THE CARBON IMPACT OF A WORKDAY

Quantifying workplace, residence, and commuting emissions across U.S. cities

Gensler RESEARCH INSTITUTE

MIT Mobility Initiative

A Collaboration between the Gensler Research Institute & the MIT Mobility Initiative

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INTRODUCTION

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Research Context

In the U.S., roughly a third of the working population has jobs that take place in an office environment.[1] This research seeks to provide new and foundational knowledge on the carbon impact of work, with a focus on three factors related to work activity: the spaces we occupy, how we power these spaces, and the ways we transport ourselves between these spaces daily.

We examine these factors via a set of basic scenarios that present pathways to reduce the carbon impact of our homes, offices, and transportation. This study considers both the potential carbon savings from commute shifts, as well as the differential in carbon emissions of working from and conditioning an office, a home, or both.

Employees, companies, governments, and policymakers can use these insights to help reduce the carbon impact of our cities and communities. While this study centers on office-workers, these findings translate to any use of “collective infrastructure” that allows less space to be conditioned to support more people.

This study examines five major U.S. cities: Chicago, Houston, Los Angeles, New York, and San Francisco. Mobility data is also provided for Boston, Denver, Miami, and Phoenix.

By analyzing emissions from both mobility and building use, this study explores the system-level efficiencies gained through urban living and working. It quantifies the trade-offs between carbon emissions from various forms of urban mobility (gas cars, electric vehicles, public transportation, bike share, and walking), and the diverse carbon profiles of different homes and workspaces that we condition throughout the day.

Globally, powering the built environment is responsible for roughly 27% of global carbon emissions, while all transportation produces another 28%.[2] Where we work, and how we get there, play a major role in shaping our carbon footprints.

We focus on knowledge workers who often have choice in their work locations — either at the individual level or at the organizational level — and therefore hold the greatest opportunity for behavioral change.

The analysis centers on the operational carbon impact of our workday decisions and does not consider embodied carbon as one of its metrics. A life cycle assessment approach to the same scenarios could be taken in future studies to account for the complexity of embodied carbon. This could include comparisons such as the carbon impact of driving a gas car you already own vs. purchasing a new electric vehicle, constructing a new office that is more energy efficient, or in moving from a larger home or office to a smaller one.

The scope of this study is limited to newly constructed offices and homes that comply with current code requirements. From a perspective of operational energy and operational carbon, new constructions are nearly always more efficient than old buildings.

By emphasizing operational emissions, the study highlights the short-term behavioral changes that individuals and organizations can implement to make immediate progress toward the decarbonization of our cities.

Our findings provide a framework to understand trade-offs between different working profiles, highlighting how our behavior choices and travel patterns affect net carbon emissions. The goal is to inform better decisions about where we live, work, and how we move between these places to collectively reduce carbon emissions.

Overview of Key Findings

Whether considering mobility options or how and what spaces we occupy, the most carbon efficient choices are those that rely on shared or public infrastructure. One bus may use more fuel than one car, but, when occupied at half or greater capacity, the bus uses less fuel per person. This relationship extends to workspaces. Higher density within a building means less energy used for lighting, heating, and cooling per person. A 10,000-square-foot office emits far more carbon than a similarly efficient 2,000-square-foot home, but is designed to accommodate many more occupants at a time.

When working in one office, 100 people require only 15%–20% of the space that 100 people each working in a single-family home would occupy. This density allows offices to expend far less energy per person than residences during a given workday.

When individuals work from an office or any shared space outside the home, their unoccupied homes become a point of opportunity to reduce energy use. This reduction, known as a "setback," can lower residential emissions in unoccupied spaces by 30%–60% from baseline, depending on the scale of action taken.

Homes and offices are typically conditioned to between 68°F and 76°F to maintain thermal comfort.[3] A moderate emissions reduction of 30% can be attained if home HVAC systems are set to 80°F for cooling and 67°F for heating during the workday. A more aggressive 60% reduction can be achieved by turning off all lights, reducing plug loads, placing appliances in standby mode, and turning HVAC systems off completely.*

For some individuals, a 30% setback reduces home energy use enough to offset the added emissions of commuting and conditioning an office. This is particularly seen when people live in larger homes, where the square foot differential between home and office is greater.

More aggressive 60% setbacks are the most effective method of decarbonizing for individuals living in cities with lower commute emissions, where density and public transit access reduce travel impact, or in places where conditioning spaces carries higher carbon costs due to colder climates or dirtier local energy grids.

Decarbonizing the commute also allows workers to cut considerable carbon emissions, particularly in more sprawling cities with longer than average commutes.

Workers can cut commute emissions by switching from gas-powered cars to public transit, biking, or walking. In cities with cleaner energy grids, electric vehicles provide another effective option to reduce emissions. Living closer to the office or otherwise reducing commute distances, particularly in car-dependent cities, can have a significant impact, complementing the energy savings achieved through home setbacks.

Research Applications

Individuals and Employees

Individuals want to be empowered to make their own choices. Many are concerned about climate change and energy security, and want to make a difference — better knowledge is needed to help people reduce their carbon impacts most effectively.

Businesses and Employers

Corporations are increasingly focused on reducing their carbon impact, driven by a combination of social responsibility, policy or code-based incentives or penalties, and the financial benefits of decarbonization and lower energy use —particularly as energy costs rise. Decisions made about how to provide and invest in workplaces for their employees have a significant carbon impact, and the provision of an efficient workplace is an opportunity for carbon reduction.

Government

Policymakers, city and transportation planners, zoning boards, public transit agencies, and city officials in general are increasingly focused on reducing their electricity peak demand and carbon impact — incentivizing behavioral change is a near-term opportunity to achieve carbon reduction. Cities also have a role to play in educating and incentivizing the behaviors of their residents.

* Assuming an eight-hour workday and two one-hour commutes.

CALCULATING THE CARBON FOOTPRINT OF A WORKDAY

Our team analyzed the carbon emissions associated with powering various residence types, office sizes, and commuting methods in each city. We then synthesized these metrics to determine the carbon footprint of an individual's workday across different work and commute scenarios.

We can estimate an office worker's carbon footprint by summing the emissions from home energy use, round-trip commuting, and office operations on a given workday.*

Commute emissions, residential emissions, and office emissions are all variable based on city, the commute mode, commute distance, residence type, residence size, office size, and office space allocated per person, among other factors.

Scenarios for Modeling Workday Carbon

To demonstrate the high variability of the carbon footprint of work, the research is structured around a prototypical set of workday scenarios, presented in the following section. Scenarios 1 through 4 represent typical schedules where individual office workers can choose whether to work from home or the office, with varying ability to reduce energy use in their residences.

SCENARIO 1
Commute, Work from Office, No Home Setback

Home	FULLY OPERATIONAL
Commute	YES
Office	FULLY OPERATIONAL

This scenario represents an all-too-common occurrence for many workers today: commuting to and working from the office, while also leaving our homes fully running and conditioned as if they were also occupied throughout the day. In every city, for every residence type, and for every commute type, this is the most carbon-intensive option possible.

SCENARIO 2
Commute, Work from Office, Mild Home Setback

Home	SYSTEMS SETBACK 30%
Commute	YES
Office	FULLY OPERATIONAL

By adjusting HVAC systems to 80°F for cooling and 67°F for heating, individuals can reduce their residential emissions by an estimated 30% during the workday.

SCENARIO 3
Commute, Work from Office, Aggressive Home Setback

Home	SYSTEMS SETBACK 60%
Commute	YES
Office	FULLY OPERATIONAL

This scenario represents a more aggressive approach to residential energy use reductions while in the office. By aggressively reducing loads on heating and cooling systems, reducing plug loads, and shutting down appliances, individuals can reduce their residential energy consumption and carbon emissions by up to 60% during the workday.

SCENARIO 4
No Commute, No Office Setback, Work from Home

Home	FULLY OPERATIONAL
Commute	NO
Office	FULLY OPERATIONAL

This represents a typical scenario resulting from hybrid work scheduling. In this instance, an individual has chosen to work from home while their desk at their office remains unoccupied. As in Scenario One, this results in double conditioning of spaces, exacerbating carbon emissions from building operations in most cities. However, the elimination of the commute meaningfully reduces carbon emissions in cities with long commutes for individuals using gas cars.

* "Workday" assumes eight hours working in the office or home, with two one-hour commutes for office work.

Workday Carbon Emissions Comparison

Data is shown by housing type, commute mode, and city for each scenario.

0 10 20 30

Kilograms CO_2e per person, per day

CHICAGO

A dirty, coal-fueled grid and colder temperatures drive up workday emissions in Chicago.

		Work From Office Aggressive home setback	Work From Office Mild home setback	Work From Office No home setback
Private car (self-drive)	Single-family	16.98	22.61	28.25
	Multifamily	13.94	17.30	20.65
Electric Vehicle		13.58	19.21	24.84
		10.54	13.89	17.25
Public Transit		12.01	17.64	23.27
		8.97	12.32	15.68
Walking		10.90	16.53	22.17
		7.86	11.22	14.57

Work From Home Office available, No commute*
22.17
14.57

*Individuals do not commute in this scenario.

HOUSTON

Long, car-dominated commutes account for a significant portion of carbon footprints in Houston.

		Work From Office Aggressive home setback	Work From Office Mild home setback	Work From Office No home setback
Private car (self-drive)	Single-family	13.64	15.92	18.21
	Multifamily	12.31	13.59	14.87
Electric Vehicle		8.18	10.46	12.74
		6.85	8.13	9.41
Public Transit		6.75	9.03	11.31
		5.41	6.69	7.98
Walking		5.32	7.60	9.89
		3.99	5.27	6.55

Work From Home Office available, No commute
9.89
6.55

LOS ANGELES

Long commute distances increase gas car emissions while a cleaner grid keeps electric vehicle and home emissions down.

		Work From Office Aggressive home setback	Work From Office Mild home setback	Work From Office No home setback
Private car (self-drive)	Single-family	8.97	9.99	11.01
	Multifamily	8.45	9.07	9.70
Electric Vehicle		3.87	4.89	5.90
		3.34	3.97	4.59
Public Transit		3.40	4.42	5.44
		2.88	3.50	4.13
Walking		2.41	3.43	4.45
		1.89	2.51	3.14

Work From Home Office available, No commute
4.45
3.14

NEW YORK CITY

In NYC, space efficiency makes office work the best choice for reducing carbon emissions despite colder temperatures compared to other cities.

		Work From Office Aggressive home setback	Work From Office Mild home setback	Work From Office No home setback
Private car (self-drive)	Single-family	12.57	16.36	20.15
	Multifamily	9.44	10.89	12.34
Electric Vehicle		9.21	13.00	16.79
		6.08	7.53	8.98
Public Transit		8.54	12.33	16.12
		5.41	6.86	8.31
Walking		7.45	11.24	15.03
		4.32	5.77	7.22

Work From Home Office available, No commute
15.03
7.22

SAN FRANCISCO

San Francisco's cleaner grid keeps emissions lower in all scenarios.

		Work From Office Aggressive home setback	Work From Office Mild home setback	Work From Office No home setback
Private car (self-drive)	Single-family	9.16	10.87	12.59
	Multifamily	7.81	8.52	9.23
Electric Vehicle		4.62	6.33	8.04
		3.27	3.98	4.68
Public Transit		4.12	5.83	7.55
		2.77	3.48	4.19
Walking		3.32	5.03	6.75
		1.97	2.68	3.39

Work From Home Office available, No commute
6.75
3.39

Three big takeaways from our workday scenarios.

Sprawl Makes Commutes Matter	Density Puts Buildings First	Grids Define Local Footprints
In spread-out cities, choosing transit over cars avoids the most emissions.	In compact cities, home energy setbacks drive the biggest carbon cuts.	Where electricity is more dependent on fossil fuels, the same lifestyle produces higher emissions.

Results

Analyzing these scenarios, there are many trends that hold true across all office workers. Workers living in multifamily homes emit less carbon per workday than those living in single-family homes. Workers who commute to work by walking or public transit emit less carbon per workday than those commuting by car. Workers who live in smaller homes and/or occupy less space in the office always emit less carbon per workday. Workers living in larger single-family homes have the most agency to reduce carbon through residential setbacks.

Any scenario in which a worker is double-conditioning space (e.g. fully operating their home while an office environment is also available to them) is an opportunity for savings by exploring setbacks.

In every city, a worker taking public transportation or walking/biking to work will realize the greatest carbon emission savings by working from the office and setting back their home, except in rare cases in which they occupy more space at the office than in their residence.

In cities with significant percentages of residents commuting by gas cars, the scenarios can become more complicated, highlighting the parallel need to decarbonize our commuting patterns. Individuals should refer to their own city, housing type, and commute mode to find their lowest-emitting work pattern. Organizations can also survey their employee population (investigating housing type and commute mode) to determine the lowest-emitting scenario for their given workforce.

Due to variations in energy sourcing between cities, workers in Californian cities like San Francisco and Los Angeles nearly always emit the least carbon, while workers in Chicago nearly always emit the most carbon, no matter the scenario. In Los Angeles, for example, the average single-family residence emits 6.21 grams of CO_2e per square foot, while the average single-family residence in Chicago emits over five times that figure — 27.78 grams of CO_2e per square foot.

The carbon impact of the commute is most striking in cities like Houston and Los Angeles where commute distances are longer, and gas car commutes are more prevalent. In these cities, switching to public transit affords considerable carbon savings. Our calculations suggest that individuals in Houston can cut their commute emissions by nearly 20,000 grams of CO_2e every week (assuming they commute on three out of five days) by simply switching from a gas car commute to a public transit commute. This one switch avoids emitting nearly one million grams of CO_2e annually.*

Individuals can also explore pathways for carbon reduction not reflected in these scenarios, such as carpooling to reduce commute emissions or desk sharing to reduce the amount of office space per person. Any strategy that increases the use density of transit options, residences, or the office will reduce workday carbon emissions.

Given today's commute and work patterns, the most impactful action individuals in Chicago and New York can take to decarbonize their work lives is to work from the office and aggressively set back their home systems on as many days as possible. For those still commuting via car in those cities, shifting toward public transit or other low/no-carbon transit modes is also still highly impactful. In more sprawling car-centric cities like Houston and Los Angeles, the actions are the same but the order flips — shifting from gas cars toward EVs, public transit, and micromobility has the greatest potential impact, followed by working from the office along with home setbacks.

Minimizing commuting carbon then opens the door to the carbon savings of working from the office and setting back their home — avoiding long commutes in gas-powered cars is a crucial option for reducing carbon footprint but still should not be treated as a reason to avoid the savings of home setbacks.

Individuals can further explore strategies for reducing their own workday carbon emissions with a custom dashboard tool built for the purposes of this research. **Click here to access.**

* Assuming 50 work weeks in a year.

THE CARBON IMPACT OF HOMES AND OFFICES

Energy Use Differences Between Single-Family and Multifamily Residences

On a per-square-foot basis, single-family homes are generally more energy-intensive than multifamily homes. Single-family homes, whether detached houses or townhouses, have a per-capita larger façade and roof exposure to outdoor temperature and weather fluctuations. They therefore require more insulation and better structural efficiency to avoid leaky building envelopes that threaten to imbalance internal comfort and demand higher conditioning loads, thereby using more energy.

Multifamily structures tend to have fewer external walls per unit, which helps reduce energy consumption related to heating and cooling. Larger multifamily buildings also often have dedicated facility management staff that proactively work to reduce energy use to lower the cost of business operations. By contrast, persons occupying single-family residences are much less likely to take actions to regularly make marginal adjustments to fine tune or optimize home energy systems or have the technical knowledge necessary to seek out and perform upgrades.

This trend, however, does not hold in Houston and Los Angeles, where multifamily residences tend to perform more inefficiently than single-family residences on a per-square-foot basis. This disparity is due to the scale of dehumidification and conditioning mandated by code in these cities. Shared spaces, including hallways, stairwells, lobbies, and support space, all must be conditioned, resulting in higher emissions per square foot. However, as multifamily residences are more densely occupied, they emit less carbon per person than single-family homes despite the higher carbon intensity per square foot.

Assumptions for Residential Buildings

Our team leveraged data from Replica and the U.S. Census to determine the average square footage and household size (occupancy) for single- and multi-family residences in each of our five cities.*[4, 5] Depending on the city, the average multifamily residence ranges from 700–1,100 square feet with around two occupants. The average single-family home ranges from 1,800–2,200 square feet with around three occupants. Based on these estimates, the average per-person square footage for homes varies from approximately 350–700 square feet. This data represents an average across the city population — many workers occupy significantly more space at home, particularly those living alone.

Assumptions for Office Buildings

In this study, we assume buildings are of 2019 construction and meet modern energy codes. These buildings incorporate features like high-performance glazing, advanced HVAC technology, and efficient lighting systems. These updates enable code-compliant buildings to operate with substantially lower energy intensity, reflecting the progress made in building efficiency over the past few decades.

All calculations use an estimated average of 150 square feet per worker in an office space. This figure is based on Gensler's internal benchmarking and expertise from ongoing design work for workplace clients. This range can vary depending on location, with workers in higher-cost urban areas occupying less space than those in more sprawling, suburban corporate campuses where space can act as an amenity.

* This study assumes all homes are of 2019 construction.

ASHRAE CLIMATE ZONES

ZONE 0 EXTREMELY HOT	ZONE 1 VERY HOT	ZONE 2 HOT	ZONE 3 WARM	ZONE 4 MIXED	ZONE 5 COOL	ZONE 6 COLD	ZONE 7 VERY COLD
Abu Dhabi	Miami	Houston	Shanghai	London	Berlin	Moscow	Anchorage
Jakarta	Honolulu	Atlanta	Los Angeles	New York City	Boston	Minneapolis	Winnipeg

The Impact of Regional Climate Zones

Most energy use in residences and offices is employed for human thermal comfort. This includes heating in cold climates, cooling in hot climates, and dehumidification in wet climates. Our systems aim to create a comfort range of approximately 68–74°F with no greater than 50% relative humidity.

Climate zones therefore play an important role in determining building energy consumption. In general, the more extreme a climate, the more energy is required to maintain thermal comfort.*

Houses in colder climates tend to use more energy than those in warmer climates, as heating is a more energy intensive activity than cooling. Many heating systems also still rely on on-site combustion of oil or natural gas, while cooling systems are more likely to be all-electric, opening the door for renewable energies.

Energy Use Intensity (EUI) by city and space type

All numbers are shown in kBtu/sf/year, a measure of Energy Use Intensity (EUI).†

	Office	Single-family	Multifamily
Chicago	**36.00**	**55.70**	**42.40**
New York City	**32.60**	**47.00**	**36.90**
Houston	**31.20**	**27.10**	**29.30**
San Francisco	**21.60**	**33.50**	**26.70**
Los Angeles	**22.10**	**21.30**	**24.60**

The Carbon Impact of Energy Sourcing

Carbon emissions vary between cities and states because electricity is produced at the local or regional scale. Localized production means that electricity can come from one or several energy sources based on local regulations and resource availability, including coal, oil, natural gas, biomass, geothermal, nuclear, hydro, solar, and wind energy.

Since each locality derives its electricity from a unique mix of renewable and fossil-fuel sources, operating one square foot of space in two different locations results in different carbon emissions for equivalent amounts of power used.‡

Estimating Carbon Emissions Per Square Foot

Carbon emissions per square foot are calculated by first determining the energy use intensity (EUI), which is found by dividing the total energy consumption of a space by its square footage. The EUI is then multiplied by the carbon factor of the grid (pounds of Carbon Dioxide Equivalent [CO_2e] per kWh) — a figure determined by regional energy sourcing. This calculation provides the carbon emissions per square foot, known as Carbon Intensity, for a given space.

Carbon intensity by city and space type

Carbon intensity varies greatly between U.S. cities due to differences in energy sourcing. All numbers shown in pounds of CO_2e/sf/year.§

	Office	Single-family	Multifamily
Chicago	**31.10**	**48.15**	**36.40**
New York City	**21.91**	**31.53**	**24.75**
Houston	**20.91**	**18.14**	**19.36**
San Francisco	**9.46**	**14.66**	**11.68**
Los Angeles	**9.67**	**9.33**	**10.76**

* Office and multifamily assumed to follow applicable regional ASHRAE 90.1 2019 standard; single-family assumed to follow applicable regional ASHRAE 90.2 2018 standard.

† For offices, calculations assume 2019 construction with chillers for cooling, electric space heating, and electric water heaters. For residences, calculations assume 2019 construction with DX coils for cooling, electric heating, and electric water heaters.

‡ As utilities update their generation mix, grid emissions may fluctuate from what is reported in this study.

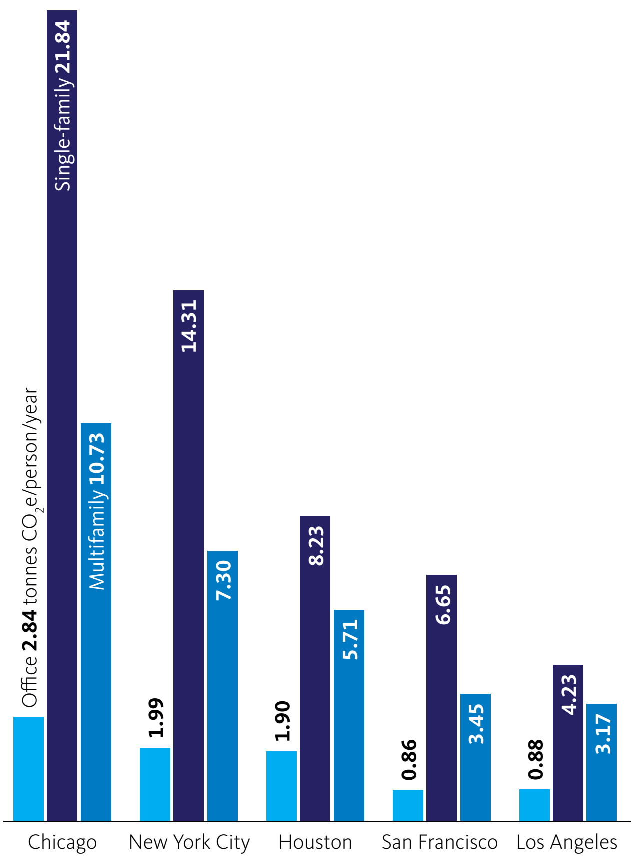
§ For offices, calculations assume 2019 construction with chillers for cooling, electric space heating, and electric water heaters. For residences, calculations assume 2019 construction with DX coils for cooling, electric heating, and electric water heaters.

Calculating the Estimated Daily Carbon Emissions Per Person in Homes and Offices

With carbon intensity measures in hand, calculating carbon emissions per person in a given space type requires multiplying carbon intensity by the estimated number of square feet occupied per person. The resulting total is the estimated daily carbon emissions per person in each building type in each city.

Annual carbon emissions per person by space type*

All numbers shown in metric tonnes of CO_2e/person/year. Rounded to the nearest tenth of a tonne.



Opportunities to Reduce Carbon Emissions: Exploring Energy Setbacks

Setbacks are an energy-saving strategy in which an office or home reduces its energy use during a given time period by turning off or setting back home systems. Setbacks can be employed manually by occupants and building managers or automatically with motion-sensor lights, smart thermostats, or automated Building Management Systems (BMS).

Home Energy Setbacks

Residences are often amenable to setbacks. During the workday, people with unoccupied homes can set HVAC systems into temperature ranges, 80°F for cooling and 67°F for heating, to cut residential emissions by an estimated 30% over a 10-hour period.† The impact is further magnified when HVAC systems are turned completely off. Additional energy savings come from turning off lights, reducing plug loads, and placing appliances on standby. Depending on the scale of action taken, home energy setbacks can reduce residential emissions by up to 60% from baseline for 10 hours through behavior change alone.‡

About 40% of residential energy use is always required for safety-related functions like refrigeration, mold control, and preventing frozen pipes. Energy use setbacks are also only possible in entirely unoccupied spaces, when there are no occupants who require lighting, conditioning, and appliance use. While figures differ from city to city, we estimate that these setbacks will be feasible for between 34%–47% of Americans.§

Office Energy Setbacks

Office setbacks tend to function differently, for both design and operational reasons. Office buildings with traditional five-day/week occupancy employ some level of setback for lighting and HVAC systems on evenings and weekends as standard practice. Turning office buildings off completely is very rare; once operational, the design of most office buildings assumes some level of ongoing performance for the full lifespan of the building.

For office setback scenarios, this research applies an estimated maximum-available setback that decreases energy use by 50%. This is based on the typical maximum drop in office operations associated with unoccupied periods, such as weekends and holidays.

Understanding the different modes people use to commute, distances they travel, frequency of travel, time of travel, and other factors allow us to generate individual and city-level insights. Combining this commute data and its associated carbon footprint with home and office carbon emissions can give an accurate picture of cumulative emissions for a given workday.

* Assuming one occupant for every 150 square feet in offices, 650 square feet in multifamily residences, and 1,000 square feet in single-family residences.

† Assuming an eight-hour workday and two one-hour commutes.

‡ In multifamily residences, occupants may not retain control their heating, reducing setback viability.

§ Includes individuals living alone, individuals with roommates, and couples without children.

THE CARBON IMPACT OF THE COMMUTE

Calculating the Aggregate and Per-Trip Carbon Impact of Different Transit Modes

Carbon Impact of Commuting by Gas Car

Our team used the EPA figure of 400gms of CO_2 per mile for Light Duty Vehicles (LDVs: passenger cars, trucks, SUVs) which constitutes the majority of commute trips per car, be they by personal vehicle or taxi/transportation (TNC: Uber, Lyft).[6] This figure is based on the average fuel efficiency of the U.S. LDV fleet, which is 22.2 mpg. Given that diesel vehicles form a very small portion of the U.S. LDV stock,[7] only gasoline cars were calculated.

It's important to note that carbon emissions for ride-hail services such as Uber and Lyft are higher when accounting for deadhead miles,[8] which are the miles driven without a passenger. However, only the operational emissions of the ride are considered here.

The Carbon Impact of Commuting by Electric Vehicle

In the United States, Electric Vehicle (EV) efficiency for the 242 commercially available MY2024 models was calculated at 2.59 miles per kWh. Using the average U.S. grid carbon emissions of 373 grams of CO_2 per kWh, the average operational emission figure for an EV was determined to be 144 grams of CO_2 per mile.[9]

The Carbon Impact of Commuting by Public Transit

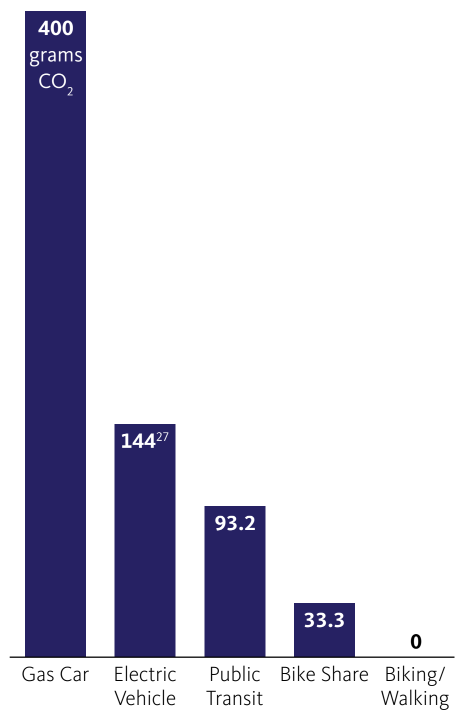
Calculating emissions of public transit is complex, especially when comparing different cities with varying mixes of bus fleets, heavy and light rail, and para-transit services. Due to the lack of readily available data on exact passenger kilometers traveled across each mode, an average of the emissions per passenger mile for metro/urban trains, electric buses, hybrid buses, and internal combustion engine buses was used. This average, derived from the Organisation for Economic Co-operation (OECD) and Development (OECD), provides an operational emission figure of 93.2 grams of carbon dioxide equivalent per passenger mile.

The Carbon Impact of Commuting by Bike Share or E-Scooters

The maintenance and rebalancing of bike share and shared e-scooter systems via vans and other such methods generate operational carbon emissions that must be accounted for. The figures in a study by the International Transport Forum[10] are based on the combined fuel and operational greenhouse gas emissions across shared bikes and e-scooters. Because exact mode-share data for each micromobility option is unavailable, an average of the operational and fuel emissions of 33.3 grams of CO_2 per mile was used.

Gas cars are the highest-emitting commute mode*

Emissions per mile (grams CO_2)



* EV figures reflect U.S. average emissions: exact value varies by local grid mix.

The Carbon Impact of Commuting by Walking or Personal Bicycle

Operational carbon emissions are considered to be zero for commutes by walking and privately owned bikes.* While pedal assist e-bikes[11] and e-scooters[12] have some operational carbon from charging, the figure between 4–5 grams of CO_2 per mile is extremely low. We arrived at this figure looking at the range and battery capacity of some of the most popular e-bikes and e-scooters and using the average U.S. grid carbon emissions of 373 grams of CO_2 per kWh, referenced above.

Determining Commute Patterns in American Cities

Most surveys and analysis present readers with one number for average commute distance for the U.S. or each U.S. city. This approach is problematic because commute distance and commute mode are often linked. For example, people in car-dominant cities are more likely to live further from the city center, increasing their commute distance. Conversely, individuals living in dense cities may walk or bike, choosing to live closer to the city center with shorter commute distances. Given the differences among cities, a single average commute distance across all modes is not sufficient. City-specific, mode-specific distances and shares of the mode were examined to arrive at a more accurate picture of how people move across different cities.

Our analysis of commute patterns in the five U.S. cities began by considering Replica mobility data.[13] Replica was selected as it housed data for all the cities in our study, reported a significant number of trips (in the millions) in each city, and showed strong correlation with actual mobility counts in an evaluation by the Texas A&M Transportation Institute.[14] The Replica datasets examined were for travel on a typical Thursday in the Fall of 2024, with destinations within the city geography defined by the 2020 Census and trip purpose categorized as "Work."

No constraints were placed on the origin, as commuters in most American cities come from multiple zones — within city limits, suburbs and neighboring towns, and rural areas. All these commuters into the city fall under the target group of this study. A typical Thursday was preferred over Monday or Friday, as post-pandemic work patterns show that Tuesday to Thursday are the days people are more likely to commute to work.[15] Other mobility data points that were accessed from this database included trip distanceprimary mode, starting hour, and trip duration.

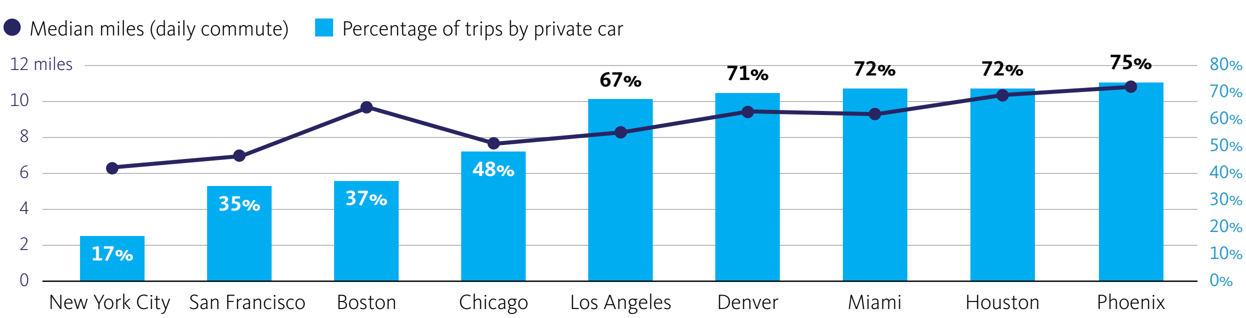
The data suggests significant city-to-city variation in the way people move, influenced by factors such as population, job types, transit networks, road networks, city layout, design, and age. This variation is evident across commute mode, distance, and duration.

Differences in Commute Distance by Mode

At around 80% of total trips, cars are the preferred commute mode for most Americans. According to the American Community Survey, 71.7% of people commute by driving alone, and 8.5% carpool to work.[16] Our analysis found that, while the car is dominant in aggregate, its use varies across cities.

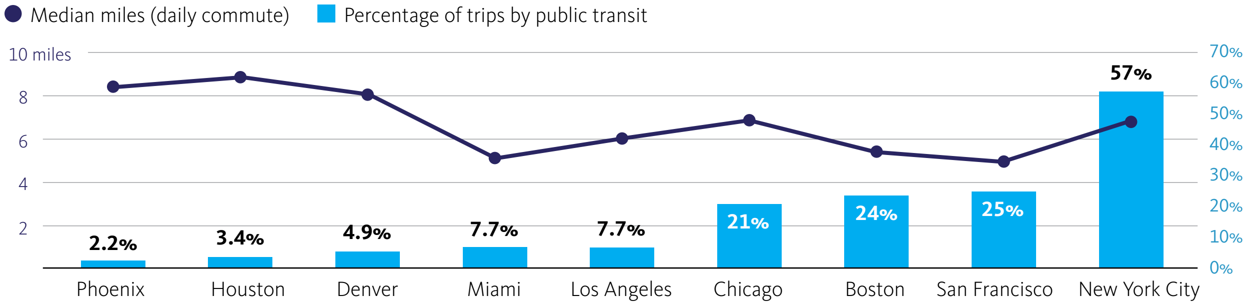
U.S. cities with a well-connected transit system such as New York City, San Francisco, Boston, and Chicago have a lower car commute share compared to cities built for car-based travel such as Los Angeles, Denver, Miami, Phoenix, and Houston. People take longer commutes in sprawling, car-centric cities like Houston, Phoenix, and Denver. Larger commute distances lead to more car usage and dependency, as the low density and sprawl makes other modes less viable.

Private Car Commutes: Median Daily Miles and Mode Share by City



* Only mechanical bicycles and pedal assist e-bikes are considered zero emission active commute modes.

Public Transit Use Across Cities: Median Commute Distance and Share of All Trips



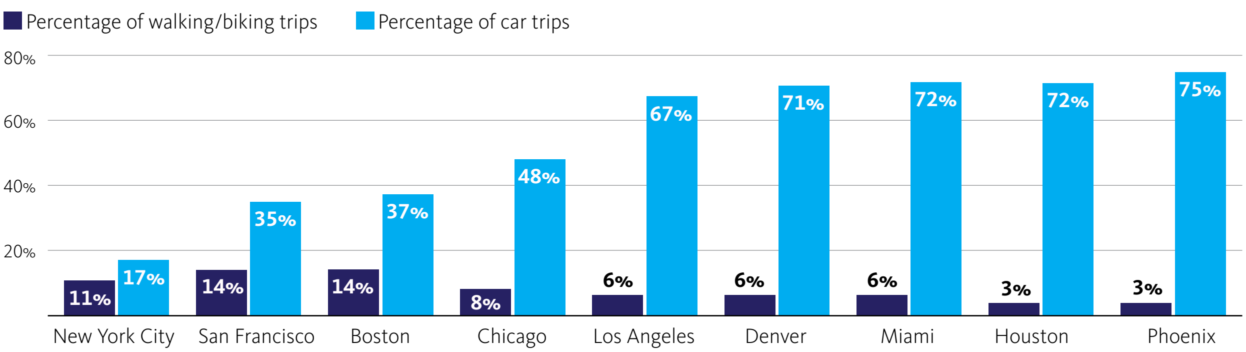
The same analysis was performed for public transit. The overall commute distances for people using transit are lower in cities with higher transit share. Additionally, cities with the highest car usage tend to have the lowest transit usage, and vice versa.

Currently, New York, San Francisco, and Boston have a significant number of trips taken via active modes. Most of these active trips are walking rather than bicycling. The data also clearly indicate that as cars become the dominant mode of commuting, the number of active trips falls drastically.

Walking and biking commutes are inversely correlated with commutes by car.

Walkability greatly improves with compactness, but good walking infrastructure is often neglected in car-centric cities where everything is built around driving and parking. While changing the physical layout and housing stock of our cities is not an easy or quick process, implementing dedicated bike lanes is much simpler and can encourage people[17] who otherwise drive to start using e-bikes for their commute.

Walking and Biking Commutes Are Inversely Correlated with Car Commutes Across Cities



CONCLUSION

Smart choices will lead to meaningful change. The long-term value of carbon reduction is multifaceted and impactful. On the city scale, it will lead to improved air quality, better community health with fewer respiratory and cardiovascular diseases, and job creation to support a green economy. Organizations will benefit from reduced healthcare costs due to better air quality as well as lower energy costs. As individuals, carbon reduction will lower costs through energy efficiency at home and will reduce health-related illnesses and related costs. In the long-term, carbon reduction will increase our collective energy security and open the door for breakthrough innovations and new technologies while helping to halt and reverse anthropogenic climate change.

The objective of this research study is to to help workers and corporations make informed decisions as they seek to decarbonize the impact of work behaviors. In the five cities studied (Chicago, Houston, Los Angeles, New York, and San Francisco), we evaluated multiple trade-offs in energy demand including the size of one's home and office, commuting methods, the impact of turning energy systems down or off, and the influence of the local energy grid.

For individuals who work in collective infrastructure spaces, like the office, setting back thermostats to save energy and carbon in spaces not being used, like the home, has a significant impact. Smart thermostats can make these setbacks easier by enabling individuals to preset the thermostat to consistently reduce heating and cooling while sleeping, or when away from home.

In offices, greater opportunities for energy and carbon savings come from efficiency than setbacks. Organizations can play an important role by designing smaller and more efficient office spaces that reduce the square footage used per employee — allowing less space to be conditioned each day and lowering per-person carbon emissions. Adopting reservation systems allows greater control over office occupancy enabling the conditioning of only the floors or zones within the building that are fully occupied.

Emission Reduction Strategies for Office Development

Reduce square footage occupied per employee	Encourage more use of shared spaces	Implement zoned HVAC systems	Adopt energy-efficient heating and cooling
Invest in green spaces	Provide infrastructure for bike use	Select sites with public transit options	Purchase renewable energy from the grid

Emission Reduction Strategies for Residential Development

Incorporate on-site renewable energy	Electrify HVAC systems where grids are clean	Integrate smart home energy systems	Improve insulation and airtightness
Design for passive heating and cooling	Upgrade to LED lighting	Prioritize multifamily development	Plan for walkable neighborhoods

Encouraging more use of shared spaces instead of individually assigned ones promotes flexible space use and better allocation of resources. Implementing zoned HVAC systems that can be turned down when areas are not fully occupied conserves energy and reduces carbon footprints. The use of energy-efficient electric, HVAC, and plumbing fixtures further reduces energy and water consumption.

The Impact of Office Age and Performance

Older office buildings are often less energy efficient than new constructions due to outdated thermal comfort systems and operational protocols. These structures typically have inefficient insulation, windows, and HVAC systems, leading to higher energy demands. In contrast, buildings constructed or retrofitted to meet modern energy codes incorporate features like high-performance glazing, advanced HVAC technology, and efficient lighting systems.

Prioritizing upgrades to older buildings can yield substantial energy and carbon savings, as targeted interventions in insulation, HVAC, and lighting often deliver the greatest reductions. These updates enable code-compliant buildings to operate with substantially lower energy intensity, reflecting the progress made in building efficiency over the past few decades.

Across major U.S. cities, office spaces are becoming increasingly energy efficient, as improvements in building design, advanced technologies, and stricter municipal energy codes have significantly reduced energy use in heating, cooling, and lighting.

Fully net-zero offices have also gained traction in recent years as buildings eliminate on-site fossil fuel combustion and fully electrify. Renewable energy in the form of solar, wind, and geothermal, whether produced on-site or procured from utilities, can bring net operational emissions to zero and make commercial buildings even more efficient spaces to inhabit.

Reducing the Carbon Impact of Commuting

For individuals, behavioral changes to minimize the carbon impact of commuting are clear: gas cars always emit the most carbon; micromobility options like walking or biking have negligible impact; public transportation has a carbon impact, but at a scale much lower than traveling by car; and if driving a car, an electric vehicle has a lower impact than a gas car.

Organizations can reduce their collective carbon footprints by strategically addressing the commute patterns of their employees. Locating offices near micromobility and public transit nodes makes it easier for employees to avoid using individual cars. Providing employee-sponsored commuter benefits and shuttles to transit hubs can also reduce driving trips and further cut emissions.

On the city scale, shifting the population toward low- and no-carbon commute modes should be the priority. In a city like Chicago, transportation alone releases 12 million metric tons of carbon annually, with personal vehicles contributing the largest percentage.[18] By supporting well-developed public transportation systems, cities can reduce the number of car trips and thereby lower emissions.

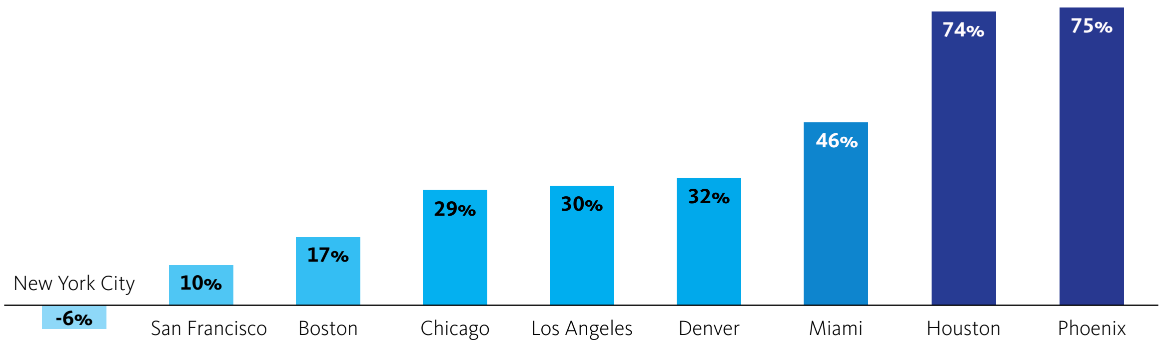
Providing walkable or cyclable streets, dedicated bike lanes, and shaded sidewalks promote healthier, more sustainable modes of transportation. Shared transportation options like buses and trains can further decrease the reliance on single-occupancy vehicles.

Transit and density are two sides of the same coin. Robust public transit systems beget denser geographies, promote more transit-oriented housing, reduce urban sprawl, and promote shorter commute distances.

In nearly all cities, workers commuting by car travel much longer distances than those commuting by public transit. Because car commuters travel longer distances, and because switching from cars to public transit reduces emissions by 33%–76% (depending on commute mode), expanding public transit options can play a significant role in decarbonizing transportation.

Commutes by private car tend to be longer than those by public transit

Additional median commute miles for private car versus public transit



Walkability and bikeability greatly improves with urban density. However, effective walking and biking infrastructure is often neglected in car-centric cities where urban planning prioritizes driving and parking. While changing the physical layout and housing stock of our cities is not an easy or quick process, implementing dedicated bike lanes is much simpler and can encourage people who otherwise drive to start using e-bikes for their commute.[20]

Further Considerations for Transit Mode

Over decades, technical advances in travel modes have increased travel speeds leading to larger city sizes and the growth of suburban living. Despite these improvements, average travel times have remained relatively constant.[21] This phenomenon, known as the "travel time budget," suggests that individuals consistently allocate between one and one-and-a-half hours per day to travel, regardless of improved travel efficiencies, thereby adjusting their pattern of movements to take advantage of greater distances within the same timeframe.

It's a standard assumption used by transportation planners (and much of the public) that our goal is always to minimize travel time. We assume that in an ideal world our commute time would approach zero, a scenario in which people could somehow access employment, goods and services, and other destinations without moving. However, the ideal commute time is not zero. Research instead suggests that the average ideal commute time is around 15–20 minutes.[22]

Travel has intrinsic value that should be recognized and in two distinct ways:

- It enables access to meaningful activities, including work, entertainment, healthcare, social connection, and more.
- Many people integrate activities into the travel time itself.

While mobility might decrease if essential goods and services are nearby, it will never drop to zero because travel itself holds value. And yet, it's also clear that addressing the friction of modern commuting is a significant opportunity to unlock greater happiness and additional positive activities on behalf of the greater population.

In a myriad of studies, including Gensler's own research, office workers see their commutes as a distinct barrier to in-office work.[23] Complete access to everything we need without moving is purely theoretical; practical life always requires some level of mobility.

Over the past decade, there has been a significant increase in active modes of commuting such as walking and bicycling in certain U.S. states and cities.[24] Active modes also offer positive benefits to personal fitness and community health.[25] From a societal perspective, in addition to reducing the burden on the healthcare system, active modes also have nearly zero carbon emissions impact. However, limitations such as distance and weather can affect how often one can choose to commute primarily using an active mode.

APPENDIX

Differentiators of this Study

This is not the first study to explore the carbon footprint of work. However, most previous studies conducted on this topic have either ignored or discounted the impact of home emissions, focusing either solely on carbon emissions from commuting or the trade-offs between commute emissions and office emissions. However, as discussed further in this study, residences are the largest contributor to building operation emissions in urban areas. This research includes residences to provide a more complete picture of the carbon footprint of work.

When someone goes to the office, the impact of their home and its operational carbon footprint do not disappear; it must be considered. Critically, home emissions are not a sunk cost — they can be reduced by up to 60% by changes in daily behavior such as limiting use of lighting, heating, and cooling systems. By considering residential emissions, we can capture one of the most impactful places for carbon reduction.

This study additionally differentiates itself by leveraging city-specific data rather than nationwide statistics. Using only national data engenders results that are too general, and not directly applicable to a specific location. Regional differences in electricity production and commute patterns account for a considerable portion of an individual's carbon footprint. While this study is limited to a select consideration of major U.S. cities, the results are far closer to the reality of carbon emissions in each of these locations.

Our cities are comprised of a mix of buildings of varying ages, types, sizes, conditions, and uses — all connected by a network of public and private open spaces, power grids, utilities, roadways, sidewalks, and public transit networks. It is crucial to the foundations of this study that we better understand the carbon impact of accessing and occupying urban spaces and are clear in the scope of research.

In conducting this study, we have prioritized transparency of methods, data, and assumptions. We seek to open this dialogue by providing complete insight into the data used to reinforce our claims. This includes the theory behind our inputs, the sources of our data, and the numbers used in our calculations. In this way, we seek to provide one of the first fully transparent studies into the carbon footprint of work.

Literature Review and Additional Secondary Sources

A Systematic Review of the Energy and Climate Impacts of Teleworking | IOPscience

Climate Mitigation Potentials of Teleworking are Sensitive to Changes in Lifestyle and Workplace Rather than ICT Usage | PNAS

Is Remote Work Actually Better for the Environment? | Harvard Business Review

GLOSSARY OF TERMS

ASHRAE

The American Society of Heating, Refrigeration, and Air Conditioning Engineers. A professional association responsible for, among other things, developing comprehensive energy standards for buildings.

Carbon Dioxide Equivalent (CO_2e)

A measure of greenhouse gas emissions expressed in terms of the amount of CO_2 that would have the same global warming impact.

Carbon Footprint
The total amount of greenhouse gases (measured in CO_2e) emitted by an individual over a given period.

Carbon Intensity
The amount of CO_2e emissions produced per unit of energy or space (e.g., per kWh or per square foot).

Climate Zone
A geographic area defined by long-term temperature, humidity, and weather patterns that affect building energy performance and code requirements.

Commute
Regular travel between home and workplace, by car, public transit, bike, or walking. Defined in this study as one hour in each direction.

DX Coils
Direct Expansion Coils, components in HVAC systems where refrigerant absorbs or releases heat directly to cool or heat air.

Electric Vehicle (EV)
A vehicle powered entirely or partially by electricity using a rechargeable battery rather than an internal combustion engine.

Energy Modeling
A simulation process used to estimate a building's energy consumption and performance under various design and operational conditions.

Energy Setback
An automatic or manual adjustment to HVAC, lighting, and other energy-intensive systems to reduce energy use when a space is unoccupied.

Energy Use Intensity (EUI)
A metric that expresses a building's annual energy use per square foot, typically in kBtu/sqft/year.

Grid Capacity
The maximum amount of electricity that the power grid can deliver at any given time without risk of overload.

Grid Load
The total demand for electricity on the power grid at a specific time, influenced by users, devices, and weather.

Heat Pump
A device that transfers heat between indoors and outdoors, providing both heating and cooling by using electricity to move heat rather than generating it directly.

HVAC
Heating, Ventilation, and Air Conditioning. The systems used to regulate indoor climate, air quality, and comfort in buildings.

Internal Combustion Engine (ICE)
An engine that generates power by burning fuel (e.g., gasoline or diesel) inside the engine's cylinders.

Kilowatt Hour (kWh)
A unit of energy equal to using 1,000 watts of power for one hour, commonly used to measure electricity consumption.

Onsite Combustion
The burning of fuels like natural gas, oil, or propane directly at a building or facility to produce heat or energy.

Site Emissions
Greenhouse gas emissions that occur directly at a building or site, typically from onsite combustion.

Source Emissions
Total greenhouse gas emissions including both onsite and offsite (e.g., power plant) emissions associated with energy use.

Transmission Loss (TL)
The energy lost as electricity travels through transmission and distribution lines from power plants to end users.

Workweek
The standard number of days and hours a person works in a week, considered in this study to be 40 hours over five days, plus 10 hours of commute time if working in-office.

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