COMPARISON OF THE SELF-RESPONSE AND TELEPHONE INQUIRY METHODS OF OPINION RESEARCH IN ASSESSING OVERALL PERFORMANCE AND CONSUMER PREFERENCE FOR ALTERNATIVE FUEL VEHICLES IN THE U.S. FEDERAL FLEET

Timothy C. Coburn, Margaret V. Whalen, National Renewable Energy Laboratory
Timothy C. Coburn, NREL, 1617 Cole Blvd., Golden, CO 80401

Key Words: Consumer Preference, Survey Re-design, Modality Change, Alternative Fuel Vehicles

INTRODUCTION

To reduce national dependence on imported oil and to improve urban air quality, the U.S. Department of Energy (DOE) is heavily promoting development and deployment of alternative fuels and alternative fuel vehicles (AFVs). On behalf of DOE, the National Renewable Energy Laboratory (NREL) has undertaken an extensive evaluation of light-duty AFVs (sedans, delivery vans, etc.), which includes the surveying of drivers to determine vehicle performance, consumer preference, and overall vehicle acceptability. As part of the survey protocol, respondents are asked to report certain vehicle operating data and/or contrast their perceptions about AFVs with those of otherwise similar gasoline models (controls). The target population is restricted to drivers of vehicles contained in the U.S. Federal fleet.

Over time, two different operating modes have been employed in this assessment: a self-response, mail-in postcard survey conducted over a period of four years; and a telephone questionnaire survey conducted over a period of one year. The postcard technique was employed first, and data was collected and analyzed. After some concerns were raised about data quality and cost, the survey approach was changed to one of conventional telephone inquiry conducted once each quarter, and the overall methodology was re-designed. Objectives, methodological issues, operational efficiency, and overall effectiveness of the two different approaches are compared in this paper. Information concerning frame and sample composition is also discussed.

SURVEY OBJECTIVES

The primary objective of the original mail-in postcard (self-response) survey was to evaluate AFV performance and reliability, and to compare them with the performance and reliability of otherwise identical gasoline vehicles, through the use of voluntary driver reports. Survey respondents were asked to supply information concerning the types and amounts of fuel used by the vehicles they drove, record the odometer readings associated with each refueling event, and note any vehicle drivability problems. Through this process of continuous measurement, profiles of in-use fuel economy and vehicle reliability were compiled.

While the objectives for the telephone survey were related to those of the self-response survey, they were still somewhat different, and they were intended to yield considerably more detail. Whereas the self-response survey was principally focused on estimation of fuel economy, problem occurrences, and related vehicle operating characteristics, the telephone survey placed greater emphasis on the attitudes, preferences, and behaviors of the vehicle drivers. Included in this second survey were questions aimed at determining the types of fuel used and drivers' refueling characteristics, estimating the types and frequency of vehicle problems, evaluating overall vehicle drivability, assessing driver preference for various vehicle types, and determining specific driver attitudes toward the use of alternative transportation fuels (convenience, accessibility, safety, etc.). The telephone survey was also aimed at determining certain trip characteristics, such as frequency, distance driven, and whether city or highway driving was primarily involved.

SURVEY COVERAGE

The two surveys were both implemented to obtain consumer information and operating characteristics pertaining to AFVs, as well as comparative information about similar gasoline vehicles (controls), in service in the U.S. Federal fleet. The scope of these surveys was limited to light-duty vehicles comprising a variety of sedans, pickups, minivans, and delivery/passenger vans. The self-response survey encompassed vehicles from model years 1991-1995, while the telephone survey involved vehicles from model years 1988-1996. A number of makes and models were included, all of the "Big 3" U.S. automakers (Ford, Chrysler, and General Motors) being represented. Vehicles were stationed at many locations around the country, and operated by various Federal agencies.

SAMPLING METHODOLOGY

The self-response, mail-in postcard survey employed a stratified sample selection methodology, using vehicle model year as the stratification factor. Vehicles were chosen from those available in the Federal fleet, with sample size designed to balance cost against the need to assess the range of available AFV technology.

Prior to initiating the survey, it was known that the U.S. General Services Administration (GSA), with encouragement and funding from DOE, planned to acquire many AFVs over a multi-year period and to place them in fleets at various locations around the country. Given the available funding and knowledge of

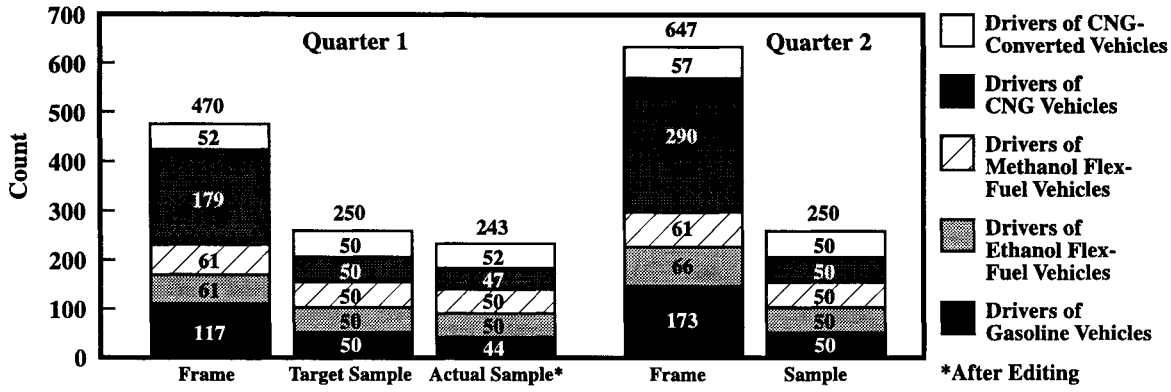


Figure 1. Frame and sample sizes for the first two quarters of the telephone survey

GSA's plans, the total target sample size (both AFVs and controls) was set at 1,000 vehicles, those units to be incrementally selected in subgroups as new makes and models were manufactured in successive model years. The sample allocation for AFVs was set at 50, 250, 350, 50, and 50 of GSA's 1991 through 1995 model year acquisitions, respectively, as well as another 225 gasoline controls from the same model years. These counts were weighted toward the earlier model years to facilitate longer vehicle tracking (GSA typically disposes of passenger vehicles after three years of service); except that the allocation for model year 1991 was restricted because of limited production and the relative newness of AFV technology.

By the time the survey was inaugurated in 1992, GSA had only purchased a modest number (66) of 1991 model year AFVs and placed them in fleets at four locations around the country (sites where alternative fuel was deemed to be continuously available). Consequently, all these vehicles, plus 16 gasoline controls, were included in the survey. As anticipated, GSA purchased much greater numbers of AFVs in successive years as new makes and models were produced, assigning them to more locations than the original four.

In the years beyond 1992, vehicles were selected at random for inclusion in the survey from the total number available, without particular regard to geographic location, agency assignment, or service role. Although stratification on the basis of these factors was not part of the formal sampling plan (because not all factors were completely crossed), some balancing of the sample pool was subsequently applied to accommodate the unwillingness of certain host fleets to participate in the survey, and to better account for weather and altitude effects across the country. Finally, the lowest mileage vehicles were chosen whenever possible in order to facilitate the tracking of performance and deterioration over time.

The telephone survey also employed a stratified sampling methodology, but the stratification factor was different. After considering survey costs and other resources, an overall target sample size of 250 drivers of each of five different vehicle types (gasoline; compressed natural gas, original equipment; compressed natural gas, converted; ethanol flex-fuel, and methanol flex-fuel) was established. Fifty drivers of each vehicle type were targeted to be surveyed in each of four successive calendar quarters. No attempt was made to additionally stratify the sample in advance according to make, model, manufacturer, or service location because the relatively small size of the quarterly sample would not support more extensive categorization.

Within the five strata (vehicle types), a process of selective sampling from the driver frame available each quarter was employed (see the discussion on frame development below). This technique approximates simple random sampling (SRS) within each stratum. To accommodate anticipated non-response, drivers were sampled and immediately surveyed one at a time, this process continuing until the target sample size was reached, or until the frame was depleted. A goal of sampling without replacement--in the sense that no

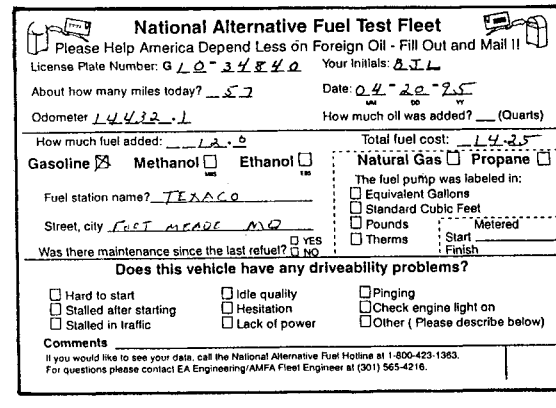

National Alternative Fuel Test Fleet
Please Help America Depend Less on Foreign Oil - Fill Out and Mail It
License Plate Number: G 10-34840 Your Initials: BJL
About how many miles today? 57 Date: 04-20-95
Odometer 14422.1 How much oil was added? (Quarts)
How much fuel added: 12.0 Total fuel cost: 14.25
Gasoline ☒ Methanol ☐ Ethanol ☐ Natural Gas ☐ Propane ☐
The fuel pump was labeled in:
☐ Equivalent Gallons
☐ Standard Cubic Feet
☐ Pounds ☐ Therms
Metered Start Finish
Fuel station name? TEXACO
Street, city FORT MEADE MD
Was there maintenance since the last refuel? ☐ YES ☐ NO
Does this vehicle have any driveability problems?
☐ Hard to start ☐ Stalled after starting ☐ Stalled in traffic
☐ Idle quality ☐ Hesitation ☐ Lack of power
☐ Pinging ☐ Check engine light on ☐ Other (Please describe below)
Comments
If you would like to see your data, call the National Alternative Fuel Hotline at 1-800-423-1363.
For questions please contact EA Engineering/AMFA Fleet Engineer at (301) 565-4216.

Figure 2.--Example of mail-in postcard response form

single driver would be surveyed more than once over four quarters--was established. Since the frame and strata sizes were expected to change each quarter, each driver's probability of selection depended on the quarter in which that individual's name appeared in the frame.

FRAME DEVELOPMENT

Because of its emphasis on vehicle operating characteristics, development of a frame for the self-response survey was centered around the available vehicle population. All light-duty vehicles in the U.S. Federal fleet are uniquely identified, with the total number being known by GSA according to type, make, model, and geographic service location. Therefore, to establish the sampling frame, GSA was asked to identify the geographic locations and agencies to which AFVs had been assigned, and to prepare a list of all AFVs located at those sites. Similar lists of otherwise identical gasoline vehicles were also prepared.

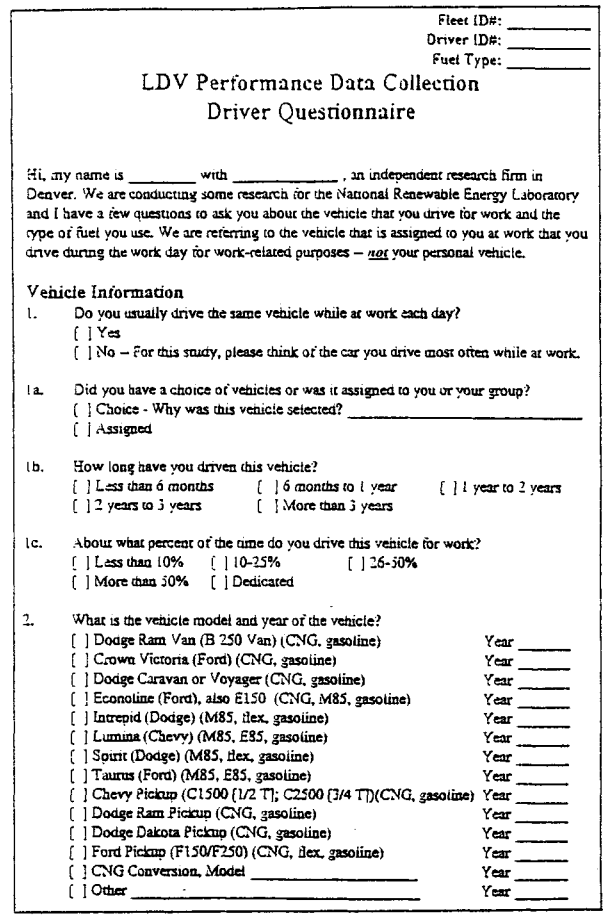
The resulting frame was a simple compilation of these vehicle lists. However, owing to the sequential nature of GSA's purchases of AFVs across model years, new lists were prepared each year, and the resulting frame was different for each of the survey years. Vehicles were randomly selected from the frame prepared each year according to the sampling methodology and pre-determined sample sizes noted above.

In comparison, frame development for the telephone survey was centered on vehicle drivers. Unfortunately, no comprehensive list of drivers was available, the population of drivers of Federal fleet AFVs was unknown, and not all the AFV drivers already known to NREL were easy to locate. Consequently, the decision was made to employ a sequential process for frame construction, relying on fleet managers--a smaller population of individuals--for driver identification. Even this approach was not problem-free, because tabulating fleet managers for Federal agencies turned out to be a difficult and time-consuming process. In addition, an early check of selected fleet managers revealed that it would still be difficult to obtain a sufficient number of AFV driver names to satisfy the needs of the survey.

The following procedure was ultimately adopted. An inaugural list of fleet managers was developed by NREL personnel using information gained in a pre-test of a concomitant survey of fleet managers. These fleet managers were contacted and asked to provide the names of drivers in their fleets--particularly, the names of drivers of AFVs--and or the names of other fleet managers or drivers of AFVs. This collection of names served as the initial survey frame. As the actual fleet manager survey progressed, its respondents were asked to supply the names of drivers who could be included, or the names of other fleet managers who could be contacted.

In this manner, the size of the frame evolved as the survey progressed. Information gained during the survey in Q_i was used to develop the frame for the survey in Q_{i+1}, where Q is the survey quarter in question. The resulting frame was a list of drivers.

Although the frame was continuously being expanded, a cut-off date was imposed each quarter beyond which no new names could be added; the only



Fleet ID#: _____
Driver ID#: _____
Fuel Type: _____

LDV Performance Data Collection
Driver Questionnaire

Hi, my name is _____ with _____, an independent research firm in Denver. We are conducting some research for the National Renewable Energy Laboratory and I have a few questions to ask you about the vehicle that you drive for work and the type of fuel you use. We are referring to the vehicle that is assigned to you at work that you drive during the work day for work-related purposes – *not* your personal vehicle.

Vehicle Information

1. Do you usually drive the same vehicle while at work each day?
[ ] Yes
[ ] No – For this study, please think of the car you drive most often while at work.

1a. Did you have a choice of vehicles or was it assigned to you or your group?
[ ] Choice - Why was this vehicle selected? _____
[ ] Assigned

1b. How long have you driven this vehicle?
[ ] Less than 6 months [ ] 6 months to 1 year [ ] 1 year to 2 years
[ ] 2 years to 3 years [ ] More than 3 years

1c. About what percent of the time do you drive this vehicle for work?
[ ] Less than 10% [ ] 10-25% [ ] 26-50%
[ ] More than 50% [ ] Dedicated

2. What is the vehicle model and year of the vehicle?

[ ] Dodge Ram Van (B 250 Van) (CNG, gasoline)	Year _____
[ ] Crown Victoria (Ford) (CNG, gasoline)	Year _____
[ ] Dodge Caravan or Voyager (CNG, gasoline)	Year _____
[ ] Econoline (Ford), also E150 (CNG, M85, gasoline)	Year _____
[ ] Intrepid (Dodge) (M85, flex, gasoline)	Year _____
[ ] Lumina (Chevy) (M85, E85, gasoline)	Year _____
[ ] Spirit (Dodge) (M85, flex, gasoline)	Year _____
[ ] Taurus (Ford) (M85, E85, gasoline)	Year _____
[ ] Chevy Pickup (C1500 [1/2 T]; C2500 [3/4 T])(CNG, gasoline)	Year _____
[ ] Dodge Ram Pickup (CNG, gasoline)	Year _____
[ ] Dodge Dakota Pickup (CNG, gasoline)	Year _____
[ ] Ford Pickup (F150/F250) (CNG, flex, gasoline)	Year _____
[ ] CNG Conversion, Model _____	Year _____
[ ] Other _____	Year _____

Figure 3.--Page 1 of the telephone survey questionnaire

caveat being that enough drivers representing each type of vehicle had been identified to accommodate the target strata sample sizes. This restriction facilitated the preparation of a single list each quarter so that formal sample selection could proceed in an orderly fashion. Figure 1 compares frame and eventual sample sizes for the first two rounds (quarters) of the telephone survey.

There were some additional frame-construction difficulties associated with the telephone survey. First, it was difficult to find enough drivers of gasoline controls whose vehicles exactly matched the make/model/model-year combinations of the AFVs driven by individuals contained in the survey frame. Second, it was not always possible to identify the type of vehicle operated by a driver in advance of sample selection, resulting in some post-stratification, editing, and data elimination. In fact, drivers were not always sure of the type of vehicle they operated. Third, the sequential process of frame construction resulted in some inadvertent geographic clumping, which may have adversely affected the representativeness of the sample. Finally, it was difficult to locate enough drivers of alcohol flex-fuel vehicles that were being operated on

Table 1. Numbers of vehicles and driver responses for the two surveys

	Mail-In Postcard		Telephone Survey**	
Vehicle Types	Number of Vehicles	Number of Driver Responses*	Number of Vehicles	Number of Driver Responses
Compressed Natural Gas (Dedicated)	330	18,776	97	97
Compressed Natural Gas (Aftermarket Conversions)	0	0	102	102
Ethanol (Flex Fuel)	71	2,274	100	100
Methanol (Flex-Fuel)	419	12,612	100	100
Conventional Gasoline	333	6,212	94	94
Total	**1,153**	**39,874**	**493**	**493**

*As tabulated from all re-fueling records; individual drivers not identified

**Results from first two survey quarters; total vehicles/responses planned to be 1,000

the designated alternative fuel a majority of the time, which presented a definitional difficulty in the frame construction process.

SURVEY OPERATIONS

For the self-response survey, all operations and data tabulation were initially conducted by NREL, and subsequently, by subcontractors. Every vehicle selected through the sampling process was furnished with a supply of single-sided, postage-paid postcards pre-printed for mailing to a central location. These postcards (of which an example is shown in Figure 2) were very simply formatted to accommodate fill-in-the-blank or check-off responses.

All drivers of each vehicle selected were instructed to complete and mail a postcard after each refueling stop. Upon receipt at the central location, responses were entered into a database management system, quality checked (e.g., successive odometer readings must be increasing), compiled, and tabulated.

The survey operation provided continuous data collection on each vehicle for its service life, or the length of the program, whichever came first. In this sense it was longitudinal, although the time intervals between measurements were not fixed (since reporting was tied to refueling events).

For the telephone survey, all sampling and survey operations were conducted by a subcontractor. Upon development, the survey instrument (questionnaire; Figure 3) and the interviewing protocol were pre-tested on a small sample of AFV drivers. Upon selection, all drivers were telephoned to determine their willingness to participate in the survey, and upon their concurrence, as noted above, they were immediately queried. The names of drivers who declined to participate were removed from the frame to alleviate further contact.

A single interviewer questioned all participants, the same instrument being used with each participant. All responses were recorded on individual survey forms, and tabulated for subsequent analysis.

Like the self-response survey, the telephone survey was longitudinal, but in the sense that it was repeated in each of four successive calendar quarters. Drivers' responses were not longitudinal, however, since the goal, if possible, was to avoid surveying each driver more than once.

SAMPLE COMPOSITION AND RESPONSE CHARACTERISTICS

Over the four-year period in which the self-response mail-in survey was conducted, information was obtained on 1,153 vehicles, of which 820 were AFVs, encompassing 39,874 driver responses (refueling records). The total number of responses represents a variable number of drivers per vehicle.

Vehicles included in the survey were located in 141 communities around the country, encompassing 18 different states. Fleet identification was not recorded, so the number of fleets represented is unknown. Figure 4 is a continental U.S. map indicating the states in which vehicles covered by the self-response survey were located.

The vehicles covered by the self-response survey also represented ten make/model/model-year combinations. They comprised vehicles manufactured by all "Big 3" automakers, five model years, and four vehicle types (gasoline; compressed natural gas, original equipment; ethanol flex-fuel; and methanol flex-fuel). As indicated above, not all combinations were available

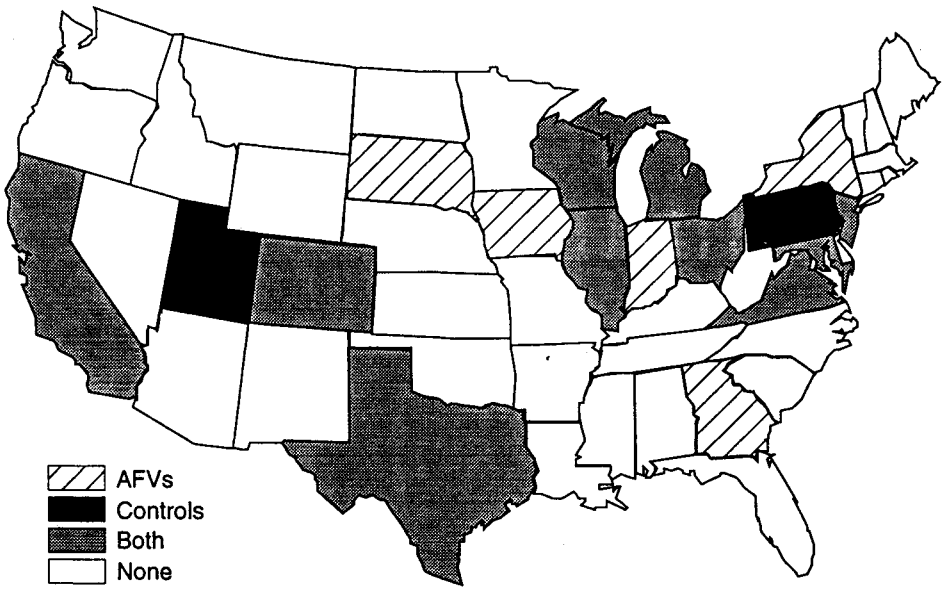


Figure 3.--States in which vehicles included in the self-response survey are located

at all locations where vehicles were surveyed. In addition, because of the alternative fuels were not continuously available at some locations, not all AFVs selected were operated on their designated alternative fuel a majority of the time

In comparison, the first two rounds (quarters) of the telephone survey garnered 493 individual driver responses representing 493 vehicles, or one driver per vehicle. The 493 vehicles were assigned to 120 different fleets, or about 4.1 vehicles per fleet. The vehicles of the drivers responding to the telephone survey were located in 76 communities around the country, representing 31 different states. Figure 5 is a continental U.S. map indicating the states in which the drivers (and vehicles) included in the telephone survey were located.

The numbers of vehicles and the associated numbers of drivers encompassed by the two surveys are tabulated in Table 1 according to the five general vehicle types of interest. The counts shown for the telephone survey cover the first two rounds (quarters) only.

COMPARISONS AND TRADEOFFS

Both the self-response and telephone survey approaches to opinion research have advantages and disadvantages. As is evident from the studies described, many such pros and cons arise through specific application of the survey techniques to particular settings or project scenarios.

For the self-response survey of vehicles discussed here, advantages included the availability of a well-defined frame, a fixed probability of selection for the sampling units (vehicles), a simple, easy-to-complete survey instrument, a restricted number of combinations of vehicle makes, models, model years, and types resulting in a focused basis of inference, a sample size designed to provide balance between cost and coverage of vehicle technology, and a large number of responses from which to draw conclusions.

Unfortunately, there were an equally large number of disadvantages. Because the self-response survey was a volunteer program, there were no real incentives for drivers to participate, and only those individuals who were most biased or most interested were sure to reply. Driver response rate could not be controlled, and the potential for non-sampling error was high (e.g., drivers forgot to reply, incomplete postcards were returned, and problems with vehicles were not consistently reported by all drivers). In addition, the postcard format restricted the amount of information that could be obtained, and the data that was recorded was difficult to quality check (drivers were not explicitly identified). A major problem was the absence of a one-to-one link between drivers and vehicles--there could be multiple drivers of the same vehicle--making the tracking of vehicle problems less than convenient. Under the self-response scheme, there was also a particular disadvantage associated with vehicles operating on compressed natural gas (CNG). Since the driving range of these vehicles on a single tank of fuel is shorter than the driving ranges of the other types of vehicles, the total number of responses likely was unduly weighted toward this vehicle type (survey responses were tied to refueling events). Finally, the use of the self-response approach in this particular application encouraged a considerable amount of "project creep," since, as time passed, there was a tendency to broaden the survey as new vehicle models were released. The results were an increase in workload and cost, a compromised sampling plan, and little or no attendant gain in statistical

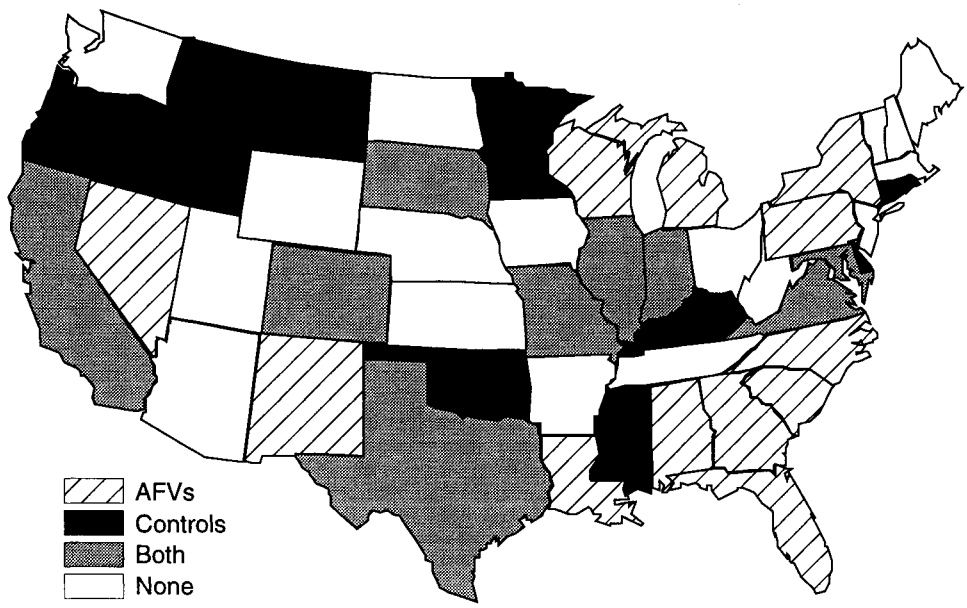


Figure 5.--States where drivers included in the telephone survey are located

reliability.

In comparison, a major positive aspect of the telephone survey was the smaller size of the project, making it less expensive to operate and easier to manage. The reduced magnitude notwithstanding, a broader spectrum of information was obtained, and through direction interaction with the respondents, the interviewer was able to extract more details concerning driver opinions and preferences. This approach facilitated good quality control and a high level of data integrity; and there was more respondent "buy-in," insuring a high rate of response.

Another important advantage of this particular telephone survey was the presence of a one-to-one link between drivers and vehicles. Any subsequent issues concerning data quality were easily tracked and resolved. The driver-vehicle association also guaranteed more consistency in the data, since the drivers had longer-term knowledge of the vehicles about which they were asked to express opinions.

On the negative side, the quality of this survey was diminished by the lack of a readily-available frame. The technique employed to compensate for the problem adversely impacted the application of random sampling, the probabilities of selection, and possibly the representativeness of the selected driver set.

Additionally, because stratification prior to sampling on the basis of vehicle makes, models, and model years could not be justified, the vehicles encompassed by the sample of drivers represented more combinations of attributes than could be meaningfully assimilated into the data analysis. Likewise, the make/model/model-year attribute combinations associated with gasoline control vehicles were not as well matched to those of AFVs as desired.

CONCLUDING REMARKS AND OBSERVATIONS

Both the self-response and telephone surveys represent accepted approaches to opinion research. They can both clearly be applied in vehicle performance and preference surveys; but, as is frequently the case, there are important tradeoffs to be considered.

Of particular note is the importance of frame construction. Availability of an adequate frame from which to sample is the single most important feature of any survey research endeavor--a point once again underscored in the comparisons presented here.

Frame considerations aside, the telephone survey approach generally offers the greater potential for statistical control, as is also evident in the preceding discussion. This survey approach is well established, and is one of the workhorses of formal contemporary opinion research.

Although it, too, is commonly used, the self-response approach, which is frequently executed in conjunction with a mail-in type of instrument, is subject to more administrative difficulties. Unless carefully managed, its use can potentially lead to a much higher degree of non-sampling error than can be practically and statistically tolerated.

Because of the study limitations, neither survey described here constitutes a textbook application of the two methodologies. Though the particular situation of researching alternative fuel vehicles and their drivers may be more problematic than others, it serves to underscore the practicalities of survey research and how they can impact statistical considerations (e.g., sample respresentativeness), as well as the necessity of early planning and close coordination among all parties involved.