IX.3 Impact of Fuel Cell and H_2 Storage Improvements on FCEVs

Aymeric Rousseau
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, IL 60439
Phone: (630) 252-7261
Email: arousseau@anl.gov

DOE Manager: Fred Joseck
Phone: (202) 586-7932
Email: Fred.Joseck@ee.doe.gov

Project Start Date: September 1, 2015
Project End Date: August 31, 2016

Overall Objectives

- Quantify the impact of system improvements on energy consumption and economic viability of fuel cell electric vehicles (FCEVs).

Fiscal Year (FY) 2016 Objectives

- Quantify the impact of fuel cell stack improvement on the cost of driving FCEVs.
- Quantify the impact of hydrogen storage improvement on the cost of driving FCEVs.
- Quantify the impact of fuel cell system improvement on the cost of driving FCEVs.
- Verify whether the current fuel cell and storage technology targets are sufficient to make FCEVs viable, even with the present day vehicle technologies.

Technical Barriers

This project addresses the following technical barriers from the System Analysis section of the Fuel Cell Technologies Office Multi-Year Research, Development and Demonstration Plan.

(A) Future Market Behavior

(C) Inconsistent Data, Assumptions and Guidelines

(D) Insufficient Suite of Models and Tools

(E) Unplanned Studies and Analysis

Contribution to Achievement of DOE Systems Analysis Milestones

This project will contribute to achievement of the following DOE milestones from the Fuel Cells section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan.

- Milestone 1.1: Complete an analysis of the hydrogen infrastructure and technical target progress for hydrogen fuel and vehicles. (2Q, 2011)
- Milestone 1.11: Complete analysis of the impact of hydrogen quality on the hydrogen production cost and the fuel cell performance for the long range technologies and technology readiness. (2Q, 2015)
- Milestone 1.12: Complete an analysis of the hydrogen infrastructure and technical target progress for technology readiness. (4Q, 2015)
- Milestone 1.16: Complete analysis of program performance, cost status, and potential use of fuel cells for a portfolio of commercial applications. (4Q, 2018)
- Milestone 1.17: Complete analysis of program technology performance and cost status, and potential to enable use of fuel cells for a portfolio of commercial applications. (4Q, 2018)
- Milestone 2.2: Annual model update and validation. (4Q, 2011 through 4Q, 2020)

FY 2016 Accomplishments

- A process was developed to quantify the individual and collective impact of improvements made in the following systems.
  - Fuel cell stack improvements
  - H_2 storage
- The impact on the following parameters was quantified.
  - FCEV weight
  - Fuel cell power requirement
  - Onboard hydrogen mass requirement
  - Fuel cell system cost
  - Hydrogen storage cost
  - FCEV fuel economy, cost, and lifecycle cost

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INTRODUCTION

FCEVs are one of the technology choices considered in the baseline and scenario (BaSce) analysis [1]. It is understood that when combined with various vehicle technology improvements, FCEVs can become economically feasible by 2025. Improvements made in light-weighting, aerodynamics, batteries, and motors help to lower the power requirement and onboard hydrogen storage that FCEVs need. In this study, we examine a scenario in which FCEV-specific technologies meet their development goals, while other vehicle technologies stagnate. This analysis will reveal the technology targets that should be met, to make FCEVs feasible with existing vehicle technologies.

Table 1 shows the technology targets assumed for this study. For each year, there are target values that could be assumed with a "low," "medium," and "high" level of technology progress. These three assumptions are shown below each year (2020, 2025, 2030, and 2045).

APPROACH

The baseline vehicle chosen for this study is the 2015 FCEV used in the BaSce analysis. This vehicle has specifications similar to vehicles currently in the market. Autonomie enables us to evaluate the fuel economy, and initial and operating costs for such a vehicle. With that information, the cost of ownership is computed. The FCEV is considered to be a feasible choice if it has the same or lower lifecycle cost ($/mile) as a conventional vehicle.

For each target year, the expected improvements in FCEV-specific technologies are added to this baseline vehicle model. Simulation results provide the improvement observed in vehicle mass, power, onboard hydrogen storage, and cost. Three scenarios are evaluated for each year.

- Fuel Cell (FC) System Impact: Fuel cell system improves over time.
- Hydrogen Storage (H_2) System Impact: Hydrogen storage system improves over time.
- Combined (H_2 FC) Impact: Both fuel cell and hydrogen systems improve over time.

This reveals the relative importance of each FCEV-specific technology, as well as their combined contribution in making FCEVs technically and economically viable.

RESULTS

Higher power and energy density for the fuel cell stack and hydrogen storage systems results in lower vehicle mass, as shown in Figure 1.

A lighter vehicle requires less power from the prime mover and less onboard energy storage. This allows us to use smaller fuel cell stacks and smaller hydrogen tanks, which will help to reduce the cost of the FCEV in the future (Figure 2).Such a vehicle will also have better fuel economy. Simulations predict about a 20% improvement in FCEV fuel economy by 2045. This will result in a reduction in operating costs. Figure 3 shows the overall lifecycle cost, expressed as the cost of driving a mile.

Present-day conventional vehicles have a lifecycle cost of 43¢/mile [1]. FCEVs are expected to match that by 2030, if the fuel cell technology targets are met. If all vehicle technologies develop as expected, then the combined improvements in batteries, motors, and vehicle light-weighting could make fuel cells competitive by 2025**.**

TABLE 1. Technology Assumptions

Parameter	Unit	2015	2020			2025			2030			2045		
			low	med	high	low	med	high	low	med	high	low	med	high
Peak Fuel Cell System Efficiency	%	59	63	65	66	64	66	67	65	67	68	68	69	70
Platinum Price	$/Troy oz	$1,500	$1,500			$1,500			$1,500			$1,500		
Specific Power FC System	W/kg	659	659	670	680	659	665	710	659	680	740	670	760	870
Power Density	W/L	640	640	720	850	640	730	890	640	740	970	690	880	1,150
Storage System Gravimetric Capacity	Useable kWh/kg	1.5	1.5	1.6	1.8	1.6	1.7	2	1.6	1.8	2.3	1.7	2	2.5
	Weight % of H_2	4.5	4.5	4.8	5.4	4.8	5.1	6	4.8	5.4	6.9	5.1	6	7.5
Storage System Cost	$/kg H_2 Useable	576	450	391	335	430	375	310	391	317	274	380	311	267
	$/kWh Stored	17.3	13.5	11.7	10.1	12.9	11.3	9.3	11.7	9.5	8.2	11.4	9.3	8
% H_2 Used in Tank	%	96	96	96	96	96	96	97	96	97	97	96	97	97

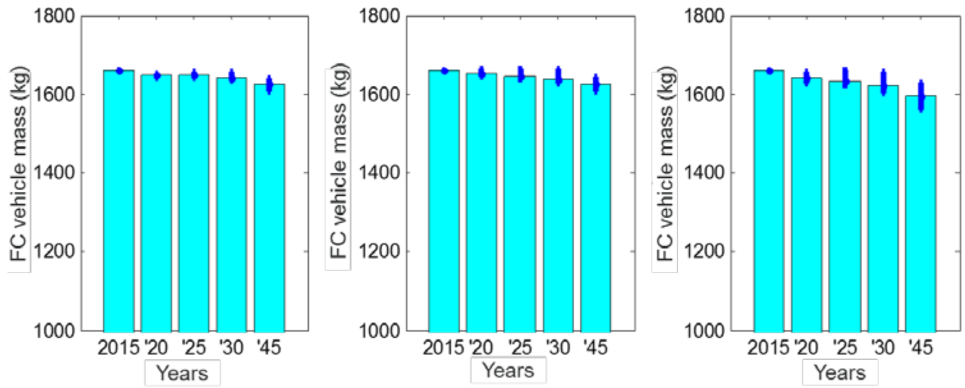

FIGURE 1. Impact of FC and H_2 technologies on FCEV mass

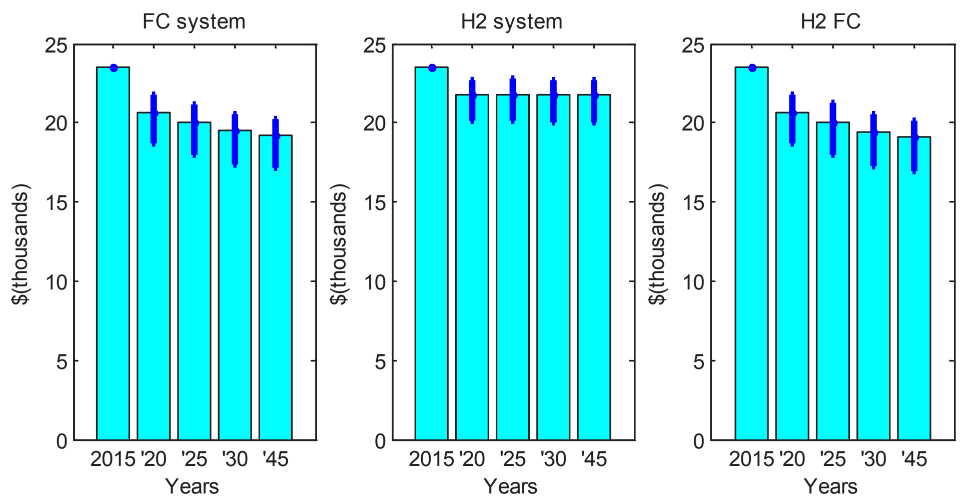

FIGURE 2. Impact of FC and H_2 technologies on FCEV cost

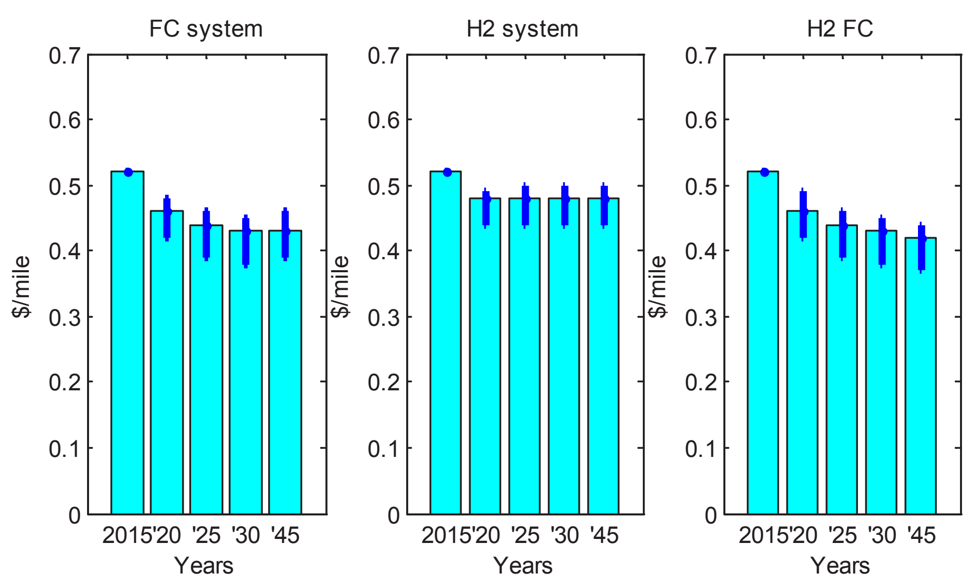

FIGURE 3. Impact of FC and H_2 technologies on lifecycle cost of FCEVs

CONCLUSIONS AND FUTURE DIRECTIONS

This study shows that if the 2030 technology targets for fuel cell technologies are achieved, then FCEVs can be economically feasible with present-day vehicle technologies. The current technology targets for 2030 are sufficient to overcome any uncertainties associated with other vehicle technologies. Fuel cell system improvement is the main factor that reduces FCEV fuel consumption. Manufacturing costs will decrease mostly due to the decrease in both fuel cell system and hydrogen tank costs.

REFERENCES

1. BaSce Analysis, 2015, *Report: Assessment of Vehicle Sizing, Energy Consumption and Cost through Large Scale Simulation of Advanced Vehicle Technologies*. Available at http://www.autonomie.net/publications/fuel_economy_report.html. Accessed May 4, 2016.