Environmental Science & Technology

Article

Cite This: Environ. Sci. Technol. 2019, 53, 4440−4449

pubs.acs.org/est

Evaluation of Real-World Gaseous Emissions Performance of Selective Catalytic Reduction and Diesel Particulate Filter Bus Retrofits

Robin Smit,[†,∥] Christos Keramydas,[†] Leonidas Ntziachristos,[*,‡] Ting-shek Lo,[§] Kwok-lam Ng,[§] Hok-lai Anson Wong,[§] and Carol Ka-lok Wong[§]

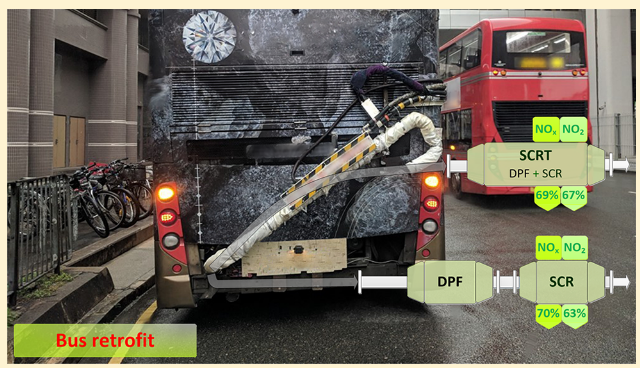
[†]EMISIA SA, Antoni Tritsi 21, GR 57001, Pylaia, Greece

[‡]Laboratory of Heat Transfer and Environmental Engineering, Mechanical Engineering Department, Aristotle University Thessaloniki, GR 54124, Thessaloniki, Greece

[§]Environmental Protection Department, Hong Kong SAR Government, 33/F, Revenue Tower, 5 Gloucester Road, Wan Chai, Hong Kong

[∥]School of Civil Engineering, University of Queensland, Brisbane, Queensland 4001, Australia

Supporting Information



ABSTRACT: This study reports on the results of gaseous pollutants emission measurements of double-decker buses in an urban road network, using portable emission measurement systems (PEMS). Measured vehicles were tested by following in-service buses on regular routes. Six Euro II and Euro III buses were retrofitted with diesel particulate filters (DPF) and selective catalytic reduction (SCR) or a combined SCR+DPF (SCRT) device. Substantial and statistically significant technology impacts were observed for several pollutants. Optimized SCR and SCRT retrofit technology reduced real-world NO_x emissions by approximately 70%, on average. Retrofit DPF slightly reduced NO_x emissions but increased direct NO_2 emissions by more than a factor of 8, on average. SCRT led to about 70% lower NO_2 levels than DPF alone, but for some vehicles higher NO_2 levels were observed as compared with the "no retrofit" situation, warranting further investigation. None of the SCR systems were found to lead to a substantial increase in NH_3 emissions after operation optimization. High NH_3 and N_2O emissions were occasionally observed while experience with the system calibration was being accumulated. Observed average N_2O emission levels for "DPF+SCR" technology were relatively high at 182 mg/kg fuel, corresponding to 1.5% of total greenhouse gas emissions. The study shows that SCR retrofit programs can be effective for NO_x reduction of transit buses but that proper calibration and regular emission monitoring are required.

INTRODUCTION

Stringent vehicle emission legislation around the world has driven the development of increasingly complex emission control systems for on-road vehicles. Emission control systems can be either integrated in the vehicle design phase (OEM) or retrofitted on in-use vehicles.[1] Retrofit emission control efforts have shifted from light-duty petrol vehicles[2] to heavy-duty diesel trucks and buses over time,[3,4] as diesel vehicles are the highest contributor of PM and NO_x emissions in many urban environments around the world.[5−7]

Retrofit systems can provide rapid and substantive reductions in emissions from in-use vehicles.[8] Undesirable side effects of retrofit technology such as a fuel penalty,[9] increased direct NO_2 emissions,[3] elevated ultrafine particle emissions,[10] and cost effectiveness of retrofit programs[11] are remaining challenges to be addressed.

A particular focus has been on retrofit buses as they operate in densely populated areas, offer long service lives (15−20 years), and regularly involve sensitive population groups (e.g., children in school buses).[12,13]

Historically, the assessment of the environmental impact of diesel retrofit programs has mainly focused on PM control devices such as oxidation catalysts and diesel particulate filters (DPFs).[9,13,14] Retrofit PM reduction devices are relatively easy to fit and often passively oxidize the collected soot. As a consequence, the effectiveness and durability of PM (and

Received: December 21, 2018
Revised: March 7, 2019
Accepted: March 15, 2019
Published: March 15, 2019

DOI: 10.1021/acs.est.8b07223
Environ. Sci. Technol. 2019, 53, 4440−4449