

OFF-ROAD VEHICLE SHOWCASE

Clean Fuels Advisory Group Meeting

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Background

- Diesel off-road mobile equipment
 - 13% of NO_x SCAB 2014 inventory
 - 6% of PM SCAB 2014 inventory
- CARB off-road rule requires turnover
 - Retire, replace, retrofit
- Retrofit may be cheapest option
- No verified products available for off-road equipment
- AQMD, MSRC, and CARB organized the Showcase



Showcase Organization

- AQMD - funding and contract administration (DPF+SCR)
- MSRC - funding and contract administration (DPFs)
- CARB - technology matching and monitoring
- Fleets - operate and maintain off-road equipment
- Manufacturers – install and maintain retrofit devices

Showcase Objectives

- Demonstrate technologies
- Facilitate field tests
- Familiarize fleets
- Accelerate verification



Technology Goals

- Variety of off-road equipment
- Variety of technologies
- Characterize emissions
- Evaluate performance and durability
- Determine conditions suitable for retrofit



Scope

	Planned	Final
SCR Technologies	5	3
Fleets	11	6
Equipment	32	12
Hours accumulated	24,000	11,114*
Funding	\$1.25M	\$0.46M

*4 equipment not completed

Typical SCR/DPF Installation



Typical SCR/DPF Installation



Typical SCR/DPF Installation



Typical SCR/DPF Installation



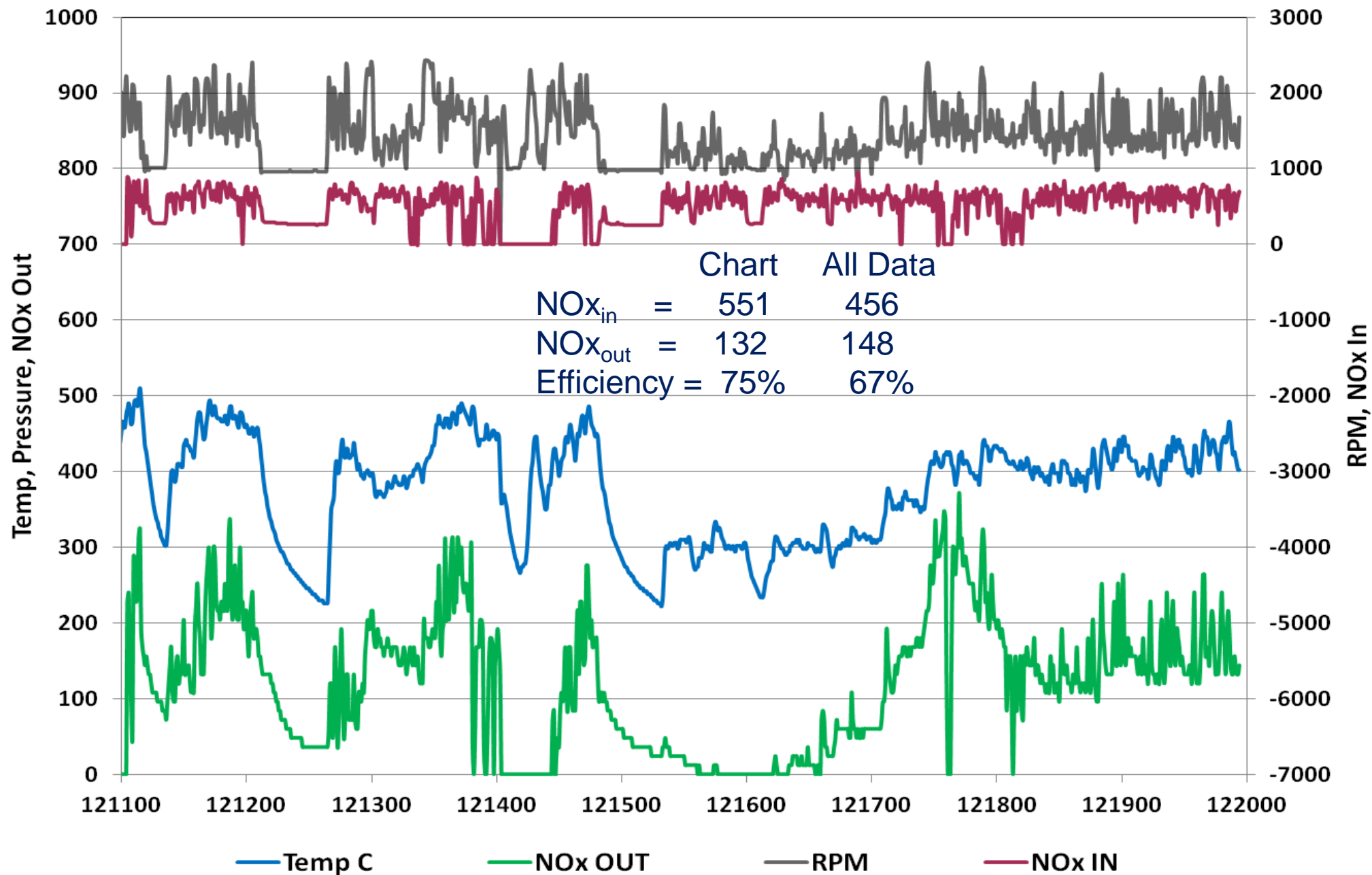
OEM vs SCR/DPF Retrofit



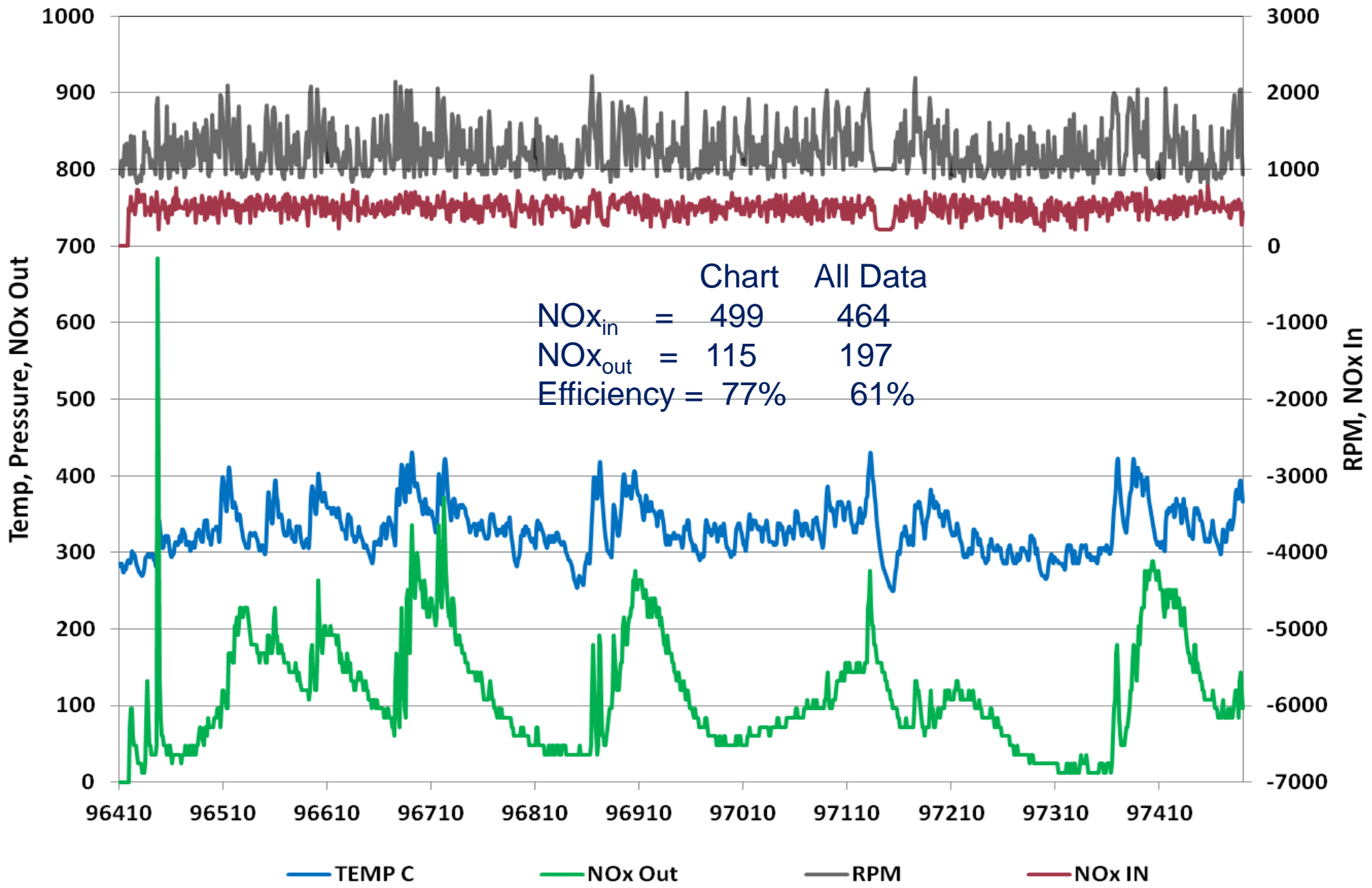
OEM vs SCR/DPF Retrofit



SHOWCASE - SCR System on Tier 1 CAT 966F Loader #6705



SHOWCASE - SCR System on Tier 1 CAT 966F Loader #6783



Results

- NOx (concentrations measured by NOx sensors)
 - NOx efficiency > 90% during some operating modes
 - Average NOx efficiency was 50-70%
- Soot and particulate emissions
 - >85% (wall flow DPFs)
 - Not measured directly
- Ammonia
 - Not measured (slip cats)



Results

- Durability issues

- Hose, wiring, and pipe failures due to vibration
- DPF plugging even with active systems
- Fleets did not provide fault information to technology companies

- Verification

- Applications submitted on 2 technologies; 1 withdrawn
- No SCR systems have yet been verified by CARB (on- or off-road)

Results vs Goals

- Variety of off-road equipment
 - Loaders, Excavators, Rough Terrain Forklifts, Dozers
 - Tier 1 or Tier 2
- Variety of technologies
 - SCR + passive DPF, SCR + active DPF, HC-SCR + active DPF
- Characterize emissions
 - 50-70% reduction of NO_x (using NO_x sensors)
 - No emission measurements (PEMS)

Results vs Goals

- Evaluate performance
 - If no failures, no loss of work capacity and no complaints
 - DPF plugging caused loss of power and complaints
 - SCR system faults caused shutdowns and complaints
- Evaluate durability
 - Early systems not rugged enough for off-road equipment
 - Several systems completed 1000 hours
 - No systems completed warranty period without failures

Results vs Goals

- Determine conditions for satisfactory retrofit
 - Engine in good condition (exclude if Tier 0, smoking, oil in fuel, poor maintenance history)
 - System fits equipment within visibility and safety limits
 - Suitable duty cycle for technology
 - Temperature profile for technology (DPF & SCR)
 - Adequate on-board electrical power for retrofit system

Conclusions

- SCR+DPF retrofit systems can reduce NO_x >50%
- Optimization of retrofit systems should increase effectiveness
- Retrofit systems must be robust for harsh environment
- Not all vehicles can be successfully retrofitted