# Sustainable Energy Development of India

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**November 2008**

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LAKSHADWEEP (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 11$^{th}$ 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***

- **<u>Energy Poverty due to Dualism in the pattern of resource-use</u>**

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

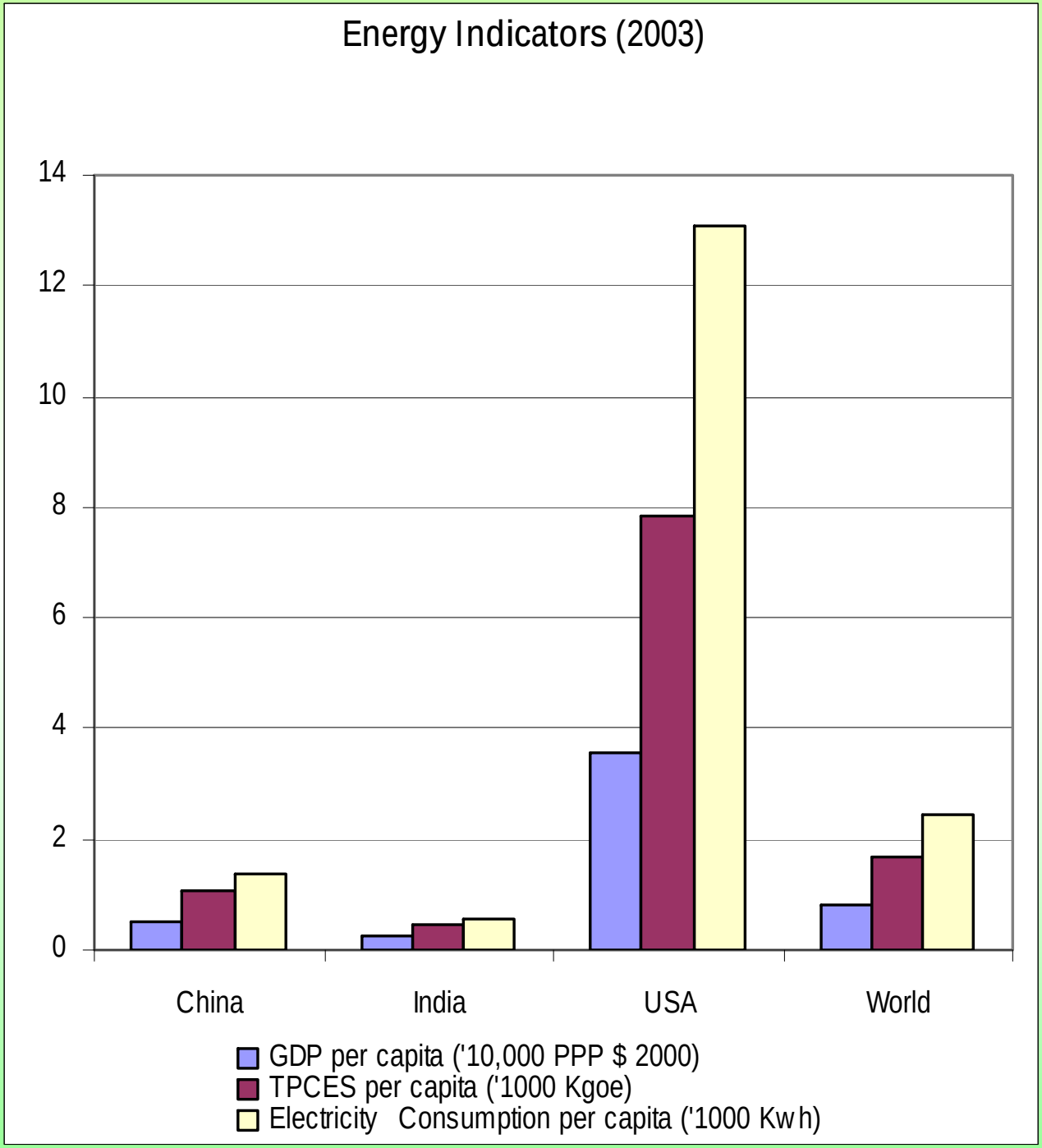
Vast majority of rural and urban poor have to depend on unclean, unconverted and highly inefficient biomass fuel for cooking. Significant lack of connectivity with electricity and/or its reliable supply for particularly the rural households. Energy Poverty removal is critical for decent quality of life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

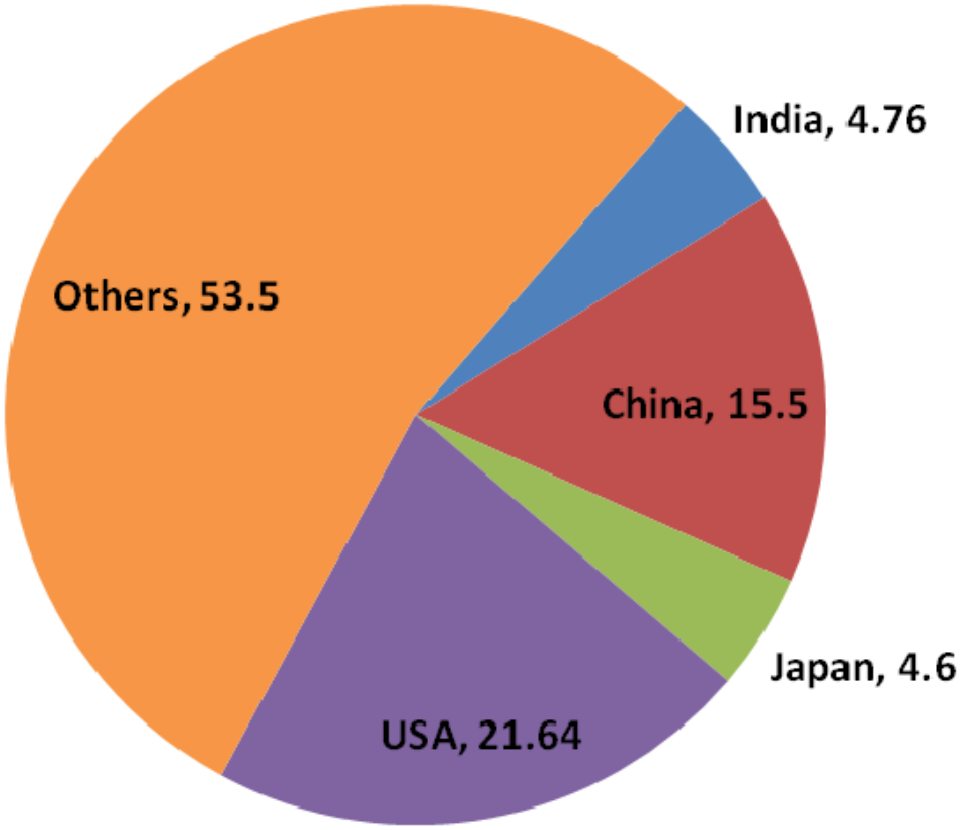
- **This would cause substitution of one kind of environmental pressure by another and may in the net, cause upward pressure on the environment as carbon neutral biomass fuel is to be replaced by fossil fuel based energy in Indian situation.**

- **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.**

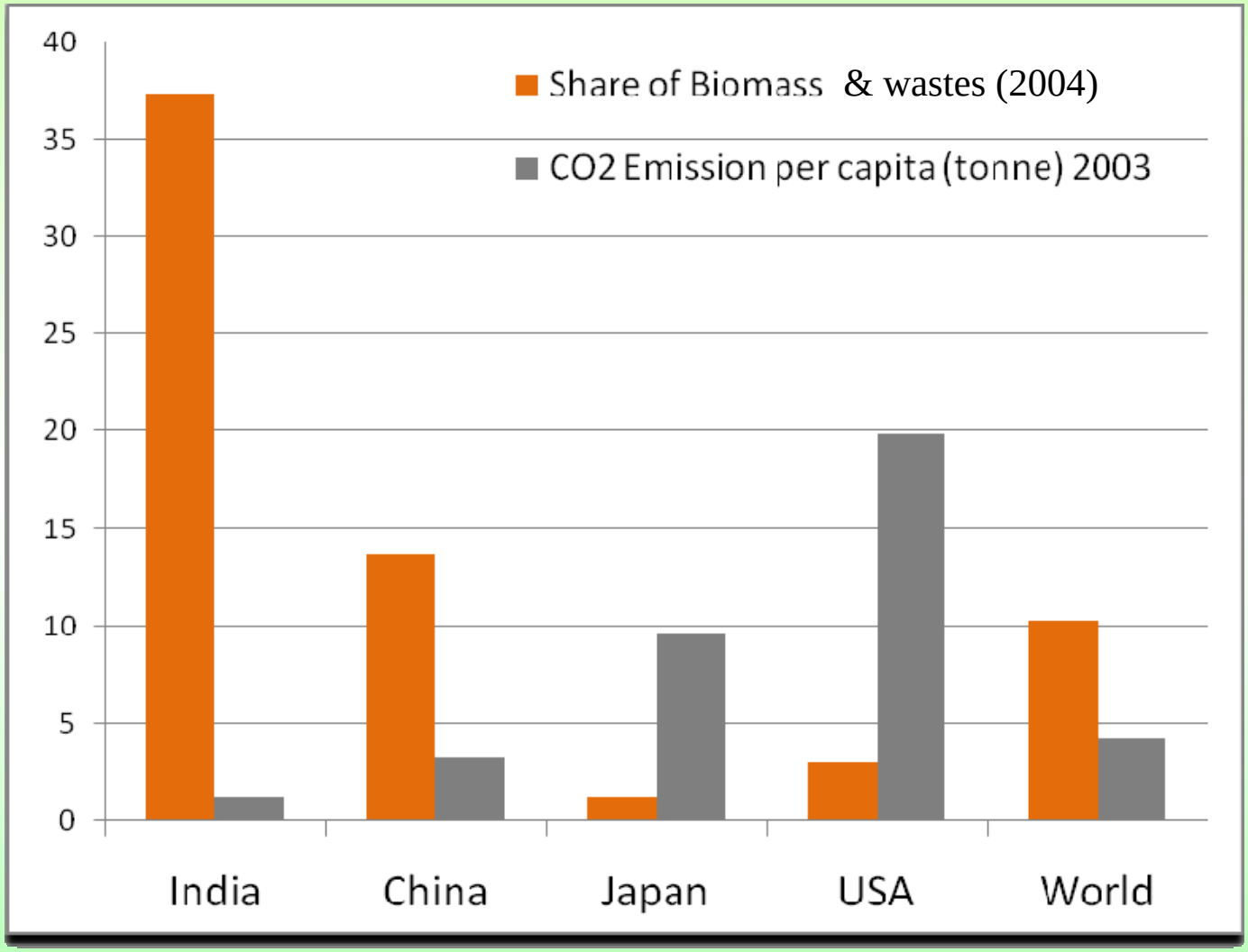
# TREND AND PATTERN OF ENERGY CONSUMPTION IN INDIA

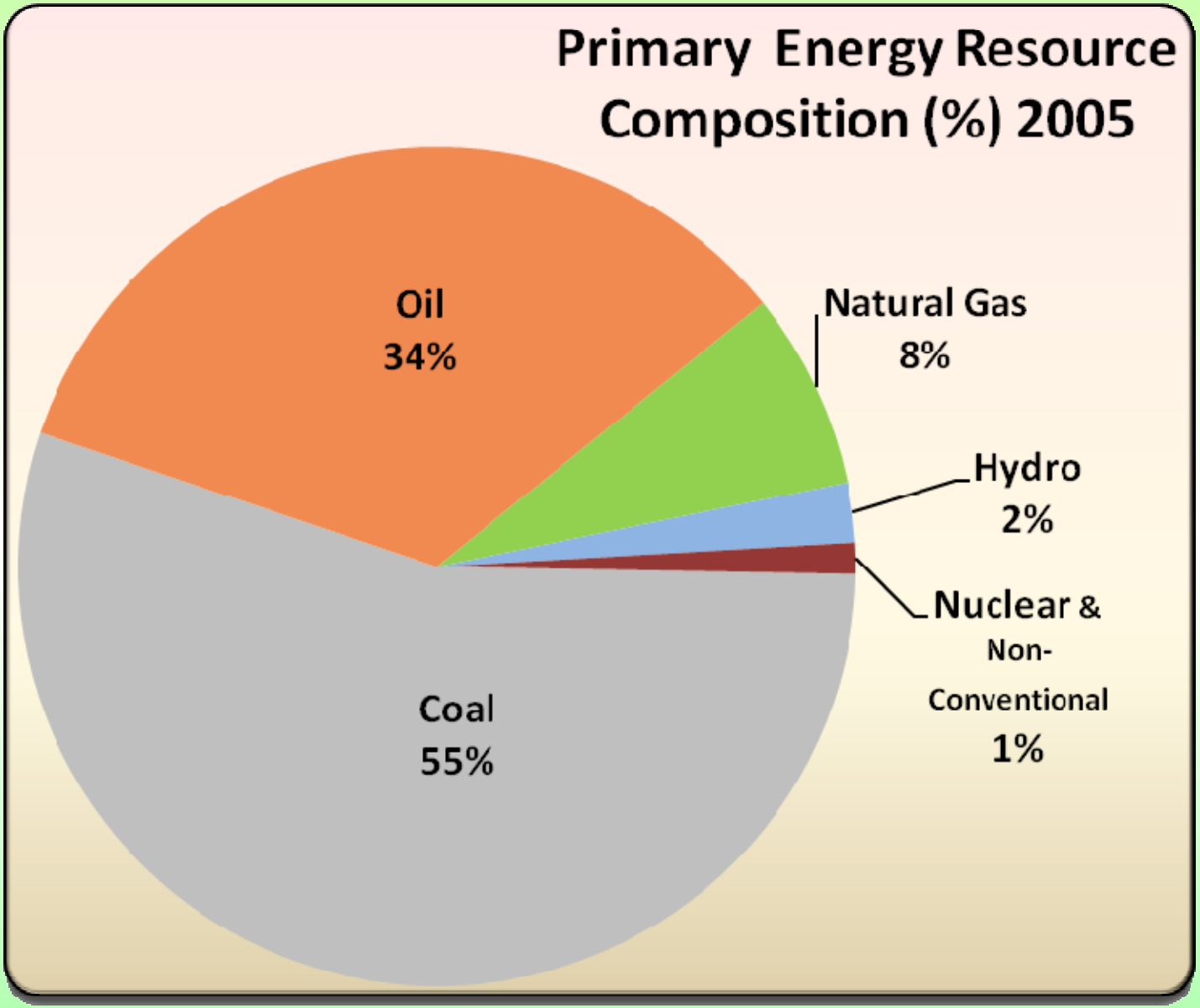

Energy Indicators (2003)
14
12
10
8
6
4
2
0
China
India
USA
World
GDP per capita ('10,000 PPP $ 2000)
TPCES per capita ('1000 Kgoe)
Electricity Consumption per capita ('1000 Kwh)

# Share of CO2 emission in World Total (%) 2003



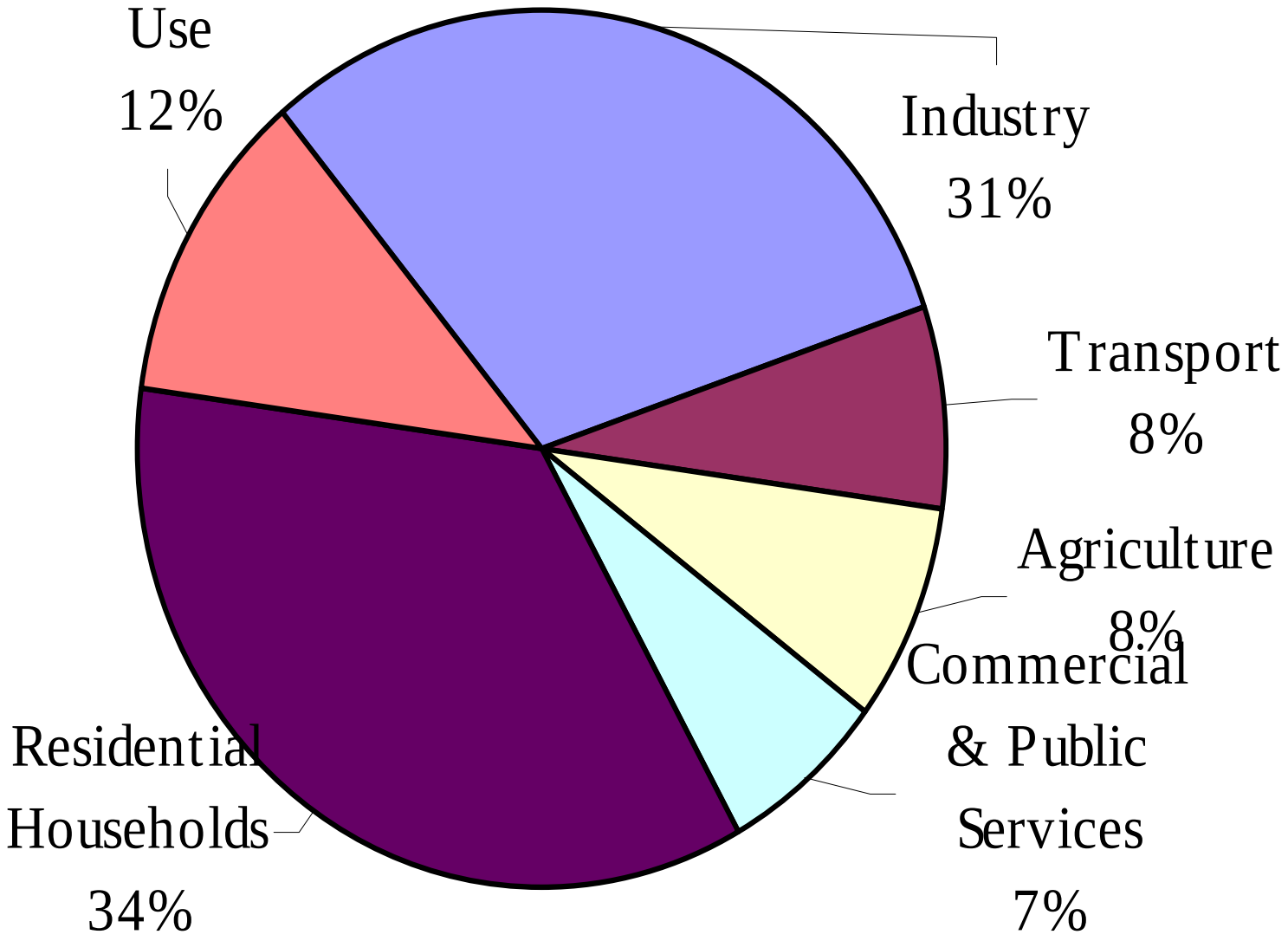
# Comparative share of Biomass and CO2 emission per capita.




Primary Energy Resource Composition (%) 2005
Oil
34%
Natural Gas
8%
Hydro
2%
Nuclear & Non-Conventional
1%
Coal
55%

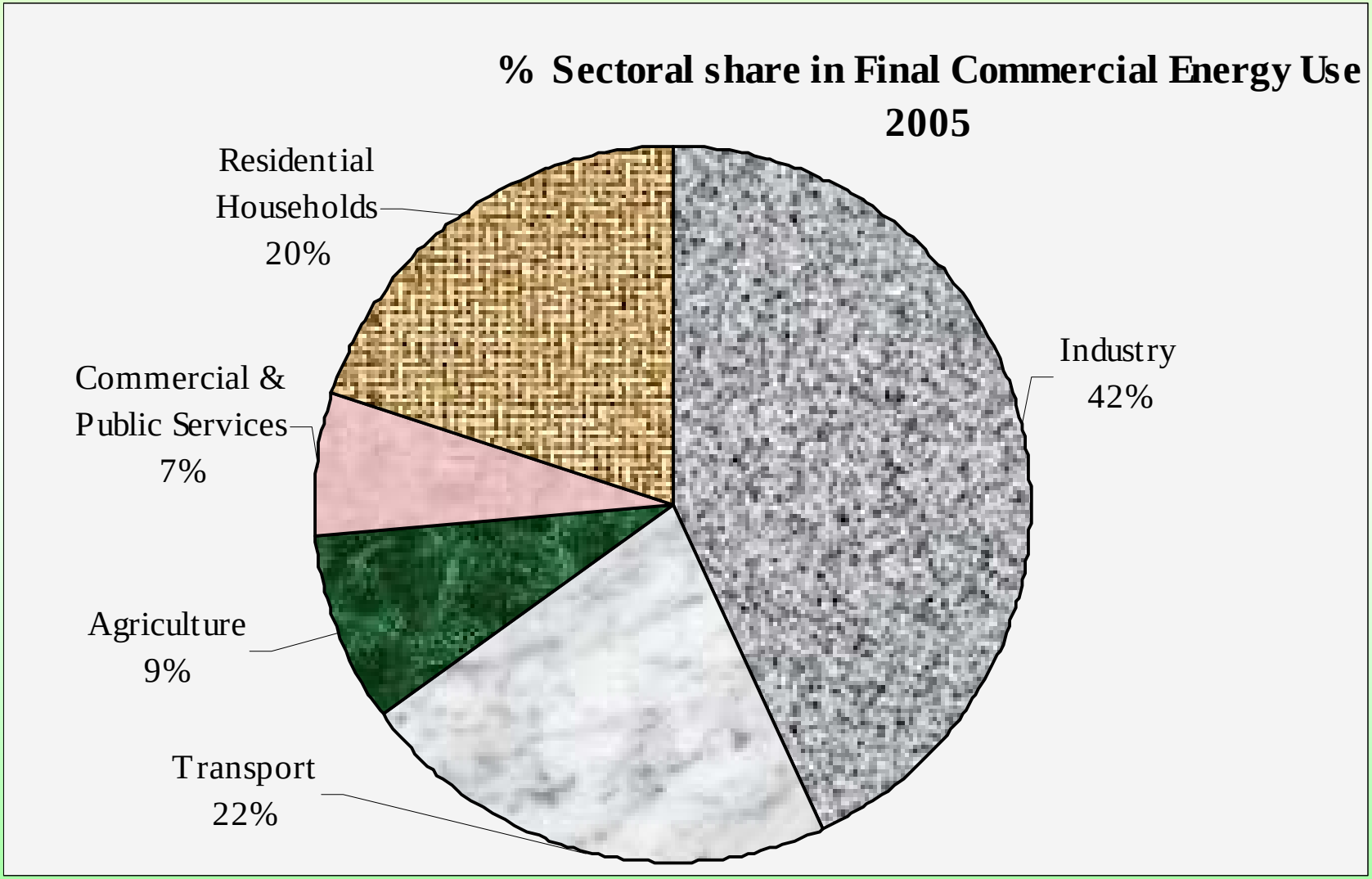
# % Sectoral Share

**Of Primary Energy 2005**

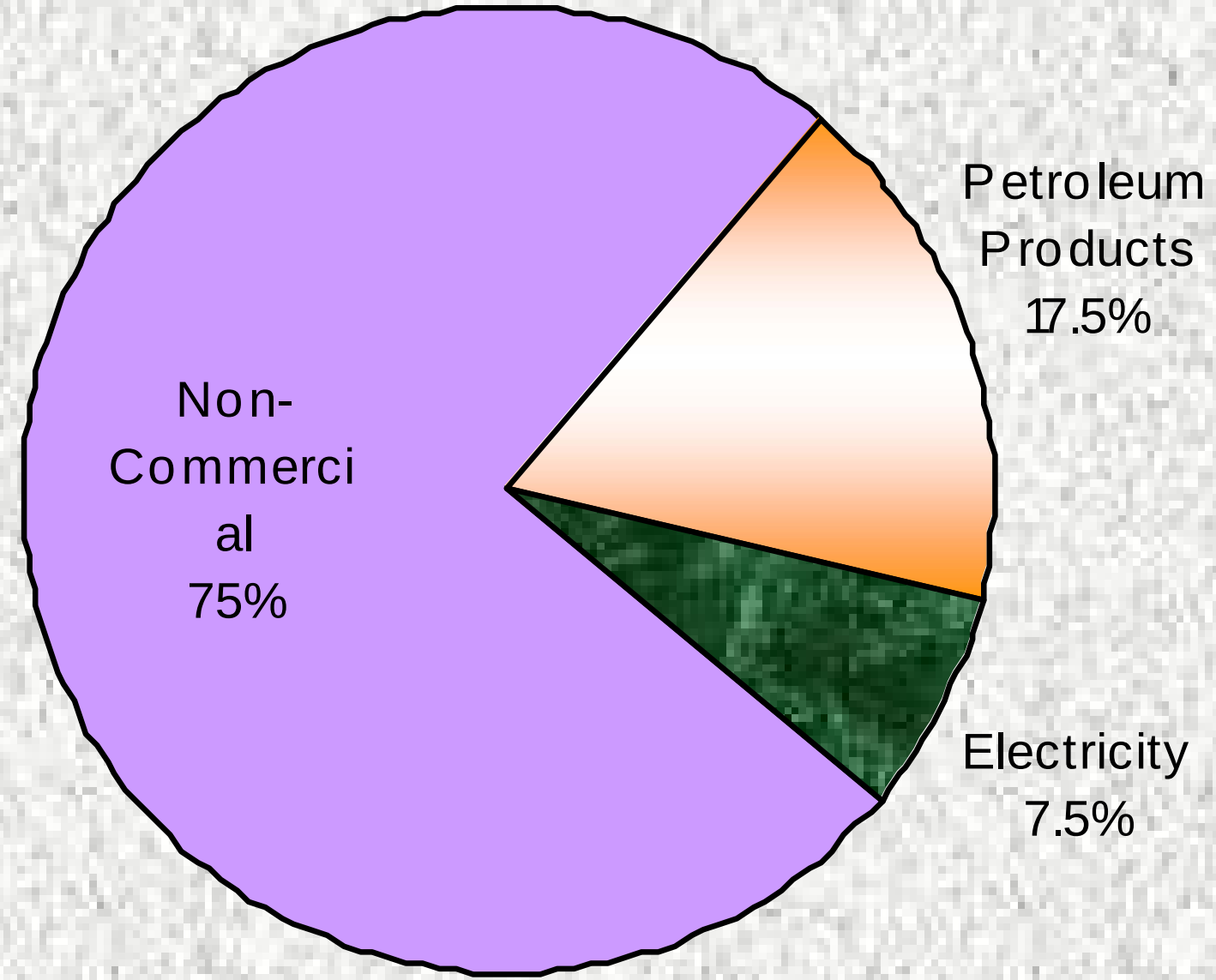


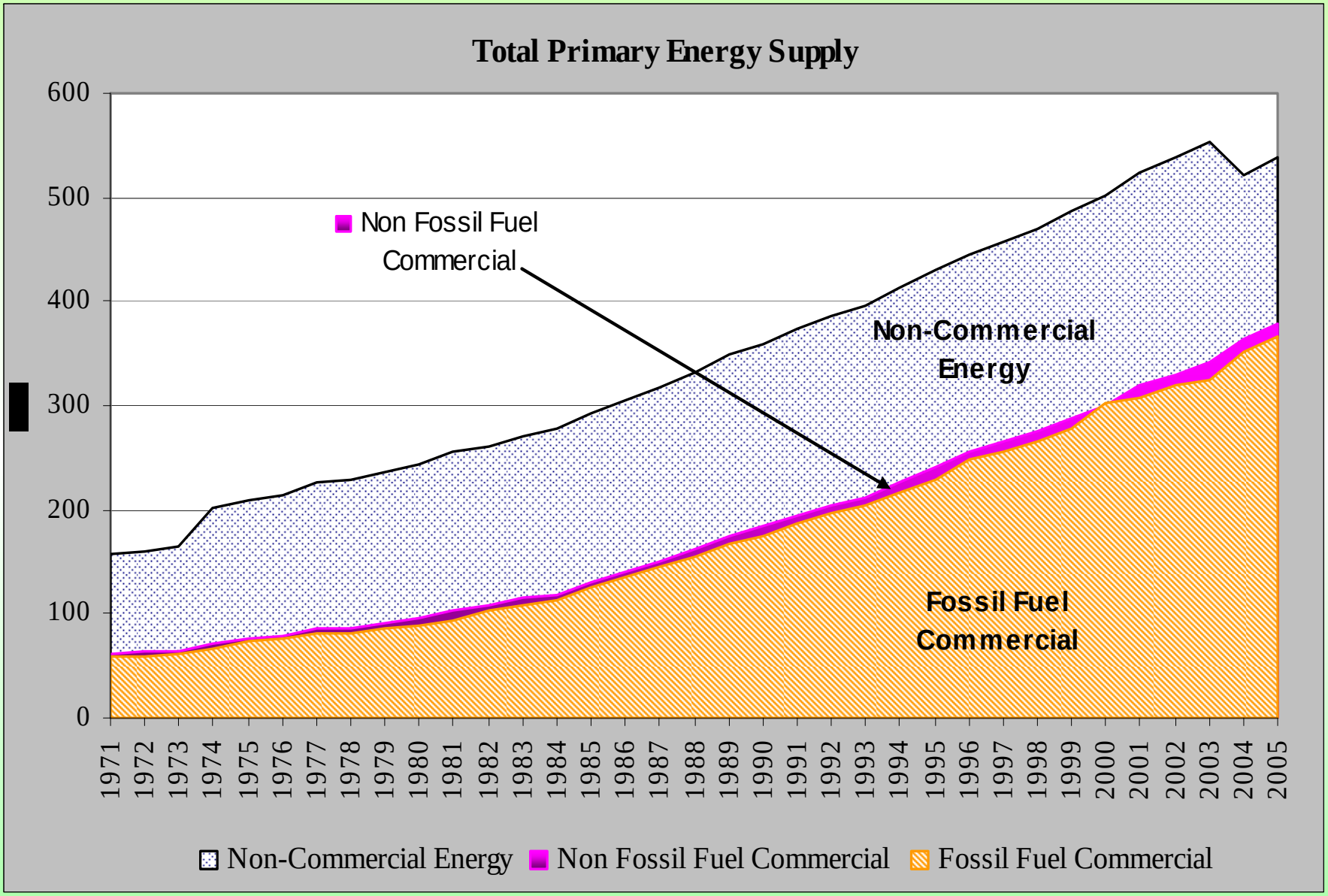
# Fuelwise Sectoral Distribution of Final Commercial Energy Use.

Unit: % Sectoral share

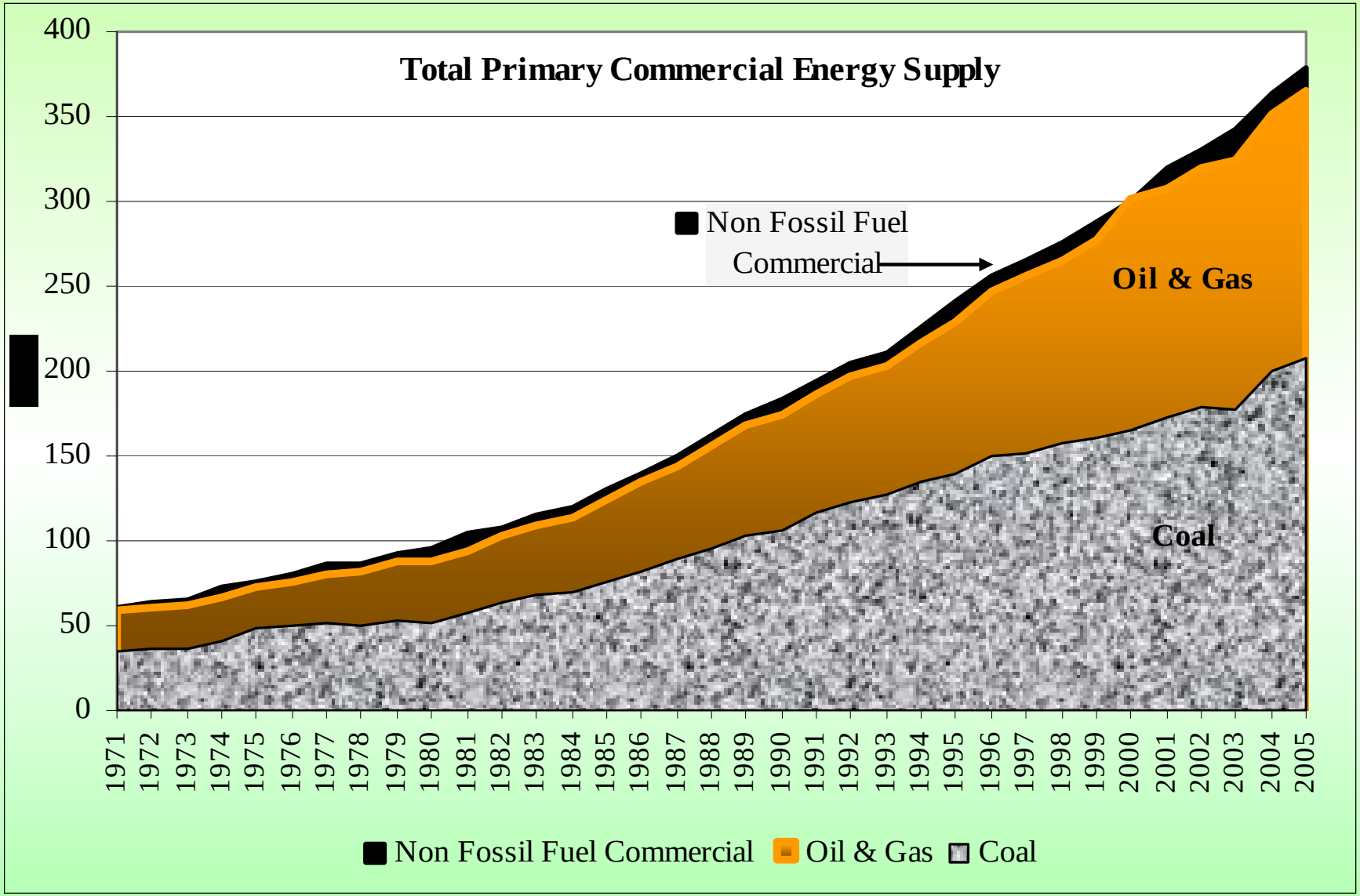


# Sources of Final Energy in Residential Sector

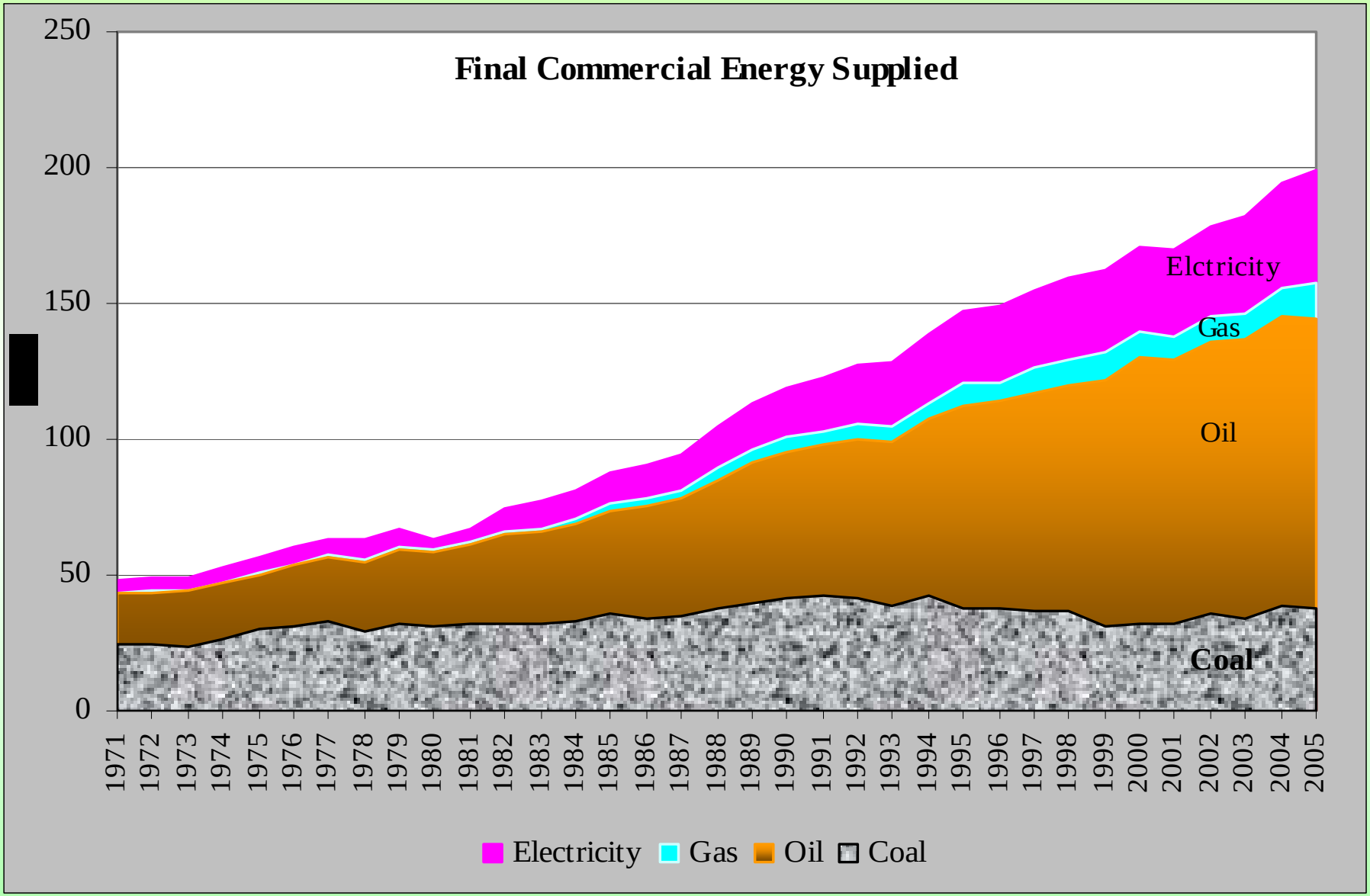





Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes.

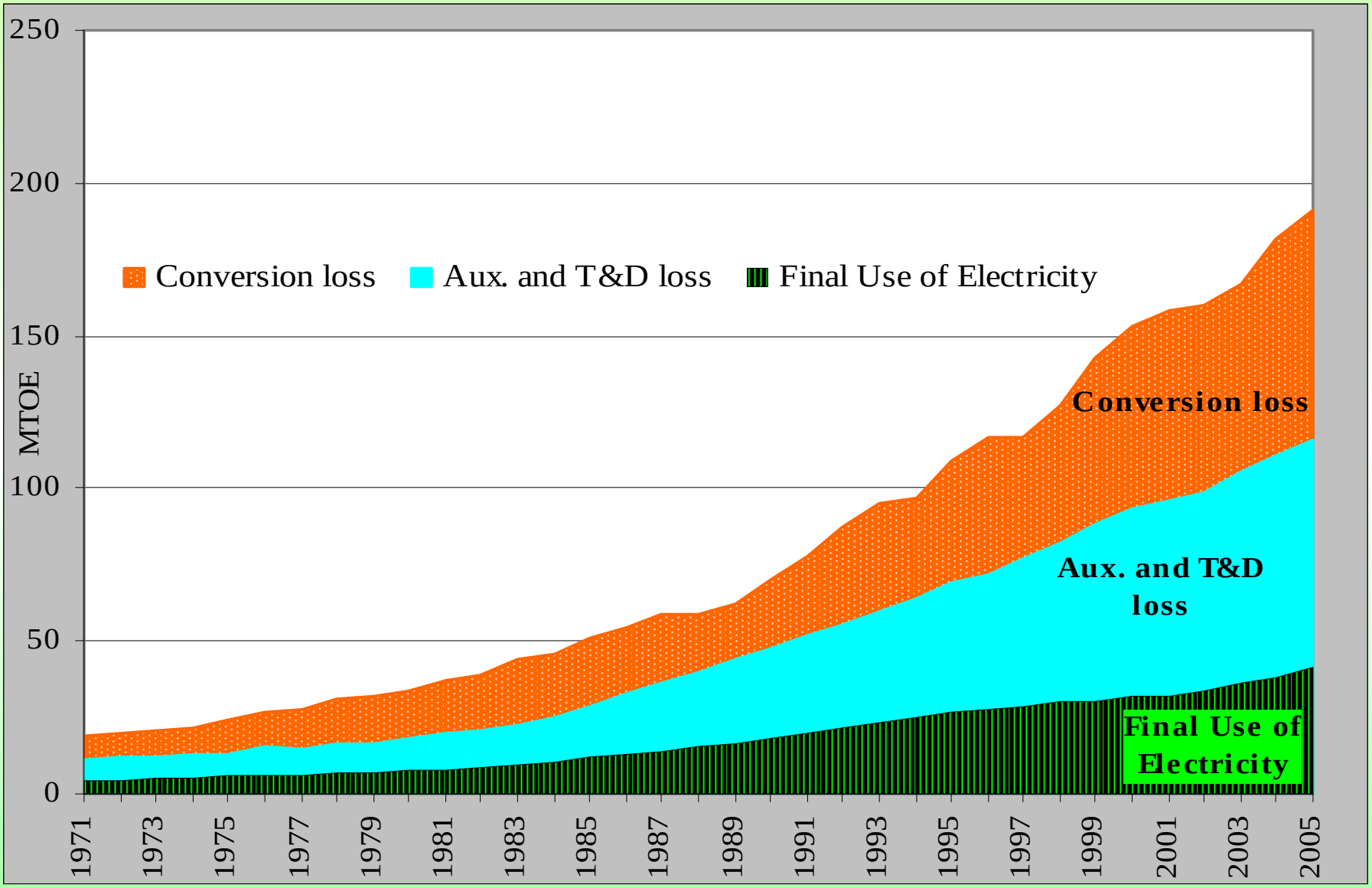



Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes.



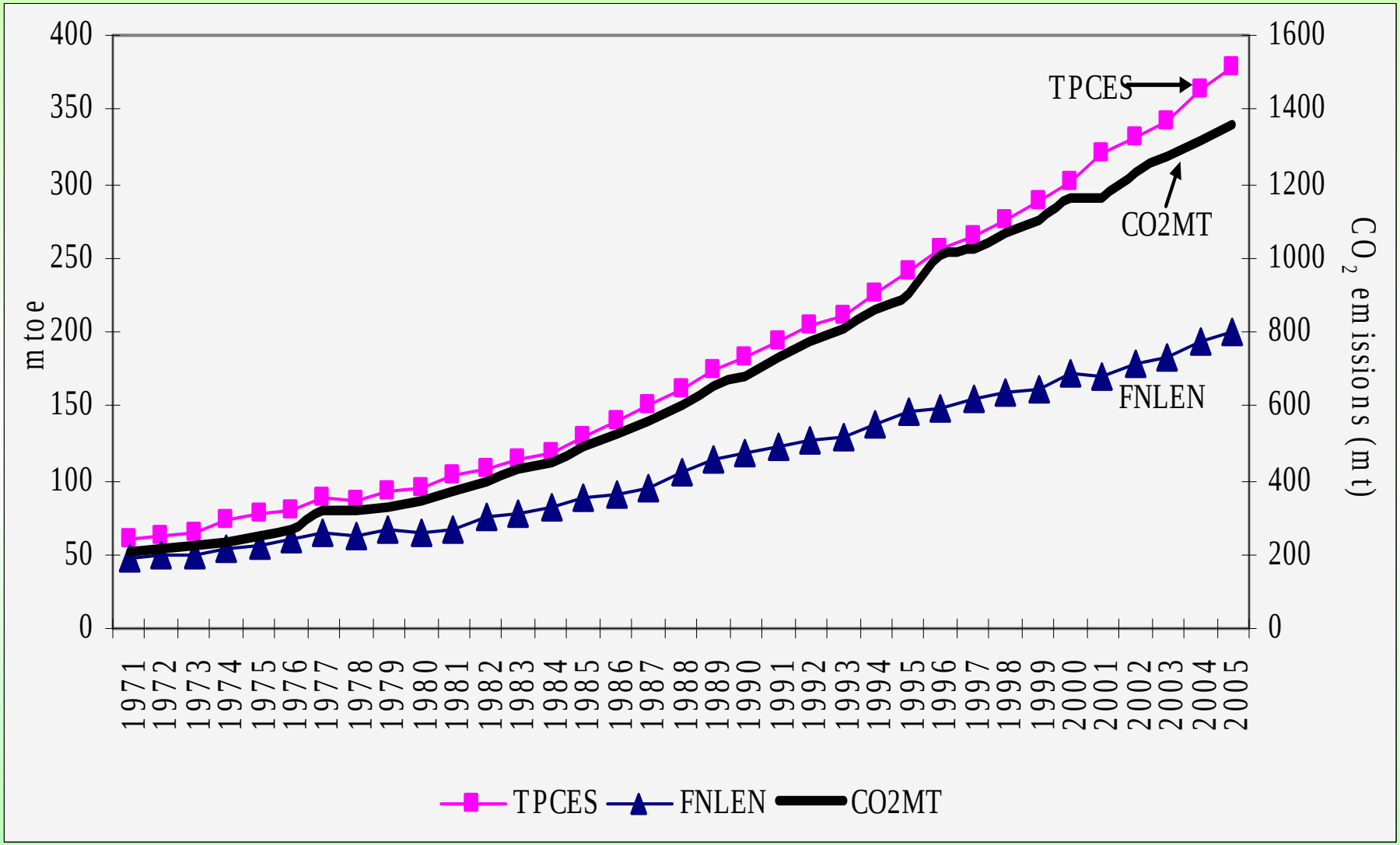

Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes.

# Total Energy Input, Losses and Final Use of Electricity.



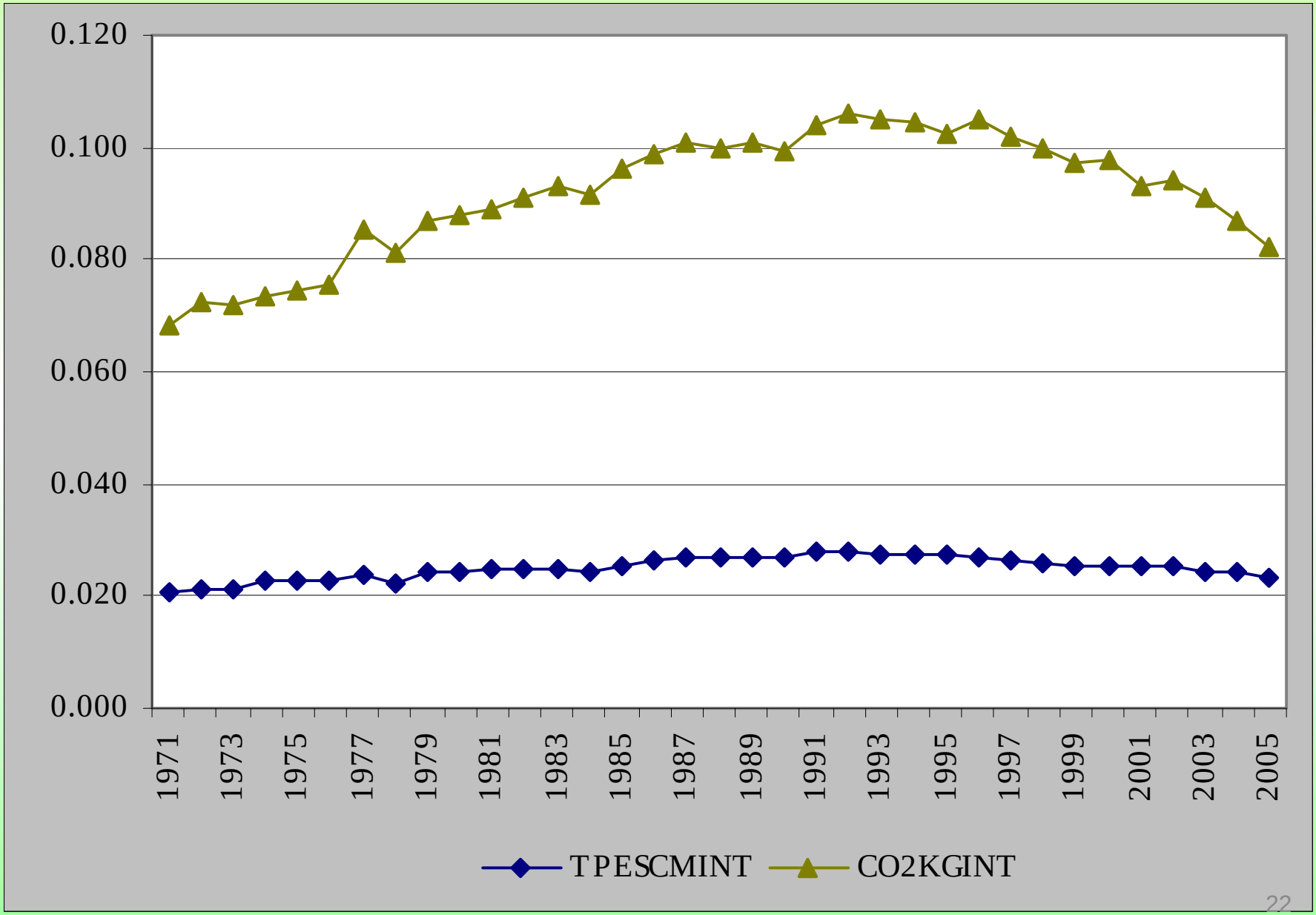

Source: Based on IEA Data on Energy balances of Non-OECD countries, different volumes

# Supplies of Total Primary and Final Commercial Energy and $CO_2$ 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.

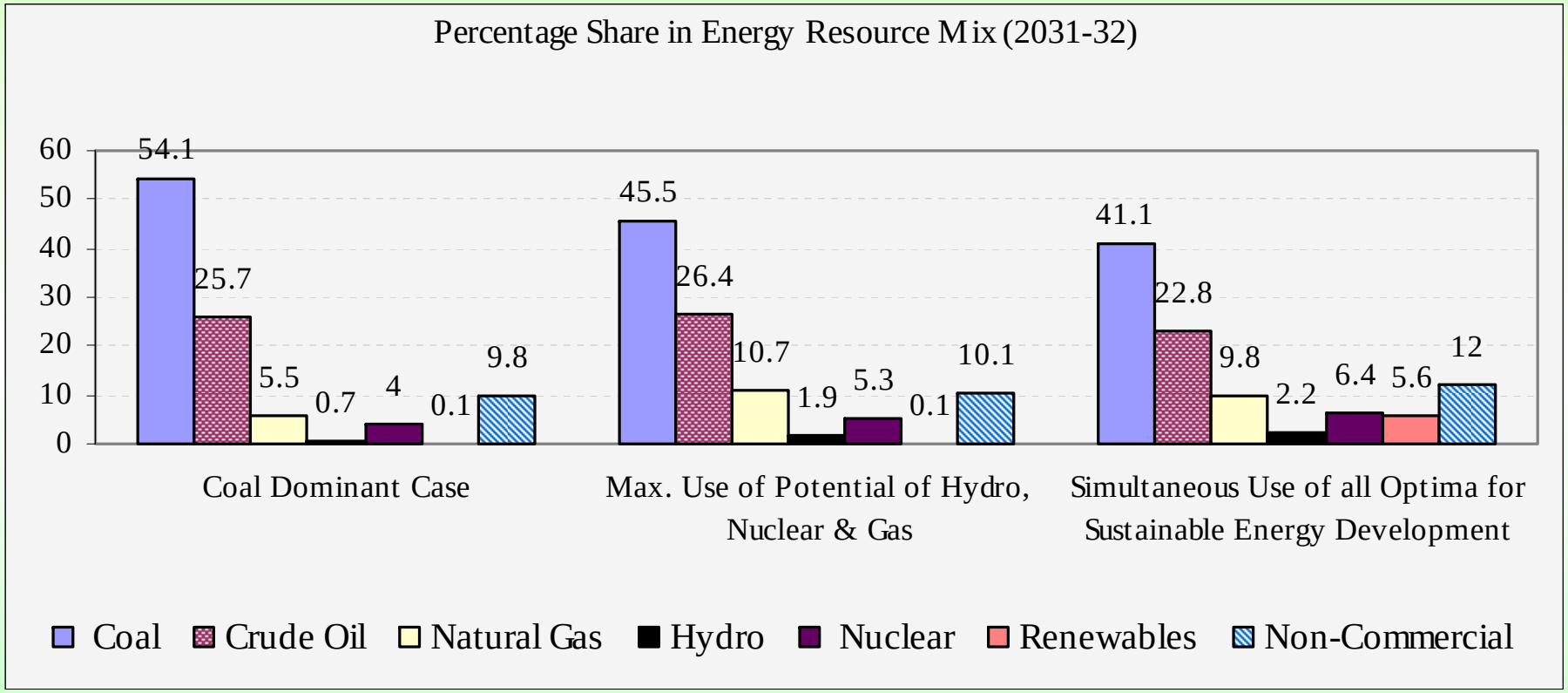
| Items | Coal Dominant Case | Max. Use of Potential of Hydro, Nuclear & Gas | Simultaneous Use of all Optima for Sustainable Energy Development |
|---|---|---|---|
| Total Energy requirement (mtoe) | 1702 | 1652 | 1351 |
| Shares of | | | |
| (a) Coal | 54.1 | 45.5 | 41.1 |
| (b) Crude Oil | 25.7 | 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.**

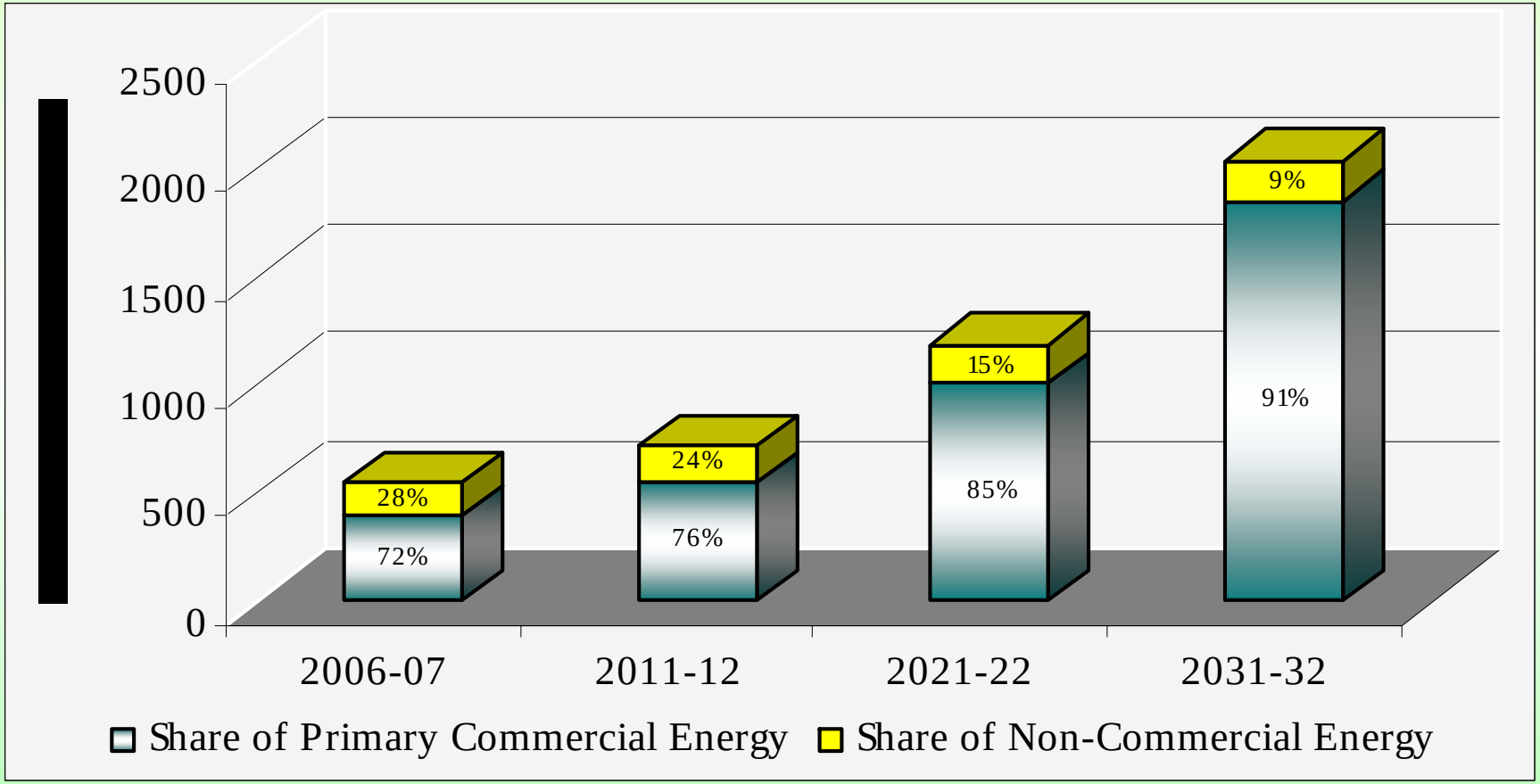
The Demand for Various Energy Items by Households. (in mtoe)

| 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 .**

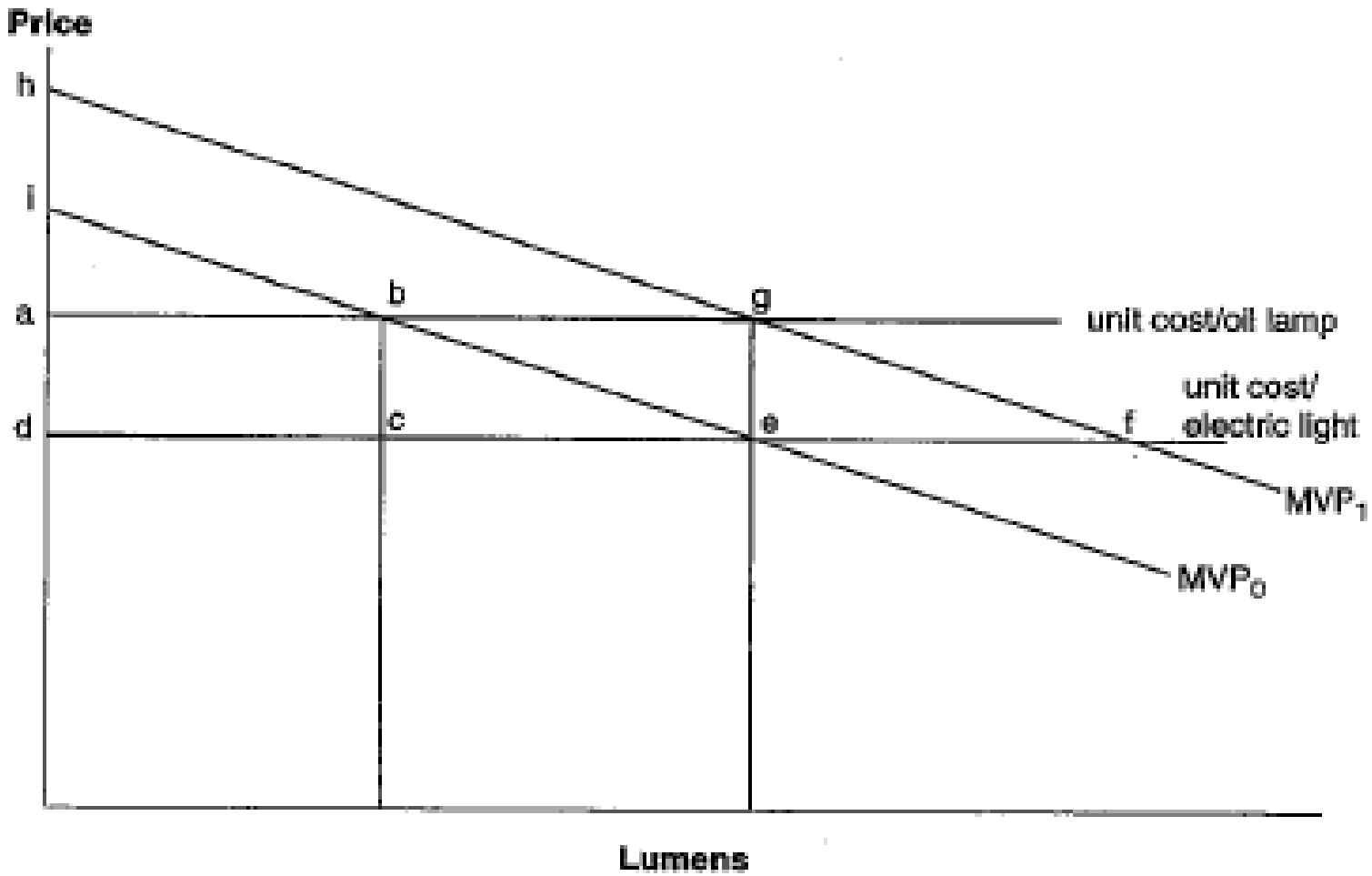



Illustration of economic effects from increased energy services utilization

*Source*: Adapted from World Bank (2002b).

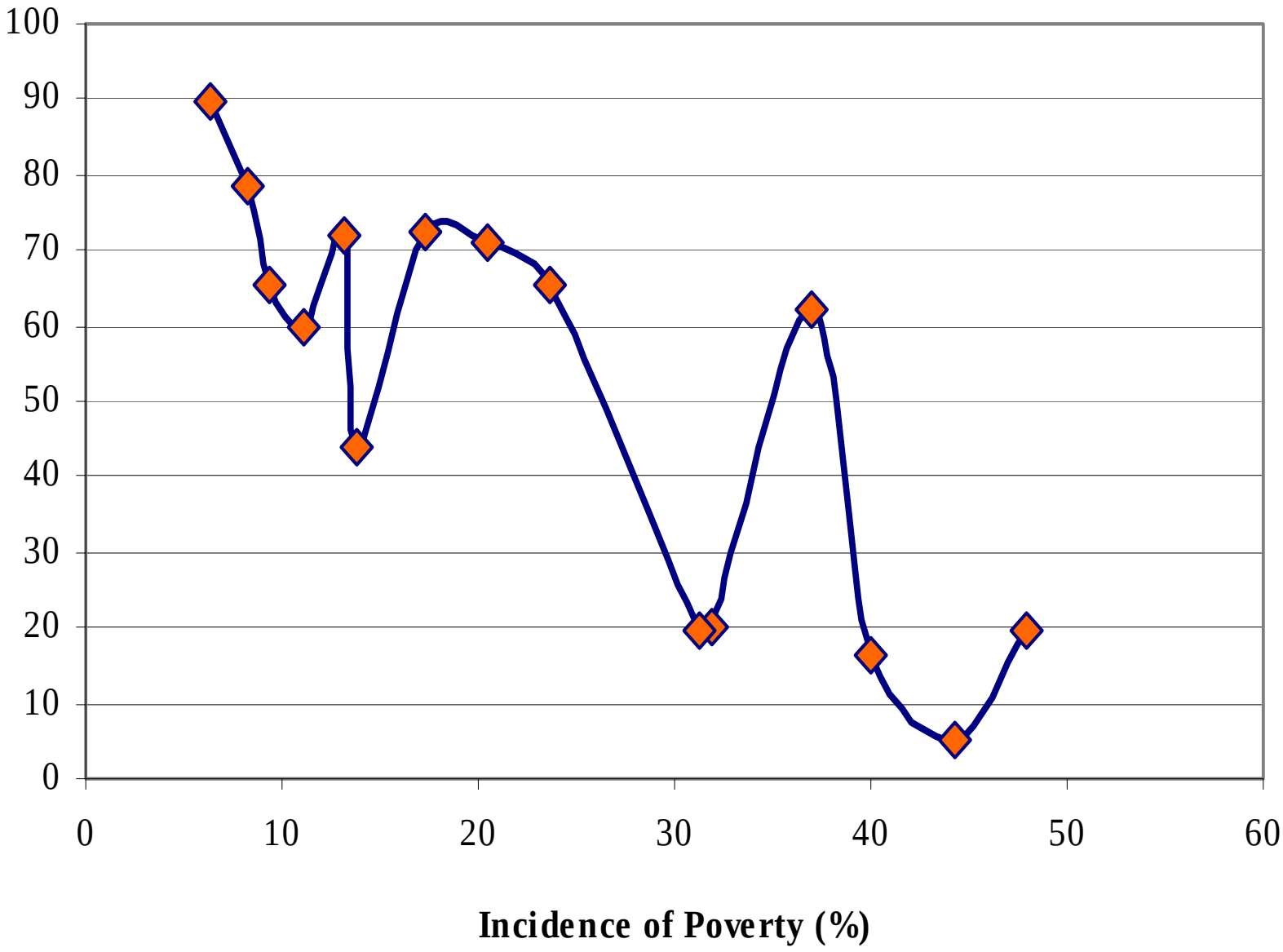
## Percentage Distribution of Households using major source of energy for Cooking : 2004-05

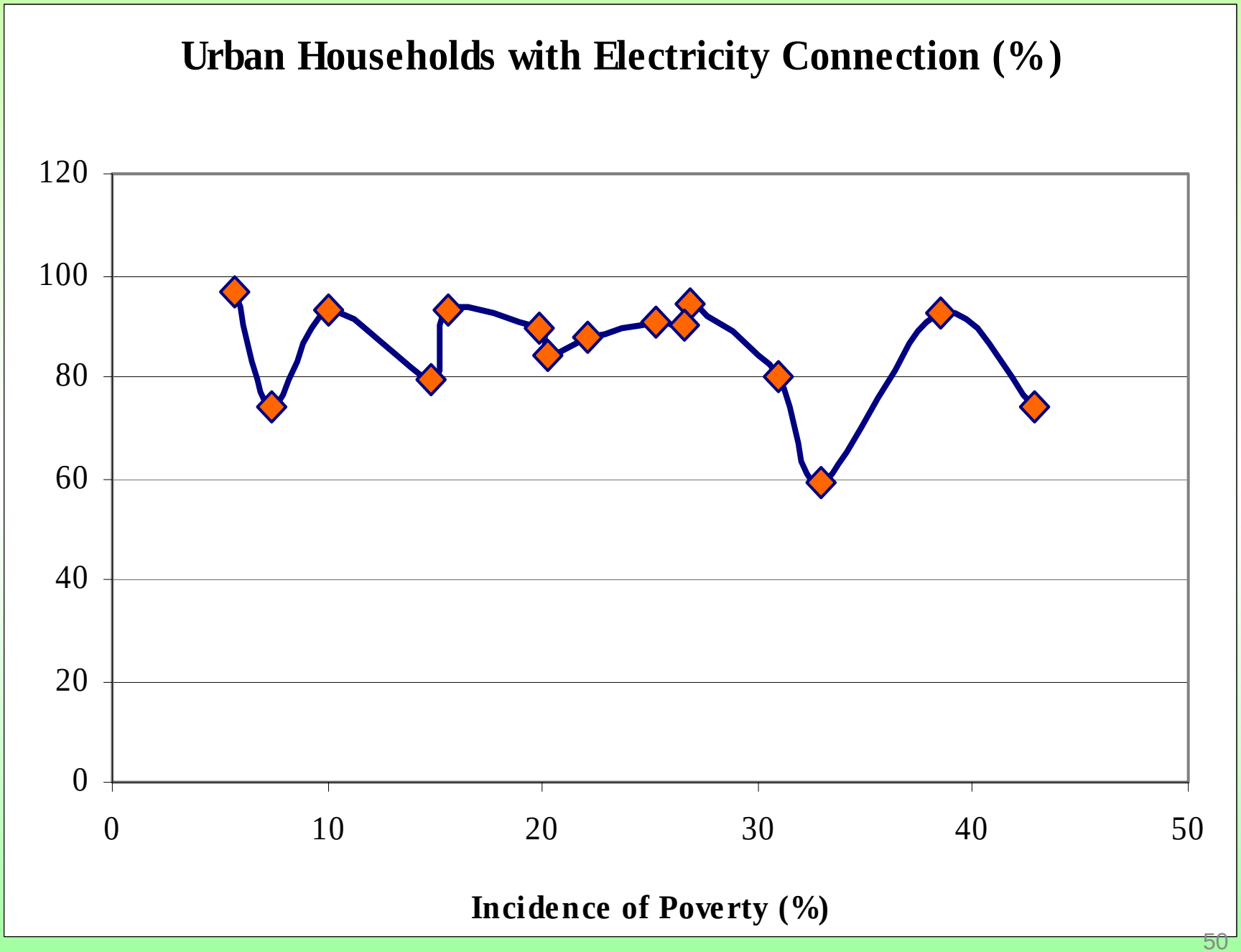
| All India | Biomass | LPG | Kerosene | Others |
|---|---|---|---|---|
| Rural | 84.1 | 8.6 | 1.3 | 6 |
| Urban | 23.7 | 57 | 10 | 9.3 |

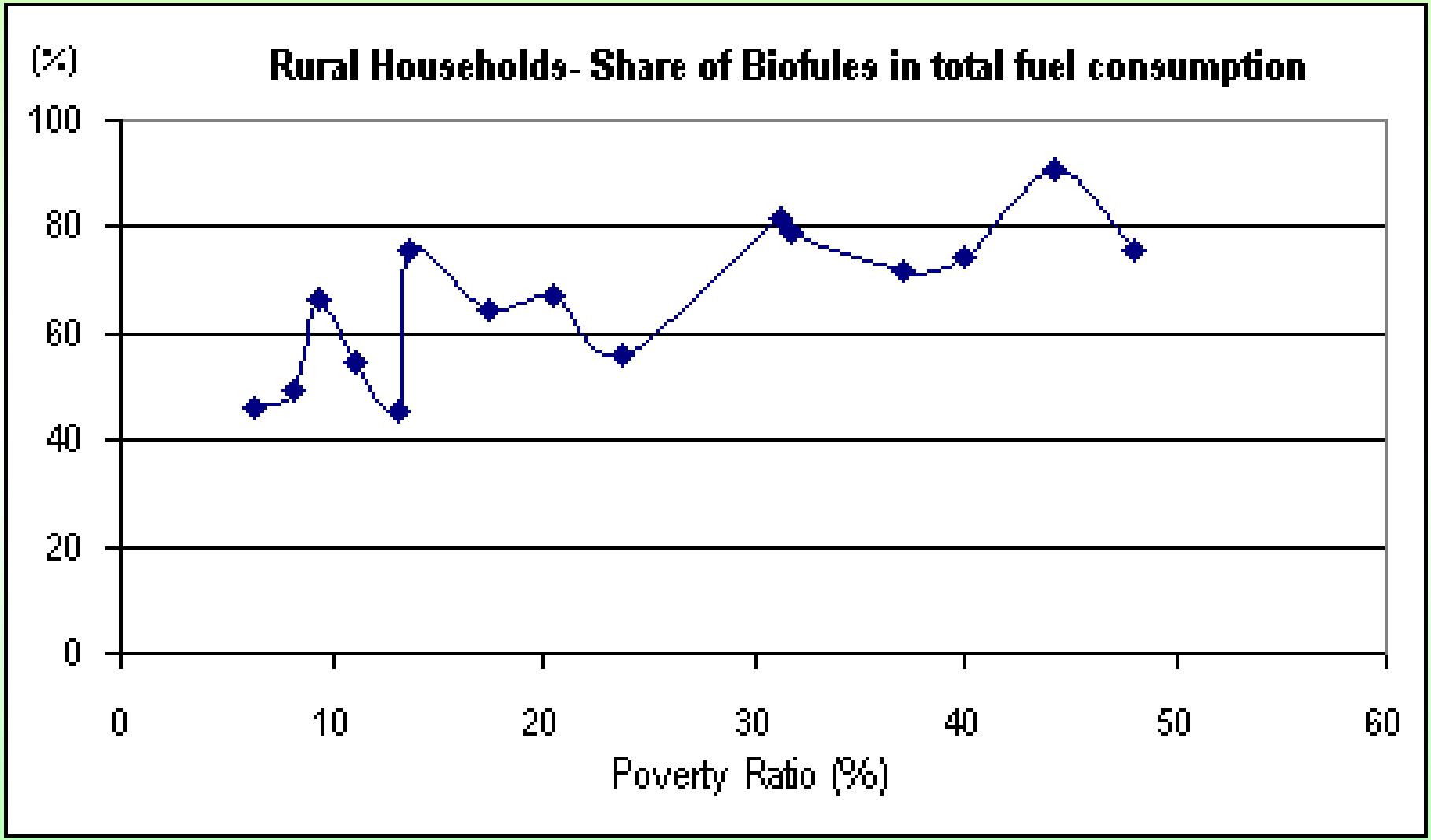
## Percentage Distribution of Households using major source of energy for Lighting: 2004-05

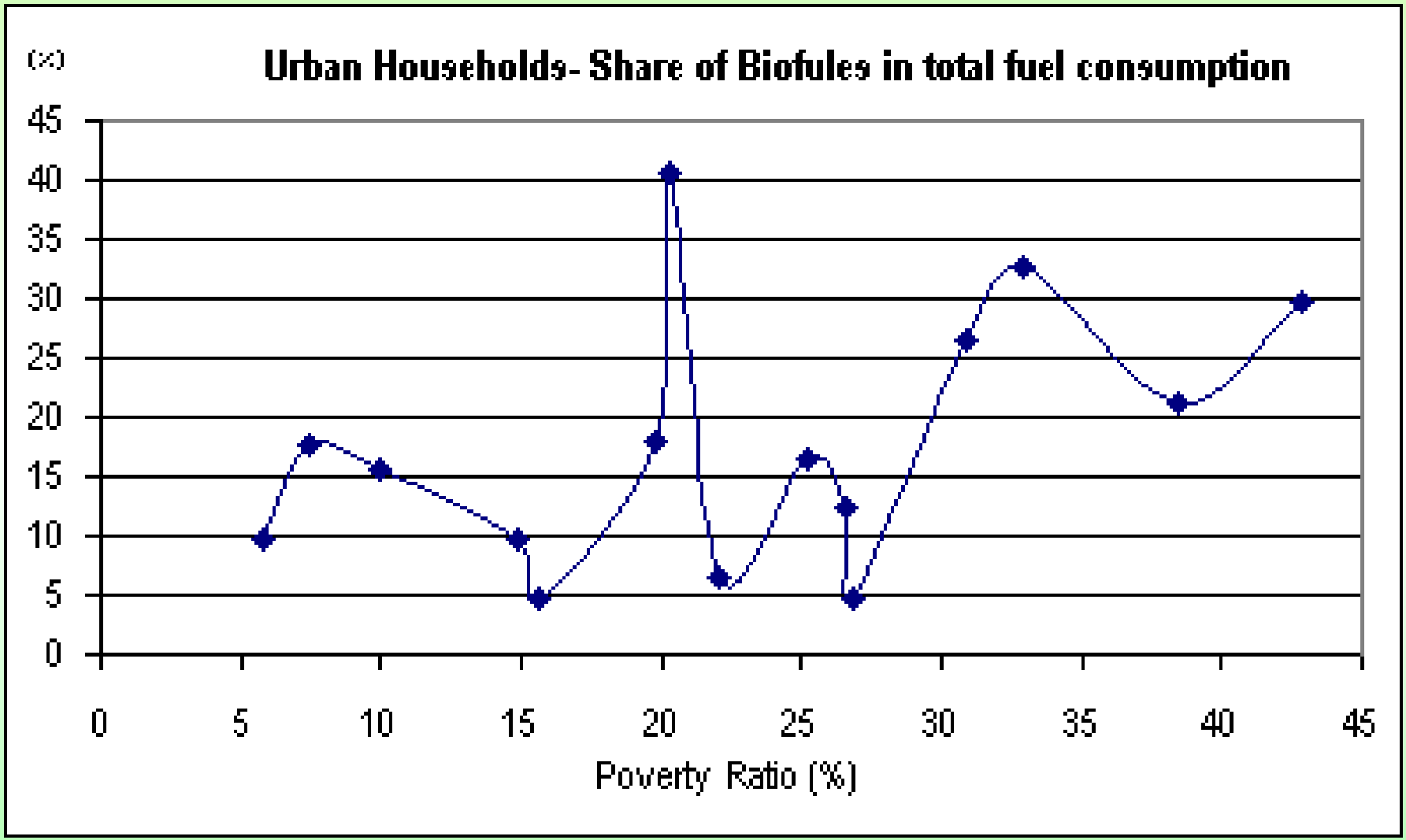
| All India | Electricity | Kerosene | Others |
|---|---|---|---|
| Rural | 54.9 | 44.4 | 0.7 |
| Urban | 92.3 | 7.1 | 0.6 |

# Rural Households with Electricity Connection (%)




Urban Households with Electricity Connection (%)
120
100
80
60
40
20
0
0
10
20
30
40
50
Incidence of Poverty (%)


Rural Households- Share of Biofules in total fuel consumption
(%)
100
80
60
40
20
0
0
10
20
30
40
50
60
Poverty Ratio (%)


Urban Households- Share of Biofules in total fuel consumption
(%)
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45
Poverty Ratio (%)

# INCOME POVERTY AND ENERGY POVERTY

## Rural Poverty Ratio Logit-relationship with Rural MPCE levels:

$$\text{LOG}\,[\text{RPOV}/(100-\text{RPOV})] = \underset{(0.001)}{1.101} - \underset{(0.000)}{0.0039}*\text{RMPCE}$$

Adj $R^2$ = 0.44 N=99

## Urban Poverty Ratio Logit-relationship with Urban MPCE levels:

$$\text{LOG}\,[\text{UPOV}/(100-\text{UPOV})] = \underset{(0.3342)}{-0.413} - \underset{(0.0024)}{0.0014}*\text{UMPCE}$$

Adj $R^2$ = 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.

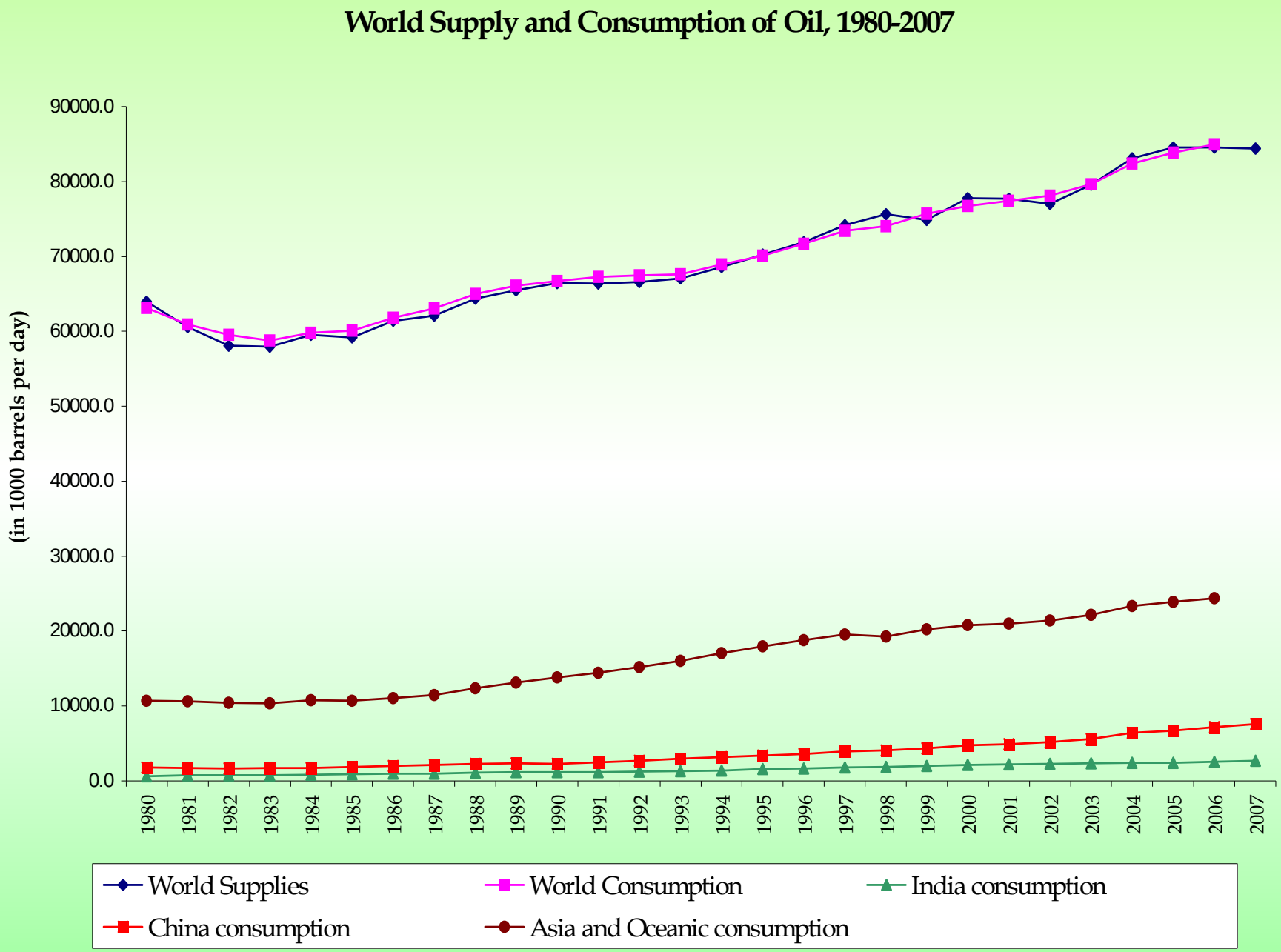
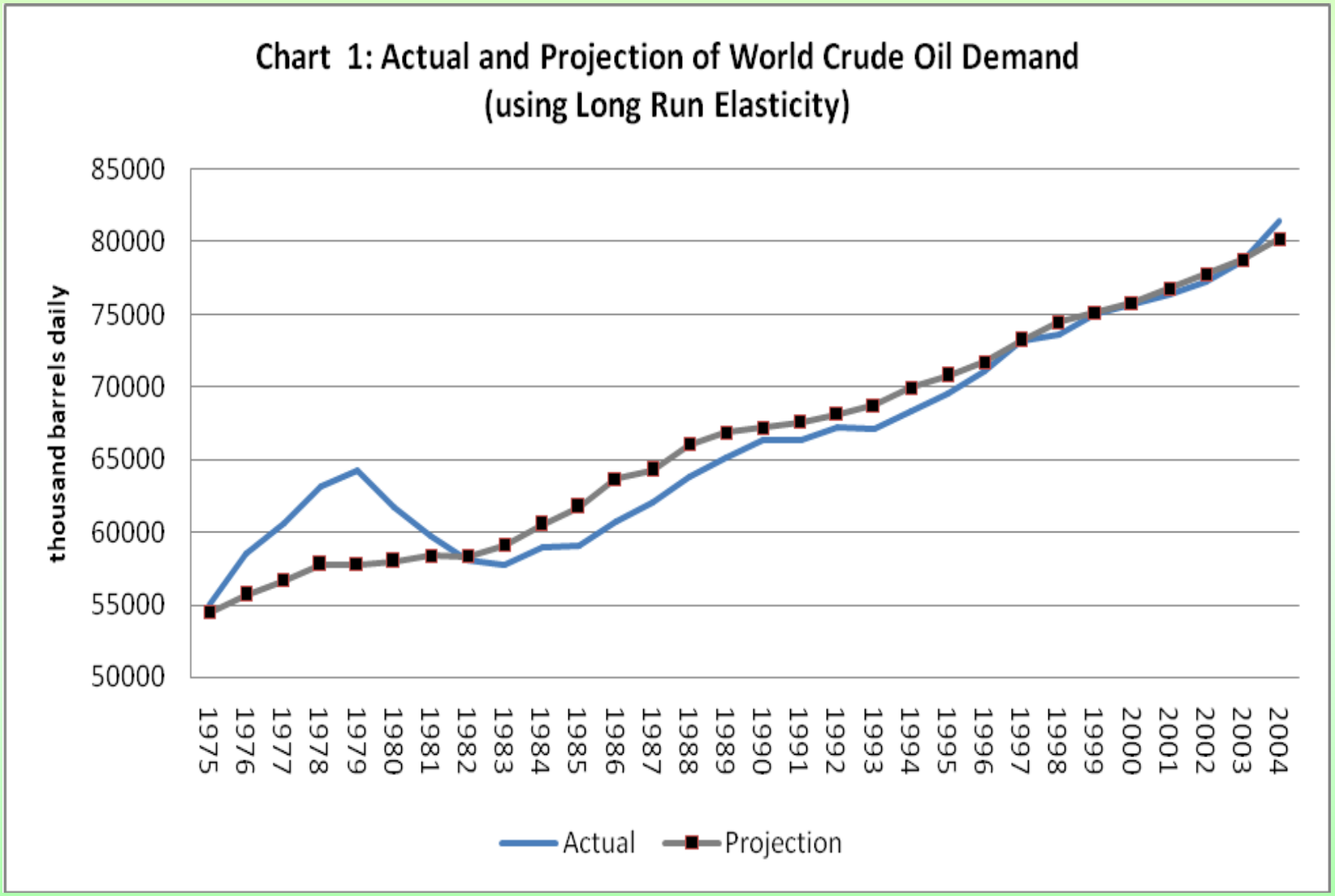

World Supply and Consumption of Oil, 1980-2007
(in 1000 barrels per day)
90000.0
80000.0
70000.0
60000.0
50000.0
40000.0
30000.0
20000.0
10000.0
0.0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
World Supplies
World Consumption
India consumption
China consumption
Asia and Oceanic consumption

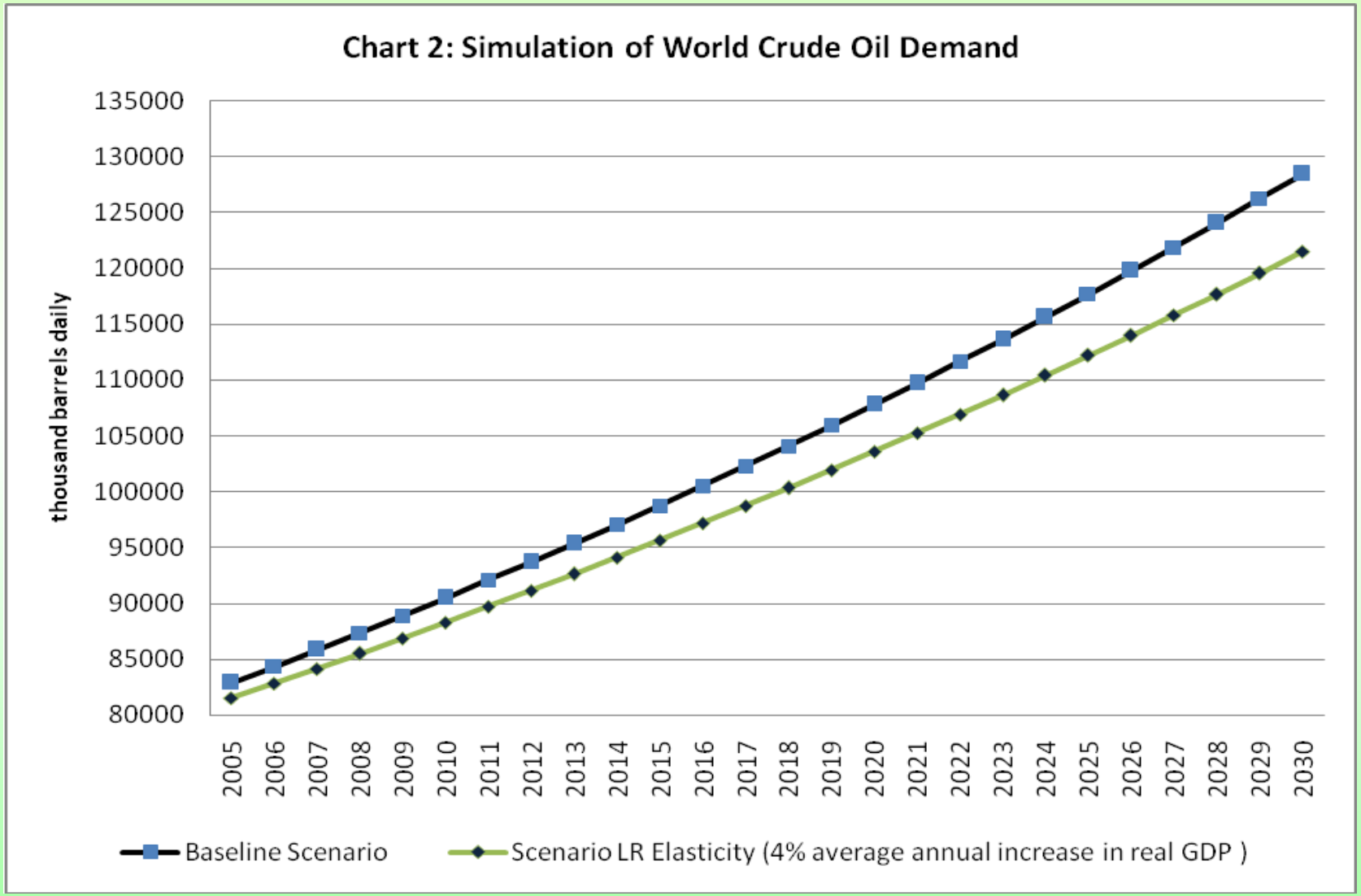
**Table 1 : Long-run price and income elasticity of demand for crude**
**(obtained through cointegration)**

| Country | Price Elasticity | Income Elasticity |
|---|---|---|
| World | -0.034 | 0. 388 |
| India | -0.028 | 1.141 |
| China | -0.063 | 0.615 |

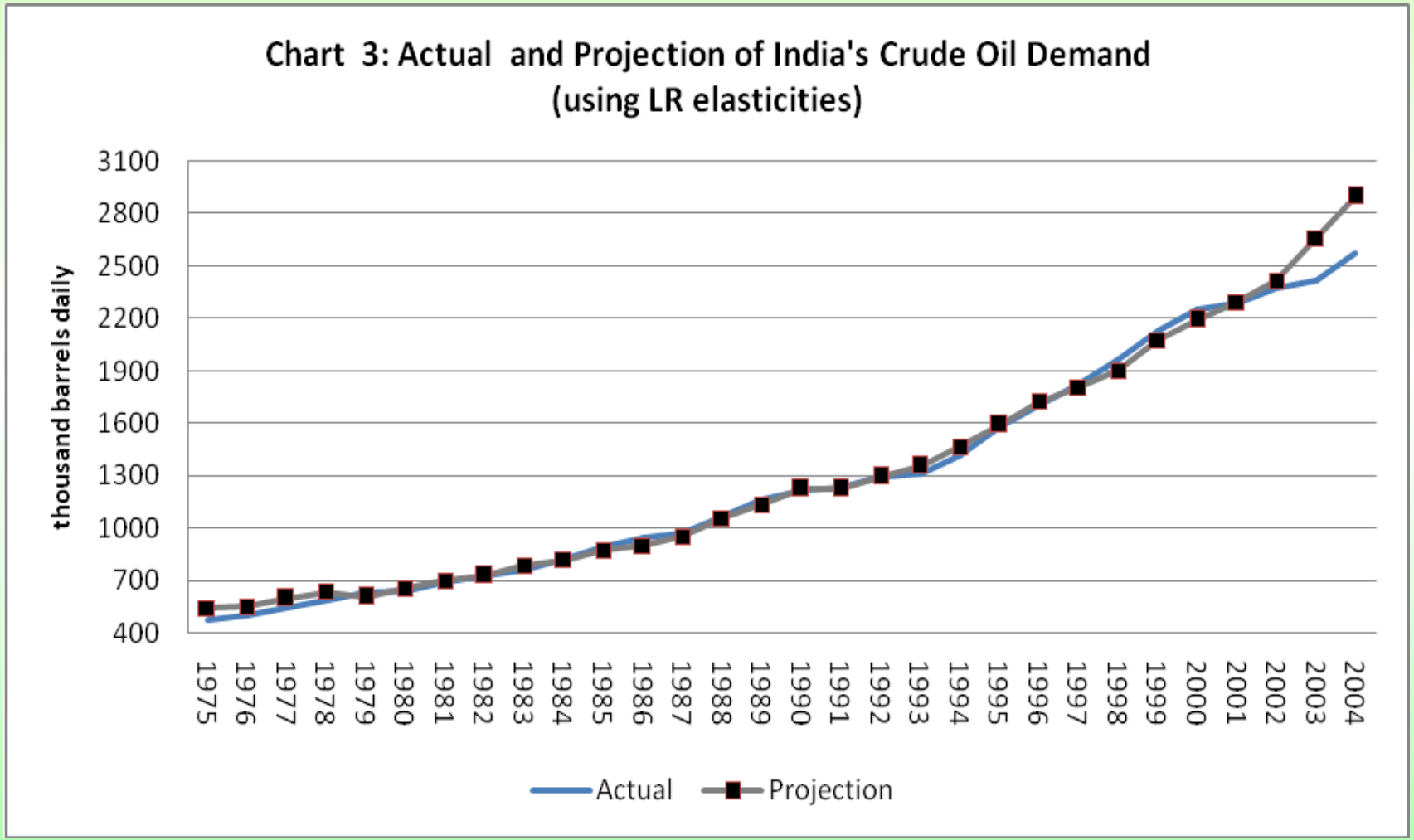
# Model properties (World Crude Demand)



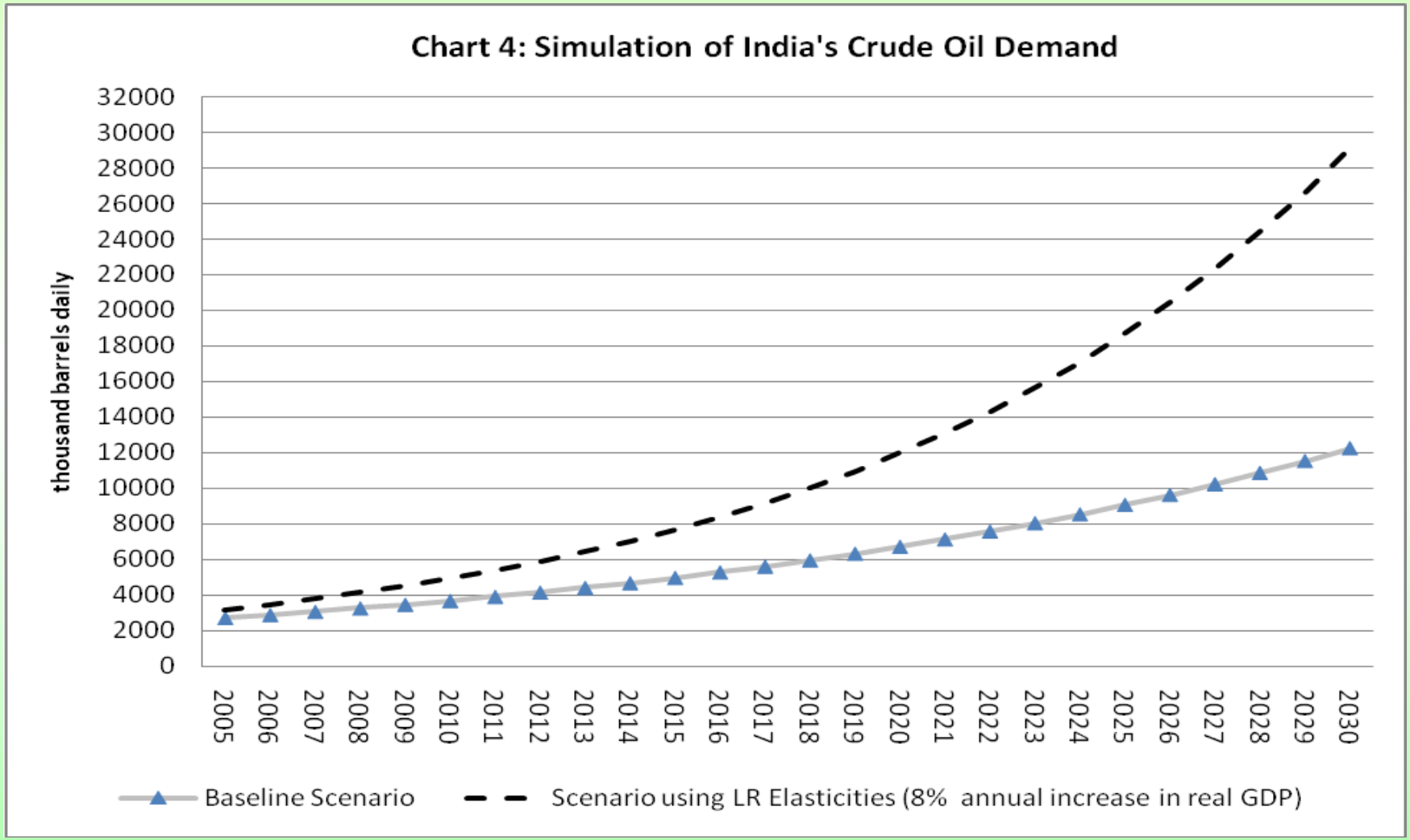
# Simulation (World Crude Demand)



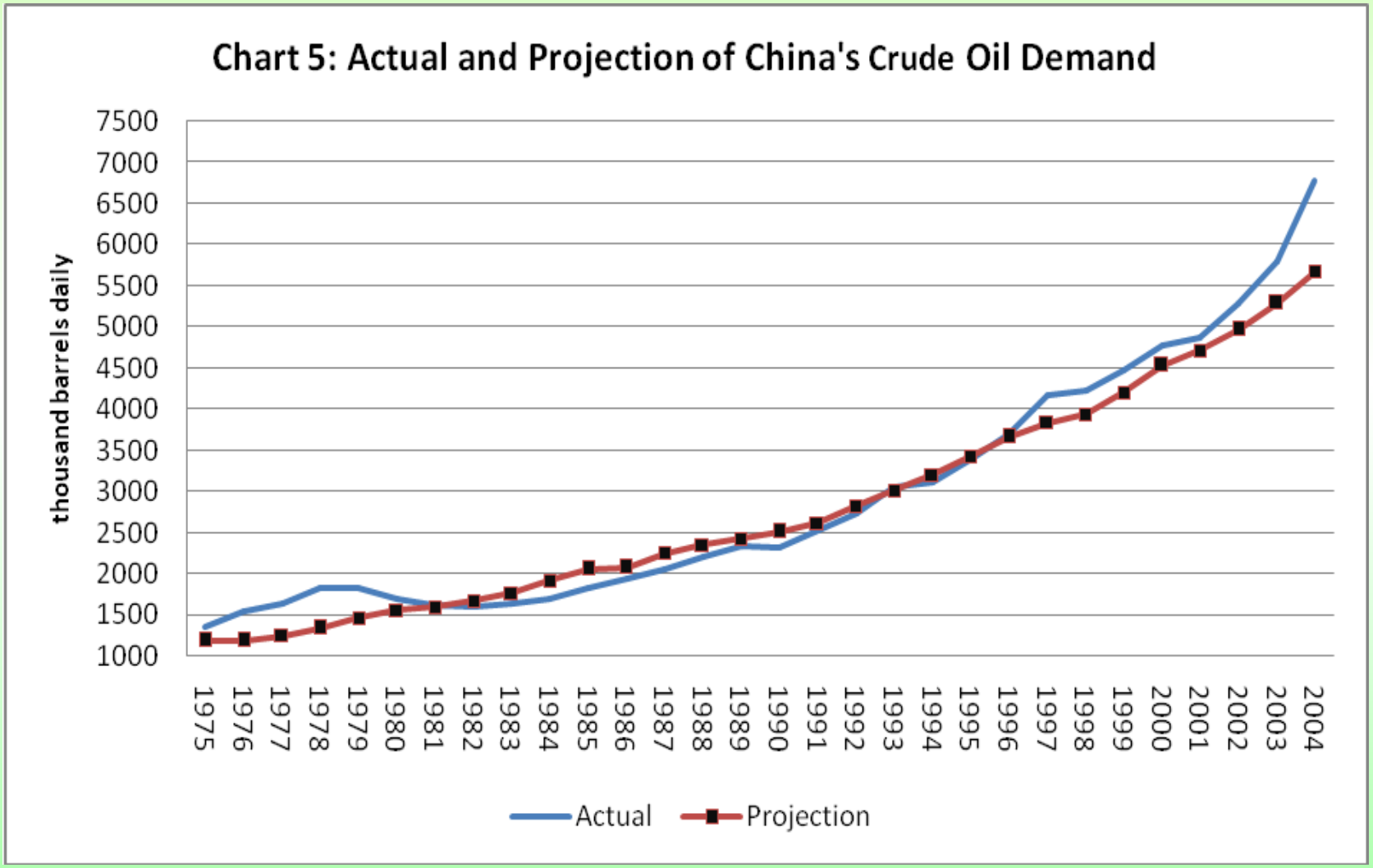
# Model properties (India's Crude Demand)



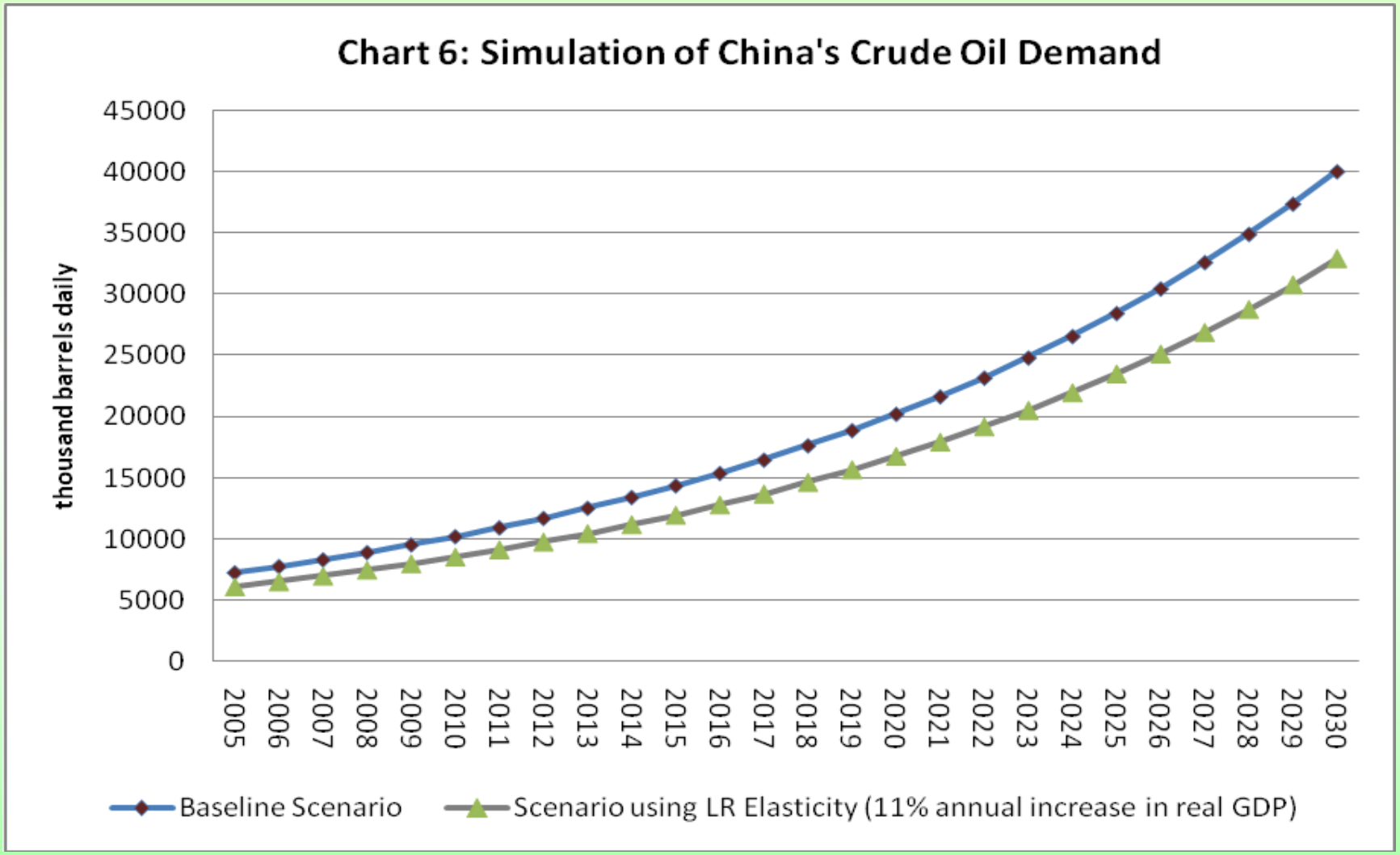
# Simulation (India's Crude Demand)



# 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 $A_2$)

| 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 |
| **Jatropha1 **** | **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

** jndicates 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 |
| **Jatropha1 **** | **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

** jndicates 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.**

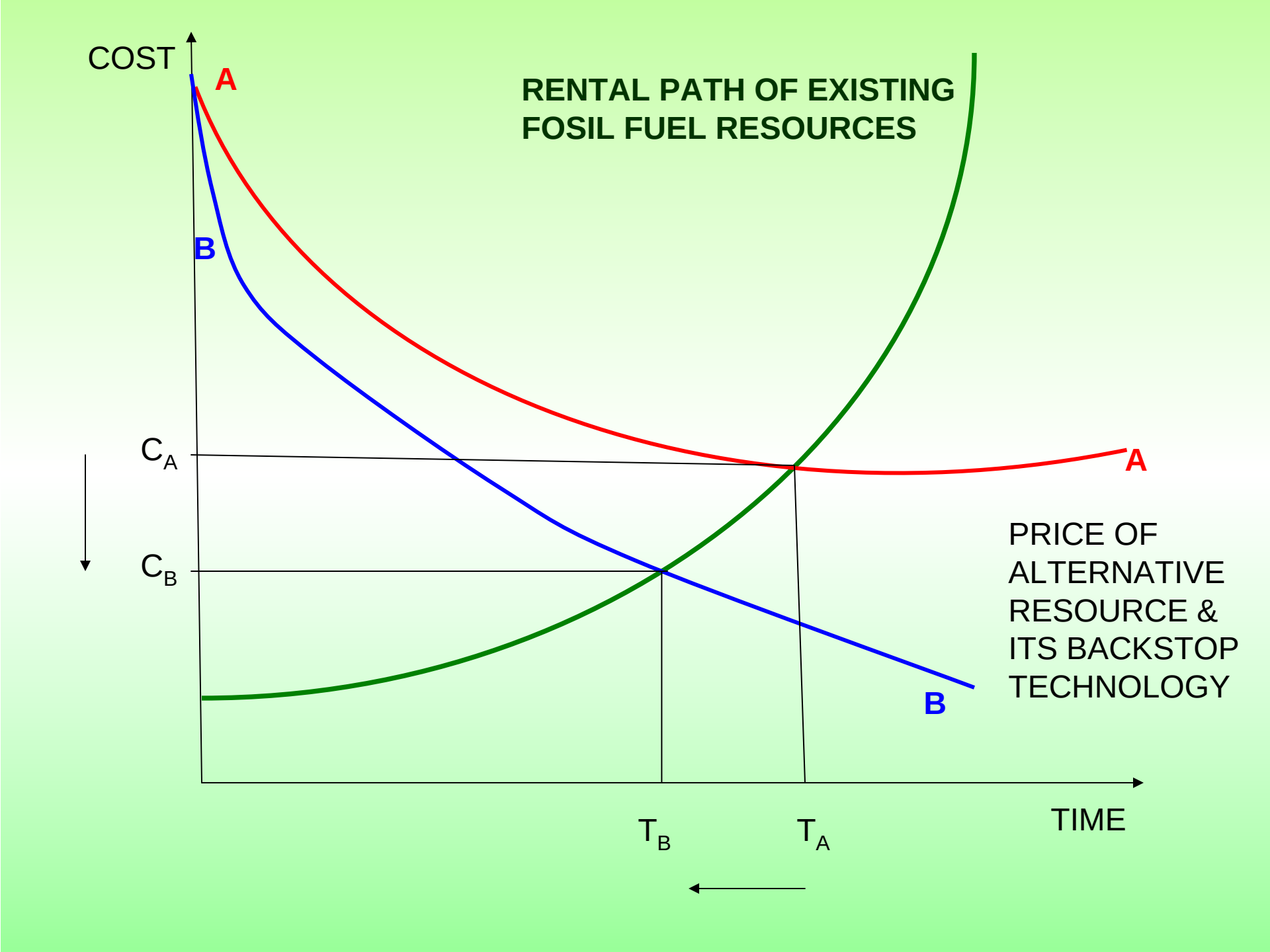
- **The initial high cost of connectivity with modern fuels being a constraint for the poor. Innovative policy initiatives like credit for such purpose is required without distorting the energy prices which is often counter-productive.**

- **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.**


COST
A
B
RENTAL PATH OF EXISTING
FOSIL FUEL RESOURCES
$C_A$
$C_B$
A
PRICE OF
ALTERNATIVE
RESOURCE &
ITS BACKSTOP
TECHNOLOGY
B
$T_B$
$T_A$
TIME

- **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