Compact Cities Electrified: United States

BRIEF FOR POLICYMAKERS

ITDP

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COVER PHOTO: Columbia Pike Transit Station in Arlington, Virginia.
SOURCE: BeyondDC via Flickr

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1. BACKGROUND

This study is the culmination of a decade of collaboration in transport modeling between ITDP and the University of California Davis.[2] Ten years of effort have produced a detailed method for high-level modeling of urban and suburban passenger transportation, but this study of the US, along with parallel studies of other countries, are the first time the model has been used to publish analytical results for a single country.

Like its predecessor, *The Compact City Scenario—Electrified*, the current publication compares the economic and environmental implications of four scenarios for the future of urban passenger transportation: 1) the current trajectory; 2) intensive electrification; 3) intensive mode shift; and 4) the combination of the latter two. But while the previous report focused on the global need to pursue these strategies, this study describes the specifics of the United States. In addition to quantifying the emissions that each scenario would entail, we have also estimated the quantities and costs—or savings—of infrastructure that would result from different scenarios for the future of the US. These results provide a "road map" for how those scenarios might be realized.

Although this is the first application of the UC Davis model in particular to the US, it is not the first time that transportation modeling has indicated the country's need for both electrification and reduced driving to achieve decarbonization goals. The Georgetown Climate Center, for example, has also shown that "if a substantial portion of [Infrastructure Investment and Jobs Act] funding is directed toward highway expansion, emissions increases from induced demand associated with highway expansion have the potential to reverse the benefits of the low-carbon transportation investments."[3]

2 ITDP & UC Davis (2021), The Compact City Scenario—Electrified; ITDP & UC Davis (2017), Three Revolutions in Urban Transportation; ITDP & UC Davis (2015), A Global High Shift Cycling Scenario; ITDP & UC Davis (2014), A Global High Shift Scenario: Impacts and Potential for More Public Transport, Walking and Cycling with Lower Car Use.

3 Georgetown Climate Center (2021), Issue Brief: Estimating the Greenhouse Gas Impact of Federal Infrastructure Investments in the IIJA.

2. FOUR SCENARIOS

Like the global study and parallel reports for other countries, this research investigates four scenarios for urban passenger transport in the US through 2050. These scenarios are diagrammed in Figure A. We start by understanding these scenarios qualitatively, including a summary of the impacts that they might have outside the scope of our modeling analysis—factors such as public health and economic inclusion. In Section 3 (page 11), we define these scenarios quantitatively for modeling.

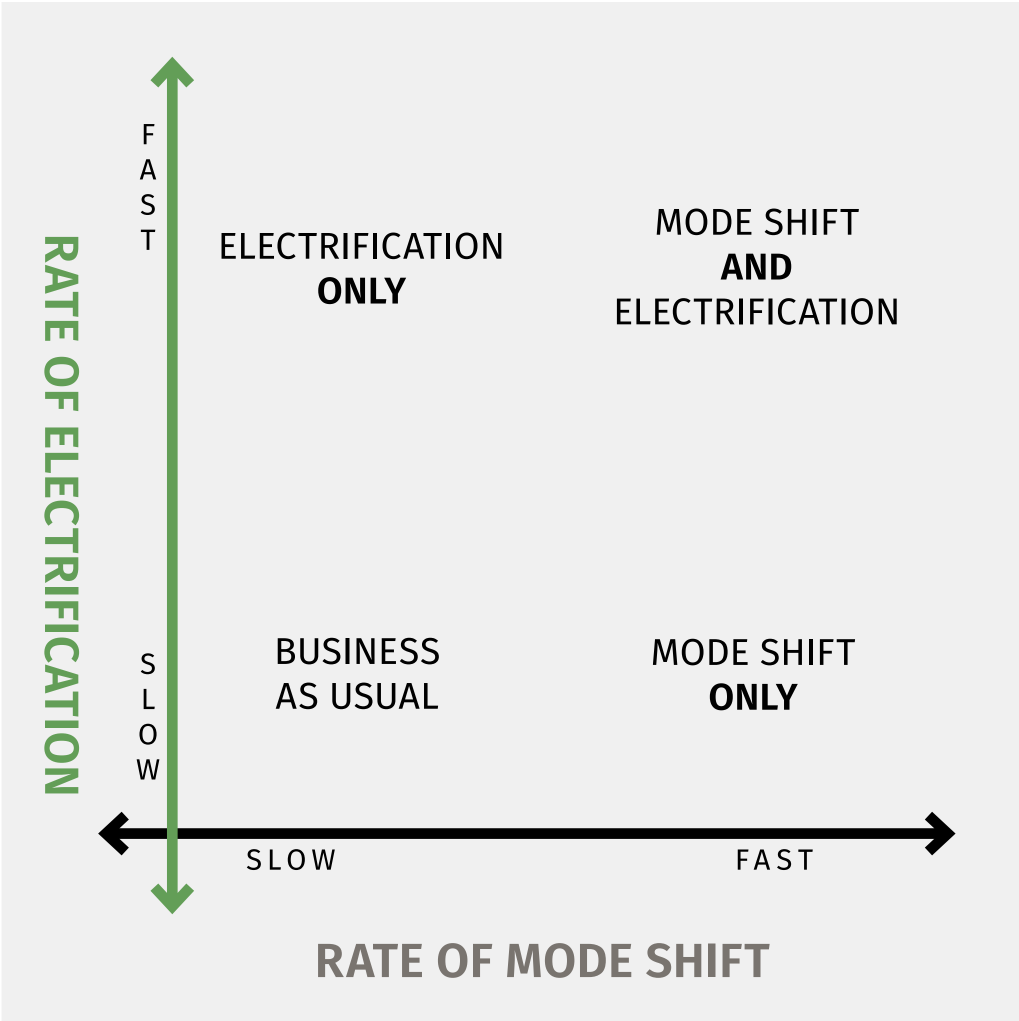

FIGURE A

BUSINESS AS USUAL ("BAU")

Traffic jams on the 101 freeway in Los Angeles typify the Business as Usual future. **SOURCE:** CALmatters.org

Assumptions:

- The US continues its current trajectory. Private motorized travel increases slightly, remaining responsible for nearly 90% of urban passenger travel. Electrification is fairly rapid, per the Inflation Reduction Act of 2022.

Qualitative impacts:

- Increase in traffic fatalities[4]
- High direct public and private costs[5]
- Reduced access to opportunities for low-income or historically marginalized people without cars, leading to increased wealth inequality[6]
- Increase in local air pollution, causing many premature deaths and increased healthcare costs[7]
- Increase in urban highways, dividing neighborhoods and subsidizing environmentally unfriendly sprawl[8]
- Increase in carbon emissions, leading to climate catastrophe[9]

4 Unsurprisingly, steady population growth has historically translated to a corresponding increase in road fatalities, particularly among pedestrians. See: National Safety Council (2021), Car Crash Deaths and Rates; Governors Highway Safety Association (2022), Pedestrian Traffic Fatalities by State: 2022 Preliminary Data.

5 For example, highway infrastructure spending per mile has risen dramatically: Accounting for inflation, $8 million in the 1960s per mile became $30 million per mile by the 1990s. See: American Economic Association (2023), Infrastructure Costs.

6 National Equity Atlas, Indicator: Car Access.

7 Despite great gains in air quality in the US, as of 2022, approximately 85 million people nationwide lived in counties with pollution levels above National Ambient Air Quality Standards. Increased natural events such as wildfires partially due to climate change will further erode air quality. See Union of Concerned Scientists (2014), Vehicles, Air Pollution, and Human Health; United States Environmental Protection Agency (2023), Air Quality National Summary, 1980–2022.

8 Greg LeRoy, JSTOR (2004), Subsidizing sprawl: Economic development policies that deprive the poor of transit, jobs.

9 Andrew Moseman, MIT Climate Portal (2022), Are electric vehicles definitely better for the climate than gas-powered cars? The answer is yes, though the extent to which improvement is meaningful is based on electricity source and manufacturing emissions. The BAU scenario will encourage car-oriented development with a limited increase of clean energy.

ELECTRIFICATION (ONLY)

An EVgo charging station in a parking lot in Fremont, California. **SOURCE:** Tada Images via Shutterstock

Assumptions:

- Electrification proceeds much more rapidly than is currently planned, following proposed EPA standards and other strong electrification policies, with 60% of new light-duty vehicles electric by 2030 and 100% shortly thereafter.

Qualitative impacts:

- 👍 Sharp reduction in carbon emissions[10]
- 👍 Sharp reduction in local air and noise pollution[11]
- 👎 Increase in traffic fatalities
- 👎 High direct public and private costs
- 👎 Reduced access to opportunities for low-income people without cars
- 👎 Increase in urban highways, dividing neighborhoods and subsidizing environmentally unfriendly sprawl
- 👎 Consumption of limited supply of critical minerals, raising concerns related to extractive industries, conservation, national security, and supply chain

Key policies:

- Supply- and demand-side EV incentives
- Ambitious fuel economy and tailpipe GHG emission standards
- Battery reuse and recycling
- Equitable placement of standardized public charging points for EVs (including two-wheelers)
- Electric grid expansion and decarbonization

10 With high electrification, the emissions from transport will be reduced sharply. See: Andrew Mosemen, MIT Climate Portal (2022). Are electric vehicles definitely better for the climate than gas-powered cars?

11 Tsoi et al., (2023), The co-benefits of electric mobility in reducing traffic noise and chemical air pollution: Insights from a transit-oriented city.

MODE SHIFT (ONLY)

In the Mode Shift (Only) future, most urban Americans will live near safe infrastructure for walking and cycling, like Atlanta's Beltline. **SOURCE:** Christopher V Jones / Atlanta BeltLine

Assumptions:

- Compact city planning is combined with reallocation of both funding and street space to walking, bicycling, and public transport. In this case, the US stops building new urban roadways, focusing instead on providing denser housing, mixed land use, and better bus/bicycle infrastructure on existing roadways. Car travel falls to three quarters of *Business as Usual* levels by 2050.

Qualitative impacts:

- 👍 Reduction in traffic fatalities[12]
- 👍 Increased access to opportunities, especially for low-income people, people of color, and other groups suffering from spatial segregation, people with disabilities and the elderly or young[13]
- 👍 Increase in walking and cycling, which improves physical and mental health, reducing healthcare costs[14]
- 👎 High local air and noise pollution from internal-combustion (ICE) vehicles relative to *Electrification (Only)*

Key policies:

- Reallocation of transport budgets to walking, cycling, and public transport, especially BRT
- Street redesigns that shift space from travel lanes and parking to BRT lanes, physically protected bicycle lanes, and footpaths
- Promotion of bicycles, especially shared electric bicycles

12 Dangerous by Design (2022).
13 See: National Library of Medicine (2023), Does the compact city paradigm help reduce poverty? Note, this is most effective in mitigating poverty in combination with housing affordability measures; also see Urban Institute (not dated), Causes and consequences: Separate and unequal neighborhoods.
14 Matthew Raifman et al. (2021), Mortality implications of increased active mobility for a proposed regional transportation emission cap-and-invest program.

ELECTRIFICATION + SHIFT

In the Electrification + Shift future, most Americans will travel by walking, bicycling, or electric vehicle, illustrated by this shared street in San Francisco. **SOURCE:** KURLIN_CAfE via Shutterstock

Assumptions:

- Compact cities and mode shift, combined with rapid electrification: *Electrification* and *Mode Shift* together.

Qualitative impacts:

- 👍 Reduction in traffic fatalities[15]
- 👍 Increased access to opportunities for all
- 👍 Increase in walking and cycling, which improve physical and mental health, reducing healthcare cost
- 👍 Extensive reduction in local air and noise pollution
- 👍 Massive reduction in carbon emissions consistent with the terms of the Paris Agreement

Key policies:

- All policies listed for *Electrification* (Only) and for *Mode Shift* (Only), except for growth in urban highways
- Creation of low-emission areas to incentivize both mode shift and vehicle electrification

15 Dangerous by Design (2022).

Achieving the *Electrification* or *Mode Shift* scenarios would require profound but feasible changes in American policy—changes that are possible under the US's current political and economic structure. They would involve restructuring how transportation budgets are allocated, how street space is used, and how taxes and subsidies are applied to vehicles and fuel—but they are incremental changes that can be reached in the current system and would not require a "revolution" in any economic, social, or political sense.

In Appendix B, we envision a narrative for the *Electrification + Shift* scenario, using the urban area of Dallas–Fort Worth as an example.

3. METHODOLOGY

This study uses the same methods as the 2021 *Compact City Scenario—Electrified* and the other 2023/2024 country-level studies published by ITDP and UC Davis. In each of these studies, we define four scenarios and estimate their impacts using the same modeling methods. This section will first describe the structure of these modeling methods and then outline our process for defining the scenarios that are taken as modeling input.

Our application of this model to the US has been reviewed by experts representing a range of national specialist institutions to help ensure accuracy. These experts' names and affiliations are listed on this brief's title page. For a more detailed description of the methodology, including a complete set of data, please review the accompanying methodological appendix.

3.1. Structuring the Model

Our study is limited to urban passenger transportation and does not include intercity travel, rural travel, or freight carriage of any kind. We define "urban" based on United Nations data, including all urban or suburban areas of 300,000 people or more.[16] This definition encompasses about 80% of the US population. Other research shows that both electrification and mode shift will be necessary to decarbonize rural/intercity[17] and freight[18] transport, and this focus in our scope allows us to model urban and suburban travel with more precision.

The model is calibrated to industry-standard data from the International Energy Agency's *Mobility Model*[19] except where more detailed US-specific data is available. This calibration determines the estimation of conditions in the base year, the projection of the *Business as Usual* scenario, and factors such as emissions factors, fuel emission intensities, and costs.

This general modeling approach was reviewed as part of the 2021 publication, and a list of reviewers can be found there.[20] Our method provides a high-level comparison of different scenarios rather than a detailed bottom-up analysis. This results in a perspective that's relevant to the urban passenger transport sector broadly rather than focusing exclusively on a handful of particular policies.

3.2. Defining Scenarios

After setting the scope and calibrating the model, the next step is to quantitatively define the four scenarios for urban passenger transportation in the US that were described on page 5 above. Beginning from a base year of 2015[21] and looking to future timepoints in 2030 and 2050, we describe possible futures. These scenarios are not intended to precisely define the only options for the future of the sector; rather, they are meant to give an idea of general trajectories that are possible for urban passenger transport.

For electrification, our forecasting is expressed in terms of the percentage of new vehicles that are electric. The *Business as Usual* and *Mode Shift* scenarios share the same lower electrification rates; the *Electrification* and *Electrification + Shift* scenarios share the same higher electrification rates. There may be fewer new cars sold per year in the *Mode Shift* scenario, but the same percentage of those cars are electric. Similarly, modal splits and travel activities (defined in terms of person-miles traveled by different modes) are identical in the *Business as Usual* and *Electrification* scenarios, with higher levels of car use; these are also identical in the *Mode Shift* and *Electrification + Shift* scenarios, with lower levels of car use.

After defining these scenarios, we will estimate their implications. For each scenario, based on the size of vehicle fleets and the amount of activity per vehicle, we estimate life cycle[22] greenhouse gas emissions (Section 4), energy consumption (Section 5), and total quantities and costs of infrastructure, vehicles, fuel, and operation (Section 6).

3.2.1. Scenarios for Electrification Rates

The ***Business as Usual* and *Mode Shift* scenarios** follow the same projections for the percentage of new vehicles that are electric, broken down by year and vehicle type—the *sales shares* of vehicles. In these scenarios, our projections are meant to align with the country's current trajectory. This projection includes the impacts of the Inflation Reduction Act (IRA) but not of any proposed policies that were not law as of October 2023, such as Advanced Clean Cars II or proposed EPA standards. These projections, shown in Figure B, are taken from the International Council on Clean Transportation's (ICCT) projections for the United States[23] and are compatible with analysis by the Rhodium Group.[24]

16 United Nations Department of Economic and Social Affairs (2018), World Urbanization Prospects.
17 International Transport Forum: OECD (2023), ITF Transport Outlook 2023.
18 Lynn H Kaack, Environmental Research Letters (2018), Decarbonizing intraregional freight systems with a focus on modal shift.
19 The *Mobility Model* is only available under a closed license, and the full dataset cannot be shared. However, all relevant variables for the US are included in the methodological appendix and may be reviewed there.
20 ITDP & UC Davis (2021), The Compact City Scenario—Electrified.
21 Selected for data availability and compatibility between sibling studies, and to avoid distortions due to COVID-19.
22 Including emissions not only from the production and consumption of fuel or electricity but also from the manufacture and disposal of vehicles and the construction and maintenance of infrastructure.
23 Sen and Miller, ICCT (2023), Vision 2050: Update on the global zero-emission vehicle transition in 2023, Tables A4 and A5.
24 Larsen et al., Rhodium Group (2022), A turning point for us climate progress: assessing the climate and clean energy provisions in the Inflation Reduction Act, Figure 10, "IRA (Central)."

The ***Electrification*** **and** ***Electrification + Shift*** **scenarios** follow sales share projections that reflect not only the IRA but also the potential impacts of proposed EPA standards for model years 2027–2032 and continued improvement in the EPA standard-setting progress after that period. These projections, shown in Figure B, are also taken from the ICCT[25] and are compatible with the EPA's own analysis.[26]

Percentages of New Vehicles that Are Electric (Rather than Internal-Combustion)						
	Business as Usual and Mode Shift (Only)			Electrification (Only) and Electrification + Shift		
	2015	**2030**	**2050**	**2015**	**2030**	**2050**
LDVs (cars and light trucks)	2%	30%	50%	2%	60%	100%
2-wheelers/ motorcycles (not including e-bikes)	2%	5%	25%	2%	40%	100%
Buses	2%	27%	45%	2%	70%	100%

FIGURE B.
Electrification rates by vehicle type, year, and scenario

3.2.2. Scenarios for Mode Shift Rates

The ***Business as Usual*** **and** ***Electrification*** **scenarios** include modal splits and travel activity projections based on the industry-standard International Energy Agency's (IEA) Mobility Model, which includes base-year estimates and future projections of travel breakdowns by mode. They can be seen in Figure E and Figure F.

The ***Mode Shift*** **and** ***Electrification + Shift*** **scenarios** follow our own calculations, in two steps. First, we project possible future urban densities in the US under a maximum-feasible policy to promote compact, mixed-use cities. Second, we identify the maximum feasible replacement of car and motorcycle travel and substitution with walking, bicycling, public transportation, telecommuting, or shorter trips, including a factor to show how mode shift can be more easily achieved in compact communities. For more detail on this modeling process, see the methodological appendix.

The first step of the calculation draws on data from the European Commission's Global Human Settlement Layer,[27] identifying the current trends in urban density and then also projecting a *compact cities* scenario in which various policies come together to achieve the following effect:

Cities in the United States immediately stop sprawling, consuming no new undeveloped urban land. Rather, population growth is concentrated in areas that currently have less than 4,000 people per km2 (about 10,000 people per square mile) to bring them to a population above that level. This threshold is arbitrary, but it reflects a general point at which it becomes feasible to serve urban areas with public transportation. The modeling approach is meant to generally represent a densification that could be achieved through "missing middle" housing[28] and zoning reform to permit by-right multifamily construction (without parking minimums) on all urban land.

This densification is meant to represent the maximum land use reform that can be achieved without anyone having to leave or redevelop their current home. It will only provide new options: If Americans wish to continue living in low-density suburbs, this degree of densification would not prevent them from doing so—and even in 2050 in the *Mode Shift* scenarios, 17 percent of urban residents will live at very low densities, below about 3,400 people per square mile (5 people per acre, or 500 people per km2).

In the *Business as Usual* projections, almost all population growth results in the expansion of areas where people live at a density between about 5,000 and 10,000 people per square mile (2,000–4,000 ppl/km2). In the *Mode Shift* scenarios, including the densification effects described above, we project that it would be possible to redirect that growth to the expansion of areas where people live at a density between 10,000 and 20,000 people per square mile (4,000–8,000 ppl/km^2), as shown in Figure C. This results in the average weighted urban densities[29] shown in Figure D.

25 Sen and Miller, Vision 2050
26 US EPA (2023), Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles Draft Regulatory Impact Analysis, Tables 13–73.
27 ghsl.jrc.ec.europa.eu/
28 Missing Middle Housing is "a range of house-scale buildings with multiple units—compatible in scale and form with detached single-family homes—located in a walkable neighborhood."
29 Weighted population density is the average of the densities of subareas of the city weighted by the populations of those subareas. Our analysis uses subareas of 1km2. It is a more meaningful indicator than simple population density, which is the total population of a city divided by the total area. See: Garrett Dash Nelson, Bloomberg CityLab (2016), The deception of density.

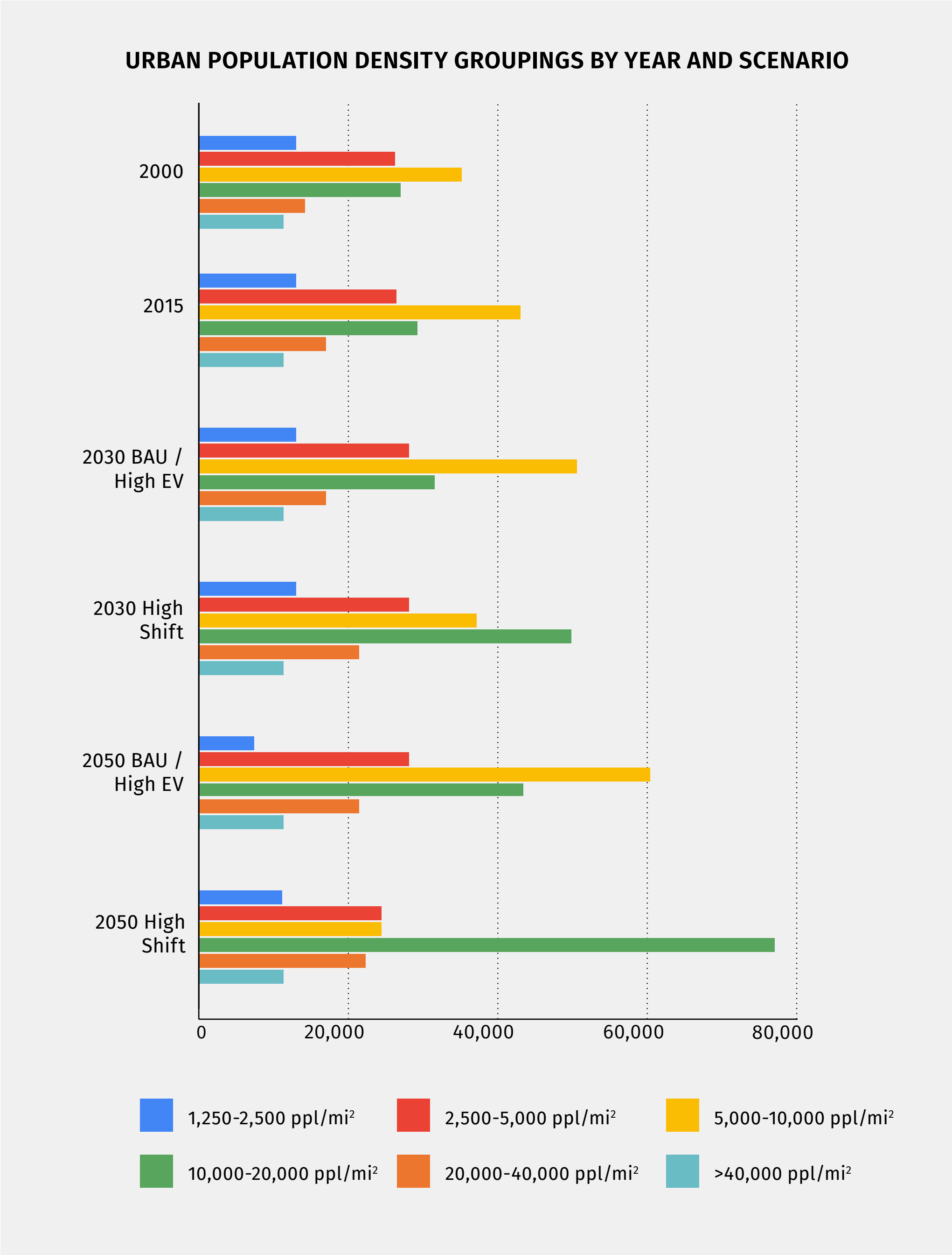

FIGURE C.
Urban density groupings

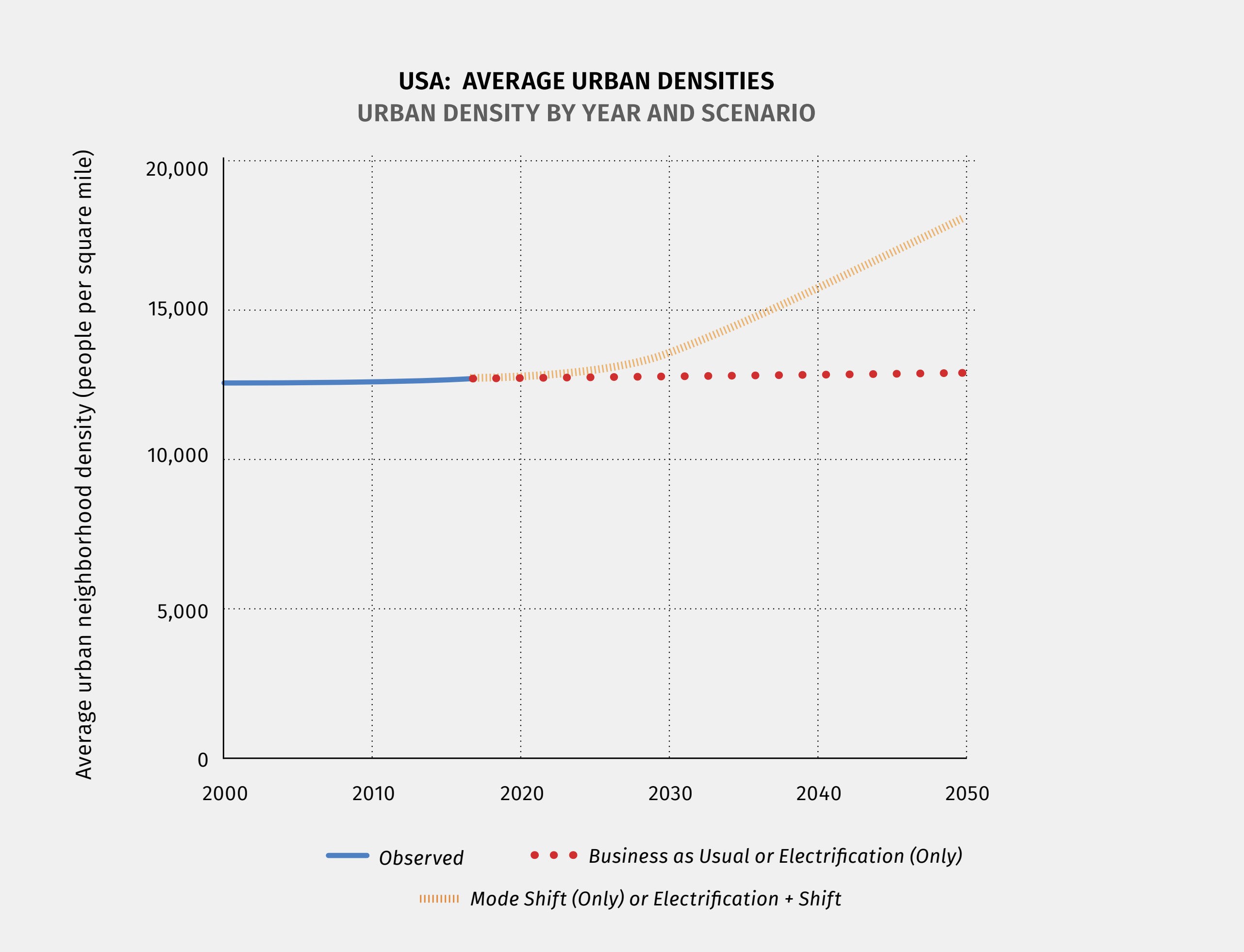

FIGURE D.
Average urban densities

In the second step, after estimating future densities, we used the projected potential urban densities to identify the maximum feasible reductions in car and motorcycle travel as a function of those densities. In more compact communities, it will be easier to replace car travel with travel by other modes. We estimate that a 13 percent reduction in car/motorcycle travel relative to 2030 *BAU* and a 37 percent reduction relative to 2050 *BAU* are achievable. The specific redistribution of this travel to other modes was based on expert judgment, approved by the US-specialist reviewers listed on page 2; more detail can be found in the methodological appendix. The results of this calculation are a modal shift relative to *Business as Usual,* shown in Figure E and Figure F below.

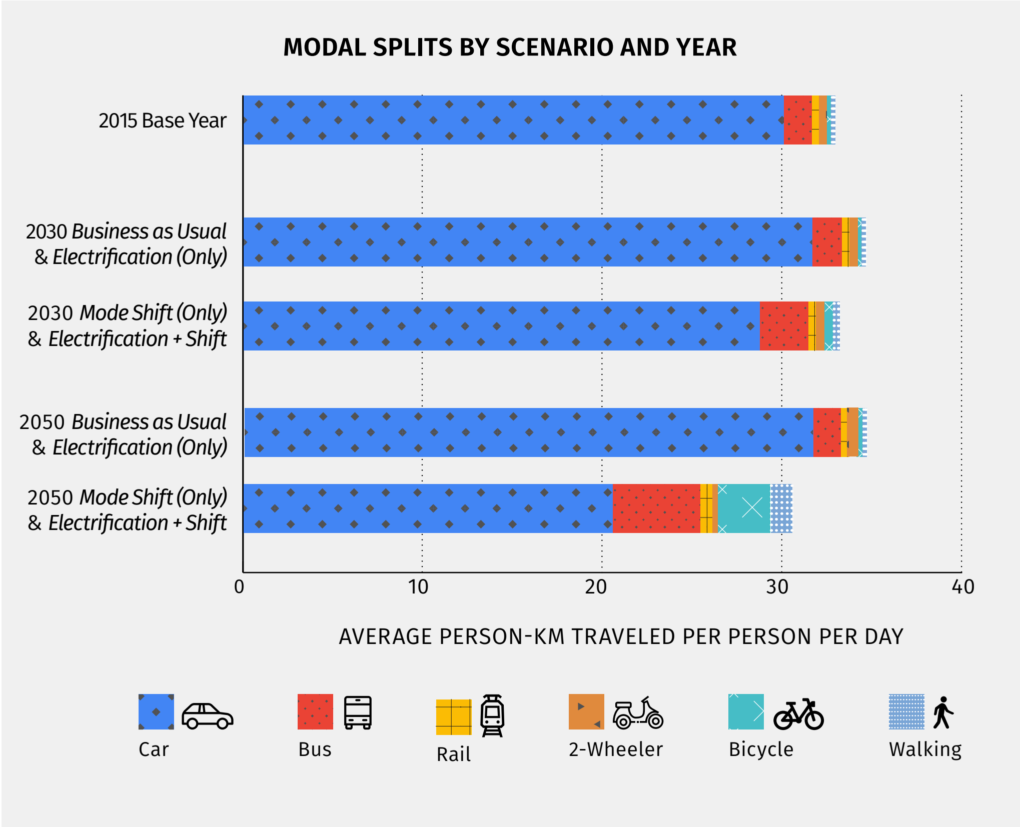

FIGURE E.
Travel activity

Mode Splits by Scenario and Year (by person-km traveled, rather than by trip; independent of overall travel activity, which grows over time)					
	2015 Base Year	**2030 Business as Usual and Electrification (Only)**	**2030 Mode Shift (Only) and Electrification + Shift**	**2050 Business as Usual and Electrification (Only)**	**2050 Mode Shift (Only) and Electrification + Shift**
Car	90%	90%	83%	90%	66%
Bus	5%	6%	10%	6%	17%
Rail	1%	1%	2%	1%	3%
2-wheeler	1%	1%	1%	1%	1%
Bicycle	1%	1%	3%	1%	10%
Walking	1%	1%	2%	1%	4%

FIGURE F.
Mode splits by percent of travel

4. SCENARIO COMPATIBILITY WITH US CLIMATE COMMITMENTS

The United States' commitments to greenhouse gas reductions are ambitious. Our modeling shows that the country's decarbonization goals in the urban passenger transport sector cannot be met with *Electrification* or with *Mode Shift* alone, but require both strategies in concert.

4.1. US Climate Targets

The US has made commitments to reduce greenhouse gas emissions and help prevent catastrophic climate change in this century. Specifically, all 196 Paris Agreement signatories agreed to "[limit] the increase in the global average temperature to well below 2°C above pre-industrial levels and [pursue] efforts to limit it to 1.5°C."

Additionally, after rejoining the Paris Agreement in early 2021, President Biden created the National Climate Task Force, a new body consisting of more than 25 cabinet-level leaders distributed across federal agencies but with the following shared objectives:

- By 2030: Reduce US GHGs by 50%–52% below 2005 levels
- By 2035: Reach 100% carbon-pollution-free electricity
- By 2050: Achieve a net-zero emissions economy
- Delivering 40% of the benefits from federal investments in climate and clean energy to disadvantaged communities[30]

This is a considerable increase from the previous US commitment to cutting emissions 26 percent to 28 percent by 2025,[31] which was categorized as "critically insufficient" by the climate action tracker analysis. However, the revamped nationally-declared contribution (NDC) is not enough to reduce US domestic emissions to the levels necessary to stay within the Paris Agreement's 1.5°C limit.[32]

4.2. Scenario Impacts on Transport Emissions

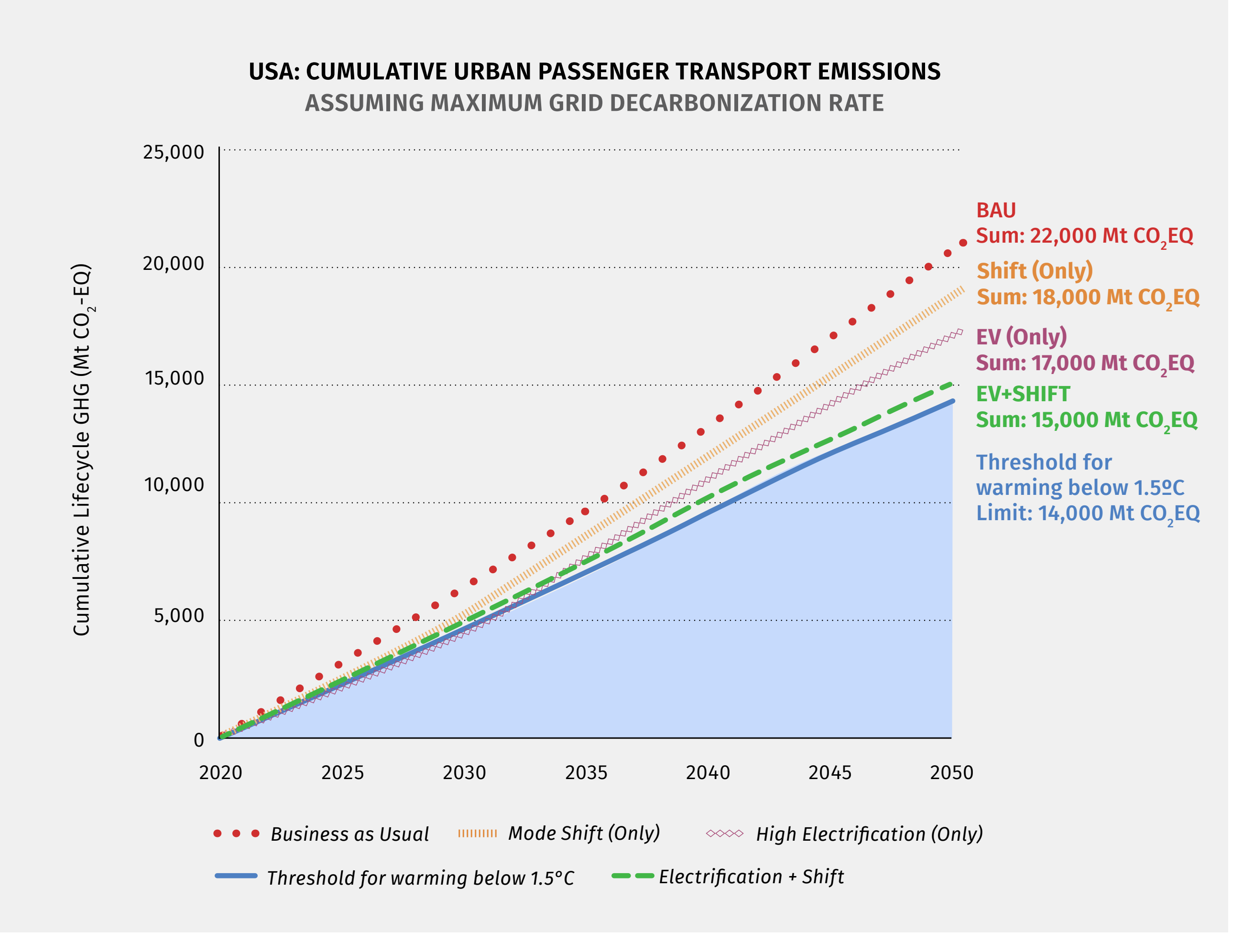

FIGURE G.
Greenhouse gas emissions by scenario

30 The White House, National Climate Task Force (n.d.), President Biden's actions to tackle the climate crisis (2021). Take Climate Action in Your Community.
31 World Resources Institute (2022), US government sets target to reduce emissions 50%–52% by 2030.
32 Climate Action Tracker (n.d.), Targets.

Although the *Electrification* and the *Mode Shift* scenarios each would cause considerable reductions in greenhouse gas emissions, only the combined *Electrification + Shift* scenario even comes close to keeping cumulative urban passenger transport emissions within a level potentially compatible with limiting climate change to 1.5°C in this century, as shown by the area under the blue threshold curve[33] in Figure G, above.[34] However, even this most extensive scenario still falls short.

Not only is *Electrification + Shift* the only scenario that approaches holding global warming within Paris Agreement goals, it is the only scenario that approaches the US's goal of achieving Net Zero by 2050.

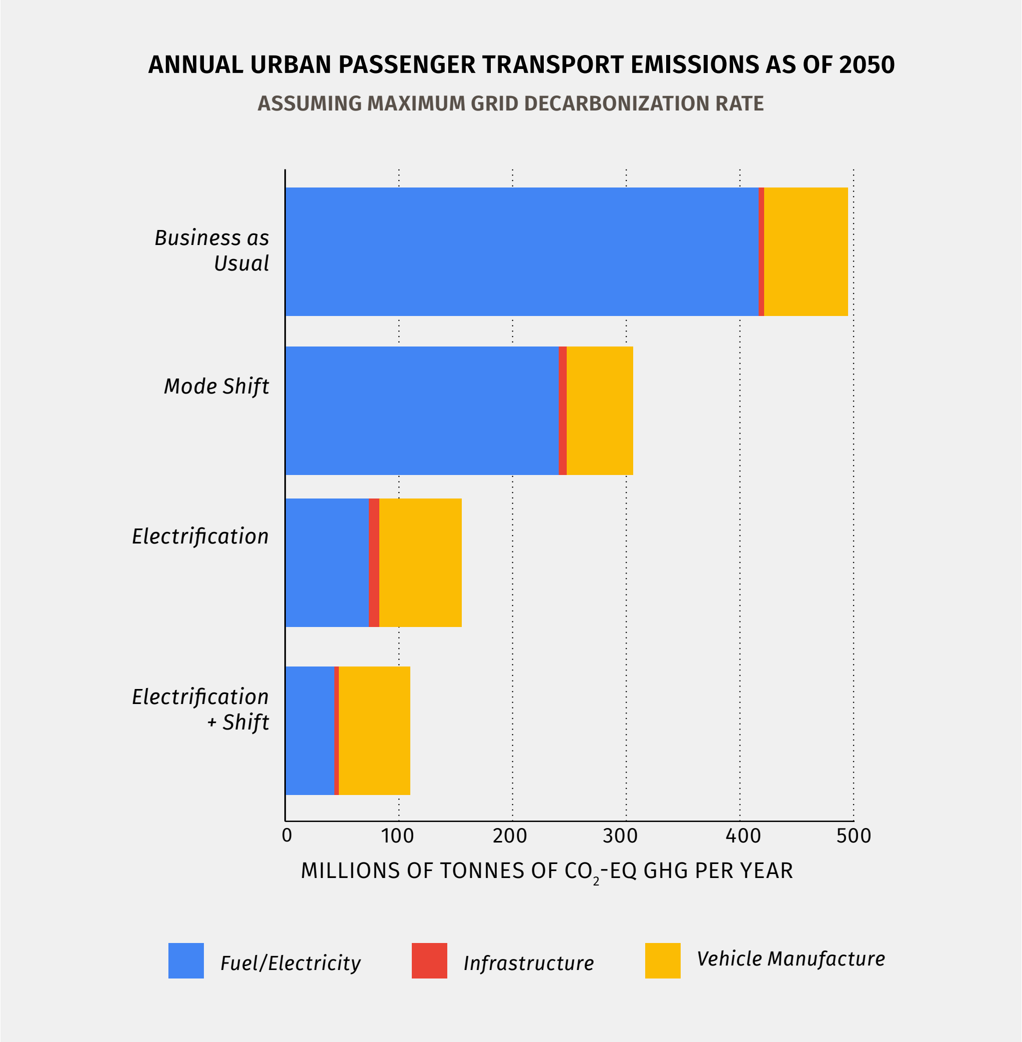

FIGURE H.
Annual greenhouse gas emissions by scenario and source

With a decarbonized grid, electric vehicles will cause very low emissions through their operation. However, the use of cars, electric or not, will still lead to substantial emissions from the paving and maintenance of roads and from the production of steel, batteries, and other industrial processes involved in vehicle manufacture and disposal. Under the *Electrification* scenarios, as can be seen in Figure H, about half of emissions are from these sources, which are much more challenging to decarbonize. Indeed, electrification actually increases manufacturing emissions by about 25 percent relative to *Business as Usual* because of the emissions intensity of battery manufacture and of heavier vehicles.[35] For the US to reach Net Zero by 2050, all emissions must be minimized, which can only be accomplished by combining *Electrification* with *Mode Shift*.

Electrification alone also requires exponential growth in the use of scarce critical minerals for batteries. The environmental, environmental justice, and national security challenges entailed by that would be significantly mitigated by combining *Electrification* with *Mode Shift* and reducing overall dependence on passenger vehicles while electrifying.[36]

33 Carbon budgets are allocated by the ratio of the US's cumulative emissions in the Business as Usual scenario to worldwide emissions in the *Business as Usual* scenario. For more detail, see the methodological appendix.
34 Note: Our analysis shows that the *Electrification + Shift* scenario will exceed the 1.5° threshold by nearly 1Gt, a shortfall that will need compensation from decarbonization of other sectors of the American economy.
35 This 25 percent figure is conservative, based on the assumption of rapid decarbonization of the manufacturing sector by 2050. Eighty percent is a reasonable estimate today: See Andrew Moseman & Sergey Paltsev, MIT Climate Portal (2022), Are electric vehicles definitely better for the climate than gas-powered cars?
36 Center on Global Energy Policy (2023), Q&A: Critical minerals demand growth in the net-zero scenario.

4.3. Mode Shift Reduces Dependence on Grid Decarbonization

Mode Shift provides a hedge against obstacles that may arise in decarbonizing the electrical grid. By combining *Mode Shift* and *Electrification*, the US may still achieve substantial decarbonization even if the shift to electric vehicles and/or renewable electricity generation is slower than optimistically projected.

Electrification alone can substantially reduce transport emissions, but electric vehicles are only as clean as the grid that powers them.

The US's electricity grid currently has an emissions intensity of roughly 230 g CO_2eq per kWh. The results displayed in the previous section have assumed a highly ambitious level of grid decarbonization in line with the International Energy Agency's (IEA) Sustainable Development Scenario. Following this assumption, the grid emissions intensity falls to almost 0 g CO_2/kWh by 2050—in line with America's Paris Agreement commitments.

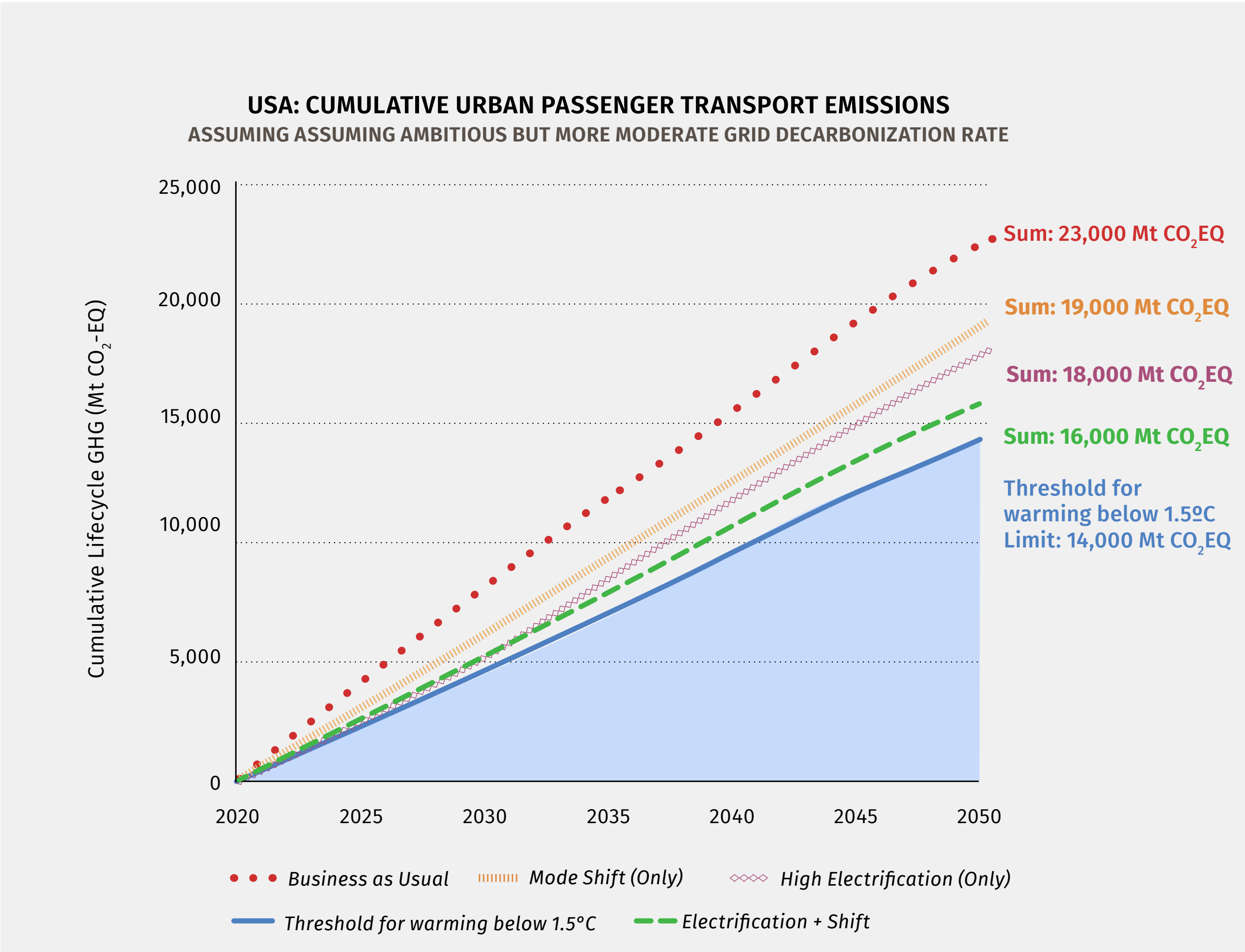

FIGURE I.
Greenhouse gas emissions by scenario, assuming slower grid decarbonization

Notwithstanding the Biden Administration's goal of achieving a carbon pollution–free grid by 2035, the combination of state policies, federal tax incentives in the IRA, and pending federal power sector regulations, current policies (as per IEA's Stated Policies Scenario) are only projected to reach a grid intensity of about 120 g CO_2eq/kWh by 2050, compared to 230 today. This is still an optimistic forecast, but in this case, our *Electrification* scenario loses some of its effectiveness in reducing cumulative emissions, while *Mode Shift* loses less, shown in Figure I above. In this case, none of the scenarios are under the blue area signifying compatibility with the 1.5°C threshold, but *Electrification + Shift* comes the closest.

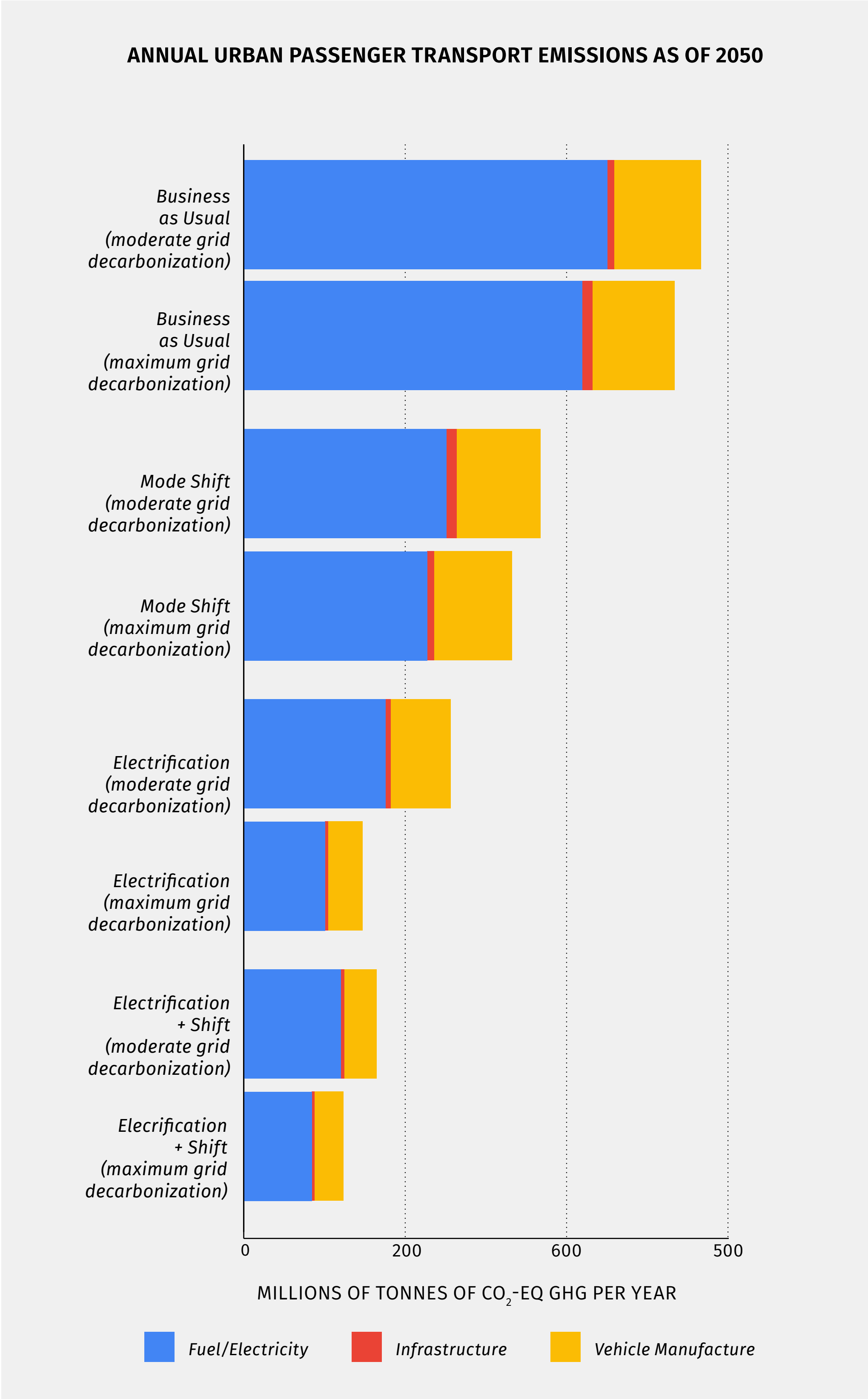

FIGURE J.
Annual greenhouse gas emissions by scenario, source, and contingency

The more conservative grid decarbonization projections also shed light on the US's prospects for reaching its goal of Net Zero by 2050, as seen in Figure J. If grid decarbonization proceeds in line with current stated policies, it will be very difficult if not impossible for the US to achieve that goal without both *Electrification* and *Mode Shift*, and even in the combined scenario, an extensive carbon-recapture effort, beyond the possibilities of known technology, will be necessary.

5. SCENARIO IMPACTS ON ELECTRICITY CONSUMPTION

Mode Shift not only provides a degree of redundancy with *Electrification,* it also reduces the burden of rapid grid decarbonization by dramatically reducing the increased electricity demand that vehicle electrification will cause. Furthermore, *Mode Shift* increases resiliency at all levels by providing redundancy in transportation options.

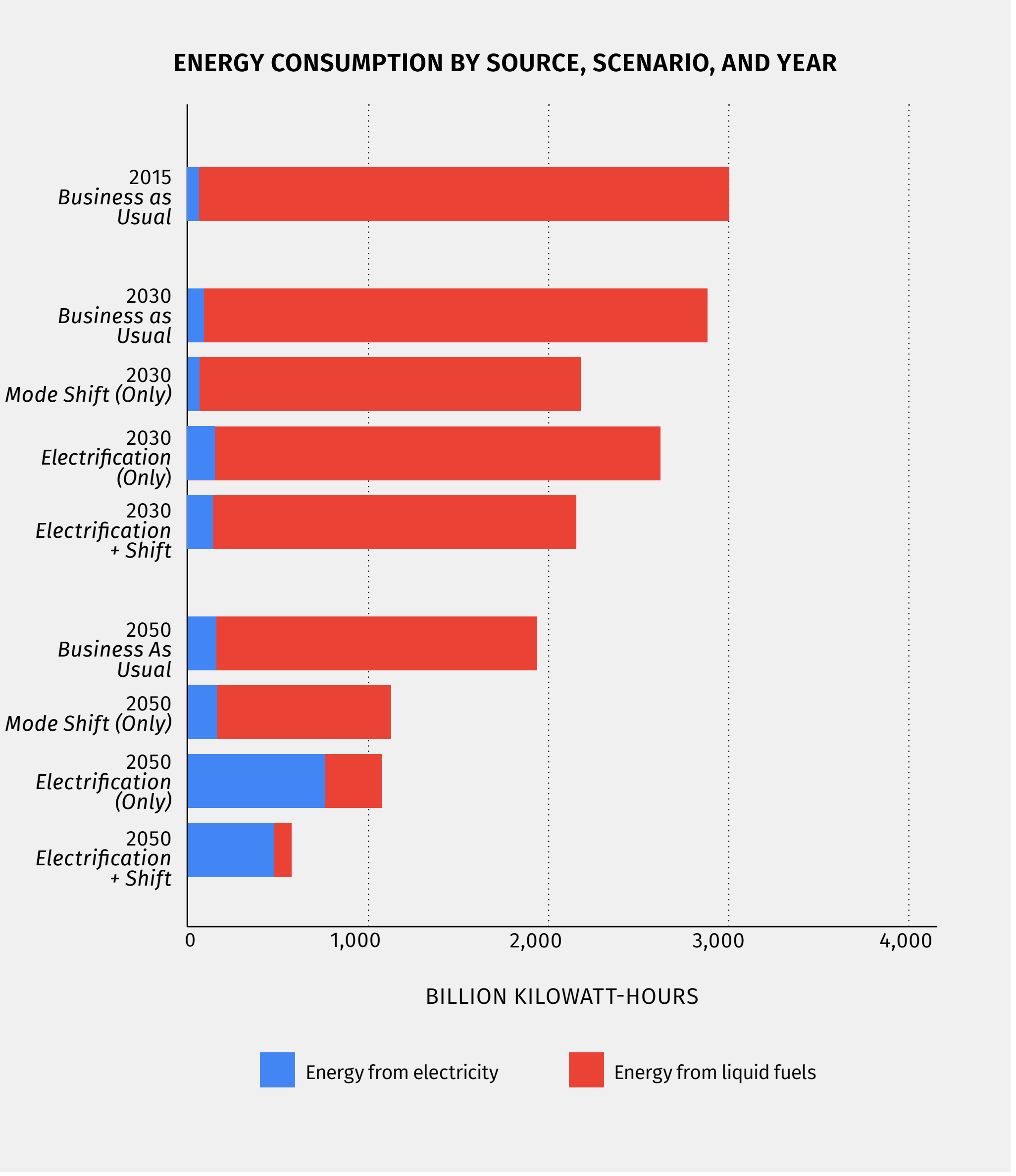

FIGURE K.
Annual energy consumption

The *Electrification (Only)* scenario represents a major reduction in total energy consumption relative to *Business as Usual,* because electric vehicles are much more efficient per mile than internal-combustion vehicles. However, that reduction in total energy consumption comes with a great increase in the use of electricity in particular, seen in Figure K.

In the *Electrification* scenario, urban passenger transport in the US will consume about 900 billion kWh of electricity annually by 2050. *Electrification + Shift* reduces this consumption by about 40 percent (340 billion kWh), or the equivalent of the annual power generation of about 70,000 wind turbines. That might mean a reduction in the costs of building infrastructure for renewable power generation or freeing up electricity for other urgent needs in the face of the climate crisis.

6. DIRECT PUBLIC AND PRIVATE EXPENSES IN EACH SCENARIO

The *Mode Shift* and *Electrification + Shift* scenarios offer efficiencies that could save about $13 trillion for the US economy overall, including savings to the public and private sectors.

The structure of a transportation system has many impacts on a nation's economy, direct and indirect. Our model tabulates only the direct impacts: the expenses of manufacturing, maintaining, fueling, and operating vehicles and the expenses of building and maintaining infrastructure. These are shown in Figure L.

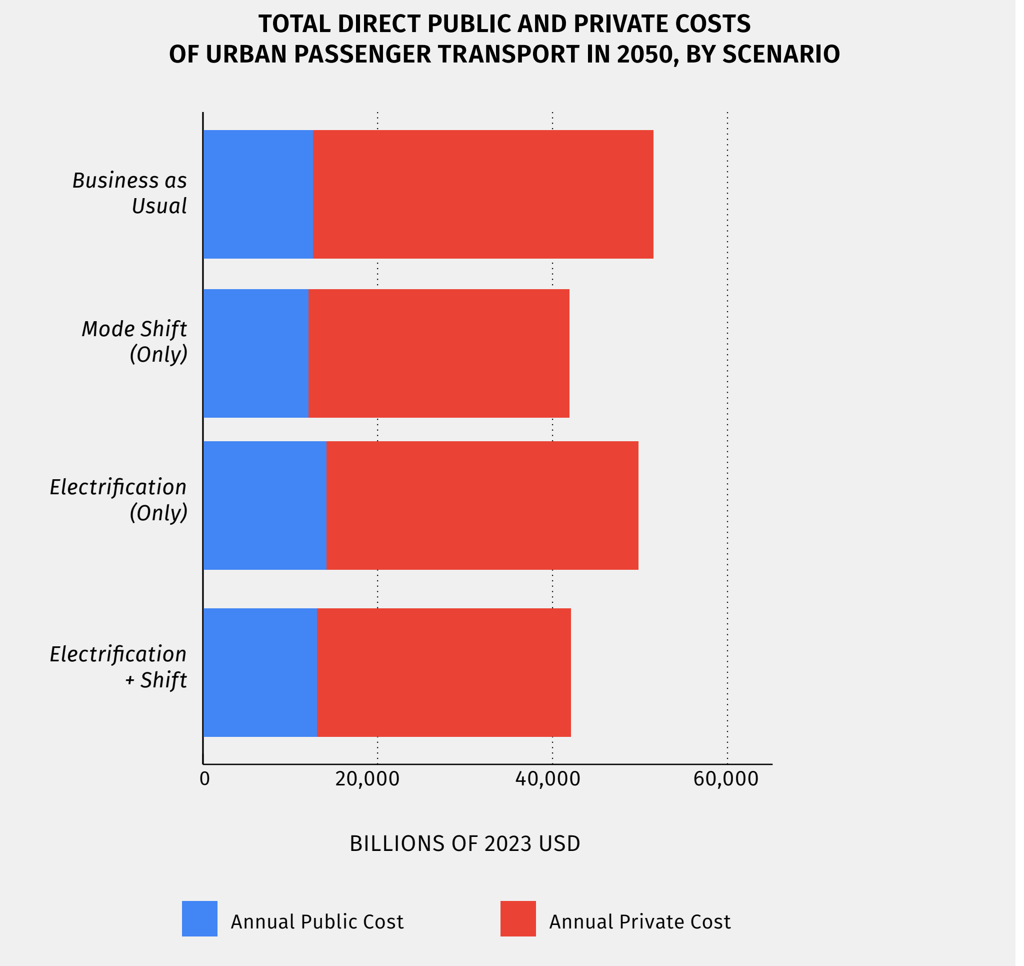

FIGURE L.
Annual direct costs of urban passenger transport

These expenses can be divided into those borne ultimately by the public sector and those borne ultimately by individuals.[37] *Mode Shift* would lead to enormous economic savings for the American economy—a cumulative savings of about $13 trillion USD. Of this, at least $2 trillion USD in savings would accrue to national, state, and local governments, tabulated in Figure N in Section 7, below.

Our calculations only include the direct costs of urban passenger transport and not indirect costs such as healthcare expenses related to vehicle collisions or sedentary lifestyles; costs related to air, noise, or water pollution; costs of farmland or natural areas lost to suburban sprawl; or, conversely, the economic benefits derived from job creation[38]. All of these indirect costs are likely to mean that the true economic benefit of *Electrification + Shift* would be many times higher than what we have calculated.

37 For the sake of conservatism, in these calculations we have assumed that the government will bear the entire cost of public transport operations—that is, fares will be free. We do expect that public transport subsidies will increase in the *Mode Shift* scenarios, though possibly not to this extreme.
38 Investments in public transit create nearly twice as many jobs per dollar as investments in new road-building. See: Transportation for America (2021), Road and public transit maintenance create more jobs than building new highways.

7. MEASURABLE GOALS FOR URBAN PASSENGER TRANSPORTATION

It is possible for the United States to achieve the *Electrification + Shift* scenario. This scenario offers enormous savings to the public sector as well as private individuals and enterprises, while also reducing emissions from urban passenger transportation to the level most closely consistent with the country's climate commitments. It will not require any additional funding beyond the resources that the United States already expends for urban passenger transportation—rather, *Electrification + Shift* will only require a change in policies and a reallocation of resources.

There are three elements that must come together to achieve the *Electrification + Shift* scenario: first, increased vehicle efficiency, primarily through electrification; second, land-use reform to make trips shorter by promoting compact mixed-use cities; third, facilitating *Mode Shift,* primarily by providing alternative infrastructure but also by pricing car travel according to its true cost.

In this section we provide evidence-based goals for each of these three elements based on the quantitative analysis in this study. If achieved, these goals would bring the benefits of the *Electrification + Shift* scenario. These goals could be accomplished in many ways, and in Appendix A, we provide basic policy agendas at the federal, state, and local levels that could help the United States reach them.

7.1. Goals for Electrification

To achieve the country's climate commitments, electrification must proceed much more rapidly than its current course. As discussed in Section 3.2.1, new sales of different vehicle types must be electrified at the rates shown in bold in Figure M below. Most importantly, 60 percent of all new light-duty vehicle sales (cars and light trucks) must be electric by 2030, and 100 percent by or before 2050. This will require not only the EPA's current proposed standards, but also continuing policy effort and consumer incentives for decades to come.

Percentages of New Vehicles that Are Electric (Rather than Internal-Combustion)

	Business as Usual and *Mode Shift (Only)*			*Electrification (Only)* and *Electrification + Shift*		
	2015	**2030**	**2050**	**2015**	**2030**	**2050**
LDVs (cars and light trucks)	2%	30%	50%	2%	60%	100%
2-wheelers/ motorcycles (not including e-bikes)	2%	5%	25%	2%	40%	100%
Buses	2%	27%	45%	2%	70%	100%

FIGURE M.
Sales of electric vehicles by year and scenario

7.2. Goals for Land Use

More compact, mixed-use urban form will have a two-fold benefit to the cities of the United States. First, when people live closer to their places of work or leisure, trips will be shorter, and so even ICE cars will emit less and cost motorists less. Second, when trips are shorter, they are easier to take by bicycle or public transport, facilitating *Mode Shift*.

Achieving the *Electrification + Shift* scenario and meeting the country's climate commitments will require the US to adopt policies that make it possible for cities to become more compact. As described in Section 7.2 below, these policies will not require anyone to live in a dense neighborhood who does not wish to—even after decades of these policies, the majority of Americans will still live at urban densities that are very low by international standards.

Reaching the *Electrification + Shift* scenario will require policies that put the country on track for the population density distribution described in Section 3.2.2—an increase from a current average weighted urban population density of approximately 13,000 people per square mile to 14,000 people per square mile in 2030 and 17,000 people per square mile by 2050.

7.3. Goals for Transportation Infrastructure

This analysis provides the clearest agenda for the third of the three components necessary to achieve the *Electrification + Shift* scenario: the specific transportation infrastructure investments that will be needed to achieve such levels of *Mode Shift* and the estimated savings that are possible by pursuing such a strategy.

Figure N, below, indicates the extent of infrastructure and vehicle investment that the US must make to reach the *Electrification + Shift* scenario. As shown in Figure N, the *Shift* element of the scenario will mean that federal, state, and local governments will save about $2 trillion USD by 2050. The expense of building and operating transit will be more than balanced by the reduced need to build and maintain highways.

Total New Infrastructure and Vehicles Required 2015–2030							
	Urban road lane-miles	BRT lane-miles	Metro rail lane-miles	Protected bicycle lane-miles	Buses	Train cars	Total cost to governments (billion USD)
Business as Usual & *Electrification (Only)*	180,000	120	81	4,000	630,000	3,500	$5,100
Mode Shift (Only) & *Electrification + Shift*	0	4,700	780	57,000	770,000	5,000	$4,100
Total new infrastructure and vehicles required 2015–2050							
	Urban road lane-miles	BRT lane-miles	Metro rail lane-miles	Protected bicycle lane-miles	Buses	Train cars	Total cost to governments (billion USD)
Business as Usual & *Electrification (Only)*	350,000	240	160	10,000	1,700,000	8,200	$13,000
Mode Shift (Only) & *Electrification + Shift*	0	26,000	3,300	190,000	2,600,000	18,000	$11,000

FIGURE N. Detailed description of infrastructure and investment requirements by scenario

This analysis provides a clear road map for transportation infrastructure investments in cities across the United States. It makes a few points clear:

- Nationwide, the US will have to immediately stop building or expanding urban roadways for cars, focusing instead on maintenance of existing roadways and on increasing the capacity of existing roadways by reallocating areas to more space-efficient modes of transport. This aligns with the study's findings concerning urban density, which show that the expansion of cities into rural or natural land must immediately stop and that growth must instead take place through the densification of existing areas.

- Cities across the country will have to build tens of thousands of miles[39] of rapid transport by 2050. The majority, nearly 90 percent of this, will be bus rapid transport (BRT) rather than metro rail.[40] This must be full BRT, as described in the BRT Standard:[41] It must have center-running dedicated busways, with off-board fare payment, intersection priority, and platform-level boarding.

- Cities will also have to build hundreds of thousands of miles of bicycle lanes. These must be physically protected lanes, not merely lanes separated from vehicle traffic by painted lines, buffer space, or small bumpers that can be driven over. They also must be separated from pedestrian traffic.

This scale of transformation, while massive, is not unprecedented. Paris decreased car travel by almost 50 percent in 30 years by investing in other modes and traffic control strategies. Jakarta and Bogotá have each built a mass transit system with more than a million riders a day in less than 15 years. There's no reason why American cities can't do the same.

39 Note that the numbers given in Figure N are for lane-miles or track-miles: A single mile of bidirectional rail is usually two track-miles; a single mile of six-lane highway is six lane-miles.
40 Light rail could function as well as BRT but would be much more expensive.
41 ITDP (2016), The BRT Standard.

APPENDIX A: BASIC POLICY AGENDA

Achieving the goals enumerated in Section 7 will require committed, coordinated action at three levels of government in the US. **Local governments** including transit agencies and metropolitan planning organizations are already leading the way, not only at the city level but also at the county and regional levels. Localities must continue to embrace policies and infrastructure that will bring their residents cleaner air, safer streets, and greater economic inclusion. **State governments**—especially state departments of transportation—make many of the decisions that determine what transport infrastructure is prioritized. States must lead the way through decisions about state-level infrastructure, such as state highway systems. States must support leading localities in building what they need while also investing in other jurisdictions that lack the resources or capacity to plan new forms of infrastructure. **The federal government** must scale this transformation across the country, both by using its resources to subsidize vehicle electrification and infrastructure reform and also by streamlining processes such as environmental reviews that could counterproductively hinder, rather than facilitate, environmentally friendly transportation. Finally, the federal government must represent the US internationally, learning from success in other countries while also contributing to international policy efforts.

This commitment and coordination must be simultaneously applied in the three areas of policy described in Section 7.1, each of which requires the many interventions outlined below.

We must **reduce the emissions of each mode of transport**, mostly by supporting electrification, but also by promoting more efficient and lighter-weight vehicles. This will be accomplished through policy, especially the EPA's proposed standards; through incentives such as fee-rebate programs or low-emission zones; and through infrastructure, such as public charging facilities.

We must reform land use to support **compact cities in which travel distances are shorter** by removing excessive zoning constraints and allowing "missing middle" housing by-right in all urban and suburban areas, while concentrating higher mid-rise development around arterial corridors. Parking requirements, in particular, must be removed across the board.

Finally, we must support ***Mode Shift* by reallocating road space and funding** away from car infrastructure and toward walking, cycling, and public transport. All streets should be safe for pedestrians and cyclists of all ages, everyone should live within a short walk of a high-frequency bus line, and all arterials and interstates should have median-running dedicated busways. Around the country, we must stop building new urban roadways by the mid-2020s, focusing instead on reallocating existing space to use roadways more efficiently.

I. Electrify Transportation with Policy, Incentives, and Infrastructure

Federal Level

1. Drive policy through setting ambitious national targets around transportation electrification, centering cross-agency collaboration and public/private partnerships in these efforts.[42]
2. Introduce federal incentives for the purchase of electric vehicles.[43] The most effective incentives combine an increased cost for dirtier internal-combustion vehicles with a subsidy for cleaner electric ones. Similar incentives should increase the cost of larger, heavier vehicles while subsidizing lighter-weight, smaller vehicles. These may include fee-rebate structures and low-emission traffic zones. Structure subsidies, such as road-user charges, to consider social and economic equity parameters.
3. Create federal funding opportunities for states to invest in smart-grid technologies that increase stability while regulating the supply of electricity to demand in real time.[44]
4. Invest in a "circular, diverse, and ethical battery supply chain" that satisfies demand and federal regulations regarding mineral use, battery sourcing, and assembly.[45]
5. Invest in a trained workforce to ensure solutions are workable.[46]
6. Strengthen federal vehicle design standards to require Intelligent Speed Assistance, automated emergency braking, pedestrian and cyclist recognition systems, and other technologies to ensure that electrification supports a zero-emission zero-death traffic system rather than making roads more dangerous with heavier e-vehicles.[47]

42 Office of Energy Efficiency & Renewable Energy (2023), The US National Blueprint for Transportation Decarbonization: A Joint Strategy to Transform Transportation; United States Environmental Protection Agency (2023), EPA's SmartWay Program; US Department of Energy (2023), DOE's Clean Cities.
43 US Department of the Treasury (2023), IRS releases guidance to expand access to clean vehicle tax credits, help car dealers grow businesses.
44 IEA (2023), Smart Grids; Grid Deployment Office (n.d.), Grid Resilience and Innovation Partnerships (GRIP) Program.
45 RMI (2023), How policy actions can spur EV adoption in the United States.
46 Office of Energy Efficiency & Renewable Energy (2023), The US National Blueprint for Transportation Decarbonization: A Joint Strategy to Transform Transportation.
47 TRB Annual Meeting Keynote with NTSB Chair Jennifer Homendy; NTSB chair Jennifer Homendy calls out "27 years of inaction" on V2X; *Wired* (2023), Supersize EVs are pushing road safety to the limit; National Association of City Transportation Officials (n.d.), Vehicle Design.

State Level

1. Set state-level timelines for zero-emission vehicle purchasing targets (new and used markets) and ICE phase-out targets for all public and private vehicles including cars, vans, buses, and light- and heavy-duty trucks. Prioritize bus electrification; public vehicle targets can help set the stage for private vehicle markets.
2. Introduce state-level incentives for the purchase of electric vehicles (including e-bikes), combining an increased cost for internal-combustion vehicles with rebates[48] or subsidies for electric ones.
3. Introduce credit/deficit programs for vehicle manufacturers that incentivize increased EV sales,[49] requiring that "deficits" incurred by sales of ICE vehicles be offset by clean vehicle sales.
4. Leverage federal funding opportunities for smart-grid technologies to ensure that the grid can support high vehicle electrification.[50]

Local Level

1. Pursue bus electrification and identify a timeline for fleet transition.
2. Establish low-emission zones to encourage electric vehicle transition.
3. Scale up charging stations for four- and two-wheeled EVs. Pursue private sector partnerships for charging sites[51] and partnerships with energy providers[52] for implementation. Consider incentives for charging placement in multi-dwelling units.[53] Streamline regulations and procurement barriers to facilitate private provision of on-street EV charging in cities.[54]

II.Reform Land-Use Policy, Update Zoning Laws, and Incentivize Sustainable, Mixed-Use, Transport-Oriented Development

Federal Level

1. Use federal legislation to tie funds to rezoning policies listed below, clearing the way for more connected neighborhoods with denser housing in both urban and suburban environments.[55]

State Level

1. Use state-level legislation to either directly enact the policies listed in C, below, or else require municipalities to do so.
2. Drive compact development and earmark affordable housing by enacting structural incentives for developers[56] (expedited permits, additional floors, tax credits).

Local Level

1. Reform zoning codes to permit by-right pedestrian-oriented, mid-rise, mixed-use development within about two thirds of a mile of urban and suburban arterial roads.
2. Even in areas more than two thirds of a mile from arterial roads, reform use-based zoning[57] in favor of mixed-use zoning, by-right permission of "missing middle,"[58] and walkability.[59]
3. Structure property taxes to charge the cost of infrastructure (sewers and roads) that serve development outside already built-up areas.[60]
4. Revise building codes to permit single-loaded "point access block" buildings.[61]
5. Remove parking requirements for development.[62, 63]

III.Support Mode Shift by Optimizing the Use of Road Space with Walking, Cycling, and Public Transport

Federal Level

1. Grant a categorical exemption under the National Environmental Protection Act law to walking and cycling projects and streamline review of public transit projects.[64]
2. Mandate that state DOTs follow the policy guidance in B, below.
3. By the mid-2020s, in line with this study's projections, cease new construction and expansion of urban roads. Use resources for maintaining and optimizing existing roadways by reallocating space to walking, bicycling, and public transport.

48 Drive Clean Rebate for Electric Cars (n.d.), Consumer FAQ.
49 Department of Environmental Protection (2021), DEP Commissioner Latourette announces adoption of clean truck rules, setting New Jersey on path for zero-emission vehicle future.
50 IEA (2023) Smart Grids; Grid Deployment Office (n.d.), Grid Resilience and Innovation Partnerships (GRIP) Program.
51 Joint Office of Energy and Transportation (2023), Private Sector Continues to Play Key Part in Accelerating Buildout of EV Charging Networks.
52 US Department of Transportation (n.d.), Electric Utilities as EV Planning Partners.
53 RMI (2023), How Policy Actions Can Spur EV Adoption in the United States.
54 *Daily News* (2022), The electric revolution, leaving Black and Brown communities behind.
55 The YIMBY Act, for example, which passed the House in August 2023, ties federal grants to reporting and responding to obstacles in zoning reform. See: American Planning Association (2023), What to expect in state legislatures on zoning reform in 2023.
56 USGBC (2014), Good to know: Green building incentive strategies.
57 *Harvard Political Review* (2021), How bad housing policy can shape a nation. (For an example of undoing single-family zoning, see Bloomberg (2022), What happened when Minneapolis ended single-family zoning.)
58 Missing Middle Housing is a range of house-scale buildings with multiple units—compatible in scale and form with detached single-family homes—located in a walkable neighborhood.
59 Form-Based Code Institute (n.d.), Standards of Practice for Form-Based Codes.
60 Department of Environmental Conservation (n.d.), Open Space.
61 Unlocking Development with Point Access Blocks (2023).
62 Parking Reform Network (n.d.), Parking Reform Map.
63 ITDP (n.d.), Breaking the Code: Off-Street Parking Reform; Urban Land Institute (n.d.), Types of Off-Street Parking Policy Updates.
64 VICE (2022), Why doesn't America build things?

4. Modernize the Manual on Uniform Traffic Control Devices to permit the construction of safe multimodal streets.[65]
5. Authorize, facilitate, and support the retrofit of interstate highways with bus rapid transit. Support the retrofit of all other roads that receive federal maintenance funding to reallocate road space to walking, cycling, and public transit.
6. Update federal reporting requirements for road and transit projects undertaken at the state level, mandating reporting on emissions levels and health risks that account for induced demand.[66] Appropriately account for demand elasticity and consider the accuracy of historic projections.
7. Revise the formula by which federal funds are allocated disproportionately to road and highway projects compared to mass transit.[67]
8. Introduce federal e-bike subsidies.
9. Tie all federal transport funding programs to the national transport goals (23 USC 150) for accountability.
10. Reform the National Highway Performance Program and the Surface Transportation Block Grant Program to ensure that road projects are not favored over investments in walking, cycling, or transit.[68]

State Level

1. Adopt a "fix it first and fix it right" approach to repairing road infrastructure rather than spending on increasing road capacity.[69]
2. Move from a "predict and provide" to a "decide and provide" modeling framework for making data-based infrastructure plans. Adopt induced-travel-sensitive impact models that consider all modes of travel equally, measuring access to destinations and capturing all impacts of transportation (including air pollution, noise pollution, GHG emissions, and road safety), not only travel time.
3. When measuring the economic impacts of time lost in congestion, use empirical evidence[70] of how much drivers value their time rather than textbook, unproven assumptions.
4. Switch from gas taxes to vehicle-mile-traveled taxes.[71]
5. Bring the cost of driving in line with its negative externalities, clearing the way for measures like low-emission zones (LEZs) and congestion charging by reshaping state and federal law to encourage their city-level deployment.[72,73]
6. Introduce time- and place-based road-use charges to many existing limited-access freeways and devote revenues to BRT and high-quality transit services and ridesharing incentives that serve tolled corridors.[74]
7. Introduce state-level e-bike and e-cargo-bike subsidies to offset the cost of transitioning from less sustainable modes.
8. Ensure transport projects are planned with a full picture of associated greenhouse gas emission performance.[75]
9. Grant a categorical exemption under state-level environmental review to walking and cycling projects, and streamline review of public transit projects.
10. Align citizen input and feedback mechanisms with the scale of the problem being addressed. For example, neighborhoods should have meaningful input on how a citywide plan is implemented in their area, but not the ability to veto overall plans or safety improvements.[76]

Local Level

1. Use traffic-calming techniques, build or widen sidewalks, and build or maintain crosswalks (with wheelchair-friendly curb cuts) on all streets and intersections. Every street in an urban or suburban area should feel safe for everyone, including young children and those with physical disabilities. Follow guidance such as the National Association of City Transportation Officials' Urban Street Design Guide.[77]
2. Build a connected network of physically protected low-stress[78] bicycle lanes to ensure that everyone feels safe (e-)bicycling from their homes to necessary destinations, even in other neighborhoods.
3. Redesign out-of-date bus networks to focus on establishing a network of frequent, connected service to maximize access to- destinations and inclusive ridership.[79]
4. Build a connected, integrated network of physically separated, center-running BRT[80] on all

65 National Association of City Transportation Officials (n.d.), Modernizing Federal Standards: Making the MUTCD Work for Cities.
66 RMI (n.d.), SHIFT Calculator State Highway Induced Frequency of Travel.
67 ENO Center for Transportation (2021), Explainer: What the "80–20 Highway-Transit Split" Really Is, and What it Isn't.
68 Georgetown Climate Center (2021), Issue brief: Estimating the greenhouse gas impact of federal infrastructure investments in the IIJA.
69 Office of Energy Efficiency & Renewable Energy (2023), The US National Blueprint for Transportation Decarbonization: A Joint Strategy to Transform Transportation.
70 CityCommentary (2017), What HOT lanes reveal about the value of travel time.
71 Tax Foundation (2020), Who Will Pay for the Roads?
72 itdp.org/wp-content/uploads/2023/02/ITDP-LEZ-Brief.pdf; section three on equity.
73 Greenlining Institute (2021), Low and Zero Emission Zones: Opportunities and Challenges in Designing Equitable Clean Transportation Policies.
74 Patrick DeCorla-Souza (2022), Converting existing general-purpose lanes to high-occupancy/toll lanes: An exploratory evaluation; Patrick DeCorla-Souza and Paul Minett (2023), Relieving traffic congestion and accommodating travel growth without expanding highways: A policy evaluation for the eastern segment of the Capital Beltway.
75 Georgetown Climate Center (2023), Bipartisan Infrastructure Law funding has the potential to reduce GHG pollution from transportation in New Jersey.
76 See: Steve Higashide (2019), *Better Buses Better Cities*, "Get representative, strategic public input," pp. 136–137.
77 National Association of City Transportation Officials (n.d.), Urban Street Design Guide.
78 Mineta (2012), Low-stress bicycling and network connectivity.
79 Jarrett Walker, Human Transit (2021), Basics: Access, or the wall around your life.
80 ITDP (2016), The BRT Standard.

arterial roads and highways. Use left-turn restrictions[81] on roads that are not grade-separated. Focus on building stations in the most densely populated or densely used areas.
5. Ensure provision of an adequate supply of secure bicycle parking at transit stops, with protected cycleways connecting transit to activity centers and neighborhoods.[82]
6. Implement demand-sensitive pricing for curb parking in all neighborhoods. In heavily congested areas, implement transportation demand-management policies such as congestion charging.
7. For all local aspects of project review and funding allocation, follow the guidance given in B above.
8. Fund and hire government staff positions need to implement the transportation priorities listed above.

APPENDIX B: IMAGINING COMPACT CITIES ELECTRIFIED IN THE US

The context of the US presents a particular set of challenges: The long history of car-oriented development, concentration of authority at the state level, and political polarization all stand in the way of rapid electrification and modal shift. However, the US also has unique opportunities: Immense funding is available through the Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act (IRA). Political will to improve transportation is building rapidly, and the country is seeing a surge in technological advancement in electrification.

Section 2.1 of this report has presented a qualitative exploration of the study's four scenarios; Section 3.2 defined them quantitatively. Appendix A provided a policy agenda for the city, state, and local levels to help achieve this future. Here, Appendix B will present a narrative of what the *Electrification + Shift* future might look like in the US, taking the urban area of Dallas as an example.

The Dallas–Fort Worth metropolitan area exemplifies the challenges shared by the country. It is the fastest-growing of large US cities, and among the most sprawling and car-dependent. A full quarter of the city's downtown has been given over to parking lots, and 96 percent of commuters drive to work.[83] Historical injustices, including but not only "redlining," have resulted in spatial segregation that limits economic opportunities to this day.[84] A light rail, completed in the year 2000, has failed to generate large ridership due to meandering routes that often avoid the most densely populated areas.[85] Staggering income inequality between vehicle owners and public transport riders is both a cause and effect of missed opportunities in a workforce where car ownership is often the price of entry.

Dallas also exemplifies the opportunities available to the US. Only about 1 percent of registered vehicles in Dallas are electric as of October 2023,[86] but while current EV sales may be low, they're rising quickly; Dallas leads the state in electric vehicle sales, accounting for 38 percent of the Texas total—a 54 percent increase over a year ago. State and local subsidies such as tax rebates as well as regional initiatives have encouraged the adoption of EVs, and the cost of charging has been kept low. Like most cities throughout the midwestern and western parts of the US, the Dallas region has a relatively consistent grid pattern in its street network, meaning its geography can be efficiently served by bus transit—and the region's bus transit has recently been made 30 percent more efficient in connecting people to destinations and across income levels by a network redesign.[87] Dallas has also begun maximizing the impact of its light rail system through transit-oriented development,[88] while the city government has started rejecting highway expansions.[89]

The next steps for Dallas–Fort Worth, and regions across the country, are clear. Ramp up fee-rebate programs to subsidize electric vehicles—including e-bicycles and other small vehicles—while bringing ICE vehicle costs in line with their negative externalities. Invest heavily in public charging infrastructure and enable vehicle-to-grid technology. Reform the zoning code to permit mid-rise multifamily buildings and small-scale retail within a quarter mile of all arterials to permit smaller multifamily construction everywhere, to encourage accessory dwelling units, and to remove all parking minimums. Also provide measures for greater hous-

81 National Association of City Transportation Officials (n.d.), Transit Street Design Guide.
82 US Department of Transportation (2022), Improving safety for pedestrians and bicyclists accessing transit.
83 American Community Survey (2022).
84 Ken Kalthoff (2020). Redlining effects still seen in Dallas.
85 Yonah Freemark, The Transport Politic (n.d.), An extensive new addition to Dallas light rail network makes it America's longest.
86 DFW Clean Cities (2021), Electric Vehicles in Texas.
87 Jarrett Walker, Human Transit (2022), Dallas: Welcome to Your New Network
88 City of Dallas Office of Economic Development (not dated) TOD TIF District
89 Robert Wilonsky, *The Dallas Morning News* (2019), Dallas City Hall beats back TxDOT's early plans for I-30's $1.3 billion makeover.

ing affordability,[90] as raising supply alone is rarely adequate for the lowest-income residents. Invest immediately in large-scale expansion of the bus fleet using electric buses to create citywide grids of high-frequency bus service. Reallocate road space to build center-running bus rapid transit on all main arterials and interstate highways. Build protected bicycle lanes on all multi-lane roads. Build wide sidewalks and safe, marked crosswalks suitable for people in wheelchairs on all streets.

These policies all have precedents in the United States. Many cities have already implemented several, making dramatic strides in zoning reform and extensive development of BRT and cycling infrastructure.[91]

After 25 years of these policies, a representative resident might live in a decades-old bungalow that's been expanded to fit a second housing unit with a separate front door. Other families may save money by living in a small or mid-rise apartment building. With more housing and transportation options, all families will have the option to save money by forgoing the cost of buying a car. In most neighborhoods, families will be able to take a short, comfortable, and safe walk or e-bike ride to their local park, their kid's school or day care, or a grocery store. If they commute, they'll be able to walk or take a shared e-bike to a BRT line and get to work in the same time that it used to take driving in traffic.

Many residents of the Dallas–Fort Worth area, along with other regions in the US, will be able to live without a car, though many will still own and drive them. These vehicles will be electric, and despite having less dedicated road space, reduced demand will mean traffic remains consistent with today's levels. When someone arrives at their destination by car, finding a parking space with an electric charger will be convenient but probably not free. While they're parked, their vehicle might serve as a backup battery to the grid, part of a decentralized network helping to manage the difference between peak-hour demand and the supply of power from wind and solar generation.

While these changes may seem hard to imagine, there is precedent. They represent a return to a time-tested form of urban planning common in the United States for most of its 250-year history, based around the needs of people and commerce. The relatively recent shift toward car-centric planning represents a sharp break from both tradition and economic efficiency. Throughout the history of the US, the country's cities have reinvented themselves many times, often showing dramatic transformations over the course of short decades. In the face of the climate crisis, another transformation is possible.

APPENDIX C: METHODOLOGICAL DOCUMENTATION

Because of its length, the methodological documentation has not been included in this layout of the report. It is available at LINK.

90 For example, see: NYC Housing Preservation & Development (2023), Low-income housing tax credits; University of Texas Arlington College of Architecture, Planning and Public Affairs (2017), Transport Equity.
91 Jake Blumgart, *Governing: The Future of States and Localities* (2022), How important was the single-family zoning ban in Minneapolis?

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