

GREENING THE COMPANY'S FLEET – CASE STUDY OF AVTOSTEKLO LTD

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Transport is responsible for 30 % of all greenhouse gas emissions in Slovenia. Companies specialized in transport are challenged with seeking solutions how to reduce the pollution from their fleets on one side and reducing costs and increasing efficiency on the other. Greening the companies fleets is in rise all over the world. Beside reducing the costs the environmental issues such as carbon footprint is becoming more and more important for company's image. This paper is based on a research study of company Avtosteklo Ltd. Their primary activity is replacement of windscreens on vehicles which is often done at customers' homes or at their work places therefore company owns a fleet of 24 vehicles in 5 branches across Slovenia with huge amount of annually driven kilometres and consequently high carbon emissions. Calculations on their current fuel costs and released carbon dioxide were examined and cross-compared. Results showed that 78,9 tons of carbon dioxide is released in one month of their operations. Main goal of this paper is therefore to present possible positive effects of replacement of conventional vehicles with alternative ones. After reviewing and analysing several possibilities we have suggested replacement of conventional cars with electric ones as a long term solution since they don't release carbon dioxide in use phase. In order to identify the best solutions we have proposed also replacement of vehicles for long relations with vehicles on compressed natural gas. The study also showed significant impacts on reduction of fuel costs and vehicles maintaining.

Key words: Alternative fuel vehicles, Emissions, CO₂, Green fleet, Sustainable transport, Avtosteklo Ltd.

INTRODUCTION

Environmental pollution is becoming one of the most important issues these days. Greenhouse gas emissions (GHG) are a factor which affects climate changes the most. In this paper we studied environmental pollution caused by company's fleets and present positive effects of greening the fleets in companies, which are identified as one of the main polluters. In Slovenia there is no systematic dealing with greening the fleets, while this is the established practice already in some countries. Companies are challenged by the issue how to reduce their impacts on environment and how to maintain effectiveness with as low costs as possible. According to the Slovenian environmental agency [01] main share of greenhouse gas emissions is carbon dioxide

(further CO₂) with 82%, which is mainly the result of combustion of fossil fuels. In years between 1986 to 2007 greenhouse gas emissions grew by 175 % and the growth increases annually by 1%, which is alarming [01].

Companies worldwide are greening their fleets rapidly. Study [02] in United Kingdom compared fleet of fifty vehicles consisted of ten most popular conventional vehicles used in companies, with fleet of fifty vehicles consisted of ten most environmental friendly vehicles. Study revealed that investments in purchasing new cars would be returned in eighteen months and in the next four years the costs of the fleet would reached 60.000 £ (approx.. 75.978 €) less than the fleet consisted of conventional vehicles. At the same time the emissions of CO₂ would be decreased by 30%.

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Main goals of greening the fleets are [3]: optimization of the use of vehicles in sense of the way of travel, fuel type, optimization of the routes, size of vehicles and increasing of the use of alternative fuels and sustainable technologies. Planning the greening of the fleet could be consisted of fleet management (fuel consumption monitoring, vehicle tracking, choosing the right size of vehicle, efficient purchasing and vehicle disposal), vehicle inspections and maintenance, use of environmentally friendly detergents and rational use of water, training and education of employees about efficient driving, policies which promote green practice or green policies of purchasing, use of hybrid vehicles (mix of gasoline-electricity or diesel-electricity) and use of alternative fuels such as biodiesel, ethanol and others.

In this paper a case study of greening the fleet in company Avtosteklo Ltd. based in Celje, Slovenia is presented. Company's main activity is replacement of windscreens on vehicles. The company is a market leader in Slovenia. Replacement of windscreens is performed in their branch offices, while more and more services are preformed out on the ground. Response time is usually one day. Company has five branch offices trough Slovenia: in Ljubljana, Celje, Maribor, Murska Sobota and Novo mesto. Company has the fleet of twenty-four vehicles for the purposes of services in the field and other company's activities. Vehicles are divided in three groups: service operational vehicles, replacement vehicles for customers and company cars. All vehicles are gasoline or diesel powered.

Main goals of this study were: the most accurate description of company's existing fleet, analysis of fuel and maintenance costs, analysis of environmental impacts and identification of three alternative vehicle replacements for each sector of the fleet, with hypothesize that it is possible to find solutions to decrease fuel costs and impacts on environment.

METHODS

The study began with literature and good practices overview. Based on the synthesis of accumulated knowledge, we formed our own approach. Participation and support of the top management and cooperation of employees is crucial for greening the company's fleet. Process of planning should include measures which are not too restrictive to the participants, but must also meet

the all conditions for effectiveness of the fleet. Measures should be adapted to the company's activities and purpose of the fleet. The goal of decreasing CO₂ should be defined by the company's objective [04]. However in this case it was not exactly defined. Most commonly used activities of greening the fleet are consisted of a) analysis of the fleet (list of all fleets vehicles; number of vehicles by type, fuel type and amount of fuel consumed), b) setting goals of decreasing fuel consumption and decreased CO₂ (which should be realistic, measurable and reachable) and c) setting measures for achieving the goals (choosing most appropriate vehicles for company's purposes, eliminating unused vehicles, optimization of the driving cycle, regular maintenance an purchasing of the energy efficient alternative vehicles and electric vehicles) [05].

At the first stage the record of the fleet's current status was made. All 24 vehicles in the fleet were identified by the year of the manufacture, weight, engine power, Euro emission standard, type of engine, fuel consumption (lit/100 km) and CO₂ emissions. Based on the gathered data the calculations have been made.

Total driven kilometres of each vehicle were calculated on driven kilometres in one month and in one day. This was needed for further determination of alternative vehicles. Calculations on average CO₂ emissions for each vehicle were based on driven kilometres. Data were gathered for each vehicle group, so that we could have determined the group with the highest environmental impacts and the replacement with alternative vehicles could be done promptly.

Analysis of environmental impacts has been done with two most common used methods: Greenhouse Gas Protocol in Eco-indicator 99. Method GHG Protocol evaluates greenhouse gas emissions caused by fossil fuels. Method Eco-indicator measures impacts of vehicles on human health, quality of ecosystem and natural sources. Analysis of environmental impacts was made by computer program SimaPro, which enables gathering data from several different data bases. The same procedure was used to evaluate environmental impacts of chosen alternative vehicles and compared with conventional ones. Beside environmental impacts we were interested in savings on fuel costs and maintenance costs. Fuel costs were calculated based on driven kilometres and cost of fuel at the time the study was made [06].

After the analysis was made the solution proposals were identified. They were divided in two sections. First were short-term solutions, which can be implemented quickly in the meantime while the replacement can't be done. Company's fleet has been partly replaced with new vehicles few years ago. Vehicles are younger so it was assumed that company will not invest in new vehicles so soon. Calculations on savings of fuel costs were made for all four short term solutions, while on the catalyst solution there has been made also calculation on CO₂ reduction.

As long term solutions the replacement of the whole fleet was proposed. Most suitable alternative vehicles were proposed for each sector because different segments of vehicles have different requirements. Analysis was made which appropriate alternatives exist on the EU market. We considered different criteria such as vehicle size, price and range. Proposed alternatives were selected from the range of identified alternatives with comparative analysis of different alternatives based on economic evaluation of return of investment (ROI) with special emphasis. Electric vehicles were most focused on, the gas-powered vehicle and hybrid vehicle were also proposed. Electric vehicles seemed most suitable option because of the focus on reduction of CO₂ as they don't cause any emissions during the operating time. Gas-powered vehicles were chosen for the replacement of the vehicles with high number of driven kilometres, because the electric vehicles on the market have short battery range and interruptions of the work can't be met. Vehicles in the mobile unit sector were chosen based on size of the van and possibility of reconstruction of the back part, beside of environmental impact reduction. Company's demand was to keep the practical use of the existing vehicles, which are designed in the way that serves employees in the most suitable way. The whole spectre of electric light vehicles was searched. Replacement for two vehicles was found among gas-powered vehicles, since those two could serve to the highest amount of driven kilometres per day. Replacement vehicles were considered to be replaced by electric vehicles only, since the range was not a problem in this case. Smaller vehicles with lower price were searched. In the sector of company's business sector it was considered to replace them with alternative vehicles

approximately the same class as the existing ones.

Technical data was gathered for each alternative vehicle. Electric vehicles were identified by size (height, width), highest speed, range and fuel/power consumption, time of recharging battery, maximum load and price of the vehicle. Gas-powered vehicles were considered by capacity, highest speed, range, gas consumption per 100 kilometres, CO₂ emissions and price. Hybrids were considered by use of energy as well by the use of gasoline. Chosen alternative vehicles were compared with all conventional vehicles in the existing fleet by fuel costs, maintenance costs and CO₂ emissions. In this paper the most suitable replacement for each conventional vehicle from the fuel cost and CO₂ emissions reduction perspective is presented.

RESULTS

The fleet consists from 24 vehicles in three different sectors by their purpose. First sector are mobile units (in total 9 vehicles – 5 different models). All of them are light duty vehicles and they are used for service on field. There is converter for electricity from 12V to 220V, so they can maintain their own electricity for the use of equipment needed to provide service [06]. Interior is equipped with shelves for tools and appliances and special holders for windscreens. The routes for each vehicle are carefully planned with the assistance of special computer program, which enables weekly and monthly planning of the routes. Drives are being optimized and planned by regions. Vehicles are not being in use all the time, since the activities are seasonal. Second sector are replacement vehicles which serve for the time when customer's car is under repair in one of the branch offices. Most of the customers come to the branch office for the repair, but still they need a car, so they can use one of the replacement cars. There are eight vehicles for the customers. One branch offers also a bicycle as a replacement for the time of repair. The last sector includes business cars, which serve for the business activities. There are seven cars, but the study refers only to six, since the data for one car were not available. In Table 1 there are more details about company's fleet.

Table 1: Presentation of existing fleet [07, 08, 09 and 10]

Type/criterion	Year	Euro emission standard	Type of engine	Fuel consumption per 100 km combined	CO ₂ combined (g/km)
MOBILE UNITS					
Renault Master (2)	2013	EURO 5	Diesel	6.8	214
Renault Master (2)	2008		Diesel	6.9	176
Ford Transit Custom (2)	2014	EURO 5	Diesel	6.5	172
Ford Transit(2)	2013	EURO 5	Diesel	6,6	186
Renault Traffic	2007		Diesel	6.7	175
REPLACEMENT VEHICLES					
Škoda Citigo (8)	2014	EURO 5	Gasoline	4.5	105
BUSINESS VEHICLES					
Ford Focus 1.6 TDCI	2014	EURO 5	Gasoline	4.5	105
Ford C-Max	2014	EURO 6	Diesel	4.5	117
Škoda Octavia 1.6 TDI (2)	2013	EURO 5	Diesel	3.8	99
Volvo S80	2009	EURO 4	Diesel	5.9	155
Volvo V70	2009	EURO 4	Diesel	6.5	172

Table 1 shows that all vehicles are fossil fuel powered. Replacement vehicles Škoda Citigo are gasoline powered while all the others are diesel powered. The oldest vehicle is Renault Traffic (2007); the newest vehicles were manufactured in 2014. The highest fuel consumption has Re-

nant Master (2008) with 6.9 liters per 100 kilometres. The highest emissions are emitted from Renault Master (2013) 214 g/km. The amounts of emissions CO₂ were calculated by the sectors and shown in the table below (Table 2).

 Table 2: Kilometers driven and CO₂ emissions

Sector	km/year	km/month	km/day	CO ₂ tons/year	CO ₂ tons/month	CO ₂ tons/day
Mobile units	227.589	29.964,18	951,13	42,78	5,43	0,17
Replacement vehicles	115.399	11.539,90	379,41	12,12	1,21	0,04
Business vehicles	446.336	41.741,97	2.042,88	61,35	5,56	0,19
Total	789.324	83.246,05	3.373,42	116,25	12,20	0,40

All together amount of driven kilometres was 789.324 per year. The highest amounts of released CO₂ emissions were in business vehicles sector, which was the result of high age of vehicles and high amount of driven kilometres. Mobile units sector has a little bit lower amounts, which is result of not being in service all year. Sector replacement vehicles has as expected the lowest amounts which is the result of the use of vehicles by customers for short trips only. Figure 1 shows percentage values for each sector. Data about kilometres driven per day were crucial for selection of alternative vehicles. Equation (1) is the base for calculating only average daily driven kilometres, but the data is relevant enough

for the purpose of choosing the right alternative electric vehicles. Amounts of driven kilometres and CO₂ emissions are shown in Table 3. Equation 1: Equation for calculation of average daily driven kilometers:

$$\text{Driven kilometres in time unit/ number of work days in time period} = \text{average number of kilometres driven per day}$$

Table [3] shows that the amounts of average driven kilometres per day are rather different by vehicles. In total company makes 3 370.7 kilometres per day, which results in 396.59 kg of CO₂ emissions. Highest amount of kilometres driven mobile units sector is 168.49 and the lowest 7.2 kilometres.

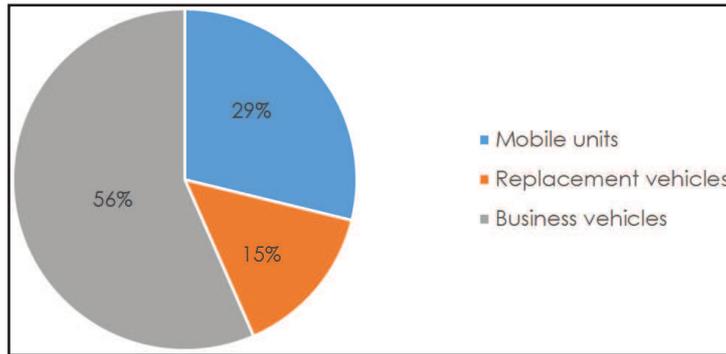


Figure 1: Shares for each sector (kilometers)

Table 3: Driven kilometers and CO₂

Vehicle	Average kilometres driven per day (km)	CO2 emissions per day (kg)
MOBILE UNITS		
Renault Master 1	168.49	36.06
Renault Master 2	390	67.08
Ford Transit Custom 1	7.2	0.15
Ford Transit 1	69.03	12.84
Ford Transit Custom 2	14.23	2.45
Renault Traffic	75.74	13.25
Renault Master 3	61.46	10.82
Renault Master 4	82.82	14.58
Ford Transit 2	79.44	13.90
REPLACEMENT VEHICLES		
Škoda Citygo 1	59.14	6.21
Škoda Citygo 2	57.81	6.07
Škoda Citygo 3	38.04	3.99
Škoda Citygo 4	32.47	3.41
Škoda Citygo 5	52.65	5.53
Škoda Citygo 6	49.88	5.24
Škoda Citygo 7	32.50	3.41
Škoda Citygo 8	56.92	5.98
BUSINESS VEHICLES		
Ford Focus	131.40	15.37
Ford C-Max	151.87	17.77
Škoda Octavia 1	197.12	19.51
Volvo S80	582.73	90.32
Volvo V70	164.38	28.27
Škoda Octavia 2	815.38	14.38
Total	3370.7	396.59

Replacement vehicles sector has highest amount 59.14 kilometres and lowest 32.47 kilometres. Vehicles with lowest amounts are from the branch office where as a replacement vehicle the bicycle is offered. One of the business vehicles makes 815.38 kilometres which is the highest amount in whole fleet. The lowest amount in business sector

is 131.40 kilometres. Amount of driven kilometres was the base for calculations in fuel costs, which are presented in Figure 2. Fuel cost calculations were made on June 27th, 2015. When addressing fuel prices and return in investment in alternative fuelled vehicle, investor must be aware of fuel price volatility and possible changes in fuel prices during the vehicle's operational time.

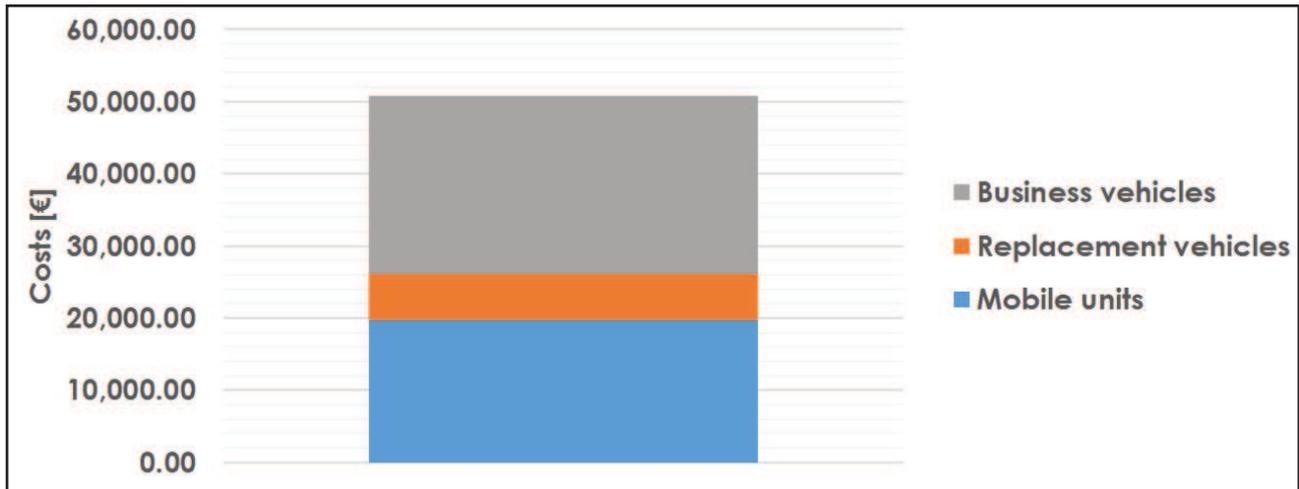


Figure 2: Fuel costs per year

Highest fuel cost was in business vehicle sector 24664.53 €, followed by the sector of mobile units with 19770.94 €. The lowest fuel costs were in replacement sector 6376.95 €.

Replacement vehicles best suited with alternatives VW e-up!, Renault Twizy 80 and Yogomo Ma4E. After further analysis and comparisons VW e-up! and Renault Twizy 80 were selected as the most appropriate for European market.

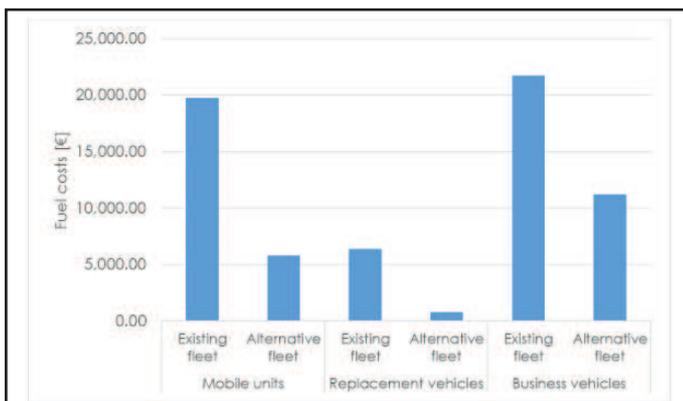


Figure 3: Comparison of costs existing fleet vs. alternative fleet

Total fuel costs were 50812.42 €. Table [4] presents all selected vehicles with compared fuel costs (Figure [3]) and CO₂ emissions (Figure [04]). Proposed alternative replacements in sector mobile units were: Nissan e-NV200, Renault Kangoo Maxi Z. E., Ford Transit Connect EV in Fiat Fiorino 1.4 8V Natural Power. Analysis and comparisons between existing fleet and selected proposals showed that Fiat Fiorino 1.4 8V Natural Power which uses natural gas as power, was the best choice for two vehicles. It was chosen because other alternative vehicles weren't suitable for this range. Fiat Fiorino has 300 kilometres of range which is more than enough for daily needs. Alternative vehicle to replace all other existing ones was Renault Kangoo Maxi Z. E with range 170 kilometres with fully charged battery; vehicle can be loaded with 800 kilograms.

Two business vehicles would be replaced with alternatives Ford Focus Electric and Tesla model S. Ford Focus has highest speed 135 km/h, which is more than the highest speed limit in Slovenia. Range with fully charged battery is 135 kilometres. Advantage of this vehicle is that has quick charging battery that can be charged up to 80% in just 30 minutes. Tesla model S has 415 km range and is the best electric vehicle to buy in Slovenia (from the range perspective). We have chosen two hybrid vehicles, powered with gasoline and electricity. Lexus IS 300h has engine EURO 6 and can reach 200 km/h. This model has the lowest CO₂ emissions among Lexus vehicles. VW Golf GTÉ is connecting hybrid, with range using electricity 50 kilometres, combined with full tank of gasoline the range is up to 939 kilometres. The last proposed alternative vehicle is Mercedes Benz B 200 NGD, which uses compressed natural gas as power. Beside gas-power there is also gasoline tank with 12 liters capacity. Range is 500 kilometres on natural gas only. Figure [3] shows comparison of fuel costs of existing fleet with selected alternatives. With selected alternatives fuel costs for mobile unit sector would be 5827.95 €, which results in 70.5 % savings. Fuel cost for business vehicles would be 11219.98 €, which is 54.51 % savings. In sector replacement vehicles the savings would be highest, 87.8 %, with fuel costs only 777.87 €. Total replacement of existing fleet with alternative one would result in total 64,9 % fuel cost savings.

Table 4: Selected alternative vehicles

Vehicle from existing fleet	Proposed alternative	Type of power
MOBILE UNITS		
Renault Master 1; Ford Transit Custom 1	Fiat Fiorino 1.4 8V Natural Power	Natural gas
Ford Transit Custom 2; Ford Transit 1; Renault Traffic; Renault Master 2; Renault Master 3; Renault Master 4; Ford Transit 2	Renault Kangoo Maxi Z.E.	Electricity
REPLACEMENT VEHICLES		
Vehicle 1; Vehicle 3; Vehicle 5; Vehicle 8	VW e-up!	Electricity
Vehicle 2; Vehicle 4; Vehicle 6; Vehicle 7	Renault Twizy 80	Electricity
BUSINESS VEHICLES		
Ford Focus	Ford Focus Electric	Electricity
Volvo S80	Tesla model S	Electricity
Volvo V70	Lexus IS 300h	Hybrid (gasoline and electricity)
Škoda Octavia 1; Škoda Octavia 2	VW Golf GTE	Hybrid (gasoline and electricity)
Ford C-Max	Mercedes Benz B 200	Natural gas

Figure [4] presents comparison of CO₂ emissions for existing fleet and alternative one. With existing fleet company caused 116.25 tons CO₂ in the time of measuring. With alternative vehicle fleet, consisting from almost electric vehicles, two gas vehicles and two hybrid vehicles, company would cause just 21.82 tons of CO₂. This means 81.14 % less CO₂ emissions. At the end of study we compared environmental impact of the use of alternative vehicles, to verify if we choose environmental friendly vehicles. Table [5] represents results we got from program SimaPro and data base Ecoivent. We took into account the 100 000 kilometres, because this is the range, which is done in all three sectors in very short time. Results are in Eco indicators points (Pt).

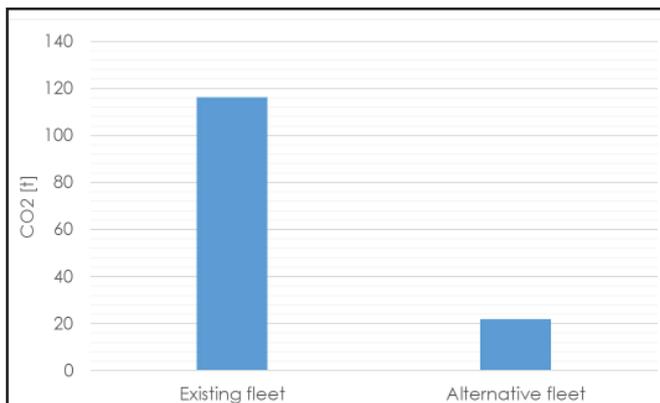


Figure 4: Comparison of CO₂ emissions existing fleet vs. alternative fleet

Following vehicles were compared: vehicle with gasoline and vehicle with diesel engine were compared, both of them EURO 5 emission standard, which is most common standard in existing fleet; electric vehicle; gas powered vehicle and hybrid vehicle with 70% gasoline and 30% electricity power. Total environmental impacts is sum of impacts on human health, impacts on quality of ecosystem and impact on sources used to produce the vehicle. All compared vehicles with exception of electric vehicle, have the highest impact on human health. This is average 93.1 % of total environmental impact. Lowest total environmental impacts has electric vehicle resulting in 374 Pt and highest impact on sources (58.2 % of total impacts) which was expected since the production of electric vehicles is environmentally the most problematic. The gas powered vehicle has second lowest total environmental impacts and lowest impacts on sources. Highest total environmental impacts has vehicle with gasoline engine 863 Pt and not diesel as expected.

DISCUSSION AND CONCLUSION

Study confirmed the fact that fleets have huge impacts on environmental pollution. Amounts of CO₂ are enormous because of high amount of driven kilometres. Alternative vehicles replacements can result in huge impacts on fuel consumption, fuel costs and consequently on environment.

Table 5: Environmental impact of alternative vehicles compared with conventional vehicles based on range 100.000 km, method Eco-indicator 99

Vehicle	Total environmental impacts (Pt)	Impacts on human health (Pt)	Impacts on quality of ecosystem (Pt)	Impact on sources (Pt)
Vehicle with gasoline engine (EURO 5)	863	821	18.6	22.6
Vehicle with diesel engine	772	737	19.3	15.7
Electric vehicle	374	150	4.1	220,0
Hybridni vehicle (gasoline, electricity)	716.3	619.7	14.2	81.8
Vehicle on gas power	709	675	19.2	14,5

Second fact is that fuel consumption is very high and consequently this causes high fuel costs in companies. Reason for high fuel consumption is usually in use of older vehicles. In project of greening the fleet in company Avtosteklo Ltd. participation and support of the top management was on high level, which resulted in high amount of data of existing fleet gathered in company. Top management is very interested in greening the fleet because of reduction of fuel costs and in improving their public image. We did our best to form solutions not only environmentally kind but also suitable to the company's activities as well as to their possibilities of financing. The main goal of reducing emissions of CO₂ was accomplished, although we didn't set any values. Another goal was met in this study: to prove that replacement of conventional vehicles with alternative ones results in significant reduction of emissions. The most consuming part of the study was calculating amounts of fuel consumption and emissions produced. Second challenge was to find alternative solutions which would meet goals set and on the other hand all standards suitable for company. We evaluated all vehicles in existing fleet as significant for the company's activities that is why we did not eliminate any of those. Optimization of travel routes wasn't done, because the company already successfully optimizes it, as well as regular maintenance of fleet's vehicles. Suggested alternative vehicles were carefully selected in order to meet all company's needs, reduce fuel consumption and CO₂ emissions, as well having in mind not to put too much financial burden on company. Purchase of alternative vehicles still may be huge investment, so we suggested few cheaper short term solutions, for the period before replacing the vehicles, until within few years total change of the fleet is done. Replacement with electric vehicles was suggested as long term project.

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