

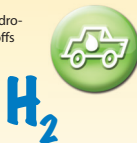
Evaluation of Hydrogen Storage System Characteristics for Light-Duty Vehicle Applications

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Objectives and Approach

Objectives

- Demonstrate an approach to evaluate hydrogen storage system characteristic trade-offs across several vehicle configurations
- Estimate the sensitivity of hydrogen storage system improvements on vehicle viability



Background

Hydrogen Storage Engineering Center of Excellence (HSECoE)
 • Under Department of Energy (DOE) Fuel Cell Technologies Program within the Office of Energy Efficiency and Renewable Energy
 • Complement the three materials-based hydrogen storage CoEs
 • Research and develop onboard vehicular storage systems and components that will reach DOE targets while meeting vehicle related packaging, safety, cost and performance requirements

Approach

- Use an integrated system modeling approach by combining vehicle, cost and viability models to evaluate overall system performance
- Evaluate numerous vehicle combinations to take advantage of unique characteristics of individual storage systems



Technical Targets

DOE Onboard Hydrogen Storage System Targets Considered

Storage Parameter	Units	2010	2015
System gravimetric capacity	kWh/kg	1.5	1.8
Storage system cost	\$/kWh	TBD	TBD
Peak discharge rate	(g/s)/kW	0.02	0.02
Transient response (10% - 90%)	sec	0.75	0.75

Referenced previous 2015 target of \$2/kWh for this analysis

Source: www1.eere.energy.gov/hydrogenandfuelcells/storage/pdf/targets_onboard_hydro_storage_explanation.pdf

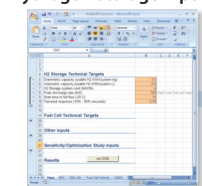
Fuel Cell Power System Targets Considered:

Characteristic	Units	2005	2010	2015
Energy efficiency @ 25% of rated power	%	60	60	60
Energy efficiency @ rated power	%	50	50	50
Specific power	W/kg	500	650	650
Cost	\$/kW	100	35	25
Transient response (10% - 90%)	sec	2	1	1

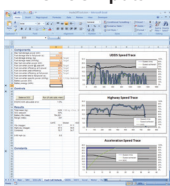
Source: www1.eere.energy.gov/vehiclesandfuels/resources/fcvt_plans_roadmaps.html

Model Framework

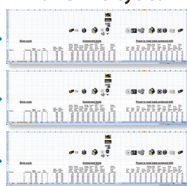
Hydrogen Storage Inputs



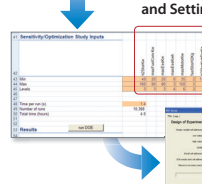
Vehicle Inputs



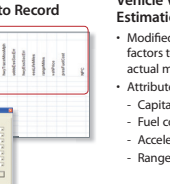
Run Drive Cycles



Design Variables and Settings



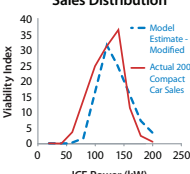
Results to Record



Vehicle Viability Estimation

- Modified weighting factors to reflect actual market trends
- Attributes considered
 - Capital cost
 - Fuel cost
 - Acceleration
 - Range

Majority Buyers Sales Distribution



Experiment Design and Assumptions

Design of Experiments

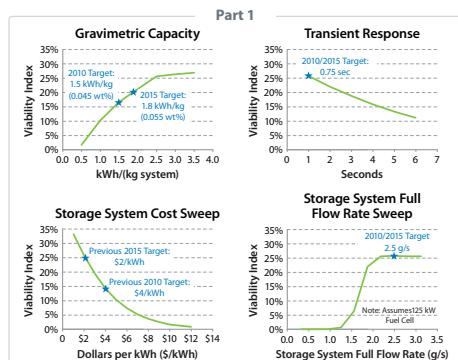
Part 1: Target sensitivities for fixed component sizes

	Gravimetric Capacity (kWh/kg)	Transient Response (sec)	Cost (\$/kWh)	Full Flow Rate (g/s)/kW
Minimum	0.5	1	\$1.00	0.0025
Maximum	3.5	6	\$12.00	0.025
Levels	7	6	12	10

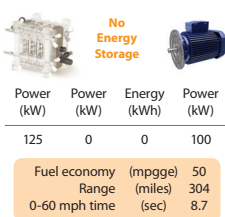
Part 2: Target sensitivities capturing component sizing interactions

	Gravimetric Capacity (kWh/kg)	Fuel Cell Peak Power (kW)	Motor Peak Power (kW)	ESS Peak Power (kW)	ESS Energy (kWh)
Minimum	0.5	25	25	20	0
Maximum	5	175	200	80	3
Levels	10	4	8	7	4

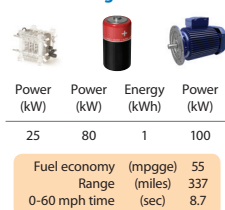
Results



"Part 1" Configuration



"Most Viable FCV" Configuration



¹ Same as "Best NPC FCV configuration"

Conclusions

- Estimated the sensitivity of hydrogen storage system improvements on vehicle viability
- Decreasing fuel cell power and increasing battery power can help preserve vehicle viability with slow transient response storage systems
- Using the "Most Viable" and "Best NPC" approaches provides similar results

