2022

Michigan Hydrogen and Fuel Cell Electric Vehicle Deployment Plan

“H2 FCEV Roadmap 2022”

Michigan - Hydrogen Economy

- Zero Emission Vehicles
- Climate and Energy
- Low Carbon Fuel
- Economic Growth

Michigan Hydrogen and Fuel Cell Electric Vehicle Deployment Plan
"H2 FCEV Roadmap 2022"

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Table of Contents

Index of Figures

Index of Tables

EXECUTIVE SUMMARY

Zero emission hydrogen Fuel Cell Electric Vehicles (FCEV) are technically available, reliable, and are, or are soon to be, cost competitive with other zero emission transportation applications including battery electric vehicles (BEV). Hydrogen FCEV offer quiet and efficient operations with extra value to increase fuel diversity, transportation reliability, and environmental performance including a reduction of carbon dioxide (CO_2) emissions. In addition, the supply chain to manufacture fuel cell technology, hydrogen fuel, hydrogen distribution, and hydrogen refueling can support advanced clean energy employment, job creation, and economic development.

The hydrogen applications for zero emission FCEV transportation that appear to be competitive now or will be within the next decade include:

- Large commercial fleets with long driving range vehicle (400 mile / 650 Km) routes;
- SUV passenger vehicles with long driving range (375 mile / 600 Km) routes;
- Mid-sized vehicles with long driving range (250 mile / 400 Km) routes;
- Buses for long distance (280 mile / 450 Km) urban routes;
- Bus coaches for long haul (310 mile / 500 Km) routes;
- Forklift material handling with 2 X 8-hour shifts and 10 kW motor power;
- Medium-duty trucks with long range (310 mile / 500 Km) routes; and
- Heavy-duty long-haul trucks and with long range (375 mile / 600 Km) routes.[1]

Fleets are especially well-suited for hydrogen applications due to high utilization of refueling infrastructure and a favorable economy of scale to produce fuel cell and hydrogen components. Applications that will be challenged include small passenger vehicles for short range urban transportation which will compete with BEV technology, commuter trains where existing catenary systems have electric infrastructure already in place, aircraft where other fueling systems including biodiesel may be a more competitive alternative for low carbon fueling, and shipping where infrastructure for electric recharging exists and use of biodiesel may provide a more competitive alternative.

Hydrogen fueling will be possible with hydrogen produced on site potentially powered with renewable energy or with hydrogen produced from central production facilities with delivery from specialty vehicles. Delivery of hydrogen through dedicated hydrogen pipelines or blended with natural gas in existing natural gas pipelines with subsequent separation of the hydrogen for market users may be possible with an increased economy of scale and help decarbonize energy infrastructure.

Cost competitiveness is primarily due to:

- A growing economy of scale for the manufacture of fuel cell units and hydrogen storage tanks on FCEVs;
- Target cost for production of low cost hydrogen derived from diverse domestic resources estimated at less than \$2.00/kg with a delivered and dispensed cost of \$4.00/kg; [2]

[1] Path to hydrogen competitiveness, A cost comparison, Hydrogen Council, January 20, 2020.
[2] DOE Hydrogen and Fuel Cells Program; "Annual Progress Report:" https://www.hydrogen.energy.gov/annual_progress19_h2fuel.html#b; April 2020.

- Future production of hydrogen at $2/kg by 2025 and $1/kg by 2030 via net-zero-carbon pathways, in support of the Hydrogen Energy Earthshot goal of reducing the cost of clean hydrogen by 80% to $1 per 1 kilogram in 1 decade ("1 1 1");[3]
- High volume production of renewable hydrogen produced with low cost electricity from wind and solar energy may further reduce the cost of hydrogen and increase the utilization of renewable energy facilities;[4]
- Lower cost transportation and distribution of hydrogen with an increased economy of scale for transportation and delivery; and
- High utilization of centralized hydrogen refueling systems with capacity growing to 1,000 kg/day per refueling station.

While the deployment of FCEVs may be technically viable at many locations for many different types of users and early market adopters, this plan focuses on hydrogen and fuel cell applications that are both technically and economically viable for public and private fleet users. With input from the US Department of Energy, National Renewable Energy Laboratory, the Connecticut Center for Advanced Technology. and the Northeast Electrochemical Energy Storage Cluster, this Michigan Hydrogen and Fuel Cell Electric Vehicle Deployment Plan "H2 FCEV Roadmap 2022" recommends initial development of the following market opportunities for vehicles and supporting hydrogen infrastructure to meet economic, environmental, and energy needs:

- **1,238 FCEVs (581 state passenger fleet vehicles),**
- **37 transit/paratransit buses, and**
- **14 to 15 refueling stations**

These FCEVs are recommended primarily for fleets, including state fleets, at synergistic locations where hydrogen users and producers co-exist, and for opportunistic early market adopters. Hydrogen powered fuel cells could also provide a zero-emission alternative for forklifts and other material handling equipment at warehouse facilities, airports, and other emission constrained areas. Refueling for these vehicles can be provided by hydrogen refueling stations located in areas of the state where fleets, early market adopters, and hydrogen users co-exist.

Operation of these vehicles are projected to increase environmental performance of Michigan's motive fleets with an annual reduction of carbon dioxide (CO_2) emissions by approximately 9,085 metric tons and NOx emissions by 3.762 metric tons.

At $65,000 for each light duty FCEV the capital value for the FCEVs could be as much as $80.47 million (M). At $2M per Fuel Cell Electric Bus (FCEB), the capital value for the FCEBs could be $74 M. At $2M per refueling station, the capital value l for the 14 to 15 hydrogen refueling stations could be $28 M to $30 M.[5]

Based on a 2020 economic impact analysis, the production of hydrogen energy and fuel cells, including related R&D, contributes to Michigan's economy by providing:

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[3] https://www.energy.gov/eere/fuelcells/hydrogen-production.

[4] Peterson, David, James Vickers, Dan DeSantis; "Hydrogen Production Cost From PEM Electrolysis – 2019;" DOE Hydrogen and Fuel Cells Program Record; February 3, 2020. High volume production of renewable hydrogen produced with low cost electricity from wind and solar energy may further reduce the cost of hydrogen and increase the utilization of renewable energy facilities. projected to be less than $3.00/kg with a projected future case production cost of less than $2.00/kg. https://www.hydrogen.energy.gov/pdfs/19009_h2_production_cost_pem_electrolysis_2019.pdf.

[5] As the market evolves, these capital costs will likely decrease providing more buying power for consumers.

- Over **$187 million in revenue and investment**;
- Estimated **862 direct, indirect, and induced jobs**;
- Estimated **$5.7 million in state and local tax revenue;** and
- Nearly **$57 million in employee compensation.**

Over 300 Michigan workers are involved in the production of, and R&D activities related to, hydrogen energy and fuel cells. These workers are supported by almost $100 M in revenue and investment, including investment in a large joint venture. The hydrogen energy and fuel cell sector in Michigan has a total economic impact including multiplier effects of an estimated $187.3 M in output, 862 full- and part-time jobs, and $56.7 M in employee compensation. The hydrogen energy and fuel cell sector's economic impact in Michigan generates an estimated $5.7 M in state and local tax revenue. Michigan's hydrogen energy and fuel cell sector supports at least one job in 98 other industries, and there are multiplier effects of five jobs or more in 28 industries.

The deployment of hydrogen and fuel cell technology will reduce dependency on oil; improve air and water quality; help meet carbon and zero emission vehicle (ZEV) requirements; improve opportunities to utilize renewable energy from indigenous sources such as biomass, wind, and solar photovoltaic (PV) power; provide clean energy revenues; and increase the number of energy sector jobs within the state.

This plan provides links to relevant information to assess, plan, and initiate hydrogen and FCEV deployment to help meet the energy, economic, and environmental goals for the State of Michigan. Policies and incentives that support hydrogen and fuel cell technology will increase deployment, thus increasing production and creating jobs throughout the supply chain. As deployment increases, an economy of scale will develop and manufacturing costs will decline, positioning hydrogen and fuel cell technology to compete more effectively in a global market without incentives. Policies and incentives to purchase and support the deployment of FCEVs, FCEBs, and hydrogen refueling can be coordinated regionally to maintain this advanced clean transportation sector as a global exporter for long-term growth and economic development. Overall, the execution of this plan will maintain Michigan's role as a global showcase for regionally manufactured transportation technology while reducing NOx and CO_2 emissions and as new jobs are created for businesses and industry.

Special thanks go to the Michigan Economic Development Corporation, US Department of Energy, National Renewable Energy Laboratory, supply chain companies that were assessed for economic impact, and key businesses and industries including General Motors that provided information and/or review of this document.

INTRODUCTION

This Michigan Hydrogen and Fuel Cell Electric Vehicle Deployment Plan "H2 FCEV Roadmap 2022" was created with support from the US Department of Energy (DOE) and the National Renewable Energy Laboratory (NREL) with assistance from the Northeast Electrochemical Energy Storage Cluster (NEESC) to increase awareness and facilitate the measured deployment of hydrogen and fuel cell technology. The intent of this guidance document is to make available information regarding the economic value and deployment opportunities to increase environmental performance and energy reliability using hydrogen and fuel cell technologies potentially made by businesses in the State of Michigan.

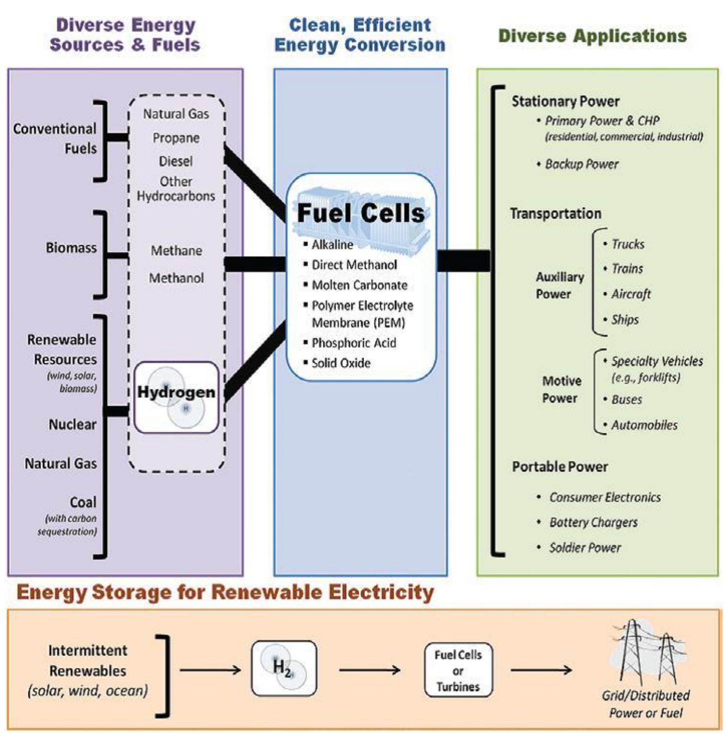
Technology Description

A fuel cell is a device that uses, but does not burn, hydrogen (or a hydrogen-rich fuel such as domestic natural gas) and oxygen to create an electric current with no moving parts. Fuel cells occupy a technology platform that when coupled with electric drivetrains have the potential to replace the internal combustion engine (ICE) in vehicles and provide power for stationary and portable power applications. Fuel cells are in commercial services throughout the world, providing thermal energy and electricity to power the grid, homes, and businesses. Fuel cells are also used in vehicles, including automobiles, trucks, buses, forklifts and other land, marine, air, and space equipment.

Hydrogen can be produced using a wide variety of resources available in Michigan. Hydrogen can be renewable and produced by waste, biomass, wind, and solar energy. Production technology includes electrolysis of water, steam reforming of natural gas, coal gasification, thermochemical production, and biological gasification (see Figure 1).

Natural gas, which is composed of four (4) hydrogen atoms and one (1) carbon atom (CH_4), has the highest hydrogen-to-carbon ratio of any energy source. Furthermore, natural gas is widely available, is relatively inexpensive, and is primarily a domestic energy resource. Consequently, natural gas shows potential to serve as a transitional fuel for the near future hydrogen economy. Over the long term, hydrogen will be produced from renewable technologies and may be used for energy storage of intermittent generation including solar and wind resources.[6]

Figure 1 – Hydrogen Production



Source: Department of Energy (DOE), Energy efficiency and Renewable Energy (EERE), "Clean, Efficient, and Reliable Power for the 21st Century

[6] DOE EERE; "Hydrogen Production"; https://energy.gov/eere/fuelcells/hydrogen-production, January 2018.

Industry/Market Status

Demand for hydrogen and fuel cell technology has increased as development costs have declined, and awareness of economic and environmental benefits has grown. A key market driver is policy favoring low carbon technology for climate change mitigation. Cost reductions have come from an increased economy of scale in the manufacture of fuel cell components, hydrogen, and hydrogen storage tanks. The cost reductions have led to steady growth in the hydrogen and fuel cell industry in the US, with large and small companies located across the country. States and local governments are also recognizing the advantages of hydrogen and fuel cell technology in providing energy resiliency, reduced emissions, improved air quality, and economic growth. Many states have established policies to promote the adoption of hydrogen and fuel cell technologies and/or initiated collaborative efforts to accelerate adoption. Globally, the market for hydrogen transportation is encouraging with The Hydrogen Council vision of more than 400 million cars, 15 to 20 million trucks, and around 5 million buses in 2050, which constitute on average 20 to 25% of their respective transportation segments. The market for hydrogen and hydrogen technologies includes revenues of more than $2.5 trillion per year, and jobs for more than 30 million people globally.[7]

Transportation applications include motive power for passenger cars, buses, trucks, and specialty vehicles, including forklifts. Early market adopters of these FCEVs may include fleet operators due to their ability to run fixed-routes with certain refueling needs and amortize refueling infrastructure costs across a fleet. As consumer education increases, hydrogen fueling infrastructure expands, and as costs of FCEVs become more competitive with conventional vehicles, FCEVs will gain greater market acceptance, resulting in faster market penetration. Eighteen governments, whose economies account for 70 per cent of global GDP, have announced strategies and targets for deploying hydrogen energy solutions including the deployment of 10 million (M) FCEVs and 10,000 hydrogen refueling stations by 2030.[8]

Stationary fuel cells (not assessed in this Roadmap) are providing stable power and heat around the world in microgrids, wastewater treatment plants, food and beverage plants, office buildings, telecommunication hubs, data centers, retail stores, universities, hospitals, hotels, government facilities, and other applications. Large-scale fuel cell systems are being deployed to support the electric grid where transmission is constrained, or where increased reliability is sought. These fuel cell systems are providing clean and dispatchable 24/7 power generation to complement the increasing deployment of intermittent solar and wind resources and support grid reliability. While stationary systems are not assessed in this Roadmap, many components are synergistic to transportation fuel cells, accelerating learning and achieving economies of scale in the industry.

A Business Case for Clean Transportation in Michigan

This Plan indicates potential value for the gradual replacement of fossil-fueled vehicles with FCEVs. Government and private sector stakeholders are now investigating criteria and developing commercial models for the use of hydrogen and renewable energy as a replacement of hydrocarbon fuels in the transportation sector, which accounts for 26.5 percent of Michigan's total energy consumption (see Table 1).[9] FCEVs have several advantages over conventional vehicles (see Table 2) and can reduce price volatility, decrease dependence on oil, improve environmental performance, and provide greater transportation efficiency.

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[7] The Hydrogen Council, Hydrogen scaling up. November 2017 https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf.

[8] Path to hydrogen competitiveness, A cost comparison, Hydrogen Council, January 20, 2020.

[9] U.S. EIA; "Michigan;" https://www.eia.gov/state/?sid=MI#tabs-2; April 17, 2020.

There has been increasing interest by consumers and fleet managers to purchase FCEVs and operate them with fuel from new hydrogen fueling stations. This strategic approach will help to establish hydrogen refueling for fleet vehicles with potential use of funding from public and private sources, and the VW Partial Consent Decree, while providing flexibility for hydrogen refueling developers to address and reduce costs associated with infrastructure, operation, maintenance, and product distribution.

Table 1 – Criteria for Deployment

- High Population Density
- Areas with Early Market Adopters
- Areas with Hydrogen Production and Use
- Areas with Alternative Refueling Stations
- Non-attainment areas for criteria pollutants

Drivers

Environmental quality, energy resiliency, and economic benefits are driving the development of hydrogen and fuel cell technologies for regional, national, and global markets. Federal research and tax incentives have been important drivers for deployment of FCEVs, hydrogen infrastructure, and power generation.

The age distribution of hydrogen and fuel cell companies suggests these companies are poised for expansion. The proximity of automotive original equipment manufacturers (OEM) and supply chain companies in Michigan provides a competitive advantage for research, design, development, manufacturing, and export of commercial products to national and international markets. Michigan has been identified as the "Global Leader in Next-Generation Mobility." In terms of key public/private partnerships and being competitive in mobility-related patents on a national scale, Michigan continues to be highlighted as an epicenter for the testing and deployment of electric vehicles.[10]

Environmental Benefits

The combustion of fossil fuels for motor vehicles is a significant source of Nitrogen Oxides (NOx) and Carbon Dioxide (CO_2) emissions. In the transportation sector, zero-emission FCEVs could replace existing conventional vehicles in Michigan, starting with 1,275 fleet/transit vehicles, reducing annual CO_2 tailpipe emissions by approximately 9,085 metric tons and NOx emissions by 3.762 metric tons.[11] The reduction of these emissions through the use of fuel cell technology could improve air quality, reduce health problems, reduce carbon emissions that contribute to climate change, and help to meet National Ambient Air Quality Standards. Additionally, this transition would play a key role in helping the State reach its 2025 goal to reduce greenhouse gas emissions by 26 percent to 28 percent below 2005 levels.[12]

Table 2 – FCEV Advantages

- Quiet Operations
- Zero Tailpipe Emissions
- Domestic fuel supply
- Price Volatility Reduction
- Energy Independence / Security
- High Efficiency / Long Range

Energy Resiliency

Extreme weather events and potential for disruption of conventional fuel supplies emphasize the need for local and state action to deploy clean, reliable, and diversified alternative fuel vehicles.

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[10] MEDC; "Michigan is Automobility;" https://www.michiganbusiness.org/49c568/contentassets/46143f8b8741443a94ee213342dd9ed1/michigan-is-automobility-report-1.pdf; April 2019

[11] Assumes passenger car tailpipe emissions of CO2 are reduced by 4.67 metric tons CO2E/vehicle /year; transit bus emissions of CO2 are reduced by 89.27 metric tons CO2E /vehicle/year; NOx emissions for passenger vehicles at .213 g/mile x 11,443 and .59 g/mile x 34,000 for diesel fuel transit buses. https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

[12] C2ES; "U.S. State Greenhouse Gas Emissions Targets;" https://www.c2es.org/document/greenhouse-gas-emissions-targets/; July 2019.

Michigan now supports more than 3 million light duty vehicles, approximately 730 buses for public transportation, and over 5,500 refueling stations primarily for gasoline and diesel refueling.[13,14,15] There are at least 14,000 electric vehicles registered in the State of Michigan (approximately .05% of all light-duty vehicles).[16] Increased diversity in fuel supply, vehicle technology, and vehicle refueling are expected to increase transportation reliability and resiliency.

Refueling / Energy Security

Models for hydrogen infrastructure deployment have been developed by OEMs, NREL, state stakeholders in California, H_2USA, and Northeast States for Coordinated Air Use Management (NESCAUM). This plan complements those efforts to help coordinate the initial development of hydrogen refueling infrastructure to improve the value of FCEVs to customers that will enable growth and distribution of zero emission vehicle (ZEV) technology into the marketplace. Potential sites for development include areas with high population density and early market adopters, and where alternative refueling stations exist or could be developed (see Table 1 and Appendix II – "Michigan: Market Potential for Hydrogen and Fuel Cell Transportation Applications).

Refueling station siting may be of concern with local officials, first responders, and local residents. Concerns regarding hydrogen are often based on safety. Public education of residents and safety training for public officials and first responders will be helpful for local permitting and community acceptance.

Production of hydrogen for use as a transportation fuel is possible using natural gas, renewable energy such as solar energy, or from hydrogen rich compounds such as ammonia and biofuel. Due to the large amounts of these available resources within the US, it is not likely that the production of hydrogen would be linked to the import of liquid petroleum, crude oil, or diesel fuel. While the price of gasoline and diesel fuel has temporarily 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 wind and solar energy.

Economic Impact[17]

Michigan's hydrogen and fuel cell supply chain companies realized substantial value in revenue and investment.[18] Companies involved in this industry include manufacturing, parts distributing, fuel processing, supplying of industrial gas, engineering based research and development (R&D), coating applications, and managing of venture capital funds.

Table 3 shows the economic impact of Michigan's hydrogen and fuel cell supply chain.

The IMPLAN Economic Analysis, independently commissioned for this H2 FCEV Roadmap, suggests that Michigan's hydrogen and fuel cell industry can be a contributor in maintaining the state's economic vitality with ties to the automotive transportation industry, particularly in

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[13] Statista.com; U.S. Automobile Registration in 2018, by State;" https://www.statista.com/statistics/196010/total-number-of-registered-automobiles-in-the-us-by-state/; April 18, 2020.
[14] Federal Transit Administration; "The National Transit Database (NTD);" https://www.transit.dot.gov/ntd; April 18, 2020
[15] AtoZdatabases; Search SIC "5172;" https://www.atozdatabases.com/home; April 18, 2020.
[16] Plug in America; "Electric Vehicles in Michigan;" https://pluginamerica.org/wp-content/uploads/2017/04/Michigan_Electric_Vehicle_Factsheet_May_20171.pdf; May 2017.
[17] Economic impact derived from an IMPLAN Economic Impact Model, Todd Gabe PhD, Economic Consultant, 2020. This analysis assesses the direct, indirect, and induced values of the Michigan hydrogen and fuel cell supply chain using 2019 data.
[18] Senate Fiscal Agency (SFA); "Michigan's Economic Outlook and Budget Review;" https://www.senate.michigan.gov/sfa/Publications/BudUpdates/EconomicOutlookMay19.pdf; May 2019.

retaining advanced research and manufacturing jobs, generating increased investments, and delivering tax revenue.

Table 3 – Michigan Economic Data – Hydrogen Fuel Cell Industry

	Michigan Economic Data
Supply Chain Members	400+
State/Local Tax ($M)	5.7+
Direct Revenue and Investment ($M)	$94.5
Direct Jobs	310
Direct Labor Income ($M)	$29.4
Indirect Revenue and Investment ($M)	$50.2
Indirect Jobs	267
Indirect Labor Income ($M)	$15.1
Induced Revenue and Investment ($M)	$42.7
Induced Jobs	285
Induced Labor Income ($M)	$12.3
Total Revenue and Investment ($M)	$187.3
Total Jobs	862
Total Labor Income ($M)	$56.7

Over 300 Michigan workers are involved in the production of, and R&D activities related to, hydrogen energy and fuel cells. These workers are supported by almost $100 M in revenue and investment, that includes an investment in a large joint venture. The hydrogen energy and fuel cell sector in Michigan has a total economic impact including multiplier effects of an estimated $187.3 M in output, 862 full- and part-time jobs, and $56.7 M in employee compensation. The hydrogen energy and fuel cell sector's economic impact in Michigan generates an estimated $5.7 M in state and local tax revenue. Michigan's hydrogen energy and fuel cell sector supports at least one job in 98 other industries, and there are multiplier effects of five jobs or more in 28 industries.[19]

Consistency with the "Road Map to a US Hydrogen Economy"

From a national perspective, the recently released "Road Map to a US Hydrogen Economy" identifies the importance of hydrogen to achieve a lower-carbon energy mix, while reinforcing US energy leadership and strengthening the economy. Executing actions specified in this analysis could result in as much as $140 billion per year in revenue and 700,000 jobs by 2030, and $750 billion per year in revenue and 3.4 M jobs by 2050 domestically in the US. Goals highlighted in the report can be replicated at the local and state level. [20] Immediate next steps include:

- Establish Dependable and Technology-neutral Decarbonization Goals
  - Specific Policy and Regulatory Actions
  - Updated Codes and Standards
  - Public Incentives and Standards
- Increase Public Awareness and Acceptance
- Pilot Hydrogen Use in Other Applications
  - Early commercially viable applications - *Light/Heavy-duty vehicles*
  - Mature applications scale up – *Forklifts & Backup*
  - Transport – Development of fueling infrastructure to support FCEV adoption – *Fleets*

[19] Economic impact derived from an IMPLAN Economic Impact Model, Todd Gabe, PhD, Economic Consultant, 2020. This analysis assesses the direct, indirect, and induced values of the Michigan hydrogen and fuel cell supply chain using 2019 data.
[20] "Road Map to a US Hydrogen Economy;" ushydrogenstudy.org. . http://www.fchea.org/us-hydrogen-study, November 2019.

FUEL CELLS FOR TRANSPORTATION

Table 4 – Transportation Targets
• Public/Private Fleets
• Bus Transit
• Trucks
• Material Handling
• Ground Support Equipment

Targets for FCEV deployment and hydrogen infrastructure development include public/private fleets, bus transit, trucks, and specialty vehicles (see Table 4). Zero emission FCEVs could replace existing conventional fleet vehicles in Michigan, starting with 1,238 passenger vehicles[21], providing annual CO_2 emission reductions of approximately 5,782 metric tons and NOx emission reductions of approximately 3.02 metric tons. Additionally, the introduction of 37 zero emission fuel cell electric buses (FCEBs) in Michigan could reduce annual CO_2 emissions by approximately 3,303 metric tons and NOx emissions by approximately .742 metric tons.

Automakers are now making plans to comply with state ZEV programs.[22] Several states have committed and signed a Memorandum of Understanding (MOU) requiring large-volume automakers to sell approximately 3.3 M ZEVs between 2018 and 2025; 1.24 M of which are defined as "Electric and/or Hydrogen Fuel Cells" with the remainder being plug-in hybrid electric vehicles (PHEV).[23] Although Michigan is not one of the states that have signed the MOU, if Michigan were to follow this deployment model it would have the potential of deploying approximately 47,000 FCEVs over the next decade. (see Appendix I)

California has one of the most aggressive hydrogen FCEV deployment plans in the US and is often viewed as a leader in policy development. Additional information on plans, activities, and progress in state planning with California can be found at 2019 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development. [24]

Passenger Vehicle Fleets (Light-Duty Fleet Vehicles)

There are over three million passenger fleet vehicles classified as non-leasing or company owned vehicles in Michigan.[25] Passenger vehicles at transportation hubs for fleets are favored candidates for FCEVs with hydrogen fueling because they mostly operate on fixed routes or within fixed districts and can be fueled from a fully utilized centralized station. Vehicle types and routes favored for FCEV applications include large commercial fleets with long range vehicle (400 mile / 650 Km) routes, SUV passenger vehicles with long range (375 mile / 600 Km) routes, and mid-sized vehicles with long range (250 mile / 400 KM) routes.[26] Applications that will be challenged include small passenger vehicles for short range urban transportation which will compete with battery electric technology.

As illustrated in Appendix II – "Michigan: Market Potential for Hydrogen and Fuel Cell Transportation Applications," clusters of fleet vehicles in Michigan are located primarily in the Detroit, Flint, and Grand Rapids areas. These clusters have an immediate market potential for 1,238 light and medium duty FCEVs with relatively long-range requirements. Refueling will

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[21] Analyses conducted by the Connecticut Center for Advanced Technology (CCAT) based on the ZEV eight-state MOU, IHS Markit light duty automotive, NREL medium/heavy-duty vehicle data for Michigan. Note that this analysis is intended as a conservative approach based on use of fleet vehicles and is not intended as a substitute for full market deployment projections provided by SERA NREL modeling.
[22] Electrive.com; "https://www.electrive.com/2020/01/29/first-customers-for-bosch-fuel-cell-trucks/;" Randall, Chris; January 2020; Denner, Volkmar (Bosch CEO) - Up to 20 per cent of all electric vehicles could be on the road with fuel cells by 2030.
[23] State Zero-Emission Vehicle Programs Memorandum of Understanding, www.nescaum.org/documents/zev-mou-8-governors-signed-20131024.pdf. Additional states have or are also considering signing this MOU.
[24] 2019 Annual Evaluation of Fuel Cell Electric Vehicle Deployment & Hydrogen Fuel Station Network Development, July 2019. https://ww2.arb.ca.gov/sites/default/files/2019-07/AB8_report_2019_Final.pdf
[25] Michigan Vehicle Fleet data provided by IHS Markit (light duty vehicle and NREL (medium/heavy duty vehicles).
[26] Path to hydrogen competitiveness, A cost comparison, Hydrogen Council, January 20, 2020.

require 12 to 13 hydrogen refueling stations to support these vehicles. At an estimated $65,000 for each vehicle, the initial capital value for FCEVs could be as much as $80.47 M. While this analysis uses a conservative base cost of $65,000 per light duty FCEV, it is likely that vehicle costs will decrease with market deployment and at scale manufacturing.

Bus Transit

There are approximately 730 transit buses that provide public transportation services in Michigan.[27] Although the efficiency of conventional diesel buses has increased, buses have high potential for energy savings by using high efficiency, zero emission fuel cells. FCEBs have an average fuel economy of approximately 7.9 miles per kilogram of hydrogen, which equates to approximately 7 miles per diesel gallon equivalent (DGE).[28] The average fuel efficiency of conventional diesel transit buses is approximately 3.87 miles per gallon.[29] The use of hydrogen has the potential to reduce diesel fuel use by approximately 8,800 gallons and 89.26 metric tons CO2 emissions per vehicle, per year.[30] The long term use of FCEBs may require: 1) fueling infrastructure to be co-located with the FCEB maintenance/storage facilities, 2) redundancy of fuel supply, 3) generally accepted fuel measurements & certifications, and 4) an acceptable track record for up-time performance. Favored bus applications and routes include buses for long distance (280 mile / 450 Km) urban routes and bus coaches for long haul (310 mile / 500 Km) routes.[31] As illustrated in Appendix II, "Michigan: Market Potential for Hydrogen and Fuel Cell Transportation Applications," transportation hubs have an immediate market potential for 37 FCEBs, and two hydrogen refueling station to support the buses. At an estimated $2M for each vehicle, the initial capital value for FCEBs could be $74 M. While this analysis uses a conservative base cost of $2M per FCEB, it is likely that bus costs will be closer to $1M with an ultimate target of $600,000.[32]

Truck Hauling (Medium/Heavy-Duty Fleet Vehicles)

Decarbonization of long-haul (Class 7 and 8) trucks favors technology that provides long range, fuel availability and relatively fast refueling, and reliable truck hauling without weight penalty for heavy fuel or battery loads. Such long-haul applications are currently in development and expected within this decade.[33] Favored applications and routes include medium-duty trucks with long range (310 mile / 500 Km) routes and heavy-duty long-haul trucks and with long range (375 mile / 600 Km) routes.[34] This application may be of high value in Michigan to support shipping and drayage. The Port of Los Angeles, CA provides a model for development of zero emission drayage to support shipping.[35] No projection for hydrogen truck applications is made for this initiative because of the generally private commercial nature of interstate truck hauling; however, it is suggested that Michigan consider public/private partnerships for shared refueling if and where

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[27] Federal Transit Administration; "NTD Transit Agency Profiles; https://www.transit.dot.gov/ntd/transit-agency-profiles; January 4, 2020.

[28] NREL; "Fuel Cell Buses in U.S. Transit Fleets: Current Status 2018;" https://www.nrel.gov/docs/fy19osti/72208.pdf; December 2018.

[29] CARB Innovative Clean Transit Regulation Standardized Regulatory Impact Assessment. http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/ICT_SRIA_ARB_4-23-18.pdf.; April 19, 2018.

[30] Assumes an average transit bus travels approximately 34,000 miles annually and 3.87 miles/gallon. http://www.afdc.energy.gov/data/10309. Calculated based on 10,160 grams CO_2 per gallon for diesel fuel.

[31] Path to hydrogen competitiveness, A cost comparison, Hydrogen Council, January 20, 2020.

[32] Eudy, Leslie, Matthew Post, and Matthew Jeffers. American Fuel Cell Bus Project Evaluation: Third Report. NREL, Technical Report NREL/TP-5400-67209 May 2017.

[33] McKinsey Energy Insights, McKinsey Center for Future Mobility; "New Reality: electric trucks and their implications on energy demand;" https://www.mckinseyenergyinsights.com/insights/new-reality-electric-trucks-and-their-implications-on-energy-demand/; September 2017 – Expected share of Trucks sales in 2030 for the US to be 13 percent.

[34] Path to hydrogen competitiveness, A cost comparison, Hydrogen Council, January 20, 2020.

[35] Green Car Congress, Toyota, Kenworth, POLA and CARB unveil next-gen heavy-duty fuel-cell truck; ZANZEFF 23 April 2019. https://www.greencarcongress.com/2019/04/20190423-tfcv.html.

possible. APPENDIX II – "Michigan: Market Potential for Hydrogen and Fuel Cell Transportation Applications," identifies truck stop and port locations that may be viable targets for hydrogen refueling due to high volume traffic from medium/heavy-duty trucks.

Specialty Vehicles

Table 5 – Materials Handler Advantages

- Lower Total Cost of Ownership
- 80% Lower Refueling/recharging Labor Cost
- 75% Less Space Required for Refueling
- Improved Net Present Value (NPV)
- Zero Emissions

Specialty vehicles, such as materials handling equipment, airport tugs, street sweepers, and wheel loaders are used by a variety of industries, including manufacturing, construction, mining, agriculture, food sales, retailers, and wholesalers. Batteries that currently power some equipment for indoor use are heavy and take up significant storage space while only providing limited, often restricted to six hours of run time. Fuel cell powered equipment has zero emissions, a lower annual cost of ownership, and almost twice the estimated product life than battery powered equipment. Fuel cell powered lift trucks can be operated indoors, can operate up to eight hours before refueling, can be refueled quickly (2-3 minutes), and eliminate the need for battery storage and charging rooms (see Table 5). Favored applications include forklifts with 2 X 8-hour shifts and 10 kW motor power.[36]

Fuel cell powered materials handling equipment is already in use at dozens of warehouses, distribution centers, and manufacturing plants in North America. Large corporations that are currently using or planning to use fuel cell powered material handling equipment across the country include: Central Grocers, FedEx Freight, Sysco Foods, Amazon, and Walmart.[37] Most recently, Lipari Foods has selected Plug Power fuel cells and hydrogen fueling station solutions to power the electric material handling vehicles at its campus in Warren, Michigan.[38] No projections for hydrogen forklift applications are made for this initiative because of the generally private commercial nature of materials handling; however, it is suggested that Michigan consider public/private partnerships for shared refueling if and where possible. APPENDIX II – "Michigan: Market Potential for Hydrogen and Fuel Cell Transportation Applications," identifies warehouse and port locations that may be viable targets for hydrogen fueled material handling fleets, due to their larger sized footprints.

Other Applications

Applications that will be challenged include small passenger vehicles for short range urban transportation which will compete with battery electric vehicle (BEV) technology, commuter trains where existing catenary systems have electric infrastructure already in place, aircraft where other fueling systems including biodiesel may be a more competitive alternative for low carbon fueling, and shipping where infrastructure for electric recharging and use of biodiesel may provide a more competitive alternative. [39] While these applications may evolve, this Roadmap does not make any specific recommendations for deployment at this time. However, it is suggested that Michigan consider public / private partnerships for shared refueling if and where possible.

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[36] Path to hydrogen competitiveness, A cost comparison, Hydrogen Council, January 20, 2020.
[37] U.S. DOE, "Early Markets: Fuel Cells for Material Handling Equipment;" www.energy.gov/sites/prod/files/2014/03/f9/early_markets_mhe_fact_sheet.pdf; October 2016.
[38] Plug Power; "Plug Power Partners With Lipari Foods on a Gendrive Hydrogen Fuel Cell-Powered Fleet;" https://www.ir.plugpower.com/Press-Releases/Press-Release-Details/2019/Plug-Power-Partners-with-Lipari-Foods-on-a-GenDrive-Hydrogen-Fuel-Cell-Powered-Fleet/default.aspx; April 2019.
[39] Path to hydrogen competitiveness, A cost comparison, Hydrogen Council, January 20, 2020.

Hydrogen Infrastructure

Hydrogen refueling infrastructure, consisting of production or delivery, storage, and dispensing equipment, is required to support FCEVs, including light and medium duty passenger fleet vehicles, buses, trucks, and material handling equipment.

Hydrogen fueling will be possible with hydrogen produced on site with electrolysis technology potentially powered with renewable energy or with delivery of gaseous or liquid hydrogen produced from central production facilities. Delivery of hydrogen through dedicated hydrogen pipelines will require an economy of scale to support a significant investment in infrastructure; however, blending of hydrogen with natural gas in existing natural gas pipelines with subsequent separation of the hydrogen for market users may present a lower-cost option to help decarbonize existing energy delivery infrastructure with reduced investment in infrastructure improvements.[40]

While costs for hydrogen refueling infrastructure typically range from $1 M to $3.26 M per station, it is possible that construction of these stations could be backed by private sector financing or developed publicly in conjunction with deployment of high efficiency ZEV fleets.[41] For example, Air Liquide is currently constructing hydrogen fueling stations in the Northeast, California, and countries in Europe and Asia to support the initial deployment of FCEVs in high population density areas.[42] At an estimated $2 M for each refueling station, the initial market potential for hydrogen refueling stations developed to support FCEV and FCEB deployment could be $28 M to $30 M for 14 to 15 refueling stations. Potential locations for hydrogen refueling infrastructure with fleet clusters, early market adopters, and other factors are identified in APPENDIX II – "Michigan: Market Potential for Hydrogen and Fuel Cell Transportation Applications."

The cost of fuel and electricity are key drivers in the final cost of hydrogen production. Target cost for production of low cost hydrogen derived from diverse domestic resources is estimated at less than $2.00/kg with an ultimate delivered and dispensed cost of $4.00/kg.[43] Future production of hydrogen is projected at $2/kg by 2025 and $1/kg by 2030 via net-zero-carbon pathways in support of the Hydrogen Energy Earthshot goal of reducing the cost of clean hydrogen by 80% to $1 per 1 kilogram in 1 decade ("1 1 1").[44] High volume production of renewable hydrogen produced with low cost electricity from wind and solar energy may further reduce the cost to hydrogen and help to increase utilization of intermittent renewable resources .[45] These prices are generally competitive with conventional hydrocarbon fuels and offer additional value in being domestically produced, renewable, and zero emissions from the vehicle tailpipe.

Deployment Summary

A capital investment of $43.7 M to $54.7 M for infrastructure development and FCEV deployment for state fleets and early market adopters could provide a solid framework to support 1,238

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[40] M. W. Melina, O. Antonia, and M. Penev, "Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues", NREL/TP-5600-51995, March 2013.

[41] California Air Resources Board; Joint Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California; December 2015; CEC-600-2015-016.

[42] Presentation by Air Liquide, "Northeast H2 Fueling Station Network", H2 Station Update, Air Liquide Advanced Technologies U.S. December 2017.

[43] DOE Hydrogen and Fuel Cells Program; "Annual Progress Report:" https://www.hydrogen.energy.gov/pdfs/progress19/h2f_overview_2019.pdf, April 2020.

[44] https://www.energy.gov/eere/fuelcells/hydrogen-production.

[45] Peterson, David, James Vickers, Dan DeSantis; "Hydrogen Production Cost From PEM Electrolysis – 2019;" DOE Hydrogen and Fuel Cells Program Record; February 3, 2020. Current case, high volume production of renewable hydrogen produced with low cost electricity from wind and solar energy may further reduce the cost to hydrogen to be less than $3.00/kg with a projected future case production cost of less than $2.00/kg. https://www.hydrogen.energy.gov/pdfs/19009_h2_production_cost_pem_electrolysis_2019.pdf.

passenger FCEVs and the development of up to 14 to 15 hydrogen refueling stations. An additional $14.8 M (20 percent of $74 M) would be needed for the acquisition of 37 zero emission transit/paratransit buses.

- ***1,238 Fuel Cell Electric Passenger Vehicles (581 FCEVs for MI State fleet) - $14.9 to 24.9 million.***[46, 47]
- ***37 Fuel Cell Transit/Paratransit Buses - $14.8 million (20 percent state cost-share/80 percent federal cost share).***[48]
- ***H_2 Infrastructure (14 – 15 Stations) - $14 to $15 million (50 percent of capital cost).***

Funding for this investment could come from the private sector, federal and state resources[49], and from other sources, potentially including the VW Partial Consent Decree. The VW Partial Consent Decree has allocated approximately $64 M to Michigan for transportation that includes engine repowering and alternative fueling with hydrogen.[50]

POLICY

Michigan's proximity to major transportation markets, concerns over energy reliability, policy to support improvement of air quality and reduction of carbon for protection of climate, and opportunity to support automotive OEMs and use an existing robust supply chain have resulted in renewed interest in the development of efficient and cost-effective alternative transportation technologies.

Generally, Michigan is in a favorable position to develop policy supportive of FCEVs, FCEBs, and hydrogen refueling with consideration of the following:

- Measured and long term scheduled purchase of FCEVs and FCEBs with emission and efficiency standards for state fleets using state funds and federal cost sharing,
- Creation of per vehicle, point of purchase incentives and tax incentives derived from fuel taxes to accelerate private fleet purchase of FCEVs,
- Provide FCEV/ ZEV incentives with use of HOV and renewable parking privileges,
- Development of publicly accessible hydrogen refueling to support FCEVs and FCEBs using state, federal and/or compliance funding (i.e., VW Compliance Penalty Funds),
- Establishment of incentive grants for development of commercial hydrogen refueling stations available for public use,
- Establishment of Time of Use electric rates for low cost renewable hydrogen production,
- Establishment of Renewable Energy Credits (REC) for renewable hydrogen,
- Streamline siting regulations and creation of tax incentives for development of renewable hydrogen infrastructure, and

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[46] While the state of Michigan does not currently offer an incentive for the purchase of an FCEV, it is considering a $5,000 to $7,000 vehicle incentive to stay competitive with other FCEV friendly states.

[47] 1,238 total FCEVs consisted of 581 government vehicles and 657 non-government vehicles. Government vehicles are estimated to cost $20,000 - $35,000 per vehicle (581 * 20,000 = $11,620,000; 581*35,000 = $20,335,000). This Plan proposes that non-government vehicle owners be provided a $5,000 - $7,000 incentive for purchasing a FCEV (657 * 5,000 = $3,285,000; 657 * 7,000 = $4,599,000). $3,285,000 + $11,620,000 = $14,905,000; $4,599,000 + $20,335,000 = $24,934,000.

[48] It is projected that an order for 40 fuel cell buses would reduce the cost to $1 million or less. NREL, Fuel Cell Buses in U.S. Transit Fleets: Current Status 2017; https://www.nrel.gov/docs/fy18osti/70075.pdf.

[49] The Federal Transit Administration's Bus & Bus Facilities Infrastructure Investment Program could provide states and direct recipients 80 percent of the net capital project costs to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities including technological changes or innovations to modify low or no emission vehicles or facilities.

[50] Michigan EIBC; "Plans for $64 Million from Volkswagen Settlement Announced; Michigan Clean Energy Leaders Project Recap;" https://mieibc.org/plans-for-64-million-from-volkswagen-settlement-announced-michigan-clean-energy-leaders-project-recap-2/; September 1, 2018.

- Development of a comprehensive H2 FCEV ZEV program for plan execution with public education and a dedicated state point person.

Specific policies adopted by other states and potentially available for consideration by Michigan policymakers are displayed in Appendix IV – State Energy Policy/Incentives for Fuel Cell and Hydrogen Transportation.

CONCLUSION

Hydrogen and fuel cell transportation technology provides significant opportunities for more efficient use of cleaner energy, decarbonization, job creation, and economic development. FCEVs are now competitive within several markets including use of hydrogen for fuel cell forklifts used in materials handling. Several other markets including transportation fleets for light and medium duty passenger vehicles, buses and medium/heavy-duty trucks are expected to emerge as competitive with other zero emission transportation options within this decade as the cost of hydrogen production, capital cost for equipment, and hydrogen distribution costs decrease through an increased economy of scale. Many companies, countries, and states in the US have committed to this transformation and have announced ambitious plans to increase use of hydrogen fuel cell technology to increase sustainability and to meet carbon emission targets.

Michigan is in an exceptionally favorable position with a strong automotive supply chain that is conducive to the production of components and development of facilities necessary for the manufacture of FCEVs and hydrogen refueling. Realizing approximately $187 M in revenue and investment, Michigan's hydrogen and fuel cell industry supply chain is estimated to have contributed over $5.7 M in state and local tax revenue. As emerging hydrogen and fuel cell technology gains momentum, the number of companies and employment in the industry is expected to grow substantially. In addition, hydrogen and fuel cell technology provides an opportunity for Michigan to utilize its renewable energy industry using hydrogen and fuel cells more fully for transportation and energy storage. Such use could maintain Michigan's role as a global showcase for regionally manufactured transportation technology while reducing NOx and CO_2 emissions and as new jobs are created for businesses and industry. The near-term market opportunities for Michigan include:

- **1,238 FCEVs (581 FCEVs for Michigan State fleets);**
- **37 transit/paratransit buses; and**
- **14 to 15 hydrogen refueling stations (to support FCEV and FCEB deployment).[51]**

These market opportunities represent a short-term investment for long-term productivity that can be accelerated with policy that encourages execution. To facilitate the execution, Michigan will need to consider policies and initiatives for funding, financing, a schedule for goal implementation, assignment of work responsibilities, and long-term commitment for success. The result will be a win-win-win with decarbonization and improved environmental performance, energy reliability with diversified fueling, and economic development with advanced technology job creation.

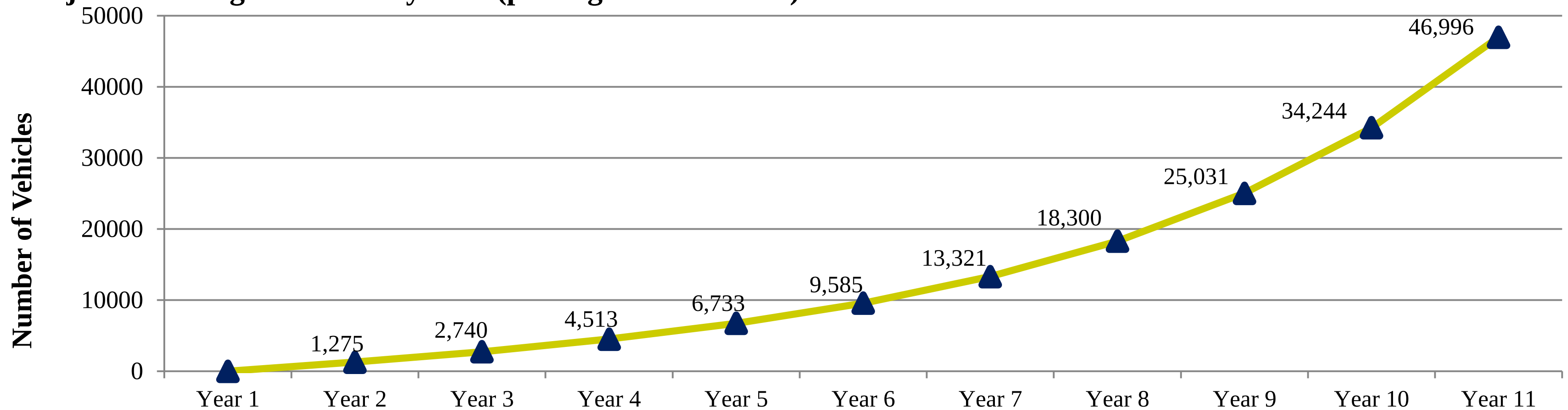
[51] A target of 14 to 15 refueling stations has been calculated as a conservative initial approach to support FCEV and FCEB deployment into the existing Michigan economy. A more aggressive approach with a more mature deployment market could require 35 initial station locations as identified by NREL.

APPENDICES

APPENDIX I – MICHIGAN ZEV ROLLOUT [52]

	Eight (8) State MOU		Projections for FCEVs per each State[53]								
Deployment Year	**Total Sale Requirements**	**Total ZEV Sales Requirements**	**CA**	**CT**	**MA**	**NY**	**RI**	**VT**	**OR**	**MD**	**MI**
1	0	0	0	0	0	0	0	0	0	0	0
2	89,543	33,587	3,595	545	1,008	1,860	167	91	467	662	1,275
3	192,402	72,168	7,725	1,172	2,167	3,998	360	195	1,003	1,423	2,740
4	316,902	118,866	12,724	1,930	3,569	6,584	592	321	1,652	2,344	4,513
5	472,806	177,344	18,984	2,879	5,325	9,824	883	479	2,465	3,497	6,733
6	673,031	252,446	27,023	4,099	7,580	13,984	1,258	682	3,509	4,977	9,585
7	935,407	350,860	37,558	5,696	10,535	19,435	1,748	948	4,878	6,918	13,321
8	1,285,032	482,001	51,596	7,826	14,472	26,699	2,401	1,302	6,701	9,503	18,300
9	1,757,645	659,272	70,572	10,704	19,795	36,519	3,284	1,781	9,165	12,998	25,031
10	2,404,566	901,925	96,547	14,643	27,081	49,960	4,493	2,436	12,538	17,782	34,244
11	**3,300,000**[54]	1,237,792[55] [56]	132,500	20,096	37,165	68,565	6,166	3,344	17,208	24,404	46,996

Projected Michigan FCEVs by Year (per Eight-State MOU)



[52] Data provided is an averaged projection that does not account for different market drivers and/or incentives/barriers that could substantially change the deployment ratios between state and the delivery of different ZEV/hybrid vehicles.

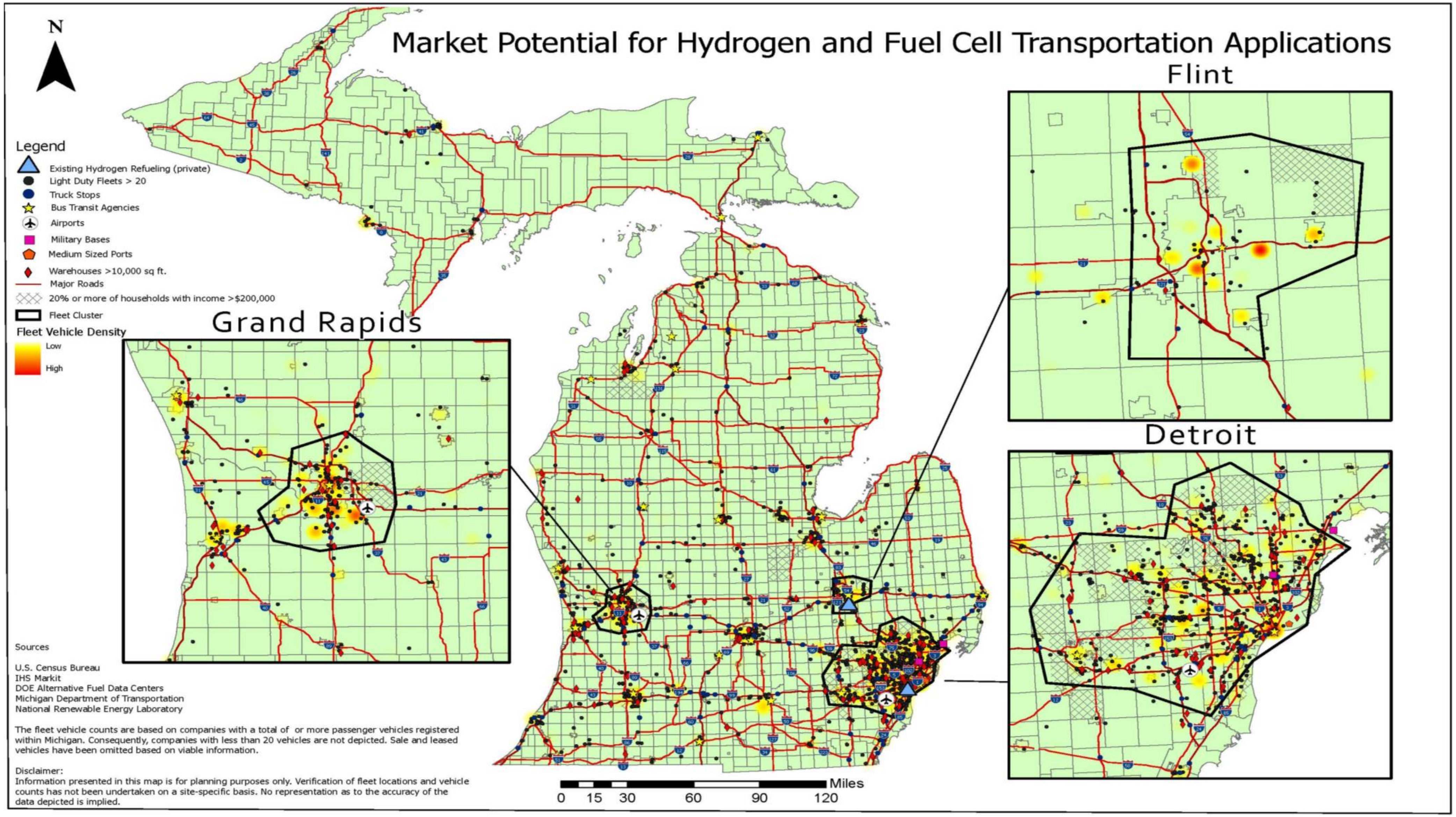
[53] Derived from applying 5.814 percent to FCEVs. The 5.814 percent was calculated by comparing 8-State MOU data to 2017 registered vehicles by state. These projections for FCEVs assume 25 percent of all ZEVs (FCEVs and BEVs). Some states have fallen short of meeting projection estimates.

[54] California Environmental Protection Agency Air Resource Board; http://www.arb.ca.gov/newsrel/newsrelease.php?id=620; October 24, 2013.

[55] Derived from a DOE projection of California ZEV (FCEV and BEV), California transitional ZEV (plug-in hybrids), and California total sales (ZEV and transitional). These projections were applied to the other seven (7) states' 2011 registered vehicle data to estimate potential ZEV vehicle requirements.

[56] DOE EERE; "Fact #771 California Zero-Emission Vehicle Mandate is Now in Effect;" https://www.dropbox.com/s/jrl4gbzgw7tsy5p/Fact%20%23771%20%20March%2018%2C%202013%20California%20Zero-Emission%20Vehicle%20Mandate%20is%20Now%20in%20Effec.pdf?dl=0; March 18,2013.

APPENDIX II – Michigan: Market Potential for Hydrogen and Fuel Cell Transportation Applications



APPENDIX III – Michigan SWOT Analysis

Environment factors internal/external to Michigan's existing hydrogen and fuel cell industry are provided below in the form of an economic strengths, weaknesses, opportunities, and threats (SWOT) assessment. The SWOT analysis provides information helpful in matching the industry's resources and capabilities to the competitive environment in which it operates.

Strengths

- *Transportation Power* – Appeal to market, environmental drivers, volatile fueling prices, long commuting distance, high concentration/density of vehicles in urban areas, tax incentive program.
- *Renewable Energy* – Support for clean energy.
- *Diversity* – Support for fuel diversity from industry and fleet owners.
- *Economic Development* - Significant OEM manufacturing and R&D capacity, extensive supply chain, state support for industry retooling.
- *Consumer Behavior* – Minimal change in the fueling process and consumer behavior.

Weaknesses

- *Transportation Power* – Hydrogen infrastructure build-out needed.
- *Economic Development Factors* – Long-term state incentives needed. Upfront infrastructure investment is required.
- *Renewable Energy* – Competition from clean but not renewable natural gas.

Opportunities

- *Transportation Power* – Supply chain buildup opportunities led by industry leaders, such as Ford and General Motors (GM).
- *Economic Development Factors* – Industry expansion and investments in new advanced technology will help to support R&D and high-tech jobs.
- *Environmental* – Setting decarbonization goals with minimal costs to the consumer.
- *Energy Storage* – Opportunity to better manage use of renewables.

Threats

- *Transportation Power* – Lack of consumer education and reliance on conventional technology.
- *Economic Development Factors* – Competition from other states/regions.
- *Environmental* – Limited window of opportunity.
- *Supply Chain* – Suppliers of key components may not be available.

APPENDIX IV – Michigan Policy for Hydrogen Transportation

State Energy Policy/Incentives for Hydrogen Transportation										
	ME	NH	VT	MA	RI	CT	NY	NJ	MD	MI
Zero Emission Vehicle (ZEV) Program (FCEV/H_2 Infrastructure)			Eligible	Eligible	Eligible	Eligible	Eligible		Eligible	
ZEV Purchase Target for State Government Fleets (TBD)			Eligible	Eligible	Eligible	Eligible	Eligible		Eligible	
Purchase Incentives/"Point-of-Purchase" Rebates				Eligible	Eligible	Eligible	Eligible		Eligible	
Fuel Incentives										
Time of Day Rates for Hydrogen Production										
Public/Private Infrastructure Partnership						Eligible	Eligible			
Fuel Efficiency Standard (Private/State Fleets)			Eligible	Eligible	Eligible	Eligible	Eligible	Eligible	Eligible	
Refueling Infrastructure Incentives				Eligible		Eligible	Eligible			
REC Available for Renewable H_2										
Tax Incentives			Eligible		Eligible		Eligible	Eligible	Eligible	Eligible
HOV Lanes and Parking Incentives							Eligible	Eligible		
One Stop Regulatory Approval										
Identified State "Point" Person				Eligible	Eligible	Eligible				
NEESC Development Plan Market Potential										
	ME	NH	VT	MA	RI	CT	NY	NJ	MD	MI
Transportation Fuel Cell Electric Vehicle	137	20	92	823	171	548	2,038	3,232	960	1.238
Transportation Fuel Cell Electric Bus	7	5	4	84	14	43	349	139	83	37
Refueling Stations (low/high range)	1/2	1/2	1/2	7/9	1/2	6/7	18/23	31/34	8/10	14/15

Eligible   Eligible if Renewable

APPENDIX V – Summary of Potential Hydrogen and Fuel Cell Applications

Category	Total Units	Potential Targets	Emissions (Metric Tons/Year)	
Transportation Targets			**CO2**	**NOx**
FCEVs	80,551	1,238	5,782	3.02
Transit Buses	730	37	3,303	.742
Retail Refueling Stations	5,500	14 - 15	NA	NA

The analysis provided in this Plan conservatively estimates that the near-term market opportunities for existing fleet vehicles in Michigan could include the near-term deployment of 1,275 vehicles.