



Off-Road Equipment

Status of Technology Development

Technology	Status
Cleaner Combustion Engines	Prototype On-Road Diesel and Natural Gas Engines in Development. Goal - 90% Lower NOx than Current Standard in Process
Natural Gas	Commercially Available for Some Applications. On-Road Engine Development of 90% Lower NOx 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)

Off-Road Regulations

- Diesel in-use off-road
- Cargo handling equipment
- Large spark ignition engines
- Portable engines
- Transportation refrigeration units

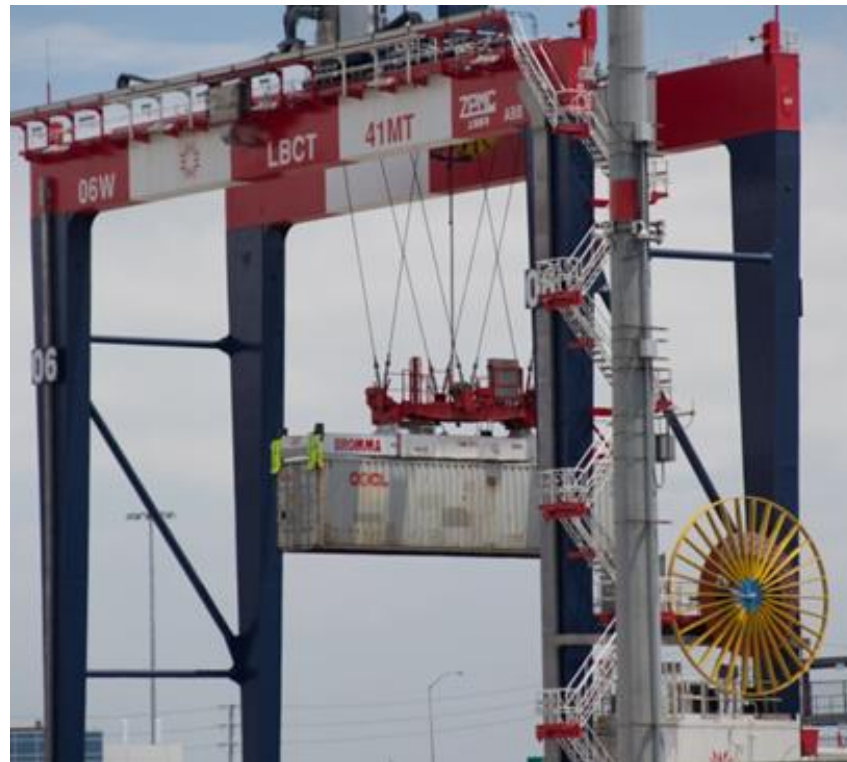
Zero or Low-NOx Yard Trucks

- Natural gas (LNG/CNG)
- Battery-electric
- Fuel cell
- Hybrid
- Cleaner Combustion Engines
 - 0.02 g/bhp-hr



Container Terminal Electrification

- Two California container terminals in process of electrification
 - LBCT's Middle Harbor
 - TraPac



Transport Refrigeration Units

- All Electric Plug-In / Batteries
- Eutectic Cold Plates
- Cryogenic Temperature Control
- Energy Efficiency

Forklifts and Construction and Mining Equipment

- Forklifts
 - Battery Electric
 - Fuel Cell
- Construction and Mining Equipment
 - Hybridization and Diesel Electric
 - Jobsite Efficiencies

Energy Efficiency

Thermal efficiency of insulated vans

- ❖ Refrigerated trailer specifications need more attention
- ❖ Insulation degrades over time
- ❖ No thermal efficiency standards in the U.S.
- ❖ European standards - UN's "ATP" Agreement
 - ❑ Must meet overall heat transfer coefficient standards when new
 - ❑ Insulation is thicker in Europe
 - ❑ Periodic testing of aged insulated vans
 - ❑ Certification renewed at six year intervals