table 2.10: Direct greenhouse gases emissions, Gg CO_2-equivalent

	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Tier I										
CO_2	740.9	725.1	449.3	304.4	327.6	250.9	385.9	216.6	239.5	584.6
CH_4	9.22	8.29	5.63	3.81	4.05	2.99	3.60	2.61	2.51	6.30
N_2O	0.87	1.01	0.53	0.36	0.40	0.33	0.71	0.28	0.37	0.90
Total	*751.0*	*734.4*	*455.5*	*308.5*	*332.0*	*254.2*	*390.2*	*219.5*	*242.4*	*591.8*
Tier II										
CO_2	1049.4	982.2	875.6	764.6	738.0	833.8	890.5	1021.7	1133.7	1303.2
CH_4	8.21	7.81	7.16	6.36	6.27	7.08	7.69	8.78	9.71	10.95
N_2O	1.25	1.02	0.77	0.60	0.52	0.56	0.56	0.64	0.71	0.88
Total	***1058.8***	***991.0***	***883.5***	***771.6***	***744.8***	***841.4***	***898.7***	***1031.1***	***1144.1***	***1315.1***

Figure 2.4 shows structure and dynamics of direct GHGs emissions by fuel types for Tier I and Tier II.

Figure 2.4: Direct greenhouse gases emissions by fuel types, Tiers I & II





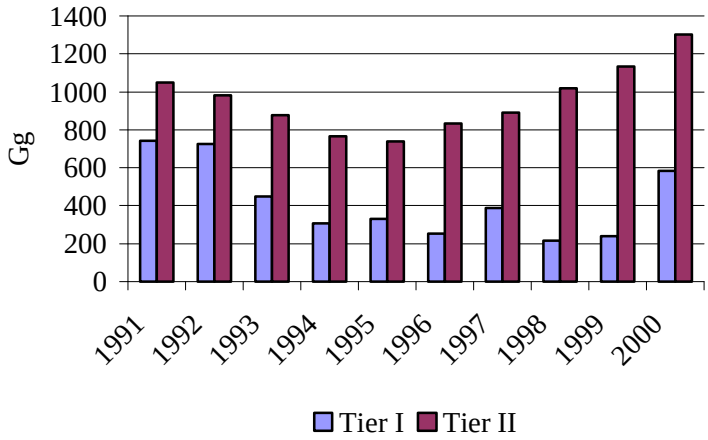
According to Tier I estimates, gasoline combustion accounted for the majority of direct emissions in 1991, decreasing from 480.6 Gg CO_2-equivalent (64.7%) to 115.9 Gg CO_2-equivalent in 1998 then increasing to 258 Gg CO_2-equivalent by 2000 (44%). Diesel fuel consumption fluctuated during the period causing corresponding fluctuations in emissions. Emissions from combustion of CNG and LPG tended to decrease throughout the period from 11.4 to 0.1 Gg CO_2-equivalent during 1991-2000 for CNG, and from 71.3 (9.6%) to 4.2 Gg CO_2-equivalent (0.7%) for LPG.

According to the Tier II estimates there was no dramatic decrease of emissions from gasoline combustion during the period with emissions decreasing slightly from 706.6 to 647.1 Gg CO_2-equivalent in 1991 and 1995, respectively, and then increasing to 1148.5 Gg CO_2-equivalent by 2000. The share of emissions from gasoline combustion increased from 66.7% in 1991 to 87.3% in 2000. Emissions from diesel fuel combustion decreased from 229.3 Gg CO_2-equivalent to 85.5 Gg CO_2-equivalent during 1991-1997 and then increased to 161.3 Gg CO_2-equivalent in 2000. Emissions from the combustion of LPG and CNG decreased from 123 Gg CO_2-equivalent in 1991 to 5.2 Gg CO_2-equivalent in 2000.

2.3.2 Carbon Dioxide Emissions

Carbon dioxide emissions were estimated applying both Tier I and Tier II approaches (figure 2.5 and table 2.11). Tier I estimates show that CO_2 emissions decreased by 21% from 1991 to 2000, whereas Tier II show a 24.2% increase. In 2000, CO_2 emissions estimated by the Tier II method were 2.23 times those estimated by the Tier I method.

Figure 2.5: CO_2 Emissions dynamics by Tiers I & II, 1991-2000



According to the Tier I methodology, the total CO_2 emissions from road transport decreased from 740.9 Gg to 584.6 Gg (or approximately by 21%) during the 10-year period. The share of CO_2 emissions from gasoline combustion during 1991-2000 decreased from 65% of total CO_2 emissions in road transport to 44%. The share of emissions from diesel fuel increased from 24% in 1991 to 55% in 2000. The share of CO_2 emissions from CNG combustion decreased from 9.6% in 1991 to 0.7% in 2000. The share of emissions from LPG fell from 1.5% to 0 during 1991-2000.

According to Tier II estimates, CO_2 emissions from road transport for all fuel types decreased from 1049.4 Gg in 1991 to 738.0 Gg in 1995, and then increased to 1303.2 Gg in 2000. Emissions from gasoline combustion contributed the largest share to total CO2 emissions from road transport -- 66.7% in 1991 to 87.3% in 2000. The share of diesel fuel in total CO_2 emissions from road transport decreased from 21.8% in 1991 to 9.7% in 1998 before increasing to 12.3% in 2000. The share of CO_2 emissions from CNG and LPG combustion decreased from 11.6% in 1991 to 0.4% in 2000.

Table 2.11: Tier I & II CO_2 emissions from road transport by fuel type, 1991-2000, Gg

Fuel type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tier I										
Gasoline	480.3	393.1	288.8	193.1	198.3	140.5	115.8	123.6	115.6	258.8
Diesel	178.3	261.7	125.0	93.1	122.2	104.8	266.5	90.6	80.8	321.4
LPG	11.4	26.6	9.6	1.4	0.6	0.2	0.4	0.1	17.8	0.1
CNG	70.9	43.7	25.9	16.7	6.5	5.4	3.2	2.3	25.3	4.2
Total	**740.9**	**725.1**	**449.3**	**304.4**	**327.6**	**250.9**	**385.9**	**216.6**	**239.5**	**584.6**
Tier II										
Gasoline	699.8	714.0	696.4	639.7	640.9	730.4	800.9	918.5	1017.7	1137.6
Diesel	228.2	191.1	138.6	104.0	84.9	94.9	85.1	99.2	114.1	160.5
LPG&CNG	164.0	104.3	55.7	29.0	17.3	12.5	6.8	5.9	2.8	7.8
Total	**1049.4**	**982.2**	**875.6**	**764.6**	**738.0**	**833.8**	**890.5**	**1021.7**	**1133.7**	**1303.2**

Table 2.12 presents CO_2 emissions by vehicle type.

Table 2.12: Tier II CO_2 emissions by vehicle type, 1991-2000, Gg.

Vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Passenger cars	168.8	231.5	304.5	350.4	421.9	529.6	603.1	693.7	739.5	787.2
Light-duty trucks and minibuses	70.5	71.6	65.3	56.9	55.1	54.9	61.0	65.7	82.4	105.7
Heavy-duty trucks	709.4	571.7	404.6	271.4	187.7	187.5	159.9	195.6	232.0	312.7
Buses	100.7	107.4	101.3	85.9	73.4	61.8	66.5	66.6	79.8	97.5
Total	**1049.4**	**982.2**	**875.6**	**764.6**	**738.0**	**833.8**	**890.5**	**1021.7**	**1133.7**	**1303.2**

In 1991 the key source of CO_2 emissions was heavy-duty trucks at 67.6%. The second largest source were passenger cars with a share of 16.1%. The shares of buses and Light-duty trucks & minibuses were 9.6% and 6.7%, respectively. During the period the shares of these four sources changed and by 2000 passenger cars became the largest CO_2 emissions source with the share of 60.4% of total CO_2 emissions from road transport. Heavy-duty trucks took the second place with 24.0% share followed by light-duty trucks & minibuses and buses at 8.1% and 7.5%, respectively.

2.3.3 Methane Emissions

Table 2.13 presents CH_4 emissions estimated by both Tiers. The "top-down" approach (Tier I) shows the decrease of total methane emission from road transport by 31.6% during the period. Gasoline combustion contributed the majority of methane emissions with a decrease from 0.34 Gg in 1991 (85%) to 0.1 Gg in 1996 (77%) and then rising to 0.19 Gg (70%) in 2000. The share of diesel fuel increased from 12.5% to 33% from 1991 through 2000. Methane emissions from LPG and CNG are insignificant.

According to Tier II estimates total methane emissions from road transport rose by 33.3% during the period. The share of gasoline combustion grew steadily from 78.6% in 1991 to 95.9% in 2000. The share of diesel combustion declined slightly from 5.5% to 3.6% during 1991-2000, while the share of gas fuel (LPG and CNG) decreased more significantly from 15.9% to 0.5%.

Table 2.13: CH_4 emissions from road transport by fuel types (Tiers I&II), Gg

Fuel type/ vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tier I										
Gasoline	0.34	0.28	0.21	0.14	0.14	0.10	0.08	0.09	0.08	0.19
Diesel	0.05	0.07	0.03	0.03	0.03	0.03	0.07	0.02	0.02	0.09
CNG	+	+	+	+	+	+	+	+	+	+
LPG	0.01	+	+	+	+	+	+	+	+	+
Total	**0.40**	**0.36**	**0.24**	**0.17**	**0.18**	**0.13**	**0.16**	**0.11**	**0.11**	**0.27**
Tier II										
Gasoline	*0.281*	*0.287*	*0.279*	*0.257*	*0.257*	*0.293*	*0.321*	*0.369*	*0.408*	*0.456*
passenger cars	0.068	0.093	0.122	0.140	0.169	0.212	0.241	0.277	0.296	0.315
Light-duty trucks and minibuses	0.025	0.026	0.024	0.021	0.020	0.020	0.023	0.025	0.031	0.040
Heavy-duty trucks	0.155	0.130	0.097	0.064	0.043	0.041	0.036	0.045	0.055	0.069
Buses	0.034	0.038	0.036	0.031	0.025	0.020	0.021	0.022	0.027	0.033

Fuel type/ vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Diesel	*0.020*	*0.017*	*0.013*	*0.010*	*0.010*	*0.011*	*0.011*	*0.012*	*0.013*	*0.017*
passenger cars	+	+	+	+	+	+	+	+	+	+
Light-duty trucks and minibuses	+	+	+	+	+	+	+	+	+	+
Heavy-duty trucks	0.017	0.015	0.010	0.008	0.006	0.006	0.005	0.006	0.007	0.011
Buses	0.002	0.002	0.002	0.002	0.004	0.004	0.005	0.005	0.005	0.006
LPG&CNG	*0.057*	*0.036*	*0.019*	*0.010*	*0.006*	*0.004*	*0.002*	*0.002*	*0.001*	*0.002*
passenger cars										
Light-duty trucks and minibuses	0.003	0.002	0.001	0.001	0.001	0.001	+	+	+	+
Heavy-duty trucks	0.048	0.030	0.015	0.007	0.004	0.002	0.001	0.001	0.000	0.001
Buses	0.006	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.000	0.001
Total	**0.36**	**0.34**	**0.31**	**0.28**	**0.27**	**0.31**	**0.33**	**0.38**	**0.42**	**0.48**

Value indicated by + is less than 10^{-5}.
Values may not sum to totals due to rounding.

2.3.4 Nitrous Oxide Emissions

Table 2.14 presents the structure of N_2O emissions estimated by the Tier II methodology for four fuel types. Total nitrous oxide emissions amount to 3 t in 2000 (884 t CO_2-equivalent). The share of gasoline combustion grew steadily during the period 1991-2000 from 23.5% to 54.1% of total N_2O emissions from road transport.

The contribution of nitrous oxide emissions from gasoline combustion by vehicle type changed during the period. In 1991 the shares of heavy-duty trucks and passenger cars were 55% and 23.5% respectively, whereas the contribution of buses and light-duty trucks & minibuses were only 12.0% and 8.8%, respectively. In 2000 passenger cars became the main source of N_2O emissions with a share of 68.9%, while heavy-duty trucks moved to the second place at 15.2%.

Combustion of diesel fuel contributed 45.0% of total N_2O emissions in 1991 and 43.9% in 2000, with the largest contribution from heavy-duty trucks. N_2O emissions from LPG and CNG combustion were insignificant.

Table 2.14: N_2O emissions from road transport by fuel types (Tiers I & II), Gg

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tier II										
Gasoline	*0.0010*	*0.0010*	*0.0010*	*0.0009*	*0.0009*	*0.0010*	*0.0011*	*0.0013*	*0.0014*	*0.0016*
passenger cars	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0009	0.0010	0.0010	0.0011
Light-duty trucks and minibuses	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Heavy-duty trucks	0.0005	0.0005	0.0003	0.0002	0.0002	0.0001	0.0001	0.0002	0.0002	0.0002
Buses	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Diesel	*0.0019*	*0.0016*	*0.0011*	*0.0008*	*0.0007*	*0.0008*	*0.0007*	*0.0008*	*0.0009*	*0.0013*
passenger cars	+	+	+	+	+	+	+	+	+	+

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Light-duty trucks and minibuses	+	+	+	+	+	+	+	+	+	+
Heavy-duty trucks	0.0018	0.0015	0.0011	0.0008	0.0006	0.0007	0.0005	0.0007	0.0008	0.0011
Buses	+	+	+	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
LPG&CNG	*0.0014*	*0.0009*	*0.0005*	*0.0003*	*0.0002*	*0.0001*	*0.0001*	*0.0000*	*0.0000*	*0.0001*
passenger cars										
Light-duty trucks and minibuses	0.0001	+	+	+	+	+	+	+	+	+
Heavy-duty trucks	0.0011	0.0007	0.0003	0.0002	0.0001	0.0001	+	+	+	+
Buses	0.0001	0.0001	0.0001	+	+	+	+	+	+	+
Total	**0.0042**	**0.0035**	**0.0026**	**0.0020**	**0.0018**	**0.0019**	**0.0019**	**0.0022**	**0.0024**	**0.0030**

Value indicated by + is less than 10^{-5}.
Values may not sum to totals due to rounding.

2.3.5 Indirect Greenhouse Gases Emissions

Emissions of CO, NO_x, NMVOC, and SO_2 from road transport are monitored and estimated by the Agency for Statistics since these gases are criteria pollutants, and are published in annual bulletin "State of atmospheric air in Kazakhstan". However these estimates do not include emissions from private passenger cars. Thus, for the purposes of this inventory, emissions of CO, NO_x, NMVOC, and SO_2 were estimated through the IPCC Tier II methodology using national emission factors. The results by fuel types and vehicle types are presented in tables 2.15, 2.16, 2.17, and 2.18 below for the four gases. The dynamics of indirect greenhouse gases emissions have similar trends, with emissions of all these gases (CO, NO_x, NMVOC, and SO_2) decreasing from 1991 through 1995 and then increasing to 2000.

Table 2.15: CO emissions from road transport by fuel type, Gg

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tier II										
Gasoline	*74.5*	*72.8*	*66.8*	*57.5*	*53.8*	*58.6*	*63.1*	*72.2*	*81.6*	*93.4*
passenger cars	11.0	15.1	19.8	22.8	27.4	34.4	39.2	45.1	48.0	51.1
Light-duty trucks and minibuses	7.3	7.8	7.2	6.4	6.1	6.0	6.7	7.3	9.3	11.9
Heavy-duty trucks	46.0	38.7	28.9	19.2	12.8	12.3	10.8	13.4	16.3	20.6
Buses	10.2	11.4	10.8	9.2	7.5	5.9	6.3	6.5	8.0	9.8
Diesel	*2.2*	*1.8*	*1.3*	*1.0*	*0.8*	*0.9*	*0.8*	*0.9*	*1.1*	*1.5*
passenger cars	0.001	0.001	0.003	0.004	0.006	0.009	0.012	0.016	0.019	0.022
Light-duty trucks and minibuses	0.016	0.016	0.015	0.015	0.019	0.023	0.026	0.026	0.030	0.038
Heavy-duty trucks	2.10	1.74	1.24	0.90	0.69	0.76	0.64	0.77	0.90	1.31
Buses	0.05	0.05	0.05	0.06	0.09	0.10	0.12	0.11	0.12	0.13
LPG&CNG	*11.4*	*7.2*	*3.8*	*2.0*	*1.2*	*0.8*	*0.4*	*0.4*	*0.2*	*0.5*

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
passenger cars										
Light-duty trucks and minibuses	0.64	0.39	0.22	0.14	0.12	0.12	0.05	0.05	0.01	0.03
Heavy-duty trucks	9.67	6.09	3.01	1.48	0.82	0.48	0.20	0.21	0.08	0.22
Buses	1.11	0.77	0.59	0.35	0.21	0.20	0.17	0.11	0.08	0.24
Total	**88.1**	**81.9**	**71.9**	**60.5**	**55.7**	**60.3**	**64.3**	**73.5**	**82.9**	**95.4**

Values may not sum to totals due to rounding.

Table 2.16: NO_x emissions from road transport by fuel type, Gg

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tier II										
Gasoline	*5.09*	*5.05*	*4.77*	*4.25*	*4.14*	*4.68*	*5.09*	*5.85*	*6.50*	*7.30*
passenger cars	1.04	1.43	1.88	2.16	2.60	3.26	3.71	4.27	4.55	4.84
Light-duty trucks and minibuses	0.31	0.32	0.30	0.27	0.25	0.25	0.28	0.31	0.39	0.50
Heavy-duty trucks	3.19	2.68	2.00	1.33	0.88	0.85	0.75	0.93	1.13	1.43
Buses	0.55	0.62	0.59	0.50	0.41	0.32	0.34	0.35	0.44	0.53
Diesel	*1.953*	*1.633*	*1.182*	*0.884*	*0.715*	*0.797*	*0.709*	*0.828*	*0.952*	*1.345*
passenger cars	0.001	0.001	0.002	0.003	0.004	0.006	0.008	0.010	0.012	0.014
Light-duty trucks and minibuses	0.010	0.010	0.010	0.010	0.013	0.015	0.017	0.017	0.020	0.025
Heavy-duty trucks	1.901	1.575	1.123	0.818	0.621	0.684	0.577	0.701	0.812	1.183
Buses	0.041	0.046	0.047	0.053	0.078	0.092	0.107	0.101	0.108	0.122
LPG&CNG	*0.761*	*0.483*	*0.254*	*0.131*	*0.077*	*0.053*	*0.028*	*0.025*	*0.012*	*0.032*
passenger cars										
Light-duty trucks and minibuses	0.042	0.026	0.015	0.009	0.008	0.008	0.004	0.004	0.001	0.002
Heavy-duty trucks	0.645	0.406	0.201	0.098	0.055	0.032	0.014	0.014	0.005	0.015
Buses	0.074	0.052	0.039	0.024	0.014	0.014	0.011	0.007	0.005	0.016
Total	**7.81**	**7.16**	**6.21**	**5.27**	**4.94**	**5.53**	**5.82**	**6.71**	**7.47**	**8.67**

Values may not sum to totals due to rounding.

Table 2.17: NMVOC emissions from road transport by fuel type, Gg

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tier II										
Gasoline	*12.1*	*11.4*	*10.0*	*8.3*	*7.3*	*7.8*	*8.3*	*9.5*	*10.9*	*8.3*
passenger cars	1.2	1.7	2.2	2.5	3.0	3.8	4.3	5.0	5.3	5.6
Light-duty trucks and minibuses	1.21	1.29	1.20	1.05	1.01	1.00	1.12	1.21	1.54	1.97

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Heavy-duty trucks	8.22	6.91	5.16	3.43	2.28	2.19	1.93	2.39	2.92	3.68
Buses	1.40	1.56	1.49	1.26	1.03	0.81	0.87	0.90	1.10	1.34
Diesel	*1.5*	*1.3*	*0.9*	*0.7*	*0.5*	*0.6*	*0.5*	*0.6*	*0.7*	*0.5*
passenger cars	+	+	+	0.001	0.001	0.001	0.002	0.002	0.002	0.003
Light-duty trucks and minibuses	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.005
Heavy-duty trucks	1.48	1.23	0.88	0.64	0.48	0.53	0.45	0.55	0.63	0.92
Buses	0.03	0.04	0.04	0.04	0.06	0.07	0.09	0.08	0.09	0.10
LPG&CNG	*0.38*	*0.24*	*0.13*	*0.07*	*0.04*	*0.03*	*0.01*	*0.01*	*0.01*	*0.01*
passenger cars										
Light-duty trucks and minibuses	0.021	0.013	0.007	0.005	0.004	0.004	0.002	0.002	0.000	0.001
Heavy-duty trucks	0.322	0.203	0.100	0.049	0.027	0.016	0.007	0.007	0.003	0.007
Buses	0.037	0.026	0.020	0.012	0.007	0.007	0.006	0.004	0.003	0.008
Total	**13.9**	**12.9**	**11.1**	**9.0**	**7.9**	**8.4**	**8.8**	**10.1**	**11.6**	**8.8**

Value indicated by + is less than 10^{-5}.
Values may not sum to totals due to rounding.

Table 2.18: SO_2 emissions from road transport by fuel type, Gg

Fuel type/vehicle type	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Tier II										
Gasoline	*0.4*	*0.5*	*0.4*	*0.4*	*0.4*	*0.5*	*0.5*	*0.6*	*0.7*	*0.7*
passenger cars	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5
Light-duty trucks and minibuses	0.04	0.04	0.04	0.03	0.03	0.03	0.04	0.04	0.05	0.06
Heavy-duty trucks	0.25	0.21	0.16	0.10	0.07	0.07	0.06	0.07	0.09	0.11
Buses	0.05	0.06	0.06	0.05	0.04	0.03	0.03	0.03	0.04	0.05
Diesel	*0.7*	*0.6*	*0.4*	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	*0.4*	*0.5*
passenger cars	0.001	0.001	0.001	0.002	0.003	0.004	0.005	0.007	0.008	0.010
Light-duty trucks and minibuses	0.007	0.007	0.007	0.007	0.009	0.010	0.012	0.012	0.014	0.017
Heavy-duty trucks	0.70	0.58	0.41	0.30	0.23	0.25	0.21	0.26	0.30	0.44
Buses	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Total	**1.17**	**1.06**	**0.89**	**0.74**	**0.68**	**0.77**	**0.78**	**0.90**	**1.01**	**1.24**

Values may not sum to totals due to rounding.

2.4 UNCERTAINTY ASSESSMENT

Estimation of GHG emissions for road transport is a rather complicated task, as it requires consideration of many parameters. At the same time it is important to make an accurate and

precise estimate as road transport is one of the key sources of GHG and noxious emissions in Kazakhstan.

This section includes assessments of the uncertainty for both activity data and emission factors. Uncertainty assessment in this study was prepared for direct greenhouse gases emissions (CO_2, N_2O and CH_4).

2.4.1 Activity data uncertainty

CO_2 emissions were estimated through both "top-down" and "bottom-up" approaches, which revealed a number of sources of uncertainty in the activity data.

First, fuel consumption data provided in the fuel and energy balance by the Agency for Statistics differs significantly from the amount of fuel consumed by road transport calculated as a sum of values for all vehicle types:

$$FCij=Nij\ Kij\ Eij$$

where **FC** – fuel consumption; **N** – number of vehicles; **K** – annual kilometers traveled per vehicle; **E** – average fuel consumption (liter/100 km); **j** – fuel type; **i** – vehicle type (passenger cars, trucks, buses, specialized vehicles).

For instance, the calculated fuel consumption in 2000 is 4 times greater than that provided in fuel and energy balance (the largest difference is for gasoline). This difference is the result of underestimation of fuel consumption by Agency for Statistics and fuels smuggled for transportation. Thus data from the fuel and energy balance provided by Agency for Statistics were considered incomplete and unreliable, and an estimate of the uncertainty was prepared for the emissions estimated through Tier II methodology.

Data on average annual kilometers traveled were taken from various sources, which in turn affected the uncertainty of the estimated fuel consumption. The Agency for Statistics collects data on average annual kilometers traveled only for vehicles owned by state and private enterprises, however their share in the total fleet decreased during the 1990-2000 period.

Data on average annual kilometers traveled by privately owned vehicles, supposed to be collected by the Road Police Department, are absent at present. Thus, average annual kilometers traveled by vehicles owned by enterprises for each vehicle type were adjusted for privately owned vehicles taking into account their shares in each vehicle types. The ratio between privately owned vehicles and vehicles owned by enterprises was defined basing on a survey of drivers (Research Institute of Transport, 2001). The share of privately owned vehicles in every vehicle type was estimated based on data from Agency for Statistics. Table 2.19 presents uncertainty of average annual kilometers traveled.

Table 2.19: Uncertainty of average annual kilometers traveled for vehicle type

Vehicle type	Country-producer	Average annual kilometers traveled (km/year) and uncertainty (km/year; %)	
passenger cars	CIS	25,606 ±1,558	25,606 ±6.1%
	USA, South Korea, Japan, Western Europe	27,490 ±1,280	27,490 ±4.7%
trucks	CIS	40,374 ±2,650	40,374 ±6.6%
	USA, South Korea, Japan, Western Europe	61,740 ±10,139	61,740 ±16.4%
buses	CIS	48,272 ±6,945	48,272 ±14.4%
	USA, South Korea, Japan, Western Europe	50,726 ±4,978	50,726 ±9.8%

The uncertainty for each vehicle type was then estimated as the weighted average of the shares by country of production. The results are as follows: passenger cars ±5.5%, trucks ±7.4%, and buses ±12.8%. According to the Rule A of the UNFCCC Good Practice a combination of uncertainties was applied to estimate the aggregate uncertainty for all vehicle types, which amounted to ± 4.8%.

Average fuel consumption uncertainty arises from aggregation by vehicle types, which according to expert assessment from Research Institute of Transport amounts to ±10% with a confidence level of 90%.

The uncertainty of the total number of vehicles is close to zero.

It is difficult to precisely assess the kilometers traveled and fuel consumption for specialized vehicles at present, thus they were placed among corresponding vehicle types (passenger cars, trucks and buses). This contributed to general uncertainty, though the share of specialized vehicles is small (2-7% of the total fleet).

Therefore, the uncertainty related to total fuel consumption by road transport amounts to ±11.1% as estimated according to the IPCC methodology:

$$U_{tf} = (U_f^2 + U_n^2 + U_k^2)^{1/2},$$

where $\mathbf{U_{tf}}$ – uncertainty related to the total fuel consumption; $\mathbf{U_f}$ – uncertainty related to average fuel consumption; $\mathbf{U_n}$ – uncertainty related to the total number of vehicles; $\mathbf{U_k}$ – uncertainty related to average annual kilometers traveled.

2.4.2 Emission factors uncertainty and general uncertainties of N_2O, CH_4 and CO_2 estimates

Good Practice provides default uncertainty assessments for particular emission sources that are to be used if additional information is absent.

The major source of uncertainty for the N_2O and CH_4 estimates is related to the emission factors and expert judgment suggests that the general uncertainty may be about ±50% for N_2O, and ±40% for CH_4. Given that uncertainty in activity data makes a small share in the general uncertainty of the N_2O and CH_4 estimates, the uncertainties based on expert opinion related to the emission factors were taken as the general uncertainty for these two gases.

Good Practice provides that the general uncertainty of estimated CO_2 is equal to approximately ±5 %. However, given that the major source of estimated CO_2 uncertainty is the activity data, the general uncertainty for this gas was taken as equal to 11.1% (section 2.4.1, Activity data uncertainty). Uncertainty related to CO_2 emission factors was considered negligible.

2.4.3 Combined Uncertainty

The combined (overall) uncertainty of road transport GHG inventories was estimated according to *Good Practice* guidelines accounting for the contribution of each direct greenhouse gas to the total GHG emissions and general uncertainty of their estimates, based on the equation below:

$$\mathbf{U_{com} = (S\ (U_{total(i)} \cdot D_{(i)}/SD_{(i)})^2)^{1/2},}$$

where $\mathbf{U_{com}}$ – combined uncertainty of the total GHG emissions estimate in road transport;
$\mathbf{U_{total(i)}}$ – general uncertainty of greenhouse gas estimate;
$\mathbf{D_{(i)}}$ – emission estimate;
i – greenhouse gas

The shares of CO_2, N_2O and CH_4 in the total GHG emissions in road transport were 99.1%, 0.1%, and 0.8%, respectively, hence the combined (overall) inventory uncertainty of emission estimates in Almaty road transport amounted to ±11%.

2.5 RECOMMENDATIONS ON IMPROVEMENT OF THE GHG INVENTORY IN ROAD TRANSPORT

The existing methodology for estimation of GHG emissions/sinks developed by the IPCC experts is based on calculation methods that require national statistical data. The Republican Agency for Statistics is the main source of the initial data to estimate GHG emissions. However additional data from other sources are required in order to conduct a high-quality estimation of GHG emissions from road transportation.

Analysis of the initial data on road transport provided by Agency for Statistics for completeness and reliability showed that the data quality tended to decrease during 1992-2000. The main reason was restructuring of road transport in Kazakhstan that involved privatizing road transport enterprises with the appearance of small and medium size enterprises that provide transport services and only passenger cars were privately owned in Kazakhstan until 1992. As the result of the government privatization program in road transport, the share of trucks and buses privately owned has been increasing dramatically. For instance by the end of 2000 in Almaty, 97% of the total fleet (passenger, buses, trucks) were privately owned vehicles, only 2% were owned by state enterprises and 1% of vehicles belonged to foreign states.

The most complete information in the Agency for Statistics used to be collected from both state and private road transportation enterprises and included the total number of vehicles indicating their total carrying capacity, seating capacity, total annual kilometers traveled, etc. Transportation activity of non-transport enterprises, such as food production and transportation, was not completely covered in the statistical reporting up to 2000. Information about the number of good order vehicles and vehicle model, for privately owned vehicles comes to the Agency for Statistics from the Road Police Department (RPD) from the annual maintenance inspection of vehicles.

Furthermore the statistical reporting for all enterprises owning vehicles does not include the rented fleet. Thus many enterprises (especially the non-transportation enterprises) do not report data on rented vehicles and hence the data collected by the Agency for Statistics was incomplete.

The amount of fuel combusted by road transport was reported in the fuel and energy balances as the sum of two sections. The first, "fuel supplied to population," which accounts for the amount of fuel consumed by privately owned vehicles. The second, "fuel consumed by road transports," included the total amount of fuel consumed by road transport in various industries, separated by “transportation needs” and “non-transportation needs”. Since 1998 fuel consumed for transportation and non-transportation needs are reported together, which makes it impossible to estimate fuel consumed by road transport completely.

Under the state program, the Agency for Statistics revised the statistical reporting forms to bring them into accord with economic conditions and international requirements. Many gaps were eliminated in the new reporting forms developed for 2001 with the implementation of the TACIS program for further improvement of the statistical reporting tables in road transportation to meet the international requirements.

The recommendations below will help to improve the statistical reporting system in the road transportation sector and thus to increase the quality of GHG emissions inventory and establish the national data collection system:

1. ***Fuel consumed by road transportation.*** Report separately the amount of fuel consumed by road transport for transportation and non-transportation needs in fuel and energy balance.
2. ***Number of Vehicles.*** The most complete data on the number of road vehicles in Kazakhstan are available from the Road Police Department. It is necessary that these data be provided to the Agency for Statistics with the vehicles separated into three sections -- 'private vehicles', 'vehicles owned by transportation enterprises', and 'vehicles owned by non-transportation enterprises'. A separation by transportation mode (passenger cars, light trucks, heavy trucks, and buses) already exists in the statistical reporting process.
3. ***Annual average kilometers traveled.*** For the 'bottom-up' approach to estimate GHG emissions, it is necessary to obtain annual average kilometers traveled by vehicles. At present these data are collected by the Agency for Statistics only for vehicles owned by transportation enterprises. The Road Police Department has developed a database that contains information on annual kilometers traveled by vehicles including those privately owned. However, not all regional road police departments are presently equipped with the computerized database, so the reporting is incomplete.

   3.1. In the interim, the average annual kilometers traveled by road transportation will be estimated through questionnaires. For instance, in 2001 the Research Institute of Transport made such estimate for the city of Almaty. In the future, national data will be provided by the Road Police Department when the database is installed in all of the regions.

   3.2. In order to obtain data on average annual kilometers traveled by rented vehicles it is necessary to introduce changes in form #2-MP "Activity of city and road transport".

   3.3. In order to obtain data on average annual kilometers traveled by vehicles of non-transportation enterprises it is necessary that such enterprises provide their information to the Agency for Statistics using statistical reporting tables similar to those used by transportation enterprises.

   3.4. To make it possible to account for the activity of individual transportation vehicles, it is necessary to develop a listing of such individuals/organizations that should report to the Agency for Statistics through statistical tables similar to those used for transportation enterprises.
4. ***Emission control technology***. Since GHG emissions depend on the type of emission control technology, it is necessary to keep separate records of vehicles with emission control technologies by vehicle type.

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