

# *Transport and CO<sub>2</sub> Emissions in Developing Countries: Doing it Right the First Time*



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LBNL  
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# ***EMBARQ***

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- A catalyst for socially, financially, and environmentally sound solutions to the problems of urban mobility





# **EMBARQ**

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- Established as a unique center within World Resources Institute in 2002, *EMBARQ* is now the hub of a network of centers for sustainable transport in developing countries.
- Shell Foundation and Caterpillar Foundation are *EMBARQ*'s Global Strategic Partners, supporting *EMBARQ* projects worldwide
- Additional *EMBARQ* supporters include
  - Hewlett Foundation
  - Netherlands Ministry of Foreign Affairs
  - BP
  - US AID
  - Asian Development Bank
  - Energy Foundation
  - Blue Moon Fund
  - US Environmental Protection Agency
  - Japan International Transport Institute

# Bringing BRT Back to Brazil





# Emancipating the Immobile in Istanbul



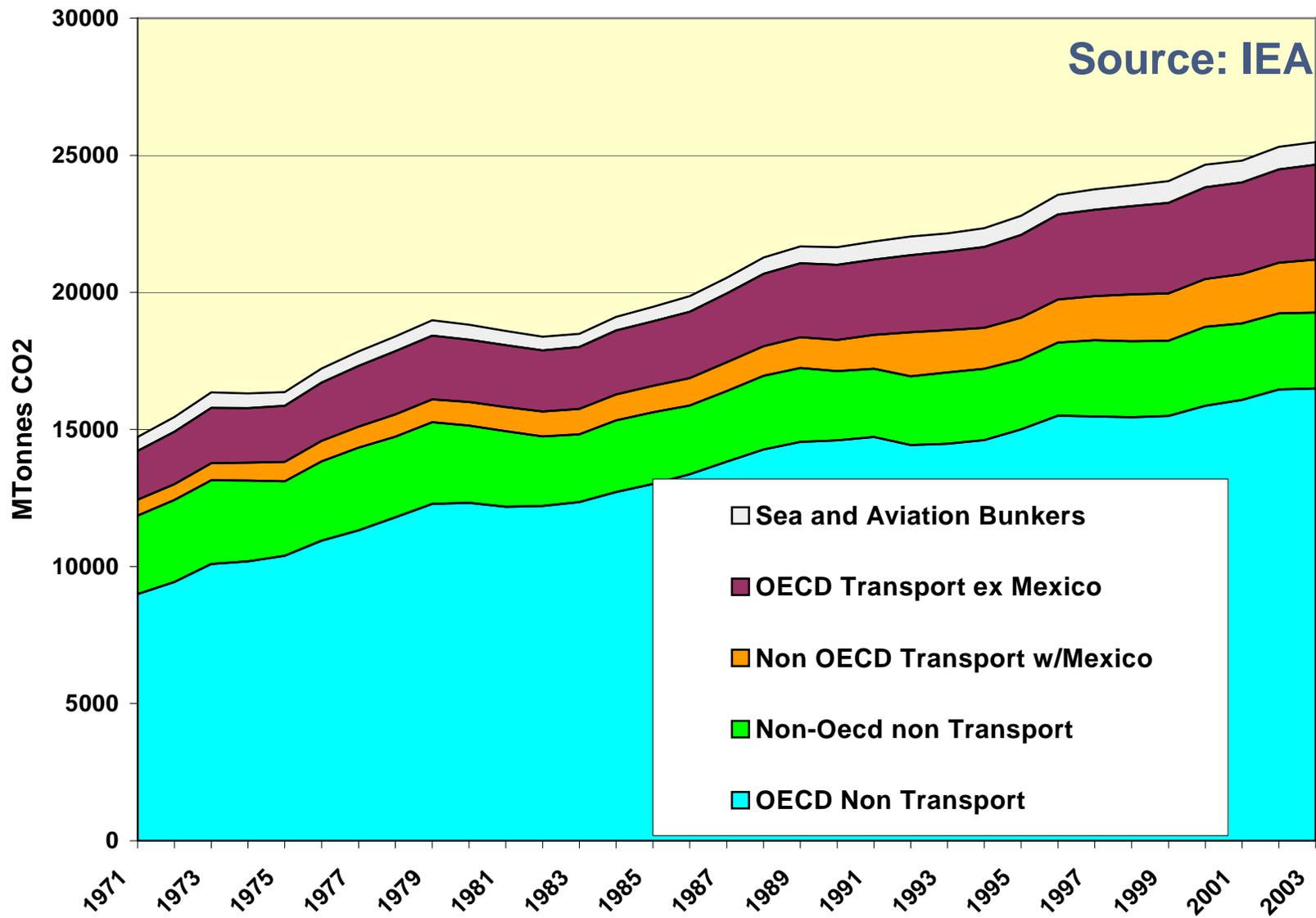


# Visions of Viability in Vietnam

(Note the bus in the lower right-hand corner)



# World CO<sub>2</sub> Emissions From Fuel



# Global Carbon (and Oil) Problems

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- **The US Is Still the Big Boy on the Block**
  - Largest oil user, GHG Emitter, also per capita or per GDP
  - Oil worries might help or hinder CO2 worries
  - Little meaningful change under Bush
- **China, India and others – Unsustainable Transport**
  - Very low emissions per capita or \$, but rising rapidly
  - Cities bogged down in impossible traffic and air pollution
  - CO2 not interesting, but energy and transport woes important
- **The Global Nature – Savings valuable World Wide**
  - Oil and CO2 are global and fungible (China syndrome)
  - Fuels, technology are global
  - Motor vehicles (and US/EU lifestyles) global



***No Clean, Low CO2 Substitutes for \$60 Oil in Quantity (>5 mn bbl/day) except More Efficient Energy Use or Higher Cost Energy***



# How Sustainable Transport Serves, not Severs, Development

- **Economic Sustainability**

- Affordable to users and authorities
- Attractive as a business
- Each mode bears social costs

- **Social Sustainability**

- Promotes access for all, not just a few
- Makes room for all
- Avoids irreversible binds

- **Environmental Sustainability**

- Leaves no burdens for future generations
- Minimizes accidents and damage to human health
- Reduces greenhouse gas emissions

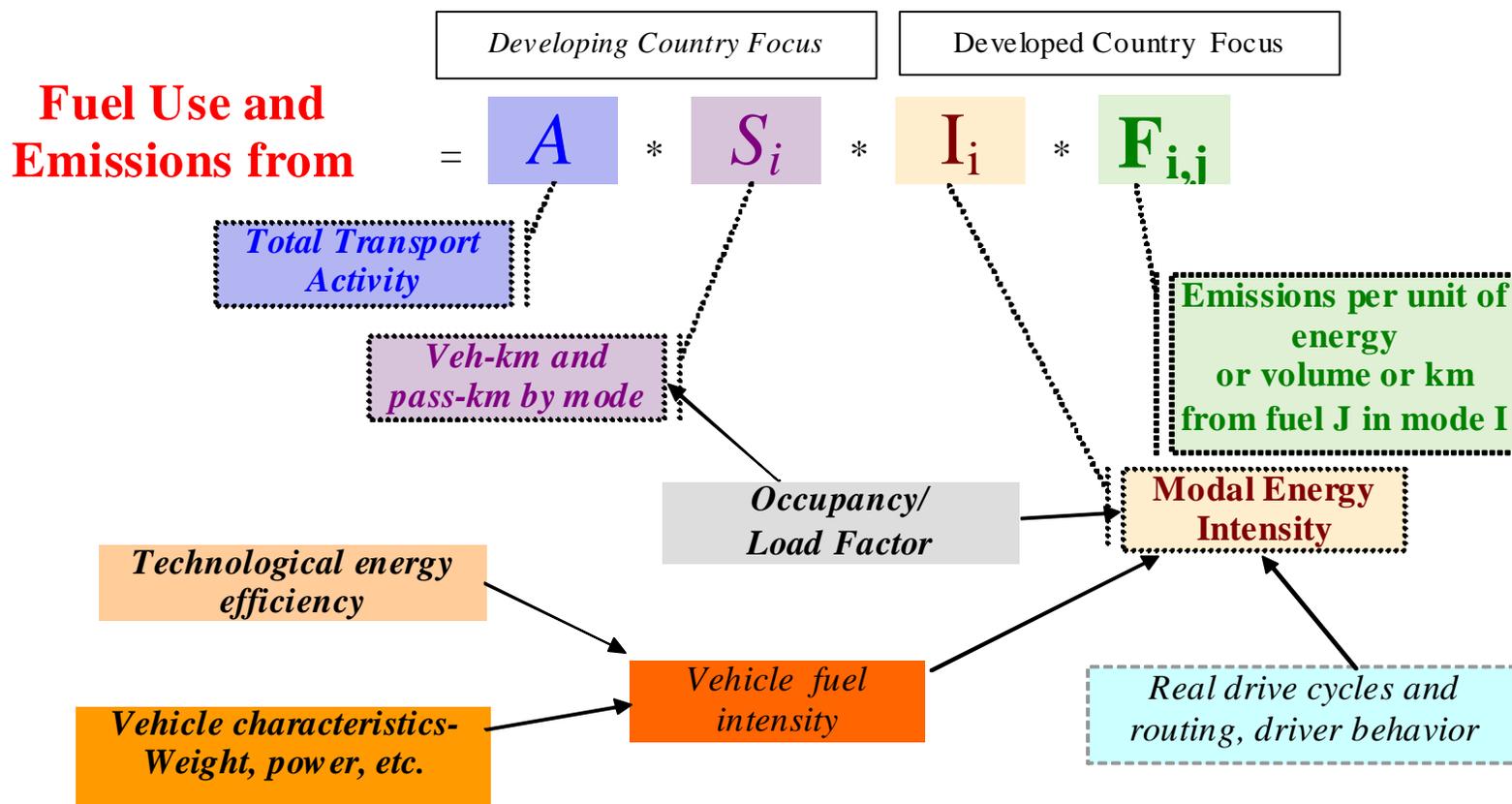


*Governance - The Roof Over these Pillars  
Make and Keep the Rules, Protect the Weak*

# Multiplicative Basis Of Approach

## The ASIF Decomposition for Fuel and Emissions

<http://www.iea.org/textbase/nppdf/free/2000/flex2000.pdf>



*Clean, Low-CO2 Transport:  
Not Just a Question of F or I*



# Quantify the Transport-Emissions Link

## *Vital Set of Research Issues*

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### Relatively Easy to Measure

- Fuel use in project vehicles or fleet vehicles
- Changes in mode towards/away from project vehicles
- Emissions in construction/destruction of vehicles/infrastructure

### What's Important but Hard To Measure

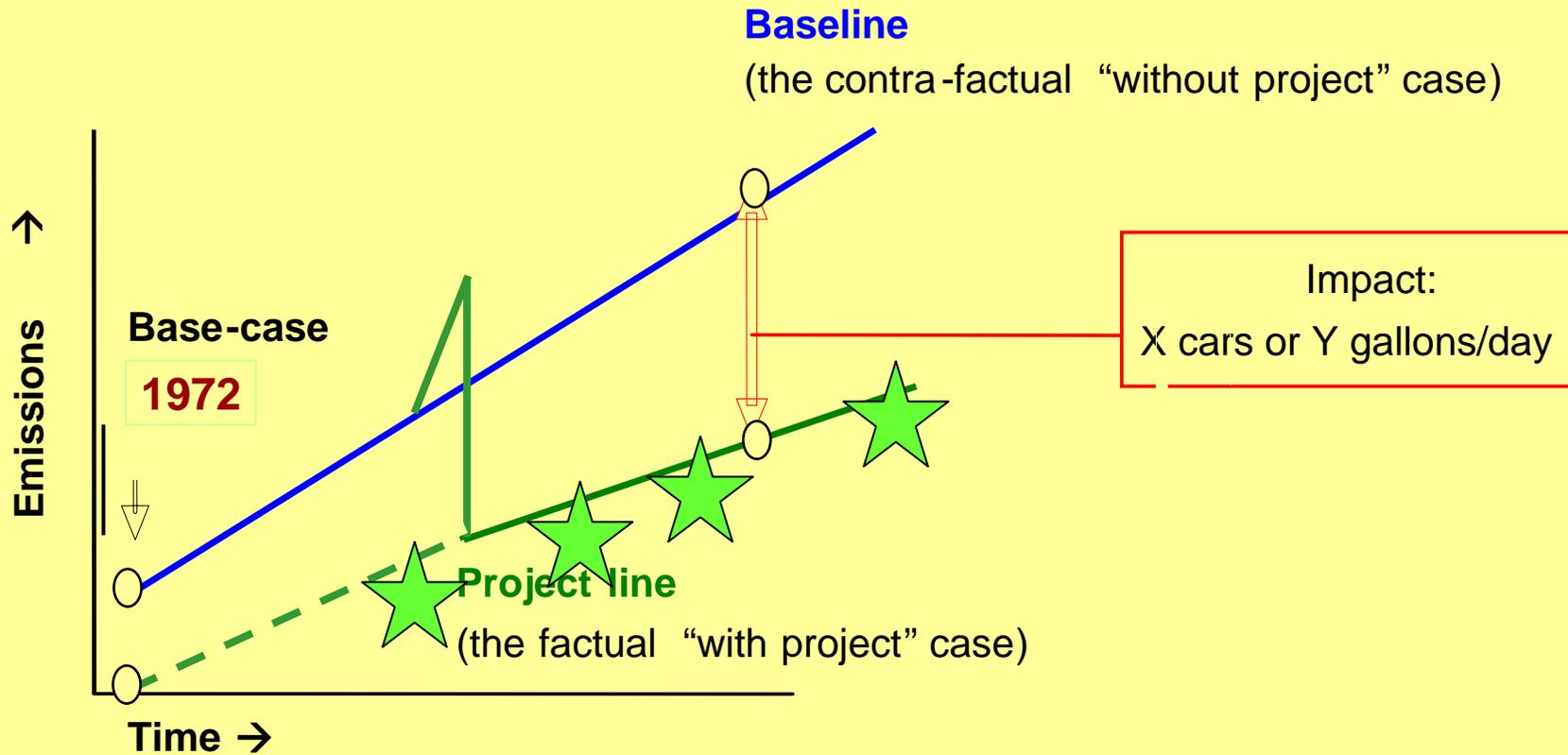
- Changes in traffic and km driven caused by transport project
- Changes in other fleet characteristics affecting fuel use/emissions
- So-called “induced demand” – a rebound effect

### What's Important, but Even Harder to Measure

- Changes in emissions resulting from changes in driving cycle
- Changes in driving from changes in land use (and vice versa)

# Measurements Have to Continue Over Time

## Example: Bay Area with or without BART



Dynamic Base-line & Project-line over time  
*After John Rogers, Trafalgar SA, Mexico*



# Emissions Trends in Wealthy Countries

## Embed CO2 in Transport Policy

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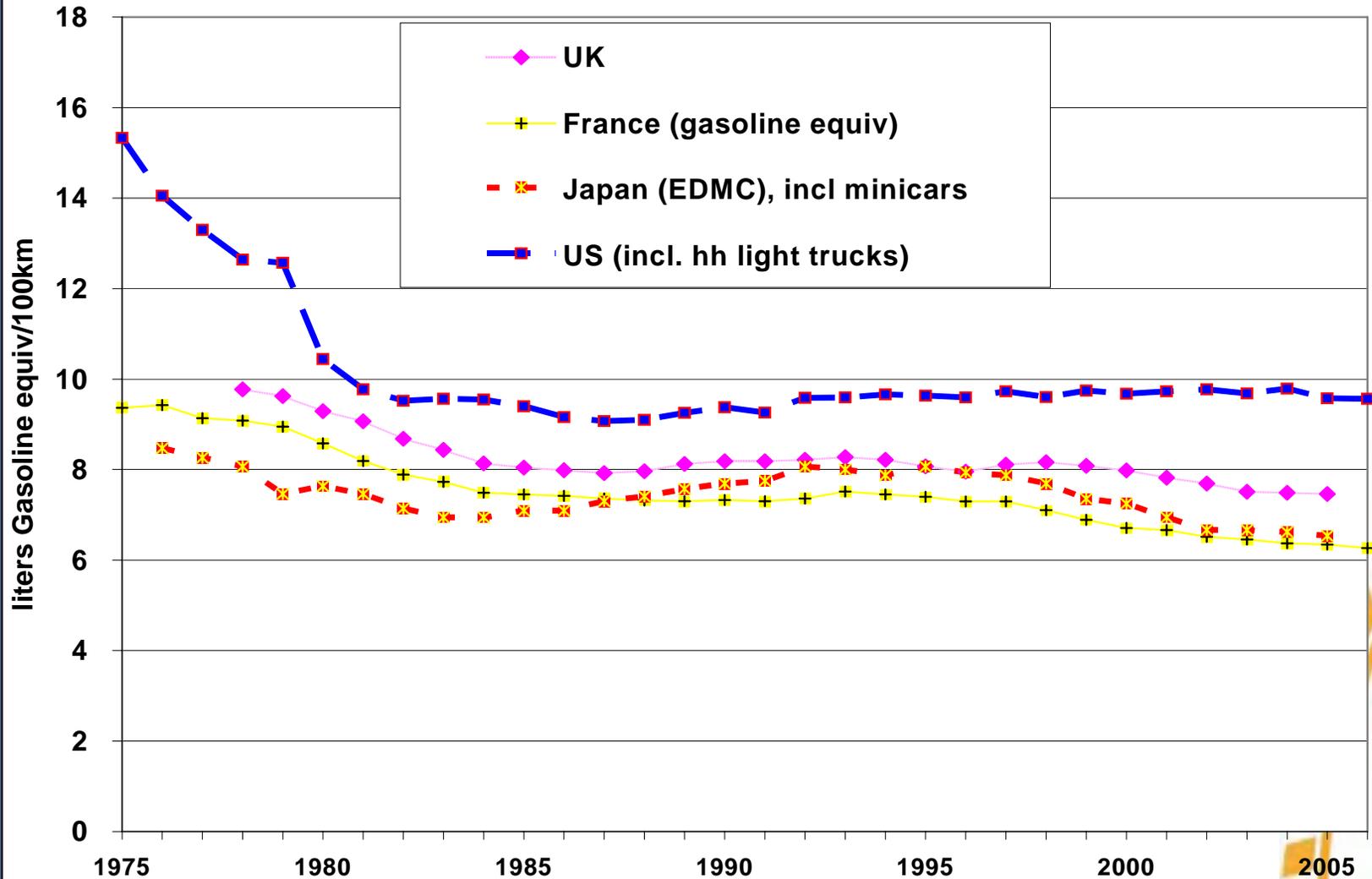
- **Growth in Motorization and Movement Slowing**
  - US has more cars than drivers, EU, J car ownership also slowing
  - Growth in car use also slowing
  - Prospects for small shifts away from cars as we age?
- **Technology Increasing and Size and Power**
  - New paradigm – smaller, slower vehicles?
  - Vol. Agreement brought some reductions in Europe, Japan
  - Little serious impact of low carbon fuels
- **Long, Slow Redesign of Transportation?**
  - Congestion charging, other internalization?
  - More compact settlements?
  - Internet replacing some travel?



# International Trends in Fuel Economy

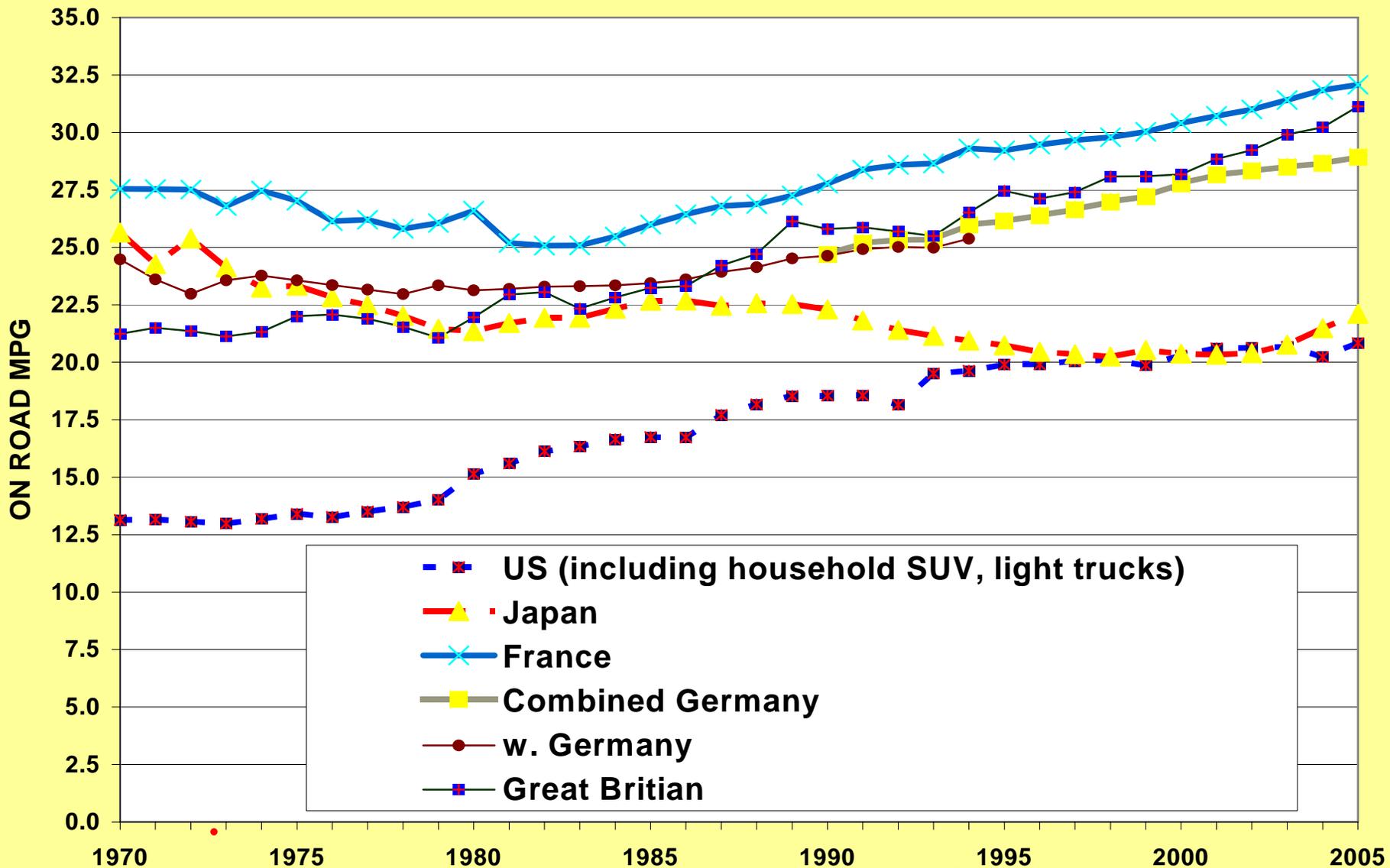
## Sales Weighted Tests of New Vehicles by Year

(10 l/100 km = 23.65 MPG)





# Real Automobile Fleet Fuel Economy – All Fuels Stagnant in the US; Heading Up in Europe



**US Has Not Measured On-road Fuel Economy Carefully Since 1985**



# Saving Energy and Emissions From Transport – The Challenge?

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- **Do Consumers Care? Seems Like it Hardly Matters**
  - Cost per km of fuel still well below its early 1980s peak
  - Gasoline share of home budget still very low
  - Car use per unit of GDP falling since early 1990s
- **Honda Tried to Offer a Real Efficiency Choice**
  - Built a CX with CVT, var. valve timing, lean burn saved 15-20%
  - Sold less than 1000 for a few hundred dollars more as a coupe
  - Hybrids are doing much better, but still limited
- **Alternative Fuels – Taking the Wind out of Sails**
  - Flex-fuel gives manufacturers unearned credits for MPG
  - Mania over “renewable fuels” hurts fuel economy
  - Ethanol subsidies hide real cost of clean oil and low CO2 alternatives

*US Stuck and a Stronger CAFÉ Might Help  
EU, Japan Need to Step up their Efforts*



# Congestion Pricing



- **Definition**
  - Charging for using roads at congested times to encourage travelers to shift to other times, routes and modes
  - Alternatives (odd-even) and voluntary approaches fail
  - More effective in regulating car use than increases in fuel taxes
- **Difference in Prices and Application**
  - Tolls higher during congested periods and lower or non-existent during uncongested periods
  - Tolls based on fixed schedule, or dynamic based on time, congestion
  - Tolls can be specific to location, distance traveled, or passing a cordon
- **Results**
  - Proven reduction in car use, higher transit, faster speeds
  - More effective in regulating car use than increases in fuel taxes
  - Implementation not free, income transfers modest

***What are Long Term Impacts on Land Use, Car Use, etc?***



# Stockholm

## Tried in 2006 After 15 Year Debate

- Tested January-July 2006
- Vehicles entering the inner city area are charged US\$1.27 – US\$2.54 per trip at 18 entry points
- Voters accepted in Sept 06 - Live this summer

## Impact

- Traffic volume decreased by 25%, removing 100,000 vehicles during peak hours
- Increasing daily public transit rider-ship by 40,000
- Daily revenue of US\$500,000 to \$2.7 million

## Other Effects

- Lower fuel use, CO2, particulate matter
- Quieter streets
- Overall benefits ~ \$100 mn/year on \$400 mn investment





# Broader Approach to Transport-CO2 Problems

## *Save Energy, Clean the Air and Streets*

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- **Raising Share of Low Impact Modes**
  - Bus rapid transit with real priority, not just expensive metros
  - Inter-modal facilities, particularly for feet, pedals, 2 wheelers
  - Development around, on top of stations (like Taksim Square)
- **Reducing Air Pollution Caused by Motor Vehicles**
  - Clean fossil fuels, and power trains (hybrids)
  - Exhaust treatment with filters, maintenance of cat converters etc
  - Smoother driving cycles
- **Improving Access with Less Vehicle Travel**
  - Congestion charging to preserve road space
  - Better enforcement of parking regulations
  - Careful planning of land use and expansion in Istanbul

***THESE ARE MANAGEMENT ISSUES,  
NOT TECHNOLOGY***



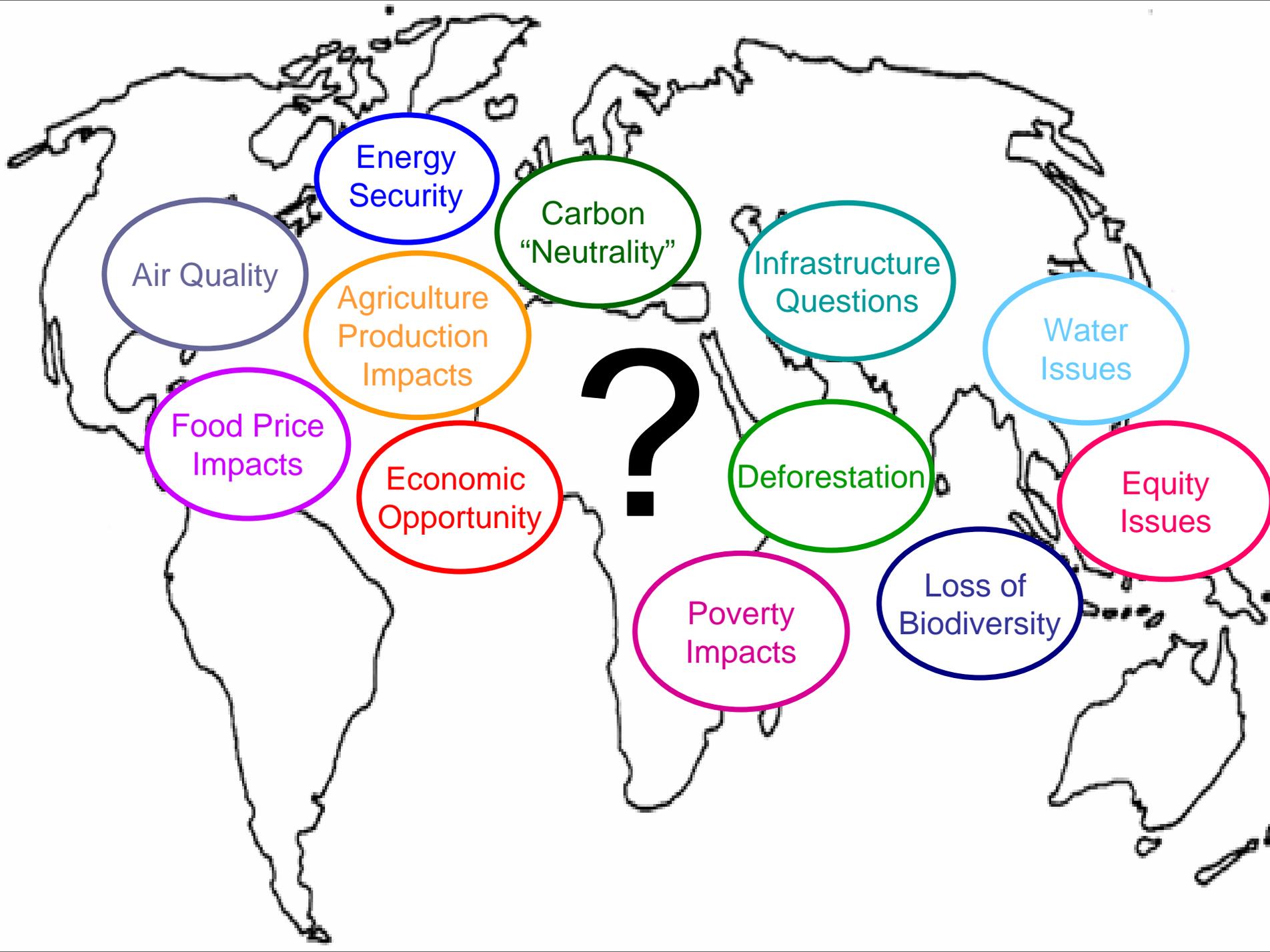
# Bio-fuels or Bio-Fools?

*Cannot Succeed without Carbon or Oil Taxes*

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- **Good News – Low Carbon “biofuels”**
  - Brazilian alcohol
  - Small-scale biodiesel
  - Prospects for cellulosic ethanol?
- **Not so Good News (particularly in the US)**
  - Subsidy-driven, energy/carbon intensive US corn ethanol
  - Flex-fuel vehicle subsidies not based on performance
  - Rush to specify chemical formulae, not low-carbon fuels
- **Worrisome Threats**
  - Food or biofuels? Mixing energy and ag. policy
  - Pressure on water, land, other carbon threats
  - Temptation to turn carbon into biofuels





Energy Security

Carbon "Neutrality"

Infrastructure Questions

Water Issues

Equity Issues

Loss of Biodiversity

Poverty Impacts

Deforestation

Economic Opportunity

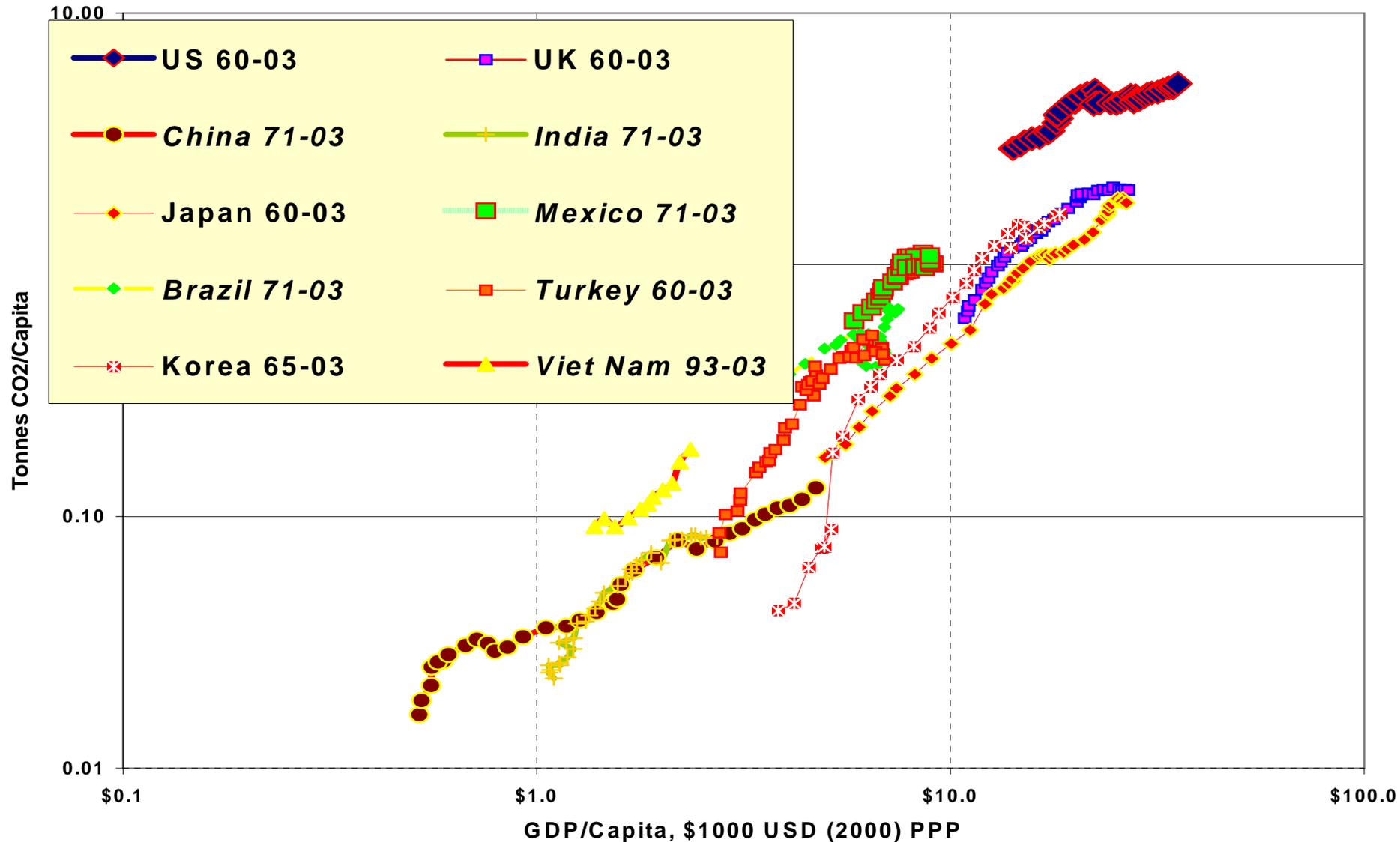
Food Price Impacts

Agriculture Production Impacts

Air Quality

# CO<sub>2</sub> Emissions from Road Transport

## A Broader Perspective





# The Broader Approach – Think Transport (Which are Relevant to Saving CO2?)

**Congestion in Istanbul**



**Shanghai Maglev**



**Honda Accord Hybrid**



**Two-Wheelers in Hanoi**



**Congestion Pricing Singapore**



**Llama Rapid Transit? Lima**



**Belching bus in Porto Alegre**



**Delhi CNG**



**Mexico City Metrobus**





# Rising Motorization in Developing Countries

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- **Individual vehicles are taking over**
  - In cities, cars typically 10-20% of trips but 80% of vehicles and congestion
  - Two Wheelers in Asia swarming
  - Roads get disproportionate share of investment
- **Environmentally More Benign Modes forced off road**
  - Buses stuck in traffic
  - Low-cost rail ignored for high cost metro
  - No sidewalks, cycle paths
- **Cities Sprawling to Accommodate Cars**
  - Housing for wealthy moving to fringes
  - Investment goes for flyovers, motorways
  - No effort to keep city centers dense but thriving





# Creating Comfort from Chaos in Mexico City From South to North?



# Creating a New System – Mexico's Metrobus

260,000 people/day over 20km for US \$60mn  
Lower emissions, CO2, reduced car traffic





**- No cars in bus lane!**

**- Next Bus**



# Energy and Environmental Gains from BRT

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- **Better Technology and Comfort Affordable**
  - Modern buses with good acceleration but low emissions/fuel use
  - Larger, faster buses make drivers more productive
  - Higher productivity makes technology, further savings affordable
- **Bottom Line on Environment -28 000 – 47 000 tc**
  - 40% lower local emissions and fuel use per passenger/km
  - Additional fuel and CO2 savings from better traffic
  - 10% of passengers formerly took cars
- **Longer Term Savings**
  - Emboldened new government to redefine transport
  - Created new BRT momentum in Mexico – 8 new lines planned
  - Put a stop to car domination of streets

***Whole Set of New Research Issues:  
New Models for Transport Systems, New  
Measurements of their Impacts***

# Diesel Retrofit Project Results

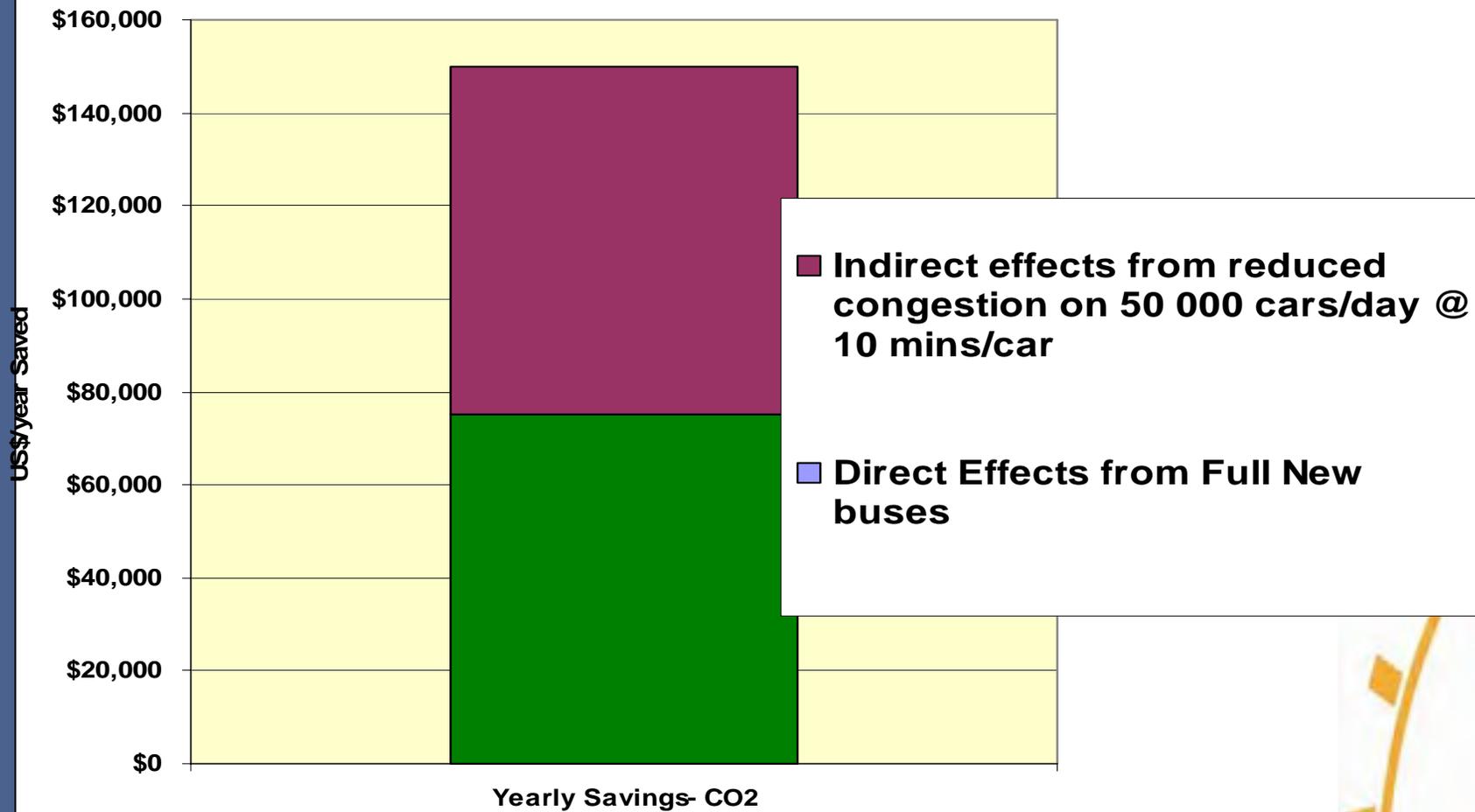


- 90% reduction in particulate emissions for newer buses.
- 23-44% reduction for older buses.
- Strong performance even at high altitude.

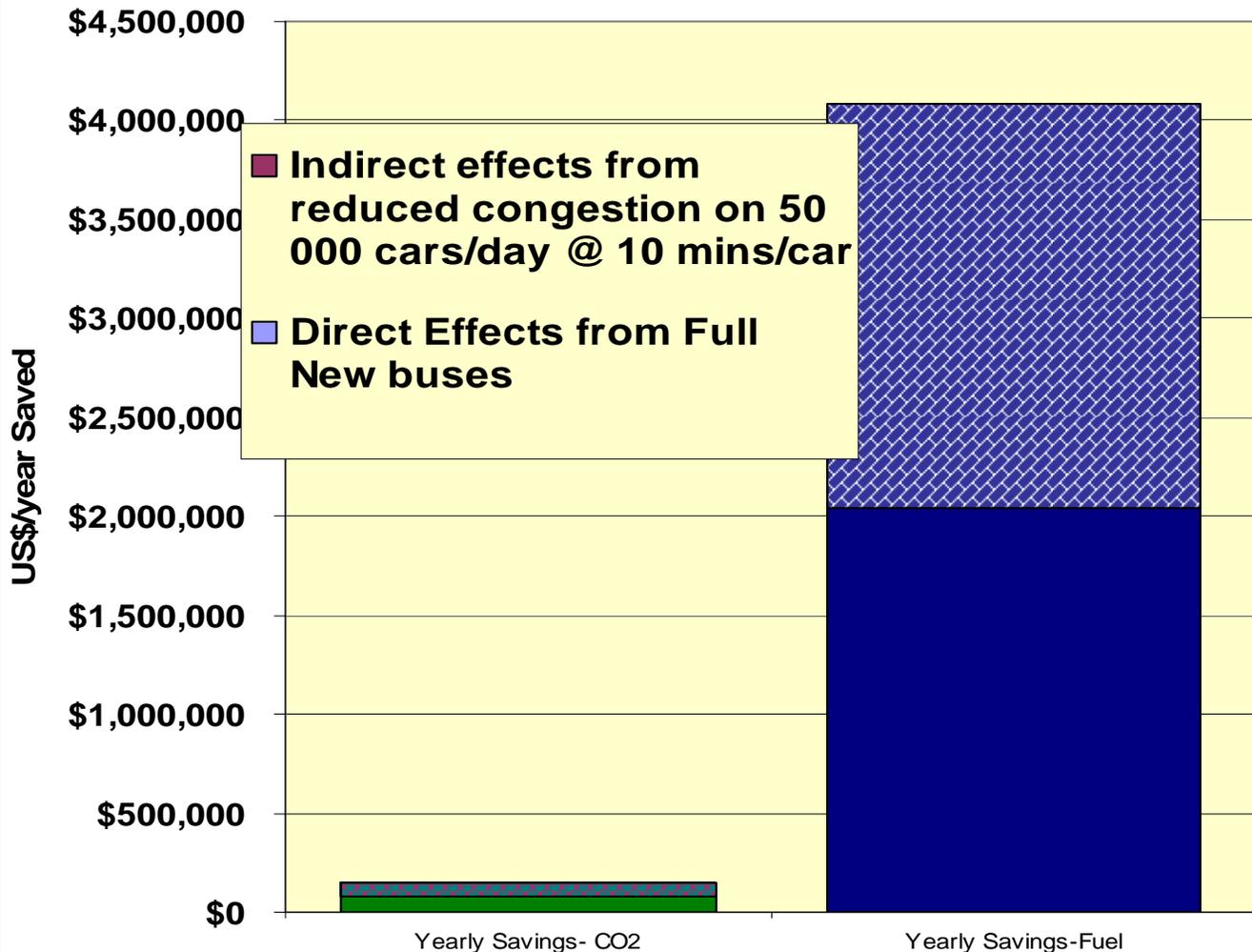
- Mayor (and almost president), other key stakeholders bought in
- State Oil Company moved forward its promised appearance of ULSD
- Similar projects in Beijing, Pune, hopefully Brasil



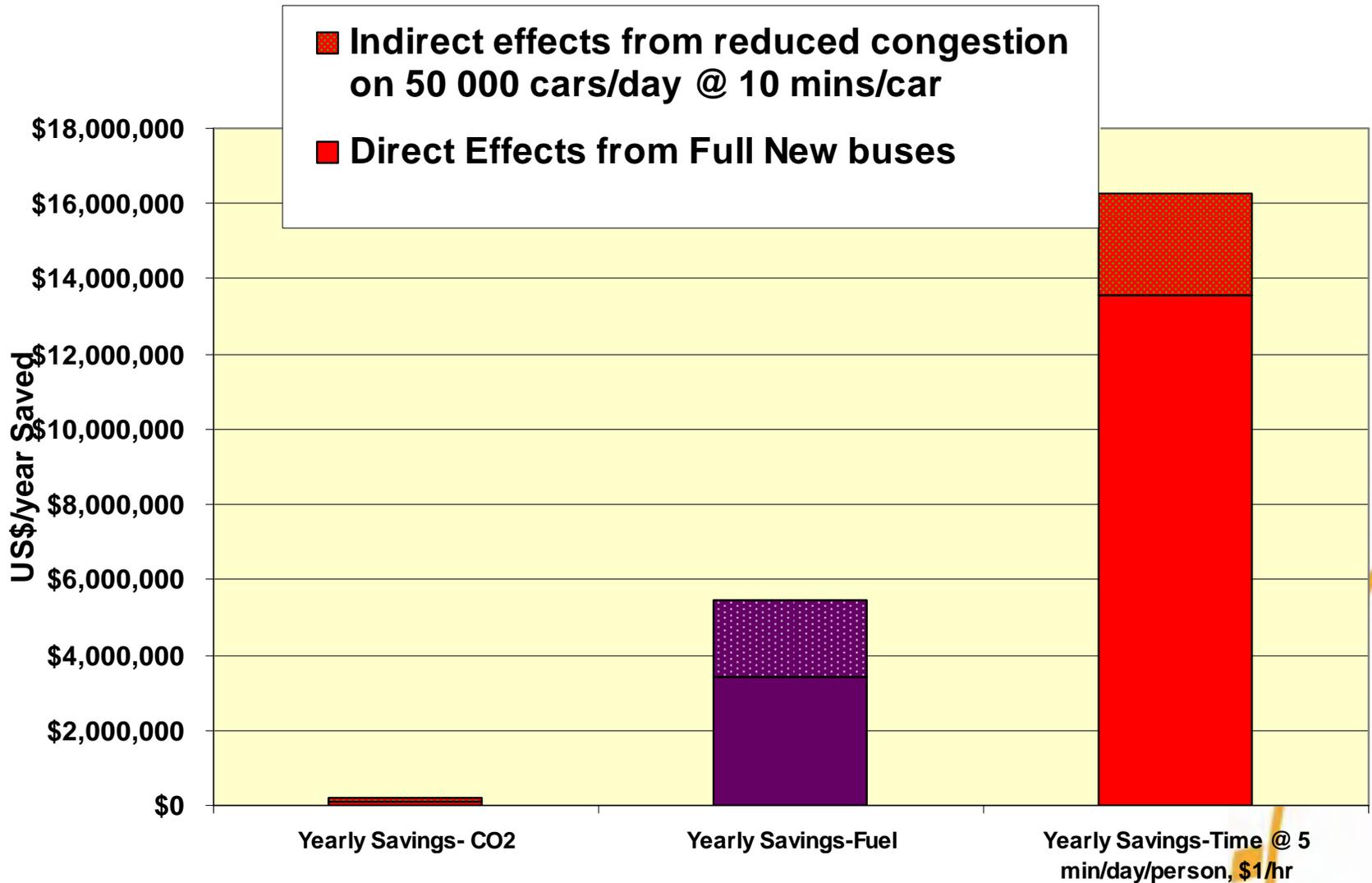
# GHG Savings at \$5/Ton in Mexico City: Hypothetical Insurgentes Corridor Case



# Fuel Savings (\$340/ton): Hypothetical Insurgentes Corridor Case



# GHG, Fuel, Time (\$1/hour) Savings Did CO2 make/break the project?



# PSUTA: Partnership for Sustainable Urban Transport in Asia



Hanoi, Vietnam



Pune, India

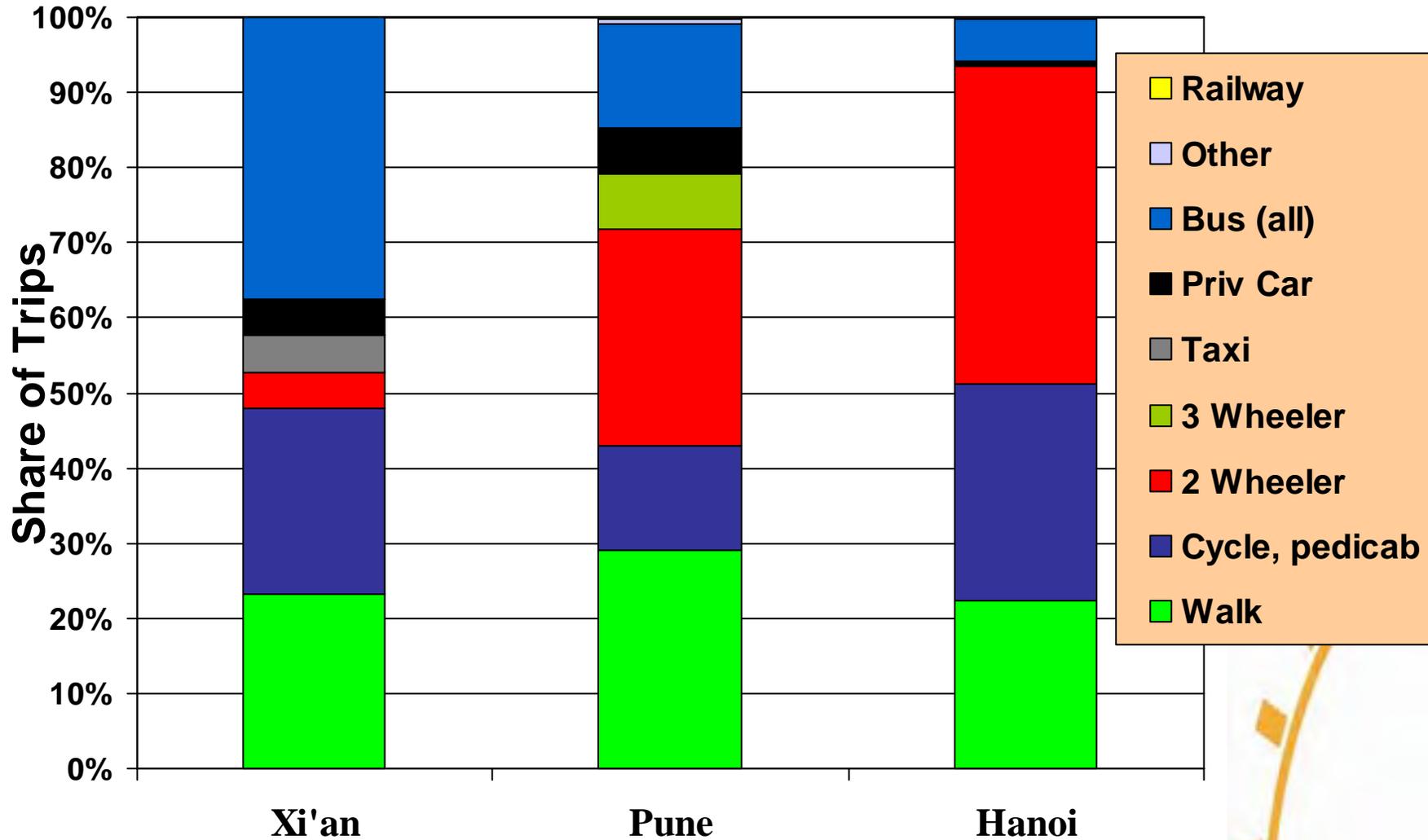


Xian, China

- **Scope**
  - Transport and environment in Asian cities, focusing on strengthening sustainability of low-emissions transport and mobility in Asian cities.
  - Work with Hanoi (Vietnam), Pune (India), and Xi'an (China), to engage key stakeholders and leaders
- **Goal**
  - Contribute towards enhancing environmental sustainability of transport and mobility in Asian cities through developing and applying **quantitative measures** of sustainability and progress towards sustainability in a number of selected cities.
- **Purpose**
  - Develop and discuss a conceptual approach to city-based sustainable transport planning that is relevant to Asia, by stimulating authorities to act!



# ACCESS AND CONGESTION: Modal Splits



# What About Clean Air in Asia?



- **Rise of Small Vehicles Undoes Progress**
  - Increases pollution by increasing use of small vehicles
  - Maintenance questionable, particularly in two-wheelers
  - Resulting congestion increases pollution
- **Poor fuel and adulteration (6<sup>th</sup> commandment)**
  - Most of Asia behind in fuel quality, although Euro 3 and 4 in sight
  - Belching heavy vehicles
  - Too much cheap diesel for cars, taxis in S. Asia
- **Little Attention to Transit Vehicles**
  - CNG substitution in buses, three-wheelers appears effective, but expensive
  - Clean diesel or even LPG should be tested

***Few Asian cities measure air quality carefully and regularly and track the emissions from real, in-use vehicles.***

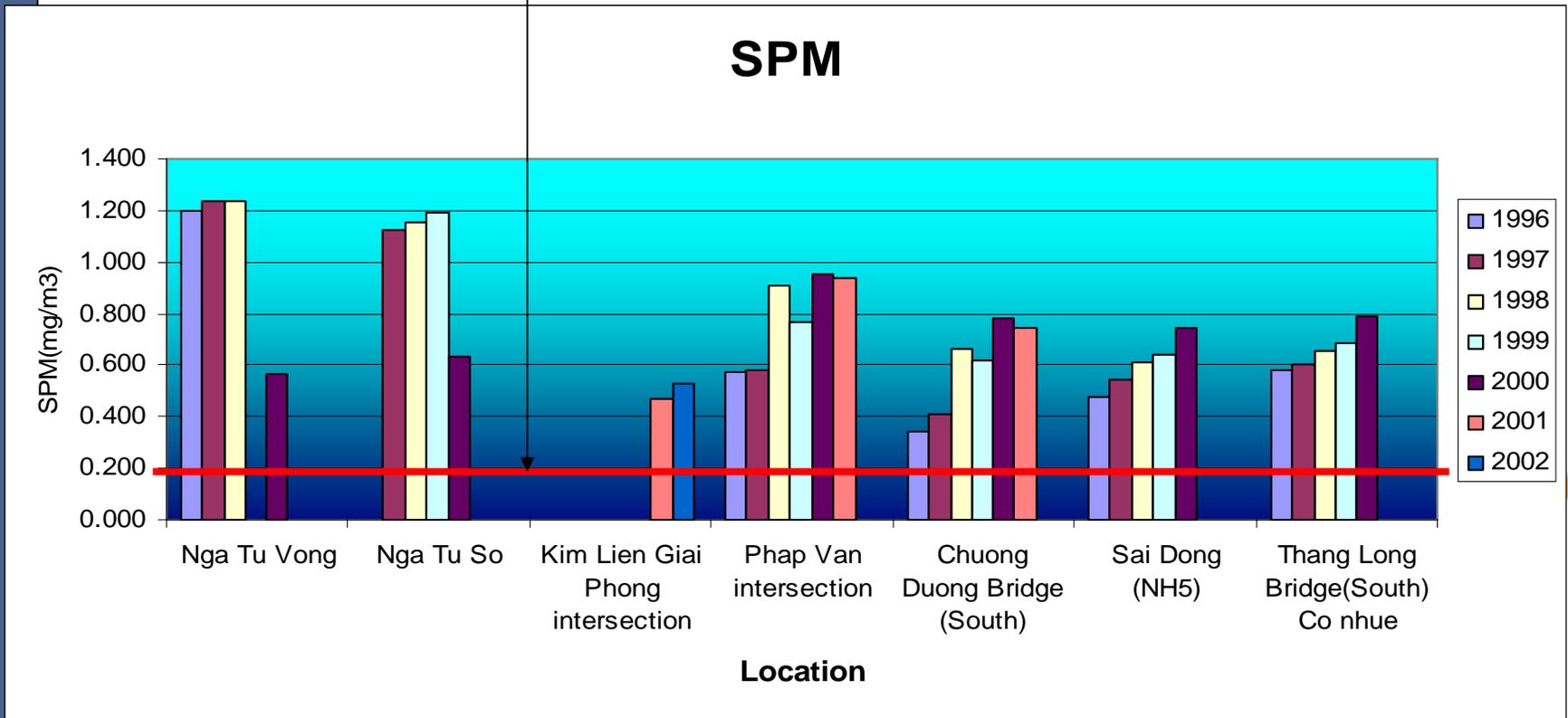


# HANOI – HEALTH and ENVIRONMENT

## Air Quality

Standard SPM=0.2 mg/m<sup>3</sup>

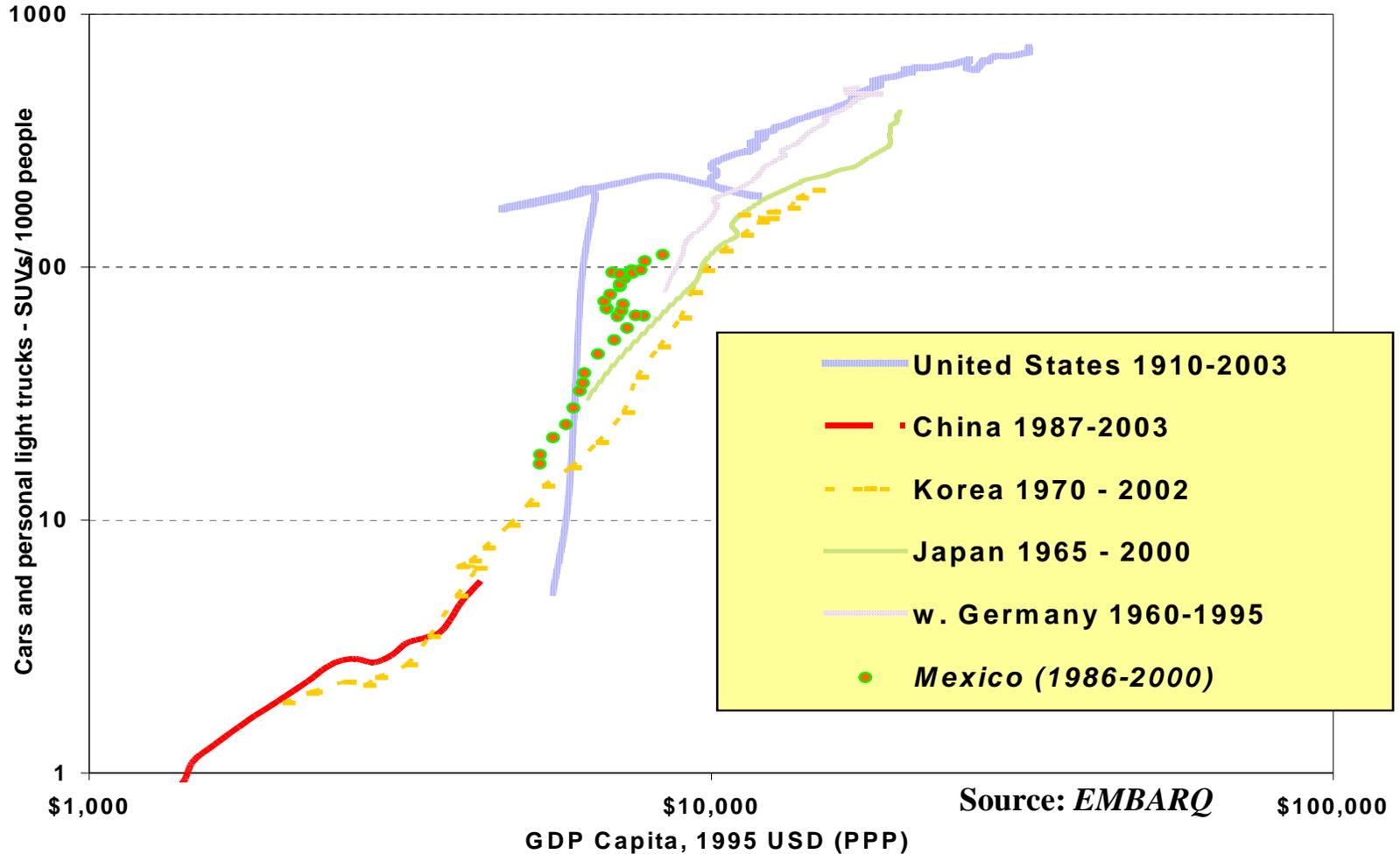
### SPM



Source : - State of the Environment in Hanoi City 2003 –DONRE of Hanoi

- Controlling pollution and giving out environmental protection mitigations in activities of vehicle- VR- 7/2002.

# Motorization in China: The China Syndrome?



***Is rapid urbanization in China and other countries putting cities and cars on a collision course?***

# Better Urban Transport in China: No Choice!



# Fast Traffic Growth in Xi'an

(source Mao Zhong-An, Xi'an)



Year 1990



Year 1999



Year 2002



<sup>40</sup>  
Year 2004

Fast Traffic Growth

South Street, Xi'an

# Cars and Urban Transport in China: Symbol for Much of the World?

- **Congestion: Cars, Other Traffic**
  - Buses and people stuck in traffic
  - Building more roads makes problem worse
  - Tough policies called for – by whom?
- **Air Pollution: Too Many Vehicles**
  - Enough old smokers to ruin air
  - New fuels, vehicles improving
  - Rising vehicle use offsets improved emissions control
- **Traffic Safety: People First**
  - Walkers, cyclists main victims
  - Too many kinds of traffic in same place, unequal road space distribution
  - More cars and speed will kill more people





# EMBARQ's Scenarios for China

<http://embarq.wri.org/en/Article.51.aspx>

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- **Illustrate and Quantify a World We Can't See.. Yet**
  - Reasonable estimates for “present values”
  - Growth based on nearby example -- Korea
  - Convergence with many other studies in the base case
- **Quantitative Assumption-Driven Outputs**
  - Vehicles, vehicle distances, fuel consumption
  - Impacts of alternative fuels
  - Total CO2 emissions
- **Qualitative Results – Transport is the Driving Factor**
  - Flesh and bones on the base case
  - Illustration of impact of “fuel efficiency” on total fuel use
  - Illustration of how a “livable cities” scenario might play out

# EMBARQ's Scenarios for China

- **Base Case – China has Korean car/GDP ratio in 2020**

- 120-160 million cars, 12,000 km/car
- 8-8.5 L/100 km if no new measures
- Closer to 2 mn bbl/day oil in 2020



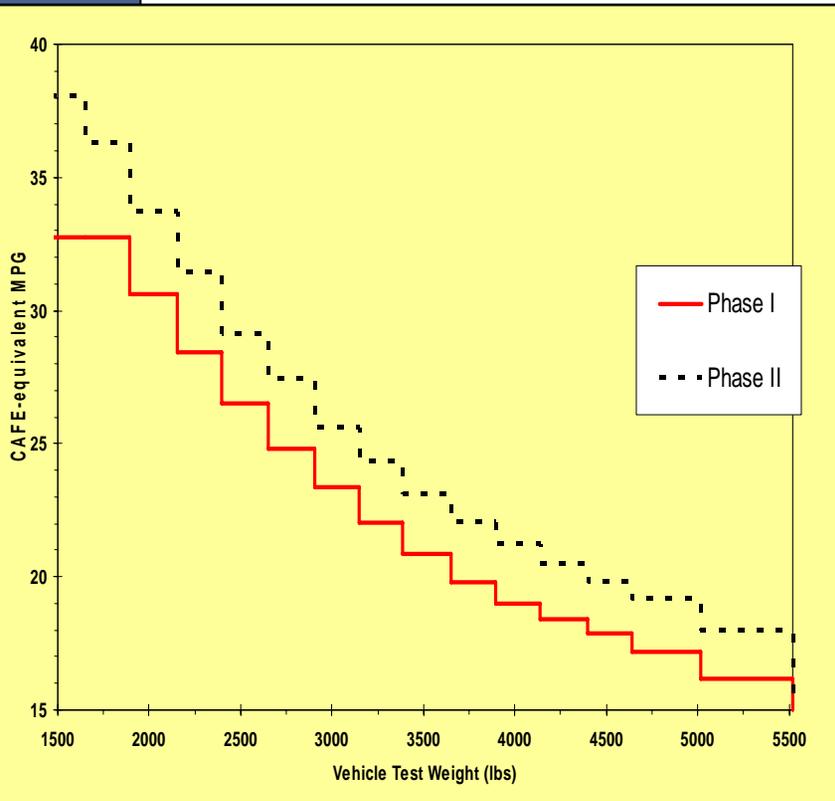
- **Oil Saving Scenario – 40% as much oil, some CNG**

- Japanese/Euro level of fuel prices
- 110-130 million cars, but less driving/car
- Fuel economy standards, some hybrids and CNG

- **Integrated Transport - Livable cities with good transport**

- Much lower car ownership and use– avoiding the plague
- Very small cars (incl. slow electrics, hybrids) to avoid space and congestion problems in cities
- Serious BRT, car-use restraint, land-use planning

# China's New-Car Fuel Economy Standards: A Start



## Weight-class based

- Car of given weight cannot use more than a given fuel use/km by tests
- Will probably impact SUVs significantly

## Overall Impact Uncertain

- 20-30% impact in each class
- Will keep cars from becoming guzzlers
- Will not prevent larger market shares of heavy, fuel intensive cars

## Technology not the problem

- Key is car size, power, utilization
- Manufacturers can choose techs.
- Fuel taxes, externalities next?



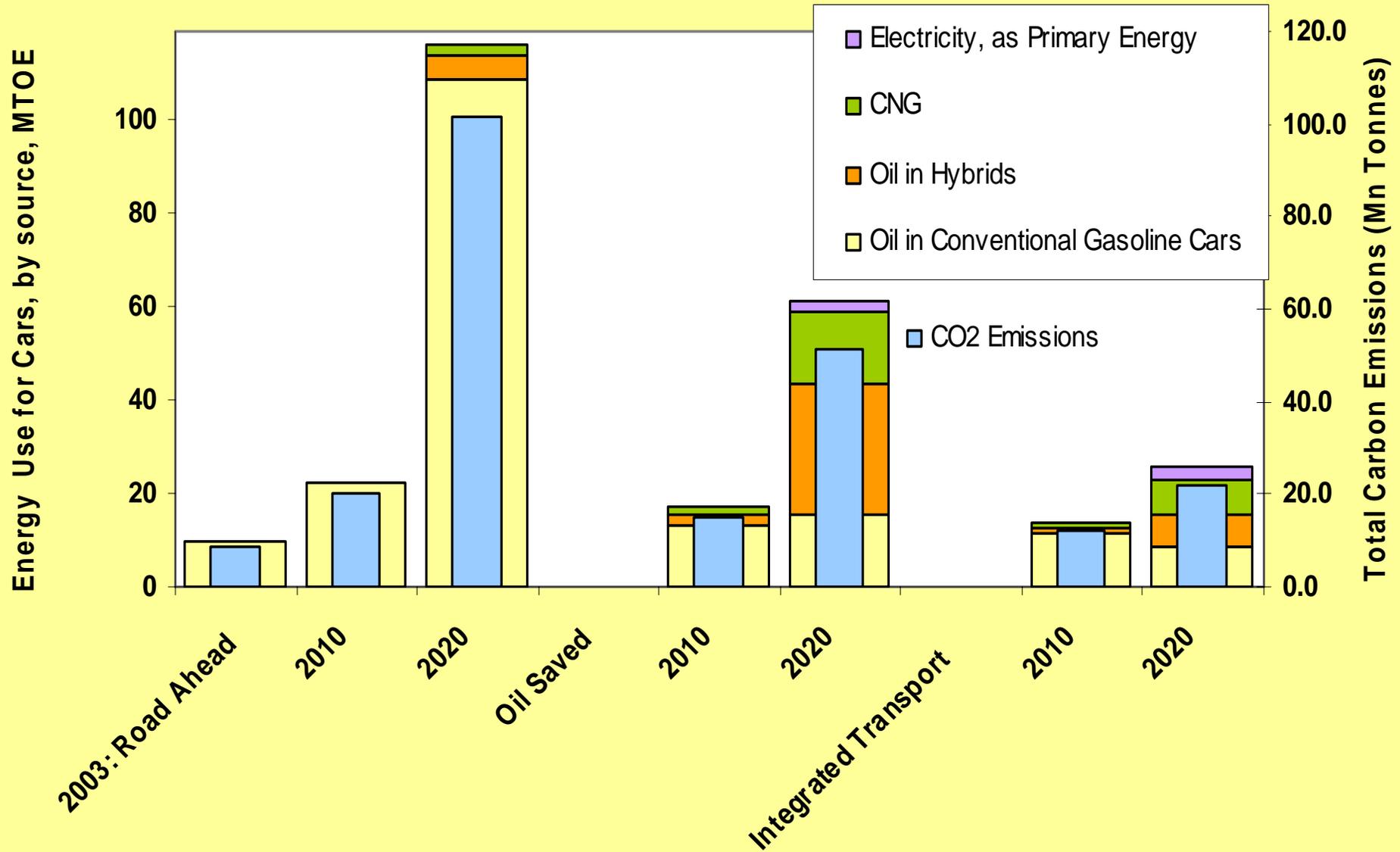
# Alternative Fuels or Fools? Tough Choices for China

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- **Ethanol and other “Biofuels”**
  - Modest experience, but high costs
  - Issue of land, water, pollution – what’s new here?
  - Scaling up may just be unreasonable
- **Fossil Alternatives**
  - Lots of LPG and CNG, but these not real alternatives
  - Gas to liquids, but where’s the gas?
  - Coal to liquids – methanol or synthetic liquids?
- **A Third Way? Coal and Electrification?**
  - Start with hybrids, battery electrics?
  - Coal to hydrogen/fuel cells with sequestration?
  - Electric drive now for most city vehicles??

***Key Element:  
Fuel and Externality Pricing***

# Sustainable Transport for China: Cars and CO<sub>2</sub> Emissions in 2020





# Conclusions:

## Will China Decarbonize?

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- **Urban Transport Solutions is the Umbrella**
  - Make room for 300 million more urbanites – land use planning
  - Scale up of bus rapid transit
  - Next steps – restraints on car use (congestion pricing?)
- **Clean Air Also Means Fewer Kilometers**
  - Fuel economy standards a valuable first step
  - Real urban transport – not just token BRT -- reform next
  - Next steps – car restraints, protection for NMT
- **Fuel Economy and Alternative Fuels**
  - Fuel economy is necessary but not sufficient
  - Alternative fuels prospects grim – competition for land
  - Main threat/hope – coal/decarbonized hydrogen?

***Avoiding the Multiple Problems of Too Many Cars  
Is Much Easier than Mitigating them when its too late!***

# India Inclinations

- **Economic and Population Growth**

- India is now the world's fourth-largest economy
- Middle class quadrupled (> 250 mn) over the past 20 years
- Population projected to peak in 2065

- **Motorization Growth**

- Motor vehicles increased from 1.86 mn in 1971 to 67 mn in 2003
- Motorized two-wheelers (account for over 70% of the total fleet)
- Automobile boom now underway

- **Environmental and Social Impacts**

- Increased traffic deaths/injuries, pollution, noise, congestion
- Fuel and carbon emissions increased by 61%
- Poor data, little timely monitoring of transport and its impacts



# Scenarios and Assumptions for India

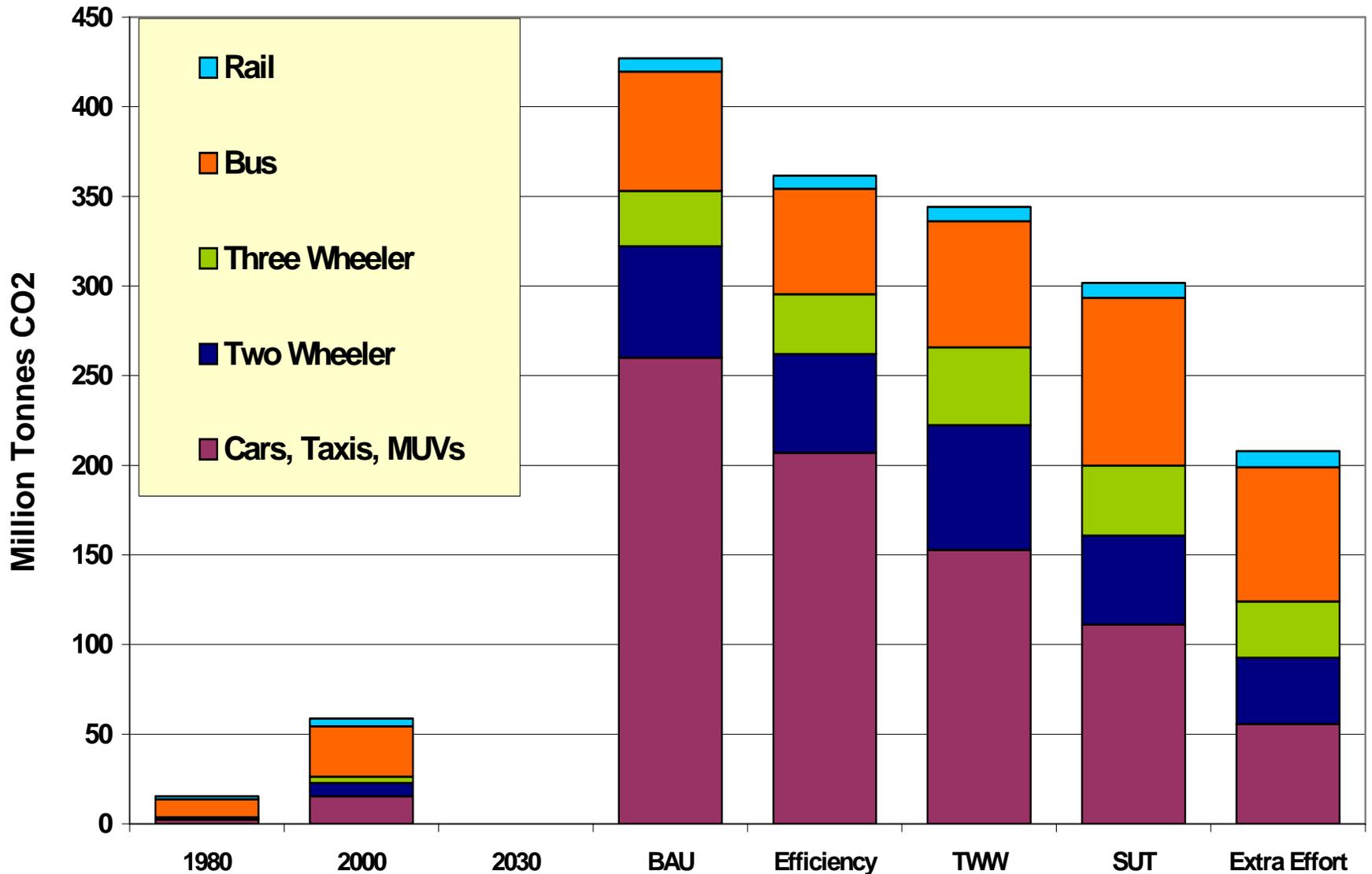
## w. Shyam Menon, W Bank

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- **Business as Usual (BAU)**
  - Unconstrained development of road traffic and vehicle demand
  - Infrastructure is assumed to not be a constraint
- **Energy Efficiency**
  - Higher fuel efficiency
- **Clean Two and Three wheelers**
  - Cleaner fuels and two and three-wheelers
  - Increases in two and three wheeler modal shares
  - Reduction in all other types of private transport modes
- **Sustainable Cities/Urban Transport (SUT)**
  - Demand management and modern mass transit
  - Regulation of private car use reflected by reduction in modal share
  - Widespread implementation of BRT systems
- **Extra Effort -- All of the above**



# CO<sub>2</sub> Emissions by Transport Mode





# Hanoi – the Two Wheeler World? The Future for all Asian Cities?

## Low Energy, Low Emissions Mode

- Very energy efficient
- Low emissions with clean fuels
- No local emissions with e-bikes



## • Traffic and Safety – If Protected from Cars

- Takes up far less space than cars
- Need to slow down, obey rules
- Need better solution to parking

## • A Safe, Two-Wheeled, Low Carbon Future?

- Protect the crowded, historical areas from cars
- Cluster homes, jobs in dense surroundings
- Explore city bikes to use after long journeys into town





# Developing Countries: Emissions Avoidance Cheaper, Easier than Emissions Saved

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- **Technology**

- Chose small individual vehicles, two wheelers, large buses
- Grow home industry of low carbon vehicles
- Chose among low carbon, clean fuels before its too late

- **Demand Management – Focus on Urban Areas**

- Singapore, Curitiba lead examples on early transport concepts
- Mexico City, Bogota good examples on “retrofit” transport strategies
- Other cities need to develop away from high-carbon modes

- **Markets and Regulation**

- Get prices “more right” before it’s politically too hard to fix them
- Enforce clean fuels and vehicles, traffic and safety rules
- Build relationships among authorities at local, national level

***CO2 not Focus – Fuel Saving of Some Interest,  
Good Transport As a Goal gets CO2 Cobenefits?***



# Energy and Oil Options for Transport

## What We Need to Know

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- **How to Get Consensus and Action on CO2 and Oil?**
  - Carbon tax and other measures
  - Fuel economy standards
  - How to save oil without making it with carbon?
- **Thinking about a New Transport Paradigm**
  - Cars will be more efficient, also lighter, smaller, slower
  - Urban transport systems prioritize people over vehicles
  - Clear regulatory decisions reinforced with taxes – markets for transport?
- **New Paths for Developing Countries?**
  - Can they focus on healthy cities and sustainable transport, not cars?
  - Can they develop low-oil, low-carbon technology
  - Can they define their own examples, not just follow the US or Europe

***Who it Takes: Vehicle and Fuel Makers,  
Global Leaders, Maybe the US?***

# Thank You

Lee Schipper – [schipper@wri.org](mailto:schipper@wri.org)

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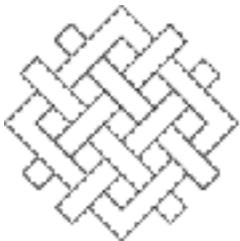


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