PROCEEDINGS OF THE NEIGHBORHOOD ELECTRIC VEHICLE WORKSHOP

UCD-ITS-RR-94-23

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Timothy E. Lipman

Institute of Transportation Studies
University of California, Davis
Davis, California 95616
916/752-6548 Fax 916/752-6572
http://www.engr.ucdavis.edu/~its

PROCEEDINGS OF THE NEIGHBORHOOD ELECTRIC VEHICLE WORKSHOP

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Workshop Organized and
Proceedings Edited by:

Timothy E. Lipman
Kenneth S Kurani
Daniel Sperling

Institute of Transportation Studies
University of California, Davis

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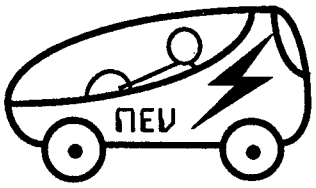

THE NEV LOGO

The Neighborhood Electric Vehicle logo on the cover of this report was designed by Sophia Pagoulatos as part of a joint City of Davis/ITS-Davis entry in a national competition: The Electric Vehicle and the American Community. The goal of the competition was to describe, in pictures and words, electric vehicle uses and infrastructure. She provides these comments on the logo design:

"The NeV logo is about the rediscovery of community. Symbolically, the NeV is an integral part of the house and family. Its purpose is to take people from their homes into that nearly-lost realm of the neighborhood. The NeV takes people to places that are close to home; the conventional vehicle often takes us somewhere else altogether.

The hand drawn character of the logo conveys simplicity. The NeV is small and quiet and plugs right into our homes and neighborhoods. It's clean. It's friendly. It's a lighter way to get around."

I. Overview

Neighborhood electric vehicles (NEVs) are small, very efficient EVs that are designed to be used for urban trips at relatively low speeds. They provide the potential for greatly reduced air pollution, energy use, petroleum imports, greenhouse gas emissions, and roadspace. Because they are very energy efficient, they are better suited to the limitations of today's batteries than are full-sized EVs designed for highway travel. As supplements to a household's group of vehicles, NEVs could be used for the vast majority of short trips. Because these trips account for a disproportionate share of emissions, NEVs provide even greater per-kilometer emission reductions than full-sized EVs.

The primary motivation for automakers to produce and sell EVs is the zero-emission vehicle (ZEV) mandate issued by the California Air Resources Board (CARB) in 1990. This mandate requires major manufacturers to produce and deliver for sale a number of ZEVs equal to 2% of their California sales in 1998. This percentage rises to 5% in 2001 and eventually reaches 10% in 2003. The northeastern states have requested permission from the U.S. EPA to adopt similar rules. Many NEVs qualify as ZEVs.

In addition to the ZEV mandate, other recent legislative acts contain provisions that encourage the production, sale, and use of EVs, including the 1992 Energy Policy Act (EPAct), the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), and the 1990 Clean Air Act Amendments (1990 CAAA). Also, new rules are being proposed that would allow EVs to be included in calculations of manufacturer's Corporate Average Fuel Economy ratings.

In order to explore the potential for NEVs to help solve air quality, energy, and transportation problems, the Institute of Transportation Studies at the University of California at Davis conducted a one-day conference on June 30, 1994. The Neighborhood Electric Vehicle Workshop brought together leaders from industry, government agencies, and academia to examine the

technology, land use, infrastructure, policy, and marketing issues surrounding the introduction of NEVs.

The specific goals of the workshop were to:

1. Identify the primary regulatory and physical barriers to the introduction of NEVs;

2. Initiate the building of coalitions to advance the development of NEV policies, support infrastructure, and marketing efforts;

3. Explore the links between transportation and land use which hinder or aid the NEV concept;

4. Discuss the role of continued and expanded NEV demonstrations and market research programs;

5. Exhibit and discuss the latest NEV technologies and vehicle designs; and

6. Establish an action agenda to promote continued NEV development and implementation.

The workshop was divided into four main sessions and a final open forum session. Each session included at least three presentations in order to provide a range of views on each session topic. The workshop concluded with an open forum session, in which all participants were invited to discuss their views on the subjects raised during the earlier sessions.

This report is a summary of the Neighborhood Electric Vehicle Workshop. It is organized into eight parts. The first is this overview. The second is a summary of the key topics and discussions of the workshop as a whole. The third through sixth parts summarize the presentations in each of the four main sessions. These summaries are editorial versions of written reports by the authors, or modified transcripts of the actual presentations. The seventh is a transcript of the final open forum session. The eighth and final part is an appendix that includes the workshop agenda and information on participants and presenters.

II. Summary of Key Topics and Discussions

The Neighborhood Electric Vehicle Workshop was carefully designed to explore the essential issues facing the introduction of NEVs into communities in the U.S. The workshop was divided into four primary sessions, and a final session that included a panel discussion, an open forum, and an action agenda discussion. The four primary sessions were:

1. Initial Questions and Issues: What is a NEV?
2. Land Use and Infrastructure for NEVs
3. New Market Opportunities for NEVs
4. Regulatory Issues for NEVs

Session One: Initial Questions and Issues

The workshop commenced with a session addressing the basic question: "What is a NEV?" The first speaker, Dr. Paul MacCready of AeroVironment Inc., articulated the broadest view of the character of these vehicles. He interprets NEVs to be the subset of all vehicles that are more than bikes but less than cars. Such vehicles would include electric-assist bicycles, as well as a variety of other low-speed vehicles. Dr. MacCready emphasized that it takes very little energy to move a person from one point to another, and that NEVs are well-suited to the limitations of current battery technology. According to Dr. MacCready, the future of NEVs is complicated by two factors. First, there is such a wide variety of possible NEVs. Second, NEVs have to fit into a system that, at least in the U.S., is totally dominated by full-sized cars.

The second speaker to discuss the form and function of the NEV was Mr. William MacAdam of the Trans2 Corporation. Mr. MacAdam discussed the multi-use vehicle that Trans2 will soon be producing. This vehicle is a low-speed, two-passenger NEV that is targeted for sale in golf cart communities and other areas where it can be safely operated. Such other areas may include other resort communities, those with privately-owned roadways, amusement parks, other recreational facilities, and other areas where long driving ranges are not necessary and the benefits of NEVs are highly desirable. In Mr.

MacAdam's view, NEVs are low-speed vehicles that are marketable because they provide benefits that conventional vehicles do not offer. These benefits include an absence of "tailpipe" emissions, ease of operation, low noise, and low maintenance.

Mr. Kevin Gunning presented a detailed account of the vehicle that Amerigon is producing as part of the CALSTART NEV program. The Amerigon vehicle is of a somewhat different character than the vehicles described by Dr. MacCready and Mr. MacAdam in that it can be operated on freeways for short distances -- perhaps a few miles. As Mr. Gunning explained, such vehicles may have greater market appeal than vehicles that are limited by speed constraints to surface streets This may be particularly true in southern California where, as CALSTART has said, "the freeway is part of our neighborhoods." One appeal of the Amerigon vehicle is that it can be configured into different forms for different uses -- a utility vehicle, a low-speed vehicle for resorts or retirement communities, or a sport-image vehicle.

Session Two: Land Use and Infrastructure for NEVs

The second workshop session focused on the interplay between land use planning and transportation infrastructure design with regard to the potential for encouraging the use of NEVs. Mr. Michael Replogle of the Environmental Defense Fund stressed the opportunities created by recent legislation for the development of integrated and mutually supportive initiatives to reduce air pollution and promote energy efficiency. The Clean Air Act of 1990, the Intermodal Surface Transportation Efficiency Act of 1991, the Energy Policy Act of 1992, and the National Climate Action Plan of 1993 have provided the potential for major structural reform and technological innovation in transportation planning and implementation. Reforms might include the substitution of more efficient vehicle types, such as neighborhood vehicles, and the use of renewable energy for transportation propulsion. Mr. Replogle stressed that NEVs alone are not the answer to all of our transportation problems, but suggested that they could help us to achieve significant reductions in emissions of criteria pollutants and greenhouse gases, greater energy efficiency, and the development of "livable" communities. These socially desirable ends could be achieved if the

introduction of NEVs was coupled with goal-oriented IVHS programs, demand management strategies, and infrastructural and transportation control measures aimed at providing a convenient and safe environment for NEV use.

Professor William Garrison of the University of California at Berkeley brought to the session 20 years of experience in researching the potential use of neighborhood vehicles. He suggested that NEVs have not been successfully introduced to date due to both a market and a supply failure. A fundamental problem is that the valuable externalities of small, efficient vehicle production -- such as better neighborhoods and reduced pollution, congestion, and fuel use -- cannot be used by producers to offset their costs. Professor Garrison also suggested that an underlying problem has been the elusiveness of champions for small vehicles. He believed in the 1970s that simply pointing out the benefits of neighborhood vehicles would be sufficient to lead to implementation. Failing this, the 1980s brought hope that the goal of reducing petroleum dependence would be an adequate stimulus. Now, Professor Garrison hopes that highway agencies will be the leaders, but is concerned that the lack of an immediate pay-off to those in key decision-making positions may continue to be a problem. Ultimately, the potential that NEVs offer will only be realized through cooperation between vehicle suppliers, infrastructure providers, and regulatory agencies.

The session closed with a presentation by Mr. John Wohlmuth of the City of Palm Desert on the city's Golf Cart Transportation Program. This is a five year demonstration project authorized by an act of the California state legislature. It is intended to explore traffic and safety issues inherent in incorporating small, low speed vehicles into an existing transportation network. Since January 1, 1993, residents of Palm Desert have been allowed to use golf carts on city streets, aided by the development of specialized infrastructure to separate golf carts from other traffic, provide secure parking spaces for golf carts near store entrances, and provide recharging facilities in downtown areas. In 1993, the program included 80 participants who drove 120,000 miles with no accidents and a documented reduction of nearly 4 tons of pollutants. A questionnaire distributed to the participants in the program revealed that 95% of those surveyed provided positive comments about the

program and that 90% were not limited by the travel range of their vehicles. Palm Desert hopes to have a total of 500 registered golf carts by 1997.

Session Three: New Market Opportunities for NEVs

Mr. Albert Sobey placed market opportunities for neighborhood vehicles within the broader context of the future of transportation in the U.S. Mr. Sobey suggested that NEVs could play a valuable role in reducing energy use, particularly if coupled with other advanced transportation systems such as innovative transit and real time traffic management. Urbanized regions could reduce fuel consumption by 7% to 10% with the use of battery-powered neighborhood cars, according to Mr. Sobey, and the emissions benefits should be even larger due to the replacement of the majority of cold-start emissions.

The market research conducted on NEVs by ITS - Davis was presented by Dr. Kenneth Kurani. The concept of a household's "activity space" -- consisting of the locations and time schedules of its activities and the travel modes and routes used to access those activities -- has been used to investigate whether households can create a useful NEV activity space, as a prerequisite to including a NEV in its choice set for its next vehicle purchase decision. In the ITS - Davis study, NEVs were placed in households in Davis and Sacramento. Activity diaries and interviews were completed to explore the use patterns and general opinions of the vehicles. The ITS - Davis research concluded that while the lack of freeway capability is an important perceived purchase barrier, NEVs may find market niches in multi-car households if they are reliable and inexpensive to purchase and operate. NEVs would find their greatest potential in households with geographically compact activity spaces accessible by surface streets. New vehicle ownership arrangements would allow households to use NEVs without absorbing the risk of a new vehicle type (as station cars or employer-provided vehicles). Alternatively, the purchase of NEVs would also be more attractive if access to long-range, high-speed vehicles could be provided through cooperative arrangements or the expanded availability of rental vehicles.

Mr. William Warf of Pacific Electric Vehicles discussed the results of joint efforts with SMUD to study the market potential and technical merit of NEVs through the leasing of 34 City-el vehicles. The primary problems that users of

this three wheel, one seat vehicle have identified are poor ride and handling, low top speed, and high price. These results suggest that a four-wheel vehicle with room for two occupants and somewhat higher performance would have significantly greater market penetration potential. Mr. Warf elaborated the preliminary design specifications and energy budget of a new prototype. This four-wheel, two passenger vehicle would have a top speed of 40 mph and a weight of 390-440 kg. The provision of adequate passenger safety and compliance with the FMVSS is, in Mr. Warf's estimation, the primary hurdle to be overcome in the development of this vehicle.

Session Four: Regulatory Issues for NEVs

The final main session of the workshop focused on the regulatory environment surrounding the introduction of NEVs. Issues addressed included vehicle air quality impacts, safety, and liability. Mr. Thomas Evashenk of CARB's Mobile Source Division clarified the role of NEVs in helping to meet the goals of the ZEV mandate. Vehicles would qualify for ZEV credit under the mandate provided that they were manufactured for on-road use, employed zero-emission technology, and had four wheels. Three-wheeled NEVs could be certified as ZEVs in order to qualify for consumer incentives, but the production of such vehicles would not entitle the manufacturer to ZEV credits. CARB believes that NEVs can provide positive benefits in helping to meet the goals of the mandate, but feels that being too liberal in granting ZEV credits to NEVs might enable manufacturers to avoid producing full-sized EVs.

In addressing the potential energy and and environmental impacts of NEVs, Dr. Mark Delucchi of the Institute of Transportation Studies at UC Davis called for better and more sophisticated analyses of EV air quality impacts. Dr. Delucchi suggested that simple comparisons of the powerplant emissions generated by EV recharging with the tailpipe emissions of conventional vehicles are nearly meaningless from both social welfare and air quality regulatory perspectives. Since powerplant emissions do not in general occur in urban areas, the impact on human populations of a certain amount of pollution produced is not as severe as the impact of the same amount of pollution from tailpipes. More accurate and meaningful analyses, Dr. Delucchi argued, would compare full-fuel cycle emissions from both the

generation of electricity for EVs and the production, delivery, and use of petroleum for conventional vehicles. Such analyses should also take into account the spatio-temporal characteristics of emissions, particularly with regard to impacts on human populations. Dr. Delucchi concluded by stating that in his view NEVs would provide positive air quality and energy use benefits almost anywhere that they were used.

The issue of NEV safety was discussed by Dr. Frank Tokarz of Lawrence Livermore National Laboratory. All NEVs classified as passenger cars must either meet the Federal Motor Vehicle Safety Standards (FMVSS), or obtain temporary exemptions from any unmet standards, in order to be operated legally on public roads. Several of the FMVSS may prove problematic for NEVs, including standards on vehicle defrosting and defogging systems, steering wheel displacement, occupant crash protection, side impacts, and roof crush resistance. Exemptions to the FMVSS are available based on economic hardship, the demonstration of low-emission vehicles, and the existence of an equivalent level of safety; but these exemptions are temporary and the petitioner must state an intent to eventually comply with the standards when submitting a petition. The exemption based on the demonstration of low-emission vehicles would presumably be the most likely avenue for NEV manufacturers to obtain NHTSA compliance if all standards cannot be met. Lawrence Livermore National Laboratory has an ongoing project -- the Vehicle Impact Simulation Technology Advancement Project -- to develop computer crash simulation models for NHTSA. Also, LLNL is collaborating with CALSTART to do computer testing on Amerigon's "running chassis" vehicle, and to develop the Advanced Transportation Technology Assistance Center.

Finally, Mr. Armen Hairapetian of the law firm Lewis, D'Amato, Brisbois & Bisgaard discussed liability issues for NEV manufacturers. Mr. Hairapetian clarified the role of the FMVSS in protecting manufacturers from liability suits by pointing out that the FMVSS are minimum standards. Even full compliance with the FMVSS would not insulate a manufacturer from liability. Also, Mr. Hairapetian suggested that simply because NEVs would travel at relatively slow speeds does not mean that safety should not be addressed because many personal injury lawsuits result from collisions taking

place at speeds as low as 10 or 15 mph. The main areas of liability concern for NEV manufacturers would be defects in design and manufacture and failure to warn. A NEV would need to protect occupants to a reasonable level of safety, but to the degree that a vehicle was clearly less safe than a full-sized automobile, some degree of protection from liability could be afforded by warning consumers of the limitations of the vehicle. Mr. Hairapetian also pointed out that everyone in the stream of commerce for a product could be held jointly and severally liable for injuries resulting from the use of the product. Designers, manufacturers, and distributors could all be adversely affected by lawsuits, and adequate testing to assure occupant safety is thus of critical importance.

Session Five: Panel / Open Forum / Action Agenda

The final workshop session was designed to allow participants to question speakers on issues raised during the earlier sessions, and to provide an opportunity for all participants to discuss the future of NEV development and implementation efforts. The session commenced with a panel discussion moderated by Professor Sperling, and included an open forum and a discussion of a NEV action agenda. The primary issue discussed during this session was the liability risk for NEV manufacturers. This is a central concern because some NEV designs may operate under temporary exemptions from the FMVSS until more permanent exemptions or amendments to the standards can be obtained, or until the rules are changed to allow small, lightweight vehicles to operate without full FMVSS compliance. The issue of perceived versus actual risk was identified as a critical feature of the liability issue, with vehicles that clearly do not provide the same level of occupant protection as a full-sized vehicle being less prone to liability suits than those that would appear to provide the same level of protection. Thus, vehicles similar to bicycles or scooters clearly do not provide much occupant protection, and manufacturers would therefore be relatively free of liability in the event of occupant injuries resulting from the use of such vehicles. Vehicles that looked like cars, on the other hand, but did not provide much protection would expose manufacturers to greater liability risks. A large gray area would seem to exist that includes most NEV designs.

Other issues discussed during the final session included the difficulty of obtaining vehicle insurance at a reasonable premium level, the amount of insurance needed by NEV manufacturers to protect against liability suits, the role of further NEV demonstrations, possible conflicts between NEVs and bicycles, and opportunities to build coalitions with other interest groups with similar goals. A complete transcript of this session has been included in Section VII. Immediately after this final session, discussions continued informally and vehicle demonstrations were conducted.

Conclusion

NEV development and implementation is consistent with the thrust of recent legislative actions, including ISTEA, the 1990 CAAA, and the EPAct. The combination of technological advances and ever more stringent air quality regulations has provided an unprecedented opportunity to introduce lightweight EVs. These vehicles would provide significant environmental and social benefits wherever used; but regulatory, political, economic, and infrastructural barriers all conspire to constrain vehicle and modal diversity, promoting the continued dominance of full-sized conventional automobiles.

Two decades of research on neighborhood vehicles by William Garrison, Albert Sobey, Paul MacCready, ITS - Davis researchers, and many others suggests that NEVs could provide numerous direct and synergistic benefits. These include:

- reducing total emissions of hydrocarbons, oxides of nitrogen, and carbon monoxide;
- lowering energy consumption, diversifying energy supply options, and enhancing energy security;
- reducing greenhouse gas emissions;
- downsizing the land use and infrastructure demands of the automobile system;
- better integrating personal vehicle use with transit systems;
- making communities more "livable" by reducing noise, pollution, and high-speed travel; and

- creating a neighborhood environment conducive to even more economically and environmentally sustainable pedestrian and bicycle travel.

Obstructing the introduction of NEVs are: 1) a complex and rigid automobile regulatory environment, 2) a largely unknown and untested market, 3) potential liability risks for manufacturers, and 4) the need to develop specialized roadway infrastructure in areas where NEVs must comingle with faster moving traffic.

Market reasearch conducted by ITS - Davis and others suggests that NEVs can be well utilized in households with geographically compact "activity spaces" if they are affordable and reliable. If existing economic and convenience incentives are bolstered to offset initially high NEV purchase and ownership costs, then the regulatory and infrastructure issues could be methodically resolved. Communities particularly conducive to NEVs, such as Palm Desert, California, and other retirement and resort areas, could be the intial sites for the widespread introduction of these new vehicles. Other areas with amenable climates and topographies could follow.

The challenges associated with redirecting an automobile system that is dominated by a heavily entrenched and capitalized industry are considerable. However, new strategies are needed to counter the nation's escalating motor vehicle use, persisting urban air pollution, and continued dependence on petroleum fuels. We can take advantage of the opportunities offered by a new wave of transport technologies to achieve greater accessibility in our transportation system with reduced environmental and social impacts. Clearly, NEVs alone will not solve our transportation problems; but, if integrated with transportation demand management strategies, innovative land use planning, and expanded modal diversity, NEVs could play a key role in the transition to a more efficient and environmentally benign transportation system.

III. Session One: Initial Questions and Issues

What is a NEV?

Paul B. MacCready
Chairman of the Board
AeroVironment Inc.

Introduction

This presentation was aimed at setting the stage, according to a personal view, for the subsequent more specific papers. It employed video and slides, that cannot be reproduced here, to illustrate how efficient certain electric vehicles can be if developed with efficiency as a high priority item and how applicable they therefore become for certain use niches where zero pollution has high priority and the limitations of batteries for storing energy are not inhibiting.

An underlying theme is that providing mobility with less consumption of resources (money, time, roads, materials, energy) is a necessary aspect of a world that is desirable and sustainable. The NEV is a positive approach to the challenge. The introduction to the video that was shown, "Doing More With Much Less", is attached here as Appendix A. It explores some of the bigger issues. The video used a series of vehicles to illustrate the points: the Pathfinder, a solar-powered airplane for "eternal" flight in the stratosphere; the human-powered Gossamer Condor and Gossamer Albatross; a number of pedaled vehicles at a competition of the International Human Powered Vehicle Association; the Flying Fish pedaled hydrofoil; the solar-powered GM Sunraycer car; the GM Impact battery-powered car; AV's electric assist bicycles; the AV Pointer, a tiny, battery-powered surveillance drone airplane; sailplanes; and the solar-powered Solar Challenger airplane.

Where NEVs Fit in the Wide Range of Vehicles

Vehicles for surface transportation of people and goods range from wheelchairs to trains, powered by muscle, electricity or chemical fuel, operating on various surfaces, subject to various regulations and human needs and expectations. Within this broad matrix there is a subset of vehicles that are more than bikes, are less than cars, locally produce zero pollution because they are battery powered, and serve market/use niches for limited

purposes (neighborhood, errand, local travel, short ranges at low speeds) that do not require more energy than present batteries can provide. These NEVs (neighborhood electric vehicles) have obvious potentials in the U.S. and even more globally.

Exploring NEV's future is particularly complicated by two factors. First, the topic is somewhat confusing because there is such a large variety of possible vehicles and uses. Second, and more significant, in the U.S. NEVs must fit into a system dominated by cars. Anything different than a car does not initially fit comfortably. For a century, our cars, roads, housing, work, and habits have grown in a symbiotic relationship that now inhibits change. Introducing a battery-powered car into the system, or a CNG, methanol, or hydrogen-powered car, is relatively easy. The regulations, traffic lanes, safety, parking, etc. are the same as for a regular car.

To some extent the situation is similar for bicycles. They have accommodated to our car-dominated society, being operated cautiously where they avoid or at least minimize interaction with cars. An electric assist device to help power a bike does not change the situation, as long as it does not lure the bike operator to speeds or actions untypical of biking. The situation is similar for motor scooters and mopeds. They now have limited use niches in the U.S., which will be the same if battery power is substituted for the polluting 2-cycle motors that power them at present.

NEVs are usually considered to be 3 or 4 wheel, and fit between bicycles operated in limited niches and cars that meet Motor Vehicle Safety Standards (MVSS) and operate on freeways. There is confusion about whether at the upper end some 4-wheel vehicles that meet MVSS and can operate at freeway speeds but have short range are NEVs or just battery-powered cars. In any case they would provide ZEV credits for a manufacturer. My personal view is if such a vehicle does those things it will be competing with other small ZEVs that are produced in large quantity (such as Geo-Metro conversions) and that therefore are inexpensive. I suspect the NEV would be made in smaller quantity and thus not be competitive -- unless it deletes all the creature comforts that the marketplace has shown people tend to value.

In the U.S., liability problems, and traffic regulations and our traffic habits, create barriers to the commercial introduction of small electric vehicles limited to a speed of, say, 35 mph. Such vehicles do not fit comfortably with either bikes or cars. Globally there is probably a much more welcoming environment. In many cities of Southeast Asia, not yet dominated by cars, a whole range of vehicles from bikes to trucks and buses seem to operate companionably -- as long as a great deal of attention is paid to using horns.

Final Comments

In 1992, as AeroVironment moved into the electric assist bike area and began a test project with participants from Monrovia for the South Coast Air Quality Management District, we paid considerable attention to the problems of liability, regulation, and finding niches where the vehicles could be operated safely. We organized a small workshop on these critical non-technical challenges. An action item from that workshop was to hold a larger event in the future -- an event that considers all these items and additionally brings in demonstrations and commercial interests. This workshop at Davis is the larger event.

NEVs in some form are an essential part of our global transportation future. Just more cars cannot be the answer. Even if technology permits them to be zero polluting, safe, inexpensive, and everything a customer/user wants, their very attractiveness will exacerbate traffic and parking stresses, and contribute to more time wasted in commuting. Our future mobility will come from a system incorporating a range of vehicles; more mass transit; and ways of decreasing travel needs by car pooling, by 4-day work weeks and telecommuting, and by changing relationships between home, office, and recreation. NEVs probably have a significant role in this scenario, in the U.S. as well as other countries. It will be a long process to establish the satisfactory system. One obvious recommendation is to emphasize demonstration projects that deal not only with technology but also with users, infrastructures, regulations, etc. In other words, the real world. Such projects will be informative to all participants, and provide publicity for the practicality of the NEV concept.

Introduction to the video: Doing More With Much Less
Prepared for: Technology, Entertainment, Design (TED)-5
Monterey, California
February 25, 1994
By: Paul MacCready, AeroVironment Inc.

Doing more with less is so intrinsic to the explosively-growing information technology field that the concept scarcely needs new emphasis. However, this presentation looks at the subject from a slightly different angle -- a perspective relating to vehicles. The vehicles shown here being unusual, sometimes beautiful, and mostly big, provide a dramatic visual metaphor for the doing more with less theme -- a theme that is harder to visualize when showing a microprocessor getting smaller or more intelligent. But more importantly, the vehicles help us explore the theme where function precludes miniaturization -- where the care and feeding of the human body, rather than the mind, is considered.

A comment often made in the information technology field sets the stage. Electronic engineers note that if cars had been developed over the last two decades as effectively as the technology and economy of data bytes, the modern Cadillac would now sell for about one dollar. Unfortunately it would also be the size of a walnut -- inconvenient for transporting people (who strongly resist being miniaturized).

Vehicles that transport people and their goods emphasize the fundamental issue that our biological mass is at least as important as brains, the mind, and information. This mass is rapidly growing, as 250,000 more people inhabit the earth every day.*

In the long evolution of life on earth there have been occasional surges, transitioning life to a higher level of sophistication when some new biological feature supported exponential growth to another limit. These surges have been occurring at shorter and shorter intervals. We're in the

* A writer noted that we humans, plus our livestock and pets, now represent 97% of the mass of living animals on earth outside the oceans, with all natural wildlife totaling only 3%. Since humans and the animals they controlled probably were only a negligible percentage of the globe's animal mass before we started agriculture and civilization 10-15 millennia ago, we can declare ourselves the winners.

midst of one now, somewhat defined by the explosive exponential growth of non-biological information technology -- change so fast it can only be graphed on semi-log paper. There are no obvious limits to where improving computer power, interactive technologies, virtual reality, data compression and distribution, etc. will be taking our minds. But there is an associated challenge: the growth in numbers, demands, and needs of human bodies -- their transportation, feeding, housing and managing. Doubling times are a few decades, the growth can be plotted on linear graph paper, and the growth is squashing against limits. Civilization can't double population, feed everyone, and put 10 billion cars on new roads without severely stressing earth's resources (and without further disdaining the value of nature, and especially the animal world of which we humans used to be a part).

Computers and information can help us gentle the crunch, buy some time, by assisting technology to design and produce better yet cheaper devices, to put brains into products for making them more efficient, and to coax us to conserve (such as telecommuting instead of commuting). Thus information technology can help human bodies, but not fully solve the basic problem of the steady growth of bodies and appetites on a non-expanding earth. The keys to that solution are wisdom and foresight -- talents at present more in the province of humans than computers.

Anyhow, here's Doing More With Much Less, illustrated by efficient vehicles -- demonstrating a necessary (but not sufficient) feature of the shift toward a desirable, sustainable world.

All the vehicles shown in this video operate on relatively small power. Some are human powered, most are electric (photovoltaic energy and/or battery), one is an electric-human hybrid, while the sailplanes efficiently exploit atmospheric motion from the sun's heating of the earth. Even the vehicles that might be deemed "impractical", compared to conventional ones powered by burning fossil fuel, have a special value. The emphasis on efficiency that was forced on their designers generated new insights, attitudes and goals -- all underlying the development of those vehicles shown that have the potential for commercial viability.

It's a win-win-win situation for society, industry, and the individual consumer when practical "doing more with much less" vehicles get widely produced, purchased, and used to replace vehicles that serve customers and society less well.

What is a NEV?

William MacAdam
President
Trans2 Corporation

Four years ago, my partners and I formed a company to analyze the potential market for vehicles that would supplement an automobile. We began by asking whether all cars needed to be general purpose - that is - do everything: go fast, perform well at low speeds, carry 1 or 4 passengers, serve commuters as well as be used for vacations with cargo. Minivans, jeeps, and explorers all began life as a special or limited purpose vehicle, but in time added features until, eventually, these vehicles became general purpose vehicles and are used as cars most of the time. Today, vans, pick-up trucks, and sport utility vehicles together reportedly outsell cars. Who is kidding whom? These vehicles have become cars, but because of a quirk in the laws, they choose to be defined as trucks to avoid many of the safety and emission features required on cars. The picture was clear to us: any vehicle that we would develop would not be a car and could not be confused or mistaken as one - nor would it suggest car-like performance.

We wanted to create a small vehicle for low speed street use, but history has shown the consequences of what are viewed as diminished cars - they typically fail to sell in the volumes needed to sustain them. In Europe or Asia they may sell, but in the U.S. they become collectors items (i.e. Crosley, Rambler, Mini Cooper and Fiero). Three and a half years ago, we discovered a market for vehicles that could offer advantages to consumers as an alternative to a car - and by emphasizing its advantages over cars for short distance and low speed use, not by emphasizing that it is a small car. Simply making cars smaller creates problems for the operator. Calling these vehicles sub cars is troublesome because to the consumer a car is a car, regardless of its size.

Trans2 chose to build up rather than size down. We created a much improved bicycle or scooter rather than shrinking a car. For example, rather

than shrinking the size of the occupant space we expanded it. We went to 4 wheels for stability, designed a front wheel drive system for better handling and performance, and positioned the weight in such a manner to offer a low center of gravity and overall vehicle balance. We made our vehicles as tall as mini vans for good visibility of both the driver and other vehicles. We emphasize ease of entry and ease of exit. We made our vehicles fun to use, easy to use, and safe to use.

We emphasize safety by limiting speed and range. Trans2 vehicles are truly neighborhood vehicles. They are compatible with the environment in which they will operate. They are compatible in terms of speed (they go just fast enough) and compatible in terms of range (they go far enough).

Where are these vehicles to be used? They will be used in neighborhoods and within communities wherever the streets do not exceed 25 mph. Where does this environment exist? It exists in neighborhoods, resorts, college communities, campuses, and retirement communities. Is this is a limited market? You bet it is! But so were the first calculators, personal computers, and microwave ovens. Will it remain limited? Who knows. We do believe that to succeed, the market will demand vehicles designed for special circumstances. Needs create markets, not mandates. Choices expand them. Customer satisfaction sustains them. After 3 1/2 years of product development that has included 3 generations of prototype vehicles, clay modeling, design, and engineering for testing and demonstration, Trans2 has created a vehicle that matches the technology needed to satisfy the use and the price and the environment in which it is used.

Don't think of Trans2 vehicles as golf carts. What Trans2 has created is a multi-use vehicle that can be used on roadways in neighborhoods as well as on golf courses. Our multi-use vehicle will be supplemented in the future with other models and will serve market niches in which we can satisfy a market need. You can see our vision today - it is sitting outside and before the day is over you can drive it.

What is a NEV?

Kevin Gunning
NEV Program Manager
Amerigon

Note: This summary has been prepared from an outline provided by the presenter.

The definition of a neighborhood varies in relation to land use patterns and the level of urbanization and infrastructure development. As a result, neighborhood electric vehicles (NEVs) can be of different designs depending on the environment in which they are to be used. In closed communities, NEVs need not have freeway capability or high top speeds. In many California metro areas, however, it may be difficult to access some "neighborhood" activities without the use of freeways. In these areas, NEVs with freeway capability would have the greatest market appeal.

As part of the Amerigon NEV program, extensive discussion took place with regard to the nature and design characteristics of key NEV attributes. While freeway capability was not seen as essential in all areas, this feature was deemed desirable. The discussion resulted in the identification of the following essential vehicle characteristics: a top speed of at least 60 mph, a range of 60 miles, compliance with all FMVSS requirements, and a seating capacity of two adults and two teen-age children.

The styling of the Amerigon vehicles is shown in figures 1 through 3. The vehicle has three battery packs, rear wheel drive, and a 2-door hatchback configuration. An extruded aluminum space frame has been used to take advanage of lower tooling costs, light material weight, and ease and quickness of modification if necessary (figure 4). The vehicle has four wheel independent suspension and the weight of the batteries and drive train has been distributed throughout the vehicle. Two battery packs are located under the front seats, one battery pack is under the hood, and the motor and controller are in the rear (figure 4).

The vehicle body shell was modeled in clay, and then was digitized and analyzed with a computer. The vehicle frame was analyzed for strength and was also optimized to fit with the body structure (figure 5). A key project focus was the ergonomic layout of the vehicle interior. Full size tape layouts were done to verify the vehicle would fit a 5% female to a 95% male in front, and up to a 70% male in the rear (figure 6). The complete instrument panel design includes seven basic pieces, and layouts were done to verify proper positioning of all controls. Interior test bucks were done to collect feedback on desired seating positions and control positions (figure 7).

To verify proper aerodynamics, a 1/4 scale clay model was prepared. This model was tested in the aero lab at Caltech with and without spoilers, using smoke and tufts to help visualize air flow (figures 8 to 10). The overall drag coefficient was measured at 0.31. Dynamic stability and roll and yaw couplings were also checked, and better yaw coupling was observed with the spoiler than without.

The vehicle has been designed to use recyclable body panels. Generally, the vehicle is environmentally "friendly" and uses low cost tooling. Economics show favorable cost tradeoffs for low volumes of less than 10,000 or 20,000 vehicles per year when compared with conventional designs. The vehicle is designed to be affordable, practical, and fun (figures 11 and 12).

Figure 3: Standard NEV configuration for general urban use

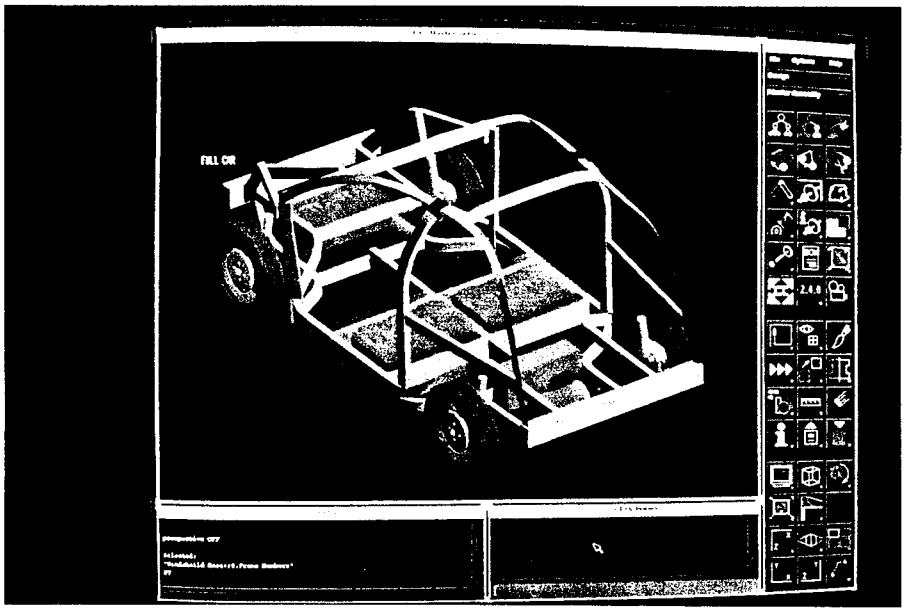

Figure 4: Computer graphic showing frame design, suspension, and drive components

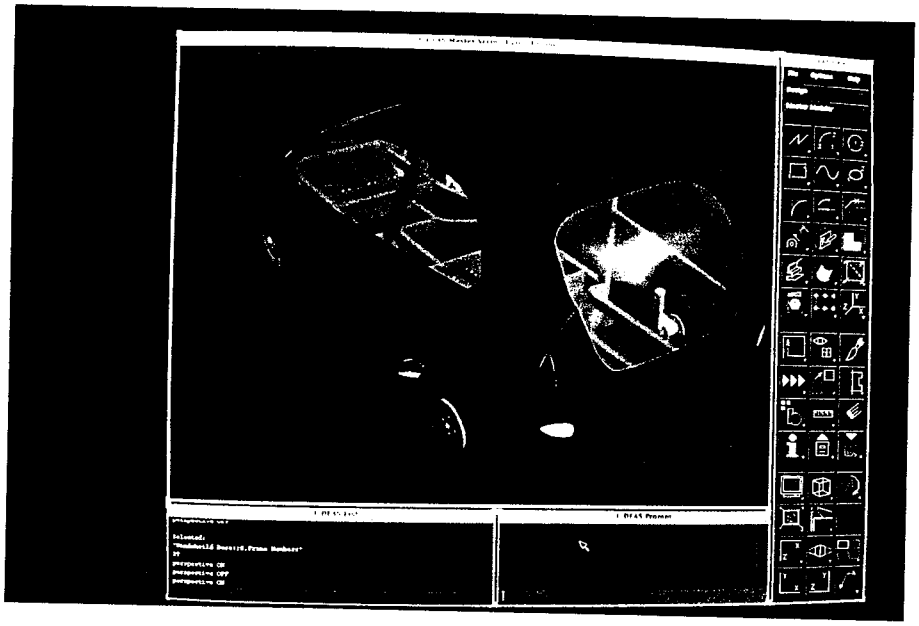

Figure 5: Computer graphic showing optimization of frame with body structure

AMERIGON

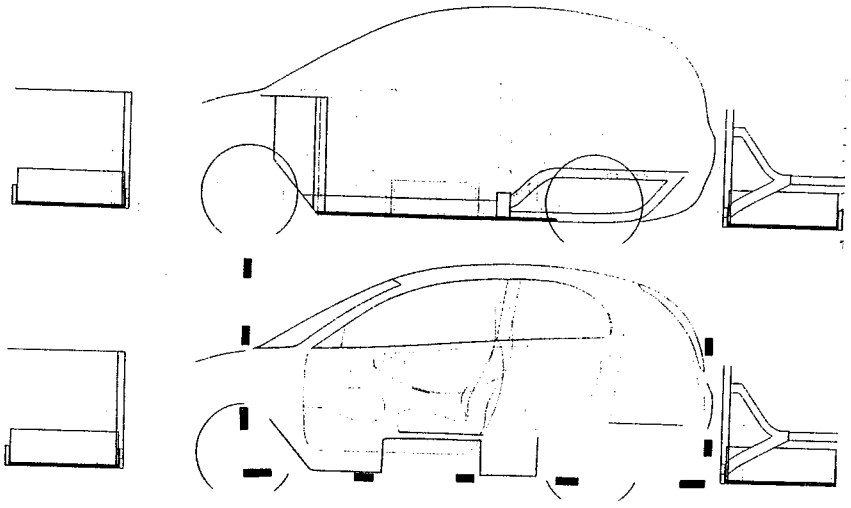

Figure 6: Drawings developed to evaluate driver and passenger ergonomics

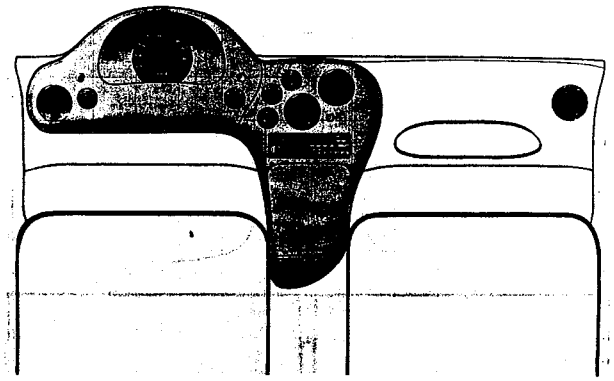

Figure 7: Full-size tape drawing of instrument cluster and console

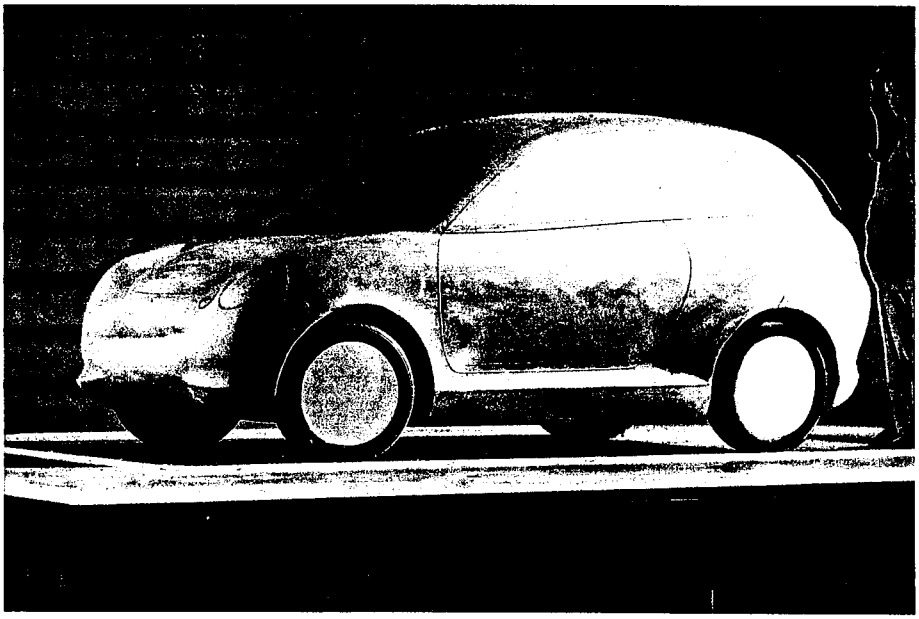

Figure 8: One-quarter scale clay model

AMERIGON

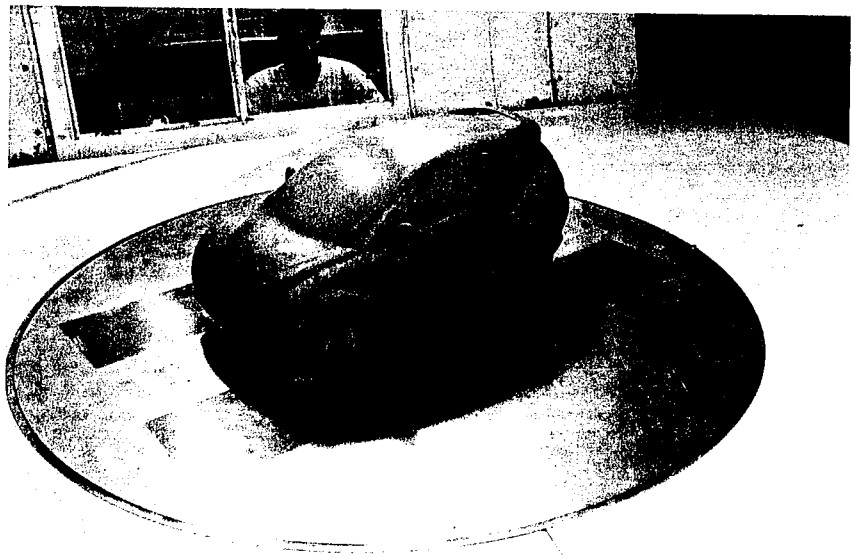

Figure 9: Aerodynamic testing (spoiler #2 @ 10 degrees)

AMERIGON

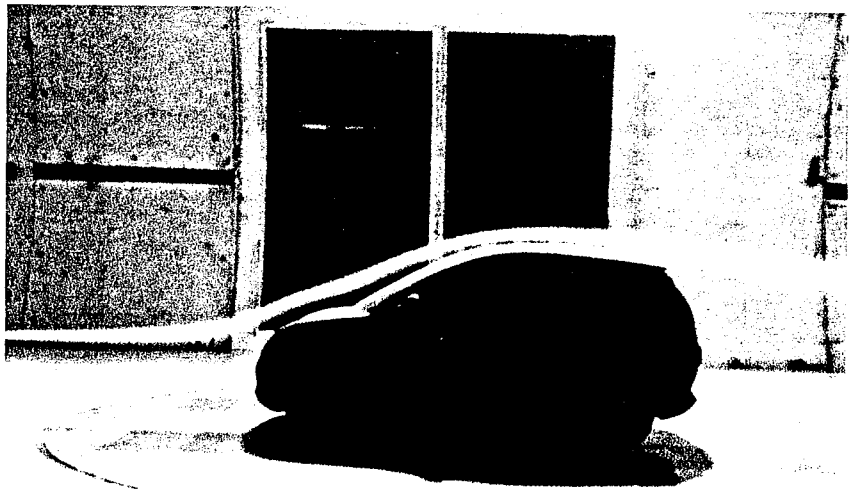

Figure 10: Aerodynamic testing (spoiler #1 smoke visualization)

IV. Session Two: Land Use and Infrastructure for NEVs

Some Thoughts on the Future of Neighborhood Vehicles in America

Michael Replogle
Transportation Project Co-Director
Environmental Defense Fund

Timothy E. Lipman
Institute of Transportation Studies
University of California, Davis

Introduction

Making transportation more environmentally and economically sustainable will require major innovations in how we apply information, communications, and propulsion technologies to transportation, as well as reforms in system pricing, street space allocation, and land use policies. This paper discusses some ideas about the relationships between these and how the market for small Zero Emission Vehicles (ZEVs) and neighborhood electric vehicles (NEVs) might be affected by other innovations and reforms affecting transportation and land use. NEVs include hybrid vehicles with low tailpipe emissions as well as the lightest motor vehicles -- electric-motor assist bicycles and tricycles.

More environmentally efficient and innovative vehicle types including electric, flywheel, hydrogen, and hybrid systems powered from renewable energy sources offer long-term promise to reduce greenhouse gas emissions and U.S. dependence on imported petroleum in coming decades. However, a combination of factors have seriously weakened modal diversity and reduced consumer choice in transportation and land use across America in recent decades. These include large hidden subsidies encouraging sprawl and automobile-dependence; the failure of the market to capture substantial externalized costs of fossil fuel use; regulatory policies that have reduced diversity in public transportation, urban design, and vehicle design; and infrastructure system design and management policies hostile to non-motorized transportation. Substantial gains in motor vehicle efficiency have been used not to reduce resource consumption, but to increase the average horsepower of vehicles in use.

In the context of this subsidized and protected market, the Clean Air Act (CAA) Amendments of 1990 established the "California Car" ZEV mandates to guarantee a minimum market size for alternative clean propulsion technologies. This may provide the foundation for more sustainable transportation industries of the 21st century. The ZEV mandate will not solve our transportation or air quality problems but is playing a useful role in promoting development of new technologies and stimulating consideration of market-based mechanisms for reducing air pollution emissions.

The effects of the ZEV mandate will depend on many contextual factors. Technological advances including ZEVs, Intelligent Vehicle Highway Systems (IVHS), and telecommunications and information system technologies will all be needed to help make transportation more efficient and sustainable. These are important to help us increase vehicle energy efficiency, manage growth of travel demand through pricing, and increase safety and community livability by limiting vehicle speeds to those that are safe and optimal for the operating environment.

Context for Introduction of ZEVs and NEVs

The U.S. transportation sector is facing prospects for major structural reform and technological innovation in coming years. The CAA of 1990, Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), Energy Policy Act of 1992, and the National Climate Action Plan of 1993 offer many expressions of these themes. In the framework of "sustainable transportation," ideas for a multi-modal long-term least cost framework for transportation and land use are being articulated, as occurred in the electric utility industry in the 1970s and 1980s. States and regions are beginning to wrestle with how to better coordinate transportation and land use policy, considering pricing reforms in transportation, and restructuring air quality and transportation planning and decision-making. The context for introduction of ZEVs in the late 1990s is thus a changing marketplace ripe with opportunities for mutually supportive public policy and private sector initiatives.

Several trends and forces are likely to influence the market for ZEVs and the potential for small neighborhood ZEVs in particular over the next two decades:

- Increasing specialization of household vehicle fleets, with lower initial vehicle acquisition costs and higher per trip and per mile operating costs, and gradual movement towards full-cost pricing of transportation.
- Increasing use of "smart systems" in transportation and community life, as information and communications technologies foster changes in the management of traffic, transit services, and goods movement for greater safety, convenience, and efficiency in resource utilization.
- Increased pressures for CO_2 emissions reduction which will favor increases in motor vehicle efficiency, vehicle downsizing, travel demand management, and development of renewable energy sources, with reduced dependence on fossil fuels.

Transportation and Global Warming

The Problem

An issue of growing concern to many around the world is the prospect of rapid and highly disruptive climate change caused by a buildup of "greenhouse gases," such as CO_2, an odorless and colorless gas that is the largest component of petroleum-fueled motor vehicle exhaust. Global warming threatens to cause large economic, social, and environmental dislocations and damage, stimulating major geopolitical instability in coming decades and potentially destroying large ecosystems. Anticipated increases in average surface temperatures of the Earth range as high as 2-5 degrees Centigrade over the next century. At a minimum, rising sea levels and attendant coastal erosion and storms will impose growing economic and human costs. United Nations scientists have estimated that an immediate 60% reduction in greenhouse gas emissions would be needed just to stabilize current greenhouse gas levels in the atmosphere.

The U.S. is one of the largest contributors of CO_2 and its transportation sector accounts for more than a fourth of its anthropogenic CO_2 emissions. Rapid

growth in VMT in the 1980s caused transportation related CO_2 emissions to grow faster than other major anthropogenic sources of CO_2. In 1985, the transport sector consumed 63% of all oil used in the U.S., 44% of petroleum used in Western Europe, 35% in Japan, and 49% in developing countries, or roughly half of all petroleum used globally. Thus, the transport sector, particularly petroleum-fueled motor vehicles, accounted for more than 15% of global carbon releases from anthropogenic sources.

Response to Date

The Global Climate Change Treaty signed at the World Conference on the Environment (UNCED) in Rio de Janeiro in 1992 signaled the rising attention to this problem by world leaders. The U.S. National Climate Action Plan, announced by President Clinton in August 1993, is the first small step in the development of more comprehensive U.S. policies in response to this problem. The transportation conformity requirements of the CAA provide one instrument to reduce CO_2 emissions from transportation. The Clinton Administration's National Climate Action Plan offers a further small step with its proposal to "cash out" employer-provided parking subsidies. Much greater efforts will be required to implement the President's April, 1993 pledge to reduce U.S. CO_2 emissions to 1990 levels by the year 2000, as required by the Rio accords. Significant reduction of the fastest growing large source of U.S. CO_2 emissions -- transportation -- will require concurrent reforms in land use, transportation pricing and management, and vehicle technology.

Many other CAA strategies for reducing emissions of CO, VOC, and NO_x -- enhanced I/M, reformulated gasoline, and tighter vehicle tailpipe emission standards -- make no significant contribution, and in some cases degrade vehicle fuel economy and related CO_2 emission rates. Measures which increase highway capacity and speeds in many cases stimulate added automobile travel demand over time, leading to long-term growth in CO_2 emissions, even if in the short-term these capacity increases temporarily alleviate congestion and hence increase speeds and vehicle fuel economy per VMT or vehicle hour traveled.

Strategies for Reducing CO2 from Transportation

Responses to the global climate change problem will need to occur across many sectors of the global economy and will necessitate new mechanisms for internalizing long-term costs into short-term pricing if the marketplace is to be used effectively to address this long-term global problem. Key areas for action in relation to transportation-related greenhouse gas emissions are:

(1) Increasing Efficiency of Current Vehicle Types. Improvements in vehicle technology and vehicle downsizing have led to significant reductions in per-mile emission rates of all major pollutants, but VMT growth rates have frequently outpaced vehicle fuel efficiency improvements (Reference 1). Carbon releases due to motor vehicles are directly related to fuel economy as well as fuel source and type. Significant further improvements are possible in motor vehicle technology to improve fuel economy and reduce emission rates for carbon and other pollutants. Fuel use rates of the global automobile fleet could be cut in half over the next several decades if currently available technologies were widely applied throughout in manufacturing new cars. Tax and regulatory incentives such as "feebates" and emissions trading under sectoral and industry emission caps offer promise for progress in this area.

(2) Substitution of More Efficient Vehicle Types. Much of the improvement in average automobile fuel economy in the U.S. has been offset by the substitution of larger, heavier, less fuel efficient light trucks for automobiles in recent years. Large reductions in CO_2 emissions could come from promoting a shift in the other direction towards lighter and more fuel efficient motor vehicles. If maximum vehicle acceleration rates and top vehicle speeds, as well as maximum vehicle load capacities were reduced for a portion of the vehicle fleet, this could produce significant further reductions in energy use and CO_2 emissions per VMT. By reducing vehicle performance requirements, the size and weight of the vehicle propulsion systems can be cut dramatically, which allows further reduction in vehicle weight. Together, this could lead to a reduction in energy use requirements per passenger-kilometer or payload-kilometer on the order of 90 percent or more compared to current fossil-fueled,

freeway-capable vehicles. If only a modest share of the vehicle fleet in use were to consist of such smaller, lighter weight, lower performance vehicles, suitable for specialized use for shorter trips on arterial and secondary streets, there would be a major reduction in motor vehicle CO_2 emissions.

(3) Use of Renewable Energy for Transportation Propulsion. Renewable energy now accounts for less than 10 percent of the current U.S. energy supply, but this could increase significantly over the next several decades. In the long-run, there is potential for much greater reductions in CO_2 emissions with the widespread substitution of non-polluting and renewable energy sources -- solar, wind, wave, biomass, and possibly fusion power -- as fossil-fuel use peaks and declines sometime in the 21st century. For transportation applications, these will depend on propulsion systems based on energy carrier technologies, such as hydrogen or electricity (Reference 2). Indeed, the ZEV mandates of the CAA are intended to lay a foundation for development of such systems. Given the energy storage densities of current portable battery and gas energy storage media, there are major cost and efficiency advantages in minimizing vehicle size, weight, and performance when introducing these propulsion technologies. With current technologies, freeway capable electric vehicles generally require a large, heavy, and expensive load of batteries.

(4) Transportation System and Demand Management. Regardless of the efficiency improvements gained from technological progress, there are good reasons for promoting comprehensive application of smart technologies, transportation pricing, growth management, pedestrian and bicycle friendly transportation and community planning, and other demand management strategies. These promise the potential for significant added cuts in CO_2 emissions over the next half century while supporting more efficient economic growth. Traditional travel demand management, relying solely on voluntary measures and directed solely at work trips, is generally agreed to be inadequate. It needs to be replaced with comprehensive demand management that infuses all aspects of transportation planning and operations. This must include significant

changes in pricing, a focus on both work and non-work travel, promotion of accessibility and proximity rather than mobility, and promotion of non-motorized travel and telecommunications to reduce motor vehicle demand growth (Reference 3). These strategies will, in turn, likely make small ZEVs more attractive over time compared to full-size petroleum-fueled motor vehicles, at least for certain kinds of travel.

Diversification of Household Motor Vehicle Fleets

Ten or fifteen years ago, there were fears in the auto industry that the market for automobiles would become saturated in North America as households reached the point of one car per licensed driver. However, motor vehicle ownership has continued to grow at a modest pace as households have purchased increasingly specialized vehicles to meet particular requirements. It is increasingly common to see households with more vehicles than licensed drivers, with fleets composed of a mixture of touring cars, compact cars, light trucks, recreation vehicles, sports cars, and motorcycles. It appears likely that a market could be developed for environmentally-friendly, small, lightweight, high energy efficiency ZEVs, which would be used for short-distance trips and errands.

A "neighborhood car" might come to be seen as the easiest, cheapest, and most practical way to travel to the rail station, to the day care center, to the local park or health club, and for shopping. These kinds of trips comprise a growing share of total daily trip starts, petroleum use, and mobile source emissions, as work related travel continues to make up a smaller share of trips. Most of these nonwork trips are short -- typically less than 5 or 6 miles, and often as short as 1 or 2 miles. In many modern, wealthy suburbs with relatively high automobile ownership in the Netherlands, Germany, Switzerland, Scandinavia, and Japan, one finds a large share (often 20-30 percent) of these trips made by bicycle. In America they are made mostly by cars and light trucks.

The California ZEV mandate may lead to near-term market availability for the first time of some small efficient vehicles of this sort, since the most affordable electric cars will likely offer lower speeds and limited range, at least in the near term. However, manufacturer liability issues and the current

Federal Motor Vehicle Safety Standards pose major barriers to many smaller neighborhood vehicle types, and vehicles with fewer than four wheels will not be credited as "ZEVs" under the California program. Ultra-light neighborhood vehicles, such as electric-motor assisted bicycles and tricycles, with or without wind shells, avoid many key liability issues that challenge larger neighborhood vehicles, since ultra-lights are obviously less protective of their occupants.

Many Baby Boomers who came of age with the environmental movement and gas lines may find such vehicles more appealing than the marginally more efficient -- but still gasoline powered -- minicars produced recently by the auto industry, like the Geo Metro. If the costs of motor vehicles were more fully internalized through tax policies, vehicle inspection and registration fees, feebates, and other instruments, many consumers would likely seek access to lower cost, lower performance vehicles, such as neighborhood vehicles.

Small neighborhood vehicles face formidable obstacles in America, however. With only a small current market, commercially-available neighborhood vehicles today are mostly hand-built or retrofit from production models of small gasoline-powered motor vehicles. Thus, despite lower performance and versatility, they carry the premium price tag associated with high unit manufacturing and marketing costs. The California ZEV mandate may help assure a threshold level of market demand and lay a foundation for market-driven growth. Motor vehicle emission accounting and trading systems offer promise in other regions to establish economic incentives for least cost strategies to reduce ozone precursors and carbon dioxide emissions. Integrated strategies that address transportation facility design and management, demand management and pricing, and new options for vehicle access should be able to demonstrate significant potential for cost-effective reduction of emissions, but these require joint public and private sector initiative.

Intelligent Transportation Systems (ITS)

An important area for public-private partnership is in the development of Intelligent Vehicle Highway Systems (IVHS). The application of information

and communications/control systems technologies in transportation management and operations promises major increases in system safety, performance, and efficiency. The federal IVHS program has been funded at over $200 million for the past several years, supporting research and development efforts.

As it has developed to date, the U.S. DOT IVHS program is a set of technologies in search of a problem, with excessive focus on how to increase the capacity of existing highways and to boost the attractiveness of automobiles and trucks. Unless redirected, key elements of IVHS may face challenges in some metropolitan areas because of negative long-term effects on air quality.

However, IVHS could be used in a goal-directed fashion to implement CAA and ISTEA objectives such as demand management, congestion management, energy conservation, and improved traffic safety (Reference 4). If such reforms are indeed put in place, IVHS could significantly expand the potential market for small neighborhood vehicles in the late 1990s and early 2000s. IVHS could be used as the enabling technology for road and parking pricing and for electronic motor vehicle speed limitation. These could have significant effects on the potential market for neighborhood vehicles by encouraging proximity and access, improving traffic safety, and rewarding those who travel in a more resource-efficient manner. There should be far more thinking and research on how IVHS might be used to limit vehicle speed and acceleration rates on individual roads and in sensitive areas electronically.

This could be a cost-effective way to reduce emissions, improve traffic safety, and bolster community livability. It could complement other measures to slow down and "calm" traffic on low-volume residential streets and in commercial areas where pedestrians, bicycles, and public transit should be given a legetimate place. Automated speed limitation could smooth traffic flow on arterial roads with computer-synchronized traffic signals, reduce emissions and safety problems caused by speeders on high speed expressways, and reduce top vehicle speeds automatically when icing and fog or accident tie-ups occur.

The use of these systems could expand the market potential for small, lightweight, neighborhood vehicles suitable for local non-freeway travel. Whether propelled by batteries, small engines, supercapacitors, flywheels, human power, or a combination, these vehicles would allow individuals and businesses opportunities to better tailor the vehicle chosen for a particular trip to their end use requirements. Use of these systems could help complement a needed realignment of transportation subsidies and investments, the reallocation of street space to restore opportunities for walking, bicycling, and rapid transit, and smart land-use policies that encourage reinvestment in cities and close-in suburban centers where managed growth and managed streetspace and parking will help solve rather than exacerbate pressing traffic and social problems.

Travel Demand and Growth Management

The use of NEVs could do much to reduce the environmental impacts of personal mobility, but even greater benefits could be realized by coupling their introduction with well integrated transportation demand management (TDM) and land use planning. In general, most TDM efforts to date have been narrowly focused on peak period highway performance and have overlooked the opportunity to guide the evolution of longer term travel demand (Reference 5). Broader efforts that address non-work trips, non-peak period travel, and shorter trips, and that incorporate urban design and land use planning considerations, could help to slow the current trend of rapidly escalating motor vehicle use. The integration of long and short term demand and growth management strategies with pricing schemes encouraging the use of neighborhood and non-motorized vehicles could produce substantial benefits for both society and the environment.

ISTEA and the CAA provide new impetus for TDM by requiring large regions with unhealthy air to expeditiously implement all reasonably available measures that will improve air quality and requiring metropolitan areas to develop effective congestion management systems. These measures have been prompted by the realization that conventional air quality improvement strategies, focusing primarily on VOC reductions and increases in vehicular capacity, are often ineffective in the long term (Reference 5). Reduction in

VMT and conventional vehicle trip starts offers the prospect for more sustainable pollution prevention, and will be needed to meet ozone health standards in America's more polluted regions. Efforts to encourage the use of NEVs, which produce no cold-start emissions and hold the potential to replace the vast majority of short automobile trips, could become an integral part of long-term air quality improvement strategies.

More comprehensive analysis methods that recognize induced travel and land use effects call into question conventional methods that endorse speed increases and HOV lanes as means to combat ozone formation. These newer methods recognize the potential of traffic calming to improve pedestrian, bicycle, transit, and neighborhood vehicle use and reduce emissions (Reference 5). The emerging view recognizes that HOV projects may increase long term travel demand by encouraging low-density automobile dependent sprawl at urban fringes, to the ultimate detriment of air quality.

The development of comprehensive, well-interconnected, traffic calmed street networks would allow the use of bicycles and NEVs to be integrated with slowed conventional traffic, while at the same time improving the safety and desirability of pedestrian travel. Street design standards need to be revised to better accomodate these NEV, bicycle, and pedestrian networks, but can result in improved air quality and more livable communities.

The introduction of NEVs along with integrated transportation demand, growth, and congestion management strategies would produce synergistic reductions in air pollution, energy use, greenhouse gas production, and VMT by conventional vehicles.

Global Perspectives

Copenhagen is one example of success in developing a bicycle network on arterial streets by removing parking and reallocating street space. The Netherlands, Japan, and Australia offer models for comprehensive neighborhood traffic management using traffic calming.

In the Netherlands, introduction of small neighborhood vehicles would not likely be a sound policy today because it would cut into the market share of

more sustainable bicycle travel. However, in the US, the short trip travel market is dominated by less sustainable automobile travel, so neighborhood vehicles offer improved environmental and economic efficiency.

Conclusion

Small neighborhood vehicles are not the solution to American transportation problems but they could play an important role in reducing energy use in automobile dependent communities and expanding multi-modal options. They could fill a vital niche in the marketplace of transportation choices early in the next century and facilitate the development of "smart communities" that are planned for maximum resource efficiency and proximity, rather than maximum resource consumption and mobility. However, many current public policies work against the use of small NEVs. Coordinated least-cost transportation system planning and management and pollution prevention strategies could help NEVs realize their potential.

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Market and Supply Failure; Champions; and Discovery

William L. Garrison
Professor
Institute of Transportation Studies
University of California, Berkeley

This discussion uses Moses' 40-years of wandering in the wilderness as metaphor. Moses emerged from the wilderness with an organized society. Having worked on neighborhood vehicle topics for about 20-years, perhaps I'm half way to some organized thoughts about neighborhood vehicles. Words summarizing remaining pieces of the puzzle are given in the title to this paper, and, after reviewing my wandering, they will be discussed.[1]

About 20-years ago, I began the first of my investigations of the neighborhood vehicle concept. Although work began just after the first petroleum price shock, fuel efficiency wasn't the motive for the work. The thought was that historical "accidents" and the "lock-in" that pervades complex systems once they begin to be deployed had yielded a automobile-highway system ill suited for the times. By lock-in we refer to fixed protocols, predominate technologies that smother nascent ones, and the difficulty of changing one thing (e.g, vehicles) without changing another (e.g., roads). A system that would provide a wider diversity of services would seem to be desirable, as would a system easier of access by those with limited resources and/or driving skills.

The point of departure was curing dysfunctions. There are lots of system features that are quite logical given the history of the highway system. Even so, they may be recognized as dysfunctional, for example, the sharing of roads by vehicles with highly varied weights and the use of a 3,500 lb automobile to

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[1]I've not been alone, for I have worked with about 20 others. A few coworkers will be mentioned in the text.

Organizations providing support or working in partnership included the U.S. Department of Transportation, California Department of Transportation, Electric Power Research Institute, General Motors Corporation, and Booz Allen & Hamilton.

move one or two persons. Curing such dysfunctions should improve services, and treat energy and environmental problems along the way.

The work had a "soup to nuts" span. (References 1, 2, and 3) It reviewed vehicles available, road needs, and drivers' license and road use ordinances. Deployment of neighborhood cars and their facilities in representative cities was treated using scenarios. Our conclusion was, This is obviously a good idea. Our thought was that the good news would spread, champions would appear, and implementation would follow. Our limited efforts to spread the word through publications yielded some surprising feedback--including, This is silly, everyone knows that mass transit is the answer to transportation problems.

Interest in electric vehicles swelled after the '72 OPEC embargo, and at about that same time transportation analysts developed disaggregate choice models. Applying the model to choices of electric vehicles, a study of consumers' preferences for electric vehicles was undertaken. (Reference 4) One task was to truly disaggregate to individual choices. To explain: while choice models are described as disaggregate because they are specified on the choices of individuals, they are calibrated and used for an aggregate, a population. John Calfee wanted to experiment by doing a study that calibrated on individuals, and he took main responsibility for the work undertaken.

Respondents were given information on a variety of electric vehicles (price, range, etc.) and use scenarios, and were asked to make choices between them and conventional vehicles (given variations in petroleum fuel costs). The neighborhood vehicle entered because it and its postulated uses was one of the choices given respondents. The analytic aspects of the study went well. Not unexpectedly, electric vehicles as replacements for conventional vehicles did not fare well under most any specification of conventional vehicle costs.

I was surprised that the neighborhood vehicle also didn't fare well. One thought was that petroleum issues were not sharply in view, so we attempted to market our findings in Hawaii where there is overall energy dependence on petroleum. (Reference 5) No champion was found for our ideas.

After thinking about the work for several years, I began to speculate that we had been unable to give respondents a vision of the neighborhood vehicle and its uses, as well as a vision of how the vehicle and its facilities might dampen the impact of conventional vehicles in neighborhoods and open opportunities for neighborhood enhancements.

My most recent investigations began when Albert J. Sobey's enthusiasm for the General Motors Lean Machine spilled into California and the Caltrans. Three wheeled, high performance, fuel efficient and relatively inexpensive, the vehicle might serve well as a commuting vehicle, so we began investigations of benefits and costs to vehicle users and to agencies providing highways, as well as to society in general through decreasing congestion, fuel use, and emissions. (References 6, 7, and 8) Narrow in width, the commuter car might be operated on one half of a conventional highway lane (Figure 1).

Estimated net benefits were great. Also, it appears that while an expanding population of commuter vehicles would require considerable adjustments to highways, adjustments could be made in an incremental and cost-effective fashion. Indeed, the advantages to agencies providing road facilities are so great that we expected them to champion the transition to small vehicles.

The neighborhood car was revisited, this time with emphasis on just how the vehicle and its paths might fit in new (to be built) and old neighborhoods. (Reference 9) Peter Bosselmann and his students developed a variety of design alternatives responding to community interests in more green space, expansion of buildings on existing lots, and sequestering uses of conventional cars from residential areas. (Figure 2) While the overall concepts seemed to be well received by reviewers, many reviewers were not pleased by our notions of neighborhood improvements. Consequently, we are wary of designs, such as those for neoclassical communities, that impose designers' values on communities.

Paul MacCready stressed that consumers design vehicles. We have a similar feeling about neighborhood vehicles and their communities. Communities should evolve designs that suit their needs and resources.

20-Years and Counting

And here is the way we now see the situation. First, there is market and supply failure. Suppliers actions may contribute to valuable externalities (e.g., better neighborhoods; reduced congestion and national petroleum fuel use) which they cannot use to off-set their costs. The risk of producing a novel vehicle is high, perhaps too high for a favorable production decision in the case of the commuter vehicle. Finally, and perhaps most importantly, there are needs for cooperation among suppliers -- those who provide roads, those who supply vehicles, and those who regulate must work together.

Second, improved mobility (lower cost, wider availability of services, etc.) is an immediate pay-off from the introduction of small vehicles and it should play a role in the introduction of small vehicles and their uses. Such vehicles and their services may be a beginning for other changes in the auto-highway system, such as special truck roads and freight movement systems. But when thoroughgoing change is imagined, it should be recalled that social and economic developments triggered by transportation improvements were the "great bottom lines in the sky" that pulled transportation improvements. Such great bottom lines for small vehicle systems are yet to be imagined.

We suspect that such pay-offs might trace from mobility and infrastructure improvements through opportunities to redevelop built environments to new patterns of production and consumption. But that is only a conjecture. A way has to be found for individuals to try-out services and discover their pay-offs.

Third, champions for small vehicles remain elusive. In the '70s we thought that just pointing out that neighborhood vehicles seemed to be a good idea would be enough. In the '80s we thought that those concerned with petroleum dependence would take the ball. In the '90s, highway agencies seem the logical leaders. It may be, of course, that those thoughts are correct, and it just takes time for the ball to roll. It also may be that the lack of champions is a symptom of market and supply failures. There is no immediate pay-off to persons in key decision-making situations, so there are no champions.

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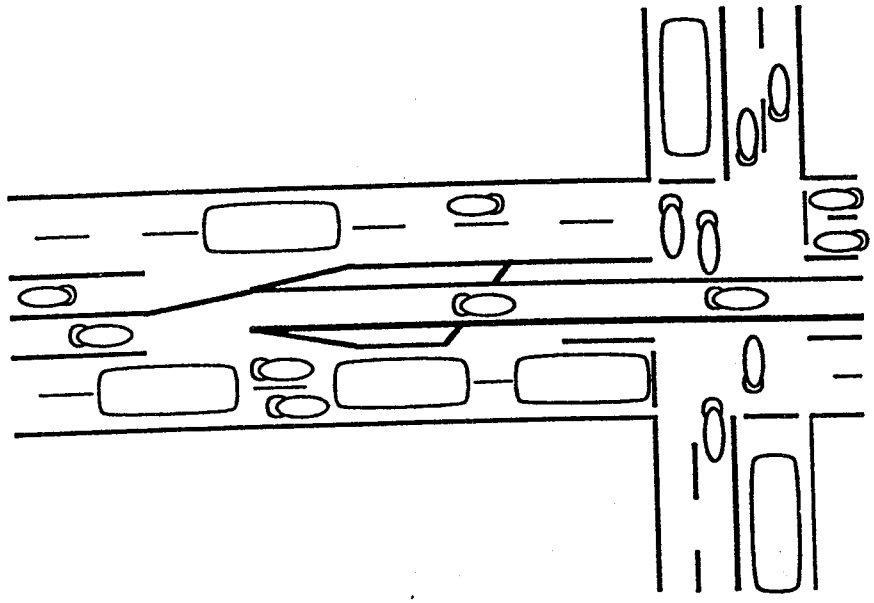


FIGURE 1: INTERSECTION WITH SHARED LANES AND REVERSIBLE FLYOVER FOR COMMUTER VEHICLES

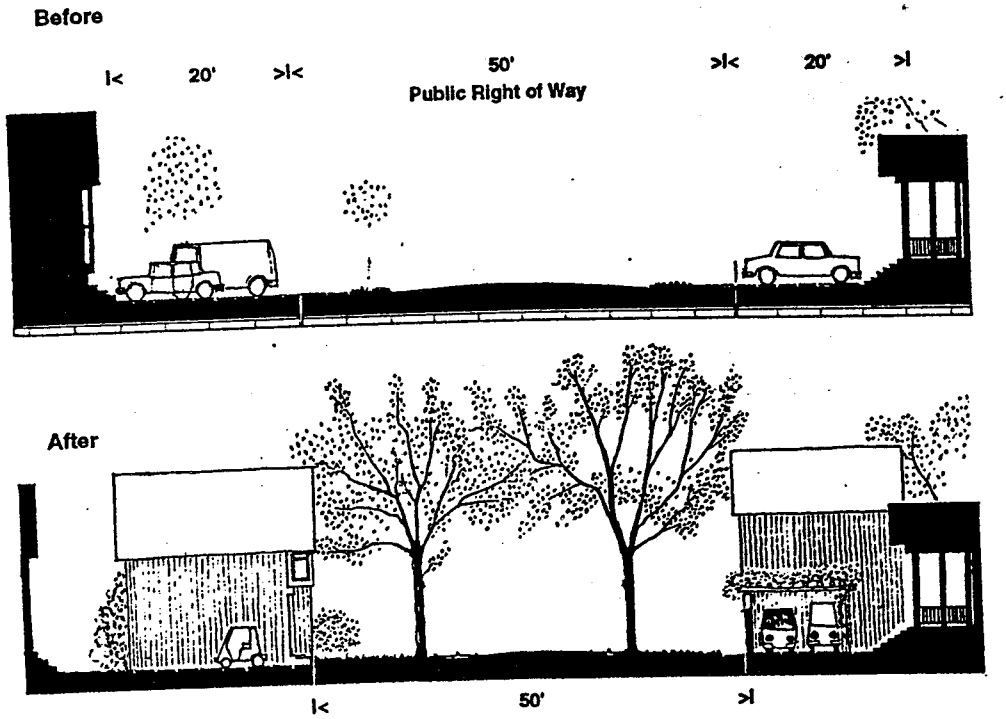


FIGURE 2: HOW NEIGHBORHOOD VEHICLES MIGHT ENABLE LARGER STRUCTURES ON EXISTING LOTS

City of Palm Desert Golf Cart Transportation Program

John Wohlmuth
Assistant to the City Manager
City of Palm Desert, California

Note: This summary has been prepared from a videotape of the workshop session and constitutes a modified transcript of the presentation. It has been reviewed by the presenter for accuracy.

For over a year and a half, the City of Palm Desert has had a golf cart transportation program. Following is a brief history of how that program came about and a description of how it works.

The California Vehicle Code (CVC) governs the roads and highways in California. A city cannot override the CVC. For example, we cannot set a speed a limit less than 25 mph, and we cannot determine how golf carts are to be used. The CVC defines a golf cart as a vehicle that weighs under 1300 pounds, goes less than 15 mph, and holds two passengers and golf bags. The golf cart can be used in most communities within one mile of a golf cart on 25 mph streets.

There are two paragraphs in the CVC that pertain to golf carts, and back in 1991 the California Attorney General issued a 40 page interpretation of those two paragraphs. The interpretation stated that the speed limit of an intersection is the speed limit of the street in the intersection with the highest speed limit. For example, an intersection of a 40 mph street and a 25 mph street would have a speed limit of 40 mph. So under the interpretation, golf carts could not enter that intersection.

The City of Palm Desert undertook to change the vehicle code for just Palm Desert. We received a good deal of opposition on the state level and it took two assembly bills to get the program through. The second bill, Assembly Bill 1229, passed in May of 1992 and allowed the City to conduct a five-year pilot program. We have a total budget of $200,00 and have designed streets, signage, and other amenities for the program.

The City of Palm Desert is located in the Coachella Valley and is a destination golf resort area. There are 27 golf courses located within the city limits. There are about 20,000 golf carts in the valley and approximately 7,000 of those golf carts are located in Palm Desert. Of those 7,000, more than half are owned by the golf courses, so we estimate that there are about 3,000 individually owned golf carts in Palm Desert.

With regard to the infrastructure for the program, not every street in the City of Palm Desert is golf cart legal. Every residential street is golf cart legal, and we have designated three types of lanes, similar to bicycle lanes - Class I, II, and III. Class I lanes are totally separated from other traffic, Class II lanes are striped and signed, and Class III lanes are located on streets where golf carts and other vehicles can mingle safely. Class III lanes are only on streets with speed limits of 25 mph.

In some cases, we have left a parking lane and created an 8 foot, combined golf cart and bicycle lane. The lanes are designed to provide safe travel for golf carts throughout the city, but in some cases it was not possible to provide lanes in all areas. In some instances, particularly when roads cross major arterials, the lanes end and the golf carts must use the sidewalk to access residential streets.

The City has also endeavored to provide charging facilities. The range of a golf cart is approximately 35 miles, and the city is small enough that a range of 20-25 miles would probably be adequate to access any location in the city limits. Most people therefore feel comfortable with the ranges that their golf carts provide, but we wanted to "push the envelope" and provide public charging of electric vehicles. We are allowed to use some of our AB 27566 funding for this purpose under the rules of the South Coast Air Quality Management District. One of the first problems we encountered is that not all chargers, couplers, and batteries are alike. The industry has not yet standardized charging componentry and we are now asking them to do that.

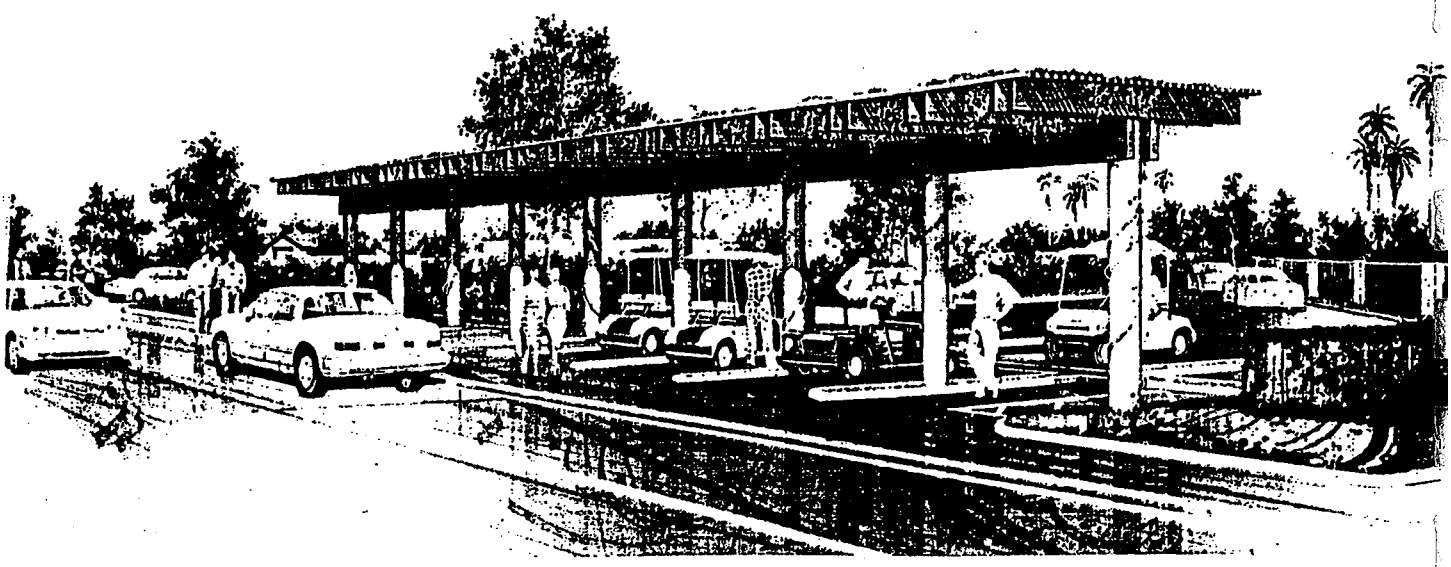
A charging facility at our local mall allows golf cart owners to charge their vehicles for free. The charging units there are standard, and not quick charge.

The average residents spend about $67 dollars at the Mall on an average visit of about 90 minutes. The average out-of-town visitor spends about $120 on an average visit of almost 2 hours, so the Town Center Mall is willing to subsidize charging at a cost of 7 cents per hour.

We are also developing a charging facility at the Civic Center, located near the Town Center Mall, where golf cart owners will be able to charge their vehicles in the shade. The stalls in the facility are wide enough to accommodate full-sized electric vehicles.
With Southern California Edison, we have developed a system whereby the golf carts cannot be driven away while they are plugged in.

There is no standard symbol for signage for a golf cart lane, but the Palm Desert symbol is being considered by the Federal Highway Administration as a standard symbol, so we are tackling that issue for the rest of the country.

During the next two years, the City of Palm Desert plans to expand the pilot program by providing additional routes and registering new program participants. The city has established a goal of 500 registered golf carts by 1997.



PALM DESERT ELECTRIC CHARGING STATION - NORTH
PALM DESERT, CALIFORNIA

SOUTHERN CALIFORNIA EDISON COMPANY

V. Session Three: New Market Opportunities for NEVs

Some Thoughts on the Potential for Advanced Transportation Systems

Albert J Sobey
President
Albert Sobey Associates

Introduction

Other papers in this meeting have described some specific neighborhood vehicle designs and experiences in their development. I was asked to provide some thoughts about the potential development of alternative vehicle and equipment concepts. My objective is to describe some of the results of looking at transportation from the standpoint of the purpose of transportation and how that can lead to new system concepts that could provide improved mobility - at attractive economic and societal costs.

I have investigated several alternative technologies and product concepts including; commuter and neighborhood cars, improved freight systems, real time traffic management systems and innovative transit systems. In combination they can improve mobility - while reducing energy consumption and emissions. Some forecasts by the U.S. Department of Energy indicate that total transportation fuel consumption could increase from 20 to nearly 50% by 2010. By that time approximately half of the energy used for transportation would be by commercial vehicles, primarily trucks but also railroads, air lines, ships and pipelines.

One purpose of this paper was to describe some transportation system concepts and technologies that should provide improved transportation services for people and goods while helping to meet the public's concerns over the availability of energy and the problems with emissions.

Cars can be designed for specific trip purposes. Innovative freight equipment and services can reduce total energy use while providing more effective service to shippers. Improved traffic control systems can reduce traffic delays

and congestion. New propulsion systems may reduce energy consumption by nearly 50% with existing vehicle technology. The potential benefits of alternative propulsion systems, gas turbines, stirling engines, battery electric propulsion, fuel cells and new fuels are discussed in other papers. Many of the innovations that will be described should be attractive enough to be commercialized without mandates - eventually.

The questions include: What level of energy and noxious emission reductions can be achieved by the commercialization of products that people think are superior in (cost, performance, or utility) than existing products? Can the commercialization of attractive new vehicle concepts and technologies be accelerated rapidly enough to be a factor in alleviating public concerns?

Personal Vehicles

Several alternative personal vehicle and system concepts, in combination, have the potential of reducing the energy consumed by personal vehicles as much as I think that it is technically and economically practical to do with the design of passenger cars (short of using fuel cells). Accelerating the use of these vehicle and system concepts could avoid the need for mobility restraints or accelerating the introduction of new technologies before they are adequately developed. The most attractive innovations include: cars designed for specific trip purposes, increased use of computers and communication systems and improved traffic controls.

Automobile Characteristics

There are approximately 180 million personal vehicles (cars and light trucks) in the United States. The number has increased about 2.5 percent per year over the last decade. The annual sales projections, through 2030, could be as illustrated in figure 1 for the United States and California, assuming that the sale of cars continues to increase proportionately to increases in family income. These projections will undoubtedly be wrong. They will be too high if family incomes do not increase in proportion to Gross National Product Increases. The forecasts may be to low if new transportation concepts (half-width and neighborhood cars) reduce the average cost of a new car

significantly. Or the cost of cars (and energy) may increase more rapidly than family incomes.

Figure 1: Exponential Growth of Light Vehicle Sales

	NATIONAL		CALIFORNIA	
	2% per year	3% per year	2% per year	3% per year
1995	15,000,000	15,000,000	1,180,000	1,200,000
2000	16,000,000	17,000,000	1,250,000	1,300,000
2005	17,500,000	19,000,000	1,350,000	1,450,000
2010	19,000,000	21,000,000	1,480,000	1,600,000
2015	20,000,000	23,000,000	1,600,000	1,700,000
2020	22,000,000	26,000,000	1,700,000	2,000,000
2025	24,000,000	29,500,000	1,900,000	2,300,000
2030	24,500,000	32,500,000	1,950,000	2,500,000

There is little public information available on how people make choices between cars - or how they value various attributes. An early 1980's study by Cheslow can help illustrate the choices (Reference 1). He summarized the results of a number of previous studies. The investigators used different methods and, not surprisingly, found that the value placed on various attributes changed with income, family size, age etc. These studies indicated that, depending on need, income etc, people would pay the amount shown in figure 2:

Figure 2: Perceived Value of Automotive Attributes

$ 15 to $ 150	To reduce fuel consumption one mpg
$ 45 to $ 100	To reduce 0-60 acceleration one second (below 20 sec)
$ 999 to $ 1,600	To increase range 50 miles above 300 miles

The studies indicate that most people are willing to pay more for increased range (a larger fuel tank?) than the comparable improvements in fuel

economy. This may reflect the inconvenience of having to go to a gas station to refuel. Range becomes the time between visits to the gas station.

The projected "willingness to pay" for improved milage (which averaged $45 miles per gallon improvement) was approximately the same as the cost of the fuel, which would have been saved over the first two and a half years of the vehicles life based on the fuel prices at the time these studies were prepared. Oil prices have declined significantly since this paper was prepared. The data probably overstates what people will pay, now, for improvements in milage.

It is not certain that these trends should be used in reverse to project the price reduction needed to sell a limited range car. A focus group study conducted by Beggs (Reference 2) concluded that the average participant attached a disutility of $4,000 (1977 $) to a vehicle with a range of 50 miles compared to a car which has a range of 200 miles. Other estimates have been even larger.

Unfortunately for those who would like to view car purchases scientifically, the final choice of the car purchased may be based on secondary attributes, frequently styling, some times something as simple as a coffee cup holder.

Improvements in family sedans - Most of the progress in reducing the energy consumptions of cars since the 1970's has been due to two factors.

First, Reduction in weight and acceleration performance.
Second, Improved fuel control systems.

The improvements possible with these factors are approaching the practical limits. Prior to the first energy shock of the mid 1970's the energy consumption of the average personal car (corrected for changes in weight, performance and regulations) decreased between one and two percent per year. If this trend continues the fuel consumption of cars (in the absence of additional regulation) should decrease about as shown in figure 3.

Figure 3: Trends in Automobile Fuel Consumption (corrected for size and performance)

Year	1% per year		2% per year	
	Gallons per mile	Miles per gallon	Gallons per mile	Miles per gallon
1993	0.036	27.7	0.036	27.7
2000	0.034	29.5	0.032	31.2
2005	0.032	31.0	0.029	34.5
2010	0.031	35.5	0.026	38.0
2020	0.028	36.0	0.022	46.5

Note: Average CAFE rating of Domestic US Cars in 1993 was 27.7 mpg

Additional improvements to fuel consumption of typical "family sedans" can be accomplished by:

1 Reducing weight
2 Reducing acceleration performance
3 Reducing tire or rolling resistance
4 Reducing aerodynamic drag
5 Reducing accessory power requirements
6 Reducing losses in the propulsion systems

We are approaching the point of diminishing return on each of these except new kinds of propulsion systems such as fuel-cells.

The potential gains by reducing weight and acceleration are illustrated by figure 4. The data are based on the assumption that a "family sedan" based on existing technology which weighs 3,000 lbs (loaded) will provide 27.5 mpg (on EPA schedules) and can be accelerated from zero to 60 mpg in 8 seconds. Cutting the weight in half (to 1500 lbs) will improve the fuel economy to about 47 mpg with the same propulsion technology. Using a less powerful engine (65 vs 100 hp) will improve the fuel economy to over 50 mpg and increase the acceleration time to 14 seconds.

Figure 4: Reducing Energy Consumption of "Family Sedans"

Weight (Pounds)	Engine (Horse Power)	Energy (Mpg)	Acceleration (Zero To 60 Mph)
3000	100	27.5	8 seconds
3000	68	30-32	14 seconds
1500	50-55	45-47	8 seconds
1500	35-37	50-52	14 seconds

The problem is how to build an economically competitive, safe car that only weighs 1500 lbs when you consider that, in addition to 40 to 70 lbs of gasoline, 10 to 40% of the weight (one to four 150 lb passengers) can be useful load. The car must weigh 850 lbs to 1000 lbs empty.

Composite plastic structures have been suggested as a way to make significant reductions in weight. Plastics have many advantages including increased stiffness and the ability to reduce assembly labor by combining parts. However it is not clear that composites will be economically superior to metal structures. Their problems include: cost of materials, low cycle time (high tooling or labor costs) damage assessment and repairability. After some apparently minor accidents, it might be necessary to replace the under bodies on cars that have a composite under body (frame etc). In effect throwing the car away because there may be damage that can not be seen on the surface. The people developing metal structures are taking plastics challenge seriously and making major improvements. Of course, further improvements could be provided by reducing the rolling resistance or aerodynamic drag - but the majority of what can be accomplished in these areas already has.

Tire design is a compromise between cornering capability, wet road performance, ride quality, life and energy consumption. Reducing rolling resistance has usually compromised steering, braking and control on wet roads. Some studies indicate that a 10% reduction in rolling resistance is feasible (Reference 3). If true, this would have the advantage of being applicable to essentially all existing cars as tires wear out.

Major reductions have been made in reducing aerodynamic drag. Cars designed in the 1960's and 1970's typically had drag coefficients (Cd) ranging from 0.4 to 0.5. The results of wind tunnel tests of a family of body shapes indicate that the minimum possible is in the order of 0.15 Cd - but these shapes may not be practical for most vehicles. Drag coefficients are now down to about 0.25 to 0.30 Cd with acceptable appearance. Drag is not the only important aerodynamic parameter - lift and yaw forces can also be critical. The drag of many cars increases significantly in cross winds (up to 20 percent in a 10 mph side wind at 60 mph). Very light cars may require active aerodynamic controls to maintain adequate stability in cross winds, gusts or in mixed traffic with large trucks.

There is room for innovation in reducing the energy consumption of accessories. According to a study by R.W. Bartholomew of the National Institute of Standards and Technology, air conditioning can require from 2 to 8 horsepower. Alternators can require from 0.75 to 2 hp, electrical devices (headlights, windshield wipers etc) from 0.4 to 1 hp, power steering from 0.33 to 2 hp and cooling fans from 0.1 to 4 hp. In total accessories could require from 3.5 to 17 hp depending on the conditions and the technology embodied in the numerous devices on the car. Power requirements for climate control will increase with the phase out of the fluorocarbons because of their suspected role in damaging the ozone layer.

Alternative Automobiles

Automobile companies divide the car market into a large number of segments based on vehicle size (compact, standard, luxury), appearance (luxury, family, sport), functions (four door, two seat, vans, convertibles) etc. The marketers place their products and those of their primary competitors in the defined boxes. Automobile companies usually base their market strategies on the evolution of their existing product lines. That way they build on prior experience in manufacturing and create customer loyalty.

Working backward from how cars are actually used can lead to a different product mixes. This approach has lead to identifying new markets which can be satisfied by new categories of vehicles. Even if these market appear well

defined they may be too small for the major companies to build cars at prices which will be attractive to the customers. It has been difficult to sell management on concepts which meet niche markets, but this may be changing. New assembly techniques may make it practical to build small fleets to confirm if a market exists and to serve it competitively as the demand increases.

The number of cars available to the average household is increasing. In 1990 over 90% of the households in the United states had access to a car, 38% had two cars and nearly twenty percent had three. The historical trends are shown in figure 5. Prior to the 1960's, people purchased a car for the maximum use that they expected. Many station wagons were purchased for a planned two week vacation for the family. Where three or more cars are available, the first car is used for 40 to 50 % of the travel, the second 25 to 30 %, and the third 15 to 20 %.

The estimates for 2000 and 2010 are extensions of prior trends modified for the increased car ownership. If disposable incomes continue to increase, the U.S. DOE's projections, based on US DOE forecasts, imply that the number of cars per person will increase by about 20% by 2010. The number of two car households could increase to 60 to 70% of the total and three cars would be available to 50 to 60% of the households. Many households will have more than one car per licensed driver.

Figure 5: Car Ownership (Millions of Households)

Year	None	One	Two	Three +	Total
1969	13 (21%)	29 (48%)	16 (26%)	3 (5%)	62
1977	11 (15%)	26 (35%)	25 (34%)	12 (16%)	75
1983	11 (13%)	29 (34%)	29 (34%)	16 (19%)	85
1990	8 (9%)	31 (33%)	35 (38%)	19 (20%)	93
2000 low	*7 (7%)*	*33 (33%)*	*37 (38%)*	*21 (22%)*	*105 est*
2000 high	*7 (7%)*	*35 (33%)*	*40 (37%)*	*25 (23%)*	*107 est*
2010 low	*8 (7%)*	*39 (33%)*	*42 (36%)*	*27 (24%)*	*116 est*
2010 high	*6 (5%)*	*40 (33%)*	*44 (37%)*	*30 (25%)*	*120 est*

Households with multiple car fleets have cars for different purposes. The "household fleets" may include a truck, a van, a off road or four wheel drive, and a family sedan. I see future cars falling into three basic categories:

First	Image cars
Second	Utility Cars
Third	Special purpose cars (Alternative Automobiles)

An image car can be a Jaguar, Corvette, or Geo Metro depending on the image one wants to project. The utility car can be a used car, van, light truck etc. The special purpose cars can include cars for commuting, for going to the store or parking at the transit stop.

The marketing problem of alternative automobiles should can be approached in two ways:

First	Determine who will be the first to use them and
Second	Determine, if accepted, how large could the market be.

There have been many attempts to categorize purchasers. One example is SRI International's Values and Life Styles Program. SRI characterized about a dozen categories. For simplicity I have grouped them into five:

Percent of U.S. Population - 1986	
1. Belongers	39%
2. Achievers and Emulators	29%
3. Societally Conscious	12%
4. Survivors and Sustainers	11%
5. I-Am and Experientals	9%

Note: Assumes 2.5%/year GNP Growth

The Belongers category includes those who have been described as "Chevrolets and Apple pie" people. Most are conservative in their outlook. The size of this category will change least with economic growth - but the

individual households will differ. Some Sustainers will move in to it at high growth. Some Emulators will move down at low rates of growth.

The Achievers and Emulators are those who have made it (financially), or want people to think that they have. The share of people in this category might increase to 30 to 35% at higher rates of economic growth. In a pessimistic scenario the share might drop to 20 to 25%. They tend to be conservative in fiscal matters, but may support societally beneficial initiatives.

The Societally Conscious group includes the people who take the environment seriously. Some have suggested that they would pay up to 20% more for environmentally benign products. They provide the leadership for environmental and other societal activities. But electric car sponsors have found that they are conservative in their buying practices and tend to wait until some one else proves that the new products work, and are environmentally beneficial.

The I-AM and Experientals include those who are interested in self expression. They include the early adapters who will be the first to try new things, like battery powered cars. While the things which interest this group tend to be personal, they support societally beneficial changes, particularly if they satisfy their self images. The number of people in this category will increase significantly at higher rates of economic growth. It could be near zero at low rates.

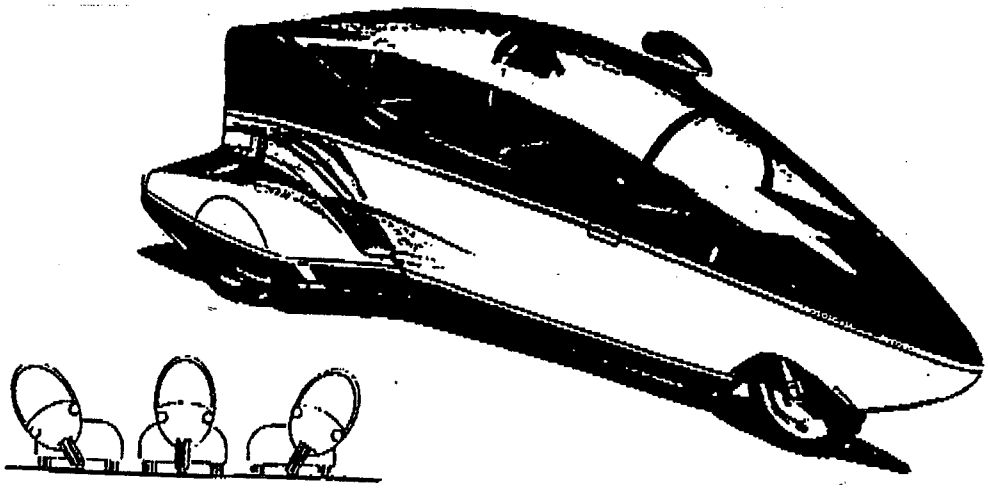
The Survivor and Sustainer categories include those who are barely making it in society. Very few can purchase cars or homes. A logical assumption is that by 2030 this category would have decreased to less than 10 % of the population.

Since the information summarized in this figure was developed nearly ten years ago recent studies should be reviewed for more timely information. SRI has recently revised the names and definitions of the categories.

Commuter Cars

More than 80 percent of the commuting trips are made by one person alone in his or her car. Studies for the California Department of Transportation (Caltrans) impled that 20-30% of the commuting trips could be made in a single passenger car. Single passenger (or two in tandem) cars are being studied by industry and transportation authorities. The California Dept of transportation calls them narrow lane cars - GM calls them Lean Machines. They only require about half the lane width of a conventional car (Reference 4). Two can be driven side by side on most roads. Three to four can be parked in the same space as a conventional car.

Figure 6: Half Width Commuter Car



The embodiment shown in figure 6 is what I would call the one and a half seat model. It has a place in the back for a child or adult in an emergency. The production version can be approximately 40 inches wide and 10 to 12 feet long. The estimated weight for a production version is 550 lbs with one passenger. Its drag coefficient should be below 0.20.

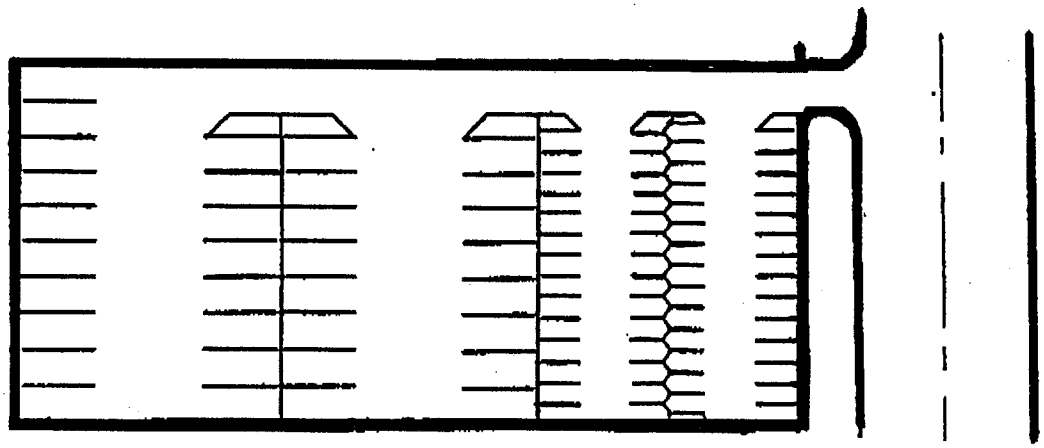
Lean machines can provide sports car like performance and still get up to 150 mpg with conventional gasoline engines (100-120 mpg with air-conditioning). The GM version cambers, or leans, like a bicycle or airplane in a turn. Drivers are more likely to use its full cornering capability to avoid accidents because they will not slide across the seat during turns. They are fun to drive.

One of the major advantages of narrow lane cars is the ability to increase road capacity with minimal investment. When, or if, added capacity is needed Caltrans would add narrow lanes that only half width cars (and motorcycles) could use (Reference 5). Since these "lanes" would not have to be reinforced for trucks they could cost much less, and be easier to maintain than conventional roads. The Michigan Department of Transportation estimates that paving an existing gravel road could cost $170,000 per mile. Expanding an existing road from two lanes to five lanes typically would cost $3-3.5 million per mile. A six lane boulevard would cost twice as much. A new toll road in Northern Virginia is expected to cost about $10 million per mile. The proposed Santa Anna Viaduct Express toll road (two lanes each direction) would cost $18.5 billion for 11.7 miles (Reference 6).

The half width car concept has been on the shelf since the late 1970's because of concerns over product liability. Even if it is safer and has fewer accidents and injuries per mile it may have some which are different and unique to it. One successful suit against the manufacturer could wipe out all of the expected profits for decades. There have been some discussions with the California Department of Transportation (Caltrans) about the need to provide protection from liability suits during the demonstrations and introduction of this and other societally beneficial transportation concepts.

When people are exposed to the concept they are particularly interested in the fact that three to four can be parked in the same space as a single conventional car as illustrated in figure 7.

Figure 7: Parking Requirements for Conventional and Narrow Lane Cars



Neighborhood Cars

Even in large metropolitan areas about half of all urban trips take less than 10 minutes. Figure 8 summarizes the average travel times by trip purposes. The share of personal business and shopping trips is expected to increase while work trips decrease in the next few decades. The number of trips less than 10 minutes should increase to 51 to 55 percent by 2005.

Figure 8: Percent of Total Urban Trips by Average Times and Purpose (1970)

	Trip Duration			
Trip Purpose	0-5 Min	5-10 Min	10-15 Min	over 15 min
Personal Business	9.5 %	11.0 %	4.0 %	1.5 %
Shopping	13.5 %	6.5 %	2.5 %	1.0 %
Work Related	3.0 %	6.5 %	9.0 %	32.0 %
Total	**26.0%**	**24.0 %**	**15.5 %**	**34.5 %**

Source: SRI New Systems Study - 1967

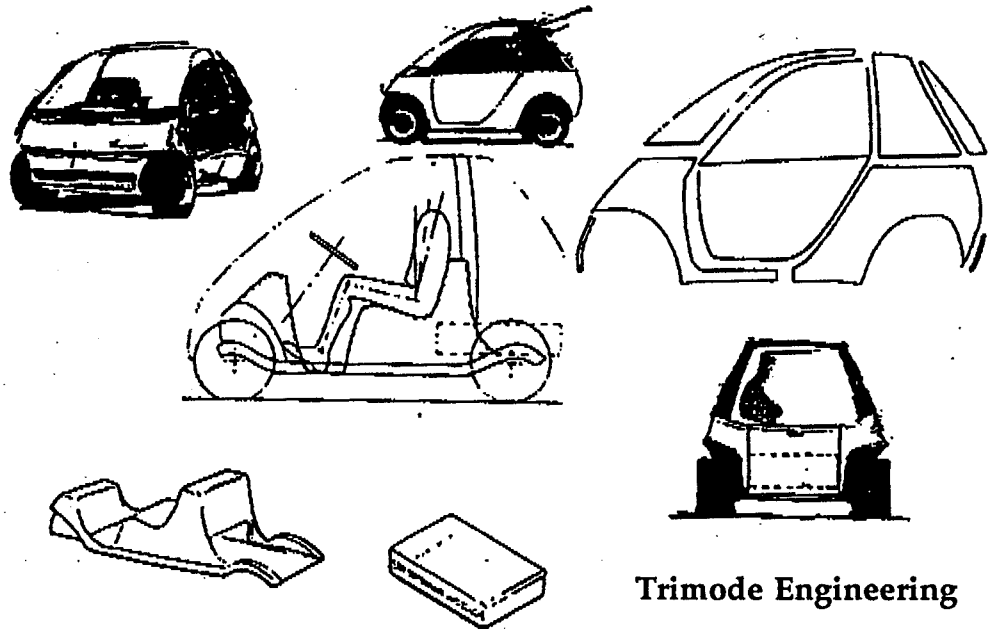
This potential requirement offers the opportunity for a new class of car designed for short trips (primarily shopping). These cars probably should accommodate two passengers, have most automobile amenities, but may be restricted in top speed and not allowed on freeways. Full automobile safety standards should be possible. Studies of this market by the University of California at Davis have shown that for half the households the minimum acceptable range for a neighborhood electric vehicle (NEV) would be 50 miles (Reference 7). Seventy five miles would be the minimum acceptable for three quarters of the households. However few people would purchase a car that was just capable of their minimum distance. Less than ten percent would be comfortable with a car that only went 50 miles. Half the households would want a range of 90 miles in any car they would purchase.

Neighborhood cars are a logical application for battery electric propulsion systems. The range requirements (two ten minute trips between recharging) can be easily met with conventional lead acid batteries. New kinds of

batteries would not be required unless they reduce life cycle costs or improve reliability. Charging at home will avoid the nuisance of going to a gas station.

The neighborhood cars should be designed for a high level of reliability - that is confidence of completing a trip. System redundancy including the use of non-pneumatic tires should essentially eliminate maintenance concerns. The advantages of these small cars include the opportunity to use simple construction such as illustrated in figure 9.

Figure 9: Exploded View of Simple Neighborhood Car



Trimode Engineering

Many of the longer trips including commuting by transit can be divided into segments where a short range car would be useful. Plans are being developed that should lead to the demonstration of a version of the neighborhood car designed specifically for access to transit.

Neighborhood cars should be attractive to the aging population. By equipping them with proximity warning devices it may be possible for people who would not otherwise be entitled to drive a conventional car to use them. Those eligible could include those to young to have a "conventional" license (a boon for the mothers who provide taxi service) the handicapped, and even those who may have lost their conventional license by "driving under the influence".

The use of battery powered neighborhood cars could make it possible to reduce the fuel consumption in an urbanized region by 7% to 10%. The emission benefits should be even greater because it is difficult to control the emissions generated by piston engines while they are warming up. Unfortunately the magnitude of the benefits of reducing emissions during warmups have yet to be assessed accurately.

Family of Cars

The benefits of a family of cars designed for different kinds of trips will increase as the number of cars per household increases. When the family of cars concept was first discussed with regulators, the idea was greeted with skepticism. The concept ran counter to the goal to get people out of cars - or to get back to one car per household. The idea that using cars designed for specific trips could reduce emissions and energy consumption took a change in thinking - which seems to have happened.

The potential benefits include: reductions in infrastructure costs, reduced congestion, and lower personal transportation costs. These cars will enable people to maintain the same (or improved) quality of life and mobility while meeting energy and environmental requirements.

These designs are compatible with new small volume production concepts. They could be assembled in small widely distributed facilities, close to the major markets. Half width cars could be demonstrated in three years and be in production in five years after a full commitment is made. Neighborhood cars even sooner. The development costs are in the tens of millions.

In combination, the family of alternative cars (commuter, neighborhood) could reduce energy consumption in large cities by 12% to 24% (4% to 8% of total transportation energy consumption) and provide an even greater reduction in emissions. No new technical breakthrough are required. But their use may require some changes in traffic regulations.

Automobile Leasing

Automobile leasing is becoming an attractive option for many people. Some automobile industry authorities believe that within the next decade the majority of new car "acquisitions" will be leased.

Leasing opens some other opportunities. For example, Purdue University experimented with a shared car leasing concept in the early 1980's (Reference 8). Their concept was for a "customer" to lease the smallest car which would meet their daily needs and have, as a part of the contract, access - on demand - to other cars, trucks, and vans. This could be described as the "virtual" family of cars concept.

The advantages of this concept include lower overall cost of personal transportation, increased confidence of having a working car always available (a replacement should be available quickly). The convenience of having a van for large parties, a truck for moving material or a Cadillac for impressing clients or future mother in laws. This service should be a natural growth market for car rental companies which usually have excess cars available on weekends, the time that most customers would want a different vehicle.

Purdue obtained a number of the smallest cars (Japanese Kai cars) which were then available and had people use them for several years. For safety reasons the "customers" were not allowed to go over 55 mph. They found that timely access to the fleet vehicles was important. The concept was expected to be most attractive in apartment or condominium areas or where the cars could be reached by a short walk (perhaps at the neighborhood convenience store or gasoline station).

An interesting observation is that in Japan, this category of ultra light car had more accidents (fender benders), and fewer fatalities, than larger cars. The reason may have been the self selection that occurred. The purchasers were disproportionately older single women who never had driven before.

Bicycles

Bicycles can serve some of the same travel purposes as neighborhood cars. Many people advocate increased use of bicycles for commuting and personal

transportation. They are emission free and the "healthy" thing to do (Reference 9). The U.S DOT estimates that the increased use of bicycles could save between 16 and 24 million barrels of oil per year (approximately one days consumption) if the number of bicycle commuters were to increase from the present estimated half million to three and a half million.

Bicycles have been used by generations of school children. They are still used (in decreasing numbers) in China and other developing nations. They are not the solution for everyone (on snowy and rainy days - perhaps for no one). Many people (particularly those over 60) do not have the physical stamina to ride far.

But the most serious problem is their safety record. It would be interesting to determine the relative risks of commuting by bicycles and automobiles. Unfortunately we do not have good information on how far people travel by bicycle, but we can compare the risks on a per vehicle basis. In 1988 there were about 1,000 bicycle fatalities in the U.S. (Reference 10). On a fatalities per vehicle basis this comes to about one death per 1,100 bicycles. One third of the killed were under 15, one third were between 15 and 24 and the balance over 25 years of age. I sometimes wonder why more bike riders are not seriously injured as they tend to ignore traffic signals and lanes .

There were 45,000 automobile related fatalities in 1988 (some were car-bicycle accidents). This is one fatality for every 4,000 cars. On this basis bicycles are three to four times as dangerous as cars - on a per vehicle basis. They undoubtedly are many times more dangerous on a per mile basis. This can be alleviated, but not solved, by bike lanes and better enforcement of traffic rules.

Congestion

One of the problems that is frequently raised by people concerned over the environment and energy consumption is the increase in traffic congestion, which leads to "unnecessary" delays, wastes energy, frustrates drivers and requires increasing infrastructure investments. The state and local highway departments face serious problems in providing adequate road capacity. In many regions the funding available is insufficient to provide proper road maintenance, much less increase the capacity to meet changing need.

The problem of traffic congestion is easily misinterpreted. The most widely accepted definition of congestion is:

> **The difference in travel time during free flow conditions (1 am) and the travel time during congestion (5 pm).**

The societal definition might be:

> **The time spent by travelers whose trip time exceed their accepted time budgets (20-25 minutes for most commuters).**

Congestion appears to be self limiting. When trip times exceed their time budgets most people relocate or take new jobs. If the car is stopped much of the time, but the total trip takes less than 20 minutes, congestion will be a nuisance but will not be so objectionable as to cause people to relocate. If it takes much longer than that many people will make a change. The change is usually to a job or place to live that is less desirable. The major exception is probably people in two professional upwardly mobile households. This cost of congestion is seldom considered in planning for new facilities.

Professor Gordon of the University of Southern California has found that the commuting time for the average person is decreasing in almost all major U.S. Cities (Reference 11). Some authorities think that the people questioned in these surveys underestimate the time they spend traveling. But even if the times are debatable the direction of change should not be.

Figure 10: Some Changes In Average Work Trip Times

City	All modes (minutes) 1980 - 1985	Auto (minutes) 1980 - 1985	Transit (minutes) 1980 - 1985	% trips by transit 1980 - 1990
Chicago	28.2 - 26.4	24.5 - 23.0	45.0 - 44.0	18.0 - 17.1
Dallas	22.8 - 23.2	22.6 - 22.7	38.1 - 40.7	3.4 - 3.2
Detroit	23.3 - 19.9	23.1 - 19.9	40.9 - 44.5	3.7 - 2.4
Los Angeles	24.3 - 22.8	23.7 - 22.1	40.5 - 39.0	7.0 - 6.5
Phoenix	35.6 - 34.0	28.1 - 26.3	47.6 - 46.2	2.0 - 2.1
San Diego	19.6 - 19.6	20.3 - 19.5	38.9 - 39.5	3.3 - 3.3
San Francisco	25.3 - 24.4	23.1 - 21.3	39.4 - 33.2	16.6 - 19.5
Washington DC	28.5 - 26.2	26.9 - 25.0	41.7 - 38.4	15.5 - 14.7

Sources: U.S. Bureau of Census, Urban Transportation Monitor
1985 American Housing Survey

Another view of congestion is that it is evidence that a region is being overused -a disease which is countered, not by providing more capacity, but by providing alternative origins and destinations in more attractive surroundings.

There is a general impression that congestion is a new phenomena. But it has been with us a long time as photographs of major U.S. cities about the turn of the century show. Even the Romans had to ban certain kinds of traffic during peak periods. Traffic may be expected to increase to the point that some congestion occurs no matter how much capacity is provided. On the other hand the delays caused by congestion are unlikely to increase to the extent predicted by some highway officials.

Conclusion

In summary, there are several advanced transportation concepts that can have a significant impact on the energy consumption and generation of emissions from transportation without requiring the development of new propulsion and energy systems. I am confident that there are other concepts with equivalent benefits to those that I have discussed. In this paper I have attempted to illustrate the potential benefits of these concepts. Since we do not have definitive studies of the extent of the market penetration or use I have assumed several levels of use. This should be considered illustrative and will undoubtedly change in detail when more comprehensive studies can be made.

Figure 11 summarizes the benefits of half width commuter cars in terms of energy savings and emissions for different levels of market penetration. The figure is based on the assumptions that single passenger work trips represent 25-30% of urban travel and that the total single passenger trips including non work purposes represent 45-60% of urban travel. Since we will need real world experience to estimate the actual use of half width cars, I have shown the relative benefits of three levels of use. The emission savings should be larger than the energy savings but as noted earlier cannot be predicted with confidence because of the lack of suitable analysis programs.

Figure 11: Potential Energy Savings of Commuter (Half Width) Cars

	Percent of Total Transportation Energy	
% of 1 passenger trips	Energy Savings	Emission Reductions
10%	1-1.5%	>1.5%
20%	2-3%	>3%
40%	3-5%	>4%

Note: Preliminary Estimate

Figures 12 summarizes the benefits of neighborhood cars in terms of energy savings and emissions for different levels of market penetration. The figure is based on the assumption that shopping trips under ten minutes represent 11 to 15 percent of urban travel and that the total trips under ten minutes represent half of urban travel. As above, the emission savings should be larger than energy savings but cannot be predicted with confidence because of the lack of suitable analysis programs. Additional analysis will be required to better define these estimates, and to determine how they differ in different urban regions.

Figure 12: Potential Energy Savings of Neighborhood Cars

	Percent of Total Transportation Energy	
% of trips <10 min.	Energy Savings	Emission Reductions
10%	1.5-2%	>2%
20%	3-4%	>4%
40%	5-7%	>7%

Note: Preliminary Estimate

I hope that the potential benefits (economic, and societal) of these new transportation concepts and technologies will be sufficient value to encourage people and companies to pursue their development and commercialization. The implementation of these concepts will require effective cooperation between the public and private sectors. The use of some unconventional transportation concepts and services may require changes in the "culture."

While changes are difficult they are occurring. Smoking is decreasing, Computer use for recreation is a new and increasing phenomena.

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Marketing NEVs to Households

Kenneth S Kurani
Research Associate
Institute of Transportation Studies
University of California, Davis

Introduction

"Neighborhood electric vehicles" (NEVs) include a wide variety of vehicle types, ranging from electric-assist cycles to small, "freeway capable" vehicles. What they all have in common is their purpose: to replace the most polluting, least efficient trips made by full-size, internal combustion engine vehicles (ICEVs). These trips are characterized by short distances, low average speeds and frequent speed changes and stops. Further, these trips may often be linked together as drivers access several local activities -- increasing ICEV emissions through multiple warm soak cycles.

The wide variety of NEVs are suited to different applications, and thus different market segments. The demonstration projects and marketing studies conducted to date by the Institute of Transportation Studies at UC Davis have focused on the household vehicle market. Further, while we have developed infrastructure and policy studies which include new residential developments, we have focused our market assessments and demonstration projects primarily on how NEVs might fit into the existing urban structure of California.

One or more of this series of studies have included the entire spectrum of NEV types with the exception of electric-assist cycles. But this discussion focuses on the middle ground of vehicle types -- 1 and 2 seat vehicles with top speeds in the range of 30 to 40 mph and ranges of 20 to 30 miles. These vehicle types have been represented by the City-Com City-El and the Kewet El-Jet.

NEV Market Research Efforts at ITS-Davis

In our market research we have both examined existing communities where NEV-like vehicles are in use and used a variety of techniques to create information contexts in which people unfamiliar with NEVs can competently imagine how such a vehicle might fit into their household's stock of vehicles. The elements of ITS-Davis NEV market research include:

- case studies of the "golf cart communities" Sun City, Arizona and Palm Desert, California;
- one-day ride-and-drive clinics in which people review a wide variety of electric vehicles, including NEVs;
- vehicle trials in which households are given use of a NEV for a one-week period; and
- a multi-part survey of household vehicle purchase intentions based on existing household vehicle holdings, purchase intentions, travel diaries and maps of activity locations.

Unifying Theoretical Concepts

The variety of vehicle types, the differences between household and fleet applications, and the differences between placing NEVs in existing urban development versus transportation infrastructures specifically designed for NEVs, represent a potentially confusing array of research possibilities. We use the concept of a household "activity space" to provide a unifying thread throughout our NEV research.

A household's activity space is defined by:

- the household members' activities;
- the time schedule of those activities;
- the geographic location of those activities;
- the modes and routes used to access those activities; and
- linkages between activities.

Linkages include both linkages between one person's series of activities -- e.g. whether the male household head makes a trip to his dentist on the way home from work -- and linkages between household members -- e.g. whether

that same person makes a stop at daycare on his way home from the dentist to pick up a child.

The constraints on a household's activity space are:

- the household structure of relations and responsibilities;
- vehicle ownership and availability of other transport modes;
- a time schedule;
- an income budget; and in the case of electric vehicles, and NEVs in particular,
- a distance budget.

This last constraint is new to households. ICEVs, and their ubiquitous network of fuel stations, provide very long daily range -- the distance one can travel in a day is limited by time constraints (and speed limits), not the total amount of energy which can be stored on the vehicle or the rate at which that energy can be replenished. But battery EVs, and NEVs in particular, will have short ranges and may require a few hours to recharge from a household 110 volt outlet. Providing the information context for households to competently imagine how they would incorporate a vehicle of limited range into its stock of vehicles is the core of the designs for all of our studies. (In the case of golf cart case studies, we examine households which have already incorporated limited range (and low speed) vehicles into their households.)

From previous work, we identified two elements within the overall activity space which determine a household's demand for driving range:

- The Routine Activity Space is defined by that set of activities which the household accesses on a daily and weekly basis (including all the other associated dimensions -- location, mode and route to access, etc.);
- A Critical Destination is a destination which a household member feels they must be able to reach in the limited range vehicle, even if the "unlimited range" gasoline vehicle is not available.

As an additional premise for the NEV research we include:

- Households have, or can create, sub-spaces of their activity space which are defined by the choice of travel mode.

Given these, our initial research question is:

- "Can a household create a useful NEV activity space so that a NEV is included in the household's choice set for its next vehicle purchase decision?"

Household NEV Trials

Results from the household NEV trials illustrate both the use of the activity space concept and how households learn about how range, speed and size limits shape their opinions and possible NEV purchase intentions.

Households were selected to participate in the trials based on employment by the University of California (which affects the nature of work trip travel, but was necessary for liability reasons) and household location criteria. Because the UC Davis Medical Center is located in Sacramento, we were able to place vehicles in homes in Davis and Sacramento. In this way, we explored differences in household response based on spatial scale, traffic levels and speeds and the prior existence of mode-defined activity sub-spaces within the households' activity spaces.

Each household was given either a City-Com City-El or a Kewet El-Jet to use for a one week period. Each driver in the household maintained an activity diary for the week and the household participated in an interview afterward. Drivers recorded their complete activity space for the trial week: trip purpose (activity); modes (including alternatives to the NEV if it was used); trip times; routes; trip sequence links and activity links with other household members. Respondents recorded their routes on maps for each trip.

A composite route map of all the the household's trial week travel was prepared for use in the interviews. The interview moves through 3 phases:

- Orientation to explain the map to the household, to explore typical travel not made during the diary week and unusual trips which were made, and to review household use of non-automotive modes;

- Discussion of NEV use to explore how range, recharging, speed, size and safety perceptions affected actual and potential NEV use; and

- NEV purchase potential.

Selected Results from Household Trials

Mode Defined Activity Sub-Spaces

Residents in Davis were more likely than those in Sacramento to already have mode-defined activity sub-spaces. For many Davis households, bicycles provide access to work (the University campus), grocery shopping and other shopping, especially in the university/downtown area. Other errands run during the day will be made on foot or bike, if bike is the mode to work. In contrast, residents in a variety of different neighborhoods in Sacramento rarely left home by any other mode than automobile. Transit ridership is low in all households in both cities. While the university campus is conveniently served by bus, residents in both Davis and Sacramento asserted that bus and rail transit schedules did not provide the flexibility required to maintain convenient links to other activities and household members.

The specific existence of a "bicycle activity space" does indicate that households will create such sub-spaces distinguished by travel modes, but does not itself appear to be positively associated with desire to buy a NEV. The NEV must sufficiently distinguish itself from a bicycle to trigger a purchase intention. In several households this means the vehicle must be sufficiently larger and faster than a bicycle, while remaining sufficiently less expensive than an automobile. For many of the Davis households, a vehicle must have the requisite performance to reach nearby towns before it would be seriously considered for purchase as a replacement for an existing household vehicle. This performance level is well beyond that of the NEVs that households drove in these trials.

Infrastructure Limits on NEV-Activity Space

In Sacramento in particular, we see the effects of existing urban infrastructure on households' ability to create a useful NEV-activity space. Some households were located in residential enclaves surrounded by high-speed arterials. The high-speed streets served as barriers to access to all but a limited number of activities. Even the larger, higher speed El-Jet (as compared to the City-El) was not a comfortable vehicle for many households to use. Unfortunately, this land use and transportation infrastructure pattern is

typical of the majority of the suburban communities north and east of downtown and midtown Sacramento. Indeed, this land use pattern is typical of suburbs throughout California and the nation.

However, ubiquitous land use and infrastructure patterns are not required for infrastructure barriers to exist to NEV use. In some instances, a single obstacle may represent a sufficient barrier to the household imagining a useful NEV-space. We see examples of this in Davis and Sacramento: to access the university campus and downtown Davis, residents of west Davis must cross State Highway 113; to access the Medical Center and downtown Sacramento, residents of north Sacramento must cross the American River. In both cases, only a limited number of options are available to make the crossing. The City-El was judged to be a poor replacement for a bicycle in one west Davis household because the choice of routes across Highway 113 dictated that the City-El be driven on a busy street with several traffic signals, whereas a bicycle allowed access to the same activity locations via quiet, residential streets and a pedestrian/bicycle only overcrossing of the highway. Similarly, a household in north Sacramento which drove the Kewet El-Jet explored three different available crossings of the American River -- none of which was entirely satisfactory.

Activity Space and NEV Market Potential

Most households in Davis and some in Sacramento illustrate the activity space dimensions which are most conducive to NEV use, and thus NEV purchase. These are:

- high density of household activities located within a compact geographic area;
- activities accessible by many low, or appropriate, speed streets; and
- flexibility in assignment of vehicles through high vehicle ownership or a compatible structure of links between household members' activities.

Households which rejected the notion of buying a NEV fall into one of three groups:

- those for whom some attribute ruled out NEVs entirely (usually vehicle occupancy/cargo capacity or safety perceptions of small vehicles);
- households which lacked crucial, suitable roadway links to important activities; or
- households in which the NEV-activity space is not clearly differentiated from the sub-space of some superior (cleaner, cheaper, safer, bigger) mode.

Conclusions

Accepting that a household must first be able to define a useful NEV-activity space before competently imagining a NEV purchase decision, our work to date leads us to conclusions about desirable characteristics of NEVs and to possible markets for them.

NEVs for Household Markets: Two Types of NEVs

The distinction between freeway capable and non-freeway capable vehicles is an important one to many households. Even to those which learn that a large amount of their daily travel can be accomplished in a non-freeway capable vehicle, the non-freeway limit is an important perceived purchase barrier. Thus NEVs are a distinct class of vehicles. Within this distinction though are finer ones still. Two types of NEVs can be distinguished from each other based upon our work to date: vehicles suitable for immediate use in many urbanized areas and vehicles suitable for use in communities, industrial parks or other facilities designed specifically for, or otherwise amenable to, low speed vehicles. We summarize possible characteristics of the two types below:

Type 1: For use in existing communities.

- 45 mph top speed
- "Brisk" acceleration -- 0-40mph in not more than 8 seconds
- Available in 2 to 4 seat configurations.
- Meets slightly Modified FMVSS.

Type 2: For use in purpose built environments.

- 25 mph top speed.
- 0-25 in approximately 5 seconds.
- Available in 2 to 4 seat configurations.
- Meets highly modified FMVSS or exempt.

(Note that the Type 1 NEV is not intended to preclude the use of electric-assist bicycles in existing urban areas.)

NEV Driving Range?

We have not specified a lower bound on desirable range for either type of NEV. Few households in the NEV trials experienced any problems with the 20 to 30 mile range capabilities of the vehicles in the trials. Continued experience with the vehicles might lead some households to explore further afield and thus to desire more range. The range requirements for NEVs are likely to be a function of where they lie on the spectrum from electric-assist cycles to short-hop freeway vehicles. The lower the vehicle's top speed capability, the more likely it is that time, not distance, will be the important constraint on a NEV-activity space. People traveling slower will not choose to travel as far because the time it takes to get to an activity location becomes prohibitively long, regardless of how suitable the streets and traffic level.

Compact Activity Space Accessible by Surface Streets

To market vehicles which are not capable of long-distance, high-speed travel, we need to shift our perspective. We need to shift from our stereotypical vision of Los Angeles, and begin to look at Pasadena, Altadena, Burbank, Northridge, El Monte, El Segundo and the other towns and cities which make up the urban area; to look for those people who live their lives within compact activity spaces accessible by surface streets. We need not to think of selling cars in the metropolitan region stretching from the Sacramento River to the Sierra foothills, but of selling transportation options in Davis, mid-town Sacramento, Roseville and Fair Oaks. From this perspective, NEVs can provide a superior transportation option to multi-car households, allowing them to maintain a high level of accessibility at a lower cost. NEVs may also represent a superior transportation option to used ICEVs. Many used cars are driven primarily for local travel. If NEVs are inexpensive to buy, cheap to

operate and reliable, they may represent a superior transportation option to used ICEVs.

New Vehicle Ownership Arrangements

In adapting a NEV to their use, many households speculate on the possibility of new ownership arrangements and how these might affect their willingness to include a NEV in their household fleet. Discussions followed two lines: NEV ownership arrangements in which the household would not have to absorb the risk of this new vehicle type, and ICEV ownership arrangements which would allow the household to own only NEVs but have access to a long-range, high-speed vehicle. Examples of the first type would be NEVs operated as station cars and employer-provided vehicles; the later would include cooperatives which rented large ICEVs to their members and expanded commercial rental ICEV availability.

Acknowledgment

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City-El Demonstration Project

William R. Warf
Owner
Pacific Electric Vehicles

Abstract:
Pacific Electric Vehicles is working with SMUD to study the market potential and technical merit of Neighborhood Electric Vehicles (NEV's). The study involves the leasing of 48 City-el electric vehicles which were manufactured in Denmark and acquired for the program. Utilizing the information gained from the market and technical study, a NEV prototype is being developed for the US market.

This presentation will overview the scope of our project including what we have learned so far about the marketplace and the technology. A summary of the product specifications for our prototype EV is presented, and the pollution reduction benefits of NEVs relative to other electric vehicles is discussed.

Program Overview

SMUD has a large EV fleet consisting of 38 vehicles. This fleet is composed of 14 City-els, 2 Trans2s, 2 Horlacher prototypes, 11 conversion pick-ups, 4 passenger car conversions, 3 Conceptor G-Vans, and 2 Electric busses. The SMUD EV program includes study of a flywheel battery system, freeway capable low mass vehicles, station cars, and neighborhood EVs. Additionally, Pacific Electric has 48 City-el's.

Our part of the program is to manage the NEV project and to acquire technical and marketing data through leasing the City-els. We are testing components, studying light weight glazing, and constructing a NEV prototype. So far we have leased 34 of the 48 vehicles at $120 per month. Tests of advanced batteries and US made components are ongoing. To date we have realized about 12,000 City-el miles, and have used about 8 M-W hours of electricity measured at the plug. All lease customers receive mandatory training in safe City-el use, which provides an operator's orientation to the vehicle systems and a strong warning regarding the cornering limitations of the vehicle.

Based on our studies to date, we define a NEV as a vehicle that meets consumer needs for short trips or errands that do not require freeway travel. An NEV has a 35 mile range at 35 mph, a top speed of 44 mph, low cost and low energy use. NEVs utilize existing infrastructure because of low power requirements.

Market Study Results

Is there a market for such a vehicle? All the market studies say yes, if the right combination of utility, comfort, and cost is achieved. This conclusion is based on market study results from our own customer interviews, ITS studies, DeVry Institute of Technology Studies, and surveys of McClellan Air Force Base personnel using the City-el performed by California State University, Sacramento. Somè of these survey results are summarized below.

In studies of individuals in Atlanta and South Florida performed by Sandra McKee of DeVry, 31 % of respondents surveyed indicated the most troublesome part of car use is stopping to refuel with gasoline. Most respondents in this survey drive 30-50 miles per hour, and can accomplish their transportation needs without using the freeway. All respondents say cars are too expensive.

Joe Orsini of Sacramento State University performed interviews of City-el operators at McClellan AFB. The interviews were performed upon introduction to the vehicle, and at 6 and 12 weeks after introduction. These respondents indicated that the vehicle's range and speed were acceptable on Base. They liked the accessories, quiet operation, and ease of parking. It is interesting to note they mentioned the air quality benefit of the vehicle only in the first interviews.

Regarding concerns about the City-el, the Air Force Base users express dissatisfaction with the ride and handling. Because of vehicle size and "flimsy construction" these interviewees expressed strong concerns regarding using the City-el off of the Air Force Base. It seems likely that our warnings regarding the handling properties of the vehicle have made an impact, and may have influenced our study results.

We have talked to many people regarding the City-el. They have said that if we had a vehicle with four wheels and two seats they would buy one. The main dislikes of the City-el are the three wheeled design, poor ride and handling, slow top speed, one seat design, and high price ($8000).

These Market Survey results suggest to us that a well developed vehicle that has roughly the same capabilities and finish as the City-el, and in which people can feel safe and go a little faster, is sellable in sufficient numbers to warrant tooling for limited production. The first step is to develop a prototype with the attributes of the City-el, with more utility, comfort and convenience than a City-el.

Technical Study Results

Compared to other EV's, Neighborhood vehicles have more modest performance requirements because there is no need for higher freeway speeds. A lower power drive, charger, and a significantly smaller battery pack can be used, all of which will contribute to lower production and life cycle costs. NEVs will operate at lower voltage, which may mean easier compliance with electric codes, and which greatly simplifies the charging system.

NEVs have disadvantages also. These limited use transportation products will not be accepted quickly unless the price is low. An NEV must be small, light, and at the lower bounds of the "personal space envelope," which is the volume inside the vehicle that allows passengers to feel comfortable. In addition, the Federal Motor Vehicle Safety Standards are based on larger cars, and a production NEV has to satisfy the current standards.

Review of all available measured data regarding the energy use of EVs confirms that energy use is a strong function of vehicle mass. NEVs can be expected to use energy between 80 and 300 W-h/mile depending on the systems employed in the vehicle. Conventional, heavy vehicles, including EV conversions, will use between 300 and 1200 W-h per mile. View graphs illustrating "at the plug" energy use from Solar Cup Denmark and from the SMUD fleet are provided in the attachment to illustrate this fact.

Advanced electronics and light weight allowed the Felix to use less energy, carry two people, and go almost as fast as up-rated City-el prototypes in Solar Cup Denmark.

It is worth noting that the City-el charger includes a holding charge during which the charger draws 40 W as long as it is plugged in. If the vehicle is unplugged, a small current draw will discharge the batteries over a span of 4-6 days, so it is usual for City-el users to leave the vehicle plugged in. The result of this design is that energy use in a City-el varies strongly with the amount of vehicle use. A chart was prepared from measured data which illustrates this fact. This explains the variation in City-el energy usage in Solar Cup versus the use seen at SMUD. In fact, SMUD drives their City-els about a mile a day on average, which probably means a couple of miles every other day.

The City-el systems were dissected to examine the energy losses in various parts of the vehicle system. The rolling resistance was determined by roll down test, and a plot made for power required at the average measured coefficients of drag and rolling resistance. At the road, a City-el requires about 1.5 kW at 30 miles per hour, and 3.5 kW at 45 miles per hour. This results in energy usage in average trips of about 57 W-h per mile at the road, and about 190 W-h per mile at the plug, neglecting holding charge and "always on" losses. The systems diagram and the pie chart provide a breakdown of the difference between at the plug and at the road energy use.

We have postulated a preliminary design specification and an energy budget for our prototype NEV "Picador". These are provided in the attached view graphs titled "Picador: Vehicle Dynamics", "Picador: Electrical Drive" and the pie chart titled "Picador NEV average energy use, Engineering goals, 140 W-h/mi at Plug".

Is pollution proportional to energy use?

A brief analysis was performed to quantify emissions from electric vehicles charged by fossil fuel generated energy, compared with internal combustion engines in vehicles. In order to make the comparison, the emissions

regulations were translated into the mass of allowable pollution per unit energy generated from both fixed and mobile sources. The analysis does not attempt to incorporate a thorough cost-benefit analysis, costs of refining the fuels, concentrations of pollutants, or the actual electric power generating mix. This is necessarily an overly simplistic approach, but the result suggests that allowable pollution is indeed a function of energy use, and therefore a function of vehicle mass. The assumptions used in the calculations are provided in the attached view graphs.

One surprise was that the regulations permit higher emissions per unit energy from a high mileage economy car than they would for a lower mileage car. This seems consistent with the economy car's lower market price, since simpler control technologies need to be applied to keep costs down. See GAS.XLS Chart 3, attached.

Given the assumptions used, the emissions from light weight EVs work out to between 0.3 and 0.7 grams per mile, while heavier electric vehicles emit between 1 and 3 grams per mile.

PV Recharging

I was surprised at the amount of energy lost in transmission from the power plant to the user. The longer the transmission distance, the larger the losses. This suggests further work is needed to develop recharging of vehicles using fixed photo-voltaic arrays, which might have essentially zero transmission losses. The problem is the cost of the arrays, and the space they take up.

Using the energy use data presented for the SMUD fleet, the area of a PV array required to fully recharge a vehicle in 6 hours after a 10 mile trip was estimated. NEVs are the most feasible to recharge using photovoltaics, since a smaller array is needed. My calculation shows that NEVs might be recharged by a 4 square meter array, while converted passenger vehicles will require 8 - 12 square meters, and pick-ups and G-vans will require more than 20 square meters of array surface. The results of my calculation are shown in the chart "energy use for 10 miles, PV array area for 6 hour recharge".

Summary

Neighborhood EVs can provide greater benefits than other EVs in terms of reduced energy use and pollution, and lower cost. Market study results are encouraging, in that consumers have identified a variety of vehicle attributes that may be more important than range and speed. Consumers suggest that a vehicle similar to the City-el that offers more utility, more comfort, and a little more speed would be quite acceptable for much of their transportation needs.

The largest problem in NEV development is the ability of a small, light vehicle to provide adequate passenger safety, and to fulfill the crash test standards provided in the Federal Motor Vehicle Safety Standards. It is noted that since a NEV is by definition slower than conventional automobiles, the overall safety of passengers is easier to achieve than it is in vehicles capable of higher speeds.

Neighborhood EV: Definition

- Fit users needs for around town errands, short trips
- 35 miles per hour, 35 mile range
- 44 miles per hour top speed
- Low cost
- Low energy use, 100 - 150 W-h / mile at plug
- Existing technology & no special infrastructure

DeVry: Sandra McKee Market Studies in South Florida and Atlanta

- "To our amazement 31% of individuals surveyed felt stopping to put in gas in the car was most bothersome part" (of car use)
- 70 % of respondents can accomplish there transportation needs without the freeway
- 60 % drive 30 - 50 mph most of the time
- 100 % say cars are too expensive

Orsini's McClellan City-el User Survey: Attributes

- Speed and Range acceptable on base, and for some public street uses
- Accessories acceptable to good
- Quiet Operation
- Parking is very easy
- Note the air quality benefit is mentioned at first, but over several months...no longer brought up.
- Also note, these users are driving the City-el for free!

Orsini's McClellan City-el User Survey: Concerns

- Safety Concerns ranged from a feeling of aprehension to fairly strong fear
- Suspension design resulting in a harsh bumpy ride is an annoyance, and a safety item.
- "It looks a little flimsy"
- "I don't think I would use it in the (off Air Force Base) real world."
- Helmets don't fit, making vehicle less suitable for "fleet" use.

Pacific EV's Market Study

- "If you had one with four wheels and two seats I'd buy one"
- "look, the car of the future"
- Main dislikes of Mini-el:
  - 3 wheels ... Helmet ... poor ride and handling
  - Too Small / Too Slow
  - One Seat
  - Price Too high!
- "It's like driving a bicycle in the lane for cars"

Summary of Market Surveys:

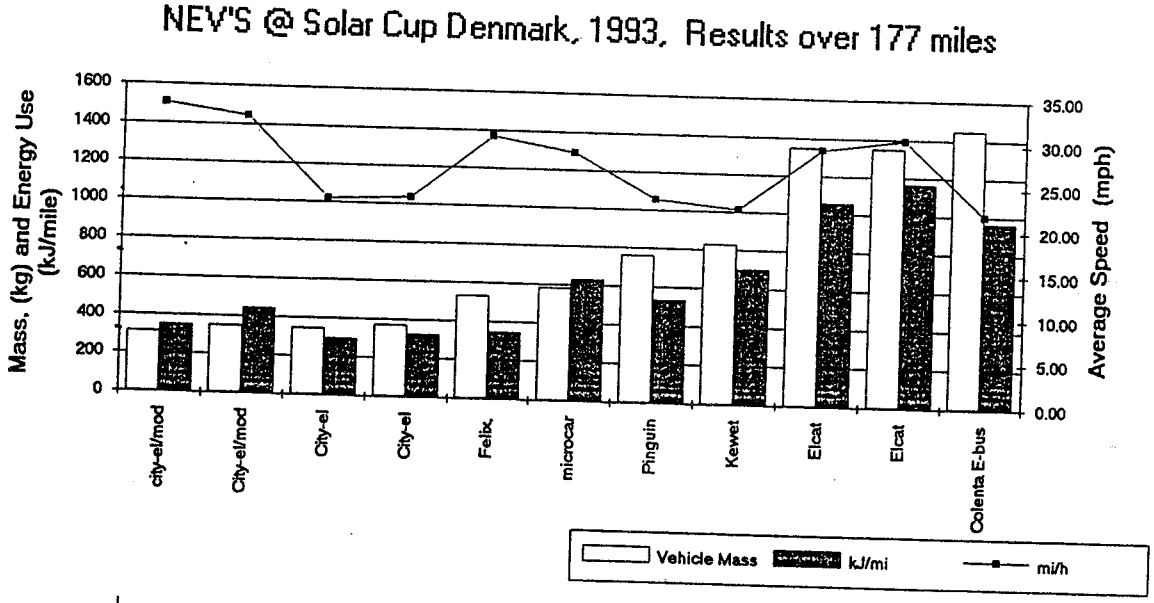
- People understand the benefits of a low energy use vehicle
- People mention safety first
- Utility, comfort, and convenience are minimums for a saleable NEV
- Range and speed of the City-el are acceptable values for most, a little higher speed capability is in order

Advantages of NEV Concept

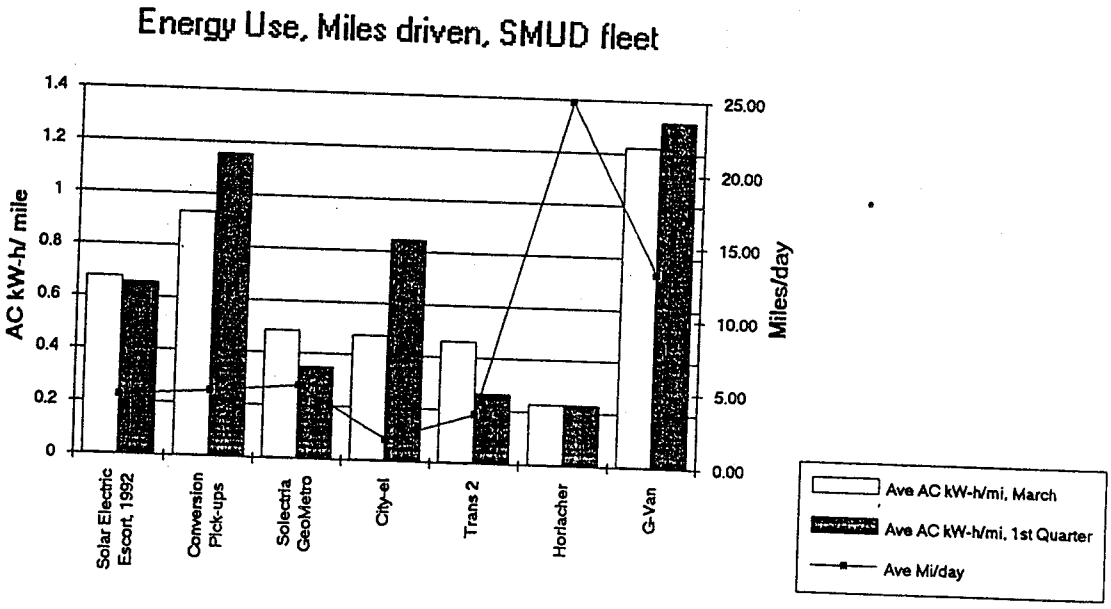
- Modest performance requirements
- Smaller battery pack...
  - fewer weak links (cells in series)
  - longer battery pack life
  - lower battery replacement cost
- Smaller Motor, less power required
- Charge any where without special plugs
- Lower Voltage may mean easier code compliance
- Pollution reductions more significant, since pollution is proportional to energy use
- Replace least efficient use of IC engine cars

Disadvantages of NEV Concept

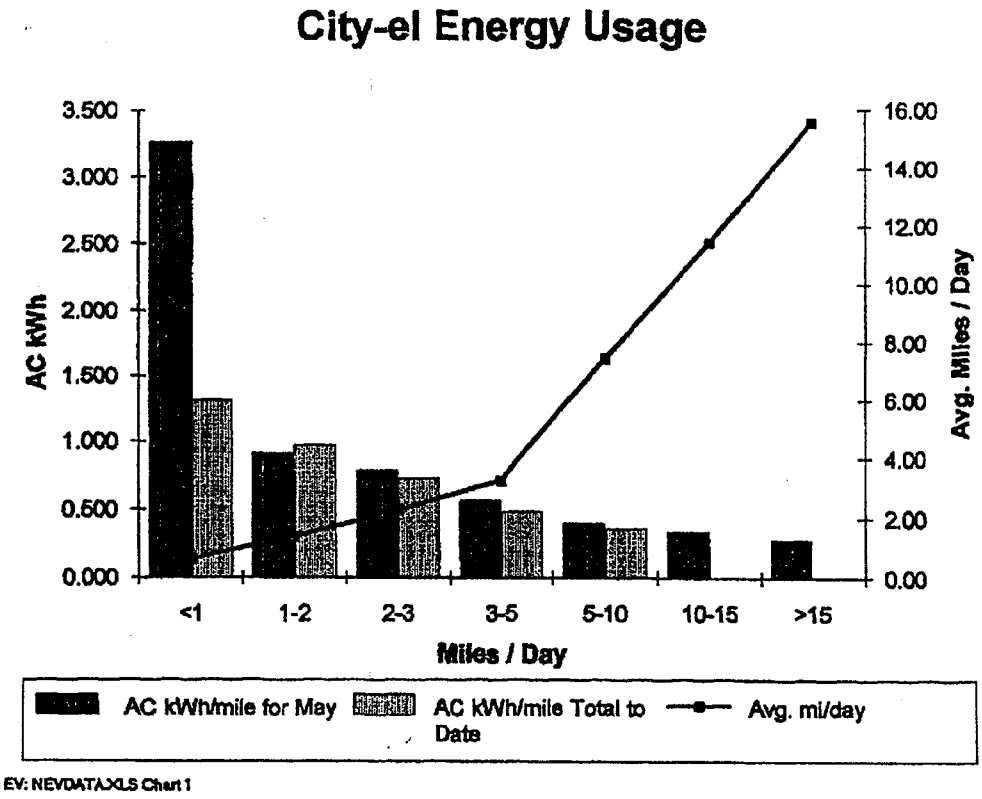
- New Transportation Product, Education required as to which specific needs are met
- NEV needs to be small, and light, we will push personal space envelope
- FMVSS are tailored to larger cars
- Market acceptance will be slower, because of difference in concept
- Product must be in-expensive, price sensitivity is greater than a freeway capable EV



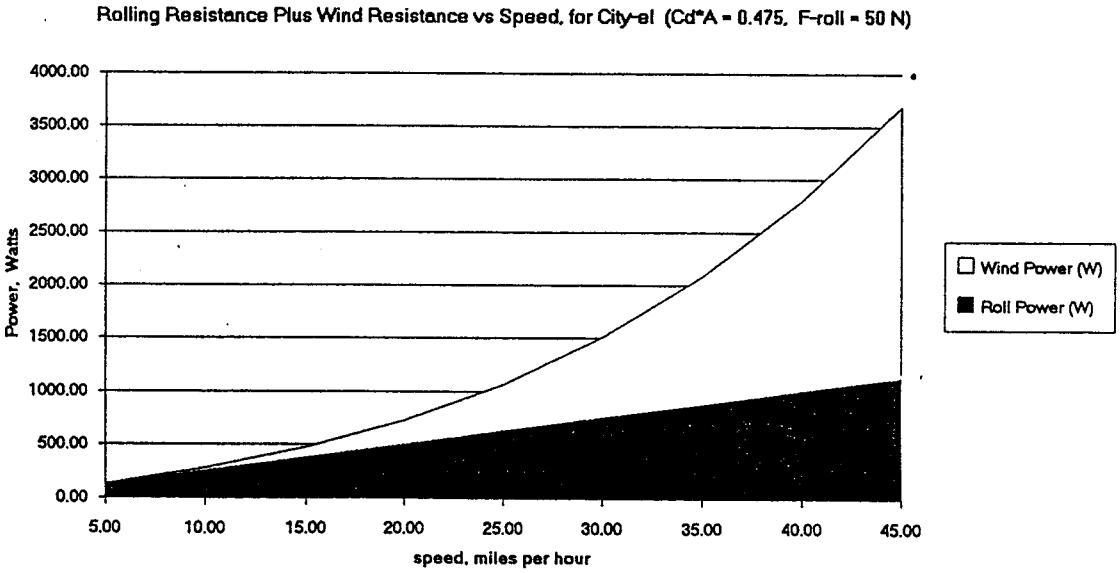
PEV SOLARCU2.XLS Chart 5 6/27/94



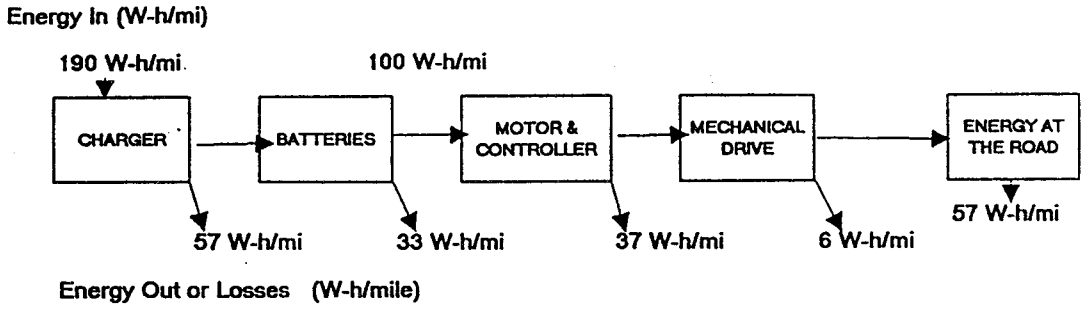
PEV SMUDDATA.XLS Chart 1 6/27/94



Pacific EV: NEVDATA.XLS Chart 1

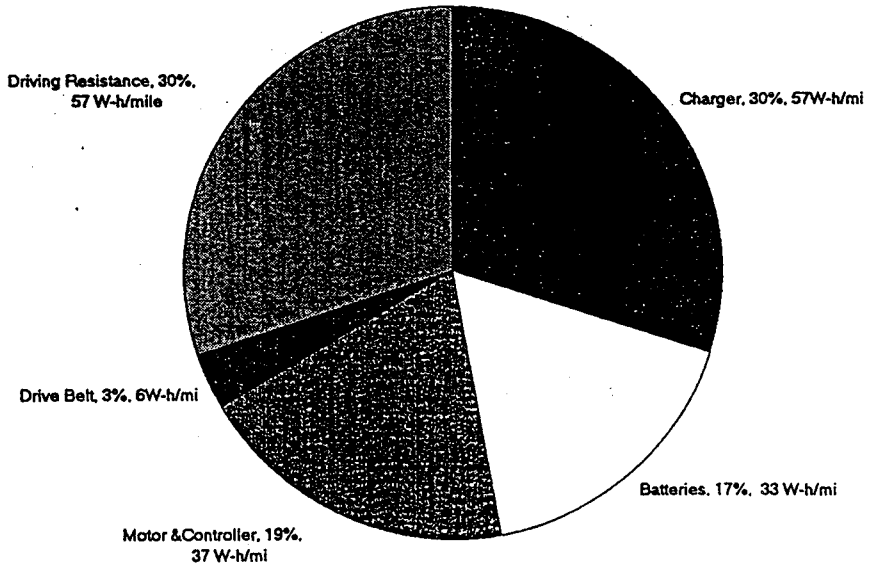


City-el, Average Energy Use of Main Systems



Note, Neglects holding charge and "always on" losses

City-el Systems Energy Use, Average per mile traveled, 190 W-h/mi total at plug



PEVCELENRGY.XLS Chart 16/28/94

Picador: Vehicle Dynamics

- Mass: 390-440 kg (depending on configuration and batteries)
- Frontal Area: 1.50 m^2
- Cd: 0.3
- Cd*A = 0.45
- Tires: 120/80-16
- Low un-sprung mass (need composite wheels or other suspension components)
- top Speed: 40 mph
- Range 20-40 miles

Picador: Electrical Drive

- 48 V system
- 130-180 kg battery weight
- 3.1-4.3 kW-hour (useful DC) battery capacity
- 5 kW motor (brushless servo drive?)
- Electronic speed limiter
- Regenerative braking

Stationary Sources Basic Data and assumptions

- CO... low 50 PPM to High 100 PPM
- NOx... low 3 PPM to High 10 PPM
- above is at 15% O2 in stack gas
- Assumed 40MJ/kg fuel energy
- Assumed stoichiometry of 14.5 kg air / kg fuel
- Assumed Process operates at 1.75 times stoichiometry to achieve excess O2
- Result: 35-72 ng pollutants / Joule produced

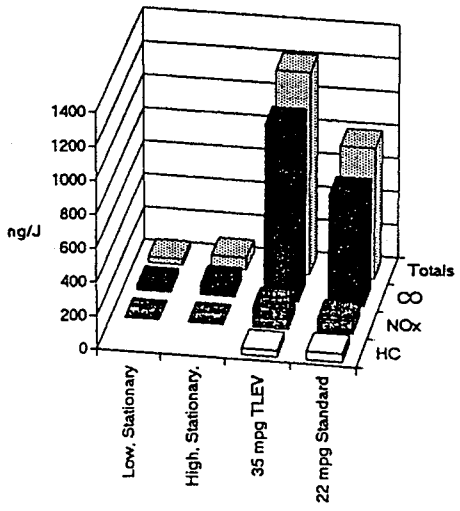
Is pollution proportional to Energy Use?

- I looked at basic requirements for stationary and mobile sources
- Emissions from Stationary sources are measured in PPM in off gas or ng of bad gas per Joule produced
- Emissions for vehicles are measured in g/mile

Mobile Sources, basic Data and assumptions:

- CO ... 3.4 g/mile
- NOx ... 0.4 g/mile
- HC ... 0.125 for TLEV
- HC ... 0.250 for standard car
- Stoichiometry: TLEV - 1.2
- Stoichiometry: Standard - 1.1
- O2 in exhaust: 3% TLEV, 1.5% Standard
- MPG: 35 for TLEV, 22 for Standard car
- Result: 1211 ng / Joule for TLEV, 784 ng / J Standard car...

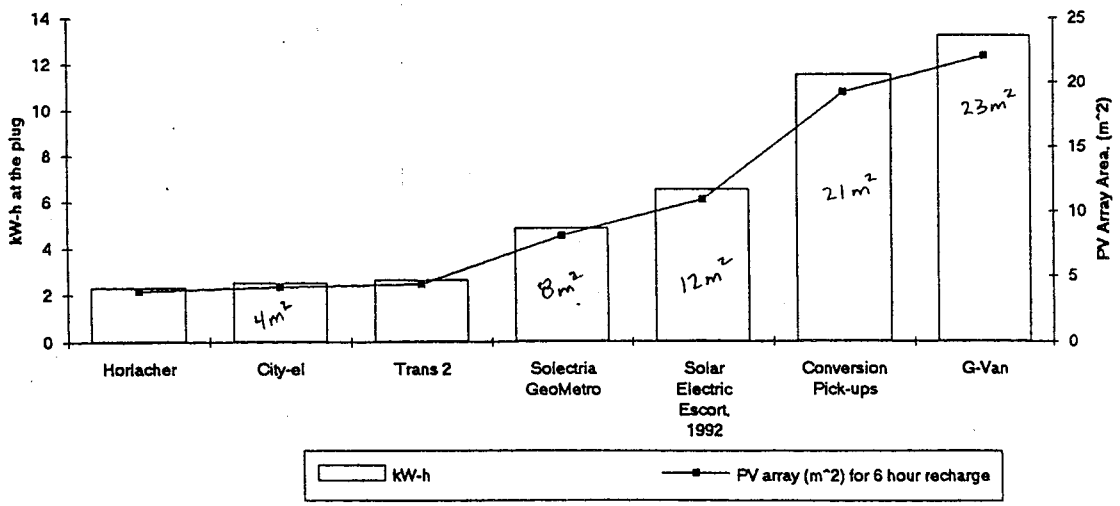
Emissions permitted, stationary vs. Mobile Sources

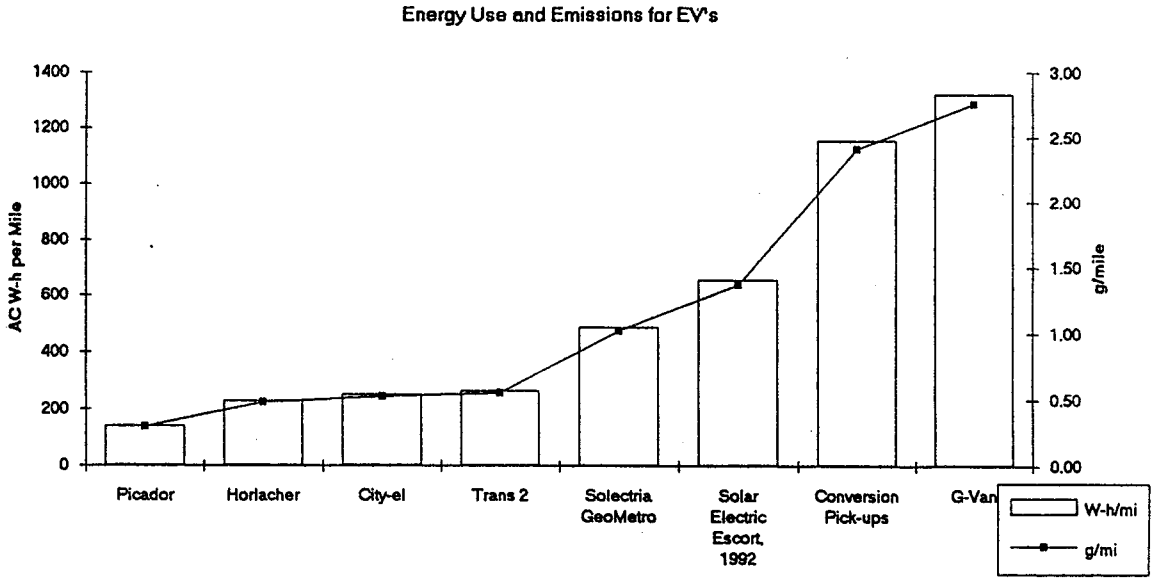


Emissions... equivalent for EV's

- It is pretty easy to multiply ng/J by energy per mile to get equivalent pollutants
- At the power plant, the energy produced must be distributed to where it is used...
- So I assumed:
- 75% transmission losses, and
- 50 % efficiency of fossil fuel to electricity at the power plant

Energy use for 10 miles, with PV array area for 6 hour recharge





Summary:

- A light vehicle which meets consumers needs is possible, it will be more like an improved City-el than a normal car... more utility, more comfort, and a little faster than the City-el
- NEV's use less energy, have fewer batteries, and will cost less than fully capable electric cars
- The Air Quality benefits of NEV's are larger than other EV's
- Final note: Crash safety is our biggest hurdle, this problem is the focus of our present chassis work... a low mass suit of armor!

VI. Session Four: Regulatory Issues for NEVs

CARB's Zero-Emission Vehicle Mandate and the Role of Neighborhood Electric Vehicles

Thomas Evashenk
Air Resources Engineering Associate
Mobile Source Division
California Air Resources Board

In September of 1990, the Air Resources Board (ARB) adopted the Low-Emission Vehicle and Clean Fuels regulations. These regulations established stringent emission standards for four new classes of light- and medium-duty vehicles. In order of increasing stringency, the vehicle classes are transitional low-emission vehicles (TLEVs), low-emission vehicles (LEVs), ultra-low-emission vehicles (ULEVs), and zero-emission vehicles (ZEVs). For light-duty vehicles, the regulations require that auto manufacturers meet an annual, increasingly stringent fleet-average requirement for non-methane organic gas emissions. Manufacturers are provided flexibility in meeting the fleet-average requirement each year in that they may produce any combination of TLEVs, LEVs, and ULEVs, as long as the fleet-average requirement for each model year is met.

Beginning in 1998, however, two percent of each large manufacturer's passenger car and light truck fleet produced for sale in California must be comprised of ZEVs. This percentage increases to five percent in 2001 and 2002, and to ten percent in 2003. Initially, the zero-emission vehicle mandate applies only to manufacturers that sell more than 35,000 vehicles in the state of California each year. In 2003, the mandate will also apply to manufacturers that sell between 3,001 and 35,000 vehicles in California each year. Manufacturers that sell less than 3,000 vehicles per year in California are not subject to the mandate.

Importantly, the regulations do not require minimum performance standards or minimum size requirements for a vehicle to receive credit towards the zero-emission vehicle mandate. Additionally, no specific definition of neighborhood electric vehicle (NEV) is included in the regulations. The

regulations do allow for electric medium-duty vehicles (vehicles weighing between 6,000 to 14,000 pounds gross vehicle weight) to receive the same amount of credit provided to light-duty electric vehicles.

To provide flexibility to industry in meeting the zero-emission vehicle mandate, the ARB adopted a credit trading provision as part of the regulations. If a manufacturer chooses to produce and sell more than the mandated percentage of ZEVs, that manufacturer will earn credits. These credits can be retained and used by the manufacturer in later years, or sold to another manufacturer that chooses to produce less than the mandated percentage of ZEVs. Alternatively, under the ARB's mobile source emission reduction credit guidelines, the manufacturer can make ZEV credits available to ZEV purchasers to be used as part of mobile source emission reduction credit programs. Zero-emission vehicles used to generate mobile source emission reduction credits can be used towards a manufacturer's mandated ZEV percentage requirement, but cannot count towards the manufacturer's NMOG fleet-average standard for that model year. The ARB recently amended the regulations to allow manufacturers that introduce ZEVs prior to 1998 to accrue credits without those credits declining in value until after 1998. This flexibility may be especially beneficial to NEV manufacturers in allowing them to provide vehicles to larger manufacturers for credit towards the mandate.

To receive certification as a ZEV, the Low-Emission Vehicle regulations require that a manufacturer provide information which includes vehicle identification and description, the projected number of vehicles produced for sale in California, the number and type of batteries used, energy usage, and the vehicle range, as measured using the ARB's All-Electric Range Test. To date, the ARB has certified a wide variety of vehicles as zero-emission vehicles. These vehicles include prototype vehicles developed by major manufacturers, smaller NEVs, and converted vehicles, including conversion packages.

Receiving zero-emission certification from the ARB, does not necessarily mean that the vehicle can receive ZEV credit. For example, although the Citycom City-El NEV has received certification as a zero-emission vehicle, the

vehicle is not eligible for credit toward the mandate due to its classification as a motorcycle. The regulations use the definition of motorcycle as found in the Motor Vehicle Code Section 400. The code defines a motorcycle as being any motor vehicle designed to travel on not more than three wheels and weighing less than 1,500 pounds. If the vehicle is electrically powered, it is defined as motorcycle if it weighs less than 2,500 pounds and has a maximum speed of 45 miles per hour. Consequently, an electric vehicle such as the City-El would be defined as a motorcycle and would not be eligible for credit as a zero-emission vehicle.

The ARB staff believes that NEVs and sub-car electric vehicles can replace fossil-fueled vehicles in many niche markets, as well as help foster the development of larger electric vehicles. These vehicles are ideal for short, local trips that do not require high speeds. Moreover, these vehicles are well suited for use as "station cars."

Conversely, the staff has concerns related to the introduction of small, limited-performance electric vehicles. The ZEV mandate and associated air quality benefits are based upon the assumption that electric vehicles will closely match the performance characteristics of conventional vehicles. Of primary concern is that the use of NEVs will not generate the expected air quality benefits, on a per-vehicle basis, due to their limited application and performance. It is also possible that the introduction of NEVs and sub-car electric vehicles could reduce the incentive for manufacturers to produce full-size electric vehicles. It may be more economical for a manufacturer to purchase NEVs to meet the minimum ZEV production requirement, rather than develop full-size, full-performance electric vehicles.

The early introduction of limited-performance electric vehicles could reinforce a common public perception that electric vehicles are little more than "glorified golf carts." Consequently, it is important for purchasers of NEVs and other electric vehicles to be made fully aware of the vehicle's capabilities at the time of purchase. Another concern is the potential safety problem related to NEVs and other small electric vehicles.

The ARB's Low-Emission Vehicle regulations allow for a wide variety of electric vehicles, including four-wheeled NEVs, to receive zero-emission vehicle credit. Determination of credit eligibility is independent of vehicle performance (e.g. top speed, range, acceleration) or size. Both small electric vehicles as well as vehicles defined in the medium-duty classification can receive credit towards the zero-emission vehicle requirement. The ARB staff believes that NEVs can play a limited role in reducing motor vehicle emissions in certain niche applications and help promote electric vehicle technology.

EVs Certified by the ARB

Large Manufacturers	NEVs	Converted Vehicles
Ford Ecostar	Kewet El-Jet	Electricar ECO (Geo Metro)
GM Impact	Citycom City-El	Solectria Force
Chrysler Minivan	Cushman Electric	Conversion packages

Conclusions

- Wide variety of EVs, including 4-wheeled NEVs, can receive zero-emission vehicle credit
- Credit currently independent of performance (e.g. range, top speed)
- NEVs can play an important role in reducing motor vehicle emissions
- No plans at this time to modify treatment of NEVs

Emissions and Energy Impacts of NEVs

Mark Delucchi
Research Ecologist
Institute of Transportation Studies
University of California, Davis

Note: This summary has been prepared from a videotape of the workshop session and constitutes a modified transcript of the presentation. It has been reviewed by the presenter for accuracy.

In this talk I will address the issue of why the existing studies of the emissions impacts of electric vehicles are inaccurate and should probably not be taken too seriously. I hope to convince you of this and get you excited to do better research.

First, I'll give a quick summary of the general emission result comparisons of electric vehicles (EVs) and internal combustion engine vehicles (ICEVs) that are quoted widely. Typically, we hear that if EVs are substituted for ICEVs, hydrocarbon and carbon monoxide emissions will be practically eliminated, nitrogen oxide emissions will probably go down, and sulfur dioxide and particulate emissions will probably go up, especially on a percentage basis.

I do not think that this means very much or is particularly interesting, and here is why. There are at least four ways that one could compare the emissions, or more broadly speaking the air quality impacts, of EVs with ICEVs. The first way, which is most typical and probably the most useless, is to compare emissions from powerplants with emissions from the tailpipe of ICEVs. I will admit, of course, that I am responsible for doing studies somewhat like that in my earlier years before I became enlightened to better methods. Why is this wrong? People who do these studies usually acknowledge that they have left out certain emissions, that they have not accounted for the time of day or exposure, and that they have not accounted for emissions of other pollutants. But this is typically justified by explaining that these are "minor" effects.

My point today is that these are not minor effects. In fact, these effects may dominate the sort of "first round" emissions calcuations that we hear quoted all the time. I would argue that at least in certain parts of California it would be better to compare the tailpipe emissions of ZEVs to the "tailpipe" emissions of ICEVs, to give a more accurate picture of the overall effects on people or welfare. That is, one should count ZEV emissions as zero and ICE vehicle emissions as tailpipe emissions, and take the difference between them as the emissions reduction benefit. I would argue that in some cases that would be the more accurate representation.

Still better, of course, would be to compare the so-called "full-fuel cycle" emissions from the ICE vehicle petroleum production-refinery cycle with the full-fuel cycle from the EV fuel production and use cycle. That full-fuel cycle includes "upstream processes" such as crude oil drilling and transport, and the petroleum refining process. Upstream emissions are significant, and often occur near or in urban areas. Also, the cycle should include the gasoline marketing system, which produces significant VOC emissions. That is the full-fuel cycle.

At a minimum, we would want to compare those ICEV fuel cycle emissions to the full emissions from the EV fuel cycle, which consists almost exclusively of emissions at powerplants. But that still is not really good enough, because the emissions from powerplants occur at such different places and different times than emissions from motor vehicles that adding them all together really is close to meaningless. The main exception would be in the case of greenhouse gas emissions, whose effects do not generally depend on variations in space and time.

So it would be better to do emissions comparisons stage by stage, end-use versus end-use, distribution versus distribution, and fuel production versus fuel production. Here powerplant emissions, which are usually mistakenly compared to end-use emissions, would be more properly compared with emissions from petroleum refineries, because they tend to have some similar characteristics. (Actually, the powerplant emissions would be primarily during the night due to overnight recharging, while refinery emissions would occur more-or-less constantly.)

Then, we could continue to compare more minor emissions from feedstock production and distribution. We could do these comparisons stage-by-stage and then give some sort of weights for time of day and exposure, at a minimum. These calculations would tend to favor EVs because the emissions will generally be at night and away from urban areas. This is very important because both within the air pollution regulatory community and for cost-benefit analysis, the most important effect of emissions is the effect on human health. In order for there to be an effect on human health, people have to be where the emissions are and be exposed to them. Emissions from tailpipes affect people more than emissions from powerplants by orders of magnitude -- it is not a trivial effect.

The best thing to do would be to take all of this and go that last hard yard toward a full cost-benefit analysis. In such an analysis we would not make up weights but we would actually calculate air quality changes and then calculate the exposure of people, crops, and materials. The last part would be to figure out what the responses are to those exposures, and then evaluate them.

How would that come out? As far as I know, no one has done that in a credible fashion. There has been at least one study of the air quality, not emissions, impacts of EVs versus ICEVs. That was done in the South Coast Air Basin and the finding was that essentially we get a complete reduction in ozone for every ICE vehicle that is replaced with an EV. Certainly, though, no one has gone beyond that to do a full cost-benefit or exposure analysis for any significant number of regions.

We could go out and take someone's estimate of the externality cost, that is the monetary value, of air pollution damages from electricity production, and someone else's estimate of the monetary cost of damages from ICEVs. Gasoline has an externality cost of on the order of $0.30 per gallon, not including global warming or road dust emissions. This translates to an externality cost of on the order of a penny a mile. The externality cost of electricity produced by fossil fuels has a very wide range, from about $0.003 to $0.03 per kwh. The low is end is for natural gas, and the high end is for current coal technology. If we take 3 miles per kwh as a ballpark estimate for

an EV, we get an externality cost of $0.001 to $0.01 per mile, compared to roughly $0.01 per mile for gasoline. But these are hugely uncertain numbers because it matters what the base for power production is. Not only is there a big difference between coal and natural gas, but the type of coal matters a great deal. The biggest damages from coal-fired powerplants are from sulfur dioxides and particulates, but if there is a cap on sulfur emissions then there are no sulfur related impacts of EV recharging. Also, high-technology particulate removal would make a big difference, and so on.

The efficiency of EVs is also very important. Also, there is an uncertainty of 20-40% in atmospheric chemistry models, and probably more in places other than L.A. There is uncertainty with regard to exposures, and possibly in some cases orders of magnitude uncertainty in the dose-response behavior to emissions. So cost-benefit analysis is a difficult problem, and the total uncertainty could be at least an order of magnitude.

Nevertheless, this is I think the only way to get sensible, policy-useful results with regard to the air quality impacts of EVs. Just comparing powerplant emissions to tailpipe emissions in my opinion does not tell us very much.

Now let us take efficiency out of the list of factors that contribute to the uncertainty in determining the air quality impacts of EVs. Efficiency is interesting not only because it is an important determinant of emissions but also because it is an important factor in life-cycle costs. Efficiency alone is very difficult to determine for several reasons. The first reason is the drive cycle. The fuel use of ICEVs can vary by at least a factor of three from urban, stop-and-go type driving to highway driving. The efficiency of EVs can vary substantially as well, depending on the type of battery, the age of the battery, how frequently it is cycled, whether the vehicle has regenerative braking, and so on.

Also, it matters very much what kind of EV we compare with what kind of ICE vehicle. This is not something we can determine purely from engineering principles because we need to know what type of vehicle people would have bought if they did not buy the EV that we are hypothesizing they use as a substitute. Do we compare small ICEVs to small EVs, or do we

assume that manufacturers would not be making ICE NEV-type vehicles if they were making NEVs? This matters because weight and maximum power have significant impacts on energy use.

Nevertheless, despite these problems, having myself made a tentative start toward developing the cost-benefit analysis described above, it is my opinion that NEVs will have positive benefits almost anywhere that they are used. This includes most places in the northeast where power is produced by coal. But it is clear that work needs to be done on the details of exposure and cost-benefit analysis, and on actually modeling life-cycle costs and vehicle choice decisions. So, I will conclude with that positive statement, but I also want encourage the development of more in-depth and proper comparisons of the energy and emissions impacts of EVs in comparison with ICEVs.

Vehicle Safety Design Concepts: Review of FMVSS and Related LLNL Activities

Frank Tokarz
Transportation Research Program Leader
Lawrence Livermore National Laboratory

Note: This summary has been prepared from a videotape of the workshop session and constitutes a modified transcript of the presentation. It has been reviewed by the presenter for accuracy.

The purpose of this talk is to provide a brief overview of the Federal Motor Vehicle Safety Standards (FMVSS) as they pertain to NEVs, and to relate them to the activities at our lab. Our lab is very much interested in applying our advanced technology to the transportation industry. We are particularly interested in helping small and intermediate size businesses that promote solutions to transportation problems.

EVs are like other cars in that they must meet the FMVSS. In total, there are about 57 or 58 standards that must be met for passenger cars. These standards have been developed since 1966, when the Department of Transportation / National Highway Traffic Safety Administration (DOT/NHTSA) was asked to develop and enforce standards for passenger car safety. The standards that would likely be difficult for NEVs to meet are primarily those concerned with crash protection.

NHTSA standards can be placed into two broad categories: crash avoidance and crashworthiness. Crash avoidance standards apply to both new EV designs and conversions. These standards include FMVSS 102, which relates to the transmission. This standard requires a device indicating whether the vehicle is in forward or reverse, and also requires a braking effect when shifting to a lower gear. Standard FMVSS 103 relates to vehicle defrosting and defogging systems. ICEVs produce excess heat, but EVs do not so they must have special systems to comply with this standard. Standard FMVSS 105 relates to brake systems. EV designs may involve redistributions in vehicle weights relative to conventional vehicles, and they must still comply

with this standard. NHTSA is currently rewriting both standards 103 and 105 so that they are more applicable to EVs.

With regard to crashworthiness, FMVSS 204 relates to the displacement of the steering wheel during a frontal crash. FMVSS 208 requires a certain level of occupant crash protection during a 30 mph frontal crash. This standard can only be met with test data, which requires the actual crash testing of a vehicle with a test dummy inside. Computer testing is not adequate to meet this standard. FMVSS 214 is a side impact standard which specifies maximum injury criteria for side crush impacts. This standard will be phased-in according to the following schedule: 10% of 1994 models, 25% of 1995 models, 40% of 1996 models, and 100% of all models after 1996 must meet the standard. FMVSS 216 pertains to roof crush resistance. To pass this standard, a vehicle must be able to withstand a load with a weight of 1.5 times the unloaded weight of the vehicle placed on the front part of the roof.

One important note on the occupant crash protection standard is that Congress has required that all vehicles must be equipped with airbags after 1999.

It is the responsibility of the manufacture to self-certify that each vehicle meets the FMVSS. The procedure for self-certification is defined by DOT's Office of Vehicle Compliance.

There are three ways to obtain an exemption from a standard. Economic hardship, the demonstration of low-emission vehicles, and the existence of an equivalent level of safety all are arguments that may be used to obtain an exemption from a standard. For NEVs, the demonstration of low-emission vehicles would probably be the most likely way to obtain an exemption. These exemptions are temporary.

In order to obtain an exemption, the petitioner would have to provide financial information that demonstrates economic hardship or that substantiates that the vehicle is low-emission. Also, the petitioner would have to submit proof that obtaining the exemption would not unreasonably degrade the safety of the vehicle, and would also have to arguethat the

exemption would help to further the development of the vehicle. Finally, the petitioner would have to make the statement that the vehicles would be built to meet the standard by the end of the exemption period, and that no more than 2,500 vehicles would be built under the exemption.

At Lawrence Livermore National Laboratory, there currently is an ongoing project to develop vehicle computer crash simulation models for NHTSA and DOT's Federal Highway Administration (FHWA). This project is called the Vehicle Impact Simulation Technology Advancement Project. Over the years, our lab has developed a crash simulation program called DYNA3D. Essentially 100% of computer crash simulations in the world have been done using this code or a derivative of this code. This simulation program has been a useful tool to help the agencies develop new standards, and to save money by first simulating crashes before conducting actual crash tests.

Other ongoing projects include a collaboration with CALSTART to do computer testing on Amerigon's "running chassis" vehicle. Also, we are trying to team up with CALSTART to develop the Advanced Transportation Technology Assistance Center. This project would allow small to medium sized businesses to access and use the resources at LLNL to develop transportation technologies.

In general, NHTSA is concerned about occupant crash protection, while FHWA is concerned with roadside safety hardware. For example, signposts and lightpoles are designed to snap off when hit by a 3200 pound car. What happens when they are hit by a 1500-1800 pound car? They do not snap off. So, FHWA is asking what they should do if we start moving toward smaller vehicles. NHTSA is concerned about the compatibility between different sizes of cars. If a Mercedes hits a golf cart, should NHTSA change the standards on the Mercedes to make it less of a hazard to the golf cart? Mercedes does not want to do that because it just costs them money. NHTSA has to address both the small and large vehicles, and this creates a compatibility problem.

FEDERAL MOTOR VEHICLE SAFETY STANDARDS

STANDARD	DESCRIPTION	DIFFICULTY FOR NEV
MVSS-101	Control and display	no difficulty
MVSS-102	Transmission shift lever sequence*	possibly difficult
MVSS-103	Windshield defrosting and defogging*	no difficulty
MVSS-104	Windshield wiping and washing	no difficulty
MVSS-105	Hydraulic brake systems*	no difficulty
MVSS-106	Brake hoses	no difficulty
MVSS-107	Reflecting metal surfaces	no difficulty
MVSS-108	Lights and reflectors	no difficulty
MVSS-109	New pneumatic tires	no difficulty
MVSS-110	Tires and wheels	no difficulty
MVSS-111	Rearview mirrors	no difficulty
MVSS-112	Headlamp concealment devices*	no difficulty
MVSS-113	Hood latch systems	no difficulty
MVSS-114	Theft protection*	no difficulty
MVSS-115	Vehicle identification number	no difficulty
MVSS-116	Hydraulic brake fluids	no difficulty
MVSS-117	Retreaded pneumatic tires	no difficulty
MVSS-118	Power operated windows*	no difficulty
MVSS-122	Motorcycle brake systems*	no difficulty
MVSS-123	Motorcycle controls, displays*	no difficulty
MVSS-124	Accelerator control systems*	no difficulty
MVSS-125	Warning devices	no difficulty
MVSS-201	Occupant protection - interior	most difficult
MVSS-202	Head restraint	most difficult
MVSS-203	Steering wheel impact*	possibly difficult
MVSS-204	Steering system rearward movement	possibly difficult
MVSS-205	Glass	no difficulty
MVSS-206	Door locks and hinges	no difficulty
MVSS-207	Anchorage of seats	no difficulty
MVSS-208	Occupant restraints	possibly difficult
MVSS-210	Seat belt anchorage	possibly difficult
MVSS-211	Wheelnuts and hub caps*	no difficulty
MVSS-212	Windshield mounting*	possibly difficult
MVSS-213	Child restraint systems	no difficulty
MVSS-214	Side Door Strength	possibly difficult
MVSS-215	Bumper (Canada only)*	possibly difficult
MVSS-216	Roof Crush Resistance	most difficult

FEDERAL MOTOR VEHICLE SAFETY STANDARDS (Cont'd)

STANDARD	DESCRIPTION	DIFFICULTY FOR NEV
MVSS-218	Motor cycle hemets*	no difficulty
MVSS-219	Windshield intrusion	possibly difficult
MVSS-301	Fuel system integrity*	possibly difficult
MVSS-302	Flammability of interior materials	no difficulty
CFR-541	Vehicle theft prevention	no difficulty
CFR-565	Vehicle identification number	no difficulty
CFR-566	Manufacturers identification	no difficulty
CFR-567	Certification	no difficulty
CFR-570	Vehicle in use inspection	no difficulty
CFR-574	Tire information and record	no difficulty
CFR-575	Consumer information	no difficulty
CFR-575-101	Vehicle stopping distance	no difficulty
CFR-576	Record retention	no difficulty
CFR-577	Defect notification	no difficulty
CFR-579	Defect & non-compliance responsibility	no difficulty
CFR-580	Odometer disclosure requirements	no difficulty
CFR-581	Bumper damage limit requirements*	no difficulty
CFR-582	Insurance cost information	no difficulty
CFR-585	Automatic restraint phase in*	possibly difficult

*may not be directly applicable to NEVs

Sources: U.S. Department of Transportation. National Highway Traffic Safety Administration. Applicability of Federal Motor Vehicle Standards to Electric and Hybrid Vehicles. Washington, D.C. 1978.

Albert J. Sobey. Draft: "Plan for the Assessment of Regulatory Requirement for the Half Width Vehicles. " October 2, 1989.

Liability Issues for NEVs

Armen Hairapetian
Partner
Lewis, D'Amato, Brisbois & Bisgaard[1]

Note: This summary has been prepared from a videotape of the workshop session and constitutes a modified transcript of the presentation. It has been reviewed by the presenter for accuracy.

As part of the Jumpstart workshop last year, Bob Wrede of our law firm prepared an excellent survey of the status of the law with regard to the liability criteria used by various states and I would recommend it as excellent reading for understanding the applicable legal standards. Today I would like to address the issues that courts are dealing with regard to liability, but first I would like to correct the impressions regarding two issues that have been raised earlier in the day.

First, the Federal Motor Vehicle Safety Standards (FMVSS) are the federal standards with which automakers must comply to sell vehicles for use on roads in the United States of America. There are certain exemptions to the standards that were discussed earlier, but by and large the standards must be complied with at some time. Compliance with the FMVSS, however, does not insulate you from liability. Attorneys in an injury case would argue that those are minimum standards and that the car should have been designed better to survive the crash and protect the occupant. Juries have assigned liability to manufacturers even when vehicles totally complied with the FMVSS. For example, there is a standard for seatback strength. The seatback should support a force of a certain amount of inch-pounds in a frontal collision of 30 mph - approximately 3,000 inch-pounds. In a trial last year, the plaintiff's expert argued that the standard is a minimum standard and that it should be increased to a 50,000 inch-pound standard, which Volvo and Mercedes-Benz purportedly meet. In that case, the jury was swayed by the

[1]Armen Hairapetian is a member of the Product Liability Group of Lewis, D'Amato, Brisbois & Bisgaard. Mr. Hairapetian is continuing the contributions made by that firm to the NEV industry, particularly the advice and support provided by Bob Wrede at the Jumpstart Workshop last year.

argument that such a rigid seat would not be safe by other criteria and would subject the driver to a risk of neck injury. But this is an example that shows that the FMVSS merely establish a basic level of protection and that they do not necessarily protect manufacturers from liability.

The second issue that I would like to address is the speed issue. It has been mentioned that these vehicles would be going 25-35 mph, and that there is a safety issue there. The mean fatality rate in the U.S. occurs at a delta-V or change in speed of just over 30 mph. Driving a car at 30 mph into your neighbor's wall or garage is the equivalent energy force to driving off of a three story building. So 30 mph is a serious standard and that is why most federal standards require crash testing at 30 mph. Low speed does not necessarily mean safety or low liability. Most personal injury lawsuits, that from a defense perspective are clogging up the court system, occur at speeds of 10-15 mph. These are often cases of whiplash from collisions from the rear, or sometimes even at 15 mph there is an intrusion of the steering column into the passenger compartment and that opens up the issue of liability for the manufacturer. So just because the speeds are low does not mean that safety should not be addressed.

In terms of liability for NEVs, there is a safe presumption that any standard of liability applicable to gasoline powered vehicles would also be also be applied by attorneys and courts to NEVs. The main areas of liability for which manufacturers are held accountable are defects in design, manufacture, and failure to warn. In terms of design, there clearly would be a lot of important issues that NEV manufacturers would need to address. The critical one would be occupant safety protection within the passenger compartment. Plaintiff's lawyers refer to the need for a "survival space" for the occupant. In any crash there should be that zone that protects the passenger from intrusion of any object. With a small, lightweight vehicle such as a NEV that would be a difficult issue to address, but a balance must be found with vehicle design. With some of the NEVs here, the steering column may intrude into the driver but perhaps a collapsible steering column could be designed. It is important to realize that most of the safety features in today's automobiles have come about as the result of litigation and because of adverse verdicts suffered by GM and others. The vehicle hood that is designed to collapse in a

"V" in an accident instead of going through the windshield was designed in response to an adverse verdict when the hood went into the passenger compartment and injured the driver. So GM and Ford did not have the great foresight to develop these things early on, but they adjusted over time. The importance for the NEV industry is that it is a fledgling industry that does not have the resources of GM and Ford to absorb large verdicts. So it is important for that reason to consider and meet these issues early on and not later on.

The failure to warn issue is one for which NEVs in general may have an advantage because people purchasing a NEV are aware from looking at the vehicle that it is not a Cadillac or Mercedes and that safety in a crash may not be at the same level. For that reason, it may be possible to develop a sheet of instructions warning purchasers of all of the limitations of the NEV and reviewing it with them at the time of the purchase at the dealer level. This would require a lot of planning and foresight, and such a list of instructions would need to comply with certain statutes, but there may be a possibility to warn NEV purchasers because of the nature of the NEV consumer. The purchaser may believe that they are doing a social good by purchasing the vehicle and may be willing to accept a lower level of safety. But this would need to be a conscious decision and not one imposed on the consumer by the NEV manufacturer and/or dealer.

There may be a possibility in the future of legislation to protect the industry, much as medical malpractice liability has been limited to protect doctors to a certain level of damages. The legislature may also be willing to do that to protect the electric vehicle industry and limit liability to $50,000 or $100,000 per incident, or something of that nature. That is probably a long way away, however, given that the plaintiff's bar is very strong in the legislature and may be successful in blocking any such legislation. Just yesterday, the United States Senate suffered a filibuster for the thirteenth straight year of the product liability reform law to protect manufacturers, even though the law had bi-partisan support.

NEV manufacturers have certain issues with which they must be particularly concerned. For example, NEVs have a certain weight distribution and the weight is placed differently in the vehicle. This might place a danger to the

occupant of the vehicle depending on where they are in the vehicle and where the batteries are located. So the weight distribution would be important with regard to objects hitting or intruding into the occupant. Similarly, the batteries would probably be compared in a trial to the gasoline tank of a conventional vehicle, and integrity must be ensured to contain the batteries. If the batteries contain acid, then the acid must be contained. We could imagine a Crown Victoria smashing into the battery cells of a NEV and spewing battery acid on the occupants, causing injury. That would be something for which the NEV manufacture may be held accountable. To taken an even worse example, the Crown Victoria smashes into the NEV and a mother is wheeling her baby carriage across the street and the battery acid spews onto the sidewalk and into the baby carriage. That could shut down the company because you would be looking at punitive damages as well as compensatory damages because the plaintiff would argue that that is something the manufacturer should have known about. That could be reckless and malicious conduct under California law. So it is these types of issues that are peculiar to NEVs and that the designers and manufacturers of vehicles must consider.

It is important to realize in product liability law, especially in California, that everyone in the stream of commerce of the distribution of the product is held liable for damages caused by that product. That would include the designer, the manufacturer, the distributor, the dealer, and the lessor of the vehicle. The reason for this is to protect consumers from off-shore manufacturers and designers who would be shipping the product to a friendly distributor, who could then claim that they are not responsible for how the product is designed. To protect against that, the laws have been set to allow consumers to sue everyone in the stream of commerce who would then be held jointly and severally liable. It would then be between those parties to sue each other for indemnity and for paying their share of the damages. The damages could be large enough to shut down the designer, manufacturer, or distributor of a NEV right off the bat.

To sum up, NEV manufacturers must consider today's issues of product liability, design and manufacture defects, and failure to warn, but they must go one step further to consider issues particular to NEVs. Manufacturers

must have a proper understanding of product liability issues and the FMVSS, but they must also do testing to protect the occupant beyond those arguably minimum standards. Beyond that, the issues particular to NEVs must be given thought and foresight, even if that means doing additional testing and delaying marketing. One of the arguments that plaintiff's attorneys love to make is that it just would have taken one more test to see if the vehicle was safe for a consumer to use in a reasonably foreseeable manner. That test might have cost $5,000, but now the suit is for much more. So it is that type of argument that must be considered in the battleground of vehicle liability for NEV manufacturers. The plaintiff's bar is your enemy in designing and manufacturing vehicles, and that must be remembered at all stages of NEV development.

VII. Session Five: Panel/Open Forum/Action Agenda

Note: This session has been transcribed from video tape with minimal modification. All comments have been included with as much accuracy as possible, with the exception of those that were inaudible. Workshop speakers are identified by their initials, and other participants are identified by the notation "PT." The following speakers made comments in this session: Thomas Evashenk (TE), Armen Hairapetian (AH), William MacAdam (WM), Paul MacCready (PM), Cece Martin (CM), Michael Replogle (MR), Albert Sobey (AS), Daniel Sperling (DS), William Warf (WW), and John Wohlmuth (JW).

Part One: Panel Discussion led by Daniel Sperling with Armen Hairapetian, Paul MacCready, Thomas Evashenk, and William MacAdam.

DS: We ought to have a short discussion before we move on about some of these issues, just to clarify them. This question is directed at Armen, but Paul and Bill will have some comments. My memory of when the lawyer Bob Wrede spoke about a year ago at the subcar workshop held by Aerovironment in Monrovia is that he stated that if a vehicle does not look, feel, or drive like a conventional vehicle, then it would not be held to the same liability standard. We know that when we drive a motorcycle or ride a bicycle, we're assuming a certain level of danger or lack of safety, and that makes the manufacturer not liable in the same way. First of all, is that your understanding and do you have any elaboration on that?

AH: I would definitely agree with Bob that something that is not a vehicle would not be held to the same standards as a vehicle. If it doesn't look like a vehicle, then it would fail the duck test - if it doesn't look like a duck or quack like a duck, then it is not a duck. On the other hand, it is a vehicle. The argument would be that it is designed to travel on public roads, with speeds of 35-45 mph. The use of the vehicle would decide whether it is a vehicle or not, and that is something that urban planners and manufacturers would have to consider. Bob's comments I think were accurate, but I think the definition of whether it is a vehicle or not, the legal standard, would depend on the use of the vehicle.

DS: In other words, a vehicle like the Trans2, which has a top speed under 25 mph, would probably not be treated as a regular vehicle, but something with a higher top speed might?

AH: One thing to emphasize is that there is no federal law about liability. Each state and jurisdiction has its own law about what manufacturers are liable for and what they are not. So the unfortunate answer is that there is no one answer unless you look at each state, and to look at the laws of each state and research what the standards are for each vehicle. I'm inclined to agree with you, but I'm afraid to be so generic.

PM: I agree with Bob Wrede, and I agree with the lawyer here. I think it gets clearer when you're on a bicycle or a motorcycle. You know that it is not a car. It doesn't have roof crush safety requirements, it doesn't meet the motor vehicle safety standards, and it is a motorcycle or a bike. It doesn't protect you if someone runs into you from the side. I think that's understood. If you're in a car, that looks like a car, but that turns out to be made from bike parts and weighs 130 pounds, then the manufacturer is in trouble. It seems easy to describe these extreme cases, but then we get into the middle ground. Bob Wrede's conclusion was that if you the manufacturer acted with great responsibility -- tested, and got the vehicles used where they should be that liability concerns, although seriously annoying, would not stop the business and would not stop the country from benefitting from using the product. So he was a little upbeat, and said that logic would prevail. In general, though, if you're getting into the car business, it is clear that it is a big boy's business. That's why there are only a few auto manufacturers and they are giant. They are able to handle these things and when they come out with new cars, it's a billion dollar investment of many years, just as though you're coming out with a wide-bodied jet. There are many small operators, coming into fields with great originality, but many of them don't realize that by the time you go into mass production and warrant a product it's had many years of crash testing and liability protection. It's a big, expensive process so there's going to be a big crunch in the next few years.

AH: One thing I'd like to mention is that the court factors in what the consumers expectations are of the product. I think in almost every state that is a standard for liability, and I think that the important issue is that if you see a bicycle you're not going to expect it to be a vehicle. When you see a Cadillac, you expect it to be a vehicle. The question then is the middle ground. Will a

consumer expect that a neighborhood electric vehicle that goes 25 mph and that is used on a public road, or a special lane, to be the same as another vehicle? I think that the liability standard will be the important one. The other problem in California is the risk-benefit analysis. Do the risks outweigh the benefits?

PM: It gets to where and how it's used too. It's not just the vehicle, it is the use of that vehicle. On a golf course, it's probably pretty safe. If it is going through the middle of town, it may not be. Another thing that comes out of this is that the technology, the stimulus, for these vehicles comes from the U.S., but the real markets may be in other countries where the liability situation is a lot different.

WM: Yes, all American auto manufacturers have what they call their "China car project." They see that as the stability of those countries improves, the market is huge. And the product won't have to meet all of the same tests.

PT: Japan has a subcar class called the "kei" car class, that they've had on the roads for years. They are characterized by their small size and low horsepower. It is primarily for these vehicles that they have developed a relaxed licensing process.

AS: Those cars in Japan have the greatest frequency of accidents, but the lowest frequency of harm, because they are driven differently than other cars.

WM: In France there is a class of vehicle that up until recently did not require registration and did not require licensed drivers. They used two-stroke engines. You rarely saw them in the city because of the stigma attached to them, identifying the driver as someone who lost their license. But they made somewhere from 9,000 to 13,000 of them a year. They are now starting to convert them to electric and they've lost their stigma. Now they even enjoy a whole new snob appeal.

DS: That those vehicles exist in Japan and France, is that because there are no lawyers there? Or that their laibility laws are less stringent? What is the difference?

PT: It's a combination of factors, but their liability laws are much more relaxed around personal injury.

PT: There's still the understanding that we have to take responsibility for driving and operating motor vehicles and that we don't place the responsibility on someone else.

AS: There are other cars working in England, the Robins. I don't know if you are familiar with them. Basically, they are three-wheeled motorcycles with bodies around them, and they are dangerous. If anyone has been to England and seen them, they have probably seen their troubles.

AH: England has liability system where if you file a lawsuit and you don't win you have to pay the attorney fees on the other side, which in a liability suit could be significant. So, they have fewer lawsuits. In the United States, and especially in California, the rules are very much in favor of plaintiffs because we have what is called the "comparative leverages" system of liability. Even if a manufacturer is 1% negligent for an injury and the plaintiff was driving drunk, backwards on a street at 65 mph and getting 99% of the fault, that 1% is enough to get you on the hook for economic damages, which would include lost earning and loss of future income. So, 1% of liability in California could mean millions of dollars to a manufacturer, even if the plaintiff is mainly at fault. So the system under comparative leverages encourages lawsuits because you have a contingency attorney getting a percentage of the fee with no money out of the plaintiff's pocket, and there's going to be some percentage of the fault allocated to the manufacturer. So it's worth it to file. Until the legislature addresses that issue in the U.S. and particularly in California, the U.S. will be a litigation haven.

PT: Have there been attempts to change this?

AH: It has been attempted ever since it was adopted, and the trial lawyers and particularly the assembly speaker are very much against it, in my understanding.

PM: If it was publicized, wouldn't voters take care of it?

AH: Well, yes and no. Voters are the consumers that are filing the lawsuits.

PT: The voters did pass the deep pockets law, which limited...

AH: It limited non-economic damages to your share of the fault, which is usually a large amount for pain and suffering, but you still get economic damages.

PT: On the other hand, you have to look at the benefits of protecting the plaintiffs.

AH: That's a balance which has to be addressed and that each person has to be strike for themselves.

PM: If we're getting to action items, it sound as though this is a very key aspect of the whole thing. That's why we involved a lawyer a year ago and it's being followed up now. It sounds as though it is one of the more important things that we must address, and around California and around the country to see if there are better solutions for it. There may be other developments that are being stifled as well, and perhaps a conference just on that would be more important than a conference on technology.

DS: What are some ideas or recommendations for how this could be dealt with?

WM: Well CARB started all of this. Why don't we look to them for some answers?

PM: There are other fields that have had similar problems, such as hangliders and experimental aircraft. One solution is that the companies developing these have pioneer companies with zero net worth, and that makes them not very attractive targets for being sued. But there are no big companies in that field, so I don't know if we could do that here. But that is an interesting solution for small companies.

WM: I think there's a practical point to being sued, and the return that people get from it. I'm not an attorney, but I think that in Europe if the products meet certain standards it is very difficult to sue beyond the standard. And I don't think that in this country we or anyone will be able to change the makeup of the rules for product liability and litigation. Certainly I don't think anything is going to happen in our lifetime. What are we, 0 for 13 did you say? On the other hand, new products come out on a regular basis. I think it would be a mistake if we viewed Armen's comments as throwing a bucket of cold water on all of this and walk away and say that it isn't going to happen. I simply point out that the all-terrain vehicle industry this past year enjoyed its highest sales level since the Consumer Product Safety Commission started regulating them because they were killing so many people. They sold this past year 250,000 vehicles. Now they peaked in I believe in 1984 and 1985 with 550,000 vehicles, but there were only four producers. That's a billion dollar industry and it has weathered one hell of a storm, and if you look at the financial statements of the companies that make them they don't have huge reserves set-up for product liability. Part of the focus is that, and it gets back to Paul's comment, it depends on how they're used and by whom they're used and where they're used. They pulled the three-wheeler off the market for sales, but the population is as big now as it ever was. They just keep going back to repair shops and they're just as dangerous now than ever. I think the market's been saturated, and it's not a huge market. But there is a utilitarian use on ranches and in certain places and I think it's an important vehicle. Part of what they've done is to cut the speeds down, except in the models that are being raced. Dan and I talked for a couple of years, and almost everything that is being used is governed by the axiom that speed kills. I'm not an engineer but I believe that it's one-half mass times velocity squared. It doesn't take much on the velocity side to really have an effect.

WW: I'd like to know about insurance, and what's the rule about how much insurance to have?

WM: That's a good question, and those are the kinds of issues, Bill, that I think groups like this can effect. Armen's right that there are no federal laws,

and part of what we've found in Washington is that it's unlikely that we as a manufacturer will have any influence. It's consumer groups that hold most the cards. We're back to some of the issues that people mentioned earlier. Regardless of how we as a manufacturer want to design it, the government is going to tell us. I think to a great extent it's up to us to focus on where the vehicle makes sense, and that appropriateness depends on the vehicle and its use. And then together with CARB and universities - that's a tremendous amount of leverage. I think California is ideally situated because this is where the emphasis is coming from. And its coming from a variety of different state agencies and a variety of different consumers.

WW: I'd like to comment on the way the certification is taken care of, for example with the City-El. They just sent the vehicle down and said "yep, it passed all of the certification." So, there's no such thing in New York as self-certification. In a particuarly wasteful sense, DOT will frequently go buy electric vehicles and test them themselves anyway to find out whether or not they meet the standards. They actually waste money testing them twice.

DS: Let's shift it a little bit here and bring up, just because it's so important, the issue of the ZEV credits. The reason it's so important is because of the tradeable nature of the ZEV credits, that means that these credits very plausibly could be worse $3-4,000 dollars each. And that's because there's a fine of $5,000 for not selling a ZEV, so presumably the value of the credit, of just buying it from someone else instead of absorbing the fine, will be something less than $5,000 but since the differential between what you can sell it for and what it costs to make it is probably going to be more than $5,000. So the end result of that analysis logic is that the credits will be worth probably from $3-5,000 each. So these credits would accrue to any manufacturer of any electric vehicle, if they are accepted as a ZEV. So, essentially for a NEV manufacturer this is a $3,000 or $4,000 subsidy or cash payment. So this becomes very important, this issue of what is a ZEV or not. I'd just like to pin this down a little more, since we have Tom here. It seems clear that three-wheelers would not qualify right? And what about the Trans-2?

TE: At this point in time, the regulation - as I mentioned earlier it seems sort of awkward that vehicles of the same size and with the same performance but different only in that one has three wheels and one has four wheels would be treated differently is bizarre, but that is how the regulation is now. That can be changed, certainly.

PM: Isn't there a certification of the Motor Vehicle Safety Standards?

TE: Not expressly in the regulation, although I think that you would expect that any vehicle that would be on the road would meet the safety standards.

PT: There is another point here, not at your level but at the federal level with CAFE. That does specifically, the federal law does specifically say four wheels.

TE: In fact, we had calculated the value, we did a rough calculation of the value impact for the impact of CAFE for producing electric vehicles, and we came up with a value of $1,000 to $2,000 per EV produced. That's a lot of money but the impact of one EV is substantial because the CAFE is based on oil import and fuel choices.

PT: I've seen even bigger numbers than that.

TE: We wanted to err on the safe side so we couldn't be attacked, but it would certainly be several thousand dollars.

DS: Actually though, those rules have not been finalized in terms of how much credit an EV gets in CAFE, as of a week ago. It could range in value from about 100 mpg to about 600 mpg.

DS: Well we've got that Trans2 worth about $6,000 in credits now -- from CAFE and ZEV credits -- before it even gets on the road!

PT: What's the thinking behind not allowing motorcycles to get ZEV credits?

TE: The regulations were written to encourage the development of electric vehicles to replace ICE vehicles, and the definition at that time were taken as

any vehicle which excluded motorcycles. So I don't know if the people intended to exclude motorcycles or if it just fell out of the definition of an electric vehicle that didn't include electric motorcycles. I don't know for certain.

PT: Shouldn't it be that the most efficient vehicles get the most credits?

TE: Well, the credits aren't based on that. We would like to encourage the efficient use of energy, but that's not the purpose of the credits.

PM: It's emissions, not energy. This is the air resources board.

MR: There's a somewhat similar thing going on in the eastern part of the country where I'm from. The Ozone Transport Commissioned has recently adopted a petition to the EPA to adopt California car standards for twelve states. There's a lot of debate now about how to translate those standards to the northeast, where we have different weather conditions and especially colder weather, and where the ZEV Mandate might face much tougher conditions in which the vehicle would operate. In fact the Environmental Defense fund has put on the table a proposal to simply measure what the emissions difference is between the ZEV Mandate emission level and the level of emissions that we get from the FedLEV that the auto manufacturers have proposed with their supercar. And to assign responsibility to manufacturers and to let them figure out what the cheapest way is to meet that, whether it's with freeway-capable ZEVs, whether it's with hybrids, whether it's with neighborhood EVs, or electric motorcycles, or mopeds, or buying emissions from someone else to satisfy it, but I just wanted to throw that into this thing, where I see everyone getting sort of wrenched around with somewhat arbitrarily defined standards that sometimes get in the way of the fundamental objective that were trying to accomplish, which is to reduce emissions at the lowest cost.

DS: That was a good point. Mark Delucchi said in his presentation that such a simplistic type of analysis to measure emissions is almost meaningless from a public policy perspective -- that we need much more sophisticated analysis.

MR: Mark and I just talked about this in the hallway and he acknowledged that we're making progress in looking at emission reduction by time of day, by fuel mix, and going back to the source. But it is a challenge to come up with a good measuring system. I think that it is a fruitful way to go.

DS: I suggest that we end this panel session, and then have a few minutes of questions for any of the other speakers, and then spend about fifteen minutes defining some action items.

Part Two: Open Forum

DS: Are there any questions?

PT: A lot of interest in electric vehicle development from the federal standpoint has been motivated by getting the California economy up and going and solving the air resources issue. There is also a volume problem -- if production is low, the unit costs are very high. I wonder if any of the producers here are looking at offshore markets as a means to get the volume of production up high enough to reduce unit costs.

TE: My guess is that it would be better to manufacture overseas and to use the labor there. Perhaps clone a manufacturing plant that was designed here. But I doubt that you would be very successful building here and trying to take your production model elsewhere. It would be better to produce closer to the market.

PT: So a smaller producer in the country of purchase could have a lower price than a larger producer here?

TE: I think so.

DS: Any other questions?

PT: If we end up in California in the year 2005 or 2010, there will probably be by that time somewhere on the order of 2 million electric vehicles, and while

much of the recharging of the vehicles' batteries will be at night, has there been any work done on the availability of power from the utilities?

DS: This isn't really a NEV issue, but I'll give a quick response. Studies have shown that you can get up to about 10 or 15 percent penetration of the light duty vehicle fleet without having much of an effect on the utilities, given that most of the charging will be at night.

PT: There is some risk of localized shortages, but it probably isn't very serious.

PT: I'm wondering about neighborhood electric vehicle and bicycle conflict. I know that in Palm Desert they let you down the bike lanes, and that is where they would probably be in almost any city or town. And they're running 25-30 mph and the average bike is going 15 mph. It seems like there's a conflict there. Am I right or has anyone looked into it?

MR: If you've got low volumes of bicycles and low volumes of NEVs then it probably works just fine, but as you start to get much higher levels of either vehicle competing for the same space then you've got conflict. I think the whole thing is a question of speed differentials. If the speed differentials are small, then you can mix these things fairly easily but if you get significant speed differentials - 25 mph versus 12 mph for a bike - then you start to push that particularly with the wider neighborhood EVs. Then you really need to think about separating those lanes, or reducing the speed of the EVs. The whole question of separation versus integration has to relate to the key questions of how dense the mix is and how great is the speed differential.

CM: Earlier I wanted to ask John Wohlmuth when you were talking about the Palm Desert experience and you had a slide showing a picture of a recharging station and said that it would be large enough to accomodate larger vehicles, but would at first only be used for the smaller vehicles. I guess what I'm wondering in terms of land uses, how are you going to accomodate multiple vehicles when there's a mix? Is the smaller vehicle going to be disadvantaged by the larger vehicle taking space away or is there some way that you're thinking of to give the smaller vehicle the advantage?

JW: We're designing projects right now. Fortunately, in the City of Palm Desert the economy hasn't hit us too hard so we've had since we've incorporated this project three or four major development of 500-800,000 square feet. And they've all been conditioned to put in golf cart parking. Golf cart parking is approximatey 5' by 8' or 5' by 10' spaces. So when you're designing them into an area you get 3 to 4 golf cart spaces in a 10' by 20' regular car space. So when you're designing them in it's relatively easy to accomodate the golf cart parking. Several areas, like in the downtown center mall, have been able to restripe an area parking lot to accomodate the golf carts, and they choose to do that in the most accessible spaces. There's a couple of reasons for that, one is that they want to promote the use of the carts and another is that the golf carts at this time are not able to be locked, so you want the highest level of security. It hasn't been a problem in Palm Desert. I talked to a couple of other cities and when you get into a downtown area, especially with parallel parking, it could be a problem but not in larger parking areas.

Part Three: Action Agenda

DS: Now let's spend a few minutes looking at a few questions about where we go from here. The first one is the NEV definition, and I'm going to suggest that we put that aside for now. There are three topics that I think are important, interesting, and useful to address: demonstrations, coalition building, and regulatory action. Let's start with demonstrations. We've heard quite a few people say that it is the consumer that decides what the vehicles are, and we've heard that we may know what consumers want. We need to just get some vehicles out there to probe these market niches and find out what it is that people want and how the market might evolve. Given that, what are some ideas about how to move forward with demonstrations, from that point of view. Any thoughts?

PT: One possible example is the upcoming Solar Energy Expo and Rally which is coming up in July in Ukiah. It's moving from a strictly competitive rally format with electric vehicles, to this year giving points for passenger

miles carried. So in other words, people are getting points for giving rides in the vehicles that are competing against each other as they go out and go a certain distance and come back. This provides the general public with an opportunity to interface with conversion machines and neighborhood electric vehicles. This is something to keep in mind as a sort of hands-on kind of demonstration.

PT: It seems to me that a really excellent opportunity would be to create a larger fleet of vehicles. When I say larger I mean maybe 500 or 1,000 vehicles that are NEV sized and low-geared, but with maybe a higher gear as well. This could dovetail with the needs of the Station Car folks, whether its BART or other folks that are interested in that type of arrangement because that gives the largest variety of consumers a one-on-one direct experience with the technology and an opportunity to familiarize themselves with the vehicles' positive attributes. This could be a tell-tale about whether or not those same users might eventually want to buy that type of vehicle. That type of activity could also be dovetailed with the type of study that you do, where research is gathered from some percentage of those users. So, I would think that an important next step is to work with people like BART, and to create some sort of RFP where perhaps two or three of these smaller companies could have connections with one larger organization like CALSTART or Pacific Electric Vehicles. This group could create a small fleet - a larger small fleet - of vehicles that could be used in that manner, and create more exposure to the public.

DS: Any other thoughts? Desires? Bill...

WM: I think Bruce Severance's idea is a good one. On the other hand, I thought one of the objectives of this conference was to define what was the composition of the neighborhood electric vehicle. I guess I'm wondering if there's really a need for a separate class or a distinction to be made for what we'd like to refer to as the neighborhood electric vehicle. Most of us live in neighborhoods and we can drive a neighborhood vehicle today, whether its built by Toyota or Volkswagen or everybody else. In the absense of a definition, or something we can point to more specifically, I just wonder how much value there is in demonstrations. We just build two prototypes and

those things are expensive, and to make up 500 vehicles, someone is going to have to cough up a hell of a lot of money, and it also takes a hell of a lot of time. I remember several years ago there was a lot of talk about Caltrans standing behind the liability issue and the insurability issue during the time that the classifications and the vehicles and a lot of these questions were being answered, particuarly in terms of where people used them and how people used them.

AS: I'm not sure if that Caltrans position still holds, but the tentative agreement was that they would stand behind an accident that was due to the machine, due to a mechanical failure and so on, but only during the demonstration -- a year, a year and a half, two years. But that may be long enough for an insurance company to put some numbers together. I've mentioned to two people here that a little less than a year ago I was asked to testify to Congress on the Clean Car Program and in my testimony I mentioned that new technologies could probably not be introduced until there is some experience the insurance companies can use in establishing rates. And I got a load of bricks on me. They came down hard over that. Nothing else that I said really bothered them, but that really did.

WW: That's a problem we're seeing because all of our private customer's rates are increasing. We started out leasing to our private customers with about $25 dollars a month in insurance costs, and the latest we've discussed has been about $80 a month. So that's going to put a bit of a damper on things. State Farm apparently feels that they're being a guinnea pig and don't want to insure anymore for a while until they see what happens, and all of the other companies were high to begin with. So, I've asked my insurance guy if we can get some sort of a group rate for all of our customers where they all pay some share, but I think some kind of probing of the insurance...apparently they're moving us from a neighborhood electric vehicle category into a scooter category into a uni-category that includes everything from a G-Van to a Kewet to a City-El. I'd like to see some insurance efforts.

PT: For a small producer who is delivering primarily ICE conversions to our cutomers, this is a critical issue for us. And I'd like to see if others are

experiencing this. Where can we go to get advice for our customers on where to get reasonable liability insurance. If anyone has any leads, that would be really useful. I think this is an issue that is going to have to be directly addressed. It's as important as the technical issues, because if we get the vehicles but the insurance companies are not willing to insure them at reasonable premiums, where are the customers going to be? I think this needs to be addressed.

PT: It seems that liability is a key barrier, if not a potential barrier, and I wonder if it isn't appropriate for us to discuss or brainstorm as a group what the possible scenarious would be that would enable a group of joint venturers to enter the picture and produce some timely electric vehicles. I realize the importance of this issue and I felt that Armen's comments were some of the most salient in getting electric vehicles implemented in the short term - NEV sized vehicles. It may be more important to look at liability, as opposed to defining a NEV with regard to its size or its top speed capability. It seems that the market will tend to define those characteristics in the long run. Perhaps we should look for a moment at the philosophical issue of whether all vehicles, regardless of weight, should meet FMVSS standards, or attempt to meet FMVSS standards, and to make a plan where if some demonstration fleet were created it fell under an exemption with an intent to meet FMVSS sometime in the future. I guess everyone in the room is going to have a different idea about what particular NEV they are going to stand behind, but I think it would be good to volley ideas on that issue.

PT: I think that one of the issues in terms of liability as we were discussing earlier is that the customer defines the product in a sense, and the customers expectation also intercept the liability standards, and that is governed by where the vehicles are going to be used. If these vehicles are going to be in with heavier, faster vehicles or not it seems would be a major issue in terms of establishing what a NEV is.

PT: I think there's a real problem with speed differential on arterials, with 50 mph as a true speed and vehicles on average on a lot of arterials in Sacramento at least going faster, and if you're looking at a 25 mph vehicle going in the same lane, consumers won't buy them. And if 25 mph vehicles

were kept in restricted use circumstances, where they're not any faster or any slower than the vehicles around them, or you've got to boost the top speed of what is a NEV, and all of the associated things of batteries and so on.

PT: I think another important issue related to that came up earlier, where we questioned the usefulness of a vehicle that is certified under the FMVSS, but only goes 25 mph. Why would you want to go to the trouble of building a vehicle that meets those strict crash requirements, but that doesn't go as fast as everything else on the road. You're kind of tying both feet together in that instance and tripping over yourself, so it has an inherent...the positive characteristic of such a vehicle of course is that you're going to reduce the discharge rate of the batteries and you're going to somewhat increase the life-cycle characteristics of the batteries, and that's the one positive thing. So in the long run you might reduce life-cycle and replacement cost. The negative side would be the consumer perception. It's going to be either a perceived or actual safety liability. So, why not go the whole 100 yards and make a touchdown and make a vehicle that goes 55 mph, and maybe that someone would feel comfortable jumping on the freeway for two or three miles and then jumping off. I'm not saying that we should do that, but I'm raising the question.

TE: It's an issue of size and costs. The whole idea of a neighborhood electric vehicle is that it be small, very lightweight, and very compact. Once you add capabilities and make it highway capable, it's not small. It doesn't work.

MR: I think the whole notion of a neighborhood vehicle is recognizing the limitations of current electric technology, and battery storage technology. The key to the niche is to have very small size and very lightweight, which means you're not going to be able to meet high-speed crash standards. And so there is a niche for a neighborhood vehicle with low speeds, and light weight which gives you low costs, and low cost engineering. I think the emphasis should be put less on trying to figure out ways of overcoming the limitations of that type vehicle and more on looking at how do you create an infrastructure and street environment in which you have an interconnected network on which it is safe and convenient to operate lightweight, low speed, low performance, cheap, high-efficiency vehicles for these short trip needs.

And I think the biggest bang for the buck there is finding common cause with bicyclists and pedestrians and parents with kids who are worried about where can they play, and our aging society, which more and more of us as we get older find it harder and harder to cross the street. Unless we focus on livable communities and create traffic calming, speed limitation changes that are legal and enforced, or electronic. And for that type of approach we should begin to create market niches in selected areas and to demonstrate these concepts in a much bigger fashion.

PT: I'd like to just respond to that and say that I'd be interested in hearing what other people are thinking, but I'm seeing some vague sense of a consensus emerging here that if we have this low-speed, mosquito car that it should have a dedicated lane or else you're asking for liability problems down the road. And in that instance it's going to be a vehicle dedicated to communities and it's going to be implemented only in those communities that create dedicated lanes for those vehicles, and it's going to have a limited initial market.

MR: The alternative to dedicated lanes is widespread traffic calming where you simply limit the speed of all motor vehicles in that area to say 25 mph or 20 mph. While at first thought that's a radical notion for a society that's addicted to speed, I think it's part of a paradigm shift that's occurring in values of the society in a lot of places. It obviously won't happen everywhere all at once and it will only take root in selected communities initially. Maybe Davis is a community like that where you have 25% of the workers and 40% of the students commuting by bicycle and there's a strong culture that's accepting of other values than speed as the primary objective. So it could be that communities like Davis or Palo Alto, or other university settings, are where these are going to be springboarded - or resorts or retirement communities like Palm Desert. We've got to demonstrate it in those contexts in order for it to take root in places like Berkeley or Marin County or pockets in Los Angeles. But I think there is a potential for that to catch on once you demonstrate how it can improve the quality of life by limiting the speed of all vehicles except on certain routes that give access to other towns or regions.

AS: I wanted to raise a couple of questions. We've been talking about the technology as if it's a continuum. It's not necessarily a continuum. One very specific example is that if you're trying to look at what people want to buy in neighborhood cars, they felt that short range, convenience, and confidence. I'm not talking about reliability in the classic sense, but confidence that the machine will be able to make the trip. Part of that for example is non-pneumatic tires. Non-pneumatic tires are probably good up to about 40 mph or 45. That may be sort of a technical triggerpoint, but it also applies to the type of structure we use and the type of materials we build the vehicles from. Low-speed, small vehicles probably should use a plastic structure, so there's some technological stepping stones that may in fact, not drive it, in the sense of saying this is exactly 40 pmh, but rather drive it in the sense of the receptivity of the costs of the machines and how they get used.

DS: I propose that we've done enough work for today and that we continue the talks more informally, unless anyone has a burning thought they want to communicate. OK, one burning thought.

PT: I just wanted to say that the city of Davis and the University has a fleet of 700 vehicles that they are interested in converting to electric, so there's a good opportunity there.

PT: I just want to emphasize one point that Michael Replogle raised, and that is if you're talking about neighborhoods, my last neighborhood was L.A. and that's where the cars are. I don't think Palm Desert is a typical community with 27 golf courses. You guys are going to have to talk about freeways.

VIII. Appendix

Workshop Agenda

Time	Activity
8:30-9:30 am	Reception and Vehicle Exposition / Demonstration
9:30-9:45 am	Welcoming Remarks Daniel Sperling, ITS-Davis
9:45-11:00 am	Initial Questions and Issues • What is a NEV? Paul MacCready, AeroVironment Inc. William MacAdam, Trans2 Corp. Kevin Gunning, Amerigon
11:00-11:15 am	Break
11:15-12:30 am	Land Use and Infrastructure for NEVs • Land Use / Urban Form Michael Replogle, EDF • Community and Urban Design Impacts William Garrison, UC Berkeley • Roadway Infrastructure Case Study John Wohlmuth, City of Palm Desert
12:30-1:30 pm	Lunch
1:30-2:45 pm	New Market Opportunities for NEVs Chair: Tom Turrentine, ITS-Davis • Opportunities for Alternative Cars Albert Sobey, Albert Sobey Associates • Consumer Vehicle Purchase and Use Kenneth Kurani, ITS-Davis • Demonstration Project Responses William Warf, Pacific Electric Vehicles

2:45-4:15 pm	Regulatory Issues for NEVs Chair: Cece Martin, CA Elect. Transp. Coalition • NEVs are ZEVs? Thomas Evashenk, CARB • Emissions and Energy Impacts Mark Delucchi, ITS-Davis • Vehicle Safety Design Concepts Frank Tokarz, LLNL • Liability Issues for NEVs Armen Hairapetian, Lewis D'Amato Brisbois & Bisgaard
4:15-4:30pm	Break
4:30-5:30pm	Open Forum / Action Agenda
5:30-7:00 pm	Wine Tasting, Refreshments, and Vehicle Exposition

Workshop Speakers

Mark Delucchi is a Research Ecologist at the Institute of Transportation Studies at the University of California at Davis.

Thomas Evashenk is an Air Resources Engineering Associate with the Mobile Source Division of the California Air Resources Board.

William Garrison is Emeritus Professor of Civil Engineering at the University of California at Berkeley.

Kevin Gunning is Neighborhood Electric Vehicle Program Manager with Amerigon.

Armen Hairapetian a Partner with the law firm of Lewis, D'Amato, Brisbois, and Bisgaard and a member of its Product Liability Group.

Kenneth Kurani is a Research Associate at the Institute of Transportation Studies at the University of California at Davis.

William MacAdam is President of the Trans2 Corporation.

Paul MacCready is Chairman of the Board of AeroVironment Incorporated.

Cece Martin is Deputy Executive Director of the Calfornia Electric Transportation Coalition.

Michael Replogle is Co-Director of the Environmental Defense Fund's Transportation Project and a Director of the Institute for Transportation and Development Policy.

Albert Sobey is the President of Albert Sobey Associates.

Daniel Sperling is Director of the Institute of Transportation Studies and a Professor of Civil Engineering and Environmental Studies at the University of California at Davis.

Frank Tokarz is Transportation Research Program Leader at the Lawrence Livermore National Laboratory.

Tom Turrentine is a Post-Graduate Researcher at the Institute of Transportation Studies and a Doctoral Candidate in Anthropology at the University of California at Davis.

William Warf is the Owner of Pacific Electric Vehicles.

John Wohlmuth is Assistant to the City Manager for the City of Palm Desert, California.

Workshop Participants

Lee Ackerson
510-837-7835

Lee Arikara
ITS - Davis
UC Davis
Davis, CA 95616
916-752-1543

Lance Atkins
Pacific Electric Vehicles
8500 Weyand Ave
Sacramento, CA 95828
916-381-3509

Martin Bernard
National Station Car Assoc.
963 Hillcroft Circle
Oakland, CA 95610
510-839-6054

Michael Bogdanoff
South Coast AQMD
21865 East Copley Drive
Diamond Bar, CA 91765
909-396-3254

Rick Brown
CF International
PO Box 7352
Incline Village, NV 89452
702-345-6577

Omar Brownson
UC Davis
Davis, CA 95616
916-754-0433

Victoria Carella
Planning Department
City of Davis
23 Russell Blvd.
Davis, CA 95616
916 757-5626

John Chisholm
CF International
PO Box 7352
Incline Village, NV 89452
702-345-6577

Sean Co
UC Santa Cruz
196 Seacliff Drive
Aptos, CA 95003
408-685-3635

Janet Cohen
Davis TMA
TAPS
UC Davis
Davis, CA 95616
916-752-8412

Mark Delucchi
ITS-Davis
UC Davis
2025 Academic Surge
Davis, CA 95616
916-752-6500

Blake Dickinson
ITS - Davis
UC Davis
Davis, CA 95616
916-752-1543

Tom Evashenk
Air Resources Board
Mobile Source Division
PO Box 2815
Sacramento, CA 95812
916-445-8811

Mike Gage
CALSTART
3601 Empire Avenue
Burbank, CA 91505
818-565-5600

Ed Gallagher
UC Santa Cruz
196 Seacliff Drive
Aptos, CA 95003
408-685-3635

Prof. William Garrison
ITS-Berkeley
112 McLaughlin Hall
UC Berkeley
Berkeley, CA 94720
510 642-9062

A. Reed Gibby
Dept. Civil Engineering
California State University
Chico, CA 95929-0930
916-895-5342

Peter Graney
ITS - Davis
UC Davis
Davis, CA 95616
916-752-1934

Kevin Gunning
Amerigon Inc.
404 E Huntington Dr.
Monrovia, CA 91016
818-932-1200

Armen Hairapetian
Lewis, D'Amato, Brisbois & Bisgaard
Suite 1200
221 N. Figueroa St.
Los Angeles, CA 90012
213-250-1800

Brodie Hamilton
Transportation and Parking Services
UC Davis
Davis, CA 95616
916-752-3728

Kevin Hanley
Dept. Civil Engineering
Cal. State - Chico
Chico, CA 95929-0930

Kent Harris
PG&E
Mail Code H28C
PO Box 770000
San Francisco, CA 94177
415-973-6981

Thomas R. Hayes
City of Chico
Planning Office
P.O. Box 3420
Chico, CA 95927-3420
916-895-4851

Gabe Hopper
UC Santa Cruz
196 Seacliff Drive
Aptos, CA 95003
408-685-3635

Darroll Ida
Nissan North America
990 W. 190th St., Suite 410
Torrance, CA 90502
310-719-8527

Patrick Kennedy
SMUD
PO Box 15830 MS 30A
Sacramento, CA 95852-1830
916-732-6578

Kenneth Kurani
ITS - Davis
UC Davis
Davis, CA 95616
916-752-6500

Tim Lipman
Institute of Transportation Studies
UC Davis
Davis, CA 95616
916 754-1450

Mark Loomey
CF International
PO Box 7352
Incline Village, NV 89452
702-345-6577

William J. MacAdam
President
Trans2 Corporation
37682 Enterprise Court
Farmington Hills, MI 48331
313 513-2800

Paul MacCready
Aerovironment Inc.
222 E. Huntington Dr. Suite 200
Monrovia, CA 91016-3424
818 357-9983

Cece M. Martin
CA Electric Trans. Coalition
Deputy Executive Director
1303 J Street Suite 770
Sacramento, CA 95814
916 552-7077

Carl M. Maxey
Leigh Fisher Associates
2329 Parker St. #2
Berkeley, CA 94702-2883
510-649-1199

Dave McCutcheon.
E.V. Fabrication and Supply
PO Box 47
Elk, CA 95432
707-877-3541

Athena Miller
EV Association of the Americas
601 California St, Suite 502
San Francisco, CA 94108
415-249-2690

Richard Morrison
Bank of America
Environmental Policies and Programs
#5800
PO Box 37000
San Francsico, CA 94137
415-622-8144

Victoria Nerenberg
Bay Area Rapid Transit District
Manager, Technology Advances
212 9th St.
Oakland, CA 94607
510 869-2416

Joe Orsini
CSUS
4544 Vega Del Rio Dr.
Fair Oaks, CA 95625
916-278-6992

Sophia Pagoulatos
Parks and Community Services
City of Davis
23 Russell Blvd.
Davis, CA95616
916 757-5626

Barry Pearson
Pacific Electric Vehicles
8500 Weyand Ave
Sacramento, CA 95828
916-381-3509

Michael Replogle
Environmental Defense Fund
1875 Connecticut Ave NW
Washington, D.C. 20009
202 387-3500

Marilyn Riley
Ford Motor Company
925 L Street, Suite 340
Sacramento, CA 95814
916-442-0111

Bruce Severance
Amerigon Inc.
3601 Empire Ave.
Burbank, CA 91505
818 565-5500

Susan Shaheen
ITS - Davis
UC Davis
Davis, CA 95616
916-752-1934

Candy Skarlatos
Bank of America
Unit 5800
PO Box 37000
San Francisco, CA 94137
415-622-8150

Albert Sobey
Albert Sobey Associates
730 North Valley Chase
Bloomfield Hills, MI 48304
313-642-5508

Daniel Sperling
ITS - Davis
UC Davis
Davis, CA 95616
916-752-7434

Aram Stein
ITS - Davis
UC Davis
Davis, CA 95616
916-752-1934

Kris Steward
Wade Associates
2140 Professional Dr., Suite 140
Roseville, CA 95661
916-783-8980

Peter Talbert
TranSport Studios
1258 N. Main St. Unit B2B
Fort Bragg, CA 95437
707-961-0459

Frank Tokarz
Lawrence Livermore National Laboratory
Box 808 L 654
Livermore, CA 94551
510-423-3459

Tom Turrentine
ITS-Davis
196 Seacliff Drive
Aptos, CA 95003
408 685-3635

Marty Van Duyn
SMUD
Electric Transp. Dept.
PO Box 15830 - MS30A
Sacramento, CA 95852-1830
916-732-5533

William R. Warf
Pacific Electric Vehicles
Research and Development
190 Ford Road, Suite 111
Ukiah, CA 95482
707-485-0652

Paige Warren
Univ. of Texas - Austin
1302 E. 29th St.
Austin, TX 78722
512-474-6574

Roger Willmarth
331 Sandpiper Drive
Davis, CA 95616
916-653-9426

John Wohlmuth
City of Palm Desert
73-510 Fred Waring Drive
Palm Desert, CA 92260-2587
619 346-0611