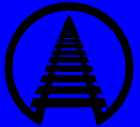


RRs & Air Quality

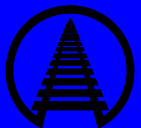
Transportation Research Board
Multi-Modal Air Quality Workshop
Jan. 22, 2006

Michael J. Rush
Association of American Railroads



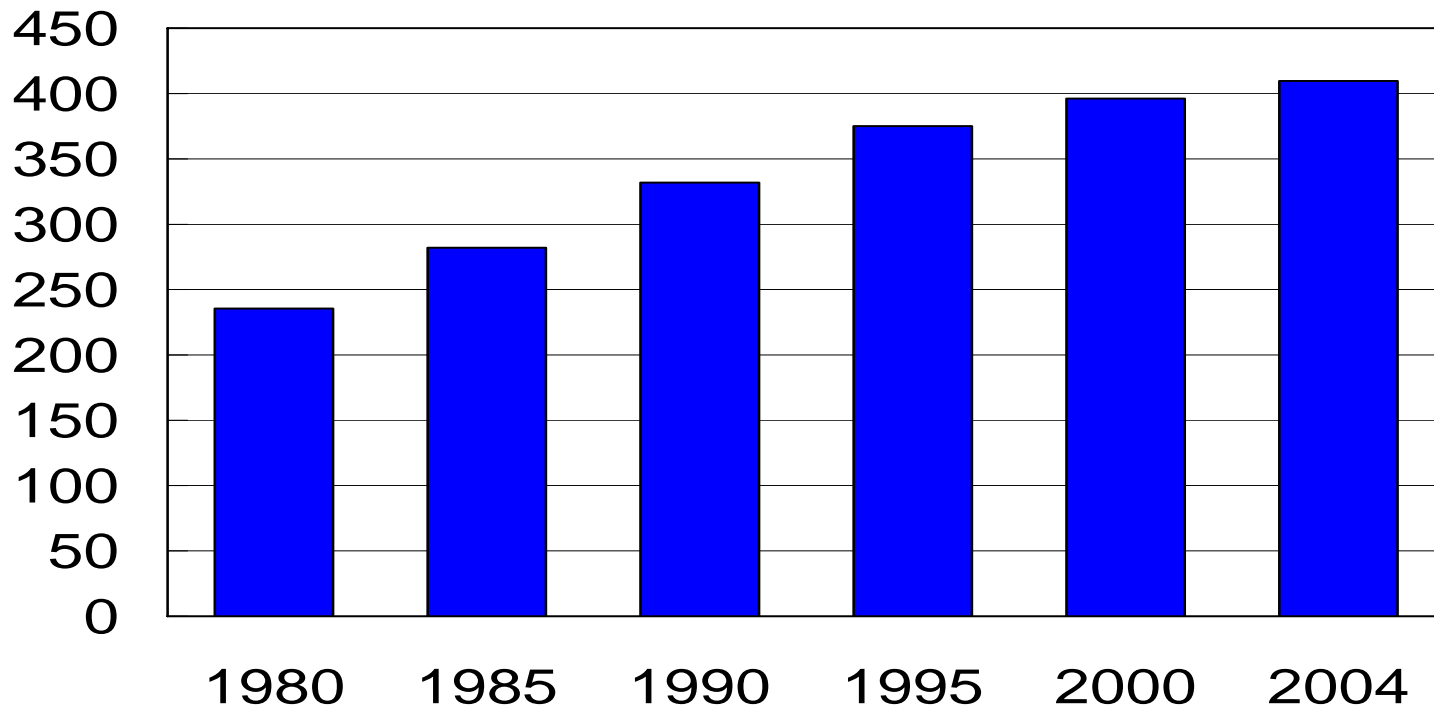
Locomotive Percent of Inventory

- Locomotive % of mobile source inventory (1996): 7.0 NO_x, 3.7 PM_{2.5}, 0.1 CO
- Locomotive % of mobile source inventory (2030): 10.2 NO_x, 4.1 PM_{2.5}, 0.1 CO
- 3-1 emissions advantage over trucks

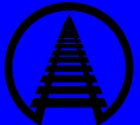


RRs Are Very Fuel-Efficient

**Gains in Railroad Fuel Efficiency
(Ton-Miles Per Gallon of Fuel Consumed)**

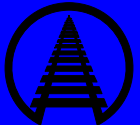


Source: AAR



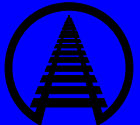
EPA Regulation

- 1998 Tier 0, 1, 2 standards
 - New & remanufactured locomotives
 - Tier 2 (line-haul): NO_x, 5.5; PM, 0.2
- 2005 Fuel Standards
 - 2007: 500 ppm
 - 2012: 15 ppm
- Upcoming NPRM (“Tier 3” Standards)



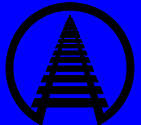
Locomotive Engines Are Different!

- Horsepower
 - Locomotives: up to 6,000 hp
 - Nonroad engines: 700 hp or less
- Speed
 - Locomotives: medium speed (300 – 500 rpm)
 - Nonroad engines: high speed (900 – 1800 rpm)
- Cylinders
 - Locomotives: 12 or 16 cylinders
 - Nonroad engines: 8 cylinders or less



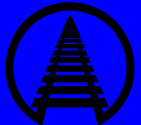
Locomotive Engines Are Different!

- Coolant
 - Locomotives: no antifreeze
 - Nonroad engines: antifreeze
- Size
 - Locomotives: constrained due to tunnels, tracks
 - Nonroad engines: not similarly constrained
- Bore
 - Locomotives: approx. 9 inches
 - Nonroad engines: approx. 4 inches

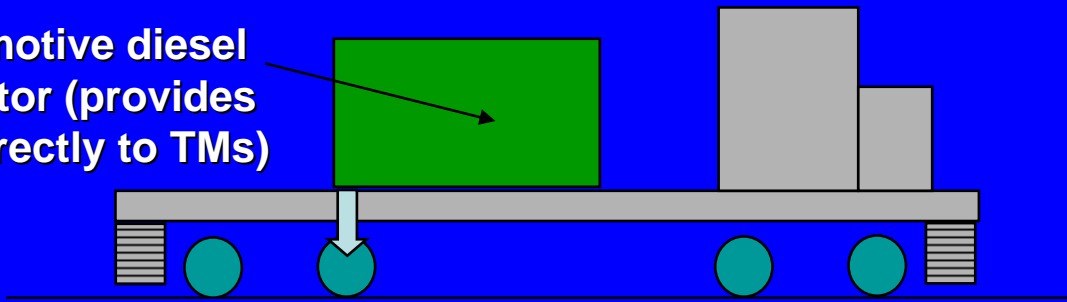


RR Initiative: Switch Power

- Hybrids
- Gen-set switchers
- Natural gas



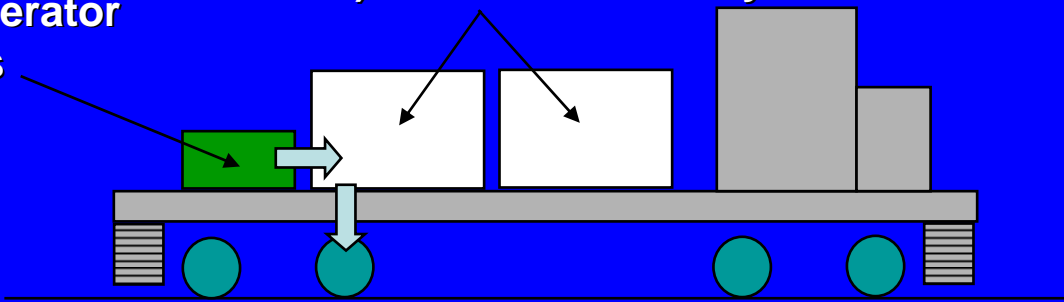
1500-to-2000 locomotive diesel engine and generator (provides electrical power directly to TMs)



Conventional Diesel Switcher

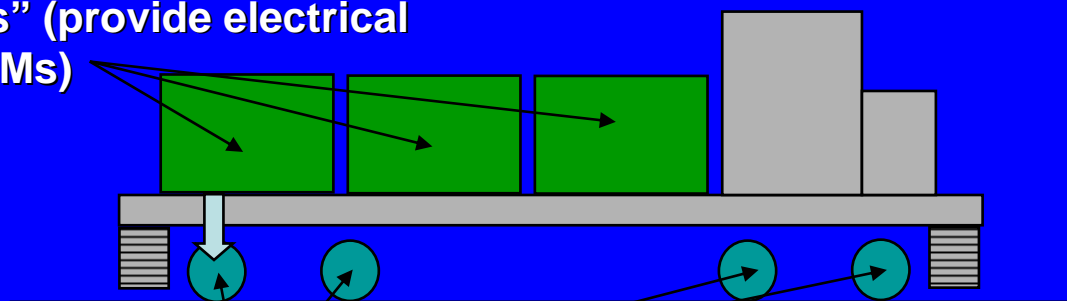
Battery packs (provides electrical power to TMs) ... an "electrical flywheel"

290 HP diesel-generator "genset" (charges batteries)

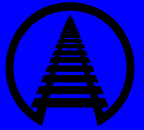


Diesel-Battery Hybrid Switcher

Two-or-Three 627-to-700 HP diesel-generator "gensets" (provide electrical power directly to TMs)

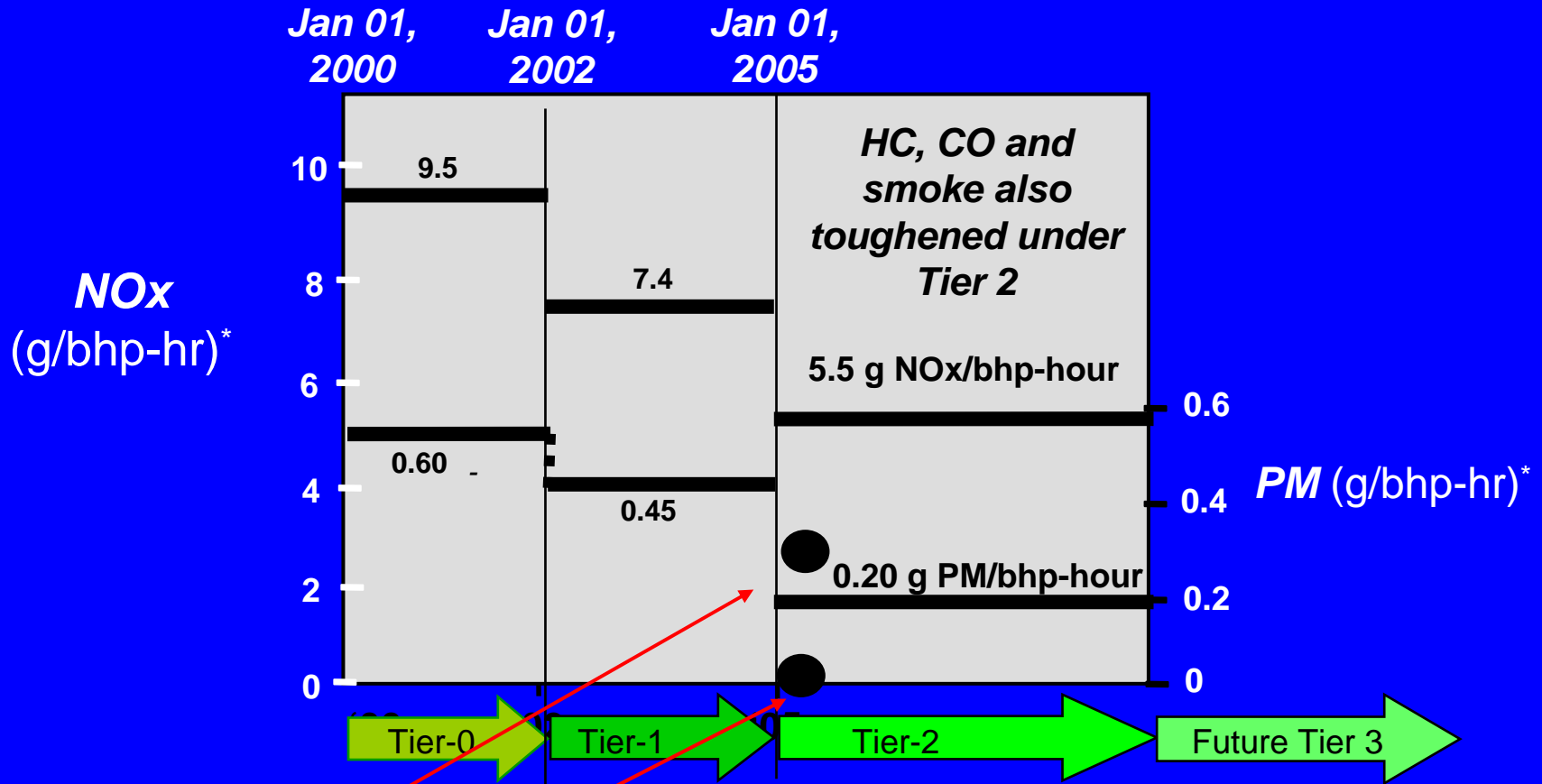


Genset Switcher



Traction motors (TMs)

Hybrid/Gen Set Emissions



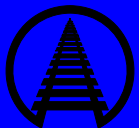
*Based on line-haul duty cycle

Nominal NOx and PM EPA ratings of hybrid and genset switcher



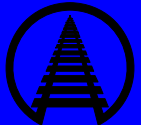
RR Initiative: DPF Research

- BNSF/UP field testing of DPF on 2-4 locos in 2006 using Hug technology
 - HUG DPFs used in Switzerland on new 2000 hp and retrofitted 1200 hp units
- EPA/SWRI/UP test in 2006: oxidation catalyst



RR Initiative: Idle Reduction

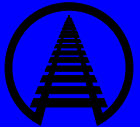
- EPA duty cycle idling time:
 - Switchers: 56%
 - Line haul: 38%
- APU
- Automatic stop/start



RR CA Initiatives

- 1998 MOU
 - Accelerated introduction of Tier 2 loco's

- 2005 MOU
 - Idle-reduction technology
 - Risk assessments
 - CARB fuel
 - Remote sensing technology



Energy Policy Act of 2005

- § 751: DOE research program
- § 756: EPA 50-50 program to support deployment of idle reduction/energy conservation technologies
- § 791: EPA & state grants/loans for diesel emissions projects
 - Addressing rail yard emissions a criterion
 - Ineligible: \$ to achieve mandated reductions

