



Status and Issues for Ethanol in the United States

Alternative Fuel and Advanced Vehicle Technology Market Trends

National Renewable Energy Laboratory

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Current Market Status

State of the Technology

Ethanol is a renewable fuel made from corn and other plant materials. E85, a marketing term for a gasoline-ethanol blend containing 51% to 83% ethanol (depending on geography and season), is used in flexible fuel vehicles (FFVs). FFVs and E85 have been commercially available for 20 years.

While FFVs have been available since the early 90's the market expanded rapidly after 1997 as manufacturers began offering more models capable of using E85. Today, the number of FFVs and E85 stations continues to grow, but at a slower pace than in past years. Pricing E85 is challenging because of its lower energy content, which results in fewer miles per gallon than gasoline. While FFVs and E85 are readily available throughout the United States, the greatest number of stations is located in the Midwest near areas of ethanol production and FFVs are most prevalent in the Midwest, California, Florida, and Texas (Figure 1).

Fuel

In January 2015, there were approximately 200 ethanol production facilities in the United States, with total and operating capacities of 15.1 and 14.6 billion gallons, respectively.¹ According to the U.S. Energy Information Administration (EIA), ethanol production and consumption was 13.3 billion gallons in 2013, and appears to be on track to exceed that in 2014 with 11.8 billion gallons through October.²

Ethanol production and consumption remain at their highest levels. Ethanol is delivered by rail and truck to blending terminals that store neat ethanol (E98) and gasoline. Several ethanol producers load rail cars with E85 at the plant for delivery to end-use customers. This minimally deployed technique, of direct sales of E85 from a plant to a station, reduces costs significantly and is one the industry intends to expand outside of the Midwest.

While the Alternative Motor Fuels Act of 1988 was an initial driver of manufacturers producing FFVs. Two main factors are driving the expansion of the E85 market today are:

1. Federal requirements that regulated fleets use biofuels and purchase alternative fuel vehicles (AFVs) have led to a base market and a sustained interest in E85.
2. The Renewable Fuel Standard (RFS) which established a minimum volume of renewable fuel to be blended into transportation fuels. Ethanol is one of the fuels specified in the RFS.

¹ Biorefinery Locations. Renewable Fuels Association. <http://www.ethanolrfa.org/bio-refinery-locations/>

² http://www.eia.gov/totalenergy/data/monthly/pdf/sec10_7.pdf

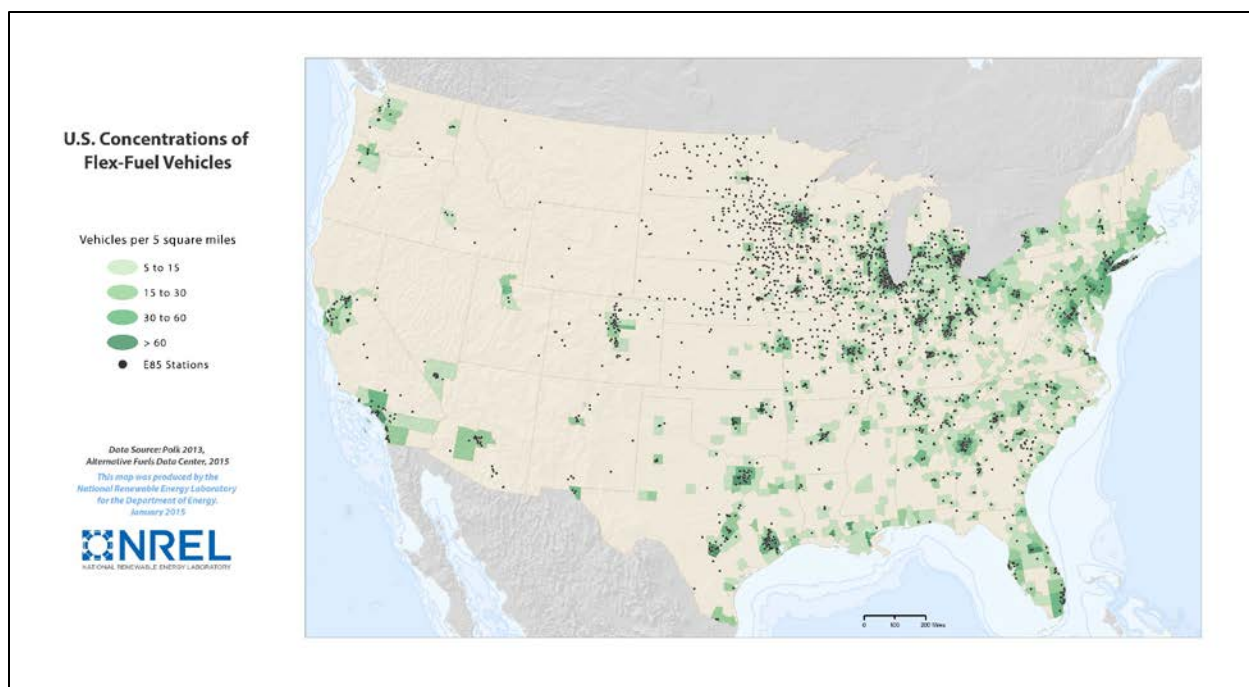


Figure 1. FFVs and E85 station locations

Vehicles

FFVs have an internal combustion engine and are capable of operating on gasoline, E85, or any combination of the two. Other than employing an ethanol-compatible fuel system and powertrain calibration, FFVs are similar to their conventional gasoline counterparts.³

FFVs are the most predominant AFVs in the nation (Figure 2), with 16.4 million registered FFVs at the end of 2013.⁴ As of December 2013, FFVs accounted for 6.6% of all vehicles and 18.6% of new vehicle registrations.⁵ In 2014, 90 FFV models were available, accounting for more than 40% of all available AFV models (Figure 3).⁶ The majority of FFVs are owned by consumers, and the number of registered vehicles continues to increase.

³ Alternative Fuel Data Center (AFDC), "Flexible Fuel Vehicles," http://www.afdc.energy.gov/vehicles/flexible_fuel.html

⁴ R.L. Polk & Company

⁵ Ibid

⁶ AFDC, "Light-Duty AFV, HEV, and Diesel Model Offerings by Fuel Type," <http://www.afdc.energy.gov/data/categories/afvs-and-hevs>

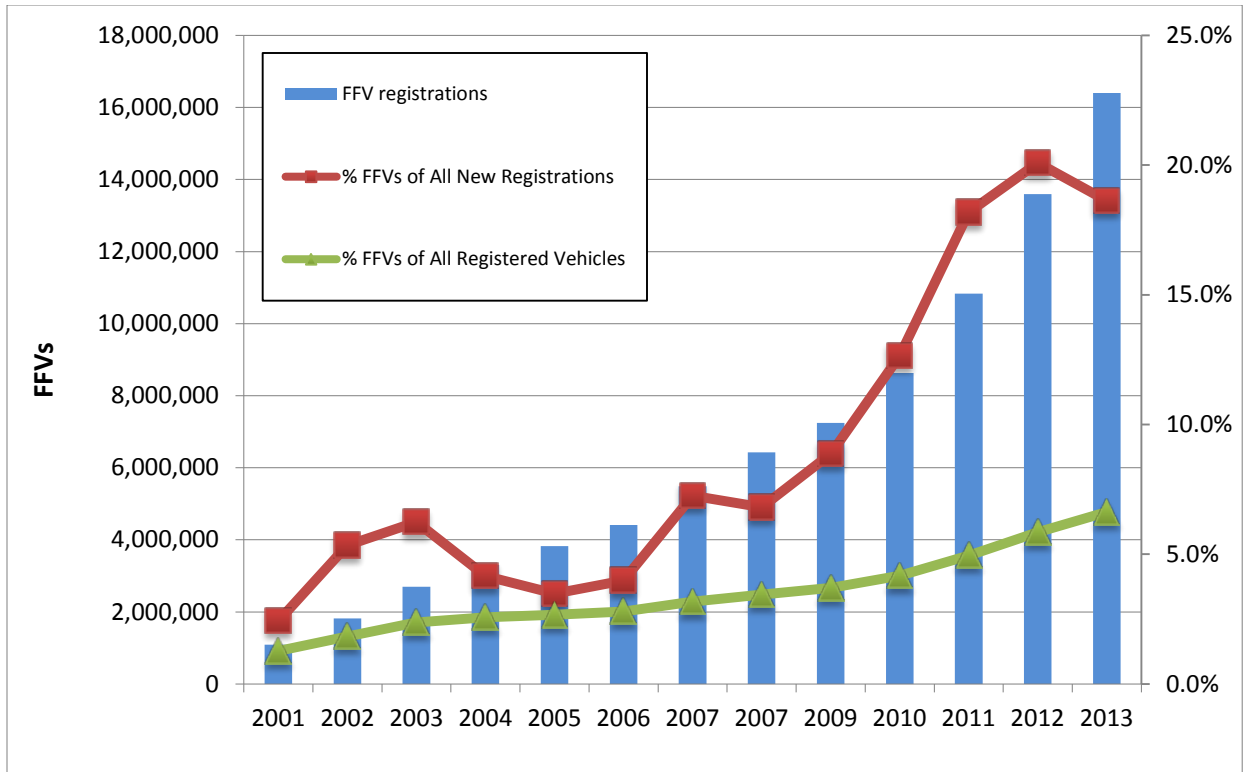


Figure 2. FFVs and market penetration⁷

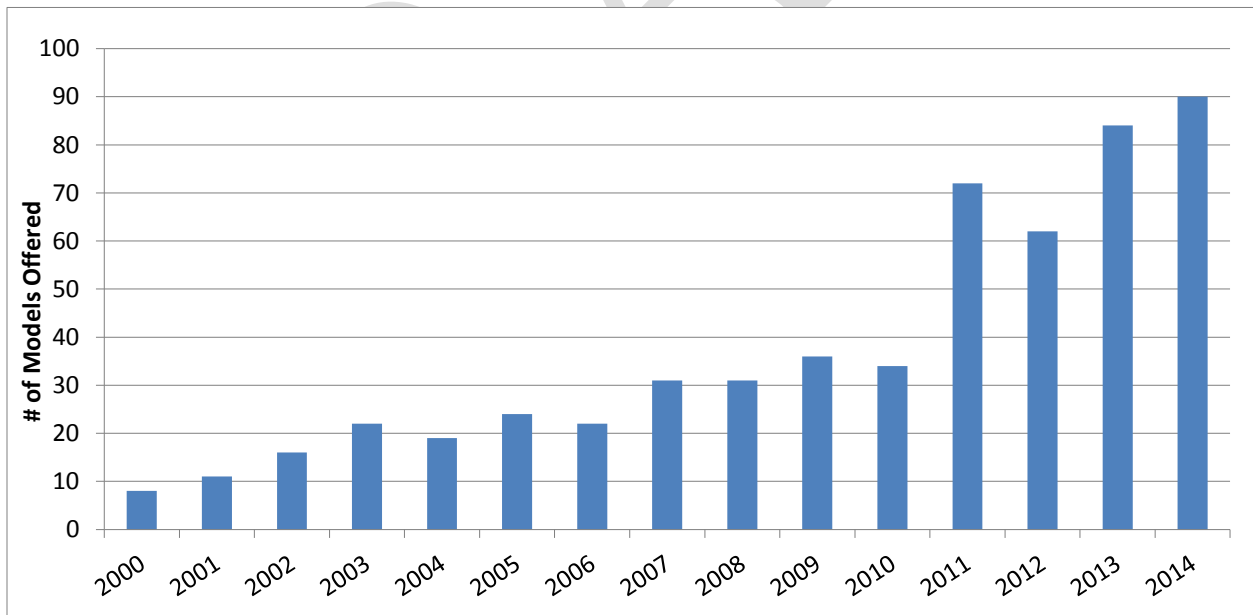


Figure 3. FFV model availability⁸

⁷ Source: R.L. Polk & Co.

Vehicle Policies

Numerous federal laws and Executive Orders dictate requirements for federal and state fleets.

- Under the Energy Policy Act (EPA) of 1992, 75% of new light-duty vehicles acquired by covered federal fleets must be AFVs.
- Executive Order 13423, issued in January 2007, requires federal agencies with 20 vehicles or more in their domestic fleets to increase their alternative fuel use by 10% per year, relative to the previous year.
- Issued in October 2009, Executive Order 13514 requires federal agencies to develop and annually update a Strategic Sustainability Performance Plan that includes a stipulation that federal agencies with more than 20 vehicles must reduce petroleum use by 2% per year.
- EPA also requires state and alternative fuel provider fleets with 50 or more vehicles in certain locations to purchase AFVs.

While none of these policies specifically requires FFVs, compliance has largely been met with FFVs due to availability and cost.

Federal and State Fleets

While E85 fuel sales are not specifically tracked nationwide, the federal government is likely the largest buyer of E85, with sustained growth in E85 usage over time (Figure 4). In 2015, EPA 2005 alternative fuel use requirements were waived for more than 55,000 federal FFVs. Vehicles may be waived from alternative fuel use when they are garaged more than 5 miles or 15 minutes from an E85 station, or in cases where fuel costs are prohibitive (per EPA 2007, Section 701).

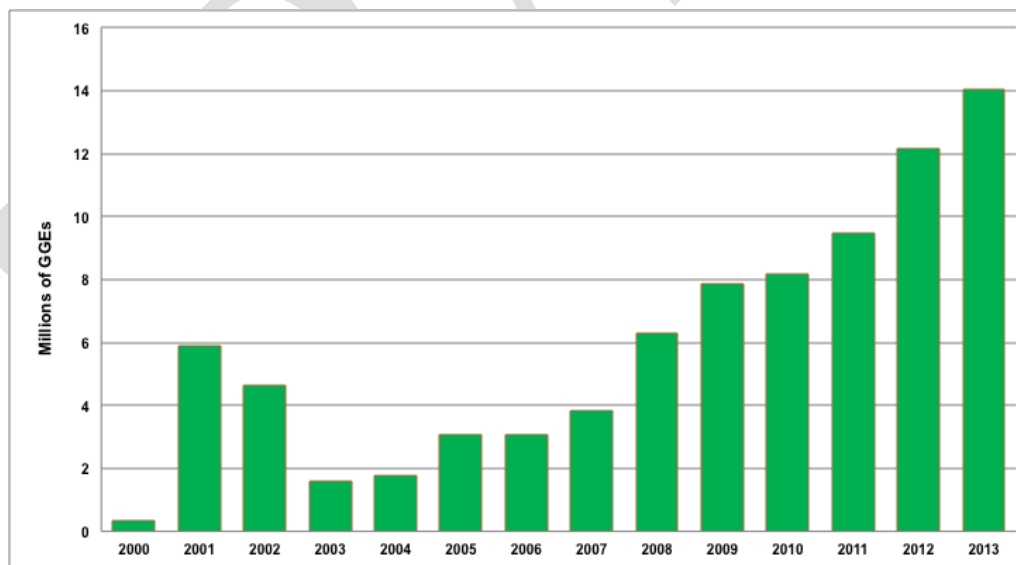


Figure 4. Federal FFV E85 use⁹

⁹ DOE Sustainable Federal Fleets Performance Data, “Alternative Fuel Consumption by Fuel Type,” http://federalfleets.energy.gov/performance_data#acquisitions

Infrastructure

The number of E85 stations has increased steadily, and it is available in 47 states and the District of Columbia (Figure 6). The highest concentrations of E85 stations are in the Midwest, largely due to nearby ethanol production facilities and greater familiarity with the fuel (Figure 7).

As highlighted in Figure 1, there are opportunities to deploy more stations, particularly in areas such as Louisiana that have high concentrations of FFVs but few E85 stations.

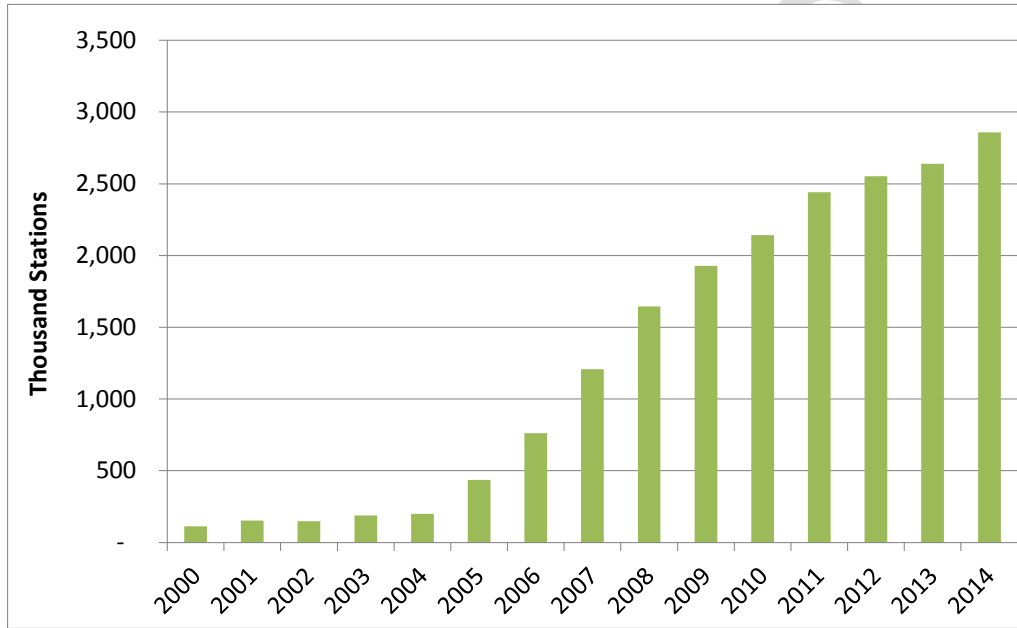


Figure 6. E85 stations¹⁰

¹⁰ AFDC, “U.S. Alternative Fueling Stations by Fuel Type, <http://www.afdc.energy.gov/data/categories/fuels-infrastructure>

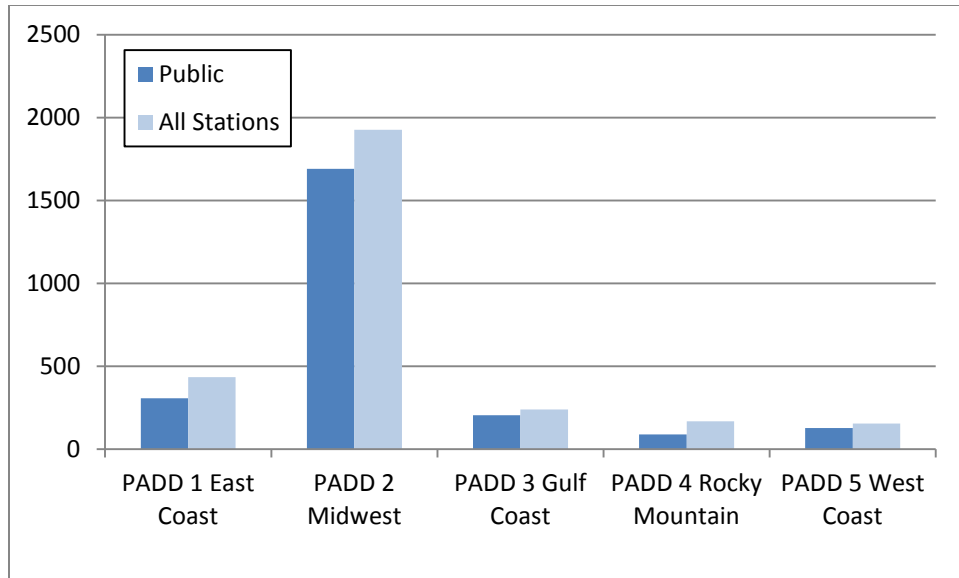


Figure 7. E85 stations by region as of January 2015¹¹

Laws and Incentives

The Alternative Motor Fuels Act enacted in 1988 laid the groundwork for CAFÉ credits for manufacturers of vehicles that use alcohol either exclusively or as an alternate fuel in conjunction with gasoline or diesel. While FFVs were available in the early 90's the market expanded rapidly after 1997 as manufacturers began offering more models capable of using E85.

Some states have AFV or fuel use incentives, such as grants and loans that are available for FFVs. The state of Illinois, for example, has an E85 fuel use rebate of up to \$450 per year per vehicle. Kansas has an income tax credit for FFV purchases; the individual claiming the credit must provide evidence of purchasing at least 500 gallons of E85 between the vehicle purchase date and December 31 of the following calendar year.

There are no federal laws requiring stations to sell E85, nor are there federal incentives for E85 infrastructure. However, the RFS requires the use of biofuels, and E85 contributes to meeting overall obligations. In addition, twenty-two states have specific infrastructure regulations or requirements for alternative fuels, and 23 states have alternative fuel infrastructure incentives, mostly in the form of tax credits, grants, and loans.

Trends

Infrastructure Compatibility

Significant progress has been made in recent years to determine the compatibility of existing fueling hardware with E85. Underwriters Laboratory (UL) covers most equipment at refueling stations. However, most E85 stations were established prior to the availability of UL-certified E85 dispensers and associated equipment. This was usually through a waiver from the local authority with jurisdiction (e.g., fire marshal, building inspector). Biofuels guidance from the

¹¹ AFDC, "Alternative Fueling Station Counts by State," http://www.afdc.energy.gov/fuels/stations_counts.html

U.S. Environmental Protection Agency’s Office of Underground Storage Tanks allowed tank and associated equipment manufacturers to issue statements of compatibility.¹² This has resulted in the determination that the majority of existing tanks are capable of storing blends of up to E100.¹³

Table 1. Station Costs for One Refueling Position for Various Ethanol Blends¹⁴

Equipment	Station Costs for One Refueling Position at a Station			
	E0-E10 (new) ^a	E15-E25 (retrofit) ^b	E15-E25 (new) ^a	E26-E85 (new) ^a
Use an Existing Tank				
Dispenser	\$17,000	\$2,100	\$17,500	\$23,500
Hanging Hardware & Shear Valve	\$282	\$835	\$835	\$926
Tank Cleaning Cost	\$1,500	\$1,500	\$1,500	\$1,500
Total (using an existing tank)	\$18,782	\$4,435	\$19,835	\$25,926
New Tank ^c	\$95,000	\$95,000	\$95,000	\$95,000
Total (with new tank)	\$113,782	\$99,435	\$114,835	\$120,926
a-assumes one new dispenser is installed; dispenser costs are typical but could be more or less depending on various options. while all stations sell E10, it is included for comparison purposes				
b-E25 UL listed retrofit kits are available for existing dispensers; these were deployed to address E15 and UL only offers E10, E25, and E85 as testing fuels				
c-Installed tanks and all associated tank equipment cost at an existing station; tank costs are the same regardless of fuel stored; tank at a new station is \$75,000.				

Fuel Economy Regulations

Recently updated Corporate Average Fuel Economy (CAFE) regulations change the FFV credit scheme by requiring manufacturers to demonstrate that FFVs are using E85—something few vehicles are designed to track. Because it is nearly impossible for manufacturers to demonstrate that the FFVs sold are using E85, some manufacturers may reduce FFV production.

Emissions Benefits

According to EIA, the United States imported approximately 60% of the petroleum consumed in the country in 2005; that number fell to about 35% in 2013. Ethanol production contributed to this reduction in petroleum imports—ethanol accounted for about 10% of motor fuel consumption. Nearly all ethanol is used in low-level E10 blends.

Using ethanol as a vehicle fuel has measurable greenhouse gas (GHG) emissions benefits compared to using gasoline. The carbon dioxide (CO₂) released when ethanol is used in vehicles is offset by the CO₂ captured when crops used to make ethanol are grown. As a result, FFVs running on ethanol produce less net CO₂ than conventional vehicles per mile traveled. Using corn-based ethanol instead of gasoline reduces life cycle GHG emissions by 19% to 52%, depending on the energy source used during ethanol production.¹⁵ Using cellulosic ethanol provides an even greater benefit—reducing GHG emissions by up to 86%. Additionally, E85 is less volatile than gasoline, and low-level ethanol blends result in lower evaporative emissions. Numerous studies have compared the emissions of E85 and gasoline. E85 decreases emissions of CO₂ and many harmful toxics, such as benzene, but it increases acetaldehyde emissions.

¹² Environmental Protection Agency Office of Underground Storage Tanks, “Guidance - Compatibility of UST Systems with Biofuel Blends,” <http://www.epa.gov/oust/altfuels/biofuelsguidance.htm>

¹³ A list of compatible equipment is available in the appendices of the “Handbook for Handling, Storing, and Dispensing E85 and Other Gasoline-Ethanol Blends,” http://www.afdc.energy.gov/uploads/publication/ethanol_handbook.pdf

¹⁴ Source: Refueling equipment distributors, manufacturers, and the Petroleum Equipment Institute

¹⁵ AFDC, “Ethanol Vehicle Emissions,” http://www.afdc.energy.gov/vehicles/flexible_fuel_emissions.html

Niche Market Opportunities

Few of the more than 16 million FFVs in the nation actually use E85, which presents a significant opportunity to establish more stations, particularly in areas with incentives, federal fleets, or a high concentration of FFVs. There are some challenges, however, mostly related to E85's price competitiveness and lack of consumer knowledge about their vehicles' capacity to run on high-level ethanol blends.

Impact of Retail Station expansion: Data from the National Association of Convenience Stores (NACS) indicate there were over 150,000 locations selling motor fuel in 2013. Using data from stations with a position for E85, the average gallons of E85 sold was 436.

Scenario 1 below demonstrates the potential reductions due to growing E85 locations by one-third from 2,595 to 3400 stations, assuming average use stays consistent. **Scenario 2** adds an increase in the FFV population to the station growth scenario to predict what additional impacts might be.

Impact of Retail Station expansion

	Petroleum Use (barrels)	GHG (tons)
Scenario 1	-15,640.5	-2,987.4
Scenario 2	-17,225.6	-3,290.2

Strategies for Advancing the Use of E85

Coordination with Existing Clean Cities Activities

Communication Products

- **Maintain the Ethanol Handbook:** Ensure the Ethanol Handbook is current. It is among the most downloaded documents in the Alternative Fuels Data Center (AFDC). Feedback indicates it is very useful in the regulatory area and among retailer groups. To promote it's availability by continuing the relationship with the National Association of Convenience Stores (NACS), the API Tanks conference. Conduct a webinar with Clean Cities coordinators to educate them about the content of the handbook and inform them about how to use it with retailers.
- **AFDC and Clean Cities Websites:** www.afdc.energy.gov; www.cleancities.energy.gov; A variety of tools and information are provided on these sites.
- **MotorWeek Series:** www.youtube.com/cleancitiestv For more than 15 years, Clean Cities has had a long-standing relationship with *MotorWeek* which produces a series of Clean Cities success stories and feature-length segments for public television.

Partnerships

- **National Clean Fleets Partnership:** www.eere.energy.gov/cleancities/national_partnership.html; Through the National Clean Fleets Partnership, Clean Cities works with large private fleets to cut petroleum use. The initiative provides fleets with resources, expertise, and support to incorporate alternative

fuels and fuel-saving measures into their operations. Of the nearly 30 national partner fleets many own FFVs. These fleets could work closely with Clean Cities to reduce their petroleum consumption and build greater throughput at public E85 stations, thereby increasing retail sales of E85. Fleets can receive specialized resources, expertise, and support to incorporate alternative fuels and advanced vehicles into their operations and share lessons learned with the Clean Cities network.

Technical Assistance

- **Clean Cities University:** www1.eere.energy.gov/cleancities/toolbox/university.html This represents an online training tool for Clean Cities coordinators that can be expanded. In addition to a current ethanol courses,
- **Tiger Teams:** www1.eere.energy.gov/cleancities/technical_assistance.html Clean Cities has offers local coalitions and stakeholders troubleshooting for specific vehicle or infrastructure complexities related to alternative fuels and advanced technologies.

Tools

- **AFDC Station Locator:** www.afdc.energy.gov/locator/stations/ A comprehensive set of data for E85 and all alternative refueling locations across the US. Data can also be searched to identify where mid-level blends are available.
- **AFLEET Tool:** <http://greet.es.anl.gov/afleet> Helps fleets calculate petroleum use, cost of ownership and air pollutant and GHG emissions. Stakeholders have asked for more vehicle types to be included in AFLEET, an Alternative Fuel Life-Cycle Environmental and Economic Transportation Tool.
- **PREP Tool:** www.afdc.energy.gov/prep/ The Petroleum Reduction Planning Tool helps a vehicle fleet reduce petroleum consumption and greenhouse gas (GHG) emissions. A comprehensive plan can be created for a fleet by using several savings methods.

New Clean Cities' Activities

- **Stakeholder engagement:** The ethanol industry has suggested that E85 stations are underrepresented in the AFDC's station data. Face-to-face meetings every six months to discuss data methods and differences in AFDC versus crowd-sourced websites will ensure an open dialogue about accuracy and why the data differ.
- **Increase awareness of successes:** Work with stakeholder groups (e.g., National League of Cities) to communicate the successes that cities like Chicago have had implementing E85. Increase case studies and general outreach on the overall positive impacts of ethanol.
- **Expand collaboration with regulated fleet programs:** Partner with fleet programs to develop workshops or other engagement activities to increase E85 use in regulated fleet vehicles.
- **Identify direct-source opportunities:** Work with coordinators and station owners to identify opportunities to source E85 directly from an ethanol plant for substantial cost savings.
- **Retail station education: Work with NACS and API Petroleum Marketers group to educate members about E85 opportunities.** Such activities would help them understand

how to economically add E85 to their stations, select the most appropriate dispensing equipment, and promote E85 via their marquees or other methods. Offer webinars to their members, seek speaking roles at conferences, educate them about the work that Coordinators do locally.

- **Document E85 successes:** Document successful strategies and approaches used by coalitions to promote E85, educate consumers who may drive FFVs, and push related information to coalitions via webinars and print documents.
- **Engage directly with consumers:** Define a strategy to engage with consumers via dealerships, car groups such as AAA, and other organizations that communicate with non-fleet drivers. Convene a panel of coordinators to understand how they've been successful with E85 stations and use and translate that to a larger audience through webinars, print material and templates.

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