



Hybrid Power



High Power, High Value, Hydraulic Hybrids

Brad Bohlmann
Business Development Manager, Advanced Technology
Eaton Corporation – Fluid Power Group

February 13, 2008



Eaton: A Proven Leader in Commercial Hybrid Vehicles

- Eaton is the only hybrid system supplier developing both hybrid electric and hybrid hydraulic solutions.
- This puts Eaton in the unique position of being able to offer our customers the best possible solution, not just the one we have.

HEV and HHV Comparison

- The value proposition for any hybrid is dependent on the vehicle's duty cycle.
- Hybrid electric systems have much higher energy storage capacity, and generally have low to moderate power capabilities.
- In addition, hybrid electric systems can more easily provide an auxiliary electric power source from the vehicle.



HEV and HHV Comparison

- Hybrid hydraulic systems have much higher power capabilities, for a shorter length of time.
- In addition, they typically regenerate more braking energy than hybrid electric systems.



HEV and HHV Comparison

- Eaton has studied both technologies in a wide variety of applications.
- We believe that there are significant opportunities for both technologies.
- In some cases the choice of technology is clear, in others it is less so.
- The market is still evaluating both technologies in many cases.

Eaton Hybrid Programs

Electric Hybrids

- Eaton has focused on building parallel hybrid electric systems, as they provide the best balance between costs and benefits.
- FedEx Express, UPS, and a number of utilities have incorporated the Eaton HEV into their fleets. We are also working with Coca Cola and a number of others.

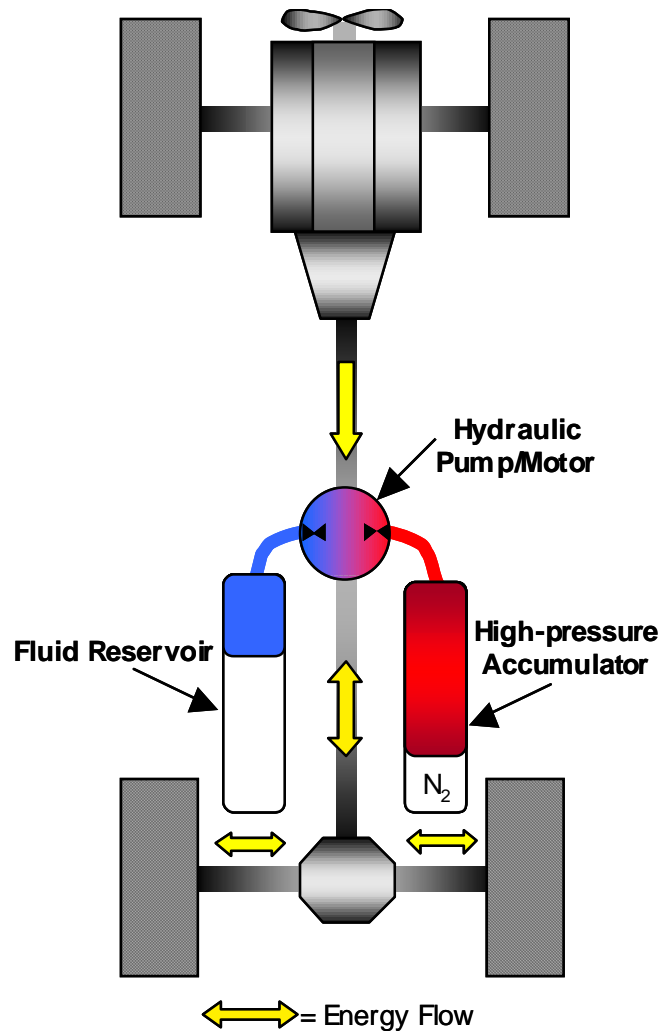


Hydraulic Hybrids

- Eaton has active programs on both parallel and series hybrid hydraulic systems. The target applications range from light to heavy duty commercial vehicles.
- The first Eaton parallel hybrid hydraulic system will be commercialized for refuse trucks in 2008.



Parallel Hydraulic Hybrid Architecture



Eaton HLA[®] System for Heavy Duty Trucks

- In a parallel hydraulic hybrid, the conventional vehicle driveline is *supplemented* by the addition of the hybrid system.
- The system is best suited for vehicles that operate in stop and go duty cycles. Examples include refuse trucks and buses.
- The value proposition is provided by:
 - Improved fuel economy achieved through regeneration of braking energy
 - Lower maintenance costs. Brake life is increased 2-4 times.
 - Improved productivity (e.g., more refuse pickups per day) due to the extra power the HLA system provides.
- Fuel economy and emissions improvements of 20-30% and payback periods of 3 years or less are possible in vehicles making frequent stops.

Current Status: HLA System for Light & Medium Duty

- A diesel hydraulic hybrid shuttle bus on a Ford E-450 chassis was delivered to the US Army in May 2006.
- The vehicle met or exceeded all of the program goals including demonstrating >25% fuel economy improvement on the EPA city driving cycle and reducing in-cab noise during acceleration by more than 6 dBA.
- Eaton is continuing its work applying the HLA system to light & medium duty commercial vehicles.



Class 4 Chassis Rolls Test Data

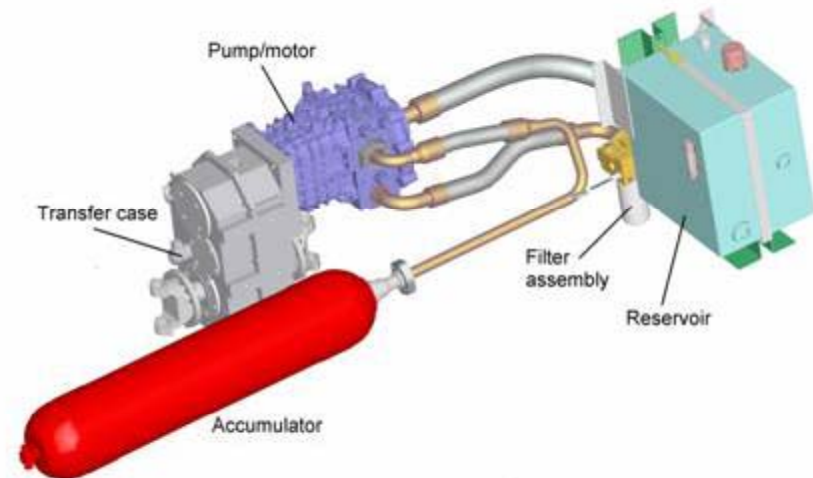
% improvement with the HLA System			
Vehicle Weight (lb)	NO _x	CO ₂	Fuel economy (mpg)
12,000	17.5%	20.8%	26.2%

Significant improvements in fuel economy and emissions

Ford E-450, 6.0L diesel engine, 5 speed automatic transmission
with an Eaton Generation 3 HLA system on LA-4 city driving cycle

Current Status: HLA System for Heavy Duty

- Eaton began delivering a fleet of refuse trucks with pre-production HLA systems to end users in December 2007. These vehicles will be used in refuse collection service for approximately one year.
- Eaton plans to release the HLA system for use in Peterbilt 320 refuse chassis in the second half of 2008.



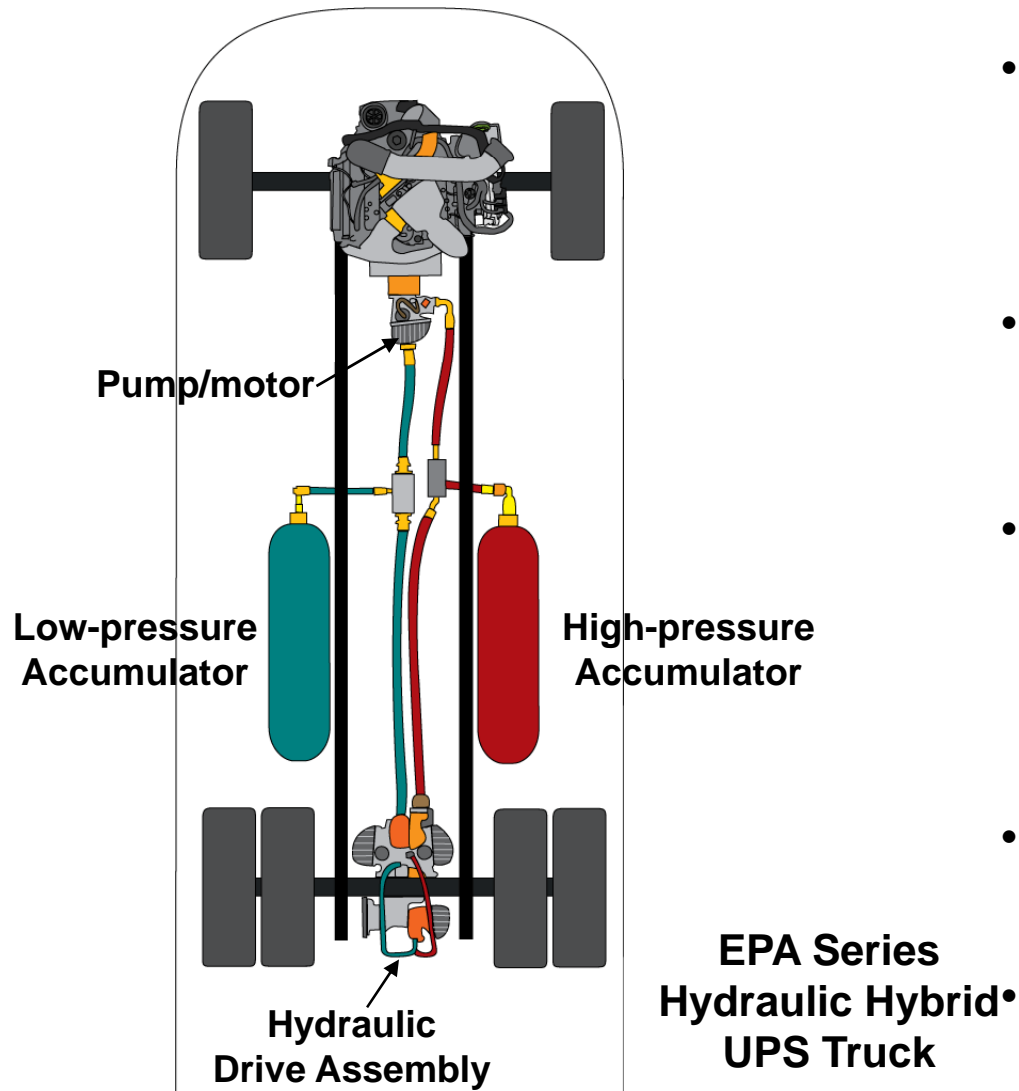
Class 8 Refuse Truck Test Data

	Economy Mode	Productivity Mode
Fuel Economy Improvement ¹	28%	17%
Vehicle Acceleration	+2%	+26%
Productivity (Cycle Time Improvement)	N/A	11.5%
Brake Life	>2x	>2x

¹ During waste pickup (100 feet between stops)

Vehicle Configuration: Peterbilt 320 chassis @ 63,000lb GVW
CAT C-10 315 hp engine
Allison 4560 5-speed automatic transmission

Series Hydraulic Hybrid Architecture



- In a series hydraulic hybrid, the driveline is *replaced* by the hybrid system. The transmission is removed and energy is transferred from the engine to the drive wheels through fluid power.
 - The technology is suited to a broader range of applications than parallel hydraulic hybrids, though benefits are still greatest in stop and go duty cycles.
 - The value proposition is provided by:
 - operating the engine at a “sweet spot” of best fuel consumption facilitated by the CVT functionality of the hybrid system
 - regeneration of braking energy
 - shutting the engine off when not needed
 - Fuel economy improvements with this technology are significantly higher than those attainable by the HLA system.
- This technology is in the prototype stage.

Current Status: Series Hydraulic Hybrid

- The series hybrid hydraulic UPS truck demonstrated 50-70% better fuel economy than a standard UPS truck over the EPA City Cycle with no degradation in performance.
- 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.
- Eaton plans to continue working to commercialize series hybrid hydraulic systems. These systems are several years from commercialization.



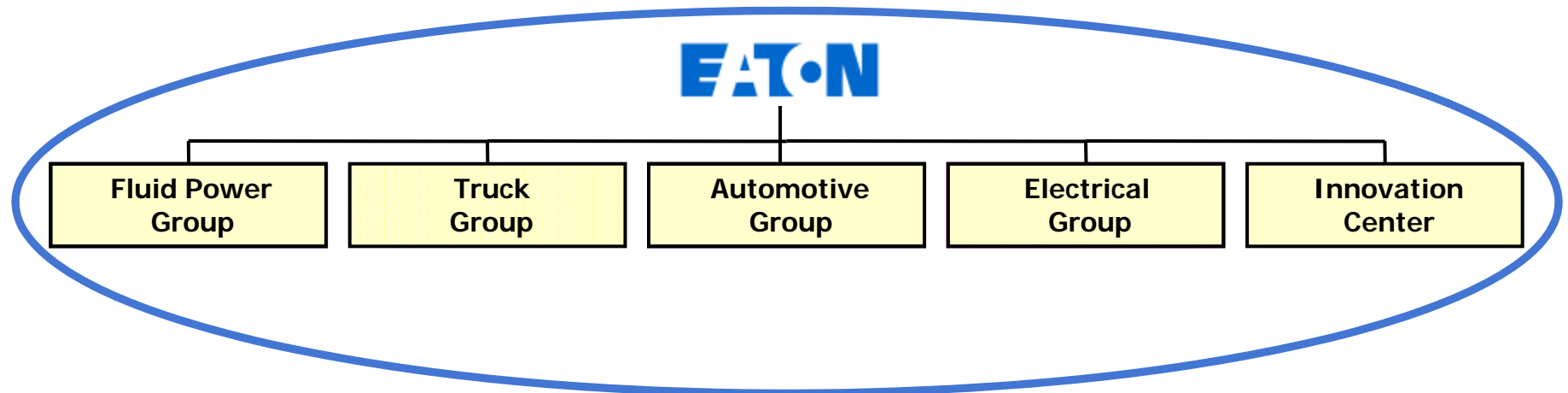
In Summary

- Eaton has made a substantial commitment to develop technologies that will simultaneously reduce energy consumption and exhaust emissions.
- Eaton is developing a portfolio of hybrid electric and hybrid hydraulic products that will provide solutions in a wide variety of on- and off-highway vehicles.
- Eaton is currently offering hybrid electric products for commercial vehicle applications and our hybrid hydraulic products will enter the market in 2008.

In Summary

- Eaton appreciates the visionary support provided by the State of Texas through its NTRD grant program. The grants we have received have helped to accelerate the commercialization of the HLA system.
- The State of Texas is benefitting today by being the first state to have fuel efficient and emissions reducing HLA systems in real world refuse collection service.

The Power of One Eaton



Eaton is globally positioned with world-class engineering expertise and manufacturing capabilities in the Fluid Power, Truck, Automotive, and Electrical markets.

Eaton Corporation
2006 Sales \$12.4B
63,000 employees
Sells products in more than 125 countries worldwide