

PUBLIC FLEET SUPERVISORS ASSOCIATION



Biodiesel Fleet Implementation

Public Fleet Supervisors Association
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**PEOPLES
FUEL
COOPERATIVE**

BioSolar Group

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Diesel Engines Pollute the Air

- Diesel exhaust is toxic and carcinogenic
- 20,000 Americans die each year from lung disease from diesel exhaust particulates
- 400,000 Americans suffer from asthma and lung disease related to diesel exhaust; problem acute in West Oakland, BayView
- Diesel exhaust is even more of a problem in congested cities with older diesels
- Sulfur oxides in exhaust lead to acid rain
- Environmental Justice implications everywhere...



Diesel Engines Here for Long Term



- Diesel engines are still one of the most reliable, energy efficient & powerful propulsion systems; long engine life
- New diesel engine technologies & regulations will reduce exhaust emissions dramatically; plus new after-treatment
- Diesel-Electric hybrids do help reduce impact; electric buses have decades of success on the steep hills of SF
- CNG buses in widespread use but problems persist
- However, the diesel fuel remains toxic to workers & the public as volatile flammable liquid; threat to groundwater
- 2/3 of our petroleum is imported now; jobs/trade balance
- Diesel fuel production at refineries in the western states cannot keep up with the demand – opportunity for biofuel
- The long-term sustainability of non-renewable petroleum fuel is a real issue for the US and developing countries
- The rising price of diesel fuel is promoting alternative fuel and the need to stabilize price, without reference to existing fuels

Enter Biodiesel

- A diesel displacement fuel made from plant oils, animal tallow or recycled cooking oils through a chemical process to remove glycerin and yield methyl or ethyl esters optimized for combustion
- Renewable, agriculturally produced alternative fuel to displace imported petroleum; similar price
- Biodiesel itself is non-toxic, non-flammable and non-volatile, making it safer to handle & store
- Biodiesel contains little sulfur and no aromatics
- When blended with petroleum diesel or burned as a pure fuel, biodiesel can significantly reduce diesel engine exhaust PM, CO, HC, S & toxics

Biodiesel B100 Properties

- Ultra low Sulfur (typically < 8 ppm)
- No Aromatics (& low PAH emission)
- High Cetane (> 52 , improved ignition)
- High Lubricity (even 1% restores ULSD lubricity)
- Biodegradable (soil, marine, aquatic ecosystems)
- Non-Toxic (but harmful to aquatic habitats)
- Non-volatile (< 2 mm Hg vapor pressure)
- Non-flammable (Flash Point > 300 Deg F)
- Solvent action of fuel on seals, gaskets, tank liners
- Must meet ASTM 6751 specifications or problems result with precipitations, contaminants & failures

Important Biodiesel Parameters

- Complete Reaction to $>97\%$ conversion to avoid partially reacted glycerides remaining in fuel
- Removal of Glycerin (gums engine valves)
- Removal of Catalyst (caustic hydroxide)
- Removal of Alcohol (flash point issues)
- Absence of Free Fatty Acids or Soaps

- Should be insured via ASTM D 6751
[New revisions coming including oxidation stability]

Biodiesel

Specification ASTM 6751

<u>Property</u>	<u>ASTM Method</u>	<u>Limits</u>	<u>Units</u>
Flash Point	93	130 min.	degree C
Water & Sediment	2709	0.05 max.	vol. %
Carbon Residue (100% sample)	4530	0.05 max.	wt. %
Sulfated Ash	874	0.02 max.	wt. %
Kin. Viscosity, 40C	445	1.9 - 6.0	mm ² /sec.
Sulfur	5453	0.05 max.	wt. %
Cetane	613	47 min.	
Cloud Point	2500	By Customer	degree C
Copper Corrosion	130	No. 3 max.	
Acid Number	664	0.80 max.	mg KOH/g
Free Glycerin	6854	0.020	wt. %
Total Glycerin	6854	0.240	wt. %
Phosphorous	4951	10 max	ppm
Distillation, T90 AET	1160	360 max	degree C

ASTM D6751 Highlights

- Acid number – for degrading, oxidized fuel
- Flashpoint – for residual methanol
- Water & sediment – fuel fouling, deposits
- Sulfated ash – for residual catalyst
- Total glycerin – for incomplete conversion, detects residual mono, di and tri glycerides
- Free glycerin – inadequate fuel washing
- New ASTM updates will include specs for Na^+ , K^+ and oxidation stability

Biodiesel is for ALL Diesel Engines

- No engine or vehicle conversion
- For blends of 20% or less just good fueling practices are needed
- For high blends up to 100% a second level of watchfulness will be needed to identify potentially non-compatible parts, fuel stability and quality

still no engine conversion

How can Biodiesel be used?

- In low levels with petrodiesel ULSD (B2 - B5) to restore the lubricity after hydrotreatment that removes the sulfur and lubricating compounds
- As a blending stock with regular diesel (B20)
- As a pure fuel (“Neat” or B100) Common among biodiesel enthusiasts and is increasingly gaining use in fleets and in target equipment.



Biodiesel Performance Properties



**BIODIESEL RETURNS
ENVIRONMENTAL BENEFITS
WITHOUT
SACRIFICING OPERATING
PERFORMANCE**

- B20 has Similar Performance to Petrodiesel:
 - Torque
 - Horsepower 98%
 - Mileage -2%
 - Range – 2%
- BTU Content
 - (120,000 BTU/gal for B100 vs. 126,000 for diesel fuel)
- Cold Flow
 - (5 °F for soy-based B20)

Ecology Center - Smoke Opacity Testing of Biodiesel Exhaust

Opacity Trials April and November 2000 by Mike Robertson,
Professor of Transportation Technology, College of Alameda



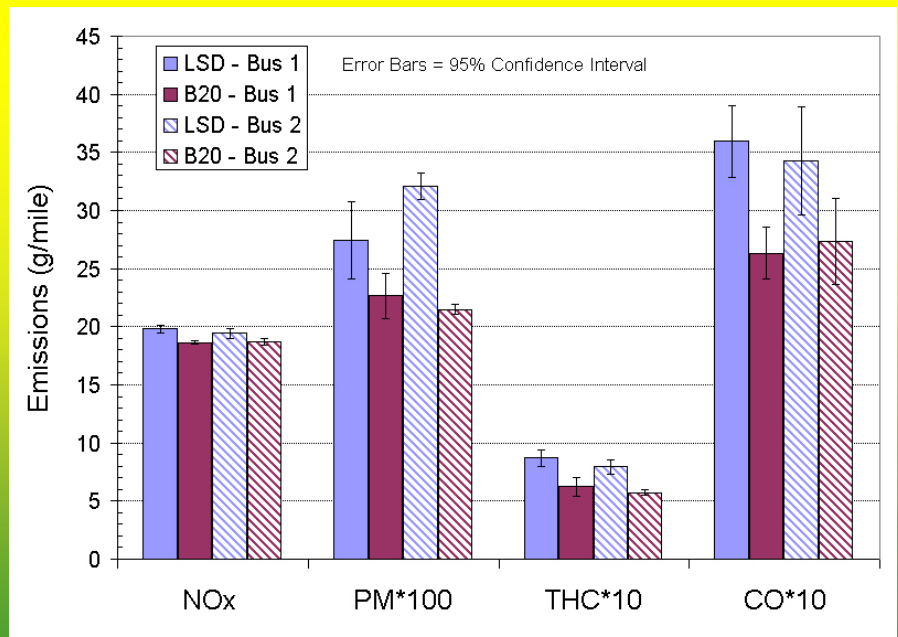
B-20 reduced opacity by 12-15%; B-100 reduced by 75-85%

Cleaner Emissions
per Early DOE-NREL & EPA
Research Summaries

Emission Type	B100	B20
Unburned Hydrocarbons (HC)	-56-67%	-11-20%
Carbon Monoxide (CO)	-43-48%	-12-18%
Particulate Matter (PM)	-47-55%	-12%
Air Toxics & Mutagenicity	-60-90%	-12-20%
Oxides of Nitrogen (NO _x) (old EPA Draft Report 2002)	+6-10%	+1.2-2%

Biodiesel Bus Chassis Dynamometer Testing

- NREL research by Dr. R. McCormick
- B20 vs. conventional diesel fuel
- 2 in-use buses tested (40,000 lb GVWR)
- City Suburban Heavy Vehicle Cycle (CSHVC) at 35,000 lb inertia
- Cummins ISM 2000 Engine
- Fuel economy reduction $\approx 3\%$
- Emission reductions (g/mile basis)
 - **PM $\approx 18\%$**
 - **HC $\approx 29\%$**
 - **CO $\approx 24\%$**
 - **NO_x $\approx 4\%$**
 - **statistical confidence > 99%**



Using Biodiesel Lowers Greenhouse Gas Emissions of our Vehicles



- Closed Carbon Cycle: CO₂ of engine emission taken up by oil crops in following season
- 80% life cycle reduction in CO₂ from exhaust to crop
- Energy Balance 3.24 to 1 for soy, 7:1 for recycled feedstock fuel
- Compression Ignition Engine is 30% to 40% More Efficient Than Gasoline engine (ask Europeans)
- Al Gore's "Inconvenient Truth"
[See the movie!]

Low Blends: 2-5% Biodiesel

- Potentially an enormous market as low percentage lubricity enhancer in new ultra-low sulfur diesel (ULSD) June/Oct 2006
- E.U., U.S. (MN, WA), & Brazil have new mandates for use of low biodiesel blends
- “Transparent” to fleets and public
- Easy to implement once biodiesel is available and production meets demand
- France already at 5% (15% in cities)
- But - minimal ‘street level’ health benefits

B20 “U.S. Standard Blend”

- Certified as EPA Alternative Fuel: allows increased use by military & government
- Modest environmental & health benefits
- Noticeable improvements in smoke & odor
- Slight NO_x increases depending on engine, feed stock & additives used
- “Drop in” fuel: easy substitute for diesel
- Federal and US Military non-combat fleets
- Federal tax credit incentives boost sales

Emerging US Markets for B20

- School buses, transit buses, public works
- Municipalities with strong environmental public support to clean up older vehicles
- Older transit fleets (nearly 130 old diesel buses in SF are still 2-stroke engines)
- New Diesel-Electric buses will be replacing older buses in SF; first one here
- Standby generators and heavy equipment

Higher Blends and B100

- B50: “California” 50% blend in Ultra Low Sulfur Diesel plus additives to achieve at least a 25% reduction in PM, carcinogens and air toxics without a significant NO_x increase
- B100: “Neat” biodiesel for school buses and urban construction equipment to displace petroleum entirely and maximize environmental + health benefits of pure agricultural “liquid solar energy”

B100 School Buses

Berkeley Unified School District

“Think
Globally,
Act
Locally”
... Teach
Children



2 Years
on B100
City of
Berkeley

Protecting our
Children – our
most pressing
mission

2005 School Bus Studies

UCB/UCLA and CARB

- Inside school bus, children are exposed to 70% more PM than if they were riding in a car following the same bus in city traffic
- Univ. Washington study of asthmatic children riding in school buses vs. riding in cars to school
- Engineering changes in buses; sealed crankcase oil system; after-treatment of exhaust
- Avoid cueing of buses; minimize idling
- Reducing PM by even 18% with B20 would be a significant and an immediate benefit to children; consider B50 or B100

Particle Traps and Oxidative Catalysts

- Reduce PM, CO and HC by 50-90%
- Require ULSD; on most new diesel buses
- Retrofitted to most diesel buses, but not to 2-stroke and some older engines
- Biodiesel is compatible with most devices; CARB certified traps/filters in CA for B20
- B20 increases PM reduction by 62% in oxidative catalysts (NREL study 2005)
- B20 extends longevity, less maintenance

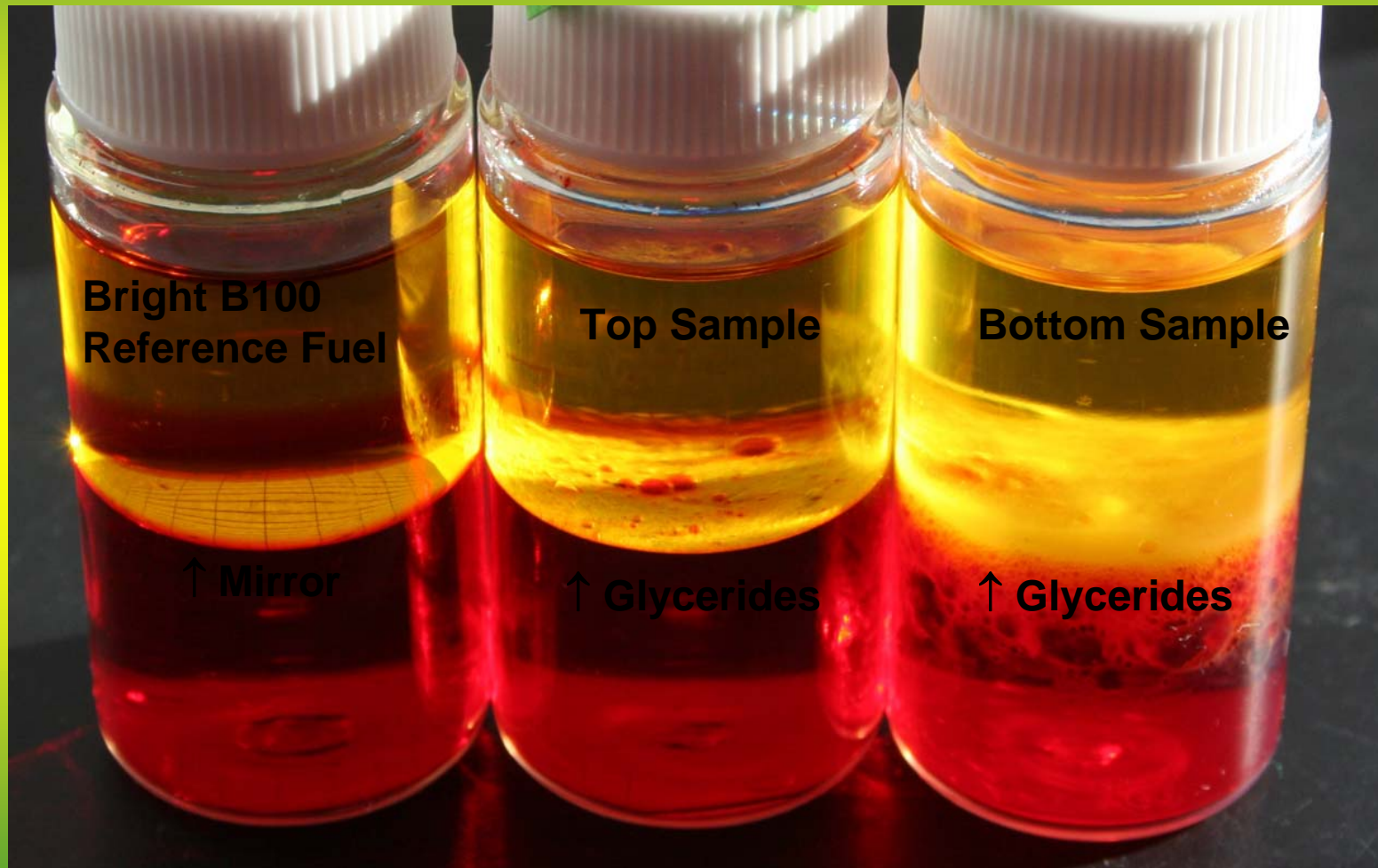
Fuel Quality Control: A Mindset at 3 Levels from Plant to Fleet

- Production at the plant: feed stock to fuel
 - BQ 9000 or other rigorous QA program
 - ASTM 6751 specs and certifications
 - Certificate of Analysis for each batch of fuel
- Distribution, storage and handling
 - BQ 9000 or other rigorous QA program
 - Protocols, documentation, monitoring
- Fleet operator storage, dispensing & use
 - Protocols, documentation, monitoring

Common Culprits for Problems

- Most problems seen with B100, not B20, but water & sediment are bad for all fuels
- Residual catalyst & methanol degrade seals & gaskets— fuel injection pumps
- Residual glycerides, soaps, long chain saturated esters, unreacted fats leave deposits, foul engine, and degrade crankcase oil
- Contaminating fats can also clog filters
- Bacterial growth in tanks clog filters and deteriorates the fuel; same with aged fuel

Detecting near-spec and off-spec fuel : top vs. bottom of rail car of B100



0.76% Monoglycerides, 0.38% Diglycerides, 0.62% Triglycerides
0.31% Total Glycerin with <0.005% Free Glycerin in composite

Aging Oxidized B100 Examples Relative to Fresh Bright Reference



“Smoke ‘n Mirrors” or a reliable diagnostic tool for the industry?

**pHLip
Test**



Preparing Fleets for B20

- Audit and inspect condition of fuel storage tanks: professionally clean and certify tank
- Install moisture/particle traps on tank vents
- Protocols for avoiding accidental water intrusion or contamination during fuel fills
- Use biocides to reduce bacterial growth
- Regularly take samples off bottom of tank, confirm no water/sediment; use field test kits to confirm quality of delivered B100

Additional Precautions for Diesel Fleets

- On-board fuel tank checks: drain and test for sediment, water or signs of infection
- Check for incompatible fuel tank spray-on liner in some vehicles (e.g., PG&E, WA)
- Check OEM for warranty updates on newer engines before using B20 mention the Mag Feurgeson Act
- Note that fuel contract with distributor holds them responsible for fuel quality and storage/delivery/sampling protocols
- City fuel storage tanks have to be well maintained, free of water and sediment, tested

First Steps

- Education
- Call engine manufactures and fuel suppliers
- Clean tanks at the yard
 - Assign cost
 - Define cleaning company
- Blend delivered (recommended) vs. blend on site (two tank solution)

Second Steps

- Train Fleet Mechanics
 - Fuel Filters
 - Housing/swap out of rubber parts
- Pilot now!
 - Pilot now to prepare for tomorrow
 - Keep accurate records
 - Expect initial headaches
- Move toward fleet wide application
 - Train Drivers
 - 866-BIODIESEL Hotline is staffed 24/7

Technical Recommendations for B20 Fleet Use Based on Existing Data **B20 Fleet Evaluation Team: June 2005**

Biodiesel is the pure, or 100 percent, biodiesel fuel. It is referred to as B100 or "neat" biodiesel.

A biodiesel blend is pure biodiesel blended with petrodiesel. Biodiesel blends are referred to as BXX. The XX indicates the amount of biodiesel in the blend (i.e., a B20 blend is 20 percent by volume biodiesel and 80 percent by volume petrodiesel).

Ensure the biodiesel meets the ASTM specification for pure biodiesel (ASTM D 6751) before blending with petrodiesel. Purchase biodiesel and biodiesel blends only from companies that have been registered under the BQ-9000 fuel quality program.

Ensure the B20 blend meets properties for ASTM D 975, Standard Specification for Diesel Fuel Oils or the ASTM specification for B20 once it is approved.

Ensure your B20 supplier provides a homogenous product.

Avoid long term storage of B20 to prevent degradation. Biodiesel should be used within six months.

Prior to transitioning to B20, it is recommended that tanks be cleaned and free from sediment and water. Check for water and drain regularly if needed. Monitor for microbial growth and treat with biocides as recommended by the biocide manufacturer. See the NREL Biodiesel Storage and Handling Guidelines for further information <http://www.nrel.gov/vehiclesandfuels/nbf/pdfs/tp36182.pdf>.

Fuel filters on the vehicles and in the delivery system may need to be changed more frequently upon initial B20 use. Biodiesel and biodiesel blends have excellent cleaning properties. The use of B20 can dissolve sediments in the fuel system and result in the need to change filters more frequently when first using biodiesel until the whole system has been cleaned of the deposits left by the petrodiesel.

Be aware of B20's cold weather properties and take appropriate precautions. When operating in winter climates, use winter blended diesel fuel. If B20 is to be used in winter months, make sure the B20 cloud point is adequate for the geographical region and time of year the fuel will be used.

Perform regularly scheduled maintenance as dictated by the engine operation and maintenance manual. If using B20 in seasonal operations where fuel is not used within 6 months, consider storage enhancing additives or flushing with diesel fuel prior to storage.

These recommendations on use of B20 are preliminary and are not provided to extend or supplant warranty limitation provided by an individual engine or equipment supplier. Use of B20 blends is solely at the discretion and risk of the customer and any harm effect caused by the use of B20 are not the responsibility of the engine or equipment maker.

B20 Fleet Evaluation Team Members

Cummins, John Deere, International Truck and Engine Corp, DaimlerChrysler, Caterpillar, Ford Motor Company, General Motors, Department of Defense, Siemens, Delphi Automotive Systems, Volkswagen, Engine Manufacturers Association, MARC-IV Consulting, ASG Renaissance, Bosch, FleetGuard, NREL, BMW of North America, Mack Trucks, Stanadyne Automotive Corporation, Suncor, CNH Global, Parker-Hannifin-Racor Division, and DENSO International America.



2004

Biomass

BIODIESEL

Handling and Use Guidelines



DOE/GO-102004-1999
Revised November 2004



U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable



www.biodiesel.org link

Cold Flow



http://nbb.org/resources/reportsdatabase/reports/gen/20050728_Gen-354.pdf

Regulatory Status of Biodiesel in California

- Despite historical roots here, Biodiesel is NOT yet accepted as an Alternative Fuel by the State
- Despite Federal Status and EPA Act Credits for Gov't Fleets, it took legislation (SB975) to allow Gov't fleets to continue using B20 in CA
- CA Dept. Food & Ag, Div. Measurement Standards allows biodiesel to be sold as an “additive” up to 20% (1997) or as B100 sold at central fueling facilities to known “fleets”
- CARB still has many issues, including NO_x and need for much more extensive testing in CA

Biodiesel History in SF Bay Area

- 1992-94: “SunRider” B100 powered boat out of Pier 39 & cruised 35,000 miles around the world back to SF!
- 1993-99: Marine Biodiesel on SF Bay; Marine Biodiesel League 1996; 1997: NREL Grant for SF Bay Biodiesel
- 1999: UC Davis became the first B20 fleet in CA
- 2000: Ecology Center Berkeley became first B100 fleet
- 2001: First B100 Station on continent opened at Olympian on 3rd St., SF (World Energy & CytoCulture)
- 2003-4: More stations open - BioFuel Oasis, SF Biodiesel Coop with People’s Fuel, San Jose, Ukiah, Santa Rosa, Monterey, Laytonville (now 700 across US)
- 2003-04: City of Berkeley operates all diesels on B100
- 2006: SF Mayor G. Newsom’s Executive Order for B20
- 2007: SF works on vertical integration from Urban Resource to transportation fuel

Mayor Gavin Newsom's Executive Order for B20 Mandate

- All diesel-using departments shall begin using a B20 biodiesel blend as soon as practicable in all diesel vehicles and other diesel equipment, with the following incremental goals in each department's use of B20:
 - 25% of diesel vehicles and other equipment by December 31, 2006;
 - 50% by July 1, 2007; and
 - 100% by December 31, 2007.
- All diesel-using departments shall then pursue further increases in the use of biodiesel through the use of greater-than 20% blends and/or neat biodiesel (B100)
- Currently the Largest City coordinating Biodiesel pilot programs through all fleet managers at once

Implementation of B20 City-Wide

- Phase in use of B20, starting with survey of diesel engine inventory in Departments
- SF Fire Department started B20 trials May
- SFO shuttle buses about to purchase B20
- SF Zoo already started
- SF Muni will conduct “performance tests” this winter, then phase in B20
- City wide use of B20 by end of 2007:
- 8 million gallons of blend, 1.6 million gal B100

SF Departmental B20 Fleets

- SF Muni: 130 old 2 stroke diesel buses, hundreds of more modern buses retrofitted with particle traps. One new diesel-electric hybrid bus (3 major fueling locations around the City)
- SF Department of Public Works: 100s of various trucks, street sweepers, heavy equipment (central shops fuel tanks)
- SF Fire Department: city wide fire trucks and diesel engines, small fuel tanks at stations
- SFO Shuttle buses, SF Zoo, others

Other City of SF Biodiesel Projects

- Cal Trans EJ grant to establish inventory of ALL diesel exhaust in Bayview Hunters Point area, mitigate with B20 to replace diesel and PT's
- Green Depot EJ grant to set up biodiesel filling stations & distribution in SF, esp. Bayview area
- City College grant for biodiesel training program for low income neighborhoods
- City College EPA Grant for biodiesel training manuals for end users, fleet managers and fuel distributors
- Fueling Cooperatives providing high blend expertise and quality programs for access and quality assurance
- SFPUC initiating a vegetable oil recycling program to target source separation in kitchens to reduce FOG load while stabilizing City's fuel prices. Potentially 6 million gallons/yr

Pour in Solution

- Seek interest within your fleet and community
- Find funding for tank cleaning, pilot program, expansion to fleet wide use while increasing blend percentages
- Survey the industry for high quality fuel availability and work with suppliers and fuel contract managers
- Speak with other fleet managers for relevant experience
- Consult with industry experts to ensure you have the latest information you need to run a successful biodiesel pilot program



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