

# Off-Road Equipment - Overview of Potential Zero- and Near-Zero Technologies



**Working Group Meeting No. 2**

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# Off-Road Commercial/Industrial Equipment is Very Diverse

- Includes Equipment with Varying Duty Cycles, Engine Sizes, Fuel Types, and Operating Locations
- Control Technology Required to Match Equipment Type
- Multiple Technologies in Development or Available
- Technologies May be Combined for Greater Scope and Reductions



# Potential Zero- and Near-Zero Technologies

Technology	Application
Cleaner Combustion Engines	Equipment Types where Additional Emissions Controls are Feasible
Natural Gas	Equipment at Fixed Sites or Returning to Equipment Yards at Night
Hybrid Systems	Equipment with Energy Recovery Duty Cycles or High Percentage of Idle/Low Power Operations

# Potential Zero- and Near-Zero Technologies (cont.)

Technology	Application
Plug-In Hybrid Electric	Equipment with Energy Recovery Duty Cycles or High Percentage of Idle/Low Power Operations with Access to Grid Power
Fuel Cell	Equipment at Fixed Sites or Returning to Equipment Yards at Night
Battery Electric	Equipment with High Percentage of Standby Time or Low Load Time at Site with Grid Power

# Status of Potential Zero- and Near-Zero Technologies

Technology	Status
Cleaner Combustion Engines	Prototype On-Road Diesel and Natural Gas Engines in Development. Goal - 90% Lower NO <sub>x</sub> than Current Standard in Process
Natural Gas	Commercially Available for Some Applications. On-Road Engine Development of 90% Lower NO <sub>x</sub> than Current Standard in Process
Hybrid Systems	Commercially Available for Selected Applications
Plug-In Hybrid Electric	On-Road Heavy Duty Truck Demonstrations in Process
Fuel Cell	Forklifts Commercially Available and Other Equipment in Process (On-Road Heavy Duty Trucks, Buses, TRUs, GSE)
Battery Electric	Industrial Equipment Commercialized. Other Equipment Demonstrations in Process (On-Road and Off-Road Trucks, TRU)

# Potential Zero- and Near-Zero Technologies by Category

Category	Technologies
Construction and Mining	Cleaner Combustion Engines, Hybrid Systems
Commercial	Cleaner Combustion Engines, Fuel Cell
Industrial	All
Transport Refrigeration Unit (TRU)	Cleaner Combustion Engines, Fuel Cell, Battery Electric
Lawn and Garden	Battery Electric, Cleaner Combustion Engines
Ground Support Equipment (GSE)	Battery Electric, Cleaner Combustion Engines, Plug-In Hybrid and Hybrid Systems, Fuel Cell