

Sustainable Energy Development of India

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Recent High Economic Growth of India, the state of Poverty and the concern for Environmental Sustainability.

NDP Growth Rate (Annual Average) Agr. growth Per capita income growth

1868 – 1898:	0.99	1.01	0.59
1900 – 1946:	0.86	0.31	- 0.01

GDP Growth rates:

1950 – 01 to 1980 – 81	3.5
1980 – 81 to 1990 – 91	5.6
1990 – 91 to 2000 – 01	5.7
2000 – 01 to 2005 – 06	6.8
2002 – 03 to 2005 – 06	8.3

Poverty Ratio			
	Rural	Urban	Overall
1973 – 74	56.4	49.0	54.9
1977-78	53.1	45.2	51.3
1983	45.7	40.8	44.5
1987 – 88	39.1	38.2	38.9
1993-94	37.3	32.4	36.0
2004 - 05	28.3	25.7	27.5

- The slow pace of decline in poverty ratio in spite of higher growth since economic reforms.
- The approach of 11th Five Year Plan towards faster inclusive growth.
- Target of 9% GDP growth over the long term Planning horizon.
- The energy implication of such macroeconomic development strategy is expected to result in substantive growth of carbon intensive infrastructure and energy sector development.

- **Energy Economists till now have focused on**

- (a) the issues of *Energy Security* arising from sustained oil price rise and geo-political turmoil**

- (b) Global environmental sustainability – Global Warming and Climate Change; Issues relating to growth and curbing of CO2 Emission, etc.**

- **There is a relative neglect of *Energy Poverty issue***

- **Energy Poverty due to Dualism in the pattern of resource-use**

The consumption basket of the rich consists of goods and services which have greater intensive use of fossil fuel, minerals, chemicals etc. than that of the poor.

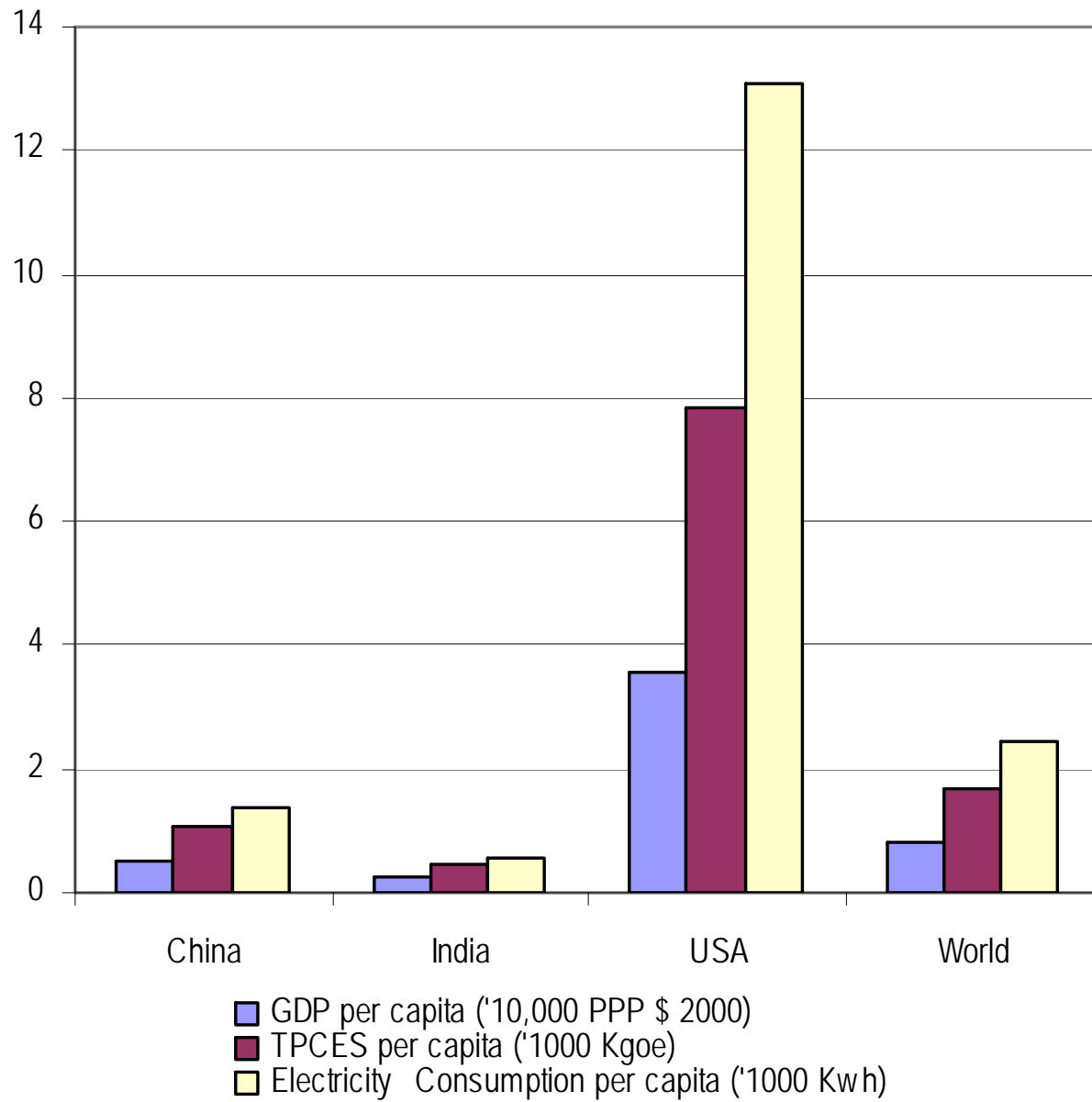
There is Dualism also in the pattern of direct energy consumption by Households

Vast majority of rural and urban poor have to depend on unclean, unconverted and highly inefficient biomass fuel for cooking. Significant lack of connectivity with electricity and/or its reliable supply for particularly the rural households. Energy Poverty removal is critical for decent quality of life and human development.

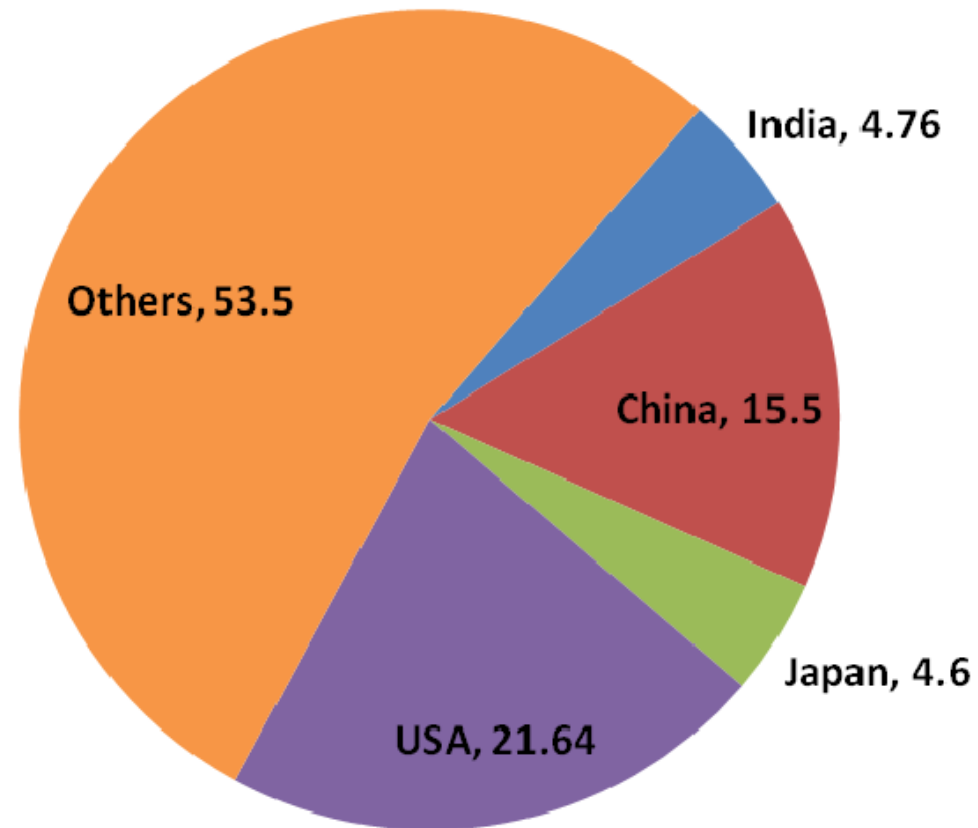
- Need to address the issue of *Energy Poverty* along with that of *Energy Security* and *Environmental Sustainability* by providing the common people adequate access to modern clean energy.
- This would cause substitution of one kind of environmental pressure by another and may in the net, cause upward pressure on the environment as carbon neutral biomass fuel is to be replaced by fossil fuel based energy in Indian situation.
- The issues of equity of access and transition to modern energy forms need to be taken up along with those of global climate change and regional environmental issues.

TREND AND PATTERN OF ENERGY CONSUMPTION IN INDIA

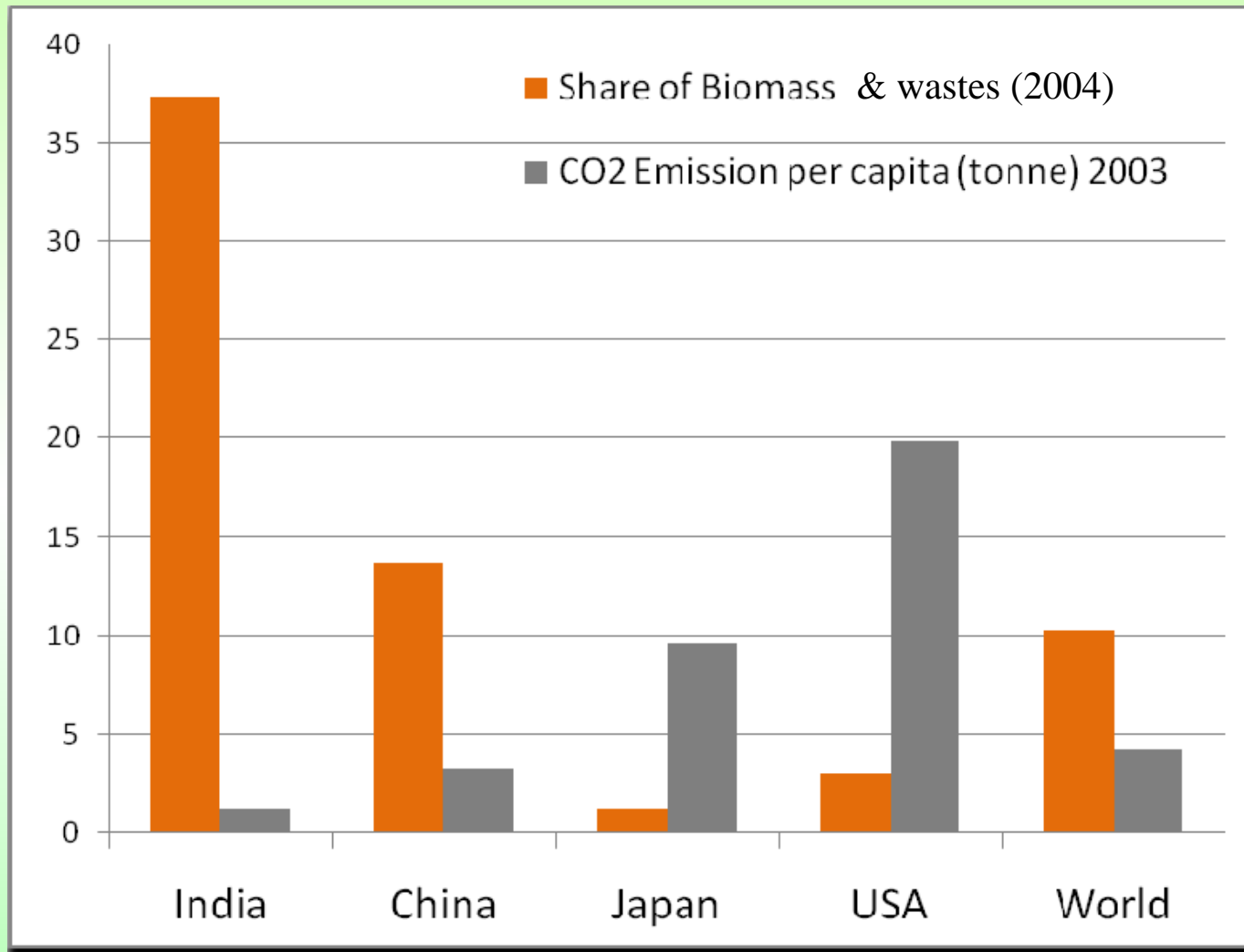
Energy Indicators (2003)



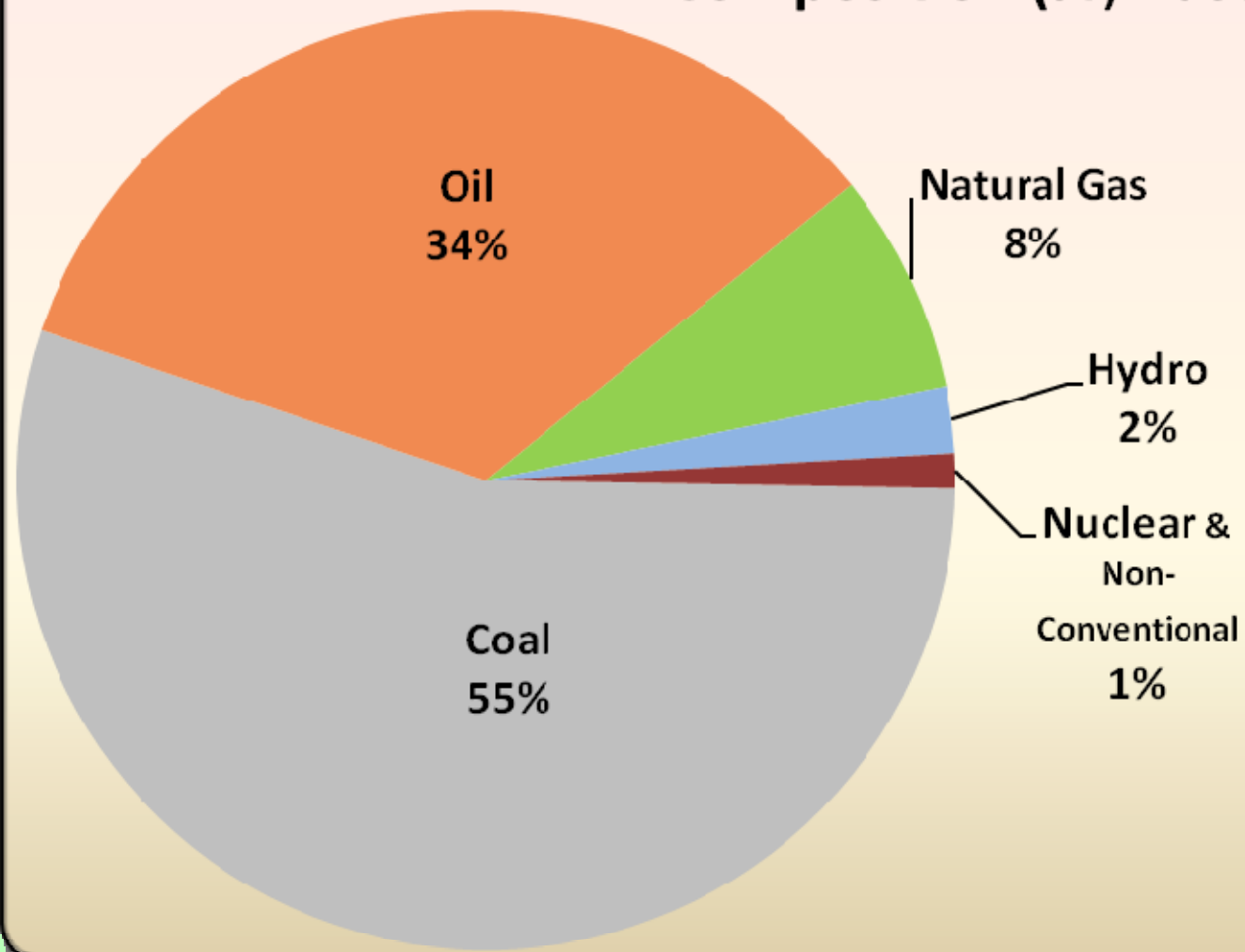
Share of CO2 emission in World Total (%) 2003



Comparative share of Biomass and CO2 emission per capita.



Primary Energy Resource Composition (%) 2005



% Sectoral Share Of Primary Energy 2005

Non-Energy
Use

12%

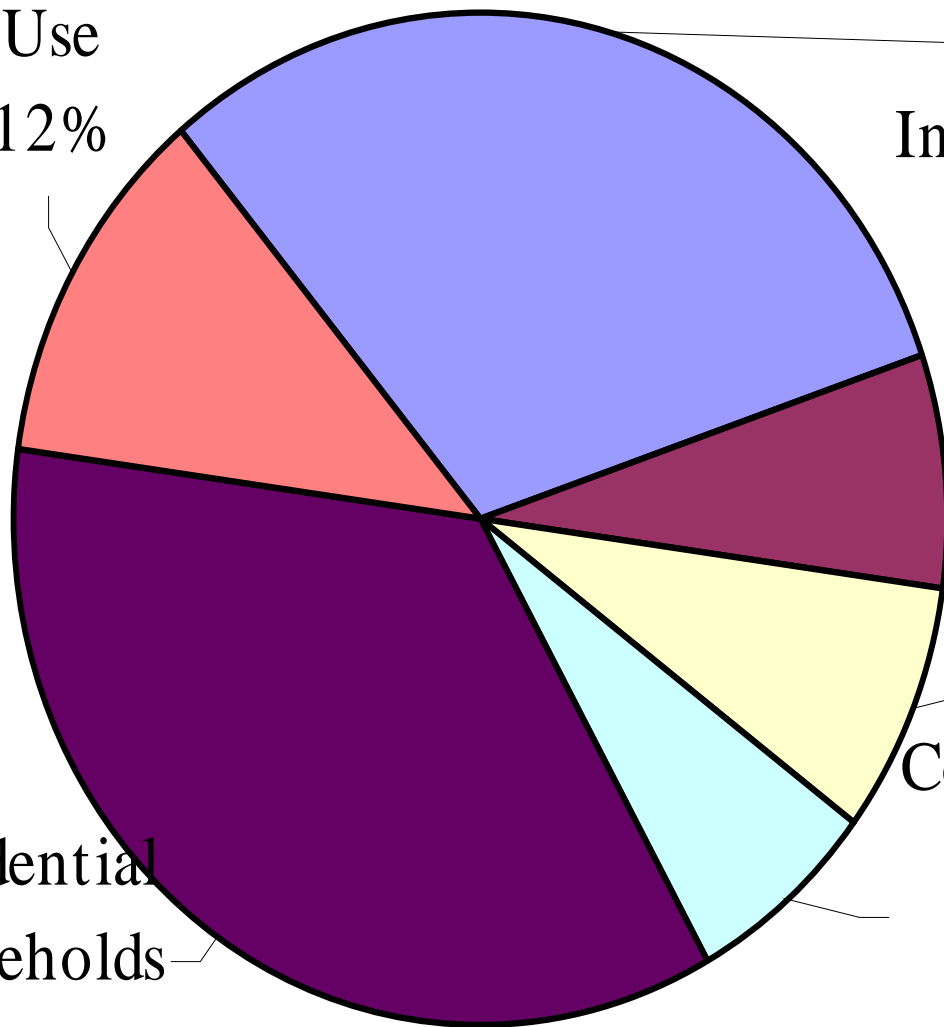
Industry
31%

Transport
8%

Agriculture
8%

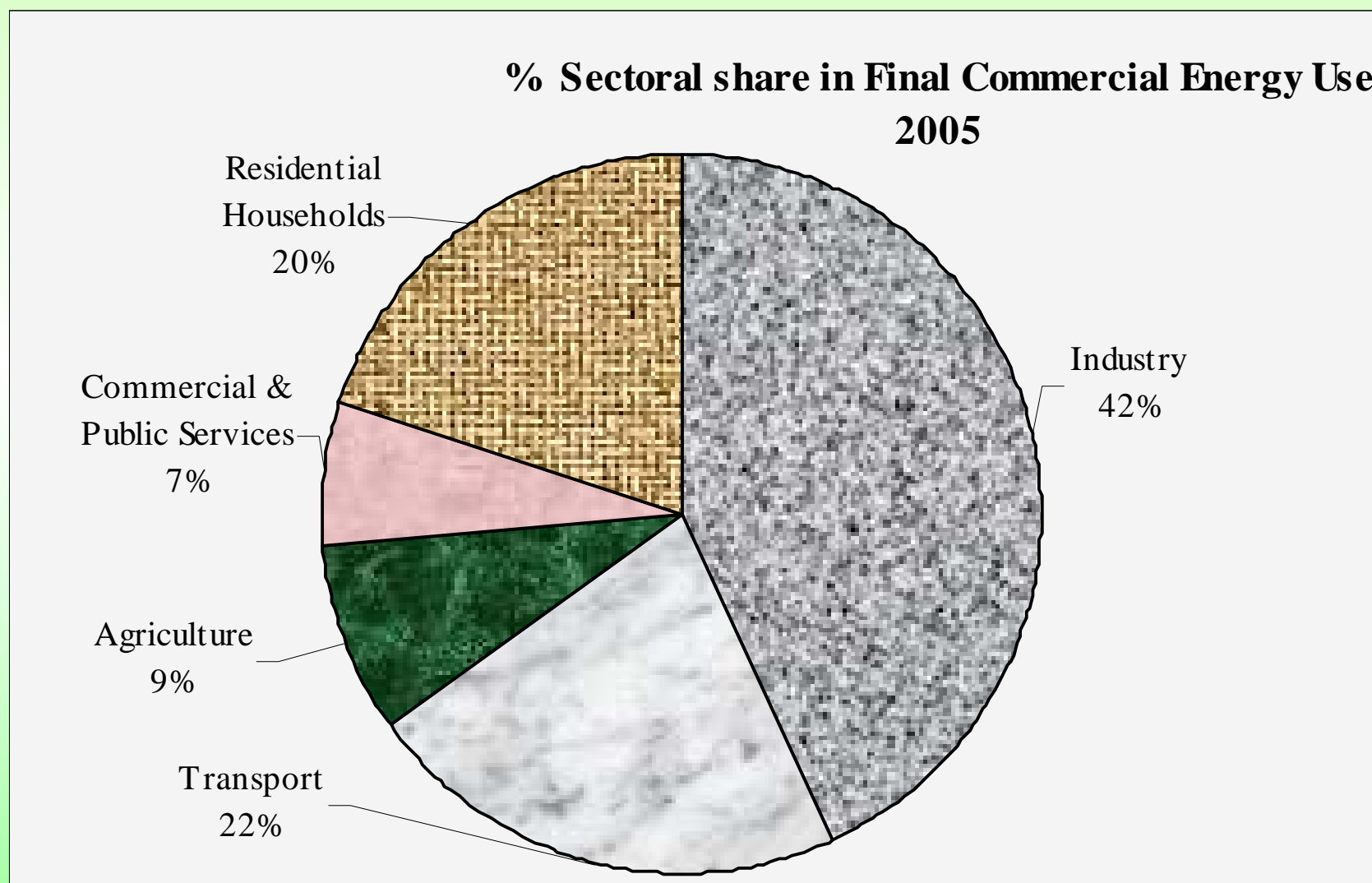
Commercial
& Public
Services
7%

Residential
Households
34%

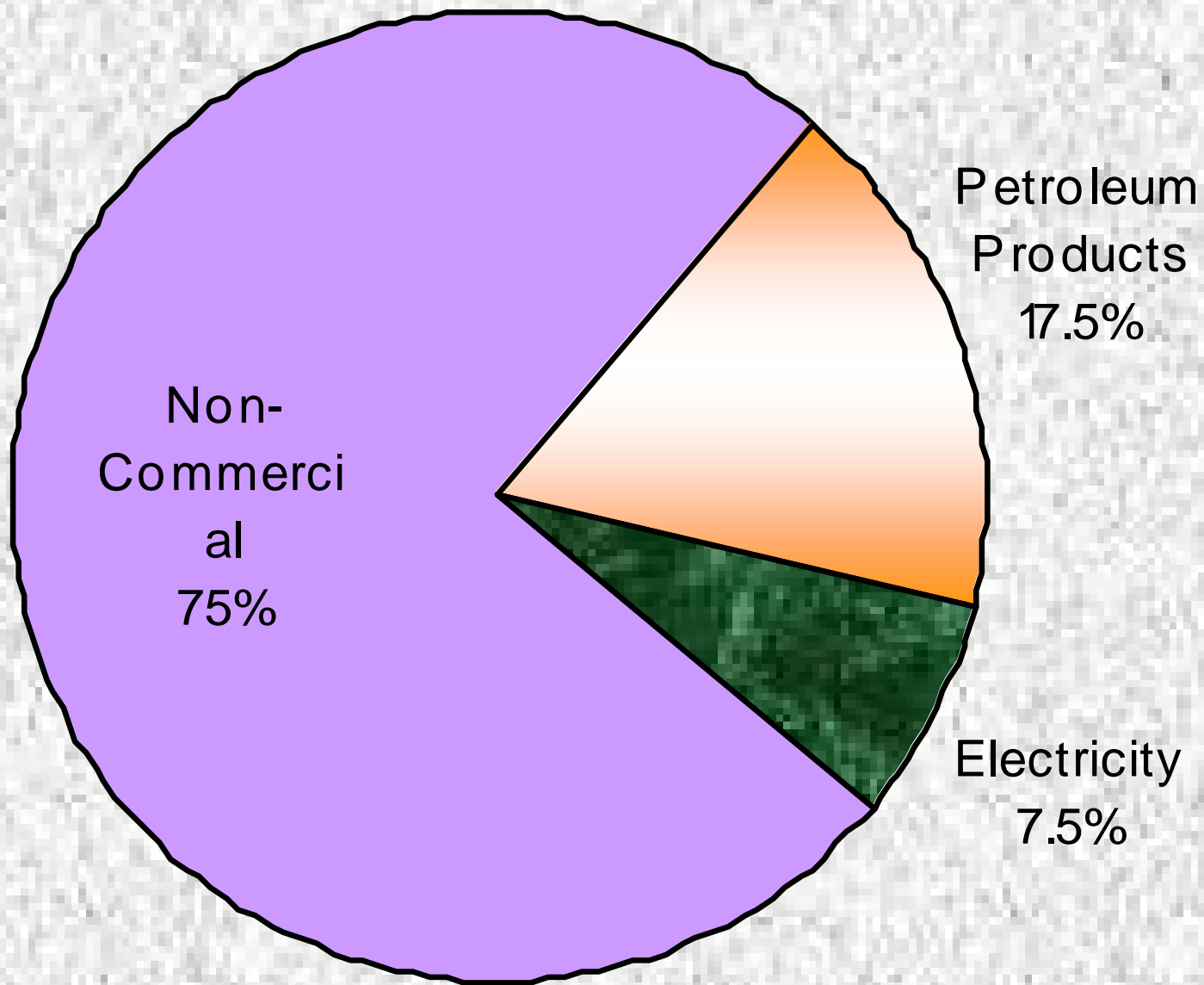


Fuelwise Sectoral Distribution of Final Commercial Energy Use.

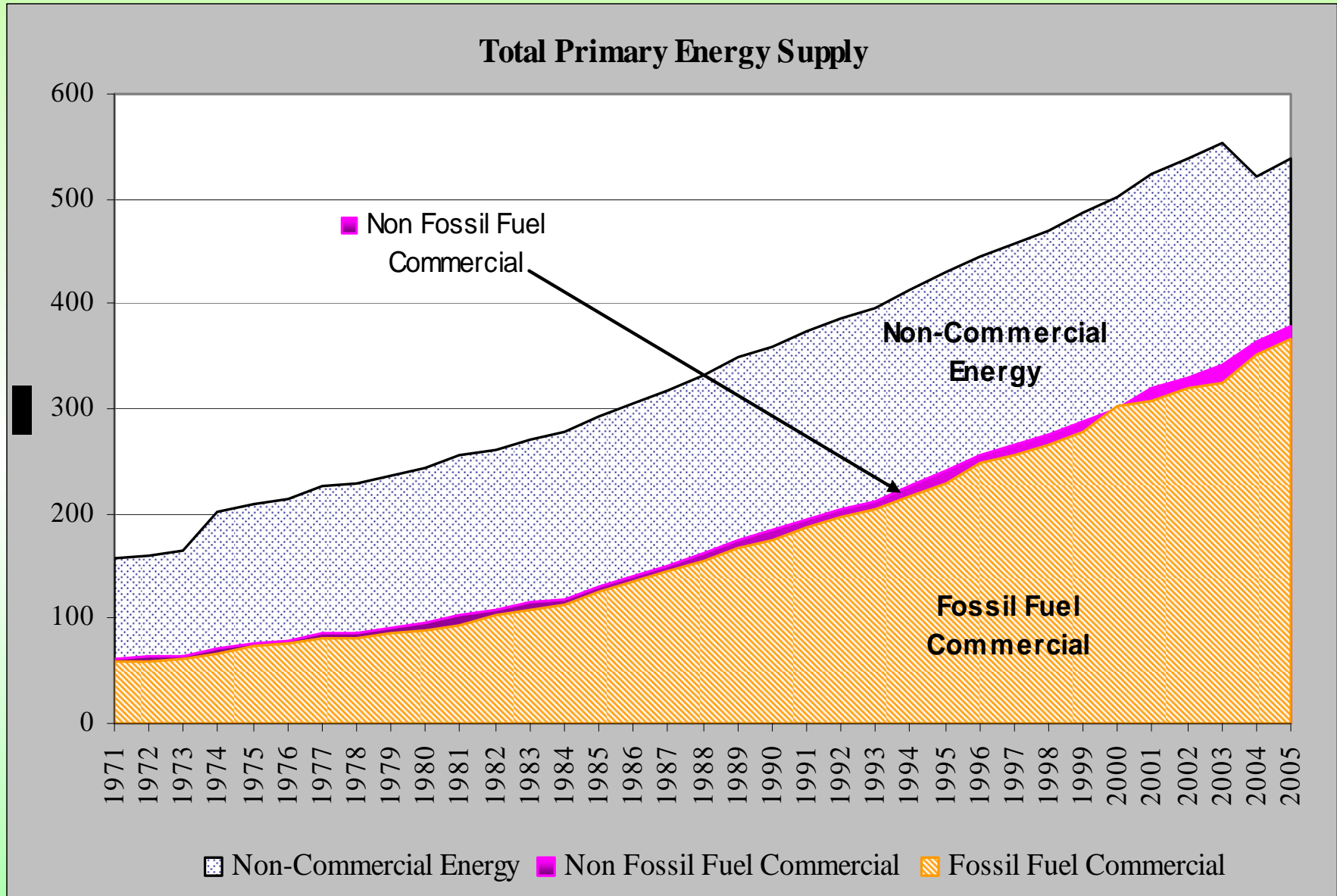
Unit: % Sectoral share



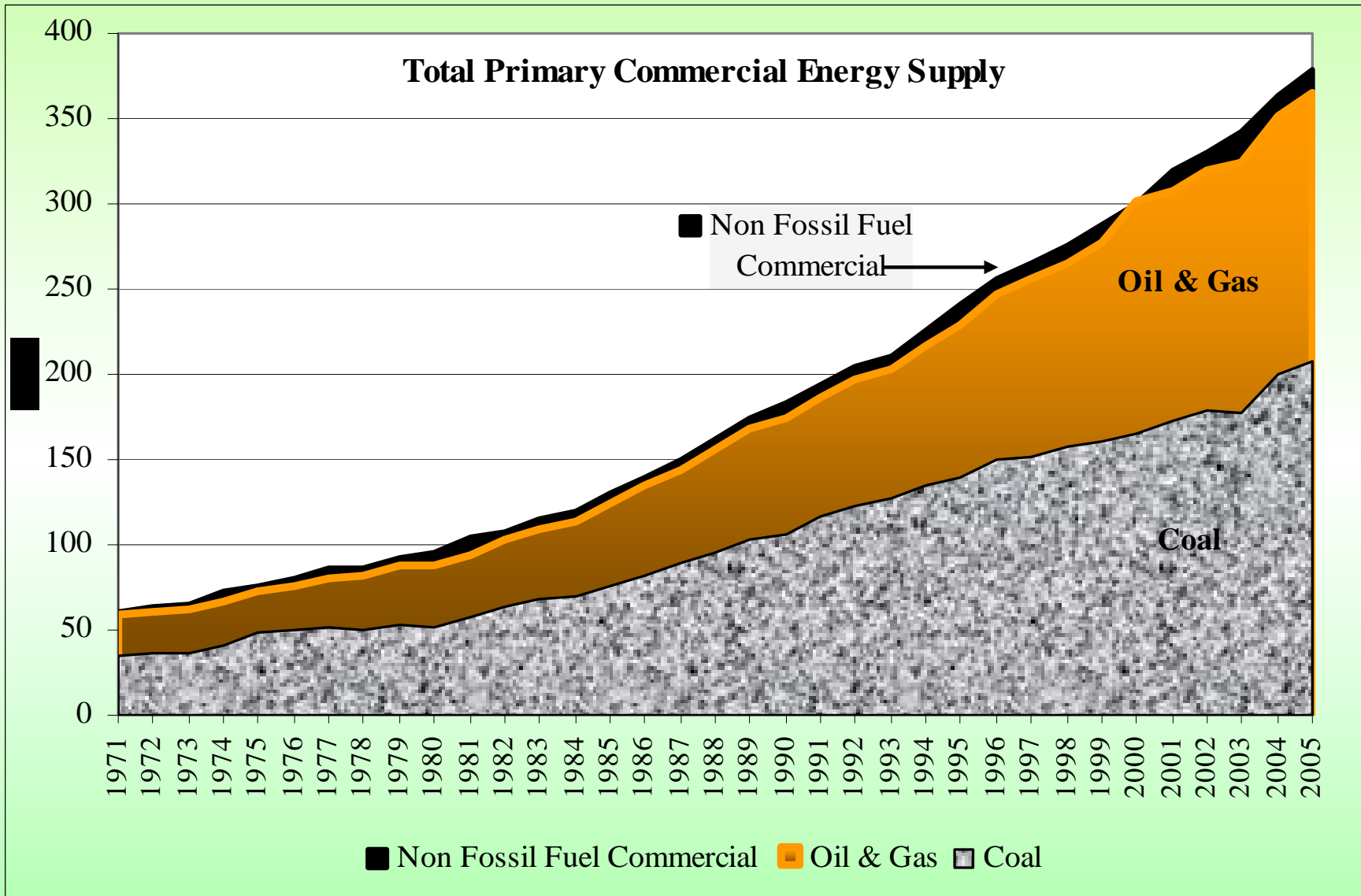
Sources of Final Energy in Residential Sector



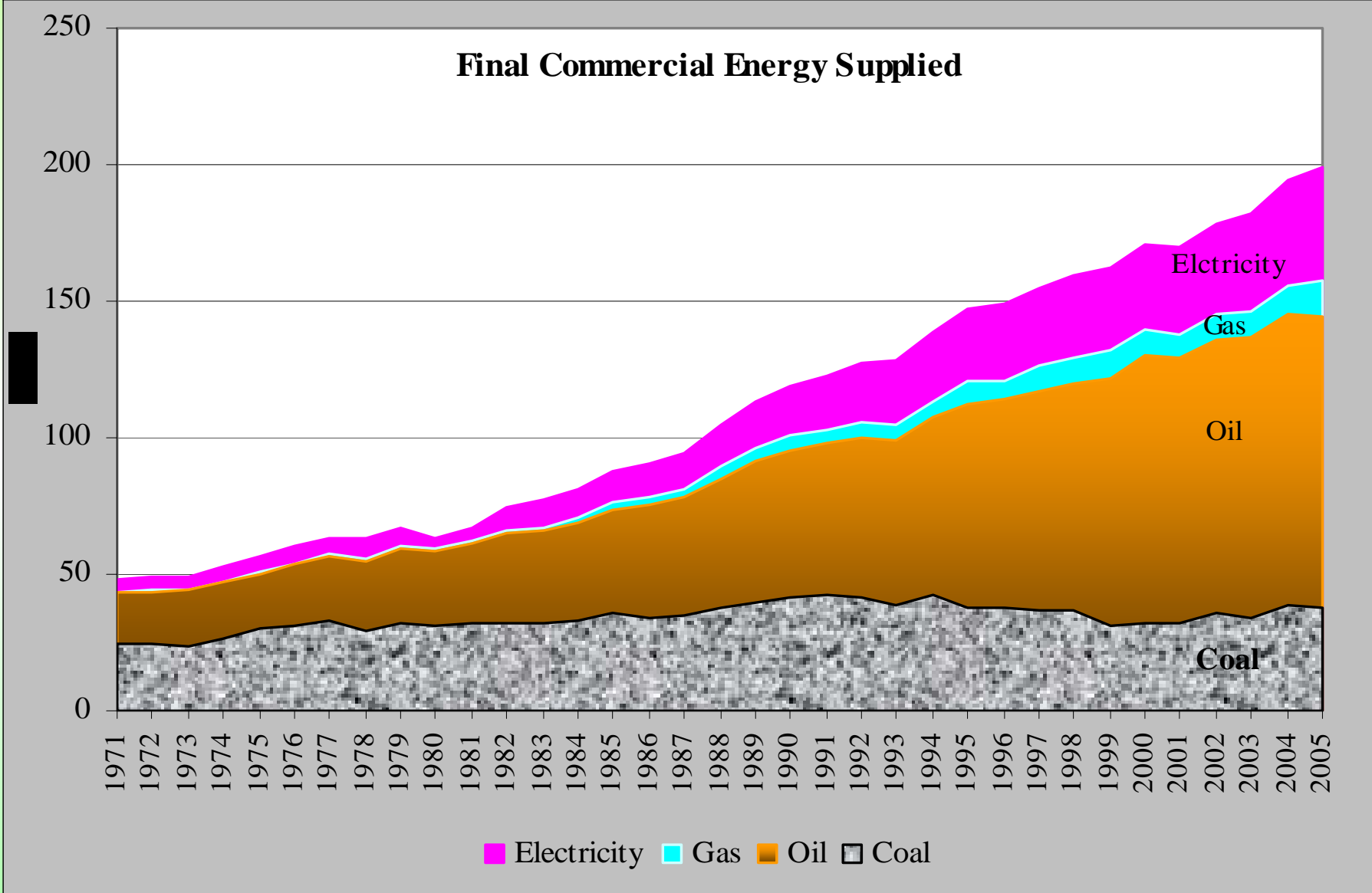
Total Primary Energy Supply



Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes.

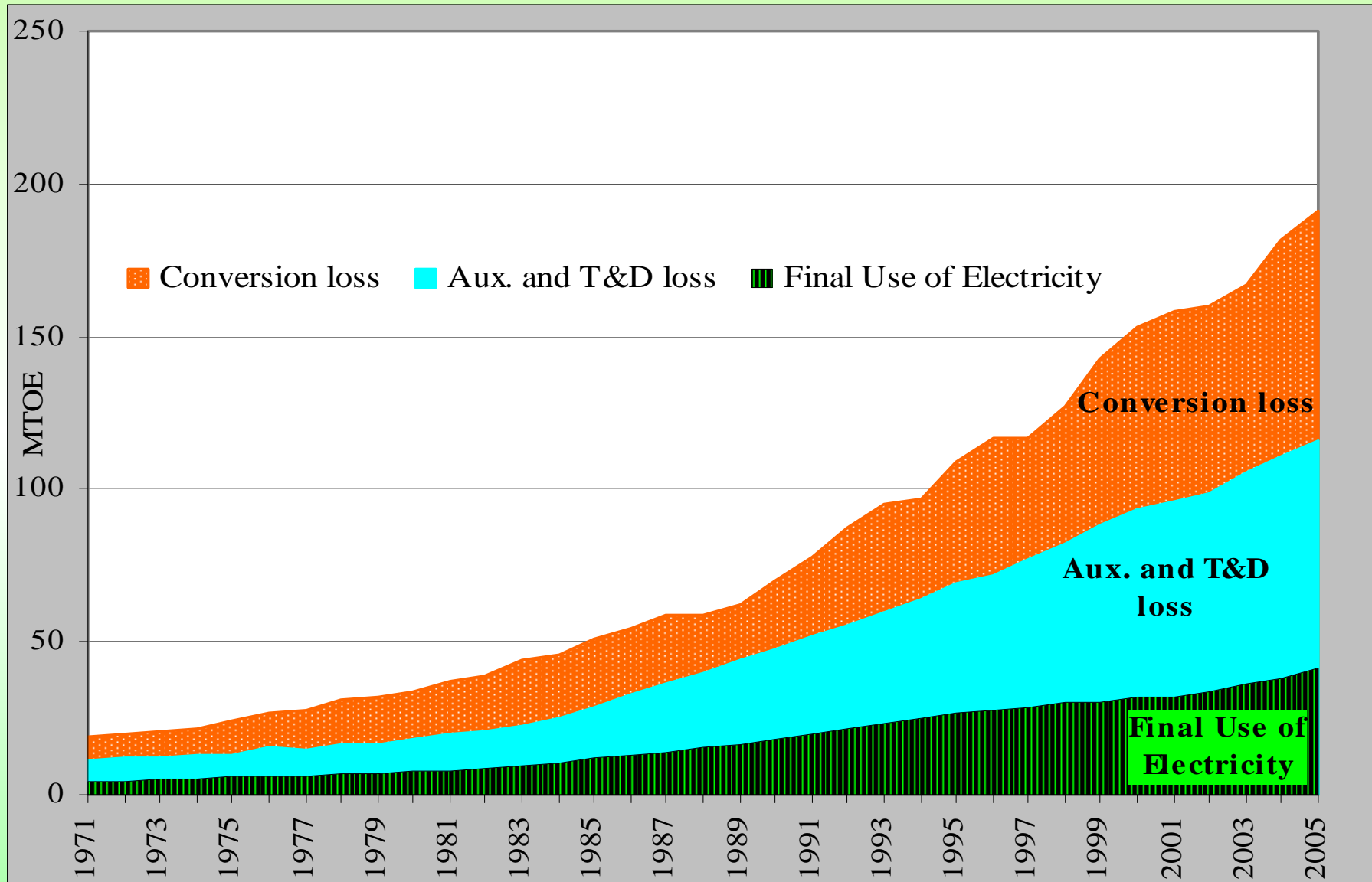


Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes.



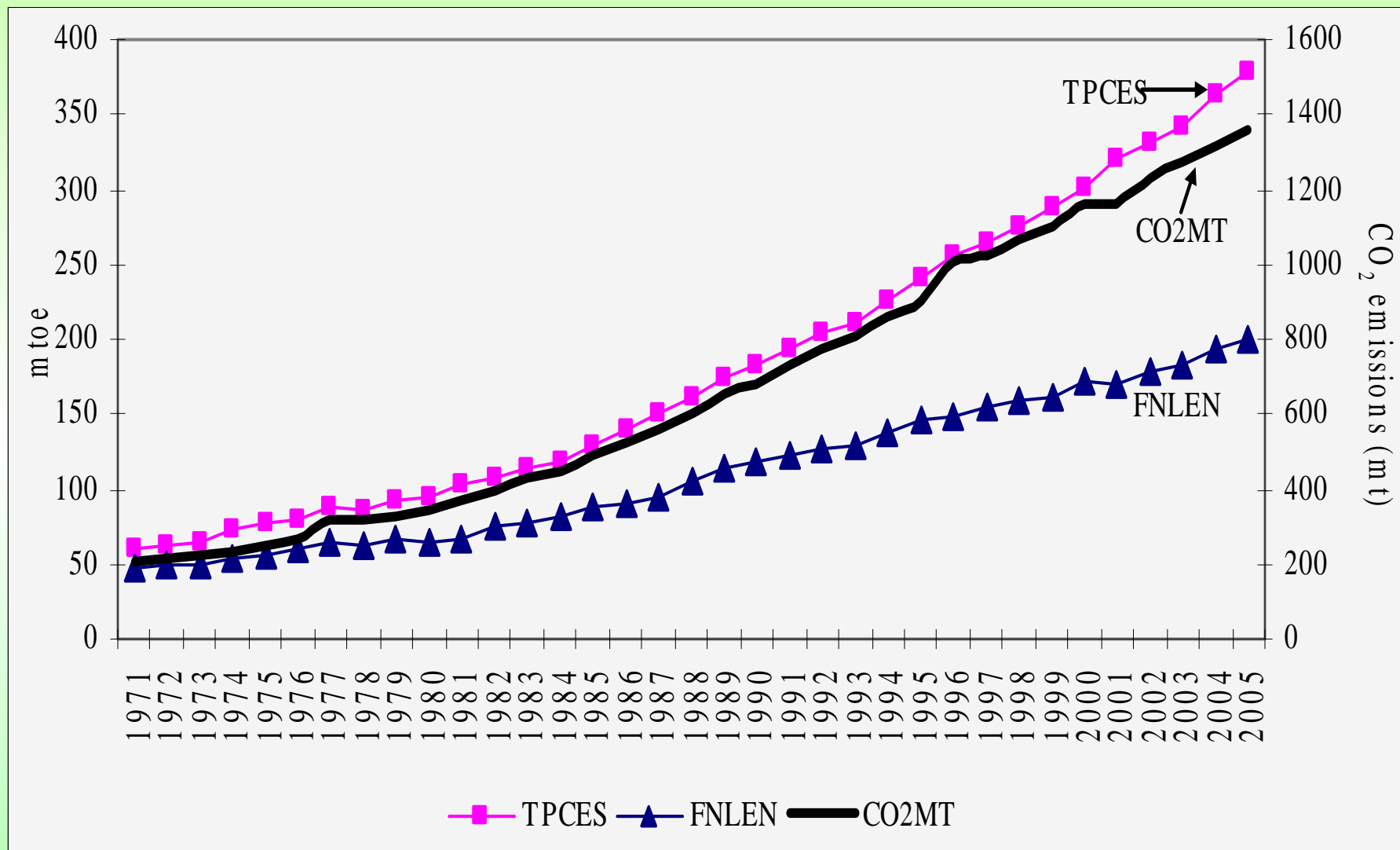
Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes.

Total Energy Input, Losses and Final Use of Electricity.



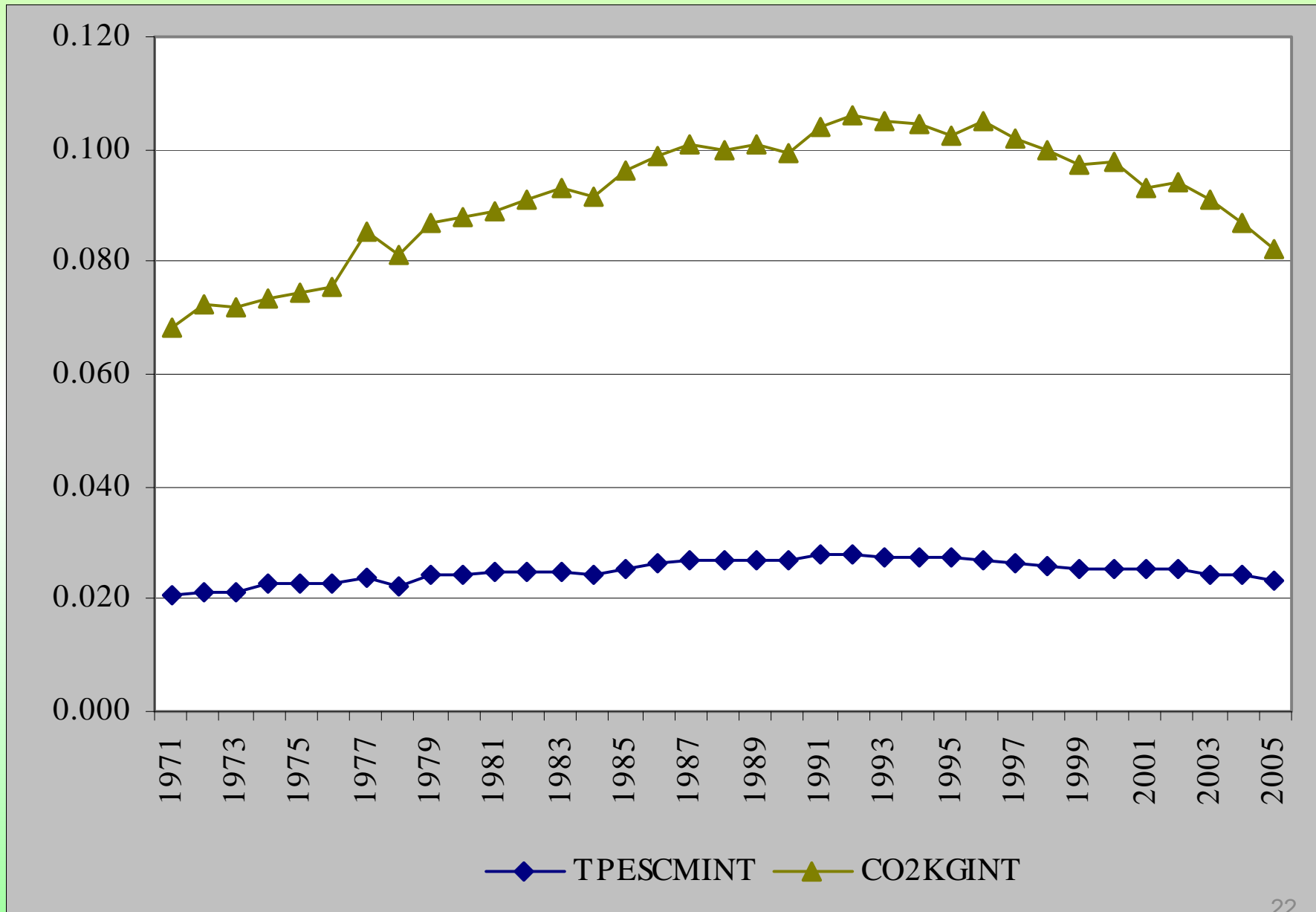
Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes

Supplies of Total Primary and Final Commercial Energy and CO₂ Emissions.



Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes.

Primary Commercial Energy and CO2 intensity over time



GDP-Elasticities of Energy Use in India

Variable	1971-1990	1991-2005
GDP at Factor Cost	-	-
CO2	1.47	0.75
Total Primary Energy	0.86	0.52
Total Primary Commercial Energy	1.28	0.79
Total Final Consumption Energy	1.09	0.56
Gross Generation of Electricity	1.77	0.98

Decomposition Analysis of Growth of Primary Energy Intensity of GDP in India.

Unit: % change over the period

Period	Total Effect	Structural Effect	Technological Effect	Residual
1971-1990	20.2	16.4	3.5	-0.1
1990-2005	-28.8	0.6	-29.0	-0.3

Source: Author's own estimation using the Conventional Divisia Method and IEA data on Energy balances of Non-OECD countries, different volumes.

Decomposition Analysis of Growth of Final Energy & Fuel-wise Intensity of GDP in India.

Unit: % change over the period.

Fuel	Period	Total Effect	Structural Effect	Technological Effect	Residual Effect
Final Energy	1971-1990	11.57	18.52	-5.87	negligible
	1990-2005	-32.57	4.83	-35.10	-0.89
Electricity	1971-1990	64.88	11.12	49.67	-0.86
	1990-2005	-12.77	-5.64	-7.54	-0.03

Source: Author's own estimation using the Conventional Divisia Method and IEA data on Energy balances of Non-OECD countries, different volumes.

Share of final compositional effect in the total change in Carbon Intensity of Energy in India.

Unit: % increase over the period

Period	Sector	Total Effect	Compositional Effect
1971-1990	Aggregate Economy	11.38	-0.26
1990-2005	Aggregate Economy	-1.05	-1.34
1971-1990	Electricity	58.68	40.07
1990-2005	Electricity	5.00	1.52

Source: Author's own estimation using the Conventional Divisia Method and IEA data on Energy balances of Non-OECD countries, different volumes.

Economic Reforms and Delinking of Energy & Growth

In the post reform period, the **sectoral structural adjustment** caused little change in primary energy intensity contributing only an annual increase of **0.04%** per annum on this account.

On the other hand, the **technological changes** brought about by the increased industrial competitiveness and the inflow of foreign investment and technology due to liberalisation contributed to the decline of energy intensity at the rate of **2.3%** per annum.

**ENERGY RESOURCE
ENDOWMENT AND FUTURE
PROJECTIONS OF INDIA'S
ENERGY DEVELOPMENT**

Energy Resources for Planning

Table 5: Fossil Fuel Reserves of India as on 2005
(Unit: Million tonnes of Oil equivalent)

Resources	Proved	Production (2004-05)	Net Imports (2004-05)	Proved Reserve to Production
Extracted Coal	13489	157	16	86
Extractable Lignite	1220	9		136
Oil	786*	34	87	23
Natural Gas	1101*	29	3(LNG)	38
Coal Bed Methane	765			

* indicates Balance of recoverable Reserves

Source: Planning Commission, 2006a.

Table 6: Renewable Energy Resources of India
(Unit: mtoe per year)

	Resources	Present	Potential
1	Hydro Power Capacity (in MW)	32, 000	1,50,000
2	Biomass		
	(a) Fuelwood	140	620
	(b) Biogas*	0.1	15
3	Bio-Fuels @		
	(a) Biodiesel	-	20
	(b) Ethanol	<1	10
4	Solar @		
	(a) Photovoltaic		1200
	(b) Thermal		1200
5	Wind Energy	<1	10
6	Small Hydro-power	<1	5

Based on the assumption of Community Plants.

@ Based on assumptions regarding land availability (for details see the source)

Source: Planning Commission, 2006a.

Table 7: Potential Availability of Nuclear Energy of India

	Resource Base	Metal resource (tonnes)	Electricity Energy (GWe-Yr)	Electricity Capacity (MWe)
1	Uranium Metal	61,000		
	(a) In PWHR	-	330	10,000
	(b) in Breeder	-	42,200	5,00,000
2	Thorium Metal	2,25,000		
	In Breeder	-	1,50,000	Very large

Present Installed Capacity Mwe 3400

Source: Planning Commission, 2006a.

Indian Planning Commission's Projections for the future:

(Integrated Energy Policy Committee Report, 2006)

- Use of Linear Programming Optimisation model to find out the **least cost option** to meet the 9% GDP growth requirement along with **Sector Restructuring** which would ensure faster removal of **poverty** and **inclusiveness of growth**.
- Unconstrained cost minimisation giving coal-dominating scenario.

For environmental concerns, the model builds in additional constraints to generate the additional scenarios:

- Full development of hydro of 1,50,000MW ,
- Maximisation of use of nuclear potential,
- Use of gas to generate 16% of electrical energy (where natural gas is supplemented by coal bed methane and in –situ coal gasification)
- Demand side management to reduce electricity demand by 15% ,

- Attainment of higher conversion efficiency of thermal power generation to 38-40% from the pre-existing level of 36% for 500 MWE plants,
- Rise of railways' share in freight traffic from 32% to 50%, Increase of fuel efficiency of motor vehicles by 50%,
- Forced utilisation of the renewable potentials to the extent of 3000MW wind power, 10,000 MW of solar power, 50,000 MW of biomass power, 10 Mt of bio-diesel, and 5 mt of ethanol by 2031-32.

Table 27:

Projected Primary Commercial Energy Requirement for Maximum Hydro-Nuclear Potential Use and for GDP Growth Rate of 9% in India by the Expert Committee for Integrated Energy Policy.

Year	Total Primary Commercial Energy (mtoe)	% share of				
		Coal	Oil	Natural Gas	Hydro	Nuclear & Non-Conventional
2005	379.19	54.9	34.0	7.6	2.3	1.2
2011-12	546	51.8	34.1	8.8	2.2	3.1
2021-22	1011	51.5	30.8	11.0	2.3	4.4
2031-32	1858	50.4	29.5	12.9	1.9	5.3
Compound Annual Growth Rate (%) of Total Use of Fuels	6.4	6.3	5.6	8.0	5.9	11.2
GDP elasticity of fuel use	0.71	0.7	0.62	0.88	0.65	1.24
Rate of Growth of Energy Intensity of GDP(%)	-2.6	-2.7	-3.4	-1.0	-3.1	2.2
Per Capita Consumption of Commercial Energy in 2032 (kgoe)	1266	638	373	163	24	67

Source: Planning Commission 2006a.

Table 30:

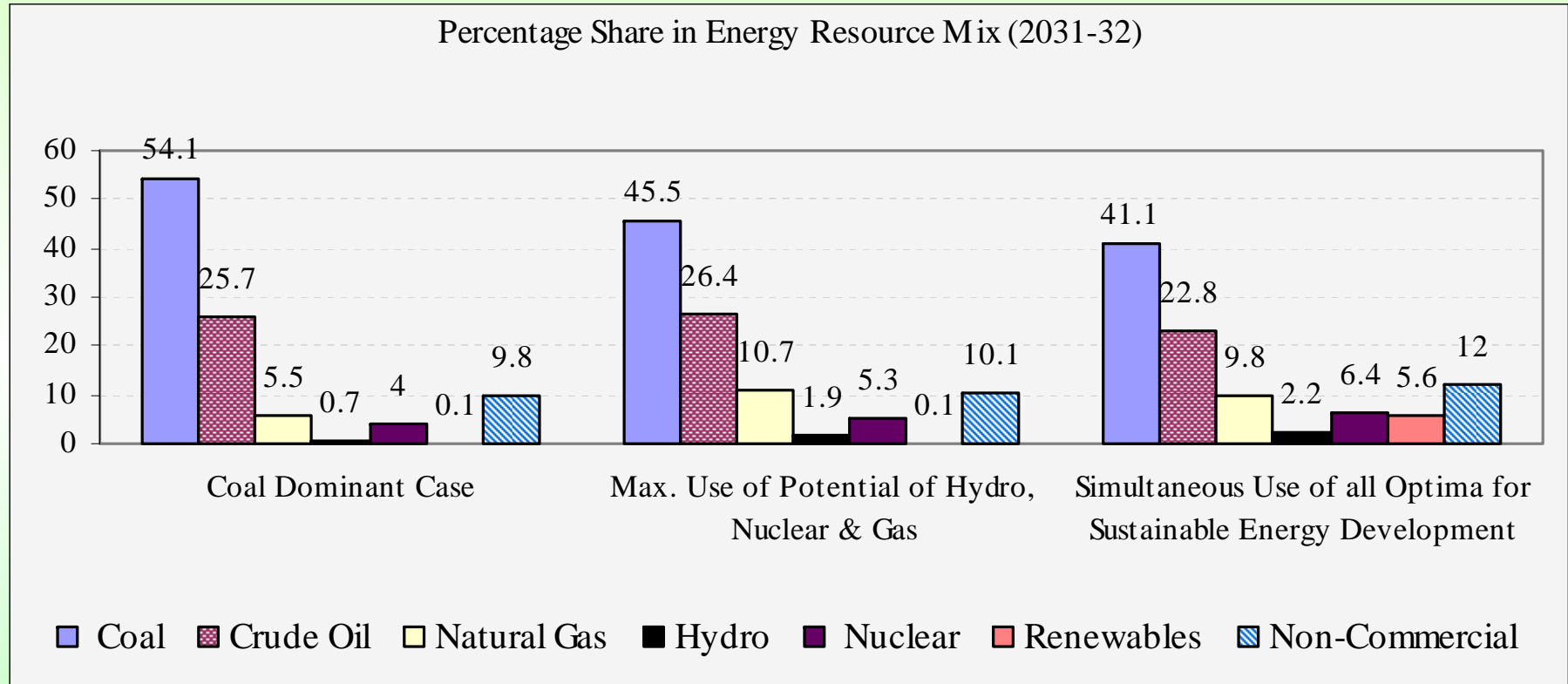
Energy Resource Mix for 8% GDP Growth in 2031-32, India.

Items	Coal Dominant Case	Max. Use of Potential of Hydro, Nuclear & Gas	Simultaneous Use of all Optima for Sustainable Energy Development
Total Energy requirement (mtoe)	1702	1652	1351
Shares of			
(a) Coal	54.1	45.5	41.1
(b) Crude Oil	25.7	26.4	22.8
(c.) Natural Gas	5.5	10.7	9.8
(d) Hydro	0.7	1.9	2.2
(e) Nuclear	4.0	5.3	6.4
(f) Renewables	0.1	0.1	5.6
(g) Non-Commercial	9.8	10.1	12.0

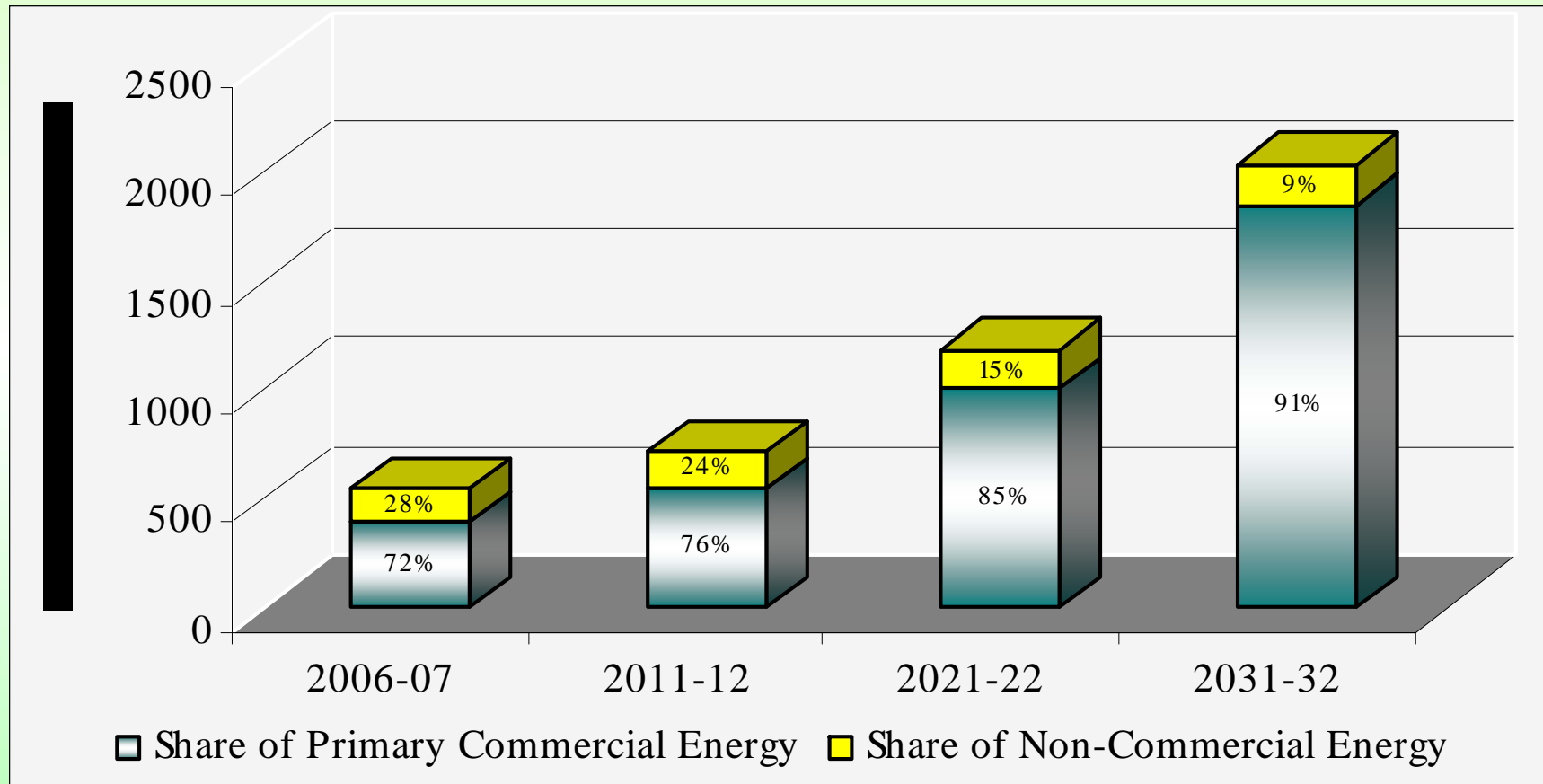
Source: Planning Commission 2006a.

The Demand for Various Energy Items by Households.						(in mtoe)
Year	Fire Wood	Dung Cake	Kerosene	LPG	Electricity	Total
2000	79.62	29.61	10.07	6.42	8.43	134.15
2006	88.78	37.33	12.77	16.87	19.26	175.01
2011	88	31.16	13.16	27.36	33.63	193.31
2021	96.67	30.28	13.71	44.72	59.35	244.73

Energy Resource Mix for 8% GDP Growth in 2031-32.



Projected Total Primary Energy Requirement with GDP Growth Rate of 9%.



Future Projections and Policy Issues

It is important to notice that the dependence of India on coal in 2031-32 will remain 51% in electricity generation and have a share of over 41% in the total primary energy mix even as per the best environmental scenario among the options.

The gas resource is to be used only for peaking power even when it is forced as an option.

The capacity utilisation of hydro power is found to be low because of the low availability of water resources.

However, the total energy need as per the best option economises the requirement of

(a) the total primary energy resources by 21%,

(b) demand for primary commercial energy by 19% ,

(c) coal and oil by 38% and 28% respectively in 2031-32 vis-a-vis the coal dominant option,

(d) CO₂ emission expected to go down by 35% in the terminal year.

CO2 Implication

The CO2 emission to grow from the current level of 1 billion tonne per year to 5.5 billion tonne as per the high coal development scenario and 3.9 billion tonne as per the most environmentally conserving scenario. Even with all these energy sector developments, India's per capita carbon emission would be in the range of 2.6 to 3.6 tonnes of CO2 while the same for the US and the World on the average has been 20 tonnes and 4.5 tonnes respectively in 2004.

Non-conventional Energy Resources

However, even at the best the non conventional renewables cannot provide more than 5.6% of total energy requirements. Any failure of other options to provide the designated supply, the economy of India has to fall back upon coal to meet any deficiency.

ENERGY POVERTY ANALYSIS

Biomass Fuel for Cooking

**Indoor Pollution. Health risk for Women and Children:
Premature death.**

**Opportunity Cost of Collection time for Women and Children:
Loss of Earning and Educational opportunities**

Degradation of Forests due to over harvesting of fuel wood

Highly Inefficient fuel :

Biomass 10 – 12%,

Charcoal 25%,

Kerosene 45%,

LPG 50 – 75%

Energy Poverty in Lighting

Kerosene or Candle for lighting : Highly inefficient fuel

Lack of access to electricity reduces the productivity of educational efforts, denies the opportunity of use of a whole variety of equipment.

**Causes Lack of access to communications like TV, Radio.
Restricts the length of a day and opportunities of reading.
Special impact on women.**

The problem of reallocation of time over 24 hours.

**Dynamic externalities of modern energy services -
higher human capabilities and long run earning .**

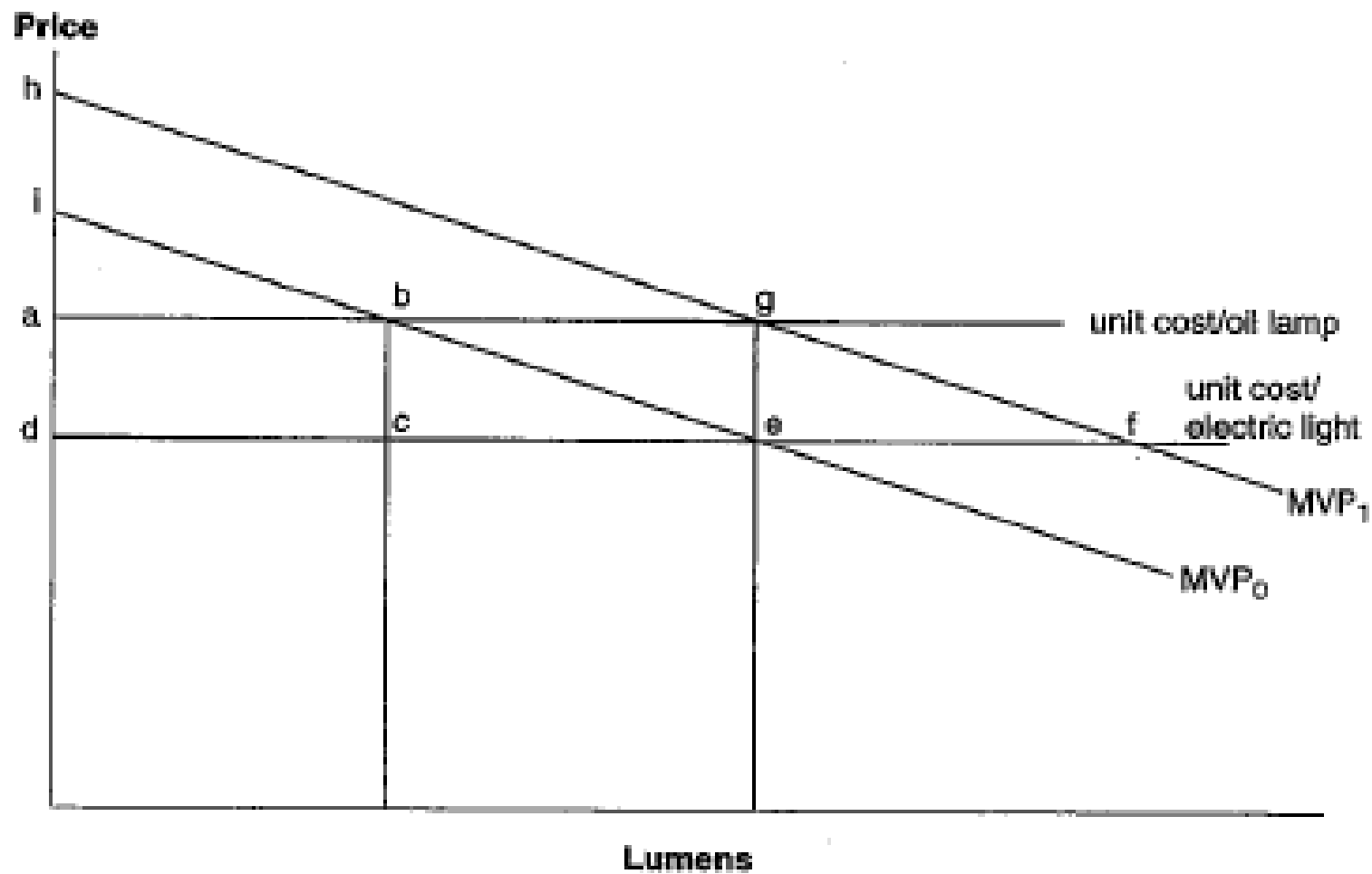


Illustration of economic effects from increased energy services utilization

Source: Adapted from World Bank (2002b).

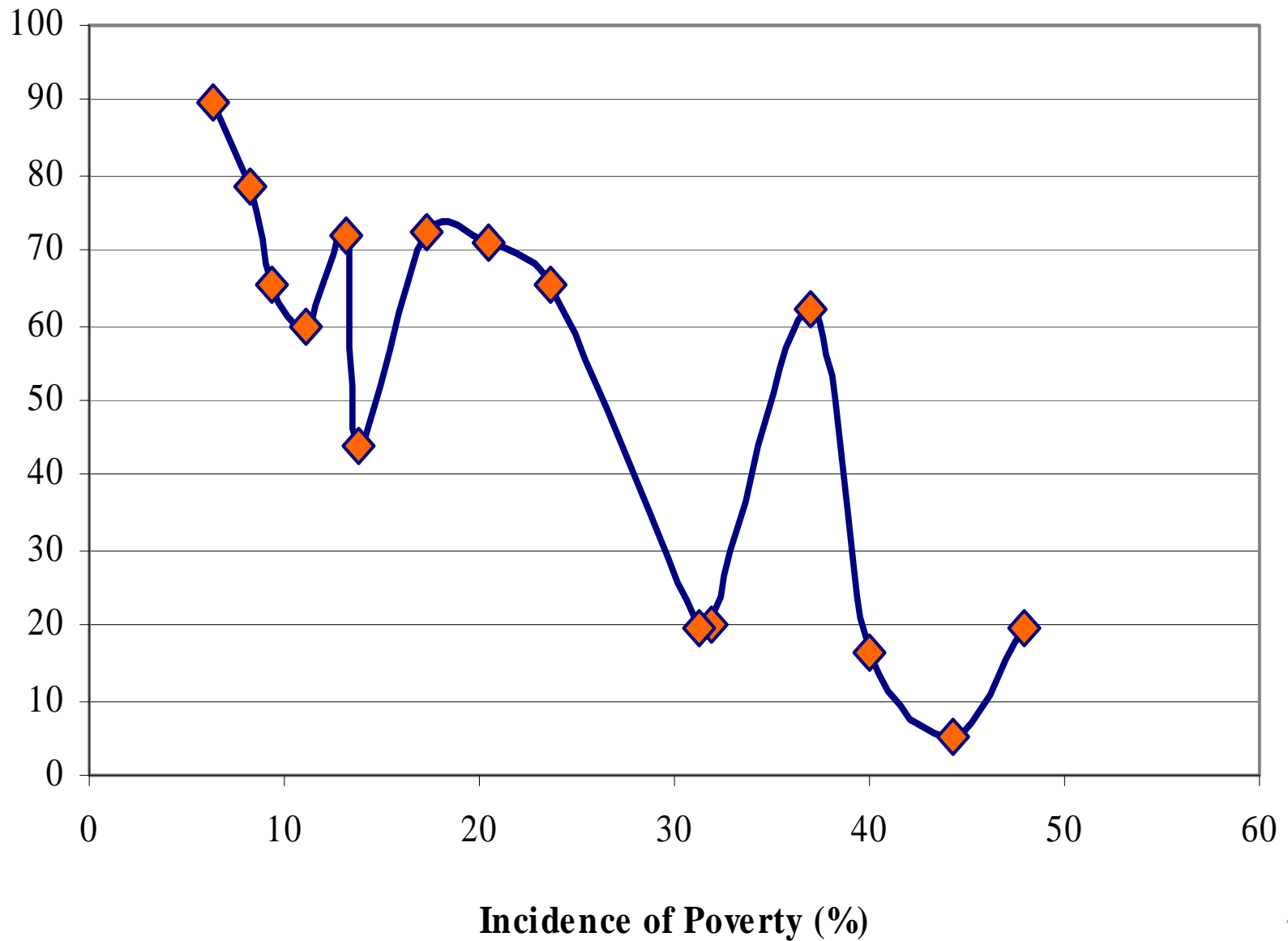
Percentage Distribution of Households using major source of energy for Cooking : 2004-05

All India	Biomass	LPG	Kerosene	Others
Rural	84.1	8.6	1.3	6
Urban	23.7	57	10	9.3

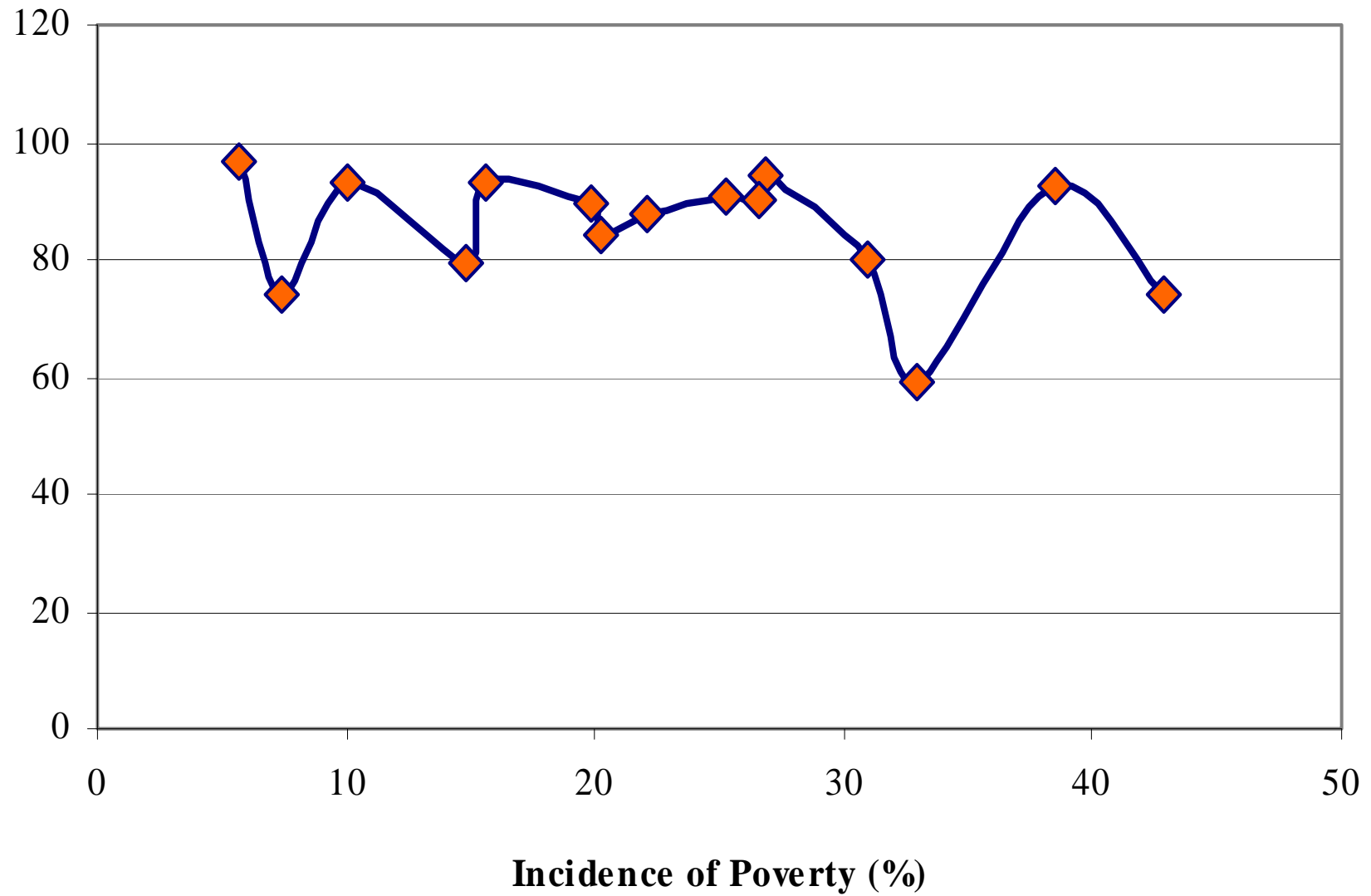
Percentage Distribution of Households using major source of energy for Lighting: 2004-05

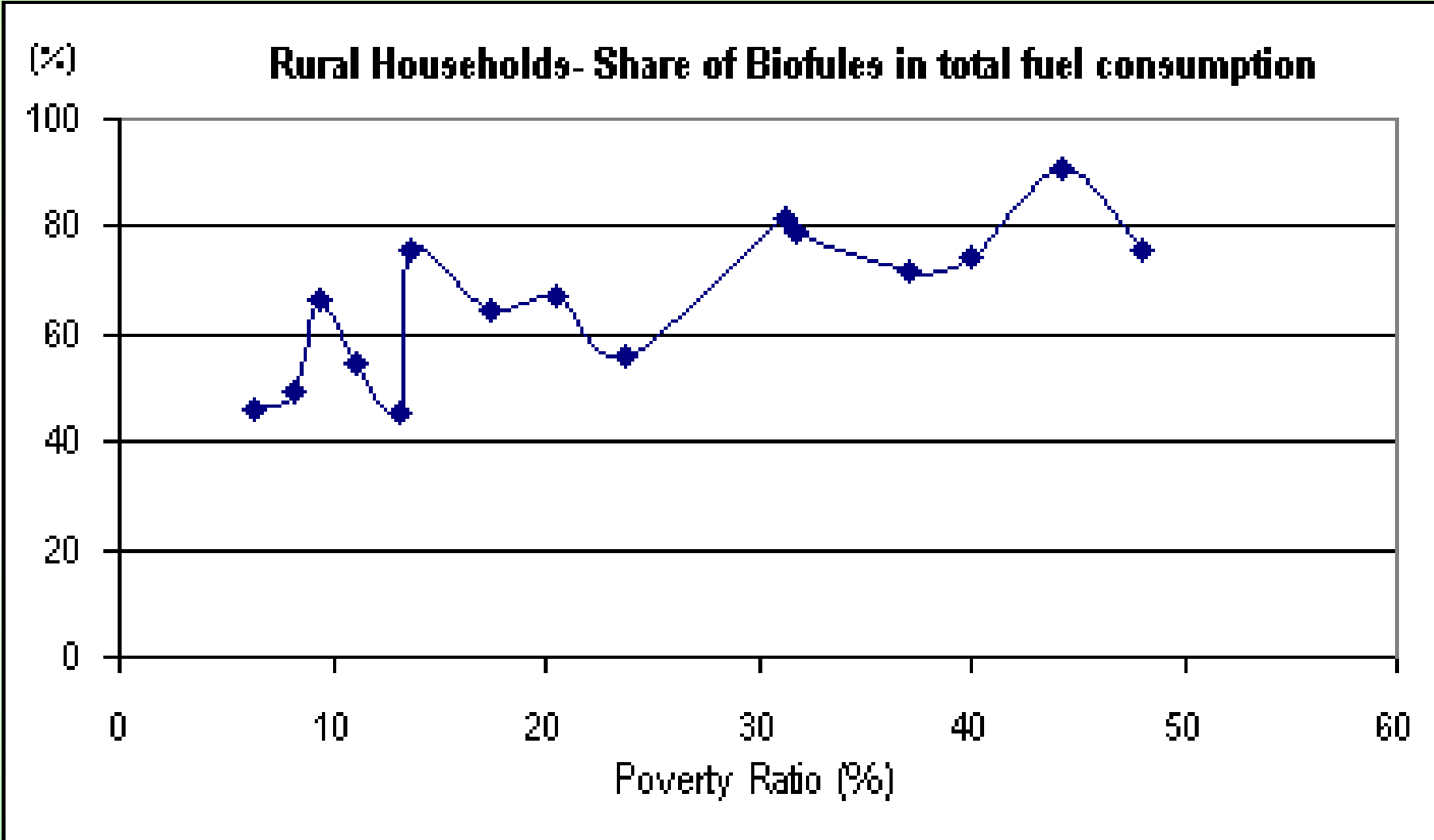
All India	Electricity	Kerosene	Others
Rural	54.9	44.4	0.7
Urban	92.3	7.1	0.6

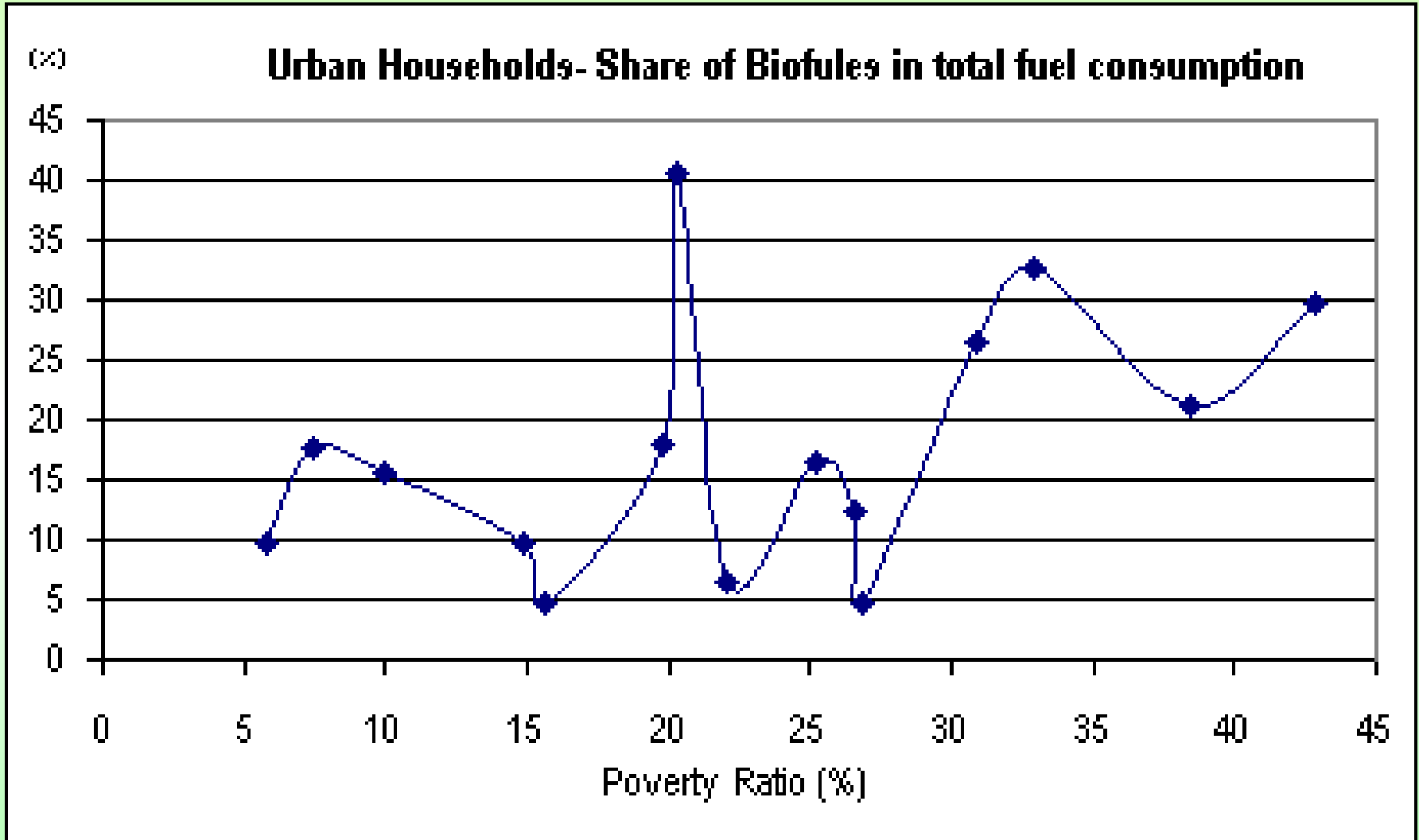
Rural Households with Electricity Connection (%)



Urban Households with Electricity Connection (%)







INCOME POVERTY AND ENERGY POVERTY

Rural Poverty Ratio Logit-relationship with Rural MPCE levels:

$$\text{LOG [RPOV/(100-RPOV)]} = 1.101 - 0.0039*\text{RMPCE}$$

(0.001) (0.000)

Adj R² = 0.44 N=99

Urban Poverty Ratio Logit-relationship with Urban MPCE levels:

$$\text{LOG [UPOV/(100-UPOV)]} = -0.413 - 0.0014*\text{UMPCE}$$

(0.3342) (0.0024)

Adj R² = 0.11 N=99

Source: Based on National Sample Survey Organisation Reports, NSS 1993/94 (50th Round), 1999/00 (55th Round) and 2004/05 (61st Round); Govt. of India.

Poverty Ratio and Monthly Per Capita Expenditure in India

	Rural	Urban
Monthly Per Capita Consumption Expenditure* (MPCE) (Rs.) 2004-05	504.9	866.1
Poverty Line**(Rs.)	321.9*	443.3*
Poverty Ratio (%)	28.3	25.7
Target Poverty Ratio	4%	3%
Target MPCE (Rs.)	1060.15	2172.4

*: In Constant Prices with base = 1999/00; ** based on 2400Kcal intake per capita for Rural & 2100Kcal per capita for Urban population.

Relationship between Primary Source of Energy and MPCE Regression Results

Source of Energy	Dependent Variable	Constant	MPCE	Adjusted R ²
Rural				
Electricity for Lighting	Proportion of HHs* using Electricity	-1.268	0.002	0.765
Biomass for Cooking	Proportion of HHs using Biomass	2.913	-0.002	0.808
Kerosene for Cooking	Proportion of HHs using Kerosene	-5.712	0.002	0.644
Kerosene & LPG for Cooking	Proportion of HHs using Kerosene & LPG	-5.599	0.004	0.756

*: HHs: Households

Source of Energy	Dependent Variable	Constant	MPCE	Adjusted R ²
Urban				
Electricity for Lighting	Proportion of HHs using Electricity	0.932	0.002	0.694
LPG for Cooking	Proportion of HHs using LPG	-1.983	0.001	0.510
LPG & Kerosene for Cooking	Proportion of HHs using LPG & Kerosene	-0.715	0.001	0.478

Source: Estimated using data from National Sample Survey Organisation Reports, NSS 1993/94 (50th Round), 1999/00 (55th Round) and 2004/05 (61st Round); Govt. of India.

The estimated accessibility of modern energy for lighting

	Income - Poverty Ratio	
Rural Sector poverty ratio	28.3%	4%
Proportion of household With access to electricity%	44	84
Urban Sector poverty ratio	25.7	3
Proportion of household With access to electricity%	88	96

The estimated accessibility of modern energy for cooking
Income - Poverty Ratio

Rural Sector poverty ratio 28.3% 4%

Proportion of household
 With access to biomass % 80 - 84 44 - 48

Proportion of household
 With access to kerosene % 5 35

Proportion of household
 With access to LPG % 8 19

Urban Sector poverty ratio 25.7 3

Proportion of household
 With access to LPG 59 79

Proportion of household
 With access to kerosene % 3 7

Residual proportion of households
 With access to other fuels, incl. biomass, soft coke, etc. 38 14

ENERGY SECURITY: CASE OF OIL

India's Import Dependence of Energy

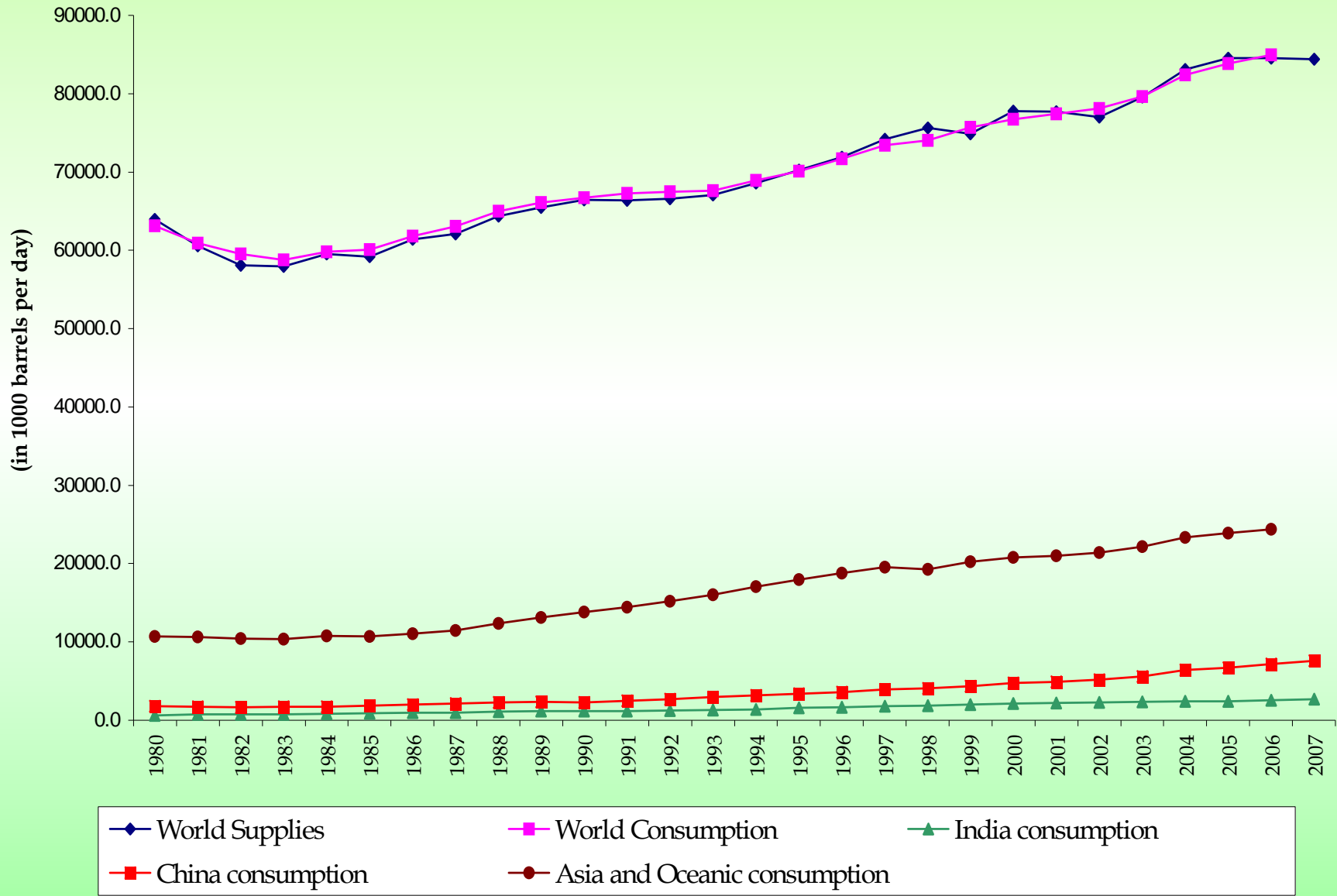
Year	Share of net import in total primary commercial energy supplies (%)	Share of oil import in total net import of energy (%)	Import as percentage of total oil supplies***	Global oil price index 1993=100	Real global oil price index for India 1993=100
1	2	3	6	4	5
1971	24.32	100	63	3.24	21.88
1980	24.85	98.6	61*	56.11	172.17
1985	12.07	100	-	66.34	135
1990	17.24	86.6	39**	78.38	106.55
1995	22.1	84.1	-	107.97	90.23
2000	30.43	84.5	64	246.82	152.62
2005	32.07	75.22	-	461.34	235.82

Source: 1. Estimated by the author on the basis of crude oil price data collected from British Petroleum and Energy balances for non-OECD countries of the International Energy published by OECD

2. Column 6 from Ministry of Petroleum and Natural Gas, cited in Subramanian et al (2005)

Note: * Figure pertains to year 1981, ** Figure pertains to year 1991, *** total oil supplies refers to sum of production and import of crude oil in India for the respective years.

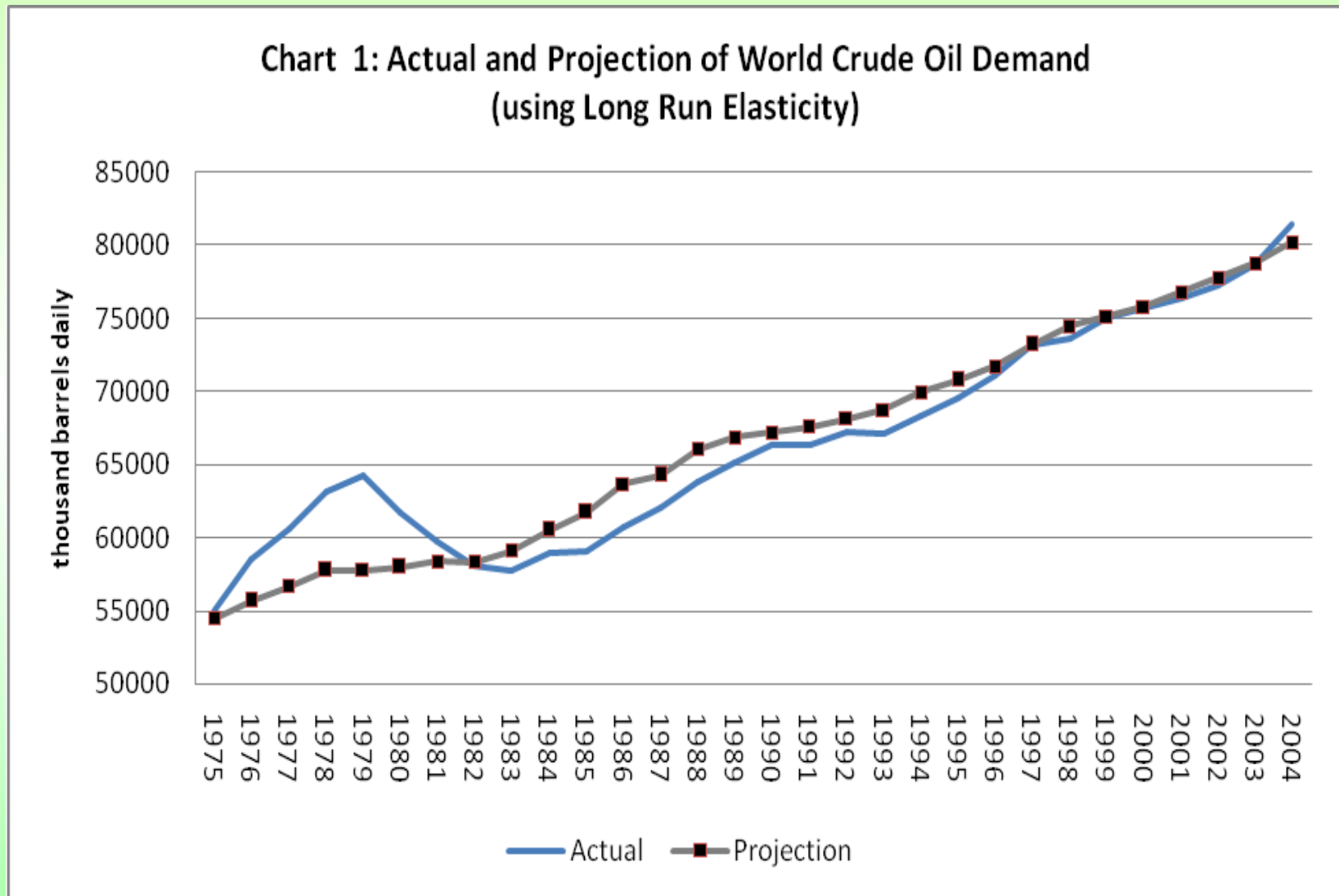
World Supply and Consumption of Oil, 1980-2007



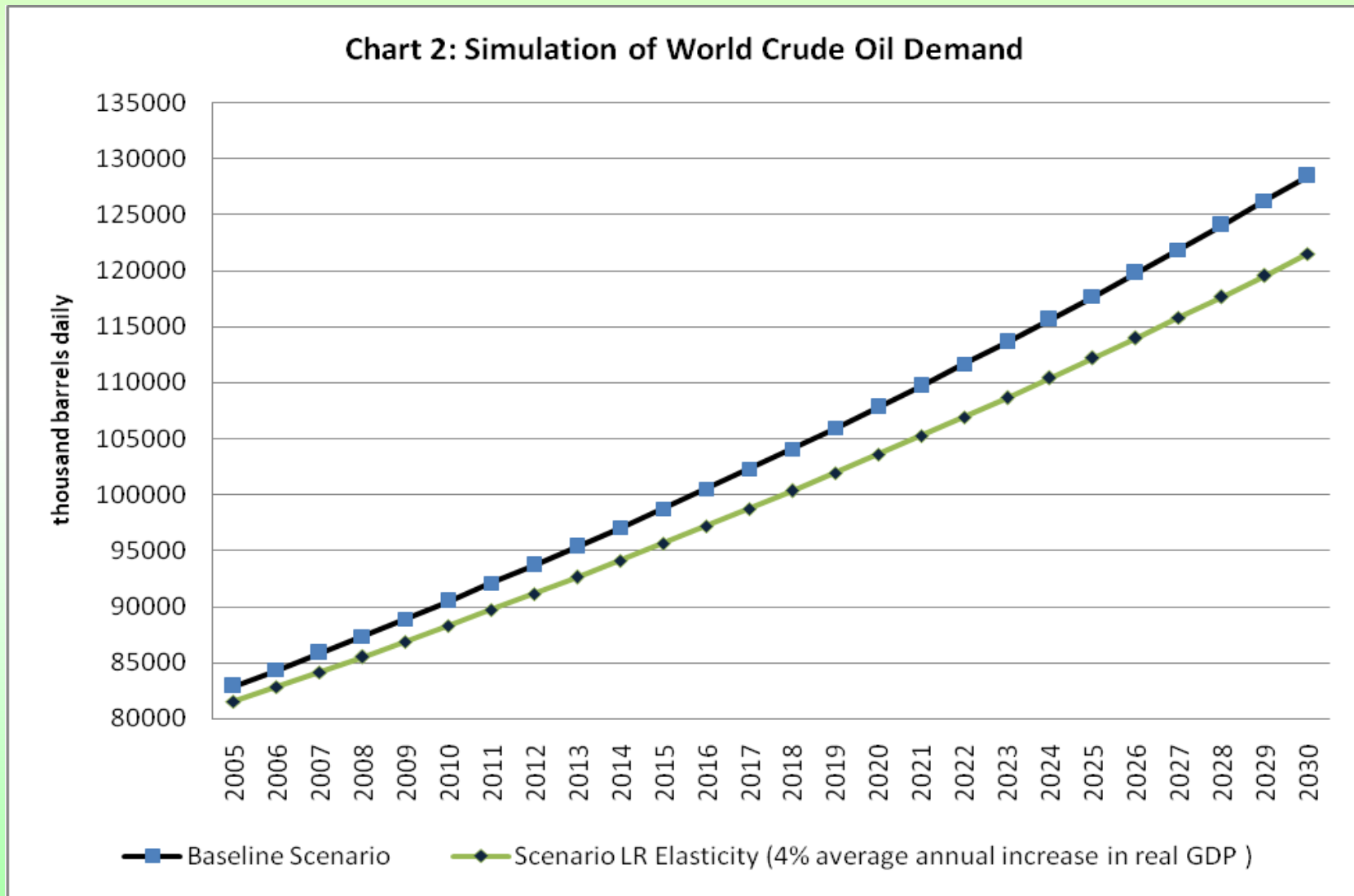
**Table 1 : Long-run price and income elasticity of demand for crude
(obtained through cointegration)**

Country	Price Elasticity	Income Elasticity
World	-0.034	0.388
India	-0.028	1.141
China	-0.063	0.615

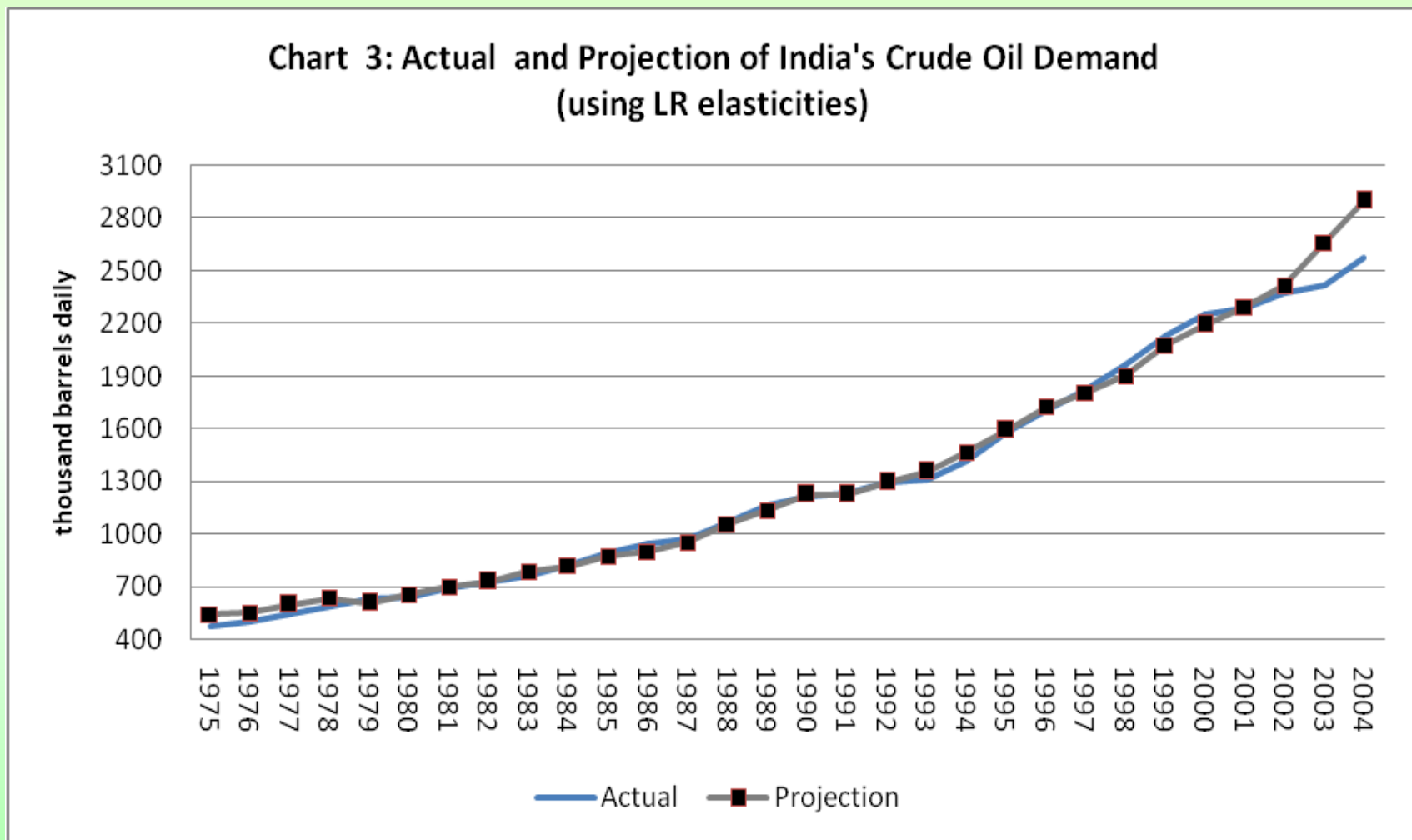
Model properties (World Crude Demand)



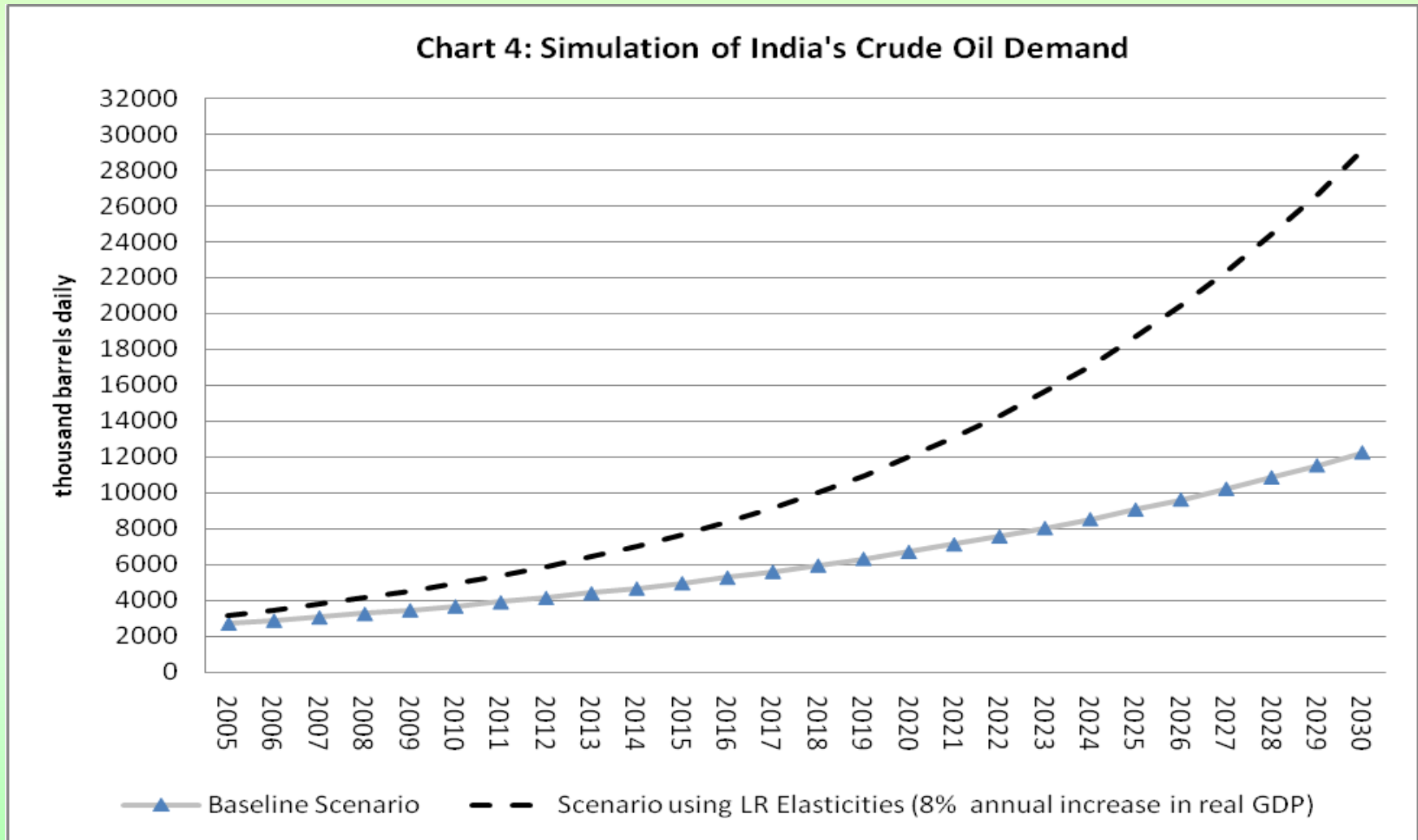
Simulation (World Crude Demand)



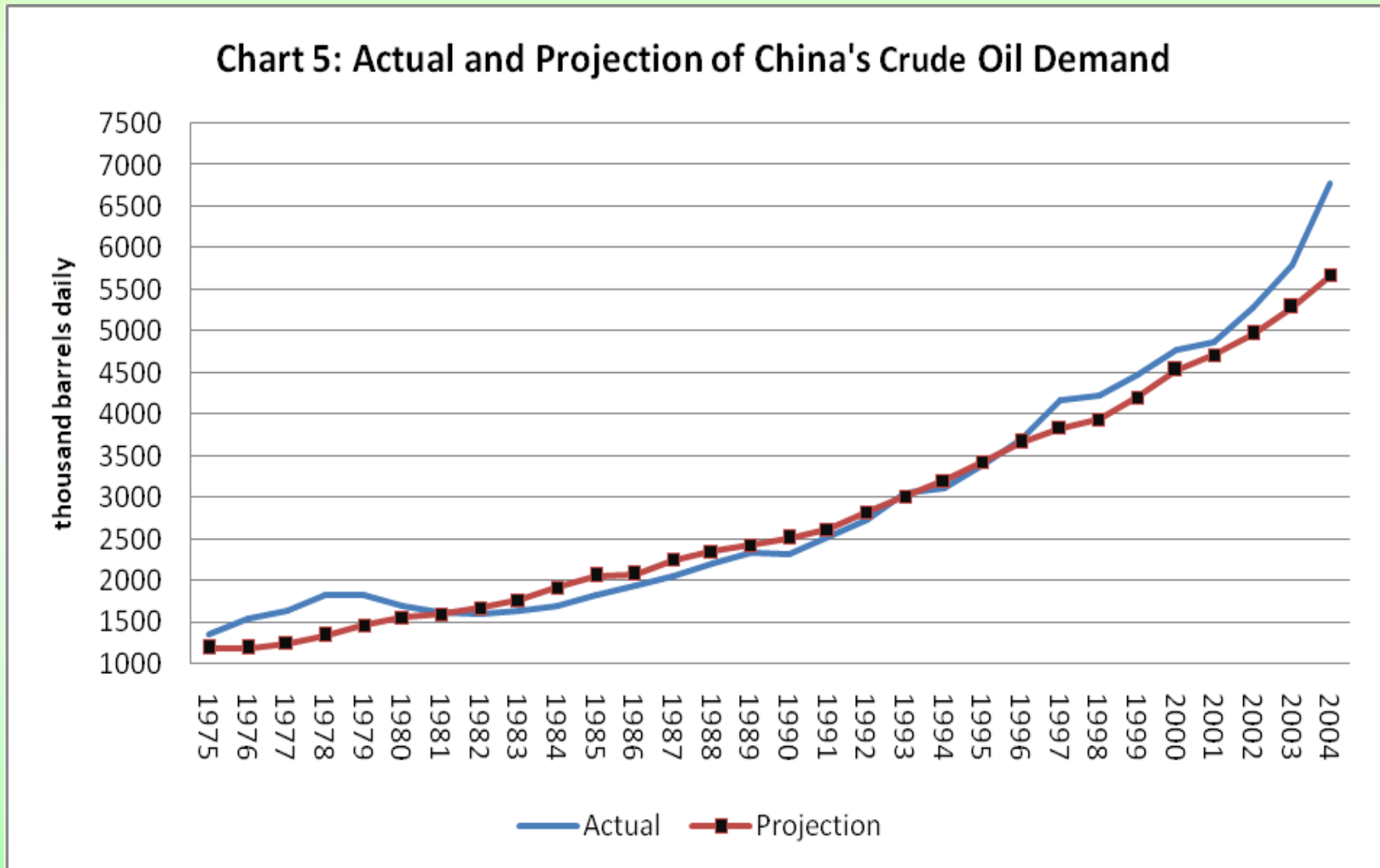
Model properties (India's Crude Demand)



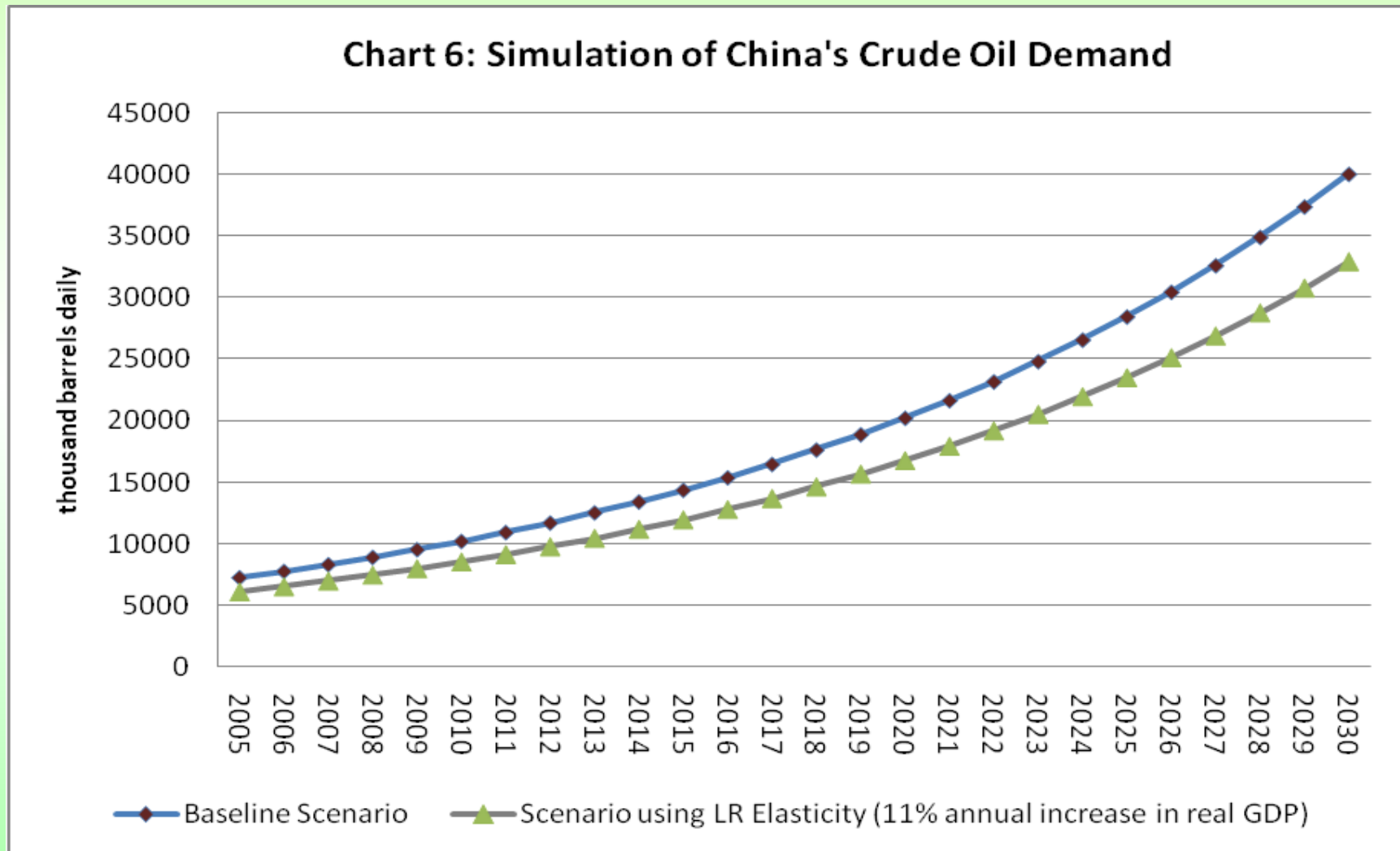
Simulation (India's Crude Demand)



Model properties (China's Crude Demand)



Simulation (China's Crude Demand)



For Oil Security Policy for Jatropha Cultivation in Wasteland

In a market economy, the **profitability and the ground rent** from land use for alternative crops decide the pattern of land use in agriculture.

In a regime of high oil price, the high **Gross value of Output** to Cost ratio and high **ground rent** for jatropha plantation crop may induce diversion of land use from food crops to such energy plantation.

Hence, the concern for **food security** in a scenario of sustained oil price rise in real terms, decline in per capita domestic foodgrains availability and existence of substantive amount of poverty.

The setting up of **bio refinery** would further encourage diversion of land in any State where it is located.

Pricing of jatropha seed on the basis of its energy potential parity with high speed petroleum diesel price, would ensure high return.

Small cultivators with limited credit availability, may again be restrained from switch to such land use for jatropha if the credit requirement be substantive due to relative **high cost of cultivation per acre.**

Based on the Techno economic data on bio-refinery prepared by IRADe for TIFAC and those on jatropha cultivation prepared by the Tamil Nadu Agricultural university, the relative competitiveness in terms of cost, profitability and land rental have been worked out for various competing crops in selected states as given in the following tables.

Paid Out Cost (Cost A₂)

States	Haryana	Tamil Nadu	Uttar Pradesh	Maharashtra	West Bengal	Uttaranchal	Chattisgarh
Sugarcane	16,540	37,700				14,611	
Wheat*	13,628				13,467	10,343	7,584
Paddy	17,967	19,338	10,057		12,681	9,683	6,752
Bajra	3,485			7,361			
Rapeseed & Mustard*	7,887		7,174		10,405		
Urad		3,518	2,527				3,181
Gram*				7,595			5,953
Groundnut		16,221					
Cotton		16,178		14,947			
Sesamum		6,477					
Jowar		5,706		6,325			
Maize			4,549			3,161	2,927
Tur			4,545				
Jatropha1**	19,443	19,443	19,443	19,443	19,443	19,443	19,443
Jatropha 2 **	19,443	19,443	19,443	19,443	19,443	19,443	19,443
Jatropha 3**	19,443	19,443	19,443	19,443	19,443	19,443	19,443

* indicates value figures in 2005-06 prices

** indicates simulated values at alternative prices of seed output

1 for Rs 5/-, 2 for Rs.6/- and 3 for Rs 12/- per kg of seed

Gross Value of Output to Cost A2 ratio

	Haryana	Tamil Nadu	Uttar Pradesh	Maharashtra	West Bengal	Uttaranchal	Chattisgarh
Sugarcane	4.40	2.06	3.87	2.18		3.62	
Wheat*	1.97		1.64		1.14	1.54	1.26
Bajra	1.66		1.74	1.09			
Paddy	2.01	1.28	1.72		1.50	1.80	2.10
Rapeseed & Mustard*	2.96		2.76		1.64		
Urad		2.14	2.18				2.42
Gram*			3.77	1.96			4.29
Groundnut		1.70		1.14			
Jowar		1.04		1.10			
Cotton		1.29		1.25			
Sesamum		1.78	4.46				
Maize			1.94			1.94	2.06
Soyabean				1.26			1.52
Jatropha 1 **	2.57	2.57	2.57	2.57	2.57	2.57	2.57
Jatropha 2 **	3.09	3.09	3.09	3.09	3.09	3.09	3.09
Jatropha 3 **	6.19	6.19	6.19	6.19	6.19	6.19	6.19

* indicates value figures in 2005-06 prices

** indicates simulated values at alternative prices of seed output

1 for Rs 5/-, 2 for Rs.6/- and 3 for Rs 12/- per kg of seed

Ground Rent

	Haryana	Tamil Nadu	Uttar Pradesh	Maharashtra	West Bengal	Uttaranchal	Chattisgarh
Sugarcane	49,061	30,732	30,489	44,797		35,148	
Wheat*	8,926		4,152		-2,376	131	138
Bajra	-1,309		-327	-1,230			
Paddy	14,044	1,244	2,498		245	2,054	3,917
Rapeseed & Mustard*	9,969		8,801		3,302		
Urad		2,211	1,199				2,190
Gram*			13,830	4,822			18,037
Groundnut		6,368		-3,289			
Jowar		-2,552		-1,517			
Cotton		-729		682			
Sesamum		3,226	4,947				
Tur			9,449	5,504			
Maize			-1,134			-3,125	114
Soyabean				1,093			2,007
Jatropha 1 **	30,557	30,557	30,557	30,557	30,557	30,557	30,557
Jatropha 2 **	40,557	40,557	40,557	40,557	40,557	40,557	40,557
Jatropha 3 **	100,557	100,557	100,557	100,557	100,557	100,557	100,557

* indicates value figures in 2005-06 prices

** indicates simulated values at alternative prices of seed output

1 for Rs 5/-, 2 for Rs.6/- and 3 for Rs 12/- per kg of seed

**Critical HSD price Rs per Litre for Jatropha to be competitive
with other crops in land use**

States	Haryana	Tamil Nadu	Uttar Pradesh	Maharashtra	West Bengal	Uttaranchal	Chattisgarh
Sugarcane	27.50	22.33	22.26	26.29		23.57	
Wheat*	16.17		14.83		12.99	13.69	13.70
Bajra	13.29		13.56	13.31			
Paddy	17.62	14.01	14.36		13.73	14.24	14.76
Rapeseed & Mustard*	16.47		16.14		14.59		
Urad		14.28	13.99				14.27
Gram*			17.56	15.02			18.74
Groundnut		15.45		12.73			
Jowar		12.94		13.23			
Cotton		13.45		13.85			
Sesamum		14.57	15.05				
Tur			16.32	15.21			
Maize			13.34			12.77	13.69
Soyabean				13.96			14.22

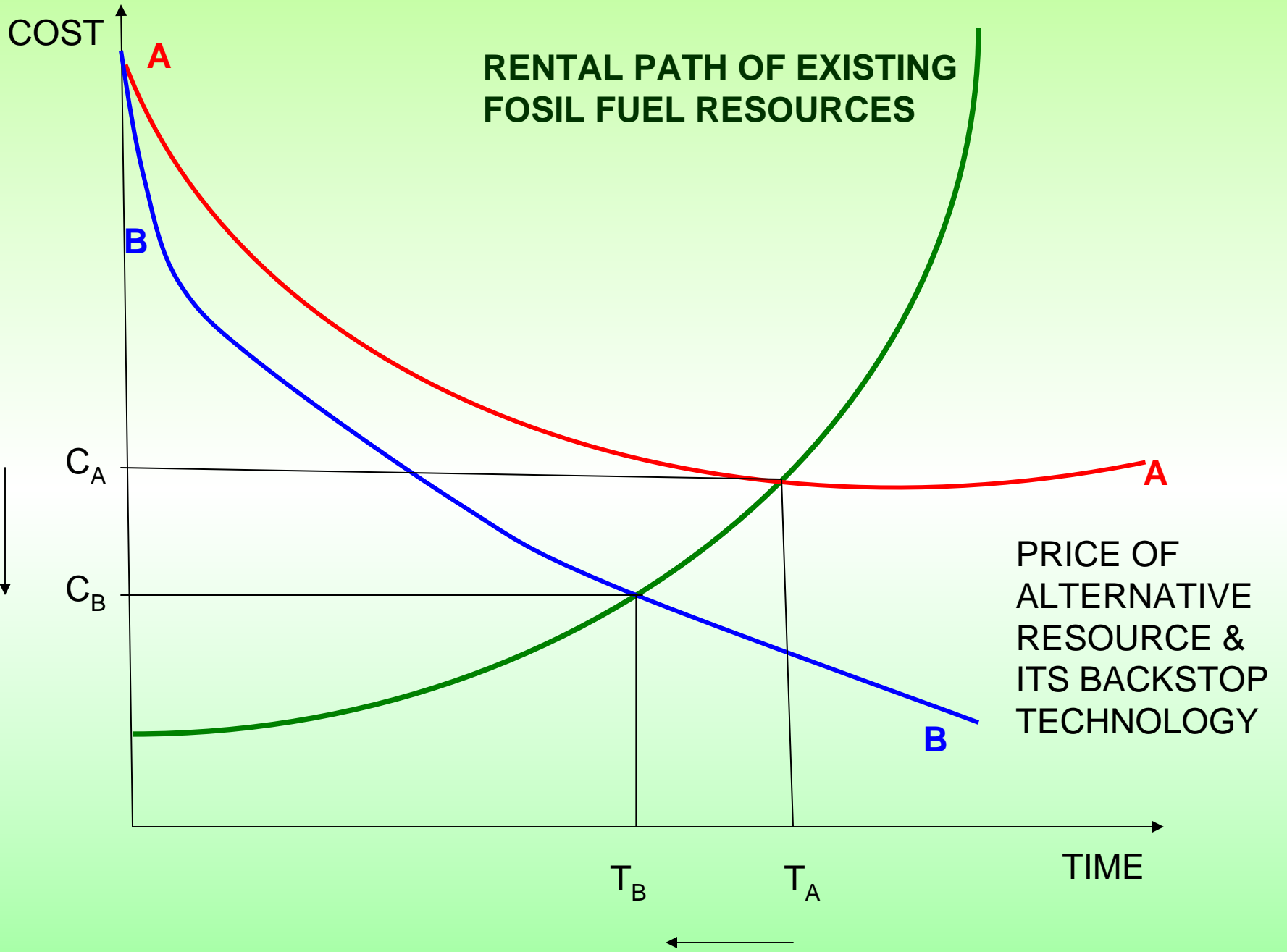
Critical HSD price \$ per barrel for Jatropha to be competitive with other crops in land use

	Haryana	Tamil Nadu	Uttar Pradesh	Maharashtra	West Bengal	Uttaranchal	Chattisgarh
Sugarcane	75	61	61	72		64	
Wheat*	44		40		35	37	37
Bajra	36		37	36			
Paddy	48	38	39		37	39	40
Rapeseed & Mustard*	45		44		40		
Urad		39	38				39
Gram*			48	41			51
Groundnut		42		35			
Jowar		35		36			
Cotton		37		38			
Sesamum		40	41				
Tur			44	41			
Maize			36			35	37
Soyabean				38			39

CONCLUDING POINTS

- **Technology and Supply side initiatives for ensuring adequacy of modern energy for removing energy poverty of the households.**
- **The initial high cost of connectivity with modern fuels being a constraint for the poor. Innovative policy initiatives like credit for such purpose is required without distorting the energy prices which is often counter-productive.**
- **Reliable supply of electricity in rural India is an imperative. The so-called rural indicators of electrification of GOI is misleading.**

- **Importance of development of non-conventional carbon free energy for decentralised generation of electricity and for local supply of clean fuels to households.**
- **Necessity of reducing the cost of new energy sources like solar, thermal, photo-voltaic, wind and others by raising the pace of investment in R&D and taking initiative in wider deployment of the technology.**
- **Importance of North-South co-operation in R&D and Technology deployment which can only lead to decline in costs and dynamic externalities.**



- **Policy Intervention for balancing the concerns of food security and oil security in respect of land-use change induced by bio liquids development for transport.**
- **Necessity of new technology in transport which would substitute oil by electricity or by substantive energy conservation.**
- **Importance of assessment of available wasteland for bio-ethanol or bio-diesel development.**

Mitigation of Environmental Stress

1. Energy Conservation, Demand side efficiency improvement options.
2. Supply side efficiency improvement of coal thermal plants
3. T& D Loss reduction
4. Non conventional Renewable technologies
5. Coal gasification or liquefaction.

Should India be proactive on technology front. Or wait for the advancement of technologies for short run saving of costs. Cost benefit analysis using integrated models.

- Results of simulations of IMACLIM-R (Shalizi 2007) show **lower benefit-cost ratio for delayed implementation** of new technologies as the increased environmental cost of the earlier period is not compensated by lower cost of later period for a growing energy system like that of India.
- Problem of **financial resources** and initial investment and technology are often the **constraints** for sustainable energy development of India, which combines environmental conservation with equity.

- It is possible to combine the abatement of **global warming** with poverty alleviation and human development as there exists significant space in our domain of choices in preference structure and in technology and resources for such combinations.

- Fortunately we do not live in a hopeless world where it is entirely an issue of development vs. environmental conservation or climate control.

- **Clean energy is a fundamental requirement for both the abatement of global warming and human development as it directly contributes both to lowering of carbon emissions as well as to higher educational and health attainment of the households of the developing countries.**
- **Global technological co-operation for clean coal development, nuclear fuel supply and development of technology for biomass conversion into cleaner energy form can help to resolve the challenge of sustainable energy and human development.**

THANK YOU