The Effects of Biodiesel and Other Alternative Diesel Fuels on Emissions from Diesel Vehicles

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Biodiesel Background

- Can be readily substituted for standard diesel
- Can be produced domestically from renewable sources
- Legislative incentives have stimulated increases in biodiesel fuel use
- Growing body of data demonstrating benefit of biodiesel in reducing THC, CO, and PM
  - Some compared to Federal #2 diesel
- Recent CE-CERT biodiesel emissions results for light heavy-duty diesel vehicles were less promising in comparison with a 10% aromatic Calif. diesel

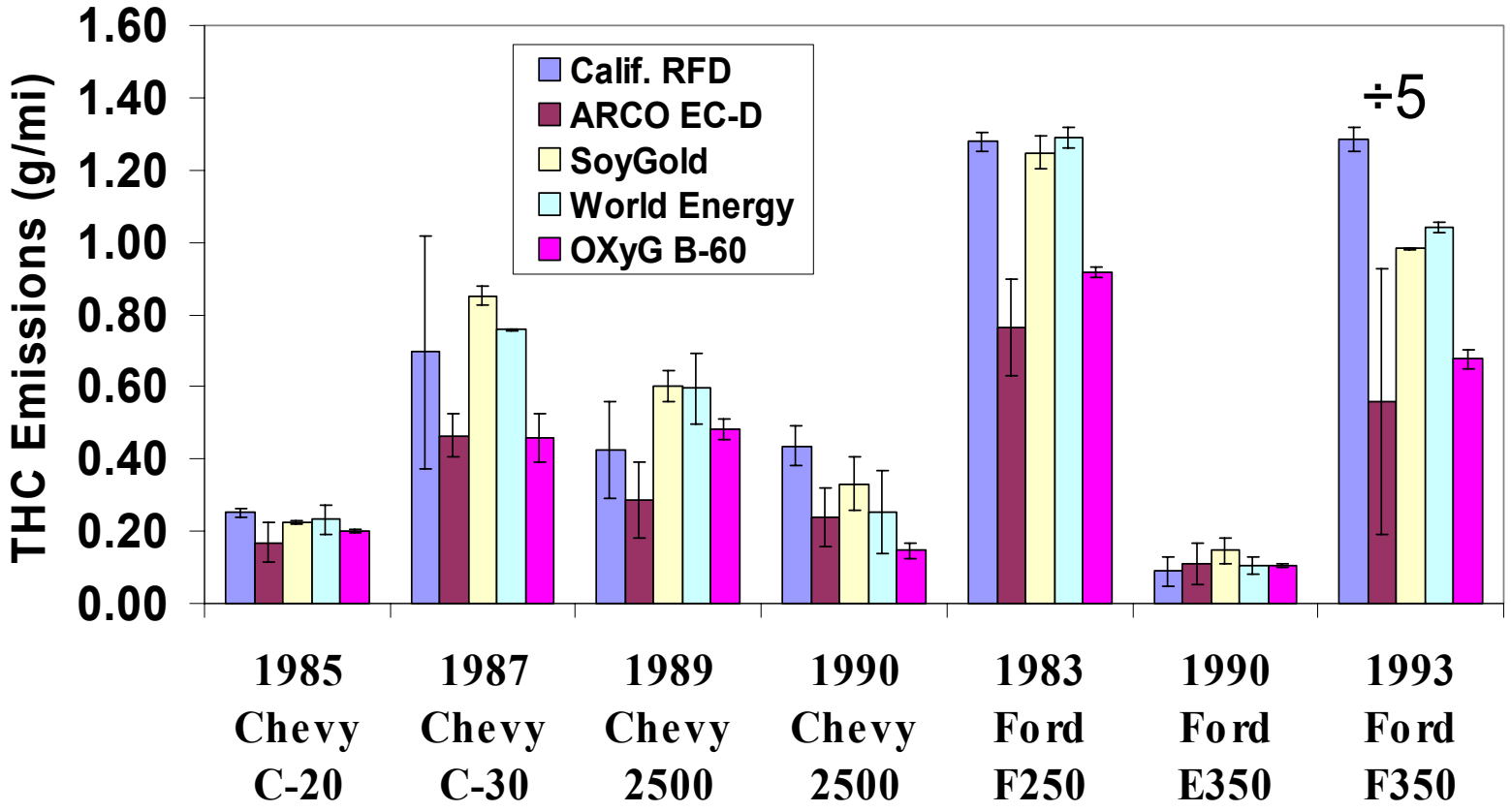
ARCO EC-Diesel Background

- New generation clean diesel fuel
- S < 15 ppm, aromatics < 10%v, cetane near 60
- Demonstration projects: San Diego School District, Cities of LA and Santa Monica, Hertz Equipment, and Ralphs Grocery Co.
- Being used in conjunction with Passive Regenerating Particulate filters for maximum emissions benefits
  - Johnson Matthey and Engelhard
- Low sulfur also enables NO_x catalyst technologies
- ECD-1 more commercial version S < 15 ppm

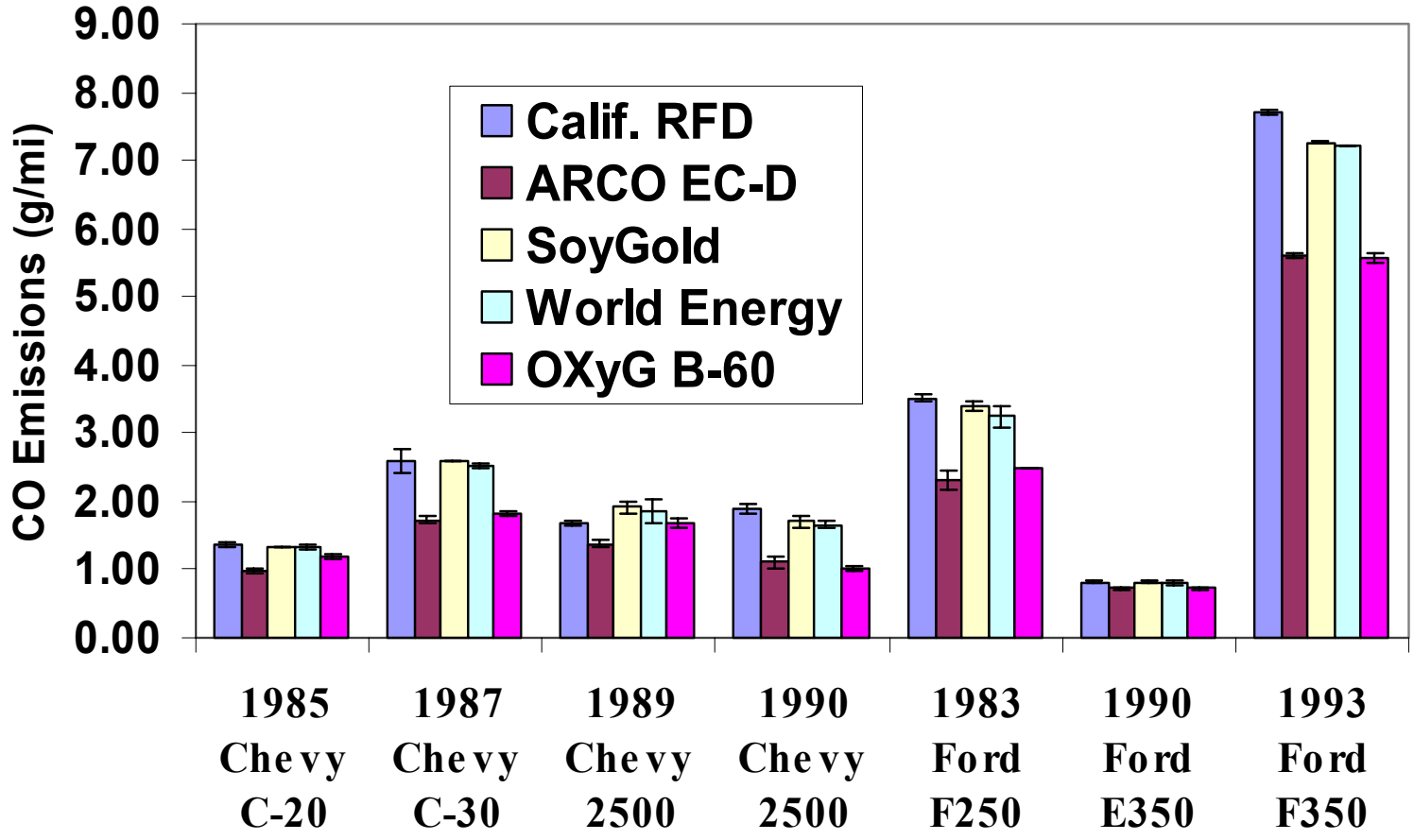
Testing Overview

- **5 fuels**
  - **in-use California diesel**
  - **ARCO's EC-diesel**
  - **20% blend with SoyGold biodiesel (soy-based)**
  - **20% blend with World Energy biodiesel (soy-based)**
  - **20% blend with OXyG B-60 biodiesel (yellow grease-based)**
- **7 Light heavy-duty diesel vehicles**
- **Emissions measured: THC, NO_x, CO, PM**
- **PM analyses: elements, trace metals, OC and EC, ions - 5 vehicles**
- **Semi-volatile and particle PAHs - 5 vehicles**
- **Hydrocarbon speciation - 2 vehicles**
  - **C_1-C_{12} GC bags and C_8-C_{20} tenax sampling**

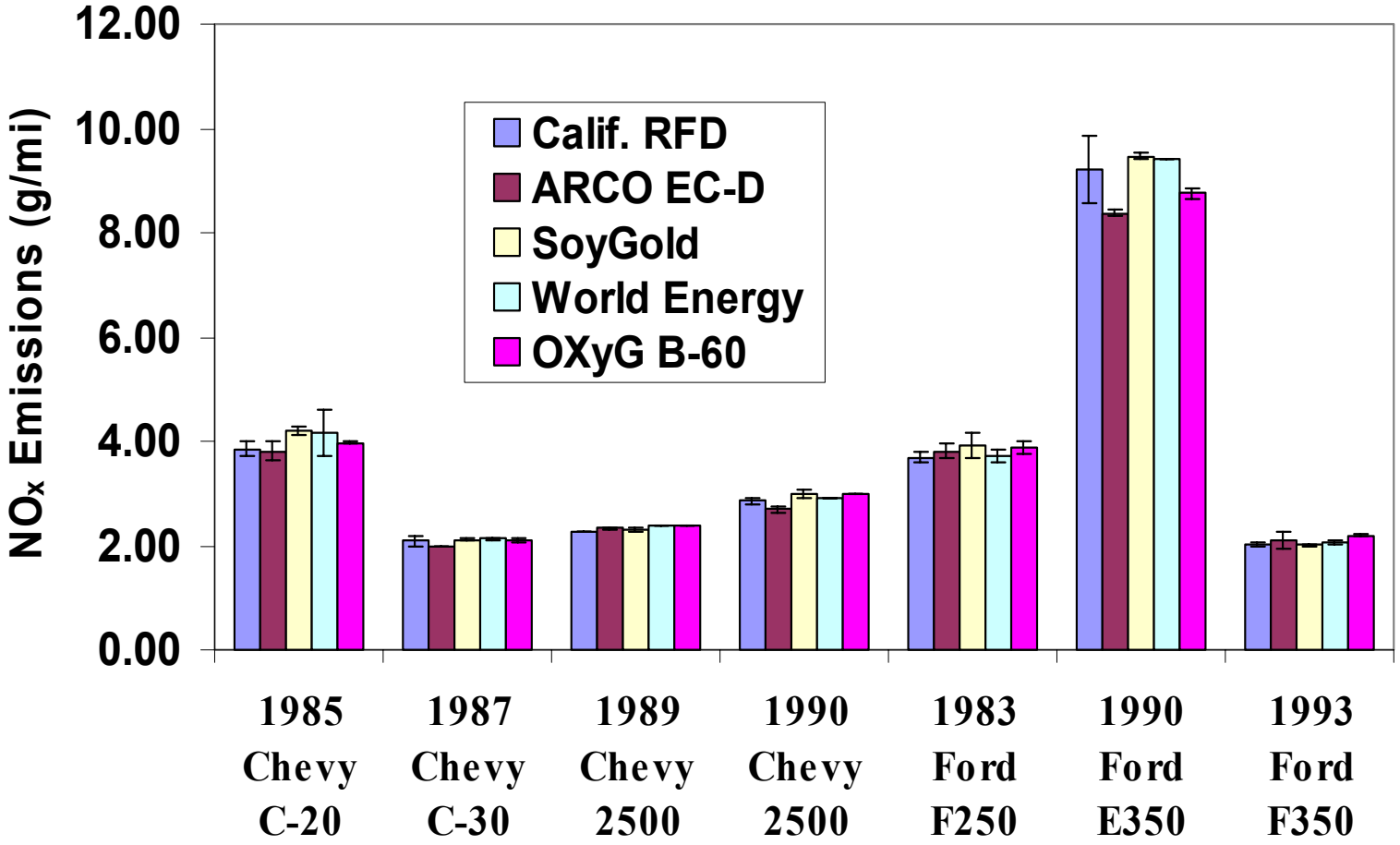
FTP THC Emissions



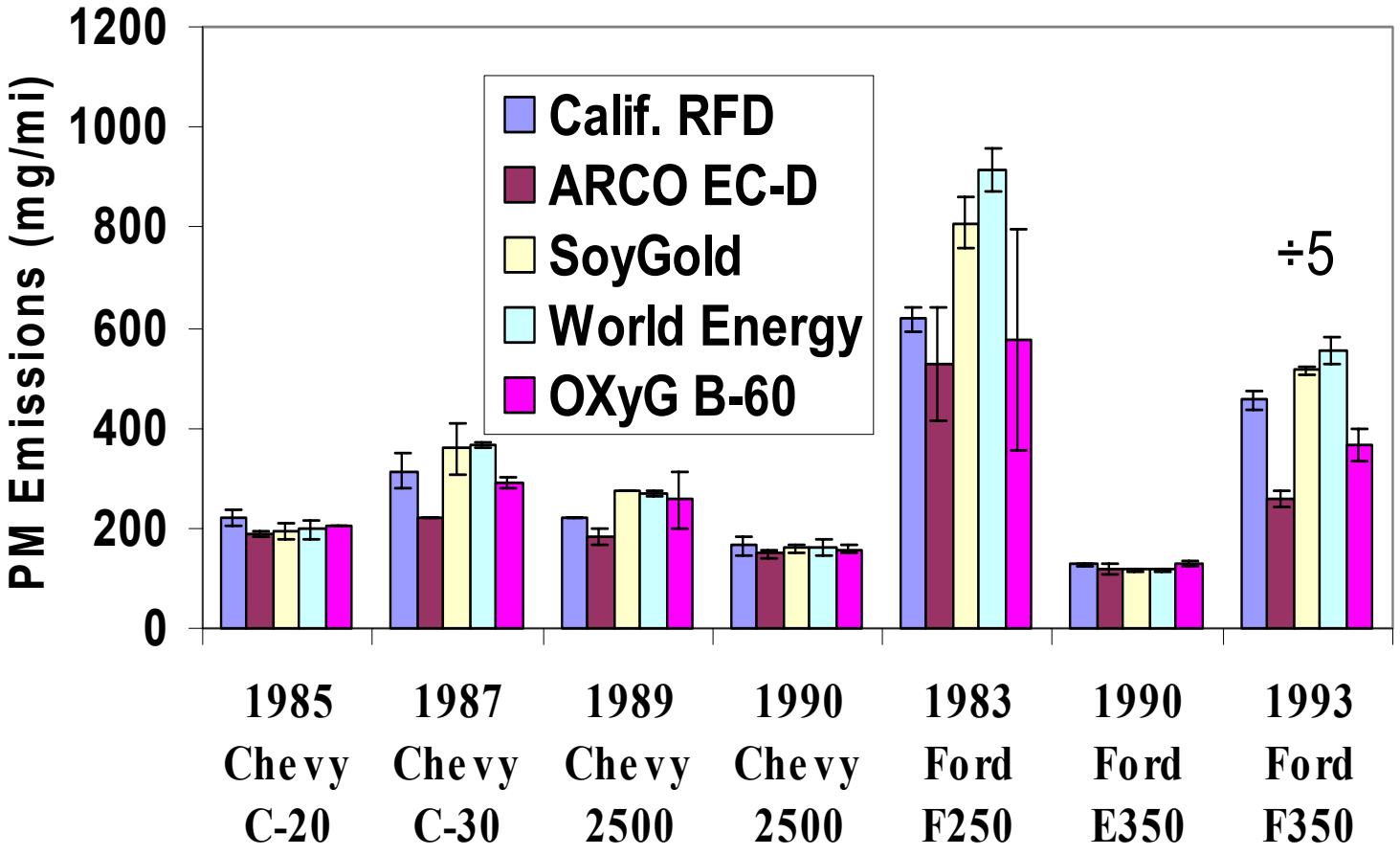
FTP CO Emissions



FTP NO_x Emissions



FTP PM Emissions



Results

- **Overall, THC and CO emissions were similar for RFD and soy-based biodiesels**
- **THC and CO emissions were lower for ARCO EC-diesel and yellow-grease biodiesel compared to RFD**
- **NO_x similar for all fuels and blends**
- **Only ARCO EC-diesel provided significant PM reductions relative to the Cal. RFD**
- **Best performing fuels each have cetane numbers in excess of 60**

Future Studies

- **The role of biodiesel fuels in non-tactical military applications is expanding**
- **Just initiated program sponsored by Department of Defense – Environmental Security Technology Certification Program**
- **Program run through Naval Facilities Engineering Service Center, Port Hueneme**
- **Obtain emissions data for DoD diesel engines fueled with various biodiesel fuels.**
- **Test two yellow-grease and one soybean oil based biodiesel. Results will be compared to ULSD and JP-8.**
- **Evaluate fuel additives.**
- **Focus on obtaining emissions data not currently available in the literature.**
- **Test a minimum of 8 vehicles and 2 stationary engines.**
- **Use EPA-approved duty-cycles and test procedures.**
- **Assist with obtaining approval to use yellow-grease-based biodiesel in GSA vehicles and approved for purchase by DLA (DESC).**

TEST ENGINES AND VEHICLES

- **8 VEHICLES selected from buses, trucks, non-road and tactical vehicles.**

- **3 ENGINES selected by Army Aberdeen Test Center (ATC) for on-road monitoring of emissions using EPA Rover system (no PM).**

- **OFF-ROAD VEHICLE tested cooperatively with SERDP off-road project if SERDP funds permit.**

TEST CYCLE/FUEL MATRIX

Item No.	Test Location	Application Description	Owner/ Operator	Engine Make/Model	Model Year	Fuel Type/ Fuel Additive	Test Cycle/Load	Regulated Emissions	PM Charact-erization
1	CAVTC	Thomas Bus License No. G3200583	Camp Pendleton	CAT 3126, 330 HP	2000 Engine 1999	B20(soy) ULSD	CBD, NYBC, UDDS	All	No
	On-Road						On-Road	CO, HC, NOx	No
2	CE-CERT	HMMWV (Hummer)	Nellis AFB	GM 6.5L Model A2	TBD	ULSD JP-8 B20(YGA) B50(YGA) B70(YGA) B100(YGA) B20(soy) B100(YGA) + Additive 1 B100(YGA) + Additive2	FTP, US06	All	JP-8 B20(YGA) B100(YGA) FTP Modes Only
3	Naval Base East Coast	Aircraft Tow Vehicle				JP-5 B20(YGA)	In-Use, 8-Mode	CO, HC, NOx	No
4	CE-CERT	Stake Truck, Ford F-series		Cummins 5.9L - 175	1998 Engine 1997	ULSD B20(YGA) B20(soy)	13-mode	All	No

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Item No.	Test Location	Application Description	Owner/ Operator	Engine Make/Model	Model Year	Fuel Type/ Fuel Additive	Test Cycle/Load	Regulated Emissions	PM Charact-erization
5	CE-CERT	Tractor, Ford L-9000	Port Hueneme	Caterpillar 102-9557	1994	ULSD B20(YGA) B20(YGB)	CARB, UDDS On-Road	All	ULSD B20(YGA) CARB Cycle only
6	Aberdeen	Fork lift	Aberdeen	Perkins YPKXL03 OUA1	TBD	ULSD B20(soy)	In-use	HC, CO, NO_x	No
7	CE-CERT	Ford F-350 Pick-up	Nellis AFB		2003	ULSD B20 (soy)	FTP US06	All	No
8	CE-CERT	New Bus	Camp Pendleton		2003	ULSD B20(YGA) B20(soy)	13-Mode	All	ULSD B20(soy) One Mode only
9	CE-CERT	Stationary Back-up generator	Nellis AFB	TBD	TBD	ULSD B100(YGA) B20(YGA)	5-Mode	All	ULSD B100(YGA) 75% Power Mode Only
10	CE-CERT	Army 60 KW Tactical Generator	Fort Irwin	TBD	TBD	JP-8 B20(YGA)	5-Mode	All	No

The End

- **Funding**
  - **South Coast Air Quality Management District**
  - **Southern States Power Company**
  - **Department of Defense - Environmental Security Technology Certification Program**
  - **Department of Defense – Strategic Environmental Research and Development Program**
- **Papers**
  - **Durbin and Norbeck. 2002. *Environ. Sci. & Technol.*, vol. 36, 1686-1691.**
  - **Durbin, Collins, Norbeck and Smith. 2000. *Environ. Sci. & Technol.*, 34, 349.**
  - **Durbin, Zhu and Norbeck. 2003. *Atmos. Environ.*, vol. 37, 2105-2116.**