Pay-to-Save Transportation Pricing Strategies and Comparative Carbon Reductions to EPA's Proposed Rule for Existing Electric Utility Generating Units

Paper Word Count: 7,229
Abstract Word Count: 234

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November 15, 2014

[1] The views expressed are not necessarily those of the Federal Highway Administration, U.S. Department of Transportation, or Cambridge Systematics.

ABSTRACT

Converting fixed driving costs to variable per-mile charges, and offering cash savings in lieu of parking for bundled or otherwise "free" parking, encourages voluntary curtailment of driving and related decreases in greenhouse gas (GHG) emissions, air pollution, congestion, and crashes. This research explores the efficacy of a potential regulatory approach to help achieve carbon reduction goals by setting transportation efficiency targets based on deploying three transportation demand management strategies—(1) pay-as-you-drive-and-you-save (PAYDAYS) car insurance, (2) parking cash-out, and (3) the conversion of state and local sales taxes applying to newly purchased vehicles to mileage taxes designed to raise equivalent revenue. Using a mid-range medium-run price elasticity of -0.22, a year 2030 comparison is made between the projected state-level and national GHG emissions reductions of the proposed transportation policies with projected reductions from the U.S. Environmental Protection Agency proposed rule for electric utility existing sources. Enacting the proposed transportation efficiency targets would yield nationwide GHG emissions reductions of 29.2% of those of the proposed electric utility rule (on top of the reductions of that proposed rule), and would bring about reductions greater than those calculated for the electric utility rule in 13 states plus the District of Columbia. Results are also presented using a lower-bound (-0.15) and upper-bound (-0.30) price elasticity, with the former leading to 20.6% of the GHG emissions reductions of the electric utility rule and the latter leading to reductions of 38.3%.

INTRODUCTION

Proposed rulemaking by the U.S. Environmental Protection Agency (EPA), Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units (June 18, 2014), has garnered substantial praise within the environmental community, including being called by environmentalists the most important regulatory action the U.S. government has ever proposed to reduce carbon emissions and address climate change. (In terms of policy strategies that have already been enacted to reduce carbon emissions, the joint rulemaking of EPA and National Highway Traffic Safety Administration (NHTSA) to regulate carbon emissions and fuel economy from model year 2017-2025 light duty vehicles is widely credited with reducing carbon emissions more than any other U.S. government action to date.) Among other things, the draft electric utility rule for existing sources recognizes the important role of demand-side efficiency improvements in setting and reaching carbon emissions reductions targets. This research paper examines the possibility of meaningfully adding to the anticipated carbon emissions reductions of the draft rule by adopting an analogous rulemaking structure to set and meet reduction targets associated with policies that encourage personal transport efficiency.

This research explores the efficacy and touches upon the legality of a potential regulatory approach to achieving the aforementioned objective and calculates the level of greenhouse gas (GHG) emissions reductions that would result from setting transportation efficiency targets based on deploying three transportation demand management strategies that have either been demonstrated or modeled to be effective at encouraging reductions in vehicle-miles traveled (VMT). These strategies, described in more detail later in this paper, are (1) pay-as-you-drive-and-you-save (PAYDAYS) car insurance, (2) parking cash out as an option that employers choosing to subsidize commuter parking would be required to offer their employees, and (3) converting state and local sales taxes applied to newly purchased vehicles to mileage taxes spread over the first three years of vehicle ownership that are set at a rate to raise equivalent revenue.

As with the proposed electric utility rule for existing sources, the efficiency strategies examined here are used only to calculate statewide targets that a state in turn could meet using these strategies or equivalently effective strategies of its choosing. The projected transportation emissions reductions are compared, both nationally and state-by-state, against those anticipated from the prevailing 30%-nationwide-average-reduction-by-2030 target proposed in the electric utility rule (alternative targets are also mentioned to elicit comments in that proposed rule). The comparison, though, is between 2012 and 2030, instead of starting from 2005 (a peak year for power-sector carbon emissions and also a year of very high personal transport emissions), which is the year the electric utility rule uses as its baseline to derive the figure of a 30% reduction by 2030.

EPA'S PROPOSED RULE AND AN ANALOGOUS TRANSPORTATION RULE

This section first describes EPA's proposed rule, then discusses other rulemakings to reduce carbon emissions. We review the legislative authority asserted with the various rulemakings and mention one source in the literature that asserts broad EPA authority to regulate carbon in all sectors. We make no judgment about claims of legislative authority that may or may not exist for any hypothetical "existing vehicles" efficiency rulemaking, but provide this brief discussion as background for researchers who may want to further explore this topic.

EPA's proposed rulemaking, Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, is groundbreaking in its creativity and use of legal authority under the Clean Air Act to structure state-level carbon emissions targets that, among other things, directly engage consumers to change their behaviors to help meet such targets. Individual state-level targets are expressed as a rate (in pounds) of carbon dioxide equivalent emissions per megawatt hour of power generated for 2030. EPA also shows—in accompanying documentation available on-line (USEPA, June 2, 2014)—2012 state-level emissions rates, although, as noted above, its overall reduction claim is based on a comparison with higher emissions levels from 2005. Among the four pillars of the proposed rule is a mechanism for setting targets and crediting demand-side energy efficiency measures. In a previous rulemaking, EPA finalized carbon emissions standards for new electric utility generating units.

EPA and NHTSA together addressed carbon emissions from new vehicles by promulgating fuel economy standards. Authority for such standards, as detailed within that rulemaking, are grounded in Title II of the Clean Air Act, Emission Standards for Moving Sources. Title II deals almost exclusively with new motor vehicles, although the rulemaking establishing the standards allows credits for so-called off-cycle emissions reductions (from technologies that would reduce vehicle emissions, such as from "active seat ventilation" that would reduce air conditioning use, but where it would not be captured by the vehicle test procedures), and also provides carry-back and carry-forward credit opportunities (meaning that automakers over-complying with fuel-efficiency requirements in one year would earn credits that could be redeemed to meet another year's target), but this title has never been used to justify either legally-binding emissions targets for preexisting vehicles or states instead of automakers being held responsible for meeting such targets, both of which are contemplated as part of this research. (It does, though, include a number of provisions to ensure that new vehicles continue throughout their operating lives to adhere to emissions standards that applied at the time of their production by addressing issues such as warranties for vehicle emissions control technologies.) EPA and NHTSA had seriously considered ideas proposed by Daimler and Garmin to ease fuel efficiency requirements by granting off-cycle emissions credits for technologies that would avoid crashes or help drivers from getting lost. The rulemaking ultimately rejected this request on the technical grounds that it would be too difficult to accurately measure benefits, but nowhere asserted that it lacked the legal authority to grant this if its technical concerns could be overcome.

Various alternative legal mechanisms have been proposed by New York University's Institute for Policy Integrity for regulating carbon emissions. The organization asserts that Section 211 of the Clean Air Act allows EPA to control or prohibit the manufacture—including importing and refining—or sale of fuel. While typically used to control fuel additives, the Institute asserts that the authority is framed broadly enough to allow EPA to deploy any number of control strategies. Under a similar vein, the Institute asserts EPA authority for an economy-wide approach to regulating carbon emissions under Section 115 (International Air Pollution) of the Clean Air Act (Lienke and Schwartz, 2014).

If it is determined that a legal mechanism exists for an "existing vehicles" efficiency rulemaking, there is precedent for binding states to adhere to transportation control measures (TCMs), including pricing strategies, that have long been incorporated in some State Implementation Plans designed to bring states into compliance with Clean Air Act standards. EPA and other agencies have also issued numerous related "how to" guidance documents, assisting with the development and measuring of emissions impacts of TCMs.

SELECTED POLICIES AND SPECIFIC POLICY PARAMETERS FOR GHG REDUCTION CALCULATIONS

Excessive reliance on driving alone in many metropolitan regions throughout the U.S. is causing overwhelming traffic congestion, air quality, and safety problems, and is a major contributor to U.S. GHG emissions. These problems are exacerbated by the fact that, while the fixed costs of driving are quite high, the incremental costs for each mile of driving are low. Most of the costs of owning and operating a vehicle are fixed. Once a person has chosen to acquire and insure a vehicle, which is the case for the vast majority of Americans, there is little financial incentive not to use it for most trips. By contrast, the per-trip price for public transit is generally noticeably higher than the incremental cost of driving.

In exchange for reducing fixed driving costs and for revealing otherwise hidden parking costs (such as employer-provided parking), many drivers—especially lower income ones—would readily accept new mileage charges and would relish cash-in-lieu-of-parking benefits that they control by the amount of driving they choose to do and by how they decide to travel to work. Motorists, of course, will only reduce their driving when the savings offered by usage-based pricing exceeds the value of particular drive-alone trips to them. Driving reductions result from voluntary trip consolidation, carpooling, alternative transportation use, and forfeiting of low-value trips.

Various studies have shown transparent pricing of parking and vehicle travel to be tremendously beneficial in reducing VMT and related negative externalities. One modeling study, in particular, shows such strategies to be the most effective for reducing U.S. GHG emissions from the transportation sector, while also saving most households substantial sums of money. Specifically, the report, "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions," a joint effort of multiple Federal agencies, environmental organizations, and Shell Oil, shows the importance of implementing various packages of policy measures in reducing VMT and related GHG emissions. Significantly, when fully-variable PAYDAYS insurance was added to a bundle of land use/transit/non-motorized transportation measures (one of a number of policy bundles evaluated), the model showed a 44% increase in the reduction of transportation-related GHG emissions through 2050 than without the inclusion of such insurance (Cambridge Systematics, Inc., 2009).

For this paper, we have developed a spreadsheet model to permit the evaluation of three transportation-oriented policy strategies detailed below. The model equations are presented at the end of the paper. Figure 1 provides a summary of the model parameters.

PAYDAYS Insurance

Policy Background

PAYDAYS insurance—also commonly known as usage-based insurance—converts all or some portion of fixed insurance costs to per-mile or per-minute-of-driving charges. Traditional rating factors (e.g., residential location, gender, age, and driving record) are directly incorporated into usage-based rates (including applying lower per-mile rates in rural areas than in urban areas), with such rates also reflecting the specific coverage a driver chooses. PAYDAYS insurance is likely to result in charges that more accurately reflect crash risk, based, as they are, on usage. By contrast, traditional insurance rates vary little, if at all, based on mileage, even though few claims are made for damages, such as theft, that may happen when a vehicle is not being driven.

Studies estimate VMT would drop between 8 and 20% if all fixed automotive insurance costs were converted to usage-based, with the more recent estimates tending to be on the lower side of this range (Litman, 2004; Barrett, 1999; Parry, 2005; Bordoff and Noel, 2008; Ferreira and Minikel, 2010). The Brookings Institution has calculated that between $50 and $60 billion in net benefits would accrue in the U.S. from reduced driving related externalities if fully-variable PAYDAYS premiums became the standard insurance product offering (Bordoff and Noel, 2008).

University of California Professor of Law and Professor of Economics, Aaron Edlin, has researched the insurance-costs-to-others externality of driving in traffic-dense states. His research in California concluded that an additional insured driver causes between a $1,725 and $3,239 increase in total statewide insurance costs to other drivers compared to only $10 in North Dakota (Edlin, 1996).

By providing affordable insurance to low-income motorists who are willing to limit their mileage, PAYDAYS could reduce the number of uninsured motorists (Litman, 2004). It has been projected that 63.5% of households with insured vehicles (63.7% of urban households, 62.9% of rural households, and approaching 80% for the poorest of households) would save an average of 28% on their total premiums, or about $496 annually for households that do save for fully variable PAYDAYS premiums (Bordoff and Noel, 2008).

While, as discussed above, the risk of an insurance claim is directly related to driving exposure, there is a debate as to whether it is appropriate to convert all fixed insurance costs to mileage charges. Since benefits are principally a result of consumers reducing their mileage due to higher variable costs of driving, benefits will be reduced if not all insurance costs are made variable. Researchers at the Massachusetts Institute of Technology (MIT) matched claims data that insurance companies are required to report to the State of Massachusetts with mileage data from annual vehicle inspections. The data included $502 million in reported claims corresponding to almost 3 million cars driven about 3.4 billion miles. The period recorded for insurance claims and mileage tended to match fairly closely (within months), but not precisely. The study concluded that—when also accounting for territory and class (reflective of years of driving experience)—the “best fit” premium pricing model included a fixed fee that covered the first 2,000 miles of driving, plus a fee for additional miles (with both the fixed and per-mile prices varying by individual risk factors). The projected result for Massachusetts, a high-cost insurance state, was that applying the “best fit” model to premium pricing—where on average 53% of the premium would be made variable—would yield a 5.0% reduction in driving, versus a 9.5% reduction with a fully variable pricing model (Ferreira and Minikel, 2010).

Because for a variety of reasons higher mileage drivers tend to present a lower per-mile risk than lower mileage drivers, and vice versa, a PAYDAYS pricing model that fails to differentiate customers based on a multitude of demographic factors will invariably overestimate the "fixed risk" of an individual driver and underestimate his or her per-mile driving risk. If a pricing model were sophisticated enough to differentiate the risk of every driver, it could then reflect the likelihood that if an individual curtails his or her driving by a certain percentage, that driver's probability of getting into a crash should be cut by the same percentage, assuming that the nature of driving (mixture of time and place, plus the condition of the driver) that he or she does remains similar despite reduced mileage (Litman, 2004). Thus, a more sophisticated "best fit" model would almost certainly yield a lower fixed premium and higher variable premium than what was developed through the MIT research.

Among the costs car insurance companies incur that are unrelated to claims on a household's insured vehicles, some are linked to having an additional policyholder (e.g., sending out bills, accepting some number of unprofitable high-risk or "non-standard" insureds based on a company's total number of insureds, automatically providing policyholders insurance on rental cars, etc.), some relate to the price of the insurance premiums (e.g., percentage-based taxes and commissions), and some are just general administrative and overhead costs (e.g., building leases, company personnel and legal departments, etc.). Costs in the first category are appropriately apportioned evenly among policyholders; costs in the second category should be mileage-based, at least to the degree that the premiums from which they are derived are mileage-based; and costs in the third category could legitimately be apportioned either on a per-policyholder or premium-dollar basis, with the latter being preferable as it would lead to premiums that vary more by mileage and thus further reduce GHG emissions.

Scenario Description

For the sake of this scenario, it is assumed that, on average, premiums in 2030 are 70% usage-based. This number falls between what previously was offered in the marketplace (start-up Milemeter, Incorporated's fully variable premium structure—although 2,000 miles of premium had to be purchased every six months to keep the policy active—when it offered insurance in Texas until a couple of years ago) and what are now the most variable products available in at least some states (ranging in variability from about 50% to 60%) from State Farm's Drive Safe & Save product, National General (formerly GMAC) Insurance's Low-Mileage Discount program, and start-up MetroMile, Incorporated's only product offering. These available products offer premiums that are probably less variable than would result if instead of individual insurance companies owning data collected for PAYDAYS pricing, the consumer would, propelling the market to respond to consumers shopping their data for better prices by offering PAYDAYS premiums that are more variable and competitive. The 70% figure used in this analysis matches the level of premium variability required to be eligible for State of Oregon PAYDAYS insurance tax credits (Oregon Code, Chapter 317 (Corporate Excise Tax), Sec. 317.122), a state public policy "best practice." State insurance commissions could also require PAYDAYS pricing as a condition to approve a product offering, if consistent with state law either current or amended.

There are a variety of reasons that insurance premiums could be higher or lower in 2030 than they are today. This analysis assumes that if premiums are 30% fixed and 70% variable in 2030 that the fixed cost and variable per-mile rate would be the same as today (if today's premiums were kept at the same level, but restructured to be 70% variable), but that the total average premium cost for the 2030 base case will be lower, commensurate with EIA's estimate for reduced per capita VMT.

Parking Cash Out

Policy Background

Approximately 95% of employers provide their employees free parking at work, while only 5% of private-sector employers offer other transportation commute benefits (Bureau of Labor Statistics, 2010), and even where such alternative benefits are offered, they are generally capped at a far lower value than the parking subsidy that is provided. For these and other reasons, most employees choose to drive alone to work.

Parking cash out modifies existing employer-provided parking-only commute benefits to reward employees for using alternative transportation, while allowing employees who choose to continue to drive and park at work to do so without penalty. Both employers and employees benefit from parking cash out, since employees who accept the cash-out offer experience increased incomes, funded by savings from employers' reduced business expenses (because of not having to lease or otherwise subsidize as much parking). This helps employers in recruiting and retaining good employees.

Among 1,700 employees in eight case-study firms in Southern California, parking cash-out implementation led to an 11% reduction in drive-alone commute trips and a 12% reduction in commute vehicle-miles traveled (Shoup, 1997). Studies of parking cash out in Seattle, Washington, and the Minneapolis-St. Paul metropolitan area yielded similar results, with a 10% reduction in employee parking demand in Seattle (Glascock, et al., 2003) and an 11% shift to alternative transportation modes in Minneapolis-St. Paul (Van Hattum, et al., 2000). The benefits from this level of reduced driving can be quite high, including enhanced livability insofar as some land dedicated for parking purposes can be used for community enhancement. Parking cash out is revenue positive to governments since a portion of employees who drive alone to work and are provided a tax-exempt car-parking benefit from their employers would, if offered, choose to accept an alternative commute benefit that includes some taxable cash in exchange for utilizing other transportation.

The Internal Revenue Service already has procedures for establishing the value of parking benefits, which is needed to determine the appropriate cash-out value. Specifically, 26 CFR 1.132-9 bases such value on the costs that an individual would incur in an arm's-length transaction for a space in a comparable lot in the same general location under the same or similar circumstances.

There is a small effort required on the part of companies to establish internal systems to accommodate parking cash out, as there would be to set up any new system. Companies could also incur some benefit-related costs, including from employees who had been offered parking but had not used it accepting newly-available cash, and from cash benefits being subjected to employer payroll taxes. Employers, however, have the option to defray such costs by reducing very slightly subsidies to those who park or by charging a very small amount to park if it is now free. Since there is not a single recorded case of an employer that has begun offering cash out later taking away such an offer, the evidence is clear that employers do not see offering cash out as burdensome or costly, or at least not so burdensome or costly so as to exceed the value it provides in terms of employer-employee relations. It is important to note that nothing that is being contemplated here would alter the discretion otherwise available to employers to make choices about the parking benefits they offer to their employees or to make changes to such benefits at any time.

Ideally, the average statewide value of commuter parking could be discerned for the purpose of this modeling exercise. In reality, though, such data are only readily available at the city level, and even then are imperfect. Another challenge is that local zoning codes within the U.S. almost always require more parking be built than is used even if offered for free (or bundled with other costs), let alone if cost-recovery pricing were applied. For those owning, leasing, or otherwise in control of multiple parking spaces, most would rather make the parking available below cost (or as a “freebie” for employees or bundled with rent) rather than leaving it unused and getting no revenue or other benefit for it.

Scenario Description

The policy being considered here would have states prohibit employers from discriminating against non-drivers in the commuter benefits that they offer. It would require that, when a parking subsidy is provided, an equivalently-valued subsidy for those who do not drive to and park at work also be offered or the parking subsidy loses its tax-exempt status at the state level. The state-level requirement to offer parking cash out could be timed to give employers abundant time to shed unneeded parking (through a new lease with less parking, subletting unused parking spaces, or selling spaces) and thus to recoup costs for spaces no longer needed by employees who accept the cash-out benefits in lieu of parking. Well before 2030, it is envisioned that a state-level parking cash-out requirement would apply in all cases where there is an employee parking subsidy.

One reasonable policy approach for 2030 would be to require that commuter parking charges or cash-out values be set at a minimum of cost-recovery levels. This would allow plenty of time between now and then to change parking codes so as to eliminate the perverse incentive to oversupply and then to heavily subsidize commuter and other parking, and for excess preexisting parking to be sublet or sold, such as to occupants of new buildings constructed with too little parking, or otherwise repurposed, such as for building storage space. King County, Washington, as part of the development of its Right-size Parking Calculator, very recently went through an exercise with its development consultant, Kidder Mathews, to determine values (based in part on land costs and the type of parking that is built) for cost recovery parking charges in multi-family residential developments. The specific objective was to find the minimum parking charges that would be needed to generate returns high enough to justify the provision of the parking, using the same approach as was used for calculating the minimum rents that would be required to justify building the housing units. (While the scenario examined for this research paper is for workplace parking instead of residential parking, the approach to discerning cost-recovery parking charges should be nearly identical.)

King County’s cost-recovery parking charges, derived in detail in an August 15, 2014 final memorandum from Kidder Mathews to King County, range from a minimum of $242 per space per month for a suburban, above-ground two-story parking structure to $344 per space for underground garage parking in Seattle's Central Business District (Howe and George, 2014). It would be very reasonable for a state to require parking cash-out benefits (when parking is subsidized) of at least the lowest cost recovery level that was calculated here ($242 per space per month), but because this cost is so much above what some state political leaders at this point might perceive as reasonable, a much lower average $121 per month ($1,452 per year), or half the $242 cost, cash-out value is modeled. (To reach this $121 average cost in states with the most abundant levels of preexisting commuter parking, a minimum cash-out value might have to be established, perhaps at $100 per month.) The analysis assumes that the current ratio of commute-related VMT to overall VMT (27.77%) will remain the same in 2030. Current statewide per-vehicle VMT was multiplied by the nationwide 27.77% figure, and then reduced to reflect EIA's 2030 nationwide VMT projections for a per-capita reduction in driving from today's levels. For commuters driving to work (whether alone or in a carpool), 95% of whom are receiving a parking subsidy today as noted above, the annual cash-out value ($1,452) was divided by state-level per-vehicle commute VMT, adjusted for 2030, to determine the per-mile opportunity cost of the cash-out offer.

Converting Fixed-percentage Sales Taxes to Mileage-based Taxes

<u>Policy Background</u>

As with other measures to convert fixed driving costs to usage-based charges, replacing fixed vehicle sales taxes with mileage-based taxes for newly purchased vehicles (and replacing fixed annual registration fees with mileage-based user fees for all vehicles, which is not part of the proposed policy scenario) would result in reduced VMT, especially in the states where sales taxes are the highest. It would also spur new vehicle sales (generally with lower carbon emissions than vehicles that are replaced) as it would reduce, by the amount of the sales tax, the money that a buyer would need to have or borrow to make a purchase. The literature converges upon a price elasticity of about -1.0 for new vehicle sales and EPA and NHTSA have used this figure in their fuel economy rulemaking (USEPA and USDOT/NHTSA, 2012). Thus, in the State of Michigan, with its 6% sales tax, to take one example, new vehicle sales are estimated to increase by about 6% if this tax were to be eliminated and replaced with a mileage-based tax on newly purchased vehicles, providing a huge co-benefit in the form of a healthier U.S. auto industry.

<u>Scenario Description</u>

The specific scenario modeled takes the population-weighted combined state/local sales taxes that are charged on newly purchased vehicles, and converts them to mileage-based taxes, designed to raise the same amount of revenue. According to the Tax Foundation, 45 states collect statewide sales taxes and 38 collect local sales taxes (Tax Foundation, 2014). Table 1058, Retail Sales and Leases of New and Used Vehicles, from the Statistical Abstract of the United States, provided that 51,434,000 vehicles were sold in 2010 for an average new and used car combined price of $13,105 (U.S. Census Bureau, 2012). The scenario here assumes that the same portion of the vehicle fleet newly purchased in 2011 will also be newly purchased in 2030, and then applies the population-weighted combined average applicable state/local sales tax to the average-priced newly purchased vehicles as a mileage-fee spread over a three-year period (using statewide average per-vehicle VMT in 2011, but lowering it proportionately based on EIA's 2030 nationwide VMT projections as compared to 2011 VMT).

This, of course, is a simplification, as local sales taxes would only be converted to mileage fees where they exist, instead of being averaged out across all new vehicle purchases in a state, and states are likely to adjust per-mile fees downwards for rural drivers and upwards for urban drivers reflective of rural drivers driving more miles than urban drivers. Mileage fees are calculated assuming no change in VMT, when in reality VMT will go down because of such fees, and thus states are likely to charge a higher mileage fee (yielding greater carbon emissions reductions than this model indicates) reflective of the expectation of reduced mileage so that they don't lose revenue. If a state implements this policy in 2027 or earlier, the mileage-fee would apply to all vehicles purchased within the previous three years.

Not included in the calculations, but nevertheless appropriate to convert to mileage-based fees for states striving to meet the emissions targets of this proposal, would be: (1) converting a host of state general tax revenue sources for transportation-related expenditures to mileage-based fees, and (2) converting fixed annual vehicle registration fees to mileage-based fees. In the case of the latter, one state-by-state source of data estimates that average annual costs for vehicle taxes and fees slightly exceed costs for gasoline ($1,058 versus $1,028) (Persaud, 2014).

ALTERNATIVE STRATEGIES TO MEETING CARBON REDUCTION TARGETS

Same Strategies, but with a Behavioral Economics Twist

Another issue to consider when projecting the benefits of vehicle-use and parking pricing is the degree to which behavioral economics strategies are deployed in concert with the new pricing to encourage reductions in driving beyond what would be realized without the use of such strategies. Behavioral economics, a discipline combining economics and psychology to explain consumer decision making, offers important insights to maximize consumer acceptance and benefits. Research focused specifically on PAYDAYS insurance, but which could also be applied to other vehicle-use pricing strategies, identified the following product features and related communications protocols as most likely to increase consumer response (i.e., lead to greater reductions in driving) at all levels of premium:

- Direct and transparent per-mile charges (no rebates or requirements to purchase miles in large use-or-lose bundles);
- Frequent billing emphasizing tangible (check or even cash) as opposed to less tangible (credit card) payment forms;
- Reinforce pricing through e-mail reminders and taxi-like in-vehicle meters;
- Negotiate transit pass discounts and matching funds to buy down prices of alternative transportation modes;

- Provide individualized assistance to customers to reduce driving by identifying alternative transportation, trip consolidation, and trip elimination (e.g., through Internet shopping) options; and
- Establish reasonable driving-reduction goals for participants and provide, contingent upon achieving such goals, frequent-flyer-program-like status-related designations and rewards and "regret lottery" rewards, where participants would regret it if they had to forfeit a lottery award for failing to meet a goal (Greenberg 2010).

The benefits discussed in this research presumed that PAYDAYS insurance and vehicle sales taxes converted to mileage fees would be presented to drivers as a pure per-mile charge without the "bells-and-whistles" suggested immediately above that would likely enhance driver responsiveness to the pricing.

In a similar vein, even with a monthly parking cash-out offer (which is what was modeled), employees who are able to forgo driving their car and parking at work on any particular day are not incentivized to do so once they have chosen to keep monthly parking. A daily-in-lieu-of-monthly parking cash-out offer, which a state could also encourage or require, would create such an incentive. The PayGo Flex-pass tested this idea in Minneapolis, where employees received a $7 rebate on days they did not use parking and a $2 rebate on days they used transit instead of parking (reflective of the prorated daily cost of each), resulting in recipients cutting their driving days from 78.5% to 59.8% of work days at the end of the pilot period (Lari, et al., 2014).

Extensions or More Aggressive Forms of the Modeled Policies

As noted in the sections above discussing the specific policies modeled, more aggressive versions of the modeled policies, or logical extensions of such policies, could be deployed by states to exceed the emissions reductions of the modeled policies. While government officials in some states may choose to exceed the overall targets, others may not want to pursue all of the three modeled policies, or in some cases may not want to pursue them in a form as aggressive as that which was modeled (regardless of how modest those policies might be). Such states would then need to pursue some other strategies more aggressively than modeled to make up for shortfalls resulting from not pursuing others.

Many examples are possible. A state could encourage or require insurance policies that are 90% or more variable, instead of 70%; could apply a much higher minimum parking cash-out value (e.g., $242 per month, instead of the $141 modeled); or convert to mileage fees all vehicle-related taxes and fees instead of just sales taxes. As noted in the previous section, a host of fixed transportation-related fees besides sales taxes on newly purchased vehicles, and general-revenue taxes supporting transportation infrastructure and services, could be converted by a state to mileage-based fees. Similarly, states could incentivize, through tax credits or other policies, car leases to include direct mileage charges. (While vehicles depreciate based on age and mileage, vehicle leases are generally structured such that only a flat monthly fee is charged regardless of mileage, with end-of-lease overages for excess mileage rarely being assessed and collected.)

RESULTS

GHG Reductions from Modeled Policies

As noted, converting fixed or hidden driving costs to variable and transparent charges or cash-out benefits would result in reduced VMT. The levels of reductions are projected using observed results from previous before-after studies where consumers experienced a change in their per-mile cost of driving and adjusted their driving habits in response. These studies derive a price elasticity, which expresses the change in mileage as a function of the change in price. The overall benefits of pricing strategies are very sensitive to the price elasticity that is selected.

Some studies on price elasticity include vehicle repair and depreciation costs as part of the variable costs of driving, while others include only immediately transparent costs, such as fuel, tolls, and out-of-pocket parking expenses. When more costs are included, the percentage change in the cost of driving resulting from new variable charges is less than when fewer costs are included, thereby resulting in a higher price elasticity (making it difficult to compare studies). In addition, price elasticity changes with time, with short-term elasticity being lower than long-term elasticity (where drivers have more time to arrange for alternatives, like carpooling and teleworking).

Major studies on PAYDAYS insurance, for example, have converged on a lower-bound consensus elasticity figure of -0.15, based on finding a “conservative average” of results from previous price elasticity studies (Edlin, 1996, Bordoff and Noel, 2008, Ferreira and Minikel, 2010). That is, if the per-mile cost of driving (including fuel costs and insurance premiums that are tied directly to mileage, but generally excluding vehicle wear and tear because drivers may not consider it) doubles, drivers are expected to cut their VMT by 15%.

In this analysis, we use -0.15 as the lower-bound price elasticity and also consider only fuel costs as the starting point for driver’s per-mile price. For the mid-range elasticity in the “featured” results, this research relies on a recent analysis of medium-run elasticity of VMT with respect to gasoline price for new vehicles in California of -0.22. That analysis used “a unique and extremely rich vehicle-level dataset of all new vehicles registered in California in 2001-2003 and then subsequently given a smog check in 2005-2009, a period of steady economic growth but rapidly increasing gasoline prices after 2005” (Gillingham, 2013). An upper-bound price elasticity of -0.30 is easily justified (indeed even as a mid-range elasticity) by other research of multiple price elasticity studies (Litman, 2012). In constructing the model application, we used the arc elasticity approach (Pratt, 2013) (see Equation 8).

As presented in Table 1, using a mid-range, medium-run price elasticity of -0.22, our analysis shows that enacting a regulatory scheme to achieve the policy-based transportation efficiency targets discussed in this paper would yield nationwide carbon emissions reductions of 29.2% of those of the proposed clean power rule (on top of the reductions of that proposed rule), or 196 versus 671 million metric tons (MMT) reduction in CO_2e. The transportation efficiency measures would bring about GHG reductions greater than those calculated for the proposed clean power rule in 13 states plus the District of Columbia, representing 27.7% of the U.S. population. EPA attributes 18% of the 671 MMT reduction in CO_2e in the power rule to energy efficiency strategies, or 121 MMT of CO_2e. Thus, the transportation efficiency measures would yield 162% of the emissions reductions of the power rule's energy efficiency measures. Results are also presented using a lower-bound (-0.15) and upper-bound (-0.30) price elasticity, with the former leading to 20.6% of the carbon emissions reductions of the electric utility proposed rule for existing sources and the latter leading to reductions of 38.3%.

It is worth noting that had NHTSA and EPA not set such aggressive fuel economy standards, the vehicle fleet in 2030 would be far less efficient and the impact of mileage reductions on carbon emissions resulting from the transportation efficiency policy outlined in this research would be much greater. Similarly, if implementation were to be required earlier than 2030, the reductions would also be greater, as the fuel economy standards require year-over-year improvements in vehicle efficiency meaning that earlier-year reductions in VMT will yield greater fuel savings than later-year reductions.

Table 2 provides a summary of the results of the analysis by state for the -0.22 price elasticity scenario. For Vermont and the District of Columbia, EPA's proposed rule did not establish emissions reductions goals due to a lack of eligible power plants. The EPA Integrated Planning Model (IPM), used by EPA to illustrate the power rule reductions at the state level, does not include Alaska and Hawaii, although these states are covered by the proposed rulemaking. In the case of three states—Kentucky, Maryland, and Rhode Island—the IPM actually indicated increases in emissions over the Base Case. One source theorized that this is not an irrational result if rate-based efficiency measures displace a cleaner generating source with a less clean source (The Brattle Group, 2014).

Table 1. Model Application Summary

Scenario	Assumed Price Elasticity	Total Nationwide Million Metric Tons (MMT) of CO_2e Reduction	Percentage of Nationwide Power Rule MMT of CO_2e Reduction	Number of States (including D.C.) Where Transportation Reductions Exceed Power Plant Reductions	Percentage of U.S. 2030 Population Total Represented by these States
1	-0.15	138.3	20.6%	11	21.1%
2	-0.22	196.0	29.2%	14	27.7%
3	-0.30	257.2	38.3%	18	34.3%

Table 2. Summary of Analysis by State for Selected Scenario

	CO_2E Reduction in Million Metric Tons (MMT)			CO_2E Reduction in Million Metric Tons (MMT)	
State	Estimated EPA Power Rule	Estimated Transportation Policy Strategy	State	Estimated EPA Power Rule	Estimated Transportation Policy Strategy
Alabama	21.8	3.4	Montana	1.3	0.8
Alaska	N/A*	0.4	Nebraska	2.9	1.1
Arizona	23.6	5.1	Nevada	0.2	2.1
Arkansas	36.2	1.9	New Hampshire	2.8	0.9
California	10.4	25.9	New Jersey	15.1	4.4
Colorado	11.4	3.1	New Mexico	2.0	1.4
Connecticut	1.4	2.0	New York	6.8	6.9
Delaware	0.5	0.6	North Carolina	32.6	5.6
District of Columbi	0.0	0.2	North Dakota	2.9	0.4
Florida	54.2	17.0	Ohio	10.0	6.9
Georgia	44.2	7.8	Oklahoma	26.6	2.1
Hawaii	N/A*	0.7	Oregon	1.5	2.3
Idaho	1.2	1.0	Pennsylvania	39.2	5.9
Illinois	12.8	6.5	Rhode Island	-2.3	0.6
Indiana	7.3	3.9	South Carolina	4.9	3.3
Iowa	2.5	1.7	South Dakota	2.7	0.5
Kansas	3.0	1.6	Tennessee	11.8	4.4
Kentucky	-11.7	2.6	Texas	126.9	17.0
Louisiana	1.0	3.1	Utah	17.4	1.7
Maine	4.6	0.7	Vermont	0.0	0.4
Maryland	-2.0	3.7	Virginia	11.0	5.0
Massachusetts	4.8	3.7	Washington	4.1	4.1
Michigan	22.5	7.5	West Virginia	29.5	0.9
Minnesota	22.6	3.6	Wisconsin	20.2	4.2
Mississippi	11.4	1.7	Wyoming	13.0	0.4
Missouri	3.7	3.6			
			TOTAL	**670.8**	**196.0**
			As % of EPA Power Rule		**29.2%**

Notes: Using price elasticity of -0.22
Green indicates states where reductions from transportation strategies exceed power rule.
Power rule reductions are based on EPA Integrate Planning Model (IPM) Base Case 5.1.3 versus Option 1 State Case. Negative reductions are estimated by IPM for Kentucky, Maryland, and Rhode Island.
* IPM does not address Alaska or Hawaii.

A Note About Benefits Unrelated to Carbon Emissions

While outside the scope of this research, it is nevertheless worth noting that transportation pricing measures, because they reduce VMT, eliminate a host of driving related externalities aside from carbon emissions. EPA sets per-mile emissions standards for non-carbon tailpipe pollutants, meaning that the fewer miles driven, the lesser the pollutant emissions. Congestion reduction has been shown to be disproportionately greater than mileage reductions at times where overall VMT has decreased. For example, a 2008 INRIX report, “The Impact of Fuel Prices on Consumer Behavior and Traffic Congestion,” concluded that the price spikes led to a 26% reduction of peak-hour congestion, resulting from a much smaller reduction (i.e., around 3%) in VMT (INRIX, 2008). Crash reductions, and likely insurance claims’ reductions, would be about 1.34 times the reduced VMT accounting for multiple-vehicle crashes that would not have occurred had one of the vehicles involved been off the road (Greenberg, 2002). Finally, Federal Highway Administration models estimate that the level of public infrastructure investment that is required to maintain economic efficiency is 3 to 5¢ less for every mile not driven (Greenberg, 2002).

Policies focused only on carbon emissions reductions, most prominently and recently the joint EPA/NHTSA fuel economy rule (USEPA and USDOT/NHTSA, 2012), actually increase VMT, and thus VMT-related externalities, because they result in lower fuel costs per mile traveled and therefore more driving (which is known as the “rebound effect”). Thus, absent deploying new forms of variable transportation pricing such as of the types modeled in this research, the carbon emissions reductions from the fuel economy standard will be diminished due to the rebound effect.

ARE THESE RESULTS REAL? EXPECTED MARKET DEVELOPMENTS, ABSENT GOVERNMENT INTERVENTION

Starting Considerations: EPA’s Proposed Electric Utility Rulemaking for Existing Sources

A number of states, such as California, and multi-state consortiums, such as the Northeast States for Coordinated Air Use Management (or NESCAUM), are already taking aggressive actions to curtail greenhouse emissions and have committed to more aggressive implementation going forward. EPA’s emissions targets generally reflect best practices, including projecting the effects of already-enacted policies. It can be argued that EPA’s proposed rulemaking would “lock in” best practices for states that are deploying them, which is itself a benefit. The same could be said about this proposal for transportation emissions reductions, although best practices in the three policy areas that were explored in this research are somewhat weak.

The Energy Information Administration’s (EIA’s) 2030 VMT Projections

EIA developed a “Reference Case” scenario for VMT growth through 2040, plus a Low VMT and a High VMT case. All of its scenarios are anchored on assumptions related to the fuel cost of driving, disposable personal income, employment, vehicles per licensed driver and past VMT trends. In none of the scenarios, at least as can be discerned from EIA's documentation, are the policies that are modeled in this research paper included, meaning that such policies are presumed not to be implemented in 2040 (or 2030) (USEIA, April 2014, and USEIA, July 2014).

While accurately projecting whether state governments might, absent a Federal rulemaking, mandate parking cash-out (which California alone currently does, but only under narrow and limited circumstances) or convert vehicle sales taxes to mileage-based fees is not feasible, more could be said about possible market deployment of PAYDAYS insurance.

Insurance companies today have compelling reasons to use telematics for market segmentation and do offer consumers some incentives to gain their cooperation (e.g., "PAYDAYS insurance lite" policies where some minor discounts are offered in exchange for drivers sharing telematics data). However, these firms experience little market pressure to use the data to offer genuine PAYDAYS premiums.

Companies that fail to use telematics for segmentation face fairly extreme adverse selection risk. For example, one firm that facilitates insurance companies in offering usage-based insurance asserted the following benefits of its driver evaluation scoring at a recent industry conference: when insurance companies with sophisticated, but not telematics-informed, premium-setting models use its usage-based score to recalculate premiums, 10% of drivers had an expected loss ratio (meaning the ratio of claims paid to premium dollars collected) of 30% or less of the average-driver loss ratio and another 10% of drivers, at the other extreme, had an expected loss ratio that was 250% greater than the average (Harbage, 2013). Clearly, adverse selection will occur if some companies have this data, and price accordingly, while others do not, and the latter will likely be unable to price in a way that will both retain market share and enable continued profitability.

The benefits of having consumers appreciate how their driving affects their rates and then being provided an opportunity to change behavior to save on premiums may be lost if "black box" pricing becomes the norm. ("Black box" pricing refers to where an insurance company gathers and applies usage-based data in premium setting primarily for improved market segmentation—to offer the most attractive rates to the lowest-risk drivers within any rate class—but without the consumer having any detailed knowledge as to how their usage characteristics affect their rates.) This concern is not just theoretical since the majority of the over two million people who have signed up for telematics-enabled insurance products are not provided by their insurance carriers significant personalized guidance about reducing their crash exposure and earning premium savings as a result.

The key unknown, though, is whether the PAYDAYS insurance products that are to become prevalent in the marketplace will provide transparent and variable pricing that encourages motorists to reduce their risk exposure in order to secure a lower rate, or instead whether the products will improve driver segmentation without offering such incentives (and, thus, without yielding benefits). The question remains whether, absent policy intervention (which could be a mandate, but may instead be targeted tax credits), drivers will be afforded this opportunity. Similar questions also apply to the policy interventions modeled within EIA's proposed electric utility rulemaking.

CONCLUSIONS

EPA's proposed electric utility rule for existing sources has opened up people's imaginations as to how consumers can be encouraged to adopt efficient behavior, without necessarily enacting a carbon tax (although it is not precluded as a means for states to meet the proposed rule's targets). In the case of personal transport emissions from existing vehicles, this research illustrates just how substantial the opportunity is to convert fixed and hidden costs to variable and transparent ones, yielding enormous reductions in GHG emissions that could build significantly on the projected reductions from EPA's proposed electric utility rule.

MODEL DOCUMENTATION

The parameters and equations used in applying the scenarios in our model are detailed below. The nomenclature for the parameters is as follows: (1) for the first letter, "S" indicates that there is a different value for this parameter in each state, while "F" indicates that there is only a single Federal figure; (2) for the second letter, "E" is for a parameter used mostly or exclusively for power rule emissions calculations, while "T" is for a parameter used mostly or exclusively for transportation emissions calculations, and; (3) for parameters consisting of four characters and ending in an "F," as all four-character parameters do, the "F" indicates a "Federal sum" of all of the state-level figures.

Equation 1 – Power Rule Reduction

$$Power\ Rule\ Reduction = SE1 + SE2$$

Where:

SE1 = CO_2 emissions reduction in MMT in 2030 based on the difference reported from the U.S. EPA Integrated Planning Model (IPM) Base Case versus the Option 1 State Case (Based on USEPA, June 12, 2014)

SE2 = CO_2 equivalent emissions reduction in MMT in 2030 due to emissions reduction in annual NOx as reported from the U.S. EPA IPM Base Case versus the Option 1 State Case (Based on USEPA, June 12, 2014)

Note:

We converted NOx to CO_2 equivalent emissions using global warming potential index value of 298 (IPCC 2014 [Table 8.7]).

Equation 2 – Estimated 2030 VMT by State

$$SC1 = FT4 \times \frac{\frac{ST2}{ST3}}{\frac{ST2F}{ST3F}} \times \left(\frac{ST4}{ST4F}\right)$$

Where:
ST2 = Vehicle miles of travel (VMT) in 2011 for state
ST2F = Total VMT in 2011 (U.S. total)
ST3 = Estimated population in 2011 for state
ST3F = Population of all states in 2011 (U.S. total)
ST4 = Projected population in 2030 for state
ST4F = Projected population of all states in 2030 (U.S. total)
FT4 = Projected VMT in 2030 for U.S.

Equation 3 – Estimated 2030 Cost per Mile for Pay-As-You-Drive Insurance (100% Penetration) by State

$$SCA = \frac{ST5 \times FT9}{\frac{ST2}{ST1}}$$

Where:
ST1 = Registered light duty vehicles (LDV) in 2011 for state
ST2 = VMT in 2011 for state
ST5 = Average car insurance premium from January 2014 for state
FT9 = Percentage of insurance premium that is assumed variable (U.S. average)

Equation 4 – Estimated 2030 Cost per Mile for Parking Cash Out

$$SCB = \frac{FT10}{\frac{ST2 \times FT5}{(ST7 \times ST8) + \frac{(ST7 \times ST9)}{FT2}} \times \frac{FT4}{ST2F}} \times \frac{ST4F}{ST3F}$$

Where:
FT2 = Average vehicle occupancy of carpool/vanpool
FT4= Projected VMT in 2030 for U.S.
FT5 = U.S. percentage of commute VMT of total VMT in 2009
FT10 = Average parking cash-out value modeled
ST2 = VMT in 2011 for state
ST7 = Number of workers in 2011 for state
ST8 = Percent drive alone to work in 2011 for state
ST9 = Percent carpooling to work in 2011 for state
ST2F = Total VMT in 2011 (U.S. total)
ST3F = Population of all states in 2011 (U.S. total)
ST4F = Projected population of all states in 2030 (U.S. total)

Equation 5 – Estimated 2030 Cost per Mile for Sales Tax Converted to VMT Tax

$$SCC = \frac{FT13 \times \frac{ST6}{FT11}}{\frac{ST2}{ST1} \times \frac{FT4}{ST2F}} \times \frac{ST4F}{ST3F}$$

Where:
FT4 = U.S. projected VMT in 2030
FT11 = Number of years over which sales tax charges for newly purchased vehicles is distributed
FT13 = Average U.S. vehicle sales price (new and used) in 2010
ST1 = Registered LDV in 2011 for state
ST2 = VMT in 2011 for state
ST2F = Total VMT in 2011 (U.S. total)
ST3F = Population of all states in 2011 (U.S. total)
ST4F = Projected population of all states in 2030 (U.S. total)
ST6 = Combined population-weighted state/local sales tax rates in 2014

Equation 6 – U.S. Percentage of Commuter VMT with Free Parking

$$SC2 = FT5 \times FT8$$

Where:
FT5 = U.S. percentage of commute VMT of total VMT in 2009
FT8 = Percentage of workers with free parking

Equation 7 – U.S. Percentage of New Vehicles in LDV Fleet within Past Three Years

$$SC3 = \frac{FT12}{ST1F} \times FT11$$

Where:
FT11 = Number of years over which sales tax charges for newly purchased vehicles is distributed
FT12 = U.S. LDV sales and leases (new and used) in 2010
ST1F = Registered LDVs (U.S. total)

Equation 8 – Generalized LDV Fleet Reduction Price Elasticity Equation

$$LDVR = Q_1 \times \left(\left(\frac{P_2}{P_1} \right)^{\eta} - 1 \right)$$

Where:
Q_1 = Original LDV miles to which potential strategy applies
P_1 = Cost per mile of gasoline
P_2 = Cost per mile of gasoline plus cost per mile of applicable strategies
η = Price elasticity

Equation 9 – LDV Fleet Reduction in Driving due to Factors A+B+C

$$LDVR_{A+B+C} = SC1 \times SC2 \times SC3 \times \left(\left(\frac{SCA + SCB + SCC + \frac{FT7}{FT6}}{\frac{FT7}{FT6}} \right)^{FT1} - 1 \right)$$

Where:
SC1 = Estimated 2030 VMT by state (see Equation 2)
SC2 = U.S. percentage of commuter VMT with free parking (see Equation 6)
SC3 = U.S. percentage of new vehicles in fleet within past three years (see Equation 7)
SCA = Estimated 2030 cost per mile for PAYDAYS insurance (100% penetration) by state (see Equation 3)
SCB = Estimated 2030 cost per mile for parking cash out (see Equation 4)
SCC = Estimated 2030 cost per mile for sales tax converted to VMT tax (see Equation 5)
FT1 = Price elasticity
FT6 = U.S. LDV average fuel economy in 2030
FT7 = U.S projected fuel price in 2030

Equation 10 – LDV Fleet Reduction in VMT due to Factors A+B

$$LDVR_{A+B} = SC2 \times (1 - SC3) \times \left(\left(\frac{SCA + SCB + \frac{FT7}{FT6}}{\frac{FT7}{FT6}} \right)^{FT1} - 1 \right)$$

Where:
SC1 = Estimated 2030 VMT by state (see Equation 2)
SC2 = U.S. percentage of commuter VMT with free parking (see Equation 6)
SC3 = U.S. percentage of new vehicles in fleet within past three years (see Equation 7)
SCA = Estimated 2030 cost per mile for PAYDAYS insurance (100% penetration) by state (see Equation 3)
SCB = Estimated 2030 cost per mile for parking cash out (see Equation 4)
FT1 = Price elasticity
FT6 = U.S. LDV average fuel economy in 2030
FT7 = U.S projected fuel price in 2030

Equation 11 – LDV Fleet Reduction in VMT due to Factors A+C

$$LDVR_{A+C} = SC1 \times SC3 \times (1 - SC2) \times \left(\left(\frac{SCA + SCC + \frac{FT7}{FT6}}{\frac{FT7}{FT6}} \right)^{FT1} - 1 \right)$$

Where:
SC1 = Estimated 2030 VMT by state (see Equation 2)
SC2 = U.S. percentage of commuter VMT with free parking (see Equation 6)
SC3 = U.S. percentage of new vehicles in fleet within past three years (see Equation 7)

SCA = Estimated 2030 cost per mile for PAYDAYS insurance (100% penetration) by state (see Equation 3)
SCC = Estimated 2030 cost per mile for sales tax converted to VMT tax (see Equation 5)
FT1 = Price elasticity
FT6 = U.S. LDV average fuel economy in 2030
FT7 = U.S projected fuel price in 2030

Equation 12 – LDV Fleet Reduction in VMT due to Factor A

$$LDVR_A = SC1 \times \left(1 - \left((SC2 \times SC3) + \left(SC2 \times (1 - SC3)\right) + \left(SC3 \times (1 - SC2)\right)\right)\right) \times \left(\left(\frac{SCA + \frac{FT7}{FT6}}{\frac{FT7}{FT6}}\right)^{FT1} - 1\right)$$

Where:
SC1 = Estimated 2030 VMT by state (see Equation 2)
SC2 = U.S. percentage of commuter VMT with free parking (see Equation 6)
SC3 = U.S. percentage of new vehicles in fleet within past three years (see Equation 7)
SCA = Estimated 2030 cost per mile for PAYDAYS insurance (100% penetration) by state (see Equation 3)
FT1 = Price elasticity
FT6 = U.S. LDV average fuel economy in 2030
FT7 = U.S projected fuel price in 2030

Equation 13 –Reduction in CO_2E due to Application of Strategies

$$CO_2e\ Reduction = \left(LDVR_{A+B+C} + LDVR_{A+B} + LDVR_{A+C} + LDVR_A\right) \times \frac{FT3}{FT4}$$

Where:
$LDVR_x$ = LDV reduction in VMT due to strategy *x* (see Equations 9-12, above)
FT3 = LDV CO_2 equivalent emissions in 2030 in U.S.
FT4 = Projected VMT in 2030 in U.S.

Figure 1 – Model Parameter Summary

Description		Parameter	Units	Source
State-Level Parameters and Inputs				
Energy/Power				
SE1	CO_2 emissions reduction in 2030		MMT	Uses Difference between EPA Integrated Planning Model (IPM) Base Case and Option 1 State Case
SE2	CO_2 equivalent emissions reduction due to annual NOx emissions reduction in 2030		MMT	Uses Difference between EPA IPM Base Case and Option 1 State Case
Transportation				
ST1a	Registered cars in 2011			from BTS STS Table 5-1
ST1b	Registered pickups in 2011			from BTS STS Table 5-1
ST1c	Registered vans in 2011			from BTS STS Table 5-1
ST1d	Registered sport untility vehicles in 2011			from BTS STS Table 5-1
ST1	Registered light duty vehicles (LDV) in 2011			derived value
ST2	Total vehicle miles of travel (VMT) in 2011			from BTS STS Table 5-3
ST3	Estimated population in 2011			from BTS STS Table 5-3
ST4	Projected population in 2030			Census, 2005 Interim State Population Projection, Table 1
ST5	Average car insurance premium from January 2014			insure.com
ST6	Combined state/local sales tax rates from January 2014, population weighted			Tax Foundation
ST7	Number of workers in 2011			from BTS STS Table 4-1
ST8	Percent drive alone to work in 2011			from BTS STS Table 4-1
ST9	Percent carpooling to work in 2011			from BTS STS Table 4-1
Federal-Level Parameters and Inputs				
Transportation				
FT1	Price elasticity	-0.22		Gillingham, K. (2013)
FT2	Average vehicle occupancy of carpool/vanpool	2.4		Based on 2010 CTPP (Table A102106)
FT3	LDV CO2 equivalent emissions in 2030	1,108	MMT	U.S. EIA VISION 2014 AEO Base Case
FT4	U.S. projected VMT in 2030	3,228,085	in million:	U.S. EIA VISION 2014 AEO Base Case
FT5	Percentage commute VMT of total VMT in 2009	27.77%		Based on 2009 National Household Travel Survey (NHTS)
FT6	LDV average fuel economy in 2030	32.6	MPG	U.S. EIA, Annual Energy Outlook 2014, Table A7
FT7	U.S. projected fuel price in 2030	$ 3.21	per gallon	U.S. EIA VISION 2014 AEO Base Case
FT8	Percentage of workers with free parking	95%		Bureau of Labor Statistics
FT9	Percentage of insurance premium that is variable	70%		Author modeled policy
FT10	Average parking cash-out value	$ 1,452	per year	see paper
FT11	Number of years over which sales tax charges for newly purchased vehicles is distributed	3	years	see paper
FT12	U.S. LDV sales and leases (new and used) in 2010	51,434,000		U.S. BTS, National Transportation Statistics, Table 1-17 (January 2012)
FT13	Average U.S. vehicle sales price (new and used) in 2010	$ 13,105		U.S. BTS, National Transportation Statistics, Table 1-17 (January 2012)
ST1F	U.S. registered LDV (sum of state-level figures)	229,259,112		U.S. BTS, State Transportation Statistics 2013, Table 5-1
ST2F	U.S. total VMT in 2011 (sum of state-level figures)	2,946,132	millions	U.S. BTS, State Transportation Statistics 2013, Table 5-3
ST3F	U.S. population (sum of state-level figures)	311,587,816		U.S. BTS, State Transportation Statistics 2013, Table 5-3
ST4F	Projected U.S. population (sum of state-level figures)	363,584,435		U.S. Census Bureau, Population Division, Interim State Population Projections, Table 1, 2005.

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