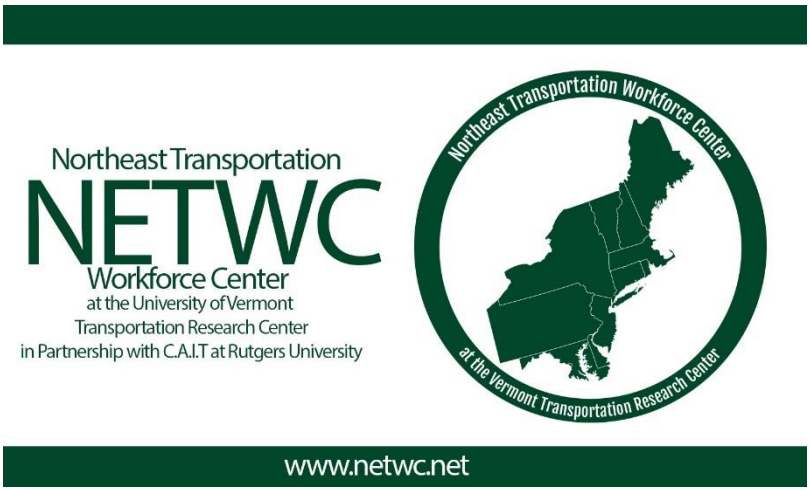


The Emerging Clean Transportation Workforce: Opportunities and recommendations to support the growing alternative fuels industry

Gabrielle Freeman
Glenn McRae
Peggy O'Neill-Vivanco

University of Vermont - Transportation Research Center
Northeast Transportation Workforce Center
2018

Acknowledgements

Vermont Clean Cities is funded by a grant from the U.S. Department of Energy

Northeast Transportation Workforce Center
At the University of Vermont
This material is based upon work supported by the U.S. Department of Transportation under Cooperative Agreement No. DTFH6114H00022. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the Author(s) and do not necessarily reflect the view of the U.S. Department of Transportation.

Based on the previous research and report by Abby Bleything, Greer Cowan, Glenn McRae, and Linnea Meyers (2016) UVM Transportation Research Center

Table of Contents

List of Figures

Abbreviations

AFDC – Alternative Fuel Data Center
AFV – Alternative fuel vehicle
CAFE – Corporate average fuel economy
CDL – Commercial driver's license
CNG – Compressed natural gas
CTE – Career technical education
DOE – Department of Energy
EV – Electric vehicle
EVSE – Electric vehicle supply equipment
FCEV – Fuel cell electric vehicles
FHWA – Federal Highway Administration
HEV – Hybrid-electric vehicle
ICE – Internal combustion engine
LNG – Liquefied natural gas
LPG – Liquefied petroleum gas
NAFTC – National Alternative Fuels Training Consortium
NETWC – Northeast Transportation Workforce Center
NREL – National Renewable Energy Laboratory
OEM – Original equipment manufacturer
RFS – Renewable fuel standard
RNG – Renewable natural gas
SOC – Standard occupational classification
VTO – Vehicle Technologies Office
ZEV – Zero emission vehicle

Executive Summary

America's transportation system is the backbone of its economy, connecting households to employment, healthcare, and education and supporting the movement of goods and services across supply chains. This system while indispensable is facing mounting challenges in traffic and congestion, decaying infrastructure, over-dependence on foreign oil, and in many communities a lack of infrastructure for public transit, cyclists, and pedestrians. In 2017, congestion alone cost the U.S. an estimated $305 billion from lost worker productivity, wasted fuel, and other economic factors.[1] Even this number fails to account for the true size of the problem, externalizing traffic's toll on health, both external (air pollution) and internal (stress), and the environment. In fact, the transportation sector is now the largest source of climate-changing greenhouse gas emissions in the nation.[2] As increasing tailpipe emissions continue to alter the climate, amplified extreme weather and natural disasters could threaten the safety and reliability the transportation system, as well as increase the costs of maintaining it.

Clearly, a break from business as usual is needed to create a transportation system that is cleaner, more equitable, and accessible. While solving transportation's modern challenges will require a number of place-based solutions, such as walkable and bikeable streets and improved access to public transit, this paper focuses on expanding the use of alternative fuels, for example with electric vehicles (EVs). More EVs on the road means spending less on imported fuels, saving consumers billions of dollars at the pump, and keeping more transportation dollars within local economies. These economic gains are especially key in rural communities, where on average households spend 7% more of their budgets on transportation compared to urban households.[3]

As Northeast states increasingly invest in clean energy and transportation, tens of thousands of new jobs in fields such as science, technology, engineering, and math (STEM); public transit; and construction will be created. The evolving landscape of transportation technologies, from EVs to autonomous vehicles, will require new educational programs, training, and competencies.

This paper examines what education and training programs exist today to support the alternative fuels transportation industry, and provides recommendations on further building out a workforce pipeline to meet anticipated growth. Job seekers should read on to discover what training and education opportunities are currently available, while educators and workforce development professionals are provided with recommendations on how to provide more training and education programs to keep pace with the growing market for EVs and other alternative fuels.

Background

The mix of fuels used to power vehicles on U.S. roadways is diversifying rapidly. While gasoline and diesel are still dominant, an increasing percentage of vehicle power is coming from alternatives such as electricity, biofuel, and hydrogen. Alternative fuel vehicles (AFVs) are being promoted by a number of federal and state policies due to their potential to provide public benefits by reducing greenhouse gas emissions that are warming the planet, improving energy security, and improving air quality.[4]

Any vehicle that can be powered by a fuel other than gasoline or diesel qualifies as an AFV according to standards set by the U.S. Department of Energy (DOE). The AFV market also includes various combinations of vehicle drivetrains run in part by gasoline, such as extended range hybrid-electric vehicles. The DOE breaks down Alternative Fuels into three main types: 1); electric (e.g. battery electric vehicles, hybrid-electric vehicles, hydrogen fuel cell vehicles) 2) biofuels (e.g. ethanol, biodiesel, renewable natural gas); and 3) fossil fuels (e.g. compressed natural gas, liquefied natural gas, propane) (see Appendix A for more in-depth discussion of each alternative fuel).

Automotive manufacturers and their suppliers (OEMs) have designed vehicles in all duty classes to run on alternative fuels. In addition to OEM vehicles that were designed to run off of a single alternative fuel, there is a growing market for converting or retrofitting traditional internal combustion engine (ICE) vehicles to dual-fuel applications, typically in propane and natural gas hybrid formats. Dual-fuel vehicles can operate off of either fuel, reducing operator anxiety surrounding fuel availability or pricing. Biodiesel, compressed natural gas (CNG), and propane are often used to substitute fuel in vehicles that run on diesel, most commonly in medium- and heavy-duty vehicles. Ethanol and electricity are often used in replacement of traditionally gas-powered light-duty vehicles. While hydrogen as a transportation fuel is in its market infancy, government and industry are working toward clean, economical, and safe hydrogen production and distribution for widespread use in fuel cell electric vehicles (FCEVs). FCEVs are beginning to enter the consumer market and the market is also developing for buses, material handling equipment (such as forklifts), ground support equipment, medium- and heavy-duty vehicles, and stationary applications.

Although many AFV technologies, along with their associated benefits, are economically viable and available on the market today, the relative immaturity of the sector and various market failures are delaying their wide-scale deployment.[5] Hybrid and all-electric vehicles, two of the fastest growing types of AFVs, still only represented a combined 5% in market share in 2017.[6] Nevertheless, it is no longer so much a question of *if* the transportation landscape will shift away from reliance on petroleum-based fuels as *when*. As the AFV market matures, bolstered in no small part by public policy and technological developments, the U.S. workforce will need to respond to new fuel production, infrastructure build-out, vehicle and infrastructure maintenance, fueling, and vehicle operations.

Purpose and Scope

This paper aims to:

1) Explore the alternative fuel industry and workforce as it exists today, providing job seekers, educators, and workforce development professionals with a clear outlook regarding its growth prospects as well as an overview of the training and education opportunities identified as currently available, and

2) provide recommendations on how training and education for the alternative fuel workforce can be improved to better support the needs of the growing and diverse alternative fuels industry.

This paper builds on the previous work of the Northeast Alternative Fuel Workforce Network (see Appendix B), an initiative headed by the Northeast Transportation Workforce Center (NETWC) in partnership with thirteen Clean Cities coalitions.[7]

Methodology

In order to gather information on the current state of the alternative fuel transportation workforce, NETWC partnered with members of the national Clean Cities network. Clean Cities coalitions act as part of the DOE's Vehicle Technologies Office by working locally to advance affordable, domestic transportation fuels and technologies. The bulk of data for this study, conducted from 2016-2018, was collected from Clean Cities' principal staff, or coordinators, and Clean Cities' partners, or stakeholders, through surveys, phone interviews, and a webinar discussion. Additional data on alternative fuel infrastructure, specifically fueling stations, was collected from the DOE-managed Alternative Fuels Data Center (AFDC).

In 2016, NETWC released a survey to Clean Cities' coordinators and stakeholders across the country asking about regional workforce needs in the alternative fuels industry. The survey was adapted from previous study assessing the alternative fuel landscape in California and led by the California Community College Chancellor's Office Center of Excellence.[8] Responses were received from forty-three coalitions, with a 100% response-rate from coordinators in the Northeast, and forty-one stakeholders. NETWC presented findings from these research efforts through both a webinar and a white paper titled *Alternative Fuels in Transportation: Workforce needs and opportunities in support of reducing reliance on petroleum fuels*.[9]

An updated version of the 2016 survey was redistributed to coordinators in the Northeast region to gauge if and how understanding of the alternative fuel workforce had shifted over the course of the past three years. This paper uses both sets of survey data from 2016 and 2018 to reveal the underlying trends in the alternative fuel and clean vehicle industries and make informed predictions regarding its future workforce needs. It is worth noting that the more recent round of surveying received significantly less overall responses, eleven in total. While there are many factors that could potentially explain the lower response-rate, a couple to highlight are: 1) the 2016 survey was distributed nationally whereas the 2018 survey focused more exclusively on Northeast coalitions; and 2) the 2016 survey was able to leverage the networks of thirteen coalitions through a formalized partnership whereas the 2018 survey represented an independent effort by the NETWC.

In addition to the survey, a comprehensive database of alternative fuel education and training programs was developed in conjunction with the National Alternative Fuels Training Consortium (NAFTC). The database includes programs at a variety of different levels: K-12, community college, technical college, university, professional development, and career technical education (CTE). The purpose of this database is twofold. On a practical basis, it serves as a tool for students and professionals interested in the dynamic alternative fuels industry and the programs are accessible through NETWC website.[10] In the context of this research, the database illuminates the major gaps in alternative fuels training and education, which will in turn direct attention and investment to undertrained areas of the workforce that ultimately act as barriers to alternate fuel adoption.

Overview

The Alternative Fuel Market and Workforce

Aggregating a total of ninety-nine survey responses from both 2016 and 2018 shows that responses were spread across the country. Figure 1 shows that the majority of response came out of the Midwest (32%), closely followed by the Northeast (30%). Regional distinctions are important to note because certain types of alternative fuels are more prevalent in certain areas compared to others, which can create a place-based bias. For instance, ethanol use and research is largely concentrated in the Midwest due to the prevalence of the corn industry in these states.

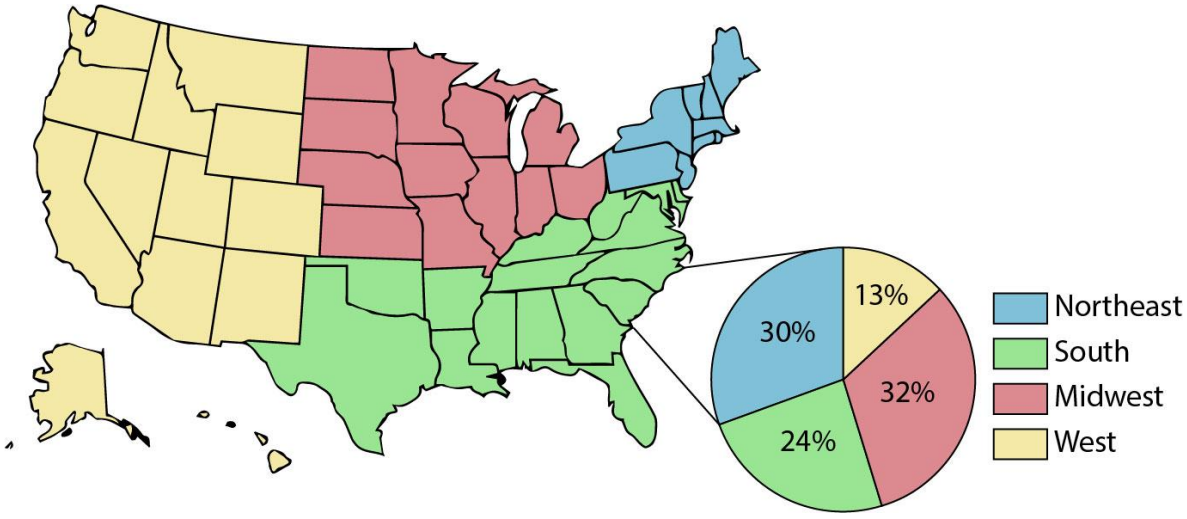


Figure 1. Overall percentage of survey responses from different regions.

Respondents were polled on which alternative fuels in their region were used in vehicles, produced, or subject to research and development (R&D). As shown in Figure 2, CNG receives the most use in vehicles, followed closely by EVs. Electricity and biodiesel were selected as the most commonly produced fuels, while hydrogen receives the most research attention and investment.

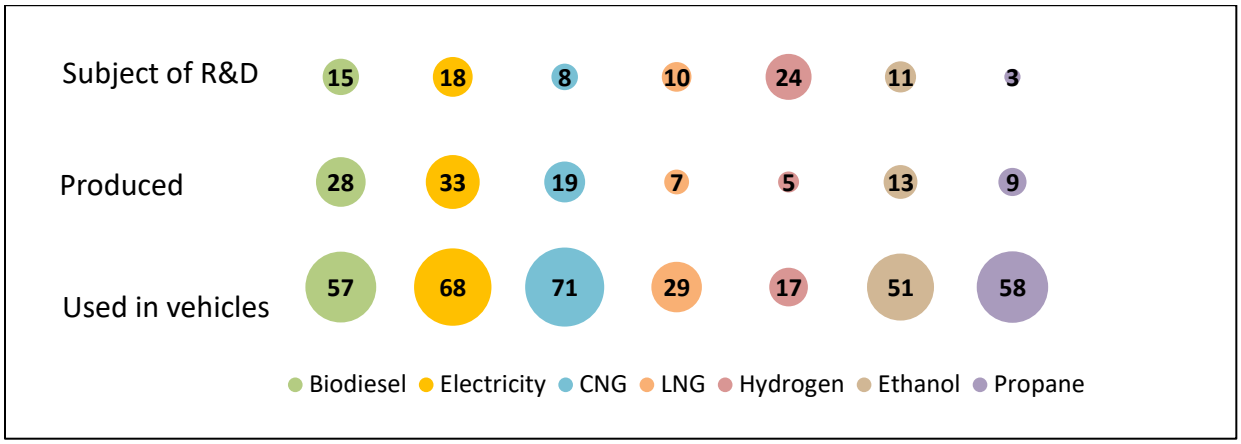


Figure 2. Overall survey response indication of different alternative fuel use, production, and research.

When asked about which factors were driving and depressing growth in the alternative fuel and AFV sectors, respondents answered optimistically. Five out of eight categories were indicated as be overall market drivers, with similar response-rates for both 2016 and 2018. Market factors were selected as predominate driver of growth. The category 'environmental factors' came in second and was selected by 82% of respondents in 2018, compared to 57% of respondents in 2016; an increase that reflects the increasing priority to improve the transportation sector's emissions profiles in the face of poor urban air quality and global climate change concerns. The third most-selected driver, legislative policies, is also indicative of increasing government legislation to address rising transportation emissions. Respondents' comments elaborated that market growth can largely be attributed to decreasing costs of AFVs, increasing alternative fueling infrastructure, governmental mandates for renewables, and jurisdictional preferences for locally-sourced fuels.

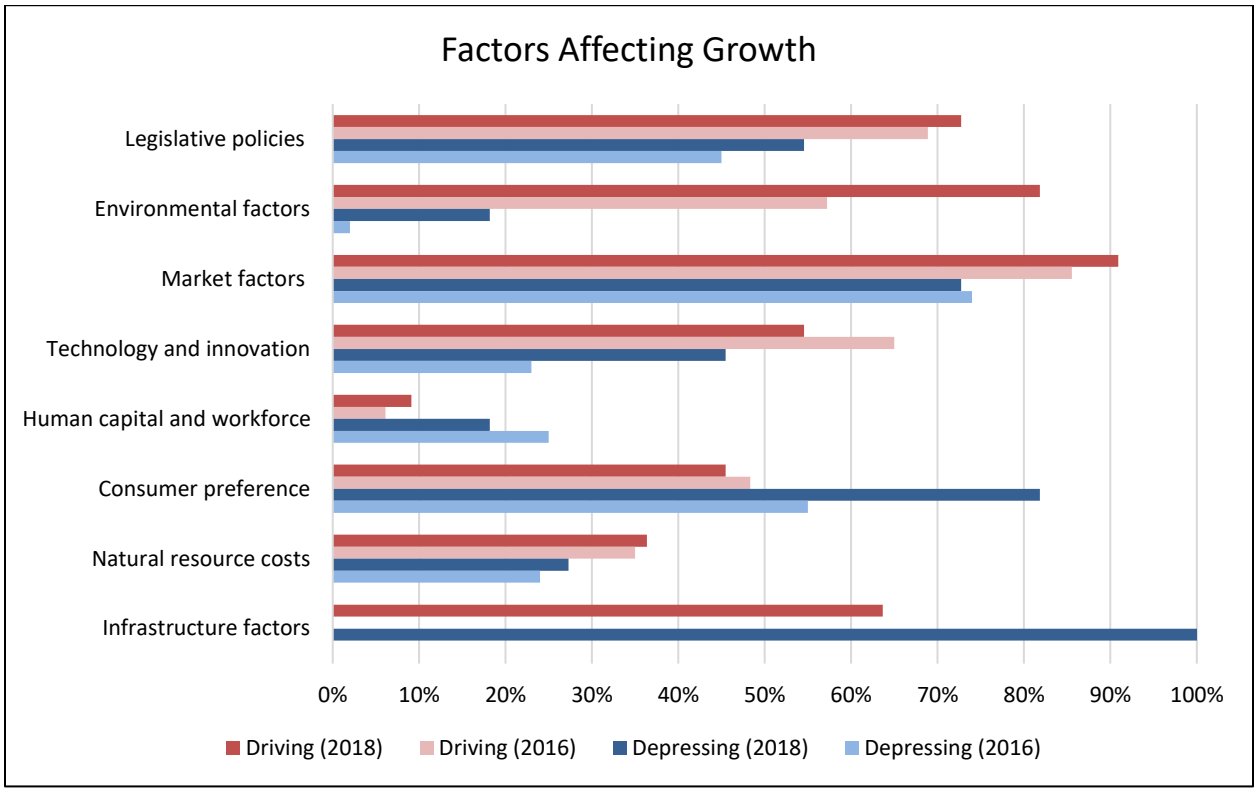


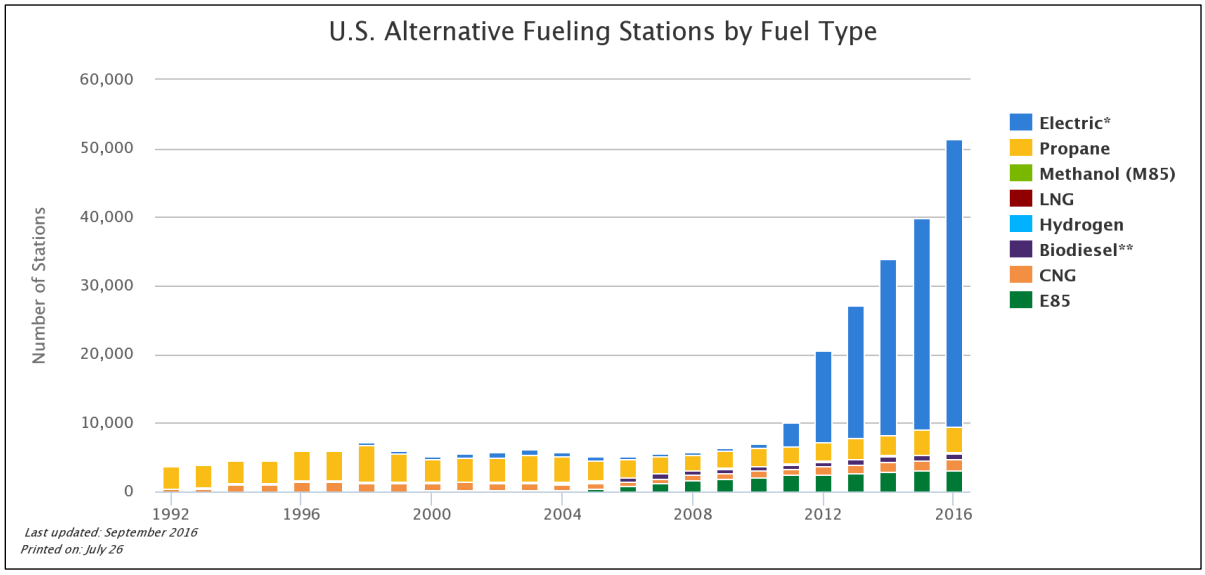
Figure 3. Percentage of respondents who identified categories as factors driving growth and depressing growth in alternative fuels.

Some respondents predict that much of the **growth** in alternative vehicles would be from hybrid and electric vehicles (EVs), a perspective backed by market research. Bloomberg New Energy Finance recently published a long-term forecast of global EV adoption, predicting that by 2040, 55% of all new car sales and 33% of the global fleet will be electric.[11] Bloomberg's findings point to tumbling lithium-ion battery prices, down 79% since 2010, and the increasing number of available EV models—both of which could be classified as market factors—as driving the market forward. The report also indicates policy support as an important factor, citing the fact that in 2017, 21% of all global EV sales were in just 6 Chinese cities, all of which have significant restrictions on buying and using new internal combustion engine (ICE) vehicles. Pro-EV policies in the US are on the rise as well; a report series conducted by the North Carolina Clean Energy Technology has been charting the growth in state legislation on transportation electrification. Their latest report for Q1 in 2018 found that 42 states and DC took legislative and regulatory action on EVs, with 17 states considering policy changes to encourage EV market development.[12]

Slow infrastructure build out as a factor **depressing** the alternative fuels market, an added category in the 2018 survey, was indicated as the top reason that inhibited growth, followed by consumer preference. Outside of these two factors, human capital and workforce were the only other category respondents indicated as more of an overall market barrier. Respondents specifically mentioned a general lack of AFV promotion and affordability compared to ICE vehicles and the crucial need for more alternative fuel infrastructure. Additionally, one

respondent pointed out that fleet managers and consumers tend to be averse to investing in new technologies without proper vetting, and that the constantly changing array of AFV technologies could be impacting the entire sector's growth. Another stated that the AFV market suffers from a general lack of credible information and education created by both a lack of consumer experience and misinformation from petroleum and food companies. Other concerns addressed included uncertainties about AFV incentives, fueling stations, conversion costs, and taxes and subsidies for the oil industry.

In looking specifically at EVs , survey responses correlated with market research results. One recent study found the limited availability of infrastructure in terms of rapid-charging stations to be the biggest barrier to EV adoption.[13] The lack of adequate electric vehicle supply equipment (EVSE) also heavily influences consumer preference, and has been cited as a major barrier to consumer EV acceptance by the National Renewable Energy Lab (NREL) alongside concerns around EV range, or the distance traveled on a single charge, and cost.[14] The upside to this finding is that build-out of EVSE has been accelerating since 2011 (see Figure 4).



* Starting in 2011, electric charge equipment was counted by the plug rather than by the geographical location. This is different than other fuels, which only count the geographical location regardless of how many dispensers or nozzles are on site.
** Stations selling low-level biodiesel blends (less than B20) are included in the station listing only for the years 2005-2007

Figure 4. Growth in alternative fueling stations by type (Source: AFDC).[15]

NREL's study found an increase in consumer awareness of EVSE as well. The 2017 report found that only 26% of respondents are aware of charging stations they pass regularly, available at their places of work, or at the stores and places they frequent, up from 20% in 2016 and 18% in 2015.

Building on this background, the survey effort continued to focus on short and long-term outlooks for the alternative fuel industry's workforce demands. In the 2018 survey, respondents were additionally asked how the workforce had changed over the past couple of years; answers pointed to steady workforce growth with 46% responding that AFV-related employers added workers, 36% that staffing levels had remained relatively the same, and 18% that employers had

reduced their workforce. Looking to the future, respondents of the 2018 survey were overwhelmingly optimistic. When asked about workforce expectations in the short-term (1-2 years), 73% of respondents answered that employers would add workers and 27% predicted that staffing levels would stay relatively constant. For the long-term (3-5 years), 91% pointed to future growth and only 9% answered that employment levels would remain static.

None of the respondents in the 2018 survey indicated that employment would be reduced for either the short or long-term. These results are even powerful when compared to the 2016 survey, when 13% thought that the workforce would be reduced in the short-term and 27% in the long-term. Responses in 2016 cited mass retirements of baby boomers, highlighted falling gas prices, and discussed the workforce implication of autonomous vehicles.

Recent market data once again correlated with respondents' outlook. With rapid growth in EVs leading the charge, the global alternative fuel market as a whole is estimated to more than double over the next four years. Zion Market Research reported that the alternative fuel market, valued at approximately $255 billion in 2016, will reach an estimated $592 billion by 2022.[16] This projected market growth will undoubtedly have major implications for the workforce, adding jobs and requiring new training and education programs to keep pace with changing technologies and employer demands.

Opportunities and Challenges in the Alternative Fuels Workforce

Both market data and industry sentiment paint a compelling picture for the advancement of the clean transportation market. However, an inadequate workforce, in numbers and skills, is one of the possible factors that are, and can continue to, inhibit AFV deployment. For any alternative fuel to gain market share, there is an entire network of professionals who need education and training in the various processes it takes to produce different fuels as well as engineer vehicles and build out an alternative fueling infrastructure. Moreover, there are number of accessory professions, including auto mechanics, emergency responders, governmental officials, sales representatives, and waste disposal operators who need at least a cursory understanding of different alternative fuels. See Appendix C for a discussion and visualizations detailing the workforce needs of different alternative fuels.

The final section of the survey asked how significant the following challenges were to alternative fuel employers:

- Finding and recruiting entry-level employees with AFV training,
- Finding and recruiting experienced employees,
- Keeping current employees up-to-date on training, or
- Retaining employees recruited by competitors.

Responses from 2016 indicated that finding and recruiting experienced employees as the most significant challenge. In 2018, the highest ranked answer changed to finding and recruiting entry-level employees trained in alternatives. One respondent noted that the demand for new workers was high enough that many students in alternative fuel programs get hired before they've even completed their courses. Another reported a shortage in the supply of certified

technicians needed to keep up with the inspections and maintenance requirements for CNG and propane vehicles.

Other noteworthy comments included the assessment that mechanics and commercial driver's license (CDL) drivers were hard to find regardless of whether they had been trained in alternative fuels. There was also general industry concern over investing in training workers in high turnover positions, with companies preferring to bring in outside contractors to help with alternative fuel maintenance and infrastructure rather than training staff who may then leave the company in the short-term to work for competitors. Lastly, market fluctuations and alternative fuel policies were noted as influencing personnel decisions because of their unpredictable and inconsistent nature.

Despite these challenges, opportunities in clean vehicle markets are increasing. The National Resources Defense Council's Environmental Entrepreneurs (E2) initiative has been analyzing and reporting clean energy job growth in the US for over a decade. Since 2016, they have reported sector details on job growth in the advanced clean vehicle sector, charted in Figure 5. The reports also list specific macro and micro economic events contributing to recent job creation in clean vehicles, such as California-based Tesla Motors' 14-fold growth since 2010 from a start-up to a major employer at its car and battery production facilities. The top five states for clean vehicle jobs for 2018 are, in order: Michigan, California, Texas, Indiana, and Ohio.[17]

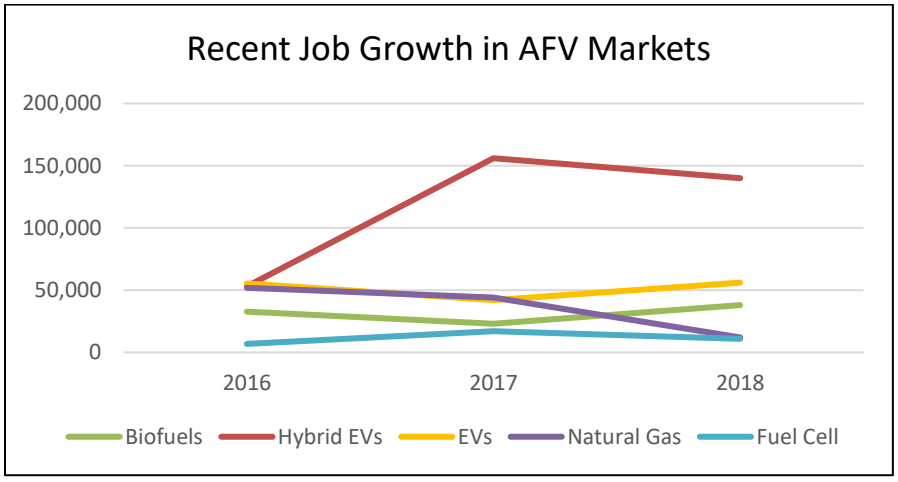


Figure 5. Growth in clean vehicle jobs according to E2's 2016, 2017, and 2018 Clean Jobs America report[17,18,19]

E2's data, which was based of the U.S. Energy and Employment report, shows explosive growth in jobs related to hybrid EVs and steady job growth across all other sectors except natural gas.[20] The drop in natural workers likely represents an industry-wide struggle to retain profitability amid low commodity prices.

With increasing market share and job opportunities in the alternative fuel and vehicle markets, it is critically important to build-out the necessary education and training pipelines to sustain a qualified workforce. Due to the fact that many of these fuels operate outside of traditional ICE processes, the knowledge of the existing workforce is typically not transferable to alternative

fuels. Although some re-training of the existing workforce might be necessary, investment in training and education is better spent on the future workforce, starting in grade school. The following sections detail the current state of affairs for each level of education in terms of the availability of AFV education and training, illustrated with examples of programs that offer possibilities for replication.

Pathways and the Education/Training Continuum

K-12 awareness building

Alternative fuel education can be introduced in curriculum and activities at all grade levels. This provides an early awareness of how we meet our mobility needs and the role alternative fuels can and does play. Incorporating alternative fuels and sustainable transportation concepts into lesson plans that complement math and science classes is a straightforward way to introduce these concepts early on. Well-conceived curriculum and programming can enable educators to meet requirement in science and math standards as well as in other fields. Curriculum that is built to meet these educational requirements is more likely to be adopted. Moreover, early exposure to these fields and related career options in sustainable transportation can promote the transportation sector as a viable career path in the eyes of young students.

Currently, the majority of alternative fuel curricula offered at the K-12 level is in the form of optional or additional project-based courses that students can elect or apply to enroll. These courses often provide engaging experiences for students, but there is a limited supply of this type of curricula. Teachers can select to use curriculum, exercises and projects. Students (particularly middle and high school) can choose to take part in after school clubs, or vacation camps if they have an interest. To build a better informed public and increase the awareness and interest in careers related to alternative fuels a more concerted effort by employers and advocates to find partnership with elementary and secondary education programs will be required.

Profile: Clarkson University, Sustainable Transportation Fuels Partnership Program

This program is part of a project-based learning program that places Clarkson University and St. Lawrence University fellows in local K-12 schools to teach STEM subjects. The program goal is to promote sustainable transportation fuel as an important subject in the eyes of young students. The fellows first teach the students about the problems with current petroleum transportation fuels, then introduce them to alternative fuels, and finish with a hands-on project.

Profile: *Transportation Careers Lesson Plans*

The Federal Highway Administration (FHWA), in partnership with the U.S. Department of Education and Advance CTE, and the association of state CTE directors, supported a program to develop lesson plans in transportation across the K-12 continuum. This website provides a series of grades 6-12 curriculum units that will introduce students to careers, skills, and concepts one would need to succeed in the transportation industry. All lesson plans were developed by teachers for teachers with input from their industry partners and are free for everyone to use. This content will enable teachers to expand, enhance and reinforce academic content and as a result improve transportation education as well as academic achievement.

Profile: SWITCH Vehicles Lab

The SWITCH Vehicles Lab, based out of California, performs trainings for teachers on how to incorporate electric vehicle technology into their classrooms and curricula. The company formed in response to a problem that schools were having procuring vehicles on which students could learn. An assessment of training programs found that one of the most significant challenges they face is finding the resources for new training equipment or getting the equipment donated.[21] The

SWITCH Lab program curriculum is adaptable by grade level and offers both middle school and community college lesson plans. In addition, the company produces SWITCH vehicle kits available for purchase, advertised as providing training tomorrow's electric vehicle technicians. At $32,000 per kit, the cost may seem prohibitive for some schools, however the SWITCH Lab works with each school to find opportunities to secure funding through various partnerships and sponsors.

Community and Technical Colleges

Community and technical colleges tend to be career-focused in nature. Programs may result in an associate's degree, certificate of completion, or diploma depending on the school and are typically involve a good deal of hands-on training. The National Alternative Fuels Training Consortium (NAFTC) operates a network of national training centers and associate training centers, which includes a number of community and technical colleges across the country certified to teach alternative fiuels. Most often, alternative fuel courses at these schools are part of a program in automotive technology, designed to training future or current technicians who can install, maintain, and repair both traditional and alternative transportation technologies. Courses on alternative fuels are occasionally offered as a core requirement, however the majority are elective. These courses are commonly generalized introductions to all alternative fuels. Specializations are either general or fuel specific, and the majority of fuel specific specializations are offered in EV and hybrid technologies.

Compared to other regions of the U.S., the Northeast does not have a large number of community college automotive programs that include an alternative fuel course or specialization. There are many models already in practice across the country, and the challenge now is successfully generating interest in replicating them in community colleges in the Northeast and making alternative fuels a core curriculum topic within automotive technician degrees. In the future, the field will benefit from community college efforts to create courses and programs that cater not only to technicians, but also for workers in manufacturing and engineering.

Profile: Linn-Benton Community College (LBCC), Advanced Transportation Technology Center

The Advanced Transportation Technology Center, located in a new 35,000 square foot facility in Lebanon, Oregon, provides training to apply, develop, and adopt alternative energy in biofuels, EVs, CNG, propane, hybrid, telematics and new technologies. While the LBCC currently only offers a standard AAS in Automotive Technology and an AAS in Heavy Equipment/Diesel Technology, the Center will soon be home to new certificate programs: Advanced Alternative Fuels Certification, Alternative Fuels for Fleet Managers, Alternative Fuels for Consumers, and courses for first responders and truckers in alternative fuels.

Profile: Blue Ridge Community College, Alternative Transportation Technology

The Alternative Transportation Technology program prepares individuals to apply technical knowledge and skills to the maintenance of AFVs, hybrid electric vehicles and the conversion of standard vehicles to AFV status. Topics includes instruction in electrical vehicles, hybrid electric vehicles, liquefied petroleum gas vehicles, compressed natural gas vehicles, hybrid fuel technology, biofuels, electrical and electronic systems, engine performance, diagnosis and repair, and conversion/installation. The program offers a diploma as well as two certificates, one in

general alternative fuels and another specializing in advanced electric drive. Graduates will be prepared to enter careers as entry-level technicians in the transportation industry.

University

Four-year universities are focused on workforce needs that require a higher level of credential, such as a bachelors or masters. The most common university programs related to alternative fuels are engineering programs (chemical, mechanical, and electrical) that prepare students to design and manufacture alternative fuel and advanced vehicle technologies and infrastructure. Many universities also offer relevant curricula under departments that are sustainability-themed. These programs and courses tend to be less technical and more oriented towards planning and design.

Both types of instruction are needed: technical engineering courses train future works to manufacture and maintain alternative fuel vehicles and infrastructure while generalized sustainability courses help raise awareness on the environmental, social, and economic benefits of alternative energy systems.

Profile: New York University (NYU), Sustainable Urban Environments, BS

Run through NYU's Tandon School of Engineering, the major in Sustainable Urban Environments gives students an understanding of the social and technical issues in urban environmental problems, and an appreciation of the policy and planning approaches that are necessary to create more sustainable cities. The program prepares students for a number of various fields, including urban planning and design. Students need to take at least one transportation course as a core requirement and may take others as electives. Relevant transportation courses include: Introduction to Transportation Systems, Traffic Engineering, History of New York City Transit System, and Beyond Oil: Fueling Tomorrow's Vehicles.

Profile: Michigan Tech, Hybrid Electric Vehicle (HEV) Curriculum

Michigan Tech's pioneering program in HEV engineering, one of the first of its kind in the nation, was started with a $3 million U.S. DOE grant and $750,000 of in-kind contributions from industry sponsors and partners. The coursework provides advanced knowledge and hands-on labs in the design, analysis, control, calibration, and operating characteristics of HEVs. Over thirty courses are offered on campus, online, and—thanks to the showpiece of the program—on the road through a mobile lab. The program is flexible an can be taken informationally as a non-degree seeking student, for a graduate certificate, or for an MS in Mechanical or Electrical Engineering with a focus in HEV engineering.

Professional Development

In a field with rapidly evolving technologies, continuing professional development is crucial to ensure that workers are up-to-date on relevant training. This is especially true for members of the accessory workforce (see Appendix C) which includes mechanics and technicians, the sales representatives, first responders, and other professionals who maintain and support the expansion of the alternative fuels market. Professional development programs tend to be short certifications or trainings designed for full-time professionals. Often these programs are offered through industry organizations or equipment manufacturers who offer in-house training for fleet

managers who purchase their products. Professional development programs are increasingly offered online to make training accessible regardless of location.

Profile: Electric Vehicle Infrastructure Training Program (EVITP)

This program provides training and certification for electricians, teaching them to install electric vehicle supply equipment (EVSE). The training program, developed in cooperation with industry (automakers, utilities, EVSE equipment manufacturers, and other key stakeholder associations) and is offered through a network of electrical industry training centers and community colleges. The curriculum covers the installation of current electric vehicle infrastructure technologies and includes a section on emerging technologies.

Profile: *The National Biodiesel Automotive Technician Training Program*

The National Biodiesel Automotive/Diesel Technician Training program was created in collaboration with a network of automotive-diesel trainers, biodiesel experts, and education curriculum developers. This continuing education program is aimed at educating diesel automotive instructors and service technicians nationwide about biodiesel and biodiesel blends for use in the field. With this education, diesel technicians are able to better advise customers and other technicians about the true impacts of using biodiesel and biodiesel blends in diesel equipment, as well as its beneficial impact on global warming and reduced dependence on foreign oil. This program allows diesel technicians to more accurately diagnose the root cause of problems with equipment in for service as it relates to both petrodiesel and biodiesel issues, and how these problems can be avoided in the field regardless of the root cause.

Online Education and Training

Professional development training are not alone in moving increasingly towards online formats. More and more certifications and even MS degrees can be earned remotely through online platforms. Online education and training options tend to be significantly more cost-effective and offer more flexibility than traditional education programs in terms of time and location.

Profile: National STEM Consortium, Electric Vehicle Technology Program

National STEM Consortium, a collaborative of ten colleges in nine states, offers an academic certificate in Electric Vehicle Technology. The program is built on a 30-semester-credit model and includes two tracks: (1) Electric Vehicle Development, and (2) Electric Vehicle Service. Graduates are prepared for product development positions in the automotive, communications, solar, wind turbine, and smart grid industries and service positions in the automotive industry.

Profile: Triangle Alternative Fuels First Responder Online Training Modules

Intended for fire safety professionals, this free online training program was put together by the NC Office of State Fire Marshal and NC Solar Center. The training includes separate sections on EVs, biofuels, and gaseous fuel vehicles and is designed to give emergency response personnel the opportunity understand the potential hazards unique to alternative fuel vehicles and stations and familiarize themselves with relevant specialized emergency procedures.

Recommendations

Overall, alternative fuel education and exposure warrants more attention and investment across the entire spectrum, from grade school to professional development. Given the identified need for entry-level employees with alternative fuels training, increasing the number of post-secondary programs should be given a high priority. Figure 6 shows that the number of post-secondary programs (community college, technical college, and university) by state across the country.

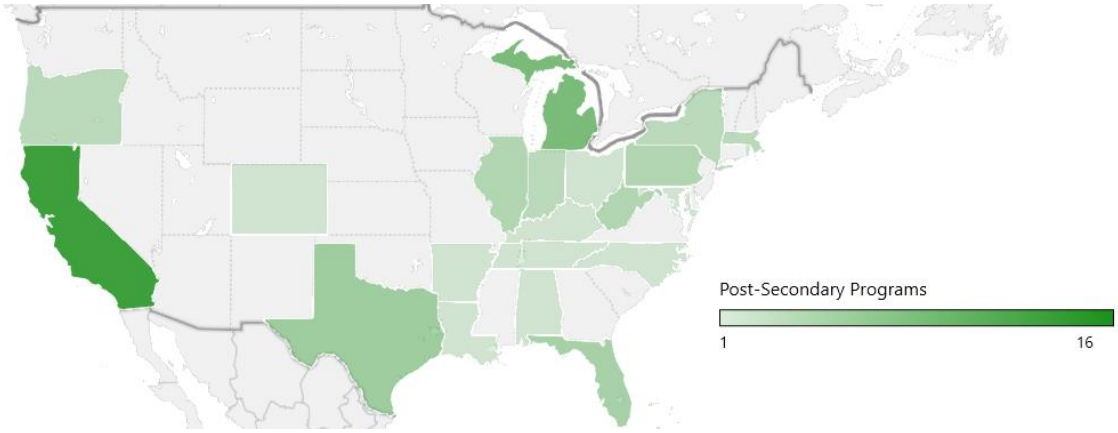


Figure 6. Number of post-secondary programs specializing in alternative fuels and/or AFVs by state.[22]

By far, California has the highest concentration of programs, followed respectively by the Michigan, Texas, and Florida. The following recommendations can be used to help fill the gaps in AFV education and training.

Recommendation 1: *Build partnerships to keep post-secondary programs in pace with evolving technologies and industry needs.*

As has been demonstrate successfully in other fields (e.g., Advanced Manufacturing, Healthcare) creating a robust pathway for skill building and work opportunities in alternative fuels, education and industry must partner together. Building curriculum in post-secondary institutions can take several years to get classes certified and programs established. When technology is advancing quickly, classes or programs can become outdated before they're even offered. Community and Technical Colleges typically have workforce development offices, whose mission is to partner directly with industries or industry clusters to create customized opportunities to provide training and skill building for future employees. In some cases, industry partners play key roles in helping to design curriculum, provide training spaces in real-work settings, practicums for students, and even mentors and instructors. Colleges and universities can use industry partnerships to design programs of student research and learning, practicums, internships and coops to empower students with applied as well as theoretical learning and keep pace with changes in technology and industry practices.

Recommendation 2: *Coordinate local training and education efforts through Regional Transportation Workforce networks and partners.*

Regional Transportation Workforce Centers have the outreach resources to effectively promote alternative fuel education at the grade school level into local automotive vocational schools and post-secondary programs. These centers can help make the AFV workforce a priority and establish a long-term vision on the sector's needs, ideally in conjunction with other key partners such as major local employers and regional Clean Cities coalitions. Compiling a database of AFV programs, heading up an alternative fuels working group, or hosting listening sessions with employers and other relevant stakeholders are a few of the ways in which these centers can work to coordinate regional training and education.

Recommendation 3: *Leverage the Clean Cities and NAFTC networks to build partnerships in AFV training and education.*
Clean Cities coalitions are well positioned to help facilitate connections between fleets and qualified trainers or educational institutions. As regional alternative fuel experts, coordinators are aware of existing local training programs and informed of major national opportunities, such as workshops and conferences. NAFTC provides a database of existing training centers and expertise. Both programs offer good starting points for efforts to expand the AFV knowledge base.

Recommendation 4: *Engage workforce boards on AFV gaps and opportunities.*
Workforce boards present a key opportunity to expand AFV training. These boards exist in all fifty states and are tasked with directing federal, state, and local funding to workforce development programs. The alternative fuels industry is still emerging in most regions, and there is limited understanding of the field as a growth opportunity among workforce development agencies. Most workforce boards do not have a high level of awareness to see how alternative fuels fit within their planning and regional needs. The workforce boards can be hard to engage with due to their tendency to focus priorities on a given sector—a focus often guided by legislative edicts. Regional and statewide studies demonstrating the economic benefits of AFVs can be an effective means of sparking the attention of those setting the focus of workforce boards' agendas.

One challenge preventing the growth of technical college courses on alternative fuels is the fluctuation in demand for specific fuel types. Technical colleges will not continue to offer a course or training that is not resulting in job placement for their students, so until a large direct alternative fuel job market is identified to get students hired post training, course offerings will continue to be inconsistent. Collaborating with industry is key to continue forward momentum with this type of training.

Conclusion

State and federal policies and initiatives addressing public health, energy security, and climate change continue to press for development in alternative fuels and advanced vehicle technologies. A number of factors will continue to expand the market for alternative fuels, the vehicles they power, and the infrastructure that supports them. As petroleum fuel prices rise, it is expected that the foundation laid now will encourage more rapid adoption of these fuels and investment in the infrastructure. The lessening of barriers, and increased roll-out of connected and autonomous vehicles will ultimately be tied to a larger electric-powered fleet.[23] While much attention is given over to technological innovation, little attention has been directed to the corresponding emerging changes in or development of new skills and knowledge that need to be embedded in the workforce to take these efforts forward.

NETWC initiated this inquiry to reveal and address the challenges related to developing a workforce to design, establish, operate and maintain the infrastructure to support an alternative fuel fleet even while these fuels are a small percentage of the market share. Building awareness, creating active partnerships with industry and educational entities, and advancing policy initiatives are all efforts that provide the foundation for the future innovations that are deemed critical to transforming and building a sustainable transportation system for the country.

Up to this point, workforce initiatives have largely focused on workers such as emergency first responders, sales teams, and automotive technicians, and their ability to integrate alternative fuel technical expertise and knowledge into their existing capacity. The workforce training more specific to each fuel (i.e. operations and equipment manufacturers) has been primarily provided by the fuel industry itself, relying on internal trainings of employees. Build out of fueling infrastructure has been slow, and relied on skillsets from related fields, but as manufacturing, production of fuels, and build out of fueling and maintenance infrastructure increases, having a trained pool of students entering the workforce will become essential.

This paper seeks to continue the conversation around the makeup of the current alternative workforce and existing educational landscape, and aims to identify opportunities to best prepare the workforce for growth in alternative fuels across a diverse range of employers and industries.

Do you have any additional comments or suggestions that would inform future updates of this paper? Please communicate your ideas and information to the NETWC, especially concerning training and education programs at Vermont Clean Cities Coalition *vtccc@uvm.edu*

Appendix A

Types of Alternative Fuels

Electric or Zero Emission Vehicles (ZEVs)

- EVs, prevalent in the light-duty market, receive their power from an electrically charged battery. The life cycle emissions of an EV or plug-in hybrid electric vehicle depend on the sources of electricity used to charge it, which varies by region.
- Hydrogen can be produced from domestic resources and is still in its relatively early stages as a transportation fuel. One of the challenges of using hydrogen as a fuel is the ability to efficiently extract hydrogen from compounds such as water (H^2O), hydrocarbons (such as methane, CH_4), and other organic matter. A fuel cell electric vehicle (FCEV) running on hydrogen emits water vapor and warm air as exhaust and is considered a zero-emission vehicle.[24]

Biofuels

- Ethanol is produced domestically from corn and other crops and produces, on average, 40% less greenhouse gas emissions than conventional fuels. This reduction increases to 105% when cellulosic feedstocks are used. Currently ethanol is used in the same class of vehicles as gasoline.
- Biodiesel is derived from vegetable oils and animal fats and is a cleaner-burning replacement for diesel fuel. Newer applications can be derived from algae and other non-traditional vegetable oils.[25]
- Renewable Natural Gas (RNG) is essentially biogas—the gaseous product of the decomposition of organic matter—processed to purity standards. Capturing biogas from landfills and livestock operations reduces emissions by preventing methane, a pollutant twenty-five times as potent as carbon dioxide, from being released into the atmosphere.

Fossil Fuels

- Natural gas is a fossil fuel that is extracted from shale formations and coal beds, and most commonly found in heavy-duty vehicle applications. Natural gas vehicles emit 27% less carbon dioxide than diesel.[26] In addition, because natural gas fuel systems are completely sealed, the vehicles produce no evaporative emissions.[27] Natural gas comes in two formats: compressed natural gas (CNG) and liquefied natural gas (LNG). Because of economic constraints, nearly all natural gas fueling stations are connected to the pipeline.
- Propane, also called liquefied petroleum gas (LPG), is a domestically abundant fossil fuel with a wide variety of vehicle applications. Compared with vehicles fueled by conventional diesel and gasoline, propane vehicles can produce lower amounts of some harmful air pollutants and greenhouse gases, depending on vehicle type, drive cycle, and engine calibration.[28\]

Appendix B

The Northeast Alternative Fuel Workforce Network

The Northeast Transportation Workforce Center (NETWC) was established through a FHWA grant to help create opportunities in transportation workforce development. In 2016, NETWC facilitated the Northeast Alternative Fuel Workforce Network, a working partnership with thirteen Clean Cities Coalitions. This partnership helped facilitate the initial research for this paper, and host the national webinar, *Driving without Gas: How Electric Vehicles are Transforming the Education and Workforce Landscape*. The U.S. Department of Energy funds Clean Cities Coalitions to advance private and public sector strategies and efforts that reduce dependence on imported and petroleum-based fuels in U.S. fleets. The Clean Cities mission is consistent with the goals of the federal Energy Policy Act of 1992, the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. In the Northeast, with the support of Clean Cities Coalitions, several regional agreements have served to mobilize extensive efforts to convert to non-petroleum fuels for transportation and build out the infrastructure that would support such a transition (see Appendix A for a list of these agreements).

The Clean Cities Coalitions that worked in partnership on the Northeast Alternative Fuel Workforce Network are:

Capital Clean Cities of Connecticut (CT)
Norwich Clean Communities (CT)
Greater New Haven Clean Cities Coalition (CT)
Greater Washington Region Clean Cities Coalition (DC)
Delaware Clean Cities Coalition (DE)
Maine Clean Communities (ME)
New Jersey Clean Cities Coalition (NJ)
Capital District Clean Communities (NY)
Clean Communities of Central New York (NY)
Genesee Region Clean Communities (NY)
Eastern Pennsylvania Alliance for Clean Transportation (PA)
Ocean State Clean Cities Coalition (RI)
Vermont Clean Cities Coalition (VT)

Appendix C
Overview of Alternative Fuels Workforce

As the use of alternative fuels increases, the demands on its workforce will evolve. The alternative fuels workforce is defined as those who are responsible for:

- production of alternative fuels;
- distribution of the alternative fuels;
- production of vehicles that run on alternative fuels;
- development and deployment of alternative fueling infrastructure; and
- maintenance and repair of vehicles.

Developing each alternative fuel requires skilled laborers to cultivate or capture the fuel, as well as to process, distribute, and dispense it. To better illustrate the overall alternative fuels workforce, it can be broken down into three categories: the production of the fuel, the development of the infrastructure, and the accessory workforce.

Figure A-1 outlines the first category of the production workforce, detailing the various operations required to take each fuel from raw material to fueling station. Note that each fuel type has a unique chain of operations that result in a usable on-road fuel.

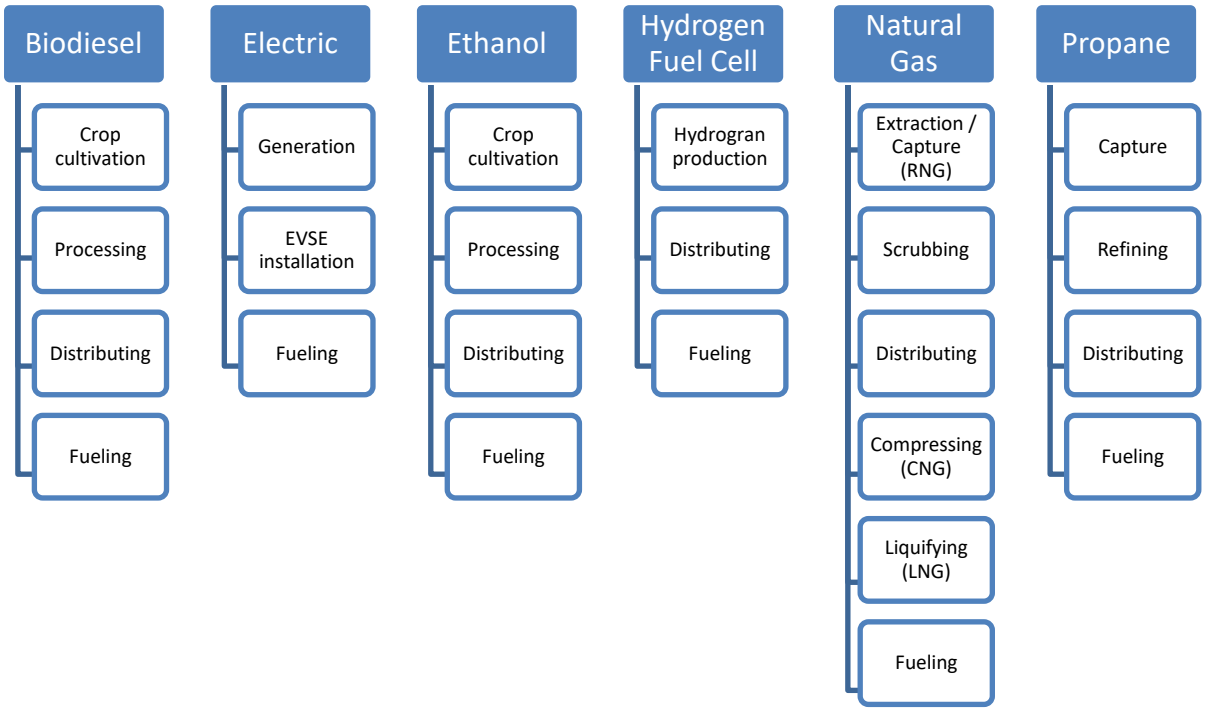


Figure A-1. The production workforce involved in each alternative fuel.

Following production, a workforce is needed to manufacture the equipment and supplies needed to extract, distribute, store, and fuel vehicles. Figure A-2 shows the variability of equipment needed based on the fuel. For any of these steps in the sequence, there is a workforce creating and maintaining the equipment.

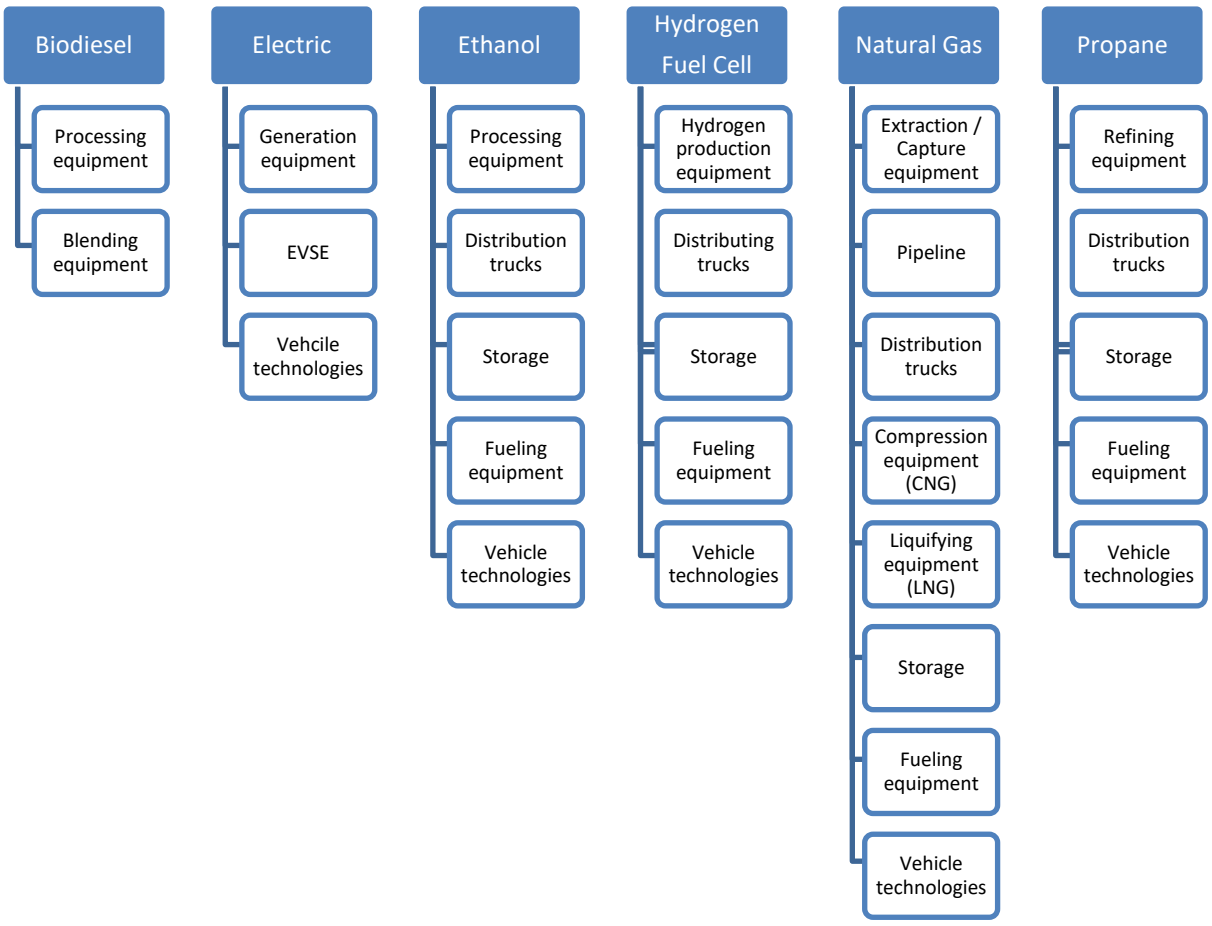


Figure A-2. The manufacturing and supply workforce needed to supply alternative fuel vehicles and infrastructure.

Lastly, the accessory workforce represents jobs that entail many duties not directly related to alternative fuels, however workers possessing at least a cursory understanding of these fuels will be necessary for the growth of both career paths in the fields represented by these fuels, as well as the alternative fuel industry itself. This category of workforce tends to receive the most emphasis in regards to alternative fuel trainings. These types of professions, detailed in Figure A-3, include auto mechanics, emergency responders, governmental officials, sales representatives and waste disposal operators.

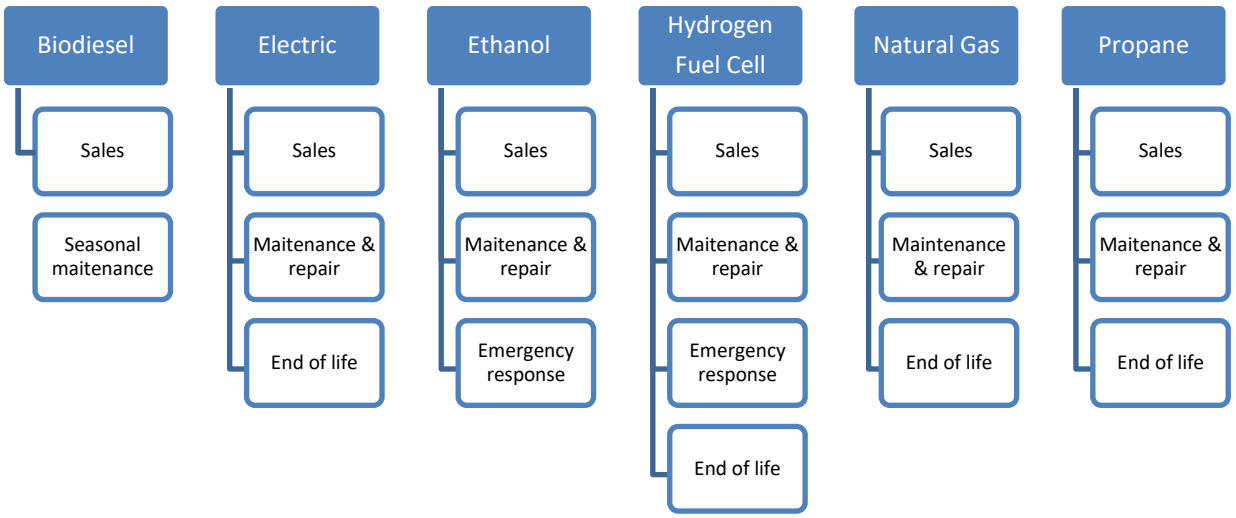


Figure A-3. The accessory workforce needed to maintain and support the alternative fuel market.

Appendix D

Timeline of Northeast Regional Agreements that Mobilize Efforts to Reduce Petroleum Use in Transportation

2009 – Regional Greenhouse Gas Initiative (RGGI) is established as the first market-based regulatory program in the United States to reduce greenhouse gas emissions. RGGI is a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont to cap and reduce carbon dioxide emissions from the power sector.

2010 – The Transportation Climate Initiative (TCI) is launched by the RGGI states along with the District of Columbia to reduce the carbon emissions from the transportations sector. Participating states start taking action through working groups focused on regional priorities, such as clean vehicles and fuels.

2011 – Northeast Electric Vehicle Network is established as a ZEV task force project of the Transportation and Climate Initiative to coordinate electric vehicle infrastructure planning and deployment throughout the Northeast and Mid-Atlantic region.

2013 – Eight states, including Maryland, Massachusetts, New York, Rhode Island, and Vermont, sign a memorandum of understanding (MOU) committing to coordinated action to ensure the successful implementation of their state zero-emission vehicle (ZEV) programs and create a Multi-State ZEV Action Plan.

2014 – Vermont introduces its state ZEV Action Plan.

2016 – Connecticut, New York, and Vermont sign on the Compact of States and Regions, an initiative designed to provide transparent disclosure of local progress in meeting the goals to combat climate change set out in the Paris Agreement

- Vermont Comprehensive Energy Plan – Vermont adopts a Comprehensive Energy Plan outlining a pathway to transition 90% of Vermont's total energy needs to renewable sources by 2050. The plan includes transportation sector strategies that address alternative fuels, including to "electrify and increase the efficiency of light-duty vehicles" and "increase the efficiency of heavy-duty vehicles and power them with renewable fuels, such as advanced liquid or gaseous biofuels"

2018 – The ZEV task force introduces a new Multi-State ZEV Action Plan (2018-2021) to accelerate ZEV adoption by mainstream consumers. The same eight states are involved and joined by New Jersey.

Appendix E
Alternative Fuel Legislation

Alternative fuel and fuel economy legislation dates back to the Clean Air Act of 1970, which created initiatives to reduce mobile sources of air pollutants. Following the Clean Air Act of 1970, in 1975 the Energy Policy and Conservation Act established Corporate Average Fuel Economy (CAFE) standards that required the distribution of fuel economy information to consumers. To incentivize alternative fuel vehicle development, the Alternative Motor Fuels Act of 1988 created vehicle manufacturer incentives in the form of CAFE credits (see Figure A1). Under the Energy Policy Act of 2005, congress created the Renewable Fuel Standard (RFS) program that requires a certain volume of renewable fuel to replace or reduce the petroleum-based transportation fuel, heating oil or jet fuel. More recently, the Consolidated Appropriations Act of 2016 extended and reinstated a number of the alternative fuel tax credits from the Tax Increase Prevention Act of 2014.[29]

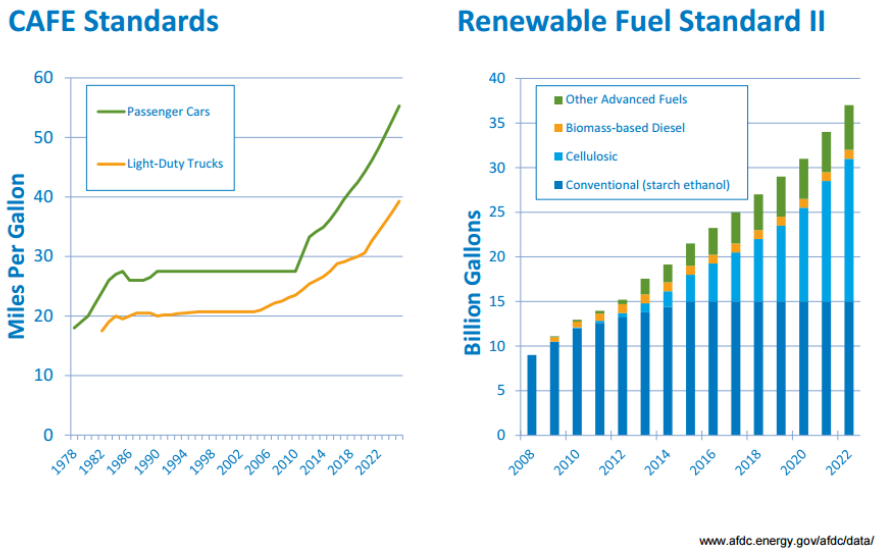


Figure A-4. National policies shaping the alternative fuel market.[30]

States have also implemented their own incentives, laws, and regulations to support the alternative fuel and advanced vehicle markets with a localized focus. For example, many states offer AFV and battery electric vehicle project funding and car purchase rebates, as well as favorable tax rates on alternative fuel production and use.[31]

Appendix F

Additional AFV Workforce Development Resources

There are a variety of existing programs targeted toward developing the alternative fuel workforce both on the national and local levels. The following is a list of national programs that provide resources about AFV workforce development:

- Northeast Transportation Workforce Center: http://netwc.net/
- National Alternative Fuels Training Consortium (NAFTC): http://www.naftc.wvu.edu/
- National Automotive Technician Education Foundation (NATEF): http://www.natef.org/
- NFPA: http://www.nfpa.org/
- National Biodiesel Board (NBB)'s Biodiesel Automotive Technician Training Program: http://www.biodieselautomotive.org/
- Renewable Fuels Association Education and Training: http://www.ethanolrfa.org/pages/students-and-teachers-education-and-training
- Ethanol Emergency Response Coalition: http://www.ethanolresponse.com/
- List of Electric Vehicle Workforce Education & First Responder Training: http://www.afdc.energy.gov/vehicles/docs/ev_training_and_education.xls
- Certified Electric Vehicle Technician (CEVT) Training Program: http://www.cleantechinstitute.org/Training/CEVT.html
- NGVAmerica (now includes Clean Vehicle Education Foundation): http://www.ngvamerica.org/media-center/technical-and-safety-documents/
- Natural Gas Vehicle Institute (NGVi): http://www.ngvi.com/
- National Institute for Automotive Service Excellence: https://www.ase.com/Home.aspx
- Alternative Fuel Data Center: http://www.afdc.energy.gov/
- Alternative Fuel Training Network: http://www.afvtraining.net
- Sustainability Education & Economic Development (SEED) Center – Transportation & Fuels: http://www.theseedcenter.org/Resources/Resource-Center?catid=14
- Center for Advanced Automotive Technology (CAAT): http://autocaat.org/Home/

Appendix G

Alternative Fuel Green Job Classifications

Job classifications were collected from several different published studies and existing databases concerning green jobs. The studies include two from the US Bureau of Labor Statistic on careers in biofuels and electric vehicles respectively and a study by Jobs for the Future on preparing students for careers in the clean economy.[32,33,34] The databases used include www.careeronestop.org using the Transportation filter. One database from Virtual Career Network at www.vcn.org using the All Green Careers filter. All gathered information was matched with Standard Occupational Classifications (SOC) from the Bureau of Labor Statistics.

Engineering Occupations	Drafters, Engineering Technicians and Mapping Technicians	Scientific Occupations	Agricultural Workers	Construction and Extraction Occupations	Business, Sales and Financial Operations Occupations

• Chemical engineering
• Electrical engineering
• Electronics engineering
• Industrial engineering
• Materials engineering
• Mechanical engineering
• Agriculture engineering
• Civil engineering
• Environmental engineering
• Operating engineering
• Locomotive engineering
• Aerospace engineering
• Automotive engineering
• Fuel cell engineering
• Logistics engineering
• Transportation engineering
	• Electrical engineering technician
	• Automotive engineering technicians
	• Mechanical engineering technicians
	• Environmental Engineering Technician
	• Mechanical drafters
	• Fuel cell technicians
		• Physical
		  • Chemist
		  • Material scientist
		  • Chemical technicians
		• Life
		  • Biochemists and biophysicists
		  • Microbiologists
		  • Biofuels Processing Technician
		  • Biomass Plant Technician
		• Social
		  • Urban and regional planners
			• Farmworkers and laborers, crop nursery and greenhouse
			• Agriculture equipment operators
			• First-Line Supervisor of Agricultural Crop and Horticultural Worker
			• Agricultural Technician
			• Precision Agriculture Technician
				• Electricians
				• Construction equipment operators
				• Carpenter
				• Construction and Building Inspector
				• Pipe Fitter and Steamfitter
				• Rail-track laying and maintenance equipment operators
					• Buyers and purchasing agents
					• Logisticians
					• Energy Auditor

					Sales and Related Occupations • Retail salesperson • Wholesale and manufacturing sales representatives
Management Occupations	**Installation, Maintenance, and Repair Occupations**	**Transportation and Material Moving Occupations**	**Production Occupations**	**Office and Administrative Support Occupations**	**Computer Occupations**
• Industrial production managers • Farmers, ranchers and other agriculture managers • Transportation managers • Logistics manager • Supply chain managers • Marketing managers • Biofuels Production Manager • Construction Manager	• Electrical power-line installers and repairers • Industrial machinery mechanics • Automotive specialty technicians • Electrical Power-Line Installer and Repairer • Electrical and Electronics Repairer, Powerhouse, Substation, and Relay • Welder, Cutter, and Welder Fitter • Automotive Technician	• Bus drivers, transit, and intercity • Bus Drivers, School, or Special Client • Freight forwarders • Industrial truck and tractor operators • Railroad conductor and yardmasters • Truck drivers, heavy and tractor-trailer • Transportation vehicle, equipment and systems inspectors • Transportation planners	• Electrical and electronic equipment assemblers • Electromechanical equipment assemblers • Engine and other machine assemblers • Machinists • Chemical equipment operators and tenders	• Customer service representatives • Dispatchers • Shipping, receiving and traffic clerks • Sustainability Specialist • Farm and Home Management Advisor	• Software developers • Computer-controlled machine tool operators • Computer Numerically Controlled Machine Tool Programmer
					Arts and Design Workers • Commercial and industrial designers

Figure A-5. Alternative Fuel Job Titles by Occupation type

AFC Careers matched with Bureau of Labor Statistics SOC's:

17-2000 - Engineers
17-2041 – Chemical Engineers
17-2071 - Electrical Engineers
17-2072 - Electronics Engineers
17-2112 - Industrial Engineers
17-2131 - Materials Engineers
17-2141 - Mechanical Engineers
17-2021 - Agriculture Engineers
17-2051 - Civil Engineers
17-2081 - Environmental Engineers
17-2199 - Operating Engineers
17-2199 - Locomotive Engineers
17-2011 - Aerospace Engineers
17-2199 - Automotive Engineers
17-2199 - Fuel cell Engineers
17-2199 - Logistics Engineers
17-2199 - Transportation Engineers

17-3000 – Drafters, Engineering Technicians and Mapping Technicians:
17-3027 – Electrical engineering technician
17-3029 – Automotive engineering technicians
17-3027 – Mechanical engineering technicians
17-3025 – Environmental Engineering Technician
17-3013 - Mechanical drafters
17-3-29 - Fuel cell technicians

12-2000 - Physical Scientists:
19-2031 - Chemist
19-2032 - Material scientist
19-4031 - Chemical technicians

19-1000 - Life Scientists:
19-1021 - Biochemists and biophysicists
19-1022 - Microbiologists
19-4099 - Biofuels Processing Technician
19-4099 - Biomass Plant Technician

19-3000 - Social Scientists:
19-3051 - Urban and regional planners

51-000 - Production Occupations:
51-2022 - Electrical and electronic equipment assemblers
51-2023 - Electromechanical equipment assemblers
51-2013 - Engine and other machine assemblers
51-4041 - Machinists
51-9011 - Chemical equipment operators and tenders

11-0000 - Management Occupations:
11-3051 - Industrial production managers
11-9013 – Farmers, ranchers and other agriculture managers
11-3071 - Transportation managers
11-9199 - Logistics manager
11-9199- Supply chain managers
11-2021 - Marketing managers
11-9199 - Biofuels Production Manager
11-9021 - Construction Manager

49-0000 - Installation, Maintenance, and Repair Occupations:
49-9051 - Electrical power-line installers and repairers
49-9041 - Industrial machinery mechanics
49-3020 - Automotive specialty technicians
49-9051 - Electrical Power-Line Installer and Repairer
49-2095 - Electrical and Electronics Repairer, Powerhouse, Substation, and Relay
49-9099 - Welder, Cutter, and Welder Fitter
49-3029 - Automotive Technician

47-0000 - Construction and Extraction Occupations:
47-2111 - Electricians
47-2070 - Construction equipment operators
47-2031 - Carpenter
47-4011 - Construction and Building Inspector
47-2152 - Pipe Fitter and Steamfitter
47-4061 - Rail-track laying and maintenance equipment operators

13-0000 - Business and Financial Operations Occupations:
13-1021 - Buyers and purchasing agents, farm products
13-1-81 - Logisticians
13-2011 - Energy Auditor

41-0000 - Sales and Related Occupations:
41-2031 - Retail salesperson
41-4010 - Wholesale and manufacturing sales representatives

15-1100 - Computer Occupations:
15-1130 - Software developers
51-4012 - Computer Numerically Controlled Machine Tool Programmer
51-4011 - Computer-controlled machine tool operators

27-1000 - Arts and Design Workers:
27-1021 - Commercial and industrial designers

43-0000 - Office and Administrative Support Occupations:
43-4051 - Customer service representatives
43-5030 - Dispatchers
43-5070 - Shipping, receiving and traffic clerks
43-9199 - Sustainability Specialist
43-9199 - Farm and Home Management Advisor

45-2000 - Agricultural Workers:
45-2092 - Farmworkers and laborers, crop nursery and greenhouse
45-2091 - Agriculture equipment operators
45-1011 - First-Line Supervisor of Agricultural Crop and Horticultural Worker
45-2099 - Agricultural Technician
45-2099 - Precision Agriculture Technician

Transportation and Material Moving Occupations:
53-3021 - Bus drivers, transit, and intercity
53 -3022 – Bus drivers, school, or special client
53-7062 - Freight forwarders
53-7051 - Industrial truck and tractor operators
53-4031 - Railroad conductor and yardmasters
53-3032 - Truck drivers, heavy and tractor-trailer
53-6051 - Transportation vehicle, equipment and systems inspectors
11-3071 - Transportation planners

References

1. Cookson, Graham. 2018. "INRIX Global Traffic Scorecard." INRIX Research. Accessed August 25, 2018. Retrieved from http://inrix.com/scorecard/

2. Ho, Bruce and Uchenna Bright. 2018. "Transportation Reimagined: A Roadmap for Clean and Modern Transportation in the Northeast and Mid-Atlantic Region." Natural Resources Defense Council. Accessed August 15, 2018. Retrieved from https://www.nrdc.org/sites/default/files/transportation-reimagined-roadmap-ne-midatlantic-report.pdf

3. Litman, Todd. 2017. "Public Transportation's Impact on Rural and Small Towns: A Vital Mobility Link." American Public Transportation Association. Accessed August 25, 2018. Retrieved from www.apta.com/resources/reportsandpublications/Documents/APTA-Rural-Transit-2017.pdf

4. Greene, David, and Steven Plotkin. 2011. "Reducing Greenhouse Gas Emissions from U.S. Transportation." Center for Climate and Energy Solutions. Accessed July 30, 2018. Retrieved from http://www.c2es.org/publications/reducing-ghgemissions-from-transportation.

5. Dougherty, Sarah and Nick Nigro. 2014. "Alternative Fuel Vehicle & Fueling Infrastructure Deployment Barriers & the Potential Role of Private Sector Financial Solutions." Center for Climate and Energy Solutions. Accessed July 30, 2018. Retrieved from: https://www.afdc.energy.gov/uploads/publication/afv_fueling_infrastructure_deployment_barriers.pdf.

6. U.S. Energy Information Administration. 2018. "Annual Energy Outlook 2018 with projections to 2050." U.S. Department of Energy. Accessed July 30, 2018. Retrieved from: https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf

7. Bleything, Abby, Cowan, Greer, McRae, Glenn and Linnea Myers. 2016. "Alternative Fuels in Transportation: Workforce needs and opportunities in support of reducing reliance on petroleum fuels." Northeast Transportation Workforce Center.

8. Coleman, Laura, Lindstrom, Evgeniya, Milan, Theresa, and Lori Sanchez. 2014. "Alternative Fuels & Advanced Transportation Technologies: Automotive workforce needs assessment." Centers of Excellence. Accessed July 30, 2018. Retrieved from: http://coeccc.net/reports/31e4b11e-47b9-4de9-a2c6-657af5ffb2f6

9. Northeast Transportation Workforce Center. 2016. "Driving without Gas: How electric vehicles are transforming the education and workforce landscape." University of Vermont Transportation Research Center. Retrieved from: http://netwc.net/evwebinar/

10. Northeast Transportation Workforce Center. 2018. "Program Search." University of Vermont Transportation Research Center. Retrieved from: http://netwc.net/program-search/

11. Bloomberg New Energy Finance. 2018. "Electric Vehicle Outlook 2018." Bloomberg LP. Accessed July 31, 2018. Retrieved from: https://bnef.turtl.co/story/evo2018?teaser=true

12. North Carolina Clean Energy Technology Center. 2018. "The 50 States of Electric Vehicles." NC State

University. Accessed July 31, 2018. Retrieved from: https://nccleantech.ncsu.edu/the-50-states-of-electric-vehicles-report-released-by-nccetc/

13. Ipsos. 2017. "Speed and availability of charging biggest barriers to electric car adoption by 2040. Accessed July 31, 2018. Retrieved from: https://www.ipsos.com/ipsos-mori/en-uk/speed-and-availability-charging-biggest-barriers-electric-car-adoption-2040

14. National Renewable Energy Lab. 2017. "The Barriers to Acceptance of Plug-In Electric Vehicles: 2017 Update." US Department of Energy. Accessed July 31, 2018. Retrieved from: https://www.afdc.energy.gov/uploads/publication/barriers_acceptance_pev_2017_update.pdf

15. Alternative Fuels Data Center. 2016. "U.S. Alternative Fueling Stations by Fuel Type. US Department of Energy. Accessed July 31, 2018. Retrieved from: https://www.afdc.energy.gov/data/10332

16. Zion Market Research. 2018. "Global Alternative Fuel Vehicle Market Share 2016: Industry Type, Segments Analysis & Forecast 2022." Accessed July 31, 2018. Retrieved from: https://globenewswire.com/news-release/2018/03/09/1419896/0/en/Global-Alternative-Fuel-Vehicle-Market-Will-Reach-USD-592-30-Billion-by-2022-Zion-Market-Research.html

17. Environmental Entrepreneurs. 2018. "Clean Jobs America." Natural Resource Defense Council. Accessed July 31, 2018. Retrieved from: https://www.e2.org/cleanjobsamerica/

18. Environmental Entrepreneurs. 2016. "Clean Jobs America." Natural Resource Defense Council. Accessed July 31, 2018. Retrieved from: https://www.e2.org/wp-content/uploads/2016/03/CleanJobsAmerica_FINAL.pdf

19. Environmental Entrepreneurs. 2017. "3 Million Clean Energy Jobs in America." Natural Resource Defense Council. Accessed July 31, 2018. Retrieved from: https://www.e2.org/wp content/uploads/2017/02/E2_CleanEnergyJobs_National.pdf

20. National Association of State Energy Officials. 2018. "U.S. Energy and Employment Report." Accessed August 1, 2018. Retrieved from: https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5afb0ce4575d1f3cdf9ebe36/1526402279839/2018+U.S.+Energy+and+Employment+Report.pdf

21. California Community Colleges Chancellor's Office. 2013. "Alternative Fuels & Advanced Vehicle Technologies: Program assessment of automotive and electrical programs in California Community Colleges." Accessed August 1, 2018. Retrieved from: https://www.gcccd.edu/sdic-regional-consortium/documents/consortium/sswg/altfuel-ccc_custom_ca_13.pdf

22. National Alternative Fuel Training Consortium. 2018. "NAFTC Members." West Virginia University. Accessed July 31, 2018. Retrieved from: http://naftc.wvu.edu/training-centers/

23. Fulton, Lee, Mason, Jacob and Dominique Meroux. 2017. "Three Revolutions in Urban Transportation." UC Davis Institute of Transportation Studies. Accessed August 25, 2018. Retrieved from https://steps.ucdavis.edu/wp-content/uploads/2017/05/STEPS_ITDP-3R-Report-5-10-2017-2.pdf

24. Alternative Fuels Data Center. 2018. "Hydrogen Basics." US Department of Energy. Accessed August 1, 2018.

Retrieved from: http://www.afdc.energy.gov/fuels/hydrogen_basics.html

25. Abishek, Monford, Patel, Jay, and Anand Rajan. 2014. "Algae Oil: A Sustainable Renewable Fuel of Future." Biotechnology Research International. Accessed August 1, 2018. Retrieved from https://www.hindawi.com/journals/btri/2014/272814/

26. US Energy Information Administration. 2018. "Frequently asked questions: How much carbon dioxide is produced when different fuels are burned?" Accessed August 25, 2018. Retrieved from https://www.eia.gov/tools/faqs/faq.php?id=73&t=11

27. Alternative Fuels Data Center. 2018. "Natural Gas Benefits and Considerations." US Department of Energy. Accessed August 1, 2018. Retrieved from: https://www.afdc.energy.gov/fuels/natural_gas_benefits.html

28. Alternative Fuels Data Center. 2018. "Propane Benefits and Considerations." US Department of Energy. Accessed August 1, 2018. Retrieved from: https://www.afdc.energy.gov/fuels/propane_benefits.html

29. Alternative Fuels Data Center. 2018. "Key Federal Legislation." US Department of Energy. Accessed August 1, 2018. Retrieved from http://www.afdc.energy.gov/laws/key_legislation

30. National Renewable Energy Laboratory. 2013. "Alternative Fuels Market and Policy Trends." US Department of Energy. Accessed August 1, 2018. Retrieved from http://www.nrel.gov/docs/fy13osti/59328.pdf

31. Alternative Fuels Data Center. 2018. "State Laws and Incentives." US Department of Energy. Accessed August 1, 2018. Retrieved from http://www.afdc.energy.gov/laws/state

32. Richards, Emily. 2013. "Careers in Biofuels." US Bureau of Labor Statistics. Accessed August 1, 2018. Retrieved from: https://www.bls.gov/green/biofuels/biofuels.htm

33. Hamilton, James. 2011. "Careers in Electric Vehicles. US Bureau of Labor Statistics. Accessed August 1, 2018. Retrieved from: https://www.bls.gov/green/electric_vehicles/electric_vehicles.pdf

34. Jobs for the Future. 2015. "Greenprint: A Plan to prepare community college students for careers in the clean economy" Accessed August 2, 2018. Retrieved from: https://www.jff.org/resources/greenprint-plan-prepare-community-college-students-careers-clean-economy/