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INVESTIAGTION OF POSSIBLE IMPROVEMENTS OF GREENING THE PRIVATE CARS IN HUNGARY FOCUSING ON ECONOMIC ASPECTS

Abstract: Minimizing environmental load and pollution originating from road transport is a just demand of society. The climate of Earth changes as a result of pollution from transport which in turn influences the status of society and economy. A major part of environmental pollution comes from transport. Road transport is the main "culprit" in the sector. Our paper analyses the environmental and economic effects created by the conversion of private cars participating significantly – due to their total number – in the Hungarian road transport. Collecting data we analysed the situation evolving with the use of alternative fossil fuels (LPG and CNG) from the point of view of the companies and that of the individuals as well.

Keywords: *CNG private car, LPG private car, conversion, feasibility*

1. Introduction

Transport needs to be sufficient within the space defined by social, economic and environmental factors so as to satisfy the mobility needs of society in an economically efficient and environment-friendly way (*Tánczos, 1994*). Minimizing environmental load and pollution originating from road transport is a just demand of society. A major part of environmental pollution comes from road transport sector. The utilization of renewable alternative energy sources like liquid bio-fuels (*Bereczky, 2008*), (*Laza, Bereczky, 2008*) or gaseous fuels will have a major role in mitigating the climate change while the increasing energy and mobility demand of the humanity need to be fulfilled and the sustainable

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development should be maintained (*Torok, 2009*). Renewable gaseous fuels like biogases or hydrogen utilized in gas engines can be an alternative and effective way to fulfill remarkable part of these demands (*Meggyes, Bereczky, 2007*), (*Szwaja, 2009*), (*Torok, 2009*), (*Zöldy, 2009*). Our paper analyses the environmental and economic effects created by the conversion of private cars participating in the Hungarian road transport. Collecting data we analysed the situation evolving with the use of alternative fossil fuels (LPG and CNG) from the point of view of the companies and that of the individuals as well. The economic model based on the tools of project financing and developed by the authors.

2. The autogas (LPG) and the natural gas (CNG)

The characteristics of autogases as compared to those of conventional fuels are presented in Table 1.

Table Characteristics of autogases

Characteristics of the fuels	Gasoline	Diesel oil	LPG	CNG
Density on 15 °C	0.73	0.84	0.55	0.14-0.16
Energy density MJ/kg, MJ/l	44.0/31.4	42.5/35.7	46/25	48/8
Boiling point [°C]	+25/+110	+150/+360	0/-42	-163
Burning point [°C]	220	340	500	540-600
Octane rating	92-98	-	100-105	118-120

source: (http://www.medic-car.hu/oldal.php?oid=38&tid=42)

Due to their high octane rating gasous fuels do not need to contain anti-knocking additives. The gaseous fuel can be perfectly mixed with the air getting into the engine. The biggest advantage is that autogases contain simple hydrocarbons unlike conventional fuels. The two components of liquefied petroleum gas are propane (C_3H_8) and buthan (C_4H_{10}). Densified natural gas consists mainly of methane (CH_4), the simplest hydrocarbon. It is well known that due to these characteristics outlined above autogases burn more perfectly than conventional fuel. Emission of nitrogen oxids

(NO_X) is 20-40 % less, emission of carbon monoxide (CO) is 60-90 % less and emission of hydrocarbon is 40-60 % less than in case of gasoline consumption. Due to more perfect burning particle matters (PM) cannot be found in the exhaust gases of gas-powered cars.
Car owners would mainly like to achieve a reduction in operating costs. As is known the costs are dominated by the price of fuel. Autogases become more and more popular as they can contribute even to a 50 % reduction of fuel costs in an ideal case. (Legal) use of LPG in Hungary has really started to gain place from the middle ‘90s. Car owners (chiefly the freight forwarders and taxi drivers) might enjoy the benefits from the savings due to the use of autogas throughout the world. Thus they do not only improve their own financial situation but help reduce the emission of greenhouse gases as well. – The NO_X component in the exhaust gases is 20 % of that of a gasoline engine, the carbon dioxide (CO_2) emission is 15 % less – the volume of unburnt fuel is less than in the case of gasoline consumption, there is no lead emission and the carbon monoxide emission is also nearly zero.

Advantages:

- LPG is the cheapest
- it is one of the most environment-friendly fuel
- the range of the vehicle gets larger
- relatively dense network of filling stations (even in Hungary)

Disadvantages:

- LPG is a fossil fuel
- the instalment costs are high, several hundred thousand HUF, depending on the model
- need of extreme conversion of the vehicle the traces of which cannot be hidden
- stricter, more complex and more cost expensive MOT test, regular inspections
- requires a large space in the boot
- it is prohibited to enter in some parking houses and garages below floor level with gas-powered cars

- in order to reach the same performance level extra fuel consumption is present as compared to cars with gasoline engines

The biggest advantage of CNG is that they contain simple hydrocarbons unlike conventional fuel. The gas fuel contains less particle matter and polluting material than conventional fuel. The ratio of CO, HC and NO_X is significantly lower than in the case of gasoline engines, because the lack of sulphur and lead in these fuels decreases vitally the presence of the formerly mentioned chemical substances in the exhaust gases. The quality of CNG gas used as engine fuel is the same as the natural gas used in the households. The gases compressed to 250 bar pressure are produced at the filling stations with high pressure compressors and the vehicles are filled up with this gas. The gas gets to the filling stations via the national network. The pressure of the autogas in the gas cylinder strongly depends on the changes in temperature but this can be ignored from the point of view of engine operation. The CNG tank can be filled in two ways:

- at high pressure (this is the so called „slow filling") or
- at high pressure (also called „quick filling") http://gazauto.hu/oldal.php?oid=34

Advantages:

- it is cheap
- perfect burning
- very favourable (small) environmental load

Disadvantages:

- fossil fuel
- one does not like to travel with four 2-300 bar pressure gas cylinders
- Distorting effects in Hungary:
- there is no filling station network in Hungary
- the fuel is an excised product
- there is no state subsidy on public transport http://www.alternativenergia.hu/wp-content/themes/alternativenergia/tudjmegtobbet.php?catid=85

3. Comparative analyses

The mathematical basis of the economic model used for the economic calculations and comparisons is as follows:

(1) $MT_{ij} = F_{ij} + E_{ij}$ [HUF/year]

, where:

MT_{ij}: Savings per year in case of fuel i {gasoline, diesel, LPG, CNG} and vehicles class j {private cars, buses}[HUF/year]

F_{ij}: Benefits originating from the difference in consumption in case of fuel i {gasoline, diesel, LPG, CNG} and vehicles class j {private cars, buses}[HUF/year]

E_{ij}: Benefits from the difference in emission (if there is a state subsidy) in case of fuel i {gasoline, diesel, LPG, CNG} and vehicles class j {private cars, buses}[HUF/year]

(2) $F_{ij} = \acute{E}FK_{ij} \cdot r_{ij}$ [HUF/year]

, where:

$\acute{E}FK_{ij}$: Total kilometres covered annually in case of fuel i {gasoline, diesel, LPG, CNG} and vehicles class j {private cars, buses}[km]

ρ_{ij}: Specific annual fuel consumption in case of fuel i {gasoline, diesel, LPG, CNG} and vehicles class j {private cars, buses}[HUF/km/year]

(3) $MI_{ij} = \acute{A}K_{ij} / MT_{ij}$ [év]

, ahol:

MI_{ij}: ROI (Return On Investment) in case of fuel i {gasoline, diesel, LPG, CNG} and vehicles class j {private cars, buses}[year]

$\acute{A}K_{ij}$: Cost of vehicle conversion in case of fuel i {gasoline, diesel, LPG, CNG} and vehicles class j {private cars, buses}[HUF]

(4) $$NPV_5 = \sum_{t=0}^{5}\left(\frac{B-K}{(1+r)^t}\right); NPV_{15} = \sum_{t=0}^{15}\left(\frac{B-K}{(1+r)^t}\right); \text{[HUF]}$$

, where

$NPV_{5;15}$: net present value (calculated for 5 and 15 years)

r: interest rate of the alternative investment

(5) $$NPV_5 = \sum_{i=0}^{5}\left(\frac{-\left(ÁK_t * ÁAS_t\right) - BTK_t + (ÁAS_t * MT_t - BÜK_t) * PA}{(1+r)^t}\right)$$

[HUF]

, where

$ÁAS_t$: number of annually converted cars in year t

BTK_t: cost of the instalment of a filling station in year t

$BÜK_t$: cost of the operation of a filling station in year t

PA: P/A ratio for the calculation of the 5 and 15 year, 8% NPV annuity

(6) $$É = \frac{X_2 - X_1}{NPV_2 - NPV_1}\left[\frac{[X]}{HUF}\right]$$

, where:

É: sensibility of NPV to the changes in parameter X (number of cars converted, kilometre covered annually, fuel price)

The economic analysis of private cars can help mainly the civil sphere and fleet managing firms before such kinds of investments.

Table Data of the economic analysis

	Annual savings due to the conversion of one vehicle	**Savings to the national economy due to the conversion of one vehicle [%]**	**NPV of the conversion of one vehicle (for 5 years, 8%)**	**ROI of the conversion of one vehicle**	**IRR (5 years)**
PC_Gasoline_LPG	192,880.00	6.28%	550,169.84	1.14	83.45%
PC_Gasoline_CNG	245,560.00	4.97%	630,521.08	1.43	64.30%

PC_Diesel_LPG	51,900.00	20.38%	-492,763.30	13.49	-26.00%
PC_Diesel_CNG	54,103.00	18.01%	-483,966.72	12.94	-25.13%
New_Diesel_CNG	54,103.00	18.01%	216,033.28	0.00	

(source: result of own calculations)

The Table 2. clearly shows **the advantage of gasoline cars** over diesel cars the reason of this being that it is more expensive to convert the latter.

Table Data of the economic analysis

	Sensibility analysis (NPV)			**NPV ~ 0**	
	Km covered /year	**Price of gasoline/ diesel**	**Number of cars converted**	**Number of converted cars needed for the operation of a filling station**	**Number of converted cars needed for the instalment and operation of a filling station**
PC_Gasoline_LPG	2.60%	0.13%	0.0002%	15.00	38.00
PC_Gasoline_CNG	-1.02%	-0.12%	-0.0001%	13.00	119.00
PC_Diesel_LPG	9.65%	0.13%	-0.0002%	na	na
PC_Diesel_CNG	9.26%	0.13%	-0.0002%	na	na
New_Diesel_CNG	9.26%	0.13%	0.0005%	na	na

(source: result of own calculations)

The sensibility Analysis of NPV above clearly indicates the dominance of the **kilometres covered annually**. At the instalment and operation of filling stations the aim was to determine the ROI and the number of cars has been changed so as to reach this (NPV~0). The following diagrams show the effect of the changes in input parameters for the four car types.

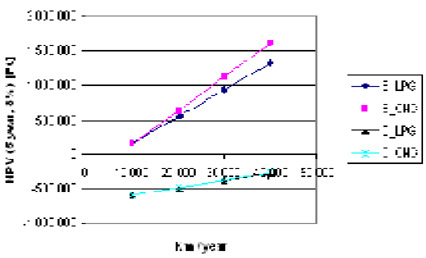

Fig. NPV (P/A, 5 years, 8%) as a function of the kilometres covered annually
(source: result of own calculations)

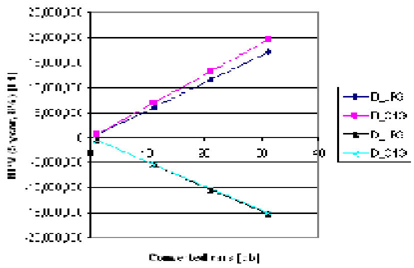

Fig. NPV (P/A, 5 years, 8%) as a function of the number of cars converted
(source: result of own calculations)

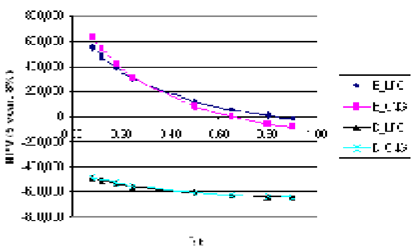

Fig. NPV (P/A, 5 years, 8%) as a function of the changes in the cost of capital
(IRR= point of intersection on the axis)
(source: result of own calculations)

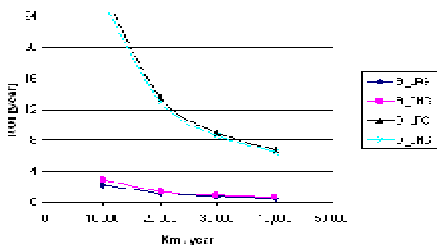

Fig. ROI as a function of kilometres covered annually (source: result of own calculations)

4. Summary

Minimizing environmental load and pollution originating from road transport is a just demand of society. A major part of environmental pollution comes from transport. Road transport is the main “culprit” in the sector. Our paper analyses the environmental and economic effects created by the conversion of cars with the use of alternative

fossil fuels (LPG and CNG). In case of private cars individuals **shall consider the conversion of gasoline engines only due to the lower conversion costs**. Owning to the availability of a national network of filing stations **the results of this consideration will in most of the cases be the LPG conversion** the costs of which will be recovered in 1-1.5 years time (annual savings: 200 000 HUF).
In case of fleets the instalment of filling stations is problematic, since the options are limited by the high costs of CNG. Generally also in this case the conversion of gasoline engines is reasonable. For LPG cars, if a filling station also needs to be installed and operated, at least 40 cars have to be converted. If it only needs to be operated (if e.g. the station is installed from EU subsidy) then the conversion of 15 cars is sufficient. If we plan the conversion of CNG cars (in which case in 90 % a filling station is to be installed) then the costs of station instalment and operation can be covered from the conversion of 120 cars, while the operation costs only are covered from the conversion of 13 cars.

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