Pathway for Plug-in Hybrids

Advanced Transportation Technologies

Clean Transportation Solutions™

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Fighting Global Warming

IPCC Climate Change Mitigation Report (May 4):

- More fuel efficient vehicles
- Hybrid vehicles
- Cleaner diesel vehicles
- Biofuels
- Modal shifts to rail and public transport
- Non-motorized vehicles
- Land use and transit planning
Transportation CO₂ Increases; Industrial CO₂ Decreases

- Transportation-related emissions higher than industrial CO₂; passed industrial CO₂ level in 1999
- Remains the largest source of energy-related CO₂
- Between 1990-2005 transportation CO₂ grew 23.4%
- Accounted for 33% of all energy-related CO₂ emissions in 2005

Source: Energy Information Agency

CO₂ Emissions by End-Use Sector (1990 – 2005)

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The New “Strike Zone” in Transportation

Air Quality

Balances all three competing needs

Integrated Solutions Needed

Energy Security

Climate Change

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Why Hybrids Are Gaining Traction with Fleets

- Rising fuel costs: Optimizing urban truck drivelines is becoming critical for fuel efficiency, emissions
- Major engine changes – and increased cost/complexity – coming in 2007-2010 to comply with EPA emissions requirements
- Trend toward integrated engine/drivelines in trucks
- Increasing electrical power needs in heavy vehicles and equipment
- Idle Management is a growing issue
- Productivity/performance complaints from cleaner engines
Timeline to Commercialization:
Hybrid Tech Just Starting in Trucks

Trucks are not Priuses!
Tech introduction 10 years behind cars
BUT: big fuel impact per truck

Development
Test prototypes and systems

Pre-Production
Field pilot assessments (10-50 vehicles)

Production Intent
Assembly line builds up to 100+

Early Production
Initial commercial volumes – still high incremental cost

TOOLS:
R&D Support
Pre-Production Deployment Support (HTUF)
Purchase Incentives

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Plug-in Hybrid Electric Vehicles

• Lots of attention and interest in PHEVs among policy makers, environmentalists
• Benefits: increased fuel economy, GHG reductions, possible zero emission driving
• Cost and life cycle of energy storage (batteries) are prime limiter
• Most focus is on passenger cars – trucks offer additional challenges
• All current PHEVs are conversions from small firms – very few on road
• No OEM production dates set – though increasingly “hinted at”
Several Plug-in Hybrid Truck (PHET) Efforts Underway

- DaimlerChrysler to expand its fleet of Sprinters in hybrid, PHET and battery electric
- Believes big leap in battery technology necessary to make plug-ins viable
- Odyne fielding and testing several PHETs, including refuse truck in Fresno, CA
- PG&E and EPRI developing PHET Class 5 utility truck – possible completion in 2008
- Roughly 24 hybrid and plug-in school buses moving into test using IC/Enova system
Newest Plug-In Prototype: Dueco-Odyne Utility Truck

- 33,000 pound Material handler chassis/body
- 50kw electric motor provides mild driving assist – connects via PTO
- Main function is to operate truck at work site without main engine operating
- Features possible 8 hour operation; electric air conditioning
- 35 kwh lead-acid battery pack; recharge off grid or optionally off engine
Plug-in Hybrid Electric Truck (PHET)
Task Force of HTUF

• Biggest User Interests:
  ➢ Fuel Savings & Emission Reduction increase over hybrids
  ➢ Petroleum Displacement with electricity-Cheaper-Cleaner-Domestic
  ➢ Down the road: carbon reduction?
  ➢ Fuel savings sufficient to justify business case?

• Other benefits we expected from PHETs
  ➢ Extended life-time due to reduced idling
  ➢ Increased maintenance periods and lower maintenance costs
  ➢ Replace diesel generators on trucks
  ➢ Benefit of extended quiet operations
  ➢ Benefits of export power and V2G
  ➢ Health and environmental benefits

• How do we include those into the business case?

• HTUF developing “road map” and possible next steps for PHET
Additional Values of PHEV

• Introduction of new technology opens up new applications – transportation and…

• Stored electricity in batteries can be used for applications other than driving

• Advantages of electric power – fast response, clean, quiet, versatile
Use of Power from Grid
Connected Vehicles

- Power can flow both ways – charge batteries and discharge to the grid (V2G)
- Two-way flow and vehicle-grid interactions create many new opportunities and uses

Grid-connected vehicle can provide:

1. Emergency or back-up power supply
2. Power support, electrical or telecom substation
3. Profitable Grid Management- Ancillary Services
4. Storage / integration with renewables (e.g. wind power)
Utilities – Good First Demonstrations for PHEV

- Utilities have large and diverse fleets
- Have experience with electric power and the grid
- Early adopters of hybrids
- Can do early demonstrations of additional uses/value of PHEV (export power, V2G)
The Key Drivers for PHEV

Additional Value of PHEV needs to be included

Need to understand better where this cross over is

Energy Storage/System Cost

Fuel Savings (efficiency + lower fuel cost)
HTUF PHET Roadmap
How do we get there faster?

Stage 1:
Added energy storage and grid connection

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<td>Add modular energy storage to existing trucks, assess with fleets (providing more engine off time at work site) 10-20+ trucks</td>
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Stage 2:
Optimize hybrid driveline for added energy storage

Flash upgrade deployed trucks with greater driveline functionality (existing deployed trucks and 50 new)

Stage 3:
Integrate electrified components for low-speed, short range electric drive and start-stop capability

Capability added to new trucks with all above features and lower driveline cost, assess with urban work fleets

Goal: Organic growth - PHET offered as variant to commercial hybrid drivelines, takes advantage of commercial path improvements
Status of Hybrid & PHEV Truck Development

• Not Yet at “Tipping Point” for hybrid commercialization – but making strong progress
  – Have sped commercialization process by 1-2 years
    • Two truck makers entering production-intent manufacturing process
  – Still behind automotive curve – but business case is driver
  – Need assistance to cross cost gap to first production
  – Must increase early volumes

• Hybrids are one of several critical “wedge” strategies to boost fuel economy, reduce GHG
  – First targets urban vocational trucks
  – Will likely also have Class 8 impacts
  – Enabling technology for many future advancements
  – Expect yearly volumes to exceed 1-2-thousand in next 3 years

• Need targeted incentives: Federal and State
  – Partnership of fleets, manufacturers and government
  – Structured to work in commercial, not consumer, market
  – Also need regional incentives and “aligned” incentives across regions
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