A Low Carbon Vision for Bhopal:
Transitions in Residential and Transport Sector

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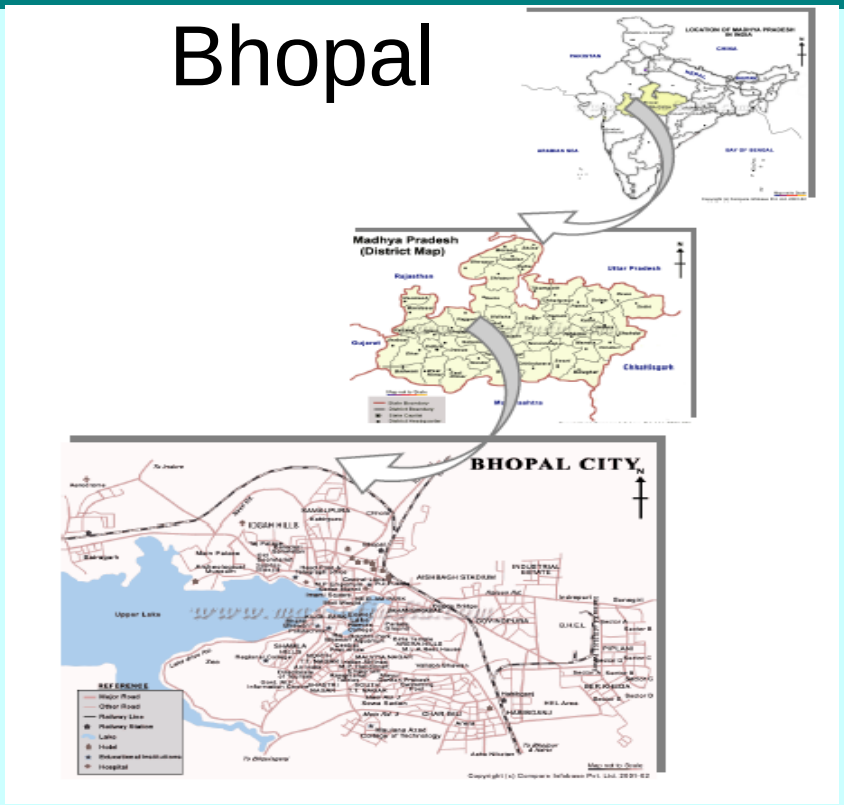
The Study area



- The city is centrally located in India
- The climate is composite climate representing a large part of India
- 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.

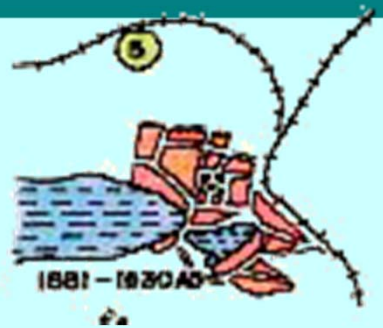
Bhopal: Chronological Development

1010 - 1200 AD

1201 - 1800 AD

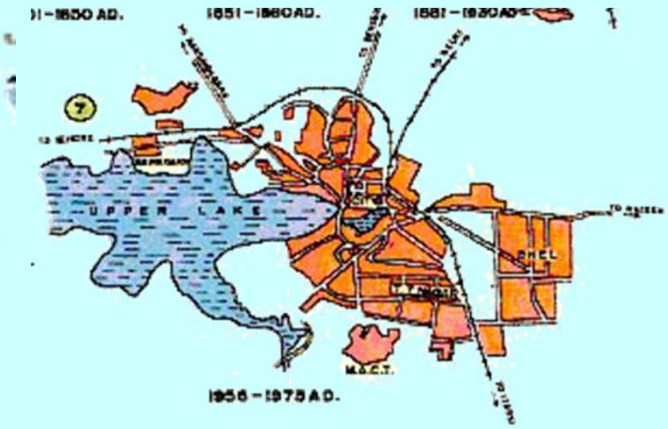
1801 - 1850 AD

1851 - 1880 AD

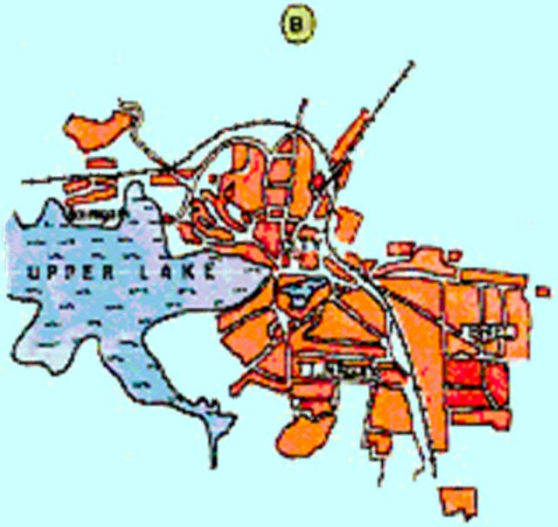


1881 - 1930 AD

1931 - 1955 AD



1956 - 1973 AD



1974- 2000 AD

Bhopal: Demographic trends

Year	Bhopal urban population (in million)	Growth rate (in %)	Percentage of urban to Total population
1951	0.10	36.03	43.30
1961	0.22	117.87	61.60
1971	0.39	72.63	68.60
1981	0.69	78.96	74.90
1991	1.06	54.13	78.80
2001	1.43	36.85	80.53

Source: CENSUS 2001

Bhopal: Distribution of households

Area	Total/ Rural/ Urban	Total number of households	By source of lighting					
			Electricity	Kerosene	Solar energy	Other oil	Any other	No lighting
Bhopal	**Total**	**335,376**	**323,091**	**11,152**	**443**	**200**	**158**	**332**
Rural		62,648	54,503	7,893	90	57	24	81
Urban		272,728	268,588	3,259	353	143	134	251

Area	Total/ Rural/ Urban	Total no of HH	By type of fuel used for cooking									
			Firewood	Crop residue	Cow dung	Coal, Lignite	Kerosene	LPG	Electricity	Bio gas	Any other	No cooking
Bhopal	**Total**	**335,376**	**81,146**	**3,850**	**8,805**	**1,133**	**86,470**	**150,636**	**526**	**706**	**647**	**1,457**
Rural		62,648	50,570	1,415	7,210	16	838	1,924	54	284	275	62
Urban		272,728	30,576	2,435	1,595	1,117	85,632	148,712	472	422	372	1,395

Source: CENSUS 2001

Bhopal: Land-use pattern

Unit = Hectare					
Land use	**Land allocation (BDP* 1991)**	**Land habitated area**	**% of total area**	**Land allocation proposed (Draft BDP 2005)**	**% of total area**
Residential	4050	3660	46.20%	8190	46.80%
Commercial	405	243	3.07%	650	3.71%
Industrial	1135	692	8.74%	1389	7.94%
Public and Semi-public	1215	912	11.51%	1258	7.19%
Public utilities	280	200	2.52%	488	2.79%
Recreational	1415	1153	14.55%	2925	16.71%
Transportation	1620	1062	13.41%	2600	14.86%
Total	10120	7922	100.00%	17500	100.00%

*BDP: Bhopal Development Plan

Bhopal: Energy consumption pattern

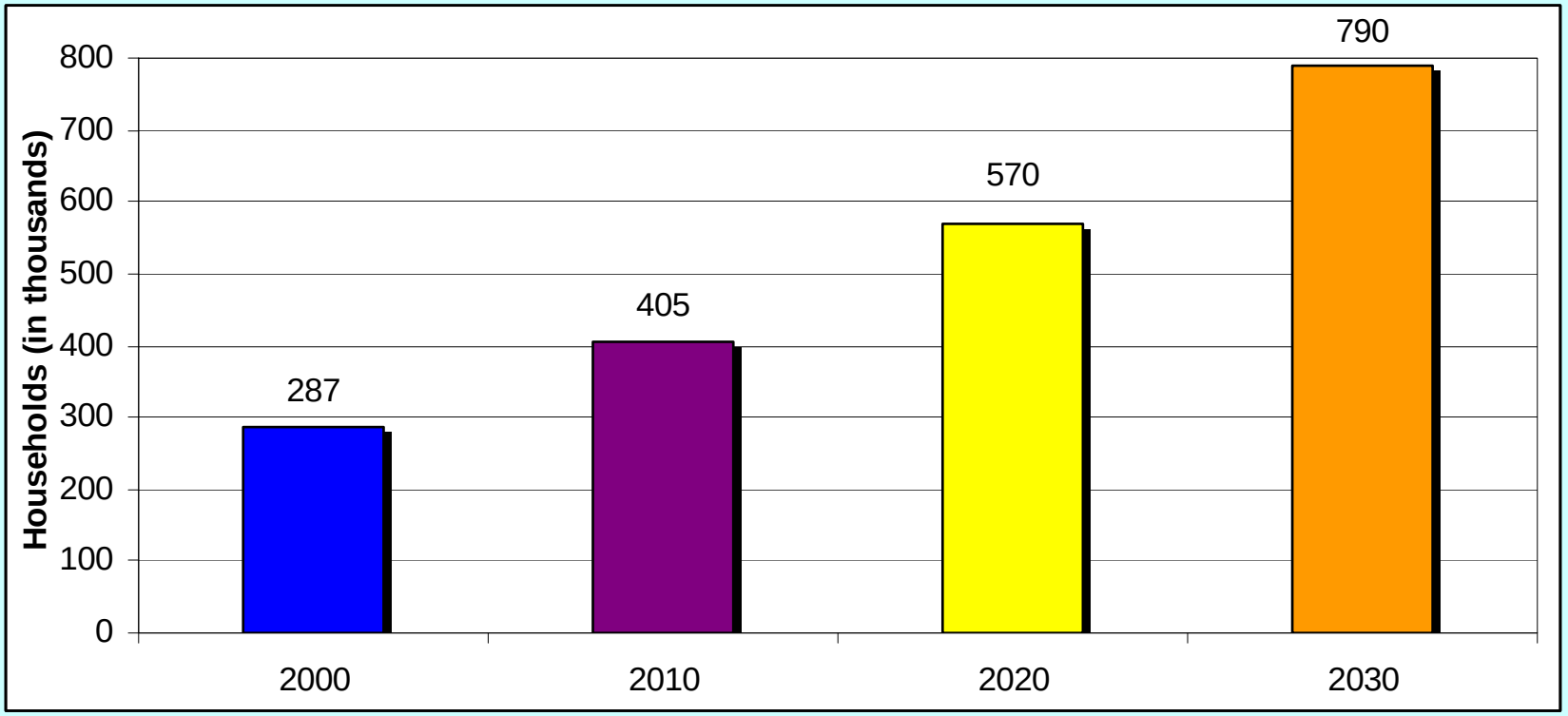
- Fuel consumption is growing with rising human and vehicular population

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.

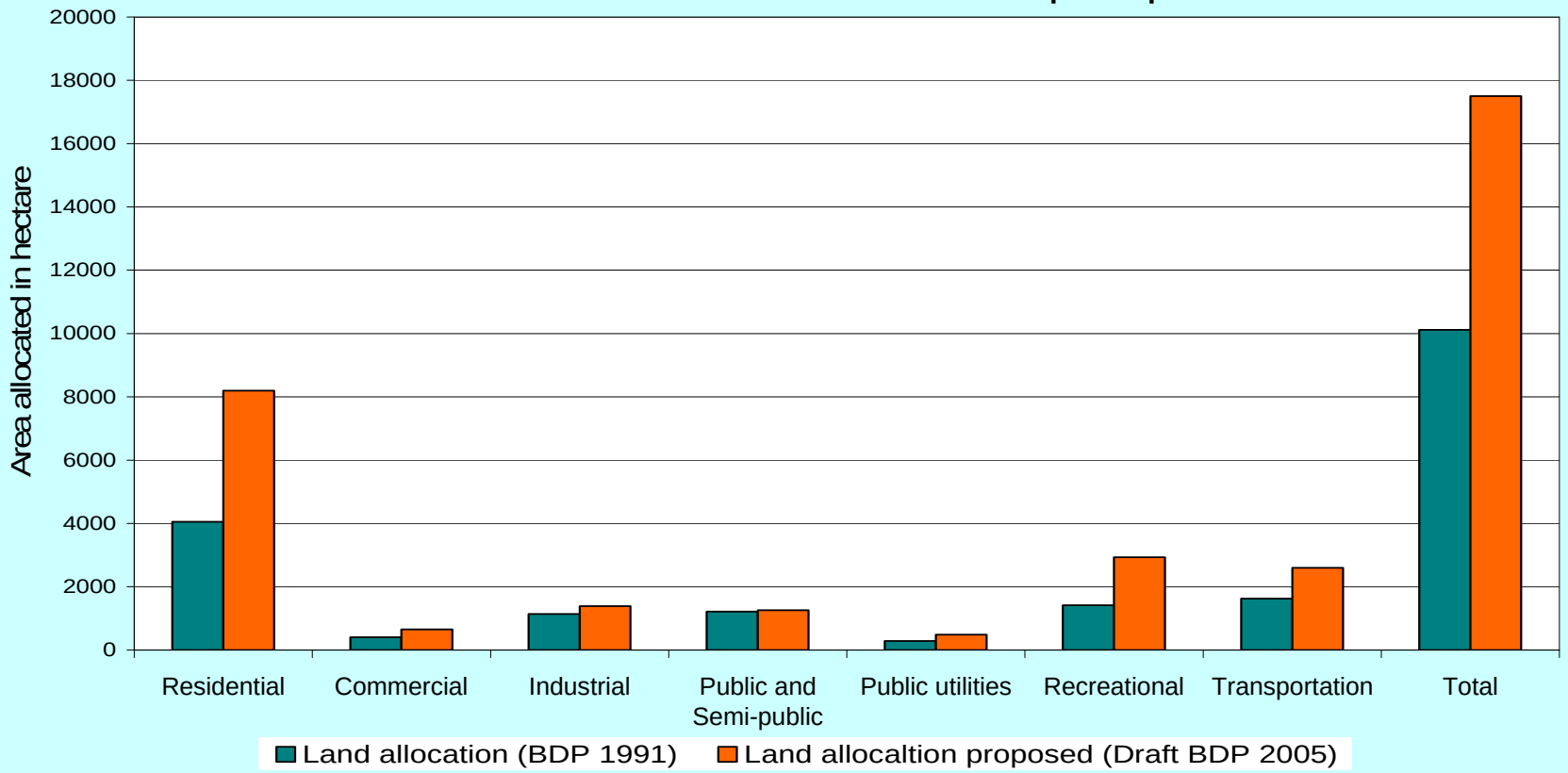
Bhopal: Drivers of change

- **Population growth**
  - 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 3.5 million by 2021.



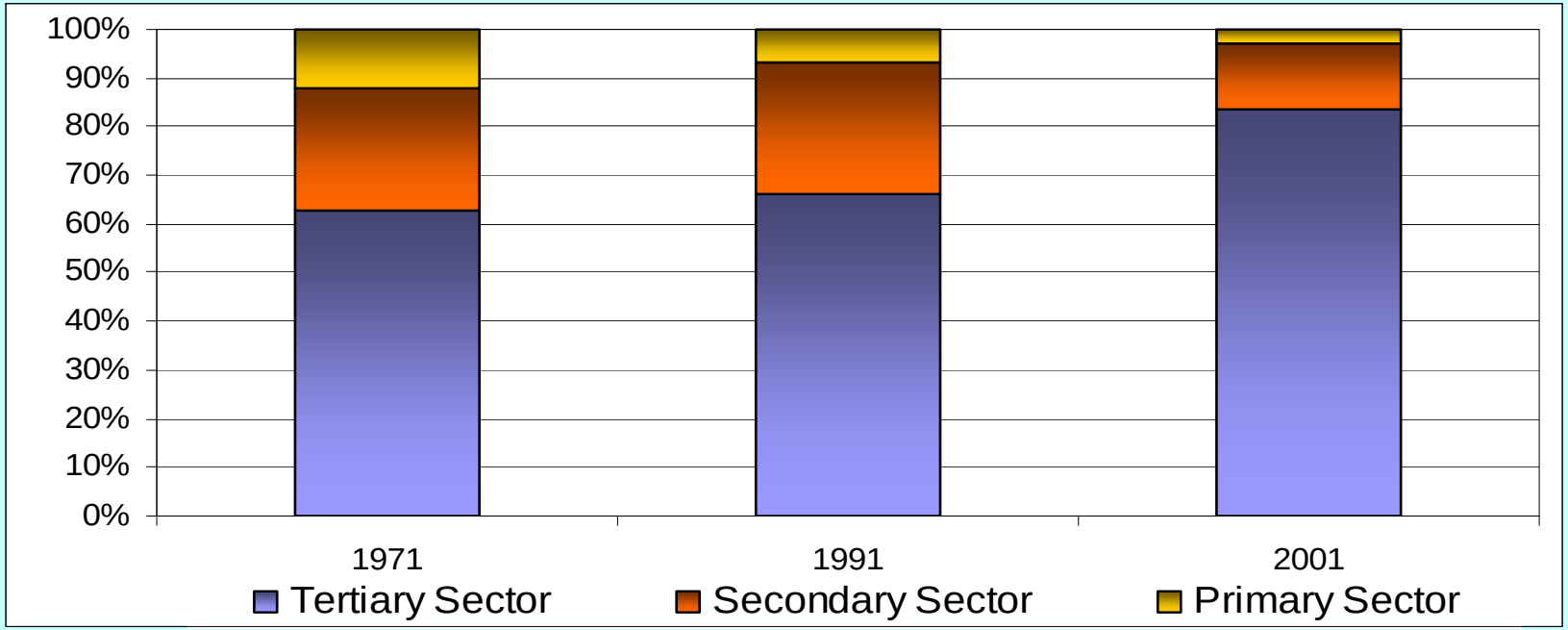
Bhopal: Drivers of change

- **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 the two plan period.



Bhopal: Drivers of change

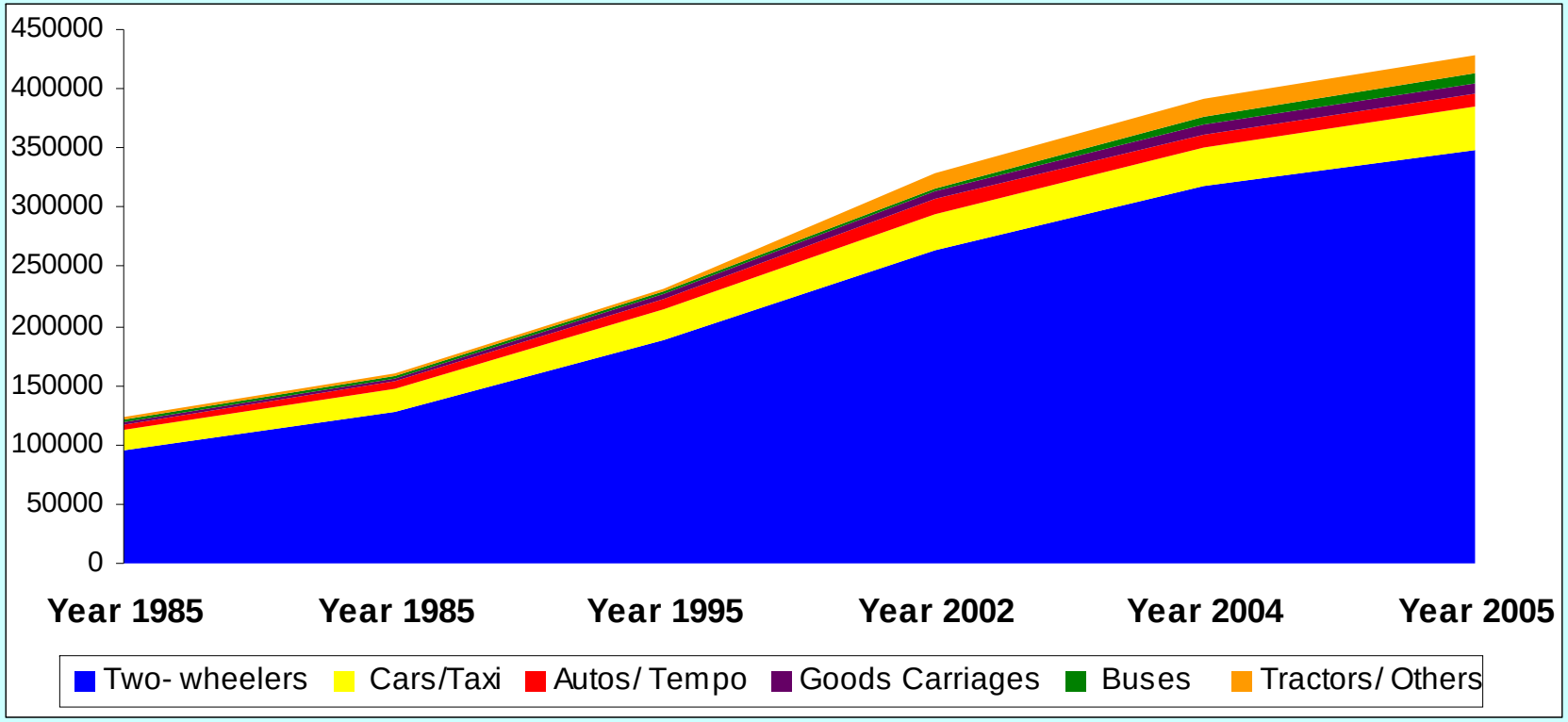
- **Changing occupational pattern**
  - The occupation in tertiary sector has grown from 64% in 1971 to 87% 2001.
  - The distribution of workers in secondary sector has moved up from 33% to 36% in 1991



Source: NRS, 2002

Bhopal: Drivers of change

- **Vehicular growth in two decades**
  - In last two decades the total motor vehicles have grown more than three times.
  - Two wheelers registered growth from 79% in 1987-88 to 94% in 2003-04.



Source: Road Transport Office, Bhopal, Ministry of Road Transport, Government of Madhya Pradesh

Two Scenarios

- Business As Usual (BAU) scenario
  - The present trend in Bhopal city has been considered with existing technology in both residential and transport sector with prevailing economic and demographic trends. The BAU scenario for future energy consumption and emissions projection in Bhopal city 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 city that is expected take it towards ***Low Carbon Society***. the energy consumption trajectory / emissions trajectory in residential and transport sector in 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

Bhopal LCS: Seven Actions

Action 1:
Green
Governance

Action 2:
Holistic
Habitat

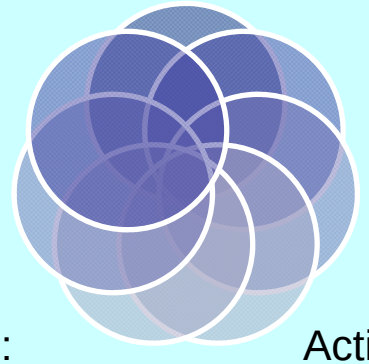
Action 3:
Sustainable
Style

Action 4:
Cellular
City Form

Action 5:
Form and
Flow

Action 6:
Nurturing
Nature

Action 7:
Rural
Riches



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

Actions towards LCS Bhopal 2035

- Action-1: **G**reen **G**overnance
  - 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: **H**olistic **H**abitat
  - 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: **S**ustainable **S**tyle
  - 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: **C**ellular **C**ity Form
  - 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: **F**orm and **F**low
  - 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: **N**urturing **N**ature
  - 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: **R**ural **R**iches
  - 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.

AIM/Enduse SIMULATION

PRELIMINARY RESULTS

Model Specification for Bhopal District

- Sub-region
  - Bhopal Urban
  - Bhopal Rural
- Sectors –Multi sector with detailing of

- **Residential sector**
  - quantify the relationship between household energy requirement and variables like HH no, family size, expenditure and lifestyle type; that explain the variation in household and energy requirement and emissions generated.
  - Services considered-
    - Cooking
    - Lighting
    - Space Cooling and Heating
    - Water Heating
    - Other Appliances TV, Fridge, W M/c

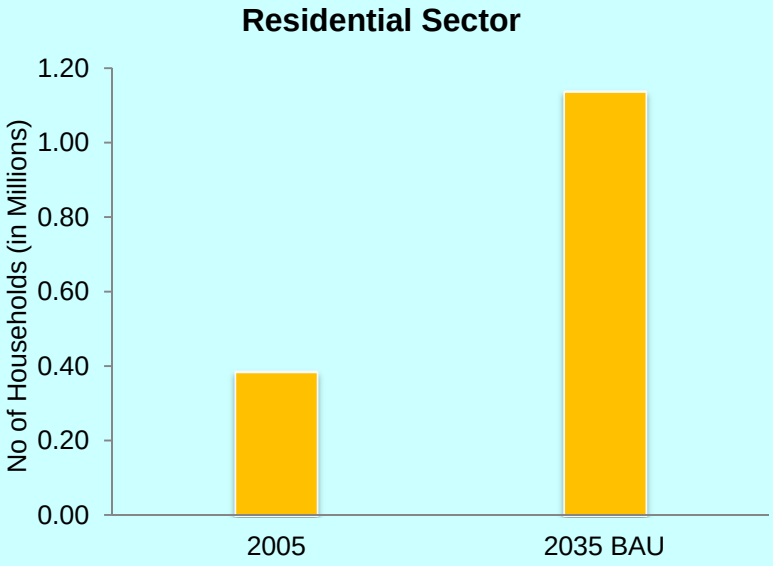
- **Transport sector**
  - depict the relationship between the growing transport demand for same sets of variables, explaining the energy requirement with variation in mode of transport technologies and generated emissions.
  - Services considered-
    - Passenger transport
    - Freight transport

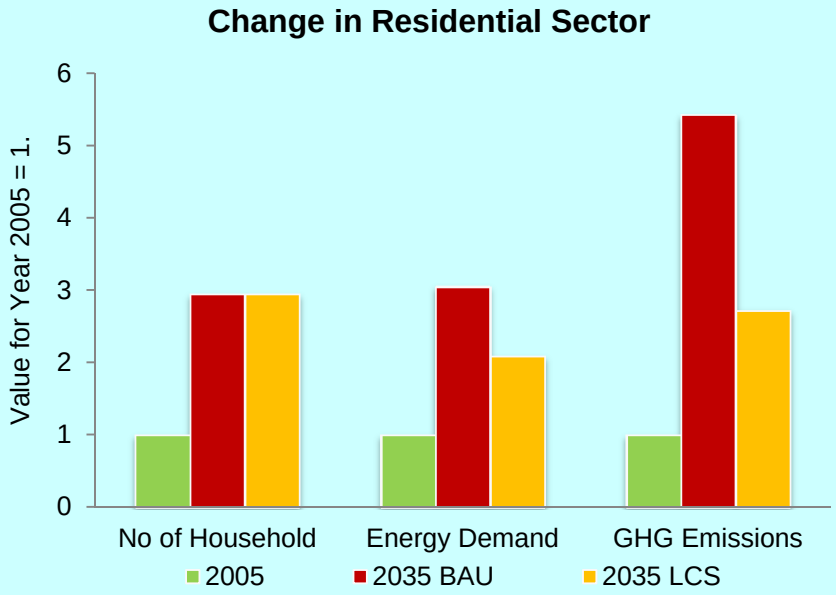
Policy challenges in Bhopal

- Residential
  - 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

Mitigation: Residential Sector

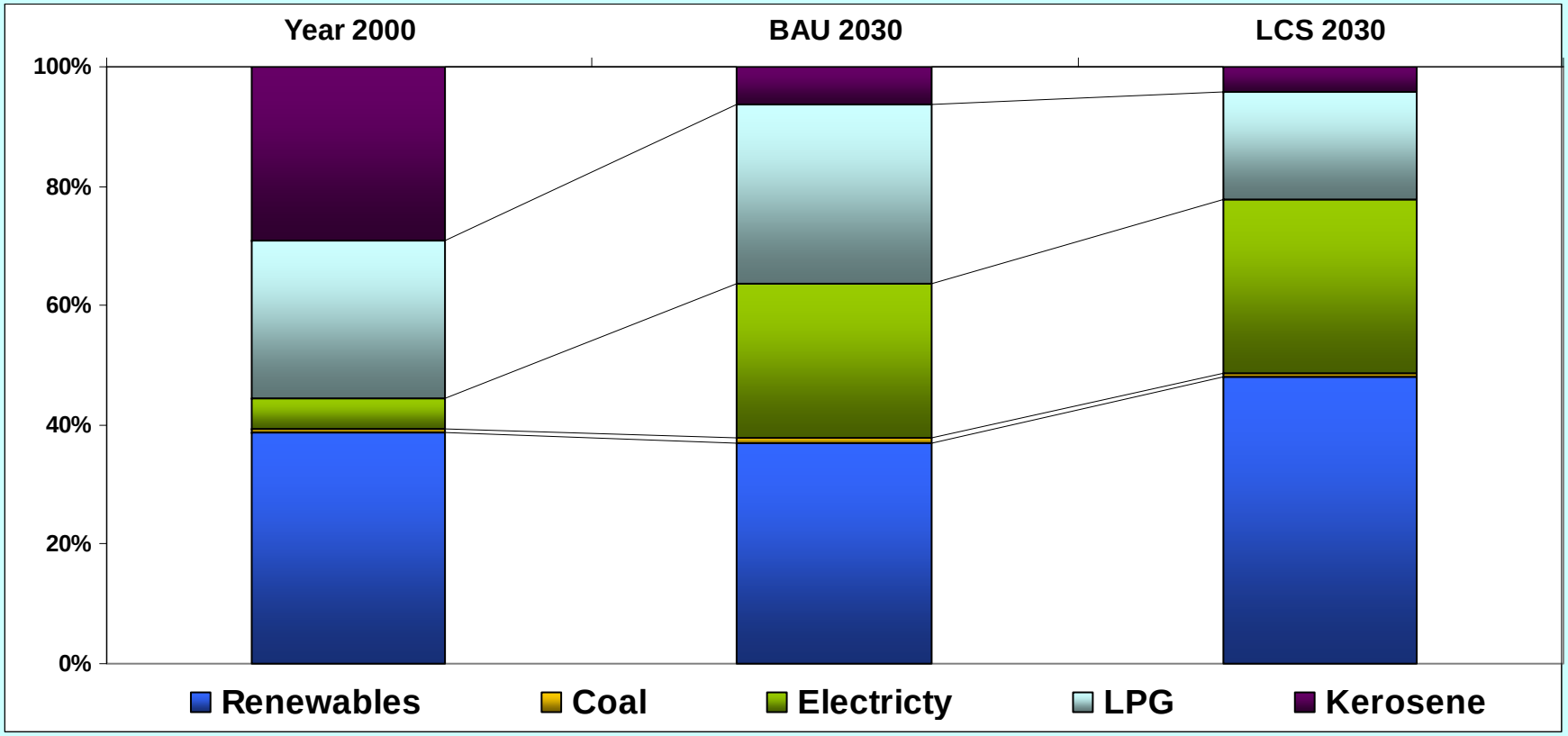
- Technology Efficiency Improvements
- Fuel Switch
- Behavioral Changes
- New Technology Adoption
- Retrofitting





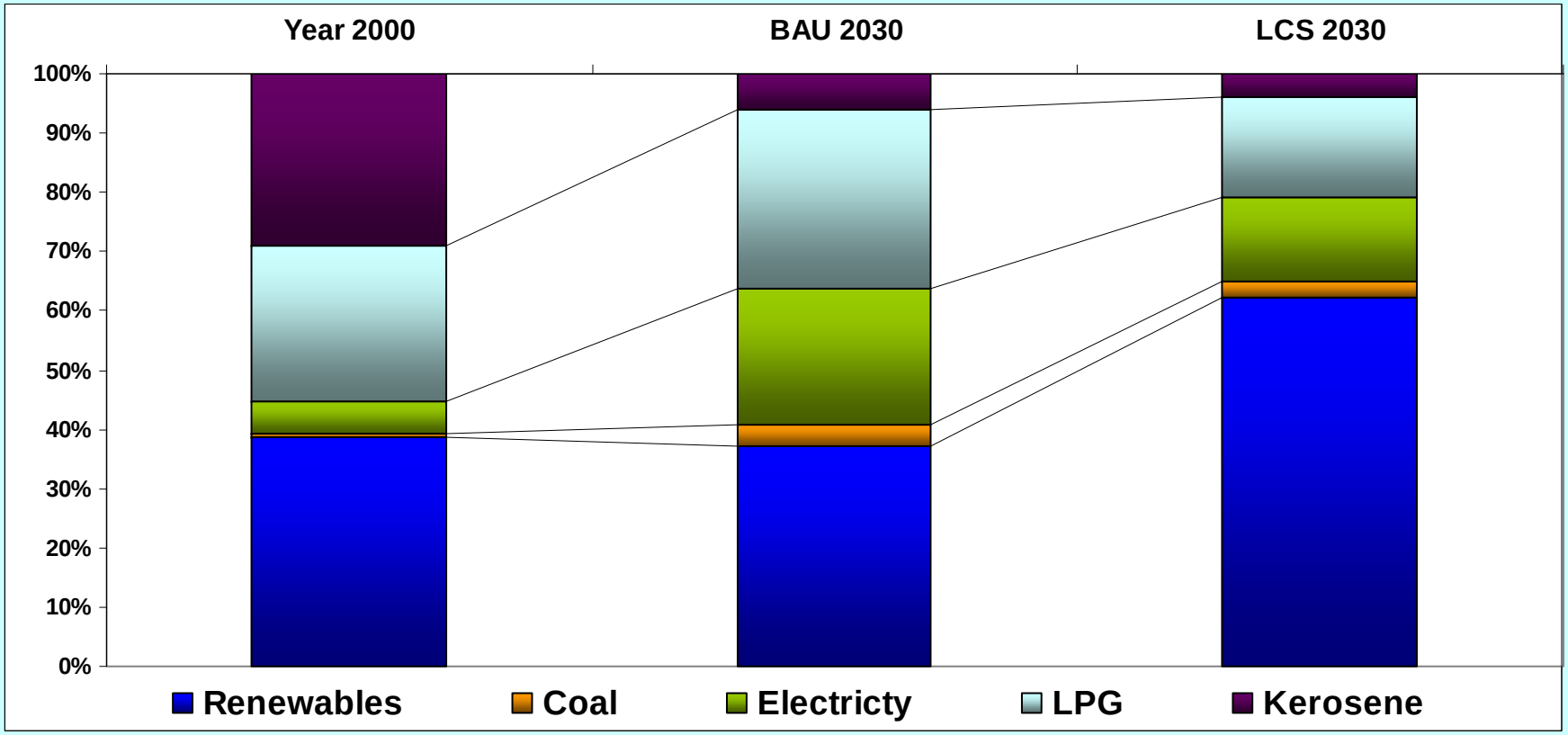
Residential Sector – Fuel Mix

Bhopal -BAU and LCS scenarios



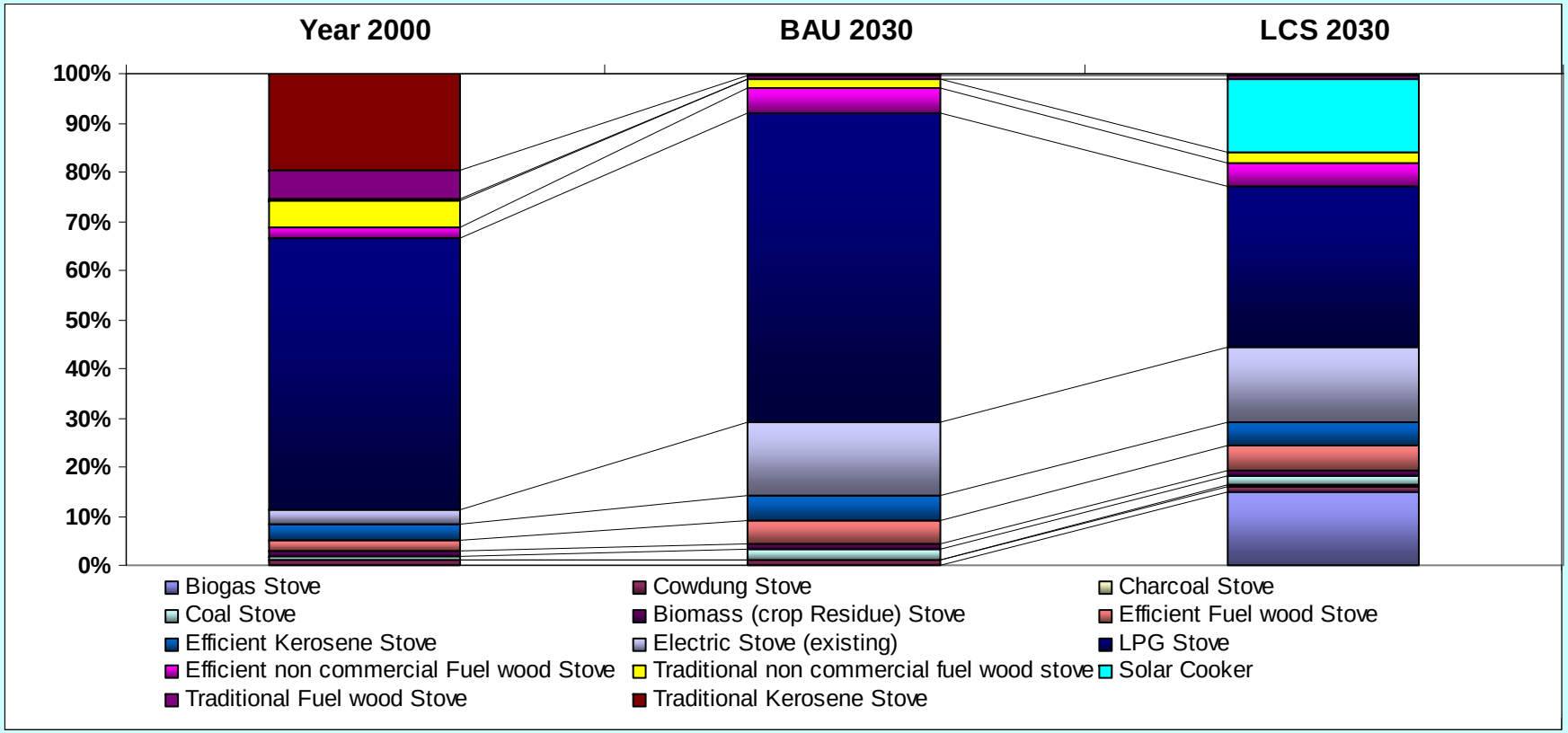
Residential Sector – Fuel (Cooking) Mix

Bhopal - BAU and LCS scenarios



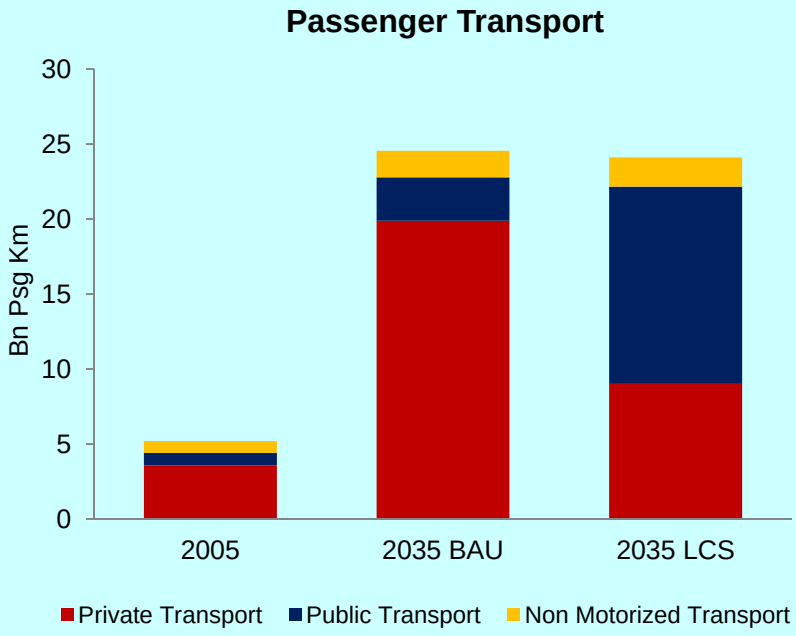
Residential Sector – Technology (Cooking devices) Mix

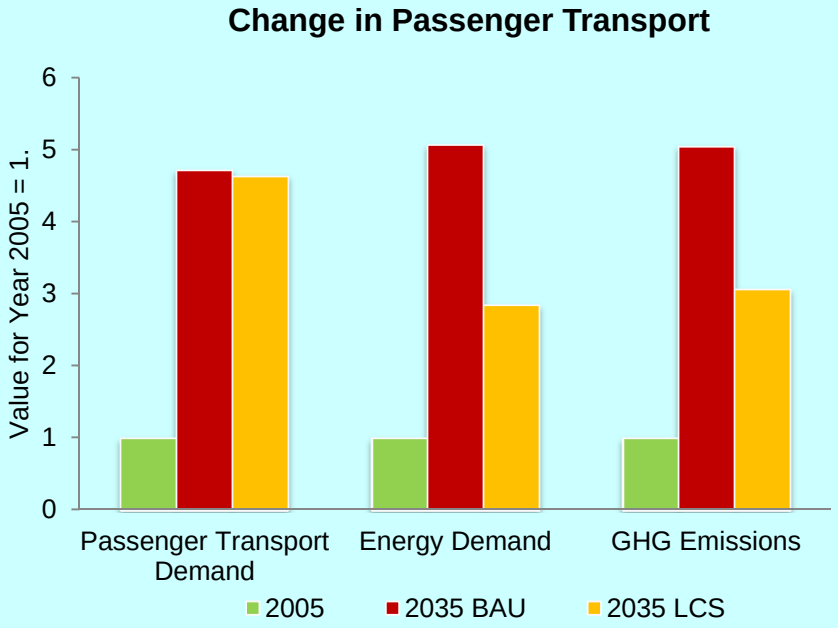
Bhopal - BAU and LCS scenarios



Mitigation: Passenger Transport

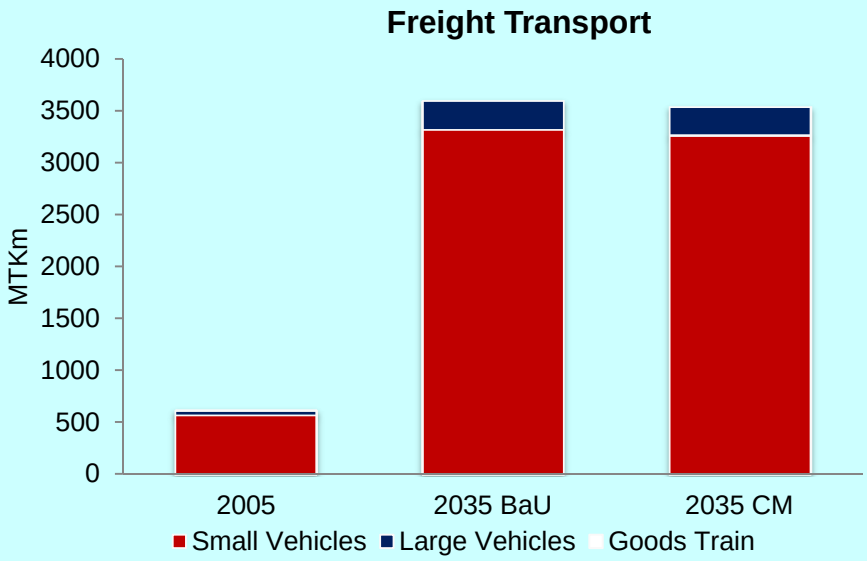
- Technology Efficiency Improvements
- Fuel Switch
- Improved Traffic Management
- Shift to Public Transport & Implementing ITMS

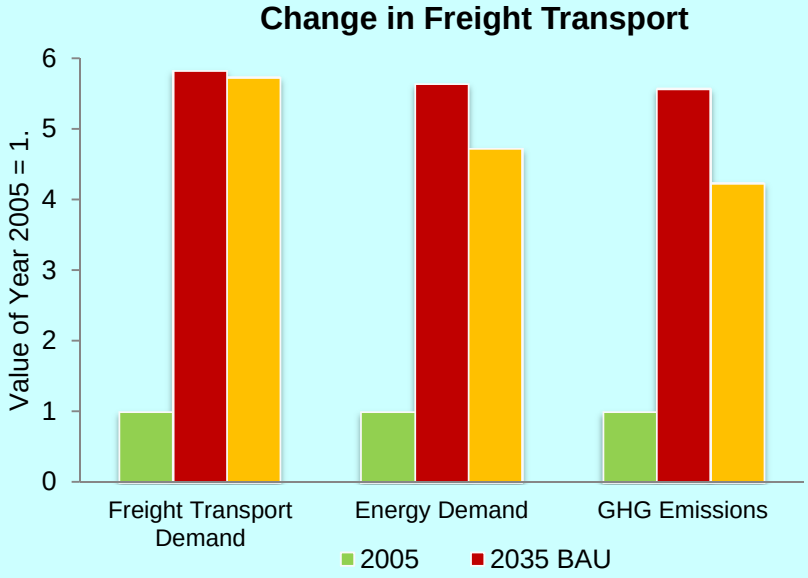




Mitigation: Freight Transport

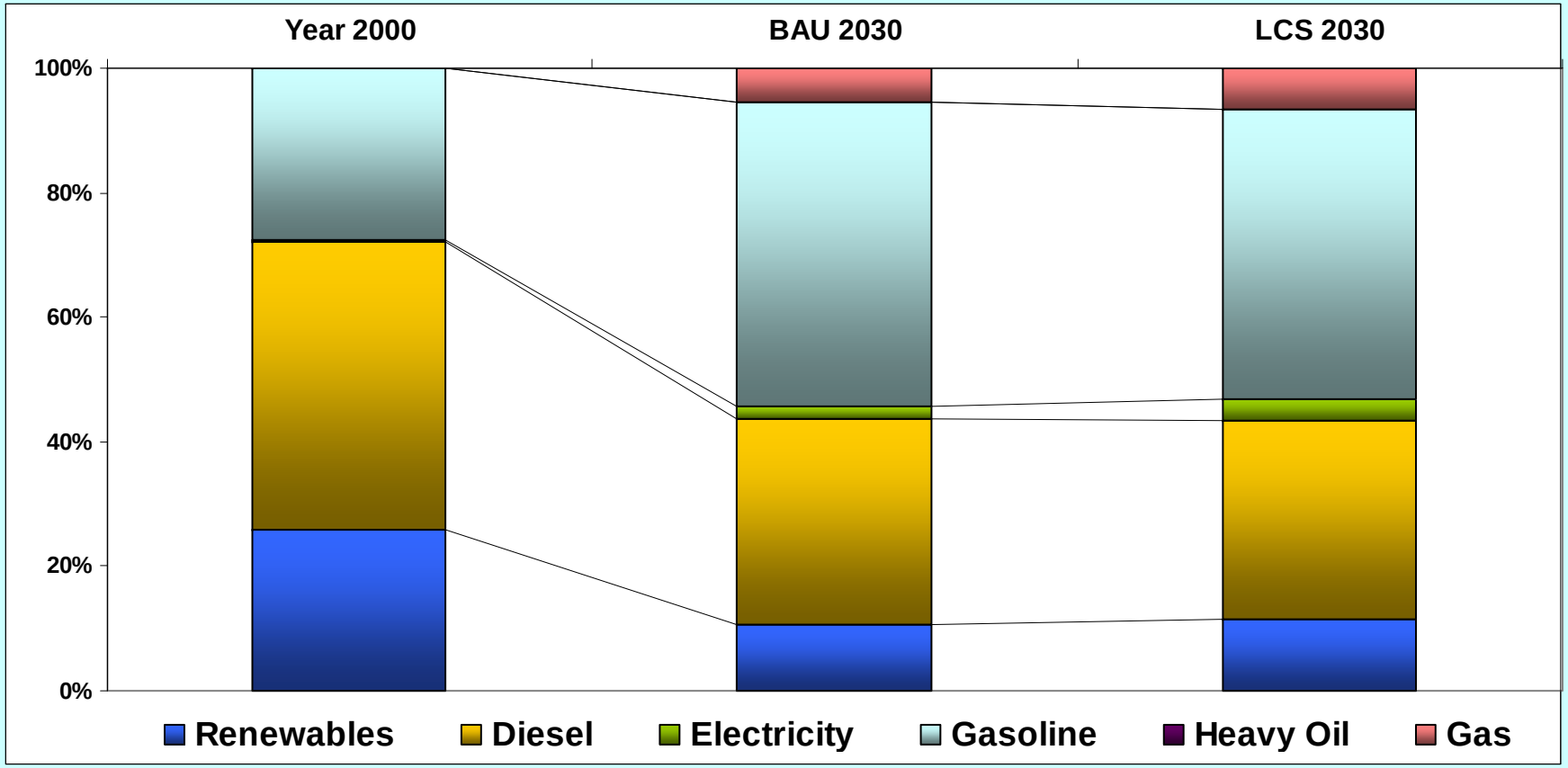
- Technology Efficiency Improvements
- Fuel Switch
- Implementing IMTS





Transport Sector- Fuel Mix

Bhopal - BAU and LCS scenarios



Residential Sector: Policy Measures

- ***Energy audit programmes***
  - Conducting energy audits to evaluate the most cost effective improvements.
- ***Fiscal Incentives***
  - Loan, grants and incentives programmes for energy conservation measures
- ***Energy code for New buildings***
  - Encourage or require increased installation of efficient lighting systems
  - Requirement of more efficient cooling systems
  - Increase window insulating values and requirement of shading devices
- ***Harnessing renewable energy***
  - Use of renewable energy sources to meet rapid growth of energy demand, supporting economic development without increasing atmospheric greenhouse gas concentrations.





Transport Sector: Policy Measures

- ***The cost-effectiveness of technology-specific policies:*** to be carefully considered like banning certain vehicles or prohibiting traffic in certain areas.
- ***Use of alternative fuels:*** vehicles using LPG/CNG emit considerably less particulate matter than conventional diesel.
- ***Traffic management measures:*** such as coordination of traffic lights, zebra crossings, side paths, left turns which yields significant economic benefits because it decreases congestion and improves mobility as a step towards integrated transport management system (ITMS).
- ***Demand management:*** through provision of public transport, fiscal measures, area wide licensing, pricing instruments such as differential pricing for access and preferential treatment of high-occupancy vehicles. Public transport dedicated bus.
- ***Use of non-motorized transport (NMT) mechanism:*** to be promoted by curtailing motorization and elimination of impediments to NMT. Government intervention, like introducing stringent parking restrictions and constructing safe bicycle routes.
- ***Inspection and maintenance*** *of vehicles and retirement and scrapping;* retirement and scrapping of old vehicles and improved maintenance.

Thanks!!