Energy intensity in India during pre-reform and reform period – An Input-Output Analysis

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Abstract

India annually consumes about three percent of the world's total energy. The country is the world's sixth largest energy consumer. Indian domestic energy resources are highly utilised and the economy is a net energy importer particularly of petroleum products.

The energy requirement of an economy is sensitive to the rate of economic growth and energy intensity of producing sectors. The energy intensity is the function of technological progress and it varies from sectors to sectors. Continued economic development and population growth are driving energy demand faster than India can produce it. India's electricity sector currently faces capacity problems, poor reliability, and frequent blackouts. Moreover, industry cites power supply as one of the biggest limitations on progress. The shortfall means the country will increasingly have to look to foreign sources of energy supplies, transported mostly via ship and pipeline. The Ministry of Power estimates that to support government targets for 8% annual GDP growth, the electric power supply will have to increase by more than 10% annually, which seems highly unlikely. Substantial foreign investment would be needed to achieve that kind of growth, and foreign investors have had substantial difficulties making projects happen in India. The India government has focussed much attention on coal as the means to generate half of its future electricity demands. Oil and natural gas have been downplayed somewhat because of uncertainty in global supply and price, and because heavier reliance on these two sources would require even greater imports. Thus it is not easy to increase the supply of energy. In this context it is important to analyse sectoral energy intensity in the Indian economy.

The present paper uses a static input output framework to estimate the intensity of energy of different sectors in Indian economy during 80's and 90's. The paper uses four consecutive input output tables (1983-84, 1989-90, 1993-94 and 1998-99) to calculate direct and total (direct + indirect) energy intensities. The basic purpose is to capture the pre reform as well as reform period performance in energy sector as Govt. of India has initiated few stalwart strategies for energy sectors in the year 1991-92 (on the eve of the reforms). The paper reports the findings and finally suggests proper policies.

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1. Introduction

The Indian economy uses a variety of energy sources, both commercial and non-commercial. Fuelwood, animal waste and agricultural residue are the traditional or `non-commercial' sources of energy that continue to meet the bulk of the rural energy requirements even today. However, the share of these fuels in the primary energy supply has declined from over 70% in the early 50's to a little over 30% as of today. The traditional fuels are gradually getting replaced by the "commercial fuels" such as coal, lignite, petroleum products, natural gas and electricity.

At the time of Independence, the country had a very poor infrastructure in terms of energy production and supply. The per capita consumption of energy was abysmally low and the access to energy was very inadequate for the common people. The economy was dependent largely on the non-commercial sources of energy for meeting the requirements of the households and on animal and human energy in case of agriculture and transport. During the 50 years that followed Independence, the demand for energy, particularly for commercial energy, registered a high rate of growth contributed largely by the changes in the demographic structure brought about through rapid urbanisation, need for socio-economic development and the need for attaining and sustaining self reliance in different sectors of the economy.

2. Energy Scenario in India

Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environmentally friendly.

India ranks sixth in the world in total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations. The country, though rich in coal and abundantly endowed with renewable energy in the form of solar, wind, hydro and bio-energy has very small hydrocarbon reserves (0.4% of the world’s reserve). India, like many other developing countries, is a net importer of energy, more than 25 percent of primary energy needs being met through imports mainly in the form of crude oil and natural gas. The rising oil import bill has been the focus of serious concerns due to the pressure it has placed on scarce foreign exchange resources and is also largely responsible for energy supply shortages. The sub-optimal

consumption of commercial energy adversely affects the productive sectors, which in turn hampers economic growth.

Coal meets approximately 63 percent of the country's total energy requirements. India now ranks 3rd amongst the coal producing countries in the world. India is currently the fourth largest oil consumer in the Asian-Pacific region after Japan, China and South Korea.

If we look at the pattern of energy production, coal and oil account for 54 percent and 34 percent respectively with natural gas, hydro and nuclear contributing to the balance. In the power generation front, nearly 62 percent of power generation is from coal fired thermal power plants and 70 percent of the coal produced every year in India has been used for thermal generation.

The distribution of primary commercial energy resources in India is quite skewed. On the consumption front, the industrial sector in India is a major energy user accounting for about 52 percent of commercial energy consumption. India annually consumes about three percent of the world's total energy. The country is the world's sixth largest energy consumer, and is in fact a net energy importer. India's year 2000 energy consumption by fuel is shown in Table 1.the production and consumption gap during 90s can also derived from table 2.

Table 1: India's Energy Consumption by Fuel (Year 2000)

Fuel	**Usage(Quads)**
Coal	6.68
Petroleum	4.12
Natural Gas	0.90
Hydroelectric	0.79
Nuclear	0.17
Non Hydro Renewables	0.01
Total	12.67

Source: DOE/EIA

Table 2: India's TPEP and TPEC, 1990-2002(in Quads)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
TPEP	6.82	7.16	7.33	7.49	8.00	9.48	8.75	9.17	9.37	9.59	9.81	10.21	10.41
TPEC	8.02	8.39	8.86	9.24	9.97	11.49	11.15	11.76	12.17	12.74	13.48	13.84	13.98

Source: DOE/EIA

Continued economic development and population growth are driving energy demand faster than India can produce it. Despite increases in energy use in India, **consumption on a per capita** basis is still one of the lowest in relation to other countries. In 2000, India's per capita consumption was 12.6 million British thermal units (Btus) against a world average of 65.4 million Btus and a U.S. average of 351 million Btus.

The **energy intensity**, which is energy consumption per unit of GDP, has increased in India since the early 1970s and it is one of the highest in comparison to other developed and developing countries.This is in sharp contrast to the developments in China and in OECD countries. For example, it is 3.7 times that of Japan, 1.55 times that of the United States, 1.47 times that of Asia and 1.5 times that of the world average. Thus, there is a huge scope for energy conservation in the country. During the pre-reform period, the commercial energy sector was totally regulated by the government. The economic reform and liberalization, in the post 90s, has gradually welcomed private sector participation in the coal, oil, gas and electricity sectors in India**.**

Expected energy demand growth poses challenges for India

By 2020, India's demand for commercial energy is expected to increase by more than 2.5 times *(IEA World Energy Outlook 2000).* Underpinning this trend will be the ongoing growth in population, urbanisation, income, industrial production and transport demand.

For India to tackle the economic and environmental challenge of its demand growth it is important to have a good understanding of how these and other factors shape energy use in the various sectors of the economy. Detailed and coherent information is needed in order to judge the potential for energy efficiency improvements or to measure the progress of already implemented policies.

Over the years, the high rate of growth of energy demand could be sustained primarily through increased dependence on commercial energy sources such as coal, oil, natural gas and electricity. However, the energy supply system that has developed over the years has tended to depend more and more on non-renewable energy resources, the availability of which is severely limited. Moreover, development of some of these energy resources is beset with serious environmental implications. To some extent, subsidised prices of certain forms of energy also led to end-use inefficiencies and, therefore, an increase in the gross energy demand. All these factors have raised questions about the long-term sustainability of such an energy supply system. Moreover, with the rapid increase in demand for petroleum products, the country has become a heavy importer of oil. The present trends indicate that in the absence of adequate measures of demand management, the

country may have to resort to import of other forms of energy as well and this has raised issues of long-term energy security of the country.

A number of studies have been so far carried out with reference to the energy sector in India and other developing and developed countries, its intensities and other aspects. Next section deals with that.

3. Literature Survey

Intensity based works have been done by Skolka (1984), Howrath, Schipper, Anderson (1993), for Austria, Wu and Chen (1989) for Taiwan and Gowdy (1992) for Australia. Wu and Chen (1989) have presented an application of hybrid-unit formulations of energy input-output analysis for energy intensity variations in Taiwan for the period 1971-84. The analytical results indicate that about 85% of the economic sectors show remarkable downward trends in total primary energy intensity implying the effectiveness of energy conservation measures. Gowdy (1992) has explained labour productivity and energy intensity in Australia during 1974-87. Results indicate a decline in productivity growth rates during 1972-82 for both energy and labour. Howrath, Schipper, Anderson (1993) have examined the trends in the structure and intensity of final energy demand in five OECD countries between 1973 to 1988 (i.e. Japan, U.S.A, Denmark, West Germany and Norway). They conclude that the changes in the structure of a nation's economy may lead to substantial changes in its Energy/GDP ratio that are unrelated to changes in the technical efficiency of energy utilization. An application to aggregate energy intensity for manufacturing in ten OECD countries is conducted by Grenning et al. (1997). They have applied six decomposition methods in their analysis. Industrial energy intensities have been examined by Freeman, Niefer, Roop (1997). They identify and discuss several issues and problems that arise in the construction of commonly used industrial energy intensity indicators. In particular they focus on issues that arise due to the use of alternative measures of output as intensity indicators. Another intensity based work has been done by Battjes, Noorman, Bicsiot (1998) by using an Input-output mode for OECD- Europe (Germany, The Netherlands, Ireland)l. The authors estimate the energy intensities of imports by means of the average energy intensities of the region in which the country is situated. Gardner and Elkhafif (1998) attempt to provide insight into the changes in industrial structure and energy intensity that occurred in Ontario between 1962 and 1992. Energy intensity and the relationship between CO_2 emission and primary energy GDP has studied by Roca and Alcantara (2001) for Spain.

Some methodological issue regarding energy intensity has been raised by Arrous (2002). He shows that integrating energetic resources into input-output analysis does not need any a priori

reformulation of this analysis. Miller and Blair consider that such integration needs using hybrid units in order to satisfy some energy conservation conditions. He shows that these conditions are specifically defined and founded on a particular case, inspired by empirical data of the U.S economy. Bernard et al. (2004) applied principal components analysis to assess the information derived from six energy intensity indicators for Quebec, Ontario, Alberta, and British Columbia from 1976 to 1996. They use two measures of total energy use (thermal and economic) and three measures of industry output (value added, value of production, and value of shipments). They have shown that the variation of the six energy intensity indicators that is accounted for by the first principal component is quite large.

As energy intensity and efficiency are quite dependent factor on each other so the present study also try to compose some literature on energy efficiency. Bossebouef and Richard (1997), Eyre (1998), Geller et al. (1998) have worked on the issue of energy efficiency. The evaluation of environmental and energy efficiency is outlined by Bosseboeuf and Richard (1997) for France during 1973 to 1993. Using over 200 explanatory energy efficiency indicators they have evaluated and characterized the sectoral trends in energy efficiency over 20 years. Eyre (1998) focuses on the effects of liberalisation on those characteristics of energy markets, which underpin the long-term energy inefficiency in U.K. The efficiency of use of electricity in Brazil is examined by Howard Geller et al. (1998). They review the efforts made for electricity conservation and DSM programmes in Brazil during 1970 - 96. They discuss in detail the status of electricity conservation measures in each sector of the economy. Finally, they try to show the main barriers inhibiting energy efficiency improvements and suggest strategies to overcome them. Haas and Schipper (1998) in their work consider irreversible efficiency improvements as a major reason for the moderate growth in energy demand after the plummeting of the oil price in 1985. They test different econometric models to take into account efficiency indicators. Sinton et al. (1998) provide a comprehensive overview of the policy measures and implementation approaches in China and identify some major challenges that need to be dealt with to maintain the extraordinary efforts to reduce energy intensity. Energy efficiency leads to consumption was derived by Greening et al (2000). The gains in the efficiency of energy consumption will result in an effective reduction in the per unit price of energy services. They concluded that the range of estimates for the size of the rebound effect is very low to moderate.

Energy intensity base literature in Indian context is very rare considering IO approach. Various authors have the studied energy intensity problem. One of the elaborate and earliest individual efforts in this regard is of Henderson (1975). Along with the wide ranging review of the energy sources he discusses the policy prospects for Fifth Five Year Plan. His findings of increasing

energy intensity in the decade of the sixties and its relation to output change and change in energy coefficient provide certain basic information on the nature of country's energy scene. The change of energy intensity in India has been explained by Bhattacharya (1998) in his recent study. He has shown two factors (a) structural change in GDP, and (b) non-structural changes such as improvement inefficiency, energy conservation etc. His study tries to show the energy conservation and its demand management of coal crude-oil and electricity. His study is based on the challenges and opportunities during the Eighth Plan. He concludes that a directional change towards a less energy intensive pattern of growth is in any case necessary. Tiwari(1999) uses an input}output framework to calculate energy intensities for different sectors in Indian economy. But his study was confined till 1989-90 as termed as pre-reforms.

Some of these studies were in relation to individual sub-sectors of energy whereas a few were in the nature of analysing the energy sector scenario in an integrated framework. The present paper places emphasis on the energy intensity in India during pre-reforms and reforms covering a period of 15 years (1983-84 to 1998-99) with proper policy suggestions. The basic purpose is to capture the pre reform as well as reform period performance in energy sector as Govt. of India has initiated few stalwart strategies for energy sectors in the year 1991-92 (on the eve of the reforms).

4. Model formulation

We start our model formulation from a static monetary input-output model. Mathematically, the structure of the input-output model can be expressed as:

$X = Ax + Y$ ……. (1)

The solution of (1) gives

$X = (I - A)^{-1} Y$ ……. (2)

Where $(I - A)^{-1}$ is the matrix of total input requirements .For an energy input-output model, the monetary flows in the energy rows in equation (2) are replaced with the physical flows of energy to construct the energy flows accounting identity, which conforms to the energy balance condition (Miller & Blair 1985). We apply a “hybrid method” based on Miller & Blair (1985), and it always conforms to energy conservation conditions.

Therefore, in equation (2), X is a hybrid unit total output vector (nx1) in which the outputs of energy sectors are measured in million tonnes of coal replacement (MTOE), while the outputs of other sectors are measured in million rupees (M.RS). Y is a hybrid unit final demand vector (nx1), in which the final demands for different types of energy are measured in MTOE, while the final demands for the outputs of other sectors are measured in M.RS. A is a hybrid unit technical

coefficient matrix (nxn), in which the unit of the input coefficients of energy sectors from energy sectors is mtoe /mtoe; the unit of the input coefficients of energy sector from non energy sectors is M.RS/ mtoe, the unit of the input coefficients of non energy sectors from energy sectors is mtoe /M.RS; and the unit of the input coefficients of non-energy sectors from non-energy sectors is M.RS/M.RS. I is an identity matrix (nxn).

Energy model

The basic balance equation of an energy I-O model can be expressed as

$F_k = \sum_j F_{kj} + F_{kd} = \sum_j e_{kj} X_j + F_{kd}$ ---------- (3)

Where F_k is the total energy use by fuel type, F_{kj} the total energy use by fuel type k in sector j, F_{kd} the total energy use by fuel type k in the final demand sector, e_{kj} the direct energy input coefficient of sector j by fuel type k and X_j the gross output of sector j.

Rewriting equation (3) in matrix form and substituting equation (2) into equation (3) yields:

$F = EX + F = E(I-A)^{-1} Y + F = RY + F$ ---------- (4)

Where R is total energy input coefficient matrix. The elements of R represent direct and indirect effects caused by changing one unit of final demand.

5. Data modification

The basis of the data of this study are the four Input-Output tables of the Indian economy for the years 1983-84,1989-90,1993-94 and 1998-99 prepared by CSO(1985, 1995,2000, 2004 unpublished). Input-Output tables are Commodity by Commodity tables consisting of 60 x 60 sectors. These have been aggregated to 47 sectors on the basis of the nature of commodities. Here we have considered three energy sectors coal, crude oil &natural gas and electricity separately and other 57 non energy sectors have been aggregated to 44 non-energy sectors.

The fuel rows are converted into physical units using the methodology discussed above. We convert the monetary units of energy sectors into physical unit from the energy data published by CMIE report. Three energy sectors like coal as million tonnes, crude petroleum in million tonnes, natural gas in million cubic meter and electricity in T.W.H have been converted into one common unit which is million tonnes oil equivalent or mtoe. For better presentation of results this mtoe unit has been transformed to Thousand tons of oil equivalent (**thoutoe**).

6. Empirical Results

The energy intensity has been defined as the energy consumption in mtoe (later converted to thoutoe) per million rupees of output (indirect case) and mtoe per MRs. of final demand (in total case) for sectors other than fuel sectors. The direct energy coefficient is obtained from transformed technical coefficient matrix. The fuel rows directly give the fuel consumed per unit of output. However, considerable insights can be gained by tracing fuel rows across sectors through the elements of R matrix. For example, for construction activities along with fuel inputs, various other inputs like cement, iron and steel, coal tar, etc. are required which in turn require certain other inputs for their manufacture along with fuel inputs. These fuel inputs consumed by raw materials that go into construction activity act as indirect input to construction activity.

The fuel rows of R matrix give the total direct and indirect fuel flowing into different activities. This direct and indirect fuel inputs per unit output of different sectors termed as total energy intensities or direct and indirect energy intensities emphasize that the associated energy consumption are essential part of that sector's activity and need to be considered as an integral part of operating that activity.

The total and direct energy intensities for different fuels for the 47 sectors as indicated by fuel rows of 1983-84,1989-90,1993-94 and 1998-99 R matrix are listed in Appendix A.The top ten sectors performance in case of three energy sectors is explained below.

The present study shows that direct coal intensity reduced sharply for the sectors like coal tar products(.798 in 1983-84 to .113 in 1998-99), fertilizer (.050 in 1983-84 to .016 in 1998-99) and non metallic mineral products and increased for the sectors like Iron and steel(.048 in 1983-84 to .584 in 1998-99), cement and non ferrous basic metal. On the other hand a paper product fluctuates through out the study period.

Table 1A: COAL

Top 10 sectors from **direct coal intensity**(thousand ton oil equivalent/mrs)					
		1983-84			**1989-90**
1	Coal tar products	0.798	1	Coal tar products	0.513
2	Cement	0.133	2	Cement	0.158
3	non-metallic mineral products	0.069	3	Iron and steel	0.076
4	Fertilizers	0.050	4	non-metallic mineral products	0.046
5	Iron and steel	0.048	5	Inorganic heavy chemicals	0.030
6	Railway transport services	0.027	6	Organic heavy chemicals	0.026
7	Paper, printing & publishing	0.026	7	Paper, printing & publishing	0.023
8	Beverages	0.014	8	Beverages	0.020
9	Cotton textiles	0.012	9	Fertilizers	0.018

10	Miscellaneous manufacturing	0.008	10	Non-ferrous basic metals	0.017

Top 10 sectors from **direct coal intensity**(thousand ton oil equivalent/mrs)					
		1993-94			**1998-99**
1	Coal tar products	0.291	1	Iron and steel	0.584
2	Cement	0.136	2	Cement	0.563
3	Iron and steel	0.061	3	Non-ferrous basic metals	0.184
4	Inorganic heavy chemicals	0.050	4	Coal tar products	0.113
5	non-metallic mineral products	0.046	5	Paper, printing & publishing	0.017
6	Railway transport services	0.038	6	Fertilizers	0.016
7	Paper, printing & publishing	0.037	7	Inorganic heavy chemicals	0.013
8	Organic heavy chemicals	0.021	8	Organic heavy chemicals	0.005
9	Non-ferrous basic metals	0.019	9	Miscellaneous metal products	0.005
10	Fertilizers	0.017	10	Other Machinery	0.005

Like direct coal intensity the total intensity of coal tar products also reduced abnormally i.e. from .926(1983-84) to .126(1998-99). Coal products basically coal intensive because it is manufactured by distillation of coal. Performance of cement is also mentionable because the intensity declined from .181 in 1983-84 to .070 in 1998-99(though a slight increment has been observed during 1983-89. on the other hand iron and steel industry and railway transport services on an average increased from 1983-84 to 1998-99. Other mentionable sectors like other machinery, electrical and electronic appliances, industrial machinery and other transport services gained its position within top 10 sectors in this regard during 1998-99. So these sectors are becoming more coal intensive than previous years. Another most important sector is fertilizer which has reduced its total coal intensity quite sharply after 1990s.

Table 1B: COAL

Top 10 sectors from **total coal intensity**(thousand ton oil equivalent/mrs)					
		1983-84			**1989-90**
1	Coal tar products	0.926	1	Coal tar products	0.576
2	Cement	0.181	2	Cement	0.222
3	Fertilizers	0.126	3	Iron and steel	0.181
4	Iron and steel	0.124	4	Non-ferrous basic metals	0.107
5	Inorganic heavy chemicals	0.114	5	Inorganic heavy chemicals	0.107
6	non-metallic mineral products	0.108	6	non-metallic mineral products	0.095
7	Storage & warehousing	0.085	7	Organic heavy chemicals	0.091
8	Gas and Water	0.078	8	Miscellaneous metal products	0.090
9	Paper, printing & publishing	0.062	9	Fertilizers	0.078
10	Non-ferrous basic metals	0.061	10	Paper, printing & publishing	0.071

Top 10 sectors from **total coal intensity**(thousand ton oil equivalent/mrs)					
		1993-94			**1998-99**
1	Coal tar products	0.319	1	Other Machinery	0.343
2	Cement	0.175	2	Iron & steel	0.157
3	Iron and steel	0.134	3	Railway transport services	0.132
4	Inorganic heavy chemicals	0.087	4	Coal tar products	0.126
5	Paper, printing & publishing	0.074	5	Miscellaneous manufacturing	0.112
6	Non-ferrous basic metals	0.074	6	Non-ferrous basic metals	0.090
7	Clay and non-metallic mineral products	0.072	7	Electrical and Electronic appliance	0.087
8	Miscellaneous metal products	0.065	8	Cement	0.070
9	Organic heavy chemicals	0.062	9	Industrial machinery(F & T)	0.065
10	Railway transport services	0.060	10	Other transport services	0.054

Table 2A: CRUDEOIL AND NATURAL GAS

Top 10 sectors from **direct Crude Oil and natural gas intensity**(thousand ton oil equivalent /mrs)					
		1983-84			**1989-90**
1	Petroleum products	0.5352	1	Petroleum products	0.4007
2	Fertilizers	0.0207	2	gas &water	0.1301
3	non-metallic mineral products	0.0005	3	Fertilizers	0.0810
4	Non-ferrous basic metals	0.0003	4	Coal tar products	0.0312
5	Iron and steel	0.0002	5	Organic heavy chemicals	0.0105
6	Industrial machinery(F & T)	0.0001	6	Inorganic heavy chemicals	0.0080
7	Inorganic heavy chemicals	0.0001	7	Other chemicals	0.0066
8	Other chemicals	0.0001	8	Misc. Services	0.0027
9	Food and food products	0.0001	9	Iron and steel	0.0008
10	Beverages	0.0001	10	Food and food products	0.0007

Top 10 sectors from **direct Crude Oil and natural gas intensity**(thousand ton oil equivalent/ mrs)					
		1993-94			**1998-99**
1	Petroleum products	0.559	1	Petroleum products	0.200
2	Coal tar products	0.138	2	Fertilizers	0.065
3	Fertilizers	0.091	3	Miscellaneous manufacturing	0.005
4	Organic heavy chemicals	0.021	4	Paints, varnishes and lacquers	0.004
5	Inorganic heavy chemicals	0.014	5	Other chemicals	0.003
6	Paints, varnishes and lacquers	0.012	6	Plastic products	0.003
7	Other chemicals	0.011	7	Rubber products	0.003
8	Miscellaneous manufacturing	0.006	8	Industrial machinery(F & T)	0.002
9	Plastic products	0.005	9	Non-ferrous basic metals	0.002
10	Rubber products	0.005	10	Electrical and electronic mach	0.002

Direct crude oil intensity in Petroleum product sector is always top in ranking, though its share declined gradually from 1983-84 to 1998-99. Another important sector in this respect is fertilizer which fluctuates throughout the study period. Rank of Inorganic heavy chemicals is also declined to 15th. Iron and steel

sector was crude oil intensive during 80s but its share gradually reduced after 90s. Other most important sectors dominate during 90s are plastic and rubber products, paints and varnishes, other chemicals.

Table 2B

Top 10 sectors from **total Crude Oil and natural gas intensity**(thousand ton oil equivalent / mrs					
		1983-84			**1989-90**
1	Petroleum products	**0.592**	1	Petroleum products	0.412
2	Fertilizers	**0.156**	2	gas &water	0.159
3	Organic heavy chemicals	**0.096**	3	Fertilizers	0.125
4	Other transport services	**0.066**	4	Coal tar products	0.055
5	Coal tar products	**0.049**	5	Other transport services	0.051
6	Storage & warehousing	**0.046**	6	non-metallic mineral prod	0.046
7	Clay and non-metallic mineral products	**0.045**	7	Organic heavy chemicals	0.043
8	Metallic and non-metallic minerals	**0.044**	8	Metallic and non-metallic minerals	0.039
9	Non-ferrous basic metals	**0.043**	9	Inorganic heavy chemicals	0.039
10	Inorganic heavy chemicals	**0.042**	10	Non-ferrous basic metals	0.033

Top 10 sectors from **total Crude Oil and natural gas intensity**(thousand ton oil equivalent /mr					
		1993-94			**1998-99**
1	Petroleum products	0.577	1	Petroleum products	0.205
2	Coal tar products	0.162	2	Other transport services	0.126
3	Fertilizers	0.130	3	Fertilizers	0.085
4	Other transport services	0.072	4	Other Machinery	0.075
5	Organic heavy chemicals	0.054	5	Railway transport services	0.045
6	Paints, varnishes and lacquers	0.043	6	Miscellaneous manufacturing	0.031
7	Inorganic heavy chemicals	0.043	7	Electrical and Electronic app	0.025
8	Clay and non-metallic mineral products	0.039	8	Non-ferrous basic metals	0.021
9	Other chemicals	0.037	9	Iron & steel	0.021
10	Iron and steel	0.034	10	Industrial machinery(F & T)	0.019

But the total intensity figures for crude-oil sector also reveals almost same. The petroleum products ranked first throughout but share declines. Similarly coal tar products performance also had fallen after 93-94. Fertilizer though kept its performance but little bit reduced. Other transport services increased its share gradually. Railway transport services, other machinery and miscellaneous manufacturing also deserved mentionable during 1998-99.

Table 3A: Electricity

Top 10 sectors from **direct electricity intensity**(thousand ton oil equivalent / mrs)					
		1983-84			**1989-90**
1	Gas and Water	**0.010**	1	Cement	0.007
2	Inorganic heavy chemicals	**0.008**	2	Non-ferrous basic metals	0.006
3	Fertilizers	**0.006**	3	Inorganic heavy chemicals	0.006
4	Non-ferrous basic metals	**0.006**	4	Storage & warehousing	0.006
5	Cement	**0.005**	5	gas &water	0.005
6	Storage &warehousing	**0.005**	6	Organic heavy chemicals	0.005
7	Metallic and non-metallic minerals	**0.004**	7	Metallic and non-metallic minerals	0.005
8	Wool, Silk & Synthetic fibre textiles	**0.003**	8	Jute, hemp, mesta textiles	0.004
9	Coal tar products	**0.003**	9	Iron and steel	0.003
10	Iron and steel	**0.002**	10	Fertilizers	0.003

During 1980s the sectors like inorganic heavy chemical, cement, gas and water supply, metallic and non metallic mineral, storage and ware housing, non ferrous basic metals are mostly direct electricity intensive. Apart from these sectors railway transport services, other transport services, other machinery cotton textile specially iron and steel gained its share during 90s.

Top 10 sectors from **direct electricity intensity**(thousand ton oil equivalent / mrs)					
		1993-94			**1998-99**
1	Cement	0.004	1	Railway transport services	0.017
2	Storage & warehousing	0.004	2	Other transport services	0.004
3	Organic heavy chemicals	0.003	3	Storage &warehousing	0.004
4	Non-ferrous basic metals	0.003	4	Other Machinery	0.003
5	Paints, varnishes and lacquers	0.003	5	Non-ferrous basic metals	0.003
6	Other transport services	0.002	6	Cotton textiles	0.002
7	Jute, hemp, mesta textiles	0.002	7	Iron and steel	0.002
8	Inorganic heavy chemicals	0.002	8	Fertilizers	0.001
9	gas &water	0.002	9	Miscellaneous manufacturing	0.001
10	Cotton textiles	0.002	10	Jute, hemp, mesta textiles	0.001

Table 3B

Top 10 sectors from **total electricity intensity**(thousand ton oil equivalent / mrs)					
		1983-84			**1989-90**
1	Gas and Water	0.016	1	Non-ferrous basic metals	0.0136
2	Inorganic heavy chemicals	0.016	2	Inorganic heavy chemicals	0.0122
3	Fertilizers	0.013	3	Cement	0.0112
4	Storage & warehousing	0.013	4	Organic heavy chemicals	0.0102
5	Non-ferrous basic metals	0.011	5	gas &water	0.0087
6	Coal tar products	0.009	6	Fertilizers	0.0086
7	Cement	0.009	7	Iron and steel	0.0085
8	Metallic and non-metallic minerals	0.007	8	Storage & warehousing	0.0082
9	Wool, Silk & Synthetic fibre textiles	0.006	9	Metallic and non-metallic miner	0.0072
10	Iron and steel	0.006	10	Jute, hemp, mesta textiles	0.0071

Top 10 sectors from **total electricity intensity**(thousand ton oil equivalent / mrs)					
		1993-94			**1998-99**
1	Cement	0.0079	1	Railway transport services	0.026
2	Non-ferrous basic metals	0.0074	2	Other Machinery	0.022
3	Organic heavy chemicals	0.0069	3	Miscellaneous manufacturing	0.010
4	Storage & warehousing	0.0061	4	Other transport services	0.009
5	Paints, varnishes and lacquers	0.0060	5	Non-ferrous basic metals	0.008
6	Iron and steel	0.0053	6	Electrical and Electronic appliance	0.007
7	Inorganic heavy chemicals	0.0052	7	Storage & warehousing	0.006
8	Jute, hemp, mesta textiles	0.0050	8	Iron & steel	0.006
9	Other chemicals	0.0048	9	Industrial machinery(F & T)	0.005
10	Paper, printing & publishing	0.0047	10	Fertilizers	0.004

The most important point to note from the study that cement sector is becoming less electricity intensive after 1993-94. Iron and steel performance is almost same throughout. But railway transport services, other transport services, miscellaneous manufacturing and electrical and electronic appliances rather gained in this respect.

On the whole the study reveals that on an average the energy intensity of the Indian economy is declining though few sectors are getting more energy intensive after 90s. The manufacturing sector is the largest consumer of commercial energy in India. In producing about a fifth of India's GDP, this sector consumes about half the commercial energy available in the country. The most energy-intensive industries- iron and steel, cement, pulp and paper, fertilizers, and textiles - that account for over 52 per cent of the total energy consumed by the country.

For iron and steel nearly 37 per cent of Indian steel is produced by the technically outmoded open-hearth furnace, which is no longer used in industrialized countries. Even in plants where the basic oxygen process is used, plant efficiencies are relatively low. Higher efficiencies also possible through improvements in the quality of coking coal. But after 90s the situation is changed, now a days the steel industries are using efficient coal and production technology has also been improved and far efficient than 80s as it is reflected from the present study. Energy efficiency improvements of 20 to 30 per cent for fuel use and 12.5 to 22 per cent for electricity use are expected by 2025 in India.

Another energy intensive sector is cement. Specific energy intensities for cement produced in India are 261 kg coal/tonne, and 406 kg coal/tonne for the dry and wet processes respectively. The dry process is more energy-efficient and a shift to this process would be profitable hence total energy demand, and further pollution, could be reduced drastically. Opting for the best available technology would lead to a reduction of around 12.0 tonnes of coal consumed per tonne of cement produced i.e. from 48 to 36 tonnes. This defines savings in terms of both coal requirements and pollutant emissions. Significant energy savings are made possible in the manufacture of cement in India after 90s. technological innovations such as pre-calcination systems and suspension pre-heaters has been incorporated in the dry process which is currently used for the manufacture of over 64 per cent of the total cement production of India.

The installed capacity for paper production in India is 2.7 mt and is expected to rise to 4.25 mt by the turn of the century. In India, the energy efficiency of a typical large mill is much lower than that of its counterpart in an industrialized country. Even a relatively modern mill in India consumes 70 per cent more heat and 7 per cent more electrical energy to produce a tonne of paper than does a typical Scandinavian mill, for instance. Further, the Indian mill is likely to purchase

more fuel and power since the co-generation potential of Indian units has not yet been exploited. As this industry will continue to grow, driven by increasing literacy and the demand of the packaging industry, energy intensity is likely to decline

Chemical fertilizers have recorded a phenomenal increase in the last decades in India, and this growth might continue, driven by the demand for food grains. However, the efficiency of fertilizer use has also been improved. Gas-based fertilizer plants are more energy-efficient than those based on naptha or fuel oil, and India is increasingly shifting to the natural gas option. It is estimated that energy efficiency per tonne of fertilizer produced could easily be raised by 20 per cent.

As govt of India already taken efficiency measures for energy intensive sectors which is clearly reflected from our study. Improvements in coal consumption rates would also reduce pollution. Further process improvements and a sectoral shift, i.e. from energy-intensive production to services, would have a bearing on the fuel mix and hence the energy consumption levels in the country. What becomes apparent is that energy-efficiency improvements are of great importance, although other improvements will be needed as well.

Table 4: Energy Intensity

	DIRECT				TOTAL			
	1983-84	1989-90	1993-94	1998-99	1983-84	1989-90	1993-94	1998-99
Coal	5.97	10.86	7.33	2.76	20.89	30.86	26.26	41.16
Crude oil &n. gas	0.18	1.12	2.87	1.71	11.24	11.49	16.01	10.56
Electricity	254.82	212.25	224.07	261.24	382.06	315.28	329.36	425.56

In this paper we have looked at the sectoral energy intensity of the Indian economy since 1983-84. The most important point to reveal that energy intensity really reduced for some traditional energy intensive sectors but on the other hand some new sectors also entered in the economy. On an average the direct intensity of coal has been reduced during 1983-98 but the total intensity for the same increased (table 4). Tendency of oil intensity is on the whole fluctuating but if we estimate the 15 years performance then the rise and decline is very marginal in case of direct and total respectively. Though the direct intensity of the electricity sector has increased a little bit but the abnormal increment has been observed in case of total intensity. This analysis stresses that indirect energy consumption is very important and should be seen as a fundamental part of the activity.

7. Conclusion and policy

In this paper we calculate direct and total energy intensities for the year 1983-1984, 1989-1990, 1993-94 and 1998-99 using Input-output transaction tables.

Our results on direct energy intensities indicate that coal tar activity has highest energy intensity primarily because of input use of coal in coal tar manufacturing. Next most coal intensive sector is cement with direct coal intensity of .0584 thoutoe/mrs of output in 1998-99 as compared to .133 thoutoe/mrs in 1983-1984. Non-metallic mineral products, which include refractories, glass, bricks, concrete products, etc., follow cement with coal intensity of .069 thoutoe/mrs in 1983-84 as well as .004 thoutoe/mrs in 1998-99.

We estimate direct and indirect coal intensity of various sectors, coal intensity of coal tar and cement both has reduced Cement is followed by iron and steel.

The total oil intensity is highest for other transport services. Similarly, electricity intensities also increase when indirect electricity consumption is accounted for. Nonferrous metals have the highest direct electricity intensity followed by wool, silk and synthetic textiles and other metallic minerals. However, when total electricity intensities are considered, the electricity intensity of non-ferrous metals shared high which is followed by wool, silk and synthetic textiles.

These sectoral rankings and changes in their ranks over time indicate that there have been some changes in energy consumption of these sectors. There may be other factors like lower capacity utilization, fuel switching, etc., which also affect the ranking. Though there have been considerable improvements in energy intensities of different sectors, it would still have to be reduced further by changing technologies and improvement in end-use efficiencies. The sectors, which have become coal intensive during 1983-84, are paper and paper products, non-ferrous metals, and wool, silk synthetic textiles. While coal intensity in cement, iron and steel, non-metallic mineral products and fertilizers have improved. The oil intensity has worsened in coal tar products; jute, hemp, mesta; wool, silk, synthetic textiles; non-metallic mineral products; leather and leather products etc. Non-ferrous metals; wool, silk, synthetic textiles; coal tar products; have become more electricity intensive while cement, fertilizer, iron and steel, etc. have reduced electricity intensity. This is an important result and points to an important policy conclusion. Nonmetallic mineral products are largely an informal sector which includes brick manufacturing, refractories, cement products, glass, etc. Traditional methods used by this sector are energy intensive and definitely have a scope for improvement. Agriculture has become energy intensive. Textiles is another sector which is both formal and informal and has become energy intensive. Paper and paper products require enhanced initiative on energy efficiency like fertilizer and cement sectors, which have improved their energy efficiency. This analysis would help us to get a

clear picture of energy consumption pattern in Indian economy and enables to derive proper policies for further improvements in this sector. Here we can mention some relevant policies in this respect.

Energy Policies are mainly based on conservation. Energy conservation has received attention in India since the mid 70s. The impact of energy conservation efforts are felt at a very low pace as the commercial energy consumption per capita is low in the country and efficient end use devices are costly. Recent rapid increase in energy demand, mainly in the industrial and the service sectors has created a renewed awareness about the economic advantage of energy conservation.

Structural changes in the economy has led to expansion of the industrial base in the country, and subsequently the increase in demand for energy. Electricity generation sector has not expanded at a desirable level. This has also supported a renewed effort on energy conservation.

The energy conservation efforts in India have to be viewed in terms of coal and lignite being the long term sustainable local energy resources. Small resources of petroleum and natural gas will be exhausted shortly and in the medium and long term the import of oil will increase.

We have to encourage those industries, which are using more **energy efficient technologies** and introduce new technology at a more rapid rate than in the past. This is only possible by the proper enhancement of expenditure on **Research and Development** projects.
We have to ensure **efficiency in the use of energy** in all production processes extensively. For instance, since India has vast reserves of coal, it is the primary fuel in the industrial sector and therefore it makes sense to use them in cost effective manner, rather than continue their pattern of current use. India has always relied heavily on coal for generating electricity with a conversion efficiency of 23% on an average (Mongia et al 1994). Coal use for electricity generation and consequent carbon emissions could be lowered by about 30% with modernization of existing coal-based power plants. From efficient point of view it is also necessary to shift away from the use of coal and oil towards natural gas and renewable energy sources.
A proper weightage should be given to review the use of all energy intensive materials and provide for substitution of less energy intensive materials. And there is a need to support basic R&D in the energy sector for speedy assimilation of technology.

India follows an energy policy which is divided into short term, medium term and long term measures. These can be summarised as follows:

Short term

- initiate measures for reducing technical losses in production, transportation and end-use of all forms of energy.
- initiate action to reduce the energy intensity of the different consuming sectors of the economy and promote conservation and demand management through appropriate organisational and fiscal measures.
- maximise satisfaction of demand for energy from indigenous resources.

Medium term

- initiate steps towards progressive substitution of petroleum products by coal, lignite, natural gas and electricity so as to restrict the quantum of oil imports to the 1991 level.
- initiate action for accelerated development of all renewable energy resources, especially the available hydro-electric potential.
- initiate appropriate organisational changes in the case of different energy sub-sectors consistent with the overall energy strategy.

Long term

- promote an energy supply system based largely on renewable sources of energy
- promote technologies of production, transportation and end-use of energy that are environmentally benign and cost effective.

These policies are formulated on the basis of the performance of the sectoral energy intensities in India from 1980s. Most important concern is oil price hike. Though after 70s the hike of oil prices happened frequently but the severe hike again occurred in 2004 after 90s. As we have noticed from our study that till 1998-99 the sectoral oil intensity dominates to a large extent. It also implied that the alternative technology has not yet been captured the Indian market upto required level. One of the basic reasons behind these oil price hikes is oil dependence economy. The first and foremost strategies should be to introduce alternative fuel like CN.G, Natural gas and bio gas fuel instead of oil to cover up the extra strain arising due to hike.

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Appendix

Direct and total sectoral energy intensities for 1983-1984

		direct /coal	Total/coal	direct /cr.oil	Total/cr.oil	Direct/ele	Total/elec
1	Agricultural crops	0.000466	0.007913	0.000000	0.010015	0.000297	0.000990
2	Animal husbandry	0.000000	0.004499	0.000000	0.005129	0.000000	0.000522
3	Forestry and logging	0.000000	0.003024	0.000000	0.007690	0.000024	0.000309
4	Fishing	0.000000	0.001421	0.000000	0.005805	0.000000	0.000144
5	Metallic and non-metallic mineral	0.000664	0.034915	0.000000	0.044168	0.004211	0.006650
6	Food and food products	0.005605	0.019275	0.000117	0.015207	0.000418	0.001786
7	Beverages	0.014946	0.043199	0.000065	0.022491	0.000451	0.002515
8	Tobacco products	0.002666	0.010777	0.000000	0.007522	0.000112	0.000858
9	Cotton textiles	0.012447	0.039128	0.000000	0.019605	0.002003	0.004474
10	Wool, Silk & Synthetic fibre text	0.004657	0.039067	0.000009	0.017076	0.002938	0.006374
11	Jute, hemp, mesta textiles	0.007847	0.032750	0.000000	0.023292	0.001613	0.003945
12	Miscellaneous textile products	0.004999	0.024472	0.000002	0.013142	0.000751	0.002850
13	Wood and wood products	0.001098	0.006048	0.000002	0.006341	0.000244	0.000677
14	Paper, printing & publishing	0.026129	0.062093	0.000022	0.017065	0.001815	0.004833
15	Leather and leather products	0.001893	0.013828	0.000000	0.012357	0.000311	0.001547
16	Rubber products	0.003257	0.022356	0.000000	0.020204	0.000454	0.002474
17	Plastic products	0.000887	0.028601	0.000000	0.024466	0.001763	0.004455
18	Petroleum products	0.000024	0.007716	0.535215	0.592159	0.000219	0.000946
19	Coal tar products	0.798515	0.926988	0.000000	0.049616	0.002834	0.009414
20	Inorganic heavy chemicals	0.007484	0.114109	0.000126	0.042951	0.008041	0.015537
21	Organic heavy chemicals	0.004789	0.028822	0.000000	0.096145	0.001894	0.004122
22	Fertilizers	0.050407	0.126974	0.020701	0.156950	0.006208	0.013434
23	Paints, varnishes and lacquers	0.004394	0.032968	0.000014	0.033506	0.001037	0.003871
24	Other chemicals	0.005956	0.031414	0.000119	0.027596	0.000914	0.003449
25	Cement	0.133494	0.181385	0.000000	0.022227	0.005093	0.008772
26	Non-metallic mineral products	0.069467	0.108378	0.000548	0.045874	0.001213	0.003721
27	Iron and steel	0.048443	0.124306	0.000166	0.030159	0.002116	0.006137
28	Non-ferrous basic metals	0.006729	0.061002	0.000328	0.043864	0.005680	0.010763
29	Miscellaneous metal products	0.006563	0.046126	0.000003	0.015980	0.001032	0.003624
30	Tractors and agri. implements	0.006622	0.058744	0.000000	0.024228	0.000604	0.003811
31	Industrial machinery(F & T)	0.001350	0.051156	0.000142	0.020265	0.000772	0.003910
32	Other Machinery	0.001272	0.048167	0.000008	0.018416	0.000737	0.003675
33	Electrical and Electronic appl	0.000804	0.033460	0.000057	0.019899	0.000593	0.003563
34	Rail equipments	0.001634	0.019538	0.000028	0.009610	0.000445	0.001735
35	Other transport equipments	0.001577	0.040863	0.000007	0.019859	0.000672	0.003279
36	Miscellaneous manufacturing	0.008050	0.044573	0.000002	0.020036	0.000930	0.003952
37	Construction	0.000000	0.039548	0.000000	0.011216	0.000517	0.002318
38	Gas and Water	0.000000	0.078303	0.000000	0.028347	0.009521	0.016198
39	Railway transport services	0.027673	0.048509	0.000000	0.030016	0.001592	0.003114
40	Other transport services	0.000787	0.008874	0.000000	0.066091	0.000339	0.001053
41	Storage and warehousing	0.000000	0.085042	0.000000	0.046480	0.005046	0.012902
42	Communication	0.000000	0.004758	0.000000	0.002979	0.000289	0.000649
43	Medical and health	0.000000	0.015994	0.000000	0.014426	0.000377	0.002013
44	Misc. Services	0.002387	0.009439	0.000000	0.006361	0.000375	0.000979

Direct and total sectoral energy intensities for 1989-90

		direct	total	direct	total	direct	total
		coal	coal	Crude oil	Crude oil	electricity	electricity
1	Agricultural crops	0.000223	0.010617	0.000001	0.012430	0.000376	0.001357
2	Animal husbandry	0.000001	0.006333	0.000000	0.005996	0.000000	0.000757
3	Forestry and logging	0.000000	0.003730	0.000000	0.005445	0.000040	0.000385
4	Fishing	0.000000	0.003954	0.000000	0.011206	0.000014	0.000433
5	Metallic and non-metallic min	0.001470	0.041037	0.000000	0.039243	0.004502	0.007218
6	Food and food products	0.005423	0.023186	0.000708	0.016900	0.000440	0.002332
7	Beverages	0.020092	0.046600	0.000702	0.017475	0.000889	0.003284
8	Tobacco products	0.001031	0.019172	0.000000	0.013103	0.000146	0.002086
9	Cotton textiles	0.006809	0.044624	0.000004	0.021257	0.002492	0.006092
10	Wool, Silk & Synthetic fibre	0.004010	0.044679	0.000053	0.021598	0.002000	0.006196
11	Jute, hemp, mesta textiles	0.009554	0.050400	0.000002	0.022054	0.003617	0.007066
12	Miscellaneous textile products	0.001386	0.031360	0.000229	0.017863	0.000758	0.004188
13	Wood and wood products	0.001005	0.008733	0.000002	0.006761	0.000294	0.001021
14	Paper, printing & publishing	0.023563	0.071549	0.000000	0.018809	0.002312	0.006440
15	Leather and leather products	0.001087	0.029914	0.000000	0.019806	0.000743	0.003843
16	Rubber products	0.010601	0.042935	0.000000	0.019906	0.001286	0.004534
17	Plastic products	0.001279	0.039378	0.000112	0.021097	0.001635	0.005513
18	Petroleum products	0.000356	0.010069	0.400722	0.412124	0.000200	0.001020
19	Coal tar products	0.513069	0.576817	0.031169	0.055677	0.000437	0.004054
20	Inorganic heavy chemicals	0.030904	0.107195	0.008035	0.039195	0.006259	0.012231
21	Organic heavy chemicals	0.026336	0.091203	0.010479	0.043331	0.004851	0.010177
22	Fertilizers	0.018654	0.078967	0.080961	0.125657	0.002651	0.008562
23	Paints, varnishes and lacquers	0.007336	0.059760	0.000028	0.027349	0.001642	0.006770
24	Other chemicals	0.005127	0.044921	0.006591	0.030106	0.001538	0.005452
25	Cement	0.158967	0.222711	0.000000	0.025669	0.006513	0.011230
26	Non-metallic mineral products	0.046305	0.095650	0.000007	0.046764	0.002192	0.005772
27	Iron and steel	0.076719	0.181526	0.000790	0.032440	0.002724	0.008471
28	Non-ferrous basic metals	0.017238	0.107719	0.000613	0.033213	0.006327	0.013604
29	Miscellaneous metal products	0.013518	0.090643	0.000580	0.026632	0.001990	0.006964
30	Tractors and agri. implements	0.003597	0.052911	0.000514	0.017244	0.001349	0.004672
31	Industrial machinery(F & T)	0.002700	0.062684	0.000642	0.023078	0.000978	0.005067
32	Other Machinery	0.001910	0.061209	0.000599	0.022559	0.000973	0.005079
33	Electrical and Electronic appl	0.000344	0.040492	0.000454	0.019083	0.000668	0.004246
34	Rail equipments	0.015823	0.057995	0.000000	0.024034	0.001677	0.004796
35	Other transport equipments	0.000335	0.045946	0.000001	0.020227	0.001056	0.004797
36	Miscellaneous manufacturing	0.000532	0.034585	0.000014	0.017534	0.000736	0.003806
37	Construction	0.000243	0.058242	0.000034	0.016392	0.000186	0.003300
38	Gas and Water	0.000013	0.045619	0.130089	0.159222	0.005427	0.008672
39	Railway transport services	0.016261	0.041803	0.000000	0.020344	0.001386	0.003255
40	Other transport services	0.000000	0.012307	0.000000	0.051007	0.000396	0.001586
41	Storage and warehousing	0.000058	0.040047	0.000000	0.014767	0.005514	0.008169
42	Communication	0.000000	0.010029	0.000000	0.005585	0.000580	0.001366
43	Medical and health	0.000000	0.023180	0.000000	0.016588	0.000320	0.002942
44	Misc. Services	0.005263	0.040905	0.002745	0.025813	0.001570	0.004659

Direct and total sectoral energy intensities for 1993-94

		direct	total	direct	total	direct	total
		coal	coal	Cr.oil	Cr.oil	Electricity	Electricity
1	Agricultural crops	0.000009	0.008797	0.000002	0.015740	0.000716	0.001572
2	Animal husbandry	0.000000	0.003497	0.000000	0.005868	0.000000	0.000578
3	Forestry and logging	0.000000	0.002867	0.000000	0.006663	0.000023	0.000295
4	Fishing	0.000000	0.003485	0.000000	0.014518	0.000045	0.000478
5	Metallic and non-metallic min	0.000031	0.011761	0.000000	0.020168	0.001454	0.002403
6	Food and food products	0.004418	0.016262	0.001419	0.020068	0.000454	0.002024
7	Beverages	0.013210	0.031373	0.001257	0.017968	0.000578	0.002241
8	Tobacco products	0.000842	0.013378	0.000000	0.012590	0.000315	0.001601
9	Cotton textiles	0.004420	0.025835	0.000007	0.024421	0.001844	0.004319
10	Wool, Silk & Synthetic fibre	0.006087	0.032770	0.000508	0.024328	0.001679	0.004725
11	Jute, hemp, mesta textiles	0.008583	0.031774	0.000003	0.028946	0.002360	0.004963
12	Miscellaneous textile products	0.001215	0.019753	0.000655	0.020498	0.000480	0.003008
13	Wood and wood products	0.001763	0.011579	0.000023	0.011504	0.000560	0.001550
14	Paper, printing & publishing	0.037194	0.074369	0.000095	0.022482	0.001784	0.004726
15	Leather and leather products	0.000938	0.015795	0.000007	0.015965	0.000569	0.002326
16	Rubber products	0.007541	0.034336	0.004931	0.029919	0.001430	0.004282
17	Plastic products	0.000857	0.030020	0.005276	0.029584	0.001551	0.004532
18	Petroleum products	0.000410	0.008283	0.559222	0.577385	0.000214	0.001188
19	Coal tar products	0.291318	0.319982	0.137777	0.162712	0.000714	0.003535
20	Inorganic heavy chemicals	0.050063	0.087444	0.013919	0.043144	0.002223	0.005165
21	Organic heavy chemicals	0.021247	0.062492	0.020776	0.054977	0.003449	0.006930
22	Fertilizers	0.017440	0.050872	0.091352	0.130349	0.001371	0.004389
23	Paints, varnishes and lacquers	0.008980	0.049876	0.012116	0.043932	0.002545	0.006024
24	Other chemicals	0.010681	0.043060	0.010620	0.037833	0.001731	0.004785
25	Cement	0.136030	0.175141	0.000000	0.027777	0.004454	0.007922
26	Non-metallic mineral products	0.046445	0.072919	0.000000	0.039020	0.001328	0.003584
27	Iron and steel	0.061220	0.134232	0.001285	0.034079	0.001723	0.005279
28	Non-ferrous basic metals	0.019396	0.074318	0.001655	0.032517	0.003315	0.007421
29	Miscellaneous metal products	0.010314	0.065818	0.001212	0.026647	0.001378	0.004678
30	Tractors and agricultural implements	0.004462	0.050559	0.002276	0.027981	0.001531	0.004601
31	Industrial machinery(F & T)	0.003006	0.037403	0.002692	0.028576	0.001374	0.004286
32	Other Machinery	0.001736	0.047284	0.001645	0.024458	0.001301	0.004095
33	Electrical and Electronic appliance	0.000510	0.037597	0.001537	0.024274	0.000961	0.003945
34	Rail equipments	0.003889	0.045736	0.000000	0.018755	0.001077	0.003563
35	Other transport equipments	0.000712	0.039278	0.000002	0.023452	0.001760	0.004699
36	Miscellaneous manufacturing	0.000709	0.034246	0.005734	0.026765	0.001401	0.004161
37	Construction	0.000270	0.042948	0.000068	0.020479	0.000597	0.002911
38	Gas and Water	0.000000	0.017079	0.000019	0.010864	0.002110	0.003378
39	Railway transport services	0.038180	0.060980	0.000000	0.018080	0.001760	0.003517
40	Other transport services	0.000000	0.021021	0.000000	0.072789	0.002490	0.004387
41	Storage and warehousing	0.000000	0.024877	0.000000	0.014397	0.004121	0.006121
42	Communication	0.000000	0.010145	0.000000	0.006471	0.001330	0.002121
43	Medical and health	0.000000	0.016857	0.000000	0.018363	0.000189	0.002135
44	Misc. Services	0.001249	0.008846	0.001029	0.006864	0.000477	0.001165

Direct and total sectoral energy intensities for 1998-99

		direct	total	direct	total	direct	total
		coal	coal	Cr. oil	Cr. oil	Electricity	Electricity
1	Agricultural crops	0.000010	0.004052	0.000003	0.007422	0.000126	0.000477
2	Animal husbandry	0.000001	0.001299	0.000000	0.001873	0.000000	0.000155
3	Forestry and logging	0.000000	0.002981	0.000000	0.003929	0.000018	0.000349
4	Fishing	0.000039	0.001676	0.000013	0.005347	0.000023	0.000186
5	Metallic and non-metallic mineral	0.000009	0.006128	0.000000	0.004614	0.000432	0.000964
6	Food and food products	0.002150	0.009163	0.000711	0.007816	0.000253	0.000974
7	Beverages	0.003993	0.009417	0.000431	0.003434	0.000177	0.000652
8	Tobacco products	0.000288	0.009257	0.000000	0.006061	0.000182	0.001046
9	Cotton textiles	0.002623	0.023897	0.000083	0.007617	0.002225	0.004362
10	Wool, Silk & Synthetic fibre	0.001692	0.013007	0.000013	0.004243	0.000680	0.001913
11	Jute, hemp, mesta textiles	0.002436	0.015425	0.000041	0.006087	0.001207	0.002426
12	Miscellaneous textile products	0.000309	0.010650	0.000420	0.004726	0.000207	0.001561
13	Wood and wood products	0.000493	0.012905	0.000054	0.005460	0.000803	0.001930
14	Paper, printing & publishing	0.017166	0.036589	0.000010	0.005485	0.000819	0.002326
15	Leather and leather products	0.000609	0.011055	0.000113	0.005447	0.000338	0.001428
16	Rubber products	0.002717	0.017006	0.002909	0.009287	0.000834	0.002240
17	Plastic products	0.000283	0.018279	0.003174	0.009571	0.000879	0.002536
18	Petroleum products	0.002773	0.009529	0.200293	0.205032	0.000339	0.000909
19	Coal tar products	0.113400	0.125625	0.001651	0.007153	0.000377	0.001575
20	Inorganic heavy chemicals	0.013548	0.025579	0.000569	0.004514	0.000680	0.001588
21	Organic heavy chemicals	0.005987	0.017302	0.000137	0.004399	0.000927	0.001837
22	Fertilizers	0.016843	0.052260	0.064674	0.084520	0.001468	0.004395
23	Paints, varnishes and lacquers	0.004365	0.022342	0.003529	0.010115	0.001039	0.002559
24	Other chemicals	0.004510	0.022690	0.003463	0.011191	0.000988	0.002644
25	Cement	0.056375	0.070109	0.000000	0.004733	0.001184	0.002429
26	Non-metallic mineral products	0.004193	0.007999	0.000015	0.002848	0.000142	0.000431
27	Iron and steel	0.058484	0.156730	0.001306	0.020999	0.001504	0.006098
28	Non-ferrous basic metals	0.018432	0.090196	0.001996	0.021013	0.002784	0.008260
29	Miscellaneous metal products	0.005841	0.035026	0.000445	0.006693	0.000407	0.001969
30	Tractors and agri. implements	0.000792	0.029823	0.000342	0.007073	0.000365	0.002016
31	Industrial machinery(F & T)	0.003487	0.065000	0.002254	0.018891	0.000912	0.004769
32	Other Machinery	0.005284	0.342556	0.001081	0.074559	0.003017	0.021706
33	Electrical and Electronic appliance	0.000515	0.087057	0.001764	0.024768	0.001083	0.007032
34	Rail equipments	0.002787	0.045445	0.000037	0.008963	0.000651	0.002897
35	Other transport equipments	0.001123	0.025592	0.000061	0.006420	0.000540	0.002038
36	Miscellaneous manufacturing	0.000597	0.111948	0.005473	0.031392	0.001265	0.009635
37	Construction	0.000000	0.032569	0.000000	0.007615	0.000401	0.002032
38	Gas and Water	0.000000	0.012401	0.000018	0.003397	0.000925	0.001900
39	Railway transport services	0.003971	0.131504	0.000000	0.044881	0.016523	0.026293
40	Other transport services	0.000000	0.054360	0.000000	0.126402	0.004079	0.008771
41	Storage and warehousing	0.000000	0.031994	0.000000	0.009383	0.003660	0.006288
42	Communication	0.000000	0.008062	0.000000	0.003204	0.000458	0.001166
43	Medical and health	0.000000	0.012031	0.000000	0.006681	0.000071	0.001475
44	Misc. Services	0.000202	0.009722	0.000000	0.005845	0.000281	0.001193