U.S. Department of Energy FreedomCAR & Vehicle Technologies Program

Advanced Vehicle Testing Activity

Advanced Technology Vehicle Testing – 41st Power Sources Conference

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Presentation Outline

- AVTA Goal
- AVTA Testing Partners
- Light-Duty Hybrid Electric Vehicle Testing
- Hydrogen Fuel Pilot Plant
- Hydrogen Internal Combustion Engine (ICE) Vehicle Testing
- Neighborhood & Urban Electric Vehicles
- WWW Information Address

AVTA Goal

- **Benchmark & validate the performance of light-, medium-, & heavy-duty vehicles that feature one or more advanced technologies, including:**
  - **ICE's burning advanced fuels, such as 100% hydrogen and hydrogen/CNG-blended fuels**
  - **Hybrid electric, pure electric, & hydraulic drive systems**
  - **Advanced batteries & engines**
  - **Advanced climate control, power electronic, & other ancillary systems**

AVTA Testing Partners

- **Qualified Vehicle Testers (50 – 50 cost share)**
  - **Electric Transportation Applications (lead)**
  - **Arizona Public Service**
  - **Bank One**
  - **Ford Motor Company**
  - **Luke AFB**
  - **New York Power Authority**
  - **Red Cross**
  - **Southern California Edison**
  - **Salt River Project**
  - **Cites of Palm Springs, Palm Valley, Phoenix, Vacaville, and San Diego**

Hybrid Electric Vehicle Testing

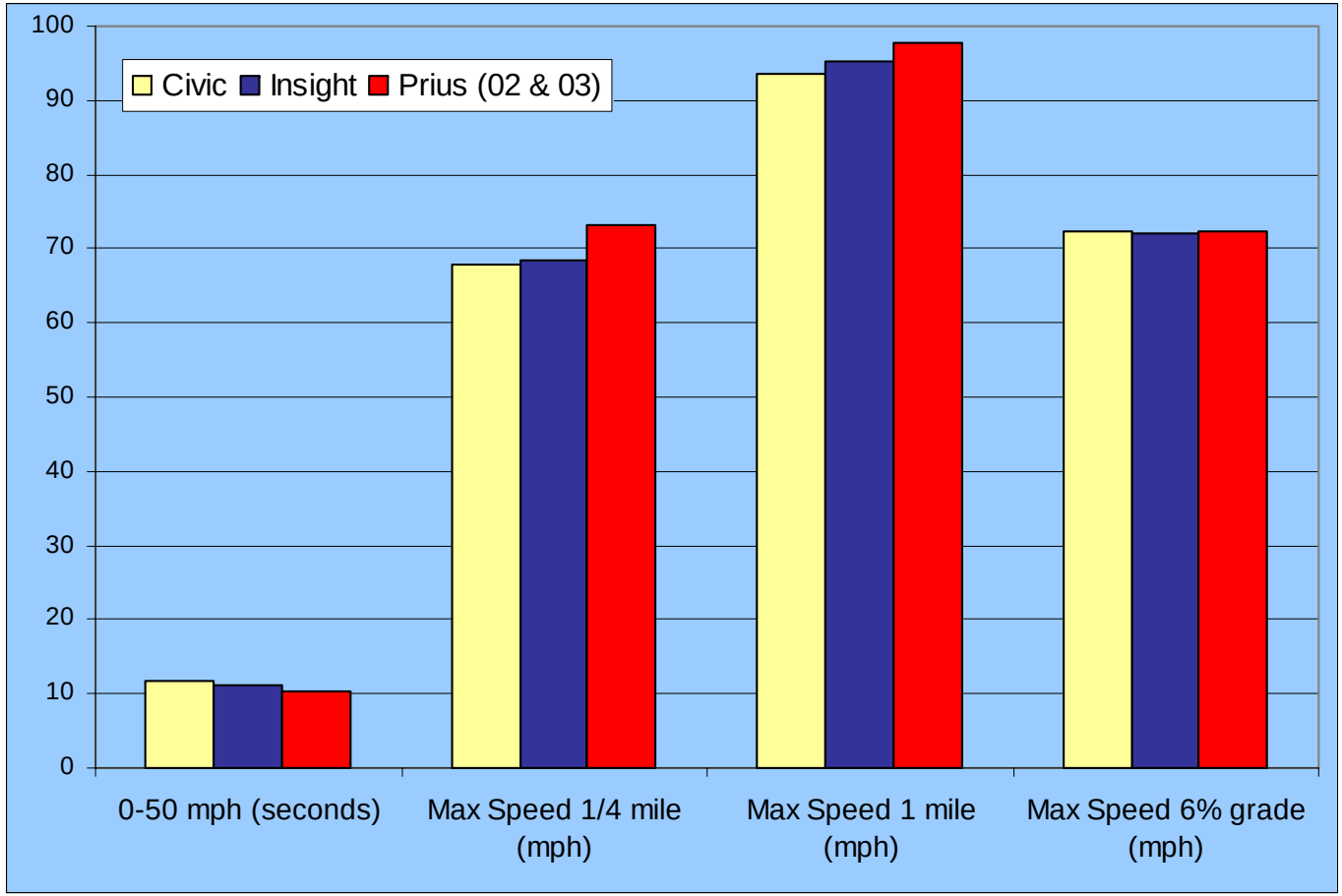
- Honda Insight
- Honda Civic
- MY ’02 & ’03 Toyota Prius
- MY ’04 Toyota Prius
- Fleet & accelerated reliability testing
  - Bank One, Red Cross, Arizona Public Service, ETA
  - Fuel use, maintenance, repairs & driver experience
- Baseline Performance testing (dynamometer & closed track testing)
  - Fuel economy, acceleration, max speed, braking, & handling

Hybrid Electric Vehicle Specifications

Manufacturer / Model	Battery Technology	System Voltage	Pack Capacity (C/2)	Electric Motor
Honda Civic	NiMH	144 V	6.0 Ah	10 kW
Honda Insight	NiMH	144 V	6.0 Ah	10 kW
Toyota Prius ('02 & '03)	NiMH	274 V	6.5 Ah	33 kW
Toyota Prius ('04)	NiMH	202 V		50 kW

Hybrid Electric Vehicle Testing

- **Baseline Performance testing results**

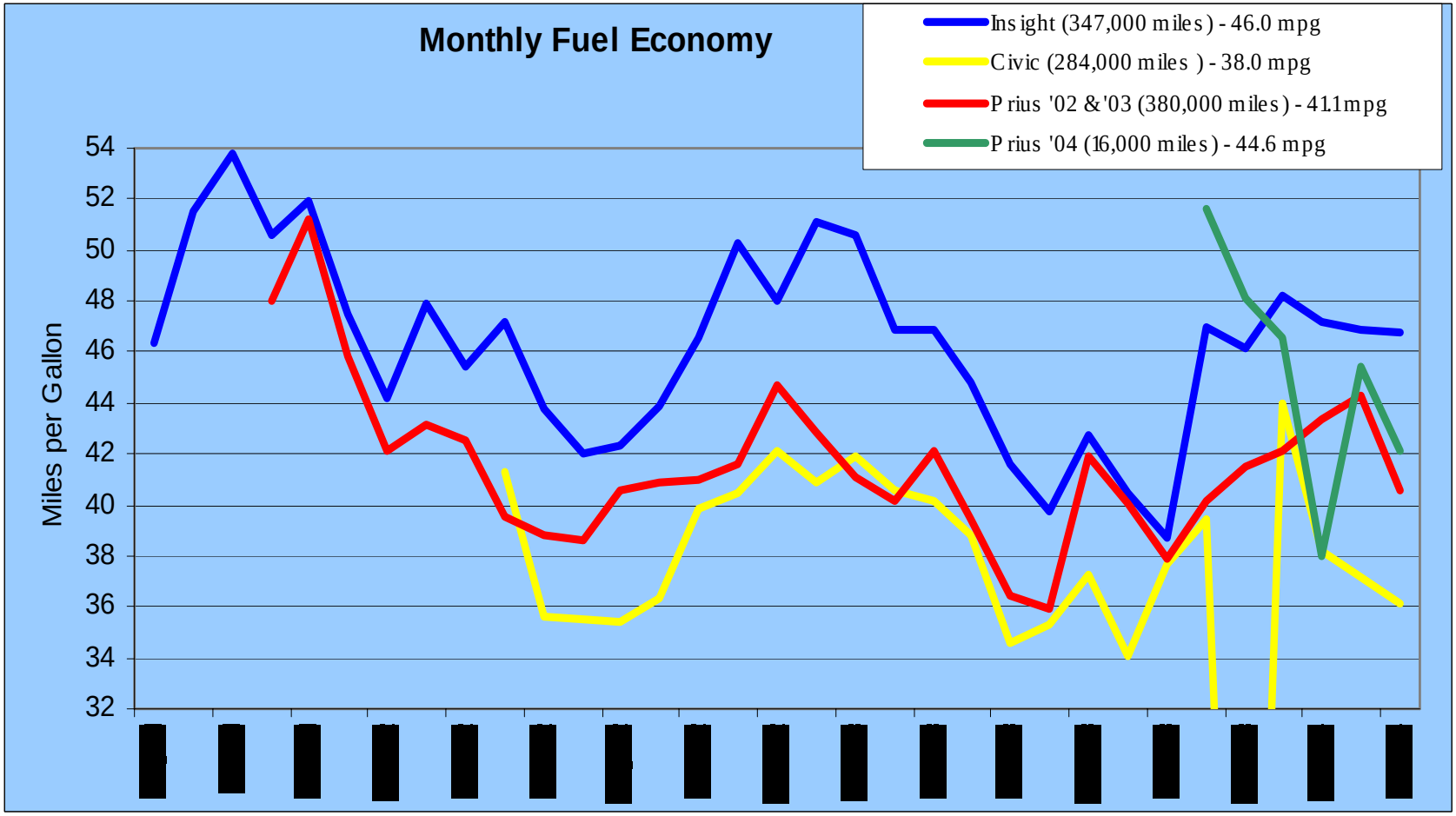


Hybrid Electric Vehicle Testing

- **Fleet & accelerated reliability testing (1+ million miles)**
  - **6 Honda Insights (347,000 miles) 46.0 mpg**
  - **4 Honda Civics (284,000 miles) 38.0 mpg**
  - **6 MY 02 & 03 Toyota Prius (380,000 miles) 41.1 mpg**
  - **2 MY 04 Toyota Prius (16,000 miles) 44.6 mpg**

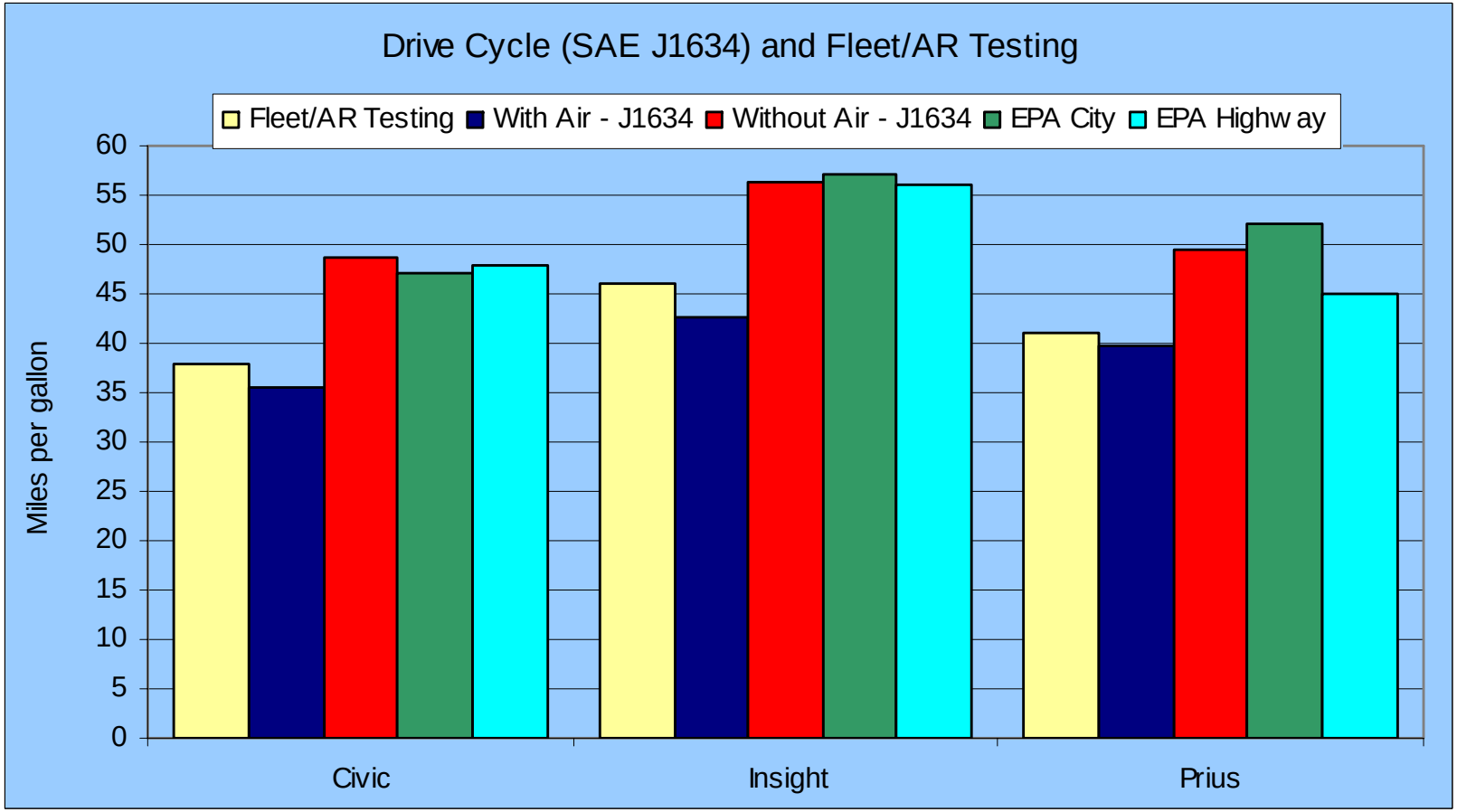
Hybrid Electric Vehicle Testing

- **Fleet and accelerated reliability testing**



Hybrid Electric Vehicle Testing

- **Baseline Performance, fleet and accelerated reliability, and EPA testing results**



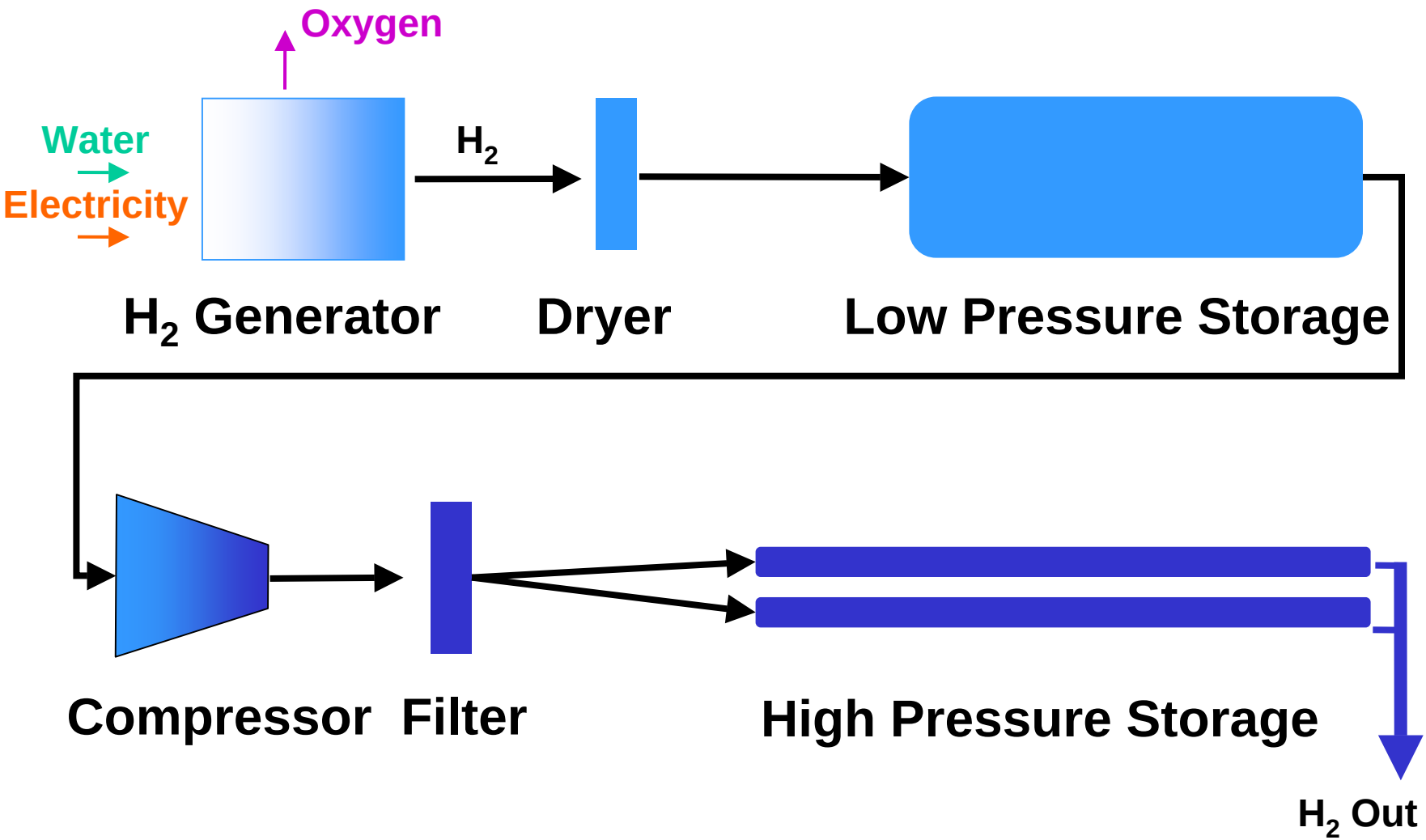
Hybrid Electric Vehicle Testing

- **2004 HEV candidate test vehicles**
  - **MY 04 Toyota Prius (started testing)**
  - **General Motors Sierra pickup**
  - **Toyota Highlander SUV**
  - **Lexus RX400 SUV**
  - **Honda Accord**
  - **Ford Escape SUV**

Arizona Public Service Hydrogen Fuel Pilot Plant (APS – HFPP)

- Onsite electrolytic hydrogen production, hydrogen & CNG (H/CNG) compression, & vehicle fueling
- Objectives:
  - Evaluate the safety & reliability of operating ICE vehicles on hydrogen & blended hydrogen fuels
  - Evaluate hydrogen vehicle fueling infrastructure
  - Quantify hydrogen ICE vehicle costs, performance, & emissions

APS – HFPP: Hydrogen Sub-System



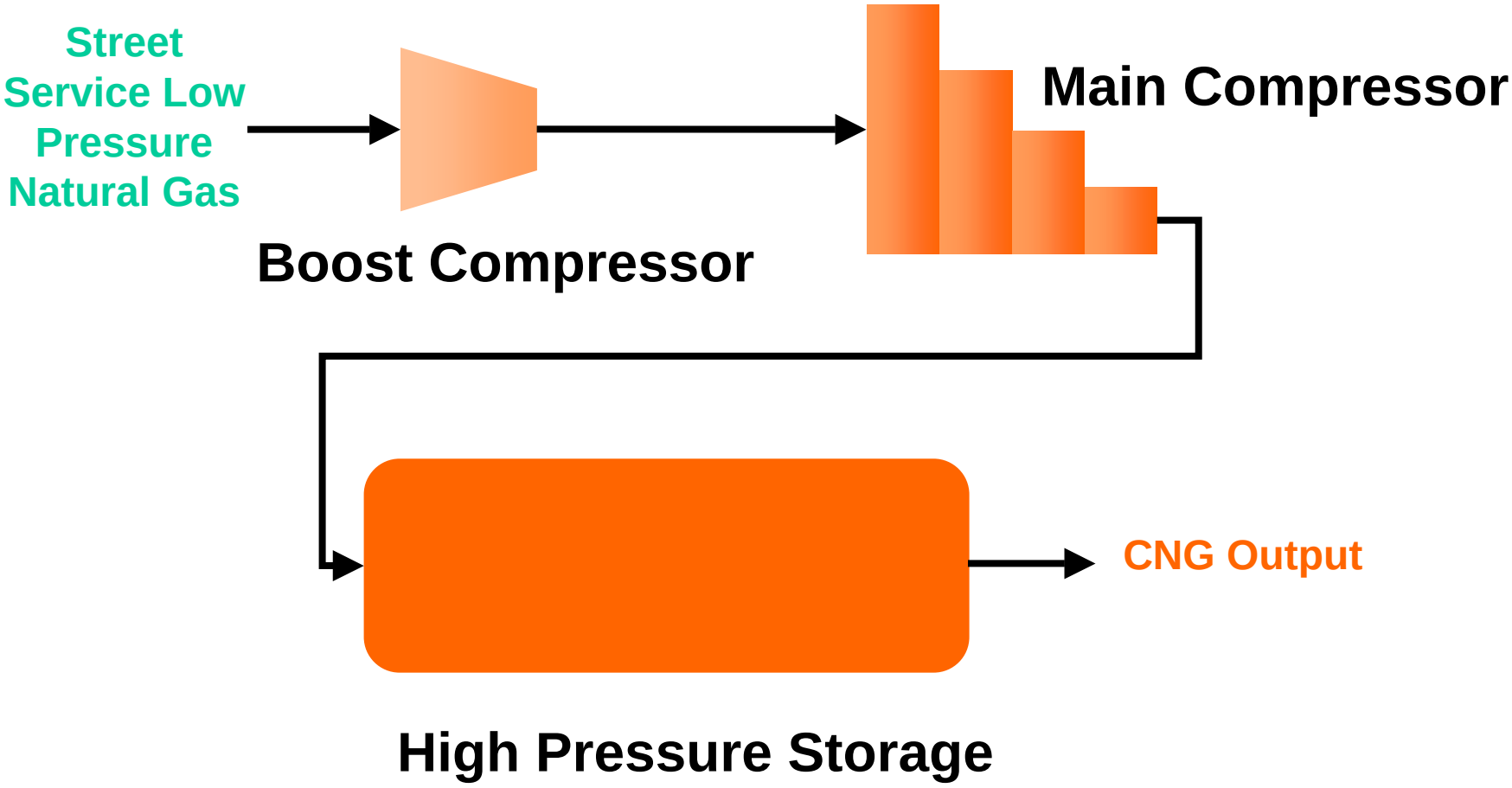
APS – HFPP: Hydrogen Sub-System

- Proton Energy Systems' HOGEN PEM stationary fuel cell operating in reverse
- Hydrogen generator
  - PEM fuel cell, 57 kW, 20 cells
  - 300 SCFH hydrogen output, 150 psi
  - 17 kWh per 100 SCF hydrogen
- Hydrogen dryer
  - 300 SCFH
- Hydrogen compressor
  - Oil free diaphragm compressor
  - Three stage compression
  - 6,100 psi output
- Hydrogen - 99.9997% purity

APS – HFPP: Hydrogen Sub-System

- Low pressure hydrogen storage (lower tank)
  - 8,955 SCF @ 150 psi
- High pressure hydrogen storage (upper 2 tanks)
  - 17,386 SCF @ 6,000 psi
- Hydrogen monitoring system (150 nodes instrumented) - examining production tradeoffs

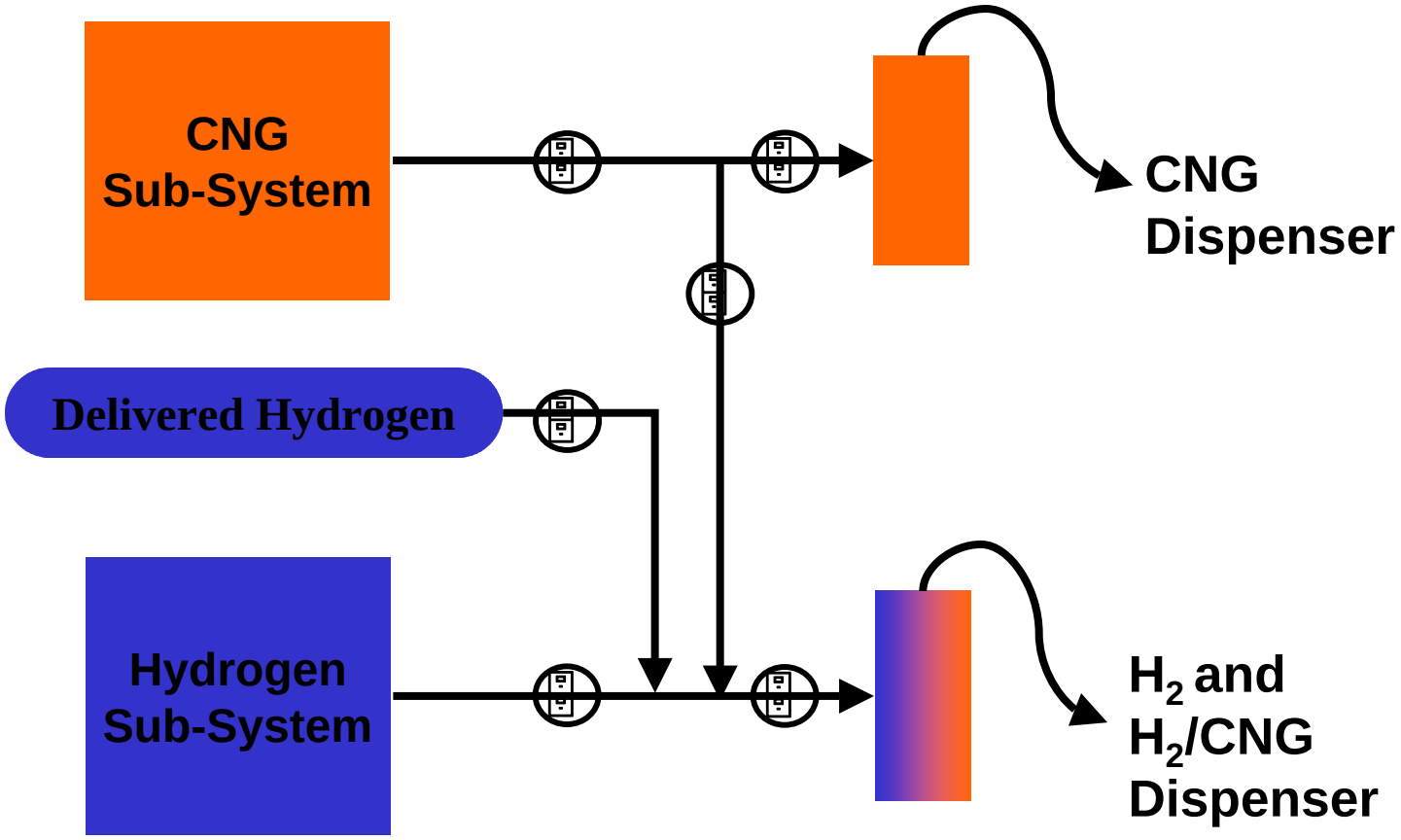
APS – HFPP: CNG Sub-System



APS – HFPP: CNG Sub-System

- CNG Boost Compressor
  - 300 SCFM @ 60 psi
- CNG Main Compressor
  - 350 SCFM @ 5,000 psi
  - Multi-Stage Piston
- CNG Storage/Pressure
  - Low: 11,079 SCF @ 3,600 psi
  - Medium 5,711 SCF @ 4,500 psi
  - High: 5,711 SCF @ 5,000 psi

APS – HFPP: Fueling System



APS – HFPP: Fueling Dispenser

- Dispense pure hydrogen or pure CNG fuel
- Blend and dispense H/CNG blended fuels
- Includes metering and electronic billing Interface

Hydrogen/CNG ICE Vehicle Testing

- **Initial ICE hydrogen vehicle testing**
  - **Ford F150 up to 30% H/CNG (continues testing)**
  - **Ford F150 up to 50% H/CNG**
  - **100% hydrogen Mercedes Benz van**
  - **Dodge van on 15% H/CNG (continues testing)**

Hydrogen/CNG ICE Vehicle Testing

- Ongoing hydrogen ICE vehicle testing
  - 8 vehicles 15% H/CNG - S-10s, Sierra pickups, Blazers, Dodge Ram van
  - Ford F150 30% H/CNG (tested at 100% CNG, 15%H/CNG, and 30% H/CNG)
  - Ford F150 - 100% hydrogen, 5.6 liter, 32 valve, 35%+ efficiency
  - Ford F150 – 100% hydrogen, 5.4 liter 16 valve, production engine
  - Emissions testing, oil analysis
  - 200,000+ hydrogen test miles

Hydrogen/CNG ICE Vehicle Testing

- **F150 30% H/CNG ICE vehicle testing results**

Fuel Blend	Time to 60 mph (seconds)	Fuel Economy (miles/gge)	Range (miles)
CNG	10.10	23.3	122
15% H/CNG	10.97	22.6	110
30% H/CNG	12.68	23.5	102

Hydrogen/CNG ICE Vehicle Testing

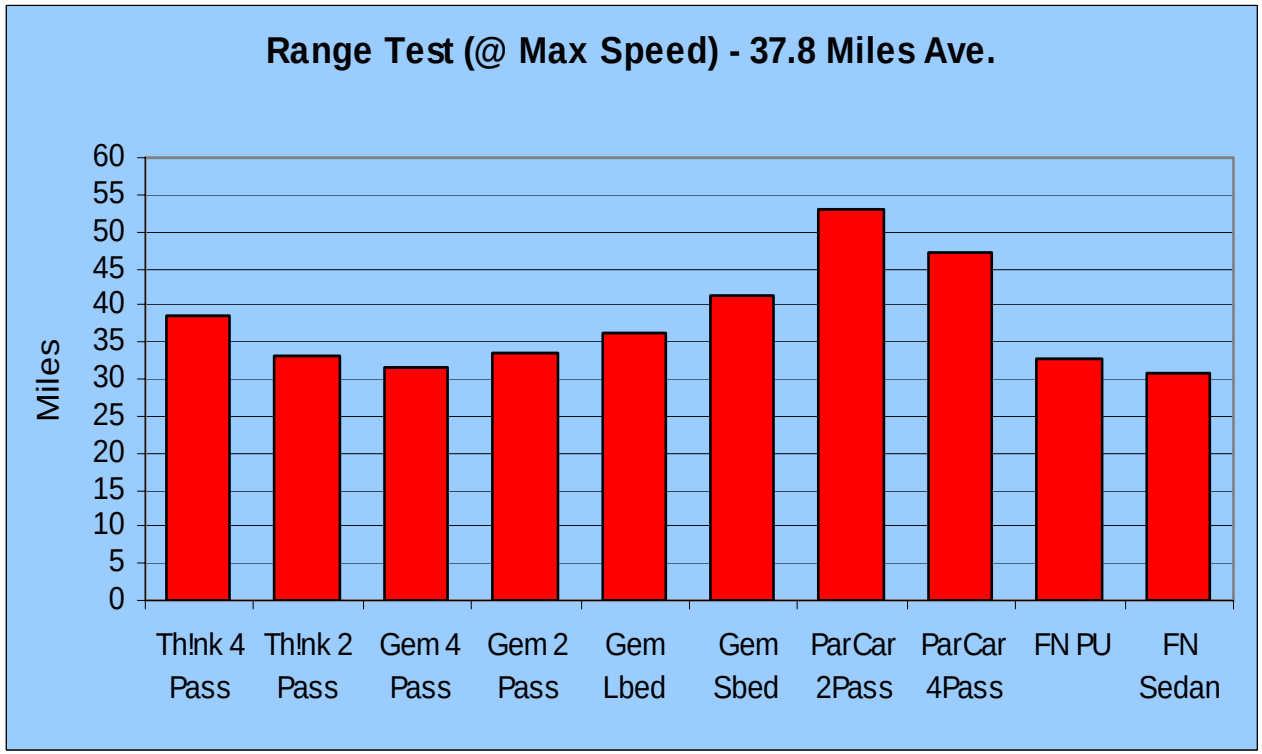
- **F150 30% H/CNG ICE vehicle testing results**

Fuel Type	Percentage Change in Emissions Testing					
	NMHC	CH_4	HC	CO	NO_X	CO_2
Gasoline	Base	Base	Base	Base	Base	Base
CNG	-80	+967	+35	-63	-34	-24
15% H/CNG	-78	+1000	+40	-70	-26	-27
30% H/CNG	-89	+1050	+37	-73	-25	-28

NMHC=Non-Methane Hydrocarbons
HC=Total Hydrocarbons
NOx=Oxides of Nitrogen
CH_4=Methane
CO=Carbon Monoxide
CO_2=Carbon Dioxide

Neighborhood Electric Vehicle Testing

- **NEVAmerica Baseline Performance Testing**
  - **Completed NEVAmerica testing of 10 NEVs (max speed, acceleration, range, braking, charging)**
  - **Gel, glass mat, and flooded lead acid batteries**



Neighborhood Electric Vehicle Testing

- 90 NEVs in fleet testing (including fast charging)
  - San Diego Police Department
  - Luke Air Force Base
  - Palm Valley
  - Palm Springs

- 2004 NEVAmerica Baseline Performance Testing
  - 5 NEVs with lithium polymer and lead acid batteries

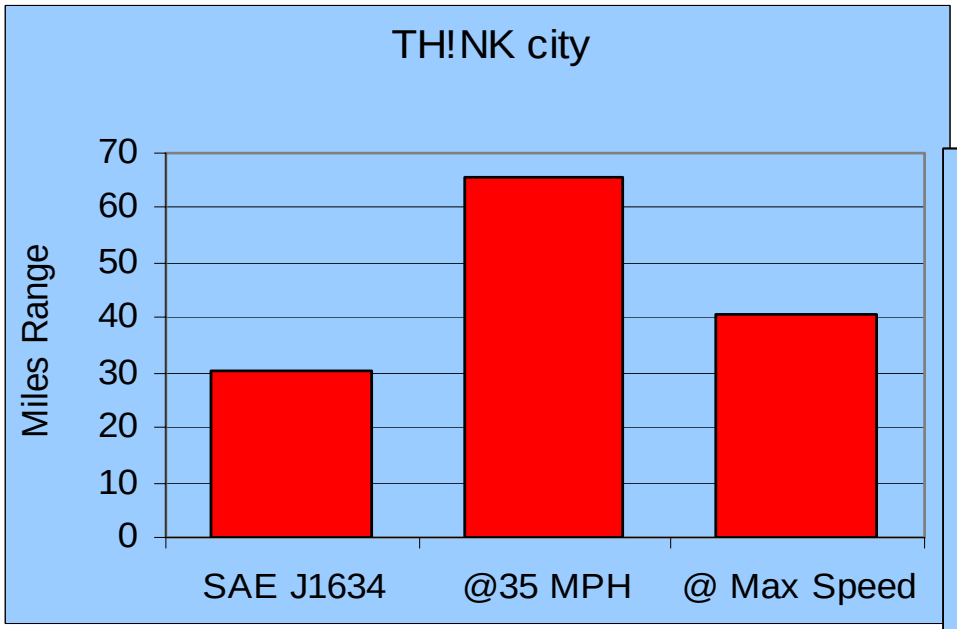
Urban Electric Vehicle Testing

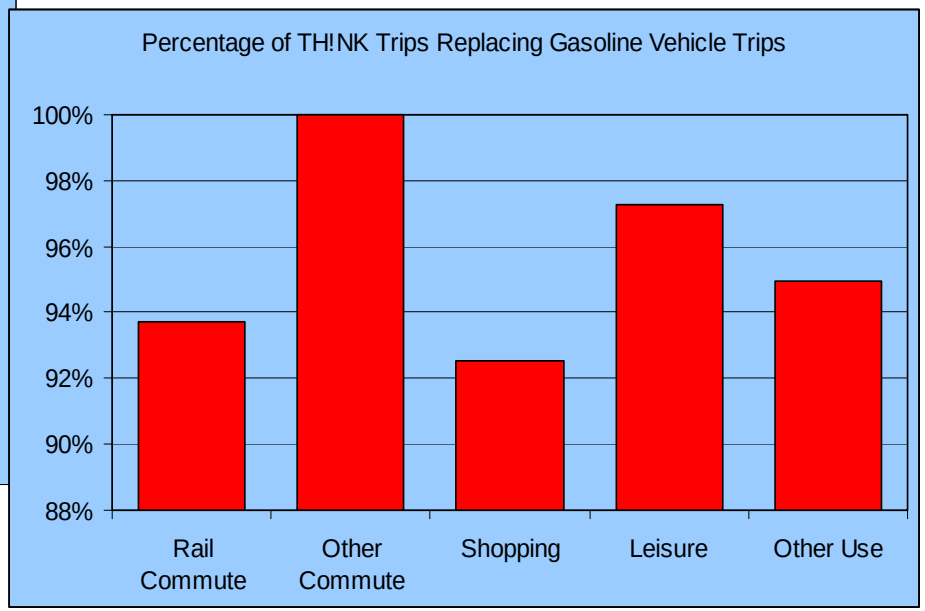
- UEVAmerica Baseline Performance Testing
  - Completed TH!NK city testing
- Fleet and accelerated reliability testing
  - 90 TH!NK cities in New York commuter fleet demonstration (miles driven, energy use, gasoline trips avoided, driver demographics)
  - 240 TH!NK cities in national demonstration
  - 5 Nissan Hyper-mini UEVs in fleet testing
  - TH!NK in accelerated reliability testing
  - Vehicle use 225,000+ miles

NYPA/TH!NK Clean Commute Program

Urban Electric Vehicle Testing

- **Ford/TH!NK *city* – SAFT NiCd, 19 modules, system voltage – 114 VDC, system capacity (C/3) 100 Ah**





All vehicle testing reports and fact sheets, as well as this presentation are available via:

http://avt.inel.gov