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# **CNG conversion of motor vehicles: Co-benefits in Dhaka**

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# Background

- Dhaka: capital of Bangladesh
  - A mega-city of 12 million
  - Air quality among the worst
  - Motor vehicles major contributor
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- Significant push from the policy makers to convert motor vehicles to CNG
  - 1 Jan 2003, all 2 stroke 3 wheelers banned in Dhaka
  - All government vehicles instructed to convert





# Benefits

- Climate change benefits
  - Lower CO<sub>2</sub> emissions
  - Lower NO<sub>x</sub> emissions
  - Lower PM emissions => lower black carbon
- Air quality (health) benefits
  - Lower CO emissions
  - Lower NO<sub>x</sub> emissions
  - Lower SO<sub>x</sub> emissions
  - Lower PM emissions
- Energy security benefits
- Economic benefits



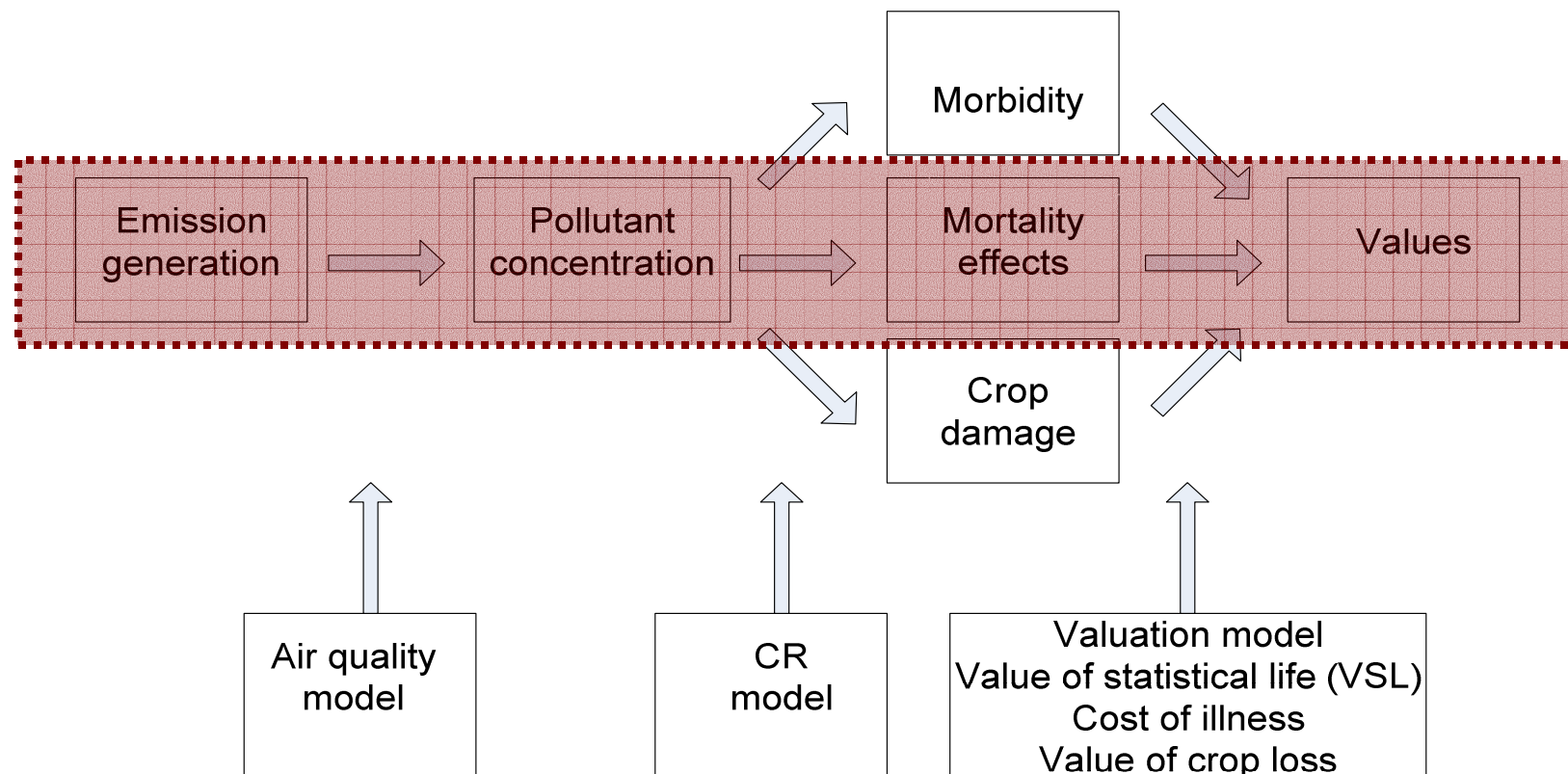
# Climate Change Benefits

- Climate change benefits
  - Lower CO<sub>2</sub> emissions : 25%
  - Lower NO<sub>x</sub> emissions : 35-60%
  - Lower PM emissions => lower black carbon
- Applicable for good conversion/OEM
- Poor conversion: CH<sub>4</sub> leakage
- Can be worse ! (CH<sub>4</sub> higher GWP)
  
- Subjective judgment: no climate change benefit



# Health Benefits: Impact Pathway Model

- Top-down (allocation of national costs)
- Bottom-up (impact pathway) => Better approach

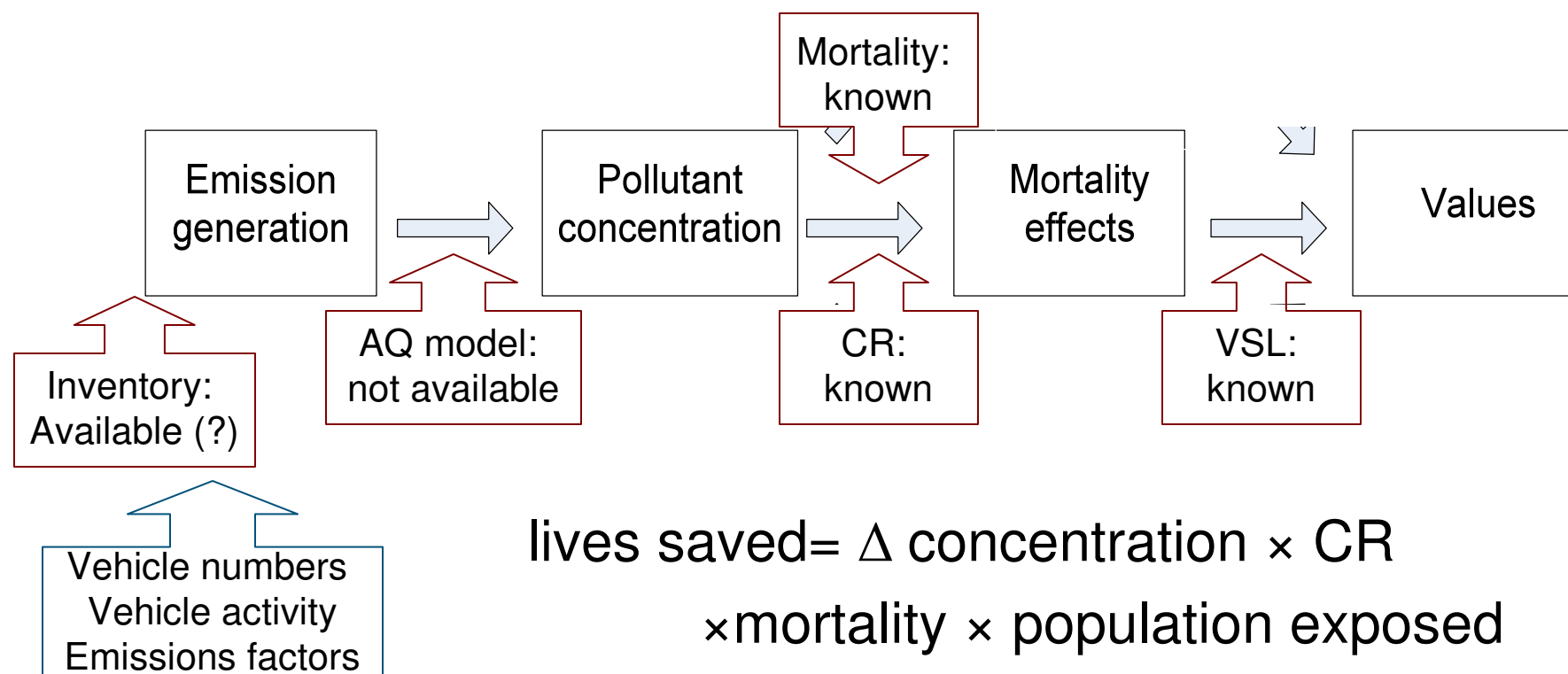


Please do not quote the numbers: results are preliminary only



# Impact Pathway Model: Difficulties

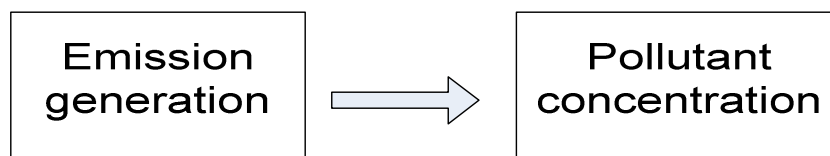
- Two AQ model runs, one with baseline emissions, another with policy emissions
- $\Delta$  concentration = policy effect



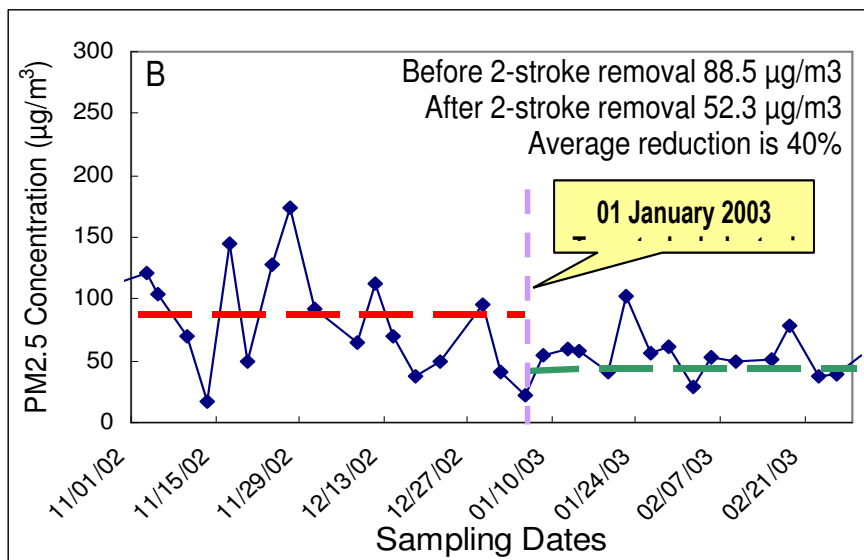
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# Impact Pathway Model: AQ model



- How to relate emissions to concentration directly?
- Prior information on banning 2 stroke baby taxies
- Fine PM mostly due to vehicle combustion



- 40% reduction in PM2.2 concentration
- Roughly 40% reduction in transport PM emissions



# Emissions Inventory/Concentration

- Base emissions factors from World Bank
- Conversion not known for sure
- 80,000 NGV in mid-2007 (IANGV)

## Results

- 9% reduction in direct PM emissions
- $\approx 9\%$  reduction in average PM concentration
- Average PM concentration  $109 \mu\text{g}/\text{m}^3$  in 2007
- $\approx 10.78 \mu\text{g}/\text{m}^3$  change in concentration



## Lives Saved

- CR: 11% increase in all cause mortality 'rate' every 10  $\mu\text{g}/\text{m}^3$  change in concentration (for adults)
- Cause specific (respiratory and cardiovascular) mortality
  - (WHO-global burden of disease)
- Resp. & card. mortality rate: 6.23 per thousand *adults*
- 8 million *adults* in Dhaka

## Results

- 5390 lives saved (95% CI: 2150-9730)
- USD 5.4 billion @ VSL USD 1 million
- (compare: CO2 benefits !!)

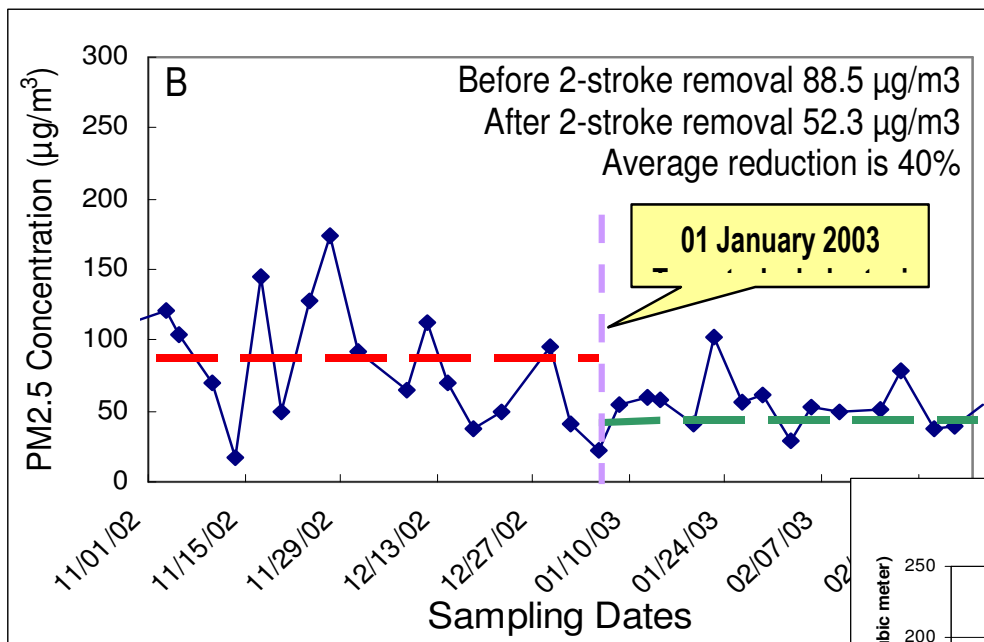


# Uncertainties

- Data, data, data!
  - Air quality data
  - Vehicle activity by vehicle class
  - Emission factors of existing vehicles
  - Emission performance of converted CNG vehicles
  - Numbers converted
  
- Applicability of linear roll back model for air quality
- Linearity of CR function
- VSL
- Assumptions

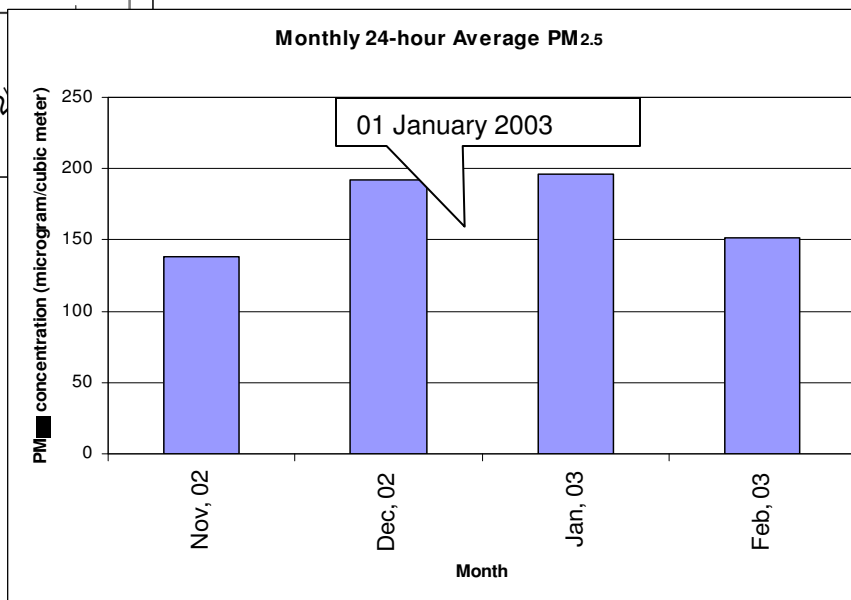


# Uncertainty: Example in AQ Data



PM2.2, BAEC  
40% reduction

PM2.5, AQMP  
No reduction!!





## Uncertainties: Vehicle data

Vehicle types	Vehicle No. % difference	Vehicle activity % difference
Motor Car	16.5	-64.4
Jeep/Microbus	0.1	-68.9
Taxi	13.3	49.4
Bus	17.6	-152.9
Minibus	7.6	-18.0
Truck	-7.7	-64.4
Auto-rickshaw	-155.5	-9.6
Motorcycle	-9.5	-27.9
Others	1.3	-80.8
Total (w/ bikes)	-4.2	
Total	-1.3	

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# Uncertainties

- Data, data, data!
  - Air quality data
  - Vehicle activity by vehicle class
  - Emission factors of existing vehicles
  - Emission performance of converted CNG vehicles
  - Numbers converted
- Average concentration reduction could be less
- Applicability of linear roll back model for air quality
- PM<sub>2.5</sub> Emissions has been increasing...why?
- Linearity of CR function
- VSL



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# Costs

- Infrastructure costs
- Conversion costs
- Congestion costs!
- Cost of poor quality conversion



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# Future Work

- Very much an ongoing work
- Secondary PM ?
- Examine data and identify key gaps
- Economic cost-benefit analysis at full conversion
- Develop a policy tool
- Quantify uncertainties
- VSL in developing countries (SP survey?)



## Main Finding

- Around 5400 lives saved (USD 5.4 billion worth)
- Possibly more at the end of full conversion
- Quantifying health benefits vital to transportation project's cost benefit analysis
- Focus on carbon financing could be misleading
  
- Beware of the numbers, lots of uncertainties
- Explicitly specify the uncertainties as well as possible



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Thank You

Please do not quote the numbers yet !!!

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