

# City Applications

## Modeling Needs & Integrated Modeling

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**WMO/GURME, Pune, India**  
**December 9<sup>th</sup>, 2008**

air pollution →

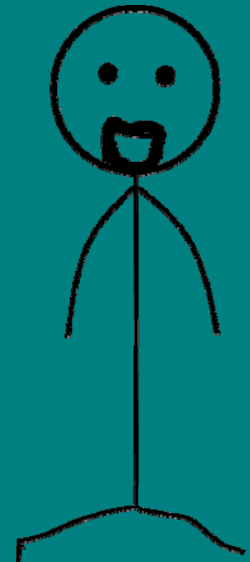
time →

now

5 yrs

10 yrs

20 yrs



# Topics Covered

- Overview of Information required and available for an AQM
- Demonstration of tools
- Summary of applications
- Details from three cities
  - Hyderabad, Ulaanbaatar, Hanoi

# Cinderella's Shoe ..

Every city is different

- Understand their sources & priorities

One tool doesn't fit all

- Needs local customization

Need stakeholders participation (a lot)

- Sharing is caring !!

Informed decision making is key

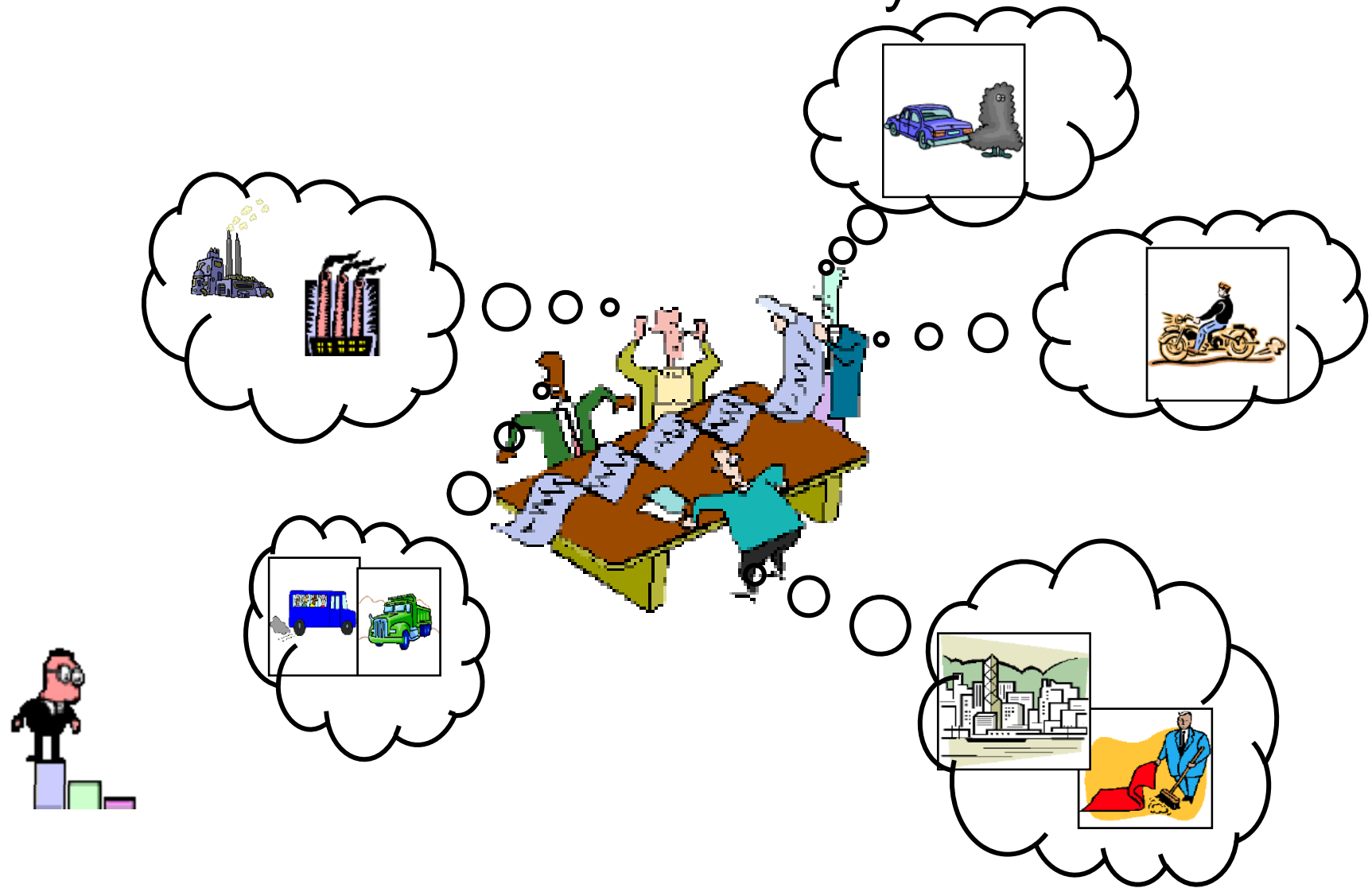
Why AQM

# Concept of Integration



# Let the “Blame Games” begin..

Sources are Many



.. making a decision is a decision

# Why informed decision making is important?



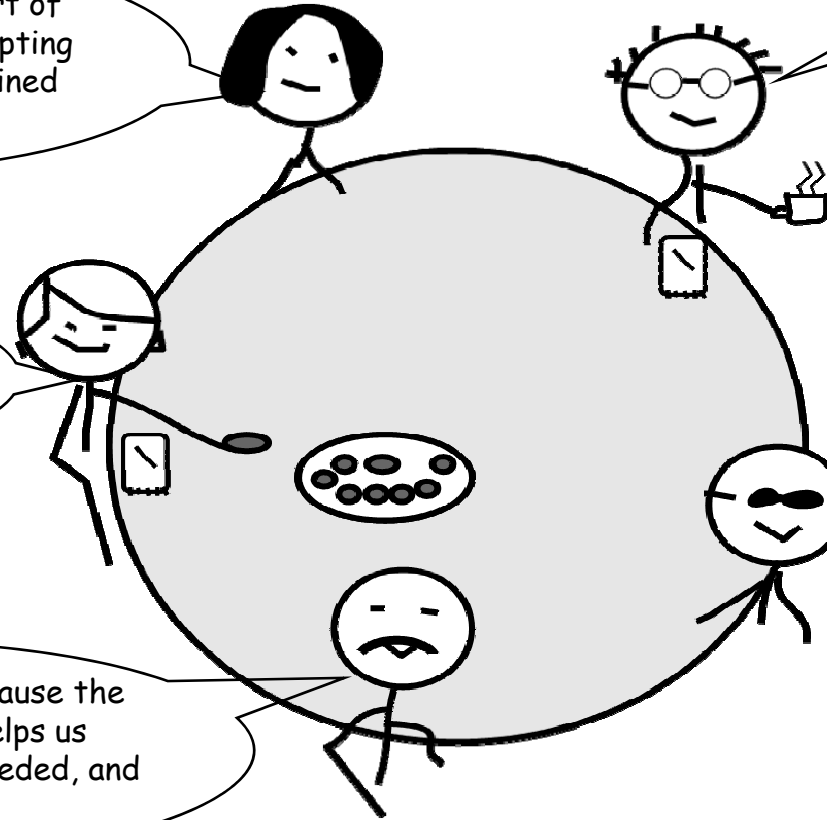
Stakeholders that are part of the process are more accepting of a scientifically determined outcome

More scientifically rigorous

leads to more effective outcomes and easier monitoring of progress

Prioritizes cost-effective measures

Easier to implement - because the systematic approach helps us identify exactly what is needed, and how much



# Remember..

.. Waiting is futile

.. Check what's done

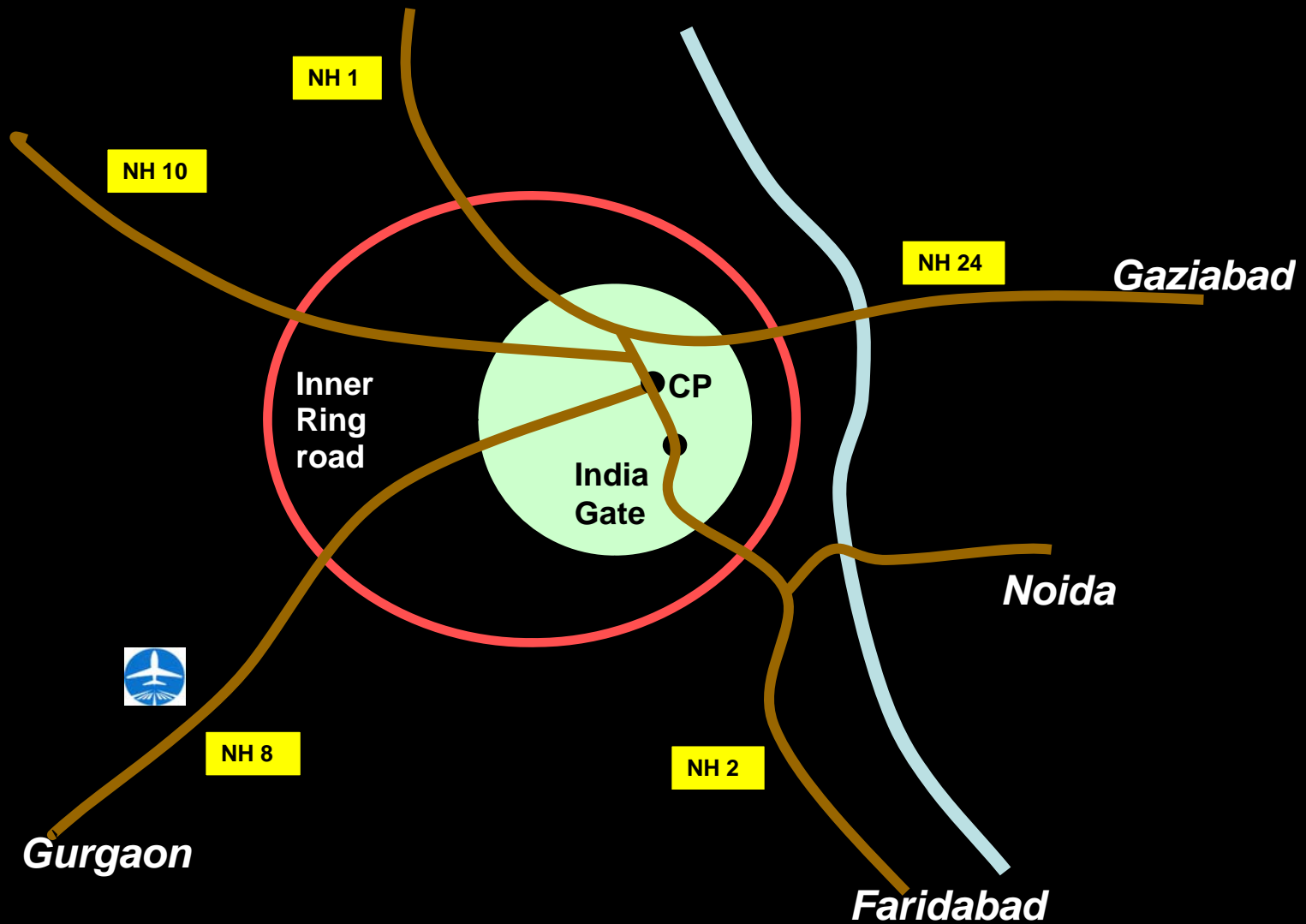
.. Start doing something



Number of Cities

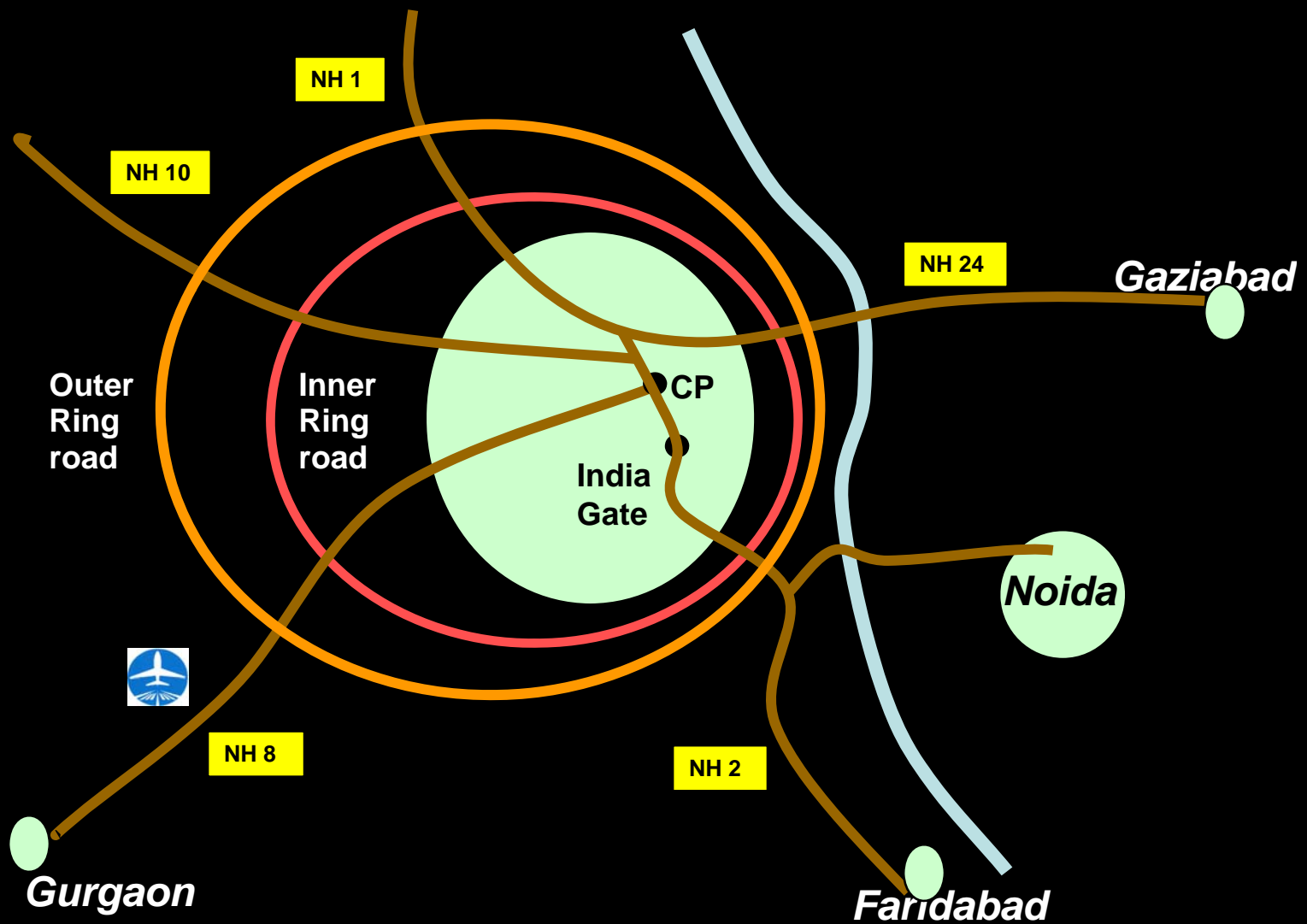
Google Earth

# Delhi.. 1975



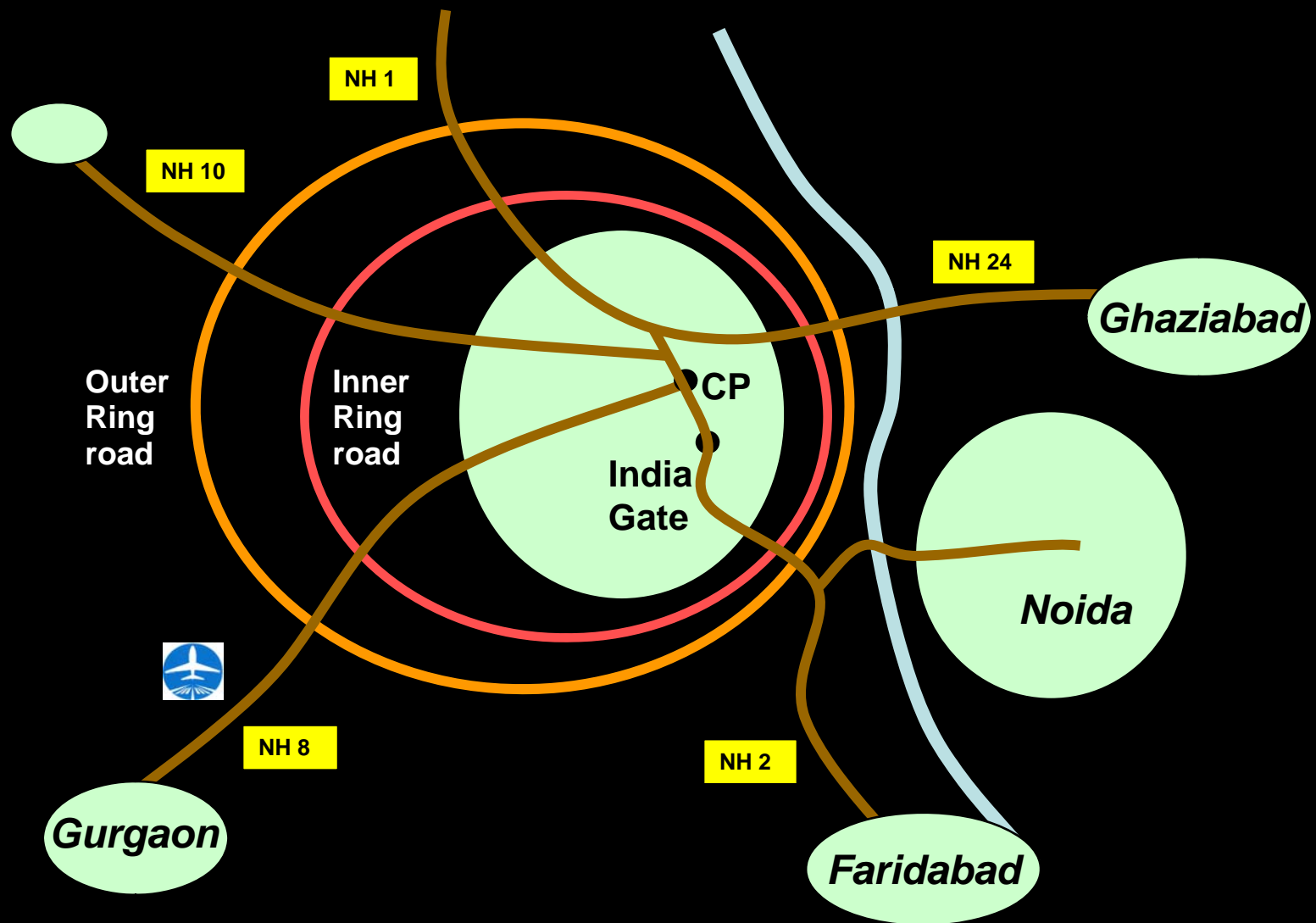
Source: Reproduced from Presentations by TheTIS & Harvard University

# Delhi.. 2000



Source: Reproduced from Presentations by TheTIS & Harvard University

# Delhi.. Today.. NCR



Source: Reproduced from Presentations by TheTIS & Harvard University

# 300 cities >2 m pop by 2025 + thousands of Secondary Cities

Health, Visibility, Agriculture,  
Economy



Source: Google Earth & [www.demographia.org](http://www.demographia.org)

# Cities: A Problem & Solution



**Energy Demand**



**Industries**



**Waste**



**Transport**



**Domestic**

----- **3 D's** -----



**Renewables**



**Efficiency**



**Management**

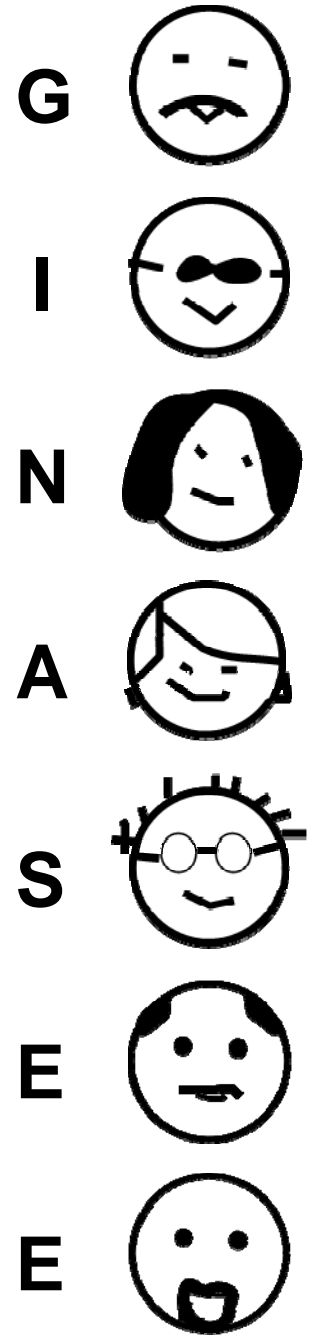
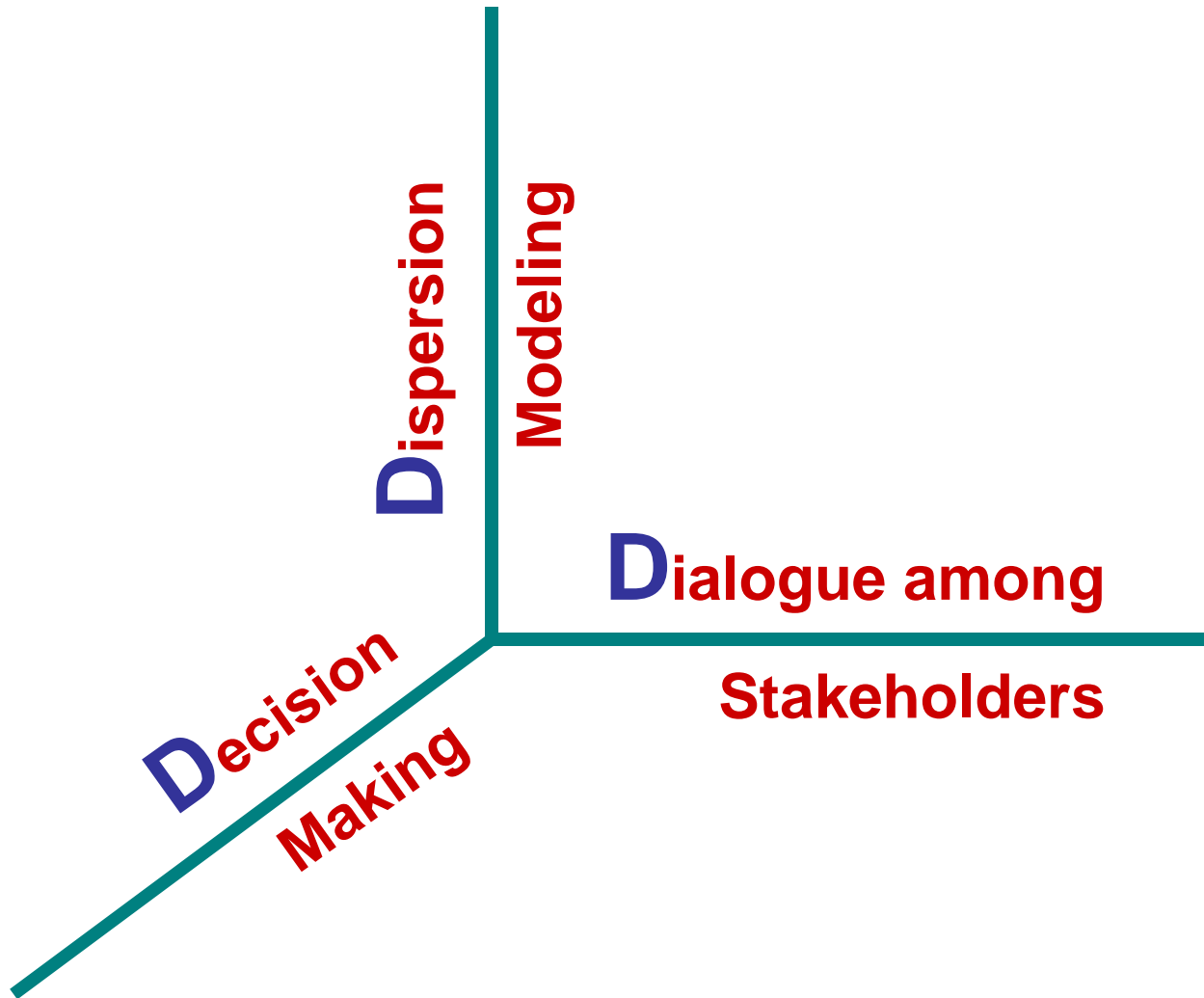


**Buses/NMT**



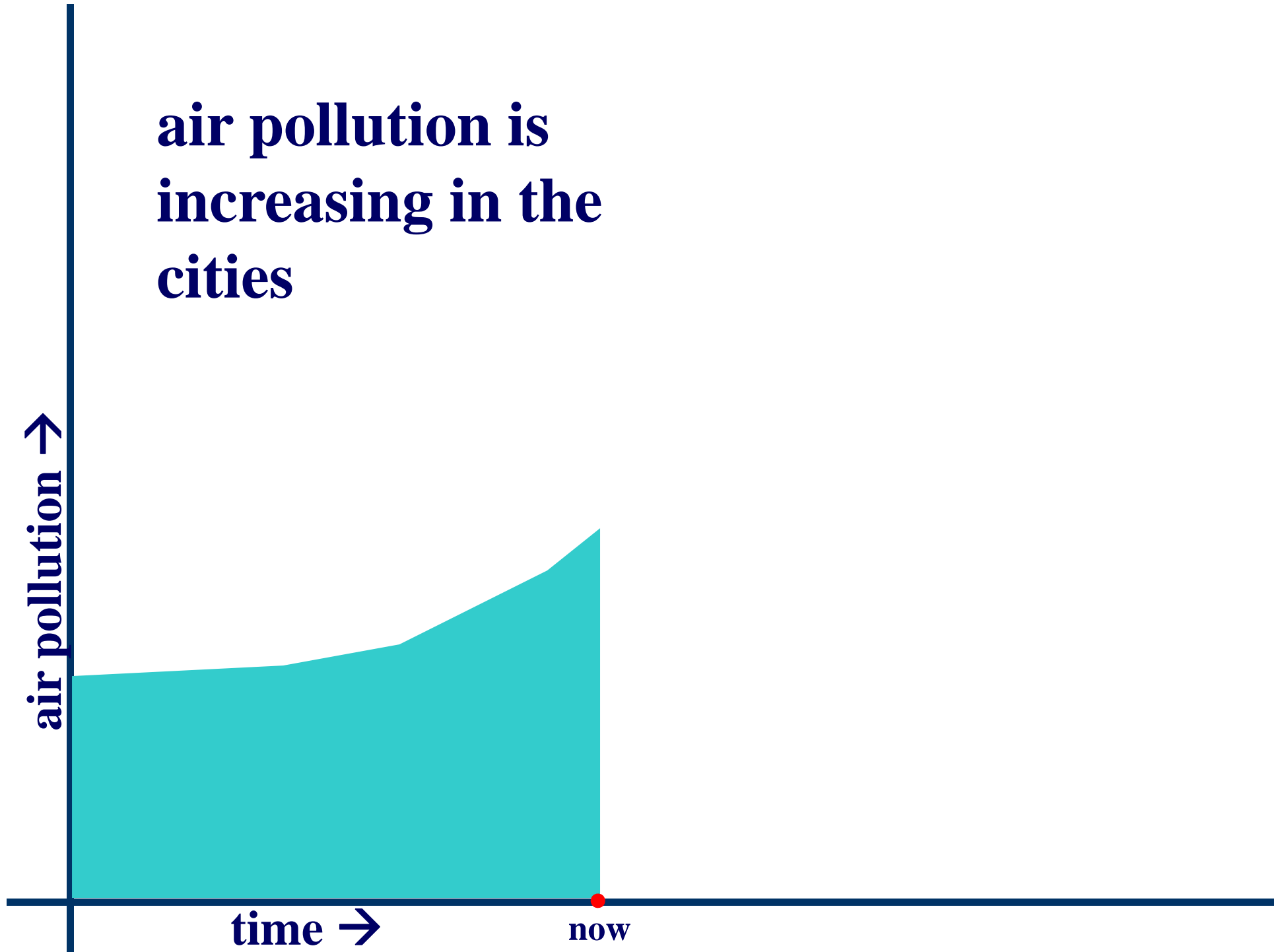
**Cleaner Fuels**

# 3 D Effect



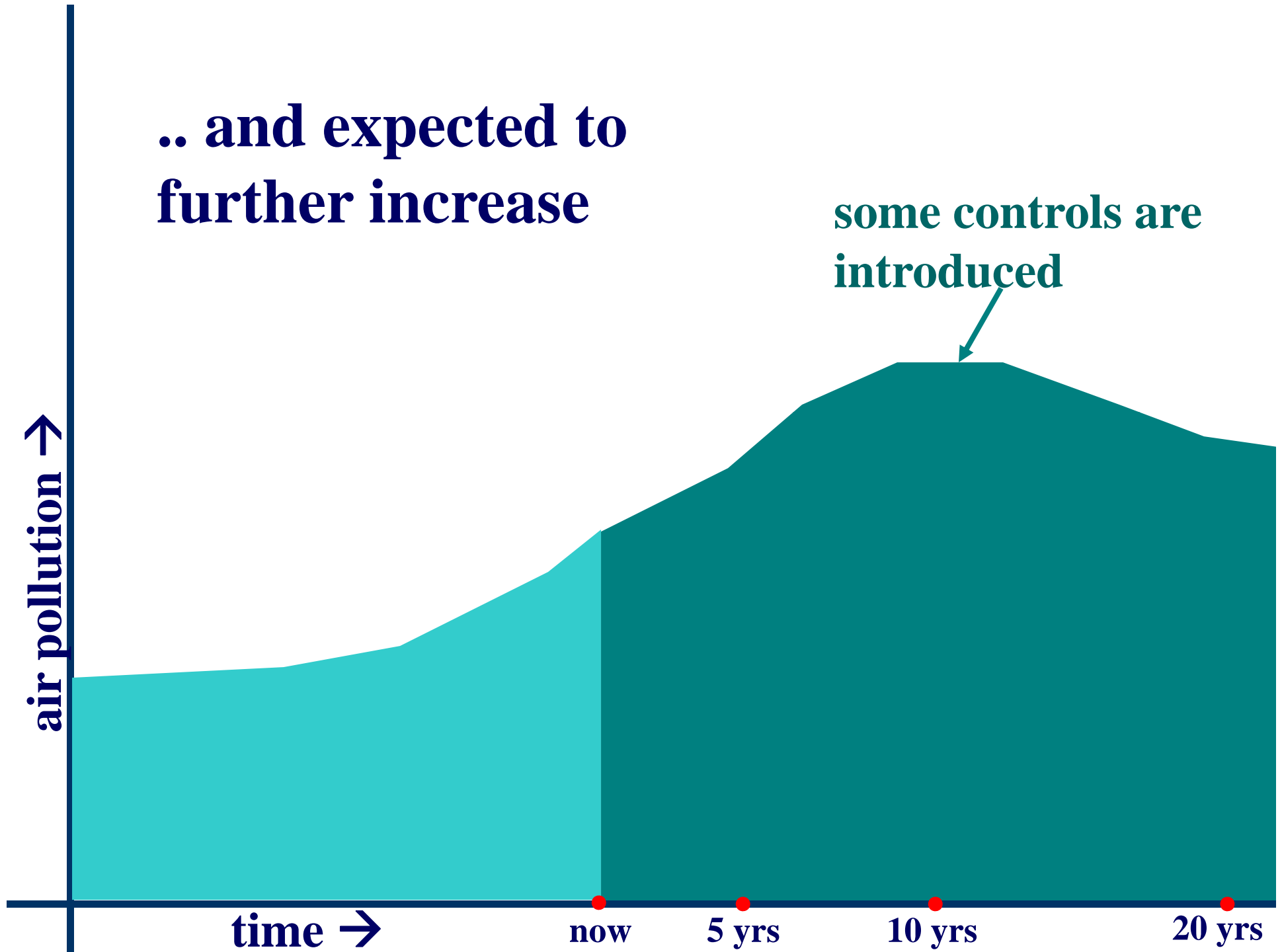
Disclaimer: All characters are fictional ☺

**air pollution is  
increasing in the  
cities**

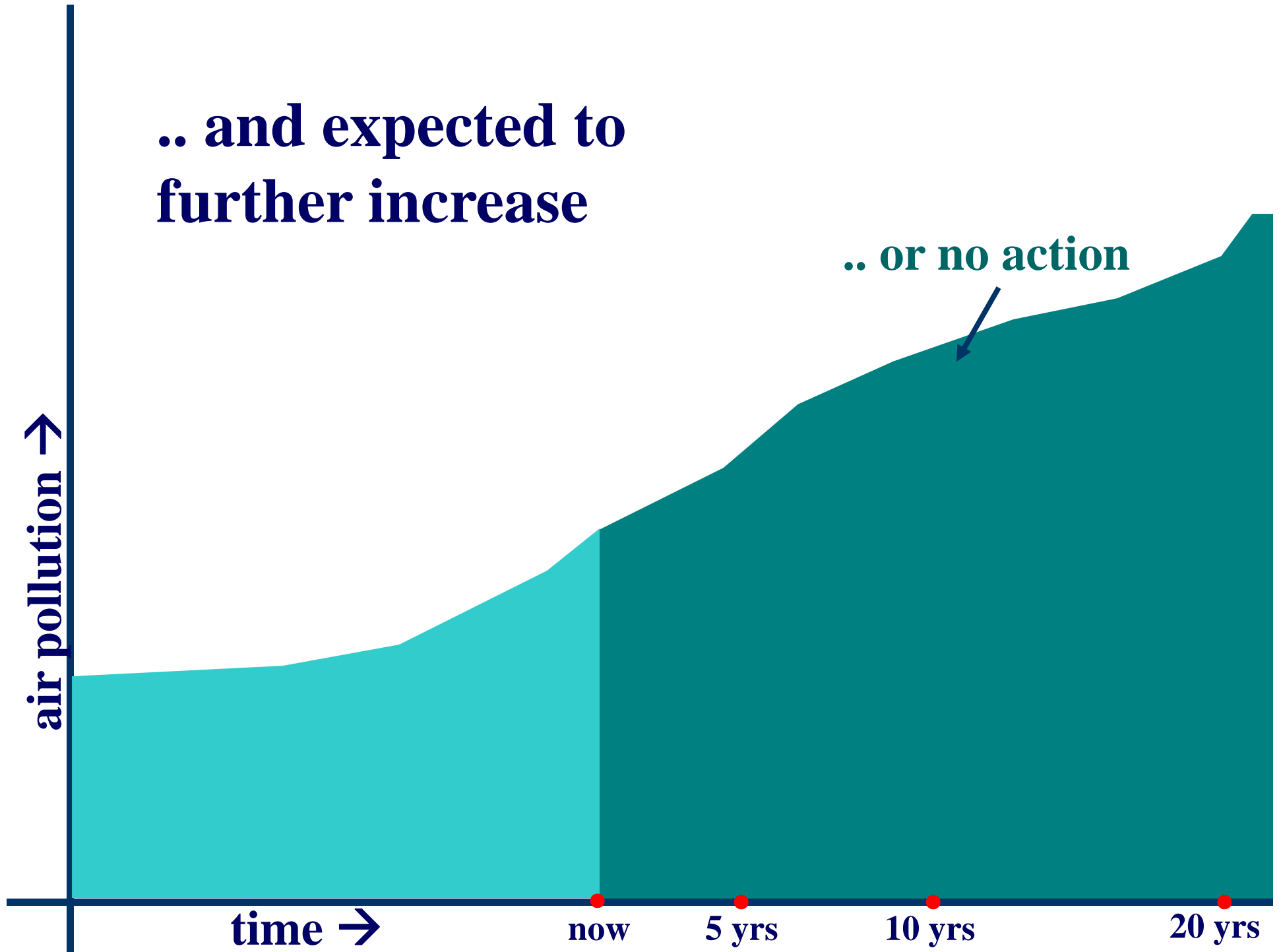


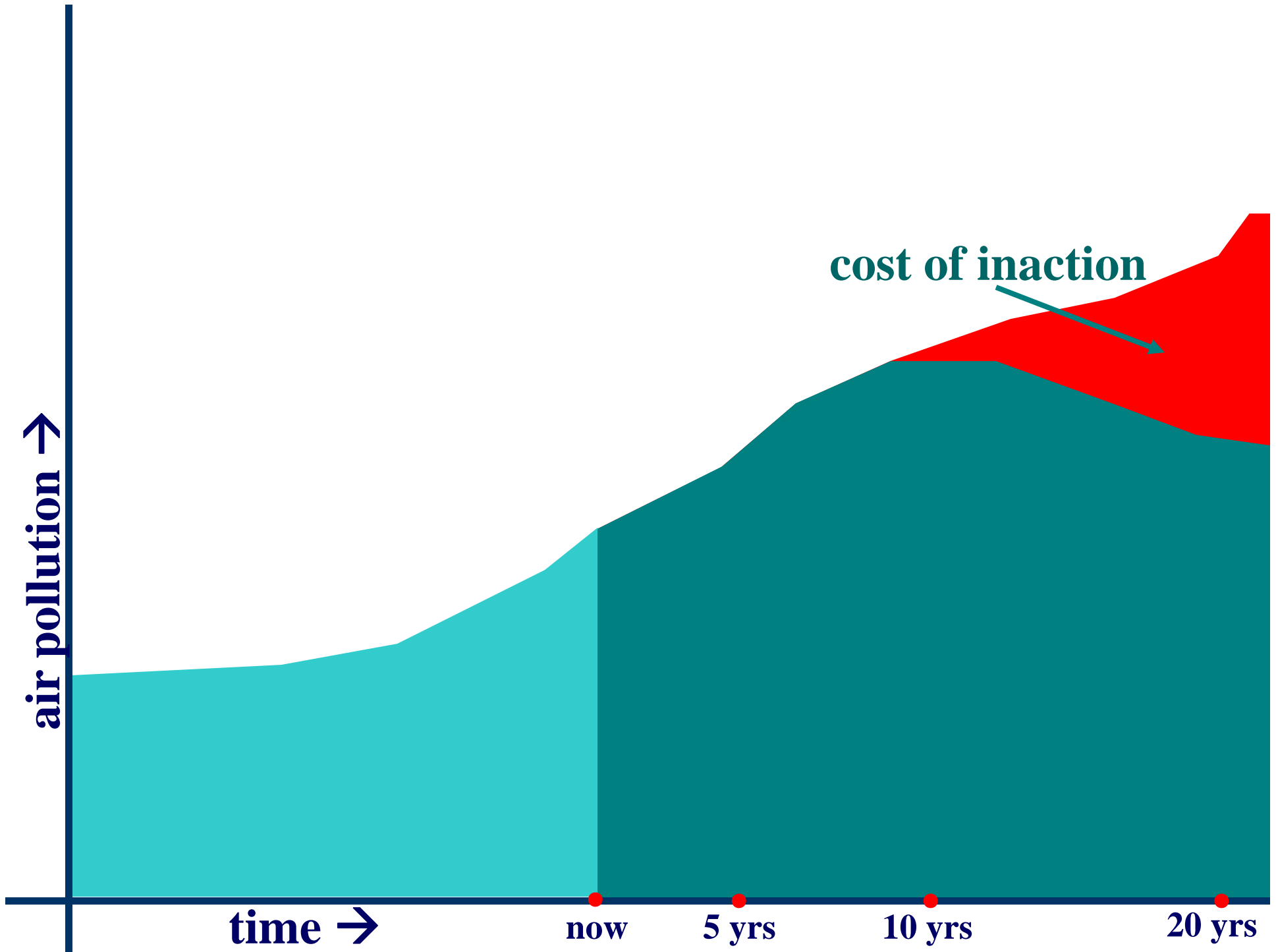


**.. and expected to  
further increase**



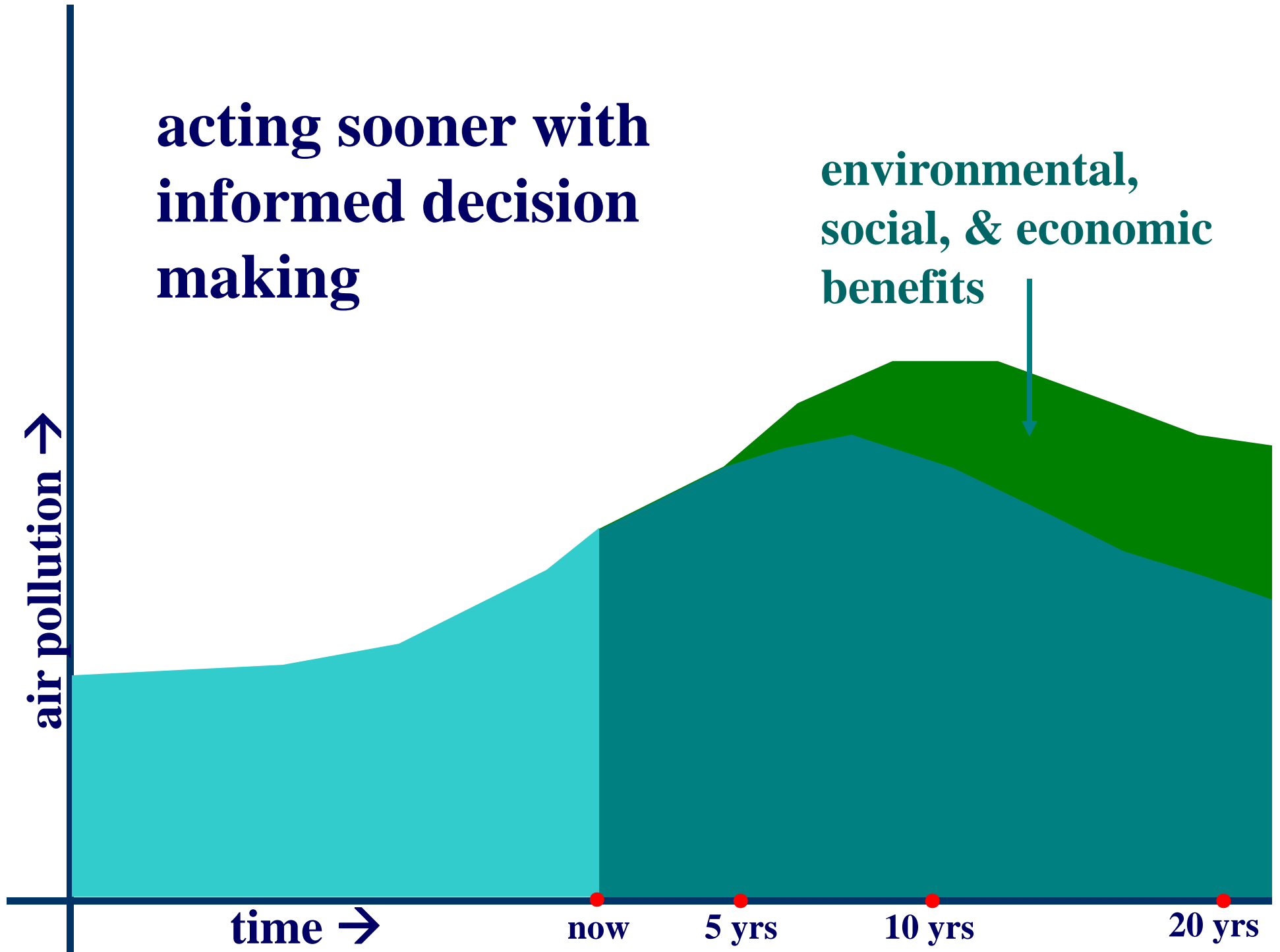
**.. and expected to  
further increase**





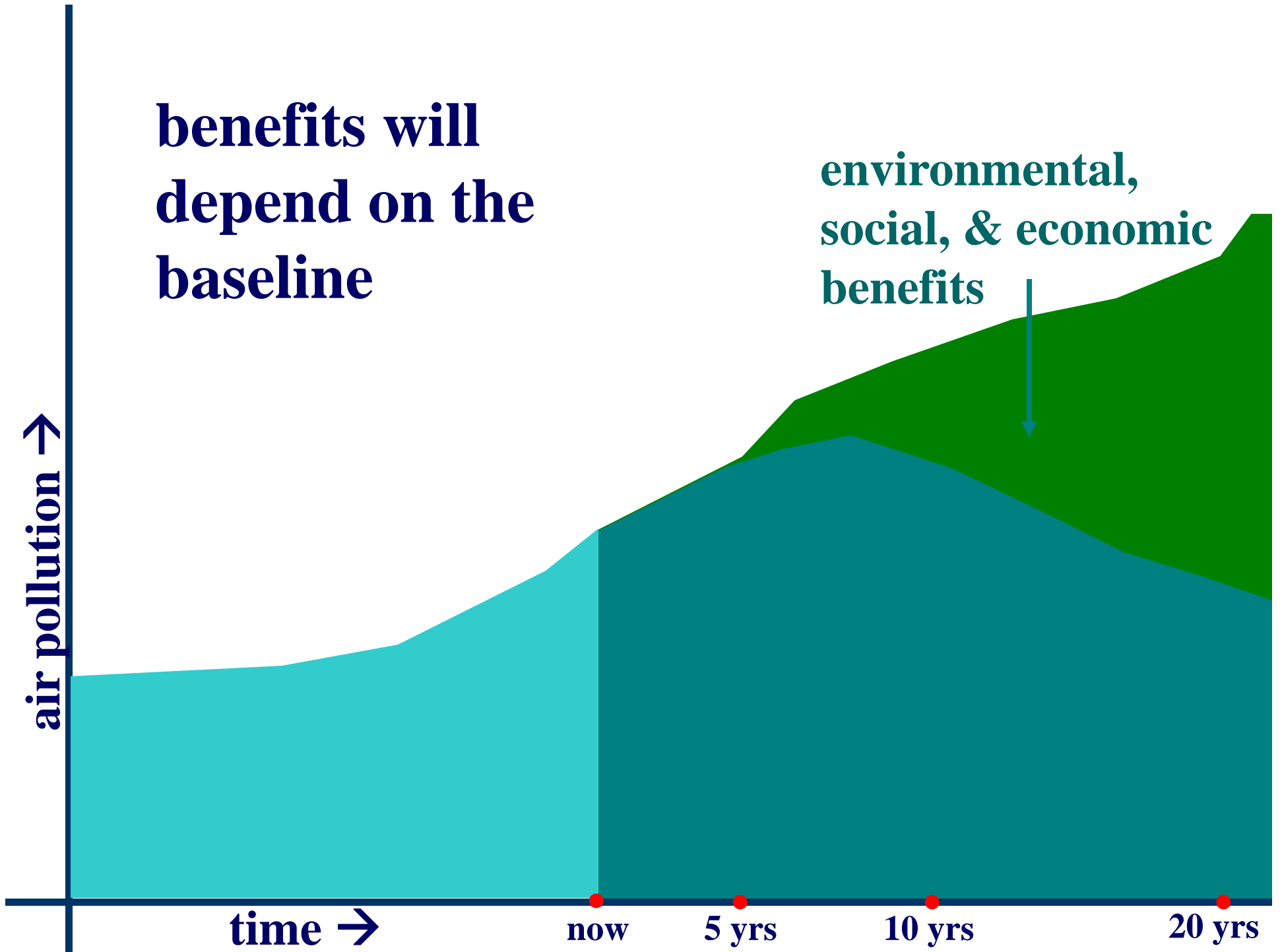
**acting sooner with  
informed decision  
making**

**environmental,  
social, & economic  
benefits**

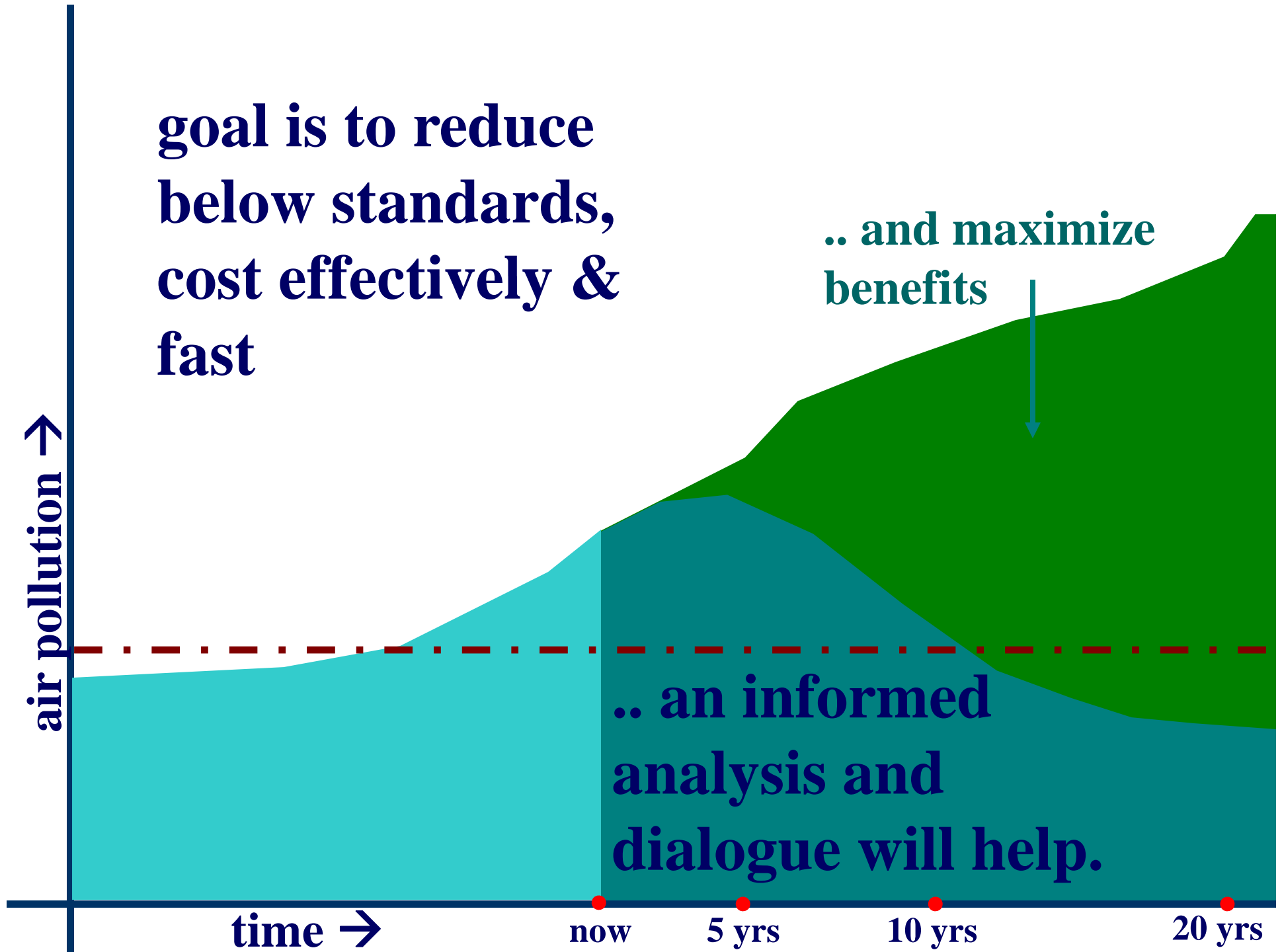


**benefits will  
depend on the  
baseline**

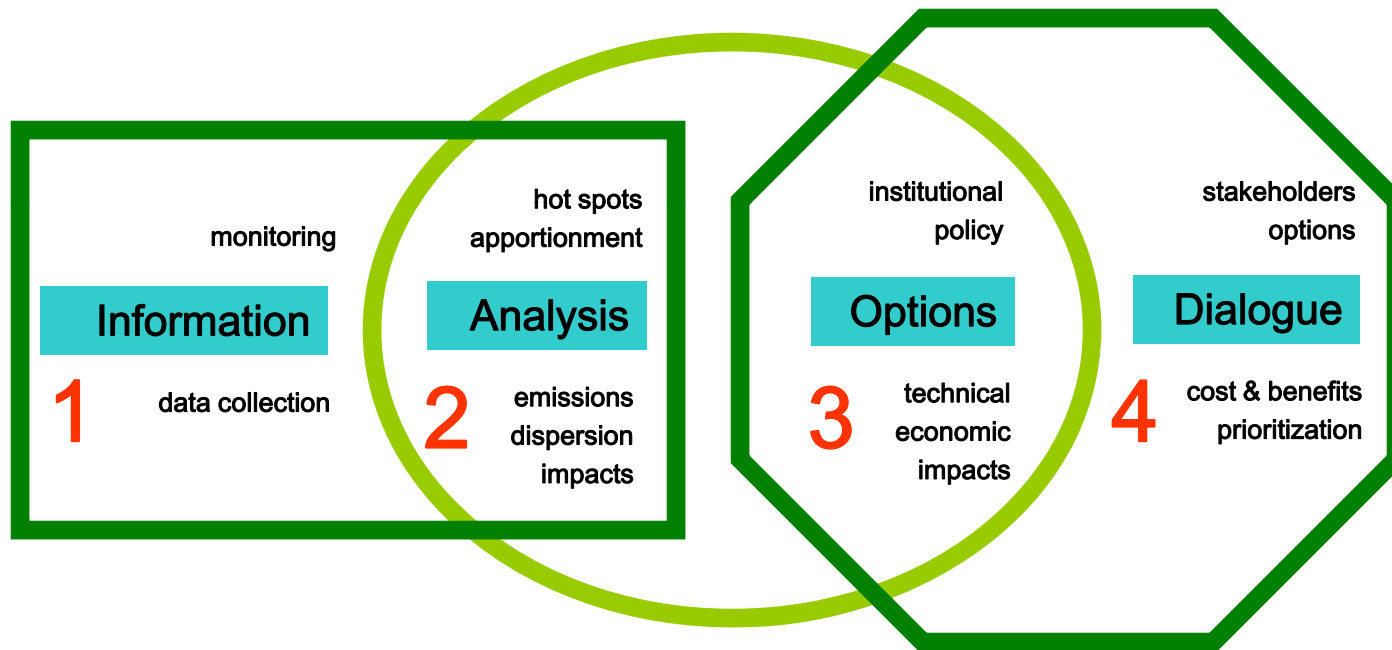
**environmental,  
social, & economic  
benefits**



**goal is to reduce  
below standards,  
cost effectively &  
fast**

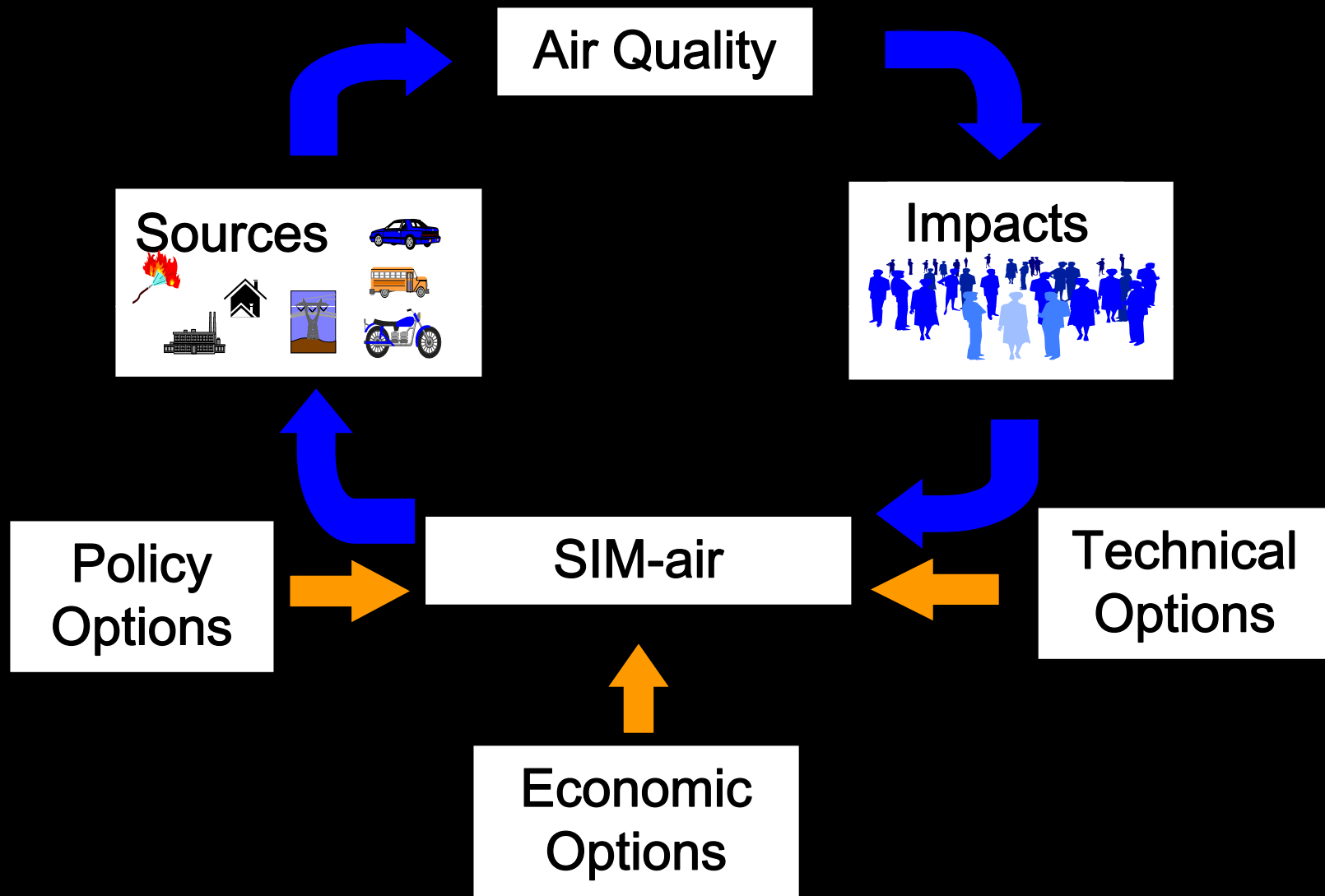


# Small steps..



.. for BIG reductions

# Simple Interactive Models



Details @ [www.sim-air.org](http://www.sim-air.org)



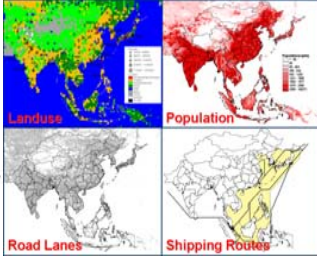
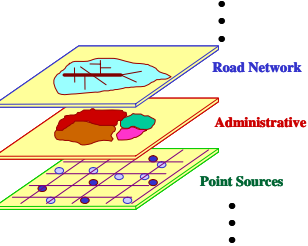
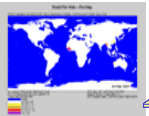
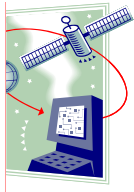
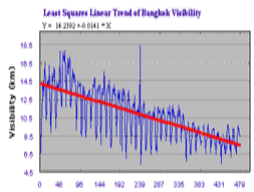
# Simple objectives..

Collate first, complicate later

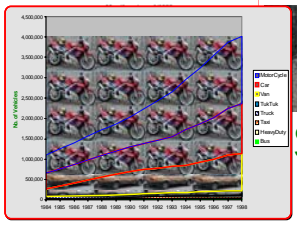
Apply tools for analysis

Evaluate C&B of options

Support stakeholder dialogue



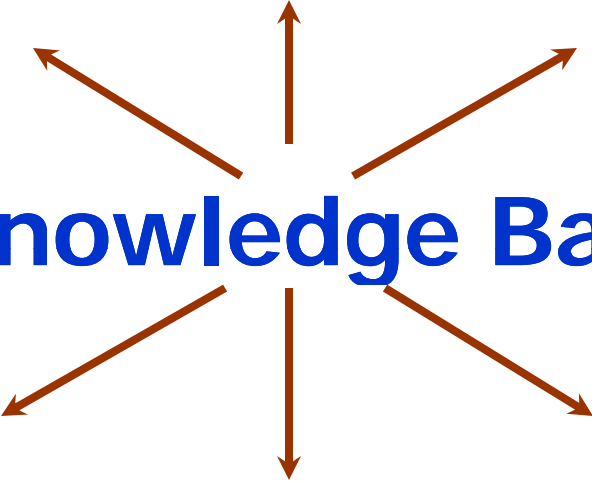
ISC3  
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ATMOS  
CMAQ  
WARF  
HYSPLIT  
RAMS/MM5



Statistics, Remote Sensing, GIS, Databases

Models

# Knowledge Base



Monitoring



Analysis

Stakeholders



Reports



Environmental Agencies

# GAINS/RAINS Model

@ <http://www.iiasa.ac.at/~rains>

The screenshot shows the GAINS Europe online web application in Mozilla Firefox. The browser window title is "GAINS Europe online - Mozilla Firefox". The address bar shows the URL <http://www.iiasa.ac.at/web-apps/apd/gains/EU/index.login>. The page header features the IIASA logo and the text "GAINS - Europe Greenhouse Gas and Air Pollution Interactions and Synergies". A red-bordered box contains the message: "Please note that the initialization functionality is currently not available due to maintenance activities." Below this, there are "Login" and "Glossary" buttons. The main content area is titled "GAINS online :: login" and includes a login form with fields for "Username" and "Password", a "Restore last work session" checkbox, and a "Login" button. To the right of the login form, the heading "Welcome to the GAINS Model" is followed by a paragraph: "The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)-Model provides a consistent framework for the analysis of co-benefits reduction strategies from air pollution and greenhouse gas sources." Below this, it states "The model considers emissions of:" followed by a list: Carbon dioxide (CO2), Methane (CH4), Nitrogen oxides (NOx), Nitrous oxide (N2O), Particulate matter (TSP, PM10, PM2.5 and PM1), Sulfur dioxide (SO2), and Volatile organic compounds (VOC). Further down, it says "Certain versions of the GAINS Model also contain:" followed by a list: Ammonia (NH3), Carbon monoxide (CO), and Fluorinated greenhouse gases (F-Gases). The final section, "The GAINS Model consists of several screen options, which display information pertaining to:", lists: Economic Activity Pathways (activities causing emissions), Emission Control Strategies (evolution of emissions and control), Emissions Scenarios (emissions computed for a selected scenario), Emission Control Costs (displays emission control costs), and Impacts. The browser's taskbar at the bottom shows the Windows Start button, the GAINS Europe online application, and other open applications like "DIESEL 2008 Side Event" and "Microsoft PowerPoint ...". The system clock shows 9:51 PM.

GAINS Europe online - Mozilla Firefox

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<http://www.iiasa.ac.at/web-apps/apd/gains/EU/index.login>

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Gmail - Inbox (35) - sguttikunda@gmail... MIT Integrated Framework: Climate Climate Change Impacts: Scientific Ame... GAINS Europe online

**GAINS - Europe**  
Greenhouse Gas and Air Pollution Interactions and Synergies

Please note that the initialization functionality is currently not available due to maintenance activities.

Login Glossary

**GAINS online :: login**

Username  
Password

Restore last work session

Login

Read disclaimer  
Register

**Links**

APD Web site  
IIASA Web site

Co-funded by the LIFE Programme of the European Union as part of the project

[EC4MACS](#)

European Consortium for Modelling of Air Pollution and Climate Strategies

## Welcome to the GAINS Model

The Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS)-Model provides a consistent framework for the analysis of co-benefits reduction strategies from air pollution and greenhouse gas sources.

The model considers emissions of:

- Carbon dioxide (CO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Nitrogen oxides (NO<sub>x</sub>)
- Nitrous oxide (N<sub>2</sub>O)
- Particulate matter (TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub>)
- Sulfur dioxide (SO<sub>2</sub>)
- Volatile organic compounds (VOC)

Certain versions of the **GAINS Model** also contain:

- Ammonia (NH<sub>3</sub>)
- Carbon monoxide (CO)
- Fluorinated greenhouse gases (F-Gases)

The **GAINS Model** consists of several screen options, which display information pertaining to:

- **Economic Activity Pathways**  
activities causing emissions (energy production & consumption, passenger & freight transport, industrial and agricultural activities, solvent use, etc.)
- **Emission Control Strategies**  
the evolution of emissions and control over a given time horizon
- **Emissions Scenarios**  
emissions are computed for a selected emissions scenario (combination of energy pathway and emissions control strategy), emission factors, results displays, and input values are also available under this action
- **Emission Control Costs**  
displays emission control costs computed for a selected emissions scenario
- **Impacts**

Done

start GAINS Europe online ... DIESEL 2008 Side Event Microsoft PowerPoint ... 9:51 PM

# SEI Emissions Handbook

Email: [harry.vallack@sei.se](mailto:harry.vallack@sei.se)

SEI - Atmospheric Environments Programme : Project Description - Mozilla Firefox


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http://www.sei.se/index.php?section=atmospheric&page=projdesc&projdescpage=99928

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Gmail - Inbox (35) - sguttkunda@gmail... MIT Integrated Framework: Climate SEI Climate Change Impacts: Scientific Ame... SEI - Atmospheric Environments ...

### Download Manual



**Download Workbook  
Excel XLS (4.9 Mbytes)**

Download Manual  
PDF Format (9 Mbytes)

Download Manual  
MS Word Format (8.6 Mbytes)

### Sponsorship

This project is jointly funded by the BOC Foundation (in the UK), the US Environment Protection Agency (US-EPA) and the Swedish International Development Cooperation Agency (Sida).

If you would like further information about this project please visit the [GAPFORUM Website](#) or contact:

Harry Vallack  
Stockholm Environment Institute - York Centre  
Grimston House  
University of York  
Heslington  
YORK YO10 5DD, UK

Tel +44 (0) 1904 432894  
Email: [harry.vallack@sei.se](mailto:harry.vallack@sei.se) (replace AT with @)

**Geographic focus:** Global



Done

start SEI - Atmospheric En... DIESEL 2008 Side Event Microsoft PowerPoint ... 9:57 PM

# HEAT Emissions Database

## @ <http://www.iclei.org/heat>





View portal in: English

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**Welcome to the HEAT home portal!**

ICLEI - Local Governments for Sustainability is an international association of local governments dedicated to fostering a sustainable world. With valuable support from US Agency for International Development (USAID), ICLEI developed the Harmonized Emissions Analysis Tool (HEAT) online software to support local greenhouse gas and air pollution emission reduction planning. This software provides capacity to local governments to seek to reduce GHG emissions based on sound governance, economic development, improved waste management, energy efficiency, better urban mobility, and better air quality. Beyond being a planning tool, this site offers consultants, NGOs, government agencies, academics, and others free tools to translate energy, transportation and waste activities into pollution emissions.


In general the software will:

- Build an emissions inventory based on local energy use, transportation demand, and waste practices
- Help a user/city build a simple emissions forecast
- Set a target/goal for reducing emissions (e.g., reduce GHG emissions by 10%)
- Quantify emission reduction activities and their co-benefits
- Develop, report, and track progress made in meeting that target.

HEAT features 24/7 access from any computer with an internet connection and an optional downloadable standalone application for off-line work. Initial countries for which HEAT is being prepared include India, Indonesia, South Africa, and Brazil.

Enjoy the site and please be sure to provide your comments.

**NEWS**  
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# Bangkok, Thailand, 2008

		Average Speed					Average Speed					Average Speed		
		10	20	30			10	20	30			10	20	30
		Light Duty Vehicles					Heavy Duty Buses					Heavy Duty Trucks		
<b>HC</b>	<b>Pre-1994</b>	0.52	0.32	0.25	<b>Pre-1995</b>	2.35	1.31	0.93	<b>Pre-1995</b>	1.46	0.93	0.71		
<b>CO</b>		1.88	1.32	1.07		10.17	6.59	5.11		13.12	10.35	9.02		
<b>NO<sub>x</sub></b>		2.97	2.34	2.03		19.68	12.00	8.98		15.02	10.44	8.44		
<b>CO<sub>2</sub></b>		414.74	317.95	272.17		1299.06	843.09	654.71		1163.51	921.26	803.67		
<b>PM</b>		216.18	187.54	172.59		1319.11	962.30	800.18		2445.90	1859.44	1583.94		
<b>HC</b>	<b>1994-96</b>	0.36	0.24	0.20	<b>1996-97</b>	1.81	1.10	0.82	<b>1996-97</b>	1.65	1.18	0.96		
<b>CO</b>		1.51	1.09	0.90		17.40	16.02	15.26		4.24	3.46	3.08		
<b>NO<sub>x</sub></b>		3.37	2.60	2.24		22.45	13.30	9.80		14.24	10.88	9.30		
<b>CO<sub>2</sub></b>		409.56	322.43	280.32		1317.69	999.87	850.79		1185.70	980.67	877.59		
<b>PM</b>		153.14	155.50	156.90		1928.59	1759.84	1668.06		933.68	880.38	850.62		
<b>HC</b>	<b>1997-99</b>	0.34	0.21	0.16	<b>1997-2000</b>	0.85	0.46	0.32	<b>1997-2000</b>	1.83	1.22	0.97		
<b>CO</b>		1.83	1.08	0.79		18.21	15.42	13.99		4.24	3.46	3.08		
<b>NO<sub>x</sub></b>		2.87	2.23	1.93		19.68	12.00	8.98		15.02	10.44	8.44		
<b>CO<sub>2</sub></b>		437.58	342.34	296.56		1789.18	1154.76	893.83		1401.33	1127.40	992.71		
<b>PM</b>		169.94	166.20	164.05		835.09	620.84	522.00		1283.03	925.60	764.66		
<b>HC</b>	<b>after 2000</b>	0.27	0.19	0.16	<b>after 2001</b>	1.83	1.05	0.76	<b>after 2001</b>	0.83	0.55	0.43		
<b>CO</b>		1.70	1.37	1.21		6.36	3.72	2.72		5.40	3.61	2.85		
<b>NO<sub>x</sub></b>		1.45	1.14	0.98		13.50	9.47	7.70		15.07	10.03	7.91		
<b>CO<sub>2</sub></b>		420.66	342.25	303.35		1474.90	1038.44	845.75		1438.36	1009.98	821.27		
<b>PM</b>		138.24	145.44	149.83		1116.67	982.14	911.09		447.67	410.40	390.06		

# CPCB, India, 2008

Central Pollution Control Board ::>> Programme/projects > Air/Quality Pollution > Source Apportionment Studies - Mozilla Firefox

http://cpcb.nic.in/Source\_Apportionment\_Studies.php

Environmental Data Bank  
CLICK HERE

CPCB [ HIGHLIGHTS ]  
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fine particulates (PM 10 & PM 2.5 ), being most critical. Besides, separate projects on Development of emission factors for vehicles and Development of emission profiles for vehicular as well as non-vehicular sources have also been taken up, which would provide necessary inputs to source apportionment studies. Details of the projects, executing institutes and approximate costs are as follow:

Project	Institute
SA for Delhi	NEERI
SA for Bangalore	TERI
SA for Pune	ARAI
SA for Mumbai	NEERI
SA for Chennai	IITM
SA for Kanpur	IITK
EF for Vehicles	ARAI
SP (vehicles)	ARAI
SP (other sources)	

The scope for source apportionment studies includes preparation of emission inventories, monitoring of ambient selected locations (07 – 10 locations covering different land use viz. residential, industrial, kerbside, background receptor (CMB8) & dispersion models to assess the contribution from various sources, future projections and evi

**Present status of work**

Memoranda of collaborations have been signed with identified project executing institutes. Sites for air quality mo begin soon at other cities. Air quality monitoring would be carried out for three different seasons. Primary surv factors is nearly complete. In order to ensure that results of six studies are comparable, a common methodolo Procedures (SOPs) for sampling and analysis prepared and circulated to project executing agencies. Studies are strategies, the outcome of the studies would provide vital database on air quality, emission inventories for future

**Documents for reference**

- CONCEPTUAL GUIDELINES AND COMMON METHODOLOGY FOR AIR QUALITY MONITORING, EMISSION II
- MODEL STANDARD OPERATING PROCEDURES (SOPs) FOR SAMPLING AND ANALYSIS AIR QUALITY CITIES
- DRAFT REPORT ON "EMISSION FACTOR DEVELOPMENT FOR INDIAN VEHICLES"**

**Table: Average emission factors (in gm/km) for Indian vehicles**

Vehicle Type	CO	HC	NO <sub>x</sub>	CO <sub>2</sub>	PM
Scoter 2-St Post 2005 >80cc	0.14	0.36	0.02	38.5	0.057
Scoter 4-St Post 2005 >100cc	0.46	0.15	0.25	42.1	0.015
MC 2-St Pre 2000 >80cc	2.94	2.44	0.05	24.2	-
MC 4-St Post 2000 <100cc	1.65	0.51	0.27	25.0	0.035
MC 4-St Post 2000 >100cc	1.46	0.50	0.54	24.8	-
MC 4-St Post 2005 >200cc	0.72	0.52	0.15	45.6	0.013
JW 2-St Post 2000 <20cc	1.37	2.53	0.20	62.4	0.045
JW 2-St Post 2005 <20cc	1.15	1.53	0.16	71.5	0.043
JW 4-St Post 2000 <20cc	1.97	0.34	0.40	62.7	0.030
JW 4-St Post 2005 <20cc	2.25	0.77	0.53	73.8	0.015
JW Diesel Post 2000 <50cc	2.05	0.16	0.69	173.9	0.347
JW Diesel Post 2005 <50cc	0.41	0.14	0.51	131.6	0.091
JW CNG-4S Post 2000 <200cc	1.06	0.26	0.50	77.7	0.015
JW CNG-2S Post 2000 <200cc	0.65	2.36	0.19	57.7	0.118
JW LPG-2S Post 2000 <200cc	1.76	1.33	0.04	68.2	0.130
P.Car Petrol Pre 2000 <1000cc	4.82	0.58	0.65	98.6	0.019
P.Car Petrol Post 2000 <1000cc	1.36	0.24	0.20	126.4	0.004
P.Car Petrol Post 2000 >1400cc	2.74	0.19	0.21	142.9	0.006
P.Car Petrol Post 2005 >1400cc	0.84	0.12	0.09	172.9	0.002
P.Car Diesel Pre 2000 <1600cc	0.87	0.22	0.45	129.1	0.145
P.Car Diesel Post 2000 <1600cc	0.72	0.14	0.84	156.8	0.190
P.Car Diesel Post 2005 <1600cc	0.04	0.28	0.28	148.8	0.015
P.Car Diesel Pre 2000 >1600cc	0.64	0.25	0.61	166.1	0.180
P.Car CNG Pre 2000 <1000cc	0.85	0.79	0.53	149.4	0.001
P.Car CNG Post 2000 <1000cc	0.04	0.46	0.74	143.5	0.006
P.Car LPG Pre 2000 >1000cc	6.78	0.35	0.50	130.9	0.001
P.Car LPG Post 2000 >1400cc	2.72	0.23	0.20	140.0	0.002

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Done

# Average EF's in VAPIS

	Gasoline			Diesel			CNG				
	2Ws	3Ws	Cars	Cars	LDV	HDT	Bus	3Ws	Cars	LDV	Bus
PM <sub>10</sub>	0.10	0.20	0.10	1.00	1.25	2.00	1.50	0.10	0.05	0.02	0.02
PM <sub>2.5</sub>	0.05	0.08	0.03	0.60	0.50	1.00	0.80	0.05	0.02	0.01	0.01
SO <sub>2</sub>	0.02	0.02	0.07	0.40	0.30	1.00	1.00	0.00	0.00	0.00	0.00
NO <sub>x</sub>	0.15	0.10	0.20	1.25	2.00	10.0	10.0	0.35	0.20	3.50	2.50
CO	2.50	8.00	5.00	2.00	2.50	3.50	3.50	3.50	1.00	3.50	3.50
CO <sub>2</sub>	40	80	200	250	500	850	850	70	100	450	450
HC	1.50	5.00	1.00	0.40	0.20	1.00	1.00	0.15	0.02	0.10	0.10

VAPIS: Vehicular Air Pollution Information System  
 @ [www.sim-air.org](http://www.sim-air.org)



# SIM-air Working Paper Series

## In 2008

01. Creating GIS Road Maps for Urban Centers
02. Four Simple Equations for Vehicular Emissions Inventory
03. Informed Decision Support for AQM in Developing Cities
04. Simple & Interactive Tools for Air Pollution Analysis
05. Urban Air Pollution Analysis in Ulaanbaatar, Mongolia
06. Estimating Health Impacts of Urban Air Pollution
07. Estimating Road Dust Emissions: Methods & Parameters
08. Co-Benefits: Management Options for Local Pollution & GHG Emission Control
09. Air Pollution & Co-Benefits Analysis for Hyderabad, India
10. What is Particulate Matter: Composition & Science
11. Urban Transport in India: Not so Fast for Nano Car

**Details @ [www.sim-air.org](http://www.sim-air.org)**

# SIM 06-2008 – Health

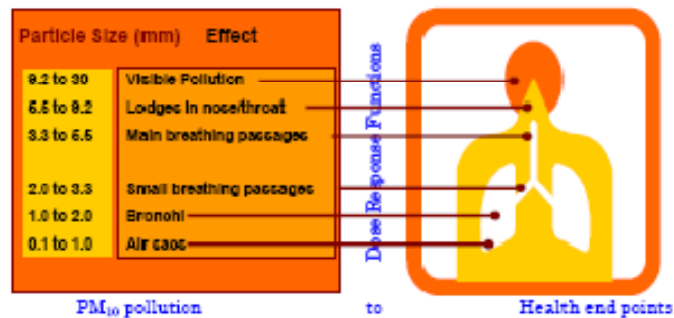
## SIM-air

Simple Interactive Models for Better Air Quality  
www.sim-air.org

### Estimating Health Impacts of Urban Air Pollution

Dr. Sarath Guttikunda  
New Delhi, India  
October 2008

SIM-06-2008



# SIM-air Cities 2008



**Details @ [www.sim-air.org](http://www.sim-air.org)**



# Pune, India

Times of India, July 25<sup>th</sup>, 2008

## City Wastes Rs 34 Crore Every Year Due To Idling, Finds Study

# Switch off at signals, save fuel

Aditi Wipat | 1001

**Pune:** Every Puneite wastes at least Rs 100 worth of fuel per year by not switching off his/her vehicle at traffic junctions, as per a study conducted by Puneite, Survir Kher. Applying this equation to entire Pune, Kher says the entire city wastes about Rs 34 crore due to idling of vehicles. A geologist by profession, Kher was inspired to study the relationship between pollution and idling of vehicles by the road traffic jams he faced everyday in the city.

"I cross the Law College road junction everyday. The situation there is appalling. I studied the Pune Municipal Corporation's (PMC) annual environment status report, and realised that it did not provide any relevant data. That was when I embarked on this study," said Kher.

Assuming that each vehicle idles for about two minutes per day (which, he confesses, is a very conservative estimate), ve-



The study finds that idling vehicles waste upto 19,000 litres of fuel and emit 45 tonnes of greenhouse gases every day in Pune.

hicles in the city waste up to 19,000 litres of fuel every day and emit 45 tonnes of greenhouse gases, said Kher.

Elucidating on the methods used for calculation, Kher described how he used the annual environment status report of the PMC to obtain the statistics. He further obtained a carbon calculator for vehicles created by the Canadian Office of Energy Efficiency and multiplication factors from World Bank Energy reports. "I thought the calculations will be very complex. But after obtaining the tools,

I realised that it was a matter of mere multiplication," said Kher.

He added that for the purpose of calculation, he had estimated that most engines of vehicles were produced in the years between 1998 and 2005. "The efficiency of vehicles changes with usage, and also depending on the level of maintenance. Since the vehicles in the city are neither brand new nor very old, I chose this period." Kher stressed that while the emphasis is on carbon dioxide emissions, other pollutants like sulphur dioxide are as harmful, if

not more. While the effects of carbon emissions will be visible in the medium to long term, effects of particulate pollutants are immediately visible in terms of health hazards.

"We must accept that no one is going to stop using their vehicles very soon. But simple acts like switching off your vehicle while waiting for the signal to turn green can help you and the environment in a big way. There are western countries that use hybrid cars — cars that switch to electric engines while idling. But it is still a long way off for India," said Kher.

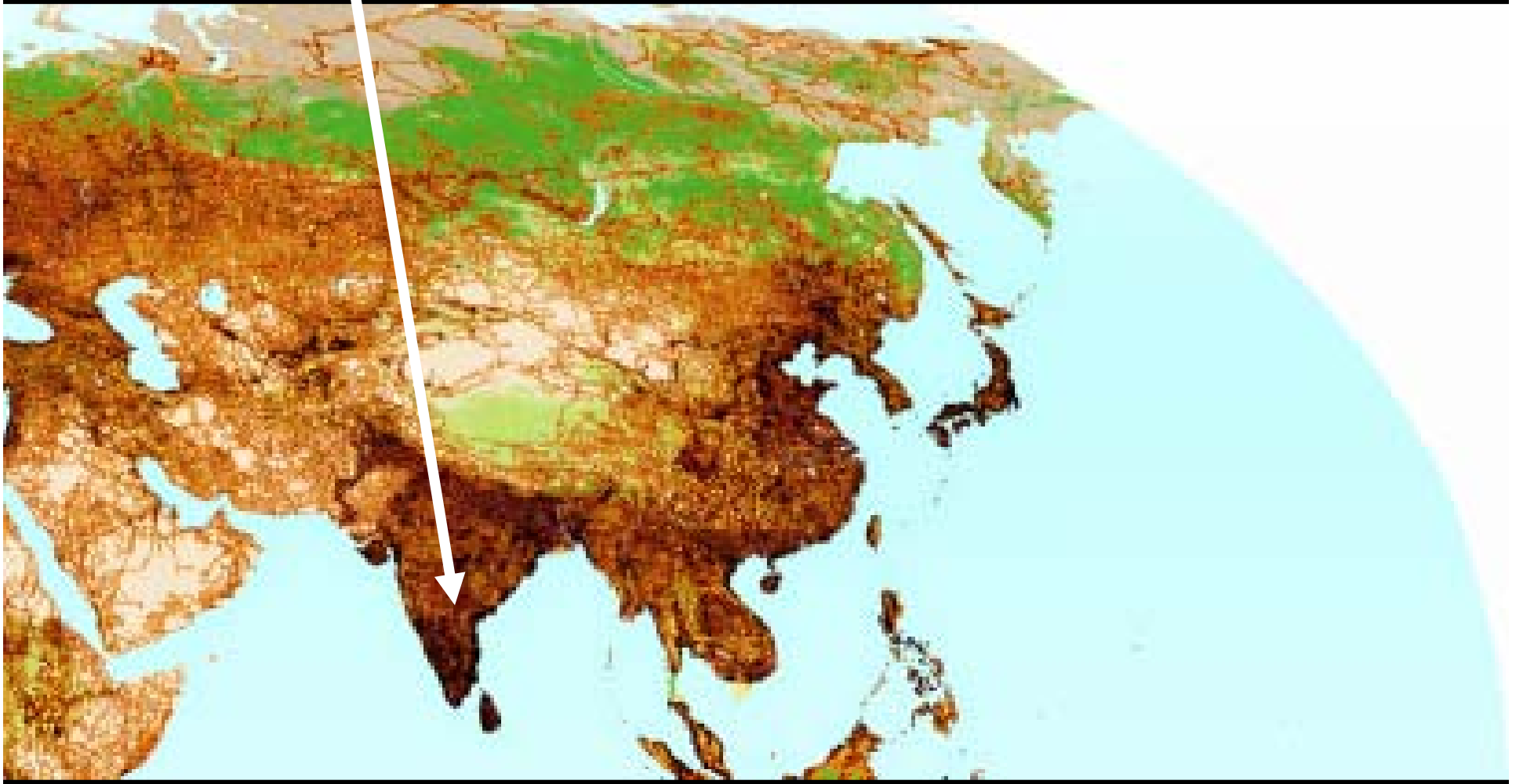
Kher has uploaded his findings on his website. "A lot of people have downloaded the graphs I have created for their personal usage. While I did the study to satisfy my curiosity, I am happy if it is being used as a resource by someone. Reporters from Pakistan and US have written to me, as also students from all over the world," said Kher.

The study while elementary in nature and made using very conservative estimates, proves the benefits of switching to fuel-efficient ways of driving for the city. According to the study if all Puneites reduced their idling time by one minute everyday it will have benefits equivalent to removing 3,000 cars off the roads of Pune.

# City Applications

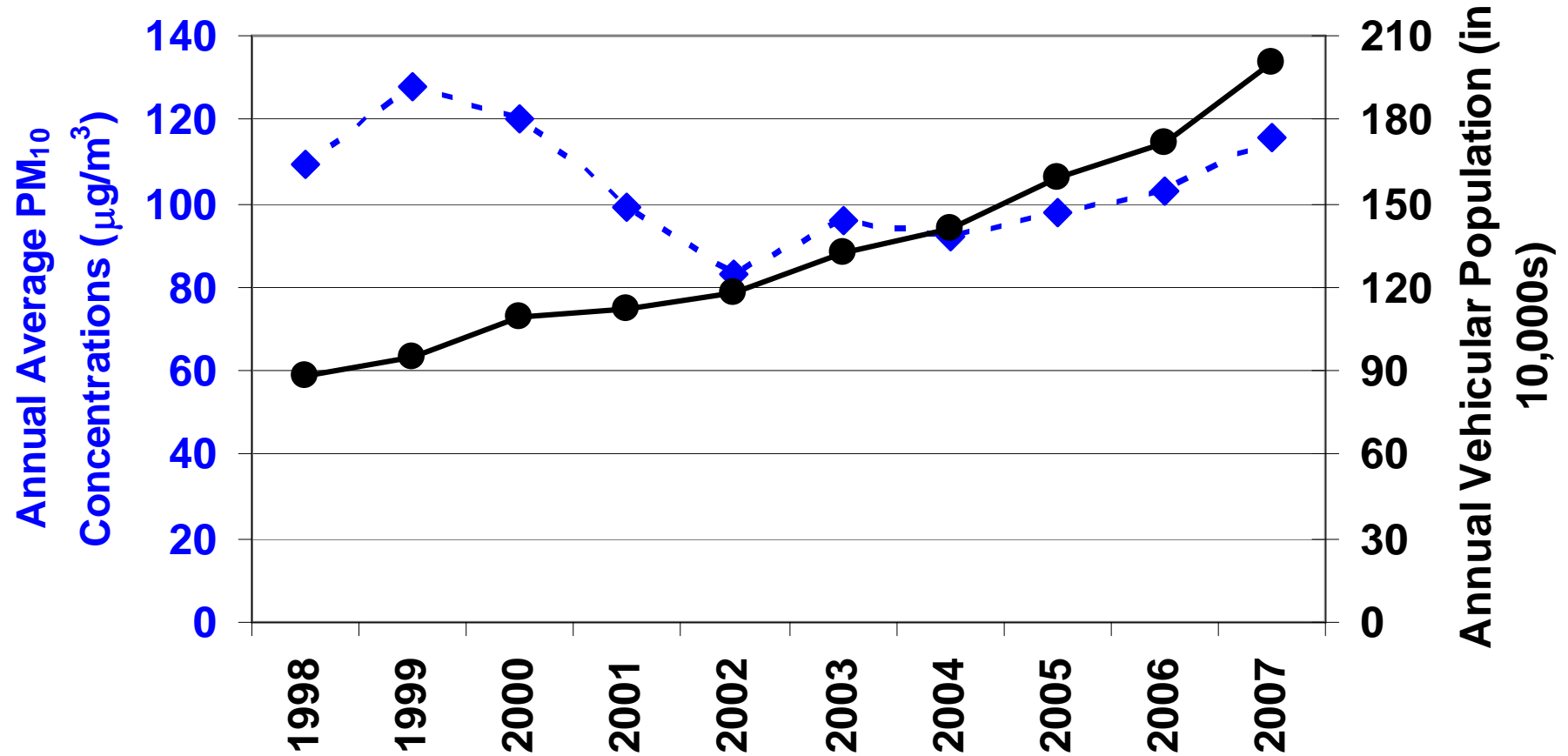
# Hyderabad, India

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**2006-08**

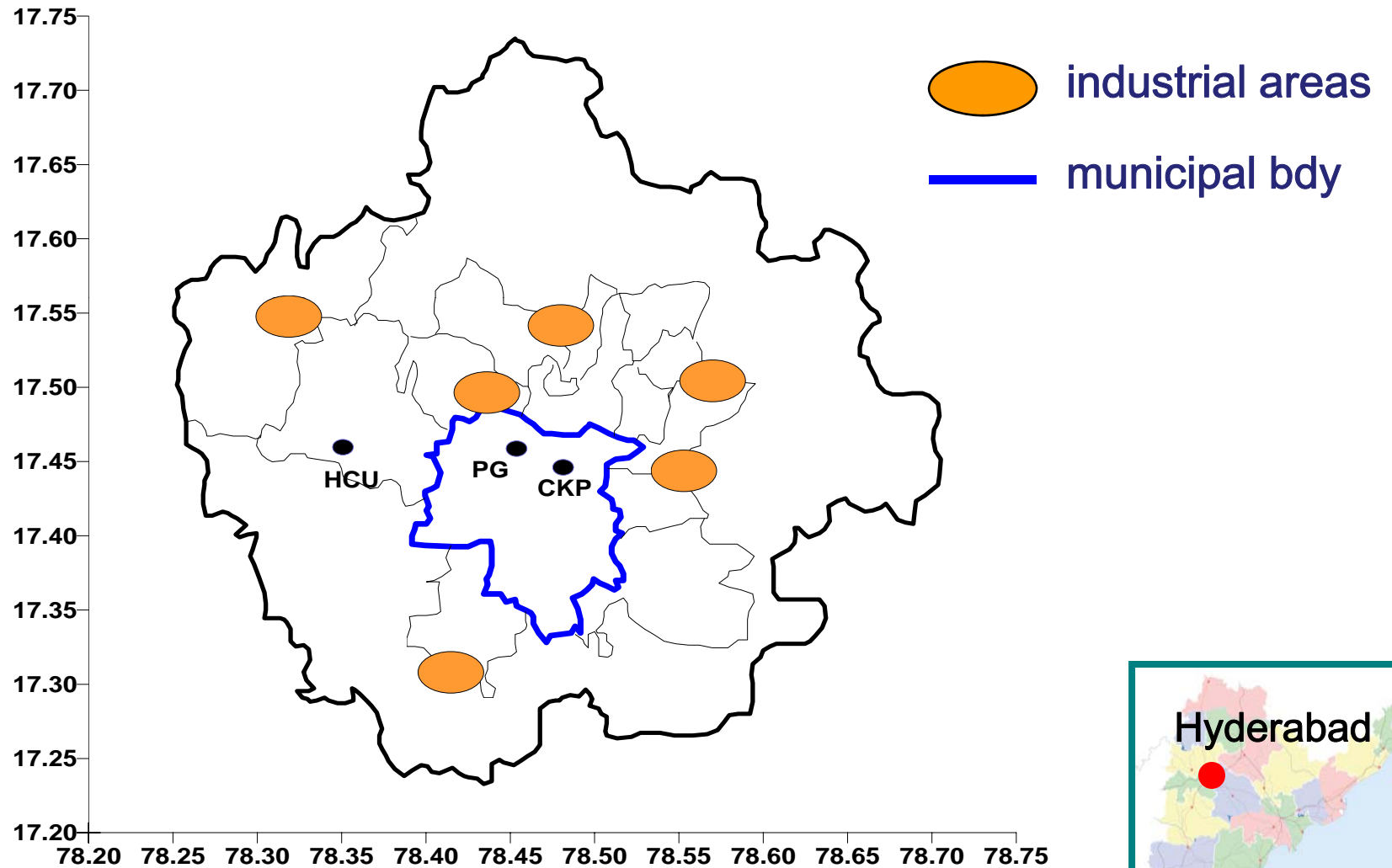
# Transport vs. Air Quality



Total Vehicles; 2002 = 14.5 L; 2006 = 18.0 L; 2007 = 20.0 L

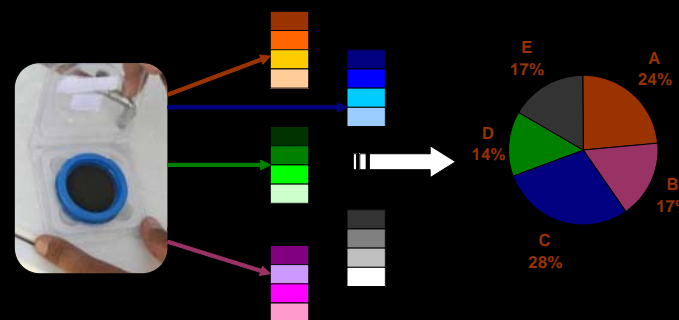


# Hyderabad Urban Development Area



# Source Apportionment Study

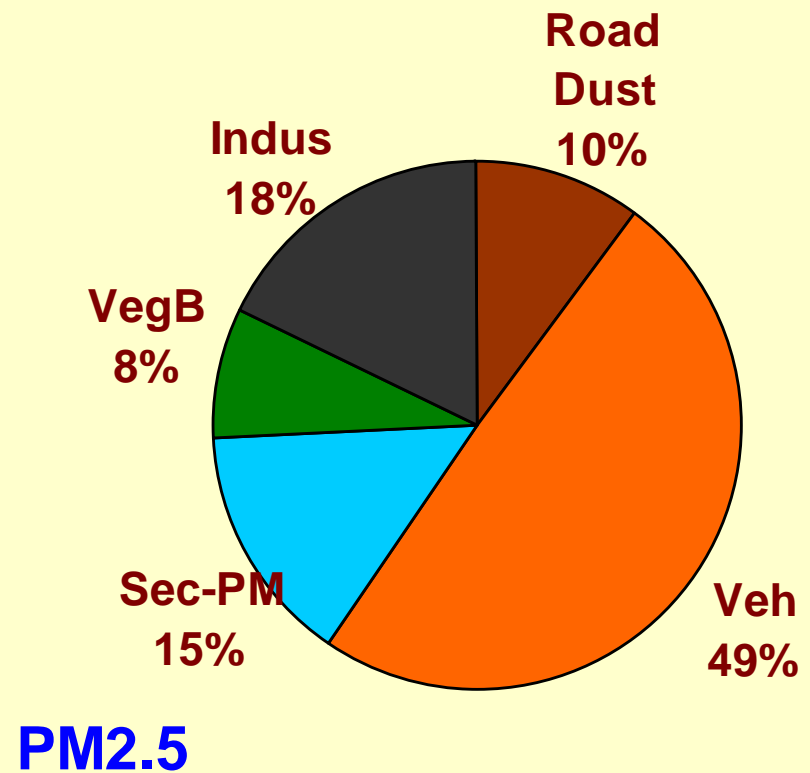
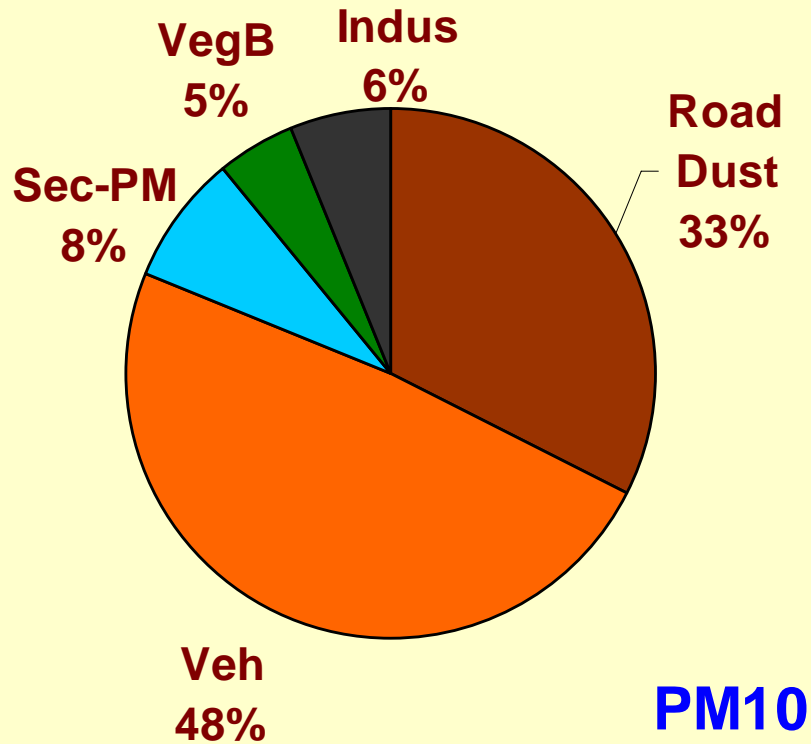
- Three seasons in 2005-06
- Three sites (PG, CKP, HCU)
- Airmetrics MiniVol samplers
- 24-hour sampling periods
- Filters
  - $PM_{10}$  and  $PM_{2.5}$
  - Teflon/quartz fiber filters
- Averages
  - $PM_{10}$  ranged 59 to  $160 \mu\text{g}/\text{m}^3$
  - $PM_{2.5}$  ranged 26 to  $86 \mu\text{g}/\text{m}^3$



Receptor Model: CMB 8.2

Detailed report @ [www.urbanemissions.info](http://www.urbanemissions.info)

# CMB Results: Average Sectoral Contributions



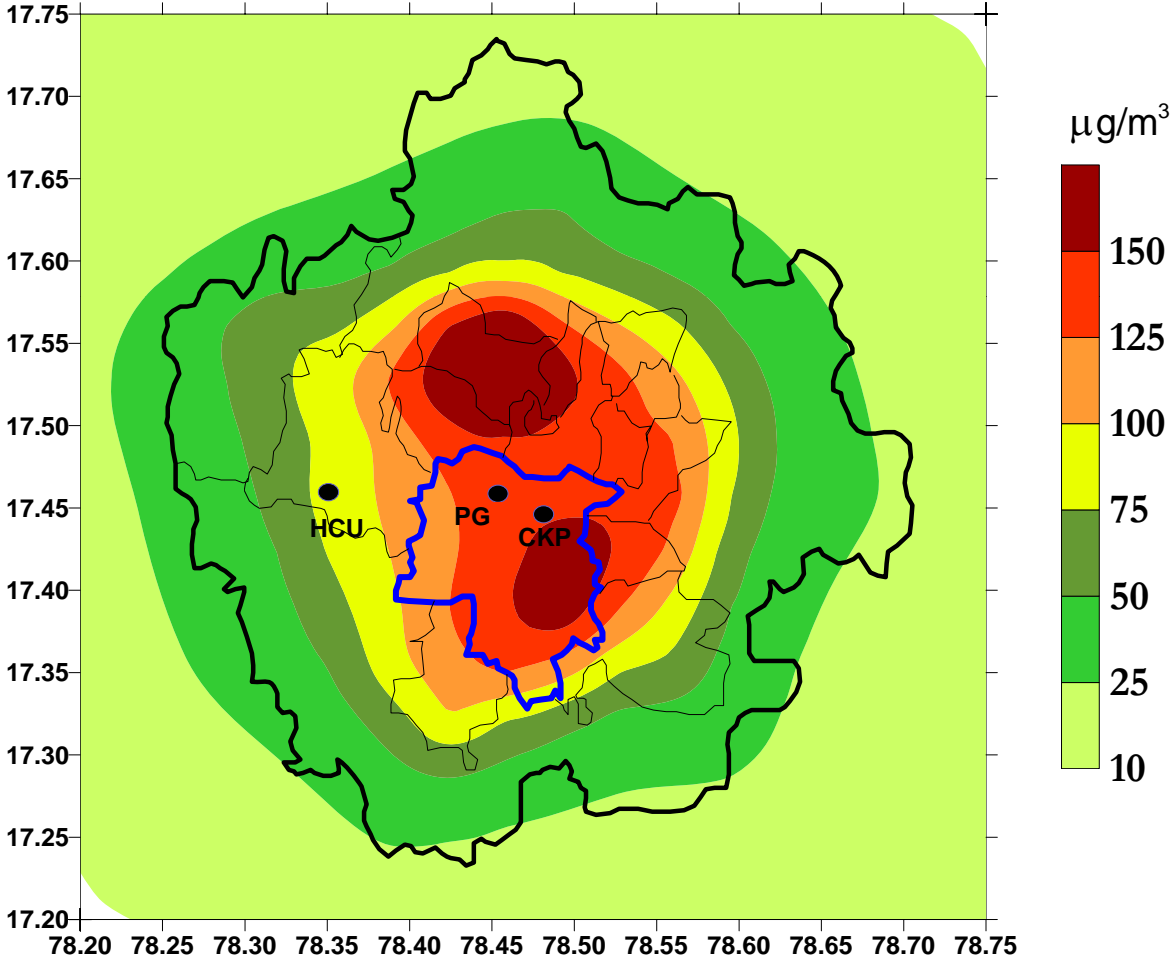
# Emission Inventory (yr 2006)

Category	PM <sub>10</sub>	SO <sub>2</sub>	NO <sub>x</sub>	CO <sub>2</sub>
Vehicular activity	8,410	6,304	38,772	6,260,099
Paved road dust	3,422			
Unpaved road dust	5,110			
Industry	11,054	7,110	7,836	916,486
Domestic	1,845	667	545	83,485
Open Waste Burning	810			
<b>Total</b>	<b>30,473</b>	<b>14,081</b>	<b>47,152</b>	<b>7,260,070</b>

in tons/yr

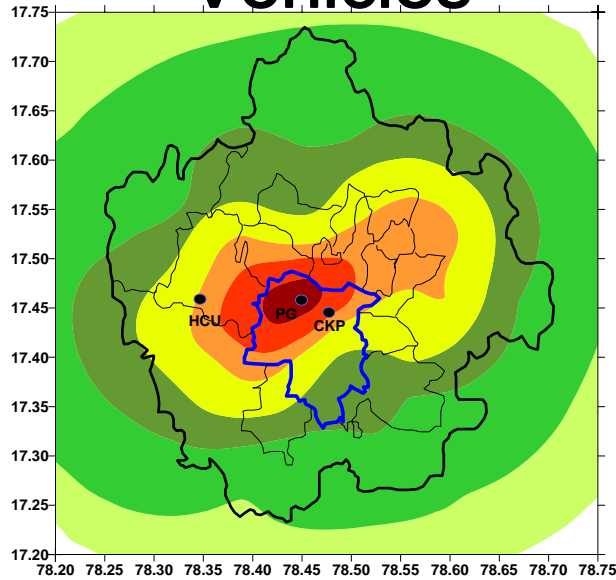
Detailed report @ [www.urbanemissions.info](http://www.urbanemissions.info)

# Modeled Annual Average PM<sub>10</sub>

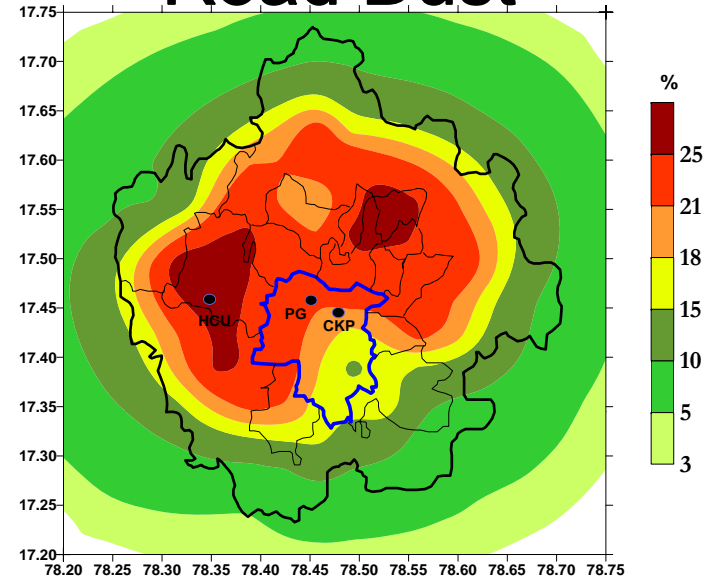


# % Estimated Contribution of Sectors

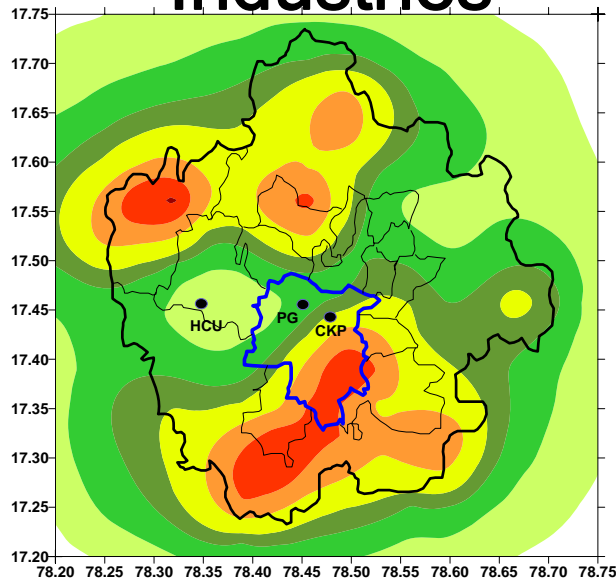
## Vehicles



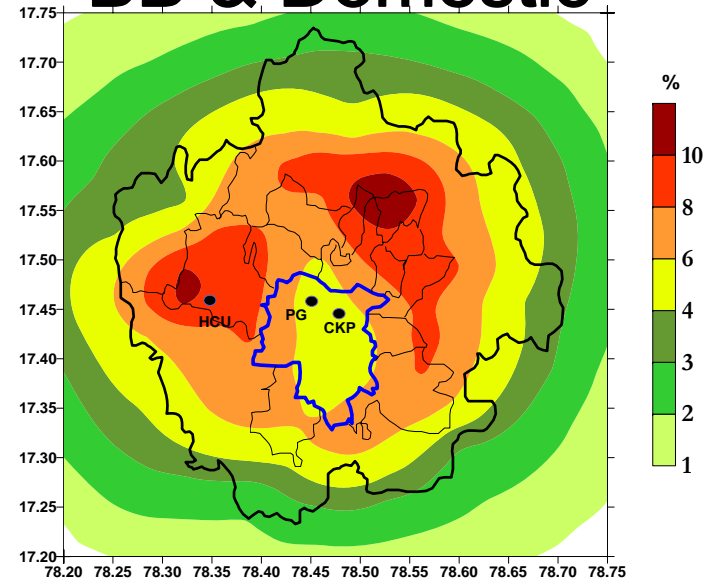
## Road Dust



## Industries



## BB & Domestic



# Top-Down vs. Bottom-Up

Location	Vehicles		Veh+RD		Industry		Dom+OWB	
	SA	M	SA	M	SA	M	SA	M
Punjagutta	54 ± 10	40-45	81 ± 10	66-70	13 ± 10	15-20	5 ± 10	4-6
Chikkadpally	45 ± 10	40-45	80 ± 10	60-66	15 ± 10	20-30	4 ± 10	4-6
HCU	43 ± 10	30-35	80 ± 10	50-60	16 ± 10	10-15	5 ± 10	8-10

SA = top-down = source apportionment

M = bottom-up = modeled

Detailed report @ [www.urbanemissions.info](http://www.urbanemissions.info)

# Action Plan for Air Pollution Reduction

## Co-Benefits Analysis



# Hyderabad: Proposed Action Plan

- Road maintenance
- LPG for 3 W's
- Public transport
- New emissions standards
- Phase-out for old 2 W's, 3 W's, & Cars
- Industrial energy efficiency
- Garbage management

# Co-Benefits for 2020

## Estimated Overall Percent Reductions

Intervention	PM <sub>10</sub> (%)	CO <sub>2</sub> (%)
100% buses to CNG	11.6	16.2
Public transport	6.1	9.8
Wet & vacuum sweeping	6.9	
I & M	1.2	3.8
Abolish diesel gen sets & biomass	14.2	2.0
Control illegal garbage burning	1.6	
Coal use in domestic sector	3.1	0.6

Detailed report @ [www.urbanemissions.info](http://www.urbanemissions.info)

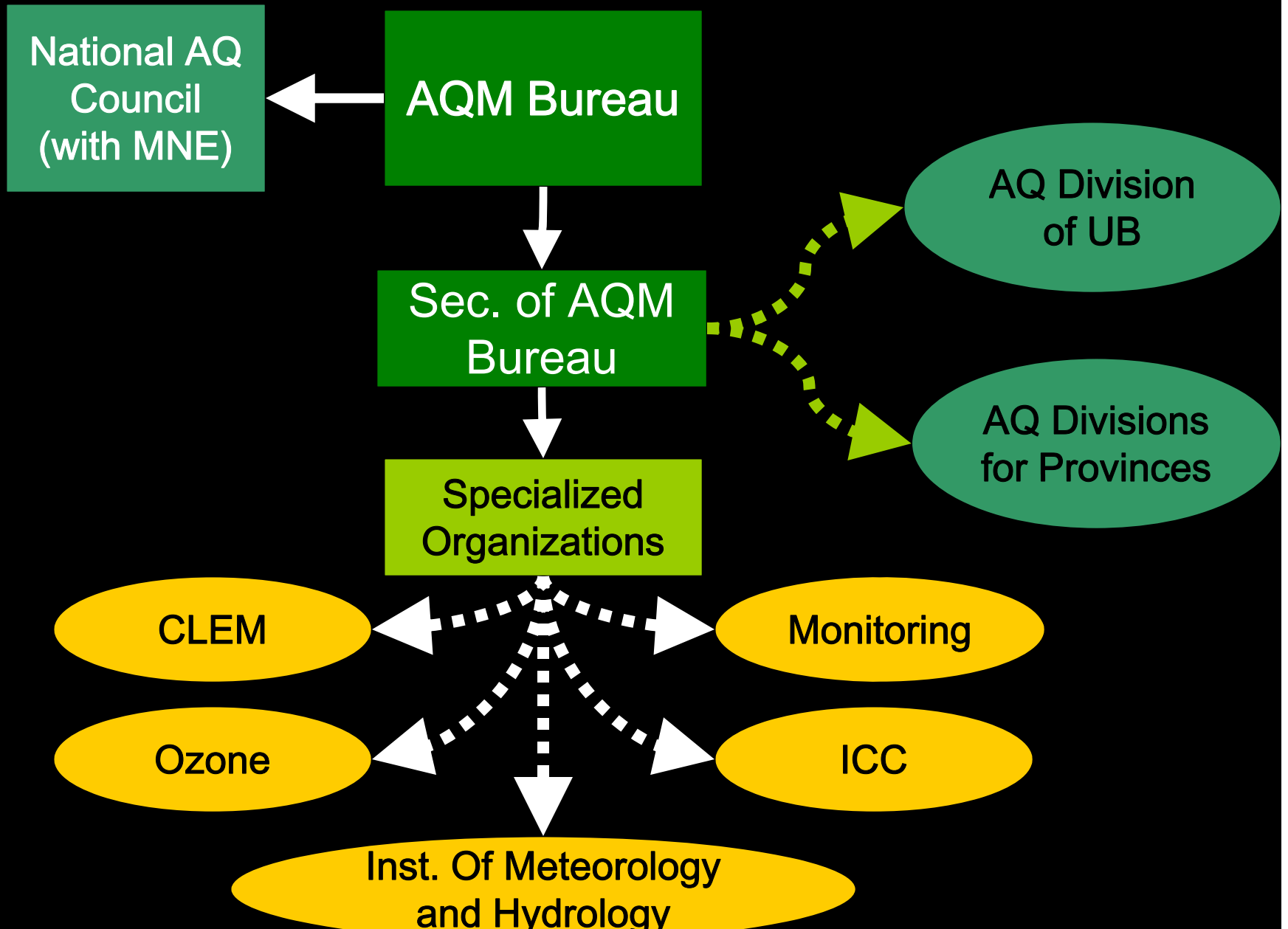
# Ulaanbaatar, Mongolia

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2007

# AQM Bureau @ Ulaanbaatar



# Dispersion in Winter...



# In Migration of Population



# Stoves: cooking & heating



# ... fly ash from power plants





# Garbage Burning



# Brick Industry



# Fugitive Dust... May 7<sup>th</sup> 2007



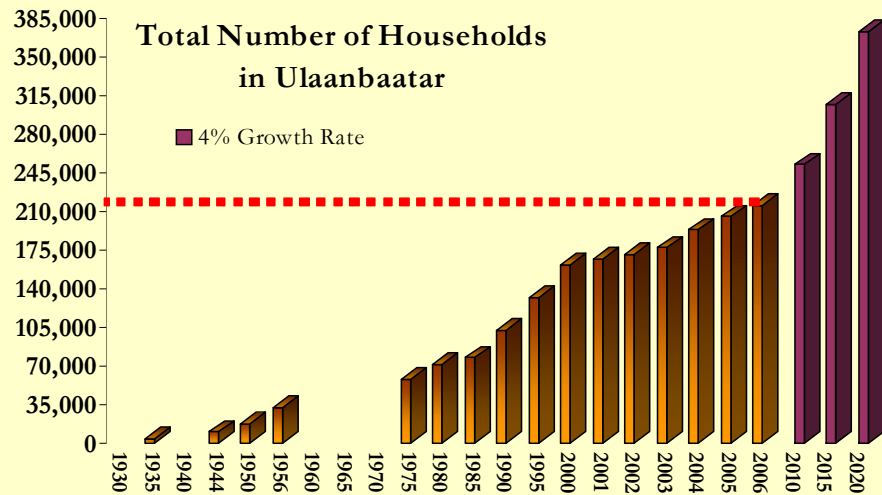
# Traffic

(image from google earth)



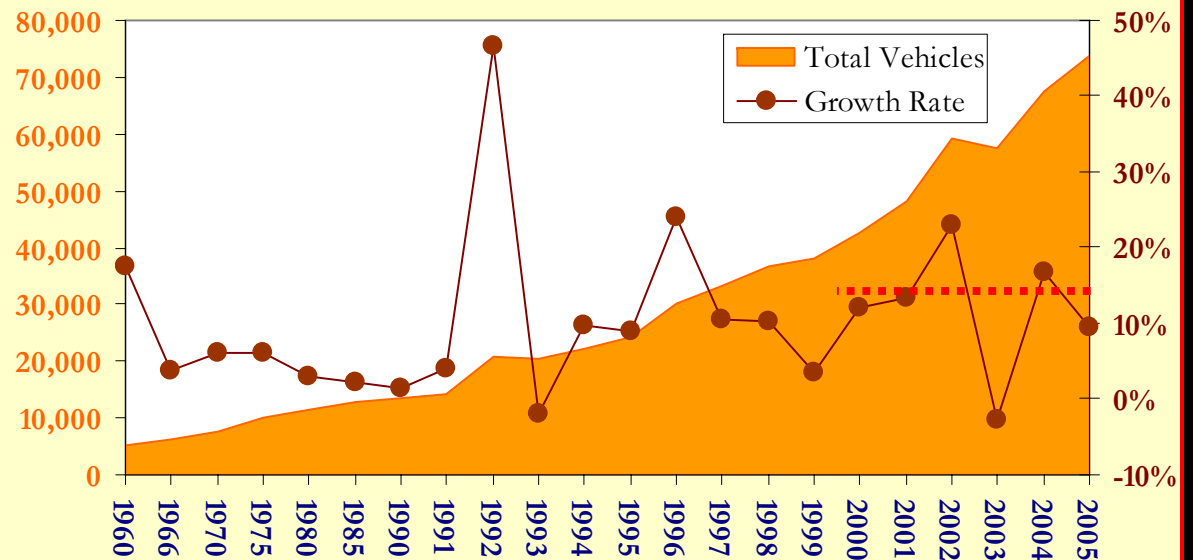
# Fugitive Dust from Vehicles



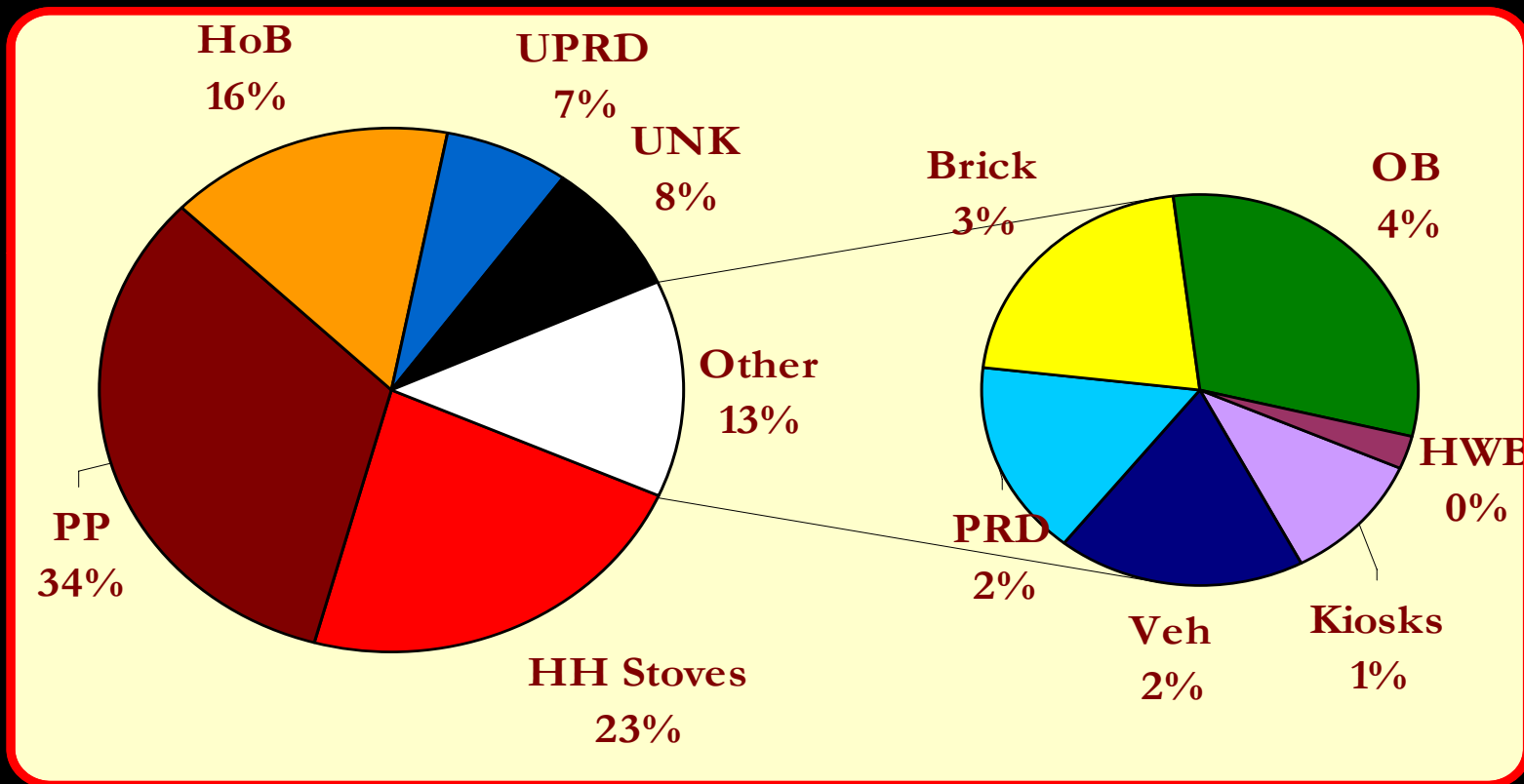


# Households = Cooking & Heating

# Transport, A Growing Sector



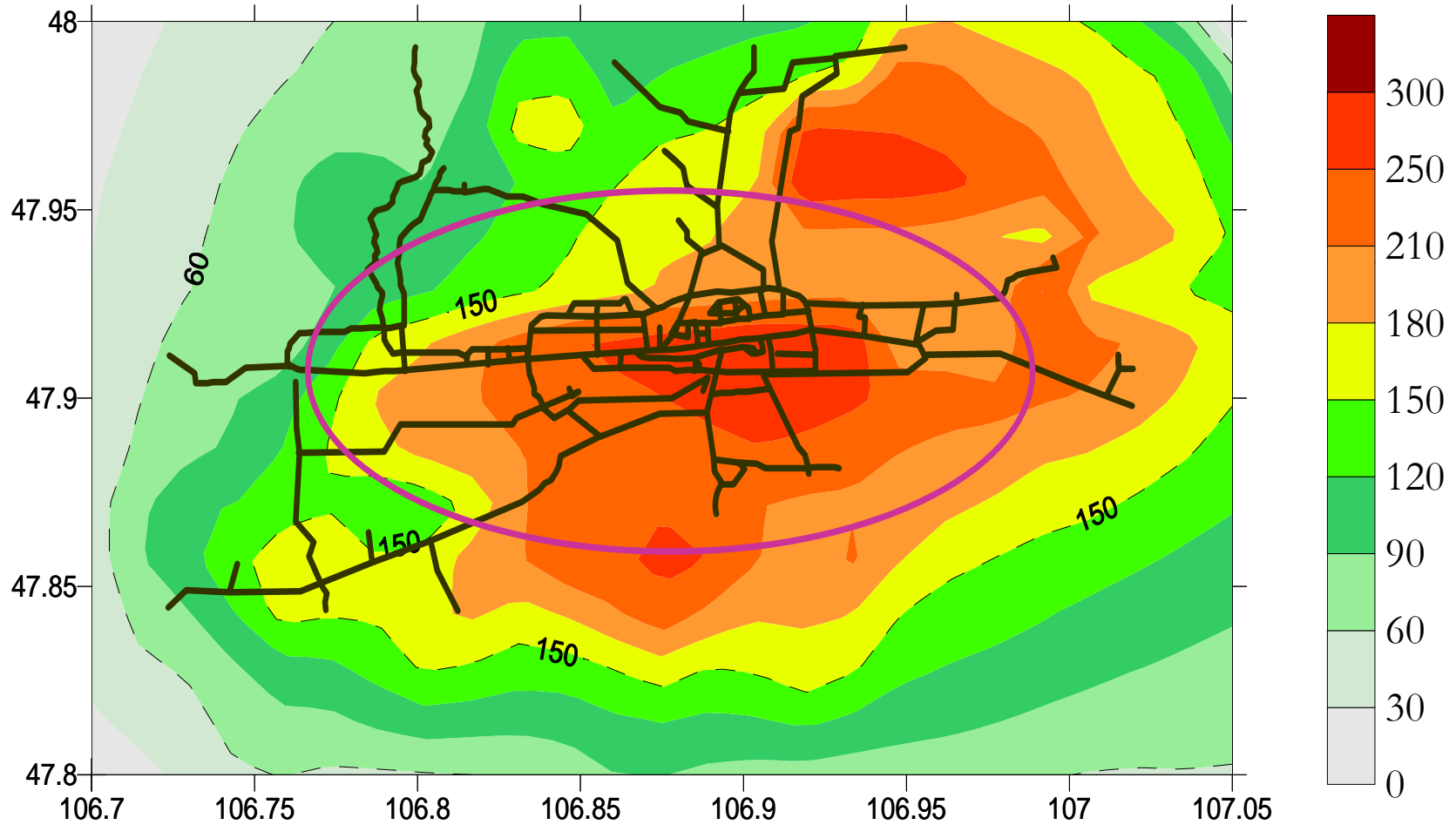
# PM<sub>10</sub> Emissions (2006)



Estimated @ 98.5 ktons (annual)

Detailed report @ [www.urbanemissions.info](http://www.urbanemissions.info)

# Modeled PM<sub>10</sub> Concentrations





# Plan of Action 2008-20

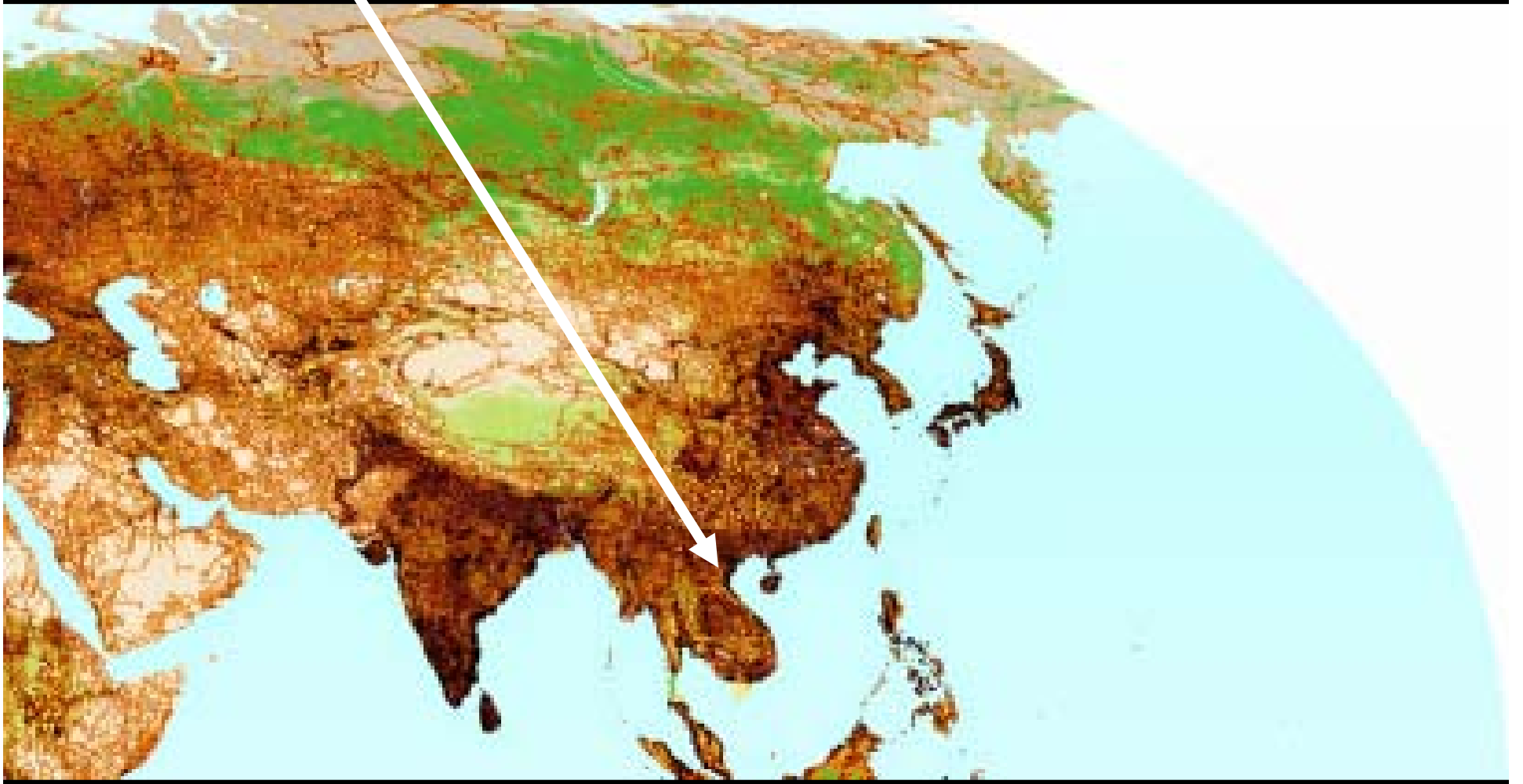
- Monitoring
- Clean coal for domestic sector \*\*\*\*
- Heating only boilers to central heating
- New combustion technologies for PP's
- ESP's for PP's & larger industries
- Fly ash control to brick making
- Energy efficiency at brick & cement

# Briquette Technology



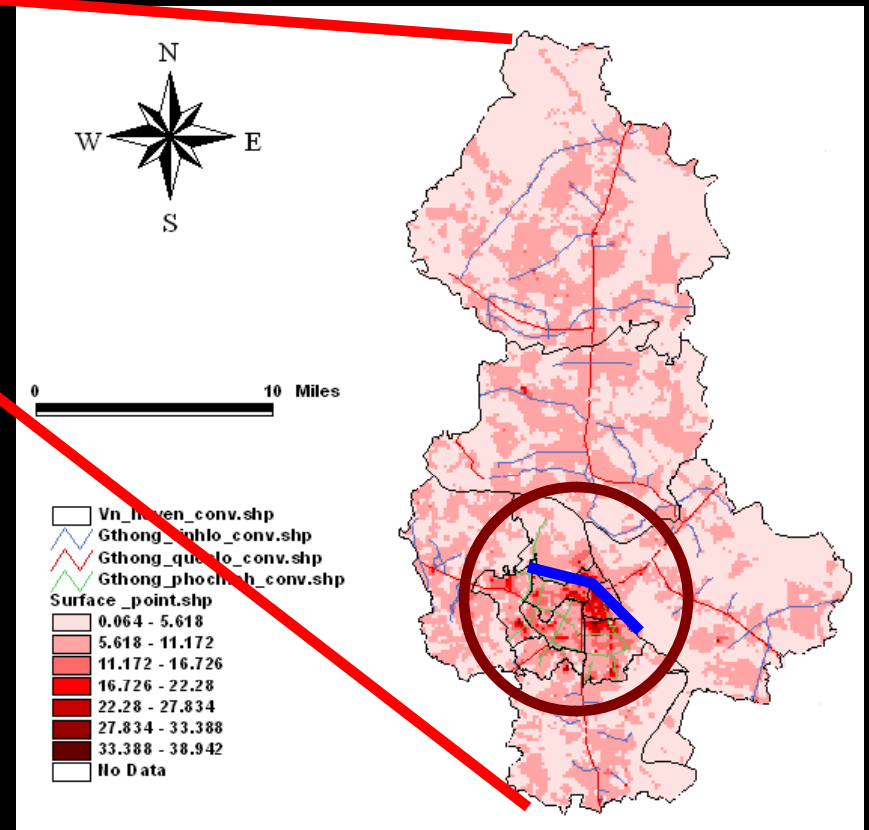
# Hanoi, Vietnam

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2008

# Hanoi, Vietnam



# In City Pollution Sources



## Non-Transport

- ~ a large industry
- ~ domestic
- ~ coal mining
- ~ & related transport
- ~ power plant

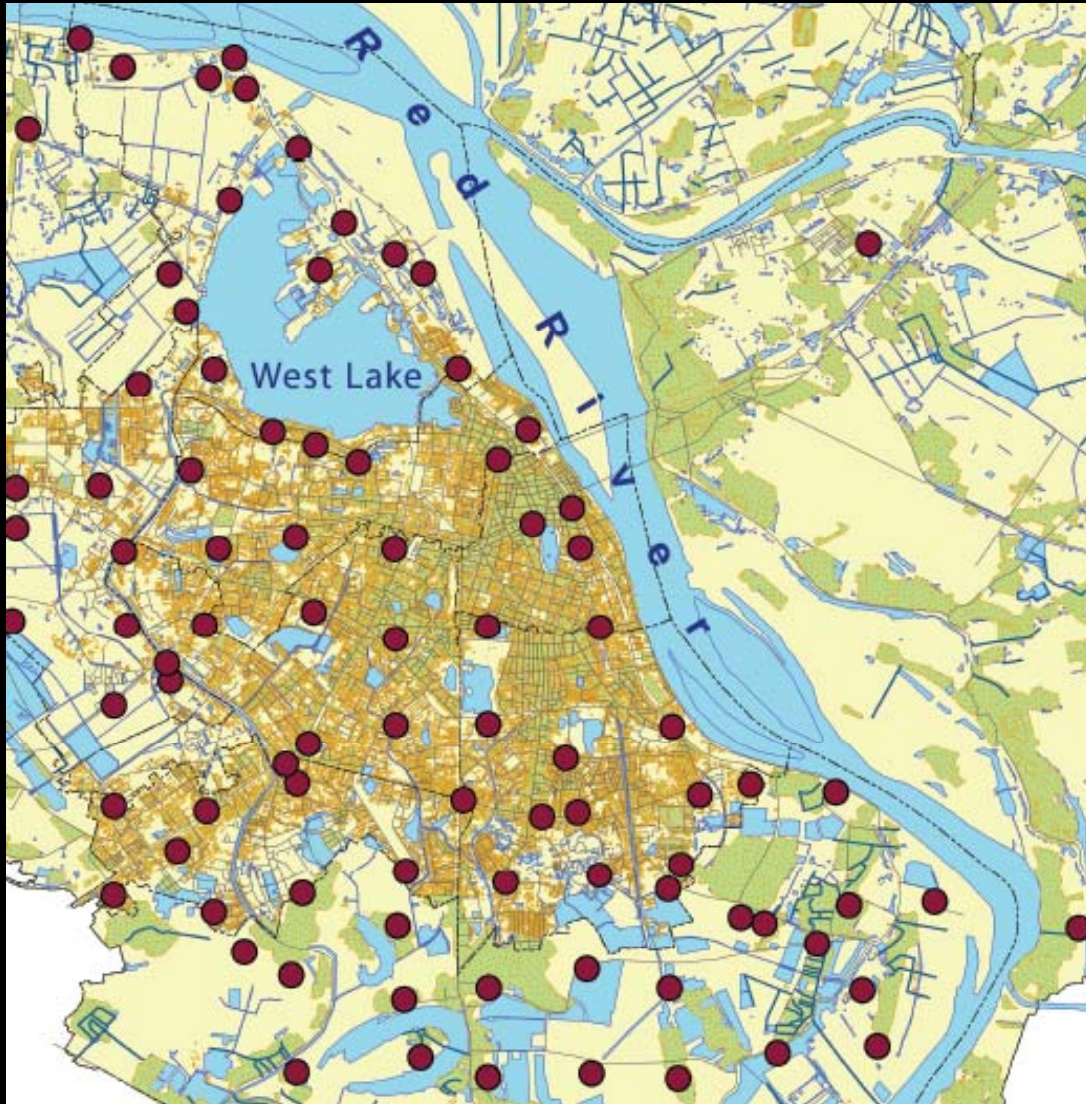
# In City Pollution Sources

## Transport

- ~1.6 million in 2006
- ~ 90% are motorcycles
- ~ Dust levels are high
- ~ Cars are increasing
- ~ low public transport



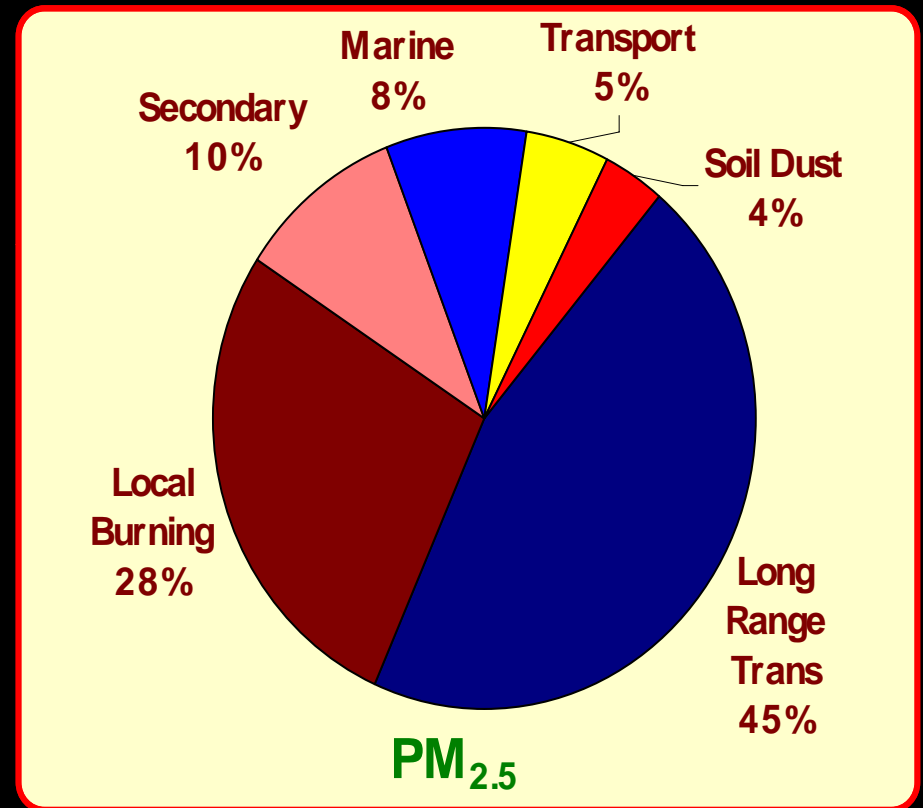
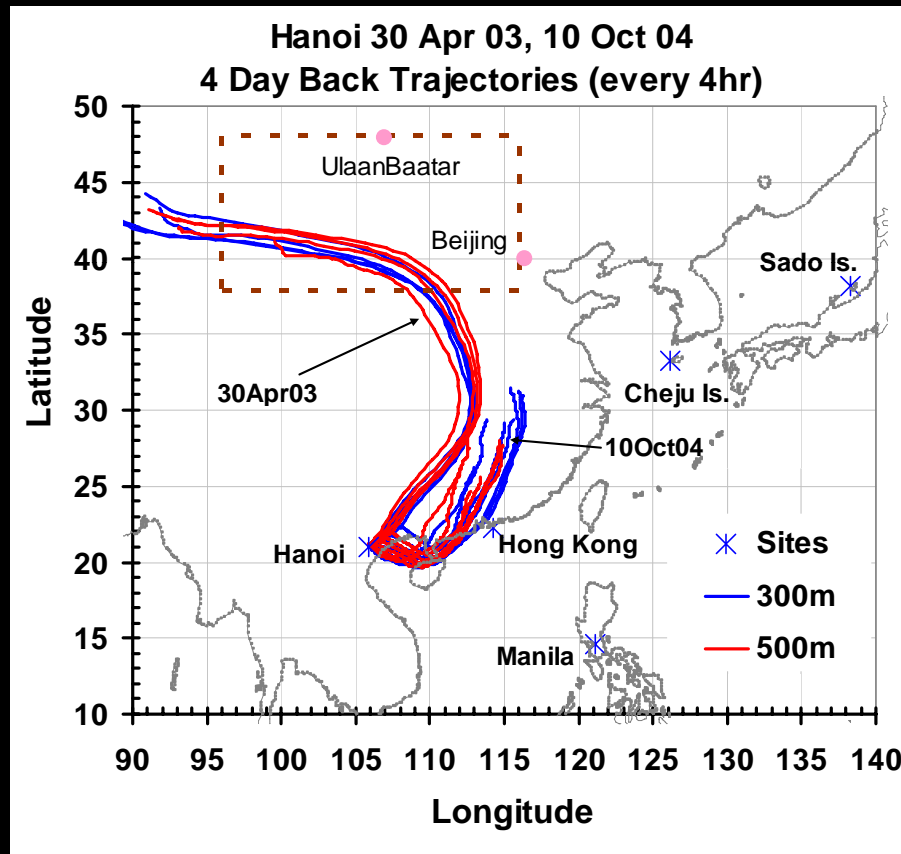
# Passive Samplers – 2006-07



$\text{NO}_x$  &  $\text{SO}_2$

Averages are  
~2 times the  
standards

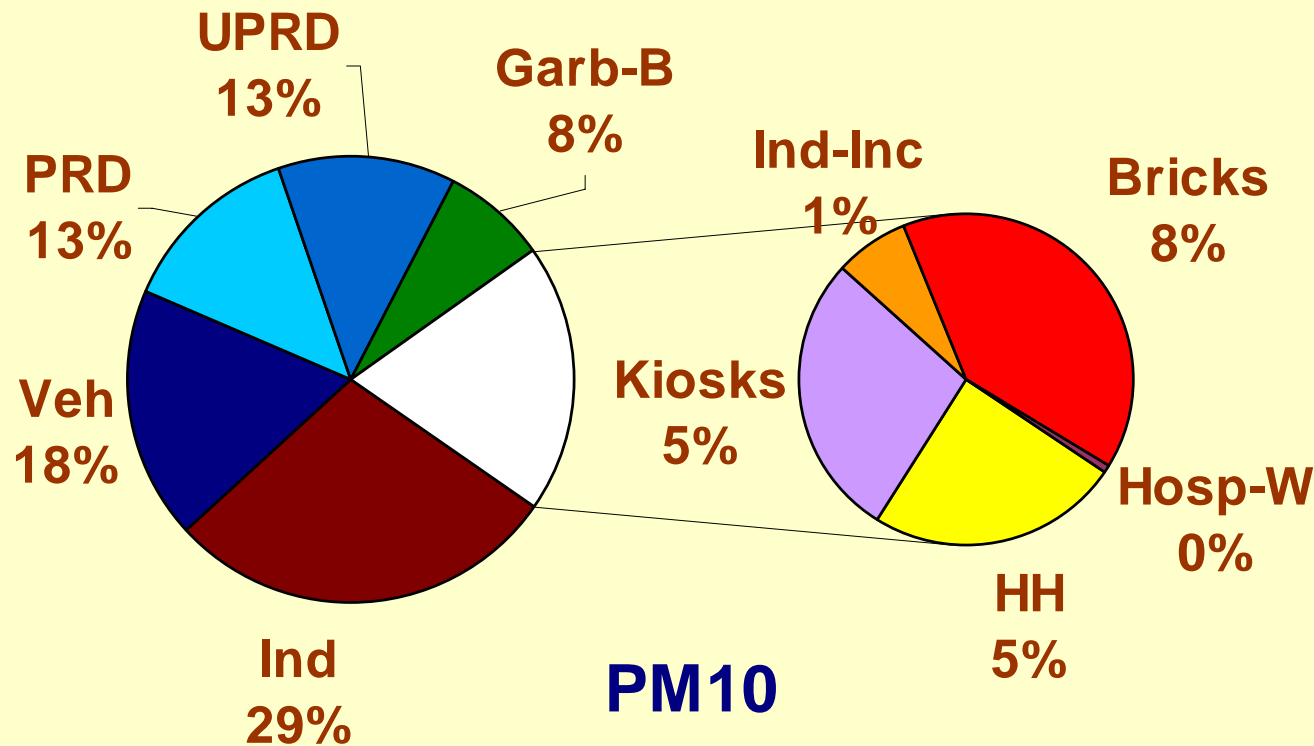
# Source Apportionment for PM



Cohen et al., 2006 using back trajectories; Hien et al., 2004 using receptor modeling



# PM<sub>10</sub> Emissions (2005)

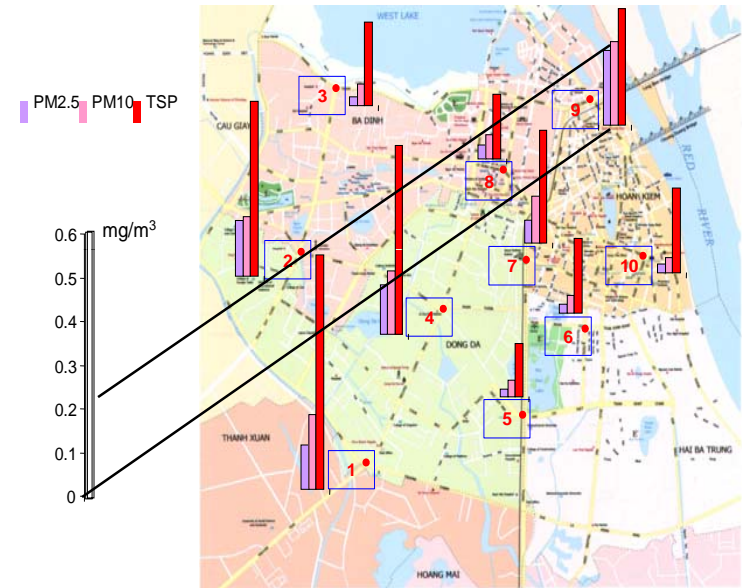
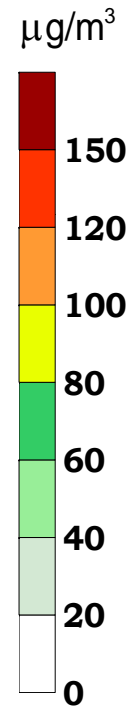
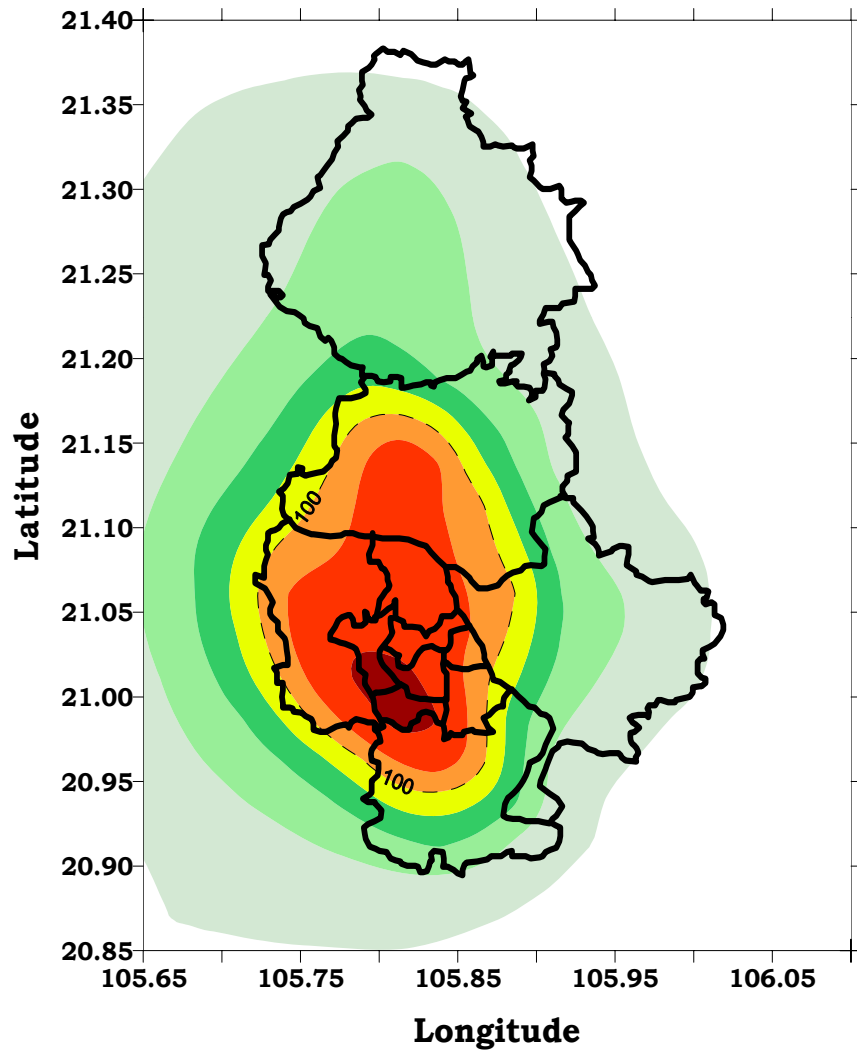


other  
pollutants

NO<sub>x</sub>,  
SO<sub>2</sub>, &  
CO<sub>2</sub>

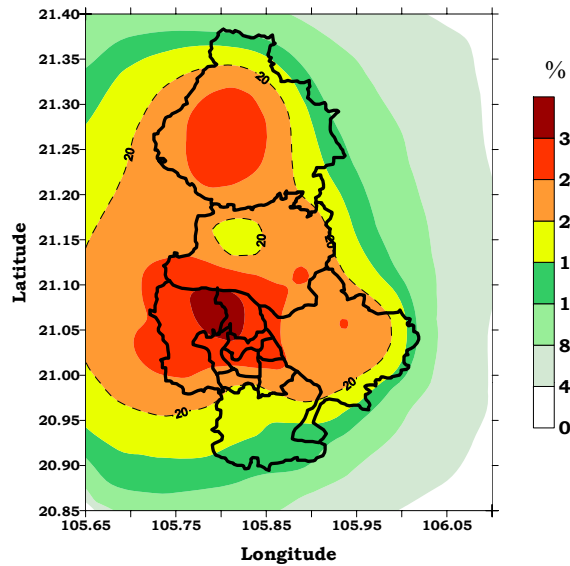
Estimated @ 23.5 ktons (annual)

# Modeled PM<sub>10</sub> Concentrations

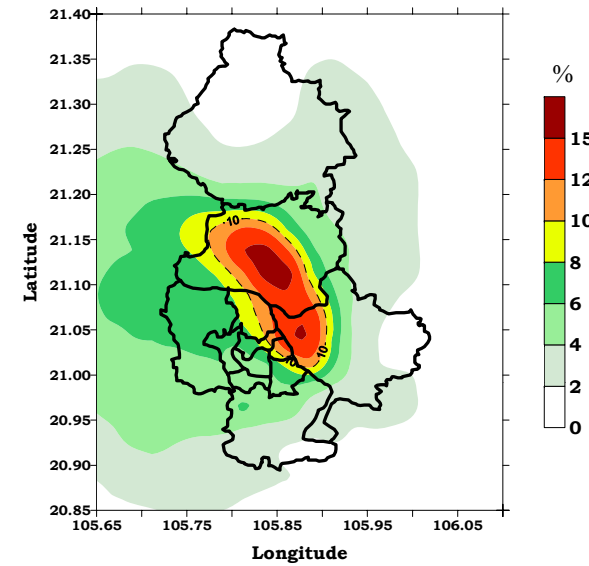


# % Estimated Contribution of Sectors

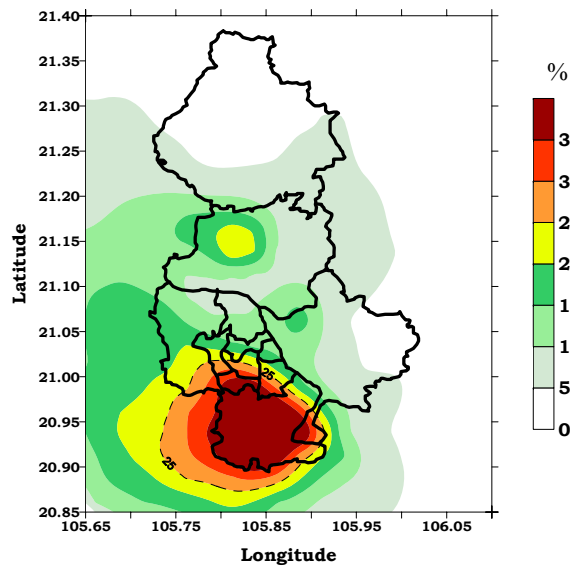
## Vehicles



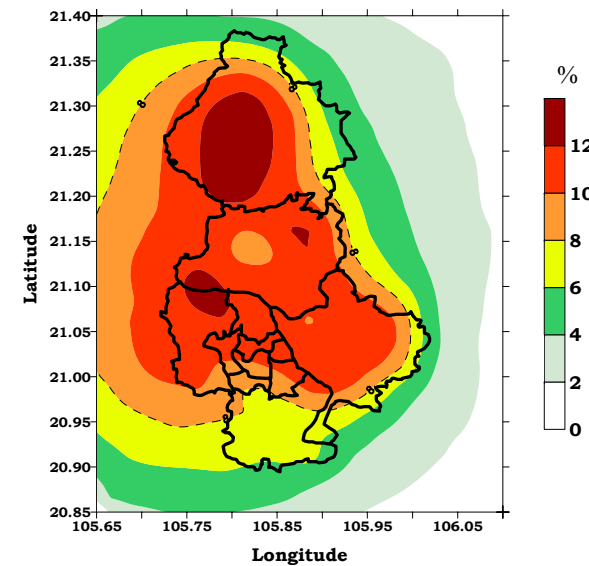
## Road Dust



## Ind - Bricks



## BB & Domestic



# Hanoi: AQM Plan 2020

- Road maintenance
- Mass transport – road & rail
- New emissions standards for 2W's & cars
- Industrial zoning & energy efficiency
- ESP's for larger industries
- Alternative fuels for domestic
- Landfill management

# Challenges ahead..

What goes in.. Comes out

Tools are plenty

Need more collaborative action

Informed decision making is key

To join SIM-air mailing list, send email to  
[simair@urbanemissions.info](mailto:simair@urbanemissions.info)

# Thank you

Dr. Sarath Guttikunda  
@ [www.urbanemissions.info](http://www.urbanemissions.info)

December 2008