Impact of Fuel Cell System Peak Efficiency on Fuel Consumption and Cost

2014 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review

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Sponsored by Fred Joseck

Project ID # AN044

Project Overview

Timeline

- Start: September 2014.
- End: September 2015.
- Status: 80% complete.

Barriers

- Provide guidance on component targets and future R&D directions.

Budget

- FY13 DOE Funding: $50K
- FY14 DOE Funding: $100K
- Total Project Value: $150K

Partners

- Argonne Fuel Cell System Experts.
- Inputs from industry and academia.

Relevance – What is the Fuel Displacement and Cost of Advanced Fuel Cell Systems?

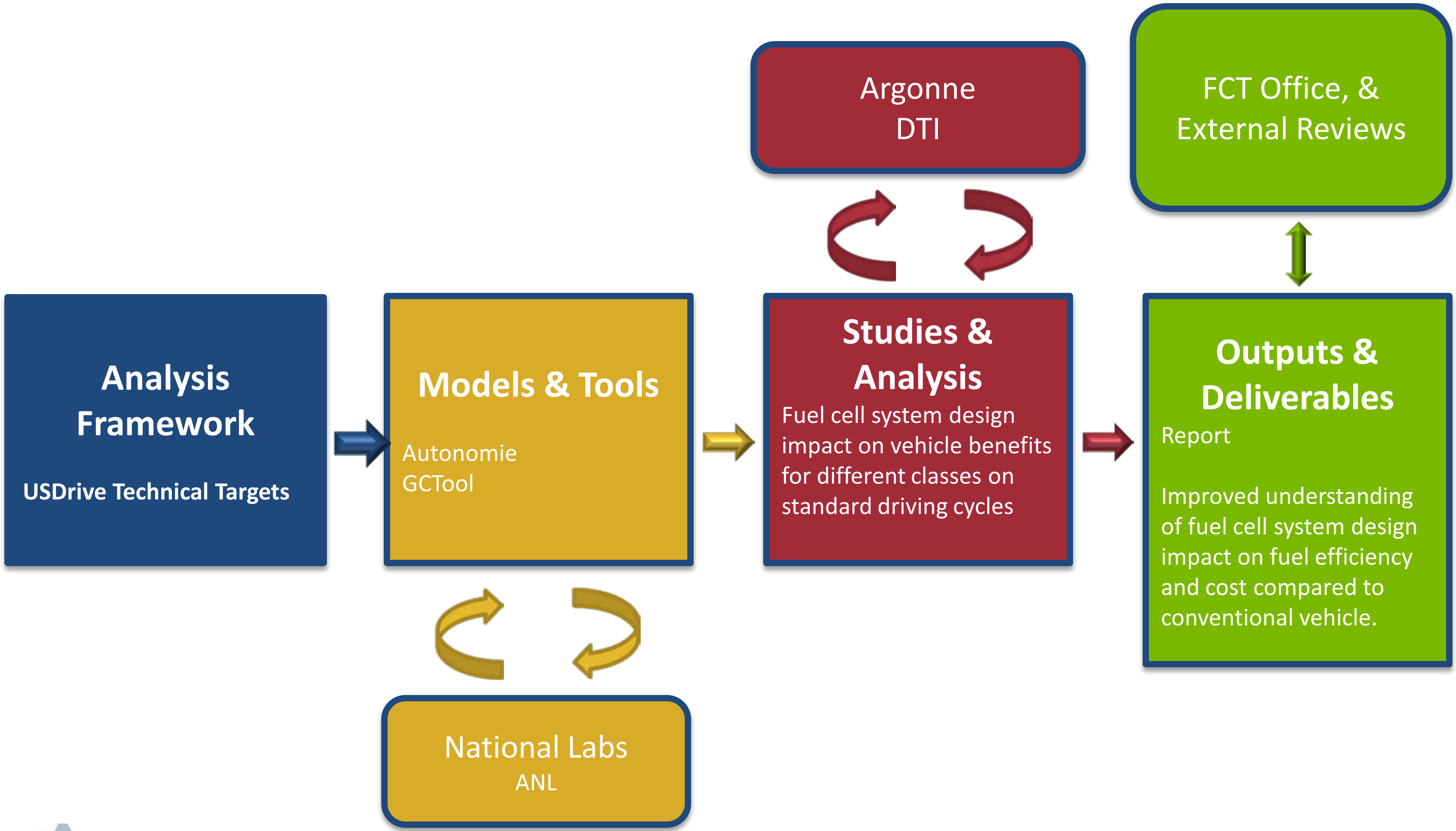
Use of current technology to determine baseline technology

R&D Improvements

- Evaluate benefits of aggressive fuel cell system peak efficiency compared to the current target of 60% from an energy consumption and cost point of view.
- Provide guidance on future research priorities by evaluating the potential of technologies to accelerate petroleum displacement.

Approach

Impact of Fuel Cell System Peak Efficiency on Fuel Consumption and Cost



Approach

- Gather component and vehicle assumptions from experts
- Size the vehicles to meet similar vehicle technical specifications (I.e. performance, range…)
- Model several vehicle classes, including compact car, midsize car, small SUV, large SUV, pickup truck
- Evaluate the impact of aggressive fuel cell system performance on component sizing and weight
- Perform the simulations on the US standard driving cycles (i.e. UDDS and HWFET).
- Evaluate the impact of aggressive fuel cell system performance on vehicle energy consumption
- Compare fuel cell hybrid vehicle energy consumption and cost to their respective conventional vehicles

Technical Accomplishments

Fuel Cell System Assumptions

Parameter	Units	2013			2030		
		Low	Med	High	Low	Med	High
Specific Power FC system	W/kg	400	400	400	580	660	740
Power Density	W/L	410	410	410	600	730	980
Peak Fuel Cell System Efficiency at 25% Rated Power (Aggressive Projection)	%	60	60	61	65	67	68
Peak Fuel Cell System Efficiency at 25% Rated Power (Constant Efficiency)	%	60	60	60	60	60	60
Platinum Price	$/Troy Oz	$1,800	$1,800	$1,800	$1,800	$1,400	$1,100

Fuel.Cell.Cost=(x*1246.5*(Stack.UnitsPerYr)^-0.2583+(Pt.Price*y))*Fuel.Cell.kW*(Fuel.Cell.kW/Base.80kW)^z

(x,y,z): Coefficients
Stack.UnitsPerYr = 500,000
Pt.Price: Platinium Price
Fuel.Cell.kW: Fuel Cell Power

Costs are assumed for high production volumes

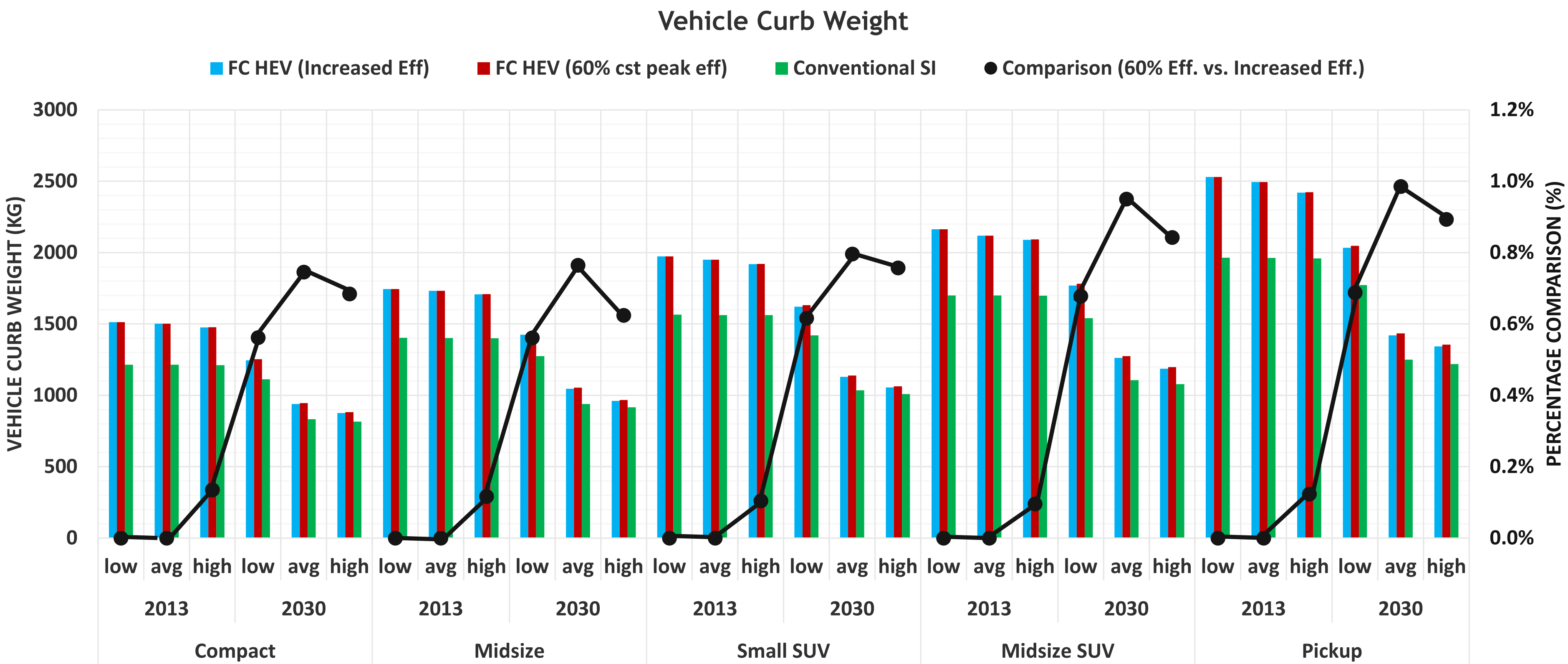
Technical Accomplishments
Hydrogen Storage Assumptions

Parameter	Units	2013			2030		
		Low	Med	High	Low	Med	High
System Gravimetric Capacity	Useable kWh/kg	1.41	1.41	1.41	1.5	1.67	1.96
	Useable kg H2/kg of Tank system	0.042	0.042	0.042	0.045	0.050	0.059
System Volumetric Capacity	Useable kWh/L	0.947	0.947	0.947	1.27	1.5	1.6
	Useable kg H2/L	0.028	0.028	0.028	0.038	0.045	0.048
Cost	$/Useable kg H2	$769	$769	$769	$418	$334	$267
Percentage H2 used in Tank	%	95%	95%	95%	97%	97%	97%
Range on combined, adjusted Mpgge	miles	320	320	320	320	320	320

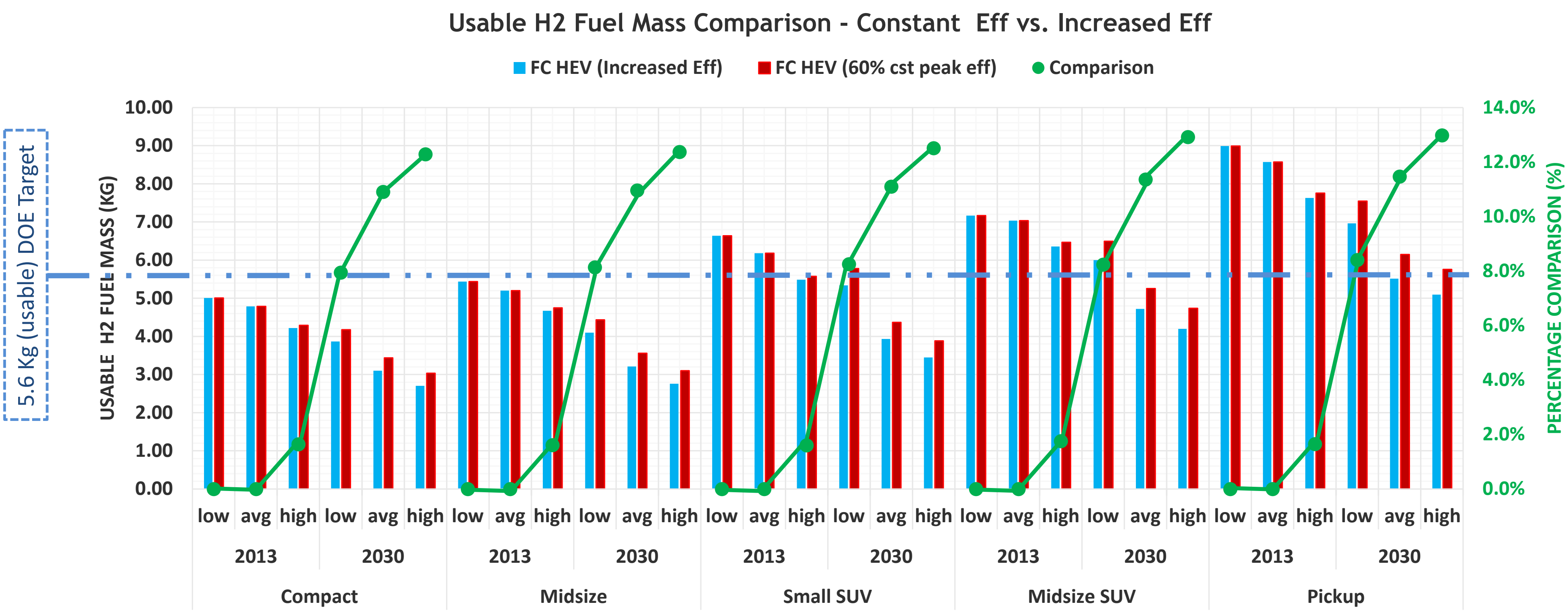
H2.Storage.Cost=Cost.Coefficient*Fuel.Mass
H2.Storage.Mass=Fuel.Mass/Gravimetric.Capacity

Technical Accomplishments

Fuel cell vehicles weight similar to conv. vehicles by 2030



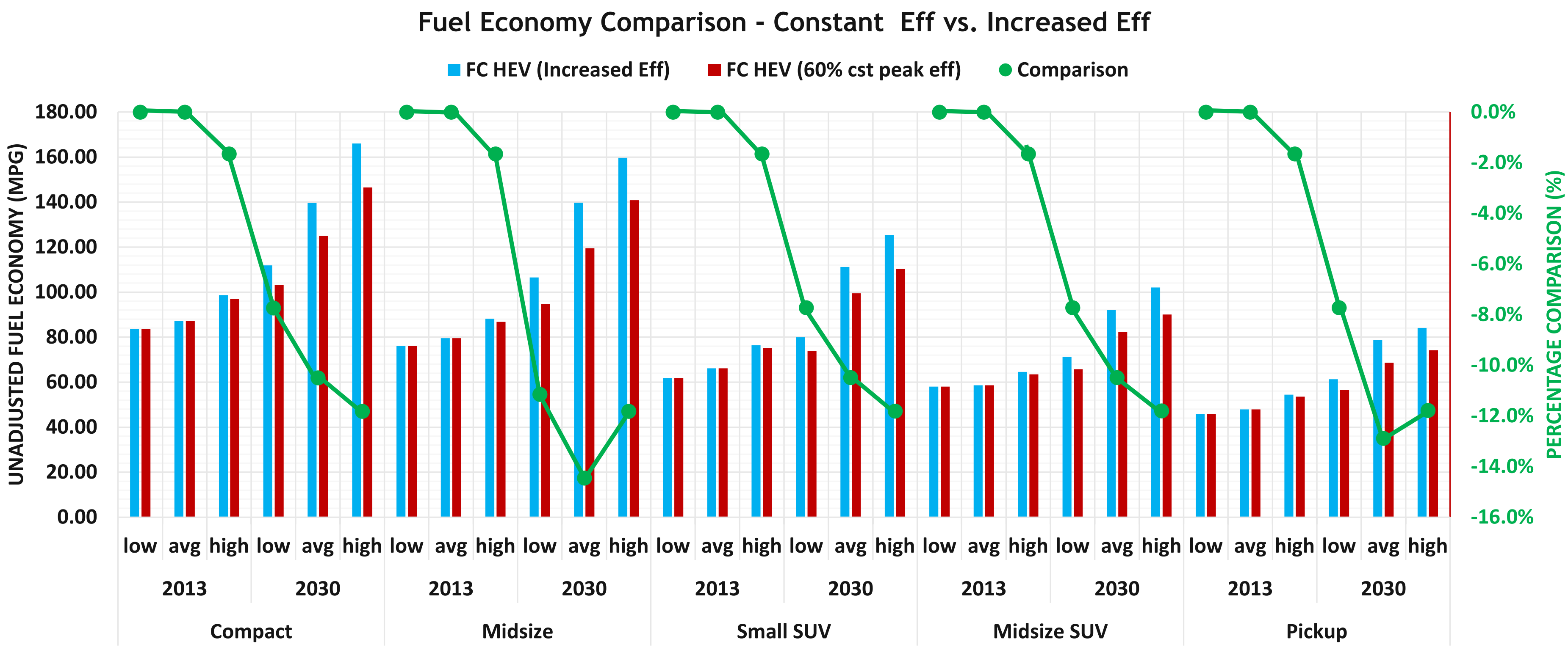
Technical Accomplishments
Aggressive fuel cell system peak efficiency lead to significant reduction in onboard H2 weight by 2030 (up to 12%)



- Current DOE target exceeds range requirements for most vehicles by 2030

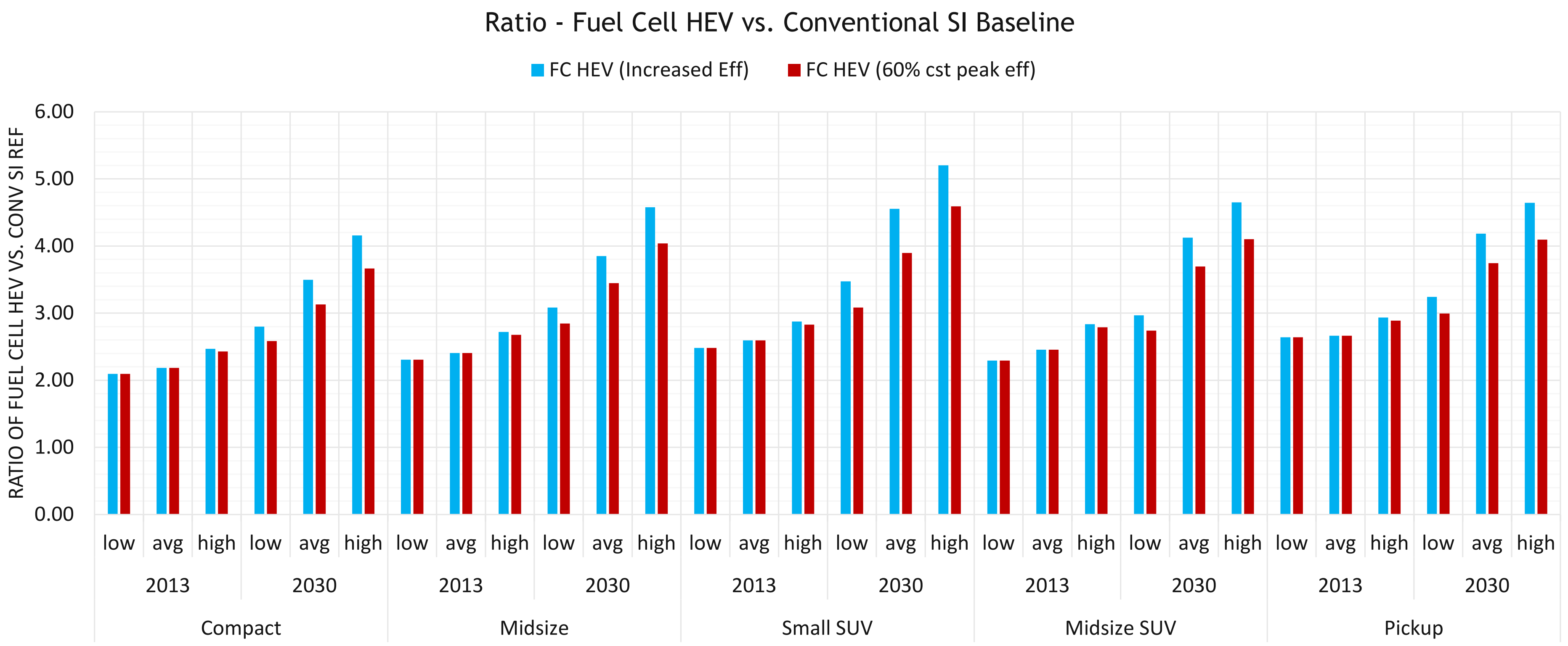
Technical Accomplishments

Aggressive fuel cell system peak efficiency lead to significant fuel savings on the EPA combined driving procedure



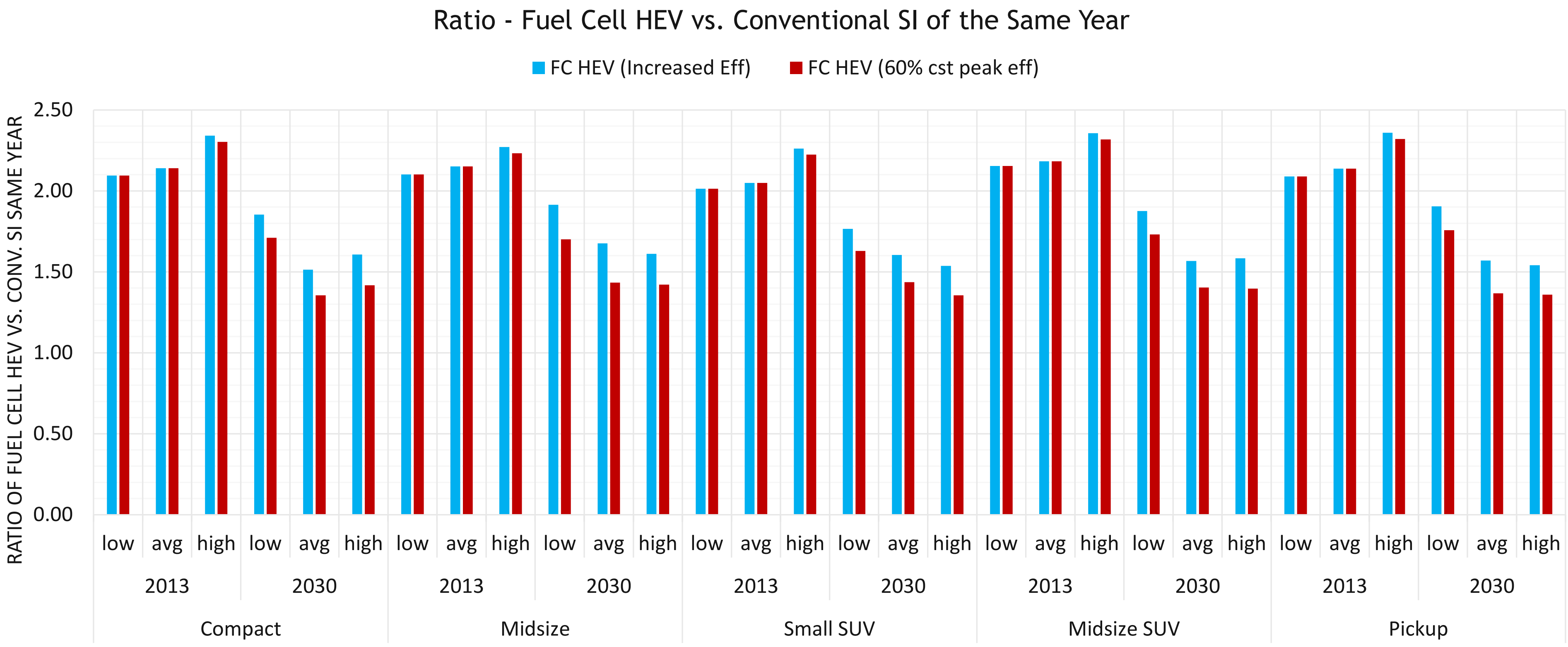
Technical Accomplishments

By 2030, Fuel Cell HEVs could be up to 5 times more fuel efficient than today's conventional baseline



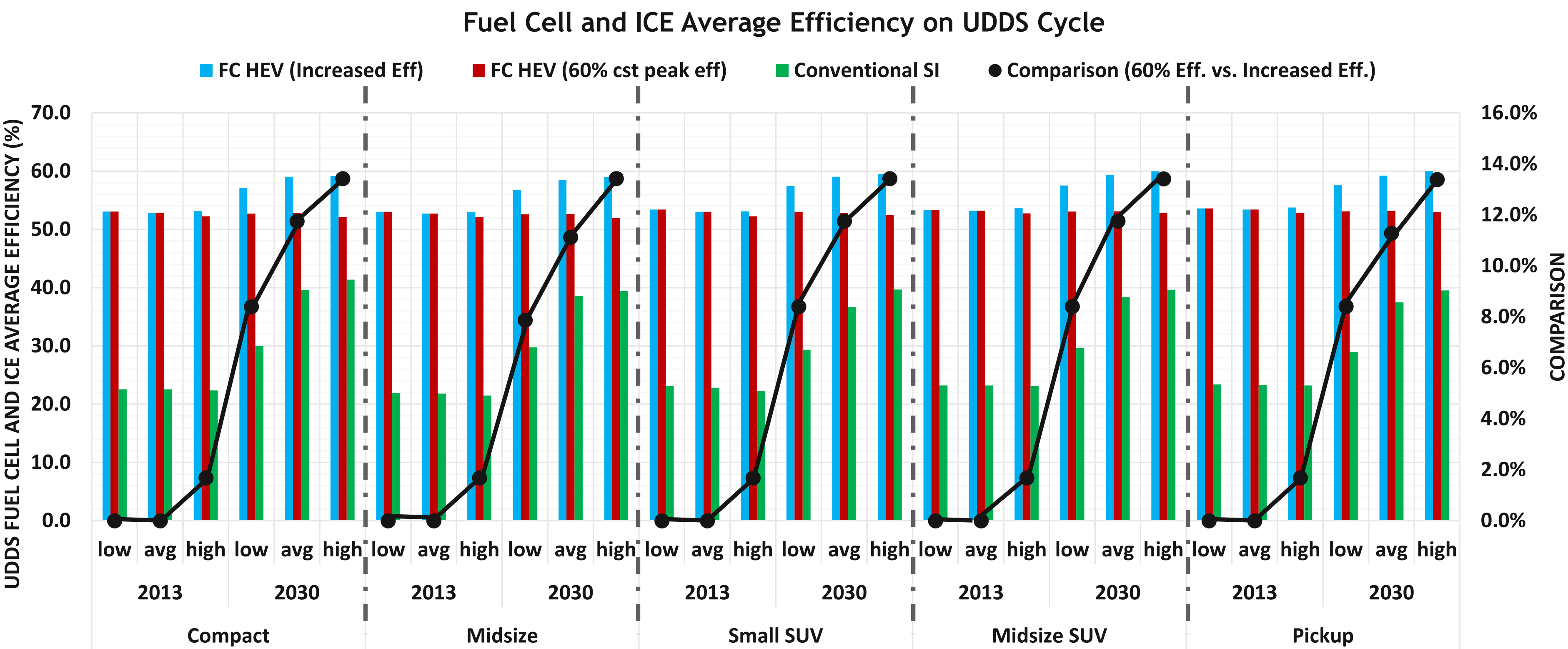
Technical Accomplishments

By 2030, fuel cell HEVs fuel economy tend to get closer to the respective conventional gasoline vehicle of the same year (ratio closer to 1.5).



Technical Accomplishments

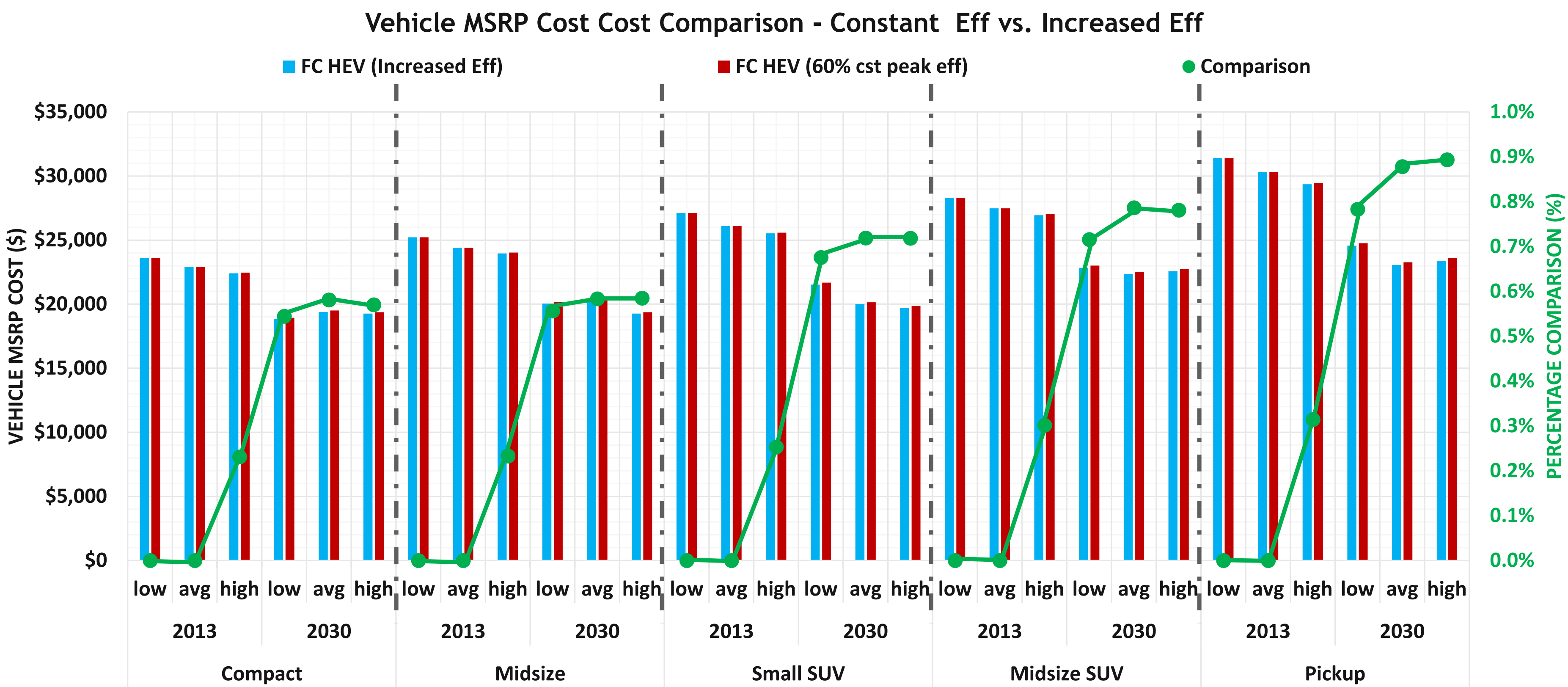
Gasoline engines get more competitive as the engine efficiency significantly increases by 2030



- Aggressive Fuel Cell Peak efficiency targets could provide up to 14% of Fuel Cell average efficiency increase on the UDDS cycle by 2030

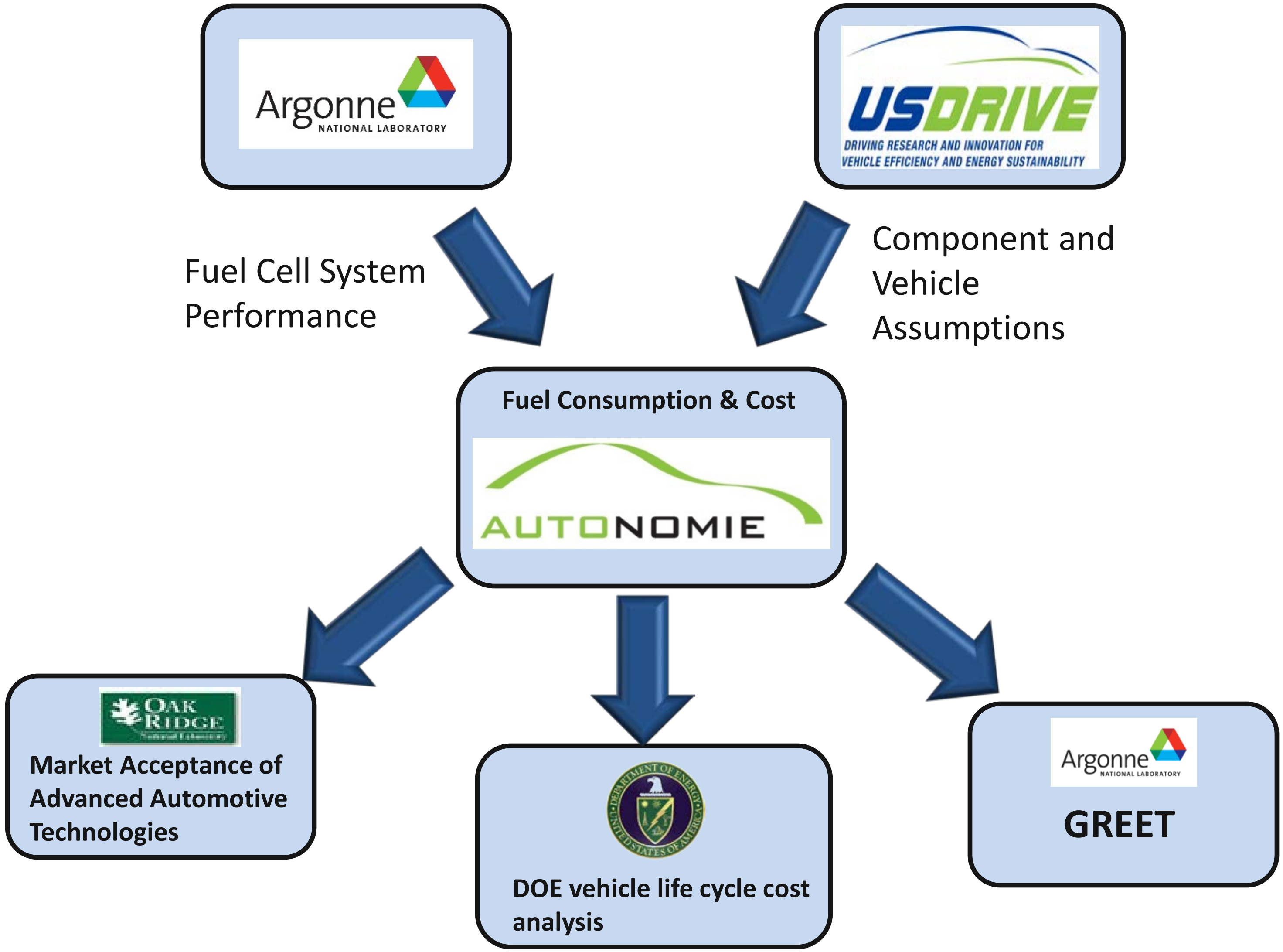
Technical Accomplishments

Aggressive Fuel Cell System Peak efficiency could provide small cost benefit by 2030



- Cost benefits increase with heavier vehicles

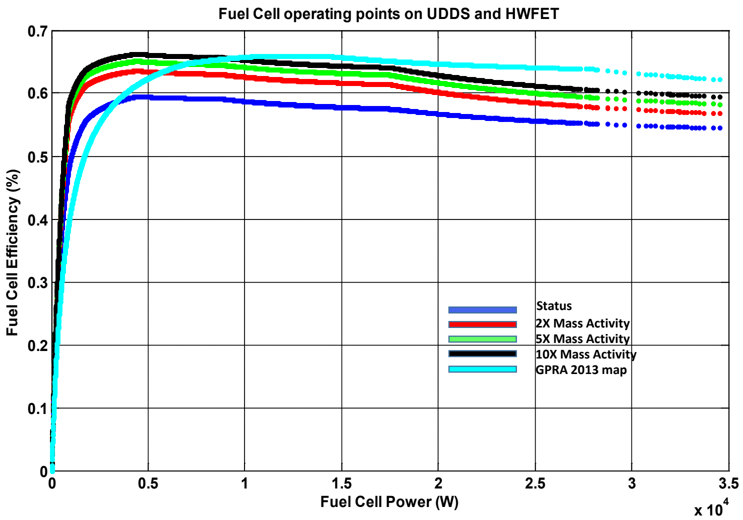
Collaboration and Coordination with Other Institutions



Ongoing and Future Work

- Develop specific fuel cell systems using high fidelity GCTool model for different mass activity to understand the impact of higher efficiency on component design and cost.

GCTool Performance Maps



- Update the vehicle simulation results using high fidelity plant model and detailed cost analysis
- Understand the impact of the fuel cell system and hydrogen storage performance and cost requirements compared to other powertrain technologies to ensure successful commercialization path.
- Provide guidance for long term requirements for peak power and onboard hydrogen weight.

Summary

- Full vehicle simulations were performed to assess the vehicle energy consumption and cost of current and future fuel cell vehicles compared to conventional powertrains as well as aggressive fuel cell system peak efficiencies.
- Aggressive fuel cell system peak efficiency targets could increase fuel economy from 10 to 15% while slightly decreasing cost.
- The cost decrease is mostly due to the decrease of hydrogen tank cost (8 to 13%)
- Compared to conventional vehicles, fuel cell vehicles achieve similar weight and a fuel economy up to 4x higher by 2030
- Current DOE targets for both fuel cell peak power (80 kW) and onboard hydrogen weight (5.6 kg) will exceed the requirements for most vehicle classes by 2030.