

# ***THE BNSF FUELCELL-HYBRID SWITCH LOCOMOTIVE FOR THE LOS ANGELES BASIN***



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# ***NATIONAL & WORLDWIDE CHALLENGES***

- **National energy security**

- Approx. 98% of the energy of the transport sector is based on oil
- More than 60% is imported
- Political instability threatens supply disruptions

- **Global climate change**

- CO<sub>2</sub> concentration in the atmosphere is increasing rapidly
- Polar ice caps and glaciers are melting
- Severity of storms and droughts is increasing

**These challenges have a common origin: Oil**



# ***WHY FUELCELL RAIL?***

- **Marries best features of conventional locos (catenary-electric and diesel-electric) but avoids their disadvantages**
  - Zero chemical and low acoustic emissions at the vehicle (i.e., catenary-electric)
  - Relatively low infrastructure cost (i.e., diesel-electric)
  - Zero total CO<sub>2</sub> emissions if primary energy is renewable or nuclear
  - Perhaps 10% more efficient overall than a diesel- or catenary-electric
- **Current issues**
  - Relative high cost of fuelcells (hand built)
  - Entrenched competing technologies and fuels
  - Hydrogen storage



# ***PROJECT OBJECTIVES***

**An industry-government partnership is developing a fuelcell-hybrid switch locomotive leading to commercial locomotives that:**

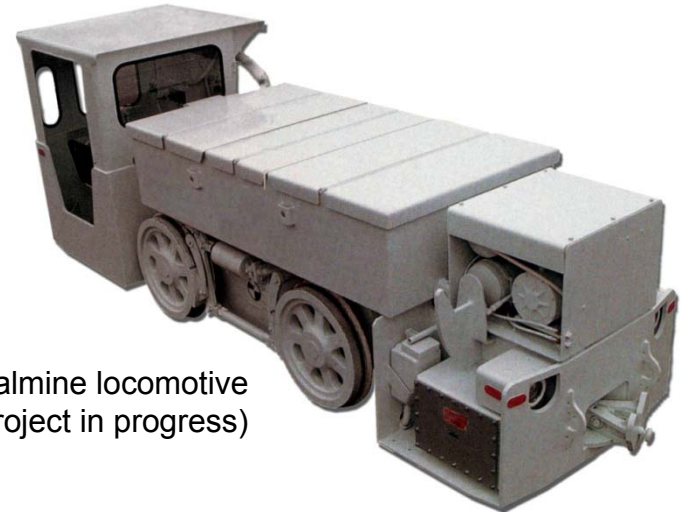
- Reduce air and noise pollution in urban rail applications, including seaports. (To be demonstrated in the LA Basin)
- Serve as a mobile backup power source (“power-to-grid”) for military bases and civilian disaster relief efforts.

# HIGH-POWER FUELCELL VEHICLE DEVELOPMENT

Vehicle Projects Inc has a unique history (since 1998) of developing large fuelcell vehicles



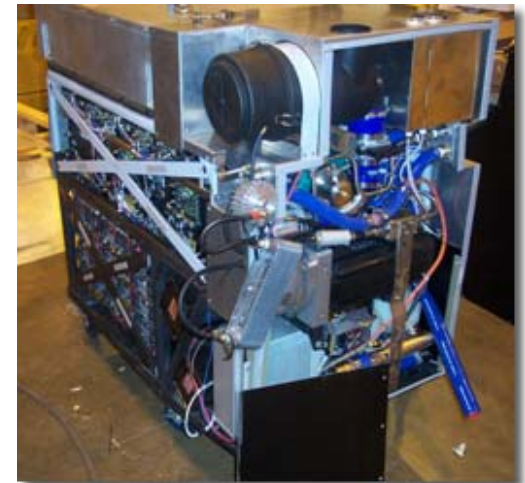
Fuelcell mine locomotive, a non-hybrid



FC coalmine locomotive (project in progress)



Coal loco metal-hydride storage (complete)



Coal fuelcell-hybrid powerplant (complete)

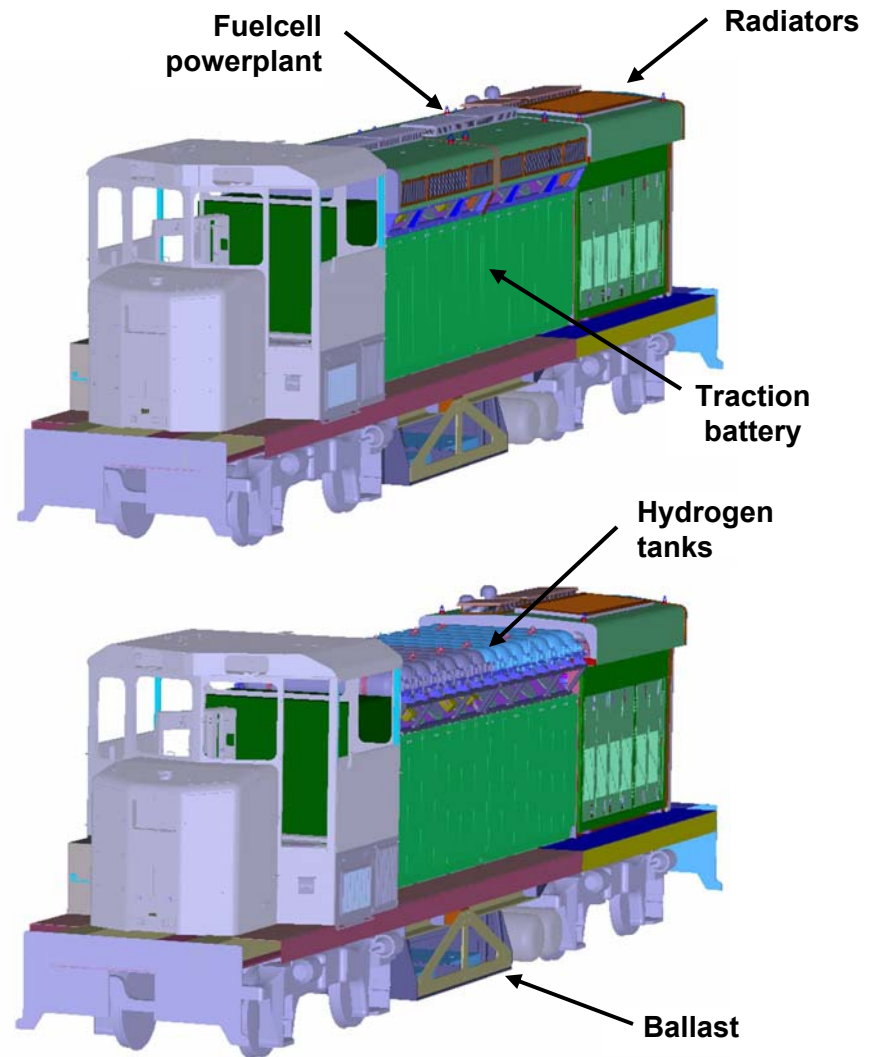
# ***REAR VIEW OF FUELCELL SWITCH LOCOMOTIVE***



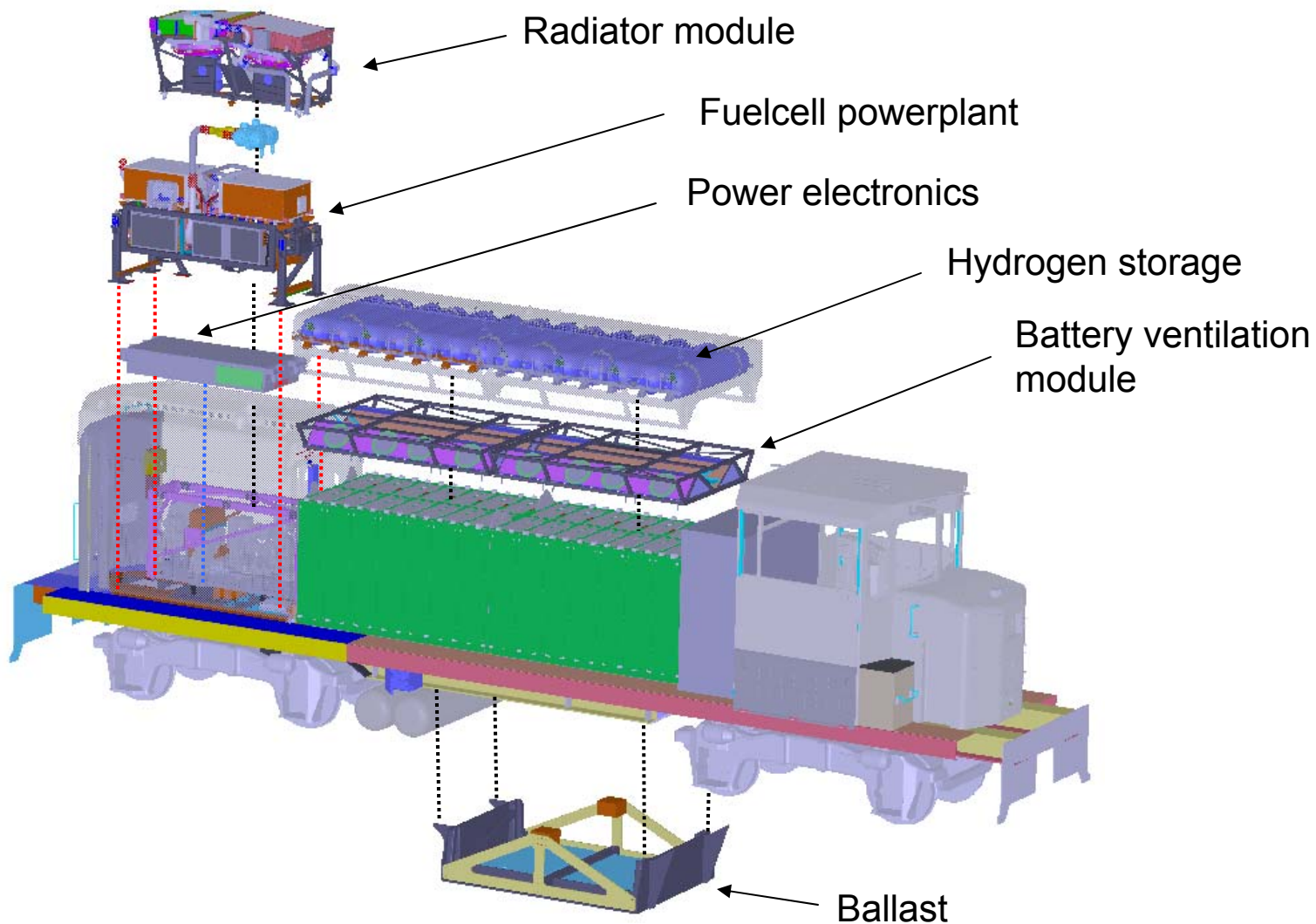
31 July 2008, BNSF Topeka SMT

# ***CAD MODEL OF FUELCELL-HYBRID SWITCHER***

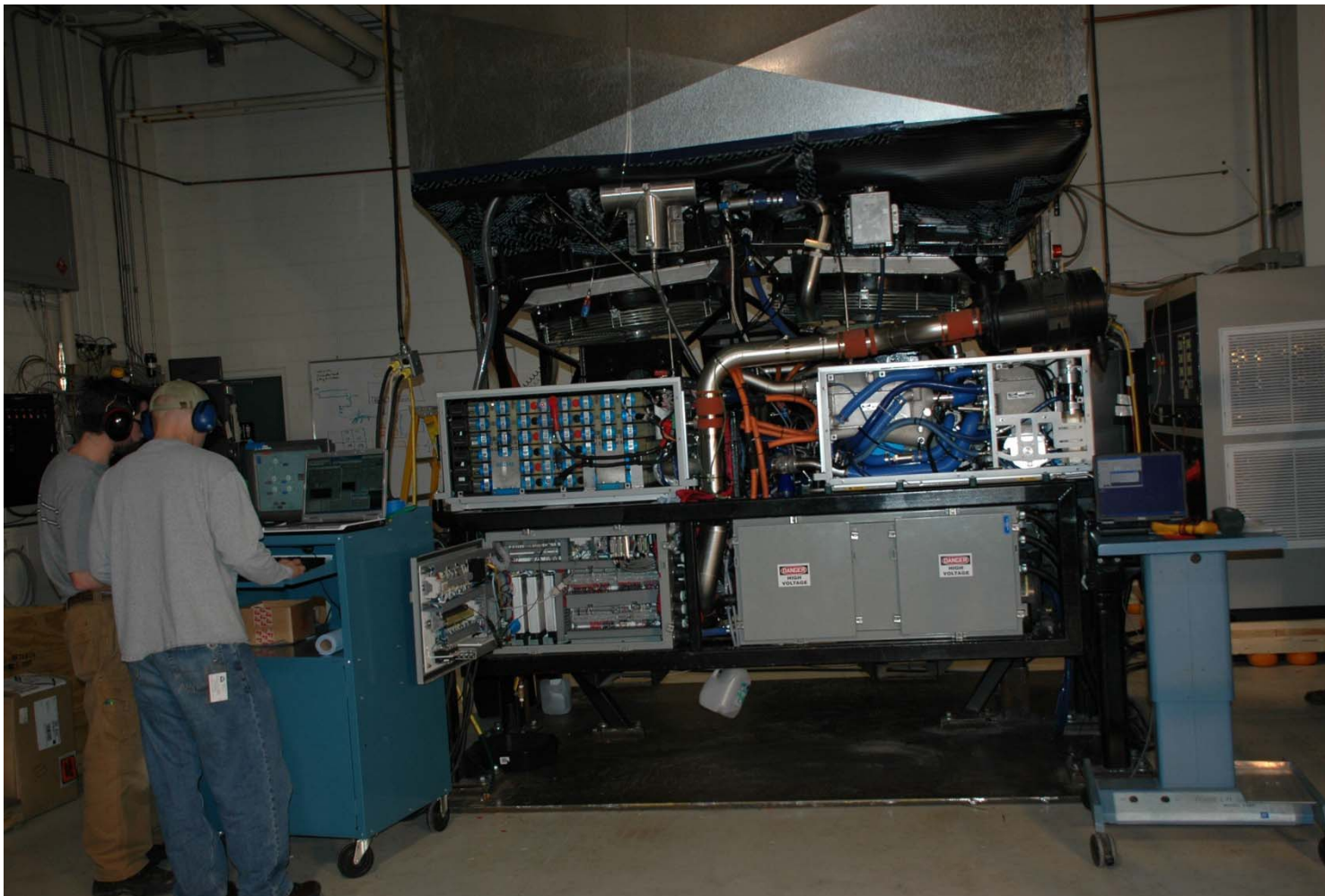
- 240 kW (320 hp) fuelcell prime mover
- 70 kg hydrogen at 350 bar (5100 psi) at roofline
- Traction battery allows transients above 1 MW
- 9000 kg extra ballast to bring to 127 tonne



# EXPANDED VIEW OF VEHICLE



# ***POWERPLANT UNDER TEST IN DENVER***



31 January 2009

# ***INVERTER TEST LOAD: DUMPS POWER TO GRID***



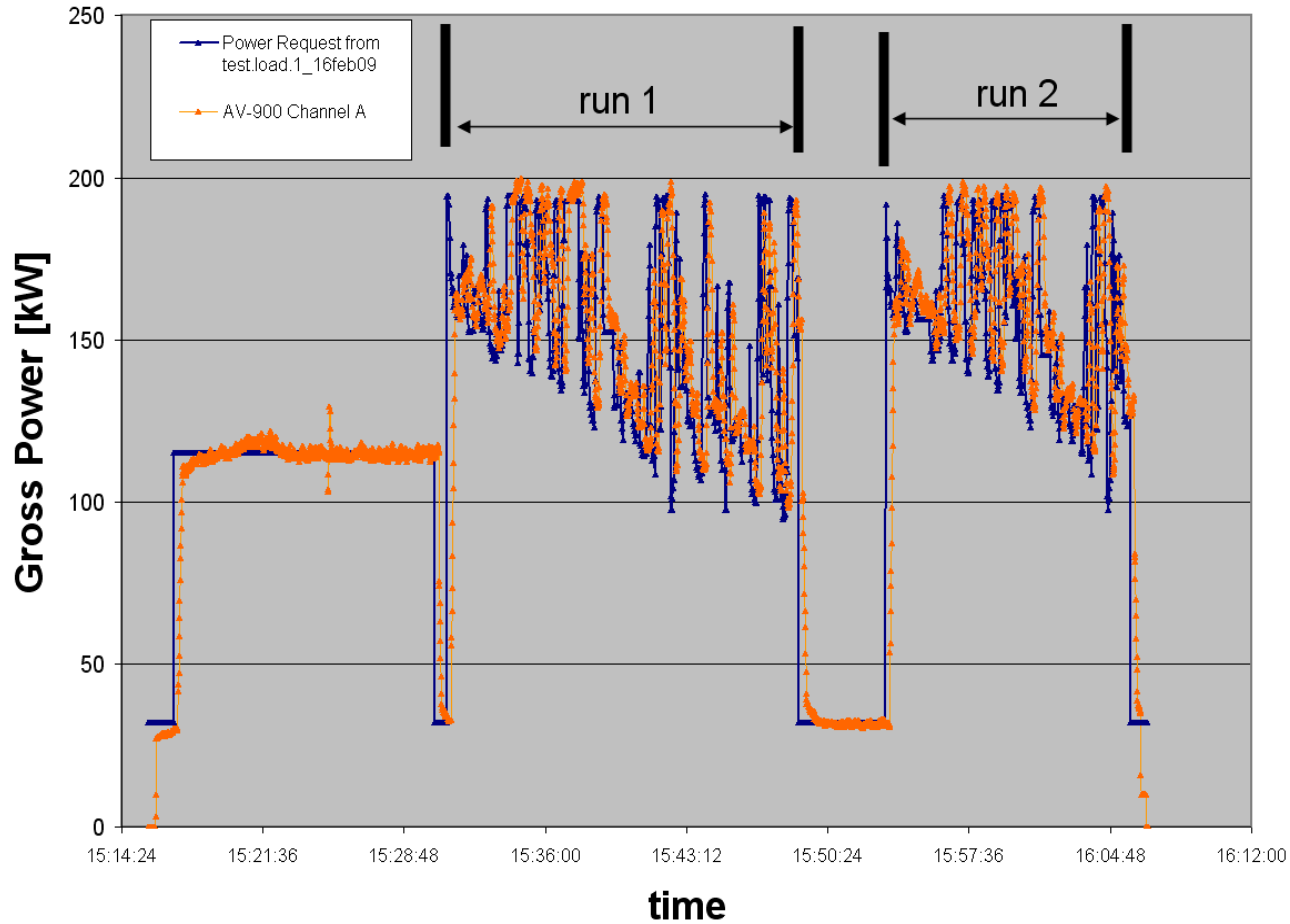
# **POWERPLANT OPERATING AT 200 KW**

*(230-240 kW net expected)*



# LOAD-FOLLOWING TESTS TO 200 KW

test.load.1\_16feb09



# LA RAILYARDS OF DEMONSTRATION (COMMERCE & HOBART)



# ***COSTS***

- **To assess costs of fuelcell locomotives for LA, we must assess the social costs of conventional technology**
- **Fuelcell costs must also be compared to total costs of conventional “clean” technology**
- **“Clean diesels” with exhaust after-treatment have many issues to resolve: space claim, complexity, reliability, efficacy**
- **Catenary-electric locos**
  - Catenary-electric locos are energy inefficient
  - Usually are a large GHG emitter
  - Have very high infrastructure costs (US\$6-8/mile)



## ***SOCIAL COSTS (US EPA, 2030)***

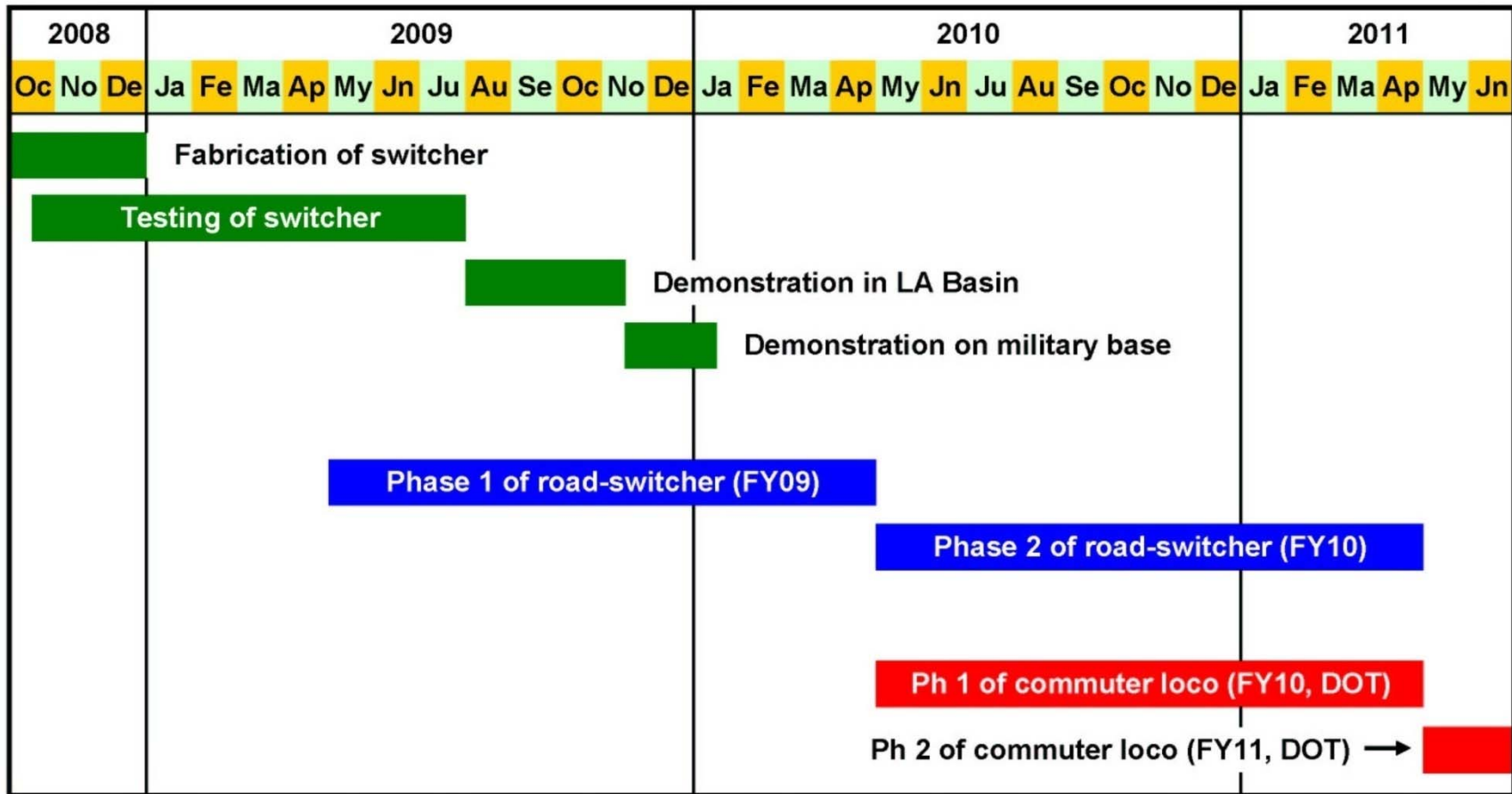
- **Reduce annual PM by 27,000 tons**
- **Prevent up to 1,100 PM-related premature deaths**
- **Prevent elevated diesel PM cancer risk near railyards**
- **Prevent 120,000 lost work days (all emissions)**
- **Prevent 120,000 school day absences (all emissions)**
- **Annual savings in social costs: \$9.2 - \$11 billion**



# ***CALIFORNIA ZERO-EMISSIONS TARGETS***

- **Elimination of 4.7 tons per day of diesel particulate matter**
- **Elimination of 204 tons per day of nitrogen oxides**
- **Elimination of 12 tons per day of reactive organic gases**
- **Elimination of 8 tons per day of sulfur oxides**
- **Bring production of the six Kyoto gases to zero (GHGs)**
- **Bring all airborne pollution from rail to zero**

# PROJECT SCHEDULE





# ***CONCLUSIONS***

- **The fuel-cell switch locomotive can be a totally zero-emissions vehicle**
- **Use in urban railyards can prevent PM-based illnesses due to rail**
  - Railyard neighbors experience high air-pollution concentration
  - Line-haul locomotives disperse emissions over much broader areas
- **HYPOTHESIS: The fuelcell locomotive is the least-cost solution for LA when the social costs of diesel-electrics and infrastructure costs of catenary-electrics are considered**



## ***FINANCIAL SUPPORT (ALL PROJECTS MENTIONED)***

**US Department of Energy, Hydrogen Program**

**US Department of Energy, Office of Industrial Technologies**

**Natural Resources Canada, Emerging Technologies Program**

**US Department of Defense, Defense Logistics Agency**

**BNSF Railway Company**

**National Institute for Occupational Safety and Health (NIOSH)**

**Fuelcell Propulsion Institute**

**Corporate cost-share contributors**

