Fuel Cell Electric Vehicles: A Business Case for Clean Transportation in Connecticut

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Introduction:
Government and private sector stakeholders are now developing commercial models for the use of hydrogen and renewable energy as a replacement of hydrocarbon fuels in the transportation sector, which accounts for 30.3 percent of Connecticut's total energy consumption. Fuel cell electric vehicles (FCEVs) have several advantages over conventional vehicles, including:

- Zero emissions with high efficiency operation;
- Energy security with fuel produced using domestic and/or renewable resources;
- Quiet operations with electric motor drive and no internal combustion;
- Economic operation that offers competitive pricing and a hedge against fossil fuel price volatility; and
- Long range with short duration refueling that achieves parity with fossil fuel vehicles today.

Zero Emission Operation and High Efficiency:
FCEVs operate on pure hydrogen with use of a fuel cell to convert hydrogen fuel carried on the vehicle with oxygen from the atmosphere into electricity. The by product is water with zero tailpipe emissions. Use of solar photovoltaic and electrolysis technologies that are currently in commercial use would result in hydrogen production with zero or near zero emissions. Use of biofuel feedstock and anaerobic digestion could also produce hydrogen with low and net zero carbon emissions. Zero emission FCEVs could replace existing conventional fleet vehicles in Connecticut providing annual carbon dioxide (CO2) emission reductions of approximately 10,300 pounds per vehicle and NOx emission reductions of approximately 5.4 pounds per vehicle.[1]

Potential annual reductions for 60 FCEVs compared to conventional light duty gasoline:

- CO2 emissions = 309 tons;
- NOx emissions = 324 pounds; and
- Fuel = 31,200 gallons.

Hydrogen is well suited for fleet and transit operations
- *Hydrogen contributes to energy independence*
- *Hydrogen provides operational flexibility*
- *Hydrogen is ideal for centralized fueling of large fleets*

Energy Security:
Production of hydrogen for use as a transportation fuel is possible using natural gas, renewable energy such as solar energy, or reformation of hydrogen rich compounds such as ammonia. It is not likely that the production of hydrogen would be tied to the import of liquid petroleum crude oil or diesel fuel. While the price of gasoline and diesel fuel has stabilized, these liquid fuels are derived from crude oil which is not renewable and subject to price and supply volatility. Hydrogen as an energy carrier has value for energy security because it can be sourced from a variety of domestically available feedstocks, including renewable and biofuel energy.

[1] Assumes passenger car tailpipe emissions of CO2 are reduced by 4.67 metric tons CO2E/vehicle /year and NOx emissions for passenger vehicles at .213 g/mile x 11,443. https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

Quiet Operations:
FCEVs use electric motor drives without internal combustion and are relatively quiet. This operation is of high value for urban operations and other locations with sensitive sound receptors.

Economics:
FCEVs are expected to be available in Connecticut, Massachusetts, New York, and New Jersey in the near future as hydrogen fueling infrastructure is developed to support these vehicles. In California, both Toyota and Honda are currently offering a 36 month lease for their FCEV with a $15,000 credit for the hydrogen fuel. In addition, several states including Connecticut offer a rebate on the lease or purchase of FCEVs. Consequently, the total cost to operate the FCEVs (lease and fuel costs) can be less than conventional vehicles and plug-in electric vehicles with comparable styling and comfort. The economics of the FCEV, based on the lease details currently available to select California customers, would be more favorable if the vehicles could operate the maximum number of miles that the $15,000 fuel credit could support.

Range and Refueling:
Although battery electric vehicles produce zero emissions, vehicle range is limited and they are subject to long duration or multiple recharging events per day; major factors for fleet operations. Vehicles fueled with hydrogen also offer zero emissions, and have a range over 300 miles or more per fill with a typical refill time of less than 5 minutes. Drawbacks with both battery electric and FCEVs include requirements for dedicated recharging and/or hydrogen refueling. Battery electric vehicle recharging would require dedicated recharging equipment and FCEVs will require hydrogen refueling infrastructure with on-site storage. Cold weather will impact the range of all electric drive vehicles; however, FCEVs are expected to perform without significant reduction of power and range even with heating and air conditioning.

Summary and Conclusion:
Electric drive vehicles appear to be the technology of the future offering high efficiency and clean operations. Without the use of ZEVs, urban areas may be challenged to achieve compliance with air quality standards. Hydrogen fueled FCEVs offer quiet operation, zero emissions, long range, and a conventional refueling experience. Battery electric vehicles also offer quiet operations and zero emissions, but have limited range and typically need to recharge more frequently or over long durations. Both electric drive technologies require dedicated recharging and/or refueling; however, battery electric vehicles may be best suited for use on short duration trips and/or when their operation can accommodate the required recharging time. Hydrogen FCEVs may be best suited for a broad range of fleet operations where vehicle range is a priority and hydrogen refueling is available and convenient.

Table 1: Analysis of Simple Payback for FCEVs[2]

Fuel Cell Fleet Vehicle Economic Model				
Passenger Vehicle	**Vehicle (Ford Fusion se)**	**Toyota Mirai FCEV**	**Honda Clarity FCEV**	**BEV (2018 Ford Fusion Energie se Hybrid)**
Capital Cost with Destination Charges	$24,270	N/A	N/A	$32,180
Amount Due at Signing	$964	$2,499	$2,499	$973
Dealer Incentive Federal tax credit CHEAPR Incentive	$2,000			$9,257
Lease cost per month	$319.00	$349.00	$369.00	$328.00
Lease term (months)	36	36	36	36
Mileage allowance	12,000	12,000	20,000	12,000
Mileage per Lease term	36,000	36,000	60,000	36,000
Cost per mile over lease term		$0.15	$0.20	
Fuel Efficiency - City (Miles/GGE)	21.00	67.00	69.00	104 (elec+gas)/42 gas
Fuel Cost ($/GGE)	$2.52	$12.00	$12.00	$2.52
Full Term Lease Costs	$12,448	$15,063	$15,783	$12,781
Fuel Incentives	$0	$15,000	$15,000	$0
Fuel Cost/Value of Fuel	$4,320	$6,448	$10,435	$872
Full Term Lease Costs and "out of pocket" Fuel Costs	$16,768	$15,063	$15,783	$13,653
CHEAPR Rebate		$5,000	$5,000	see above
Cost ($/mile)	$0.47	$0.28	$0.18	$0.38

Notes: Does not include taxes, registration, and other dealer fees; or the value of avoided environmental, energy security, and budgetary related price volatility control benefits

[2] Costs and lease terms are for illustrative purposes only and subject to change. Please consult with an authorized dealer for specific details and restrictions.

Resources

Vehicle Lease Details and Fuel Efficiency:

www.EVConnecticut.com

www.fueleconomy.gov

www.ford.com (lease details and incentives are valid 1/3/2018 through 4/2/18)

https://automobiles.honda.com/clarity-fuel-cell (lease details and incentives are valid through 4/2/18 for CA)

https://ssl.toyota.com/mirai/fcv.html (lease details and incentives are valid 1/3/2018 through 4/2/18 for CA)

Personal communications with Toyota dealership in CA 1-23-18.