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External costs of passenger cars in Latvia

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ABSTRACT

Transport is one of the major contributors of greenhouse gas (GHG) emissions. In Latvia 29.8 % from GHG emissions come from transport. Often the influence of it is measured only from air pollution, mainly CO_2 emissions and health effects caused by them, perspective, not considering other external costs associated with it. In this paper, external costs from passenger cars are calculated for Latvia's current situation. These costs include air pollution, climate change, noise, and well-to-tank analysis. Current situation costs were then compared to different scenarios of battery electric vehicle (BEV) mix in Latvia's passenger car fleet. The results indicate that having a higher BEV mix in the fleet reduces external costs.

Keywords: Externals costs, Battery electric vehicles, Transport, GHG emissions

NONMENCLATURE

Abbreviations	
BEV	Battery electric vehicle
EU	European Union
GHG	Greenhouse gas
ICEV	Internal combustion engine vehicle
LV	Latvia
Pkm	Passenger kilometer
Vkm	Vehicle kilometer
WTT	Well-to-tank

1. INTRODUCTION

The European Union has set a target to become climate-neutral by 2050, in line with the Paris Agreement [1]. This is binding to all EU states, including Latvia.

Transport remains a key obstacle to achieving the climate targets. In European Union transport sector is responsible for 29% of GHG emissions [2]. In Latvia transport sector is responsible for 29.8% of GHG emissions, majority of which is contributed by passenger cars [3].

Transport plays an important role in our society, but it is generally unclear how big are external costs of it. The Handbook on the external costs of transport [4] lists eight main externalities of transport of which four are dependent on the type of motor and energy the vehicle is using:

- Air pollution;
- Climate change;
- Noise;
- Well-to-tank emissions.

In this study, the external costs of passenger cars is calculated for Latvia's current passenger car fleet. In addition, three other scenarios with different BEV mix (30%, 70%, 100%) are calculated and compared to current situation.

2. DATA AND ASSUMPTIONS ABOUT LATVIA'A PASSENGER CAR FLEET

2.1 Current situation of Latvia's passenger car fleet

- Currently in Latvia there are 695596 registered, in technical order, and insured passenger cars [5].
- The average age of passenger cars is 14.9 years, and the average car drives 14500 km per year [6].
- Passenger car fleet mix by main energy consists of [7]:
  - Gasoline: 35.7%;
  - Diesel: 63.9%;
  - Electricity: 0.2%;

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- Other: less than 0.1%.
- Passenger car fleet mix by motor size [8]:
  - <1.5 l: 10.9%;
  - 1.5-2.0 l: 51.7%;
  - >2.0 l: 31.3%;
  - Unknown: 6.1%.

2.2 Assumptions necessary for calculations

- Average car corresponds to Euro 4 emission standard.
- Passenger car fleet divides accordingly between energy means and motor volume.
- Energy means marked as "others" is not taken into calculations and gasoline, diesel, and electricity proportions are normalized.
- For the calculations needed for <1.5 l motor size, will be used values from <0.8 l and 0.8-1.4 l motor sizes and for the calculations needed for 1.5-2.0 l motor size, will be used values from 1.4-2.0 l motor size given by the Handbook on the external costs of transport [4].
- Motor size marked as "unknown" is not taken into calculations and other values are normalized.
- It is assumed that all passenger car variations drive the same distance of 14500 km per year.
- It is assumed that all cars are driven equal amounts of distance in metropolitan, urban, and rural areas.
- To translate passenger kilometers (pkm) to vehicle kilometers (vkm) it is assumed that there is 1.9 person in a vehicle [9].
- Noise external costs for BEV are assumed to be half of those by ICEV [10].
- Normalization of the calculated external cost results is determined by the EU-28 average GDP relationship with Latvia's GDP.

3. EXTERNAL COSTS OF PASSENGER CARS

3.1 Air pollution

Air pollution external costs cover health effects, crop losses, material and building damage, and biodiversity loss.

As described in Table 1, 1 pkm by passenger car produces 0.54 €-cent external cost associated with air pollution. That means that in one year the total Latvia's passenger car fleet is responsible for 28.85 million euro external costs associated with air pollution.

Table 1 Marginal air pollution external costs from passenger cars in Latvia.

Fuel type	Motor size	Air pollution cost	Normalized by motor size proportion	Normalized by energy proportion
	l	€-cent/pkm		
Petrol	<1.5	0.08	0.01	
	1.5-2.0	0.11	0.06	
	>2.0	0.11	0.04	0.04
Diesel	<1.5	1.11	0.13	
	1.5-2.0	1.11	0.61	
	>2.0	1.11	0.37	0.71
Electric		0.05	0.05	0.00
Total (by EU-28 GDP)				0.75
Total (by LV GDP)				**0.54**

Introducing a higher mix of BEV in the fleet has a positive effect, bringing air pollution external costs down by up to 26.76 million euros, as shown in Fig.1.

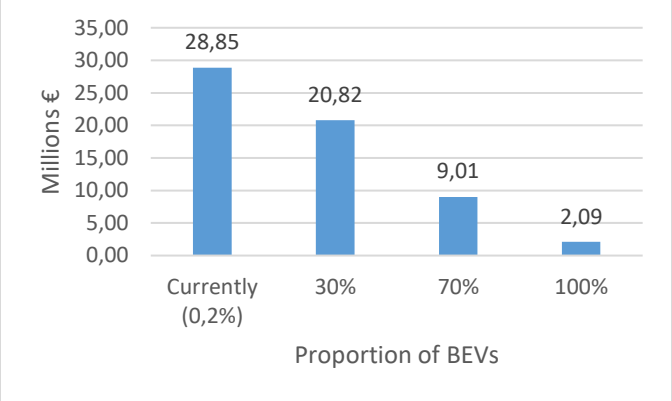

Fig. 1 Air pollution external costs with different BEV mix in Latvia's passenger car fleet

3.2 Climate change external costs

Identifying climate change costs of passenger cars is important because internal combustion engine (ICEV) usage results in CO_2, N_2O, and CH_4 emissions, which all are GHG and contribute to climate change.

As described in Table 2, 1 pkm by passenger car produces 0.87 €-cent external cost associated with climate change. That means that in one year the total Latvia's passenger car fleet is responsible for 46.43 million euro external costs associated with climate change.

Table 2 Marginal climate change external costs from passenger cars in Latvia

Fuel type	Motor size	Air pollution cost	Normalized by motor size proportion	Normalized by energy proportion
	l	€-cent/pkm		
Petrol	<1.5	0.89	0.10	
	1.5-2.0	1.14	0.63	
	>2.0	1.50	0.50	0.44
Diesel	<1.5	0.85	0.10	
	1.5-2.0	1.17	0.65	
	>2.0	1.36	0.45	0.77
Electric		0.00	0.00	0.00
Total (by EU-28 GDP)				1.21
Total (by LV GDP)				**0.87**

Introducing a higher mix of BEV in the fleet has a positive effect, bringing climate change external costs down by up to 46.43 million euros, as shown in Fig.2.

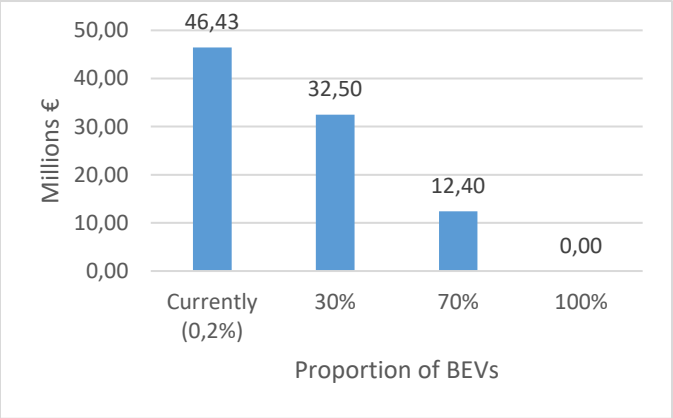

Fig. 3 Climate change external costs with different BEV mix in Latvia's passenger car fleet

3.3 noise external costs

Noise emissions from traffic pose a growing problem due to a combination of greater urbanization and an increase in passenger cars.

Data for noise measurements is available only for Latvia's capital Riga. In Riga, a total of 526100 people are exposed to day-evening-night average sound levels of 55 dB or higher from road traffic [11], see Table. 3.

Table 3 People affected by noise pollution in Riga, Latvia

L_{den}, dB	55-59	60-64	65-69	70-74	>75
Affected people	133900	188900	143900	54400	5000

Weighting factors for gasoline, diesel and electric vehicles are 1, 1.2, and 0,55 accordingly [4, 10] and environmental prices for traffic noise range from 31 €/pers/year for 55-59 dB affected people to 72 €/pers/year for >75 dB affected people. In Table 4 are shown the current situations noise external costs.

Table 4 Marginal noise external costs from passenger cars in Latvia

Energy type	External costs (million €/year)
Gasoline	6.13
Diesel	13.16
Electricity	0.02
Total	**19.31**

Introducing higher mix of BEV in the fleet has a positive effect, bringing noise external costs down by up to 9.89 million euros, as shown in Fig.3.

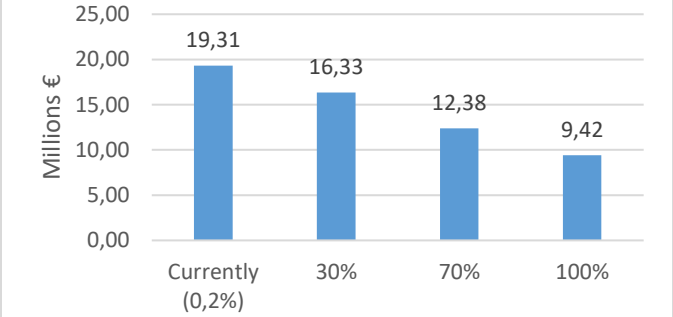

Fig. 2 Noise external costs with different BEV mix in Latvia's passenger car fleet

3.4 *Well-to-tank external costs*

Energy production (well-to-tank or WTT) lead to a significant part of various emissions. WTT includes extraction of energy sources, refinery, transportation, transmission, building of energy plants, building infrastructure.

As described in Table 5, 1 pkm by passenger car produces 0.25 €-cent external cost associated with WTT. That means that in one year the total Latvia's passenger car fleet is responsible for 13.29 million euro external costs associated with WTT.

Table 5 Marginal WTT external costs from passenger cars in Latvia

Fuel type	Motor size	WTT external cost	Normalized by motor size proportion	Normalized by energy proportion
	l	€-cent/pkm		
Petrol	<1.5	0.34	0.04	
	1.5-2.0	0.43	0.24	
	>2.0	0.56	0.19	0.17
Diesel	<1.5	0.20	0.02	
	1.5-2.0	0.27	0.15	
	>2.0	0.31	0.10	0.18
Electric		0.83	0.83	0.00
Total (by EU-28 GDP)				0.35
Total (by LV GDP)				**0.25**

Introducing higher mix of BEV in the fleet has a negative effect, bringing WTT external costs up by up to 18.64 million euros, as shown in Fig.4.

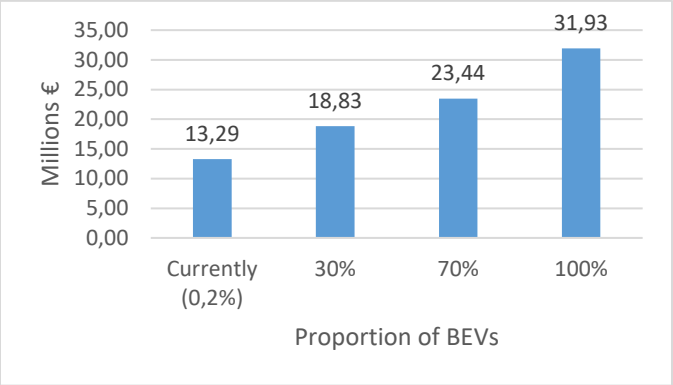

Fig. 4 WTT external costs with different BEV mix in Latvia's passenger car fleet

4. CONCLUSION

All external cost categories in current situation combined cost Latvia 107.88 million euros per year. Introducing a higher mix of BEVs in Latvia's passenger fleet brings down the external costs associated with air pollution, climate change, and noise, but will bring up energy production costs.

If all of Latvia's passenger car fleet would consist 100% of BEVs the external costs from the categories covered in this paper would have a combined cost of 43.45 million euros per year. In this way the external costs would decrease by 64.43 million euros or 60%.

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