The Municipal Mobility Manager:
A New Transportation Funding Stream from Carbon Trading?

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ABSTRACT

This paper analyzes five different options for incorporating the transportation sector into a carbon cap-and-trade program. An upstream system at the refinery or importer level would be administratively simple, but would lead to minimal reductions in transportation emissions due to inelastic demand for driving; in effect, emissions reductions would be “exported” to the electricity generation and industrial sectors. A downstream system at the household level would lead to similar changes in emissions, but raise major administrative and privacy issues. Greater changes in behavior might result from a vehicle manufacturer-based scheme, but there are complex administrative issues and tailpipe standards appear to be achieving the same result.

An offset system would provide financial incentives for a wider range of abatement measures, including those undertaken by local governments such as Smart Growth zoning, parking pricing and transit improvements. Empirical experience with the Clean Development Mechanism, however, suggests that transportation offsets, particularly those reliant on travel behavior changes, face significant hurdles in proving “additionality” and documenting emissions savings. This paper therefore proposes a “municipal mobility manager” trading design, under which local governments would assume responsibility for transportation emissions. This would give them the same financial incentives to implement abatement measures as under an offset scheme, but avoid the methodological and administrative challenges. The paper also argues that *any* design for including transportation in a carbon trading program will be beneficial, as it would avoid the tendency to overallocate permits to other sectors and force more realism in the expected emissions reductions from transportation.

INTRODUCTION

Transportation has proven one of the most stubborn challenges in reducing carbon emissions. As efficiency measures pay off in other sectors, transportation grabs a larger slice of the pie. Motor vehicles account for more than 40% of greenhouse gas emissions in California, and 28% in the United States as a whole *(1, 2)*. Transportation is the fastest growing source of greenhouse gas emissions in the world *(3)*.

There is certainly no shortage of policy prescriptions for measures to reduce emissions from transportation, including greater fuel efficiency, biofuels, transit, parking management and smart growth. In most cases, however, the implementation link is still missing: we understand *which* policies and projects will achieve emission reductions, but not *how* they can be introduced. Given that there have long been strong rationales to implement most of the measures for purposes of local air quality and congestion, it is unclear how a shift in the discourse to climate protection can speed their introduction.

Climate change does bring one significant new policy lever: market mechanisms. California's Global Warming Solutions Act of 2006, for example, provides an option for "market-based compliance mechanisms" to implement the statewide emissions cap, and carbon trading programs are being explored in other states and at the federal level. Agencies such as King County Metro have expressed interest in using carbon finance to help fund transit service *(4)*.

To date, however, market-based mechanisms have tended to focus on stationary emitters, to the exclusion of mobile sources. The first phase of the European Emissions Trading Scheme includes only four sectors: iron and steel, minerals, energy, and pulp and paper. And just one transportation project has been registered under the Kyoto Protocol's Clean Development Mechanism (CDM). Analysts have concluded that implementing carbon trading for transportation poses far greater challenges than for other sectors. With upstream trading, carbon trading effectively equates to a small additional gasoline tax. The administrative issues related to downstream trading, meanwhile, are challenging, with no guarantee that behavioral changes would be any greater.

This paper suggests that analysts have overlooked the potential to regulate the transportation sector at a different scale. Rather than households or refineries, we might look to *cities*[1] *or regions* as the appropriate point of regulation. Under this model of trading, local governments would need to surrender carbon allowances based on transportation emissions within their territory, giving them financial incentives to consider carbon emissions when making land-use and transportation decisions.

At the same time, *any* design of carbon trading in the transportation sector has the potential to reduce emissions in other sectors – even if there is no change at all in transportation emissions. In Europe, permits have been overallocated to rent-seeking electricity generators and industrial users, based on over-optimistic assumptions about the scale of reductions from policies and measures in non-capped sectors such as transportation. A wider cap that encompasses the

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[1] In this paper, I use "city" as convenient shorthand for any local government entity, including towns and counties.

transportation sector can provide a counterweight that leads to a more rational allocation of effort between sectors.

This paper focuses on California, where it has the most immediate relevance, but it applies equally to carbon trading programs elsewhere. It begins by providing a brief history of carbon trading applications to transportation, focusing on the Clean Development Mechanism. It discusses different approaches for carbon trading in the transportation sector, such as upstream, downstream and vehicle manufacturer-based systems. The paper then outlines a potential municipal "mobility manager" approach, and concludes by discussing the relative merits of the alternatives.

TRANSPORTATION IN THE CLEAN DEVELOPMENT MECHANISM

The earliest emissions trading programs were implemented in the United States, and some incorporated transportation. For example, refineries could trade pollution credits during the phase-out of lead in gasoline in the 1980s *(5)*, and the Clean Air Act amendments of 1990 included a provision for mobile source emission reduction credits, although few were created in practice *(6)*.

More extensive experience – or at least discussion – of a wider role for transportation in carbon trading programs has come through the Clean Development Mechanism (CDM). One of several market-based mechanisms of the Kyoto Protocol, the CDM allows Annex I (developed) countries to purchase Certified Emissions Reductions (CERs) from abatement projects in non-Annex I (mostly developing) nations. One CER equates to one metric ton of CO_2-equivalent.

In practice, however, transportation projects under the CDM have faced significant barriers. The only large-scale project to date – the TransMilenio Bus Rapid Transit (BRT) scheme in Bogotá, Colombia – was registered in December 2006; the estimated reduction is 246,563 metric tons CO_2-equivalent per annum. In comparison, 844 CDM projects in total had been registered by November 2007, and were expected to generate 1.1 billion CERs by the end of 2012 (*7*). Transportation accounts for just one out of the 47 large-scale methodologies approved to date, plus one for biofuels that is not transportation-specific (Table 1). (Once approved by the CDM Executive Board, a methodology can be applied to specific projects; the Bogotá BRT project uses Methodology AM0031.)

TABLE 1 TRANSPORTATION METHODOLOGIES PROPOSED FOR CDM

Methodology	Name or Description	Status
AM0031	Methodology for Bus Rapid Transit Projects	Approved
AM0041	Production of biodiesel based on waste oils and/or waste fats from biogenic origin for use as fuel	Approved (not transportation-specific)
NM0052	Urban Mass Transportation System (TransMilenio), Bogotá DC, Colombia	Rejected by Executive Board (EB), 1-3 Sept, 2004 Subsequent version approved as AM0031
NM0069	Biodiesel production and switching fossil fuels from petro-diesel to biodiesel	Rejected by EB, 23-25 Feb, 2005
NM0082 and NM0082-rev	Khon Kaen fuel ethanol project	NM0082 remanded by EB, 6-8 July, 2005, for revisions/reconsideration. NM0082-rev rejected by EB, 10-12 May, 2006 Subsequent version withdrawn as NM0185
NM0083	AutoLPG in India – A Road Transport Sector Fuel-Switching Project	Rejected by EB, 23-25 Feb, 2005
NM0108 and NM0108-rev	Production of biodiesel from perennial non-edible oil crops for use as fuel	NM0108 remanded by EB, 28-30 Sept, 2005, for revisions/reconsideration NM0108-rev rejected by EB 21-23 March, 2007
NM0109	Sunflower Methyl-Ester Biodiesel Projects in Thailand	Rejected by EB, 6-8 July, 2005
NM0128	Modal shifting in industry for transport of product/feedstocks	Rejected by EB, 23-25 Nov, 2005
NM0129 and NM0129-rev	Transportation Bio-Fuel Production Project with Life-Cycle-Assessment	NM0129 remanded by EB, 6-8 July, 2005, for revisions and possible reconsideration. NM0129-rev rejected by EB, 21-23 March, 2007
NM0142 and NM0142-rev	Palm Methyl Ester – Biodiesel Fuel (PME-BDF) production and use for transportation in Thailand	NM0142 remanded by EB, 10-12 May, 2006, for revisions/possible reconsideration. NM0142-rev rejected by EB, 2-4 May, 2007
NM0158	Mexico, Insurgentes Avenue Bus Rapid Transit Pilot Project	Rejected by EB, 29 Oct – 1 Nov, 2006 Subsequent version under consideration as NM0229
NM0185	Khon Kaen fuel ethanol project	Withdrawn
NM0201	Cosipar Transport Modal Shift Project	Withdrawn
NM0205	Improving the Energy Efficiency of Buses in Argentina	Rejected by EB, 20-22 June, 2007
NM0223	Western Cape Biodiesel Project	Rejected by EB, 20-22 June, 2007
NM0224	Manufacturing of Bio-diesel from Crude Palm Oil and Jatropha Oil	Rejected by EB, 15-19 Oct, 2007
NM0229	Methodology for Mass Rapid Transit Projects	Under consideration
NM0233	Methodology for vegetable-derived fatty acid methyl ester biodiesel production for transportation	Under consideration
NM0237	GHG Reductions through Improved Occupation Rate of Public Transport Units	Under consideration

Source: Compiled from (*7*). Excludes small-scale methodologies. EB = CDM Executive Board

There are several reasons why few transportation-related CDM projects have been registered so far. The most obvious is additionality – the need to demonstrate that the project would not have happened "but for" the CDM, and is thus "additional" to the baseline scenario. The Bogotá BRT project, although ultimately registered, was hampered by these concerns. If it were possible to build Phase I of TransMilenio without the CDM, ran the argument, then Phase II should not need this source of funding. *(8)*

Second, making the case for additionality is even more difficult given that CERs will account for only a small amount of total project funding. Some of the most detailed analysis is provided by Browne *et. al. (9)*, who analyze three potential projects in Santiago, Chile. Hybrid diesel-electric buses would be cost-effective based on reduced fuel consumption alone, making it difficult to argue the additionality case. For bikeways, the CDM could offset between 9% and 33% of the cost of a citywide network, assuming a $10/CER price. For some land-use changes, the CDM might fully offset any costs, but the uncertainties in both costs and travel impacts are far greater.

Third, transaction costs are often high. Sandvik *(8)* estimates that projects delivering less than 30,000 tons of CO_2 reductions per year will pay more than 20% of total income in transaction costs. The approved methodology for BRT, for example, details data collection requirements for total distance driven by taxis, buses, motorcycles and private cars; average vehicle occupancy rates; average trip distances; passenger counts; bimonthly survey data on how passengers would have traveled in the absence of the BRT system; scrappage of older buses; average speeds; and numerous other data points. Lengthy amounts of time spent agreeing methodologies for certifying reductions are another source of transaction costs. Once standardized, the cost will certainly fall, and some authors are sanguine about the prospects for future methodologies (*10*), but the upfront cost and risk for "pioneer" projects undoubtedly pose barriers.

Finally, the nature of the CDM may have encouraged technology-based projects at the expense of those that seek to induce behavioral changes, and thus bring broader societal and development benefits in addition to the greenhouse gas savings. Fuel switching has dominated, with limited attention paid to transit and none to land-use and non-motorized travel projects (Table 1). Consequently, Wright & Fulton (*11, p. 12*) ask whether "we are looking for transport CO_2 emissions in the right places." They point out that while many projects have focused on alternative-fuel buses, the mode share effect (i.e., reducing auto use) of transit may dwarf the technology effect (i.e., fewer emissions per bus mile).

An examination of the staff recommendations on methodology approval to the Executive Board, and the proposed methodologies themselves, also illuminates some of the reasons for favoring fuel-switching rather than mode-shifting projects. Leakage and rebound concerns[2] have led to reluctance to accept several projects that rely on behavioral changes (e.g. mode shift). For example, the methodology for the Insurgentes BRT project in Mexico City was partly rejected due to a "very broad project boundary definition";[3] proponents sought to take credit for shifts in

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[2] Leakage refers to changes in emissions beyond the project boundary, e.g. changes in load factors on other buses. Rebound (which can be a form of leakage) refers to a feedback effect, where reduced congestion (e.g. from elimination of private microbuses on a corridor) or transportation prices induce additional trips.

[3] All citations from methodologies and staff reports are taken from (*7*).

travel patterns on the BRT corridor, without survey evidence that could directly tie people's travel decisions to BRT.

In contrast, less ambitious projects seem to reap rewards. The staff recommendation for the (ultimately rejected) Insurgentes BRT methodology notes that the "project is too small to affect overall traffic patterns at the municipal level or level of motorization." It notes approvingly: "This should in fact be a condition for using the methodology." Indeed, the proponents of the (also rejected) Argentinean bus fuel-efficiency methodology (NM0205) argue that the limited scope of their project (fuel-switching only, with no behavioral changes) is a substantial advantage as it avoids rebound and leakage effects.

These documents also bring up a more subtle issue related to risk. In essence, the CDM is a highly risk-averse mechanism, which in the transportation sector will favor small, incremental technological changes and ignore the wider structural urban factors that shape travel behavior. The project-level basis of the CDM is also ill-suited to measuring effects on a region-wide level. While the emissions reduction from fuel-switching are (relatively) predictable and the baseline is easier to establish, any project that relies on behavioral change is subject to much greater uncertainties related to baseline emissions, mode shift, the development of supportive land-use patterns, and the extent of any rebound effect. It also makes it virtually impossible to use CDM for any planning or engineering studies or political consensus building work, as neither project implementation nor emissions reductions can be guaranteed. With sufficiently many projects, this variability will average out, but it does not provide the basis to issue CERs tied to a specific project.

The obstacles presented in this section to incorporating transportation in the CDM are not necessarily insurmountable. Nor are most specific to transportation – additionality and baseline concerns in particular have dogged many CDM projects in other sectors, and there are certainly wider problems with the CDM (*for example, 12)*. However, although several other BRT projects and new methodologies are in the pipeline (*10*), the challenges will limit the number of transportation projects coming forward under the CDM in the immediate future. As Browne *et. al*. *(9, p. 73)* suggest: "Although they have the potential to contribute positively to long-term sustainability goals such as motorized trip reduction, projects that specifically address transportation demand do not fit well into CDM as it is currently designed. This is in part due to uncertainty of projected impacts and difficulties monitoring change in travel behavior."

CONCEPTUAL APPROACHES TO CARBON TRADING IN TRANSPORTATION

Most authors who have considered the incorporation of transportation in a cap-and-trade program appear to have implicitly assumed an upstream trading model (i.e., at the refinery or importer level). However, the impacts of transportation carbon trading will likely vary considerably depending on the model of trading that is introduced. The following sections therefore discuss in detail the potential models that have been proposed: upstream, downstream, vehicle manufacturer, and offsets. These options are not mutually exclusive; hybrid systems are also possible *(13, 14)*.

Upstream Trading

"Upstream" trading has been by far the most popular choice among analysts looking to include transportation in an emissions trading program, including the recommendations from the California Market Advisory Committee (*15*). Usually, refineries or importers are seen as the logical point of regulation, and would be required to hold permits for the carbon content of their products. An upstream approach coupled with carbon-efficiency standards for vehicle manufacturers achieves the broadest coverage with minimal administrative costs (*13*).

The main issue posed by an upstream model is *how* refineries and importers would be expected to reduce their emissions. In practice, refineries have few tools at their disposal – apart from process emissions savings, their only option is to alter the carbon composition of gasoline, for example by blending in ethanol. Thus, only one of the terms in the decomposition shown in Figure 1 is directly targeted under this approach (Carbon/Gallons), and in California and the European Union, this is already being addressed by regulation. For example, Governor Schwarzenegger's January 2007 Executive Order sets a "low carbon fuel standard" to reduce the carbon content of passenger vehicle fuels by 10% by 2020, measured on a lifecycle basis.

FIGURE 1 DETERMINANTS OF TRANSPORTATION EMISSIONS

$$P \times \frac{PMT}{P} \times \frac{VMT}{PMT} \times \frac{Gallons}{VMT} \times \frac{Carbon}{Gallons} \times \frac{CO_2}{Carbon} = CO_2$$

Description	Pop.	Person Miles Traveled	Vehicle Miles Traveled	Fuel Use	Carbon Content	CO_2 released to atmosphere	Emissions
Explanatory factors and policies		Mobility Land use	Motorization Mode share	Fuel efficiency	Fuel type	Carbon capture & storage	

Under an upstream model, then, most of the impact would come from higher fuel prices, as refiners pass on the cost of carbon allowances. In general the impact on emissions would be relatively small due to inelastic demand for vehicle travel. According to one set of estimates, long-run fuel price elasticities fall into the -0.6 to -0.8 range *(16)*. If passed through to the consumer, a permit price of $30 per metric ton of CO_2 would add $0.27 to the price of a gallon of fuel, reducing long-run consumption by 5%-7% and short-run consumption by even less.[4]

In effect, the transportation sector would "outsource" its emissions reductions responsibilities to stationary sources – it would tend to purchase credits rather than undertake the abatement itself. This is not in itself a problem, in that the overall level of emissions reductions – the cap – would still be achieved. Upstream trading also has advantages of complete coverage and administrative simplicity, given that there are just 175 refiners and 200 oil importers in the United States *(14)*. However, it does suggest that emissions reductions are not necessarily reduced at least cost, since there would be little additional incentive to implement the full range of abatement measures in

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[4] Based on a carbon content of gasoline of 2,421 grams/gallon (US EPA figures) and a gasoline price of $3/gallon. 2,421 x 44/12 (conversion from C to CO_2) = 8,877 gr/CO_2.

the transportation sector, specifically those that fall outside the purview of refiners, importers and households. Meanwhile, the significant co-benefits attached to many transportation projects, such as congestion mitigation and local air quality improvements, may be foregone.

Downstream Trading

In the transportation sector, any downstream emissions trading would most likely be implemented at the level of the individual motorist. The attraction for some analysts is the assumed greater sensitivity of motorists to price signals when implemented at the downstream level, presumably due to psychological factors. Raux & Marlot *(17)* envision that motorists would receive an initial free allowance and buy additional permits, which would be held on a smartcard, at the fuel pump or through a bank. Other ideas include capping the number of automobiles and trading vehicle ownership permits, or trading parking permits or vehicle miles traveled allowances *(18)*. Alternatively, downstream transportation trading could be part of a broader system of "personal carbon quotas" *(19)* or "domestic tradable quotas" *(20)* that encompass an individual's entire carbon footprint.

The administrative complexities, however, not to mention civil liberties and equity concerns (but see (*21*)), suggest that such a downstream model would be impractical. The price signals appear to be minimal – a few tens of euros per year *(17)*. And there is little evidence to support the contention that downstream trading would change behavior any more than an equivalent price signal applied upstream.

Vehicle Manufacturers

An alternative option, passing responsibility to vehicle manufacturers, lies outside the upstream/ downstream framework, as it does not lie directly on the fuel supply chain. The California Climate Action Team sees this approach as the most practical way to bring the transportation sector under the umbrella of a cap-and-trade program *(1)*. Albrecht *(22)* finds that this could reduce emissions by 25-38% over a period of 15 years.

Under the system envisaged by Winkelman *et. al. (13)*, manufacturers would be required to purchase permits for emissions imputed to their vehicles. They would have incentives to reduce emissions from their fleet, bringing the Gallons/VMT term in Figure 1 under the scope of the cap-and-trade system. Other advantages include avoiding politically sensitive fuel-price increases, low administrative costs (due to there being few auto manufacturers), and the influence of manufacturers over both fuel type and purchase decisions *(14)*.

The tradeoff involves some degree of complexity and technical challenge. First, "imputed" or "embedded" emissions from each vehicle would need to be accurately quantified. Another question is whether manufacturers would be responsible for lifetime emissions from new vehicle sales, or all vehicles on the road. The former would not capture emissions from previously sold vehicles; the latter would distort new vehicle prices and hold manufacturers accountable for actions that they can only partially control *(13)*. There are also administrative complexities in avoiding double counting with an upstream system in other sectors *(14)*. Finally, vehicle manufacturer trading would address only one mechanism for reducing carbon emissions – unlike an upstream cap, it would neither reduce vehicle travel nor the carbon content of fuels – and so the first-best solution would not be attained.

Offsets

An offset approach would not cap emissions from the transportation sector. However, municipalities, transit agencies, developers and other organizations would be able to put forward transportation projects that offset emissions from the stationary sector. Importantly, the transportation sector would need to be outside the emissions cap, otherwise offsets would be double counted – once as the offset itself and a second time through reduced fuel consumption. An offset program could not be coupled with upstream or downstream trading or a vehicle manufacturer-based program.

The Clean Development Mechanism provides the most extensive experience with transportation offsets. There has also been interest elsewhere *(for example, 23)*. It is difficult to see, however, how the fundamental barriers exposed by the CDM can be overcome in an offset program in the industrialized world – assuming that the same stringent standards for additionality and precision are applied. Indeed, higher project and monitoring costs compared to those in developing countries may render the value of offset credits negligible. There may be a role for offsets under voluntary programs such as the Chicago Climate Exchange, as being explored by agencies such as King County Metro *(4)*. The Climate Trust, meanwhile, reports three transportation projects in its offset portfolio, including an arterial management project in Portland, OR. But it will be more challenging to implement them under a mandatory cap-and-trade program with more stringent standards.

MUNICIPAL MOBILITY MANAGER

Conceptual Basis

An alternative option is for municipalities to serve as the manager of urban transportation emissions, and perhaps those from residential and commercial buildings as well.[5] Municipalities would need to purchase allowances equal to the emissions that they manage, and would have incentives to implement emissions reduction measures. Large airlines and railways would participate directly. While intriguing, the only reference in the literature appears to be an offhand comment by Haites *(6)*.

Wide variations in vehicle travel between different municipalities can often be traced to decisions on land-use (e.g. allowable densities, mix of uses, parking ratios), transportation investments (e.g. roadway capacity, bicycle facilities, transit priority) and parking and roadspace pricing. Indeed, the differences between gas-guzzling and fuel-efficient cities are often more striking than those between SUVs and hybrid vehicles. According to Caltrans figures, San Francisco residents drive only 60% as much as Los Angeles County residents. On a global scale, the range is even greater. A Munich resident emits just 28% as much CO_2 from transportation as

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[5] A variant of this proposal might be “city carbon caps.” The idea is similar to downstream multi-sector trading at the household level (such as personal carbon quotas), but emissions would be aggregated at the city level, reducing transaction costs.

the average Houston dweller *(24)*. This is not to say that these cities are directly comparable, but rather to show that urban form and transportation infrastructure can be as important in explaining carbon emissions as vehicle choice.

Carbon trading could provide the necessary price signal that prompts cities to rationally choose a less carbon intensive path. In this way, the emissions trading program would target the "PMT/P" and "VMT/PMT" terms – i.e., overall mobility and mode share – shown in Figure 1. This option would capture all of the potential of offsets, but render moot any questions regarding additionality or baselines, together with the associated transaction costs. Rather than avoiding all semblance of risk, as under the CDM, municipalities would bear the risk if their investments did not produce the expected emissions reduction benefits.

Municipalities may be one logical entity to fulfill this mobility manager role.[6] Alternatively, the system could be implemented at the regional level through Metropolitan Planning Organizations (MPOs), which although usually lacking local land-use control have much greater power over major investment decisions. MPOs could pass on the costs or revenues to municipalities under some mutually agreed formula. There is also an important parallel with air quality conformity under the Clean Air Act. A regional carbon cap would be the equivalent of an attainment standard, but rather than an ultimate "all or nothing" non-compliance penalty of suspending federal transportation funding, an MPO would simply need to purchase CO_2 allowances.

Attribution and methodology are clearly major issues. Transportation emissions would need to be attributed to a specific municipality, or for longer-distance travel, to a State agency, rail or bus operators or airlines. One fundamental question is whether to make municipalities responsible for all trips made by their residents (which would reduce incentives for destination-end policies such as employee parking charges); for one-half of the emissions from each trip end in their jurisdiction; or for all vehicle travel on municipal streets (regardless of where the occupants reside or their destination). A trip-end approach would be most desirable, as it would reduce perverse incentives to eliminate through traffic, and many (but by no means all) abatement measures are implemented at the origin or destination site. However, this would be the most methodologically complex, as it would require either detailed travel diaries or surveys and traffic counts at a representative sample of both residential and non-residential locations.

Ultimately, methodological issues tend to argue for a regional-level approach, as the difference between the three approaches will be less pronounced at a larger scale. Emissions could be calculated based on vehicle miles traveled and speeds on a representative sample of roadways, together with the regional vehicle fleet composition. An adjustment factor would account for through traffic. There is already a basis for gathering these types of data; in California, for example, Caltrans publishes vehicle travel data aggregated by county.

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[6] Note that the Municipal Mobility Manager concept as I employ it here is different from mobility managers with a primarily outreach function to promote ridesharing, transit, etc, often at the employer level. The latter concept with a programmatic focus raises issues of attribution, geographic boundaries, etc. The Municipal Mobility Manager discussed here would simply overlay a carbon emissions function onto existing governments (local or regional) with transportation responsibilities. It would therefore eliminate the need to track emissions changes resulting from specific programs.

Equity is another concern, as an emissions trading program would penalize auto-intensive counties while rewarding urban, transit-focused jurisdictions. Given that most past actions (such as land use) cannot be reversed in the short- to medium-term, this might be considered inequitable and certainly politically challenging to implement. The most practical option is to grant free permits to all counties in line with baseline emissions. Only future increases in vehicle travel would therefore have a fiscal impact. To the extent that this is caused by growth, municipalities could levy impact fees on new development equal to the present value of future emissions; this may help to avoid any disincentive to accommodate growth and provide a fiscal incentive in favor of infill and transit-oriented projects.[7] Alternatively, counties could receive additional permits each year based on population change. Auto-intensive development would then become a fiscal burden; infill, transit-oriented and pedestrian-oriented development a fiscal boon. At the same time, local governments would have a fiscal interest in lobbying for more stringent fuel-efficiency standards and lower-carbon fuels.

In general, there are sound economic arguments against granting free permits rather than auctioning them *(25)*. In this trading system design, however, the free permit allocation simply represents a transfer from one arm of government to another and free allocations are thus less problematic. Indeed, one option is for the whole "mobility manager" system to be seen as an overlay on existing transportation funding streams which transfer revenue to local governments. One can envisage existing population-, road miles-, registered vehicles- or revenue-based formulae being partially replaced by a greenhouse-gas-emissions-per-capita-based system. Transit and highway funding under existing federal (SAFETEA-LU) or state (e.g. California's Transportation Development Act) formulae could be adjusted by the value of the net carbon allowances required.

A "mobility manager" approach also has interesting implications for transportation funding more generally. Most notably, this model of trading system would add to the cost of highway projects, to the extent that the expansions induce traffic, as the sponsoring agency would need to factor the present value of carbon allowances into project costs. In effect, a portion of highway budgets would flow to emissions reduction projects elsewhere in the economy.

Assessing the Potential

One obvious question is the extent to which a "mobility manager" carbon trading system would reduce emissions in the transportation sector, or whether higher costs or political barriers would lead most abatement to be undertaken in the stationary sector. A full assessment would require two research efforts – construction of the supply curve of abatement measures, and assessment of how political and institutional barriers for different types of projects are affected by fiscal incentives. For example, does increased revenue make transit priority measures or parking pricing more politically feasible?

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[7] The San Joaquin Valley Unified Air Pollution Control District provides a model for this via its Indirect Source Rule; a fee is assessed on new developments proportionate to their impact on criteria pollutants. Dense, mixed-use developments that locate close to transit pay lower fees. Cities could also adjust the fee structure to take into account other considerations, for example by waiving the fee for specific desired uses.

This analysis is far beyond the scope of this paper, but it is useful to present a simplified analysis of the impact of carbon trading on project costs. In the same way as supply curves of greenhouse gas abatement have been developed for energy projects, indicating the amount of abatement available at a given carbon price, the same concept can be used to identify potential greenhouse gas savings through transportation planning. Such supply curves have been estimated for energy-efficient vehicle technology *(26)*, but I am not aware of their use in a transportation planning and infrastructure context.

Some of the best data on the cost-effectiveness of transportation investments in reducing emissions comes from the Congestion Mitigation and Air Quality Improvement (CMAQ) Program. While cost-effectiveness is assessed in terms of criteria pollutants, these results can be approximately converted to CO_2 through the use of standard emission factors, assuming that these are proportional (an assumption likely to hold for projects that reduce vehicle travel). Table 2 shows the results of this exercise.

TABLE 2 COST-EFFECTIVENESS OF TRANSPORTATION ABATEMENTS

Type of Project	Examples	Median Cost per Ton/CO_2	Cost Range
Traffic flow improvement	Carpool lanes, incident management	$1,154	$31 - $7,350
Ridesharing	Carpool matching, vanpools	$277	$16 - $1,203
Travel demand management	Employer trip reduction programs	$207	$31 - $2,372
Telework		$3,403	$180 - $111,176
Bicycle/pedestrian		$1,136	$57 - $4,658
Transit	Shuttles, new capital systems	$817	$51 - $26,676
Fuels and technology	Alternative-fuel vehicles, inspection	$403	$24 - $7,685

Source: Calculated from *(27)*, Table E-5, which provides cost effectiveness data in terms of criteria pollutants. These are converted to CO_2 by dividing by 74, making the following assumptions based on (*27*): weighting factor of 4:1 for NOx:VOC used in (*27*); NOx emission factor 0.84 gr/mile plus 1.56 gr/trip; VOC emission factor 0.44 gr/mile plus 3.19 gr/trip; average trip length 7.5 miles, CO_2 emission factor 372 gr/mile. These result in average emissions per trip of 2790 gr CO_2 and 37.93 gr weighted criteria pollutants.

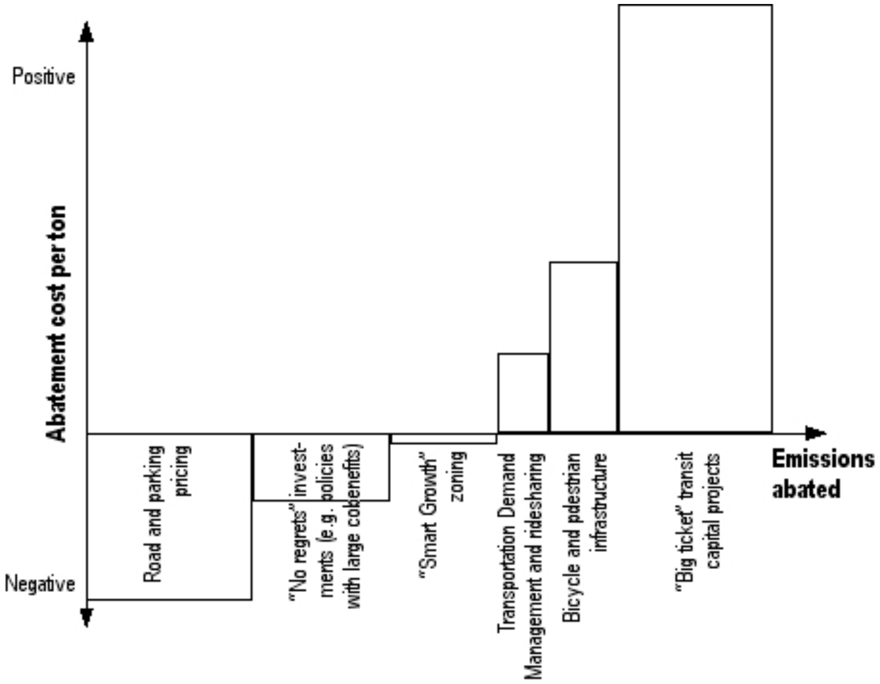
The most obvious conclusion from these results is that greenhouse gas abatement through transportation planning and infrastructure is prohibitively costly. Travel demand management has the lowest median cost of any category, and even here the $207 cost per metric ton of carbon abated compares poorly to future CO_2 allowance price estimates that are well below $50 per ton.

However, this conclusion would be premature for several reasons. First, there is a wide range of costs – all project types in Table 2 except teleworking have some projects with abatement costs of less than $60/ton. Second, the analysis does not quantify co-benefits, such as congestion reduction, local air quality improvement and public health. The important question is not whether carbon finance would fully fund any project, but whether it can provide sufficient funding to push a project “over the edge.”

Third, the CMAQ program has had a relatively narrow focus, and negative cost abatements (i.e., those that generate revenue) are not included in Table 2. These types of projects might include congestion and parking pricing. Smart growth planning, meanwhile, can lead to infrastructure cost savings compared to typical patterns of “sprawl” *(28)*. Other low-cost abatements might include road diets (e.g. converting four-lane highways to three lanes plus bicycle lanes), and highway capacity reductions such as freeway removals in San Francisco and Milwaukee. Finally, Table 2 does not reflect the potential for carbon prices to play a role when considering new infrastructure alternatives – such as transit vs. highway expansion options to mitigate congestion in a corridor.

Figure 2 thus presents a conceptual abatement cost curve that takes into account the data in Table 2, but considers a wider range of abatement options. This is a qualitative assessment only, but indicates the types of projects that might be cost-effective in reducing emissions. Certainly, there are large political costs and institutional barriers associated with the low- and negative-cost options, but this is also true for abatement measures in other sectors.

FIGURE 2 CONCEPTUAL ABATEMENT SUPPLY CURVE



CONCLUSION

Counterintuitively, carbon trading in the transportation sector could lead to economic efficiency gains – even if no abatement is undertaken at all. This hypothesis is drawn from evidence related to the political economy of permit allocation, particularly in the European Emissions Trading Scheme (ETS). Here, permits for electricity generators and industrial users were overallocated in the initial round, and a similar effect can be seen in the Phase II of the ETS. Betz *et. al. (29)* report that Phase II emissions trading budgets are only 3% below projected 2010 emissions, due to National Allocation Plans[8] that assume far greater reductions through policies and measures in other sectors (principally transportation). They conclude (p. 381):

> From the perspective of cost efficiency, we find that, with the possible exception of the UK, the non-trading sectors have to bear a disproportionately high share of the reduction efforts in all EU-15 MS [member states]. Thus, while the ETS enables the trading sector to cost-efficiently achieve its ET [emissions trading] budget, the economy as a whole pays a premium for giving a more generous share of the Kyoto budget to the ET sector rather than to those sectors where it would cost more to achieve emission reductions.

This outcome is easily explained by the political costs of a more stringent allocation in the industrial and electricity generation sectors, and rent seeking by these market participants. The political route of least resistance is to identify greater reductions from policies and measures in the transportation sector – at the expense of economic efficiency. This allows the National Allocation Plan to "meet" the national cap, while reducing the effort required from the sectors that participate in trading. In contrast, an emissions trading scheme design that included all sectors would provide a countervailing force against an underallocation of permits to the transportation sector.

These largely pragmatic arguments – coupled with the sheer scale and growth of transportation emissions – provide a compelling case for including transportation in any carbon trading program. This paper has sought to analyze the merits of different models of doing so. I conclude that upstream or downstream trading designs would have little impact on transportation sector emissions, with a downstream design facing enormous issues of administrative feasibility. While the desired cap would be achieved, inelastic demand for gasoline means that this would largely be accomplished through abatement measures in the stationary sectors.

This is not necessarily a bad outcome, but it would miss out on the potential for numerous low-cost transportation abatement measures. As these are often the responsibility of local governments, upstream or downstream trading designs would not provide any direct price signal for their implementation – leading to inefficiencies and welfare losses, and a higher carbon price than is necessary to achieve a given level of abatement.

A vehicle manufacturer-based system is one alternative design for carbon trading. There are certainly practical issues, such as how to impute lifetime emissions to a vehicle at the time of sale *(10, 11)*. More fundamentally, however, fuel economy standards *(30)* and feebates *(31)* may be equally effective in encouraging optimal fuel efficiency in the vehicle fleet.

That leaves offsets and a "municipal mobility manager" design as two options that provide local governments with the requisite price signals. Offsets are intuitively appealing, but the experience with the Clean Development Mechanism casts significant doubt on whether worthwhile projects can overcome barriers such as demonstrating additionality, accounting for all sources of leakage, and transaction costs. They are also ill suited for transportation projects which rely on multiple

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[8] National Allocation Plans (NAPs) establish the relative abatement efforts in sectors within and outside the Emissions Trading Scheme. They also determine how permits are distributed between individual installations (e.g. generating units).

co-benefits, of which greenhouse gas reductions are just one. Moreover, offsets are an inherently risk averse mechanism, making it difficult for “riskier” projects (where carbon abatement is uncertain) that rely on behavioral changes to qualify. It is difficult to see how offsets in a California program, for example, where the California Global Warming Solutions Act of 2006 (AB32) requires emissions reductions to be “real, permanent, quantifiable, verifiable, and enforceable by the state board,” could be designed to be more flexible than the CDM.

A mobility manager design, in contrast, provides the same fiscal incentives as offsets. However, transaction costs (on a per-project basis) are avoided, and questions of additionality become moot. More importantly, a mobility manager design is wider in scope than offsets; it provides incentives to reduce greenhouse gas emissions in all policy areas, whether from new development (through smart growth), or through internalizing the carbon cost of highway expansions. And in the same way that carbon trading in other sectors has stimulated upper management involvement in environmental issues, a municipal mobility manager design might provoke greater attention from mayors, city councils and city managers due to its fiscal impacts.

I do not argue that a cap-and-trade system is a necessary condition to provide these price signals to local governments. Indeed, one can easily think of a range of ways to achieve this goal, most notably broader transportation funding reform that rewards municipalities and regions that cut emissions. Nor do I argue that cap-and-trade is superior to a carbon tax or an increase in the gasoline tax. However, there is great political momentum at present behind cap-and-trade. The potential measures to reduce greenhouse gases from transportation have been known for many years. Carbon trading may provide a mechanism to help implement them.

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