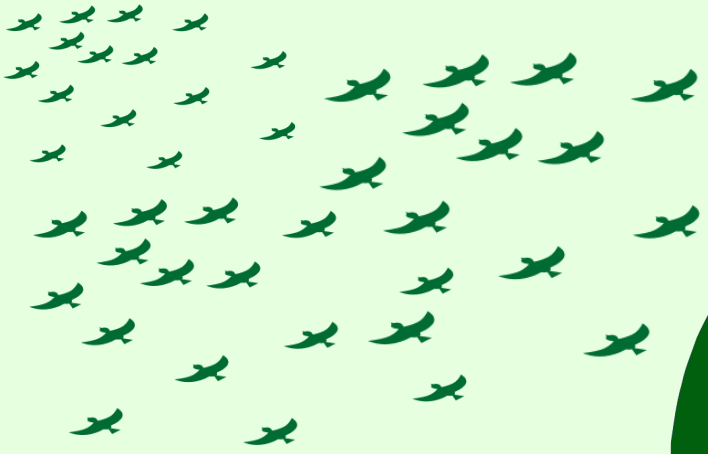


An Air Quality Management Action Plan for Hanoi, Vietnam

URBAN emissions .info

Sarath Guttikunda

SIM-air working paper series # 14-2008

(UEinfo) was founded in 2007 with the vision to be a repository of information, research, and analysis related to air pollution. There is a need to scale-up research applications to the secondary and the tertiary cities which are following in the footsteps of the expanding mega-cities. Advances in information technology, open-data resources, and networking, offers a tremendous opportunity to establish such tools, to help city managers, regulators, academia, and citizen groups to develop a coordinated approach for integrated air quality management for a city.

UEinfo has four objectives: (1) sharing knowledge on air pollution (2) science-based air quality analysis (3) advocacy and awareness raising on air quality management and (4) building partnerships among local, national, and international airheads.

This report was conceptualized, drafted, and designed by the members of UEinfo.

All the working papers and more are accessible @ www.urbanemissions.info/publications

Send your questions and comments to simair@urbanemissions.info

An "Air Quality Management" Action Plan for Hanoi, Vietnam

City of Hanoi, Vietnam

[1]Hanoi, the capital city of Vietnam, located on the right bank of the Red River. Hanoi is located at 21°2' N, 105°51' E covering 921 sq. km. **Figure 1**[2] presents the geographical location of the city and road density of Hanoi. The northern bank covers 71% of the land for 31% of the population and southern bank is more densely populated with 29% of land for 69% of the population[3].

Hanoi's population is estimated at 3.2 million in 2005 and is constantly growing. This growth puts a lot of pressure on the limited infrastructure and environment, some of which is antiquated and dates back to the early 20th century.

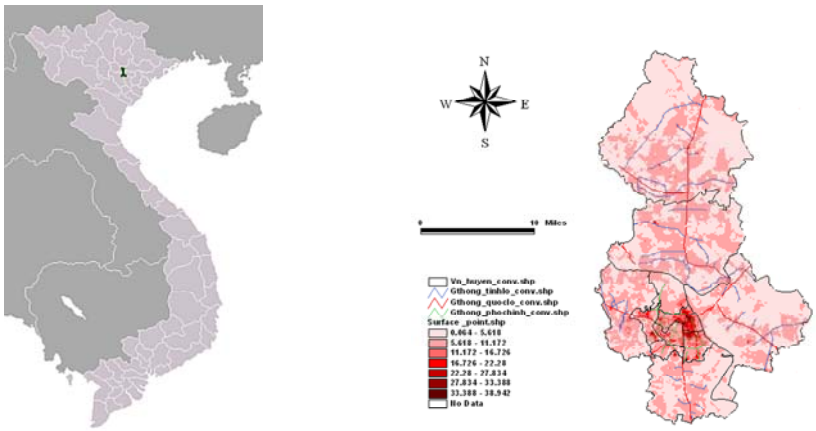


Figure 1: Geographical location of Hanoi and Hanoi road density in km/km^2

While the institutional and legal resources for environmental protection are in place, the ambient air quality in Hanoi is fast degrading under the pressure of surging population numbers (with an expected increase of 1.5 - 2 million by 2020), transportation demand (with an increase of 30 times over the period of 1995 to 2005 in motorcycle traffic and passenger cars), and economy growth (with 11.2% increase in GDP contributed by 80% from production industries and construction in 2005). As with many developing country cities, the emissions from transport and industrial sector are dominant air pollution sources.

Urban AQM is becoming increasingly important in a sustainable growth context. Almost all the megacities of today (e.g., Bangkok, Beijing, Mumbai, Tokyo, and Manila in Asia) and potential megacities of tomorrow (e.g., Xian, Pune, and Hanoi) suffer from urban air pollution and its environmental health consequences. Hanoi' authority has recognized the

---

[1] This study was funded by Swiss Vietnamese Clean Air Program (SVCAP) and supported by Department of Natural Resources and Environment (DONRE) of Hanoi, Vietnam. This study was conducted in 2007-08. The study results were presented by DONREH at BAQ 2008.

[2] In August, 2008, the administrative boundaries of Hanoi changed and becoming Greater Hanoi, covering two more districts to the south and west. This study was conducted before the changes.

[3] Hanoi statistical year book, Hanoi, Vietnam (2006)

threats of degrading ambient air quality. The study "Urban Air pollution in Asian sities"[4] jointly conducted by the Clean Air Initiative for Asian Cities[5], Stockholm Environment Institute, and the United Nations Environment Program, grouped Hanoi among cities with limited management capacity.

This AQM capacity needs immediate improvement and the efforts to reduce local emissions need strengthening.

It is difficult for city managers to address these problems in a systematic manner given a history of limited capacity, institutional fragmentation, poor availability and quality of data, lack of adequate modeling tools, poor public participation and a bewildering array of management options.

In October, 2007, Swiss Vietnam Clean Air Program (SVCAP) with the relevant local and national stakeholders organized a preliminary workshop on AQM in Hanoi. The sessions also included a training session on key components of AQM and necessary steps required to develop an AQM action plan for Hanoi. Decision makers stated that the data requirements, array of options, and experiences from cities are plenty and confusing at times and there was not sufficient information or knowledge base to plan local responses even though all agreed on the seriousness of the air pollution in Hanoi and necessity to act. Development planners agreed on a consensus to prepare a consolidated set of guidelines, which would enable them to develop a baseline to compare the widely varying options, for example, bus rapid transport and promoting public transport at a large scale, stricter regulations for motorcycles, and improved energy efficiency in industrial and domestic sectors, which will enable to choose between investment projects with largest cost effectiveness to air quality in Hanoi.

The objective of this study (funded and coordinated by SVCAP) is to shed some light on the following set of issues:

- What is likely to be the trend in air pollution levels – under a business-as-usual (BAU) scenario in Hanoi in 2010 and up to 2020?
- What are the likely associated levels of emissions that could have damaging consequences at the local level (especially for PM)?
- What domestic interventions will make a significant difference in the air quality relative to BAU scenario?

The results from this study are expected to be a key source of information for those involved in air quality management and other environmental assessment activities relating to Hanoi, so that the management options can be evaluated from appropriate economic, social and environmental perspectives.

[4] Schwela, et. al., 2006. Urban Air Pollution in Asian Cities: Status, Challenges and Management. Earthscan Publications, UK.
[5] Clean Air Initiative for Asian Cities (CAI-Asia) @ www.cleanairnet.org

AQM in Hanoi, Vietnam

Air Quality Monitoring

In Hanoi, rapid urbanization combined with growing demand for energy resources and exponential growth in vehicular fleet are contributing to deteriorating air quality. Adequate information on status of air quality is an essential prerequisite for any rational and objective AQM program, and for formulating action plans. The monitoring of air quality in Hanoi started in the early 1990s. To that effect, investment on air quality monitoring networks in Hanoi has been considerably higher than the nationally averaged level. Seven of the 20 automated stations (15 stationary and 5 mobile ones) in the country are located in Hanoi.

Most recently, series of air quality monitoring studies conducted in Hanoi.

- MONRE - Collected hourly concentration of pollutants in the air in 2003 and estimated of traffic emission with resolution of 1 km x 1 km (presented in Figure 1)
- JICA - Monitored 24 hour concentration of pollutant in the air at traffic intersections during August, 2005
- SVCAP – Operated passive sampler network for January and February, 2007
- DONREH – Monitored hourly pollutant concentrations at urban centers, industrial areas, and streets during several months of 2006 and 2007
- CENMA – Conducted monitoring from March to June 2007 at 6 industrial areas and 13 urban areas

Details of each of the campaign are described in the studies SVCAP's final report[6]. Currently, there is no central network or authority connecting and consolidating data from all stations. The fact that stations are operated by different agencies and data collected in various formats makes it difficult to present and review a comprehensive assessment of the air quality.

[7]Sources of Air Pollution

Emissions come from a variety of sources such as power plants, industries, transport, biomass and waste burning, domestic and commercial fuel burning, resuspension of the road and construction dust, etc., and it is essential to define the type of emission source in order to measure the impacts of air pollution.

---

[6] SVCAP, 2008. Hanoi air quality management plan for 2020. Swiss Vietnamese Clean Air Program, Hanoi, Vietnam & CAI-Asia and ADB, 2006. Country Synthesis Report on Urban Air Quality Management in Asia: Viet Nam. Clean Air Initiative for Asian Cities, Manila, Philippines.

[7] Some news articles on air pollution in Vietnam include the following
Statistics reveal pollution woes in capital @ http://english.vietnamnet.vn/social/2007/03/674100/
Hanoi: 59% of motorbikes violate exhaust fume standards @ http://english.vietnamnet.vn/social/2007/05/698964/
Nation seeks foreign advice on cutting motorbike fumes @ http://vietnamnews.vnanet.vn/showarticle.php?num=01ENV230108
The Economy and the Traffic Are Humming in Hanoi @ http://www.nytimes.com/2007/07/07/world/asia/07vietnam.html
Frankenstein vehicles envelop Hanoi in extra smog nightmare @ http://english.vietnamnet.vn/social/2008/03/772106/
Urban areas grow without rhyme or reason @ http://english.vietnamnet.vn/social/2008/03/772671/
Masking the pollution problem @ http://www.thanhniennews.com/features/?catid=10&newsid=36855
Call for more public transport, fewer cars @ http://vietnamnews.vnagency.com.vn/showarticle.php?num=07SOC131108
Air pollution hazards higher than thought @ http://www.speroforum.com/site/article.asp?id=9036
Polluting brick kilns likely to keep on keeping on @ http://vietnamnews.vnagency.com.vn/showarticle.php?num=01ENV140708
Trucks full of dust pollute HaNoi @ http://vietnamnews.vnagency.com.vn/showarticle.php?num=01ENV271008
Air pollution peaks in HCM City @ http://vietnamnews.vnagency.com.vn/showarticle.php?num=05SOC130608

The major sources of air pollution include the combustion of fuels for electricity generation, transportation, industries, space heating, and cooking. Besides primary emissions of PM, SO_2, NO_x, and HCs, chemical reactions in the atmosphere produce secondary pollutants such as ozone which is responsible for photochemical smog and haze. Chemical transformation is also responsible for a significant portion of ambient PM in the form of sulfates and nitrates from SO_2 and NO_x emissions respectively.

Table 1: Vehicular population in Hanoi in 2005[8]

Vehicle type	Fuel base	No. of vehicles	% Total
2 & 3 Wheelers	Petrol	1,494,800	89.7
Cars (small & medium)	Petrol	120,000	7.20
Buses	Petrol	7,000	0.42
Trucks	Petrol	100	0.01
Cars (small & medium)	Diesel	20,000	1.20
Buses	Diesel	800	0.05
Trucks	Diesel	23,720	1.42

In Hanoi, motor vehicular activity is a major source of emissions, causing both primary and secondary pollution. Most of the people have access to motor vehicles where private transport accounts for ~97% of passenger trips. It is estimated that a total of 1.6 million vehicles are registered in Hanoi in 2005. **Table 1** presents share of motor vehicles in use in

[8] Results are updated from NILU (2006) studies on air quality management in Hanoi

Hanoi in 2005. Ninety percent of the vehicle fleet is dominated by motorcycles[9]. Accordingly, the modal share of motorcycle among the mechanized trips is high at ~60 percent. In 2001 less than 4% of trips were made by bus, the only form of public transport (except taxis). The poor still depend on bicycles and non-motorized modes which account for ~25% passenger trips. According to the Transport Police Department of Hanoi, registered motorcycles in Hanoi are increasing at ~13,5% per year.

[10]Car ownership is relatively low, but increasing at ~10% a year. High population density and new construction in built-up areas have congested the city and demanding more space to sustain the growing vehicle use at levels significantly higher than the present. Underdevelopment of public transportation is one of the main reasons of rapid increase in motorcycle population and private cars. Estimates for 2006/07 puts total vehicular fleet at ~2 million, which is a ~15% increase per year since 2005.

Besides the direct vehicular exhaust emissions, resuspension of the fugitive dust on the roads is a constant source of PM. Due to dry conditions, constant vehicular activity, wear and tear of tires, high construction activities, and dusty roads.

A fair amount of PM, SO_2, NO_x, and CO_2 emissions come from coal and oil combustion in the industries; especially from the brick industry in the outskirts of the city, which is known to burn biomass such as rice husk. In the city limits, tanning and textiles are dominant industrial types.

Domestic emissions come from using the coal for cooking and partly heating. In the central Hanoi, use of coal is limited in the domestic and commercial (restaurants and roadside establishments) sectors. However, outside the city, contribution of coal is high. According to DONREH, there are at least 12,000 such kiosks using 6 kg/day of coal on average for cooking purposes. Of the domestic sector, it is estimated that 5% of the households use coal for cooling at 2kg/day average. Such usage also leads to indoor air pollution, which is not covered in this report.

During the harvest season, the burning of the field residue is a major source of pollution following the long range transport (LRT) of the pollutants. A series of source apportionment studies performed by Hien et al., (2004)[11] and Cohen et al. (2006)[12], estimate ~40% of ambient PM originates outside the city. These LRT sources are both of local and regional scale - for example, a combination of biomass burning, thousands of small brick kilns north of the city and contribution of regional LRT due to proximity to China and Thailand. Of all the sources, the long range transport between regions and nations is hard to investigate and estimate. **Figure 2** presents summary of back trajectory analysis from Cohen et al.,

[9] Evaluation of the Emissions from 2-Stroke Motor Cycles @ http://www.cleanairnet.org/lac/1471/articles-40938_resource_1.pdf

[10] Also see EMBARQ Program on Hanoi, Vietnam, A World Resources Institutue's (WRI) Center for Sustainable Transport @ http://embarq.wri.org/en/ProjectCitiesDetail.aspx?id=8; their latest report "Measuring the Invisible" outlines emission reduction strategies for the Hanoi transport sector.

[11] Hein, et. al., 2004. PMF receptor modeling of fine and coarse PM10 in air masses governing monsoon conditions in Hanoi, northern Vietnam. Atmospheric Environment 38, 189-201.

[12] Cohen, D., et. al., 2006. Source apportionment for Hanoi, Vietnam. www.cleanairnet.org/baq2006/1757/docs/SW23_3.ppt

calculated for every four hours of the sampling period and results based on receptor modeling from Hien et al.

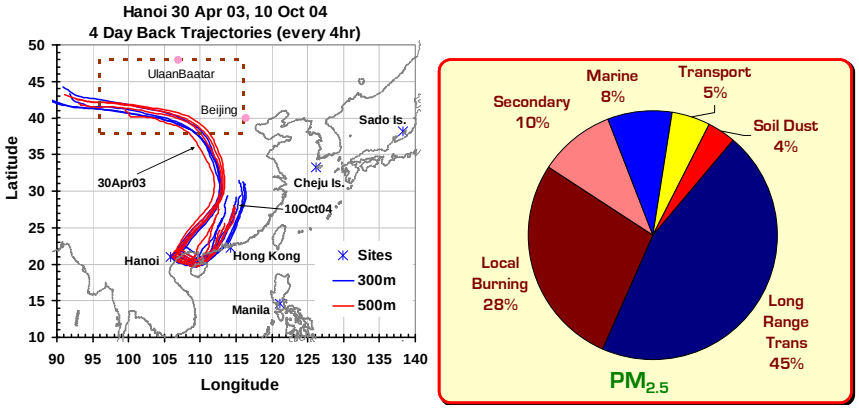


Figure 2: Source apportionment results for Hanoi. Left Panel: Cohen et al., 2006 using back trajectories; Right Panel: Hein et al., 2004 using receptor modeling

Cohen et al., concluded that the secondary sulfur for most parts has its origin in China and secondary sulfur accounted for ~20% of the measured PM_{10} sample. Similarly, Hien et al., concluded that for the fine ($PM_{2.5}$) fraction, contribution of LRT is ~45% of the local air pollution in Hanoi. In city, major air pollution sources remain the vehicular exhaust, fugitive dust, and coal from industrial and domestic use.

Among the miscellaneous sources, city of Hanoi also operates six incinerators with varying capacities and feed ranges from domestic garbage (the largest), construction, industrial, medical, and agro waste. Due to cities proximity to the sea, sea salt is a common occurrence in the fine fraction, as can be seen in **Figure 2**.

Status of AQM

Since 2000, AQM within Hanoi city has picked up momentum followed by a series of air quality monitoring studies by various agencies. Besides the air quality monitoring studies, there are several short term studies incorporated in regional planning in the Master study on major economic region[13]. Research studies also focused on environmental management, legal framework and environmental monitoring. Numerous decisions on emission reduction were passed for Vietnam in general, and for Hanoi. There is no current system that reviews whether such policies and decisions have had any impact on the air quality of Hanoi or the country.

In Hanoi, the participation of public on AQM related activities is also limited at this point. The online information from monitoring stations was designed to be disseminated through mass media such as newspaper, radio, television, and internet. However, at present, the operation of electronic information boards on displaying real time pollutants levels at DONREH and Department of Transportation is very sporadic and unreliable. Among all the agencies conducting air quality monitoring, the network of stations run by MONRE is

[13] AQM capacity building workshop - http://www.cleanairnet.org/caiasia/1412/article-73019.html

most synchronized since 2002 (updating hourly data from the stations to the database center in Hanoi).

In general, non-governmental offices (NGOs), civil society, and advocacy groups are not common, not only for air quality related issues but most environmental sectors.

Air Pollution Analysis in Hanoi

Emissions Inventory

A thorough and transparent bottom-up emission inventory of stationary and transportation combustion sources was compiled under this study. The emission inventory included ambient air pollutants such as PM_{10} (and $PM_{2.5}$), SO_2, and NO_x for all combustion sources operating within the Hanoi city area for year 2005. This analysis was conducted using a simple calculation tool[14] utilizing activity levels from domestic, industrial, and transport sectors and emissions factors from studies across Asia, where local specific information is not available, and utilizing the information collected from various institutions and past studies such as NILU, 2006 and JICA, 2007[15].

Table 2 presents a summary of total emissions estimated for Hanoi at 23.5 ktons for PM_{10}, 4.4 ktons for SO_2 and 27.3 ktons for NO_x for year 2005. Major assumptions include the pollutant emission factors for vehicles taken from other studies in Asia, paved and unpaved road dust based on methodology presented in USEPA's AP-42 report[16], and a survey based estimate of household and open burning in the city. For the industrial emissions, the numbers are extrapolated from the fuel consumption data provided by DONREH. NILU, 2006, estimated the total PM_{10} emissions to be in the range of 15 ktons, which did not include the fugitive dust sources and industrial incinerators.

Table 2: Estimated emissions inventory for year 2005, tons/year

Category	PM_{10}	SO_2	NO_x
Households	1,099	358	307
Kiosks	1,261	263	220
Industries	6,665	1,407	1,919
Industrial Incinerators	338		
Vehicular Activity	4,322	1,869	24,537
Paved Road Dust	3,120		
Unpaved Road Dust	3,036		
Brick Manufacturing	1,817	466	390
Garbage Burning	1,800		
Medical Incinerators	37		
Total	**23,496**	**4,363**	**27,373**

[14] Simple Interactive Models for Better Air Quality (SIM-air) @ www.sim-air.org

[15] JICA and HAIDEP, 2007. The Comprehensive Urban Development Programme in Hanoi Capital City of the Socialist Republic of Vietnam (HAIDEP); NILU (2006) studies on air quality management in Hanoi

[16] US EPA's AP-42 Emission Factors database @ http://www.epa.gov/ttn/chief/ap42/

In the transport sector, motorcycles and trucks dominate the PM_{10} emissions for two different reasons. In case of motorcycles, it is the number of the vehicles on the road, while for trucks it is the use of diesel and aging fleet. Although individually, motorcycles comply with the emission norms, with ~1.5 million motorcycles on the road, contribute ~38% of the vehicular PM_{10} emissions. Similarly for the fugitive road dust, which is a function of vehicle kilometers traveled, and vehicle weight, motorcycles dominate the dust source contribution followed by large vehicles – buses and trucks.

Although quality assurance plans are in place to ensure the best results, there are uncertainties and limitations to consider when evaluating an emission inventory.

Dispersion Modeling & Impact Assessment

For this study, we utilized ATMoS dispersion model[17]. Meteorological data was obtained from NCEP Reanalysis[18] fields for the grid containing Hanoi. All the simulations were conducted using meteorological data for year 2005. Modeled annual average concentrations of PM_{10} are presented in Figure 3.3 along with measurements from JICA study in 2005. A background concentration of $12\mu g/m^3$ is assumed for this modeling exercise based on the monitoring data and source apportionment studies. Because of varying dispersion characteristics, primary PM concentrations are calculated in two bins – fine ($PM_{2.5}$) and coarse (PM_{10} – $PM_{2.5}$) fractions. The estimated annual average includes primary PM emissions and secondary PM due to SO_2 and NO_x emissions in the form on sulfates and nitrates. All the secondary sulfate and nitrate concentrations were assigned to $PM_{2.5}$ fraction.

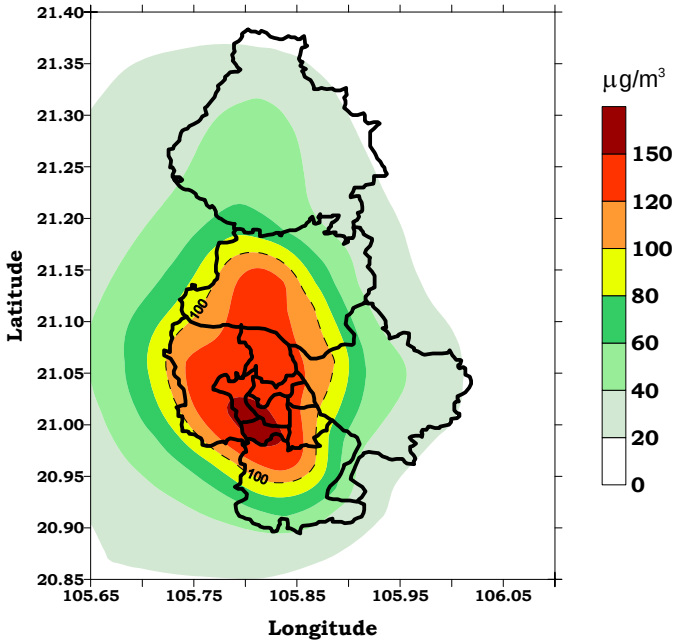


Figure 3: Modeled annual average PM_{10} concentrations in 2005

[17] Calori et al, 1999. An urban trajectory model for sulfur in Asian megacities: model concepts and preliminary application. Atmospheric Environment 33, 3109–3117

[18] NCEP Reanalysis Meteorological database @ http://www.cdc.noaa.gov/cdc/data.ncep.reanalysis.html

The highest concentrations in **Figure 3** represent the areas with highest industrial density. The meteorology is from East to West for most of the year, which also explains the contribution of LRT from South China. On an average, the south of the river residing ~70% of the population, experiences PM levels of 100-120 μg/m^3. Measurements from JICA study in 2005 for PM_{10} ranged from 50 μg/m^3 on the river front to an average of 320 μg/m^3 in the industrial areas to the southwest.

The ambient concentrations were calculated for individual sectors to evaluate their contribution and strengths for pollution control. **Figure 4** presents percent contributions for individual sectors to annual average concentrations and contribution of secondary PM (sulfates and nitrates). For this exercise, emissions from individual sectors were analyzed separately for PM, SO_2, and NO_x, to segregate the results as much as possible. On an average, secondary PM contributes 10-15% of total PM_{10}, and 20-30% in the fine $PM_{2.5}$ fraction. Note that this doesn't include the secondary from LRT. The vehicular and industrial pollution dominates the ground level concentrations. Vehicular emissions and resuspension dust is emitted at ground level and their dispersion characteristics are limited to the local surroundings, making them the most contributor in the urban parts of Hanoi.

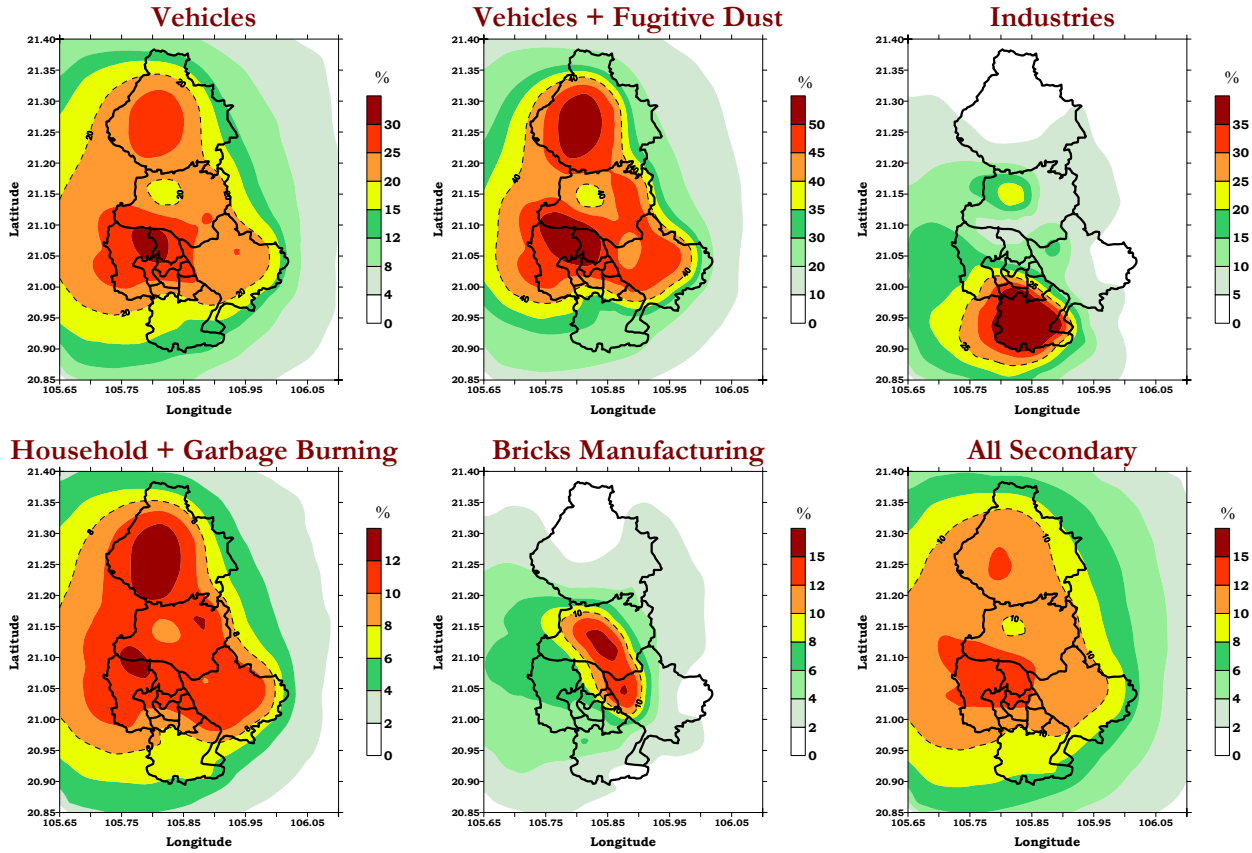


Figure 4: Modeled percent contribution of sectors to annual PM_{10} in 2005

In case of industrial sources, due to stack heights of 20-50m, tendency for local LRT is higher and this is represented in a more scattered plot for industrial contribution in **Figure 4**.

In the municipality where the density of population is the highest, the contributions range between 25-35% for vehicular, 45-60% when combined with road dust, 10-25% for industrial sources. Domestic and garbage burning sources ranged between 10-15% and concentrated outside of the municipal boundaries. The city landfill is located to the southeast of municipal boundary. Brick Kilns to the north contributed locally between 6-20%.

Air Pollution Forecast for 2010 & 2020

Socio – economic development goal is to maintain steady economic growth and to improve the quality of life along with the cultural values. The infrastructure is vital for economic development. While technical and social infrastructure in Hanoi does not meet the societal demands, Hanoi's population increase as well as immigration from other surrounding provinces is putting pressure on environment. Urban development and construction plan from now to 2020 has been approved by the Government. Hanoi People's Committee has already completed the master plan for the districts.

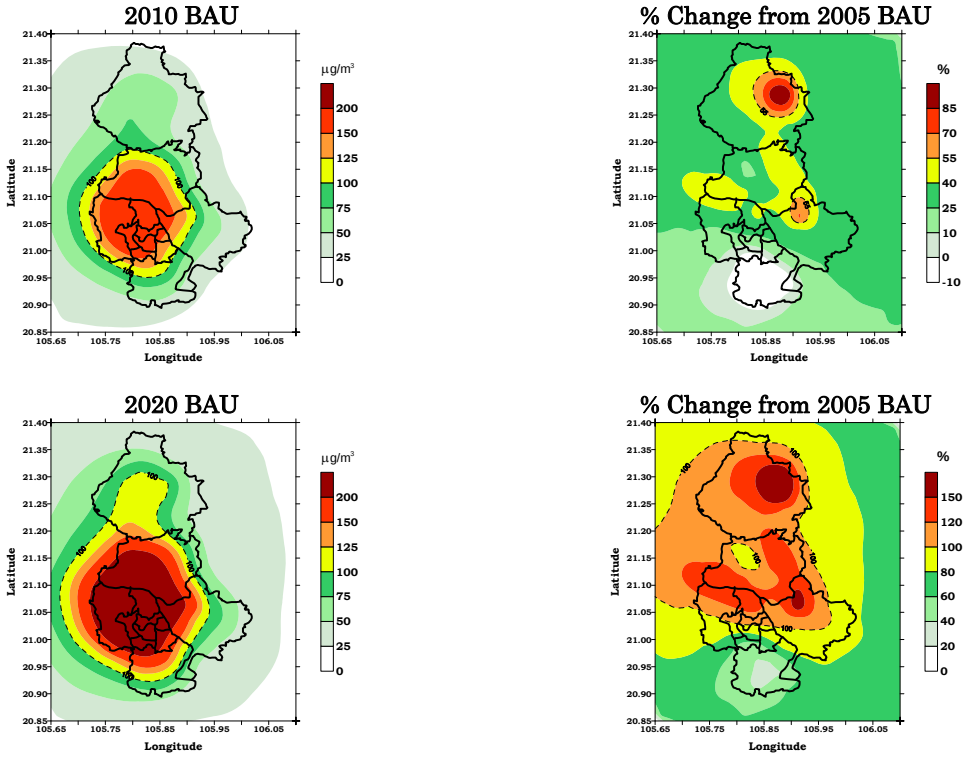


Figure 5: Modeled annual average PM_{10} concentrations in 2010 and 2020 under BAU

Following the stakeholders' workshop by SVCAP in October, 2007, utilizing the baseline developed for year 2005, emissions inventory analysis is extended for year 2010 to 2020 at five year intervals under business as usual (BAU) scenario. Details of the projections on emissions inventory and analysis for each of the sectors are presented in SVCAP, 2008. Annual average concentrations for 2010 and 2020 BAU scenario are presented in **Figure 5**.

The annual averages on total PM_{10} are expected to increase by at 50% in the urban parts of Hanoi (see right panels of **Figure 5**). The decrease in concentrations to the south of the river is primarily due to the movement of industries expected in 2010. Some of the industries are expected to relocate to the north, increasing the local contributions up to ~80%. Under the infrastructure projects, an increase in the paved roads is assumed for 2010 and subsequently 2020.

An unabated emissions scenario for 2020 results in more than doubling of the ambient PM_{10} concentrations. Under the scenario, PM_{10} levels are expected to average above 200μg/m^3 against a guideline of 80μg/m^3. It is important to note these are concentrations under the assumption that NO new technologies or regulations will be put in place in the next decade of growth.

Table 3: Change in number of health impacts in 2010 and 2020 compared to 2005 BAU

Health Endpoint	Number of Cases Incurred		Change from 2005 BAU	
	2010	**2020**	**2010**	**2020**
Mortality	1,260	2,824	688	2,252
Adult Chronic Bronchitis	2,174	4,872	1,187	3,885
Child Acute Bronchitis	19,580	43,889	10,690	34,999
Respiratory Hospital .Admission	513	1,150	280	917
Cardiac Hospital Admission	450	1,008	246	804
Emergency Room Visit	21,181	47,479	11,564	37,862
Asthma Attacks	260,942	584,916	142,464	466,438
Restricted Activity Days	3,444,434	7,720,888	1,880,524	6,156,978
Respiratory Symptom Days	16,466,340	36,910,203	8,989,967	29,433,830

Under BAU, for the estimated ambient levels presented in **Figure 5**, additional health impacts incurred compared to 2005 BAU are calculated and presented in **Table 3**. Due to density of the population to the South of Red River, increase in the exposure area, and population exposed, the number of mortality cases is expected to at least double by 2010 and more than quadruple by 2020[19].

Hanoi's 2020 AQM Action Plan

Viet Nam's main priority continues to be economic development, with the environmental concerns taking second. This relationship between economy and environment has been experienced in both developed and developing countries worldwide.

In the next decade, given the economic trends, increasing energy demand, growing vehicular population and urbanization, air pollution (outdoors and indoors) will be one of the critical issues to address in the growing urban centers like Hanoi and HCMC. Under 2020 BAU, the air pollution levels are expected to at least double the current levels, increasing its impact on human health.

[19] For details on the methodology to estimate health impacts of air pollution and the dose response functions utilized for these calculations, see the SIM-06-2008 @ www.urbanemissions.info/simair and the SVCAP final report for Hanoi specific details. A overview of health impacts of outdoor air pollution is published by the Health Effects Institute @ www.healtheffects.org

In this study, an 'exposure reduction' approach for PM is considered the primary driver to improve air quality than just a localized control measure, where the costs of reducing concentrations are likely to be high. Developing an AQM system that explicitly targets health risks is a challenging task. Pollutant concentrations can vary considerably in time and space, and pollution sources that contribute to exposure may do so to different extents. Of particular concern are the so-called hot spots, such as industrial estates and transport corridors, where pollutant concentrations are significantly higher than the average ambient concentrations.

The policy measures proposed are expected to formulate more cost-effective interventions and more importantly to maximize public health improvements across the general population.

Key strategy components for wider implementation of air pollution control interventions are

- Strengthening government, multi/bilateral and international agency awareness of the links between energy, pollution, health, and development, and their commitment to action. This is conducted through institutional capacity building at various levels and a better understanding of pollution sources and their strengths as outlined in the previous chapters.
- Facilitating collaboration between relevant sectors (government: health, environment, housing, energy, etc; as well as NGOs and businesses) at national and local levels.
- Support for technical development and evaluation of interventions; support for favorable institutional development, capacity building at governmental, private, and academic levels, and information dissemination; support from multi/bi-lateral agencies with finances and implementation strategies and capabilities.

Aside from using the **environmental police officers** to enforce the laws against emission violators in industrial and transport sector and against waste burning in the domestic sector, **comprehensive media & information campaigns** should be launched by the government and concerned groups through the television, newspapers, and radio.

Implementation Strategy

Development of cost effective measures to attain the emission and ambient targets involves efforts and continued innovation of stakeholders at national, state, & local levels. Implementation of these recommendations will require a commitment by all parties (such as DONREH, MONRE, CENMA, international and bilateral agencies, research organizations, and academic institutions) over several years. As that transition occurs, it is important that action on individual programs to reduce emissions continues to maintain progress toward cleaner air. A planning process comprised of leaders and experts of DONREH in consultation with specialists and researchers from universities, institutes and other related agencies composed an implementation strategy through 2020 is summarized in **Table 4**.

Table 4: Implementation strategy and priorities for AQM in Hanoi

Action	Organizations Responsible	ST (2010)	MT (2015)	LT (2020)
Improving legal frameworks				
Drafting City AQM Plan	Hanoi DoNRE, City stakeholders with guidance from MoNRE	∞	∞	
Drafting Clean Air Act	MoNRE, VEPA, MoT, MoH, MoC, MoTI, and City DoNREs		∞	∞
Revision of Ambient and Emission Standards	MoNRE/VEPA, DoNRE, MOH		∞	∞
Hanoi AQM Capacity Strengthening				
Building Institutional Capacity to Manage AQM	MoNRE, VEPA, People's Committees, Hanoi DoNRE	∞		
Mapping Air Quality Research Agenda	Universities, Research Institutions, MoNRE, DoNRE, MoH, People's Committees	∞	∞	
Integrated Air Monitoring System	MoNRE, VEPA, People's Committees, Hanoi DoNRE	∞	∞	∞
Increased Public Awareness	VCAP, Development partners, Universities, Civic society	∞	∞	∞
Improved Air Pollution Source Identification (Emissions Inventory)	MoNRE, VEPA, People's Committees, Hanoi DoNRE		∞	∞
Air Dispersion Modeling and Impact Assessment	Research Institutions, MoNRE, DoNRE		∞	∞
Develop Decision Support System (DSS)	Research Institutions, MoNRE, DoNRE			∞
Air Pollution Control Measures and Management Options				
Reducing pollution from mobile sources	Vietnam Register, MoT, People's Committees, Hanoi DoNREs	∞	∞	
Reducing pollution from stationary sources	MoTI, MoNRE	∞	∞	
Reducing pollution from area sources	People's Committees	∞	∞	
Trans-boundary air pollution	Ministry of Foreign Affairs		∞	∞
AQM Financing				
Financing research studies, pilot products, and donor lending	MoPI, International Cooperation Office, MoNRE, MoTI, Local Governments, Development partners	∞	∞	∞

Abbreviations: MoPI = Ministry of Planning and Investment; MoT = Ministry of Transport; MoNRE = Ministry of Natural Resources and Environment; DoNRE = Department of Natural Resource and Environment; MoTI = Ministry of Trade and Industry; VEPA = Vietnam Environmental Protection Agency; VCAP = Vietnamese Clean Air Program; MoH = Ministry of Health; MoC = Ministry of Construction;

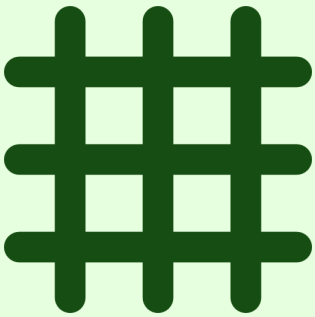
In Conclusion

For the Hanoi city, an immediate action plan needs to include:

- Raise awareness of the impacts of air pollution on health; opportunities to reduce air pollution more cost effectively and efficiently; and benefits of alternatives measures among decision-makers at political, public, and media levels;
- Encourage dialogue on political, economic, and regulatory frameworks best suited for successfully promoting strategies and increasing investment from the state and the private sector;
- Encourage local stakeholder (government, public, and private) commitment to intensify efforts to promote pollution reduction alternatives;
- Contribute to a wider dissemination of information relevant to these topics;
- Provide a platform for the development of innovative methodologies – technical, legal, institutional, and economic;

On a long term basis, city needs to include:

- Establishment of a wider air pollution monitoring network;
- Development of methodology to track changes in emission patterns to better understand and inform decision makers of pollution trends;
- Formulate policy measures with structured stakeholder interactions, to maximize environmental health benefits.



www.urbanemissions.info