

**Global Forum on Transport and Environment in a Globalising World**  
**10-12 November 2008, Guadalajara, Mexico**



## **Mitigating the Risk of Climate Change by Reducing Travel by Light Duty Vehicles**

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## FOREWORD

This paper was prepared by Walter Hook, Executive Director, Institute for Transportation and Development Policy (ITDP), as a contribution to the OECD/ITF *Global Forum on Transport and Environment in a Globalising World* that will be held 10-12 November 2008 in Guadalajara, Mexico. It discusses ways to mitigate the risk of climate change by reducing travel by light duty vehicles.

## TABLE OF CONTENTS

MITIGATING THE RISK OF CLIMATE CHANGE BY REDUCING TRAVEL BY LIGHT DUTY VEHICLES.....	4
1. Introduction .....	4
2. Bus Rapid Transit .....	5
3. Congestion Charging .....	7
4. Parking Reform.....	10
5. Traffic Cells.....	11
6. Alternative License Plate, HOV and HOT schemes .....	12
7. Blocking or Removing Highways .....	12
8. Downgrading Roads, One Way and Two Way Roads, and Area Traffic Control Systems.....	13
9. Cycling and Mode Share .....	13
10. Bike Parking.....	14
11. Bike Sharing and Car Sharing.....	15
12. Modernizing the Human-Powered Vehicle itself.....	16
13. Transit-Oriented Development, and Urban Revitalization .....	16
14. Freight and logistics and their relationship to changes in retailing.....	18
15. Conclusion .....	19
REFERENCES .....	20

## MITIGATING THE RISK OF CLIMATE CHANGE BY REDUCING TRAVEL BY LIGHT DUTY VEHICLES

### 1. Introduction

1. The International Energy Agency (IEA) projects that transport sector CO<sub>2</sub>e emissions will continue to increase by about 1.6% per year until at least 2030 (WBCSD 2004). The IEA estimates are conservative. They ignore the fact that worsening congestion is likely to compromise vehicle fuel efficiency, that vehicle costs are dropping rapidly in China and India, and that high carbon fuels derived from coal or tar sand are coming onto the market as oil prices rise. The hope that ethanol or biodiesel would become a viable low carbon fuel is increasingly questioned: even cellulosic ethanol may do little to reduce CO<sub>2</sub>e emissions if land use and other full fuel cycle impacts are considered. Most experts agree that vehicles can be made considerably more fuel efficient, perhaps by as much as 40%, by 2030 or so. (Zimmer, et. al. 2008) But fuel efficient vehicles also make driving cheaper, and there is growing evidence that many of the CO<sub>2</sub>e gains of fuel efficiency are dissipated through increased driving. In short, technical opinion is rapidly coming to the conclusion that reducing vehicle kilometres travelled (VKT) has to be a central part of any transport sector climate change mitigation strategy..

2. Three types of vehicle travel are growing rapidly: light duty vehicles, trucks, and air travel. VKT continues to grow in most OECD countries in most years. It fell in the US in the last two years due to rapid increases in oil prices. Transport sector CO<sub>2</sub>e emissions actually fell in Japan and Germany and stabilized in France over the last few years, with VKT remaining reasonably stable. Again, oil prices had a lot to do with it. But the IEA projections show most of the increases in global VKT coming from the developing world, with China and India being responsible for a large share of the growth. These countries are seeing double digit growth rates in their motor vehicle fleets.

3. The US government and many US-based institutions have ignored even the possibility of reductions in VKT as a climate strategy. The World Business Council for Sustainable Development (WBCSD), in their *Mobility 2001* report, stated that “the trend toward privately owned motor vehicles and away from reliance on “conventional” forms of public transport (such as buses and subways) is nearly universal.”<sup>1</sup> In all the talk of US energy independence, no mainstream US politician has ever suggested that driving less might be part of the solution to oil dependency or climate change. US politicians and the WBCSD merely reflect a nearly universal belief among most American experts and some Europeans as well that driving less must result in a sacrifice of lifestyle, or, in economic terms, a loss in ‘consumer utility’. This belief is equally shared by most leaders of the Indian and Chinese governments as well: the world’s leaders seem to assume that as incomes rise, public transit and bicycle use will *de facto* fall, and that any effort to convince the Indian or the Chinese governments to reduce VKT is tantamount to asking them not to develop economically.

4. The McKinsey CO<sub>2</sub>e abatement cost curve (Enkvist, P. *et al.*, 2007), an otherwise promising tool for targeting climate change interventions, thus far excludes all VKT reduction strategies on the grounds that the tool only measures ‘technological change’ and not ‘behavioural change’.

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<sup>1</sup> World Business Council for Sustainable Mobility (2001), p. 1-4.

5. There is no theoretical justification for treating investments in new technology differently from investments in better transit systems or better transport service logistics as fundamentally different economic phenomenon. This bias towards technology-based solutions is perhaps a reflection of vested interests, but it is also perhaps a quirk of mainstream economic jargon. Robert Solow won the Nobel Prize for *Growth Theory: An Exposition*, (Solow, 1970) where growth was attributed to ‘technological change’. Technological change shifted society’s aggregate production function outwards, meaning that everything a society can produce with a given amount of capital and labour increases with technological innovation. Nelson and Winter (1982) later pointed out that this shift in the aggregate production function is actually just a residual that needs to be explained empirically. Scott (1989) later pointed out that ‘technological change’ is actually an investment that permanently changes economic arrangements that increases the amount that society can consume sustainably with a given amount of capital and labour. In other words, any ‘investment’, narrowly defined, whether it be an investment in deploying new technology or an investment into transportation infrastructure, is just as likely or unlikely to shift the aggregate production function outwards, and hence be part of what Solow originally labelled ‘technological change’.

6. McKinsey and most of the US public has been under the misimpression that any reduction in VKT must *de facto* result in a loss of ‘consumer utility.’ Indeed, sometimes reducing VKT does result in a loss of consumer utility. A downturn in the economy can lead to giving up discretionary travel with a loss of consumer utility. However, there are numerous ways of reducing VKT which actually improve consumer utility. This paper is concerned only with these measures. All of the measures discussed in this paper, if implemented properly, will yield a gain in consumer surplus and hence show a positive result from a cost benefit analysis. They will yield aggregate consumer utility benefits in China and India even more readily than in the United States. There is thus no economic reason why the leaders of these countries should not embrace these measures, and in fact, they are.

## 2. Bus Rapid Transit

7. Bus Rapid Transit (BRT) is the most important recent example of a transport investment that can reduce CO<sub>2</sub>e and VKT, while significantly increasing consumer utility. BRT is a mass transit system that generally replicates many of the operational advantages of metro systems, using bus technology operating primarily on surface streets. Passengers pay to enter the BRT station, which is generally built on a platform level with the bus floor. Passengers can then enter or exit any of the buses’ doors at once without the delays associated with payment, dramatically reducing bus delay at station stops. BRT systems also tend to have physically separated exclusive bus lanes with various signal priority measures at the intersections to increase bus speeds and busway capacity. The most advanced BRT systems include complex operational plans, with multiple routes including express and local services, and passing lanes at each stop. With these basic combined measures, BRT can reach speeds and capacity levels that surpass all but the highest capacity metro rail systems, with the current peak being 45,000 passengers per direction per hour, which was observed on the TransMilenio BRT system in Bogota (TransMilenio, 2005).

8. BRT systems can reduce VKT while significantly increasing consumer utility in the following ways:

- Many private motor vehicle passengers, generally in the range of 10% - 20% in affected areas, voluntarily shift back to buses, reducing private vehicle kilometres travelled. The time lost to passengers that shifted from private car to buses is generally less than the time savings accrued by both bus passengers and the remaining motorists.
- Far fewer buses travelling far fewer bus kilometres were able to serve the same number of bus passengers because of much higher speeds and load factors. In other words, bus kilometres travelled drops significantly due to operational efficiency gains within the bus system itself.

- Because buses operating in mixed traffic lanes cause congestion due to their frequent starting and stopping, removing the buses from the mixed traffic lanes to their own designated lanes generally increases the flow of mixed traffic and reduced its fuel consumption, at least temporarily.

9. Of course, not all the BRT systems that have been built in recent years have had these positive impacts. Many of them have made quite serious design and operational planning mistakes which did not lead to these positive outcomes. But all of the best systems did have these outcomes.

10. Cities that implemented good quality BRT systems saw their transit mode share increase in the affected corridors and even system-wide. The impact on modal split and vehicle kilometres travelled is affected by a lot of variables, but the Bogota data warrants some analysis. Bogota from 1995 until 2005 built 84 kilometres of exclusive high speed BRT trunk corridors, which are served by an extensive network of feeder buses. It also implemented other measures, such as the construction of 300km of bike lanes, the removal of nearly a third of downtown on-street parking, the widening and improvement of sidewalks, and the introduction of a demand management scheme which restricted car use by vehicles with certain license plate numbers on certain days of the week. Disaggregating the modal shift impacts of these separate measures is difficult. With all these interventions, from 1995 to 2005, total public transit mode share increased from 55.7 to 57.2. Biking increased from .5% to 4%. Private car and taxi use dropped from 18.9% to 17.4% (JICA Household OD Survey, 1995; DANE Household OD Survey, 2005). Total vehicle kilometres travelled by private motor vehicle increased marginally, but the net CO<sub>2</sub>e impact of this mode shift was a reduction of about 65,000 tons of CO<sub>2</sub> between 1995 and 2005. Measured against a baseline of projected sharp increases in VKT, TransMilenio received approval for carbon credits estimated to be roughly t300,000 by 2009. (Grueter, 2006) This shift occurred in the context of continuous economic growth. The TransMilenio project also yielded a highly favourable cost benefit analysis, enabling it to receive World Bank financing for Phase II. The notion that VKT cannot be reduced without a loss of consumer utility is a fallacy. Bogota data seems to indicate that for cities between 5 and 10 million roughly an 8 kilometre per year expansion of a full BRT system, combined with demand management and cycling promotion measures can lead to a stabilization of transit use at quite high levels.

11. Curitiba's BRT system has been in place the longest, but Curitiba only collected a reliable household OD survey in 2002, so comparable modal split data is not available. Extrapolating from transit system ridership data and car ownership statistics, a reasonable estimate is that Curitiba managed to maintain roughly stable transit ridership levels around 70% from the year the system was introduced in 1974 until the mid 1980s, with transit ridership falling in the late 1980s and early 1990s, then rising in the mid 1990s and falling again after 2000 to around 56% when measured in 2002 (excluding walking trips). Curitiba stopped expanding its BRT system after 1982, adding only 12 additional kilometres in 2000, though today significant system upgrading is under way. In this smaller city of about 1.7 million, about 3km per year of BRT system expansion was necessary to stabilize transit mode share.

12. Recent data from Sao Paulo, where 84 kilometres of lower level bus priority corridors were built between 1997 and 2007, and an integrated ticketing system with free transfers was introduced, modal share of private cars decreased from 47% to 42%, while bus mode share increased from 34% to 39%. (Metro-Pesquisa OD 1997, SPTrans, CET and Metro 2007 OD Survey). This resulted in about 17,000 tons of CO<sub>2</sub> reduction per kilometre of bus corridor, and once again showed that around 8km of bus corridor per year was required to roughly stabilize transit mode share.

13. Cities that invested in BRT outperformed cities that invested in Metros in maintaining transit mode share. Mexico City, for example, with the best metro system in Latin America, saw its public transit mode share drop from 80% to 72% from 1980 to 1990, despite huge investments into its metro system. Similar declines have occurred in most cities that have invested heavily in metro systems. The main reason

for this is that metros are expensive, and take a long time to build, so cities are rarely able to expand them at a pace that keeps pace with urban growth and suburbanization.

14. Not all BRT systems are alike. The first wave of BRT systems, built in Brazil in the 1980s, such as Sao Paulo, Belo Horizonte, Porto Alegre, and Goiania, also built central median busways, but these systems differed from Curitiba in significant ways. All of these systems were 'open' BRT systems, where existing buses and their existing routes were simply relocated into central median bus lanes. Because no new buses were procured, it was impossible to achieve the sort of metro-like bus-station interface that is required for high speed and performance. Furthermore, in other Brazilian cities, the BRT facilities only existed on the trunk corridors, but did not penetrate the city centres. Upon reaching the city centres, the buses entered into mixed traffic, and usually terminated at a depot. This had a lot to do with the way in which bus services had historically been allocated to different private operators. In many Brazilian cities, private operators were given control over different sections of the city's public transit market, divided up like slices of a pizza. This resulted in major difficulties for passengers which wanted to pass through the city centre. Discussions with Brazilian experts indicates that the main reason that full BRT of the type seen in Curitiba did not spread to other Brazilian cities was resistance on the part of the private bus companies to route restructuring and greater public sector control over their operations.

### **3. Congestion Charging**

15. The other recent success has been the growth of travel demand management measures that have reduced light vehicle travel. Most of these demand management measures reduce VKT while improving consumer utility. With a congestion charge, for example, some consumers will choose to shift from driving their car to taking a bus or staying home. They will lose some consumer utility as they are induced to shift to a less desirable mode of travel, or not to make the trip at all. However, their decision to not get on the road played a key role in reducing travel time for all the remaining motorists and bus passengers. The loss of consumer utility by the 'tolled off' is generally heavily outweighed by the additional consumer surplus enjoyed by the remaining traffic. For this reason, congestion charging often yields a highly positive cost benefit analysis, and hence an increase in consumer utility, despite a reduction in total VKT. Reducing VKT in this case yields an increase, rather than a reduction in consumer utility.

16. Congestion charging has been discussed as an option since a seminal economic article by Nobel Prize winning economist William Vickery in the 1950s. The first real world example emerged in Singapore in 1975. At that time, it was an 'area licensing scheme', (ALS) where motorists wishing to enter the central business district (CBD) had to have a special second license on their windshield. The license cost \$3 per day or \$60 per month. If they did not have this license, they had to pay a fine. It was enforced by police standing at gantries around the city centre. This very low-technology solution was relatively cheap to implement, and worked well. The system was expanded in 1990 to also include highway tolls.

17. The ALS was not exactly a congestion charge, because whether or not there was congestion you had to pay to enter the zone, and the charge did not vary during times of the day that are more congestion. In 1998, Singapore upgraded to an electronic road pricing (ERP) scheme. The ERP operated with a small electronic unit inside the vehicle. The car operator has to put cash on the payment unit in advance, create an account with the payment system manager, and pay in advance. Each time the vehicle passes a gantry, a charge is deducted from the cash card or unit. There were initially 33 gantries in 1998, most of these in a ring around the CBD, and by 2005 the number of gantry points expanded to 48, with a growing number of them on congested areas of major highways. In this way, the charge is set based on a rough approximation of actual congestion conditions on the road, so it is closer to a real congestion charge than the ALS. The system required a set of enforcement cameras that took a picture of any car that passed which did not have a valid electronic cash unit on board. These enforcement cameras were generally placed on the same gantries.

18. Before ALS in 1975, the share by public transport, which was buses at the time, to the CBD was 33%. As with Curitiba, it is surprising that no consistently measured and reliable modal split data is readily available from Singapore. There is so little consistency in the published modal split data from Singapore that to establish any reliable trend line is precarious. It appears that when the ALS was first introduced, only about 46% of trips to the CBD were by public transit, which at that time was only buses. By the time the MRT system became operational in 1988, modal split for transit had risen to over 65%, and by most accounts today it is still over 60%. Given that Singapore's per capita income is similar to that of the US, (\$29,600 compared to \$30,600 in 2000), this is a very impressive transit mode share. As with TransMilenio in Bogota, the impact on modal split and VKT was not only the result of the cordon toll or the road user charge, but resulted from a number of inter-related measures. Along with the ERP, Singapore implemented a lot of other measures, such as a Vehicle Quota System (VQS) requiring each car-owner to obtain a fixed number of 'Certificates of Entitlement', and pay a very high Annual Registration Fee (ARF). They also facilitated high density real estate development at transit hubs through land banking, zoning, and other measures. Attributing the modal shift impacts to each of these separate measures would require further research (Luk, 1999).

19. After Singapore, several Nordic cities introduced ring tolls around their CBDs, including Trondheim, Bergen, Oslo, and Riga. These ring tolls were a flat toll for entering the CBD on any of the major roads which did not vary with congestion and used simple toll gates. There were very few roads accessing the CBD and a couple were actually closed. These toll gates introduce travel delay, but they were required by law to accept cash payments. It succeeded in reducing traffic by 3% - 5%, and increased mass transit use by 6% - 9%. None of these systems vary charges according to congestion level or time of day.

20. London was the next major city to implement a cordon toll, in 2006. London reviewed the experiences in Singapore and the Nordic countries, and decided to try to reduce the system's operating costs by implementing an electronic cordon charge that relied only on an enforcement system. The idea was that if motorists had a legal responsibility to simply pay the £8 charge, if they paid the charge no account would need to be established for them. Only violators needed an account. No cash cards or cash points were necessary. Only the enforcement cameras on the gantries were necessary for identifying the license plates of violators. In Singapore, however, the cameras only needed to identify the license plates of violators. In London, they had to take a picture of all the license plates, to determine if the motorist had paid or not. Accounts only had to be established for violators, who were fined £80 if they did not pay by midnight, but the data collection and telecommunications costs of this, in addition to the back-office functions associated with the various payment options, ended up having operational costs even higher than in Singapore. This system also has the disadvantage of having limited flexibility in moving away from a flat cordon charge towards a system where pricing might vary with the time of day or the location.

21. The modal split impacts from 1996 until today in central London are reasonably complex. With the introduction of the £8 congestion charge, car trips dropped 30%, taxi trips increased by 20%, motorcycle trips increased by 20%, bike trips doubled, and bus trips increased by 15%. This led to a drop in CO<sub>2e</sub> emissions in the impact area, but did not result in any significant PM<sub>10</sub> benefits because buses and taxis in London run on diesel and generate higher levels of particulate emissions than the car trips they replaced. The travel-time savings benefit, which was about a 20% increase in bus speeds when the system first opened, has now largely been eroded as motorists are getting used to the higher fares (Kelly, F. 2008, from TfL).

22. Politically, the Phase I of the London system was successful, and Livingstone was initially re-elected. The expansion of the system had less demonstrable benefits, however. The charge was to be increased to £12 for a bigger zone. Livingstone lost his re-election bid, not primarily because of this but because of a general trend against Labour nationally and some unrelated scandals. The new conservative Mayor has promised to roll-back the congestion charge to the Phase I levels and zoning. Many are



speculating that given the high incomes in London, maintaining the modal shift benefits of the charge and a high level of service on the roadways might require continual and steep increases in the charge which might be deemed socially unacceptable.

23. In 2006, Stockholm opened a trial congestion charge. Their system used a cash box/cash card technology similar to that used in the Singapore ERP system. Stockholm like Singapore has very limited access points, and only 13 points control access to the CBD. Each of these was given a gantry with a cash point. The charge for entering the control zone varied during the time of day, from 0 to 20 SEK, but not by location. The London congestion charging scheme spends 55% of its total revenue on the operating and capital costs of the system, while the Stockholm and Singapore schemes spend only about 40% of their revenue on the capital cost and operating cost. (ECMT, 2006). Congestion dropped by 25% on the specific roads where the toll was applied, 30 – 50% less delay time in cues. It led to an estimated 10% - 14% reduction in CO<sub>2e</sub> emissions from the CBD and about 2% city wide.

24. Politically, the congestion charge was a trial and voters were allowed to retain or reject it in a referendum in 2006. The measure was approved by the local voters by a fairly narrow margin. The Social Democratic national government which implemented the charge lost the re-election campaign, but because of the referendum the new government decided to re-impose the system, and it was re-imposed permanently in 2007.

25. Most recently, in 2008, Milan introduced the Ecopass. Ecopass is a cordon tolling system that substantially varies the charge based on the emission category of the vehicle. Euro V vehicles pay a much lower daily fee than Euro I or II vehicles. Other than this, the system is similar to the London system, where motorists have to pay in advance and enforcement is handled by electronic license plate recognition cameras. The Milan Ecopass program reduced CO<sub>2e</sub> emissions by 7% throughout the day, increased transit ridership by 9.7%, and increased bus speeds by 12%. It seems to have been quite successful in reducing non-CO<sub>2</sub> emissions like PM<sub>10</sub> (14% daily) and Nitrogen Oxides (9% daily) (Milan, 2008).

26. The recent political success of congestion charging in London and Stockholm makes it likely that similar measures will ultimately be adopted in developing countries. Politically, it should be easier to implement in a developing country city where motorists are disproportionately from upper income-groups, but it would take a concerted public relations campaign. In Sao Paulo, former Mayor Martya Suplicy developed plans to implement a congestion charge during her last administration, but never announced them. Recently, in her re-election campaign against Mayor Kassab, she accused Kassab of having a secret plan to implement congestion charging as a way to win votes. (Kassab won the election).

27. In most cases, the congestion charges have been earmarked or otherwise applied to mass transit system improvements, though in the case of London, much of this benefit was lost by nearly equal cuts in national government support to the city of London for the same transit investments.

28. As with BRT, there are better and worse ways of implementing a congestion charge. The recent development of Geographic Positioning System(GPS)-based charging mechanisms will make it possible to much more carefully pinpoint charges to specific locations and times, improving the net consumer benefits achievable from charging schemes by as much as 50%, by better relating the charging to specific congestion points. GPS technology also promises the possibility of integrated charging systems for both road use and parking. There is thus a lot of scope for advocacy and technical assistance for cities interested in congestion charging, but a significant political initiative is required to make these innovations a reality. All of these measures would yield extremely large increases in consumer utility.

#### 4. Parking Reform

29. There is school of thought that market rate parking charging is a superior form of demand management to the congestion charge. Currently, most cities around the world significantly undercharge for on-street parking. At the same time, in many cities, local zoning ordinances require real-estate developers to build a certain minimum number of parking units into new buildings, and these minimums bear almost no relationship to what might be economically optimal, let alone what would be optimal from a CO<sub>2</sub>e mitigation perspective.

30. For on-street parking, transportation experts now know that it is optimal to have a parking occupancy rate of about 85%, so that a driver can readily find a parking spot. At higher occupancy rates, motorists are forced to waste time and fuel circling around looking for a free parking spot, generating needless CO<sub>2</sub> and other emissions. Undercharging for on street parking generally results in the most convenient spaces being occupied by the shopkeepers and employees themselves, forcing the multitude of customers to walk longer distances and circle for parking. If curbside charging were optimized, then the customers would be able to find a space, and the employees and shop owners would park farther away, reducing aggregate walking time significantly.

31. Parking is also critical because all trips must begin with a walking trip, and because walking is the slowest form of travel, the farther you have to walk to reach that mode, the longer your travel time. According to Knoflacher (2006), if you can park directly in front of your house and your office, this is always going to be faster than walking to the nearest bus stop and waiting. Only when you have to walk farther to get your car than you do to take the bus or your bike will these alternative modes become faster door-to-door. On-road congestion charging does nothing to change this dynamic.

32. Parking reform is also a better access point if the objective is to reclaim scarce curb space for cycling facilities, expanded walkways, or urban street furniture.

33. The CO<sub>2</sub> impacts of optimizing on street parking charges are fairly complex to estimate. While the net CO<sub>2</sub>e impact of optimizing on-street parking charges is no doubt positive, two competing factors need to be measured. On the one hand, if parking is optimized from a pricing perspective, then the travel time cost of a car trip relative to a transit trip will actually drop. Higher turnover rates will reduce cruising kilometres, but also might induce some modal shift towards private cars because while parking has become more expensive, it has also become much more convenient. Studies indicate that higher charges with higher rotation rates actually increase car trips to shops on commercial locations. (Shoup, 2007)

34. From a CO<sub>2</sub>e perspective, off-street parking regulation is perhaps even more important than on-street parking. One of the best ways to ensure that rapidly urbanizing areas do not urbanize in an auto-dependent manner, is to restrict the amount of off-street parking included in new developments. Historically, US zoning laws have tended to require new developments to build very high levels of parking per rental unit based on observed statistical averages for specific land uses. These averages are driven by suburban developments, where questions of transit accessibility have not been factored in. As a result, in the US, transit accessible dense urban locations sometimes have similar parking requirements to low-density suburban areas, forcing developers to develop even more parking than they would from a purely commercial perspective. Though Europe has for a longer time had both parking minimums and also parking maximums in city centres, the US is far behind in this, and many developing countries have followed in the US lead, though the minimums tend to be lower than in the US. A recent study of the CO<sub>2</sub> impact of these parking minimums on the outer boroughs of New York City estimated that they will generate an additional 400,000 MT of CO<sub>2</sub>e per year (Weinberger *et al.*, 2008).

35. The technology exists to actually monitor the occupancy of on street parking places within a zone and adjust the parking fees automatically, though most applications of this technology have yet to be implemented.

36. The CO<sub>2</sub>e impact also greatly depends on how the parking revenue is spent. If the money is spent building additional off-street parking garages, then the CO<sub>2</sub> impacts of increasing parking fees could be quite negative. However, examples like Pasadena, where on-street parking revenues have been used to improve public space, could have extremely positive CO<sub>2</sub> impacts.

37. Most interesting in parking is finding ways to unlock the innovative and logistical power of the private sector to optimize parking systems while generating revenues for climate friendly solutions. In a few cases, private companies like Central Parking are being contracted out by cities to manage on-street parking, optimize parking fees, and to also manage the security and maintenance of public space in the zone. Interviews with public officials indicate that the main problem with this solution is that the parking companies do not necessarily offer the best quality service or the best deal in the non-parking services. There is nonetheless enormous scope for governments to use clever contracting processes to attract consortiums capable of optimizing both functions, or to simply have parking management revenues earmarked to the city and then using the revenues for climate friendly transport interventions through standard municipal competitive tendering.

38. Documenting global, particularly European best practice in parking policy is a critical next step, and this must include best practice in terms of the contract structures and administrative structures.

## **5. Traffic Cells**

39. There is a school of thought that traffic cells are a better way to manage traffic than through charging. There are often many zones in a city which are important destinations, generally the central business district, but also entertainment districts, residential districts, etc. It is generally optimal to have major transportation links serving long distance trips designed for higher speeds. Higher roadway speeds tend to have an adverse impact on the quality of street life and in the adjacent buildings, so generally it is best not to locate these longer distance transport links in the middle of important destination zones. Destination zones like commercial streets or residential streets, by contrast, need to be designed to accommodate highly complex largely non-motorized movements of extremely short distances.

40. A simple strategy for improving the quality of life and the air quality in such 'destination' zones is to make it impossible, via the selective use of one-way streets or the severance of through streets, to pass *through* the zone by private motor vehicle. This will force private vehicular traffic with destinations outside the zone onto peripheral streets, significantly reducing traffic inside the zone. If such a strategy is employed only for private motorists, while transit vehicles and bicycles are allowed to pass directly through the zone, this can significantly increase the travel time advantages of public transit and cycling vis-a-vis alternative modes to strategic locations.

41. Oxford, England and Stockholm are the best known examples of traffic cells linked with direct transit services, with very significant improvements in bus ridership. Paris' Quartiers Verts, or green quarters, also partially function as traffic cells. Such a strategy is often employed in European cities with historical centres.

42. Unfortunately, many developing country cities are still busy pushing high speed motorways through their historical centres, following the inglorious example of the US during the 1950s and 1960s. Sao Paulo is an interesting example of a reverse traffic cell, where a high-speed motorway passed directly under the CBD, while bus passengers are deposited in unsavoury bus terminals on the periphery of the

CBD and forced to walk up steep hills past abandoned buildings, informal vendors and vagrants to reach their downtown offices.

43. Spreading the practice of traffic cells to the developing world would be an excellent service that might also help preserve some important historical cities, many of which are facing significant blight.

## **6. Alternative License Plate, HOV and HOT schemes**

44. Mexico City, Bogota, and Sao Paulo all implemented traffic restrictions where vehicles with odd or even license plates (Mexico City and Sao Paulo) or license plates ending in a specific number (Bogota) were not allowed to enter the city center on certain days. These programs have led to a one-time reduction in motor vehicle trips into the central business district, with significant short-term reductions in traffic, particularly in lower-income cities with fairly limited vehicle ownership. The problem with all of these methods is that over time they lose their effectiveness. In Sao Paulo, the traffic levels under this *rodizio* scheme returned to original levels within about six years. In Bogota and Mexico City, the same phenomenon has occurred. The problem is simple: people just buy more cars to get around the ban, so they usually keep a very old and polluting car with the alternative license plate for use on those days when the ban is in effect. With motor vehicle costs falling in relative terms over time and incomes rising, such schemes are not an ideal solution, and they are politically unpopular. It is probably fairer to the public to allow them to simply pay a fee when they need to enter the city center, than restricting access to the city center to those people wealthy enough to afford multiple vehicles, and less likely to encourage the use of older, more polluting vehicles.

45. Jakarta has a variation of this called a three-in-one scheme, where only vehicles with three or more passengers are allowed to enter the CBD. This program has worked somewhat, leading to a triple peak in the traffic, one before the 3 in 1 comes into effect, one at the natural peak, and one after it is no longer in effect. It also spawned a market for 'jockeys', young boys who will get in your car to create the necessary 3 passengers.

46. HOV lanes are of course used all over the world for encouraging people to share vehicles. These have been somewhat effective, mostly on highways, and work well in combination with express bus services that use highways for part of their route. There has recently been some experience of combining such special highway lanes with a tolling option, or what is called 'HOT' lanes, "High Occupancy or Toll". Minnesota, Texas, and Colorado have all opened HOT lanes. HOT lanes are a particularly important strategy for the US and possibly Europe where it is rare to find corridors where public transit demand is above 2000 pphpd. In many auto-dependent cities in the US there are few existing corridors with transit demand levels high enough to justify converting an existing lane to BRT from a pure efficiency point of view. In these conditions, it is important to allow other types of vehicles to use the same infrastructure, whether it is taxis, trucks, emergency vehicles, or car pools. The important thing is that the regulatory structure optimizes the use of the lane so that it does not congest and also minimizes congestion in the remaining vehicle lanes.

## **7. Blocking or Removing Highways**

47. A growing number of cities are actually removing highways or refusing to build new highways. The most famous case is the major highway over downtown Seoul that was torn down, and the underground river revitalized, between 2002 and 2005. The highway was so blighting that the economic effects of the road itself were far more negative than the economic benefits of serving the traffic. Seoul upgraded its bus system to a light BRT system serving a parallel corridor, and the result was a huge shift to mass transit. Milwaukee, Wisconsin has also torn down some highways, and San Francisco never rebuilt both the Central Freeway and the Embarcadero Freeways after the 1989 Loma Prieta earthquake.

48. In some cases, older elevated roads serve no important traffic function, yet severely blight neighborhoods. Such roads can often be removed. The Sheridan Expressway in New York is one such road that may be dismantled.

## **8. Downgrading Roads, One Way and Two Way Roads, and Area Traffic Control Systems**

49. The leading traffic system planners in the 1960s and 1970s developed several techniques to increase traffic speeds and surface street capacity. These techniques were successful at increasing speeds, but they often tended to increase speeds for private vehicles at the expense of transit speeds, and the directness of cycling and walking routes. The increased speeds also tended to lead to increased roadway fatalities and deteriorate the quality of life in city centres. As such, these measures which were intended to revitalize urban areas often had precisely the opposite impact, turning once vital neighborhoods into high speed motorways.

50. In the 1960s and 1970s, many two-way urban boulevards were turned into high-speed one-way urban highways. One-way streets simplify traffic signals from multi-phase to two-phase, reducing delay. They also made possible the introduction of 'greenwaving', using area traffic control systems which greatly expanded the speed and capacity of urban streets.

51. In cities with a dense street grid, these measures are probably nearly optimal from a capacity and flow perspective. However, when these one-way street measures are applied to cities in developing countries with extremely limited street grids, they often greatly increased the indirectness of routes. A study of the one-way street system in Surabaya, Indonesia by the World Bank concluded that it created an additional 7000km of needless additional vehicular traffic each day. It also increased the indirectness of route for cyclists and cycle rickshaws from a factor of about 2 to a factor of 4, rising as high as a factor of 9 in some cases (point-to-point distances allowed by the street network compared to the distance as the crow flies). Downtown Sao Paulo, a modernist traffic planners dream, transformed a ring of tree-lined boulevards into 'the rodizio', a ring of high-speed one-way roads that circle and blight the city centre. In cutting edge cities like Paris, these one-way highways are being converted back into two-way boulevards. As part of Paris' modernization program it completely redesigned the Boulevard Magenta, changing it from a high-speed road to a boulevard, for example.

## **9. Cycling and Mode Share**

52. Bike use in Copenhagen was about 1/3 of car use in 1970, and today bike use at 36% mode share is greater than car use. A similar phenomenon of increased bicycle use is observable in several Dutch and German cities as well. This resulted from a major shift in policy to promote cycling since the 1970s. New York City has seen a near tripling in bike trips since 2000, largely contemporaneous with the dramatic expansion of cycling facilities under the Bloomberg administration. Paris, with the introduction of the Velib bike sharing program, and the construction of new cycling facilities and slow speed zones, has doubled cycling in the last five years.

53. In the developing world, from the 1970s until the 1990s, Chinese cities were the most cycling-friendly cities in the world, with some cities like Tianjin having over 60% of their trips by bicycle, and even heavily motorized cities like Guangzhou having 25% bike mode share into the 1990s. Highway interchanges featured fully grade segregated cycling facilities, commercial areas virtually all had secure guarded and extremely inexpensive bicycle parking. In the 1980s, as families became richer, many people switched from overcrowded buses and walking to cycling, to the point where many roads were congested with bicycles. In the 1990s, national policy turned against the bicycle to encourage both increased bus ridership and the consumption of automobiles and motorcycles. The East Coast cities which hosted automobile manufacturing facilities were the most aggressive in tearing out their cycling facilities, while

Western cities, without auto manufacturing, such as Chengdu, tended to retain their cycling infrastructure. In Guangzhou, bike use dropped from something like 26% in 1990 to 8% by 2005, (Guangzhou 2005 Household OD Survey) while in Chengdu and other western cities it stabilized around 30% to 40%. This drop was actually reflected in targets embedded in the municipal master plans.

54. Somewhere around 2005, a growing number of cities started to realize that this policy was causing a lot of traffic congestion and air pollution. Particularly in the south, motorcycle use was exploding with adverse social consequences, such as increased motorcycle-based crime, but also pollution and accidents. This led to a backlash against motorcycles, and a growing tolerance for bicycles again as of today. After a decade of tearing out bike lanes in Shanghai, Guangzhou, and other East Coast cities, bicycle use is recovering and new cycling facilities are being built, while motorbikes are being systematically banned in a growing number of cities.

55. In India, bicycle use varies greatly from city to city. Bike infrastructure in India is decades behind China, and virtually non-existent, though bike mode share was pretty high, around 9% in Delhi in the early 1990s. Bike mode share has been dropping fast in India since. The new BRT systems being designed in Delhi and Ahmedabad both have good cycling facilities designed into them, and their success or failure is tied to the fate of the BRT movement. Cycle rickshaws still constitute an important part of the commercial traffic in some secondary cities and in parts of Delhi.

56. In Latin America, bike mode shares had generally followed US trends, slipping below 1% of trips in major metropolitan areas. Bogota, under the leadership of Mayor Penalosa, did an about-face. The construction of some 300km of Grade A cycling facilities brought bike mode share up to about 4%. Rio de Janeiro also invested heavily in cycling facilities, and saw their bike mode share increase similarly, from about 0.5% to about 4%. Curiously, bike mode share in Curitiba also increased to nearly 5%, though the cycle lanes that they built were nearly useless and most cyclists are simply using normal streets or operating inside the bus lanes. Under Mayor Ebrard, Mexico City has recently launched a significant increase in Grade A Cycling facilities, with 50km promised this year. Sao Paulo, though quite hilly, has also initiated pilot bikeway schemes. Other cities are rapidly following in their footsteps, with Guadalajara and Puebla developing the most ambitious cycling network plans. Santiago de Chile also built a pilot bike network in three of the downtown municipalities, and this small network is being expanded. Another 20 cities in the World Bank's Latin American GEF portfolio for Brazil, Argentina, and Mexico include some form of bike infrastructure improvements.

## **10. Bike Parking**

57. For bike parking, Japan has state of the art parking facilities at many major train stations, China has built some good functional facilities but it could do a lot more. The Netherlands has great facilities at the rail stations. Germany has some great bike parking facilities also. Bogota's TransMilenio Phase II has a great free bike parking facility that is included in the price of the ticket. The Bike Station group in Long Beach has built some very nice bike parking, rental and retail facilities in downtown Long Beach, in Santa Barbara, and about a dozen other cities, with a new facility at Union Station in Washington in the works. They benefit from high-class architecture, and a sort of branding that makes the model attractive. There is no reason why this bike station effort could not be commercialized, however, and turned into a transitional phase for a broader bike sharing program.

58. At a major transit hub, like a rail station, maybe you need a Type I facility, a huge multi-service facility which provides all bike-related amenities, from bike parking retail sales, daily rentals, repairs, showers, lockers, maybe even books and information about cycling and transportation, maps, coffee, all the amenities. Maybe this Type I facility can also be a place to get a shared bike. This is the sort of thing being planned at Union Station, and that exists at some rail station bike parking facilities in Europe, though

interestingly in Washington DC, there is no relation to this facility and the bike sharing program. Why not? These are not needed everywhere, only in very high volume destinations.

59. Phase II facilities might only have guarded parking for private bikes and shared bikes, some minor repairs, and minor retail. Phase III might have only parking for private and shared bikes. Phase IV maybe only a bike rack. If a person can rent and return a bike at any Phase I or Phase II Bike Station, then you already have a mini bike sharing network. It was irritating to me that in Holland you have to return your rental bike to the same train station it was rented. By franchising the bike stations, you could return them to any facility, with much greater convenience. This then moves on to bike sharing.

## **11. Bike Sharing and Car Sharing**

60. Paris Velib has revolutionized the prospects of bike sharing systems. Starting in the late 1990s, there were credit-card based bike sharing systems in place in a dozen or so European cities, including Rennes, Amsterdam, Vienna, Lyons, Oslo, Brussels, Stockholm, Helsinki, and Barcelona, but they were small in scale. With bike sharing, scale matters a lot. In Paris, bicycle mode share increased by only 48% from a very low baseline from 2001 to 2006, despite a huge investment in good cycling facilities. They did surveys to determine the obstacles to bike use, and bike parking both at home and the office was the main problem. The bike sharing system overcomes this problem, because they are parked on the street.

61. Velib opened in 2007 with 10,648 bicycles and 750 parking stations, and was set to have 20,600 bicycles and 1451 stations by the end of 2007. There is a parking station every 300 meters in the center of Paris. The system attracted over 1 million rides in 18 days, and it's getting nearly 100,000 rides per day, some percentage of which were previously motor vehicle trips.

62. There is no question that the link between on street advertising and bike sharing is part of what made this a success. A big corporation like DeCaux or Clear Channel would never have been bothered with bike sharing if there was not some lucrative contract associated with it. Because DeCaux and Clear Channel are corporations, they are now promoting bike sharing all over the world, and this is a dynamism that a NGO can rarely match. Buenos Aires, Sao Paulo, Mexico City, are all talking about bike sharing programs, and these are just the ones we know about.

63. A few things about bike sharing can be improved upon, and questions remain. First, the system is more expensive to operate than it needs to be, because they guessed wrong about the number of parking spaces they needed and the fleet size they needed at each parking stand. Some places are oversubscribed, some undersubscribed, and to compensate the company needs to shift bikes around, which costs a lot and generates some CO<sub>2</sub>. Optimizing this from the beginning is a modeling exercise that someone should work on, and I am sure it could cut the operating costs a lot.

64. The contract structures are also important. If one company comes in with a contract in Zone I, expanding the system to a wider zone with a compatible technology is difficult to do without violating competitive tendering. Either when the contract is initially tendered, the winning firm should win the rights to a very large area, even if not implemented all at once, or else the contract needs to stipulate that whatever payment system is put into place must be open to expansion and use by other firms with compatible technology.

65. Other questions for bike sharing include how these facilities relate to other bike rental and sales, and why it needs to be a DeCaux or Clear Channel to implement them. Currently Paris bike sharing only has parking for Velib bikes, which means that normal cyclists have to find somewhere else to park, but there is no reason why some normal private bike parking could not be provided at the same time. Velib is also oriented to short-term rentals, but sometimes long-term rentals are what you want. Interaction between

the Bike Share and the Bike Station concept would make for some interesting new possibilities, as discussed above.

## **12. Modernizing the Human-Powered Vehicle itself**

66. In developed countries, the bicycle and human-powered vehicle supply itself is not really an obstacle to bike use. People are rich, and the cost of the bike relative to incomes is so low that one can buy virtually any type of bike reasonably easily in the developed world.

67. In the developing world, however, the situation is different. Bicycle markets in India are heavily protected, monopolistic, and resistant to innovation, and consumers are often very poor and highly sensitive to price and quality. In Africa users are very poor, many markets are protected by tariff barriers, and lack of any domestic supply contributes to high costs.

68. ITDP had a major project to modernize the Indian cycle rickshaw, and the new design took off, selling over 300,000 units, and winning as many as 15% of their customers from previously motorized modes. This project was a reasonably big success in the field, but the process of innovation stopped when the new design was accepted. What is needed is a commercially driven process of continual innovation in human-powered vehicle technology, and this is difficult to induce because the profit margins are too low to attract innovative entrepreneurs or for sexy first time products to yield enough of a premium to encourage innovation. There are also monopolistic conditions in the vehicle supply sector. Aggressive international bike firms in partnership with new entrepreneurs in emerging markets, if they were to partner, could greatly improve the quality and reduce the cost of good quality non-motorized vehicles, and become a force for continual innovation.

69. ITDP's California Bike project in Africa succeeded in demonstrating to South African bike companies that a market exists for better quality bikes in Africa, selling over 7000 lower cost, higher quality bikes. The brand name is going to be taken over by ProBike and hopefully become a Pan Africa franchise.

## **13. Transit-Oriented Development, and Urban Revitalization**

70. The simple goal of encouraging high-density development along high-capacity transportation corridors, and low-density along low-capacity transportation corridors, seems trivial theoretically, but politically it is exceedingly rare. The problem looks completely different in different contexts, and therefore has to be approached differently.

71. In the US, the decline of the central city and the resulting automobile-based transportation system resulted from a combination of push and pull factors, varying from the structure of housing finance, a history of racism, subsidization of private car travel, weak municipal control over criminal activity, and reasonably standard problems of old building stock, like old machinery, developed under different economic conditions, being obsolete to the economic needs of the modern economy, and the relative costs of facilitating this transition.

72. The US has made enormous strides in the last few decades slowing down and reversing the process of central city decline, though the process is highly heterogeneous. New York City has added population since 1980, and has finally reached an all time high, after several decades of losing population after World War II. The density of the city, and transit ridership, are growing rapidly and this process is projected to accelerate. There were many factors behind this turnaround, some of them macroeconomic, but some of them with relevance to an action agenda.



73. Large areas of New York were badly blighted, with disinvestment and criminal activity. Turning these areas around required not only transport system investments (the NYC MTA received a massive investment in infrastructure renewal starting in the 1980s that saved the system) but also the creation of a variety of public-private partnerships for assembling and redeveloping land (the Empire State Development Corporation), infrastructure modernization and investment, and pro-actively marketing these areas of the city and attracting major investors. In addition, Business Improvement districts were created, which did a lot to bring activities to the areas, improve street cleaning, security, installation and maintenance of high quality street furniture, and promotional activities.

74. These interventions are now well established in the US and Europe, but virtually unknown even in the better developed parts of the developing world.

75. In post-socialist Central and Eastern Europe, the dynamics of urban restructuring were fundamentally different. Huge international developers were desperate to invest in the central cities of Central Europe, but were prevented from doing so largely by regulatory barriers intended to protect indigenous capital, and by a complex maze of property title complications related to restitution claims from pre-Socialist times, to corrupt and opaque land privatization processes after the transition, and a host of bureaucratic regulatory problems that served no particular purpose other than to drive any developer to the suburbs just to escape the regulatory tangle. This mess was as true for brownfields as blighted historical neighborhoods as it was for transit accessible old railway yards. ITDP, together with former real estate developers, US experts from the APA and brownfield experts from the EPA, helped the Czech national government and several municipalities initiate brownfield revitalization programs to overcome these barriers. The lessons learned are fascinating but somewhat specific to transitional economies that have gone through a process of de-militarization and de-industrialization. We succeeded in facilitating the redevelopment of several brownfield sites in the Czech Republic which established a valuable precedent. In Budapest, ITDP's partner organization CAAG worked with the 9<sup>th</sup> District to do some extremely innovative urban revitalization, but this was only possible because the properties had remained in the hands of the District government. ITDP Europe has excellent information on this which could be very valuably extended to Eastern European and municipalities in former Soviet states, where similar issues are frequently confronted.

76. ITDP started urban revitalization programs in Sao Paulo and Mexico City, where the problem of city center blight was emerging as well, with a dynamic somewhat different than in the US, but with some similar characteristics. In both Mexico City and Sao Paulo, the government had yet to develop the sort of legal mechanisms, let alone the institutions required, for the government to seize derelict properties (even if they are in tax arrears), assemble the properties, improve the infrastructure, and attract investors. In the Centro Historico of Mexico City, there was the additional confusion of the properties being historic landmarks enmeshed in a needlessly restrictive historical preservation legislation. As a result of the restrictions on private investment, valuable historical properties are being allowed to collapse and be used as surface parking. Business Improvement Districts have been discussed, but are generally viewed with suspicion. These problems were also exacerbated by poor parking regulation, criminality, and other problems.

77. Convincing governments of the need for such institutions, getting them to focus on a specific revitalization strategy, and giving them the legal powers to bring about intelligent change in urban form, is an enormously complex task, but an important one if the city centers are not to be allowed to decay.

78. In China, most of the land remains indirectly or directly government property, so it has been extremely easy to increase the density of urban development. Any time a mass transit system is built, or even a road widened and a bus service added, the properties along the infrastructure tend to be torn down and replaced by high-rise buildings by private developers. Transit-adjacent development is an automatic

process in China, and there is no real ‘urban blight’ in the sense it is meant in the US. However, much of this high-density development is not well-designed to encourage a pedestrian-friendly environment or a smooth interaction with surrounding mass transit systems. Convincing Chinese developers to implement more humane and pedestrian-friendly design could help a lot.

#### **14. Freight and logistics and their relationship to changes in retailing**

79. In many parts of the developed world, particularly in Europe, emissions from private passenger vehicles are stabilizing, while emissions in the freight sector are growing rapidly. It is not yet well known the impact that the transition to internet-based commerce is going to have on transportation systems, but it is likely that it can help households live car-free (virtually everything can be delivered to the door), while increasing the amount of trips by delivery vehicles.

80. It is not yet known the impact of the replacement of corner retail establishments with big box retail chains, but the following is known based on past ITDP research. Firms like Ikea and WalMart claim that their freight systems greatly rationalize trucking, which is a key to their competitiveness, and which they claim reduces CO<sub>2</sub> emissions. This is entirely possible, though one must also look at what the introduction of this big box retail store does to the travel patterns of their customers, and this entirely depends on where these facilities are located.

81. In China, Wal-Mart is as frequently located on a pedestrian mall in the inner city as it is on an orbital motorway. Such a big box store probably has fairly efficient internal freight logistics, and as the customers tend to arrive using mass transit or bicycle, there is nothing particularly wrong with this model. In Latin America, it is likely to be located on a highway, but likely to serve primarily residents from smaller towns and rural areas who may actually be traveling less far than they used to. In Central Europe, it could be in the city center or on a major arterial or transit hub, or on an outer ring road. The more transit-friendly the location, the more likely the consumers will generate less emissions, and we will assume the trucking is reasonably efficient. In the US, these facilities tend to be huge generators of traffic, and this traffic-generation is probably greater than the benefits gained from efficient internal freight logistics.

82. In conclusion, these big box retail chains are sensitive to government policy. If they locate in a downtown area in the US or Central Europe, and that downtown area allows them to build a massive 2000 unit parking garage, the impact of the development on local emissions will be very bad. If the government encourages them to locate in transit accessible locations, it will be less bad. In short, the main problem lies with the impact on consumer travel behavior more than the logistics of freight itself.

83. In Europe, there is also a problem that a lot of the railways are publicly owned, and many of them are not particularly well-managed. In Central Europe, they often serve as slush funds for certain political parties, are very subject to political manipulation, and hence they are often not terribly competitive. In the US, the freight railways are largely private, and they have managed to maintain mode share in heavy long-distance freight distribution. Fixing this problem in Europe, encouraging rail freight and combined transport, is bound up in the problems of privatizing the state railways, which is a messy and complicated business.

84. Certainly, one thing that will help is fully internalizing the costs that trucking freight imposes on the road network. Trucks are responsible for a disproportionate level of wear and tear on the roads, and road user fees are rarely structured in a way which fully reflects this. It was a long political battle to even allow governments in Europe to charge through trucks fees for road damages and environmental problems that they caused, because the EU blocked this on the grounds of barriers to free trade, and in fact many were proposed in ways that were prejudicial to foreign trucks. Recent revisions in the EU EuroVignete system I believe allow for eco-taxation of trucking under certain circumstances.

85. There are also some national road user fees imposed on trucking in Germany and under discussion in the Netherlands which should help end the pricing distortions that favor trucking over freight rail. Germany charges trucks a fee for trucks over 12 tons on 12,000km of its autobahn system. The system uses 500,000 on board GPS units to track and bill the trucking companies.

## **15. Conclusion**

86. From a greenhouse gas point of view, there are numerous chances for implementing measures that both reduce VKT and CO<sub>2</sub>e emissions, while yielding net increases in consumer utility. These interventions will need to be massively scaled-up, particularly in the cities of the rapidly urbanizing parts of the world, like China and India, before their urban transportation systems are locked into the sort of auto-dominated urban forms that have driven up transport sector CO<sub>2</sub>e emissions in most OECD countries.

87. Vehicles and fuels are manufactured by a relatively limited number of large multinational firms that are sensitive to regulatory pressure to clean-up their fuels and improve the efficiency of their engines. As private firms, they are already partially responsive to fuel prices and consumer pressure, and their engines and fuels are reasonably well optimized for their customers' needs. For improvements in this sector, national government-based regulatory strategies may yield important CO<sub>2</sub>e reductions. But they might also fail, if low-cost but very dirty fuels emerge or these corporations are powerful enough to resist regulatory pressures.

88. Bringing about reductions in CO<sub>2</sub>e emissions through reductions in VKT, by contrast, has to be done through a fundamentally different strategy. Fortunately or unfortunately, current transportation infrastructure investments and the allocation of road space is far from what would be optimal from an economic perspective. These decisions are made largely by government bureaucracies, responding largely to political pressure or simply bureaucratic inertia. As such, there is a wide range of measures that could be implemented which would both dramatically increase consumer utility and yield a very positive economic rate of return, while simultaneously reducing VKT and CO<sub>2</sub>e. It is disturbing that this area, so ripe with potential, has been until recently largely ignored by the US and other governments.

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