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Commercial Fleet Demand for Alternative-Fuel Vehicles: Results from a Stated-Choices Survey of 2,000 Fleet Operators in California

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1. OBJECTIVES AND RESEARCH CONTEXT

It is important to learn how fleet operators are likely to evaluate alternative-fuel vehicles (AFV's, also called clean-fuel vehicles). United States clean-air and fuel-management legislation (U.S. DOE, 1994) and specific zero-emissions and ultra-low-emissions vehicle mandates in California (California Air Resources Board, 1992) ensure that fleets will be targeted as early adopters of emerging clean-fuel technologies.

Fleets might be the leading sector for several reasons (Golob *et al*., 1995): First, there are incentives and mandates that are intended as a direct stimulants of fleet demand. Second, manufacturers might be forced to make financial concessions to fleet purchasers and lessors in order to meet mandated sales quotas. Third, the on-site refueling capabilities and mechanical expertise available at many fleet sites might be key factors in the adoption of the new technologies. Finally, competitive fuel prices might make certain types of AFV's cost-effective for certain types of fleet operations. Potentially, fleets could provide sufficient demand to encourage economies of scale for the manufacture of AFV's, because fleets account for about 23% of annual new-car purchases (Miaou, *et al.,* 1992, citing MVMA).

Although it is widely recognized that fleets are critical to the growth of alternative-fuel technologies, survey data needed to develop fleet demand models have been generally unavailable prior to 1994, due to the difficulty of establishing a representative sample of both business and government organizations with fleet operations. The current study provides results from a large, broad-based sample of fleet sites in California, part of a broader project to develop an integrated vehicle demand forecasting system for both households and fleets (Brownstone, *et al*., 1994).

The 1994 California Fleet Site Survey was based on a comprehensive sample derived from motor-vehicle registration records, and a survey response rate in excess of 70% was obtained.

Initial results from the 1994 California Fleet Site Survey are explored In this paper. The paper is organized as follows: Previous research is discussed in Section 2, followed by a description of the survey in Section 3. Fleet site characteristics are explored in Section 4. Vehicle utilization is analyzed in Section 5, and the effects of fleet operators' awareness of clean fuel mandates is explored in Section 6. Near-term AFV purchase intention is examined in Section 7. A model of vehicle choice is presented in Section 8 to provide insights into the attribute tradeoffs that fleet managers are likely to exhibit when making future vehicle acquisitions in the presence of AFV's. Finally, the conclusions drawn to date are reported in Section 9.

2. PREVIOUS RESEARCH

Previous fleet demand research has been discussed in Golob, *et al.* (1995) and is summarized here. Research encouraged by the oil crises of the 1970's focused on the ability of fleets to use low-range vehicles, and on how fleet managers might make trade-offs among factors such as mileage and operating cost (e.g., Berg, *et al.*,1984, and Hill, 1987). However, a new set of research priorities emerged in the late 1980's. The introduction of the U.S. Clean Air Act Amendments (U.S. EPA, 1990) and the consideration of regional mandates in California created a need to enumerate the number of fleet vehicles and how they were used at sites (e.g. Wachs, *et al.*, 1985). Although the U.S. Census Bureau details truck inventories every five years, their report falls far short of providing the information needed for policy planning (Census, 1990).

There are also a growing number of marketing-based studies commissioned by fuel suppliers such as electric and natural gas utilities, equipment manufacturers, and others in emerging AFV industries. Many of these studies parallel the commercial introduction of a small number of electric, methanol, and compressed natural gas vehicles. Some of the studies concentrate on segments of existing or likely alternative fuel users and elicit basic operating data, and attitudinal and opinion measures. A variety of research techniques are used, from focus groups to more large scale-surveys (e.g. Runzheimer, 1993; Macro, 1994).

Finally, there is a small, but increasingly valuable body of findings accumulating from alternative fuel vehicle fleet trials. The trials have used a variety of different vehicle-types, and test a number of different fuels, primarily methanol, compressed natural gas, and electricity (e.g. Batelle, 1994).

There is more extensive literature on the demand for alternative fuel vehicles by households, but such studies have not in general been extended to non-residential fleets. For example, it is not known whether there is a fleet analogy for the construct of a "green" consumer -- that is, a certain type of individual (firm) that is more environmentally conscientious in its (fleet) decision making activities (Golob, *et al.,* 1995). Another issue which has not been tested is the substitution and reassignment of vehicles under low-range conditions. Seemingly, fleets have a greater capacity than households to re-assign vehicles to different routes and drivers. On the other hand, issues of safety, insurance cost, and risk associated with a new technology may be more salient to fleets because of their corporate liability.

Several major findings emerge from descriptive studies of fleet demand for alternative-fuel vehicles (AFV's):

> (1) *Operating characteristics are of foremost importance.* Fleet decision making is believed to be rational and based on objective criteria such as direct cost, reliability, and job suitability (Berg, 1985, Miaou *et al.*, 1992). AFV purchase intentions vary according to the availability of on-site refueling and the operational uses of the vehicles. There are also indications that certain vehicle classes, such as vans or pick-up trucks, are more likely candidates for alternative fuels because of their refueling patterns and lower annual mileage. (Berg *et al.*, 1984).

(2) In the industrial organizational literature it is believed that *larger firms and fleets are more likely to adopt innovation* (Mansfield,1968). Extrapolating to fleets, it may be that larger firms can reassign vehicles among drivers or can more readily adopt new operating procedures. They may also have better on-site capability, like on-site refueling and service. Another explanation is that large firms reach decisions differently: there is a characteristic of decision making that makes them more willing to experiment and "risk" new technology.

(3) The literature shows that *government and public utility fleets are currently more willing than commercial fleets to use alternative fuel vehicles.* Since many fleet studies pre-date important new regulations on AFV adoption, it is not known whether fleets are reacting to mandates, or to other factors. As a recent study observes (Easton Consultants, 1991), mandates will become of increasing importance to all fleets.

There are three categories of factors cited in Golob, *et al.* (1995) that could be key to fleet decision making concerning AFV's. First, there are a number of *fleet-specific factors* that will influence the ability to use alternative fuels such as the presence of on-site refueling, vehicle use and mileage, and vehicle type. Second, *organizational factors* also appear to be key to understanding future alternative fuel use. We do not understand why fleets that have similar characteristics, like duty cycle and mileage, make different decisions to adopt or test alternative fuels. Finally, there is recognition that *mandates and incentives* are playing an increasingly larger role in alternative fuel decisions, as the dates approach for implementing various clean-fuel regulations.

We explore the role of each of these factors, and their interactions, through an analysis of the 1994 California Fleet Survey data.

3. SURVEY METHOD

Sampling fleets reliably and systematically has been one of the most intractable problems for researchers (Hill, 1993). In this study extensive work was undertaken to develop a representative sample. Existing samples and fleet lists were examined for their completeness and deemed unacceptable. Negotiations were then made, through various state agencies, to gain access to lists of state motor vehicle registrations in California. Rigorous protocols were incorporated to ensure that individual respondents were de-identified, and that the data-set could not be used for commercial purposes.

The final sample is based upon a proportionate sample of vehicles registered to sites with 10 or more registrations. Rule-based algorithms were developed to exclude households with large numbers of registered vehicles, and to identify slight differences in registration names and addresses as likely fragments of the same fleet site. The final sample excluded fleets registered to state and federal governments, rental and leasing fleets, emergency vehicles, and fleets composed only of large trucks (>14,000 lb. GVW). State and federal government fleets were deemed to be the subject for future research.

Following a pre-test, a two-part survey instrument was administered to fleet operators between February and June, 1994. The response to the initial CATI (Computer Assisted Telephone Interview) was 71%, once an eligible fleet manager could be identified. Information from this survey was used to customize a mail survey, which had an effective response rate of 78%.

The customized follow-up mail questionnaire was composed of three main parts (Golob, *et al.,* 1995):

(1) Detailed questions were asked about vehicle acquisitions and operations for the largest vehicle class at the site, and for a second vehicle class, which was assigned at random from the list of other vehicle cla{ses (if any) operated there. Detailed information was restricted to two vehicle classes in order to reduce the survey length and minimize non-response. For each vehicle type, questions included the number of vehicles and their average annual vehicle miles traveled (VMT) by usage category, how they are maintained, and the manner in which the vehicles are disposed of and replaced.

(2) A stated preference choice task (a type of conjoint analysis) was presented for two vehicle classes. In each task, the respondent was asked to allocate future fleet acquisitions from a set of hypothetical future vehicles defined according to an experimental design. Manipulated in that design were the vehicle fuel type (gasoline, electric, compressed natural gas, and methanol) and vehicle attributes, including vehicle capital cost, operating costs, range between refueling, refueling times, and fuel availability.

(3) Extensive information was compiled on attitudes, intentions, and fleet decision making. The attitudinal questions involved importance scales for a series of AFV acquisition criteria, AFV purchase intention, and opinions about the expected reliability, and safety of different fuel types.

The final sample consists of 2,711 CATI and 2,131 mail completions. Most analyses are based on 2,023 responses that exclude 108 sites that had less than 10 vehicles. Survey weighting will be based on comparisons between the survey sample and the entire fleet inventory that can be identified through processing of the State of California vehicle registrations file. This weighting is not yet available.

4. FLEET SITE CHARACTERISTICS

4.1. Industry Sectors

It is not widely known how vehicles are distributed across various industries, because a random sample of business establishments does not generate a representative sample of those that operate fleets. We provide some preliminary data about businesses that operate fleets, with the caution that non-response may have varied across industry segments. Sample weighting should reduce such potential biases.

The industry classification was developed through a two-step process. First, fleet managers were asked to classify their organization in one of 12 categories and provided additional operating information. Since there were known inconsistencies, each entry was manually reviewed and cross-classified by trained coders. Using this method, only about 2% of organizations could not be classified. Definitions of the categories are self-explanatory, although businesses within service-industries were the most complex to code.

City and county government agencies account for the largest proportion of fleet sites that were contacted (14.4%), but this may also partially reflect a greater likelihood on the part of these fleet managers to participate in a University of California Study. About 60% of the fleets in the sample were in five of the thirteen sectors: government fleets (14.4%), construction and contracting (13.0%), household services and trades (12.7%), manufacturing (11.4%) and services for business (10.0%). The sample excludes rental company fleets and those of federal and state government agencies.

TABLE 1: Sample Breakdown by Industry Sector

Fleet Sector	Number of Fleet Sites	% of Total
Agriculture	94	4.6
Automotive Business or Service	66	3.3
Banking & Insurance	56	2.8
City & County Government	291	14.4
Construction & Contracting	263	13.0
Household Services and Trades	256	12.7
Manufacturing	230	11.4
Miscellaneous Industries	32	1.6
Retail & Wholesale Sales	133	6.6
Services for Business & Professional Orgs.	202	10.0
Schools (public & private)	195	9.6
Transportation & Communications	162	8.0
Unknown	*43*	*2.1*

4.2. Fleet Size

Fleet size is another variable that is difficult to assess from published research because previous studies have often been confined to one or two key industries. The size of the fleet is believed to be correlated with the willingness to adopt innovation, as well as the availability of on-site refueling, vehicle specialization potential, different replacement policies, and other key AFV demand factors.

There were approximately 136,000 vehicles in the sample, but their distribution across sites is highly skewed towards large organizations. While approximately 50% of the sample fleet sites had 25 vehicles or less, these sites account for only 13% of the total fleet vehicles. Half of the vehicles are in fleet sites of 200 vehicles or more.

4.3. On-Site Refueling And Maintenance

On-site refueling is often considered essential to AFV diffusion because it can reduce reliance upon an outside refueling infrastructure. On-site refueling is one of the essential reasons why fleets are expected to adopt clean fuels in advance of households. Although 44% of the overall sample had on-site refueling facilities today, the use of such facilities varies widely. Table 2 shows a breakdown of the sites within each organizational sector according to whether: (1) they currently have on-site refueling, (2) they do not have it now, but either had central refueling in the past or indicated that it was physically possible to have on-site refueling at their location, or (3) they indicated that it was *not* possible to have central refueling.

TABLE 2: On-Site Refueling Capability by Site Organization Type

Fleet Sector	On-site refueling capability (%)			
	has presently	not now/ feasible	not feasible	unknown
Agriculture	71	25	4	0
Automotive Business or Service	24	49	27	0
Banking & Insurance	14	11	66	9
City & County Government	76	20	4	0
Construction & Contracting	41	39	17	3
Household Services and Trades	20	40	34	6
Manufacturing	41	33	23	3
Miscellaneous Industries	28	38	28	6
Retail & Wholesale Sales	35	38	24	3
Services for Business & Professional Orgs.	25	32	40	4
Schools (public & private)	72	21	5	2
Transportation & Communications	42	27	29	3
Total sample	43.8	30.8	22.4	2.9

Fleets that use on-site refueling most frequently are those in agriculture (71%), city and county government (76%) and school (72%) sectors. Fleet sites with considerably less on-site refueling include those in the construction (41%), manufacturing (41%), and transportation/communication (42%) sectors. Fleet sectors that are least likely to have on-site refueling capability are banking and insurance, and business and household services and trades. Such sectors might have smaller fleets, they may be based in dense urban areas, the vehicles might be taken home by employees at night, or the vehicles might be driven in less predictable patterns.

4.4. On-Site Maintenance

The ability to service and maintain vehicles on-site is often held, along with on-site refueling, to be an important characteristic for alternative fuel vehicle adoption. The absence of a wide-spread AFV service infrastructure suggests that fleets might have to rely on their on-site capabilities in the near term. However, this is dependent upon cost factors, the ability to train mechanics, and procures for obtaining parts. Forty percent of the fleet sites in the sample had the capacity to service at least two different vehicle classes on-site, while 33% of the sites always contracted out for service. The remaining sites in the sample serviced only one of two vehicle types on-site.

Table 3 lists the maintenance locations for a site's primary vehicle type and one other vehicle type they operate (if any). Fleet sites with small (shuttle) buses are most likely to perform maintenance for such vehicles on-site, while mini-vans are more likely to be serviced off-site. On-site maintenance is also more common for full-size (standard) pick-up trucks and medium duty trucks under 14,000 gross vehicle weight.

TABLE 3: Maintenance Locations by Vehicle Type

Vehicle type	Total fleet sites	Primary maintenance location (%)		
		On-site or at another co. location	Contracted to outside garage/lessor	Other or unknown
Cars	823	42.9	44.2	8.7
Mini-vans	310	33.6	47.1	19.3
Full-size Vans	523	43.6	44.4	8.8
Compact Pickups	560	45.5	40.2	14.3
Full-size Pickups	1019	53.9	32.2	13.9
Small Buses	69	63.8	20.3	16.0
Trucks <14,000 lb. GVW	587	52.8	33.6	13.6

5. VEHICLE UTILIZATION

Vehicle miles of travel (VMT) and other components of fleet vehicle duty cycles are commonly regarded as the most critical component of AFV feasibility. However, aggregate measures of VMT are problematic because averages typically must be computed across the combination of multiple types of vehicles and multiple vehicle functions within a particular fleet. Thus, a decomposition of VMT by vehicle type and function, controlling for fleet site characteristics, is a useful means of assessing vehicle usage requirements. We accomplish this through regression analysis.

Table 4 provides a breakdown of average annual VMT by fleet sector. Fleet sites in the transportation and communication sector record the highest VMT (approximately

36,000 miles per year per vehicle), followed by sites in the automotive sector, business services sector, and retail and wholesale trade sector. Schools record the lowest VMT (14,000 miles).

TABLE 4: Average Annual Vehicle Miles Traveled
for All Purposes by Site Organization Type

Fleet Sector	Average Annual VMT
Agriculture	22,300
Automotive Business or Service	28,300
Banking & Insurance	18,400
City & County Government	16,500
Construction & Contracting	24,500
Household Services and Trades	22,300
Manufacturing	23,700
Miscellaneous Industries	16,700
Retail & Wholesale Sales	27,900
Services for Business & Professional Orgs.	28,000
Schools (public & private)	14,000
Transportation & Communications	36,000

A regression model was computed to explain annual average VMT simultaneously as a function of: (1) utilization category, (2) vehicle type, and (3) fleet site characteristics. The regression results are listed in Table 5. The dependent variable is scaled in terms of 1,000 miles. The percent variance accounted for by the regression is 0.094. The constant of 16,420 miles provides a baseline VMT from which comparison can be made. VMT varies widely by industry sector, with the lowest VMT reported by schools and the banking and insurance industry. Average VMT for government agencies is not significantly different from the constant, while VMT for the remaining sectors are all greater than this constant.

VMT is associated with site-size, supporting the contention that larger organizations are better able to rotate their vehicles, or allocate them across multiple drivers. Organizations that have more fleet sites are also less likely to have a higher VMT per vehicle. However, there is a very large and significant coefficient for the variable which measures how dominant the primary vehicle type is relative to all other vehicle types at the site. Fleet sites at which there is a limited number of vehicle types exhibit more extensive vehicle usage, compared to fleets that have a wider variety of vehicle types. It is likely that organizations with a single vehicle-type have a more specialized function (e.g. courier services). These regression results also confirm that small buses log considerably more miles than other vehicles types, as do vehicles used in courier services, sales-calls, and transportation of people. Significant terms were found for the interactions of vehicle type and utilization category; these are potentially important fleet market segmentation variables.

TABLE 5: Regression of Average Annual VMT as a Function of

Vehicle Utilization Category, Vehicle Type, and Site Characteristics

Explanatory Variable	Coefficient	*t*-statistic
Constant	16.42	10.6
Fleet sector dummies *(base: city and county government)*		
Agriculture	5.89	3.2
Automotive Business or Service	7.97	3.6
Banking & Insurance	-2.57	-1.0
Construction and Contracting	5.72	4.3
Household Services and Trades	4.71	3.4
Manufacturing	2.54	1.8
Retail & Wholesale Sales	6.75	3.2
Services for Business & Professional Orgs.	4.50	3.1
Schools	-3.36	-2.4
Other fleet site characteristics *(base: 20 - 119)*		
Site Size 10-19 (dummy)	-2.57	-3.2
Site Size 120-499 (dummy)	-2.87	-2.4
Site Size 500 or more (dummy)	-4.18	-1.8
Site is Organization's Only Site in CA (dummy)	-1.41	-1.8
Organization has 20 or More Sites in CA (dummy)	-5.74	-2.6
On-site Refueling Present (dummy)	-1.58	-2.0
Vehicle type dummies *(base: compact pickups)*		
Cars	2.00	1.5
Minivans	2.75	1.8
Full Size Pickups	3.01	2.5
Small Buses	12.21	4.0
Trucks <14,000 lb. GVW	3.76	2.4
Fraction of fleet that is the primary vehicle type	12.50	8.9
Utilization category dummies *(base: "other" uses)*		
Courier	16.23	4.6
Pickup/Delivery	4.68	3.2
Haul Equipment	-1.98	-1.6
Service/Maintenance	0.056	0.0
Sales Calls	10.56	4.5
Transport People	14.45	9.0
Employee Use	0.335	0.2
Utilization X type interaction dummies		
Full-size Pickup X Service/Maintenance	-3.60	-2.0
Car X Employee Use	-4.23	-1.8
Truck < 14,000 lb. GVW X Pickup/Delivery	-4.55	-1.7
Car X Sales Calls	-6.49	-2.2
Truck < 14,000 lb. GVW X Service/Maintenance	-6.98	-2.7

6. AWARENESS OF AFV MANDATES

The survey elicited fleet operators' perceptions of whether or not their site was subject to any of the myriad of regulations requiring the use of alternative-fuel vehicles. Overall, 28% of the sample believed that there was legislation requiring their organization to use alternative fuel vehicles. By sector, 50% of the local and county governments perceived regulation, while only 23.3% of the commercial fleet managers perceived that their site was regulated.

Awareness of legislation requiring use of alternative fuel vehicles varied systematically across fleet sites in several ways. First, fleet operators at larger sites, and at sites with central refueling facilities, were more aware of such legislation. Second, there was a difference by type of fleets. A binomial probit model (Maddala, 1983) was estimated to explain differences in awareness of AFV regulation as a function of fleet site characteristics, the dependent variable being coded as: 0 = not aware, 1 = aware (Table 6). City and county government fleets were more likely to perceive that their site is subject to AFV mandates. Manufacturing organizations and schools were also somewhat likely to perceive regulation, and other important predictors of awareness were the presence of on-site refueling, the size of the fleet. The fleet size effects are consistent with the limitation in some clean-fuel legislation to fleet sites of twenty or more vehicles.

TABLE 6: Binomial Probit Model of Belief that Site is Subject to AFV Mandates
Base categories are agriculture and site size 20-29

Explanatory Variable	Coefficient	*t*-statistic
Automotive Business or Service	-0.050	-2.40
City & County Government	0.131	5.14
Construction & Contracting	0.024	1.00
Household Services and Trades	-0.072	-3.06
Manufacturing	0.059	2.52
Retail & Wholesale Sales	-0.050	-2.21
Schools	0.089	3.77
Site size 10-19	-0.139	-5.99
Site size 15-19	-0.121	-5.10
Site size 30-59	0.033	1.34
Site size 60-119	0.131	5.44
Site size 120 or more	0.187	7.39
Organization Has More Than One Site in CA	0.047	2.23
On-site Refueling Present (dummy)	0.129	5.46

7. NEAR-TERM AFV PURCHASE INTENTION

In this section, we apply some of the descriptive information about fleet operations, and fleet decision making to develop a model of *near-term* fleet acquisitions. The propensity to purchase a clean fuel vehicle <u>within the next two years</u> was measured in the survey on a five-point scale, where the mid-point choice was "somewhat likely". The specific wording was: "What is the likelihood that one or more alternative fuel vehicles will be purchased for this location within the next two years?" Reliability analysis based on comparing results with a similar question asked in the follow-up mail survey eliminated 125 respondents.

An appropriate regression method for determining differences among fleet sites in terms of stated AFV purchase intentions is the ordered-response probit model (also known as the "ordered probit model"), developed by Aitchison and Silvey (1957) and Ashford, (1959). The ordered-response probit model respects the dependent variable as an ordinal scale, not requiring the tenuous assumption of equal intervals between the semantic scale points (Maddala, 1983). Results are listed in Table 7.

Fleet site characteristics associated with the near-term AFV purchase intention can be identified from the results in Table 7. Larger fleets are more likely to intend to make an AFV acquisition, even when differences in decision making styles and awareness of AFV mandates are taken into account. It is likely that size is a proxy for several factors (Golob, *et al.*, 1995): First, larger firms have greater ability to absorb risk and liabilities associated with a new vehicle. Second, on an operational level, they may have greater ability to rotate drivers and vehicle assignments in order to accommodate limited range vehicles. Finally, at an organizational level, larger firms may also be more attracted to the favorable publicity and image associated with use of clean fuels.

TABLE 7: Ordered-Response Probit Model of Stated Intention to Purchase Alternative-Fuel Vehicles
Base categories are agriculture and site size 20-29

Explanatory Variable	Coefficient	*t*-statistic
Automotive Business or Service	-0.035	-1.58
City & County Government	0.180	7.03
Construction & Contracting	-0.090	-3.74
Household Services and Trades	-0.067	-2.82
Manufacturing	-0.061	-2.60
Retail & Wholesale Sales	-0.032	-1.42
Schools	-0.009	-0.39
Site size 10-19	-0.028	-1.17
Site size 15-19	-0.040	-1.67
Site size 30-59	-0.000	-0.01
Site size 60-119	0.079	3.26
Site size 120 or more	0.232	9.09
Site is Organization's Only Site in CA	-0.041	-1.91
On-site refueling present (dummy)	0.121	5.10

Fleet sector is also an effective predictor of near-term AFV interest. City and county government is the only sector that is positively inclined to acquire AFV's. Two other sectors, manufacturing and construction, display an opposite tendency of not intending to acquire AFV's. Fleet operators at sites in these sectors may perceive that current AFV's will not meet their duty-cycle needs, such as heavy delivery and hauling. Operational factors might also explain why on-site refueling is a significant predictor of purchase-intention. Firms that have on-site refueling view it as more practical and feasible to operate alternative-fuel vehicles, given the current relatively low level refueling infrastructure.

These model results for near-term AFV purchase intention closely parallel the results from the probit model of perceived awareness of AFV mandates (Table 6). Specifically, government sites appear more likely to acquire alternative-fuel vehicles, as do sites with on-site refueling, and sites with larger fleets. In the previous analysis, school fleets and manufacturers were aware of the mandates, but the purchase-intention model indicates that these fleets indicate that they are unlikely to acquire AFV's in the near-term.

8. A STATED-PREFERENCE VEHICLE CHOICE MODEL

8.1. Methodology

The mail-out portion of the 1994 California Fleet Site Survey was sent to the person identified in the CATI portion of the Survey as being responsible for acquisition of the vehicles at the sample fleet site. In most instances, the mail-out respondent was the same as the CATI respondent, but for many sites, the person or persons responsible for vehicle acquisition was someone other than the fleet site operations manager interviewed in the CATI survey. Often the vehicle acquisition manager was at a different location, e.g., the company headquarters. The Survey thus involved complicated contact protocols to establish identities and appropriate introductions.

Managers responsible for vehicle acquisition were asked to complete a maximum of two stated preference (SP) tasks. In each task, they were asked to allocate their future fleet purchases for a given vehicle type (e.g., car, minivan, etc.) by using a set of hypothetical future vehicles defined according to an experimental design. The format of this task is similar to the survey instruments used in household vehicle choice SP tasks (Bunch, et al., 1993; Golob, et al., 1993), but the respondents in the Fleet Survey were allowed to choose varying numbers of vehicles to make up their entire fleet. The experimental design manipulated the vehicle fuel type and vehicle attributes, including vehicle capital cost, operating costs, range between refueling, refueling times, and fuel availability. These design variables are listed in Table 8.

Each vehicle acquisition manager was presented with these vehicle allocation tasks for the most prevalent vehicle class at their site and for a second vehicle class selected at random from those classes in operation at the site. In the case of sites operating only one vehicle class, only one stated choice task was presented. In each task there were three vehicle types available, randomly selected from the four types included in the study, namely, gasoline vehicles, methanol vehicles (MV's), compressed natural gas vehicles (NGV's), and electric vehicles (EV's). The specific operating characteristics of the three types varied from survey to survey according to an experimental design approach developed by Bunch, *et al.* (1994). For fleet sites operating more than one vehicle body type, all four fuel types were represented in the two allocation tasks presented to the respondent. This design approach allows the possibility of estimating models that do not require the assumption of independence from irrelevant alternatives with respect to fuel type.

The indicated number of vehicles assigned to each fuel type by the respondent was converted to a fraction of the total number of vehicles for that vehicle body type and used as a weight in a maximum likelihood estimation procedure. A weight of zero was assigned to fuel types that were not picked at all by the respondents.

Table 8: Stated Preference Task Design Variables

Variable	Acronym
generic variables	
Capital cost of vehicle in $	capital cost
Vehicle range in miles	refueling range
Number of refueling stations relative to gas stations (gasoline = 1)	station density
Tailpipe emissions relative to new 1993 gasoline vehicles	emissions
electric - specific variables	
operating cost with overnight recharging in cents/mile	EV off-peak cost
operating cost with day-time recharging in cents/mile	EV peak cost
Number of vehicles with similar fuel type on California roads	EV penetration
hybrid dummy (0 = battery only / 1 = with gas range extender)	EV hybrid
on-site recharging time in hours	EV on-site time
EV service station recharging time in minutes	EV station time
cargo capacity compared to gasoline vehicles	EV cargo
compressed natural gas - specific variables	
Operating cost in cents/mile	NGV operating cost
Number of vehicles with similar fuel type on California roads	NGV penetration
dual fuel dummy: (0 = NGV only; 1 = can also run on gasoline)	NGV dual fuel
cost of installing NGV slow-fill refueling on-site in $	NGV slow-fill cost
cost of installing NGV fast-fill refueling on-site in $	NGV fast-fill cost
on-site slow-fill refueling time in hours	NGV slow-fill time
on-site fast-fill refueling time in minutes	NGV fast-fill time
service station refueling time in minutes	NGV station time
home refueling unit installation cost	NGV home-fill cost
cargo capacity compared to gasoline vehicles	NGV cargo
methanol - specific variables	
Operating cost in cents/mile	MV operating cost
Number of vehicles with similar fuel type on California roads	MV penetration
cost of installing methanol refueling on-site in $	MV on-site cost

8.2. Choice Model Results: Generic Vehicle Attributes

It was determined that a multinomial conditional logit model (Maddala, 1983) effectively explained vehicle allocation choices. In this paper, a parsimonious version of the choice model is presented. This model fits the SP data well, with a log-likelihood (initial) = -5087.2, and a log-likelihood (model) = -4455.9 with 34 degrees of freedom and 2131 observations. This corresponds to a pseudo-R^2 of 0.12. The coefficients of the model are presented in Table 9. Design variables that were insignificant are excluded from this model; their inclusion did not significantly increase the log-likelihood.

The coefficient for <u>capital cost</u> is statistically highly significant with the expected sign. The interaction terms involving capital cost and fleet sector dummy variables indicate that city and county government fleet sites are *more sensitive* to capital cost (the coefficient for this sector is the sum of the main effect of capital cost and the interaction term, which almost doubles the main effect). Also, the manufacturing and construction sectors appear to be more sensitive to capital cost, but these interaction effects are estimated with a lower level of statistical confidence.

As expected, <u>range</u> was found to be an important vehicle attribute, and fleet sites where vehicles are used for transporting people have a significantly higher coefficient for range. The ratio of the range coefficient (.00219) to the capital cost coefficient (-.0000265) indicates that the trade-off between range and capital cost is approximately $80.00 per mile. On the average, respondents have equal probabilities of preferring vehicles with each reduced mile of range compensated by an $80.00 reduction in cost, or each added mile of range having a $80.00 premium in cost. Adding 25 miles of range is equivalent to a $2,000.00 cost premium, etc. Certain sectors, particularly government and manufacturing sites, have a much lower dollar value of range, because of their higher sensitivity to capital cost. Fleet sites with personnel transport functions have a higher dollar value of range due to their higher sensitivity to range.

The choice model is specified with one <u>operating cost</u> variable for gasoline vehicles, NGV's and MV's, and two operating cost variables for EV's: operating cost for off-peak (night-time) recharging and operating cost for peak (day-time) recharging. All the coefficients had the correct negative sign. The non-EV operating cost and capital cost coefficients imply that fleet acquisition managers are indifferent between a capital cost increase of approximately $2,200 for a reduction in operating cost of $.01 per mile. The coefficients for EV operating cost indicate that fleet managers are less sensitive to EV operating costs relative to operating costs for other fuels.

The <u>availability of alternative fuel stations</u> off-site was also important to fleet managers, indicating that fuel infrastructure should be an important element of policies aimed at encouraging the adoption of alternative-fuel vehicles. However, reduced <u>tailpipe emissions</u> was found to be a significant predictor of vehicle choice only for the government and school sectors. This indicates that fleet operators in other sectors may be guided by economic and other practical concerns, rather than purely environmental factors, in their vehicle selections.

Table 9: Conditional Logit Model Of Vehicle allocation Choice

Explanatory Variable	Coefficient	*t*-statistic
Capital cost	-.0000265	-4.78
capital cost 🕮 fleet sector = city and county gov.	-.0000235	-2.12
capital cost 🕮 fleet sector = construction	-.0000143	-1.31
capital cost 🕮 fleet sector = manufacturing	-.0000239	-1.88
Range	0.00219	6.39
Range 🕮 utilization category = transport people	0.00152	2.77
Station density	0.213	2.27
Operating cost (NGV, methanol, gasoline)	-0.0583	-4.91
Emissions 🕮 fleet sector = city/county gov. or = school	-0.409	-2.70
NGV dual fuel	0.294	3.59
EV off-peak cost	-0.01287	-0.41
EV peak cost	-0.0162	-1.62
gasoline on-site refueling available	0.267	3.49
EV on-site refueling time in hours.	-0.0688	-1.66
EV station time	-0.00468	-1.57
NGV station time	-0.0253	-2.49
Cargo capacity (EV and NGV)	0.147	1.31
EV constant	-0.895	-2.51
EV constant 🕮 vehicle type = compact pick up	0.289	2.14
EV constant 🕮 utilization category = transport people	0.484	3.39
EV constant 🕮 vehicle type = trucks 🖮14,000# GVW	-0.395	-2.47
EV constant 🕮 utilization cat. = service/maintenance	0.349	3.23
EV constant 🕮 fleet sector = schools	0.769	4.16
EV constant 🕮 fleet sector = agriculture	-0.632	-1.82
NGV constant	-0.363	-2.43
NGV constant 🕮 fleet site size 🖏120 vehicles	0.424	3.04
NGV constant 🕮 fleet sector = city and county gov.	0.297	2.34
NGV constant 🕮 fleet sector = schools	0.439	2.71
NGV constant 🕮 fleet sector = retail and wholesale	-0.261	-1.49
NGV constant 🕮 fleet sector = banking, ins., real est.	-0.754	-1.95
MV constant	-0.261	-2.95
MV constant 🕮 fleet sector = schools	-0.297	-1.70
MV constant 🕮 fleet sector = transport. and comm.	-0.268	-1.65
MV constant 🕮 fleet sector = agriculture	0.342	1.84

8.3. Choice Model results: Fuel-Specific Effects

Fleet managers clearly prefer gasoline vehicles over alternative fuels, *ceteris paribus*. Gasoline was defined to be the base fuel, and the choice-specific constants for the other three fuels are negative. However, there are many significant interaction terms involving the fuel-choice-specific constants and fleet site characteristics. These interaction terms indicate that there are considerable differences in the unexplained preferences for fuels of fleet market segments, but no fleet segment showed a significant preference for any alternative fuel over gasoline.

There are important fleet segments in terms of electric vehicle (EV) preferences: Agricultural sites have strong aversions toward EV's, as do sites operating trucks from 6,000 to 14,000 lb. gross vehicle weight. Positive preferences are exhibited by schools, which might be manifesting a more intense environmental concern. Schools also favor NGV's and these results are consistent with the awareness among school fleet operators of AFV mandates (Table 6), and the sensitivity of their choice to tailpipe emissions.

Several fleet market segments are predisposed towards compressed natural gas vehicles (NGV's). Specifically, large fleets with at least 120 vehicles at the surveyed site showed a significant preference for NGV vehicles, *ceteris paribus*. It is likely that firms with larger fleets have had more exposure to NGV's, are subject to various AFV regulations, and can potentially accommodate on-site refueling.

There is also a relatively stronger preference for NGV's at both city and county government fleets, as well as school fleets. This could reflect current experience with, or investigation of, the technology, as well as the specter of future regulation. Conversely, preference for NGV's is weakest among fleets in the banking, insurance and real estate sector, potentially because of a low incidence of on-site refueling fuel (Table 2) and relatively low vehicle usage levels (Table 4). Also, retail and wholesale fleets are less predisposed toward NGV's.

The dual-fuel capability of operating NGV's on gasoline increased their acceptability The coefficient of the dual-fuel variable implies that fleet managers are indifferent between a $11,000 increase in capital cost and adding dual-fuel capability. However, fleet managers also rated cargo space as important, so the reduction in cargo space to accommodate dual-fuel capability partially offsets the dual-fuel advantage. Finally, refueling time at a service station is also identified as an important variable.

Methanol is the least unattractive of the non-gasoline fuels, as indicated by comparing the choice-specific constants. Many fleet managers are familiar with methanol and some methanol vehicles are available today. Because all methanol vehicles presented in the SP tasks were flexible-fuel, they can also operate on gasoline, which is clearly a preferable attribute.

However, preference for methanol vehicles is significantly lower for both school and transportation and communication fleets. In the case of schools, this could reflect a common concern about safety. In contrast, the agricultural sector was more-predisposed towards methanol than other sectors. There are several plausible explanations for this, including similarities (and possible confusion) between methanol and ethanol, the ease of conversion between the gasoline and methanol, and geographic differences in air quality.

CONCLUSIONS AND RESEARCH DIRECTIONS

This investigation has provided new information on preferences for electric and other alternative-fuel vehicles among a wide spectrum of fleet mangers. These preferences should be important to governmental policy planners and vehicle manufacturers, because fleet demand is a critical component in U.S. Federal clean air and energy legislation and California mandates for the electric and low emissions vehicles. The underlying survey used a complex contact protocol and multiple-stage interview process in order to interview both managers responsible for fleet operations and those responsible for vehicle acquisition decisions.

The descriptive analysis pinpointed vehicle utilization as a significant parameter. Although the average fleet annual vehicle miles of travel (VMT) across all fleet sites was 16,420 miles, there was substantial variation between fleet sectors, from a high of 36,000 miles by fleets in the transportation and communications sector, to a low of 14,000 miles by schools. VMT also varies by vehicle class, indicating that fleet operations are highly differentiated. This differentiation was also apparent in fleet managers' awareness of alternative-fuel mandates and in their plans for near-term purchases of alternative-fuel vehicles.

The stated preference choice model results also showed that here were major differences in preferences between fleet market segments. For example, schools showed a positive preference towards electric vehicles and compressed natural gas vehicles, but a negative preference towards methanol vehicles. There were also substantial differences among fleet market segments in terms of attribute trade-offs. While local government fleets are exhibit a predilection toward EV's and NGV's, managers of such fleets are more sensitive to capital costs.

The choice model results also provide information on attribute trade-offs. For all fleets on average, the trade-off between range and capital cost is approximately $80.00 per mile. Because of their higher sensitivity to capital cost, government and manufacturing fleet sectors have a lower dollar value of range. Fleet sites with personnel transport functions have a higher dollar value of range due to their higher sensitivity to range. The availability of alternative fuel stations off-site was also important to fleet managers, indicating that fleets are willing to trade-off costs for fuel infrastructure, or that such infrastructure can compensate for limited vehicle range. However, reduced tailpipe emissions was found to be a significant predictor of vehicle choice only for the government and school sectors. This indicates that fleet operators in other sectors may be guided by economic and other practical concerns, rather than purely environmental factors, in their vehicle selections.

The stated preference model provides a basis for forecasting fleets' demand for alternative-fuel vehicles. These forecasts also require weights to expand the survey sample to the entire fleet population, and registration files of the California Department of Motor Vehicles are being used to develop these weights. Preliminary results show that for the six-county greater Los Angeles region there are approximately 10 million household vehicles, 430,000 fleet vehicles operated by the fleet types covered in this report, and 600,000 rental car fleet vehicles. This suggests that the fleets covered in this paper will need to purchase a disproportionate number of alternative-fuel vehicles if they are to be important contributors to meeting clean-fuel mandates.

Once the vehicle registration files are processed, we can get more information about our sample fleets' current vehicle holdings. In particular we can get the make, model, and vintage of each vehicle in the fleet. This information can be used to more closely link the fleets' stated preference choices to their revealed preferences as evidenced by their past vehicle purchases. Eventually these data could be used to fit joint stated and revealed preference models similar to our household models (Brownstone et. al., 1994).

We also plan on following all of the sample's fleet vehicles between two "snapshots" of the registration file taken one year apart. This will allow a better measure of the fleets' vehicle replacement policies. In particular, we will be able to see which fleets purchase new or used vehicles. This information is critical for forecasting the short-run dynamics of fleet purchase behavior.

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