Toward Two Billion Cars: Transforming Transportation

… and what it means for India

Daniel Sperling
Professor and Director
Institute of Transportation Studies (ITS-Davis)
University of California, Davis
and
Board Member, California Air Resources Board

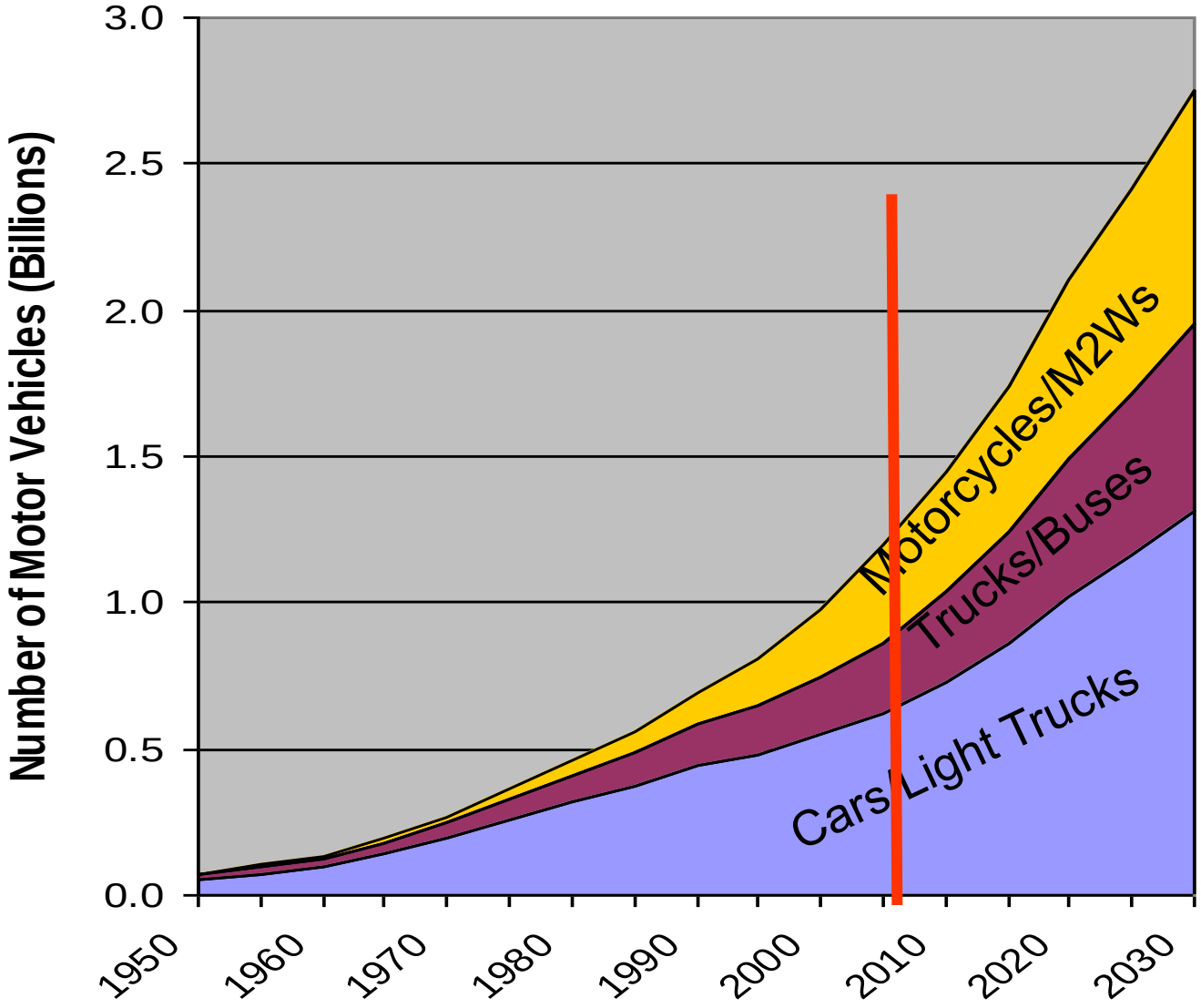
SIAM Annual Convention
Delhi
7 September 2011

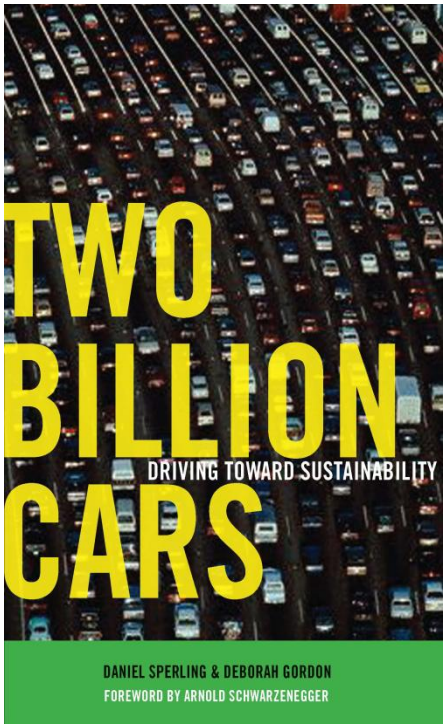
UCDAVIS UNIVERSITY OF CALIFORNIA

UCDAVIS ITS INSTITUTE OF TRANSPORTATION STUDIES

Good news and bad news

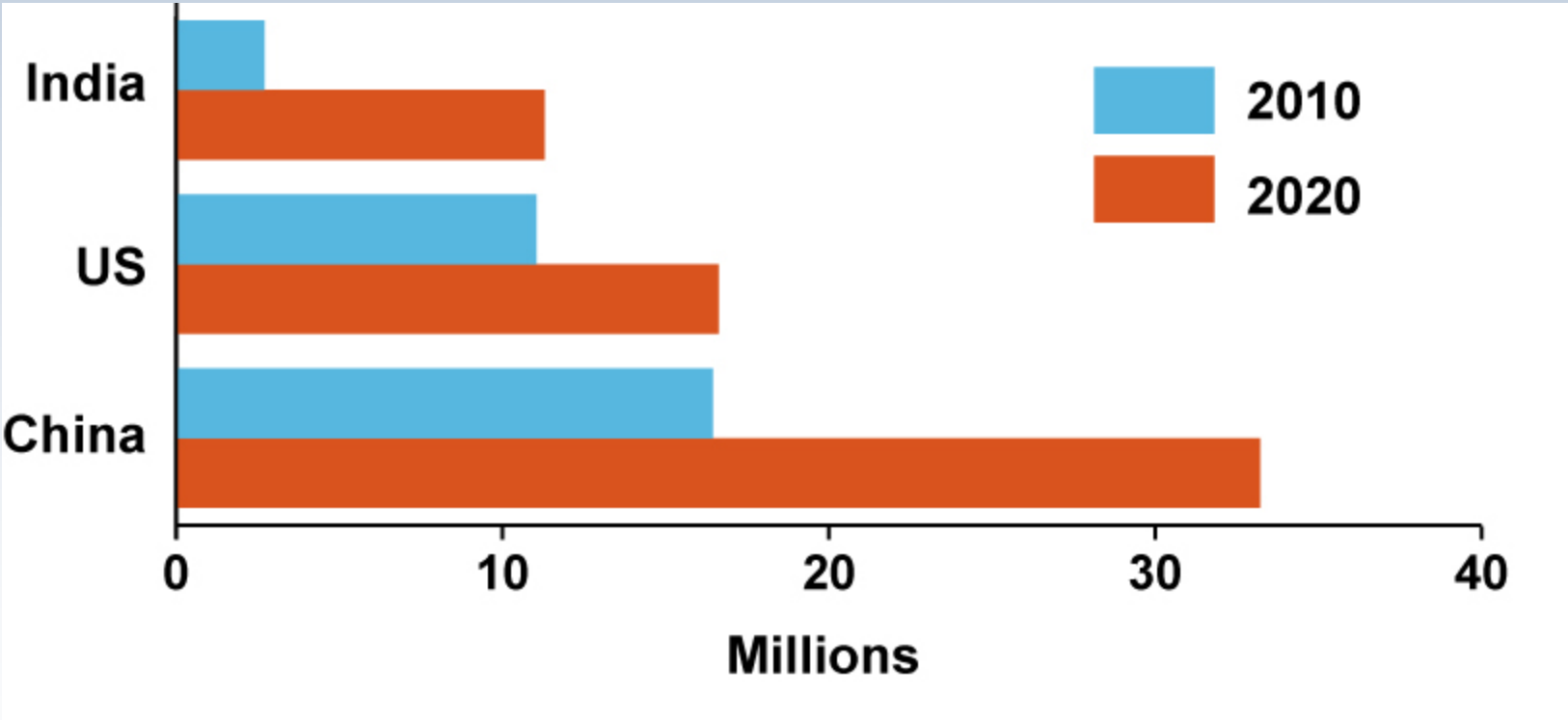
Soaring Global Demand for Vehicles (and Oil)





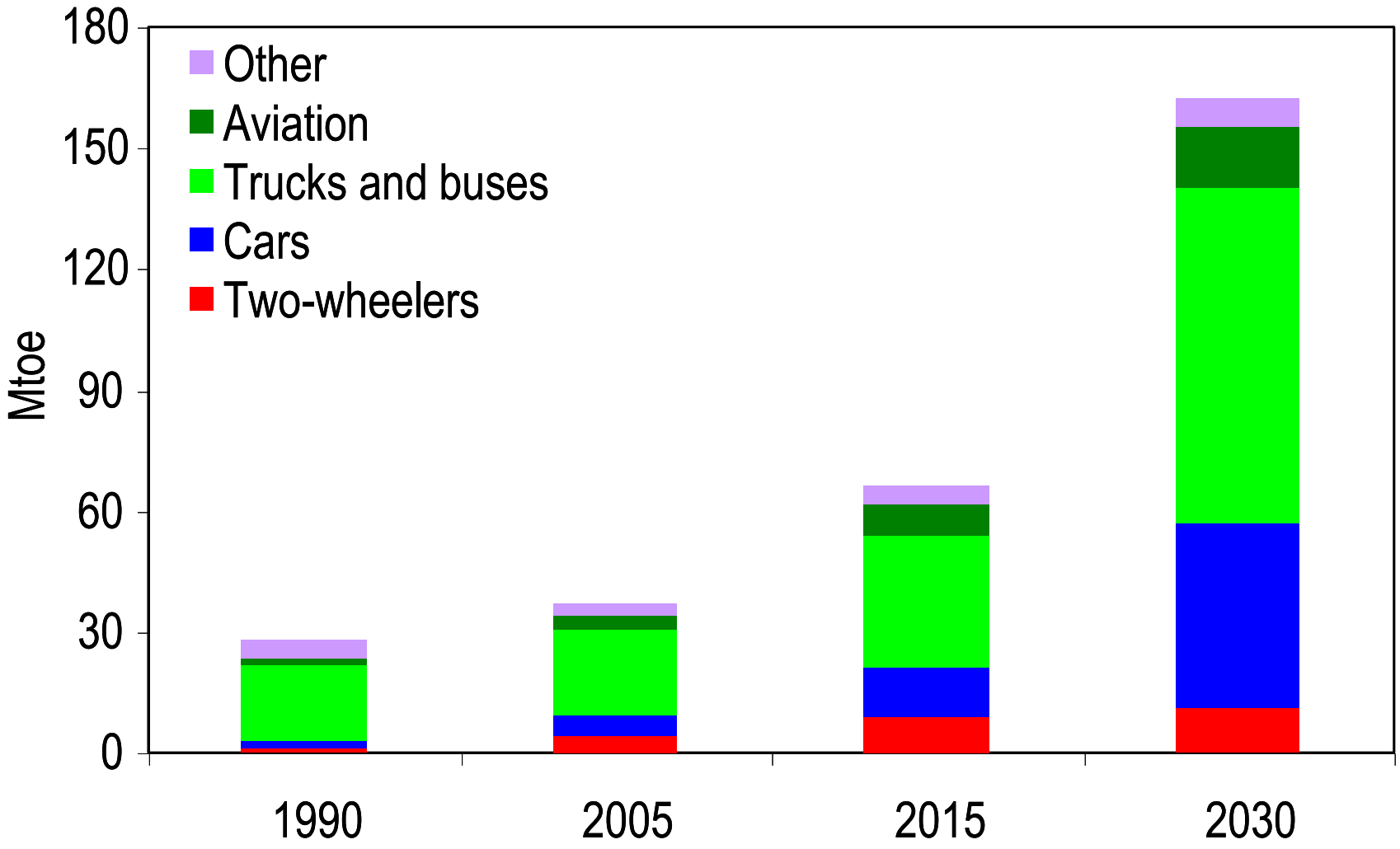
Sperling and Gordon (2009), based on DOE, JAMA, other

HUGE SUCCESS STORY: "India surpassed France, UK and Italy to become 6th largest automotive market in world in 2010, and expected to become one of three largest by 2020"



JD Power & Assoc, "India Automotive 2020: The Next Giant from Asia," June 2011

Soaring Vehicle and Oil Use in India



India #3 in GHG Emissions (~2015)

	2005		2015		2030	
	Gt	***rank***	***Gt***	***rank***	***Gt***	***rank***
US	**5.8**	**1**	**6.4**	**2**	**6.9**	**2**
China	**5.1**	**2**	8.6	1	11.4	1
Russia	**1.5**	**3**	**1.8**	**4**	**2.0**	**4**
Japan	**1.2**	**4**	**1.3**	**5**	**1.2**	**5**
India	**1.1**	**5**	1.8	3	3.3	3

Global Issues Important to India

(resulting from vehicle explosion)

1. Petroleum Imports … increasingly expensive!
2. Increasing Dependence on (Insecure) Middle East
3. Accelerating Climate Change … which will be very disruptive to India—affecting agriculture, temperatures, rain, storms

Important for India to engage internationally!

Even More Important are Local Impacts

Personal Mobility is Good … But More Cars Impose Huge Costs on People and Cities

- Air pollution and public health
- Huge cost for roads
- Traffic congestion reduces economic growth
  - Trucks move slower
  - Cars and buses move slower
- Social inequities
    - Not everyone can own a car, and thus..
    - A few rich people gain “better” mobility and access and convince govt to spend more money on roads,
    - Less money for public transport
    - Poor people suffer from more congestion

ITS UCDAVIS

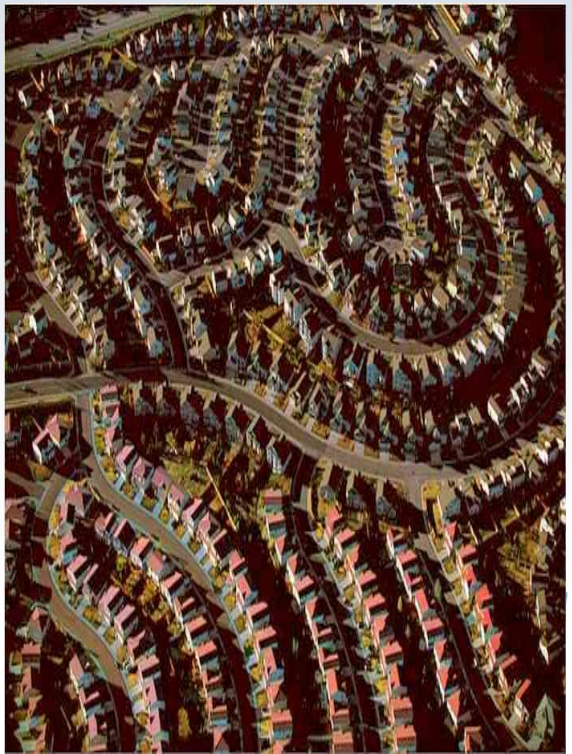
Vehicle Challenge for Indian Cities

- Superimposing motorized vehicles on established cities is difficult
  - Requires removal of neighborhoods to provide space for roads and parking
  - Requires huge amount of money for roads and parking
  - Dangerous to walkers and bicyclists
  - Damages public health (air pollution)

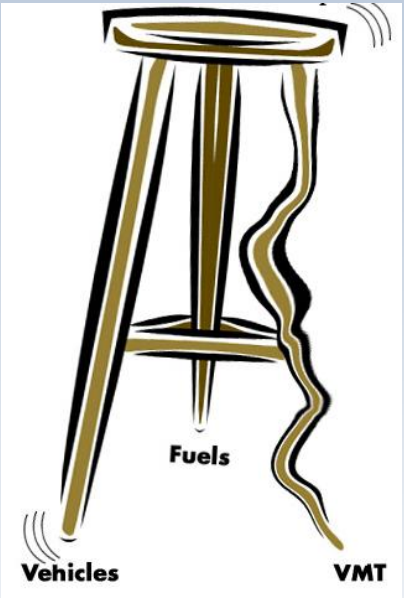
Not reasonable nor desirable for everyone to have motorized personal vehicles

india Should Not Follow California/US Model

The car-centric transport model of the US needs to be replaced—even in the US!



Need to Transform Transportation
(technology AND behavior)



- Transforming vehicles *("easiest")*
- Transforming fuels *(hard)*
- Transforming mobility and infrastructure *(hardest)*

1st Leg
Transforming Vehicles

Need to fix vehicles… Cars of future will be very clean, far more efficient and powered mostly by electric-drive

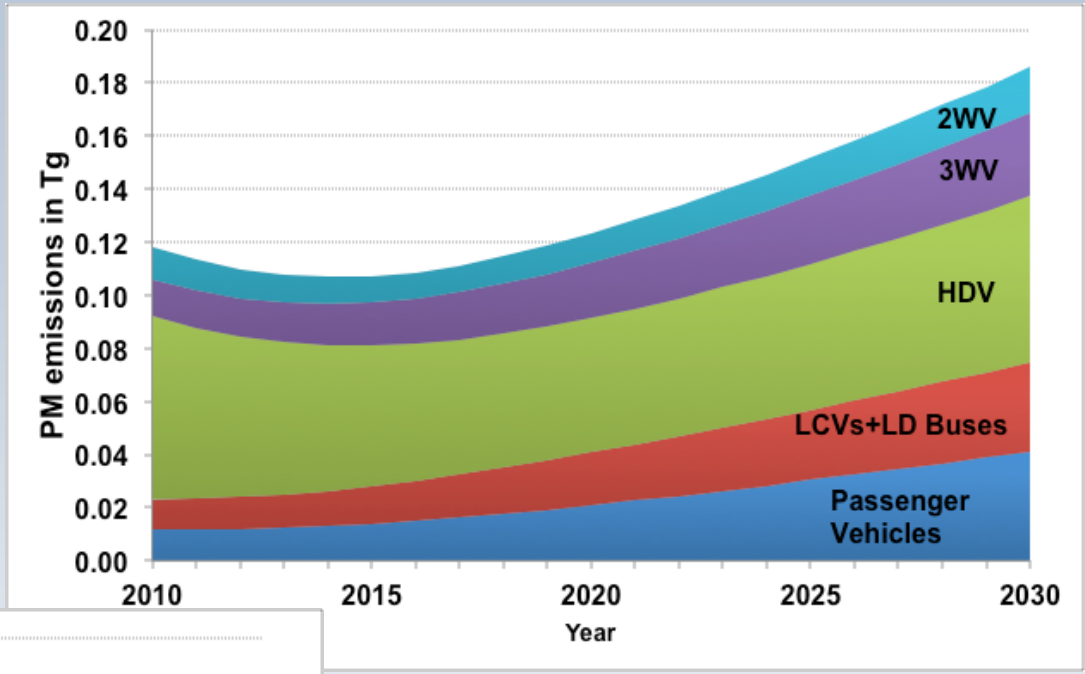
1) Technology for emission control is well known and cheap

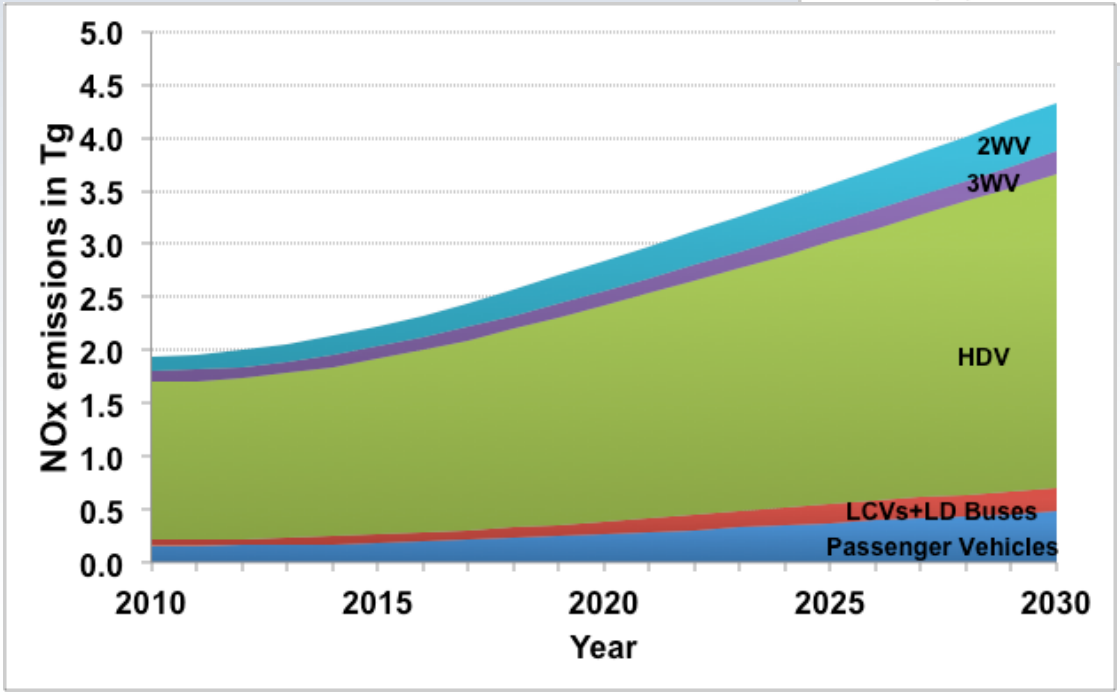
2) New evidence suggests that vehicle efficiency improvements are far easier and less expensive than previously thought.

3) New evidence suggests that batteries and fuel cells will be far less expensive than previously thought

Vehicle Pollution Increasing in India

(PM and NOx emissions)

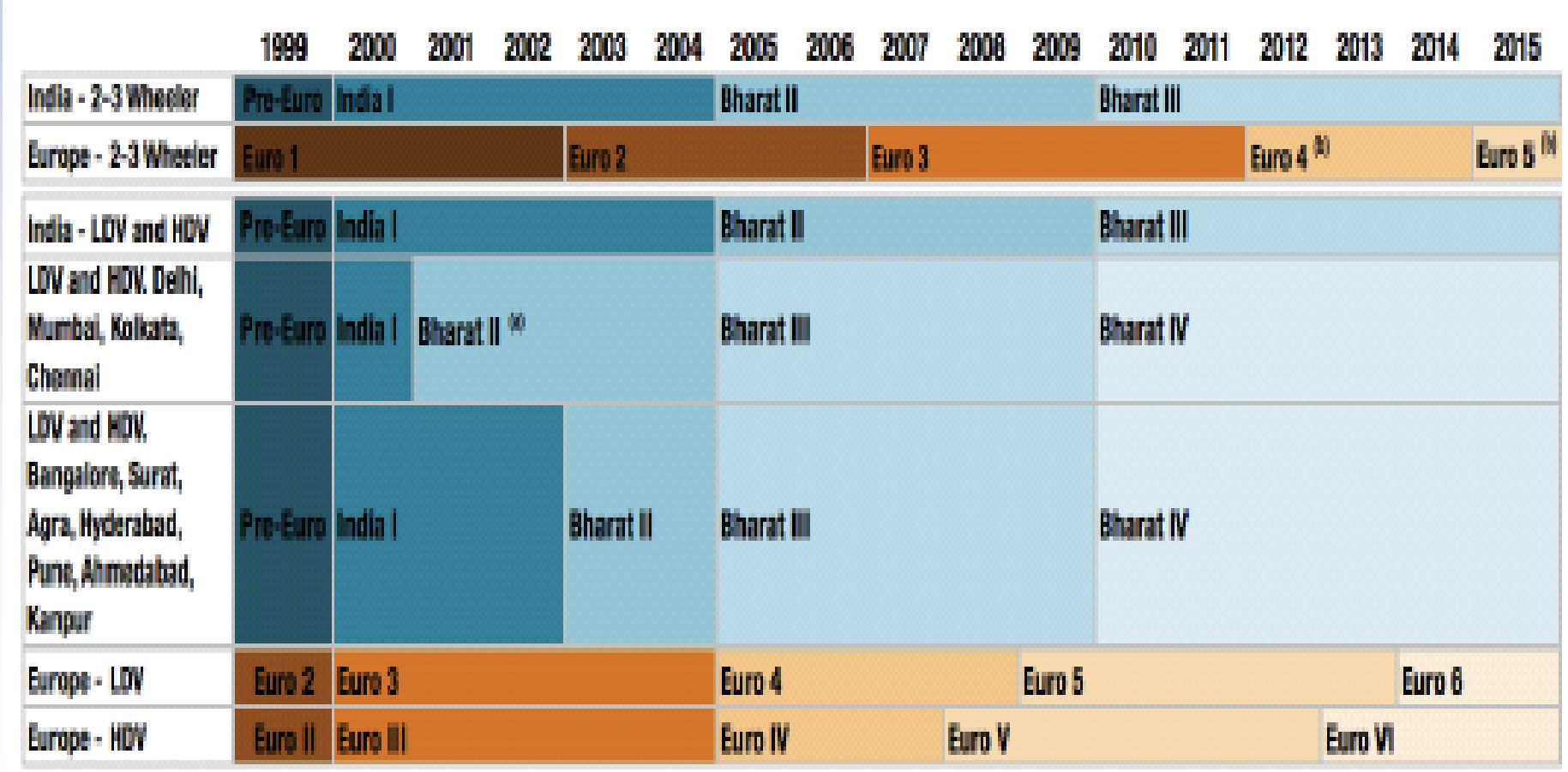




TERI/ICCT, 2011

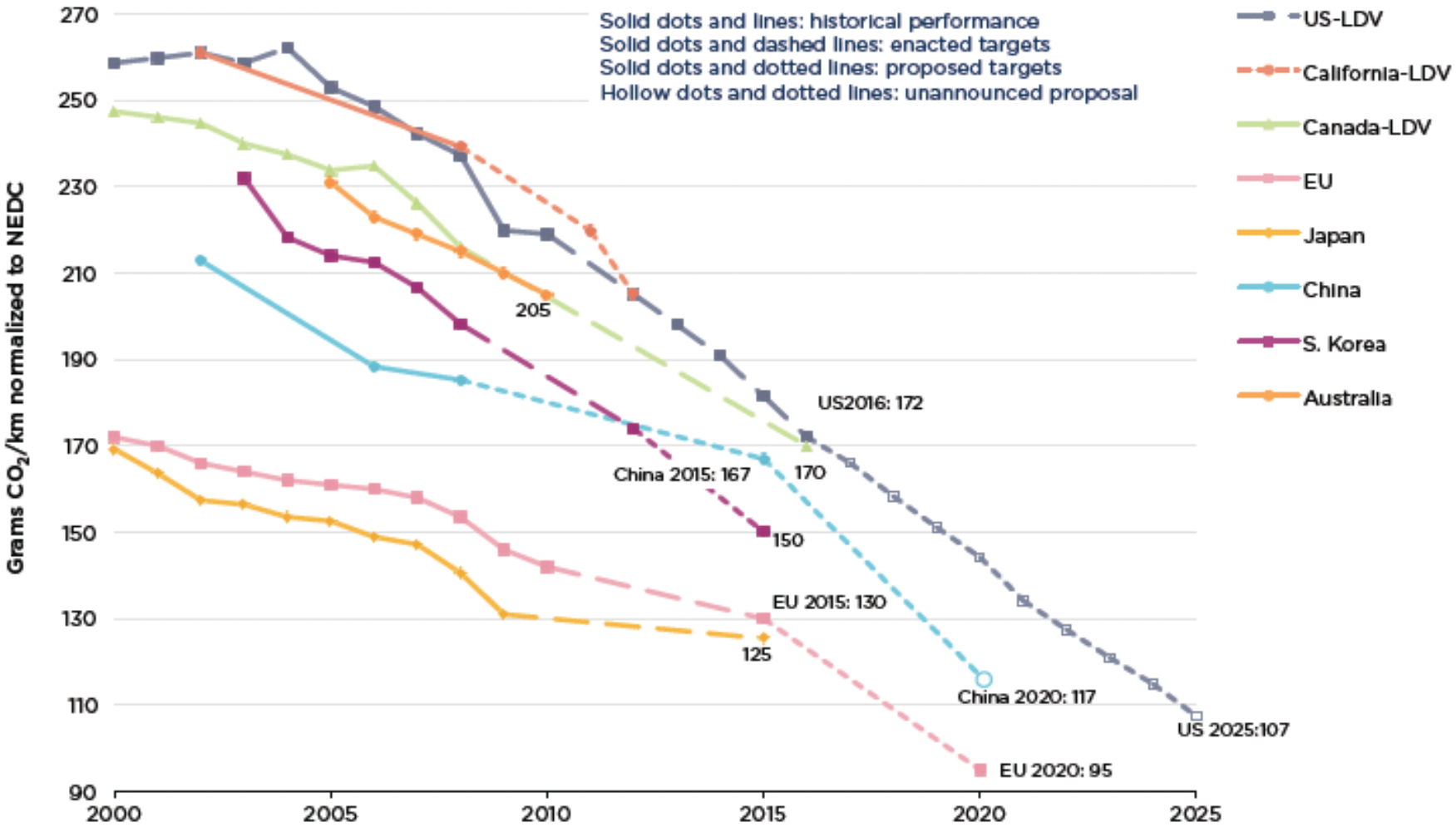
India Emission Stds Lag EU about 3-10 Years

(but advances require lower sulfur petrol/diesel)



Vehicle Efficiency Improving Everywhere

(doubling in US from 2010 to 2025)



[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
[2] US and Canada light-duty vehicles include light commercial vehicles.

Many Energy Efficient Technologies Are Being Commercialized

Vehicle system	Technology	Approximate GHG-per-mile reduction *	Percent U.S. adoption (MY2008) #
Engine	Variable valve timing	2-8%	53%
	Cylinder deactivation	3-6%	6%
	Turbocharging	2-5%	2%
	Gasoline direct injection (stoich. and lean)	10-15%	4%
	Compression ignition diesel	15-40%	0.1%
	Digital valve actuation	5-10%	0%
	Homogeneous charge compression ignition	15-20%	0%
Transmission	5 speed	2-4%	32%
	6+ speed	3-5%	21%
	Continuously variable	4-6%	8%
	Automated manual, dual clutch	4-8%	1%
Overall vehicle	Lightweighting	10-20%	–
	Aerodynamics	5-8%	–
	Tire rolling resistance	2-8%	–
	Efficiency auxiliaries (steering, alternator, A/C)	2-10%	–
	Stop-start mild hybrid	5-7%	0.2%
	Hybrid electric system	20-50%	2.2%

** Many technologies can be combined, but percents are not strictly additive; Estimations are based on NAS 2002 CAFE; US EPA/NHTSA, 2009; NESCCAF, 2004. # From US EPA, 2009*

Should India Pursue Electric-Drive Vehicles?

Battery Cost Challenge

- Today's batteries cost ~$600-900/kW-hr
- Future batteries might cost ~$300/kW-hr

- Thus, today
  - Battery for Nissan Leaf (24 kW-hr) = ~$18,000
  - Battery for GM Volt (16 kW-hr) = ~$10,000

- Future:
  - Nissan Leaf battery = ~$7000
  - GM Volt battery = ~$5000

Batteries will be very expensive even in optimistic scenarios

China EV Strategy

- China recently adopted an industrial policy to accelerate EV technology to leapfrog the US/EU/Japanese auto industry—goal was to become dominant auto exporter of EV technology
  - Seemed sensible given industry and consumer experience with e-bikes, and large lithium battery industry
- Strategy is failing because of high cost, low quality, and consumer resistance. Seems to be a shift to electric buses

Now appears transition to EVs (and PHEVs) will be slow in China, US, EU, and elsewhere

2nd Leg
Transforming Fuels

The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil.

Sheikh Zaki Yamani, Saudi Arabian oil minister for 2 decades

BIOFUELS **HYDROGEN** **ELECTRICITY**

Fuel *du jour* Phenomenon

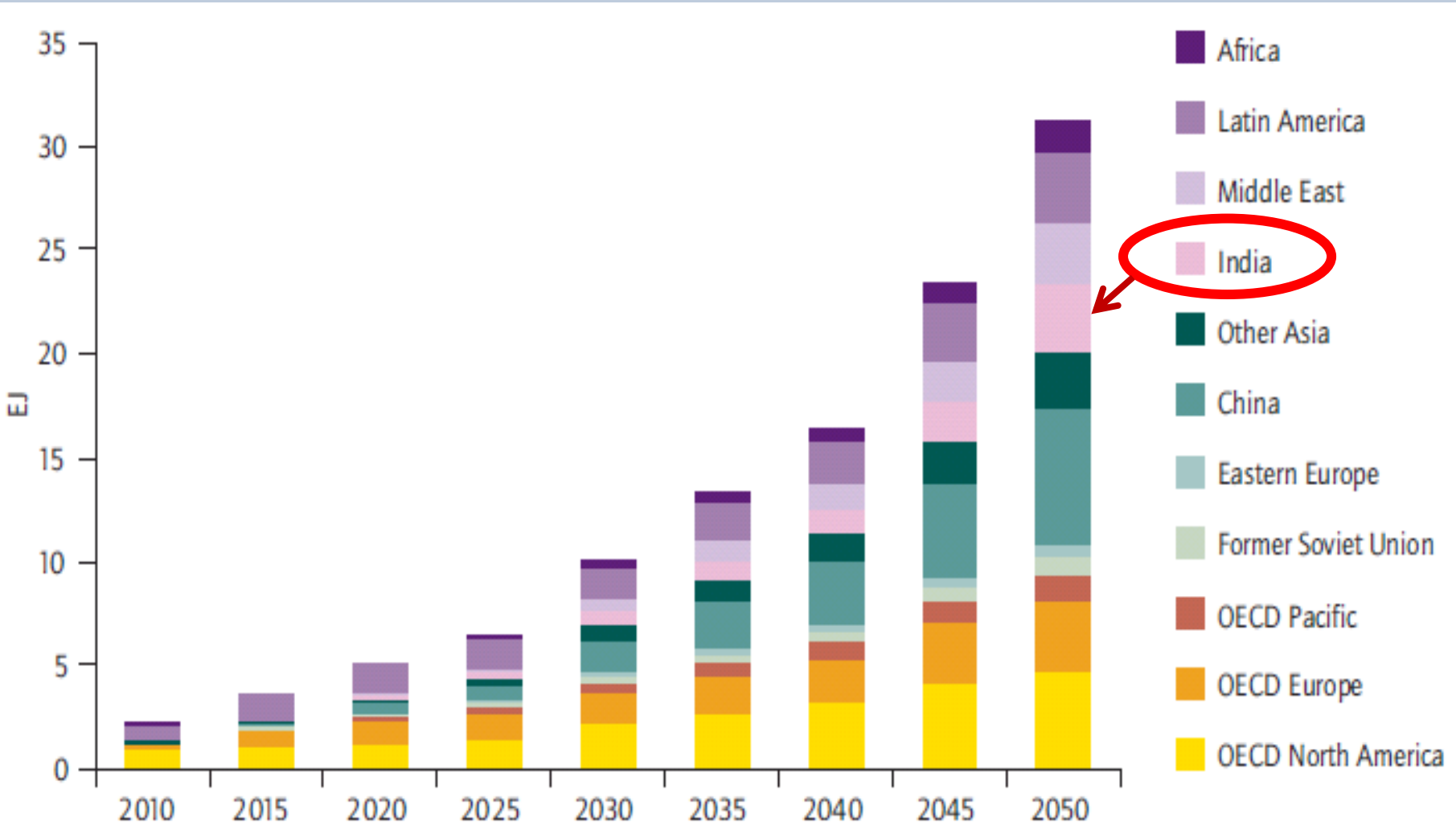
Disruptive and wasteful

- **30 years ago – Synfuels (oil shale, coal)**
- **25 years ago – Methanol and CNG**
- **20 years ago – Electricity (Battery EVs)**
- **10 years ago – Hydrogen (Fuel cells)**
- **5 years ago – Ethanol**
- **Today – Electricity (again)**
- ***What's next?***

Alternative Fuels for India

- Biofuels that do not use much land and do not compete with food
  - Agricultural waste and residues
  - Crops that grow on marginal lands
- Electricity (where not fully dependent on coal)
- Natural gas??

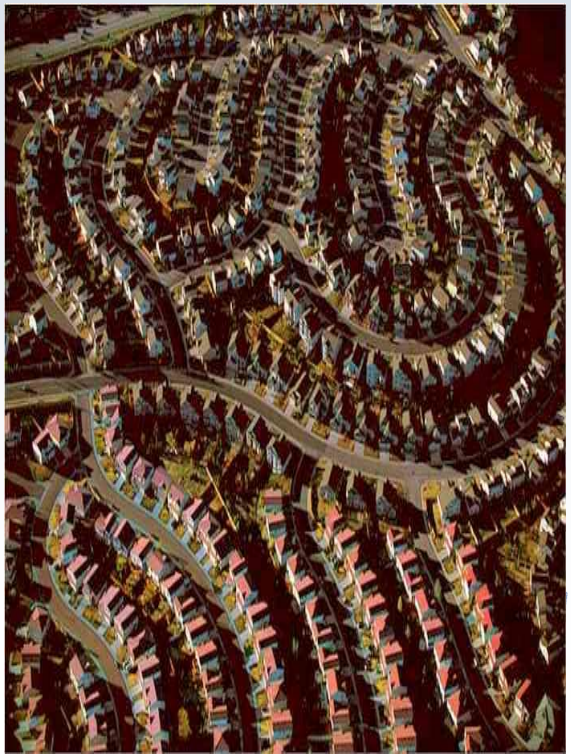
Minor Biofuel Production in India?!



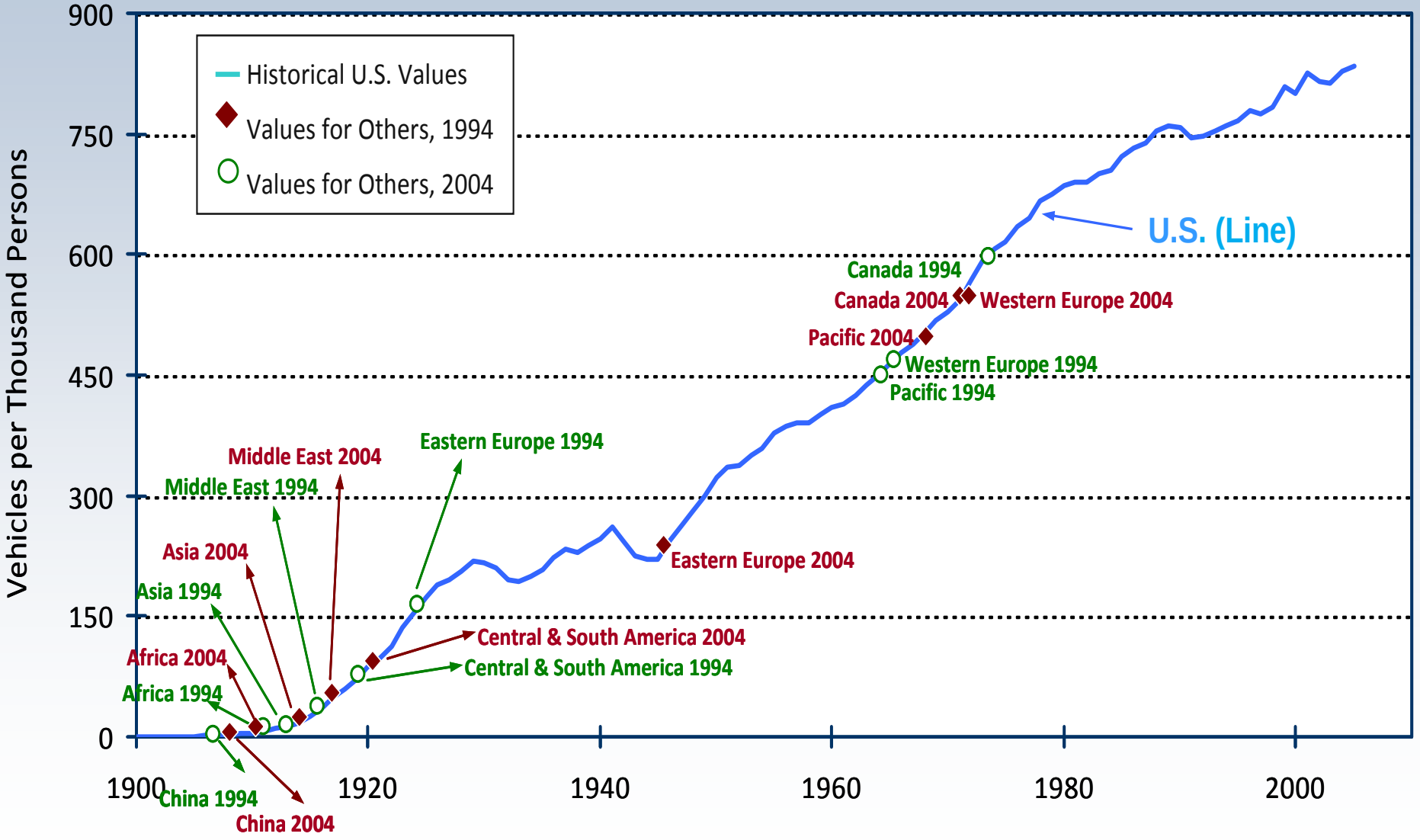
Source: IEA, 2011

3rd Leg
Transforming Mobility
(and Land Use and Infrastructure)

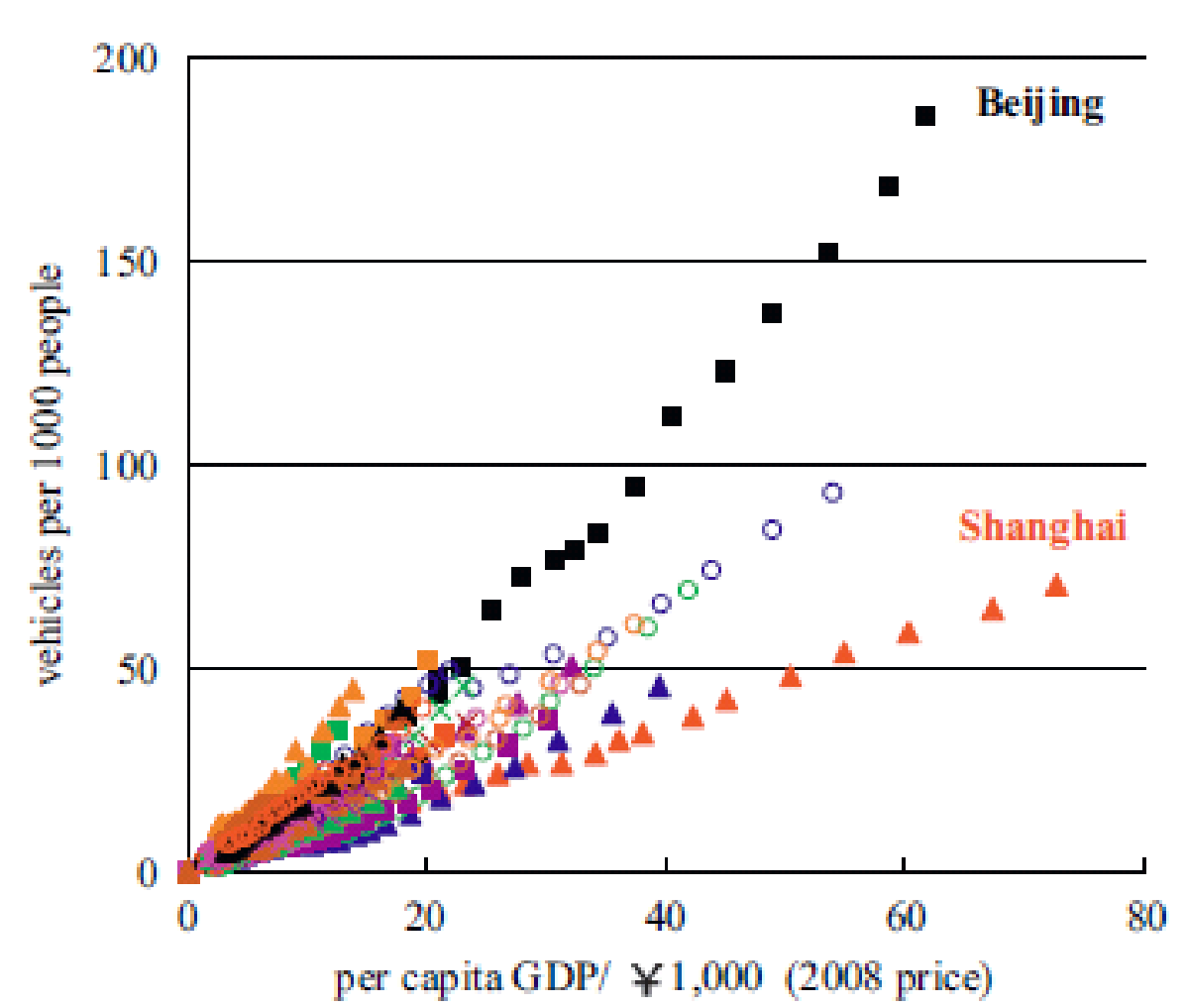
india Should Not Follow California/US Model



Rapid Growth in Vehicle Ownership in Emerging Economies



Policy Matters: Beijing vs Shanghai
(and other Chinese provinces and cities)



Hao, Wang, Ouyang, 2010

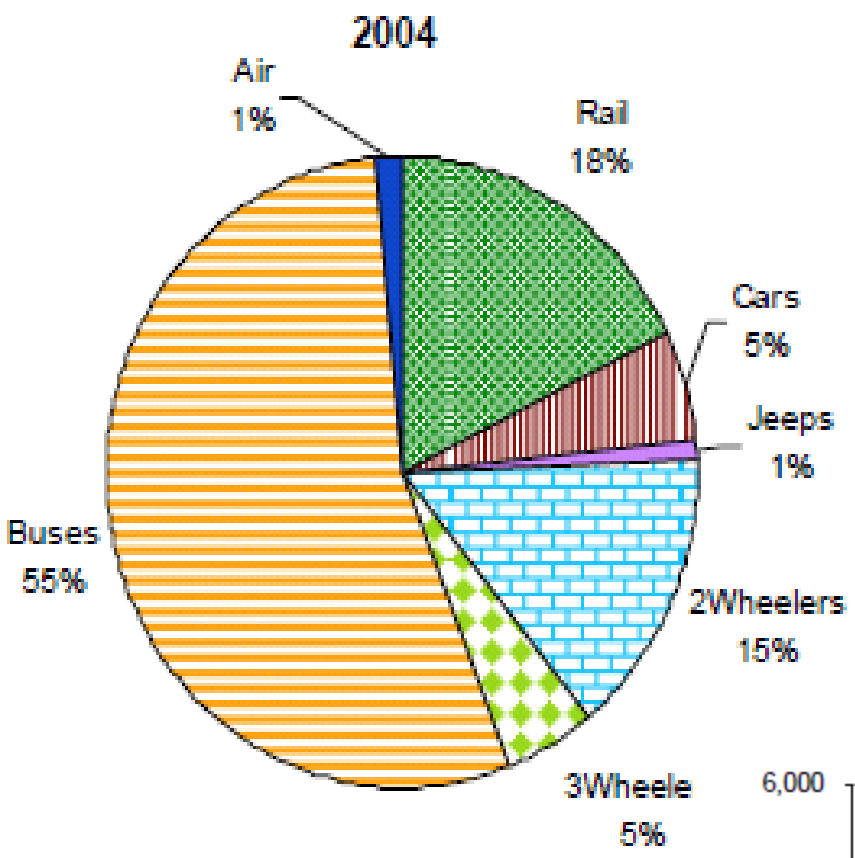
Necessary to Restrain Demand, but by Providing Good Mobility and Accessibility

- Enhance public transportation (especially for middle class)
- Charge full cost of vehicle use (pollution, energy security, GHGs) via fuel, vehicle, and usage taxes

Many Economic and Environmental Reasons to Restrain Urban Vehicle Use, Especially in Emerging Economies

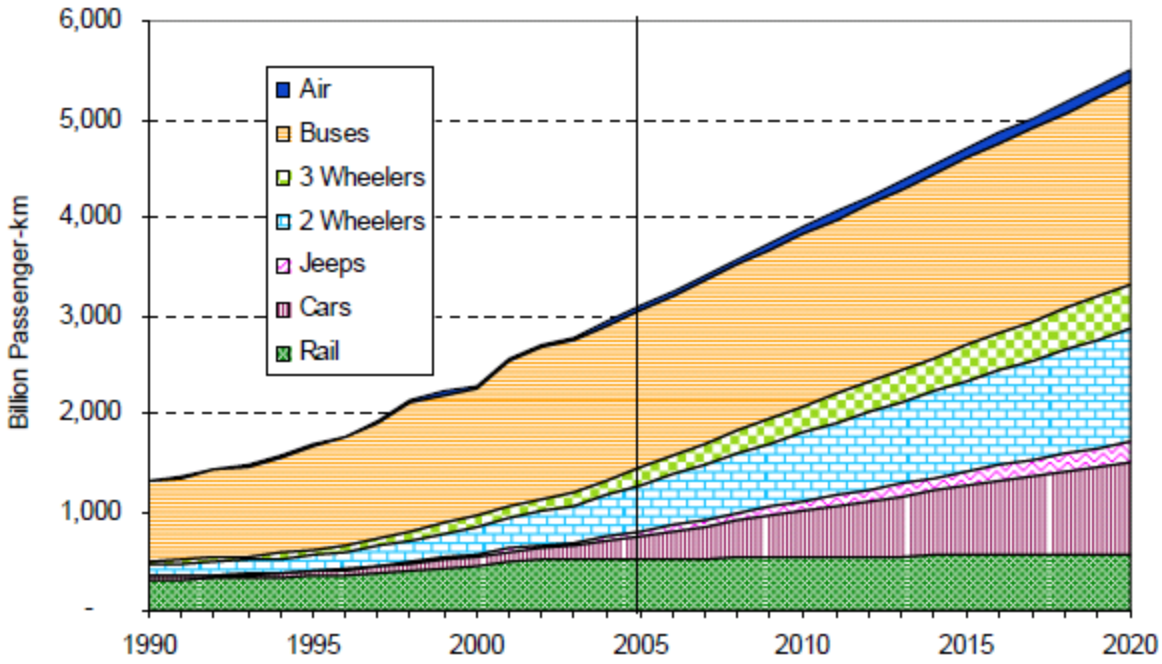
STRATEGIES TO RESTRAIN VEHICLE USE

- Urban land use management
- Pricing of vehicle use and ownership
- Improving public transportation
- Innovative mobility technology
  - Bus rapid transit
  - Small, neighborhood cars
  - Safe bicycling lanes
  - Car sharing



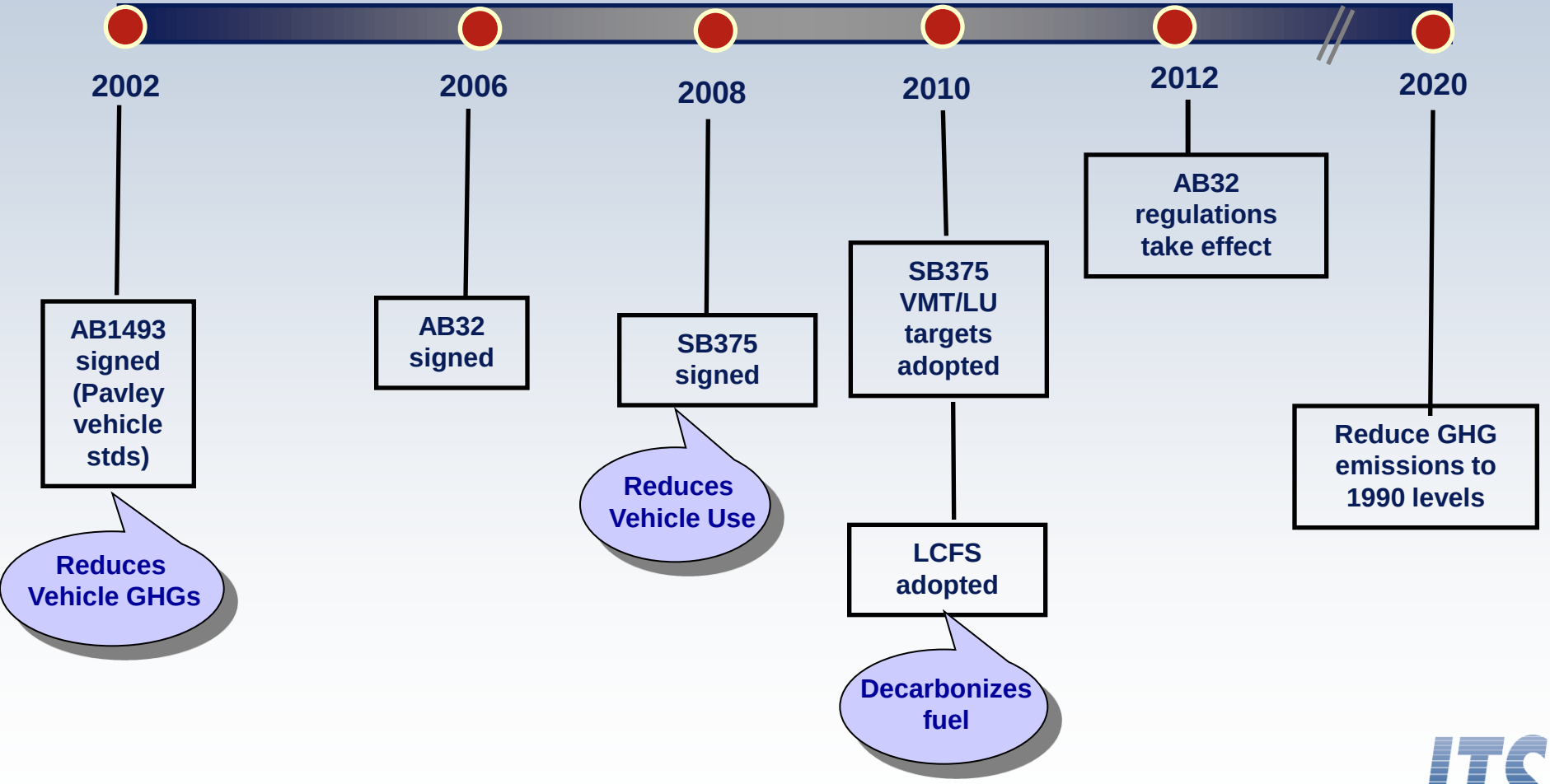
So far, Cars Still Play Small Role Moving People in India

(measured as passenger-km)



LBNL, 2009

California Pioneered Car-Centric Cities and Lifestyles … And Is Now Atoning for its Sins



Putting “Climate Policy” in Context

Strategies to reduce GHGs are almost the same strategies to reduce oil imports, air pollution, road infrastructure costs, and to improve urban livability

California Policy Model (far ahead of US)

- Carbon cap-and-trade program to create price signal for carbon (instead of gasoline tax?!) (imposed on refineries and fuels)
- Target specific GHG and oil reductions with broad array of rules and incentives

VEHICLES

- **GHG vehicle stds (cars)**
- Zero Emission Vehicle (ZEV) requirements to overcome start-up barriers
- Financial incentives for advanced vehicles (EVs, PHEVs, FCVs)

FUELS

- **Low carbon fuel standard req't for oil companies (10% reduction in carbon intensity by 2020, requiring roughly 1/3 alternative fuels)**
- 33% renewable electricity stds for electricity suppliers
- Hydrogen fuel station requirements (proposed)

VKT and Infrastructure

- **Targets for reduced VKT and sprawl (7-8% reduction in VKT/capita by 2020 and 15% by 2035)**

Suggestions to Assure Future Success of Automotive Industry, Cities, and Nation

- Build much cleaner, more efficient, safer vehicles
  - Accelerate emissions controls (India is 3-10 years behind EU)
  - Adopt strong efficiency/CO2 standards (to encourage better technology and discourage shift to larger vehicles)
- Diesel cars should be not be subsidized with lower fuel taxes
  - Diesel and petrol cars should be treated equally. Diesel has somewhat better efficiency but higher NOx and PM emissions. Petrol technology is coming closer to diesel efficiency
- Much less emphasis on:
  - Biomass (use residues and crops on marginal land, but not food)
  - EV technology (instead focus on improving conventional vehicles)
- URGENT: Auto industry should help improve public transport (including BRT). One possibility is to allow diversion of dedicated fuel tax to public transport use)

We are doomed?

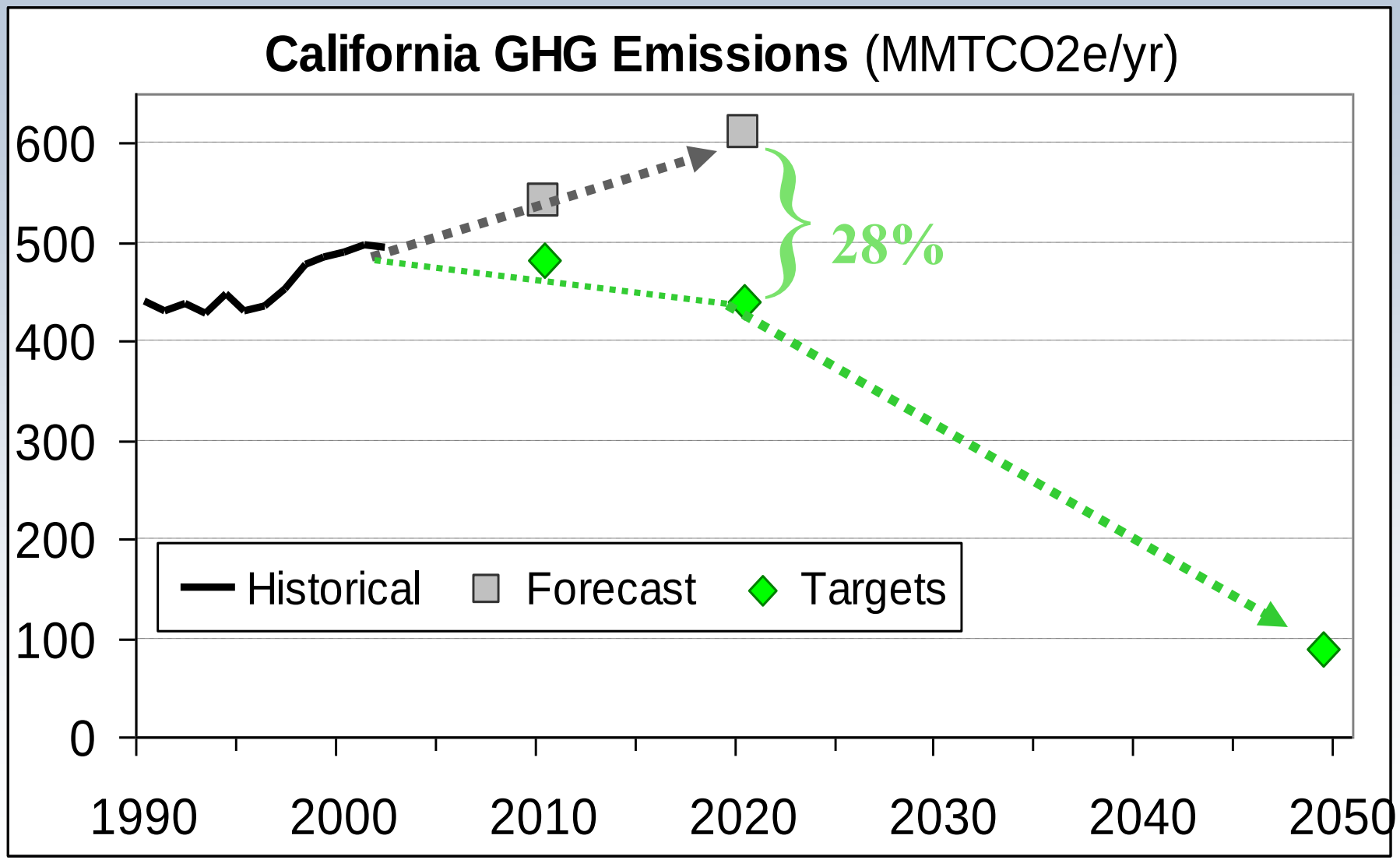
"We stand at a crossroads. One path leads to despair, the other to destruction. Let's hope we choose wisely."

Woody Allen

Heading into a painful century… but humans are incredibly creative. Eventually we will rise to the challenge?!

Thank You

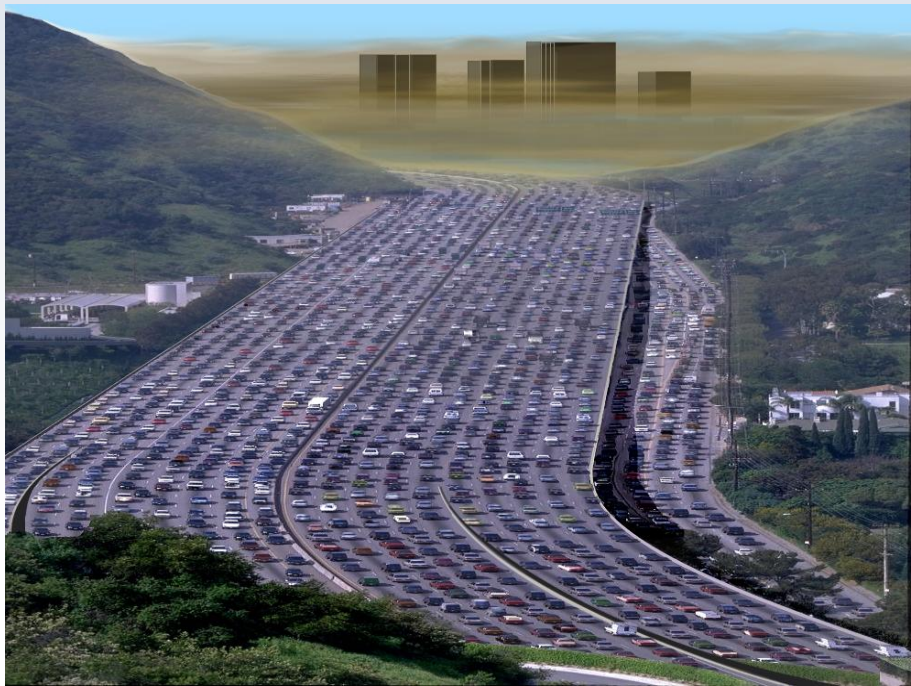
California's GHG (and Oil) Goals



Scenario 1 for India:

Let the Good Times Roll (for the Auto Industry)

- Adopt incentives and rules for improved vehicle technology (safer, more efficient, less polluting)
- Manage traffic flow better
- Increase road capacity
- Improve public transport



International Cooperation for Sustainable Transport

- Joint R&D of low carbon transport fuels such as second generation biofuels;
- Joint R&D of low carbon vehicle powertrain systems;
- Joint research and development of smart grid technologies for the diffusion of electrical cars;
- Electrical car demonstration projects in selected cities.
- Develop innovative mobility services such as car sharing, smart ridesharing,
- Share policy experiences with low carbon fuel standards, vehicle standards, zero emission vehicles, etc

Can it be done? A Measures Checklist

- Travel
  - Urban and regional planning!
  - Telematics
  - Trucking and air travel logistics
  - Pricing…and caps?
- Modal Switch
  - Better transit systems (Bogata x 1000)
  - Non-motorized mode infrastructure
  - High speed passenger rail, expanded rail for freight

Measures (cont.)

- Efficiency
  - New LDV efficiency can be doubled by 2030 at modest cost
  - Trucks and aircraft too! – though costs are less clear
  - In use efficiency must not be overlooked
- Biofuels
  - Large potential but must move toward 2nd generation
    - US corn/soy, EU wheat/rape are not the answer
  - Ultimately biofuels' contribution will depend on sustainability
    - We need to better understand impacts around the world

Measures (cont.)

- Hydrogen/electricity
  - Plug-in hybrids are promising but battery costs must come down
  - Pure EVs and H2 FCVs are stuck in slow gear
    - Breakthroughs and massive investments will be needed if these vehicles are to play a major role
  - Low GHG production H2/electricity will be needed as well

Sperling's 5 Point Program to Transform Transportation

1. Increased R&D investments (and training of next generation of scientists and engineers)
   - Batteries, fuel cells, and lightweight materials
2. Accelerate advanced vehicle commercialization
   - Near-zero emissions vehicle requirement
   - Tax credits for hybrids, fuel cell, battery-electric vehicles
3. Performance Standards for fuel/GHGs
4. Market instruments to align regulations with market
   - Fuel and carbon taxes, feebates
5. Restrain vehicle use
   - Improve public transportation, increase the cost of driving, manage urban land use

Question of Will and Vision, More Than Technology or Cost!

- Consider hydrogen and fuel cells, which many think is most expensive and difficult transition …
  - $55 billion extra over 15 years for vehicles and fuels, to get to 10% market penetration (NRC/NAS, 2008)
- Meanwhile, US spends ~$8 billion/year on subsidies for corn ethanol
- If US spent $8B/yr on vehicle electrification (PEVs and/FCVs) instead of corn ethanol, then technological (and behavioral?) transformation would be assured.

Closing Thoughts

- Transport *must and can* achieve deep GHG reductions, but it won't be easy.
- Substantial efficiency improvements in all sectors are available at modest (societal) cost
  - Costs of other types of measures are widely variable
- Role of biofuels/ hydrogen / electricity could be substantial but there are major challenges and uncertainties
- Some behavioural change probably has to be part of the solution, especially in the short-medium term
- Strong, coordinated policy actions in and across countries will be critical to success

GHG Standards Evaluated - 2025 Models

Scenario (Improvement/year)	CO2 gpm	Reduction in GHG	~MPGe* (on-road)
2016	250	Baseline	28
3%	190	24%	37
4%	173	31%	41
5%	158	37%	45
6%	143	43%	50

* Average of passenger vehicles, national fleet mix. MPGe assumes all reduction is from tailpipe.

ITS UCDAVIS

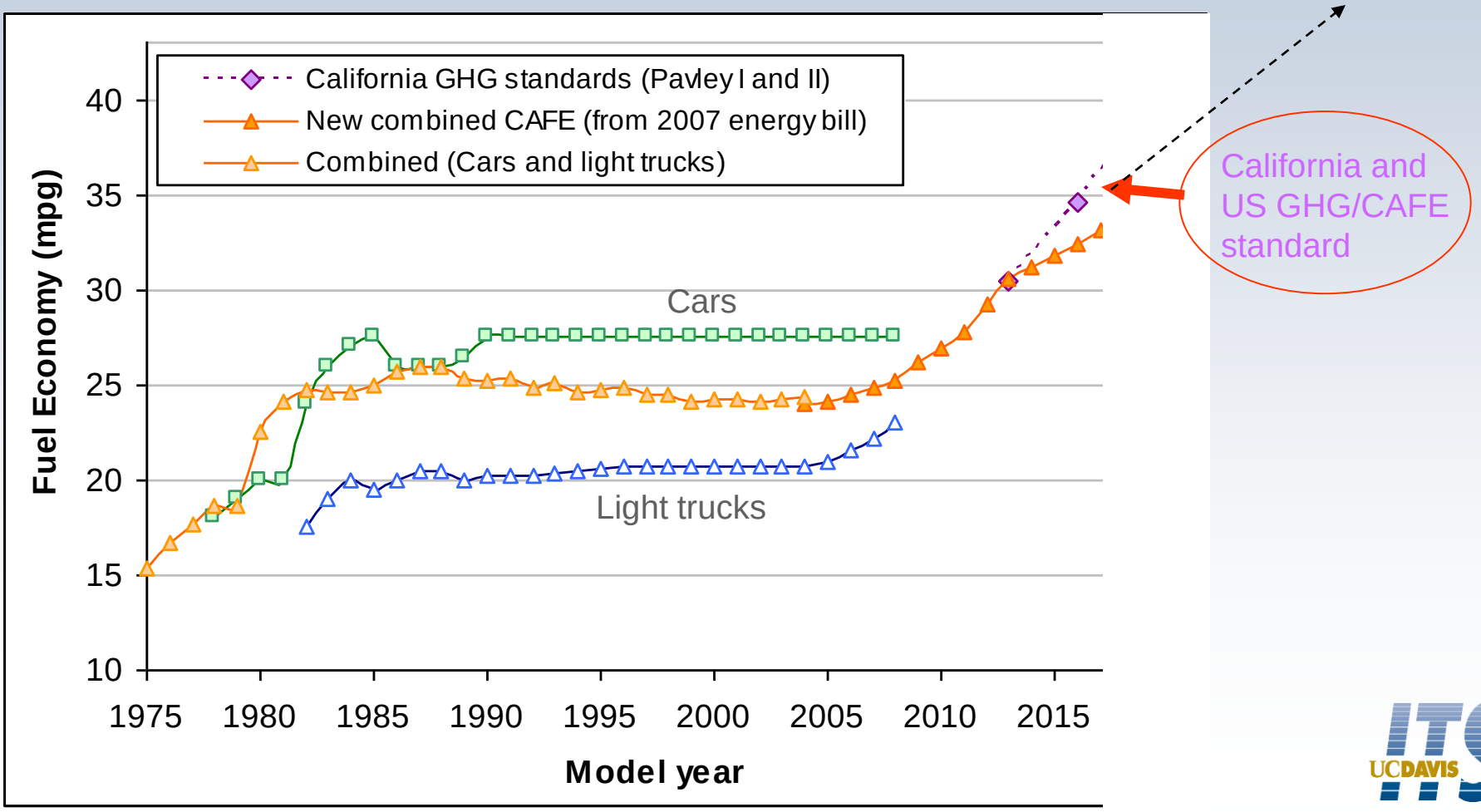
Big Ideas

- Surface passenger transportation is one of least innovative sectors in US economy
  - …and among least responsive to “sustainability” challenges
- Need to create more mobility choice
- Can build on scattered regional and local initiatives to create sustainable transportation
- Need to channel innovation (to focus the incredible creativity of humans)

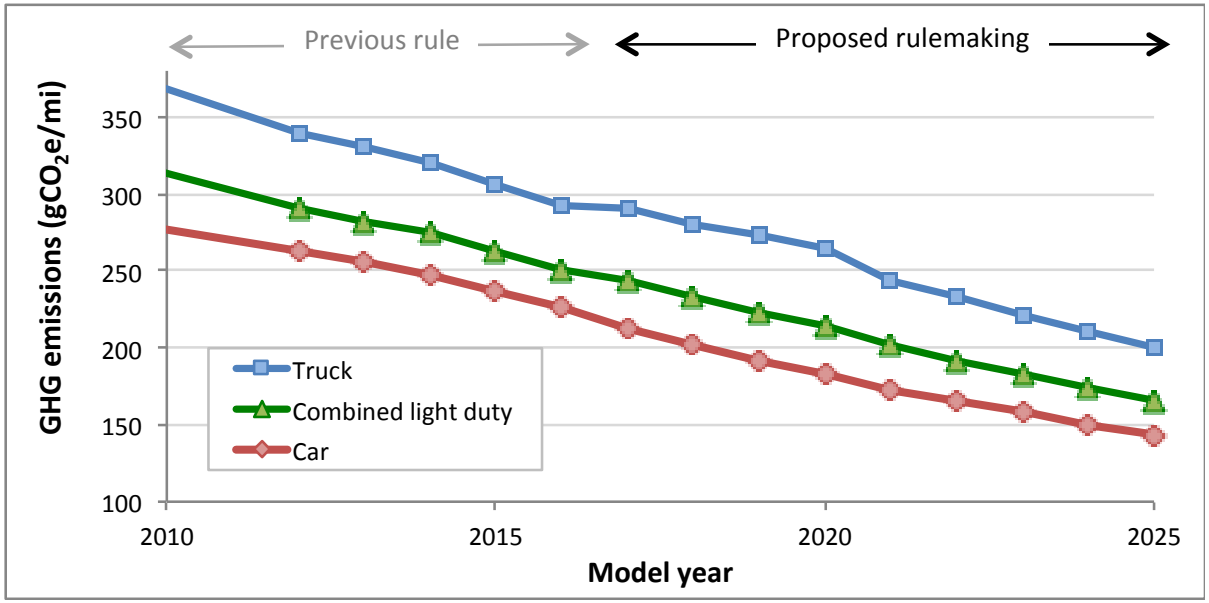
... harness market forces and utilize performance based policy

… bring science to policy

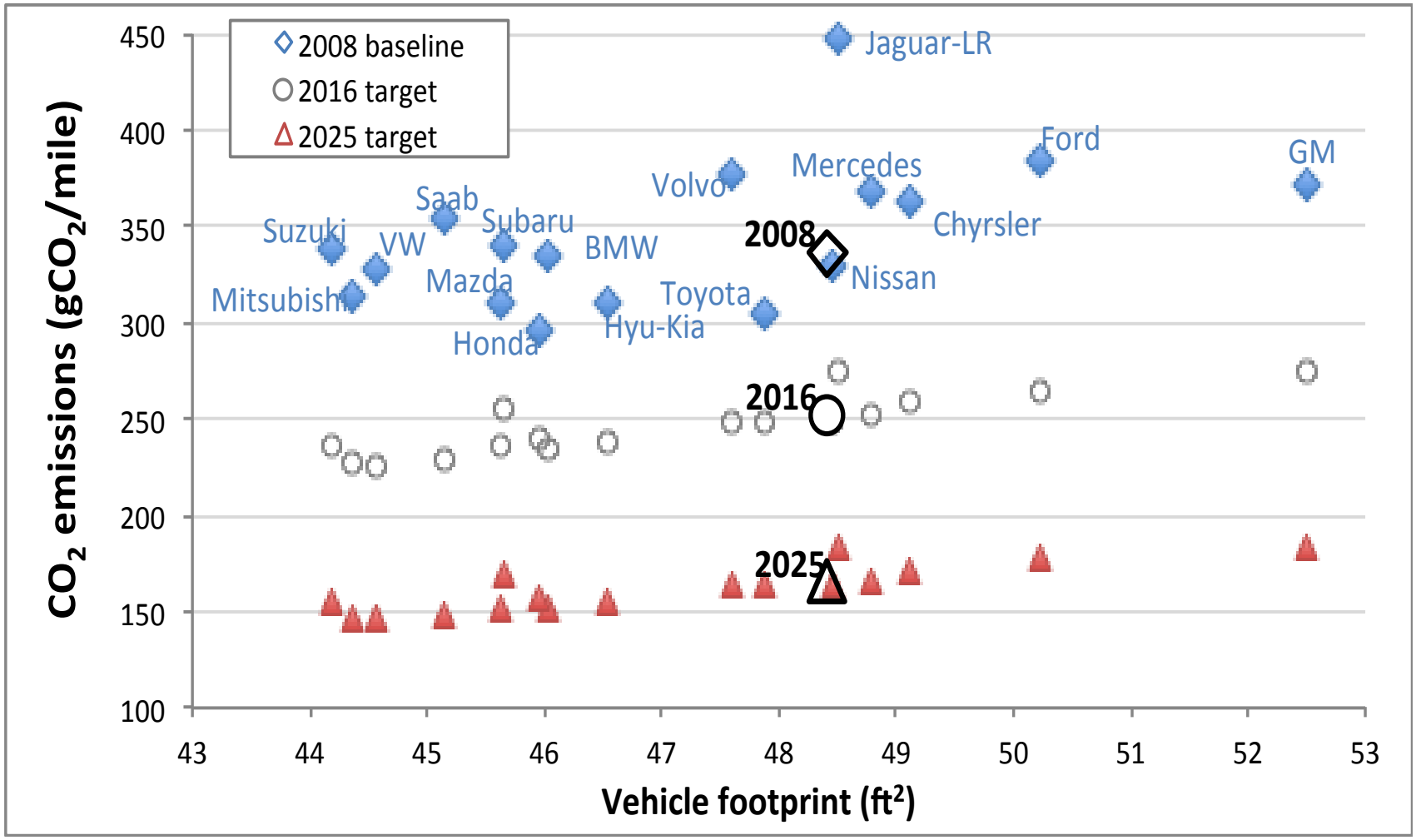
Energy Efficiency of Conventional Vehicles Will Continue to Improve



The 2008 fleet, the MY2012-2025 GHG standard targets



GHG targets by automaker

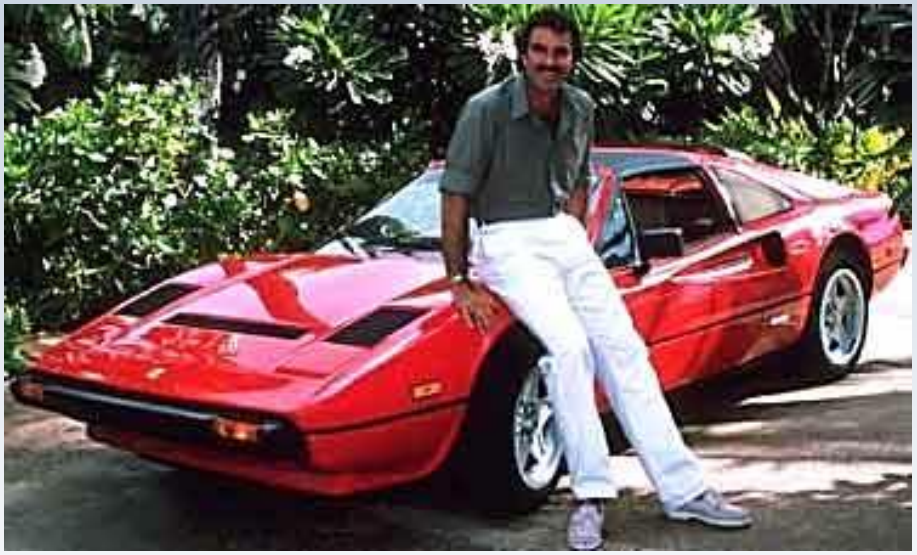


Horsepower Race Coming to End?

Toyota RAV4, 2008

7.3 seconds from 0-60 mph

Ferrari 308 GTS, 1984



7.3 seconds from 0-60 mph

Tom Selleck as Magnum, PI

Technology is central….. Vehicle efficiency will almost certainly improve dramatically in next few decades (even without EVs).

Proposed US GHG Standards for New Vehicles, 2017-2025

… reduce oil/GHG by 3-6%/year per vehicle-mile

Scenario (Improvement/year)	CO_2-eq g/mile	Reduction in CO_2-eq	~MPGe* (on-road)
2016	250	Baseline	28
3%	190	24%	37
6%	143	43%	50

*** Average of passenger vehicles, national fleet mix. MPGe assumes all reduction is from tailpipe.**

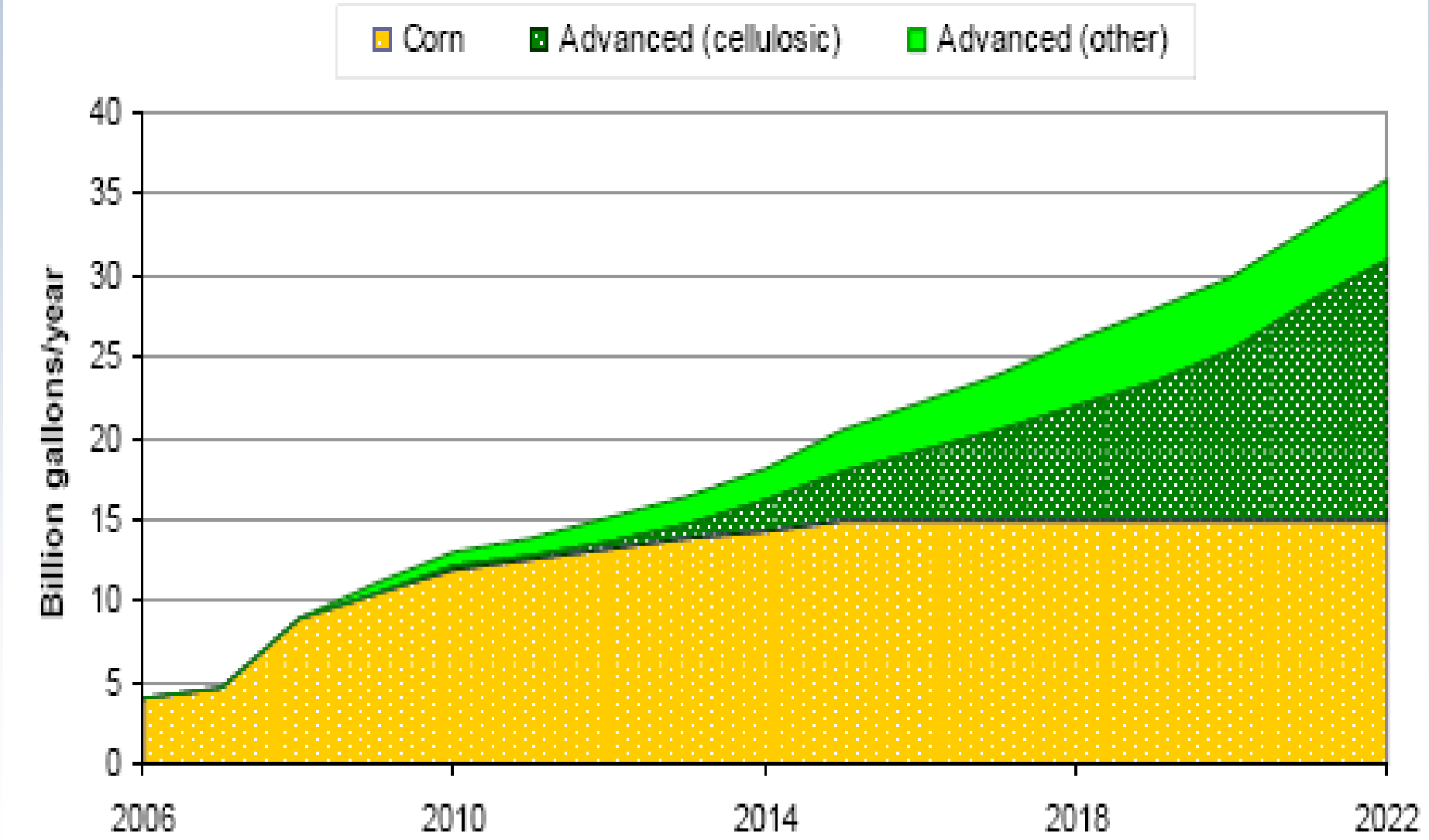
A few policy winners

- Bus Rapid Transit (Bogota, Jakarta, catching on elsewhere)
- Low-carbon vehicle policies (Japan, China)
- Improved NMT infrastructure and public bikes (Paris)
- Congestion Charging (London)

US Fuel Policy

- Biofuels mandate (“renewable fuel standard”) (adopted 2007)
  - 36 billion gallons (130 billion liters) by 2022
- **California (and EU): low carbon fuel standard,**
  - adopted 2009
  - 10% reduction in carbon intensity by 2020

US Requirements for Biofuels (EISA 2007)



California Low Carbon Fuel Standard (LCFS)

(similar to EU Fuel Quality Directive)

Most Promising Policy Approach to Transform Oil Industry?

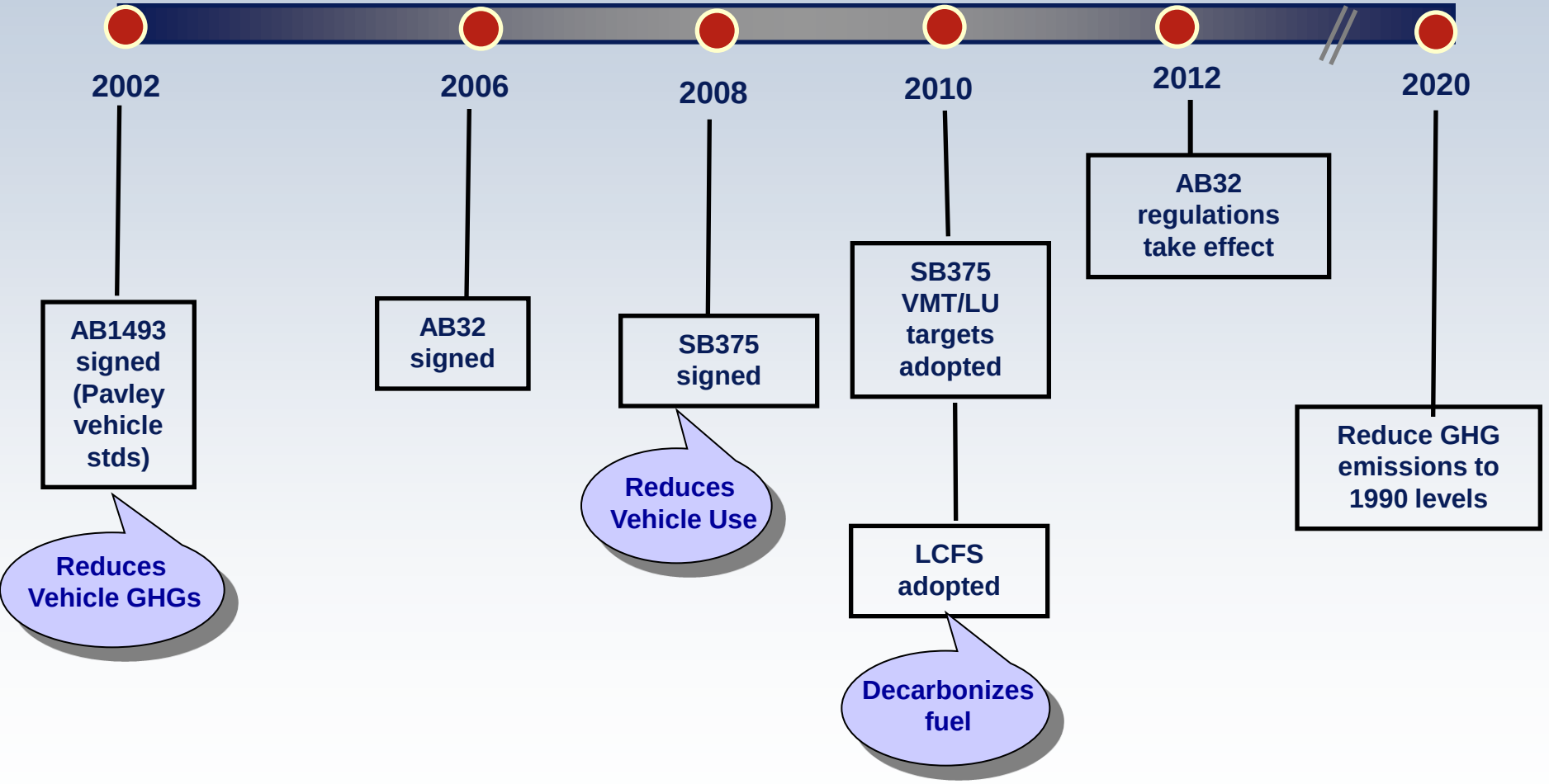
Policy Design

- 10% reduction in carbon intensity of transport fuels by 2020
- Oil refiners are point of regulation
- Allows credit trading (harness market forces)

Why Important and Good Policy?

- Not a mandate: Doesn't pick winners and includes all fuels
- Harnesses market forces (via tradable credit market)
- Stimulates innovation and investment
- Performance based
- Relies on lifecycle analysis (science based)

California's Leadership with (Transportation) Climate Policy



California Law to Reduce VMT and Sprawl (SB375)

- Imposes targets on cities to reduce land use sprawl and VMT via compact development, improved transit, and pricing
  - **GHG targets imposed on major cities (sept 2010):**
    - **2020: 7-8% reduction/capita (mostly via reduced VMT)**
    - **2035: 13-16% reduction/capita (mostly via reduced VMT)**

- Weak incentives so far (need to find way to financially reward cities)

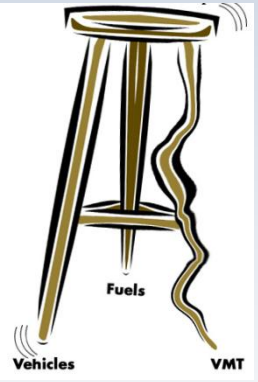
- Why good policy?
  - Provides performance-based mechanism for funding cities
  - Defers to local governments
  - Empowers local governments to do good planning and investment
    - Policies to reduce VMT and GHGs are aligned with good planning practices (generate large co-benefits:reduced infrastructure costs, healthy communities)

Policy model for rest of US and world?

California's Policy Model to Reduce Oil Use and GHGs

VEHICLES

- **GHG vehicle stds (cars) (US will soon adopt stds for heavy trucks)**
- ZEV requirements to overcome start-up barriers
- $ for PEVs and FCVs (Calif: $5000/veh; US: $7500/veh)



FUELS

- **Low carbon fuel standard (plus US biofuels mandate)**
- 33% renewable electricity stds for utilities (Sept 2010)
- Hydrogen fuel station requirements (proposed)

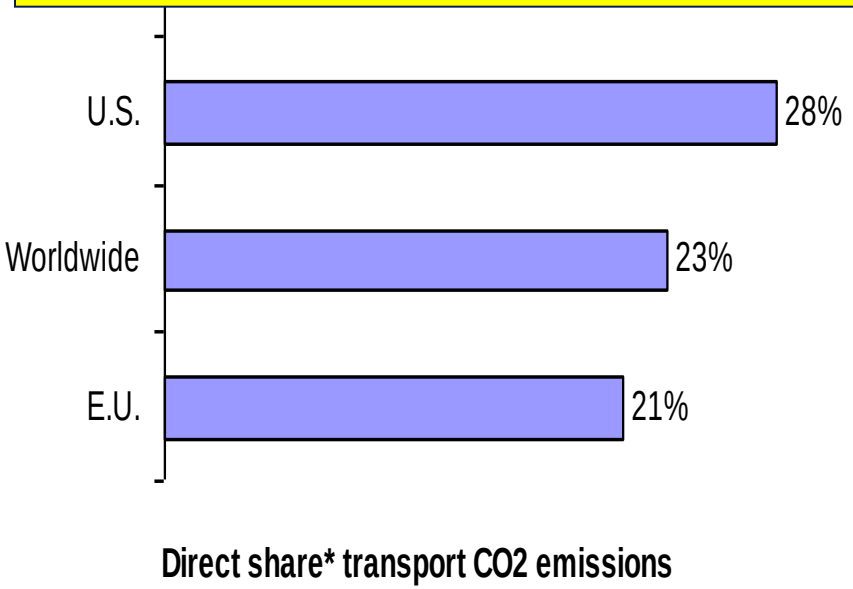
VMT and Infrastructure

- **Targets for reduced VMT and sprawl (SB375),**

Plus carbon cap and trade on vehicle fuels (Dec 2010)

Transportation Plays Large Role in Climate Change and Oil Security

Transportation accounts for ¼ of CO_2 emissions in world



Transportation accounts for 2/3 of oil in US and ½ in world

EIA, 2006

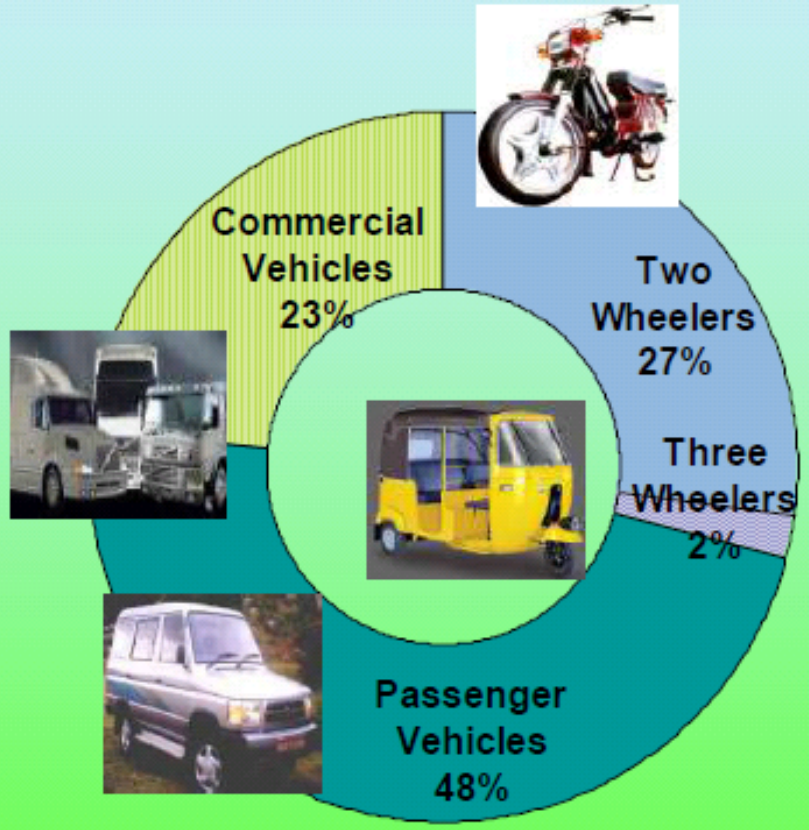
Indian Automotive Industry

- Estimated industry turnover 2009-10: USD 56 bn
- Exports account for 10% of vehicle production
- Around 5% of India's GDP
- Around 22% of manufacturing GDP and one of the highest contributors to State and Central Government finances
- Employment: Direct 600,000 people + 12.5 mn indirect
- Investments announced FY 08-12 : USD 19 billion
- Unique characteristics:
  - OEMs - Presence of strong local OEMs & Most global MNCs present
  - Building brand India
  - Establishing strong engineering and sourcing centers

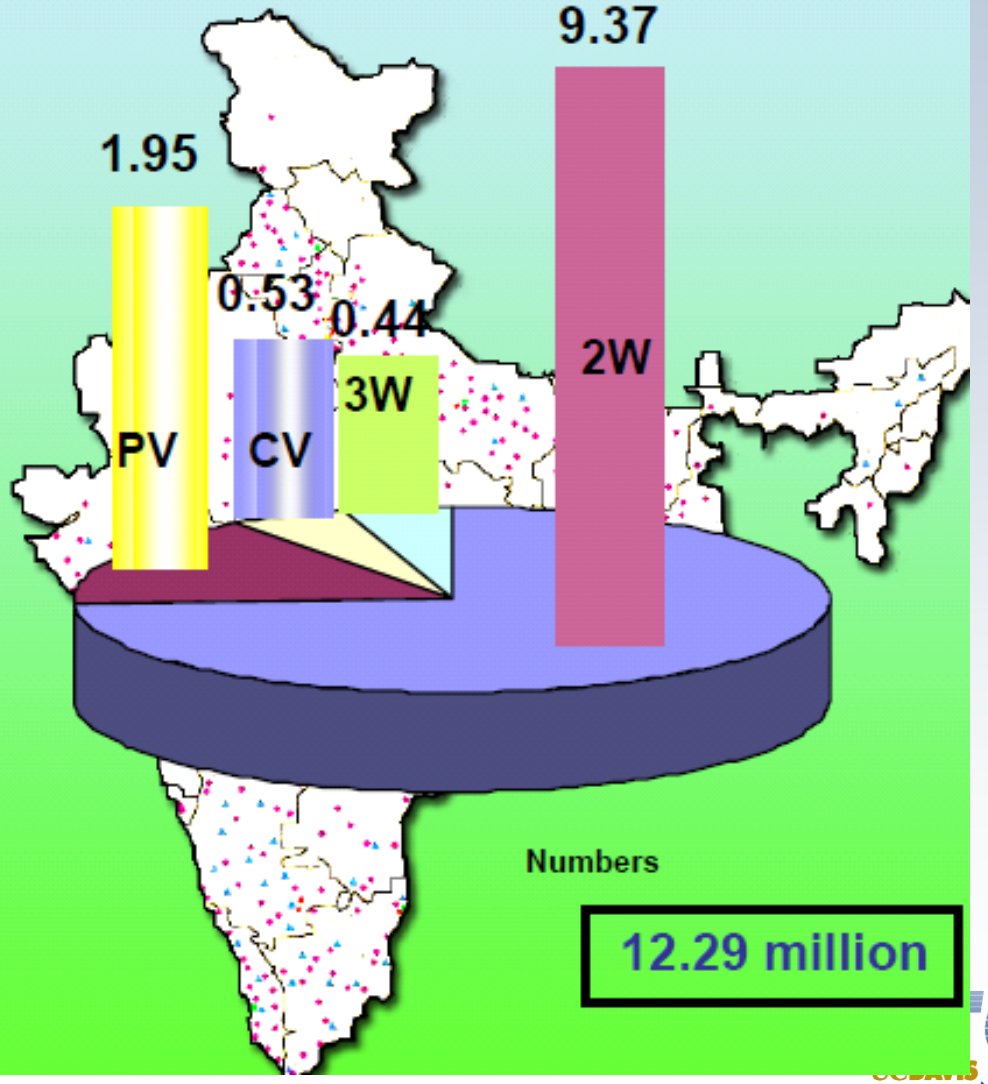
SIAM, 2010

ITS UCDAVIS

Auto Industry Today



% Share in Value



Numbers

12.29 million

SIAM Data 2009 -10

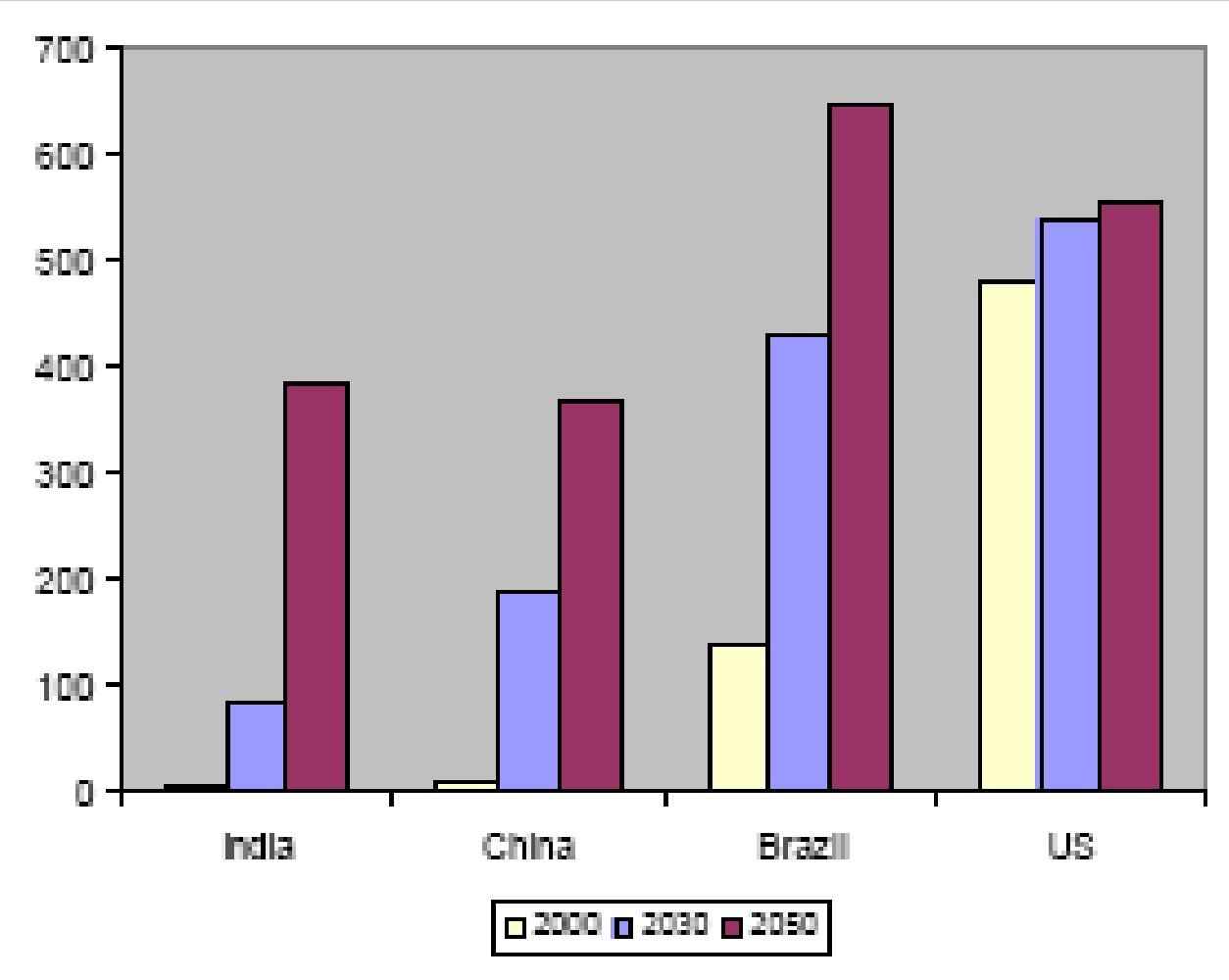
SIAM

City	Cars / 1000 people
Germany	565
France	480
US	453
Japan	451
Malaysia	271
South Korea	238
Mexico	145
Brazil	103
Thailand	57
Indonesia	18
Philippines	9
China	27
India	10

Source: WARDS, 2009; All figures for 2008

ITS UCDAVIS

Projected Car Ownership per 1000 people



The King Review of Low Carbon Cars, 2007

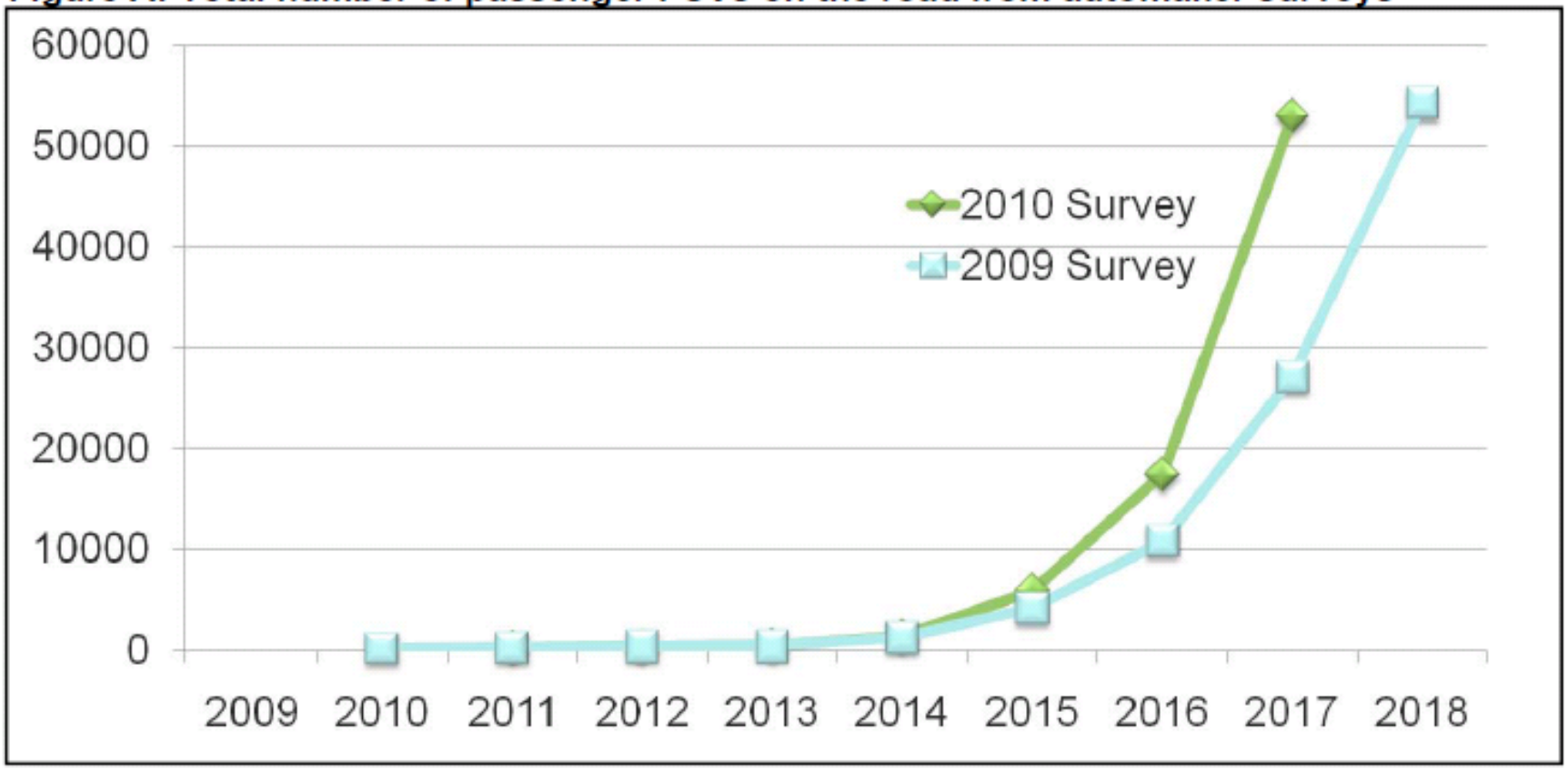
PEVs and FCVs show promise, though probably much slower than politicians/media suggest. Even so, battery and fuel cell technology is advancing rapidly.

Old Generation EVs

New Generation PEVs/FCVs (w/strong industry support)

Automaker Projections of FCVs on Road in world?!

Figure A: Total number of passenger FCVs on the road from automaker surveys



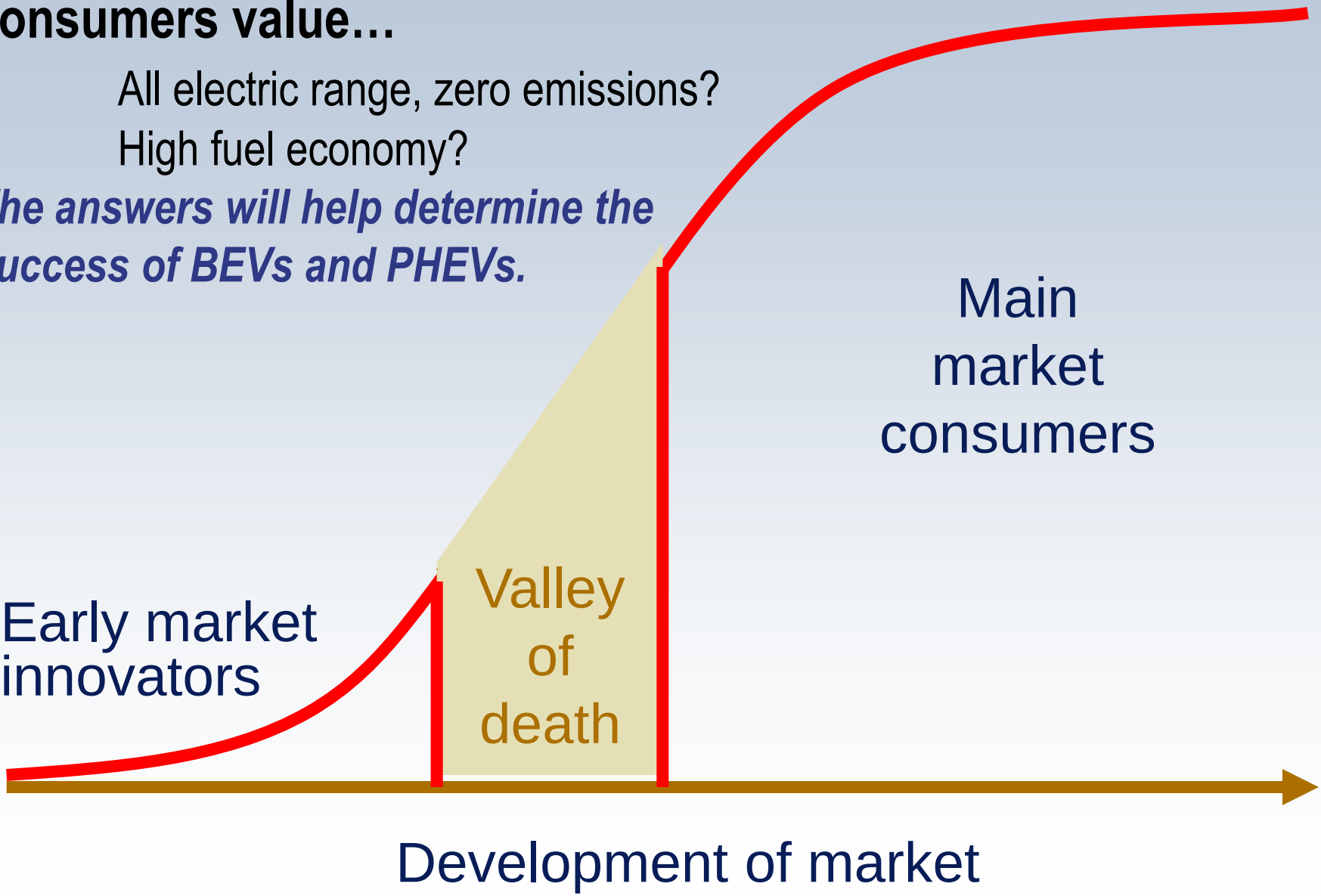
[3] Joint Fuel Cell Bus Workshop Summary Report,
http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/buswksp10_summary.pdf

Great uncertainty how market will evolve. How will consumers value…

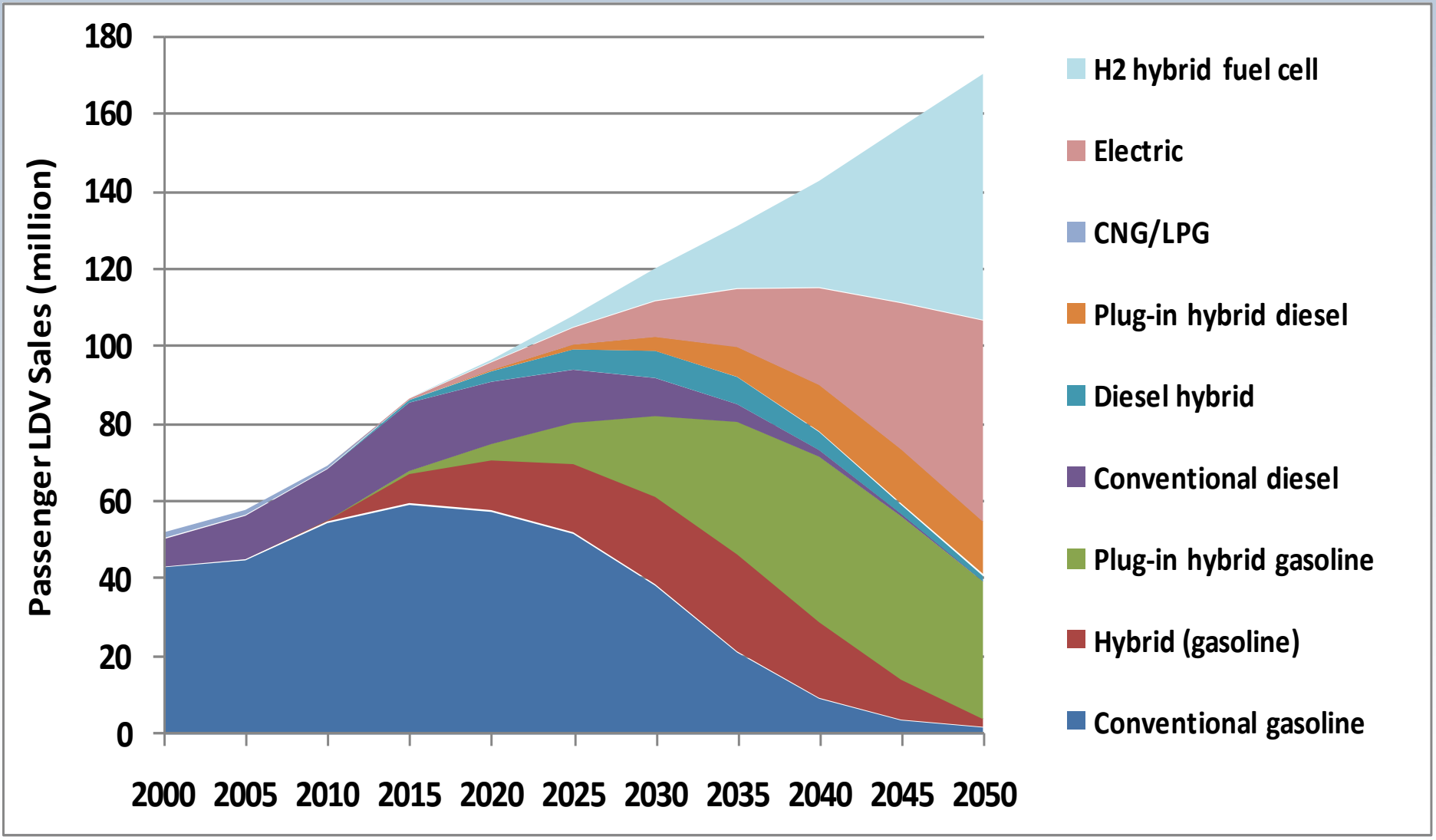
All electric range, zero emissions?

High fuel economy?

The answers will help determine the success of BEVs and PHEVs.



IEA Aggressive CO_2 Scenario… Almost All Cars are Electric-Drive in 2050

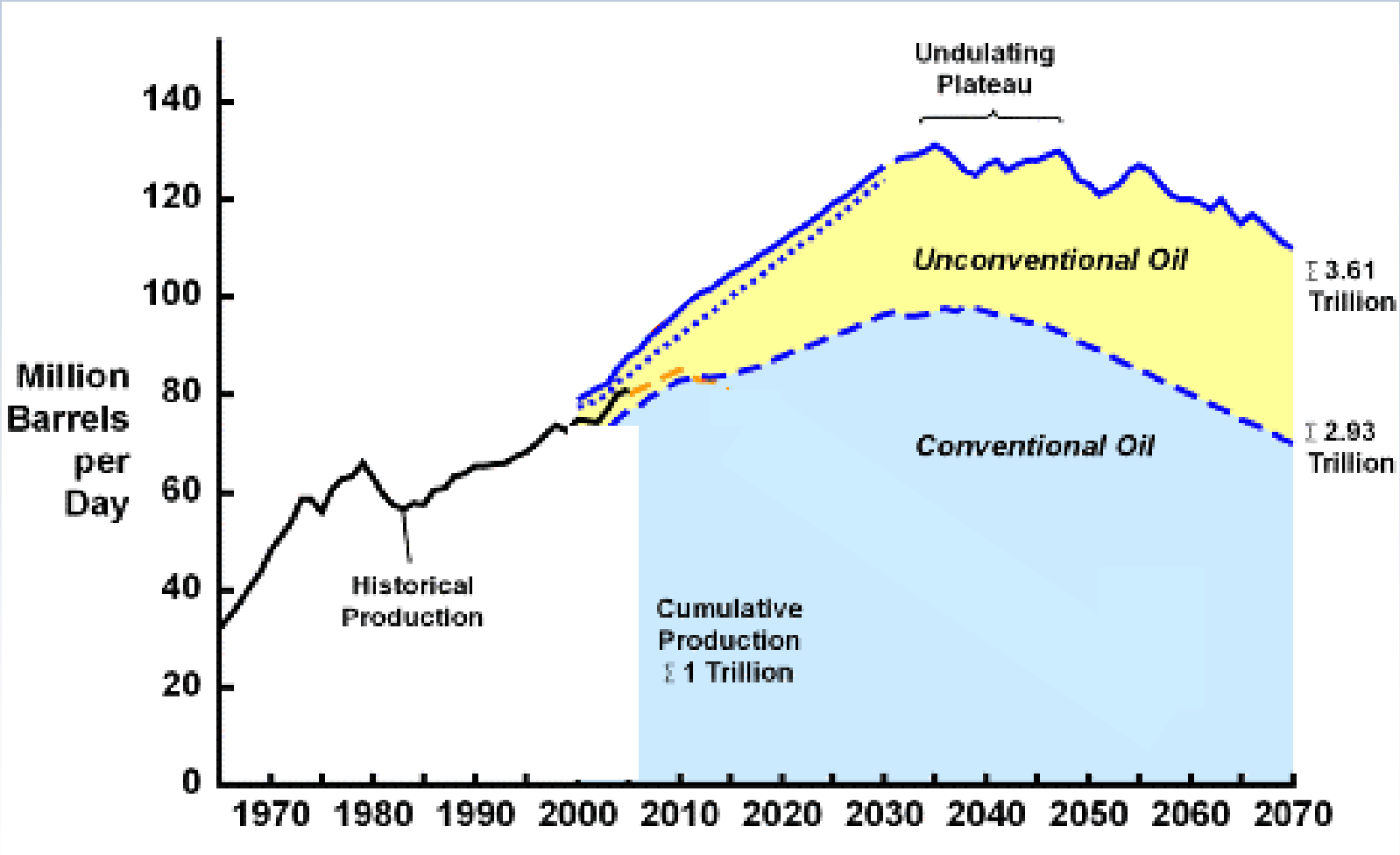


IEA, 2009 (blue map scenario: 50% reduction in CO2-e emissions by 2050)

Rural vehicles for rural devt

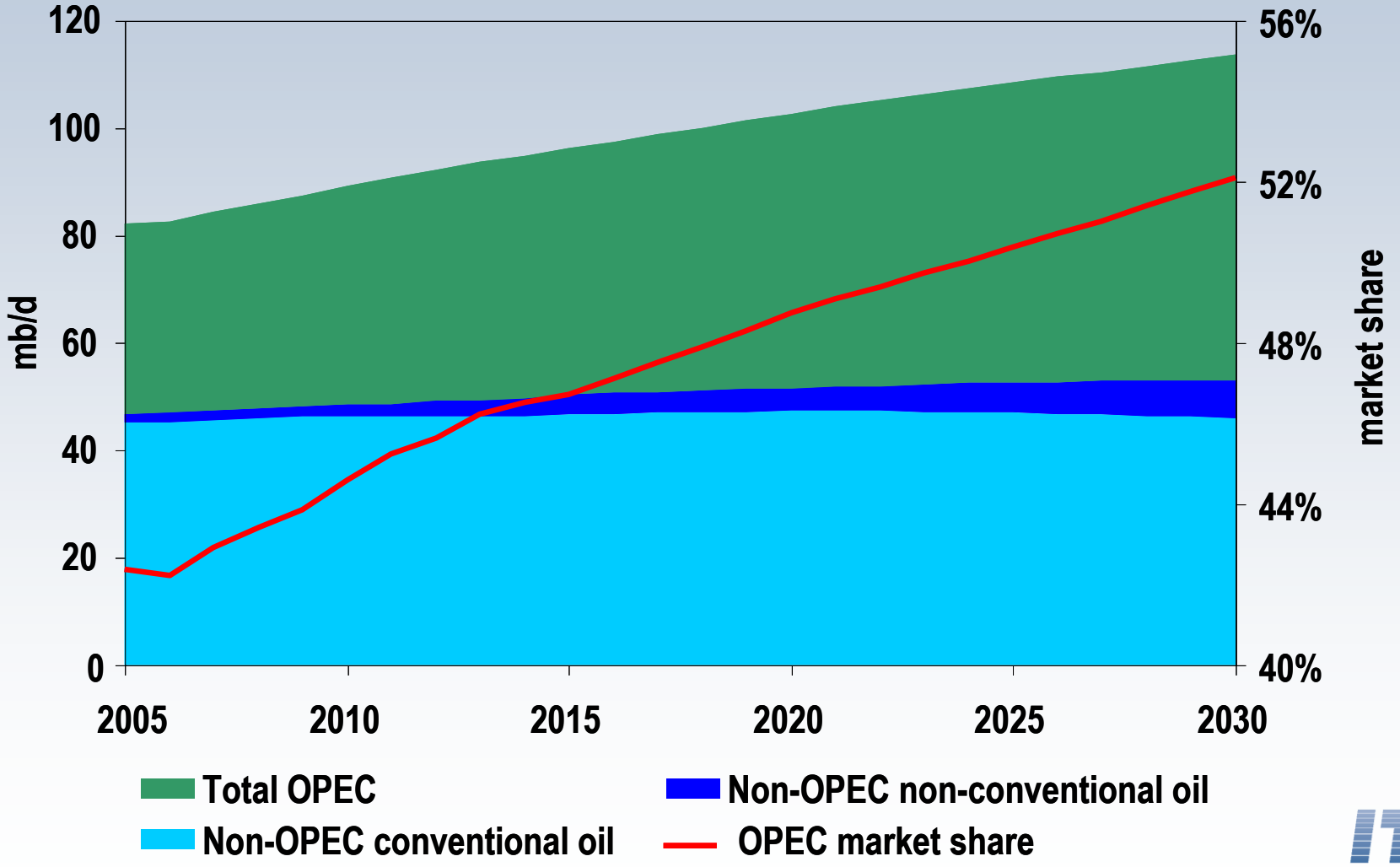
Problem #1: Oil Supply "Inadequate"?

How Will 2 Billion Cars Be Fueled?



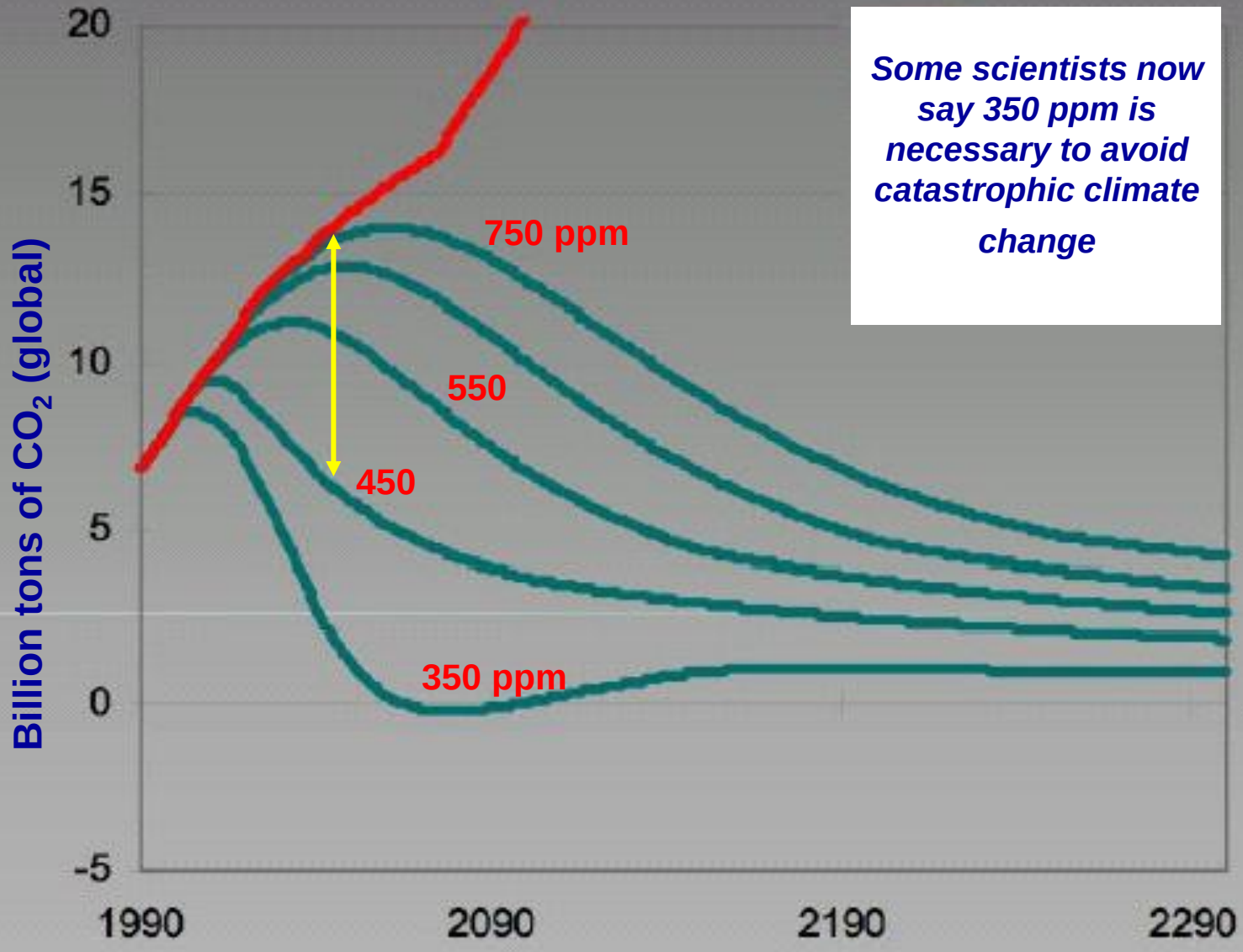
Source: Cambridge Energy Research Associates, 2006 (in Sperling and Gordon, *2 Billion Cars*, 2009).

Problem #2: Middle East Gaining More Control of Oil Production



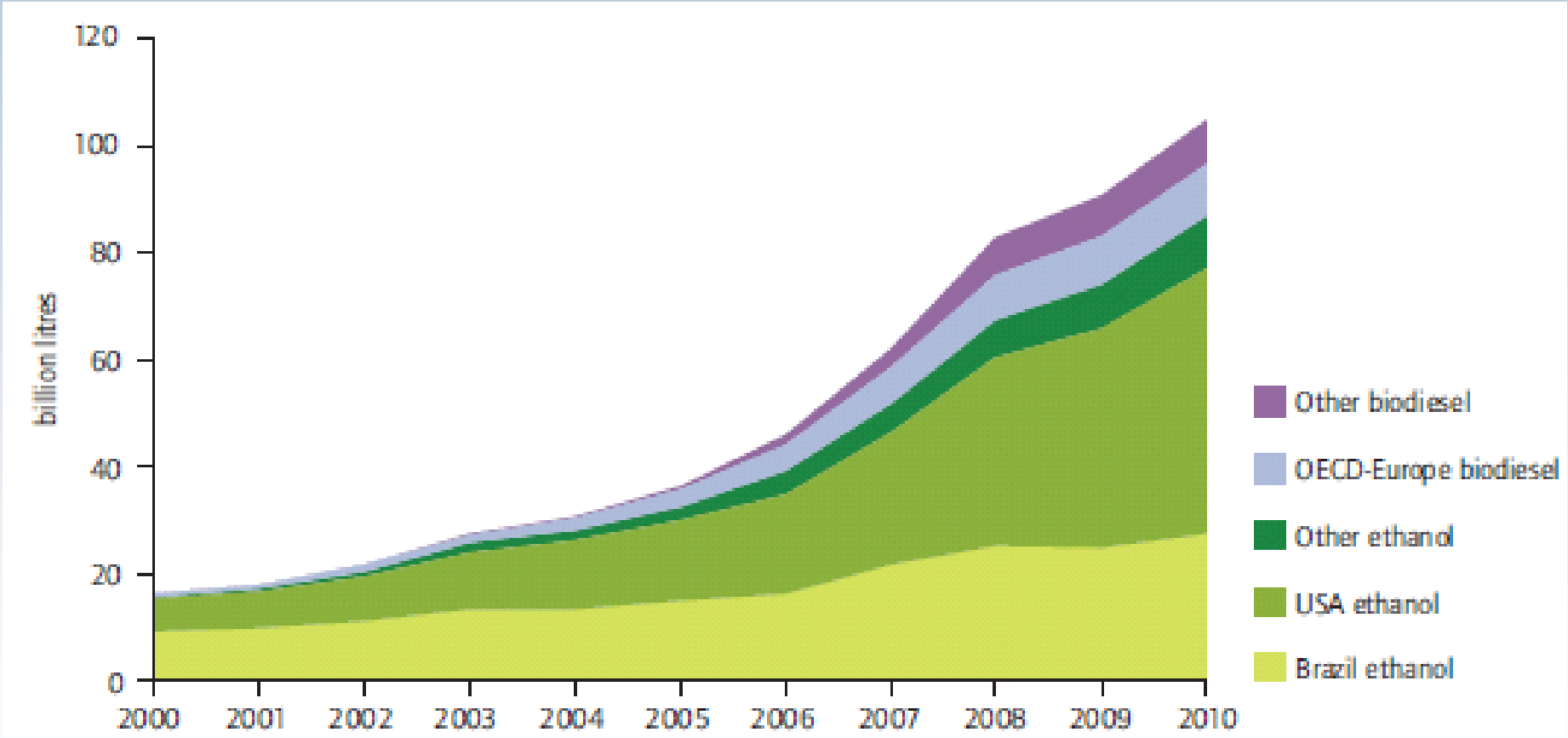
Source: IEA reference scenario

Problem #3: Climate Change



Some scientists now say 350 ppm is necessary to avoid catastrophic climate change

World Biofuel Production



IEA, 2011

Mode choice as function of Income