

**Enstrat International Ltd**



**The Impact of Low and Ultra-low Sulphur Diesel on the Emissions of In-use Diesel Vehicles**

**(Study of Bangalore, Bangkok & Manila)**

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**Project Objectives**

- Calculate the impact of low and ultra-low Sulphur diesel fuels (down to 50 ppm sulphur) on NO<sub>x</sub>, PM<sub>10</sub> and SO<sub>x</sub> emissions of three major Asian cities: Bangalore, Bangkok and Metro Manila
- For each city, simulate the implementation of a broad range of emission control measures, from EURO II to EURO IV or V fuel and vehicle technologies, as well as advanced inspection and maintenance programmes
- Assess the impact of the diesel fuels:
  - a) Alone
  - b) Together with advanced diesel vehicle emission control technologies

**Project Approach and Timing**

- In-use vehicle population and traffic data for each of the 3 cities were collected through reputable local experts:
  - Bangalore --- TERI
  - Bangkok --- PCD
  - Metro Manila --- UP NCTS
- NO<sub>x</sub>, PM<sub>10</sub> and SO<sub>x</sub> emissions for base cases and variant cases were calculated using an emission inventory model for mobile sources, based on the "Average Speed Approach"
- For each pollutant, emissions were estimated from 2000 to 2020
- Status:
  - Project completed in Spring 2004
  - Report issued to JPEC and ADB (the funders) in Summer 2004

**Model Input Used for Emission Calculations**

- Number of vehicles for each major type from 1980 to 2020
- Average vehicle retirement age for each type
- Average annual Kilometers travelled by vehicle type
- Average percent of total annual mileage travelled in urban, sub-urban and urban high-way type of roads for each category of vehicles
- Average speed at which the above Kilometers are travelled
- Speed dependent emission factors from EU-COPERT 3
- Fuel quality

### Base Case Conditions

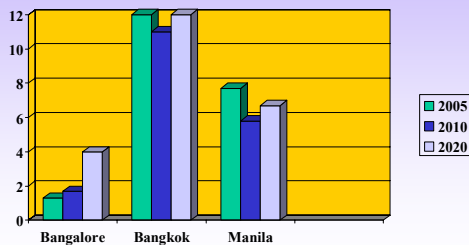
	Diesel Fuel Sulphur, ppm	Diesel Vehicle Emission Control	I&M Schemes (Idle only)
<b>Bangalore</b>	<b>500</b>	<b>Euro I (2000) Euro II (2003)</b>	<b>Yes</b>
<b>Bangkok</b>	<b>370</b> (Typical Value)	<b>Euro II</b>	<b>Yes</b>
<b>Manila</b>	<b>500</b>	<b>Euro I</b>	<b>Yes</b>

### Total Transport (Diesel & Gasoline Vehicles) Base Case Results PM10

City	Level of PM10	Direction of Change	Main Vehicle Source
<b>Bangalore</b>	<b>Lowest</b>	<b>Growing</b>	<b>Gasoline/Diesel</b>
<b>Bangkok</b>	<b>About 50% of Manila</b>	<b>Slight Reduction</b>	<b>Diesel</b>
<b>Manila</b>	<b>Highest</b>	<b>Growing</b>	<b>Gasoline/Diesel</b>

- Gasoline vehicle PM<sub>10</sub> contributions mainly due to m/cycles & 3-wheelers and warrant further study
- For NO<sub>x</sub> and SO<sub>x</sub> Diesel vehicles give a large contribution in all three cities, but:
- Transport gives only a small contribution to overall SO<sub>x</sub> emissions vs. stationary sources

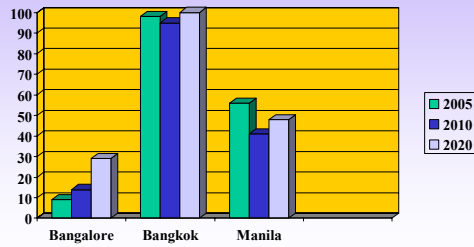
### Base Case Conditions Diesel Vehicles Only - PM10 Emissions, kt/y



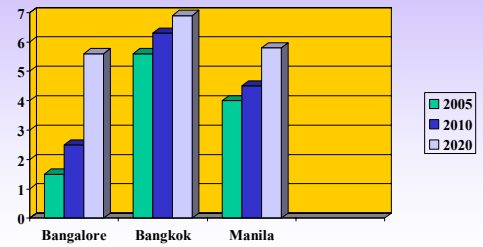
### Most Diesel PM10 is Carbonaceous (Manila – 2005 Example)

	Carbonaceous PM10 Emissions	Sulphate PM10 Emissions	Total PM10 Emissions
<b>kt/y</b>	<b>7.2</b>	<b>0.5</b>	<b>7.7</b>
<b>%</b>	<b>93.5%</b>	<b>6.5%</b>	<b>100%</b>

**Base Case Conditions**  
**Diesel Vehicles Only - NOx Emissions, kt/y**



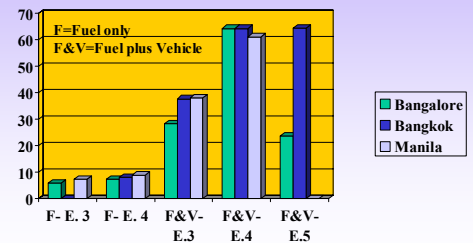
**Base Case Conditions**  
**Diesel Vehicles Only - SOx Emissions, kt/y**



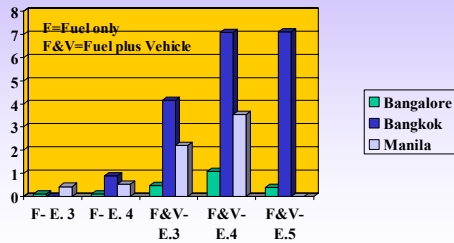
**Emission Control Cases Assessed**  
**for Each City**

- Large combination of potential emission control measures studied for each city
- Improved diesel fuel qualities: EURO III, IV & V
- More stringent vehicle emission control measures: EURO II, III, IV & V
- Advanced Inspection and Maintenance programmes
- The effect of the introduction timing of some of the control measures was also quantified
- Sensitivities studied to cover average speeds, Km driven, high emitters, etc.

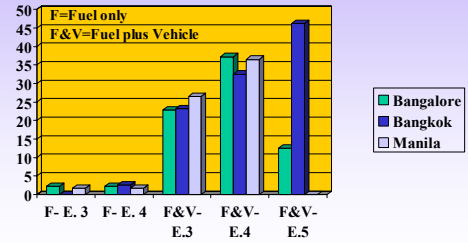
**Diesel Fuel & Vehicle Technology Effects**  
**%PM10 Reduction Vs. Base Case in 2010**



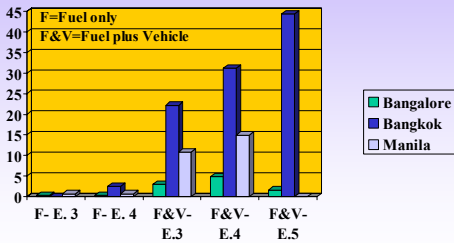
**Diesel Fuel & Vehicle Technology Effects  
kt/y PM10 Reduction Vs. Base Case in 2010**



**Diesel Fuel & Vehicle Technology Effects  
%NOx Reduction Vs. Base Case in 2010**



**Diesel Fuel & Vehicle Technology Effects  
kt/y NOx Reduction Vs. Base Case in 2010**



**Sensitivity Studies**

- Some assumptions made for vehicle fleets and their operation are subject to a certain degree of uncertainty, but can have large impacts on emissions
- Sensitivity cases were studied for traffic speed, number of high emitters in the fleets, annual Km driven by vehicles and turnover and growth rate of the fleets
- Effects of up to 10-25% change in NOx and PM<sub>10</sub> emissions were Found
- In Particular when average traffic speeds slow down (by about 5km/h) vehicle emissions levels of both NOx and PM<sub>10</sub> can Increase by up to 20-25%

**LACK OF ATTENTION TO THESE SENSITIVITIES CAN OFFSET THE EFFECT OF POTENTIALLY COSTLY EMISSION REDUCTION MEASURES!**

### Conclusions

- The implementation in 2005 of Fuel and Vehicle EURO limits **TOGETHER** can achieve very substantial PM<sub>10</sub> and NOx emission reductions in 2010 and 2020
- Fuel effects alone are modest (up to 10%), effective immediately and remain constant over time
- Low Sulphur fuels are most effective if they are introduced to enable the use of new advanced automotive technology
- Automotive technology (EURO II to IV) has a major impact on NOx and PM<sub>10</sub> Emissions with 45% to 65% reduction potential

### Conclusions (cont'd)

- The extent of the reduction depends on the base case conditions and the composition of the diesel vehicle fleets
- Advanced inspection and maintenance systems can give a reduction for NOx and PM<sub>10</sub> of up to 5% and 15% respectively
- Results are directionally consistent but vary with the total transport characteristics of the city

### Where to Find the Complete Report

1. The Complete Report on “The Emission Reduction Potential of Low Sulphur Diesel Fuels in Asian Countries” has already been Published by ADB under <http://www.cleanairnet.org/caiasia/1412/article-58109.html>

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**THANK YOU**

