EXPLAINING AND PROJECTING THE CARBON FOOTPRINT OF MEXICO'S URBAN TRANSPORT

AIGA STOKENBERGA

EMMETT INTERDISCIPLINARY PROGRAM IN ENVIRONMENT AND RESOURCES

STANFORD UNIVERSITY

TRANSPORT RESEARCH BOARD 91ST ANNUAL MEETING

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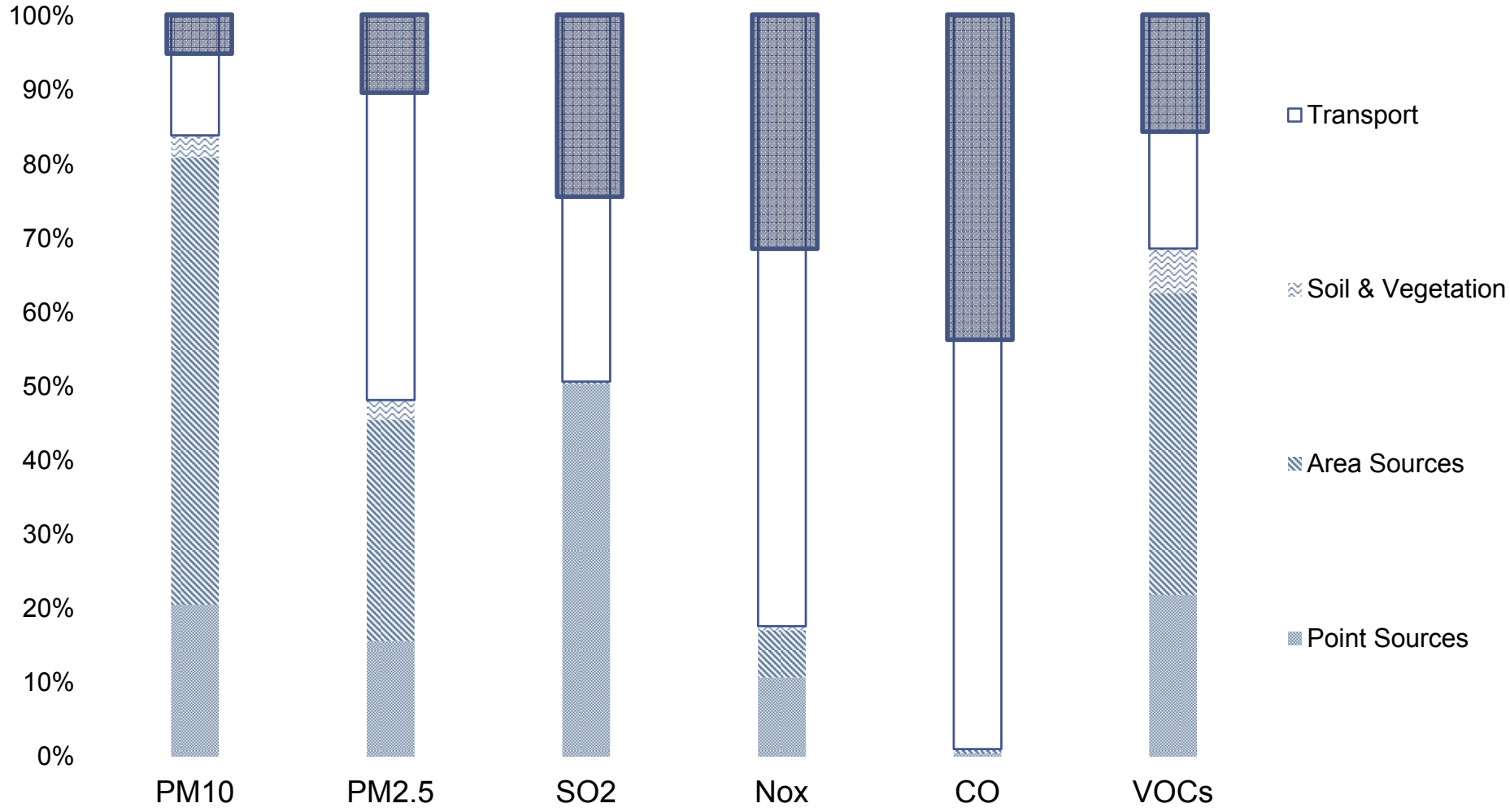
WASHINGTON, DC

Motivation / Questions of Interest

- Mexico is highly urbanized and becoming increasingly more so
- Transport sector is an increasing contributor to Mexico's overall carbon footprint … but also significant localized air pollution

Transportation patterns with impacts close to home…



Emissions in Mexico City Metropolitan Area, Ministry of the Environment of the Federal District, 2008

Motivation / Questions of Interest

- Mexico is highly urbanized and becoming increasingly more so
- Transport sector is an increasing contributor to Mexico's overall carbon footprint

- **Is there hope for decoupling increased mobility/access from rising carbon emissions?**
  - How to maintain or increase mobility (activity) but not energy consumption
  - How to decouple mobility from car dependence?

    -- Vehicle activity (a measure associated with energy use)

    -- vs. Personal and Freight mobility

- In the medium to longer run, which policies are most likely to affect auto ownership, land use, and location choice?
  - Comparing the national and the city-level data on transport energy consumption allows for consideration of both local and national policy interventions
  - Also helpful for teasing out data gaps

Methodology

- Desk research / data collection: National vs. Metropolitan-level
- Methodology: generally based on the ASIF approach

Activity / Modal **S**plit / Energy **I**ntensity / **F**uel Carbon Content

$$G = \sum_i A \times S_i \times I_i \times \sum_j F_{i,j}$$

Complemented, **at the metropolitan level**, by:

- Mexico City 2007 Origin-Destination survey + City-level GHG emissions inventories
- Approximation of current transport activity (& CO_2) per:

  (1) income group and (2) trip purpose
- Combined with observed trends in:

  (1) urban transport activity and (2) modal choices
- To arrive at projections of Mexico City's future transport-related carbon footprint

Data

Variables:

Population, household data, vehicle fleet in circulation, vehicle stock, scrapping rates, annual mileage, fuel use, vehicle imports/exports/sales, passenger/freight transport activity and associated fuel use by mode, carbon emissions by mode and trip type

- Data sources:

direct communication with- and publicly available data from

- National Population Council (CONAPO)
- National Institute of Geography and Statistics (INEGI)
- Mexican Institute of Petroleum (IMP)
- Ministry of Communications and Transport (SCT)
- Ministry of Energy (SENER)
- Mexican Association of Automotive Industry (AMIA)
- State Ministry of Transport (SETRAVI)
- Ministry of Environment of the Federal District (SMA)

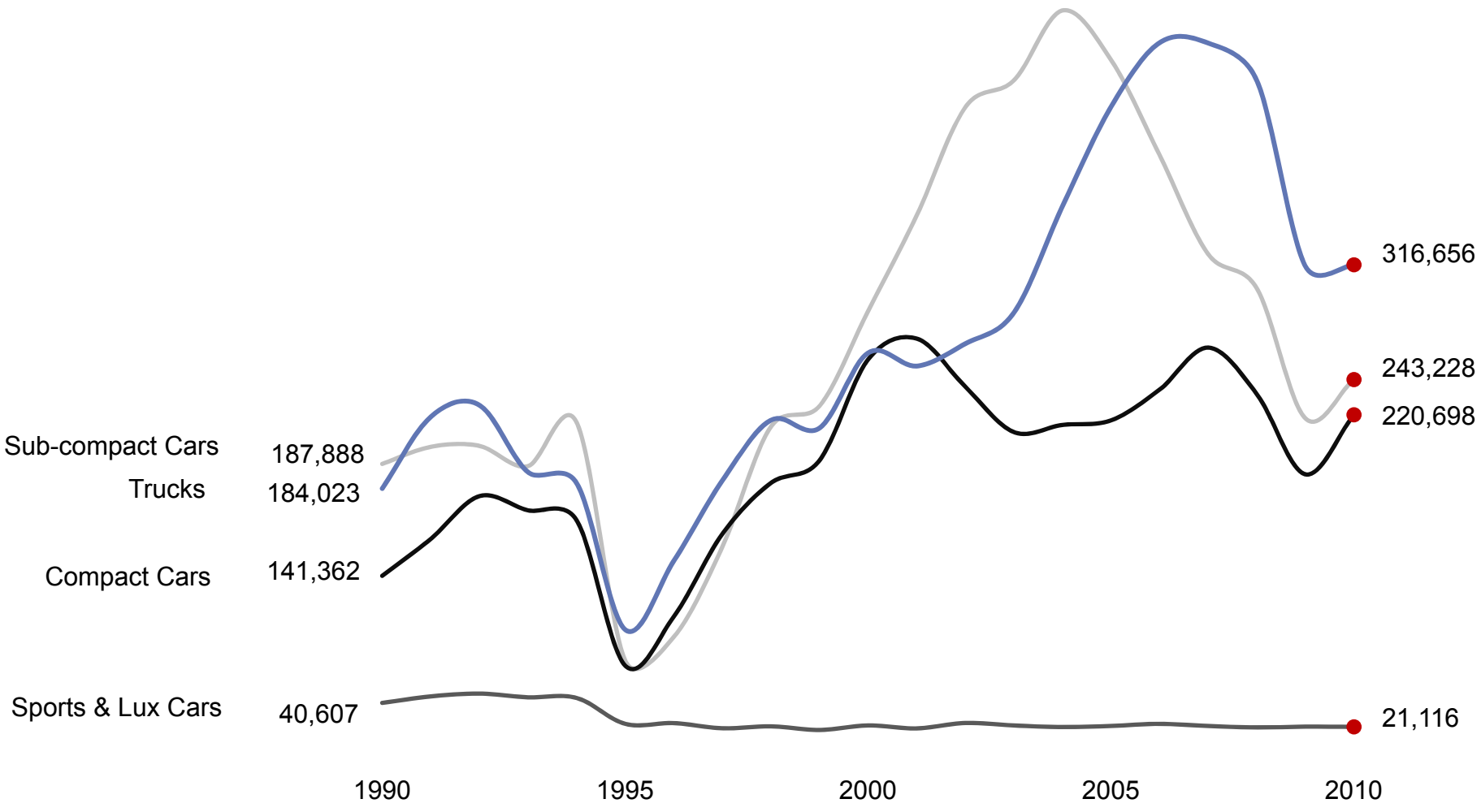
	Regulatory Scope
Secretary of Communications and Transport (SCT)	• design and execution of national transport policies • technical standards for passenger and freight vehicles • aggregated data on vehicle fleet and mileage from INEGI/IMT/IMP • cross-border movement of freight, by mode and type of commodity
Secretary of the Environment (SEMARNAT)	• standards on CO_2 emissions and energy efficiency for new LDVs • Monitoring of the Voluntary Clean Transport program (freight tr.)
National Commission for Energy Efficiency (CONUEE)	• energy efficiency guidelines for new federal/public vehicles
	Data Collection Scope
Instituto Mexicano de Transporte (IMT)	• national mode shares, including data on inter-city bus travel • tonne-km of rail and truck freight; • estimates of value of time of vehicle users
Instituto Mexicano de Petróleo (IMP)	• vehicle fleet and mileage, by origin and type of vehicle • vehicle fleet renovation rates • future projections of the above indicators
Instituto Nacional de Ecología (INE)	• efficiency data for buses and micro-buses
Ministry of Energy (SENER)	• Gasoline consumption at the national level
Petroleos Mexicanos (PEMEX)	• Gasoline production and sale at the national level • Gasoline prices

Vehicle Fleet & Activity

National-level trends

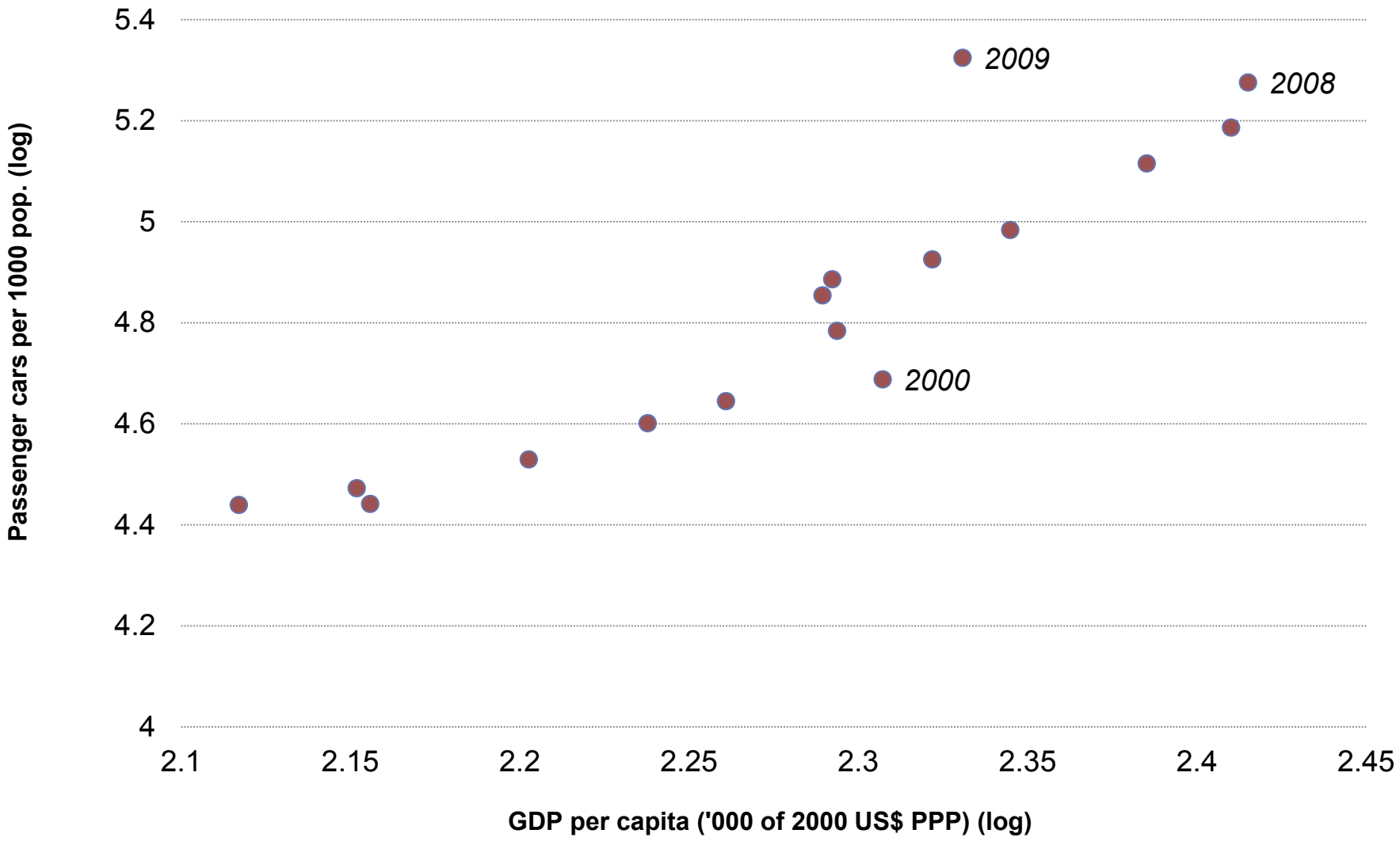
Metropolitan-level trends

New Vehicle Sales Rising



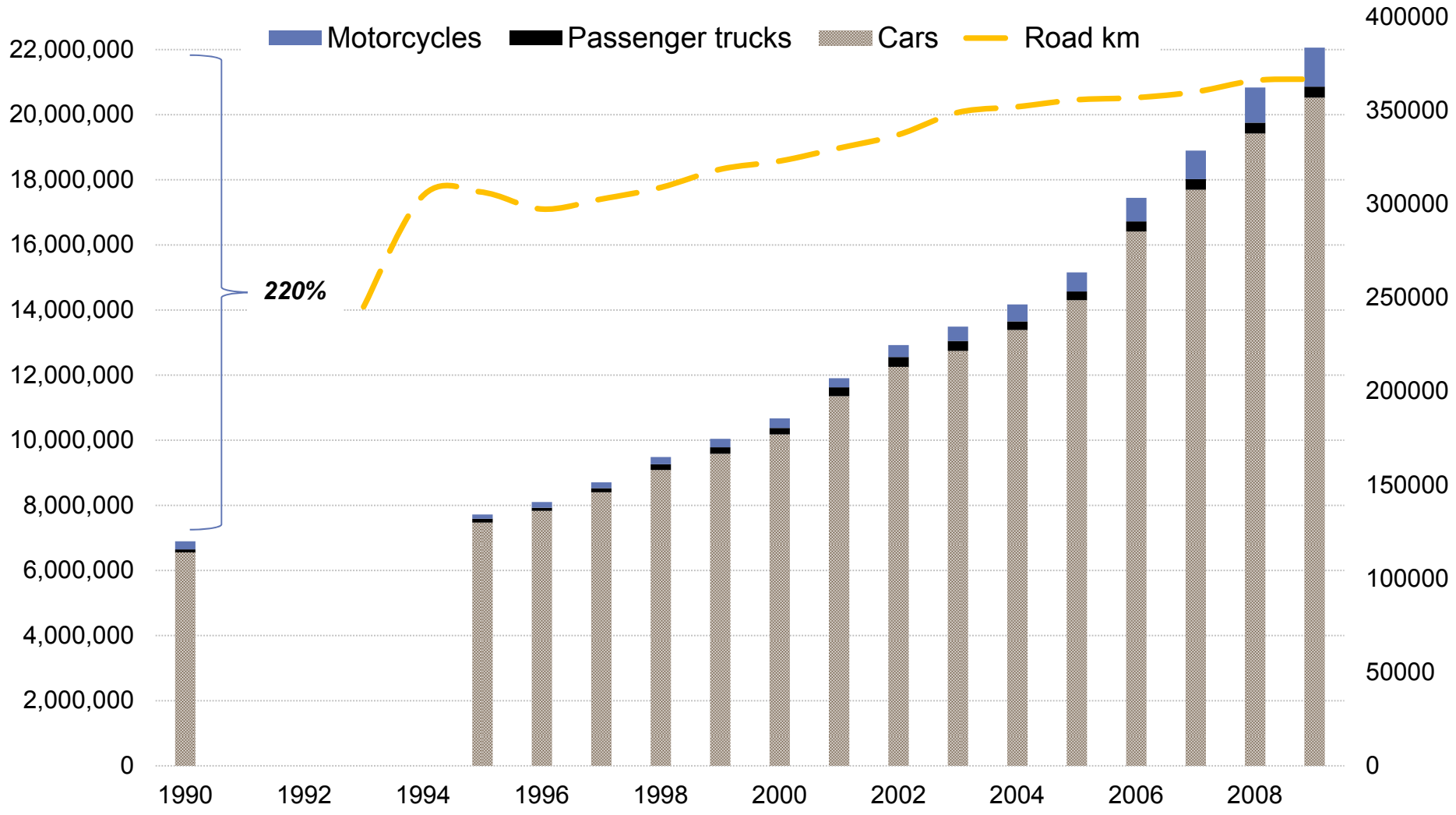
Source: Asociación Mexicana de la Industria Automotriz

Car Ownership Rising



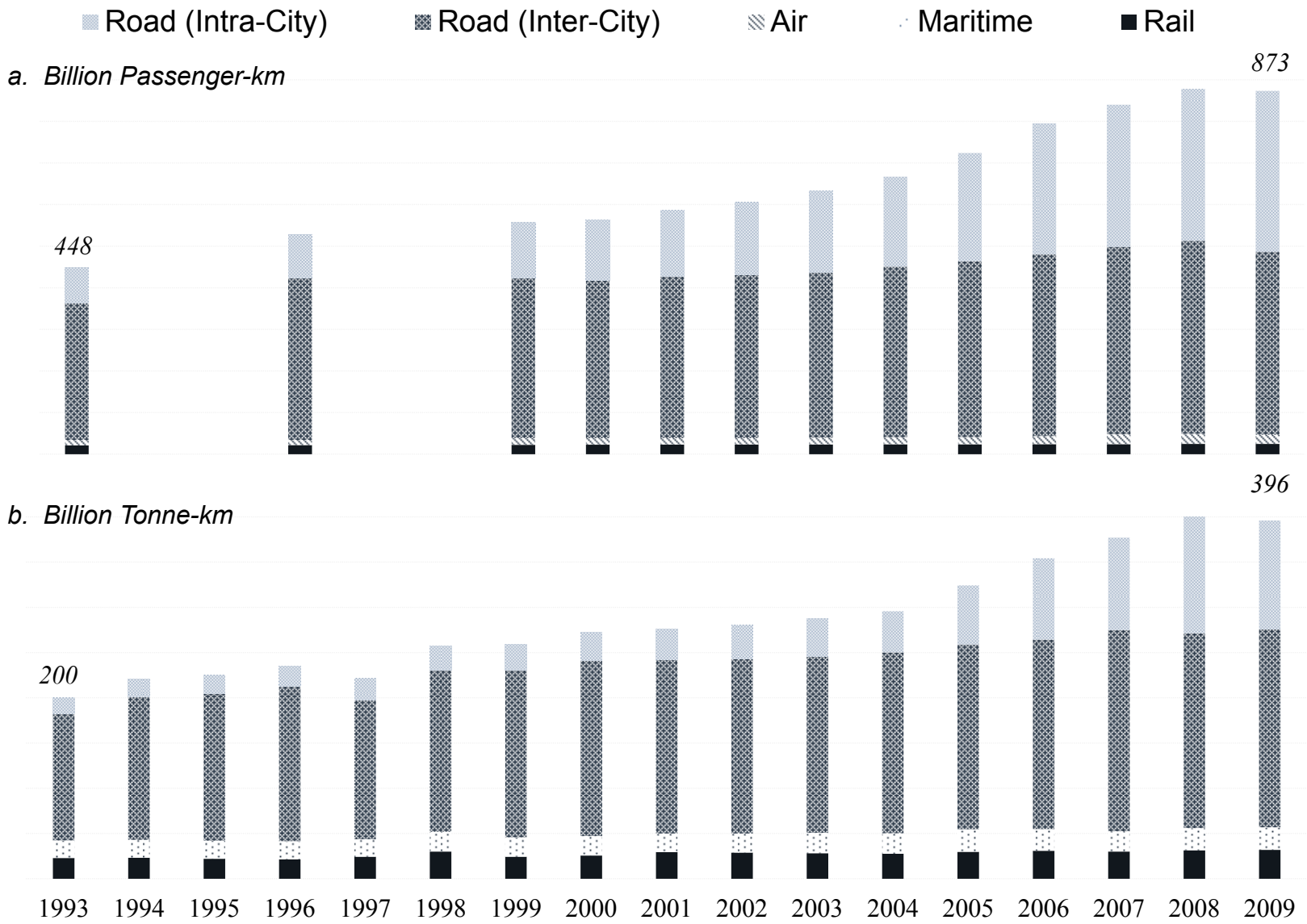
Source: IEA data on car ownership; OECD income data

… outpacing new road network construction



Source: Data collected from State governments; Ministry of Transport data on road construction

Trends: Intra-City Road Transport Activity Booming

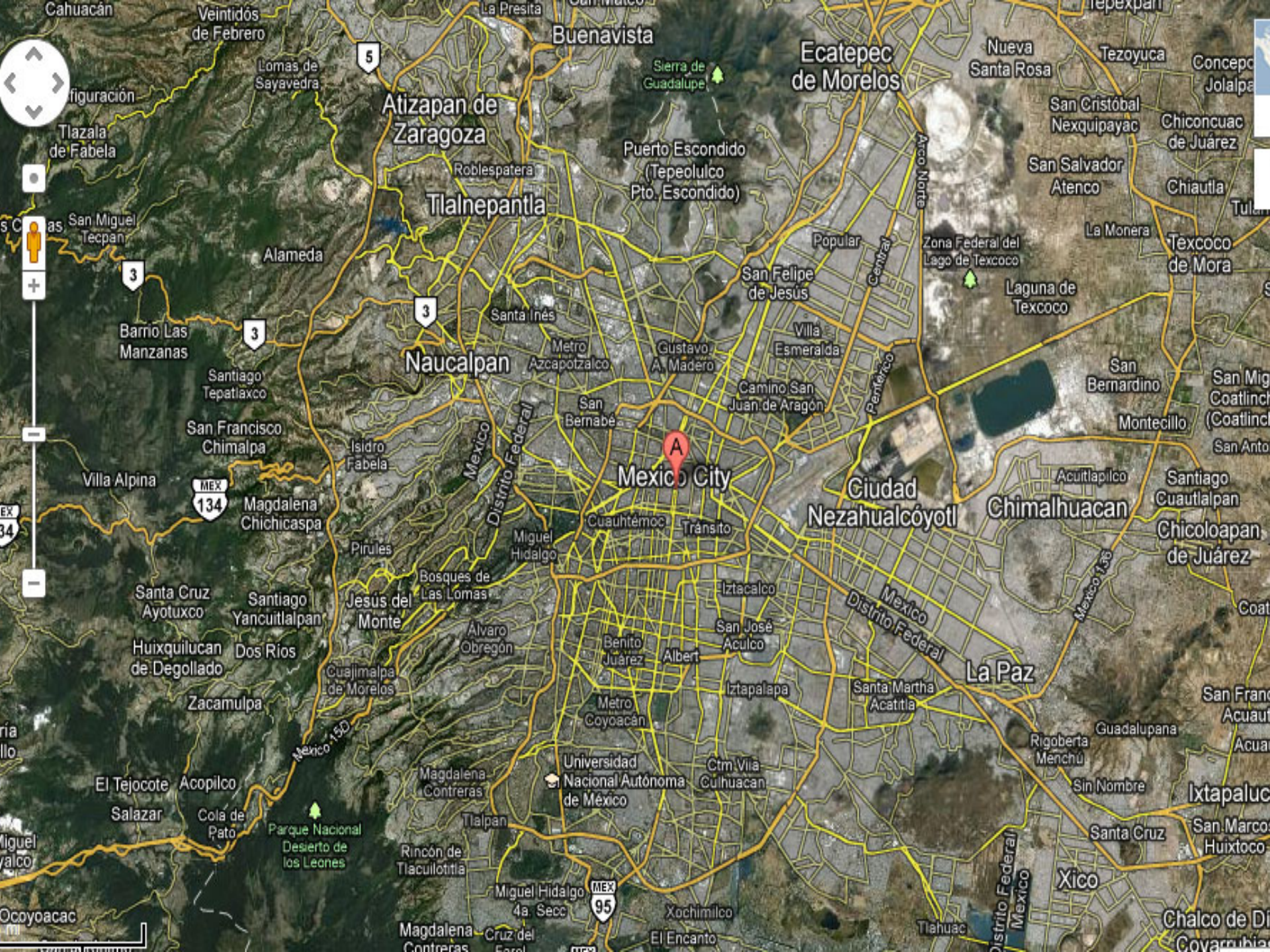


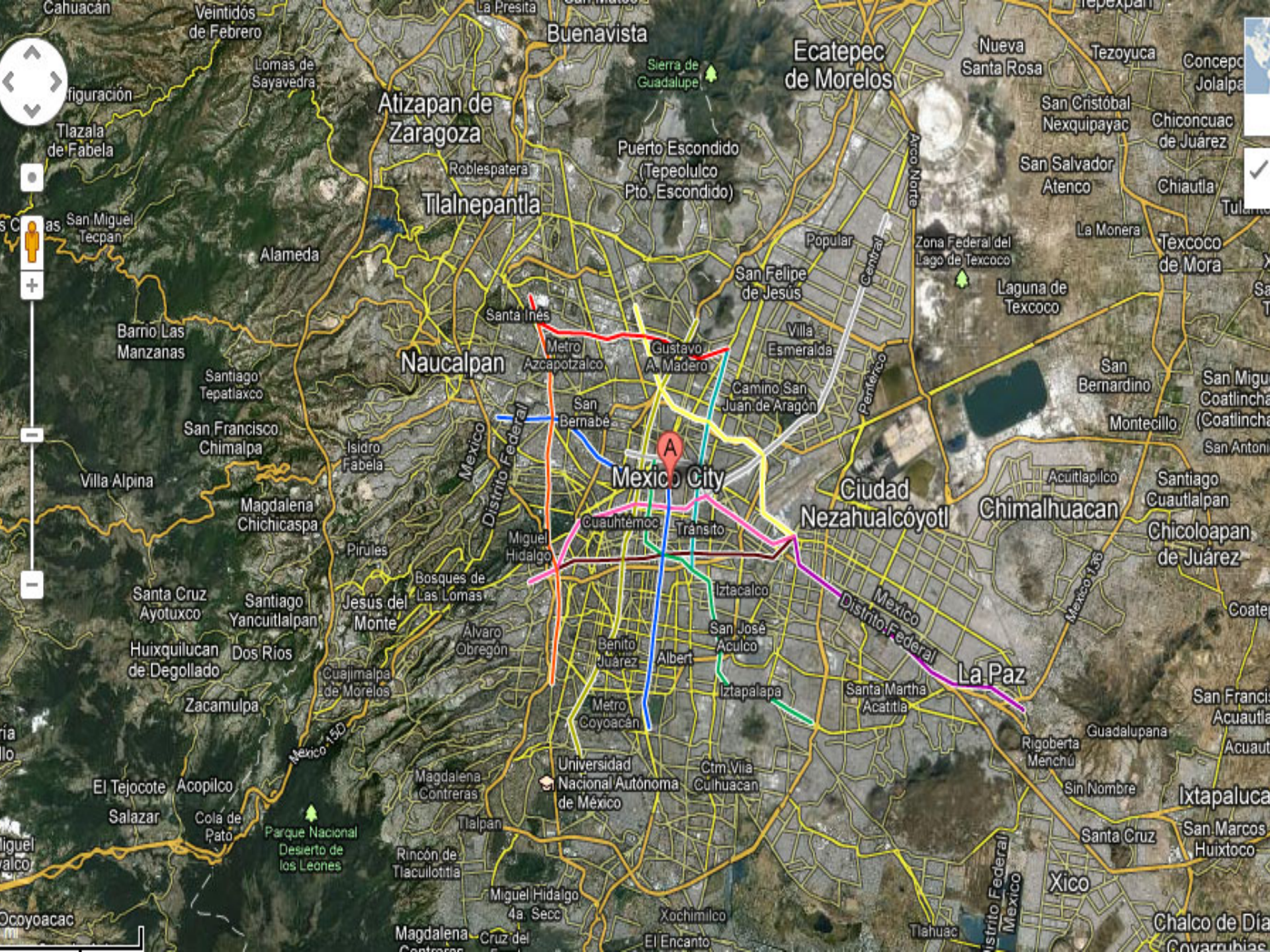
Source: SCT

Vehicle Fleet & Activity

National-level trends

Metropolitan-level trends


Cahuacán
Veintidós de Febrero
La Presita
Buenavista
Ecatepec de Morelos
Nueva Santa Rosa
Tezoyuca
Concepc Jolalpa
Lomas de Sayavedra
Sierra de Guadalupe
Atizapan de Zaragoza
San Cristóbal Nexquipayac
Chiconcuac de Juárez
Tlazala de Fabela
Puerto Escondido (Tepeolulco Pto. Escondido)
San Salvador Atenco
Chiautla
Roblespatera
Tlalnepantla
San Miguel Tecpan
Alameda
Popular
Zona Federal del Lago de Texcoco
La Monera
Texcoco de Mora
San Felipe de Jesús
Laguna de Texcoco
Barrio Las Manzanas
Santa Inés
Villa Esmeralda
Naucalpan
Metro Azcapotzalco
Gustavo A. Madero
Santiago Tepatlaxco
Camino San Juan de Aragón
San Bernardino
San Bernabé
Montecillo
San Francisco Chimalpa
Isidro Fabela
Mexico
Distrito Federal
Mexico City
Villa Alpina
Magdalena Chichicaspa
Ciudad Nezahualcóyotl
Acuitlapilco
Chimalhuacan
Santiago Cuautlalpan
Chicoloapan de Juárez
Cuauhtémoc
Tránsito
Miguel Hidalgo
Pirules
Bosques de Las Lomas
Iztacalco
Santa Cruz Ayotuxco
Santiago Yancuitlalpan
Jesús del Monte
Álvaro Obregón
San José Aculco
Huixquilucan de Degollado
Dos Ríos
Benito Juárez
Albert
Cuajimalpa de Morelos
Iztapalapa
Santa Martha Acatitla
La Paz
Zacamulpa
Metro Coyoacán
Guadalupana
Rigoberta Menchú
Universidad Nacional Autónoma de México
Ctm Vila Culhuacan
Sin Nombre
El Tejocote
Acopilco
Magdalena Contreras
Salazar
Cola de Pato
Parque Nacional Desierto de los Leones
Tlalpan
Santa Cruz
Ixtapaluc
San Marcos Huixtoco
Rincón de Tlacuilotitla
Miguel Hidalgo 4a. Secc
Xochimilco
Xico
Ocoyoacac
Magdalena Contreras
Cruz del Farol
El Encanto
Tláhuac
Chalco de Di Covarrubia
Arco Norte
Periférico
Central
Mexico 150
Mexico 136
Mexico 95
Mexico 134
Mexico 3
Mexico 5



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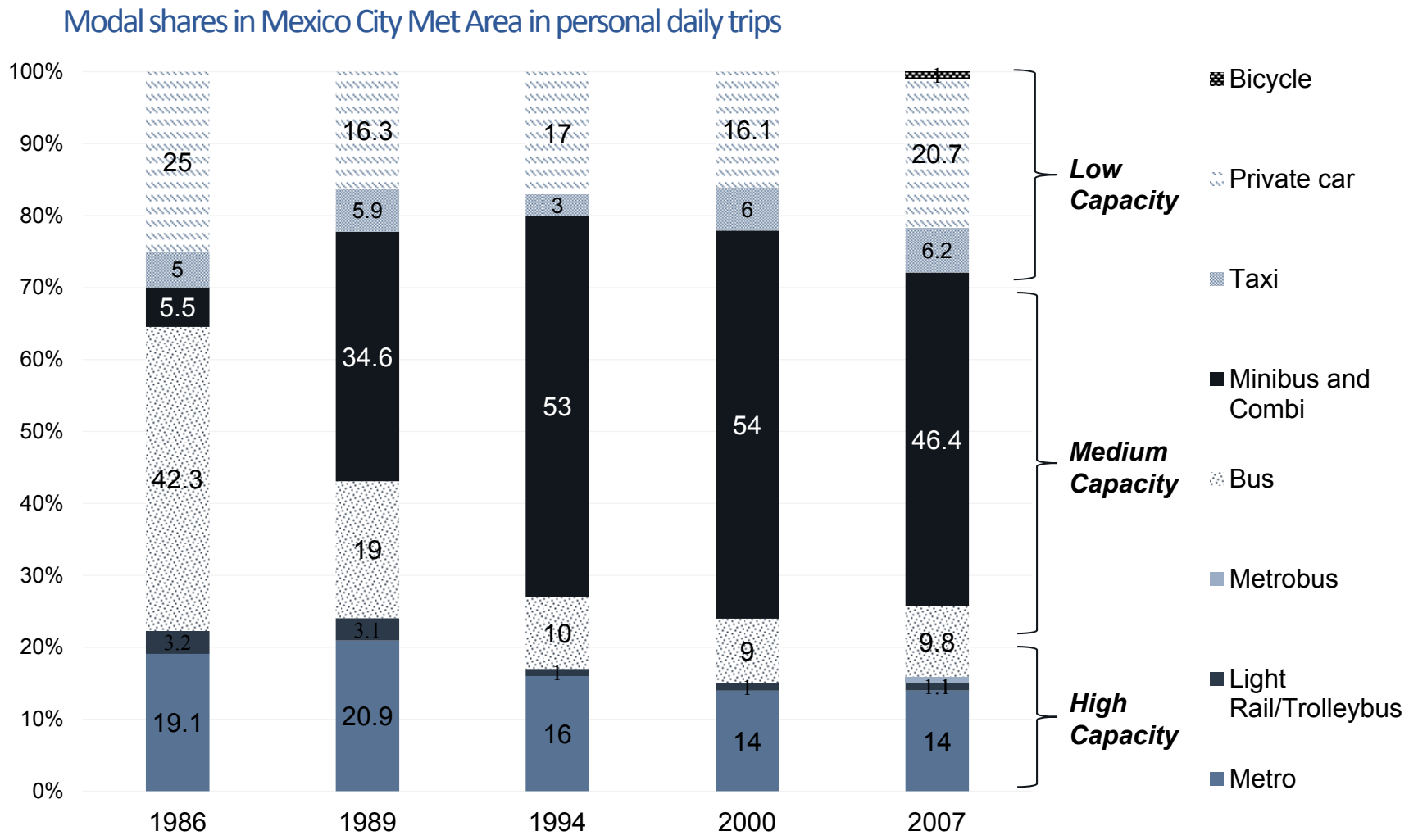
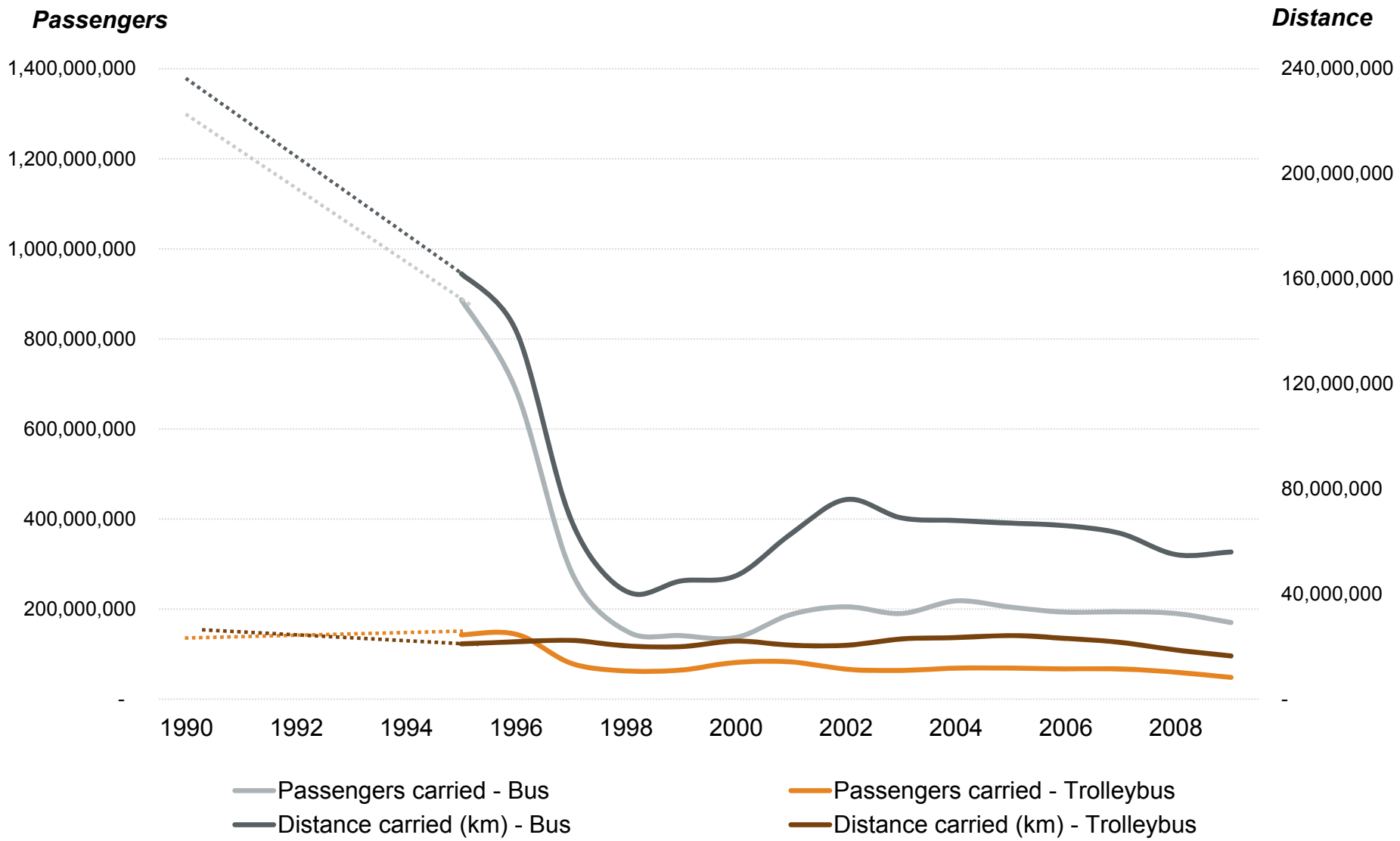
Shift towards higher capacity and lower carbon intensity at the city level?



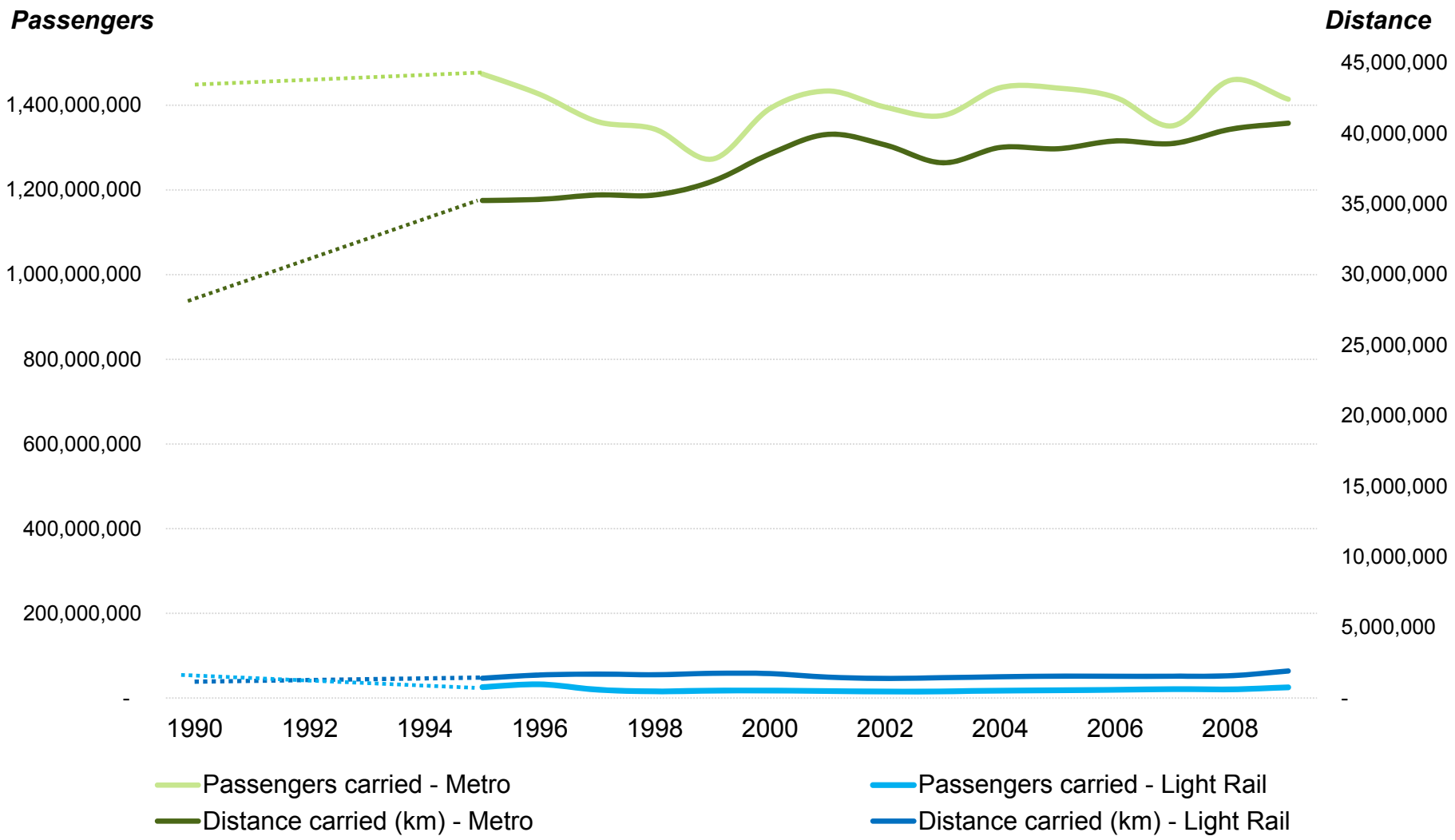
Source: *Inventario de Gases de Efecto Invernadero*. Ministry of the Environment of the Federal District, 2008.

Medium-capacity transit



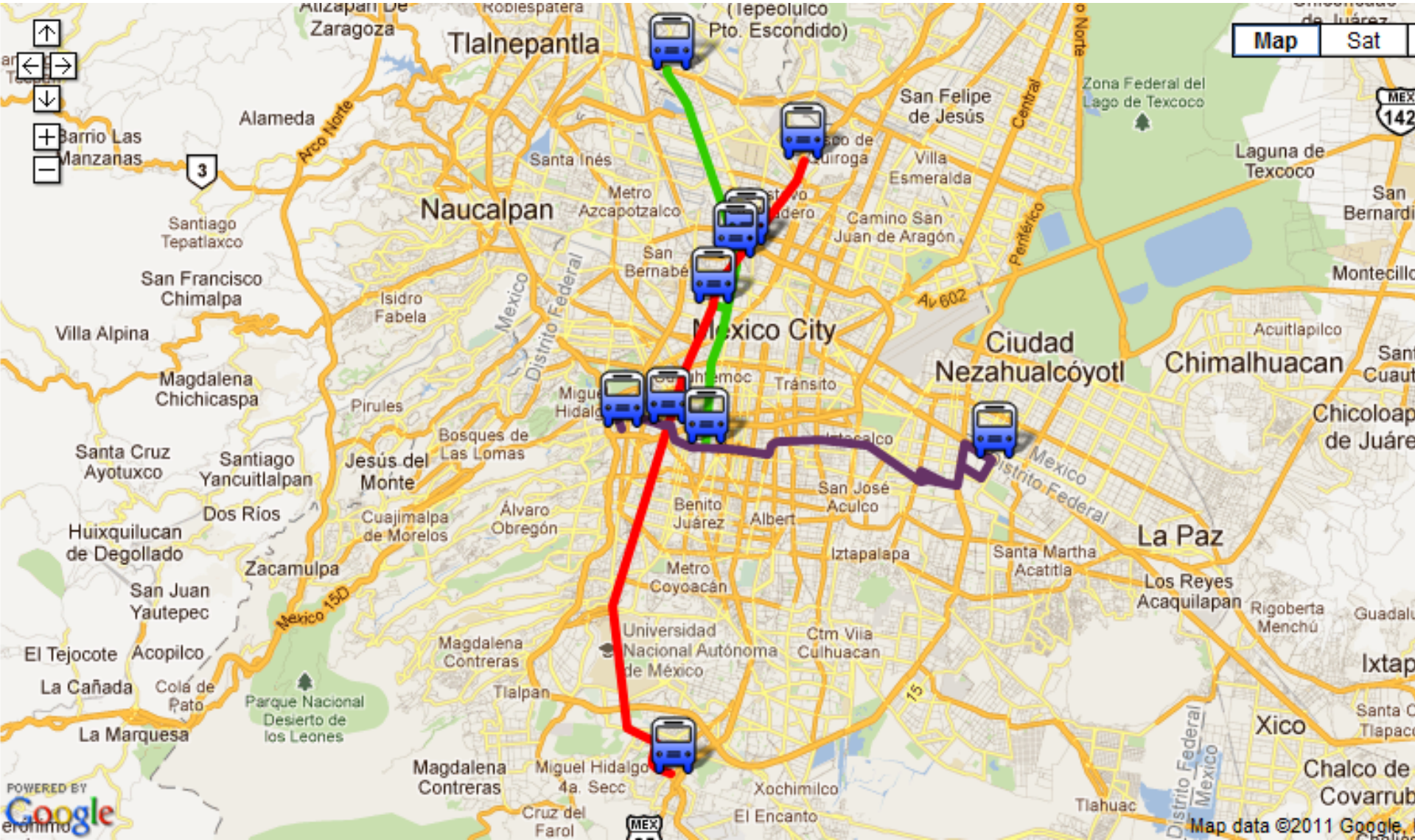
Source: INEGI

High-capacity transit



Source: Sistema del Transporte Colectivo Metro del D.F. y Servicio de Transportes Electricos del D.F.

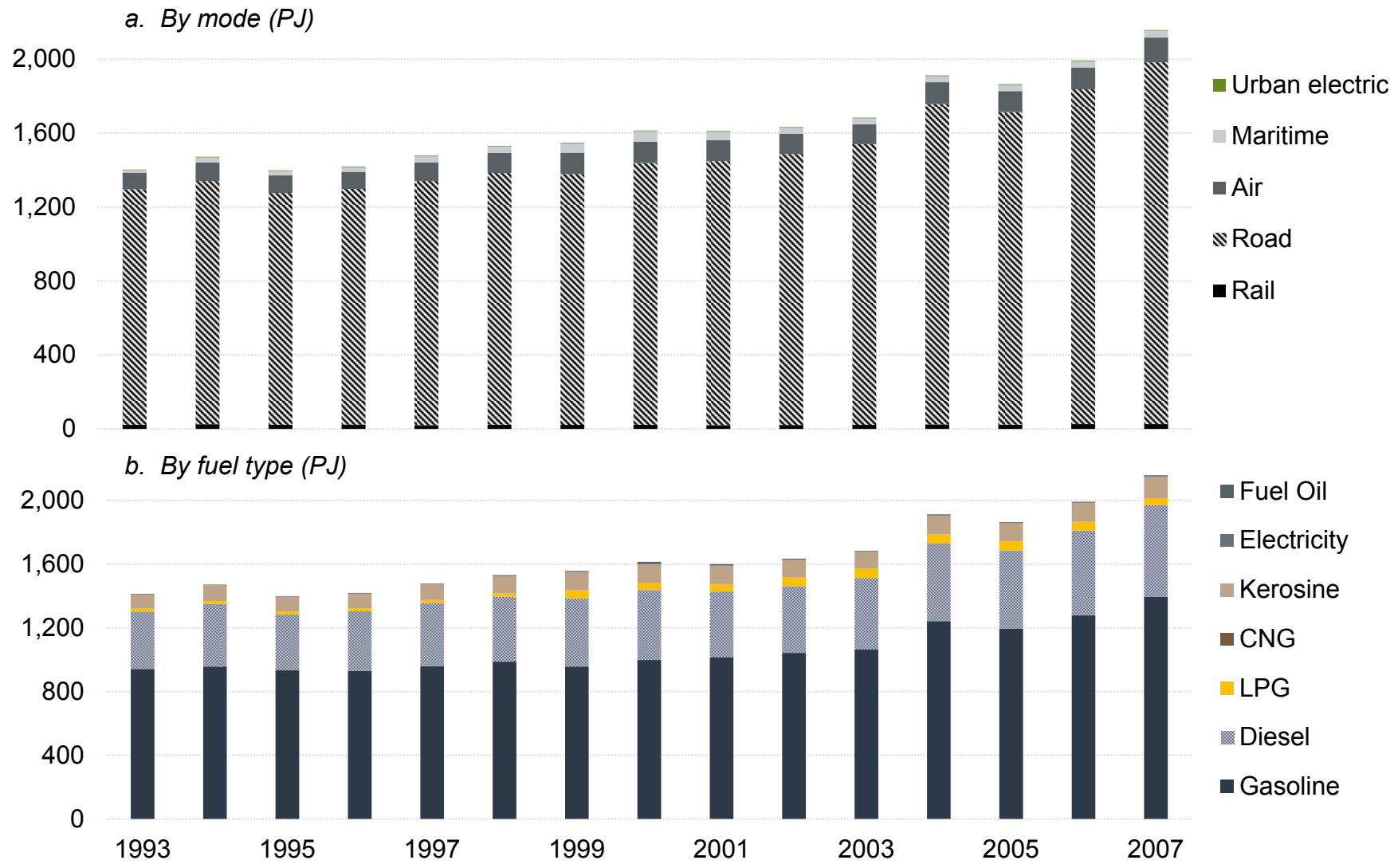
Metrobus BRT



Energy Consumption & Efficiency

National-level trends &
Metropolitan-level trends

Energy Consumption: National Data



Sources: IMT Manual Estadistico del Sector de Transporte 2009; Balance Nacional de Energia 2006; Sistemade Informacion Energetica (for years 2007-2009)

Fuel Economies

MEXICO

- SENER reported the 2007 average fuel efficiency for new gasoline vehicles at between 6.7 km/liter for light trucks and 12 km/liter for sub-compact vehicles
- IMT calculates the average fuel economy for light and heavy-duty diesel trucks, at 3.5 and 2.7 km/l, respectively
- Our aggregated estimate for the gasoline and diesel vehicle fleets:
    - In 2008, 12.1 km/l for the gasoline vehicle fleet, compared to 10.6 km/l in 2004
    - In 2008, 3.0 km/l for the diesel fleet, down from 3.25 km/l to 3.0 km/l

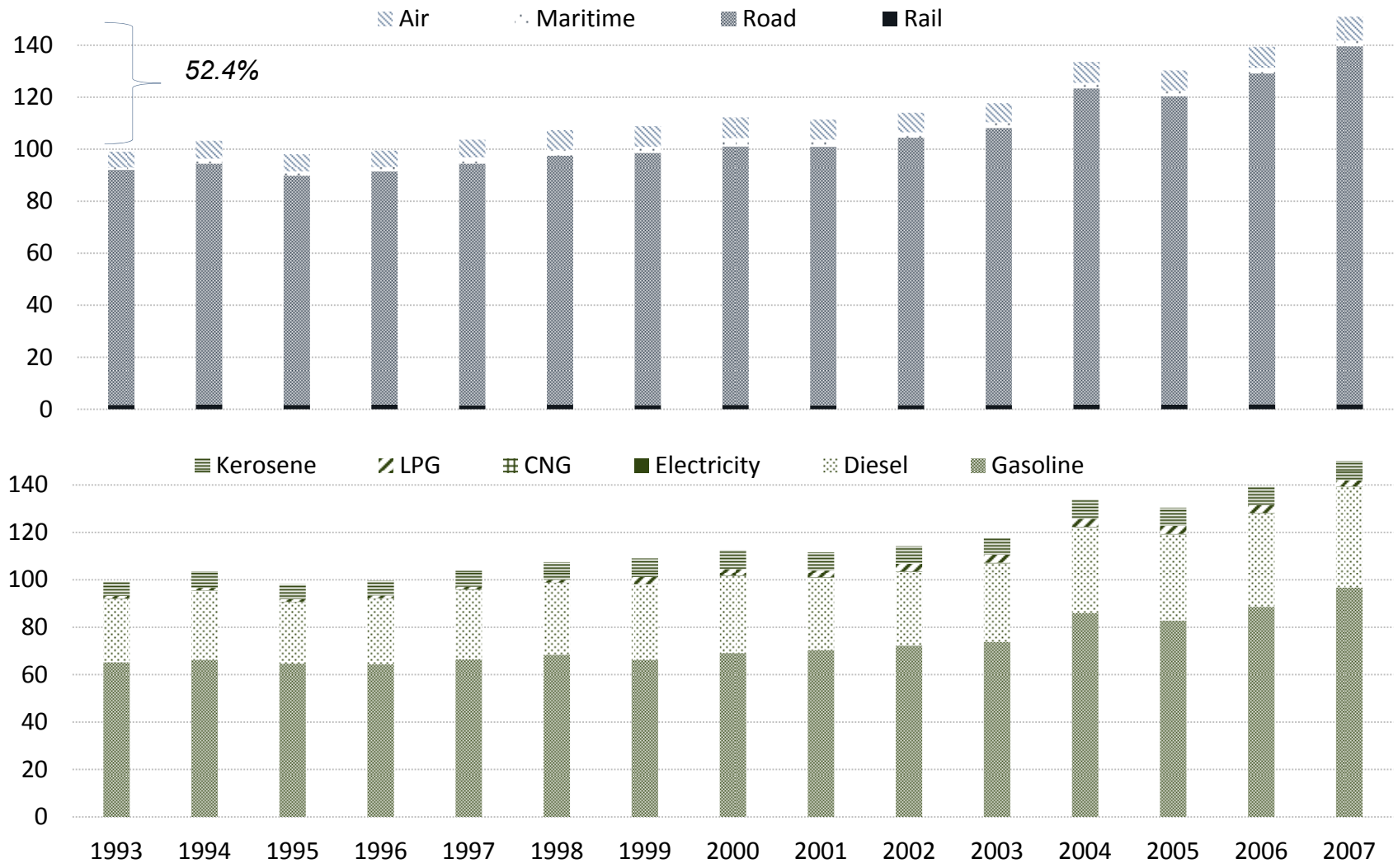
MEXICO CITY

- 10.5 km/l for gasoline vehicles, up from 9.45 km/l in 2006
- 2.6 km/l for diesel fleet, also also higher than in 2006 (2.5 km/l)

Carbon Emissions & Intensity

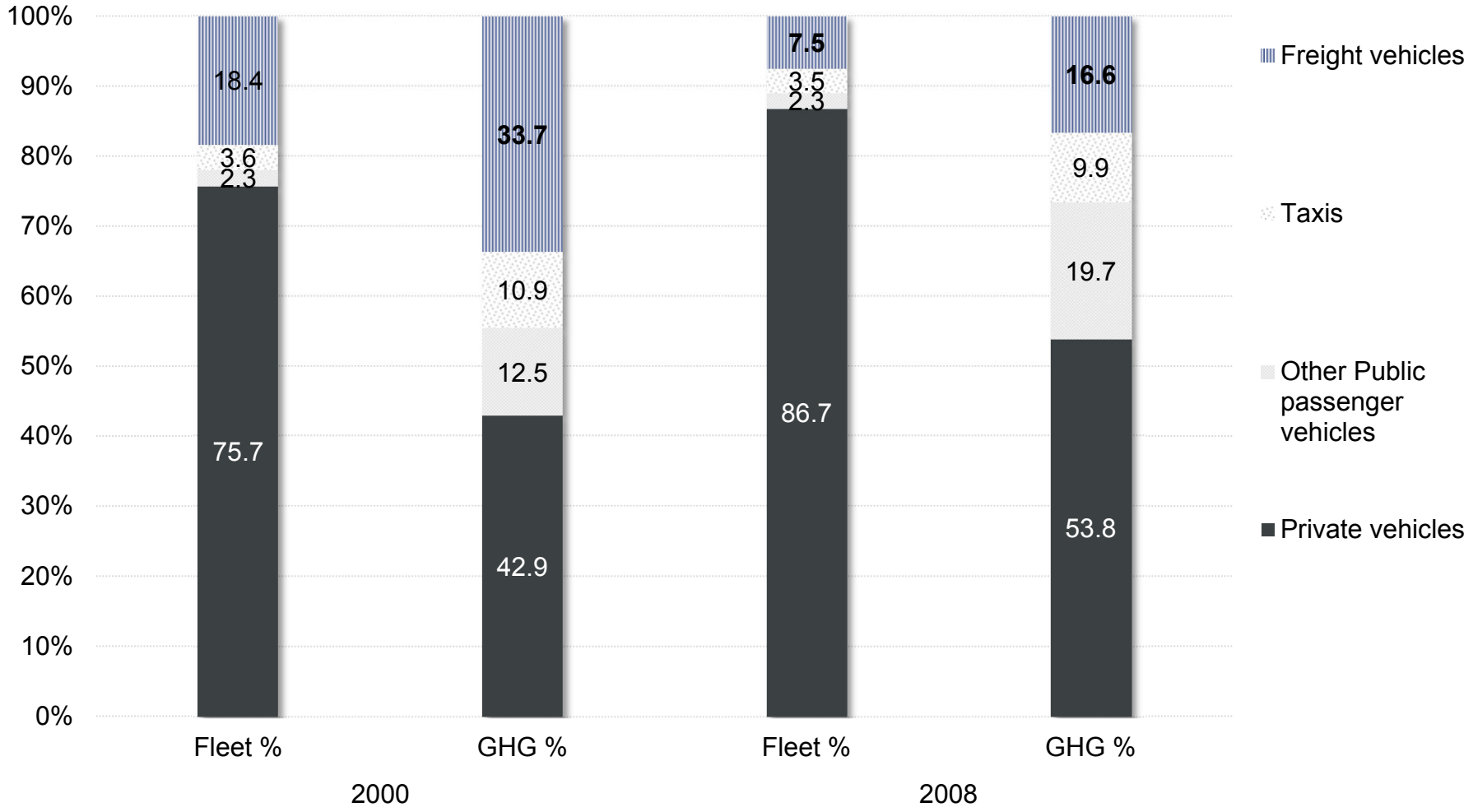
National-level trends &
Metropolitan-level trends

National CO_2 Emissions: the increasing role of diesel



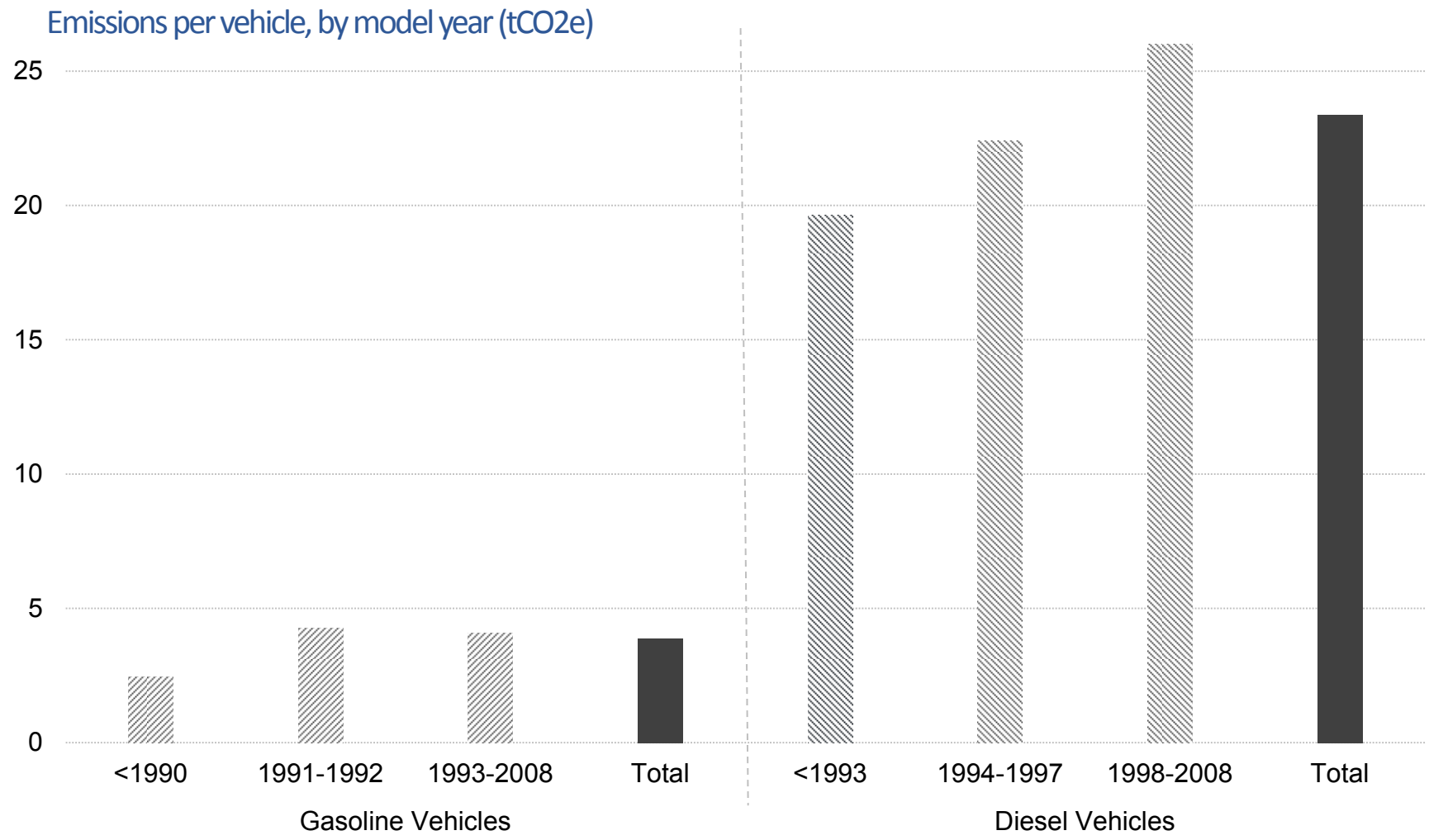
Source: SENER data on energy use and emissions factors provided by IEA (for electricity) and SMA (for other fuels).

Mexico City' Metropolitan Area's Transport Emissions: decreasing contribution of freight transport



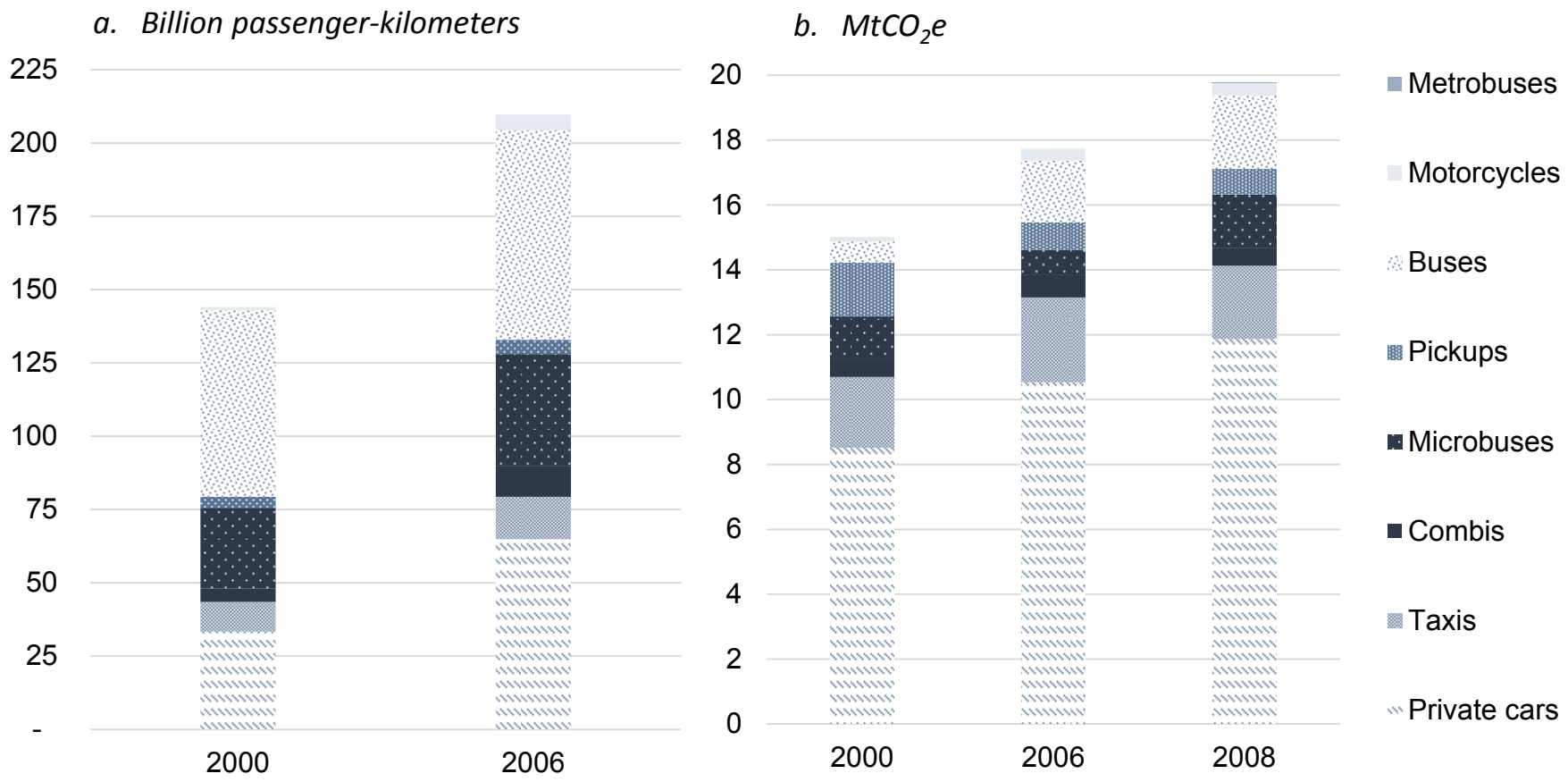
Source: *Estrategia Local de Accion Climatica del Distrito Federal*, SMA 2006; Mexico City Emissions Inventory 2008

Diesel Vehicles – concentrated in the freight sector – newer cars more carbon-intensive in per-vehicle terms



Source: Secretaria de Medio Ambiente de Distrito Federal

Mexico City's passenger transport activity and GHG emissions



Source: GHG Emissions Inventory for Mexico City. Ministry of the Environment of the Federal District.

Fly To | Find Businesses | Directions

om e.g., Utica, NY

autitlan, mexico city

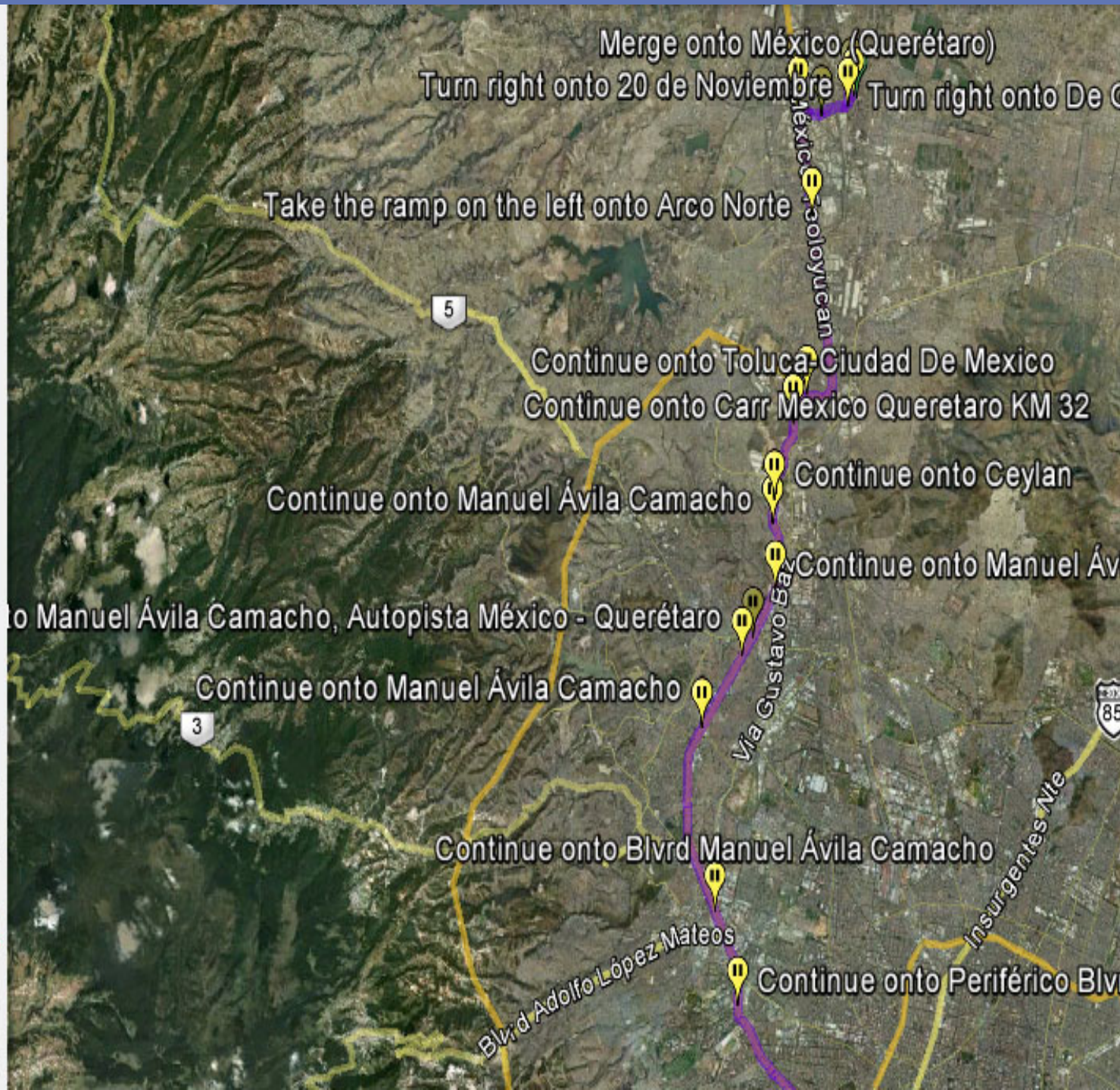
e.g., Tucson, AZ

tacalco, mexico city

- Merge onto Viaducto Pdte
  go 5.2 km
- Continue onto Viaducto Ri
  go 3.9 km
- Exit onto Viaducto Río Piec
  go 1.1 km
- Take the ramp on the left c
  go 1.7 km
- Make a U-turn at Ote 106
  go 350 m
- Turn right onto Benito Juár
  go 97 m
- Arrive at: Iztacalco, Mexico
- Route
  Distance: 49.5 km (about 39 mins)
- Mexico

Places

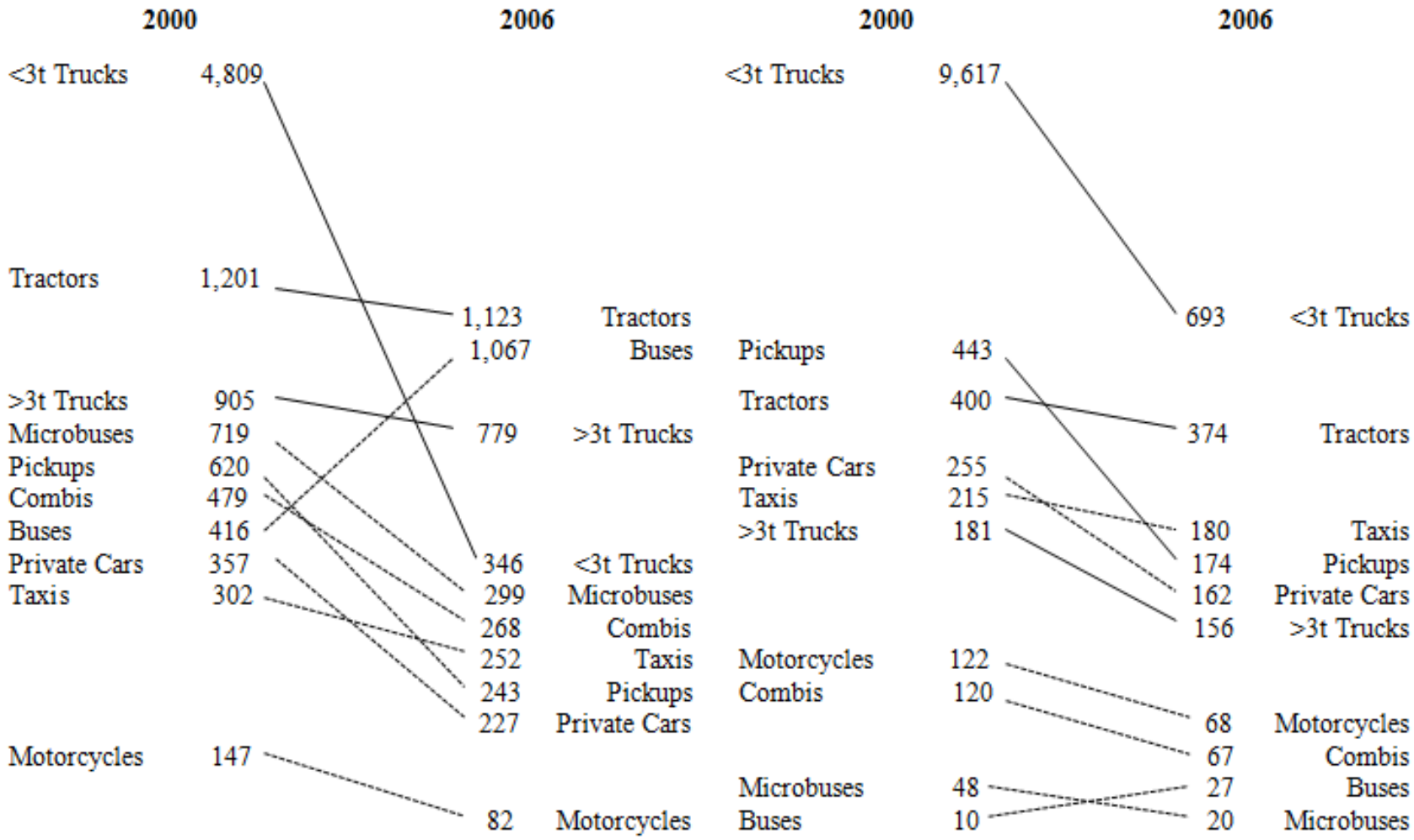
- My Places
  - Sightseeing Tour
    Make sure 3D Buildings layer is checked



Developing Alternative Emissions Scenarios

Metropolitan-level

Changing Emissions Factors of Mexico City's Road Transport Vehicles



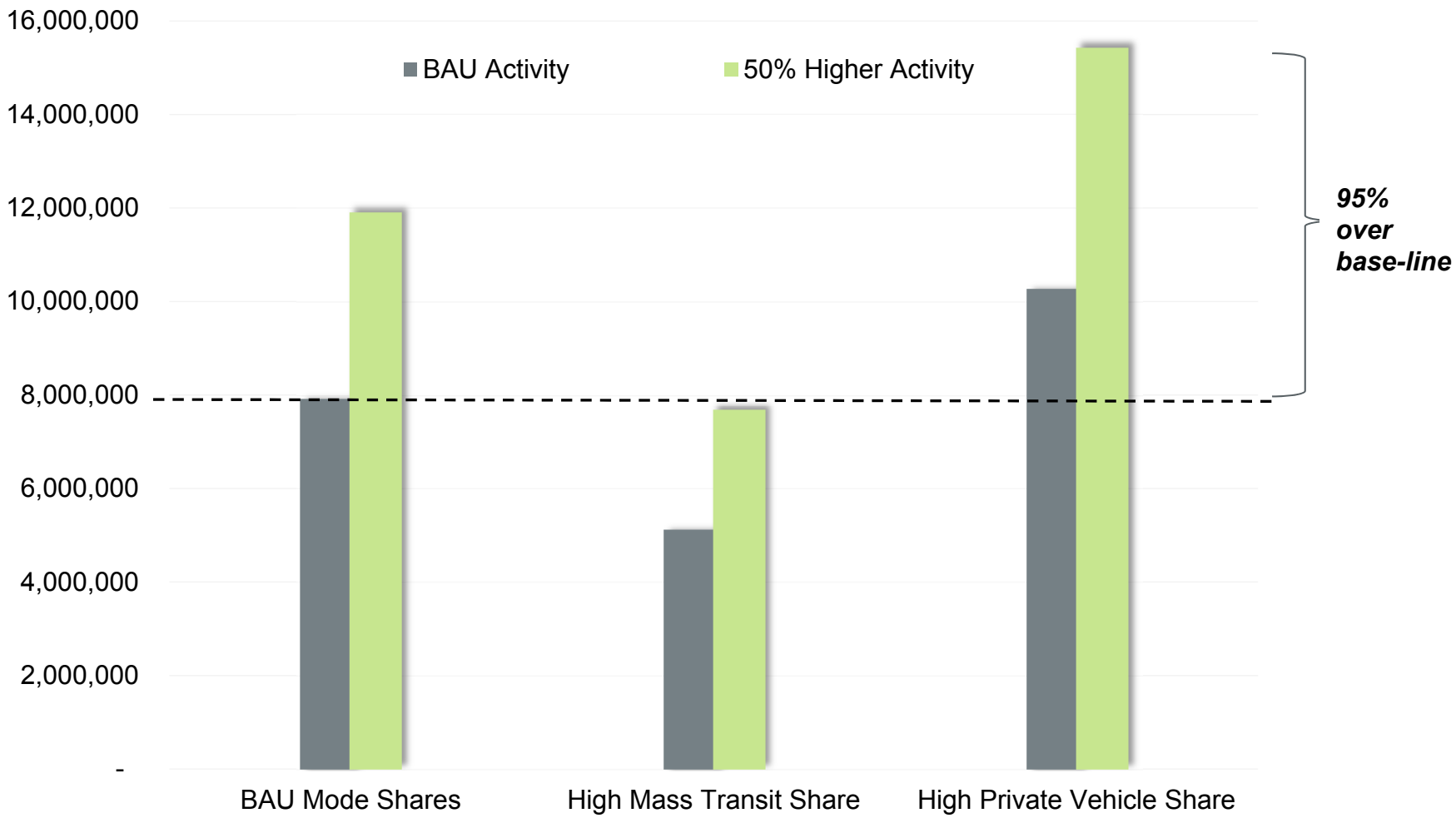
a. tCO2 / million vehicle-km

b. tCO2 / million passenger-km or ton-km

Two alternative scenarios of mobility and modal choices

	PKT SHARES OF EACH MODE, ASSUMING TOTAL PKT REMAIN AT 2007 LEVELS			PKT SHARES OF EACH MODE, GIVEN TOTAL PKT INCREASE BY 50% OVER 2007 LEVELS		
	BAU	High Mass Transit	High Private Vehicle	BAU	High Mass Transit	High Private Vehicle
PRIVATE CARS	0.2	0.05	0.33	0.2	0.05	0.33
TAXIS	0.06	0.04	0.06	0.06	0.04	0.06
COMBIS	0.05	0.04	0.05	0.05	0.04	0.05
MICROBUSES	0.17	0.14	0.16	0.17	0.14	0.16
PICKUPS	0.02	0.02	0.03	0.02	0.02	0.03
BUSES	0.33	0.4	0.23	0.33	0.4	0.23
MOTORCYCLES	0.02	0.01	0.04	0.02	0.01	0.04
METRO	0.15	0.3	0.1	0.15	0.3	0.1
	RESULTING TOTAL ANNUAL MtCO2e			RESULTING TOTAL ANNUAL MtCO2e		
	3.81	0.95	6.29	5.72	1.43	9.44
	1.27	0.84	1.27	1.89	1.27	1.89
	0.39	0.31	0.39	0.59	0.47	0.59
	0.34	0.33	0.37	0.59	0.49	0.56
	0.41	0.41	0.61	0.61	0.61	0.92
	1.03	1.25	0.72	1.55	1.88	1.08
	0.16	0.08	0.32	0.24	0.12	0.48
	0.48	0.95	0.32	0.71	1.42	0.48
TOTAL	***7.94***	***5.12***	***10.29***	***11.91***	***7.69***	***15.43***
KG CO_2e /CAPITA	361	233	468	541	350	701

Scenarios of urban passenger transport emissions (tCO_2e)



What policies would support the lower-bound scenario?

- Mobility versus Energy/GHG – how to increase access without increasing energy consumption
  - Complexity of establishing baselines when targeting sector-specific emission reductions
  - Even assuming access to the best technology, TOD-type interventions needed to contain de-densification
- Fuel economy standards may run the risk of rebound effect , especially in the presence on policies and investments encouraging private automobile use…
- There is therefore a need for complementary policies …
- … while considering the cost impacts of going green

Better Transport:

- Congestion fighting through expansion of automated tolling, real-time traffic prediction, and intelligent route planning… with significant co-benefits for in terms of travel cost, local air pollution, and GHG reduction
- Public transit expansion to counteract sprawl – and improve social inclusion
- Reinforce the slight turnaround in Mexico City towards higher-capacity public transport modes
- Urgent need for fleet replacement with high-capacity transit
- NMT opportunities for the large share of short-distance travel in Mexico City

Pricing & Standards:

- Higher gasoline taxes could help affect vehicle usage in the longer term – level playing ground for all modes
- Fuel economy standards and vehicle inspection on borders to minimize the flood of junkers
- Driver education for better fuel economy
- Greening of the electricity matrix that power rail/metro

Planned/Ongoing Policies

- US$2.7 billion ongoing federal program to finance mass transit systems and complementary interventions related to urban planning and NMT
- Fuel efficiency improvements of long-distance passenger and freight transport through improvements in heavy-duty vehicle inspection
- **Federal-level emissions standards** for in-use vehicles
- National **Voluntary Clean Transport Program** – inspections of freight vehicles (SCT)
- Mexico City's **Mandatory Vehicle Inspection Program** (PVVO) for controlling emissions of pollutants and GHGs for all type of vehicles (including freight)
- Construction of **non-motorized mobility transport corridors**
- **Renovation** of the passenger vehicle fleet as well as the taxi and the official State government vehicle fleets
- Substitution of the regular bus fleet with higher-capacity, Euro IV buses.
- Energy efficiency improvements in the Metro system
- **Fiscal instruments** for controlling vehicle fuel economy: considering higher taxes on larger and older vehicles, with exemptions from use taxes for hybrids
- Targeting carbon emissions directly: a **standard on CO_2 emissions controls and energy efficiency** for new light duty vehicles (SEMARNAT)
- Mandatory energy efficiency norms for new vehicles used by the Mexican federal public administration (CONUEE)

Next Steps

- More formal choice modeling needed to predict CO_2 impacts
- Can we predict what impact -- national, regional, corridor, or localized – will sustainable transport policies have in terms of social impacts and affordability?
- Are sustainable transport interventions contributing towards economic development at the metropolitan level and can we measure this impact and its distribution?
- Evaluation of possible displacement impacts of specific mass transit and NKT modes
- Calculation of the effects of changes in behavior on emissions other than CO_2 would be important given the considerable health concerns that automobile pollution has caused in Mexico's cities
    - Distribution of pollution impacts by income group

Thank You!

Contact:
Aiga Stokenberga
Email: astoken1@stanford.edu
Phone: +1 (202) 294 6551