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

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

Global development scenarios and Low Carbon World Roadmaps, 2005-2100

Option 1: Global scale analysis

National development scenarios and Low Carbon nations Roadmaps, 2005-2050

Option 2: National scale analysis

City development scenarios and Low Carbon Cities Roadmaps, 2005-2030

Option 3: Regional/Local scale analysis

Adapted from Matsuoka (2009)
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$_2$ emissions from energy use focus
- Extendable to other sectors and env. Loads
- Program: GAMS, Input & output: Excel

Model Application
- Illustrate quantitative future snapshot of an 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**
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

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

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

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

<table>
<thead>
<tr>
<th>Period</th>
<th>Petrol (Kilo lit)</th>
<th>Diesel (Kilo lit)</th>
<th>LPG (no. of cylinders)</th>
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<tr>
<td>2003-04</td>
<td>31300</td>
<td>38400</td>
<td>3608000</td>
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<td>2004-05</td>
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<td>40900</td>
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<tr>
<td>2005-06</td>
<td>34900</td>
<td>42700</td>
<td>3903000</td>
</tr>
</tbody>
</table>

Electricity Consumption rise

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

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

<table>
<thead>
<tr>
<th>Socio Economic Assumptions</th>
<th>2005 (Base)</th>
<th>2035 (BAU)</th>
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</thead>
<tbody>
<tr>
<td>Population</td>
<td>2121617</td>
<td>4546081</td>
</tr>
<tr>
<td>Household</td>
<td>385970</td>
<td>1136406</td>
</tr>
<tr>
<td>GDP in Billion INR</td>
<td>70</td>
<td>383</td>
</tr>
<tr>
<td>Commercial Floor Area (in Sq Km)</td>
<td>61</td>
<td>344</td>
</tr>
<tr>
<td>Passenger Transport (MPKm)</td>
<td>5204</td>
<td>24742</td>
</tr>
<tr>
<td>Freight Transport (MTKm)</td>
<td>617</td>
<td>3591</td>
</tr>
<tr>
<td>Energy Demand (Ktoe)</td>
<td>815</td>
<td>3044</td>
</tr>
<tr>
<td>CO2 Emissions (KtC)</td>
<td>683</td>
<td>3217</td>
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</table>
Simulation Results and Analysis
Energy Demand and GHG Emission

**Sectoral Energy Demand**
- Residential
- Commercial
- Industry
- Passenger
- Freight

**Primary Energy Demand**
- Coal
- Oil
- Gas
- Hydro
- Nuclear
- Solar
- Biomass

**GHG Emissions per capita**
- Residential
- Commercial
- Industry

**Sectoral GHG Emissions in Bhopal**
- Residential
- Commercial
- Industry
**Sector wise Mitigation Contribution**

**Industrial 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

**Passenger Transport**
- Value for Year 2005 = 1.

**Freight Transport**
- Value of Year 2005 = 1.

**Commercial Sector**
- Value for Year 2035 = 1.

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

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**Output (Bn INR)**
- Value for Year 2005 = 1.

**Industrial Sector**
- Energy Demand
- GHG Emissions

**Residential Sector**
- No of Household
- Energy Demand
- GHG Emissions

**Commercial Floor Space**
- Energy Demand
- GHG Emissions

**Passenger Transport**
- Energy Demand
- GHG Emissions

**Freight Transport**
- Energy Demand
- GHG Emissions

**Commercial Sector**
- Energy Demand
- GHG Emissions

**Value for 2005=1.**

**2005** | **2035 BAU** | **2035 LCS**
GHG Emission Scenario and Interventions
Mitigation Contribution

GHG Emissions Scenario

Mitigation Contribution

- Efficiency Improvement (Transport)
- Efficiency Improvement (Industry)
- Efficiency Improvement (Building)
- Fuel Switch
- Reduction in Energy Service demand
- Emissions

Residential
Commercial
Industry
Passenger
Freight
LCS Actions and Strategy Formulation
Bhopal LCS: Seven Actions

Action 1: Green Governance
Action 2: Holistic Habitat
Action 3: Sustainable Style
Action 4: Cellular City
Action 5: Form and Flow
Action 6: Nurturing Nature
Action 7: Rural Riches

SECTORAL CONTRIBUTION

<table>
<thead>
<tr>
<th>ACTIONS</th>
<th>Residential</th>
<th>Commercial</th>
<th>Industry</th>
<th>Passenger Transport</th>
<th>Freight Transport</th>
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<tbody>
<tr>
<td>1 GREEN GOVERNANCE</td>
<td>G</td>
<td>C</td>
<td>I</td>
<td>P</td>
<td>F</td>
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<tr>
<td>2 HOLISTIC HABITAT</td>
<td>R</td>
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<td>R</td>
<td>R</td>
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<tr>
<td>3 SUSTAINABLE STYLE</td>
<td>S</td>
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<td>S</td>
<td>S</td>
<td>S</td>
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<tr>
<td>4 CELLULAR CITY</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>5 FORM AND FLOW</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
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<tr>
<td>6 NURTURING NATURE</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>7 RURAL RICHES</td>
<td>R</td>
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<td>R</td>
<td>R</td>
<td>R</td>
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LCS Case Study: Bhopal 2035

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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