Assessment of the Consumer Reasons for Selection of Ethanol Fuel

Final Report
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16. Abstract

This report summarizes the findings from a study that evaluated consumer acceptance of different blends of ethanol at fueling stations in Iowa. This project expanded on an earlier evaluation of two stations that participated in the Fueling Our Future pilot program, which was administered by the Iowa Renewable Fuel Infrastructure Program (RFIP) of the Iowa Department of Agriculture and Land Stewardship (IDALS) and the Iowa Department of Transportation (Iowa DOT).

Because the two stations initially surveyed were typical of rural cooperatives, offered significantly different fuel options than Iowa's conventional gas stations, and yielded a small sample size, a second phase of the research was initiated that conducted additional surveys at 16 stations. In addition, the air quality impacts of several different implementation scenarios for Fueling Our Future and similar programs were evaluated. Because most stations where surveys were conducted did not offer a range of biodiesels, biodiesel was not included in this study.

Findings are presented for all respondents together and for drivers of flexible fuel and non-flexible fuel vehicles separately. Among other key findings, the survey showed that cost was the primary factor in fuel selection for purchasers of E-0, E-10, and E-85 ethanol blends, and compatibility of the fuel with the respondent's vehicle was a major factor for all respondents. Concerns about compatibility, followed by cost, were the top reasons why respondents did not select a higher ethanol blend. More than 80% of respondents selected the particular station due to location.

The results of the air quality analysis showed that statewide adoption of ethanol options and subsequent changes in purchasing behavior could result in a 20% reduction in nitrogen oxides (NO_x), a reduction in particulate matter (PM) emissions much greater than 100%, a 3% reduction in carbon monoxide (CO), and a 20% reduction in hydrocarbon (HC) emissions.

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1. BACKGROUND

1.1 Introduction

This report summarizes the findings from a study that evaluated consumer acceptance of different blends of ethanol at fueling stations in Iowa. This project expanded on an earlier evaluation of stations that participated in the Fueling Our Future pilot program, which was administered by the Iowa Renewable Fuel Infrastructure Program (RFIP) of the Iowa Department of Agriculture and Land Stewardship (IDALS) and the Iowa Department of Transportation (Iowa DOT). The pilot program provided funding as an incentive to encourage private sector installation of renewable fueling pumps or expansion of the selection of renewable fuel blends available.

Two stations that participated in the RFIP were evaluated in Phase I of this research project. Fuel sales information was gathered for each location, and a survey was conducted at each location to assess why customers purchased a particular type of fuel. A brief summary of the methodology and results for Phase I is provided in Chapter 2 of this report.

After the survey data from the original two stations that participated in the study were evaluated, it was decided that the applicability of the findings was limited because both stations were located in very rural areas, the range of fuel blends offered was not representative of the fuels available at other stations in Iowa, and small sample sizes resulted for both stations due to their rural locations. As a result, in a second phase of research surveys were conducted at an additional 16 stations that offered a range of ethanol blends. All but one of the additional stations where surveys were conducted received some RFIP assistance.

The focus of this report is primarily the evaluation of the data from the additional stations where surveys were conducted in Phase II.

1.2 Study Objectives and Scope

The main objective of the study was to evaluate why consumers in Iowa make a particular fuel choice when a range of ethanol options is available. This information is of interest to fueling stations that may be interested in offering different blends of ethanol. Additionally, understanding why consumers make a particular choice may help programs such as the Iowa RFIP better target future participants.

Surveys were conducted at a total of 16 stations in Phase II of this research. Although the original intent was to assess biofuel choices, including both ethanol and biodiesel, most of the stations where surveys were conducted did not offer a range of biodiesel blends. As a result, biodiesel was not included in this study. In addition to conducting the surveys, this project evaluated the air quality impacts of several different implementation scenarios for fuel choice.

Because the study focused on purchase of ethanol blends, we use the term "E-0" to refer specifically to gasoline with no ethanol content. Specific blends of ethanol are referred to by the particular ethanol blend (e.g., "E-10").

1.3 Study Highlights

The following summarizes the highlights from the Phase I (2 stations) and Phase II (16 stations) studies.

Customers at two recipients of Fueling Our Future incentives (Oak Street station in Inwood, Iowa, and Farmers' Cooperative station in Mt. Ayr, Iowa) were surveyed in Phase I, with the following results:

- The majority of customers selected E-10 (63% of all fuel sales at Inwood and 41.1% at Mt. Ayr).
- The most cited reasons for fuel purchase were compatibility with the vehicle the customer was fueling (42.2% at Inwood and 53% at Mt. Ayr), cost (24% at Inwood and 20% at Mt. Ayr), and habit (20% at Inwood and 10% at Mt. Ayr).
- The main reason customers did not select a higher ethanol blend was concern that higher blends were not compatible with their vehicles (43% at Inwood and 65% at Mt. Ayr).
- Most customers were aware that higher ethanol blends were available.

Customers at another 16 stations were surveyed in Phase II. Drivers were asked whether they owned a flexible fuel (flex fuel) vehicle, and 22% of respondents indicated that their vehicle was flex fuel, 69% indicated that it was not flex fuel, and 8% were not sure. However, many respondents who indicated that their vehicle was not flex fuel or who were unsure purchased E-15 or higher ethanol blends.

The researchers felt that respondents who purchased E-15 or higher ethanol blends understood that their vehicle could utilize those fuels but may not have understood the term "flex fuel." For tabulation purposes, respondents who indicated that they had a flex fuel vehicle or who purchased E-15 or higher ethanol blends were considered to be "flex fuel" customers, while respondents who indicated that they did not have a flex fuel vehicle and who purchased E-0 or E-10 were categorized as "non-flex fuel" customers.

Key findings of the Phase II study include the following. The findings represent all respondents unless otherwise noted:

- A total of 5.9% of respondents purchased E-15, 7.6% purchased a mid-range blend, and 7.2% purchased E-85. Current statewide averages for the use of those blends are 0.4%, 0.2%, and 0.8%, respectively.
    - A total of 17.6% of respondents with flex fuel vehicles purchased E-15, 22.6% purchased mid-range blends, and 21.5% purchased E-85.

- Responses for all respondents indicated that cost was the primary factor in the selected fuel purchase for purchasers of E-0, E-10, and E-85, while compatibility was the main factor for purchasers of E-15 and mid-range blends. Compatibility was a major factor for all respondents.
  - Cost was also cited as the main factor for those who had flex fuel vehicles and who purchased E-0, E-10, or E-85; those who purchased E-15 or mid-range blends listed compatibility as the main reason.
  - Cost was cited as the main reason for those respondents with non-flex fuel vehicles who purchased E-0 or E-10.
- A total of 4% to 9% of respondents (depending on the fuel selected) indicated that the purchased fuel was required by their employer.
- Concerns about vehicle compatibility, followed by cost, were the top reasons why respondents collectively did not select a higher ethanol blend.
  - Fuel economy was the main reason for respondents with flex fuel vehicles selecting E-0, and price was the main reason for selecting E-10.
  - Compatibility was the main reason for not selecting a higher blend for those respondents who had a non-flex fuel vehicle (both E-0 and E-15).
- Respondents were asked whether higher prices for the fuel they purchased would have impacted their decision to select E-85 (an additional 25¢, 50¢, and 75¢ per gallon).
  - A total of 45% of those who purchased E-0, 31% of E-10 purchasers, 13% of E-15 purchasers, and 34% of those who selected mid-range fuels indicated that they would purchase a higher blend if the blend they selected was 25¢ higher per gallon.
  - A similar answer resulted for 50¢ and 75¢ higher per gallon, indicating that respondents who were not initially swayed by a 25¢ increase were not likely to be swayed by an even higher increase.
  - Responses tabulated according to those who had flex fuel versus non-flex fuel vehicles were similar to the responses provided above.
- Over half of respondents indicated that they were very or somewhat likely to purchase a vehicle that more efficiently used higher blends of ethanol if such a vehicle were available.
- More than 80% of respondents selected the particular station due to location. The next most popular reasons were cost, good customer service, fuel options, and station reward programs.
- Statewide adoption of ethanol options and subsequent changes in purchasing behavior could result in the following:
  - A 20% reduction in nitrogen oxides (NOx)
  - A much greater than 100% reduction in particulate matter (PM) emissions
  - A 3% reduction in carbon monoxide (CO)
  - A 20% reduction in hydrocarbon (HC) emissions
- Because a range of biodiesel blends was only available at one station, it was not possible to estimate the impact of the adoption of biodiesel options on emissions.

1.4 Biofuels and Biorenewables Industry in Iowa

Ethanol and biodiesel had added almost $4.6 billion to Iowa's economy and generated $2.3 billion in new household income by 2015 (IRFA 2017). This bio-science-based industry has also created more than 43,000 jobs in Iowa. The Iowa biodiesel and ethanol producers have been

investing and spending more capital since 2016 to increase production (IRFA 2017). By the end of 2018, production capacity will expand by 533 million new ethanol gallons and 78 million new biodiesel gallons. This is considered the largest expansion in the industry since the early 2000s.

Iowa is a leader in the renewable energy industry due to an agricultural and manufacturing culture that produces wind energy, ethanol, and biodiesel (IADG 2017). The state ranks first and second in the production of ethanol and biodiesel, respectively. Iowa has the highest ethanol production capacity in the US, with annual production having increased significantly from 440 million gallons in 2000 to 4.1 billion gallons in 2016. Furthermore, Iowa produced nearly 30% of the nation's total ethanol in 2016. After the US Energy Information Administration (EIA) updated its monthly biodiesel production survey in October 2017, Iowa has become one of the leading states in the nation in this metric and has the highest number of biodiesel producers. Iowa is ranked second in the US after Texas in terms of biodiesel production, with an annual production capacity of 370 million gallons of biodiesel per year (US EIA 2017). There were 41 operating ethanol and 13 biodiesel facilities in Iowa as of 2016.

The Iowa Department of Revenue developed an annual sales reporting strategy for biofuel. The approach requires motor fuel retailers to provide information relevant to the sale of different fuel types in gallons. Table 1-1 shows the statewide sales information for gasoline/ethanol and represents 2,125 Iowa retail locations for calendar year 2016.

Table 1-1. Iowa gasoline and ethanol sales for calendar year 2016

Fuel Type	Locations	Total Fuel (gallons)	Biofuel (gallons)
Regular gasoline	1,745	218,549,742	NA
E-10	2,040	1,346,926,032	134,692,603
E-15 Registered	124	4,951,912	742,787
E-15 Flex	36	1,050,768	157,615
E-20	89	3,031,908	606,382
E-85	257	13,471,861	10,642,770
Total		**1,587,982,223**	**146,842,157**
Total Ethanol Blends		**1,369,432,481**	**146,842,157**

The "Biofuel" column indicates the amount of actual biofuel sold in gallons. For instance, about 1.3 billion gallons of E-10 were sold in Iowa in 2016. The ethanol portion was 135 million gallons.

As noted in Table 1-1, about 1.5 billion gallons of fuel were sold in 2016, with 1.3 billion of that being some form of ethanol blend. Additionally, 147 million gallons of pure biofuel were sold in the state of Iowa in 2016, representing 9.2% of all gasoline/ethanol fuel sales.

E-10 made up most of the fuel sales (84.8%), followed by E-0 (13.8%). E-15 made up 0.4% of fuel sales, E-20 accounted for 0.2%, and E-85 made up 0.8%. E-20 is defined as any gasoline blended with 20% to 69% ethanol, and E-85 is defined as any blend with 70% to 85% ethanol.

The classification of diesel-based fuels into clear and dyed diesel depends on whether the fuel is subject to state and federal road tax (Harpole and Awan 2017). According to the Iowa Department of Revenue, dyed diesel is non-taxable fuel and is only sold for transportation purposes on non-public roads, such as on farms, at construction sites, and for other types of heavy equipment. Tables 1-2 and 1-3 show dyed and clear diesel sales, respectively.

Table 1-2. Iowa dyed diesel sales for calendar year 2016

Fuel Type	Locations	Total Fuel (gallons)	Biofuel (gallons)
Dyed Diesel (D-0)	313	176,701,857	NA
Dyed D1-D4	30	2,148,567	85,728
Dyed D5-D10	104	31,470,394	1,573,520
Dyed D11-D19	16	468,334	69,641
Dyed D20--D49	16	795,018	163,535
Dyed D50--D100	17	73,406	36,703
Total Dyed Diesel		**211,657,576**	**1,929,127**
Total Dyed Biodiesel Blends		**34,955,719**	**1,929,127**

Table 1-3. Iowa diesel sales for calendar year 2016

Fuel Type	Locations	Total Fuel (gallons)	Biofuel (gallons)
Clear Diesel	1,168	285,060,665	NA
Clear B1-B4	89	9,429,250	280,992
Clear B5-B10	383	95,230,140	6,666,110
Clear B11-B19	233	203,079,356	30,197,900
Clear B20-B49	158	37,064,676	7,624,204
Clear B50-B100	9	28,215	14,108
Total Clear Diesel		**629,892,302**	**44,783,313**
Total Clear Biodiesel Blends		**344,831,637**	**44,783,313**

As Table 1-2 shows, 212 million gallons of dyed diesel were sold in 2016, with 35 million gallons of that being a biofuel blend. A total of 1.9 million gallons of dyed biodiesel were sold, which represents 0.9% of all dyed diesel sales.

Table 1-3 shows clear diesel sales for 2016. As the table shows, 630 million gallons of clear biodiesel were sold in the state of Iowa. More than half of that (344 million gallons) was a biodiesel blend. This represents 44.8 million gallons of pure clear biodiesel (7.1% of total sales).

1.5 Consumer Acceptance of Ethanol and Biodiesel

It is necessary to encourage consumer adoption of ethanol so that policy makers can make decisions on the development and marketing of these fuels (Pires 2011). The survival of a product in the bio-economy mainly depends on the following four factors:

- Feasibility of production technology
- Economic viability of yielding a short-term return on investment
- Ecologically sustainable development in terms of conserving and improving available resources
- Consumer acceptance

Table 1-4 summarizes the relevant research concerning consumer perception and acceptance of biofuels.

Table 1-4. Studies relevant to consumer perception and acceptance of biofuels

Reference	Research Method	Results
Ulmer et al. 2004	***Purpose:*** Assess the knowledge and perception of consumers on biofuels. The authors suggested that cost is the most important factor associated with consumer purchase decisions of ethanol. ***Method:*** Surveyed a random sample of registered voters in Oklahoma using mail strategy	• 37.6% response rate (685 respondents) • Insignificant relationship between willingness of respondents to purchase biofuels and differences in demographics, education, and income levels Respondents in Oklahoma perceived the following: • Ethanol is more environmentally friendly than gasoline (57.7%). • Cost is the most determining factor while purchasing ethanol blend. • Agreed to purchase an ethanol blend (63.2%) • Ethanol has a positive impact on Oklahoma's economy (60.3%). • Biofuels reduce US dependency on foreign oil sources (59.2%).
Selfa et al. 2011	***Purpose:*** Evaluate the perception of communities in rural areas towards biofuel production ***Method:*** Surveyed random households using a mailing strategy and interviewed stakeholder groups in local rural communities. The study targeted communities in Russell, Kansas, Philipsburg, Kansas, and Nevada, Iowa.	• 45.5% response rate in Russell (171 completed surveys), 40.4% in Philipsburg (186 completed surveys), and 45.7% in Nevada (261 completed surveys) • Two main concerns of the residents with regards to local ethanol plants included increased traffic (more congestion) and competition over resources (water scarcity in certain areas). Residents in all three communities perceived the following: • An ethanol plant is an important element to the economy of the local area (70% on average). • Ethanol plants added/provided new jobs to the local economy even though the jobs are not perceived to be highly paid (about 80%). • Benefits and costs of the ethanol plant are equal (about 30%). • Benefits outweigh the costs of the ethanol plant (40%).

Reference	Research Method	Results
House et al. 2011	***Purpose:*** Achieve a better understanding of consumer behavior in Iowa, i.e., perception and acceptance, regarding bio-products ***Method:*** Emailed random recipients to complete an online survey	• 30.2% response rate (755 received responses) • Many consumers in Iowa showed positive attitudes towards bio-products. • More consumers are willing to purchase bio-based products and fuel. • About 75% of respondents are aware of biofuels. • Almost half of respondents are currently using bio-products in their households. • More than 75% of consumers are willing to purchase bio-based products to help the economy in Iowa. • A majority of consumers support the use of biofuels to reduce the government's dependency on foreign oil (70%). • Nearly 84% of respondents perceived that it is important to use environmentally friendly products.
Cacciatore et al. 2012	***Purpose:*** Study consumer perception and knowledge of biofuels in the environmental, economic, ethical, and political domains ***Method:*** Interviewed randomly selected households in Wisconsin over the phone	• 38.8% response rate (593 completed telephone surveys) Findings from the regression model that predicted benefit versus risk perceptions across each of the four domains suggested the following: • Perceptions of the benefits of biofuels relative to the risks tend to decrease as respondents become more aware/knowledgeable. • Perceptions of respondents supporting different political parties is affected by media use.

Reference	Research Method	Results
Johnson et al. 2013	***Purpose:*** Identify any potential barriers for consumers to use biodiesel by quantifying awareness, use, and perceptions of consumers ***Method:*** Interviewed consumers at three retail fuel outlets in northwest Arkansas	• 72.4% response rate (134 interviews conducted out of 185 customers approached) • 7 out of 10 respondents claimed to be aware of biodiesel, but only less than 1% of these respondents purchased biodiesel. Customers aware of biodiesel perceived the following: • Uncertainty about the quality, performance, and effects on engine repair and maintenance (overall 45%) • Interest in purchasing biodiesel due to its characteristics, i.e., renewable fuel (88.1%) • Approval of the use of food crops to produce biodiesel (47.3%) • Believed that global warming would be reduced with increased use of biodiesel (43%).
Liao et al. 2016	***Purpose:*** Estimate the willingness to pay for E-85 ***Method:*** Conducted an intercept survey of motorists as they were refueling their vehicles in five states: California, Iowa, Oklahoma, Arkansas, and Colorado	• 972 samples of flexible fuel vehicle (FFV) motorists from 17 E-85 stations in 6 urban areas • 49% of FFV motorists chose E-85 and 51% chose E-10. • US consumers have, on average, a much lower willingness to pay for high-ethanol blends than the average Brazilian motorist. • California motorists have a mean willingness to pay for E-85 between 68% and 116% of the price of E-10. • Iowa, Oklahoma, Arkansas, and Colorado motorists have a mean willingness to pay for E-85 between 51% and 63% of the price of E-10. • Vehicle ownership, vehicle type, FFV badge, gender, age, miles traveled, motorist opinions about which fuel is better for the environment, engine, economy, and which fuel yields more miles per gallon do not statistically affect the mean willingness to pay.

The findings from this project are expected to help various stakeholders gain a better understanding of the consumer fueling preferences in Iowa. Such an understanding would provide an opportunity to increase the amount of both ethanol and biodiesel blends in the energy market.

2. SUMMARY OF PHASE I SURVEY

Phase I of this research involved the collection of survey data at two stations that received grants under the Iowa Renewable Fuel Infrastructure Program. Results were provided in a Phase I report. Relevant information from that report is provided in the following sections.

2.1 Station Summary

The Oak Street station is located in Inwood, Lyon County (northwestern region of Iowa), while the Farmers' Cooperative station is located in Mount Ayr, Ringgold County (southern region of Iowa).

Only biofuel blends are sold at the Mt. Ayr Farmers' Cooperative station, including different ethanol blends (E-10, E-15, E-30, and E-85), biodiesel blends (B-11, B-20, B-30, and B-99), and Number 2 and off-road diesel (red-dyed diesel). In contrast, Inwood Oak Wood station offers unleaded E-0, various ethanol blends in five dispensers (E-10, E-15, E-20, E-30, and E-85), and Number 2 and off-road diesel. Biodiesel may have been present in the Number 2 diesel at both stations. ASTM D975 does not require biodiesel blends of up to 5% to be labeled because they are ASTM-approved for safe operation in any compression-ignition engine that operates on diesel (US DOE 2018).

2.2 Survey Results for Fueling Our Future Participants

Surveys were conducted at both the Oak Street and Mt. Ayr stations. A survey was developed in conjunction with the project technical advisory committee (TAC). Survey Research Services (SRS) at Iowa State University's Center for Survey Statistics and Methodology reviewed each survey to ensure that it was understandable to consumer respondents and could be administered by the surveyors in just a few minutes. The objective of the survey was to assess why consumers selected or did not select higher ethanol or biodiesel blends. Age, gender, and other demographic information was requested in the survey. Other questions included the type of fuel that consumers purchased and the reason for their selection, vehicle model and year, and whether consumers were aware that their vehicle is a flexible fuel vehicle. The survey was also reviewed by the Institutional Review Board (IRB) at Iowa State University. The IRB committee requested parental approval for surveys administered to respondents under 18 years of age. Because gaining such permission was not feasible, it was decided to exclude participants under the age of 18.

The survey was tailored to the fuel sales for each station. In addition, each station was offered the opportunity to add additional questions that may be of interest to it, such as whether consumers found the station to be clean and well-maintained. Consequently, the Oak Street station wanted to learn whether customers would purchase biodiesel if it were offered at the station, and Farmers' Cooperative was interested in soliciting the opinion of its customers regarding the condition, location, and accessibility of the station.

The survey was conducted by SRS, which has trained surveyors.

Figure 2-1 presents the gender and age distributions of the respondents at each station, as well as their occupations.

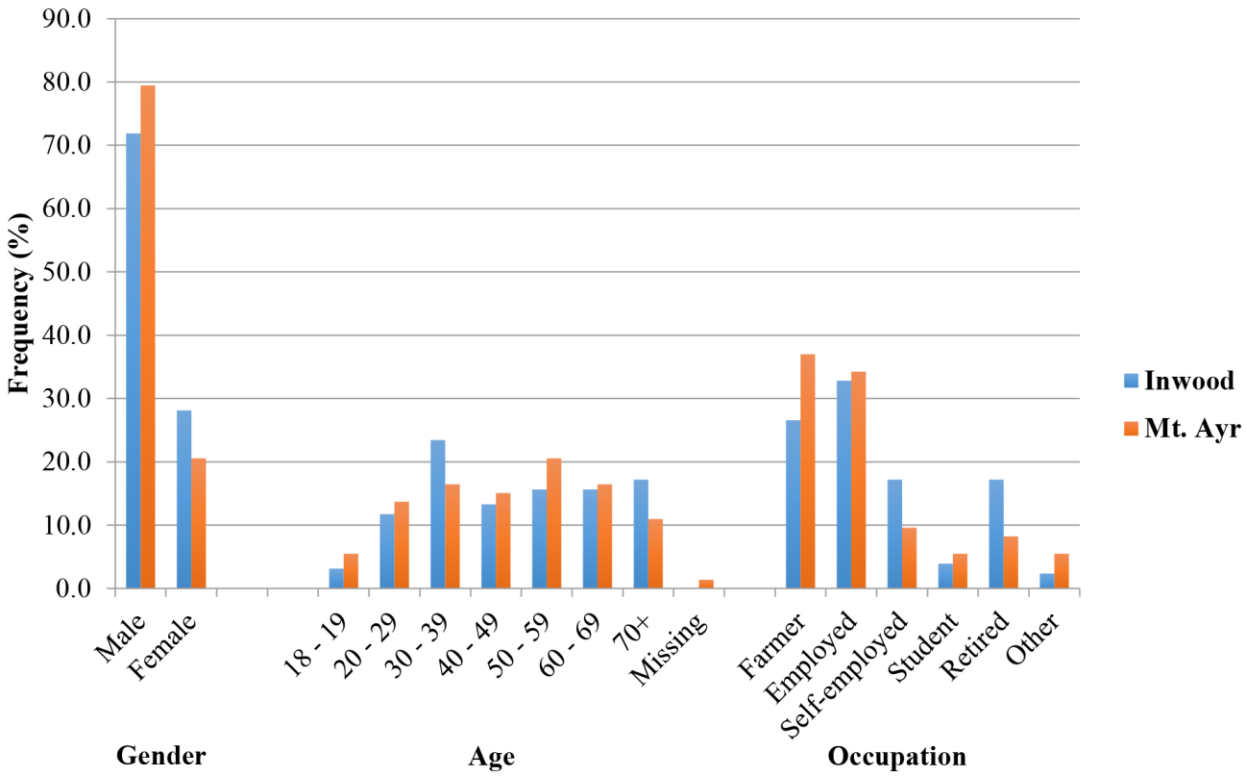


Figure 2-3. Demographic information of survey respondents

A total of 128 and 73 consumers participated in the survey at the Inwood Oak Street and Mt. Ayr Farmers' Cooperative locations, respectively.

As Figure 2-3 shows, most of the respondents at both stations were men (between 70% and 80%). It is not known why this was the case. Given that customer numbers were small at both stations, the surveyors questioned most of the customers. As a result, the skew toward male respondents is not a product of sample bias. About 60% of the consumers who participated in the survey were over 40 years old, with 26% at Inwood and 37% at Mt. Ayr identified as farmers.

Table 2-1 summarizes the responses to the questions about consumers' purchases.

Table 2-1. Results from station surveys

Question	Options	Frequency (%) Inwood	Mt. Ayr
Type of fuel purchased	E-0	16.4%	NA
	E-10	63.3%	41.1%
	E-15	0.8%	9.6%
	E-20	0.0%	NA
	E-30	1.6%	5.5%
	E-85	5.5%	6.9%
	B-11	NA	1.4%
	B-20	NA	5.5%
	B-30	NA	0.0%
	B-99	NA	2.7%
	Number 2 Diesel	12.5%	13.7%
	Off-Road Diesel	0.0%	13.7%
Main reason for not buying ethanol blends higher than E-10 and E-15	Potential Engine Damage	42.7%	64.9%
	Fuel Mileage	17.5%	16.2%
	Warranty Coverage Issues	0.0%	0.0%
	Undecided	21.4%	10.8%
	Other Reasons	17.%	8.1%
Purpose for buying off-road (red-dyed) diesel	Farming	NA	50.0%
	Construction	NA	20.0%
	Personal Vehicle	NA	0.0%
	Other Reasons	NA	30.0%
Main reason for buying a certain type of fuel	Cost	24.2%	20.6%
	Environmental Benefits	0.0%	2.7%
	Support Agriculture	3.1%	8.2%
	Higher Octane Fuel	9.4%	2.7%
	Compatible Fuel	42.2%	53.4%
	Habitual	19.5%	9.6%
	Other Reasons	1.6%	1.4%
Customers selected this particular station because	Cost	3.9%	5.5%
	More Fuel Options	1.6%	17.8%
	Location	54.7%	60.3%
	Customer Service	20.3%	0.0%
	Food Selection	0.0%	NA
	Spirits Selection	0.0%	NA
	Other Reasons	19.5%	16.4%
Customers aware of the different fuel blends offered	Yes	87.5%	83.6%
	No	8.6%	13.7%
	Undecided	3.9%	2.7%

Question	Options	Frequency (%) Inwood	Mt. Ayr
Main reason for not purchasing biodiesel fuel	Cost	NA	31.8%
	Not Compatible	NA	60.6%
	Not Environmentally Friendly	NA	0.0%
	Other Reasons	NA	1.5%
Customer rating of the station location and accessibility	Excellent	NA	65.8%
	Very Good	NA	21.9%
	Good	NA	11.0%
	Fair	NA	1.4%
	Poor	NA	0.0%
Willingness of customers to purchase biodiesel if made available	Yes	44.5%	NA
	No	42.2%	NA
	Never	12.5%	NA

As Table 2-1 shows, the majority of consumers fueled their vehicles with lower blends of ethanol (E-10) and regular diesel (Number 2 or off-road diesel), though more than 80% of the respondents were aware of the different fuel blends and the options available at the two stations.

The majority of respondents indicated that they did not select higher blends of ethanol because they believed that those fuels are not compatible with their vehicle and could potentially damage the engine.

At the Mt. Ayr Farmers' Cooperative station, 10 respondents purchased red-dyed regular diesel for farming and construction purposes (none of the participants at the Oak Street station bought this fuel type). Biodiesel fuel was only purchased by less than 10% of the respondents, and a majority of the customers who opted otherwise asserted that biodiesel is not compatible with their vehicles.

The compatibility of a type of fuel with the respondent's vehicle was the predominant selection factor cited at both stations, with cost being the second most important factor for fuel type selection. Almost half of the respondents opted to fuel their vehicles at these two stations due to ease of location, with the next most frequent responses being customer service at the Inwood station and different fuel options at the Mt. Ayr station.

About 90% of the respondents at the Mt. Ayr Farmers' Cooperative rated the condition, location, and accessibility of the station to be at least "very good."

3. EVALUATION OF ADDITIONAL STATIONS

The main objective of this research was to assess why consumers selected or did not select higher ethanol or biodiesel blends. The study originally focused on stations that received RFIP funding. However, the two stations that initially volunteered for the evaluation in Phase I did not provide a sufficient sample size of survey respondents. Additionally, these two stations were more typical of rural cooperatives than the type of stations more commonly found in Iowa's urban areas. As a result, the study was expanded to include additional stations.

3.1 Identification of Additional Locations

A list of stations in Iowa that sell biofuel blends was obtained from the Iowa Renewable Fuels Association (http://iowarfa.org). Additional information about the stations was provided by the Iowa Economic Development Authority (IEDA) and IDALS. Stations were selected based on various criteria. The types of fuel blends offered were considered to ensure a representative sample of different mid-range blends. Location was also important because the surveyors were based in Ames, Iowa, and travel time and costs to other areas of the state were prohibitive.

An initial list of sites was identified, and then each station was contacted. In some cases, conditions at the station differed from what was provided in information obtained from other sources. For instance, one station was not yet selling biofuel blends. In a few cases, the research team could not identify the owner or manager. In addition, several stations declined to participate. A final list of stations that were included in the survey is provided in Table 3-1.

Table 3-1. Stations surveyed

Station	City	Survey Dates	Unleaded Regular	Unleaded Premium	E-10	E-15	E-20	E-30	E-40	E-50	E-85	Diesel	Biodiesel	Survey Sample
Kum and Go	Ames	9/30/2016	*	*	NA	*	NA	NA	NA	NA	*	*	NA	195
Kum and Go	Ankeny	11/13/2016	*	*	*	*	*	*	NA	NA	*	*	NA	128
Kum and Go	Johnston	6/12/2017	*	*	NA	*	NA	NA	NA	NA	*	*	NA	118
Co-op Express Way	Council Bluffs	08/15/2017	*	NA	*	*	NA	NA	*	NA	*	*	NA	35
Sapp Brothers	Council Bluffs	8/16/2017	*	*	*	NA	NA	NA	NA	NA	*	*	NA	99
BP/Mother Hubbard's Cupboard	Davenport	6/11/2017 and 6/12/2017	*	*	*	NA	NA	*	NA	NA	*	*	NA	75
Agriland Fast Stop Indianola	Indianola	10/3/2016	NA	NA	*	*	NA	*	NA	NA	*	NA	NA	33
Kum and Go	Grimes	06/20/2017	*	*	NA	*	NA	NA	NA	NA	*	*	NA	63
Kum and Go	Coralville	5/12/2017	*	*	NA	*	NA	NA	NA	NA	*	NA	NA	200
Kum and Go	Tipton	5/13/2017	*	*	*	*	NA	NA	NA	NA	*	*	NA	179
NC Fast Stop	Vinton	07/30/2017	NA	NA	*	*	NA	*	NA	*	*	*	*	35
Underwood, Agriland FS	Underwood	10/21/2016 and 10/22/2016	*	NA	NA	*	NA	*	NA	NA	*	NA	NA	21
Kum and Go	Des Moines 1	5/23/2017 and 5/24/2017	*	*	*	*	NA	NA	NA	NA	*	*	NA	88
Kum and Go	Des Moines 2	5/31/2017	*	*	*	*	NA	NA	NA	NA	*	*	NA	154
Fast Stop	Grinnell	07/31/2017	NA	NA	*	*	NA	*	NA	*	*	*	NA	24
Best Food Mart	Des Moines	08/21/2017	NA	NA	*	*	NA	NA	NA	NA	*	*	NA	8

NA: indicates fuel blend was not offered at that station

As Table 3-1 shows, 16 stations were surveyed. Only 1 of them sold labeled biodiesel. (Biodiesel blends up to 5% can be sold without labeling, as noted in Section 3.2.) Stations sold an array of ethanol blends, and the blends available were not consistent among stations. For instance, 4 stations did not sell E-0 and 5 did not sell E-10. The majority of stations sold E-15, and all stations sold E-85. Additionally, 1 station sold E-20, 6 sold E-30, 1 sold E-40, and 1 sold E-50. Fifteen of the 16 stations received some RFIP assistance.

3.2 Survey Development

The objective of the surveys was to assess why consumers selected or did not select higher ethanol or biodiesel blends. The survey used for Phase I was reviewed and updated in conjunction with the TAC and SRS. Some changes were made because the stations' characteristics were different. Other questions were reworded based on feedback from the surveyors, which identified ambiguous questions or questions for which respondents struggled to select an answer.

Age, gender, and other demographic information was requested in the survey. Other questions included the type of fuel consumers purchased and the reason for their selection, vehicle model and year, and why consumers did not select a higher ethanol blend (when appropriate).

Because biodiesel was only sold at one station, responses to questions about biodiesel are not included in the summary of findings.

Additionally, the team met with Sebastien Pouliot (Center for Agriculture and Rural Development at Iowa State University), who had conducted an earlier study on consumers' willingness to pay for E-85 (Pouliot and Babcock 2014). Based on feedback from him and the TAC, additional questions were added to determine, for example, how changes in price would impact respondents' willingness to purchase higher blends of ethanol and whether consumers had an interest in purchasing vehicles optimized for mid-range ethanol blends if such vehicles were available on the market. A question about why respondents selected the individual station was added to provide feedback to station owners.

The survey was also reviewed by the IRB committee at Iowa State University. The IRB committee requested parental approval for surveys administered to respondents under 18 years of age. Because gaining such permission was not feasible, it was decided to exclude participants under the age of 18.

A single survey template was developed and used at all stations so that the questions asked were consistent. However, the survey was tailored to the fuel sales for each station to reflect the station's offerings. A copy of the survey is provided in Appendix A.

Surveys were initially conducted at several stations, and then the team reviewed the results with the on-site surveyors. The questions on subsequent surveys remained the same but were reworded to account for difficulties the surveyors were having in obtaining responses.

The survey was administered by SRS, which utilized trained surveyors. Each participating station was contacted, and, based on the availability of the surveyors, projected weather conditions, and station parameters, surveys were planned for one day at each site. Surveys were conducted at four stations during the fall of 2016 and then, due to winter weather, surveys were suspended until May of 2017. The 12 remaining stations were surveyed between May and August 2017. Dates when the surveys were conducted and the number of samples at each site are provided in Table 3-1.

Labeling requirements were in effect from June 1 through September 15 annually that, in theory, required E-15 to be labeled as "flex fuel" in most areas of the country (see Figure 3-1). Requirements for the use of the label in Iowa, however, were somewhat vague because they depended on an interpretation of fuel use and the application of the Reid Vapor Pressure waiver in the Clean Air Act. Although E-15 is approved for use in all vehicles manufactured from 2001 or later, the new labeling could have confused consumers about what fuels were appropriate for their vehicle (US EPA 2011).

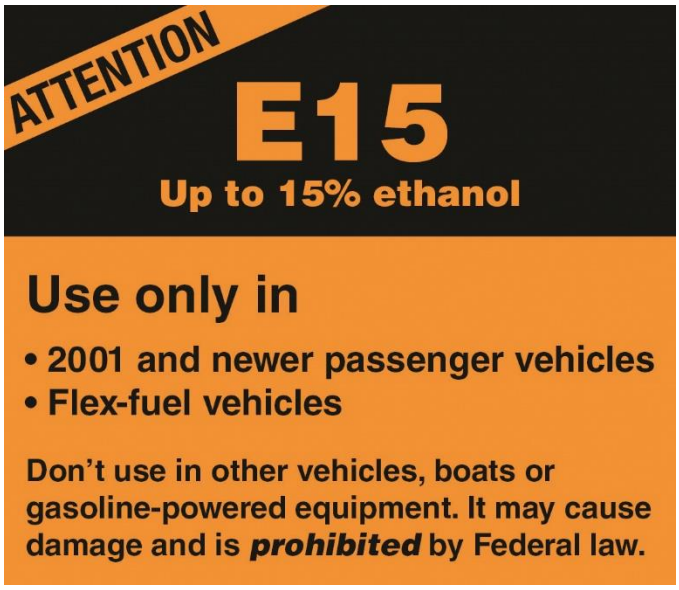


Figure 3-1. E-15 labeling

An attempt was made to compare sales during times when the labeling was present (June to September) to sales conducted between October and May to assess the impact of the labeling, if any. However, the stations surveyed in the two different time periods were not necessarily directly comparable. Additionally, it was not confirmed whether the label was consistently used at all stations where the surveys were conducted.

As noted in Table 3-1, 10 of the 16 stations had more than 50 respondents. The remaining 6 stations had between 8 and 35 respondents. Several of the stations were located in rather remote areas and had few customers. When only a few samples were obtained, data were collected on a second day when feasible. Even with an additional day of data collection, it was difficult to obtain a large sample in some cases.

Surveyors were physically present at each station and conducted in-person surveys with customers as they fueled their vehicles. The surveyors attempted to question each customer rather than collect a random sample. Customers were asked to participate in the survey and were provided with a small gift for answering the survey. The gift was a small zipped bag with a car emergency kit containing a few first aid supplies, a flashlight, an Assistance Needed sign, and a tire gauge.

3.3 General Survey Results

Data were aggregated for all stations and are summarized by topic, as described in the following sections. When a question was related to fuel purchase, only responses for gasoline/ethanol blends were tabulated. Additionally, because only a few stations sold mid-range blends, survey results for E-20, E-30, E-40, and E-50 were combined and are referred to as E-20/30 (unless otherwise stated). Table 3-2 shows a summary of demographic and other data not expanded on in subsequent sections.

Table 3-2. General survey results

Question	Options	Responses (n = 1464)
Purpose for buying off-road (red-dyed) diesel (if condition question)	Farming	63%
	Construction	25%
	Personal vehicle	13%
	Other	0%
Customers aware of different fuels blends offered	Yes	68%
	No	27%
	Undecided	5%
Gender	Male	71%
	Female	29%
Age range	18 or 19	3%
	20 - 29	19%
	30 - 39	20%
	40 - 49	18%
	50 - 59	20%
	60 - 69	13%
	70 and above	6%
Household income	Under $30,000	3%
	From $30,000 to $70,000	10%
	Over $70,000	14%
	Don’t know/prefer not to answer	4%

It is important to note that there were more male (71%) than female (29%) responses, similar to what was found at the two stations where surveys were conducted in Phase I. This trend was

reported at every station. Early in the survey process, the team met with SRS to ensure that the overrepresentation of men was not due to some bias. For instance, men may be more likely to respond to women who are conducting a survey than women are to other women, or women generally may feel less safe being stopped by any type of stranger. Women surveyors may also be more likely to approach men. SRS staff questioned their surveyors, who reported that they were attempting to survey everyone who stopped for fuel. Additionally, they reported that men were just much more likely to be buying fuel.

Responses by question are provided in the following sections. Responses are summarized for all respondents who purchased any blend of ethanol. In some cases, responses are also tabulated by whether the respondent's vehicle was a flex fuel vehicle. A discussion of responses in terms of flex fuel versus non-flex fuel vehicles is provided in Section 3.4.

3.4 Flex Fuel versus Non-Flex Fuel Vehicles

Question 10 asked respondents whether the vehicle they were fueling was a flex fuel vehicle. Results by type of fuel purchased are provided in Table 3-3. Around 22% of respondents indicated that their vehicle was flex fuel, while 69% indicated that their vehicle was not flex fuel. About 8% were not sure. As the table shows, 14% of those who indicated that their vehicle was not flex fuel purchased E-15 or a higher blend of ethanol, with 23% of respondents who indicated that they were unsure purchasing E-15 or higher. It was assumed that those who purchased a higher blend were aware that the fuel purchased was compatible with their vehicle, even if they didn't understand the term "flex fuel."

Table 3-3. Fuel purchase by respondents' indication of flex fuel vehicle

	Yes	No	Unsure
E-0	15%	22%	19%
E-10	44%	64%	58%
E-15	2%	7%	8%
E-20	0%	0%	0%
E-30	11%	6%	12%
E-85	28%	1%	4%

As a result, when responses were tabulated by whether the vehicle was flex fuel, respondents who indicated that they had a flex fuel vehicle or purchased an ethanol blend of 15% or higher were categorized as "flex fuel." Respondents who indicated that they did not have a flex fuel vehicle and purchased E-0 or E-10 were categorized as "non-flex fuel." Respondents who were unsure and purchased E-0 or E-10 were not included when responses were tabulated by vehicle type.

3.5 Type of Fuel Purchased

As noted in Figure 3-1, well over half of the survey respondents indicated that they purchased E-10.

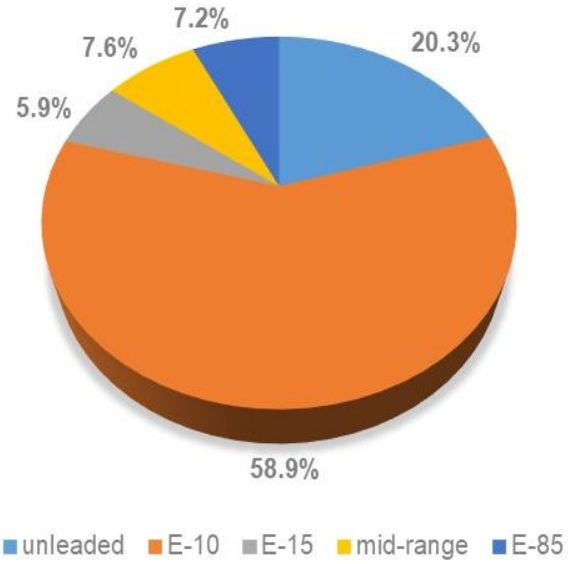


Figure 3-2. Ethanol blends purchased

About 20% of respondents purchased E-0, while 7% purchased E-85. Another 6% purchased E-15, and about 8% purchased a mid-range blend (E-20 or E-30). It should be noted that all stations sold E-0, E-10, and E-85, while only several stations sold the mid-range blends.

Statewide, 84.8% of fuel sales are for E-10 and only 13.8% are for E-0, according to 2016 reporting (Harpole and Awan 2017). There is no reason to expect that drivers surveyed in this study would have purchased E-0 at a rate higher than the statewide rate. It is likely that drivers are not aware of the difference between E-0 and E-10 because the same nozzle is often used and the fuel is not specifically labeled as E-10. In most cases, there is simply a sticker indicating that the fuel contains ethanol. As a result, the researchers felt that consumers in some cases were simply unaware that they were purchasing E-10.

Fuel purchases by respondents who had flex fuel vehicles versus those who did not have flex fuel vehicles are shown in Figure 3-3. As the right-hand figure shows, 16.0% of respondents who did not have flex fuel vehicles purchased regular unleaded, compared to only 9.8% of those who had a flex fuel vehicle. This suggests that respondents who have flex fuel vehicles are more likely to buy an ethanol blend. As the figure shows, over 90% of respondents with flex fuel vehicles purchased some type of ethanol blend, compared to 74% for those with non-flex fuel vehicles.

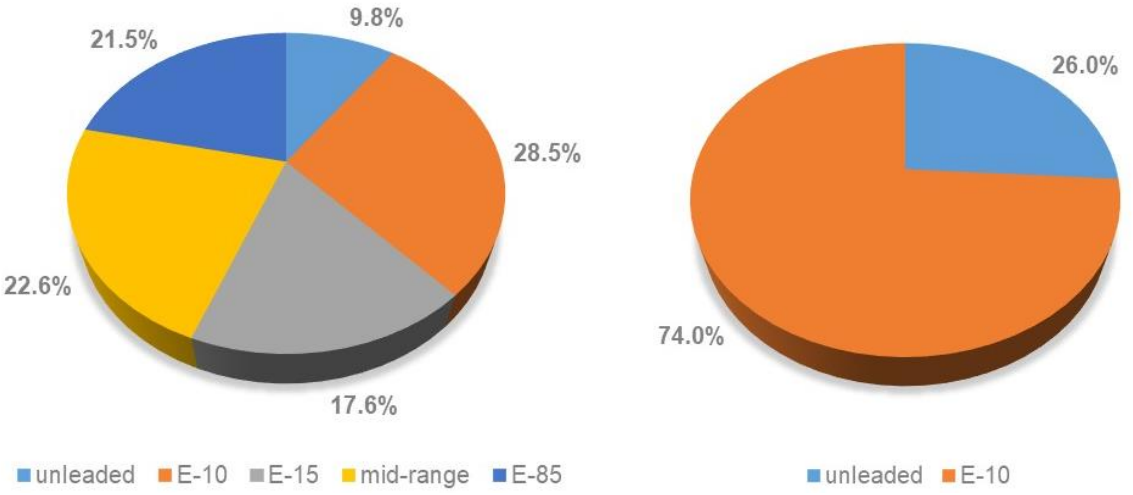


Figure 3-3. Fuel purchases by vehicle type: flex fuel (left) versus non-flex fuel (right)

3.5.1 Fuel Purchase by Age and Gender

Figure 3-4 illustrates fuel purchases by gender. As the figure shows, male and female respondents gave nearly identical responses. About 59% of men and 60% of women chose E-10, with similar percentages for men and women for other fuel blends.

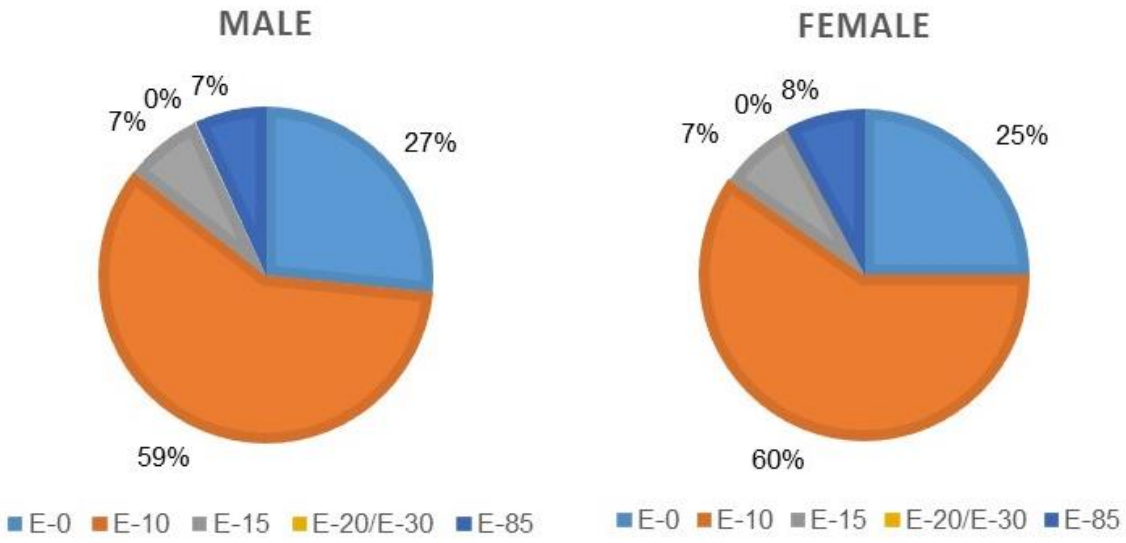


Figure 3-4 Fuel selection by gender

Responses by age are shown in Figure 3-5.

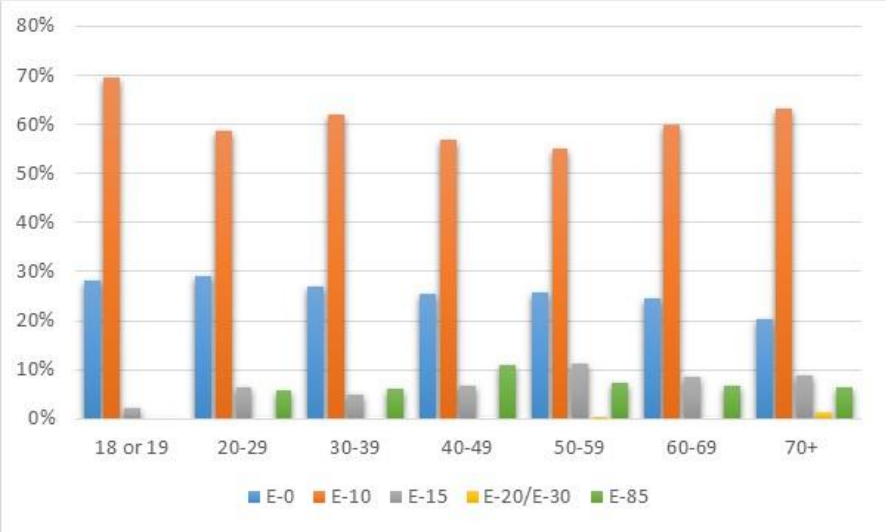


Figure 3-5. Fuel selection by age

As Figure 3-5 shows, 18- to 19-year-old respondents were the most likely out of all age groups to purchase E-10 (70%), while all other age groups exhibited similar preferences for E-10 (59% to 63%). These respondents were also the least likely to select E-85, 0% compared to 11% for 40- to 49-year-old respondents and 6% to 7% for all other age groups.

Respondents aged 50 to 59 were the most likely to select E-15, 11% compared to 9% for respondents aged 60 to 69 or 70+; 5% to 7% for respondents aged 20 to 29, 30 to 39, or 40 to 49; and 2% for respondents aged 18 to 19.

3.5.2 Fuel Purchase by Income Level

Figure 3-6 shows fuel purchase by income level. As the figure shows, respondents at all income levels were equally likely to purchase a certain type of fuel. For instance, 29% of those making under $30,000, 25% of those making between $30,000 and $70,000, and 27% of those making more than $70,000 purchased E-0. It was expected that respondents in lower income levels would be more likely to purchase higher blends of ethanol due to price disparities.

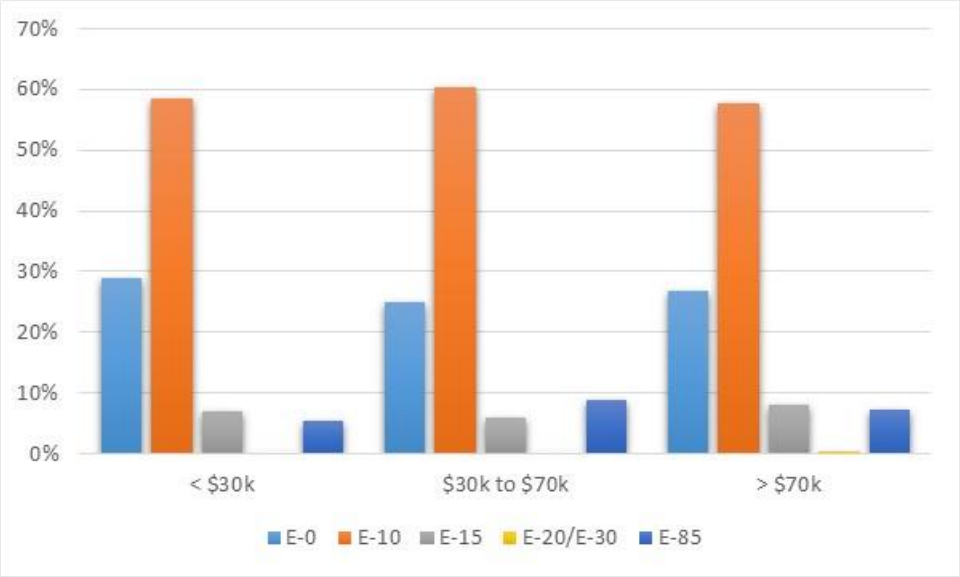


Figure 3-6. Fuel selection by income

3.6 Reasons for Selection of Fuel Purchased

Question 4 asked customers for the main reason they selected the fuel they purchased. The following wording was used for the question:

4. What is your <u>main</u> reason for buying this type of fuel?
1 = Cost
2 = Environmental benefits
3 = Supports agriculture
4 = Higher octane fuel
5 = Compatible with vehicle, Works best in this vehicle
6 = Habitual, Always buy it, No reason
7 = Reduce dependence on foreign oil
8 = Required by employer (company car)
9 = Other: _____

In this question, consumers were asked why they purchased the particular fuel they chose. The question is slightly different than Question 2, which asked respondents why they had not purchased a higher ethanol blend.

3.6.1 All Responses for Question 4

Results for Question 4 for all respondents are provided in Figure 3-7. As the figure shows, cost was the main factor for purchasers of E-0, E-10, and E-85, with 39% to 43% of these respondents reporting that factor. Cost was much less of a factor for purchasers of E-15 (2%) or E-20/30 (21%). It was somewhat surprising that cost was listed as the primary factor for purchasers of E-0 because in all cases E-0 was more expensive than any of the ethanol blends.

This result may reflect respondent beliefs that ethanol results in significantly lower fuel economy. Additionally, as noted in Section 3.5, consumers who purchased E-10 may have been under the misconception that they were buying a grade of E-0 rather than E-10 if the latter was not specifically labeled.

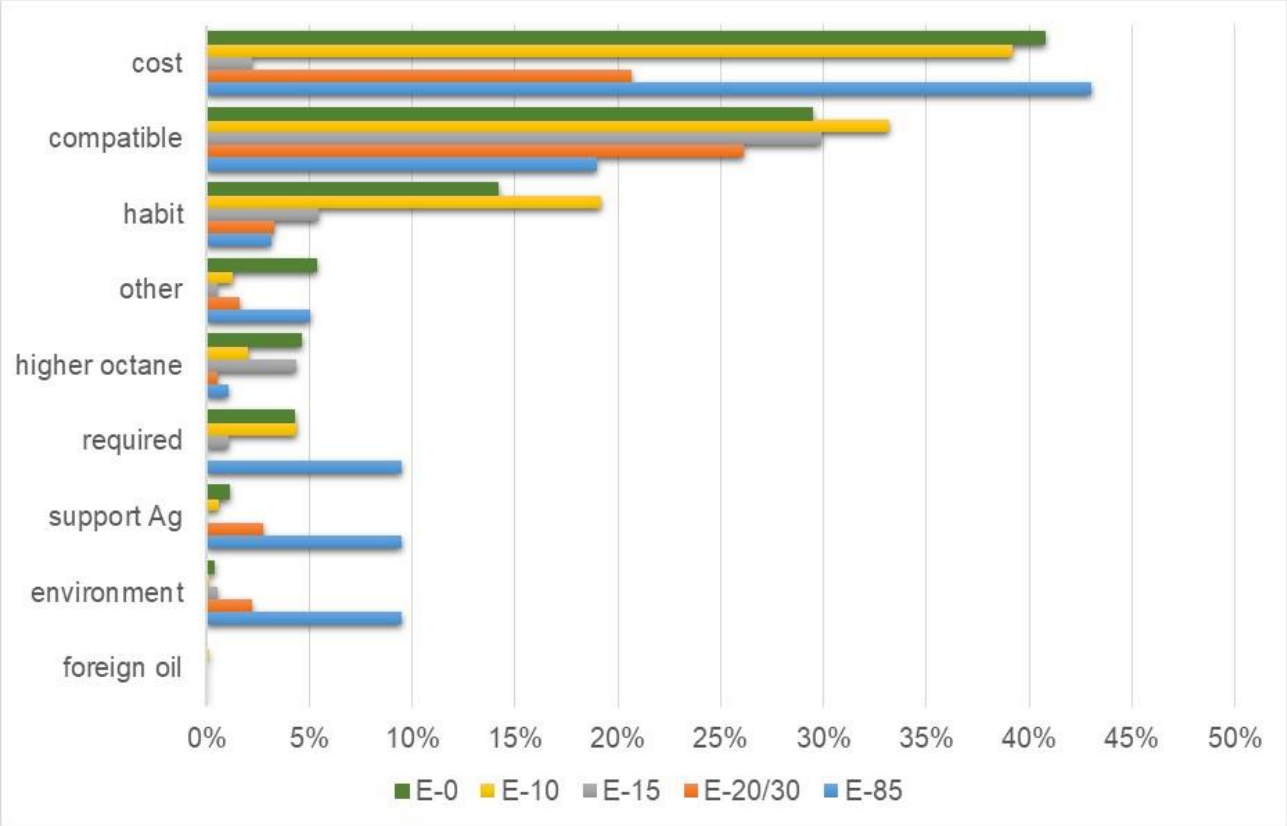


Figure 3-7. Reasons for selecting fuel purchased

The respondent's perception that his/her vehicle was or was not compatible with the fuel purchased was the next most common response for 29% of those purchasing E-0, 33% of those purchasing E-10, and 30% of those purchasing E-15. Additionally, 26% of E-20/30 purchasers and 19% of E-85 purchasers also indicated compatibility as the main reason for their fuel selection. This answer is somewhat puzzling for higher ethanol blends because those respondents were likely aware that their vehicle was compatible with lower ethanol blends.

About 5% of respondents who purchased E-0 or E-15 indicated that higher octane was their main reason for purchase. For other blends, 2% or less provided the same response.

Consumers who selected E-0 and E-10 (14% and 19%, respectively) were more likely than purchasers of other blends to purchase a particular fuel due to habit. Just 5% of those purchasing E-15 and 3% of those purchasing E-20/30 and E-85 reported that their selection was due to habit or preference.

As expected, those who selected E-85 were significantly more likely to indicate that they selected a particular blend because of environmental benefits, with 9% selecting this response. About 2% of those selecting E-20/30 and 1% of those selecting E-15 indicated environmental benefits as their main reason. Very few of those who selected E-0 or E-10 provided this response (< 1%).

Similarly, those who selected E-85 were much more likely than purchasers of any other fuel type to indicate that supporting agriculture was their main reason for fuel selection (9%). About 3% of those selecting the mid-range blends chose this response. Surprisingly 1% of those who purchased E-0 indicated supporting agriculture as the main reason for their purchase. This may indicate a simple misunderstanding of the question or may reflect the attitude that channeling crops to fuel has a negative impact on agriculture.

A number of respondents also indicated that they selected a particular fuel because it was required by their employer. About 9% of those who selected E-85 provided this response, which suggests that company policies have a significant impact on ethanol purchase. About 4% of those selecting E-0 or E-10 also indicated that their employer required this fuel.

Interestingly, very few respondents selected "reduce dependence on foreign oil" as their main reason (< 1% of all respondents). Clearly the consumers surveyed do not view dependence on foreign oil as a concern.

When a respondent indicated "other," his or her response was added to previous categories if applicable. For instance, a response coded "other" with a note of "price" was added to the "cost" category. "Other" responses were categorized by common terms, but in no case was the number of responses sufficient to create an additional category. For instance, several respondents indicated that they purchased the selected fuel by accident, but the number of such responses was insufficient to create a category for "mistake." In some cases, the code "other" was used for "no response."

3.6.2 Responses by Flex Fuel versus Non-Flex Fuel Vehicle for Question 4

The reasons that respondents with flex fuel vehicles selected the particular fuel they chose are shown in Figure 3-8. Responses for E-15, E-20/30, and E-15 are somewhat duplicative to the responses in Section 3.6.1 because only respondents with flex fuel vehicle would have been included in those categories.

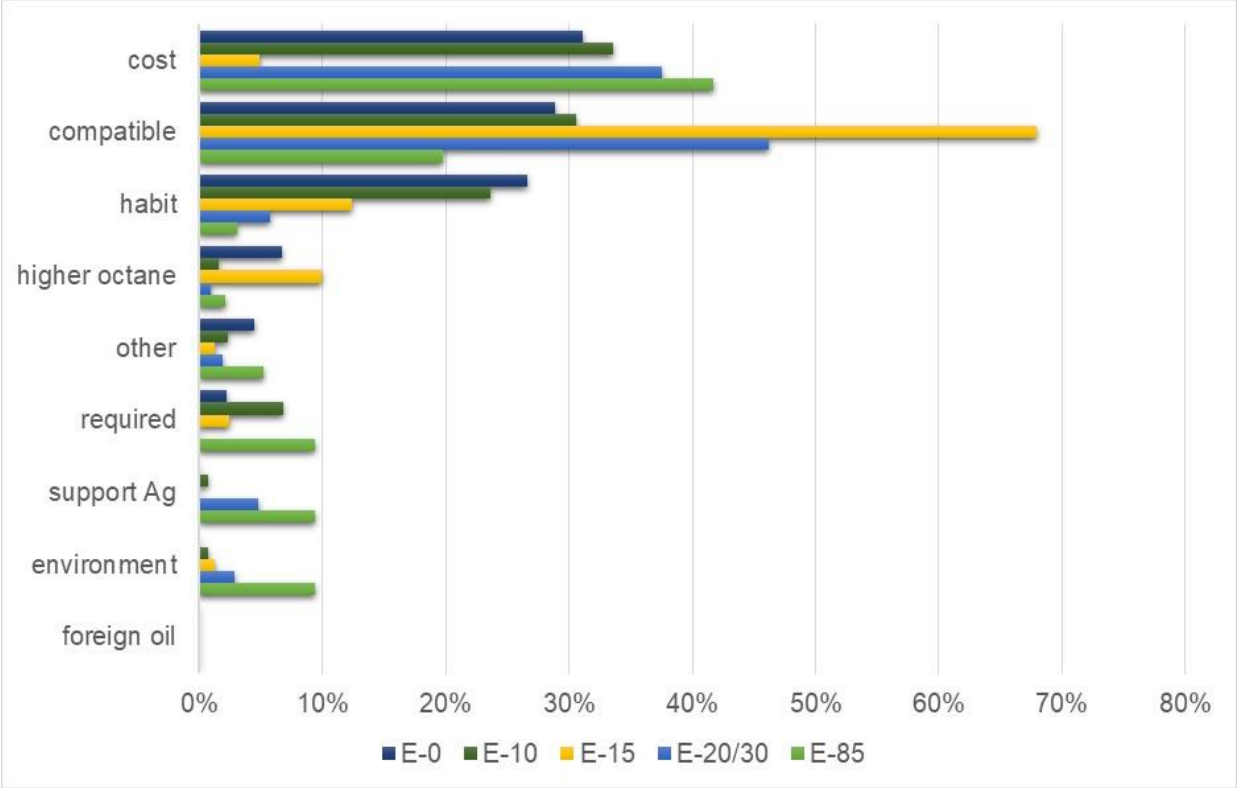


Figure 3-8. Reasons for selecting fuel purchased (flex fuel)

As the figure shows, cost was the most significant reason for respondents with flex fuel vehicles, followed by compatibility, for those purchasing E-0 (31% and 29%), E-10 (34% and 31%), and E-85 (42% and 20%). Compatibility was the main reason for those purchasing E-15 (68%), followed by habit (12%). Compatibility (46%) was also the main factor for those purchasing E-20/30, followed by cost (38%). It is not clear why compatibility was the most selected response for these two fuels. It may have been that drivers knew their vehicle could use a mid-range ethanol blend but not E-85 and they were making a conscious choice to select the blend with the highest level of ethanol that was compatible. Habit was also major reason for selecting E-20/30, E-10, and E-0 (6%, 24%, and 27%, respectively).

Figure 3-9 shows the reasons for selecting a particular fuel for respondents with non-flex fuel vehicles. Only E-0 and E-10 are included because these are the only fuels that would be selected for these vehicles. As noted, cost was the most significant factor for those selecting E-0 and E-10 (43% and 42%, respectively), followed by compatibility (31% and 35%). The third most cited reason was habit (10% and 16%, respectively).

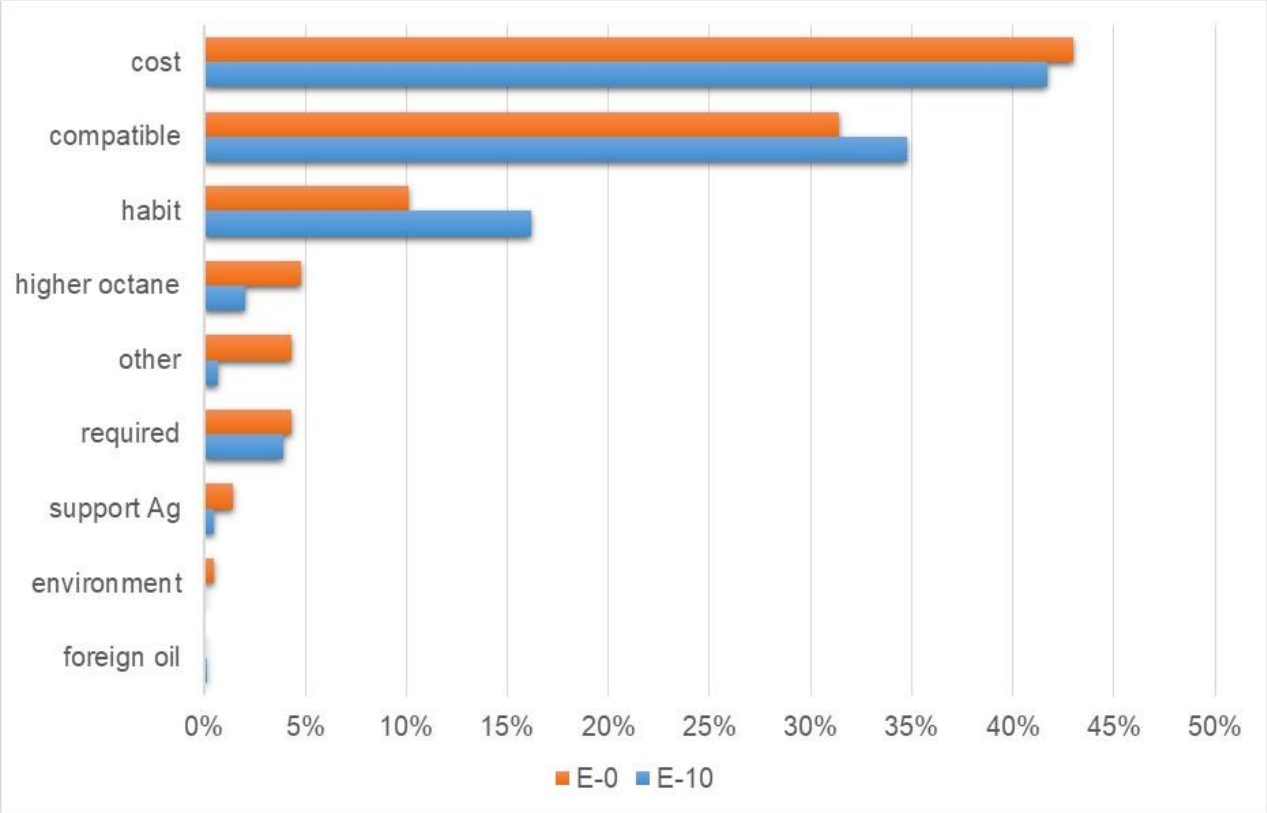


Figure 3-9. Reasons for selecting fuel purchased (non-flex fuel)

The top three reasons for selecting a particular fuel (cost, compatibility, and habit) were similar for E-0 and E-10 when comparing the responses from those who had flex fuel versus non-flex fuel vehicles.

3.7 Reasons for Not Purchasing a Higher Ethanol Blend

Respondents who purchased E-0, E-10, or E-15 were asked why they did not purchase a higher blend of ethanol. The question from the survey reads as follows:

2. What is your main reason for not purchasing a (higher) ethanol blend?
1 = Not compatible with this vehicle, potential engine damage
2 = Fuel mileage – (higher) ethanol blends don't perform as well
3 = Warranty coverage issues
4 = Don't know
5 = Other reason: _____

Whereas Question 4 asked consumers why they selected the particular fuel purchased, Question 2 asked consumers why they did not purchase a higher ethanol blend. Additionally, Question 2 was only asked of a subset of respondents (those purchasing E-15 or lower blends).

Only four responses were provided for Question 2. Cost was not expected to be a concern because successively higher blends of ethanol are cheaper. Additionally, the objective of the question was to assess what concerns existed for higher blends, such as engine compatibility. As a result, the responses were focused on concerns about compatibility, fuel economy, or vehicle warranty. The option to answer "Don't know" was geared towards respondents who simply had not thought about the choice, and "Other reason" was provided to give respondents flexibility in case the other categories did not apply. Around 35% of respondent purchasing E-0 or E-10 and 12% of respondents selecting E-15 responded "Other reason." In retrospect, it may have been advantageous to provide additional response categories similar to those used in Question 4.

When respondents selected "Other reason," they were further questioned, and their responses were recorded. These reasons were categorized according to similar responses, which included the following:

- *Awareness*: indicates that the driver was not aware of higher ethanol options or that he or she was from out of state and had not encountered the available choices before.
- *Cost*: includes references to "cost," "price," "cheaper," etc.
- *Compatibility*: includes references to "fuel not compatible with vehicle," "fuel does not work with vehicle," etc. This type of response is similar to responses that referred to "warranty," but it was felt that drivers were referring more to their vehicles not being flexible fuel vehicles rather than concerns about voiding their vehicle warranties. However, both reflect the idea that drivers have a lack of understanding about their vehicles' capabilities.
- *Knowledge*: indicates that the purchaser did not understand ethanol and includes responses such as "not familiar with ethanol," "ethanol could catch on fire easily," "ethanol is a safety hazard," etc.
- *Not owner*: these drivers indicated that the vehicle was a rental car, a company car, or belonged to a family member/friend. In some cases, respondents indicated the fuel purchased was due to company policy.
- *Preference*: indicates that the drivers preferred the option selected or purchased that fuel regularly out of habit.
- *Other*: includes all other responses that did not fit into one of the above categories and that had too few responses to include in a separate category. "Other" includes responses such as "disliked ethanol," "disliked farmers," "environmental concerns," "a family member had advised them not to buy," "concern about corn prices," or "the purchased fuel was a mistake" (for instance, they meant to purchase E-10 but selected E-0 instead).

3.7.1 All Responses for Question 4

Responses for Question 2 for all respondents are provided in Figure 3-10.

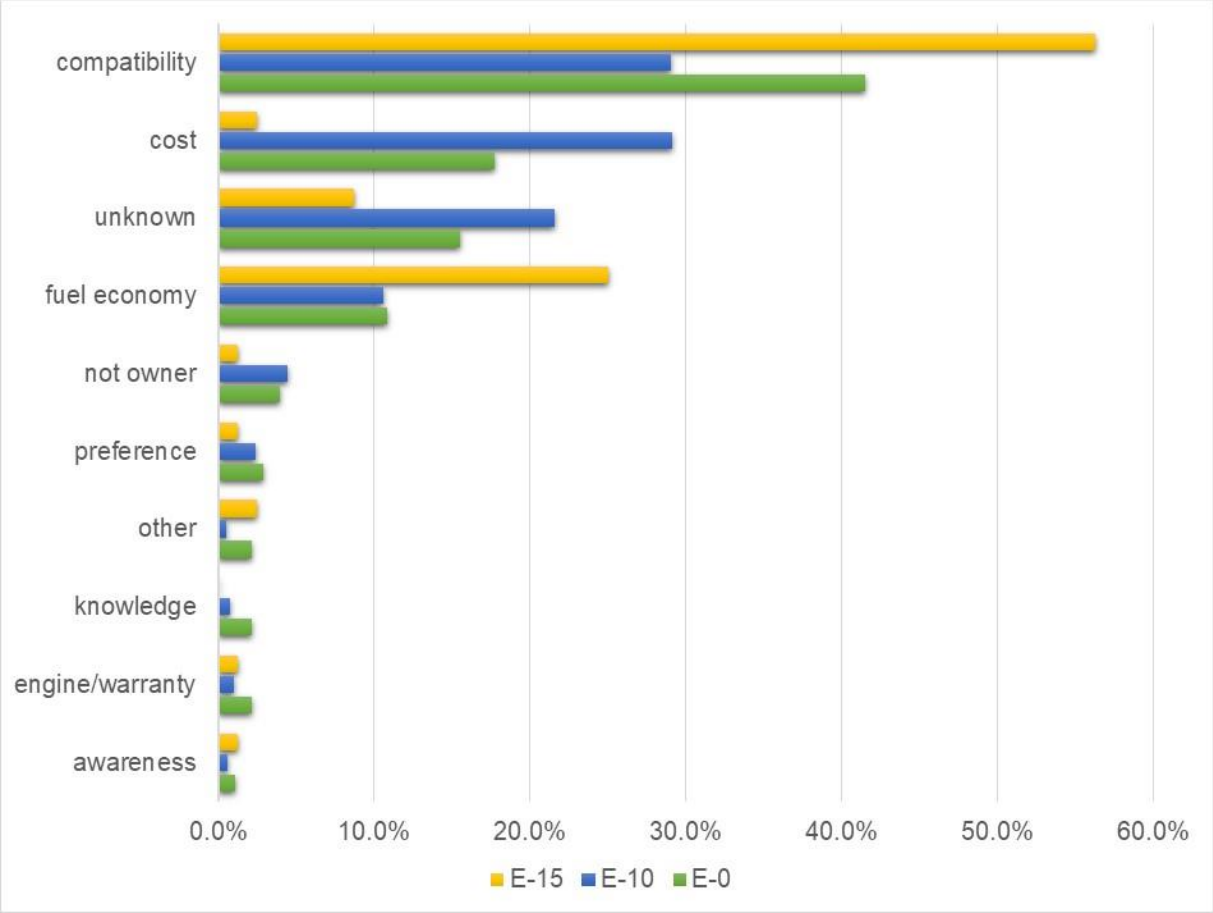


Figure 3-10. Reasons for not selecting higher blend

For purchasers of all fuel types, the most cited reason for not purchasing a higher ethanol blend was that a higher blend of ethanol was incompatible with their vehicle (41% for E-0, 29% for E-10, and 56.3% for E-15 purchasers). It is unknown whether E-0 and E-10 purchasers were referring to the next highest blend or E-85. For instance, respondents purchasing E-0 may have believed that E-10 was incompatible with their vehicle or were not aware that they had purchased E-10 and were referring to E-15 or E-85. It is also unknown whether their vehicle was actually incompatible or whether the respondents were unaware that their vehicle was a flexible fuel vehicle. Respondents who purchased E-15 were the most likely to indicate engine compatibility as their reason for not purchasing a higher blend (56.3%).

Cost was the next most cited reason for not purchasing a higher ethanol blend. About 17% of respondents purchasing E-0, 29% of respondents purchasing E-10, and 2.5% of respondents purchasing E-15 reported cost as their main reason for not selecting a higher blend. Respondents may have been interpreting cost in terms of lower energy content, because ethanol in all cases was cheaper than E-0. About 10% of E-0 and E-10 respondents did cite fuel economy as the main factor, while 25% of E-15 respondents gave this response.

About 4% of E-0 and E-10 respondents indicated that they were not the owner of the vehicle and presumably were purchasing a fuel option that they believed would work in all vehicles. In some cases, the purchase of a particular fuel type was due to company policy. Only 1.3% of E-15 respondents indicated that they did not purchase a higher blend because they were not the owner of the vehicle.

Personal preference was the next most cited reason for 1% to 3% of respondents. Engine warranty concerns, knowledge about ethanol, and awareness of the availability of other blends represented 0% to 2.5% of responses.

3.7.2 Responses by Flex Fuel versus Non-Flex Fuel Vehicle for Question 2

Reasons for not selecting a higher blend of fuel were tabulated for flex fuel versus non-flex fuel vehicles for those purchasing E-0, as shown in Figure 3-11. As the figure shows, compatibility was the primary reason for not selecting a higher ethanol blend for respondents with non-flex fuel vehicles and was the second most common response for drivers with flex fuel vehicles (49.8% versus 22.7%, respectively). Fuel economy was the main factor for respondents with flex fuel vehicles and the fourth most common response for respondents with non-flex fuel vehicles (29.5% versus 7.2%, respectively). Price was the second most common response for respondents with non-flex fuel vehicles and the fourth most common response for respondents with flex fuel vehicles (21.7% versus 11.4%, respectively). The fifth most common reason for not selecting a higher blend for both vehicle types was that the respondent didn't know why he or she did not select a higher blend or did not have a reason (13.6% for non-flex and 10.6% for flex). Company policy was listed as the reason for around 2% of respondents for both vehicle types.

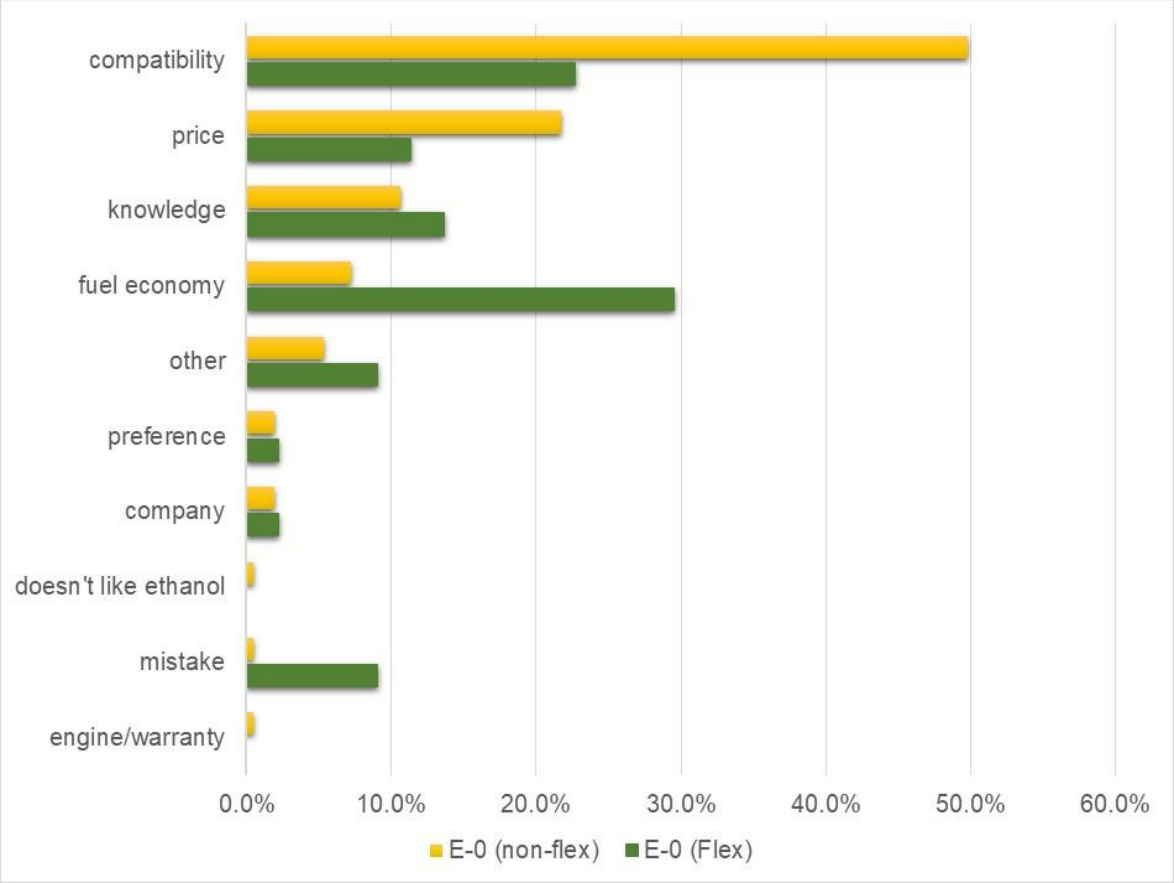


Figure 3-11. Reasons for not selecting higher blend for those purchasing E-0

The reasons given by purchasers of E-10 for not selecting a higher ethanol blend are compared in Figure 3-12 for respondents with flex fuel vehicles versus respondents with non-flex fuel vehicles. Engine compatibility was the main reason noted for respondents with non-flex fuel vehicles (33.4%) and was the fourth most common reason for those with flex fuel vehicles (11.5%). Price was the most common reason for respondents with flex fuel vehicles (28.3%) and was the second most common reason for non-flex fuel vehicles (31.0%). The second most common reason for not selecting a higher blend for respondents with flex fuel vehicles was that the respondent did not know why he or she did not select a higher blend or did not have a reason (23.7%); this response was the third most common reason for respondents with non-flex fuel vehicles (17.7%). Fuel economy was the third most common reason for respondents with flex fuel vehicles (18.3%) and the fourth most common reason for respondents with non-flex fuel vehicles (9.4%).

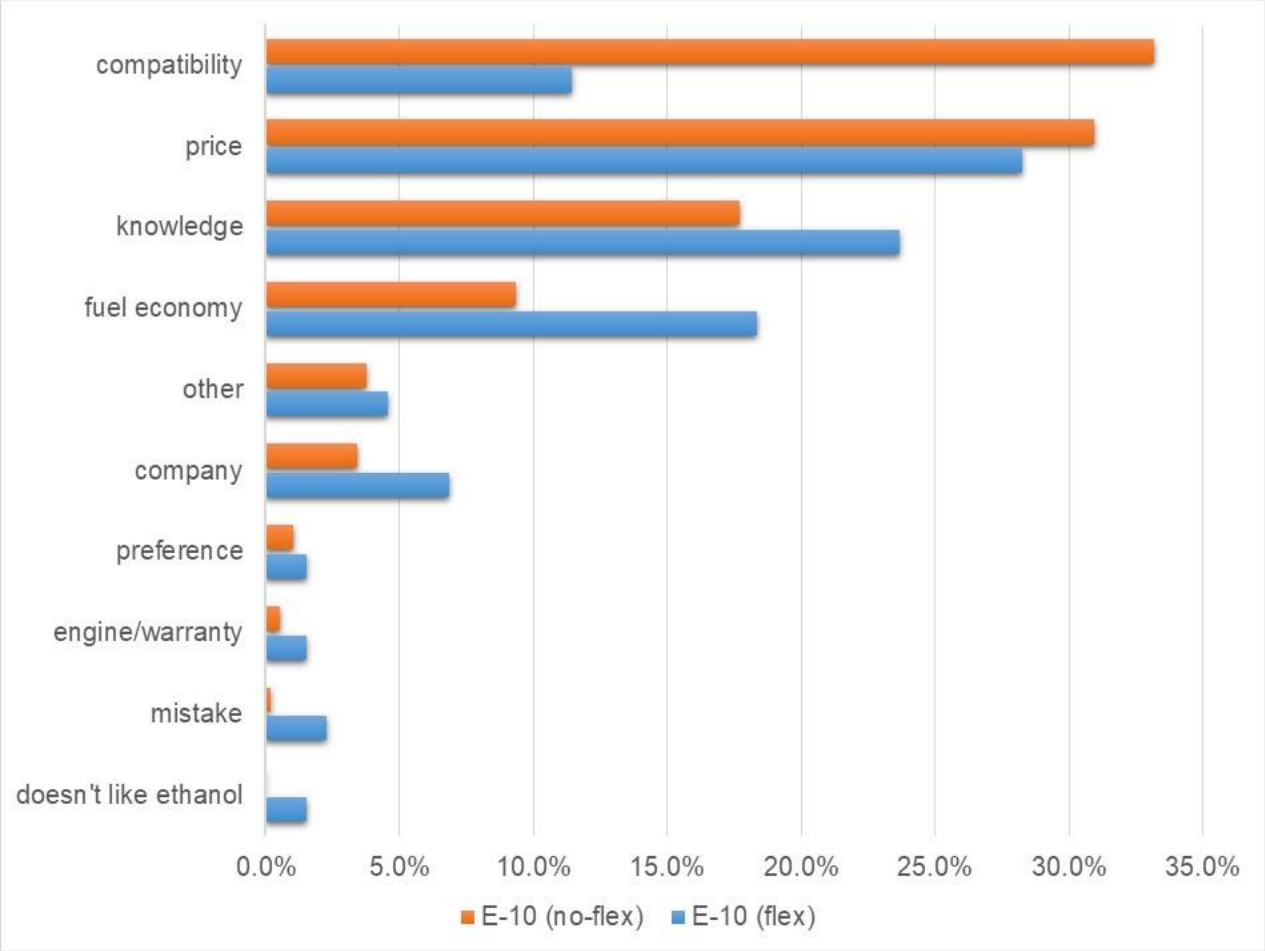


Figure 3-12. Reasons for not selecting higher blend for those purchasing E-10

3.8 Impact of Change in Price on Likelihood of Selecting E-85

The next set of questions was intended to discover whether respondents would change their purchasing behavior if fuel costs changed. Question 5 asked those who did not purchase E-85 whether they would be more likely to purchase E-85 if the cost of the fuel they did purchase that day had been 25¢, 50¢, or 75¢ higher per gallon. The surveyors calculated the cost, so if E-0 cost $2.25 on the day of the survey, respondents would be asked, "If the fuel you bought today cost $2.50, $2.75, or $3.00 per gallon, would you have been more likely to purchase E-85?" Responses included "yes," "no," or "don't know." Respondents were asked to respond at each level (i.e., 25¢, 50¢, and 75¢ higher).

All stations offered E-85. As a result, purchase of E-85 was an option for all respondents.

3.8.1 All Responses for Likelihood of Selecting E-85

Figure 3-13 provides the responses for a 25¢ per gallon increase in the price of the fuel that the respondent purchased.

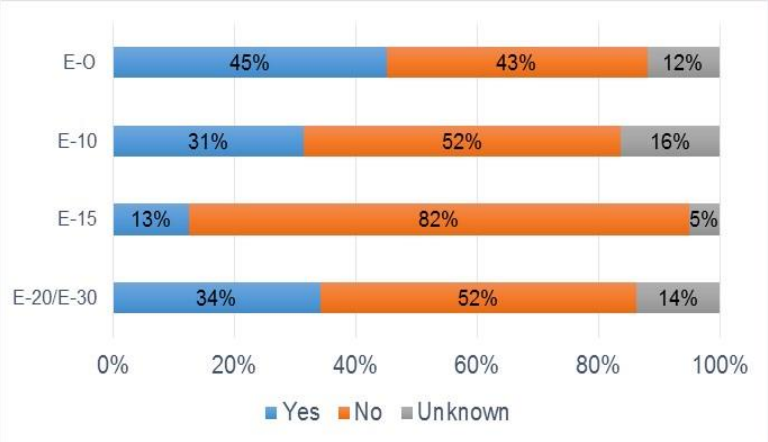


Figure 3-13. Likelihood of selecting E-85 if current fuel purchased was 25¢ higher

As Figure 3-13 shows, respondents who purchased E-0 were the most likely (45%) to indicate that they would purchase E-85. A similar percentage of purchasers of E-10 and E-20/30 (slightly over 30%) indicated that they would purchase E-85. E-15 purchasers were the most likely to indicate that they would not select a higher ethanol blend (over 55%) due to concerns about compatibility. Respondents who selected E-15 were probably more likely to understand the capabilities of their vehicles. For instance, most hybrid vehicles can utilize E-15 or lower, but not E-85. As a result, this group is expected to be the most inelastic regarding price.

Respondents were then asked whether they would be more likely to purchase E-85 if the cost of the fuel they purchased that day was 50¢ higher per gallon. Figure 3-14 shows the responses if the fuel the respondent selected cost 50¢ more per gallon.

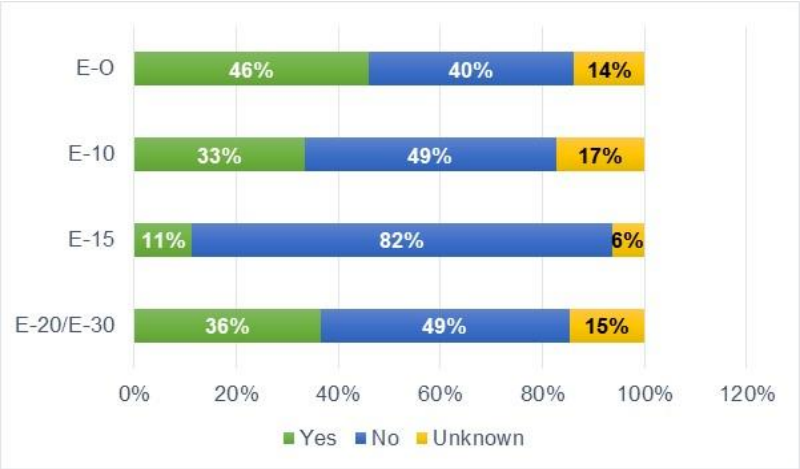


Figure 3-14. Likelihood of selecting higher ethanol blend at 50¢ higher

The responses for a 75¢ per gallon increase are shown in Figure 3-15.

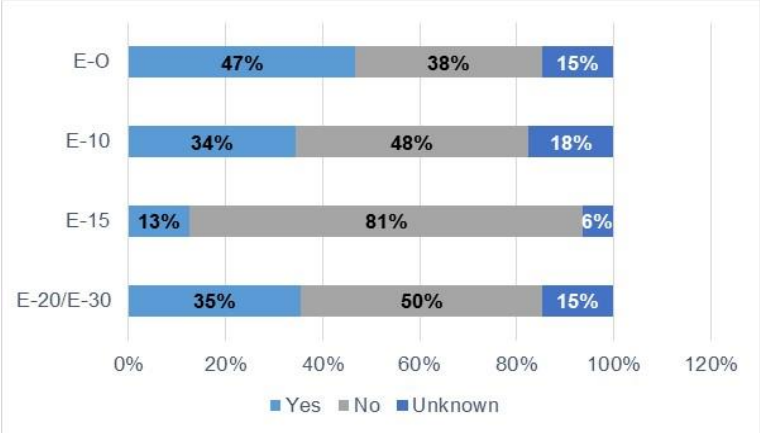


Figure 3-15. Likelihood of selecting higher ethanol blend at 75¢ higher

As the figures show, similar answers were reported for all three scenarios. For instance, 45% of E-0 purchasers indicated that they would purchase E-85 if the cost of E-0 was 25¢ higher per gallon, 46% indicated that they would purchase a E-85 if the price was 50¢ higher per gallon, and 47% would purchase E-85 if the price was 75¢ higher per gallon. A similar pattern resulted for all other fuel blends. This suggests that price is important but respondents who were not initially swayed by a 25¢ per gallon increase were not likely to be swayed by an even higher differential.

3.8.2 Responses by Flex Fuel versus Non-Flex Fuel Vehicle for Likelihood of Selecting E-85

Figure 3-16 provides the responses for a 25¢ per gallon increase in the price of the fuel that the respondent purchased tabulated according to respondents with flex fuel vehicles versus respondents with non-flex fuel vehicles. Responses are shown for E-0 and E-10 only. The responses for E-15 or mid-range blends presented in Section 3.8.1 by default only included respondents with flex fuel vehicles, so those responses are not duplicated here.

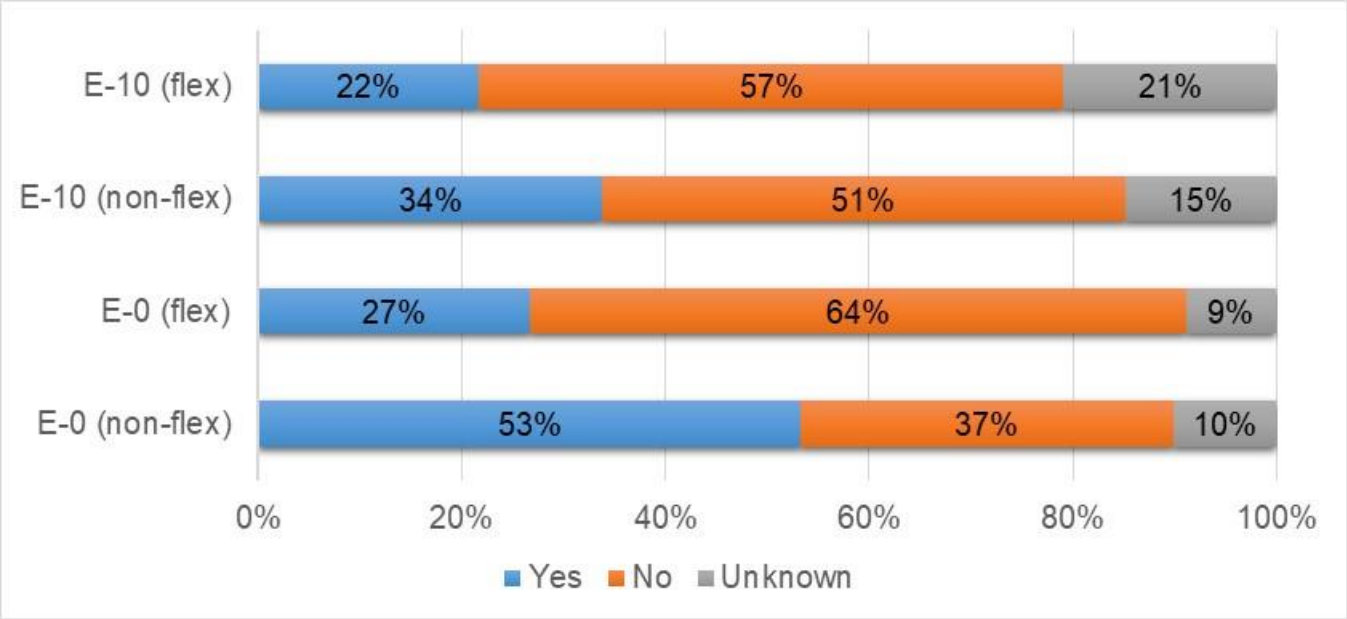


Figure 3-16. Likelihood of selecting E-85 if current fuel purchased was 25¢ higher by flex fuel versus non-flex fuel

Additionally, the responses for this section are only provided for a 25¢ per gallon increase. As noted in Section 3.8.1 responses for 50¢ and 75¢ were very similar to those for 25¢, and it is not expected that this would vary by flex fuel versus non-flex fuel vehicle type.

As Figure 3-16 shows, drivers of non-flex fuel vehicles were more likely to indicate that they would purchase E-85 (53% responded "yes"), even though they believed their vehicle was not a flex fuel vehicle. Only 27% of drivers with flex fuel vehicles who purchased E-0 responded "yes." These results suggest that either drivers were uniformly confused by the question or that respondents truly did not understand what a flex fuel vehicle is.

3.9 Likelihood of Purchasing Efficient Vehicle

Question 8 asked respondents whether they would be likely to buy a vehicle that more efficiently used higher blends of ethanol if such a vehicle were available. The objective of this question was to determine whether a vehicle that could more efficiently use ethanol blends would be of interest to consumers. The question read as follows:

If you were buying a car, how likely would you be to purchase a vehicle designed to more efficiently use higher blends of ethanol? Would you say . . .

1 = Very likely
2 = Somewhat likely
3 = Not sure
4 = Somewhat unlikely
5 = Very unlikely
6 = NO OPINION

3.9.1 All Responses for Likelihood of Purchasing Efficient Vehicle

Figure 3-17 shows the responses by income categories because income is expected to impact vehicle purchase choice.

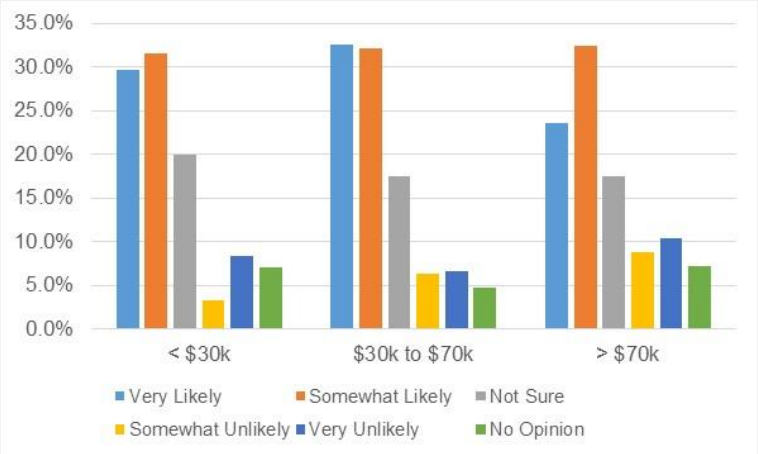


Figure 3-17. Likelihood of purchasing efficient vehicle

Surprisingly, respondents in lower income categories were more interested in purchasing a vehicle that could more efficiently use ethanol blends. Thirty percent of those making less than $30,000 and 33% of those making between $30,000 and $70,000 responded that they were "very likely." Respondents for all income levels were equally likely (32%) to answer "somewhat likely." Respondents making less than $30,000 were more likely (20%) to say that they were "not sure" than the other two income levels (17% for those making between $30,000 and $70,000 and 18% for those making more than $70,000). Additionally, those making more than $70,000 were more likely to answer that they were "somewhat unlikely" or "very unlikely." It was assumed that respondents in the higher income categories would be likely to be more educated and have more disposable income than respondents in the lower income categories. Therefore, it was surprising that respondents making more than $70,000 were not more likely to indicate a willingness to purchase a vehicle that could more efficiently use ethanol blends. It is possible that those in the lower income categories see an economic advantage in purchasing a vehicle that uses ethanol more efficiently because ethanol blends are cheaper than E-0.

3.9.2 Responses for Likelihood of Purchasing Efficient Vehicle by Flex Fuel versus Non-Flex Fuel Vehicle

Figure 3-18 shows the same information tabulated according to resondents with flex fuel vehicles versus those with non-flex fuel vehicles. Those with flex fuel vehicles were somewhat more likely to say that they were "very likely" to purchase a vehicle that could more efficiently use ethanol blends than those who had non-flex fuel vehicles (30.3% versus 25.9%, respectively). However when responses for "very likely" and "somewhat likely" were combined, 57.7% of respondents with non-flex fuel vehicles indicated they were very or somewhat likely to purchase such a vehicle, compared to 59.4% for respondents with flex fuel vehicles.

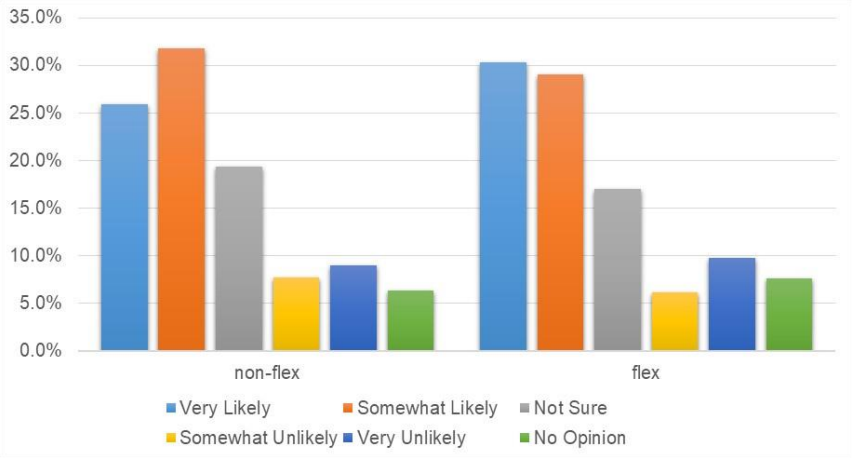


Figure 3-18. Likelihood of selecting more efficient vehicle by flex fuel versus non-flex fuel

3.10 Station Choice

Participating stations indicated that they were interested in gathering information about why customers choose their station. The research team was also interested in knowing whether consumers were likely to intentionally choose a station because it offered E-85. As a result, Question 9 was included and read as follows:

9. Why do you buy fuel at this particular station? *[Circle all that apply]*
1 = Cost
2 = More/Good fuel options
3 = Convenient location
4 = Good customer service
5 = Has E-85
6 = Other: _____

When a respondent answered "other," they were prompted to provide a reason.

These answers were coded according to similar categories. For instance, responses such as "easy to access," "on way to work," etc. were coded as "convenient location." Categories include the following:

- Convenient location
- Has car wash
- First time at station
- Convenience store options
- Has business account or company policy
- Respondent was employee of station
- Has restroom
- Prefers chain

- Has E-15
- Has good quality fuel

Responses are shown in Figure 3-19. Respondents were able to select more than one option. Over 81% of respondents selected "convenient location." Because this response was overwhelmingly larger than any other, it is not shown in Figure 3-19.

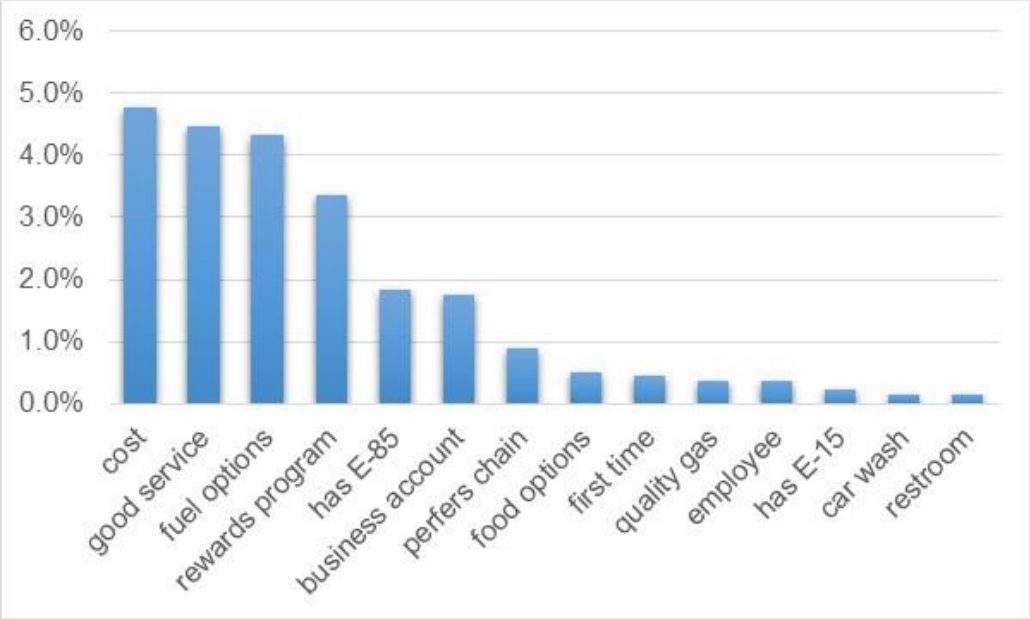


Figure 3-19. Reasons for selecting station (does not include #1 reason)

As Figure 3-19 shows, 4% to 5% of respondents selected "cost," "good customer service," or "fuel options" as the primary reasons for selecting that station (after location). About 3% said that they selected the station because of the rewards program. About 2% indicated that they selected the station because of the opportunity to purchase E-85 or because they have a business account there. About 0.5% selected the station because of the convenience store options. About 0.4% selected the station because it was their first time, they could purchase high-quality fuel, or they were an employee of the station. About 0.1% to 0.2% selected the station because the station offered E-15, the station had a car wash, or they wanted to use the restroom.

4. AIR QUALITY AND EFFICIENCY IMPACTS OF ETHANOL AND BIODIESEL

The objective of this portion of the research was to evaluate the potential air quality impacts that might be expected to result from increasing purchase of higher blends of ethanol due the Fueling Our Future initiative and other programs. The researchers reviewed the literature to obtain factors that could be used to assess the impacts. Potential scenarios were then developed for different levels of market penetration and emissions, and the fuel economy impacts for those scenarios were calculated.

An initial effort was made to find standard emission rates for various blends of ethanol and biodiesel. However, this information has not been compiled into a readily available format. The research team then contacted various experts in the field, including academics and US Environmental Protection Agency (EPA) and Federal Highway Administration (FHWA) staff. However, a widely agreed upon method to estimate ethanol or biodiesel impacts has not emerged to date. Next, the team attempted to use the latest version of the EPA's Motor Vehicle Emission Simulation (MOVES2014). An attempt was made to use Iowa-specific county-level information to obtain emission factors for the different ethanol and biodiesel blends. However, after an exhaustive survey of the literature and discussions with experts in the field, it was determined that MOVES2014 is not capable of producing emission rates for a variety of ethanol or biodiesel blends due to the lack of sufficient emission data used to develop the model.

The next step was to return to the literature and determine estimates that reflected Iowa conditions as much as possible. A significant number of studies are available that have evaluated the fuel economy or emission impacts of various biofuel blends. However, many were conducted on non-road vehicles or focused on different types of fuel stocks (rapeseed, palm, etc.) that are not relevant to Iowa. Moreover, conducting an exhaustive literature review and attempting to reconcile several hundred studies was beyond the scope of the project. As a result, and to make comparisons between different biofuel blends, the team identified several studies that were conducted using standard biofuel blends, were regularly cited, and/or had a standard testing and reporting methodology.

4.1 Summary of Air Quality and Fuel Consumption Impacts

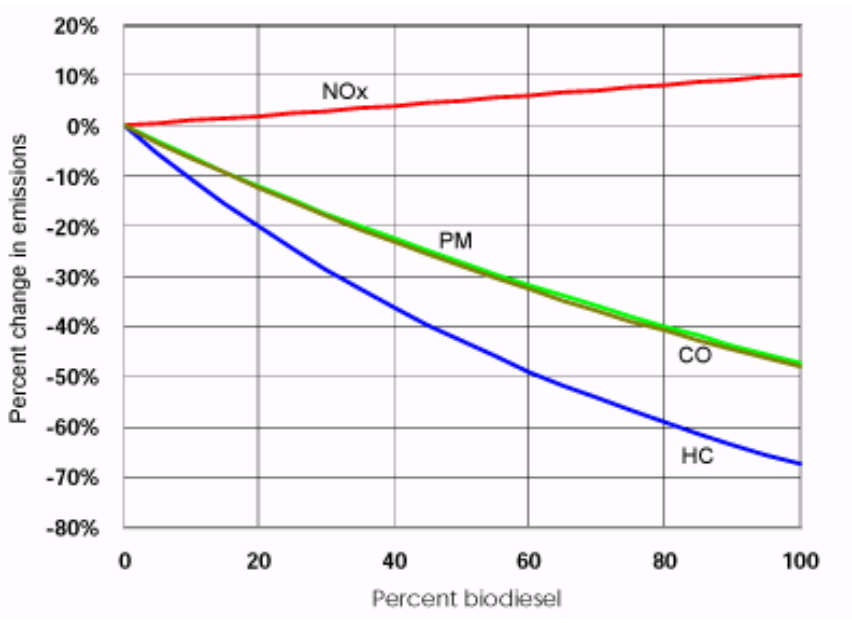
The advantages of biodiesel are that it is non-toxic, is cleaner burning, contains no sulfur, has lower levels of toxic and reactive hydrocarbon species, has lower levels of polycyclic aromatic hydrocarbon (PAH) and nitro PAH emissions, and has no aromatics (Murugesan et al. 2009a, Prabhu et al. 2013). The emission impacts of biofuels depend on many factors, including the type of raw materials used in their production, ambient temperature, vehicle characteristics, and engine load. The use of biodiesel results in longer combustion duration and shorter ignition delay, which results in low PM emissions and minimum carbon deposits (Murugesan et al. 2009a). Biodiesel contains about 11% oxygen by weight, which improves fuel combustion and, as a result, reduces soot (Schmidt 2007).

4.1.1 Information Sources

As noted in the introduction to this chapter, the team compiled a set of articles and reports that described emission studies for different blends of biodiesel or ethanol. These studies were selected because they were regularly cited and/or had a standard testing and reporting methodology. A description of the studies is provided below. The studies' results in terms of individual emissions are provided in subsequent sections in this chapter.

Oak Ridge National Laboratory (Knoll et al. 2009) conducted a test to evaluate ethanol blends for 16 vehicles. The study included late-model vehicles and used a drive cycle that reflected real-world conditions. The study was the most comprehensive study found by the team and included statistical significance and a robust test methodology. A study by Hsieh et al. (2002) evaluated ethanol blends. The study only included one vehicle but used standard ethanol and evaluated emissions at various blended rates (0%, 10%, 20%, 30%). Neither of the previous two studies included E-85. In a study by Yanowitz and McCormick (2009), the authors summarized available literature that used a standard testing methodology and that tested fuel-grade ethanol in most cases. In addition, the authors summarized emissions using the EPA certification database. Maricq et al. (2012) also conducted an evaluation of the PM emissions from various ethanol blends. The authors used two engine calibrations to estimate emissions and used a single vehicle with commercial-grade E-0 and ethanol.

Figure 4-1 provides a summary of the impact of different biodiesel blends on criteria pollutants according to a study conducted by the EPA (2002).



US EPA 2002

Figure 4-1. Average emission impacts of biodiesel blends

In the EPA (2002) study, the researchers conducted a comprehensive analysis of the emission impacts of biodiesel using publicly available data and used statistical regression analysis to correlate biodiesel blends. Sadeghinezhad et al. (2014) summarized 73 different studies to assess the emission impacts of biodiesel. The paper simply lists the studies that found an increase, decrease, or no change in emission levels and is used in this chapter to provide a point of comparison for the findings of other studies.

Several other studies were found that are specific to particular pollutants. These studies are cited in the corresponding sections below.

4.1.1 Fuel Consumption

The US Department of Energy (DOE) estimates that ethanol contains approximately one-third less energy than E-0, so a typical vehicle will experience a reduction in fuel economy of up to 4% with E-10 and 5% with E-15. A blend of E-85 is estimated to reduce fuel economy by 15% to 27% (US DOE n.d.).

Fuel consumption is initially low for biodiesel, but as the vehicle's speed increases, fuel consumption increases (Demirbas 2009). The DOE (n.d.) also indicates that blends with less than 20% biodiesel are expected to perform similarly to regular diesel, with B-20 having approximately 1% to 2% lower fuel economy. Sadeghinezhad et al. (2014) reported that most of the studies they summarized reported an improvement in fuel consumption for biodiesel (87%), while almost 10% found a decrease.

4.1.2 Carbon Monoxide

Carbon monoxide emissions are generally expected to be lower for both biodiesel and ethanol. The specific emission levels are based on a number of factors, such as fuel blend and engine load. Ethanol contains oxygen, which causes combustion to be more complete, resulting in a reduction in CO and aromatic HC emissions (Agarwal 2007).

The following CO emission reductions have been reported for ethanol blends compared to E-0:

- E-5: 15% to 25% lower (Hsieh et al. 2002)
- E-10: 25% to 65% lower (Hsieh et al. 2002); 15.0% lower (Knoll et al. 2009)
- E-15: 5.1% lower (Knoll et al. 2009)
- E-20: 50% to 85% lower (Hsieh et al. 2002); 12.3% lower (Knoll et al. 2009)
- E-30: 65% to 95% lower (Hsieh et al. 2002)
- E-85: 20% lower (Yanowitz and McCormick 2009); 34% lower (Dardiotis et al. 2015)

The following CO emission changes have been reported for biodiesel compared to regular diesel:

- B-20: 10% to 11% lower (Schmidt 2007, US EPA 2002, Williams et al. 2006, Moser 2009); 20% to 55% less (Demirbas 2009, Moser 2009, Agarwal 2007)
- B-25: 63% higher to 40% lower, depending on engine load (Murugesan et al. 2009b)
- B-100: 36% to 50% lower (Moser 2009, Agarwal 2007, Williams et al. 2006, US EPA 2002)
- B-100: 25% higher to 40% lower, depending on engine load (Murugesan et al. 2009b)

Sadeghinezhad et al. (2014) reported that 57 of the studies they summarized (84%) found a decrease in CO emissions with biodiesel blends, while 7 studies (11%) found an increase.

4.1.3 Particulate Matter

Overall, biofuels have generally been credited with a decrease in PM. Little research is available about the actual impacts of ethanol, but studies by Maricq et al. (2012) and Yanowitz and McCormick (2009) found the following:

- E-10: Little change (Maricq et al. 2012)
- E-20: 20% to 30% lower (Maricq et al. 2012)
- E-30: 30% to 45% lower (Maricq et al. 2012)
- E-85: 34% lower (Yanowitz and McCormick 2009)

Various studies on the impacts of biodiesel compared to regular diesel in terms of particulate matter emissions found the following:

- B-20: 10% to 51% lower (Schmidt 2007, US EPA 2002, Williams et al. 2006, Agarwal 2007, Fortenbery 2005, Demirbas 2009, Moser 2009)
- B-100: 30% to 48% lower (Moser 2009, Agarwal 2007, US EPA 2002)

Sadeghinezhad et al. (2014) reported that 64 of the studies they summarized (88%) found a decrease in PM emissions with biodiesel blends, while 7 studies (10%) found an increase.

4.1.4 Hydrocarbon

Hydrocarbon emissions are generally lower for ethanol and biodiesel.

The following changes in HC emissions due to different ethanol blends have been reported (with Knoll et al. 2009 reporting results for non-methane hydrocarbons [NMHC]):

- E-5: 15% to 20% lower (Hsieh et al. 2002)
- E-10: 25% to 39% lower (Hsieh et al. 2002); 12.0% lower (Knoll et al. 2009)
- E-15: 11.5% lower (Knoll et al. 2009)
- E-20: 45% to 70% lower (Hsieh et al. 2002); 15.1% lower (Knoll et al. 2009)
- E-30: 60% to 85% lower (Hsieh et al. 2002)

- E-85: 10% lower (Yanowitz and McCormick 2009); 17% lower (Dardiotis et al. 2015)

The following reductions have been quantified for biodiesel compared to regular diesel:

- B-20: 30% lower (Agarwal 2007); 20% lower (US EPA 2002)
- B-100: 77% decrease (Moser 2009); 93% decrease (Agarwal 2007); 67% decrease (US EPA 2002)

Sadeghinezhad et al. (2014) reported that 51 of the studies (90%) they summarized found a decrease in HC emissions with biodiesel blends, while 3 studies (5%) found an increase in nitrogen oxides.

4.1.5 Nitrogen Oxides

The following changes in NO_x emissions due to different ethanol blends have been reported:

- E-5: 20% lower to 20% higher (Hsieh et al. 2002)
- E-10: 25% lower to 12% higher (Hsieh et al. 2002); 5.5% lower (Knoll et al. 2009)
- E-15: 0.6% lower (Knoll et al. 2009)
- E-20: 50% lower to 0% (Hsieh et al. 2002); 12.2% higher (Knoll et al. 2009)
- E-30: 20% to 520% lower (Hsieh et al. 2002)
- E-85: 18% lower (Yanowitz and McCormick 2009); 43% lower (Dardiotis et al. 2015)

Though biodiesel reduces many toxic emissions, results for NO_x are mixed. Several studies have shown a slight increase in NO_x emissions for all biodiesel blends (Fortenbery 2005, Demirbas 2009). Blends with low percentages of biodiesel (B-2 to B-5) show a negligible increase in NO_x emissions (Fortenbery 2005). As the concentration of biodiesel in the fuel increases, so do the NO_x emissions, according to Chauhan et al. (2009). The National Renewable Energy Lab (NREL) noted that the studies correlating NO_x to biodiesel emissions have been inconsistent (Johnson 2017).

The following changes in NO_x emissions for biodiesel compared to regular biodiesel have been reported:

- B-20: 2% to 4% lower (Fortenbery 2005, Schmidt 2007, Chauhan et al. 2009, Agarwal 2007); 20% lower (Demirbas 2009)
- B-100: 12% increase (Moser 2009); 13% higher (Agarwal 2007)

Sadeghinezhad et al. (2014) reported that 20 of the studies (29%) they summarized found a decrease in NO_x emissions with biodiesel blends, while 45 studies (65%) found an increase.

4.1.6 Carbon Dioxide and Greenhouse Gases

Although both ethanol and biodiesel emit higher quantities of CO_2, it is generally thought that emissions are offset by the amount of these fuels created from renewable carbon stocks (Agarwal 2007, Chauhan et al. 2009). Little guidance is available regarding the emission differences between ethanol blends and E-0. A study by Dardiotis et al. (2015) found a 6% decrease in CO_2 for ethanol.

For biodiesel, one study using B-20 showed a reduction in CO_2 emissions of 79% when that fuel was compared to petroleum diesel (Fortenbery 2005, Demirbas 2009, Moser 2009). A study sponsored by the US Department of Energy and the US Department of Agriculture in 1998 determined that biodiesel helps minimize global warming because it can reduce CO_2 emissions by 78% (Agarwal 2007, Chauhan et al. 2009).

Of the 73 different studies summarized by Sadeghinezhad et al. (2014) that assess the emission impacts of biodiesel, 13 evaluated CO_2. Sadeghinezhad et al. (2014) reported that 5 of those 13 studies (39%) found a decrease in CO_2 emissions with biodiesel blends, while 6 studies (46%) found an increase and 2 studies found no impact.

4.2 Estimate of Emission Impact of Various Scenarios in Iowa

The impact of different scenarios for the adoption of ethanol were evaluated.

4.2.1 Emission Estimates

As noted above, standard emission rates could not be calculated using the EPA's MOVES2014 model. Consequently, results from several studies that met several criteria, as described in Section 4.1, were used to estimate emissions. Results were combined and interpolated when necessary so that impacts were consistent. Table 4-1 provides the estimates used for ethanol blends.

Table 4-1. Change in emissions due to various ethanol blends

Blend	NO_x	PM	CO	HC
E-10	-5.5%	0.0%	-15.0%	-12.0%
E-15	-6.3%*	-12.5%	-15.1%	-11.5%
E-20	-7.1%*	-25.0%	-15.5%	-15.1%*
E-85	-18.0%	-34.0%	-20.0%	-43.0%

* estimate was interpolated

Unless otherwise specified, values were chosen from selected studies and compared against the findings of other studies. In a few cases, as noted, values were missing for some cells and were interpolated.

Estimates for biodiesel blends were extracted from Figure 4-1, which is based on the results of a comprehensive analysis of the emission impacts of biodiesel using publicly available data (US EPA 2002). The extracted estimates are shown in Table 4-2.

Table 4-2. Emission reductions due to various biodiesel blends

Blend	NO_x	PM	CO	HC
B-20	2.0%	-12.0%	-12.0%	-20.0%
B-40	5.0%	-22.0%	-22.0%	-36.0%
B-60	8.0%	-31.0%	-31.0%	-49.0%
B-80	9.0%	-40.0%	-40.0%	-58.0%
B-100	10.0%	-48.0%	-48.0%	-76.0%

4.2.2 Estimate for Reduction Due to Ethanol Sales

The impact of ethanol blends on emissions in Iowa were estimated by comparing a baseline estimate to several scenarios involving different levels of market penetration for the fuels. The scenarios included the following:

- **Base Case Scenario**: This scenario assumes that all fuel sales/purchases are for E-0.
- **Statewide Fuel Scenario**: This scenario uses the current statewide fuel sales data described in Section 1.4. The market penetration of the different fuel types reflects a 2016 calendar year snapshot of fuel sales in the state of Iowa.
- **Survey Scenario**: This scenario assumes that a sufficient number of stations sell alternative ethanol blends and that consumers in the state of Iowa will behave similarly to those surveyed.
- **Adjusted Survey Scenario**: This scenario also assumes that a sufficient number of stations sell alternative ethanol blends and that consumers in the state of Iowa will behave similarly to those surveyed. However, the percentages of E-0 and E-10 have been adjusted to more closely match statewide sales data. As noted in Table 4-3, about 13.8% of gallons of purchases statewide were E-0 and 84.8% were E-10.

Table 4-3. Ethanol use

Blend	Fuel Sales	Survey	Adjusted Survey
E-0	13.8%	20.3%	13.8%
E-10	84.8%	58.9%	65.5%
E-15	0.4%	5.9%	5.9%
E-20	0.2%	7.6%	7.6%
E-85	0.8%	7.2%	7.2%

In the survey conducted at 16 stations in Phase II of this research, about 20.3% of respondents indicated that they had purchased E-0 and 58.9% reported that they had purchased E-10. As described in Section 1.4, the statewide percentages reflect total fuel sales while the survey percentages reflect only the information obtained from the surveys, which represent only a small sample of consumers. For various reasons, consumers who purchase E-10 may purchase larger quantities of fuel. For instance, many respondents indicated that they were fueling a company vehicle, and business travelers may travel more frequently and/or for more miles than the regular population. Also, as previously noted, some drivers may not be aware that they are purchasing E-10 because the same nozzle is typically used for both E-0 and E-10.

There is no reason to expect that the customers surveyed would be more likely to purchase E-0 than the general population. As a result, the Adjusted Survey Scenario assumes that the likelihood that customers purchase E-0 is equal to the statewide average. The difference between the initial survey value and statewide value for E-0 was added to the E-10 category. As a result, it is assumed that 13.8% of survey respondents purchased E-0 and 65.5% (58.9% plus the difference of 20.3% minus 13.8%) purchased E-10. The values for E-0 and E-10 in this scenario were thus adjusted to represent the assumption that purchases of E-10 would reflect the statewide average. The percentages for the higher blends of ethanol (greater than E-10) were based on the original survey values.

The difference in emissions between E-0 and the different ethanol blends was calculated by estimating the amount of reduction for each ethanol blend category weighted by the percentage of use. This analysis is a bit simplistic because emissions depend on a variety of factors such as vehicle type, driving style, ambient temperature, and vehicle load. The analysis assumes that emissions are correlated to the amount of fuel used. In addition, it assumes that survey respondents were equally likely to purchase the same amount of fuel. Although simplistic, this method was the most reasonable for comparison given the challenges in obtaining emission rates and the absence of more robust methods of evaluation.

Results for all pollutants and scenarios are shown in Table 4-4.

Table 4-4. Difference in ethanol emissions

Emission	Base	Statewide	Survey	Difference	Adjusted Survey	Difference
NO_x	—	-4.8%	-5.4%	-0.6 (-12.5%)	-5.8%	-1.0 (-19.9%)
PM	—	-0.4%	-5.1%	-4.7% (-1227.8%)	-5.1%	-4.7% (-1227.8%)
CO	—	-13.0%	-12.3%	0.6 (4.8%)	-13.3	-0.4 (-2.9)
HC	—	-10.6%	-12.0%	-1.4 (-12.9%)	-12.8	-2.2 (-20.3%)

As shown in Table 4-4, the Statewide Fuel Scenario for NO_x would result in 4.8% lower emissions overall than the Base Case Scenario, where all fuel is E-0. The Survey Scenario would result in 5.4% lower NO_x emissions, and the Adjusted Survey Scenario would result in 5.8% lower emissions. As a result, the difference between the Statewide Fuel Scenario and Survey

Scenario is -0.6%. For comparison, the Survey Scenario would result in 12.5% lower NO_x emissions than the Statewide Scenario.

As Table 4-4 shows, PM emissions are significantly lower for both the Survey Scenario and the Adjusted Survey Scenario than the Statewide Scenario. The reduction is from -0.4% to -5.1%, which is a decrease of over 1227%. Carbon monoxide emissions are slightly (4.8%) higher for the Survey Scenario than the Statewide Scenario. The Adjusted Survey Scenario would result in 2.9% lower CO emissions than the Statewide Scenario. Finally, hydrocarbon emissions are 12.9% lower for the Survey Scenario than for the Statewide Scenario, and the Adjusted Survey Scenario would result in 20.3% lower emissions than the Statewide Scenario.

4.2.3 Estimate for Reduction Due to Biodiesel Sales

An attempt was made to model emission reductions according to likely scenarios involving biodiesel purchases. However, only two stations offered biodiesel options. The Mt. Ayr Farmers' Cooperative station only offered biofuels, and the Number 2 diesel sold there was unlabeled B-5. NC Fast Stop also offered biodiesel, but only one blend was sold. As a result, it was not possible to develop a likely scenario to estimate how Fueling Our Future and other programs would likely affect the impacts of biodiesel.

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APPENDIX A. SURVEY

The survey given to participants is provided below.

Iowa Driver Survey of Fuel Use

September 2016

1. What type of fuel are you buying today?

01 = Unleaded Gasoline
02 = E-10
03 = E-15
04 = E-20
05 = E-30
06 = E-85
10 = Number 2 Diesel
11 = Off-road diesel (Red Dyed) → **3. [IF Off-Road, ASK:] Is this fuel being used for farming, construction, a personal vehicle, or for something else?**
12 = Other fuel: _____

1 = Farming
2 = Construction
3 = Personal vehicle
4 = Other: _____

→ **2. What is your main reason for not purchasing a (higher) ethanol blend?**

1 = Not compatible with this vehicle, potential engine damage
2 = Fuel mileage – (higher) ethanol blends don't perform as well
3 = Warranty coverage issues
4 = Don't know
5 = Other reason: _____

4. What is your <u>main</u> reason for buying this type of fuel? *[Probe for one main reason; read options if helpful.]*

1 = Cost
2 = Environmental benefits
3 = Supports agriculture
4 = Higher octane fuel
5 = Compatible with vehicle, Works best in this vehicle
6 = Habitual, Always buy it, No reason
7 = Reduce dependence on foreign oil
8 = Required by employer (company car)
9 = Other: _____

*[ASK Q5 & Q6 ONLY AT **E-85 STATIONS**.]*

[IF BOUGHT UNLEADED, E10 OR E15, ASK:]

5. E-85 is $_____.

If the fuel you bought today was:		**Yes**	**No**	**DK**
a. (+.25) $	**…would you consider buying E-85 instead?**	1	2	3
b. (+.50) $		1	2	3
c. (+.75) $		1	2	3

[IF BOUGHT E-85, ASK:]

6. E-85 is $_____.

Would you still buy E-85 if it cost:	**Yes**	**No**	**DK**
a. (+.25) $?	1	2	3
b. (+.50) $?	1	2	3
c. (+.75) $?	1	2	3

7. Are you aware of the different fuel blends and options available at this station?
[Can probe whether they noticed the yellow/blue pumps.]

1 = Yes
2 = No
3 = Not sure

8. If you were buying a car, how likely would you be to purchase a vehicle designed to more efficiently use higher blends of ethanol? Would you say . . .

1 = Very likely,
2 = Somewhat likely,
3 = Not sure,
4 = Somewhat unlikely or
5 = Very unlikely?
6 = REFUSE, NO OPINION

9. Why do you buy gas at this particular station? *[Circle all that apply]*

1 = Cost
2 = More/Good fuel options
3 = Convenient location
4 = Good customer service
5 = Has E-85
6 = Other: _____

10. What is the year, make, and model of this vehicle? Is it a Flex-Fuel vehicle?

[Circle vehicle type]	**Year**	**Make**	**Model**	**Is it Flex-Fuel?**
1 = Passenger car 2 = Motorcycle 3 = Van, SUV, Pickup 4 = Large truck 5 = Ag vehicle/equipment 6 = Other _____				1 = Yes 2 = No 3 = Unsure

11. Finally, I have a couple of background questions about you.

[Record Gender]	**What is your age category?**	**Is your household's yearly income . . .**
1 = Male 2 = Female	1 = 18 or 19 2 = 20 – 29 3 = 30 – 39 4 = 40 – 49 5 = 50 – 59 6 = 60 – 69 7 = 70 and above	1 = Under $30,000 2 = From $30,000 to $70,000 or 3 = Over $70,000? 4 = Don't Know, prefer not to answer

That's all the information we need. Iowa State University and the Iowa Department of Transportation thank you for your time today.

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