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Opinion

Planning for economic and environmental resilience

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ABSTRACT

Climate protection will require major reductions in GHG emissions from all sectors of the economy, including the transportation sector. Slowing growth in vehicle miles traveled (VMT) will be necessary for reducing transportation GHG emissions, even with major breakthroughs in vehicle technologies and low-carbon fuels (Winkelman et al., 2009). The Center for Clean Air Policy (CCAP) supports market-based policy approaches that minimize costs and maximize benefits. Our research indicates that significant GHG reductions can be achieved through smart growth and travel efficiency measures that increase accessibility, improve travel choices and make optimum use of existing infrastructure. Moreover, we find such measures can deliver compelling economic benefits, including avoided infrastructure costs, leveraged private investment, increased local tax revenues and consumer vehicle ownership and operating cost savings (Winkelman et al., 2009).

As a society, what we build – where and how – has a tremendous impact on our carbon footprint, from building design to transportation infrastructure and land-use patterns. The empirical and modeling evidence is clear – people drive less in locations with efficient land use patterns, high quality travel choices and reinforcing policies and incentives (Ewing et al., 2008). It is also clear that there is growing and unmet market demand for walkable communities, reinforced by demographic shifts and higher fuel prices (Leinberger, 2006; Nelson, 2007). Transportation policy in the United States must rise to meet this demand for more travel choices and more livable communities.

The academic, ideological and political debates about the level of GHG reductions and penetration rates that can or should be achieved via smart growth and pricing on the one hand, or measures such as 'eco-driving' and signal optimization on the other, have served their purpose: we know which policies are 'directionally correct' – policies that reduce GHG emissions even though we may not know the scope of those reductions. Now is the time to implement directionally correct policies, assess what works best where, and refine policy based on the results. It is a framework that CCAP calls "Do. Measure. Learn."

The Federal government is poised to spend $500 billion on transportation (Committee on Transportation and Infrastructure, 2009). CCAP encourages Congress to "Ask the Climate Question" – will our transportation investments help reduce GHG emissions or exacerbate the problem? Will they help increase our resilience to climate change impacts or increase our vulnerability? And, while we're at it, will our investment foster energy security, livable communities and a vibrant economy? Federal transportation and climate policies should empower communities to implement locally-determined travel efficiency solutions by providing appropriate funding, tools and technical support.

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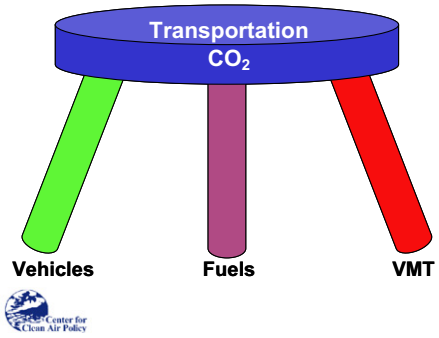
1. Transportation GHG emissions and climate change policy

There is a growing consensus that industrialized countries, such as the United States, will need to reduce their GHG emissions by 60–80% below 1990 levels by 2050 (European Commission, 2007; Höhne et al., 2007). Meeting this goal will require emissions reductions from all sectors of the economy. Nearly one-third of GHG emissions in the US come from the transportation sector, making it the nation's largest end-use source of emissions (Energy Information Administration, 2009b). Moreover, transportation has been the fastest growing source of US emissions, accounting for almost half of the net increase in total US emissions between 1990 and 2007 (Energy Information Administration, 2007).

Transportation GHG emissions are a result of three factors represented by CCAP's well known 'three-legged stool' – vehicle fuel efficiency, the lifecycle GHG emissions of fuels and how much people drive (as measured in VMT). Some stakeholders have offered a 'fourth leg' focused on system efficiency and other 'legs' for construction, operations, maintenance and construction (AASHTO; Burbank, 2009). This paper focuses on the third leg – travel demand – which also includes some system efficiency elements.



Congress has recognized the important role of transportation in contributing to GHG emissions by legislating vehicle efficiency and fuel carbon intensity reductions. However, Congress has not addressed the other leg of the stool – how much people drive. In fact, existing US transportation laws encourage more driving, increased transportation emissions and undercut our ability to reduce GHG emissions (LaHood, 2009; Good Jobs First). Between 1977 and 2007, VMT grew by 107% – even though US population increased only 37% (FHWA, 2007). In the last few years, however, Americans have actually started to drive less: for the first time since the oil shocks of the 1970s, the number of miles we drive began to flatten in 2004, and actually decreased in 2007 (Puentes and Adie, 2008). From January 2002 to January 2008 the real price of gasoline more than doubled – the sharpest rise in almost 50 years – which likely played a major role in flattening VMT growth (Fig. 1). VMT has even continued to decline after fuel prices plummeted in late 2008, which CCAP believes is due to the deep economic recession.

1.1. What will happen if transportation does not achieve significant GHG reductions?

The latest national forecast from the Energy Information Administration (EIA) projects a 15% increase in per-capita VMT for light duty vehicles (LDV) from 2009 through 2030 (Energy Information Administration, 2009a). CCAP considered a scenario in which VMT per capita continues to grow at that rate, while assuming major progress on the first two legs of the stool: vehicle technology and fuel GHG intensity.[1] Based on these assumptions, CCAP calculates that GHG emissions from passenger vehicles would be 14% below 1990 levels. However, to be on track to economy-wide GHG levels of 60–80% below 1990 levels by 2050, GHG levels must be 20–47% below 1990 levels in 2030 (Fig. 2). If VMT grows at this assumed rate, cuts in passenger vehicle GHG emissions will not be as deep as required to meet economy-wide GHG goals, then despite significant advances in vehicles and fuels. Thus, either other sectors will need to make deeper cuts in GHGs, or we will fail to meet economy-wide GHG goals.

This target level explicitly assumes proportionate reductions from all sectors. From a cost-effectiveness standpoint, the sectors with the cheapest reductions would achieve greater relative reductions – this is the point of establishing a "cap" on emissions rather than specifying emissions requirements for each sector. However, given the deep reductions required, and the lack of cost-effective reductions consistent with the magnitude needed, major efforts will be required from all sectors of the economy – including transportation. And, as we document below, smart growth and travel efficiency measures can yield significant GHG savings at a net cost savings.

CCAP concludes that if we fail to pursue cost-effective GHG reductions from the transportation sector, other sectors of the economy will need to implement more expensive solutions, ultimately costing the public more money. Even in the

[1] Key assumptions include: VMT growth rate, 2005–2030: 1.4%; population growth rate, 2005–2030: 0.8%; new LDV fuel economy in 2030: 55 mpg; LDV on-road fleet fuel economy in 2030: 35 mpg; Fuel GHG intensity in 2030 vs. 2005: −15%; 1990 LDV GHG levels vs. 2005: −20%.

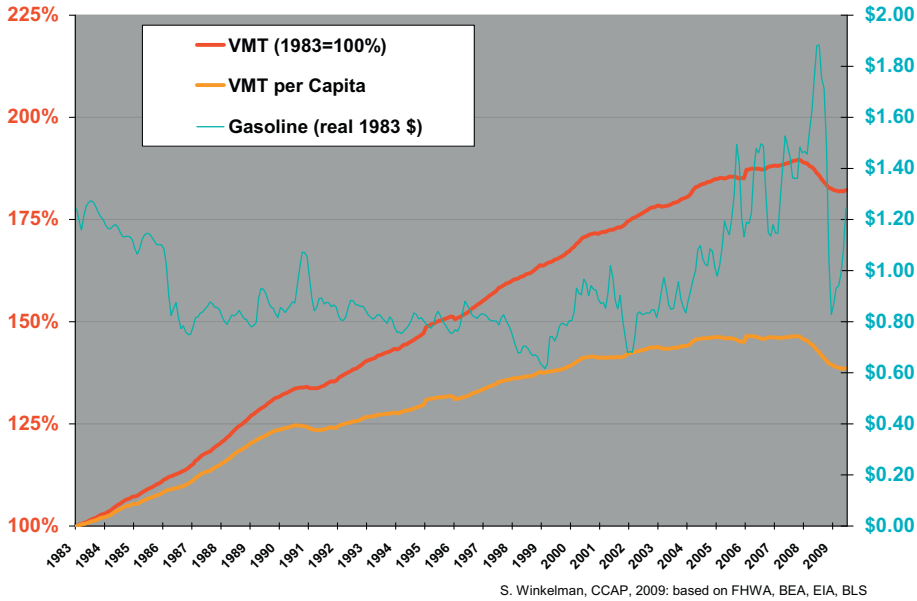


Fig. 1. VMT and Gasoline Prices 1983–2009. Source of VMT data: "FHWA Traffic Volume Trends – June 2009" (Fig. 1 – Moving 12-Month Total on All Highways); fuel price data: EIA, "August 2009 Monthly Energy Review," (Table 9.4.). Motor gasoline retail prices, US city average; CPI data: BLS, "Consumer Price Index - All Urban Consumers: Series Id: CUUR0000SA0, Not Seasonally Adjusted, US city average, All items"; population: www.uscensus.gov.

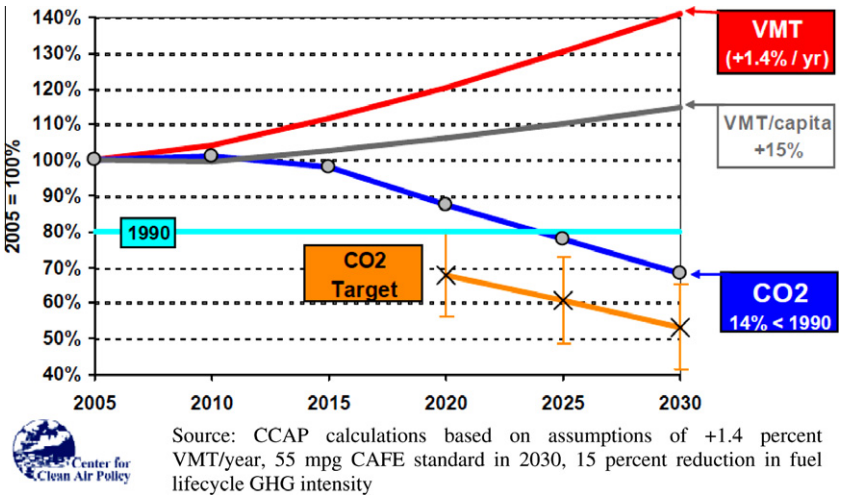
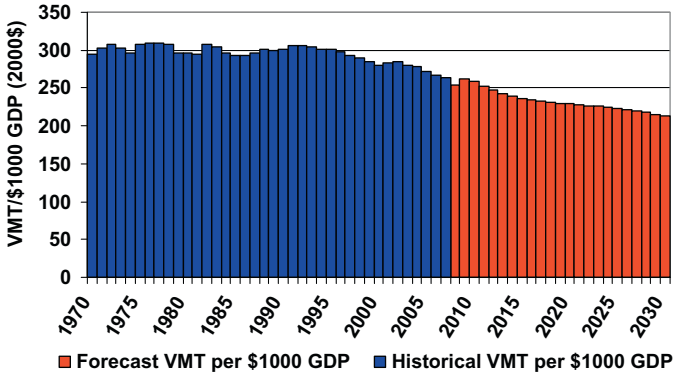


Fig. 2. Passenger vehicle GHG emissions forecast: business-as-usual VMT.

transportation realm, certain promising technologies may end up being quite expensive, such as vehicle electrification and advanced fuels (McKinsey and Company, 2007).

1.2. Is the baseline forecast right?

Rapid VMT growth will make necessary GHG reductions difficult, expensive or impossible. The good news is that EIA's VMT forecast may assume higher VMT rates than may actually occur. CCAP has recommended that EIA update the forecast to reflect recent and projected market and demographic trends indicating increasing demand for compact, walkable development. Measures of this growing demand include increasing building permits in urban areas (Ewing et al., 2009), commute and neighborhood preferences in opinion surveys (National Association of REALTORS, 2007), some housing developers shifting toward building smaller houses and others towards attached single family or multifamily homes (Leinberger, 2006; Nelson, 2007), and nation-wide demographic trends toward smaller households and a more elderly population (Leinberger, 2006; Nelson, 2007).



Source: Dan Klein, CCAP, based on data from DOT, BEA and EIA

Fig. 3. VMT per Dollar of GDP, 1970–2030. (See National Transportation Policy Project (2009). This calculation includes all sources of VMT, including light duty vehicles and trucks. (Calculation based on US Department of Transportation, Federal Highway Administration "Annual Vehicle Distance Traveled in Miles and Related Data, 1936-1995" and "Annual Vehicle-Miles of Travel, 1980-2007", http://www.fhwa.dot.gov; Bureau of Economic Analysis, National Economic Accounts "Current and Real Gross Domestic Product" http://www.bea.gov/; EIA *Annual Energy Outlook 2009 (early release)* Year-by-Year Reference Case Tables http://www.eia.doe.gov/.)

CCAP sees unchecked VMT growth as a policy choice – not a foregone conclusion. The evidence on travel behavior and the built environment (Ewing et al., 2008), coupled with demographic trends already in play, suggest that policy can play a critical role in shaping future travel demand. Uncertainty about VMT growth underscores the need for a "Do. Measure. Learn." policy framework. We need to craft a national policy that first fosters implementation and measurement at a large scale and then refines our forecasts according to the lessons learned.

1.3. Will a higher price on fuel from a cap-and-trade program reduce GHG and VMT?

An economy-wide cap-and-trade system effectively sets a price on emissions and is meant to stimulate cost-effective GHG reductions. The theory works well when applied to large point sources of emissions but breaks down when it comes to driving. For example, as depicted in Fig. 1, real gasoline prices increased more than 50% from $0.64 in 1999 ($0.64) to 2001 ($1.02) with little apparent impact on VMT until prices hit the $1.30 range in 2005. Moreover, many people do not have adequate travel options, and transportation infrastructure and land use decisions are made by a multitude of entities such that no one player can make comprehensive changes in response to a price signal (Litman, 2009).

Nevertheless, most official economic impact analyses of proposed climate legislation estimate changes in transportation fuel consumption as a function of fuel price. However, variations in fuel prices have not historically been a strong determinant of VMT as even record fuel prices remained only a fraction of total vehicle ownership costs. Moreover, typical GHG reduction analyses often assume a high cost per ton for these reductions, but ignore major economic benefits, including reduced infrastructure maintenance and capital costs (Winkelman et al., 2009). The relationship between fuel prices and travel behavior, quantified as the long-term elasticity of VMT with respect to fuel price, is estimated by some economists as -0.22 (Small and Van Dender, 2006).[2] EPA's analysis of the House and Senate climate bills estimates a CO_2 allowance price of $26–$49 per ton in 2030 (US EPA, 2009). A $50 per ton CO_2 permit price would raise the price of gasoline by $0.44, an 18% increase from a base consumer price of $2.50 per gallon and would result in a mere 4% reduction in VMT ($-0.22 \times 18\%$).[3] The price signal from a cap-and-trade system will not, on its own, yield significant GHG reductions in the transportation sector. However, many travel efficiency strategies that achieve GHG reductions also provide extensive savings and benefits to communities.

1.4. What is the relationship between VMT and the US economy?

A typical argument against slowing VMT growth centers on the historic linkage between VMT and economic growth. However, the number of miles driver per unit of GDP began to decline in the mid-1990s, and EIA projects that decline to continue through 2030 (Fig. 3) (EIA, 2010). More research is necessary to better understand the decreasing VMT intensity of the economy, though we suspect that structural economic changes away from energy-intensive manufacturing to more of an information and internet-based economy has played an important role. Below we document economic benefits of travel efficiency measures at the state and local level that we believe could lead to further divergence in VMT and GDP growth rates.

[2] Observed short-run elasticity have been even smaller (more inelastic), consistent with the expectation that neither peoples' driving patterns nor the efficiency of the vehicle fleet respond immediately to heightened fuel prices.

[3] This assumes 19.5 lb CO_2 per gallon of gasoline.

2. Expecting high quality outcomes from US transportation policy

Transportation policy impacts almost every part of our lives and affects our ability to prosper as a nation. Therefore, as a nation, we expect transportation policy to contribute to a number of seemingly disparate outcomes. For example, the Bipartisan Policy Center's five goals for national transportation policy are economic growth, national connectivity, metropolitan accessibility, energy security and environmental protection, and safety (National Transportation Policy Project, 2009). Because of the potential reach of transportation policies, measures that address multiple goals should rise to the top of the priority list in a performance-based policy framework. Slowing the growth rate of VMT can support many national policy goals: reduced roadway wear-and-tear and maintenance costs, lower capacity expansion costs, improved safety (Litman and Fitzroy), improved energy security and lower air pollution and GHG emissions. And in this report we present evidence that slowing VMT growth also provides extensive long-term economic benefits.

2.1. Transportation policy should improve mobility and accessibility

Many analysts state that mobility is the purpose of transportation policy while defining mobility as exclusively *vehicle mobility*. Oregon's Department of Transportation has a useful definition: "*Accessibility* (or just *Access*) is the ability to reach desired goods, services, activities and destinations... Access is the ultimate goal of most transportation."[4] Mobility, on the other hand,

> "refers to physical movement, including travel by walking, cycling, public transit, taxi, private automobile and other motorized modes. In general, increased mobility increases access. All else being equal, the more you can travel the more destinations you can reach. Mobility is evaluated based on travel distance and speed. Cities and other major activity centers tend to have a relatively poor *vehicle mobility* (due to congestion), but are economically successful due to excellent *accessibility* (activities that are clustered together and many travel options). This indicates that in the game of economic competitiveness, accessibility trumps mobility. This suggests that traffic congestion itself is not necessarily a major constraint on economic activity provided that land-use patterns minimize the amount of driving needed to reach common activities and destinations, and that travelers have good transport options to choose from."

This simple exercise – defining accessibility and mobility – has immense impacts on the way we view the goals, outcomes, and even performance measurements of the transportation system, as many strategies improve accessibility, improve mobility and reduce VMT. Some of these strategies include improving the mix of land uses, integrating transportation and land use, improving pedestrian and bicycle access and safety, car-pooling, and telecommuting. The American Association of Highway Transportation Officials agrees that "higher-density land-use patterns, combined with increased availability of transit service, could help to reduce the demand for automobile travel without reducing mobility" (AASHTO, 2008). In addition, many of the above strategies have the important value-added of providing access to communities that are disproportionately burdened by a strict definition of mobility, including children, the elderly, and the disabled. Furthermore, strategies that improve accessibility can lower overall household costs and improve access to jobs for workers who lack private transportation (Gao and Johnston, 2009).

2.2. Transportation policy should address changing public needs and empower personal choice

Real estate market and demographic trends indicate a robust demand for compact, walkable development (Ewing et al., 2009; Leinberger, 2006; Nelson, 2007). This kind of development, typically called "smart growth," encompasses mixed-use development, compact development, transit-oriented development (TOD), infill, low-impact development and strategies that promote the efficient use of land, infrastructure and natural resources. Evidence that smart growth is now occupying a larger share of the market is trickling in: a recent EPA report found that the urban share of building permits increased "dramatically" in almost half of the studied regions (Ewing et al., 2009). Another study found 83% of Americans want to live in communities that allow them to use their car less often (National Association of REALTORS, 2007). In *The Option of Urbanism*, developer Leinberger explains that there is pent-up demand for walkable neighborhoods, and that compact development could dominate the real estate development market if the regulatory and financial environment allowed (Leinberger, 2006; Nelson, 2007).

For those individuals and families that choose to live in transit-rich areas, the cost savings can be significant. Fig. 4 illustrates how the location of a working family's home affects their annual housing and transportation expenditures. The chart shows how living closer to work, stores and other amenities can reduce transportation costs from as much as 37% to as little as 22% of family income, without a corresponding increase in housing costs (Lipman, 2006). Another study found that households that live within 3/4 mile of public transportation and have one car save an average of $6251 annually over households with two cars and no access to public transportation (Bailey, 2007). In addition, as land-use density increases, household VMT decreases, insulating households in denser communities from rising fuel prices (Cortright, 2008) and insulating walkable neighborhoods from real estate market volatility (Cortright, 2009) . Many communities across the country are finding

[4] http://www.oregon.gov/ODOT/SUS/accessibility_mobility.shtml.

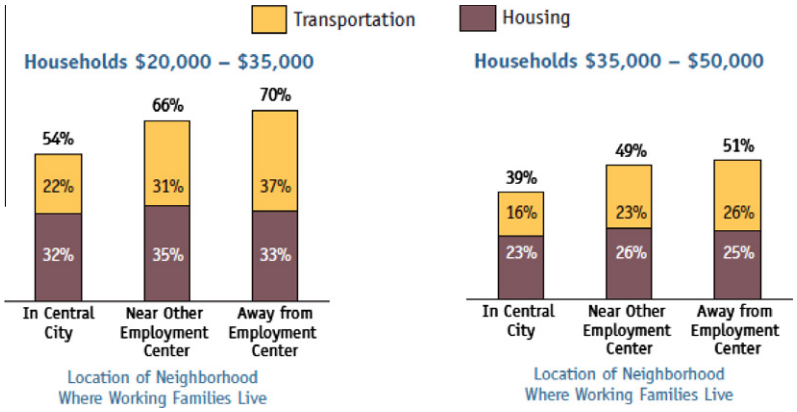


Fig. 4. Share of income spent on housing and transportation. (Center for Neighborhood Technology calculations. See Cortright (2008).) *Note:* Employment centers are job locations with a minimum of 5000 employees.

that their most walkable and transit-rich neighborhoods were also the neighborhoods that saw the least drastic decline in housing prices (Gopal, 2008; Schalch, 2008; Stiff, 2008; Jackson, 2008). This may be because households in accessible neighborhoods can choose to use alternate modes of travel if their financial circumstances change, fuel prices spike, or other changes occur. Thus, transportation efficient – that is, accessible – neighborhoods would be more insulated in the event of fuel shortages, embargoes, or an energy security crisis.

3. Smart travel investments reduce GHGs and save money

CCAP is preparing a study, "Growing Wealthier: the economic benefits of smart growth" to more thoroughly assess the net economic costs and benefits of development and transportation investments. Initial findings show that there is compelling evidence that smart growth provides significant net economic benefits via avoided infrastructure costs, increased economic activity, reduction in household travel costs, job creation, public health improvements, energy and water use efficiency.

3.1. Smart growth reduces infrastructure costs

Many studies find that smart growth produces net savings on the total costs of buildings, land, infrastructure and transportation, including fixed and operating costs for transportation systems (Muro and Puentes, 2004). A TRB report estimated national costs under smart growth scenarios compared to trend development over the period 2000–2025 (Burchell et al., 1998). The study found substantial infrastructure cost savings from compact development, as sprawl increased water and sewer costs by 6.6% and local road costs by 9.2%. Altogether, the costs of sprawl increase the cost of housing by $13,000 per dwelling unit (Burchell and Mukherji, 2003).[5]

3.2. Combining smart growth and travel efficiency can yield strong economic benefits

McKinsey & Company conducted a study for Georgia and concluded that investments in transit, demand management and freight could yield net economic benefits of $400 billion over 30 years and 320,000 jobs over 20 years (Kimley-Horn, 2009a).

3.3. Smart growth can leverage private investments

The Center for Transit Oriented Development estimates that investments in streetcars have a return on investment of 920–7500% (Ohland and Poticha, 2006). This is not a true "return on investment", however, the investment in rail car does leverage further investment, creating what is effectively a return on investment. Little Rock, Arkansas spent $20 million of public money on the Little Rock Streetcar, which helped leverage $200 million in private investment; Tampa, Florida spent $60 million in public money in the TECO Streetcar, which helped leverage $1 billion in private investment; and Portland,

[5] Based on the following findings and assumptions: sprawl produces a 21% increase in amount of undeveloped land converted to developed land (2.4 million acres) and approximately a 10% increase in local road lanemiles (188,300). Furthermore, sprawl causes about 10% more annual public service (fiscal) deficits ($4.2 billion) and 8% higher housing occupancy costs ($13,000 per dwelling unit). All based on land and infrastructure consumption as well as on real estate development and public service costs in the United States. See Ohland and Poticha (2006).

Oregon spent $73 million on the Portland Streetcar, which helped attract $2.3 billion in private investments within two blocks of the line, a more than 30-fold return on investment (Ohland and Poticha, 2006).

Smart growth policies to increase the density of development along public transit lines in Arlington, VA, created a successful transit-oriented community. Due to the high value dense development, 8% of County land generates 33% of real estate taxes (Leach, personal communication-b). The economic benefits include millions of square feet of new offices and thousands of new residential units, yet because 89% of all Arlington office space and 40% of all housing units are in Metro station areas, many roads in the county now carry less traffic than they did in 1996 (Leach, 2008). Moreover, the development around Metro stations in Arlington takes up only two square miles – which at typical regional suburban densities would have covered 14 square miles – thereby reducing infrastructure costs.

3.4. Smart growth can improve public health and reduce health care costs

Smart growth can improve public health by reducing congestion, which improves air quality and reduces the air pollution related illnesses (Frank and Engelke, 2005), and by reducing the rate of obesity (Ewing et al., 2003), which could reduce obesity-related health risks such as diabetes, heart disease, and hypertension (National Institute of Health, 1998). Increasing activity levels and reducing obesity can potentially save the US a portion of the estimated $147 billion annually spent on obesity by improving productivity, reducing workers compensation claims, and reducing health care costs (Finkelstein et al., 2009).

3.5. Smart growth can improve US energy security

US dependence on foreign oil exacerbates economic volatility and costs the US billions of dollars annually to remain ready to intervene militarily to protect oil resources. In fact, the annual cost of oil dependence in the US in 2005 was estimated to be $175–300 billion (at $50 per barrel) (Greene and Leiby, 2007). By reducing VMT, the US can reduce our dependence on foreign oil, and directly and indirectly free up billions of dollars annually for other uses.

4. Smart growth investments profitably reduce CO_2 emissions

One way of assessing the cost-effectiveness of a strategy is with the cost per ton of CO_2 reduced. This is often referred to as the 'dollar per ton' or 'marginal abatement' cost, which are the units used in McKinsey's oft-cited abatement curve (McKinsey and Company, 2009). Marginal abatement cost analysis is quite valuable for comparing GHG reduction strategies but can overlook major economic benefits. Moreover, transportation policy, which considers a broad variety of costs and benefits requires a more comprehensive analytical approach.

CCAP posits a broader view of economic benefits and a more comprehensive view of environmental benefits. For example, transit projects can appear to be very expensive on a cost per ton CO_2 basis if one only considers the CO_2 savings from new riders, the transit investment and fuel savings. If we take a broader view of transit-oriented development, a host of economic benefits become apparent, including leveraged private investment, reduced household transportation costs and increased local tax revenues. In addition, the leveraged GHG benefits from shorter drive trips and increased walk trips can be several times greater than just from increased transit ridership.

Below, we consider real-world and theoretical examples of smart growth and travel efficiency strategies through this holistic lens. In CCAP's upcoming report, "Growing Wealthier: The Economic Benefits of Smart Growth," we consider which parties accrue the costs and benefits of smart growth and travel efficiency policies and consider policy implications for achieving the most effective and high value GHG reductions.

4.1. Estimating cost-per-ton CO_2 for local-level infill development

An EPA evaluation of Atlantic Station, a 138 acre brownfield redevelopment project in downtown Atlanta, projected that the compact, transit-oriented design would generate about 340,000 VMT/day while a similar scale development in any of three outlying sites (representing typical Atlanta-area development sites) would generate 389,673–518,197 VMT per day, between 14.5% and 52.3% more (Schroeer and William, 1999). Initial surveys suggest Atlantic Station residents have an average daily VMT that is 59% lower than the typical Atlanta resident.[6] CCAP calculated a potential saving of GHG for Atlantic Station by first assuming that the development's 340,000 VMT per day were 30% less than what would have occurred had a similar scale development been built elsewhere, an estimated reduction of 132,000 VMT per day. For the years 2009 to 2059 we then assumed a linear increase in average fuel mileage from 20.7 mpg to 62.4 mpg for a vehicle fleet that would have driven a constant 132,000 additional miles daily. The carbon content of fuel was also kept constant at 19.5 lbs of CO_2 per gallon. Using these assumptions we calculated a cumulative savings of 0.63 $MMTCO_2$ over 50 years and 73 million fewer gallons of gasoline purchased in the same time period.

[6] http://www.atlanticstation.com/concept_green_projectXL08.php

According to the Atlantic Station Redevelopment Plan (ASRP), the total investment needed for infrastructure over all three phases of the project was $245 million. Of this, $50 million was provided in kind, leaving $195 million as the public investment cost. Initial calculations from the ASRP estimated the site would generate over $30 million annually in revenue from property and sales tax, and this funding stream will continue to benefit the city long after the initial investment debt is repaid (Atlanta Development Authority, 2000, p. 33). Residents and employees are projected to purchase 73 million fewer gallons of gasoline, saving millions of dollars more. Overall, the Atlantic Station redevelopment can be considered as zero cost per ton CO_2 or a cost savings per ton, depending on how the "profit" is reinvested in site amenities or transportation services in the region.

4.2. Estimating cost-per-ton CO_2 for regional smart growth

The Sacramento Area Council of Governments (SACOG) region conducted an extensive *Blueprint Transportation and Land Use Study* to explore alternative growth scenarios through 2050.[7] SACOG analysis indicates that the base case scenario would produce 14% more CO_2 than the preferred scenario featuring infill development and transportation investments.[8] CCAP calculated cumulative savings of 7.2 $MMTCO_2$ from 2005 to 2050.[9] SACOG calculated the price tag of the base case scenario to be $47.4 billion through 2050 vs. $38 billion for the preferred blueprint scenario – a savings of $9.4 billion dollars. One-third of the savings are from transportation infrastructure, another third from water infrastructure, and the last third from flood control and dry utilities (SACOG, 2006). The study cost roughly $4 million (Gordon, personal communication) – a hefty return on investment. Under this scenario, transit operating costs would increase by about $120 million per year and annual consumer fuel expenditures would decrease by $380 million.[10] CCAP calculates the net present value of the increased transit costs, fuel cost savings and avoided infrastructure costs to be $1.4 billion, yielding a net *savings* of $198 per ton.[11] SACOG also assessed the costs of land purchases, and calculated additional savings of $8.3 billion through 2050.[12] Including land purchases yields a net benefit of $341 per ton CO_2 saved (SACOG, 2006).

However, infill development can result in higher upfront costs, including adding capacity (for utilities, roads, and other infrastructure), acquiring additional permits (time consuming and complex), updating zoning ordinances, and conducting associated public participation efforts. Even if Sacramento's upfront costs amounted to $1 billion, the net savings would be $70 per ton or $211 per ton counting mitigation land purchases.[13] This underscores the policy case for making it easier build infill and mixed-use projects, which can yield short- and long-term dividends.

4.3. Estimating cost-per-ton CO_2 for bicycle infrastructure

Portland, Oregon invested substantially in bicycle infrastructure and has documented associated GHG reduction benefits. The Rails-to-Trails Conservancy calculates that increased bicycling infrastructure in Portland could reduce GHGs by 0.73 $MMTCO_2$ by 2040, with a net economic *benefit* of $1.4 billion from fuel and health care cost savings, equivalent to a net savings of $1664 per ton of CO_2 reduced (Gotschi, 2009).

4.4. Estimating Cost-per-Ton CO_2 from short-term measures

A recent study found that US oil consumption and associated CO_2 emissions could be reduced by 14% in the short term as a result of measures and programs implemented at less than $3 per ton CO_2 reduced, including car-pooling, telecommuting, compressed work week, and instructional programs for eco-driving. An additional 2.4% reduction can be achieved by reducing and enforcing highway speed limits to 55 mph – a measure which can be implemented at a cost of less than $39/ton CO_2.[14]

4.5. Estimating cost-per-ton from national GHG reduction policies

A recent analysis by Cambridge Systematics, at the request of a coalition of diverse organizations, concluded that changes to land use and transportation improvements can significantly contribute to US GHG emissions reductions. The authors

[7] http://www.sacregionblueprint.org/sacregionblueprint/home.cfm

[8] Calculation assumptions: CO_2 savings provided by Gordon Garry, SACOG, based on 9/16/04 Preferred Scenario Run with 4Ds. 51.3 tons CO_2 per day in the base case, vs. 45 tons per day in the preferred case.

[9] Under the preferred scenario, CO_2 emissions are 2 million tons lower than the base case in 2050, and transit emissions are 0.02 tons higher. We assume that savings grow exponentially over time, starting at 1 ton in 2005, growing to 1.98 million tons in 2005.

[10] CCAP calculations, assuming an average fuel price of $3.00 per gallon.

[11] CCAP NPV calculation used a 7% discount rate.

[12] Mitigation lands are land that must be purchased by a developer to satisfy mitigation requirements due to impacts from development.

[13] CCAP 's modified NPV calculation assumes $1 billion of expenditures in year one. The point of this front-loaded calculation, that even if there were major high upfront costs (planning, zoning, site preparation, etc.), the net benefits remain compelling.

[14] CCAP calculated cost per ton from the report's cost per barrel analysis: OECD/IEA, Saving Oil in a Hurry. 2005. www.iea.org/textbase/Papers/2008/cd_energy_efficiency_policy/5-Transport/5-SavingOil2005.pdf.

	Aggressive Deployment				Maximum Deployment			
	GHG Reduction (Gt)	Implementation Costs [a]	Change in Vehicle Costs [b]	**Net Cost per Tonne [c]**	GHG Reduction (Gt)	Implementation Costs [a]	Change in Vehicle Costs [b]	**Net Cost per Tonne [c]**
Land Use/Transit/ Nonmotorized Transportation	3.8	$1,439	-$3,270	**-$484**	6.3	$2,390	-$5,740	**-$531**
System and Driver Efficiency	5.0	$1,870	-$2,214	**-$69**	6	$3,338	-$2,737	**$100**
Facility Pricing	1.4	$3,271	-$1,121	**$891**	1.7	$4,484	-$1,656	**$1,632**
Low Cost	7.5	$599	-$3,499	**-$387**	9.8	$634	-$5,103	**-$457**

Fig. 5. Summary of costs of transportation and land use bundles in *Moving Cooler*. (Cambridge Systematics, *Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions*. "Summary of *Moving Cooler* Bundle Analysis Results: Cumulative GHG Reductions, Implementation Costs, and Chance in Vehicle Costs by Strategy (at Aggressive and Maximum Deployment Levels) 2010 to 2050" Table 4.15 footnotes: "Note: Gt (Gigatonne) = one billion metric tones. (a) Implementation cost is the estimated cumulative cost to implement each bundle, including capital, maintenance, operations, and administrative costs. (b) Vehicle cost is the estimated cumulative reduction in the cost of owning and operating vehicles from a societal perspective, which would result with reductions in VMT and fuel consumption experienced with implementation of each bundle. Vehicle costs DO NOT include other costs and benefits that could be experienced as a consequence of implementing each bundle, such as changes in travel time, safety, user fees, environmental quality, and public health. (c) Included cost per ton is simply the estimated cumulative cost of implementation, less the estimated vehicle cost savings divided by the estimated cumulative reduction in GHG emissions for each bundle.")

assessed the cost of different "bundles" of mitigation actions. Fig. 5 shows the magnitude of reductions and the cost per ton of reductions of transportation-related bundles at two levels of deployment – aggressive and maximum.[15]

The land use/transit/nonmotorized transportation bundle was the most cost effective bundle, at a net savings of $484 per ton CO_2 reduced with aggressive development and a net savings of $531 per ton CO_2 reduced at maximum deployment. It was also one of two bundles that became *more* cost effective when deployed at maximum levels.

The above estimates of cost per ton for transportation and land use strategies support the economic case for investing in smart growth, improved travel choices, travel demand management and smart pricing policies.

5. Potential VMT reductions achievable from best practices

5.1. Measured VMT reductions

Since 1990, the Portland, Oregon metropolitan region's smart growth policies have resulted in the addition of 48 miles of light rail and streetcar, a fourfold increase in the number of frequent bus routes and a 90% increase in transit use. While national VMT per capita grew by 8%, between 1990 and 2007 in the Portland–Vancouver region VMT per capita fell by 8–10% (Cotugno, personal communication). During this time, the region brought its GHG emissions back to 1% above 1990 levels by 2008, while population increased 14% and Portland grew as an economic center.

In Arlington, Virginia, extensive transit-oriented development policies have resulted in a 1% per year growth in population with no growth in VMT (Leach, 2009). This would be equivalent to a 22% reduction in VMT per capita from 1980 to 2005. Arlington resident per capita VMT is 38% lower than the regional average and less than half that of more suburban counties (2007/8 data) (Leach, personal communication-a). Furthermore, when Arlington residents do drive, their trips are 40% shorter, on average, than surrounding suburban counties. Arlington residents also take fewer total trips – trips by any mode – than in suburban counties, indicating that Arlington residents naturally combine multiple purposes into one trip, or "trip-chain." CCAP hopes that other communities in the Washington, DC metro area can follow Arlington's lead and reduce their per capita VMT through integrated transportation and land use strategies.

5.2. Modeled VMT reduction projections

In Sacramento, the Blueprint scenario is projected to reduce average household VMT per capita 6–10% through 2035, due to the closer destinations and alternative travel choices (Sacramento Area Council of Governments, 2007). Under SB375, the California GHG planning law, the region will plan for an even greater reduction in VMT.

[15] The land use/transit/nonmotorized transportation bundle includes adoption of growth boundaries, minimum targets for accessible development, infill support and fiscal incentives for smart growth; complete streets, bicycle and pedestrian infrastructure and traffic calming; lower public transportation fares, increased frequency and system efficiency of transit and new transit service; high occupancy vehicle (HOV) lanes, car sharing and commute reduction support; signal management, traveler information and urban consolidation centers. The System and Driver Efficiency bundle includes congestion pricing, increased public transportation, HOV lanes, car sharing, employer commute strategies, speed limit reductions, "eco-driving," freeway management, incident management, road weather management, traveler information and multimodal freight strategies. The facility pricing bundle includes parking pricing and permitting, congestion pricing, tolls, transit fare measures, increased transit, HOV lanes, traveler information, capacity expansion and bottleneck relief, and multimodal freight strategies. The low cost bundle includes parking pricing and permitting, congestion pricing, tolls, land use and bike/ped strategies, transit fare measures, car sharing, employer commute strategies, speed limit reductions, eco-driving, multiple traffic management strategies and multimodal freight strategies.

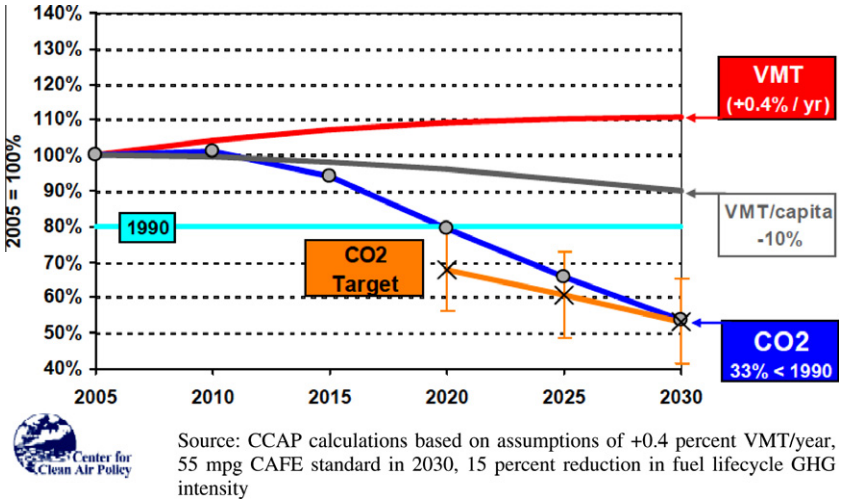


Fig. 6. Passenger vehicle GHG emissions forecast: smart growth case.

The McKinsey & Company study for Georgia projects a 6.7% reduction in VMT per capita for the Atlanta metropolitan area, from 2010 to 2030, through transit, system efficiency and TDM[16] (Kimley-Horn, 2009b). In *Growing Cooler*, Ewing et al. examined a scenario with increased density, slower growth in highway construction, faster growth in transit use, and widespread pricing policies and found that VMT per capita could be reduced 17% below 2007 levels by 2030.[17]

The Federal Highway Administration found that pricing and transportation management strategies that can each yield VMT and GHG reductions of 10% or more (US Federal Highway Administration, 1998). One of these pricing strategies, "pay as you drive" (PAYD) insurance, can save consumers and insurance companies up to $50–60 billion annually (Bordoff and Noel, 2008). A Brookings study found that a universal PAYD system in California would reduce VMT by 8%, reduce annual fuel consumption by 1.2 billion gallons and reduce air pollution, and decrease accident rates (The Brookings Institution, 2008).[18]

5.3. VMT reduction goals

Many states are adopting VMT reduction goals. The Washington State legislature has set a goal to reduce statewide VMT per capita 30% below 2020 levels by 2035, equivalent to a 23% reduction in VMT per capita below 2005 levels (Landsberg, 2009). New York State has adopted a goal to reduce total VMT by 10% below projected levels by 2020, which would keep per-capita VMT flat at 2010 levels (Renewable Energy Task Force, 2008).

5.4. Estimate of potential VMT reductions from comprehensive applications of best practices

The VMT reductions described above range from 6% to 22%, with many of the studies estimating 10–20%. Based on these studies, CCAP concludes that a 10% reduction in per-capita VMT by 2030 is achievable with comprehensive application of best practices. A 10% reduction in VMT per capita from 2005 levels could be achieved with a VMT growth rate of 0.4% per year, bringing total VMT in 2030 to 10% higher than 2005 levels. Assuming significant progress on vehicles and fuels, passenger vehicle CO_2 emissions would be 33% below 1990 levels in 2030 – on path to climate protection (Fig. 6).

A per capita VMT reduction of 10% would result in annual savings of 145 $MMTCO_2$ in 2030 – equivalent to the annual emissions of some 30 million cars or 35 large coal plants.[19] These GHG reductions would be approximately 6% of the 2030 GHG reduction goal proposed in House-passed and Senate draft versions of the climate bill.[20] (SB, 1733). Further GHG benefits may be realized from reduced traffic congestion, smart traffic management and the savings from reduced building energy and water consumption that can be achieved through compact development.

[16] *Note:* Daily VMT in 2010 (no build) is 32.9 miles. Daily VMT in 2030, averaged across options 4 and 5 is 30.7 miles.

[17] Based on Ewing et al., 2008, Chapter 8.

[18] For additional information on driving and accident rates, see Edlin and Mandic (2006).

[19] CCAP calculations assume 55 mpg CAFE standards in 2030 and a 15% reduction in fuel GHG intensity. GHG savings from VMT reduction would be higher if we had assumed lower mpg or fuel GHG savings. Coal plant and car estimates based on current US averages for a 600 MW coal plant and on-road light duty vehicle fleet.

[20] 145 MMTCO2 is 5.8% of the 2030 savings from covered sources or 4.8% of economy-wide GHG reductions in House Report 111–137: http://thomas.loc.gov/cgi-bin/cpquery/R?cp111:FLD010:@1(hr137).

Demographic changes, market changes and higher fuel prices are likely to help slow VMT growth, but policy changes are needed to increase accessibility and travel efficiency and achieve the strong economic benefits presented above.

6. Conclusions

We conclude that slowing growth in VMT is necessary, possible and worthwhile: necessary to achieve the required deep cut in GHG emissions, possible because it has been proven on the ground, and worthwhile due to the broad economic, environmental and social benefits.

This year we face unprecedented opportunities to ensure that US climate and transportation policies empower state and local governments to implement smart growth and travel efficiency policies as they strive for economic and environmental resilience.

Federal climate policy cannot resolve the nation's transportation issues, but it should help 'prime the pump' by funding innovative and cost-effective travel efficiency projects and policies to reduce GHGs and inspire replication. Directing a meaningful portion of cap-and-trade allocation values toward smart growth and travel efficiency can also enhance state and local capacity to plan, implement and measure the impacts.

Federal transportation policy should prioritize policies and projects that achieve multiple benefits at optimal cost. CCAP finds that demand management, smart growth and travel efficiency measures can maximize the efficient use of existing infrastructure, minimize the need for new infrastructure, minimize wear-and-tear, improve safety, reduce fuel use and GHG emissions, enhance economic resilience and prosperity, and enable our citizens and communities to thrive.

Federal policy should empower communities to implement locally-determined travel efficiency solutions by providing appropriate funding, tools and technical support for planning, implementation and measurement. CCAP supports performance-based policy and increased investment in high quality data to evaluate effectiveness, measure progress and inform policy design. With the members of CCAP's VMT and Climate Policy Dialogue, a diverse group of senior transportation and environmental stakeholders, we developed a set of travel data improvement recommendations to support policy performance-based climate and transportation policy (CCAP, 2009).

Asking the Climate Question is the first step to acknowledging that how we make transportation investments will have a tremendous impact on GHG emissions and community resilience to climate change impacts. *Answering* the Climate Question will require a concerted policy effort, across all levels of government, in partnership with the private sector and individuals.

CCAP offers that a "Do. Measure. Learn." approach can move us from theory to practice, from planning to results, and identify the most locally-appropriate, effective and cost-effective GHG reduction strategies. We know the direction we need to go; we know which measures are directionally correct; let us rise to the occasion and get on path toward economic and environmental resilience.

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