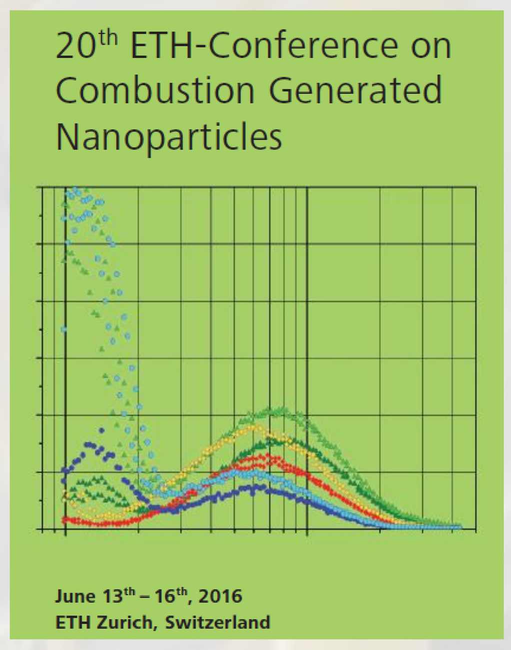
Buses retrofitting with diesel particulate filters: effects on nanoparticle emissions and vehicle performance

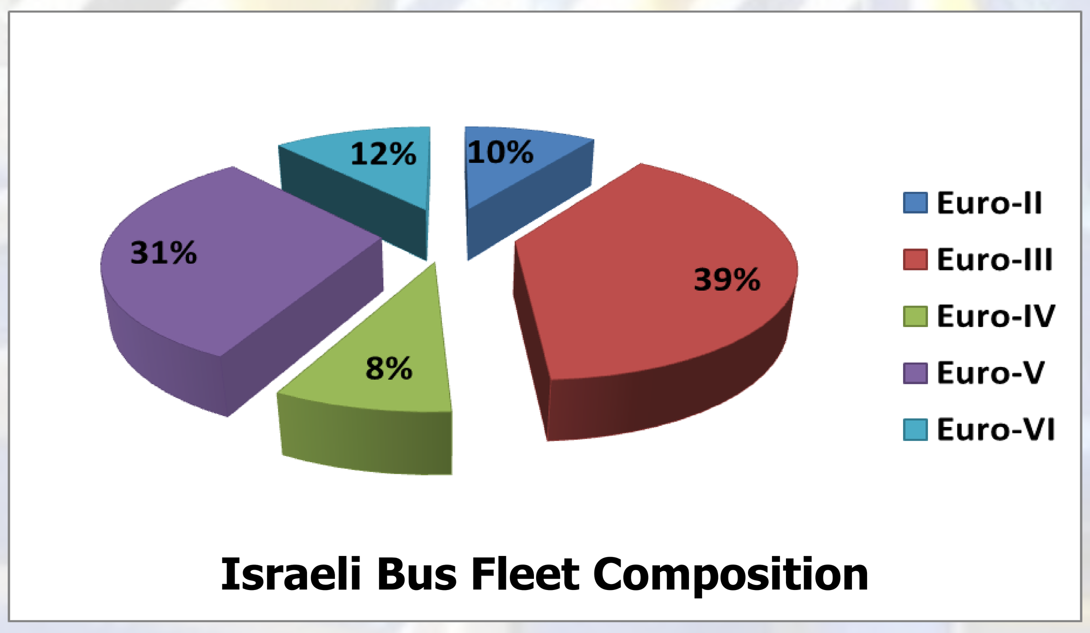
R. Fleischman*, R. Amiel and L. Tartakovsky

Technion – Israel Institute of Technology: rf@technion.ac.il



Introduction

- Inhalation of particulate matter: serious adverse health effects.
- Road transport is a main source of air pollution in Israel's population centers.
- Public transportation: based almost entirely on diesel engines
- Due to the long service life of heavy-duty diesel engine vehicles, their emission control technologies become obsolete.
- Retrofitting in-use buses with recently developed technologies is a cost effective measure to reduce particulate matter emissions.



Israeli Bus Fleet Composition

Research Goal

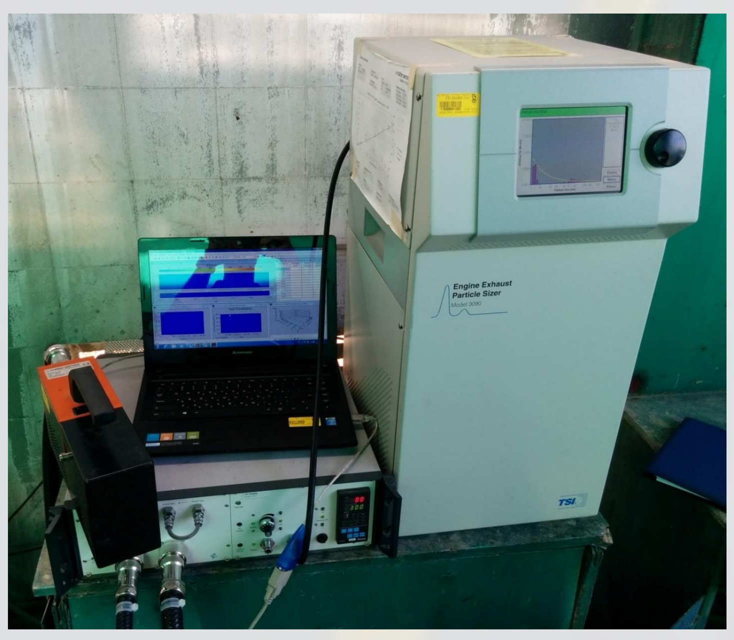
- The objective of this study is to evaluate the reduction in nanoparticle emissions of in-use diesel buses retrofitted with Diesel Particulate Filters (DPF) and to assess influence of retrofitting on the buses performance in real-world usage conditions.

Methodology

- DPFs from three different manufactures were selected.
- 18 in-use Euro III buses were selected for DPFs retrofitting:
  - 9 urban Man NL313F buses and
  - 9 intercity Mercedes-Benz OC500 coaches
- 3 different topographies
  - Flat terrain – Tel Aviv area
  - Hilly terrain – Jerusalem area
  - Combined terrain – Haifa area
- Control group of 18 identical vehicles in identical routes
- Each vehicle was tested at four different operating regimes:
  - low idle;
  - high idle;
  - Full load; 85% rated speed
  - free acceleration.
- Calculation of DPF filtration efficiency:

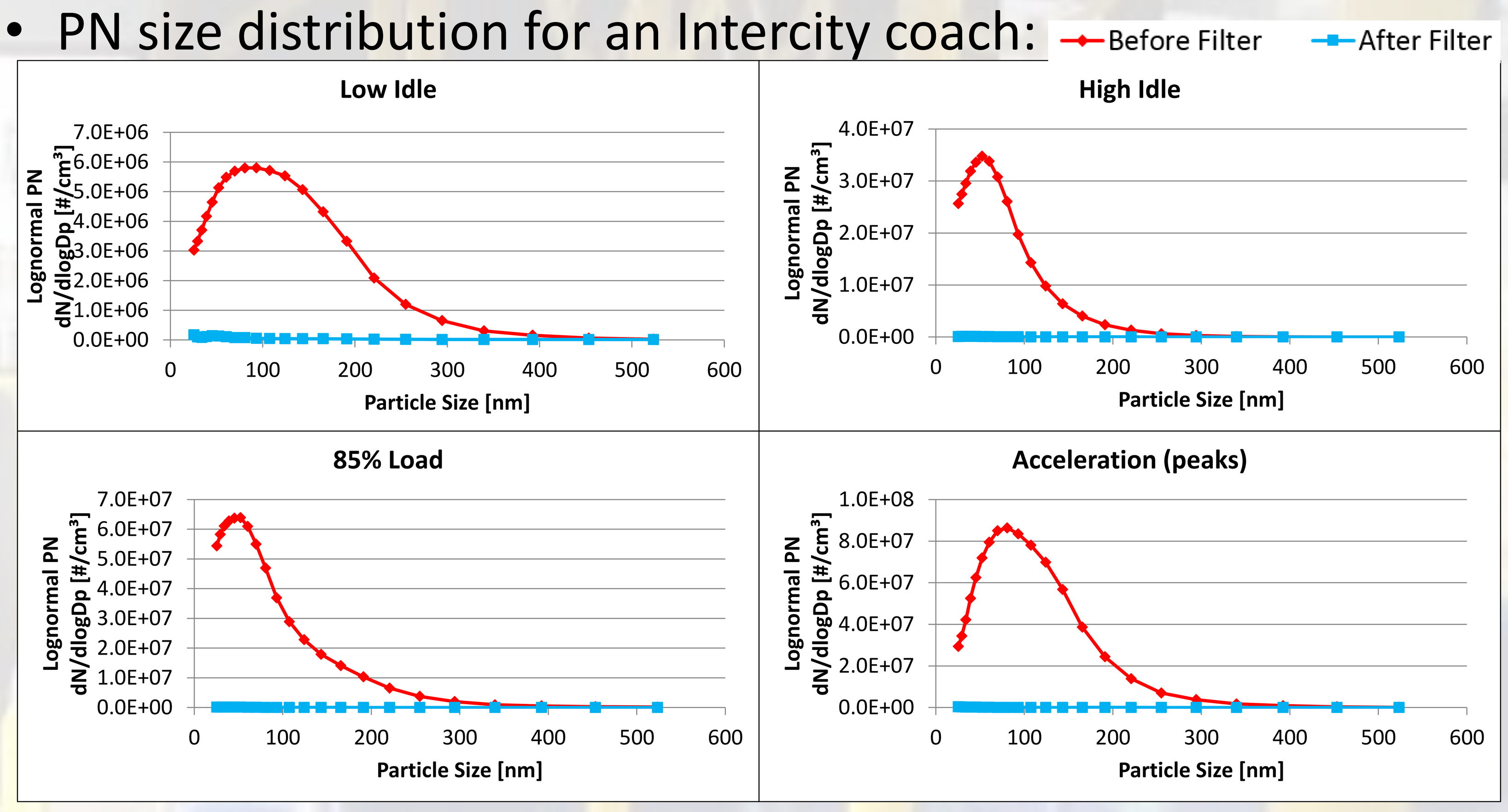
$$PNFE = \frac{(N_{W/O} - N_F)}{N_{W/O}} \cdot 100$$

- TSI 379020A-30 and TSI EEPS 3090 were used for sample conditioning and nanoparticle size distribution measurements from 23 nm up to 560 nm at sampling frequency of 10Hz.

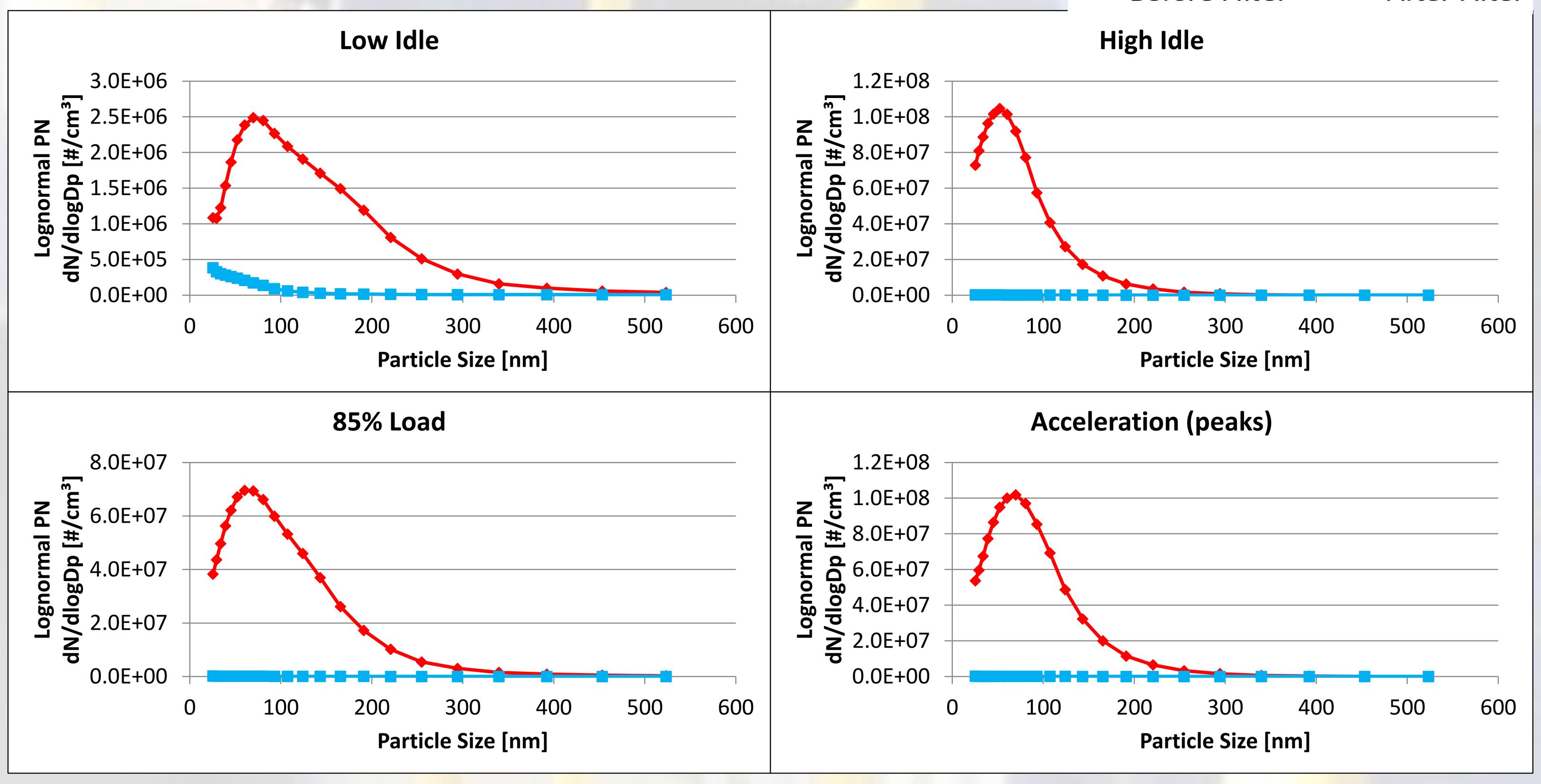


Results and Discussion

- PN size distribution for an Intercity coach:



- PN size distribution for an Urban bus:



- Total PN emissions and Filtration efficiencies for the above vehicles:

INTERCITY COACH

		Total PN Concentration [#/cm³]	PNFE [%]
Low Idle	Before Filter	4.70E+06	98.14
	After Filter	8.76E+04	
High Idle	Before Filter	2.08E+07	99.73
	After Filter	5.71E+04	
Full load, 85% rated speed	Before Filter	4.20E+07	99.83
	After Filter	7.28E+04	
Free acceleration (peaks)	Before Filter	5.76E+07	99.83
	After Filter	9.74E+04	

URBAN BUS

		Total PN Concentration [#/cm³]	PNFE [%]
Low Idle	Before Filter	1.81E+06	90.9
	After Filter	1.65E+05	
High Idle	Before Filter	6.13E+07	99.82
	After Filter	1.12E+05	
Full load, 85% rated speed	Before Filter	4.90E+07	99.79
	After Filter	1.05E+05	
Free acceleration (peaks)	Before Filter	6.36E+07	99.88
	After Filter	7.39E+04	

- At low idle regime, PNFE was found to be the smallest. At this regime, the residence time of the gases is higher, thus allowing a greater agglomeration of the particles, resulting into less and larger particles.
- Very high filtering efficiencies were found, confirming previous studies.
- Average increase of fuel consumption due to DPF: 2.5% and 2.1% for intercity and urban buses, respectively.

Conclusions

- The potential of nanoparticle emissions mitigation by DPF retrofitting of Euro III buses is clearly demonstrated.
- Average particle number filtration efficiency of the tested DPFs: 98% and 96% for intercity and urban buses, respectively
- Low idle regime: slightly lower filtration efficiencies
- Increase of fuel consumption due to DPF retrofitting: 2.5% and 2.1% for intercity and urban buses, respectively

Acknowledgments

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