# Climate and Fiscal Impacts from Reduced Fuel Use During COVID-19 Mitigation

**Fraser Shilling**

**Abstract** In U.S. states, as in most of the world, mitigation of the spread of COVID-19 was implemented by cities, counties, and governors' offices through "shelter-in-place" (SIP) and "stay-at-home" orders and related actions (e.g., closure of non-essential businesses). There were several important impacts of government SIP orders on traffic volumes, which in turn had impacts on fuel use and greenhouse gas (GHG) emissions. In this chapter, I estimate GHG emissions and fuel tax revenue at the state and nation scales before, during, and after the SIP guidance. I find that due to approximately 50% reductions in estimated vehicle-miles traveled, U.S. GHG emissions that cause climate change were reduced by 4% in total and by 13% from transportation in the eight weeks after the SIP orders went into effect. This reduction put the United States on track to meet its annual goals for GHG reduction under the Paris Climate Accord. I also calculated that the rapid decline in travel resulted in savings of $5 billion/week to U.S. drivers and a loss of $0.7 billion/week in tax revenue to the states. These consequences should feature in future transportation and climate planning as important variables that may stochastically appear, and which are beyond the influence of transportation agencies.

## 1 Introduction

Transportation is one of the primary contributors to global greenhouse gas emissions (GHG) that cause climate change [7, 12]. Transportation is also composed of many modes, including walking, cycling and ground-based, water, and air vehicle systems, all of which have partially interchangeable GHG footprints due to mode shifts [13]. Because of its importance in contributing to climate change, transportation in general and mode shifts, in particular, are important in planning for ways to mitigate climate change through travel reduction, mode-shifting, and electrification [1, 7]. In addition, it is possible to assign carbon footprints for mobility based on activity, which is tied

F. Shilling (✉)
Road Ecology Center, Institute of Transportation Studies, University of California, Davis, USA
e-mail: fmshilling@ucdavis.edu

 
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to income, and develop pricing for individual mobility choices to encourage reduced carbon emissions [15].

Estimating GHG emissions from vehicles includes life-cycle and instantaneous emission measurements and models, and is based on assumptions about fleet composition, fuel-use efficiency, fuel composition, electrification, and travel distances [8]. The primary attention in efforts seeking to reduce GHG emissions is often given to changing the energy source of vehicles (e.g., through electrification), or vehicle fuel efficiency for fossil fuel use. However, shifting travel to non-mechanized modes, paying attention to individual actions to achieve de-carbonization, and reducing mechanized travel distances could result in substantial GHG emission reductions, especially if combined with vehicle-based mitigation strategies [15].

In addition to the externalized costs to the environment, and by extension society, of individual and collective decisions to drive private vehicles, drivers also incur additional costs to maintain and fuel their vehicles, depending on the distance traveled [5]. These costs may encourage reduced driving, and thus reduced emissions, in lower-income populations [9]. Vehicle sharing has emerged both organically as an individual strategy to save money on vehicle ownership and commercially through ride-hailing and other services [3]. The actual benefits of changes in private vehicle operation in terms of GHG emissions and climate change will be measured as a combination of total miles traveled and total fuel consumed.

In California and other U.S. states, mitigation of the spread of COVID-19 was initially implemented by cities, counties, and governors' offices through "stay-at-home" and "shelter-in-place" (SIP) orders and related actions (e.g., closure of non-essential businesses). This resulted in a very rapid decrease in personal travel, especially notable in public transit (see also Chap. 17 in this volume) and air travel. In a series of reports during the spring and summer 2020, the Road Ecology Center (https://roadecology.ucdavis.edu) pointed to the potential unintended impact of reduced traffic—reduced traffic crashes and thus injuries and fatalities for people involved in the incidents (see also Chap. 11 in this volume), reduced collisions with wildlife, reduced GHG emissions, and reduced fuel use. These unexpected benefits of COVID-19 mitigation actions were highlighted during contemporaneous press articles as "silver linings," a sort-of relief valve for the persistent stress of the pandemic. The Road Ecology Center and later publications (e.g., for rail, Tardivo et al. [14] point to this period of travel adjustment as a good time to learn new ways to plan transportation. Over a year since the first SIP orders, most modes of travel that were reduced have increased, some (such as single-occupancy vehicles) to levels similar to before the pandemic. But the lessons from the pandemic-induced travel reduction were not lost and are being captured in books like the one you are reading.

This chapter investigates several short-term and continuing impacts of government SIP orders on rates of travel, as measured by vehicle-miles traveled, estimated fuel use, estimated fuel-cost savings to drivers, and estimated lost revenue to states from reduced fuel tax. I define four periods of U.S. road-vehicle travel during the pandemic: Phase 0: immediately prior to the pandemic SIP orders, which was before mid-March 2020 for most states; Phase 1: between late March and late April 2020, which witnessed a rapid change in traffic patterns to a temporarily reduced plateau;

Phase 2: beginning in late April 2020 and extending into winter 2021, which saw a gradual increase in traffic as SIP orders were reversed or ignored; and Phase 3: after the change in the Centers for Disease Control (CDC) guidance in mid-May 2021, when traffic in most U.S. states was similar to the same period in 2019, and most SIP orders and pandemic guidance had ended. I used traffic data (vehicle miles traveled, VMT) from Streetlightdata.com.[1] To estimate fuel use and equivalent GHG emissions, I used average fuel economy and GHG emissions rates for U.S. vehicles, assuming no appreciable change in fleet composition (EPA, 2017).[2] To estimate fuel costs, I used an average gasoline price of $2.59 across the U.S. (Source: USDOE, Alternative Fuels Data Center).[3] I used a California legislative source for information about California's SB1 legislation.[4] Lastly, I used estimated fuel tax rates from the American Petroleum Institute.[5]

## 2 Pandemic Impacts on Travel

### *2.1 Changes in Traffic*

Using daily travel data from Streetlightdata.com, I calculated the change in daily vehicle miles traveled (VMT) for every county in the United States from Phase 0 to Phase 1 (see Introduction for Phase definitions). Streetlightdata uses custom algorithms with cell phone tracking data to estimate how many miles people drive per day. Streelightdata estimated that the total miles traveled in the first week of March 2020 in the United States was 76.5 billion miles, while the total miles traveled in the second week of April 2020 was 42.0 billion miles. This 45% reduction in total miles traveled was reflected in the range of reductions seen across each state (Table 1).

Although traffic (VMT) increased during Phase 2, after the initial dramatic reduction following SIP guidance (early to mid-March 2020), traffic remained reduced in the United States as a whole until January 2021 (Fig. 1a, Phase 3). There are few other datasets available to evaluate total traffic in a large geographic area like the U.S. Apple Inc. collects data from iPhones and other devices about requests for driving directions. They have estimated the relative volume of directions requests per country/region, sub-region, or city around the world, compared to a baseline volume on January 13, 2020.[6] According to these data, the volumes of driving directions

[1] See https://streetlightdata.com.

[2] See https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

[3] See https://afdc.energy.gov/data/.

[4] See https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1.

[5] See https://www.api.org/oil-and-natural-gas/consumer-information/motor-fuel-taxes/gasoline-tax.

[6] See https://covid19.apple.com/mobility, accessed 6/7/2021.

**Table 1** Reduction (%) in vehicle-miles traveled for the U.S. states between the first week of March (3/2-3/8, Phase 0) and the second week of April (4/11–4/17, Phase 1)

| State | % reduction VMT (%) | State | % reduction VMT (%) | State | % reduction VMT (%) |
|---|---|---|---|---|---|
| Wyoming (WY) | 31 | Maine (ME) | 40 | Nevada (NV) | 48 |
| Idaho (ID) | 32 | Iowa (IA) | 41 | Florida (FL) | 48 |
| Arkansas (AR) | 34 | West Virginia (WV) | 41 | Delaware (DE) | 48 |
| Oregon (OR) | 34 | Kentucky (KY) | 42 | Minnesota (MN) | 48 |
| Alabama (AL) | 36 | Nebraska (NE) | 43 | Maryland (MD) | 49 |
| Montana (MT) | 37 | Louisiana (LA) | 43 | California (CA) | 49 |
| South Carolina (SC) | 37 | Missouri (MO) | 43 | Pennsylvania (PA) | 49 |
| Utah (UT) | 37 | Virginia (VA) | 43 | Rhode Island (RI) | 50 |
| Mississippi (MS) | 38 | Kansa (KS) | 43 | Connecticut (CT) | 50 |
| North Dakota (ND) | 38 | Wisconsin (WI) | 44 | Colorado (CO) | 52 |
| Washington (WA) | 39 | Indiana (IN) | 44 | Massachusetts (MA) | 52 |
| New Mexico (NM) | 39 | South Dakota (SD) | 44 | Michigan (MI) | 54 |
| Tennessee (TN) | 40 | Texas (TX) | 45 | New York (NY) | 55 |
| Oklahoma (OK) | 40 | Ohio (OH) | 45 | New Jersey (NJ) | 56 |
| North Carolina (NC) | 40 | Illinois (IL) | 45 | District of Columbia (DC) | 65 |
| Arizona (AZ) | 40 | Vermont (VT) | 45 | | |
| Georgia (GA) | 40 | New Hampshire (NH) | 46 | | |

*Data source* Streetlightdata.com

requests in the United States declined rapidly between early March 2020 and mid-April 2020 (Fig. 1b), with an average reduction of 45% for April 1–15, 2020. This reduction is essentially identical to the change in traffic measured as estimated VMT.

Figure 1a shows changes in traffic (vehicle-miles traveled, VMT) between January 1, 2019 and March 31, 2021). The yellow line represents the daily VMT for 2019,

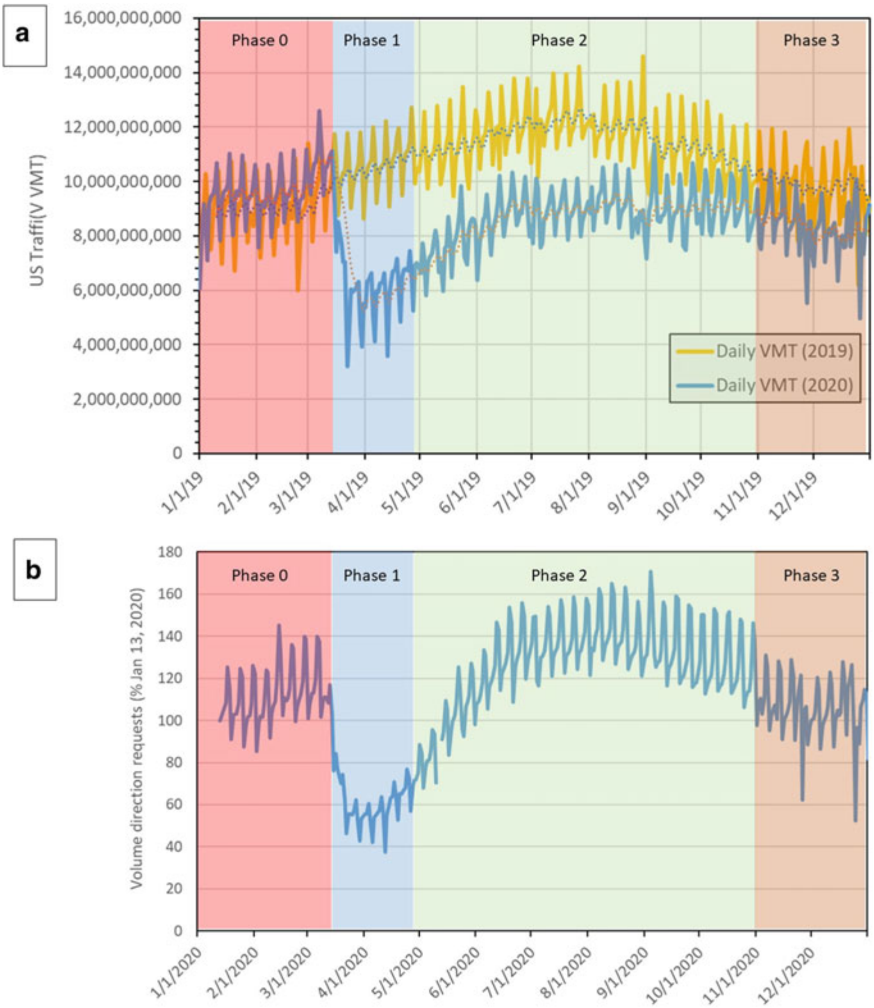


**Fig. 1** Changes in traffic (vehicle-miles traveled, VMT). *Data source* https://covid19.apple.com/mobility (data accessed on 6/7/2021)

the blue line for 2020, and the dotted line represents the 10-day moving average of daily VMT. Short-term variation in daily VMT is due to greater VMT on weekdays (versus weekends), while long-term variation is due to seasonal changes in travel patterns. Figure 1b depicts changes in volumes of requests for driving directions on Apple devices, relative to the volume on January 13, 2020.

The initial rapid reduction in U.S. traffic between early March 2020 and early April 2020 (Phase 1) was replaced by a second phase (Phase 2) of gradual increase in traffic volumes until approximately January 7, 2021, when the 10-day moving average VMT was equal to or greater than the average January VMT in 2019 (Fig. 2a). There were

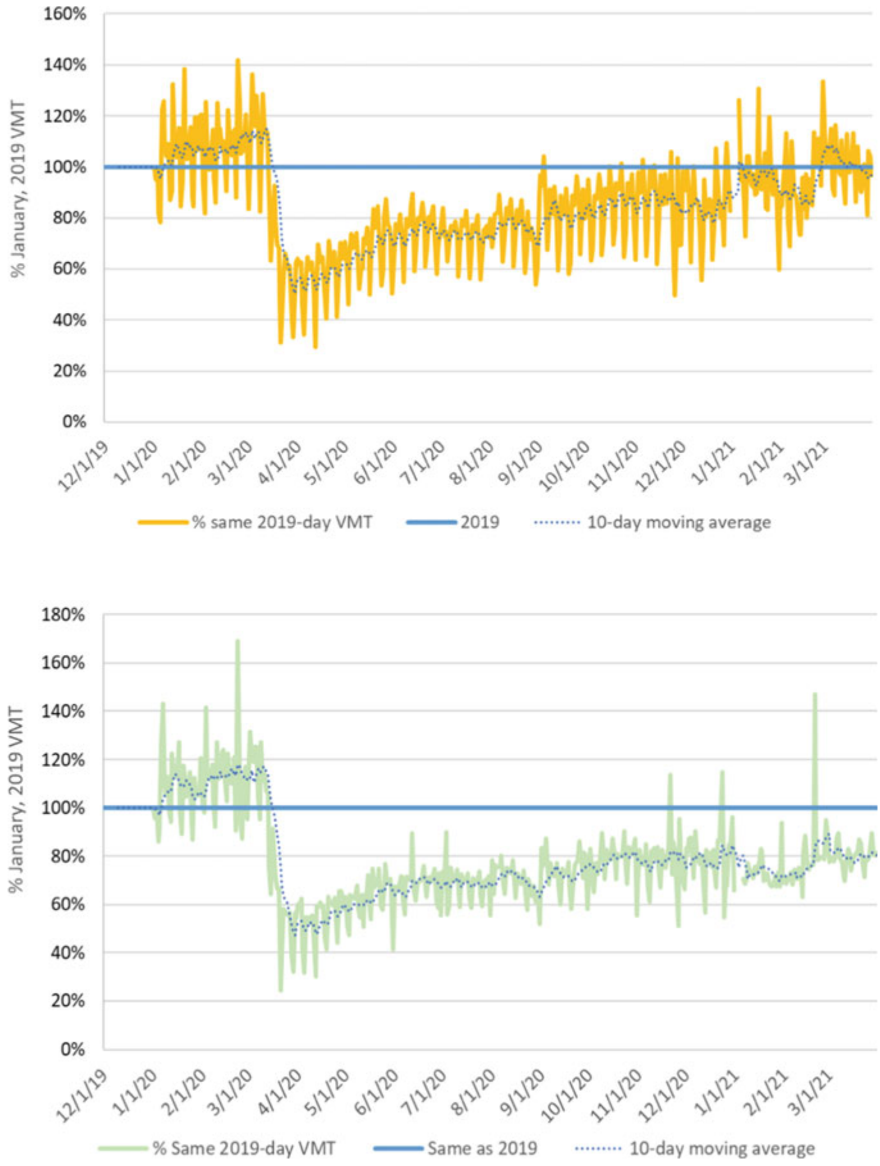


**Fig. 2** Comparison of traffic between the United States (**a**) and California (**b**). *Data source* https://covid19.apple.com/mobility

days before and after that date when daily VMT was greater than the same weekday in 2019, but it appears that traffic had largely returned to pre-pandemic (i.e., 2019) levels for the United States as a whole by early January 2021. In contrast, California's traffic remained depressed by about 20% through March 31, 2021 (Fig. 2b). Other states showed some variation in the timing and amount of increases in traffic during Phase 2, but the overall pattern was similar. It is not obvious why California's reduction was different from the remainder of the United States, and it is possible that it is an artifact of the source of the Streetlightdata VMT data—movement patterns and distances of cell phones.

Figure 2 shows the comparison of traffic between the United States (Fig. 2a) and California (Fig. 2b) on the same weekday in 2019 (e.g., first Monday, 2020 compared with the first Monday, 2019) as a percent of the average of traffic (VMT) in January 2019. The solid line represents the daily VMT in 2020 compared with the same week-day in 2019, while the dotted line represents the 10-day moving average of the values represented by the solid line.

## *2.2 Change in Greenhouse Gas Emissions*

The reduction in VMT resulted in a proportional decrease in greenhouse gas emissions from vehicles burning fossil fuels. In the United States, the transportation sector, including personal vehicles, accounts for about 29% of the total GHG per year [12]. These GHGs are usually quantified as "carbon dioxide equivalents" ($CO_2$eq), which reflect the different global warming potential of the various GHG emissions from vehicle fuel combustion. I used average fuel economy rates for U.S. vehicles using information from the Environmental Protection Agency (EPA),[7] which is based on the fleet composition and fuel types. I assumed that the fleet composition did not change from 2019 to 2020 in terms of the proportion of light-duty (e.g., passenger automobiles) and heavy-duty vehicles (e.g., freight trucks). I estimated the GHG emissions equivalent to VMT in Phases 0, 1, and 2, before, during, and after the SIP guidance for COVID-19 mitigation. The total for the first week of March 2020 was 31 million metric tons $CO_2$eq, while for the second week of April 2020, it was 17 million metric tons $CO_2$eq. Because of the nature of the calculation, the 45% decline in ($CO_2$eq) was identical to the reduction in travel VMT. There was variation in degree of reduction in travel and thus in GHG emissions among the states (Fig. 3).

The reduction in travel persisted during April 2020 and then gradually increased, which was reflected in a gradual increase in GHG emissions. Vehicle travel generally increases from year to year, but comparing calculated emissions during the pandemic with the same period during the last pre-pandemic year (2019) is one way to index the savings in GHG emissions that resulted from the traffic reductions.

[7] See EPA (2017) https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

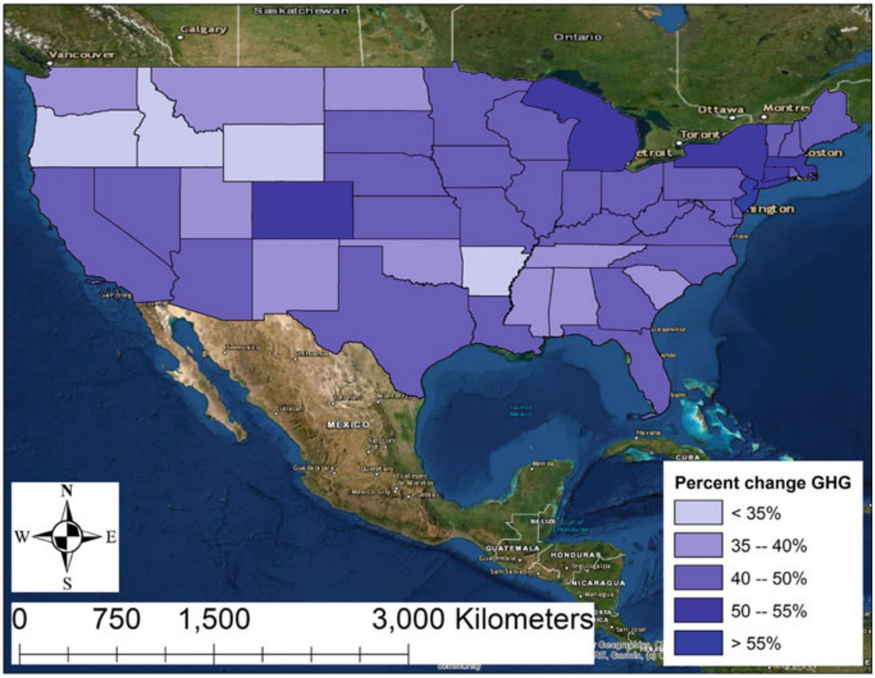


**Fig. 3** Comparison of the percent reduction in GHG emissions (MT $CO_2$-equivalents) from Phase 0 (pre-pandemic) to Phase 1 among the U.S. states. *Data source* Author; secondary data source: EPA (2017), see Footnote 7

The pandemic-related reduction in traffic resulted in an estimated 332 million metric tons fewer GHG ($CO_2$eq) emissions from U.S. vehicle travel that in the previous equivalent period. This represents a 15% decrease in transportation-related annual GHG emissions and a 4% decrease in total annual GHG emissions in the United States (Table 2).

**Table 2** Reduction in vehicle traffic and GHG emissions between the reduced-traffic pandemic period (3/9/2020–1/7/2021) and the equivalent period in 2019–2020

| Period/Year | Pandemic reduction (3/9/2020–1/7/2021) | Equivalent period pre-pandemic (3/9/2019–1/7/2020) | Total reduction cf. 2019 GHG |
|---|---|---|---|
| VMT | $2.50 \times 10^{12}$ | $3.332 \times 10^{12}$ | $-0.82 \times 10^{12}$ |
| GHG ($CO_2$eq) MT | $1.01 \times 10^{9}$ | $1.34 \times 10^{9}$ | $0.33 \times 10^{9}$ |
| Total GHG reduction | | | 4.2% |
| Transportation GHG reduction | | | 14.6% |

*Data sources* Streetlightdata.com; EPA (2017)

### *2.3 Reduction in Fuel Use and Tax Revenue*

In the first week of March 2020, U.S. daily travel used an estimated 3.4 billion gallons of fuel. Due to reduced daily travel following government guidance, the United States used only 1.9 billion gallons of fuel in the second week of April 2020 at an average gasoline price of $2.59 across the United States.[8] This reduction in use is equivalent to a savings of about $4 billion/week to U.S. drivers. For the sake of simplicity, I used gasoline prices and taxation as a proxy for all fuels, while recognizing that this is imperfect.

Every U.S. state charges a fuel tax, which varies by state. I multiplied the state-specific tax rate by the estimated fuel use per state to calculate the total revenue per week for the first week of March 2020 (Phase 0) and the second week of April 2020 (Phase 1). The state fuel tax revenue was reduced from $1.1 billion per week in March (Phase 0) to $587 million per week in April (Phase 1), a difference of more than $500 million/week. The total reduced U.S. fuel use for Phases 1 to 3 was 37.0 billion gallons of fuel, equivalent to savings to drivers of $95.7 billion and a loss of fuel tax revenue to states of $11.5 billion.

California relies upon a fuel tax triggered by Senate Bill 1 (SB1) in 2017 that potentially can generate $53 billion over 10 years to support highway construction and maintenance and transit improvements to reduce GHG emissions.[9] This source of revenue is intended to support state and local transportation and other projects. The current SB1 excise tax rate is 17.6 cents/gallon (gasoline), and the total CA fuel tax rate is about 63 cents/gallon (gasoline).[10] Diesel fuel has higher rates. The fuel use and SB1 tax revenue for the first week of March 2020 were 377 million gallons and $64 million, respectively. The fuel use and SB1 tax revenue for the second week of April 2020 were 193 million gallons and $33 million, respectively. The Phase 0–1 difference in weekly fuel use and revenue was 184 million gallons and $31 million. The difference between the total CA fuel tax revenue before and after the SIP order (Phase 0–1) was $115 million per week. For the entire Phase 1–Phase 3 traffic-reduction period, the travel reduction would be equivalent to 4.1 billion gallons of fuel not being used and a fuel costs savings to drivers of $10.6 billion and a loss (to the state government) of fuel sales tax revenue of about $2.57 billion.

## 3 Discussion and Conclusion

This chapter provided an overview of how reduced vehicle traffic during the pandemic resulted in an estimated reduction in GHG emissions from the transportation sector in the United States. The estimated reduction includes several important facets: (1) It points to GHG savings that are now "in the bank" in the sense that GHG emissions

[8] The source of this data is USDOE, Alternative Fuels Data Center, https://afdc.energy.gov/data/.

[9] See https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1.

[10] See https://www.api.org/~/media/Files/Statistics/StateMotorFuel-OnePagers-January-2020.pdf.

were reduced; (2) there is an important potential lesson that reducing VMT can immediately contribute to mitigating climate change; and (3) human behaviors (e.g., less driving) that were adaptive to the pandemic have the potential to contribute to long-term changes that reduce GHG emissions.

The United States and other countries contribute GHG emissions to the atmosphere at an accelerating rate, one which assures large changes in regional climates, sea levels, and even habitability of parts of the Earth. The primary response from governments and academics seems to be to reduce the *net* carbon or carbon-equivalent emissions from industrial and other activities, while maintaining or growing economic and other rate processes [12]. Although there is no evidence that this experiment will work, there has been little focus on other strategies that could rapidly reduce GHG emissions, such as reduced carbon footprint from transportation, in addition to other strategies currently investigated. In this chapter, I addressed the possibly valuable lesson from the pandemic that we could drive less and immediately provide climate change benefits. Although I did not address the lifestyle and workplace changes that accompanied the pandemic and led to less driving, these have been extensively covered in the press and elsewhere.

Government guidance to mitigate the pandemic has primarily consisted of orders to close or limit businesses and non-essential travel by the public. There was a 31–65% reduction in daily travel among U.S. states and the District of Columbia and overall, a 45% reduction in travel across the United States. This indicates that the guidance from the Centers for Disease Control (CDC) and individual states' SIP and similar orders at the municipal scale had a profound effect on daily travel, expressed as miles traveled. This driving reduction resulted in an estimated 45% drop in fuel use, which had inevitable knock-on effects on greenhouse gas emissions and state fuel tax revenue. Residents of U.S. states largely followed government SIP guidance, resulting in the U.S. having sufficient vehicle-related GHG emission reductions over an eight-week period (Phase 0–Phase 1) exceeding the annual target reductions under the Paris Climate Accord (>2%/year reduction) by 2%, for a 4% total annual reduction. This value is very similar to the recently published quantification of the reduction in estimated GHG emissions during the pandemic shut-downs. Le Quere et al. [10] estimated a reduction of 17% of daily global GHG emissions by mid-April, with half coming from surface transport. They also estimated that the total emissions reductions for 2020 were 4–7%.

Because of a sustained reduction in driving, California's reduction in GHG emissions has been greater than the U.S. states' average, putting it on track to get halfway to its 2050 goal for GHG emissions by 2021. Of course, all of these benefits of the SIP orders began to retreat after vaccines allowed normal economic and travel activity to resume, or at least gave the impression that the activity would be safe. This was generally true, except for California, where travel rates remained reduced by as much as 20% through the spring of 2021, compared to the same days in 2019. The continuing reduction could be related to a stronger effect in California of the "work from home" (WFH) strategy that many institutions adopted during the pandemic and which some may be retaining. Although WFH is not new, it rapidly expanded during the pandemic as an adaptation to the reduced travel and contact resulting from the

SIP orders and guidance [2]. Although the WFH strategy holds promise in reducing unnecessary travel and GHG emissions, it poses a risk of exacerbating inequities because of who can work from home and who cannot [2]. For example, ridership on public transit vehicles, which have higher energy efficiency than personal vehicles, plummeted to even lower depths and will take longer to recover, because of fears of transmitting/contracting the virus when in close proximity to other transit riders.

It is possible that the U.S. public is adapting to the multiple unintended consequences of the pandemic response, which may intentionally or unintentionally lead to a reduction in harm from travel and economic activity. The most immediate effect, discussed in this chapter, was the reduction in vehicle distance traveled, which resulted in a reduction in fuel use and fuel costs/taxes. An expected consequence of using less fuel in the United States is a reduction in states' tax revenues from fuel purchases. U.S. states use state and other taxes to maintain and expand highway and road systems. Expanding and otherwise improving road lanes leads to alternating increases in travel and congestion [4, 6, 11]. These tax-fueled expansions lead to greater GHG emissions, assuming most vehicles rely directly or indirectly on fossil fuels. So, an interesting feedback loop created by the pandemic was the reduction in tax revenue, leading to less funds available for road system expansion, leading to reduced GHG emissions. This suggests that during non-pandemic periods, targeting fuel tax revenues could be another control valve on GHG emissions—that is, by limiting fuel tax revenue, the expansion of surface transportation modes that result in GHG emissions would be curtailed. Alternatively, fuel taxes could be re-directed to reductions in total (i.e., not "net") carbon emissions from transportation.

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**Fraser Shilling** is the Director of the Road Ecology Center at UC Davis. He received his PhD from USC and his work examines three main areas in transportation ecology: (1) the impacts of environmental disruptions on transportation and other systems, (2) the impacts of traffic noise and light on wildlife use of habitat and wildlife crossing structures, and (3) the impact of roads and highways on ecological processes. He is the lead organizer for the International Conference on Ecology and Transportation (ICOET) and co-organizer of the Global Congress on Linear Infrastructure and the Environment.