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Co-Benefits: Management Options for Local Pollution & GHG Emissions Control

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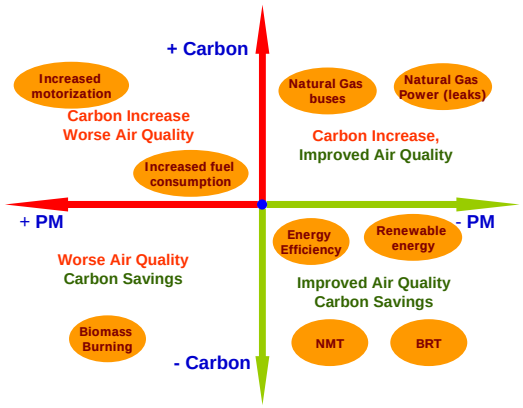


Co-Benefits: Management Options for Local Pollution & GHG Emissions Control

[1]While discussing the co-benefits, it is important to understand two things. (a) Economic, social, and environmental growth (triple bottom line) – occurs first in the urban centers (b) The urban centers will be the first to react to any policy and regulation changes on emission control – local and global.

Focusing on global emissions alone will not be enough - we need to get out of this pervasive either-or thinking. Local pollution and global climate change are not mutually exclusive. Instead, they are meant to be tackled together. One without the other will not work. It's a matter of simple mathematics and increasing the effectiveness of the interventions via co-benefits.

Due to regulations and compliance issues for urban centers – industrial and residential, the primary driver for any policy intervention remains the local air pollution. It is important to note that reducing local air pollution via technical, policy, or economic interventions, leads to co-benefits reducing not only the particulate pollution but also regional pollutants such as sulfur dioxide causing acid rain or carbon dioxide leading to climate change.

Co-Benefits Framework for Multi-pollutant Strategy

For a growing number of cities, the main environmental concern still remains local pollutants[2], primarily the particulate matter (PM_{10} with aerodynamic diameter less than 10 μm and $PM_{2.5}$ with aerodynamic diameter less than 2.5 μm). The cities with higher transport quotient are now experiencing higher ambient levels of Ozone, which is formed due to chemical reactions between the NO_x and VOC emissions.

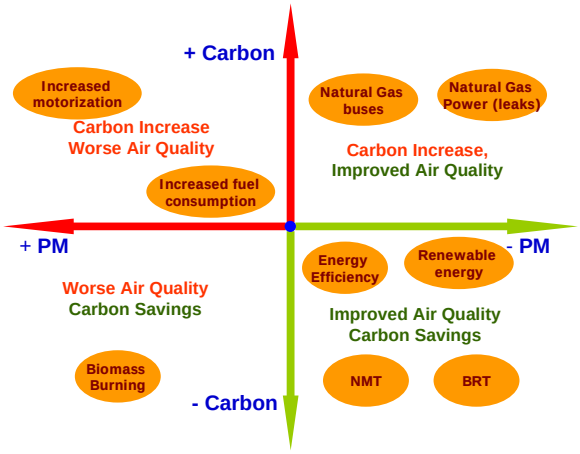


Figure 1: Co-benefits of management options[3]

[1] A version of this paper is submitted to IGES (Tokyo, Japan) Carbon Resilient Society Series 2008. Under Review

[2] Ambient air quality monitoring data in Asia - http://www.cleanairnet.org/caiasia/1412/article-59646.html

[3] Source: Modified from presentation by Dr. Cornie Huizenga, Executive Director, CAI-Asia, Manila, Philippines

Almost all the megacities of today (e.g., Bangkok, Beijing, Mumbai, Tokyo, and Manila) and potential megacities of tomorrow (e.g., Xian, Pune, and Hanoi) in Asia suffer from urban air pollution and its environmental health consequences. A recent conference on Co-benefits[4] concluded that

Current science emphasizes the urgent need to address air pollution and climate change in an integrated way. We should no longer treat these two issues separately as we strive to achieve sustainable development and a low carbon society.

In both developing and industrialized countries, abatement of air pollution and mitigation of climate change have generally been treated separately. There are, however, large benefits in considering the control options together; such approaches would mostly lead to increased health and/or climate benefits and decreased costs.

A co-benefits approach is increasingly becoming a starting point for discussing integrated programs benefiting climate change and air quality alike[5]. **Figure 1** depicts a scenario where the co-benefits can aide decision making over a variety of control measures. For example, policies designed to reduce the impact of transport on air quality by tackling congestion and encouraging a shift to public transport, walking, and cycling should also reduce CO_2 emissions. Measures to improve energy efficiency and cut energy demand, reduces air pollutants and GHG emissions together during electricity generation.

In the developing countries, this approach is being recognized as a practical and effective tool in technical, policy, economic, and institutional perspectives.

Further more, transport, the fastest growing GHG emitting sector[6], is also one of the main culprits (if not the primary) causing air pollution in a growing number of cities. **Figure 2** presents a summary of share of transport to local air pollution, based on a series of source apportionment studies in the megacities across the world. These represent only the direct emissions from the vehicles and not include the fugitive dust from paved and unpaved roads due to the vehicular activity, which is a major part of the measured particulates, especially in the developing countries. In Asia, the secondary cities, with population more than 2 million are increasing and following the trends of megacities, given the economic and industrial growth, demanding more personal cars, and increasingly facing the air pollution problems.

The one parameter that connects the transport and emissions is the usage, for the modelers, it is vehicle kilometers traveled (VKTs). More VKT = more fuel burnt = more emissions (local and global). The solution to reducing pollution at any level is reduction of VKT, especially passenger vehicles with low capacity. The growing number of vehicles on the

[4] Co-Benefits conference by Global Atmospheric Forum - http://www.sei.se/gapforum/conf/index.php

[5] Theme of the 5th Better Air Quality Conference for Asian Cities, the largest air quality conference of Asia is "Co-Benefits", www.baq2008.org

[6] http://www.ipcc.ch/graphics/graphics/ar4-wg3/jpg/fig-1-3a.jpg and http://www.ipcc.ch/graphics/graphics/ar4-wg3/jpg/fig-1-3b.jpg

road is also the leading cause of congestion resulting is loss of fuel efficiency[7], more emissions at the intersections, higher ambient concentrations and higher exposure levels. Overall, by reducing the number of VKTs and better traffic management will result in better fuel efficiency = less fuel burnt = less emissions (local and global).

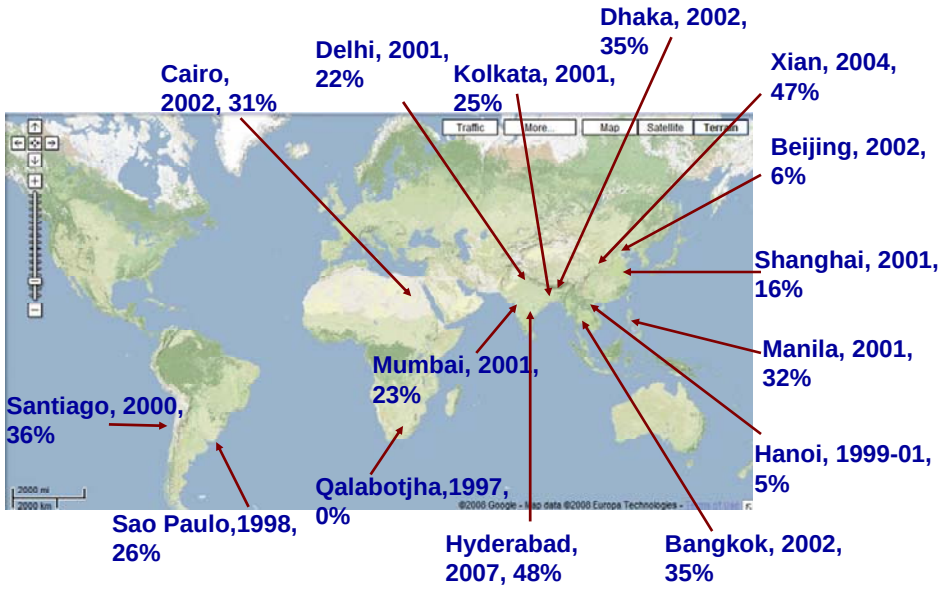


Figure 2: Summary of source apportionment results, presenting the year of study and share of transport to measured ambient air quality[8]

With the growing awareness for clean air[9], besides the pressure to support the infrastructure needs, priority will shift to air pollution and then the global GHGs. However, this shouldn't suggest that the concept of low carbon society takes the second seat. The interventions that cities are trying to implement, ranging from improving public transport (road and rail) or promoting non-motorized transport, the benefits for local and global pollutants and sustainability are mutual.

This paper is intended to present an overview of control measures for air pollution and GHG emission reductions.

[7] Impact of idling in Pune City, http://suvratk.blogspot.com/2008/07/my-five-minutes-of-fame-as-citizen.html

[8] Guttikunda, S. K., and Johnson, T., et al, 2008, Handbook of Source Apportionment Techniques and Results, The World Bank, Washington DC, USA – http://www.urbanemissions.info/pmsa

[9] Clean Air Initiative for Asian Cities – http://www.cleanairnet.org

Control Measures for Local Air Pollutants & GHG Emissions Control

It is difficult for city managers to address air pollution and GHG emissions reductions 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 policy, technical, economic, and institutional management options listed in **Table 1**.

Table 1: Categorized array of control measures for decision makers

Policy & Legal	Technical	Economic	Institutional
Urban planning	Cleaner technologies	Taxes	Monitoring
Industrial zoning	End of pipe control	Pricing	Emission
Residential zoning	devices	Charges	standards
Energy efficiency	Fuel improvements	(congestion)	Fuel standards
Traffic management	Cleaner production	Fines for	Inspections
Public transport		violations	Enforcement
Non-motorized		Subsidies	Maintenance
transport		Tradable permits	Capacity building
Environmental law			Knowledge base
Compliance			Awareness

There is no single measure on its own that will realize the full attainment of the co-benefits objectives and so packages of measures will need to be deployed. Measures can be technological (e.g. fitting pollution abatement technologies to road vehicles and industrial processes) as well as measures designed to change behaviors (e.g., smarter choices, traffic management measures, incentives for cleaner vehicles and road pricing).

Road transport is a key source and the two main trends in the transport sector working in opposite directions are (1) new vehicles becoming individually cleaner in response to emission standards legislation but (2) total VKTs are increasing. Promising areas of improved co-benefits are (a) introduction of an effective inspection and maintenance program for all types of vehicles, starting with passenger cars and motorcycles (b) improving the quality of fuel by decreasing the sulfur content of diesel to reduce SO_2 emissions – a precursor to secondary PM (c) introducing stricter regulations against fuel efficiency of the vehicles on the supply side of the road transport (d) promoting public transport and increasing access to public transport via infrastructure development for bus rapid transport and metro rail systems and last but not the least (e) promoting non-motorized transport in the cities by building walkways and bikeways.

In case of public transport, bus rapid transport (BRT) is a growing trend[10]. The cities of Bogata and Curitiba are revered examples for BRT[11] and while Latin America cities have been the BRT pioneers, the technology is spreading to the rest of the world. **Table 2** presents a list of cities currently operating or preparing to implement BRT systems in Asia. While the BRT is effective in improving the traffic conditions and creating opportunities to shift people

[10] Bus Rapid Transport Center - http://www.gobrt.org/whatis.html

[11] BRT systems in Latin America - http://thecityfix.com/brt-systems-in-latin-america/

from personal to public transport, one should consider if by just increasing the bus fleet and improving the inspection and maintenance program might create the same opportunities. This distinction and understanding of the local needs is necessary and might be cost effective, if an informed decision is made by the stakeholders. There is a lot of interest in this intervention, due to its appeal to the politicians and the public, but it is important to better understand the system for effective and speedy implementation[12], especially to avoid the failures of Delhi, India (2008)[13] [14].

Table 2: Bus Rapid Transit in Asia[15]

Systems in Operation (17)		Systems in Planning (37)			
Akita, Japan	Ankara, Turkey	Ahmedabad, India	Jaipur, India Mysore, India	Bangkok, Thailand	T'ainan, China
Fukuoka, Japan	Jakarta, Indonesia	Bangalore, India	Pimpri-Chinchwad, India	Chiang Mai, Thailand	Tienjing, China
Gifu, Japan	Kunming, China	Bhopal, India	Rajkot, India	Colombo, Sri-Lanka	Wuhan, China
Kanazuwa, Japan	Beijing, China	Surat, India	Karachi, Pakistan	Shenzhen, China	Wuxi, China
Miyazaki, Japan	Hangzhou, China	Vijaywada, India	Incheon, South Korea	Shanghai, China	Xi'an, China
Nagaoka, Japan	Shijiazhuang, China	Vizag, India	Surabaya, Indonesia	Shenyang, China	Xiamen, China
Nagoya, Japan	Taipei,China	Delhi, India	Makati City, Philippines	Jinan, China	Chengdu, China
Nigata, Japan	Seoul, South Korea	Hyderabad, India	Metro Manila, Philippines	T'aichung, China	Chongqing, China
Pune, India		Indore, India	Metro Cebu, Philippines	Huai'an, China	Guangzhou, China

Among the fuel substitution options, liquefied petroleum gas (LPG) and compressed natural gas (CNG), appears to be a relatively wide-scale method of reducing local pollution in the transport sector, provided availability of the necessary infrastructure to supply and administer at larger scales. LPG is primarily suited to cars and small petrol vehicles and is currently in use by at least ~50% of the 3-wheelers in urban India, after they are retrofitted from petrol base. The CNG is suited for light duty trucks and heavy duty buses in the public transport, but the supply chain is limited. The Delhi transport corporation[16] operates the largest CNG based bus transport system in the world. Other cities like Hyderabad (India) are trying to replicate the CNG conversion, but the availability is a growing issue. Currently five public transport buses are in testing phase with a supply of 3 tankers of CNG every day from filling stations in Vijayawada (India). Similar initiatives are in planning stages for cities like Hanoi (Vietnam), Kathmandu (Nepal), and Lahore (Pakistan). With these alternative fuels, the cost benefits are mainly applicable where high mileages are the norm. These are infrastructure dominated measures to ensure supply and distribution and needs long term feasibility studies.

Hybrid vehicles are still in the beta stage, with dual fuel cars and 3-wheelers, and some electric bikes. The proportional saving of energy (more mpg) is truly green. If optimistic, perhaps the hybrid cars will start an alternative approach to transport, increasingly using efficient electrical motors, as seen among a small fraction of motorcycles[17].

[12] Taxonomy of Delhi and Sao Paulo BRT - http://thecityfix.com/towards-a-better-brt-taxonomy/

[13] Delhi BRT, as good as scrapped - http://www.itdp.org/index.php/news_events/news_detail/brt_as_good_as_scrapped/

[14] Delhi BRT trial stirs public furor - http://www.itdp.org/index.php/projects/update/delhi_high_capacity_bus_trial_stirs_public_furor/

[15] Source: Modified from presentation by Dr. Cornie Huizenga, Executive Director, CAI-Asia, Manila, Philippines

[16] Delhi Transport Corporation with ~3100 CNG buses - http://dtc.nic.in/

[17] Environmental impacts of E-Bikes in China - http://www.its.berkeley.edu/publications/UCB/2007/VWP/UCB-ITS-VWP-2007-2.pdf

Table 3: Local and global: Synergies and conflicts for transport sector[18]

Local intervention	Synergy with global concerns	Conflicts with global concerns
Introducing CNG or other alternative liquid fuels	CNG was introduced for in Delhi, Beijing, and Bangkok for air pollution control. CNG or propane vehicles emit less PM than conventional vehicles.	Leakages of un-burnt CNG may increase eCO_2 emissions in heavy-duty engines.
Introducing low-sulfur diesel	High-quality and low sulfur diesel fuel may help reduce CO_2 emissions if additional CO_2 emissions at refineries do not offset such gains.	
Promoting electric and hybrid vehicles	Electric vehicles have no tailpipe emissions, including all air pollutants and CO_2.	Electric and hybrid vehicles have compromised-driving performance and are expensive. The CO_2 benefits depend on the fuel mix of electricity generation (via LCA).
Introducing emissions/fuel efficiency standards for vehicles	Standards help to reduce local air pollutants and CO_2 emissions per vehicle-km (by type or size).	If VKT of individual vehicles increases or if people switch to vehicles with bigger engines, the total eCO_2 will increase, although the individual standards are met.
Promoting mass transport and discouraging use of private cars	By improving overall energy performance; reducing congestion; and reducing fuel use, this measure reduces CO_2 emissions.	Inefficiency in operation of mass transport systems tend to reduce their occupancy and promote private modes of transport; the gain may be less than expected.
Introducing reformulated gasoline	Reformulated gasoline can help reduce smog, VOC, and toxic air pollutant emissions.	Reformulated gasoline compromises with fuel economy nominally by 1 or 2%; therefore, CO_2 might increase.
Biofuels (ethanol blended gasoline or biodiesel)	Biofuels can reduce eCO_2 emissions.	Some conflicting studies have reported an increase in eCO_2 emissions in their life cycle assessments.
Inspection and Maintenance systems; driver behavioral training	This measure improves fuel efficiency of the vehicle; thereby reducing CO_2 emissions.	Rebound effects need to be monitored
Congestion pricing and traffic management	Reduces congestion and idling; discourages car use; results in fuel savings;	However, the exact impact on eCO_2 emissions is unknown.

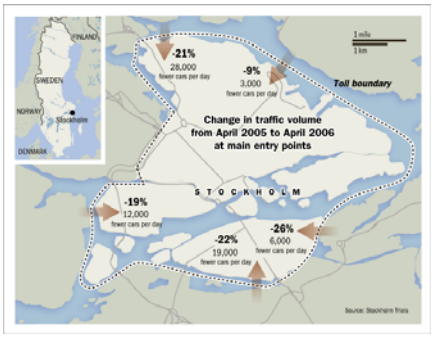
Among the non-road transport interventions, the fugitive dust due to entrainment is a major source of air pollution. This intervention is for 100% local benefits. In the past, the city officials have piloted heavy machinery sweepers followed by wet sweeping to control the dust loading on roads, which are operated at the night time[19].

[18] Source: Modified from presentation by Dr. Dhakal, at Better Air Quality 2006, Jogjakarta, Indonesia – www.baq2006.org

[19] Dust Busters @ CAI-Asia - http://www.cleanairnet.org/caiasia/1412/article-58207.html

Congestion pricing[20] in the urban centers is among the first of economic measures and successfully implemented in the cities of Singapore (Singapore), London (UK) and Stockholm (Sweden)[21]. Congestion pricing is the practice of charging motorists to use a roadway, bridge, or tunnel during periods of the heaviest use. Its purpose is to reduce automobile use during periods of peak congestion, thereby easing traffic and encouraging commuters to walk, bike or take mass transit as an alternative. It is important that city provides for the alternative transport modes before implementing this measure. On an average, in London, congestion pricing is expected to reduce 20-30% of the downtown passenger car traffic and promote the non-motorized transport[22]. In Singapore, the average traffic speed increased by at least 10 mph. In 2006, Stockholm experienced an immediate reduction of at least 20 percent in the daily car use[23]. In all three cities, a reduction in eCO_2 emissions between 10 to 20 percent is expected, along with health benefits of reducing the local pollutants. Economic instruments like congestion pricing have been successful in these cities for one important reason - the cities operate a widely accessible public transport system which can support the shift to car-free transport. The public transport is still in its infancy (at the levels comparable to developed countries) in Asian cities and the social and economic structure of the cities is a barrier yet to cross for effective implementation of this option.

Stockholm, Sweden



London, UK

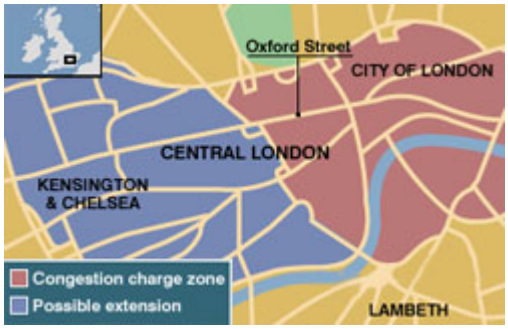


Figure 3: Congestion pricing zones in Stockholm and London

In the **industrial sector**, the energy efficiency of fuel combustion[24], especially coal and diesel, is vital. The industrial sector and (to some extent) the domestic sector uses substantial amount of diesel and bunker fuel for alternative power using generator sets. The mix of fuels range from wood to coal to oil to other biomass and some unconventional sources. With the energy demand in the industrial sector rapidly growing, strict implementation of energy efficiency will have a significant influence on local and global emission levels[25].

[20] More on road pricing on Wikipedia @ http://en.wikipedia.org/wiki/Road_pricing

[21] Stockholm congestion pricing scheme reducing 25 percent traffic in one month - http://www.edf.org/page.cfm?tagID=6241

[22] London's two wheel transformation and congestion pricing - http://www.guardian.co.uk/uk/2008/feb/09/transport.world1

[23] Stockholm Syndrome by Wall Street Journal - http://online.wsj.com/article/SB115681726625048040.html

[24] The "Energy Efficiency Guide for Industry in Asia" provides a 6-step methodology to improve industrial energy efficiency; case studies with technical information on different energy equipment, training materials, and other tools are available @ www.energyefficiencyasia.org for assistance

[25] The Climate Group, 2008, Energy Efficiency Opportunities - www.breakingtheclimatedeadlock.com

Industrial zoning and land-use planning are also key to reducing the exposure levels. With the city expanding in all four directions, the human exposure to higher pollution levels is expected to increase, and it is important that authorities introduce clear interventions to move the densely packed industries away from the populated areas. And while urban planning, new commercial and residential establishments should consider implications of zoning, and on vehicle traffic and pedestrian movement.

For example, in Delhi (India), a large portion of the industries were relocated to the outskirts at the same time of the CNG bus conversion, which resulted in a coupled effect of reducing the air pollution emissions by at least 30-40 percent. However, while the impact of each of the interventions is unknown, this was effective in reducing the local emissions. It is important to note that anytime there is relocation, the industries are bound to improve the technology in-use and power consumption patterns, which results in the co-benefits of reducing the fossil fuel use and GHG emissions. This was also evident during the Olympic games of 2008, when stricter regulations prohibited half of the passenger cars to travel in Beijing (China) on a daily basis and either relocated or stopped the industrial activity in the city limits[26].

Interventions to substitute unconventional fuels with traditional fuels which can be controlled better are also encouraged. In some of the manufacturing sectors, such as tanning and bricks, it is known to burn unconventional field residues adding to unaccounted local and global emissions. This can also be averted by introducing stricter emissions standards to small and medium scale enterprises followed by periodic inspections and enforcement.

With the real estate booming in Asia, the share of brick and cement industries is increasing and so is the local and global emissions. Today, there are a series of approved CDM mechanisms to support speedy conversions to energy efficient systems and technology to re-use the residual heat and material from the plants[27].

The programs similar to Green buildings in India[28] are increasing in residential complexes, exhibition centers, hospitals, educational institutions, laboratories, information technology parks, airports, government buildings, and corporate offices. The move is opening up new challenges and opportunities for everyone from architects, builders, material, and equipment suppliers to real estate developers, property operators, and individual owners and a way to low carbon society.

The **power plants** are the largest energy consumers in any nation and coal is still the low-cost, per BTU, mainstay of both the developed and developing world, and its use is projected to increase[29]. The pollution though not directly affecting the local ambient levels, due to their release height and dispersion to longer distances compared to ground level sources such as transport and domestic sector, their impact felt at various levels –

[26] China uses games to showcase gains in energy efficiency - http://online.wsj.com/article/SB121624092517259523.html
[27] Cement from CO_2 - http://www.sciam.com/article.cfm?id=cement-from-carbon-dioxide
[28] Indian Green Building Council, http://www.igbc.in/igbc/home.jsp
[29] The future of coal - http://web.mit.edu/coal

particulates, the most emitted on a source basis, SO_2 and NO_x emissions causing regional acid rain and largest GHG emissions[30] leading to climate change.

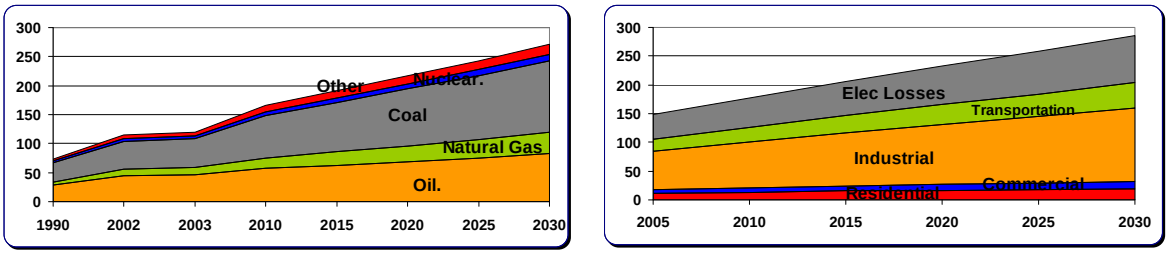


Figure 4: EIA Reference case energy consumption by fuel and sector in Asia (Quadrillion BTU)[31]

In Asia, China is experiencing the most of acid rain episodes, due to bludgeoning power generation industry[32] [33]. In the late 90's, the RAINS-Asia program analyzed this issue and successfully negotiated and suggested series of solutions for the Asian countries[34]. Among the state of the art technology for the power plants, IGCC and combined heat and power (CHP) appears to be the economic choice for new coal plants. The CHP systems are known to produce up to 60-65 percent efficiency compared to 30-40 percent efficiency among the known technology[35] and reduce the electricity generation losses significantly (shown in **Figure 4**). The demand for electricity is predominantly in the urban centers and the proximity of the power plants and coal processing units, makes them one of the largest targets for co-benefits. UNFCCC has also approved a CDM methodology for CO_2 emissions, supporting the power plants implementing newer technology to improve efficiency and cut local and global emissions[36]. The flyash is increasingly being used in the brick manufacturing adding to material savings and economic benefits.

In the **domestic sector**, most often, only the urban residential areas are supplied with LPG. The poor in the slum areas, along the construction sites (the most in the last five years), and partly some restaurants, still use conventional fuels such as coal and unconventional fuels such as biomass and agricultural waste, which is closely related to social behavior. As part of the urban planning, more regulated supplies are required to control this uncertain source of emissions.

In the households, efficient lighting and energy efficient appliances need promotion[37]. IFC led, Efficient Lighting Initiative[38], catalyzed vibrant markets for energy efficient lighting over three years to reduce GHG emissions in seven countries-- Argentina, the Czech Republic, Hungary, Latvia, Peru, the Philippines, and South Africa. One of the success

[30] Global GHG Emissions from various sectors - http://www.ipcc.ch/graphics/graphics/ar4-wg3/jpg/fig-1-3a.jpg
[31] Energy Information Administration - http://www.eia.doe.gov/oiaf/ieo/pdf/ieoreftab_2.pdf
[32] Can coal and clean air co-exist in China - http://www.sciam.com/article.cfm?id=can-coal-and-clean-air-coexist-china
[33] Acid rain and air pollution analysis for China - http://go.worldbank.org/R22KKMM0N0
[34] RAINS-Asia (and now GAINS) Program - http://www.iiasa.ac.at/rains/index.html
[35] Combined heat and power – Evaluating the benefits - http://www.iea.org/Textbase/Papers/2008/CHP_Report.pdf
[36] CDM for fossil fuel power plants - http://cdm.unfccc.int/EB/034/eb34_repan02.pdf
[37] Strong growth in CFL bulbs reduces electricity demand, World Watch Institute - http://www.worldwatch.org/node/5920
[38] Efficient Lighting Initiative (ELI) - http://www.efficientlighting.net/

stories in 2008 is the programmatic CDM methodology for supporting cheaper supply of CFL's in India, undertaken by the Bureau of Energy Efficiency[39]. This program is intended to share the CDM revenues with the public, by reducing the market price of CFL's. A pilot is currently underway, in the city of Vizag (India) to sell CFL for Rs. 15 (~US$0.3)[40].

In the domestic and to some extent in the industrial sectors, the share of renewable energy, in the form of wind and solar power, is slowing increasing. The renewables, which offer a chance to reduce carbon emissions, clean the air, and put our society on a more sustainable footing. This has however brought about the need for technology innovation to lower costs, and requires skilled manpower, especially in the developing nations where technology advancement is limited.

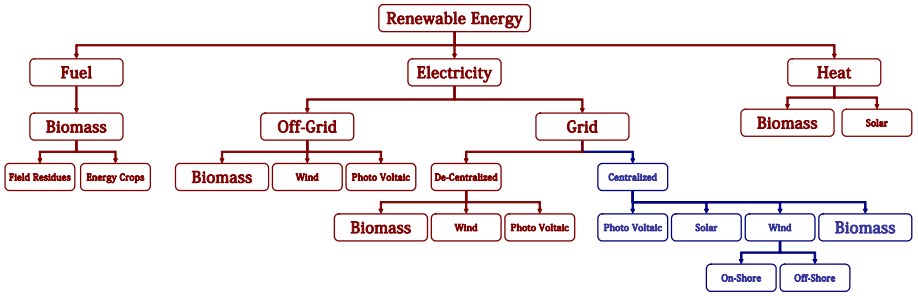


Figure 5: Types of renewables in use at small (local) and large scale[41]

In 2007, more than $100 billion was invested in new renewable energy capacity, manufacturing plants, and research and development[42]. **Figure 5** presents an overview of types of renewable energy in use.

Most common interventions are biomass, wind, and solar, in various capacities for domestic and industrial usage. Interesting point to note is that most of the interventions are local based than large scale projects feeding the electricity grid. The biomass projects like Jatropha in India[43] or African countries[44] have been successfully implemented to cover local energy needs; benefiting the locals from not only reducing their carbon foot print by moving away from the fossil fuels, but also reducing the local problems such as indoor[45] and outdoor air pollution.

Also the solar and PV installations have been successful at small scale and primarily at the rural level, benefiting electricity needs, water heating, and some cooking[46]. The city of Rizhao (China) was declared the first carbon neutral city this year, using solar water heaters

[39] CDM for CFL's by Bureau of Energy Efficiency, India - http://www.bee-india.nic.in/

[40] CFLs At Rs 15 In Visakhapatnam - http://www.india-server.com/news/cfls-at-rs-15-in-visakhapatnam-4111.html

[41] Source: Modified from presentation by Dr. Shukla, for the open symposium on, Developing Visions for a Low-Carbon Society Through Sustainable Development, Tokyo, June 13, 2006

[42] REN21, 2008. Renewables 2007 Global Status Report, GTZ Publications

[43] Jatropha in India, http://www.jatrophabiodiesel.org/ and Indian railways investing in Jatropha - http://tinyurl.com/6ny4o3

[44] Jatropha in Africa, http://www.ecoworld.com/home/articles2.cfm?tid=367

[45] Cleaning up indoor air with human waste in China, - http://www.sciam.com/article.cfm?id=smoky-home-cleaning-up-indoor-air

[46] Solar Cities: Habitats of Tomorrow - http://sc.ises.org/;
Solar (and Sustainable) Cities - http://www.martinot.info/solarcities.htm

and small scale bio-digesters[47]. The Worldwatch report states, "*the fact that Rizhao is a small, ordinary Chinese city with per capita incomes even lower than in most other cities in the region makes the story even more remarkable*"[48]. Wind energy is one of the largest growing renewable energy sources feeding the grid – on-shore[49] and off-shore[50].

In the developing countries, the **indoor air pollution** is a primary health hazard. Main interventions in place to check this problem include provision of improved cooking stoves, kitchen designs with proper ventilations, and some innovative technological options such as solar heaters and cookers. Similar to the transport sector, if the efficiency of the stove burning is improved, the fuel burnt will less and hence less exposure to the pollutants and less GHGs produced.

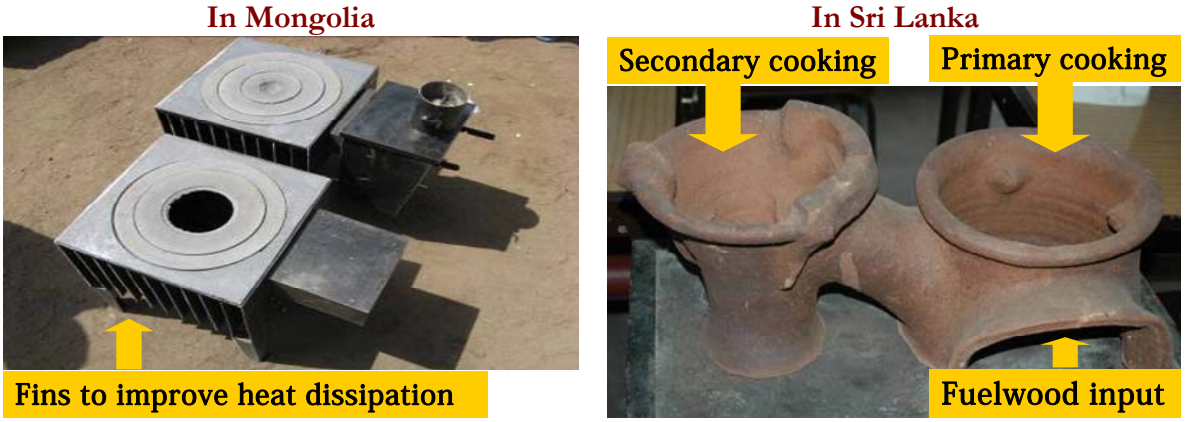


Figure 6: Improved stove designs in use

In **Mongolia**, the interventions put in place are expected to derive co-benefits to the largest extent. Especially, the improved stoves introduced under the global environmental facility program, are expected to deliver at least 20 percent reductions in the coal and wood usage. The results are published as part of the ESMAP knowledge series[51]. In 2006, with more than 120,000 households using at least 5 tons of coal per year, results in reduction of 120,000 tons of coal usage, equivalent of ~24,000 tons of CO_2 per year – a co-benefit and way to low carbon society. This analysis[52] focuses more on the outdoor air pollution, but the indoor air pollution is as important and the improved stove was effective in reducing these affects significantly[53].

In 2008, the EBRD is spearheading a project to help over 140,000 households in Ulaanbaatar switch from using the high polluting raw coal that swathes parts of the capital in smog for six months a year to clean coal[54]. The short term actions such as installing solar

[47] Sunrise in first Carbon neutral city - http://www.sciam.com/article.cfm?id=sunrise-on-chinas-first-carbo-neutral-city
[48] The Worldwatch report - http://us.oneworld.net/article/view/149798/1/
[49] China's Wind Power Development Exceeds Expectations, World Watch Institute - http://www.worldwatch.org/node/5758
[50] http://ecoworld.com/blog/2008/10/17/re-powers-50-megawatt-offshore-windturbine/
[51] IAP in Cold Climates and Stoves, ESMAP knowledge series – http://www.esmap.org
[52] Urban air pollution analysis for Ulaanbaatar, Mongolia – http://www.urbanemissions.info
[53] ESMAP, 2005, Impact of improved stoves on indoor air quality in Ulaanbaatar, Mongolia – http://www.esmap.org
[54] Clean coal initiative in Mongolia by EBRD - http://www.ebrd.com/new/pressrel/2008/081023a.htm

panels, introducing efficient stoves, education and awareness of kitchen ventilation are less capital intensive and while they require mobilization at the user level, are relatively easier to implement and beneficial for indoor and outdoor pollution control.

In 2008, **Cambodia** became the first carbon trading cooperative[55] for the stoves program, which is very encouraging for the other developing countries to follow. The Geres Climate Change Unit, responsible for putting the program together says it is an example of how a small-scale, not-for-profit project can break into the carbon credit market and lead to not only reducing the indoor air pollution by fuel savings, but also carbon benefits.

A similar program in **Sri Lanka**, introduced a stove called "Anagi" by a local NGO called IDEA[56]. They improved from the local 3-stone stove to a design using flue gas for secondary burning. This stove sells for a very reasonable cost with a 2 year life time and is expected to provide at least 30 percent reductions in the fuelwood used for cooking. A methodology to cash in on these reductions of renewable biomass like fuelwood is under works and looking forward to replicate the success stories of Cambodia.

One of the serious measures which need immediate attention is the biomass **waste burning** at the landfills, roadsides, and residential areas. It is a common site in the fall time when the fallen leaves are swept and put to fire; throughout the year piles of rubbish at residential curb sites put to fire, emitting unprecedented amounts of particulates and other carcinogenic emissions. A complete ban of this activity is a must. With the introduction of CDM methodologies[57], waste to energy programs[58] either by incineration or methane capture is gaining ground over traditional energy sources for in-situ use.

Lastly, among the non-measures, an important aspect of policy planning is **knowledge base management**. In order to make informed choices amongst this bewildering array of options discussed above, decision-makers need to be able to analyze these options from an environmental, economic, social, political, and economy viewpoint. This approach is effective in brining together interdisciplinary stakeholders and collecting knowledge from a large pool of decision makers and end users. All this requires flexible analysis frameworks to evaluate options as they emerge, which, in turn, need substantial quantities of relevant information on various aspects of emissions and characteristics of management options.

[55] Cooperative CDM program for Stoves in Cambodia - http://www.phnompenhpost.com/index.php/2008091621686/National-news/Cambodia-pioneering-world-s-first-carbon-trading-cooperative.html

[56] Anagi stove in Sri Lanka - http://www.bioenergylists.org/en/node/670

[57] UNFCCC approved CDM methodologies - http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

[58] Waste to Energy programs - http://en.wikipedia.org/wiki/Waste-to-energy

Operationalizing Co-Benefits Framework

A successful strategy to address air pollution and GHG emissions will and should include a combination of short term and long term solutions.

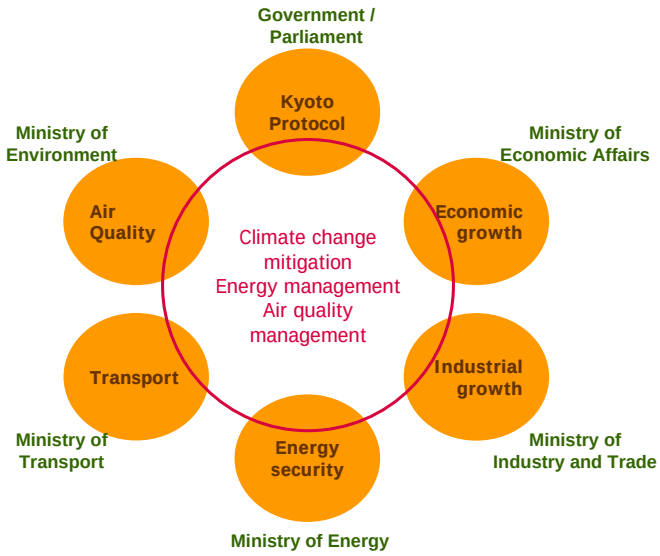


Figure 7: Policy and institutional integration to achieve co-benefits[59]

Operationalizing the idea of co-benefits will require specifying which **institutional arrangements** will be employed and which incentive structures will be established to reap said benefits. Unfortunately, integrating among the multi-stakeholder network (presented in **Figure 7**) in any city that respond to these questions presents yet another challenge. This challenge arises, in part, from the fact that environmental goals are interdisciplinary with varying levels of impacts. Some measures require international agreement, for examples the measures targeting the GHG emissions, while the others can be more determined at national or local level.

The study "Urban Air pollution in Asian sities" jointly conducted by the Clean Air Initiative for Asian Cities (CAI-Asia), Stockholm Environment Institute (SEI) and the United Nations Environment Programme (UNEP) ranked cities for information available and their decision making capacity[60]. This capacity in Asia needs immediate strengthening and the efforts to address local and global emissions in a co-benefits framework.

[59] Source: Modified from presentation by Dr. Cornie Huizenga, Executive Director, CAI-Asia, Manila, Philippines

[60] Schwela, et. al., 2006. Urban Air Pollution in Asian Cities: Status, Challenges and Management. Earthscan Publications, UK

Recommendations

Some policy recommendations:

- The interaction of policies and knowledge base to better understand the air pollution and climate change have not been sufficiently investigated[61]. Policy research aimed at clarifying the synergies and trade-offs in this field could help to develop instruments that work both ways[62] [63].
- Local circumstances, both physical and socio-economic, should be taken into account when addressing problems. The level of technical development, possibilities for financing, and the energy intensity of the economy are important factors determining the effectiveness of measures.
- Policy harmonization could be maximized by choosing the **most promising options**.
- With the growing awareness of linkages between black carbon (component of PM) and climate radiative forcing [64], inclusion of all possible synergies with interchangeable credit system for air quality and climate mitigation will be beneficial at local and global level[65].
- Indoor air pollution is a policy area in its own right and tightly linked to poverty alleviation policy[66]. Any intervention here is meant to produce co-benefits.
- Low carbon society is not an obstacle to economic development, especially if it is combined with air quality policy. This paper demonstrates that there is sufficient common ground for policy integration, leading to benefits in both fields, and in principle, to broader support for a future regime stretching beyond carbon.

The '**most promising options**' for the relevant sectors, based on co-benefit criteria, cost-effectiveness, long-term contribution to transitions, public and political acceptance, and policy compatibility are:

- Industry -- Reducing energy demand and improving efficiency;
- Energy production -- More efficient fuel conversion, renewable energy;
- Transport -- Fuel switch to CNG or LPG; increased use of mass transit; vehicle maintenance and scrappage of old vehicles;
- Households -- energy efficiency in cooking stoves, and renewable or cleaner energy for cooking and lighting;

Point being, for an effective strategy towards a low carbon society, actions need to be customized and addressed at the local level, with local priorities at hand.

[61] Global Atmospheric Forum - http://www.sei.se/gapforum
[62] CURBair – cdm & urban air pollution - http://www.curb-air.org/
[63] Pollution from China's coal casts global shadow - http://www.nytimes.com/2006/06/11/business/worldbusiness/11chinacoal.html
[64] BC pollution emerges as a major player in global warming - http://www.sciencedaily.com/releases/2008/03/080323210225.htm
[65] United States Congress requesting EPA to study the impacts of BC on climate change, Bill HR 7250, October, 2008 - http://www.govtrack.us/congress/billtext.xpd?bill=h110-7250
[66] Indoor air pollution @ WHO - http://www.who.int/indoorair/en/