DRAFT – DO NOT CITE OR QUOTE. FOR DISCUSSION PURPOSES ONLY.
TRU Diesel PM Control Technology Option Matrix[1] 2-14-02

Technology	PM/Nox Control Efficiency	Demonstrated in TRUs?	Cost[2]	Verified with ARB for TRU?	Pros	Cons	Proposed Timing for New TRUs[3]	Proposed Timing for In-Use Retrofits[4]
Electric standby	100% when in use at facility.	Yes	Truck: $350-$600 Trailer: $2000-$2600, plus facility infrastructure.	NA	Dramatic reductions in health risk near facilities. Option now available for truck models and some trailer models.	No health risk reductions along roadways, current retrofit costs high.	Phase 1	
Synthetic Diesel or Fischer-Tropsch (GTL) Diesel	30% PM; 4-11% NOx	No	$0.15 to $0.25 per gal more than CARB diesel.	No	Available now. 0-5% sulfur, no aromatics in fuel – very low PAH emissions, high cetane # - lower NOx.	2-3% fuel penalty, 2-4% torque loss, Viton hoses and seals required for pre-1993 engines.	Phase 1	Phase 2.
Biodiesel (100%)	25-50% PM; 12% NOx increase (can be reduced with additives and fuel system adjustments).	No, but 200 hour tests on Yanmar 3-cylinder DI engine passed EMA tests with no problems.	$2.00/gal plus taxes; fueling infrastructure costs.	No	No engine modifications necessary for post-1993; compared to diesel: higher Cetane, better lubricity, better energy balance, no sulfur, reduces greenhouse gas emissions, substantial reductions in PAH emissions.	Cost, 7% lower torque, higher BSFC, replace hoses and seals with Viton required for pre-1993, shorter shelf life due to microbe growth (controlled with additives), higher pour point affects cold weather performance.	Phase 1	Phase 2

[1] Trade names mentioned herein do not imply ARB endorsement.

[2] Costs shown are based on best information now available. Annualized cost and cost-effectiveness will be analyzed as technologies are demonstrated.

[3] Phases indicated have the following meaning:
Phase 1 – This option will be evaluated for possible inclusion in the first phase of regulation. Board adoption 2002, proposed compliance date 2004.
Phase 2 – This option will be evaluated for possible inclusion in the second phase of regulation. Board adoption in 2004, proposed compliance date 2006.
Phase 3 – This option will be evaluated for possible inclusion in the third phase of regulation - special engine category emission standards that would apply to all new TRU engines. Board adoption - 2006. Proposed compliance date - 2009.
In addition, control technology readiness for TRU application in Phase 2 may be evaluated further during the proposed Technology Review in late 2003.

[4] See Footnote 3.

DRAFT – DO NOT CITE OR QUOTE. FOR DISCUSSION PURPOSES ONLY.

Technology	PM/Nox Control Efficiency	Demonstrated in TRUs?	Cost	Verified with ARB for TRU?	Pros	Cons	Timing for New TRUs	Timing for In-Use Retrofits
CNG		Yes		NA	Available now. Reduces NOx and PM simultaneously.	Significant compliance costs for >25 hp LSI[5] Regulation, gaseous fuel supply, storage system, compression station, periodic tank inspections.	Phase 1	Phase 2
LPG		Under development		NA	Reduces NOx and PM simultaneously.	Same as CNG.	Phase 1	Phase 2
Gasoline				NA	Reduces NOx & PM simultaneously	LSI issue.	Phase 1	
Water emulsions (Lubrizol/PuriNox)	63% PM (74% with DOC); 14% NOx	No	15% higher cost than conventional diesel.	Yes	Available now, no engine modifications necessary, reduces NOx and PM simultaneously, emission reduction credits allowed.	Requires periodic agitation to extend shelf life, higher BSFC, up to 15% increased operating costs.		Phase 2.
Active Particle Traps – electric regeneration (Rypos Trap)	70-90% PM	No	Unknown	No	Independent of exhaust temp, sulfur level tolerant, low back pressure.	Durability unknown, cost unknown, may require generator upgrade.		Phase 2
Bi-fuel CNG Fumigation[6]	40-85% PM; 20-80% NOx	Yes	Unit conversion <$400, but fuel system cost is $6K to $8K.	No	Lower fuel costs (depends on current cost of fuels), reduced engine oil change frequency.	Gaseous fuel supply & storage system, compression station, periodic tank inspections, added fuel tank weight cuts into payload.		Phase 2.

[5] LSI stands for Large Spark-Ignited Engine.

[6] Data shown as reported by ThermoKing. ARB has not reviewed detailed data.

Technology	PM/Nox Control Efficiency	Demonstrated in TRUs?	Cost	Verified with ARB for TRU?	Pros	Cons	Timing for New TRUs	Timing for In-Use Retrofits
Fuel-borne Catalysts (FBC)	50-60% PM; 34-40% NOx	No	On-board dosing system: $500-$1,000 (factory), $0 to $3000 for field retrofit, + $0.03 to $0.10/gal.	Rhodia and Lubrizol in process.	Improves fuel economy 10-20%, can be used in conjunction with a particle trap to enhance emission reduction.	Difficult to assure FBC use, 5 year shelf life, if properly packaged to eliminate light exposure.		Phase 2
Passive Particle Traps (catalyzed diesel particulate filters - CDPFs)	85-95% PM	Yes, but some issues with first prototype.	MECA[7] est. $3,300 to $5,000 initial cost[8], $167 installation, $156 annual maintenance.	No	Automatic regeneration if exhaust achieves regeneration temperature for necessary duration.	Match may be incompatible due to low exhaust temperatures; back pressure affects fuel economy, engine performance & life; & annual maintenance.		Phase 2
Diesel Oxidation Catalysts	15-30% PM	R&D only	MECA est. $400 - $600, $167 installation, $64 - $712 annual maintenance.	No	Commercially available, installed on thousands of larger engines.	Sulfur content >500 ppm affects performance and durability.		Phase 2
Fuel Cells	100% PM; 100% NOx (near zero emissions)	No	Unknown	NA	Zero/near-zero emissions, reduced water pollution (oil leaks), lower greenhouse gas emissions (CO2), higher fuel economy, quieter, smoother operation, energy diversity.	Technical issues remain to integrate components to meet consumers' performance and cost demands.	Phase 3	Phase 2
Offroad Engine Standards (special category)	Depends on standard.	NA	Unknown	NA	Reductions in health risk near facilities & along roadways.	Delayed effects.	Phase 3	NA

[7] MECA stands for Manufacturers of Emission Controls Association.

[8] ThermoKing's experience is lower initial costs than MECA's estimate.