

# Heavy Hybrid Vehicle Commercialization Progress and Directions



*Advanced Transportation  
Technologies*

*Clean Transportation  
Solutions* SM

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May 3, 2007**



# Recent Hybrid News – Momentum Growing

- 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
- 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



# 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**
  - Speed commercialization and reduce overall costs by creating common fleet requirements, joint purchase commitments, increasing volumes





# 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



IC/Enova hybrid shuttle bus



Freightliner Class 6/7 hybrid utility truck



ISE hybrid cutaway shuttle bus





# Class 8 Hybrids – New Possibility

- *Peterbilt is now testing this hybrid prototype of its heavy-duty Model 386 tractor, an example of the new capabilities and markets emerging for hybrid technology*





# 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*



# Plug-In Hybrid Electric Trucks

- New prototypes in testing
  - Odyne refuse truck in Fresno
  - DCX Sprinter vans
  - School buses
- Business case still highly constrained by cost of energy storage
- Tech limitations: trucks need electric steering and braking to be effective – not yet commercially available





# 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



# HTUF Working Groups

- 4 Core Working Groups of fleet truck users now operating;
- 1 WG partnership with NTEA (light truck)
- 2 new groups forming (Class 8 and construction equipment)
- 1 Task Force: Plug-in HE Trucks (PHET)
  - 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
  - Shuttle Bus Working Group – launched with support of Federal Transit Administration

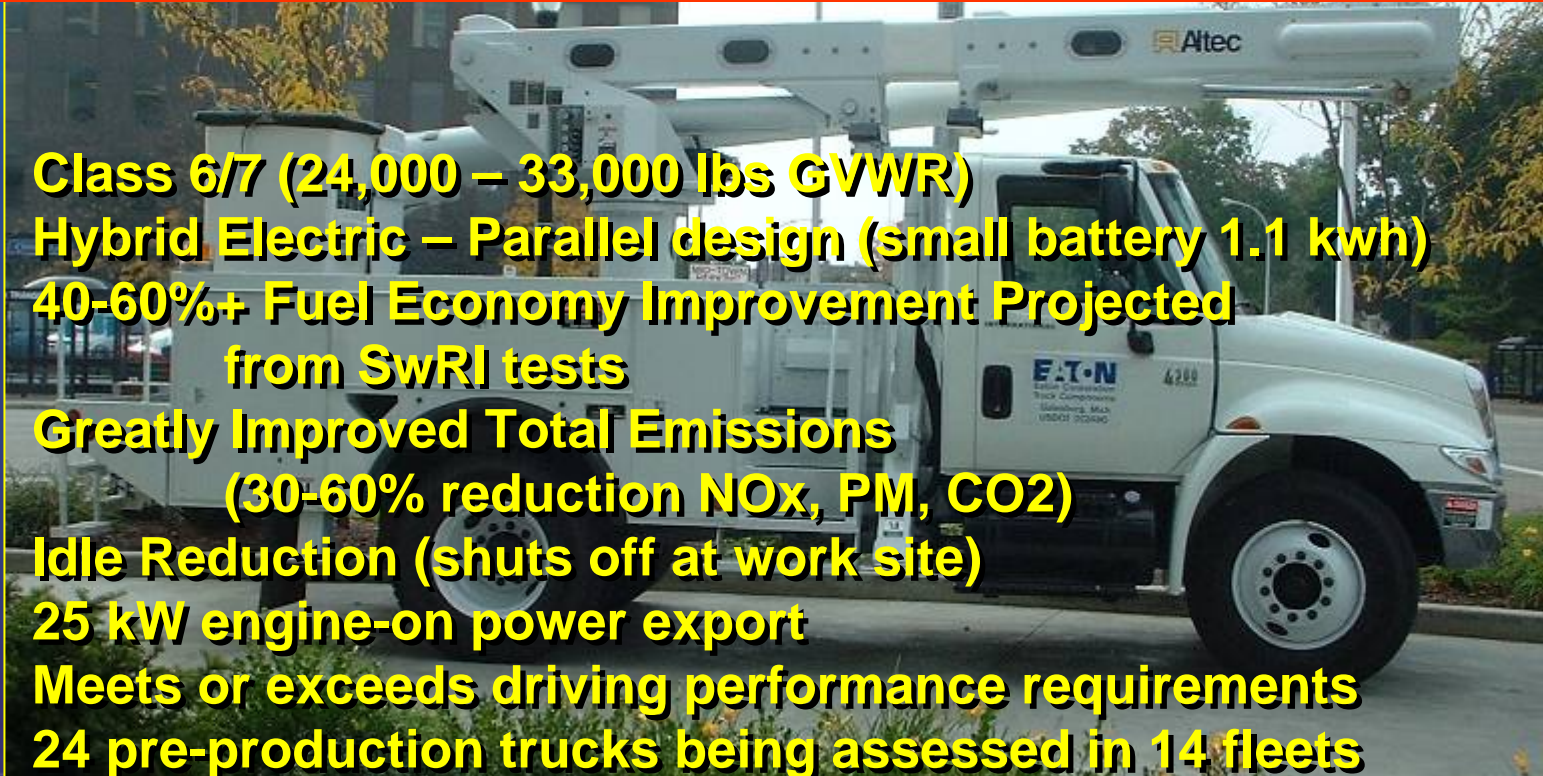




# First HTUF WG Deployment: Hybrid Electric Utility Truck

**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**

# 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





# Ports of Long Beach/LA Hybrid Yard Hostler Demo

- Project kicks off with port tenant in 2006
- Project Goals:
  - Establish requirements for a hybrid in yard hostler duty cycle
  - Seek commercial industry proposals to meet requirements
  - Build and test proof of concept prototype
  - Evaluate and analyze hybrid truck business case and commercialization potential and barriers
  - Considering linking HTUF WG to this effort to expand fleet involvement, explore military non-tactical truck interest



Other partners:  
Kalmar, LBCT, EPA



*Yard tractors are a common terminal vehicle at ports, distribution and shipping yards*

# 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



# 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

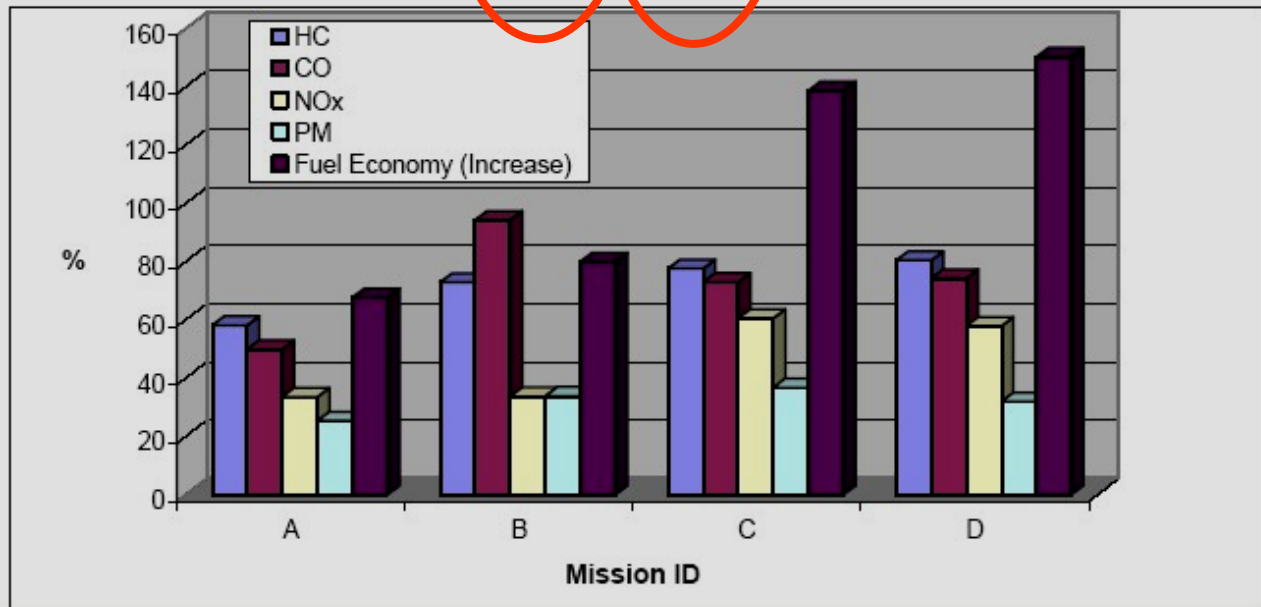




# Emissions Reductions by Mission

**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



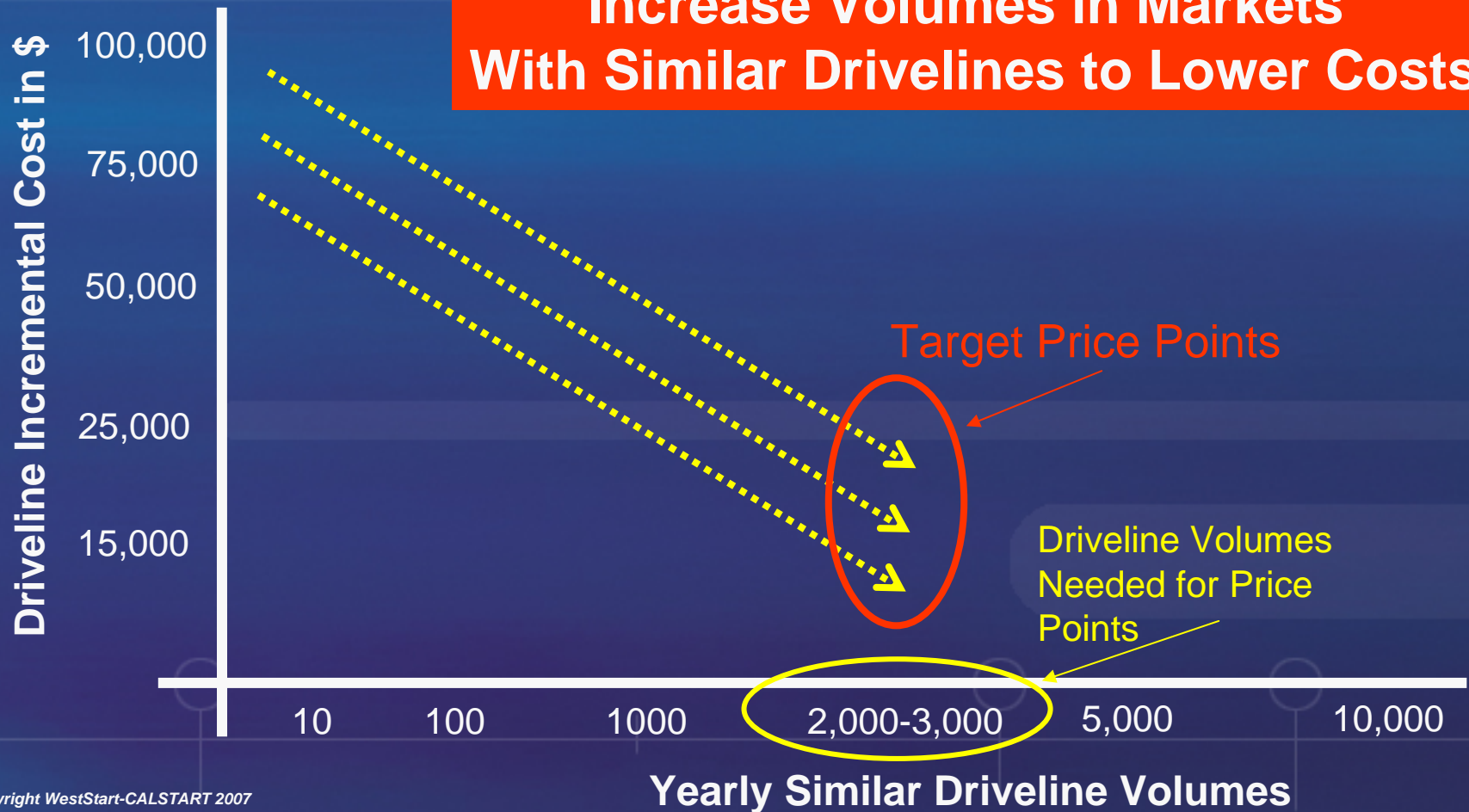
*Reductions just from hybrid system, no additional after treatment*

*CO2 reductions closely tracked fuel reduction percentages*



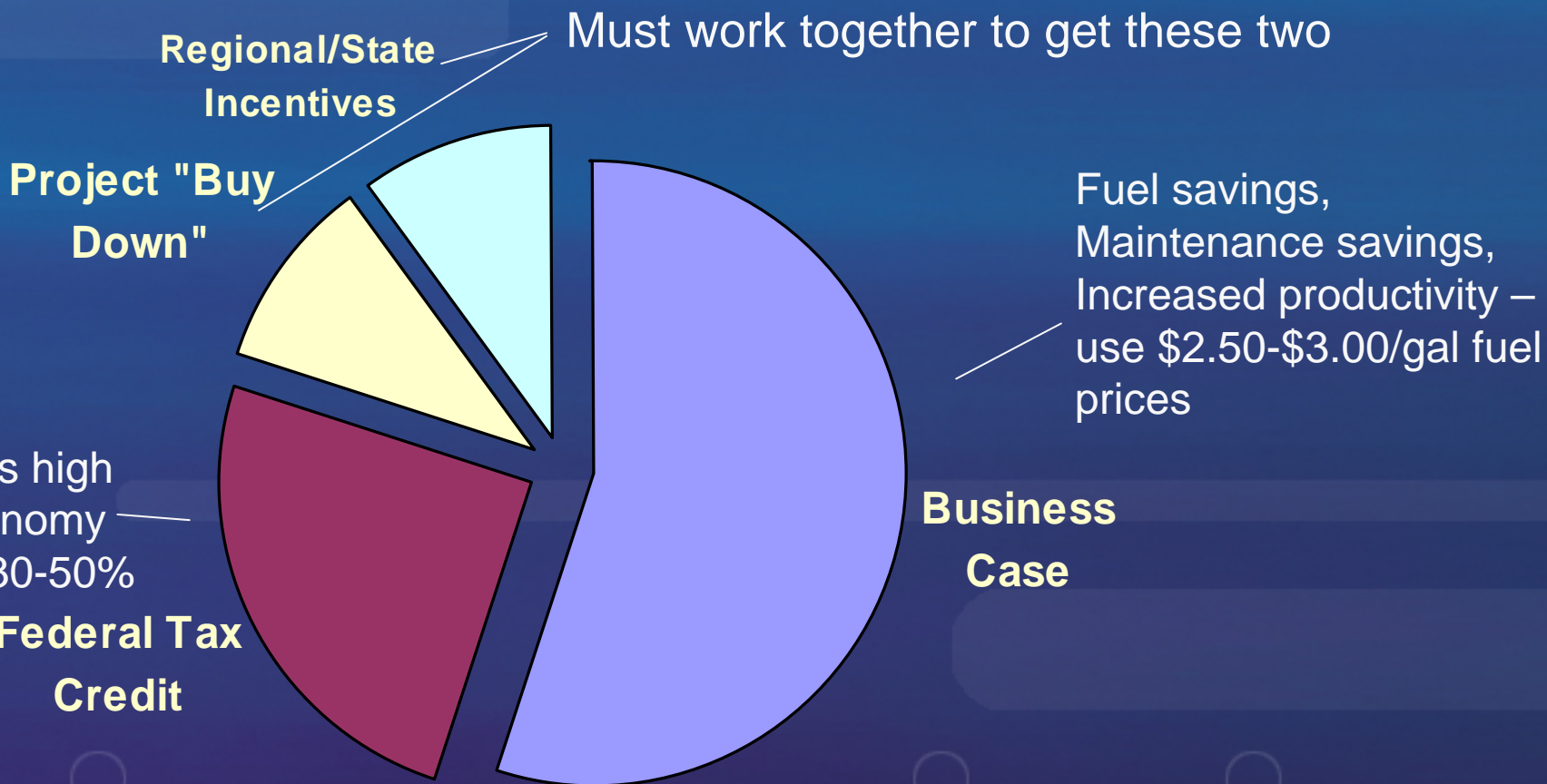
# What's Next?

**Increase Volumes in Markets  
With Similar Drivelines to Lower Costs**





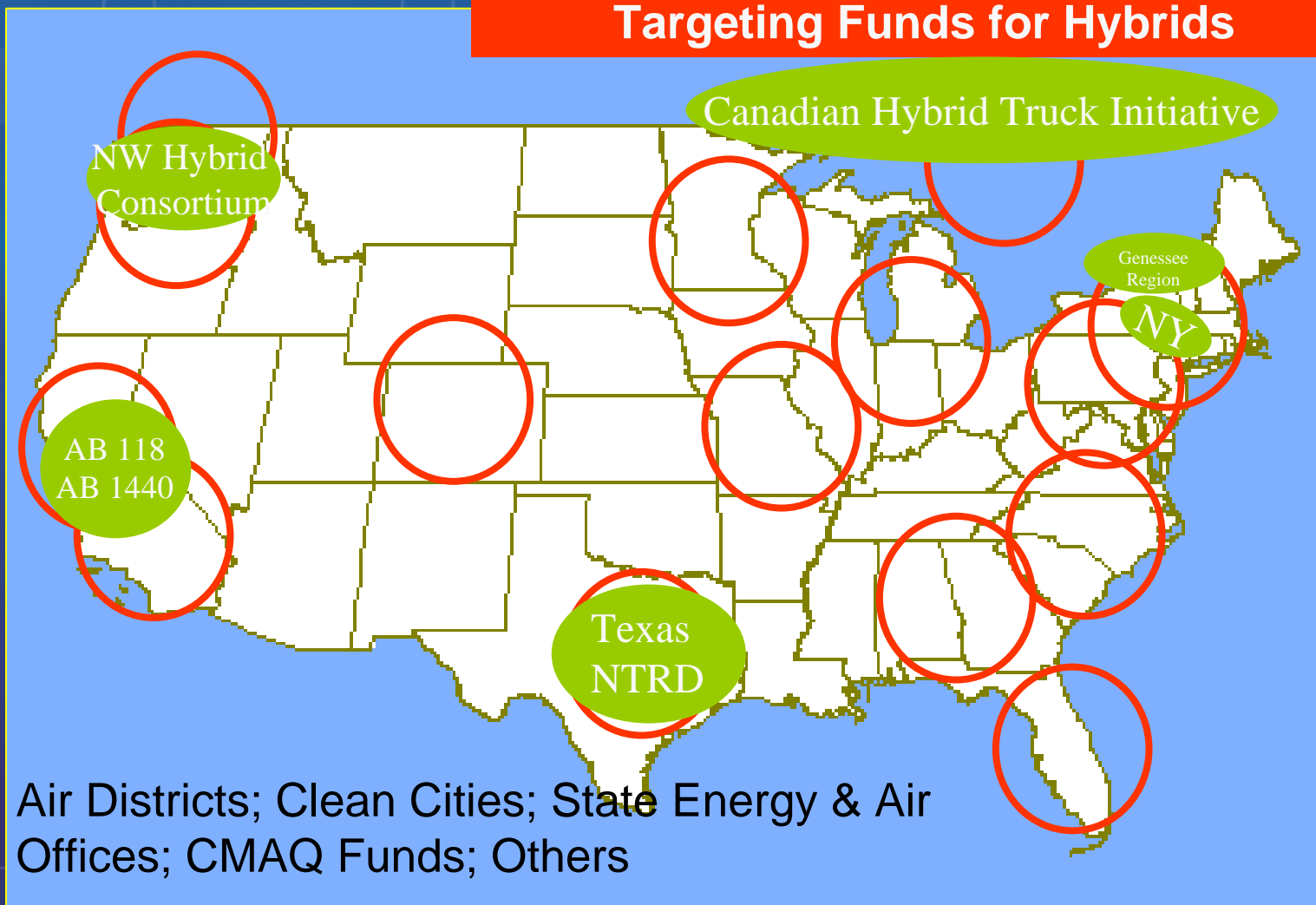
# Hybrid Incremental Cost – The “Wedges”





# In Next 2 Years, Need Additional Incentives

Developing Regional Hybrid Incentives:  
Targeting Funds for Hybrids



Air Districts; Clean Cities; State Energy & Air Offices; CMAQ Funds; Others



# NW Hybrid Consortium

## Good Example of Success:

- Public agency and private fleets in NW/Puget Sound region organized commitment to hybrid deployments with HTUF
- 14-plus fleets currently supporting in region
- Just have received \$250,000 from EPA (announced Nov 15) for 10 trucks, and additional \$150,000 from regional agencies to expand
- Key military assessment locations also in NW

## Fleet supporters include:



## Seattle Public Utilities



*Expanded Partnership: Discussing a joint conference in 2007 focused on committing to actions to reduce GHG and petroleum in transportation*

# Plug-in Hybrid Electric Truck (PHET) Task Force Activities



- HTUF held PHET Workshop Feb 13, 2007 in Los Angeles
- 45 attendees to explore interest, challenges for plug-in trucks
  - Southern Company sponsored meeting
- Biggest User Interests:
  - Fuel Savings & Emission Reduction increase over hybrids
  - Petroleum Displacement with electricity-Cheaper-Cleaner-Domestic
  - Down the road: carbon reduction?
- HTUF developing “road map” and possible next steps for PHET



# PHET Challenges: Similar, Yet Very Different

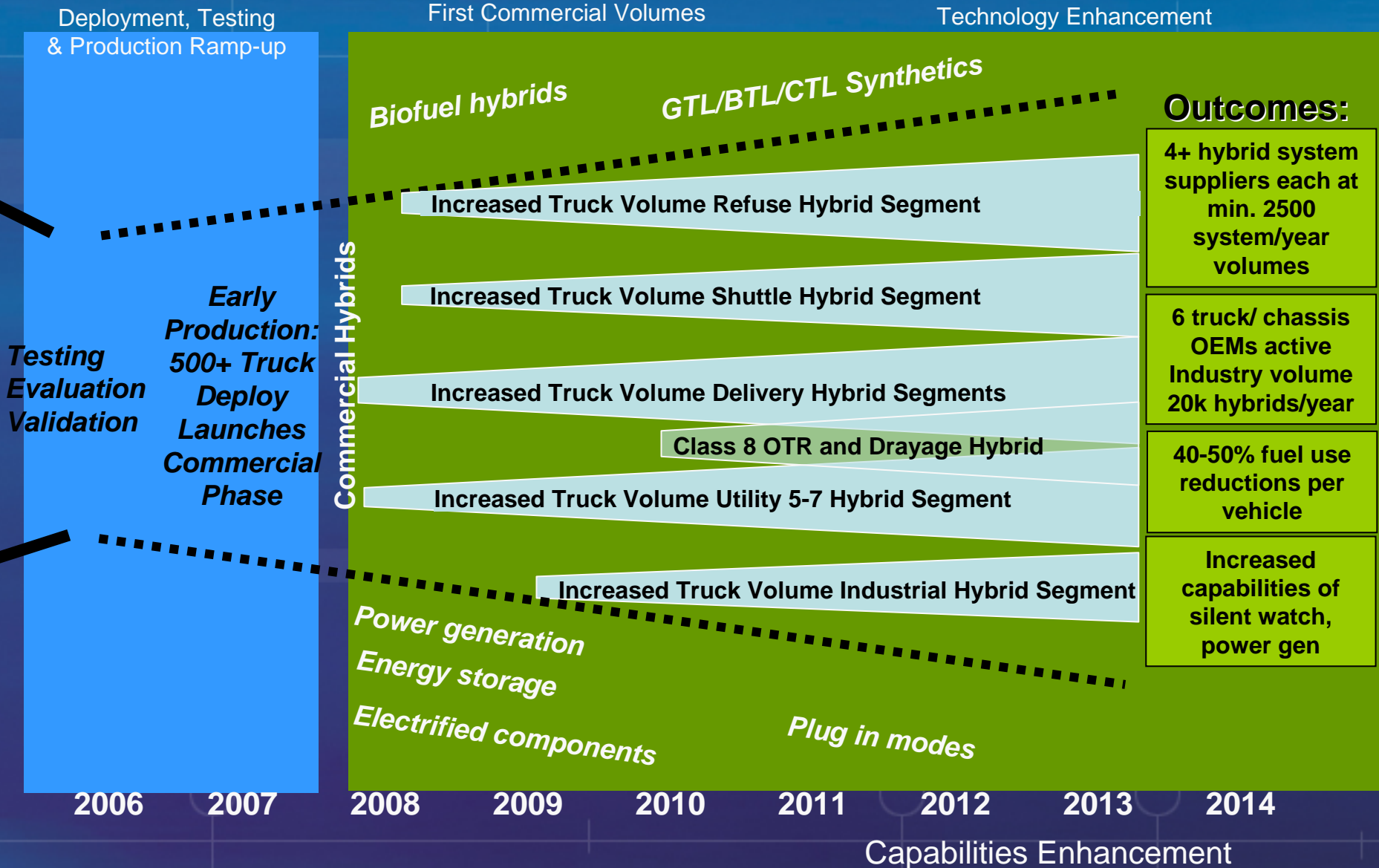
**Not simply  
a Hybrid  
Scale-up  
Strategy !**

\*Not yet  
commercially  
available in  
trucks →

	HEV	PHET
Plug	No	Yes
Battery	~ 1-2 kWh	>>> 2-10X
Charging	Motor only	Motor & Plug
Type of Battery	Power	Energy
SOC range	30/40 – 60/70%	20 – 80+%?
Thermal mngt	Yes	Yes <sup>+</sup>
Electrified components*	Valuable but not required	Yes
Electric drive	Launch	Full range
System weight	300-500 lbs	400-1000+ lbs
System Cost	\$40-60k +	TBD (battery)

# 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
  - Need assistance to cross cost gap to first production
  - Must increase early volumes, justify commercial investments from manufacturers
- **500+ truck deployment** is goal for next push of HTUF effort
  - **Next deployments will be highly leveraged** risk-share
  - Deployment stages go from pre-production (15-50 vehicles) to production intent (100+ vehicles) to early production (500+ vehicles) in each application/Working Group
- **Need Regional Partners for targeted incentives**
  - **States, regions are ideal structures**
  - Partnership of fleets, manufacturers and government
  - Need regional incentives and “aligned” incentives across regions



# HTUF National Meeting 2007

- Join us in Seattle September 19-21
- Technology and market progress
- Incentives getting special focus
- Exploring 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)**



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# Focus Area for HTUF: Top Early Hybrid Applications

**“Beach Head” Markets Show Best First Promise**

**Class 7/8 Refuse trucks**

**Class 3-6 Urban delivery trucks**

- package delivery
- beverage delivery

**Specialty Truck Applications (Class 4-7)**

- Utility “Bucket” trucks
- Telecom/cable trucks

**Class 6-8 Heavy Urban delivery trucks**

- regional heavy distribution (beverage, grocery, postal)

# HTUF "Commercialization Funnel"

