World's First Full Hydraulic Hybrid SUV Presented at 2004 SAE World Congress

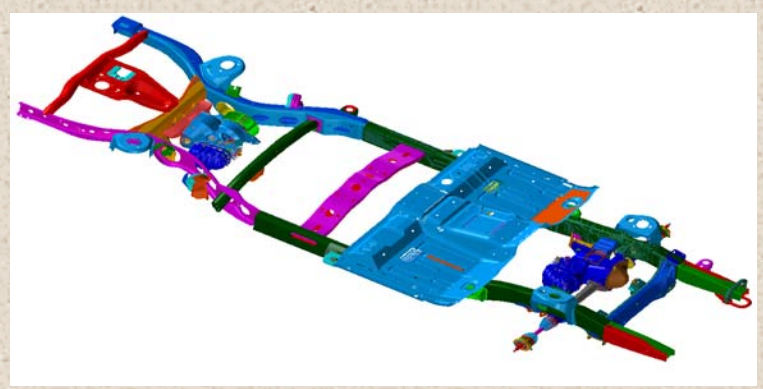
- In collaboration with its partners, the U.S. Environmental Protection Agency (EPA) has been researching advanced technology for the past ten years. EPA has had research partnerships with several organizations including Ford Motor Company, Eaton Corporation, Army's National Automotive Center and Parker Hannifin Corporation.

- Hydraulic hybrid technology is one of the EPA research areas, with the vehicle presented at SAE being the first-ever SUV with a fully hydraulic drivetrain.

- Hydraulic hybrids increase vehicle fuel economy in two main ways: they allow the engine to be operated at much more efficient modes and they permit the recovery of energy that is otherwise wasted in vehicle braking.

- The vehicle displayed was a diesel hydraulic hybrid with a projected 55% improvement in fuel economy due to the hydraulic hybrid technology. The hydraulic hybrid technology is projected to increase the cost of a large SUV by about $600, which would be quickly recouped by the consumer's lower fuel and maintenance costs. Another 30-40% improvement is available through the conversion of the gasoline engine to a diesel engine.

- Improved fuel economy reduces greenhouse gas emissions, lowers dependence on imported oil, as well as saves consumers money.



- Full hydraulic hybrid technology means that the conventional transmission and transfer case have been removed and replaced with a hydraulic drivetrain; EPA has also replaced the large gasoline engine with a small diesel engine.

- The hydraulic components are easily packaged in this vehicle because the conventional transmission and transfer case were deleted.

- Hydraulics are an exciting alternative to batteries for making a hybrid vehicle–while electric hybrids add a battery pack, electric generator/motor, and power electronics, hydraulic hybrids add an accumulator (which stores energy as highly compressed nitrogen gas) and one or more hydraulic pump/motors.

- EPA and its partners have active programs to demonstrate the commercial potential of hydraulic hybrids.

Full Hydraulic Hybrid SUV

Projected Design Examples

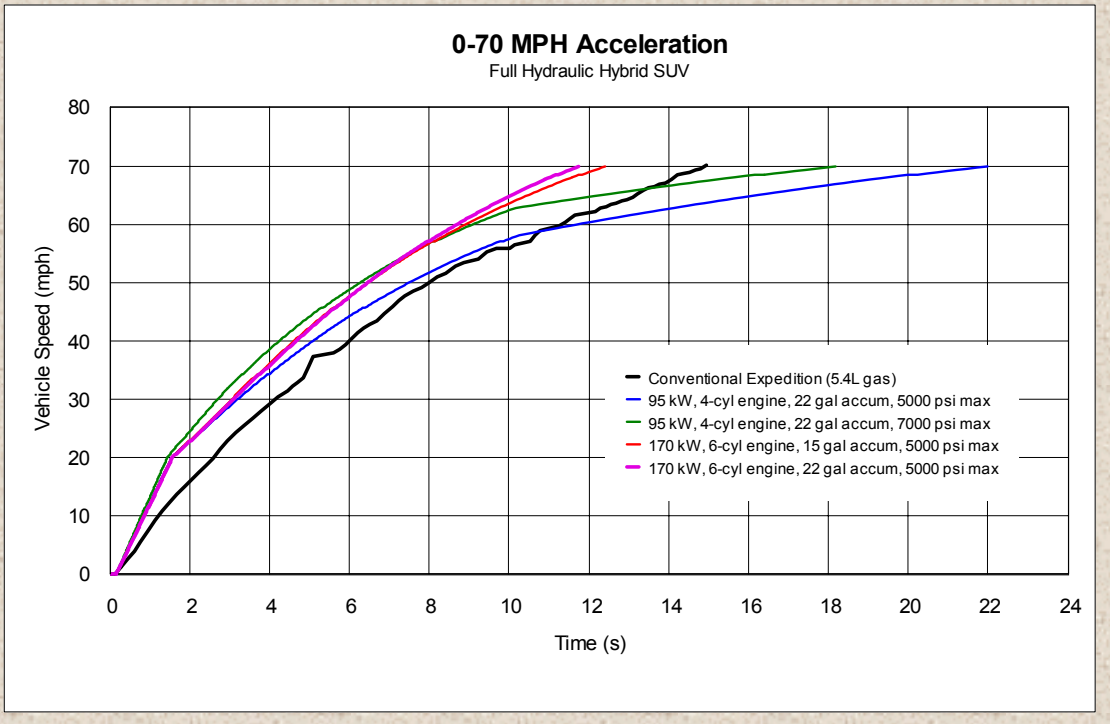
Large 4WD SUV	*Medium Engine Package*	*Small Engine Package*
Diesel Engine	**3.8-liter** (170 kw)	**1.9-liter** (95 kw)
Accumulators	**15 gals**	**22 gals**
Weight Increase	**360 lbs** (163 kg)	**125 lbs** (57 kg)
	Fuel Economy – label values	*Fuel Economy – label values*
City	**32 mpg**	**33 mpg**
Highway	**22 mpg**	**23 mpg**
Combined	**27 mpg**	**28 mpg**
	Cost/Payback	*Cost/Payback*
Cost Increase	**$2,200**	**$1,000**
Consumer Payback	**2.5 years**	**1.1 years**
Net Lifetime Savings	**$4,800**	**$6,300**
	Performance	*Performance*
0-to-60 mph acceleration *(at test weight)*	**8.9 seconds**	**11.4 seconds**
Max sustained speed *(at GVWR)*	**108 mph**	**90 mph**
Max sustained grade *(at 70 mph at GVWR)*	**9.1%**	**3.5%**
GVWR plus towing *(at 65 mph at 5% grade)*	**12,000 lbs**	**6,900 lbs**

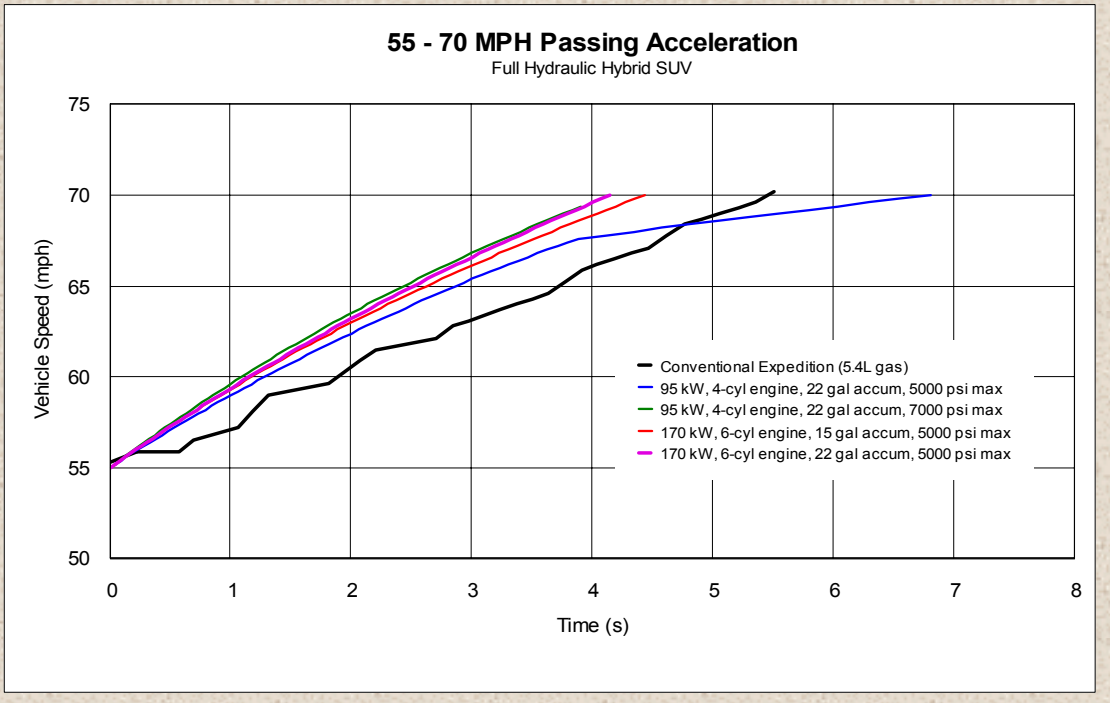
Economic assumptions: Mature high-volume production, vehicle life of 14 years and 188,000 miles, $1.50 per gallon fuel price, 7% discount rate, and 26% retail price mark-up

For more information: *See "Progress Report on Clean and Efficient Automotive Technologies Under Development at EPA"*, Interim Technical Report, January 2004, at www.epa.gov/otaq/technology

Full Hydraulic Hybrid SUV

Projected Performance Examples





EPA Advances in Hydraulic Components

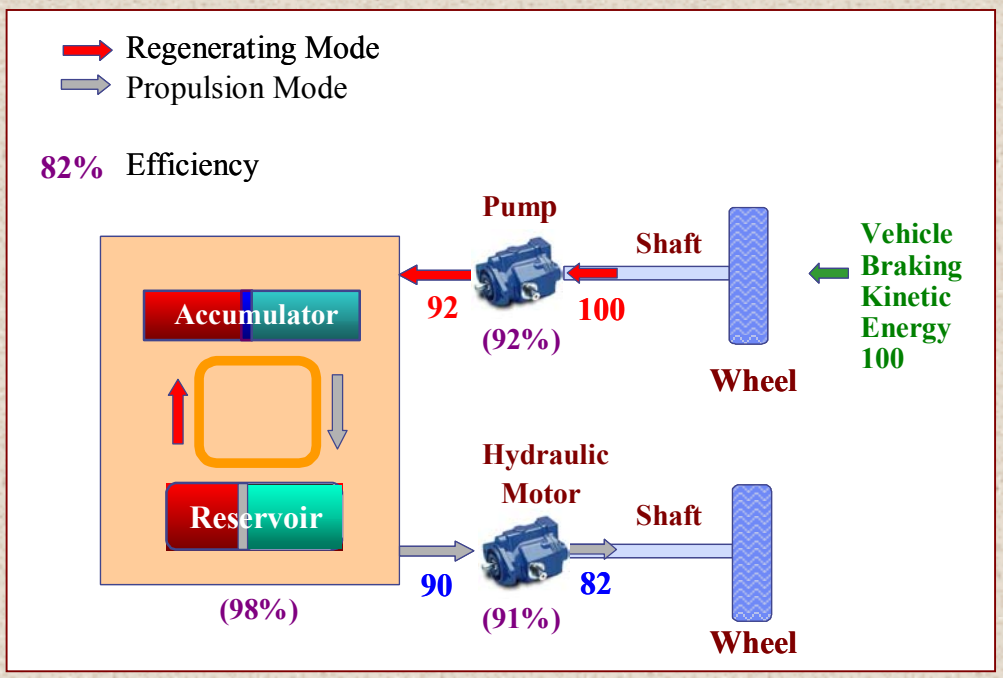
Composite Accumulators

Charge/Discharge Cycle Efficiency	**95 % to 99%**
Overall Weight	**240 pounds** (22 gallon system)
Weight Reduction	**80 to 90%** *(from steel piston type accumulators)*
Specific Energy	**~8 kW-sec/kg**
Energy Density	**>50 kW-sec/gallon**
Power Density	**3 kW/kg**
Specific Costs	**$10/kg**
Operating Pressure	**5000 psi**
Next Generation - Operating Pressure	**7000 psi**

Pump Motors

Peak Efficiency	**95+%**
90+% Efficiency	**over 60% of the operating map**
Power Density	**5 kW/kg** (w/integrated mode valve)
Next Generation - Power Density	**7 kW/kg** (w/integrated mode valve)

This hydraulic system can store and re-deliver about 80% of braking kinetic energy back to the wheels.



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