Cost and Value of Vehicle Range: Roles in Estimation of Market Penetration of Electric and Hybrid Electric Vehicles

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Objective

- To assess the incremental impact of changes in vehicle range on consumer choice.

Question

- Why is range a problem sufficient to prevent significant market penetration of electric vehicles?
  - Issue 1: What is the value of range to the consumer for feasible ranges of EVs?
  - Issue 2: How does cost of range in EVs relate to this consumer value of range

To estimate consumers' value of range vs. other attributes, DOE/OTT funded the collection of data for the "National Survey."

- A stated-preference survey of the contiguous United States excluding California
- Modeled after California survey conducted by the University of California's Institute for Transportation Studies
- For detailed discussion, see Tompkins et al, 1998, Transportation Research Record 1641, pp. 130-138

A revised model was developed in 1998 whose coefficients are used by EIA and OTT.

- Purchase price
- Fuel cost (both for gasoline and alternative fuel)
- Maintenance cost (battery cost folded in for EVs & HEVs)
- Fuel availability of the alternative fuel (% of gasoline)
- Home refueling (yes/no)
- Range (on alternative fuel and on gasoline, as applicable)
- Acceleration (0-30 mph)
- Number of alternative fuel vehicles on the road "in region"
- Luggage space (either 100% or 67% of gasoline vehicle)
- Top speed

Note: Results for and effects of underlined variables are included in this presentation

Numerous discrete choice models were estimated, evaluated, and refined.

- Stated-preference data were used.
- Multinomial and conditional logit models were estimated.
- Periodic verification of results were conducted.

There were a number (actually a whole lot) of database management preliminaries.

- Full database contains 33,677 records
- Total of 17 choices in 2 sets of respondent selection cards — used & new vehicles: ‘98 & ‘01
- Estimated data set constrained to households selecting new vehicles
- Condensed data set contains 17,489 records
- Represents 1,440 households
- Choices ranged from 4 to 17 new vehicles

Descriptive Statistics on Range by Detailed Vehicle and Fuel Type

Types in Estimate	Types in Data Base	Average	Standard Deviation	Minimum	Maximum
Gasoline	Gasoline	324	51	250	400
Alternative Fuel (Dedicated)	Dedicated Gaseous ^	215	36	175	300
	Dedicated Electric*	103	44	40	200
Multi-Fuel (Alternative Fuel and Gasoline)	Flex-Fuel Alcohol	312	47	250	400
	Dual Fuel Gaseous ^	398	63	280	525
	Hybrid Electric	299	64	210	470

•indicates that vehicles had home refueling; ^ indicates that some of the sample

In these estimates, vehicle range is grouped into three categories.

Fuel Type	Average	Standard Deviation	Minimum	Maximum
Gasoline (Dedicated)	324	51	250	400
Alternative Fuel (Dedicated)	149	69	40	300
Multi-Fuel	335	68	210	525

A series of MNL models was specified and estimated.

$$Prob[y_t = j] = \exp(\beta' x_{jt}) / \sum_{i}^{n} \exp(\beta' x_{it})$$

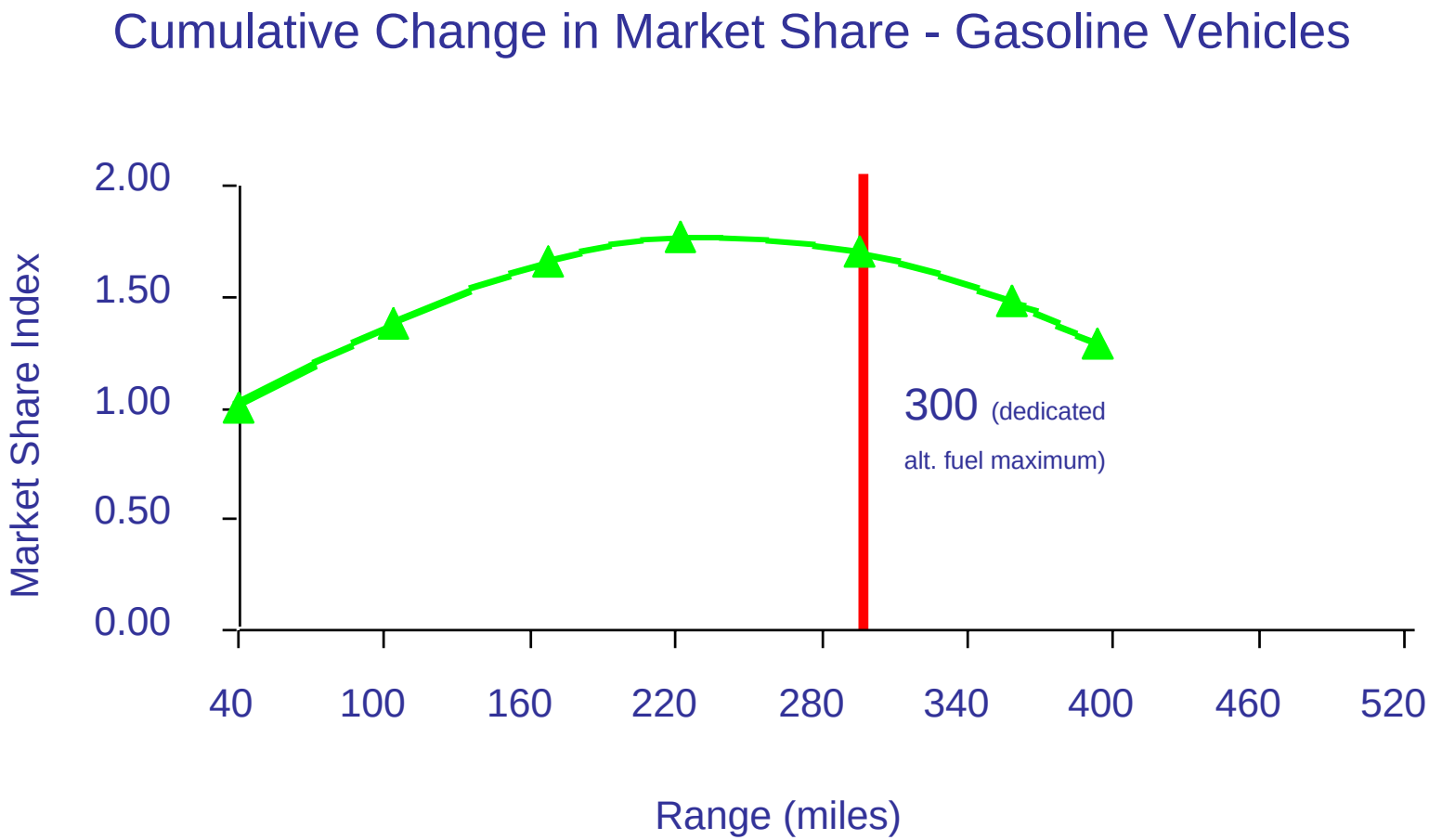
Parameter Estimates for Range-Related Variables

Coefficient	Estimate	Standard Error	Z-Value
Gasoline Linear	8.03E-03	1.99E-03	4.04
Gasoline Quadratic	-1.66E-05	4.21E-06	-3.95
Dedicated AFV	2.01E-03	1.43E-03	1.40
Multi-Fueled Linear	2.44E-03	1.61E-03	1.52
Multi-Fueled Quadratic	-3.39E-06	2.86E-06	-1.19

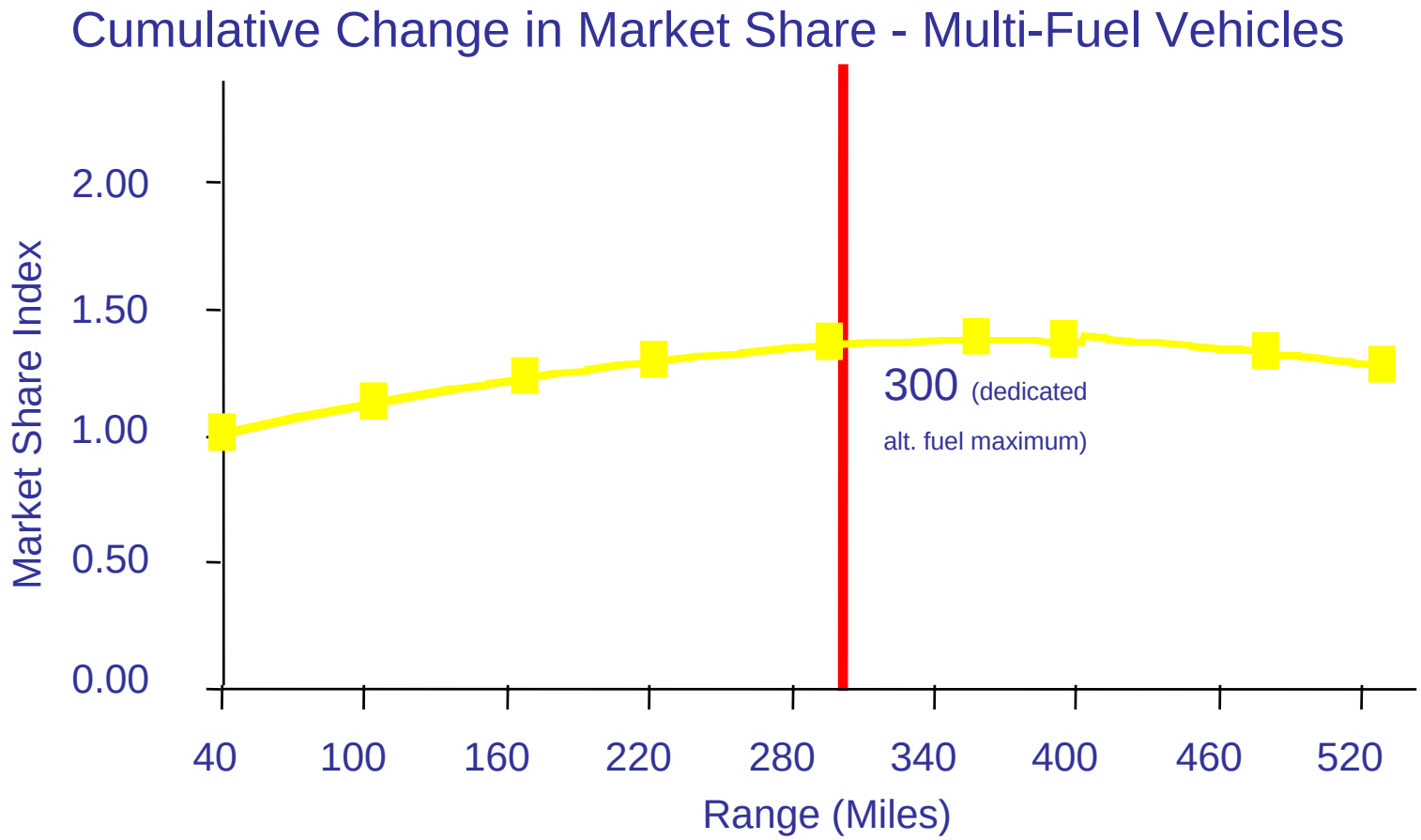
The addition of quadratic range terms significantly improves the model fit.

Model	Log-Likelihood Value	Chi-Square	Level of Significance
No Range Variables	-3326.709	NA	NA
Range Linear	-3323.217	6.98	0.10
Range Quadratic	-3315.220	22.98	0.005

Change in Gasoline Market Share in Response to Changes in Range

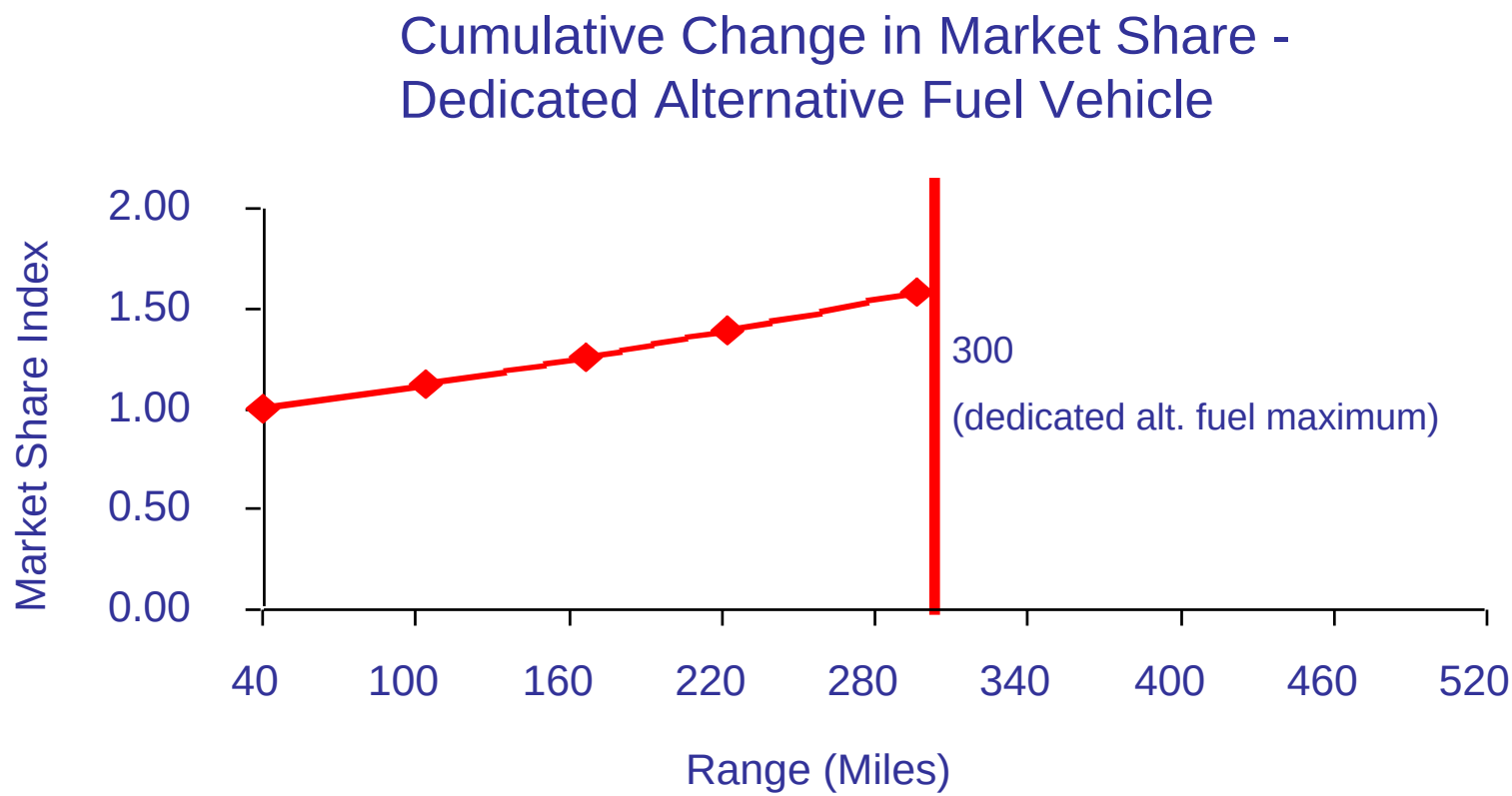


Change in Multi-fuel Vehicle Market Share in Response to Change in Range



Note: Gasoline plus alternative fuel. Minimum alternative fuel availability is 5% of the gasoline total, and many of the vehicles in this set have home refueling

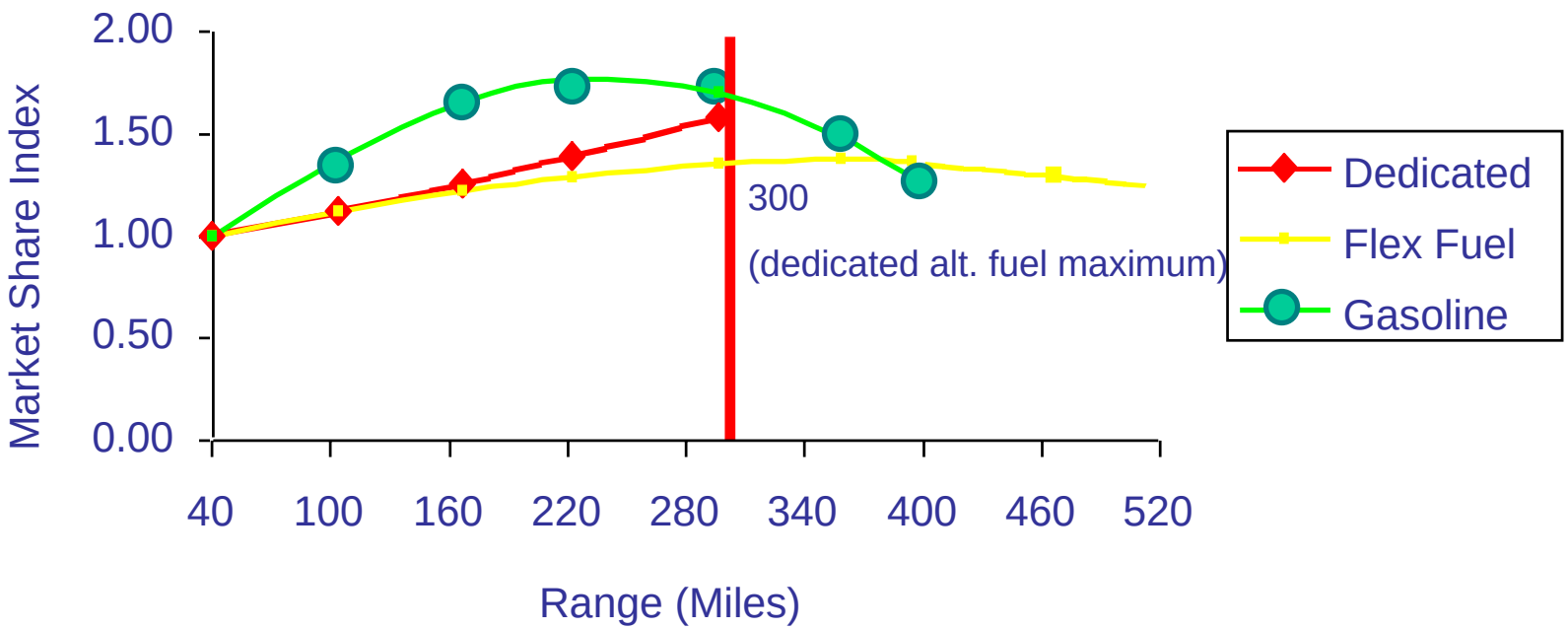
Change in Dedicated AFV Market Share in Response to Change in Range



Note: Either electric or natural gas. Minimum alternative fuel availability is 5% of the gasoline total. All electrics have home refueling, many gas vehicles do also.

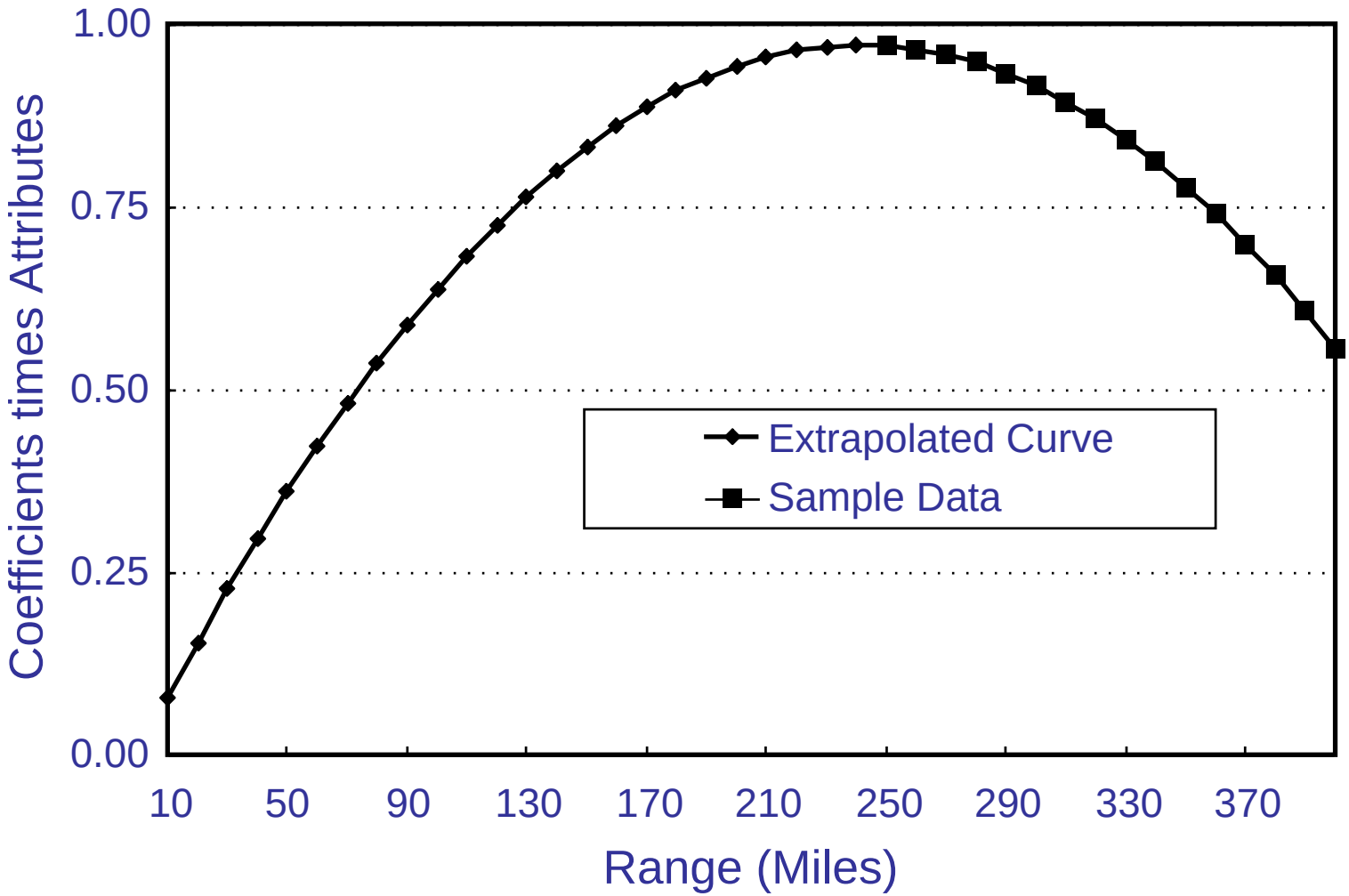
Change in Market Share in Response to Changes in Range - All Types

Cumulative Change in Market Share - Gasoline vs. Alternative Fuel Types

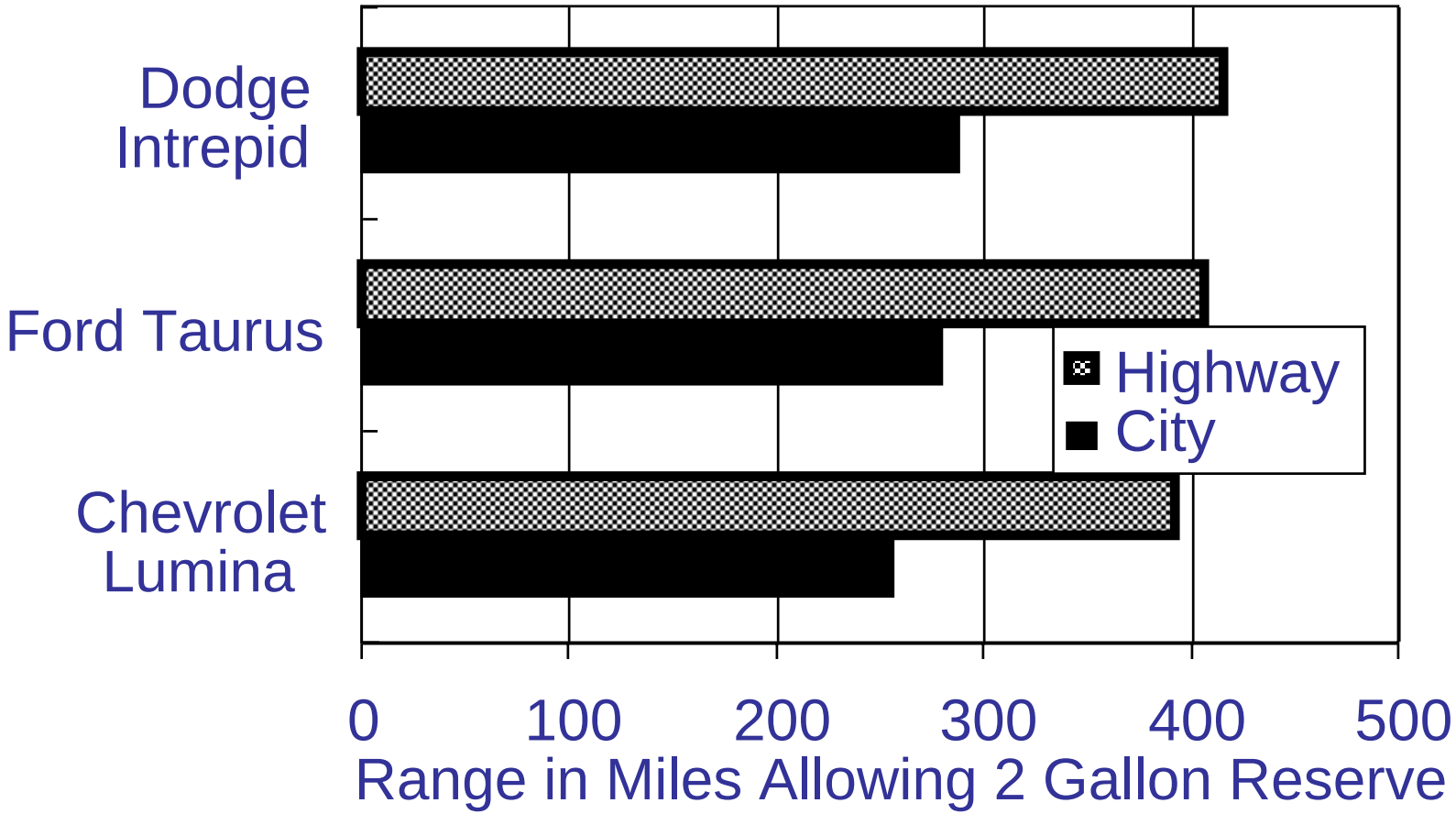


Note: The vast majority of the dedicated fuel vehicles seen by respondents have home refueling, but none have more than 25% station fuel availability of gasoline

Repeated tests confirm respondents think gasoline LDVs can have too much range.



Practical city driving range is near the estimated optimum for gasoline vehicles.



Note that the vehicle descriptors did not specify “city” or “highway” range. If respondents judged acceptable range by normal experience - until the fuel light comes on in everyday driving, the response on desired gasoline range is then logical.

Context of survey respondents' evaluation of the value of range for AFVs is important.

- Most AFVs included home refueling.
- All AFVs had information that the alternative fuel was available at a minimum of 5% of gasoline stations and a maximum of 25%.
- Also, the only other variable unique to AFVs was the "number of alternative fuel vehicles on the road in your region" variable.