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DPF-Retrofit in Israel – First Results of the Pilot Test

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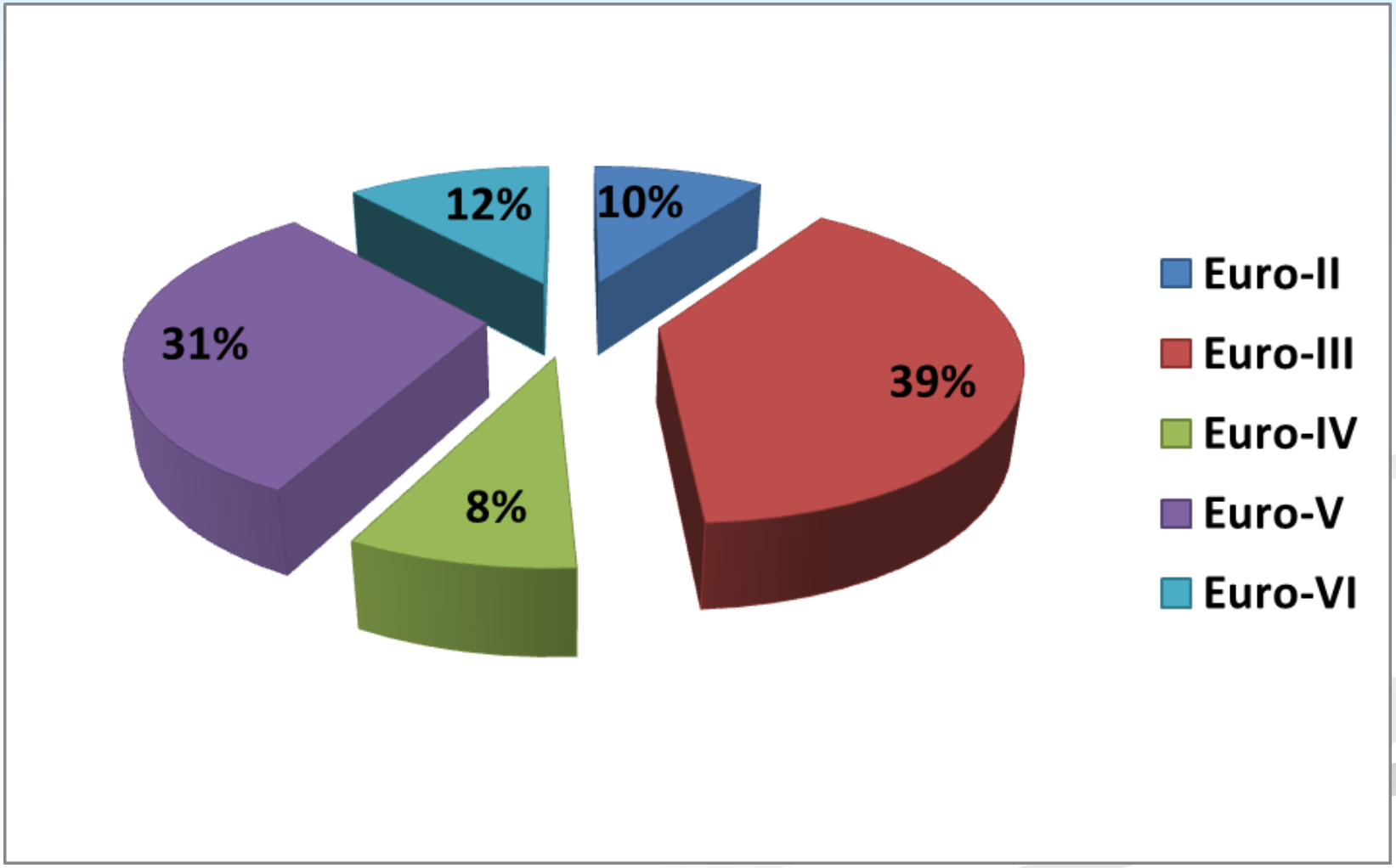
Motivation

- ✓ **Transportation is the main source of air pollution in Israel's cities and population centers**
- ✓ **Public transportation is almost entirely based on diesel engines**
- ✓ **The Israeli government authorized a major plan to battle air pollution in Israel:**

- ➢ Low Emission Zone in Haifa – by end 2016
- ➢ 11M NIS - to fund DPF retrofitting in some 700 polluting diesel vehicles – tender is published
- ➢ 10M NIS - to fund DPF retrofitting in garbage trucks – tender will be published in 2016
- ➢ Orders to reduce emissions from large HD vehicle fleets - published

Israeli Bus Fleet Composition



Goals

- Assessment of nanoparticle emissions mitigation from in-use diesel buses by retrofitting diesel particle filter

- Assessment of DPF retrofitting influence on real-world fuel consumption and other operational aspects of urban and intercity buses

Buses tested

- 18 Euro-3 buses were selected for retrofit
  - 9 urban MAN buses (mileage: 450,000-580,000 km)
  - 9 intercity Mercedes buses (mileage: 1,200,000-1,600,000 km)

- Particle filters
  - Three different makes
  - CRT regeneration technology
  - VERT-certified filters

- Three typical usage topographies
  - Flat terrain – Tel Aviv area
  - Hilly terrain – Jerusalem area
  - Combined terrain – Haifa area

Methodology

Operation modes:

- Low idle
- High idle
- Full load, 85% rated speed
- Free acceleration

Measurements:

- Particle number (PN) concentration and size distribution
- EEPS-3090 TSI Inc.
- Sampling temperature – 300^{o}C
- Particles above 23 nm were considered
- Engine speed, vehicle velocity, power on the wheels

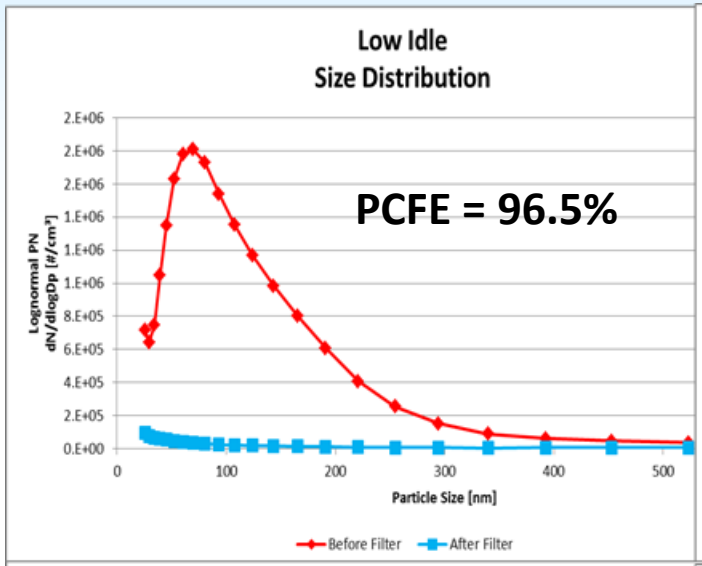
All the measurements – at DPF inlet and outlet

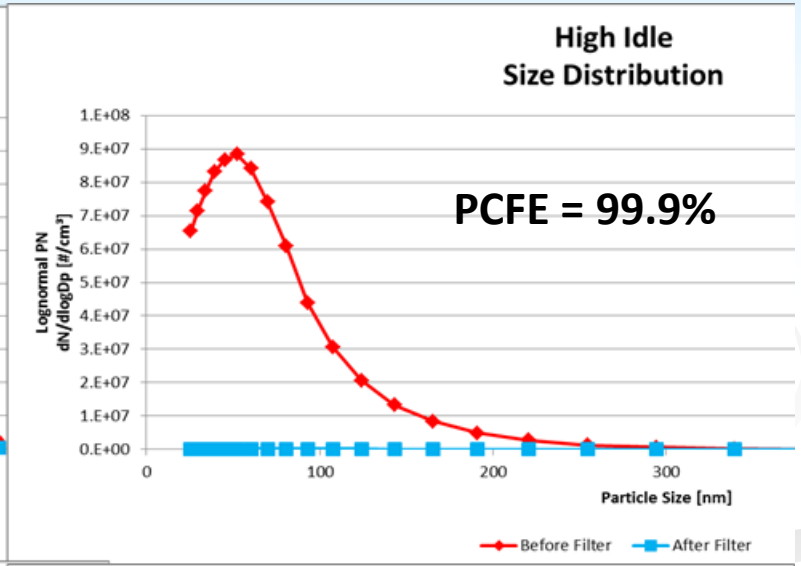
Experimental setup

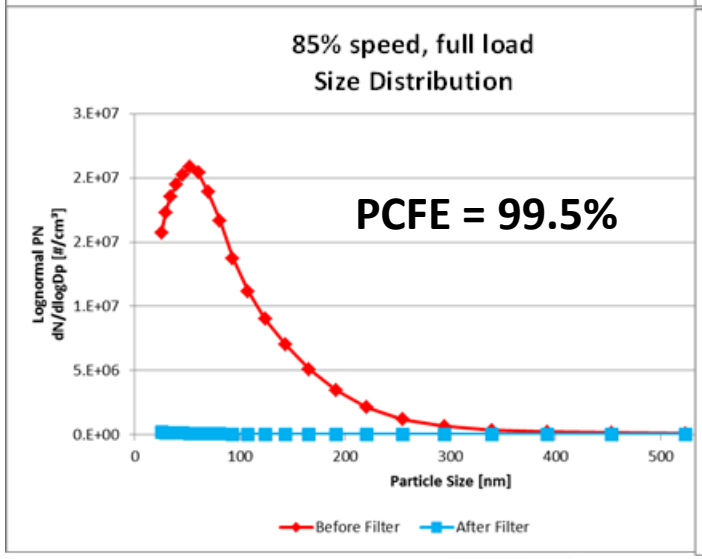
PN Measurement rounds:

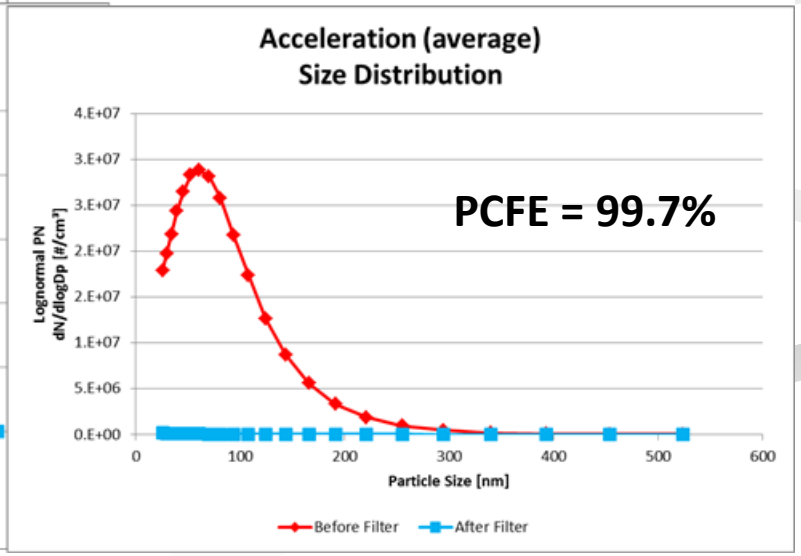
1. One-three weeks after DPF installation – approx. September 2015
2. Four months later – January 2016
3. The last round is planned to be performed in May 2016

Size Distribution of Nanoparticle Number Concentrations

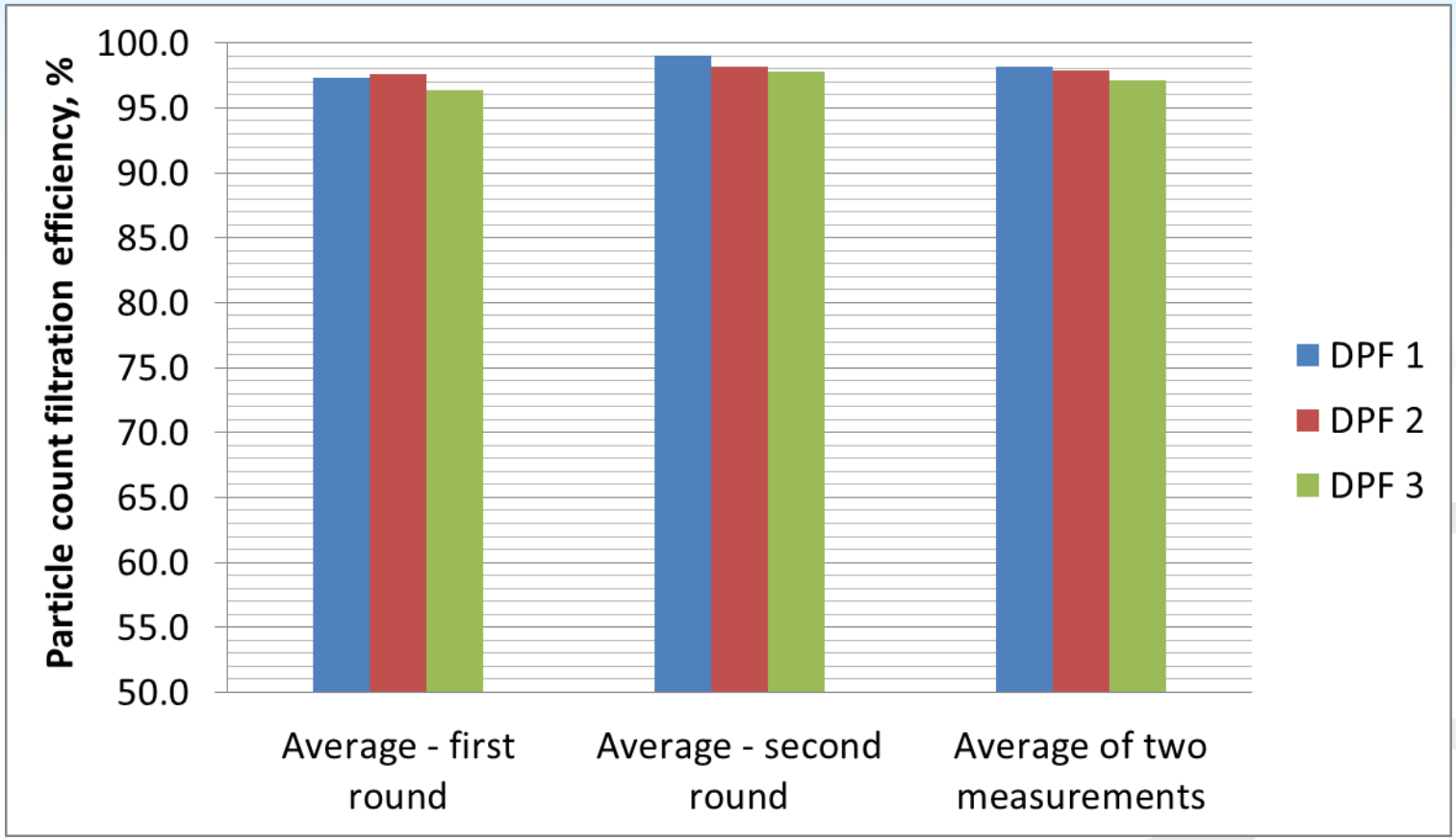






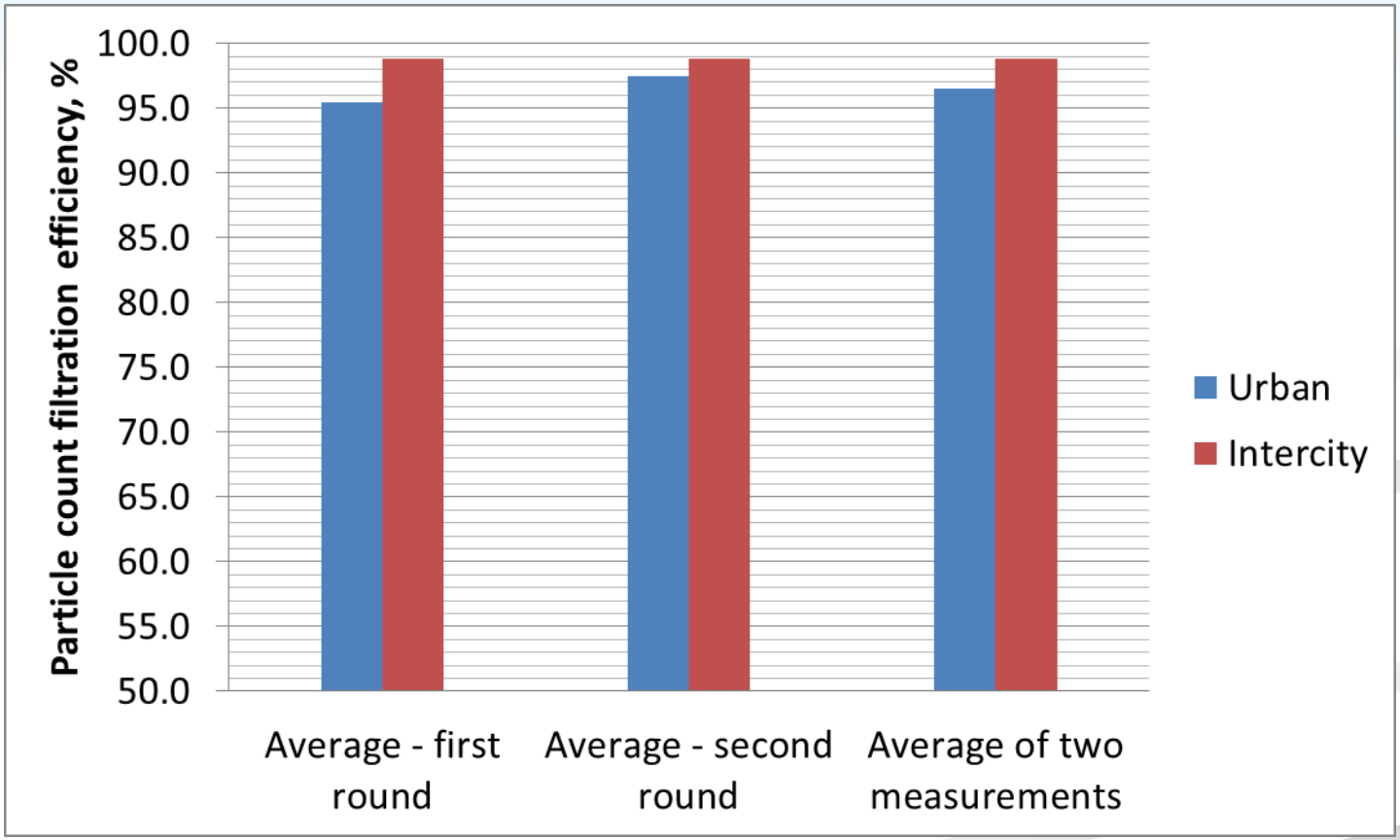


Particle count filtration efficiency



Average PCFE varies between 97 – 98%

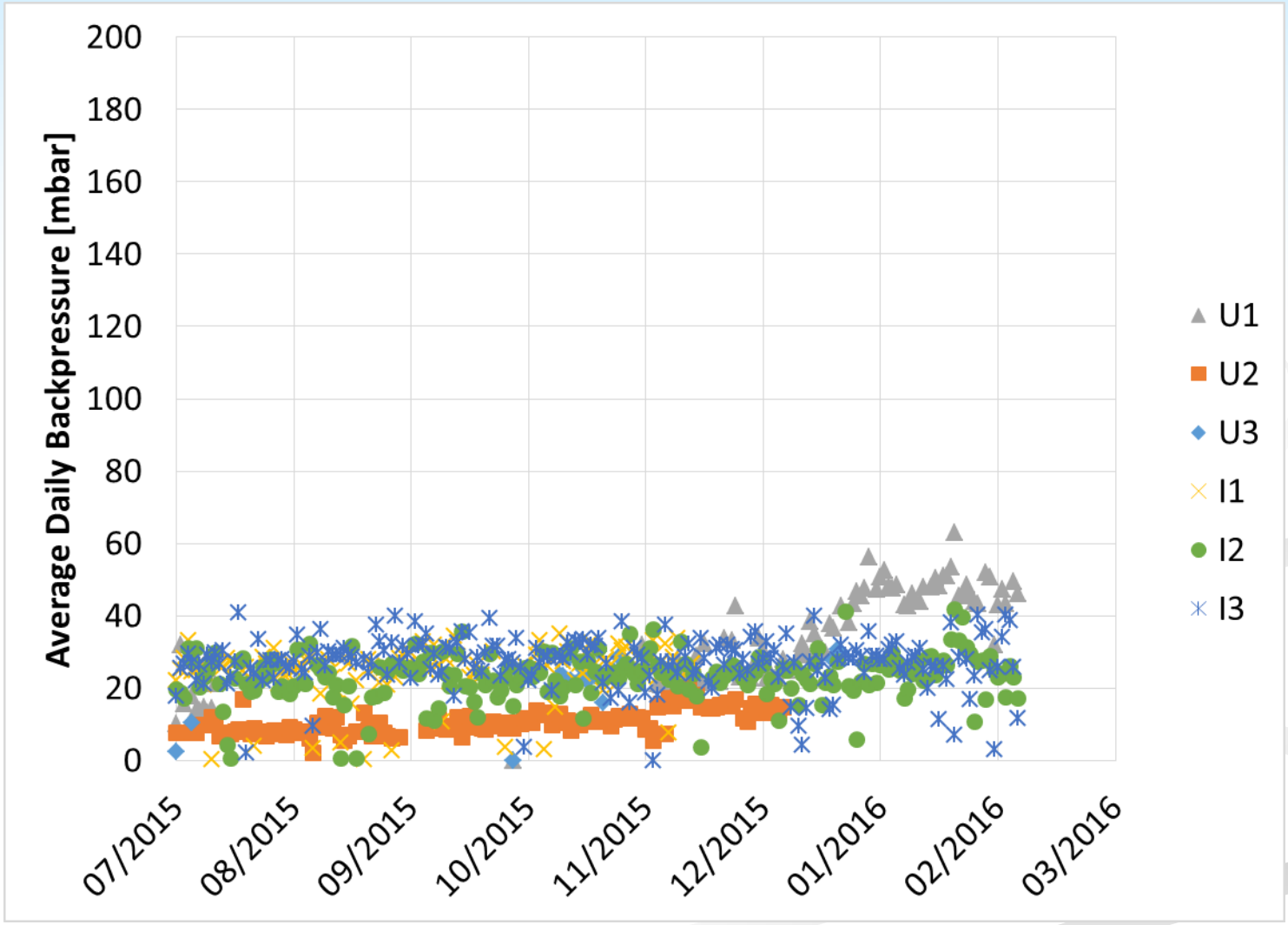
Comparison of PCFE for urban and intercity buses



Somewhat higher PCFE for intercity buses.

The trend is kept for all tested DPF types

Backpressure

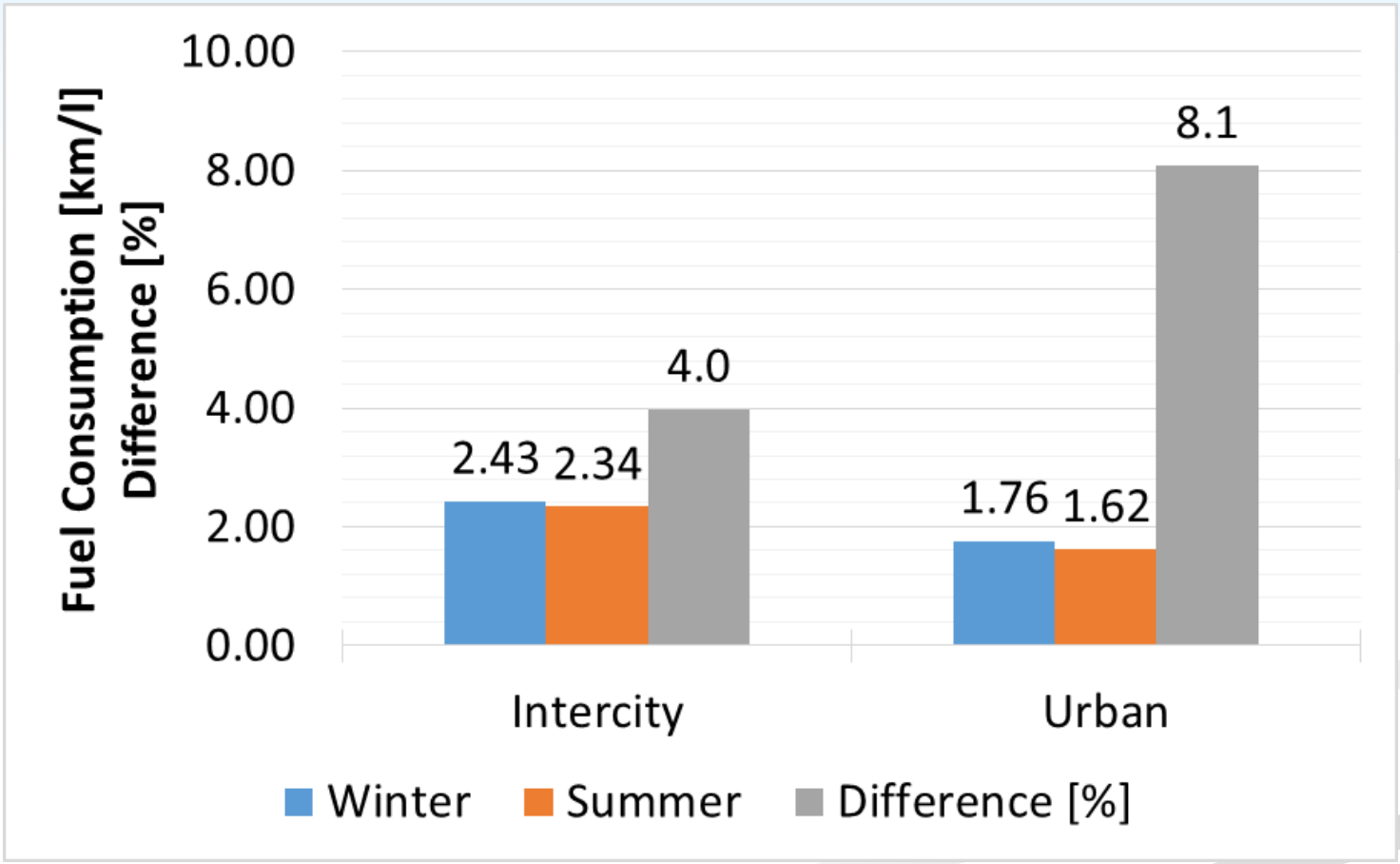


U1, 2, 3 – urban buses 1, 2, 3

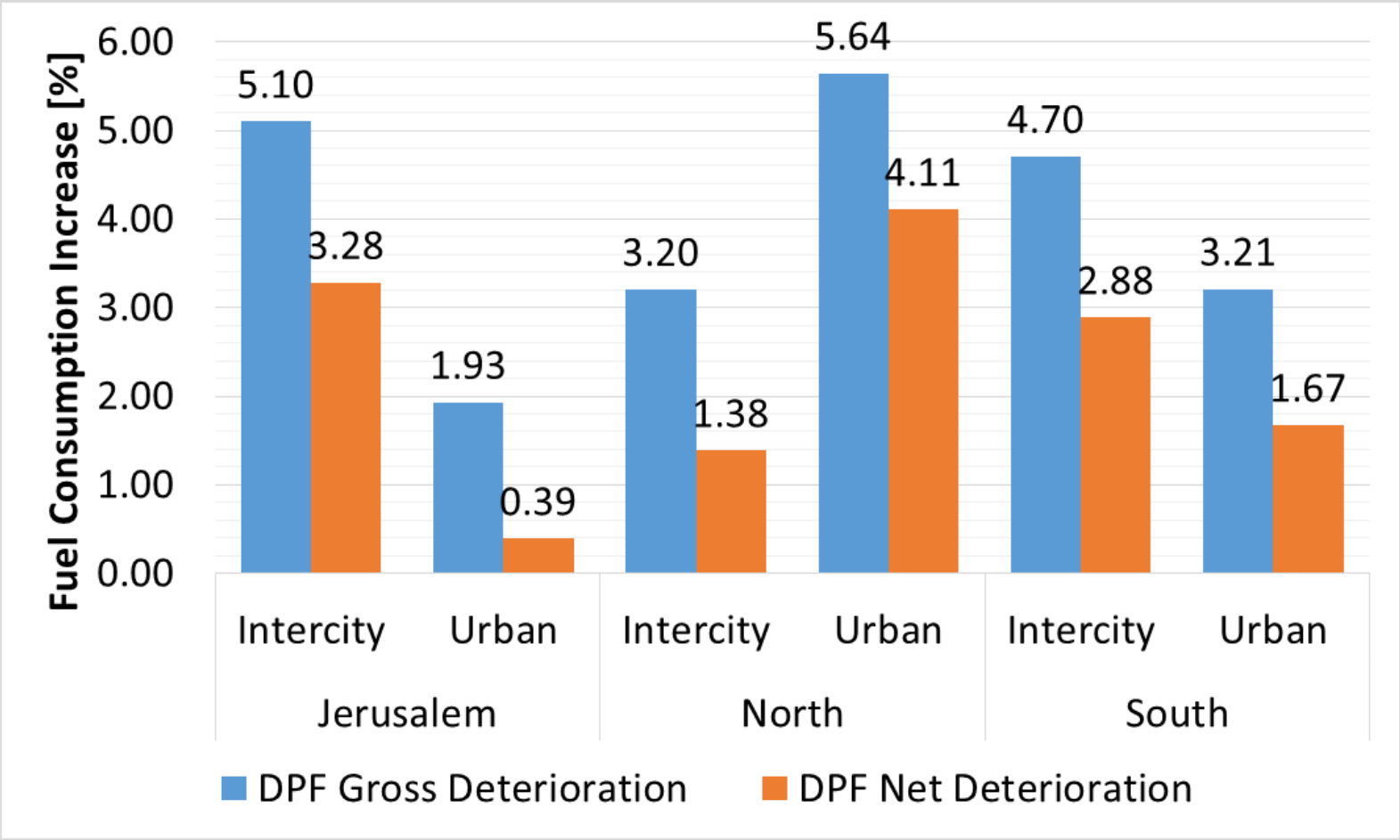
I1, 2, 3 – intercity buses 1, 2, 3

Fuel Consumption – seasonal variation

Average data for 36 buses: pilot + control group



DPF effect on fuel consumption



Average increase of fuel consumption due to DPF:

- Urban buses – 2.1%
- Intercity buses – 2.5%

Conclusions

✓ **Average particles count filtration efficiency of DPFs – 97-98%**

✓ **Particles count filtration efficiency of DPFs is somewhat higher for intercity buses. The trend is kept for all tested DPF types**

✓ **Backpressure values after half a year of real world usage do not exceed 60 mbar**

✓ **DPF retrofitting lead to increase in fuel consumption by 2% for urban buses and approx. 2.5% for intercity buses**

✓ **No influence on frequency of engine repair was detected till now**

✓ **No deterioration in buses drivability was reported**

Next steps

- ✓ **Pilot is planned to be continued till June 2016**
- ✓ **Next PN measurement round – in May 2016**
- ✓ **Decision on massive retrofit of in-use buses in Israel – in few months**

Acknowledgments

This work is financially supported by Egged Bus Co. We are grateful for the fruitful cooperation in the experiments carrying-out and readiness to contribute to the air quality improvement in Israel.

The authors are grateful to the VERT Association and the Israel Ministry of Environmental Protection for their continuous collaboration and support.

Save the date

4th International Workshop

Nanoparticle Emissions from Heavy-Duty Vehicles

In memoriam Professor Yoram Zvirin

Thursday, June 21, 2016

Andrew Davidovits Auditorium, D. Dan and Betty Kahn Building
Faculty of Mechanical Engineering, Technion, Haifa

8:30 – 9:00	**Welcome and Registration**
Opening session	**Chairman: Leonid Tartakovsky**, Technion
9:00 – 9:30	**Welcome:** ***Yisrael Dancziger***, Director General, Israel Ministry of Environmental Protection ***Yona Yahav***, Mayor of Haifa ***Anath Fischer***, Deputy Executive Vice President for Research, Technion ***Yoram Halevi***, Dean, Faculty of Mechanical Engineering, Technion
9:30 – 10:00	**Keynote lecture:** **Particle emissions of internal combustion engines and their control** ***David Kittelson***, University of Minnesota, USA
Morning session	**Chairman: Michael Shapiro**, Technion
10:00 – 10:25	**Health effects of combustion generated ultrafine particles (UFP): How UFP can enter the human organism – size matters** **Peter Gehr**, Faculty of Medicine, University of Bern, CH
10:25 – 10:50	**Physical & chemical considerations of Atmospheric Pollution by Ultrafine Particles.** **Andreas Mayer,** VERT Scientific Committee, TTM Niederrohrdorf, CH
10:50 – 11:35	**Coffee break**
Noon session	**Chairman: Jan Czerwinski**, Bern University of Applied Sciences
11:35 – 12:00	**Vision and strategies on reduction of particle emissions from diesel vehicles in Israel** **Amir Zalzberg**, Head of Transportation and Fuel Department, Israel Ministry of Environmental Protection, IL

12:00 – 12:25	**Haifa plan for reducing air pollution from transportation** **Ofer Dressler,** Director, Haifa District Association for Environmental Protection, IL
12:25 – 12:50	**VERT Activities and Experience with DPF Retrofitting** **Lars Larsen,** VERT President, DK
12:50 – 14:00	**Lunch**
Afternoon session	**Chairman: Andreas Mayer**, TTM
14:00 – 14:25	**Effects of diesel particle filters on performance of in-use buses** **Leonid Tartakovsky,** Technion – Israel Institute of Technology, IL
14:25 – 14:50	**Recent Advances in Measurement Technology for Low Particulate Emissions in a Legislative Framework** **Oliver Bischof,** European Sales Manager, TSI Inc., DE
14:50 – 15:15	**Quality Control of Retrofitted DPF-Systems** **Thomas Lutz**, ETH, Swiss Institute of Technology, Zürich, CH
15:15 – 15:45	**Coffee break**
Evening session	**Chairman: Amir Zalzberg**, Israel Ministry of Environmental Protection, IL
15:45 – 16:10	Emission Control in OEM-application (ev. Cummins?) to be confirmed
16:10 – 16:35	**Other pollution sources: nanoparticle emissions from gasoline direct-injection vehicles & NO_x/NO_2 emissions from diesel vehicles** **Jan Czerwinski,** IC-Engines & Exhaust Emissions laboratory, Bern University of Applied Sciences, CH
Public Panel discussion 16:35 – 17:20	**Issues and challenges of particle emissions mitigation – technology, legislation and enforcement aspects** Moderator – **Andreas Mayer**, TTM
Closing remarks 17:20 – 17:25	**Leonid Tartakovsky**, Chairman Organizing Committee

* The Program is subject to changes

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Thank you for your attention!

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