DOE Hydrogen Program

Discrete Choice Analysis of Consumer Preferences for Refueling Availability

Marc W. Melaina
Hydrogen Technologies and Systems Center, NREL

June 13th, 2008

Project ID #: AN15

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

Project start date:
September 2007
Project end date:
July 2008
Percent complete: 60%
(phase I complete)

Budget

Total project funding

- $510 K (DOE)

Funding received in FY07

- $190 K (DOE)

Funding for FY08

- $320 K (DOE)

Barriers

Systems Analysis

A. Future Market Behavior: "…hydrogen supply, vehicle supply, and the demand for vehicles and hydrogen are all dependent and linked."

Hydrogen Production

Reduce the cost of hydrogen to $2.00-$3.00/gge (delivered) at the pump.

- Depends upon size and number of early stations required.

Partners

Subcontractor: PA Consulting (with Knowledge Networks)

Project lead: Marc Melaina, NREL

Objectives

- Quantify consumer reluctance to purchase an alternative fuel vehicle due to a lack of refueling availability.
  - Based upon survey results
  - Reluctance is expressed as a cost penalty against the purchase price of a vehicle
- Compare survey results to comparable results derived from analytic models
  - Assuming a certain “cost of time” associated with the additional distance traveled to a station
- Develop a general discrete choice model for major urban areas

Milestones

System Analysis MYPP Milestone

- "Begin a coordinated study of market transformation analysis with H2A and Delivery models" (2007 MYPP, p. 4-14)

Project Milestones

Survey Work

• Design and field survey in 3 urban areas	Nov. 2007
• Complete subcontractor report (phase I)	Feb. 2008
• Design and field survey in 4 additional urban areas	May 2008
• Complete final subcontractor report (phase II)	Aug. 2008

Other Work

• Compare results to analytic derivations	July 2008
• Complete final synthesis report	Sept. 2008

Approach: Discrete Choice Methodology

- Discrete choice methods are commonly applied in decision analyses of preferences for products with similar attributes

Hypothetical Example:

Attribute	Product A	Product B
A - Color	A1	B1
B - Speed	A2	B2
C - Cost	A3	B3
Choice:	☐	☑

- Previous studies of vehicle choice have included refueling availability as an attribute, but none have treated this attribute with a sufficient level of detail
- Attributes included in survey:
  - Vehicle Purchase Price
  - Fuel Costs ($/mo)
  - Vehicle range (miles)
  - Refueling availability
    - Various types (*see below*)

Approach: Choosing between two hypothetical vehicles

What we asked:

- Respondents were asked to choose between two vehicles:
  - Conventional Vehicle
  - Alternative Fuel Vehicle
- Both vehicles were described as being identical to the respondent's most recently purchased vehicle (with 3-4 years)

The Alternative Fuel Vehicle (AFV)

Described as identical to the Conventional Vehicle (CV) in all respects, except two:

1) Social and Environmental Benefits
   - Virtually no oil use, no smog-forming pollutants, and reduction in greenhouse gas emissions by 30%-70%
2) Limited refueling availability
   - Metropolitan, Regional and National geographic scales

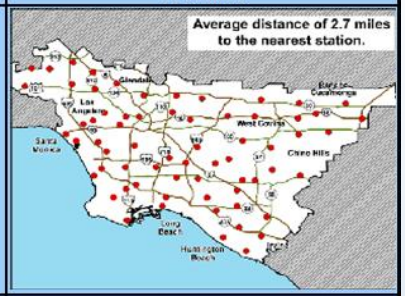
Approach: Ensuring Clarity and Consistent Responses

- A series of preliminary questions were used to familiarize the respondents with:
  - Concepts used in the survey (e.g., AFV; percent of stations)
  - Maps used for each geographic scale
    - e.g., asked them if they could locate their homes on map
  - Types of choices they would be making in the discrete choice portion of the survey

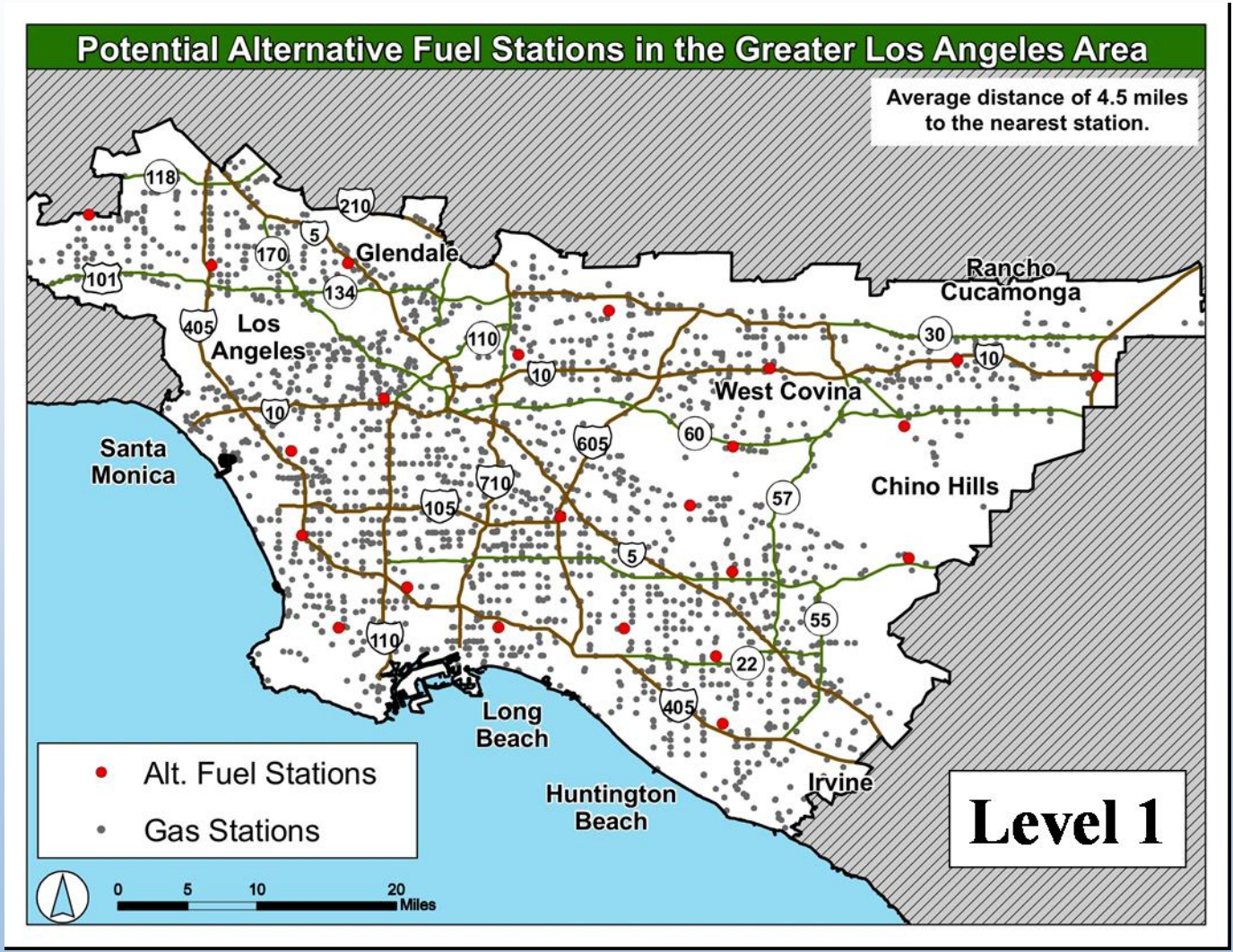
- Follow-up questions and one-on-one interviews inquired about the difficulty of the survey
  - Only a small fraction of respondents found the survey very difficult
  - Map sizes were increased after the first round of beta testing

Approach: Discrete Choice Survey Format (L.A. example)

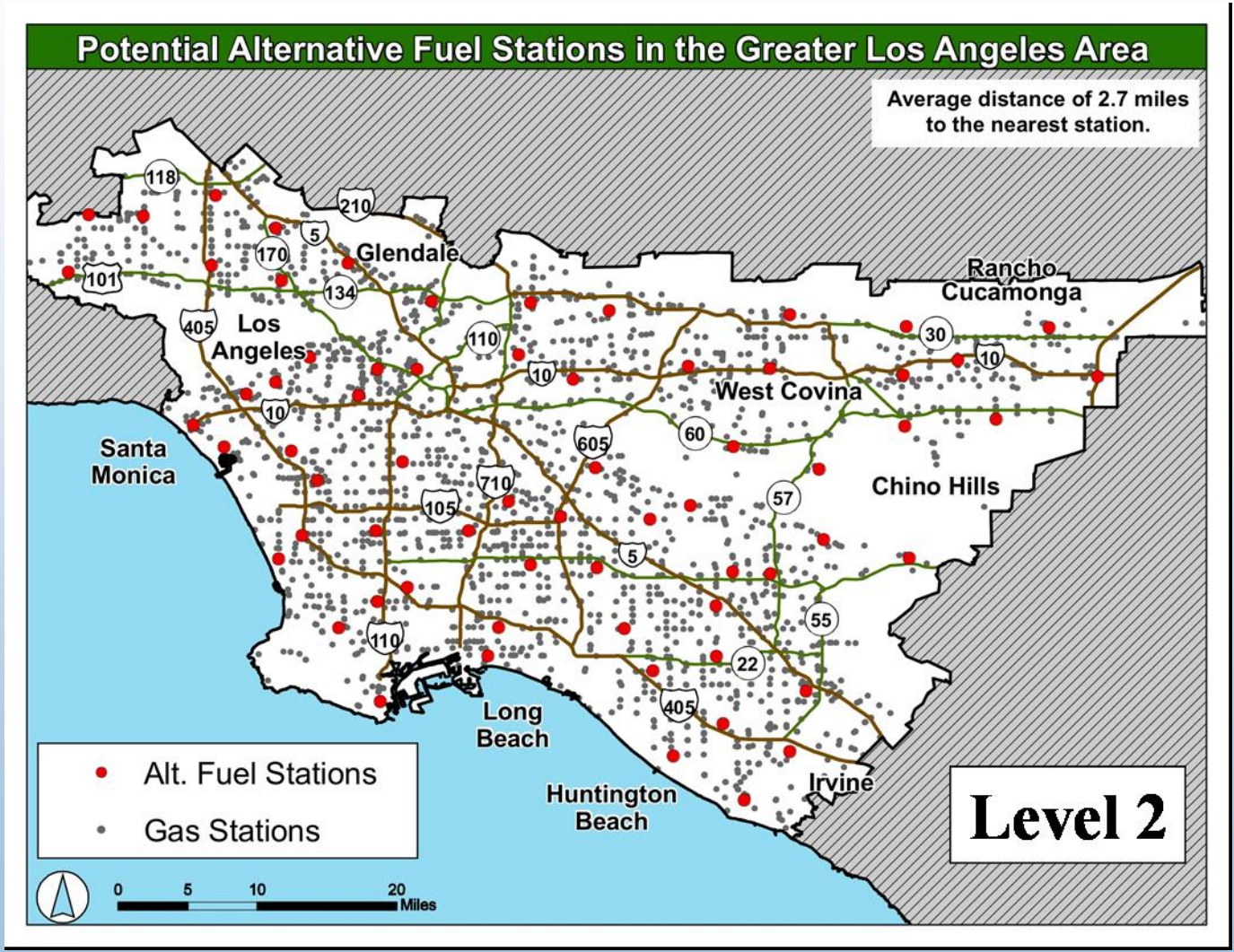
Each refueling availability attribute has 4 levels

	Gasoline Vehicle Similar to YOUR VEHICLE	Alternative Fuel Vehicle Similar to YOUR VEHICLE
Vehicle Attributes		Virtually NO oil used or imported No smog emissions 30%-70% fewer Greenhouse Gas emissions
Driving Range	Same as YOUR VEHICLE	X miles
Average Distance to the nearest Metro Area Refueling Station	0.4 miles	
Number of stations within 150 miles of the metro area	3,000	
Long Distance Trips that are Possible	All destinations are possible	
Distance Between Highway Stations Varies	Varies	X miles
Fuel Cost ($/month)	$ X	$ X
Purchase Price	$ X	$ X
Vehicle you are MOST likely to purchase	☐	☑

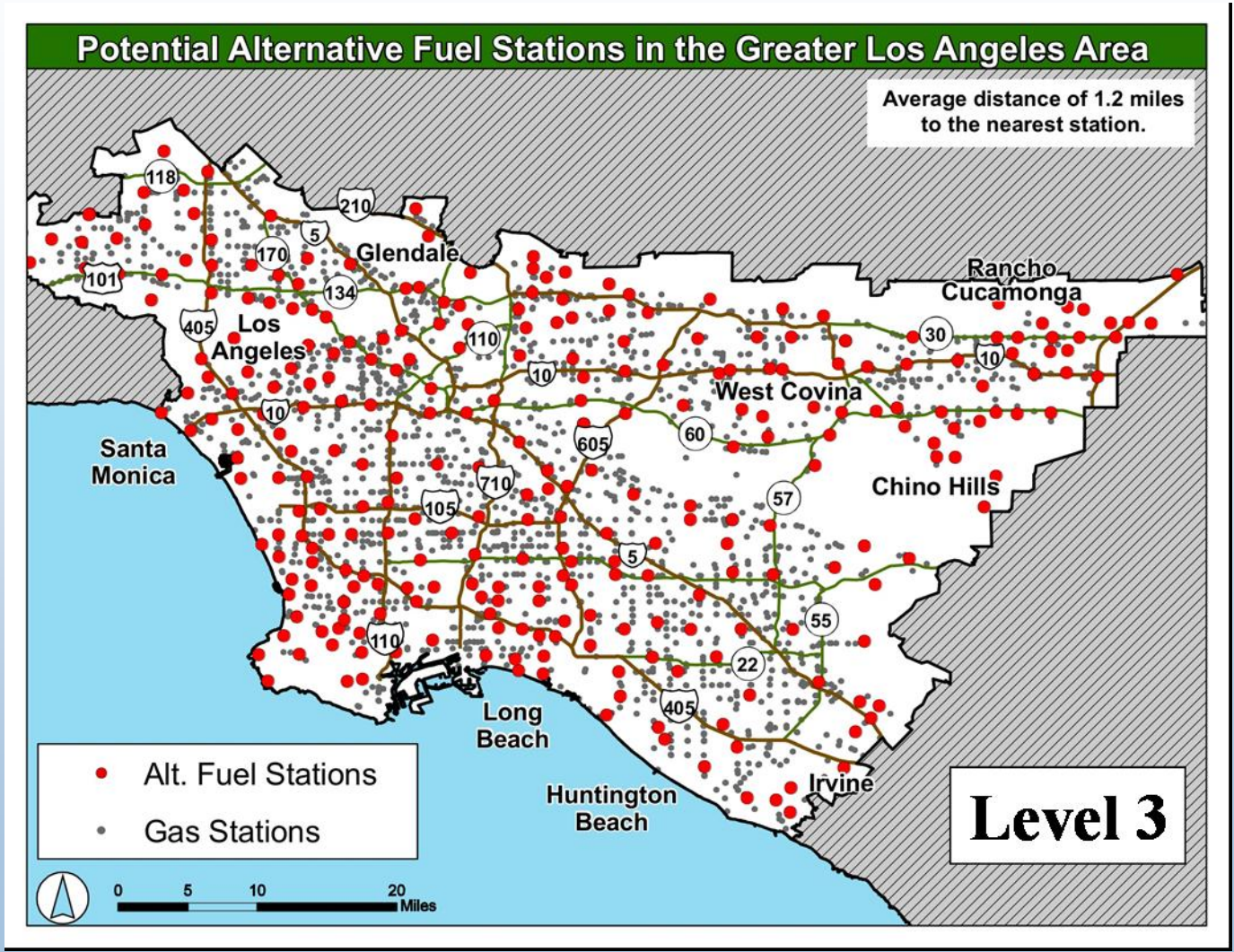
Approach: Metropolitan Maps (L.A., Level 1)



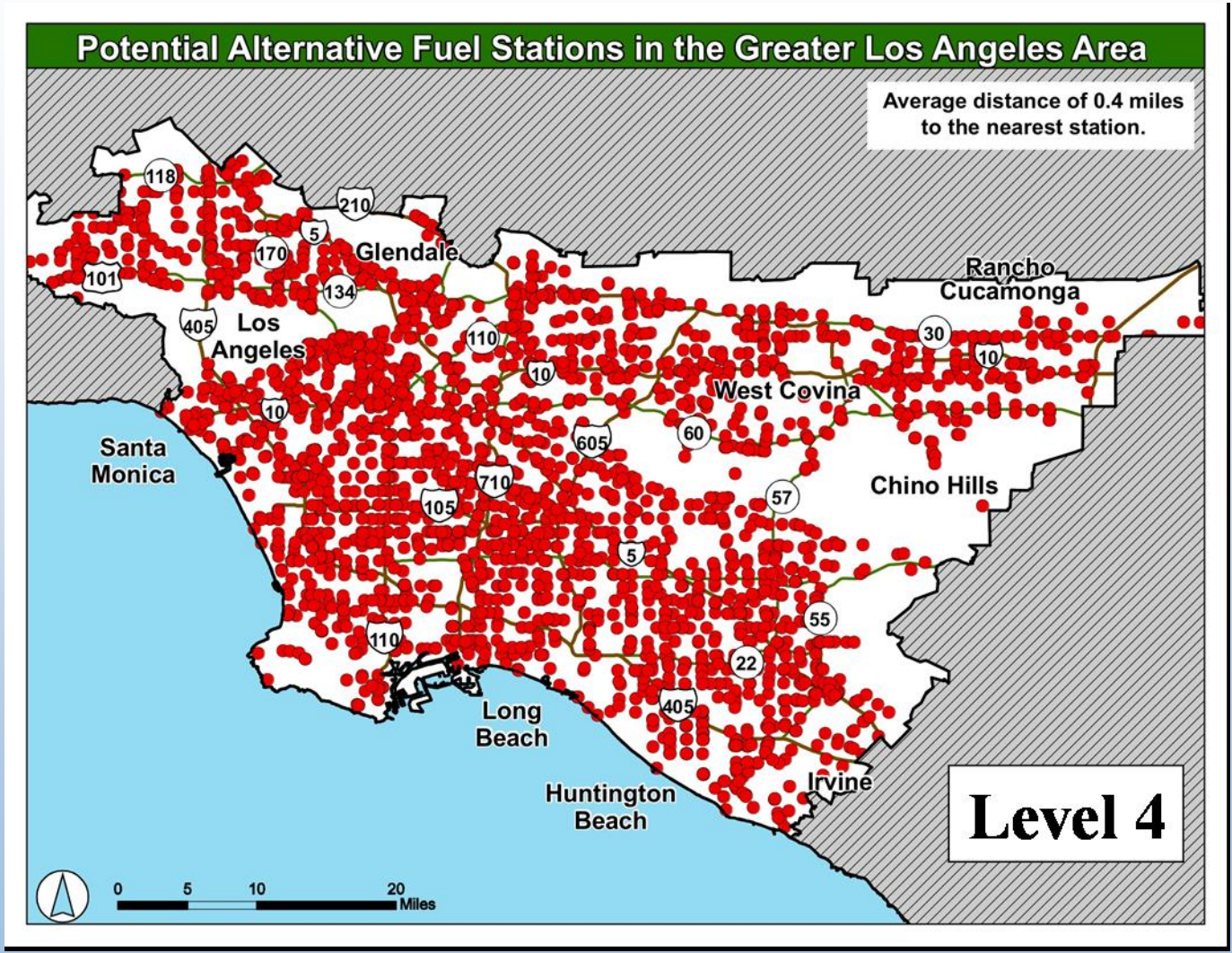
Approach: Metro Area Maps (L.A., Level 2)



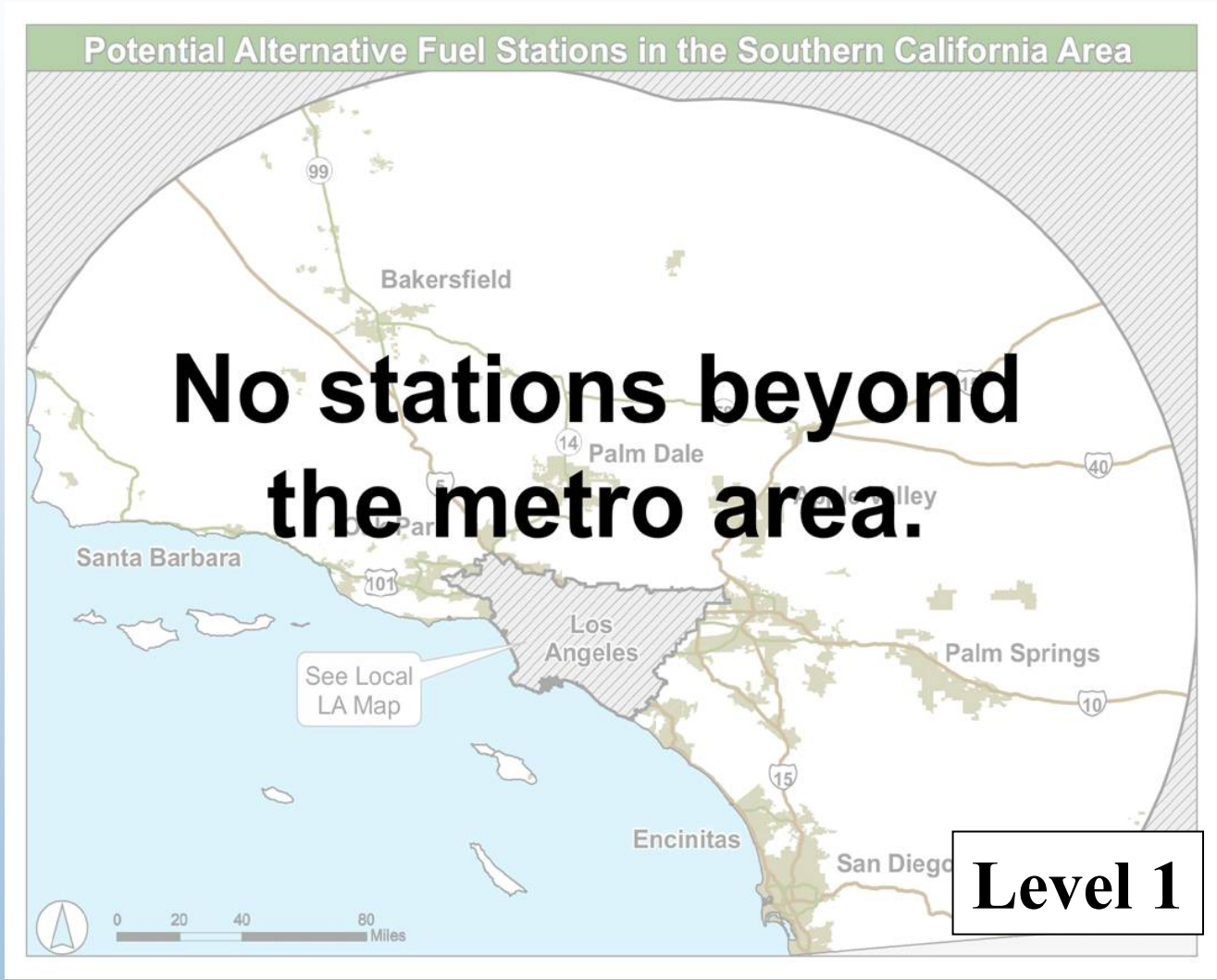
Approach: Metro Area Maps (L.A., Level 3)



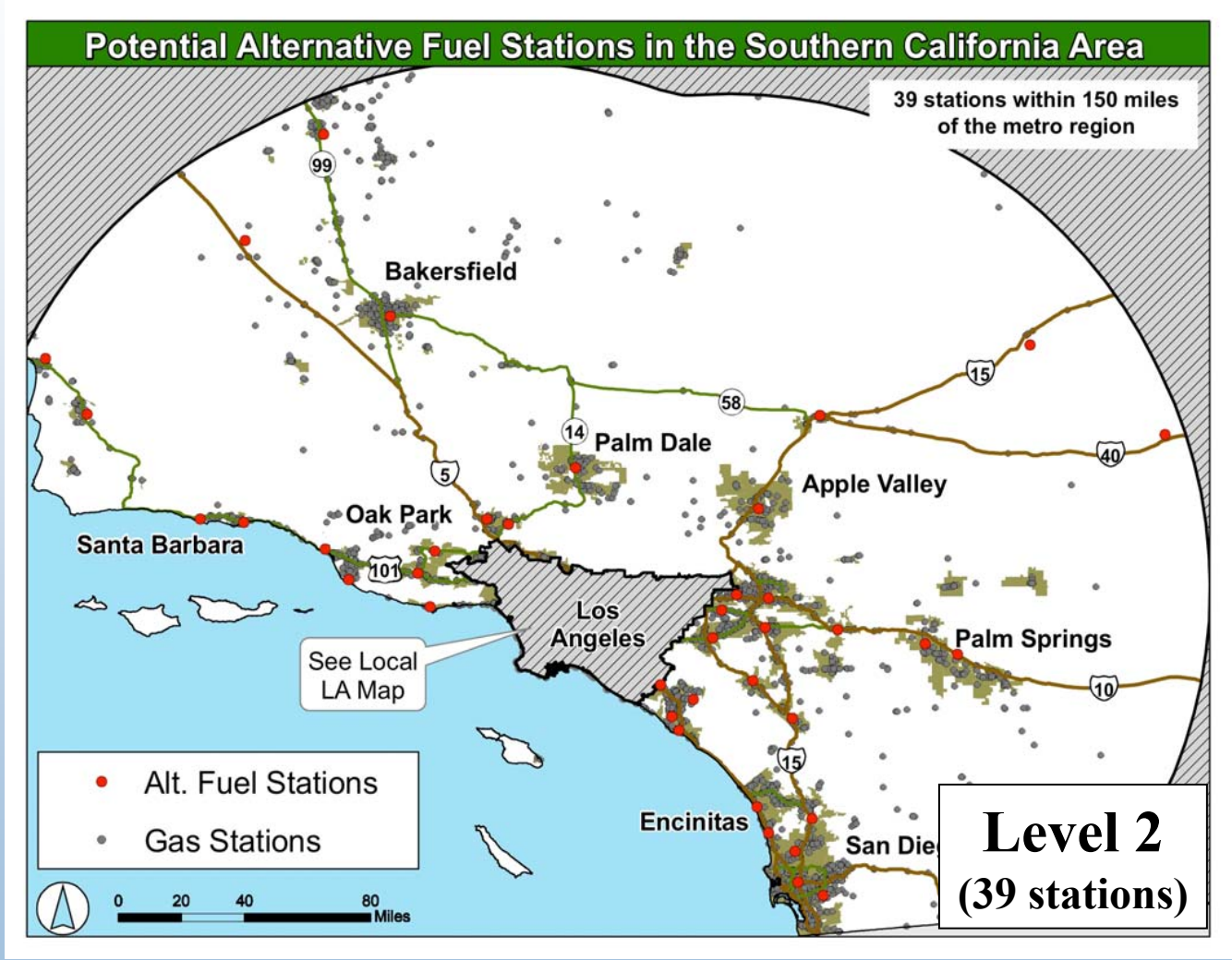
Approach: Metro Area Maps (L.A., Level 4)



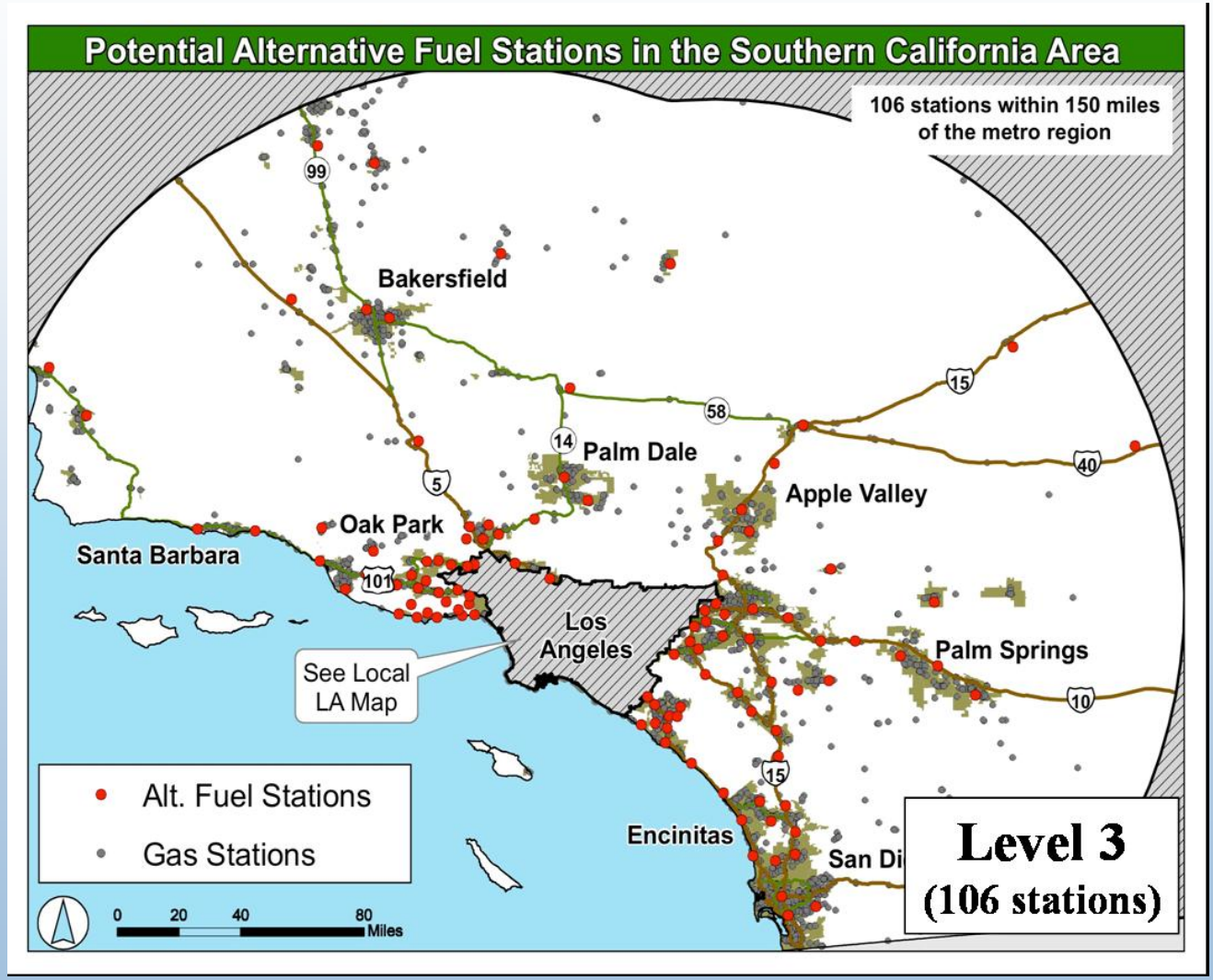
Approach: Metro Region Maps (L.A., Level 1)



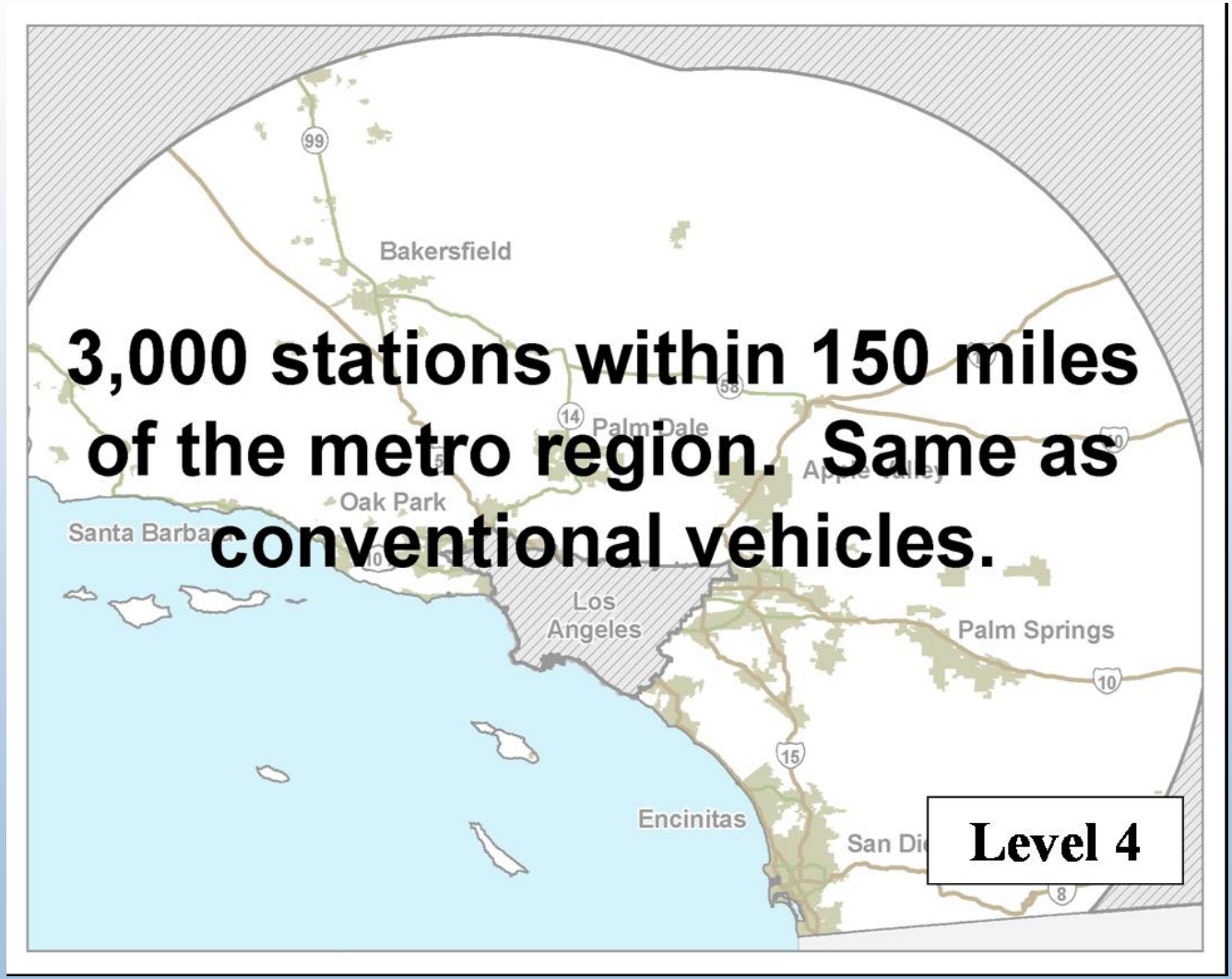
Approach: Metro Region Maps (L.A., Level 2)



Approach: Metro Region Maps (L.A., Level 3)

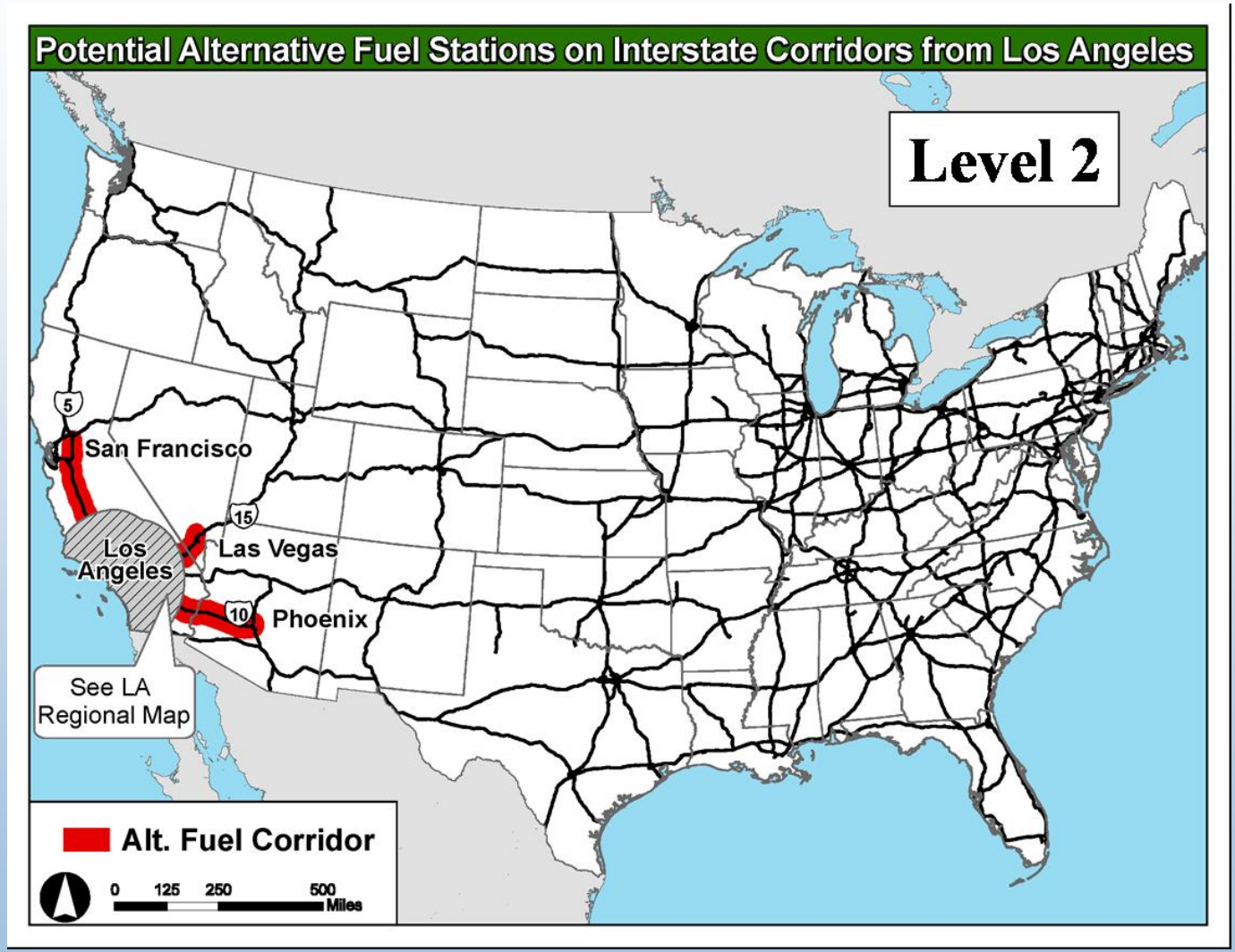


Approach: Metro Region Maps (L.A., Level 4)

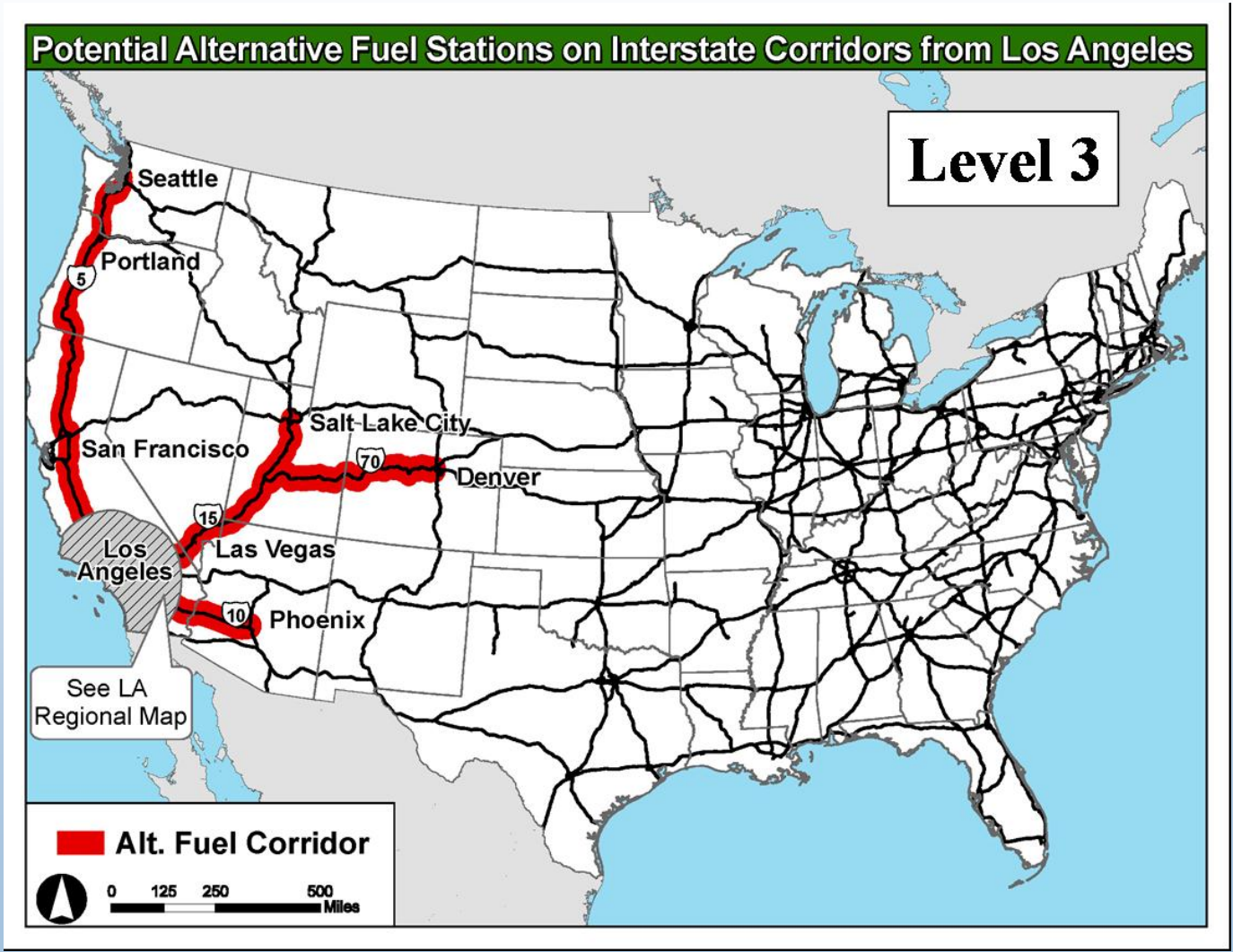


Approach: Interstate Maps (L.A., Level 1)

Approach: Interstate Maps (L.A., Level 2)



Approach: Interstate Maps (L.A., Level 3)



Approach: Interstate Maps (L.A., Level 4)

Approach: Equivalent Dollar Values

- Cost penalty results can be expressed on the same dollar value basis as the purchase price of the vehicle
- Each attribute is included in a utility function, and parameters result from fitting the function to the survey responses
- The utility function includes attributes (*X*) and corresponding coefficients (β):

$$U_i = \beta_i X_i$$

Values for *i* represent distinct attributes

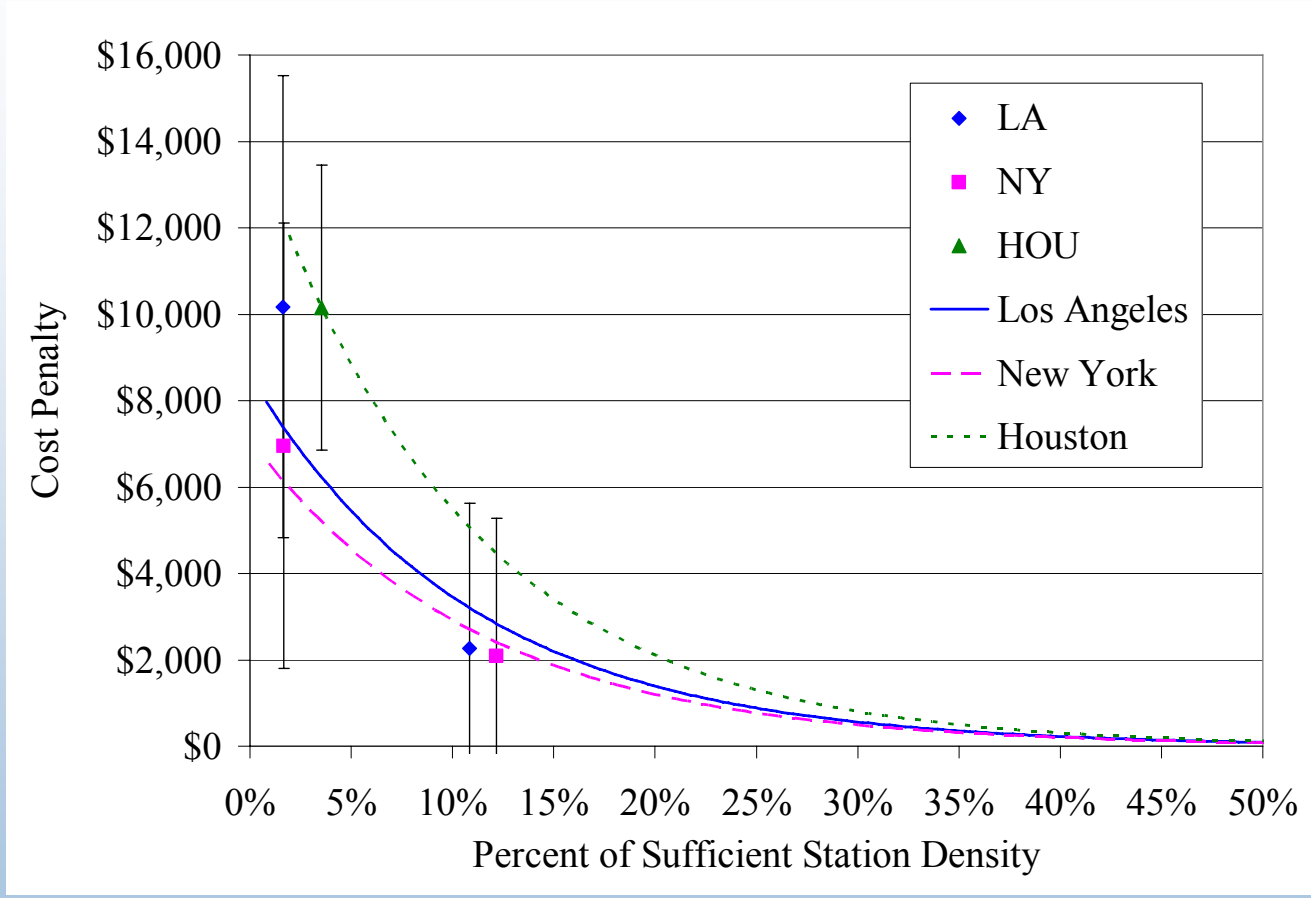
- The value of any attribute level can be expressed in terms of equivalent dollars values using the vehicle purchase price coefficient as a basis:

$$V_i = \frac{X_i \beta_i}{\beta_{VPP}}$$

Results: Overview

- Fielded survey in households in 3 major urban areas
  - Los Angeles, Houston and New York
  - Total of 1486 completed surveys
- Cost penalty results were consistent with expectations
  - Penalties increase at lower levels of availability
  - Lower penalties found for higher density cities (e.g., NY)
  - Exception was regional result for L.A.
  - Additional survey work will help clarify regional results
- Found statistically significant results for most of the geographic levels of refueling availability
  - Some levels were not distinguishable for some cities
  - Additional survey work will make levels more visually distinct

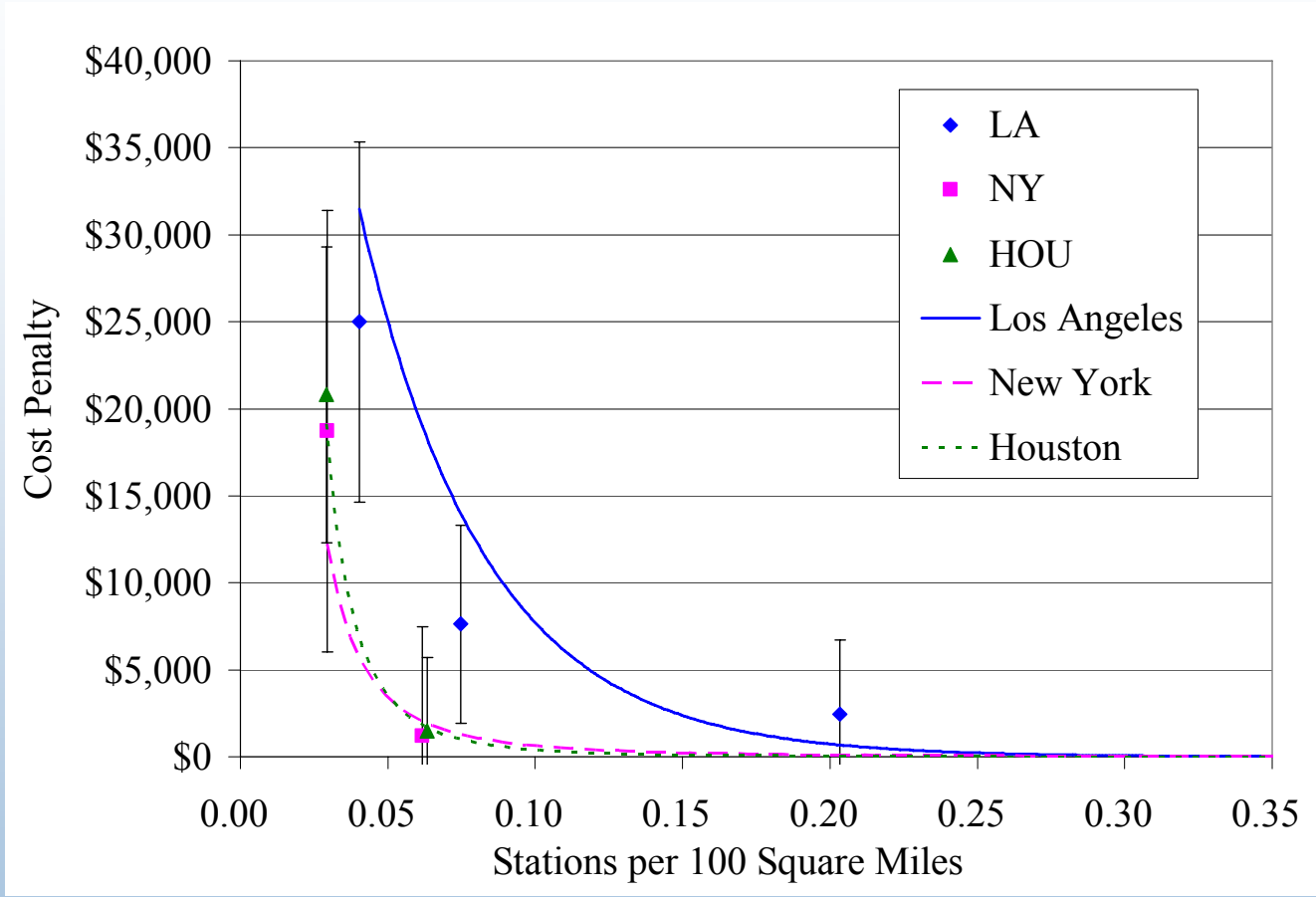
Results: Cost Penalties for Metro Area Coverage follow an Exponential Trend



Note: HOU only has 2 data points

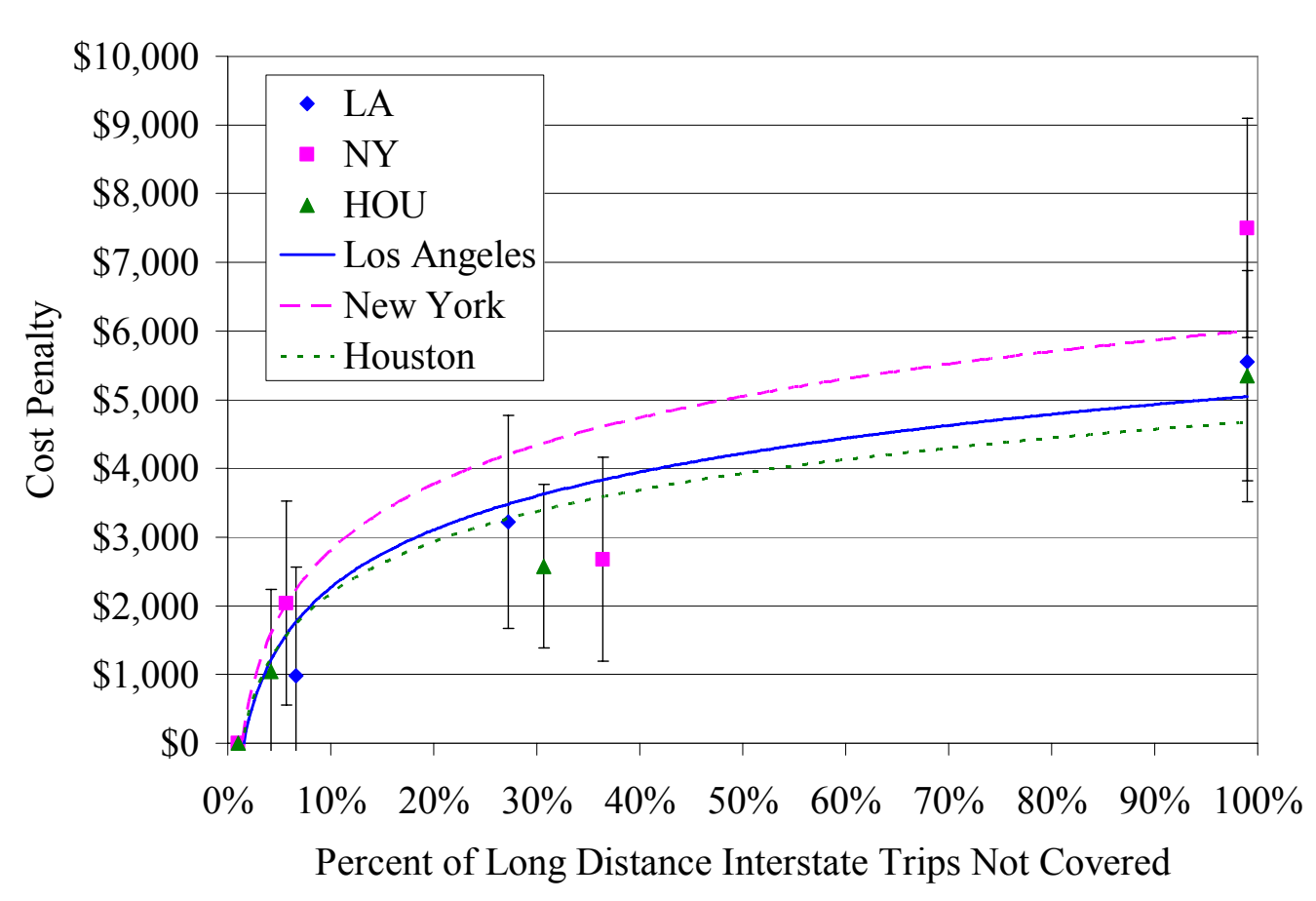
- Lower costs for higher population density: NY < LA < HOU
- Basis is percent of sufficient stations (less than existing stations).

Results: Regional Cost Penalties Follow Exponential (LA) and Power (NY, HOU) Trends



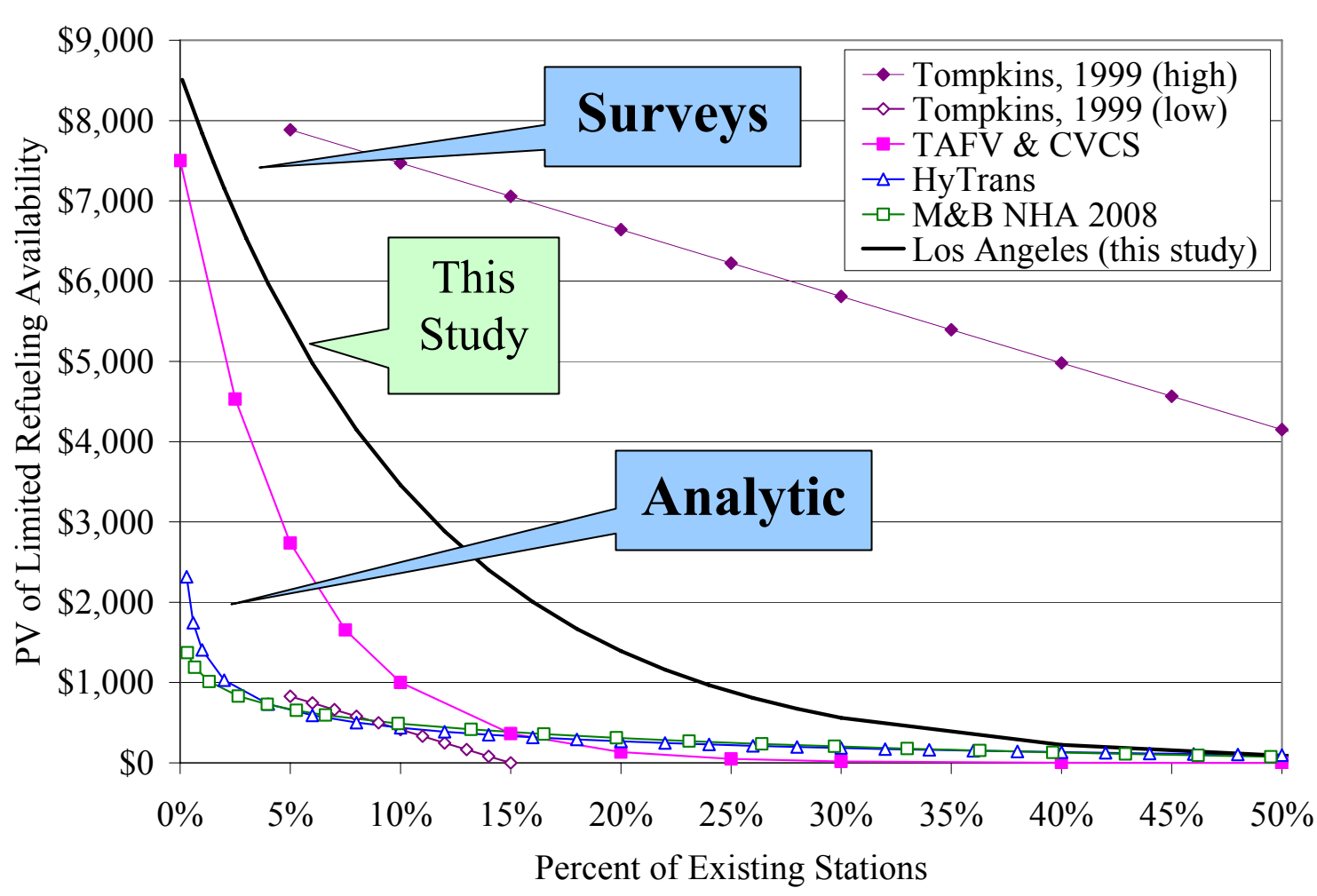
Higher cost penalties for LA warrant additional survey work to understand preferences for regional availability.

Results: Significant cost penalties ($1000-$2000) remain even for long, infrequent trips



Note the inverted basis: long distance trips *not* covered

Results: Metro cost penalties are high relative to comparable studies



At 10% of existing stations, cost penalty is $3000 - $4000

Future Work

Motivation for analysis of additional urban areas:

- We would like to have a *general* cost penalty function that can be extrapolated to a large number of major urban areas.
- Penalties may vary between different city sizes and densities.
- Some geographic levels could not be valued with statistical significance

Analysis of preferences in four additional urban areas:

  - Seattle, WA
  - Minneapolis – St. Paul, MN
  - Atlanta, GA
  - Washington, DC

  These four cities were chosen based upon their range of sizes and population densities.
- Expect results of additional surveys within 4 months of signing new subcontract with PA Consulting

Summary

- Consumer cost penalties for limited refueling availability are higher than those reported in most other studies
  - $3000-$4000 for 10% coverage of existing urban stations
- The penalties for limited coverage at regional and interstate/national scales are comparable to those at the metropolitan area scale
- Cost penalties are probably exaggerated because they are based upon **stated preference** survey results
- Additional research is required to reconcile penalties based upon **stated preferences** and **analytic derivations**
- High cost penalties associated with limited refueling availability would provide a strong justification for financial support of more extensive hydrogen station networks for early vehicle markets