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Ryan Daley, John Nangle, Gabrial Boeckman, and Mackay Miller

NREL is a national laboratory of the U.S. Department of Energy
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Technical Report
NREL/TP-5400-61777
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All judgments in the final analytic methodologies and interpretations are the responsibility of the authors and not of the experts acknowledged above.

Acronyms and Abbreviations

AFV	alternative fuel vehicle
CNG	compressed natural gas
DOE	Department of Energy
E85	ethanol-gasoline blends containing 51% to 83% ethanol
EPAct	Energy Policy Act
FEMP	Federal Energy Management Program
FleetDASH	Fleet Sustainability Dashboard
FFV	flexible fuel vehicle
FY	fiscal year
GGE	gallons gasoline equivalent
GSA	General Services Administration
NREL	National Renewable Energy Laboratory
NP	non-purchaser
P	purchaser
SLD	stated likelihood to drive
SP	swing purchaser
TA	trained and aware
uTuA	untrained and unaware

Executive Summary

For more than two decades, Congress and the White House have looked to the federal fleet to lead a national transition to alternative fuels and advanced vehicle technologies. Accordingly, federal fleets are a frequent subject of legislative and executive efforts to support alternative fuel and advanced vehicle technology deployment, energy security, and environmental sustainability.

Section 701 of the Energy Policy Act (EPAct) 2005 (EPAct § 701) requires that all dual-fueled alternative fuel vehicles (AFVs) in the federal fleet be operated on alternative fuel 100% of the time when they have access to it. However, most drivers do not choose alternative fuel even when it is available. In Fiscal Year (FY) 2012, drivers of federal flexible fuel vehicles (FFVs) leased through the General Services Administration (GSA) fueled with E85[1] 24%[2] of the time when available—falling well short of the EPAct § 701 requirement to use alternative fuel. If federal vehicles used E85 100% of the time, the estimated impact is a 45 million gasoline gallon equivalent (GGE) increase over the 12.2 million GGE of E85 use reported in FY 2012.

Given that federal fleet vehicle drivers do not use their own money to pay for fuel, this behavior is difficult to explain on economic grounds—as is commonplace in research on refueling behavior. Identifying the motivation behind this behavior is critical to understanding how to encourage and increase alternative fuel use in the federal fleet and beyond.

NREL surveyed federal fleet drivers in June 2012 to identify the factors that influence fuel-purchasing behavior, and analyzed actual federal fleet refueling behavior from FY 2009 to 2012. This paper discusses the results of the survey and analysis, and how this research will aid in the design and implementation of intervention programs aimed at increasing alternative fuel use and reducing petroleum consumption.

Hypotheses, Empirical Data, and Survey Findings

We began the project with two primary hypotheses:

- Information scarcity increases the tendency to miss opportunities to purchase E85.
    - Many drivers do not know that they are driving FFVs or how/where to find E85.
    - Drivers perceive the availability of E85 to be less convenient than it actually is.
    - Drivers perceive that they fuel with E85 more often than they actually do.

[1] E85 is a term that refers to high-level ethanol-gasoline blends containing 51% to 83% ethanol, depending on geography and season.
[2] This includes the 12 agencies in our empirical dataset at the time of the survey; they refueled with E85 at varying rates ranging from a low of 6% to a high of 39%.

- Even with perfect information, there are limits to how far drivers will go out of their way to purchase E85. A range of factors, including (but not limited to) habit, convenience, job performance, and attitudes toward E85 and the mandate to use it, determine these limits.

These hypotheses were tested against empirical fuel purchase data and reported fuel purchasing behavior.

Empirical Data

Federal fleet drivers are a diverse group of people with a diverse set of transportation needs. From shuttle drivers to scientists, park rangers, law enforcement officers, doctors, food inspectors, military recruiters, engineers, and emergency response personnel, drivers of federal vehicles cover a broad spectrum of people, geographies, and vehicle types. As such, they are potentially the only fleet-based population that resembles the general population. The federal fleet provides us with a diverse empirical dataset and nationwide living laboratory to study the deployment of alternative fuels and advanced vehicle technologies.

Access to empirical data for AFV refueling behavior is rare. This project is unique because NREL maintains a database that tracks all fuel purchases for federal agencies that voluntarily participate in the Fleet Sustainability Dashboard (FleetDASH) project funded by DOE's Federal Energy Management Program (FEMP). Refueling transactions by federal AFVs are cross-referenced with the DOE Alternative Fueling Station Locator to determine whether a driver had access to alternative fuels at that station location or anywhere within a 5-mile radius. When these drivers purchase gas or diesel the transactions are flagged as "missed opportunities" to purchase alternative fuel.

The data analyzed in this project cover vehicles leased by 12 federal agencies from the GSA, which provides a common dataset across all the agencies and allows for a robust comparative analysis. Refueling data include vehicle identifiers (vehicle identification number [VIN], tag, vehicle fuel type) as well as details of the individual transaction (date/time, station address, fuel type, and volume).

Survey Objectives

The primary objective of the NREL survey was to establish a meaningful dependent variable that would be observable both through direct means (e.g., tracking actual refueling behavior) and indirect means (e.g., follow-on surveys). As such, the survey team focused on establishing a baseline understanding of the stated likelihood to drive (SLD) out of one's way to purchase alternative fuel, which was asked two different ways:

- What is the likelihood that you would drive the following distances out of your way to purchase E85? Please answer as a percentage ranging from 0% (I would never drive this additional distance to fuel with E85) to 100% (I would always drive this additional distance to fuel with E85).
    - 1 mile or less
    - 1–3 miles

    - 3–5 miles
    - 5 miles or more.
- What is the likelihood that you would drive the following additional time increments out of your way to purchase E85? Please answer as a percentage ranging from 0% (I would never drive this additional time increment to fuel with E85) to 100% (I would always drive this additional time increment to fuel with E85).
    - 5 minutes or less
    - 5–10 minutes
    - 10–15 minutes
    - 15 minutes or more.

Survey questions were classified into five topical categories, including:

- **Demographics**—Age, gender, education
- **Awareness**—Knowledge of their statutory requirements and their own performance
- **Operational**—Driving habits, including how long they've been driving federal vehicles, whether they consistently drive the same vehicles, weekly mileage, and garage locations, as well as the types of locations, routes, and roads they drive
- **Technology**—Perceptions about E85 related to the availability and convenience of fueling infrastructure, vehicle performance, and price
- **Motivation**—Factors that influenced their driving for work, where they decided to purchase fuel, and whether or not they decided to purchase E85.

The long-term objective of the NREL study is to utilize the results of this survey to (1) add to the literature on refueling behavior in the context of overcoming barriers to wider deployment of emerging technologies in alternative fuels and advanced vehicles, and (2) inform the development and implementation of behavioral interventions designed to increase the utilization of alternative fuels.

Survey Results

Results of NREL's survey show that increased awareness of the requirement to use alternative fuel correlates with higher SLD and should be the focus of an initial round of behavioral interventions. Future research at NREL will investigate the impact of positive and negative feedback mechanisms, as well as direct and indirect feedback within an organization.

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1 Introduction and Context

Beginning with AFV acquisition requirements in EPAct 1992, federal fleets have been a frequent subject of legislative and executive efforts to support alternative fuel and advanced vehicle technology deployment, energy security, and environmental sustainability. The intent behind these efforts is to have the federal fleet lead a national transition to alternative fuels and advanced vehicle technologies.

The federal fleet is the only "fleet" that bears any resemblance to the general public and average consumers given (1) the broad cross-section of the population represented by drivers of federal fleet vehicles, (2) a wide variety of transportation needs, and (3) the prevalence of light-duty passenger vehicles. Other fleets are either too specialized or too geographically concentrated to provide insights that could be applicable to the general public. As such, the federal fleet provides us with a diverse empirical dataset and nationwide living laboratory to study the deployment of alternative fuels and advanced vehicle technologies.

Our research focuses specifically on EPAct § 701, which requires that all dual-fueled AFVs in the federal fleet be operated on alternative fuel 100% of the time when they have access to it. As noted by Kelley and Kuby (2013), access to empirical data for AFV refueling behavior is rare. This project is unique because NREL maintains an active database that tracks all fuel purchases at the transaction level for federal agencies volunteering to participate in the FleetDASH project funded by FEMP. Refueling transactions by federal AFVs are cross-referenced with the DOE Alternative Fueling Station Locator to determine whether a driver had access to alternative fuels at that station location or anywhere within a 5-mile radius. When these drivers purchase gas or diesel the transactions are flagged as "missed opportunities" to purchase alternative fuel.

This empirical dataset shows that most drivers do not choose alternative fuel even when it is available. In FY 2012, drivers of federal FFVs leased through GSA fueled with E85 24%[3] of the time when available—falling well short of the EPAct § 701 requirement to use alternative fuel. Given that federal fleet vehicle drivers do not use their own money to pay for fuel, this behavior is difficult to explain on economic grounds—as is commonplace in research on refueling behavior. Identifying the motivation behind this behavior is critical to understanding how to encourage and increase alternative fuel use in the federal fleet and beyond.

This paper discusses the results of a June 2012 survey of federal fleet drivers designed to identify the non-cost-based behavioral factors influencing fuel-purchasing behavior as well as an empirical analysis of actual refueling behavior during FY 2009 to 2012. We began this project with two primary hypotheses:

[3] This includes the 12 agencies in our empirical dataset at the time of the survey; they refueled with E85 at varying rates ranging from a low of 6% to a high of 39%. This report focuses specifically on FFVs and E85 as they constitute the overwhelming majority of dual-fueled vehicles in the federal fleet.

1. Information scarcity increases the tendency to miss opportunities to purchase E85.
    a. Many drivers do not know that they are driving FFVs or how/where to find alternative fuel.
    b. Drivers perceive the availability of E85 to be less convenient than it actually is.
    c. Drivers perceive that they fuel with E85 more often than they actually do.
2. Even with perfect information, there are limits to how far drivers will go out of their way to purchase E85. A range of factors, including (but not limited to) habit, convenience, job performance, and attitudes toward E85 and the mandate to use it, determine these limits.

This research will aid in the design and implementation of intervention programs aimed at increasing the use of alternative fuels and reducing petroleum consumption by reducing missed opportunities to purchase alternative fuel.

2 Literature Review

The scope of the NREL federal refueling behavior study is quite unique; however, substantial academic research has been conducted on the individual components of this study. This multidisciplinary approach allowed NREL to develop a survey and research focus grounded in energy policy and public policy program evaluation, technology deployment, behavioral economics, and management theory. This section provides an overview of existing academic research as it relates to NREL's study.

2.1 Energy Policy Program Evaluation

Federal fleet requirements are well documented in official publications, including *Guidance for Federal Agencies on E.O. 13514 Section 12, Federal Fleet Management* (DOE 2010) and *Comprehensive Federal Fleet Management Handbook* (DOE 2014) (see Figure 1). Initially, EPAct 1992 required that 75% of all light-duty vehicles acquired in metropolitan statistical areas be AFVs. Helwig and Deason (2007) noted the lack of a requirement to actually use alternative fuel in federal AFVs as a core deficiency of EPAct 1992. This shortcoming was first remedied via Executive Order (E.O.) 13149, *Greening the Government Through Federal Fleet and Transportation Efficiency*, and subsequently addressed by EPAct § 701, which requires that all dual-fueled AFVs in the federal fleet be operated only on alternative fuel unless they receive a waiver through FEMP. Waivers are granted if (1) alternative fuel is not reasonably available within 5 miles or a 15-minute drive of the vehicle's garage location, or (2) alternative fuel is unreasonably more expensive than gasoline (DOE 2014).

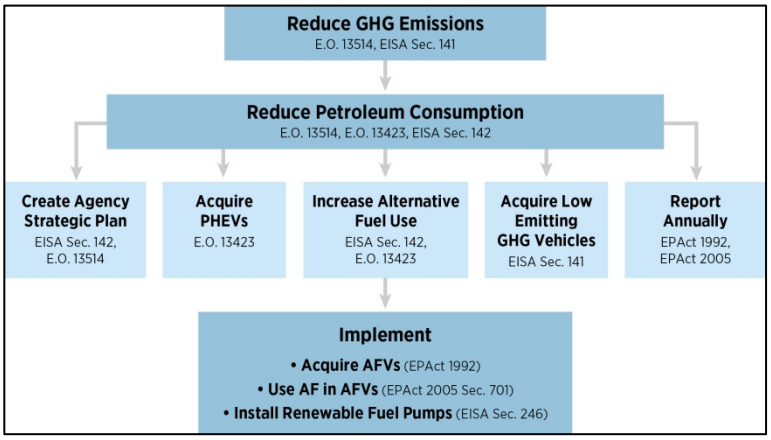

Figure 1. Federal fleet requirements (DOE 2014)

In addition to EPAct § 701, the Presidential Memorandum – Federal Fleet Performance was issued on May 24, 2011. This memo requires that "…agency alternative fueled vehicles must, as soon as practicable, be located in proximity to fueling stations with available alternative fuels, and be operated on the alternative fuel for which the vehicle is designed. Where practicable, agencies should encourage development of commercial infrastructure for alternative fuel or provide flex fuel and alternative fuel pumps and charging stations at Federal fueling sites" (White House 2011). While the requirement to

use alternative fuel has remedied some of the initial shortcomings of EPAct 1992, underutilization of alternative fuel plagues federal fleet efforts to reduce petroleum use.

An extensive body of academic literature has dealt with various aspects of EPAct and related federal statutes, while only a few have focused specifically on implementation of these requirements within the federal fleet. Helwig and Deason (2007), and Deason and Jefferson (2010) focused their attention on the suboptimal vehicle acquisition strategies that left many federal FFVs without access to alternative fuel. Their basic premise is that smarter placement of FFVs, near existing alternative fuel infrastructure, will lead to significant improvements in alternative fuel consumption. While these studies were instructive for the purpose of informing high-level vehicle acquisition strategies, the authors were unable to account for the actual operational geography of federal FFVs and assumed that most fueling occurs in close proximity to a garage location.

Despite the suboptimal placement of some federal FFVs, the fact remains that EPAct 1992 has been successful at getting FFVs deployed throughout the federal fleet: 63% of the 174,469 federal FFVs were determined to have access to alternative fuel during FY 2012, a significant improvement from FY 2009, when only 54% had access.[4] Another noteworthy success comes from Corts (2010), who found that mandated government AFV acquisition programs in effect provide an incentive for retail station owners to invest in alternative fuel. He further concluded that "…a government fleet mandate is essentially a costless initiative that apparently yields sizable benefits in terms of stimulating E85 availability" (p.232), whereas the impact of private FFV ownership was much less important to stimulating E85 infrastructure development. It is unfortunate that Corts was unable to include federal government fleets in this study because he briefly mentions two ideas unique to the federal fleets, which we suspect may add weight to his conclusions: an alternative fuel purchasing mandate and published information on the location of government AFVs. While EPAct § 701 covers the first idea, FEMP has been publishing the location of waivered FFVs since 2008[5] on the grounds that a station owner is more likely to invest in infrastructure if they know these AFVs are nearby, though it is unclear if this information actually factors into station owner decision-making.

2.2 Refueling Behavior

A lack of vehicles and a lack of refueling infrastructure are often cited as the barriers to our nation's transition away from petroleum and the solution thus far has generally focused on policy-driven growth and demand (Fiorese et al. 2013; Timilsina and Shrestha 2011). Most literature in technology deployment presumes a technological or economically rational solution to overcome deployment barriers, yet we know from behavioral economics that consumers simply do not act rationally in the real world. Our empirical datasets show that FFV drivers often resort to their default behavior of refueling with gasoline even when E85 is conveniently available. We therefore posit an additional and equally consequential barrier: lack of actual consumer demand for alternative fuels, especially when drivers are faced with a choice of fuels to power their vehicles.

[4] http://federalfleets.energy.gov/performance_data
[5] http://federalfleets.energy.gov/performance_data#waivers

This is problematic for the future prospects of all vehicles in which the consumer can use more than one fuel: FFVs, bi-fuel compressed natural gas (CNG) or propane vehicles, and even plug-in hybrids. This possibility is noticeably absent among proponents of the Open Fuel Standard (Luft and Korin 2009; Luft 2011; Knittel 2012), which advocates providing consumers with fuel choice by mandating the production of plug-in hybrid FFVs. These vehicles could run on electricity, ethanol, methanol, or gasoline and thereby provide consumers with various fuel options to meet their transportation needs or provide a buffer against price fluctuations in one fuel or another. Yet Open Fuel Standard proponents fail to recognize that this prospect is ineffective if most consumers revert to their default behavior and fuel with gasoline, if they ever start using an alternative fuel to begin with—a problem that is endemic with FFVs today.

This is also problematic from the standpoint of a transition from first-generation, corn-based ethanol, to second-generation ethanol produced from other sources. While there is not a lot of literature on competing technology generations (Suurs and Hekkert 2009), work on the prospects and potential of advanced biofuels is generally optimistic about its future. Differences in opinions abound as to when second-generation products will be commercially viable and which technological paths will prevail (Baker and Keisler 2011; Fiorese et al. 2013; Timilsina and Shrestha 2011). The actual transition to second-generation ethanol may be jeopardized because actual consumer demand for high-ethanol blends has lagged. Add the over-dramatization of corn-based ethanol's shortcomings, and we should not expect there to be sufficient demand for second-generation ethanol if we cannot even stimulate moderate demand for first-generation.

Academic work on the subject of refueling behavior is limited. Two more commonly explored questions involve (1) driving behavior—what drivers can do while behind the wheel to maximize fuel efficiency (so-called eco-driving), and (2) refueling behavior relative to the siting of potential alternative fueling stations and how to serve drivers effectively with limited fueling infrastructure. Early analyses on the latter subject came from Sperling and Kitamura (1986), Dingemans et al. (1986), and Kitamura and Sperling (1987), while more recent work includes Upchurch et al. (2010), Nicholas (2010), and Kelley and Kuby (2013).

Nicholas (2010) concluded[6] that the initial rollout of alternative fueling stations should be focused on entrances to highways and other high-volume roadways, while Kitamura and Sperling (1987) specifically mention high-volume commuting routes. Using diesel as a proxy for alternative fuel, Sperling and Kitamura (1986) suggested that a network of stations equal to 10% of gasoline stations could be sufficient to mitigate concerns about fuel availability when purchasing a vehicle. Unfortunately, Dingemans et al. (1986) found that very few drivers would likely learn the locations of alternative fueling stations; however, they recommended disseminating information on the local availability of these stations to help solve this problem.

[6] The authors did not test these findings against the location of existing alternative fuel infrastructure—there were 21 publicly accessible E85 stations in the study area of Sacramento, California, at the time of publication (http://www.afdc.energy.gov/locator/stations/).

An underlying assumption in these previous studies is a technological solution; that is, once the ideal locations have been identified it is simply a matter of "build it and they will come." In a similar vein, economic analyses suggest the next step in the equation: "price it and they will buy" (Babcock and Pouliot 2013). Greene (1989) noted that consumer fuel choice is highly sensitive to price, with Babcock and Pouliot (2013) adding to those findings by recommending the appropriate price differentials that would entice consumers to purchase more E85.

We believe that the cost of E85 is an important barrier to address, and we know that refueling is so routinized "though the processes of information acquisition, experimentation, and habit formation" that drivers across demographic and socioeconomic backgrounds are primarily focused on convenience and price (Kitamura and Sperling 1987). Still, price is not the only barrier to overcome. Findings by Dingemans et al. (1986) show that significantly lower prices often do not entice drivers to travel additional distances and that many drivers simply refuel at the most convenient and familiar station, even if it costs more and despite survey responses suggesting drivers will make a more rational economic decision (Sperling and Kitamura 1986; Kitamura and Sperling 1987). These early studies also provide the platform on which to explore the non-cost behaviors of refueling in sociological and psychological terms (Kitamura and Sperling 1987) based on situational and site-specific variables (Sperling and Kitamura 1986), which to date remain almost entirely unexplored.

Very little work has focused on the actual utilization of alternative fuel infrastructure, though some recent research efforts have been conducted to understand the role of infrastructure availability, convenience, and consumer awareness. For the purposes of this study, the most relevant of those focused on variables like route selection in relation to fueling stations, origin and destination points, and garage location. Taken together, these studies begin to inform our understanding of the actual refueling behavior of AFV drivers.

Kelley and Kuby (2013) investigated station choice among drivers of dedicated CNG vehicles (i.e., those that must operate exclusively on that fuel) in Los Angeles. The authors found that a higher percentage of drivers refueled at the station requiring the least deviation from a route (defined as the path from origin to destination) as opposed to the station located closest to the driver's home. In this particular case, drivers cited a threshold of approximately a 5-minute deviation from their routes. These findings are consistent with findings from Nicholas (2010) and Kitamura and Sperling (1987) that most drivers want to fuel near a trip's origin, frequently refuel on commuting routes, do not necessarily refuel close to home, and have a low distance/time threshold to deviate from those paths. These findings contradict the methodology used to determine "access to alternative fuel" based on a garage location (Helwig and Deason 2007; and Deason and Jefferson 2010; DOE 2011)—which serves as a proxy for "home" when driving a work vehicle.

It must be noted that the subjects of the Kelley and Kuby (2013) study drive dedicated CNG vehicles; they are no different than drivers of traditional gasoline or diesel vehicles in the sense that they must operate exclusively on one fuel. In fact, they are most closely

linked with diesel fueling patterns where availability and convenience are tightly linked and drivers are more accustomed (trained) to alter driving routes or planned stops to accommodate refueling at specific stations (putting convenience second). The authors note the uncertainty of applying these results to FFV drivers because they can purchase either gasoline or E85, thus "making the refueling behavior unrepresentative of how consumers behave when faced with a sparse network of stations" (p. 5). The question of interest in their study focuses on the sparse network of fueling infrastructure, but to suggest the FFV drivers seeking to utilize E85 are not faced with the same scarcity of stations would be inaccurate. In fact, FFV drivers are faced with more choices, not fewer, which negate the impact of availability and place a greater emphasis on convenience. We attempt to build on this work by investigating station choice and fuel choice.

A study by Johns et al. (2009) presents the only work we have encountered that explores fuel choice in dual-fueled vehicles. Based on the theory of reasoned action, Ajzen and Fishbein (1980), Johns et al. (2009) established four primary determinants of fuel choice behavior:

- Pre-existing attitudes
- Subjective norms
- Behavioral control
- Communication.

They found that the most significant factors influencing fueling behavior in dual-fuel vehicles were as follows:

- Vehicle performance
- Informal communication among peers
- Fueling station convenience.

Attitudes regarding alternative fuels (e.g., positive or negative views around using alternative fuels), organizational incentives, and training did not appear to influence use.

In light of the above findings, it is unlikely that training, incentives, and attempts to modify attitudes are enough to significantly change refueling behavior on their own. Since E85 station locations remain sparse and driver routes may not be easily modified, the "absolute" convenience of fueling with E85 is essentially fixed in the short term. Nonetheless, convenience also has a perceptual component. Specifically, awareness of fueling station locations may be imperfect, and fueling behavior may be driven to some degree by habit ("I always fuel at this station"), thus leading to imperfect estimations of convenience. Dingemans et al. (1986) briefly touches on a remedy for this problem by recommending local campaigns designed to increase consumer awareness of alternative fuel availability.

That the work of Johns et al. (2009) was a one-organization study is a limitation noted by the authors, but only because they did not find a correlation between employees' attitudes

toward environmental issues or AFV technologies and their fueling behavior. In fact, we think that this is a limitation of all the findings in this study. However, their work undoubtedly establishes a good foundation on which to explore the refueling behaviors of FFV drivers. Our work builds on this by investigating similar issues across a wide swath of organizational, operational, and geographic contexts.

2.3 Organizational Behavior and Management

While we have mentioned our hopes that federal fleet drivers may provide some insights into the behavior of the general public, the fact remains that these drivers operate in a heavily regulated environment and are subject to a wide variety of organizational cultures and constraints influencing individual behaviors and attitudes. We will quickly explore some relevant literature in organizational behavior and management.

In the case of a local governmental organization transitioning to AFVs, Johns et al. (2009) cited the lack of institutionalized, effective reward and sanction programs designed to promote compliance with organizational objectives. Their findings showed a clear lack of oversight and accountability relative to alternative fuel use. Also relevant is the relationship between job performance and alternative fuel use. It should be no surprise that they found when employee performance was evaluated on productivity alone, alternative fuel use suffered. We frequently hear anecdotal complaints that going out of one's way to purchase alternative fuel is not "part of my job description" or "takes too much time out of my ability to conduct 'real work.'" Accordingly, mechanisms to encourage and incentivize employee behavior in line with federal and organization objectives are of interest.

These authors provided an excellent review of the literature on these subjects, so we will revisit only some highlights. In particular, they noted "the importance of supervisory behaviors, such as open communication, openness to employee participation in decision making, feedback on performance, and exposure of employees to learning opportunities, to the successful implementation of innovative ideas within the organization" and stressed the importance of informal communication between colleagues as well as organizational rewards, incentives, and reprimands. This is all in line with others' findings that the success of environmental initiatives is a function of organizational support for employees' effort (Ramus and Steger 2000). Of course, the effort required to purchase alternative fuel is relatively high, and we suspect that increasing convenience and reducing that level of effort will be critical.

This research makes it clear that there is a relationship between management input and employee behavior, and that this and other considerations need to be integrated into successful efforts aiming to increase utilization of existing alternative fuel infrastructure. Accordingly, our interests move toward the impact of the design and delivery of various feedback mechanisms, including positive and negative feedback (Fishbach et al. 2010, Oskamp et al. 1994) as well as direct and indirect feedback (Ehrhardt-Martinez et al. 2010; Darby 2006; Abrahamse et al. 2005) within an organization.

Research into positive versus negative framing of feedback is widespread, but not in the specific case of refueling behavior. In Tversky and Kahneman (1974), a general

framework for the impact of framing on "rational choice" was presented, specifically that framing the effects can significantly impact the formulation of decision problems, thus impacting decision making generally. More recently, Fishbach et al. (2010) researched the differences between positive and negative feedback generally as it pertains to goal commitment and progression. Their research suggested specifically that positive feedback motivates commitment to overarching organizational goals while negative feedback drives progress in individual tasks.

Some research has also investigated the limitations of feedback. For example, some studies suggest that the socioeconomic characteristics of the target population can influence the effectiveness of feedback (e.g., Abrahamse et al. 2005; Allcott 2009; Costa and Kahn 2010). In addition, Finkelstein and Fishbach (2011) demonstrated the impact of framing depending upon the subject's experience level, specifically finding that beginner audiences respond better to positive feedback that reaffirms commitment to the original goal, while advanced audiences seek negative feedback that provides specific information on what they've done wrong and how to progress.

An important variable in framing research involves context—specifically, the intent and circumstances surrounding the positive and negative framework. How audiences perceive feedback is a significant factor in the equation. Emotional and behavioral influences, such as pride, hope, and ego, may factor heavily into whether positive or negative feedback drive change. This correlates with Louro et al. (2007), as outlined by Fishbach et al. (2010), in that self-regulating activities are driven more by negative feedback as audiences progress beyond initial goal commitment: "Beginners increased their efforts in response to success (versus failure) feedback, but as they advanced toward their goal, they tended to increase their efforts in response to failure (versus success) feedback." We must also recognize that while purely informational feedback will increase knowledge, it may not motivate individuals to change their behavior and thus may have only a modest impact (Steg 2008; Wilson and Dowlatabadi 2007). Specifically, Wilson and Dowlatabadi (2007) observed that in order for information to motivate a change in behavior it must be "simple, salient, personally relevant, and easily comparable rather than technical, detailed, factual, and comprehensive."

3 Empirical Analysis of Refueling Behavior

This section provides an overview of E85 infrastructure density and change, and the refueling data and methods used in our empirical analysis. Then we discuss trends in national, seasonal, annual, regional, and market-specific refueling behavior.

3.1 E85 Infrastructure Density and Change

The lack of E85 refueling infrastructure is a common anecdotal complaint from FFV drivers. This section provides a brief view of the E85 infrastructure market and how it changed between 2009 and 2012 as a precursor to how that infrastructure is utilized and how differences in infrastructure availability impact refueling behavior.

In 2012 there were 2,282 publicly accessible E85 stations in operation across the United States, a 25% increase from 1,821 in 2009. While the growth is noticeable, these total figures pale in comparison to the roughly 106,000 gas stations[7] nationwide. It is difficult to gauge the availability of a limited resource like E85 by looking at aggregate numbers only. In order to gauge the state of market penetration by E85 stations in different parts of the country, we looked at a variety of metrics: percent growth in the number of stations, station density per square mile, ratio of population to E85 stations, publicly registered FFVs per E85 station, as well as some combinations of these metrics.

Ultimately, we settled on a ratio of two metrics: gasoline vehicles per gas station versus FFVs per E85 station. This "market score" provides a simple indication of FFV and E85 market penetration whereby a score of one indicates that there were as many FFVs per E85 station as there are gasoline vehicles per gas station; a number greater than one indicates that there are fewer FFVs per E85 station than gasoline vehicles per gas station. The nationwide market score was 0.38 in 2012. To find this score we cross-referenced Homeland Security Infrastructure Project data, a federal database of gas station locations nationwide, with the Alternative Fuels Data Center Station Locator[8] to compare the number of stations in each state. The number of vehicles registered in each state is drawn from RL Polk[9] data. We then applied the cutoffs in Table 1, Market Score Range column, to categorize E85 markets by state.

[7] The exact number of gas stations in the United States is difficult to obtain and varies widely between sources. We utilize data from the Homeland Security Infrastructure Project (2012).
[8] http://www.afdc.energy.gov/locator/stations/
[9] https://www.polk.com/

Table 1. E85 Infrastructure Change and Market Designations

Market Name	Market Score Range	E85 Stations (2009)	E85 Stations (2012)	Percent Change ('09-'12)	Gas Stations (2012)	FFVs (2012)	Gas Vehicles (2012)	Market Score
Established	> 0.75	1,065	1,195	12%	13,667	2,077,750	27,503,168	1.16
Emerging	0.25–0.75	541	650	20%	22,966	3,288,175	48,856,523	0.42
Developing	0.10–0.25	146	325	123%	39,362	4,488,596	91,565,935	0.17
Nascent	< 0.10	63	112	78%	25,229	3,827,657	50,672,478	0.06
Zero	0.00	6	0	-100%	4,384	498,754	8,255,357	0.00
TOTAL	**n/a**	**1,821**	**2,282**	**25%**	**105,608**	**14,180,932**	**226,853,461**	**0.35**

The number of registered FFVs per E85 station drives the variability in market designations. Nationwide, there is not tremendous variability in the number of gas vehicles per gas stations: Hawaii has the most gas vehicles per gas station (3,385) and Vermont has the fewest (1,190). By contrast, Louisiana has more than 165,500 FFVs per E85 station while South Dakota has 770 FFVs per E85 station. Accordingly, the established markets have the lowest ratios of FFVs per E85 station (ranging from 770–3,000) and are followed fairly closely by the emerging markets (2,800–9,700). The range of this ratio grows significantly in the developing markets (8,200–22,800) and the nascent markets (22,800–165,500). The Midwest dominates both the established and emerging categories while the other regions have a solid mix of market characteristics. Figure 2 shows the breakdown of E85 markets by state.

E85 infrastructure growth was not evenly distributed across the net gain of 461 stations. Many locations also experienced a contraction in their E85 markets over this timeframe and in the same way that growth in the E85 markets was not evenly distributed, neither were the losses. It is difficult to gauge the impact of these losses because a number of the communities losing stations remain strong markets. Minnesota is a good example, having lost 31 stations—the only "established" state to do so—though it still had 351 stations in 2012, the most of any state. No other state lost more than four stations.

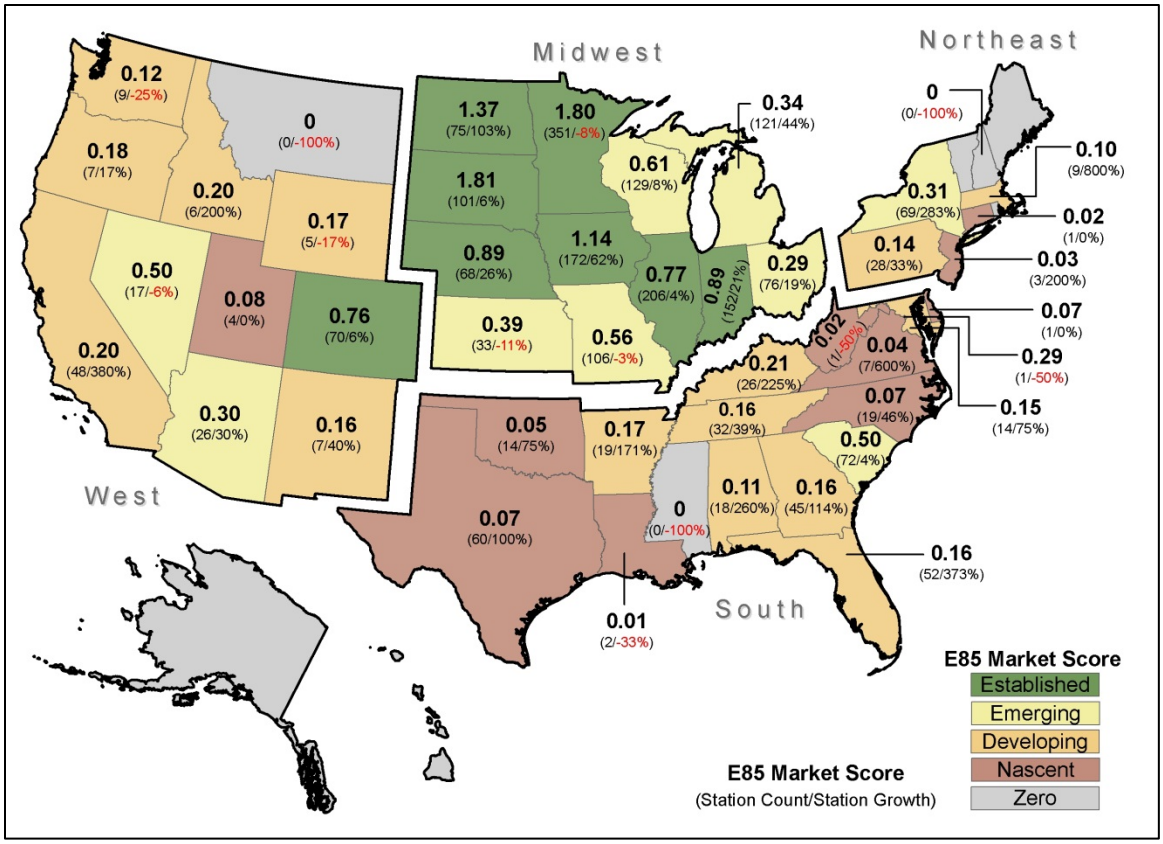

Figure 2. Regional divisions and E85 market scores by state, 2012.
Illustration by Jennifer Melius, NREL

Of course, our interest resides in the growth of E85 refueling stations from 2009 to 2012. In aggregate numbers the growth is fairly evenly distributed across the different markets, while it is easy to see that the percentage growth was strongest in the developing markets. This includes strong growth in California (especially Sacramento), Florida, and Georgia, with smaller but noticeable gains in Alabama, Kentucky, and Arkansas. Growth was strong in the nascent markets, primarily concentrated in North Carolina and Texas, but is overshadowed by the massive gasoline vehicle population in Texas. In the established markets, significant growth was experienced in North Dakota, Iowa, Nebraska, and Indiana. New York and Michigan showed the strongest growth in the emerging markets.

While the Midwest continues to be the dominant market for E85 station concentrations and growth, it would be a misnomer to characterize E85 as a strictly regional fuel. Strong markets still appear as isolated "islands" outside the Midwest, but the emergence of these markets is encouraging for the prospects of greater E85 use nationwide, especially in such high-profile eastern cities as New York, Atlanta, and Miami. Moving west the growth and market strength are apparent in the major population centers of Texas, Oklahoma, Colorado, Arizona, and Nevada, while the cities on the Pacific coast continue to lag behind other parts of the country. Johnson and Hettinger (2014) provide a more detailed review of the geography of alternative fuel deployment. Beyond the scope of this

project, an understanding of the economic and demographic characteristics of these markets would be welcome.

3.2 Empirical Analysis Methodology

The NREL team had access to transaction-level refueling data (all fuel purchases) for 12 federal agencies.[10] The data analyzed in this project cover vehicles leased by these agencies from GSA—as opposed to vehicles owned by the agencies—which provides a common dataset across all the agencies and allows for a robust comparative analysis. Refueling data include vehicle identifiers (VIN, tag, vehicle fuel type) as well as details of the individual transaction (date/time, station address, fuel type, and volume).

In order to see a complete picture of the available data, the NREL team combined the transaction data with agencies' inventory data, which include all of the demographic data for the fleet vehicles including license plate, VIN, year, make, model, customer contact, garage address, and other details. While combining the two datasets, we also ran a variety of analyses for each transaction, including days since the last fill-up, miles since the last fill-up, distance from the garage location to the nearest E85 station, and the distance of each refueling transaction from the garage location and to the nearest E85 station.

According to the statutory definition of "access to alternative fuel," every refueling instance that occurs within 5 miles of a publicly accessible retail E85 station that accepts the Wright Express fueling card used by GSA leased vehicles is considered to have access to alternative fuel. With this definition in mind, refueling instances were categorized into four types of "opportunities":

- **Made opportunities**: FFV purchases of E85
- **Missed opportunities**: FFV purchases of gasoline at a location that was within 5 miles of an E85 station
- **Opportunities**: All FFV transactions within 5 miles of an E85 station (made opportunities plus missed opportunities)
- **Non-opportunities**: FFV purchases of gasoline at a location further than 5 miles from an E85 station.

The analysis covers FY 2009 through 2012 and includes a variety of agencies such as defense, land management, law enforcement, research, and service providers. In total, the dataset tallies more than 167,000 vehicles, 16 million transactions, and nearly 240 million GGE of fuel purchased. However, because this study is focused on alternative fuel use, the dataset was further refined to include only FFVs. Vehicles classified as law enforcement and emergency response are excluded due to their exemption from EPAct § 701. We also exclude states[11] without publicly accessible E85 in 2012.

[10] NREL would like to acknowledge that access to these data is the result of projects funded through the DOE FEMP Sustainable Federal Fleets program: https://federalfleets.energy.gov/

[11] Alaska, Hawaii, Montana, Mississippi, Maine, Vermont, New Hampshire, and Rhode Island.

A significant amount of federal fleet refueling occurs at stations owned by and located on federal facilities. Across the 4-year period for which we have data, 34% of E85 purchases occurred at federal facilities, while the same can be said for only 5% of gasoline purchases. These facilities are not accessible to the public and access to particular fuels is often restricted such that FFV drivers can refuel with E85 only. These stations were excluded from the analysis. Geocoding errors were also a concern due to inconsistencies in detail provided for refueling station addresses; the final analysis focuses on the 73% of transactions geocoded at the most accurate levels.[12] Our final sample[13] included 67,361 individual FFVs and 4.4 million transactions at publicly accessible retail stations.

The genesis of this research centered on the idea of missed opportunities to purchase alternative fuel for a couple of reasons. First and foremost, missed opportunities to use E85 constitute the lowest of the low-hanging fruit in terms of our ability to reduce petroleum consumption and increase the use of alternative fuels: the vehicles are already on the road and the infrastructure is already in the ground. Second, missed opportunities constitute non-compliance with EPAct § 701. What remains is the behavioral component that connects the driver to the E85 station and puts E85 into the vehicle. To understand the empirical reality of this phenomenon we tested the following hypotheses:

- Missed opportunities have a temporal component and they will decrease over time as infrastructure availability increases.
- Missed opportunities have a familiarity component and they will be lower
    - The closer the purchase is to the vehicle's garage location
    - When there is an E85 station within 5 miles of the garage location
    - When vehicles have access to E85 infrastructure more frequently.
- Results may vary based on season,[14] region, and E85 markets. For example, we hypothesize that missed opportunities will be lower in the Midwest,[15] in established markets, and in summer months.

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[12] Google geocoding services provide the following levels of geocoding, in order of accuracy: premise, address, intersection, street, postal code, locality, region, unknown, NULL. When geocoding addresses, our processes first check for a geocode with accuracy at the *address* level or better. Due to uncertainty regarding the actual placement of a location, we default to the *postal code* accuracy level when geocoding results that are returned at the *intersection* or *street* levels. Approximately 26% of all stations are geocoded at the *postal code* level. Stations that are geocoded as *locality, region, unknown,* and *NULL* are not assigned a latitude and longitude and are excluded. Fewer than 1% of all stations fall into this category.

[13] We are also aware that transactions at the point of sale can record inaccurate fuel purchases due to problems in the coding of a fuel pump's card reader and subsequent translation of the data through a number of systems to its output via GSA (e.g., E85 purchases are recorded as gas purchases, and vice versa). The full extent of this problem is unknown and identifying these stations was not possible within the scope of this analysis.

[14] Using a quarterly breakdown of the federal fiscal year (October to September): Q1 = Fall (October, November, December); Q2 = Winter (January, February, March); Q3 = Spring (April, May, June); Q4 = Summer (July, August, September).

[15] Regional breakdowns are based on the "Census Regions and Divisions of the United States" used by the U.S. Census Bureau (available at http://www.census.gov/geo/maps-data/maps/pdfs/reference/us_regdiv.pdf).

To test these hypotheses we first looked at total opportunities to purchase E85 and missed opportunities—as a percentage of all fuel purchases by FFV drivers—monthly from FY 2009 to FY 2012. These results are shown in Figure 3 and Figure 4 and discussed below. We then plotted missed opportunity rates versus six variables, two in each of the following three categories, at the state level using a scatter-plot linear regression:

- **Availability of E85**: These variables control for the impact of E85 infrastructure availability.
    - **Opportunity rate**: The percentage of all FFV transactions that occur within 5 miles of an E85 station (missed opportunities plus made opportunities divided by all refueling instances).
    - **Waiver-ineligible**: The percentage of FFVs ineligible for a waiver from EPAct § 701 requirements, and therefore required to use E85.
- **Market conditions**: These variables control for the state of the E85 market in which the vehicles are operating.
    - **Market score**: Gasoline vehicles per gas station versus FFVs per E85 station.
    - **Growth rate**: Percent change in the number of E85 stations from FY 2009 to FY 2012.
- **Operational characteristics**: These variables control for the frequency of vehicle use and distances traveled.
    - **GGE per vehicle**: GGE used per vehicle from FY 2009 to FY 2012.
    - **Distance from home**: Average distance of transactions from the vehicles' garage locations.[16]

[16] Distance of a transaction from the "garage location" is used instead of the actual reported mileage with each transaction. When drivers purchase fuel they are required to enter the odometer reading, but the process is prone to human error and the observed data are too inconsistent to utilize for analysis.

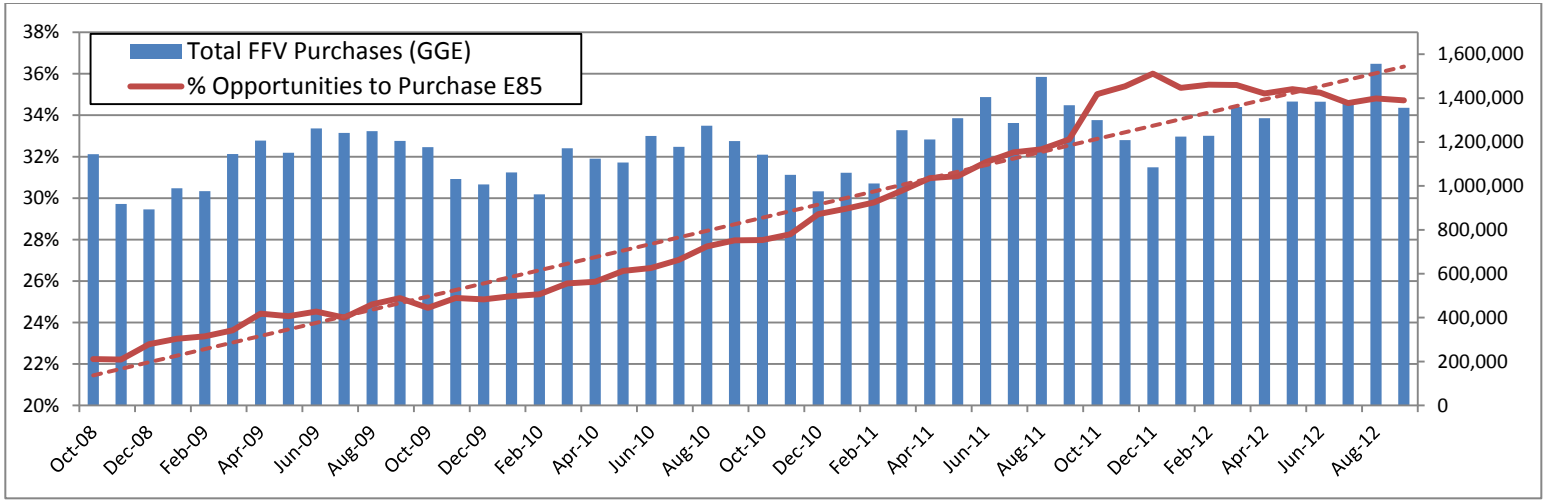


Figure 3. Opportunities to purchase E85 as a percentage of all FFV fuel purchases

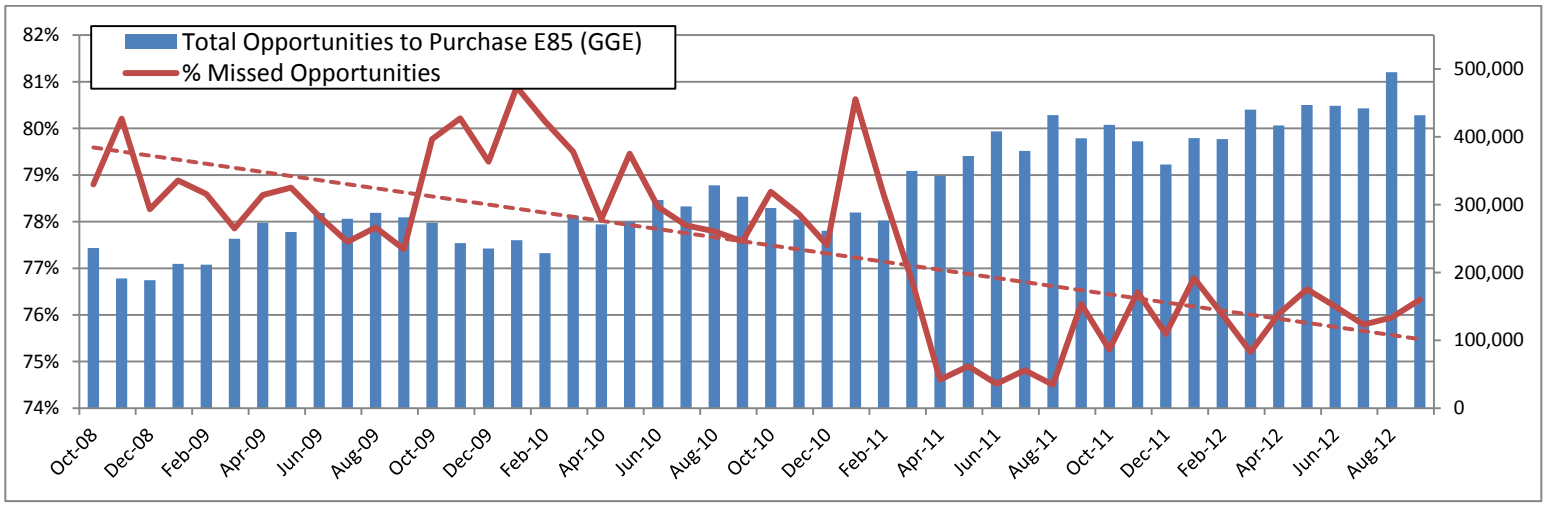


Figure 4. Missed opportunities as a percentage of all FFV opportunities to purchase E85

3.3 National Trends in Refueling Behavior

Following the trend of increasing retail availability of E85 over FY 2009–2012, this analysis shows steadily increasing opportunities to purchase E85 as a percentage of all FFV fuel purchases (see Figure 3). These opportunities rise steadily from about 23% in early FY 2009, peaking in December 2011 before leveling off over the remainder of FY 2012 and holding steady at a little more than one third of all FFV fuel purchases. By comparison, total volume of fuel purchases by FFVs held fairly steady during the same timeframe and shows consistent seasonal fluctuations in usage. Of course, the rise in opportunities to purchase E85 is a positive development. But as we know, the bigger issue remains missed opportunities to purchase E85—they account for 77% of all opportunities to purchase E85 over the 4 years tracked.

As shown in Figure 4, missed opportunities are trending downward and appear to have stabilized even more quickly than total opportunities to purchase E85. The dramatic drop from 80.6% in January 2011 to 74.6% by April 2011 came 9 months prior to the December 2011 peak of total opportunities. Of course, this comes with the additional good news that usage of E85 shows a corresponding rise over these 4 years. From a national perspective, this supports our hypothesis that missed opportunities would decline over time.

Two additional trends are worth mentioning. First, missed opportunities do not follow the same gradual, steady trend that characterizes total opportunities. They jump quickly in early FY 2009 and plateau through early FY 2011. The dramatic drop in the middle of FY 2011 is noticeable before they stabilize around 76% through the end of FY 2012. It is difficult to know exactly what causes this drop in missed opportunities. Though we cannot draw direct causal relationship between the two, it is worth noting that in FY 2011, FEMP began investigating the phenomenon of missed opportunities and helping volunteer agencies to identify and reverse them. This eventually led to the development of the FleetDASH[17] Web application, which went live in early FY 2012 and is designed to help federal agencies track and eliminate missed opportunities. It may also be that fleet managers and drivers simply became more aware of and familiar with expanding E85 infrastructure, or perhaps agencies ramped up management efforts to grow and monitor E85 use.

We had suspected that we would see correlations in missed opportunity trends relative to the operational characteristics of federal FFVs, but we cannot confirm our hypothesis that missed opportunities will decrease when a vehicle operates closer to its garage location (see Figure 5). We also find no correlation with the GGE consumed per vehicle. On the other hand, three variables did exhibit a negative and statistically significant correlation to missed opportunities: opportunity rate, waiver-ineligible, and E85 market score. In a basic sense this reveals that familiarity matters—the more often drivers are in proximity to E85 stations, the less likely they are to have missed opportunities. We are able to confirm the hypotheses that missed opportunity rates will be lower when there is an E85 station within 5 miles of the garage location and when vehicles have more frequent access to E85 infrastructure.

[17] https://federalfleets.energy.gov/FleetDASH/

The negative correlation of missed opportunities to the waiver-ineligible variable speaks to the efficacy of the EPAct § 701 requirement to use alternative fuel. Those who are required to use it are more likely to do so. On the other hand, there is clearly an unintended consequence of restricting the requirement to use E85 to only those vehicles that have access to E85 within 5 miles of their garage location: all other drivers are exempt, regardless of how frequently they are in actual driving proximity to an E85 station.

Four states best fit this mold: Minnesota, Iowa, Wisconsin, and North Dakota (see Figure 5). Not surprisingly, Minnesota and Iowa are leading the way in all three of the statistically significant variables: the highest opportunity rates (>74%), among the highest waiver-ineligible rates (58% and 64%, respectively), and market scores greater than one; their overall missed opportunity rates are 45% and 53%, respectively.

Wisconsin is the outlier in this group in terms of its market score (0.61), but it is otherwise a top performer in terms of opportunity rate (68%), waiver-ineligible rate (54%), and overall missed opportunity rate (51%). By contrast, North Dakota is the outlier with a very low waiver-ineligible rate (35%). It would appear that it has been able to overcome the waiver paradox given the overall strength of its market: opportunity rate (62%), market score (1.37), and an overall missed opportunity rate of 62%, the fifth lowest overall. All four of these states exemplify the trends we would hope to see: steadily rising opportunity rates and steadily declining missed opportunity rates.

Only the E85 growth rate shows a positive correlation with missed opportunities. While not statistically significant on a national level, the positive coefficient is nonetheless instructive about the growth of infrastructure. Among the states with the largest growth, missed opportunity rates remain very high. California (90%), Florida (96%), and New York (81%) are instructive examples—all three had growth rates that exceeded 280% and at least 48 stations in 2012. All three states experience significant growth in their opportunities to purchase E85, but remain on the lower end of the spectrum in terms of overall opportunity rates, waiver ineligibility, and market score; only California shows a decreasing missed opportunity trend (95% in 2009 to 86% in 2012).

The lessons here are twofold. First, the market growth is noteworthy but these are massive new markets, nowhere near the maturity—in terms of how long the stations have been in operation—at which we would expect missed opportunity rates to drop significantly. Second, consumers need a chance to catch up with the market growth; they need time to become aware of and begin to regularly use a station. Even in the Midwest states mentioned above, all of which had strong markets in 2009, the lowest missed opportunity rates occur in 2012—3 years later. The time gap between when E85 infrastructure is installed to when it is more heavily and regularly utilized could be instructive to policy-makers, fuel providers, and station owners.

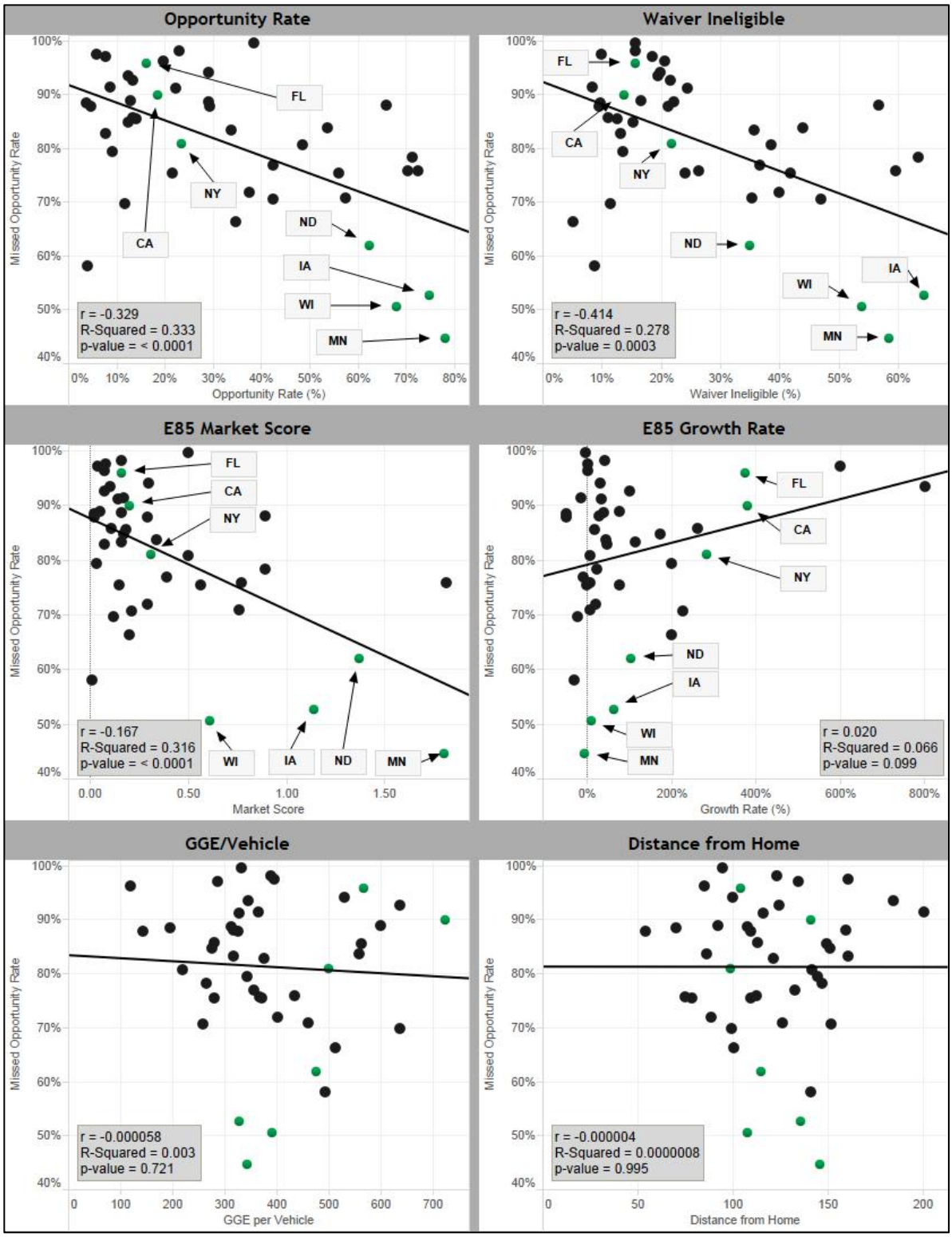


Figure 5. Linear regression of missed opportunity rates

3.4 Seasonal, Annual, Regional, and Market Trends in Refueling Behavior

In a somewhat unexpected result, the impact of E85 availability and operational characteristics on missed opportunities does not change according to the season.[18] We had expected to see some changes in the winter months in particular, perhaps related to driver concerns with cold weather and the potential for high blends of ethanol to gel and cause "cold-start" problems for some vehicles, or simply because drivers may be less willing to go out of their way to purchase E85 when it is cold outside. We did not confirm this hypothesis. We believe that this speaks to the continuity of operations, and therefore driving needs, for most federal agencies throughout the year. These results are shown in Table 2; more complete results are show in Appendix A.

Table 2. Linear Regression of Missed Opportunity Rates by Season, Year, Region, and E85 Market

	Missed Opportunity Rate	Opportunity Rate	Waiver Ineligible	E85 Market Score	E85 Growth Rate
Seasonal					
Fall (First Quarter)	77.9%	28.0%	22.6%	n/a	n/a
Winter (Second Quarter)	78.0%	28.8%	23.3%	n/a	n/a
Spring (Third Quarter)	76.8%	29.5%	25.6%	n/a	n/a
Summer (Fourth Quarter)	76.5%	30.0%	28.0%	n/a	n/a
Annual					
FY 2009	78.3%	23.8%	27.9%	n/a	n/a
FY 2010	79.0%	26.2%	22.2%	n/a	n/a
FY 2011	76.4%	30.7%[a]	26.4%[a]	n/a	n/a
FY 2012	76.0%	35.2%[a]	23.7%[a]	n/a	n/a
Region					
Midwest	69.1%	61.7%	48.3%	0.78	12.5%
Northeast	85.7%	17.4%	19.5%	0.14	161.9%
South	85.6%	17.0%	20.3%	0.12	79.0%
West	84.3%	22.7%	14.9%	0.26	30.9%
E85 Markets					
Established	68.1%	69.1%	49.9%	1.16	12.2%
Emerging	77.4%	42.2%[a]	33.6%[a]	0.42	20.1%
Developing	84.7%	19.9%	17.2%	0.17	122.6%
Nascent	89.4%	9.3%	16.0%	0.06	77.8%
National Averages	**77.2%**	**29.1%**	**25.0%**	**0.35**	**99.1%**

[a] Statistically significant at the 95% confidence level.

[18] The market condition variables are excluded from the seasonal and annual comparisons because we lack a means to view infrastructure growth below an annual level of granularity, and the market growth figure is calculated as a comparison of FY 2009 to FY 2012 and does not specifically account for changes that occurred in FY 2010 and FY 2011.

From an annual perspective, we see that the availability of E85 begins to have a significant impact in FY 2011 and FY 2012. This conforms to the results we discussed earlier, where missed opportunities drop dramatically in the middle of FY 2011 and essentially hold steady around 76% through the end of FY 2012. From these results we are also able to see that the impact of E85 infrastructure growth was only fully realized in the latter 2 years when opportunity rates jumped noticeably from 25% in 2009 and 2010 to more than 33% in 2011 and 2012.

In another surprising result, the statistical significance of opportunity rate, waiver-ineligible, and E85 market score completely disappear from a regional view. We also see mixed results with regard to the impact of different variables (positive versus negative) on missed opportunities. For example, waiver-ineligible has a positive correlation with missed opportunities in the Northeast, and E85 growth has a negative correlation with missed opportunities in the Midwest (see Figure 6). While our variables are not significant within any individual region, they do highlight the homogeneity within each region and do not diminish the impact of the Midwest or the largely regional nature of E85 availability and use.

It is precisely because of the Midwest that these variables become significant in the nationwide models. We are able to confirm our hypothesis that the Midwest has the lowest overall missed opportunity rates (69%) and along with the West experiences a steadily dropping missed opportunity rate. In contrast, both the Northeast and South have steadily rising missed opportunity rates. The Midwest has by far the highest opportunity rate, waiver-ineligible percentage, and E85 market scores.

This finding is reinforced when we view the results by E85 market divisions. Only the emerging markets show the same statistically significant correlations between the missed opportunity rate versus the opportunity rate and waiver-ineligible variables. This happens because five of the nine states in this market segment are in the Midwest (Kansas, Missouri, Wisconsin, Michigan, and Ohio) and they show drastically different performance than the other four states in the emerging market group: Nevada, Arizona, New York, and South Carolina. It is instructive to focus some attention on these four states, along with Colorado—the only established market outside the Midwest (see Figure 6).

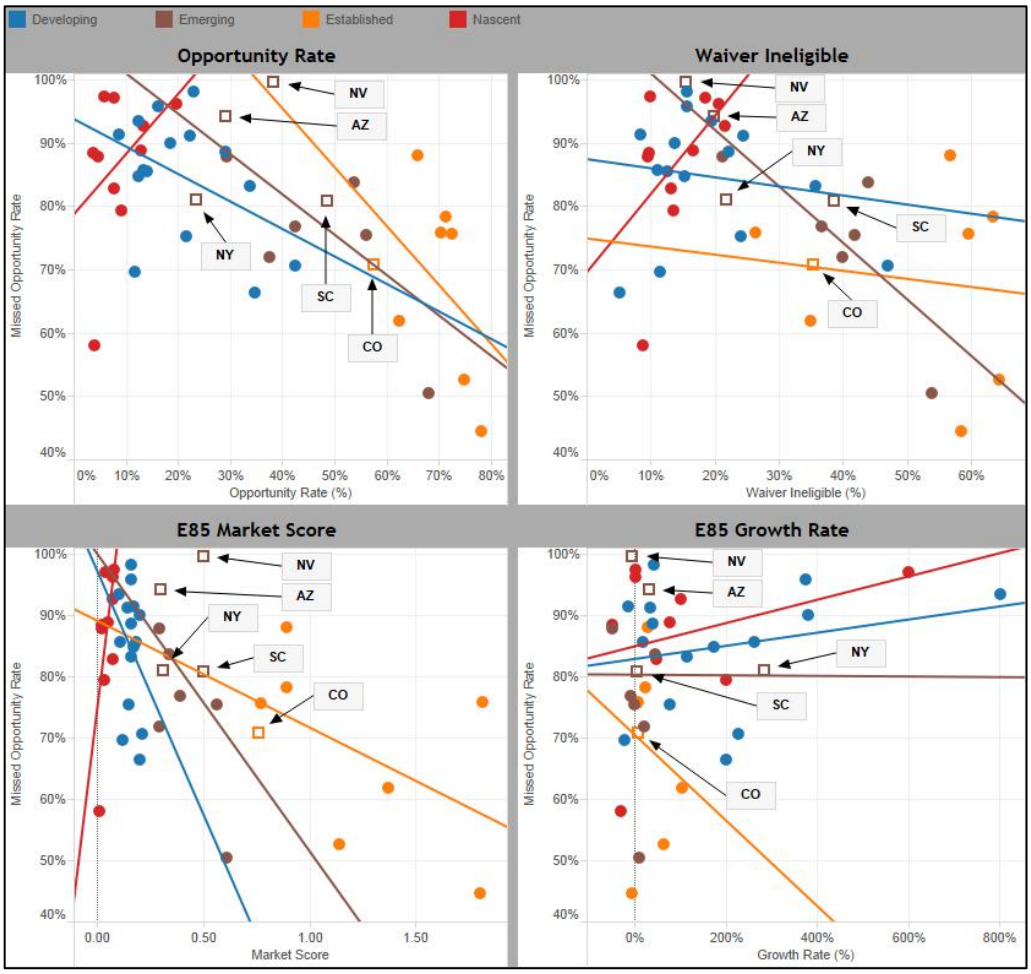


Figure 6. Linear regression of missed opportunity rates by E85 market

Obviously, all of these states have a reasonable number of E85 pumps to support many of the FFVs on their roads. Arizona and Nevada represent smaller markets that existed in 2009. Every E85 station in Nevada in 2012 was located in the Las Vegas metropolitan area; the opportunity rate rose from 30% in FY 2009 to 43% in 2012, but missed opportunities have essentially stayed at 100% through all 4 years. Arizona shows a similar experience: stations are confined to Phoenix and Tucson with opportunity rates rising from 20% to 37% between 2009 and 2012, and missed opportunity rates climbing from 91% to 96%.

Colorado and South Carolina are much larger markets (70+ stations each), with low growth rates (6% and 4%, respectively), and they have the highest opportunity rates in the group: more than 57% in Colorado and more than 48% in South Carolina. Despite markets that look fairly similar to some of the Midwest states, the missed opportunity rates in Colorado (71%) and South Carolina (more than 81%) perform more like their regional counterparts than states with similar market scores. New York is the newcomer to the group with a 283% growth rate and E85 stations jumping from 18 in 2009 to 69 in

2012. Not surprisingly, their opportunity rate rose from 18% to 27%, but missed opportunity rates look like South Carolina's at 81%.

3.5 Discussion of Refueling Behavior Findings

What do these results teach us about the refueling behavior of FFV drivers and the availability of E85? The opportunity rate and the waiver-ineligible variables paint a fairly clear picture of a technological solution to increasing E85 use (i.e., build it and they will come). When FFV drivers have an E85 station near "home" (which means they are required to use E85 in the case of the federal fleet) and they have more frequent access to E85 when refueling, they are more likely to use E85.

However, despite the statistically significant results for these variables, the coefficient and R-squared values are not particularly strong—generally accounting for 20%–30% of the variability in missed opportunity rates. Additionally, we find that these variables are in fact significantly correlated with one another, leading to some redundancy in their impact on missed opportunity rates (see Table 7); which means that more than two thirds of the variability in missed opportunity rates cannot be accounted for with these variables.

Nevada, Arizona, New York, South Carolina, and Colorado are cases in point that surprised us with above average missed opportunity rates in maturing E85 markets. This leads us to one fairly basic conclusion: just because you build a station does not mean the drivers will come. That there is not solely a technological solution to the problem runs contrary to much of the literature in alternative fuels deployment, and poses a significant challenge for a transportation future in which consumers have multiple choices of fuel to power their vehicles.

The next logical place to look for an explanation would be on the economic side: the impact of the cost of the available fuels versus the expected return. And while we presume that this is a significant factor for the general consumer, it should be a moot point for federal drivers operating a vehicle on a GSA lease. The billing mechanism used by GSA serves as a financial incentive for FFV drivers to use E85 in GSA-leased vehicles: GSA charges lessees a flat mileage rate (as opposed to paying for the fuel at cost) regardless of whether a driver purchases gasoline or E85. As such, traditional concerns about the price spread of E85 to gasoline and lower fuel efficiency while operating on E85 due to lower energy content are moot. Additionally, the money that these drivers are using is not their own and should not have the same impact on their refueling behavior as would otherwise be the case.

Only a behavioral component remains as an explanatory variable for the continued lack of E85 use among federal FFV drivers. The behavioral traits that lead to missed opportunities, or made opportunities for that matter, are not identifiable from our empirical dataset. The remainder of this paper focuses on our research into the behavioral traits that are important to the increased use of E85, while future research will investigate the impact of targeting those behaviors with tailored behavior change campaigns.

4 Stated Preference Survey of Federal Flex Fuel Vehicle Drivers

This section discusses the results of a June 2012 survey of federal fleet drivers designed to identify the non-cost-based behavioral factors influencing fuel-purchasing behavior.

4.1 Survey Design and Implementation

The NREL survey did not follow a specific predetermined survey methodology since the research was the first if its kind. Our primary objective was to establish a meaningful dependent variable that would be observable both through direct means (e.g., tracking actual refueling behavior) and indirect means (e.g., follow-on surveys). As such, the survey team focused on establishing a baseline understanding of the SLD out of one's way to purchase alternative fuel, which was asked two different ways:

- What is the likelihood that you would drive the following distances out of your way to purchase E85? Please answer as a percentage ranging from 0% (I would never drive this additional distance to fuel with E85) to 100% (I would always drive this additional distance to fuel with E85).
    - 1 mile or less
    - 1–3 miles
    - 3–5 miles
    - 5 miles or more.
- What is the likelihood that you would drive the following additional time increments out of your way to purchase E85? Please answer as a percentage ranging from 0% (I would never drive this additional time increment to fuel with E85) to 100% (I would always drive this additional time increment to fuel with E85).
    - 5 minutes or less
    - 5–10 minutes
    - 10–15 minutes
    - 15 minutes or more.

In light of the above objectives, questions administered are classified into five topical categories to facilitate analysis and discussion, including:

- **Demographics**—Age, gender, education
- **Awareness**—Knowledge of their statutory requirements and their own performance
- **Operational**—Driving habits, including how long they've been driving federal vehicles, whether they consistently drive the same vehicles, weekly mileage, and garage locations, as well as the types of locations, routes, and roads they drive

- **Technology**—Perceptions about E85 related to the availability and convenience of fueling infrastructure, vehicle performance, and price
- **Motivation**—Factors that influenced their driving for work, where they decided to purchase fuel, and whether or not they decided to purchase E85.

The long-term objective of the NREL study is to utilize the results of this survey to (1) add to the literature on refueling behavior in the context of overcoming barriers to wider deployment of emerging technologies in alternative fuels and advanced vehicles, and (2) inform the development and implementation of behavioral interventions designed to increase the utilization of alternative fuels.

Survey design began early in FY 2012 and included various rounds of design review by subject matter experts at NREL, DOE, and outside sources. A test survey was administered to fleet drivers at NREL to assess clarity, relevance, and the appropriateness of the survey in terms of topics and time required to complete it.

The final survey was conducted online and distributed via email on June 11, 2012. A second email notice and reminder was distributed on July 10, 2012; the survey was available online until July 20, 2012. The research team utilized a contact list developed by FEMP[19] and housed at NREL to distribute the survey to 8,976 points of contact; these emails were forwarded to an additional 1,871 contacts for a grand total of 10,847 recipients. The emails sent from NREL went only to points of contact known to be involved in federal fleet management and operations. This set of contacts consisted of known government email domains such as .gov (6,564) and .mil (2,899), as well as other known agency affiliates under the following domains: .net (65), .edu (141), .com (218) and .org (232).

Participation in the survey was voluntary and anonymous. As such, the resulting sample of responses can be viewed as a convenience sample, as time, funding, and federal constraints did not allow for a fully randomized sample. At the time of the survey, there was uncertainty of the relationship between the email recipients and the fleet managers from whom FEMP collects transaction and inventory data. In other words, a given point of contact may have been an actual driver of a fleet vehicle, a fleet manager, or other personnel. Accordingly, the first question in the survey is "Do you drive a federal fleet vehicle?" Those responding "no" were directed not to complete the survey.

In total, NREL received 3,314 completed surveys, a response rate of 31%. All survey respondents were asked a set of 22 questions, which included all of the demographic and operational questions as well as a small subset of the motivation, awareness, and technology questions. Respondents indicating that they drive FFVs were asked the full set of 34 questions, which expanded on the motivation, awareness, and technology questions. Since the primary focus of the research project is to understand attitudes and behaviors related to purchasing E85, the vast majority of our analysis focuses on the 1,370 respondents who indicated that they drive FFVs (Figure 7). Future work will

[19] This contact list is compiled from attendee lists from the 2010, 2011, and 2012 FedFleet conferences, obtained by the FEMP federal fleet team as exhibitors at these conferences; the Federal Automotive Statistical Tool; and customer contacts listed in the Reports Carryout Inventory Reports, a GSA database.

investigate the complete dataset in greater detail, but some valuable insights are explored below.

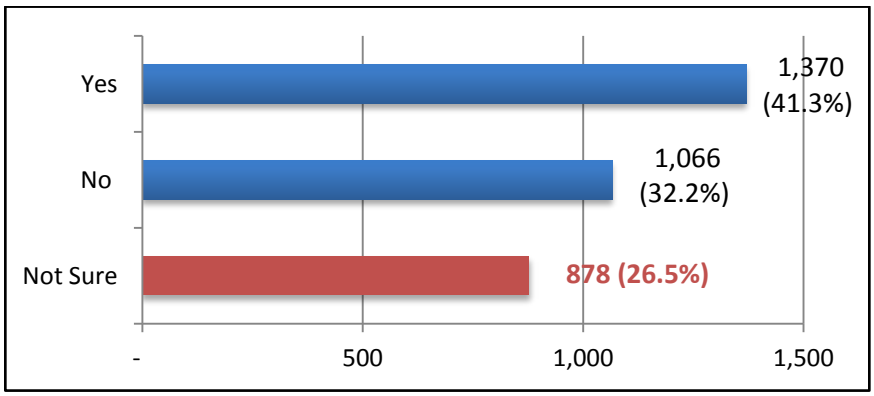


Figure 7. Survey question results: "Can your primary federal vehicle use E85 fuel?"

Because there is no existing demographic profile of federal fleet drivers that we are aware of, there is no means to compare the federal fleet driver to the demographic profile of the entire federal workforce and know if we have a fully representative sample. In order to establish some connection, we compared the percentage of surveys filled out by individual agencies to each agency's percentage of vehicles in the federal fleet in FY 2011. This suboptimal method is complicated by the 600-plus surveys completed at IP addresses we could not associate with an agency. Still, we suspect that Department of Defense and Postal Service drivers may be slightly underrepresented in our sample, while Department of Agriculture, Department of Transportation, and Office of Personnel Management drivers may be slightly overrepresented.

We also discovered some instances where we suspect that respondents misunderstood a question or found it difficult to answer, or that our question design was poor. For example, question 24 asks, "How far is the nearest E85 fueling station from your primary federal vehicle's primary garage location?" Since we did not allow for a "none" answer, we suspect that answers of "0 miles" may actually have been intended to mean "none," as opposed to "I have a station at my location." Additionally, questions 28, 30, and 34[20] included the option to select "not sure," "never used E85 in my vehicle," or "never used gasoline in my vehicle" (see Appendix F). Due to the large number of respondents selecting these options for these questions, our results are skewed in favor of the "not sure," "never used E85," and "never used gasoline" responses, making the results unclear. We do not include these questions in our findings. This is unfortunate because these questions were designed to test FFV performance and fuel efficiency while using E85, and the cost of E85 versus gasoline.

[20] Question 28: How does your primary federal vehicle's fuel efficiency compare using E85 vs. regular gasoline? Question 30: How does your primary federal vehicles perform using E85 vs. regular gasoline? Question 34: How does the price of E85 compare to regular gasoline in your primary federal vehicle's operating area?

There may also be a slight nonresponse error in which we failed to obtain complete data from all survey responses, though we believe that this impact is minimal given that respondents could not submit the survey unless they had completed all questions. In some instances it is also possible that respondents simply filled in questions randomly to complete and submit the survey. We removed surveys with obvious errors, leaving the NREL study with a final sample size of 1,268 FFV driver surveys.

4.2 Survey Analytic Methodology

Initial steps in the analysis involved segmentation of the data in three different ways to facilitate comparisons that would yield meaningful results. These segmentations are as follows (a summary of these segmentations and the associated n-sizes are presented in Table 3):

- **Time versus distance.** SLD demand curves quickly revealed that respondents' likelihood to go out of their way to buy E85 drops markedly beyond the 3-mile and 10-minute thresholds (Figure 8). Accordingly, our analytic effort was focused on the 1-mile or less/1–3 miles and 5 minutes or less/5–10 minutes segments.

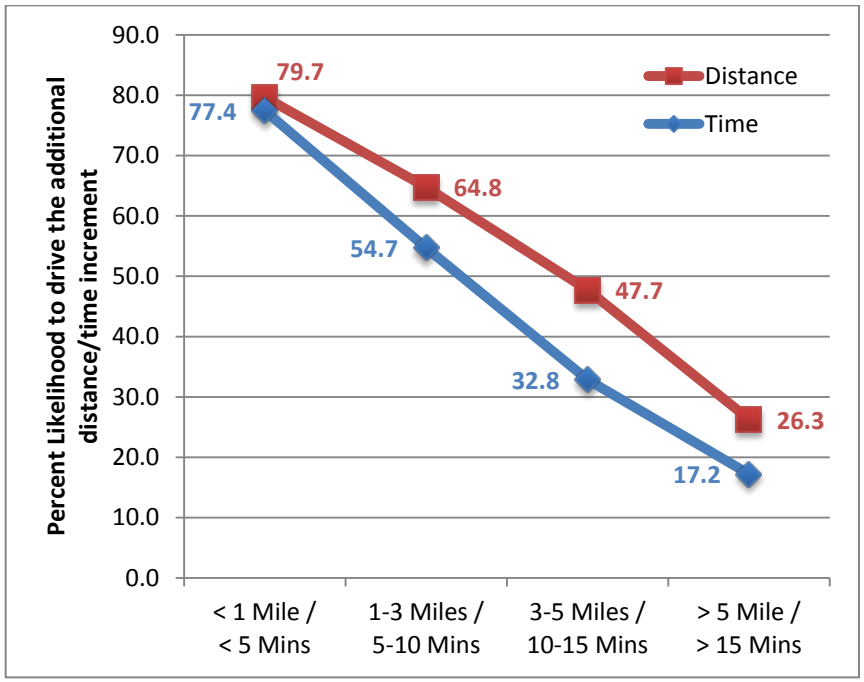


Figure 8. Percentage likelihood that drivers would travel additional distance/time to purchase E85

- **Purchaser cohorts.** With a wide range of responses to the SLD questions, even within the shorter time/distance increments, it was necessary to segment these responses into purchaser cohorts based on the percentage of the time drivers would go the extra distances to purchase E85: Purchasers (P): ≥ 80%; Swing Purchasers (SP): < 80% and ≥ 20%; and Non-Purchasers (NP): < 20%.

- **Training and awareness.** The survey included two questions related to respondents' basic "training and awareness" of their responsibility to use E85 when they have access to it. Question 20: When fueling your primary federal vehicle, are you required to use E85 fuel when it is available? Question 32: Have you received training on federal fleet requirements for E85 use?" Respondents who answered "yes" to both questions were categorized as "trained and aware" (TA), while those who did not were categorized as "untrained and unaware" (uTuA).

The NREL analysis involved a comparison of these four segmentations:

- Purchasers versus Swing Purchasers versus Non-Purchasers (P/SP/NP)
- Purchasers versus Swing Purchasers versus Non-Purchasers within the trained and aware group (P/SP/NP-TA)
- Purchasers versus Swing Purchasers versus Non-Purchasers within the untrained and unaware group (P/SP/NP-uTuA)
- Trained and aware versus untrained and unaware group (TA/uTuA).

The analysis and output were performed using Mathematica computational software. Depending on the nature of the question, the responses in each category were compared based on one of the following: percentage for binary answers, mean, median, or weighted mean. For binary answers, (e.g., gender, yes/no), the comparison between groups was based on the proportion of respondents selecting one of the answers. In cases where respondents provided numerical information, such as annual miles driven, the comparison between groups was made based on the mean or median of the values provided. The decision of which estimate of centrality to use was based on examining the distributions for symmetry. If the data distribution passed statistical tests for being approximately normal, the mean value was used; the median value was used for skewed distributions.

For questions the respondent could answer by choosing a number between 1 and 6, the comparison between groups was made based on weighted mean. The weights were calculated to be the percentage of respondents who answered with a given number; e.g., the percentage of people answering 1. The weighted mean (M_w) was then calculated as the sum of the numeric answers multiplied by the percentage of respondents who chose that number, using the following formula:

$$\mathrm{M_w} = \frac{\sum_{i=1}^{n} w_i v_i}{\sum_{i=1}^{n} w_i}$$

where w_i is the weight, given by the percentage of respondents who selected the answer with the value v_i.

The tests for binary answers were carried out using a standard test for differences in proportions:

$$z = \frac{\hat{p} - \hat{q}}{\sqrt{\hat{p}\hat{q}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Where $\hat{p}$ and $\hat{q}$ are the means of the two columns of data that are being compared. The P-value is then calculated with the following formula:

$$P\text{-value} = 2[1-\Phi(|z|)]$$

where $\Phi(|z|)$ is the standard normal distribution. All statistical tests were performed with a two-sided Z-test at the 95% confidence limit (Table 3):

Table 3. Data Segmentation and Associated n-Sizes

	TA	uTuA	Grand Total
Distance: 1 mile or less			
P	345	580	925
SP	36	130	166
NP	34	133	167
Distance: 1-3 miles			
P	267	410	677
SP	81	225	306
NP	67	208	275
Time: 5 minutes or less			
P	335	546	881
SP	45	155	200
NP	35	142	177
Time: 5-10 minutes			
P	208	288	496
SP	119	291	410
NP	88	264	352

5 Survey Findings

This section breaks down the results of the 2012 survey based on the topical categories used to analyze the results: demographics, awareness, operational, technology, and motivation.

5.1 Federal Fleet Demographics

As mentioned earlier, there is no existing demographic profile of the federal fleet driver that we are aware of. Our results begin to fill this void by utilizing our full dataset of 3,314 surveys to establish a profile of these drivers. Federal fleet drivers who responded to our survey were 69% male and 31% female. The overall average age of these drivers was 48.1 years (median of 50.0) and there was very little difference in the distribution across age ranges between male and female (Figure 9). Survey respondents are well educated: 92% reported having completed at least some college, and 56% reported having either a bachelor's or a post-graduate degree.

The operational characteristics of the federal fleet vary widely and cover a broad geographical area; we received survey responses from all 50 states and the District of Columbia. Light-duty vehicles dominate the federal fleet and survey responses reflected this (Figure 10). Respondents also cover a broad spectrum in terms of where they drive (Figure 11) and the type of roads they utilize (Figure 12). We also asked drivers about the types of routes that characterized their driving requirements. The options included on-site (e.g., campus, military base); off-site, fixed route (e.g., service territory, delivery route); off-site, as-needed (e.g., travel to meetings, on-demand requests); long-distance (transport, multi-day trips); and other. Off-site, as needed dominated the responses to this question (Figure 13).

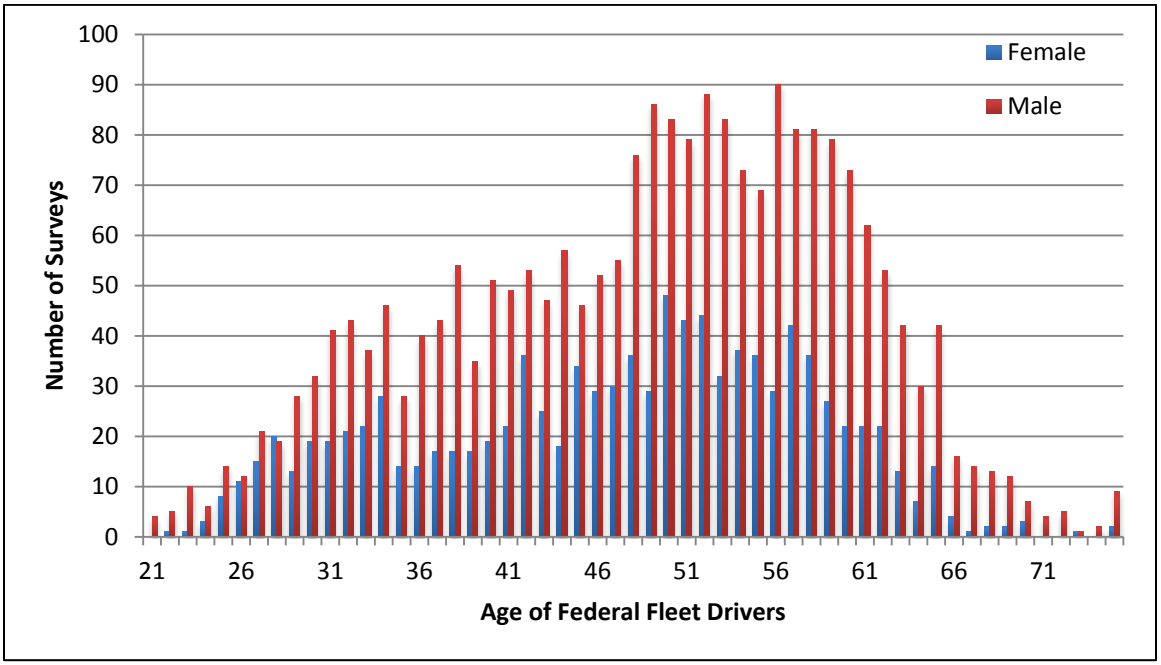


Figure 9. Distribution of survey respondents' ages

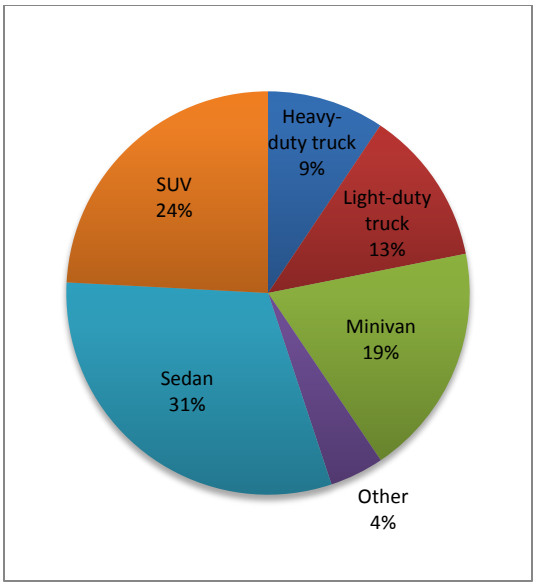


Figure 10. Vehicle types

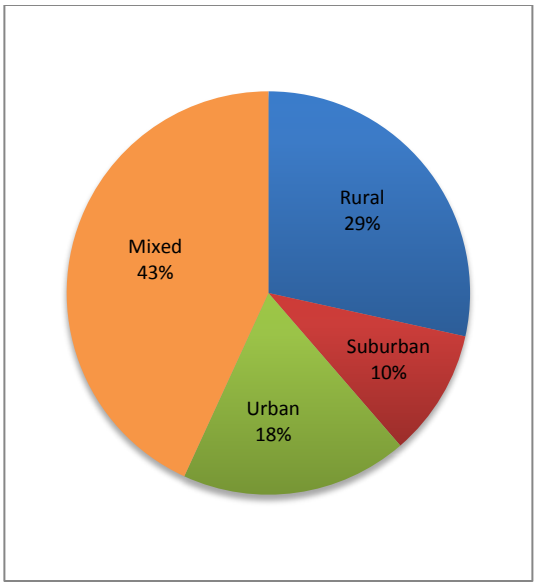


Figure 11. Driving locations

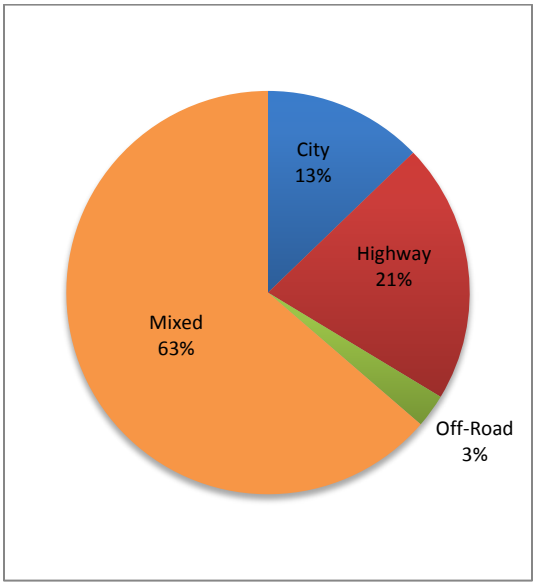


Figure 12. Road types

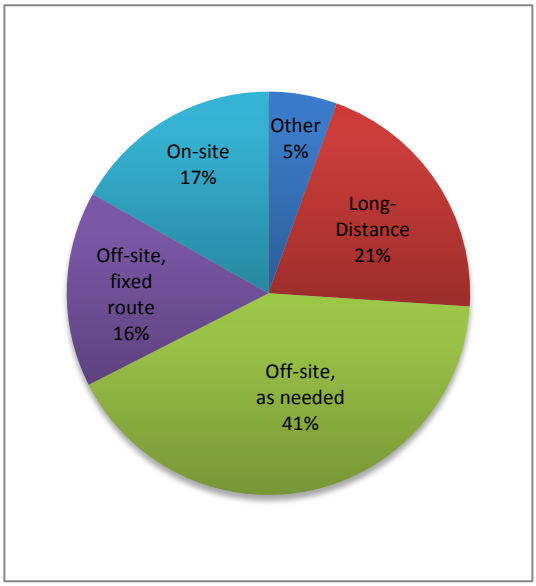


Figure 13. Route types

The reported distance that these drivers typically drive in the course of a week also varied greatly, with the largest percentage of drivers reporting distances of less than 50 miles per week (Figure 14). A quarter of drivers reported driving distances greater than 250 miles per week. Seventy percent of respondents reported that they had been driving federal vehicles for more than 5 years (Figure 15)—since before EPAct § 701 was enacted in 2007. The operational characteristic that may be most critical to the results of the NREL analysis is that more than half (51%) of respondents stated that they do not always drive the same vehicle. Clearly, going back and forth between vehicle technologies and trying

to figure out what fuel can be used by the vehicle they're driving presents an added layer of complexity and effort for drivers.

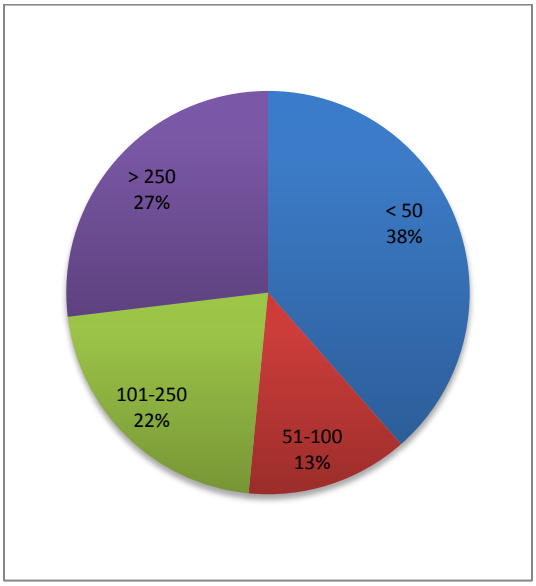


Figure 14. Miles driven in a typical week

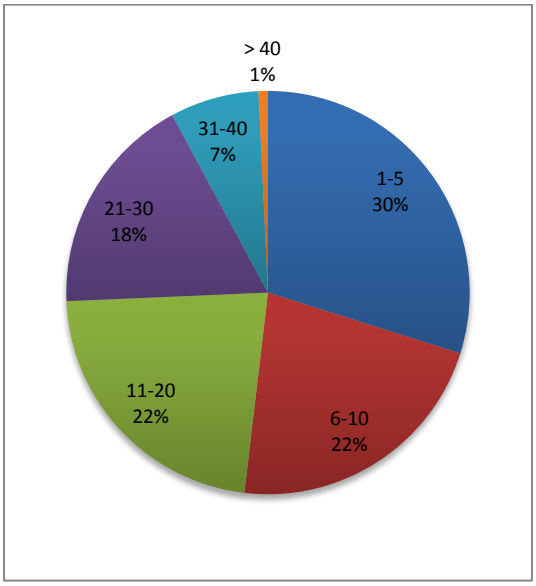


Figure 15. Years driving a federal vehicle

5.2 Flex Fuel Vehicle Driver Awareness

Overall, the majority of FFV drivers (67%) stated that they are required to use E85 (Q20), but this figure drops dramatically as we move from Purchaser (P) → Swing Purchaser (SP) → Non Purchasers (NP). The results of the awareness questions are listed in Figure 16. Perhaps more disturbing, only 36% reported having received any training on federal fleet requirements for E85 use (Q32); that percentage also drops dramatically as we move from P → SP → NP. A critical component of such training would be knowledge of where to purchase E85. Thus, is not surprising that we see such a dramatic difference in the responses to Q33 (Figure 17), both moving from P → SP → NP and in the TA/uTuA comparison.

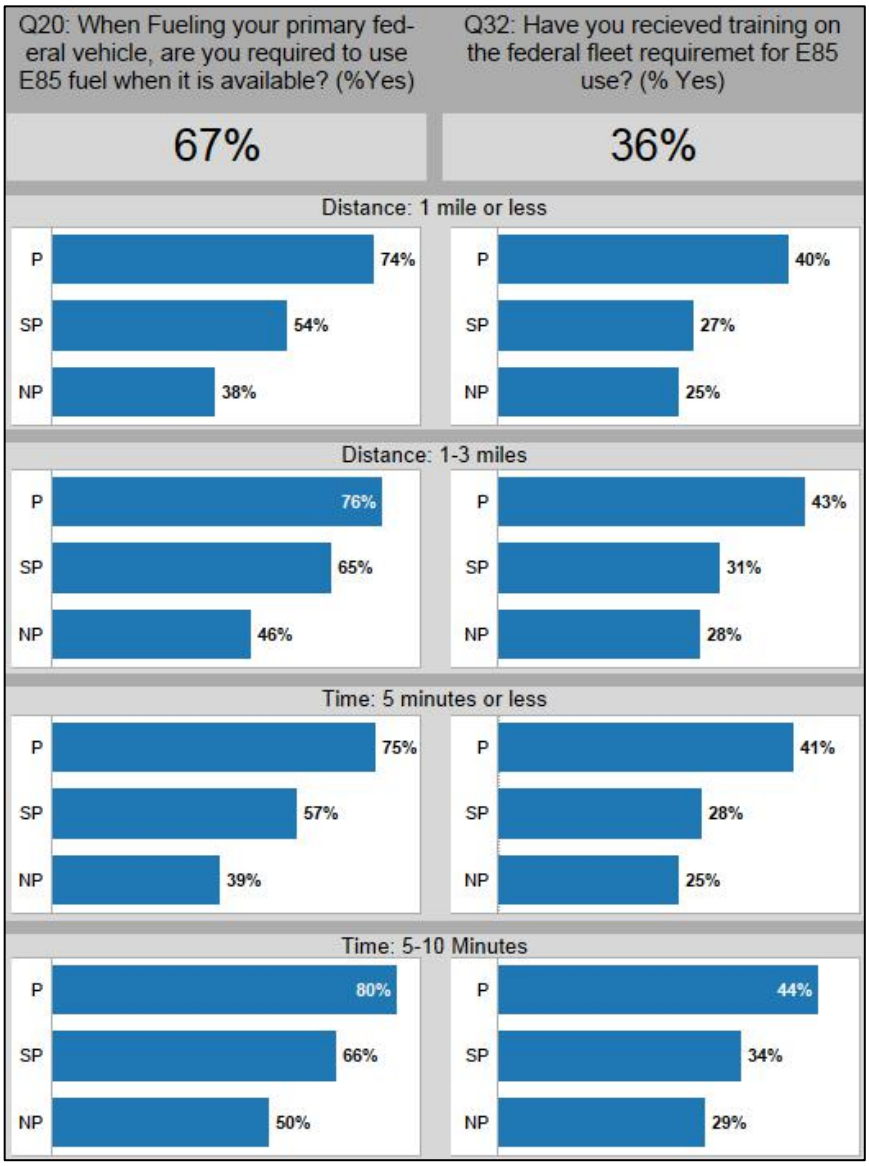


Figure 16. Awareness questions[21]

We would have thought that the lack of awareness of E85 availability would be less of an issue than it is, given the level of effort by DOE to develop and publicize the Alternative Fueling Station Locator.[22] Despite these efforts, awareness is low, and we suspect that this is a significant contributing factor to the low rates of E85 usage across the federal fleet. With respect to feedback, Q21 and Q22 offer some valuable insights into the management of federal fleet drivers (Figure 17). The statistically significant results (see footnote 23) are not consistent, but the overall low percentage of "yes" responses to both

[21] In Q20, all of the cohort comparisons are statistically significant; in Q32 the differences between P is statistically significant from SP and NP in all cases, but the differences between SP and NP are not. It is also worth noting that Q20 was purposefully placed well ahead of Q32 so as not to "lead" respondents.
[22] http://www.afdc.energy.gov/locator/stations/

Q21 and Q22 tell us that, with respect to compliance with EPAct § 701, federal FFV drivers have very little management oversight and are not held accountable for their actions related to the use of alternative fuel. Taken together, the awareness questions point to a fairly intuitive result: management and accountability matter.

Of particular interest to our future research is federal FFV drivers' awareness of their own behavior and performance. Empirical datasets allow us to test this in two different ways: how frequently federal fleet drivers actually purchase alternative fuel versus how often they perceive that they purchase alternative fuel (Figure 18), and the availability and convenience of E85 fueling infrastructure versus drivers' perception of availability and convenience (Figure 19).

In terms of federal FFV drivers' stated (perceived) E85 use (Q17), aggregate responses fall closest to "around 25% of the time" (3.58 weighted mean), differ significantly in most cases across all of the P/SP/NP comparisons, and move closer to "never" from P → SP → NP; there are significant differences in the TA/uTuA comparison as well. This is a bit surprising, as we had expected federal FFV drivers to overestimate their E85 use, but our empirical refueling data show us that in FY 2012 FFV drivers refueled with E85 23% of the time when they had access to it. The empirical data are reinforced by the vastly higher rate of NPs stating that they have chosen not to use E85 when it was available (Q18). By comparison, the responses to Q18 among the purchasers and swing purchasers contradict the empirical data, suggesting that those drivers simply do not know when they have access to E85 and miss opportunities to fuel with it. Either way, it is clear that federal FFV drivers have a fairly accurate picture of their E85 usage, or lack thereof.

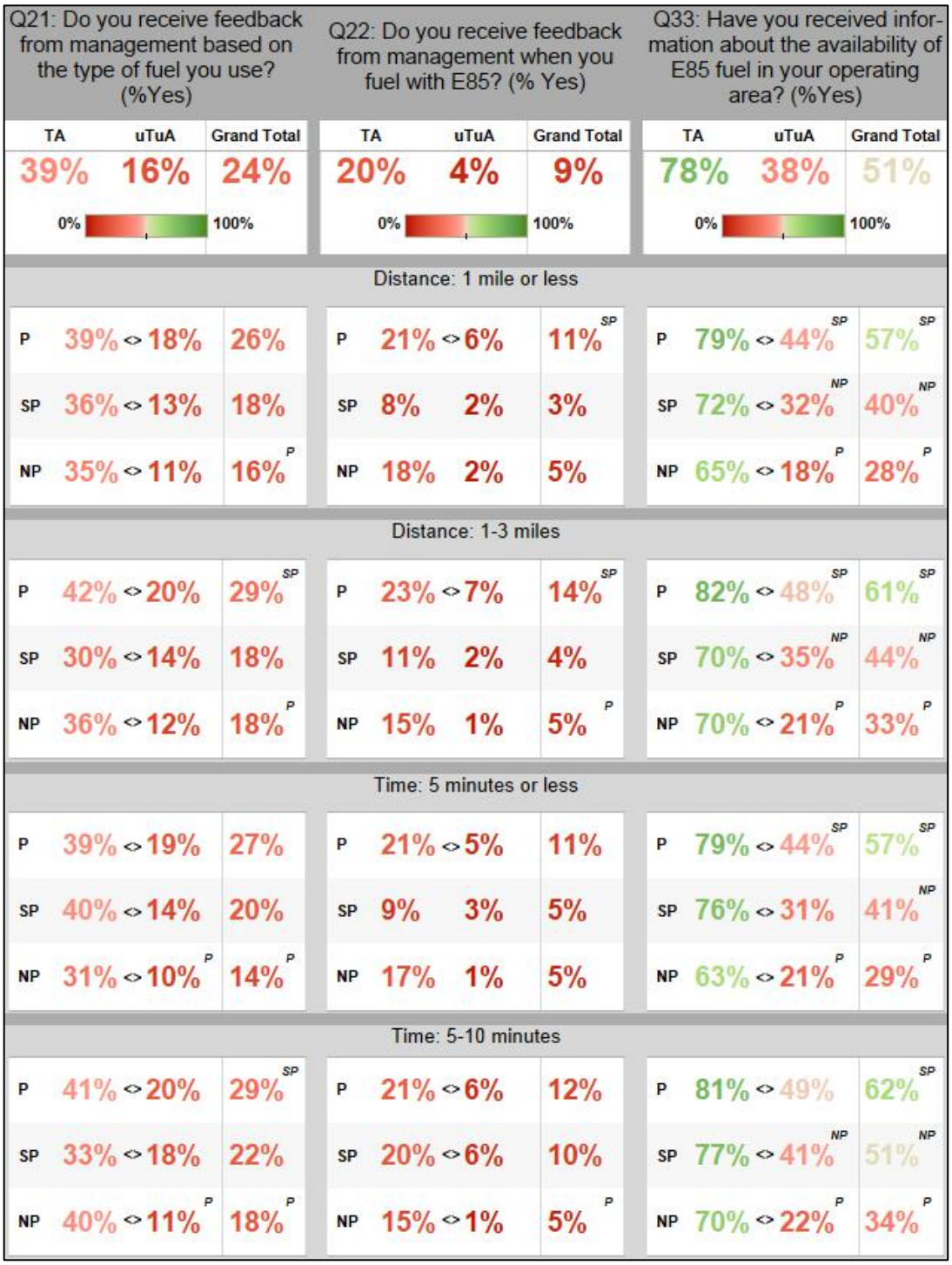
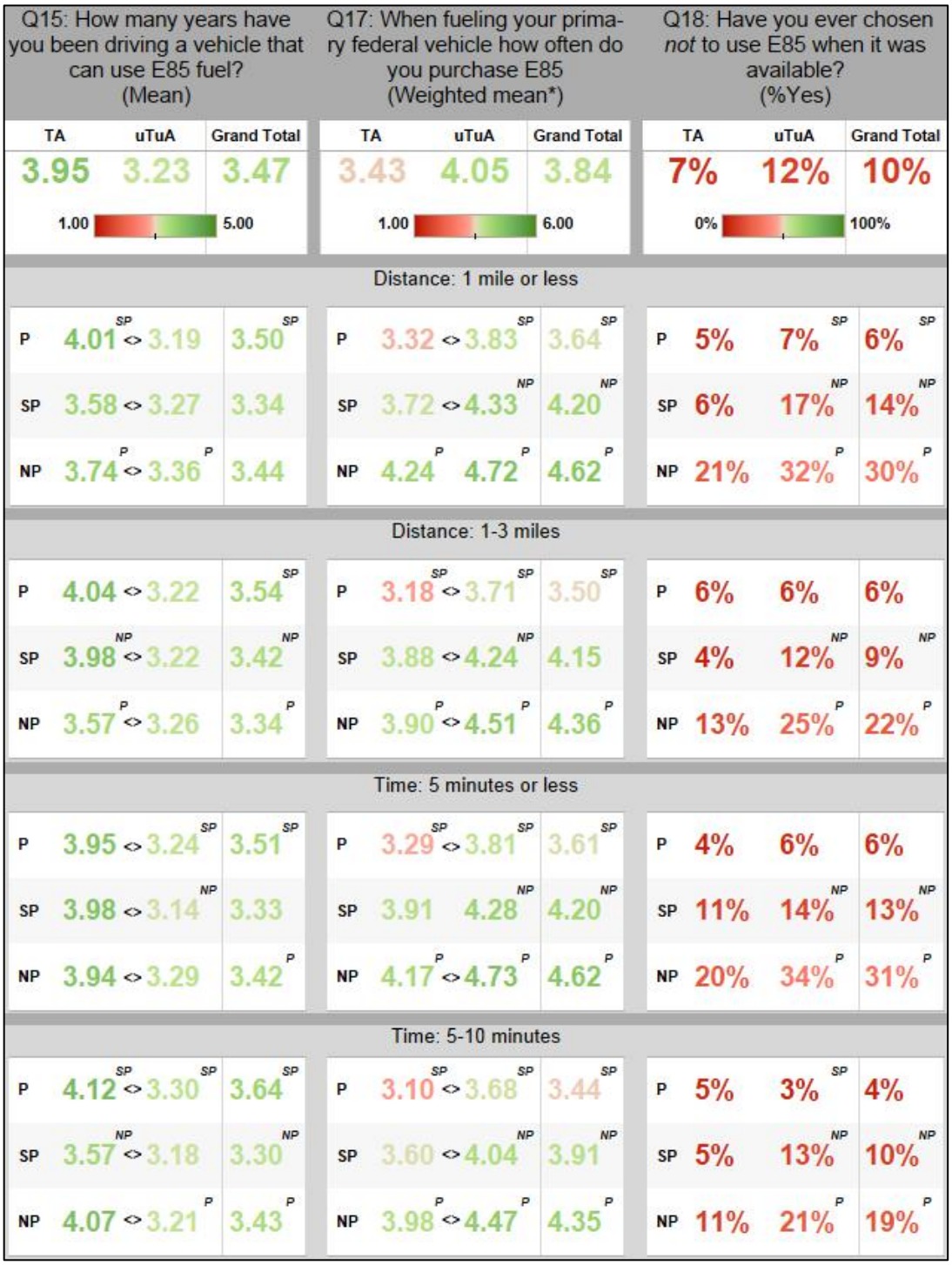


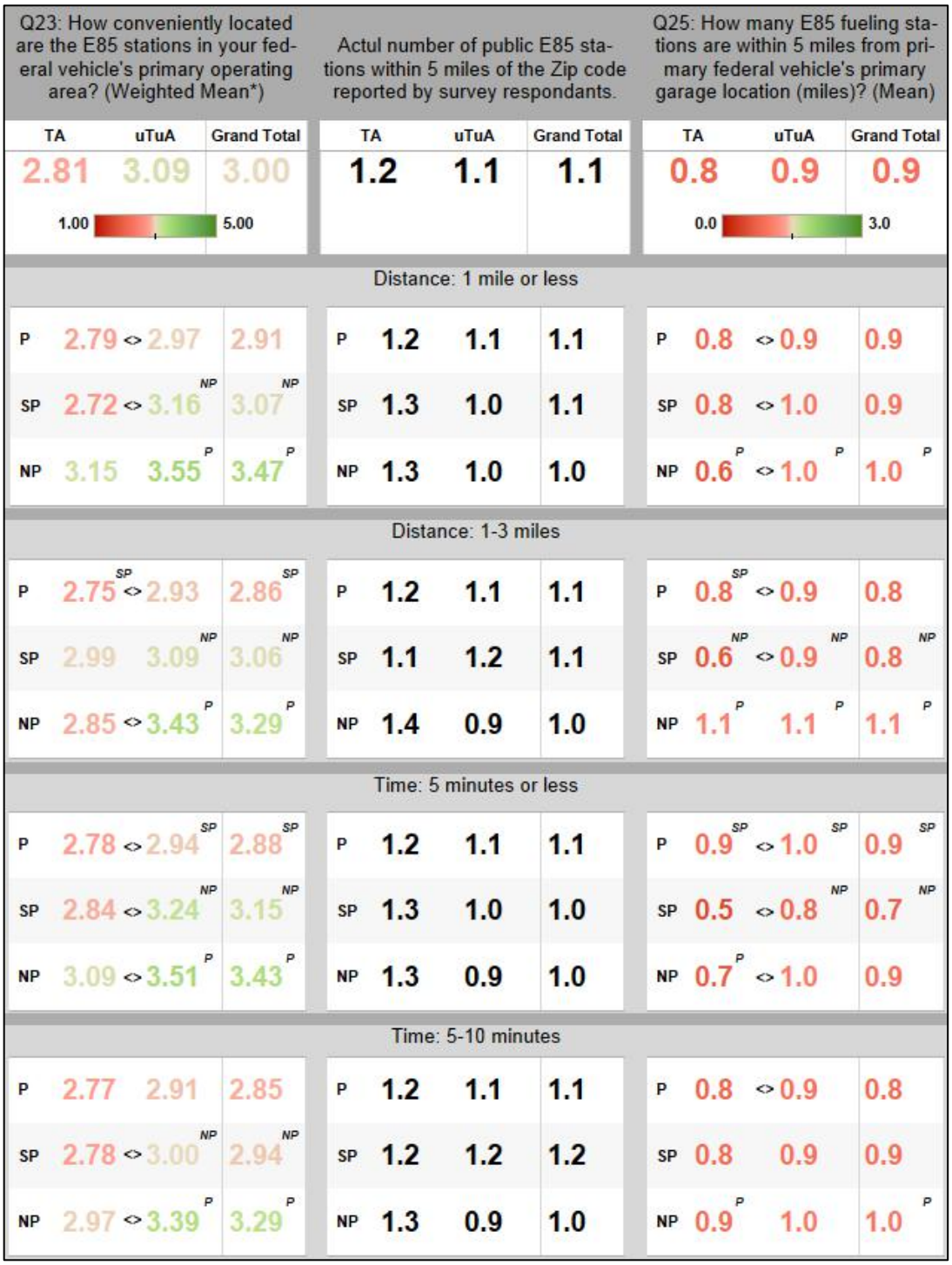
Figure 17. Comparison of responses to awareness questions[23]

[23] Statistically significant differences between the TA and the uTuA groups are indicated by the "<>" symbol. P, SP, or NP listed to the right of any figure indicates a statistically significant difference from the listed purchaser cohort. All statistical tests were performed with a two-sided Z-test at the 95% confidence limit.



*Q17 answers are weighted accordingly: (1) Always, (2) Around 75% of the time, (3) Around half of the time, (4) Around 25% of the time, (5) Never, (6) Not Sure.

Figure 18. Perception versus reality: actual refueling behavior



*Q23 answers are weighted accordingly: (1) Very convenient, (2) Somewhat convenient, (3) Not convenient, (4) Unavailable, (5) Not Sure.

Figure 19. Perception versus reality: infrastructure availability

Not surprisingly, more FFV drivers view infrastructure availability as "not convenient," moving closer to "unavailable" as we go from P → SP → NP and TA → uTuA. The TA respondents in each category consistently view E85 availability as slightly more convenient than the uTuA in those same categories. To test perception versus reality for the availability of E85, we asked how many E85 stations were within 5 miles of respondents' garage locations (Q25). We compared this figure to the number of publicly accessible E85 stations in operation at the time of the survey within 5 miles of the center point[24] of the ZIP code provided as the primary garage location in Q7. Not surprisingly, federal FFV drivers consistently underestimate the availability of E85 stations—but not by much. Interestingly, based on the total responses, the NP respondents generally have a more accurate perception of E85 availability than do P and SP respondents, and we see a similar trend from uTuA → TA.

5.3 Flex Fuel Vehicle Driver Operational Characteristics

On the operational side, three questions reveal particularly interesting results. First, there is a noticeable urban/rural divide (Q10), with NP reporting significantly higher rates of rural driving. Second, NPs report driving the most miles per week while Ps report driving the fewest, especially in the TA group. In many ways, the responses to Q9 (Figure 31) and Q10 (Figure 32) are complementary and suggest that a variety of operational constraints are contributing to low alternative fuel usage across the federal fleet. Third, there is a significant difference in the TA/uTuA comparison with regard to the percentage of respondents stating that they always drive the same vehicle (35% and 52%, respectively). Those driving just one vehicle are likely to be the most frequent travelers driving the longest distances whereas those driving multiple vehicles are likely utilizing pool vehicles in an on-demand fashion. In fact, this latter scenario is most common: 41% of respondents selected the "off-site, as-needed" route type in response to Q12 (see Figure 13). As such, its stands to reason that on any given day, drivers may simply not know (or do not check) what type of vehicle they're driving and are traveling to disparate locations—increasing the likelihood that they would not seek to fuel with E85.

5.4 Flex Fuel Vehicle Driver Views on Technology and Performance

With regard to respondents' knowledge of the technological issues surrounding E85 use, we are unable to use some of our results due to an error in question design. Questions 28, 30, and 34 were all designed to test perceptions of E85 performance and price. Unfortunately, the responses "not sure" and "never used E85 in my vehicle" were so voluminous that they skewed our results in their favor; when we remove these answers from our analysis, the n-sizes become too small to report on the results of our comparisons with a reasonable level of confidence. However, if we take a brief look at the aggregate responses to questions related to fuel efficiency, vehicle performance, and price, we find a knowledgeable population of FFV drivers.

[24] Due to the large variability in the sizes of zip codes, especially in western states and rural areas, the accuracy of this methodology varies.

With regard to the fuel efficiency of E85 relative to regular gasoline, the prevailing perception is "a little worse," an accurate reflection of how we would expect E85 to perform on a miles-per-gallon basis. In total, 57% of respondents stated that they were concerned about the fuel efficiency of E85 (Figure 20), with no significant differences between P/SP/NP. At the same time, the significant differences in the TA/uTuA comparison suggest that training and awareness make a difference: The TA FFV drivers appear to be aware of the lost energy content of E85 and the associated impact on fuel efficiency. Similarly, with regard to the price of E85 relative to regular gasoline, perception falls right between "E85 costs about the same as regular gasoline" and "E85 is a little less expensive." This is, generally speaking, where we expect E85 prices to be: The national average in April 2013 was $3.59/gallon of gasoline and $3.30/gallon of E85.[25]

Responses to vehicle the performance question (Figure 20) are counterintuitive—we would expect the performance of a vehicle to remain constant or improve slightly due to the higher octane of E85 (all things being equal with fuel quality). In total, 47% of respondents stated that they were concerned about the performance of E85, with one notable significant difference: NPs within the TA group. Their higher level of concern about vehicle performance is noticeable.

[25] http://www.afdc.energy.gov/fuels/prices.html

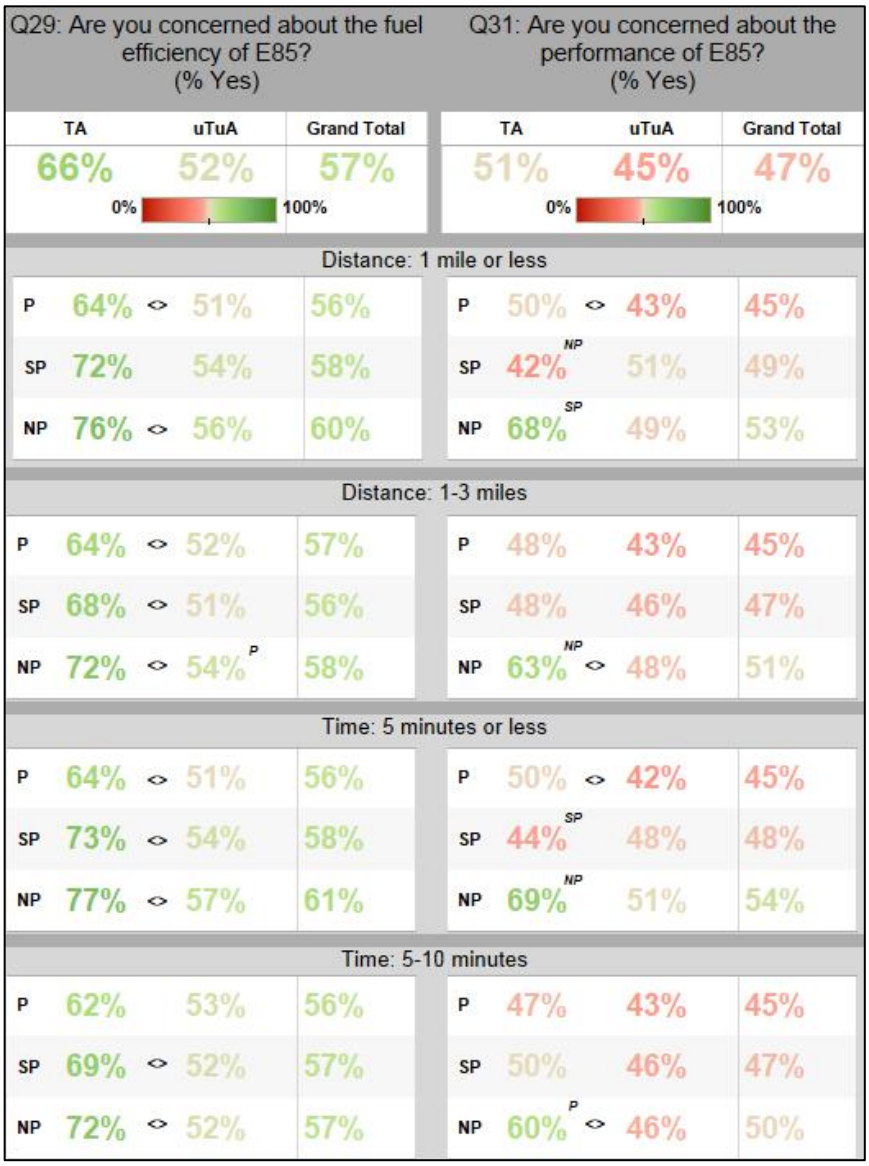
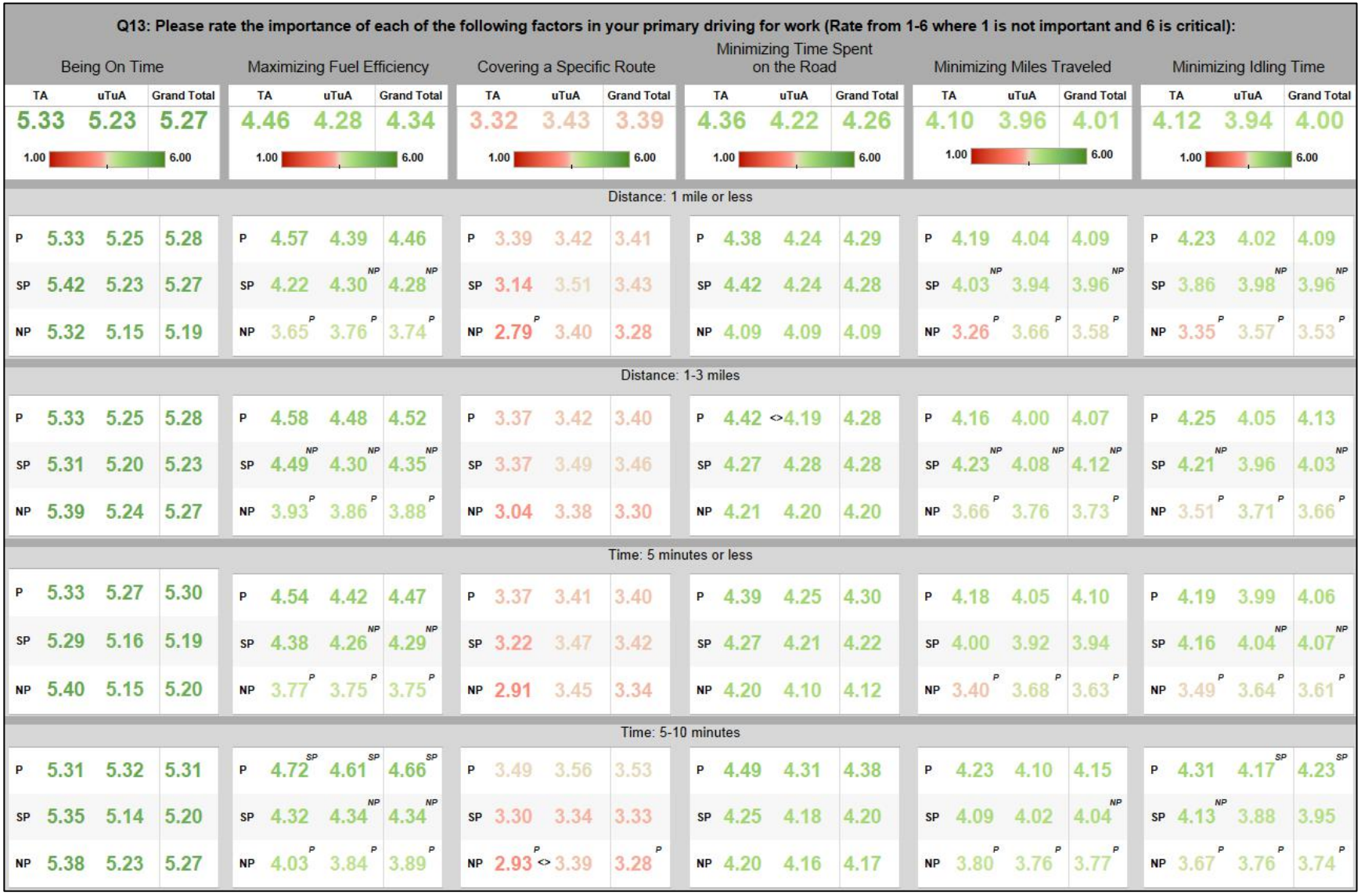


Figure 20. E85 fuel efficiency and performance questions

5.5 Flex Fuel Vehicle Driver Motivation

In order to gauge what motivates drivers when operating federal FFVs, we asked three questions where respondents ranked the relative importance of a variety of factors on a scale of 1–6 where 1 is not important and 6 is critical. The results of the motivation questions are listed in Appendix E. In terms of what is generally important to federal FFV drivers in driving for work (Q13), "being on time" was far and away the most important, but with no significance whatsoever in the cohort comparisons. "Minimizing time spent on the road" showed the same trend and was also rated highly across the board (Figure 21).



Q13: Please rate the importance of each of the following factors in your primary driving for work (Rate from 1-6 where 1 is not important and 6 is critical):

	Being On Time			Maximizing Fuel Efficiency			Covering a Specific Route			Minimizing Time Spent on the Road			Minimizing Miles Traveled			Minimizing Idling Time		
	TA	uTuA	Grand Total	TA	uTuA	Grand Total	TA	uTuA	Grand Total	TA	uTuA	Grand Total	TA	uTuA	Grand Total	TA	uTuA	Grand Total
	5.33	5.23	5.27	4.46	4.28	4.34	3.32	3.43	3.39	4.36	4.22	4.26	4.10	3.96	4.01	4.12	3.94	4.00
	1.00 – 6.00			1.00 – 6.00			1.00 – 6.00			1.00 – 6.00			1.00 – 6.00			1.00 – 6.00		
Distance: 1 mile or less																		
P	5.33	5.25	5.28	4.57	4.39	4.46	3.39	3.42	3.41	4.38	4.24	4.29	4.19	4.04	4.09	4.23	4.02	4.09
SP	5.42	5.23	5.27	4.22	4.30 NP	4.28 NP	3.14	3.51	3.43	4.42	4.24	4.28	4.03 NP	3.94	3.96 NP	3.86	3.98 NP	3.96 NP
NP	5.32	5.15	5.19	3.65 P	3.76 P	3.74 P	2.79 P	3.40	3.28	4.09	4.09	4.09	3.26 P	3.66 P	3.58 P	3.35 P	3.57 P	3.53 P
Distance: 1-3 miles																		
P	5.33	5.25	5.28	4.58	4.48	4.52	3.37	3.42	3.40	4.42 <>	4.19	4.28	4.16	4.00	4.07	4.25	4.05	4.13
SP	5.31	5.20	5.23	4.49 NP	4.30 NP	4.35 NP	3.37	3.49	3.46	4.27	4.28	4.28	4.23 NP	4.08 NP	4.12 NP	4.21 NP	3.96	4.03 NP
NP	5.39	5.24	5.27	3.93 P	3.86 P	3.88 P	3.04	3.38	3.30	4.21	4.20	4.20	3.66 P	3.76	3.73 P	3.51 P	3.71 P	3.66 P
Time: 5 minutes or less																		
P	5.33	5.27	5.30	4.54	4.42	4.47	3.37	3.41	3.40	4.39	4.25	4.30	4.18	4.05	4.10	4.19	3.99	4.06
SP	5.29	5.16	5.19	4.38	4.26 NP	4.29 NP	3.22	3.47	3.42	4.27	4.21	4.22	4.00	3.92	3.94	4.16	4.04 NP	4.07 NP
NP	5.40	5.15	5.20	3.77 P	3.75 P	3.75 P	2.91	3.45	3.34	4.20	4.10	4.12	3.40 P	3.68 P	3.63 P	3.49 P	3.64 P	3.61 P
Time: 5-10 minutes																		
P	5.31	5.32	5.31	4.72 SP	4.61 SP	4.66 SP	3.49	3.56	3.53	4.49	4.31	4.38	4.23	4.10	4.15	4.31	4.17 SP	4.23 SP
SP	5.35	5.14	5.20	4.32	4.34 NP	4.34 NP	3.30	3.34	3.33	4.25	4.18	4.20	4.09	4.02	4.04 NP	4.13 NP	3.88	3.95
NP	5.38	5.23	5.27	4.03 P	3.84 P	3.89 P	2.93 P <>	3.39	3.28 P	4.20	4.16	4.17	3.80 P	3.76 P	3.77 P	3.67 P	3.76 P	3.74 P

Figure 21. FFV driver motivations when driving federal fleet vehicles

Interestingly, the second-highest-rated factor was "maximizing fuel efficiency" which, along with "minimizing idle time" and "minimizing miles traveled," was included to test the importance of other petroleum reduction strategies. While the latter two factors were not rated particularly high in importance, an interesting trend did emerge: The P/SP/NP comparisons reveal that the NPs rate this as significantly less important than Ps do in nearly every instance, and significantly less than SPs do in most instances: NPs are simply less interested in reducing petroleum use.

Of critical importance to the NREL analysis and future research is the need to develop an understanding of what factors drivers consider when deciding where to purchase fuel. To address this, we asked respondents to rank the importance of various factors in deciding where to fuel their vehicles (Q16, Figure 36) and whether to purchase E85 (Q19, Figure 37). It is worth noting briefly that the most important factor in both decisions was "acceptance of my fuel-purchasing card." This is a very real constraint, as many federal drivers utilize fleet fuel purchasing cards, and if a station does not accept their cards, they cannot buy fuel. This is not a universal constraint, as many drivers of vehicles owned by the agencies (as opposed to those leased through GSA) utilize traditional credit cards accepted almost universally to purchase fuel.

Beyond purchasing cards, "location/convenience" was highly rated in both Q16 and Q19. That this factor was rated quite a bit higher than "fuel cost" (Q16) and "cost of E85 versus regular gasoline" (Q19) makes intuitive sense—when a driver is low on fuel, or simply looking to fuel up before a long trip, we should expect that driver to select the most convenient location regardless of price. And, considering how highly rated the "time" factors were in Q16, we should not be surprised that convenience is so highly rated among FFV drivers while they are working.

It is interesting to note the significant drop-offs in the importance given to the "availability of E85" (Q16) and "following federal regulations" (Q19) as we move from P → SP → NP and from TA → uTuA. Perhaps it is not surprising that we see these results, but it is odd that federal FFV drivers placed such a high importance on "following federal regulations" relative to "availability of E85," which is generally rated much lower, barely registering among the NPs. The discrepancy in the importance placed on these two factors reinforces the impact of training and awareness.

In designing the survey questions, we were particularly careful about our treatment of sensitive sociopolitical issues surrounding the environment and climate change, energy security and the politics of oil, greenhouse gas emissions, or the debates surrounding ethanol. Still, these topics cannot be ignored and in order to gauge the importance of these factors we included "environmental benefits" and "using a domestic fuel source" in the responses to Q19. There was very little difference in the TA/uTuA comparison, but the significant changes across all of the P/SP/NP comparisons are striking, especially P → NP and SP → NP. However, there is one area in which the differences in the results are not significant: going from P → SP under domestic fuel source. While Ps clearly seem to rate environmental benefits as more important than using a domestic fuel source, SPs regard them as relatively equal.

What is perhaps most unsettling about the results in the motivation questions is that, on average, federal FFV drivers have been driving FFVs for more than 3 years (Figure 18). Furthermore, FFVs have been a significant part of the federal fleet inventory for nearly a decade, not to mention their significant quantities in the general population. That this technology is still vastly underutilized in reducing petroleum consumption speaks volumes about the challenges of increasing the utilization of alternative fuels.

6 Discussion

Answers to the demographic and operational questions reveal that anecdotal descriptions of federal fleet drivers hold true: they are a diverse group of people with a diverse set of transportation needs. From shuttle drivers to scientists, park rangers, law enforcement officers, doctors, food inspectors, military recruiters, engineers, and emergency response personnel, drivers of federal vehicles cover a broad spectrum of people, geographies, and vehicle types. As such, they are potentially the only fleet-based population that resembles the general population in any meaningful way.

But given the absence of quality demographic information for federal fleet drivers and our inability to identify and target messaging at individual drivers, these characteristics, however informative, do not provide a framework around which behavioral interventions should be designed. For example, our sample shows that only one in three federal drivers is female, and women may be better candidates for increasing alternative fuel use as the P cohort consistently has the largest percentage of women. Due to a lack of statistically significant results yielded by the demographic questions, with the exception just noted, the demographic data are not presently useful for designing interventions. Still, they may produce some more useful results if used to analyze the responses in similar fashion to the TA/uTuA comparison used in our analysis. This additional analysis was beyond our project scope.

We find it curious that price was rated as highly as it was among federal FFV drivers given that they are not paying for fuel out of their own pockets. On the one hand, perhaps this is a good sign that federal employees are sensitive to the price of fuel in that perhaps they are trying to be good stewards of the taxpayer dollar. But this seems unlikely given the relatively low importance they place on the "cost of E85 versus regular gasoline." On the other hand, this may simply be inertia from their own habits when driving personal vehicles. In any case, the fact that the money is not their own allows us to focus interventions on the non-cost factors contributing to low usage of E85, which would be far more difficult in a study of drivers in the general public.

On the whole the results of this survey do validate the assertion that information scarcity leads to low rates of E85 use in the federal fleet, but not necessarily for the reasons that we hypothesized. We know that a large pool of drivers do not even know if they are driving E85 FFVs (see Figure 7), but we also find that those who know they are driving FFVs have a fairly accurate picture of the technology, infrastructure availability, and how often they refuel with E85. We are also able to validate that there are limits to how far drivers will go out of their way to purchase E85: drivers' stated likelihood to go out of their way to buy E85 drops markedly beyond the 3-mile and 10-minute thresholds.

It seems that federal FFV drivers value the rules and want to follow them: those who know about the requirement to use E85 and have received training on how to implement the requirement are more likely to fall into the P cohort. Of course, simply knowing what you're required to do or having received training on how to do it does not mean that the action to do so will follow. If federal drivers are not held accountable for their actions, it is predictable that they would not use E85 as often as they could.

A lack of infrastructure and the relative inconvenience of existing stations are two oft-cited reasons for consumers' lack of motivation to use alternative fuels. That federal FFV drivers generally have such an accurate picture of E85 infrastructure availability runs counter to our other findings relative to information scarcity. It also suggests that information on the location of E85 stations is not likely to increase utilization of that infrastructure on its own. We believe that if all three of these characteristics are addressed in aggregate, consumption of E85 within the federal fleet could rise dramatically.

Behavioral interventions that aim to increase driver awareness and management feedback can be deployed efficiently and cost-effectively at scale, even without applicable data on the characteristics of individual drivers. Available datasets allow us to provide federal fleet drivers and managers with feedback on their actual performance in combination with resources available to raise awareness of infrastructure availability, the EPAct § 701 requirements *and* training on implementation.

Of course, designing and implementing a behavior change campaign of this nature is not without real-world constraints. For example, we find that many federal drivers spend a significant amount of time on the road and therefore outside of an office environment. Obviously, this limits the amount of time they have available for training and reduces the frequency of their direct interactions with management, thus limiting the opportunities for feedback to be delivered. Where time away from the office presents one hurdle, traveling long distances presents another: as drivers spend less time in familiar locations, the likelihood that they know where to find alternative fuel should be reduced. On the other hand, if they travel long distances but regularly utilize familiar routes, they may simply be unwilling to deviate from known driving patterns. The fact that we see no statistically significant differences relative to routes and road types traveled suggests that there is likely a heavy combination of all these factors at play. In the end, the fact remains that for many federal FFV drivers travel is not routinized; this could represent a barrier to their ability to form default behaviors around E85 purchases at retail stations.

We are well aware of the political, environmental, and economic sensitivities surrounding first-generation ethanol and we must respect their influence when designing interventions. For example, while we could expect an environmentally framed message to resonate with Ps, the results show that we could expect such a message to lose some of its effectiveness with SPs. But it is not the Ps we are concerned about; we want to nudge the SPs into the P category. As such, we could expect that messaging framed around the use of a domestically sourced fuel would resonate equally well with both groups and minimize the possibility of "scaring off" the SPs.

7 Conclusion

Government AFV acquisition programs have been successful at deploying FFVs throughout the federal fleet, and fueling infrastructure is catching up to FFV deployment. However, actual utilization of E85 remains lower than it could be. While federal FFV drivers seem to value the rules and want to follow them—those who know about the requirement to use E85 and have received training on how to implement the requirement are more likely to be E85 purchasers—simply knowing the requirements or receiving training does not mean that the action to purchase E85 will follow.

There are three overarching institutional/structural characteristics among federal FFV drivers that, if addressed in aggregate, should increase drivers' willingness to use more alternative fuel across and within various agencies and departments:

- Awareness of and training on the requirement to use alternative fuel
- Feedback from management to drivers concerning the type of fuel used
- Drivers receiving information on the availability of E85.

7.1 Training and Management Feedback

Our survey results demonstrate that increased awareness of the requirement to use alternative fuel correlates with higher SLD and should be the focus of an initial round of behavioral interventions. Because these results are applicable to all drivers and agencies, behavioral interventions designed to increase driver awareness and management feedback can be deployed efficiently and cost effectively, even without applicable data on the characteristics of individual drivers. Future research at NREL will investigate the impact of positive and negative feedback mechanisms, as well as direct and indirect feedback within an organization. These behavioral interventions will be designed to provide fleet managers and drivers with:

- Feedback on drivers' actual refueling behavior
- A basic level of information on the EPAct § 701 requirement
- The opportunity to take an eLearning course on implementation of that requirement.

Designing and implementing a behavior change campaign is not without real-world constraints. Many federal drivers spend a significant amount of time on the road outside of an office environment. This limits the amount of time they have available for training and reduces the frequency of their direct interactions with management, which limits opportunities for feedback.

7.2 Getting the Word Out About E85 Availability and Reliability

FFV drivers often resort to their default behavior of refueling with gasoline even when E85 is available. However, NREL was able to confirm that missed opportunity rates were lower when there was an E85 station within 5 miles of the garage location and when vehicles had more frequent access to E85 infrastructure. In addition, our analysis shows

that consumers need time to become aware of and begin to regularly use new alternative fueling stations. In states that had strong alternative fuel markets in 2009, the lowest missed opportunity rates occurred 3 years later in 2012. The time gap between when E85 infrastructure is installed to when it is more heavily and regularly utilized could be instructive to policy-makers, fuel providers, and station owners.

Swing purchasers and non-purchasers of alternative fuel appear to be more concerned about a change in fuel technology and any possible effect on vehicle performance that could compromise their transportation needs or reliability. That FFV technology is still vastly underutilized in reducing petroleum consumption suggests that urban myths surrounding E85 are at least as pervasive as we are led to believe from anecdotal evidence. Additional reassurance that using E85 should not compromise vehicle performance or reliability may prove necessary and effective as part of a behavior change campaign.

In the end, we cannot expect every driver to use E85 every time that it is available. Following the logic employed during political elections, our aim is to focus on the "swing purchasers" to see if we can sway enough of them toward greater use of E85 with the goal of helping federal agencies reduce their petroleum use and meet their sustainability requirements.

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Appendix A. Regression Results

Figure 22 through Figure 26 and Table 4 through Table 7 show missed opportunity rates by season, year, region, and market.

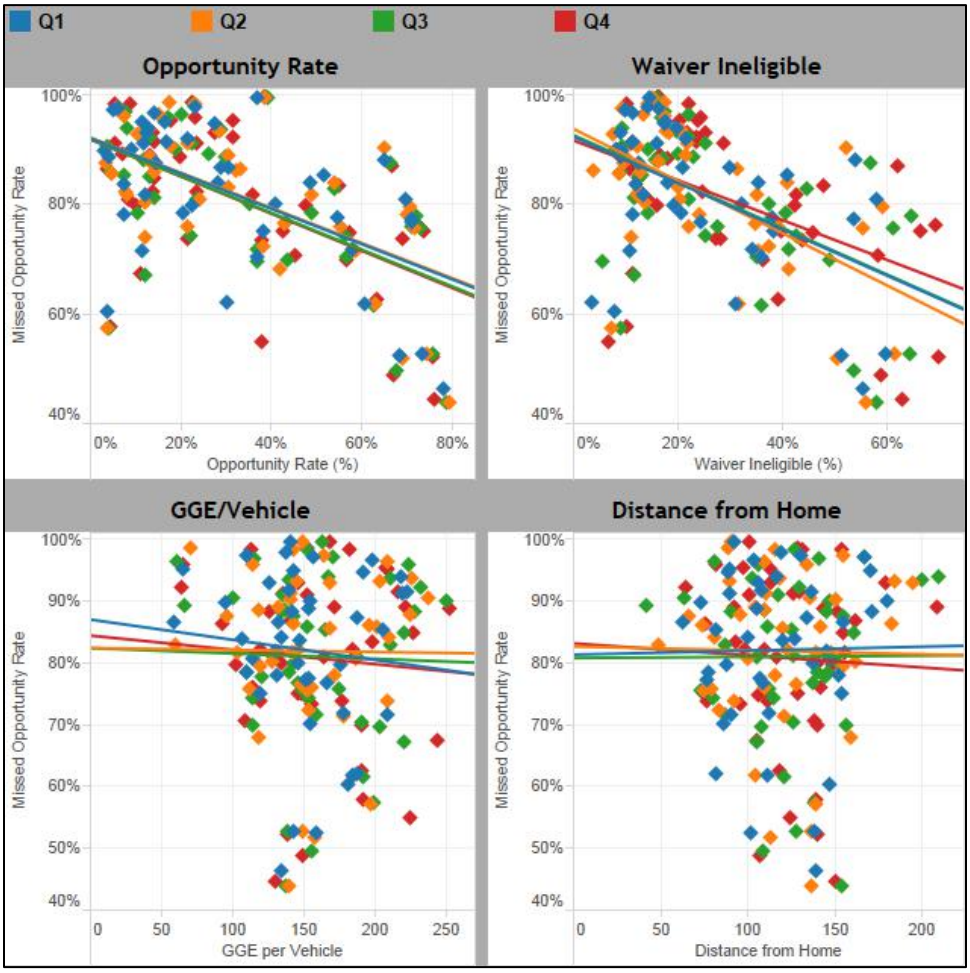


Figure 22. Scatter plot of missed opportunity rates by season

Table 4. Linear Regression of Missed Opportunity Rates by Season

Season	Variable	r	Intercept	R-squared	p-value
Fall (Q1)	Opportunity Rate	-0.321	0.919	0.323	<0.0001
	Waiver Ineligible	-0.420	0.921	0.255	0.0006
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	-0.0003	0.868	0.009	0.5502
	Distance from home	0.00006	0.812	0.0002	0.9255
Winter (Q2)	Opportunity Rate	-0.320	0.920	0.326	<0.0001
	Waiver Ineligible	-0.474	0.936	0.333	<0.0001
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	-0.000032	0.822	0.0001	0.9506
	Distance from home	-0.000062	0.825	0.0002	0.9215
Spring (Q3)	Opportunity Rate	-0.335	0.917	0.338	<0.0001
	Waiver Ineligible	-0.422	0.924	0.289	0.0002
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	-0.000086	0.822	0.001	0.8602
	Distance from home	0.000019	0.806	0.00002	0.9767
Summer (Q4)	Opportunity Rate	-0.338	0.917	0.311	0.0001
	Waiver Ineligible	-0.362	0.915	0.230	0.0011
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	-0.0002	0.843	0.005	0.6415
	Distance from home	-0.0002	0.830	0.002	0.7929

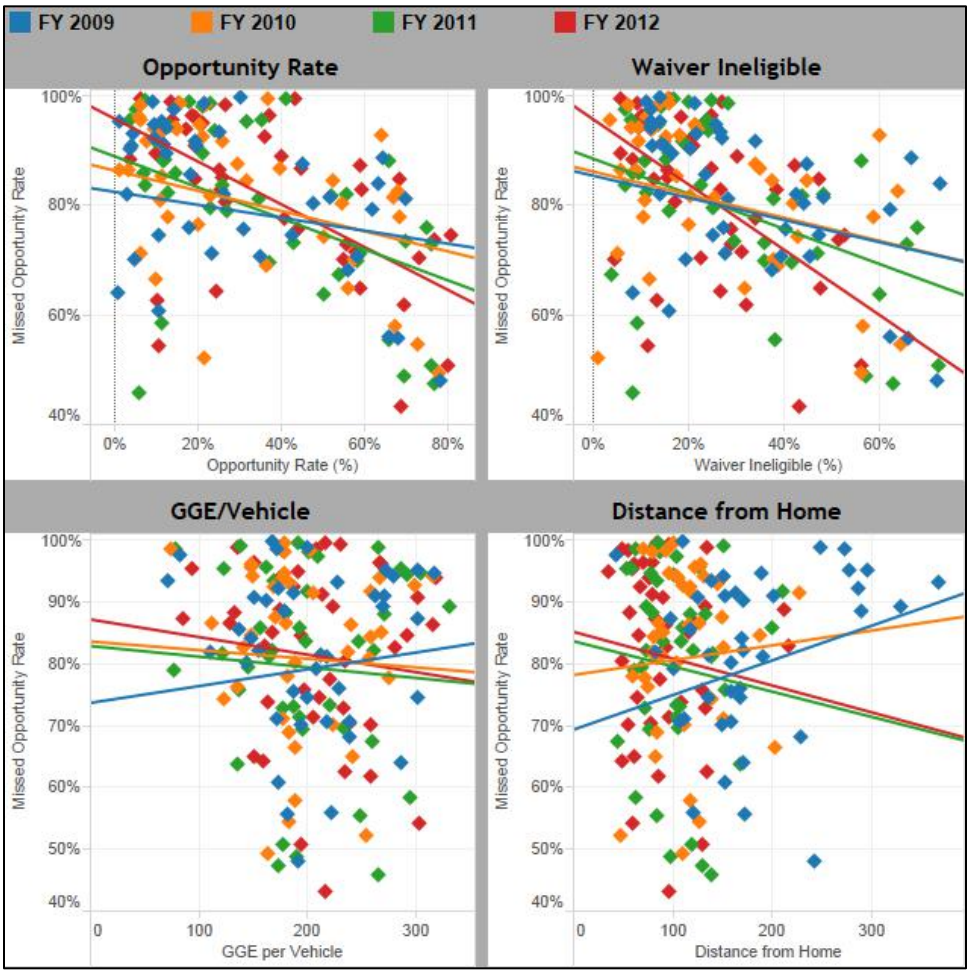


Figure 23. Scatter plot of missed opportunity rates by year

Table 5. Linear Regression of Missed Opportunity Rates by Year

Year	Variable	r	Intercept	R-squared	p-value
2009	Opportunity Rate	-0.118	0.823	0.021	0.3504
	Waiver Ineligible	-0.201	0.852	0.039	0.2022
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	0.0002	0.735	0.007	0.5927
	Distance from home	0.0006	0.692	0.042	0.1860
2010	Opportunity Rate	-0.184	0.862	0.058	0.1244
	Waiver Ineligible	-0.210	0.860	0.047	0.1699
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	-0.0001	0.835	0.002	0.8011
	Distance from home	0.0002	0.780	0.002	0.7581
2011	Opportunity Rate	-0.282	0.888	0.170	0.0060
	Waiver Ineligible	-0.319	0.883	0.138	0.0140
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	-0.0002	0.827	0.004	0.6993
	Distance from home	-0.0004	0.835	0.008	0.5640
2012	Opportunity Rate	-0.390	0.956	0.348	<0.0001
	Waiver Ineligible	-0.593	0.955	0.293	0.0002
	E85 Market Score	n/a	n/a	n/a	n/a
	E85 Growth Rate	n/a	n/a	n/a	n/a
	GGE/Vehicle	-0.0003	0.870	0.010	0.5151
	Distance from home	-0.0004	0.850	0.011	0.5003

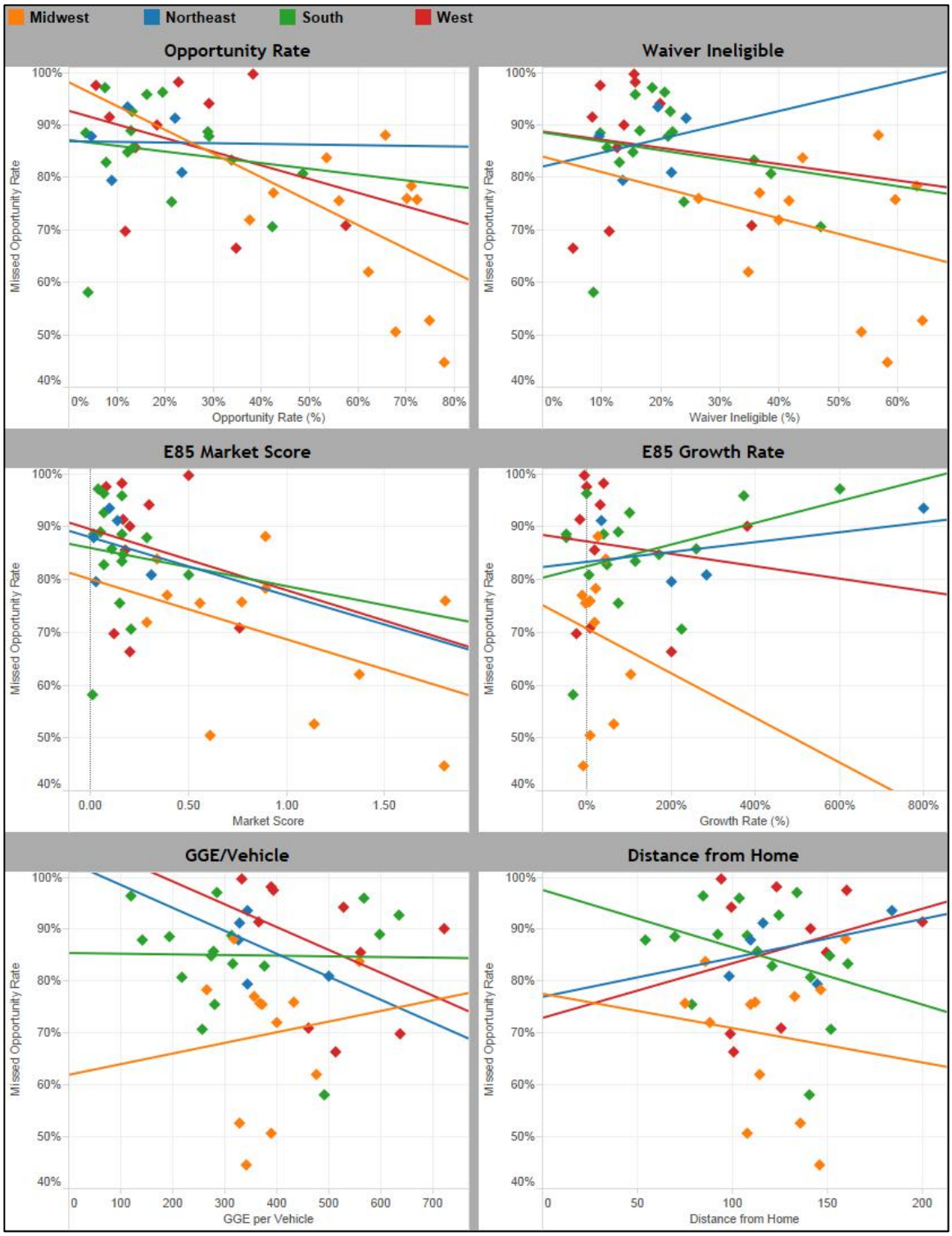


Figure 24. Scatter plot of missed opportunity rates by region

Table 6. Linear Regression of Missed Opportunity Rates by Region

Region	Variable	r	Intercept	R-squared	p-value
Northeast	Opportunity Rate	-0.013	0.868	0.0003	0.979
	Waiver Ineligible	0.265	0.819	0.068	0.672
	E85 Market Score	-0.110	0.879	0.044	0.736
	E85 Growth Rate	0.009	0.832	0.189	0.565
	GGE/Vehicle	-0.0004	1.029	0.281	0.358
	Distance from home	0.001	0.768	0.175	0.484
South	Opportunity Rate	-0.110	0.870	0.021	0.591
	Waiver Ineligible	-0.171	0.885	0.032	0.501
	E85 Market Score	-0.072	0.859	0.008	0.748
	E85 Growth Rate	0.021	0.824	0.124	0.181
	GGE/Vehicle	-0.00001	0.853	0.0003	0.942
	Distance from home	-0.001	0.975	0.121	0.187
Midwest	Opportunity Rate	-0.453	0.981	0.176	0.175
	Waiver Ineligible	-0.295	0.839	0.071	0.402
	E85 Market Score	-0.114	0.800	0.188	0.159
	E85 Growth Rate	-0.042	0.706	0.010	0.756
	GGE/Vehicle	0.0002	0.618	0.013	0.723
	Distance from home	-0.001	0.775	0.016	0.694
West	Opportunity Rate	-0.260	0.926	0.108	0.353
	Waiver Ineligible	-0.156	0.887	0.010	0.779
	E85 Market Score	0.895	-0.116	0.036	0.600
	E85 Growth Rate	-0.012	0.871	0.014	0.744
	GGE/Vehicle	-0.0004	1.079	0.191	0.207
	Distance from home	0.001	0.728	0.079	0.431

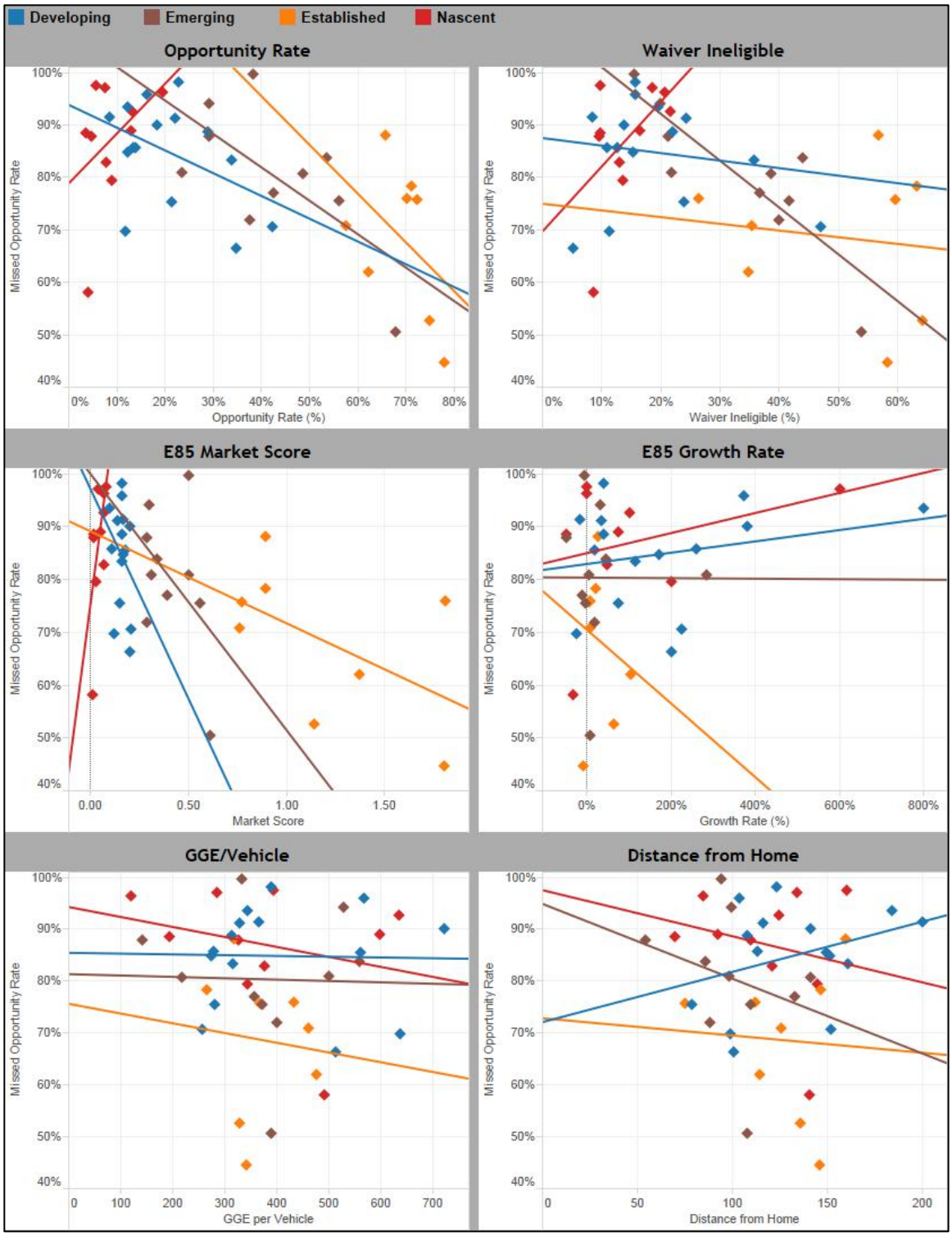


Figure 25. Scatter plot of missed opportunity rates by market

Table 7. Linear Regression of Missed Opportunity Rates by Market

Market	Variable	r	Intercept	R-squared	p-value
Established	Opportunity Rate	-0.929	1.327	0.1904	0.280
	Waiver Ineligible	-0.128	0.749	0.0178	0.753
	E85 Market Score	-0.175	0.891	0.2782	0.179
	E85 Growth Rate	-0.070	0.704	0.0323	0.670
	GGE/Vehicle	-0.0002	0.755	0.0096	0.818
	Distance from home	-0.0003	0.727	0.0038	0.885
Emerging	Opportunity Rate	-0.637	1.074	0.4379	0.037
	Waiver Ineligible	-0.893	1.099	0.7180	0.002
	E85 Market Score	-0.486	1.001	0.1960	0.200
	E85 Growth Rate	-0.0005	0.803	0.00001	0.993
	GGE/Vehicle	-0.00003	0.812	0.0006	0.944
	Distance from home	-0.001	0.948	0.0689	0.464
Developing	Opportunity Rate	-0.434	0.938	0.1950	0.099
	Waiver Ineligible	-0.143	0.874	0.0250	0.574
	E85 Market Score	-0.796	0.974	0.0674	0.350
	E85 Growth Rate	0.011	0.828	0.0551	0.400
	GGE/Vehicle	-0.00001	0.853	0.0005	0.936
	Distance from home	0.001	0.720	0.1123	0.222
Nascent	Opportunity Rate	0.951	0.786	0.1683	0.239
	Waiver Ineligible	1.237	0.695	0.2602	0.132
	E85 Market Score	2.846	0.739	0.3795	0.058
	E85 Growth Rate	0.019	0.849	0.0937	0.423
	GGE/Vehicle	-0.0002	0.942	0.0716	0.455
	Distance from home	-0.001	0.974	0.0476	0.545

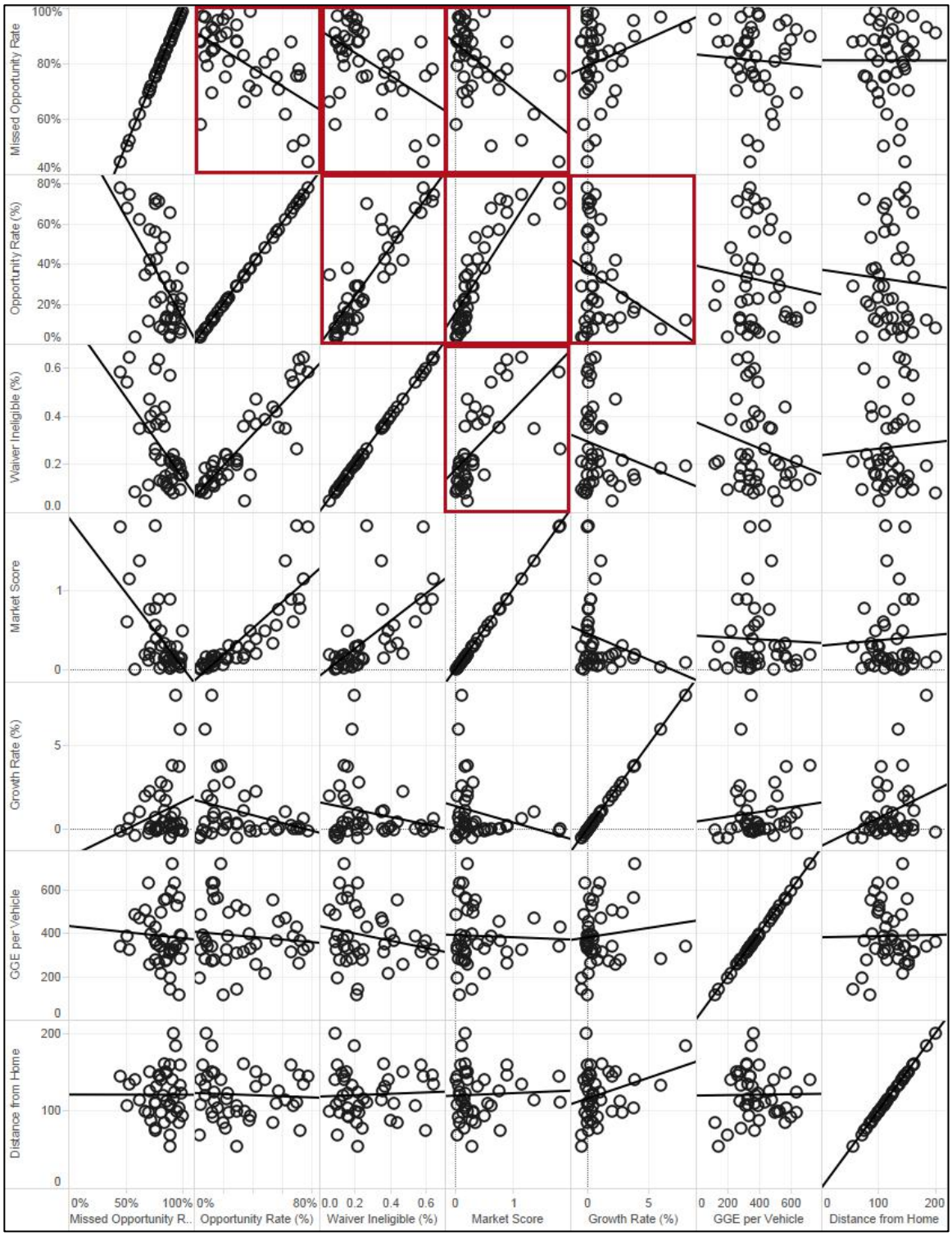
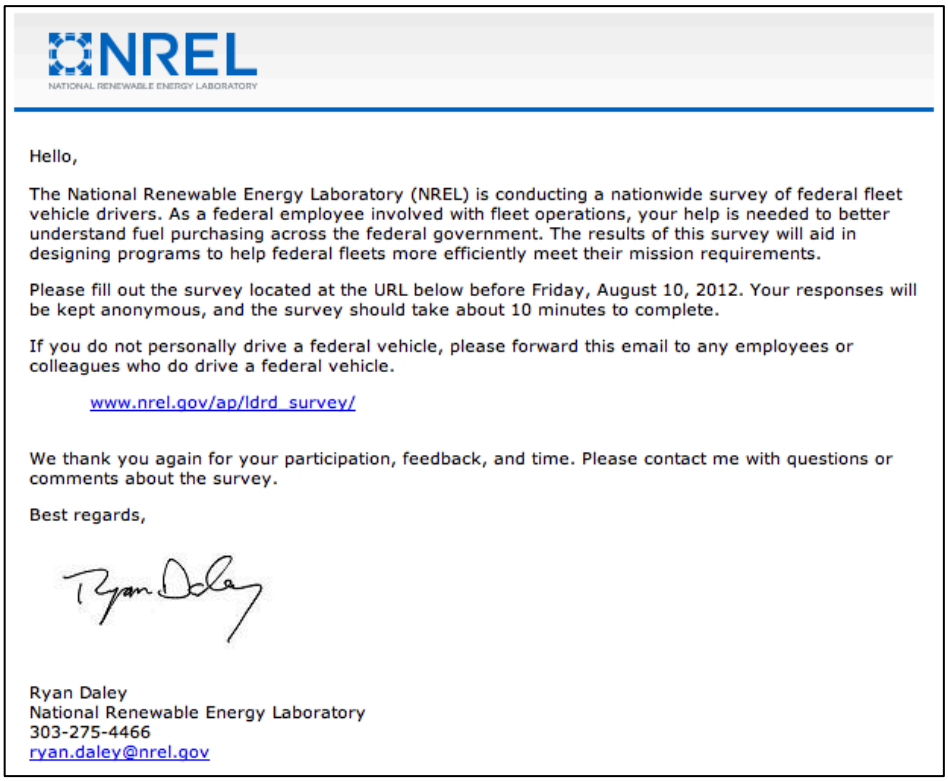


Figure 26. Scatter plot matrix of all variables[26]

[26] Scatter plots bordered in red are statistically significant at the 95% confidence level.

Appendix B. Survey Invitation

Figure 27 and Figure 28 show NREL's initial survey invitation and follow-up survey reminder email.



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Hello,

The National Renewable Energy Laboratory (NREL) is conducting a nationwide survey of federal fleet vehicle drivers. As a federal employee involved with fleet operations, your help is needed to better understand fuel purchasing across the federal government. The results of this survey will aid in designing programs to help federal fleets more efficiently meet their mission requirements.

Please fill out the survey located at the URL below before Friday, August 10, 2012. Your responses will be kept anonymous, and the survey should take about 10 minutes to complete.

If you do not personally drive a federal vehicle, please forward this email to any employees or colleagues who do drive a federal vehicle.

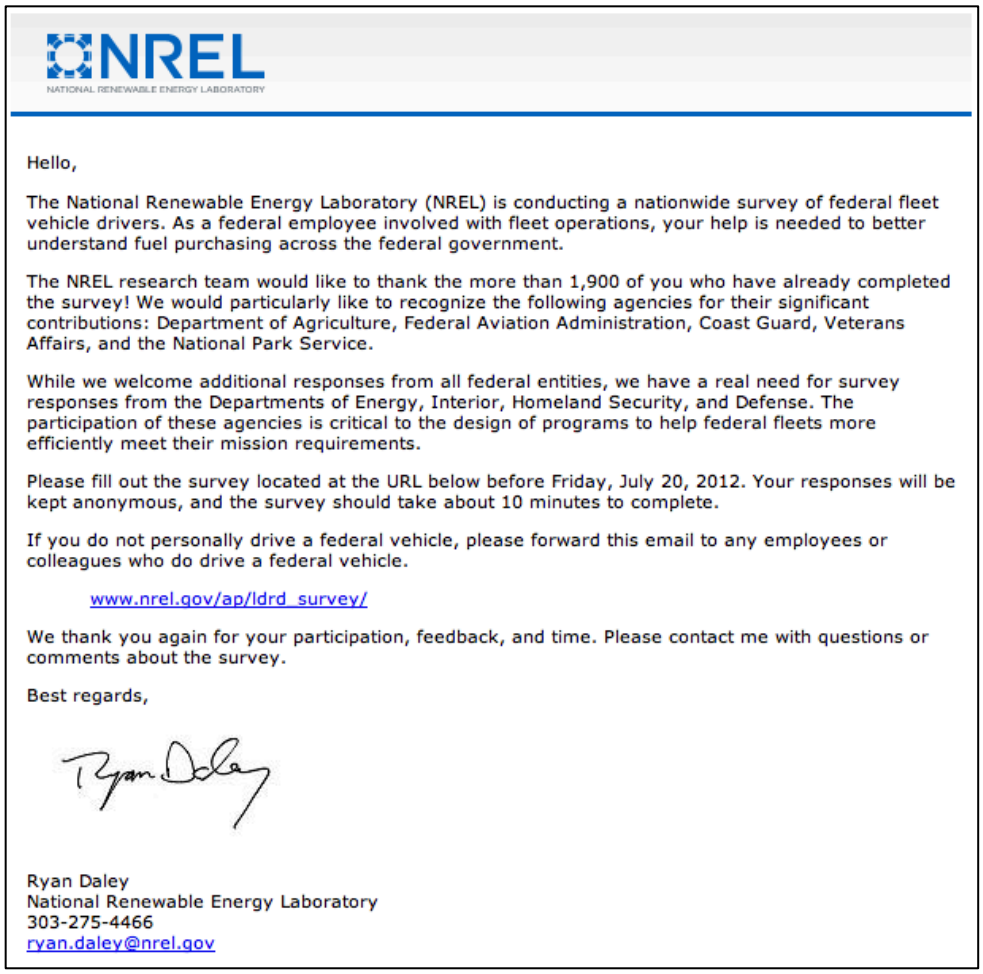
www.nrel.gov/ap/ldrd_survey/

We thank you again for your participation, feedback, and time. Please contact me with questions or comments about the survey.

Best regards,

Ryan Daley
National Renewable Energy Laboratory
303-275-4466
ryan.daley@nrel.gov

Figure 27. Initial survey invitation distributed June 11, 2012



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Hello,

The National Renewable Energy Laboratory (NREL) is conducting a nationwide survey of federal fleet vehicle drivers. As a federal employee involved with fleet operations, your help is needed to better understand fuel purchasing across the federal government.

The NREL research team would like to thank the more than 1,900 of you who have already completed the survey! We would particularly like to recognize the following agencies for their significant contributions: Department of Agriculture, Federal Aviation Administration, Coast Guard, Veterans Affairs, and the National Park Service.

While we welcome additional responses from all federal entities, we have a real need for survey responses from the Departments of Energy, Interior, Homeland Security, and Defense. The participation of these agencies is critical to the design of programs to help federal fleets more efficiently meet their mission requirements.

Please fill out the survey located at the URL below before Friday, July 20, 2012. Your responses will be kept anonymous, and the survey should take about 10 minutes to complete.

If you do not personally drive a federal vehicle, please forward this email to any employees or colleagues who do drive a federal vehicle.

www.nrel.gov/ap/ldrd_survey/

We thank you again for your participation, feedback, and time. Please contact me with questions or comments about the survey.

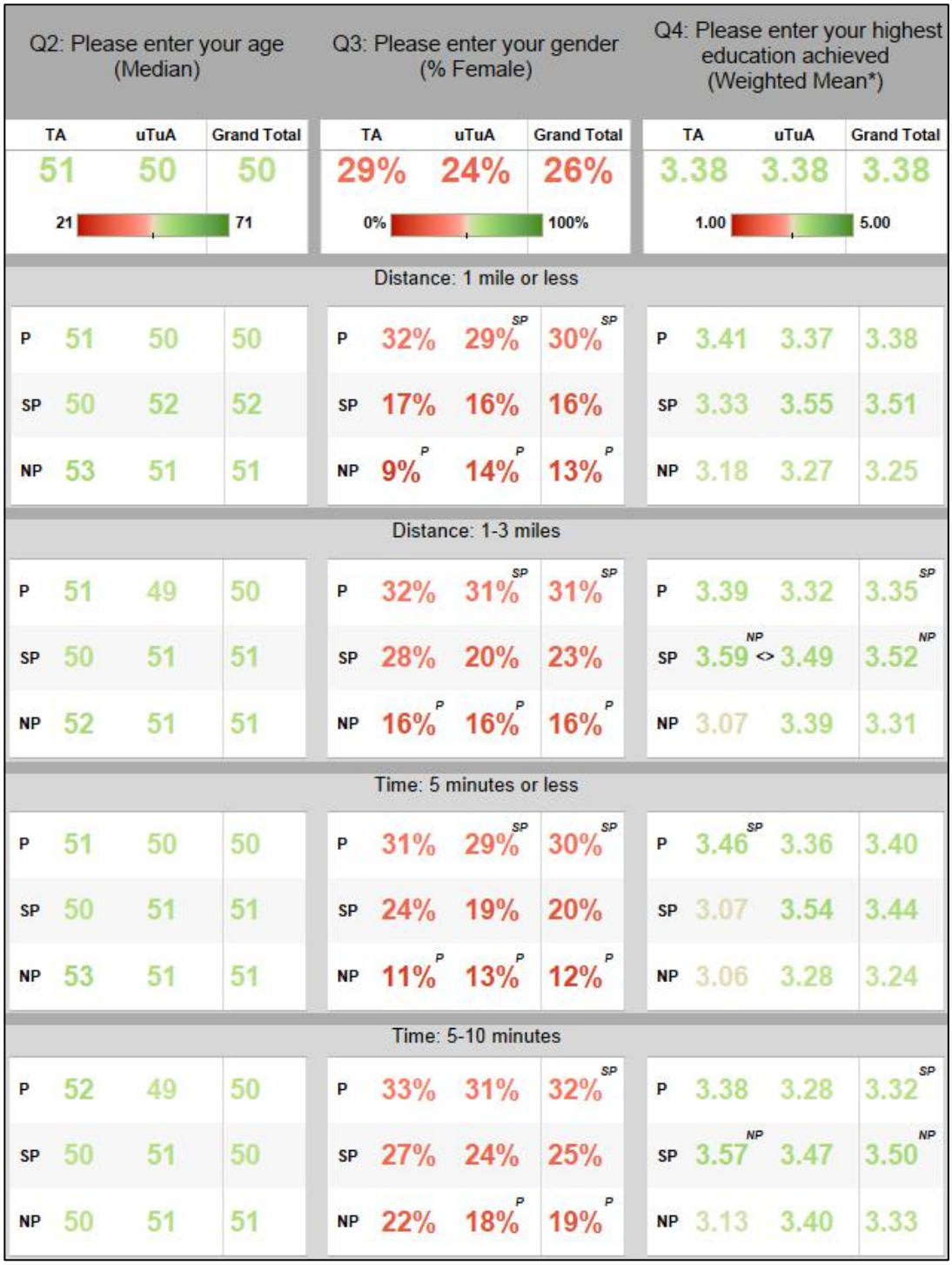
Best regards,

Ryan Daley
National Renewable Energy Laboratory
303-275-4466
ryan.daley@nrel.gov

Figure 28. Reminder survey invitation distributed July 10, 2012

Appendix C. Demographic Questions

Figure 29 compares responses to survey questions regarding driver demographics.



*Q4 answers are weighted accordingly: (1) High school diploma or equivalent, (2) Attended some college, (3) Associate's degree, (4) Bachelor's degree, (5) Post-graduate degree.

Figure 29. Survey demographic questions 2, 3, and 4

Appendix D. Operational Questions

Figure 30 through Figure 34 compare responses to survey questions regarding fleet operations.

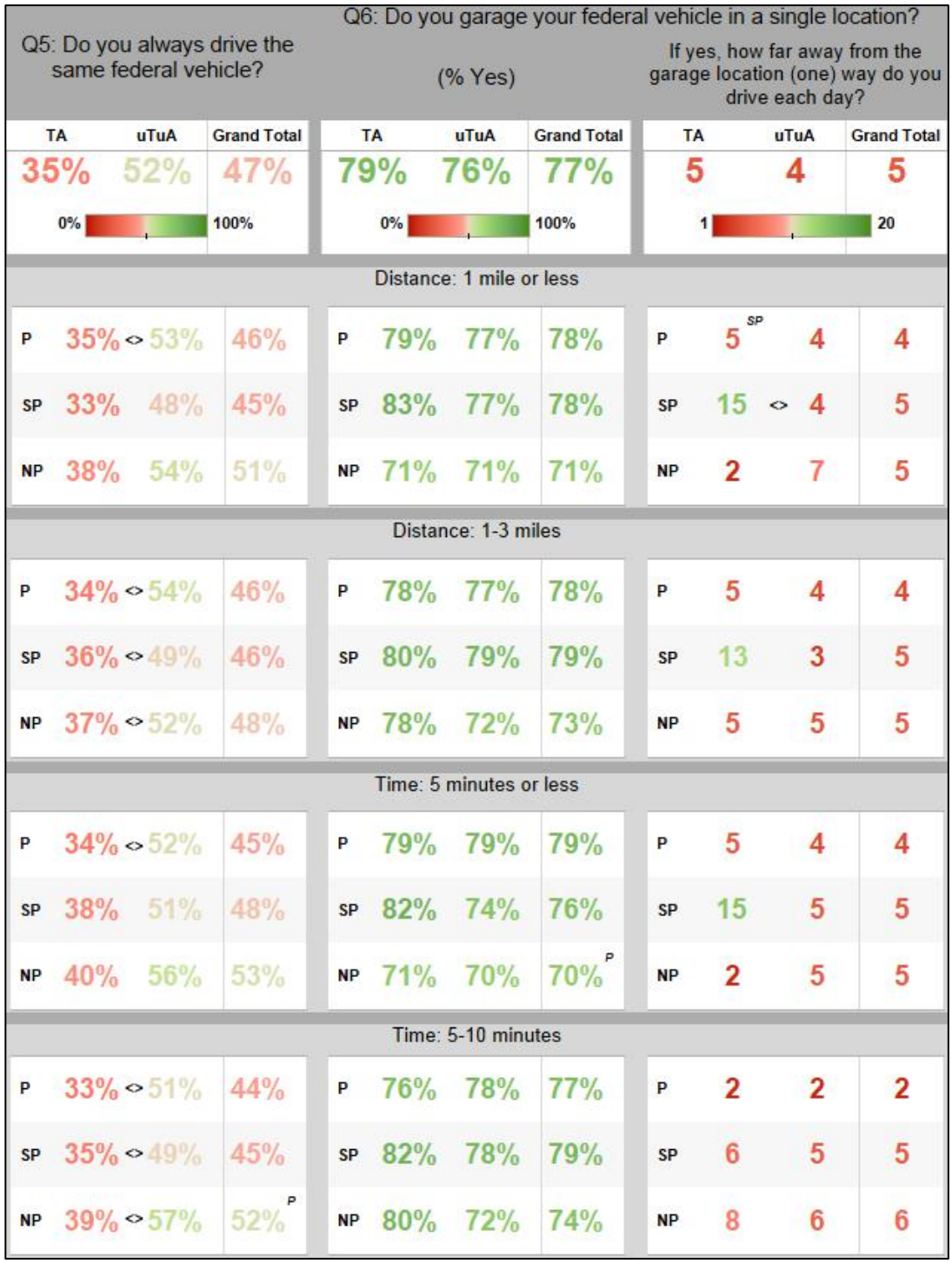


Figure 30. Survey operational questions 5 and 6

	Q8: How many years have you been driving a federal vehicle? (Median)			Q9: How many miles do you typically drive your primary federal vehicle per week? (Median)			Q14: Do you fuel your primary federal vehicle, or is it handled by someone else? (% Yes)		
	TA	uTuA	Grand Total	TA	uTuA	Grand Total	TA	uTuA	Grand Total
	11	10	10	100	150	120	98%	97%	97%
	1		20	0		300	0%		100%
Distance: 1 mile or less									
P	11	<> 10	10	75 SP	<> 131	100	98%	98%	98%
SP	11	11	11	200	150 NP	188	100%	94%	95%
NP	12	11	11	126	200 P	200 P	100%	95%	96%
Distance: 1-3 miles									
P	12	10	11	75	<> 150	100	98%	98%	98%
SP	11	10	10	100	150	150	98%	96%	96%
NP	10	10	10	150	200	165 P	99%	95%	96%
Time: 5 minutes or less									
P	11	10	10	75	<> 123	100	98%	98%	98%
SP	12	10	10	150	150	150	98%	95%	96%
NP	11	11	11	101	200 P	200 P	100%	95%	96%
Time: 5-10 minutes									
P	12	11 SP	11 SP	55	<> 120	100	98%	97%	97%
SP	11	10	10	100	136	100	97%	97%	97%
NP	12	10	10	126	<> 200 P	180 P	99%	96%	97%

Figure 31. Survey operational questions 8, 9, and 14

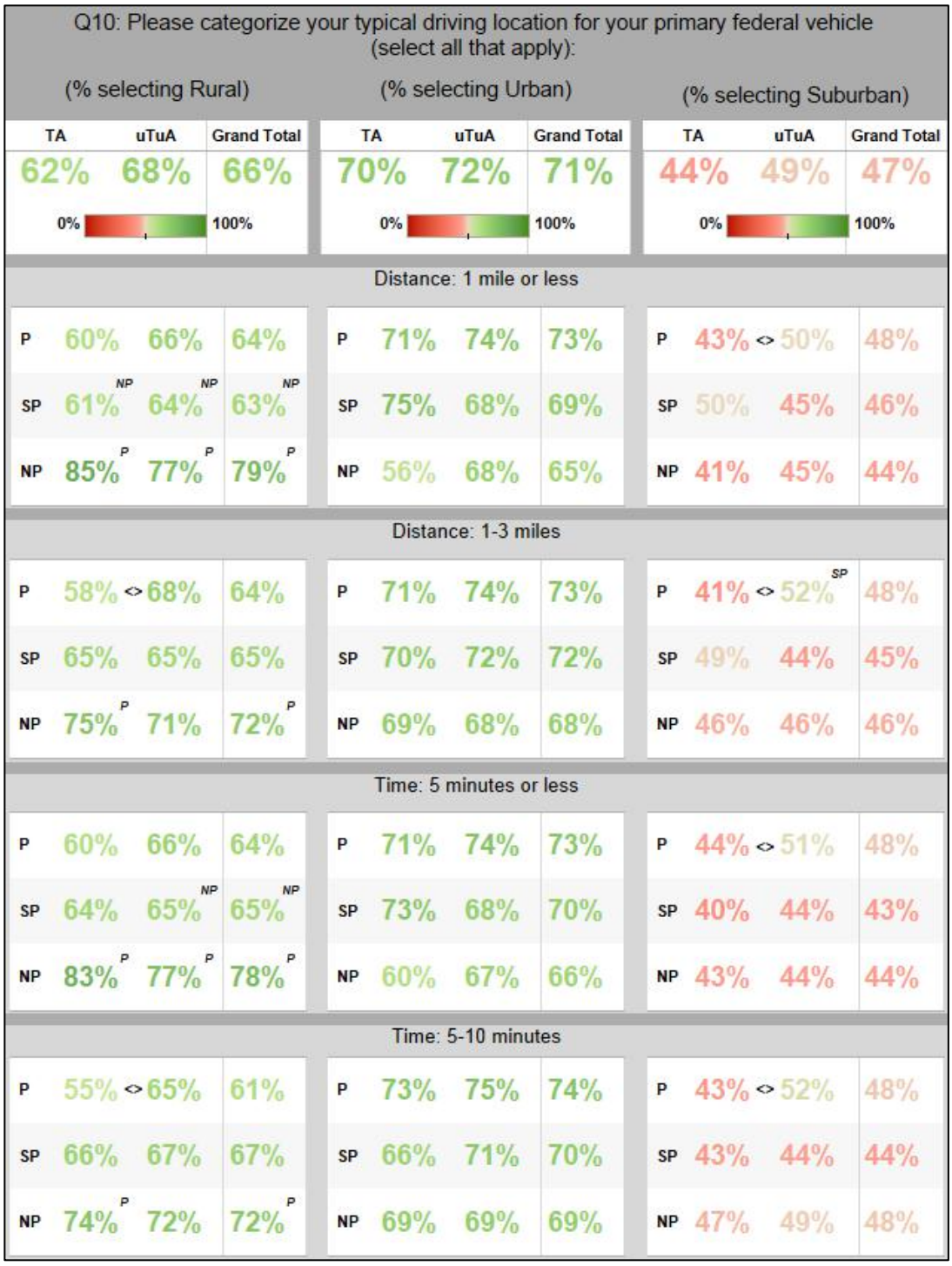


Figure 32. Survey operational question 10

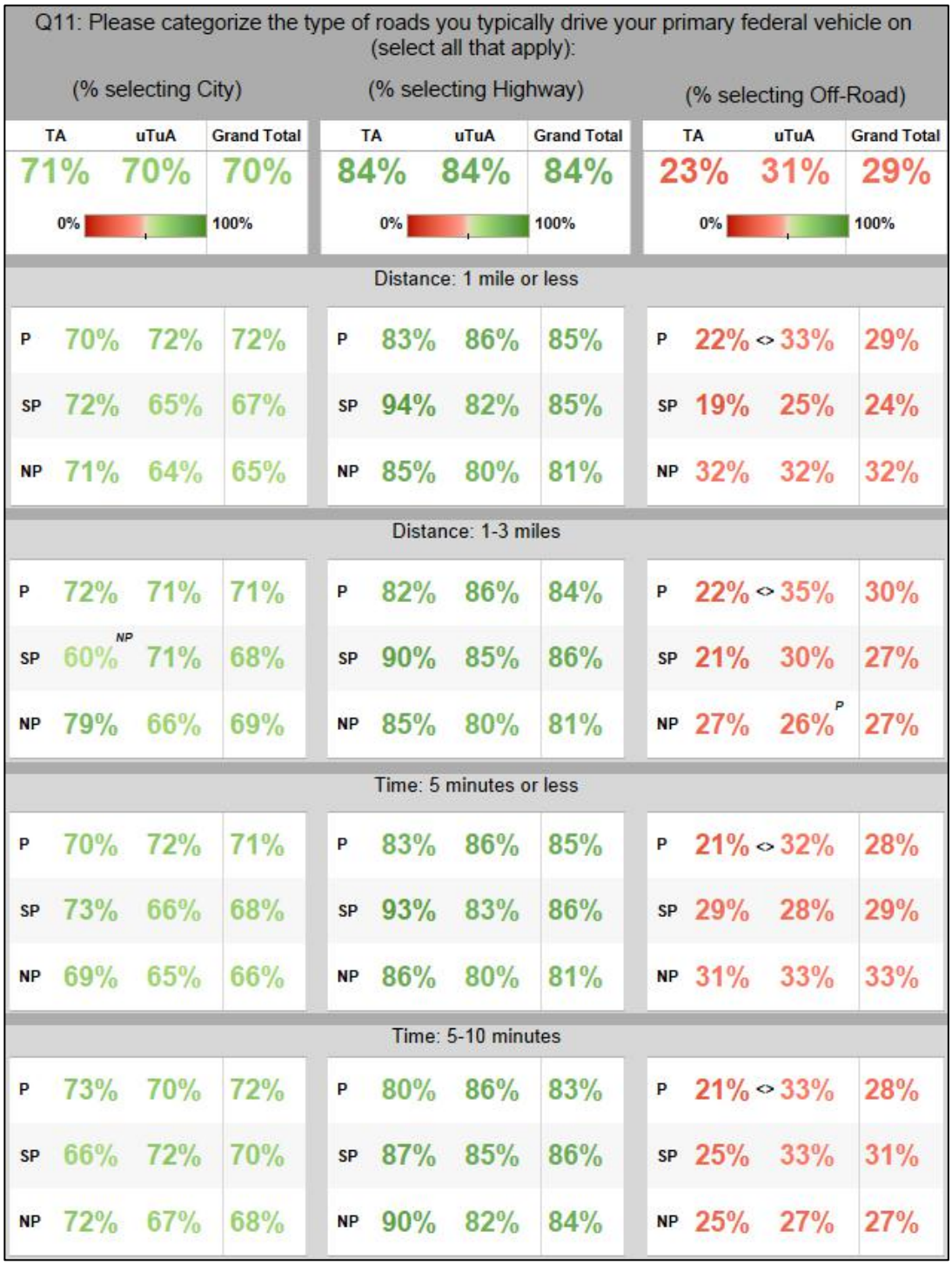


Figure 33. Survey operational question 11

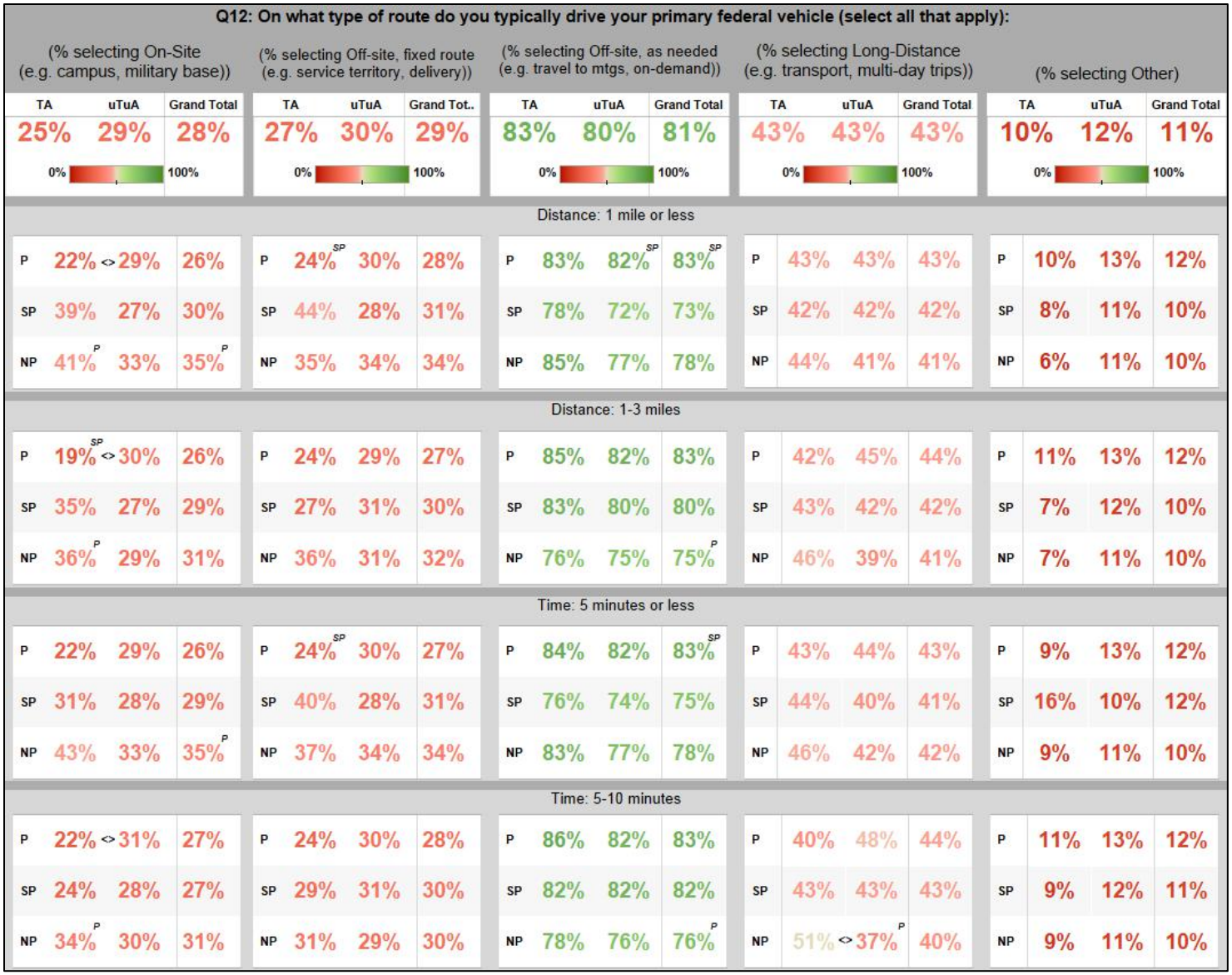
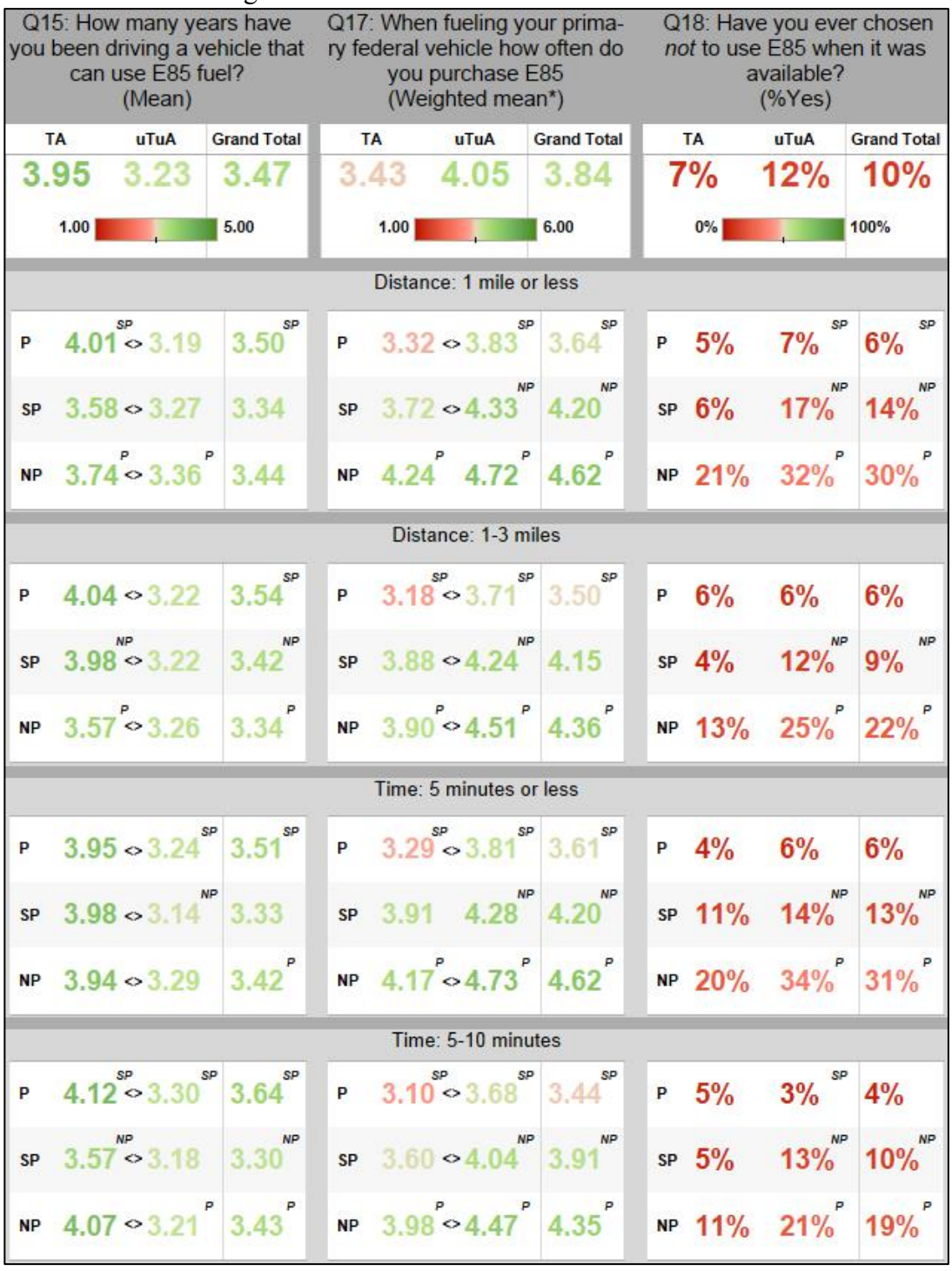


Figure 34. Survey operational question 12

Appendix E. Motivation Questions

Figure 35 through Figure 38 compare responses to survey questions regarding motivations for fueling behavior.



*Q17 answers are weighted accordingly: (1) Always, (2) Around 75% of the time, (3) Around half of the time, (4) Around 25% of the time, (5) Never, (6) Not Sure.

Figure 35. Survey motivation questions 15, 17, and 18

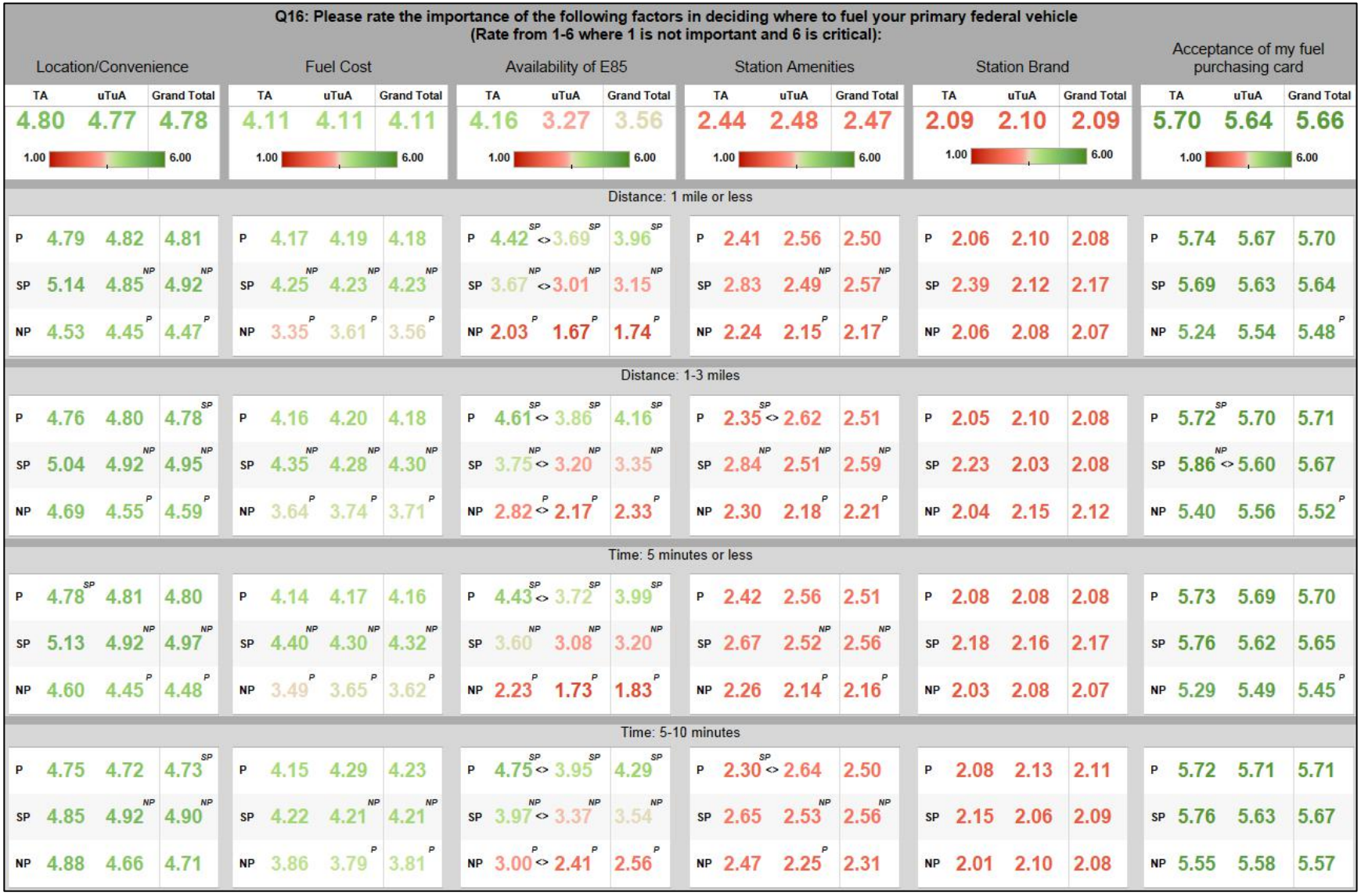


Figure 36. Survey motivation question 16

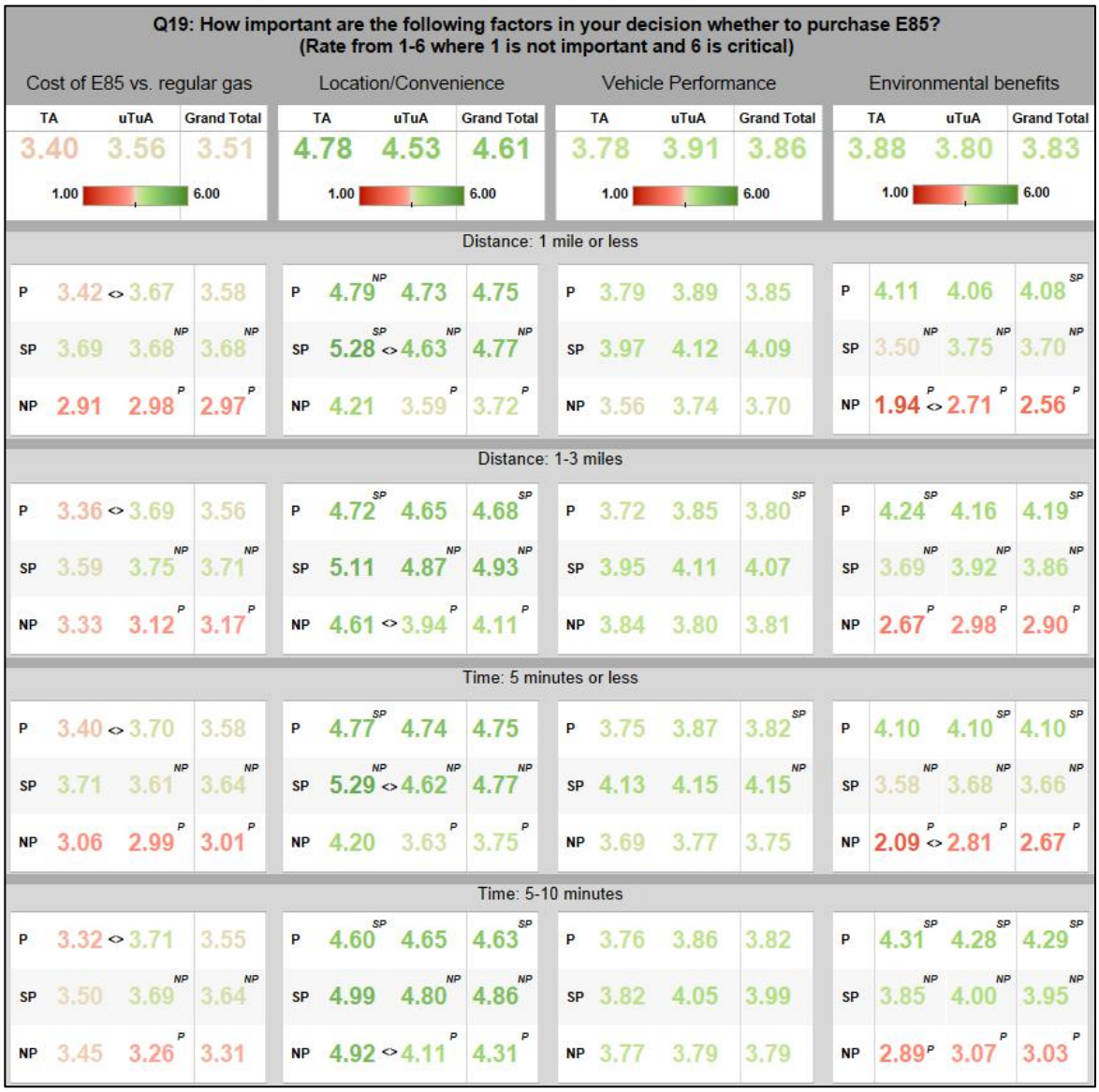
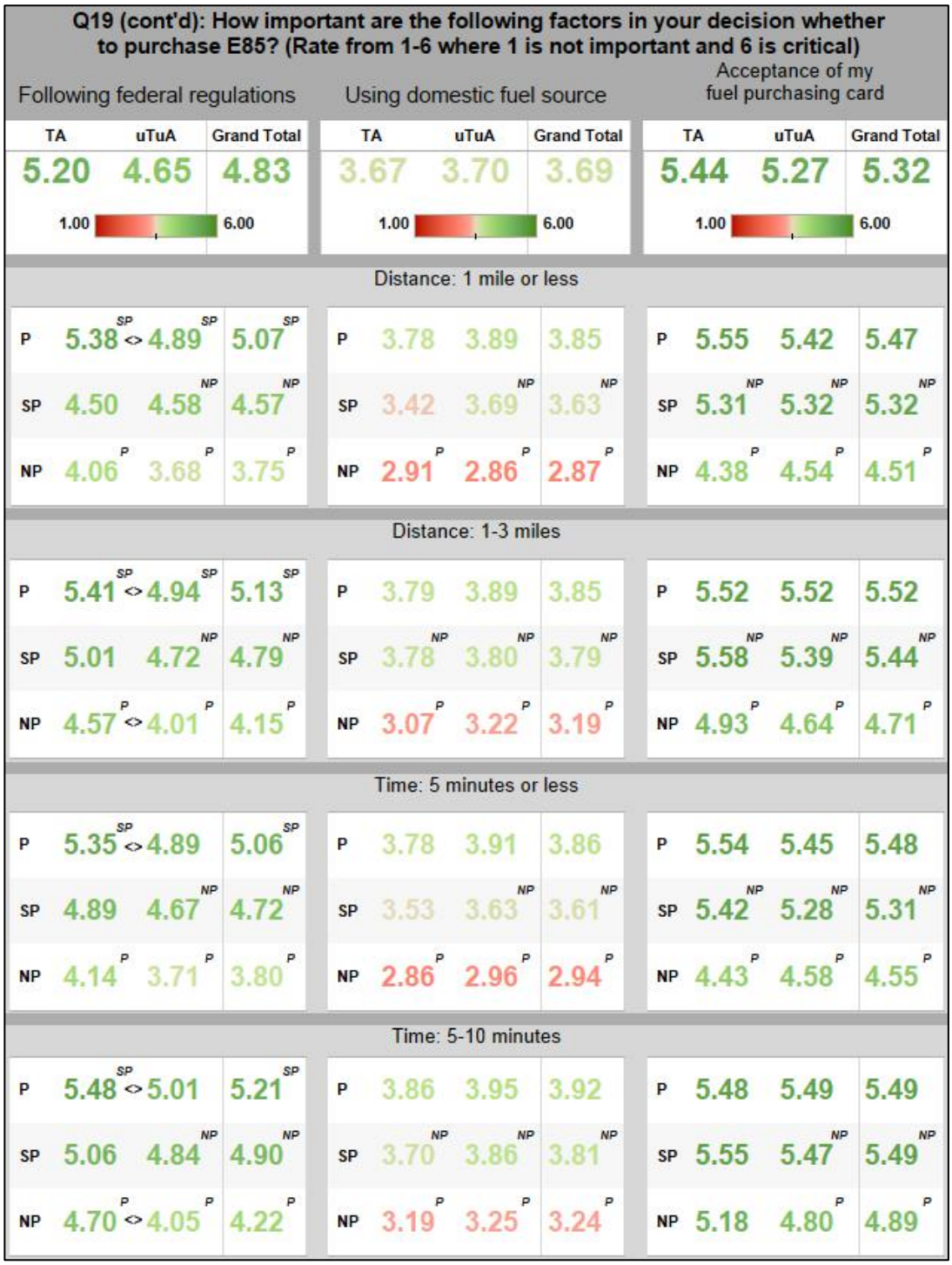


Figure 37. Survey motivation question 19 (continued on next page)



Appendix F. Awareness Questions

Figure 39 through Figure 42 compare responses to survey questions regarding E85 awareness.

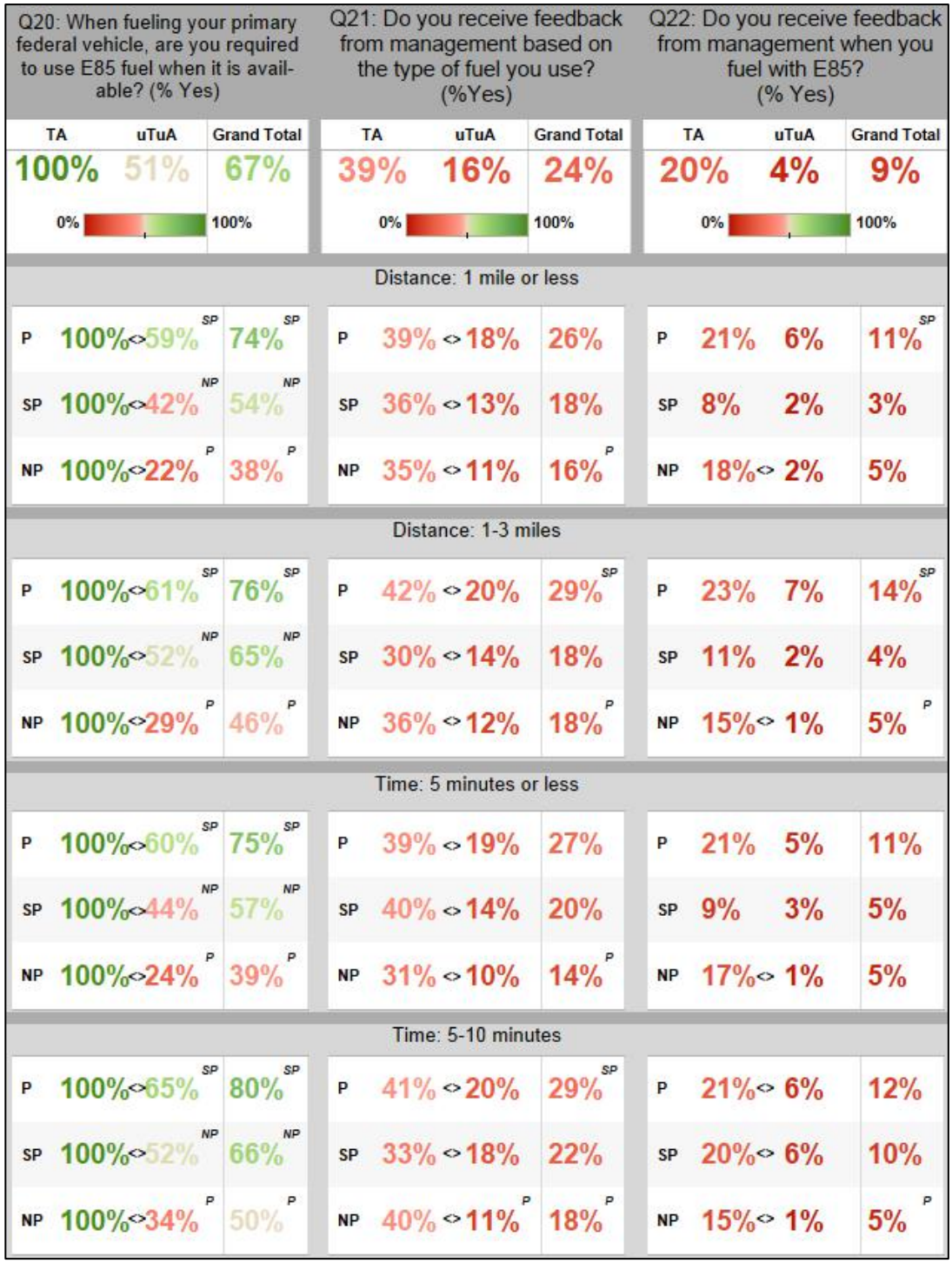
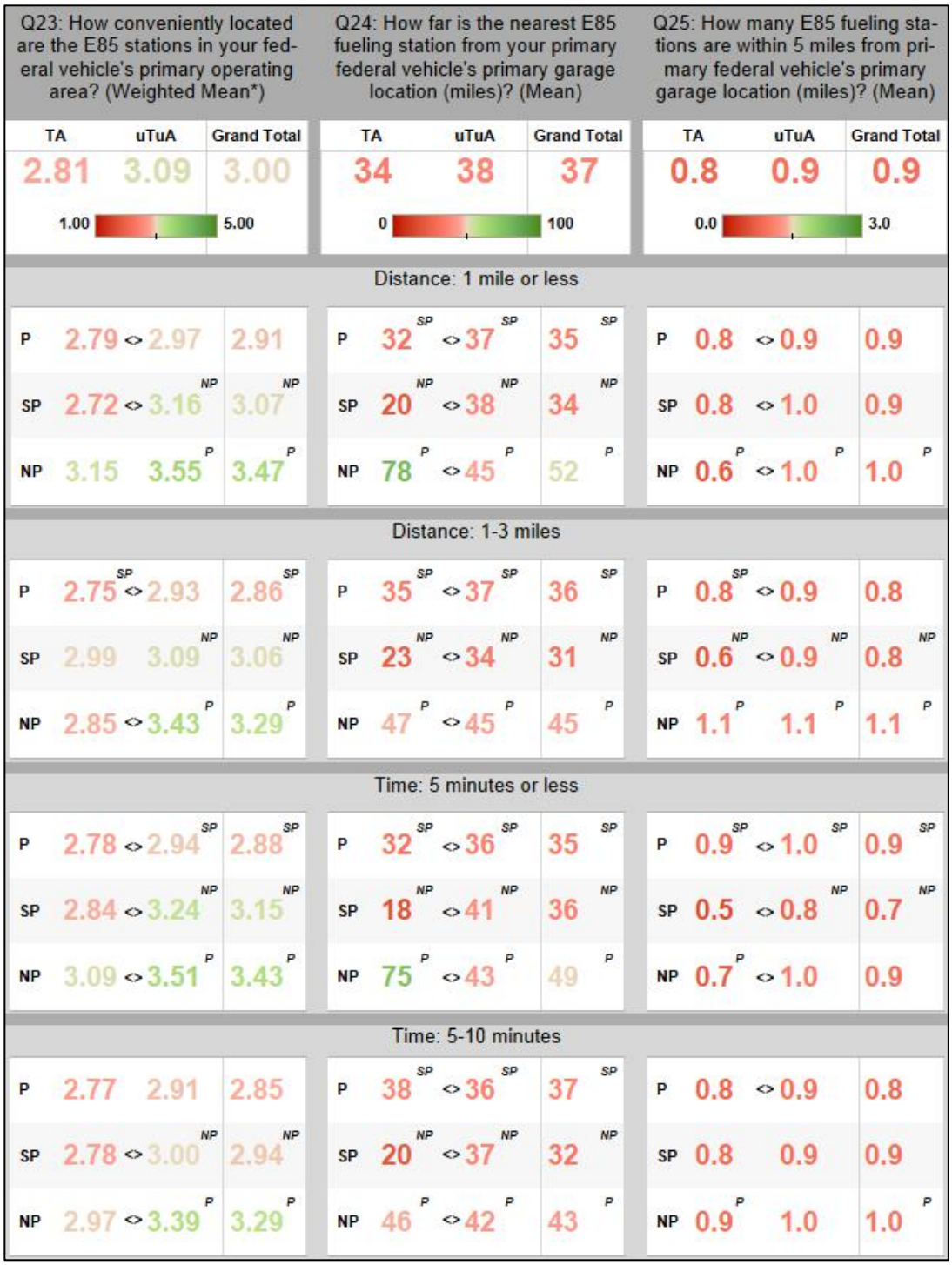


Figure 38. Survey awareness questions 20, 21, and 22

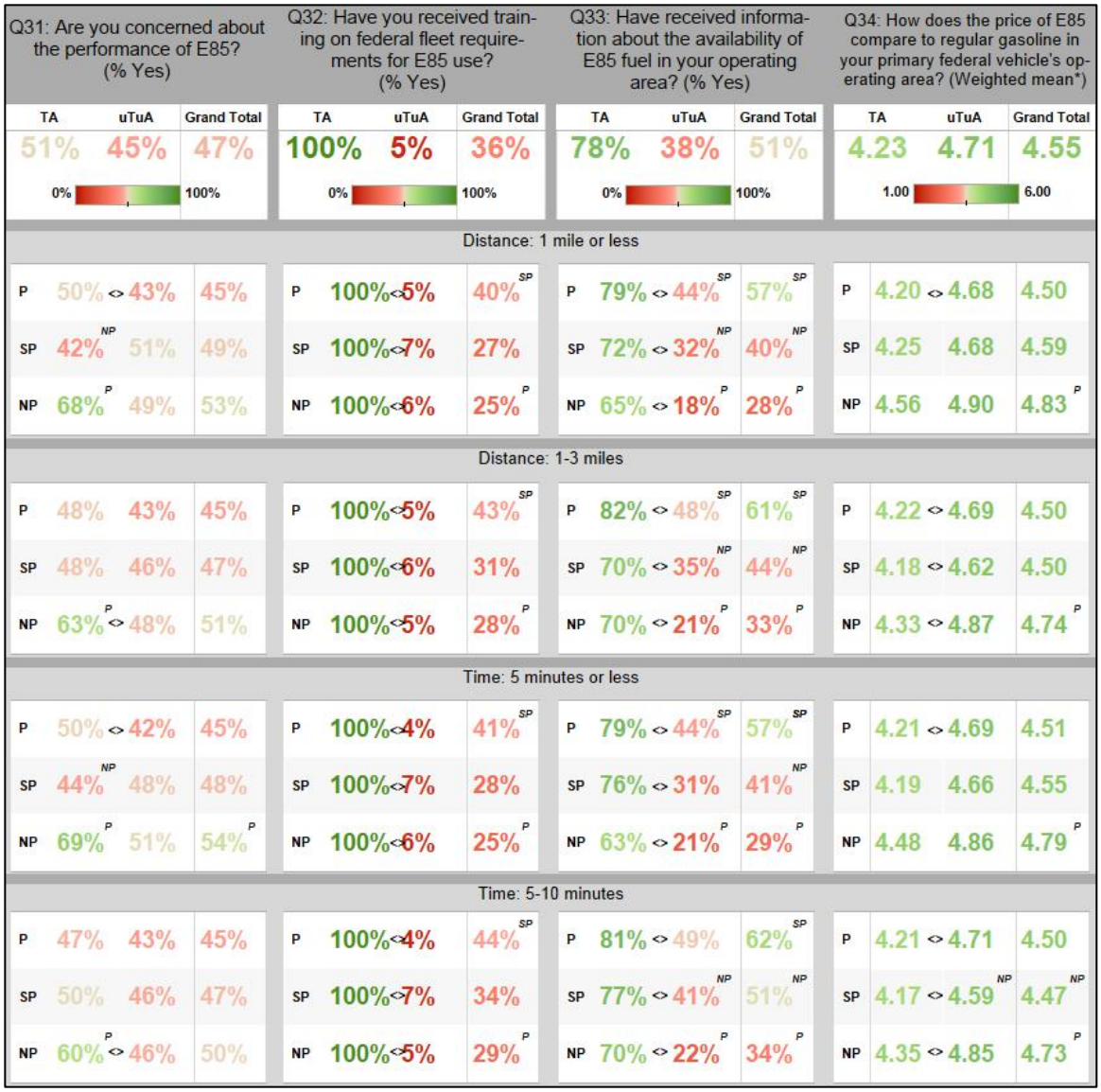


*Q23 answers are weighted accordingly: (1) Very convenient, (2) Somewhat convenient, (3) Not convenient, (4) Unavailable, (5) Not Sure.

Figure 39. Survey awareness questions 23, 24, and 25

*Q28 and Q30 answers are weighted accordingly: (1) Much better, (2) A little better, (3) About the same, (4) A little worse, (5) Much worse, (6) Not sure, (7) Never used E85 in my vehicle, (8) Never used regular gasoline in my vehicle.

Figure 40. Survey awareness questions 28, 29, and 30



*Q34 answers are weighted accordingly: (1) E85 is much more expensive, (2) E85 is a little more expensive, (3) E85 costs about the same as regular gasoline, (4) E85 is a little less expensive, (5) E85 is much less expensive, (6) Not sure.

Figure 41. Survey awareness questions 31, 32, 33, and 34