Fuel Displacement & Cost Potential of CNG, LNG, and LPG Vehicles

2012 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review

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Jason Kwon, Aymeric Rousseau
Argonne National Laboratory

Sponsored by David Anderson

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U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Project Overview

Timeline

- Start: September 2011.
- End: September 2012.
- Status: 20% complete.

Barriers

- Evaluate the fuel displacement potential of different fuels.
- Provide guidance on future funding decisions.

Budget

- FY11
  - $200K

Partners

- Light duty OEM (engine data)
- Heavy duty OEM (engine data)
- Ricardo (cost)

Relevance

OEMs are Announcing Many CNG Models Worldwide

2012 Honda Civic named "Green Car of the Year"

General Motors said it would offer a natural-gas option on the 2013 Chevrolet Silverado and GMC Sierra 2500 heavy-duty pickup trucks

Audi announced at Geneva 2012 a CNG version of the A3

"Adding a hard-working, fully capable CNG-powered truck to the Ram lineup makes a lot of sense – both economically and environmentally", said Fred Diaz, Ram Truck President and CEO Ram Truck Brand– Chrysler Group LLC

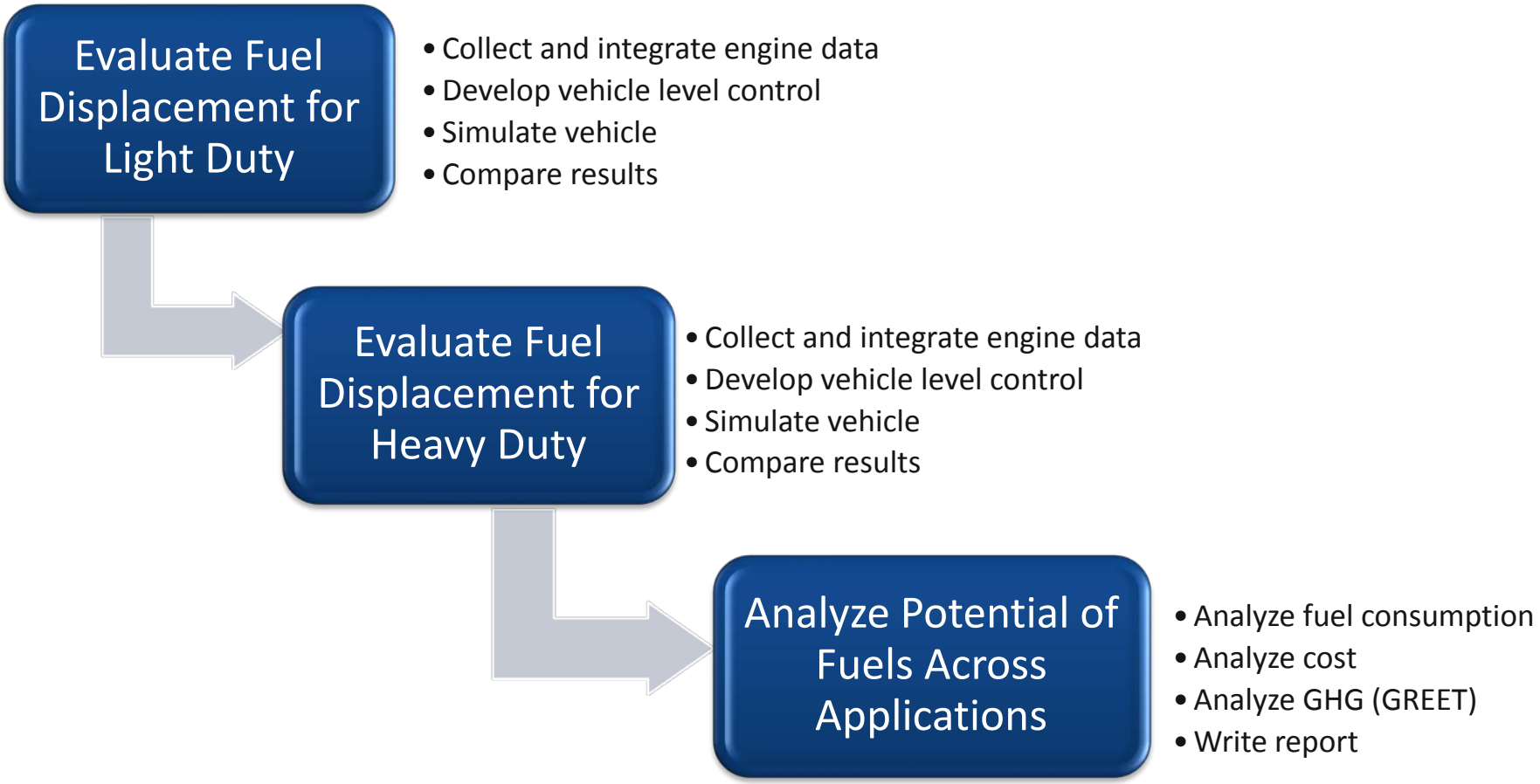
"FT-Bh serves as a study for how even greater fuel efficiency might be achieved in the medium term by using two alternative powertrains," said Toyota in a statement. "A compressed natural gas hybrid with 38g/km CO2 emissions and a plug-in hybrid, emitting just 19g/km."

Relevance

The objective is to evaluate the fuel displacement potential of CNG, LNG and LPG vehicles

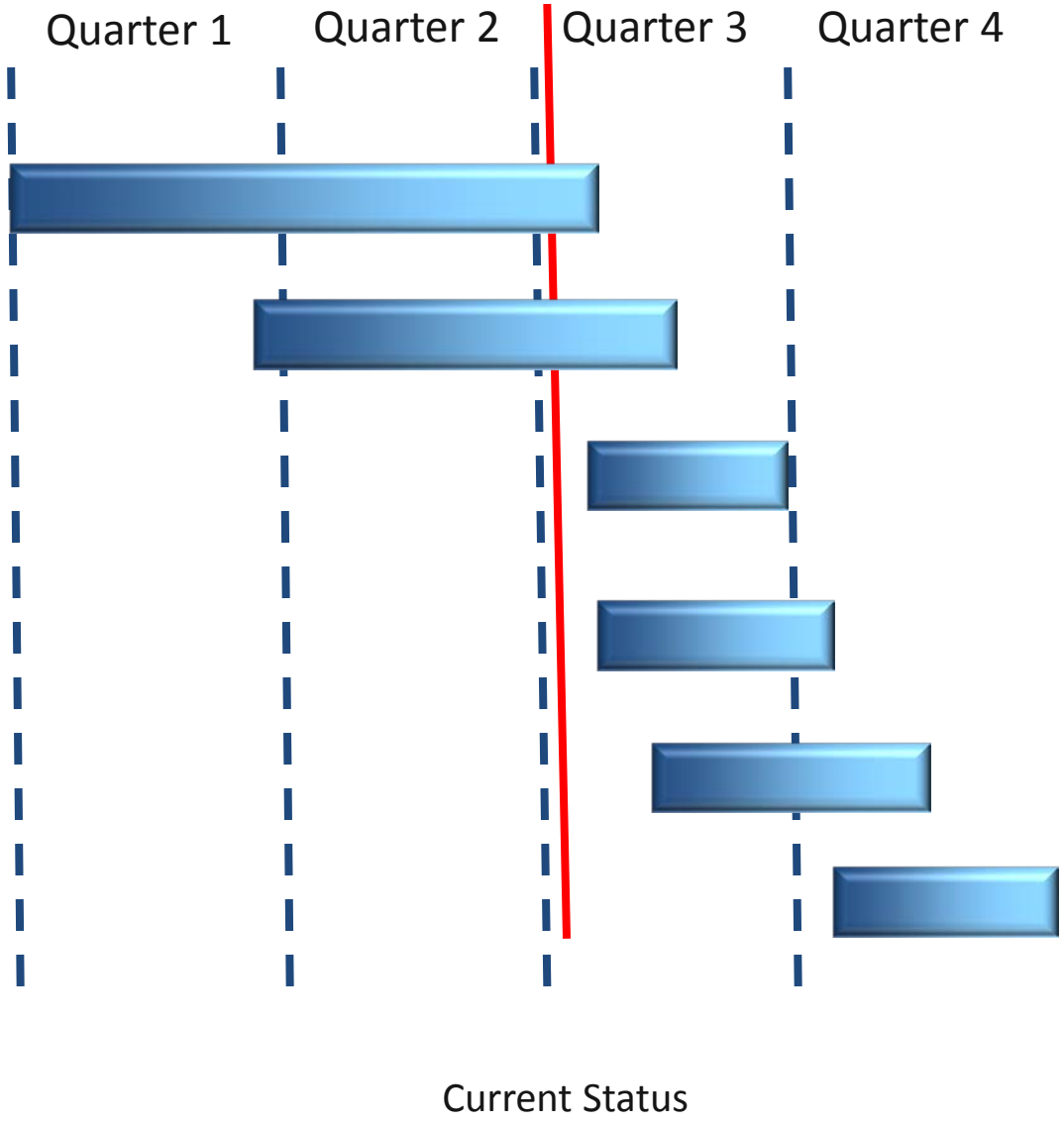
- This study directly supports the diversification of energy source and oil reduction
- What vehicle applications and powertrain configurations would best benefit from these fuels?
- How should the vehicle control strategies be changed to optimize the fuel displacement?

Approach


Evaluate Fuel Displacement for Light Duty
• Collect and integrate engine data
• Develop vehicle level control
• Simulate vehicle
• Compare results
Evaluate Fuel Displacement for Heavy Duty
• Collect and integrate engine data
• Develop vehicle level control
• Simulate vehicle
• Compare results
Analyze Potential of Fuels Across Applications
• Analyze fuel consumption
• Analyze cost
• Analyze GHG (GREET)
• Write report

Milestones

- Collect engine data for different fuels and applications
- Evaluate fuel displacement on light duty vehicles on standard cycles
- Evaluate impact on real world drive cycles
- Evaluate fuel displacement on heavy duty vehicles on standard cycles
- Evaluate fuel displacement on heavy duty vehicles on real world cycles
- Write report



Technical Accomplishments
Light Duty Conventional Vehicle Characteristics

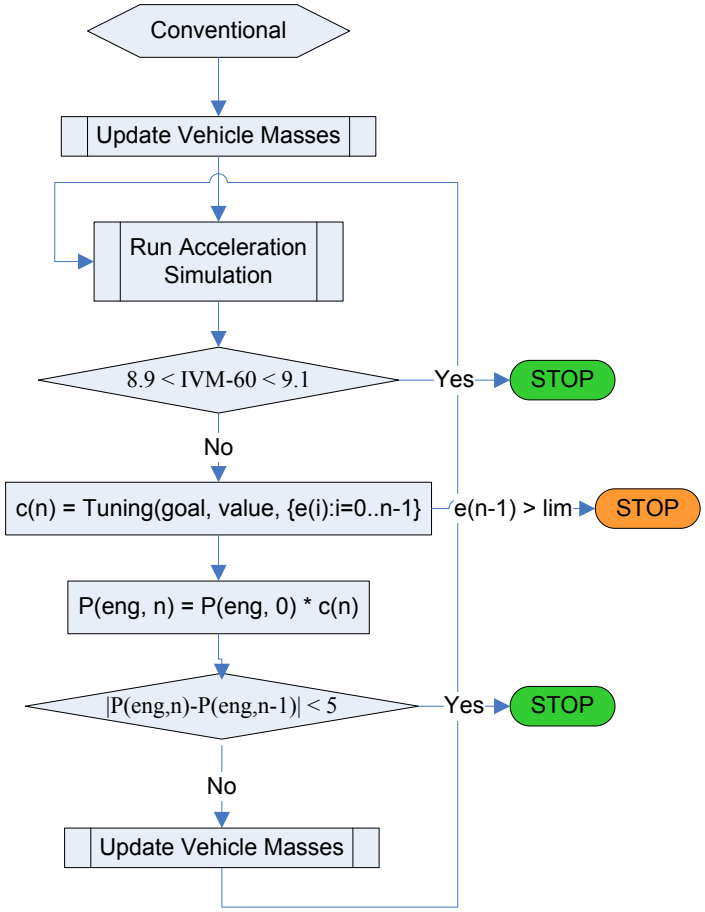
	Unit	OEM Gasoline	OEM CNG	Gasoline with Resizing	CNG with Resizing
Engine	kW	136	112	136	145
Transmission		1st: 2.563, 2nd: 1.552, 3rd: 1.022, 4th: 0.727, 5th: 0.52			
Final Drive		4.43			
Tires		P195 / 65 R15			
Curb Weight	kg	1585	1650	1585	1675
0-60 mph	sec	9.5	10.2	9.5	9.5

Use of CNG fuel in the same engine leads to lower performance

Important: The OEM provided us with the gasoline and CNG map of the same engine to allow a fair comparison

Technical Accomplishments

Automated Sizing Algorithm used to Properly Size the Vehicle to Match the Vehicle Technical Specifications



The entire vehicle is built based on each individual component assumptions

Technical Accomplishments
Conventional Light Duty Vehicle Results

No Engine Resizing (data used as provided by OEM)

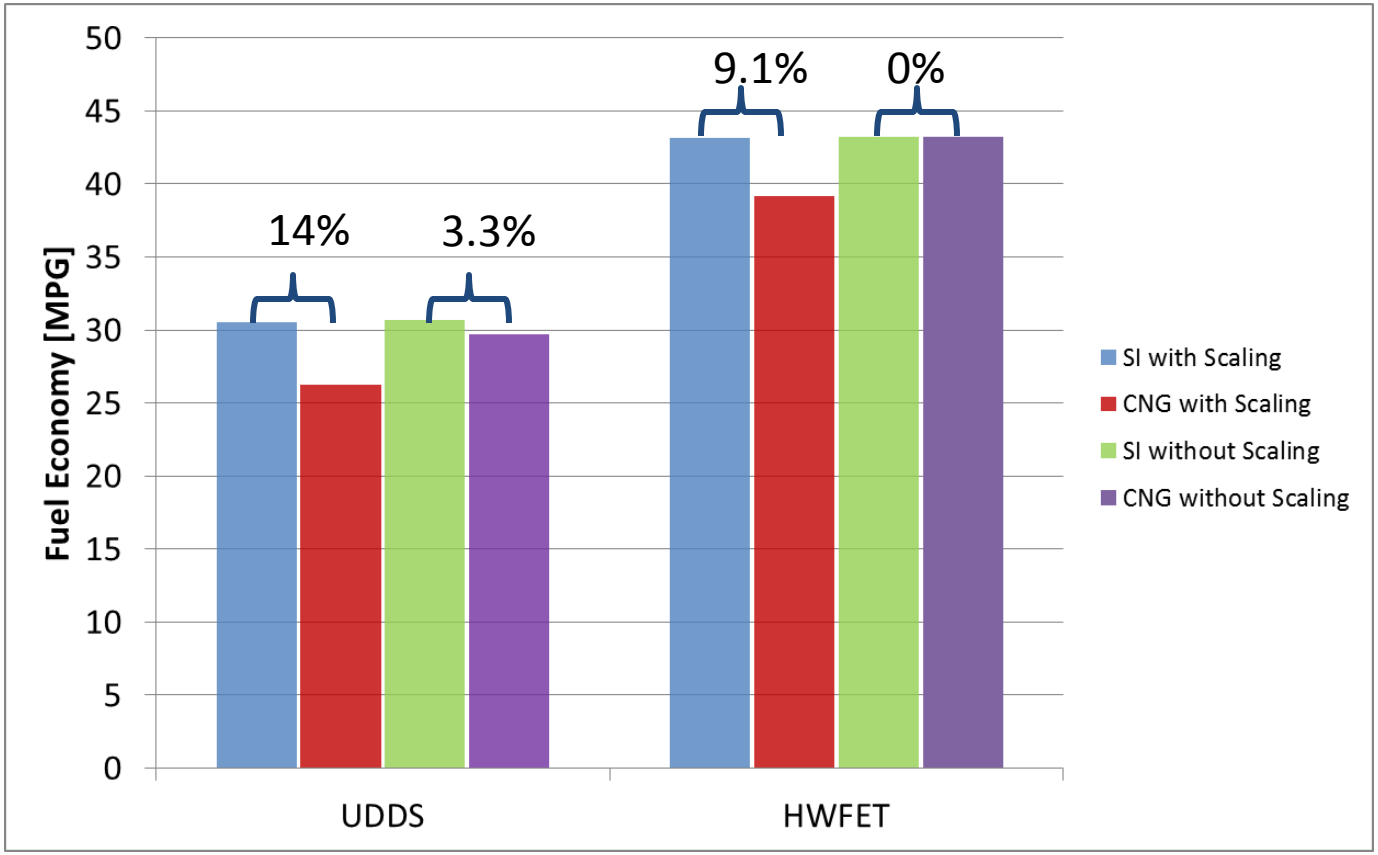
	Unit	Gasoline	CNG without Resizing	Percentage Difference
Fuel Consumption	l/100km	6.42	6.56	-2
Fuel Economy	MPGGE	36.6	35.8	

With Engine Resizing (CNG ICE sized to match VTS)

	Unit	Gasoline	CNG with Resizing	Percentage Difference
Fuel Consumption	l/100km	6.42	7.32	-12
Fuel Economy	MPGGE	36.6	32.1	

VTS: Vehicle Technical Specification

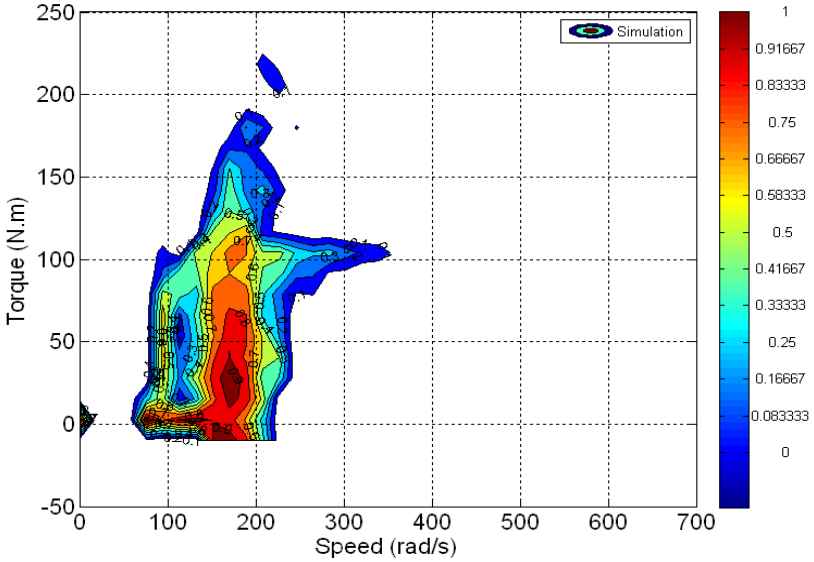
Technical Accomplishments
Conventional Light Duty Vehicle Results



Most of the fuel consumption penalties occur at low load on the UDDS drive cycle (3.3% without scaling and 14% with scaling) compared to the HWEFT (respectively 0% and 9.1%)
=> Hybridization would lower the CNG penalty

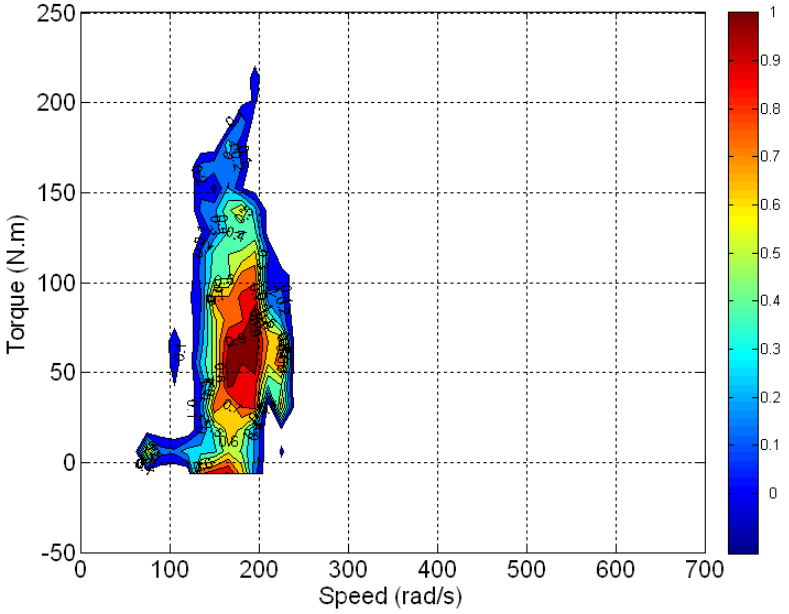
Technical Accomplishments
Conventional Light Duty Vehicle Results

CNG ICE on UDDS – With scaling

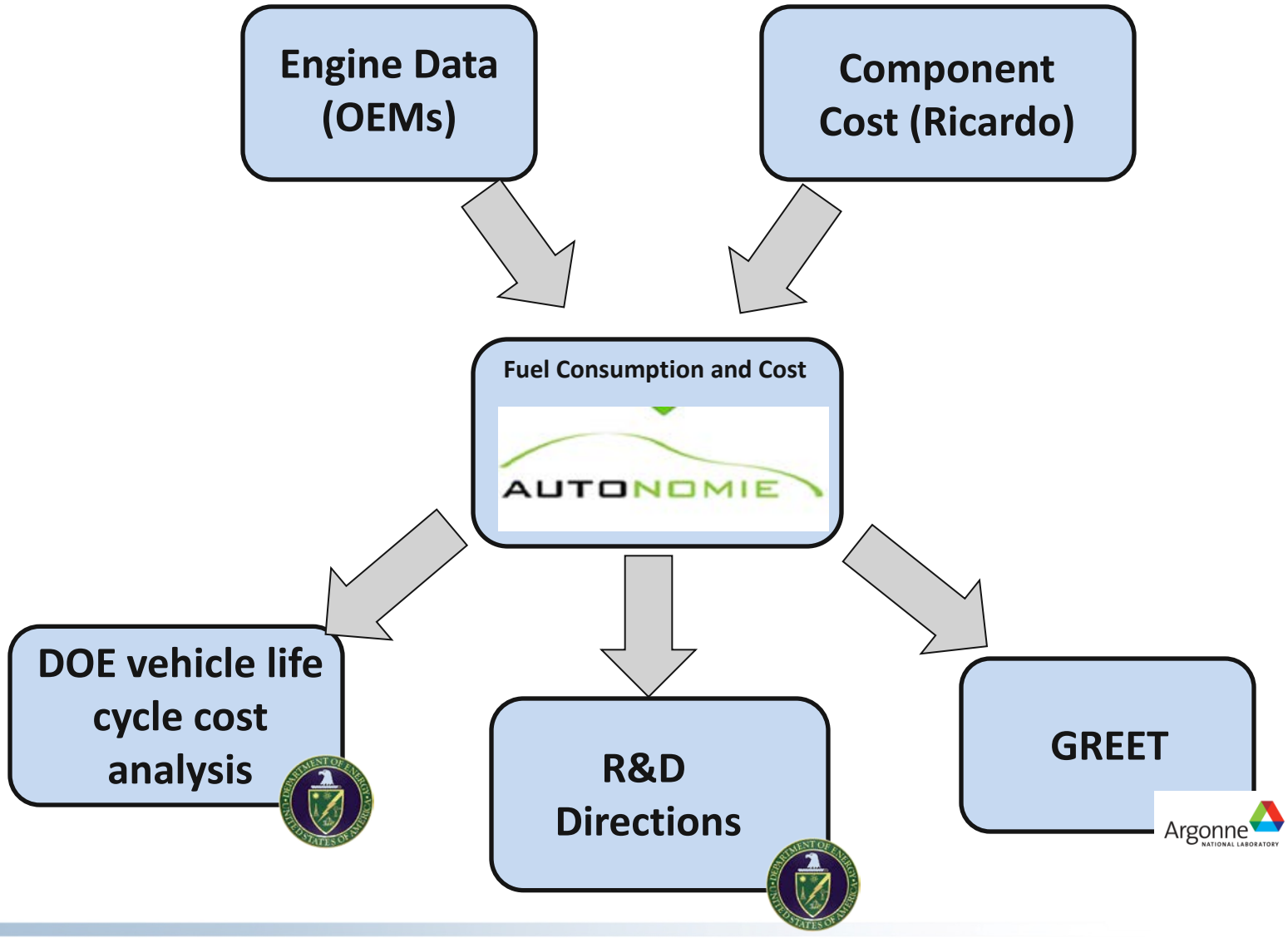


Low efficiency at low load penalizes the CNG under urban driving conditions on a conventional vehicle

CNG ICE on HWFET – With scaling



Collaboration and Coordination with Other Institutions



Proposed Future Work

FY12 On going work

- Evaluate the fuel displacement potential on several electric drive vehicles (HEVs, PHEVs) for light duty applications
- Implement medium and heavy duty (MD&HD) engine data, including LNG and LPG)
- Define component sizing for each MD&HD application
- Select the drive cycles for each MD&HD application
- Evaluate the fuel displacement potential on several electric drive vehicles (HEVs, PHEVs) for medium and heavy duty applications

FY13 Potential Activities

- Evaluate MD&HD different applications
- Evaluate potential of future CNG, LNG, LPG engine technologies (i.e., direct injection)

Summary

- Study evaluates the fuel displacement potential of CNG, LNG and LPG fuels for different applications (i.e., light duty, delivery truck, transit bus) and powertrain configurations (i.e., conventional, electric drive).
- For conventional light duty vehicles, current CNG technology leads to:
  - 2% fuel consumption penalty when the engine is not resized (CNG has then lower performance).
  - 12% fuel consumption penalty when the engine is resized (CNG has then lower performance).
- Future work will focus on evaluating different powertrain configurations, applications, component sizes and controls strategies on a variety of drive cycles from a fuel consumption and cost perspective.