
# Sustainable Transport for Developing Countries: Scenarios for India

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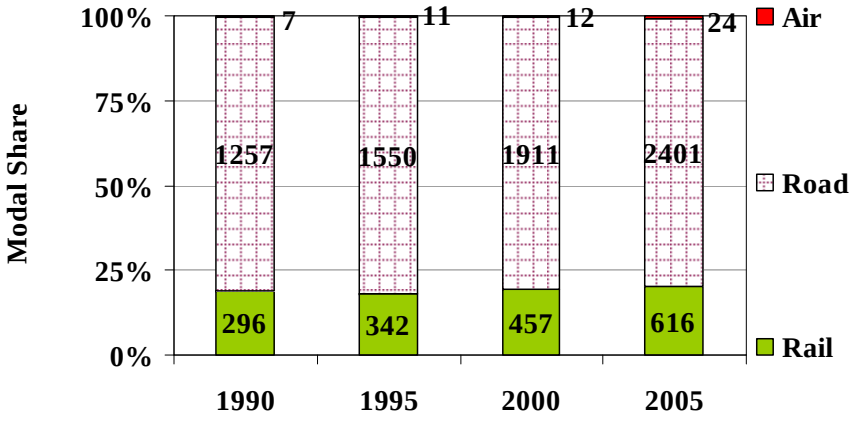
# Introduction

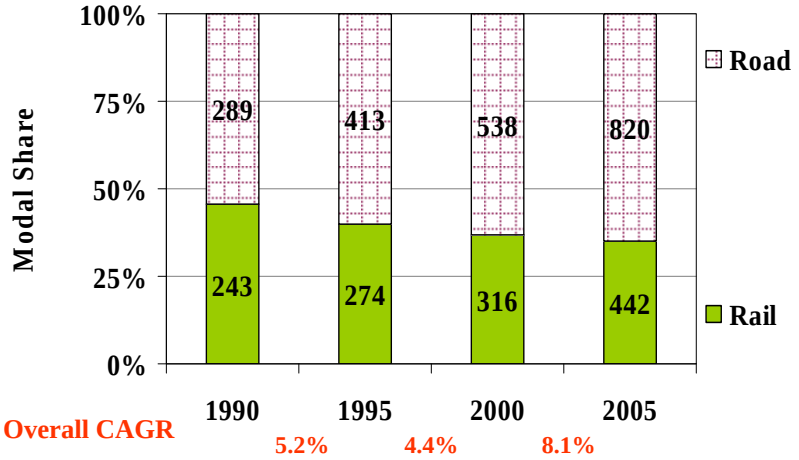
- Transport Challenges
  - Major Energy consumer and $CO_2$ emitter (IEA, 2008)
  - Increasing share of energy and $CO_2$ emissions (IEA, 2008)
  - Resilient to energy prices (Hughes et. al., 2006) and carbon prices (Fenhann, 2008)
- Transport & Developing Countries
  - Strong bi directional linkages between transport and development
  - Transport causing local externalities in the form of air pollution, accidents and congestion.
  - Largest increase in energy demand and $CO_2$ emissions in future to come from transport sector to originate from developing countries

# Indian Transport System – A Snapshot

**Domestic Passenger Traffic (Billion PKM)**




**Domestic Freight Traffic (Billion TKM)**




## Energy Demand from Transport (Mtoe)

| | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|
| Gasoline | 3.79 | 5.01 | 7.08 | 9.25 |
| Diesel | 19.47 | 29.02 | 23.02 | 23.59 |
| Natural Gas | | | | 0.72 |
| | 23.26 | 34.02 | 30.09 | 33.56 |

**Faster growth in cars / 2 wheelers as compared to buses**

## Road Networks ('000 kms)

40% Traffic

| | 1990 | 1995 | 2000 | 2005 |
|---|---|---|---|---|
| National Highways | 33 | 34 | 52 | 67 |
| State Highways | 124 | 134 | 133 | 128 |
| Other Roads | 1826 | 2899 | 2231 | 3120 |

# Transport Infrastructures

- National Highway Development Programme
- Dedicated Rail Freight Corridors (DRFC)
- Metros – Delhi, Mumbai, Hyderabad, Bangalore, Ahmedabad
- Bus Rapid Transit System – Delhi, Ahmedabad, Surat

- Unresolved debates around
  - BRTS Vs Metro
  - DRFC Vs Road

Bus Rapid Transport System


Metro Rail

# Research Question

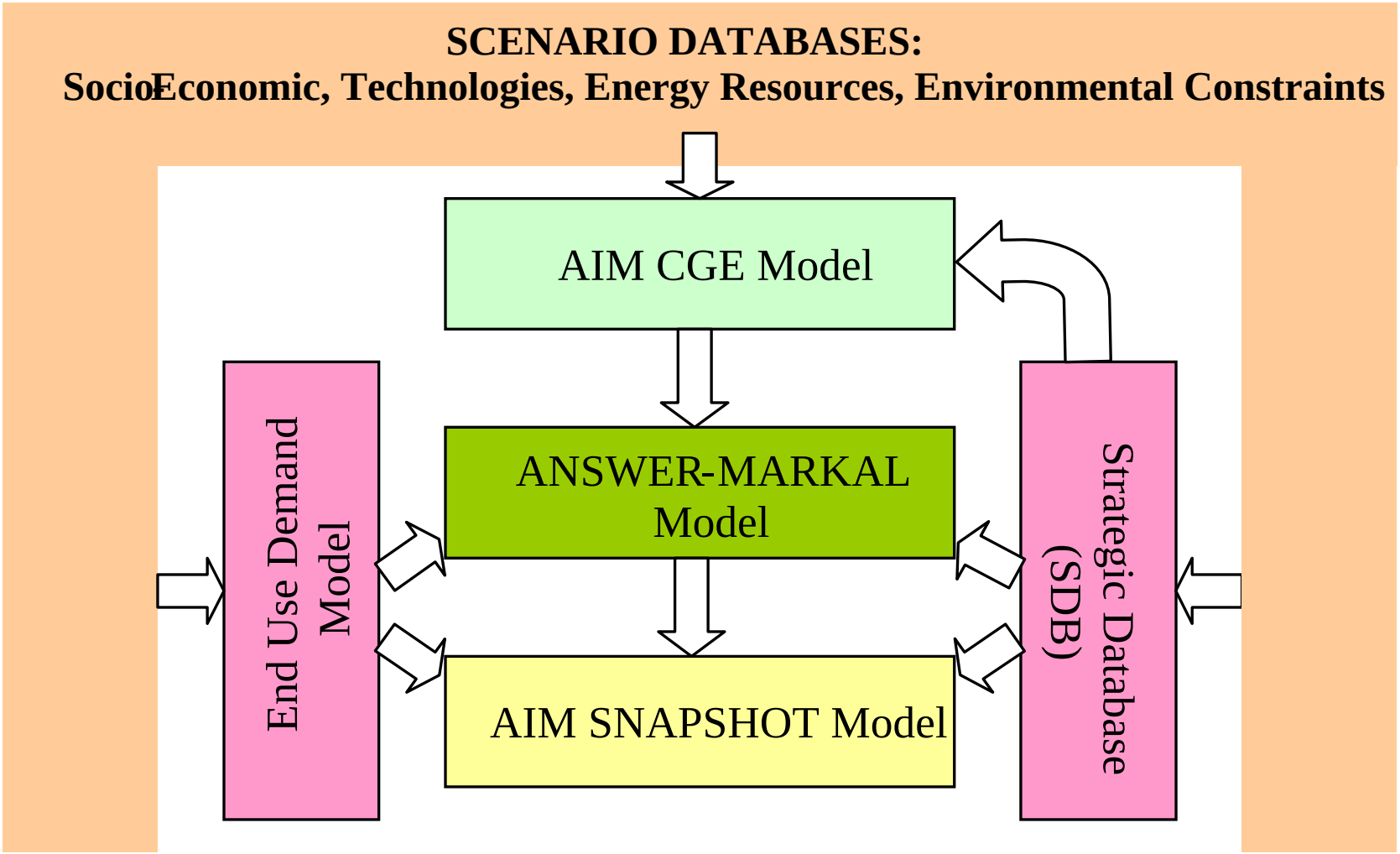
- What would be the modal and technology choices in a carbon constrained world?
- What would be the sustainability impacts of these choices?

# Research Gaps

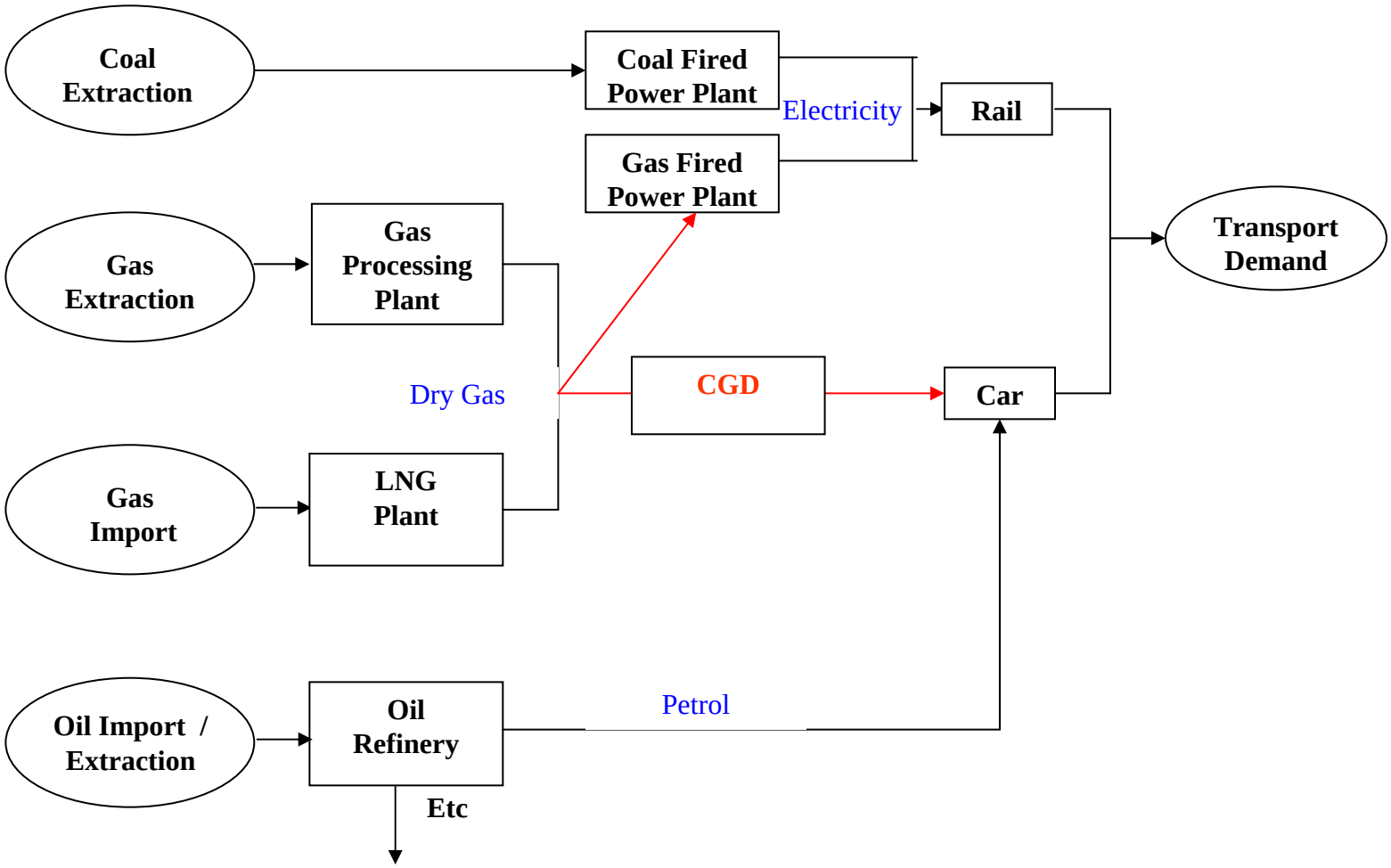
- Future mobility and modal choices (Schafer & Victor, 2000)
- Technology choices under a carbon constrained world (Turton, 2006; Turton & Moura, 2008; Lund & Lempton, 2008)
- Modal Choice and Urban Form (Grazi et. al., 2008, Cervero & Kockelman, 1997)
- Integrated evaluation of modal choices under a carbon constraint
- Plus incorporation of sustainability impacts – congestion, accidents,

# Model

# Model Framework



# Reference Energy System



# Model Extensions

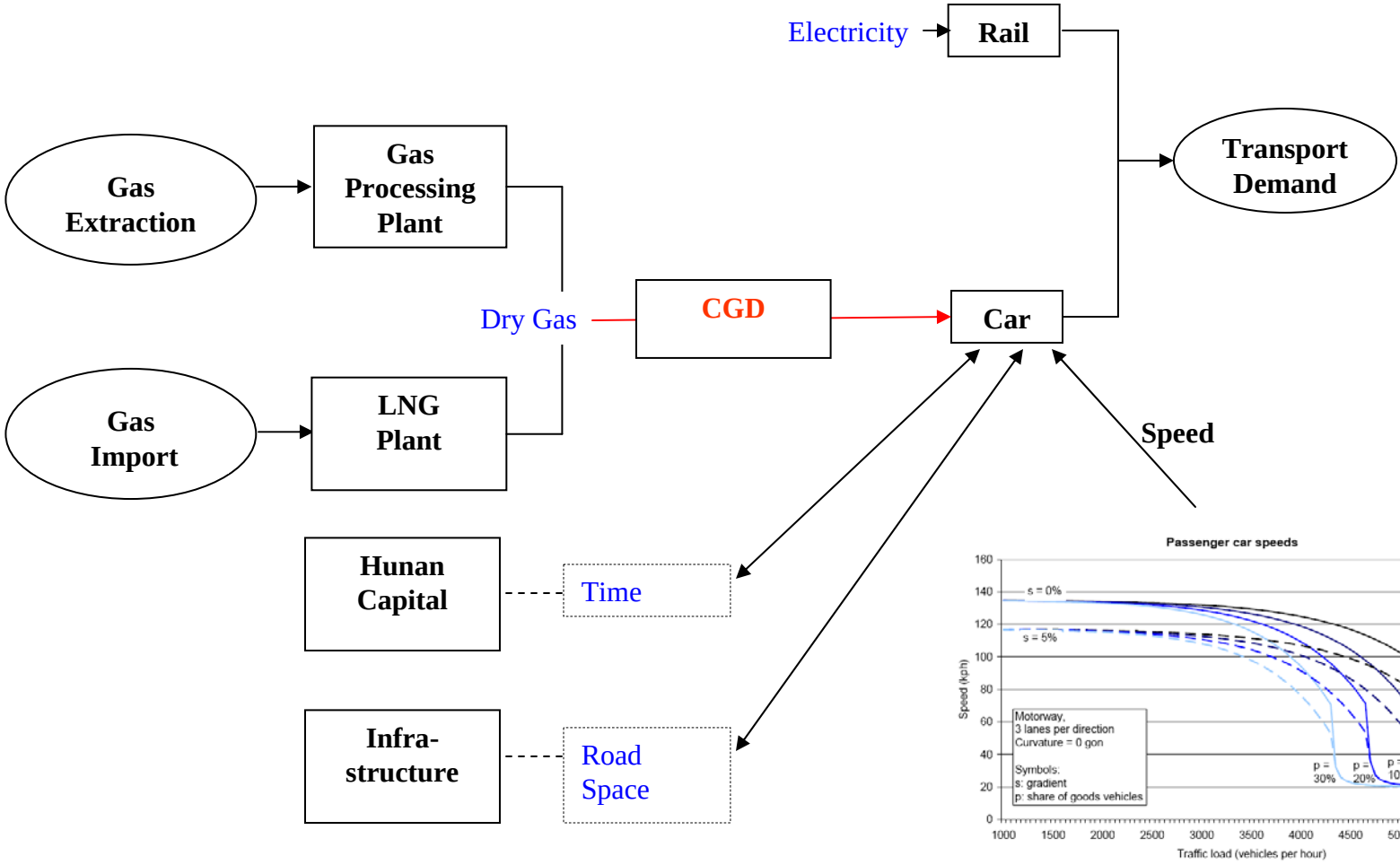
- Technology Choice ignores value of Individual Time
- Sustainability Impacts - Limited to internalization of air pollution, climate change and user charges
- Introduce congestion, accident and infrastructures in the model
- Congestion has the highest costs (Maibach et. al., 2008)

**Possible impact of transportation systems on sustainability**

| Economic impacts | Social impacts | Environmental impacts |
|---|---|---|
| Congestion | inequity of impacts | air pollution |
| Barriers to mobility | mobility disadvantaged | climate change |
| Accident damages | Human health impacts | water pollution |
| Facility cost | community cohesion | Noise |
| Users' costs | community livability | habitat damage and loss |
| Depletion of non-renewable resources | Aesthetic | |

Source: Adapted from Litman, 2003

# Reference Energy System : Sustainable



# Scenarios

# Base Scenario: Assumptions

**1. GDP**

- **Ann. Growth Rate: 7.2% from 2005-50 (2050 Economy: 23 times larger than 2005)**

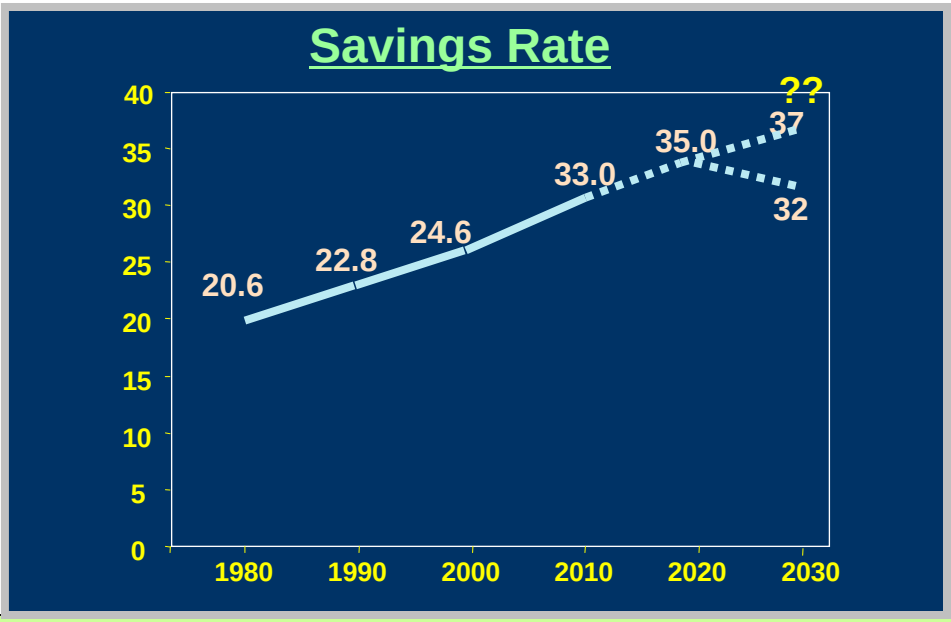
**2. Population**

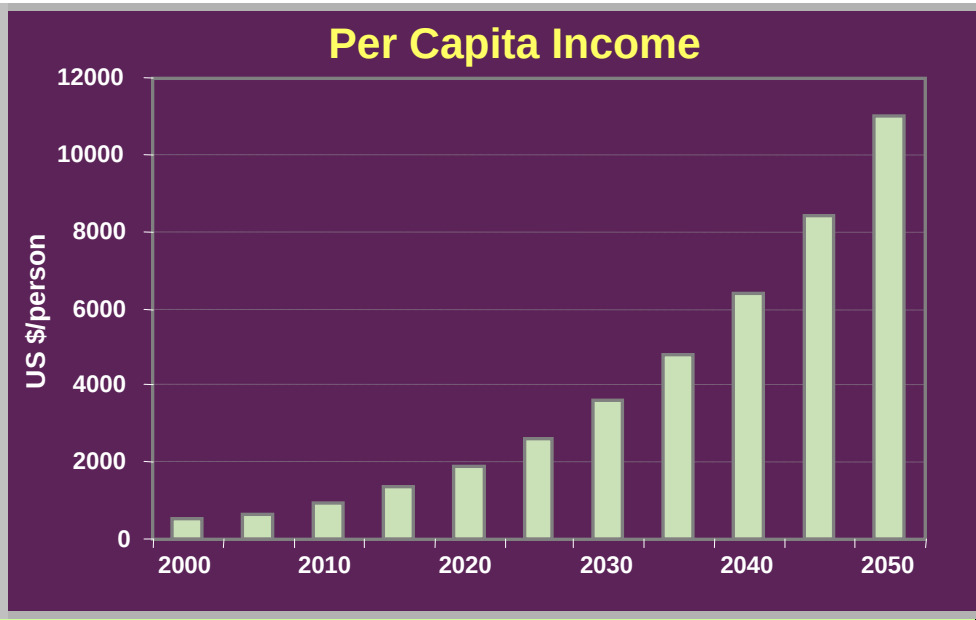
- **Grows from 1021 Million in 2000 to 1593 Million in 2050**

**3. Carbon Regime**

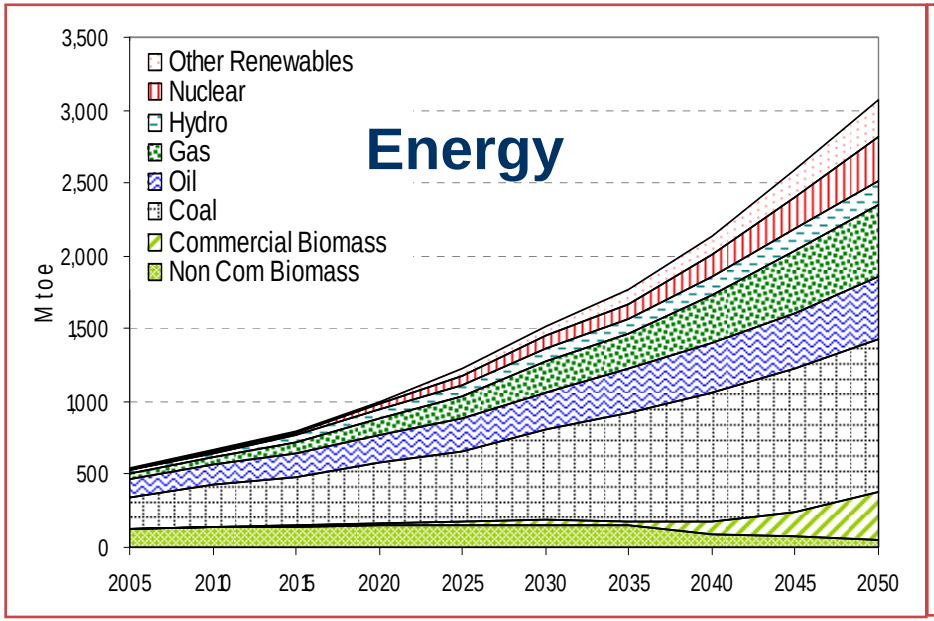
- **650 ppmv $CO_2e$ Concentration**

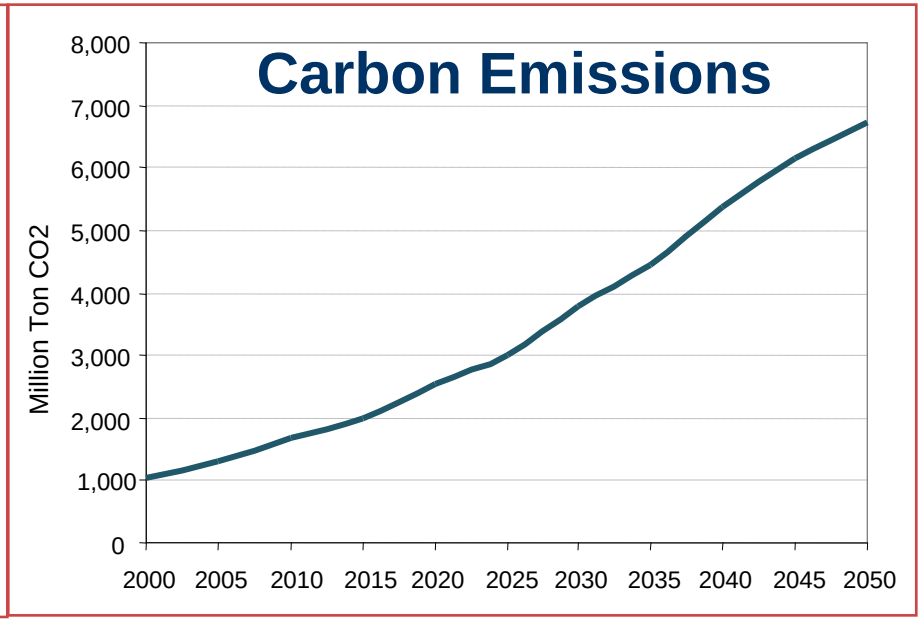
**4. Transport – No internalization of congestion, accidents and road cost**



# Energy and Carbon: Base Case




## Results: Energy and Carbon Intensity

**Annual Improvement From 2005-2050:**

**Energy Intensity: 3.14 (%)**

**Carbon Intensity: 3.07 (%)**

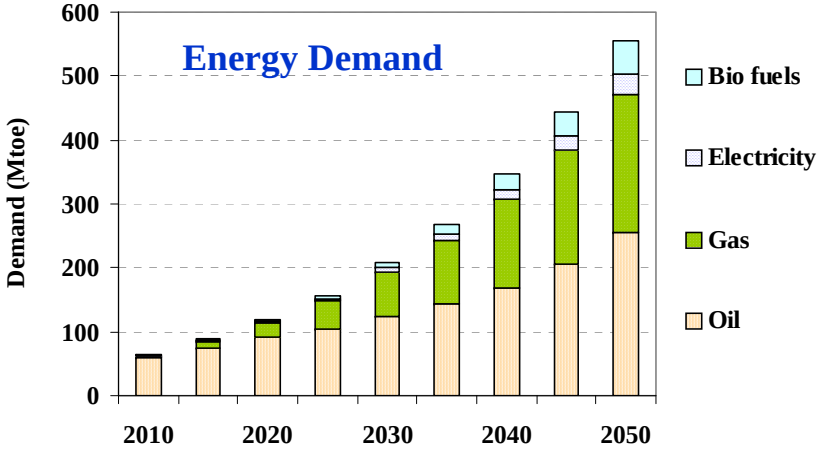
**Decarbonization of Energy: -0.07 (%)**

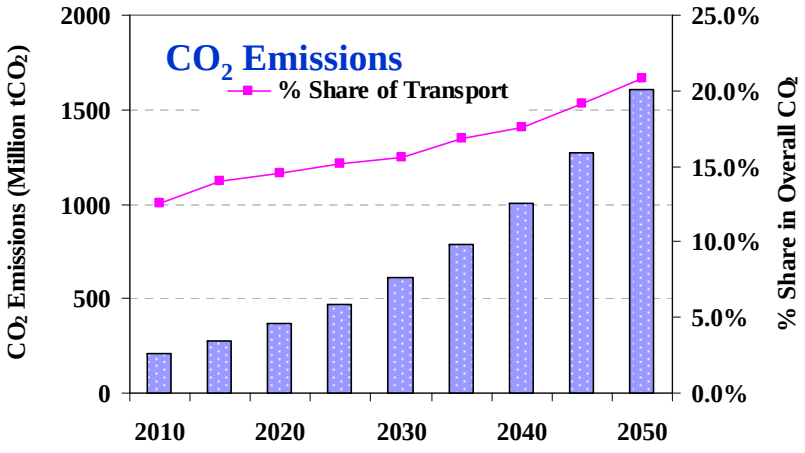
**Direct Investment in Energy Projects:**

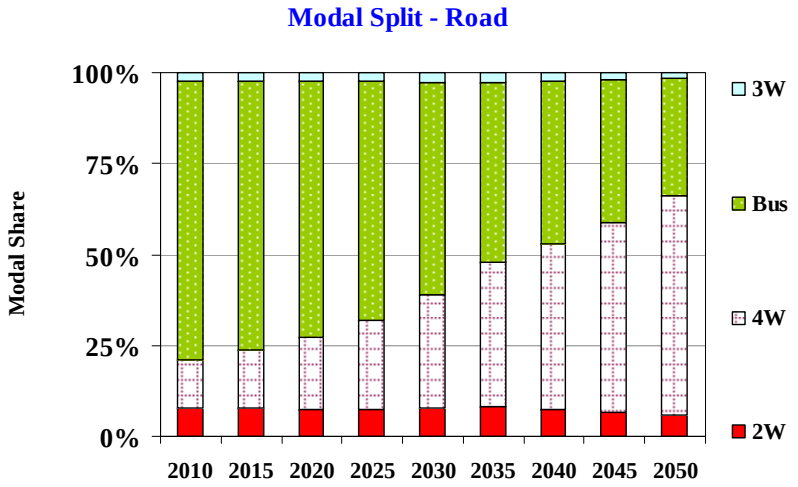
**2010-30: US$ 1.2 Trillion**

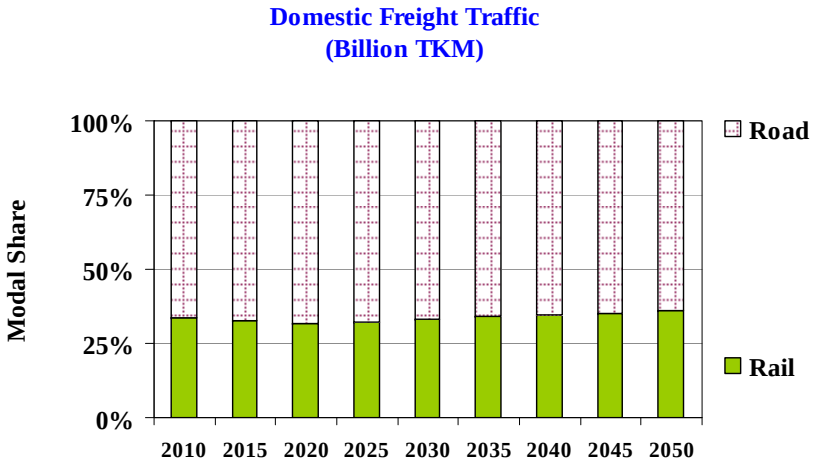
**2030-50: US$ 2.3 Trillion**

# Results Transport: Base Case



# Stabilization Target and Visions

1. **Global Stabilization Target Assumption:**
   - **550 ppmv $CO_2$e Concentration (3$^o$ C temperature increase)**
   - **450 ppmv $CO_2$e Concentration (2$^o$ C temperature increase)**
2. **Two Development Pathways for India:**

   **(with same total $CO_2$ emissions from 2005 to 2050)**

   1. **Conventional Vision: Climate Actions at Margin of Conventional Development path**
   2. **'Sustainability' Vision: Aligning Climate Actions with Mainstream Development Actions**

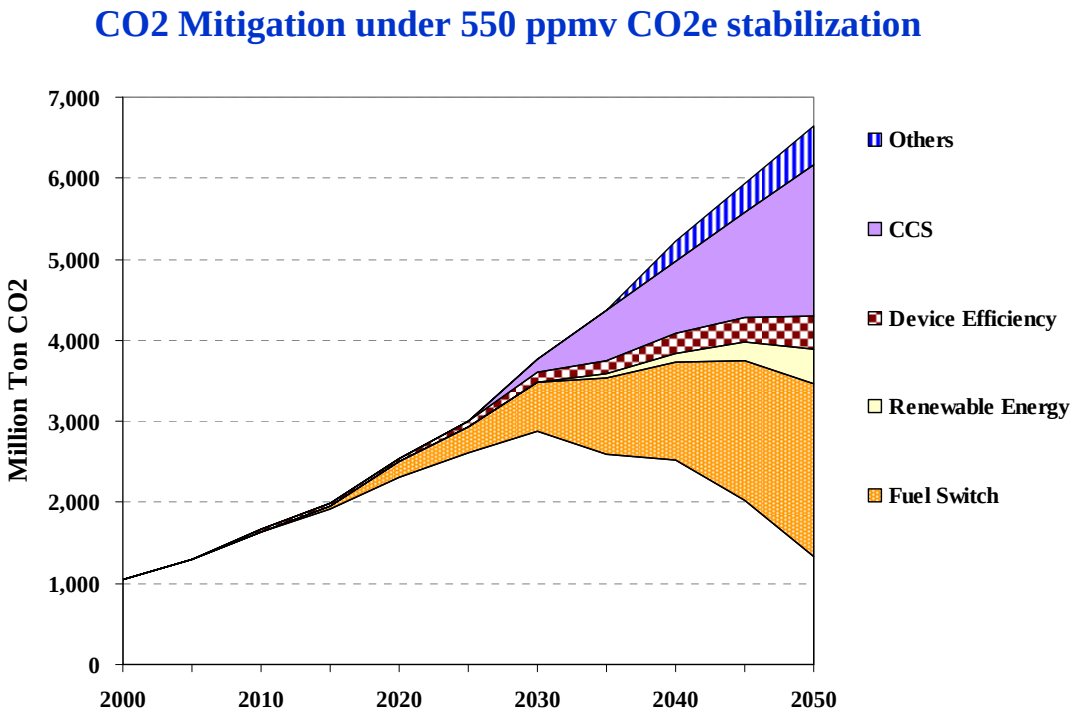
# Managing Climate via Conventional Vision

## Policy Drivers

1. Top-down/Supply-side actions
2. High Carbon Price as main instrument
3. Climate Focused Technology Push

## Transport Sector Impacts

1. Minimal
2. Some fuel switching towards Bio fuels and Natural Gas
3. Fuel Efficiency

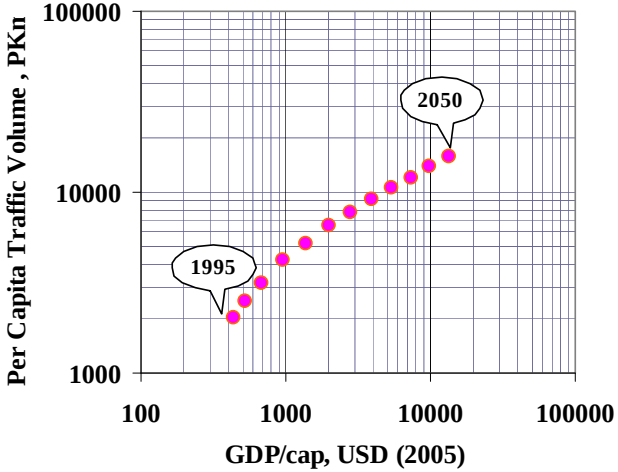


# Sustainable Interventions: Transport

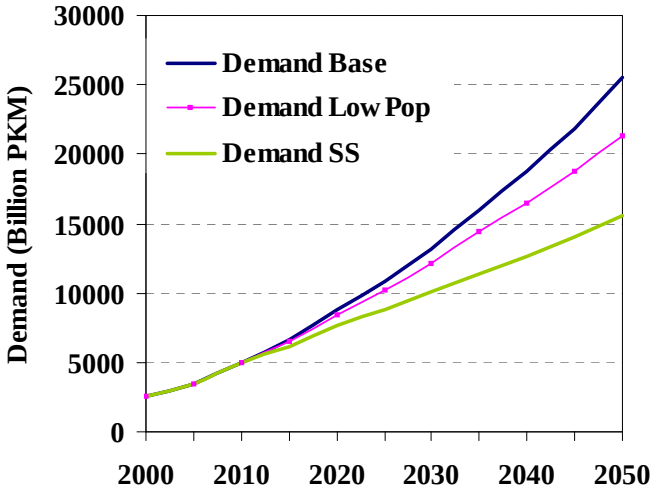
# Demand Interventions

- Demand Reduction
  - Lower Population in Sustainable world
  - Lower Per Capita Demand due to urban planning, substitution of travel by communication & IT. It is assumed that Indian demand would towards world average

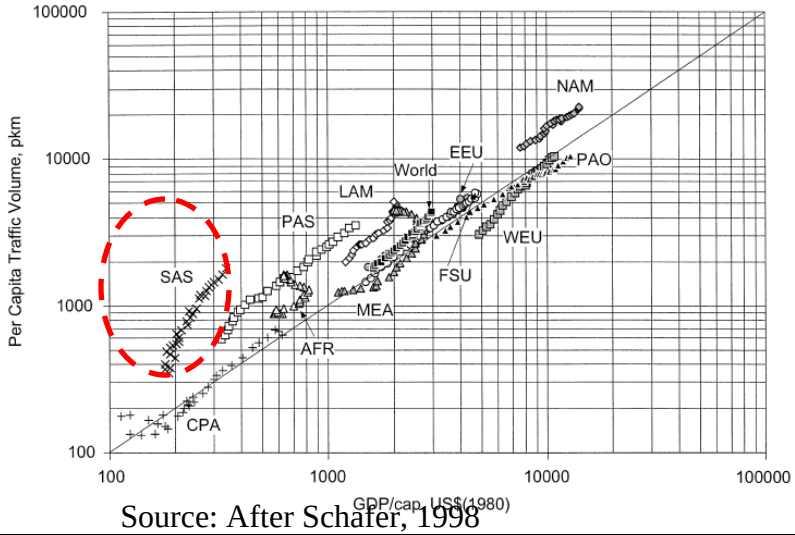
**Per Capita Mobility (Base Case)**




**Aggregate Passenger Demand**




**Per Capita Mobility World**




Source: After Schafer, 1998

# Internalization of Congestion

## Price of Road Space

- National Highways (NH) take 40% of traffic and have just 2% road area (GoI, 2008)
- Road up gradation to 4 lanes for GQ, NS, EW (~ 20% of NH) under National Highway Development project.
- Funded by a cess of Rs. 2 per litre of Diesel and Petrol and tolls
- Peak Traffic ~ 126 PCU per km when speed 60 km/hr →Rs 0.36 Million per PCU (46 Million for building one km of a four lane road)

## Value of Time

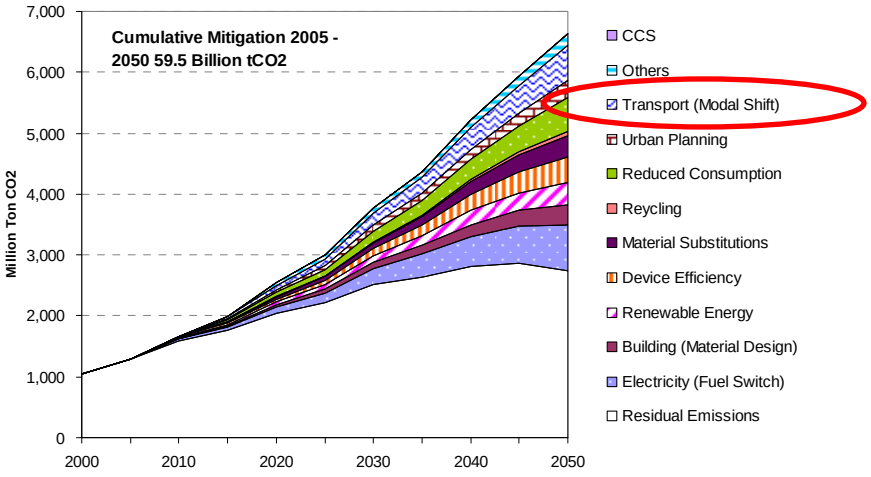
- Indians travel more than world average of 1.1 hrs / day. In cities average travel time as high as 3 hrs (Pucher et. al., 2005)
- High Income inequlaity. A quarter of population can not afford even public transport and just walk spending as high as 4 – 5 hrs on travel (Pucher et. al., 2005)
- Therefore half of per capita income assumed

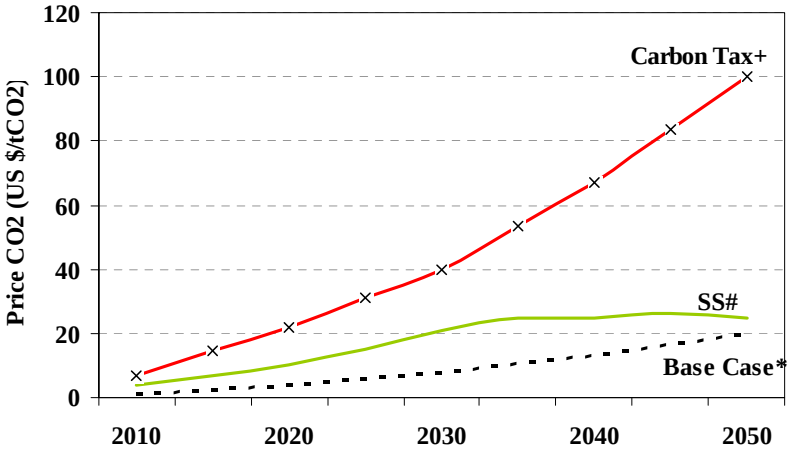
## Traffic Scenario – Year 2005

| | Unit | 2 W | 4 W | Bus | Truck | Other |
|---|---|---|---|---|---|---|
| Population | Million | **51.9** | **9.5** | **0.8** | **3.7** | **6.8** |
| Utilization | tKm/pa | **3.5** | **8** | **65** | **44** | **8** |
| All India Traffic | BV Km/pa | **182** | **76** | **50** | **165** | **55** |
| NH Traffic (40%) | BV Km/pa | **17** | **30** | **30** | **115** | **22** |
| Road Space | PCU | **0.5** | **1.0** | **3.0** | **3.0** | **2.0** |
| Traffic Density | Veh. /day | **1378** | **3151** | **3121** | **12032** | **2277** |
| Traffic Peak | Veh./ km | **3.4** | **7.9** | **7.8** | **30.1** | **5.7** |

# 550 PPMV with Sustainability

- Transport Sector and modal switching important for a low carbon society with sustainability transition
- Brings down the cost of achieving 550 ppmv and essential for a more stringent 450 ppmv target
- Sustainability impacts and their sensitivity however not known



# Thanks

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