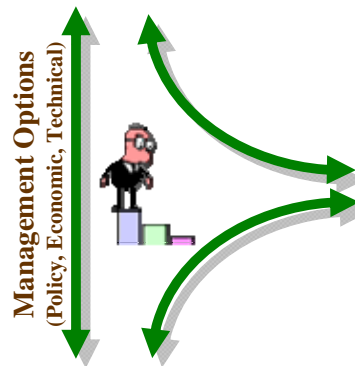
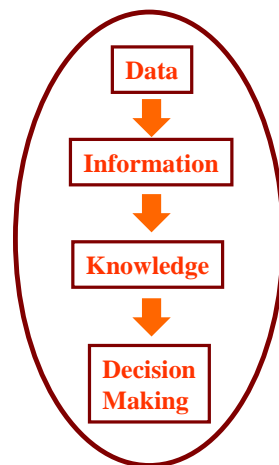


Simple & Interactive Tools for Air Pollution Analysis

Dr. Sarath Guttikunda

Dr. Harshadeep Nagaraja Rao

September, 2008



Awareness, Problem
Identification, Analysis of
Alternatives, Decision
support, and Collaboration

Analysis & errors are sole responsibility of the author(s).

© www.urbanemissions.info

Simple & Interactive Tools for Air Pollution Analysis

Why Simple & Interactive

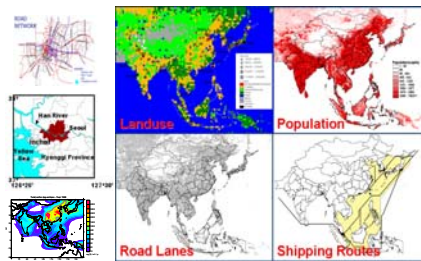
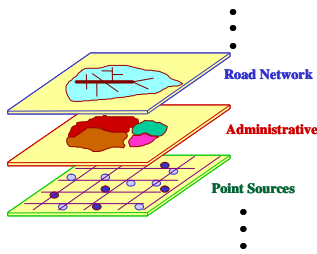
Air quality is deteriorating in many cities in the developing world. Addressing these problems requires access to and analysis of basic information on the sources of air pollution, their impacts, and management options. However, in most cities in the developing world, there are significant problems of institutional capacity to collect and analyze such information.



Monitoring



Reports



Geographical Information Systems (GIS)



Archives



Models are Plenty



Collation, Model Use, & Analysis

It is a sobering fact that in many cities, there is little in the way of an organized and accessible basic knowledge base or air quality model to analyze management options. However, this is just the tip of the proverbial iceberg, as there exist thousands of secondary cities (see SIM-2008-003) with even less information or modeling where it is as (if not arguably more) important to have basic air quality concerns be mainstreamed into their rapid development. Else, they will be condemned to face the same growth-pollution trajectory as their megacity counterparts. Decisions on land use planning,

zoning, transportation systems, industrialization paradigms, etc. are best made as early as possible in the planning process and can help not only air quality but overall quality of life improve in such cities.

But **what *can* city managers do** on air quality even if they were convinced of the importance of the issue and the need to do something about it?

Most cities lack long-term monitoring records and the records that exist are primarily used for awareness raising (e.g. billboards, media reports) and not effectively for planning to address the air quality problems. Most cities do not have air quality emission, dispersion, or impact models (or detailed source apportionment studies) that can guide the identification and selection of management options – and where they do exist, they tend to be in the realm of academia or one-off consultancy studies. Hence, awareness programs on air quality tend to be generic and unfocussed without supporting data or analysis.

Many enterprising technical specialists may turn to public domain models that are downloadable on the internet – but these (e.g. EPA models) tend to be quite data-hungry and tailored for regulations in other countries. Some go directly to the solutions used in cities with a good reputation for AQM globally – e.g. options such as low-sulphur diesel, CNG buses, Bus Rapid Transit, relocating industries, etc. – without an analysis of the problem. This paralysis of lack of analysis is usually broken in some cities either by judicial activism or enterprising city managers that latch on to one or two of these solutions. However, solutions resulting from these activities, although often laudable, are not necessary even in the realm of cost-effective solutions that even back-of-the-envelope calculations may suggest.

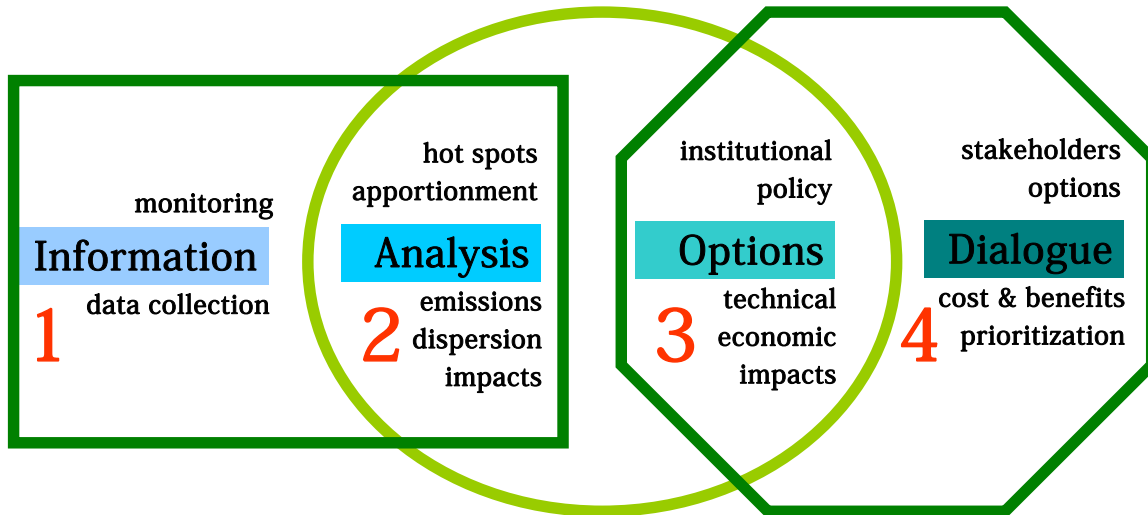
- Data required is scattered, but not non-existent
- Models are many, but need customization for individual cities, based on local needs
- Parameters for modeling are many, but need to identify the critical ones
- Any analysis of AQM components takes time, but simplified frameworks can help
- Resources are limited (institutional & financial), but analysis is possible with minimum
- Perfection is not the goal, but a better understanding on sources and their implications
- Averages are GOOD

Every city has unique air quality challenges that require customized approaches depending on its setting (e.g. critical pollutants, sources, meteorology, population distribution, history, institutions, information base, etc.) and a *one-size-fits-all strategy is undesirable and potentially counter-productive*.

The cost of making good air quality models based on international high-quality consultancies is prohibitive when considered for all the megacities and rapidly evolving secondary cities (many megacities of tomorrow) in the developing world. So what can be done? A potential solution is to develop a new generation of air quality management tools that are *simple, interactive, and customizable* to the needs of each city

and that can help provide “zero-order” insights into the key issues and options to improve air quality management. These need to be supplemented by both technical innovations (e.g. use of remote sensing datasets) and institutional innovations (e.g. structured stakeholder participation, capacity-building through learning-by-doing) working together to support some air quality management framework (e.g. developing and implementing air quality management plans for the city on a continuous basis forever). At a basic level, these tools would need to provide a *simple framework* to organize and update *critical data* on air quality customized for the needs and data availability in each city. As awareness grows, and senior policy makers and city managers are convinced of the need for well-argued robust options even in an environment of poor information, better tools can slowly get introduced as institutional capacity is built. This will avoid the “gold-plated” solutions that are litter shelves and lonely computers in pollution control offices that only one or two people know about and almost never get used for decision making.

Informed Decision Making for Air Quality Management



What is the alternative? Cities will continue to grow in a haphazard manner with little regard to air quality. Timely actions will not be taken and public health will continue to worsen. It is a price that should not be paid in the quest for the “*best*” analytical approach when more systematic back-of-the-envelope calculations aided by the power of the PC and internet today can be harnessed to help enthusiastic pollution crusaders in cities of the developing world.

What is proposed?

1. Data
 - a. Organize existing data (pollutants, sources, levels, impacts, options)
 - b. New data sources (e.g. remote sensing)
 - c. Collect new data (e.g. new monitoring)
2. Analysis
 - a. Stocktaking of past and on-going efforts
 - b. SIM-air type approach where useful
 - c. Air quality Status and Trends report
 - d. Air Quality Management Plan (including analysis of options) – updated on a rolling basis
3. Institutional
 - a. Identify air quality stakeholders
 - b. Structured Stakeholder Consultations
 - c. City Air Quality Teams (e.g. analytical and advisory group(s))

Key is to establish a baseline with available data instead of waiting for data availability

A model is not a crystal ball which can forecast the future, although unfortunately many people think that this is what their purpose is. Ideally a model should be sensitive to the policy questions which one is trying to evaluate. The model does not shed light on what policies/options should be evaluated! But the potential benefits of implementing one.

Applications of SIM-air (so far..) Details @ www.sim-air.org



On the Ground: Data Collation

The first step to better informed AQM planning is to collate the existing knowledge base. This includes information about stakeholders, especially ones that could provide rich sources of information such as environmental agencies; NGOs; universities; research institutes; traffic-, energy-, and industry-related departments; and international agencies.

A minimum knowledge base would focus on - Primary & Secondary Data

- Geography of the city
 - A map showing corners with latitude and longitude or at least two points on the map
 - Location of major residential and industrial areas
 - GIS maps (digital)
- City characteristics
 - Major sources of air pollution
 - Dominant source of pollution
 - Monitoring status
 - General idea of the topography of the city
- Transport Sector
 - Base year
 - Number of vehicles by major categories
 - Splits in the vehicular categories by fuel (Diesel, Gasoline, LPG, CNG)
 - Expected growth rates among the categories for the next ten years
 - (An estimate of) average vehicular kilometers traveled per day
- Domestic Sector
 - Base year
 - Number of households in the city
 - Type of fuels used
 - Average fuel use per day
- Waste / Garbage
 - Average waste generated per household
 - Waste collection in the city (tons per day), if any
 - (An estimate of) average waste burnt in the residential areas
- Industries
 - Types of fuels used (and fuel characteristics – ash and sulfur content)
 - Types of dominant industries
 - Average fuel consumption per year (by industrial type)
- Power plants (if any)
 - Types of fuels used (and fuel characteristics – ash and sulfur content)
 - Types of dominant industries
 - Average fuel consumption per year (by power plant)
- Monitoring
 - Types of pollutants monitored, number of monitors and monitoring data, preferably for PM10 and PM2.5, multiple years
 - Meteorological data (wind speeds, wind directions, and mixing heights)
- General information past studies – emission inventories, dispersion modeling, and impact assessment

SIM-air Components

The following sections demonstrate the various sections of the SIM-air and the outputs.

Components:

- Emission calculators
- Projection estimates
- Emission source contributions
- Emission distribution schemes
- Dispersion modeling & contributions
- Health impact analysis
- Options analysis
- Optimization of options
- Summary Sheets

In Conclusion

The objective of the **SIM-air tool** is not to provide a final answer to the AQM, but to provide beginning of collation of data, better understanding on the local pollution sources, information needs and availability, and help the analysis with relative ease. Readers can access toolkits to play and examples @ www.sim-air.org

Available tools:

1. SIM-air PLUS - Analyze and project air pollution data over 3 time periods
2. SIM-air Lite - Generate a 1-year snapshot of air pollution estimates
3. VAPIS 1.01 – Vehicular Air Pollution Information System
4. *v*-dust 1.01 – Vehicular fugitive dust analyzer
5. *smart*-CART – Smart Carbon Analysis for Road Transport

Emission Calculators

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

Summary Sheet

CBL = Current Baseline; TBL = Target Year Baseline; TC = Target Year Controlled

	2005	2015	2015	Change
Total Emissions (tons/year)	CBL	TBL	TC	Change
PM10	106,841	145,093	130,583	-11%
SO2	136,242	169,019	161,352	-4%
NOx	111,327	159,757	148,219	-8%
CO2	22,970,364	26,216,884	20,808,765	-26%

	CBL	TBL	TC
PM10 Ems	1869	11938	3227
	10533	9047	13682
	3712	13682	15037
	4763	2489	3000
			2273

	CBL	TBL	TC
PM10 Conc	84	110	126
	117	131	134
	110	129	142
	105	121	89
			87

	CBL	TBL	TC
PM10	2605	14808	4481
	13186	13156	19110
	5146	19110	21014
	6137	3530.8	4218
			3029

	CBL	TBL	TC
PM10	103	135	155
	144	161	164
	135	158	174
	128	149	109
			106

	2005	2015	2015	Change
% Contribution (PM10 Emissions)				
Domestic	8%	8%	5%	3%
Open Burning	13%	13%	14%	-1%
Industries	15%	14%	14%	-1%
Brick Kilns	1%	1%	1%	0%
PRD	26%	29%	28%	0%
Power Plants	15%	14%	15%	-2%
Transport	21%	22%	22%	0%

	CBL	TBL	TC
Average PM10 Concentration	112	153	137
% Change from CBL		37%	23%

	2005	2015	2015	Change
Mortality Effects Reduced			1,352	Persons
Resp. Symptoms days Reduced			29,146	thousand days
Health Costs Avoided			1,533	mil US\$

	PM10	SO2	NOx	CO2
For Target Controlled - Tons/yr				
Domestic	6,544	4,563	3,142	5,694,559
Open Burning	18,027	18,027	18,027	18,027
Industries	18,868	37,735	3,445	-
Brick Kilns	1,732	2,647	873	1,447,303
PRD	36,893	-	-	-
Power Plants	19,677	83,626	4,526	590,304
Transport	28,843	15,353	118,207	13,058,572
Total	130,583	161,952	148,219	20,808,765

	Options	Cost (M \$)	Min	Max
Conversion of Diesel to CNG Buses	12%	158	0	100
Low Sulfur Diesel (ppm S)	2000	0	15	2000
Scrappage 2st to 4 st for 2-Wh	1%	1	0	100
Scrappage 2st to 4 st for 3-Wh	0%	0	0	100
Removal of 3-Wheelers	2%	6	0	100
Trucks Using Bypass	0%	-	0	100
Coal to LPG for Domestic	25%	13	0	100
Kerosene to LPG for Domestic	1%	1	0	100
Wood to LPG for Domestic	10%	7	0	100
Improving Eff in Brick Kilns	3%	19	0	30
Improving Eff in Industries	9%	277	0	30
Promoting Public Transport	18%	264	0	20
Introduction of BRT	0%	-	0	100
Shift of Brick Kilns	0%	-	0	100
I & M program for Cars	9%	2	0	100
Paved Road/Wet Cleaning	6%	1	0	100
Improving Cookstove Eff	47%	44	0	100
Conversion of Gas Taxis to LPG	0%	0	0	100
Controlling Open Burning	9%	32	0	100
Total		827		

Budget \$500 million

Reduction 10% 3% 3% 3%

Schematics Scen_Comps Summary Help Health_Impacts Emiss_Distribution Domestic Vehicles Br

Projection Estimates

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

80%

Arial 10

D50

Vehicle Characteristics - Target Year = 2015			Emission Factors (gm/km)				Total Emissions (tons/yr)				% Annual Growth Rates	
Vehicle Type	# Vehicles	VKT (km/day)	PM10	SOx	NOx	CO2	PM10	SOx	NOx	CO2		
2 Wheeler - 2st	740,122	20	0.10	0.08	0.30	70.0	540	432	1,621	378,202	4.0%	< >
2 Wheeler - 4st	977,337	20	0.02	0.02	0.10	50.0	143	143	713	356,727	5.0%	< >
3-Wheeler - 2st	179,085	40	0.10	0.08	0.30	70.0	261	209	784	183,075	6.0%	< >
3-Wheeler - 4st	35,817	40	0.02	0.02	0.10	50.0	10	10	52	26,146	6.0%	< >
Car/Jeep/Van-Gasoline	1,343,916	30	0.40	0.08	1.00	150.0	5,886	1,177	14,716	2,207,783	3.0%	< >
Car/Jeep/Van-Diesel	814,447	30	0.95	0.30	1.50	250.0	8,472	2,675	13,377	2,229,650	5.0%	< >
Car/Jeep/Van-CNG	35,265	30	0.20	0.08	0.80	100.0	77	31	309	38,615	3.5%	< >
Car/Jeep/Van-LPG	35,265	30	0.20	0.08	0.80	100.0	77	31	309	38,615	3.5%	< >
Taxi-Gasoline	10,305	100	0.35	0.12	1.00	200.0	132	45	376	75,228	7.5%	< >
Taxi-Diesel	1,708	100	0.90	0.50	1.50	300.0	56	31	94	18,704	5.5%	< >
Taxi-CNG	640	100	0.10	0.10	0.80	100.0	2	2	19	2,336	2.5%	< >
Taxi-LPG	1,031	100	0.10	0.10	0.80	100.0	4	4	30	3,161	7.5%	< >
Medium Bus - Diesel	67,041	100	1.60	0.80	17.00	1,000.0	3,915	1,958	41,599	2,447,015	5.3%	< >
Medium Bus - CNG	5,187	100	0.70	0.40	12.00	500.0	133	76	2,272	94,672	10.0%	< >
Large Bus - Diesel	51,203	130	1.60	0.80	17.00	1,000.0	3,887	1,944	41,303	2,429,600	2.5%	< >
Large Bus - CNG	3,258	130	0.70	0.40	12.00	500.0	108	62	1,855	77,291	5.0%	< >
LD Truck - Diesel	107,513	50	2.50	2.20	2.20	1,000.0	4,905	4,317	4,317	1,962,118	3.0%	< >
HD Truck - Diesel	13,439	300	2.50	2.20	2.20	1,200.0	3,679	3,237	3,237	1,765,906	3.0%	< >
Total							32,289	16,384	126,984	14,334,895		
% Chang							-45.0%	-42.7%	-46.7%	-44.4%		

Vehicle Characteristics - Target Year = Controlled			Emission Factors (gm/km)				Total Emissions (tons/yr)			
Vehicle Type	# Vehicles	VKT (km/day)	PM10	SOx	NOx	CO2	PM10	SOx	NOx	CO2
2 Wheeler - 2st	735,980	20	0.10	0.08	0.30	70.0	537	430	1,612	376,086
2 Wheeler - 4st	981,479	20	0.02	0.02	0.10	50.0	143	143	716	358,240

Domestic Vehicles Brickkilns OpenBurn PRD Industries Powerplants Options Emissions-CBL Emis

Ready

Source Contributions to Emissions

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10 B I U

J27

Summary Sheet

CBL = Current Baseline; TBL = Target Year Baseline; TC = Target Year Controlled

	2005		2015	
	CBL	TBL	TC	Change
Total Emissions (tons/year)				
PM10	135,841	145,093	130,783	-11%
SO2	36,242	169,019	161,932	-4%
NOx	111,327	159,757	148,210	-8%
CO2	22,970,364	26,216,884	20,808,765	-26%

	2005		2015	
	CBL	TBL	TC	Change
% Contribution (PM10 Emissions)				
Domestic	8%	8%	5%	3%
Open Burning	13%	13%	14%	-1%
Industries	15%	14%	14%	-1%
Brick Kilns	1%	1%	1%	0%
PRD	26%	29%	28%	0%
Power Plants	15%	14%	15%	-2%
Transport	21%	22%	22%	0%

	2005	2015	Change
Average PM10 Concentration	112	153	-11%
% Change from CBL		37%	23%

	2005	2015	Change
Mortality Effects Reduced		1,352	Persons
Resp. Symptoms days Reduced		29,146	thousand days
Health Costs Avoided		1,533	mil US\$

	PM10		SO2		NOx		CO2	
	2005	2015	2005	2015	2005	2015	2005	2015
For Target Controlled - Tons/yr								
Domestic	6,544	4,563			3,142	5,694,559		
Open Burning	18,027	18,027			18,027	18,027		
Industries	18,868	37,735			3,445	-		
Brick Kilns	1,732	2,647			873	1,447,303		
PRD	36,893	-			-	-		
Power Plants	19,677	83,626			4,526	590,304		
Transport	28,843	15,353			118,207	13,058,572		
Total	130,583	161,952			148,219	20,808,765		

	CBL	TBL	TC
PM10 Ems	1869 11938 3227 2124	2605 14808 4481 2948	2339 14197 4010 2682
	10533 9047 13682 2604	13186 13156 19110 3686	12661 11385 16752 3226
	3712 13682 15037 6859	5146 19110 21014 8928	4644 16752 18427 8245
	4763 2489 3000 2273	6137 3530.8 4218 3029	5710 3063 3750 2741
PM10 Conc	84 110 126 95	115 148 173 129	103 135 155 116
	117 131 134 102	159 181 184 139	144 161 164 125
	110 129 142 110	151 176 196 149	135 158 174 134
	105 121 89 87	143 166 122 119	128 149 109 106

Options		Cost (M \$)	Min	Max
Conversion of Diesel to CNG Buses	12%	158	0	100
Low Sulfur Diesel (ppm S)	2000	0	15	2000
Scrappage 2st to 4 st for 2-Wh	1%	1	0	100
Scrappage 2st to 4 st for 3-Wh	0%	0	0	100
Removal of 3-Wheelers	2%	6	0	100
Trucks Using Bypass	0%	-	0	100
Coal to LPG for Domestic	25%	13	0	100
Kerosene to LPG for Domestic	1%	1	0	100
Wood to LPG for Domestic	10%	7	0	100
Improving Eff in Brick Kilns	3%	19	0	30
Improving Eff in Industries	9%	277	0	30
Promoting Public Transport	18%	264	0	20
Introduction of BRT	0%	-	0	100
Shift of Brick Kilns	0%	-	0	100
I & M program for Cars	9%	2	0	100
Paved Road/Wet Cleaning	6%	1	0	100
Improving Cookstove Eff	47%	44	0	100
Conversion of Gas Taxis to LPG	0%	0	0	100
Controlling Open Burning	9%	32	0	100
Total		827		

Budget \$500 million

Reduction 10% 3% 3% 3%

Schematics Scen_Comps Summary Help Health_Impacts Emiss_Distribution Domestic Vehicles Br

Distribution Schemes

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10

G4

Emission Distribution

Return to Main BACK to DATA INPUTS

Source Load Distribution Matrix

Source (Non Trans)	Select Scheme	C-1-1	C-1-2	C-1-3	C-1-4	C-2-1	C-2-2	C-2-3	C-2-4	C-3-1	C-3-2	C-3-3	C-3-4	C-4-1	C-4-2	C-4-3	C-4-4
Domestic	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
Open Burning	Households %	7%	6%	6%	7%	7%	4%	4%	5%	10%	4%	4%	10%	10%	6%	6%	4%
Industries	Industries %	0%	15%	0%	0%	5%	0%	20%	0%	0%	20%	0%	20%	15%	0%	0%	5%
Brick Kilns	Brickkilns %	0%	25%	15%	0%	15%	25%	0%	0%	10%	0%	10%	0%	0%	0%	0%	0%
PRD	Road Density %	1%	2%	2%	1%	2%	20%	20%	2%	2%	20%	20%	2%	1%	2%	2%	1%
Power Plants	Power Plants %	0%	40%	0%	0%	40%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	0%

Source (Trans)		C-1-1	C-1-2	C-1-3	C-1-4	C-2-1	C-2-2	C-2-3	C-2-4	C-3-1	C-3-2	C-3-3	C-3-4	C-4-1	C-4-2	C-4-3	C-4-4
2 Wheeler - 2st	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
2 Wheeler - 4st	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
3-Wheeler - 2st	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
3-Wheeler - 4st	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
Car/Jeep/Van-Gasoline	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
Car/Jeep/Van-Diesel	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
Car/Jeep/Van-CNG	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
Car/Jeep/Van-LPG	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%
Taxi-Gasoline	Population %	2%	4%	4%	2%	4%	10%	15%	4%	4%	15%	20%	4%	2%	4%	4%	2%

Ready

start

Sarath K. Guttikunda ... C:\Documents and Se... SIM-Side Event - Part... EN 2:13 PM Sunday 12/10/2006

Interactive Data Mod... Microsoft Excel - SIM-...

Concentrations and Contributions

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10 B I U

B53

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
31		Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
32		Transport	4	5	6	5	5	7	7	5	5	6	8	5	5	6	5	4		
33		Total	5	6	8	6	7	8	8	7	7	8	10	6	6	8	6	6		
34																				
35																				
36		PM10 Total	C11	C12	C13	C14	C21	C22	C23	C24	C31	C32	C33	C34	C41	C42	C43	C44	Avg	
37		Domestic	7	8	10	7	9	11	11	8	9	10	13	8	8	10	7	7	9	
38		Open Burning	12	13	17	13	15	16	14	15	17	14	17	17	18	18	12	12	15	
39		Industries	12	20	18	16	18	20	29	18	20	30	20	28	24	21	17	18	20	
40		Brick Kilns	1	3	3	2	3	3	2	2	2	1	2	1	1	2	1	1	2	
41		PRD	22	23	31	23	26	40	36	24	26	34	38	24	22	30	23	23	28	
42		Power Plants	9	19	14	10	19	9	9	9	9	6	14	6	6	7	6	3	10	
43		Transport	21	24	33	24	28	33	33	27	28	32	39	27	25	33	23	23	26	
44		Total	84	110	126	95	117	131	134	102	110	129	142	110	105	121	89	87	112	
45																				
46																				
47		Reference	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80		
48		Exceedances	4	30	46	15	37	51	54	22	30	49	62	30	25	41	9	7		
49																				

Transfer Matrix Concs-CBL Concs-TBL Concs-TC Menudata BRT Shift using VN EF Calcs

Ready

start

Sarath K. Guttikunda ... C:\Documents and Se... SIM-Side Event - Part... Interactive Data Mod... Microsoft Excel - SIM-... Source-Receptor Mod...

EN

2:55 PM Sunday 12/10/2006

Summary Sheets

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10 B I U

J27

Summary Sheet

CBL = Current Baseline; TBL = Target Year Baseline; TC = Target Year Controlled

	2005	2015	2015	
	CBL	TBL	TC	Change
Total Emissions (tons/year)				
PM10	106,841	145,093	130,583	-11%
SO2	136,242	169,019	161,952	-4%
NOx	111,327	159,757	148,219	-8%
CO2	22,970,364	26,216,884	20,808,765	-26%

	2005	2015	2015	
	CBL	TBL	TC	Change
% Contribution (PM10 Emissions)				
Domestic	8%	8%	5%	3%
Open Burning	13%	13%	14%	-1%
Industries	15%	14%	14%	-1%
Brick Kilns	1%	1%	1%	0%
PRD	26%	29%	28%	0%
Power Plants	15%	14%	15%	-2%
Transport	21%	22%	22%	0%

	2005	2015	2015	
	CBL	TBL	TC	Change
Average PM10 Concentration	112	153	137	-11%
% Change from CBL		37%	23%	

	2005	2015	2015	
	CBL	TBL	TC	Change
Mortality Effects Reduced			1,352	Persons
Resp. Symptoms days Reduced			29,146	thousand days
Health Costs Avoided			1,533	mil US\$

	PM10	SO2	NOx	CO2
For Target Controlled - Tons/yr				
Domestic	6,544	4,563	3,142	5,694,559
Open Burning	18,027	18,027	18,027	18,027
Industries	18,868	37,735	3,445	-
Brick Kilns	1,732	2,647	873	1,447,303
PRD	36,893	-	-	-
Power Plants	19,677	83,626	4,526	590,304
Transport	28,843	15,353	118,207	13,058,572
Total	130,583	161,952	148,219	20,808,765

	CBL	TBL	TC
PM10 Ems	1933 11938 3227 2124	2605 14808 4481 2948	2339 14197 4010 2682
	10533 9047 13682 2604	13186 13156 19110 3686	12661 11385 16752 3225
	3712 13682 15037 6859	5146 19110 21014 8928	4644 16752 18427 8245
	4763 2489 3000 2273	6137 3530.8 4218 3029	5710 3063 3750 2741
PM10 Conc	84 110 126 95	115 148 173 129	103 135 155 116
	117 131 134 102	159 181 184 139	144 161 164 125
	110 129 142 110	151 176 196 149	135 158 174 134
	105 121 89 87	143 166 122 119	128 149 105 106

Options	Cost (\$/yr)	Min	Max
Conversion of Diesel to CNG Buses	12%	0	100
Low Sulfur Diesel (ppm S)	2000	15	2000
Scrappage 2st to 4 st for 2-Wh	1%	0	100
Scrappage 2st to 4 st for 3-Wh	0%	0	100
Removal of 3-Wheelers	2%	0	100
Trucks Using Bypass	0%	0	100
Coal to LPG for Domestic	25%	0	100
Kerosene to LPG for Domestic	1%	0	100
Wood to LPG for Domestic	10%	0	100
Improving Eff in Brick Kilns	3%	0	30
Improving Eff in Industries	9%	0	30
Promoting Public Transport	18%	0	20
Introduction of BRT	0%	0	100
Shift of Brick Kilns	0%	0	100
I & M program for Cars	9%	0	100
Paved Road/Wet Cleaning	6%	0	100
Improving Cookstove Eff	47%	0	100
Conversion of Gas Taxis to LPG	0%	0	100
Controlling Open Burning	9%	0	100
Total	827		

Budget \$500 million

Reduction 10% 3% 3% 3%

Schematics Scen_Comps Summary Help Health_Impacts Emiss_Distribution Domestic Vehicles Br

Health Impacts

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

70%

Arial 10

E38

Health Impacts

Health Effect	Effect/Capita/ $\mu\text{g}/\text{m}^3$	DALY/10,000 cases	WTP-Monetary Value per case (2004 US \$)	Effect	Effect/capita			
					100,000	100,000	100,000	100,000
Premature Mortality	0.000014	100,000	166,667	1,352	0.00	0.00	0.00	0.00
Adult Chronic Bronchitis	0.00004026	12,037	33,333	3,889	0.00	0.00	0.00	0.00
Respiratory Hospital Admission	0.0000057	264	833	551	0.00	0.00	0.00	0.00
Cardiac Hospital Admission	0.000005	20,000	50,000	483	0.00	0.00	0.00	0.00
Emergency Room Visit	0.00024	3	21	23,184	0.00	0.00	0.00	0.00
Child Acute Bronchitis	0.000544	12,037	16,667	52,551	0.01	0.01	0.01	0.01
Asthma Symptom Day	0.0029	4	13	280,143	0.03	0.04	0.05	0.04
Restricted Activity Day	0.03828	3	8	3,697,884	0.46	0.52	0.67	0.49
Acute Respiratory Symptom Day	0.30172	3	8	29,146,434	3.63	4.13	5.27	3.89

Health Effect	DALYs	WTP (1999_mil_US \$)	Effect	Total Effects			
				C-1-1	C-1-2	C-1-3	C-1-4
Premature Mortality	13,524	225.40	1352	17	19	24	18
Adult Chronic Bronchitis	4,681	129.64	3,889	48	55	70	52
Respiratory Hospital Admission	15	0.46	551	7	8	10	7
Cardiac Hospital Admission	966	24.15	483	6	7	9	6
Emergency Room Visit	7	0.48	23,184	289	329	419	309
Child Acute Bronchitis	63,256	875.85	52,551	655	745	950	702
Asthma Symptom Day	112	3.50	280,143	3,491	3,972	5,065	3,740
Restricted Activity Day	1,109	30.82	3,697,884	46,081	52,432	66,858	49,364
Acute Respiratory Symptom Day	8,744	242.89	29,146,434	363,205	413,263	526,973	389,082

Return to Main

C11 C12 C13
C21 C22 C23
C31 C32 C33

Health Impacts Emiss Distribution Domestic Vehicles Brickkilns OpenBurn PRD Industries Power

Options Analysis

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

Arial 10 B I U

J27

Summary Sheet

CBL = Current Baseline; TBL = Target Year Baseline; TC = Target Year Controlled

	2005	2015	2015	
	CBL	TBL	TC	Change
Total Emissions (tons/year)				
PM10	106,841	145,093	130,583	-11%
SO2	136,242	169,019	161,952	-4%
NOx	111,327	159,757	148,219	-8%
CO2	22,970,364	26,216,884	20,808,765	-26%

	2005	2015	2015	
	CBL	TBL	TC	Change
% Contribution (PM10 Emissions)				
Domestic	8%	8%	5%	3%
Open Burning	13%	13%	14%	-1%
Industries	15%	14%	14%	-1%
Brick Kilns	1%	1%	1%	0%
PRD	26%	29%	28%	0%
Power Plants	15%	14%	15%	-2%
Transport	21%	22%	22%	0%

	2005	2015	2015	
	CBL	TBL	TC	Change
Average PM10 Concentration	112	153	137	-11%
% Change from CBL		37%	23%	

	2005	2015	2015	
	CBL	TBL	TC	Change
Mortality Effects Reduced			1,352	Persons
Resp. Symptoms days Reduced			29,146	thousand days
Health Costs Avoided			1,533	mil US\$

	PM10	SO2	NOx	CO2
For Target Controlled - Tons/yr				
Domestic	6,544	4,563	3,142	5,694,559
Open Burning	18,027	18,027	18,027	18,027
Industries	18,868	37,735	3,445	-
Brick Kilns	1,732	2,647	873	1,447,303
PRD	36,893	-	-	-
Power Plants	19,677	83,626	4,526	590,304
Transport	28,843	15,353	118,207	13,058,572
Total	130,583	161,952	148,219	20,808,765

	CBL	TBL	TC
PM10 Ems	1869 11938 3227 2124	2605 14808 4481 2948	2339 14197 4010 2682
	10533 9047 13682 2604	13186 13156 19110 3686	12661 11385 16752 3226
	3712 13682 15037 6859	5146 19110 21014 8928	4644 16752 18427 8245
	4763 2489 3000 2273	6137 3530.8 4218 3029	5710 3063 3750 2741

	CBL	TBL	TC
PM10 Conc	84 110 126 95	115 148 173 129	103 135 155 116
	117 131 134 102	159 181 184 139	144 161 164 125
	110 129 142 110	151 176 196 149	135 158 174 134
	105 121 89 87	143 166 182 119	128 149 109 106

Options		Cost (M \$)	Min	Max
Conversion of Diesel to CNG Buses	12%	158	0	100
Low Sulfur Diesel (ppm S)	2000	0	15	2000
Scrapage 2st to 4 st for 2-Wh	1%	1	0	100
Scrapage 2st to 4 st for 3-Wh	0%	0	0	100
Removal of 3-Wheelers	2%	6	0	100
Trucks Using Bypass	0%	-	0	100
Coal to LPG for Domestic	25%	13	0	100
Kerosene to LPG for Domestic	1%	1	0	100
Wood to LPG for Domestic	10%	7	0	100
Improving Eff in Brick Kilns	3%	19	0	30
Improving Eff in Industries	9%	277	0	30
Promoting Public Transport	18%	264	0	20
Introduction of BRT	0%	-	0	100
Shift of Brick Kilns	0%	-	0	100
I & M program for Cars	9%	2	0	100
Paved Road/Wet Cleaning	6%	1	0	100
Improving Cookstove Eff	47%	44	0	100
Conversion of Gas Taxis to LPG	0%	0	0	100
Controlling Open Burning	9%	32	0	100
Total		827		

Budget: \$500 million

Summary Sheet | Reduction 10% 3% 3% 3%

Schematics Scen_Comps Summary Help Health_Impacts Emiss_Distribution Domestic Vehicles Br

Optimization

Microsoft Excel - SIM-air-v2.0.xls

File Edit View Insert Format Tools Data Window Help

Type a question for help

80%

Arial 10

J27

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
11	Domestic		8%	8%		5%	3%		PM10	117	131	134	102		159	181	184	139		144	161	164	125	
12	Open Burning		13%	13%		14%	-1%		Conc	110	129	142	110		151	176	196	149		135	158	174	134	
13	Industries		15%	14%		14%	-1%			105	121	89	87		143	166	122	119		128	149	109	106	
14	Brick Kilns		1%	1%		1%	0%																	
15	PRD		26%	29%		28%	0%																	
16	Power Plants		15%	14%		15%	-2%																	
17	Transport		21%	22%		22%	0%																	
18																								
19																								
20	Average PM10 Concentration		112	153		137	-11%																	
21	% Change from CBL			37%		23%																		
22																								
23	Mortality Effects Reduced					1,352	Persons																	
24	Resp. Symptoms days Reduced					29,146	thousand days																	
25	Health Costs Avoided					1,533	mil US\$																	
26																								
27	For Target Controlled - Tons/yr		PM10	S02		H0x	CO2																	
28	Domestic		6,544	4,563		3,142	5,694,559																	
29	Open Burning		18,027	18,027		18,027	18,027																	
30	Industries		18,868	37,735		3,445	-																	
31	Brick Kilns		1,732	2,647		873	1,447,303																	
32	PRD		36,893	-		-	-																	
33	Power Plants		19,677	83,626		4,526	590,304																	
34	Transport		28,843	15,359		116,887	13,058,572																	
35	Total		130,583	161,952		148,219	20,808,765																	
36																								
37	Reduction		10%	3%		3%	3%																	
38	Desired (tons/year)		130,583	163,948		154,964	25,430,378																	
39																								
40																								
41	Target (tons/year)		130,583	163,948		154,964	25,430,378																	
42	Original (tons/year)		145,093	169,019		159,757	26,216,884																	
43	Actual Reductions		10%	4%		7%	21%																	
44																								
45																								
46																								

Options

	Cost (M \$)	Min	Max
Conversion of Diesel to CNG Buses	158	0	100
Low Sulfur Diesel (ppm S)	0	15	2000
Scrappage 2st to 4 st for 2-Wh	1	0	100
Scrappage 2st to 4 st for 3-Wh	0	0	100
Removal of 3-Wheelers	6	0	100
Trucks Using Bypass	-	0	100
Coal to LPG for Domestic	13	0	100
Kerosene to LPG for Domestic	1	0	100
Wood to LPG for Domestic	7	0	100
Improving Eff in Brick Kilns	19	0	30
Improving Eff in Industries	277	0	30
Promoting Public Transport	264	0	20
Introduction of BRT	-	0	100
Shift of Brick Kilns	-	0	100
I & M program for Cars	2	0	100
Paved Road Wet Cleaning	1	0	100
Improving Cookstove Eff	44	0	100
Conversion of Gas Taxis to LPG	0	0	100
Controlling Open Burning	32	0	100
Total	827		

Budget \$500 million

Optimization-Setup Solve

Copy to Scenario 1 Copy to Scenario 2 Copy to Scenario 3

Schematics Scen_Comps Summary Help Health_Impacts Emiss_Distribution Domestic Vehicles Br

Ready