Carnegie Mellon University
Wilton E. Scott Institute
for Energy Innovation

POLICY BRIEF

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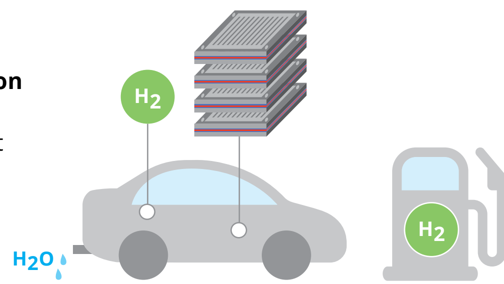
Fuel Cell Electric Vehicles

Opportunities and Challenges Facing Fuel Cell Electric Vehicles

FUEL CELL ELECTRIC VEHICLES COULD DRIVE SUSTAINABLE TRANSPORTATION FORWARD

Fuel cell electric vehicles (FCEVs) are powered by proton exchange membrane fuel cells (PEMFCs), which are low-temperature (typically less than 100 °C), electrochemical devices that convert hydrogen and oxygen directly into electric power. There is no combustion of petroleum-based fuels. The “stack” consists of PEMFCs combined in series and parallel to provide the desired electrical performance.

H_2O is the Only Tailpipe Emission
During operation, FCEVs produce zero carbon and criteria pollutant emissions.*



Hydrogen Infrastructure
Forty retail hydrogen refueling stations have opened in the U.S., 39 of which are in California.[1] The state aims to open 100 cumulative stations by 2020 and 200 stations by 2025.[2]

Hydrogen Storage Enables 350+ Mile Driving Range
FCEVs operate on 700 bar compressed hydrogen gas, which enables a driving range exceeding 350 miles.[3] However, to improve storage cost and performance, material-based technologies (e.g., adsorbents, metal hydrides and chemical storage) are under research and development.[4]

ANTICIPATED COSTS, DURABILITY AND REFUELING STATION AVAILABILITY

We conducted formal interviews[5] and a workshop[6] with experts to assess the anticipated future cost and performance of fuel cell and hydrogen technologies. By 2050, PEMFC systems could meet the U.S. Department of Energy’s (DOE’s) system cost target of $30/kW and nearly meet the stack durability target of 8,000 hrs.[7,†,‡,§]

2020
Cost = $62/kW
Durability = 4,500 hrs

2030
500 refueling stations

2035
Cost = $46/kW
Durability = 6,000 hrs

2035
19% of respondents specified adsorbents as the most viable storage technology (67% compressed gas).

2050
Cost = $30/kW
Durability = 7,500 hrs
10,000 refueling stations

2050
44% of respondents specified adsorbent or chemical storage as the most viable storage technology (50% compressed gas).

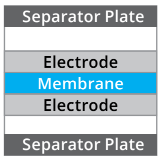
* *Vehicle operation excludes potential emissions from upstream sources, such as hydrogen production.*

† *Cost is defined as the fuel cell system’s production cost divided by the system’s net power output. Durability, which is measured during drive-cycle testing, is the time until the fuel cell stack’s rated power reduces to a value that is 10% less than its beginning-of-life rated power.*

‡ *Median values reported. Experts ranged in their assessments.*

§ *All costs are expressed in 2017 USD and assume 500,000 systems are produced per year.*

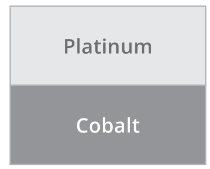
BARRIERS TO REDUCING COST AND IMPROVING DURABILITY



Fuel Cell

Platinum Loading

Seventy percent of respondents identified the amount of platinum catalyst in the electrodes as the most considerable barrier to reducing PEMFC system cost. Experts also identified separator plate and membrane costs as considerable.



Instability of Catalysts

Forty-one percent of respondents identified the instability of platinum alloys (e.g., platinum-cobalt) as the most considerable barrier to improving stack durability. Experts also identified platinum sintering and dissolution as considerable.

Summary

Automotive PEMFC systems could meet the DOE's cost and durability targets by 2050. Also, by this time, hydrogen refueling stations could number in the thousands and possibly reach 10,000. In addition, compressed gas will likely be the most viable near-term hydrogen storage technology, while materials-based storage (with additional R&D) could become viable in the long-term.

Our findings further suggest that an increase in PEMFC and hydrogen R&D spending will accelerate progress toward meeting cost and performance targets.

Creating regulatory and incentive-based policies are recommended governmental actions to advance the widespread viability of FCEVs.

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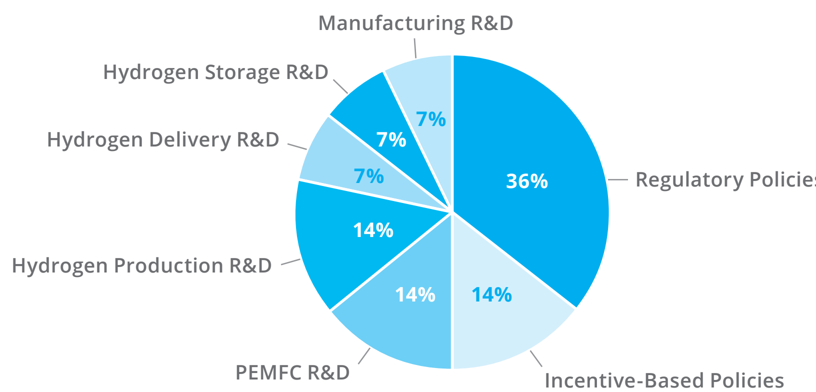
RECOMMENDED GOVERNMENTAL ACTIONS TO ADVANCE FCEV VIABILITY

Experts identified the most important governmental action to advancing the widespread viability of FCEVs — regulatory policies (including zero emission vehicle mandates and low-carbon fuel standards), followed by incentive-based policies and R&D.[6] The chart below shows the percentage of respondents who chose each action:



Percentages do not sum to 100% due to rounding.

1 *U.S. Department of Energy. Alternative Fuels Data Center. Available at: afdc.energy.gov/stations/#/find/nearest [Accessed May 1, 2019].*

2 *Baronas, J. and Achtelik, G. 2018. Joint Agency Staff Report on Assembly Bill 8: 2018 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California. Available at www.energy.ca.gov/2018publications/CEC-600-2018-008/CEC-600-2018-008.pdf.*

3 *Honda. 2019. Clarity Fuel Cell. Available at: automobiles.honda.com/clarity-fuel-cell [Accessed May 7, 2019].*

4 *U.S. DRIVE. 2017. Hydrogen Storage Tech Team Roadmap. Available at: www.energy.gov/sites/prod/files/2017/08/f36/hstt_roadmap_July2017.pdf.*

5 *Whiston, M.M., et al. 2019. Expert Assessments of the Cost and Expected Future Performance of Proton Exchange Membrane Fuel Cells for Vehicles. Proc Natl Acad Sci USA 116 (11): 4899–4904.*

6 *Whiston, M.M., et al. 2019. Workshop on Proton Exchange Membrane Fuel Cell Cost, Durability, and Market Viability. Manuscript in preparation.*

7 *U.S. Department of Energy. 2017. Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan: Fuel Cells. Available at: www.energy.gov/sites/prod/files/2017/05/f34/fcto_myrdd_fuel_cells.pdf.*

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