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# Energy Efficiency and $CO_2$ Emissions of the Transportation System of Kazakhstan: A Case of Almaty

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## Abstract

Energy saving in the transport sector in the framework of the annual growth of energy consumption, the degree of negative impact on the environment and the amount of harmful emissions are becoming increasingly important. The article considers the world tendencies of energy consumption in transportation sector and emphasizes its dependency from oil. Also article describes the dynamics of energy use and $CO_2$ emissions from transport of city Almaty. In conclusion authors identify a number of problems in the transport sector, which hinder the implementation of energy efficiency measures and measures to reduce $CO_2$ emissions.

**Keywords:** Transport, Energy efficiency, $CO_2$ emissions, Air Pollution, Energy consumption, Fuel.

**JEL Classification Codes:** Q01, Q20,Q54, R41.

## 1. Introduction

Atmosphere protection from the harmful effects of vehicle emissions is an urgent environmental problem. The annual increase in vehicular traffic and significant expansion of individual car park cause an emissions increase in the contribution to the total emissions of harmful substances into the air. The problem of air pollution is relevant to many cities in the world, despite a significant improvement in air quality over the last 30-40 years. It is clear that reducing the negative impact of transport on the environment is possible mainly due to the improvement of the level of "green" and energy efficiency of the vehicles.

It is widely recognized that energy efficiency is the most cost-effective and affordable means of solving many of the problems of energy supply, including energy security, socio-economic impact of rising energy prices and climate change mitigation. Measures for energy efficiency of transport not only reduce fuel consumption, but also help to overcome other problems arising from the use of different transport modes. Effective organization and operation of public transport contribute to a significant reduction in energy costs, reduce congestion, noise, local air pollution, the risk of accidents and greenhouse gas emissions, as well as providing economic growth in general.

## 2. Main Part 1

According to the International Energy Agency (IEA), in the period 1990-2011 transport has become the fastest growing sector of energy consumption: energy consumption has increased by almost 55% to 102 exajoules (EJ) (excluding international bunkers) (Figure 1). Today, there are huge regional differences in energy consumption for transport. So the United States, Canada, Australia and Saudi Arabia are among the countries with high levels of energy use per capita. At the same time, India and neighboring countries, as well as some African countries expend about 20 times less energy to transport[1].

The use of different types of fuel vary by region. In Europe, Latin America and India the main fuel is diesel fuel, while in North America, the Middle East and in the OECD Pacific region dominated by gasoline. On the territory of the former Soviet Union compressed natural gas (CNG) and liquefied petroleum gas (LPG) have a large share among fuels for transport. Only a small fraction of the energy used comes from natural gas, electricity or biomass. According to forecasts, along with an increase in renewable fuels, types of petroleum-based maintain its dominant position, while possessing a specific gravity greater than 90%. IEA expects oil demand growth in the transport sector by 2030 by 25%. However, the future development of this demand varies greatly between regions.

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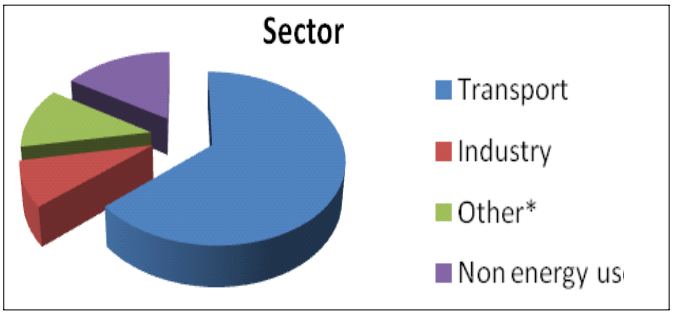
1) Public transport and energy efficiency. Sustainable transport: a collection of materials for policy-makers in developing cities. - GIZ. 2013. - 106 c. - http://www.giz.de




* Including agriculture, commercial and public services, housing and other
Source: IEA (2014).

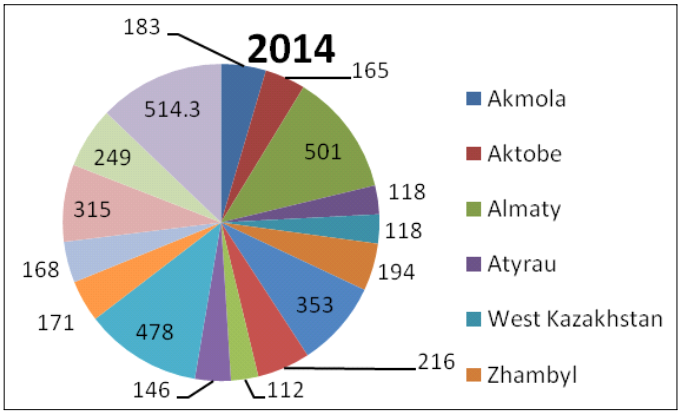
**<Figure 1>** Oil Use by Sectors, 2012

Analysis of energy consumption in transport, according to the IEA suggests that the world's energy consumption of road transport is far ahead of all other types and significantly influences the growth of energy transport in general: in 2010 it accounted for 90% of total energy consumption of transport. While other types of transport in this period increased power consumption by only 5%, the power consumption of road transport increased by 55%[2)].

There is a close link between energy consumption and emissions due to the almost complete dependence AMG, buses and airplanes from fuel derived from crude oil. Since the radical changes in the structure of fuel consumption from year to year does not occur, the trend in emissions of carbon dioxide ($CO_2$) in the transport sector is repeated trend of energy consumption. Currently it provides 22% of all $CO_2$ emissions, which is about 7 Gt. and 5 Gt. of it accounted for cars and trucks.

## 3. Main Part 2

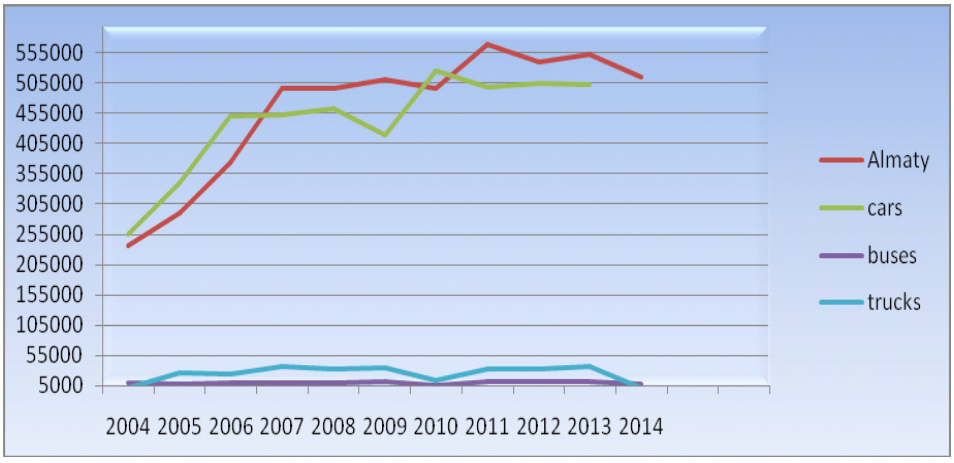
Almaty is the largest metropolis in the Republic of Kazakhstan. The population is 1,548,400 people on January 2015 according to the Department of Statistics of Almaty city. Respectively, Almaty takes the first place in the Republic (about 13%) at the number of cars that in amount proportion is 514,300 units of vehicles in 2014, at 100 inhabitants account for 30.7 vehicles (Figure 2).




Source: Committee of statistics of Republic of Kazakhstan

**<Figure 2>** Amount of Vehicles at Regions in 2014 (Thousand Tons)

The number of vehicles increased 2 times over the last 10 years according to the Committee of Statistics of the Republic of Kazakhstan (Figure 3). At the same time, the cars are the most part of vehicles – there are more than 90%. Trucks do




Source: Committee of statistics of Republic of Kazakhstan

**<Figure 3>** Dynamics of Vehicles and Distribution by Types in Almaty City (Tons/Years)

2) Energy Efficiency Indicators: Essentials for Policy Making .IEA.

not exceed 40,000 units for all years, as a percentage of the volume range from 0.5 to 2%. The number of buses also has small percentage - there are from 0.2 to 0.6% by year, there is from 7000 to 12 000 in units.

The number of vehicles is increasing rapidly till 2007 in Almaty, due to the favorable economic situation in the country. There is moderate growth observed from 2007 to 2009. Consumer ability decreases in 2009 due to the economic crisis. There is grown of vehicles number since 2010 in general. The number of vehicles is 514,266 units in the city of Almaty in 2014. If it considers the dynamics for each type of vehicle, the situation would be similar to the overall picture of the growth of the number of vehicles in the city of Almaty.

By Car: there is a sharp increase in the number of cars until 2006. The number of cars increased dramatically by 2010. There has been a modest increase of cars after 2010., the number of cars is 503,090 units in Almaty city in 2014.

By bus fleet, the average increase is 10% per year from 2004 to 2009, there is about 1000 units / year. Decline in the number of buses by 50% observed in 2010. There was a moderate increase in the bus fleet In the period from 2011 to 2014. The number of buses was 7675 units in the city of Almaty in 2014.

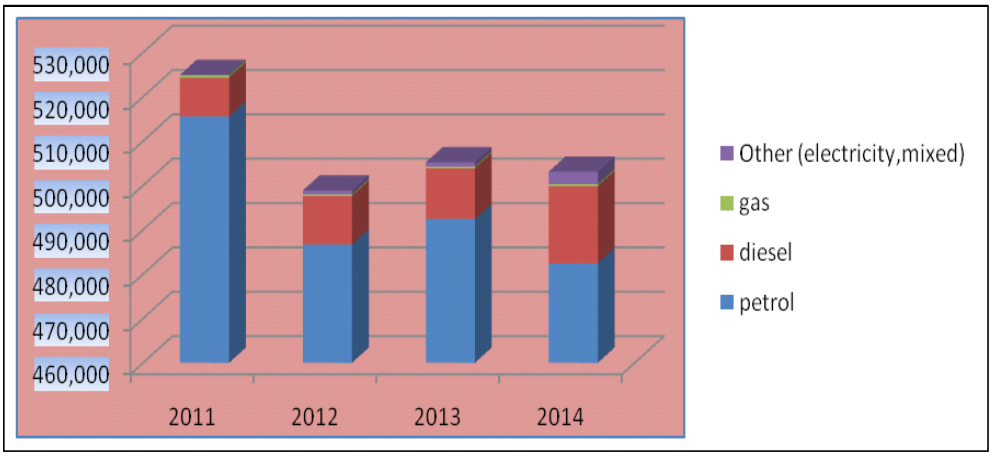
The situation on trucks is similar to the dynamics growth in the number of buses: there is an increase of trucks from 2004 to 2007, the annual average of 8%, which is about 3000 units per year. The number of trucks decreased by 50%, which is about 18 000 units in 2010. There is moderate growth after 2010. The number of trucks is 26 million units in Almaty city in 2014.

increased from 1.6% to 3%. The number of vehicles using gas (liquefied petroleum gas and liquefied natural gas) is reduced from 0.1% to 0.08% in Almaty city. Also, the vehicles operates from 0.016% to 0.5% at the mixed fuel (electricity and gas, electricity) (Figure 4).

The main amounts of cars are produced abroad in Almaty city and in Kazakhstan in general. A characteristic feature of these cars is using petrol with a higher octane number. Unfortunately, though Kazakhstan has large reserves of fossil fuels, about 20-45% of petrol with higher octane is imported products. Primarily, this is due to the fact that oil refineries built in the Soviet Union, have been established for the production of low-octane fuel in the main, and have limited ability to change the structure of production at the moment.

Also the factor that domestic oil prices significantly lower than export prices plays an important role. Thus, local oil producers have more incentive to export crude oil, but not for sale in domestic market[3].

Fuel consumption depends on the engine displacement of the car. Distribution of registered motor vehicles / year in terms of the engine displacement and the dynamics of change over the years in Almaty city are given in Table 1.




Source: Committee of statistics of Republic of Kazakhstan0

**<Figure 4>** Dynamics of Fuel Using and Distribution of Fuel by Types in Almaty (ths. units/years)

The situation at fuel energy consumption in Almaty city is similar to the situation in the country as a whole. According to the Committee of Statistics of the Republic of Kazakhstan, the number of vehicles using petrol reduces from 98% to 96% from 2011 to 2014, while the proportion of vehicles run on diesel fuel

3) Survey and analytical report: emissions of transport sector, the standards of fuel quality and the politician of economy of fuel in Kazakhstan - http://www.unep.org/Transport/new/PCFV/pdf/rus_cleanfuel_UNEP-CAREC_report.pdf

**<Table 1>** Distribution of Registered Vehicles in Terms of Engine Displacement

| Year<br>Engine Displacement | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Number of registered vehicles | 12092 | 7253 | 3112 | 9049 | 9484 |
| including: | | | | | |
| till 1100 cb.cm. | 82 | 109 | 82 | 153 | 108 |
| over 1100 till 1500 cb.cm. | 486 | 404 | 139 | 621 | 553 |
| over 1500 till 2000 cb.cm | 3216 | 2 052 | 1 273 | 3 196 | 3 348 |
| over 2000 till 2500 cb.cm | 2912 | 1 628 | 393 | 1 865 | 2092 |
| over 2500 till 3000 cb.cm | 2872 | 1 677 | 397 | 1 673 | 1 636 |
| over 3000 till 4000 cb.cm | 1605 | 780 | 458 | 931 | 903 |
| over 4000 cb.cm | 919 | 603 | 370 | 610 | 844 |

Source: Ministry of Internal Affairs of the Republic of Kazakhstan

According to the Ministry of Internal Affairs of the Republic of Kazakhstan, a small part of the market is occupied by cars with engine displacement from 1.1 to 1.5 liters: the number of the cats increased from 4.5% to 5% per year (Figure 5). Most car owners prefer cars with an engine displacement in the range of 1.5-2 liters. Every year the number of such cars increases. The percentage ratio growth is observed from 25% to 35% per year. The number of cars with engine displacement of 2 to 2.5 liters increased also about 20% per year from 2010 to 2014. Number of cars with engine displacement of 2.5 to 3 liters is reduced from 23% to 17% per year from 2010 to 2014.

The number of registered vehicles with an engine displacement of 3 to 4 liters reduced from 13% to 9% also. The number of imported cars with engine displacement more than 4 liters is increased by about 1% per year. But the reduction of such vehicles is observed in 2014 compared with 2013 year. The main factor in this decline is the increase in the tax on transport, for cars with engine displacement more than 3.0 liters.

Exhaust emissions by road transport are among the main sources of air pollution in Almaty city due to the expansion of the vehicle fleet and the increase in fuel consumption. The concentration of major pollutants in the air exceeds the maximum permissible limits. It is known, (Ecotech.kz, 2013) that 80% of air pollution accounts for emissions from vehicles in Almaty[4].

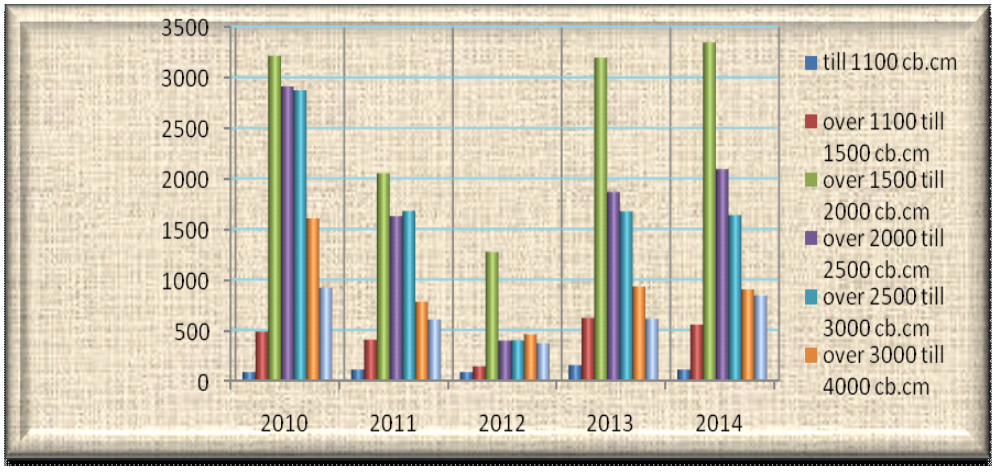
The share of $CO_2$ emissions from the transport sector is 99.35%, the proportion of methane and nitrous oxide is very small and are 0.54% and 0.12%, respectively. It is very natural, because the mass fraction of these gases formed during the combustion of fuel is very low. Accordingly, the calculation of $CO_2$ emissions has been used as the main greenhouse gas for the observation of the dynamics of greenhouse gas emissions from the transport sector of Almaty city.

For a basis was taken approach from the Methodic of calculation of emissions of greenhouse gases approved by the order of the Minister of environmental protection of the Republic of Kazakhstan from 24 November 2009 year № 251-ө for calculation of emissions of $CO_2$.

Calculations of $CO_2$ emissions are made on formula:

$$E = M \times K_1 \times TH3 \times K_2 \times 44/12$$

Where: E – annual $CO_2$ emission in weight units (tons/year); M - actual fuel consumption per year (tons/year); K1- carbon




Source: Ministry of Internal Affairs of the Republic of Kazakhstan

**<Figure 5>** Dynamics and Distribution of Vehicles in Terms of Engine Displacement in Almaty

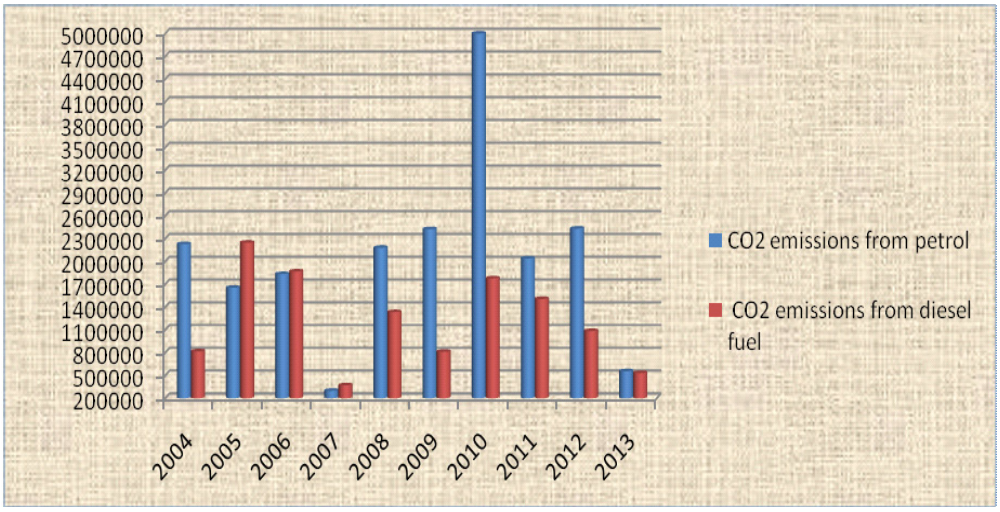
4) A comprehensive program to reduce air pollution in Almaty from 2009 to 2018.

oxidation coefficient of the fuel (shows the share of burnt carbon), CNV - calorific net - value (Joule/tons); K2 – carbon emission coefficient (tons C / Joule); 44/12 – coefficient for recalculation of emissions of carbon C in carbon dioxide $CO_2$. (Table 2).

**<Table 2>** Coefficients for $CO_2$ Emissions Calculation

| Fuel type | Calorific net – value (Joule/tons) | Fraction of carbon oxidation, K1 | Carbon emission coefficient K2, tC /Joule |
|---|---|---|---|
| Petrol | 44,21 | 19,13 | 0,995 |
| Diesel | 43,02 | 19,98 | 0,995 |

Source: Methodic of calculation of emissions of greenhouse gases approved by the order of the Minister of environmental protection of the Republic of Kazakhstan from 24 November 2009.




Source: The official statistical collections on fuel and energy balance of Kazakhstan for 2005-2014.

**<Figure 6>** $CO_2$ Emissions from Transport in Almaty City from 2004 to 2013 (Tons/Year)

Dates on actual consumption of fuel (petrol, diesel) from 2004-2014 were taken from the official statistical collections on fuel and energy balance of Kazakhstan for 2005-2014.

If to consider the emissions from vehicles in Almaty city for 2004-2014 years, the amount of $CO_2$ emissions increased gradually, that is caused by a saturation of domestic market cars in rather good condition, and also consumer opportunities of the population. Data for 2007 make us doubt and in this regard emissions of this year are wrong (Figure 6).

The moderate growth of $CO_2$ emissions from transport sector is observed from 2004 to 2009. Emissions from petrol sharply increased, emissions from diesel fuel keep moderate growth in 2010. $CO_2$ emissions increased slightly from 2011 to 2012. The amount of $CO_2$ emissions is sharply reduced, both from petrol, and from diesel fuel in 2013.

## 4. Conclusion

Thus increasing the fuel efficiency of vehicles is one of the priority areas to reduce $CO_2$ emissions and improve overall energy efficiency. As one of the priorities in the field of reducing greenhouse gas emissions is to develop vehicles that use alternative sources of fuel or natural gas, is the most suitable fuel. Development of legal documents and regulations on the use of vehicles with a smaller engine displacement and restrictive requirements for the year of manufacture of vehicles also contribute significantly to the efficient of resources use and reduce greenhouse gas emissions from motor vehicles.

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