Environmental Consequences of Road Pricing

A Scoping Paper for
The Energy Foundation

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Introduction

Road pricing has been called a concept that economists love and everyone else hates – or at least sidesteps. Between those poles stands the transportation reform community, intrigued by pricing's theoretical potential to reduce highway travel but leery of its impacts on the poor, its kinship to unfettered free-marketeerism and its political unpopularity.

Not too long ago, the idea of using road pricing to shape or reduce travel looked a lot like roadkill, as the 1994-95 Republican "revolution" threatened to set back anything smacking of social engineering for at least a generation. Now, however, pricing appears to be climbing off the pavement and onto the policy stage, aided by such factors as state and municipal road-financing deficits; persistent traffic congestion; limited results from non-pricing transportation control measures[1,2]; and an apparent easing in anti-government sentiment. Equally important, technologies for collecting road tolls efficiently and unobtrusively have gone on line, clearing the way for time-of-day charges and other road-pricing measures.[3] If transportation reform advocates have kept their distance from pricing, a growing number now appear willing to give it a closer look.

At the same time, however, road-building interests have been advancing their own version of road pricing – *new* roads or lanes financed by tolls. While these projects do not conform to the environmentalist model of road pricing, which would impose user fees on *existing* facilities, and at relatively stiff levels to boot, they nonetheless do constitute a form of road pricing. Indeed, to the extent that a model

[1] Transportation control measures (TCMs) listed in the 1990 Clean Air Act Amendments include improved public transit, high-occupancy vehicle (HOV) lanes, employer-based transportation management plans, trip-reduction ordinances, park-and-ride facilities, limitations on motor vehicle use in downtown or other areas, bicycle and pedestrian programs and facilities, and incentives to use non-motorized transportation. See 42 U.S.C. § 7408(f)(1)(A) (1994).

[2] See, for example, Institute of Transportation Engineers, "TDM At A Crossroads," Washington, DC, 1996. In this "preliminary report," ITE concludes that "TDM programs do not affect the travel behavior of a large enough proportion of the driving population to serve as a tool of regional air quality control or areawide congestion management." (p. 3). As support, the report cites major studies during 1993-96 by U.S. DOT/EPA, the General Accounting Office, Apogee Research, the Institute for Transportation Engineers, and Cambridge Systematics (see p. 3n).

[3] At least four congestion-pricing pilot projects are moving toward possible implementation on existing highways around the country – outside San Diego, in Houston, in Minneapolis and on the Tappan Zee Bridge in New York State.

exists for road pricing in America, it is the use of tolls by states and so-called public authorities to finance new roads and bridges during the first half of the century, prior to the advent of the Interstate Highway System.[4] A new project built on that model, involving four new tolled lanes on State Road 91 in Orange County, California, has generated wide (and favorable) news coverage as the first working demonstration of congestion pricing in the United States.

In this context, advocates are having to confront the environmental effects of road pricing. In December 1996, the Energy Foundation commissioned the author to prepare this scoping paper on this issue. What follows is drawn from a literature review and discussions with a range of advocates.[5]

The matter largely boils down to three questions:

1. Will road pricing increase or reduce vehicle miles traveled (VMT) and the associated environmental and social costs?

2. How will road pricing affect urban form and land use?

3. Will road pricing facilitate or inhibit highway expansion?

The first question is important because environmental and social harms rise more or less in tandem with motor vehicle usage, as fuel consumption, emissions, crash consequences, neighborhood disruption, and so forth all tend to vary with the aggregate level of vehicle travel, or VMT.

The second question is important because transportation policy decisions are bound up with America's 50-year move of jobs, residences and activity centers out of central cities and into suburbs and exurban areas. If pricing could aid urban redevelopment, it could counteract suburban sprawl and its associated environ-

[4] The use of tolls to finance not only completed but future highway facilities was perfected by Robert Moses at the Triborough Bridge & Tunnel Authority in New York City beginning in the 1930s. See Robert A. Caro, *The Power Broker: Robert Moses and the Fall of New York*, Alfred A. Knopf, 1974, especially Chapters 28 and 33.

[5] This report does not address road pricing's equity implications. For a brief overview that seeks to join pricing to equity concerns, see Charles Komanoff, "Road Pricing – A Key to Transportation Justice," in *Progress*, Surface Transportation Policy Project, Nov. 1996, p. 6.

mental and social damages that transcend mere vehicle miles traveled. Conversely, in some guises pricing might become yet another factor undermining central cities.

The third question is important because highway expansion brings about its own set of social and environmental damages by paving over farmland, dividing communities and invading open space. Moreover, with evidence mounting that highway expansion itself generates new travel, this question subsumes the first two, to a considerable extent.

Conclusions in Brief

1. *Pricing s Effect on VMT*: Road pricing will virtually always dampen VMT (vehicle miles traveled), in the sense that an individual highway or a highway system employing user charges will have less travel than the same highway or system in which motorists drive for free. A possible exception to the rule is revenue-neutral congestion pricing, but at worst this should increase VMT only minimally. An important caveat is the possibility that road pricing could trigger indirect but significant changes in the financing and governance of roads and alternative modes that could lead to increased VMT in some circumstances.

2. *Pricing s Effect on Urban Form*: The effects of road pricing on urban form and land use depend on the pricing mechanism, where and how widely it is applied, the current metropolitan configuration and, especially, the uses to which the proceeds are put. No single generalized conclusion can be drawn. As a rough guide, area-wide pricing using VMT fees will tend to support development at the center and to discourage development at the urban or suburban fringe, although this result could be undermined if the proceeds are used for highway construction. Similarly, pricing limited to the central city can strengthen the urban core if the proceeds are used to offset the increased cost of driving – by reducing sales taxes, for example. Corridor-based, revenue-neutral congestion-pricing is the pricing form least likely to favor the central city, although it will not necessarily harm it.

3. *Pricing s Effect on Highway Expansion*: Insofar as it dampens VMT and eases highway bottlenecks, road pricing on existing highways should

tend to defray "demand" for highway expansion. However, highway expansion in America has historically been determined less by "objective" considerations such as travel demand, and more by political influence, availability of financing and institutional momentum. With road-builders again embracing road tolls as a funding source, advocates need to be wary of capacity expansions sold with a patina of pricing.

Two further observations are also critical:

4. How the proceeds from road pricing are used is not only pivotal to making pricing equitable and politically viable, but it can also determine the environmental impacts of pricing proposals. At one extreme, the proceeds could fund new roads, reinforcing suburban development and engendering VMT; at the opposite pole, pricing revenues could support central cities if the proceeds are targeted to reducing taxes or improving transit there.

5. Road pricing is not an end in itself. Under positive circumstances, it can be an important way to reconfigure our transportation system to provide more travel opportunities for more people while reducing environmental damage. But pricing has traditionally been employed by road-builders to serve highway expansion, and it is being used for that purpose today. Moreover, the political process through which road pricing is implemented may be as important as the pricing measure that results, particularly if the market-based aspect of road pricing is leveraged to weaken non-market transportation values, such as universal access to transit. Thus, advocates should take care that pricing does not become a tool for regressive policy or paradigm shifts in transportation.

Road Pricing: A Quick Primer

The term *road pricing* is a rubric for a variety of mechanisms that charge motorists by their consumption of road space, clean air and other natural and community resources. Among the forms pricing can take are:

- VMT charges – charges levied directly on vehicle miles traveled;
- weight-distance taxes – charges based on a combination of miles traveled and vehicle weight or size;

- smog fees – charges based on a combination of miles traveled and emissions per mile;
- congestion pricing – tolls that vary by time-of-day, with higher charges during peak periods and lower rates off-peak.

Although congestion pricing often dominates discussions of road pricing, it is merely one form, albeit one with a powerful attraction to economists (to whom the omission of congestion fees is a vexatious and egregious market failure) and to those who view transportation largely from a motorist perspective that regards traffic jams as the leading (or even the only) problem of automobility.

The list of pricing mechanisms does not include cashing-out "free" parking (essentially universal travel vouchers for employees, shoppers, etc.) or pay-as-you-drive insurance (where some car-insurance costs are purchased with gasoline). These mechanisms, while intriguing and potentially promising ways to discourage motor vehicle use, are means of re-allocating travel costs by changing the terms of payment, rather than motorist user fees per se.[6]

Mechanisms for implementing road pricing vary, and some still need refinement of their technology or at the level of application. For example, VMT fees could be read annually from odometers or measured on highways via transponders. However, the former might be vulnerable to tampering and would not discriminate between local and far-off travel (and thus would not easily reflect differences in per-mile societal costs of travel), while the latter could lead to "rat-running" (diversion to local streets) if only major highways were metered. The per-mile emission ratings needed to calculate smog fees could be measured at testing stations or read from a standard "blue book" compilation for each model-year, or a combination thereof, but neither approach would capture emission "spikes" from hot starts or rapid acceleration.[7] With advances in technology and regulatory mandates, it should soon be possible to register mileage as well as emissions con-

[6] For a discussion of the various road pricing mechanisms and their relationship to the societal costs of highway travel, see Charles Komanoff, "Pollution Taxes for Roadway Transportation," *Pace Environmental Law Review*, Fall 1994. Another useful primer is Eco Northwest, *An Introduction to Congestion Pricing for Oregon Policy Makers*, Portland, OR, March 1995.

[7] In a novel twist, the late Prof. William Vickrey, the 1996 Nobel laureate in economics, suggested letting motorists base their smog fee on emissions measured at licensed test centers, giving them incentive to tune their vehicle prior to the test. See "Making New York City Work" in *Challenges of the Changing Economy of New York City, 1992*, Baruch College Council on Economic Education, 1992, pp. 3-11.

tinuously, in real-time, and to store the data on a computer chip.

The discussion here will distinguish between pricing *existing* roads and highway lanes and pricing *new* roads and highway lanes. Pricing existing highways that do not now have tolls is necessarily *revenue-positive*. Pricing highways that presently have tolls can be *revenue-positive* or *revenue-neutral,* or even *revenue-negative*, as in a proposal floated by a New York-area official to encourage night-time truck movements by reducing off-peak truck tolls on bridges and tunnels.[8] Pricing new roads and lanes necessarily raises revenue, but this generally is applied to finance the new facilities.

1. Will road pricing increase or reduce vehicle miles traveled (VMT) and the associated environmental and social costs?

This question is considered for the major categories of pricing measures.

VMT (Vehicle Miles Traveled) Fees

In the economist's neoclassical model, VMT fees will always reduce vehicle miles traveled. Just as a tax on potato chips will reduce consumption of potato chips, as consumers shift some chip purchases to substitutes (e.g., other snack foods, other potato products, other foods entirely, or even non-food items), a tax on vehicle miles traveled will reduce vehicle miles traveled. According to this model, which economists have sanctified as the Law of Demand, demand curves do not bend backwards. People always purchase less of a commodity when its price rises, except in the rare instance of completely "inelastic" demand; and they never demand more, except for certain conspicuous goods, for which high price may connote high status.

The neoclassical framework is an excellent guide to the short-term, direct effects of road pricing on VMT. Because no VMT tax has yet been put into practice, we must rely on travel demand modeling to gauge the magnitude of the effect. An illustrative result is an estimate by the late modeler Greig Harvey that a 5¢/mile

[8] This proposal was floated as a trial balloon in 1996 by New York City Deputy Mayor and Metropolitan Transportation Authority board member Rudy Washington. The Authority's Triborough Bridge & Tunnel Authority subsidiary is now selecting a consultant to analyze a broad range of revenue-positive as well as other congestion-pricing measures.

VMT fee would reduce passenger travel by 11% in the four major counties of Southern California. In deriving this estimate, Harvey incorporated "bounce-back" from reduced congestion (as improved travel times engender a rebound in travel), but did not attempt to estimate further VMT effects from land use changes.[9]

Of course, the world is more complex and less predictable than the neoclassical model, particularly in transportation. Potential exceptions abound to the rule that VMT fees will reduce VMT. For one thing, sufficiently high VMT fees will generate huge revenues ($5 billion a year in the Southern California example); if the revenues were allocated to new highway construction, the resulting highway expansion could conceivably generate enough new VMT to offset the price-induced reduction on existing roads. Or, enactment of VMT fees could be part of an overhaul of transportation finance in which fiscal subsidies were removed from transit as well as roads; the resulting deterioration or collapse of transit service would at least partially offset the direct VMT reduction from the mileage fee.

This is not to undercut the main point: a VMT fee on existing roads will suppress VMT on those roads under almost any circumstances, and at fees of a nickel a mile or more the effect is likely to be substantial. (After all, 5¢/mile is roughly equivalent to $1 per gallon of gasoline.) Rather, it is to underscore the political and social complexity of transportation, and of road pricing in particular. Pricing, especially so powerful a form as a VMT fee on existing roads, will be realized (if at all) not as a technical refinement of current policy but as part of a larger process in which financing, construction and perhaps the very purpose of travel are re-examined. Advocates should bear in mind these larger ramifications as they evaluate VMT fees and the gamut of road pricing possibilities.

Congestion Pricing

Revenue-positive congestion tolls will also reduce VMT, although by a lesser amount than VMT fees that raise the same amount of revenue. The difference arises in part because congestion tolls produce proportionately greater travel-time savings and, hence, greater motorist bounce-back, than equivalent VMT fees. In

[9] Harvey's model provides the analytical underpinning for Michael Cameron's seminal report, *Efficiency and Fairness on the Road*, 1994, Environmental Defense Fund, Oakland, CA. Incorporating the land-use effects of a Southern California area-wide VMT fee would almost certainly raise the estimated VMT reduction above 11%, as businesses and individuals began relocating to reduce travel costs.

addition, congestion pricing would result in some on-peak trips switching to non-tolled or cheaper off-peak rates, further attenuating the reduction in VMT.

Modeling by Greig Harvey provides a useful guide here as well. In one of his many analyses of the San Francisco-Oakland Bay Bridge for the Metropolitan Transportation Commission, Harvey studied the effects of different increases from the current flat-rate $1 toll. Whereas a new flat toll of $1.80 was projected to reduce the number of daily crossings by 3.1%, a congestion pricing scheme raising the same revenue but charging $3 for peak trips and $1 off-peak would diminish daily crossings somewhat less, by 1.8%.[10] The congestion-based pricing scheme has less prospective effect on VMT because the time improvement draws some congestion-sensitive peak travelers who now use other modes (e.g., BART rapid transit, or carpool in the HOV-3 lane) or who avoid the corridor altogether during the peak; and because the off-peak discount attracts additional trips.[11]

Revenue-neutral congestion pricing is a different matter, so far as VMT is concerned. In revenue-neutral congestion pricing, an existing flat toll is replaced by a time-sensitive toll which is higher in peak hours and is discounted off-peak. The likely effect of such programs on vehicle miles traveled is zero, or at most a very small net increase, as four simultaneous effects cancel each other out, as follows:

- peak travel is more expensive, and so declines;
- peak travel is less congested (faster), drawing some travelers back into the peak;
- off-peak travel is cheaper, and so increases;
- off-peak travel is more congested (slower), pushing some travelers away, but probably less than the "bounce-back" into peak hours.

In effect, new off-peak trips (by price-sensitive travelers) plus new on-peak trips (by time-sensitive travelers) should be largely offset by fewer off-peak trips (by time-sensitive travelers) plus fewer on-peak trips (by price-sensitive travelers).

This conclusion is supported by a recent Port Authority-sponsored study of congestion pricing on its Lincoln and Holland Tunnels and George Washington

[10] Greig Harvey, personal communication, Jan. 24, 1997.

[11] Other work by Greig Harvey and Elizabeth Deakin also suggests that VMT fees in California would reduce VMT considerably more than would equivalent-revenue congestion pricing. See their draft final report for the state Air Resources Board, *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts*, Contract No. 92-316, June 1995, Table 7.11.

Bridge crossings between New York and New Jersey. One revenue-neutral scenario in the study entailed replacing the current $4 eastbound car toll with a congestion-based premium fee of $5.40 during weekday morning rush hours and a discounted price of $3.65 at all other times. Analysis of this scenario, based on stated-preference surveys of motorists using these corridors, suggested that total daily volumes on the three facilities would remain the same within a fraction of a percent.[12] Without prejudging the outcome, it stands to reason that the Tappan Zee Bridge congestion-pricing study being undertaken by the New York Thruway Authority will find similarly that a revenue-neutral time-varied toll structure will leave the number of daily Hudson River crossings essentially unchanged.

If congestion pricing is unlikely to add significantly to car trips, why do environmental advocates sometimes disparage it as a VMT-builder? There are several reasons. First, some advocates have seized on the likelihood that higher peak tolls will lead some affluent travelers with high values of time to take longer trips, or to mode-shift from transit (now that the higher tolls have opened up highway space) without acknowledging the countervailing effects outlined above. Second, as noted earlier, it is conceivable that congestion pricing (along with other pricing measures) would arrive as part of a transportation "paradigm shift" in which other modes (transit) are further de-funded, forcing more travelers into single-occupant vehicles.[13]

Third, the highly-publicized advent of congestion-priced toll lanes on California State Route 91 in Orange County has led some advocates to conclude that congestion pricing must necessarily open up land on the metropolitan fringe to sprawl development. But although the new SR91 lanes are facilitating exurban sprawl, this is not an artifact of congestion pricing per se, but a product of the physical capacity expansion effected by the new lanes. The new SR91 lanes without pric-

[12] Lawrence B. Doxsey, Eclipse Research Corp., "Incentive Tolls for Congestion Management: A Planning Tool for the Port Authority of New York and New Jersey," presented at Transportation Research Board, 76th Annual Meeting, Washington, DC, Jan. 16, 1997. The revenue-neutral scenario does not appear in the paper but was part of Doxsey's oral presentation; it shows a 25% reduction in peak-period delay hours at the three toll plazas. The finding of insignificant net change in total trips is from a personal communication with Mr. Doxsey, Jan. 23, 1997.

[13] Conversely, Harvard professor John Kain posits an intriguing feedback loop through which congestion pricing, even when revenue-neutral, could enhance bus service and patronage as price-sensitive commuters switch to buses, generating new revenues that are used to improve service, which further increases ridership. See Kain, "Impacts of Congestion Pricing on Transit and Carpool Demand and Supply," in *Curbing Gridlock*, op. cit., pp. 502-553, particularly p. 538.

ing would be just as much of a sprawl-inducer as the actual congestion-priced new lanes. Similarly, had congestion pricing been imposed on the old four-lane SR91, with no expansion, travel would not have increased appreciably there, even if the pricing had somehow been made revenue-neutral. (Revenue-positive congestion pricing on the old SR91, with no new lanes, would have reduced VMT.)

For transportation-reform advocates seeking to restrain and reduce overall motor vehicle use, the issue of congestion pricing is similar to the issue of HOV lanes. Converting existing lanes to pricing (and raising revenue), whether through flat or time-varied tolls, will discourage trips and reduce travel, as will reserving existing lanes for high-occupancy vehicles. Conversely, adding new lanes, even if priced, will encourage trips and increase travel, as will adding new HOV lanes.[14]

Smog Fees and Weight-Distance Charges

Both smog fees and weight-distance charges would function similarly to VMT fees, with this difference: smog fees would reflect per-mile emissions as well as miles traveled, while weight-distance charges would capture the effect of vehicle size or weight in addition to VMT. Thus, for the same level of revenue, either mechanism would be expected to reduce vehicle miles traveled almost as much as a straight VMT fee.

From an environmental standpoint, smog fees would "make up the difference" by provoking disproportionate reductions in emissions, as motorists undertook any of a host of actions – emissions-system maintenance, shifting short trips (with their smog-priced and, thus, high-priced cold starts) to bike/walk, increased use and/or purchase of less-polluting vehicles such as CNG or electric – in addition to reducing miles driven.[15] For their part, weight-distance charges would engender disproportionate reductions in use of heavier vehicles, as both motorists and goods-shippers acted to reduce their road fees by mode- and vehicle-shifting away from heavier to lighter vehicles or to rail.

[14] The definitive report on HOV lanes is *Re-Thinking HOV: High Occupancy Vehicle Facilities and the Public Interest*, by Christopher K. Leman, Preston L. Schiller and Kristin Pauly (Chesapeake Bay Foundation, Annapolis, MD, 1994).

[15] Some of these changes, especially the alteration of short trips, would probably require that the smog fees be based on real-time measurement of emissions.

An extra potential virtue of smog fees is their close connection to pollution as it is understood by the general public. The citizenry may detest traffic jams, fear heavy trucks and even dislike "traffic" in an overall sense, but what to economists look like logical antidotes – congestion tolls, weight-distance charges or straight VMT-based fees – are still big steps for the average person. Smog fees, in contrast, would be levied directly on poisonous emissions, making them more palatable, at least in theory. Moreover, as Roland Hwang of the Union of Concerned Scientists points out, it may be easier to funnel road-pricing proceeds to environmentally beneficial uses when the revenues are derived through smog fees than from other mileage-based fees. Whereas straight VMT fees have the appearance of user fees, which society typically spends on the item used (i.e. roads), emission-based fees have a different lineage – that of polluter-pays fees which are more logically spent in ways that can reduce the environmental harm of the pollution.[16]

Gasoline Taxes

Higher gasoline prices, whether wrought through taxes or so-called market forces, depress demand for travel by raising the operating cost component of driving. A graphic instance of this was the immediate drop in driving during the oil-price shocks of 1973 and 1978-79, although both events were exacerbated by gas distribution problems as well as economic slumps. Over the long term, however, the link between higher gas prices and fewer miles traveled weakens considerably, since motorists have the option of buying more fuel-efficient vehicles as well as reducing travel. From a policy standpoint, the primary effect of increased gasoline taxes is reduced gasoline consumption, with VMT reductions secondary.[17]

Accordingly, for a given level of revenue, VMT-related fees appear to be far more effective in reducing travel than gasoline tax hikes.[18] Thus, where fiscal pressures lead policy-makers to seek higher motorist revenues, advocates whose first concern is limiting vehicle miles traveled rather than petroleum conservation should

[16] Roland Hwang, Union of Concerned Scientists, presentation to a meeting of transportation advocates organized by the Energy Foundation, San Francisco, Feb. 8, 1997.

[17] A literature review drawn from worldwide experience suggests that elasticities of VMT with respect to gasoline prices are -0.2 to -0.25 short-term, but only -0.05 long term. See Greig Harvey, "Transportation Pricing and Travel Behavior," in *Curbing Gridlock,* op. cit., p. 95.

[18] Per dollar of revenue, fees on vehicle miles traveled should reduce VMT four to five times more than gas tax increases. See previous footnote.

support VMT fees before gas taxes. Moreover, some jurisdictions statutorily require that gasoline tax revenues be allocated to highways. For example, the Oregon state constitution restricts the use of fuel tax revenues to roads. In these instances, new types of fees such as VMT charges might offer a path to flexible allocation, although it is also possible that the same restrictions would be attached to the new charges.[19]

2. How will road pricing affect urban form and land use?

This question does not have a simple answer. The effects of pricing on land use will depend on many variables, including the current urban and regional configuration, the type of pricing measure(s) under discussion, and the extent of the area in which pricing would be applied. Perhaps the most significant determinant is the use to which the revenues would be put.

Revenue Use as Key to Pricing s Effect on Urban Form

Consider a proposal to initiate or increase road pricing in a central city, say San Francisco or New York City. The pricing measure could involve citywide VMT fees, or perhaps new or increased charges on key corridors such as the San Francisco-Oakland Bay Bridge or New York's East River bridges.

At first blush, such a proposal could appear to disadvantage the city vis-a-vis the surrounding region, which (in this example) continues to "enjoy" free highways. In this view, although central-city pricing would ease traffic congestion (particularly if time-of-day pricing is employed), the positive value of the time savings could be swamped by the anticipated financial burden to affected motorists. It is also argued that the mere specter of higher road charges in the central city could be a last straw for shoppers and developers who are already questioning the viability of downtown, particularly if their "windshield perspective" has sensitized them to strictures against auto use.

[19] The Oregon Environmental Council is pursuing VMT fees, in part, for this reason. (Telecom with Jeff Allen, OEC executive director, Jan. 2, 1997.) Note also that although high gasoline taxes in Europe are often cited as a discouragement to driving, several presenters at the Jan. 1997 TRB 76th Annual Meeting characterized them as a bar to VMT-based road-pricing. Following presentation of a paper, "Transport Strategy for Polish Cities," Slobodan Mitric of the World Bank remarked, "Many people are starting to feel gas taxes are counter-productive for urban transportation. . . It becomes hard to tell people paying huge gas taxes that they must pay again to use the roads."

What is missing from such an appraisal is any positive use of the revenues generated by the pricing measure. The dollars that motorists pay through pricing, and which arguably could turn them against the road-priced central city, also constitute a resource for making urban commerce and daily life easier, better and more affordable. To offer just a few examples, road pricing revenues could go to:

- reduce existing taxes, perhaps regressive taxes such as sales taxes; in one example, more than 3 percentage points could be shaved off a current sales tax if all of the revenues from a nickel-a-mile VMT fee were dedicated to that purpose;[20] or
- support non-auto transportation – transit, cycling and walking; or
- provide rebates to people living in the priced area; in another example, a nickel-a-mile VMT fee could finance a $350 annual rebate to every person (including children) in the priced area;[21] or
- a combination of the above measures.

These benefits would not be limited solely to cities, but would be available to any jurisdiction in which pricing was applied.

In sum, bringing revenue use into the cost-benefit equation could tip the balance powerfully in favor of the road-priced area, as congestion and pollution are alleviated while motorist fees are redistributed in ways that enhance equity and access. But this conclusion, while a useful guide, is also based on the neoclassical economic model and overlooks a host of confounding issues: governmental inefficiency in using or rebating revenues, popular resistance to redistributive measures, the power of well-heeled interests to siphon off revenues (e.g., for tax abatements), and the human tendency to react more negatively to losses and costs than positively to wins and gains. Still, this discussion suggests that districts that implement pricing need not be burdened as a result, and might in fact emerge stronger.

With the revenue-use issue as backdrop, and bearing in mind the other caveats at the start of this section, following is a rough guide to the effects of pricing on urban form and land use.

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[20] A nickel-a-mile VMT fee throughout Long Island, NY could finance a reduction from the current 8¼% sales tax to 5%. See Charles Komanoff, "Should the L.I.E. [Long Island Expressway] become a Toll Road?," *Newsday*, Oct. 8, 1995.

[21] In the 14-million-person, four-county Southern California region, $5 billion a year from a nickel-a-mile VMT fee prorates to $350 per capita.

VMT Fees Applied Uniformly Over a Region

Fees based entirely or largely on vehicle miles traveled (e.g., VMT fees, smog fees, weight-distance charges), and applied over an entire region, should favor the center and disfavor the fringe. This derives from the geometric reality that *the center is closest to the greatest number of people*, and thus is best-insulated economically from pricing measures that charge by the mile. As corollaries – interlocking corollaries, really – trips in or near the center are both shorter and more suited to non-auto travel (transit, bike, walk) than are trips elsewhere in the region. Accordingly, a regime of uniform per-mile charges throughout a city or metropolitan region should weigh far less heavily upon trips and access to the center than upon trips involving the fringe. This should improve the comparative advantage of center-oriented development, including commercial uses that generate the greatest number of trips.

To reiterate an earlier concern: this conclusion may not hold if the pricing proceeds are used to expand the transportation infrastructure by, say, increasing highway capacity between the center and the metropolitan fringe. In such instances, the effects of the VMT fee (enhancing the center) and the highway expansion (enhancing the fringe) would need to be modeled in combination to reach a conclusion.

Congestion Pricing in Corridors Connecting the Fringe to the Center

Less clear in its implications for urban form is corridor-based congestion pricing, particularly revenue-neutral pricing (i.e., converting an existing flat toll into peak premiums and off-peak discounts). The leading researchers in transportation economics and land use are unanimous in insisting that the many varieties of metropolitan configurations, transport infrastructures, travel alternatives and pricing options preclude general rules.[22]

Some advocates have raised the prospect that, without urban growth boundaries or other land use controls, congestion pricing, by freeing up peak-hour highway space, could be the functional equivalent of a capacity addition. In this scenario, congestion pricing would induce further driving in the corridor by enabling further

[22] For a thorough discussion of the uncertainties in this scenario, see Elizabeth Deakin, "Urban Transportation Congestion Pricing: Effects on Urban Form," in *Curbing Gridlock*, op. cit., p. 352.

sprawl development. (This is apart from and in addition to the concern, discussed above in relation to revenue use, that introducing road pricing automatically puts the priced area at a competitive disadvantage.)

While urban growth boundaries such as Portland's are a crucial anti-sprawl measure in any event, the concern appears overstated for at least two reasons. First, improved commute travel times are only one facet of congestion pricing's effects on travel – others include higher out-of-pocket commuting costs, which will discourage some solo driving; indeed, the reason that highway space is freed up during commute hours is because some current drivers would be "tolled off the road." Second, improved circulation in the metropolitan core resulting from pricing should help retain or attract development there in preference to development on the fringe. Still, there is no question that pricing strategies by themselves, without center-oriented land-use measures (and, for that matter, provision of travel alternatives), are at best a stopgap against both sprawl and spiraling VMT.

A Mixture of Area-Wide and Corridor Fees

Douglass Lee, a veteran researcher at U.S. DOT's Volpe Transportation Center, ventured several years ago to sketch how land use would differ from today's metropolitan configurations if a combination of area-wide and corridor charges (i.e., VMT and congestion fees, respectively) were used to price highways closer to their true social costs. Lee concluded that the following changes were likely:

- Peaks in the tent [i.e., centers in the metropolitan region] would be sharper, perhaps closer together but fewer of them, with spaces in between or at least an edge to the metropolitan area;
- The CBD [Central Business District] would be more intensely developed, as would some nodes, but areas farther from subcenters would decline in intensity;
- Transportation between nodes would be in some high capacity form [e.g., vanpools, buses];
- Average [vehicle] occupancy levels would be much higher and transit would probably capture a higher mode share.[23]

[23] Douglass B. Lee, "A Market-Oriented Transportation and Land Use System: How Different Would It Be?," Sept. 1992 (revised), subsequently published in Antii Talvitie et al. (eds.), *Privatization and Deregulation in Passenger Transportation: Selected Proceedings of the 2nd International Conference*, Espoo, Finland: Viatek, Ltd, June 1992, pp. 219-238. Bulleted passages in the text are direct quotes from

Lee's findings look like a reasonable summary of the matter, insofar as his modeling exercise captures the twin objectives of environmentally-minded advocates of road pricing: both full-cost pricing (so that road users pay the full fiscal, social and environmental costs of highway travel) and marginal-cost pricing (reflected in peak charges, but also off-peak discounts, in congested corridors). Under such a program, the primary center (CBD) would be strengthened, as would regional subcenters, and transit trips would increase both within and between centers.

3. Will road pricing facilitate or inhibit highway expansion?

What Drives Highway Expansion?

> *Transportation infrastructure investment has generally been . . . made on the basis of physical standards rather than economic efficiency standards. Once the engineering capacity is reached, this is a signal for added capacity to be considered. – David Gillen, University of California at Berkeley.* [24]

As transportation reform advocates know too well, the situation is even worse than Prof. Gillen describes. For one thing, the road-building "establishment" rarely if ever considers *induced traffic*, notwithstanding recent findings suggesting that new highway capacity is soon absorbed by new trips that would not otherwise have been taken.[25] (Recognition of induced traffic was boosted in January 1997, when a U.S. District Court ruled that Illinois DOT must consider effects of highway construction on development by tying its competing "build" and "no-build" scenar-

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p. 22 of the typescript. Although Lee did not specify pricing measures in his hypothetical scenario, it is clear from his context (full-cost pricing and marginal-cost pricing) that both area-wide and corridor charges would be involved.

[24] David Gillen, "Efficient Use and Provision of Transportation Infrastructure With Imperfect Pricing," typescript, July 1995, p. 3.

[25] See Mark Hansen, "Do New Highways Generate Traffic," in *Access*, Fall 1995, University of California Transportation Center, Berkeley, CA. Hansen analyzed past highway expansion and traffic growth in California and concluded that each 10% increase in highway lane-miles has induced an immediate 2% increase in traffic at the county level, building to a 6% increase within two years. When induced traffic in neighboring counties was counted, Hansen found that traffic growth was even greater at the metropolitan level: 9% for each 10% increase in capacity. The Standing Advisory Committee on Trunk Road Assessment within the U.K. Dept. of Transport reached a similar conclusion in its 1994 report on traffic generation, *Trunk Roads and the Generation of Traffic*.

ios to corresponding socioeconomic and land-use forecasts.[26])

Even more fundamentally, highway expansion in America has historically been driven by factors that are even less need-based than static travel demand forecasts – by road-builders' and developers' political influence, by institutional momentum, and by availability of financing. It is this last consideration – financing – that particularly troubles reform advocates, who see road pricing jump-starting highway expansion by providing construction funding, much as tolls were the means to road and bridge construction in the pre-Interstate era.

This is no theoretical possibility but a scenario that is again becoming the standard path to financing and constructing highway expansion in North America. Tolls are an integral part of many new highways, including some being hotly contested by community and environmental advocates, such as E-470 outside Denver and the I-355 Tollway outside Chicago. The rationale is not an ideological or environmental commitment to road pricing, but revenue generation to satisfy bond covenants or otherwise top out the financing.

The 1997 annual Transportation Research Board conference featured several sessions describing toll roads under construction in Texas (the President George Bush Turnpike in North Dallas), Southern California (the Foothill/Eastern Toll Road in Orange County), and Ontario (Highway 407 in Greater Toronto).[27] All three roads rely heavily on tolls to leverage other financing. While the tolls themselves comprise only a minority of the dollars needed, they in effect leverage other sources such as federal ISTEA funds, grants or below-market loans from state DOT's,

[26] US District Court (Northern District of Illinois, Eastern Division), Case No. 96 C 4768, Sierra Club, Illinois Chapter; South Corridor Against the Tollway, Inc; Environmental Law and Policy Center of the Midwest; and Business and Professional People for the Public Interest vs. US DOT, FHWA, Illinois FHWA, Illinois DOT, and Illinois State Toll Highway Authority, as cited in e-mail communication from Michael Replogle (michaelr@edf.org), Jan. 19, 1997.

[27] See, for example, 1997 TRB Session 46, Innovative Finance, Part 2: Capital Finance Opportunities for Toll Road Projects, with these papers or presentations: President George Bush Turnpike (by James W. Griffin, Texas Turnpike Authority; Frank J. Smith, Texas Department of Transportation; Gregory B. Carey, Smith Barney Inc.); Foothill/Eastern Toll Road (by Walter D. Kreutzen, Transportation Corridor Agency); U.K. Aim Shadow Toll Project (by James Taylor, Lehman Brothers),; Arizona's Toll Road Experience (by Sharon B. Megdal, Arizona State Transportation Board). See also Session 83, Tolling Strategies, with papers or presentations: Innovative Financing Approach for President George Bush Turnpike (by Frank J. Smith, TX DOT); and Comparing Tolling Strategies for Highway 407 in the Greater Toronto Area (by Ali Mekky, Ministry of Transportation, Ontario, Canada).

current tolls on existing highways, or previously enacted development fees.[28]

Indeed, as the Dulles Airport toll road in Virginia has demonstrated (to its builders' financial distress), few if any corridors in America will support new roads funded entirely by tolls. (The most notable counter-example, the new toll lanes on California State Route 91 in Orange County, was aided by being sited in an existing highway, which enabled the state to discount the right-of-way sale price and also provides a ready market of motorists who can easily access the toll lanes; the lack of alternative travel corridors over its ten-mile length helps as well.[29])

As Doug Lee noted in his "prototype analysis" of a "market-oriented transportation system":

> ". . . a few additional urban expressways might possibly be feasible, but they will require substantial volumes of traffic *willing to pay congestion tolls of over $.25 per VMT.* [Moreover] the elasticity of demand may be such that the amount of mileage eliminated by efficient pricing and investment would greatly exceed the amount added, even in congested urban corridors."[30] (emphasis in original)

For comparison, tolls on the new President Bush Turnpike outside Dallas will be 7.6¢/mile, or 70% less than Lee's rough estimate of the minimum full-costed price to build highways, and more than an order of magnitude less than the estimated social cost of peak-period driving in one U.S. metropolis (see prior footnote).

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[28] The President George Bush Turnpike, a 26-mile, 8-lane (with space to add 4 HOV lanes) expressway being constructed by the Texas Turnpike Authority in the "North Dalls Golden Corridor," is arguably the most creatively financed of the group, with a below-market (4.2% interest rate) loan of $124 million from the Texas DOT, an 8-year waiver on repayment of principal and interest on that loan, and a subordinate loan of $135 million in Federal ISTEA funds with a similar 8-year grace period, among other features. In addition, the project was structured as part of the existing and established Dallas North Tollway System, shielding the new turnpike from the risk level generally associated with start-up turnpikes.

[29] The enabling law for SR91 and several other road-pricing demonstration projects in California, AB680, established "protection zones" in which the state transportation agency (Caltrans) is barred from providing alternative new capacity.

[30] Douglass B. Lee, op. cit., p. 15. Note that the full measurable costs of solo driving are far in excess of the 25¢/mile floor stipulated by Lee. For example, solo driving in Boston during busy travel periods has a total cost of 81¢ to 94¢ a mile, even excluding important costs such as pain and suffering by crash victims and their families. See *Road Kill: How Solo Driving Runs Down the Economy*, Conservation Law Foundation, Boston, 1994, pp. 6 and 15.

With admirable candor, the turnpike's lead financier concedes that "traffic levels could not support the required amount of debt to construct the project."[31]

How Will Road Pricing Affect Highway Expansion in the Real World?

In the economist's ideal world, where user fees fully offset the costs of highway travel and travelers make decisions based on marginal costs, road pricing would defray "demand" for highway expansion by dampening VMT, easing highway bottlenecks and providing incentives for more-compact urban development. In the real world as we know it, and outlined above, road pricing advocates must address questions such as these:

1. Given that road pricing strategies are user fees, and that users want their fees spent on improving the facilities for which they are paying, how likely is it that road fees can be "diverted" to environmentally beneficial schemes such as transit improvements?

   Similarly, if road building is shifted to a pay-for-use system, will transit continue to receive at least partial funding from the federal gasoline tax?[32]

2. How great is the danger that road pricing might create a perpetual funding source for road building?

3. Are the political compromises necessary to institute road pricing likely to obviate the environmental benefits that might otherwise obtain in the economist's ideal world?

These questions prompt several suggestions and approaches.

Regarding Questions 1 and 2: As we have just seen, road-builders are avidly eying – indeed, claiming – road-pricing revenues. Few if any new toll roads could be

[31] Gregory B. Carey, op. cit., notes from talk at 1997 TRB Session 46, p. 3; also at pp. 4-5.

[32] Under ISTEA, 2¢ of the 18.4¢/gallon in federal gasoline taxes is allocated to the Transit Account of the Highway Trust Fund. At current rates of gasoline consumption, this generates between $2.5 and $3 billion annually in transit funds that are disbursed through the Federal Transit Administration (along with additional revenues from the general fund).

built but for toll revenues anchoring the financing package (that being the raison d'être for the tolls). Nevertheless, debating the merits of road pricing in this context seems beside the point. Granted that new toll roads require a toll component, advocates will not stop the roads by opposing the tolls – the tolls are built in. The roads will be stopped by organizing around their fiscal, environmental and social harms, using persuasive new analytic tools (e.g., induced travel, full costs of highway travel) and galvanizing the widest possible spectrum of constituencies.

Concerning transit, it is by no means automatic that road-pricing revenues can be allocated wholly or in part to transit. As in fighting new highways, arguments for maintaining and expanding transit must be made on transit's own merits – that transit anchors development, serves the environment and provides essential transportation for people whose mobility ought to be everyone's concern. Transit also complements and supports the highway network, and thus investments in transit should be sold to motorists as a means of improving the highway facilities for which they are paying.

The case for allocating road-pricing revenues to transit will be most compelling where transit is already fully developed and functional. In perhaps the clearest such case, the Tri-State Transportation Campaign hopes to document shortly the advantages to all travelers (motorists as well as transit users) of applying prospective East River toll revenues to reversing city and state funding cuts in the New York City Transit Authority's capital and operating budgets. At the opposite extreme of suburban "edge cities" where transit has little or no foothold, it may be more politic to advocate broad-based refunds of pricing proceeds via per-capita rebates or sales-tax swaps.[33]

In cases between these extremes – metropolitan areas with functional but limited and heavily subsidized bus systems – advocates may wish to combine approaches, coupling modest revenue allocations to targeted transit service improvements with non-transportation-related rebates tailored to win broad political backing.

The possibility that road pricing's pay-for-use ideology might carry over to transit funding is particularly troubling, with virtually every transit system in America

[33] Equity-minded advocates are asked to note the national-average 4-to-1 "VMT gap" between the richest and poorest income quintiles, which suggests that per-capita rebates of road-pricing revenues could make the poorest households considerably better off. See the author's article in STPP *Progress*, op. cit.

suffering chronic under-funding that impedes maintenance of existing service, let alone improvements and expansion. It would be tragic as well as ironic if road pricing became the basis for gutting transit funding or multiplying fares. A possible antidote may be to de-emphasize the *pay-for-use* aspect of road pricing in favor of the *finite resource* argument: road use needs to be priced not merely because motorists should pay roads' full fiscal cost, but because treating a finite resource as free inevitably breeds overuse and congestion.[34] Another approach, stressing road pricing as a means to recover pollution costs, will probably work best where pricing is implemented through smog fees or some other mechanism clearly related to environmental damage (see discussion on p. 11).

Moreover, while further erosion of transit funding must be resisted, in many localities the present transit-finance system is little better than begging for crumbs. Transit advocates and operators expend inordinate energy and political capital merely treading water. If consideration of road pricing provokes a debate over transit financing, advocates should use the occasion to press for durable and broadly-supported funding regimes. The emergence of less-fuel-inefficient or non-petroleum-based motor vehicles also argues for a pro-active program of weaning transit funding from dependence on the gasoline tax.

Working in the Political Arena: Compromise or Pragmatism?

Question 3 in this section, concerning possible compromises required to advance road pricing, is especially important, and sensitive, in California. The new toll lanes on SR91, while providing a valuable, nationally-watched demonstration of the technical feasibility of electronic tolling (as well as confirmation of the very concept of road pricing), are facilitating suburban sprawl in Orange and Riverside Counties. Following on the heels of SR91, the Bay Area Metropolitan Transportation Commission is commissioning a feasibility study of adding new electronically tolled and priced lanes on 30 miles of Highway 101 in southern Sonoma County, north of Marin County.[35]

[34] The recent debacle at America Online, which precipitated massive system congestion on the Internet when it converted its user charges from pay-for-use to a monthly flat rate, would seem to be an object lesson of this principle.

[35] The MTC has positioned the toll proposal as a conversion of as-yet-unbuilt high-occupancy vehicle lanes on Highway 101. See its Request for Proposal, Dec. 4, 1996.

As a second, highly visible road-pricing demonstration, the Highway 101 project would further propagate road pricing among both transportation professionals and the public at large. But a highway expansion dressed up with pricing is still a highway expansion. A six-lane 101 will both carry and induce more traffic than the present four-lane 101, regardless of whether and in what form the two additional lanes employ pricing.

Thus, support for the toll-lane expansion of Highway 101 on the grounds that it will further demonstrate road pricing, runs the risk of confusing means and ends. Road pricing is not an end in itself, but, at its best, a key means to a large-scale reconfiguration of transportation toward much greater equity, choice and sustainability. Although years hence transportation reform advocates may view SR91 as a boon for demonstrating the efficacy of road pricing, it stretches the point to argue that an SR91 clone in Northern California is a necessary, or even helpful, next step. Rather, new toll lanes on Highway 101 are more likely to bind road pricing more closely to new highway capacity – a link that our community needs to break, not make. In any event, virtually the entire "pricing community" attending the 1997 Transportation Research Board conference was already elated over the pace of implementation and public acceptance of road pricing, in part due to the success of SR91.

Where the dilemma becomes most acute for transportation reform advocates is instances in which highway construction or expansion seems assured, despite our best efforts to stop it. In such cases, there may be value in pushing to include road pricing in the project, particularly if pricing can be applied to some existing capacity as well to the new road or lanes. The Environmental Defense Fund's Michael Replogle supports this approach in some cases, on grounds that "adding customer value to transportation" (by expanding a highway while pricing existing roads, for example) may be a necessary cost of selling pricing to the public, at least in the early stages of a long-term societal transformation toward full-cost pricing of highway travel.[36] Replogle also emphasizes that at least part of the pricing proceeds should be used to enhance transit alternatives and center-oriented development (through incentive grants to local governments for pedestrian and bike facilities, transit-oriented development projects, etc.)

[36] Michael Replogle, "Overcoming Barriers to Market-Based Transportation Reform," *Ecodecision* (Montreal), Summer 1996, pp. 51-54.

The downside to this approach, of course, is that the political standing needed to bring pricing into the equation invariably comes at a price: acceptance of the highway expansion itself. Moreover, in a kind of nightmare version of the Heisenberg Uncertainty Principle for transportation-reform advocates, not only can it be hard to tell when an expansion project is unstoppable; but acceptance of the project itself becomes a form of support which the highway-builders then exploit to make the project that much more inevitable.

There is no magic formula to resolve this dilemma. Advocates must evaluate road pricing proposals on their individual environmental and social merits, including their strategic impacts on the terms of transportation debates. Projects should neither be fought nor embraced because they do or don't conform to an abstract principal, but because they will have a reasonably predictable set of positive effects in the immediate area and may also advance (or not) a beneficial (or damaging) precedent.

It will be hard to escape compromise. For example, it is likely that the only form of congestion pricing that the New York Thruway Authority will allow in the near term on its Tappan Zee Bridge will be revenue-neutral, even though full-cost principles dictate raising tolls. But it is also true that congestion pricing on the bridge could ease pressure to expand the Cross-Westchester Expressway downstream, as well as establish a precedent for variable-rate tolls in nearby New York City, not only on presently tolled bridges and tunnels but on the untolled East and Harlem River bridges. From this standpoint, imperfect congestion pricing on the Tappan Zee Bridge could have tremendous, positive repercussions.

It is understandable if road-pricing advocates, barely emerging from the political wilderness, are tempted to embrace any pricing proposal with a chance of implementation. But where road expansion is part of the package, this path could lead to Pyrrhic victories, as pricing becomes firmly identified with more roads and more driving, instead of with stable communities, less traffic and other social benefits. Road pricing is too important, and road expansions are too damaging, to bear the risks of joining them together in more than a few trail-blazing instances.

The consequences of environmental pollution seriously affect human health, animal health, forests and vegetation, and the environment in general. Pollution not only causes physical disabilities, but also causes psychological and behavioral disorders in people. The effects of pollution are quite wide. All the types of contamination -airy, aquatic and terrestrial-have an impact on the environment.Â Pollution disturbs the ecosystem and the balance of the environment. With modernization and current development, pollution has reached its peak; global warming and diseases that are related to pollution, are on the rise. Pollution occurs in different ways: it can affect water, air, earth, it can be radioactive and sonic, among others. The immediate consequence of transport activities on the environment where the cause and effect relationship are generally clear and well understood. For instance, noise and carbon monoxide emissions are known to have direct harmful effects. Indirect impacts.Â Establishing environmental policies for transportation thus must take account of the level of contribution and the geographical scale, otherwise, some policies may just move the problems elsewhere and have unintended consequences.Â Hoban (eds) (1997) Roads and the Environment: A Handbook, World Bank Technical Paper No. 376, Washington, DC: World Bank. World Health Organization (2000) Transport, Environment and Health, WHO Regional Publications, European Series, No. 89. Share this Environmental Consequences of. Road Pricing. A Scoping Paper for The Energy Foundation.Â At the same time, however, road-building interests have been advancing their own version of road pricing â€“ new roads or lanes financed by tolls. While these proj-ects do not conform to the environmentalist model of road pricing, which would impose user fees on existing facilities, and at relatively stiff levels to boot, they nonetheless do constitute a form of road pricing. Indeed, to the extent that a model.