On-Road Development and the NGNGV Program

Paul Norton and Mike Frailey
NREL

Class 3-6 CNG Vehicle
Improving engines [improve efficiency]
Advanced electronics

Class 7-8 LNG Vehicle
Smart refueling
Improved fuel gauges

Alternative Fuel System and Vehicle Technology Development at NREL

Enabling Technologies
Developing new fuels and fuel systems with laboratory R&D

On-Road Prototype Development
Putting new technology into service to work out bugs and move technology towards commercialization

Vehicle Evaluation and Emissions
Evaluate cost, performance, and emissions for fleet operators and manufacturers and identify areas in need of further development
Alternative Fuel System and Vehicle Technology Development at NREL

Enabling Technologies

On-Road Prototype Development

Vehicle Evaluation and Emissions

The NGNGV Program

On Road Development

- Moves technology from the laboratory to the road
- Works closely with engine OEM
- Places prototype engines in revenue service
- Works through problems as they arise
- Experience gained is fed back to the OEMs to aid in development of commercial engines and vehicles
Recently Completed Projects

DDC Engines

- **DDC S50G**
  - 275 hp @ 2100 rpm
  - 890 ft*lbs. @ 1200 rpm

- **DDC S60G**
  - 330 hp @ 2100
  - 1400 ft*lbs. @ 1200

- EPA LEV
- CARB Low NOx (2.5) & .05 PM
- Availability
  - MCI
  - NABI
  - New Flyer
Mack Engines and Vehicles

Mack

• E7G 325
  • 325 hp @ 1950 rpm
  • 1180 ft*lbs. @ 1250 rpm
• E7G 350
  • 350 hp @ 1800
  • 1260 ft*lbs. @ 1250
• EPA LEV
• CARB Low NOx (2.5) & .05 PM
• Available in MR and LE chassis

Current Projects
Deere Truck Engine

John Deere 280 hp / 900 ft*lbs. 6081
- Orange County Waste Management Refuse Haulers
- Four prototype 6081 & two diesel controls (C8.3)
- Re-powered Peterbilt P320s by NGV Ecotrans
- On-Road to start in November
- Real World Verification
  - Diesel Efficiency
  - Spark Plug Life
  - Reliability

DDC S60-400G
- 400 h.p. & 1450 ft*lbs.
- Cost shared with SCAQMD and CEC
- ~5000 miles/month
- Customer interest in California and Europe
- DDC planning commercialization
Cummins C8.3G+

- 280 hp / 750 ft*lbs.
- EPA CFFV ULEV & CARB low NOx (2.5)
- Lower cost full authority ECM
- Wide band UEGO
- Knock Sensor (optional phase II)
- Total of 6 C8.3G+ and 1 Control vehicle
- Cost shared with SCAQMD, SoCAL Gas

BKM/CAP Improved C12 DFNG

- 425 hp / 1450 ft*lbs for Class 8 Trucks
- Goals:
  - Higher HP and torque than current engine
  - Increased substitution rate
  - Lower PM emissions
- Approach:
  - Knock Sensor
  - Hydraulic Supercharger
  - Turbo expander
  - Control system upgrades
- Cost shared with SCAQMD
Alternative Fuel System and Vehicle Technology Development at NREL

Enabling Technologies

On-Road Prototype Development

Vehicle Evaluation and Emissions

The NGNGV Program

Next Generation Natural Gas Vehicle Program

Class 3-6 CNG Vehicle

Advanced Technologies

Lightweight Materials

Improved Engines

Improved Fuels

Improved Infrastructure

Class 7-8 LNG Vehicle

Improved Engines

Improved Fuels

Improved Infrastructure
Vision and Goals for the Future

One medium-duty (Class 3-6) CNG vehicle and one heavy-duty (Class 7-8) LNG vehicle will be available in 2004 that:

- Implement advanced DOE natural gas and heavy-vehicle technologies
- Implement high efficiency engine technology
- Implement step change in technology over current NG vehicles
- Have exhaust emission levels below proposed emission standards for 2007
- Are fully competitive with diesel vehicle counterparts in terms of performance and life-cycle economics
- Are commercially viable
Finding the Balance….

Step change in technology

Path to Commercialization

Program Integration

Vehicle Working Group

Government

Industry

End Users

Enhanced efficiency project

Enabling technology research

Other research

Storage of CNG & LNG

Vehicle Platforms
Class 3-6 CNG
Class 7-8 LNG
## Proposed Program Timeline

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<td><strong>Creating Market Interest and OEM Support</strong></td>
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<td>Stakeholder workshops</td>
<td>Ongoing industry communications</td>
<td>Identify first-tier markets and vehicle needs</td>
<td>Define vehicle applications</td>
<td>Solicit pre-production sales</td>
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<td><strong>Prototype Vehicle Design, Development and Evaluation</strong></td>
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<td>Establish Vehicle Working Group</td>
<td>Develop design strategy and identify remaining technology obstacles</td>
<td>Define duty cycle and performance specifications</td>
<td>Complete R&amp;D to overcome remaining obstacles</td>
<td>Competitive solicitation for vehicle development</td>
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<td><strong>Fueling and Maintenance Infrastructure and Field Support</strong></td>
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<td>Evaluate existing infrastructure in first and second tier markets</td>
<td>Determine vehicle infrastructure requirements</td>
<td>Develop infrastructure support strategy</td>
<td>Coordinate infrastructure development</td>
<td>Train infrastructure staff</td>
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Upcoming NGNGV Events…

- First WVG meeting:
  May 2-3, 2000
  Chicago, IL

- Presentation and information gathering at the National Clean Cities Conference:
  May 8-10, 2000
  San Diego, CA
FY 1999 AOP Milestones

- Publish at least 2 project final reports
  - Liquid Carbonic Final Report
  - UPS Case Study

- Publish at least 2 truck evaluation reports
  - Waste Management Start-up Experiences
  - Raley’s Final Data Report

- Publish Bus Emissions Report
  - Bus update with emission summary published at APTA
  - SAE paper on emissions of buses using synthetic diesel

- Publish and present at least on SAE Paper
  - Five published and presented in Spring F&L!
1999 AOP Milestones

- Place at least 1 new Advanced Development contract
  - DDC S60G 400 hp project
- Develop 1 alt. fuel engine for commercialization
  - DDC S50G 275 hp
  - DDC S60G 330 hp
  - Mack E7G 325 hp and 350 hp

1999 AOP Milestones

- Update NREL emissions database
  - DDC 6V92 buses on synthetic diesel
  - Cummins B5.9G CNG GO Boulder buses
  - Cat 3176B DFNG Pima Gro Trucks
  - Lockheed/DDC S30 Hybrids SOON!
FY 2000 AOP Milestones

- Prepare SAE technical paper on emissions of NYC diesel electric buses.
  Data collection completed, paper is in progress

- Establish a new alternative fuel vehicle fleet for testing.
  Deere powered refuse haulers in California

- Publish report on the Next Generation Natural Gas Engine Technology.
  Suite of four reports published

FY 2000 GPRA Objectives

- On road prototype development of enhanced efficiency natural gas engines.
  At least one new test site established
  Deere powered refuse haulers in California

- Assist industry in commercializing alternative fuel heavy-duty engines in truck evaluation project.
  Form Next Generation Natural Gas Vehicle Working Group
  First meeting is on May 2 & 3, 2000
  At least one new alternative fuel engine offering
  DDC Series 60G 400 hp