

2008 FFCA - East Coast

Hydraulic Hybrid Yard Hostlers

Clean - Fuel Efficient - Cost-Effective

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What is a Hydraulic Hybrid?

A hybrid vehicle, in addition to its main engine, has a drivetrain that can recover and reuse energy

- ✓ A different kind of transmission, one that can recover, store and reuse power hydraulically (rather than electrically)
- ✓ An energy storage system
- ✓ A hydraulic drive system to convert the stored energy to motive power

Hydraulic Hybrids

- Store energy in hydraulic accumulators
- Use hydraulic pump-motors

Electric Hybrids

- Store energy in batteries and/or ultra-capacitors
- Use electric generator-motors

EPA Hydraulic Hybrid Timeline

Chassis 6 – Taurus size

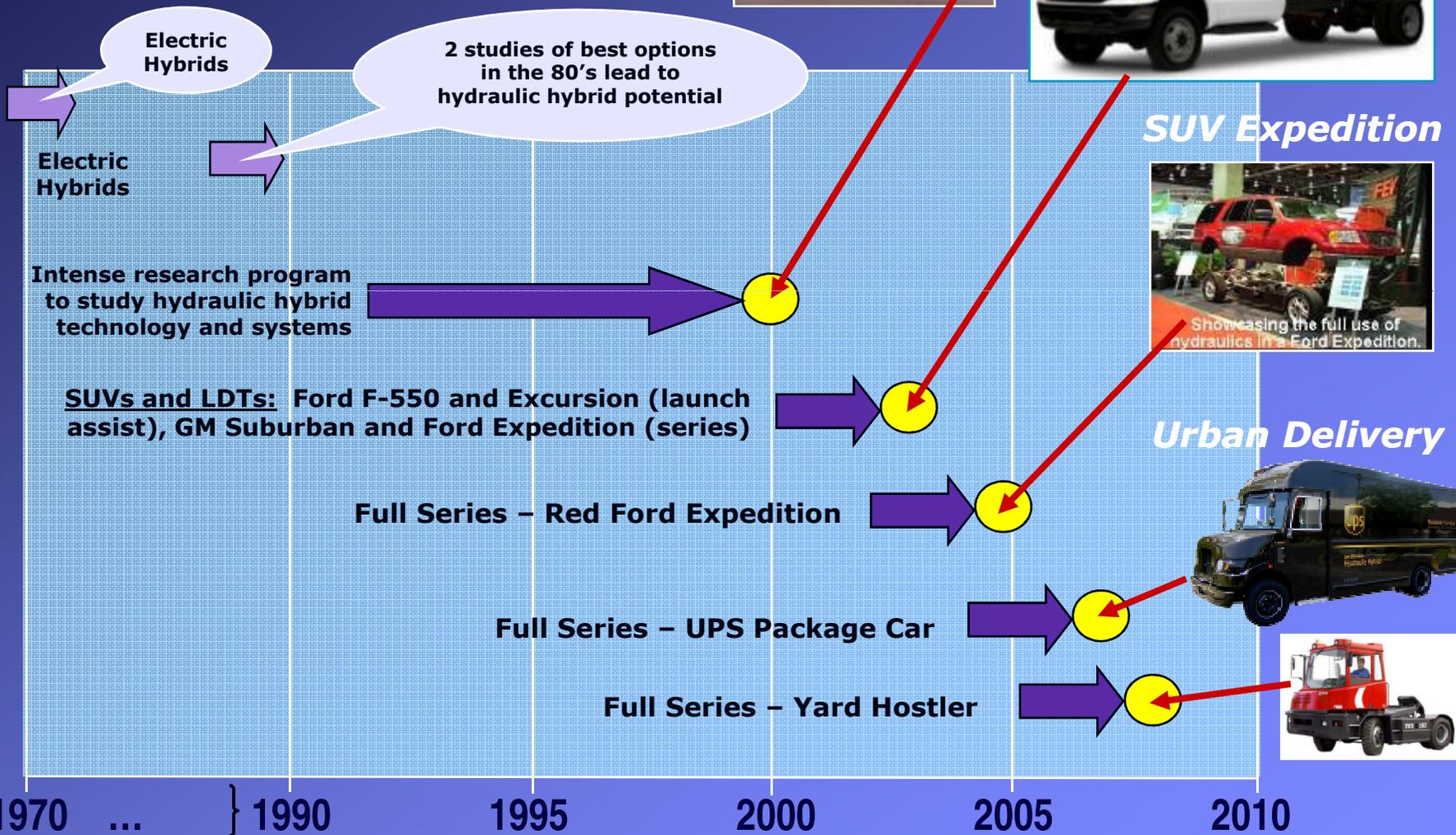
F-550 Work Truck



SUV Expedition



Urban Delivery



Series Hydraulic Hybrid Yard Hostler

Projected Benefits



- 50-60% projected efficiency improvement in port operation (preliminary)
- Fuel savings \$40,000 with \$4.75/gal fuel costs (7 years for first owner)
- Real-world demonstration to accelerate technology transfer to industry & familiarity with technology

Series Hydraulic Hybrid Yard Hostler

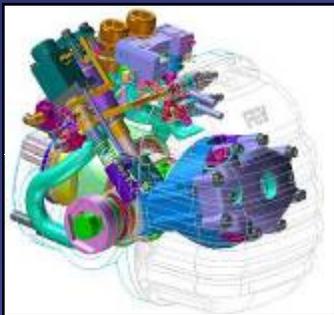
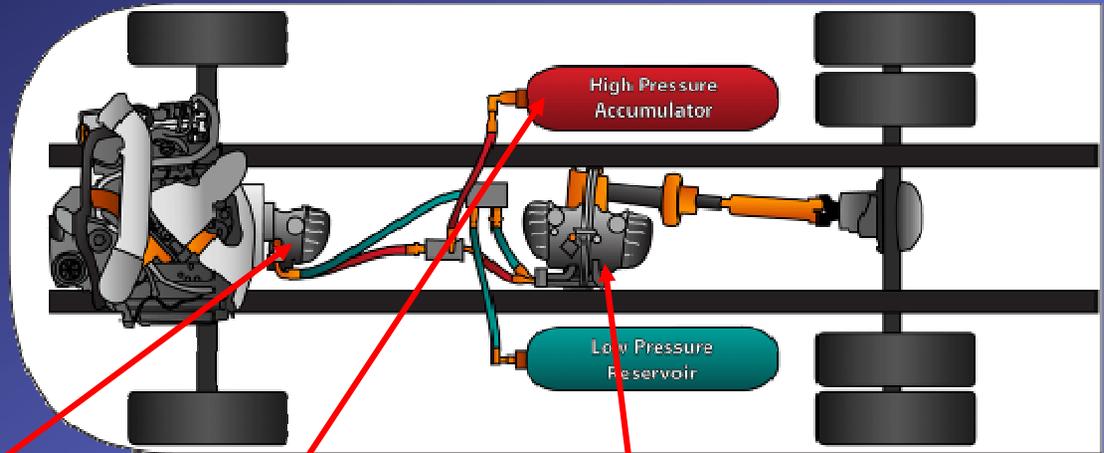


**APM
TERMINALS**



APM Terminals – Port Elizabeth, NJ

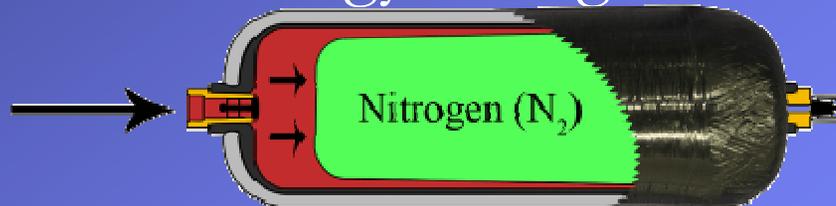
Basic Hydraulic Hybrid Components



#1 - Engine Bent-Axis Pump



#3 - Energy Storage Tank



As fluid enters either accumulator the nitrogen (N₂) in that accumulator compresses and its pressure rises.

#2 - Drive Bent Axis Pump-Motor

#4 - Oil
(Synthetic ATF)

Series Hydraulic Hybrid Urban Delivery Vehicle

Projected Benefits



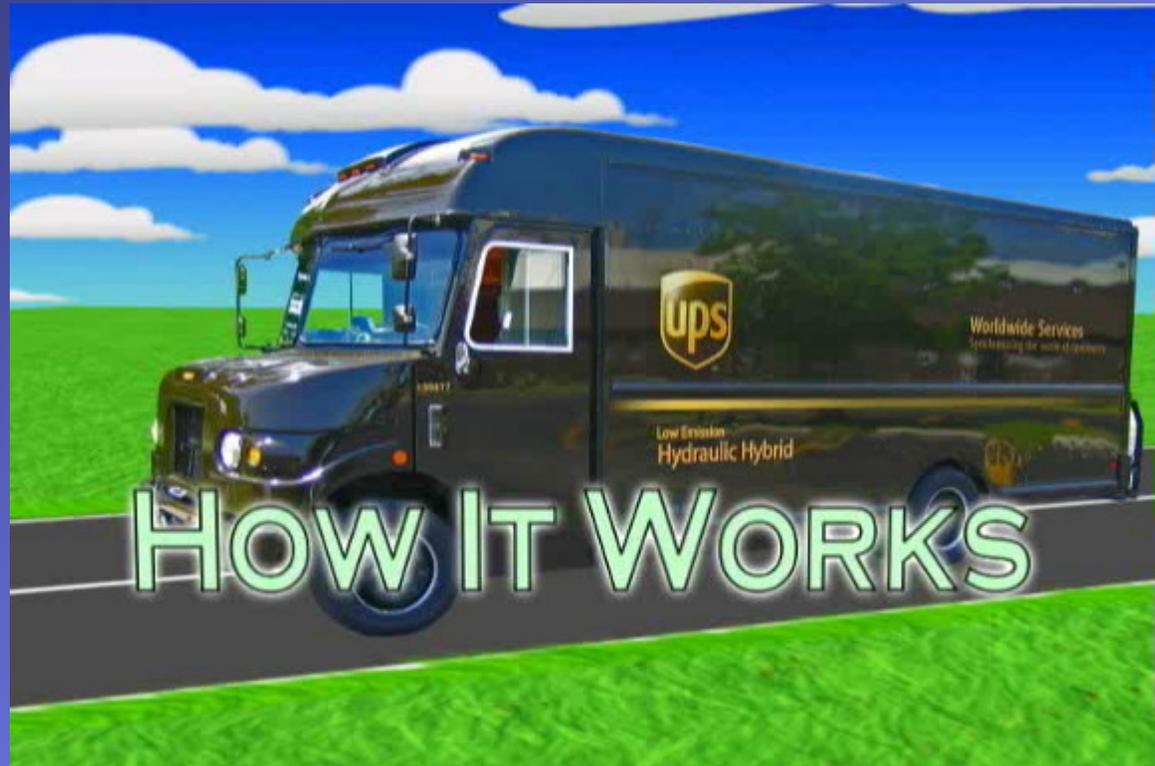
- 60-70% mpg improvement in city driving
- 2-3 year payback has attracted attention from fleets
- Potential for net Lifetime savings over \$85,000 with \$4.75/gal fuel costs
- Demonstration to accelerate technology transfer to industry & familiarity with technology
- Partners (UPS, Eaton, International Truck, US Army)

On-Road Field Testing



- **Field Tests** – On-road field testing during normal on-route package delivery began last fall in the Detroit area.
- **45-50% Initial In-Service MPG Improvement using Prototype Hardware** – More MPG is coming through improved engine-off accessories, new engine pump, more engine off time, lower weight
- **UPS Very Pleased with Initial Results** – With how the vehicle performed, and with fuel economy gains demonstrated in these early tests.
- **More Testing** – Additional field testing is focusing on evaluating the performance characteristics of options for potential “pre-production” trucks.
- **Durability Testing** – Mileage accumulation durability testing will begin in early 2008.

How Series Hydraulic Hybrids Work



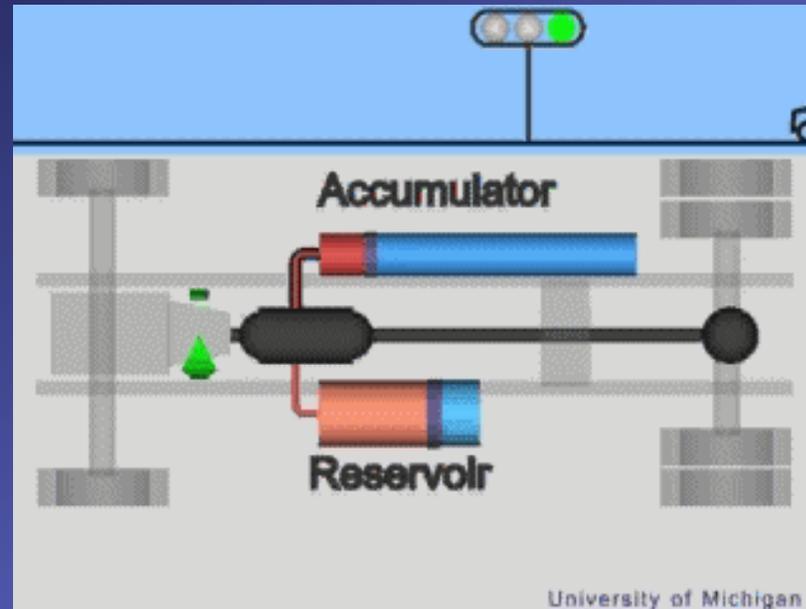
Why Series Hydraulic Hybrids?

- ✓ Highest possible fuel economy
- ✓ Lowest incremental cost
 - Shortest payback to owner
 - Highest lifetime-savings
- ✓ Ultra-low emissions
- ✓ Enables unique high-efficiency engines
- ✓ Greater reductions in greenhouse gases
- ✓ Greater reductions in imported oil

HHV Drivetrain Configurations

Parallel HHVs

- ✓ Engine
- ✓ Transmission
- ✓ Drive Pump/Motor
- ✓ Drive Shaft
- ✓ Rear Axle

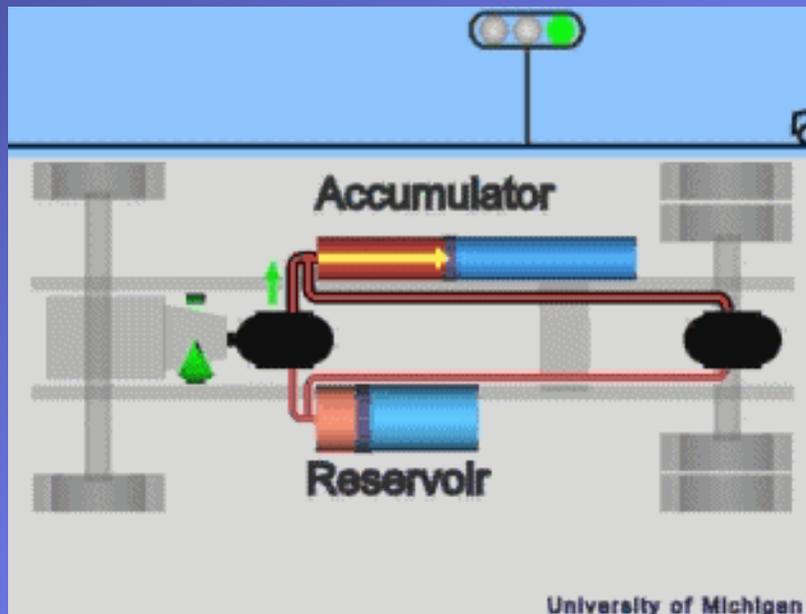


Benefits

- ✓ Fuel savings
- ✓ Reduced emissions
- ✓ Reduced brake and engine wear

Series HHVs

- ✓ Engine
- ✓ Engine Pump/Motor
- ✓ Drive Pump/Motor
- ✓ Drive Shaft (in some designs)
- ✓ Rear Axle



Benefits

- ✓ Greatest fuel savings
- ✓ Reduced emissions
- ✓ Reduced engine on-time (no idling)
- ✓ Reduced brake and engine wear
- ✓ Lowest Cost

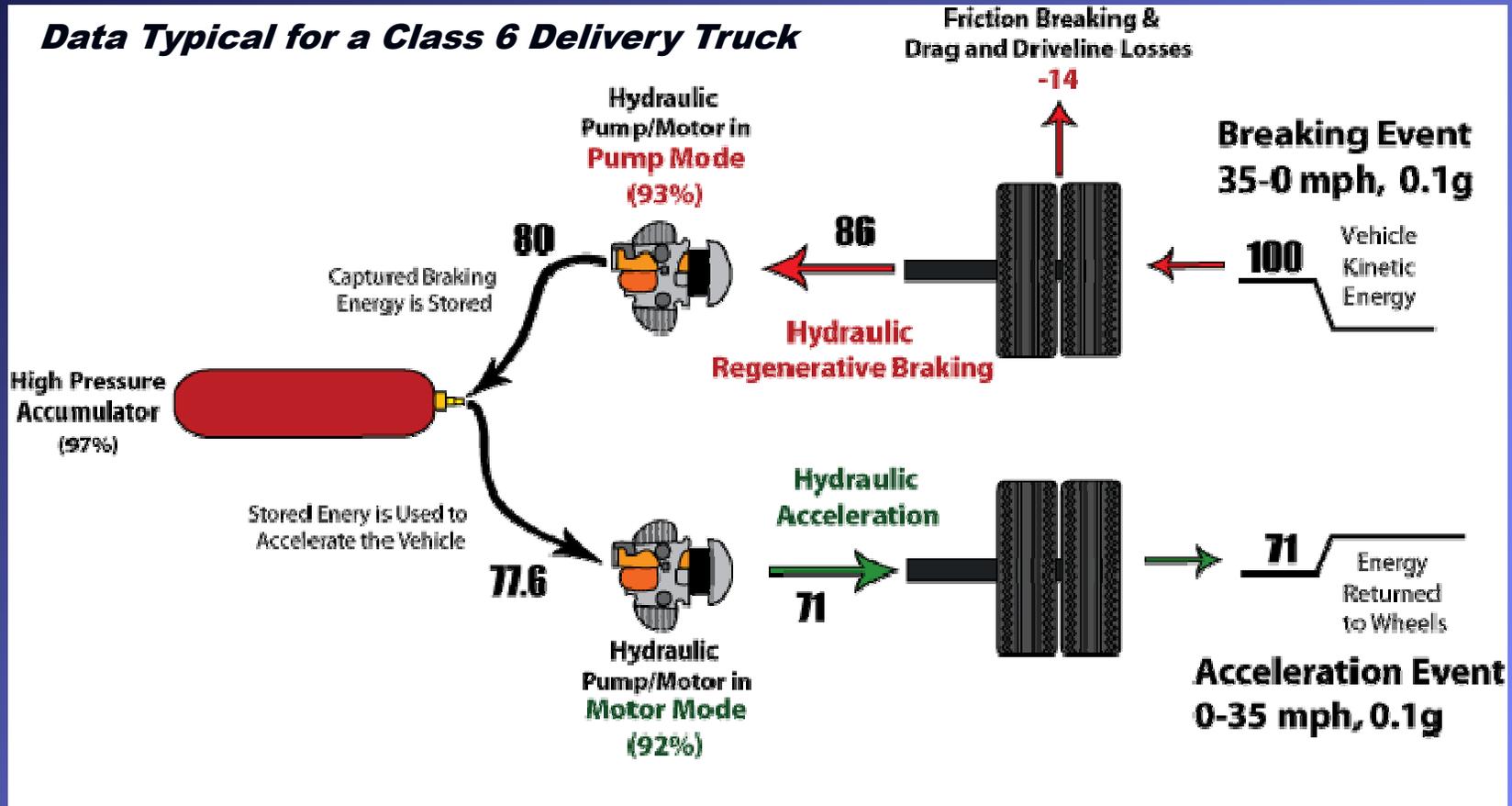
How It Works...

Strategies Which Increase Average Vehicle Efficiency

- 1. Capture and re-use energy normally lost to friction braking**
 - ✓ Regenerative Braking
- 2. Improve average efficiency of engine / drivetrain**
 - ✓ Operate engine at best efficiency
 - ✓ Shutoff engine at idle
 - ✓ Shutoff engine at all times when not needed (such as during braking and acceleration)

How It Works...

Efficiencies While Braking/Accelerating



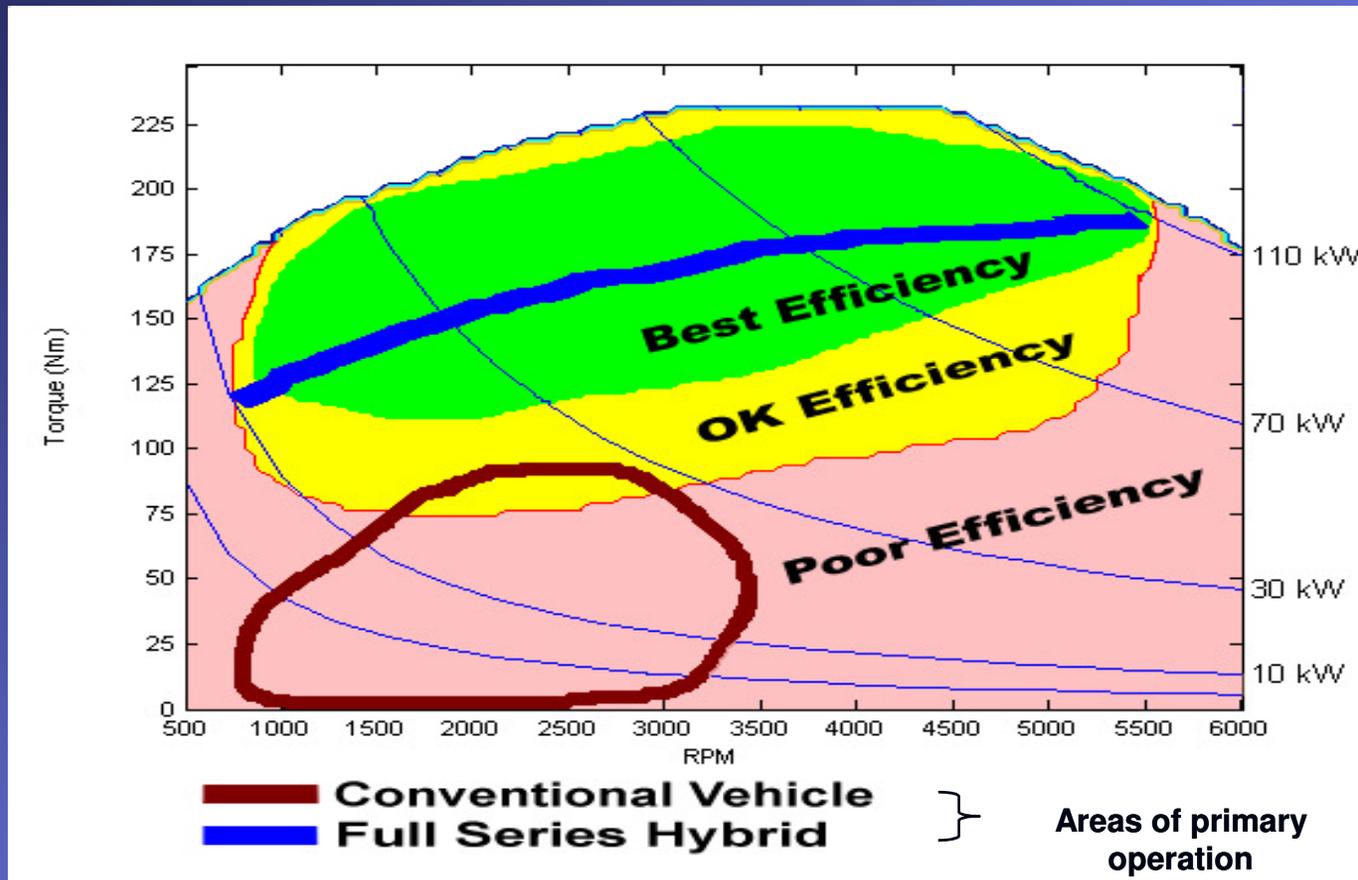
Analysis courtesy of **Automotive Research Center** – University of Michigan

Hydraulic Hybrids >70%

Electric Hybrids <25%

How It Works...

Power Map for a Typical Engine for Series Hybrids



More Information...

- ✓ **Hydraulic Powertrains Propel These Hybrid Trucks**
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<http://designnews.com/article/CA6451735.html?nid=3077&rid=1294693122&>
- ✓ **Hydraulic Hybrid Promises Big Savings for UPS**
Hydraulics and Pneumatics, October 2006
<http://www.hydraulicspneumatics.com/200/Issue/Article/False/38545/Issue>
- ✓ **EPA Delivers with Fully Hydraulic Hybrid Truck**
Hydraulics and Pneumatics, October 2005
<http://www.hydraulicspneumatics.com/200/Issue/Article/False/11985/>
- ✓ **Video Overview** – Daily Planet/Discovery Canada, November 2007
<http://mfile.akamai.com/31560/wmv/fs6.insinc.com/akamai/ctv/discovery/lowres/DISC-DPLA-071126-EP.hydraulicshybrid-preview.wmv>
- ✓ **2007 Michelin Challenge Bibendum** - Results: “The winner of delivery-truck category represented one of the most interesting technologies.” — *AUTOWEEK*, Jan 14, 2007.
- ✓ **Progress Report on Clean and Efficient Automotive Technologies Under Development at EPA** - January 2004
<http://www.epa.gov/otaq/reports/adv-tech/420r04002.pdf>
- ✓ **EPA’s Clean Automotive Technology**
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CLEAN AUTOMOTIVE TECHNOLOGY



www.epa.gov/otaq/technology