



Eaton Hybrid Hydraulic Technology & Development

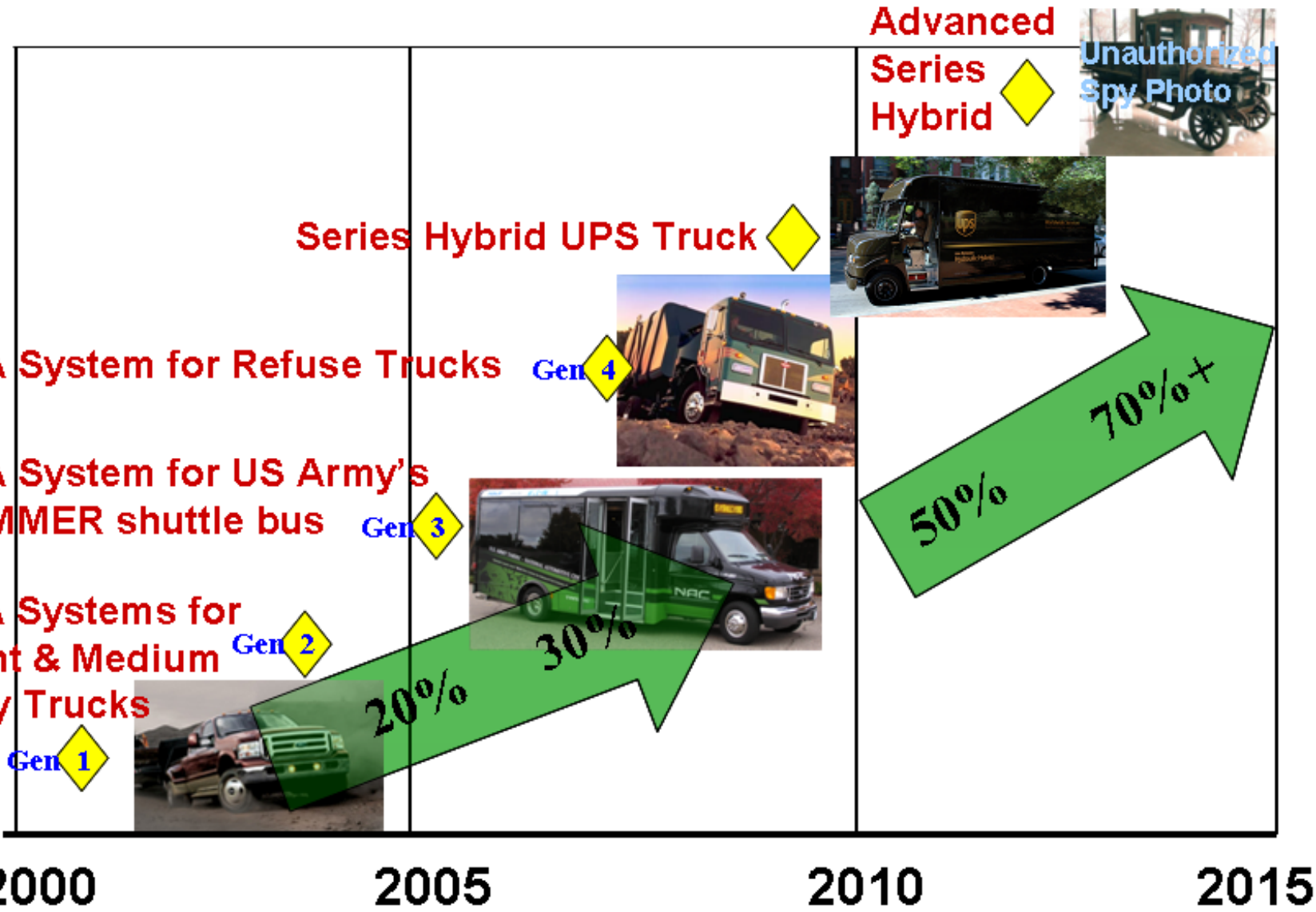
October 28th, 2009

Ben Hoxie
Chief Engineer, Series Hydraulic Hybrid



Eaton's Hydraulic Hybrid Development Roadmap

Fuel Economy Improvement



Advanced Series Hybrid



Series Hybrid UPS Truck



HLA System for Refuse Trucks Gen 4



HLA System for US Army's HAMMER shuttle bus Gen 3



HLA Systems for Light & Medium Duty Trucks Gen 2



2000

2005

2010

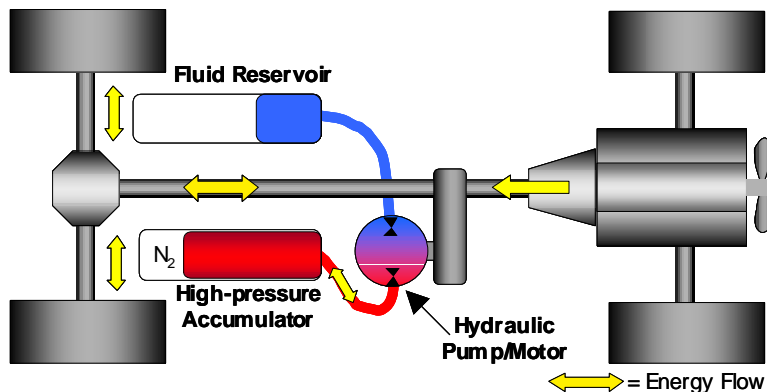
2015

Hybrid Drive Technology

... Hydraulic Hybrids: What are they??

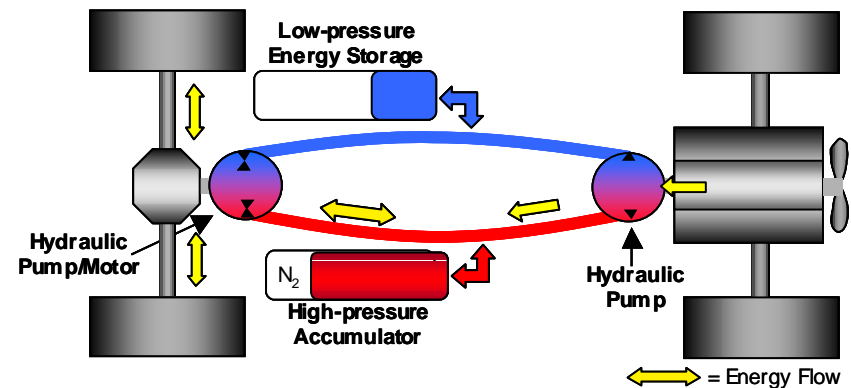
Parallel Hybrid (HLA system)

- **Attaches** to existing driveline
- Suited to heavy start-stop drive cycle
- 20-30% fuel economy improvement
- Increases vehicle brake life by 4x
- Productivity increase possible
- Reduced emissions for NO_x & CO₂
- Potential retro-fit opportunities



Series Hybrid

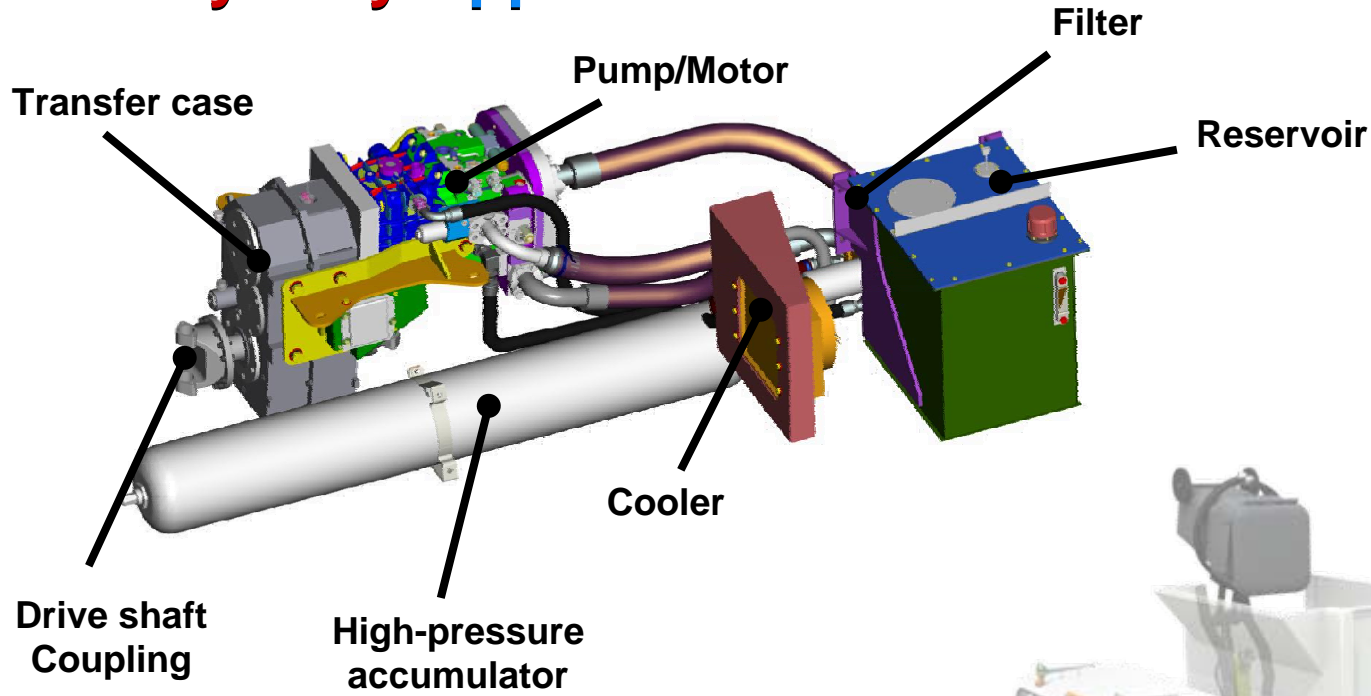
- **Replaces** entire existing transmission.
- Broad variety of duty cycles
- Energy Regeneration, CVT, Engine off
- 50%+ fuel economy improvement
- Increases vehicle brake life by 4x
- Reduced emissions for NO_x & CO₂
- 'Bundled' & fully integrated solution.



Eaton Hydraulic Launch Assist™ (HLA®) – System Overview

Designed for flexibility...

Heavy Duty Applications



The HLA System...

...Maximizing value to the refuse industry

2 Year payback based on:

Fuel savings

- Increased service intervals
- Productivity improvement

1000 gallons
per year per truck from
recovered brake energy

Brake service interval
demonstrated in fleet
to increase by 4x

Productivity improvement
possible due to 20%
increase in acceleration.
Otherwise engine resize
yields more fuel savings

Green Solution!!

Intangible value to end user;
Government Incentives

HLA System Development



2001: Ford F350



2006: Peterbilt 320 Refuse Application



2004: NAC Project Ford E450 Shuttle Bus



2007: HTUF Conference Continuous Operation



2008: Fleet Testing In Texas and Denver



2009: Production Release



2001 2002 2003 2004 2005 2006 2007 2008 2009

Current Status: HLA System

- Eaton is launching production this month on the Peterbilt 320 refuse chassis
 - Units are booked for Q4 2009
 - Currently taking production orders
- Other applications will follow

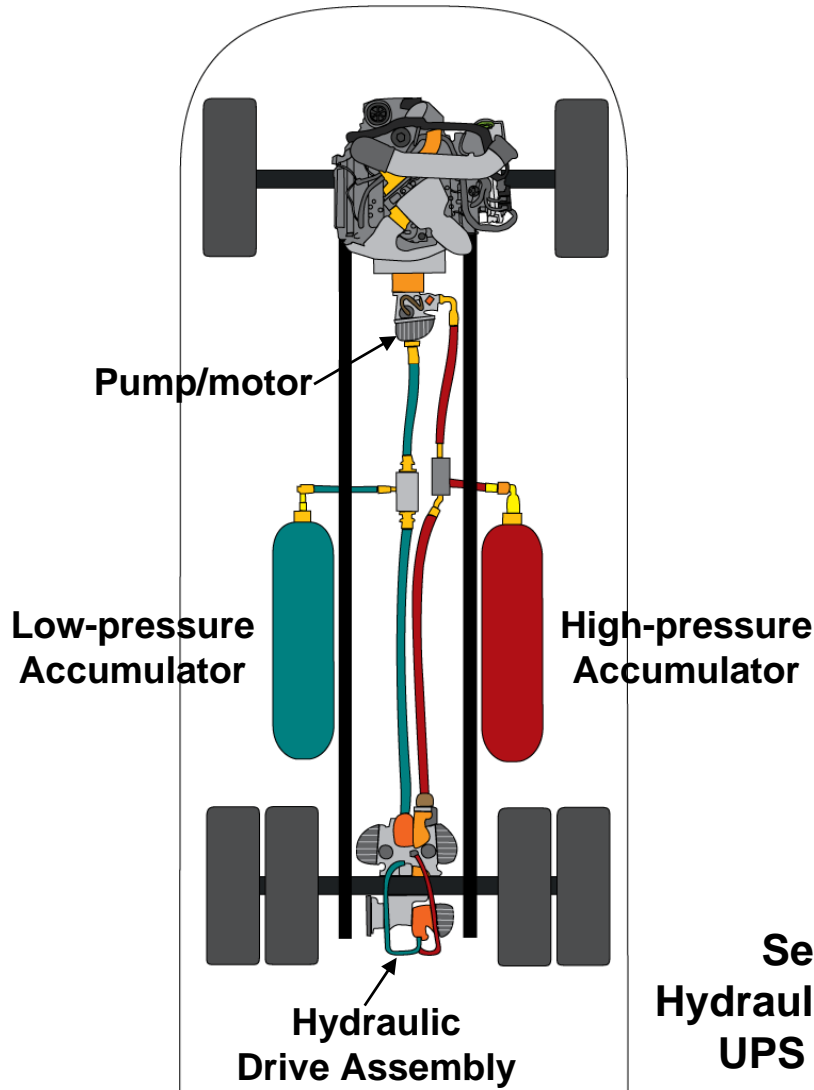


HLA Field Performance in Refuse Trucks

- HLA Systems Operation in Field: 10
- Truck Months Logged: 127
- Miles Driven: 530,000
- Stop-and-Go Cycles: 3,500,000
- Annual Savings: 1000 Gallons / Truck

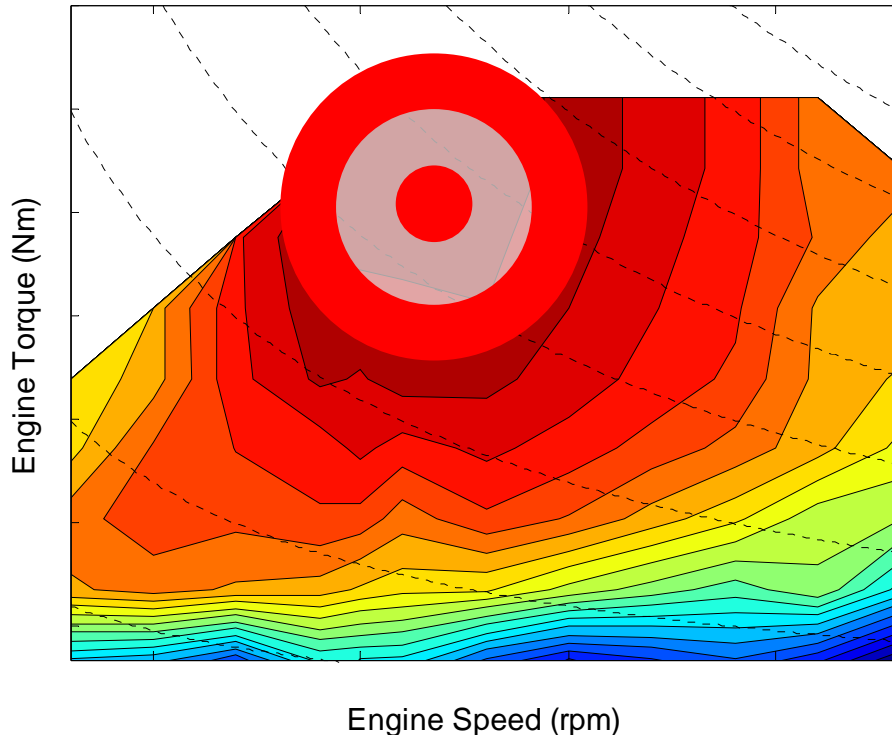
Eaton Series Hydraulic Hybrid – System Overview

Series Hybrid Hydraulic Drivetrain Architecture



- Driveline *replaced*;
Transmission removed; energy transferred from engine to drive wheels through fluid power.
- Technology suited to broader range of applications than a parallel hydraulic hybrid system though benefits are still greatest in stop and go duty cycles.

Series Hybrid Hydraulic Drivetrain



- SHH value proposition:
 - engine duty cycle modulation:
 - operating the system at a “sweet spot” of best fuel consumption facilitated by the IVT functionality of the hybrid system
 - “pseudo steady state” engine operation
 - Brake regeneration
 - Engine off function

Series Hybrid Hydraulic Drivetrain

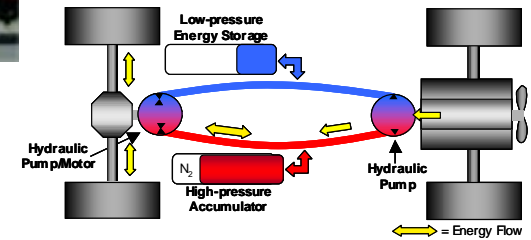
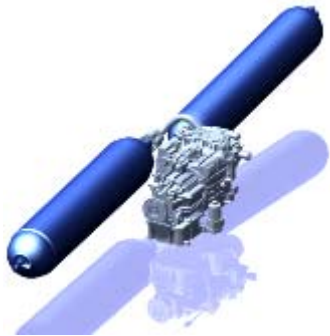
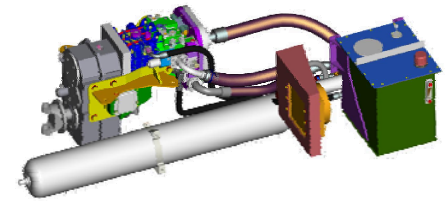
- The series hybrid hydraulic system demonstrated 50-70% improved fuel economy.
- A UPS truck equipped with the series hybrid hydraulic drivetrain was put into service in the Detroit area and achieved 45-50% better fuel economy in “real world” use.
- On October 27, 2008, UPS announced that they had ordered seven Class 6 package delivery vehicles with the Eaton Series Hybrid Hydraulic System.



Eaton's Hybrid Portfolio...



...Building Sustainable Green Solutions in Powering Business Worldwide



EATON

Powering Business Worldwide