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Aeroexpress public transport system introduction in Almaty and its impact on greenhouse gases emissions decrease in Almaty city transport sector

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Abstract. **In Almaty, there are currently more than 500,000 vehicles registered and there is an average of another 200,000 vehicles that enter the city from outlying Almaty Oblasts during working hours. The road network of Almaty has not grown since 1990 when the municipality estimated the number of cars in Almaty to be 100,000.**

Almaty public transport system degrade and became ineffective with significant loss of safety and comfort level by the reason of privatization and occurring of "shadow" taxi at the service market. [1]

Almaty airport is not connected with railway stations Almaty 1, Almaty 2 and city center by a straight and comfortable public transport route. Thus, the prevailing number of airport visitors prefer travelling on personal transport or taxi. Which is, in turn, brings a negative environmental loads. In current circumstances, the Moscow Aeroexpress transport analogue may become a good solution for Almaty.

Keywords: **public transport, greenhouse gases, pollutants, emissions decrease, sustainable transport**

I INTRODUCTION

The primary impacts of this economic growth during 1990s-2000s in Almaty as well as other cities of the former Soviet Union are:

- growth of urban sprawl of these cities, and the rapid increase in the use of private motor vehicles for urban transport;
- large increases in traffic congestion in these cities particularly during peak hours; and
- irregular development of public transport and an associated deterioration in the quality of service delivery.

The viable alternative to private cars should be public transport. Unfortunately, Almaty's public transport has evolved into a system that does not provide for comfort, convenience and efficient services to commuting passengers. Currently, almost all public transport has been privatized; only electric transport (i.e. trolleybuses and trams) is still owned and managed by the municipality under Almatyelectrotrans, a public utility company. Their service, however, is unable to compete with individual cars and private bus operators.

Almaty's public transit has evolved into a system characterized by:

- poorly maintained aged vehicles;
- overcrowding especially at peak hours that allows bus operators to maximize profits;
- lack of services in off-peak hours;
- poor mobility on roads due to traffic congestion and lack of priority for buses; and
- a lack of cleanliness on board. These complaints, however, remain unaddressed by private bus operators, while the municipality lacks control and enforcement mechanisms to ensure compliance of operators with technical and safety regulations and schedules. [1]

Almaty underground may become a good solution as a safe, regular and comfortable transport. But such barriers as small line distance 11,52 km including Sairan and Moscow stations low work load and absence of on ground transport infrastructure connected to underground make it less effective than in other cities. This fact is also aggravated by worsening of economical conditions which followed by the republic of Kazakhstan president proposal to cut funding of underground second turn construction funding. [2]

Thus, soon organization of sustainable passenger transport channel connecting railway station Almaty-1 with the city center turns questionable. Which reflects

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negatively on Almaty environmental conditions as personal transport has significant advantages in this circumstances.

Current paper goal is the evaluation of greenhouse gases (GHG) emission decrease by the introduction of Moscow Aeroexpress public transport system introduction for connection of Almaty city airport on the travel line: Almaty city airport - railway station Almaty 1, railway station Almaty 2, Rosy Bakieyv str./ Tole Bi str. cross (AZTM plant in previous) and definition of other possible positive impacts from such transport system implementation.

Almaty airport is connected with Almaty center by the automobile road (travel time by a taxi or private transport is about 15-30 minutes, depending on the traffic). The airport passenger turnover was 4589000 of people in 2014 year [3], which is about 12572 of people per day.

By the reason of high traffic loads during the rush hours travel time might rise for several times. Which, in turn, brings a negative environmental load of ineffective automobile engines functioning "stop – slow wheeling" regime.

By the experts evaluation, the CO2 emissions from Almaty automobile transport in 2015 year will become 16,8 million of tones, in 2020 – 24.0 million of tones.[1]

II EMISSIONS CALCULATION METHODOLOGY

Transport GHG emissions calculation at the route Almaty airport – Almaty-1 railway station – Almaty-2 railway station – Rozy Bakiyev street and Tole bi street crossing were made according to the United Nations Framework Convention on Climate Change (UNFCCC) \ Intergovernmental Panel on Climate Change (IPCC) "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories" [4] and National "Road transport GHG atmosphere emissions and emissions reduction calculation methodology" document project [5], containing national emission factors.

The next equations were used:

$$\text{Fuel consumption}_{ij} = n_{ij} * k_{ij} * e_{ij}, \quad (1)$$

where: i = transport kind,
j = fuel kind,
n = transport quantity,
k = kilometers quantity per year [4]

$$\text{Emissions} = 44/12 \sum (\text{Fuel} * \text{EFa}) \quad (2)$$

where:
«Emissions» – emissions in kg;
Fuel – quantity of fuel burnt in TJ;
EFa – CO_2 emission factor, equal to carbon content in one fuel kind (kg/TJ);
a – fuel kind (gasoline, diesel fuel, etc.). [5]

III INITIAL DATA

Analyzing transport routes using online service Google maps and other reference [8, 10,12], the initial calculation data are represented in tables 1-3.

Table 1 – Information on contemplated route parts length. [8,10]

Route part	Average one way length by car	Public transport routes	Average one way length by bus
Almaty airport (Akhmetov str./Maylin str. crossing) – Almaty-1 railway station	8,7 km	Bus №106	8 km
Almaty-1 railway station – Almaty-2 railway station	9,5 km	Bus №2, №73	9,25 km
Almaty-2 railway station – Rozy Bakiyev street and Tole bi street crossing	6,5 km	Bus №37, №59,№100	6,43 km
Almaty airport (Akhmetov str./Maylin str. crossing) – Almaty-2 railway station	12,7 km	Bus №86, №92, №79	12,2 km
Almaty airport (Akhmetov str./Maylin str. crossing) – Rozy Bakiyev street and Tole bi street crossing	18,3km	Bus №106	25 km
Note: *from the airport territory during the night time there is one bus route № 3 to the city center which was not taken into account as the route as uncompetitive with the daytime routes. **From the closest to airport bus station (Akhmetov str./Maylin str. crossing) moving one more route №10 which was also not taken into account as uncompetitive for the route length.			

Table 2 – Airport – city center routes timetable. [9]

Route number	Working hours	Time interval
100	6.00 – 23.40	6 мин.
106	5.26 – 23.26	8 мин.
2	6.10 – 24.00	7 мин.
27	6.30 – 23.00	5 мин.
37	6.00 – 23.45	5 мин.
59	6.00 – 23.53	6 мин.
73	6.10 – 24.00	5 мин.
79	6.00 – 00.00	6 мин.
86	6.00 – 23.30	7 мин.
92	5.30 – 00.10	6 мин.
96	5.30 – 00.10	5-6 мин.

Current paper according major requirements of "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories"[4] contains disaggregation of transport flow by transport type (gasoline, diesel, natural gas, liquid gas).Table 3 represents required data disaggregation with information on fuel consumption per 1 km.

Table 3 – Transport flow by kind and fuel disagregation.

	Transport kind	Body type	Model	Fuel type	Fuel consumption, l/ 100 km	Fuel consumption, l/1 km
Public transport	Route№79	Bus	Yutong ZK6120HGM	Compressed gas	30	0,3
	Route№2	Bus			30	0,3
	Route№92	Bus			30	0,3
	Route№73	Bus			30	0,3
	Route№37	Bus			30	0,3
	Route№86	Bus	Hyundai	Diesel	22	0,22
	Route№100	Bus	HYUNDAI		22	0,22
	Route№106	Bus	MAN		35	0,35
	Route№27	Bus	DAEWOO		22	0,22
	Route№ 59	Bus	DAEWOO		22	0,22
Personal transport	Eco taxi	Light vehicle	SsangYoung Kyron	Liquid gas	16,85	0,17
	Unoffical taxi	Light vehicle	-	Gasoline	9,3	0,09
	Private vehicle	Light vehicle	-	Gasoline	16,7	0,17
	Private vehicle	General purpose vehicle, off-road vehicle	-	Diesel	13	0,13

IV ESTIMATION

According to observations, from the airport territory and the near bus station by routes №№79, 86,92,106 by every travel arrive/ depart about 3 passengers. Thus, as the airport annual passenger turnover, passenger turnover per day 12572 we obtained the quantity of airport visitors using public transport. (Table 4).

Table 4 – Airport visitors quantity by routes.

Route number	Working hours quantity per day.	Route tour quantity per day.	Airport visitors passengers quantity per day
79	18	180	540
86	17	150	450
92	19	190	570
106	18	135	405
Total		555	1965

Considering obtained figure 1965 public transport passengers one may resume that 10607 (84,4%) airport visitors use personal transport (private vehicles, taxi, unofficial taxi).

Using coefficient 0,5 to determine vehicle quantity streaming to the city center from the airport, thus obtaining 5303 passengers per day.
According to visual analysis of airport parking content about 24% of transport are general purpose

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vehicles. As the significant share in off road transport has diesel engines, we consider that 1273 diesel cars arrive/ depart to airport parking per day.
About 10% of vehicles are equipped with gas engines (municipal taxi service "Eco taxi") which is equal to 530 cars arriving and departing from the airport territory per day.
Using the above appointed figures one can calculate GHG emissions (Table5).

Table 5. – Transport flow CO_2 - equivalent GHG emissions results.

Transport kind		Fuel type	CO2 emissions, tones/ day	CO2 emissions tones/year	CO2 equivalent CH4 emissiont, tones/day	CO2 equivalent CH4 emissiont, tones/year	CO2 equivalent N2O emissiont, tones/day	CO2 equivalent N2O emissiont, tones/year
Public transport	M.№79	Compressed gas	0,00084	0,31	0,0000051	0,0019	0,00000017	0,000061
	M.№2		0,00052	0,19	0,0000032	0,0012	0,00000010	0,000038
	M.№92		0,00086	0,31	0,0000052	0,0019	0,00000017	0,000062
	M.№73		0,00077	0,28	0,0000047	0,0017	0,00000015	0,000056
	M.№37		0,00054	0,20	0,0000033	0,0012	0,00000011	0,000040
	Group total		**0,0035**	**1,29**	**0,000022**	**0,0079**	**0,0000007**	**0,00026**
	M.№86	Diesel	1,09	398,29	0,00021	0,08	0,00021	0,08
	M. №100		0,6	230,71	0,00012	0,05	0,00012	0,05
	M. №106		3,2	1168,61	0,00062	0,23	0,00062	0,23
	M.№27		1,5	530,06	0,00028	0,10	0,00028	0,10
	M.№ 59		0,7	260,78	0,00014	0,05	0,00014	0,05
	Group total		**7,09**	**2588,45**	**0,0014**	**0,51**	**0,0014**	**0,51**
Personal transport	Eco taxi	Liquid gas	**0,000034**	**0,01**	**0,0000099**	**0,0036**	**0,000000032**	**0,000012**
Personal vehicle	Unoffic ial taxi	Gasoline	6,9	2531	0,012	4,42	0,0012	0,43
	Private vehicle	Gasoline	12,5	4545	0,022	7,94	0,0021	0,77
	Private vehicle	Diesel	8,6	3120	0,002	0,61	0,0017	0,61
	Group total		**28,00**	**10196,00**	**0,04**	**12,97**	**0,01**	**1,81**
	TOTAL		***35,***	***12786***	***0,04***	***13,48***	***0,006***	***2***

Discussion. Analysing the GHG emissions figures it is clear that the most input occurs from private vehicles functioning on gasoline and diesel fuel. The considered public transport input occurs only from Diesel engine buses and equal to 20% vs.79,8% from private vehicles (Diagram 1).

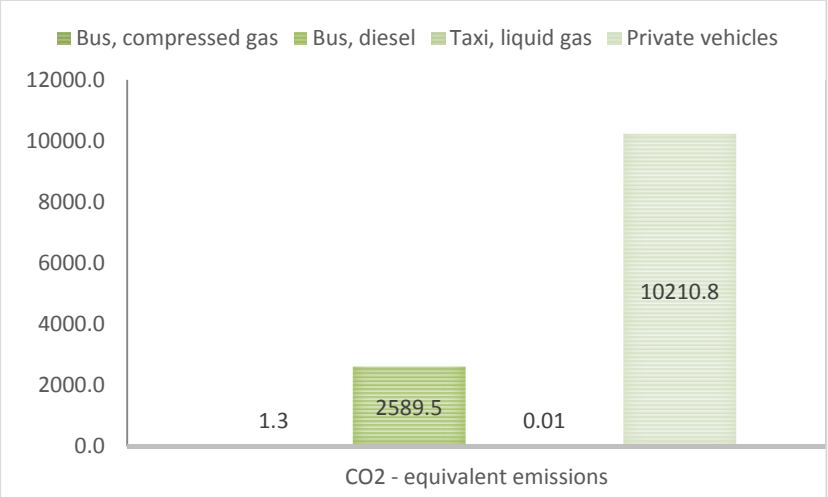

Diagram1 – GHG emission from various transport kinds within the explored route transport flow.

V CONCLUSIONS

1. As one can see the analogue of Moascow city Airexpress transport system functionin at the line Almaty city airport - railway station Almaty 1, railway station Almaty 2, Rosy Bakieyv str./ Tole Bi str. cross providing regular passenger conveyance along with some restrictions in separate groups of vehicles entering to the airport territory, excluding public transport, official taxi and flight passengers personal vehicles can decrease GHG emissions up to 5700 – 2500 tones annually.
2. Such measures will promote public transport infrastructure turning it to more sustainable transport system and improving passenger conveyance safety and comfort.
3. This introduction will positively reflect on Almaty city environmental conditions and reputation as of the modern mainstreaming city and meeting its obligations in terms of international agreements and conventions.

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