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RESEARCH PAPER

Policy Implications of Incorporating Hybrid Vehicles into High-Occupancy Vehicle Lanes

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Abstract: High-occupancy vehicle (HOV) lanes have been regarded as a cost-effective and environmental friendly option to help move people along congested routes. In spite of wide adaptation of policies, the effectiveness of HOV systems has been criticized for its under-utilization. A California statewide policy that allows hybrid vehicles to use HOV lanes was adopted under the expectation that vehicular emissions would be reduced by encouraging drivers to use fuel efficient vehicles as well traffic congestion would be eased through the more efficient use of the reserved capacity on the HOV lanes. To test the validity of this expectation, the impacts of the policy on the freeway network in Orange County, California was investigated using a method that combines a traditional planning model for demand estimation and analysis with a calibrated microscopic simulation model for accurate measures of system performance. The policy was analyzed in terms of overall system performance, corridor level performance and air quality. The key findings from this study are that the policy can be expected to have significant negative impact on HOV lanes that do not have reserve capacity. The maximum number of hybrid vehicles that the Orange County HOV system can absorb without significant degradation is about 50,000, and within this limitation, the policy can be expected to be successful in reducing emissions by allowing hybrid vehicles into HOV lanes.

Key Words: urban traffic; high-occupancy vehicle; hybrid vehicles; micro-simulation; travel demand modeling; emissions

1 Introduction

Federal and State governments are investing billions of dollars in building and promoting usage of High-Occupancy Vehicle (HOV) lanes through various programs[1]. The main motive behind this policy is to better manage the transportation system, moving more people by buses and carpools, saving travel time, reducing congestion, and improving air quality. The Federal Highway Administration (FWHA) encourages the installation of HOV lanes as an important component of an area-wide approach to help metropolitan areas address the needs that the agency has identified for mobility, safety, productivity, environment, and quality of life. In recent times, HOV lane construction has become one of the major freeway improvement strategies. Many states such as California, which is the state with the longest HOV lane miles in the US, have demonstrated the effectiveness of HOV lanes and are in the process of completing the HOV lane network[2].

Despite wide adoption of policies relating to HOV facilities by many states, Metropolitan Planning Organizations (MPOs) and cities, one criticism to HOV lanes is that they are under-utilized[3]. Based on California Assembly Bill 2628 (AB 2628) passed on September 23, 2004 and the Federal Transportation bill passed on August 10, 2005, California allows the three most fuel efficient (45 mpg or higher) hybrid vehicles (i.e. Toyota Prius, Hybrid Honda Civic, and Honda Insight) to use HOV lanes, irrespective of number of occupants. This policy was expected to reduce vehicular emissions by encouraging drivers to use fuel efficient vehicles as well as ease traffic congestion through the more efficient use of the reserved capacity on the HOV lanes. As a statewide policy, it is applied not only to such regions as the San Francisco Bay Area, where there is substantial reserve capacity on HOV lanes, but also such regions as Orange County, CA, whose HOV lanes have almost reached their nominal capacity of 1,650 vehicles per hour, carrying an

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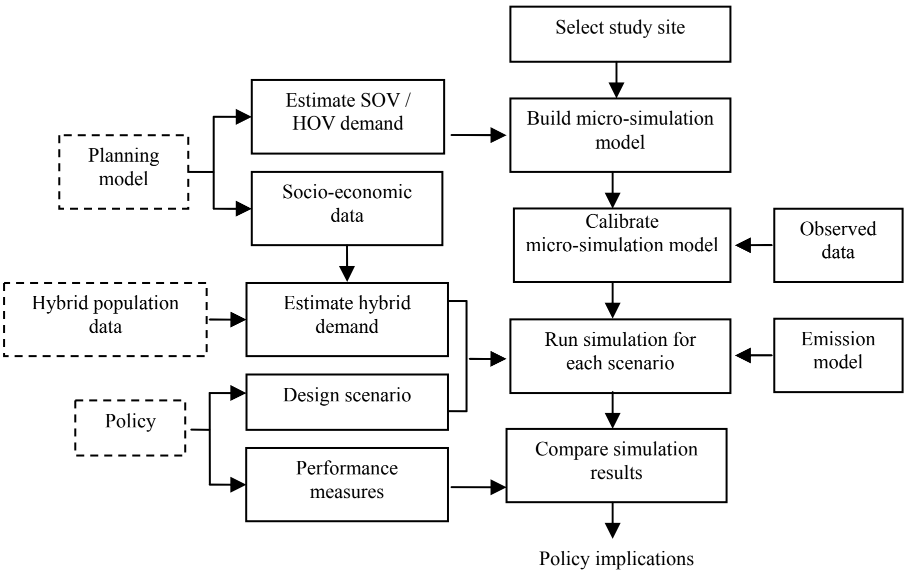

Fig. 1 Study methodology

average of 1,568 vph in 1998[4]. Hence policy makers are of interest to learn how this policy impacts the performance of the traffic system (both on HOV lanes and on general-purpose lanes).

Traditionally, transportation planning models have been used to evaluate possible impacts of a new policy. As HOV is a demand management policy that motivates solo drivers to switch to carpool, it is a candidate for such an analysis. However, HOV is also an advanced traffic management strategy because HOV drivers are capable of selecting HOV lanes or mixed-flow lanes based on traffic conditions. As a result, the hybrid-HOV policy in question could dynamically impact the whole traffic system and thus a planning-level study is not appropriate because it is an analysis that typically is based on BPR (Bureau of public roads) functions that cannot capture dynamic traffic condition and driver behavior.

Alternatively, with the advancement of computer technology and traffic modeling capability, microscopic simulation modeling has become an increasingly popular and effective tool for analyzing a wide variety of dynamic problems not amenable to study by other means. Microscopic traffic simulation emulates traffic systems at a level that includes detailed specification of roads, individual drivers, and vehicles. Micro-simulation has many applications, including ITS evaluation[5], construction management[6], operational improvement, emission[7], corridor management plan[8], traffic control studies[9,10], policy investigation[11], and so on. Similar to planning studies, it can guarantee the same demand pattern to be applied for both before and after the deployment of a policy to provide an objective evaluation. However, the limitation of the method is that evaluation results may be influenced by theoretical limitations of its base traffic models.

This paper proposes an improved method to evaluate the hybrid-HOV policy. The method combines a traditional planning method—used for demand estimation —with microscopic simulation modeling—used to provide accurate measures of the traffic system.

The remainder of the paper is organized as follows. Section 2 explains the methodology of the study, while Section 3 describes details of the simulation modeling of the study site. Section 4 designs several scenarios based on the hybrid-HOV policy and evaluates the results. Section 5 provides policy implications based on evaluation results. Section 6 concludes and discusses the limitations of the paper.

2 Methodology

The methodology adopted in this study is illustrated in Fig. 1. The study involved three important modeling components that are (a) microscopic simulation modeling; (b) demand modeling and (c) emission modeling. The microscopic simulation model for the study site was developed and then calibrated against the baseline traffic conditions. In the simulation model, the baseline demand was originally extracted from the regional planning model and then further fine-tuned using the Paramics OD estimator tool. Based on the California hybrid-HOV bill, different scenarios with different hybrid populations were designed and their corresponding hybrid demands were estimated. Then, the calibrated model was simulated under different scenarios and simulation results were analyzed and compared to show effects of the policy. This study also includes detailed emissions modeling to estimate accurate emissions. The emissions model employed in this study is a new generation model that can accurately