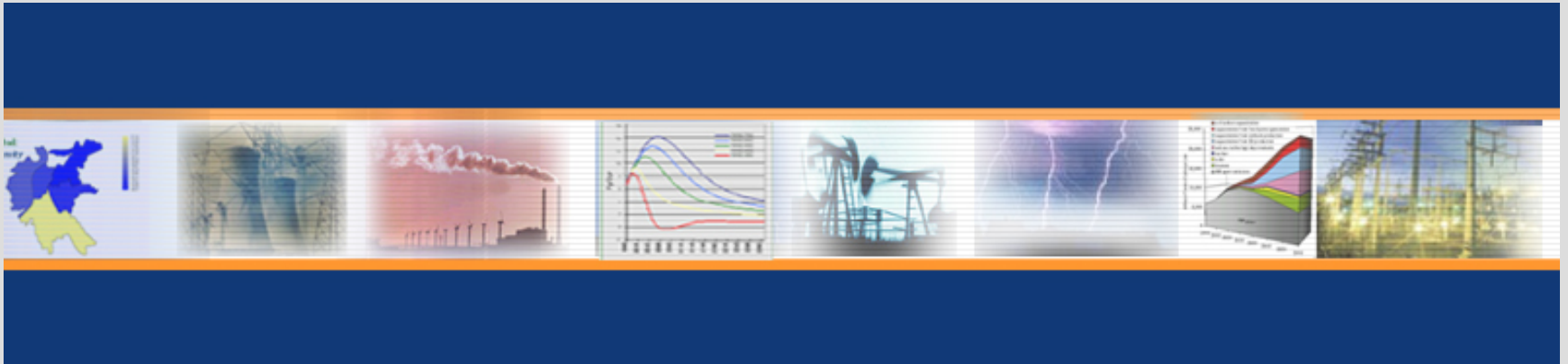


Emissions Inventory and Modeling: India Presentation



Presented by
P.R. Shukla

Presentation Agenda

1. Multi-gas Emissions inventory assessment

Period: 1985 to 2005

Gases

- CO₂
- CH₄
- N₂O

Updating based on India's Initial National Communication

2. AIM/Local model application for managing electricity sector emissions

National and State Level Applications

- SO₂
- CO₂

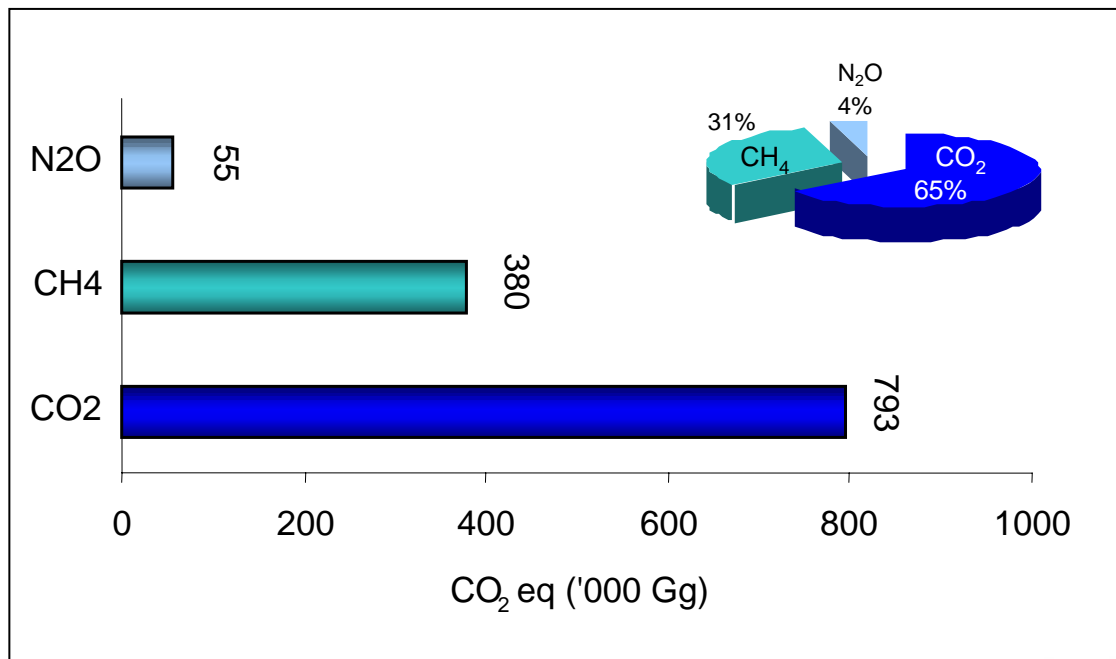
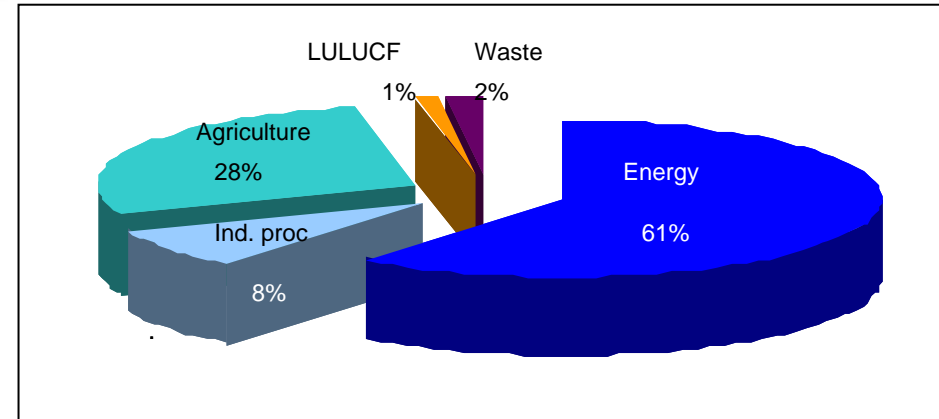
Period of Analysis: 1990 to 2030

Baseline (past) and Policy (future) Assessment

3. Conclusions and Future Work

Multi-gas Emissions Inventory Assessment

Emissions contributions of Different sectors to GHGs from India: 1994



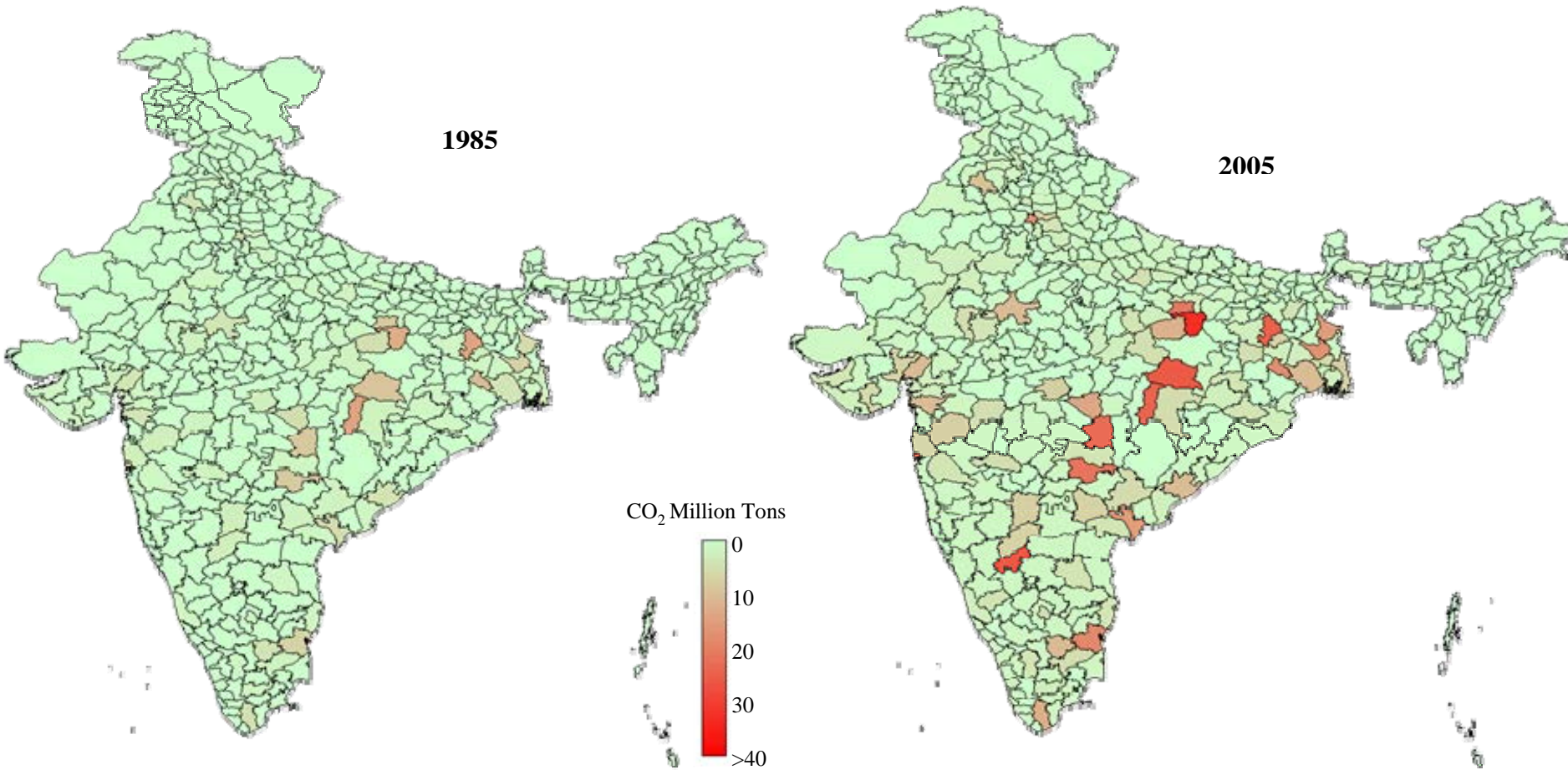
Post NATCOM Changes

- Earlier estimates used few India specific coefficients + IPCC default emission factors
- NATCOM updated emissions coefficients and estimate activity levels (e.g.)
 - ✓ Measured value of emissions co-efficient for cement production 6% higher than IPCC default value
 - ✓ Measured heat value of coking coal 20% higher than IPCC default value
- Increase of 8% emissions from previous estimates of CO₂
- Change in carbon emissions factors, esp. Indian coal, explains 1.4% of increase
- Industrial process emissions from sources that were not captured in earlier estimates. These add about 26 Mt-CO₂ to the “Other industries” category, explaining 3.2% of the upward revision
- Improvement activity data and reallocation of emissions for some categories, such as “other sectors” and “Other industries”. Activity data changes contributed 2.6% of the upward revision

Sectoral CO₂ emissions: Mt-CO₂/year

Sectors	1985	1990	1995	2000	2005
Power	146	213	379	517	638
Road	45	67	82	116	143
Railway	20	14	6	5	6
Aviation	2	2.5	3	4	5
Shipping	0.4	0.5	0.6	0.8	1
Cement industry	28	43	56	77	98
Steel industry	56	74	83	92	103
Fertilizer industry	20	22	23	23	24
Other industries	62	82	91	98	109
Other sectors	57	76	92	97	102
Total	436	593	816	1030	1229

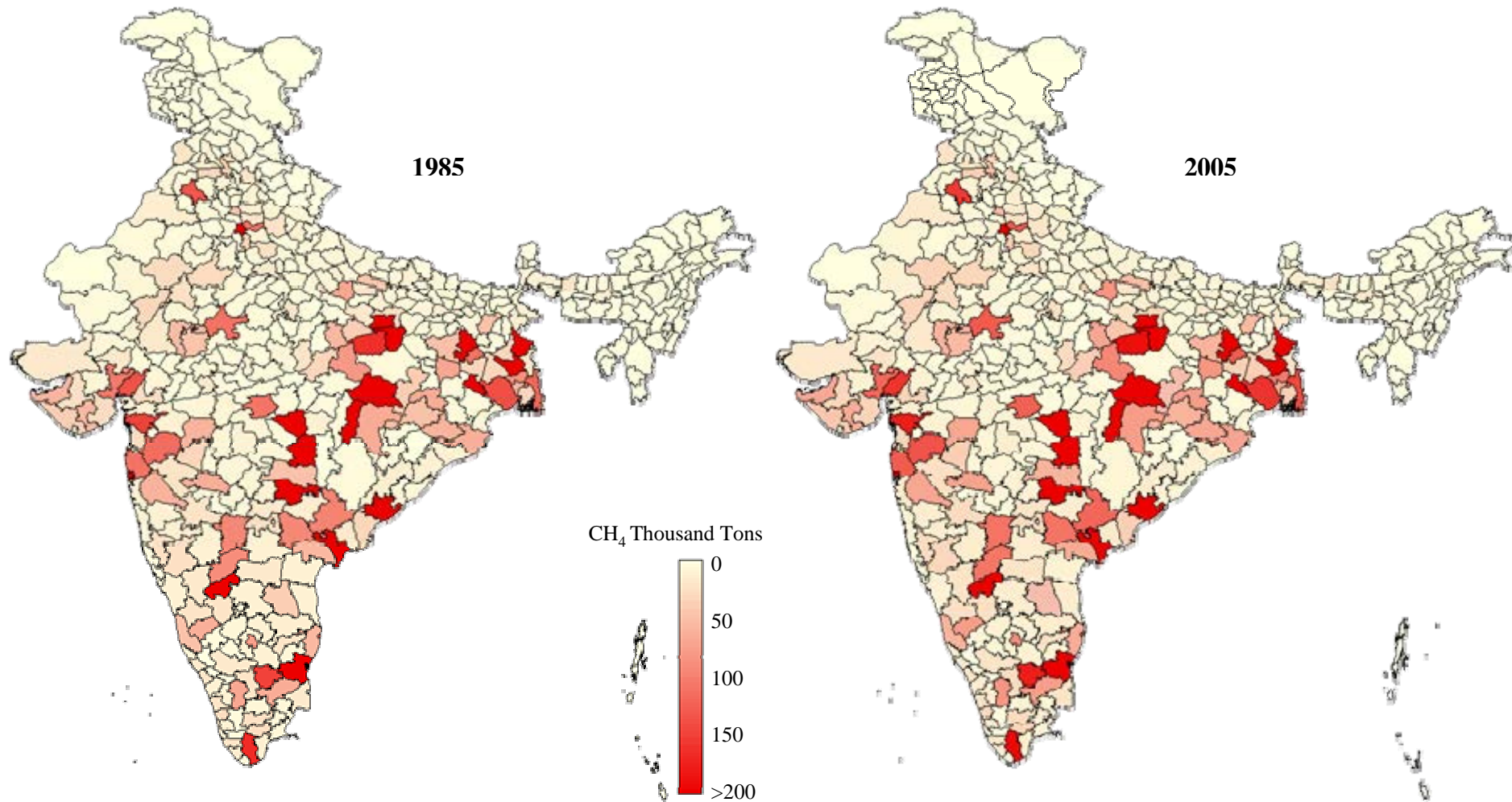
District level CO₂ emissions: 1985 & 2005



CH₄ emissions: Million Ton CH₄

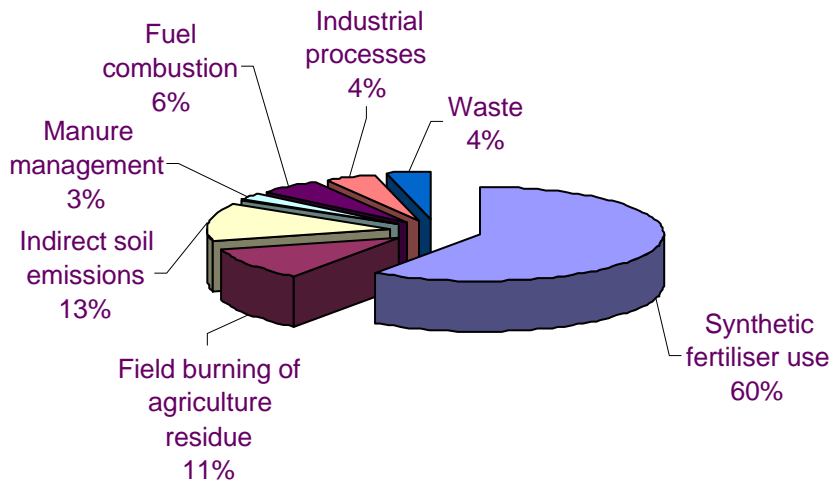
Sources	1985	1990	1995	2000	2005
Enteric fermentation	8.80	9.00	9.42	9.60	9.62
Paddy Cultivation	4.01	4.02	4.08	4.03	4.02
Biomass burnt for energy	1.61	1.62	1.67	1.76	1.80
MSW disposal	0.62	0.68	0.75	0.84	0.96
Manure Management	0.90	0.95	0.99	1.01	1.00
Oil & Natural Gas production and refining	0.23	0.50	0.65	0.94	1.13
Waste Water disposal	0.36	0.39	0.45	0.56	0.67
Coal Production	0.51	0.57	0.67	0.72	0.79
Agriculture crop residue burning	0.17	0.18	0.057	0.183	0.182
Total CH₄	17.21	17.92	18.73	19.64	20.18

District level CH₄ emissions

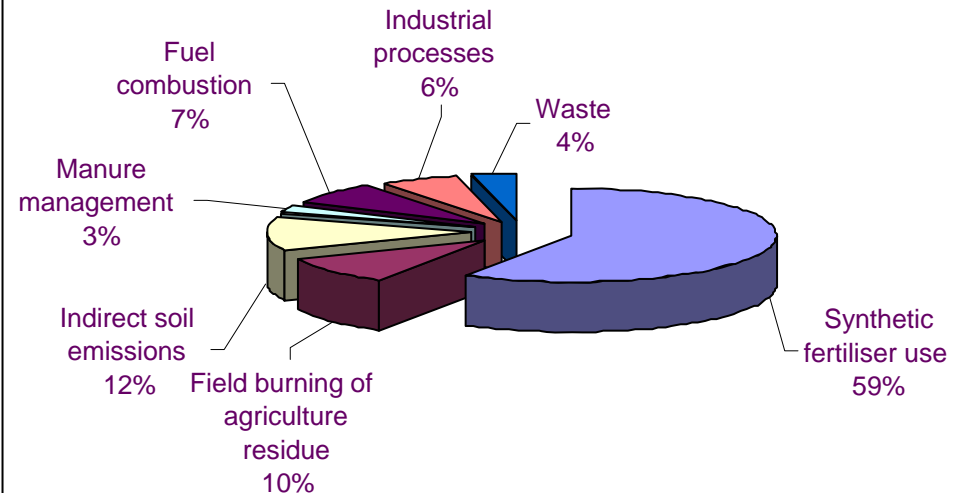


N₂O emission: Sector Shares

1985



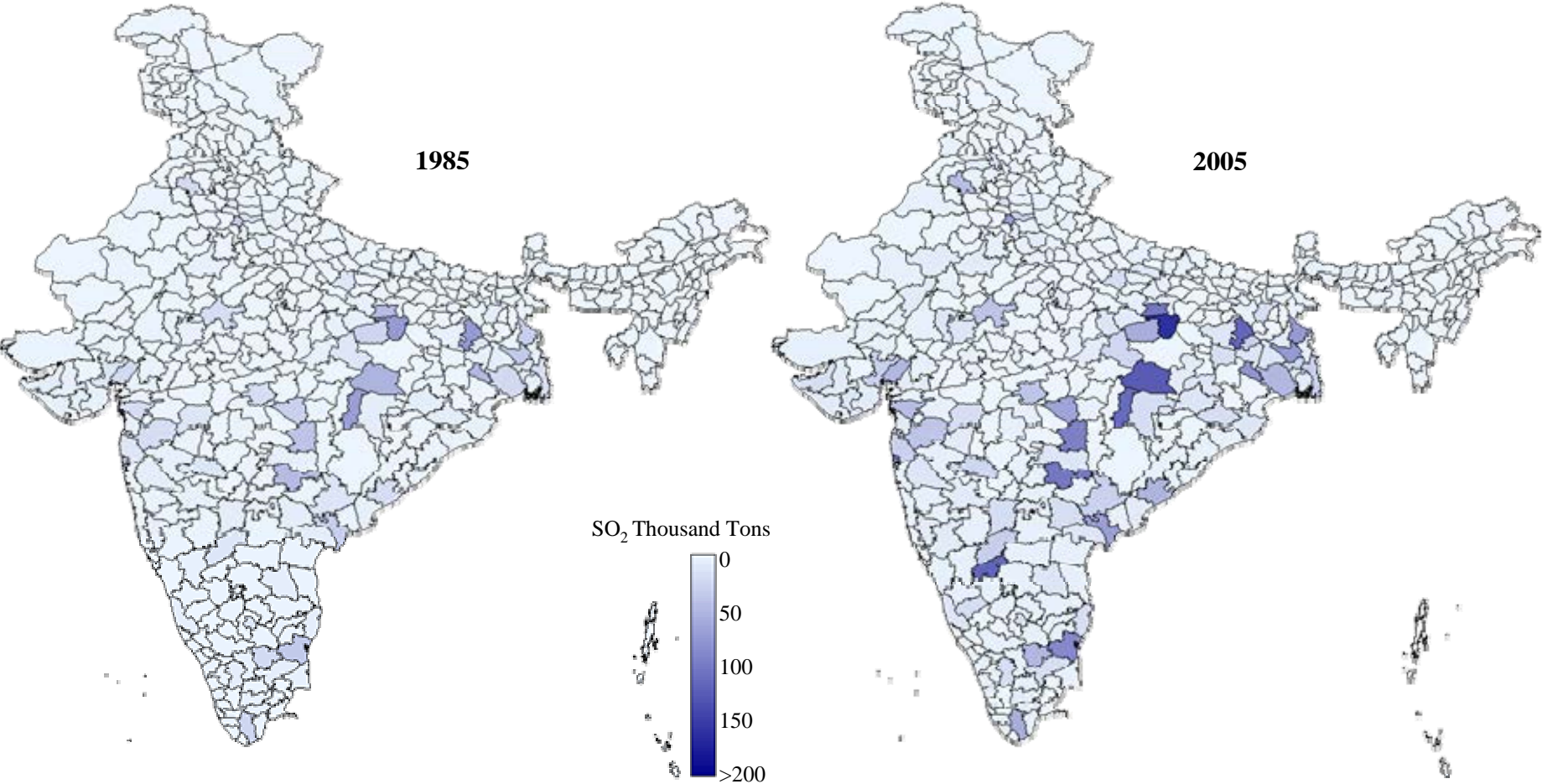
2005



Sectoral SO₂ emission: **Thousand tons/year**

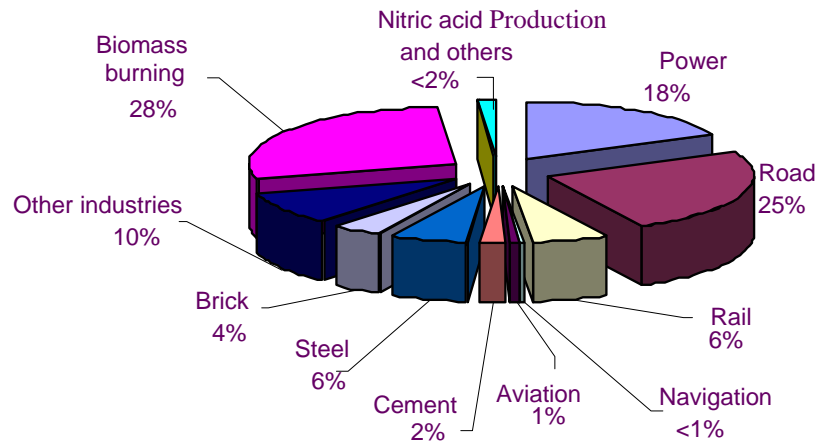
Sources	1985	1990	1995	2000	2005
Power	723.0	1046.8	1745.0	2380.4	2937.5
Steel	210.0	262.5	279.5	309.8	346.9
Fertiliser	125.0	105.9	125.1	124.3	129.7
Cement	74.2	97.2	107.7	160.0	206.0
Other Industries	437.9	576.5	604.6	651.1	724.2
Road	254.9	200.8	243.5	137.8	84.9
Rail	130.0	69.5	27.0	11.3	12.2
Shipping	6.0	8.0	9.8	13.1	14.8
Aviation	7.9	8.8	5.6	7.4	9.3
Biomass burning	215.0	216.0	217.0	215.0	210.0
Sulfuric Acid	40.0	45.0	53.1	61.3	66.0
Lead Smelting	6.0	7.8	10.8	13.0	14.8
Zinc Smelting	15.0	15.8	14.4	15.3	16.0
Copper Smelting	16.0	26.7	41.2	49.7	52.0
Other sectors	130.0	160.0	177.6	190.0	192.0
Total	2390.8	2847.3	3662.0	4339.5	5016.3

District level SO₂ emissions

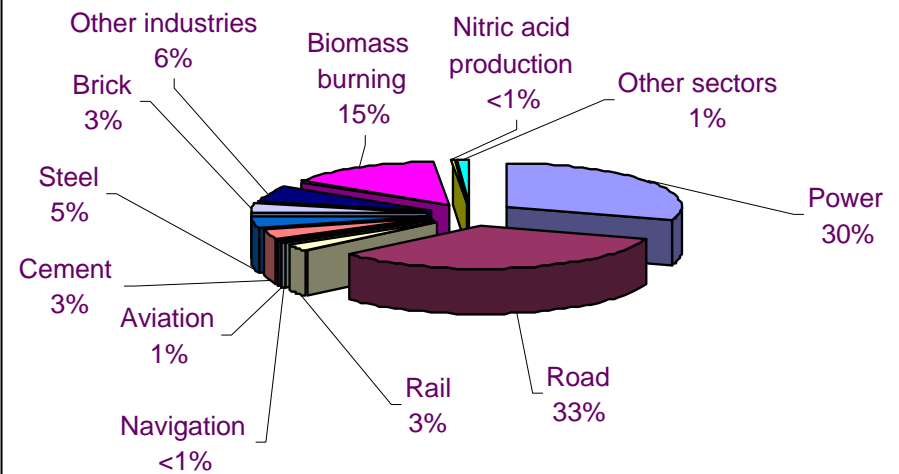


NO_x emissions: Sector Shares

1985



2005



Multi-gas emissions: Million ton

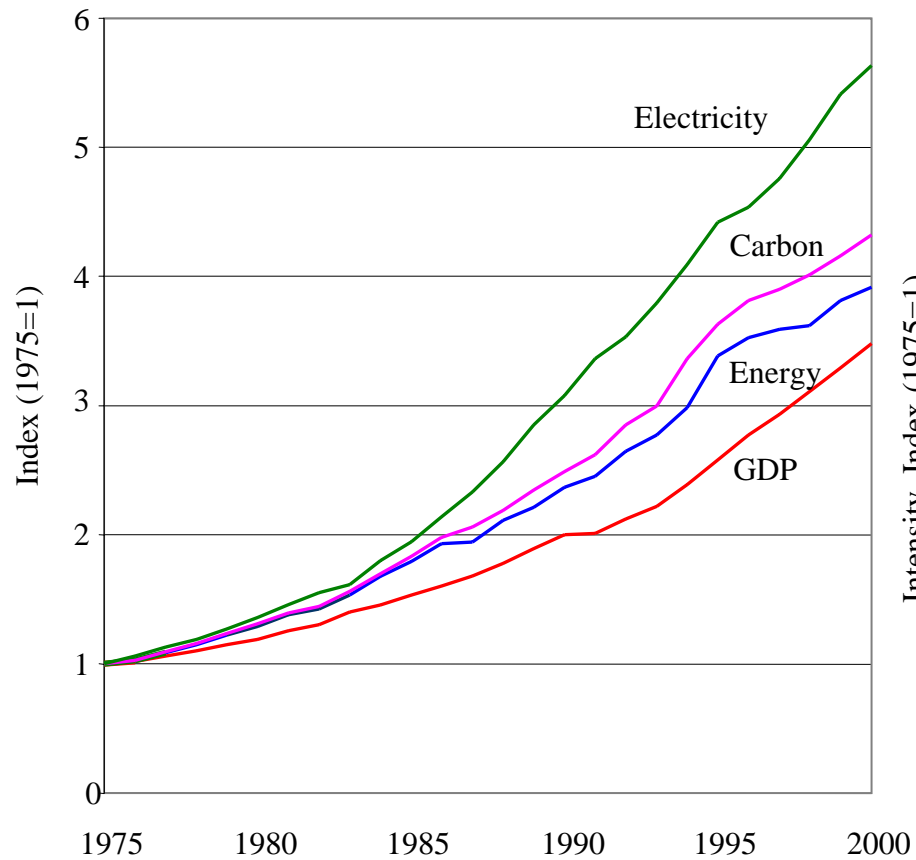
Gas/Pollutant	1985	1990	1995	2000	2005	CAGR (1985-2005)
CO ₂	436	593	816	1030	1229	5.3
CH ₄	17.21	17.92	18.73	19.64	20.18	0.8
N ₂ O	0.134	0.158	0.185	0.219	0.258	3.3
PFC (CO ₂ Eq)	3.03	5.05	5.60	7.12	8.77	5.5
HFC (CO ₂ Eq)	--	0.873	2.066	5.076	9.777	17.5
SF6 (CO ₂ Eq)	--	--	--	0.087	2.084	88.7
SO ₂	2.39	2.85	3.66	4.34	5.02	3.8
Nox	2.11	2.64	3.46	4.35	5.12	4.5
CO	33.59	34.99	37.03	40.02	42.22	1.2
Particulate	8.12	9.21	10.13	9.13	8.72	0.4

AIM/Local Model Application:

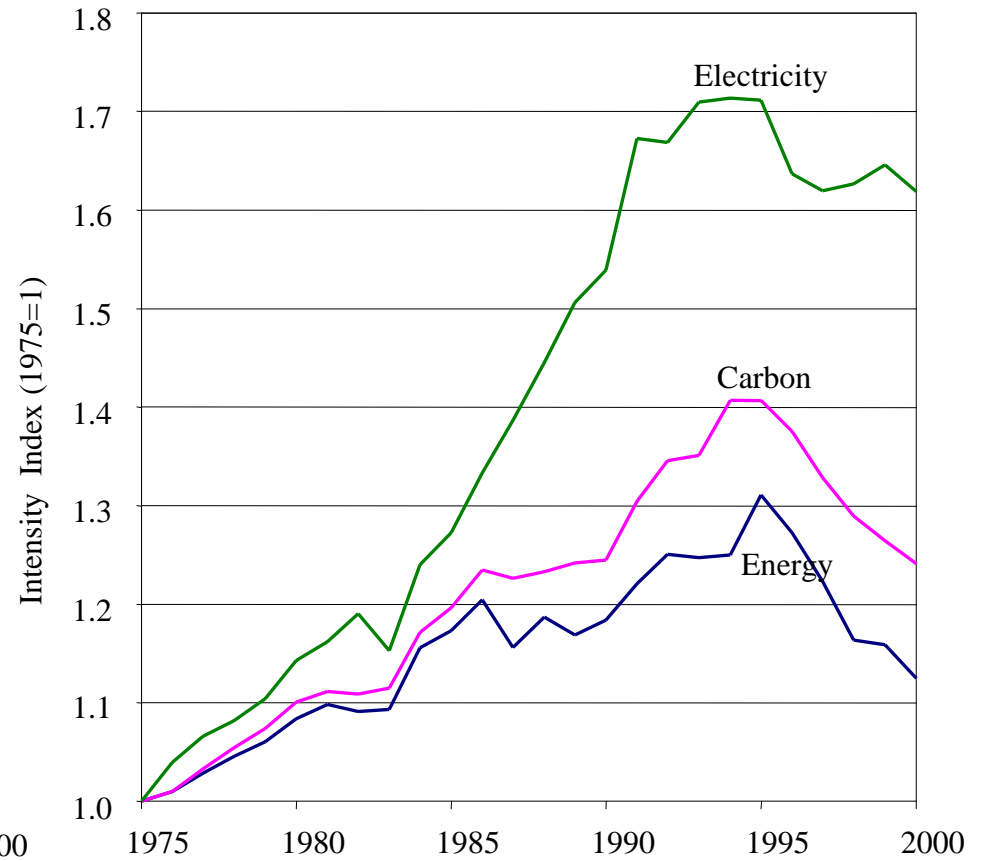
Managing Emissions from Indian Electricity Sector

India

Growth

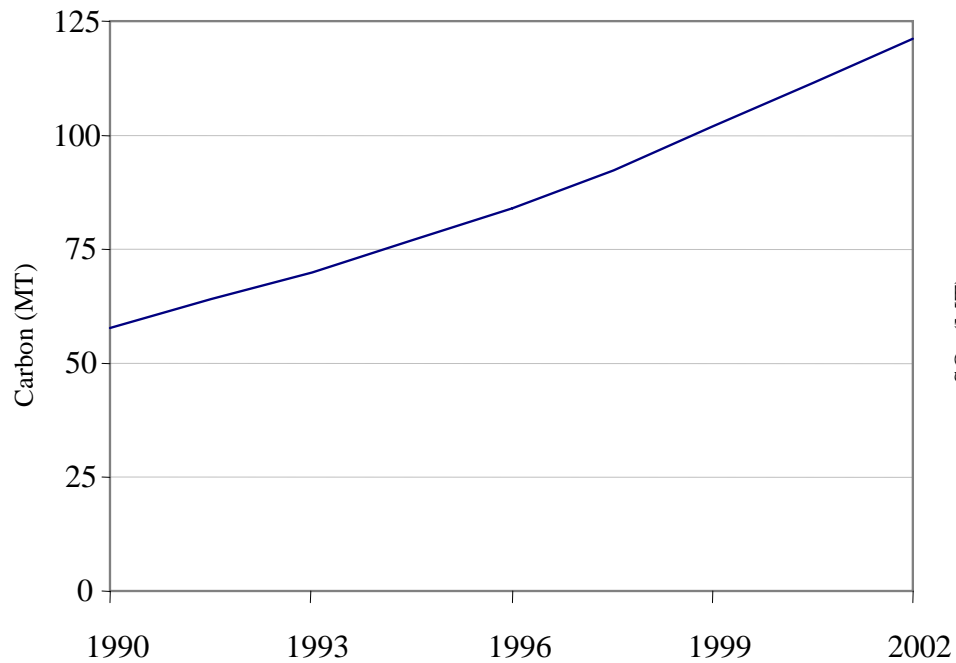


GDP Intensity

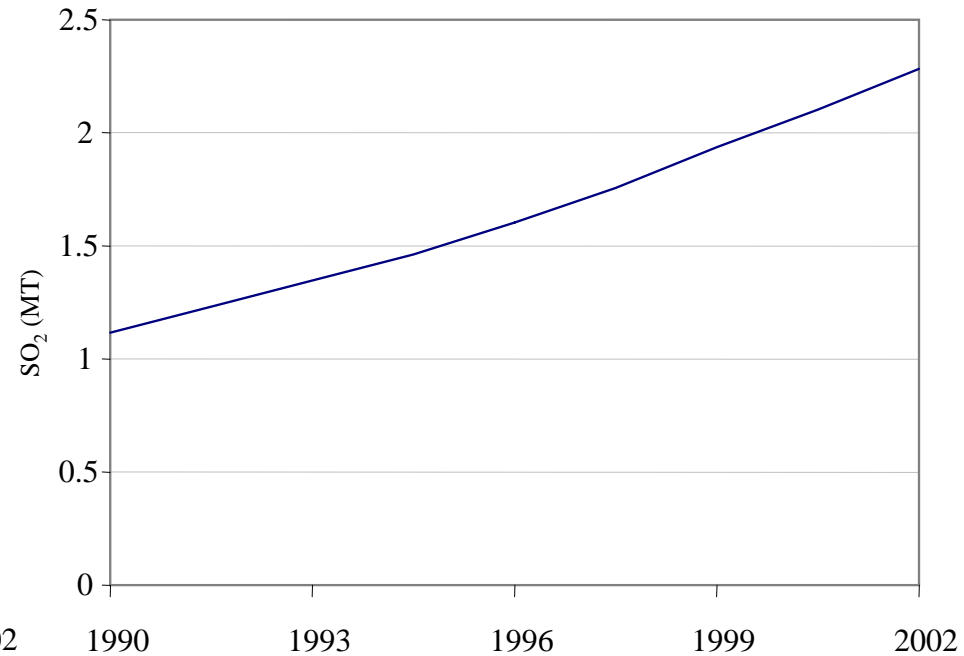


Emissions from Power Plants

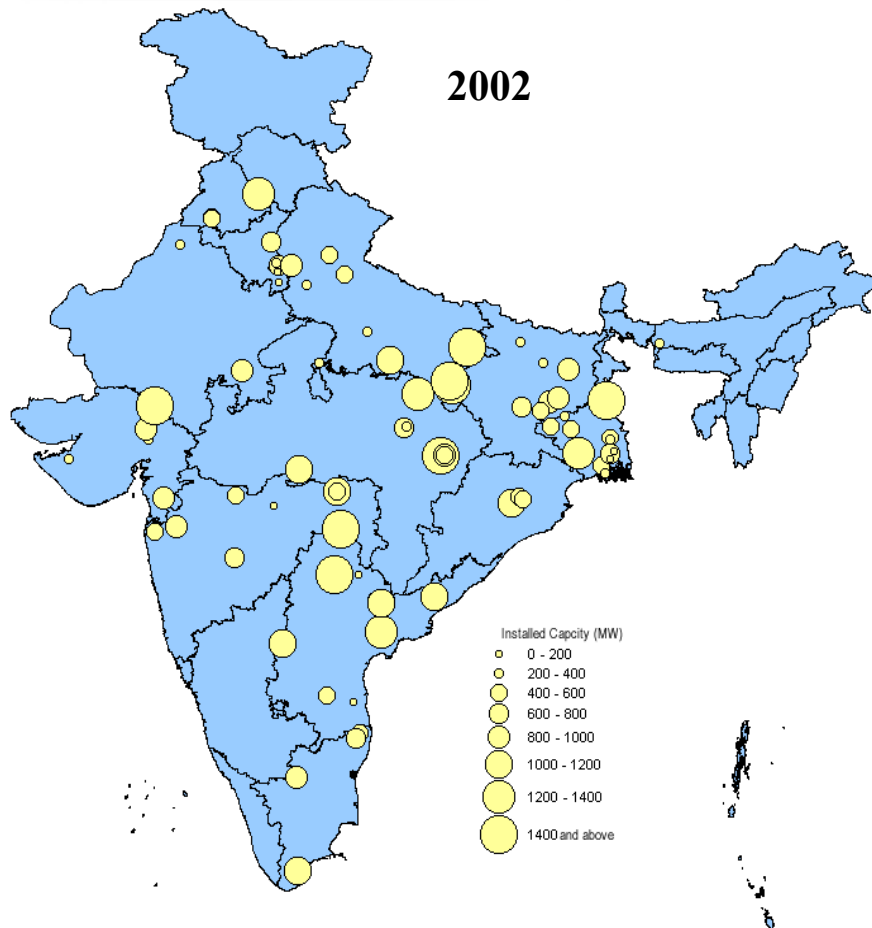
Carbon



SO₂



Indian Power Plants: Data

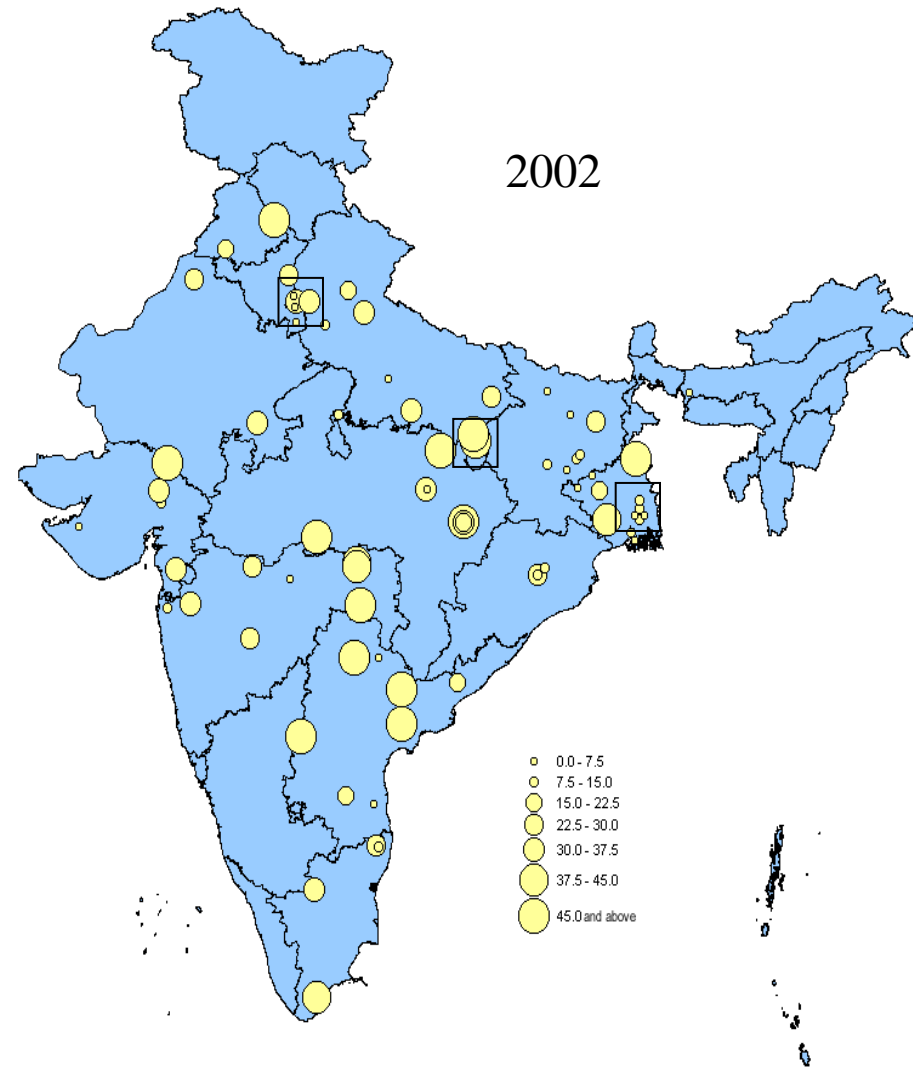
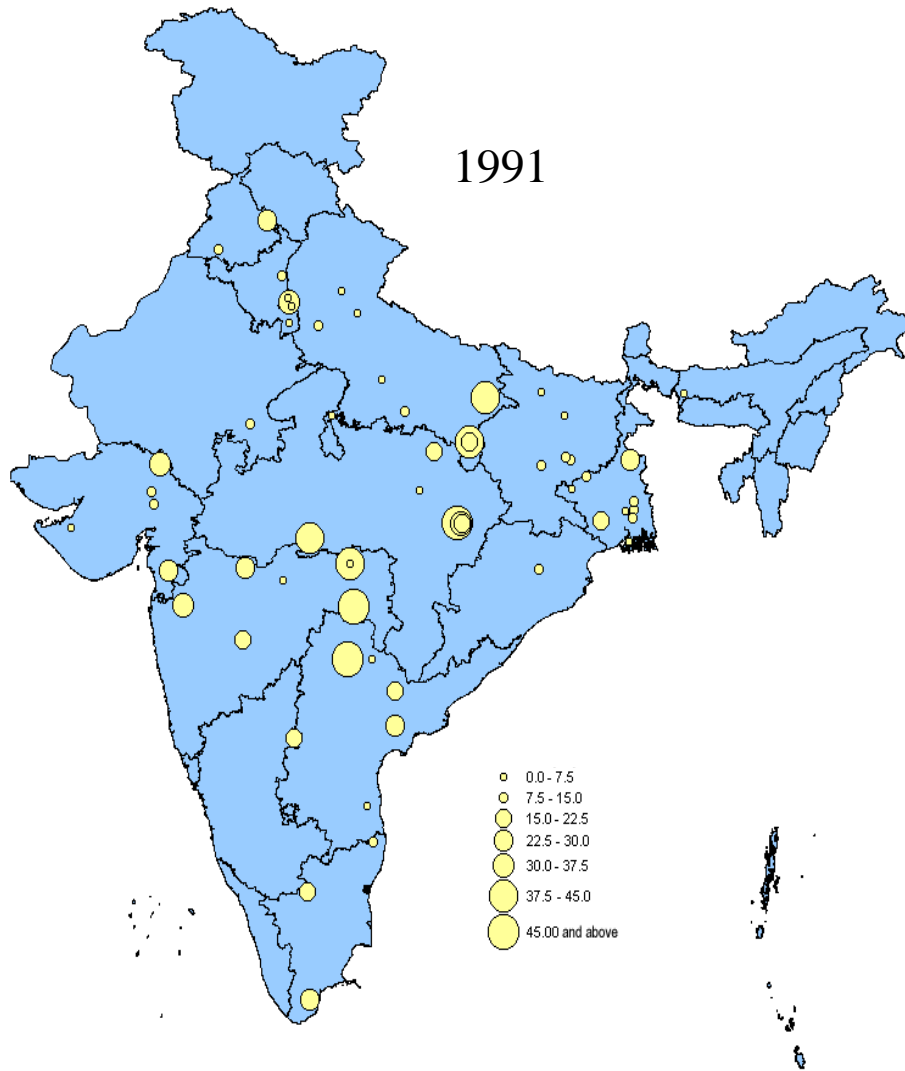


Coal plants: 75

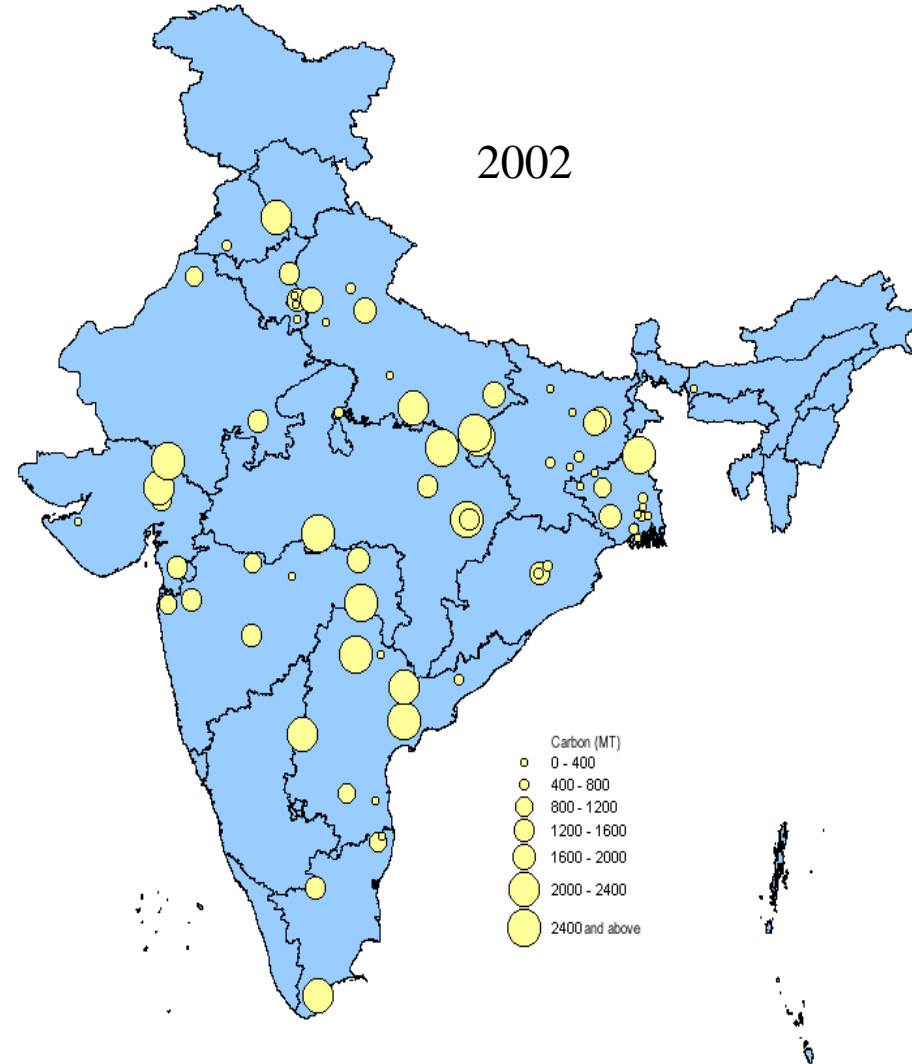
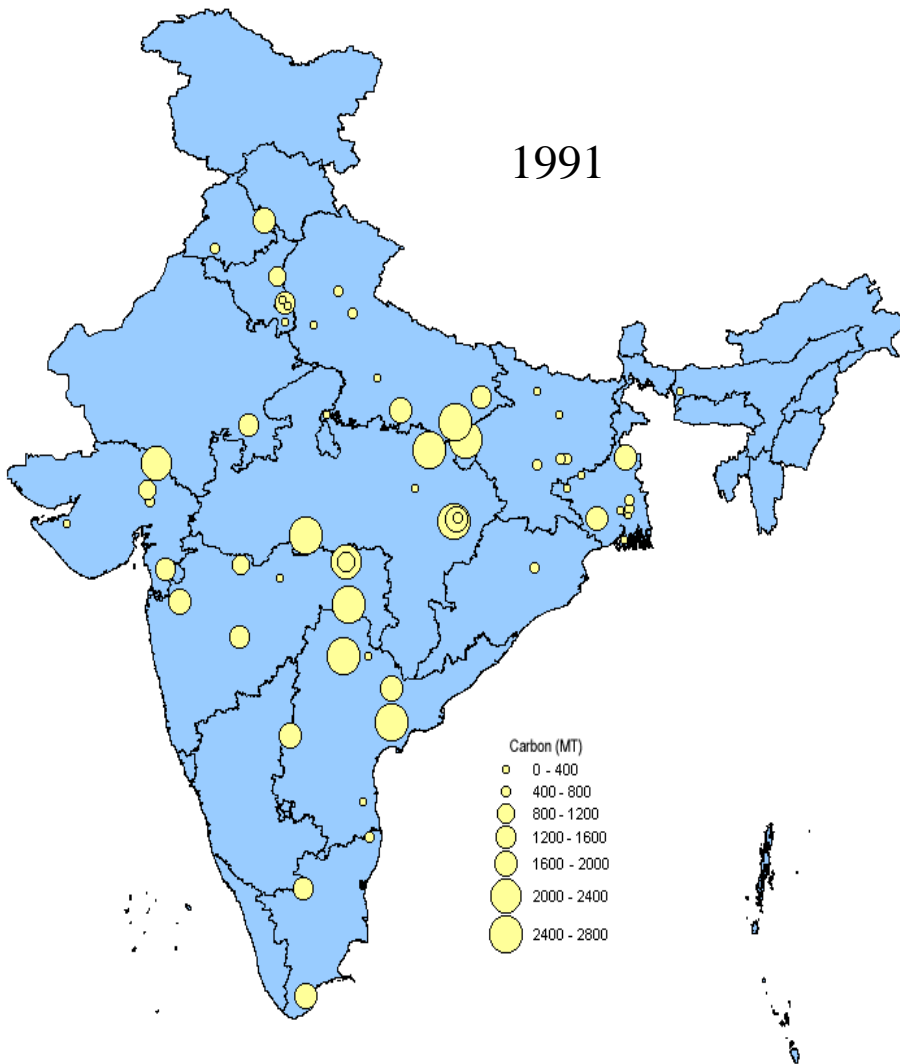
Gas/ Oil plants: 13

<i>Coal Plants</i>	Number		Capacity (GW)	
	1991	2002	1991	2002
State				
AP	5	7	2.4	5.0
Assam	1	1	0.24	0.24
Bihar	5	7	2.4	4.2
Delhi	3	3	1.1	1.1
Gujarat	5	5	3.0	3.8
Haryana	2	2	0.8	0.8
Karnataka	1	1	0.4	1.1
Maharashtra	7	8	4.3	6.5
MP	6	7	5.7	6.7
Orissa	1	3	0.5	1.9
Punjab	2	3	1.3	2.1
Rajasthan	1	2	0.6	1.1
TN	3	4	1.9	3.0
UP	9	10	6.6	8.7
WB	9	12	3.5	6.0

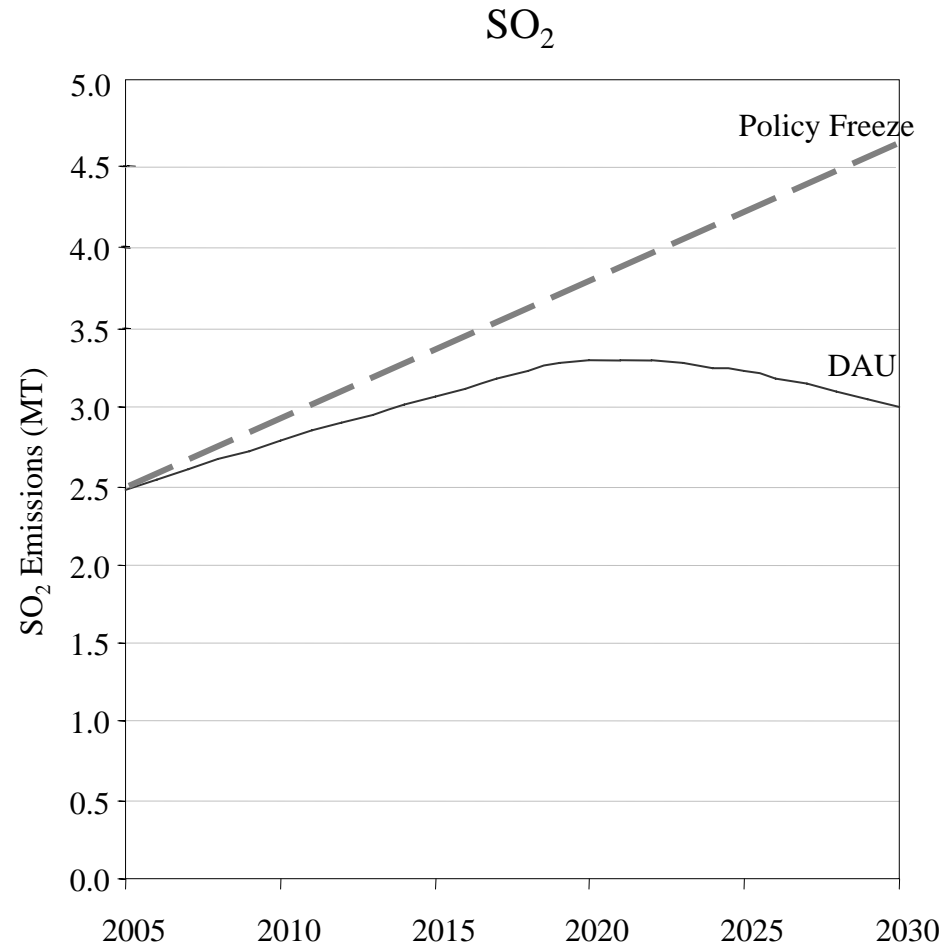
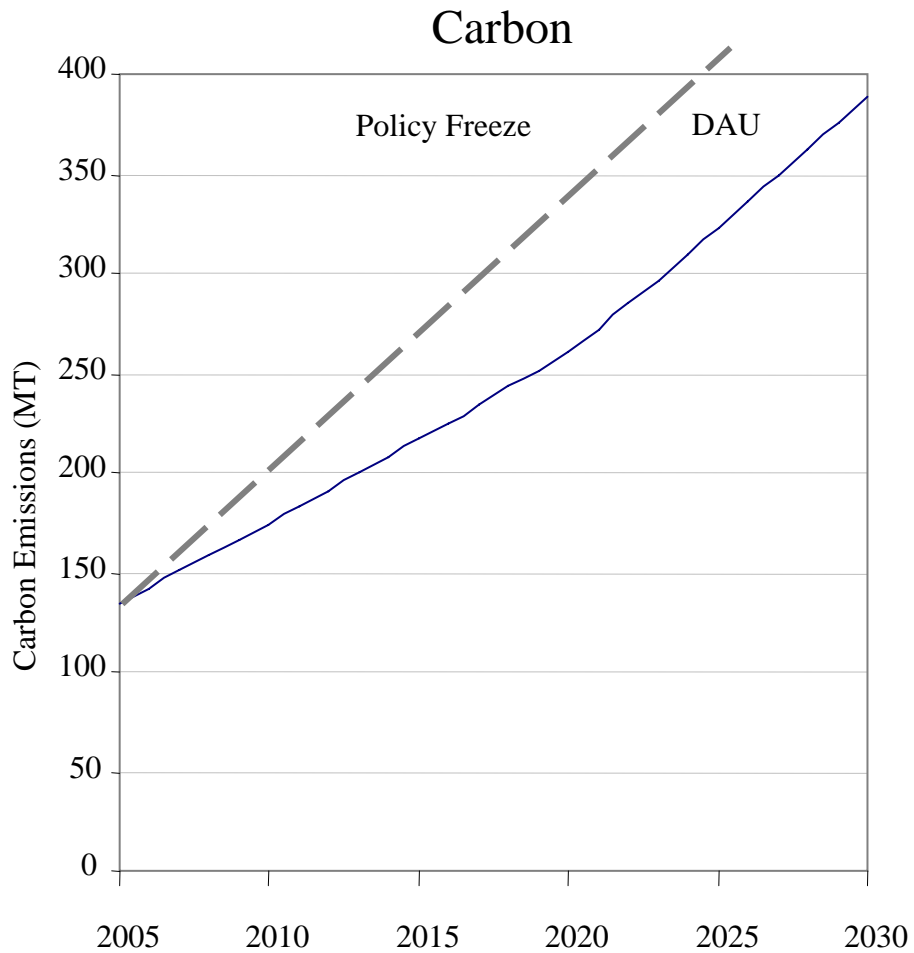
SO₂ Emissions



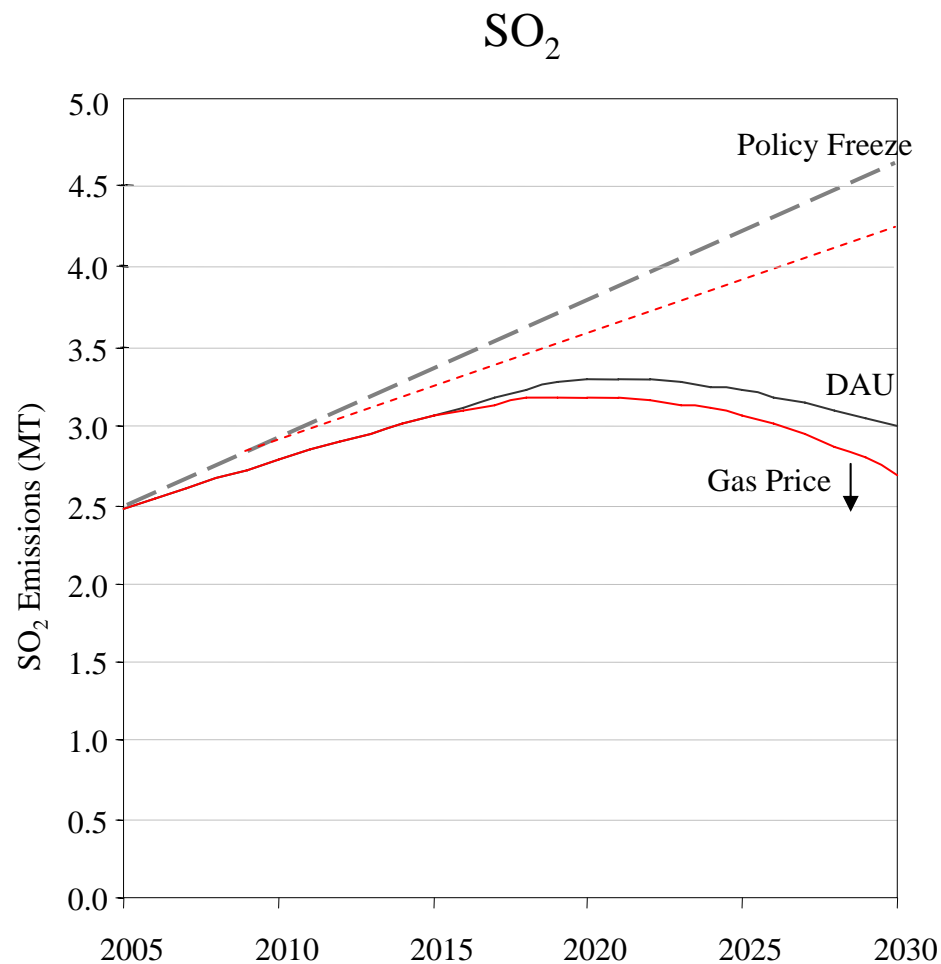
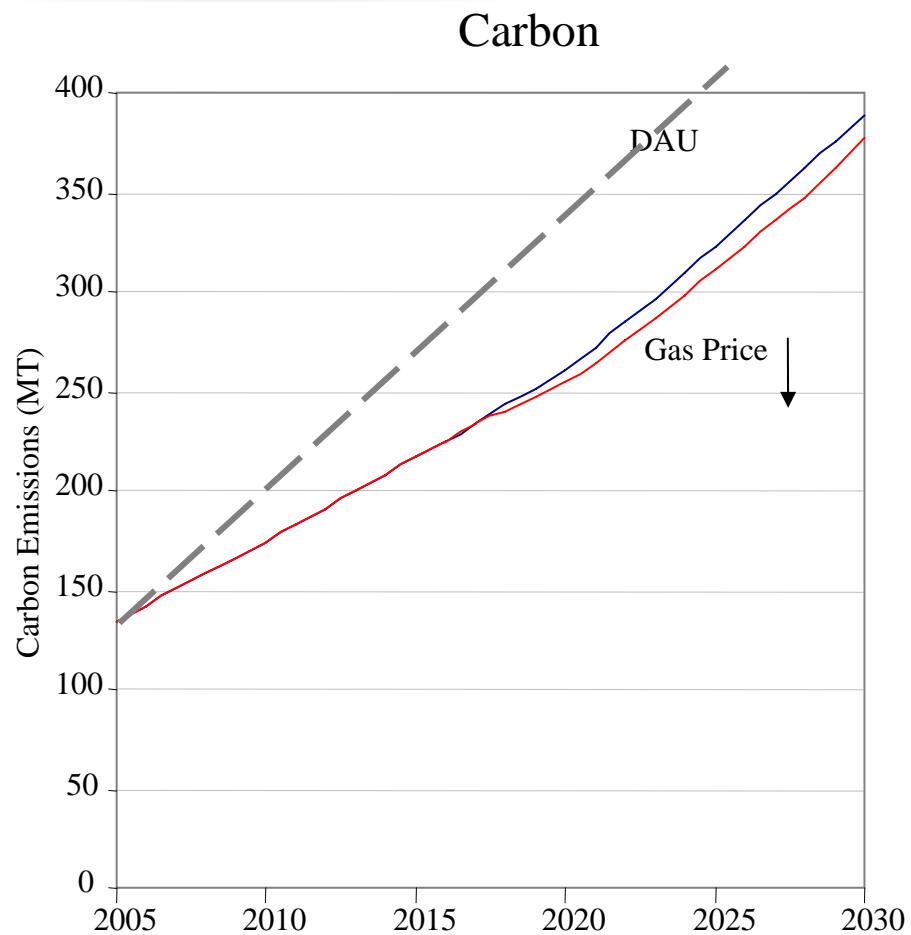
CO₂ Emissions



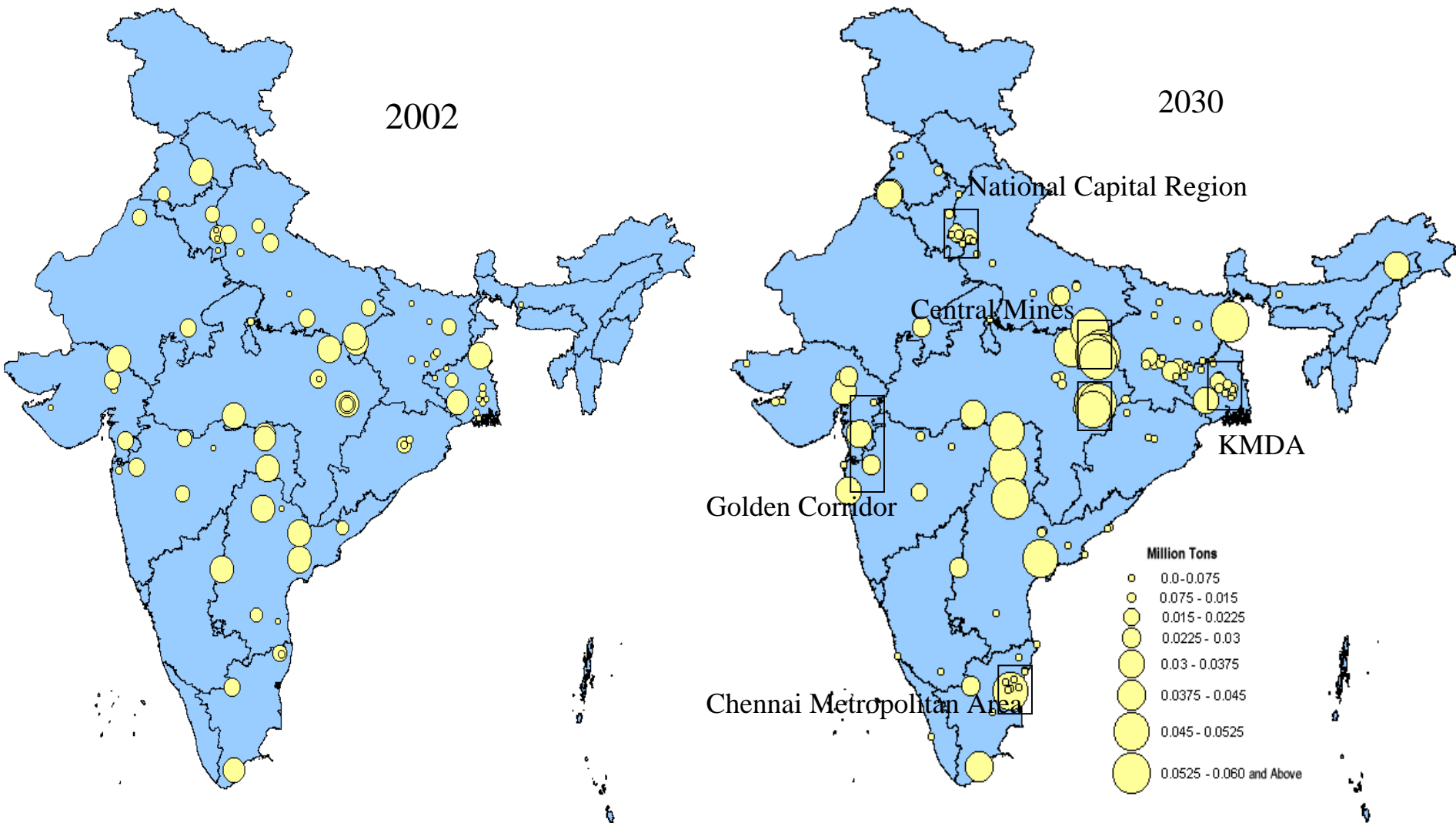
Future Emissions from Power Plants



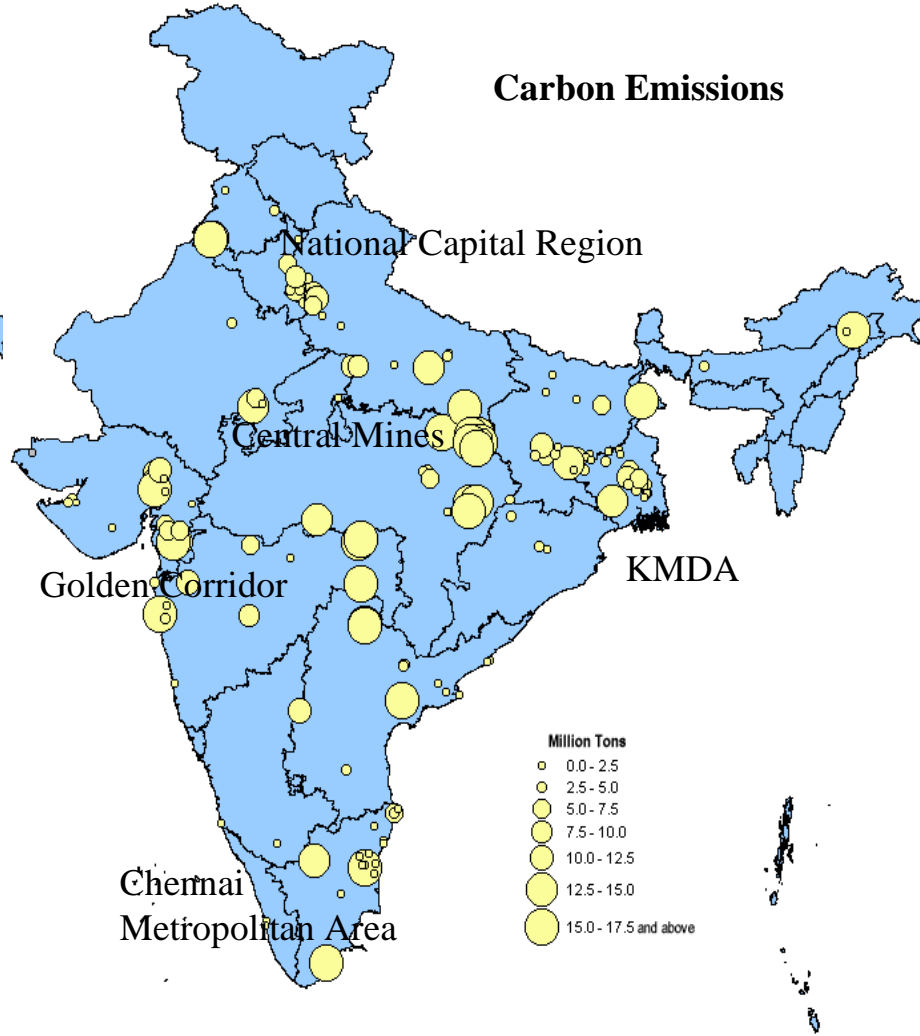
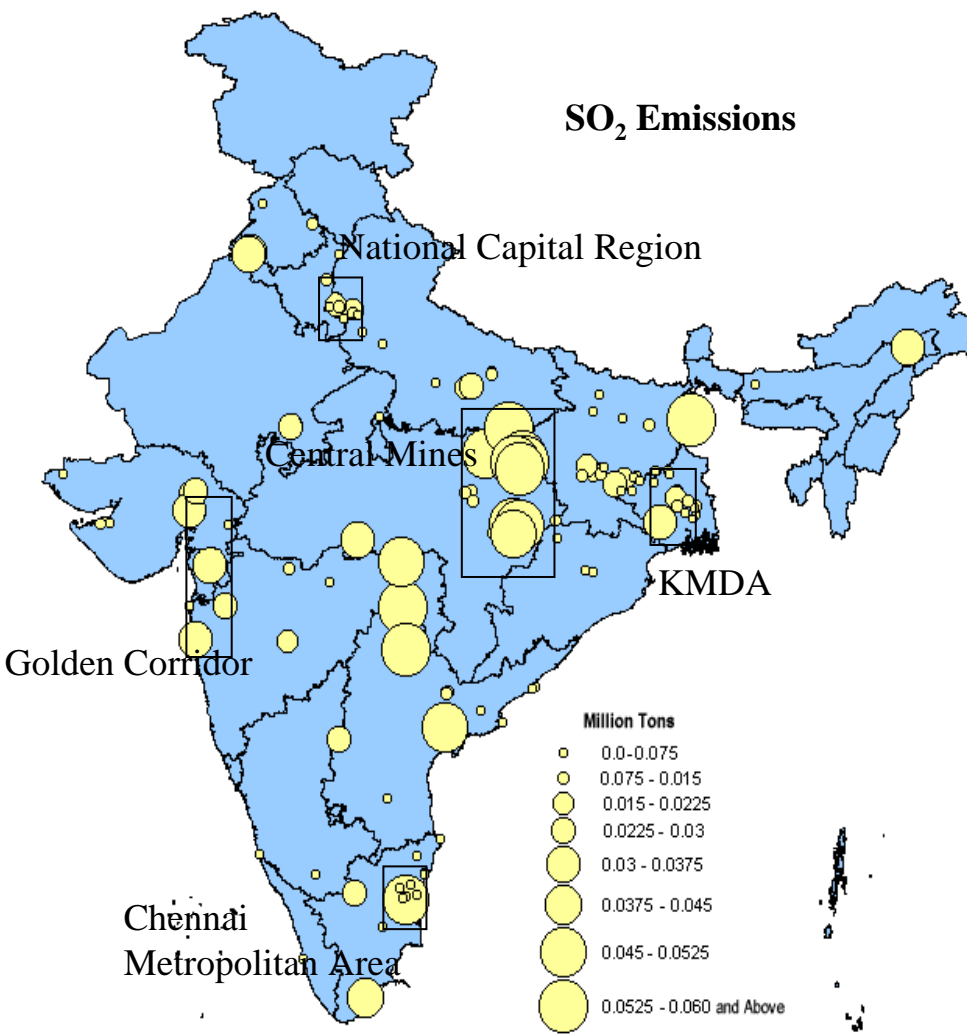
Future Emissions from Power Plants



SO₂ Emissions



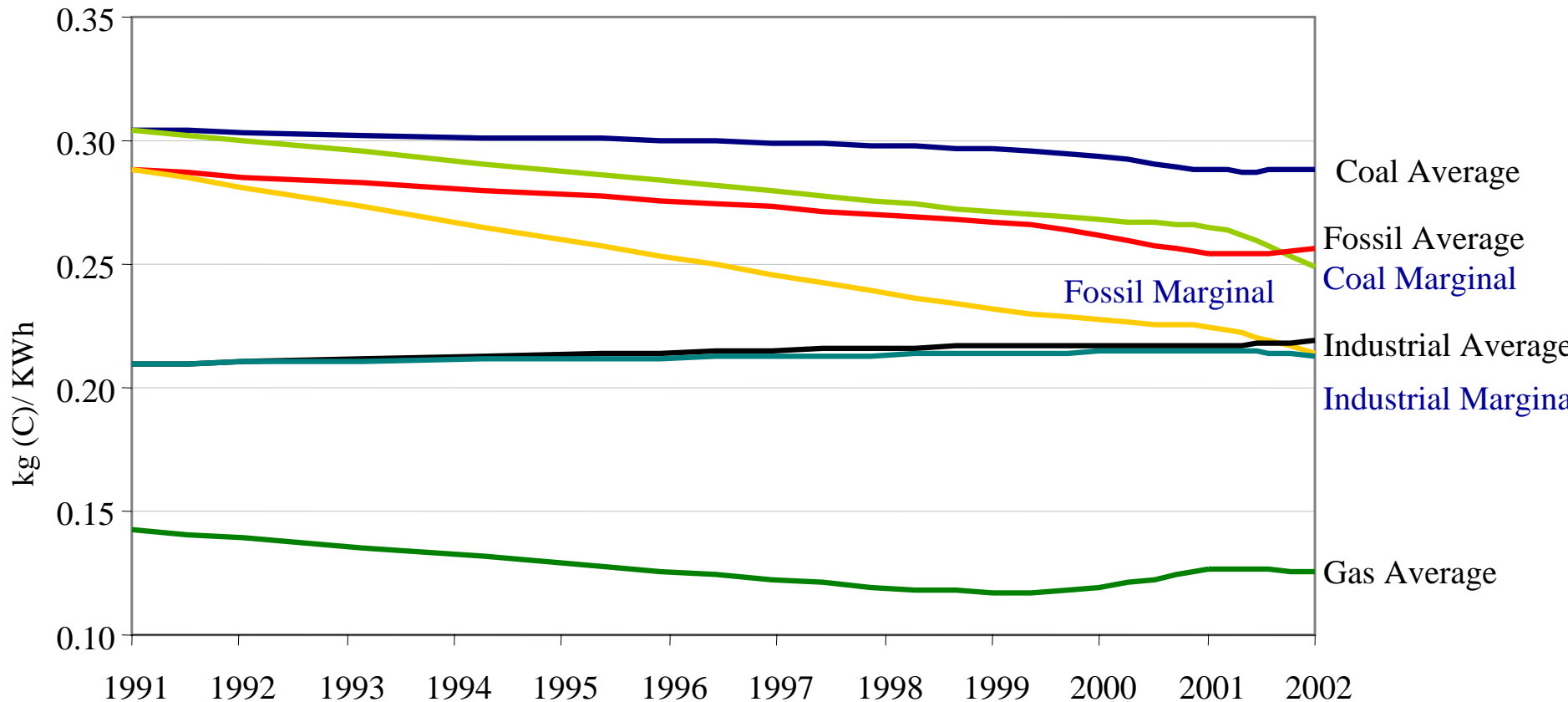
Future Emissions (2030)



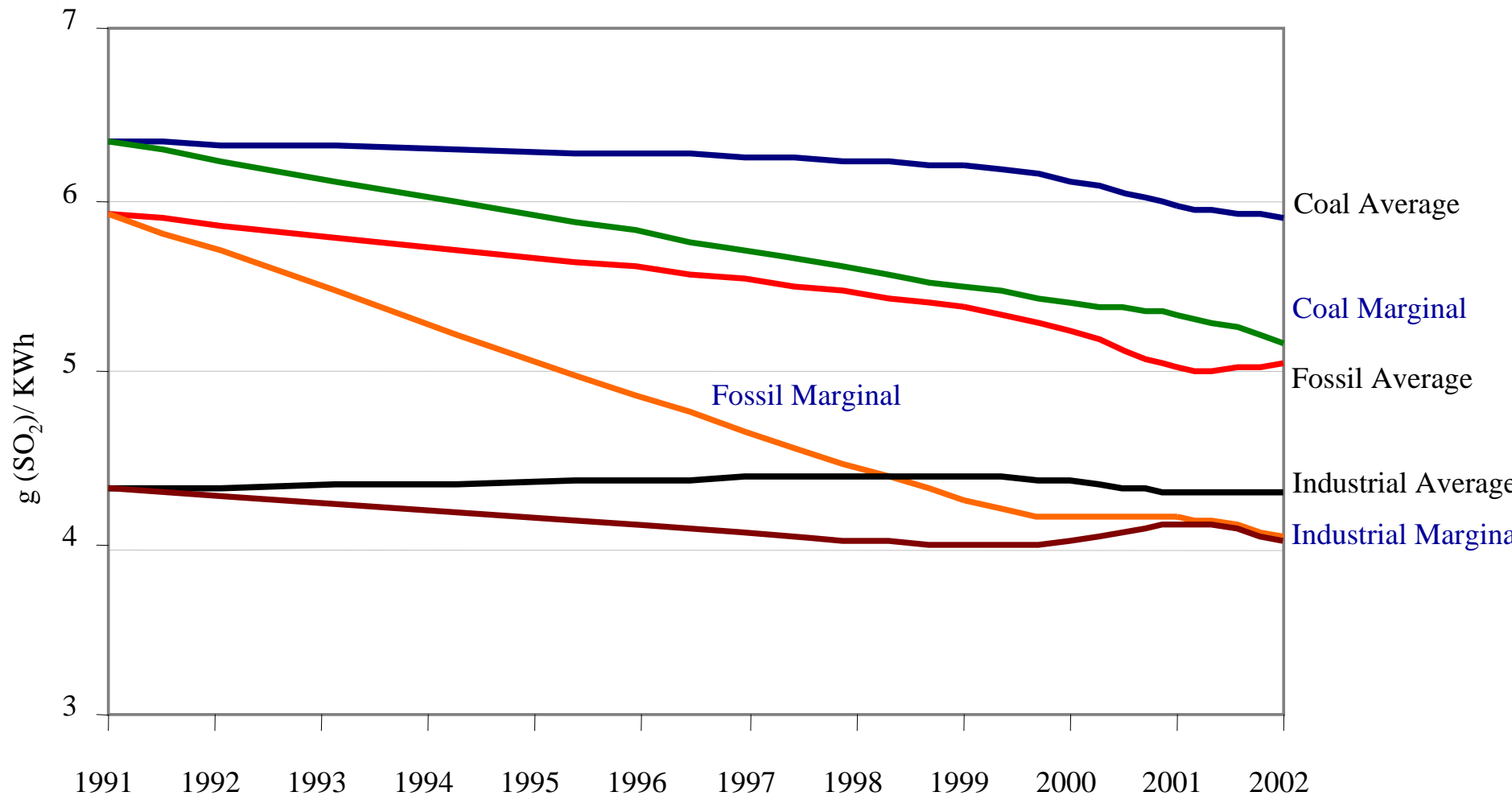
AIM/Local Model Application:

Managing Electricity Sector Emissions from Gujarat State

All India: CO₂ Emission Baselines

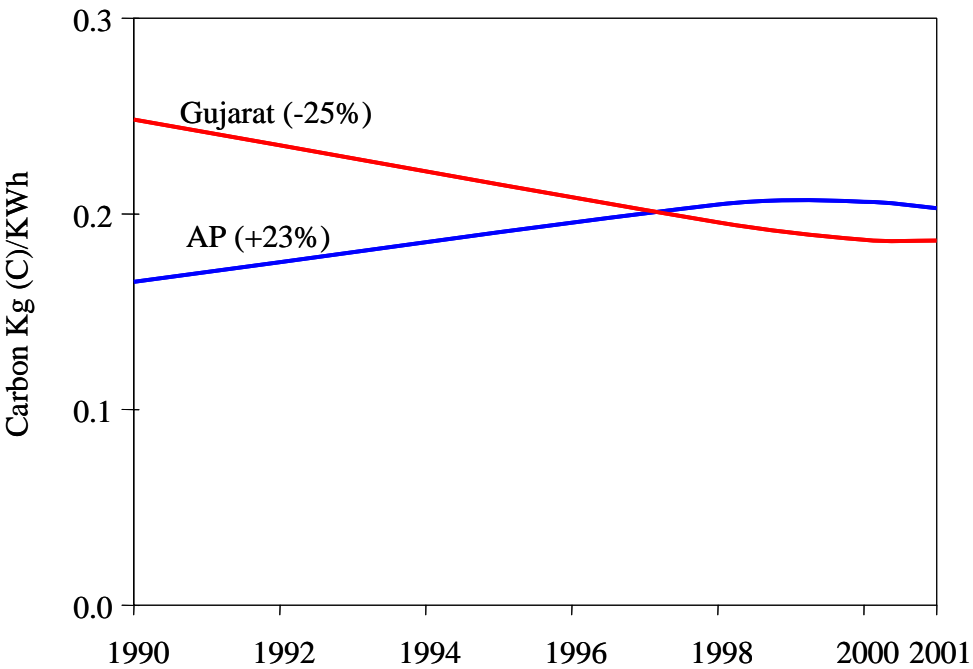


All India: SO₂ Emission Baselines

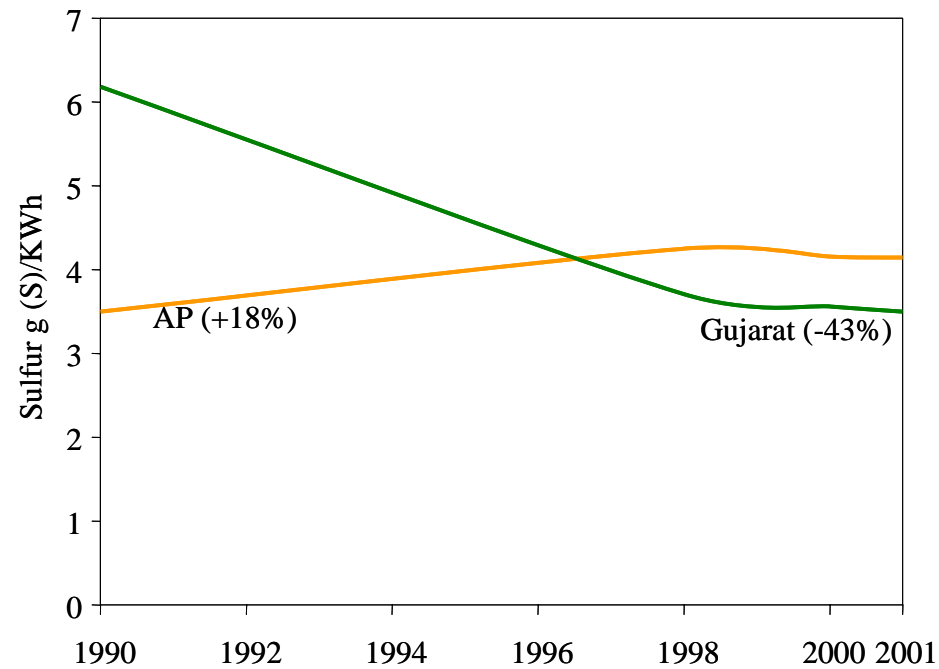


State Variation of Emission Baselines

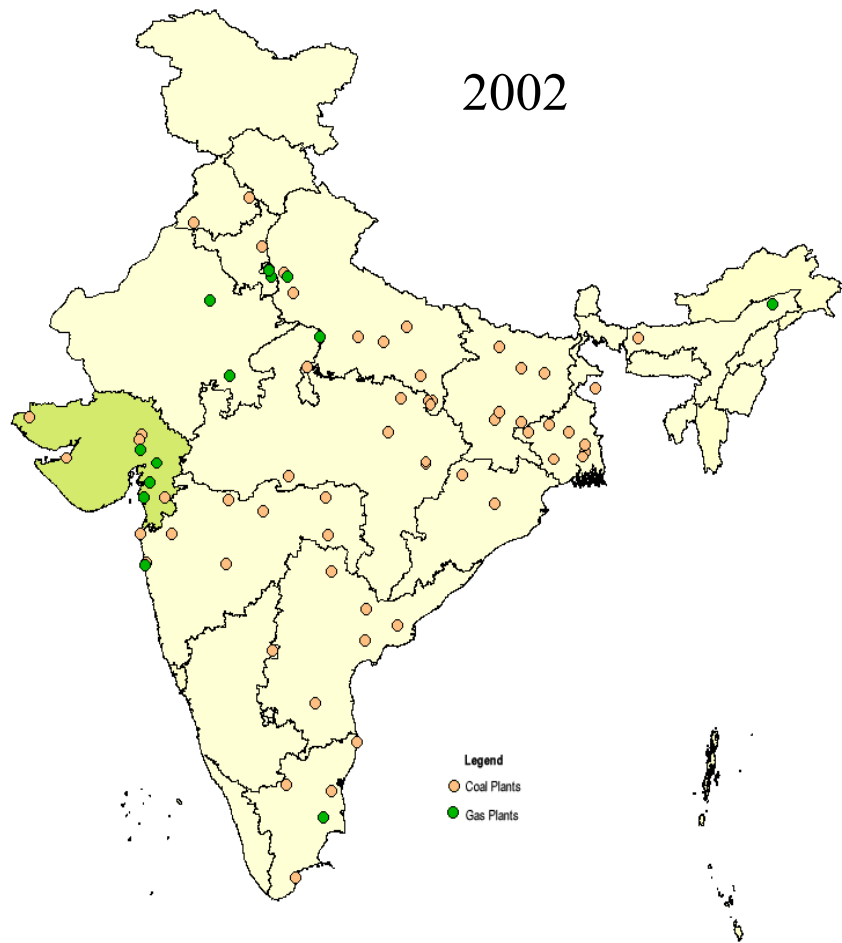
Carbon



Sulfur



Gujarat Emissions Study



Data:

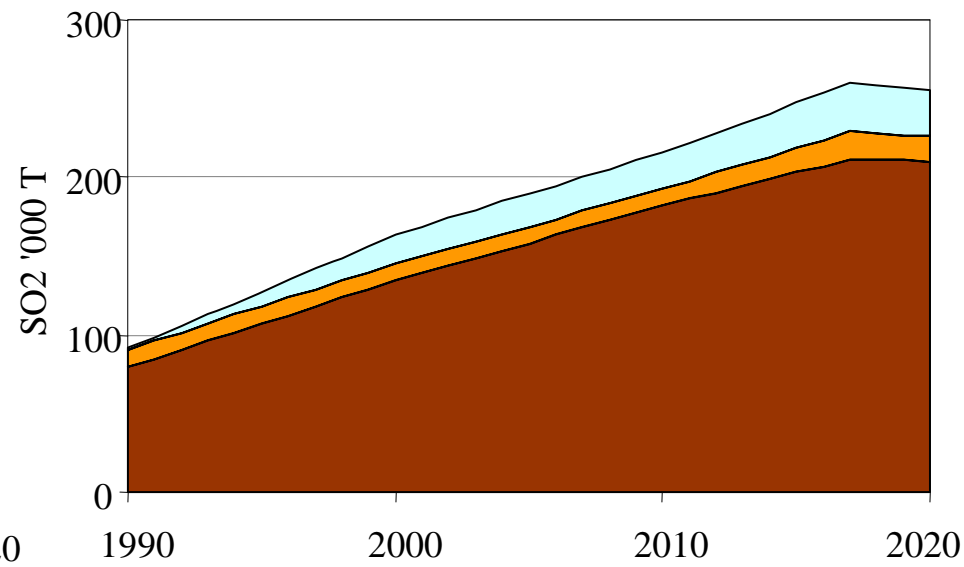
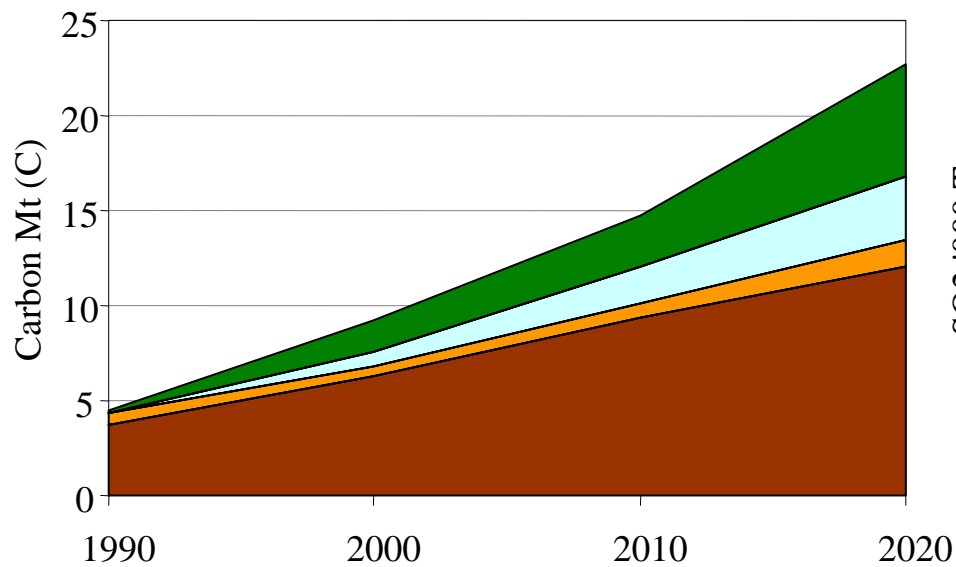
Unit Level data for
16 plants, 45 units

Fuel	Plants	Units	MW
Coal	5	23	3820
Gas/Naphtha	8	11	3159
Lignite	2	5	465
LSHS	1	6	534
Total	16	45	7978

Projections: Gujarat

Carbon

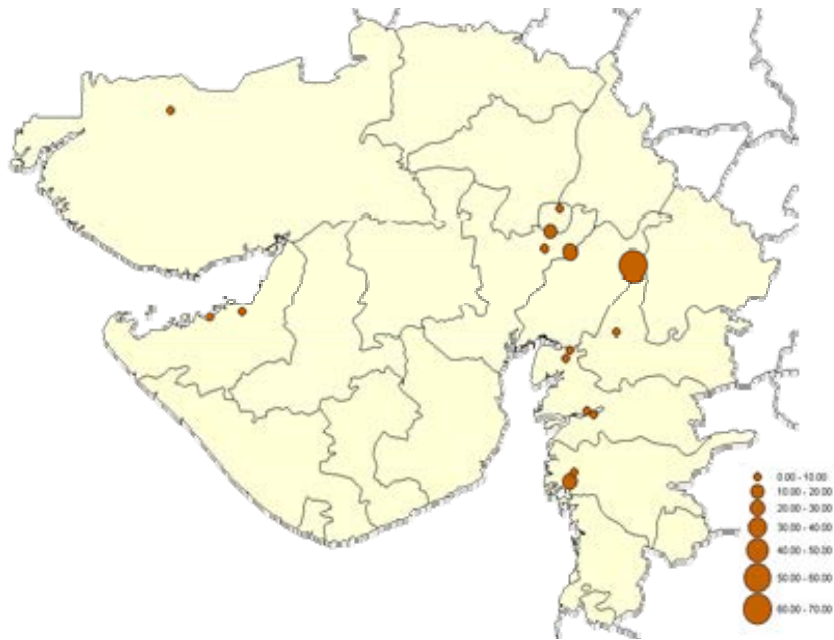
Sulfur



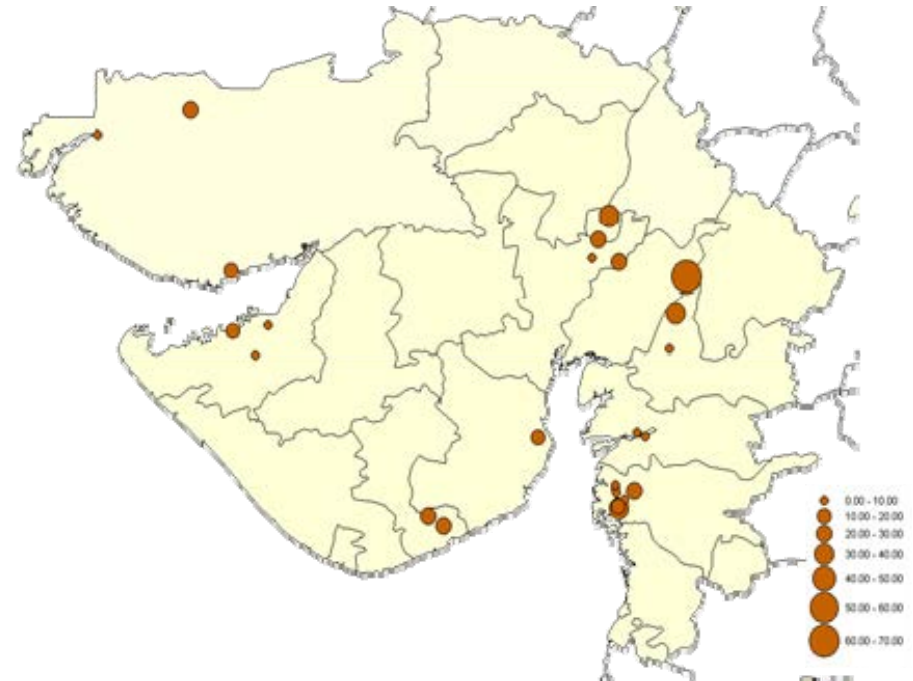
■ Coal ■ Oil ■ Lignite ■ Gas

SO₂ Emissions in 2000

2000



2020



Conclusions from AIM Local Model Application

- Rapidly rising emissions from the electricity sector
- Rising Hot spots
- Prominence of LPS
- Variations in baselines across states
- Disjoint in CO₂ and SO₂ emissions in future
- Multiple dividends from conjoint policies for emissions mitigation

Future Work

1. Multi-gas Emissions inventory assessment
 - Add F-Gases
 - Update regional inventory assessment
 - Link with technology, policy and institutional innovations
2. AIM model applications
 - AIM/Local Model Application for Urban Centers
 - Link AIM/Local application with AIM/Air Model analysis
 - CGE Model to represent special issues of developing countries (interface with CAPaBLE project)
 - Assessment of conjoint emissions mitigation policies
 - Short-term assessment for CDM potential
 - Analysis to gain insight for the beyond-Kyoto discussions
 - Modeling work with AIM team on Long-term scenarios in the contexts of AR4, EMF etc.
3. Capacity building and dissemination