Simple Interactive Models for Better Air Quality

www.sim-air.org

Simple & Interactive Tools for Air Pollution Analysis

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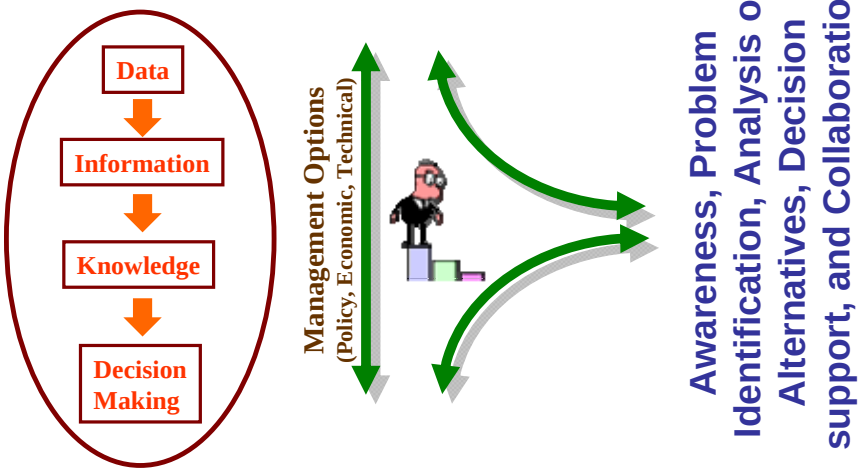

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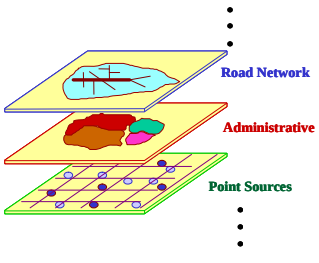
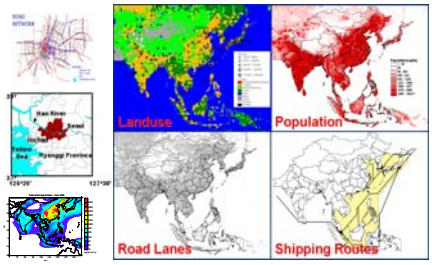
Why Simple & Interactive

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.

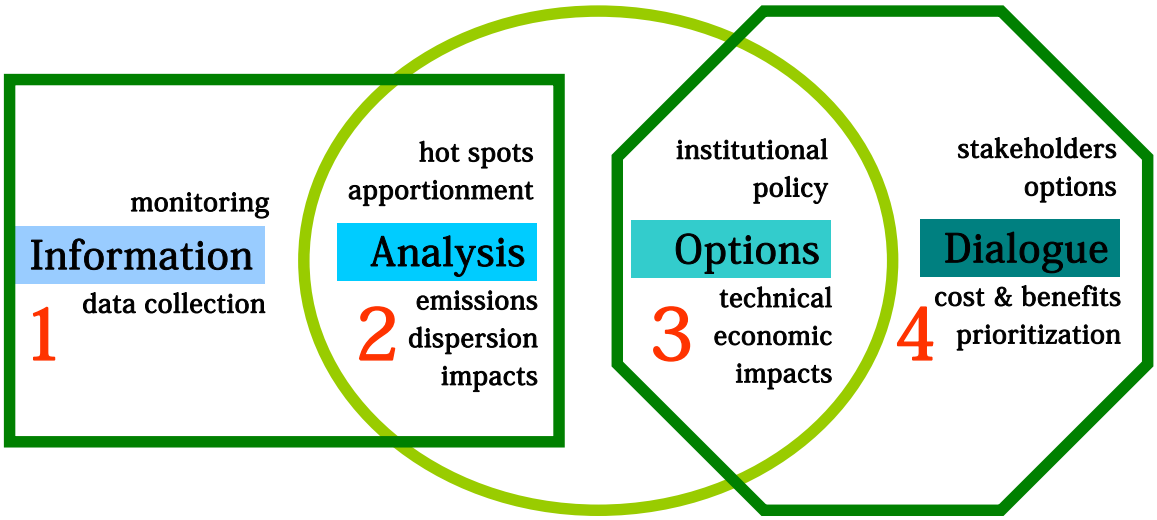
- Data required is scattered, but not non-existent
- Models are many, but need customization for individual cities, based on local needs
- Parameters for modeling are many, but need to identify the critical ones
- Any analysis of AQM components takes time, but simplified frameworks can help
- Resources 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

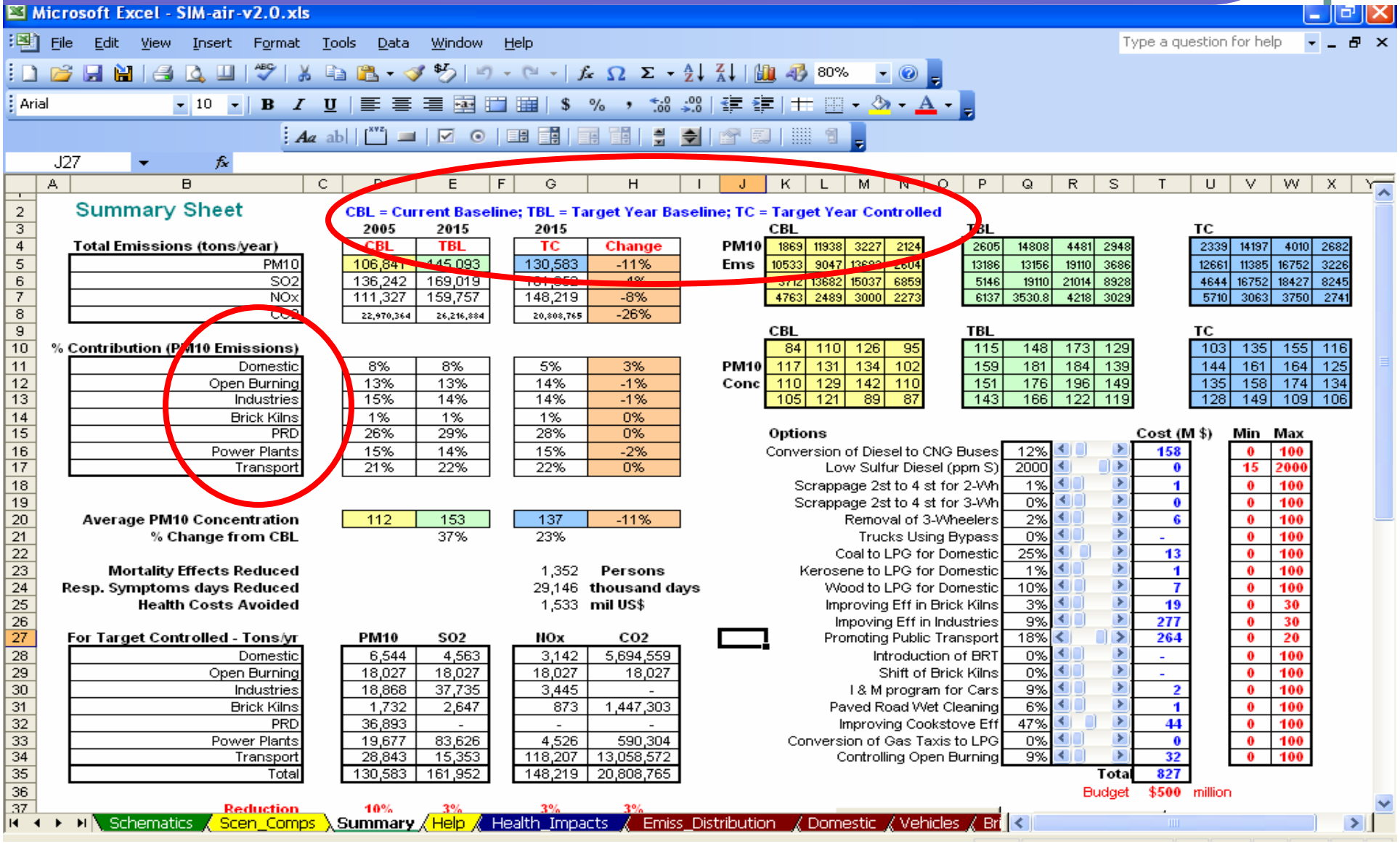
In Conclusion

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

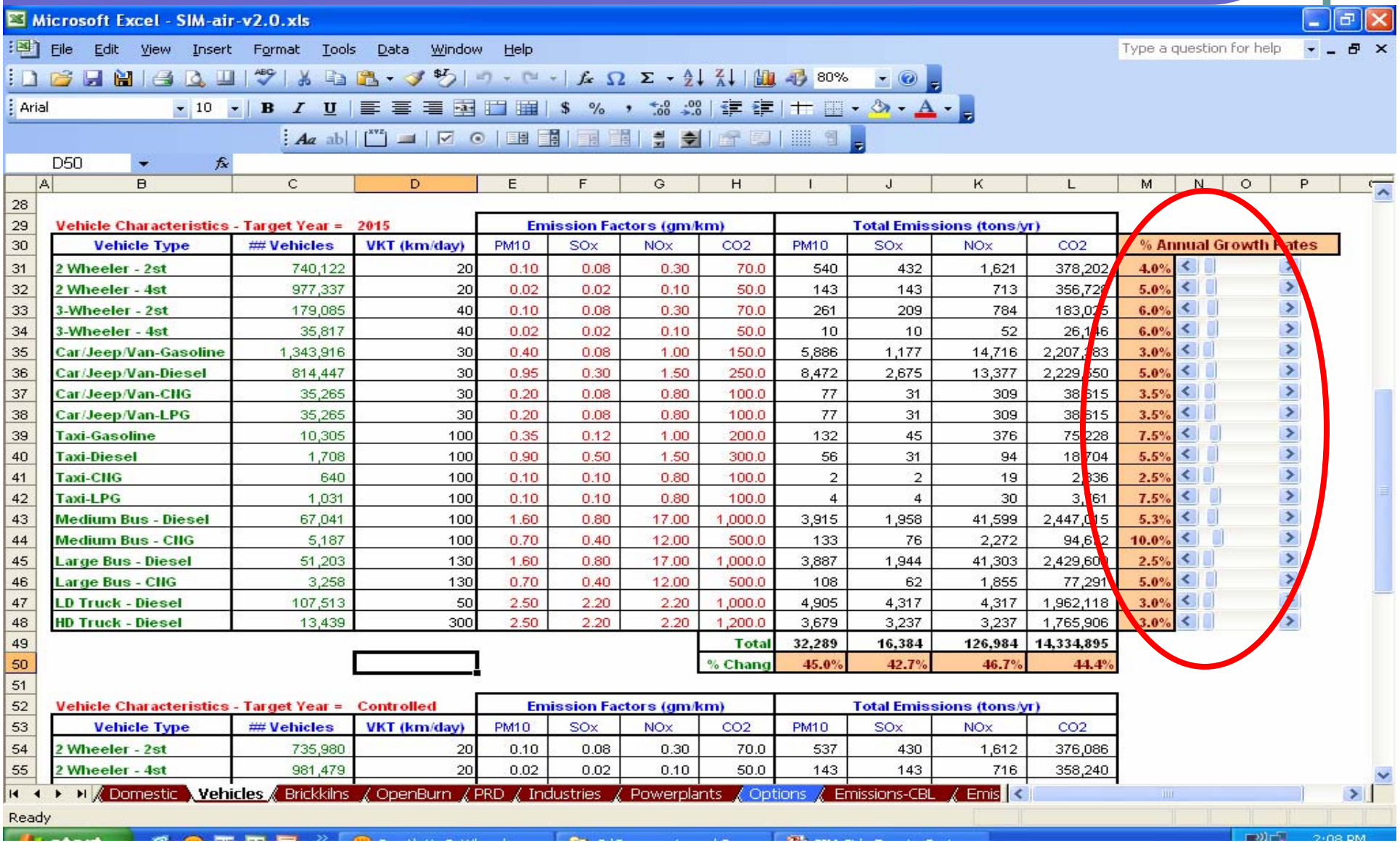
Available tools:

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



Projection Estimates



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

Vehicle Characteristics - Target Year = 2015

Vehicle Type	## Vehicles	VKT (km/day)	Emission Factors (gm/km) PM10	SOx	NOx	CO2	Total Emissions (tons/yr) PM10	SOx	NOx	CO2	% Annual Growth Rates
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	356,72	5.0%
3-Wheeler - 2st	179,085	40	0.10	0.08	0.30	70.0	261	209	784	183,07	6.0%
3-Wheeler - 4st	35,817	40	0.02	0.02	0.10	50.0	10	10	52	26,1	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,	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,	5.0%
Car/Jeep/Van-CNG	35,265	30	0.20	0.08	0.80	100.0	77	31	309	38,6	3.5%
Car/Jeep/Van-LPG	35,265	30	0.20	0.08	0.80	100.0	77	31	309	38,6	3.5%
Taxi-Gasoline	10,305	100	0.35	0.12	1.00	200.0	132	45	376	75,2	7.5%
Taxi-Diesel	1,708	100	0.90	0.50	1.50	300.0	56	31	94	18,7	5.5%
Taxi-CNG	640	100	0.10	0.10	0.80	100.0	2	2	19	2,3	2.5%
Taxi-LPG	1,031	100	0.10	0.10	0.80	100.0	4	4	30	3,6	7.5%
Medium Bus - Diesel	67,041	100	1.60	0.80	17.00	1,000.0	3,915	1,958	41,599	2,447,0	5.3%
Medium Bus - CNG	5,187	100	0.70	0.40	12.00	500.0	133	76	2,272	94,6	10.0%
Large Bus - Diesel	51,203	130	1.60	0.80	17.00	1,000.0	3,887	1,944	41,303	2,429,6	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%	

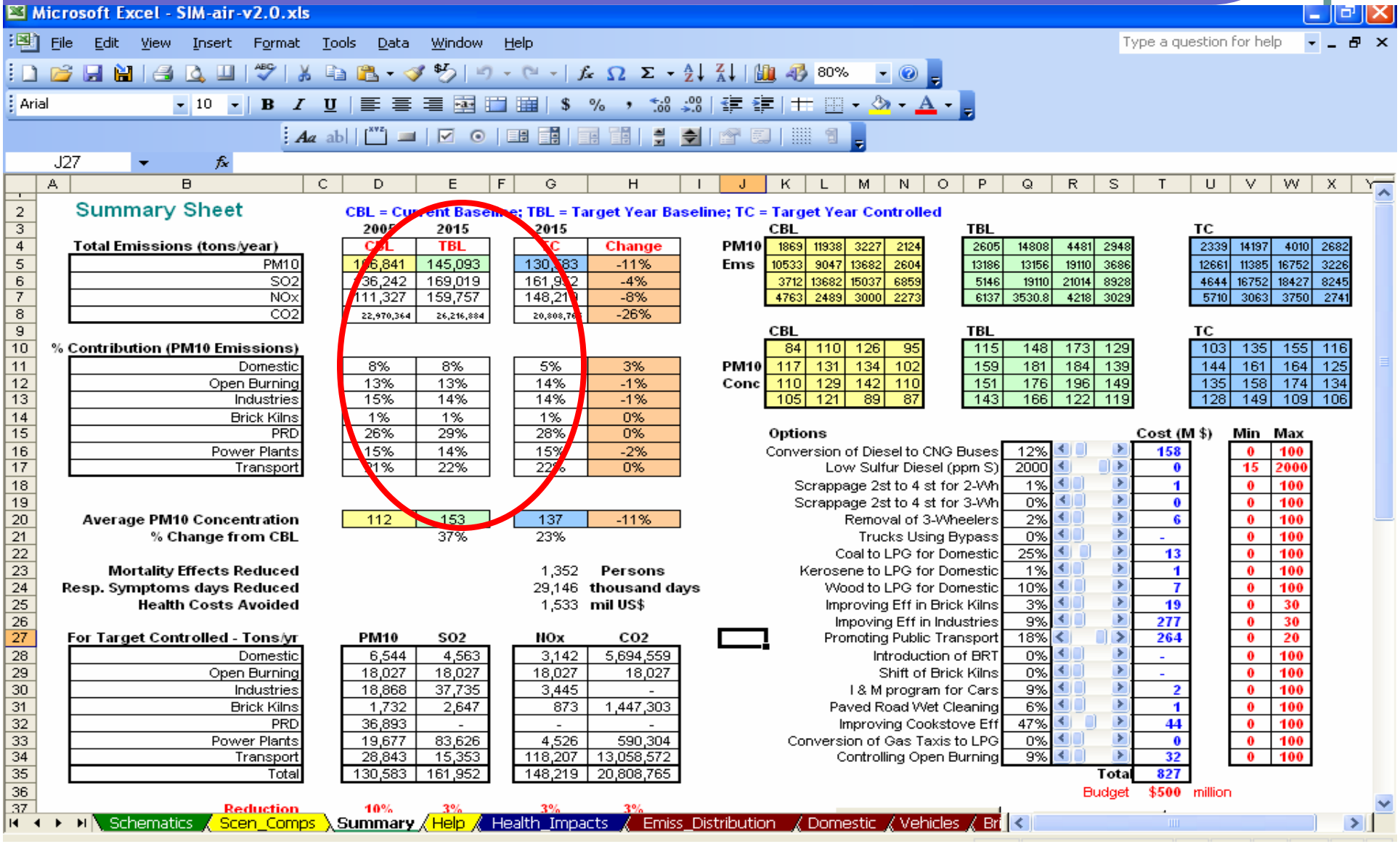
Vehicle Characteristics - Target Year = Controlled

Vehicle Type	## Vehicles	VKT (km/day)	Emission Factors (gm/km) PM10	SOx	NOx	CO2	Total Emissions (tons/yr) 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

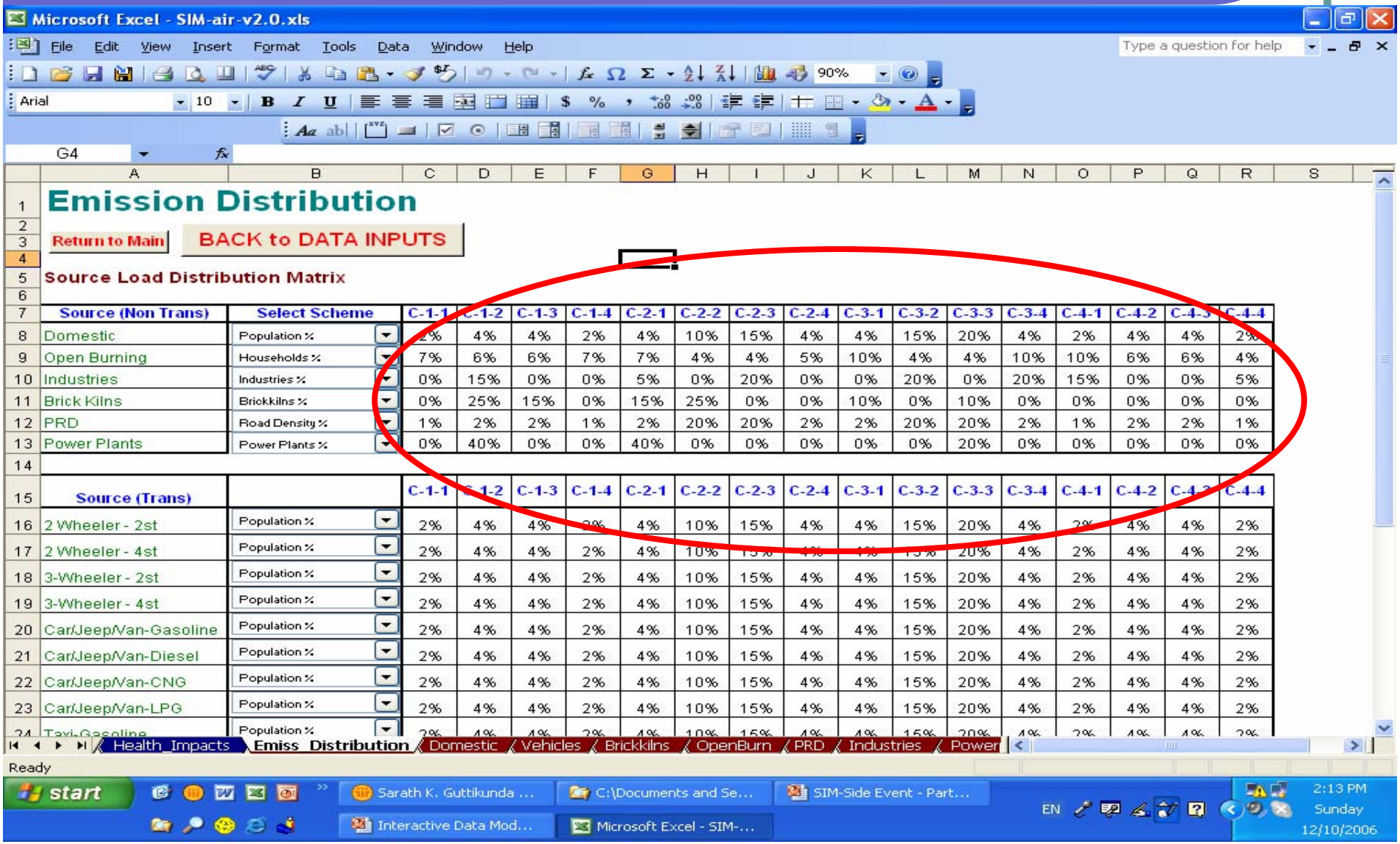
Domestic | Vehicles | Brickkilns | OpenBurn | PRD | Industries | Powerplants | Options | Emissions-CBL | Emis

Ready

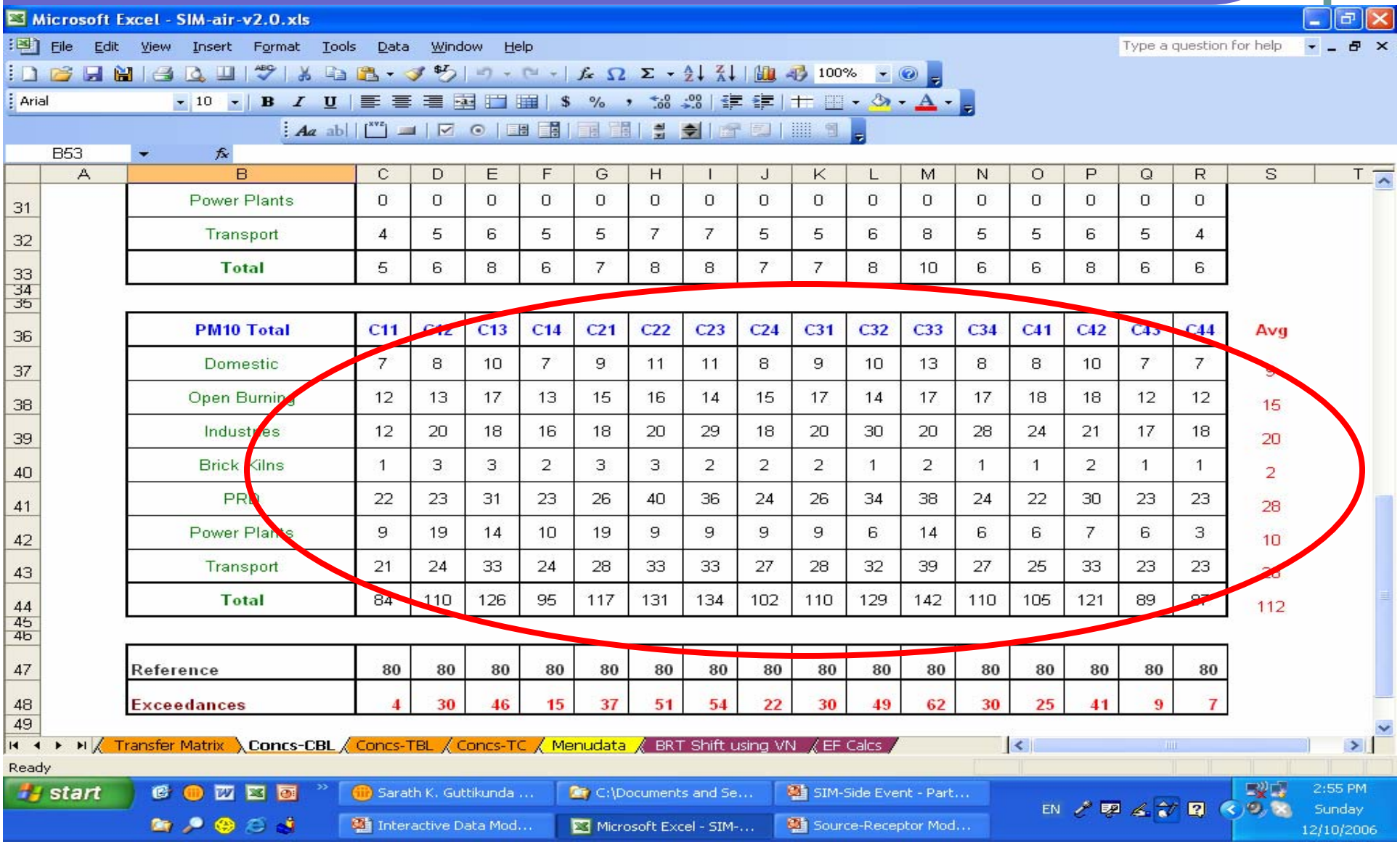
Source Contributions to Emissions



Distribution Schemes

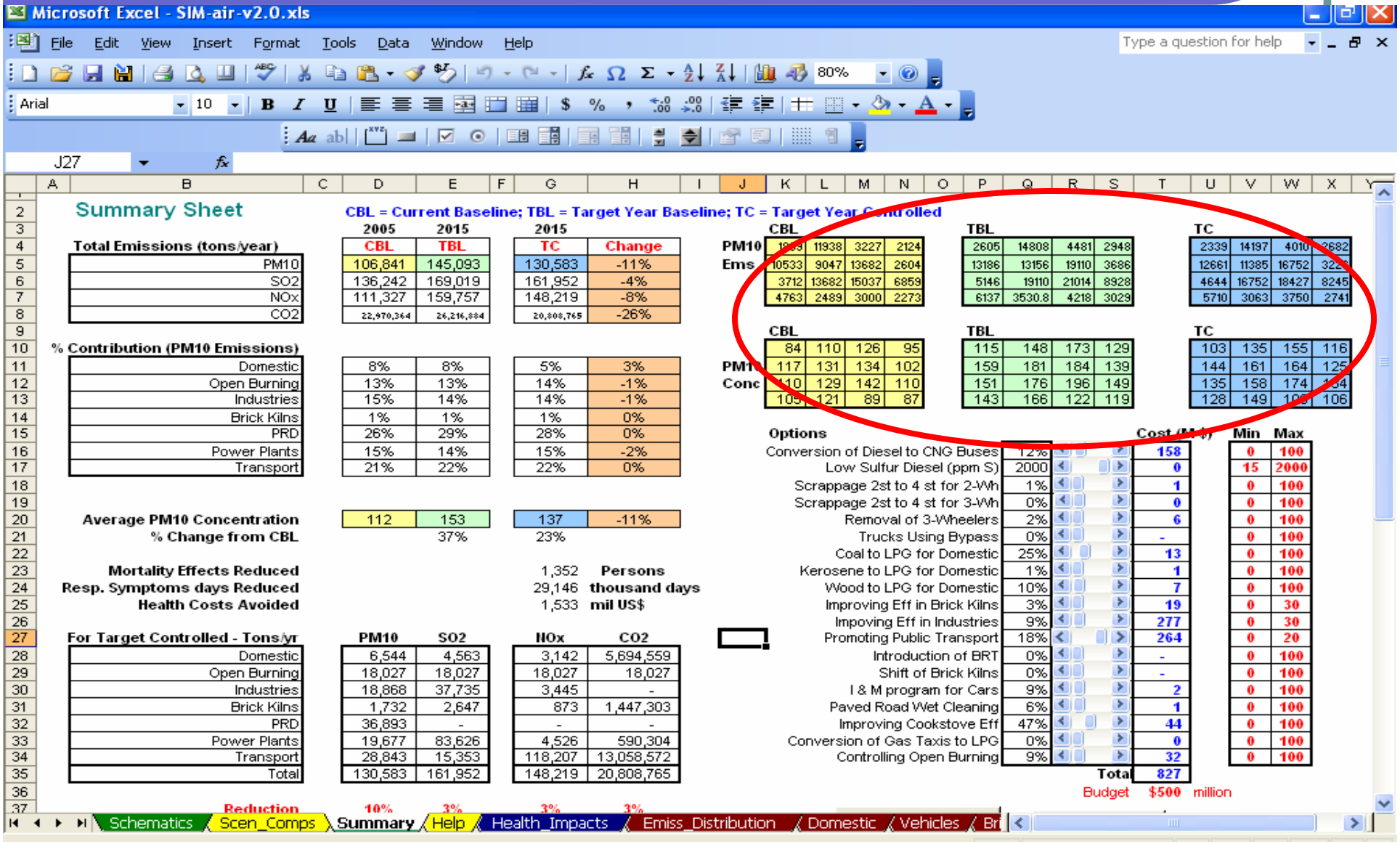


Concentrations and Contributions

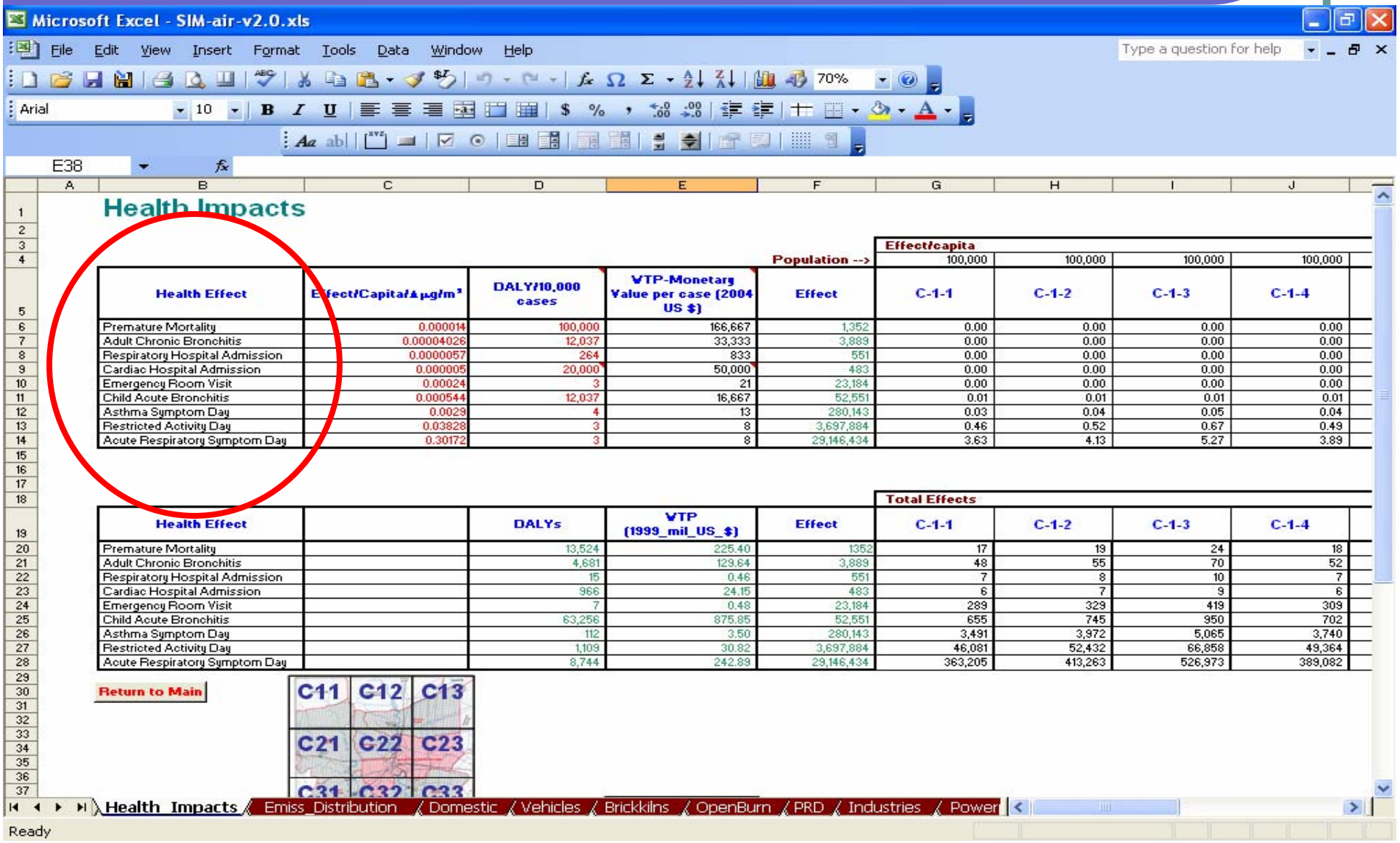


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
31		Power Plants	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
32		Transport	4	5	6	5	5	7	7	5	5	6	8	5	5	6	5	4		
33		**Total**	5	6	8	6	7	8	8	7	7	8	10	6	6	8	6	6		
34																				
35																				
36		**PM10 Total**	**C11**	**C12**	**C13**	**C14**	**C21**	**C22**	**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		
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		
44		**Total**	84	110	126	95	117	131	134	102	110	129	142	110	105	121	89		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																				

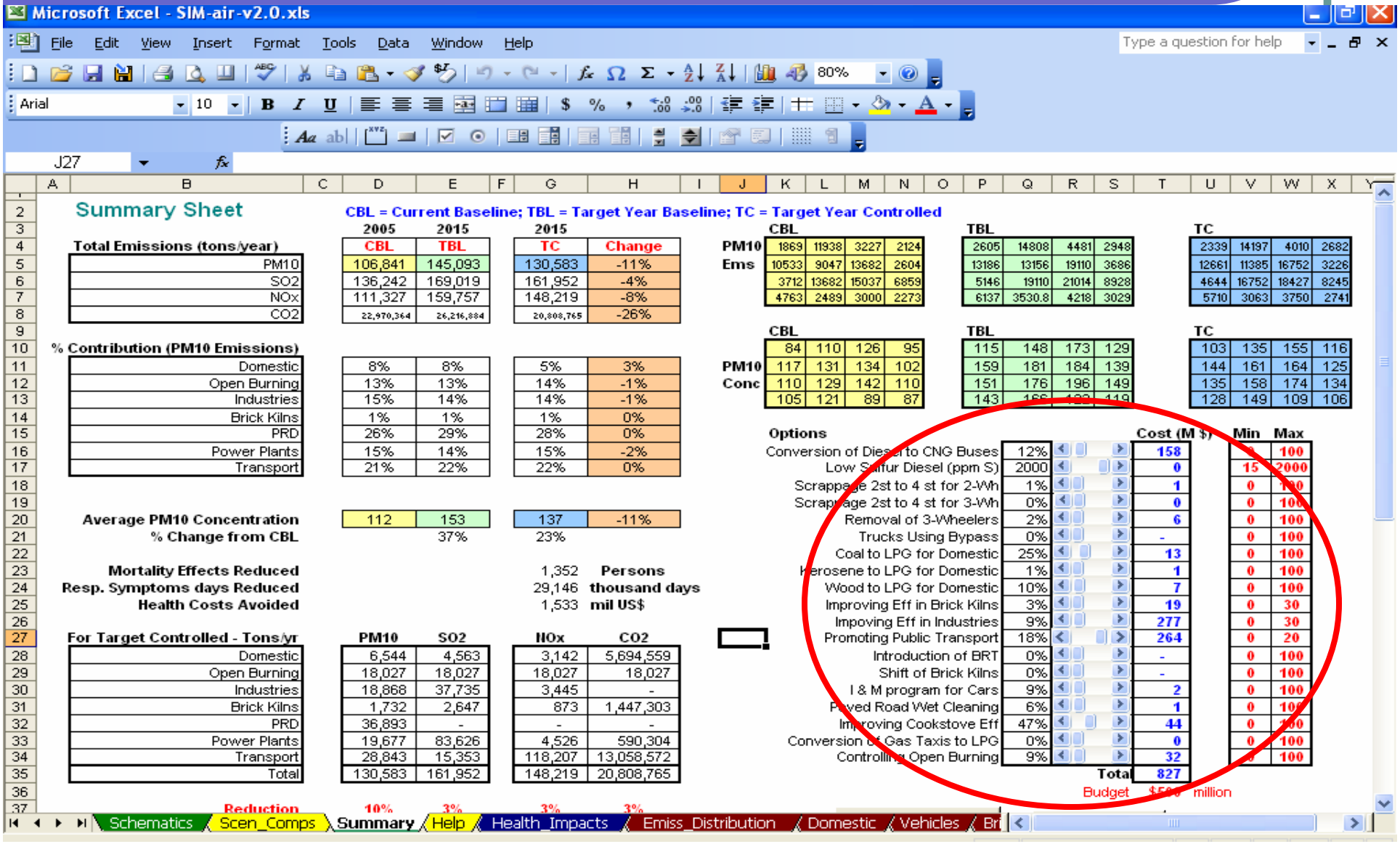
Summary Sheets



Health Impacts



Options Analysis



Optimization