Scope 3 Emissions from Commuting
Category Overview: Definition, Boundary, Methodology, and Preliminary Results

Executive Summary
Scope 3 emissions from employee & student commuting are calculated on a regular basis for Stanford University by the Scope 3 Emissions Program in Business Affairs. This paper details the boundary and methodology for developing baseline commuting emissions for calendar year 2019 and for subsequent years as remote and hybrid work became more predominant. More information on the Scope 3 Emissions Program and baseline calculations in other scope 3 emissions categories can be found in the Stanford University CY2019 Scope 3 Emissions Program Description & Inventory.

Scope 3 emissions from commuting derive from greenhouse gases emitted through the transportation of employees and students between their homes and their work or classes on-site by all modes. At Stanford, those modes are divided into 2 categories of “Driving” and “Alternative Transportation.” The breakdown of Stanford's commuting emissions for each sub-category is shown in Figure 1. The university’s scope 3 emissions from commuting in the calendar year 2019 were 22,069 MTCO2e. For perspective, this equals 11% of Stanford’s peak combined scope 1 & 2 emissions of 198,349 MTCO2e in 2011.

Figure 1: CY2019 Breakdown of Total Commuting Emissions Breakdown by Source

Transportation demand management (TDM) began at Stanford in the early 2000s; at that time, the university had a drive-alone employee commuter rate of 70%. That percentage gradually shrunk to 47% in 2019 due to the success of TDM initiatives. Unsurprisingly, employee commute emissions today are most influenced by the increasing popularity of remote and hybrid work, which determines how often employees must commute to their worksite, or if they need to attend their worksite at all. With remote and hybrid work rates increasing significantly between 2019 and 2021 at Stanford, driving emissions from employees fell by 53%. On the other hand, driving emissions from students have increased over that time, resulting in an

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overall reduction in employee & student commuting emissions of 31%. Future emissions fluctuations in this category will be largely determined by future hybrid and remote work patterns at Stanford.

**Employee and student commuting** emissions are based primarily on annual parking permit data, data from the annual commute survey conducted by Stanford Transportation each Fall, and San Francisco Bay Area average public transit distances. Elements of this data were entered into two third-party tools and one internal model. In turn, each tool was used to calculate scope 3 emissions from at least one sub-category of employee and student commuting. Below is a summary of the final methodology for each sub-category of commuting emissions:

- **Driving Emissions**: Parking permit data is used to calculate the exact distance traveled from home to worksite or campus by each parking permit holder in a calendar year; to determine the precise fuel efficiency of each vehicle driven; and to approximate the number of trips to and from work by each commuter as available, based on individually reported remote or hybrid working patterns.
- **Alternative Transportation Emissions**: Average distances traveled by mode per trip in the San Francisco Bay Area were used along with modal split data from the commute survey to estimate total passenger miles traveled by mode. Emissions factors from the U.S. Environmental Protection Agency (EPA) for each transit mode are used.

As shown in Figure 1, driving emissions have the largest environmental impact of the commute sub-categories. In 2019, driving emissions accounted for 72% of Stanford’s total commuting emissions, even though drive-alone commutes only represented 47% of all daily commutes at Stanford. While overall emissions have decreased between 2019 and 2021, driving emissions still account for most of today’s commute emissions. Continuing to incentivize alternative transportation for commutes will have a meaningful impact on emissions in addition to the expected ongoing impact of remote and hybrid work.

**Background**

Stanford is committed to achieving the “No Net New Peak-Hour Commute Trips” standard, defined by the Stanford Community Plan as no additional trips above a measured baseline during peak commute hours in the campus commute direction.1 Stanford has met and plans to continue to meet this standard, as described in its General Use Permit.

Stanford Transportation oversees all parking, commute, and other transportation-related initiatives on Stanford’s main campus and Stanford Redwood City. Stanford’s TDM program consists of innovative approaches for getting students, faculty, and staff to campus by means other than single-occupancy vehicles. Spearheaded by Stanford Transportation, the TDM program aims to reduce university-related traffic impacts, emissions, and parking demand while the campus continues to grow. The following initiatives are available to all or some Stanford commuters:

- **Free transit pass program**: Stanford Transportation offers eligible university and hospital employees free transit passes for Caltrain, VTA, SamTrans, and AC Transit that can be loaded to a Clipper Card. Stanford purchases these passes primarily for commuting to Stanford, although there is no restriction on the use of the pass.
- **Marguerite Shuttle**: Stanford’s Marguerite shuttle system is free and open to the public. With 19 routes and 49 buses, the Marguerite system provided over one million rides in FY 2022. The Marguerite fleet includes 41 electric buses, 5 diesel-electric hybrid buses, and 3 vehicles fueled by diesel.
- **Incentives for vanpooling**: Stanford incentivizes employees who commute by vanpool with a fully subsidized vanpool vehicle lease and free parking in ‘A,’ ‘C,’ or ‘Z’ commuter spaces.

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1 Stanford Community Plan, p 59. [https://stgenpln.blob.core.windows.net/document/SU_CP.pdf](https://stgenpln.blob.core.windows.net/document/SU_CP.pdf)

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● **Commute planning resources:** Stanford Transportation offers free, customized transit and bicycle planning assistance for trips to and from both campuses (the Stanford campus and the Stanford Redwood City campus) to Stanford affiliates.

● **Commute consultations:** Stanford Transportation offers one-on-one commute consultations to Stanford affiliates to answer questions about commuting to Stanford. The sessions are 15 minutes and can be used to explore public transit options and create a custom commute plan.

● **Zipcar:** Stanford affiliates are eligible for reduced price Zipcar memberships and discounted hourly and daily rates. Stanford maintains the largest university Zipcar fleet in the United States, with 74 vehicles at 33 locations.

In addition to these commute resources and incentives, Stanford Transportation offers other perks such as bicycle-sharing programs for which all departments are eligible, the Zipcar car-sharing program, and electric vehicle recharging stations. Additionally, Faculty Staff Housing programs make housing located on or near campus more accessible and affordable for Stanford staff and faculty.

### Category Definition
Stanford defines this category as emissions from the transportation of employees from home to their worksites and transportation of students living off-campus to their on-campus commitments. The standard definition for scope 3 emissions from employee commuting comes from the World Resource Institute’s Greenhouse Gas Protocol, which describes it as emissions from the transportation of employees from their homes to their worksites, including the following modes:\(^2\)

- Automobile travel
- Bus travel
- Rail travel
- Air travel
- Other modes of transportation (e.g., subway, bicycling, walking)
- Optional: Emissions associated with “teleworking”

For Stanford’s purposes, this framework for employees was also extended to student commuting emissions.

### Category Boundary
Stanford currently measures commuting emissions from all direct employees and students commuting by all modes in its boundary. The measurement includes Stanford employees who work on the Stanford campus and the Stanford Redwood City campus, where Stanford Transportation manages parking and transit options. It also includes emissions from student trips to and from their homes to their

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classes and commitments at main campus. Contractor trips (commuting or otherwise) are not currently included in this category, but the Scope 3 Emissions Program recommends the inclusion of emissions from commutes for regular contractors in this category over the long term as data becomes available. While home office emissions from employees are described in this paper to explore the effects of this topic, Stanford has decided to exclude home office emissions from its boundary given the lack of robust data to support analysis. Table 1 below summarizes the boundary of Stanford’s commuting category.

Table 1: Stanford Current Commuting Boundaries by Population & Commute Type

<table>
<thead>
<tr>
<th>Category Component</th>
<th>Conventionally Included in Employee Commuting Boundary</th>
<th>Currently Included in Stanford’s Commuting Boundary</th>
<th>Calculated, but excluded from Stanford’s Commuting Boundary</th>
<th>Excluded from Stanford’s Commuting Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving commute emissions</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative transportation</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>commute emissions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home office emissions</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Students</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All commuting emissions</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal trip emissions</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Emissions from student spouse trip</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Contractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commuting emissions for</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>regular contractors (security,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cafes, janitorial &amp; landscaping,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commuting emissions for periodic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>contractors (consultants, etc.)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

**CY2019 Calculation Methodology & Results**

Emissions calculations for commuting in the United States primarily rely on publicly available emissions factors for all transit modes researched and developed by the U.S. government. Specific sources of these emissions factors are described in the Appendix. Because these emissions factors are commonly accepted and publicly available, there is not much advantage to utilizing a third-party tool like VitalMetrics or SIMAP to calculate commuting emissions (which is not necessarily the case for all scope 3 emissions categories). An overview of the internal methodology for calculating driving-related emissions is below, followed by a slightly broader comparison of the different methodologies assessed for calculating alternative commute emissions.

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Driving Emissions

The internal methodology for calculating driving emissions related to commuting achieves a precision rarely feasible in scope 3 emissions measurement, largely due to the granularity and accessibility of data maintained by Stanford Transportation. Specifically, Stanford Transportation collects robust data associated with the sale of both daily and commuter (monthly) parking permits. The data set utilized by the Scope 3 Emissions Program includes:

- Commuter type (includes options like employee, student, residential leaseholder, and emeritus faculty. For the purposes of commuting calculations, only student, employee, leaseholder, and emeritus faculty commuter types are included)
- Home address
- Work address (if applicable)
- Vehicle make and model
- Purchase date of permit
- Date(s) of permit applicability
- Type of permit (Daily or Commuter)

Scope 3 Emissions Program staff use these fields to:

- Isolate permits applicable in the calendar year being reported, regardless of purchase date
- Calculate the exact distance traveled by each permit holder from his/her home to his/her worksite or to main campus
- Determine the precise fuel efficiency of each vehicle driven using publicly available data sets from the EPA
- Adjust calculation methodology by permit type, assuming a trip is made for each daily permit purchased, and the number of trips for each commuter permit purchased is equal to the number of workdays in that month, adjusted downward by a factor of 8.2%, which represents the alternative commute rate in 2019 (see the Alternative Transportation Emissions section below).

This methodology results in a precise estimate of the annual emissions generated by each employee or student based on the specific distance they commute in their specific vehicle. The only data inputs that are not commuter-specific in 2019 is the rate of telework for employees, and the assumed destination for students as main campus. Given the increasing rate of telework in subsequent years, the methodology has been adjusted for future years, as described in the CY2020 and CY2021 Calculation Methodologies & Results section. Further details on the 2019 calculation methodology are available in the Appendix.

Based on this methodology, total driving emissions in 2019 equaled 15,847 MTCO2e.

Alternative Transportation Emissions

The process for estimating emissions from employees and students taking alternative transportation relies much more heavily on averages and assumptions regarding transit in the San Francisco Bay Area compared to the methodology for calculating driving emissions, which is more Stanford-specific. The one Stanford-specific input for commuting emissions is the percentage of employees and students taking each form of transit.

A commuting survey is released each Fall by Stanford Transportation. One question asks about commute modes for each day of the week and asks respondents to fill it in using the prior week as a snapshot. The commute mode options available in the

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3 https://www.epa.gov/fueleconomy

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Dropdown include bicycle, bus, Caltrain, carpool, drive alone, Marguerite, vanpool, walk, and other. “Day Off” is also available if the employee or student did not work or the student did not have classes on that day. Starting in 2019, “worked remotely” was added as an option. Respondents are asked to select the mode they use for the longest leg of their commute; for example, if they walk to the Caltrain station from their home, take the Caltrain, and then take the Marguerite to their worksite, they would select Caltrain since it is the longest portion of their commute by distance.

The commute survey gets an average response rate of about 40%, and its findings are analyzed closely and applied broadly by Stanford Transportation to inform its program offerings. The employee modal split for 2019 is shown in Figure 2 below. The data below represents the percentage of days in each year that employees commuted by each mode relative to the total of all employees working days. Alternatively, the options “Telecommute” and “Day Off” indicate the percentage of days that employees did not commute to their worksites.

Figure 2: 2019 Stanford University Employee Commuter Modal Split

![Employee Modal Split Chart]

The student modal split for 2019 is shown in Figure 3 below. For students, the data below represents modes taken as a percentage of all weekdays in the academic year for 3 quarters. “Day off” represents days when classes were not held or the student did not have class or work, and telecommute refers to days when students took classes or worked remotely.

Figure 3. 2019 Stanford University Student Commuter Modal Split

![Student Modal Split Chart]
For commuters who use alternative transportation, the commute survey does not request their home and worksite addresses, so specific data on travel distance is not available. For this measurement, we used average commuter miles traveled for different forms of transit in the San Francisco Bay Area—compiled by the American Public Transportation Association. The specific mileages by transportation type are listed in the Appendix.

The modal splits and average miles traveled by transportation type are then entered into VitalMetrics and SIMAP and analyzed in slightly different ways. A different internal approach was not undertaken because it would be so similar to the processes used by the other two tools.

- **SIMAP** uses modal splits, number of staff and faculty, and average distance traveled for automobiles, bicycles, carpools, commuter rail, light rail, public buses, and walking as inputs to estimate emissions. It uses emissions factors by passenger-mile derived from data published by the EPA and the Bureau of Transportation statistics. Note that SIMAP also has a similar category for calculating emissions from student commuting. The results of that sub-category are not included in this paper.

- **VitalMetrics** uses total passenger-kilometers traveled by air, bus and other mass transit, passenger car or taxi, railway travel for commuting, and subway and other transit rail as inputs. It uses emissions factors per passenger-kilometer from the EPA.

Based on the processes described above, the modal split categories defined by Stanford must be matched to the mode types used by SIMAP and VitalMetrics, which match the emissions factor categories. Important notes regarding this mapping process include:

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● Drive-alone rates are equated to automobile travel. Other types of automobile travel, such as carpooling and vanpooling, are either listed together under “carpooling” (in the case of SIMAP) or factored into the total passenger-km included in the passenger car category (VitalMetrics).

● Caltrain is considered commuter rail

● Stanford does not collect data on subway travel or transit rail in the commute survey. However, BART is considered transit rail, and for the sake of these calculations, it assumes that all employees and students who responded “Other” in the commute survey may be referring to BART as their primary mode of transit. Thus, the percentage of “Other” respondents is equated to the percentage who travel via transit rail.

The results of the VitalMetrics and SIMAP calculations using the inputs described above are described in the following section.

**CY19 Results**

As described above, Stanford’s internal methodology for calculating driving emissions is much more precise than can be achieved through third-party tools. Nonetheless, descriptions of the approaches utilized by SIMAP and VitalMetrics for calculating driving emissions are included in the Appendix. On the other hand, calculating emissions from alternative transportation requires many assumptions, regardless of the tool employed. However, due to consistency in the assumptions made and the use of similar emissions factors across both tools used to calculate alternative transportation emissions, the results are very similar. The results of all three tools for 2019, broken down by sub-category, are included below in Table 2.

<table>
<thead>
<tr>
<th>Source</th>
<th>SIMAP</th>
<th>VitalMetrics</th>
<th>Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving Emissions (MTCO2e)</td>
<td>40,720</td>
<td>40,460</td>
<td>15,847</td>
</tr>
<tr>
<td>Alternative Transportation Emissions (MTCO2e)</td>
<td>6,984</td>
<td>6,222</td>
<td>N/A</td>
</tr>
<tr>
<td>Total Emissions (MTCO2e)</td>
<td>47,704</td>
<td>48,682</td>
<td>22,069</td>
</tr>
</tbody>
</table>

*Total internal emissions includes an internally calculated driving emissions value of 15,847 MTCO2e plus the alternative transportation value calculated by VitalMetrics of 6,222 MTCO2e.

The first key takeaway from the table above is that internally calculated driving emissions are 61-63% less than emissions calculated by the other two tools (which are somewhat similar). Some of the key drivers behind this are the types of vehicles owned by Stanford employees and the actual number of commuter trips taken. The average fuel efficiency of gas vehicles driven in 2019 was 29.9 miles per gallon for Stanford employees, and 29.8 for students (as shown in Tables 4 and 5), compared to the 2019 national average of 24.9 miles per gallon, which is the value used by the third party tools. Additionally, 14% of employee commutes and 5% of student commutes are undertaken using electric vehicles.

Lastly, the VitalMetrics and SIMAP driving emissions take into account the average modal split and driving distance rather than records of permits purchased by employees for the entire calendar year and the exact distance they commute. Therefore, the internal approach for calculating driving emissions is much more accurate than that of the third party tools and will be used for calculating driving emissions moving forward.

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The second key takeaway from Table 2 is the remarkable consistency in emissions estimates between SIMAP and VitalMetrics for both driving and alternative transportation. As described in the Appendix, these two tools both use United States-specific emissions factors developed by the public sector. While the calculation methodologies used by these tools for calculating alternative transit emissions are quite similar and highly credible, in the absence of a better internal approach for calculating alternative transportation emissions, the VitalMetrics approach will be used due to its simplicity. It is worth noting that because these emissions factors are publicly available, the VitalMetrics methodology can be integrated into in-house calculations, so while the approach will be replicated, the tool itself will not be used each year.

Digging deeper into results from the chosen methodology (internal driving methodology and alternative transport methodology from VitalMetrics), Figure 4 below shows a breakdown of emissions by group and by mode category. Driving resulted in the most emissions (72% of the total footprint). This is due to the size of the employee commuting population and their higher drive-in rates. However, among students, there are more emissions from alternative forms of transportation (9%) than there are for driving (3%).

Figure 4. Breakdown of Commuting Emissions by Group and Mode in 2019

Although employees and students had different mode splits, the contribution of each alternative transportation mode is largely consistent across both populations. Emissions by alternative transit mode for employees and students are broken down in Figure 5. In summary, Caltrain use accounts for the vast majority of emissions (more than 90% for each). Although marginal compared to Caltrain emissions, Light Rail comes in second as generating the most emissions, for students, followed by bus. For employees, the difference between these modes is de minimis.
Figure 5. Breakdown of Emissions for Alternative Transportation by Mode and Group

The relative contribution of students and employees to the total 2019 commuting footprint is shown below in Figure 6, showing that 87% of emissions were attributable to employees, and 13% was attributable to students. These numbers include driving and alternative transportation emissions. Using the internal methodology for driving emissions, and the VitalMetrics methodology for emissions from alternative transportation, Stanford’s 2019 footprint for Commuting is 22,069 MT CO2e.

Figure 6. Commuting Emissions by Group, 2019, MT CO2e and Percent of Total Commuting Emissions
Multi-Year Trends

Measuring the Impact of Remote & Hybrid Work

Given the rise in remote and hybrid work since 2019, the Scope 3 Emissions Program felt that a critical step in finalizing the methodology for calculating commuting emissions would be to not only better understand annual telework trends and their associated emissions implications, but also to experiment with newly available mechanisms for including remote and hybrid work data in emissions estimates to solidify a methodology for calculating emissions for the employee population in future years.

Stanford Transportation offers two different types of permits: daily permits and monthly commuter permits. Daily permits are purchased one day at a time, or for consecutive work days, and are most frequently purchased the same day as the parking occurs. Monthly commuter permits can be ordered for many months at a time but are paid for monthly at the beginning of the month. Therefore, while daily permits indicate one day’s worth of commuting, commuter permits don’t indicate how often the employee or student commutes to campus. In 2019, it was assumed that employees with commuter permits commuted to campus every weekday. However, in 2021, the advent of regular hybrid and remote work has decreased the frequency of commuting for these permit holders. Moreover, it has decreased it in a variable way, with some commuters still coming to campus every day and some commuting seldom.

To address this challenge, data from the commuting survey was used. While not all commuter parking permit holders completed the commute survey, in 2021 52% did. The precise number of commuting days per week for this population was used to calculate emissions. For the 48% of parking permit holders for which survey data was not available to indicate how often they drove to campus each week, staff undertook a two-pronged strategy to estimate days driven:

- For employees and students with daily permits, staff assumed that each daily permit was associated with one day of commuting
- For employees and students with commuter permits, staff assumed employees commuted the median number of times of 3 days per week, derived from the commuting survey.

This methodology resulted in an emissions total for CY21 of 22,069 MTCO2e and will continue to be used in subsequent years unless better individual data on work-from-home patterns becomes available. As shown in Figure 4, emissions from employees comprised approximately 87% of total emissions in this category, while student emissions were the source of the remaining 13%. This indicates that while employees produce the vast majority of emissions, and therefore has the most reduction potential, student related commuting emissions also holds potential for meaningful reduction.

Some additional assumptions had to be made to estimate commuting emissions in 2020, which totaled 7,733 MTCO2e. While the specific methodology for calculating 2020 emissions will not be replicated in future years due to highly unique circumstances brought about by the COVID-19 pandemic, it is described in the Appendix.

Results Analysis

As discussed above, driving emissions are the result of individual distances from home to work, vehicle type, and number of commuting days per year. The number of commuting days per year is partially determined by the number and types of parking permits purchased. A summary of each of these annual inputs, as well as the emissions outputs, is provided in Table 3 for employees, and in Table 4 for students.

Table 3: 2019-2021 Driving Emissions Inputs & Outputs

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Year over year fluctuations in parking permits, miles traveled, fuel efficiency and total emissions signal overarching trends in working and commuting patterns at Stanford. While many of these trends are in line with national trends related to remote work, some of them may be Stanford-specific. Key takeaways are summarized below, and some hypotheses are provided as justification for the trend. Additional validation and cross-referencing with other data sets will need to be performed to verify these hypotheses, but the primary takeaways are all data-driven.

- For employees:
  - Year-over-year emissions decreased by 66% between 2019 and 2020 and then rebounded by 40% between 2020 and 2021, for an overall decrease of 53% between 2019 and 2021.
  - The total number of parking passes purchased decreased between 2019 and 2020, with active commuter passes decreasing by 25% and daily passes decreasing by 45%. In 2021, the number of daily passes purchased fully rebounded and actually surpassed 2019 levels, while commuter passes only grew by 15%. This indicates that due to the advent of hybrid work, more of the commuting population purchase daily passes on the days they commute to work rather than monthly commuter passes. Between 2019 and 2021, commuter pass purchases have decreased by 14%, and daily pass purchases have increased by 4%, with a split of 73% daily pass purchases and 27% commuter pass purchases.
  - The average miles traveled per commute decreased by 33% between 2019 and 2021. This suggests that employees who commute in 2021 live roughly 7 miles closer to campus than employees who commuted previously. One explanation may be that a higher percentage of employees who live further away from their worksites have shifted to hybrid or remote work, compared to employees who live closer to their work sites.
and may be willing to commute more often. Another explanation could be that people who previously took alternative forms of transportation are now driving to work instead.

- The average fuel efficiency of employees’ vehicles decreased by 1% or 0.4 miles per gallon, between 2019 and 2021. While this is a slight difference that may be insignificant, it may also indicate that employees who work on-site more often drive slightly less fuel-efficient vehicles compared to those in hybrid or remote roles, or those who switched to driving electric vehicles initially had more fuel-efficient gasoline cars.

- The number of electric vehicles driven by employees increased by two percentage points between 2019 and 2021. Generally, the relatively high prevalence of electric vehicles contributes significantly to reducing emissions in this category and should be considered an important reduction strategy. Increased incentives for employees to purchase electric vehicles and charge them on-site should be explored.

- For students:
  - Year-over-year driving emissions decreased by 94% between 2019 and 2020. In 2021 however, associated emissions increased 4.89 times the 2019 baseline estimate for students driving.
  - Between 2019 and 2021, the number of unique parking pass student customers rose by 58%, the number of commuter passes purchased rose by 118%, and the number of daily passes purchased rose by 111%. This indicates that more students are driving to campus more regularly than in 2019, driving the associated increase in overall driving emissions for this population.
  - Student vehicles became 1% more efficient between 2019 and 2021. While minor, this may reflect the market moving towards more efficient cars.

Additionally, Tables 5 and 6 below illustrate trends in commute modes between 2019 and 2021, as collected from the commute survey and compiled by Stanford Transportation. The 2019 data is the same data illustrated in Figures 2 and 3 in the Alternative Transportation Emissions section.

**Table 5: Employee Commuter Modal Split 2019-2021**

<table>
<thead>
<tr>
<th>Year</th>
<th>Bike</th>
<th>Bus</th>
<th>Caltrain</th>
<th>Carpool</th>
<th>Drive alone</th>
<th>Marguerite</th>
<th>Other</th>
<th>Vanpool</th>
<th>Walk</th>
<th>Telecommute</th>
<th>Day Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>10.3%</td>
<td>1.5%</td>
<td>16.3%</td>
<td>10.2%</td>
<td>46.8%</td>
<td>1.5%</td>
<td>1.2%</td>
<td>0.7%</td>
<td>1.7%</td>
<td>8.2%</td>
<td>1.7%</td>
</tr>
<tr>
<td>2020</td>
<td>11.5%</td>
<td>1.2%</td>
<td>4.5%</td>
<td>1.8%</td>
<td>46.5%</td>
<td>0.3%</td>
<td>3.8%</td>
<td>0.2%</td>
<td>2.0%</td>
<td>20.9%</td>
<td>7.4%</td>
</tr>
<tr>
<td>2021</td>
<td>9.7%</td>
<td>1.7%</td>
<td>7.5%</td>
<td>3.18%</td>
<td>44.6%</td>
<td>0.5%</td>
<td>3.1%</td>
<td>0.2%</td>
<td>2.2%</td>
<td>27.3%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Table 6. Student Commuter Modal Split 2019-2021**

<table>
<thead>
<tr>
<th>Year</th>
<th>Bike</th>
<th>Bus</th>
<th>Caltrain</th>
<th>Carpool</th>
<th>Drive alone</th>
<th>Marguerite</th>
<th>Other</th>
<th>Vanpool</th>
<th>Walk</th>
<th>Telecommute</th>
<th>Day Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>32.2%</td>
<td>0.6%</td>
<td>10.6%</td>
<td>6.8%</td>
<td>30.4%</td>
<td>2.3%</td>
<td>2.3%</td>
<td>0.1%</td>
<td>3.1%</td>
<td>10.9%</td>
<td>0.8%</td>
</tr>
<tr>
<td>2020</td>
<td>27.9%</td>
<td>0.9%</td>
<td>4.7%</td>
<td>2.2%</td>
<td>34.9%</td>
<td>0.5%</td>
<td>3.6%</td>
<td>0.1%</td>
<td>5.0%</td>
<td>13.1%</td>
<td>7.1%</td>
</tr>
<tr>
<td>2021</td>
<td>35.8%</td>
<td>1.4%</td>
<td>10.3%</td>
<td>4.2%</td>
<td>28.9%</td>
<td>2.0%</td>
<td>3.7%</td>
<td>0.0%</td>
<td>6.8%</td>
<td>7.1%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

This data reveals some overall trends in both commuting frequency and preferred commute modes, including:

- Rates of overall alternative transportation use has fluctuated proportionally with telecommute rates. Thus, we can surmise that telecommuting has largely taken the place of using alternative transportation and has not significantly affected the drive-alone rate.

*Last revised February 5, 2024*
Anecdotally, there was some fear that employees might be less likely to use public transit as a commute option following the COVID-19 pandemic. This has played out in the data, with a decline in Caltrain use of over 9 percentage points between 2019 and 2021.

The predominance of carpooling and vanpooling among employees has declined since 2019. This may result from hybrid work making carpools more difficult to find since employees may travel to campus on different days.

Student mode split levels appear to have normalized close to their 2019 values. Continued analysis of commuting emissions and trends in 2022 and beyond will help reveal how enduring the trends above may be and solidify long-term Stanford-specific commuting emissions projections and reduction opportunities.

Home Office Emissions
The Greenhouse Gas Protocol lists emissions from “teleworking” as optional to include in the Employee Commuting category of scope 3 emissions, but does not provide clear guidance on calculating home office emissions, so this option does not seem to be included by most entities in practice. The Scope 3 Emissions Program explored the quantification process for home office emissions, as described below, but ultimately concluded that the data on the actual emissions impact of remote work is not clear enough at the moment for this category to be accurately quantified and included in scope 3 accounting.

Emissions from teleworking should be defined as emissions from incremental energy consumption in an employee’s home that results from that employee conducting Stanford business from home. Because these emissions would largely be generated from home office equipment, they are referred to throughout the rest of this paper as “home office emissions.”

In this experiment, home office emissions per employee were initially estimated using three different methodologies for comparison purposes: bottom-up estimates based on the individual consumption of appropriate home office equipment; a researched percentage of incremental consumption from home offices applied to average energy consumption; and metrics calculated by other employers. A detailed description of these methodologies can be found in the Appendix, with the results illustrated in Figure 7.
Method 1 uses estimates of daily home office emissions per employee multiplied by the total number of employees per year and the respective annual telecommuting rate, as shown in Table 5. The other two methods incorporate assumptions regarding average annual incremental emissions per employee, so they don't take into account Stanford’s specific telecommute rate. For this reason, we believe Method 1 is the most accurate.

The daily home office emissions used in Method 1 are calculated based on energy consumption estimates for standard equipment used in a home office: computer, monitor, lighting, air conditioning and heating. The breakdown of energy consumption between these pieces of equipment is shown in Figure 8. Heating comprises 85% of home office energy consumption. When evaluated on an emissions basis rather than energy, this percentage increases to 99.8%. Clearly, emissions from heating is the single largest source of home office emissions. Addressing these emissions by incentivizing employees to install more efficient gas furnaces or electric heat pumps would be the most effective way to reduce emissions from home offices.

**Figure 7: Home Office Emissions by Method and Year**

**Figure 8: Breakdown of Estimated Energy Consumption of Home Office Equipment (Method 1)**
This method assumes that all employees turn their heating up when they work from home, which may not be true. Some employees may keep their heat off while working from home, while other employees may keep their heat at the same setpoint regardless of whether or not they are working from home. The lack of clear evidence on this and the fact that heating is the major contributor to these emissions is the driving factor behind the vast imprecision in this category. Over time, a way to improve this method would be to collect data on how many Stanford employees turn their thermostats on or up when they work from home compared to when they work on-site.

It is worth noting that all emissions estimates in these calculations use the emissions factor associated with PG&E electricity of 0.000002 MTCO2e/kWh. This emissions factor is 103 times lower than the average emissions factor for the California grid (referred to as the WECC sub-region of the national grid), of 0.000206 MTCO2e/kWh. As a result, the emissions profile of home offices could change substantially based on which of these two emissions factors are applied. The Appendix includes a map of PG&E’s electric service area; we know from parking permit data that Stanford employees living in California predominantly live in these areas, so we’ve applied the PG&E emissions factor for electricity. However, it is worth noting that this significantly underestimates home office emissions for employees outside of California. A future improvement could be to collect data on the number of employees residing in each state and customize the emissions factors used accordingly. On the other hand, emissions factors for natural gas combustion do not vary significantly by region or utility, so we do not see the same problem arise with natural gas emissions estimates.

Using Method 1, total home office emissions equate to 725 MTCO2e in 2019 and increase to 2,797 MTCO2e by 2021. This corresponds to only 4% of employee commuting emissions in 2019 but an estimated 28% of employee commuting emissions in 2021, given the decrease in both driving and alternative commuting emissions after 2019. We estimate that employee commuting emissions decreased by 10,107 MTCO2e between 2019 and 2021. From the numbers above, we can see that home office emissions only increased by 2,072 MTCO2e or 21% of the employee commuting decrease. While these still rough estimates, they indicate that shifting to hybrid and remote work is a successful scope 3 emissions reduction strategy.
Future Considerations

There are some nuanced methodological improvements that should be considered as Stanford advances its emissions quantification efforts in the commuting category.

- Expand telecommute data to represent all employees’ individual patterns
- Improve estimates of emissions from electric vehicles
- Improve methodology for accounting for employee commuters vs. visitors to campus in parking permit data sets. Account for the more variable emissions from visitors to the extent possible, possibly by including emissions estimates for driving from the airport to campus.
- Develop a more representative estimate of modal splits. Because the commute survey uses a snapshot in time, it is possible that the responses to the commute survey are not a representative indication of commute patterns throughout the year.
- Identify Stanford-specific distances traveled for commuters using alternative transportation and develop an internal methodology to model associated emissions
- Improve estimates for home office emissions by integrating electricity emissions factors for remote workers living outside of California, gauging the number of employees who turn up their heat when working from home, and accounting for indirect emissions from the use of video conferencing software like Zoom. Consider adding these to the Employee Commuting footprint as this more precise data is collected.
- Vehicle fuel efficiency data specific to each year can be used to make each year’s calculations more precise.

Finally, some philosophical considerations and indications of potential mitigation strategies should be mentioned:

- Should emissions from employees who work remotely but fly to the Bay Area for sporadic in-person work be included in business travel or employee commute emissions?
- Based on the analysis above, average driving emissions per local employee are currently 0.70 MTCO2e per year. For remote employees, average emissions related to traveling to campus would be between 0.48 MTCO2e (if flying from Los Angeles) and 4.76 MTCO2e (if flying from Boston). If this trip were made four times per year, the average annual emissions of a remote employee would be between 1.92 MTCO2e and 19.04 MTCO2e. In other words, an employee living locally and regularly driving to campus will typically create fewer emissions than a fully remote employee traveling to campus sporadically.
- Commute emissions have decreased by more than home office emissions are estimated to have increased. This suggests that shifting to hybrid and remote work is a successful scope 3 emissions reduction strategy.
- The desire to reduce emissions in this category must be balanced with the benefits of an on-site workforce. This decision has largely been made on a unit or department basis at Stanford.
- Electric vehicles present an essential opportunity for emissions reduction in this category. Increased incentives for both students & employees to purchase and charge electric vehicles on-site could be explored.
- If emissions from employees working from home are included, should emissions from students studying and completing schoolwork at home also be included?

Conclusion

Based on the processes described above, we estimate scope 3 emissions from commuting to be 22,069 MTCO2e in CY2019. Since 2019, driving emissions have decreased by 31%. This effect will likely persist given the popularity of hybrid and remote
work, although emissions may gradually increase if expectations change regarding on-site work. While Stanford’s robust programs to help employees commute more sustainably have meaningfully impacted campus drive-alone rates since 2002, the future of hybrid and remote work patterns will likely have the greatest impact on emissions moving forward if the decrease in 2020 and 2021 are any indication. That said, the efforts of Stanford Transportation to incentivize the use of alternative transportation for both employees and students are laudable, and the Scope 3 Emissions Program will continue to seek ways to partner with Stanford Transportation to reduce both emissions and drive-alone rates for on-site and hybrid employees over the long term.
Appendix A: Detailed Calculation Methodology

Introduction

The Office of Sustainability completed the initial quantification of emissions in this category prior to the creation of the Scope 3 Emission Program. Program staff have collaborated with the Office of Sustainability to include summaries of that work in this paper, along with more recent calculations.

All transportation-related emissions data in the United States is published by the U.S. government and non-profit organizations working within the public and private sectors, including the following sources and data sets:

- **EPA Emissions Factor Hub**: This is a set of emission factors collated from both EPA’s Greenhouse Gas Reporting Program and the EPA Center for Corporate Climate Leadership’s technical guidance, including emissions from mobile combustion, upstream and downstream transportation, business travel, product transport, and employee commuting. The EPA annually updates the set.
- **EPA Inventory of US Greenhouse Gas Emissions and Sinks, 1990-2016**: This is an annual report provided by the EPA that offers a comprehensive account of total greenhouse gas emissions from all man-made sources in the United States via collaboration with hundreds of experts representing more than a dozen U.S. government agencies, academic institutions, industry associations, consultants and environmental organizations.
- **U.S. Department of Transportation**: The U.S. Department of Transportation manages the National Transit Database, which compiles, evaluates, and analyzes data submitted by state transit authorities to inform public understanding of transit systems and support regulatory efforts.
- **American Public Transportation Association Fact Books**: The American Public Transportation Association (APTA) is a nonprofit organization that represents all modes of public transportation, including bus, paratransit, light rail, commuter rail, subways, waterborne services, and intercity and high-speed passenger rail. APTA releases a public transportation fact book annually, containing national aggregate statistical data covering all aspects of the transit industry in the United States and Canada. Major sections include an overview of U.S. transit facts, transit finances and operating statistics by modes of travel, including ridership rates and distances.

These data sets are referenced in various ways by the following tools:

- **The Sustainability Indicator Management & Analysis Platform (SIMAP)**: Created by the University of New Hampshire, the SIMAP tool helps universities quantify emissions in scope 1, 2, and some scope 3 categories that are particularly applicable to higher education, including commuting, business travel & study abroad, student travel to/from home, food, paper, fuel and energy activities, and waste & wastewater. The tool is publicly available for a nominal membership fee of $600 per year.
- **VitalMetrics Carbon360 Platform**: Carbon360 is a proprietary, cloud-based solution developed at the University of Santa Barbara and now owned by VitalMetrics. The tool pulls emissions factors from a combination of databases, including its proprietary CEDA, to make it simple for customers to calculate scope 1, 2, and 3 emissions across the fifteen categories defined by the GHG Protocol. This tool cost Stanford $10,000 in its first year to deploy.
- **Internal methodology**: Because emissions factors are publicly available, Scope 3 Emissions Program developed a third estimate of emissions for employee commuting compared to the outputs of the other two tools. Specifically, the
emissions factor for CO2 per gallon of gasoline used for the internal method was sourced from the EPA’s Greenhouse Gas Emissions Factor Hub, and emissions factors for CH4 and N2O per gallon of gasoline used were sourced from The Climate Registry.

Table A-1 illustrates the sources of emissions factors that each tool applies for each mode type. This exercise highlights that most, if not all, calculations include data sourced from the public sector, which may explain their similarities in magnitude.

Table A-1: Emissions Factor Databases referenced by Calculation Tool

<table>
<thead>
<tr>
<th>Mode Type</th>
<th>SIMAP EF Source</th>
<th>VitalMetrics EF Source</th>
<th>Internal EF Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>Bureau of Transportation Statistics, EPA</td>
<td>EPA</td>
<td>EPA Emissions Factor Hub &amp; The Climate Registry</td>
</tr>
<tr>
<td>Commuter Rail</td>
<td>American Public Transportation Association</td>
<td>EPA</td>
<td>N/A</td>
</tr>
<tr>
<td>Transit Rail</td>
<td>American Public Transportation Association</td>
<td>EPA</td>
<td>N/A</td>
</tr>
<tr>
<td>Bus</td>
<td>Bureau of Transportation Statistics</td>
<td>EPA</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Total Commuting Emissions (MTCO2e)</strong></td>
<td><strong>47,704</strong></td>
<td><strong>46,682</strong></td>
<td><strong>22,069</strong>*</td>
</tr>
</tbody>
</table>

*Total internal emissions include an internally calculated driving emissions value of 15,847 MTCO2e plus the alternative transportation value calculated by VitalMetrics of 6,222 MTCO2e.

While the differences in emissions between the external tools evaluated is minute, the difference between SIMAP and VitalMetrics’ estimations and the internal one is significant. Although SIMAP’s emissions estimate is about 0.6% higher than that of VitalMetrics, it is 61% higher than that used in the internal method.

The best explanation for the difference in emissions factors is in the fuel efficiency assumptions used in each source since the rate of emissions from burning a gallon of gasoline is scientifically grounded and well-accepted. For example, as shown in Tables 3 and 4 in the body of the paper, the average fuel efficiency of Stanford employees’ vehicles in 2019 was 29.9 miles per gallon, and 29.8 miles per gallon for students. In contrast, the EPA has published an average fuel efficiency nationwide for 2019 of 24.9 miles per gallon.7 Since Stanford employees and students drive more fuel-efficient cars on average compared to the national average, this fuel efficiency leads to lower emissions per passenger mile.

### Driving Emissions

#### Internal Methodology

The below overview provides a detailed explanation of the following for internal calculations based on parking permit data:

- **Timeframe:** the method used to discern how many days of commuting were included in each parking permit

---

6 Bureau of Transportation Statistics, Table 4-20: Energy Intensity of Passenger Modes (Btu per passenger-mile)
- **Distance**: the method used to determine employees’ precise commuting distances
- **Fuel Efficiency**: the method used to determine commuters’ precise vehicle fuel efficiencies
- **Driving Radius**: the maximum assumed driving radius to inform the exclusion of some permit holders who do not live locally
- **Emissions Factors**: the sources and values of emissions factors used
- **Remote and hybrid work**: method for accounting for remote and hybrid work in varying ways throughout 2019, 2020, and 2021

**Timeframe**: As discussed in the body of the paper, calculations were made based on permit types. It was assumed that daily permits were each associated with one commute. For employees, in 2019, it was assumed that commute days associated with commuter (monthly) permits were equal to Stanford working days each month. The number of working day(s) below adhere to a 5-day work week and exclude University holidays from the day’s employees were assumed to commute to campus. The month-day counts for 2019, 2020, and 2021 used for commuter pass emissions estimates are outlined below.

**Table A-2: Stanford Working Days by Month in 2019, 2020, and 2021**

<table>
<thead>
<tr>
<th>Year</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>21</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>February</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>March</td>
<td>21</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td>April</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>May</td>
<td>22</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>June</td>
<td>20</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>July</td>
<td>22</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>August</td>
<td>22</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>September</td>
<td>20</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>October</td>
<td>23</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>November</td>
<td>19</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>December</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

For students, the number of commuting days per year was assumed to be 150, given that there are 3 academic quarters that are each 10 weeks long, and there are 5 days of class per week. This follows an assumption that all students are following this standard schedule.

**Distance**: Precise driving distance was calculated using a Google Sheets formula:³

\[
=\text{GOOGLEMAPS\_DISTANCE([Point A],[Point B], “driving”)}
\]

The average commuting distance of customers within the same calendar year was assumed as the one-way commuting distance for those whose addresses didn’t provide valid routes. Average commuting distance for each year was specific to that year’s customers in each population: the average precise distance for employees each year were used to gap-fill for employees without valid routes, and the same was done for students.

³ Information on how to use this formula sourced from [https://www.labnol.org/google-maps-sheets-200817](https://www.labnol.org/google-maps-sheets-200817)

*Last revised February 5, 2024*
For students, 450 Serra Mall, Stanford CA 94305 was used as the destination address for commuting since destination addresses are not recorded for students like they are for employees.

**Fuel Efficiency:** Each parking permit requires applicants to supply the make and model of the car(s) they drive to campus, which allows for precise fuel efficiency mapping. A database from the EPA\(^9\) reporting average fuel efficiency per make-model in 2019 was used to map fuel efficiencies in miles per gallon to vehicle data provided in the parking permit data set. If a make-model was not included in the dataset provided by the EPA, but a similar size & type car from the same company was available, this similar car’s fuel efficiency was assigned as a proxy. This was performed consistently for about 27% of the permits purchased yearly. In the case that a similar car was also not reported, the average fuel efficiency across all gas vehicles in the data set was applied; this was the case for 12-16% of permit holders each year. Customers needed to be within the distance radius (described below) to be included in the average fuel efficiency calculations. Finally, electric cars were assigned a zero fuel efficiency and assumed to generate zero emissions for all commutes undertaken in those vehicles. This underestimates the impact of electric vehicles—which derive from both their production and use—and could be improved in the future.

**Driving Radius:** Some people coming to campus who don’t regularly commute purchase parking permits. These may be employees who do not live locally, or other visitors. Regardless, they do not commute to campus regularly and should be excluded from commuting calculations. Because these visitors enter a home address on their parking permit application that is not local, a driving distance threshold was set for each year to exclude customers outside of a reasonable commuting range. This method may miss some campus visitors who do happen to live within driving distance and do not commute regularly. The driving radius for 2019 was set at 100 miles. The driving radius was increased to 125 miles in 2020 and 2021. The normalization of remote and hybrid work may allow Stanford to have more employees that live further away, who opt to go into the office a few times a week or occasionally. In the pre-pandemic era, the norm of commuting five or more days to campus per week likely constrained commuting distance for employees.

**Emissions Factors:** Since the EPA only provides a CO2 emissions factor per gallon of motor gasoline combusted, data from the Climate Registry was used to calculate CH4 and N2O emissions per gallon of gasoline to arrive at the CO2e emissions factor used.\(^10\) The input data for this calculation is provided in Table A-3.

<table>
<thead>
<tr>
<th>MT CO2</th>
<th>GWP CO2</th>
<th>MT CH4</th>
<th>GWP CH4</th>
<th>MT N2O</th>
<th>GWP N2O</th>
<th>Ratio of CO2 to CO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>1</td>
<td>0.00002</td>
<td>28</td>
<td>0.00002</td>
<td>265</td>
<td>1.01</td>
</tr>
</tbody>
</table>

Table A-4 shows the kg CO2/gal gasoline emissions factor to which the 1.01 ratio of CO2 to CO2e was applied, as shown in Table A-3, to arrive at an emissions factor of 8.84 kg CO2e to be used for internal footprinting.

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\(^9\) [https://www.fueleconomy.gov/feg/download.shtml](https://www.fueleconomy.gov/feg/download.shtml)


*Last revised February 5, 2024*
Table A-4: CO2e Emissions Factor Used for Internal Calculations:

<table>
<thead>
<tr>
<th>Kg CO2/gallon gasoline, EPA Emissions Factor Hub\textsuperscript{11}</th>
<th>Kg CO2e/gallon gasoline, internally calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.78</td>
<td>8.84</td>
</tr>
</tbody>
</table>

For emissions factor comparison purposes for 2019, total emissions for in the internal model were divided by total passenger-miles in the model to arrive at a kg CO2e/passenger-mi emissions factor. Given a driving emissions total of 15,200 MTCO2e, and a total passenger-miles count of 51,870,683 passenger-miles, 0.29 kg CO2e/passenger-mi was calculated as the internal model’s distance-based emission factor. See the Appendix Introduction section for a comparison of this emissions factor to that of the other tools.

Remote work: Each year, hybrid and remote work were accounted for in slightly different ways based on data availability and ever-changing hybrid and remote work patterns.

Given the norm that daily permits are purchased shortly before the effective date, we assume daily permit purchases indicate a single commute to campus for all years. However, because commuter passes can be purchased for months well before the purchase date, they do not clearly correlate to the number of commute days during unusual circumstances—like the COVID-19 pandemic. Therefore, variations in year-by-year assumptions related to remote work largely applied to the frequency of commutes for commuter permit holders.

In 2019, total emissions were scaled down by 10% to account for the cumulative impacts of remote work and days out of the office. Remote work was estimated at 8.2% of days worked by Stanford employees, and an additional five days per year were assumed to be taken off by each employee, either for PTO or sick days, constituting 2% of work days. This is consistent with the “Day Off” rate reported in the 2019 commute survey of 1.7%. Total 2019 emissions were scaled down by 8.2% plus 1.7% accordingly.

For all of 2020, emissions from commuter passes active before March 15 were accounted for using the same methodology used in 2019. To measure the emissions from those with commuter passes after March 15, estimated business-as-usual (BAU) emissions from commuter passes were scaled down to recorded rates of employee building entry.

During the pandemic, all possible Stanford buildings were put in “card access only” mode. The number of card swipes into campus buildings was used to estimate the total employee commutes each month. After accounting for those with daily permits, the following calculations were used to scale down emissions from active commuter passes each month, with data specific to the month:

\[
\text{BAU Commuter Swipe Emissions} \times (\text{Estimated Percent of BAU Commuters going in}) = \text{Monthly Commuting Permit Emissions}
\]

Table A-5: Scaling Factor for Emissions from Commuter Passes in 2020 by Month

<table>
<thead>
<tr>
<th>Month</th>
<th>% Commuter Pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>53%*</td>
</tr>
</tbody>
</table>

\textsuperscript{11} EPA Greenhouse Gas Emissions Factor Hub, 2018, Table 2, Motor Gasoline. \url{https://www.epa.gov/sites/default/files/2018-03/documents/emission-factors_mar_2018_0.pdf}

Last revised February 5, 2024
April 20%
May 23%
June 68%
July 25%
August 28%
September 30%
October 32%
November 31%
December 18%

*This percent is an average for March, reflecting that the first half of March saw 100% of usual swipes and that the second half of the month was estimated at 6% of usual swipes.

Finally, see the body of the paper for an explanation of remote and hybrid work integration in 2021, which is the methodology that will continue to be used in the future.

**SIMAP**

SIMAP calculated Stanford’s emissions from employee and student commuting by using distance-based emissions factors for driving alone and carpooling. SIMAP calculates emissions for staff and faculty commuting separately, using the number of commuters, mode split data, the annual number of trips, and average miles per trip by mode to arrive at each group’s estimated total passenger miles by mode. However, Stanford’s employee mode split data is not available at a faculty or staff specific level, so the same mode split between driving and carpooling – based on data inclusive of faculty and staff -- was applied to both groups and the combined inputs and outputs are presented in Table A6 below. Results for students using alternative transportation using SIMAP’s methodology are shown in Table A-7.

**Table A-6: SIMAP Employee Driving Input & Output Data**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Total Employees</th>
<th>% Of Employees using this mode</th>
<th>Average distance (miles)</th>
<th>One-way trips per commuter per week</th>
<th>Commuting weeks per year</th>
<th>MTCO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobile</td>
<td>16,998</td>
<td>46.8%</td>
<td>13.28</td>
<td>10</td>
<td>50</td>
<td>23,752</td>
</tr>
<tr>
<td>Carpool</td>
<td></td>
<td>10.2%</td>
<td>14.71</td>
<td></td>
<td></td>
<td>4,780</td>
</tr>
</tbody>
</table>

SIMAP’s calculated emissions from employees driving and carpooling into campus totaled 28,531 MTCO2e. Emissions from staff driving in alone was the top contributor at 23,752 MTCO2e.
Table A-7: SIMAP Student Driving Input & Output Data

<table>
<thead>
<tr>
<th>Mode</th>
<th>Total Students</th>
<th>% Of Students using this mode</th>
<th>Average distance (miles)</th>
<th>One-way trips per commuter per week</th>
<th>Commuting weeks per year</th>
<th>MTCO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automobile</td>
<td>18,876</td>
<td>30.4%</td>
<td>13.28</td>
<td>10</td>
<td>30</td>
<td>10,276</td>
</tr>
<tr>
<td>Carpool</td>
<td></td>
<td>6.8%</td>
<td>14.71</td>
<td></td>
<td></td>
<td>1,913</td>
</tr>
</tbody>
</table>

SIMAP’s calculated emissions from students driving and carpooling into campus totaled 12,189 MT CO2e, with driving alone also the top contributor at 10,276 MT CO2e.

Altogether, the individual totals from tables A-6 and A-7 result in total driving emissions from SIMAP of 40,720 MTCO2e, as reported in Table 2 in the body of the paper.

**VitalMetrics**

VitalMetrics’ approach uses total distance traveled and distance-based emissions factors that are mode-specific. Total passenger miles traveled annually by mode were calculated by the Office of Sustainability using the average miles per trip, mode split, number of commuters, and total trips per year. The total was converted into passenger-km, as VitalMetrics uses an EPA emissions factor based on CO2e per passenger-km. Given that the total passenger-mi figure includes both drive-alone commuters and carpoolers, a single emissions factor was applied to the figure provided. Tables 8 & 9 below show the total driving-related emissions for employees and students respectively.

Table A-8: VitalMetrics Driving Input Data, Employees

<table>
<thead>
<tr>
<th>Mode</th>
<th>Passenger-mi</th>
<th>Passenger-km</th>
<th>Emissions (MTCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger car or taxi</td>
<td>64,334,030</td>
<td>103,535,586</td>
<td>28,531</td>
</tr>
</tbody>
</table>

Table A-9: VitalMetrics Driving Input Data, Students

<table>
<thead>
<tr>
<th>Mode</th>
<th>Passenger-mi</th>
<th>Passenger-km</th>
<th>Emissions (MTCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger car or taxi</td>
<td>27,930,017</td>
<td>44,949,005</td>
<td>11,929</td>
</tr>
</tbody>
</table>

VitalMetrics calculations for emissions from employees driving to and from campus were estimated at 28,531 MTCO2e for 2019, and their calculations for emissions from students driving to and from campus were estimated at 11,929 MT CO2e, leading to total driving emissions as estimated by VitalMetrics of 40,460 MT CO2e.

**Alternative Transportation Emissions**

Non-driving alternative forms of travel include commuter rail, subway or other transit rail, and public buses. Data inputs and emissions associated with biking and walking to work are excluded from this section since there are no emissions associated with these modes. Emissions due to alternative transportation in 2020 and 2021 will also be calculated and published according to the methodology outlined here since the methodology will not change from year to year.

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The table below documents the data Stanford Office of Sustainability staff used to arrive at total annual passenger miles by mode for 2019 for employees and students. Total annual passenger miles were estimated using average miles per trip for light rail, commuter rail, and bus travel using San Francisco Bay Area data from the National Transportation Administration. Average miles per trip by mode were multiplied by the estimated annual number of trips Stanford employees and students took via each mode, as estimated by each group’s answers from the commuting survey that were scaled to the total employee population.

The National Transportation Administration collects, evaluates, and publishes ridership data submitted by local transit authorities on unlinked passenger trips and total passenger miles traveled. For each mode, annual totals of passenger miles traveled were divided by unlinked passenger trips to arrive at the estimated average distance per trip.

The primary data from the National Transportation Administration is outlined below in table A-10, which was used to provide mileage estimates by mode to SIMAP and VitalMetrics, shown in Table A-11.

**Table A-10: National Transportation Administration Data used as Inputs for SIMAP & VitalMetrics**

<table>
<thead>
<tr>
<th>2020 Public Transportation Fact Book</th>
<th>Unlinked Passenger Trips, Bay Area</th>
<th>Passenger Miles Traveled, Bay Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light rail</td>
<td>8,507,10013</td>
<td>46,981,10014</td>
</tr>
<tr>
<td>Heavy rail</td>
<td>129,044,30015</td>
<td>1,789,223,20016</td>
</tr>
<tr>
<td>Bus</td>
<td>28,473,300</td>
<td>138,466,800</td>
</tr>
<tr>
<td>Commuter Rail</td>
<td>18,504,900</td>
<td>409,333,700</td>
</tr>
</tbody>
</table>

**Table A-11: Calculated Miles Per Commuter One-way Trip by Mode**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Average Miles per trip (Calculated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subway and other transit rail</td>
<td>13.35*</td>
</tr>
<tr>
<td>Bus</td>
<td>4.86</td>
</tr>
<tr>
<td>Commuter Rail</td>
<td>22.12</td>
</tr>
</tbody>
</table>

*A weighted average of miles per trip for light and heavy rail as shown in Table A-8 was used to estimate this average.

**SIMAP**

Emissions from alternative forms of transit were calculated by SIMAP using their emissions factors for commuter rail, light rail, and bus. SIMAP calculates emissions for staff, faculty, and student commuting separately, using the number of commuters, mode split data, the annual number of trips, and average miles per trip by mode to arrive at each group’s estimated total passenger miles by mode. SIMAP’s emissions factors are derived from data on energy intensity and average

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12 Unlinked Passenger Trips refer to the "number of passengers who board public transportation vehicles," with passengers counted each time they board vehicles, no matter how many vehicles they use to travel from their origin to their destination. Passenger miles traveled indicates the cumulative sum of the distances ridden by each passenger. [https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary](https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary)


14 Ibid.


16 Ibid.

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miles per gallon by mode from the Bureau of Transportation Statistics. To arrive at average miles per gallon by mode, the Bureau of Transportation Statistics divided total miles traveled by mode annually in the US, and divided it by the estimated number of gallons of fuel used annually by mode, as provided by statistics published by the US Federal Highway Administration, based on data submitted to the administration by states. Then, emissions factors for CO2, CH4, and N2O by fuel type were taken from the EPA’s inventory of sources and sinks.

Stanford’s mode split data only differentiates between employees and students – there is no mode split available at a faculty and staff-specific level for employees. As a result, faculty and staff are combined into one “employee” group, and ascribed the mode split derived from collective faculty and staff responses to the commuter survey, which is summarized in Table 5. The student mode split calculated from the same survey, as seen in Table 6 was used for SIMAP’s calculations of emissions due to students using alternative transportation.

The Stanford Office of Sustainability provided the inputs in Table A-11, using data shown in Table A-10. Then, SIMAP applied mode-specific emissions factors to total passenger miles for each mode, arriving at an emissions estimate. These inputs and emissions calculations are shown for employees in Table A-12, and shown for students in Table A-13.

Table A-12: SIMAP Alternative Transportation Data Inputs and Outputs by Mode, Employees

<table>
<thead>
<tr>
<th>Mode</th>
<th>Total Employees</th>
<th>% Of Employees using this mode</th>
<th>Average distance (miles)</th>
<th>One-way trips per commuter per week</th>
<th>Commuting weeks per year</th>
<th>MTCO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuter Rail</td>
<td>16,998</td>
<td>16.3%</td>
<td>22.12</td>
<td>10</td>
<td>50</td>
<td>4,370</td>
</tr>
<tr>
<td>Light Rail</td>
<td></td>
<td>1.2%</td>
<td>13.35</td>
<td></td>
<td></td>
<td>142</td>
</tr>
<tr>
<td>Public Bus</td>
<td></td>
<td>1.5%</td>
<td>4.86</td>
<td></td>
<td></td>
<td>78</td>
</tr>
</tbody>
</table>

SIMAP’s total estimated emissions from alternative forms of transportation for employees in 2019 was 4,592 MTCO2e. Emissions from commuter rail were the top contributor, followed by light rail and bus.

Table A-12: SIMAP Alternative Transportation Data Inputs and Outputs by Mode, Students

<table>
<thead>
<tr>
<th>Mode</th>
<th>Total Students</th>
<th>% Of Students using this mode</th>
<th>Average distance (miles)</th>
<th>One-way trips per commuter per week</th>
<th>Commuting weeks per year</th>
<th>MTCO2e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commuter Rail</td>
<td>18,876</td>
<td>11%</td>
<td>22.12</td>
<td>10</td>
<td>30*</td>
<td>2,164</td>
</tr>
<tr>
<td>Light Rail</td>
<td></td>
<td>2%</td>
<td>13.35</td>
<td></td>
<td></td>
<td>204</td>
</tr>
<tr>
<td>Public Bus</td>
<td></td>
<td>1%</td>
<td>4.86</td>
<td></td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>

*The assumption is round trips for 5 days of class a week, 10 weeks per quarter, 3 quarters per year.

17 https://www.bts.gov/content/energy-intensity-passenger-modes

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SIMAP’s total estimated emissions from alternative forms of transportation for students in 2019 was 2,393 MTCO2e. Emissions from commuter rail were the top contributor, followed by light rail and bus. In total, emissions from employees and students commuting using alternative transportation were 6,984 MT CO2e using the SIMAP methodology.

**VitalMetrics**

VitalMetrics’ approach uses total distance traveled and distance-based emissions factors that are mode-specific. Total passenger miles traveled annually by mode were calculated by the Office of Sustainability using the average miles per trip, mode split, number of commuters, and total trips per year for employees and students. The total was converted into passenger-km for employees and students, as VitalMetrics uses an EPA emissions factor based on CO2e per passenger-km. Table A-13 shows the resulting passenger-km estimations and the emissions by mode calculated using the VitalMetrics methodology for employees, and Table A-14 shows the same information for students.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Passenger-km (Input)</th>
<th>MTCO2e (Output)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus and other mass transit</td>
<td>873,470</td>
<td>60</td>
</tr>
<tr>
<td>Railway travel for commuting</td>
<td>43,200,974</td>
<td>3,948</td>
</tr>
<tr>
<td>Subway and other transit rail</td>
<td>1,929,479</td>
<td>99</td>
</tr>
</tbody>
</table>

For employees, VitalMetrics found that the largest contributor to alternative transportation commute emissions is commuter rail, followed by other transit rail (such as light rail), then bus transport. VitalMetrics’ estimate of total emissions from alternative commutes for employees was 4,107 MTCO2e.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Passenger-km (Input)</th>
<th>MTCO2e (Output)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus and other mass transit</td>
<td>279,034</td>
<td>19</td>
</tr>
<tr>
<td>Railway travel for commuting</td>
<td>21,388,514</td>
<td>1,955</td>
</tr>
<tr>
<td>Subway and other transit rail</td>
<td>2,749,602</td>
<td>142</td>
</tr>
</tbody>
</table>

Table A-14 shows the resulting emissions by mode for students commuting to campus using the VitalMetrics methodology. As was the case with employees, emissions from commuter rail were estimated to be the highest, followed by other transit rail and bus transportation. The total estimated emissions from student alternative transportation using VitalMetrics’ approach was 2,116 MT CO2e. In total, emissions from employees and students commuting using alternative transportation was 6,222 MT CO2e according to the VitalMetrics methodology.

**Home Office Emissions**

As discussed in the paper, three methods were used to estimate home office emissions. Method 1 was ultimately selected as the most accurate but is still too imprecise to merit inclusion of this category into Stanford’s official emissions accounting.
Method 1 estimates home office emissions based on average consumption and/or hours of use of select equipment that would be used more when employees work from home. This equipment includes heating, air conditioning, computers, monitors, and lighting. Table A-15 shows the assumptions made for each type of equipment. These assumptions are converted into a daily estimate of emissions that is multiplied by working days per year, the number of total employees per year, each year’s respective telecommute rate, and emissions factors shown in Table A-13. This method resulted in annual emissions of 725 MTCO2e in 2019, 1,994 MTCO2e in 2020 and 2,797 MTCO2e in 2021.

Table A-15: Equipment assumptions for calculating home office emissions

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Unit</th>
<th>Units/hour</th>
<th>Hours/day</th>
<th>Units/day</th>
<th>Emissions, PG&amp;E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>Therms</td>
<td>N/A</td>
<td>N/A</td>
<td>0.44</td>
<td>0.0023620044</td>
</tr>
<tr>
<td>Air Conditioning</td>
<td>kWh</td>
<td>N/A</td>
<td>N/A</td>
<td>1.93</td>
<td>0.0000038541</td>
</tr>
<tr>
<td>Computer</td>
<td>kWh</td>
<td>0.0015</td>
<td>4*</td>
<td>0.06</td>
<td>0.000001200</td>
</tr>
<tr>
<td>Monitor</td>
<td>kWh</td>
<td>0.0002</td>
<td>8</td>
<td>0.02</td>
<td>0.000000320</td>
</tr>
<tr>
<td>Lighting</td>
<td>kWh</td>
<td>0.003</td>
<td>8</td>
<td>0.24</td>
<td>0.0000004800</td>
</tr>
</tbody>
</table>

*Computer assumed to be a laptop with four hours per day of active charging

Table A-16: Stanford-specific inputs for home office emissions calculations

<table>
<thead>
<tr>
<th>Inputs</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of employees</td>
<td>15,576</td>
<td>16,817</td>
<td>18,038</td>
</tr>
<tr>
<td>Electricity emissions factor, PG&amp;E (MTCO2e/kWh)</td>
<td>0.000002</td>
<td>0.000002</td>
<td>0.000002</td>
</tr>
<tr>
<td>Natural gas emissions factor, PG&amp;E (MTCO2e/therm)</td>
<td>0.0053218</td>
<td>0.0053218</td>
<td>0.0053218</td>
</tr>
</tbody>
</table>

Method 2 estimates home office emissions based on the assumption that remote work contributes to incremental annual energy consumption of 15-20%. This method uses state of California energy use averages for 2019 of 395 therms per year and 7,873 kWh per year. Using these averages, incremental electricity and natural gas consumption is calculated and multiplied by the emissions factors and annual employee counts shown in Table A-16 above. This method resulted in annual emissions of 4,911 MTCO2e in 2019, 5,302 MTCO2e in 2020, and 5,687 MTCO2e in 2021.

As discussed in the body of the paper, natural gas is the most significant contributor to home office emissions. However, electricity emissions are highly dependent on the composition of electricity served to each home. Because most employee

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21 Ibid.

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homes are in PG&E electric service areas (as shown in Figure A-1 below), the PG&E emissions factor was used for all home office calculations.

Finally, Method 3 estimates home office emissions based on published figures from a Reuters survey of 20 large companies. The details reported by six of those companies, including Salesforce, Meta, and Fidelity, show average home office emissions per employee to be roughly 536 lbs. of CO2e or about a quarter of a metric ton.24 If we multiply this figure by Stanford’s total annual employees, we arrive at emissions estimates of 3,787 MTCO2e in 2019, 4,089 MTCO2e in 2020, and 4,386 MTCO2e in 2021. However, this method is only useful for comparison purposes; because we do not have full transparency into the data used to calculate this number—including the geographies where all reporting companies are based—it wouldn’t be accurate to rely on this estimate alone.

24 [https://www.weforum.org/agenda/2022/05/companies-climate-challenge-home-offices/](https://www.weforum.org/agenda/2022/05/companies-climate-challenge-home-offices/)