Reforming the fleet of public authorities

Stylianos Zindros\textsuperscript{1,3} and Afroditi Anagnostopoulou\textsuperscript{2}

\textsuperscript{1}School of Science and Technology, Hellenic Open University, 18 Par. Aristotelous Str., 263 35, Patras, Greece
\textsuperscript{2}Hellenic Institute of Transport, Centre for Research and Technology Hellas, 1 G. Kasimati str., 185 31 Piraeus, Greece
\textsuperscript{3}Corresponding author: std142714@ac.eap.gr

Abstract. The negative environmental implications and the reduced \$\psi\$ level of social services in many urban areas have attracted significant attention over the last years. Sustainability and quality of life are evolving to demanding actions in urban areas and public authorities have started to buy cleaner, greener vehicles in order to reforming their fleets. This paper presents and analyses a case study of the Traffic Police Division of Attica transition to a new vehicle fleet. It aims to examine how they managed to decrease the inefficiencies of their transport services in terms of both operational and environmental costs by achieving reduced fuel consumption as well as Green House Gas (GHG) emissions. It focuses on the impact on the environment due to the fuel consumption of vehicle fleet by using proper performance indicators (such as l/100 km for fuel consumption, g/km for CO, g/km for CO\textsubscript{2}). Overall, the performance of reforming the fleet of the Traffic Police Division of Attica is evaluated in terms of fuel consumption and GHG reductions following a proposed approach for estimating emissions.

1. Introduction

Reduced level of social services and the negative environmental implications in many urban areas have attracted significant attention over the last years. Sustainability and quality of life are evolving to demanding actions in urban areas and recent findings \cite{1} prove that improvements in environmental pollution and social welfare are necessary. The transport sector contributes to 25.3\% of the EU’s Green House Gas (GHG) emissions and road transport is the main contributor with a share of 72\% \cite{2}. In line with the political targets of COP21 to COP26, public authorities seek to reduce carbon emissions and fuel consumption in the complex environment of urban areas. In addition, they aim to transform their activities to be sustainable and environmental friendly following the goals of the European Green Deal strategy \cite{3} which aims to “protect the health and well-being of citizens from environment-related risks and impacts”.

Emphasis is given on the transport sector which accounts for 40\% \cite{4} and constitutes a key factor of negative environmental and social impacts in urban areas. Efforts to reduce carbon emissions and fuel consumption are being imposed by the European Union (EU) and public authorities have started to buy cleaner, greener vehicles in order to reforming their fleets. Furthermore, EU packages and programmes such as Fit for 55 \cite{5}, 2027 Multianual Financial Framework \cite{6} and Next Generation EU \cite{7} were set up to provide support to the green transition. Public authorities aim to accelerate a broad market introduction of vehicles with higher environmental standards and thereby reduce fuel
consumption and pollutant emissions. For this reason, public procurement tool \[8\] is used by public authorities to cover the demand for clean vehicles provided that comply with environmental and social standards.

More recently, public procurement enhanced by the revised Clean Vehicles Directive \[9\] and could be the main lever of innovation in an attempt to improve societal and environmental goals. Progress towards environmental impacts has been actively supported during the last seven years by the European Commission \[10\], \[11\], \[12\] and constitute one of the main goals of the Sustainable Public Procurement \[13\] action. In practice, reduction of fuel consumption and GHG emissions mainly employed as goals by public authorities in Europe which implemented Sustainable Public Procurement measures \[14\]. Nevertheless, it should be noted that legitimacy and transparency are necessary to be ensured within the public procurement process in order to guarantee the effectiveness of the Sustainable Public Procurement action \[15\]. On the other hand, research community studied several and different measures and solutions (either operational or technical) to decrease the CO\textsubscript{2} emissions in the EU area \[16\], \[17\], \[18\], \[19\], \[20\].

The remainder of the paper is organized as follows: Section 2 describes the proposed methodology for evaluating the performance of reforming the fleet in terms of fuel consumption and GHG emissions and then, the case study is thoroughly presented in Section 3. The results and the evaluation outcomes are provided and discussed in Section 4 and finally, in Section 5 conclusions are drawn and pointers for future research are provided.

2. Methodology

The methodology for evaluating the performance of reforming the fleet of the Traffic Police Division of Attica considers the baseline vehicles (before reforming) and the new vehicles. Emissions are estimated using data from June 2019 to May 2021 and factors relevant to fuel use and carbon intensity. Estimated emissions are based on annualizing emissions for simplicity. Reductions in GHG emissions achieved by the new fleet are calculated by summing for each new vehicle the difference between estimates of the emissions avoided (baseline vehicle, \(EM_{\text{baseline}}\)) and the emissions produced (new vehicle, \(EM_{\text{newVeh}}\)) per kilometer traveled:

\[
GHG \text{ reductions} = \sum_i (EM_{i,\text{baseline}} - EM_{i,\text{new}})
\]

where:

- \(i\) = each pair of baseline and new vehicle
- \(EM\) = emissions per kilometer.

For each baseline vehicle:

\[
EM_{i,\text{baseline}} = CO_{2EM} + CO_{EM}
\]

where:

- \(CO_{2EM}\) = CO\textsubscript{2} emissions per kilometer
- \(CO_{EM}\) = CO emissions per kilometer.

For each new vehicle:

\[
EM_{i,\text{new}} = CO_{2EM} + CO_{EM}
\]

where:

- \(CO_{2EM}\) = CO\textsubscript{2} emissions per kilometer
- \(CO_{EM}\) = CO emissions per kilometer.

Estimated fuel consumption reductions are also based on annualizing them. Reductions in fuel consumption achieved by the new fleet are calculated by summing for each new vehicle the difference between the baseline fuel consumption (baseline vehicle, FC\textsubscript{baseline}) and the new fuel consumption (new vehicle, FC\textsubscript{newVeh}) per 100 kilometers traveled:
FC reductions = \sum_{i} (FC_{i,\text{baseline}} - FC_{i,\text{new}})

where:

\( i \) = each pair of baseline and new vehicle

\( FC \) = fuel consumption in litters per 100 kilometers.

3. Case Study
With a fleet of 267 vehicles, the Traffic Police Division of Attica needs to meet the challenge head on and create a proper strategy to make the transition to cleaner vehicles following the net-zero emissions in the EU energy system by 2050 [21] and the 1st objective of the National Energy and Climate Plan [22] for achieving reductions in GHG emissions. Vehicle emissions were giving significant cause for concern and estimated emissions quantified the potential environmental benefits of fleet reforming. Working with the Traffic Police Division of Attica, data about both baseline and new vehicles were collected and analyzed. Transitioning most of the vehicles, 222 from the 267 vehicles of the fleet, to new and cleaner with the aim to result in significant reductions in GHG emissions and fuel consumption.

In our case study, the baseline fleet represents vehicles operated from June 2019 to May 2020 and the new fleet represents vehicles operate from June 2020 to May 2021. The baseline fleet is composed by 263 gasoline vehicles and only 4 diesel vehicles. On the other hand, the new fleet encompasses only 59 gasoline vehicles and 208 diesel vehicles aiming at lower volumetric fuel consumption. In addition, the percentage of diesel vehicles was significantly increased (from 1.5% to 77.9%) since they are equipped with more energy efficient engines and have higher reductions in CO and CO2 emissions comparing to gasoline vehicles. Note that NOx and PM are not considered due to lack of relevant information.

Analysis of vehicles operated showed the “disparity” in vehicles’ emissions. For the baseline fleet, it found 19% vehicles only meet the EURO 6 emissions standard and 75% vehicles still met the EURO 3 standard in 2019. For this reason, new technology exhaust gas cleaning was introduced and now the majority of vehicles meeting EURO 6 emission standards. Figure 1 presents the composition of the baseline and Figure 2 the new fleet of vehicles. The new fleet is employed by only 11% of vehicles EURO 3 and 83% of EURO 6. A further 6% of vehicles from the baseline fleet remains the same in the new fleet and falls behind the latest EURO 6 legislation by only achieving EURO 4.

![Figure 1. Composition of baseline fleet.](image1)

![Figure 2. Composition of new fleet.](image2)
4. Results

In an attempt to present how the transition to a new fleet of vehicles reduced both operational and environmental costs, real data and information were provided and the relevant indicators (fuel consumption, CO, CO₂) were estimated based on the proposed methodology and utilizing typical consumption and emissions data of the https://www.car-emissions.com/. In a city struggling to clean up its air pollution, 20.50 (kg/km) total GHG emission reductions achieved by the new fleet of vehicles. More specifically, the total CO emissions were reduced from 0.16 (kg/km) to 0.6 (kg/km) and the total CO₂ emissions reduced from 49.58 (kg/km) to 29.18 (kg/km). In addition, 881.3 (l/km) total fuel consumption reductions were achieved proving the effectiveness of the transition.

Figure 3 summarizes the results obtained about the CO emissions for each category of vehicle (EURO 3, EURO 4 and EURO 6) both for the baseline and new fleets. The total CO emission reductions of EURO 3 vehicles are 110.33 (gr/km) and the total EURO 3 vehicles reduced from 200 in the baseline fleet to only 30 in the new fleet. On the other hand, the total CO emission s of EURO 6 vehicles are increased from 23.6 (gr/km) to 32.76 (gr/km) since the total EURO 6 vehicles increased from 50 in the baseline fleet to 222 in the new fleet.

![Image of Figure 3: CO emissions generated per type of vehicles](image)

Figure 4 summarizes the results obtained about the CO₂ emissions for each category of vehicle (EURO 3, EURO 4 and EURO 6) both for the baseline and new fleets. The total CO₂ emission reductions of EURO 3 vehicles are 38.72 (kg/km) and the total EURO 3 vehicles reduced from 200 in the baseline fleet to only 30 in the new fleet. On the other hand, the total CO₂ emissions of EURO 6 vehicles are increased from 7.90 (kg/km) to 20.61 (kg/km) since the total EURO 6 vehicles increased from 50 in the baseline fleet to 222 in the new fleet. Regarding emissions generated by EURO 4 vehicles, the total CO and CO₂ emissions do not change before and after the transition as the EURO 4 vehicles remain the same.
To assess the extent that cleaner vehicles can increase emission reductions achievable from these vehicles, an extreme bounding scenario was calculated with 100% of EURO 6 vehicles. This resulted in an increase for GHG emissions and fuel consumption compared to the reduction estimates of the new fleet vehicles after the reforming. Total GHG emission reductions estimated to 6.51 (kg/km) and total fuel consumption reductions estimated to 282.2 (l/km) by the extended scenario.

5. Conclusions
From rapid urbanization and pressure on improved air quality in modern cities, tighter regulation imposed by the European Commission in order to enable environmental consciousness of public authorities. Towards this direction, this paper presents and analyses a case study of the Traffic Police Division of Attica transition to a new fleet of cleaner vehicles. It aims to estimate reductions in GHG emissions and fuel consumption. According to the analysis of the derived results, the reforming of the fleet of vehicles covers environmental aspects while places emphasis on fuel consumption issues. The main contribution of the presented case study is the derived outcomes that generate fruitful insights and valuable information to further support future planning and decision making in the Traffic Police Division of Attica.

Besides the aforementioned observations, consideration is also given on future research and directions are drawn. An important perspective lies in setting the foundations for incorporating electric vehicles in the fleet of the Division and developing the associated roadmap.

Acknowledgments.
We would like to thank the Department of Materials and Finance Management, Traffic Police Division of Attica for their extraordinary support and assistance in this work.

References
[1] Halonen J I, Blangiardo M, Toledano M B, Fecht D, Gulliver J, Anderson H R and Tonne C 2016 Long-term exposure to traffic pollution and hospital admissions in London Environ. Pollut. 208 48-57 https://doi.org/10.1016/j.envpol.2015.09.051
[2] European Union 2015 Energy in Figures Statistical Pocketbook (Brussels: European Commission) p 190 https://ec.europa.eu/energy/sites/ener/files/documents/PocketBook_ENERGY_2015%20PD F%20final.pdf
[3] EU COM 2019 *The European Green Deal* (Brussels: European Commission) p 1-24 https://ec.europa.eu/info/sites/default/files/european-green-deal-communication_en.pdf

[4] EU COM 2009 *Mobilizing Information and Communication Technologies to facilitate the transition to an energy-efficient, low-carbon economy* (Brussels: European Commission) p 1-13 http://ec.europa.eu/information_society/activities/sustainable_growth/docs/com_2009_111/com2009-111-en.pdf

[5] EU COM 2021 *'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality* (Brussels: European Commission) p 1-15 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0550&from=EN

[6] Council Regulation (EU, Euratom) 2020/2093 of 17 December 2020 laying down the multiannual financial framework for the years 2021 to 2027 OJ L 433, 22.12.2020, p 11–22 http://data.europa.eu/eli/reg/2020/2093/oj

[7] Next Generation EU “Make it Green” https://europa.eu/next-generation-eu/index_en#ecl-inpage-30

[8] Internal Market, Industry, Entrepreneurship and SMEs 2021 Public Procurement https://ec.europa.eu/growth/single-market/public-procurement_en

[9] Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles (Text with EEA relevance) OJ L 120, 15.5.2009, p 5–12 http://data.europa.eu/eli/dir/2009/33/oj

[10] Directive 2014/23/EU of the European Parliament and of the Council of 26 February 2014 on the award of concession contracts Text with EEA relevance OJ L 94, 28.3.2014, p 1–64 http://data.europa.eu/eli/dir/2014/23/oj

[11] Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC Text with EEA relevance OJ L 94, 28.3.2014, p 65–242 http://data.europa.eu/eli/dir/2014/24/oj

[12] Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC Text with EEA relevance OJ L 94, 28.3.2014, p 243–374 http://data.europa.eu/eli/dir/2014/25/oj

[13] Sönnichsen S D and Clement J 2020 Review of green and sustainable public procurement: Towards circular public procurement *J. Clean. Prod.* 245 118901 https://doi.org/10.1016/j.jclepro.2019.118901

[14] McCrudden C 2007 *Buying social justice: Equality, government procurement, & legal change.* OUP Oxford p 679 https://doi.org/10.1093/acprof:oso/9780199232420.001.0001

[15] Dragos D and Neamtu B 2013 Sustainable Public Procurement. *Eur. Procurement & Pub. Private Partnership L. Rev.* 8 (1) 19-30 https://doi.org/10.21552/EPPPL/2013/1/159

[16] Bampatsou C and Zervas E 2011 Critique of the regulatory limitations of exhaust CO2 emissions from passenger cars in European union *Energy Policy* 39 (12) 7794-802 http://dx.doi.org/10.1016/j.enpol.2011.09.024

[17] Pavlovic J, Marotta A and Ciuffo B 2016 CO2 emissions and energy demands of vehicles tested under the NEDC and the new WLTP type approval test procedures *Appl. Energy* 177 661-70 https://doi.org/10.1016/j.apenergy.2016.05.110

[18] Zervas E and Lazarou C 2008 Influence of European passenger cars weight to exhaust CO2 emissions *Energy Policy* 36 (1) 248-57 http://dx.doi.org/10.1016/j.enpol.2007.09.009

[19] Türe Y and Türe C 2020 An assessment of using Aluminum and Magnesium on CO2 emission in European passenger cars *J. Clean. Prod.* 247 119120 https://doi.org/10.1016/j.jclepro.2019.119120

[20] Zervas E, Pouloupolos S and Philippopoulos C 2006 CO2 emissions change from the introduction of diesel passenger cars: Case of Greece *Energy* 31 (14) 2915-25 http://dx.doi.org/10.1016/j.energy.2005.11.005
[21] Tsiropoulos I, Nijs W, Tarvydas D and Ruiz P 2020 Towards net-zero emissions in the EU energy system by 2050 Insights from scenarios in line with the 2030 and 2050 ambitions of the European Green Deal https://doi.org/10.2760/062347

[22] Hellenic Republic - Ministry of the Environment and Energy 2019 The National Energy and Climate Plan https://ec.europa.eu/energy/sites/default/files/el_final_necp_main_en.pdf