

Power Sector Development and Environmental Emissions in Selected South Asian Countries

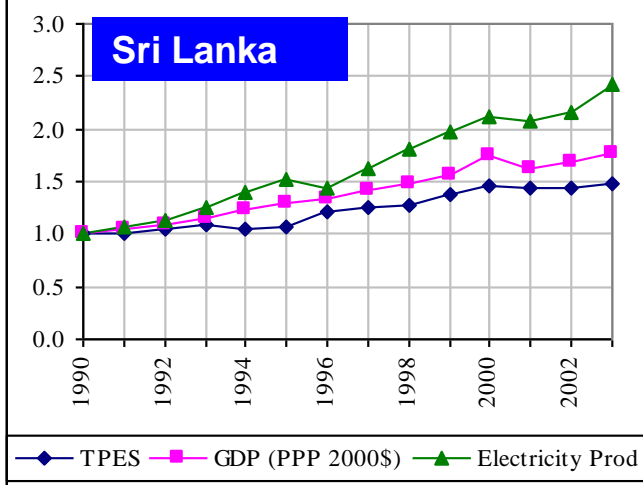
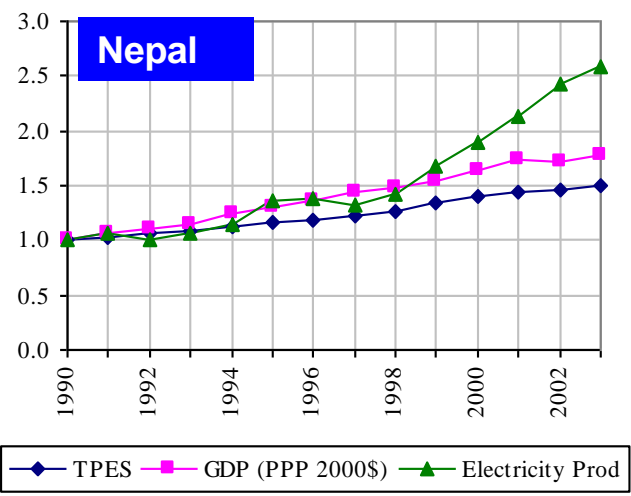
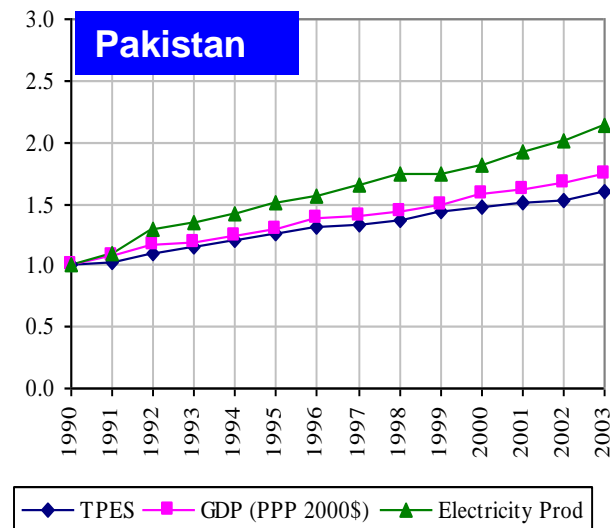
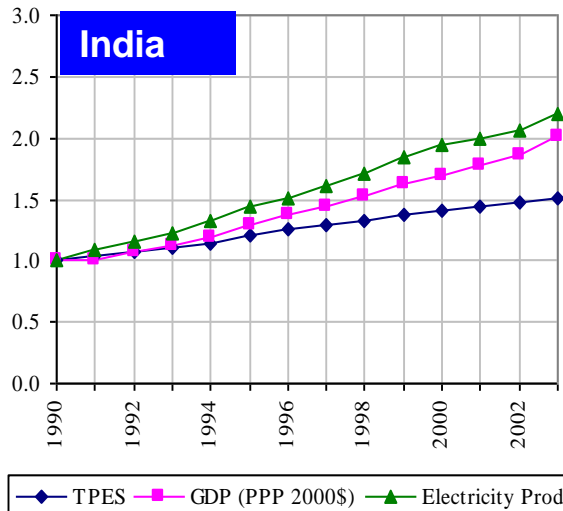
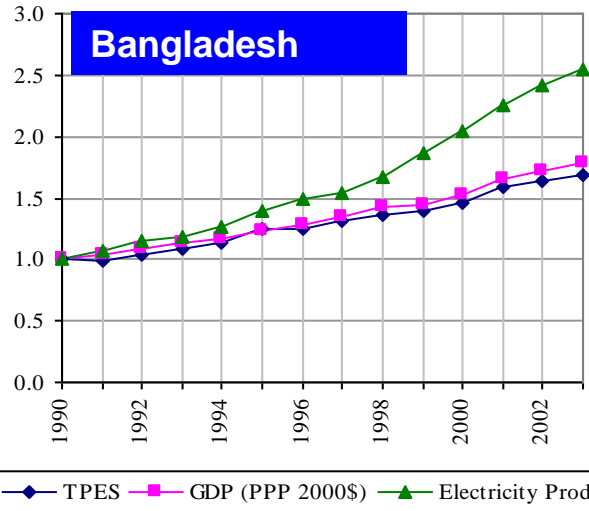
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Intergovernmental Meeting
Malé Declaration on Control and Prevention of Air Pollution and its Likely
Transboundary Effects for South Asia
12-13 September, 2006
Thimpu, Bhutan

Contents

- Overview of power sector in South Asia
- Power sector emissions outlook
- Role of carbon and energy taxes in power sector emission reductions in India and Sri Lanka

Energy, Electricity and GDP Growth (Index 1990 = 1.0)



Electricity consumption growth (1990-2003)

Country	AAGR (%)
Bangladesh	10.0
Bhutan*	11.7
India	5.4
Nepal	7.9
Pakistan	5.7
Sri Lanka	7.0

*1997-2003

Source: Estimated from Energy Statistics and Balances of NON-OECD Countries (IEA, 2005)

Electricity production shares by energy type in 1990 and 2003, %

Country	Thermal		Hydro		Others	
	1990	2003	1990	2003	1990	2003
Bangladesh	88.6	94.2	11.4	5.7	-	0.1
Bhutan+	0.04*	0.14	99.96*	99.86	-	-
India	73.1	84.4	24.8	11.9	2.1	3.7
Nepal	0.11	0.19	99.89	99.81	-	-
Pakistan	54.3	64.5	44.9	33.3	0.8	2.2
Sri Lanka	0.2	56.5	99.8	43.5	0.0	0.04
South Asia	70.5	82.7	27.6	14.7	1.9	2.6

+ Estimated from *Master Plan Study of Bhutan (JICA, 2005)*

* Corresponds to 1997 figure.

Source: *Energy Statistics and Balances of NON-OECD Countries (IEA, 2005) and*

Fuel-Mix in Electricity Production in 1990 and 2003, %

Country	Coal		Oil		Gas		Hydro		Nuclear	
	1990	2003	1990	2003	1990	2003	1990	2003	1990	2003
Bangladesh	-	-	4.3	6.7	84.3	87.5	11.4	5.7	-	-
Bhutan+	-	-	0.04*	0.14	-	-	99.96	99.86	-	-
India	65.3	68.3	4.3	4.6	3.4	11.5	24.8	11.9	2.1	2.8
Nepal	-	-	0.1	0.2	-	-	99.9	99.8	-	-
Pakistan	0.1	0.2	20.6	15.7	33.6	48.5	44.9	33.3	0.8	2.2
Sri Lanka	0.0	0.0	0.2	56.5	-	-	99.8	43.5	-	-

+ Estimated from *Master Plan Study of Bhutan (JICA, 2005)*

* Corresponds to 1997 figure

Source: *Energy Statistics and Balances of NON-OECD Countries (IEA, 2005)*

Growth of SO₂, NO_x and CO₂ Emissions from Power Sector (Index 1990 = 1.0)

SO₂ emission

	1995	2000
Bangladesh	0.83	1.39
India	1.57	1.85
Pakistan	2.44	3.78
Sri Lanka	27.20	35.80

NO_x emission

	1995	2000
Bangladesh	1.35	1.65
India	1.26	1.38
Pakistan	1.34	1.55
Sri Lanka	14.50	19.00

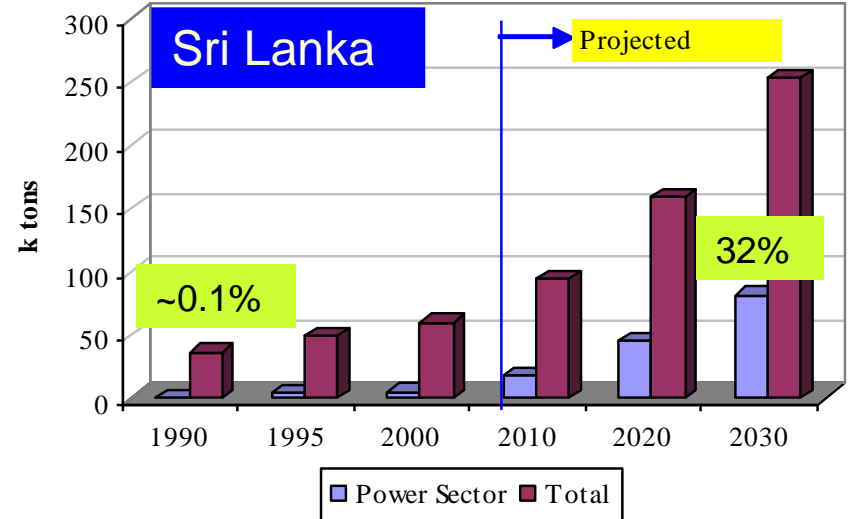
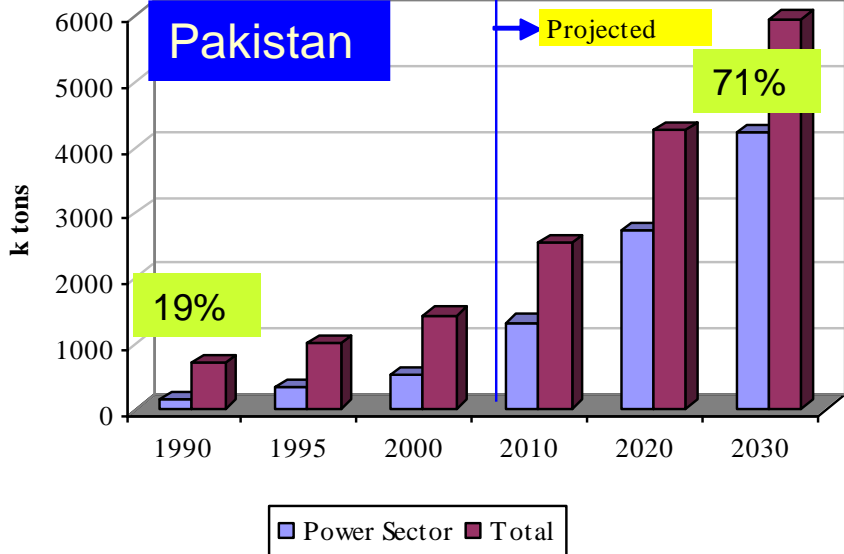
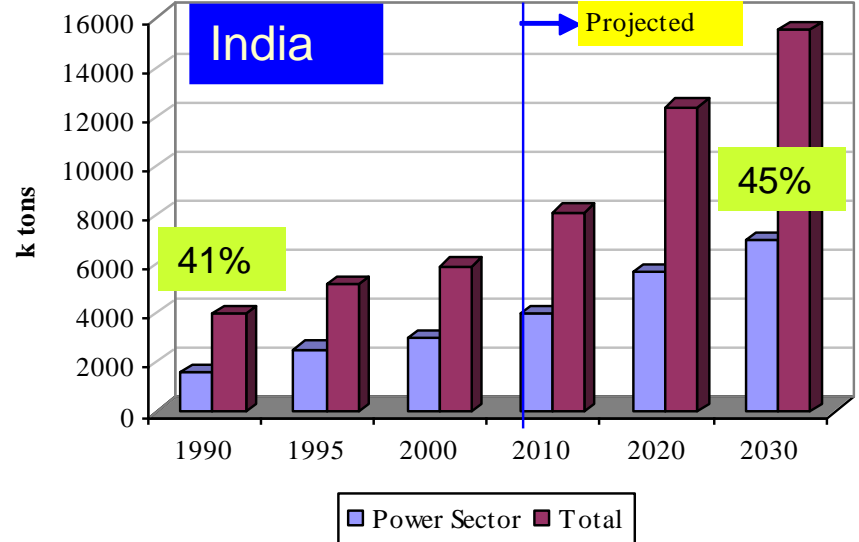
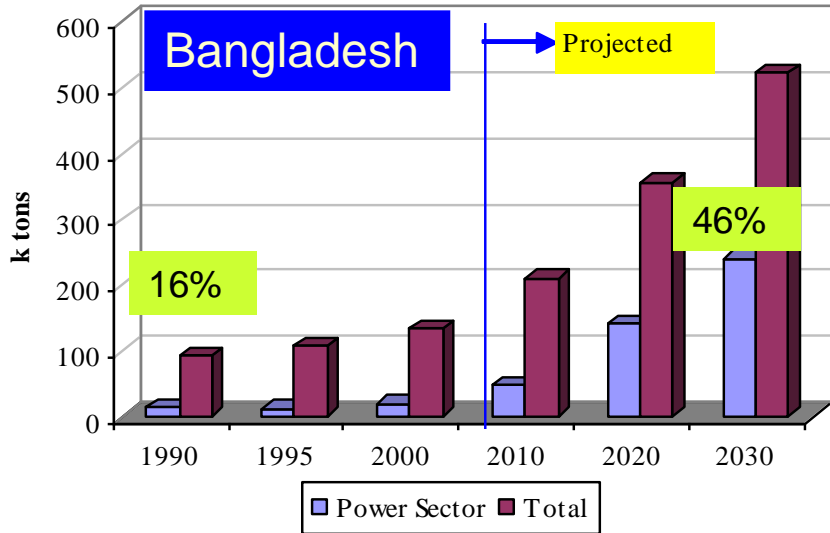
CO₂ emission

	1995	2000	2002
Bangladesh	1.48	1.98	2.55
India	1.57	2.12	2.21
Pakistan	1.50	2.13	2.18
Sri Lanka	4.80	57.20	59.20

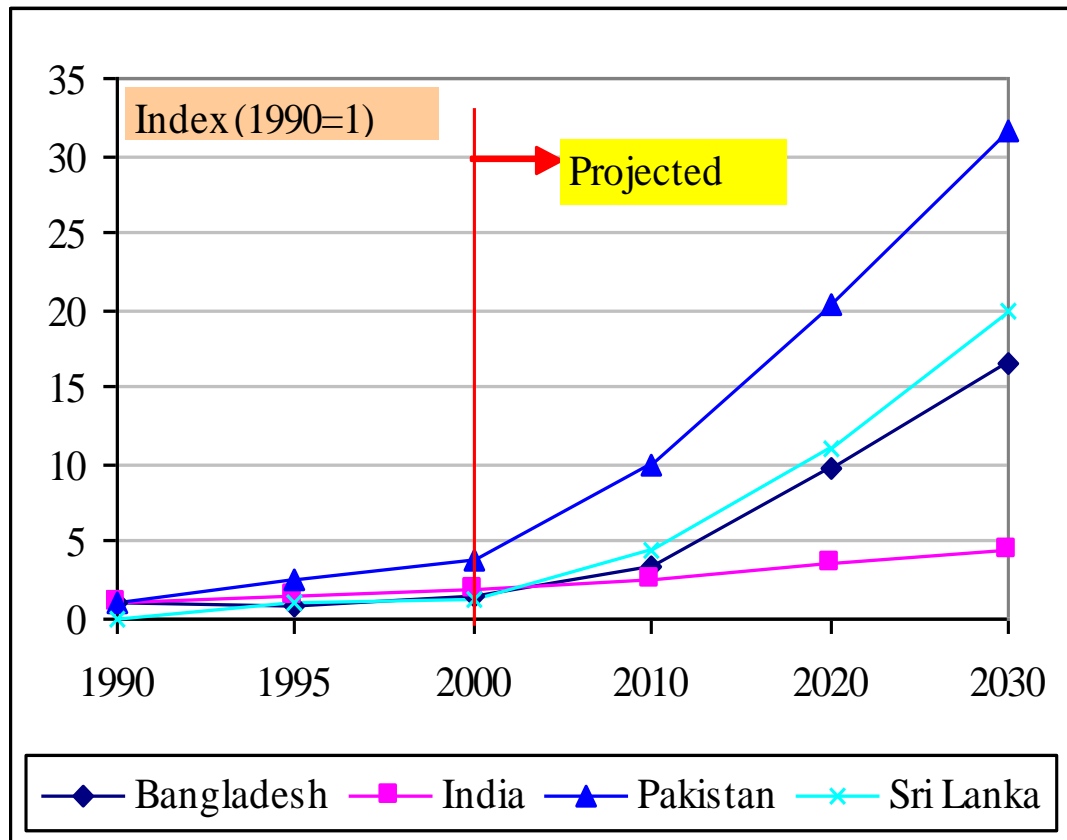
Source: RAINS (2006) [http:// www.iiasa.ac.at/rains/global_emiss/global_emiss.html](http://www.iiasa.ac.at/rains/global_emiss/global_emiss.html)
and CO₂ Emission Estimated from (IEA, 2005)

Power Sector Emissions Outlook

SO₂ Emission Projection by 2030



Projected Growth Rate of SO₂ Emission from the Power Sector

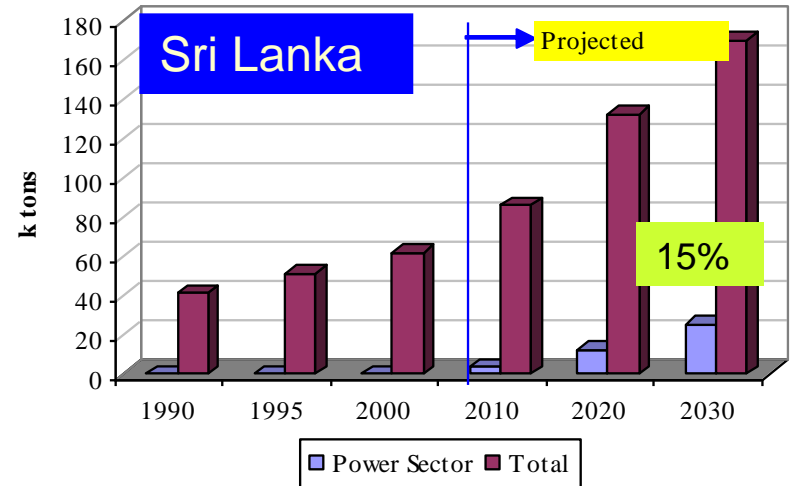
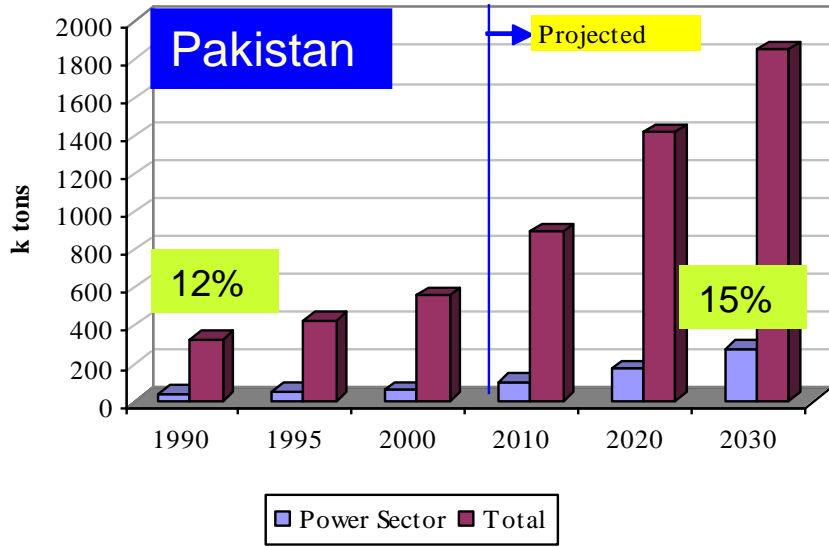
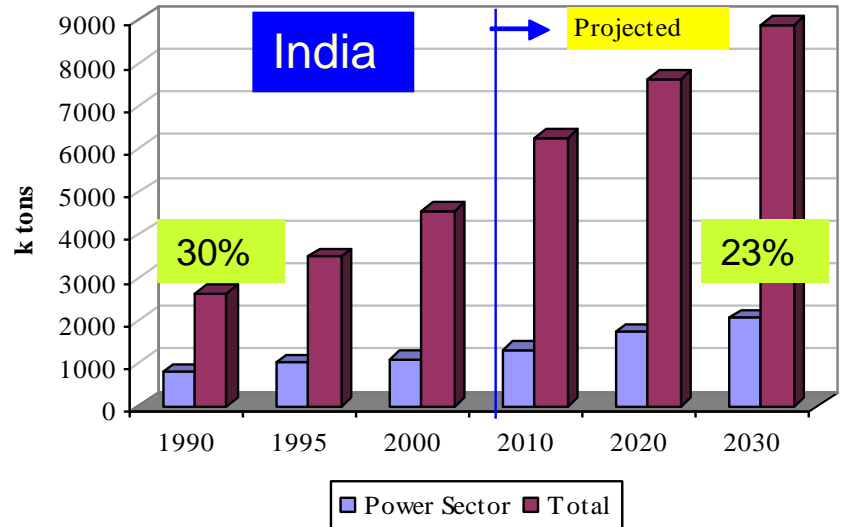
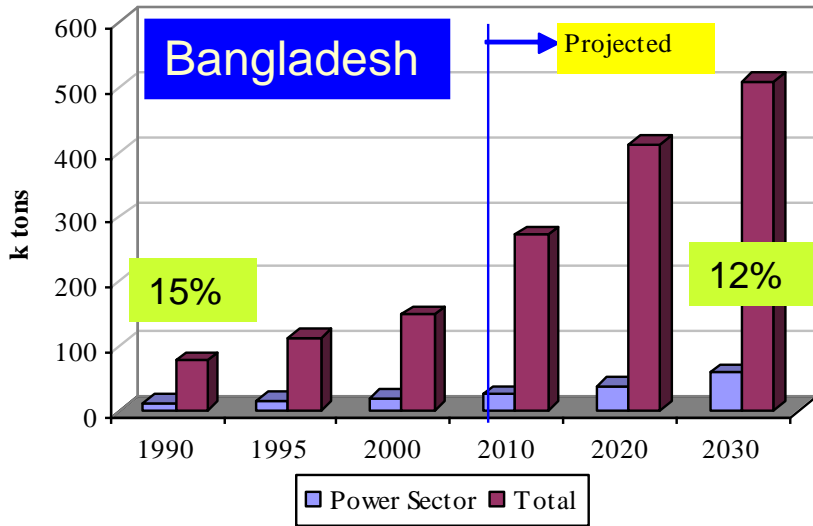


- High growth rates of power sector SO₂ emissions in Bangladesh, Sri Lanka and Pakistan; **Main reason:** low coal based generation at present and significant future additions of coal fired plants
- Relatively lower growth rate of SO₂ emission in India due to already dominant share of coal based power plants.
- In absolute terms, SO₂ emission from India many times higher than that from other countries.

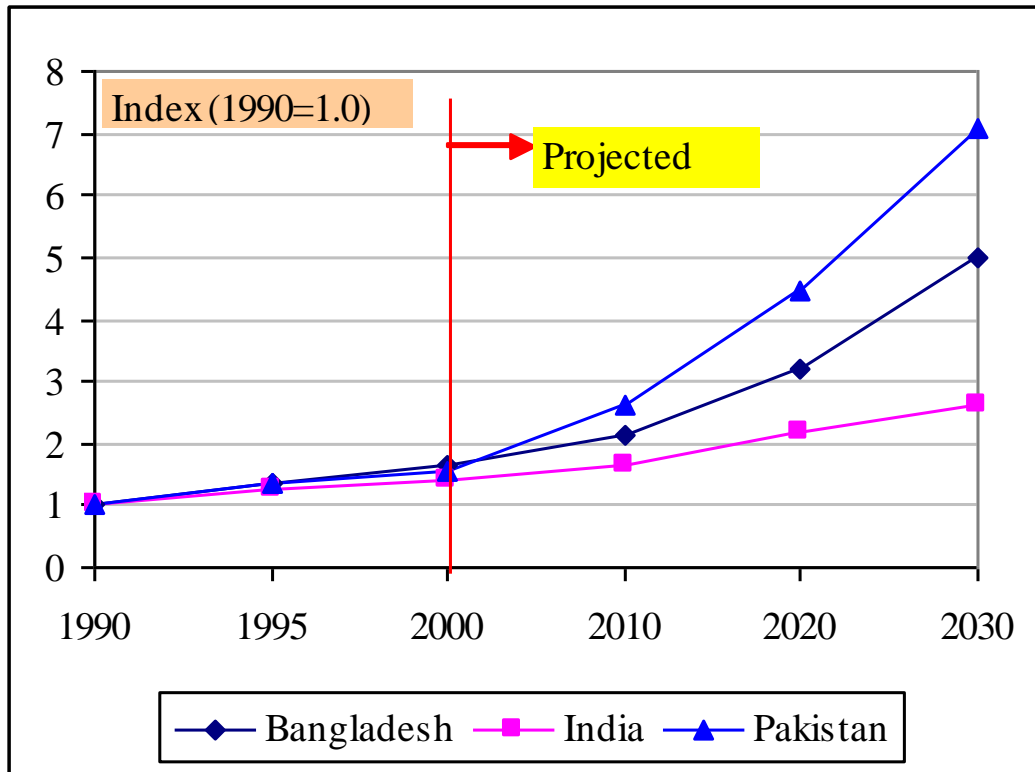
Source: RAINS (2006)

http://www.iiasa.ac.at/rains/global_emiss/global_emiss.html

NOx Emission Projection by 2030



NOx Emission from the Power Sector



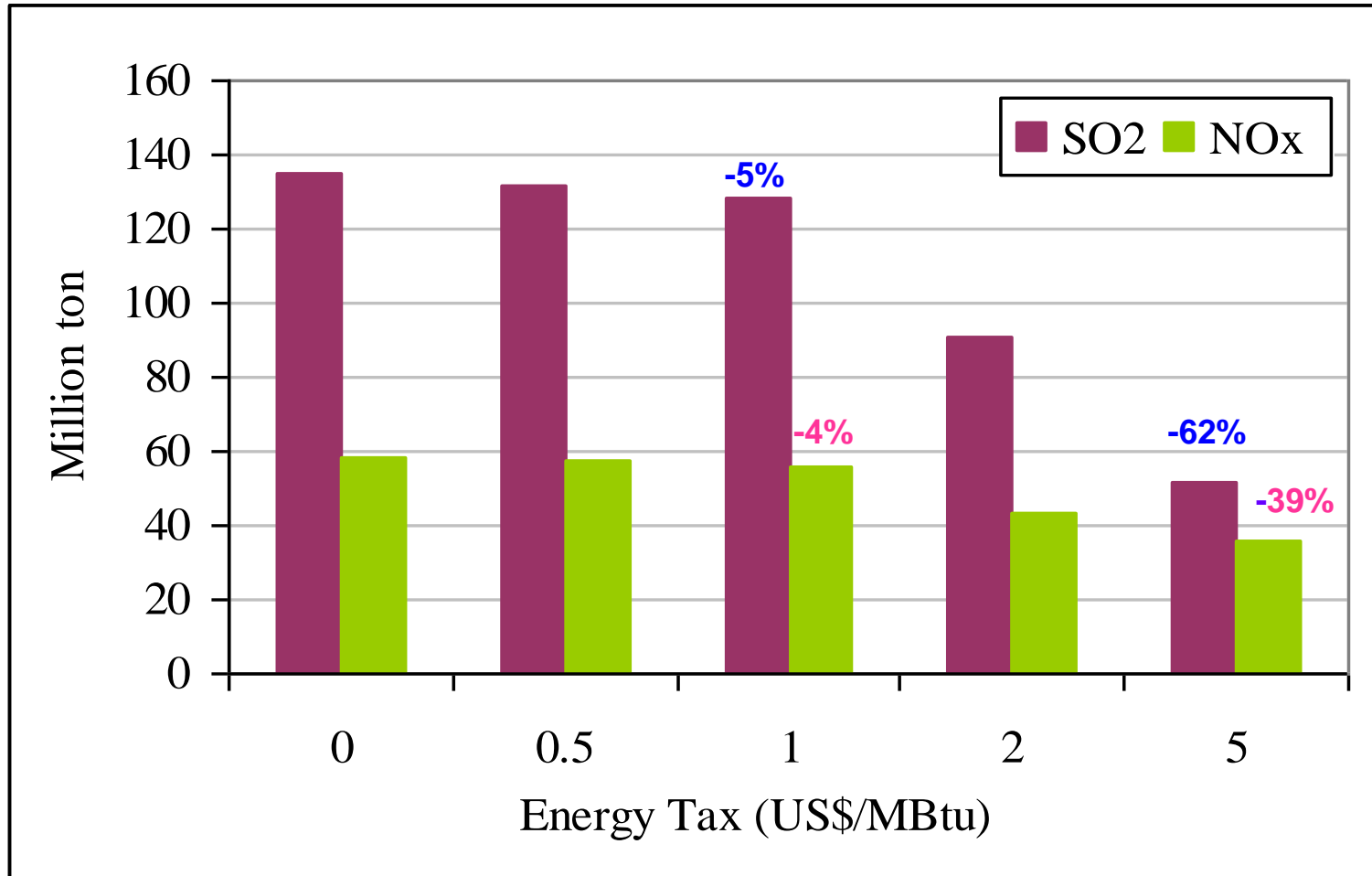
Source: RAINS (2006)

[http:// www.iiasa.ac.at/rains/global_emiss/global_emiss.html](http://www.iiasa.ac.at/rains/global_emiss/global_emiss.html)

Role of Carbon and Energy Taxes in the Power Sector emissions in India and Sri Lanka

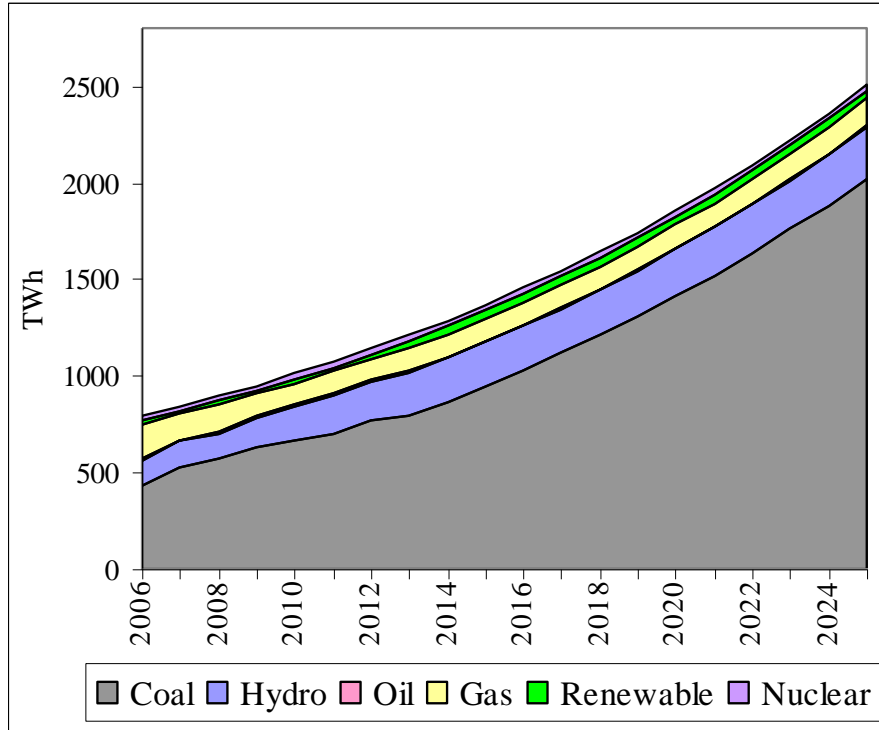
India

Role of Energy Tax on SO₂ and NO_x Emissions from the Power Sector (2006-2025): INDIA

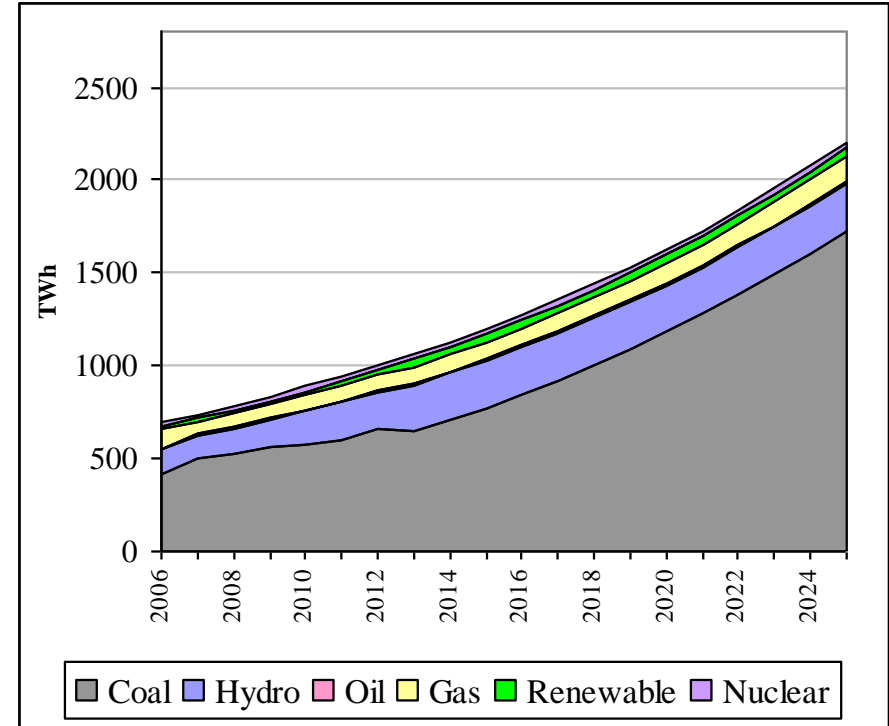


Energy tax and Electricity Generation by Fuel type (2006-2025): INDIA

Base Case

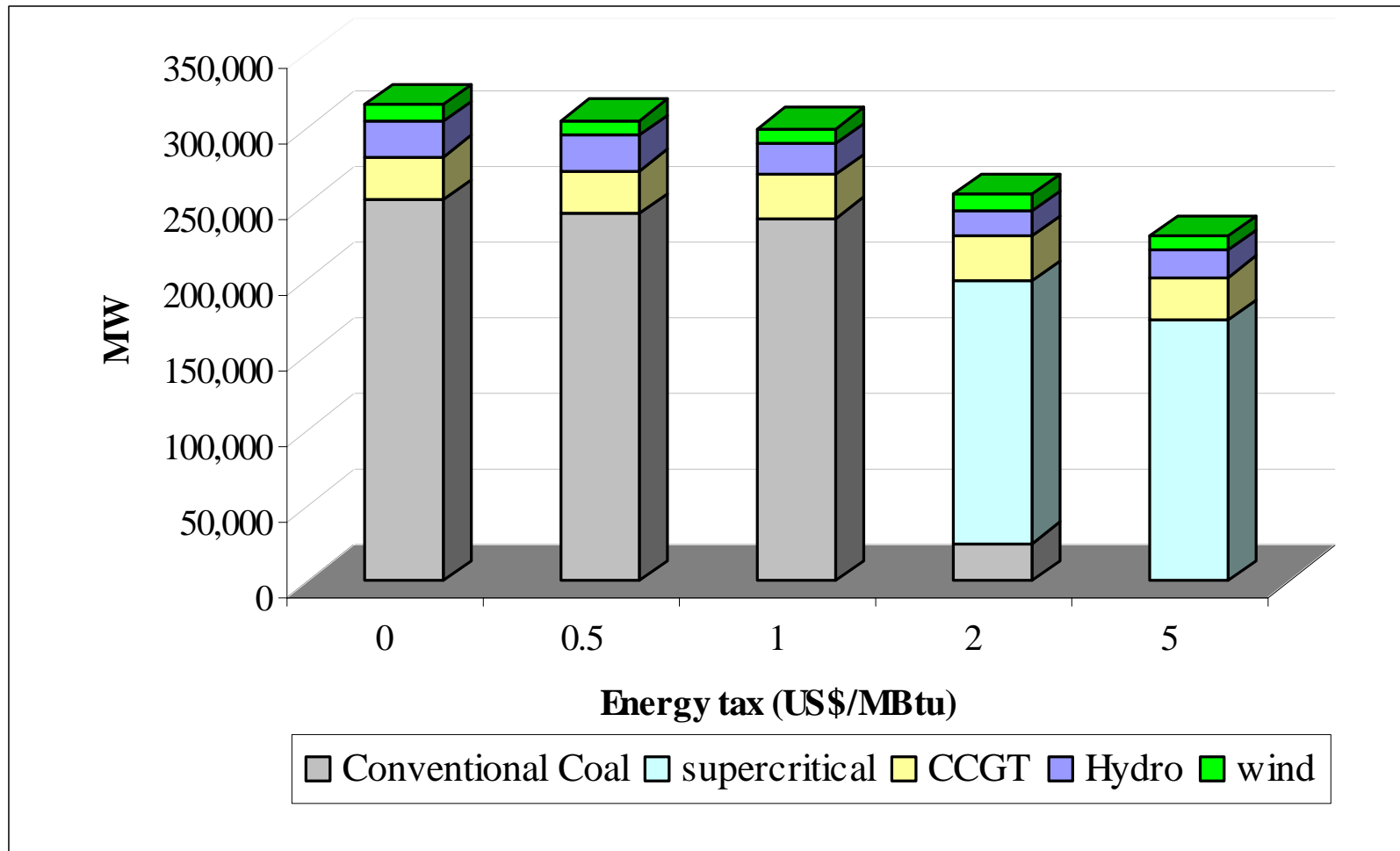


With Energy-tax (5 \$/MBtu)



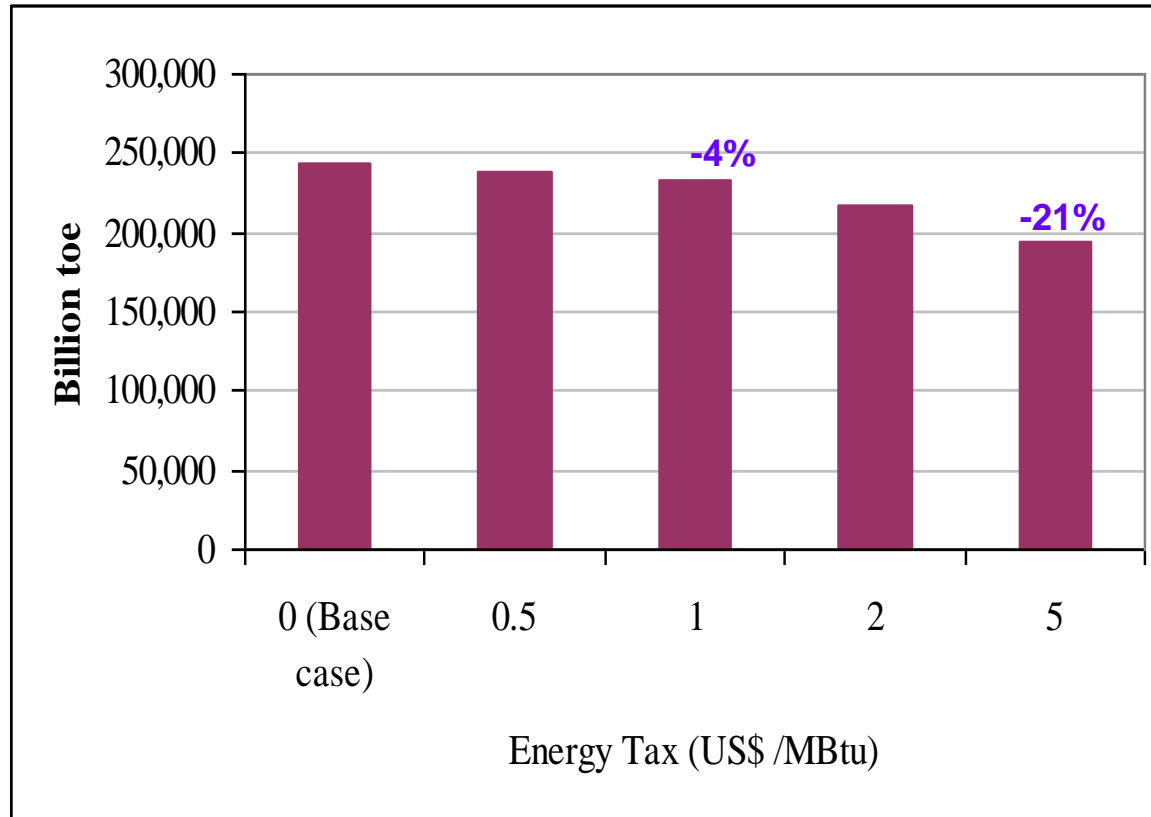
There would be a 12% reduction in cumulative energy generation during 2006-2025 with energy tax of \$5/MBtu.

Energy-tax and Power Plant Capacity Additions (2006-2025): INDIA



Energy tax above \$1/MBtu promotes clean and efficient technologies.

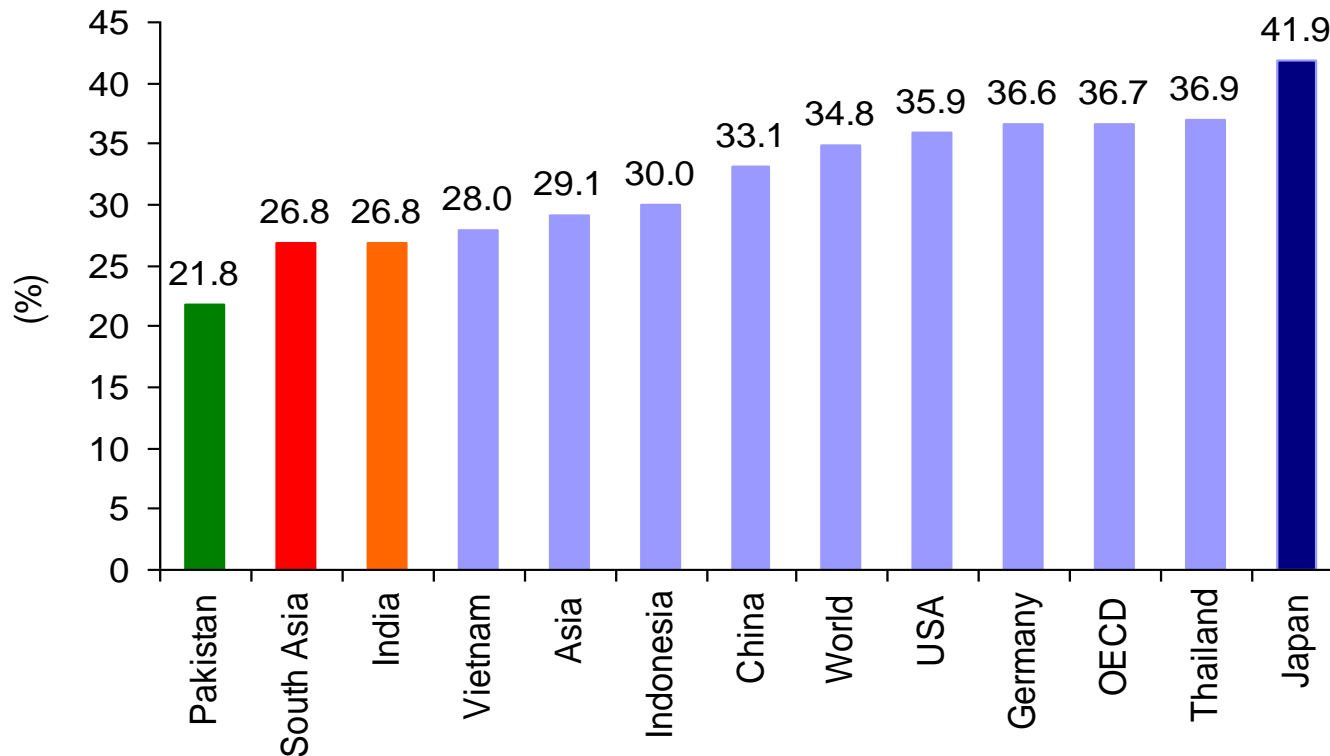
Fossil Fuel Consumption in Power Sector with Energy Tax (2006-2025): INDIA



Note: 1.0 MBtu = 0.252 Gcal

Substantial reduction in fossil fuel consumption in the power sector at energy tax above \$1/MBtu.

Scope for Energy Efficiency Improvement in Coal-Fired Generation and Potential Air Pollutant Reductions.



Thermal generation efficiency of coal-fired power plants (2002)

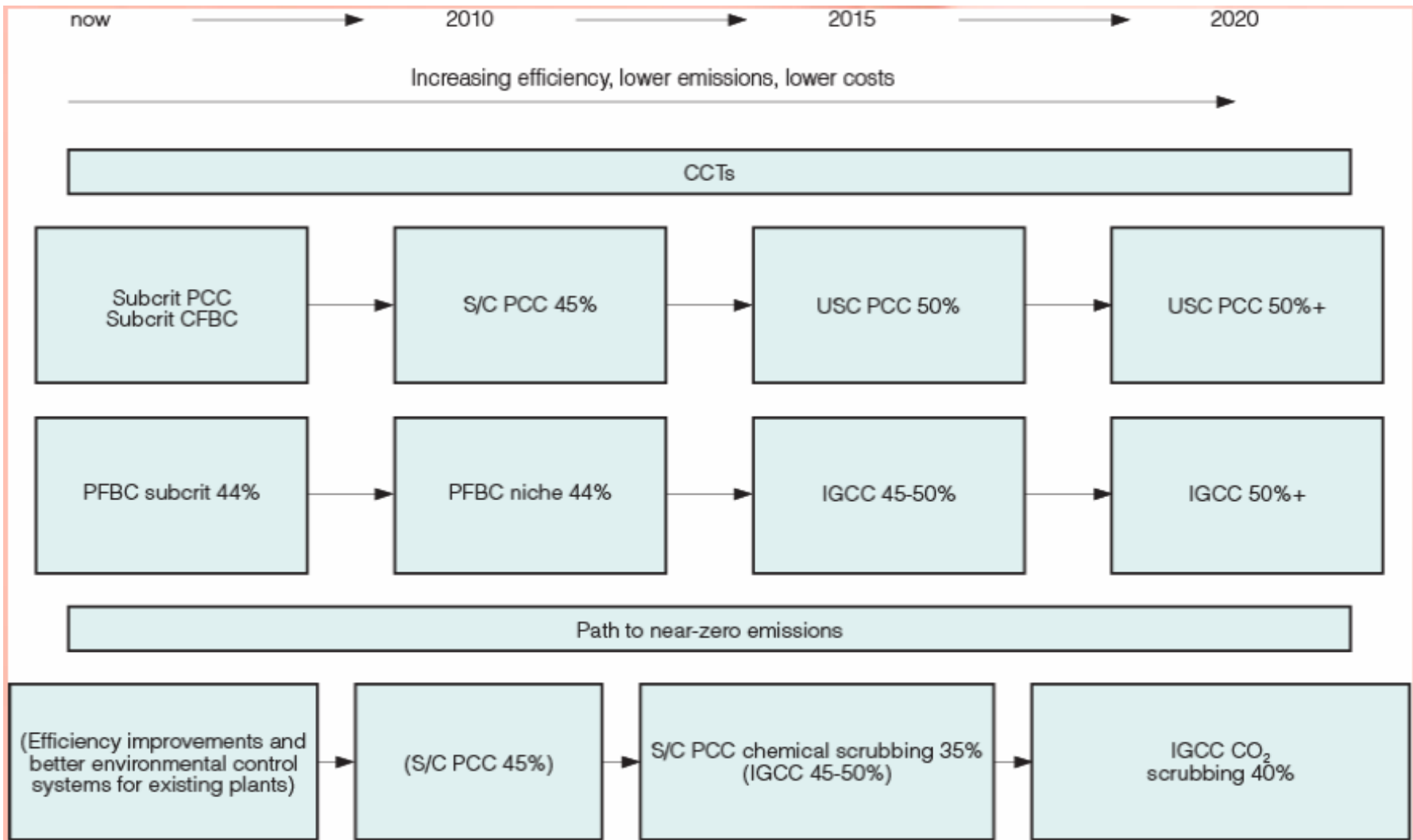
Source:

Estimated from Energy Statistics and Balances of NON-OECD Countries (IEA, 2005)

In south Asia:

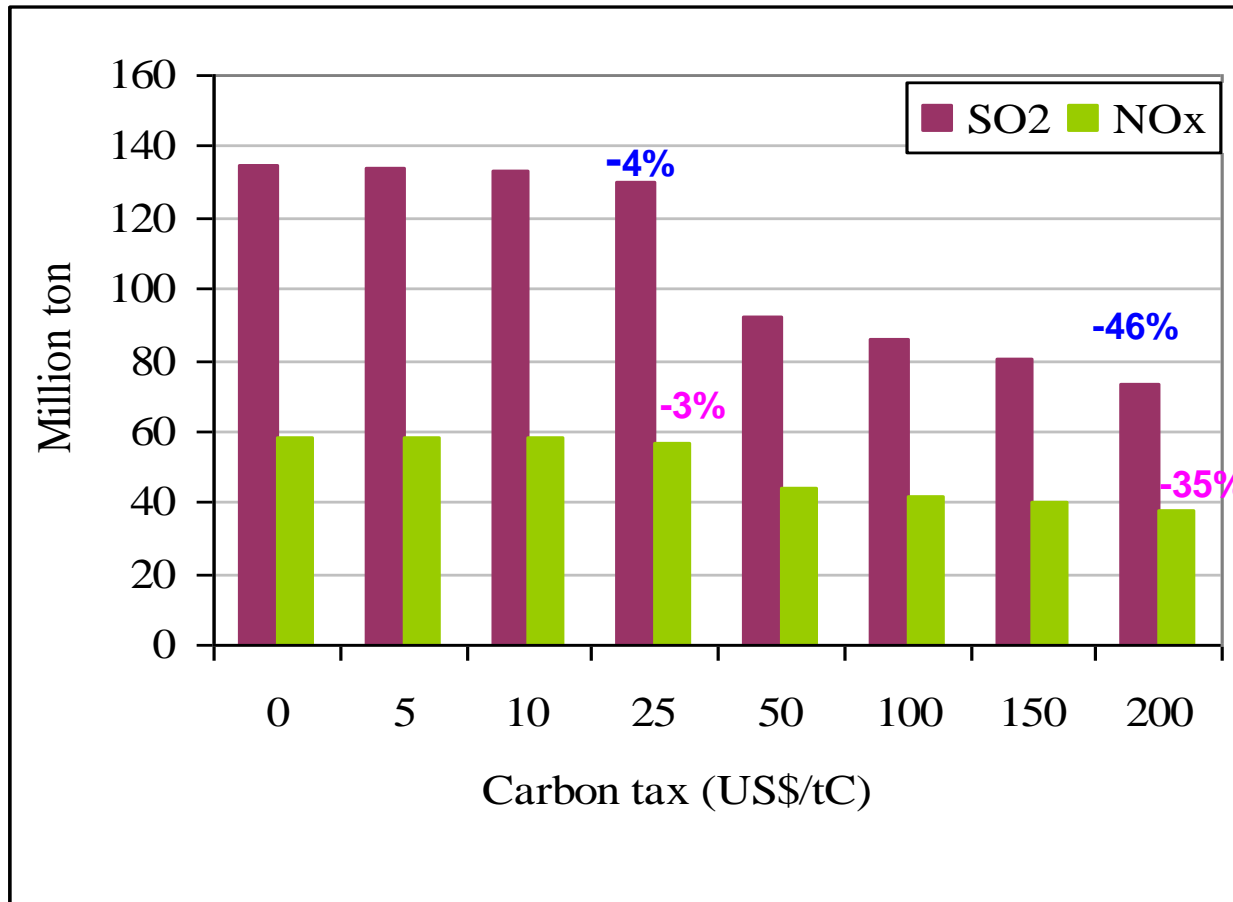
- **Potential efficiency improvement of almost 15% (compared to Japan) corresponds to about 33% reduction in coal requirement (i.e. ~ 57 Million tons of coal) in 2002.**
- **This implies reductions of about 635 thousand tons of SO₂ and 168 Million tons of CO₂ emissions in 2002.**

Scenario for Efficiency of Clean Coal Power Plant Technologies



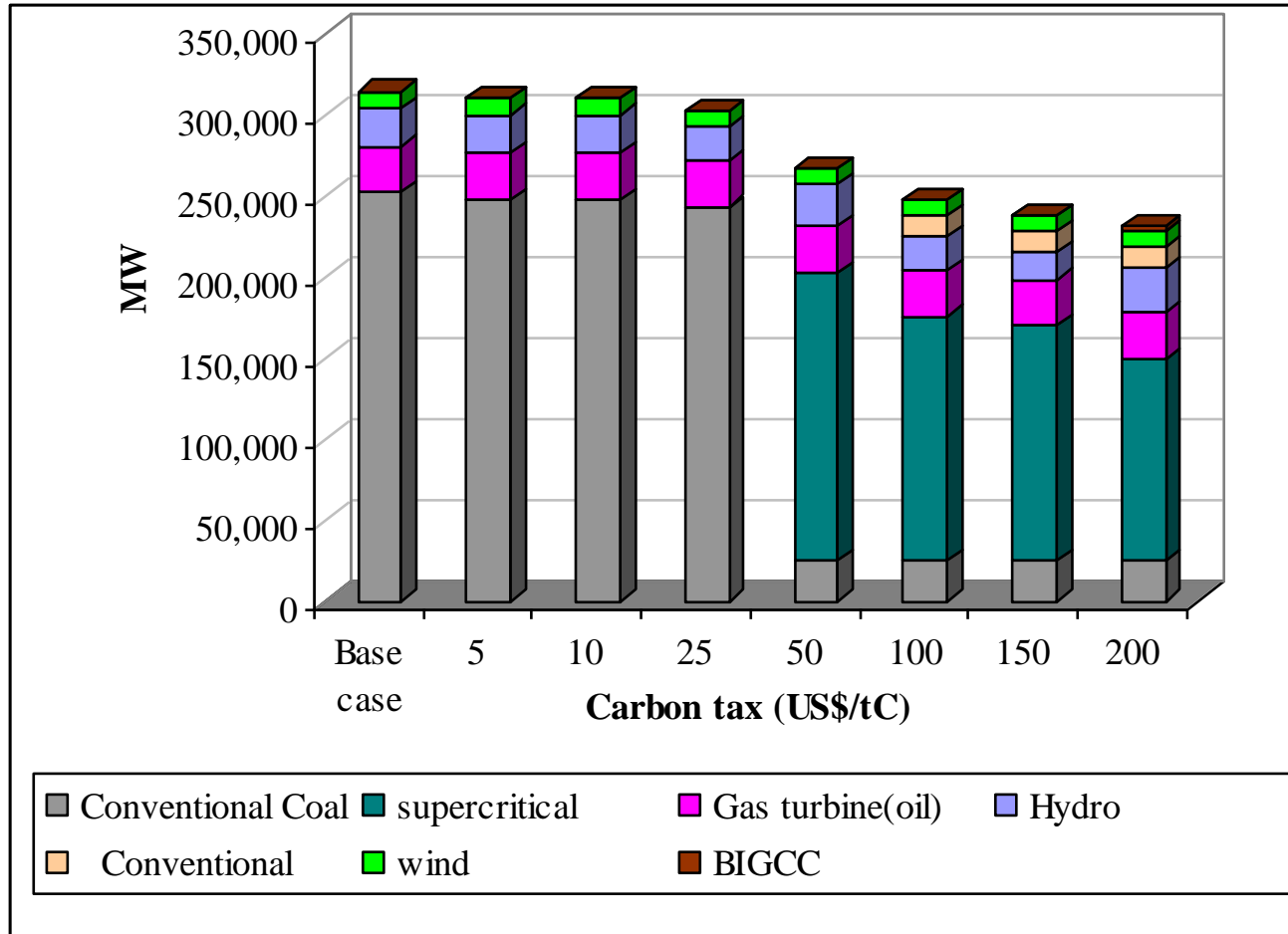
CCT: Clean coal technology; **PCC:** Pulverized coal combustion ; **PFBC:** Pulverized fluidized bed combustion; **IGCC:** Integrated gasification combined cycle; **S/C:** supercritical; **USC:** Ultra SC

Role of Carbon Tax on Power Sector SO₂ and NO_x Emissions (2006-2025): INDIA



Very little change in emissions at carbon tax below \$25/tC.

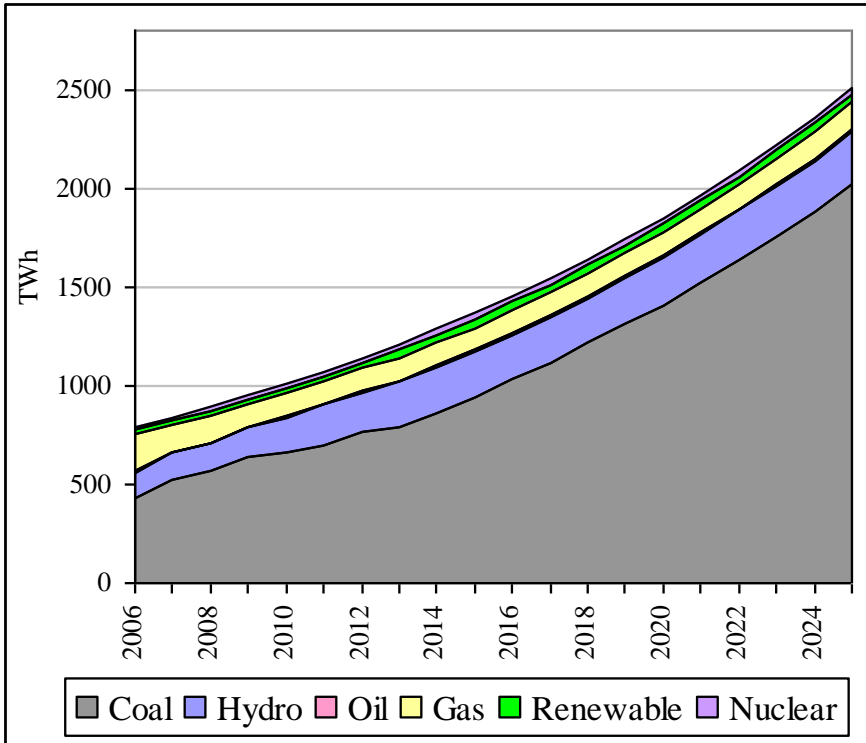
Carbon Tax and Power Plant Capacity Additions (2006-2025): INDIA



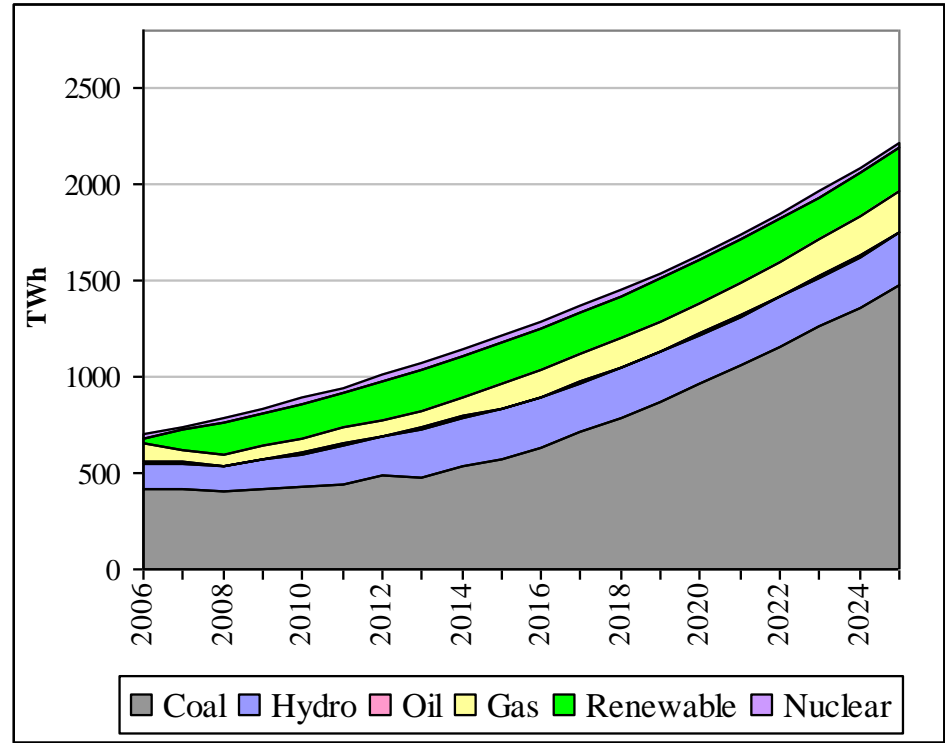
At carbon tax of \$50/tC and above, conventional coal power plants would be substituted by efficient clean coal technologies.

Carbon tax and Electricity Generation by Fuel type (2006-2025): INDIA

Base Case

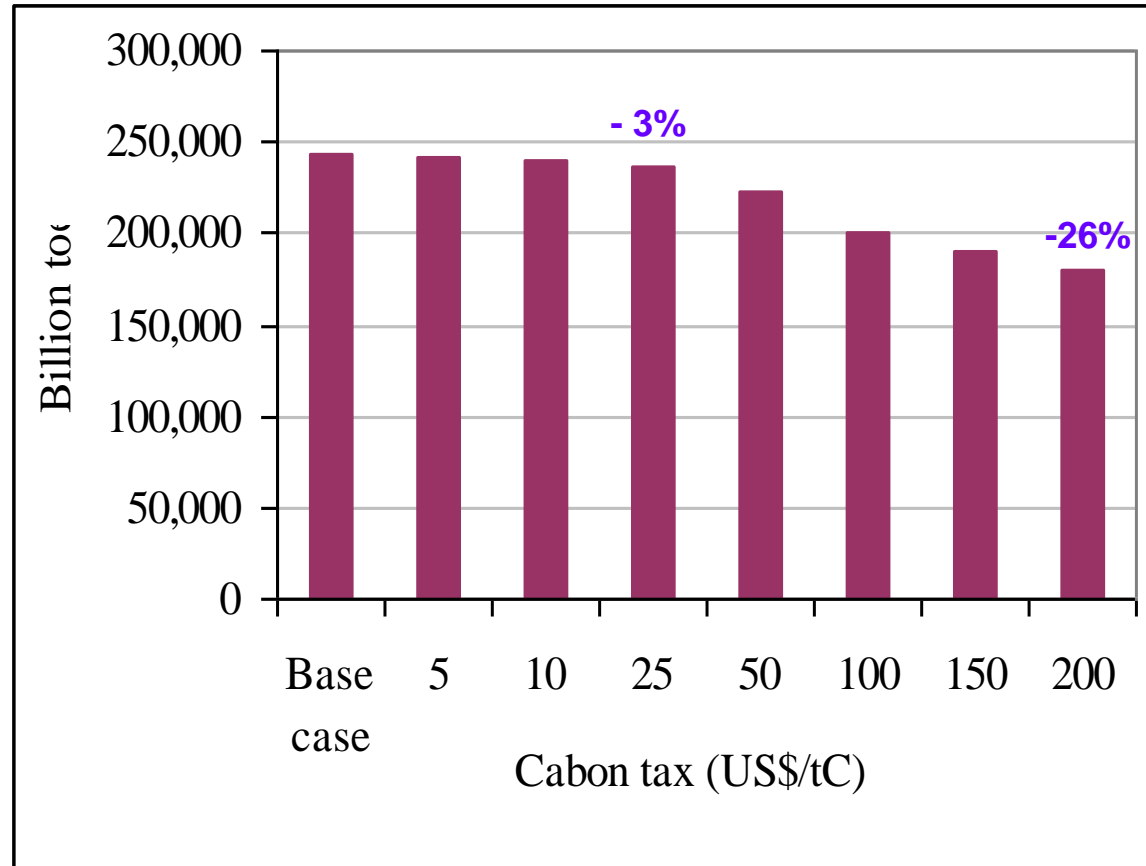


With Carbon-tax (200 \$/tC)



- **Coal based electricity generation would be partly substituted by renewables (Wind and Biomass) at higher carbon tax.**
- **There would be a 26% reduction in total energy generation during 2006-2025 with carbon tax of \$200/tC**

Fossil fuel consumption in power sector with Carbon tax (2006-2025): INDIA

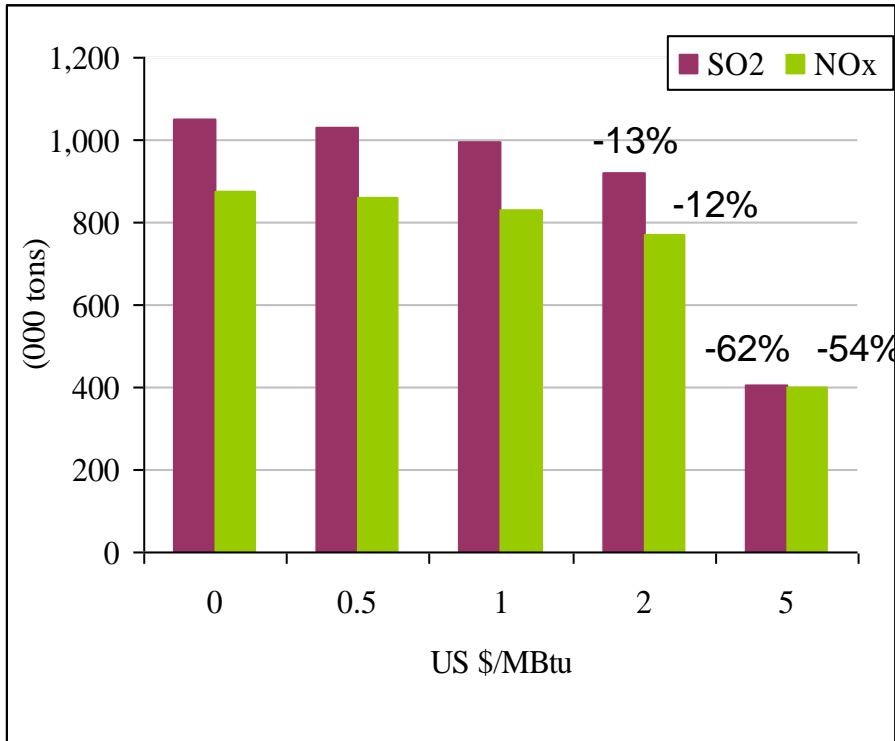


Reduction in fossil fuel consumption at carbon tax rates below \$25/tC **not significant.**

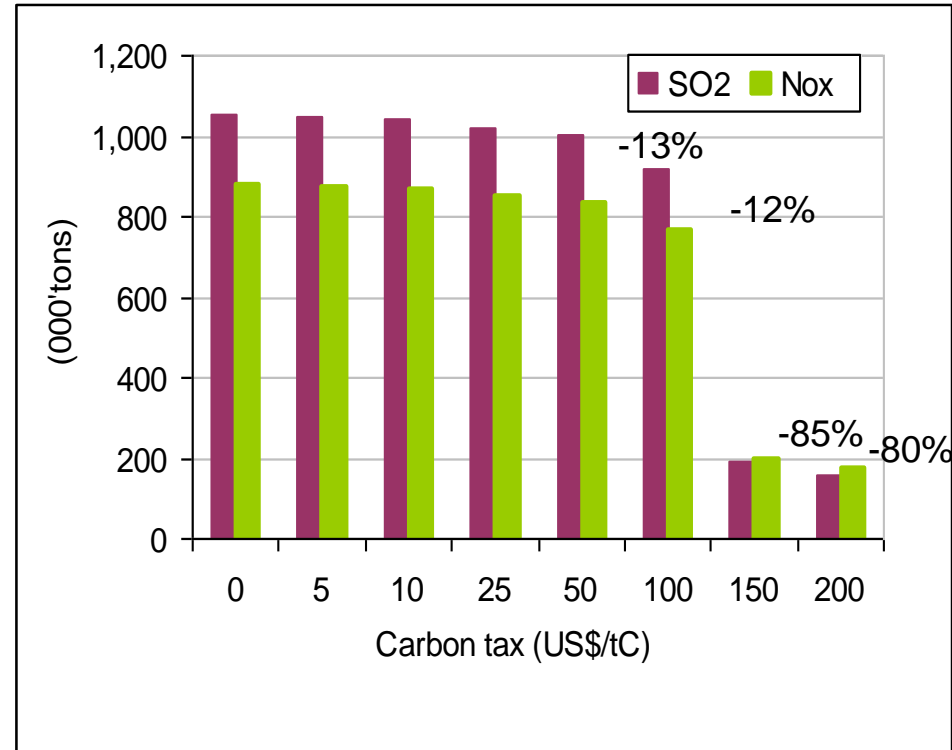
Sri Lanka

Role of Energy and Carbon Taxes in Power Sector SO₂ and NO_x Emissions (2006-2025): SRI LANKA

Energy-tax



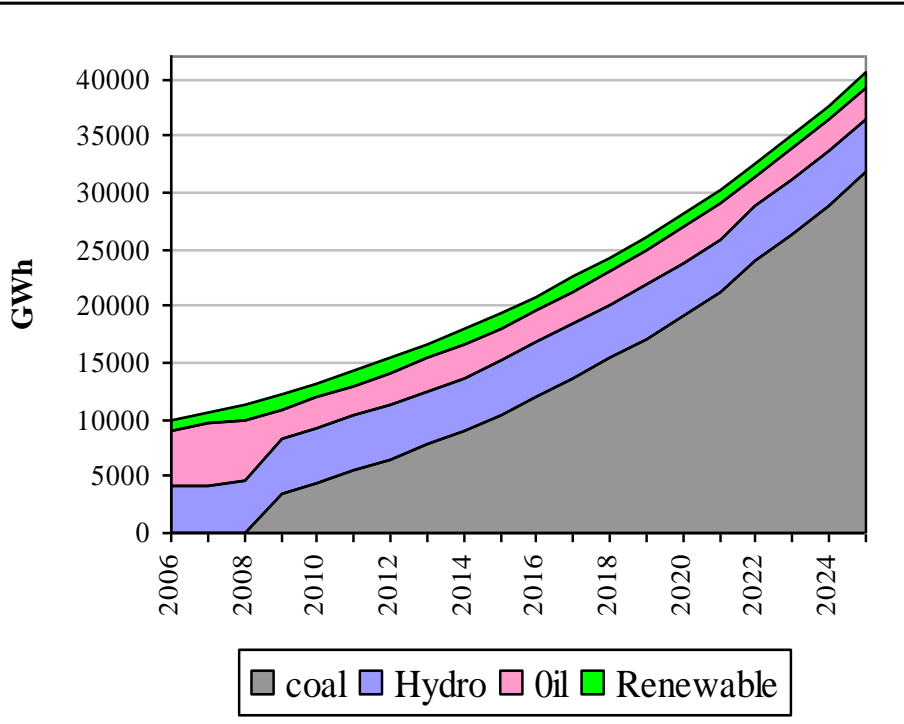
Carbon-tax



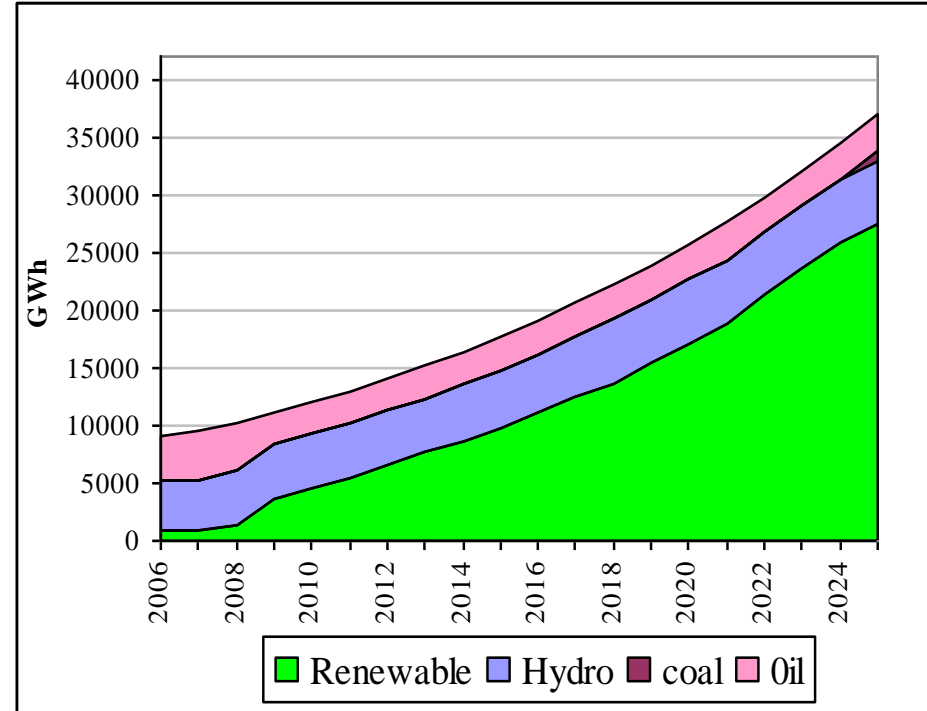
Emission reductions at energy tax below \$0.5/MBtu and carbon tax below \$25/tC below not significant

Carbon tax and Generation Mix (2006-2025): SRI LANKA

Base case



With Carbon-tax (200 \$/tC)



At high carbon tax rates, **large substitution** of coal based electricity generation in Sri Lanka **with renewables** (biomass and wind).

Conclusion and Final Remarks

- Relatively higher growth of electricity generation in South Asia
- Substantial share of power sector in total SO₂, NO_x and CO₂ emissions.
- Share of the power sector in total SO₂ emissions in South Asian countries varies from 0.1% to 41% in 1990; the share to grow in the range of 30% to 71% by 2030.
- Carbon tax below \$25/tC not so effective for emission reductions; higher tax rate needed to have significant emission reductions.
- Significant role of renewable and clean coal technologies in SO₂ emission reduction

Thank You