India PM10 Emission Inventory Training and Capacity Building Programs:
U.S. EPA Efforts for Developing a Sustainable Foundation

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Project Background

- Since January 2002, U.S. EPA and Indian Ministry of Environment and Forests working under MOU
- Goal to understand and improve air quality in India though science-based decision making
- Significant training and field study activities undertaken
- Extensive involvement of Indian federal, state, local governments, institutes, industry groups, and others

Overall Project Activities

- Overall project activities include
  - Air quality monitoring
  - Emissions inventory development
  - Air quality modeling
  - Control strategy development
  - Source apportionment
  - Health benefit assessment
- This presentation focuses on the emission inventory component

Overview of Inventory Projects

- Provided four emission inventory training projects in India
- Projects coordinated by EPA Office of International Affairs and Region 5
- Funding support from the U.S. Agency for International Development (USAID)
- Assistance by U.S. Embassy in India and U.S.-Asia Environmental Partnership (USAEP)

Multiple Project Supporters

- Indian Ministry of Environment and Forests
- India Central Pollution Control Board (CPCB)
- National Environmental Engineering Research Institute (NEERI)
- Pune Municipal Corporation (PMC)
- Maharashtra State Pollution Control Board
- U.S. Agency for International Development
- Asia Development Bank
- Others from academia and industry

Summary of EPA Sponsored Emission Inventory Projects in India

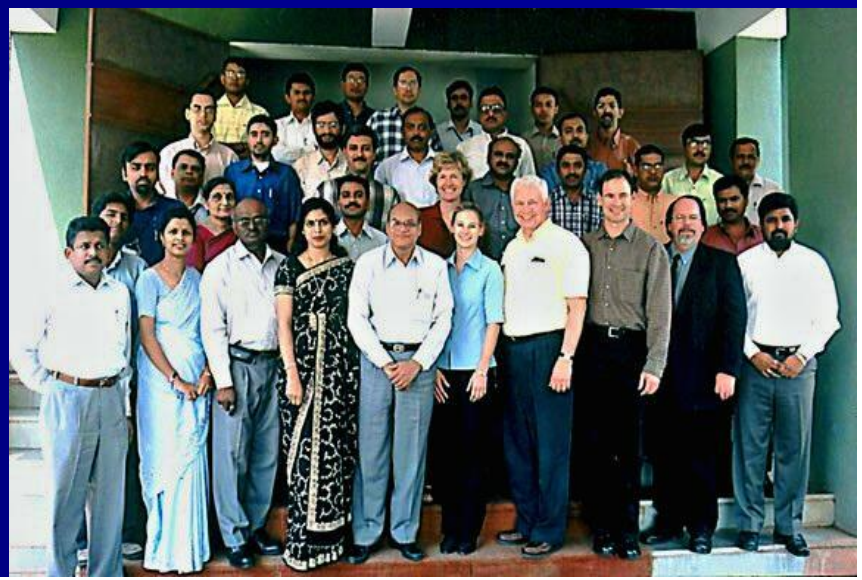
Project Date and Location	Objectives	Trainers	Participants
Training 1 2003 October 14-21 Pune	Provide general overview emission inventory training over 4 days. Meet with agency and CPCB staff to discuss next steps.	Ted MacDonald, USEPA OIA Bill Kuykendal, USEPA OAQPS Laurel Driver, USEPA OAQPS Patrick Gaffney, CARB Nichole Davis, UC Riverside, CE-CERT	Thirty participants representing national, state, and local governmental agencies, and members of academia and industry.
Training 2 2004 March 16-24 Pune	Over 7 days, work with participants to develop a preliminary PM10 emission inventory and database system for Pune region in India	Patrick Gaffney, CARB Michael Benjamin, CARB John Mooney, USEPA Region 5	A diverse team of 40 participants from several of India's governmental agencies, technical and educational institutions, and industry
Training 3 2005 November 14-18 Pune	Work with technical staff for 4 days to refine and integrate modeling and emission inventory data and methods. Provide general emissions and modeling training to project students.	Alan Cimorelli, USEPA Region 3 Akula Venkatram, UC Riverside Ajay Ojha, Pune Municipal Corporation Patrick Gaffney, CARB Michael Benjamin, CARB John Mooney, US EPA Region 5	Key technical staff from Pune Municipal Corporation, the India Center for Development of Advanced Computing, NEERI, and several university students
Training 4 2006 December 4-9 New Delhi	Using a spreadsheet-based calculation and documentation tool, train participants from 7 cities and various agency staff over 6 days to develop preliminary emission estimates.	Patrick Gaffney, CARB John Core, Core Environmental Consulting Ajay Ojha, Pune Municipal Corporation	Forty-five participants from seven cities (Delhi, Agra, Ahmedabad, Gurgaon, Nashik, Visakhapatnam and Mumbai), NEERI laboratories, CPCB, and other agencies

TRAINING 1 – OCTOBER 2003, Pune Emissions Inventory Overview

- Four days - Classroom-style emission inventory training (~30 participants)
- Included networking and coordination opportunities
- “Next-steps" brainstorming session
- Meetings with Central Pollution Control Board, U.S. Embassy, and USAID India

Training 1 - Results

- Introduced students to emission inventory fundamentals
- Identified need for more data sharing and networking among agencies
- Emphasized need for more practical, hands-on training
- Assistance needed for follow-through with inventory development



TRAINING 2 – March 2004, Pune
Pune Regional Emissions Inventory

- Intensive, hands-on emission inventory training for 40 participants
  - Included local, state, and national government; education and research organizations; industry
- Over 7 days, create an initial framework PM10 emission inventory for Pune region (~4.5 million pop.)
- Provide immersive teamwork experience, giving students multiple responsibilities

Summary of Project

- Day 1
  - Orientation & Scoping
- Days 2 – 5
  - Identify methods
  - Collect data
  - Design approaches
- Day 6
  - Finalize data
  - Load data
  - Documentation
- Day 7
  - Review results
  - Identify future milestones

Daily Schedule Overview	TUES	WED	THURS	FRI	WEEKEND	MON	TUES	WED
Emissions Inventory								
Case Study		▣						
Identification of Sources		▣						
Category Assignments		▣						
Planning Document		▣						
Inventory Source Worksheets		▣						
Methods & Data Sources Discussion		▣						
Identify Methods & Data				▣				
Review Source Worksheets		▣						
Problems & Issues		▣						
Full Group Input on Problems			▣					
Example Spreadsheets			□■					
Emission Factor & Activity Data Collection			□					
Staff Begin Spreadsheets			□					
Begin Populating Spreadsheets			□					
Rating Data Quality				□■				
Ongoing Emissions Work				□				
Group Assistance on Key Sources				□				
Presentation of Draft Emissions						□■		
Reasonableness Evaluation						□		
Identify Quick Fixes						□		
Finalize Emissions						□		
Document Methods						□		
Resolve Remaining Issues							□	
Assist With Data Loading							□	
Resolve QA & Other Issues							□	
Complete Documentation							□	
Finalize & Document Spreadsheets							□	
Compile All Documentation							□	

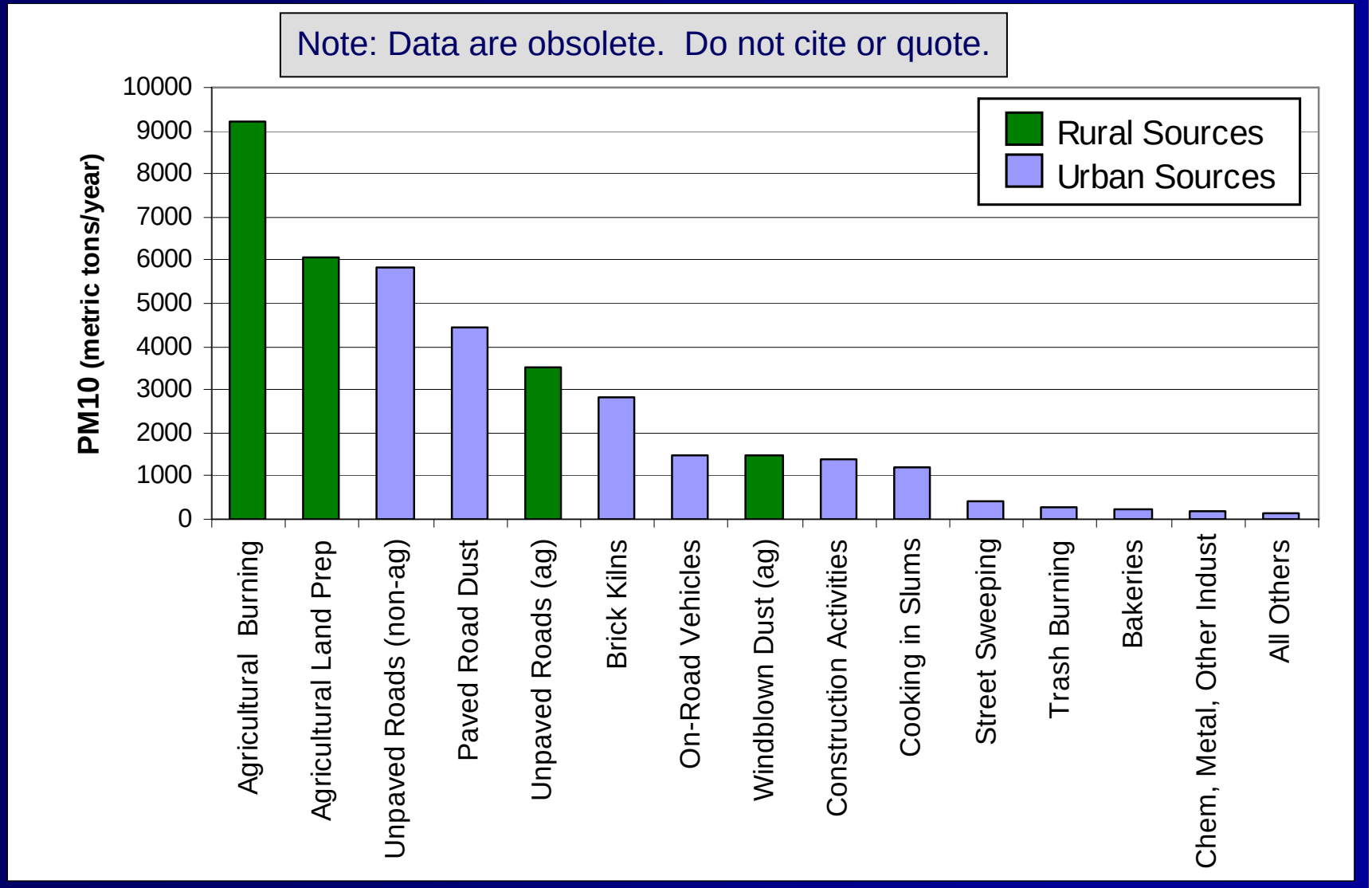
Note: Boxes marked with "□■" indicate that there will be a presentatation and discussion lead by the facilitator.

Milestones for Paved Road Dust Estimate

- Developed milestone charts to guide students and track progress

Areawide Sources	TUES	WED	THURS	FRI	WEEK END	MON	TUES	WED	Responsibility (primary, secondary)
Paved Road Dust									
Identify Staff		▣							
Evaluate Methodologies			▣						
Select Methodology			▣	▣					
Evaluate Emission Factors				▣					
Calculate Emission Factors				▣					
Evaluate Available Activity Data				▣					
Develop Activity Data				▣					
Develop Spreadsheet				▣					
Calculate Emissions						▣			
Check Assumptions & Calcs							▣		
Format Emissions for Database							▣		
Load & Validate Data							▣		
Document Methodology & Assumptions							▣		
Identify Areas for Improvement (spatial, temporal, EFs, activity, etc.)							▣		

Pune Regional PM10 Inventory for 2004



Training 2 – Results

- Participants worked amazingly hard under challenging conditions
- We completed the first-ever comprehensive PM10 inventory for an Indian city
- Substantial additional work needed to make inventory credible
- Some later issues with data interpretation

TRAINING 3 – November 2005, Pune Modeling and Inventory Integration

- Use modeling and inventory to evaluate Pune PM10 air pollution problem
- Iterative process to improve inventory, modeling, and air quality monitoring systems
- Analyze which PM10 sources contribute most to high PM10 events
- Understand the temporal and spatial patterns
- Evaluate what meteorology produces the worst PM10 impacts

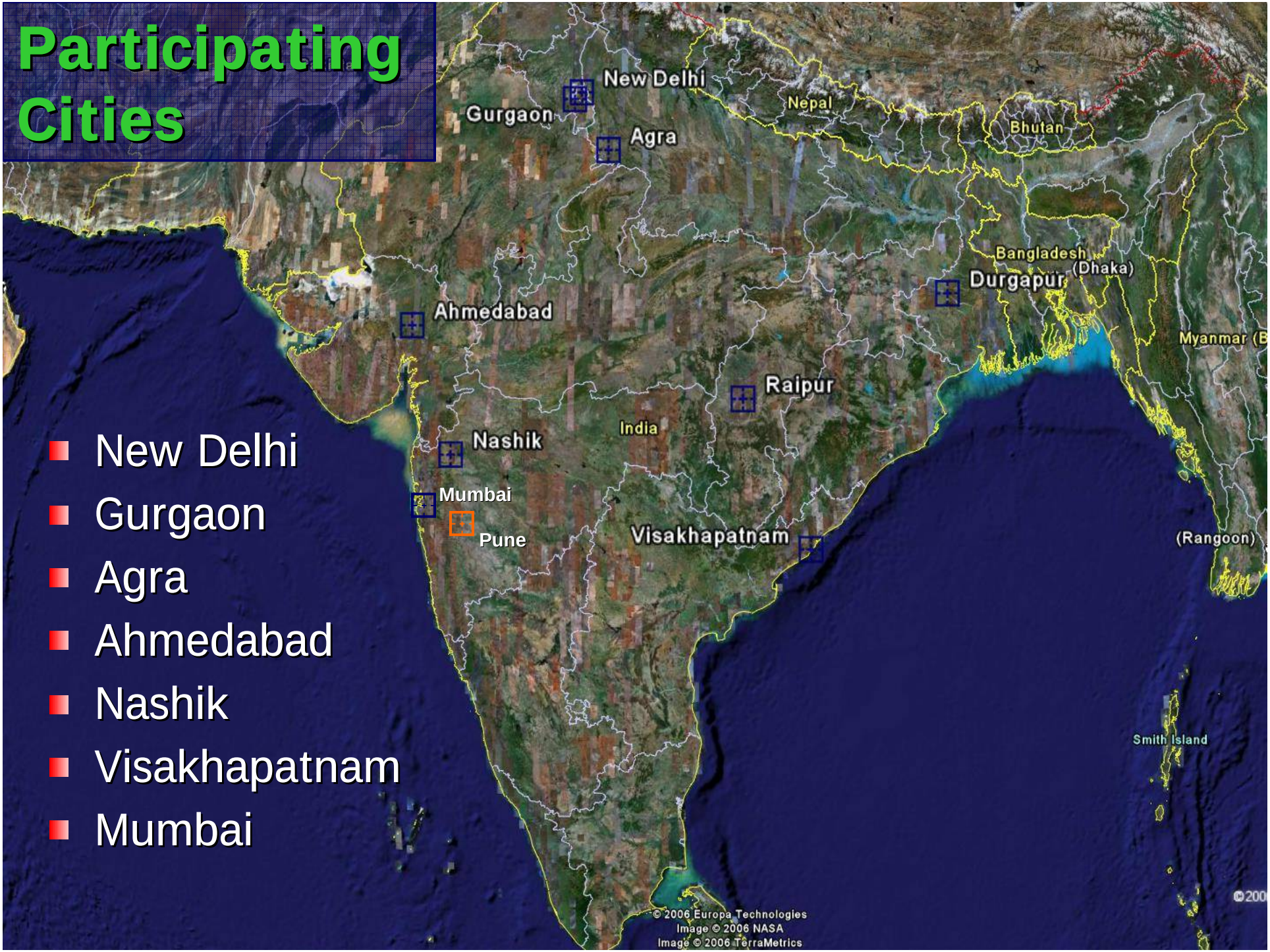
Training 3 - Results

- Corrected errors in inventory data
  - Also added spatial and temporal refinement
- Showed fairly simple urban dispersion models could effectively be used to evaluate air quality (AERMOD)
- Stagnant nighttime conditions produce high PM events
- Field study ongoing for better source identification

TRAINING 4 – December 2006, New Delhi
Multi-City Emission Inventory Training

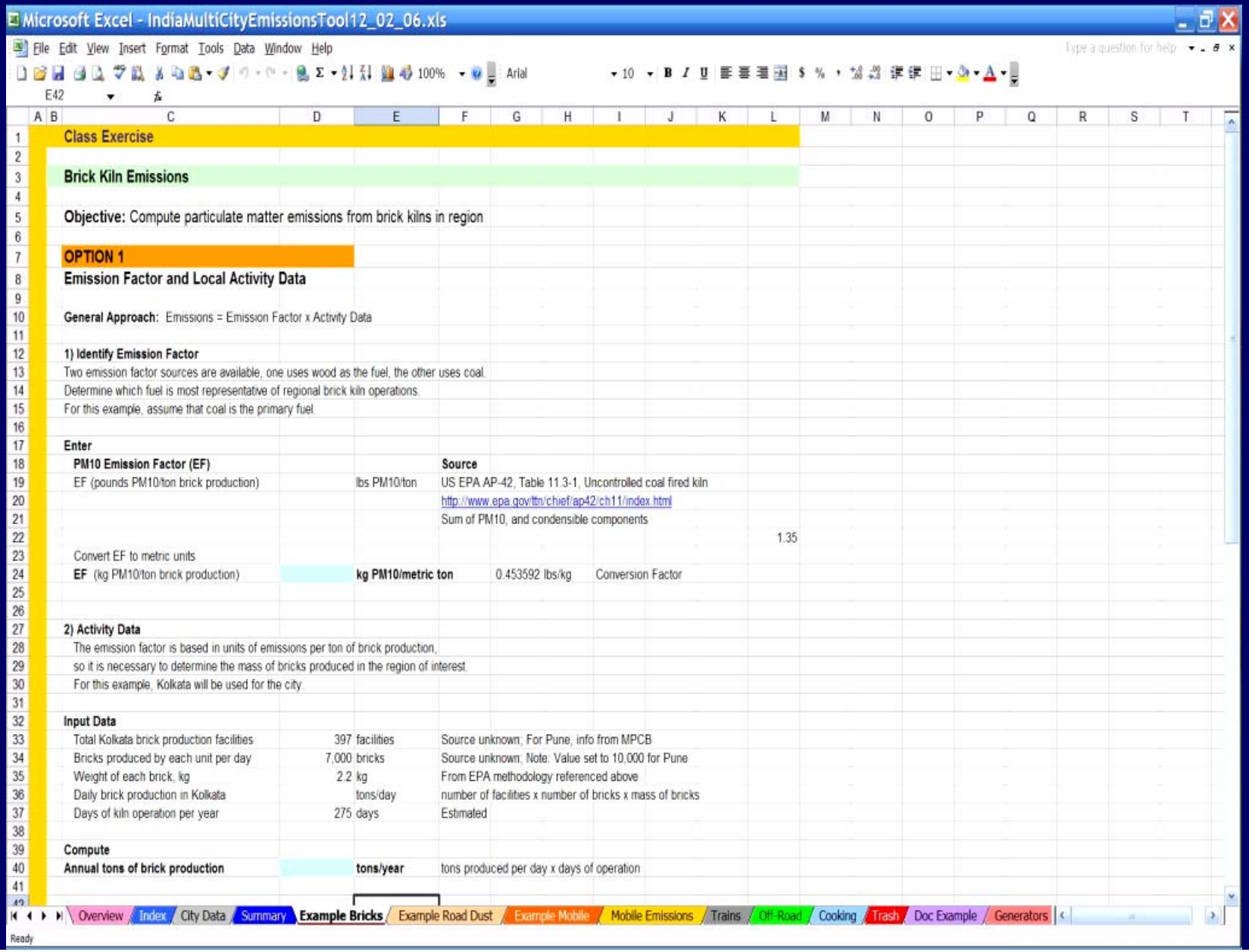
- Provide overview of emission inventory and overall air quality management concepts - build on previous work
- Divide group into 7 city-teams
- Use Indian projects and experts for mobile, point, and area emissions case studies
- Use spreadsheet emissions tool:
  - Perform local emission calculations
  - Understand resources needed
  - identify data gaps
- Prioritize future improvements

Participating Cities



- New Delhi
- Gurgaon
- Agra
- Ahmedabad
- Nashik
- Visakhapatnam
- Mumbai

Spreadsheet Tool (1 of 30 pages)



Microsoft Excel - IndiaMultiCityEmissionsTool12_02_06.xls

File Edit View Insert Format Tools Data Window Help

E42

Class Exercise

Brick Kiln Emissions

Objective: Compute particulate matter emissions from brick kilns in region

OPTION 1

Emission Factor and Local Activity Data

General Approach: Emissions = Emission Factor x Activity Data

1) Identify Emission Factor

Two emission factor sources are available, one uses wood as the fuel, the other uses coal.
Determine which fuel is most representative of regional brick kiln operations.
For this example, assume that coal is the primary fuel.

Enter

PM10 Emission Factor (EF)		**Source**			
EF (pounds PM10/ton brick production)	lbs PM10/ton	US EPA AP-42, Table 11.3-1, Uncontrolled coal fired kiln			
		http://www.epa.gov/ttn/chief/ap42/ch11/index.html			
		Sum of PM10, and condensible components			
					1.35
Convert EF to metric units					
EF (kg PM10/ton brick production)	**kg PM10/metric ton**		0.453592 lbs/kg	Conversion Factor	

2) Activity Data

The emission factor is based in units of emissions per ton of brick production,
so it is necessary to determine the mass of bricks produced in the region of interest.
For this example, Kolkata will be used for the city.

Input Data			
Total Kolkata brick production facilities	397	facilities	Source unknown; For Pune, info from MPCB
Bricks produced by each unit per day	7,000	bricks	Source unknown; Note: Value set to 10,000 for Pune
Weight of each brick, kg	2.2	kg	From EPA methodology referenced above
Daily brick production in Kolkata		tons/day	number of facilities x number of bricks x mass of bricks
Days of kiln operation per year	275	days	Estimated

Compute		
Annual tons of brick production	**tons/year**	tons produced per day x days of operation

Overview | Index | City Data | Summary | **Example Bricks** | Example Road Dust | Example Mobile | Mobile Emissions | Trains | Off-Road | Cooking | Trash | Doc Example | Generators

Ready

Training 4 - Results

- City-teams estimated local PM10 emissions
- Opportunity to meet and work with others in field
- Immersive experience to understand inventory methods, tools, limitations
- Group presentations to share and evaluate results
- Identify inventory next steps

Lessons Learned:
What It Takes To Make It Work

- Logistical support is critical
- Comprehensive planning and schedules required
- Patience and flexibility
- Be prepared for data challenges
- Persistence – keep returning

Lessons Learned (continued)

- Hands-On Training = Best Results
- Require participant presentations
- Be aware of policy implications and broader audience
  - Do not assume how results will be used or interpreted
- Leave resources and materials with participants

Project Highlights

- Emission inventory training for over 110 people in India
- The first comprehensive emissions inventory developed for an Indian city (Pune)
  - Lessons learned now being shared with other cities and organizations
- Air Quality Cell (group) established for Pune Municipality (PMC)
- PMC awarded “Government Most Committed to Air Quality Improvement” at 2004 Better Air Quality for Asian Cities conference

Project Highlights
(continued)

- Extensive array of inventory training materials developed and disseminated
- First demonstration in India of decision support system integrating monitoring, emission inventory and modeling data
- Heightened commitment and awareness by various levels of government for:
  - Building science-based urban air quality management systems
  - Crafting most cost-effective mix of control strategies
- Multi-city replication program to expand results, promote capacity building and professional networking

CONCLUSIONS

- Efforts provide tangible building blocks
- Most important work will need to be done by partners in India
  - Partners now developing India-specific tools, data, documentation, trainings
- Activities provide foundation for greenhouse gas inventories
- Efforts can improve quality of life for millions in India

Photo: Dean Driver

Questions?

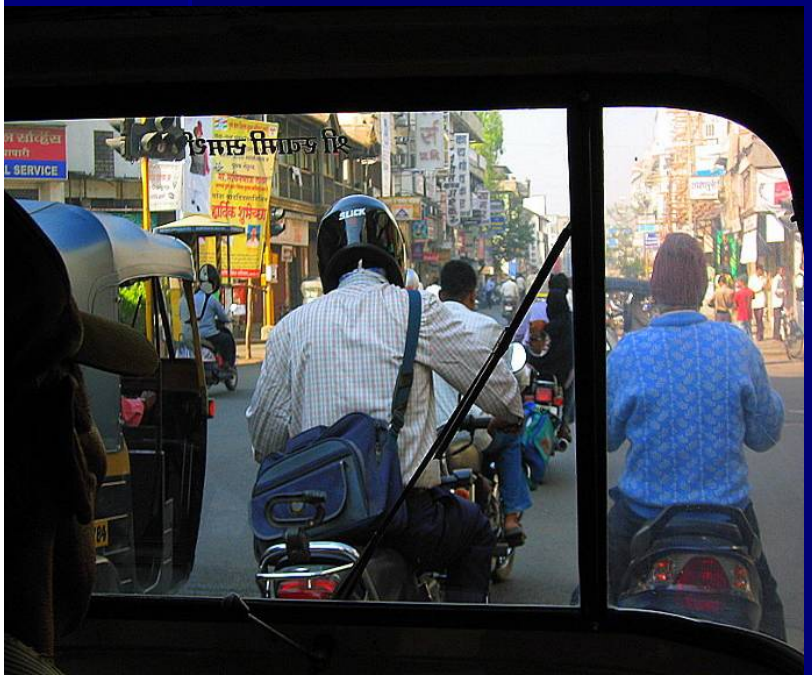


Photo: Laurel Driver