XI.2 Siting Strategies for Early H_2 Refueling Infrastructure in California: Learning from the Gasoline Experience

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Overall Objective

Provide analysis to support hydrogen and fuel network development.

Fiscal Year (FY) 2013 Objectives

- Determine the minimum number of stations necessary for the maximum number of customers to reduce investment necessary.
- Analyze strategies for early hydrogen fueling station placement, numbers, and network development to enable fuel accessibility for initial rollout of hydrogen fuel cell passenger cars.
- Conduct case studies for H_2 fuel cell vehicle rollout in California utilizing geographic information system (GIS)-based analysis for station siting and consumer convenience from the perspective of the network.

Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

(A) Future Market Behavior

(C) Inconsistent Data, Assumptions and Guidelines

(D) Insufficient Suite of Models and Tools

Contribution to Achievement of DOE Systems Analysis Milestones

This project will contribute to achievement of the following DOE milestones from the Systems Analysis section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- Milestone 1.20: Complete review of fuel cell and hydrogen markets. (4Q, 2011 through 4Q, 2020)
- Milestone 1.4: Complete evaluation of fueling station costs for early vehicle penetration to determine the cost of fueling pathways for low and moderate fueling demand rates. (4Q, 2012)

FY 2013 Accomplishments

- Assessed alternative strategies for introducing fuel cell vehicles and H_2 infrastructure in Southern California over the next decade to satisfy the California Zero Emission Vehicle regulation. Considered station placement, number, size, and type of stations.
- Assessed tradeoffs in terms of convenience from the home and while travelling around the Los Angeles region.
- Presented results in reports and talks at meetings.
- Collaborated with California Fuel Cell Partnership (CAFCP) and other stakeholders and analysts.

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INTRODUCTION

What constitutes a sufficient hydrogen network to initiate a market launch of vehicles has evolved over time. Most approaches have centered around a percentage of stations—for example, "a network should have 10% of existing gasoline stations offering an alternative fuel" or similar. However, such a transformation has an inherent boundary problem. Would this mean 10% of stations in a state? In the entire world? A city? This paper attempts to decouple the percentage of stations from the area which is being studied into the important metrics that the percentage is supposed to embody. In this way, smaller areas can be considered for market launch, and the capital outlay can be reduced.

APPROACH

In order to explore how many stations are needed for a market launch, we considered a likely early market area, Los Angeles, and examined the necessary number of stations from two perspectives important to owners and drivers: distance of the station from home (Figure 1) and distance while travelling around (Figure 2). For this study, we looked only at likely market deployment areas in Los Angeles by the California Fuel Cell Partnership which we called “market clusters” (Figure 3) and examined the population and traffic patterns for which these clusters were responsible. If this strategy can provide convenience for those vehicle owners based on these metrics, then a more far-reaching percentage of stations is not needed.

RESULTS

Clustering demand reduces the number of stations that are required to satisfy a given number of customers. Restricting stations solely to clusters has no detrimental effects on home-based refueling, but it reduces regional mobility. Although the majority of refueling is local, smaller stations that enable travel throughout the region, and perhaps in nearby regions, provide flexibility in planning how to refuel and ease the fear of running out of fuel.

Redundancy and reliability can be addressed in several ways. First, the number of stations can be increased. Second, backup capacity in the form of mobile refuelers can supplement the network when stations go down. Third, the redundancy and reliability concerns can be ameliorated with an integrated navigation and refueling information system.

The minimum number of stations per cluster in the scenarios is two to provide redundancy in the case of a station failure. However, the number of stations necessary for convenience in each cluster needs to be evaluated for every cluster separately. Generally, customers are currently about one minute away from their nearest gasoline station. Siting two hydrogen stations in downtown Los Angeles results in a 2.1 minute average travel time, whereas siting two stations in the Torrance cluster results in a 3.7 minute average travel time to a station. Creating parity in the number of minutes to the nearest station among regions may be more important than creating parity in the number of stations among clusters. As mentioned before, the size of the area in which vehicles are marketed could be reduced to bring parity in terms of travel time from home to station.

Varying the number of clusters from four to 12 presents some interesting tradeoffs given a fixed number of stations. Given 16 stations, and the choice of four, six, or eight clusters, the anomalous drop in home to station time because

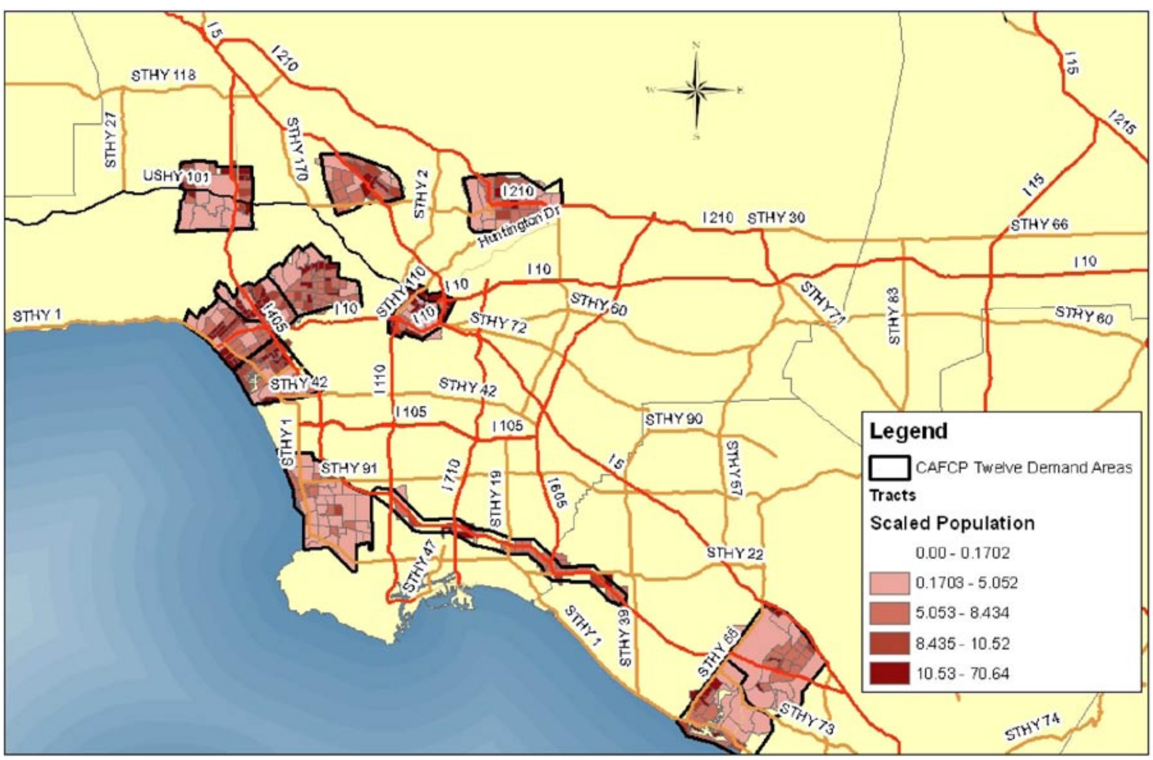

FIGURE 1. Population distribution scaled within the clusters so that each cluster represents the same number of people. Population is a proxy for attractiveness of vehicle placement. Having each cluster represent the same number of vehicles implies that each cluster is equally attractive.

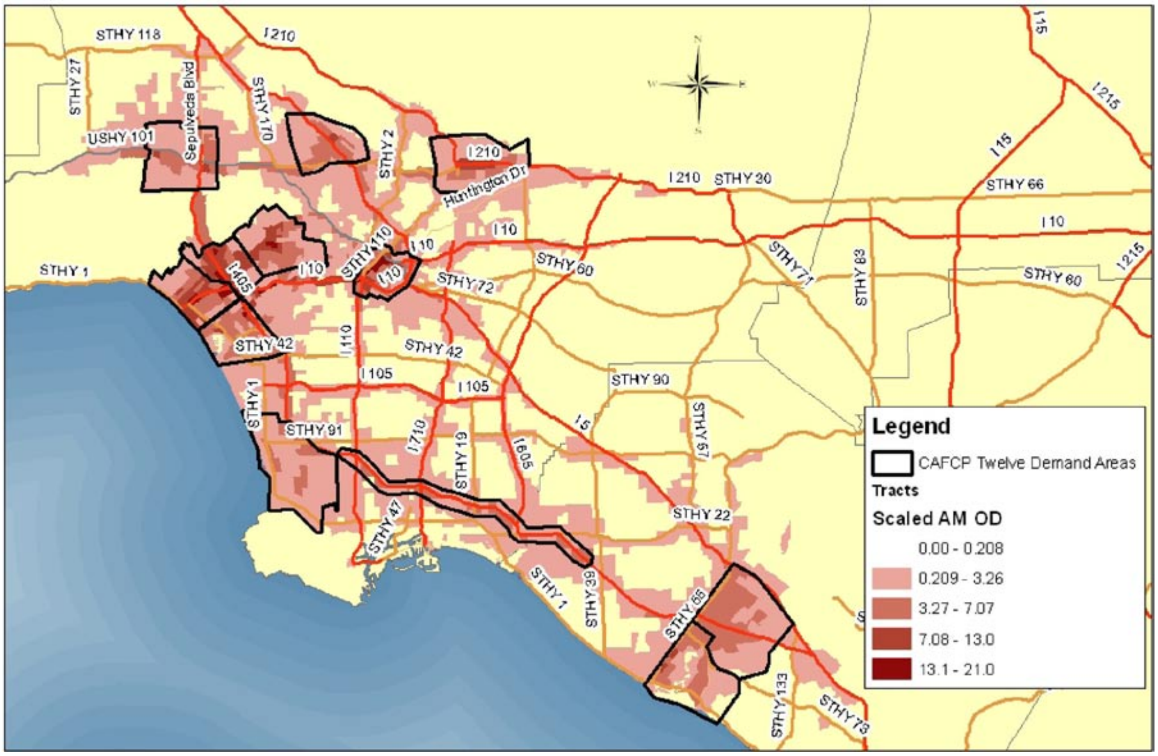

FIGURE 2. Scaled vehicle miles traveled using only trips originating within the 12 clusters during the AM period. Data were aggregated to census tracts and display was normalized by tract land area.

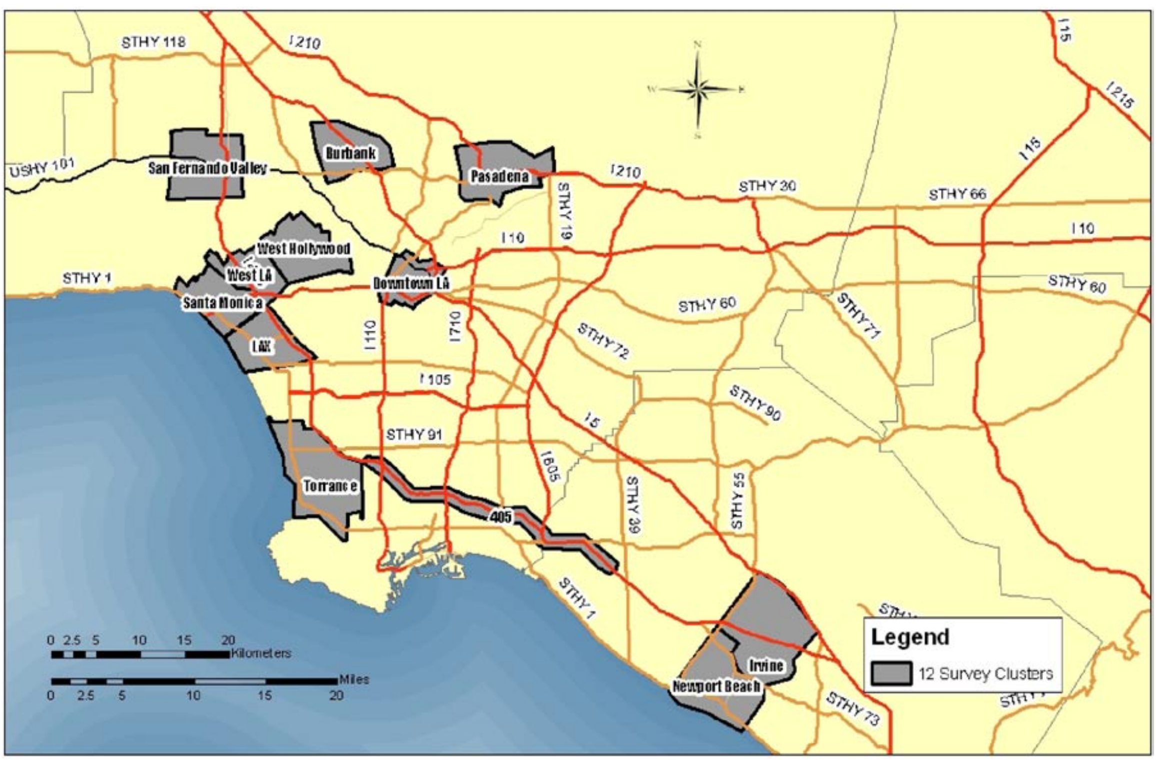

FIGURE 3. The shaded regions define the possible clusters where vehicles will be placed.

of Irvine notwithstanding, adding connector stations reduced diversion time more than adding new clusters. However, it is recognized that adding stations where there are not future market clusters presents a problem with finding partners to help site and construct the station. Stations sited outside of future market clusters may also not find a sufficient load to make them cost-effective. Therefore, a strategy of siting connector stations in future market clusters may be the most effective strategy. Interestingly, using the traffic from the four-cluster scenario, some connector stations fell into future market areas such as downtown Los Angeles, west Los Angeles, and the I-405 corridor, pointing to a possible bridging strategy to progress from rollouts in one cluster to the next.

CONCLUSIONS AND FUTURE DIRECTIONS

Overall, we find that a cluster strategy provides good refueling convenience and reliability with a relatively small number of strategically placed stations, reducing infrastructure costs. There are some limitations to this work in that it relies solely on modeling of people's needs rather that surveying respondents. We expect to find that customers would like a few stations placed far away from home for infrequent but very important trips. However, for most driving, the cluster strategy is a promising path towards reducing initial infrastructure needs in terms of total number of stations needed.

Future work

- Extend the California rollout analysis to analyze H_2 infrastructure build-out in other U.S. regions.
- Determine the market for hydrogen vehicles as a function of distance from station.
- Examine clusters that grow organically rather than decide them a priori.

FY 2013 PUBLICATIONS/PRESENTATIONS

1. Michael Nicholas and Joan Ogden, "Analysis of Rollout Strategies for Fuel Cell Vehicles and Hydrogen Infrastructure in California," presented at the UC-DOE Hydrogen Technical Advisory Committee Meeting, November 15, 2012, Alexandria, VA.

2. Joan Ogden and Michael Nicholas, "Tools for Modeling Rollout Strategies for Fuel Cell Vehicles and H2 Infrastructure," presented at NREL Hydrogen System Analysis meeting, March 12, 2013.

3. Joan Ogden, "Design and Economics of an Early Hydrogen Refueling Network for California," USDOE, project an032, Hydrogen and Fuel Cells Annual Merit Review, Arlington, VA, May 14, 2013.

4. Michael Nicholas, "Siting Strategies for Early H2 Refueling Infrastructure in California: Learning from the Gasoline Experience," project an031. USDOE, Hydrogen and Fuel Cells Annual Merit Review, Arlington, VA, May 14, 2013.