Compact Cities Electrified: Indonesia

EXECUTIVE SUMMARY

ITDP
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New research from the Institute for Transportation and Development Policy and the University of California, Davis, finds that Indonesia could feasibly reduce public-sector expenditures on urban transport at the city, provincial, and national levels by a cumulative $10,000 trillion IDR through 2050. This can be achieved by using a combination of strategies to support vehicle electrification, compact city planning, and modal shift toward walking, cycling, and public transit. Furthermore, only the combination of these strategies, not any strategy alone, will be sufficient to approach the country's commitments to reduce carbon emissions in urban passenger transport.

This study investigates four possible scenarios for urban passenger transport in Indonesia:
Business as Usual: Indonesia's current trends in city planning and vehicle sales, including policies such as Presidential Regulation No. 55 of 2019 to accelerate growth in the EV industry.
Electrification (Only): The fastest feasible replacement of internal-combustion vehicles with electric ones.
Mode Shift (Only): The fastest feasible transformation of city planning priorities in favor of compact land use and public transport, walking, and bicycling.
Electrification + Mode Shift: The combination of the previous two scenarios.

The estimated requirements to achieve each scenario and the cumulative public-sector expenditure entailed are shown in Figure A.

In addition to cost savings, the *Electrification + Mode Shift* scenario would reduce electricity consumption by 72 billion kWh per year by 2050 compared to *Electrification (Only)*. Qualitatively, this scenario would improve road safety, promote economic inclusion of marginalized groups, and reduce air pollution.

Figure A. Infrastructure requirements and direct public costs by scenario

	Percent of new light-duty vehicles that are electric	Cumulative lane-km of roadway built 2015–2050	Cumulative track-km of metro rail built 2015–2050	Cumulative lane-km of bus rapid transit built 2015–2050	Cumulative lane-km of protected bikeway built 2015–2050	Cumulative public sector expenditure on urban passenger transport 2015–2050
2015 Baseline	0%					
2050 *Business as Usual*	20%	330,000	100	700	900	62,000 trillion IDR
2050 *Electrification (Only)*	100%	330,000	100	700	900	62,000 trillion IDR
2050 *Mode Shift (Only)*	20%	90,000	900	9,200	60,000	52,000 trillion IDR
2050 *Electrification + Mode Shift*	100%	90,000	900	9,200	60,000	52,000 trillion IDR

The research also measures greenhouse gas emissions from urban passenger transportation in each scenario. The results add to a growing body of evidence and show that achieving Indonesia's Paris Agreement commitments will require both electric vehicles and a change in travel patterns. It is insufficient for *Electrification* or *Mode Shift* to occur at the fastest possible rate independent of each other—it is only by maximizing both of these complementary strategies that Indonesia can reduce emissions fast enough to even approach a level consistent with holding global warming below 1.5°C (represented by the blue area in Figure B).

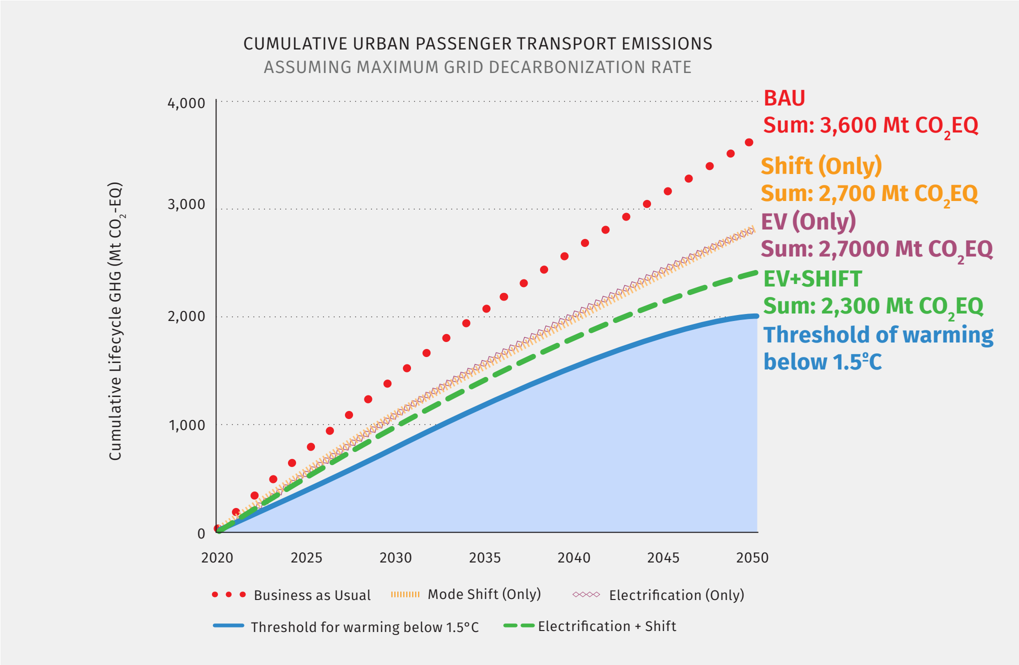

Figure B. Greenhouse gas emissions by scenario

To achieve the *Electrification + Mode Shift* scenario, Indonesia must ensure that the future of transportation and land-use policies will prioritize the movement of people rather than vehicles. Such restructuring will entail continued incentives and mandates for vehicle electrification, construction of compact mixed-use cities, and reallocation of street space and transportation funding from private motorized vehicles to walking, cycling, and public transport. In all scenarios, cars will still form an important part of the urban transport system, but the *Electrification + Mode Shift* scenario will offer Indonesians a wide range of travel options, while using clean, efficient vehicles. This scenario envisions a commitment to Indonesia's already healthy and diverse modes of transportation, with an increased investment in buses and bicycles.

With less money spent building roads, governments will have more resources to devote to other uses or to lower taxes. And with less money spent on fuel, Indonesians will have the freedom to invest more in other areas of their life. By protecting our planet from the worst threats of climate change, we will make it possible for the country to prosper long into the future.

ACKNOWLEDGEMENTS

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COVER PHOTO: People waiting for an electric Metrotrans bus at Senayan Station, part of the Transjakarta BRT system.
SOURCE: Joko SL via Shutterstock

CONTENTS

1. BACKGROUND

This study is the culmination of a decade of collaboration in transport modeling between ITDP and the University of California, Davis.[1] Ten years of effort have produced a detailed method for high-level modeling of urban and suburban passenger transportation, but this study of Indonesia and parallel studies of other countries mark 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 for Indonesia. 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 the different scenarios for the future of Indonesia. These results provide a "road map" for how those scenarios might be realized.

1 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.

2. FOUR SCENARIOS

Like the global study and parallel reports for other countries, this research investigates four scenarios for urban passenger transport in Indonesia through 2050. These scenarios are diagrammed in Figure C. 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 12), we define these scenarios quantitatively for modeling.

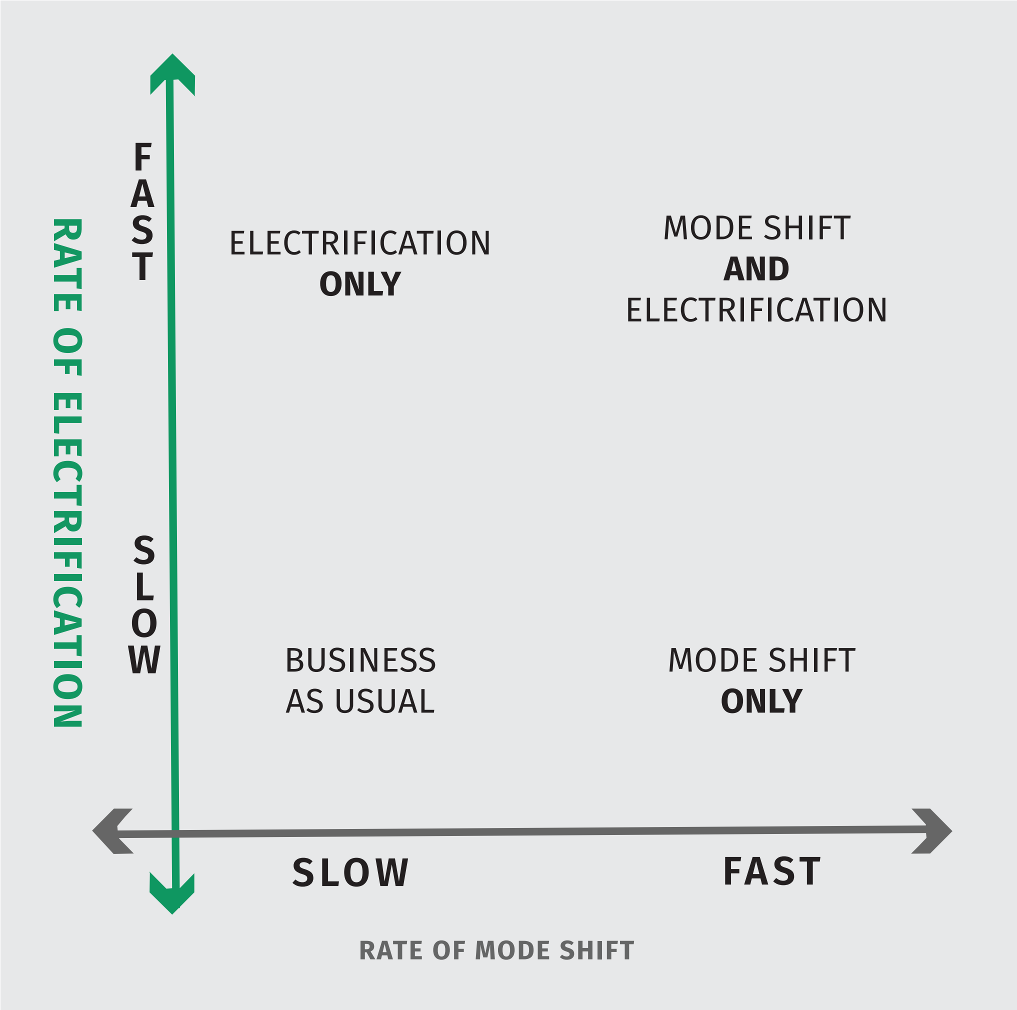

Figure C. Diagram of scenarios

Source. Daniel Supriyono via Shutterstock

Assumptions:

- Indonesia continues its current trajectory. Private motorized travel increases rapidly, becoming responsible for 36% of urban passenger travel, from 20% today. Electrification continues but remains relatively slow.

Qualitative impacts:

- Increase in traffic fatalities[2]
- High direct public and private costs[3]
- Reduced access to opportunities for low-income or other vulnerable groups without cars, leading to increased wealth inequality[4]
- Increase in local air pollution, causing many premature deaths and increased healthcare costs[5]
- Increase in urban highways, dividing neighborhoods and subsidizing environmentally unfriendly sprawl[6]
- Increase in carbon emissions, leading to climate catastrophe[7]

2 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.
3 For example, highway infrastructure spending per mile has risen dramatically:. Accounting for inflation, $8 million per mile in the 1960s became $30 million per mile by the 1990s. See: American Economic Association (2023), Infrastructure Costs.
4 National Equity Atlas, Indicator: Car Access.
5 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.
6 LeRoy, G. JSTOR (2004), Subsidizing sSprawl: Economic development policies that deprive the poor of transit, jobs.
7 Moseman, A. MIT Climate Portal (2022), Are eElectric vehicles definitely better for the climate than gas-powered cars?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.

Source. Rahman Hilmy Nugroho via Shutterstock

Assumptions:

- Electrification proceeds much more rapidly than is currently planned.

Qualitative impacts:

- 👍 Sharp reduction in carbon emissions[8]
- 👍 Sharp reduction in local air and noise pollution[9]
- 👎 Increase in traffic fatalities
- 👎 High direct public and private costs
- 👎 Reduced access to opportunities for low-income or other vulnerable groups 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

8 With high electrification, the emissions from transport will be reduced sharply. See: Andrew Moseman, MIT Climate Portal (2022)., Are Electric Vehicles Definitely Better for the Climate than Gas-Powered Cars?
9 Tsoi et al., (2023), The co-benefits of electric mobility in reducing traffic noise and chemical air pollution: Insights from a transit-oriented cityThe Co-Benefits of Electric Mobility in Reducing Traffic Noise and Chemical Air Pollution: Insights from a Transit-Oriented City.

Source. Georgina Captures via Shutterstock

Assumptions:

- Compact city planning is combined with reallocation of both funding and street space to walking, bicycling, and public transport. In this case, Indonesia slows the construction of new urban roadways, focusing instead on providing denser housing, mixed land use, and better bus/bicycle infrastructure on existing roadways. Car usage remains about constant as a share of overall passenger travel, but two-wheeler traffic falls rapidly, replaced with bicycling and public transport.

Qualitative impacts:

- 👍 Reduction in traffic fatalities[10]
- 👍 Increased access to opportunities, especially for low-income people and other groups suffering from spatial segregation, people with disabilities, and the elderly or young[11]
- 👍 Increase in walking and cycling, which improves physical and mental health, reducing healthcare costs[12]
- 👎 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

10 Dangerous by Design (2022).
11 See: National Library of Medicine (2023), Does the compact city paradigm help reduce poverty?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 neighborhoodsCauses and Consequences: Separate and Uunequal Neighborhoods.
12 Matthew Raifman et al. (2021), Mortality implications of increased active mobility for a proposed regional transportation emission cap-and-invest programMortality Implications of Increased Active Mobility for a Proposed Regional Transportation Emission Cap-and-Invest Program.

Source. Toto Santiko Budi via Shutterstock

Assumptions:

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

Qualitative impacts:

- Reduction in traffic fatalities[13]
- Increased access to opportunities for all
- Increase in walking and cycling, which improve physical and mental health, reducing healthcare costs
- 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 expansion of urban highways
- Creation of low-emission areas to incentivize both mode shift and vehicle electrification
- Achieving the *Electrification* or *Mode Shift* scenarios would require profound but feasible changes in Indonesia's national policy—changes that are possible underIndonesia the country'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.

13 Dangerous by Design (2022).

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.

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 transport of any kind. We define "urban" based on the United Nations definition, including all urban or suburban areas of 300,000 people or more.[14] This definition encompasses about 80% of the Indonesian population. Other research shows that both *Electrification* and *Mode Shift* will be necessary to decarbonize rural/intercity[15] and freight[16] 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 (IEA) *Mobility Model*[17] except where more detailed Indonesia-specific data is available. This calibration determines the estimation of conditions in the base year, the projection of the *Business as Usual* scenario, and factor considerations 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.[18] 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 Indonesia that were described on page 7. Beginning from a base year of 2015[19] and looking to future time points 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 + Mode 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-kilometers 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 + Mode 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[20] 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, and are derived from the IEA Mobility Model.

The ***Electrification* and *Electrification + Mode Shift* scenarios** follow sales share projections that reflect a much more ambitious future for vehicle electrification in Indonesia. These projections are somewhat less extreme than the Ministry of Energy and Mineral Resources' targets, which aim to have 20% of automobile sales electric by 2025 and exclusively electric vehicles on the road by 2050. This target is more ambitious than any other published target inany of the countries studied in this report series, and, lacking a clear road map, it does not seem achievable for Indonesia. Our projections align with the somewhat more realistic, but still ambitious, Glasgow Declaration to phase out the production, rather than the use, of new fossil-fuel cars by 2040.[21]

14 United Nations Department of Economic and Social Affairs (2018), World Urbanization Prospects.
15 International Transport Forum: OECD (2023), ITF Transport Outlook 2023.
16 Lynn H Kaack, Lynn H. Environmental Research Letters (2018), Decarbonizing intraregional freight systems with a focus on modal shiftDecarbonizing Intraregional Freight Systems with a Focus on Modal Shift.
17 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 Mmethodological Aappendix and may be reviewed there.
18 ITDP & UC Davis (2021), *The Compact City Scenario—Electrified*.
19 Selected for data availability and compatibility between sibling studies , and to avoid distortions due to COVID-19.
20 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.
21 https://unfccc.int/news/zero-emission-vehicle-pledges-made-at-cop26

	Percentages of New Vehicle Sales that Are Electric (Rather than InternalCombustion)					
	Business as Usual and Mode Shift (Only)			*Electrification (Only) and Electrification Mode Shift*		
	2015	2030	2050	2015	2030	2050
LDVs (Cars and light trucks)	0%	5%	20%	0%	20%	100%
2- Wheelers/ motorcycles (not including e-bikes)	0%	5%	20%	0%	25%	100%
buses	0%	5%	20%	0%	25%	100%

Figure C. 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 IEA's *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, below.

The ***Mode Shift*** **and** ***Electrification + Mode Shift*** **scenarios** follow our own two-step calculations, in two steps. First, we project possible future urban densities in Indonesia 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,[22] 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:

In the *Mode Shift* scenarios, cities in Indonesia 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 km^2 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[23] and zoning reform to permit by-right multifamily construction (without parking minimums) on all urban land.

Unlike in many other countries, much of Indonesia's urban population mostly already lives at this relatively compact level, and the existing trend is toward further densification (see Figure C). However, a shift toward furthergreater compactness is still necessary: iIn the *Business Aas Usual* trajectory, by 2050 we expect that about 27 million urban Indonesians will live at densities below 4,000 people per km^2. To meet the *Mode Shift* scenarios, by 2050 that number must fall by 2050 to about 16 million (from about 22 million today). This can be accomplished through relatively modest infill development, rather than drastic changes to neighborhoods.

22 ghsl.jrc.ec.europa.eu/
23 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."

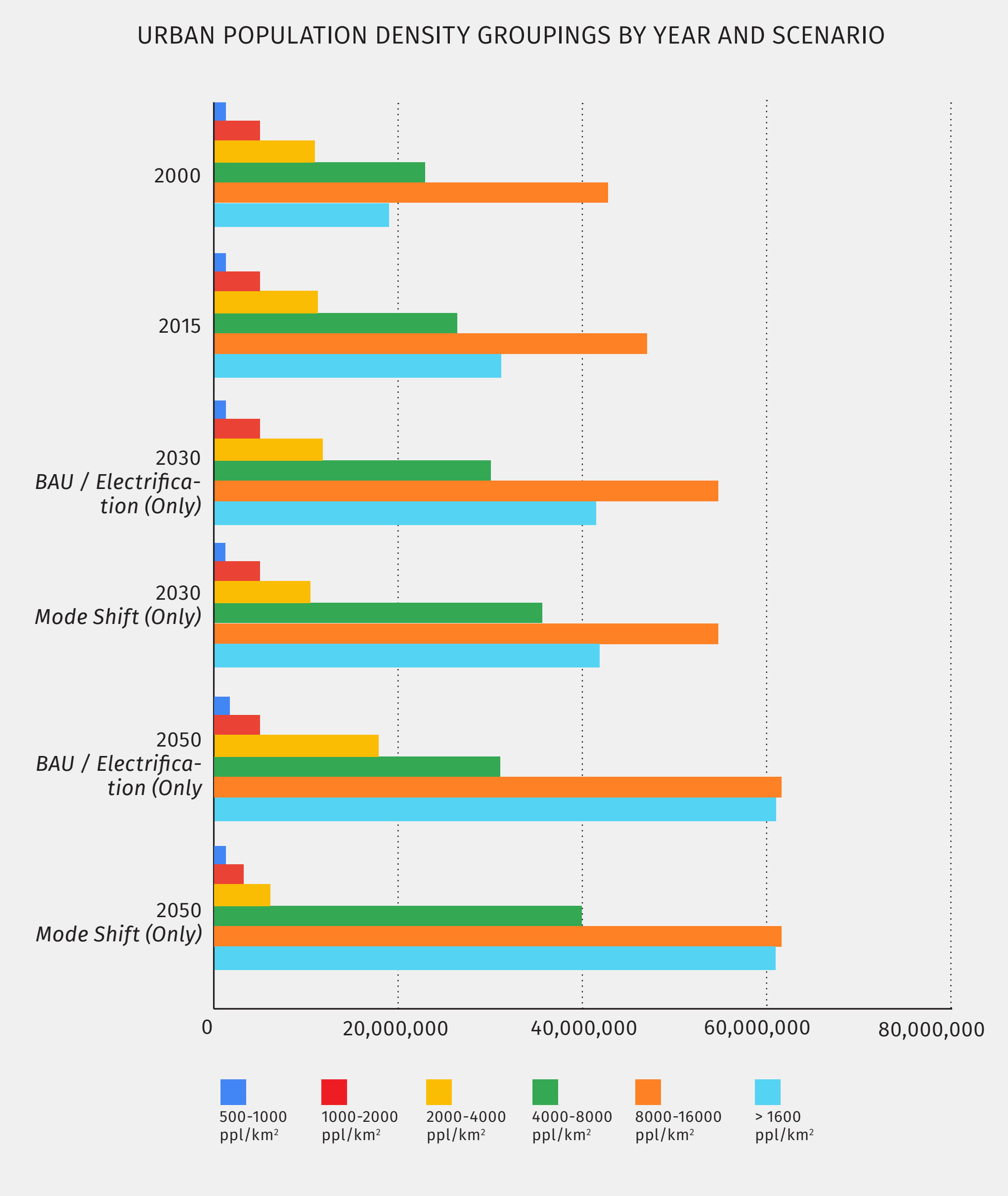

Figure D. Urban density groupings

In the second step, after estimating future densities, we used those projected 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, most significantly bus and bicycle. We estimate that an 18% reduction in car/motorcycle travel relative to 2030 *Business As Usual* and a 51% reduction relative to 2050 *BAU* are achievable. The specific redistribution of this travel to other modes was based on the distribution of density: iIn denser neighborhoods, it is easier to shift to walking and metro, while in less dense ones, bicycles and buses will be more feasible (though of course all neighborhoods will have a mix of all modes). 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, on the next page.

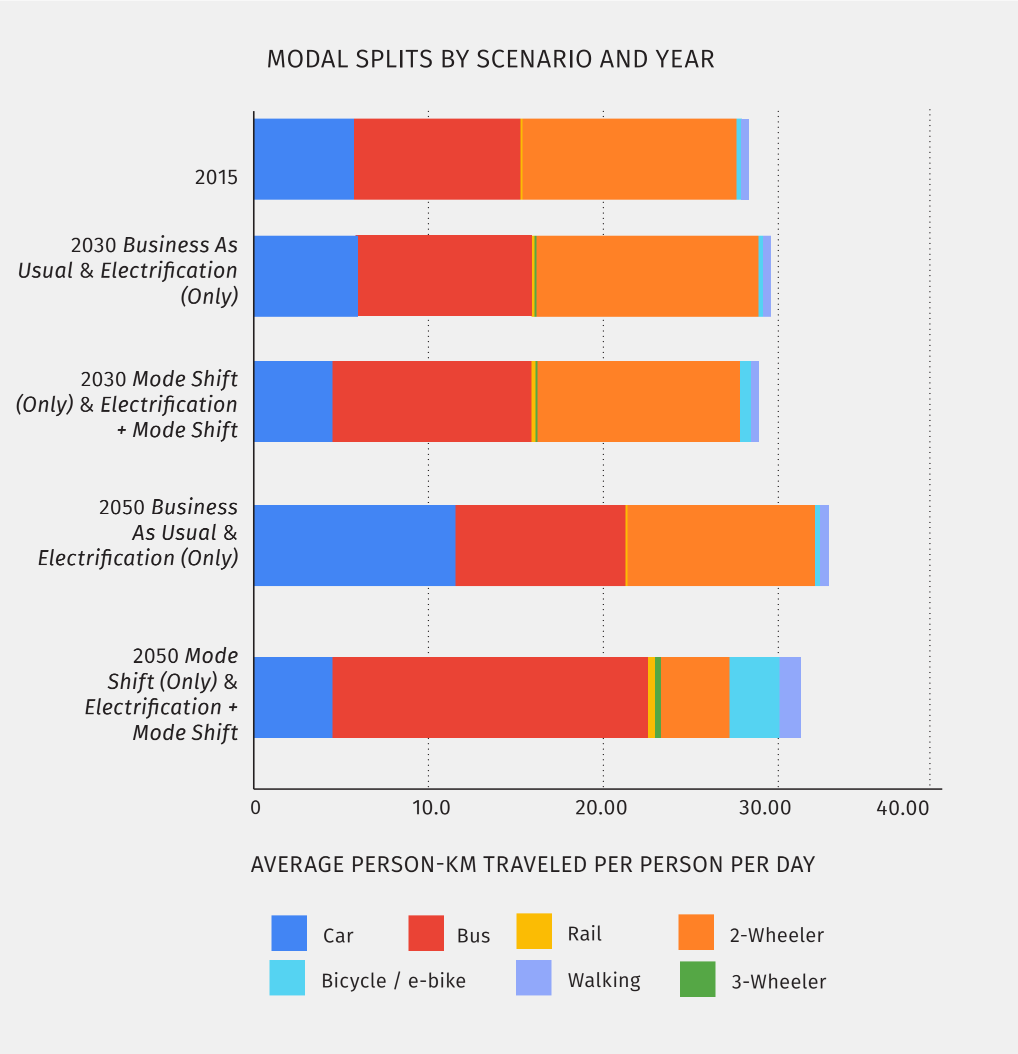

Figure E. Travel activity

Modal 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 & Electrification* (Only)	2030 *Mode Shift (Only) & Electrification + Shift*	2050 *Business as Usual & Electrification (Only)*	2050 *Mode Shift (Only) & Electrification + Shift*
Car	20%	19%	16%	36%	19%
Bus	35%	34%	38%	29%	45%
Rail	0%	0%	1%	0%	3%
3-Wheeler	0%	0%	0%	0%	1%
2-Wheeler	41%	44%	36%	33%	15%
Bicycle/e-bike	1%	1%	4%	1%	11%
Walking	2%	2%	3%	2%	5%

Figure F. Mode splits by percent of travel

4. SCENARIO COMPATIBILITY WITH INDONESIA'S CLIMATE COMMITMENTS

Indonesia's 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—they will require both strategies in concert.

4.1. Indonesia's Climate Targets

Indonesia 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."

Furthermore, Indonesia's General Planning of National Energy, released in 2017, targets a 58% reduction in emissions by 2050 relative to the authors' projections of business- as -usual. However, government policies have not yet set a road map or national plan for decarbonization of the transport sector.

Finally, Indonesia's Ministry of Energy and Mineral Resources has committed to a target of net-zero emissions by 2060.[24] Although this date is outside the scope of our study, it is clear that to achieveing this goal will require coordinated efforts to reduce emissions well before that point.

4.2. Scenario Impacts on Transport Emissions

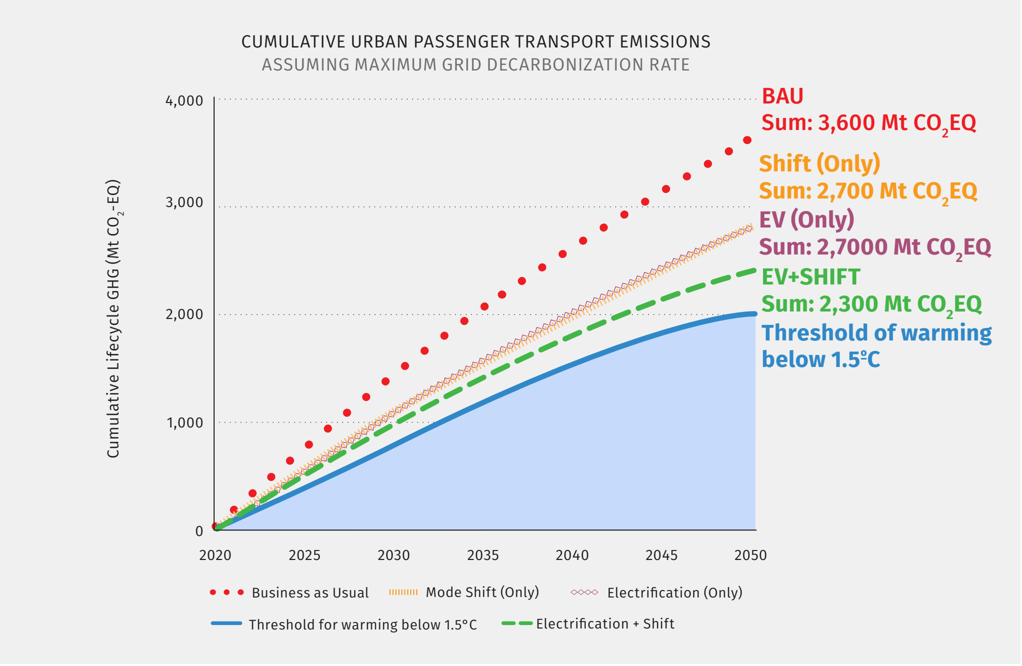

Figure G Greenhouse gas emissions by scenario

Although the *Electrification* and the *Mode Shift* scenarios each would cause considerabley reducetions in greenhouse gas emissions, only the combined *Electrification + Mode 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[25] in Figure G, above.[26] However, even this most extensive scenario still falls short.

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

24 https://www.esdm.go.id/en/media-center/news-archives/speaking-at-cop26-energy-minister-gives-indonesias-commitment-to-net-zero-emission
25 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 mMethodological Aappendix.
26 Note: Our analysis shows that the *Electrification + Mode Shift* scenario will exceed the 1.5°C threshold by nearly 1Gt, a shortfall that will need compensation from decarbonization of other sectors of the American economy.

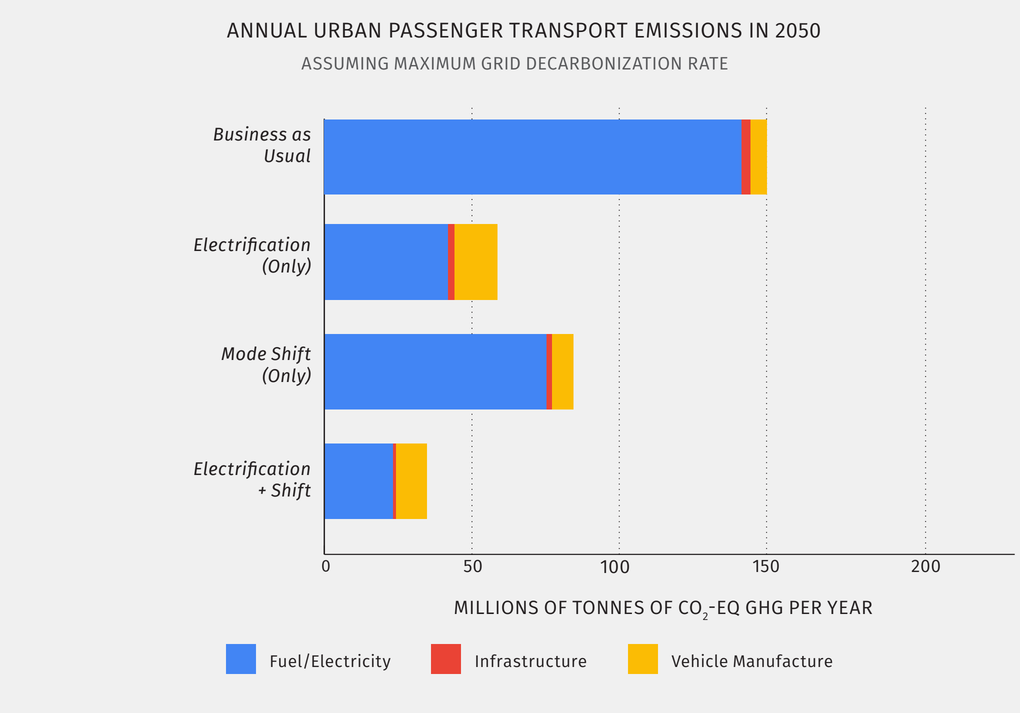

Figure H. Annual greenhouse gas emissions by scenario and source

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 seenshown in Figure G, more than half of emissions are from these sources, which are much more challenging to decarbonize. Indeed, electrification actually increases manufacturing emissions by about 15% relative to *Business as Usual* because of the emissions intensity of battery manufacture and of heavier vehicles.[27] For Indonesia to reach net zero by 2060, 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.[28]

4.3. Modal shift Reduces Dependence on Grid Decarbonization

Modal shift provides a hedge against obstacles that may arise in decarbonizing the electrical grid. By combining mode shift and electrification, Indonesia 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.

Indonesia's electricity grid currently has an emissions intensity of roughly 270 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 IEA's *Sustainable Development Scenario*. Following this assumption, the grid emissions intensity falls to about 50 g CO_2/kWh by 2050.

27 This 8 percent figure is conservative, based on the assumption of rapid decarbonization of the manufacturing sector by 2050. EightyToday 80 percent is a reasonable estimatetoday: See Andrew Moseman &and Sergey Paltsev, MIT Climate Portal (2022), Are electric vehicles definitely better for the climate than gas-powered cars?Are Electric Vehicles Definitely Better for the Climate than Gas-Powered Cars?
28 Center on Global Energy Policy (2023), Q&A: Critical minerals demand growth in the net-zero scenarioQ&A: Critical Minerals Demand Growth in the Net-Zero Scenario.

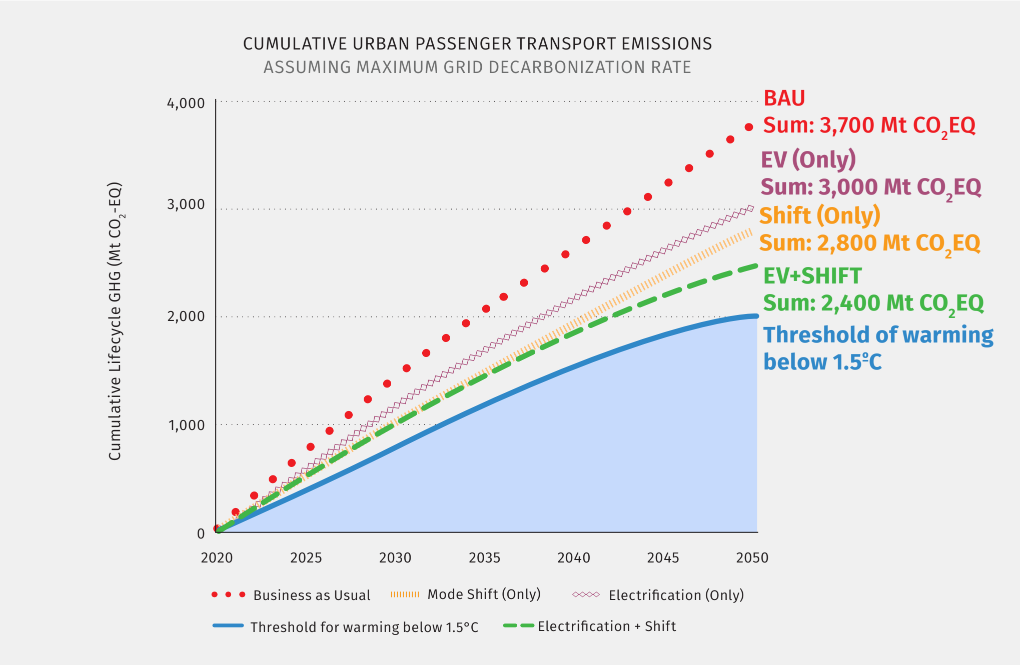

Figure I. Emissions under assumption of more moderate grid decarbonization

Current policies (as per IEA's State Policies Scenario) are only projected to reach a grid intensity of about 230 g CO_2eq/kWh by 2050, compared to 270 today. This is still an optimistic forecast, but 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 + Mode Shift* comes the closest.

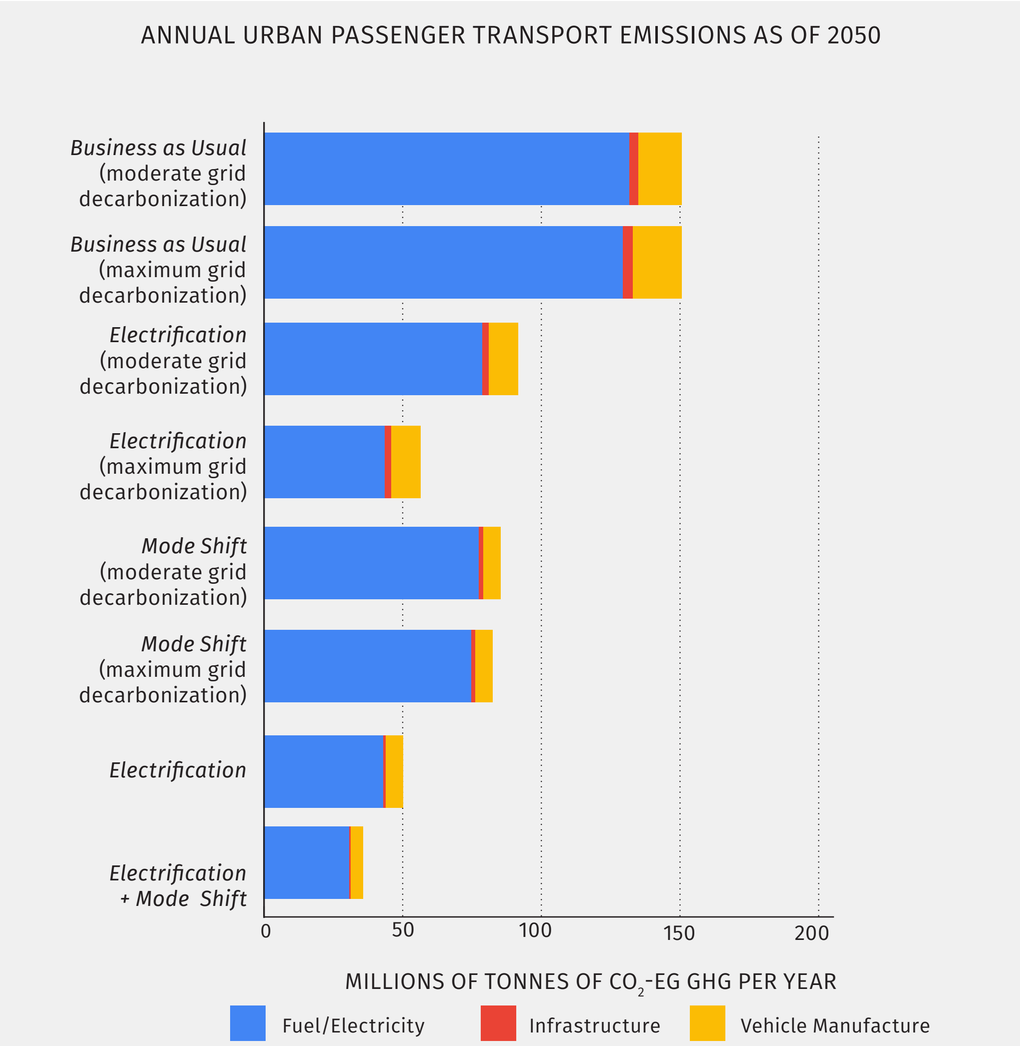

Figure J. Annual emissions as of 2050, by scenario

The more conservative grid decarbonization projections also shed light on Indonesia's prospects for reaching its goal of net zero by 2060, as seen in Figure J. If grid decarbonization proceeds in line with current stated policies, it will be very difficult if not impossible for Indonesia 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.

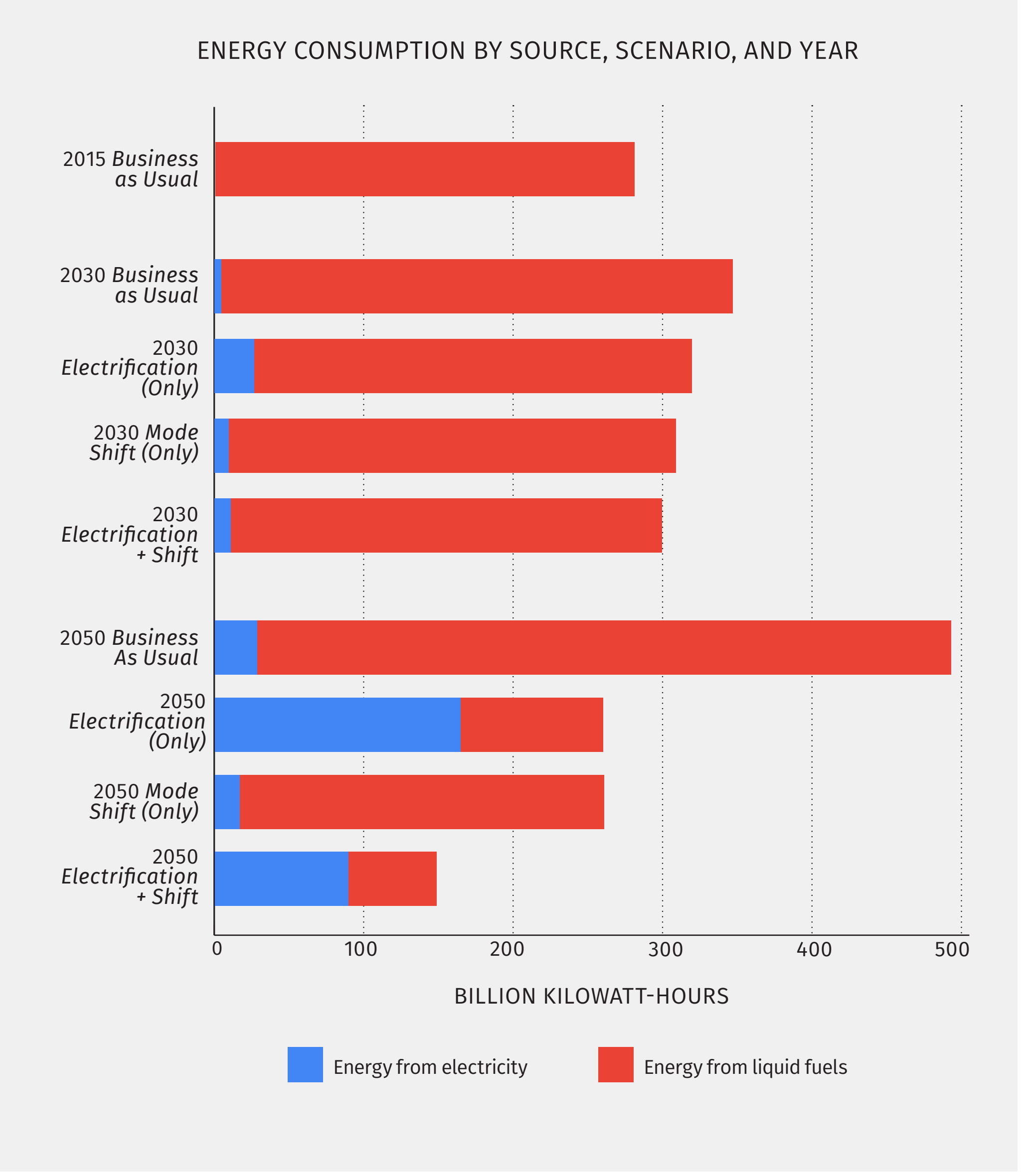

Figure K. Annual energy consumption

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, as shown in Figure K.

In the *Electrification* scenario, urban passenger transport in Indonesia will consume about 503 billion kWh of electricity annually by 2050. *Electrification + Mode Shift* reduces this consumption by about 45% (72 billion kWh), or the equivalent of the annual power generation of almost 14,000 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 + Mode Shift* scenarios offer efficiencies that could save about $38 trillion IDR for the Indonesian economy overall, including savings to the public and private sectors.

The structure of a transportation system has many impacts on a nation's economy, dboth 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.

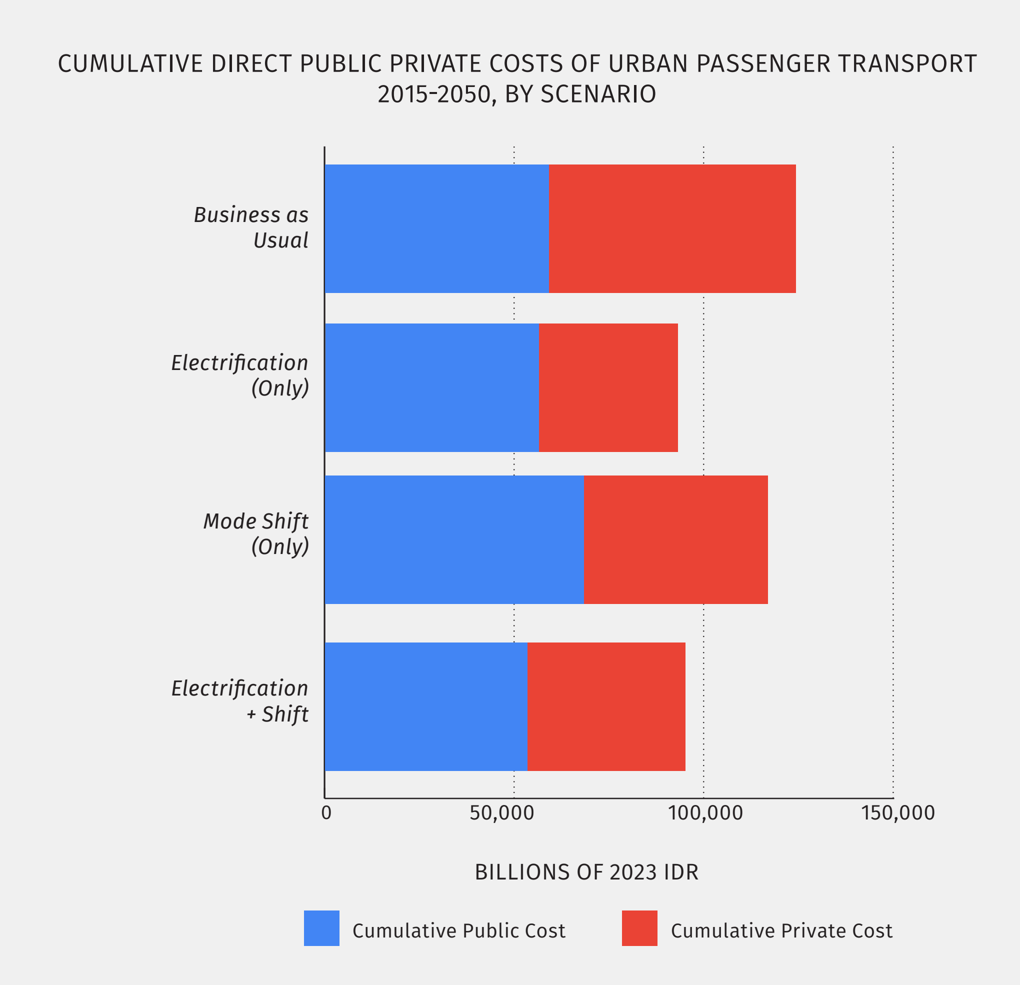

Figure L. Cumulative direct costs of urban passenger transport

These expenses can be divided into those borne ultimately by the public sector and those borne ultimately by individuals.[29] *Mode Shift* would lead to enormous economic savings for the Indonesian economy—a cumulative savings of about $40,000 trillion IDR. Of this, about $10,000 trillion IDR 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.[30] All of these indirect costs are likely to mean that the true economic benefit of *Electrification + Mode Shift* would be many times higher than what we have calculated.

29 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.
30 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 highwaysRoad and Public Transit Maintenance Create More Jobs than Building New Highways.

7. MEASURABLE GOALS FOR URBAN PASSENGER TRANSPORTATION

It is possible for Indonesia to achieve the *Electrification + Mode 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 Indonesia already expends foron urban passenger transportation—rather, *Electrification + Mode 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 + Mode 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.In this section, we provide evidence-based goals for each of these three elements based on the study's quantitative analysis. If achieved, these goals would bring the benefits of the *Electrification + Mode Shift* scenario. These goals could be accomplished in many ways, and in the Appendix we provide basic policy agendas at the national, provincial, and city levels that could help Indonesia reach them.

7.1. Goals for Electrification

To achieve the country's climate commitments, electrification must proceed much more rapidly than it is on 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, 20% of all new light-duty vehicle sales (cars and light trucks) must be electric by 2030, and 100% by or before 2050.

Percentages of New Vehicles that Are Electric (Rather than internal-Combustion)						
	Business as Usual and *Mode Shift (Only)*			*Electrification (Only)* and *Electrification + Mode Shift*		
	2015	2030	2050	2015	2030	2050
LDVs (Cars and light trucks)	0%	5%	20%	0%	20%	100%
2- Wheelers/ motorcycles (not including e-bijes)	0%	5%	20%	0%	25%	100%
Buses	0%	5%	25%	0%	25%	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 tofor the cities of Indonesia. 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 + Mode Shift* scenario and meeting the country's climate commitments will require Indonesia to maintain policies that enable compact urban development, while promoting mixed-use and transport-oriented development. As discussed in Section 3.2.2 above, Indonesian cities must reduce the number of people living at urban densities below 4,000/km^2 to fewer than 16 million.

7.3. Goals for Transportation Infrastructure

This analysis provides the clearest agenda for the third of the three components necessary to achieve the *Electrification + Mode 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 Indonesia must make to reach the *Electrification + Mode Shift* scenario. As shown in Figure N, the *Mode Shift* element of the scenario will mean that national, provincial, and city governments will save about $7,000 trillion IDR 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, km	BRT Lane, km	Metro Rail Lane, km	Protected Bicycle lanes, km	Buses	Train cars	Total cost to governments (billion IDR)
Business as Usual & Electrification (Only)	79,000	200	0	400	540,000	300	18,000,000
Mode Shift (Only) & Electrification + Shift	49,000	2,500	200	15,000	610,000	1,000	18,000,000
Total New Infrastructure and Vehicles Required 2015–2050							
	Urban Road Lane, km	BRT Lane, km	Metro Rail Lane, km	Protected Bicycle lanes, km	Buses	Train cars	Total cost to governments (billion IDR)
Business as Usual & Electrification (Only)	330,000	700	100	900	1,500,000	900	62,000,000
Mode Shift (Only) & Electrification + Shift	90,000	9,200	900	60,000	1,800,000	5,800	52,000,000

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

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

- Although there is still room for some expansion of roadways in Indonesia, road building must decrease by half in the short term and two-thirds by 2050. The financial savings through reduced road construction will be dramatic.
- Indonesia requires much more rapid transport than it currently has, and, because of the limits of cost and construction time, 90% of that will have to be BRT rather than metro or other types of rail. Rail must be used in the highest-demand areas of the country's large cities, but all cities around the country should start building BRT on all major roads.
- Protected bicycle lane networks are the most cost-efficient way of providing urban transportation. They should be safe for everyone, including children and the elderly. By 2050, everyone in a city in Indonesia should live no more than a block or two from a protected bicycle lane.

This scale of transformation, while massive, is not unprecedented. Paris decreased car travel by almost 50% in 30 years by investing in other modes and traffic control strategies. Jakarta has already built a mass transit system with more than a million riders a day in less than 15 years. There's no reason why Jakarta can't build further on this work, and no reason why other Indonesian cities can't do the same. Just as addressing the climate crisis will require both E*lectrification* and *Mode Shift,* so it will also require effort from both the national and the city governments, working together, to transform urban transport in Indonesia.

APPENDIX: METHODOLOGICAL DOCUMENTATION

Because of its length, the methodological documentation has not been included in this layout of the report. It is available at **Indonesia Drafting: Methodological Appendix**.

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