Most current emission reduction plans devote far more funding to electric vehicle subsidies than to active and public transport improvements, despite these modes’ large co-benefits. That is inefficient and unfair.

Abstract
Many jurisdictions have ambitious greenhouse gas emission reduction targets and plans. This study critically evaluates the methods used to develop these plans. It finds that the evaluation process is often biased in ways that exaggerate the benefits of clean vehicles such as hybrid and electric automobiles, and undervalue vehicle travel reduction strategies such as transportation demand management (TDM) programs and Smart Growth policies. Many plans are overly-optimistic about clean vehicle implementation speed and effectiveness, and underestimate TDM effectiveness. They often overlook clean vehicle lifecycle emissions, rebound effects, plus the high costs and inequities of clean vehicle subsidies. Most plans overlook some of the most effective TDM strategies and their co-benefits. As a result of these biases, most current emission reduction plans overemphasize clean vehicles and underemphasize vehicle travel reductions compared with what is optimal. This study suggests that to be efficient and equitable, transportation emission reduction plans should rely at least as much on vehicle travel reductions as on clean vehicle strategies, with particular emphasis on “quick win” strategies. It provides recommendations for improving analysis methods.
Introduction
Many jurisdictions and organizations have ambitious climate change (also called Greenhouse Gas or GHG) emission reduction goals and targets, and are developing plans to achieve them (1, 2). For example, President Biden recently established a target to reduce U.S. GHG emissions 50-52% by 2030 (3). Since transportation is one of the largest emission sources, it is a major component of such plans.

There are many possible ways to reduce transportation emissions. These include “clean vehicle” strategies that reduce emission rates, and transportation demand management (TDM) and Smart Growth policies that reduce total vehicle travel, as summarized in Table 1.

<table>
<thead>
<tr>
<th>Clean Vehicles</th>
<th>Vehicle Travel Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technologies and policies that reduce emission rates per vehicle-mile</td>
<td>TDM and Smart Growth policies that reduce total vehicle travel</td>
</tr>
<tr>
<td>• Shifts to more efficient and alternative fuel vehicles (e.g., hybrid, electric and hydrogen).</td>
<td>• Multimodal planning (improve walking, bicycling, public transit, ridesharing, etc.)</td>
</tr>
<tr>
<td>• High emitting vehicle scrapage programs.</td>
<td>• Smart Growth policies that create more compact and multimodal communities.</td>
</tr>
<tr>
<td>• Efficient driving and anti-idling campaigns.</td>
<td>• Transportation Demand Management programs (commute trip reduction, freight transport management, etc.)</td>
</tr>
<tr>
<td>• Switching to lower carbon and cleaner fuels.</td>
<td>• More efficient road, parking and vehicle pricing.</td>
</tr>
<tr>
<td>• Inspection and maintenance programs.</td>
<td>• Vehicle parking policy reforms.</td>
</tr>
<tr>
<td>• Resurface highways.</td>
<td>• Increase fuel prices by reducing subsidies and increasing taxes (encourages both types of strategies)</td>
</tr>
<tr>
<td>• Roadside “high emitter” identification</td>
<td></td>
</tr>
</tbody>
</table>

“Cleaner vehicles” reduce per-mile emission rates. Vehicle travel reductions reduce total motor vehicle travel. Fuel price increases help achieve both.

Which strategies are most effective and beneficial overall? That depends on how they are analyzed. This study critically evaluates the analysis methods used in typical emission reduction plans, including the types of strategies considered, models used to predict their effects on travel and emissions, and the scope of benefits and costs considered in analysis.

This is an important and timely issue. Large and rapid emission reductions are needed to protect the world’s climate. It is important to identify the most effective and beneficial ways to achieve these goals. Transportation policies have broad economic, social and environmental effects; it is important that emission reduction analysis be comprehensive, accounting for all impacts. This study provides specific recommendations for improving emission reduction planning methods.
Emission Reductions Plans Reviewed
Below are summaries of emission reduction plans evaluated in this study.

*Accelerating Decarbonization of the U.S. Energy System* ([https://nap.edu/resource/25932/interactive](https://nap.edu/resource/25932/interactive)) by the National Academy of Sciences. This major study identifies actions needed to reach net-zero emissions by 2050. Its transportation goals include 50% zero-emission vehicle sales by 2030, more multiple occupancy vehicle trips, and urban planning changes to facilitate biking and walkability. It ignores rebound effects, parking policy reforms, and efficient transportation pricing.

*Accelerating Climate Action in Israel: Refocusing Mitigation Policies* ([doi.org/10.1787/fb32aabd-en](https://doi.org/10.1787/fb32aabd-en)) by the OECD. This study emphasizes the need to reduce vehicle travel and encourage electrification using efficient pricing, multimodal transport planning, and more compact, accessible development.


*An Actionable Vision of Transport Decarbonization,* ([https://bit.ly/2mBWtZm](https://bit.ly/2mBWtZm)) by the Global Climate Action Agenda Transport Team. This study identifies ways to achieve significant emission reductions and other sustainable development goals. It identifies “quick win” actions that include transport planning reforms, electric vehicle recharging infrastructure, freight efficiency, car- and bike-sharing, active and public transport (particularly bus) improvements, better traveler information systems, phase-out fossil fuel subsidies, carbon taxes, and more efficient road and parking pricing.

*Blueprint 2030: An All-In Climate Strategy for Faster, More Durable Emissions Reductions* ([www.americaisallin.com/blueprint-2030](http://www.americaisallin.com/blueprint-2030)) describes a whole-of-society approach to cut emissions by at least 50% by 2030 and set the stage for full decarbonization before mid-century. Transportation policies emphasize vehicle electrification, but also include public transit investments and more compact and multimodal community development.


*Clearing the Air: Transportation, Land Use and Carbon Emissions in Metro Vancouver* ([https://bit.ly/3rJjkE3](https://bit.ly/3rJjkE3)) by the David Suzuki Foundation. This study evaluates a relatively small set of transportation emission reduction strategies using an outdated transportation model. It concludes that TDM and Smart Growth policies provide small emission reductions in Vancouver, Canada.

*Draft Advice for Consultation* ([https://bit.ly/3jQJTDC](https://bit.ly/3jQJTDC)) by the New Zealand Climate Change Commission. This study evaluates emission reduction strategies based on the degree they support other strategic goals. It recommends urban planning reforms, walking and cycling improvements, efficient freight management, reliable and affordable public and shared transport, plus electric or low-emission vehicles.
Driving Down Emissions: Transportation, Land Use and Climate Change, (https://bit.ly/3tLZBEw) by Transportation for America and Smart Growth America. This report argues that large emission reductions are possible by meeting the demand for housing in accessible, multimodal communities.

Driving California’s Transportation Emissions to Zero (https://escholarship.org/uc/item/3np3p2t0) by the University of California’s Institute of Transportation Studies. This study identifies ways that California can achieve carbon-neutral transportation by 2045. It states that, “Reducing VMT in California from light, medium, and heavy-duty vehicles is a critical part of reducing transportation system GHG emissions.” It identifies various TDM strategies such as car-, bikesharing and ridehailing services, public transit improvements and road pricing, but overlooks parking policy reforms and Smart Growth policies.


50 Steps Toward Carbon-Free Transportation: Rethinking U.S. Transportation Policy to Fight Global Warming (https://bit.ly/3j7G10N) by the Frontier Group. This report provides an agenda for reforming current policies that increase vehicle emissions. It recommends vehicle electrification, Smart Growth development policies, more shared mobility, active and public transport improvements, road space reallocation, efficient transport pricing, and deployment of new technologies that reduce emissions.

Net Zero by 2050: A Roadmap for the Global Energy Sector, International Energy Agency. This report describes various changes in energy production and consumption required to achieve net zero by 2050. The proposed pathways rely primarily on fuel shifting and energy efficiency gains, including shifts to low carbon fuel vehicles (particularly electricity). Behavior changes, “such as replacing car trips with walking, cycling or public transport, or foregoing a long-haul flight” are expected to achieve an estimated 4% of emission reduction targets.

Project Drawdown (https://drawdown.org) is a major planning exercise that identifies and evaluates various emission reduction technologies. It identifies outcome, such as cleaner vehicles and mode shifting, but gives little attention to the policies and incentives needed to achieve these outcomes, such as TDM incentives and Smart Growth development policies.

Transport and Climate Change Global Status Report (https://tcc-gsr.com), by Sustainable Low Carbon Transportation (SLOCAT). This detailed (365-page) report evaluates transport’s contribution to climate change, ways to reduce emission, and various success stories. It emphasizes the importance of balancing climate action with other development goals, and so advocates avoid-shift-improve prioritization which favors vehicle travel reductions over clean vehicle strategies.

Transport Climate Action Directory, (www.itf-oecd.org/tcad-measures) by the International Transport Forum. This website describes over 60 climate mitigation strategies, including their emission reductions, costs and co-benefits. It includes many TDM and Smart Growth policies.
Comprehensive Transportation Emission Reduction Planning
Victoria Transport Policy Institute

Updated NDCs – What Do They Say About Transport? ([https://bit.ly/3febltV](https://bit.ly/3febltV)) by Changing Transport. This study evaluates National Determined Contributions (NDC), which identify how countries plan to achieve their emission reduction targets. Of 47 submissions only eight include specific transport emission reduction targets, 11 specify other transport targets such as electric-vehicle adoption rates, 57% shift travel to resource-efficient modes, while only 6% aim to reduce total travel.

Zero Carbon Action Plan (ZCAP) for the United States ([www.unsdsn.org/Zero-Carbon-Action-Plan](http://www.unsdsn.org/Zero-Carbon-Action-Plan)) by the Sustainable Development Solutions Network. This major study recommends that 30% of new vehicles be electric by 2030 and per capita vehicle travel be reduced 25% by 2050. To achieve those targets it recommends shifting funds from roadways to resource-efficient modes, plus more compact development. It recommends linking transportation funding to VMT reductions. It states, “Transportation is generally seen as the most challenging sector to decarbonize, but it may also prove one of the least costly—even eventually providing large economic saving. It is also the sector with the greatest opportunity to provide a large number of associated co-benefits to travelers and society and to create a more environmentally sustainable and equitable society.”

The report, Changing Transport, Summary Analysis evaluated the commitments and goals to decarbonise transport in the Nationally Determined Contributions (NDCs) submitted to the United Nations Framework Convention on Climate Change. It found that more than half of emission reduction actions encourage fuel shifting and less than a quarter encourage vehicle travel reductions, as illustrated to the right.  

Most these studies focus on technical solutions, such as shifts to hydrogen and electric vehicles, with the assumption that these fuels will be produced by renewable processes that have minimal GHG emissions. Many mention transportation demand management, such as active and public transport improvements, but they are often assumed to have limited potential, high costs, and little public support. Most of these studies only consider emission reductions – few consider TDM co-benefits. A few of these studies recognize other sustainable development goals such as social equity (and therefore improving accessibility for non-drivers), public health and safety, and reducing sprawl-related costs, which would provide more support for vehicle travel reduction strategies (i.e., avoid-shift-improve prioritization).

These studies also vary in the perspective and scope of strategies that are considered. Some only consider outcomes, such as people driving less or using electric vehicles, while others consider the policy reforms and incentives that will required to motivate these changes, such as more multimodal transportation planning, carbon taxes, road pricing and parking policy reforms.
Common Analysis Biases
This section describes various biases found in the emission reduction plans evaluated.

Unrealistic Fleet Turnover Predictions
Many plans use overly optimistic fleet turnover predictions. For example, the Clearing the Air report assumes that current policies will eliminate conventional vehicles by 2030 and cause 90% of vehicle travel will be electric by 2050, as illustrated below. These assumptions are unrealistic.

**Figure 2** Percentage of Different Types of Personal Vehicles on the Road (11)

The “Clearing the Air” report assumes, unrealistically, that all vehicles will be efficient or zero emission vehicles by 2030. This exaggerates clean vehicle benefits.

(ICE = Internal Combustion Engine; VES = Vehicle Emission Standard)

Since only about 5% of personal vehicles are replaced each year, it takes decades for new technologies to fully penetrate the fleet unless many operable vehicles are scrapped prematurely. Electric vehicles currently represent less than 2% of new vehicle sales. Although new vehicles tend to be driven more annual miles than older vehicles, this is offset by the fact that fuel-intensive vehicle types (SUVs, light truck and vans) more slowly than cars, so the remaining fossil fuel fleet will be extra energy intensive. Optimistically, half of new vehicles could be electric by 2030, but realistically it will probably take longer, and remaining fossil fuel vehicles will skew to low fuel economy (12). With current policies, the fleet is unlikely to be fully electric by 2050, as illustrated below (13).

**Figure 3** Optimistic and Realistic Electric Vehicle Sales and Fleet Penetration

Optimistically, half of new vehicle sales could be electric by 2030, but realistically it will probably take longer, and since only about 5% of vehicles are replaced each year, it takes 15-20 years before a percentage of vehicle sales are reflected in the fleet. With current policies it is unlikely that the fleet will be fully electric before 2050.
A recent study by the Carnegie Mellon University, *Decarbonizing US Passenger Vehicle Transport Under Electrification and Automation Uncertainty has a Travel Budget*, also concluded that vehicle travel reductions are needed to reduce automobile emissions 80% by 2050 (14). Similarly, detailed analysis by the State Smart Transportation Initiative predicts that current vehicle electrification efforts will fail to achieve emission reduction targets, particularly if vehicle travel continues to grow, as illustrated below.

**Figure 4 Predicted Emissions Based on U.S. EIA’s Annual Energy Outlook** (15)

With current vehicle travel growth, due in part to rebound effects from vehicle electrification and automation, fleet electrification will not achieve 2050 emission reduction targets.

**Outdated Transportation Models**

Emission reduction plans use transportation models to predict how a policy will affect vehicle travel and emissions. Many of these models are outdated and inaccurate. For example, a major study, *The Impacts of Land Use and Pricing in Reducing Vehicle Miles Traveled*, predicted that a 25¢ per mile VMT fee, equivalent to a $5 per gallon fuel tax, would reduce affected vehicle travel just 15% (16). It explains, “This is due to the low price-elasticity of vehicle travel demand – a known feature of travel behavior that can be attributed partially to the lack of competitive alternative modes of travel in much of the region.”

Such low elasticity values are based on studies performed in the U.S. during the last quarter of the Twentieth Century when employment rates and wages were increasing, and fuel prices were relatively low, which showed very low price elasticities (17). More recent studies indicate that vehicle travel is two or three times more price sensitive than older models assume (18, 19). These biases can significantly affect analysis results. For example, if an older model predicts that a price change will reduce vehicle travel 5%, the actual long-term impact is likely to be 10-15%. Similarly, if it predicts that electric vehicles will be driven 10% more annual miles than comparable fossil fuel vehicles, the true rebound effect is probably 20-30%. Older models also underestimate TDM and Smart Growth emission reductions (20).
Rebound Effects
Because cleaner vehicles generally have lower operating costs they tend to increase total vehicle travel and associated costs. For example, electric cars cost about half as much to operate as a comparable fossil fuel car, which typically increases vehicle-miles 10-30% (21). This is called a rebound effect, and the additional vehicle-miles are called induced vehicle travel. Although there are still net emission reductions — a 10-30% rebound effect leaves 70-90% net savings — the induced travel increases congestion, infrastructure costs, crashes, and sprawl-related costs. The additional travel provides user benefits, otherwise motorists would not drive more miles, but these tend to be modest since the additional travel consists of marginal-value vehicle-miles that users are most willing to forego if their costs increase.

Lifecycle Emissions
Many plans exaggerate clean vehicle benefits by ignoring embodied emissions emitted by vehicle and fuel production, plus the additional weight of electric vehicles (their batteries typically add 500 to 1,200 pounds), which increases tire particulate emissions and crash risks (22, 23). Hybrids typically reduce emissions by a third and electric cars by two-thirds compared with comparable fossil fuel vehicles (24, 25), as illustrated right. This is good, but it is an exaggeration to call them “zero emission” vehicles. By increasing total vehicle travel and sprawl they increase emissions from road and parking infrastructure and by displacing carbon-sequestering natural lands.

High Costs and Subsidies of Cleaner Vehicles
Electric vehicles are currently expensive and receive various subsidies, as summarized in Table 2. Since a typical gasoline car produces about seven annual tonnes of carbon, compared with two for an electric car, electric vehicle emission reductions cost $100-400 per tonne, which is higher than many other strategies (26). These costs may decline as electric vehicle technologies improves, but until a vehicle-miles tax is applied, electric vehicles they will continue to receive approximately $300 annual subsidy in avoided road user taxes, representing approximately $60 cost per ton of emissions reduced.

Table 2 Typical Electric Vehicle Subsidies (27)

<table>
<thead>
<tr>
<th>Subsidy</th>
<th>Annual Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate Average Fuel Economy (CAFE) credits ($4,700 over 15 years)</td>
<td>$313</td>
</tr>
<tr>
<td>Purchase subsidy ($5,000 over a 15-year vehicle life)</td>
<td>$333</td>
</tr>
<tr>
<td>Electric vehicle recharging stations (50 free annual recharges costing $2.50)</td>
<td>$125</td>
</tr>
<tr>
<td>Road user fee exemption (12,500 annual miles, 20 mpg, 50¢ tax per gallon)</td>
<td>$310</td>
</tr>
<tr>
<td><strong>Total Annual Subsidy</strong></td>
<td><strong>$1,081</strong></td>
</tr>
</tbody>
</table>

Electric vehicles receive various subsidies that currently total more than $1,000 per year.

Many analyses overlook battery replacement costs. Batteries typically last 80,000 to 160,000 miles and cost $5,000 to $15,000, averaging about 5¢ to 15¢ per vehicle-mile (28). Costs per kwh are declining, but battery sizes and costs are increasing to improve performance and range.
**Scope of Vehicle Travel Reduction Strategies Considered**

Most emission reduction plans consider a limited set of vehicle travel reduction strategies, and omit some of the most effective. They often include active and public transport improvements, vehicle sharing, telework, and sometimes road pricing and transit-oriented development, but few include least-cost transportation planning, pay-as-you-drive (PAYD) pricing, efficient parking pricing, comprehensive Smart Growth policies, and targeted travel reduction programs (29, 30).

Large vehicle travel reductions are certainly possible. Automobile-oriented transport planning, underpriced parking, low fuel prices, and sprawl-oriented development policies cause U.S. residents to drive far more annual miles than in peer countries (31). An integrated package of cost effective transportation demand management (TDM) strategies can reduce per capita vehicle travel by 30-50%, provided it includes both carrots and sticks (32).

**Figure 6  Projected Portland Region TDM Program GHG Reductions (33)**

The Portland region’s proposed TDM program is predicted to reduce vehicle travel and associated emissions by 45%. It includes carrots (improvements to resource-efficient modes and more affordable housing in walkable neighborhoods) and sticks (efficient pricing and road space reallocation).

Many cost-effective vehicle travel reductions can be implemented quickly. For example, to reduce vehicle travel and emissions 20% by 2030, a jurisdiction could:

- Shift transportation funding from roadway expansions to walking, bicycling and public transit improvements. Establish active and public transport service quality targets.
- Eliminate parking minimums, require parking unbundling and cash out (people who don’t drive receive the cash equivalent of parking subsidies provided to motorists), plus public parking fees with revenues invested in resource-efficient transportation programs.
- Support and require commute trip reduction, school transport management, transportation management association, and other targeted TDM programs.
- Implement PAYD vehicle insurance, taxes and registration fees by 2025.
- Implement a fuel or carbon tax that starts at $20 per tonne of carbon (20₵ per gallon of gasoline) and increases 10% annually.
- Reform development policies to allow affordable housing in compact, multimodal neighborhoods.
- Establish strong logistic management programs to increase freight transport efficiency.
Co-Benefits
Cleaner vehicles conserve fossil fuel and reduce emissions but provide few other benefits, and by inducing additional vehicle travel they can increase external costs such as congestion, infrastructure cost, crashes and sprawl-related costs. Vehicle travel reductions and Smart Growth provide a far greater range of benefits, as illustrated below. Few emission reduction plans consider all of these impacts.

Table 3 Comparing Impacts

<table>
<thead>
<tr>
<th>Planning Objectives</th>
<th>Clean Vehicles</th>
<th>TDM and Smart Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increased</td>
<td>Reduced</td>
</tr>
<tr>
<td>Congestion reduction</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Roadway cost savings</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Parking cost savings</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Consumer savings and affordability</td>
<td>Higher purchase, lower operating</td>
<td>✓</td>
</tr>
<tr>
<td>Traffic safety</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Improved mobility for non-drivers</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Fossil fuel conservation</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Pollution reduction</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Physical fitness and health</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Strategic development objectives (reduced sprawl)</td>
<td>x</td>
<td>✓</td>
</tr>
</tbody>
</table>

(✓ = Achieve objectives. ✗ = Contradicts objective.) Cleaner vehicles help conserve fossil fuel and reduce pollution emissions but provide few other benefits. Vehicle travel reductions and more compact, accessible community development provide far greater ranges of benefits.

Latent Demand for Less Automobile-Dependent Lifestyles
Some emission reduction plans assume that most people want to live automobile-dependent lifestyles, so vehicle travel reductions harm consumers and are difficult to implement (34). For example, the Clearing the Air report implies that Smart Growth may reduce livability for families with children, and mode shifts are difficult and costly to achieve. There are good reasons to be skeptical of such claims.

Surveys indicate that many North Americans would like to drive less, rely more on non-auto modes, and live in more multimodal communities, provided that these alternatives are convenient, comfortable and affordable (35). TDM and Smart Growth respond to those demands. There are many examples of integrated TDM and Smart Growth programs that provide large travel reductions and benefits (36, 37). Of course, TDM and Smart Growth face obstacles, costs and uncertainties, but so do clean vehicle strategies. As previously discussed, electric vehicles, particularly larger types such as SUVs, light trucks and vans, are currently costly and will require decades to fully penetrate fleets. They receive large and regressive subsidies, and by encouraging more driving and sprawl they exacerbate traffic problems and sprawl. Their emission reductions are difficult to predict due to uncertainties concerning their future performance and costs, market penetration, rebound effects, annual mileage and scrapage rates.

Comparing Impacts
The figure below compares potential emission reductions provided by vehicle electrification and vehicle travel reductions. Fleet electrification takes decades, and considering vehicle and fuel embodied emissions, additional vehicle weight, plus rebound effects, only reduces a vehicle’s emission 60-80%. A set of TDM and Smart Growth policies can reduce North American per capita vehicle-miles to those in peer countries such as Germany, Norway and Sweden. Many of these strategies can be implemented quickly, and by reducing total vehicle ownership and sprawl, provide additional emission reductions.
Considering embodied emissions and rebound effects, electrification typically reduces emissions about 70% compared with similar fossil fuel vehicles, and will take decades to achieve significant results.

Many vehicle travel reductions can be implemented quickly, and by reducing vehicle ownership and sprawl provide indirect as well as direct emission reductions.

As a result, travel reductions provide more total percentage point years (PPY) of emission reductions than electrification.

This analysis indicates that both vehicle electrification and vehicle travel reductions are needed to achieve zero emissions by 2050. Because of the 15-20 year lag between new vehicle sales and achieving that level of vehicle fleet penetration, vehicle electrification cannot provide significant emission reductions before 2040. In contrast, many TDM and Smart Growth policies can be implemented quickly, providing earlier and more total emission reductions during the three decade period.
Summary and Recommendations

The table below summarizes various planning biases, their impacts, and ways to correct them.

Table 4  Comparing Impacts

<table>
<thead>
<tr>
<th>Planning Bias</th>
<th>Impacts</th>
<th>Corrections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exaggerates the speed of clean vehicle market penetration.</td>
<td>Overestimates clean vehicle impacts and benefits.</td>
<td>Use realistic predictions of clean vehicle deployment.</td>
</tr>
<tr>
<td>Use of outdated travel models that underestimate travel impacts.</td>
<td>Underestimates clean vehicle rebound effects, and undervalues vehicle travel reductions.</td>
<td>Use newer and better modes for predicting travel impacts.</td>
</tr>
<tr>
<td>Ignores rebound effects (increased travel by clean vehicles), and the increased external costs that result.</td>
<td>Overestimates clean vehicle benefits and underestimates their community costs.</td>
<td>Account for rebound effects and the additional external costs that result.</td>
</tr>
<tr>
<td>Overlooks embodied and upstream emissions</td>
<td>Overestimates clean vehicle emission reductions and benefits.</td>
<td>Apply lifecycle analysis that accounts for all emissions.</td>
</tr>
<tr>
<td>Failure to account for all clean vehicle subsidies, and compare them with other emission reduction strategies.</td>
<td>Underestimates clean vehicle costs and regressivity.</td>
<td>Estimate and compare unit emission reduction costs (dollars per tonne of emission reductions).</td>
</tr>
<tr>
<td>Only considers a limited and ineffective set of vehicle travel reduction strategies.</td>
<td>Undervalues TDM and Smart Growth impacts and benefits.</td>
<td>Consider a broad range of potential vehicle travel reduction strategies.</td>
</tr>
<tr>
<td>Overlooks TDM and Smart Growth co-benefits, besides emission reductions.</td>
<td>Undervalues TDM and Smart Growth benefits.</td>
<td>Account for all significant co-benefits.</td>
</tr>
<tr>
<td>Assumes that TDM and Smart Growth harm consumers and are unpopular.</td>
<td>Undervalues vehicle travel reduction impacts and benefits.</td>
<td>Consider consumer preferences for more multimodal lifestyles.</td>
</tr>
</tbody>
</table>

Current emission reduction planning practices are biased in ways that tend to exaggerate clean vehicle benefits and undervalue TDM and Smart Growth strategies. These can be corrected.

Several recent publications also conclude that vehicle travel reduction strategies provide greater benefits than commonly recognized (39, 40). For example, a New York Times article “There’s One Big Problem with Electric Cars. They’re Still Cars,” highlights problems caused by automobile traffic (41). A New Scientist article, “Electric Cars Won’t Shrink Emissions Enough - We Must Cut Travel Too,” argues that vehicle travel reductions are needed to achieve emission reduction targets (42). A Rocky Mountain Institute study, Our Driving Habits Must Be Part of the Climate Conversation, concludes that the U.S. must reduce vehicle travel by 20% to limit global warming to 1.5° (43).
Conclusions

Many jurisdictions and organizations have ambitious emission reduction targets and are developing plans to achieve them. This study finds that the analysis methods used to develop these plans are often biased in ways that favor clean vehicles (e.g., hybrid, electric and hydrogen) over vehicle travel reduction strategies (i.e. transportation demand management [TDM] and Smart Growth policies). Some of these biases have been identified in previous publications but this study is more comprehensive and systematic. It identifies eight common biases and ways to correct them.

Many plans assume that clean vehicle strategies are more effective, cost effective, fast, reliable, and popular than vehicle travel reductions. This study challenges those assumptions. Optimistically, half of new vehicles could have zero tailpipe emissions 2030, but these will primarily be cars; SUV, light trucks and van electrification is likely to lag by several years, and without strong scrapage programs many high-emitting vehicles will continue to operate for decades. As a result, clean vehicle programs will not provide large emission reductions before 2040, and are unlikely to be complete by 2050.

On the other hand, an integrated set of TDM and Smart Growth strategies could reduce transportation emissions by 40% in ways that are cost-effective overall, considering all impacts. Many current policies favor automobile travel over more resource-efficient modes. In most communities, the majority of transportation resources – money and roadway space – are devoted to automobile facilities to the detriment of other modes; most roads and parking facilities are unpriced; fuel prices are low; and development policies discourage infill. These policies cause people to own more vehicles, drive more, and spend more time and money on transport than they would if given better accessibility options and efficient incentives. Although few motorists want to give up driving altogether, surveys indicate that many would like to drive less, rely more on alternative modes, and live in more walkable communities, provided that they are convenient, safe and affordable. TDM and Smart Growth respond to those demands, and increase rewards to travellers for choosing more resource-efficient options. Many TDM strategies can be implemented quickly, reducing emissions far faster than shifts to clean vehicles.

The assumption that clean vehicle solutions are superior to vehicle travel reductions reflects an old planning paradigm which assumed that vehicle travel reductions are harmful (45, 46). The new paradigm recognizes the benefits provided by multimodal planning and Smart Growth development policies that maximize accessibility. This new perspective is particularly important for achieving social equity goals. Clean vehicle strategies tend to be unfair and regressive because they depend on large subsidies to car buyers, and exacerbate automobile dependency which harms people who rely on other modes (47). In contrast, many TDM and Smart Growth strategies improve affordable mobility options, and reduce the external costs that driving imposes on other people.

This analysis suggests that to be efficient and equitable transportation emission reduction plans should rely at least as much on vehicle travel reductions as on clean vehicle strategies, with particular emphasis on “quick win” strategies that can be implemented in a few years.

There is a positive message here. With better analysis we can identify true win-win emission reduction strategies that also help achieve other economic, social and environmental goals.
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