

# Heavy Hybrid Vehicles: Commercialization Status and What's Needed to Succeed



*Advanced Transportation  
Technologies*

*Clean Transportation  
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**Bill Van Amburg  
Senior Vice President**

**SAE Government &  
Industry Conference**

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# Recent Hybrid News – Industry Momentum Growing

- FedEx/Azure announce partnership on gas-electric hybrids
- ArvinMeritor signs WalMart agreement for Class 8 hybrids
- Oshkosh unveils hybrid refuse truck at HTUF meeting
- Peterbilt introduces Class 7 hybrid truck for customer trials
- International builds its first production-line hybrids in Nov 06
- Freightliner unveils Class 7 utility hybrid truck on M2 chassis
- IC/Enova roll out hybrid electric shuttle bus
- Azure agreement with StarTrans on producing hybrid shuttles
- Eaton developing hybrid system for Class 8 OTR trucks with Peterbilt
- UPS testing advanced series hydraulic hybrid prototype
- Bosch-Rexroth buys Dana hydraulic hybrid drive unit
- Mitsubishi-Fuso Unveil Hybrid work truck (Class 4-5 delivery cube)
- Wright Group, ISE building 50 advanced hybrid buses for Las Vegas (62-foot articulated series drive)
- Volvo announces hybrid heavy trucks for 2009 production
- Peterbilt (Paccar) completes second hydraulic hybrid refuse truck
- FedEx adding hybrid delivery vans; UPS buying 50; Purolator orders 115 Azure hybrid delivery vans





# HTUF National Meeting 2006

- 330+ attendees (20% increase from 2005)
  - One quarter fleet operators
- 14 med. & heavy hybrid vehicles
- 3 Working Group meetings and 1 PHEV Task Force meeting
- Every major truck maker and supplier in attendance



Co-Hosts:



Co-Sponsors:





# Newest Introductions



Peterbilt Class 7 hybrid utility truck

Oshkosh hybrid refuse truck



Freightliner Class 6/7 hybrid utility truck



IC/Enova hybrid shuttle bus



Kenworth Class 7 hybrid truck



ISE hybrid cutaway shuttle bus





# Class 8 Hybrids – New Possibility

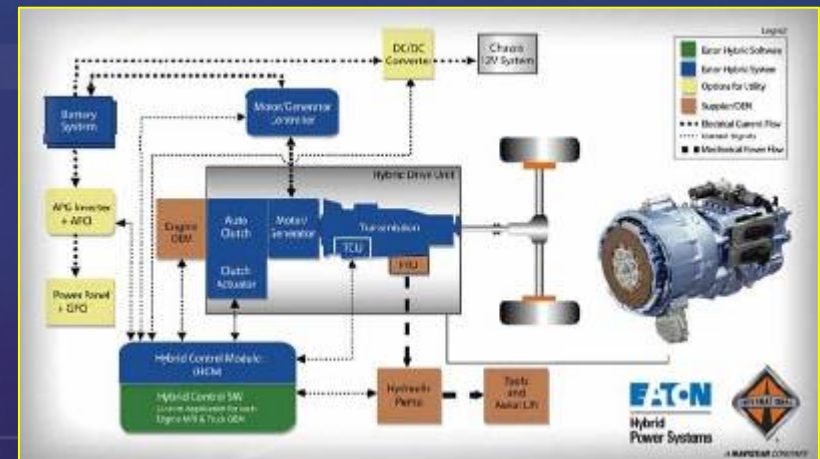
- Peterbilt/Eaton testing hybrid prototype of heavy-duty Model 386 tractor
- Example of the new capabilities and markets emerging for hybrid technology
  - Fuel economy, idle reduction combine for possible business case
- Port yard hostler hybrids to be developed in WestStart project with Ports of Long Beach and LA
- Vehicles common at port, rail and distribution centers





# Hybrid Emergency Response

- Hybrid emergency command center truck
- Generates field power – can also function on scene with engine off
- Framework for fire, ambulance designs
- Could be ideal FEMA, Guard, Homeland Security vehicle to be deployed with local agencies





# First Production

International: First “Production-Intent” Designs now being built

Building ~100 Class 6/7 hybrids

- More than 50 completed
- Remainder produced in June/July
- Incremental cost remains high and purchase assistance needed
- Roughly half are “utility” type trucks, half other applications (regional delivery/cargo, flatbed, reefer, etc.)
- **Can then move into early production – 1000 units per year to start**



*International 4300 Series Hybrid*



# Current Development Status

- Most major truck makers developing hybrids: International, Peterbilt, Kenworth, Mack, Volvo, Freightliner, Oshkosh, Ford (with Azure) Hino, Isuzu
- Several major system makers moving into or toward commercial production: Eaton, Allison, Azure, ISE, Enova, Bosch-Rexroth, Parker, BAE, Lockheed
- Major first-mover US fleets starting to adopt early units
- Still strongly US/North American technology leadership - but not assured

# Timeline to Commercialization: Hybrids Still Early in Trucks



<p><b>Development</b></p> <p>Test prototypes and systems</p>	<p><b>Pre-Production</b></p> <p>Field pilot assessments (10-50 vehicles)</p>	<p><b>Production Intent</b></p> <p>Assembly line builds of 100+</p>	<p><b>Early Production</b></p> <p>Initial commercial volumes – still high incremental cost</p>
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TOOLS:

*R&D Support* →

← *Purchase Incentives*

→ *Pre-Production Deployment Support (HTUF)*



# What's Needed?

- Trucks are different than passenger cars!
  - Hybrid concept similar; business case, volumes and technology availability different
    - No commercially available electric steering, braking, HVAC
  - Development transition 5+ years behind
- Industry could benefit from:
  - support for R&D – energy storage, electrified components;
  - funding to field pre-production fleets (10-100 vehicles per application);
  - enhanced commercially-focused purchase incentives
- Purchase incentives need to last longer, provide assistance to broader range of fuel economy benefits
- First-mover fleets ideally need up-front purchase cost reduced (tax credits not ideal tool for commercial vehicles)



# Guiding Principles of Heavy Hybrid Market Incentives

*To be meaningful, HTUF fleets and manufacturers find:*

- Incentives needed for longer time period (5-10 years)
- Incentives must be targeted at reducing the upfront purchase price
  - Need funds up-front for cash flow - incentive funds that reduce capital/purchase cost are the most valuable
  - Tax credits are not structured well to help commercial or public fleets – very little of the value reaches the fleet
  - The school bus incentive funds provide a possible model
- Incentives need to start at higher levels and decline over time
- Incentives need to encourage a broader range of meaningful improvements, not just the absolute highest achievable amounts
- There is a need to support both development and demonstration, and early sales
  - development and early commercial-path deployments
  - direct sales incentives for production vehicles
- Incentives should be simple to understand and administer
- Incentives should be technology neutral (allow electric and hydraulic solutions)

# Hybrid Truck Users Forum (HTUF)



- **User-driven process** to commercialize medium- and heavy-duty hybrid trucks in the U.S.
- **Joint WestStart-U.S. Army program (RDECOM-TARDEC-NAC)**
  - Also supported by Hewlett Foundation, DOE
- **HTUF focuses on commercializing hybrid trucks with dual-use benefits – pre-production**
  - Speed commercialization and reduce overall costs by creating common fleet requirements, joint purchase commitments, increasing volumes





# HTUF Working Groups



- **6 Core Working Groups of fleet truck users now operating, plus:**

- 1 WG partnership with NTEA (light truck)
- 1 new group forming (construction equip.)
- 1 Task Force: Plug-in HE Trucks (PHET)

- **Main Working Groups:**

- Utility/Specialty trucks – *George Survant, Florida Power & Light, lead*
- Parcel Delivery trucks – *Sid Gooch, Fed Ex Express; Bob Dengler, FedEx Ground; Robert Hall, UPS – user leads*
- Refuse Truck Working Group – *Matt Stewart, City of Chicago Sanitation, lead*
- Bus Working Group – *launched with support of Federal Transit Administration*
- Class 8 Working Group – *underway*
- Incentives Working Group – *underway*





# Parcel, Refuse & Shuttle Working Group Activities

- **Parcel/Delivery Working Group** - Involvement from key national fleets
  - (FedEx Ground; UPS; USPS; FedEx Express; Purolator)
- Joint purchase RFP for preproduction **hydraulic hybrid** in Class 4 (14,000 lb GVWR) and Class 6 (22,000 lb GVWR) – on street now
- **Refuse Working Group**
- 8 major fleets to date including private and municipal players
  - (Waste Management; Onyx; Cities of New York, Houston and Chicago)
- Joint purchase RFP on street now
- **Shuttle Bus Working Group**
- Kick off meeting Feb 2007
- Early targets: shuttles under 35-feet; paratransit; circulator bus
- Most of these buses built on truck chassis
- Developing performance requirements

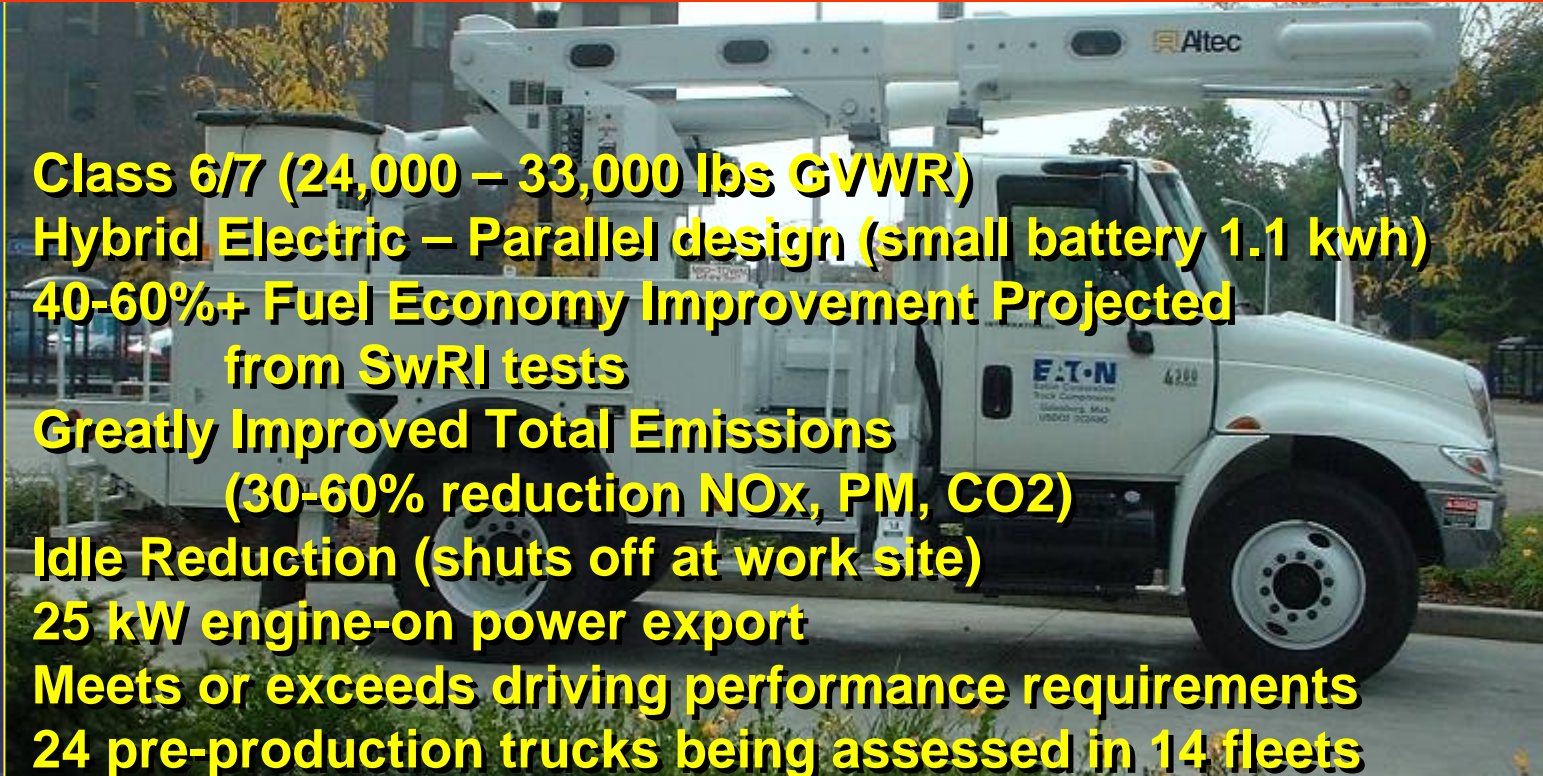




# First HTUF WG Deployment: Hybrid Electric Utility Truck

**All 24 Pre-production Trucks Now Deployed**

*Initial data shows good reliability; fuel economy varies by use  
Similar platform and driveline needs to medium military platforms*



**Class 6/7 (24,000 – 33,000 lbs GVWR)  
Hybrid Electric – Parallel design (small battery 1.1 kwh)  
40-60%+ Fuel Economy Improvement Projected  
from SwRI tests  
Greatly Improved Total Emissions  
(30-60% reduction NOx, PM, CO2)  
Idle Reduction (shuts off at work site)  
25 kW engine-on power export  
Meets or exceeds driving performance requirements  
24 pre-production trucks being assessed in 14 fleets**



# Class 6/7 Deployment Data to Date

- All 24 trucks now delivered – 6 months of service on first trucks
- 111 total truck months of service through Dec 06; 230,000 miles
- Availability of trucks high: 98.6% overall daily availability of hybrid systems
- Regular upgrades to pre-production trucks underway: DC-DC converters replaced; controller software updated
- Manufacturers challenged by more complex diagnostics of hybrids – but improving



## Fuel economy varies by fleet and use

- 55% fuel economy gain for highest fleet
- 10% fuel economy gain for lowest fleet
- Biggest variables: mileage driven versus work site “boom” time (more work site time equals better mpg)



# Fuel Use by Mission from Independent Testing

Fuel Use Reduction Over Baseline (revised):

- Mission A – **32%** reduction in fuel use
- Mission B – **35%** reduction in fuel use
- Mission C – **46%** reduction in fuel use
- Mission D – **48%** reduction in fuel use

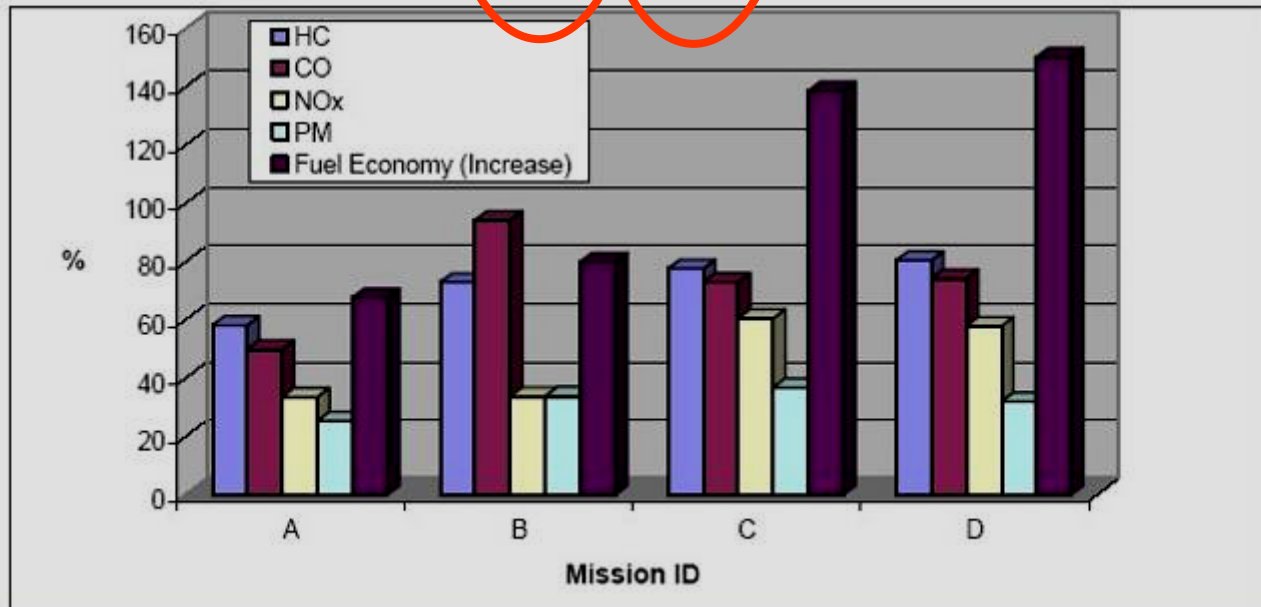




# Emissions Reductions by Mission

TABLE 10 AND FIGURE 9. PERCENT DECREASE IN RATE OF EMISSIONS (g/hr) AND PERCENT INCREASE IN FUEL ECONOMY (mpg) OBTAINED BY USING THE HEV TRUCK COMPARED TO THE BASELINE USING FOUR EATON-SPECIFIED MISSION CYCLES

Mission Cycle ID (given in Table 8)	HC (g/mi) %	CO (g/mi) %	NOx (g/mi) %	PM (g/mi) %	Fuel (mpg) % (increase)	Miles Driven	Hours of Operation (hydraulic + electric)
A	58	50	34	25	68	70	1.5
B	73	94	34	34	80	70	4.5
C	78	73	61	37	139	48	3
D	80	74	58	32	150	38	3



Reductions just from hybrid system, no additional after treatment

CO2 reductions closely tracked fuel reduction percentages



# Biofuel Hybrids: Multiplier Effect



- Hybrid vehicles combined with bio-fuel blends can lead to greatly increased petroleum offsets, GHG reductions
- Example from FPL:
  - *Hybrid utility trucks achieving 55% fuel economy increase, running on B30 blends, can cut in half the oil use of trucks they replace*
- Benefits vary by duty cycle, blend
- Reductions available today, not in future
  - for energy security and climate change



# What's Next?

Increase Volumes in Markets  
With Similar Drivelines to Lower Costs



# HTUF Planning

## Hybrid Truck Introduction Timing



2006

2007

2008

2009

HTUF Working Groups

Utility 24 trucks deploy

Delivery WG Pre-Production (15-30)

Refuse WG Pre-Production (15-30)

Utility Truck First Production (100)

Utility/Class 5-7 Truck Next Phase (500+)

Class 5 (15-50)

Shuttle/Paratransit (15-50)

Industry Launches

FedEx II (75)

FedEx III (75)

Purolator II (115)

UPS I (50)

Product Release Stages

Allison & BAE Bus Driveline production

International/Eaton 1<sup>st</sup> Production Class 6/7

Freightliner CC/Eaton 1<sup>st</sup> Production?

Azure 1<sup>st</sup> Production

Peterbilt/Eaton 1<sup>st</sup> Production?

Freightliner Class 7 Prototype – Field Pilot?

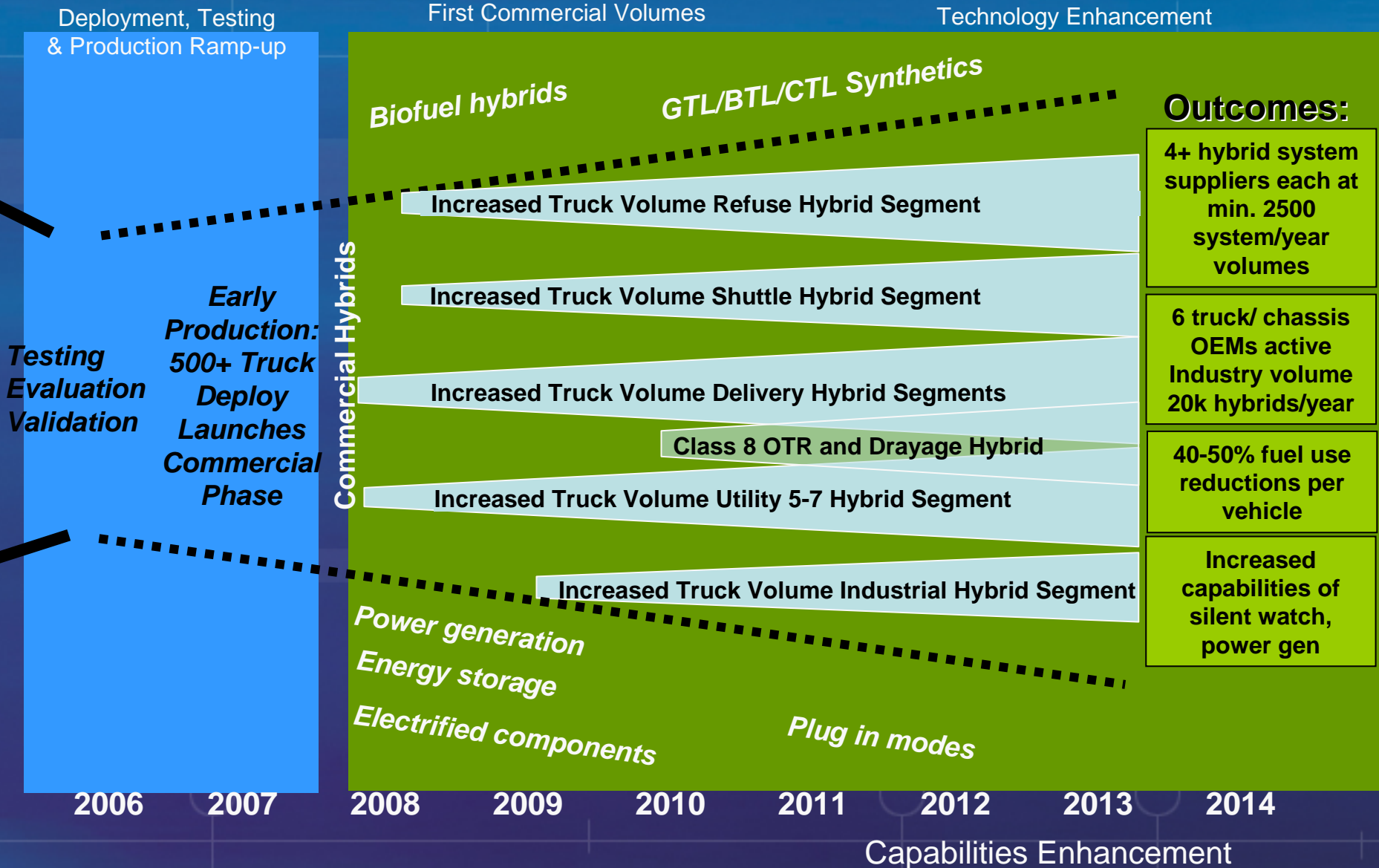
Volvo 1<sup>st</sup> Production

Peterbilt – Kenworth Class 7 Prototype – Field Pilot

Peterbilt Class 8 Concept

# HTUF: "Expanding the Funnel"

## Hybrids, Advanced Capability Trucks





# Conclusion: Status of Hybrid 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



# HTUF National Meeting 2007

- Join us in Seattle September 19-21
- 3-day event features light-duty options on first day – HTUF meetings day 2 & 3
- Technology and market progress
- Incentives getting special focus
- Special session on regional hybrid coalitions

**Clean Transportation Solutions <sup>SM</sup>**  
**Advanced Transportation Technologies <sup>SM</sup>**

**[www.weststart.org](http://www.weststart.org)**



**For info contact:**

**Bill Van Amburg  
(626) 744-5600**

**[bvanamburg@weststart.org](mailto:bvanamburg@weststart.org)**

**[www.htuf.org](http://www.htuf.org)**

