






# Developing Low Carbon Cities in Asia: A Study of Bhopal, India

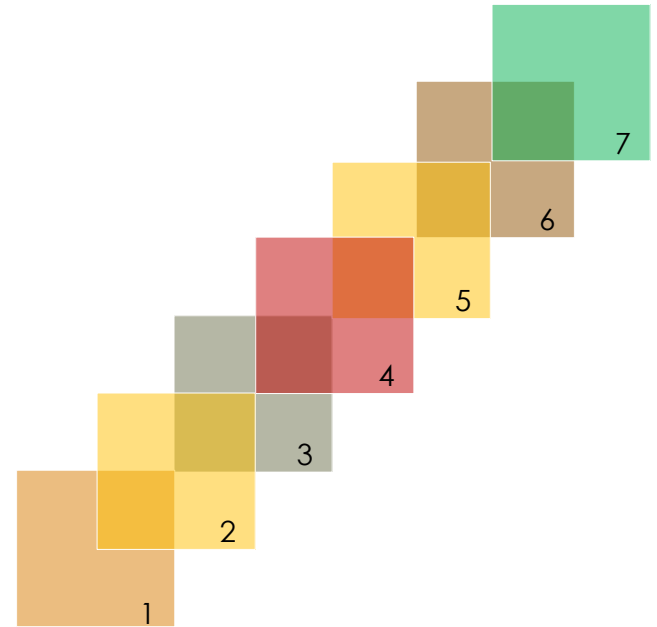
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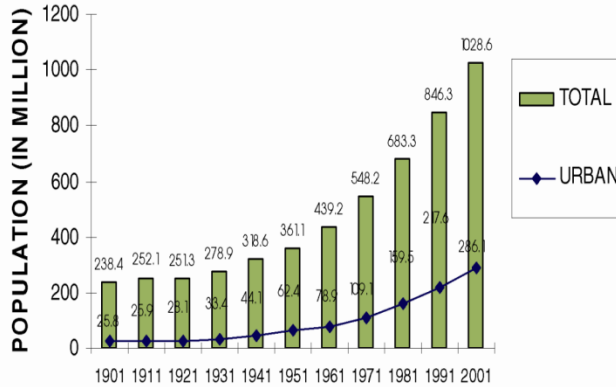
# Outline

- ❖ Indian Scenario
- ❖ Low Carbon Society (LCS) Approach
- ❖ Bhopal – An Introduction
  - ❖ Study Area
  - ❖ Drivers of Change
    - ❖ Demographic and Land use Change
    - ❖ Economic and Transport Growth
    - ❖ Growing Energy Consumption
- ❖ Bhopal LCS Study
  - ❖ LCS Vision, Timeline and Target
  - ❖ Socio Economic Assumptions and Estimates
  - ❖ Simulation Results, Analysis and Findings
  - ❖ LCS Actions and Strategy Formulation

# Indian scenario



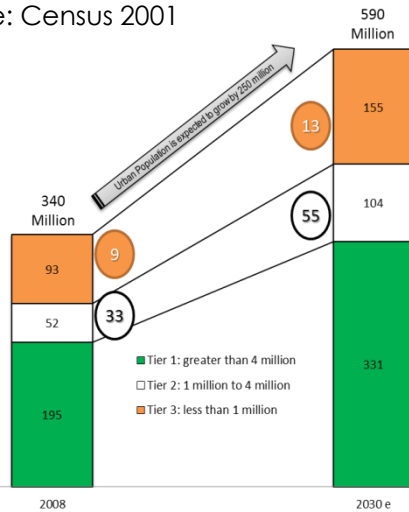
## Demographic trends and projections



YEARS

### Share of Urban population

Source: Census 2001



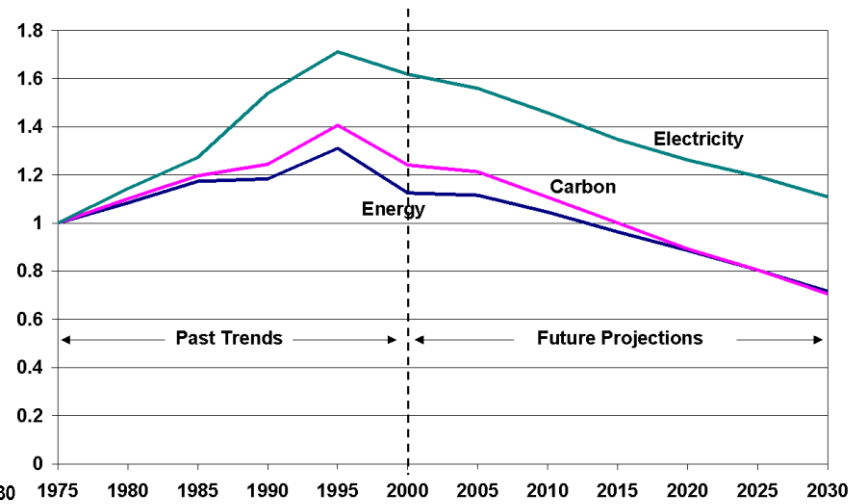
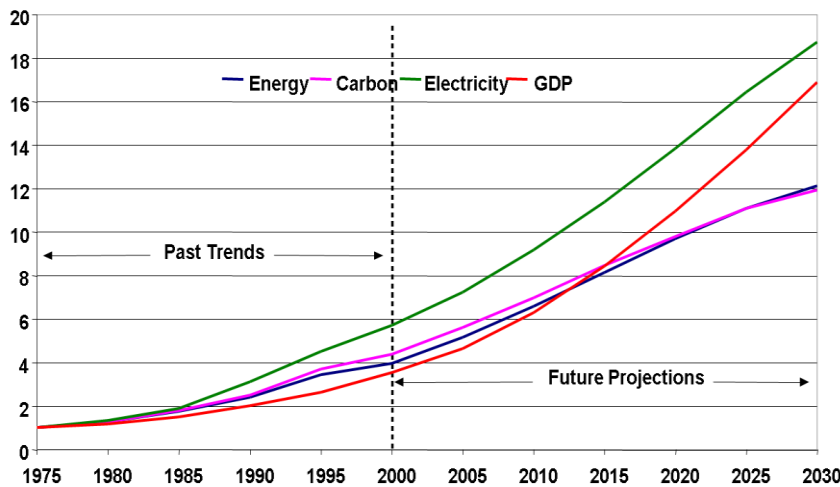
### Growth of large cities in India

Source: Mckinsey 2010

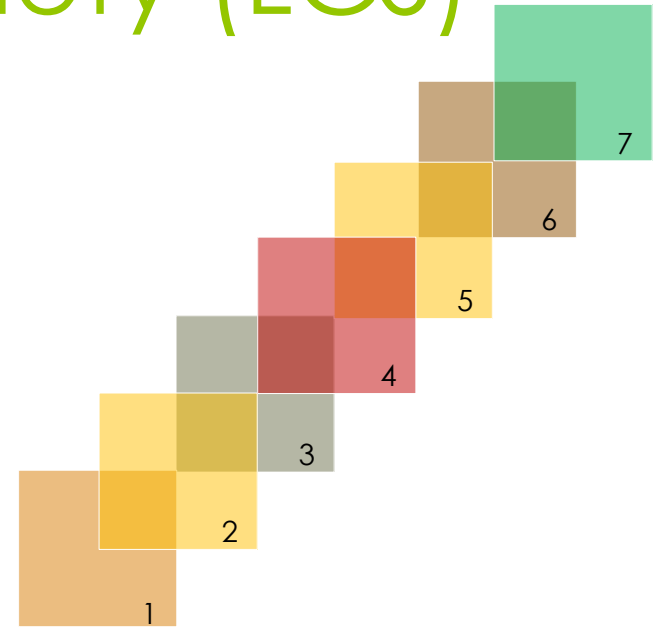


### Million-plus Cities and Urban Agglomerations

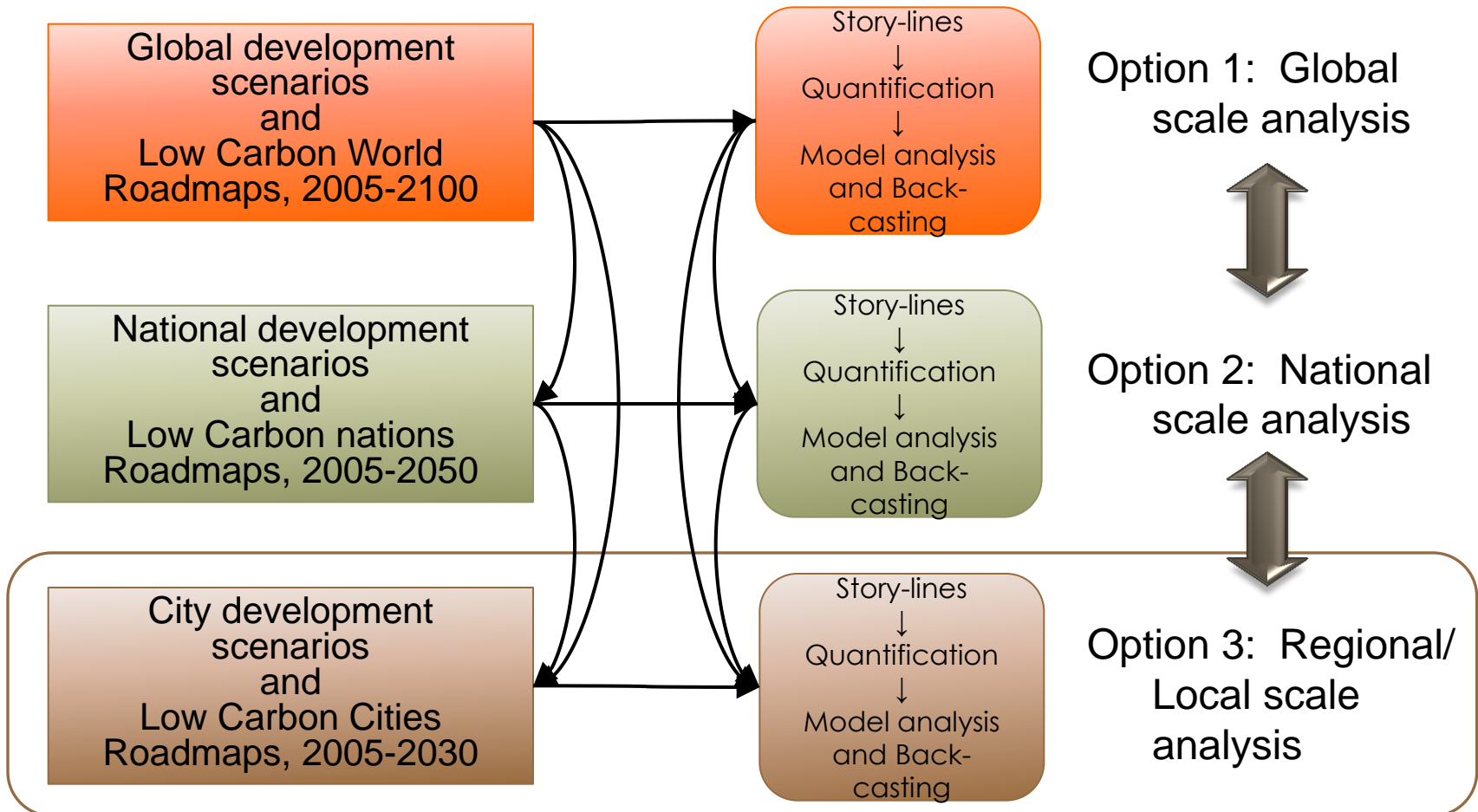
# Indian Energy, Carbon, Electricity and GDP



# Low Carbon Society (LCS) Approach



## Three regional/time scales of concern approach of Asian LCS Scenario Development



# Developing Bhopal LCS Scenario 2035

## □ Methodology

- Quantification of scenario estimates of Bhopal district
- Narrative storylines of likely future
- Description of sector-wise details of likely future
- Quantification of the macro-economic considerations and social aspects
- Identification of possible effective policy measures
- Develop action plan for policy measures



## AIM/ExSS Model

### Model Design

- A static, accounting type model
- Consists of simultaneous equations
- Keep consistency using IO analysis
- CO<sub>2</sub> emissions from energy use focus
- Extendable to other sectors and env. Loads
- Program : GAMS, Input & output: Excel

### Model Application

- Illustrate quantitative future snapshot of a area in question in order to DESIGN a LCS and evaluate its feasibility
- Analyze relationship between socio-economic conditions and environmental load
- Define a portfolio of the measures to meet the environmental target

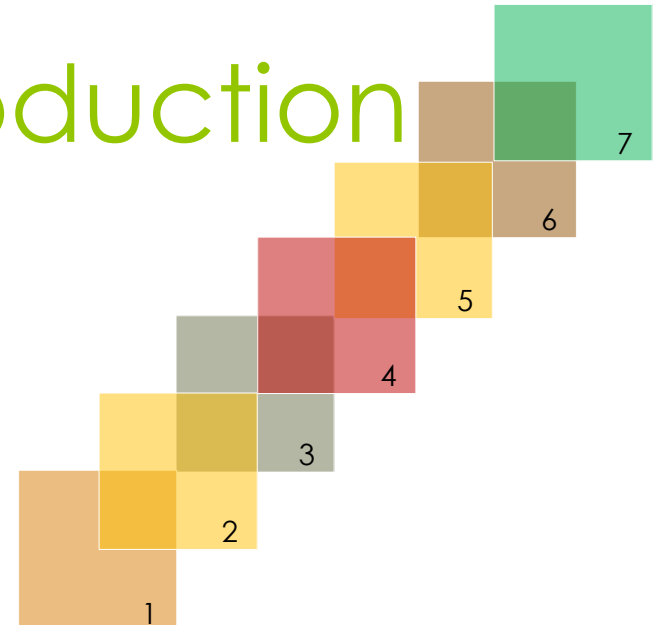
### Model Output

- ❖ Socio-economic activity level
- ❖ Environmental load (emissions)
- ❖ Low-carbon measures

Model Developed by: Dr. Kei Gomi, Kyoto University, Japan

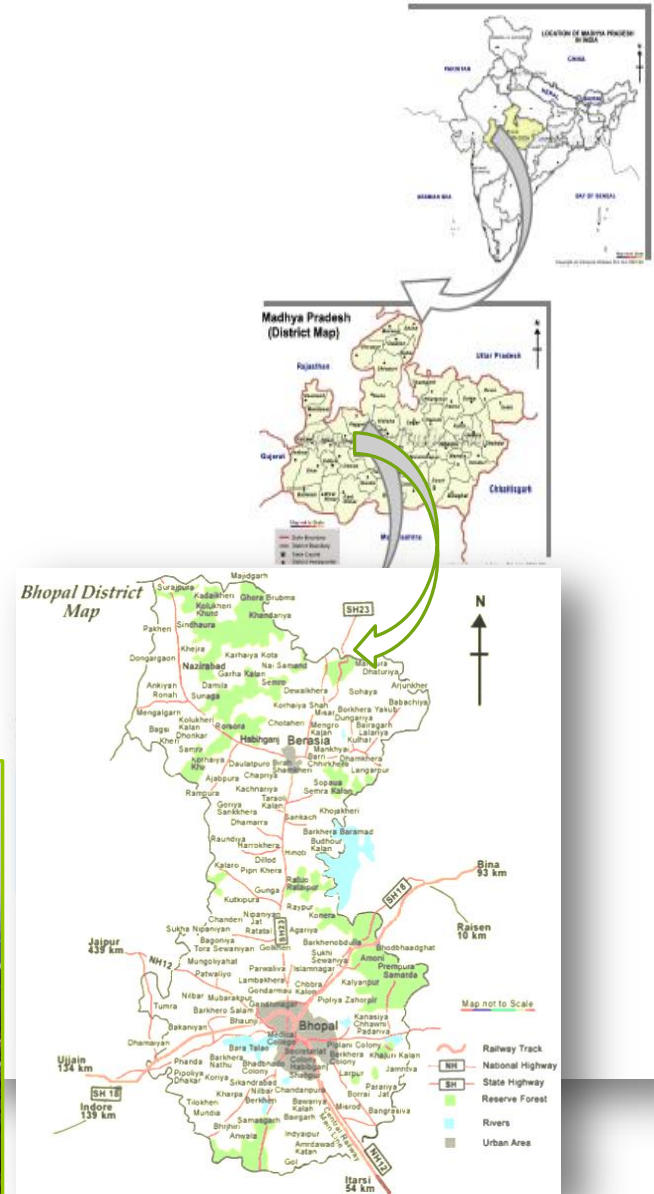


# Bhopal – An Introduction

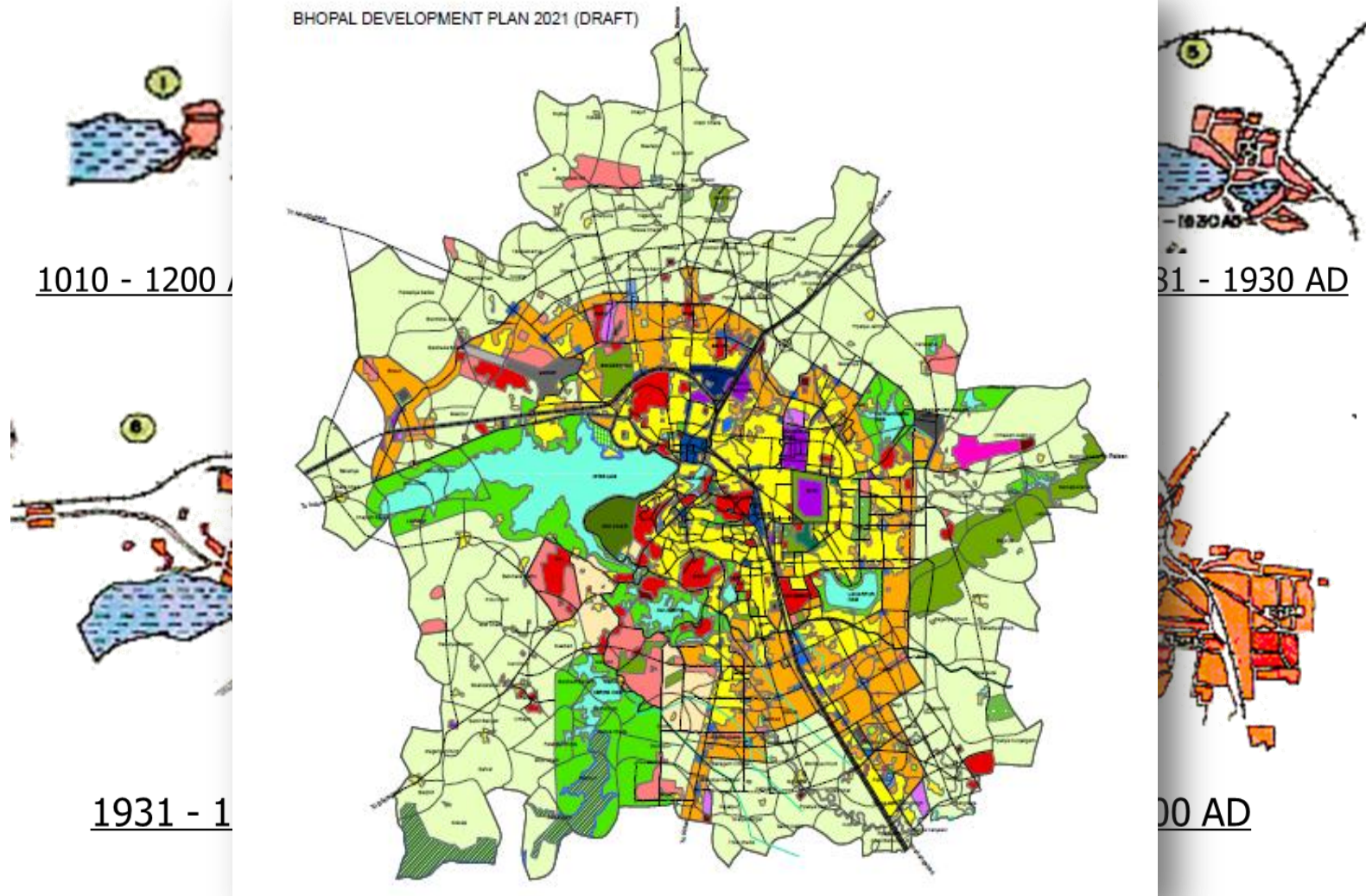


## Bhopal, India

- The city is centrally located.
- The climate is composite climate representing a large part of the country.
- The city has physical features like large water body, Hills and forests for analysis of local variations.
- A million plus city, it can represent many large Indian cities.
- Amongst the 21 fastest growing cities in India.

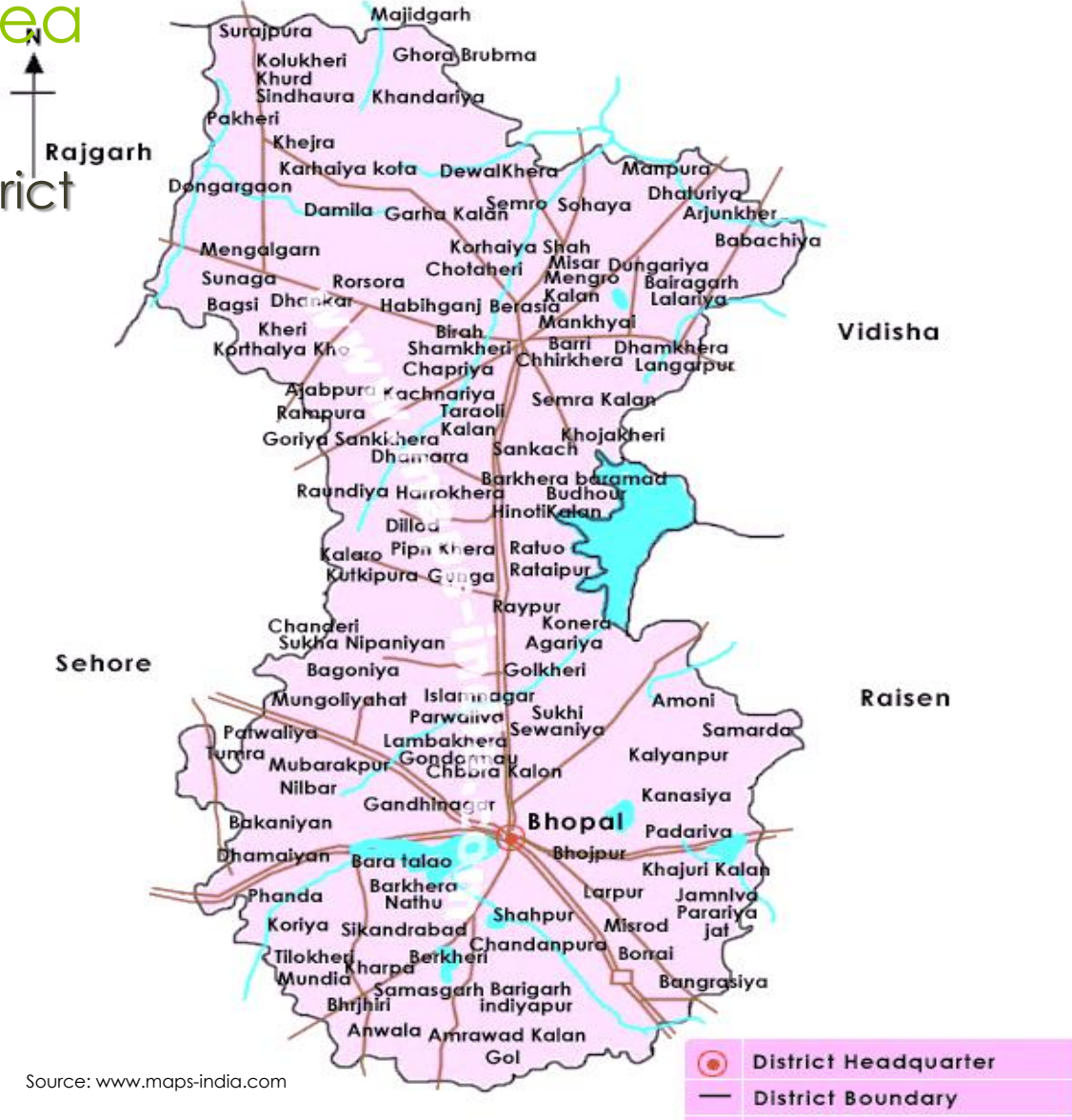


# Bhopal: Chronological Development



## The Study Area

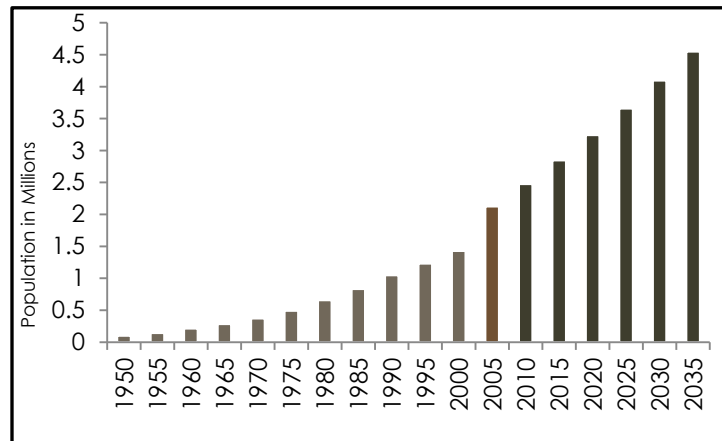
● Bhopal District



Source: [www.maps-india.com](http://www.maps-india.com)

## Drivers of Change

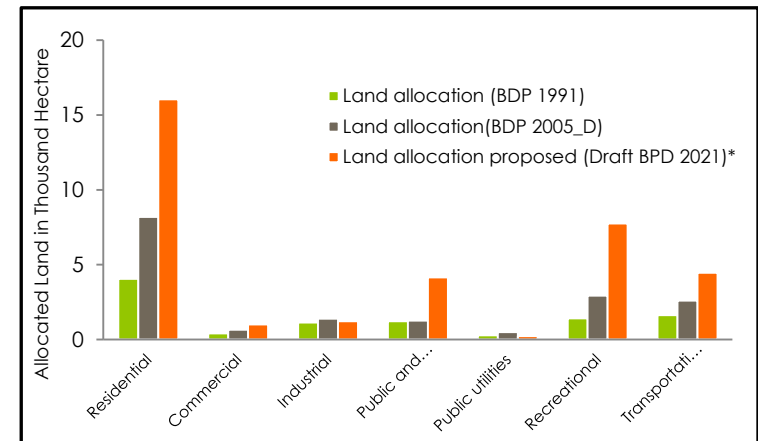
- Demographic Trends and Projection
  - Urban population has increased at an average decadal growth rate of over 70% in last 4 decades.
  - The longer perspective and various estimates indicate that the city would grow around 4.5 million by 2035.
  - No of Household would grow by three times



Estimates based on World Urbanization Prospects (Revised 2009) and UN mid term growth rates projections.

- Land use change

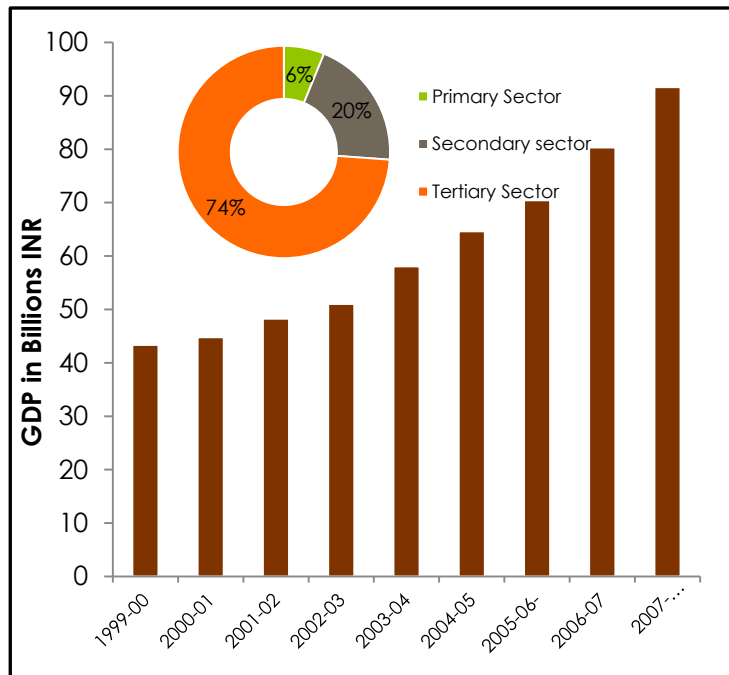
- The development plan area has expanded as the density of many wards has reached to more than 400persons/hectare.
- The residential sector has doubled in between 1991-2005 plan period.



Source: Bhopal Development Plan 1991, Draft 2005, Draft 2021

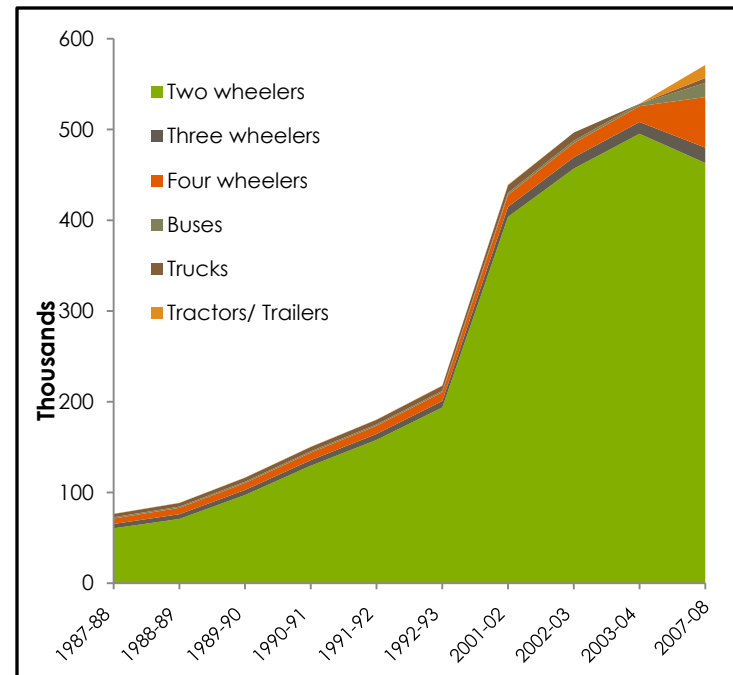
## Drivers of change

- Growing district economy
- Transport growth trends



Bhopal DGDP (at Current Prices) & Sectoral distribution

Source: District Development Report 2007-08, and Indicus District GDP 2005-06



No of Vehicles registered in Bhopal

Source: Road Transport Office 2006-07) Government of Madhya Pradesh

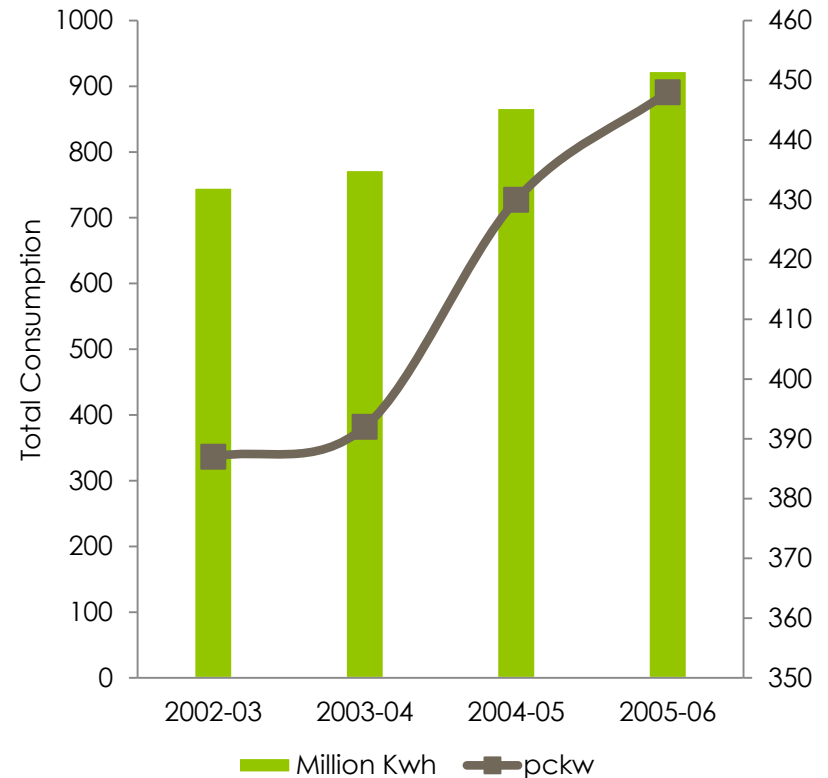
## Energy Consumption Trends

- Fuel consumption is growing with rising human and vehicular population

Period	Petrol (Kilo lit)	Diesel (Kilo lit)	LPG (no. of cylinders)
2003-04	31300	38400	3608000
2004-05	33100	40900	3800000
2005-06	34900	42700	3903000

Source: Department of Civil Supplies, Government of M. P.

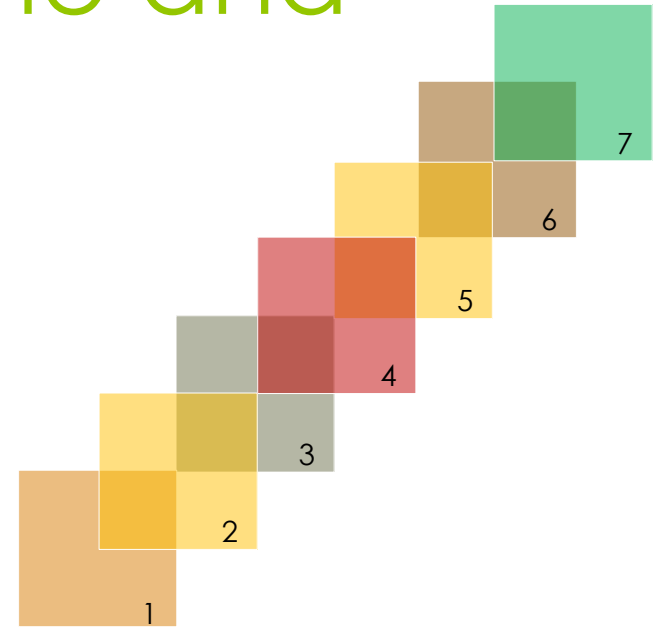
- Electricity Consumption rise



Source: District Development Report 2007-08,



# LCS Vision, timeline and target



## The Bhopal LCS vision:

### **To be a sustainable low carbon city in line with national policies**

- Ready for future and resilient to change
- Conservation and green orient for quality of life
- Economic and social competitive clean and green industries
- Efficient transport system
- Community participation in city development

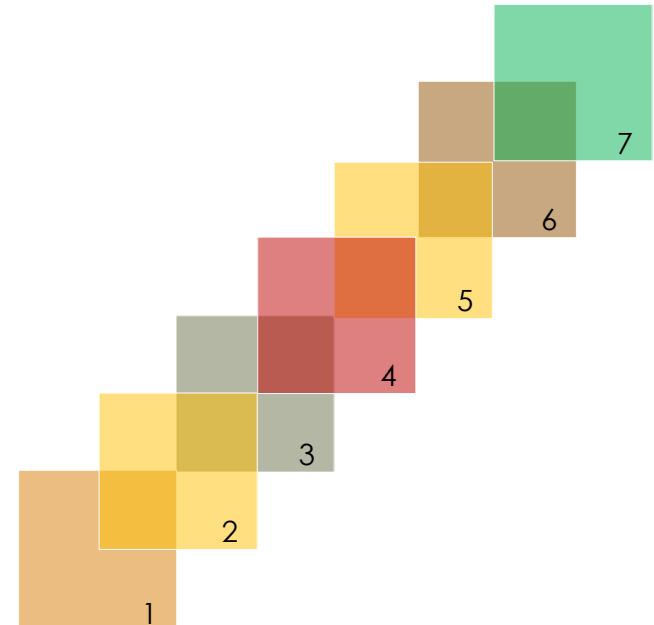
### **Timeline and Reduction Target**

- **Time Horizon:** Year 2035
  - To align city development plans and policies with national and global targets
- **Reduction Target:**
  - 40% of 2035 BAU Emissions

## The Scenarios

- Business As Usual (BAU) scenario
  - The present trend in Bhopal has been considered with existing technology and prevailing economic and demographic trends. The BAU scenario for future energy consumption and emissions projection in Bhopal envisages the continuum of present government policies, and capture forecast for various economic, demographic, land use and energy use indicators.
- Low Carbon Society (LCS) scenario
  - For analysing the possibilities of reducing the GHG emissions in future, a sustainable development future scenario is drawn here for Bhopal, that is expected to take it towards **Low Carbon Society**. The energy consumption trajectory / emissions trajectory are drawn in all the sectors of Bhopal that would result from aggressive policies to promote demand side management, energy efficiency, development of renewable energy, and other policies to promote sustainable development .

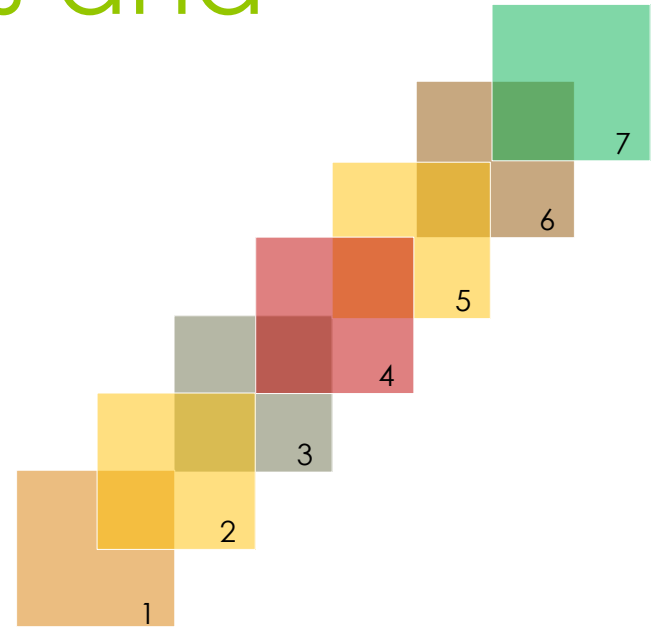
# Socio economic assumptions and estimates



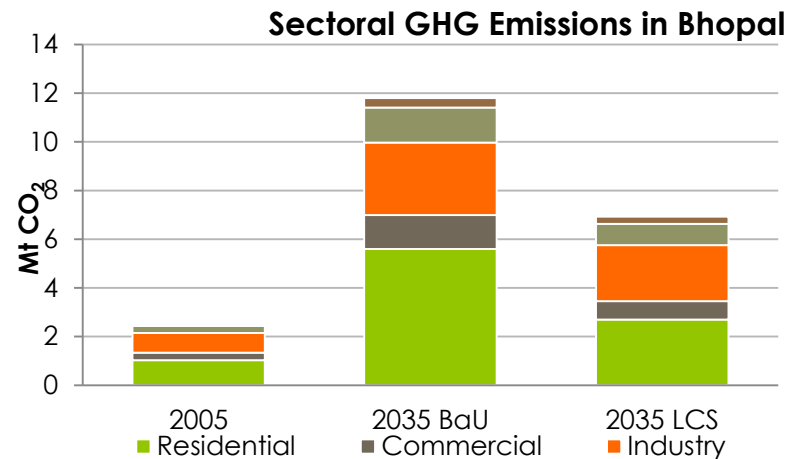
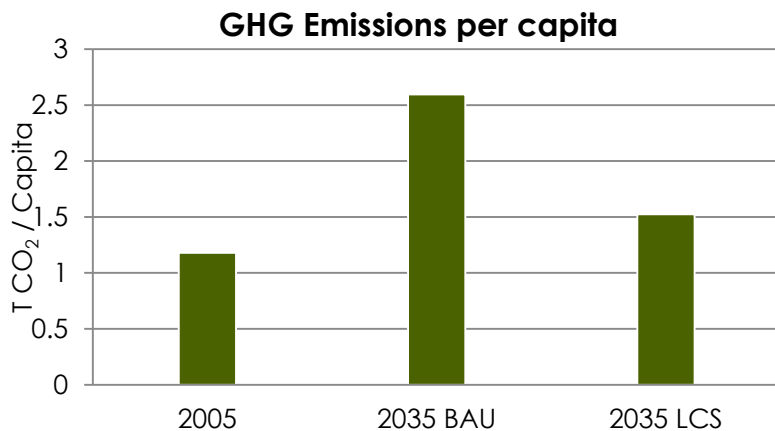
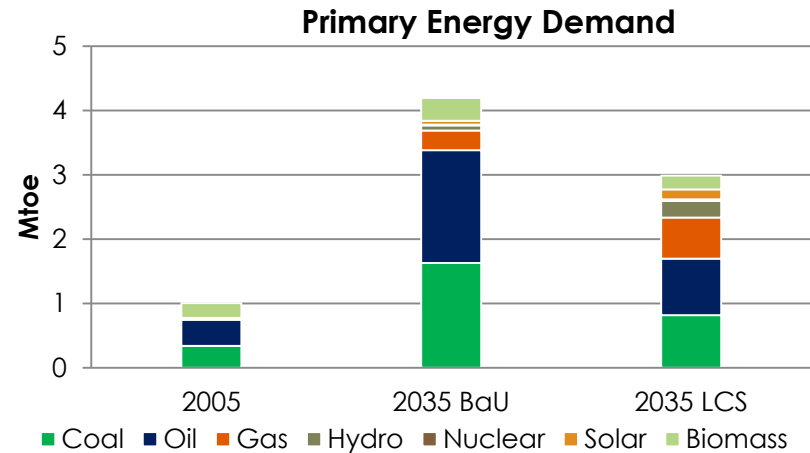
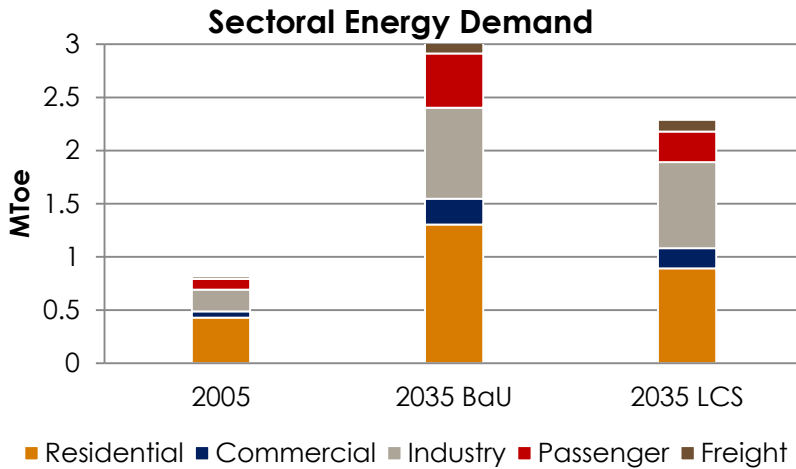
## Socio Economic Assumptions and Energy, Emission estimates from Model AIM/ExSS Output

Socio Economic Assumptions	2005 (Base)	2035 (BAU)
Population	2121617	4546081 <sup>2.6%</sup>
Household	385970	1136406 <sup>3.7%</sup>
GDP in Billion INR	70	383 <sup>5.8%</sup>
Commercial Floor Area (in Sq Km)	61	344
Passenger Transport (MPKm)	5204	24742
Freight Transport (MTKm)	617	3591
Energy Demand (Ktoe)	815	3044
CO2 Emissions (KtC)	683	3217

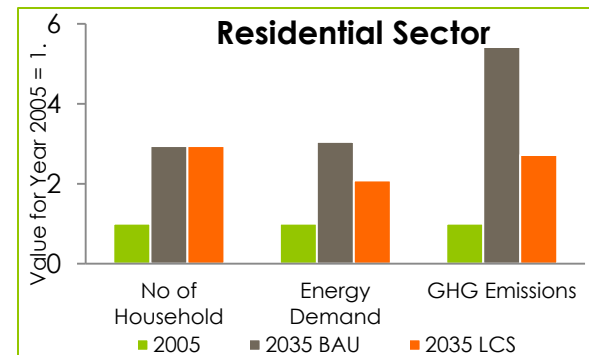
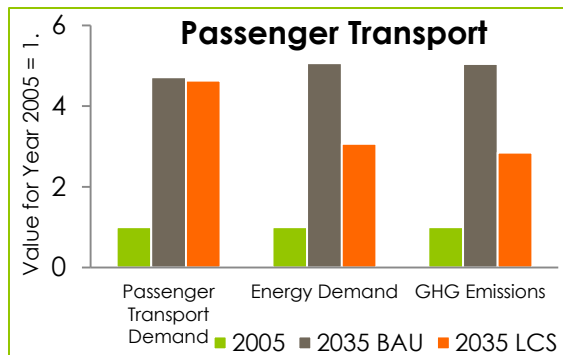
# Simulation Results and Analysis



## Energy Demand and GHG Emission

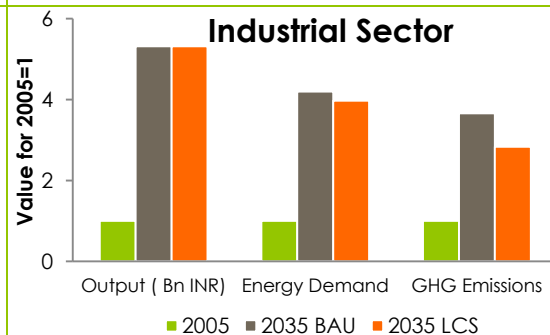


## Sector wise Mitigation Contribution



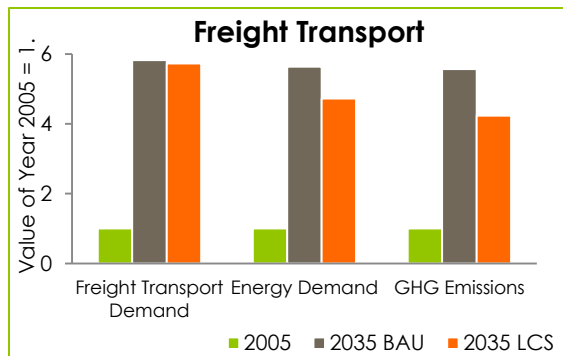
### Transport Sector

- Technology Efficiency Improvements
- Fuel Switch
- Improved Traffic Management
- Shift to Public Transport & I
- Implementing Integrated Transport Management System



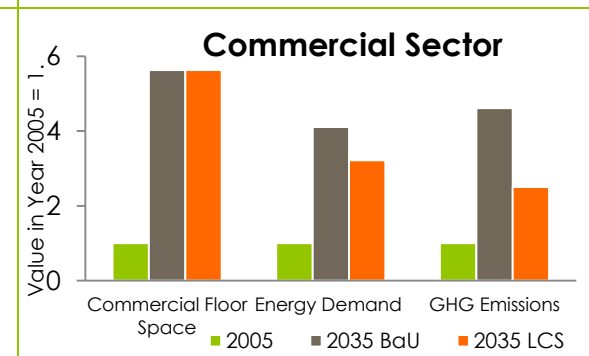
### Residential & Commercial Sectors

- Efficiency Improvements in End Use Devices
- Fuel Switch
- Behavioral Changes
- New Technology Adoption & Retrofitting
- Improved Material Efficiency in Buildings
- Change in the Nature of Power Supply



### Industrial Sector

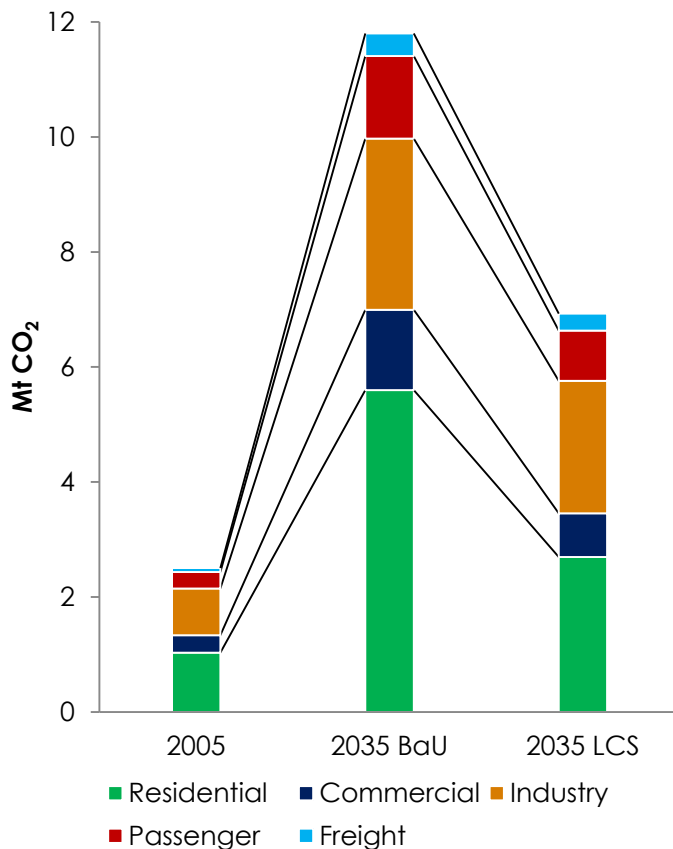
- Technology Efficiency Improvements
- Fuel Switch



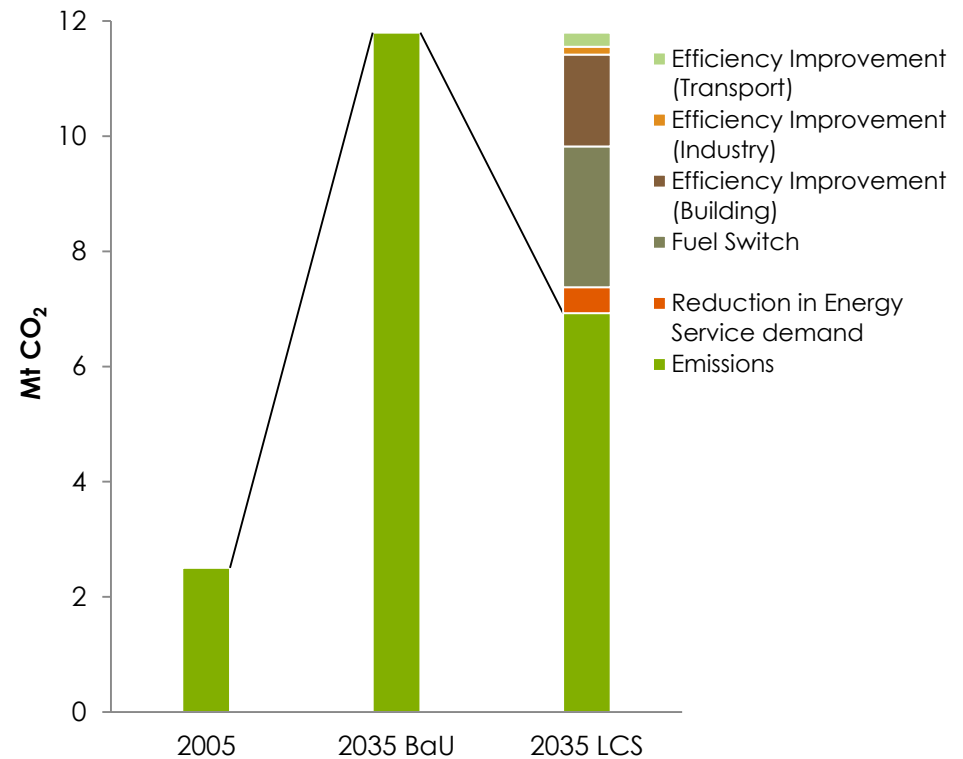


# GHG Emission Scenario and Interventions Mitigation Contribution

**GHG Emissions Scenario**



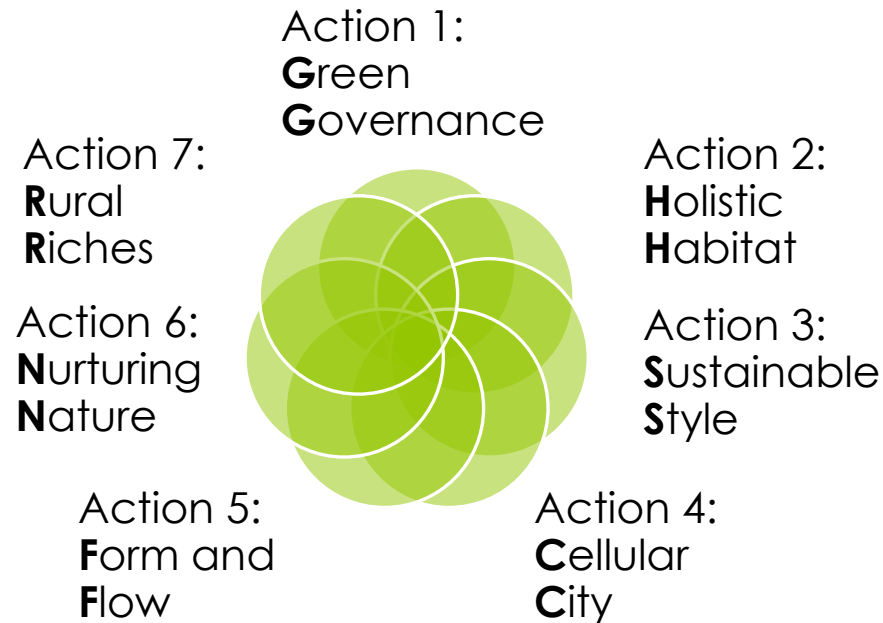
**Mitigation Contribution**



# LCS Actions and Strategy Formulation



# Bhopal LCS: Seven Actions



		SECTORAL CONTRIBUTION				
	ACTIONS	Residential	Commercial	Industry	Passenger Transport	Freight Transport
1	GREEN GOVERNANCE					
2	HOLISTIC HABITAT					
3	SUSTAINABLE STYLE					
4	CELLULAR CITY					
5	FORM AND FLOW					
6	NURTURING NATURE					
7	RURAL RICHES					

# Actions towards LCS Bhopal 2035

- Action-1: Green Governance

- Introduction of policies and Incentives across sectors incorporating sustainable practices
- Government schemes including subsidies on use of green technology
- Enforcing not only 'prescriptive regulations' but also formulating 'performance guidelines'

- Action-2: Holistic Habitat

- Application of energy efficient technology in buildings. Passive and Active methods of reducing energy consumption
- Use of multiple housing typologies according to life style and context
- Adopting time tested house forms in rural-urban transition areas (climate responsive vernacular housing)
- Use of locally available materials and technology

## Actions towards LCS Bhopal 2035

- Action-3: **Sustainable Style**

- Shifting to a low carbon lifestyle.
- Introduction to environmental concerns from primary level of education.
- Reduce, reuse, recycle
- Use of energy efficient appliances
- Walking as a way of life

- Action-4: **Cellular City**

- Developing and enhancing the existing city form of self contained settlements with mixed land use.
- Compact, discreet work-home zones requiring minimal inter-zone travel.
- Defining the city cells based on their natural settings, socio-economic homogeneity, location in the context of city structure.

# Actions towards LCS Bhopal 2035

- Action-5: Form and Flow
  - Integrating Transport with City structure – a two level approach
    - Connecting the Cells:
      - Route optimization considering the topography, water bodies and other natural barriers.
      - Reducing travel demand and time between zones.
      - Enhancing Public Transport systems.
    - Walkable Cells:
      - Transportation within compact closely knit work-home mixed land use zones.
      - Promoting non-automated means of transport-Inclusion of bike tracks, pedestrian walkways, subways and cross overs.
  - Migration to Sustainable Technology
    - Emission norms
    - Alternative fuels use
    - Traffic management (passenger and freight)
    - Parking policy

# Actions towards LCS Bhopal 2035

- Action-6: Nurturing Nature

- Leveraging on the natural and historic assets

- Lake Conservation and water management.
- Rain water harvesting at city level using natural collector zones, at community level and household level.
- Social forestry and urban forestry.
- Using indigenous plant species for urban landscaping.
- Conserving the city's heritage.
- Promoting eco-tourism and heritage tourism.

- Action-7: Rural Riches

- Promoting a better lifestyle in the rural areas

- Developing rural fringes as city's food reserve by increasing agricultural activities.
- Prevent conversion of rural land to peripheral urban housing sprawl through land use control and rural incentive schemes.
- Government incentives for developing rural housing typologies, with energy efficient technology interventions.

# Policy challenges in Bhopal

## ❑ Residential and Commercial Sector

- fuel use varies from wood, biomass, charcoal to kerosene, electricity and LPG depending on the income level.
- emissions from common fuel use.
- use of inefficient fuel and technologies is the primary cause for high GHG and local emissions.
- lower rate of conversion to new technologies, as the alternative inefficient fuel is freely and easily available and low preference for energy efficient technologies over consumer durables.
- Inefficient building designs.

## ❑ Transport Sector

- limited network of roads,
- high traffic density,
- increasing number of private vehicles,
- inadequate provisions for non motorized transport

## ❑ Industrial Sector

- large share of unorganised industrial activities
- use of inefficient fuel and technologies
- low rate of conversion to new technologies

**Next is...Developing Road Map for LCS Actions for Bhopal**





Thanks.

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