



Hydrogen Workshop for Fleet Operators



Module 5, “Prototype Light-Duty Hydrogen Vehicles”



Module 5 Outline

1. Fuel Cell Vehicles

- Ford Focus
- Honda FCX
- Toyota Highlander FCHV
- Nissan X-Trail FCV
- Mercedes-Benz F-Cell
- Hyundai Tucson FCEV
- VW Bora HyMotion

2. Hydrogen ICE Vehicles

- BMW 745h
- Ford P2000
- Ford F-350 SuperDuty
- H2H HUMMER



Dr. Craig Marks and 250 GM engineers spent 2 years stuffing a fuel cell into a 1966 GMC Handivan, which turned into "The Electovan", the first fuel cell car. First introduced at the 1967 Los Angeles Auto Show, the Electovan sported 650 feet of piping and 440-lb electrolytes.



Ford Focus

► Specifications

- Curb Weight – 2,677 lbs
- Fuel – Gasoline
- Driving Range – 350 miles
- Acceleration – 0 to 60 mph in 8.3 seconds
- City/Highway – 22/31 mpg
- Price - \$18,220

► Engine

- Displacement – 2.3 liter
- Max Power – 151 hp
- Max Torque – 154 ft-lbs



Ford Motor Company



Ford Focus FCV

► Specifications

- Curb Weight – 3,800 lbs
- Fuel – Compressed Hydrogen
- Fuel Pressure – 3,700 psi
- Max Speed – 80 mph
- Driving Range – 100 miles
- Acceleration – 0 to 62 mph in 14 seconds
- GGE – 67 mpg

► Electric Motor

- Peak Power – 90 hp

► Fuel Cell

- Type – PEM
- Stacks – Ballard Mark 900



Ford Motor Company

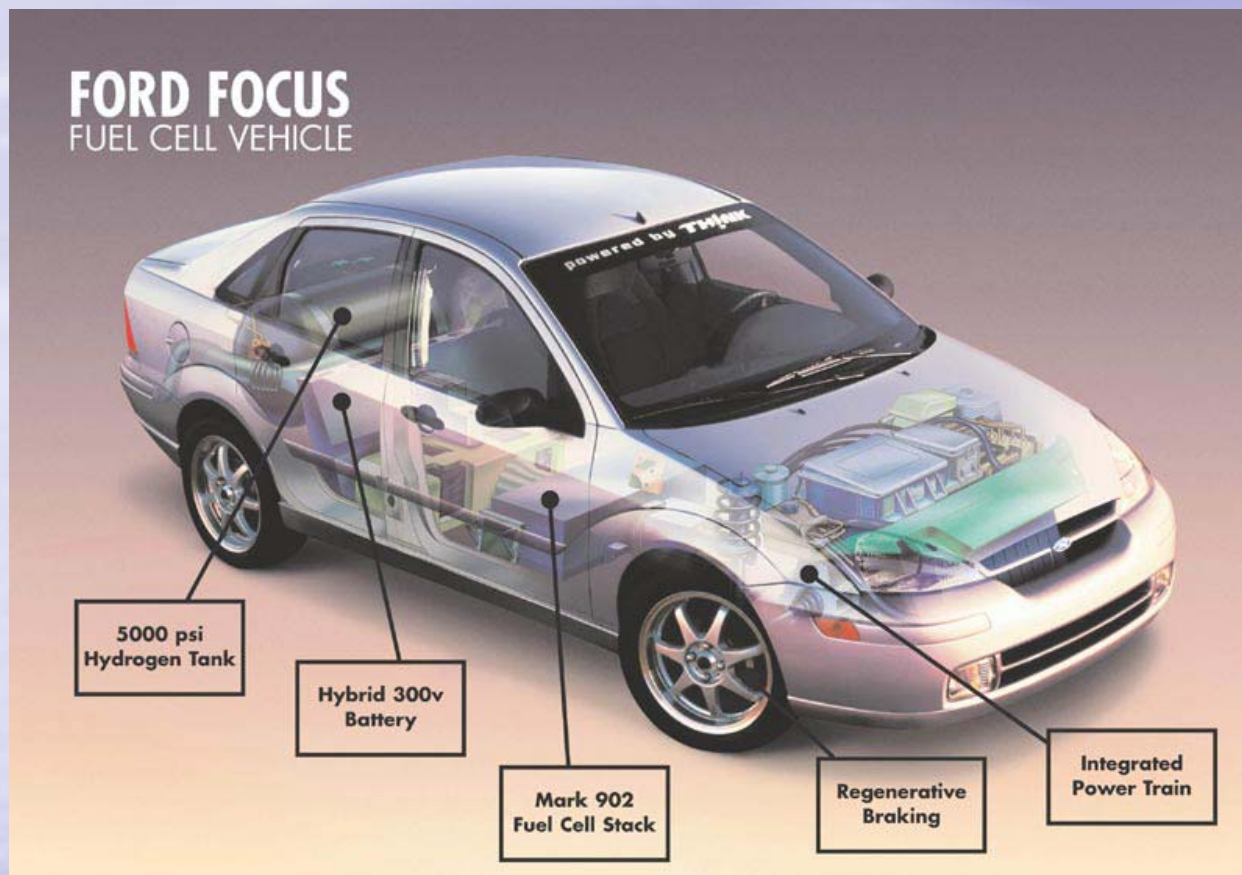


Ford Focus Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	3,800 lbs	2,677 lbs
Max Speed	80 mph	N/A
Driving Range	100 miles	350 miles
Acceleration	0 to 62 mph in 14 seconds	0 to 60 mph in 8.3 seconds
GGE (City/Hwy)	67 mpg (combined)	22/33 mpg
Engine Type	Ballard PEM Fuel Cell	Ford 2.3L
Horsepower	N/A	151 hp
Fuel Capacity (GGE)	N/A	13 gallons
Electric Horsepower	90 hp	N/A
Price	N/A	\$18,220



Ford Focus FCV



Ford Motor Company



Honda Civic

► Specifications

- Curb Weight – 2,786 lbs
- Fuel – Gasoline
- Driving Range – 370 miles
- Acceleration – 0 to 60 mph in 7.9 seconds (coupe)
- City/Highway – 26/31 mpg
- Price - \$19,570

► Engine

- Displacement – 2.0 liter
- Max Power – 160 hp
- Max Torque – 132 ft-lbs





Honda FCX

► Specifications

- Curb Weight – 3,700 lbs
- Fuel – Compressed Hydrogen
- Fuel Pressures – 5,000 psi
- Max Speed – 90 mph
- Driving Range – 190 miles
- City/Highway – 62/51 mpg
- Acceleration – Similar to Honda Civic

► Electric Motor

- Max Power – 107 hp

► Fuel Cell

- Type – PEM
- Max Power – 115 hp



Honda Motor Company

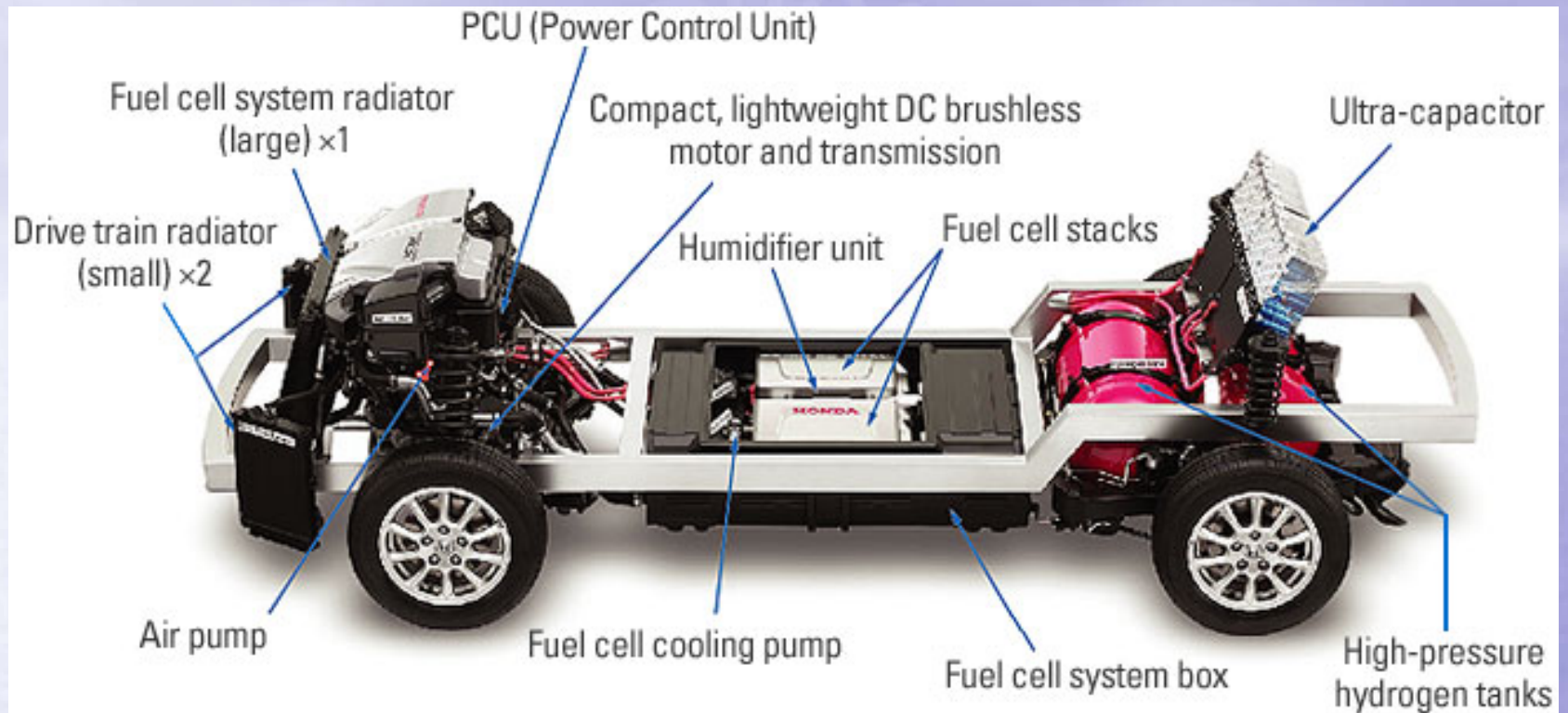


Honda Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	3,700 lbs	2,786 lbs
Max Speed	90 mph	N/A
Driving Range	190 miles	370 miles
Acceleration	Similar to Civic	0 to 60 mph in 7.9 seconds
GGE (City/Hwy)	62/51 mpg	26/31 mpg
Engine Type	Honda PEM Fuel Cell	Honda 2.0L
Horsepower	115 hp	160 hp
Fuel Capacity (GGE)	N/A	13 gallons
Electric Horsepower	107 hp	N/A
Price	N/A	\$19,570



Honda FCX



Honda Motor Company



Toyota Highlander

► Specifications

- Curb Weight – 3,880 lbs
- Fuel – Gasoline
- Driving Range – 400 miles
- Acceleration – 0 to 60 mph in 8.8 seconds
- City/Highway – 18/22 mpg
- Price - \$26,975

► Engine

- Displacement – 3.0 liter
- Max Power – 220 hp
- Max Torque – 222 ft-lbs



Edmunds



Toyota Highlander Hybrid

► Specifications

- Curb Weight – 4,245 lbs
- Fuel – Gasoline
- Driving Range – 500 miles
- City/Highway – 31/27 mpg
- Price - \$39,290



► Engine

- Displacement – 3.3 liter
- Max Power – 208 hp
- Max Torque – 212 ft-lbs



Toyota Motor Company



Toyota Highlander FCHV

► Specifications

- Curb Weight – 4,100 lbs
- Fuel – Compressed Hydrogen
- Fuel Pressure – 5,000 psi
- Max Speed – 90 mph
- Driving Range – 180 miles
- GGE – 64 mpg
- Acceleration – Similar to Toyota Highlander

► Electric Motor

- Max Power – 109 hp

► Fuel Cell

- Type – Polymer Electrolyte
- Max Power – 120 hp



Toyota Motor Company



Toyota Highlander Comparison

	Hydrogen	Gasoline	Gasoline Hybrid
Specifications			
Curb Weight	4,100	3,880 lbs	4,245 lbs
Max Speed	90 mph	N/A	N/A
Driving Range	180 miles	400 miles	500 miles
Acceleration	Similar to Highlander	0 to 60 mph in 8.8 seconds	N/A
GGE (City/Hwy)	64 mpg (combined)	18/22 mpg	31/27 mpg
Engine Type	Toyota PEM Fuel Cell	Toyota 3.0L	Toyota 3.3L
Horsepower	120 hp	220 hp	208 hp
Fuel Capacity (GGE)	N/A	20 gallons	N/A
Electric Horsepower	109 hp	N/A	N/A
Price	N/A	\$26,975	N/A



Toyota Highlander FCHV

Environment

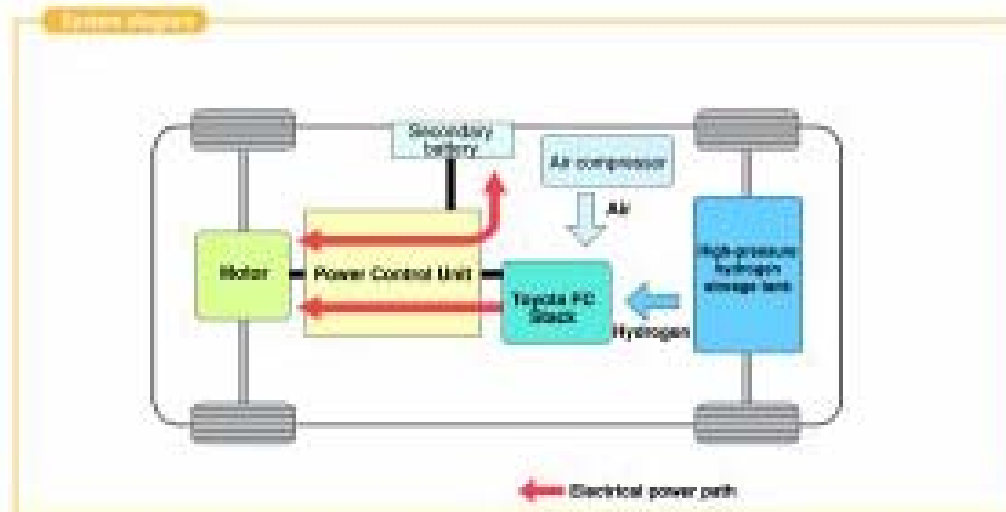
FCHV-4

FCHV-4 System Configuration

Hybrid system combining
a fuel cell and a secondary battery



FCHV



Toyota Motor Company



Nissan Xterra

► Specifications

- Curb Weight – 4,382 lbs
- Fuel – Gasoline
- Driving Range – 360 miles
- City/Highway – 17/21 mpg
- Price - \$25,750

► Engine

- Displacement – 4.0 liter
- Max Power – 265 hp
- Max Torque – 284 ft-lbs



Nissan Motor Company



Nissan X-Trail FCV

► Specifications

- Curb Weight – 2,500 lbs
- Fuel – Compressed Hydrogen
- Fuel Pressure – 5,000 psi
- Range – 220 miles

► Fuel Cell

- Type – PEM
- Stacks – UTC
- Max Power – 85 hp



Nissan Motor Company



Nissan Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	2,500 lbs	4,382 lbs
Max Speed	N/A	N/A
Driving Range	220 miles	360 miles
Acceleration	N/A	N/A
GGE (City/Hwy)	N/A	17/21 mpg
Engine Type	UTC PEM Fuel Cell	Nissan 4.0L
Horsepower	85 hp	265 hp
Fuel Capacity (GGE)	N/A	N/A
Electric Horsepower	N/A	N/A
Price	\$1,000,000	\$25,750



Nissan X-Trail FCV



Nissan Motor Company



Mercedes-Benz A-Class

► Specifications

- Curb Weight – 2,734 lbs
- Fuel – Gasoline
- Driving Range – 670 miles
- City/Highway – 30/48 mpg
- Acceleration – 0 to 62 mph in 9.8 seconds
- Max Speed – 124 mph
- Price - \$29,927

► Engine

- Displacement – 2.0 liter
- Max Power – 136 hp
- Max Torque – 185 ft-lbs



DaimlerChrysler



Mercedes-Benz F-Cell

► Specifications

- Curb Weight – 3,000
- Fuel – Compressed Hydrogen
- Fuel Pressure – 5,000 psi
- Max Speed – 87 mph
- Driving Range – 93 miles
- DGE – 50 mpg
- Acceleration – 0 to 62 mph in 13.5 seconds

► Electric Motor

- Peak Power – 87 hp

► Fuel Cell

- Type – Polymer Electrolyte

DaimlerChrysler





Mercedes-Benz A-Class Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	3,000 lbs	2,734 lbs
Max Speed	87 mph	124 mph
Driving Range	93 miles	670 miles
Acceleration	0 to 62 mph in 13.5 seconds	0 to 62 mph in 9.8 seconds
GGE (City/Hwy)	50 mpg (combined DGE)	30/48 mpg
Engine Type	Mercedes PEM Fuel Cell	Mercedes 2.0L
Horsepower	87 hp	136 hp
Fuel Capacity (GGE)	N/A	14 gallons
Electric Horsepower	N/A	N/A
Price	N/A	\$29,927



Mercedes-Benz F-Cell



DaimlerChrysler



Hyundai Tucson

► Specifications

- Curb Weight – 3,548 lbs
- Fuel – Gasoline
- Driving Range – 440 miles
- City/Highway – 20/26 mpg
- Acceleration – 0 to 60 mph in 10.2 seconds
- Price - \$22,939

► Engine

- Displacement – 2.7 liter
- Max Power – 173 hp
- Max Torque – 178 ft-lbs



Edmunds



Hyundai Tucson FCEV

► Specifications

- Fuel – Compressed Hydrogen
- Fuel Pressure – 5,000 psi
- Max Speed – 93 mph
- Driving Range – 186 miles
- Tank Capacity – 40 gallons

► Electric Motor

- Peak Power – 107 hp

► Fuel Cell

- Type – Polymer Electrolyte
- Stacks - UTC



Hyundai Motor Company



Hyundai Tucson Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	N/A	3,548 lbs
Max Speed	93 mph	N/A
Driving Range	186 miles	440 miles
Acceleration	N/A	0 to 60 mph in 10.2 seconds
GGE (City/Hwy)	N/A	20/26 mpg
Engine Type	UTC PEM Fuel Cell	Hyundai 2.7L
Horsepower	N/A	173 hp
Fuel Capacity (GGE)	40 gallons	17 gallons
Electric Horsepower	107 hp	N/A
Price	N/A	\$22,939



Volkswagen Jetta

► Specifications

- Curb Weight – 3,285 lbs
- Fuel – Gasoline
- Driving Range – 435 miles
- City/Highway – 22/30 mpg
- Acceleration – 0 to 60 mph in 9.4 seconds
- Price - \$20,390

► Engine

- Displacement – 2.5 liter
- Max Power – 150 hp
- Max Torque – 170 ft-lbs



Edmunds



VW Bora HyMotion

► Specifications

- Fuel – Liquid Hydrogen
- Fuel Temperature – -423F
- Capacity – 13 gallons
- Range – 215 miles
- Acceleration – 0 to 62 mph in 12.6 seconds
- Max Speed – 87 mph

► Electric Motor

- Max Power – 100 hp
- Max Torque – 177 ft-lbs



Volkswagen of America



Volkswagen Jetta Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	N/A	3,285 lbs
Max Speed	87 mph	N/A
Driving Range	215 miles	435 miles
Acceleration	0 to 62 mph in 12.6 seconds	0 to 60 mph in 9.4 seconds
GGE (City/Hwy)	N/A	22/30 mpg
Engine Type	N/A	VW 2.5L
Horsepower	N/A	150 hp
Fuel Capacity (GGE)	13 gallons	14.5 gallons
Electric Horsepower	100 hp	N/A
Price	N/A	\$20,390



BMW 745

► Specifications

- Curb Weight – 4,376 lbs
- Fuel – Gasoline
- Driving Range – 400 miles
- City/Highway – 18/26 mpg
- Acceleration – 0 to 60 mph in 6.0 seconds
- Price - \$67,850

► Engine

- Displacement – 4.4 liter V8
- Max Power – 333 hp
- Max Torque – 332 ft-lbs





BMW 745h

► Specifications

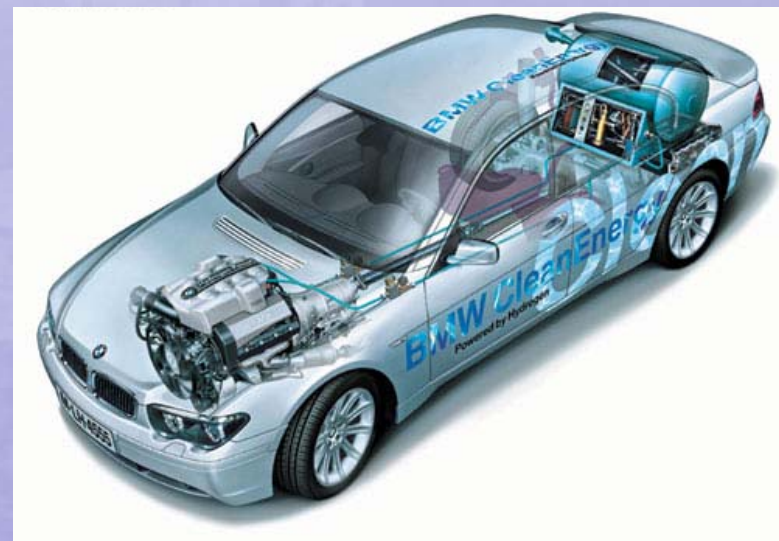
- Curb Weight – 4,255 lbs
- Fuel – Compressed Hydrogen
- Max Speed – 133 mph
- Driving Range – 190 miles

► Engine

- Type – 4.4 liter V8
- Max Horsepower – 284 hp
- Max Torque – 295 ft-lbs

► Fuel Cell

- Auxiliary Power Unit
- Type - PEM





BMW 745i Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	4,255 lbs	4,376 lbs
Max Speed	133 mph	N/A
Driving Range	190 miles	400 miles
Acceleration	N/A	0 to 60 mph in 6.0 seconds
GGE (City/Hwy)	N/A	18/26 mpg
Engine Type	BMW 4.4L	BMW 4.4L
Horsepower	284 hp	333 hp
Fuel Capacity (GGE)	N/A	N/A
Electric Horsepower	N/A	N/A
Price	N/A	\$67,850



Ford Focus

► Specifications

- Curb Weight – 2,677 lbs
- Fuel – Gasoline
- Driving Range – 350 miles
- Acceleration – 0 to 60 mph in 8.3 seconds
- City/Highway – 22/31 mpg
- Price - \$18,220

► Engine

- Displacement – 2.3 liter
- Max Power – 151 hp
- Max Torque – 154 ft-lbs



Ford Motor Company



Ford P2000

► Specifications

- Curb Weight – 4,255 lbs
- Fuel – Compressed Hydrogen
- Driving Range – 160 miles (5,000 psi), 270 miles (10,000 psi)
- Fuel Economy – 18% gain over gasoline Focus

► Engine

- Type – Zetec 2.0 liter
- Efficiency – 25 to 30% improvement over gasoline Focus





Ford Focus Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	4,255 lbs	2,677 lbs
Max Speed	N/A	N/A
Driving Range	270 miles	350 miles
Acceleration	N/A	0 to 60 mph in 8.3 seconds
GGE (City/Hwy)	26/37 mpg	22/31 mpg
Engine Type	Ford 2.0L	Ford 2.0L
Horsepower	N/A	151 hp
Fuel Capacity (GGE)	N/A	13 gallons
Electric Horsepower	N/A	N/A
Price	N/A	\$18,220



Ford F-350 SuperDuty (Gasoline)

► Specifications

- Curb Weight – 6,665 lbs
- Fuel – Gasoline
- Capacity – 38 gallons
- Fuel Economy – 11 mpg
- Price - \$32,535

► Engine

- Displacement – 6.8 liter V10
- Max Power – 362 hp
- Max Torque – 457 ft-lbs





Ford F-350 SuperDuty (Hydrogen)

► Specifications

- Fuel – Compressed Hydrogen
- Fuel Pressure – 5,000 psi
- Driving Range – 100 miles
- Fuel Economy – 25% gain over gasoline F-350 SuperDuty

► Engine

- Type – 6.8 liter V10
- Max Power – 225 hp
- Max Torque – 300 ft-lbs





Ford F-350 SuperDuty Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	N/A	6,665 lbs
Max Speed	N/A	N/A
Driving Range	100 miles	N/A
Acceleration	N/A	N/A
GGE (City/Hwy)	14 mpg (combined)	11 mpg (combined)
Engine Type	Ford 6.8L	Ford 6.8L
Horsepower	225 hp	362 hp
Fuel Capacity (GGE)	N/A	38 gallons
Electric Horsepower	N/A	N/A
Price	N/A	\$32,535



HUMMER H2 SUT

► Specifications

- Curb Weight – 6,400 lbs
- Fuel – Gasoline
- Capacity – 32 gallons
- Acceleration – 0 to 60 mph in 10.5 seconds
- Price - \$52,485

► Engine

- Displacement – 6.0 liter V8
- Max Power – 325 hp
- Max Torque – 365 ft-lbs





H2H HUMMER

- ▶ Specifications
 - Compressed Hydrogen
 - Driving Range – 50 miles
- ▶ Engine
 - Type – 6.0 liter V8





HUMMER SUT Comparison

	Hydrogen	Gasoline
Specifications		
Curb Weight	N/A	6,400 lbs
Max Speed	N/A	N/A
Driving Range	50 miles	N/A
Acceleration	N/A	0 to 60 mph in 10.5 seconds
GGE (City/Hwy)	N/A	N/A
Engine Type	GM 6.0L	GM 6.0L
Horsepower	N/A	325 hp
Fuel Capacity (GGE)	N/A	32 gallons
Electric Horsepower	N/A	N/A
Price	N/A	\$52,485



Module 5, “Prototype Light-Duty Hydrogen Vehicles”