Alternative Fuel Vehicle Readiness

A Guidebook for Municipalities

December 2017

NJTPA NORTH JERSEY TRANSPORTATION PLANNING AUTHORITY

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The NJTPA is the federally authorized Metropolitan Planning Organization for 6.7 million people in the 13-county northern New Jersey region. Each year, the NJTPA oversees more than $2 billion in transportation improvement projects and provides a forum for interagency cooperation and public input. It also sponsors and conducts studies, assists county planning agencies, and monitors compliance with national air quality goals.

Alternative Fuel Vehicle Readiness: A Guidebook for Municipalities

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This publication was prepared with funding from the North Jersey Transportation Planning Authority (NJTPA) and the Federal Highway Administration (FHWA). This document is disseminated under the sponsorship of the NJTPA and FHWA in the interest of information exchange. The NJTPA and FHWA assume no liability for its contents or use thereof.

Acknowledgements

This guidebook was developed for the NJTPA by a consultant team consisting of ICF, Greener by Design, and Fitzgerald & Halliday, Inc.

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List of Acronyms

Acronym / Abbreviation	Stands For
AC	alternating current
AFV	alternative fuel vehicle
AFDC	Alternative Fuels Data Center
BEV	battery electric vehicle or all-electric vehicle
CNG	compressed natural gas
DC	direct current
DOE	U.S. Department of Energy
FFV	flexible fuel vehicle
FCEV	fuel cell electric vehicle
FHWA	Federal Highway Administration
GHG	greenhouse gas
HEV	hybrid electric vehicle
LNG	liquefied natural gas
MPO	metropolitan planning organization
MUD	multi-unit dwelling
NGV	natural gas vehicle
NJBPU	New Jersey Board of Public Utilities
NJDCA	New Jersey Department of Community Affairs
NJDEP	New Jersey Department of Environmental Protection
NJTPA	North Jersey Transportation Planning Authority
PEV	plug-in electric vehicle
PHEV	plug-in hybrid electric vehicle
TMA	Transportation Management Association
ZEV	zero emission vehicle

Introduction

Introduction

Transportation emissions from fossil fuels are the single largest source of air pollution in New Jersey. Reducing this emissions source is integral to improving public health and meeting the state's greenhouse gas (GHG) reduction goals, as GHGs are formed from the combustion of fossil fuels, largely gasoline and diesel. Consequently, state agencies and other key players are focused on developing policies and incentives facilitating alternative fuel vehicle (AFV) use within New Jersey.

The New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Environmental Protection (NJDEP) have been particularly active through their infrastructure development efforts and programs. Metropolitan Planning Organizations (MPOs), such as the North Jersey Transportation Planning Authority (NJTPA), and non-profit organizations, such as the Sustainability Institute at the College of New Jersey (Sustainable Jersey), are also actively promoting the use of AFVs in the state.

Municipalities can play an important role in spurring the adoption of AFVs. Some key ways that municipalities support increased AFV use include:

- Encouraging AFV infrastructure development (primarily charging stations) through planning and policy changes
- Setting an example through AFV use in their own fleet and municipal contractor fleets
- Disseminating information about AFVs and infrastructure through stakeholder and public outreach

Local readiness planning efforts can accelerate the shift away from reliance on conventional fuels to AFVs. Through an inclusive, local planning process, readiness plans help develop an understanding of the market in a given municipality; identify stakeholders; determine current barriers, opportunities, and regulations related to AFV use; and develop an action plan to help support AFV market growth. Readiness plans can offer a roadmap by identifying the barriers to widespread deployment of infrastructure and vehicles, and outlining actions that will reduce or eliminate these barriers. Readiness plans also include actionable recommendations for municipal officials, local stakeholders, and the others interested in expanding the use of AFVs.

As part of its efforts to support AFVs, the NJTPA partnered with three pilot municipalities – Montclair Township in Essex County, Town of Secaucus in Hudson County, and Woodbridge Township in Middlesex County – to develop local readiness plans that encourage the widespread use of AFVs, with a focus on plug-in electric vehicles (PEVs) and natural gas vehicles (NGVs). Based on input from a variety of stakeholders, each readiness plan included a comprehensive set of strategies that a municipality can implement to become PEV and NGV ready.

Incorporating lessons learned from the individual community readiness plans, this guidebook is for all municipalities in New Jersey to design and conduct AFV readiness planning efforts in their own communities. Both the guidebook and the readiness plans were prepared in

keeping with the policies of Plan 2045: Connecting North Jersey to improve mobility, protect the environment, and take advantage of technology developments.

This guidebook highlights best practices for municipalities implementing AFV infrastructure and supportive policies. The guidebook defines and characterizes alternative fuel options as outlined in the box below. For each, it describes the benefits and challenges associated with the fuel or vehicle technology. Finally, the guidebook includes recommended actions municipalities can take to advance AFVs.

While regional deployment efforts and local lessons learned are included, this document is not meant to be a location-specific readiness plan. Instead, it outlines planning efforts the municipality can take to get ready for AFVs.

Each municipality is unique, and will be starting from a different place with varying needs and priorities. This document is designed to be general enough to assist any community, while also offering suggestions and recommendations specific enough for individual municipalities to put into practice.

Municipalities will benefit from taking a comprehensive approach to AFV readiness planning and this guidebook includes the information and direction necessary to do so. Specifically, this document provides guidance to:

- Establish a stakeholder committee or working group
- Set goals and integrate them into existing municipal plans
- Understand existing conditions and opportunities related to vehicle deployment, infrastructure development, regulatory climate, and potential funding sources
- Conduct assessments, analyses, and forecasts on the consumer and fleet markets for AFVs
- Identify gaps and understand barriers to deployment, including charging at multi-unit dwellings (MUDs), workplaces, and public locations

It also provides best practices on recommended actions for:

- Zoning and parking
- Permitting and inspection
- Stakeholder engagement
- Targeted education and outreach

Alternative Fuel Vehicles

This guidebook covers the following vehicle and fuel types:

Plug-in electric vehicles (PEVs) are powered – at least in part – by an electric motor using energy stored in a battery. Most commonly found in the light-duty market, these vehicles have zero tailpipe emissions and can offer lifetime financial savings over traditional gasoline vehicles.

Natural gas vehicles (NGVs), primarily medium- or heavy-duty vehicles such as commercial trucks, are powered by natural gas, either in compressed or liquefied form. Benefits include life cycle emission reductions and less fuel price volatility.

Propane vehicles are mostly used in light-duty pick-up and medium-duty vehicles. Fleets, in particular, benefit from reduced fuel prices and emissions.

Hydrogen fuel cell electric vehicles (FCEVs), specifically light-duty models, are just beginning to enter the market. Like PEVs, these vehicles have zero tailpipe emissions and are more efficient than conventional vehicles.

Ethanol is a liquid renewable fuel, currently found in over 97% of gasoline in the United States. E85 – an ethanol-gasoline blend containing 51%-83% ethanol – can only be used in flexible fuel vehicles (FFVs).

Biodiesel is another renewable fuel that is commonly blended with diesel for use in heavy-duty diesel vehicles, often without any engine modification.

Who Should Use this Guidebook and How?

Who Should Use this Guidebook and How?

For the purposes of this guidebook, the term "municipality" includes boroughs, townships, cities, towns, and villages as defined under New Jersey State law. While AFV planning may happen at a broader level (i.e., by county, state, or region), this guidebook is written primarily for municipal policy makers and staff, including elected officials, planning and zoning staff and boards, parking authorities, environmental commissions, and business improvement districts.

A broad audience can benefit from the information provided in this guidebook, including county and regional government personnel; public and private fleet managers; local fueling station operators; and others.

The guidebook consists of the following sections:

1. **Why Take Action?** Provides a framework by introducing the benefits of being AFV ready, as well as the state and federal actions that support AFV readiness in New Jersey.
2. **What are AFVs and What do they Require?** Summarizes each alternative fuel type, vehicle, fueling infrastructure, and other considerations.
3. **What Does it Take to Become AFV Ready?** Focuses on the steps to develop a readiness plan, including key recommendations.

SECTION 1

Why Take Action?

Why Take Action?

The number of PEVs is on the rise in New Jersey and nationally, with annual U.S. PEV sales reaching 200,000 in 2017. Consumers and fleets alike recognize the environmental, economic, and other benefits of these vehicles, and the market share is expected to continue to increase in the coming years. Municipalities need to be ready for this significant shift in transportation technology, specifically the fueling infrastructure needs. Not only will communities want to capitalize on the benefits outlined below, local governments also play an important role in ensuring that the deployment of fueling infrastructure is not impeded by zoning and parking regulations, building codes, and inspection processes. Some municipalities will want to go even further to install PEV charging at municipal facilities, offer incentives for residents and businesses, or conduct education and outreach efforts. AFV readiness planning is the first step in understanding the infrastructure needs of the community and the actions necessary to achieve them.

Benefits of AFVs

Reduce fossil energy use and support a healthy environment. More miles driven in AFVs means less petroleum consumption, resulting in public health benefits through improved local air quality and reduced GHG emissions. PEVs have no tailpipe emissions. Even when considering well-to-wheel emissions, which account for emissions from the electricity source used to charge the vehicle, PEVs are generally cleaner than conventional vehicles. New Jersey has a relatively low-carbon electricity supply compared to most states, as nearly all power is supplied by natural gas and nuclear energy, meaning that PEV operation results in fewer GHG emissions than their conventional counterparts. Use of alternative fuels can also increase communities' resilience in emergency situations, providing a much-needed diversification of the fuel supply and increasing options should there be a fuel disruption.

Contribute to economic development. AFVs can spur economic benefits for the municipality in the form of cost savings for residents, reduced fleet maintenance costs, and job creation through the installation of public fueling stations.

Proactively anticipate and prepare for future demand. Although the magnitude of AFV growth is uncertain, the region is likely to become a primary market for PEVs. In fact, New Jersey has already seen significant growth in the number of PEVs on the road, increasing by approximately one-third from mid-2016 to mid-2017.[1] If a municipality begins preparing for this growth now, it will be better positioned to serve current and future residents and visitors.

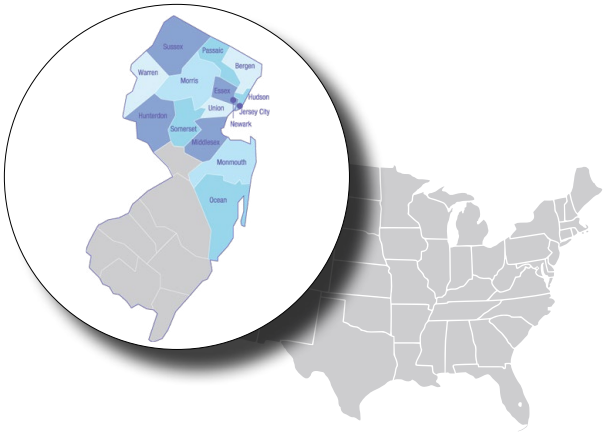
Attract residents, visitors, and businesses. Marketing a municipality as "AFV friendly" could appeal to multiple audiences. AFV adopters may view the municipality as an eco-friendly and tech-savvy destination of choice. Additionally, more AFV fueling infrastructure could increase tourism by decreasing range anxiety;[2] AFV tourists on road trips along the East Coast would be more likely to stop and spend time in municipalities where they can refuel or recharge. Companies and fleets with a sustainability-oriented mission may also establish a local presence as a result.

1 Estimate using PEV registration data from the NJDEP, comparing counts as of August 2016 and July 2017.
2 Range anxiety is the fear that a PEV battery will not provide sufficient mileage to reach the consumer's destination(s) and will run out of fuel (i.e., electricity) before there is an opportunity to recharge.

Demonstrate leadership. Proactively planning for and encouraging AFV usage will set a municipality apart as a leader in the field. Being ahead of the coming "electric car revolution" and encouraging the use of AFVs in the municipal and contractor fleets will allow the municipality to play an active role in developing best practices and setting the standards that others look to for inspiration.

State and Federal Actions Supporting AFV Readiness in New Jersey

Transportation is a regional issue, and opportunities and challenges should be evaluated regionally. This section examines what is being done regarding AFVs on the state and federal levels in terms of planning, policy, legislation, and regulation, as well as which stakeholders are supporting AFV readiness. This section reflects actions taken through the end of 2017, but federal, state, and regional efforts to advance AFV deployment will likely evolve over time.



STATEWIDE PLANNING

State energy planning activities (e.g., the December 2015 New Jersey Energy Master Plan Update) call on New Jersey to expand efforts promoting the use of AFVs, and to continue to develop policies and incentives facilitating AFV use.

The New Jersey Board of Public Utilities (NJBPU) is the state agency with authority to oversee the regulated utilities, such as electricity. The NJBPU sets electric tariffs, including off-peak rates that are an important element of PEV adoption because they can help to minimize negative impacts on the distribution system. In recent years, the NJBPU also approved various NGV tariffs for gas distribution companies, approved a pilot program for New Jersey Natural Gas to build three NGV fueling stations, and provided grants for commercial NGVs in specific counties.[3] In 2017, the NJBPU released a report that addresses the expected increase in the availability of PEVs on the road and associated opportunities and challenges facing regulators and electric utility companies.[4]

> Transportation is New Jersey's largest source of air pollution and is also the fastest growing contributor to New Jersey's GHG emissions.

The New Jersey Department of Environmental Protection (NJDEP) also has a strong role in promoting the use of cleaner AFVs. Through the "It Pay$ to Plug In" program, the NJDEP supported PEV use by providing rebates for workplace charging infrastructure throughout the state. The NJDEP is also responsible for administering New Jersey's Low Emission Vehicle (LEV) and Zero Emission Vehicle (ZEV) regulations.

STATE INCENTIVES AND REGULATORY ACTIONS

The New Jersey State Legislature has implemented policies and incentives to encourage the use of AFVs, as well as the deployment of the corresponding fueling infrastructure. The U.S. Department of Energy's (DOE) Alternative Fuels Data Center (AFDC) Laws and Incentives database includes summaries of relevant state (and federal) incentives, laws, and regulations. These include the ZEV sales and use tax exemption and the ZEV sales requirements, as well as the incentives mentioned above.

3 NJBPU, CNG Vehicle Grant Program, http://www.nj.gov/bpu/commercial/cng.html. Accessed October 23, 2017.
4 NJBPU and The Regulatory Assistance Project (RAP), "Getting From Here to There: Regulatory Considerations for Transportation Electrification," http://nj.gov/bpu/pdf/reports/RAP-NJ-BPU-electricvehicles-policymemo-may2017.pdf. May 2017

FEDERALLY-DESIGNATED CORRIDORS

The Federal Highway Administration (FHWA) designated alternative fuel corridors along certain portions of New Jersey's I-80 and I-95 corridors in late 2016. Portions of these corridors are considered to be "signage-ready" for certain alternative fuels (i.e., routes where alternative fuel is already available on or near the highway and are now eligible to feature the associated signage) and "signage-pending" corridors (i.e., routes that will need additional build-out of infrastructure to be considered signage-ready). In 2017, the NJDEP submitted an application to the FHWA to designate I-78, I-287, and I-295 as PEV charging corridors in an effort to expand the network of alternative fuel corridors in the state. To learn more about the federal designated corridors, visit the FHWA Alternative Fuel Corridors website.

SUPPORTING STAKEHOLDERS

In addition to state programs and policies, public-private partnerships, MPOs, and nonprofit organizations also play a key role in the advancement of AFVs. In New Jersey, the following organizations have been among the most prominent in this regard:

- **MPOs** are federally designated and federally funded transportation planning organizations that identify and execute transportation projects and initiatives in their areas. New Jersey has three MPOs – the NJTPA, the Delaware Valley Regional Planning Commission (DVRPC), and the South Jersey Transportation Planning Organization (SJTPO). MPOs provide technical guidance and assistance for municipal AFV readiness planning, including access to transportation demand models and data.
- **Transportation Management Associations (TMAs)** are non-profit organizations that partner with employers and governments to reduce traffic congestion and improve air quality through commuter programs and services, including education and outreach efforts promoting AFVs. Seven TMAs operate in the NJTPA region, including: EZ Ride, TransOptions, Ridewise of Raritan Valley, Keep Middlesex Moving (KMM), HART Commuter Information Services (HART), Greater Mercer TMA, and Hudson TMA.
- **Sustainable Jersey** is a non-profit organization that administers a certification program for municipalities in New Jersey that want to "go green." The NJTPA collaborated with Sustainable Jersey on the development of two action items, or recommended measures, to facilitate increased use of PEVs: Make Your Town Electric Vehicle Friendly and Public Vehicle Charging Infrastructure. There are also Green Fleets actions: Fleet Inventory and Purchase AFVs. Sustainable Jersey provides tools, training, and other types of support to communities as they pursue these actions.
- **New Jersey Clean Cities Coalition (NJCCC)** is a statewide DOE-designated non-profit coalition exclusively focused on promoting public-private partnerships related to the development and use of AFVs and the appropriate related infrastructure. The fuel-neutral coalition brings together stakeholders to address these issues by providing education, securing grant funding, and overcoming challenges. Notably, the NJCCC led the New Jersey Compressed Natural Gas (CNG) Refuse Trucks, Shuttle Buses, and Infrastructure Project, a DOE-funded AFV deployment program.[5]

5 U.S. DOE, American Recovery and Reinvestment Act, Clean Cities Project Awards, http://www.afdc.energy.gov/uploads/publication/arra_cc_project_awards.pdf. August 2016.

SECTION 2

What are AFVs and What Do They Require?

What are AFVs and What Do They Require?

There are a variety of AFV options available for both consumers and fleet operators. The pages that follow provide an overview of each fuel type, including information on emissions, fuel economy, cost, regulatory issues, and typical applications. While all of these fuels and AFVs may not currently be available in the NJTPA region, it is important to understand each option to accurately plan for them.

Photo by John De La Rosa, NREL 34236

Following each overview is additional information on the alternative fuel type, including how it is used in vehicles, what type of fueling infrastructure is needed, market conditions in New Jersey, and barriers to adoption. Municipalities have the ability to tackle many of these barriers using the information provided in this guidebook.

All fuels listed are considered alternative fuels under the federal Energy Policy Act of 1992.[6] For information on available AFV makes and models, see the AFDC Alternative Fuel and Advanced Vehicle Search. To identify fueling locations in or near a municipality, visit the AFDC Alternative Fueling Station Locator. This database is updated on an ongoing basis and includes operational and planned stations. The AFDC also has a Case Study database with information about fleets that have adopted AFVs, including those in New Jersey.

6 U.S. DOE AFDC, Alternative Fuel Definition, https://www.afdc.energy.gov/laws/391. Accessed October 20, 2017.

Electricity

DESCRIPTION

- Plug-in electric vehicles (PEVs) include all-electric or battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).
- BEVs such as the Nissan Leaf and Tesla models operate completely on rechargeable battery power.
- PHEVs such as the Chevy Volt, can be charged from the grid or run on the internal combustion engine (ICE).
- PEV charging stations are classified by the rate at which the batteries are charged

EMISSIONS

- Lower life cycle (well-to-wheels) GHG emissions, especially in regions that use low-polluting energy sources for electricity generation, such as New Jersey.
- No tailpipe emissions for BEVs and PHEVs powered entirely on electricity.

FUEL ECONOMY

- Reduced fuel costs compared to conventionally fueled vehicles because of the high efficiency of electric motors.
- Shorter driving range compared to conventional fueled vehicles for some BEVs.
- Potentially long charging times for PEVs; more fueling flexibility for PHEVs.

Photo by Dennis Schroeder, NREL 26671

COST

- Lower fuel, maintenance, and operation costs.
- Although costs are dropping, high-capacity batteries are expensive, which in turn makes vehicles more expensive.

REGULATORY/OTHER BARRIERS

- Potentially long permitting and inspection processes for new charging stations.
- Lack of available public charging stations.
- Training needed for first responders.

APPLICATIONS

- Passenger vehicles for consumers and fleets.
- A wide variety of light-duty PEVs are available. A limited but growing variety of medium-, and heavy-duty vehicles are available.

PEVs use **electricity as either their sole fuel source** or, in the case of PHEVs, a **primary fuel source** in addition to the ICE. Onboard rechargeable batteries store energy to power electric motors. Electricity can be produced from a variety of energy sources, including oil, coal, nuclear energy, hydropower, natural gas, wind energy, solar energy, and stored hydrogen. PEVs are capable of drawing electricity from off-board electrical power sources (generally the electricity grid) and storing it in batteries. New Jersey's electric generation sources are primarily natural gas (more than 50 percent) and nuclear (nearly 40 percent), making the state's power sector one of the cleanest in the country. The use of PEVs in New Jersey is particularly beneficial in terms of emission reductions. For state and national electricity source information, see the AFDC Electricity Sources and Emissions page.

PLUG-IN ELECTRIC VEHICLES (PEVs)

PEVs include PHEVs and BEVs. PHEVs are powered by both an ICE and a battery, and can be plugged-in to be charged. Their all-electric range is typically shorter than a BEV, but their total range can go up to 400 miles if the vehicle runs using the ICE. BEV ranges vary across vehicle models, with some offering a range as little as 95 miles, and others offering ranges up to 230 miles. All-electric driving ranges are increasing with advanced battery technologies becoming available.

The most common application for PEVs is passenger vehicles for consumer use, although PEVs are also used in some fleet applications, including car share programs and medium- and heavy-duty vehicles (e.g., transit buses). The number of PEVs on the roads continues to grow with a variety of new models entering the market each year, combined with the availability of state and federal incentives. For information on the current number of PEVs registered in New Jersey by county, see the NJDEP Clean Vehicles website.

Because PHEVs have ICEs, maintenance needs are similar to that of conventional vehicles. BEVs, on the other hand, require much less maintenance than conventional vehicles. Currently, there are only a handful of independent auto shops that service AFVs in New Jersey. As PEVs become increasingly more popular, PEV dealers, as well as third party repair shops, will likely begin offering mechanics and specialized equipment that are able to repair and do maintenance.

PEV CHARGING INFRASTRUCTURE

To widely use PEVs, consumers and fleets need a **developed infrastructure of charging stations**. This infrastructure may include a combination of charging at home, charging at the workplace, and public charging. Currently in New Jersey, PEV infrastructure is clustered in the northern part of the state, though there are public and private stations throughout. PEV charging infrastructure is typically differentiated by the maximum amount of power that can be delivered to a vehicle's battery. This determines the time that it takes to fully charge. Three categories of charging stations currently dominate the market:

- **Level 1** chargers consist of a standard 110 volt (V) or 120V alternating current (AC) outlet that provides two to five miles of range per hour of charging, depending on the vehicle and other factors. Level 1 is most commonly found in garages for home charging but can be suitable for some fleet and workplace charging applications. Level 1 typically requires no additional cost or installation, provided that a power outlet on a dedicated branch circuit is available near their parking location.
- **Level 2** is a 240V or 208V AC outlet, and provides 10-20 miles of range per hour of charging. Level 2 is a popular option for public charging and can also be used at the home and workplace.
- **Direct Current (DC) fast chargers** provide 60-80 miles of range per 20 minutes of charging through different types of connectors – J1772 combo, CHAdeMO, and Tesla. The connectors for DC fast charging units are not standardized across vehicle manufacturers in the same way that Level 2 charging hardware is (via the J1772 standard). In other words, not all PEVs can use DC fast chargers, and even those that are equipped for fast charging may not have on-vehicle hardware compatible with the charging unit. Higher-powered DC fast charging technology, providing up to 20 miles of range per minute of charging, is also in development.

Natural Gas

DESCRIPTION

- The two main forms of natural gas used in transportation are compressed natural gas (CNG) and liquefied natural gas (LNG).
- Infrastructure requirements for CNG and LNG stations vary considerably.
- CNG stations require more equipment and configuration, while LNG stations require less equipment, but more safety precautions during fueling.
- There are two types of CNG stations: fast-fill and time-fill.
- The type of station needed is dependent on the application. Typically, retail stations use fast-fill and fleets that have central refueling and the ability to fill over a longer period of time use time-fill.

EMISSIONS

- Vehicles emit lower life cycle GHG emissions; natural gas made from renewable sources, such as landfill gas or food waste, significantly reduces GHG emissions.

FUEL ECONOMY

- LNG is suitable for traveling longer distances than CNG since LNG occupies only a fraction of the volume of CNG, it is more economical to transport and store.
- Bi-fuel systems, enabling vehicles to run on either natural gas or gasoline, offer fueling flexibility.
- Fuel tanks are heavier than gasoline tanks, and high-pressure storage tanks take up vehicle space.

Photo by Eric Pollard, NREL 39374

COST

- Has historically been less expensive, with less price volatility, than petroleum fuels on an energy equivalent basis.
- Vehicles are more expensive than conventional gasoline or diesel vehicles, but the cost can be offset by lifetime fuel cost savings.

REGULATORY/OTHER BARRIERS

- Infrastructure developers need to be aware of the regulatory and permitting process, including technology, design, and financing challenges.
- Limited number of publicly available fueling stations.
- Training needed for first responders.

APPLICATIONS

- Well-suited to power heavy-duty trucks and buses, and other high-mileage, centrally fueled fleets.
- While some light-duty vehicle options are available, CNG and LNG are more frequently used in medium-and heavy-duty applications.

Natural gas is a domestically produced gaseous fuel, and is **readily available through the utility infrastructure**. Whether produced via conventional or renewable methods (resulting in renewable natural gas), natural gas must be compressed or liquefied for use in vehicles. CNG is produced by compressing natural gas and storing it onboard a vehicle within fuel tanks at a pressure up to 3,600 pounds per square inch. The primary use of CNG in the region is by fleet vehicles in the medium- and heavy-duty sector. LNG is natural gas in its liquid form, produced by super-cooling the gas to turn it into a liquid. Because of LNG's relatively high production cost as well as the need to store it in expensive cryogenic tanks, the fuel's widespread use in commercial applications has been limited. Because of its greater energy density, LNG is suitable for heavy-duty trucks that require longer ranges.

Natural gas is an odorless, gaseous mixture of hydrocarbons—predominantly made up of methane (CH_4). With an extensive underground pipeline distribution system, it accounts for about 30 percent of the energy used in the United States. Although natural gas is a proven, reliable alternative fuel that has long been used to power vehicles, less than one percent is used as a transportation fuel.

NATURAL GAS VEHICLES (NGVs)

There are **three types of NGVs: dedicated, bi-fuel, and dual-fuel**. Dedicated NGVs run only on natural gas. Bi-fuel NGVs have two separate fueling systems allowing them to run on either natural gas or gasoline. An example of a light-duty bi-fuel CNG option is the Chevrolet Impala, and there are a wide variety of options available in medium- and heavy-duty applications. Finally, dual-fuel NGVs (typically only seen in heavy-duty applications) run on natural gas, but use diesel for ignition assistance. The driving range of NGVs is typically less than a comparable conventional vehicle due to the lower energy density of natural gas.

The most common applications for NGVs are in medium- and heavy-duty applications, such as public transit, school bus, and refuse fleets. For information on the current number of NGVs registered in New Jersey by county, see the NJDEP Clean Vehicles website.[7]

There are some different maintenance requirements for NGVs compared to conventional diesel vehicles. Specifically, NGV fuel tanks should be inspected at regular intervals, according to federal requirements. In addition, it is important to know the end-of-life date of the tank so that it can be properly decommissioned at that time. On the other hand, since CNG burns much cleaner than diesel, CNG vehicles do not need to have diesel particulate filters or use diesel exhaust fluids, saving both maintenance costs and operational time.

NATURAL GAS FUELING INFRASTRUCTURE

Although New Jersey has an extensive natural gas distribution system in place, vehicle fueling infrastructure is limited. Therefore, fleets that are not near an existing station may need to install their own natural gas fueling infrastructure, or work with their local utility or with a private infrastructure provider.

There are nearly 30 CNG stations in New Jersey, the majority of which are private. There are no LNG stations available in the state. CNG stations are more prevalent in the southern part of New Jersey.

Photo by Warren Gretz, NREL 02488

7 The NJDEP's natural gas vehicle counts includes both NGV and propane vehicle registrations.

LPG Propane

DESCRIPTION

- Propane, or liquefied petroleum gas (LPG) is a clean-burning fossil fuel that can be used to power ICEs.
- The infrastructure needed for propane is very similar to gasoline and diesel refueling equipment.
- Propane is transported to the site via a delivery truck and put into onsite storage, traditionally above ground.

EMISSIONS

- Lower life cycle GHG and pollutant emissions than conventional fuels.

FUEL ECONOMY

- Slightly lower fuel economy, but similar driving range to conventional fueled vehicles.
- Bi-fuel systems offers fueling flexibility.

COST

- Usually less expensive than gasoline (varies seasonally).
- Vehicles are more expensive than conventional gasoline vehicles, but the cost can be offset by lifetime fuel cost savings.

REGULATORY/OTHER BARRIERS

- Lack of publicly available stations with equipment designed for fueling vehicles.
- Training needed for first responders.

APPLICATIONS

- While some passenger vehicle options are available, propane is more frequently used in fleet light-duty pickup and medium-duty applications.

Photo by Dennis Schroeder, NREL 31348

Propane has been used for decades to power light-, medium- and heavy-duty propane vehicles. A variety of propane vehicle models are available through original equipment manufacturers (OEMs) and select dealerships. Fleets and consumers also have the option of **economically, safely, and reliably converting in-use gasoline vehicles to propane operation** using qualified system retrofitters.

Propane is shipped from its point of production to bulk distribution terminals via pipeline, railroad, barge, truck, or tanker ship. Propane marketers fill trucks at the terminals and distribute propane to end users, including retail fuel sites. Several local, regional, and national propane marketers serve the NJTPA region.

PROPANE VEHICLES

There are two types of propane vehicles: dedicated and bi-fuel. Dedicated and bi-fuel propane vehicles have a similar driving range to that of conventional vehicles. Most light-duty propane vehicles are only available through conversions; however, there are a variety of medium- and heavy-duty options available. For information on the current number of propane vehicles registered in New Jersey by county, see the NJDEP Clean Vehicles website.[8]

Propane vehicles have the potential for lower maintenance costs due to the fuel's low carbon and low oil contamination characteristics, which can result in longer engine life. In addition, propane performs particularly well in cold weather.

8 The NJDEP's natural gas vehicle counts includes both NGV and propane vehicle registrations.

PROPANE FUELING INFRASTRUCTURE

Fuel providers and fleets can place propane dispensers alongside gasoline, diesel, or other alternative fueling infrastructure, or as a standalone system. The infrastructure needed for propane is very similar to gasoline and diesel refueling equipment. Many suppliers offer an inexpensive lease of the tank, pump, and dispensing equipment in return for a fuel supply contract. In these cases, the station owner or fleet is only responsible for the cost of equipment that cannot be removed from the site when the fuel contract expires, such as the electricity line or the concrete pad for the storage tank. This can make the upfront cost of propane infrastructure less expensive than that of other fuels.

There are approximately 20 propane stations in New Jersey, the majority of which are retail outlets.

Biodiesel

DESCRIPTION

- Biodiesel is a diesel replacement fuel produced from vegetable oils, animal fats or recycled restaurant oils. It is often available as a blend with petroleum diesel, most commonly B20 (20% biodiesel), B5 (5% biodiesel), and B2 (2% biodiesel).

EMISSIONS

- Less pollutants and life cycle GHG emissions than conventional fuels.

FUEL ECONOMY

- Slightly lower fuel economy compared to conventional fuel.

COST

- Can be more expensive than petroleum-based diesel.
- Diesel vehicles can run on biodiesel blends with little to no added cost.
- Biodiesel can be distributed at existing diesel stations, with minimal modifications.

REGULATORY/OTHER BARRIERS

- Lack of publicly available fueling stations providing blends greater than B5.

APPLICATIONS

- Can be used in most diesel engines without compromising the warranty, making this fuel accessible for all applications.

Photo by Charles Bensinger NREL 13531

Biodiesel is a **renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease**. It is a cleaner-burning replacement for petroleum diesel fuel. Almost all diesel engines are capable of running on biodiesel blended with regular diesel fuel, without any engine modification. The most common biodiesel blend is B20, which is a blend of up to 20 percent biodiesel mixed with petroleum diesel. B5 (5 percent biodiesel, 95 percent diesel) is also commonly used in fleets. Diesel engines depend on the lubricity of the fuel to keep moving parts from wearing prematurely. One advantage of biodiesel is that it can improve fuel lubricity at blend levels as low as one percent.

Biodiesel should not be confused with renewable diesel, which is becoming increasingly popular. Renewable diesel is made from the same feedstocks as biodiesel, but is chemically similar to petroleum diesel.

BIODIESEL VEHICLES

Almost all conventional diesel vehicles are capable of running on biodiesel, making it suitable for all vehicle and fleet applications. However, before using biodiesel in a vehicle, it is important to check the OEM engine warranty to ensure that higher-level blends are approved for use in the engine. In addition, because biodiesel can have a cleansing effect on the vehicle's fuel system, fuel filters may need to be changed more frequently after initial use of biodiesel. Biodiesel vehicles have a similar yet slightly longer range than conventional vehicles. For information on the number of diesel vehicles on the road that have the potential to use biodiesel, see the National Renewable Energy Laboratory's (NREL) TransAtlas tool, which illustrates approximate vehicle density.

BIODIESEL FUELING INFRASTRUCTURE

Installing equipment that is compatible with biodiesel blends up to B20 is just like installing conventional diesel equipment. In general, the standard storage and handling procedures used for petroleum diesel can be used for biodiesel. The fuel should be stored in a clean, dry, dark environment. Biodiesel causes far less damage than petroleum diesel if spilled or released to the environment. It is safer than petroleum diesel because it is less combustible. Biodiesel is safe to handle, store, and transport.

Diesel fuel being sold throughout New Jersey is already blended with biodiesel up to five percent biodiesel (B5), however there are few publicly available stations in the region that offer higher blends.

Ethanol

DESCRIPTION

- Ethanol is an alcohol fuel made from plant material. E85 – an ethanol blend containing 51%-83% ethanol depending on season and geography with the remainder being gasoline – can only be used in flexible fuel vehicles (FFVs).

EMISSIONS

- Lower life cycle GHG emissions and some pollutant emissions; cellulosic ethanol, produced from non-food based feedstocks such as wood chips or crop residues, significantly reduces GHG emissions.

FUEL ECONOMY

- Lower fuel economy compared to conventional fuel; consumers have to refuel more frequently.

COST

- Can be more expensive than gasoline.
- FFVs typically cost the same as conventional gasoline vehicles.
- Ethanol can be distributed at existing gas stations, with minimal modifications.

REGULATORY/OTHER BARRIERS

- Lack of publicly available E85 fueling stations.

APPLICATIONS

- Passenger vehicles for consumers and fleets.
- E85 can only be used in FFVs, which are typically only available in light- and medium-duty applications.

Ethanol is a renewable fuel made from various plant materials (i.e., biomass). Just as biodiesel is a replacement for petroleum diesel, **ethanol can be a replacement for gasoline**. The use of ethanol is widespread, and more than 97 percent of gasoline in the United States contains some level of ethanol. The most common blend of ethanol is E10 (10 percent ethanol, 90 percent gasoline). Ethanol is also available as E85 – a high-level ethanol blend containing between 51 and 83 percent ethanol depending on season and geography.[9] Due to distribution challenges, there are few publicly available stations in New Jersey that offer E85.

Photo by Kwik Trip Inc., NREL 33251

ETHANOL VEHICLES

While any gasoline vehicle can be fueled with low-level ethanol blends, FFVs are vehicles designed to operate on blends up to E85. FFVs have similar driving ranges and maintenance aspects to gasoline vehicles, making them a convenient AFV option. FFVs are typically used in any light- and medium-duty applications. Current estimates suggest that well over 100,000 FFVs are registered in New Jersey, with a significant portion of those vehicles registered in government fleets. For information on the number of FFVs on the road, see NREL's TransAtlas tool, which illustrates approximate vehicle density.

ETHANOL FUELING INFRASTRUCTURE

Low-level blends of E10 or less require no special fueling equipment, and they can be used in any conventional gasoline vehicle. Existing gasoline stations throughout New Jersey seamlessly dispense E10. It is also possible to accommodate blends above E10 in existing fueling equipment, however, some equipment will need to be upgraded to comply with federal code. There are very few fueling stations in New Jersey offering E85.

9 The federal Energy Policy Act's definition of alternative fuel only includes blends of 85% or more of alcohol with gasoline. This is currently interpreted to include the adjusted "E85" blends used in practice.

Hydrogen

DESCRIPTION

- Hydrogen can be used in fuel cells to power electric motors or burned in ICEs.
- The increased number of retail hydrogen fueling locations in select markets is supporting the initial rollout of fuel cell electric vehicles (FCEVs).
- The focus has been to add hydrogen fuel at existing gasoline stations.

EMISSIONS

- Produces no tailpipe emissions and fewer life cycle GHG emissions than conventional fuels.

FUEL ECONOMY

- Fuel economy, range and fueling time are similar to conventional fueled vehicles.

COST

- Production and fueling infrastructure costs are high.
- More expensive than conventional vehicles.

REGULATORY/OTHER BARRIERS

- A network of hydrogen fueling station is just beginning to be built in the Northeast.
- Training needed for first responders.

APPLICATIONS

- Beginning to enter the market as a fuel for passenger vehicles, however FCEV availability is very limited. Medium- and heavy-duty options are not yet commercially available.

Photo by Dennis Schroeder NREL 39802

Hydrogen can be used in a fuel cell to produce electricity, making it an **emissions-free alternative fuel produced from diverse energy sources**. The interest in hydrogen as an alternative transportation fuel stems from its ability to power FCEVs with no emissions, its potential for domestic production, its fast filling time, and the fuel cell's high efficiency.

HYDROGEN FUEL CELL VEHICLES

Vehicle manufacturers are just beginning to offer FCEVs to consumers in the northeastern United States. FCEVs use energy stored as hydrogen converted to electricity by the fuel cell. FCEVs can be used in consumer applications, as well as in heavy-duty applications such as trucking. At this time, there are no FCEVs registered in New Jersey, although several vehicle manufacturers, including Toyota, Honda, and Hyundai, have plans to introduce them into the local market over the next few years.

HYDROGEN FUELING INFRASTRUCTURE

The availability of stations providing reasonably priced hydrogen in places where vehicles will be deployed remains a key challenge to the adoption of this technology. Most retail hydrogen facilities in California, as well as those being developed in the Northeast, consist of an added hydrogen dispenser at an existing gasoline station. As part of a planned network of hydrogen fueling stations across the Northeast, two hydrogen fueling stations are under development in New Jersey (as of late 2017), one in Lodi and one in Whippany.

SECTION 3

What Does it Take to Become AFV Ready?

Photo by Matthew Staver, NREL 39254

What Does it Take to Become AFV Ready?

The first step for a municipality to become AFV ready is to engage decision makers and stakeholders to identify common goals and the actions necessary to achieve them. Evaluation and analysis of the various alternative fuels and AFV technologies is also critical at every stage of the planning process. By evaluating the community's unique needs and opportunities, a municipality can create a custom-tailored approach.

Establish a Stakeholder Committee or Working Group

AFV READINESS PLANNING PROCESS

- **Establish Stakeholder Committee**
- Set Goals
- Understand Existing Conditions
- Identify Gaps and Barriers
- Develop Recommended Actions
- Track, Revisit, and Update

Stakeholder engagement is an important part of the planning process and **critical to successful AFV deployment.** Additionally, keeping stakeholders involved throughout the process will increase the likelihood that the community accepts and implements recommendations to promote AFVs.

Forming a stakeholder steering committee, advisory committee, or working group is one way to ensure that diverse perspectives are included early and often in the readiness planning process. **A stakeholder is anyone who is interested in or impacted by AFV deployment and infrastructure.** Since each community has a unique set of stakeholders, it will be important for the municipality to discuss which stakeholders to include and what perspective those individuals and organizations bring to the planning process.

The list below shows examples of stakeholders that might be included in such a committee.

- Local government officials, including elected officials
- Local fleet managers, including the municipal fleet managers
- Community organizations
- Higher education institutions, such as colleges and universities

Key Recommendation

Identify a set of diverse stakeholders and form a committee. Meet with the stakeholders as early as possible, and continue working with them regularly throughout the planning process.

- Local businesses, including business improvement districts (BIDs)
- Utilities and fuel providers
- Other transportation organizations, including non-profits, TMAs, and MPOs
- Citizens, including representatives from multi-family housing boards

The stakeholder committee should meet regularly to review alternative fuel readiness goals, discuss potential challenges, propose solutions, and agree on next steps. A municipality may decide, for example, to have committee members review next steps and upcoming readiness activities throughout the process of creating and implementing the readiness plan so that they can provide input. However, since AFVs may be a new topic to some, at the outset of the committee's existence, consider having one educational meeting to ensure everyone understands the current technologies and fuels. TMAs and MPOs can help educate stakeholders with speakers and presentations. Spending this time early can help focus later meetings on gathering input and moving things forward, rather than explaining the basics.

Tips for Engaging the Stakeholder Group

The frequency of meetings depends on a community's own timeline and needs. Some successful projects have scheduled regular (e.g., quarterly) stakeholder meetings, but a community may choose to hold meetings more frequently, especially in the beginning of the readiness planning process, or according to project milestones.

It can be beneficial to have one municipal point of contact to coordinate the committee's activities. This reduces potential confusion and streamlines the logistics of scheduling meetings, which can be especially challenging with large stakeholder groups

Set Goals and Integrate into Municipal Master Plans

AFV READINESS PLANNING PROCESS

- Establish Stakeholder Committee
- **Set Goals**
- Understand Existing Conditions
- Identify Gaps and Barriers
- Develop Recommended Actions
- Track, Revisit, and Update

Goal setting provides **direction, inspiration, and purpose** for the team. When a team shares a clear set of mutually agreed upon goals, individuals can collaborate and compromise as they work towards a common objective. When obstacles arise, having a well-defined goal in mind allows for effective problem solving. Setting measurable goals also enhances accountability, as goals provide milestones to gauge the team's progress. In general, it's best to select three to five goals to guide readiness planning efforts.

Goals can range in scope and complexity. The focus areas may include climate change, access and awareness, increasing resilience, decreasing air and water pollution, municipal logistics, community engagement, and fleet use. The focus of each goal may overlap with other initiatives or organizations in the municipality.

Coordinating AFV readiness with other municipal activities may allow access to a **broader array of funding opportunities**, and will help strengthen the case for allocating funding towards AFV readiness. For example, a municipality may be working to reduce GHG emissions by 25 percent from current levels in the next 10 years. Demonstrating the emissions reduction benefit of AFV readiness to municipal leaders may help foster stronger support for implementation, and even generate additional funding options. Similarly, goals identified during the readiness planning process should inform future updates to Master Plans and other municipal planning documents. By aligning AFV readiness goals with the municipal emissions reduction goal or other goals, both efforts benefit from mutual support and focused coordination.

Communities do not exist in isolation – it is critical to align readiness goals and efforts with other municipal objectives, and potentially with the objectives of neighboring municipalities. Keeping apprised of regional transportation planning initiatives or neighboring community efforts can also accelerate readiness planning efforts. Joining forces with other entities makes it easier to share resources and achieve goals more efficiently. For example, an existing municipal goal may be to improve public health by reducing air pollution due to ongoing high levels of pollutants commonly associated with vehicle emissions. Demonstrating how AFV readiness actions would contribute to local and regional pollution reduction goals can help the plan gain traction with regional decision makers. A community may be able to

Key Recommendation

Set goals and integrate AFV planning into other municipal planning documents, including Master Plans.

CASE STUDY: Woodbridge Township, New Jersey

Sustainable Community Plan and Climate Action Plan, Township of Woodbridge, New Jersey (2010)

This plan addresses a diverse and comprehensive range of energy conservation and climate change topics. It includes targeted recommendations to:

- Retrofit existing vehicles or purchase new vehicles for the municipal vehicle fleet so that 25% will utilize alternative fuels or be flex fuel capable by 2015.
- "Identify and support pilot alternative fuel, car-sharing, and electric vehicle projects for businesses and residents, to encourage actions that can reduce the global warming impact of transportation."

leverage untapped resources and funding opportunities, and may even be able to team up with other municipalities planning for AFV readiness to share ideas and best practices.

To start, review plans of entities in the region (see box above for an example plan from Woodbridge Township), as well as goals of other groups within the municipality. List the areas where priorities overlap, and consider reaching out for an initial meeting to discuss collaboration.

Revisit Goals and Track Success Over Time

Planning should be a **dynamic process**, so if evaluation shows that something is not working, the team can change its approach and get back on track. The stakeholder group should routinely review goals, track progress towards meeting them, and update the goals and plans, as needed. Goals may also need to be reevaluated after the new information comes to light, such as from the market assessment process.

Understand Existing Conditions and Opportunities

AFV READINESS PLANNING PROCESS

- Establish Stakeholder Committee
- Set Goals
- **Understand Existing Conditions**
- Identify Gaps and Barriers
- Develop Recommended Actions
- Track, Revisit, and Update

Successful readiness planning involves characterizing the current AFV demand, identifying existing infrastructure, projecting future AFV demand, and evaluating the current regulatory environment. It is also critical for the municipality to have a **strong grasp of both the barriers to and opportunities** for increased AFV infrastructure deployment and alternative fuel use, as these form the basis of readiness plan implementation recommendations.

GATHER DATA

Vehicle and Infrastructure Statistics

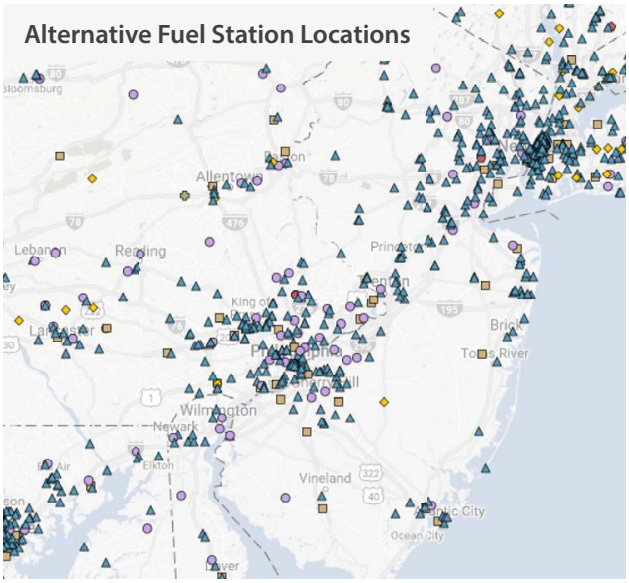
Early in the readiness planning process, a municipality should document the number of AFVs registered in the municipality and the number of AFV fueling stations installed. As the planning and implementation processes move forward, the municipality and stakeholders can measure progress against this baseline. These data points are also important to the analysis and forecasting explained later.

The NJDEP maintains AFV registration data for New Jersey, coordinating with the New Jersey Motor Vehicle Commission (NJMVC) to provided updated statistics twice a year (January and July). A municipality may request a spreadsheet containing data by sending an email to drivegreen@dep.nj.gov, using the subject line "Vehicle Registration Data Request." Other sources, such as IHS Markit (R.L. Polk & Co.), provide data for a fee.

For infrastructure data, refer to the AFDC Alternative Fueling Station Locator. Note that this database does not include residential fueling and charging stations, including those at MUDs unless they are available to the public. Planned stations are included, to the extent those plans are known.

Regulatory

A primary goal of the readiness planning process is to identify regulatory barriers that may be preventing or slowing the use of AFVs and infrastructure. Some jurisdictions may have set regulations long ago that are now outdated or inaccurate but could still be enforced. These and other barriers can be uncovered through a review of regulations and other policies currently in place or under development.



Source: AFDC Alternative Fueling Station Locator (www.afdc.energy.gov/locator/stations/)

The municipality should undertake a review of the following regulatory information to identify policies that relate, or could be interpreted to relate to AFVs, fueling infrastructure, and alternative fuels:

- Local community plans
- Zoning and parking codes
- Permitting and inspection processes and requirements
- Building codes

As part of the regulatory review process, the municipality and its stakeholders should gain an understanding of the roles and responsibilities at the local level, including departments and councils that would play a role in implementing recommended actions. It is also helpful to take a look at existing incentives and funding sources that exist at the federal, state, and local levels and would apply to AFVs and fueling infrastructure. The AFDC Laws and Incentives website is a comprehensive resource for information about relevant funding sources and incentive programs.

CONDUCT ASSESSMENTS, ANALYSES, AND FORECASTS

In order to plan for infrastructure and other needs, the municipality ideally should understand who is purchasing (and will purchase) AFVs, the current market status, the projected growth, and demand for infrastructure, as well as conduct analyses to help determine the best locations for AFV infrastructure. However, municipalities should not be deterred from initiating AFV infrastructure plans because of lack of data or analysis expertise.

A variety of approaches are available to assess the current AFV population and forecast demand. Market assessments will be much different for vehicle and fuel types geared towards the consumer market (PEVs), versus most applicable to fleets (all AFV types). The information that follows is broken down into those two categories.

One of the central challenges with AFV deployment is the accessibility of adequate fueling infrastructure to support the vehicles. A municipality may find an infrastructure demand analysis beneficial to determine where to focus new infrastructure. The goal of a demand analysis is to help guide and coordinate future infrastructure development efforts based on anticipated or projected demand. The municipality's role in analyzing infrastructure demand is most relevant for PEVs and charging infrastructure, as it serves residents, visitors, and others in the community. While the same approach could be applied to all alternative fuel types, most other fuels are best suited for fleet use and a fleet will determine if and where they install infrastructure.

One of the central challenges with AFV deployment is the accessibility of adequate fueling infrastructure to support the vehicles.

Photo by Thomas Kelsey, NREL 37699

Consumer Market: PEVs

Market assessments help a municipality understand the existing demand for PEVs and inform future demand for charging infrastructure. PEV demand and charging needs are closely related. Data on the type of PEVs that are on the road, as well as where they are registered, can help characterize the demand for charging infrastructure at different levels (including Level 2 and DC fast charging) and different applications (such as public charging). For instance, a market that is dominated by BEVs is likely to need more DC fast charging than a market that is dominated by PHEVs because BEV charging demands will likely be higher as a result of the larger batteries.

Vehicle Demand

The NJDEP Clean Vehicles website includes a map illustrating the distribution of PEVs throughout the state. The NJDEP will provide PEV and other vehicle data upon request. This data can be helpful for benchmarking the percentage of PEVs compared to all light-duty vehicles, developing a profile of PEV types in the area (BEVs and PHEVs) to better understand trends and charging infrastructure needs, and tracking progress towards PEV adoption goals. A municipality can work with the MPO to analyze available data, produce maps, and conduct additional analyses.

Market outlooks, such as those produced by the U.S. Energy Information Administration and many firms, provide insight into potential future consumer use of PEVs within a specified region and planning timeframe. These forecasts are meant to be used as a general guide in the planning process to help shape and define regional PEV usage goals. There are a variety of ways to develop market outlooks. Appendix B provides a summary of the steps,

data sets, and assumptions that were used to develop PEV forecasts for the three pilot municipalities as part of the NJTPA study. They can be applied and adapted by other municipalities in New Jersey, particularly with assistance from the MPO.

Infrastructure Demand

A charging infrastructure analysis helps to broadly identify the areas within a municipality that are most likely to see a demand for PEV charging infrastructure. It is an analytical exercise that looks at key factors that closely correlate with PEV ownership – income, hybrid electric vehicle (HEV) ownership, home ownership, and dwelling type – and regional travel patterns. It complements vehicle forecasting and introduces an important geographic component that can guide municipal policy and investments to meet the increased demand for charging infrastructure. The results can be used to highlight areas where charger deployment can be the most cost effective, as chargers located in an area where PEV drivers are most likely to travel will be utilized more.

A detailed summary of the data needs, methodology, and assumptions of the infrastructure demand analyses conducted for the pilot municipalities under the NJTPA study is included in Appendix C. Other municipalities can work with the MPO to conduct the analyses and illustrate the results.

It is important to note that an infrastructure demand analysis is not intended to exclude certain areas from potential charging installations. Municipalities should consider the results as a useful guide to coordinating and prioritizing investments in charging infrastructure at a high level.

Charging infrastructure considerations for PEVs used in fleets are typically very specific to the organization and how the vehicles will be used.

Photo by Matthew Staver, NREL 39213

For the consumer market, there are **four primary types** of charging demand to consider:

Residential

Residential areas will likely experience high demand for charging as the number of PEVs in the area continues to increase. Since residential charging takes place at home, these are locations in which likely PEV owners live. Currently, the average PEV driver charges at home about 70-90 percent of the time. Most residential charging today occurs at Level 1, as it typically does not require any additional investment on the part of the PEV owner. Level 2 charging is more common at residences for BEVs compared to PHEVs, especially those vehicles with larger batteries and therefore longer all-electric ranges. The results of a residential charging demand analysis are most useful to local utilities to understand clustering and potential grid impacts of residential charging.

Workplace

Highlights areas that will likely experience high demand for workplace charging, particularly areas where likely PEV owners work and vehicles are parked for several hours during the day. Level 1 and Level 2 charging are suitable for workplace charging; ultimately, the appropriate level of charging is something that should be determined based on facilities management, funding, and demand considerations. The workplace charging demand analysis can help municipalities identify workplaces located in the high charging demand areas, which are priority targets for employer education, outreach, and planning. The results can also help employers understand what level or amount of charging infrastructure may be needed to meet the future likely workplace charging demand.

Multi-Unit Dwellings (MUDs)

Highlights areas in the region that will likely experience high demand for residential charging and have high incidence of multi-family units. Like residential charging, MUD charging is expected to be a combination of Level 1 and Level 2 charging. The market for MUD charging is in very early stages, and the most appropriate level of charging for this application is likely to evolve as the market advances. The MUD charging demand analysis can help municipalities identify MUD buildings and property owners for targeted outreach and education about installing charging infrastructure. It can also be useful for utilities to understand potential grid impacts.

Public

Highlights areas that will likely experience high demand for public charging (i.e., other non-home or non-work charging), including areas where likely PEV owners shop, dine, and travel for recreational activities. Level 1, Level 2, and DC fast charging are all options for public charging, with dwell times (i.e., how long are drivers likely to be parked) and local site conditions (e.g., accessibility to sufficient electrical power) the most important factors determining which strategy is appropriate. The public charging demand analysis is most relevant to municipalities for determining the need for direct investment in charging infrastructure. Municipalities can use the analysis to help prioritize potential charging station locations. The public charging analysis can also assist with longer-term PEV planning and policies. For example, if demand for public charging is higher in potential redevelopment zones, the municipality may want to include requirements for charging infrastructure or pre-wiring within those zones. Finally, it can be used to identify businesses that would likely benefit most from taking on the role of site host and providing public charging infrastructure.

Once it is known where PEV demand is likely to be located within a municipality and how PEV owners are likely to charge (e.g., at home, at work, at shopping locations), the next step is to identify areas that can physically support charging infrastructure. Municipalities may wish to conduct a land use and zoning analysis to identify properties where PEV charging infrastructure is likely to be needed.

Fleet Market (All AFVs)

Government and commercial operations have different approaches to incorporating AFVs into their fleets, and the approach to market assessment should reflect those differences. The key steps for municipalities to understand the fleet market include:

1. Identify fleets in the region

AFV registration data is available via the NJDEP, following the steps noted above. Data will differentiate between fleet and commercial vehicles but will not call out the fleet or operator. It may be necessary to conduct outreach to fleets operating in and around the municipality to understand whether they are using alternative fuels or could be candidates for AFV use in the future. It is straightforward to identify government or municipal fleets; simply reach out to various government entities operating within the municipality and speak with the fleet or department manager to develop a list of fleets. Identifying commercial fleets can be more challenging. Municipalities may consider reaching out to local business groups such as the chamber of commerce to determine if they have access to some key fleets in the region.

2. Interview fleet managers

Short, semi-structured interviews with fleet managers can be useful to identify the key considerations being incorporated into AFV deployment, as well as barriers encountered. Topics of discussion may include vehicle maintenance, access to fueling infrastructure, driver operations, and fleet procurement plans and policies.

3. Support fleet analyses

A fleet interested in increasing their use of AFVs may want to pursue a comprehensive analysis or outlook using more granular detail on factors including fleet composition (e.g., vehicle make, model, and year), vehicle use (e.g., miles traveled, trip lengths, trip types, trip frequency), and fuel consumption. These types of variables can be incorporated into a total cost of ownership calculator or life cycle cost tool. The municipality can assist fleets by providing links to useful tools, and by facilitating connections with other fleets and relevant organizations.

Photo by Robert Prohaska, NREL 36841

Identify Gaps and Understand Barriers

AFV READINESS PLANNING PROCESS

- Establish Stakeholder Committee
- Set Goals
- Understand Existing Conditions
- **Identify Gaps and Barriers**
- Develop Recommended Actions
- Track, Revisit, and Update

A community may encounter gaps and deficiencies in available resources and information. Taking a **proactive approach** to addressing these challenges and gaps will facilitate AFV readiness. A "gap" is any lack of resources or information that hinders progress towards achieving a goal or completing a task efficiently. For example, the municipality may want to know to what extent existing PEV chargers are already being used, but may not be able to access that information. This gap can be addressed by conducting outreach to site hosts to ask for any usage data or estimates they are able to share. If achieving certain goals relies on specific information or contacts, the municipality and stakeholders should work to gather as much relevant information and insight as possible.

It may be valuable to start by meeting with the municipal team to determine what information exists and what is lacking. By going through each goal one by one, the team can uncover gaps and strategize about ways to address them. Certain gaps may be straightforward to remedy, while others can only be addressed by other parties, such as state-level government.

Key Recommendation

Work with stakeholders to identify gaps and barriers.

One strategy that can shed light on barriers from the public's perspective is to conduct a survey of the broader community. The survey could be as simple as a booth at a community event asking for input, or it could be an online survey of residents and businesses. For example, planners in Vermont administered a survey of stakeholders and consumers, which pinpointed PEV-related barriers perceived by the community.[10] These included vehicle range and cost, as well as concerns about vehicle reliability in harsh terrain and winter weather conditions. Using the results of a survey like this one, planners can better target their actions and message as they proceed with the readiness planning and implementation process.

Reaching out to and working with stakeholders is one way to address gaps in resources or information, as outlined in the Establish a Stakeholder Committee or Working Group section. It may be necessary to reach beyond the stakeholder committee to reach others with relevant experience and perspective. For example, speaking with local car dealerships can provide information about the local interest in PEVs.

The NJTPA study pilot municipalities identified a number of key barriers to AFV infrastructure expansion (see box below), which are important to understand as part of the readiness planning process.

The following sections do not cover all possible barriers, but provide a more in-depth look at some of the challenges municipalities should be aware of.

Key Recommendation

Gain a basic understanding of key challenges related to AFV readiness

Key Barriers to PEV Adoption

- Current vehicle cost
- Charging station build-out and range anxiety
- Consumer awareness
- Enabling charging at MUDs
- Establishing workplace charging programs
- Business case for charging station site hosts

Key Barriers to AFV Adoption

- Higher fuel costs (for some)
- Up-front vehicle cost, lack of incentives
- Economic viability of stations

10 Vermont Energy Investment Corporation, A Survey of Electric Vehicle Awareness & Preferences in Vermont, https://www.veic.org/documents/default-source/resources/reports/veic-a-survey-of-electric-vehicle-awareness-and-preferences-in-vermont.pdf?sfvrsn=2. September 2014.

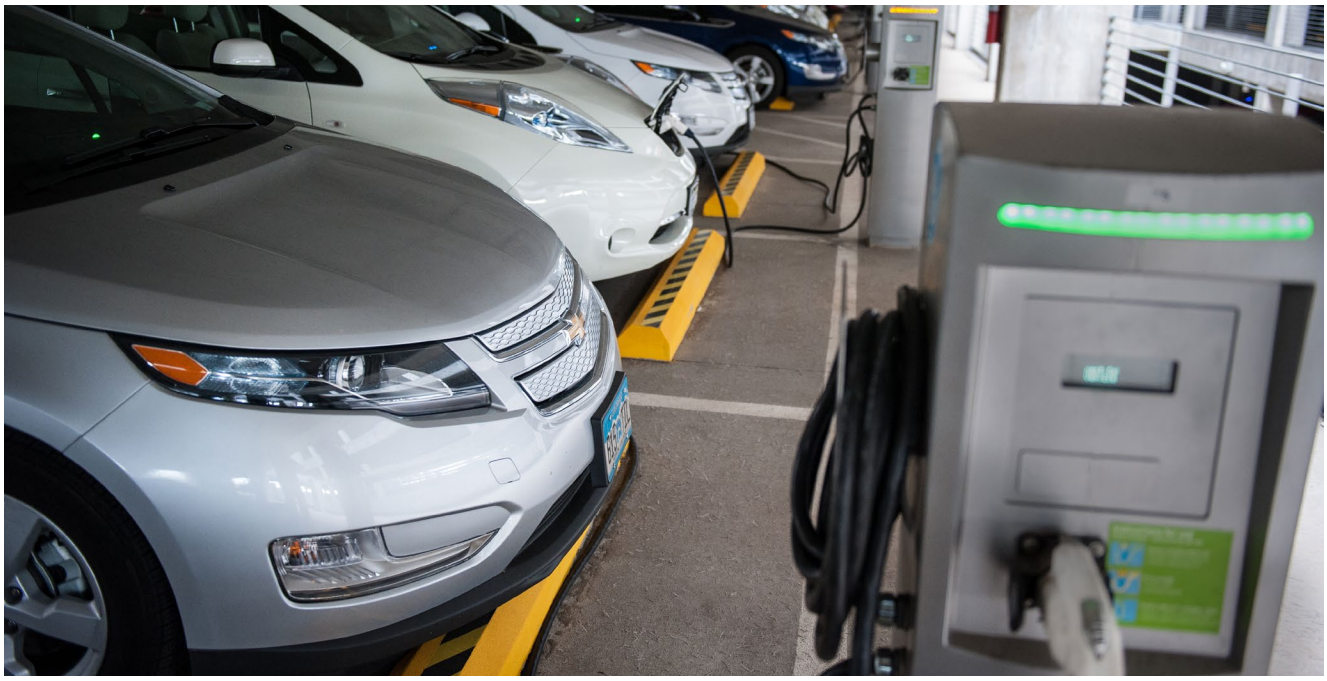


Photo by Dennis Schroeder, NREL 26685

ENABLE CHARGING AT MULTI-UNIT DWELLINGS (MUDs)

MUDs, including townhomes, are a commonly identified gap in the PEV charging market. This area continues to be one of the most challenging because of the varying dynamics between and among vehicle owner, property owner, homeowners association (HOA) in many cases, parking accessibility, electricity demand and load considerations at the facility, and long-term management of the charging equipment. PEV charging station installations in MUDs will vary depending on the building architecture, physical design, parking structures, and parking policies. There are several approaches based on case studies, however, each application is case-specific and therefore, each method should be carefully evaluated before implementation.

In **garden-style apartments and low-rise condominiums**, the biggest problem is the location of the electrical room, which may be far from the charging locations. Major excavations result in increased installation cost. One option is to install the chargers near the electrical room and designating them as a community resource for residents to share rather than installing individual charger across the property. Some issues with this option are establishing guidelines for using the chargers such as how long a resident can charge and the potential to interfere with the community's established assigned parking spaces.

For **mid- and high-rise apartments and condominiums** with parking garages, a common issue is the electrical capacity in the parking structures. Because parking lots were only designed to accommodate low electrical capacity to support lighting, elevators, and other miscellaneous loads, a costly electrical upgrade may be required depending on the current capacity, desired number of chargers, and the type of chargers. Low-cost surface-mounted conduits for circuit wirings may be an option since visual aesthetics are not a major concern in parking structures. This usually involves coordination with a local utility and electrical contractors. A Level 1 charger installation is an option to avoid electrical service upgrade, though it would taking more time to fully charge a vehicle.

In some cases, a **third-party vendor** that provides charging equipment, installations, operations, and maintenance has proven to be cost-effective and successful. Contracts can also involve a subscription-based program in which residents are directly billed for their usage with no interactions required by the property owner or the building management, eliminating any potential administrative burden.

Though these are important issues for property managers, it is not necessarily a barrier that local governments can address through zoning and parking ordinances. The most important role a municipality can play related to MUDs is to provide outreach and education to HOAs, developers, and building owners. For example, the municipality may

share sample HOA resolutions to encourage an MUD to consider factors such as liability and cost. The municipality may also explore options for charging in public parking areas near the development. This could include making certain municipally-controlled parking lots available during off-peak hours to permitted PEV drivers living in MUDs.

Conversations with MUD management companies suggest there is limited demand for PEV charging at older, established buildings. Over the near term, future demand for charging infrastructure at MUDs will be driven by new developments and significantly renovated buildings that may draw higher income tenants, as PEV charging may be an attractive amenity to future tenants. The construction phase is also the point in time when charging infrastructure installation costs are less. Recommendations for targeting education and outreach specific to MUDs are included later in the guidebook.

ESTABLISH A WORKPLACE CHARGING PROGRAM

While there is not a one-size-fits-all solution for workplace charging, there are several factors any employer should consider related to providing PEV charging at the workplace.

These include the following:

Assess demand

Employers considering whether workplace charging is right for their organization will want to start by assessing employee demand with an employee survey. The Businesses and Employers section below includes information on the types of workplaces that may benefit most from an employee-focused PEV charging program. Once this assessment is complete, employers may set goals for meeting workplace charging demand, either by planning to meet the entire need (i.e., all drivers that have expressed or will express interest in PEV charging) or by dedicating a percentage of parking spaces to PEV charging. For example, Google has a goal to dedicate 5 percent of all parking spaces to workplace charging.

Procure and install

Employers should determine what types of charging stations to purchase. There are a few decisions to make, including charging level (i.e., Level 1, Level 2), and whether or not the stations are networked. Employers should also be sure to get quotes from a number of charging station providers. Businesses will work with their electrical contractor to determine charging station placement; station installation can be an expensive process, but employers can minimize costs by siting stations in locations that require minimal trenching, boring, and electrical panel upgrades.

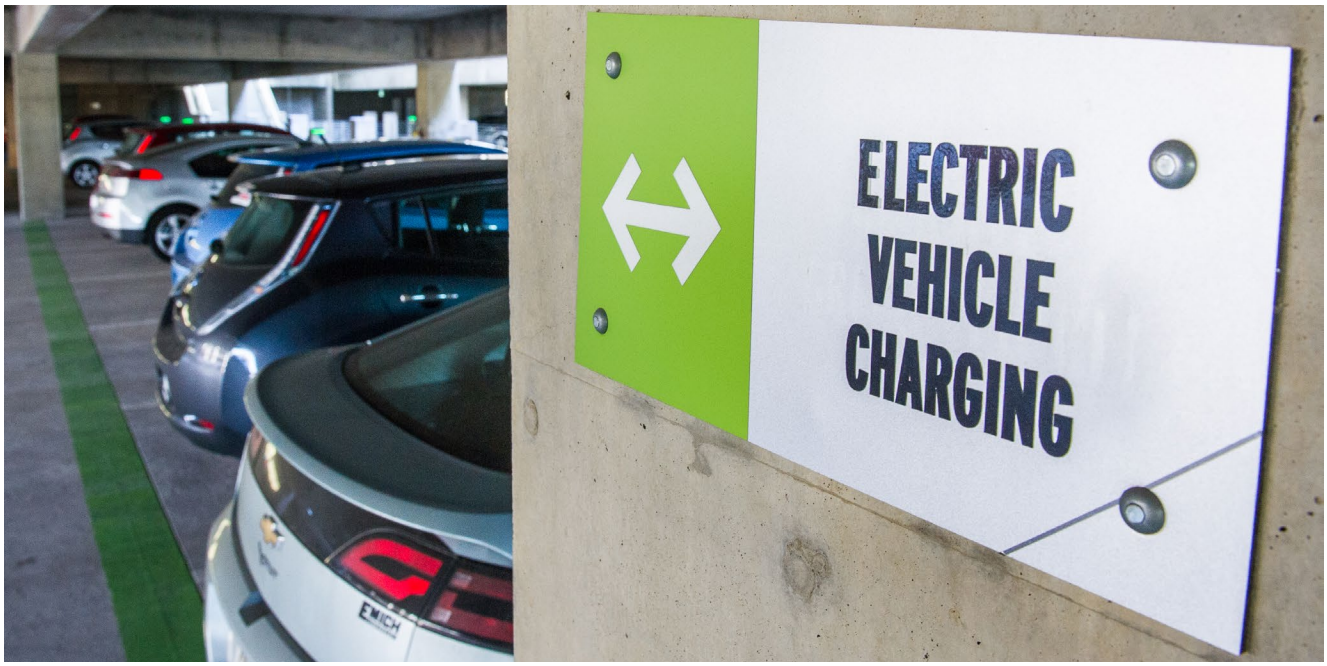


Photo by Dennis Schroeder, NREL 26765

Photo by Dennis Schroeder, NREL 32860

Manage

A well-managed, well-planned workplace charging program can ensure station access to all employees, promote strong communication between employers and station users, and encourage responsible station use. Employers will need to consider issues such as registration and liability, station sharing, and pricing. For consistency, workplaces may consider aligning with municipal zoning requirements related to the amount of time a vehicle can park in a certain space (see the Zoning Ordinance section below). In addition, it is important to differentiate between spaces set aside for employees versus patrons at a commercial destination.

Resources specific to these considerations and other aspects of workplace charging are available on the AFDC Workplace Charging for PEVs website.

DETERMINE THE BUSINESS CASE AND OWNERSHIP MODEL FOR A FUELING STATION

The economics of AFV fueling infrastructure depend on a variety of factors and vary between fuel types. In most cases, the economic viability of fueling stations includes factors such as land and station equipment costs, operational and maintenance costs, fuel prices, station throughput and design, and other related revenue streams (e.g., advertising).

There are numerous ownership models for AFV fueling infrastructure, which differ based on fuel type.

Infrastructure may be owned by a fuel retailer (e.g., a conventional fuel retail chain), public or private fleet, fuel provider (e.g., utility), or infrastructure provider. The owner of the equipment may or may not be the operator. For example, PEV charging infrastructure ownership can be retained by the station provider or transferred to the site host or another third party. The traditional sale method would make the host, whether residential or commercial, the owner and operator of the charging equipment and responsible for the operation and maintenance of the equipment. Under some contracts, the charging station provider may retain ownership of the charging equipment and provide compensation to the host for the use of the site. The charging station provider then may be responsible for the maintenance and operation of the equipment.

Some charging infrastructure business models provide charging at no cost to the driver. Access fees may be collected through subscriptions or pay per use programs. These fees generate revenue and will likely be collected at most publicly available charging sites. The revenue may be shared between the charging station provider and the charging site host, based upon the negotiated terms. This method encourages the host to maximize the utilization of the equipment. Other contracts may provide a fixed rate to the host, and are typically designed to compensate for the host's costs associated with hosting the charging infrastructure, including rent for the parking space. The balance of any revenue then would be retained by the charging station provider.

Natural gas station ownership, on the other hand, can fall into three different categories: fleet (or other end-user), local distribution company (e.g., utility), or third-party ownership. According to NGVAmerica, the national industry association dedicated to growing the NGV market, the key variables to consider include the station owner, the speed of delivery (e.g., fast-fill, time-fill), the party responsible for station maintenance, the station accessibility (i.e., public or private), the funding mechanism for infrastructure development, and the means by which payment will be collected (e.g., pay-at-the-pump, negotiated fuel contracts). Ownership models may be based on a hybrid model. For example, the utility may own the compressor, storage, and dispensing equipment, and a third party owns the land, payment card reader, and retail transaction equipment. In addition, one entity may own the station, while another operates it.

PEV Charging Service Providers

PEV charging service providers can offer a variety of services, including procurement, installation, management, ownership, and network services. Some common providers include (in alphabetical order):

- CarCharging/BLINK
- ChargePoint
- eVgo
- Greenlots
- SemaConnect
- Tesla

Photo by Matthew Staver, NREL 39207

Assess PEV Charging Fees

Owners of PEV charging spaces may contract with PEV charging service providers or third-party operators who install, operate, and set the fees on charging equipment (see box). However, when owners do have the ability to set fees—either explicitly or implicitly through their choice of operator—they face conflicting goals. Owners often need to recoup the costs of installing, maintaining, operating chargers. They may also wish to price charging in order to encourage turnover so chargers are available to those who need them most, increasing the price after a certain time period to encourage drivers to unplug and move on once the vehicles are fully charged. Both of these considerations may push operators toward charging higher fees. On the other hand, pricing charging so that driving a PEV is cheaper on a per-mile basis than a gasoline-powered vehicle creates an incentive for people to purchase PEVs or charge PHEVs so that they use more electricity and less gasoline.

When access fees are assessed, they may be set on a fixed fee, a fixed rate or a pay per energy consumed basis.

A **fixed fee** would mean that each charging session has a set cost. It would not matter how long the connection is made or how much energy is charged into the battery, since the set fee is charged. The fixed fee may be applicable for an employer in a workplace setting or when charging is provided as part of a parking lot fee. In these situations, the car is typically parked for a significant period of time.

A **fixed rate fee** may be charged if high utilization and turnover of vehicles is desired. Fees may be charged per hour or other intervals for Level 2 charging and a per minute basis for DC fast charging. It would be desirable for the PEV driver to be aware of the time the vehicle is charging to maximize the charge with the convenience of gaining range. In certain situations, the fee could change to discourage unnecessarily long dwell times in that space. For example, one rate could apply at a Level 2 charger for the first few hours, then a higher rate after that time period. Alternatively, a higher rate could be charged during busier daytime hours and a lower rate during off-peak hours.

A **pay per energy consumed** basis would require measuring the energy delivered and charging a rate based upon the amount of electricity consumed.

Membership or subscription programs may offer the same type of services. A fixed rate may be charged to the driver on a monthly basis for an unlimited number of connects or time connected at publicly available charging infrastructure. Discounts on the fixed rate may be provided by the membership program. In most cases, a pay per use is generally available although restrictions may apply based upon the membership program.

Develop Recommended Actions

AFV READINESS PLANNING PROCESS

- Establish Stakeholder Committee
- Set Goals
- Understand Existing Conditions
- Identify Gaps and Barriers
- **Develop Recommended Actions**
- Track, Revisit, and Update

Once a stakeholder committee is established, and goals and key barriers have been identified, the team can begin developing recommended actions for increasing municipal readiness. The following sections are divided into areas of focus that can serve as a guide for AFV readiness planning. Within each area of focus are one or more associated recommendations of best practices. Some recommended actions are more appropriate for or applicable to specific AFVs and fueling infrastructure, so icons are used throughout this section to easily align recommendations and topics with fuel types.

While addressing each action identified in this section is preferable, municipalities can prioritize using the methods outlined in this guidebook in order to identify and address the most pressing issues, as well as those that can be undertaken quickly, first.

When developing recommendations for a readiness plan, the municipality should address each of the following questions:

- What needs to be done in terms of community awareness and outreach?
- How will different elements of the project be funded? What are the various funding opportunities available and how can they be leveraged?
- What is the overarching timeframe intended for this process?
- What can be started now? What steps are dependent on previous steps?
- Who should be responsible for each step?
- How will progress be measured?
- How will the team be held accountable for their responsibilities?

Municipalities should consider an overall implementation time horizon of about 10 years. Each recommended action can be categorized as ongoing, to be implemented in the near-term (e.g., 1-2 years), medium-term (e.g., 3-5 years), or long-term (e.g., 6-10 years). These timeframes may be determined based on a realistic assessment of how long it will take to complete an action, or set based on the target completion date to along with a community goal. A municipality may also choose to group actions in terms of priority (high and low).

Regardless of what approach is taken, the municipality should work closely with the stakeholder committee to develop an action plan. Keep in mind that goal setting and action planning can be an iterative process. Perhaps the group discovers that some of the "high priority" actions do not align well with goals, or maybe there is a goal for which the team did not identify any concrete actions. Allow for flexibility by creating a new goal to capture desired actions, or reprioritizing a recommended action as needed.

Working with the pilot municipalities, the NJTPA found it useful to align recommended actions with the infrastructure type, particularly for PEVs. Groupings were differentiated by answering the question, who will use this infrastructure? As a result, recommendations may be distinguished by their connection to residential, MUD, workplace, public, and fleet fueling. The recommendations can also be aligned with planning areas — general plans and policies, building codes, zoning and parking codes, permitting and inspection, and fleet planning.

The most effective plans will detail specific actions and assign responsible parties to each action. That lead organization may be an entire municipal department, an organization (e.g., the TMA), or a specific stakeholder. Assigning responsibility helps keep team members accountable for making progress towards completing the action.

The following table summarizes some of the key recommendations for each focus area. Additional detail on each of areas, as well as the key recommendations, can be found in the subsequent sections.

FOCUS AREA	KEY RECOMMENDATIONS
Policy Measures: Zoning and Parking	Establish clear definitions for AFV fueling and PEV charging infrastructure.
	Amend zoning codes to include PEV charging as a permitted accessory use and to include requirements or incentives for pre-wiring (for PEV charging) or installation of fueling infrastructure.
	Amend parking codes to include restrictions, enforcement policies, and fees for municipally-controlled PEV charging stations.
Policy Measures: Permitting and Inspection	Streamline AFV infrastructure permitting and inspection procedures.
	Produce guidance documents clearly outlining AFV infrastructure permitting requirements and steps.
Policy Measures: Municipal Fleet	Assess the existing municipal fleet, develop a fleet management plan, and explore opportunities to incorporate AFVs.
Key Stakeholder Engagement	Engage in cross-jurisdictional opportunities for sharing lessons learned.
	Partner with utilities to share information, enhance market participation, and gauge impacts.
Targeted Education and Outreach	Reach out, engage, and educate relevant stakeholders.
	Identify AFV grants and other funding opportunities for fueling infrastructure development.

ZONING AND PARKING

Local governments have an important role to play in the development of public and private AFV fueling infrastructure due to their regulatory authority over zoning and parking. Through zoning codes, design standards, and parking requirements, the municipality has the opportunity to ensure both that there is sufficient infrastructure to meet projected AFV demand and that AFV fueling stations and parking spaces are effectively designed and regulated. The municipality can also use its regulatory and approval authority to ensure new development projects have ample PEV charging opportunities. There is no one right way forward, but taking action now sets a precedent that municipalities can expand upon as AFV infrastructure demand increases or development patterns shift.

Sustainable Jersey Resources

Consistency and **standardization** across municipalities for zoning codes and parking regulations will reduce confusion for municipal staff and consumers. New Jersey municipalities engaged with the Sustainable Jersey program are already exposed to many of these best practices. For instance, to earn points for the Make Your Town Electric Vehicle Friendly action, municipalities must update zoning and parking policies to encourage PEV deployment. Municipalities can choose from a list of other activities, including pre-wiring ordinances.

Key Recommendation

Definitions and Infrastructure Design Criteria

Establish clear definitions for AFV fueling and PEV charging infrastructure.

Definitions

The first step in drafting ordinances and updating the zoning code is to establish standard definitions for alternative fuels, AFVs, and related infrastructure. Without a clear definition, developers, PEV owners, and others might hesitate to install charging infrastructure. While there are no definitions for AFVs in the New Jersey Municipal Land Use Law, municipalities can look to other states and local governments for examples. Illinois provides the following definitions within the State Vehicle Code:[11]

- "Electric vehicle" means a battery-powered electric vehicle operated solely by electricity or a plug-in hybrid electric vehicle that operates on electricity and gasoline and has a battery that can be recharged from an external source.
- "Electric vehicle charging station" means any facility or equipment that is used to charge a battery or other energy storage device of an electric vehicle.

The City of Seattle provides the following definitions, which are relevant to PEV parking spaces and enforcement policies:[12]

- "Electric vehicle charging station" means a parking space that is served by battery charging station equipment that has as its primary purpose the transfer of electric energy (by conductive or inductive means) to a battery or other energy storage device in an electric vehicle, and that is 1) publicly owned and publicly available (e.g., Park & Ride parking, public library parking lot, on-street parking), or 2) privately owned and publicly available (e.g., shopping center parking, non-reserved parking in multi-family parking lots).
- "Electric vehicle parking space" means any marked parking space that identifies the use to be exclusively for the parking of an electric vehicle.
- "Non-electric vehicle" means any motor vehicle that does not meet the definition of "electric vehicle."

For the purpose of parking spaces and enforcement, Montclair Township defines a PEV as "any car, truck, or other vehicle that does not produce tailpipe or evaporative emissions or is a plug-in hybrid electric vehicle (PHEV)."[13]

Design Criteria

Infrastructure design criteria will help to ensure fueling stations are easy to find, easy for drivers to use, and meets the needs of the user, particularly in the case of public stations. Design guidelines vary based on the type of location (e.g., parking lot, conventional fueling station) but all generally consider accessibility (i.e., the amount of space needed to access the equipment), safety, equipment protection, and signage.

The municipality should understand how infrastructure design guidelines differ based on the wide variety of fuel types and fueling scenarios. Existing resources, including those noted in Appendix A, can be referenced as part of general guidelines and requirements.

Siting Considerations

Municipalities should be aware of other infrastructure siting considerations, as they are in a position to help communicate best practices related to selecting sites and installing stations. These include:

Dispensing capacity requirements, including the number of chargers or pumps

In the case of PEV charging, installers should understand the demand (via a siting analysis, discussed above) to determine whether Level 1, Level 2, or DC fast chargers will be most appropriate. For gaseous fuels, compression

11 Illinois Compiled Statues, (625 ILCS 5/), Illinois Vehicle Code, http://www.ilga.gov/legislation/ilcs/ilcs4.asp?ActID=1815&ChapterID=49&SeqStart=129100000&SeqEnd=129600000. Accessed October 20, 2017.
12 City of Seattle Municipal Code, Section 11.72.125, https://library.municode.com/wa/seattle/codes/municipal_code?nodeId=TIT11VETR_SUBTITLE_ITRCO_PT7STSTPALO_CH11.72STSTPARE_11.72.125ELVEPACHSTELVE. Accessed August 30, 2017.
13 Montclair Township Code of Ordinances, Chapter 230: Parking Lots, https://ecode360.com/MO0769.

capacity requirements will depend on the number and frequency of vehicles fueling. It is important to understand operating characteristics so that the station can deploy the appropriate fill or dispensing equipment. For CNG stations, the three generic types of equipment include fast fill (similar to a conventional gasoline fueling station), time fill (a slower option for so-called return to base operations that can be fueled slowly over a period of time e.g., overnight), or a combination fast fill and time fill station.

Fleet needs or customer profile

As a developer seeks to deploy an AFV station, it will be important to understand the needs of various fleets and other operators that will be using the station. The station owner should understand if the station will be accessible only to fleets, have public access, and if there are any so-called anchor tenants that require minimum access to fueling at particular times. Furthermore, the size of the vehicles that comprise the fleet will help size the facility appropriately.

Future infrastructure demand

Taking a "dig once" approach can help minimize the cost of future installation or expansion. For PEV charging, this includes upgrading the electrical service for the estimated future charging load and running conduit to the anticipated future charging locations.

Proximity to the fuel source

NGV fueling stations should have good proximity to both a natural gas pipeline and electrical service. The former is to meter the gas, dry it, compress it, and then dispense it into vehicles; the latter is to power the station and critical functions such as compression. For PEV charging stations, the DOE Clean Cities program provides the following recommendations:[14]

- Place the charging equipment close to the electrical service to minimize the need for trenching/boring and the costs of potential electrical upgrades.
- Instead of locating the charging station at a highly visible parking spot a great distance from the electrical panel, use signage to direct PEV drivers to the charger.
- If trenching is needed, minimize the trenching distance.
- Choose a location that already has space on the electrical panel with a dedicated circuit.

Utility Input

Involving utilities in the infrastructure site selection process can help **alleviate any unknowns or concerns** surrounding gas pressure, distance from gas distribution infrastructure, and sufficient supply of both natural gas and electricity to power the equipment. Utilities can provide **up-to-date information** about existing natural gas infrastructure in the region as well as the feasibility of a given location.

Source: NGVAmerica, CNG Station Construction and Economics, http://www.ngvamerica.org/stations/cng-station-construction-and-economics/.

Photo by Warren Gretz, NREL 05857

14 U.S. DOE, Clean Cities. 2015. Costs Associated with Non-Residential Electric Vehicle Supply Equipment. http://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf

Key Recommendation

Zoning Ordinances

Amend zoning codes to include PEV charging as a permitted accessory use and to include requirements or incentives for pre-wiring (for PEV charging) or installation of fueling infrastructure.

Zoning ordinances can facilitate (or hinder, if not developed thoughtfully) AFV fueling infrastructure deployment.

PEV Zoning Considerations

The municipality specifies how much parking should be provided at different locations or land uses through zoning ordinances, development guidelines and standards, or accompanying parking codes. It is recommended that the municipality update these documents to include charging requirements or incentives.

Zoning ordinances and development regulations are similar to building codes in that they can be used to specify how much charging or pre-wiring should be provided, and where. However, there are two key differences that enable zoning codes to provide more flexibility:

- Zoning ordinances can be used to **increase charging opportunities in high priority locations**. Building codes usually categorize land uses broadly (e.g., residential and non-residential), while zoning ordinances can be more nuanced, distinguishing between residential districts of different densities, non-residential districts with differing types and mixes of uses, or high-activity areas such as downtowns and transit stations. This means that zoning ordinances usually offer more flexibility to focus new PEV infrastructure in the places where it matters the most, such as downtowns and activity centers with high turnover or employment centers. In general, zoning ordinances should allow for Level 1 or Level 2 charging infrastructure in any district. DC fast charging may be restricted to commercial and industrial areas. As an example, the City of Methuen, Massachusetts incorporated language into their zoning code permitting Level 1 and Level 2 in single- and multi-family zones and all other zones. DC fast charging is restricted to parking lots at commercial or municipal destinations or vehicle service stations.[15]
- Zoning ordinances offer **flexible ways to require new charging infrastructure**. A zoning ordinance that requires pre-wiring could have the same effect as updating the building code. However, the municipality could also use zoning ordinances to encourage PEV charging deployment in different ways. For example, it could require actual charger installations at new developments in specific areas through zoning ordinances or development standards, or offer developers incentives such as density bonuses in exchange for providing increased charging opportunities.

The Importance of PEV Charging Stations as a Permitted, Accessory Use

Zoning codes that do not reference PEVs or charging stations can unintentionally **create barriers** to the deployment of charging stations and may leave the municipality susceptible to **legal challenges**. Amending municipal zoning code to include PEV charging stations as a permitted accessory use in all or specified zoning districts is an important first step in PEV readiness.

15 City of Methuen, Massachusetts Comprehensive Zoning Ordinance, Section V-T Electric Vehicle Charging Station and Electric Vehicle Battery Exchange Station, http://www.cityofmethuen.net/sites/methuenma/files/uploads/zoningord10217.pdf. Revised through September 5, 2017.

EXAMPLES: Zoning Ordinances in Support of AFVs

New York City's New Construction Pre-Wire Requirement

New York City requires that newly constructed and upgraded parking garages and open lots include the necessary hardware for charging infrastructure in at least 20% of the parking spaces.

Source: General Administrative Provisions for Construction Codes, Section 28-101.4.3; Building Code, Sections 406.2.11 and 406.7.11 (https://www1.nyc.gov/site/buildings/codes/2014-construction-codes.page).

Montclair Zoning – Requiring Charging Infrastructure through Redevelopment Plan

Following is an excerpt from one of three redevelopment plans for Montclair Township that include requirements for accommodating PEVs:

Seymour Street Redevelopment Plan (2016): PEV charging stations are a stated permitted use. All parking facilities within the Redevelopment Area must include a minimum of two PEV charging stations as well as the infrastructure necessary to support future demand (e.g., conduit). The car-charging facilities are the responsibility of the redeveloper.

Municipalities should consider amending the municipal zoning codes to require or incentivize pre-wiring or charging station installations at new residential and non-residential developments (see box above). Pre-wiring is when builders run electrical conduit, intended to power charging equipment, to locations where vehicles will be parked. While pre-wiring alone does not create new charging opportunities, addressing this need during the construction phase dramatically reduces the cost of installing chargers in the future. Redevelopment plans provide an opportunity for municipalities to require pre-wiring or actual station installation.

Montclair Township has requested such modifications to several redevelopment plans, including the one summarized in the box above.

Codes can also include or refer to guidance on siting and installing PEV charging stations (see above). Ideally, requirements should specify the number of chargers or pre-wired spaces to be provided at new developments of different sizes and land-use types.

If the municipality has minimum parking requirements, consider whether PEV parking should count toward overall parking requirements. Allowing PEV parking to count toward parking requirements is recommended since it would incentivize developers to provide PEV parking without increasing the total number of spaces required. The municipality could consider allowing each designated PEV space to count as three spaces toward meeting off-street parking requirements. This incentive is included in Georgia's proposed model municipal ordinance.[16]

16 Plug-in Georgia, Proposed Laws and Initiatives, A model proposed municipal ordinance to update the zoning code. http://www.plugingeorgia.com/index.php/advocate. Accessed October 20, 2017.

Other Fuel Type Zoning Considerations

Though most other new AFV fueling infrastructure will be located in areas zoned for commercial or industrial use (these areas should already allow for installation), it is important to ensure compliance with existing statewide codes and regulations and to engage local officials in the preliminary stages of any AFV fueling infrastructure development project. According to a Hydrogen Energy Center report, a challenge faced by infrastructure developers is that building code requirements are sometimes invoked for fueling systems that do not have a building component.[17] Municipalities in the NJTPA region may benefit from a collaborative effort to develop model permit terms and standards so that the process for developing, permitting, and managing non-building fueling infrastructure is more predictable across the region.

Fleets and others need to take local zoning requirements into account when developing AFV stations, not only in terms of land use considerations, but also for safety regulations relating to the storage and dispensing of fuel, including maintenance facility upgrades. Storing and dispensing fuel requires adherence to fire codes and other environmental considerations.

Additional considerations are appropriate for residential NGV fueling. Guidance from the California Statewide Alternative Fuel and Fleets Project provides an example of how cities can include residential requirements in preparation for potential at-home NGV fueling infrastructure.[18] The residential requirement would be most applicable if the consumer NGV market takes hold, which thus far has not been the case. Further, it is unlikely to develop given that no major automobile manufacturer currently offers a light-duty passenger vehicle using natural gas.

Photo by Dennis Schroeder, NREL 20040

17 Hydrogen Energy Center, Regulatory Barriers to Development of Vehicle Alternative Fuel Infrastructure in New England, http://www.gpcog.org/wp-content/uploads/2015/03/Final-HEC-report.pdf. January 2015.

18 TIAX, Natural Gas Vehicle Market Analysis, https://www.aga.org/tiax-natural-gas-vehicle-market-analysis. Accessed September 7, 2016.

Key Recommendation

Parking Ordinances and Codes

Amend parking codes to include restrictions, enforcement policies, and fees for municipally-controlled PEV charging stations.

After establishing zoning policies to encourage or require the deployment of PEV charging infrastructure, the next step is to update parking ordinances and codes to account for PEV parking spots. The goal when making these changes should be to ensure that PEVs have unobstructed access to charging equipment. If desired, also ensure that the community can recoup the costs of municipality-owned and operated publicly-available charging infrastructure by establishing charging fees.

When designating PEV parking ordinances and codes, consider applicable definitions (discussed earlier in this section), time limits, restrictions, enforcement policies, and fees.

Time limits and restrictions

While internal combustion engine vehicles are usually the most common cause of obstructing access to charging spaces, there can also be issues with PEVs being left in charging parking spaces long after the charging session has completed. It is important that drivers unplug and move their car as soon as possible to make way for other plug-in drivers to charge up when needed. One way of doing this is specifying a time limit for charging in parking codes or ordinances. A general best practice is to restrict the use of PEV charging stations to vehicles that are plugged-in and actively charging to ensure the equipment is available for drivers who need it. For example, the City of Dublin, California limits parking in charging stations to four hours and specifies that vehicle parked in PEV stations must be connected to the charging equipment.[19]

Enforcement policies

It is important to define how restrictions and time limits will be enforced. Without an enforcement policy, there is no incentive to follow the restrictions. Within parking codes and ordinances, the municipality can specify towing of vehicles in violation of the restriction or impose a fine.

- The City of Raleigh, North Carolina Code of General Ordinances requires that vehicles parked in designated PEV spaces must be connected to the charging station or be subject to a $50 fine.[20]
- The Illinois State Vehicle Code includes the following language for enforcement by towing: "Any person or local authority owning or operating any public or private off-street parking facility may, after notifying the police or sheriff's department, remove or cause to be removed to the nearest garage or other place of safety any non-electric vehicle parked within an electric vehicle charging station space designated for use by electric vehicles."[21]

Fees

Imposing fees for PEV charging can help the municipality recover costs associated with providing charging services to the public. See the Assess PEV Charging Fees section above for more detail on possible fee options. As an example, the City of Palo Alto, California charges $0.23 per kilowatt-hour to recover the cost of PEV charging stations at city facilities. This is in addition to a per-hour connection charge. The city has also established a discretionary fee of up to $5.00 per hour after the vehicle has finished charging, which is referred to as an "Electric Vehicle Charger Connection Overstay" fee.[22]

19 City of Dublin, CA, Electrical Vehicle Charging Stations, http://dublinca.gov/1482/Electric-Vehicle-Charging-Stations. Accessed August 30, 2017.
20 City of Raleigh, NC, Raleigh City Ordinance 11-2174(c) Electric Vehicle Parking FAQs, http://www.raleighnc.gov/content/PWksParkingMgmt/Documents/EVParkingFAQ's.pdf. Accessed April 10, 2017.
21 Illinois Compiled Statues, (625 ILCS 5/) Illinois Vehicle Code, http://www.ilga.gov/legislation/ilcs/ilcs4.asp?ActID=1815&ChapterID=49&SeqStart=129100000&SeqEnd=129600000. Accessed August 30, 2017.
22 City of Palo Alto, CA, Amendments to CMR 8020, FY 2018 Proposed Municipal Fee Schedule for Electric Vehicle Charges, http://www.cityofpaloalto.org/civicax/filebank/documents/57898. May 18, 2017.

Signage is important as it helps drivers identify and navigate to fueling stations and, in the case of PEV charging, clearly state time limits and restrictions that improve access to charging and facilitate enforcement. Signage can also increase the visibility of a station, drawing attention to the fuel it provides, and help alleviate any range anxiety or concerns about the lack of available infrastructure.

PEV Charging Stations

Parking ordinances can be used to standardize PEV charging station signage. The FHWA defines the minimum standards for signage, which it publishes in the Manual on Uniform Traffic Control Devices (MUTCD), updated every five to six years. The FHWA intends to include standard regulatory signage for charging stations in the next Notice of Proposed Amendment to MUTCD, but the agency has released interim designs and optional plaques detailed in the Regulatory Signs for Electric Vehicle Charging and Parking Facilities guidelines.[23] These signage designs should be included in the municipality's parking codes, general codes, or any PEV charging station related ordinances.

- Wayfinding signs are used to indicate the location of chargers and can be combined with directional arrows to guide drivers to chargers.
- Parking signs can also be used to designate restrictions or time limits on PEV charging spaces.

Other Fueling Stations

Through alternative fuel corridor designation efforts, the FHWA has also identified standard signage for CNG, LNG, propane, and hydrogen fueling stations. Specific designs and specifications can be found on the MUTCD website.

23 FHWA, Regulatory Signs for Electric Vehicle Charging and Parking Facilities, https://mutcd.fhwa.dot.gov/resources/policy/rsevcpfmemo/. Accessed August 30, 2017.

Building codes contain safety standards and specifications that guide new construction and renovations. The New Jersey Department of Community Affairs (NJDCA), specifically the Division of Codes and Standards, enforces statewide building codes – referred to as the Uniform Construction Code (UCC).

Municipalities in New Jersey are limited to the statewide UCC, and are therefore not in a position to amend building codes as they are related to PEVs or other issues. Therefore, it is recommended that the municipality focus on updating local zoning requirements rather than attempting to change the building code. However, some municipalities have taken steps to advocate for UCC updates that incorporate PEVs where appropriate and feasible.

There are two major opportunities to create building codes that support PEV deployment:

- Specify standards for PEV charging infrastructure in the building code to ensure that any charging station installations are safe and accessible.
- Require pre-wiring for charging stations to lower the cost of future installations.

Key Recommendations

Streamline procedures

Streamline AFV infrastructure permitting and inspection procedures.

Produce guidance documents

Produce guidance documents clearly outlining AFV infrastructure permitting requirements and steps.

EXAMPLE: Permitting Guidance

The City of Milpitas, California has issued guidance that summarizes the requirements for a PEV charger permit and includes diagrams illustrating typical configurations of chargers in different garage types in order to assist applicants of single-family residences with determining the proposed location of the charging system. Permit fees for residential and commercial electric vehicle charging systems are available on the website, along with electronic plan submittal and information on the building inspection procedure.

Source: City of Milpitas, CA, Electric Vehicle Charging Station Permitting
http://www.ci.milpitas.ca.gov/milpitas/departments/building-and-safety-department/electrical-vehicle-charging-station/.

Photo by City of Milpitas, CA

PERMITTING AND INSPECTION

An important piece of AFV readiness is efficient and easy-to-navigate permitting and inspection processes. The installation of AFV fueling and charging equipment typically requires obtaining municipal permits and passing inspections, the process for which currently varies by municipality. There are opportunities to streamline permitting and inspection procedures and to harmonize processes between jurisdictions. Making the permitting process easy and affordable can help speed the roll out of AFV infrastructure and make installations more straightforward. From the municipality's perspective, minimizing permit requirements can enable staff to process permits more efficiently.

All AFV Infrastructure

The permitting requirements and process can seem overwhelming to a resident, employer, developer, or other party interested in installing AFV fueling or charging infrastructure. Municipalities can help to make it more approachable and feasible by providing clear, concise information about the steps involved. Because state law dictates permitting and inspection requirements, site plan approval is one of the only aspects over which municipalities have control. Municipalities should explicitly state whether site plan approval is required for various charging station installations and explore options to exempt MUD and commercial charging stations from site plan approval process. Municipalities could also consider developing permitting checklists that help applicants through the permitting processes specific to MUD and non-residential installations.

Where possible, a municipality should work with neighboring communities to make processes and requirements consistent. This coordination will make it easier for contractors (e.g., electrical) who work throughout the region.

Residential PEV Charging Stations

NJDCA issued guidance for municipalities on PEV charging station permitting at residential locations (see box). Municipalities can also implement the following actions specific to PEV charging stations installed at single-family residences:

- ➔ Make permits available online or over-the-counter.
- ➔ Issue required permits in under 48 hours.

Photo by Matthew Staver, NREL 39210

- Set fees between $100 and $250 for residential charging station permits.
- Limit the number of required inspections to one.
- Minimize requirements for supporting materials to information about the PEV charging system (i.e., level of charger, compliance with national standards, proposed location) and electrical service (i.e., existing electrical panel service information, load calculations, whether panel upgrades or a new meter installation are required).

State Guidance on PEV Charger Permitting

The NJDCA published "Electric Vehicle Charging Stations – What you need to know," to provide guidance to municipalities on types of permitting required for the installation PEV charging stations at residential locations. A previous NJDCA article, "Electric Vehicle Charging Stations – Installation and Permit Requirements" (in NJDCA's Construction Code Communicator, Vol. 23, Number 1, Spring 2011) provides more detailed information.

In 2011, the NJDCA reviewed all applicable state codes and regulations and determined that installation of residential PEV charging equipment is considered "minor work." This means that the homeowner or contractor need only provide verbal notification to the local code enforcement agency prior to starting the installation and submit the permit application within five days of notification. This interpretation of state code streamlines the process homeowners do not have to wait up to three weeks for permit approval.

Key Recommendation

Lead by example

Assess the existing municipal fleet, develop a fleet management plan, and explore opportunities to incorporate AFVs.

EXAMPLE: Secaucus, New Jersey

The Secaucus municipal fleet includes several PEVs, including this one charging at town hall.

MUNICIPAL FLEET

If one does not exist already, a municipality should develop a fleet management plan to provide a framework for considering how AFVs might be incorporated as older vehicles are being retired. The first step is taking inventory of existing vehicles to understand how vehicles are distributed across and controlled by the various departments and offices. The fleet management plan should also include meaningful metrics for measuring progress over time. Sustainable Jersey's Green Fleets actions provide useful guidance. I If a municipality reaches the point of vehicle procurement, it should be aware of the types of AFVs that are on the current version of the New Jersey Department of the Treasury's supply contract, and of the aggregated purchase options for both vehicles and infrastructure, including the Mid-Atlantic Region initiative under Fleets for the Future as well as EV Smart Fleets.

Municipal fleet managers may have previous experience with AFVs, positive or negative, that could influence their understanding of the technology, performance, and other considerations. Education targeting these individuals is addressed later in this section, and will be a critical step to help address any misconceptions and highlight potential benefits.

Vehicle acquisition at the municipal level is often reactive and needs to happen quickly. Having an inventory and plan in place will aid the decision-making process.

Key Recommendation

Collaborate with other municipalities

Engage in cross-jurisdictional opportunities for sharing lessons learned.

KEY STAKEHOLDER ENGAGEMENT

In addition to the formal committee established at the start of the readiness planning process, there are other stakeholder that can provide valuable insight and serve as important partners to the municipality. These include other local governments and utilities.

The NJTPA region encompasses many local governments, each with its own challenges and experiences with AFV use. An individual community stands to benefit from the sharing of best practices and lessons learned by stakeholders across its neighboring jurisdictions. Successful collaboration and information-sharing will require a municipality to invest the time and resources necessary to actively engage with its neighbors. But creating and sustaining a network of stakeholders who work on AFV-related issues will help strengthen AFV readiness in both the municipality and throughout the region, reaching a greater audience.

Sustainable Jersey provides one such forum, leveraging regional hubs to connect communities. This group of green team and environmental commission members, as well as leaders in government, business, and community, can learn from a municipality and potentially support efforts going forward.

There are two broader initiatives to be aware related to AFVs and AFV readiness, namely:

- At the state level, ChargEVC is a coalition of car manufacturers, technology companies, utilities, consumer advocates and non-governmental organizations to promote PEV use in New Jersey. The organization released A Roadmap for Vehicle Electrification in New Jersey.
- The NJCCC, which supports all forms of petroleum reduction in the transportation sector, chairs a New Jersey Natural Gas Vehicle Workgroup as a committee within the NJCCC. Participating members include representatives from gas distribution utilities, vehicle and engine manufacturers; fuel and infrastructure providers; transit, refuse haulers and other fleet users of natural gas; and others interested in increasing and strengthening the deployment of low-emission NGVs throughout New Jersey.

Both initiatives provide municipalities with means to stay updated on developments and opportunities related to complementary activities at the state and regional level, such as alternative fuel corridor planning and utility rate filings.

Zoning and Parking | Permitting and Inspection | Municipal Fleet | **Key Stakeholder Engagement** | Targeted Education and Outreach

Key Recommendation

Engage with Utilities

Partner with utilities to share information, enhance market participation, and gauge impacts.

A partnership between the municipality and the local electric and gas utilities can be mutually beneficial in advancing AFV use. As mentioned earlier in the guidebook, there is a lot that municipalities can learn from utility experience. However, the municipality can also help utilities develop consumer outreach content and messaging by sharing information about AFV use and helping to distribute utility-developed materials throughout the community. For example, residents would benefit from information about time-of-use (TOU) electricity tariff structures, if offered. TOU rates charge higher electricity rates during times of peak demand and lower rates during off-peak hours. TOU rates can be advantageous for PEV owners, as drivers are encouraged to charge their vehicles overnight during the cheaper off-peak hours. TOU rates also help utilities manage demand by minimizing the adverse impacts of having all PEV drivers plug-in their vehicles when they get home from work during on-peak hours.

Electric Utilities

North Jersey is home to three major electric utilities: Jersey Central Power & Light (a FirstEnergy Company), Rockland Electric Company, and Public Service Electric & Gas (PSE&G). The NJBPU website includes a map of service territories. Electric utilities in New Jersey have already been involved in creative ways to stimulate and support the AFV market. While some of these efforts are directed internally toward the utilities' own vehicle fleets or employees, many of these efforts are also directed to providing a resource to the communities that they serve. For example, PSE&G provides an incentive for workplace charging infrastructure and has funded more than 130 charging stations at 20 sites within the service territory.[24]

Although sales of PEVs are forecasted to grow, regional impacts on the electrical grid (in terms of greater demand for electricity as more vehicles are charging) will likely be negligible for many years. However, unmanaged charging station installations and increased regional PEV ownership in specific areas could negatively affect local electrical distribution systems.

One of the primary causes of concern for PEVs is clustering of the load associated with vehicle charging. Utilities generally have a transformer replacement program to regularly target transformers that have reached the end of their useful life or have been identified as grossly overloaded. However, the adoption of PEVs may occur faster in some areas, thereby causing gaps in the information that utilities would generally use to inform their replacement programs. In order for utilities to minimize the potential grid impacts of charging PEVs, they need to know where the vehicles are being used and how they are being charged (e.g., Level 1 versus Level 2). This information allows the utility to evaluate if the local distribution system is adequate to serve PEV charging needs. One simple, but not always utilized, solution to this potential challenge is for utilities to establish a clear notification protocol so they are aware of new chargers being added to the grid. This notification could be integrated with the municipal permitting process for charging station installations. Municipalities can provide valuable perspective and advanced notice regarding anticipated PEV clustering, new construction, and DC fast charging corridors along the way.

Gas Utilities

North Jersey has three natural gas utilities: New Jersey Natural Gas, PSE&G, and Elizabethtown Gas. The NJBPU website includes a map of natural gas service territories. These companies have been engaged in AFV efforts, and have been active in various degrees in developing the CNG market. While some of their efforts are directed internally toward the utilities' own vehicle fleets, many provide support to the communities that they serve. For example, New Jersey Natural Gas, South Jersey Gas, and Elizabethtown Gas have invested in publicly available CNG fueling infrastructure over the last five years.[25] All of these utilities play a critical role in providing information and resources to any entity interested in using natural gas as a vehicle fuel.

24 Kenny Esser, PSE&G, email communication, September 6, 2017.

25 NJBPU and NJDEP, New Jersey Energy Master Plan Update, http://nj.gov/emp/docs/pdf/New_Jersey_Energy_Master_Plan_Update.pdf. December 2015.

UTILITY READINESS CASE STUDY: Los Angeles Department of Water and Power (LADWP)

While the utility regulatory scheme in California differs from that of New Jersey, it is interesting to note that the Los Angeles' municipal utility, LADWP is leading Los Angeles' PEV efforts and is a great example of the prominent role electric utilities can play in PEV readiness.

- LADWP upgraded over 250 publicly accessible charging stations, provided rebates for nearly 1,000 residential and commercial charging stations, and fully funded an additional 2,000 charging stations.
- LADWP has been promoting off-peak residential charging by offering discounted electric rates and working with charging infrastructure providers to evaluate the interaction of charging infrastructure with utility meters to enable effective time-of-use pricing.
- LADWP incorporated both light- and heavy-duty PEVs into its fleet.
- LADWP initiated the Southern California Regional PEV Plan (SoCal EV) to foster collaboration among southern California utilities, governments, automakers, businesses, and other stakeholders in support of PEV and charging infrastructure deployment.

TARGETED EDUCATION AND OUTREACH

Key Recommendations

Reach out, engage, and educate relevant stakeholders

Identify funding opportunities

Identify AFV grants and other funding opportunities for fueling infrastructure development.

Engaging community stakeholders is vital to the success of any initiative, especially AFV use. Community members need to understand the rationale behind the readiness planning effort, recognize the opportunities and benefits of increased AFV use in their community, and participate in making the vision a reality. A successful outreach campaign will require tailoring messaged to different audiences using an array of media types. Although executing this recommendation will require some upfront financial resources and staff time to prepare materials and conduct outreach, over the long run it could be relatively low cost and could be highly impactful if done

Volkswagen Clean Air Act Settlement

The VW Settlement established two programs that may result in AFV deployment and infrastructure support in the NJTPA region.

1. **ZEV Investment Plan:** VW, through a newly formed entity called Electrify America, will install, operate, and maintain ZEV infrastructure nationwide, initially focusing on 11 major metropolitan areas. Electrify America has committed to the following activities in the NYC metro area, which includes northern New Jersey:
    - Level 2 charging installation at MUDs, workplaces, and public sites;
    - DC fast charging facility installation on highway and other transportation corridors; and
    - Education and outreach that builds or increases public awareness of ZEVs.
2. **Environmental Mitigation Trust:** The State of New Jersey is eligible to receive and use approximately $72 million in funding through this trust. While the specific program in New Jersey has yet to be established or implemented, these funds could be used to replace polluting diesel equipment with cleaner vehicles, including local freight trucks, transit buses, school buses, shuttle buses, and refuse trucks. A certain portion of these funds could also be used to install PEV charging stations.

For more information, see www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement.

thoughtfully. For example, housing all of these resources in one place online will enable stakeholders to seek out the information versus only learning through active outreach.

It is critical to tap all actors early for input into the readiness planning effort, and circle back with any outcomes and to address any education and training needs. In fact, continuous engagement following the initial readiness planning effort is integral to keeping the key players accountable.

The following sections provide recommendations for outreach, education, and engagement targeting specific stakeholder groups.

As a municipality proceeds with implementation, it is important to track funding opportunities that may assist the community, stakeholders, and other partners with progress toward infrastructure development goals and targets. The AFDC Laws and Incentives website is a comprehensive resource for information about relevant funding sources and incentive programs administered at the federal, state, and local levels, as well as by utilities. Outside of the AFDC, municipalities can reach out to the local Clean Cities coalition, and staff at key state or regional agencies (e.g., NJTPA, NJDEP, NJBPU) to learn more about incentives. In addition to monitoring the AFDC database, other funding opportunities may emerge over time. These include state-level programs funded through the Volkswagen (VW) Clean Air Act Settlement (see box at left). The NJDEP established a website to provide more information specific to New Jersey.

Residents

While PEVs are gaining more attention, most residents will have questions about how they work, how much electricity they draw while charging, and how much it costs to fuel them. Even more questions will arise related to other alternative fuels, as public knowledge may be even more limited. A municipality can provide basic information such as simple fact sheets, utilizing resources available from the AFDC, the NJCCC, or Sustainable Jersey.

Housing resources in one place online will enable residents to seek out the information versus only being the recipients of active outreach. If a municipality has access to existing distribution channels, such as environmental listservs or forums like Greenable Woodbridge, it can leverage those to reach the community. Community

events, particularly those focused on sustainability, are another way to reach residents willing to learn about adopting alternative technologies in order to reduce their personal footprint. Engaging residents at these events may require municipalities to develop a poster or table-top display. These materials can also be used in more general settings, such as shopping malls, or regular gatherings, such as farmer's markets, which provide low-cost access to residents. Municipalities can also draw upon the assistance from the TMAs.

Additionally, consider efforts to target younger generations, such as student drivers, in order to change their mindset regarding miles driven per day and the reliability of AFVs for their daily transportation needs. This education may ease concerns about charging station availability, for example, and whether PEVs can fit into their lifestyle.

Multi-Unit Dwelling Property Managers

The NJTPA region includes many residents that own or rent property in MUD developments, where they might have a dedicated parking space but do not technically own the property on which they park. This presents unique challenges for PEV owners seeking to access a PEV charging station at their home, as discussed earlier in the guidebook. Residents of MUDs are often overlooked for targeted awareness and education activities related to PEVs because it is not often within a resident's power to install charging infrastructure. In areas where a significant portion of the population resides in MUDs, the municipality can have a very tangible impact on PEV deployment by creating materials to inform property managers and HOAs or boards about the overall benefit of providing the spaces, as well as key considerations.

A municipality can work with MUD stakeholders to develop policies that allow residents to install PEV charging infrastructure or provide shared charging for residents.

The MUD demand analysis can help a municipality prioritize specific developments and areas for outreach and engagement. Additional and future demand for MUD charging will be driven by new developments and significantly renovated buildings that may draw higher income tenants, as PEV charging may be an attractive amenity to current and future tenants.

See the resources in Appendix E, which are specific to MUDs in New Jersey.

Businesses and Employers

Because most municipalities have limited opportunities and resources to install publicly-accessible PEV charging infrastructure on public land, it is important for local landowners to understand how they can contribute to the charging network. A municipality can work with the TMA to reach out through existing networks to education and partner with businesses and employers that can provide public or workplace charging. In commercial areas, in particular, it will be important to have both options, so that employees are not occupying space designated for the public or vice versa.

Public Charging

A municipality and its local businesses should actively seek support in developing a robust charging station network that will ensure visitors can easily reach the town and residents without home charging can access nearby charging options for their PEVs. This will both ease range anxiety and maximize the number of miles driven in electric mode.

Providing data on public charging demand can help start the conversation with businesses and other organizations in a position to host public charging infrastructure. The municipality can share with them the results of its PEV charging siting analysis discussed earlier in the guidebook. The same siting analysis results can help the municipality determine which areas to target. The municipality should

Photo by Mike Simpson, NREL 18873

reach out to these retailers and other businesses to explain that PEV charging stations can be amenities that help draw customers, and ultimately, pose opportunities to grow the local economy through increased visitor traffic and community spending. The business case or return on investment for public charging is not always obvious, so a municipality may need to help a potential site host understand the challenges and benefits (see the Identify Gaps and Understand Barriers section above). For example, a station host should not focus exclusively on the revenue they collect from the stations via fees, they must also consider the added value of having the station on the property.

If the municipality has the means to installing charging infrastructure for use by residents and visitors, it could consider locations such as community centers and municipal parking lots. The municipality should consult demand analysis results to identify areas of high public charging demand and also consider how to make PEV charging accessible to MUD residents during off-peak times.

Workplace Charging

Providing data on workplace charging demand can help motivate workplaces to gauge employee demand and eventually install infrastructure. Similar to the approach for public charging, the municipality can share with employers the results of its PEV charging sitting analysis discussed earlier in the guidebook. It is recommended that the municipality focus outreach on employers located in employment centers since demand will likely be highest in those areas. While any employer with adequate demand is a good candidate for a workplace charging program, businesses with a sustainability or technology focus, universities, healthcare facilities, and utilities have had particular success. Large corporations and municipal, state, and federal government offices are also candidates for workplace charging. Organizations that own their property may have an easier time installing workplace charging, though leasing companies are often willing to work with tenants to meet employee charging needs.

In addition to highlighting the demand for charging infrastructure, the municipality can raise employer awareness about resources on workplace charging. For example, the AFDC's Workplace Charging for PEVs website has information for employers on evaluating and planning for workplace charging, installing workplace charging, managing workplace charging, and engaging employees. Also see the workplace charging program development discussion earlier in the guidebook. Employers will need to gauge demand (current and future) and consider the logistics of providing charging equipment, including the etiquette for moving vehicles once the charging

EXAMPLE: Workplace Charging

Photo by Bayshore Recycling

Valerie Montecalvo, President and CEO of the Bayshore Family of Companies, charges a PEV using workplace charging. Bayshore Recycling is one example of a company championing workplace charging in the NJTPA region. Bayshore Recycling received a $5,000 grant from the NJDEP to install a Level 2 workplace charger at its facility in Keasbey, part of Woodbridge Township.

Public-Private Partnerships

Municipalities should team up with business improvement districts (BIDs) to increase awareness about PEV charging stations among local businesses and coordinate efforts to build out infrastructure. The BID is typically in a position to convene business representatives, serve as a liaison between those interests and the municipality, and distribute factual information about the benefits and business case.

session is complete. They will also need to understand the approval process for new development versus existing development installations, and what activities would require a permit or approval from the local planning board versus being done independently. The TMA can serve an important role in this education process, reaching out to its network of employers to provide factual and relevant information.

An employer that has an environmentally-focused mission or strong sustainability initiatives may be priority targets for outreach by the municipality. These organizations are typically more proactive in terms of actions that can help reduce the company's carbon footprint. It is also important to engage high-level decision makers so they can understand the benefits of workplace charging and support decisions to move forward. (See example of Bayshore Recycling in box on previous page.)

A municipality can play an important role in accelerating regional AFV adoption by helping local businesses identify and pursue grant funding, both for AFVs and for workplace and fleet fueling/charging infrastructure. Once a municipality conducts a siting analysis specific to workplace charging demand, it can show it has taking a thoughtful and data-driven approach to identify particular facilities that are well suited for charging stations. In addition to equipment and installation, funding could also be used for workshops, trainings, outreach campaigns, and events that support workplace charging and fleet use of AFVs. These may be specific to one community, or coordinated with other municipalities in the region to conserve costs and increase the reach and impact.

Developers and Builders

It is critical to educate developers and builders on how they can include PEV charging infrastructure when planning and constructing new developments. More specifically, single-family garages and MUD parking lots should be wired for Level 2 charging and commercial buildings should ideally be wired for DC fast charging, where appropriate. Pre-wiring can help developers avoid unnecessary costs later on. Anecdotal industry experience indicates the cost to pre-wire a space for Level 2 charging during construction is several hundred dollars compared to thousands of dollars if the required upgrade is done once construction is completed.

> An employer that has an environmentally-focused mission or strong sustainability initiatives may be priority targets for outreach by the municipality. These organizations are typically more proactive in terms of actions that can help reduce the company's carbon footprint.

A significant portion of residents in the NJTPA region reside in MUDs, and providing these residents with convenient access to PEV charging is a key challenge discussed earlier in the guidebook. MUD developers are therefore particularly high priority targets for education and outreach. Commercial developments can provide workplace and public charging opportunities, making them priority targets as well. Developers and builders need to understand the approval process for new development versus existing development installations, and what activities would require a permit/approval from the local planning board versus being done independently. The municipality can facilitate this discussion by providing guidance materials that address questions specific to PEV charging infrastructure development.

Strategic outreach can take additional time, but it can also be highly impactful. The MUD and public charging demand maps (mentioned earlier in the guidebook) will help a municipality prioritize target developments and areas. See the resources in Appendix E, which are specific to MUDs in New Jersey.

Fleet Managers and Vehicle Maintenance Technicians

Public and private fleets can provide opportunities for AFV introduction. However, fleets often require assistance navigating and weighing the various considerations associated with AFV ownership as compared to conventional vehicle ownership. For this reason, information sharing can encourage investment in AFVs among corporate and government fleets alike.

A municipality can provide educational resources to fleet managers to educate them regarding the total cost of AFV vehicle ownership, operating considerations, and station installation costs and guidelines. The AFDC is a comprehensive starting point for this information,

Engaging Private Fleets

Collaboration with local fleets is integral to readiness planning. Because the individual consumer has extremely limited access to natural gas, hydrogen and other fueled passenger vehicle models, fleets are at the forefront of development and are providing real-world examples of how alternative fuels can be used effectively on a long-term, large-scale basis. As part of readiness planning efforts, the project team should collect input from local fleets, specifically high-mileage medium- and heavy-duty fleets.

covering all fuel and vehicle types, and includes information on technician training and other topics.

In the case of electrification, since most PEVs available today are passenger cars, near-term focus should include reaching out to fleets that use light-duty vehicles, such as car service fleets or those that provide campus security. As more medium- and heavy-duty PEV technology develops, the municipality can provide additional resources that draw upon best practices and lessons learned from local and regional case studies of fleets deploying such vehicle models. The opposite is true with NGVs; most natural gas technology is currently for use in medium- and heavy-duty vehicles. The municipality should therefore focus NGV outreach on medium- and heavy-duty fleets in the near-term, which may include shuttle buses and vans and trash collection and recycling fleets.

Fleets often require assistance navigating and weighing the various considerations associated with AFV ownership as compared to conventional vehicle ownership. Beyond providing educational materials to fleet managers, the municipality may consider organizing or funding technical assistance and training workshops for local fleet managers. For example, the National Alternative Fuels Training Consortium (NAFTC) offers a wide range of courses and workshops geared towards fleet managers, automotive technicians, and others. Their trainings are offered in both traditional classroom settings and in online formats, and they provide an understanding of the vehicle type, safety issues, operating costs, and vehicle efficiency. The NAFTC is willing to work with municipalities to tailor their courses or workshops for a particular setting. Additional information about the NAFTC course offerings, including a course schedule, can be found on the NAFTC website.

Local governments and fleet managers can also take part in trainings offered by Clean Cities coalitions. For example, the NJCCC has hosted numerous workshops and delivered presentations on a variety of issues related to the range of AFVs and infrastructure.

A fleet considering AFVs will need to understand whether new fueling infrastructure is needed or if there are existing stations available for use. The municipality can help the fleet identify public stations in the area and speak with local fleets amenable to an infrastructure partnership. There are various ownership models associated with fueling infrastructure, as discussed earlier in this guidebook.

Emergency Responders

AFV readiness cannot be accomplished without support from local institutions most immediately affected by a shift to AFVs. Providing training to key personnel – including emergency responders – will arm these individuals and teams with the tools necessary to carry out their responsibilities in an AFV-ready community.

Training first responders will ensure that safety procedures are in place in the case of any AFV or charging/fueling station-related emergency. There are several detailed resources and trainings already available to emergency responders. The most comprehensive training that is widely accessible to emergency responders is the National Fire Protection Association (NFPA) Alternative Fuel Vehicles Safety Training Program, which includes online training and an emergency field guide.

The municipality should consider reaching out to local police, state troopers, sheriff's deputies, fire departments, EMTs/paramedics, tow operators, and others to make them aware of these resources. Additionally, the NJCCC may be able to help organize a training event for emergency responders, as they have in several other locations.

Inspectors and Other Local Officials

Providing inspectors and other local officials with basic information about AFV fueling and PEV charging stations and installations will help ensure these staff can provide property owners and site hosts with additional information about safety practices and other requirements. Similarly, inspectors would benefit from access to factual information and relevant details specific to each municipality (e.g., public fueling and charging locations) since they interface with residents, businesses, and others. A municipality may consider organizing an educational session focused on codes, safety, standards, site assessments, electric load calculations, permitting processes, and utility notification.

Municipalities can partner with organizations to provide training, if necessary. The Electric Vehicle Infrastructure Training Program (EVITP) offers courses that train and certify electricians to install PEV charging stations, including a curriculum especially tailored for local government staff and stakeholders. Alternatively, there may be local staff from neighboring jurisdictions with experience from working on various types of projects who can provide a peer training workshop. Additionally, the DOE Clean Cities program produced a series of YouTube training videos on residential PEV charging station installation. Key information for training includes codes, safety, standards, site assessments, electric load calculations, permitting processes, and utility notification.

Training inspectors and other local officials is an area where regional planning authorities might step in to fund a workshop for permitting staff from each municipality in the region. Municipalities should also collaborate with neighboring communities to create an ongoing region-wide schedule of training and outreach events so that stakeholders can stay informed on opportunities across the region.

Dealerships

Dealership engagement and training results in a more educated vehicle salesforce, more likely to accurately and effectively promote the vehicles and the associated benefits. If AFV buyers have a positive experience, it will assist in the continued spread of AFV use. While only FFVs and PEVs are currently sold at traditional dealerships, fleets purchasing NGVs and propane vehicles will likely interact with OEM sales staff at some point.

In collaboration with dealerships, the municipality could consider developing a system to monitor AFV readiness by tracking purchases. The uptake of AFVs should be continually monitored – through leveraging relationships with local dealerships to determine which of the medium- and long-term readiness actions to prioritize and the appropriate level of additional funding needed to achieve AFV goals.

Photo by Dennis Schroeder, NREL 28369

Track, Revisit, and Update

Emerging technologies, government policies, and changing consumer preferences may impact AFV demand and related infrastructure needs, such as continued increase in car sharing and ride hailing services, the introduction of connected and autonomous vehicles onto public roadways, and advancements in AFV technology that can make vehicles cheaper and more attractive to consumers. To that end, municipalities should periodically review the market demand for AFVs and related infrastructure needs, updating the infrastructure siting analysis as appropriate.

Now What?

This guidebook contains a wealth of information regarding AFV readiness planning, including the steps a municipality can take to turn this guidance into an action-oriented readiness plan. There are numerous technical assistance resources in a position to provide municipalities with support and direction, including:

- The NJTPA and other MPOs
- Sustainable Jersey
- The NJCCC

In addition to the examples and case studies highlighted throughout the guidebook, municipalities should refer to the appendices for additional information. More specifically:

- Appendix A includes key resources organized to correspond with the focus areas presented in the guidebook.
- Appendix D was adapted from the DOE's Clean Cities program and provides links to relevant PEV readiness resources.
- Appendix E provides a snapshot of resources for MUD managers, HOAs, boards, and residents interested in PEV charging.

Appendices

Photos by (clockwise, from top left): Dennis Schroeder, NREL 31343; John De La Rosa, NREL 27783; Austin Marie Sipiora, NREL 43162; Matthew Staver, NREL 39250

Appendix A: Key Resources

General/Overarching:

- DOE's AFDC
- NJDEP's Clean Vehicles
- ChargEVC's Roadmap for Vehicle Electrification in New Jersey
- DVRPC's Energy and Climate Change Initiatives
- Transportation & Climate Initiative (TCI)
- New York State Energy Research and Development Authority's (NYSERDA) Electric Vehicles

Infrastructure Design, Siting, and Selection:

- DOE's PEV Handbook for Public Charging Station Hosts
- DOE's Handbook for Handling, Storing, and Dispensing E85 and Other Ethanol-Gasoline Blends
- DOE's Biodiesel Handling and Use Guide
- NYSERDA's Siting and Design Guidelines for Electric Vehicle Supply Equipment
- Chittenden County (VT) Regional Planning Commission's EV Charging Installation Guide
- California Energy Commission-funded Electric Vehicle Charger Selection Guide
- NGVAmerica's CNG Station Design
- Propane Education & Research Council's Refueling page
- AFDC Infrastructure Development pages (e.g., Hydrogen Infrastructure)

Municipal Fleet Actions:

- Fleets for the Future
- EV Smart Fleets

Education, Outreach, and Training:

- Tahoe-Truckee Tools for Users (PEVs)
- DOE eGallon (PEVs)
- NFPA AFV Safety Training

Appendix B: Recommended Plug-in Electric Vehicle Forecast Methodology

Typically, this type of analysis has a 10-20 year outlook into the future. A municipality should choose a timeframe that aligns with its regional transportation plans for consistency and potential integration.

- **Step 1: Collect existing vehicle sales and vehicle stock data.** The NJDEP can provide PEV registration data upon request. New vehicles sales data can typically be retrieved from the National Automobile Dealers Association (NADA), available at the national and state levels. Vehicle registration totals are also available online via the ZEV Sales Dashboard, maintained for the Auto Alliance; the website provides a breakdown of ZEVs by vehicle architecture, including BEVs, PHEVs, and FCEVs. Note that data sources differ and may present a range of estimates.
- **Step 2: Develop analysis scenarios.** There are a variety of factors that influence the adoption of PEVs. With market outlooks, a best practice is to develop multiple scenarios that provide a range of expected PEV deployment depending on different variables and parameters such as economic growth, fuel pricing, vehicle pricing, and consumer behavior. These scenarios should take into consideration relevant policies and programs that influence the PEV market. The table below shows the three different scenarios developed for the NJTPA pilot municipality readiness plans.

Scenario	Description
Low	Reflects adoption trends comparable to the Reference Case in the U.S. Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2016, adjusted slightly for increased potential indicated in the Mid-Atlantic region.[26] (See step 3 below for more details on this data set.)
High	Assumes that PEV adoption rates will be consistent with the Zero Emission Vehicle (ZEV) mandate in place for New Jersey,[27] with a fair-share assumption (i.e., that ZEV deployment will occur in the state on a population-weighted basis in the long-term).
GHG Stretch	The PEV strategy of the NJTPA Regional GHG Mitigation Plan calls for a 60 percent market share of PEVs by 2040 to meet state goals. The GHG stretch scenario assumes that PEV adoption rates will be slightly lower than the plan, with a 50 percent market share by 2040.

26 Using the AEO as a base for forecast provides the benefit of transparency and consistency with national-level assessments. Further, the amount of data that is required to conduct a locally specific forecasting exercise is generally prohibitive. Lastly, the data are something that can be updated annually and modified by stakeholders easily, rather than relying on some proprietary methodology.

27 ZEV programs aim to increase sales of ZEVs, which include PEVs and FCEVs, by requiring that some portion of vehicle manufacturer sales in the state be ZEVs. More information on New Jersey's ZEV mandate is available online at http://www.nj.gov/dep/cleanvehicles/LEV.pdf.

- **Step 3: Apply assumptions and data for the low scenario.** The low scenario uses data trends from the AEO 2016. The AEO provides modeled projections of domestic energy markets through 2050, and includes cases with different assumptions of macroeconomic growth, world oil prices, technological progress, and energy policies. Within these data sets, which can be downloaded from the EIA website, are information on light-duty vehicle stock by technology type. Of relevance to this analysis is the PHEV10, PHEV40, BEV100, and BEV200 (the four types of PEVs included) for the Mid-Atlantic region and the national totals in the Reference Case. From this data, a municipality can apply regional percentages of the existing vehicle stock (NADA and vehicle registration data) to determine a specific municipality's share of the total forecasted PEV stock.

- **Step 4: Apply assumptions and data for the high scenario.** The high scenario assumes that each municipality in New Jersey will achieve its own fair share of the state's ZEV mandate. The state has set out ZEV compliance paths in the New Jersey Low Emissions Vehicle Program requirements, which can be applied to the jurisdiction's share of the AEO new vehicle sales projections.
- **Step 5: Apply assumptions and data for the GHG stretch scenario.** For the GHG stretch scenario, the municipality can choose PEV adoption rates based on its regional or local plans and goals. To be consistent with the NJTPA Regional GHG Mitigation Plan, this would entail applying a 60 percent market share of PEVs to the projected existing vehicle stock by year 2040.

Appendix C: Recommended Charging Infrastructure Demand Analysis Methodology

DATA NEEDS

To conduct a charging infrastructure demand analysis, a municipality will need access to the following data:

- Demographic information from the American Community Survey (ACS) for the region on the census block group (CBG) level. This includes median household income, home ownership rates, and dwelling types (e.g., single family, multi-family).
  - Data source: U.S. Census Bureau's ACS website.
- HEV ownership counts and total vehicle counts for each CBG within the region.
  - Data source: The NJDEP maintains AFV and HEV registration data, coordinating with the NJMVC to provided updated statistics twice a year (January and July). A spreadsheet containing this data is available upon request by sending an email to drivegreen@dep.nj.gov, using the subject line "Vehicle Registration Data Request."
- Regional travel model data. Data needs to indicate the number of trips between various traffic analysis zones (TAZs) in the region for different purposes, such as commuting (home-based work trips) and shopping, running errands, and dining (home-based other trips). The municipality will also need the maximum distance between each TAZ. Regional travel modelers can also provide a translation of TAZs to CGBs so the ACS demographic data can be applied at the TAZ level.
  - Data source: The applicable MPO.

METHODOLOGY

The following methodology was used to develop the charging infrastructure demand analysis for the NJTPA study, which focused on three pilot municipalities.

The first step is to identify where PEVs owners are most likely to live, which requires identifying the likely PEV adopters. The infrastructure demand analyses are largely based upon the foundational data points of the NJTPA region's current and likely PEV ownership.[28] Socio-economic data were extracted from the ACS (five year estimates). These data are available at the CBG level and include income, tenure or property ownership, and dwelling type. The analysis also relies on vehicle registration, particularly of HEVs. The key parameters used to develop the charging infrastructure siting analysis were:

- **Income.** Market research on early adopters of PEVs suggests that households with higher incomes are more likely to purchase a PEV. Because these vehicles tend to have higher upfront costs, income can be a limiting factor and individuals with a low income might not be able to afford a PEV. Furthermore, higher income households generally buy a disproportionate share of new vehicles across all market segments and vehicle types.
- **HEV ownership.** There can be long-term fuel savings associated with HEV (and PEV) ownership, which is one of the main reasons some might invest in such a vehicle. However, research shows that households who value the non-economic (e.g., environmental) benefits of HEVs are more likely to purchase PEVs, particularly in the early adoption phases. Many HEV owners have shown a willingness to pay to reduce gasoline use that goes beyond the economic benefits of using an HEV. A Ford Motors representative noted that typical Focus Electric buyers have purchased HEVs in the past.[29] Research from the University of California, Davis (UC-Davis) supports this assumption: 68.3 percent of

28 There are multiple overlapping geographies considered in the charging infrastructure siting analysis. For instance, vehicle ownership data are provided at the ZIP code level; socio-economic indicators are provided at the CBG level; and trip data are generated for TAZs. These overlapping geographies can lead to uncertainty in the analysis; however, the analysis typically relies on values as percentages rather than absolute numbers. This approach generally minimizes uncertainty. Furthermore, this makes the analysis less sensitive to changes on a time scale less than a year. For instance, if a municipality obtains PEV ownership at six-month intervals, and seeks to update the analysis, it is unlikely it will observe substantive changes in the results.

29 Mike Tinsky, Associate Director, Sustainability and Vehicle Environmental Matters, Vehicle Electrification and Infrastructure, Ford Motor Company. Phone interview, April 9, 2012.

PEV owners surveyed either own or have owned an HEV and locations of HEV owners correlate with locations of PEV owners.[30]

- **Home ownership.** Households who own their property are more likely to purchase a PEV than those who rent, according to market research by Nissan and Chevrolet and surveys by UC-Davis and California's Clean Vehicle Rebate Project recipients. Home ownership reduces both financial and non-financial barriers to charging infrastructure deployment.
- **Dwelling type.** Dwelling type (i.e., single-family detached, single-family attached, or MUD) can help indicate PEV ownership. Consumers with a single-family detached home generally have fewer barriers to PEV adoption as they usually have access to a garage or driveway. Consumers living in MUDs are more likely to encounter barriers to installing chargers (e.g., limited space for infrastructure installation, home owners' association restrictions, installation costs for trenching, additional metering requirements, power availability).[31]

The charging infrastructure siting analysis leverages Origin-Destination trip tables from NJTPA, which indicate the number of trips from an origin TAZ to a destination TAZ.[32] Trip types include home-based work (HBW), home-based other (HBO), and non-home non-work (NHNW) trips.

The readiness plans include the mapped results of each infrastructure demand analysis – residential, MUD, workplace, and public/opportunity charging. Each demand type is presented separately (e.g., the rankings are not combined). The maps include five levels of shading, based on the percentile of each TAZ's score relative to the entire NJTPA region, and ranked as shown in the table below.

Level of Demand Scores and Percentiles

Scoring	Percentile	Demand
1	0 – 40%	Low
2	40 – 60%	Low/Medium
3	60 – 80%	Medium
4	80 – 95%	Medium/High
5	95 – 100%	High

The resulting maps help to visualize the demand by assigning a different color to each score or category. Areas shown as warmer colors represent higher demand for charging while the cooler colored areas rank lower for charging demand. Each separate area is a TAZ. The rankings and corresponding colors are based on the TAZ's demand score relative to the entire NJTPA region. For example, a TAZ ranked high on the workplace charging demand map means that area scored in the top 5 percent for workplace charging demand across the NJTPA region. Similarly, a TAZ with a public charging ranking of low scored among the bottom 40 percent for public charging in the region.

Residential Charging

The residential charging demand analysis (associated with both HBW and HBO trips) relies exclusively upon socio-economic data for each TAZ. This data determined a General Residential Charging (ResGeneral) Score, which is directly correlated with residential charging infrastructure demand. As such, no trip data was incorporated into this assessment.

30 Gil Tal, Michael Nicholas, Justin Woodjack, Daniel Scrivano, Tom Turrentine, Plug-in Hybrid and Electric Vehicle Research Center of the Institute of Transportation Studies, University of California, Davis. Plug-In Vehicles in the San-Diego Region: A Spatial Analysis of the Demand for Plug-In Vehicles. Presented by Gil Tal, May 9, 2012, at EVS 26, Los Angeles, CA.

31 Graham, R.L., J. Lieb, J. Sarnecki, R. Almazan, B. Neaman. Wise Investment in Electric Vehicle Charging Infrastructure through Regional Planning. EVS26 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium, 2012.

32 The socio-economic data are scored at the CBG-level and the trip data are available at the TAZ level. NJTPA staff provided a look-up table linking each CBG with a TAZ.

The socio-economic indicators explained above were scored with different weighting factors, which were linked to survey and market research of PEV owners and based heavily on California's extensive PEV ownership data. These factors contributed to a ResGeneral Score:

$$\text{ResGeneral Score} = \sum \propto \text{Income}, \beta \text{HEV\_Ownership}, \gamma \text{Tenure}, \delta \text{DwellingType},$$

where

$$\alpha + \beta + \gamma + \delta = 1.$$

Each weighting factor was based on the level of correlation associated with PEV ownership to date, and each factor is skewed towards the first two parameters: income and HEV ownership. The latter two factors – tenure and dwelling type – were used to differentiate amongst areas with higher potential.

The most critical parameter in this infrastructure siting analysis is income, which accounts for 60 percent of the scoring. To integrate this factor, CBGs were scored against one another by comparing the share of different income groups. This provides more granularity to the analysis than simply comparing median incomes.

The second most prominent parameter in the analysis is HEV ownership, which accounts for 30 percent of the scoring. This analysis compared the percent of HEVs owned in each CBG against the percent ownership of HEVs in that CBGs municipality and against the entire state of New Jersey. CBGs scored higher in the analysis if they had HEV ownership higher than the state median.

The tenure parameter represents the rate of home ownership relative to the median rate of home ownership for the state of New Jersey. Based on survey data and PEV market research, home ownership as a percent of the number of residential units available in a given area are short- to mid-term indicators for PEV ownership but are less effective indicators over the long-term. For this reason, the tenure parameter accounts for 5 percent of the total score. Additionally, these parameters were used exclusively to differentiate amongst areas with better than median income and HEV ownership profiles. In other words, if an area did not have a higher than median income but did have a higher than median rate of home ownership, the home ownership factor would not impact the ResGeneral Score. However, for areas with a similar median income and/or HEV ownership profile, a higher rate of home ownership would yield a higher ResGeneral Score.

For the final parameter, dwelling type, areas were scored based on the rate of single-family units relative to the median rate of single-family units. This parameter also accounts for 5 percent of the total score and a higher rate of single-family units yields a higher ResGeneral Score.

Multi-Unit Dwelling Charging

This analysis includes a new metric to estimate the likely demand for charging at MUDs. This metric was developed by using the same approach as outlined previously for the residential charging estimates, however, the value of the weighting factor for dwelling type, δ,[33] and the structure of the scoring were modified to favor areas with above median income, above median hybrid ownership, and a high share of MUDs (instead of a higher rate of single family units).

Workplace Charging

To forecast the likely demand for workplace charging infrastructure, the results of the residential siting analysis were combined with regional travel demand data to determine the TAZs within the municipality that have the highest number of trips originating from TAZs with the highest likelihood of PEV ownership. The analysis relied upon an output matrix from the NJTPA's travel model, referred to as origin-destination trip tables for home-based work trips. The trip originating from TAZ_O was multiplied by the score determined in the residential siting analysis, $\text{ResGeneral Score}_O$. The likelihood of workplace charging is simply correlated with the number of trips concluding at the workplace destination TAZ_D. The letters O and D represent origin and destination.

33 The weighting factor for dwelling type was increased to 25% from 5%, and the weighting factors for income and hybrid ownership were decreased to 50% and 20%, respectively. These changes are more subjective than the analysis behind the residential siting analysis, and it is important to update these values as the demand for charging at MUDs is better understood.

Public Charging

In the long run, public charging (also referred to as opportunity charging) will consist of predominantly Level 2 and DC fast charging,[34] with Level 2 being the charging type most feasible for municipalities to install and support. For this reason, the forecast for public charging focuses on Level 2 charging, using a methodology similar to the workplace charging analysis. However, instead of multiplying the ResGeneral Score by HBW trips, it is multiplied by HBO trips, which served as a proxy for public charging.

34 The Association of Electrical and Medical Imaging Equipment Manufacturers (NEMA). "EVSE: Powering the Electric Vehicle." https://www.nema.org/Products/Documents/nema+evse+presentation+for+communities.pdf. Accessed February 1, 2017.

Appendix D: Plug-in Electric Vehicle Community Readiness Resources

This information was adapted from a collection of resources compiled by the DOE's Clean Cities program, focusing on tools, documents, websites, and other information available via DOE's Office of Energy Efficiency and Renewable Energy.

DOE EV Everywhere Electric Vehicles: Stakeholder Solution Center

STATES AND MUNICIPALITIES

States and municipalities are key players in increasing PEV readiness. The best way for states and municipalities to improve their PEV readiness is to partner with their local Clean Cities coalition, which can connect them to specific regional resources and other relevant stakeholders.

- Plug-in Electric Vehicle Readiness Scorecard: Hosted on the AFDC, the Scorecard allows communities to assess their readiness, receive feedback about ways to improve, read about best practices, and record progress.
- Guide to the Lessons Learned from the Clean Cities Community Electric Vehicle Readiness Projects: This guide, which is on the DOE Clean Cities website, summarizes the best practices in streamlining permitting processes, revising codes, training emergency personnel, developing incentives, and educating the public based on the experiences of 16 PEV readiness projects across the country.
- Reports from the Clean Cities' EV Community Readiness Projects: These are individual reports and community readiness plans from each of the projects, hosted on the Clean Cities website. (See list of projects in chart, below).
- Zoning, Codes and Parking Ordinances: This page on the AFDC links to relevant NIST codes for electric vehicle charging.
- Handbook for Public Charging Station Hosts: This handbook on the AFDC provides an overview for what cities hosting public charging stations need to know before installation.
- Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools: Published by the Transportation and Climate Initiative, this guide provides information on the steps to create, administer, and amend planning processes, rules and regulations, including in zoning, parking, and permitting.
- EV-Ready Codes for the Built Environment: This guide, published by the Transportation and Climate Initiative, provides an overview of building and electrical codes as relating to PEVs, as well as providing recommendations specific to jurisdictions in the Northeast and Mid-Atlantic.
- Training on PEVs for First Responders through the National Alternative Fuels Training Consortium and the National Fire Protection Association provides essential education to firefighters, police officers, EMTs and others that may need to respond to accidents involving PEVs.
- Drive Electric Vermont Case Study: This case study examines the opportunities and barriers to enabling small and midsize communities to partake in the PEV market and benefit from the economic and environmental advantages of the vehicles.

EMPLOYERS

Providing charging at the workplace can encourage employees to purchase PEVs, be an attractive employee benefit, and maximize all-electric miles driven by PEV owners. The EV Everywhere Workplace Charging Challenge was a DOE program to encourage and recognize employers providing workplace charging.

- Resources to Install and Manage Workplace Charging
- Handbook for Workplace Charging Hosts

FLEETS

Like consumers, fleets can benefit from the low operating costs and other benefits associated with PEVs. Local Clean Cities coalitions can help fleets decide which technologies and models will be most appropriate to meet their needs.

- Handbook for Fleet Managers: This handbook on the AFDC provides fleet-specific information on the basics of PEVs, including issues like maintenance and charging.
- Plug-in Electric Light, Medium and Heavy-Duty Vehicle Search: This tool on AFDC provides information on PEVs that can be filtered by class/type and manufacturer.
- AFLEET Tool: Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation Tool allows fleet managers to calculate the cost of ownership, petroleum use, GHG emissions, and air pollutant emissions of AFVs.

ELECTRICAL CONTRACTORS AND INSPECTORS

The installation of residential, workplace and public charging is essential to establishing a PEV market.

Electric Vehicle Infrastructure Training Program: This program provides training and certification at community colleges and electrical training centers across the United States for people installing PEV charging equipment for residential and commercial markets.

EVSE Residential Charging Installation Video: A series of segments on the Clean Cities TV YouTube channel walk electricians through the basics of installing PEV charging infrastructure in homes, including an overview of the equipment, the relevant National Electrical Codes, inspection, and best practices.

UTILITIES

Through a partnership with the Edison Electric Institute, DOE is developing a suite of tools for utilities to support the use of PEVs.

- The Utility Guide to Plug-in Electric Vehicle Readiness: A guide from the Edison Electric Institute, this document covers structuring your company to support PEVs, adding PEVs to utility fleets, enhancing the customer experience, working with state and local governments, and managing the electrical grid with PEVs.
- Utilities Power Change: This case study showcases how PSE&G and Southern Company's unit Georgia Power are launching workplace charging programs for their commercial customers.

ADDITIONAL RESOURCES

At A Glance: Electric-Drive Vehicles

Charging Plug-In Electric Vehicles in Public

Charging Plug-In Electric Vehicles at Home

Resources for Electrical Contractors and Inspectors

Developing Infrastructure to Charge Plug-In Electric Vehicles

Plug-In Electric Vehicle Deployment Policy Tools: Zoning, Codes, and Parking Ordinances

Signage for Plug-In Electric Vehicle Charging Stations

Plug-In Electric Vehicle Handbook for Consumers

Workplace Charging: Charging Up University Campuses

Electric Vehicle Charging for Multi-Unit Dwellings (webpage with links to resources and case studies)

Massachusetts Plug-in Electric Vehicle and Charging Infrastructure Case Study

Rolling Down the Arizona EV Highway (case study)

San Diego Prepares for Electric Vehicles in Multi-Unit Dwelling Communities (text version and video)

Houston Energizes Deployment of Plug-In Electric Vehicles (case study)

Seattle Rideshare Fleet Adds EVs, Enjoys Success (case study)

Alternative Fuels Data Center Publications (search by keyword for additional resources)

Appendix E: Multi-Unit Dwelling Plug-in Electric Vehicle Charging Resources

KEY WEBSITE

- AFDC Electric Vehicle Charging for MUDs

  Includes links to guides, case studies, and other websites.

ADDITIONAL GUIDANCE DOCUMENTS

- Install Electric Vehicle Charging Stations in MUDs
- How to Install Electric Vehicle Charging Stations at MUDs
- Increasing Electric Vehicle Charging Access in MUDs in Los Angeles
- Charging at Condos, Apartments and Community Living Areas
- How to Create an Effective Condo Association Electric Vehicle Policy

ADDITIONAL CASE STUDIES

- Overcoming Barriers to Electric Vehicle Charging in MUDs: A South Bay Case Study
- ChargePoint Customer Stories

NEW JERSEY-SPECIFIC INFORMATION

- NJ Cooperator Article: Electric Revolution On the Horizon?
- MUDs Advertising PEV Charging as an Amenity
  - Dwell Luxury Apartments (http://www.dwellcherryhill.com/amenities.php)
  - Lincoln Apartments (https://www.lincolnapts.com/properties/montclair-residences-at-bay-st-station-montclair-nj/amenities)
  - Madox Apartments (http://www.madoxapts.com/amenities/)
- Other MUDs with Charging Stations
  - Based on data from networked charging station companies (as of September 2017)

Property	Address	City	Website
Queens Gate Apartments	675 Tea St	Bound Brook	https://www.queensgateapts.com/
South Independence	2 12th St	Hoboken	https://appliedapartments.com/buildings/south-independence-shipyard-apartments/
The Berkshire	1401 Hudson St	Hoboken	https://appliedapartments.com/buildings/the-berkshire-at-the-shipyard-hoboken-luxury-rentals/
Monaco	475 Washington Blvd	Jersey City	http://monacojc.com/
The Oakman	160 1st St	Jersey City	http://theoakmanjc.com/
Modera Lofts	350 Warren St	Jersey City	https://www.moderalofts.com/
Trump Plaza	88 Morgan St	Jersey City	
The Gateway	9 West South Orange Ave	South Orange	http://thegatewayso.com/
Greene 750	780 Bear Tavern Rd	Trenton	http://greene750.com/

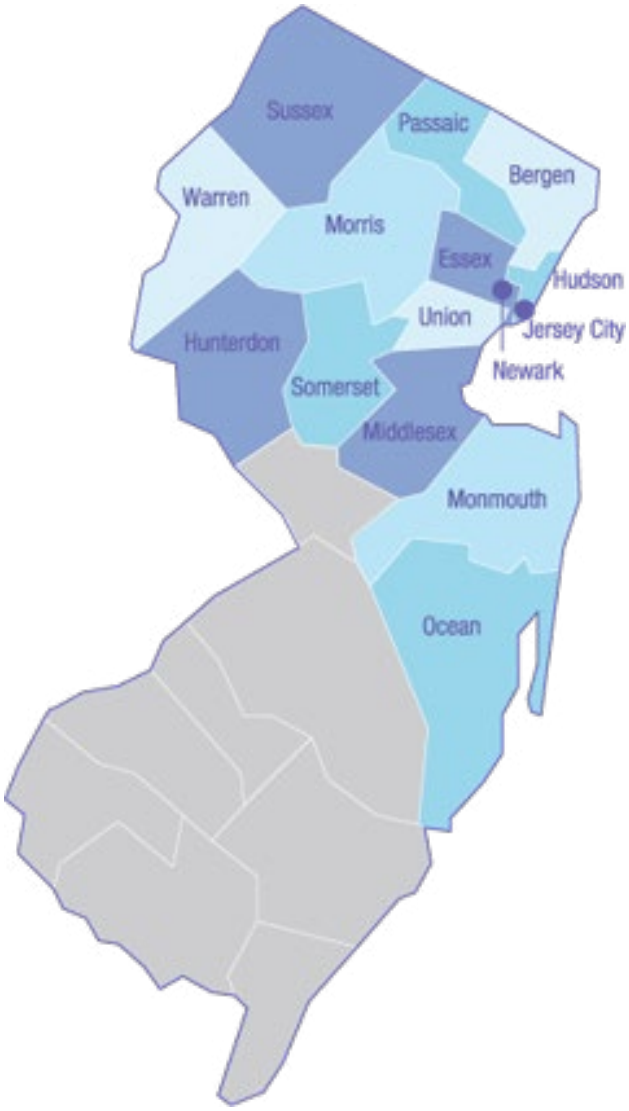
PEV CHARGING SERVICE PROVIDERS

These companies specifically call out MUDs in there marketing materials/websites. Please note there may be other companies providing these services. Also note that inclusion on this list does not mean these businesses are recommended or certified in any way.

- Blink/CarCharging – http://www.blinkcharging.com/multifamily
- ChargePoint – https://www.chargepoint.com/businesses/apartments-and-condos/ and https://www.chargepoint.com/products/multi-family-home-service/
- EverCharge – https://evercharge.net/
- Greenspot – http://joingreenspot.com/ev-ownership-2/
- SemaConnect – https://www.semaconnect.com/personalcharging/
- eVgo – https://chargedevs.com/newswire/evgo-offers-convenient-ev-charging-solution-for-multifamily-properties/
    - The Ready for Electric Vehicle (REV) program has ended, but information provided here for reference.

Appendix F: NJTPA Region

The NJTPA regional planning area consists of 13 counties within North New Jersey; Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, Sussex, Union, and Warren; and its two largest cities, Newark and Jersey City. The region spans 4,200 square miles, about half of the state's land area. It is the fourth largest MPO in the nation in terms of population, serving more than 6.7 million people and over 3.1 million jobs.[35]



The region has a robust multi-modal transportation network, including 26,000 miles of roads, 255 local and express bus routes, and 13 commuter/light rail lines with 228 stations, and 18 ferry routes from 19 piers.[36] Situated between New York and Philadelphia, the area is a regional corridor for both intra- and inter-state transportation. According to the ACS, 34 percent of regional residents work outside their county of residence and 14 percent work outside of the state. The ACS found that the majority (70 percent) of commuters report driving alone, a rate that is significant but lower than most major metropolitan areas. In 2015, the region had 149.1 million miles of vehicle travel.[37]

The NJTPA's regional transportation plan – Plan 2045: Connecting North Jersey – outlines the principles that guide project selection and provide policy and planning direction.[38] These include:

- **Help Northern New Jersey Grow Wisely** – Transportation investments should encourage economic growth while protecting the environment and minimizing sprawl in accordance with the state's Smart Growth plan, Energy Master Plan, and environmental plans.
- **Make Travel Safer** – Improving safety and security should be explicitly incorporated in the planning, design, and implementation of all investments.
- **Fix It First** – The existing transportation system requires large expenditures for maintenance, preservation, and repair, and its stewardship should be the region's highest priority.
- **Expand Public Transit** – Investment to improve the region's extensive transit network should be a high priority, including strategic expansions to serve new markets.
- **Improve Roads but Add Few** – Road investments should focus on making the existing system work better and

35 NJTPA, Plan 2045: Connecting North Jersey, https://apps.njtpa.org/plan2045.
36 New Jersey Transit, Facts at a Glance – Fiscal Year 2016, http://www.njtransit.com/pdf/FactsAtaGlance.pdf.
37 New Jersey Department of Transportation, New Jersey's Roadway Mileage and Daily VMT by Functional Classification Distributed by County, http://www.state.nj.us/transportation/refdata/roadway/pdf/hpms2015/VMTFCC_15.pdf.
38 NJTPA, Plan 2045: Connecting North Jersey, https://apps.njtpa.org/plan2045.

road expansion should be very limited without compromising the tremendous accessibility provided by the existing highway system.

- **Move Freight More Efficiently** – Investments should be made to improve the efficiency of goods movement because of its importance to the region's economy and quality of life.
- **Manage Incidents and Apply Transportation Technology** – Investments should be made to improve information flow, operational coordination, and other technological advances that can make the transportation system work smarter and more efficiently.
- **Support Walking and Bicycling** – All transportation projects should promote walking and bicycling wherever possible.
- **Increase Regional Resiliency** – Investments should be made to mitigate risks associated with sea level rise, extreme weather, homeland security, and other potential threats. Investments should consider criticality of infrastructure, vulnerability, and level of risk.

While the expansion of transit and smart land-use planning work to reduce single occupant travel, the adoption of AFVs within the region will help reduce the environmental impact of the remaining vehicle trips, supporting the NJTPA's goal of protecting the environment.