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CO_2 Emission Reduction from the Power Sector in Selected Asian Countries

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Overview of Presentation

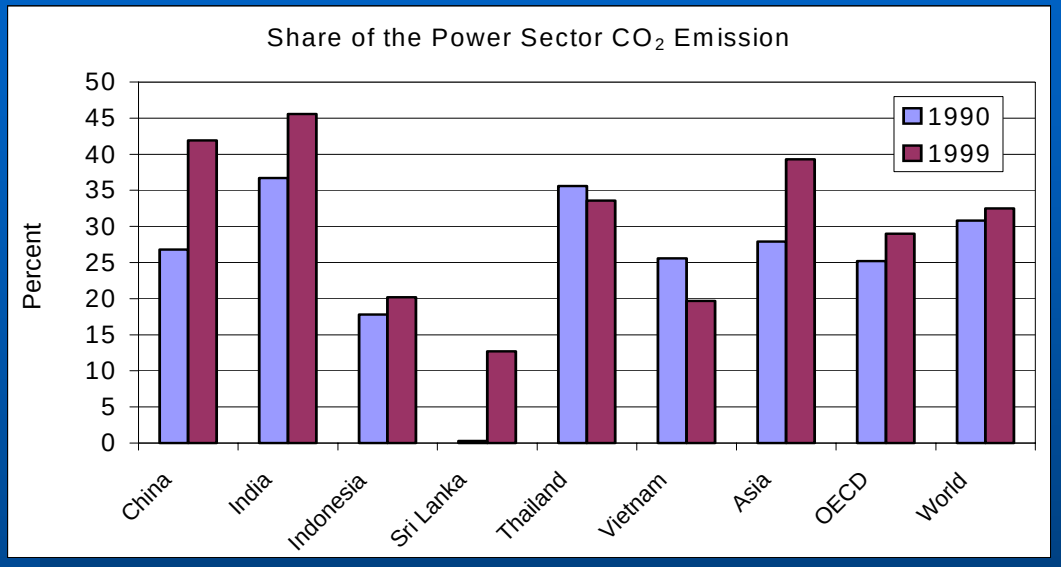
- ARRPEEC power sector project.
- Status of power sector CO_2 emission during 1980-1997.
- Least cost generation options without CO_2 emission targets.
- Least cost generation options under CO_2 emission targets.
- Marginal cost of CO_2 mitigation in selected countries.
- Implications on local/regional environmental emissions
- Conclusions

ARRPEEC -- Power Sector Project: Objectives

- Assessment of least cost supply-side options for mitigating GHG and other harmful emissions subject to emission reduction targets
- Identification of some CDM projects and assessment of their GHG and other harmful emissions mitigation potential
- Assessment of environmental and utility planning implications of Independent Power Producers (IPP) and Decentralized Power Generation (DPG)

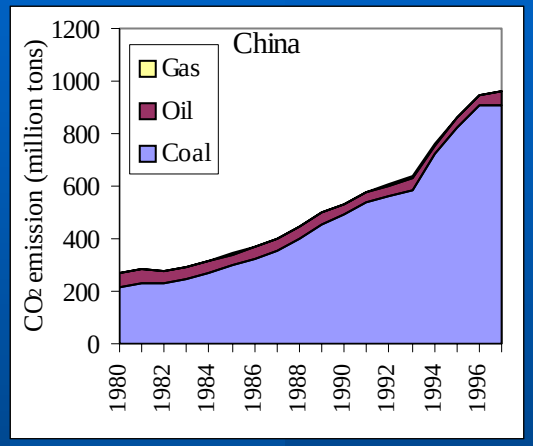
Countries Covered:
Yunan (China), NREB (India), Indonesia, Sri Lanka, Thailand and Vietnam

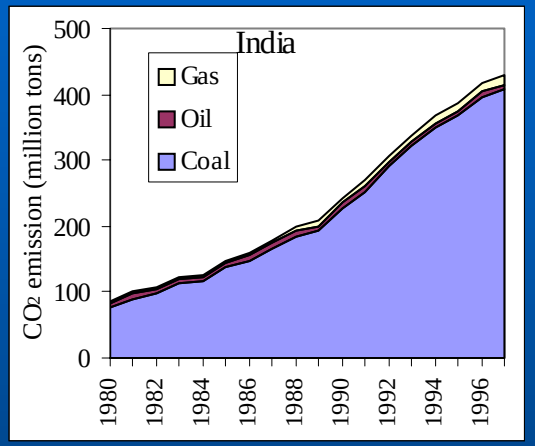
Share of Power Sector CO_2 Emissions (1990-1999)

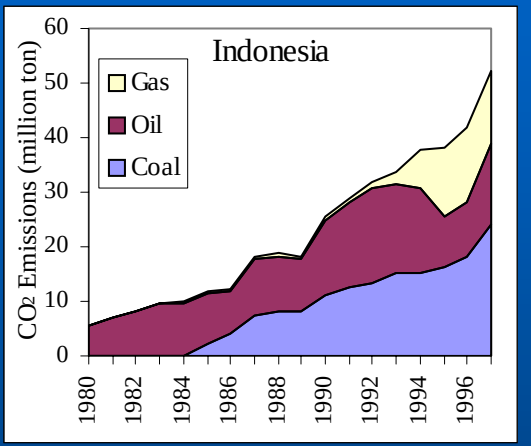


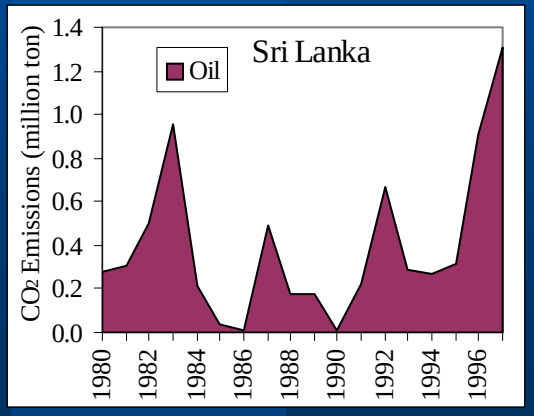
- Power sector's share in total CO_2 emission: 12% in Sri Lanka to over 42% in China and India
- Increase in the sector's share in China, India, Indonesia, Sri Lanka.
- Decrease in the share in Thailand and Vietnam.

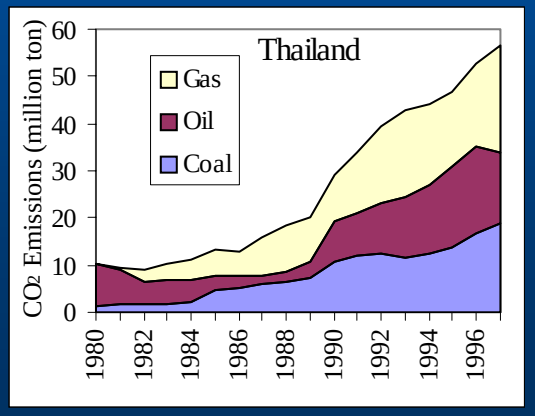
CO_2 Emission from the Power Sector (1980-1997), 10^6 tons

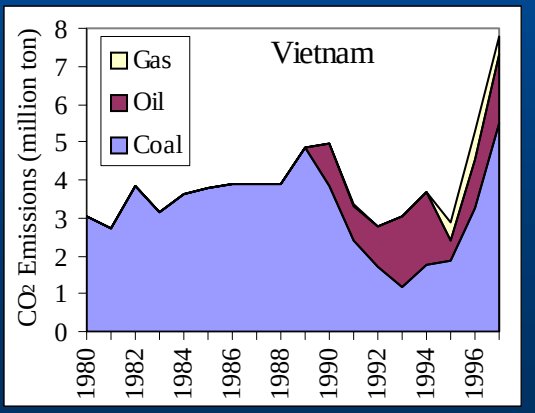




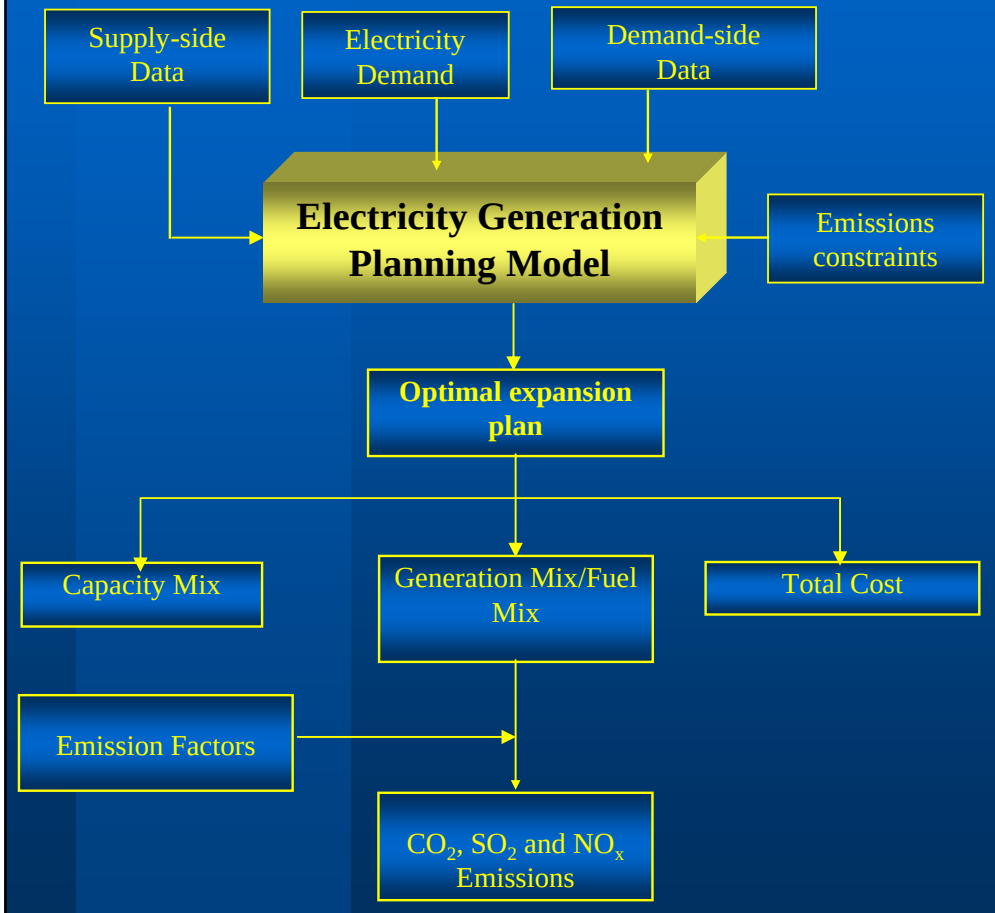








Least-cost Generation Planning Model



Minimize: Total System Costs

(capital + O&M +Fuel + DSM Cost)

Subject to:

- Power demand constraints
- Annual energy constraints
- Hydro-energy constraints
- Reliability constraints
- Fuel or resource availability constraints
- Emission constraints

Candidate Generation Technologies

Region/ Countries	Generation Technology Options		
	Conventional Thermal	Cleaner and Efficient	Renewable
Yunan -- China	Conventional Coal	PFBC	Geothermal, Hydro Solar PV, Wind
NREB -- India	Conventional Coal, Nuclear	Combined Cycle, PFBC, IGCC	BIGCC, Wind, Hydro
Indonesia	Conventional Coal, Combustion Turbine	PFBC	Geothermal, Minihydro
Sri Lanka	Conventional Coal and Oil, Diesel, Combustion Turbine	Combined Cycle, PFBC, IGCC	Wind, Minihydro, Dendro, Hydro
Thailand	Conventional Coal and Oil, Combustion Turbine,	Combined Cycle, PFBC, IGCC	Hydro
Vietnam	Conventional Coal and Oil, Nuclear	PFBC, Combined Cycle	Hydro

Note:

BIGCC = Biomass Gassification Combined Cycle, PFBC = Pressurized Fluidized Bed Combustion,

IGCC = Integrated Gassification Combined Cycle

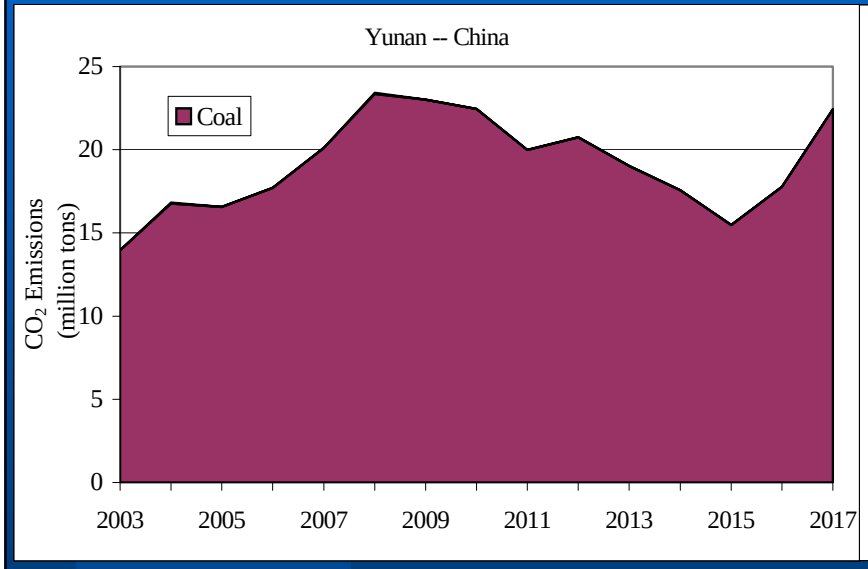
Least Cost Generation Options

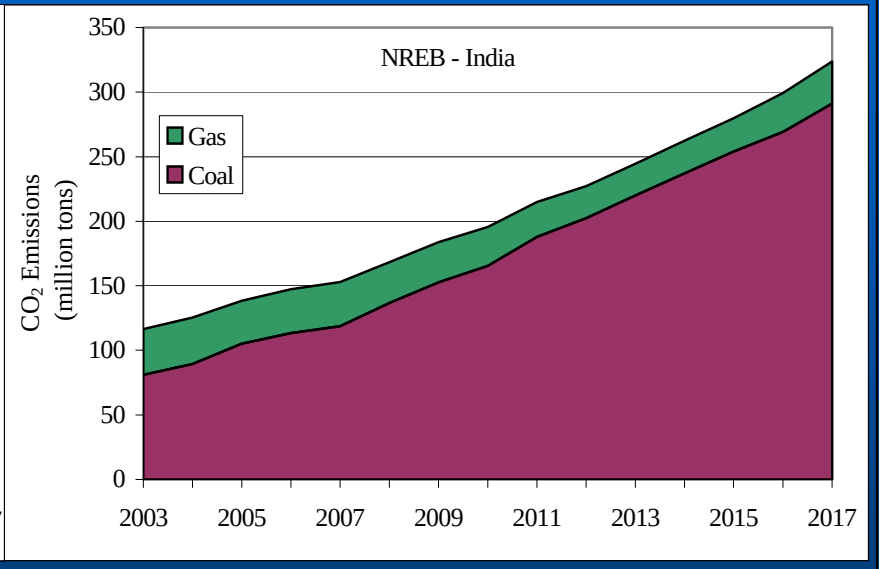
Cost effective generation technologies without CO_2 emission reduction targets

Region/Country	Generation Technology
Yunan -- China	Conventional Coal, Hydro
NREB -- India	Conventional Coal, Combined Cycle, Nuclear, PFBC, IGCC, Hydro, Wind
Indonesia	Conventional Coal, Combined Cycle
Sri Lanka	Conventional Coal, Diesel, Combustion Turbine
Thailand	Conventional Coal, Combined Cycle
Vietnam	Conventional Coal, Combined Cycle, Hydro

- Under the BAU scenario (i.e.without a CO_2 emission reduction target), cleaner, energy efficient and non-hydro renewable electricity generation technologies are not found cost effective in the selected countries except NREB (India).

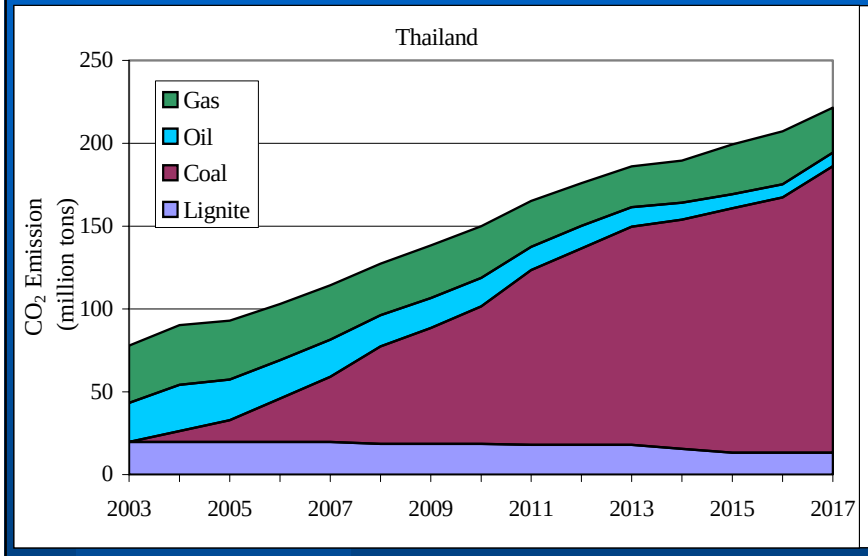
CO_2 Emission during 2003-2017, 10^6 tons

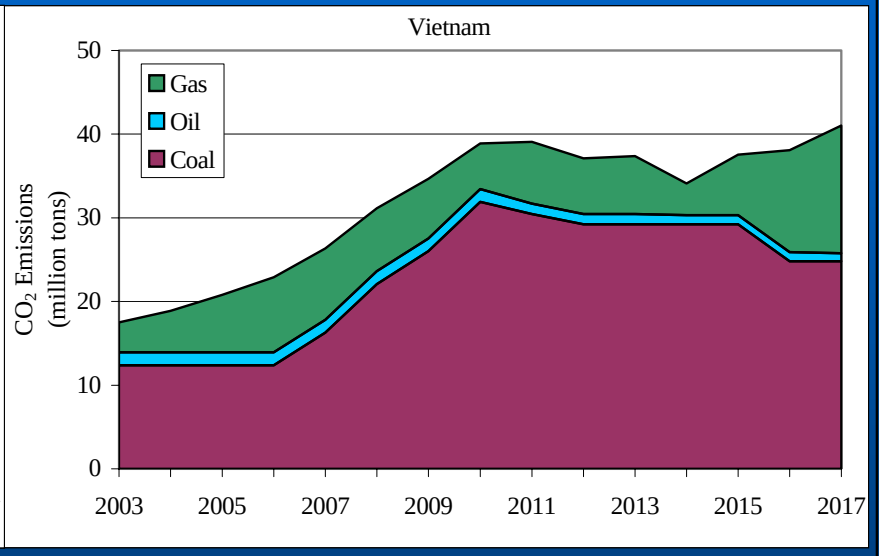




- Yunan Province (China): The power sector CO_2 emission in 2017 would be 1.6 times that in 2003.
- NREB (India): CO_2 emission in 2017 would be 2.78 times that in 2003. Increase in share of coal based generation in the power sector CO_2 emission from 70% in 2003 to 90% in 2017.

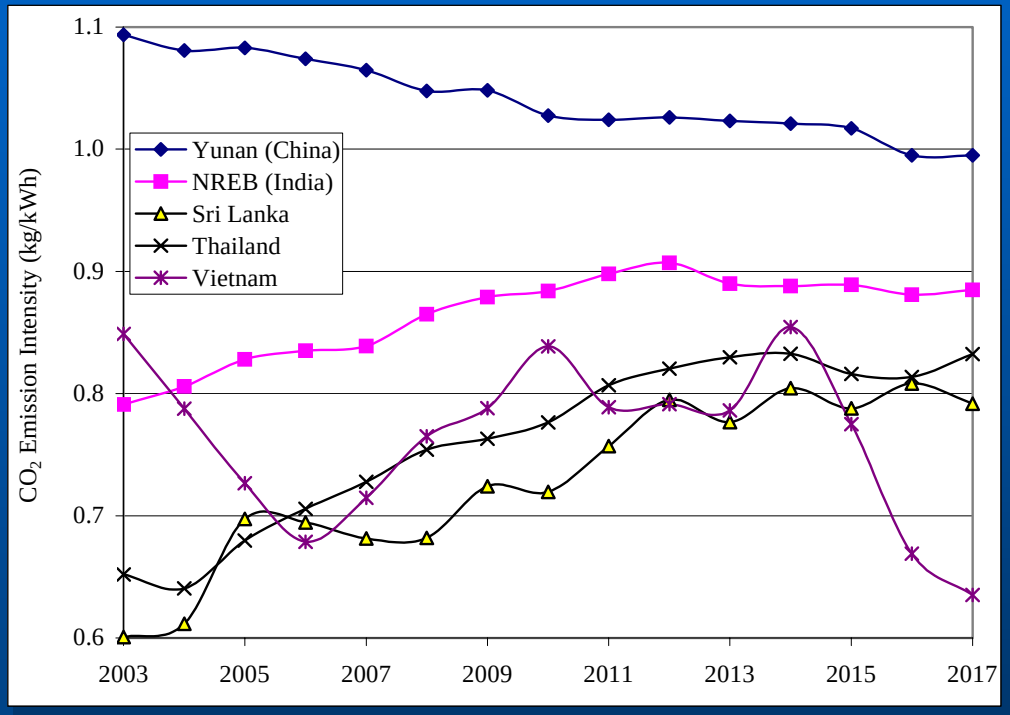
CO_2 Emission during 2003-2017, 10^6 tons (contd.)





- Thailand: The CO_2 emission from the power sector in 2017 would be 2.85 times that in 2003. The contribution of coal based generation in CO_2 emission would increase from 25% in 2003 to 84% in 2017.
- Vietnam: The CO_2 emission from the power sector in 2017 would be 2.34 time that of 2003. The contribution of coal based generation in CO_2 emission would increase from 70% in 2003 to 82% in 2010 and would decrease to 61% in 2017.

CO_2 Emission Intensity during 2003-2017 (kg CO_2/kWh)



- CO_2 intensity to increase in NREB (India), Thailand and Sri Lanka and decrease in Yunan (China)

Least-Cost Options at Selected CO_2 Emission Targets

Cost-Effective Cleaner/Energy Efficient and Renewable Technologies

- Yunan (China): IGCC, PFBC, Wind, Geo-thermal and Solar options selected at CO_2 reduction target of not less than 5%.
- NREB (India): IGCC, PFBC and Nuclear selected even without CO_2 reduction target; BIGCC selected at 5% and higher targets.
- Indonesia: Geo-thermal selected even without CO2 reduction targets.
- Sri Lanka: Wind selected at 10% and higher targets; Dendro at 20% target
- Thailand: Emission targets met by higher share of combined cycle plants; IGCC selected only at 20% reduction target.

Marginal Abatement Costs, $/ton C at 1998 prices

Country	CO_2 Emission Reduction Targets			
	5%	10%	15%	20%
Yunan -- China	11.8	14.3	17.6	NA
NREB – India	6.6	12.5	19.7	NA
Indonesia	11.0	13.8	NA	52.6
Sri Lanka	NA	17.9	NA	23.2
Thailand	15.7	20.7	NA	43.0

Ranges of MAC values:

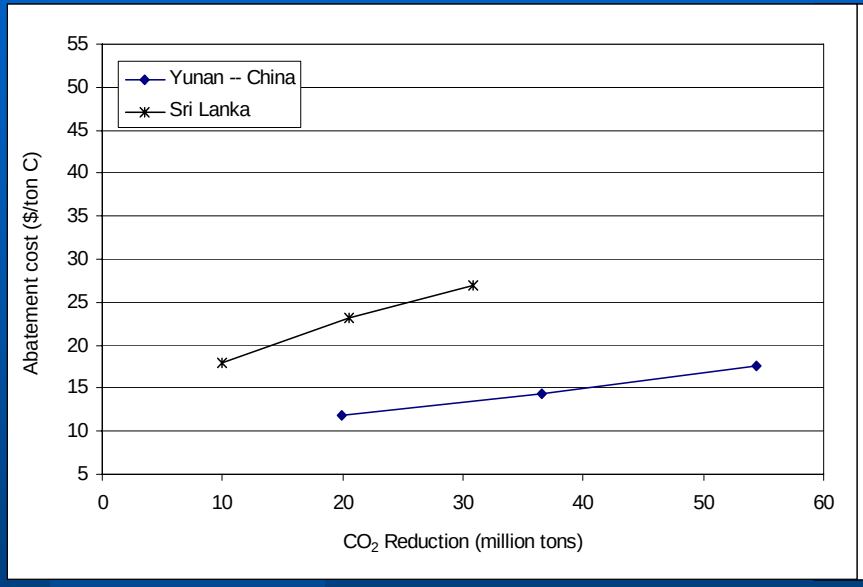
- 6.6 to 15.7 $/ton of Carbon at 5% reduction target
- 12.5 to 20.7 $/ton of Carbon at 10% reduction target
- 23.2 to 52.6 $/ton of Carbon at 20% reduction target

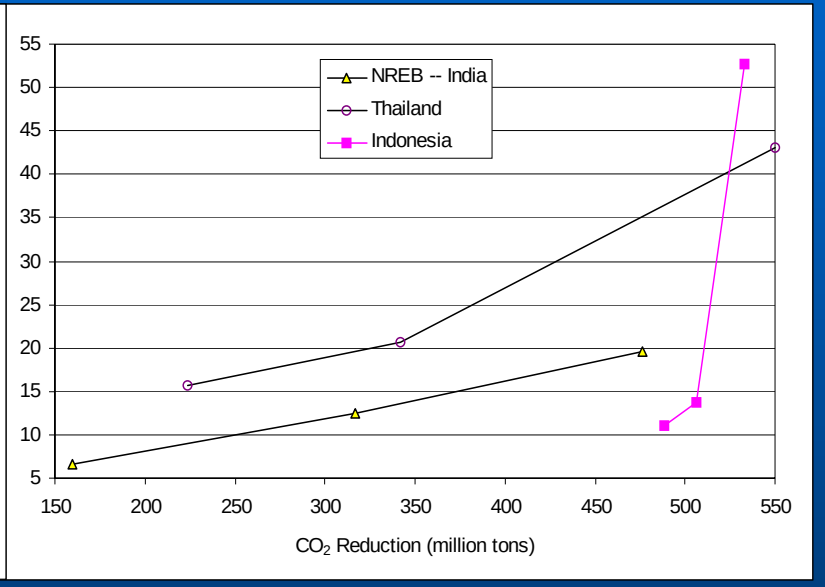
Note:

NA = not applicable

Marginal abatement costs are expressed in 1998 US $.

CO_2 Mitigation ("Supply") Curves

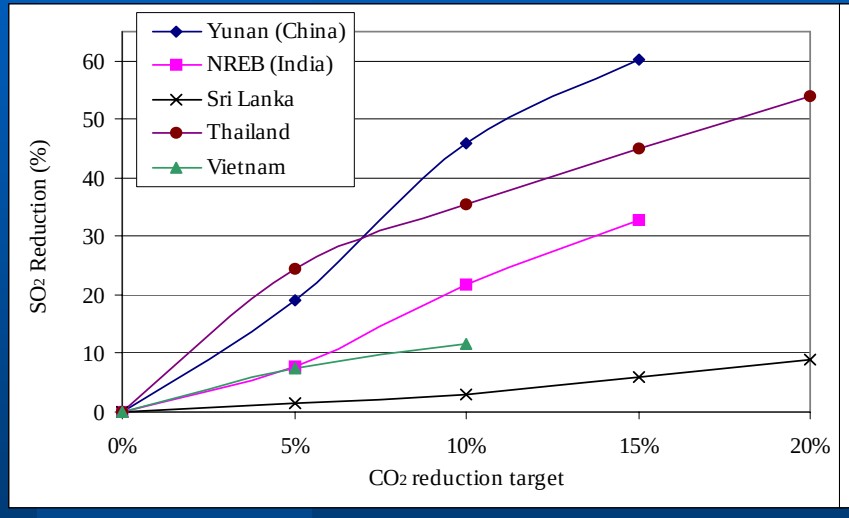




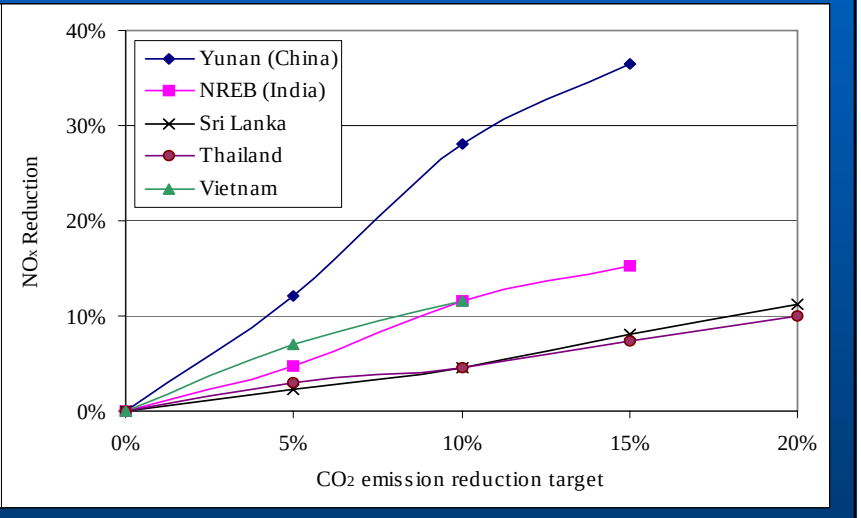
- Cost of CO_2 reduction relatively low in Yunan (China) and NREB (India).
- CO_2 emission reduction during 2003-2017, from Yunan (China), NREB (India), Indonesia, Sri Lanka and Thailand:
  - 1.3 billion tons at MAC of 20 $/ton C or lower.
  - 1.6 billion tons at MAC of 40 $/ton C or lower.
- Estimates of Full Global Trading price of carbon ranges from 22 to 88 $/ton C [Ellerman (1998), Painuly (2001)]

SO_2 and NO_x Emission Reductions

SO_2 Reduction



NO_x Reduction



- Disproportionately large % reduction in SO_2 emission (over 30%) to take place at 15% CO_2 emission reduction target in Yunan (China), NREB (India) and Thailand.
- NO_x reduction by 36% at 15% CO_2 reduction target in Yunan (China).

Conclusions

- At present costs, cleaner/energy efficient and renewable options are not cost effective under the BAU case, except in NREB (India).
- Clean coal technologies would be cost effective at 5% CO2 reduction target in Yunan (China) and at BAU case in NREB (India).
- 1.3 billion tons of CO_2 emission could be cost effectively reduced during 2003-2017 from power generation in Yunan (China), NREB (India), Indonesia, Sri Lanka and Thailand at marginal abatement cost of not more than 20 $/ton C (which less than the estimate Full Global Trading price of 22-88 $/ton C).
- Disproportionately large percentage reduction in SO_2 emission (I.e., over 30%), would take place at 15% CO_2 emission reduction target in Yunan (China), NREB (India) and Thailand.

Thank You