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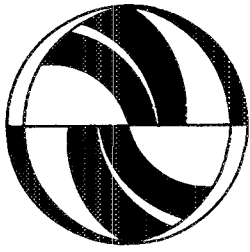
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Prospects for Neighborhood Electric Vehicles

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The University of California Transportation Center
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Prospects for Neighborhood Electric Vehicles

DANIEL SPERLING

Neighborhood electric vehicles (NEVs) are a promising strategy for easing the growing tension between demands for greater automotive travel and calls for improved environmental quality. By reducing performance and driving range expectations, NEVs overcome the battery problem of larger electric vehicles while still serving the mobility demands of many travelers. The introduction of NEVs is likely to be slowed by a web of road and vehicle rules designed with the standard vehicle of the past in mind and by uniform vehicle size expectations on the part of consumers, government regulators, and highway suppliers. The energy and environmental benefits are potentially so large, however, and the opportunity to create more human-scale communities so promising that it would be irresponsible not to pursue NEVs in a more deliberate fashion.

As cars proliferated during the twentieth century people came to rely on them more, creating a spiraling dependency. Why go to the small local grocery and hardware stores when giant department and warehouse stores are only another 20 min away by car? As dependence on cars increased, cars began to dominate streets. Streets were made wider and sidewalks narrower or nonexistent. Now most people in suburban neighborhoods often do not consider walking, bicycling, or even riding public transit. Automobility has spiraled upward, creating, in an iterative fashion, an increasingly car-centric infrastructure and social behavior.

Some excesses of automobile dependence can be avoided, but at least for the United States and other affluent countries, private transportation is here to stay into the foreseeable future (1). The growing tension between demand for greater automobility and demand for better environmental quality can be eased, however, with more environmentally benign vehicles.

One strategy is to use very small electric vehicles (EVs), for now referred to as *neighborhood electric vehicles* (NEVs). Not only will they reduce environmental degradation but they also could be a catalyst in creating more environmentally benign, human-scale communities.

THE CHALLENGE

Motor vehicles of today are capable of carrying four or more people, accelerating quickly to 100 km/hr (62 mph) and cruising comfortably at 120 km/hr. These attributes are desirable for some trips. As long as all vehicles are expected to serve all trips large powerful vehicles will be preferred. But this all-around capability comes at a cost not only in terms of the direct costs of vehicles, fuels, and road space but also external environmental costs and the indirect costs of maintaining a car-centric transportation system. Moreover for most trips and households, large, full-powered

vehicles are not necessary. Almost 40 percent of households own two vehicles, and an additional 20 percent own three or more vehicles (for a total of 54 million households with two or more vehicles) (2). About half of all trips are less than 5 mi and are made by a single person traveling at relatively low speed (3).

The problem is a uniformity of expectations by consumers, government regulators, and highway suppliers. All vehicles are expected to satisfy all purposes, all roads are built to serve all vehicles, and all rules are designed for the standard vehicle of the past. The result is an inertia that discourages innovation and change by vehicle users and suppliers.

The time is ripe for change. Continued attachment to large cars is a dam holding back a sea of policy demands. This continued attachment frustrates efforts to reduce energy consumption (via more stringent Corporate Average Fuel Economy standards), adopt battery-powered zero-emission vehicles, and create more human-scale neighborhoods.

Small cars are one outlet for relieving these pressures. They provide the opportunity not only to greatly reduce energy and environmental impacts but also to catalyze the creation of more human-scale neighborhoods. Neighborhood cars are a compelling concept that deserves to be tested and nurtured. The potential drawbacks—principally safety of occupants—are few and can be mitigated, whereas the potential social, economic, and environmental benefits are positive. Realizing those benefits requires overcoming the hegemony of large vehicles, which is not an easy task.

The key to introducing small cars is dispensing with the one-size-fits-all mentality that pervades the transportation system (4). Changes must be made in rigid safety regulations that discourage innovation, automaker hostility to small cars, standardized infrastructure designs that discriminate against small vehicles, and traffic control rules that serve only large vehicles.

The one-size-fits-all philosophy of the automobile industry is, even apart from this new class of neighborhood and commuter cars, becoming increasingly anachronistic. The principal force for change is increasing affluence and car ownership. With the growing abundance of vehicles, no longer must each vehicle serve every purpose. Vehicles can be designed to respond to more specialized desires of consumers—as is already happening. Recent examples of this shift toward more specialized vehicles, albeit in a more modest fashion than proposed here, are small and large vans, two-seat sports cars, minivans, and sport utility (luxury four-wheel-drive) vehicles.

A new group of small vehicles that follow in this tradition can be envisioned: small specialized vehicles, smaller than a subcompact car and pickup truck, including narrow commuter cars that use less road and parking space and consume less energy; small shared “station” cars that are used for accessing transit stops and

stations; small trucks used on large campuses, in office parks, on military bases, and in dense downtowns; and neighborhood cars used strictly for local travel. These niche applications could eventually constitute a large number of vehicles.

The focus of this paper is NEVs. Although this is only one of the market niches suggested and might take longer to evolve than some of the others, the long-term market potential and possible social benefits of NEVs dwarf those of other mini-EV market niches. Moreover most of the barriers facing the other small electric vehicles are common to NEVs.

DEFINING NEVs

NEVs are defined to include those vehicles that are not capable of traveling on freeways. They would tend to be small and light, but their distinguishing feature is a top speed of about 70 km/hr or less. They are unique in requiring specialized road infrastructure and in contributing to local land use goals. The other small electric vehicles identified above, such as narrow or small commuter cars with limited range and that occupy limited space, might have features in common with NEVs but are less likely to influence land use changes.

One NEV variation mentioned above is the shared-use "station car." These vehicles are intended primarily for driving to and from transit stations. They are inspired by a desire of transit operators in large cities for riders to use less parking space at stations and stimulate patronage, and secondarily to reduce the travel costs of potential patrons. Costs are reduced by using smaller and therefore inherently cheaper vehicles and shared ownership. By sharing ownership a single vehicle might be used by several commuters each day. The vehicle might be dropped off at a station by a person arriving from a residence, picked up by an arriving transit rider traveling in the countercommute direction, returned by that same person to the station later, and perhaps used by still another transit user arriving at that station in the evening and needing a ride home. The station cars could also be used during the day for personal errands or as a fleet vehicle for business trips. This concept of station cars has been experimented with in Europe and Japan with bicycles and small cars, with limited success. A station car association was formed in the United States in 1993 by several pairs of transit operators and electric utilities, principally those in the San Francisco and Chicago areas.

A general defining characteristic of NEVs is their specialization for local travel. They will have low top speeds and low power needs. Most NEVs will be very small, accommodating one or two people plus storage space, but some may be larger to accommodate families with several children. NEVs range from top-end NEVs that are intended for travel on arterial streets at speeds of up to 70 km/hr to bottom-end NEVs with top speeds of about 30 km/hr. Bottom-end NEVs would have separate rights-of-way, mixing with other motor vehicles only in specialized circumstances, such as streets with stringent speed and vehicle size restrictions. The range of NEVs need not exceed 50 km or so, because they are driven only on short trips and can be readily recharged each night.

Even bottom-end NEVs would be significant upgrades from golf carts. Consider, for instance, a prototype vehicle made by Trans 2. Although it resembles a golf cart in top speed and carrying capacity, it has superior performance, safety, and comfort. Its lower center of gravity and frontwheel drive provide improved

stability, cornering, and maneuverability; carlike suspension provides better responsiveness; the vehicles are outfitted with windshield wipers, horn, side-view mirrors, and three-point seat belts anchored to the frame; and the vehicle has a higher and more visible profile, a full array of gauges, and lockable storage areas. It has a range of 40 km, four wheels, and two seats. It is intended to be used on low-speed residential streets, separate lanes, or roads dedicated to low-speed vehicles, perhaps including bicycles. It was designed by a small company in Michigan that is currently negotiating with larger companies to assist in marketing and manufacturing. Targeted at mobility-impaired individuals, retirement communities, resorts, and new towns designed to accommodate such vehicles, it is designed to sell for about \$5,000.

One step up is the City-El made in Denmark. It has a top speed of 55 km/hr, a range of about 50 km, three wheels, and one seat plus storage space. Several thousand were sold in the 1980s and early 1990s in Europe. The selling price, including batteries, in 1993 was about \$7,000. The Sacramento Municipal Utility District imported over 100 of these vehicles in 1993 and 1994; they are leased and lent to individuals in the area.

The Kewet, another small EV produced in Denmark, was first sold in the United States in 1993. It has a top speed of 65 km/hr, four wheels, a range of 50 km, two seats, and four wheels and costs \$12,800 (in 1994). The Kewet and City-El are essentially hand-built by using primitive technology. If the vehicles were mass-produced in a modern factory the cost would be reduced dramatically.

Neighborhood vehicles need not be electric. They could burn gasoline or other fossil fuel in an internal combustion engine, perhaps hybridized with batteries, and be competitive or even superior—on a private cost basis—to pure battery-powered neighborhood vehicles. But the zero-emission vehicle (ZEV) mandate (if fully implemented) overturns such a finding. Battery power will likely dominate because, as indicated below, automakers need to sell ZEVs, and NEVs may prove to be the easiest and least costly way to do so. Moreover as NEV technology is improved, neighborhood electric cars will likely be seen as superior to neighborhood gasoline-powered cars in terms of convenience and reliability, if not cost.

CASE FOR NEVs

As indicated above the time is ripe for NEVs. Several trends and forces are converging to enhance the environmental, economic, and social attractiveness of NEVs. The potential benefits are large.

Environmental Benefits

The environmental and energy benefits of NEVs are the most obvious. NEVs are far more attractive environmentally than either gasoline-powered or even general-purpose electric cars. They consume only a fraction of the energy that conventional-size EVs and gasoline-powered vehicles do and therefore emit only a fraction of the quantity of greenhouse gases and air pollutants. Even if the power plants that supply electricity to NEVs were to rely primarily on coal, NEVs would still contribute little pollution or greenhouse gases.

The environmental and energy benefits are even more impressive, however, because NEVs replace the most polluting and in-

efficient trips of gasoline-powered vehicles: short, slow urban trips. During short trips and the first few minutes of longer trips, gasoline-powered vehicles emit 10 times or more pollutants per kilometer than they do after the catalysts are warmed up. EVs have no catalyst and no cold-hot distinction. Emissions from the last mile are as low as those from the first.

For instance compare a Kewet (750 kg including batteries) with a subcompact gasoline-powered car. Assume that trips average 4 km, speeds vary between 0 and 55 km/hr, about 60 percent of the trips are from a cold start, and electricity for the NEV comes from an average mix of U.S. power plants (which will use 52 percent coal in 2000). In this case, relative to a subcompact gasoline-powered car, the NEV would reduce carbon monoxide emissions by 99 percent, hydrocarbon emissions by 99, and nitrogen oxide emissions by 92 percent (M. W. Wang, personal communication, based on work by Q. Wang et al. 5). The already low emissions of EVs are reduced further by NEVs.

NEVs also reduce energy use and greenhouse gas emissions sharply. NEVs would use less than half the energy of a typical subcompact EV (on the basis of actual data from the Kewet as well as from simulation models) (M. W. Wang, personal communication, based on work by Q. Wang et al. 5). This energy reduction is a more than 60 percent reduction in carbon dioxide emissions relative to those of a subcompact gasoline-powered car, even with today's coal-dominated mix of power plants (using the same assumptions as for the emissions estimate). The reductions would be even more dramatic in practice because EVs are relatively more energy efficient than gasoline-powered cars at the slow speeds typical of NEV driving (but relatively less efficient than gasoline-powered cars at high speeds).

NEVs are environmentally superior compared not only with all other personal vehicles but also with mass transit. The energy consumption and emissions of a transit bus or even fixed-rail electric transit system would be considerably higher per passenger kilometer than those of a single-occupant NEV.

In summary because NEVs use so little energy and operate almost exclusively under driving conditions in which electric propulsion is most attractive, the already large benefits of EVs become overwhelmingly positive with a NEV.

Land Use and Mobility Benefits: NEVs as Catalyst

NEVs also address a variety of social ills associated with increased automobility: lack of mobility by poor, elderly, and physically disabled persons; consumption of large quantities of land; and marginalization of the most environmentally benign forms of travel: walking and bicycling.

Increased mobility for those precluded from driving because of physical disabilities is especially compelling in places where transit service is sparse, as is the case in most of the United States. The ease of driving a NEV makes it accessible to a broader range of individuals, including the expanding elderly population (the population of individuals over the age of 50 in the United States is expected to almost double between 1990 and 2020, from 63.5 million to 112 million). One option for making already easy-to-drive NEVs more accessible to mobility-impaired individuals is to substitute the driver's seat with a place for a wheelchair. Other options are to adapt the already simple driving controls to hand controls and to partially or fully automate the controls.

The use of NEVs, because of their smaller size, would provide another benefit: an opportunity to shrink lane widths and parking space and expand the capacity of existing road space.

The greatest contribution of NEVs, however, may ultimately be as a stand-in for nonmotorized travel. Over time automobiles have come to dominate the thinking and actions of local governments. Governments have focused attention on creating a safe and accommodating environment for cars—building abundant roads and parking spaces and imposing traffic controls to ensure speedy, safe travel. Many neighborhoods do not even have sidewalks. Mathematical travel demand models, used to prioritize new transportation investments, usually ignore bicycles and pedestrians. Pedestrians and bicyclists are usually afterthoughts. The most long-lasting effect of NEVs paradoxically might be to reverse the trend toward less nonmotorized travel.

The appearance of NEVs, even in small numbers, forces a rethinking of rules and investments preoccupied with the automobile. More important the use of NEVs, even in limited circumstances, provokes planners, politicians, zoning boards, and others who write building and street codes to rethink their car-centric rules and plans. NEVs would provide a justification for rewriting building and traffic rules and diverting road and land development investments toward the needs of pedestrians and bicyclists. Gradually bikeways and pedestrian paths might become more widespread and more intensively used. Walking and bicycles are not for everyone, but even a small shift from motorized vehicles would have positive effects on congestion, pollution, and energy use.

Although the details of integrating NEVs into each neighborhood would need to be worked out (as indicated later), the existence of NEVs provides an opportunity for more intimate and integrated neighborhoods, enhanced mobility, and the creation of a more hospitable environment for pedestrians and bicyclists. NEVs could be the key to easing tension between those who applaud the mobility benefits of the automobile and those who blame it for destroying the social fabric of modern communities (6).

ZEV Mandate

Instrumental in aiding the introduction of neighborhood cars will be the ZEV mandate. As major automakers confront the high cost of meeting the ZEV mandate with full-size gasoline-like electric cars, they will undoubtedly become increasingly receptive to new approaches. Recognizing the relatively poor energy storage characteristics of batteries, they will undoubtedly conclude, for the reasons listed, that smaller EVs are economically and environmentally superior and technically more sensible than larger EVs.

NEVs are arguably the most compelling application of battery-powered electric propulsion. NEVs do not suffer from the shortcomings of batteries like larger EVs do simply because they require relatively little energy or power. Their low energy needs are due to their low weight, low top speed, short driving range, and because NEVs do not travel far on any one trip, less demanding interior heating and cooling demands. Innovative energy-efficient techniques such as compressed air- and solar-powered air circulation can readily be used. In addition the low weight of the battery pack allows for a lighter structural design and therefore still greater weight and energy reductions. Although based on simple designs and relatively unsophisticated engineering, the City-El described earlier carries only 110 kg of conventional lead-acid bat-

teries, costing \$250, the Kewet carries 270 kg of batteries, and the Trans 2 carries only 130 kg of batteries. In contrast a typical subcompact EV would need more than 450 kg of lead-acid batteries (the very energy-efficient Impact prototype EV of General Motors carries 410 kg of batteries). Under mass-produced conditions NEVs should be much cheaper to own and operate than a full-size gasoline-powered or electric car.

As major automakers begin to recognize the relative ease of building a cost-competitive NEV they will likely reconsider their historic disinterest in small EVs. The key question will be: Will there be a market for what is easiest and cheapest to build?

INFRASTRUCTURE CHANGES

Inflexible safety standards and standardized roadway designs discourage efforts to introduce a neighborhood car. All roads are built to serve all vehicles, and all rules are designed for the standard vehicle of the past. Important changes are needed in government policy and practice.

A new paradigm of road design that does not revolve around conventional cars is needed. One might argue that the road system should be designed to serve pedestrians, bicycles, NEVs, conventional cars, and service trucks, in that order. Such a road system might look very different from that in most suburban communities.

Today's municipal engineers and planners rely on design standards and priorities that discourage and even preclude smaller vehicles and ignore pedestrians and bicyclists. They build wide neighborhood streets that are empty most of the time and consume large amounts of space. Professional guidelines call for a minimum street width of 6.7 m (22 ft), even though cars are less than 2 m wide. This design standard effectively disperses the neighborhoods, making car travel even more necessary. If developers prefer to build narrower roads, they must go through an arduous appeals process. This car-centric mentality discourages innovative designs, including the use of narrow roads suited to NEVs.

Some NEVs will be used on roads and in communities designed for such vehicles. Others will be used in established communities. Superimposing NEVs on an established road system is especially challenging, but not impossible. The city of Davis, California, provides a model of how such changes are possible. Through the late 1960s the city of Davis and the University of California campus adjacent to the city had a typical gridlike automobile-based road system. A few individuals started a campaign to promote bicycles. Through trial and error roads and traffic controls were gradually adapted to bicycle use. Some roads were closed to motorized vehicles, others required special permits for motorized vehicles, special bicycle lanes were created on still others, and eventually entirely new bicycle paths were built. There is now an entire network of connected bicycle paths and lanes, with traffic circles and other traffic control devices designed specifically for bicycles. Police traveling on bicycles enforce traffic rules, including stop signs, by issuing tickets.

The same process could be followed with NEVs. Although guidelines can and should be developed to assist local planners and officials, each community will need to grapple with the local circumstances (7) (see paper by Stein, this Record). Just as with bicycles in Davis, some roads can be closed to conventional vehicles permanently or for certain hours, narrower and cheaper roads can be built for NEVs (for instance through cul-de-sacs),

lanes can be set aside for NEVs on wide roads, and special crossings of major arterials can be created. In communities with transit stations and park-and-ride lots for transit and carpools, special access and parking can be created for NEVs. Preferential parking can be created in shopping areas and at workplaces. Many inexpensive changes in infrastructure can be made to accommodate and even reward NEV use.

SAFETY, LIABILITY, AND TRAFFIC CONTROL

Safety may be the most controversial aspect of small cars. Safety regulators in the United States are diligent, determined, and effective. Their mission is to increase the survivability of vehicle occupants in an accident. Safety debates are guided by this regulatory mission. But this regulatory approach is narrow; it misses the larger benefits that result from a safer system. Vehicle safety could be enhanced, for instance, by limiting the mixing of large and small vehicles, perhaps by banning trucks from roads designated for NEVs and by limiting the speed limit on NEV-designated roads by using speed bumps and other "calming" devices. Moreover local residents along speed-controlled and vehicle-restricted streets benefit by being liberated to bicycle and walk in relative safety. Unfortunately safety data do not exist for such a transportation system to determine how large and important these safety benefits might be.

The narrowed safety debate will therefore probably focus on the undeniable physical reality that an occupant of a small car is clearly more vulnerable to injury than an occupant of a larger car, all else being equal. But even at this level it is not evident that occupants of very small cars will be at greater risk, because all else need not be equal. The small car could be made safer through better design and use of safety devices inside the cabin. Race car drivers, for instance, survive crashes at 240 km/hr by using ultra-stiff shells with internal restraints.

The U.S. government, through NHTSA, has created the most detailed and prescriptive vehicle safety standards in the world. Currently there are no safety regulations or laws specific to EVs of any size or type—although several proposed rules regarding recharging, crash avoidance, and crashworthiness were issued in the early 1990s—and there are none specifically targeted at small vehicles. They currently promulgate standards only for light-duty passenger cars and trucks, motorcycles, and golf carts. (These standards are not necessarily consistent or above reproach; safety standards for minivans, for instance, although they are used disproportionately for families and children, are less stringent than those for cars.)

The golf cart category is for vehicles weighing less than 590 kg, designed to operate at not greater than 25 km/hr, and designed to carry golf equipment and not more than two people. NEVs will not qualify for this lenient category, and thus they must meet the same standards as a full-size vehicle, even though they do not travel on freeways or at high speeds.

There are exceptions. In 1967 a broad exemption from the standards was granted for four-wheel vehicles weighing less than 450 kg on the grounds that it was impossible for such vehicles to meet the general standards; that exemption was subsequently removed in 1973. NHTSA subsequently rebuffed several efforts to reinstate a similar exemption, reflecting its insistence that all vehicles meet the same standards (8) (see paper by Lipman et al., this Record).

It is uncertain how difficult it would be to obtain an exemption or create a new category for NEVs.

Manufacturers are left with two options: they may petition for an amendment to any impractical standard and may apply for a temporary exemption. It is difficult to win amendments. Exemptions may be granted on the basis of substantial economic hardship for a manufacturer that produces 2,500 vehicles per year (for manufacturers of less than 10,000 vehicles per year), as an aid in the development of new vehicle safety or low-emission engine features, or for vehicles that provide a level of safety equivalent to that provided by conventional vehicles. A NEV would easily qualify on the low-emission criteria, and possibly on the other two grounds as well. The exemptions are renewable, but it is uncertain how many renewals would be granted.

The safety of NEVs is possibly the most critical issue in determining how and where to introduce NEVs. Unfortunately little evidence is available to make a reasonable determination, largely because the safety record is sensitive to the design of the vehicle and how it is used. Bolder thinking is needed. Safety regulators must consider safety in context: one context is slow and small cars and bikes in specially designed neighborhoods.

LIABILITY

NEVs are smaller and therefore inherently less safe, all else being equal, than conventional vehicles, but this difference does not automatically imply that a manufacturer or anyone else is more vulnerable to legal action. Indeed legal precedent suggests that NEVs would not create extra liability risk (9).

Product liability falls into three categories: strict liability, negligence, and warranty. Negligence or warranty violations are not relevant because NEVs do not present new or unique negligence or warranty issues. Strict liability may be due to manufacturing, design, or warning defects. In determining liability risks for NEVs, one question is pivotal: Does the use of a NEV pose any unreasonable danger to the user?

A NEV clearly poses a danger: if the vehicle hits a truck, the occupants are likely to suffer more injury than if they had been in a 2-metric-ton luxury car. Is it, legally speaking, an unreasonable danger? Probably not. Legal precedent suggests that the danger is unreasonable only if the danger is not clear and obvious to the user of the vehicle. As long as a vehicle appears to be very different from a conventional vehicle, which by definition they will, then the liability risk is low.

This same reasoning protects manufacturers of bicycles and motorcycles from litigation. Clearly motorcycles are dangerous, but by being aware of this danger, the driver implicitly is accepting the risk. The danger is therefore not unreasonable.

An exception would be if a manufacturer could have significantly improved vehicle safety at a small cost—as Ford Motor Company could have done to eliminate the exploding gasoline tanks in its Pinto automobiles. NEV manufacturers might be vulnerable to this argument because there will be considerable experimentation initially in designing an inexpensive NEV. For instance even the apparently simple problem of installing an air bag is not simple; because the size and materials of the NEV might be different from those of a conventional car, the triggering and design of the detonator and bag must be unique to these vehicles. NEV manufacturers are protected somewhat if their designs are determined to be state of the art in manufacturing at the time of

production, but this and most other liability determinations are highly subjective. In the opinion of one product liability expert speaking at a workshop on subcars, NEVs pose no greater liability than any other vehicle, as long as an appropriate effort is made to avoid risks (9). One exception to this conclusion may be three-wheel vehicles with the single wheel in front; this configuration is widely considered to be more dangerous than the single-wheel-in-back configuration.

The goal from both safety and liability perspectives may be to create designated areas for NEVs, for instance, “drive-slow” zones. A NEV involved in an accident while in such a zone would be assumed not to be at fault—just as is the case with pedestrians in crosswalks.

TRAFFIC CONTROL RULES AND GOLF CART PRECEDENT

For a vehicle to be operated on a public road in the United States it must be registered with the state's department of motor vehicles and must be in compliance with federal safety standards for passenger vehicles or motorcycles or hold a special exemption. Three-wheel NEVs evade these restrictions because most states will probably allow them to be registered as motorcycles. In some states even four-wheel NEVs may be allowed (see paper by Lipman et al., this Record); Arizona, for instance, allows golf carts to be registered as recreational vehicles and to be licensed as motorcycles. The only regulation facing golf carts in Arizona, in addition to those related to licensing and registration, is that they must not impede the flow of traffic.

The most likely entry by NEVs into the urban community is suggested by recent urban experiences with golf carts. Until recently in California golf carts were only allowed on streets within 2.4 km of a golf course with speed limits of 40 km/hr or less. Under pressure from Palm Desert, California, a small affluent community where golf carts were becoming increasingly popular substitutes for cars, the state's Attorney General loosened the interpretation of state law to allow golf carts to operate on any street with a speed limit of 40 km/hr or less, as long as the vehicle was registered with the Department of Motor Vehicle, had license plates, and was equipped with certain minimal safety features (e.g., headlights and reflectors).

The Attorney General also allowed local authorities to designate certain streets for combined use by both golf carts and conventional vehicles. On those streets the golf cart does not have to be registered with the state or equipped in any particular way, as long as it is not operated after dark.

Accordingly in January 1993 Palm Desert designated many local streets for combined use, with the requirement that the golf carts be electric, registered with the city (but not the state), and be outfitted with headlights, turn signals, mirrors, a horn, and reflectors. Lanes have been painted on the streets to limit commingling with larger vehicles.

Palm Desert's treatment of golf carts illustrates how NEVs could be accommodated in local communities, even without the blessing of federal safety regulators; NEVs that cannot meet safety standards designed for conventional cars could be treated by local and state governments as special cases and accommodated accordingly. The challenge is to do so in a safe manner.

Ultimately federal safety regulators will have to address NEVs. The precedents being established in communities such as Palm

Desert will provide the evidence and motivation to design future rules and regulations that accommodate NEVs and protect the safety of NEV users.

MARKETING OF NEVs

One important niche for NEVs is resort communities and facilities. These are generally located on mountains, at seashores, and in other environmentally fragile areas where clean and un congested environments are highly valued. A subset of this market niche is owners of the approximately 3 million second homes in vacation areas of the United States. They could purchase a NEV and leave it at the vacation home for use on visits. Another subset of this market niche is park areas, such as Yosemite, where vehicle exhaust is damaging the natural environment. A plausible strategy is to ban gasoline- and diesel fuel-powered vehicles and replace them with electric buses, electric cars, and NEVs. According to an unpublished industry report, about 110 million people visit the 68 national parks and recreation areas in the United States annually, and many more visit national seashore parks and other federal, state, and local recreation and tourist areas. The potential for daily and hourly rental of small EVs at these sites is large.

A second niche is closed neighborhoods and communities where speeds are controlled and communities are receptive to NEVs. Palm Desert, California, is one such community.

A third market niche is mobility-impaired individuals, estimated to include about 10 million people in the United States. NEVs are easy to drive partly because they operate at slow speeds and are small and easy to maneuver. This ease of driving can be easily enhanced. Controls can be designed for hands only, similar to the thousands of motorized wheelchairs and many retrofitted gasoline-powered vehicles. Another enhancement is the use of partially or fully automated controls. Automated controls are much easier and cheaper to install on NEVs than on full-size vehicles because the speeds are much lower. Many service and delivery vehicles in factories are already fully automated, made possible by their slow speeds (and a relatively controlled environment). Partial controls could be installed on NEVs to aid with steering or braking and to avoid collisions. Automated vehicle control for conventional cars is already a primary focus of research in California and by the Intelligent Vehicle Highway Systems program of the U.S. Department of Transportation as well as many companies. With the expanding population of elderly people, many of whom are mobility impaired, neighborhood cars could become increasingly important as a means of transport.

A fourth market niche is those individuals who drive short distances to urban rail transit stations and bus park-and-ride lots. The vehicle for this niche is sometimes referred to as a *station car*. NEVs are well suited to this application. If the vehicle is owned by the rail operator or a third party and is used by multiple drivers and for other purposes during the day, the cost could be spread over a large number of people, thereby reducing the cost per trip and user.

A fifth market niche is large new developments that can be designed specifically for NEVs. In California alone neighborhood electric cars are being considered as integral elements in four new town developments covering over 40,000 ha. Several developers are considering providing a neighborhood electric car with some or all houses sold in the new towns. The potential market in these new towns is in the hundreds of thousands.

These five market niches could be just the beginning. Initially neighborhood electric cars will not be accepted in most locations because of safety problems in mixing with much larger vehicles and because road and parking infrastructure is not suited to their use. But as neighborhood cars gain acceptance in various niches, local governments and developers are likely to alter road and parking infrastructure to accommodate and even reward users of these vehicles. At the same time lobbying groups will emerge to push for changes in liability and traffic control rules that hinder the market penetration of NEVs.

Unfortunately credible quantitative estimates of market penetration have not and cannot be made at this time. Research into the potential market for NEVs is fragmentary and speculative. It appears, however, that the long-term market for NEVs could be millions per year in the United States. Even in the short term, with little change in consumer expectations and various government rules, the market might be sizable. According to unpublished industry marketing studies, about 140,000 golf carts and small electric industrial vehicles are sold annually in the United States; one such study estimates that about 20,000 golf carts are used in part for personal transportation. Market penetration will depend on a large number of factors related to ZEV and safety rule making, local initiatives to accommodate NEVs, liability rulings, rulings regarding traffic control, and the entrepreneurial initiative of manufacturers.

CONCLUSIONS

NEVs are not a panacea for near-term problems, but they are energy efficient, emit low levels of pollutants, and are scaled for neighborhood use. NEVs would use less space than conventional vehicles, provide the premise for lowering vehicle speeds in neighborhoods, and help create a more pedestrian-friendly setting while still providing high levels of mobility. They also would be economical, in part because they are an ideal application of battery-powered electric propulsion. Indeed it is a fortunate coincidence that the market applications in which electric vehicles are best suited—short trips—are also the applications in which EVs provide the largest environmental benefits. NEVs clearly are an attractive option. They fit well into any vision of a sustainable transportation-energy future.

However, will this good idea ever be realized? NEVs confront large perceptual, physical, and regulatory barriers. There is a uniformity of expectations by consumers, government regulators, and highway suppliers that results in all vehicles being expected to satisfy all purposes, all roads serving all vehicles, and all rules being designed for the standard vehicle of the past. The result is an inertia that discourages innovation and change by vehicle suppliers and users. The success of NEVs will depend on an openness by regulators and highway suppliers to new types of vehicles and entrepreneurial initiative by vehicle manufacturers.

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