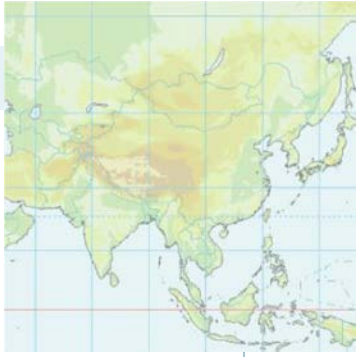

Low Carbon Society Research: Activities in India in 2013-14

P.R. Shukla
Indian Institute of Management
Ahmedabad, India

Presented in
The 19th AIM International Workshop
National Institute for Environment Studies, Tsukuba, Japan
December 13-14, 2012

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Overview of Activities (FY* 2013-14)

1. Low Carbon Society Modeling in India

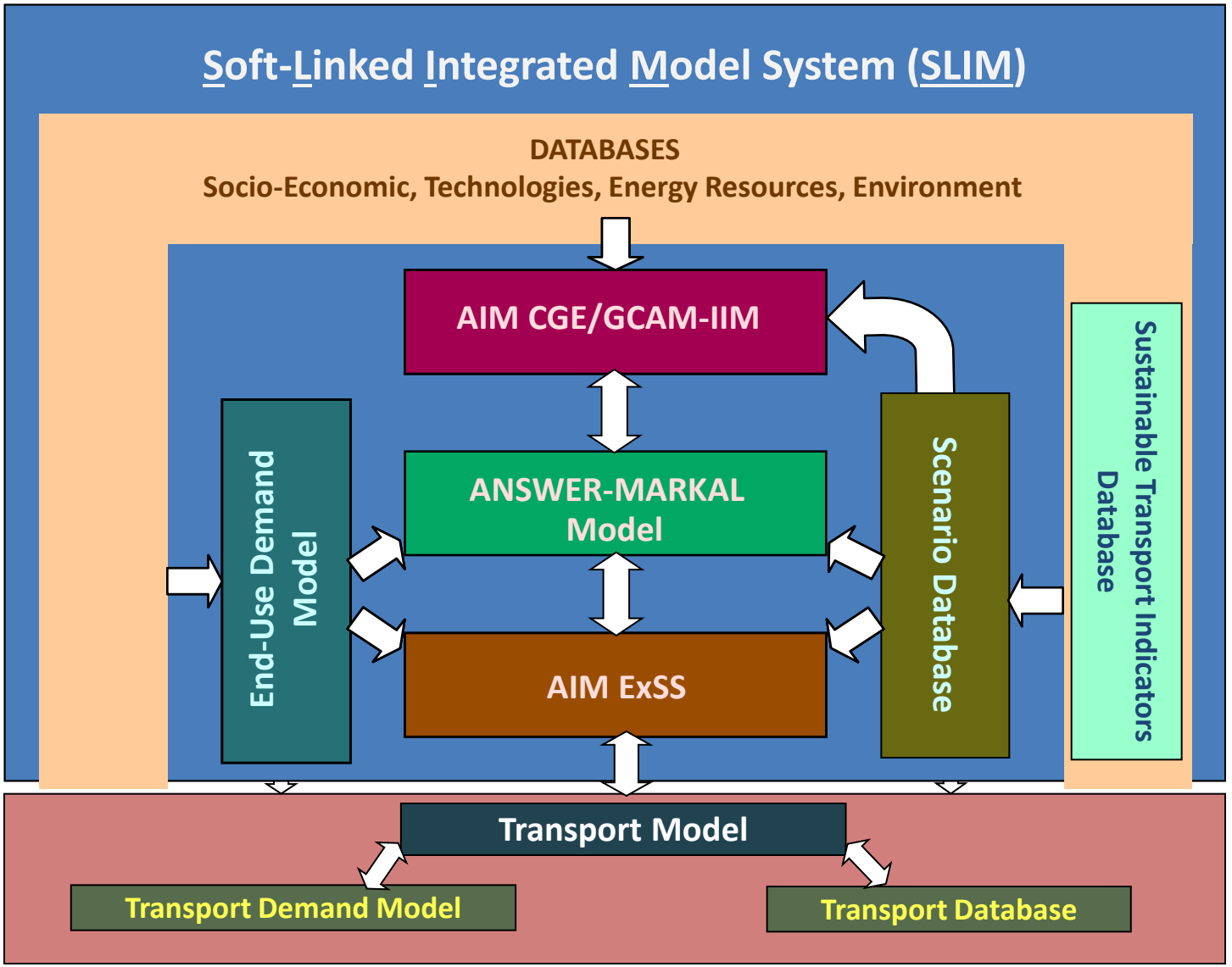
- *Model*
- *Scenarios*
- *Sector (All; Transport)*
- *Region (National, Urban)*
- *Energy Demand*
- *CO2 Emission Reduction*
- *Environmental Benefits*
- *Contribution to National Mitigation*

2. Dissemination of Research (FY 2013-14)

3. FY 2014-15: Way Forward

*FY: Fiscal Year

Soft-Linked Integrated Model



National Level Committment to Low Carbon Development (NAPCC)

India's National Climate Change Action Plan: Implementation Strategy

India's Climate Change National Action Plan (NCCAP): Implementation Strategy

8 National Missions of NCCAP

1. **Solar Energy** (20 GW Grid Solar by 2022; 20 million sq. meter collectors)
2. **Enhanced Energy Efficiency** (Avoided capacity: 19000 MW by 2014-15)
3. **Sustainable Habitat**
4. **Water Sector** (20% water use efficiency improvement)
5. **Sustaining the Himalayan eco system**
6. **A "Green India"** (20 Mil. Hectare forestation by 2020; Forest cover from 23 to 33%)
7. **Sustainable Agriculture** (Micro irrigation promotion in 40 Mil. Hectare)
8. **Strategic Knowledge for Climate Change**

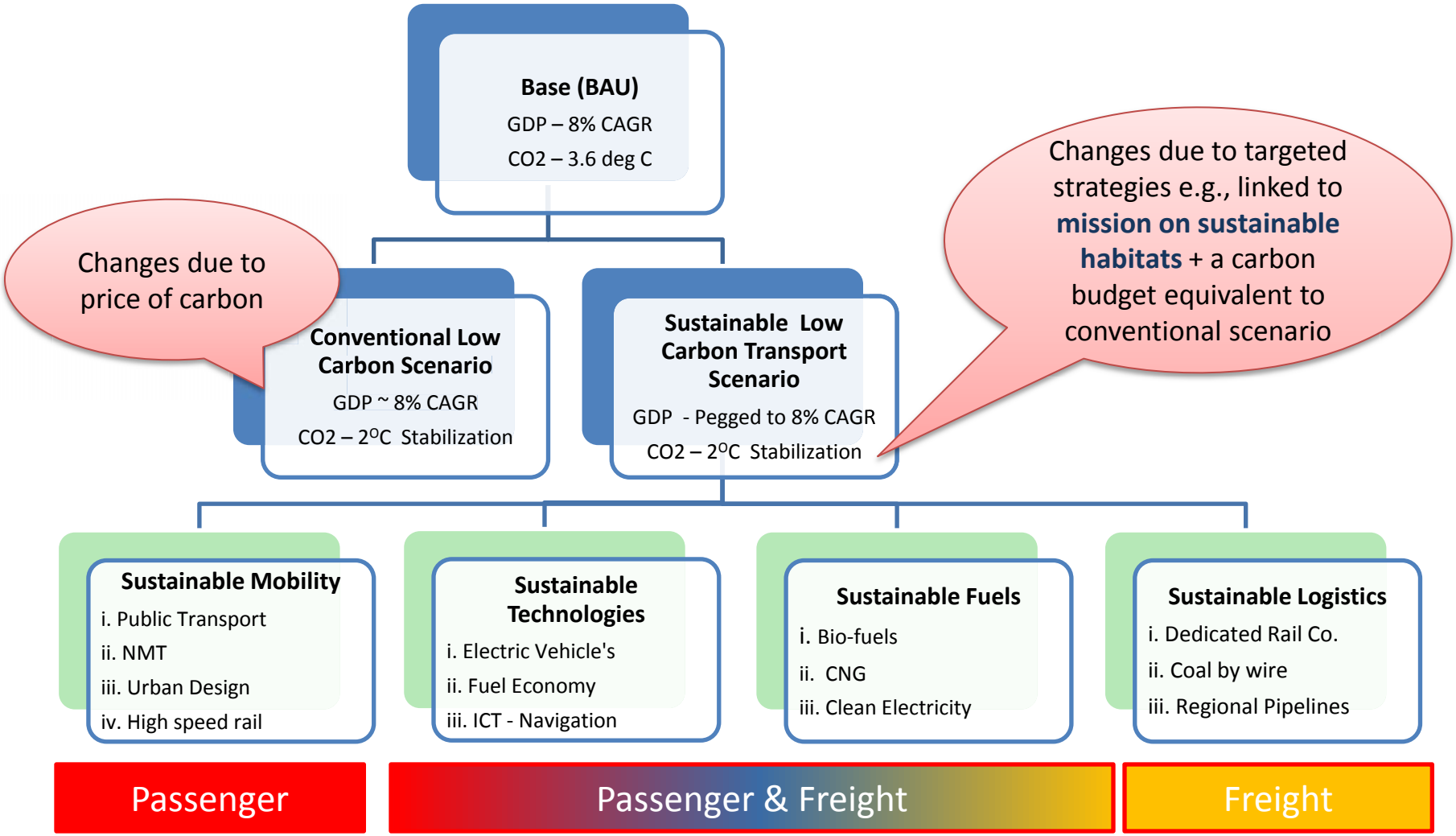
Implementation of Domestic Actions

- **Carbon tax on coal to fund clean energy**
  - US $1/ton on domestic & imported coal; fund to be used for Clean Energy
- **Enhanced Energy Efficiency measures**
  - Mandate to reduce specific energy consumption;
  - Energy savings certificates & trading
  - Energy efficiency ratings mandatory for 4 key appliances from Jan 2010
  - Reduction of 6 GW of electricity demand through mass distribution of CFLs
- **Renewable Energy Push**
  - Capital Subsidies and/or Preferential Feed-in Tariff
  - Renewable Energy Certificates Market
- **Mission on sustainable habitat**
  - Energy efficiency in residential, commercial and urban transportation
  - Managing water, wastewater and solid waste with recycling, reuse and energy creation

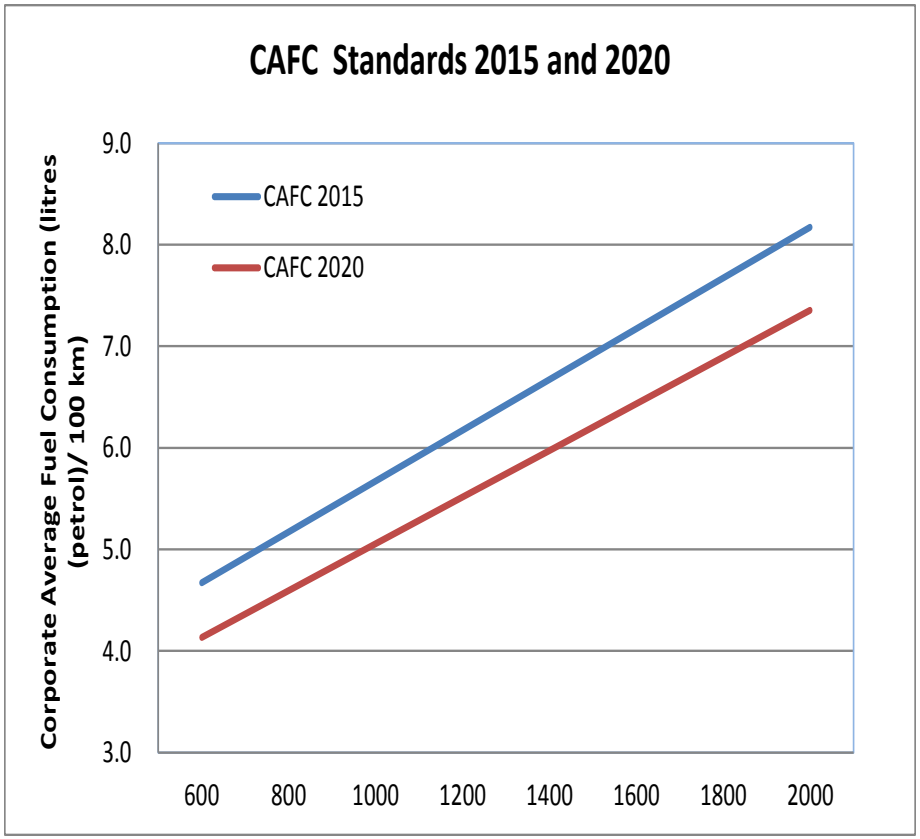
National Mission on Sustainable Habitats

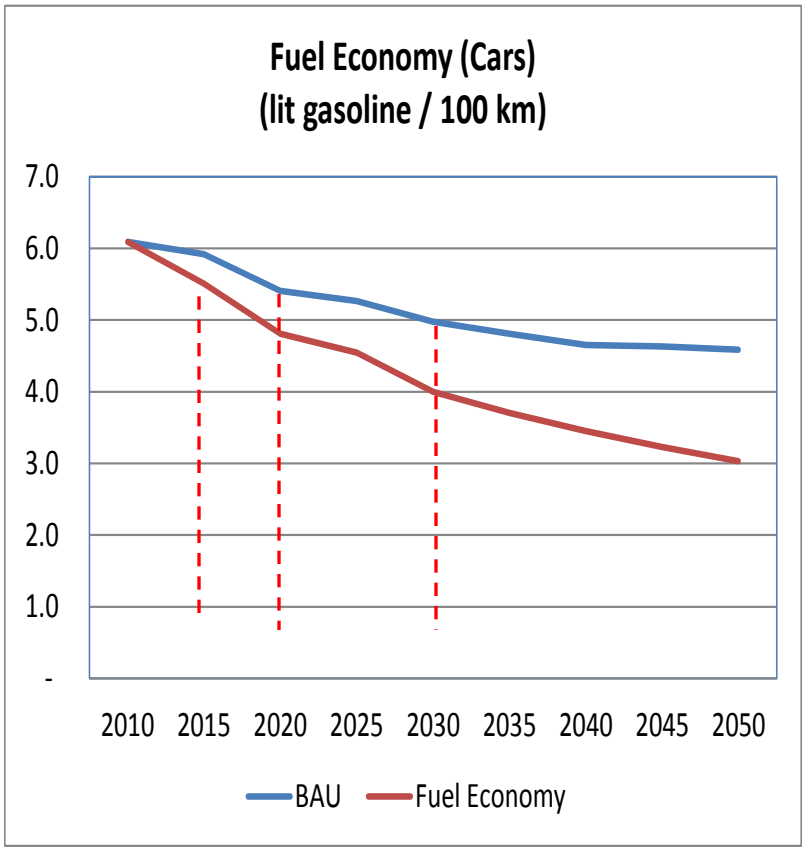
- Strengthening public transport
- Modal shift to non-motorized transport
- Planning, monitoring and co-ordination
  - Integrated urban plan
  - Multi modal integration (Unified Urban Metropolitan Transport Authority)
  - **Comprehensive mobility planning (CMP)**
  - Central financial support
  - Integrating intercity transport with urban transport
  - Service level benchmarks (SLB)
- Technology
  - fuels switch (biofuels and alternative fuels (e.g., EVs))
  - fuel efficiency standards for vehicles
  - Facilitating R&D
  - Discouraging diesel

Scenario Architecture Transport: National



Fuel Efficiency: BAU and Fuel Economy



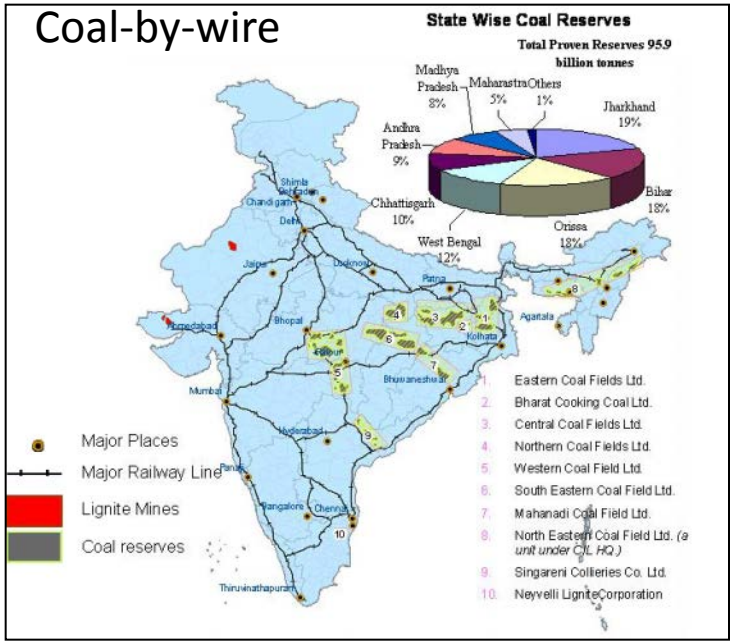


Sustainable Mobility Storyline

Non-Motorized Transport

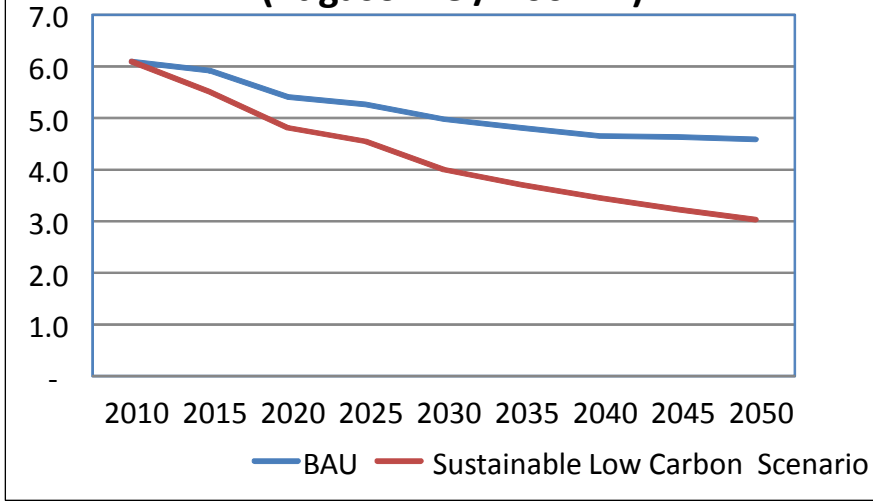
Pipe Transport

Coal-by-wire

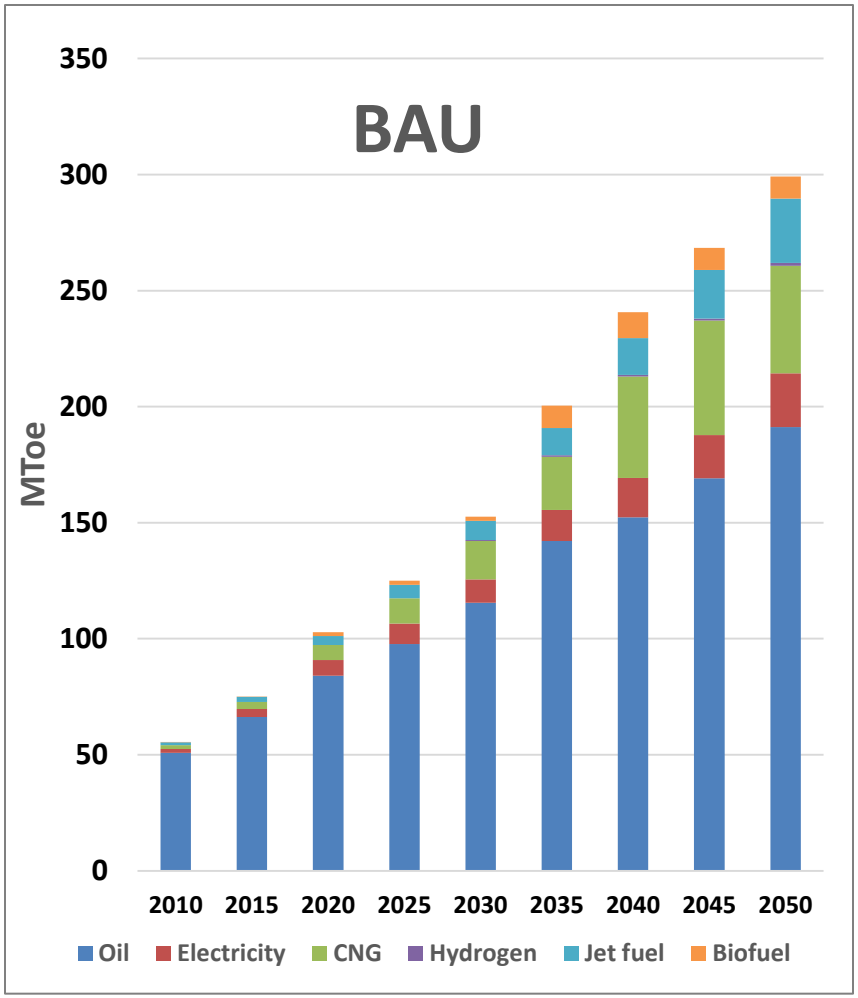


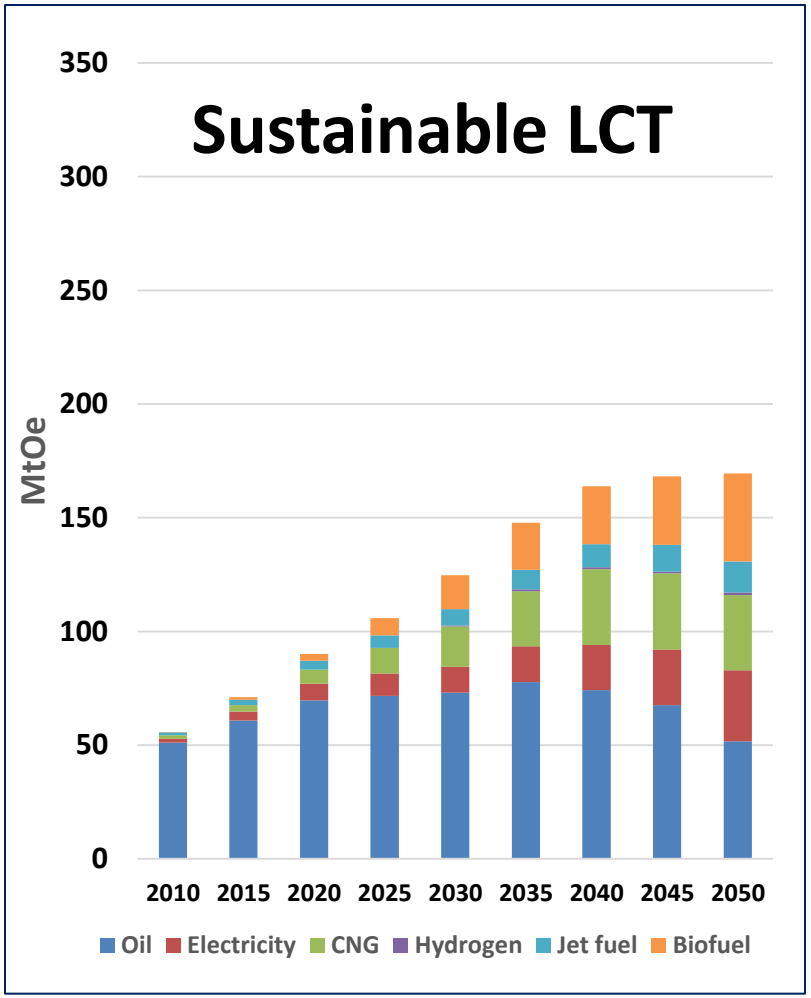
Fuel Economy (Cars)

(lit gasoline / 100 km)



Energy Mix for Transport





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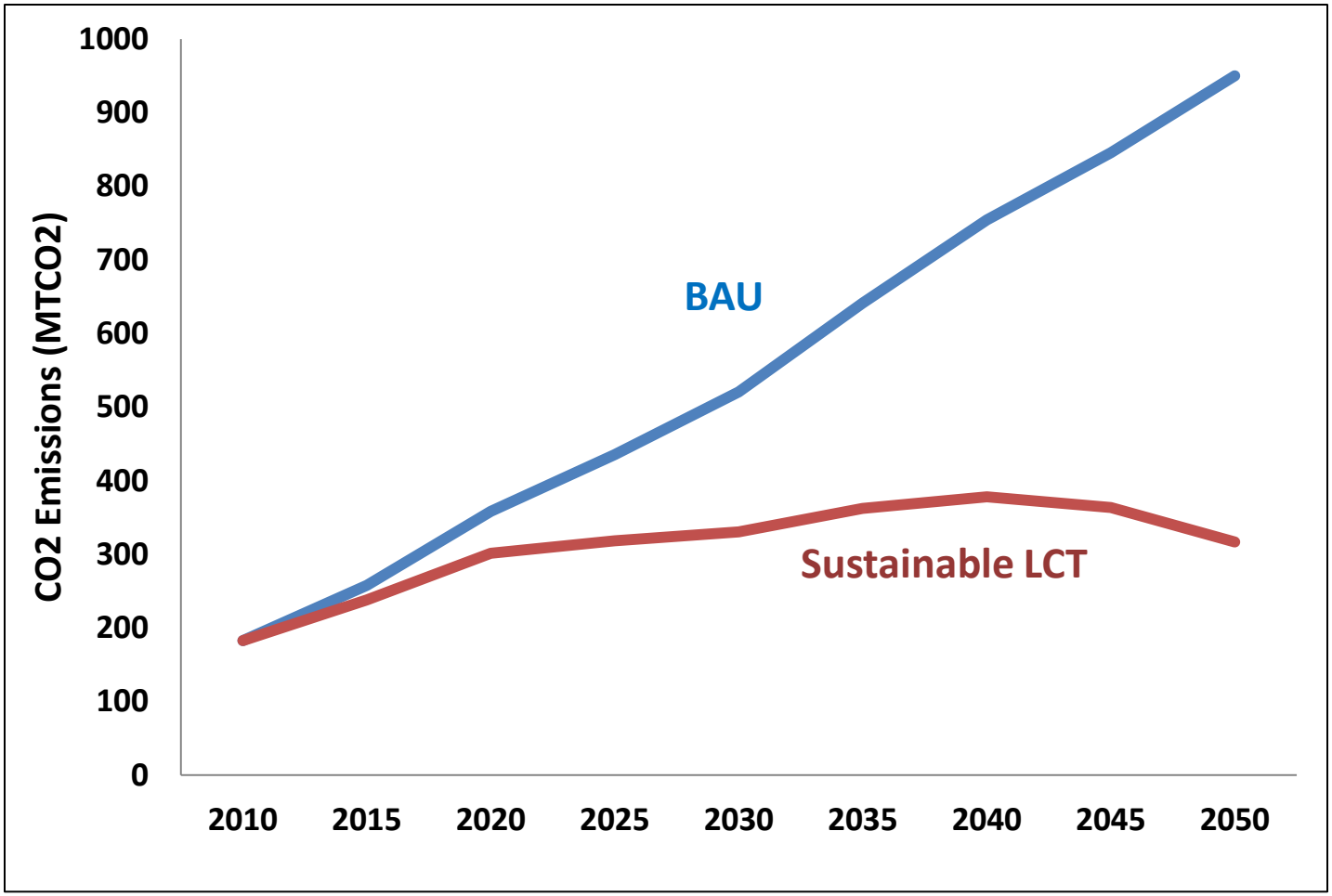
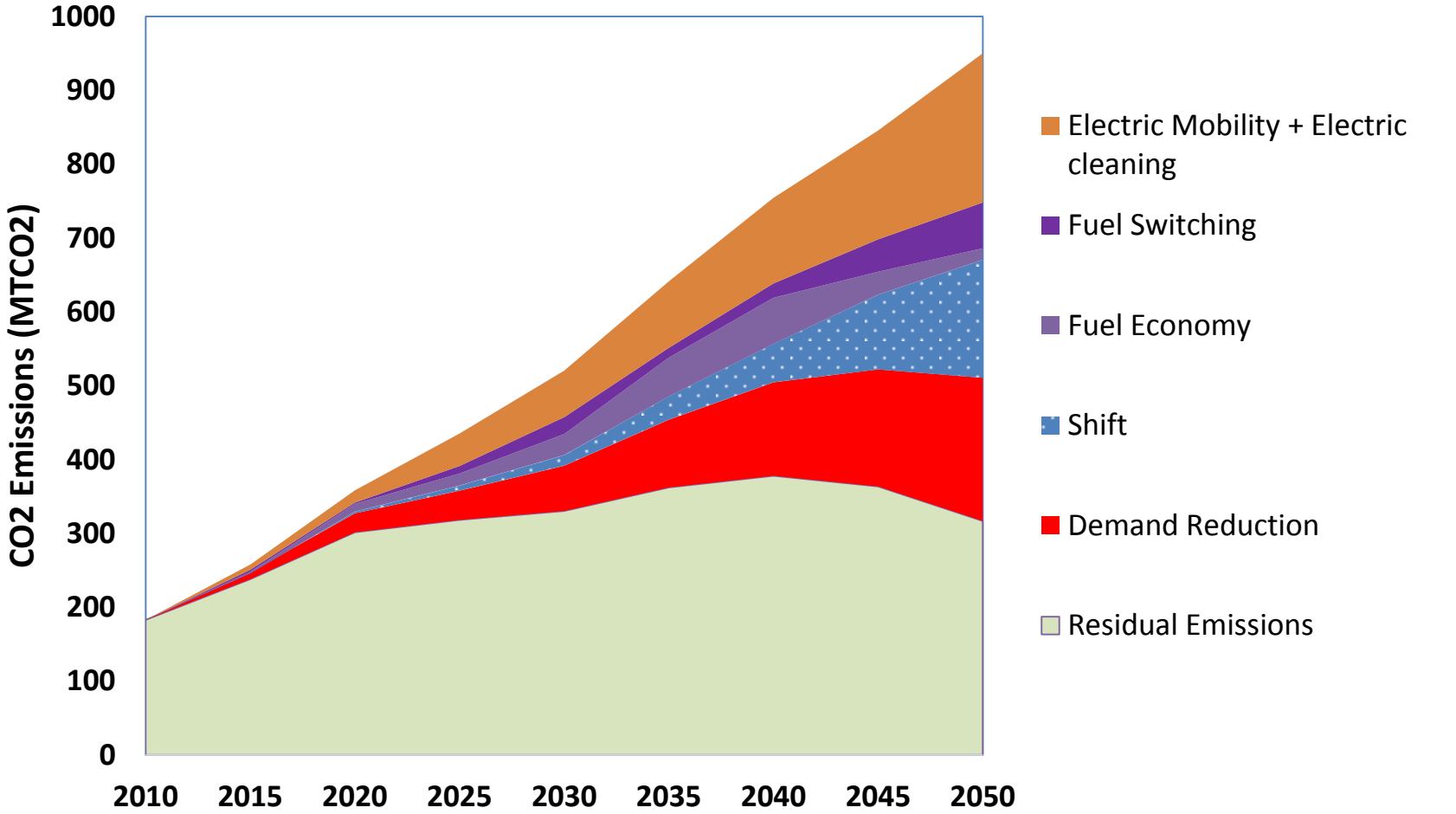
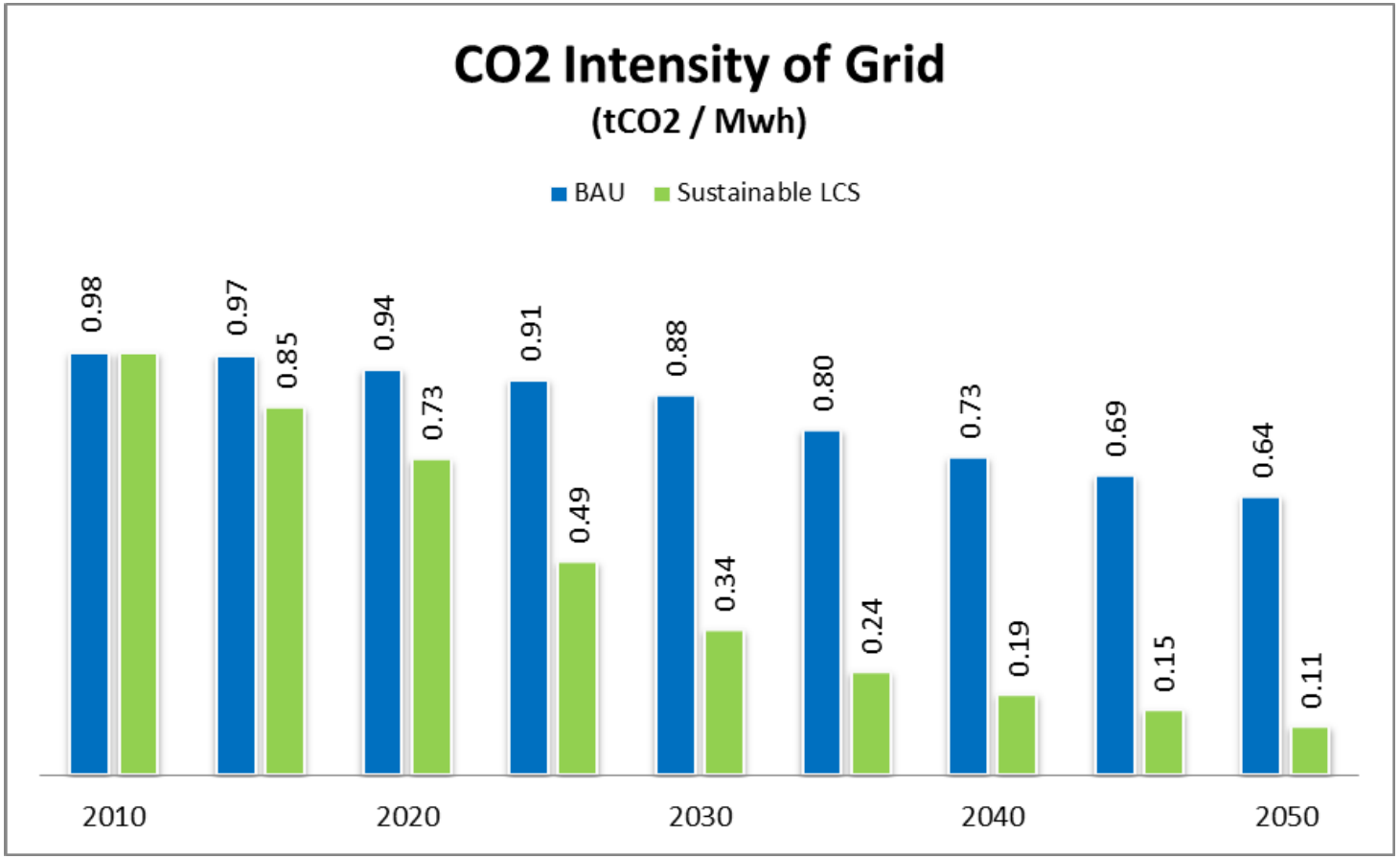
Transport Sector CO_2 Emissions



CO_2 Mitigation: Sustainable LCT Scenario

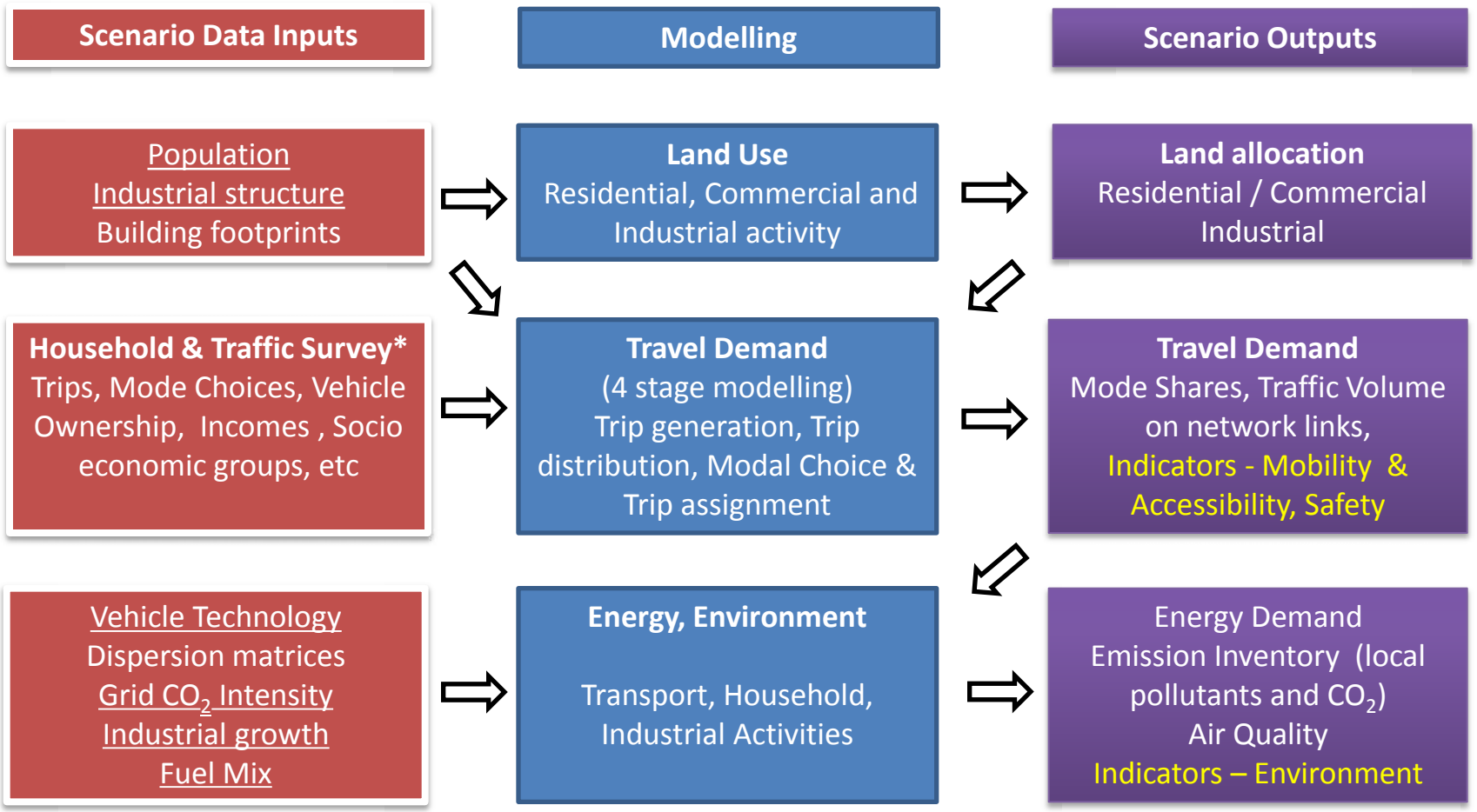


Electricity Cleaning & Electric Mobility



Including Low Carbon Urban Transport in the Comprehensive Mobility Plan

Modelling Framework for CMP*

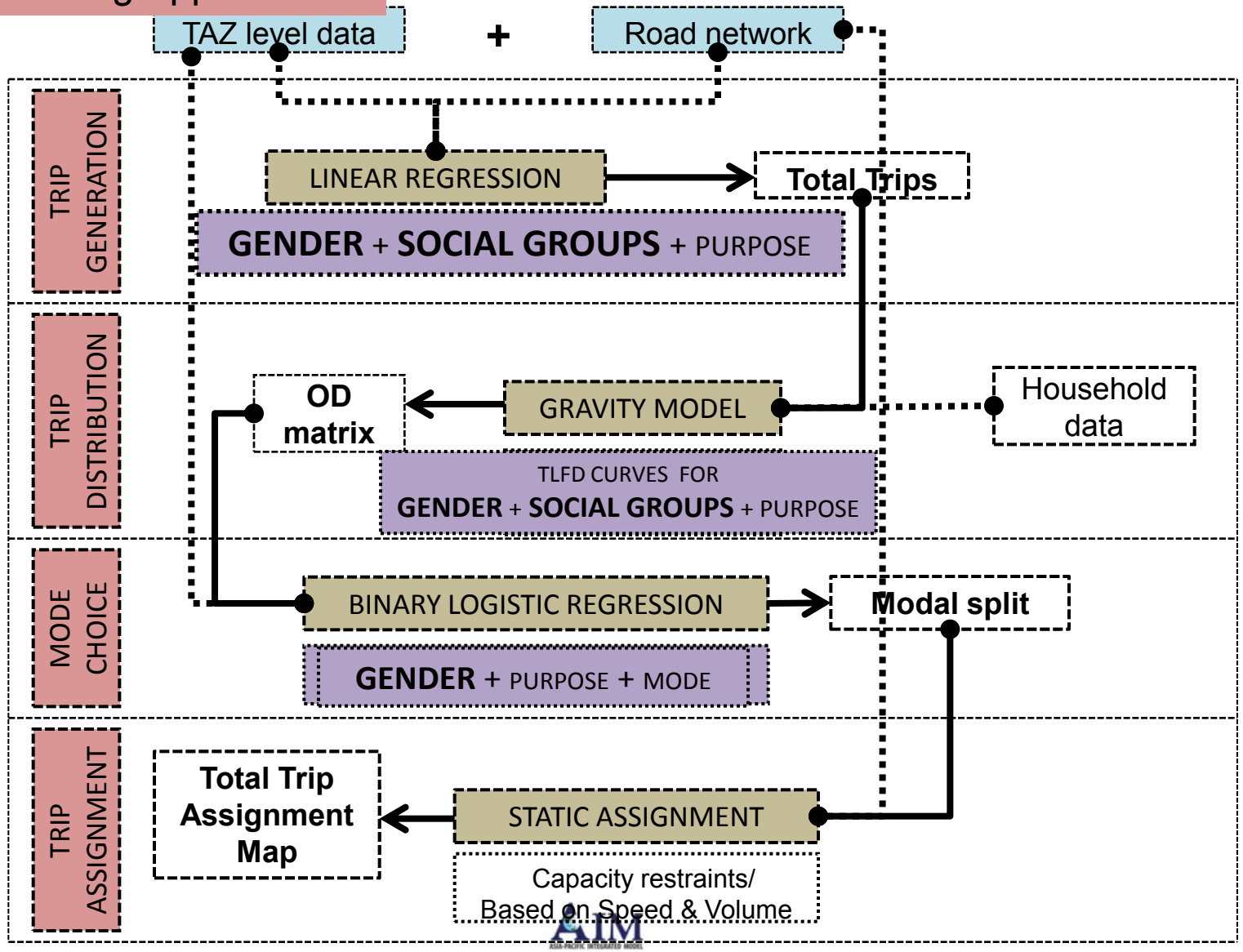


Flow of information

- Information of household surveys is collected using stratified sampling and all income groups , social groups, genders covered
- Underlined parameters can be taken from national assessments.

Modelling Framework for Travel Demand

Current Modelling Approach



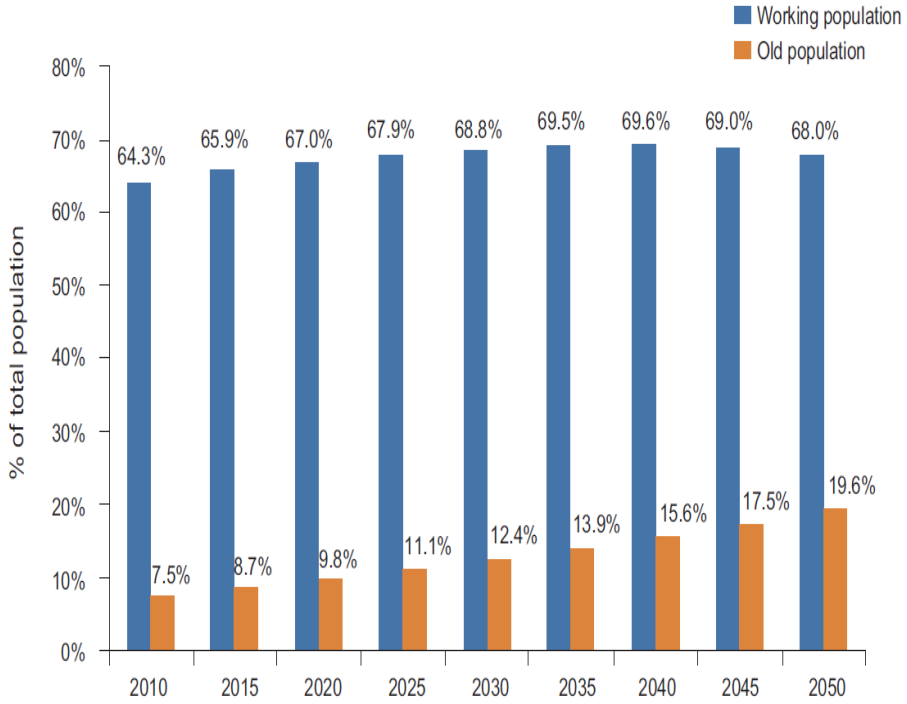
Source: Talat Munshi, 2013, LCMP Rajkot

Key Scenario Data Inputs & Sources

- Population: Growth, House Hold Size, Per capita Income (Secondary Sources)
- Travel Behaviour : House Hold & Traffic Surveys
- Vehicle technologies: Petrol Pump & Secondary Sources
- Grid CO_2 Intensity : Secondary Sources

Demographic Transitions: India

Working & Old Population

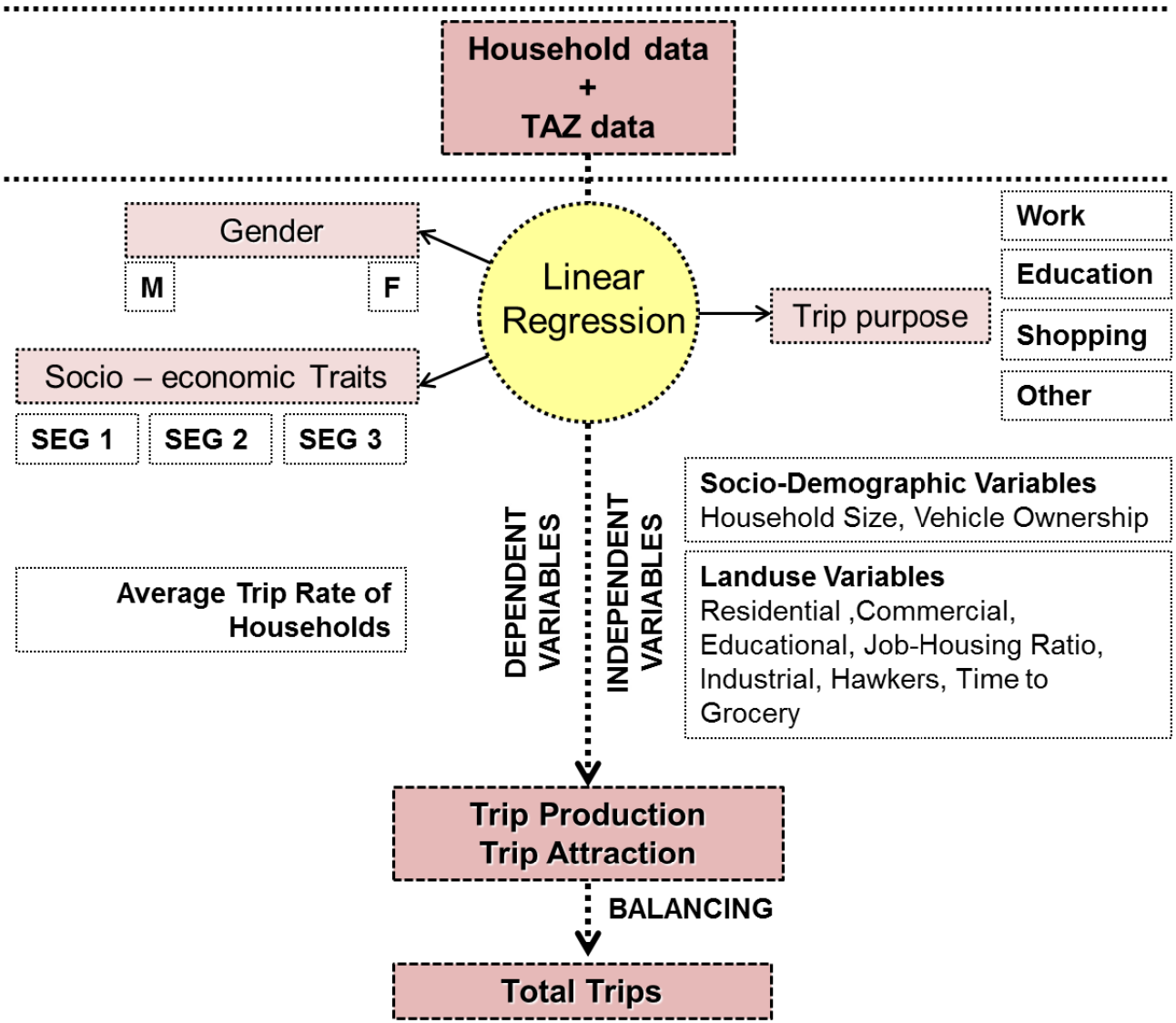


House Hold Size

Year	Average Size of Household	
	Rural	Urban
2000*	5.40	5.10
2005	5.23	4.80
2010	5.06	4.52
2015	4.90	4.25
2020	4.75	4.00
2025	4.60	3.76
2030	4.45	3.54
2035	4.31	3.33
2040	4.18	3.13
2045	4.04	2.95
2050	3.90	2.76

Source : UN Population Division

Travel Behaviour Modelling: Trip Generation



Source: Talat Munshi, 2013, LCMP Rajkot

Indicator Comparison

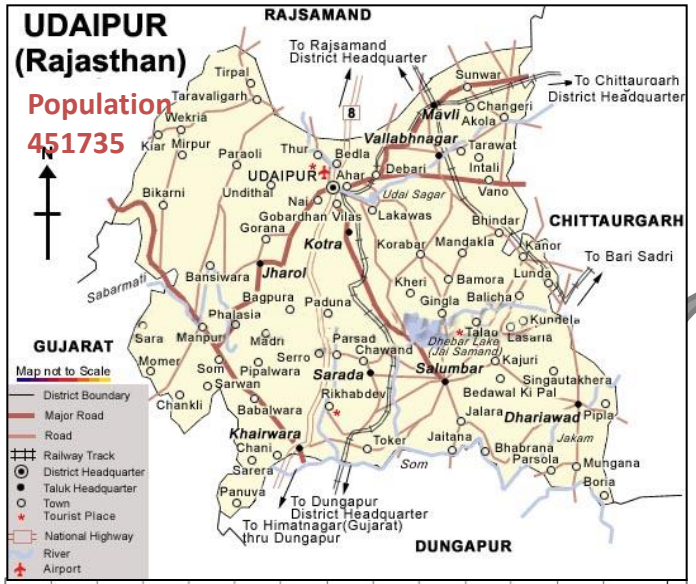
Indicator	Base Year (2013)	Business as Usual Scenario (2041)	Sustainable Urban Transport Scenario (2041)
Mobility and Accessibility			
Modal Share in %			
Modal Share of Walk	25%	20%	28%
Modal Share of Cycle	3%	2%	9%
Modal Share of Two Wheeler	48%	51%	20%
Modal Share of Car	3%	3%	1%
Modal Share of IPT	18%	22%	10%
Modal Share of Public Transport	3%	2%	32%
Trip Length (KM)			
Walk	1.18	2.06	1.89
Cycle	2.37	3.65	3.09
Two Wheeler	5.54	5.92	5.13
Car	7.06	7.51	6.56
IPT	4.52	5.55	5.32
PT	-	5	5.65
Accessibility			
% of HH within 10 minutes of walking to access PT (IPT for Base Year)	69%	60%	83%
Emission Levels Annual			
NOx (tons)	33,218	87,516	36,066
SO2 (tons)	374	1,146	591
CO2 (million tons)	25	48	24
PM10 level (tons)	10,731	25,714	8,737

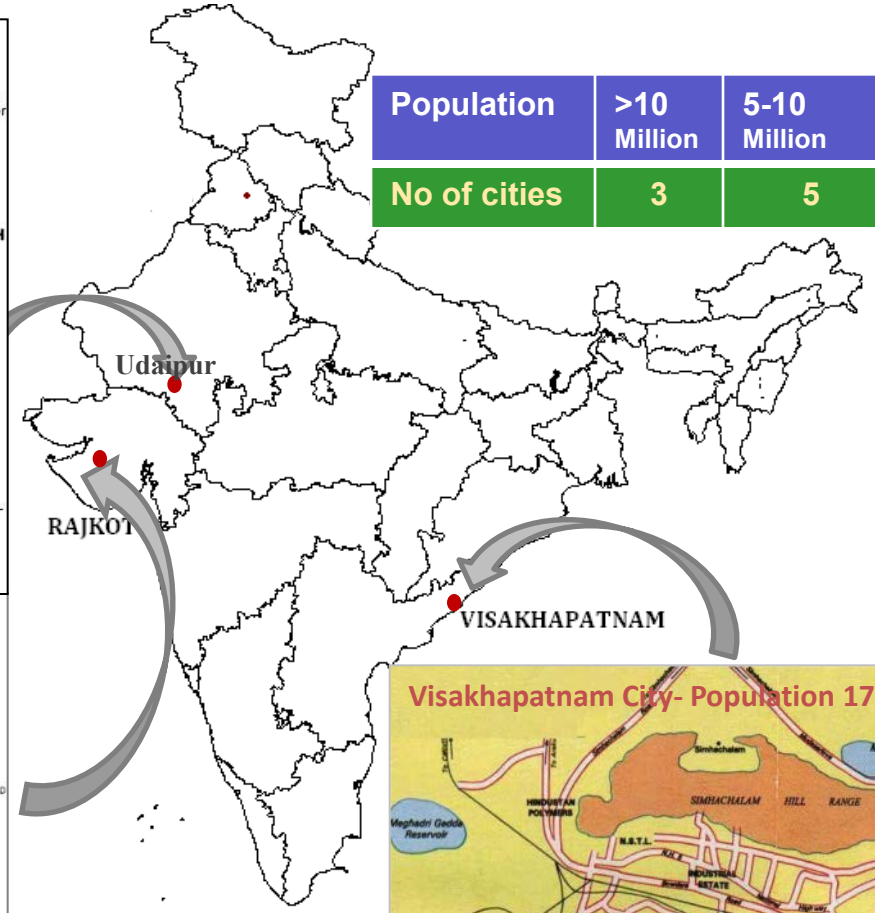
Source : Draft LCMP Report , Udaipur

Application to Cities

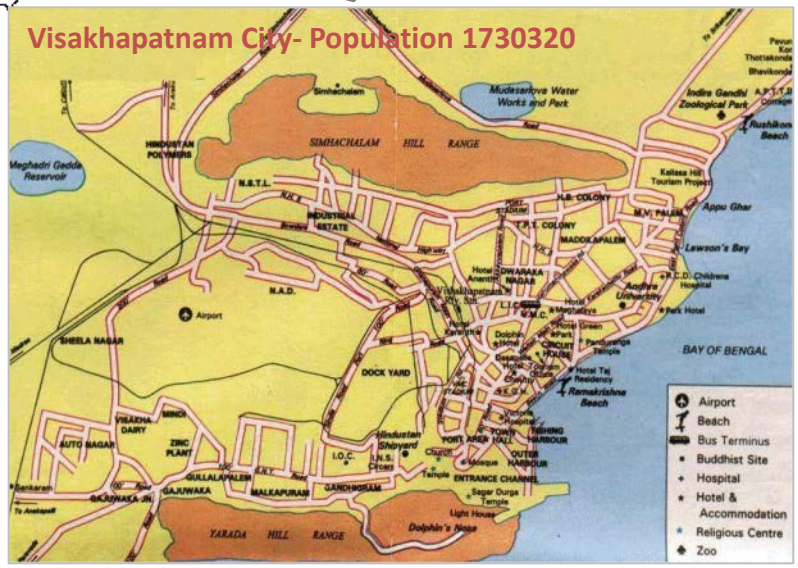
Low Carbon Benefits
Local Air Pollution Co-Benefits
Energy Benefits

Low Carbon Mobility Plans for Cities





Population	>10 Million	5-10 Million	2-5 Million	1-2 Million
No of cities	3	5	11	34



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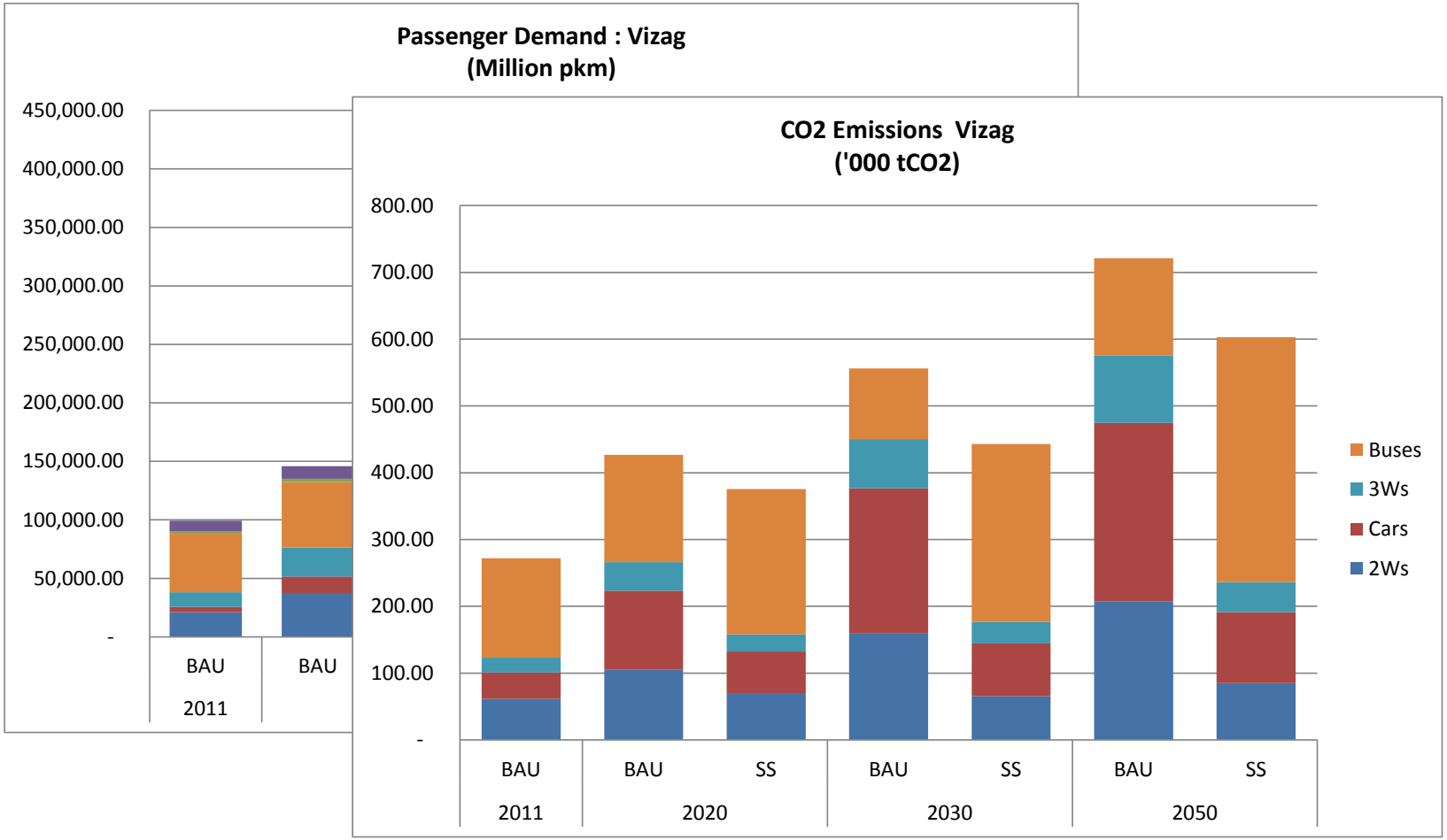
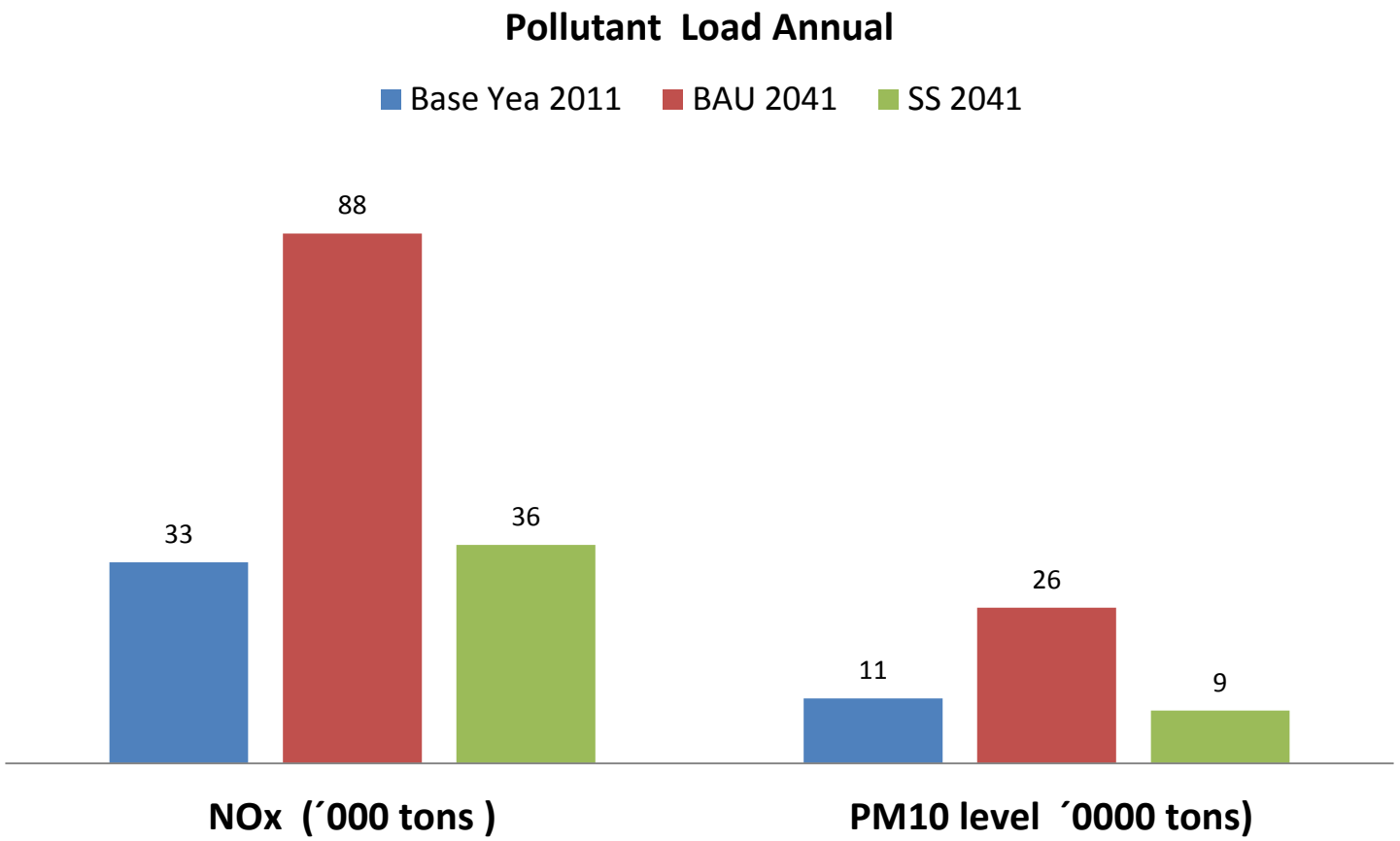
CO2 Emissions Reduction: Vishakhapatanam



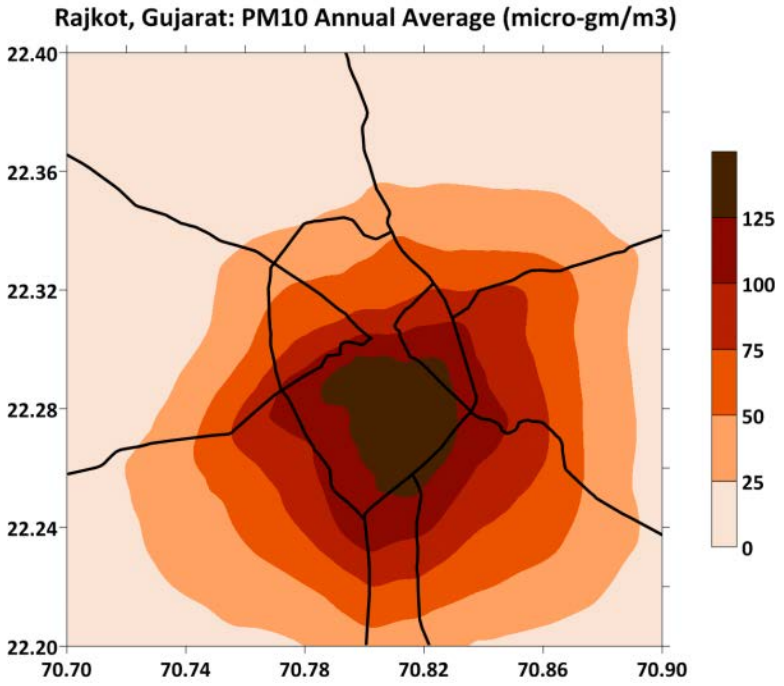
Source: LCMP Report Vizag

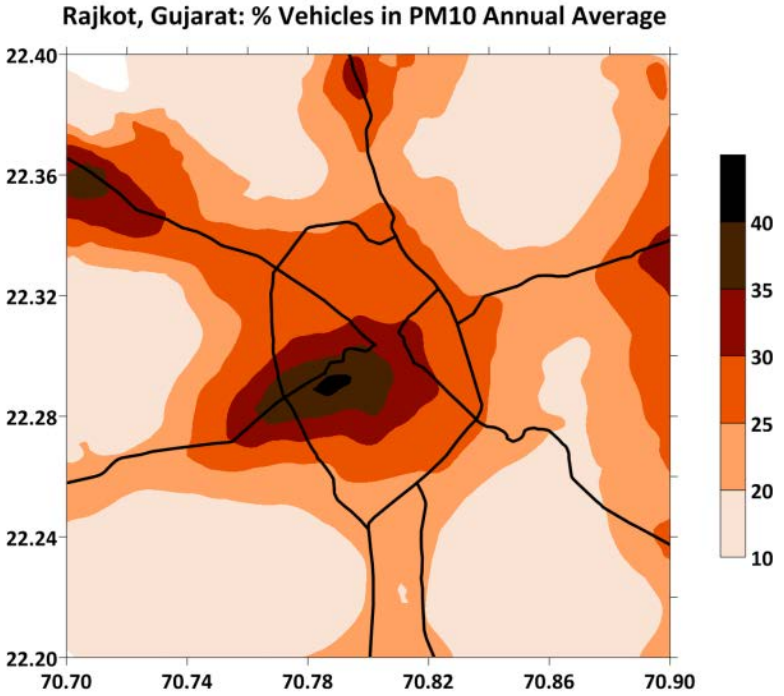
Air Pollution Udaipur



Source: LCMP Report Udaipur, Analysis Using SIM Air Model

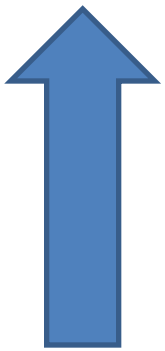
Air Pollution (PM10) Impacts





Source: LCMP Report Rajkot, Analysis Using SIM Air Model

NAMAs for India: Linking top-down and bottom-up



Global Actions Initiatives

- Global climate negotiations
- Finance for NAMAs
- Lessons from International best practices

National Targets /Policies

- National Action Plan on Climate Change
- 20-25% intensity reduction by 2020
- Biannual Reporting

Scale up Local Initiatives

- Technical support for energy efficiency, LCMPs, etc.
- Leverage finance
- Local benefits- mobility, environment, green growth

Research Dissemination & Outputs 2012-13

Presentations at LCSRNet & LoCARNet_Yokohama_July2013

Global Challenges to LCS: A Perspective

Global Challenges to Low Carbon Society: *A Perspective*

Priyadarshi R. Shukla
Indian Institute of Management Ahmedabad

Presented in:
LCS-RNet 2nd Annual Meeting
Yokohama, Japan, July 22-23, 2013

Mitigation Options: Avenues for Global Cooperation

Domain	Mitigation Options (Examples)	Avenues for Cooperation: Technology Transfer, Investments & JVs: (Examples)
Energy	Efficiency: Appliances, Vehicles Low Carbon Energy: Renewable, Nuclear Air Quality: FGD, Catalytic Converters End-of-pipe Low Carbon: CCS	• Hybrid/Electric Vehicles • Solar PV • Air Pollution Control Equipments • CCS
Infrastructure	T&D: Electricity; ICTs Transport: Urban Mass Transport; Dedicated Rail corridors, Bullet Trains, Pipelines	• Dedicated Train Corridor • Super-fast trains • Smart grid
Industrial Processes	Process Efficiency: Metal Production Product Efficiency: Solar PV	• Energy intensive industries • Product RD&D
Conservation	3R: Reduce, Recycle and Reuse resources Dematerialization:	• Drip irrigation, Water treatment • Green buildings
Behavioural	Consumption: Cool Biz, Car Share, Bicycle	• Information and Capacity Building
Planning	Urban Land-use: Vertical vs. Horizontal city, Green spaces, Industry location	• Planning Methods and Models • Greening solutions
Economic Instruments	Market: Carbon Tax, Emissions Trading, CDM C&C: Technology mandates (e.g. Fuel efficiency standards; capacity targets)	• Software for Trading Platforms • Assessment of technology learning • MRV information systems

NAMAs in India & the 2^{O}C Target

Nationally Appropriate Mitigation Actions in India towards achieving 2^{0}C global stabilization target

Priyadarshi R. Shukla
Indian Institute of Management Ahmedabad

Presented in:
LoCARNet 2nd Annual Meeting
Yokohama, Japan, July 23-24, 2013

Conclusions: National Roadmap for Actions

1. **Link Low Carbon Actions and Development Targets to identify NAMAs**
   - *Delineate NAMAs that align Sustainable Development & Climate Change Mitigation & Adaptation Actions*
2. **Many low carbon technology options deliver co-benefits; some may pose high risks (e.g. nuclear, CCS)**
   - *Assess full range of benefits, risks and co-costs of low carbon actions*
   - *Institute policies & measures to maximize co-benefits and minimize risks and co-costs*
3. **Low Energy Carbon Technology and Infrastructure Choices**
   - *Avoid technology, infrastructure, institutional & policy lock-ins into high emissions*
   - *Immense win-win opportunities exist for technology transfer and investment*
4. **Paradigm Shift towards Global 'Co-benefits' and 'Co-operation'**
   - *Global Cooperation helps spatial/temporal/sector policy coordination and delivers co-benefits (especially when markets are incomplete or inefficient)*
   - *Co-benefits reduce 'Social Cost of Carbon'*

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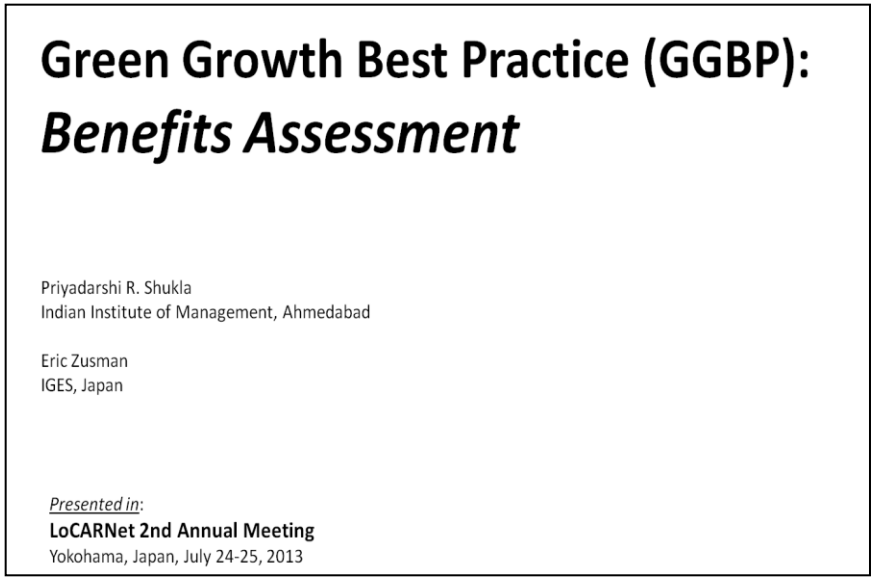
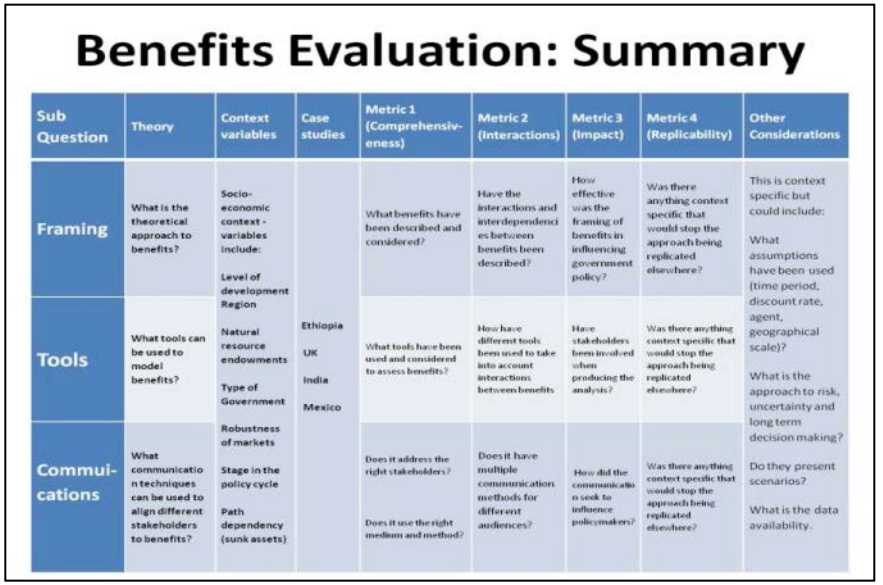
Presentations at LoCARNet_Yokohama_July2013

LC Technology Cooperation: A Perspective

Benefits of Green Growth





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Presentations at COP19_Warsaw_November_2013

NIES-AIM Side-event Nov13 COP19_Warsaw

Sustainable Low Carbon Pathway for India

(with focus on Sustainable Transport)

Priyadarshi R Shukla
Subash Dhar

COP19 Side-event Organized by: National Institute of Environment Studies (NIES), Japan
'Pathways towards Low Carbon Societies in Asia by 2050'
November 13, 2013 (16:30 to 18:00 hours, Venue: Japan Pavilion at COP19
Warsaw, Poland

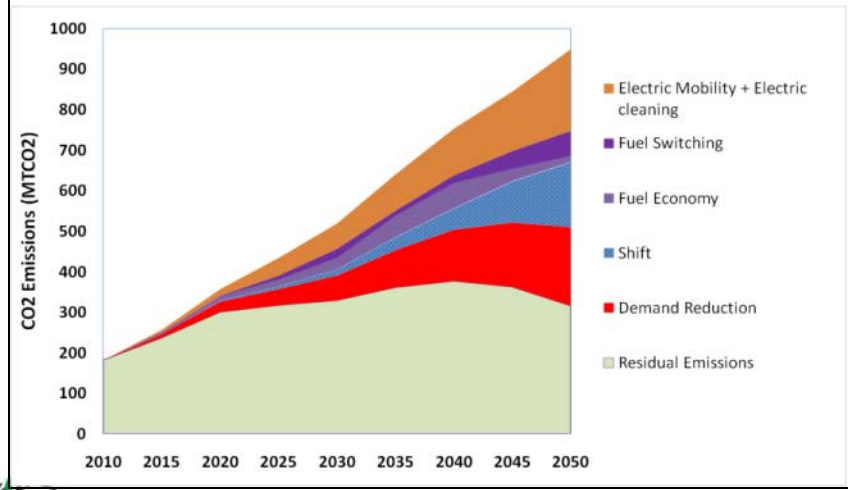
NIES-UTM Side-event Nov15 COP19_Warsaw

Sustainable Low Carbon Transport Pathway for India

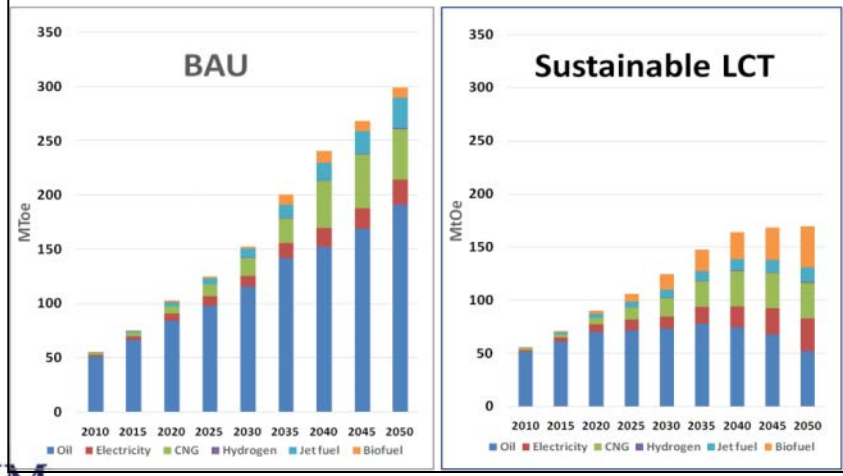
Priyadarshi R Shukla

COP19 Side-event: Organized by NIES, Japan and UTM, Malaysia
'Roadmap and Actions towards Low Carbon Societies in Malaysia and throughout Asia'
November 15, 2013 (11:30 to 13:00 hours)
Warsaw, Poland

CO_2 Mitigation: Sustainable LCT Scenario



Energy Mix for Transport



Presentations at COP19_Warsaw_November_2013

LoCAR-Net Side-event Nov15 COP19_Warsaw

Mitigation Potential towards achieving global 2°C Stabilization Target: Assessment for India

Priyadarshi R Shukla

COP19 Side-event Organized by: Low Carbon Asia Research Network (LoCARNet) , IGES and NIES

GHG Emissions Reduction Potential in Asia for the Two Degree Target

November 15, 2013 (16:30 to 18:00 hours)

Warsaw, Poland

LC Technology Targets - Nuclear

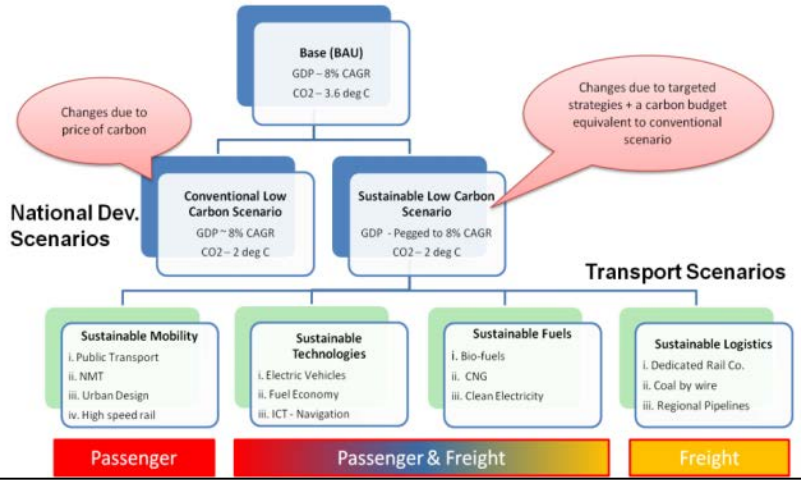
Strategic Low Carbon Energy Portfolio for India:

Economic Assessment of Targets, Subsidies and Nuclear Future

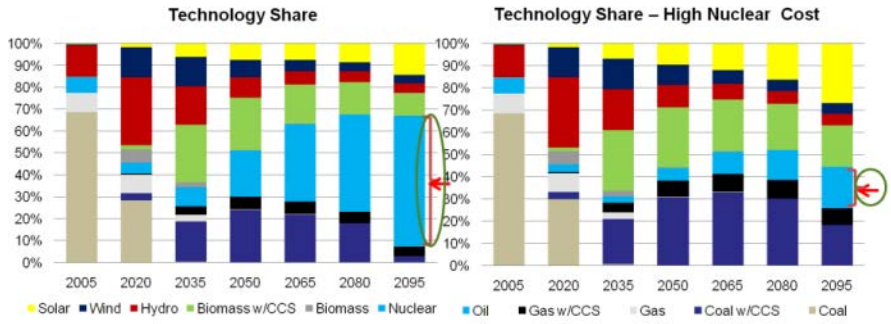
Priyadarshi R. Shukla
Indian Institute of Management Ahmedabad

November 12
COP19, Warsaw

National Development and Transport Scenarios



Post Fukushima Nuclear Price Sensitivity – 2°C Stabilization



- Higher capital cost reduce share of Nuclear significantly also in the 2°C Scenario
- Solar technology share increases considerably under this scenario
- These results are sensitive to the feasibility (i.e. risks) of Biomass with CCS

AIM Team in Global Low Carbon Modeling and Assessment Research

1. LCS-RNet
2. LoCAR-Net
3. LIMITS
4. IAMC
5. EMF

EMF 27 Paper

Role of energy efficiency in climate change mitigation policy for India

Chaturvedi V and Shukla PR. 2013. *Role of energy efficiency in climate change mitigation policy for India: Assessment of co-benefits and opportunities within an integrated assessment modeling framework.* Climatic Change

Scenario descriptions

Scenario Name	Description
Base_AllTech	**No** climate change mitigation policy scenario with **reference** assumptions for end use technology efficiencies.
Base_LowEI	**No** climate change mitigation policy scenario with **advance** assumptions for end use technology efficiencies for industry, transport and building sectors.
550_AllTech	Climate change mitigation policy scenario aiming at **3.7 W/m^2**radiative forcing stabilization by 2095 with **reference** assumptions for end use technology efficiencies. Overshoot before 2095 not allowed.
550_LowEI	Climate change mitigation policy scenario aiming at **3.7 W/m^2**radiative forcing stabilization by 2095 with **advance** assumptions for end use technology efficiencies. Overshoot before 2095 not allowed.
450_AllTech	Climate change mitigation policy scenario aiming at **2.6 W/m^2**radiative forcing stabilization by 2095 with **reference** assumptions for end use technology efficiencies. Overshoot before 2095 allowed.
450_LowEI	Climate change mitigation policy scenario aiming at **2.6 W/m^2**radiative forcing stabilization by 2095 with **advance** assumptions for end use technology efficiencies. Overshoot before 2095 allowed.

Final energy by sector and carbon emissions

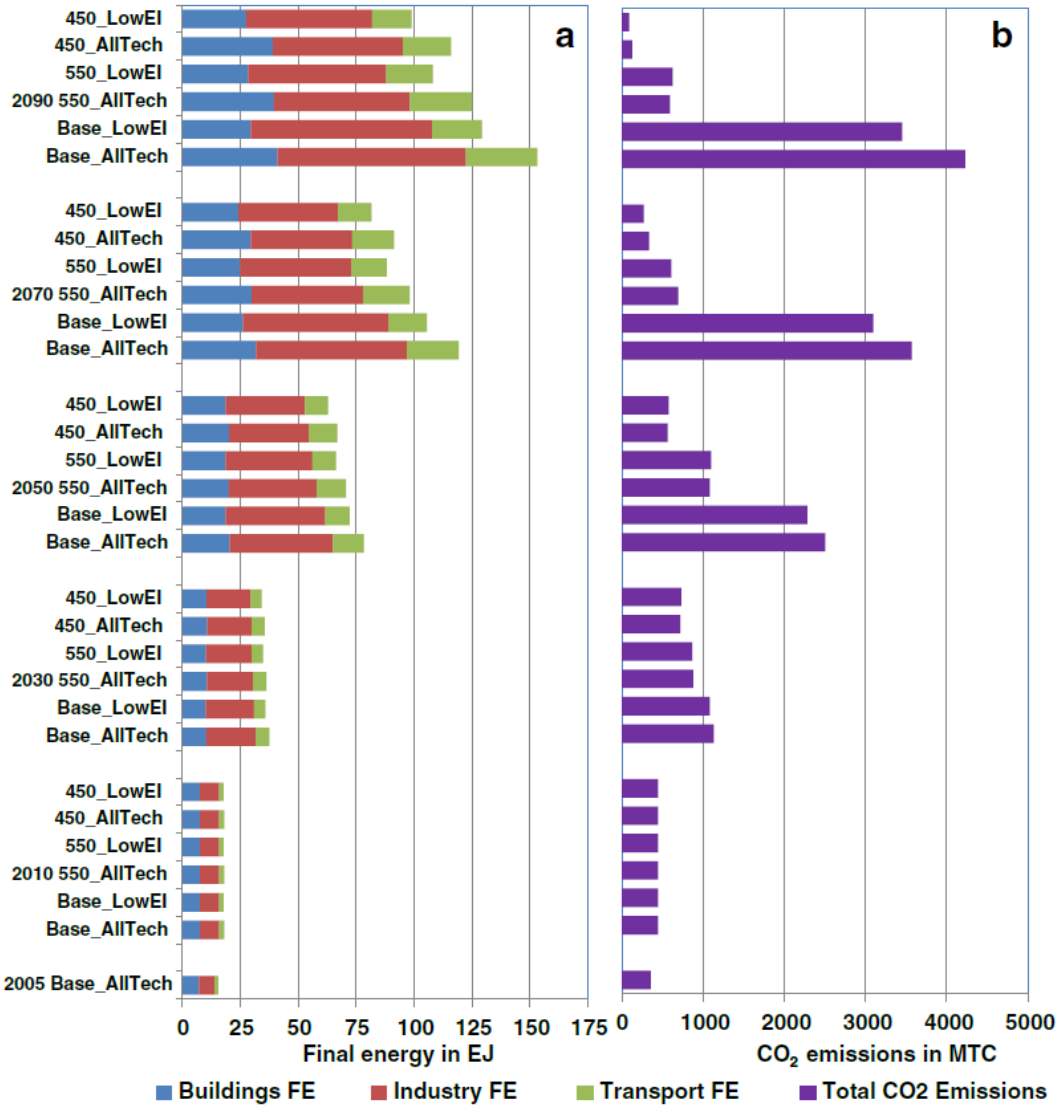


Fig. 1 a) Final energy by aggregate end use sector across scenarios b) Total CO_2 emissions across scenarios

Co-benefits of energy efficiency

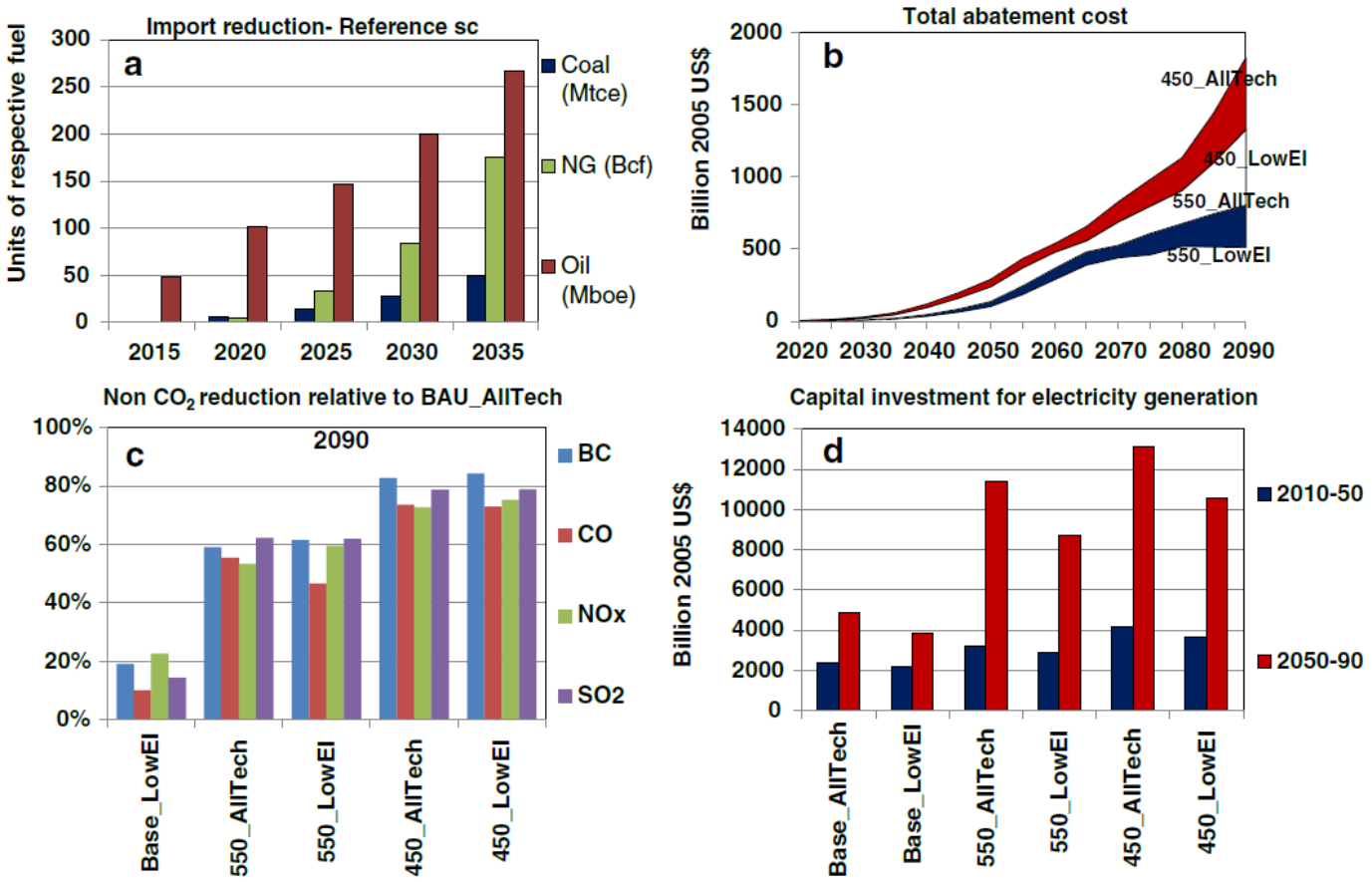


Fig. 2 Impact of enhanced end use energy efficiency policy on **a)** Import reduction under reference scenario **b)** Total abatement cost under climate policy **c)** Non CO2 reduction **d)** Capital investment for electricity generation

Research Outputs 2013-14

1. Low Carbon Scenario in India

2. State-wise Climate Change Action Plans in India

3. Technology Trends

- Energy Technologies
- Low Carbon Technologies
- Air Pollutant removal Technologies

Year 2014-15: Way Forward

Research Plan 2014-15 (1)

1. **Low Carbon Scenario and Roadmap for India**

2. **State-level Low Carbon Scenarios in India**
   a) GHGs (including Short-lived GHGs)
   b) State-level Low Carbon Roadmap

3. **Energy Supply Technology Co-benefits and Risk Assessments**
   - Renewable
   - Nuclear
   - Energy Efficiency
   - CCS

4. **Energy Demand Technology Co-benefits and Risk Assessments**
   a) Industry Sectors (Energy Intensive Industries)
      - Steel
      - Cement,
      - Non-ferrous Metals
   b) Agriculture Sector
   c) Consumption Sectors (Building, Transport)

Research Plan 2014-15 (2)

1. Asia & India LCS Plans to align with Global Stabilization Target
2. Integrated / Down-scaled (Cities/Sector) Model Development
3. Policy Application and Finance - Cities and Key sectors (NAMAs)
4. Modeling Guidebook and Database
5. Capacity Building and Dissemination

19th AIM International Workshop, December 13-14, 2013, Tsukuba, Japan

Sustainable Low Carbon Transport: Future Scenarios and Policies for India

Poojan Chokshi
Doctoral Student, Indian Institute of Management, Ahmedabad
P.R. Shukla
Professor, Indian Institute of Management, Ahmedabad

Introduction

Transport sector – Accounts for **19%** of the **energy use** and **23%** of the total global **energy-related CO_2 emissions** with its rate of growth highest amongst end-use sectors (IEA, 2009) – contributes significantly towards climate change. Hence, it is important to mitigate emissions from the sector.

Literature emphasizes on **aligning** global climate stabilization target and national sustainable development and sectoral plans to **gain various co-benefits** and move towards sustainable low-carbon pathway in the long run.

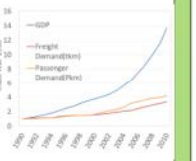
Significant co-benefits (local air quality, energy security and avoid getting locked-in into carbon intensive infrastructures and technology) can be gained by transiting towards sustainable low carbon transport.

Objectives and Methodology: To assess the long-term energy consumption and emissions from passenger transport sector in India. Our analysis uses the AIM Enduse model to explore India's urban transport scenarios till 2050. Two scenarios will be assessed: i) a conventional business as usual (BAU) scenario, and ii) a Sustainable low carbon transport (SLCT) scenario which optimally aligns India's economy to the global climate change stabilization target.

Trends

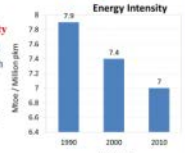
Four indicators are used to assess the **key trends** in the transport sector:

Passenger demand is not highly coupled with **economic growth**. That has implications on energy consumption.

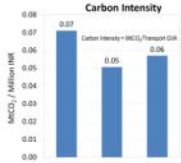


The **share** of road transport that had been on the rise up until 2005 has witnessed a decrease. However, it still forms about 80% of the total modal share

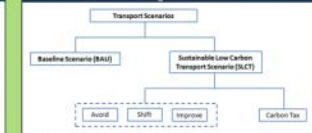
The **energy intensity** has been decreasing over the years which implies an improvement in vehicle efficiencies and technologies



The **carbon intensity** has decreased over the last decade due to efficiency improvements



Modelling Framework

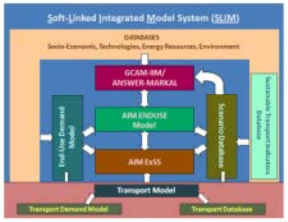


Scenario Description:

BAU Scenario: The BAU scenario assumes an average GDP growth rate of 8% between 2010-2035 benchmarking with Planning Commission Integrated Energy Policy report. Existing policies (such as fuel policy, JNNURM) and projects (like high speed rail, metro) under construction or planned in future are taken into account.

SLCT Scenario: Here, environmental concerns gain higher importance on global, national and local policy agenda. Various demand and supply side sustainable measures are categorized into: Avoid (lessen demand), shift (investment in mass transit systems) and improve (vehicle efficiencies, penetration of electric vehicles) framework. A carbon tax pegged with 2 degree stabilization target is used in addition to above mentioned measures.

Scenario Architecture

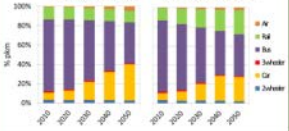


Drivers

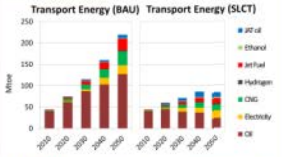
Parameter	BAU Scenario	SLCT Scenario
GDP growth rate	8% (2010-2035)	8% (2010-2035)
Passenger transport demand	Increases at the rate of 2.56%	Increases at the rate of 1.89%
Emission tax	Low carbon tax	Moderate carbon tax consistent with 2 degree stabilization target
Modal Shift	Towards motorized personalised transport	Towards mass transportation
Technology penetration	Moderate penetration of electric vehicles	High penetration of electric vehicles
Fuel mix	Moderate penetration of biofuels and CNG	High penetration of biofuels, CNG and low carbon electricity
Fuel economy	Fuel economy improves moderately	Fuel economy improves by 61%

Model Results

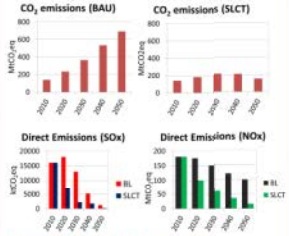
Modal share: There would be shift towards mass transit mode (like rail) in SLCT compared to BAU



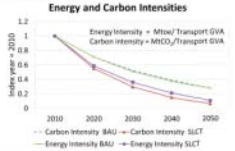
Fuel mix: Energy demand reduces by 61% compared to BAU scenario. There would be diversification towards cleaner fuels such as biofuels, CNG and electricity in the SLCT scenario compared to BAU where fuel mix is highly oil dominated



Emissions: Compared to BAU, CO_2 emissions reduce by 77% in 2050 under SLCT. There are also significant co-benefits due to improvement in air quality as SOx and NOx emissions reduce by 84% and 83% respectively in 2050 compared to BAU levels



Energy and carbon intensities: The energy intensity and carbon intensity both reduces in BAU as well as SLCT scenario, but there would be significant decoupling between energy and carbon emissions in SLCT scenario compared to BAU scenario



Results and Discussion

Owing to various SLCT measures, there is a shift from 4-wheeler towards rail, the energy and carbon intensities decrease, which result in provision of several co-benefits such as energy security, improvement in air quality, etc.

Decarbonization happens as the energy and carbon intensities decline over time due to efficiency and technological improvements, penetration of cleaner vehicle technologies, diversification into cleaner fuels and other SLCT measures.

This, in turn, results in decoupling of economic growth with energy consumption and emissions.

References:
IEA (2009). Transport, Energy and CO_2: Moving towards Sustainability. Paris.
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Thank You