Chapter II

The Indian Oil Sector: An Overview - A Select Review of Literature and Emerging Issues

This chapter attempts to provide a spectrum of Oil Industry on the backdrop of India's macro economy. It attempts to review India's energy scenario, taking into account the type and sources of primary commercial energy being used in the economy, as the drivers of India's economic mobility. It identifies sectors and consumption pattern of alternate energy in all the sectors. A review has been made of the ongoing debate as to the causality of energy consumption and economic growth based on empirical analysis. Review also has been made on issues like impact of Oil Industry on country's balance of payment. Review has been made of the changes in oil consumption during reform period with the help of input output model, with a view to understand the factors responsible for change. Factors responsible for the variation in import of petroleum products based on empirical studies have been reviewed. How did India manage the oil price shocks of 1970s and 1990s from the perspective of monetary policy, balance of payment and international financial institutions? As a whole, this chapter provides an account of the integral and dynamic linkage that Oil Industry has with Indian economy.

This chapter is organized in terms of the following sections:

1. India's energy scenario
2. Energy consumption and economic growth – empirical evidence
3. India's oil industry in a growing economy
4. Oil industry and balance of payment
5. External sector development and oil industry
6. Consumption of petroleum products

Section 2.1 – India's Energy Scene

The total final energy consumption in India is 352 million tonnes of oil equivalent (MTOE) in 2003-04. This represents a growth of 4.8% over the last decade. The steady rise in energy consumption over the past decade has been accompanied with changes in the relative share of different fuels. Major spurt has come from the consumption of Oil and Gas which constitutes 43% of the energy basket (Oil – 35% and Gas – 8%). Coal remains the dominant fuel at 55% of primary energy consumption at present.

2.1.1 Energy Consumption

India's energy consumption is rising at the rate of 3.7% per year during last decade from the level of 270 MTOE to 370 MTOE (1996-97 and 2005-06), maximum growth coming from oil and natural gas. (Table 2.1)

Table 2.1: India's Energy Consumption

Fig in MTOE

	Lignite	Coal	Oil	Natural Gas	Hydro Power	Nuclear Power	Total Commercial Energy		
							Available	Production	Imported
1980-81	2.5	56.0	34.0	1.3	3.9	0.3	97.9	75.0	23.7
1981-82	3.1	61.3	36.3	1.9	4.1	0.3	106.2	88.2	20.4
1982-83	3.4	64.4	42.2	2.5	4.0	0.2	112.3	96.9	22.5
1983-84	3.6	68.8	44.8	2.9	4.2	0.3	119.1	107.9	20.5
1984-85	3.8	72.4	47.8	3.5	4.5	0.3	126.0	116.1	20.0
1985-86	3.9	76.7	47.2	4.2	4.3	0.4	136.2	121.3	20.2
1986-87	4.7	82.3	46.5	6.1	4.5	0.4	144.5	129.7	19.7
1987-88	5.5	89.9	48.8	6.8	4.0	0.4	155.5	138.9	23.1
1988-89	6.2	98.2	54.1	7.9	4.8	0.5	171.6	151.0	26.4
1989-90	6.3	101.9	57.5	9.6	5.2	0.4	180.9	160.1	28.4
1990-91	6.9	107.5	59.7	10.9	6.0	0.5	191.5	166.7	32.1
1991-92	7.8	116.6	60.8	12.4	6.1	0.5	204.2	174.8	36.0
1992-93	8.1	121.6	63.8	13.8	5.8	0.6	213.7	175.5	43.7
1993-94	8.9	125.2	65.9	14.0	5.9	0.4	220.3	179.8	46.5
1994-95	9.5	131.1	72.2	14.9	6.9	0.5	235.1	192.0	48.4
1995-96	10.9	139.8	81.6	18.2	6.0	0.7	257.1	206.1	56.0
1996-97	11.1	148.0	85.9	18.4	5.7	0.8	269.9	212.2	62.6
1997-98	11.4	155.0	90.0	21.0	6.2	0.8	287.7	222.1	66.5
1998-99	11.5	153.0	95.6	22.0	6.9	1.0	289.9	220.9	71.7
1999-00	11.0	158.1	105.6	23.0	6.7	1.1	305.6	224.2	84.1
2000-01	11.9	163.3	107.4	23.9	6.2	1.4	314.1	230.9	93.6
2001-02	12.2	169.7	107.7	24.0	6.1	1.6	321.3	237.9	95.8
2002-03	12.7	177.9	112.0	25.7	5.3	1.6	334.7	246.9	100.6
2003-04	13.7	186.8	117.2	26.5	6.3	1.5	352.0	259.2	109.1
2004-05	14.9	200.9	120.5	26.4	7.1	1.4	369.8	272.0	118.7
2005-06	14.7	214.5	121.8	26.8	8.4	1.4	370.2	281.4	129.9

Source: Energy CMIE, February 2007

Energy consumption is a function of economic activities in the country and is backed primarily by population growth. Indian economy has grown by about 4.5% per annum on a long-term basis in the second half of the twentieth century. It grew by about 3.5% per annum from 1951 till mid 1970s. Growth in national income picked up to about 5.0% thereafter till early 1990 and has further taken a leap to 5.83 ever since the reform measures have been implemented. It has been found to be consistently growing at above 6 percent per annum during last 6 years and above 8 percent per annum during last 3 years. (Table 2.2)

Table 2.2: Annual Growth Rates of GDP and Major Sectors in the Economy

Figures Percentage

Year	GDP	Agriculture	Industry	Services
1951-79	3.50	2.24	5.18	4.55
1980-91	5.04	3.42	5.32	6.18
1992-2005	5.83	2.58	5.81	7.78
2000-2006	6.38	1.95	6.84	8.03
2003-2006	8.14	5.69	8.33	9.38

Source: India Development Report – 2002
CMIE, National Income Statistics, August, 2005 and October, 2006

With the growth of various economic sectors of the economy, the energy consumption in India has experienced a steady growth and its composition has undergone a transformation, as shown in the Table 2.3 below.

Table 2.3: Percentage Share of Different Fuels in Commercial Energy Consumption

	1953-54	1960-61	1970-71	1980-81	1990-91	1996-97
Coal	80.1	75.3	56.1	47.9	35.9	28.9
Oil & Gas	**16.7**	**19.9**	**34.7**	**41.4**	**49.1**	**54.0**
Electricity	3.2	4.8	9.2	10.7	15.0	17.1

Source: Indian Petroleum & Natural Gas Statistics – 2004-05

Oil & Gas has been increasingly replacing Coal as primary commercial source of energy. The share of Oil & Gas in the total energy consumption was 16.7% in 1953-54, which has been consistently rising over the years till its share exceeded 50% in 1996-97. Both demand and supply of alternate fuels have played role in their respective consumption. Energy consumption by different economic sectors – agriculture, industry, transport and residential – reveals the composition of fuels used in meeting energy needs in these sectors. (Table – 2.4) Further, Table 2.5 gives the sources of primary commercial energy in India.

Table 2.4: Sectoral Energy Consumption by Fuel (%) 1999/2000

Sector	Coal	Natural Gas	Petroleum products	Power	Total
Agriculture	0	1.3	9.5	89.2	100
Industry	73.1	2.4	13.6	10.9	100
Transport	0	0	98.5	1.5	100
Residential	0	1.1	71.3	27.6	100
Others	0	33.9	60.9	5.2	100

Source: TERI Energy Data Directory & Yearbook – 2001/2002

Table 2.5: Sources of Primary Commercial Energy in India

Sources	Unit	1990-91	1995-96	2000-01	2001-02	2002-03	2003-04	2004-05
Petroleum Products	MMT	57.75	77.91	106.97	110.96	111.78	115.99	120.12
Natural Gas	BCM	12.77	20.93	27.86	28.04	29.96	30.91	30.79
Coal	MMT	211.73	270.13	309.63	327.79	341.27	361.17	375.00
Lignite	MMT	13.77	22.14	22.95	24.81	26.02	27.96	30.48
Electricity	Bn KWH	289.40	418.10	554.50	579.10	596.50	633.30	587.50

Source: Economic Survey, Ministry of Finance, Govt. of India, Different years

2.1.2 Projections of India's Energy Demand

Long term projections for energy requirement depend upon assumptions of growth of the economy, growth of population, the pace at which 'non-commercial' energy is replaced by 'commercial energy', the progress of energy conservation, increase in energy efficiency etc. Planning Commission has made demand projection of India's commercial energy for next 25 years. (Planning Commission – 2005)

Planning Commission has estimated elasticity of commercial energy consumption with respect to GDP for the period 1980-81 to 2003-04, which is 0.97 and for the period 1990-91 to 2003-04, which is 0.8. Based on experience of other countries in the same GDP bracket, they have assumed two scenarios: (a) when elasticity of energy consumption with respect to GDP will be maintained at 0.8 for the whole period; (b) the elasticity will gradually decrease. (0.8 during

2004-05 to 2011-12; from then till 2021-22 it is assumed to reduce to 0.75 and from then it is assumed to maintain at 0.67)

The energy elasticity with respect to income gets reduced as the energy efficiency gets improved with refinement in technology, conservation, inter fuel substitution etc.

Two growth scenarios for the economy have been assumed: (a) GDP grows at 7% and (b) GDP grows at 8%.

Using the above elasticity, commercial energy needs have been projected for different growth scenarios as given in the Table 2.6 below: Table 2.6 also shows population projection by the Registrar of Census.

Table 2.6: Projections for Total Primary (Commercial) Energy Supply – TPES

Million Tonnes Oil Equivalent

Year	Population	GDP		TPES 1		TPES 2	
	Millions	Rs Crores @ 1993-94 prices		GDP growth rate		GDP growth rate	
		7%	8%	7%	8%	7%	8%
2006-07	1114	1,751,019	1,783,901	385	394	375	381
2011-12	1197	2,455,891	2,621,137	505	537	483	508
2016-17	1275	3,444,520	3,851,310	653	718	625	684
2021-22	1347	4,831,117	5,658,837	843	961	797	901
2026-27	1411	6,775,892	8,314,688	1,060	1,248	1,051	1,234
2031-32	1468	9,503,539	12,217,005	1,333	1,620	1,344	1,633

Note : 1. Projections based on falling elasticity with respect to GDP
2. Projections assuming no change in elasticity

Source: Planning Commission, 2005

Total Primary (commercial) Energy requirement projection has been made for each source of primary energy, namely Hydel, Nuclear, Coal, Oil and Natural Gas in the Table 2.7 below: The total requirement adds up to projections made in the above Table 2.6 under constant elasticity (TPES 2).

Table 2.7: Primary Energy Requirement – one possible scenario

Fig. in MTOE

Year	Hydro	Nuclear	Coal		Oil		Natural Gas		TPES	
Assumed GDP growth			7%	8%	7%	8%	7%	8%	7%	8%
2003-04	7	5	167	167	119	119	29	29	327	327
2006-07	9	7	200	204	124	125	35	36	375	381
2011-12	15	15	253	269	151	157	49	52	483	508
2016-17	19	29	322	360	188	201	67	75	625	684
2021-22	24	54	393	456	234	259	92	108	797	901
2026-27	34	79	517	632	294	334	127	155	1051	1234
2031-32	43	115	641	816	370	435	175	224	1344	1633
% Growth rates 2032	6.7	12.2	4.9	5.8	4.1	4.7	7.0	7.6	5.2	5.9

Source: Planning Commission, 2005

2.1.3 Conventional Supply Options

The strategies to meet the energy requirement are constrained by country's energy resources and import possibilities. Unfortunately, India is not well endowed with all the primary energy sources.

2.1.3 a Coal Supply Scenario

The proved reserves of coal, the most abundant energy resources, at the current level of consumption can last for some 80 years. If all the inferred reserves also materialize, then coal and lignite can last for more than 140 years at the current rate of extraction. Of course, coal and lignite consumption will increase in future and the reserves would last for far fewer years. If domestic coal production continues to grow at 5% per year, the total extractable coal reserves would run out in around 40 years. However, only about 45% of the potential coal bearing area has currently been covered by regional surveys. Further it is felt that both regional as well as detailed drilling can be made more comprehensive. Covering all coal bearing areas with comprehensive regional and detailed drilling could make a significant difference to the estimated life of India's coal reserves. The problems with coal are: (a) how to raise the proportion of extractable reserves; (b) ensure adequate production and (c) the need to take care of the environmental impact of coal production and use.

In-situ coal gasification can increase India's available energy from domestic resources significantly. This is so because, in-situ coal gasification can tap energy from coal reserves that cannot be extracted economically based on available open cast / underground extraction technologies. In-situ coal gasification can thus significantly increase the extractable energy from India's vast in-place coal reserves. ONGC is engaged in trials to establish its feasibility and economics for Indian coal and lignite in collaboration with the Russians. In-situ gasification has many environmental advantages. The problem of over burden removal and ash disposal faced by conventional coal mining and use is eliminated. It is the first step towards a clean coal technology since carbon can be captured from the syn-gas produced and sequestered in the mine or pumped back in oil or gas fields to enhance oil or gas recovery. In-situ coal gasification, with or without carbon sequestration could be eligible for carbon credits. Finally, in-situ coal gasification at abandoned coal mines might provide an economically attractive option for full extraction of energy from in-place reserves. Clearly, the potential for domestic energy supply based on in-situ coal gasification can be large but it has not yet been assessed.

2.1.3b Oil & Gas Supply Scenario

The reserves of crude oil are merely 739 MMT. It can sustain the current level of production for 22 years. There has been no significant step up in the crude oil reserves during the last decade in spite of large investments in exploration activities. The country has not had any significant oil find since the Bombay High fields, more than 28 years ago. As a result the crude oil production has stagnated and the gap between demand and domestic availability of crude oil is widening. Import dependence will keep rising, unless dramatic new discoveries are made. Only one third of the potential area has been explored so far. However, the reluctance of international majors to explore in India and the poor success rate of ONGC together suggest that prospects may not be very bright. Therefore, India's supply strategy can not solely rely on the possibility of finding more oil domestically.

The situation was similar in the case of natural gas till 2001-02 before the discovery of gas in Krishna Godavari basin by Reliance. The recent large discovery of natural gas by Gujarat State Petroleum Corporation (GSPC) has added to the gas reserves substantially. However, the size of the reserves of both these finds is yet to be certified by the Director General of Hydrocarbons (DGH).

Table 2.8: Reserves / Production of Crude Oil & Natural Gas

Year	Crude Oil (MMT)		Natural Gas (BCM)	
	Reserves *	Production	Reserves *	Production
1970-71	127.84	6.872	62.48	1.445
1980-81	366.13	10.507	351.31	2.358
1990-91	738.60	32.160	686.45	17.998
2000-01	702.51	32.426	760.01	29.477
2001-02	732.22	32.032	762.95	29.714
2002-03	740.55	33.044	750.71	31.389
2003-04	761.11	33.373	853.48	31.962
2004-05	739.08	33.981	922.80	31.763
2005-06	786.04	32.190	1100.99	32.202
2006-07	756.00		1075.00	

* Reserve position as on 1st April of commencing year
Source: Ministry of Petroleum & Natural Gas, Government of India

2.1.3c Coal Bed Methane

CBM is a viable alternative to natural gas fuel for several industries such as power generation, fertilizer and ceramics. It is a gas found in coal seams.

The Directorate of Hydrocarbon has estimated the country's resource base for Coal Bed Methane (CBM) to be between 1400 BCM (1260 mtoe) to 2600 BCM (2540 mtoe). To give impetus to exploration and production, Government has formulated CBM policy. Based on two rounds of bidding under the CBM policy, contracts have been signed with PSUs / private companies for the exploration and production of CBM in 13 blocks. An additional three blocks have been taken up for development on the basis of nomination. The estimated investment in these blocks is about Rs 560 crore and estimated CBM resources are to the tune of 860 BCM (765 mtoe). Commercial production of CBM from some of these blocks is expected to start in 2-3 years. Thus, at the very low current rate of production, the proved gas and CBM together can last for some 50 years.

The government has decided to auction coal bed methane (CBM) blocks in Assam, Arunachal Pradesh, Orissa, Jharkhand, Madhya Pradesh, Gujarat and Tamil Nadu in a forthcoming round of bidding. This will be the fourth such tender in six years. The bidding for these blocks will be held by the Petroleum and Natural Gas Ministry in consultation with the Coal Ministry. CBM as a technology is more Australia and US driven and the companies there have been able to successfully monetize the technology.

To date, the government has awarded 26 CBM blocks for exploration spread over 13,600sq. km. The total CBM resource in these blocks is 1,374 billion cubic meters with a production potential of around 38 mscmd.

Great Eastern Energy Corporation Ltd (GEECL) reported in June 2007 an escalation of its coal-bed methane (CBM) reserves in Raniganj block by 38.5 per cent to 1.92 trillion cubic ft. The company is also expecting to start commercial production of 1.5 million cubic ft CBM a day by end-July 2007. GEECL is listed in the alternative markets segment of LSE and brought in the first FDI in CBM sector. The project has already earned the distinction of being the first to move on development phase and is now set to produce the first CBM in the country. According to the company, the Netherlands-based Sewell and Associates Inc, in its report on June 1, 2007 has pegged the in-place reserve size at 1.92 tcf. A Schlumberger's 2005 report previously estimated the in-place reserve at 1.386 tcf. According to a release issued at the LSE, Great Eastern has completed drilling of 23 wells and established 513 mcfd (million cubic ft a day) CBM productions from nine wells. The company is targeting a 100 well drilling plan in four years. The drilling rig procured for greater cost efficiency is already shipped and is expected to arrive in India in end June 2007.

2.1.3d Nuclear

India is poorly endowed with uranium. The available uranium can fuel only 10,000 MW of the Pressurized Heavy Water Reactors (PHWR). Further, Indian uranium reserves are of extremely low grade. India is extracting uranium from less than 0.1% ores compared to ores with 12-14% uranium in certain resources abroad. This makes Indian nuclear fuel 3 – 4 times costlier than international supplies. The substantial thorium reserves can be used but that requires that the fertile thorium is converted into fissile material. In this context, a three stage nuclear power program is envisaged. This program consists of setting up Pressurized Heavy Water Reactors (PHWRs) in the first stage, Fast Breeder Reactors (FBRs) in the second stage and reactors based on the Uranium 233 – Thorium 232 cycle in the third stage. It is also envisaged that in the first stage of the program, capacity addition will be supplemented by electricity generation through Light Water Reactors (LWRs), initially through imports of technology and with the long term objective of indigenization. PHWR technology was selected for the first stage, as these reactors are efficient users of natural uranium for yielding plutonium fuel required for the second stage FBR program. The FBRs will be fuelled by plutonium and will also recycle spent uranium from the PHWR for breeding more plutonium fuel for electricity generation. Thorium as blanket material in FBRs will produce Uranium 233 to start the third stage.

The total installed nuclear power generation capacity in India is 3,310 MW. Another 3,420 MW of generation capacity is currently under construction. All these reactors use uranium as fuel and they form the first stage of the India's nuclear program. All these projects are being executed by Nuclear Power Corporation.

The spent fuel coming out of these plants can be processed to yield plutonium, which can also be used as fuel in a fast breeder reactor. This forms the second stage of India's nuclear program. India's first fast breeder reactor of 500 MW is being constructed at Kalapakkam near Chennai by Bharatiya Nabhikiya Vidyut Nigam (BHAVINI).

The third stage of the program envisages conversion of thorium into uranium, which can then be used as fuel. India has very large reserves of thorium

2.1.4 Renewable Energy Resources

Given the limited amount of domestic resource of conventional energy sources, renewable energy resources become important. India's renewable energy resources are summarized in the Table 2.9 below.

Table 2.9: Renewable Energy Resources

Resources	Unit	Present	Potential	Basis of Accessing Potential
Hydro-power	MW	30,936	1,50,000	Total potential assessed is 84,000 MW @ 60% of load factor or 1,50,000 MW at lower load factors
Bio Mass				
Wood	Mtoe / year	140	620 *	Using 60 million Ha wasteland yielding (20) MT/Ha/year
Biogas	Mtoe / year	0.6 @	4	In answer 12 million family sized plants
		0.1	15	In community based plants if most of the dung is put through them
Bio Fuels				
Bio diesel	Mtoe / year	-	20 *	Through plantation of 20 * million Ha of wasteland or 7 * million hectares of intensive cultivation
Ethanol	Mtoe / year	< 1	10	From 1.2 million hectares of intensive cultivation with required inputs
Solar				
Photovoltaic	Mtoe / year	-	1200	Expected by utilizing 5 million Ha wasteland at an efficiency level of 15% for solar photovoltaic cells
Thermal	Mtoe / year		1200	MWe scale power plants using 5 million Ha
Wind Energy	Mtoe / year	< 1	10	Onshore potential of 65,000 MWe at 20% load factor
Small Hydro-power	Mtoe / year	< 1	5	

@ Based on 50% plants under use

* The availability of land and inputs for getting projected yields is a critical constraint

Source: Planning Commission, 2005

India's hydel resources are estimated to be 84,000 MW at 60% load factor. The current utility based installed capacity is 30,955 MW and the average annual generation over the last 3 years was 71 BkWh, giving a load factor of 29%. At such a load factor and installed capacity of 1, 50,000 MW including some 15,000 MW of mini hydel plants (size < 25 MW), may be justified with the available potential hydroelectric energy. Such a strategy would ensure that hydro is maximally used for meeting peak loads and all new projects would need to be designed with this objective in mind. The undeveloped potential is mainly in North East, Himachal and Uttaranchal.

The accelerated hydro developmental plan aims to being 50,000 MW of new capacity. Out of this, 25,690 MW are in Arunanchal Pradesh. The problems of environment, ecology and social problems of resettlement of project affected people have delayed development of hydro projects, particularly those that involve large storage dams. Of 50,000 MW, 31,000 MW are Run of the River (ROR) scheme. However, the available energy varies from month to month and is estimated that 19,660 MW of ROR schemes would generate 2 BkWh of energy in the lean month and 13 BkWh in the high inflow month giving load factors of 14% to 90%.

Onshore wind energy potential is estimated to be around 45,000 MW. Currently, it is claimed that Indian wind farms deliver a capacity factor of about 17% on average. As a first level of approximation, this would permit a grid connected wind capacity of as much as 20,000 MW at the current size of India's grid. The actual grid connected wind capacity is only about 3,600 MW. This reflects both a poor exploitation of claimed potential and, perhaps, the exaggerated claims of capacity factors. Even if one goes by the wind potential of 65,000 MW (as estimated by the Wind Power Society), inclusive of off-shore potential and further assumes that technological innovation will raise capacity factors to 20%, the total contribution of wind energy to India's energy mix will remain below 10 Mtoe. Even though its contribution will be marginal, wind power especially at the lagging ends of the grid provides several benefits and should be pursued wherever it is viable.

Bio mass is the major domestic fuel for cooking. This is mainly agricultural byproducts and gathered wood. The domestic use in the year 2000 was 80 mtoe. Along with dung cakes, which provided 30 mtoe, bio-mass based fuels provide 81% of domestic energy. Currently bio-mass is providing 1/3 of India's total primary energy. This non-commercial energy sub-sector is essentially managed by women without technology, management or investment, involving backbreaking drudgery and with likely environmental damage and unsustainable practices. What needs to be done to make this energy resource more sustainable is to improve the efficiency and convenience of using this bio mass, for example, through wood gasification or bio gas plants. The rural people aspire to have clean and convenient fuel like their urban counterparts. Though falling in its share of total energy mix, bio mass dependence shall continue to rise in absolute terms.

India has had a 40 year old bio gas program. The total number of family size bio gas plants installed is 3.7 million. Evaluation studies show that only half of these are in use. Community based plants can process dung from households with less than 3-5 animals required for a family size plant and also use any excess gas available from family sized plants. Managing a community sized plant that ensures voluntary cooperation of all stakeholders is however a challenge but is possible. (Planning Commission, 2005)

Bio mass can be a major energy source if fuel wood plantations are developed. This requires land which may have other competing uses. In fact, bio mass, bio fuels and solar energy on sizeable scale all require large amount of land. At some relative prices, farmers may themselves decide to use their land for producing energy. Wood plantations offer the best option for bio mass based supply sources along with a huge employment potential. Wood gasification or direct combustion, both provide possible options for power generation.

Bio diesel provides an option to substitute diesel. While bio diesel from non edible oils such as Jatropha, Karanj, Mahua etc have attracted lot of attention recently, its economics practicality depends largely on the yields one can get from wasteland and / or the returns one can get from good quality land with irrigation and fertilizer compared to other crops.

Ethanol is used in Brazil as a fuel for cars. Under Indian situation of scarcity of land and water, the available quantities of ethanol, when used as feedstock for production of chemicals and potable alcohol offer higher economic and opportunity costs to the country rather than its use as an admixture with gasoline. If technology can be developed to economically collect and convert rice straws which are currently burnt, or if intensive cultivation of land for crops to produce ethanol constitutes an attractive option to farmers, adequate qualities of ethanol can be available to blend petrol with 10% ethanol. At present, ethanol as a transport fuel can make some contribution but is not likely to constitute a major option.

The entire ethanol blended petrol (EBP) program, five per cent ethanol with 95 per cent petrol, is primarily based on the ethanol produced within the country. The total ethanol requirement of State-owned oil marketing companies is approximately 5.6 lakh kilolitres per annum in the notified States and Union Territories. Based on its availability, the Government may consider introduction of 10 per cent ethanol blending in petrol in future. The Ministry of Petroleum and Natural Gas had issued notifications for implementing the program nationwide, except in Jammu and Kashmir, North Eastern states, Andaman and Nicobar, and Lakshadweep where ethanol cannot be made available due to logistics reasons. With effect from November 2006, supply of EBP commenced initially in Uttar Pradesh, Uttarakhand and subsequently in Maharashtra, Delhi, Karnataka, Tamil Nadu, Goa and Andhra Pradesh.

Besides being an environment-friendly fuel, ethanol has a positive economic impact in terms of increased demand for sugarcane, reduction in fuel imports and savings in valuable foreign exchange. Increased demand for ethanol will strengthen rural economics and create more jobs in the rural sector.

Transport infrastructure today is clearly vulnerable due to its overwhelming dependence on a single fuel source that is crude oil. Petroleum products like petrol and diesel account for about 96% of transport fuels, with liquefied petroleum gas (LPG), compressed natural gas (CNG), electricity and bio-fuels making up for the remainder. Unlike hydrocarbons, bio-fuels are renewable and so, by and large, do make eminent sense environmentally. The commercial viability of bio-fuels does depend on future oil prices, public policy and technological breakthroughs. The indirect tax benefits and excise exemptions for bio-fuels announced in the Union Budget ought to incentivize blended fuel. Already, the target is 10% blending of petrol with ethanol by 2010. As a matter of fact, there are real possibilities for expanding the range of feedstock for bio-fuels. The "second generation" bio-fuel technologies include cheaper sources of non-edible biomass such as crop and forest residue. This would require biotechnical solutions to produce bio-fuels, and the development of multi-product bio-refineries. The expert opinion is that ethanol from sugarcane can compete with oil prices round $40/bbl, which is way below today's international price of crude. But in India, ethanol is made from molasses, a byproduct of the sugar industry. This is a circuitous route for ethanol production. In sharp contrast, Brazil, which produces over 15 Gl of ethanol, does so by directly processing sugarcane feedstock. Its ethanol is seen as price competitive with imported transport fuels. Without the requisite geographical conditions, ethanol here may not be produced as cheaply but it does make policy sense to aim for higher than 5% blending ratio. What is required is a standalone ethanol policy that blends well with energy policy and which is quite removed from the vexed political economy of sugar. Further, advanced conversion technologies such as bio-ethanol from ligno-cellulosic feedstock would better gel with Indian conditions, given our increasingly water-challenged conditions and the fact that sugarcane is unquestionably a water-intensive crop. The cost analysis of bio-fuels need to be in terms of "liter of petrol equivalent" (lpe), since bio-ethanol has a lower calorific value of about 63% of petrol; that of bio-diesel is around 91% of diesel. However, bio-fuels have superior engine combustion properties, which make up for lower heat values. Current commercial bio-ethanol production costs range from $0.25/lpe (sugarcane, Brazil) to corn ethanol $0.60/lpe (US), where prices are heavily subsidized. As for bio-diesel, the prevalent productions costs add up to $0.90/l using oilseeds like rape and soybean; the costs are slightly lower using palm oil. The projections are that by 2015, improved processes, learning by doing and scale economies ought to reduce production costs of bio-ethanol to $0.25-0.65/lpe. For bio-diesel, the like figures are seen at $0.40-0.75/lpe. The bottom line is that bio-fuels could become a "potential part solution" to transport fuels, with rising oil prices and worsening local and global pollution levels. A forward-looking policy for bio-fuels should also mean rural and agricultural development in a more equitable, sustainable manner via newer 'cash crops' and the possibility of using wastelands for bio-diesel.

Solar energy has a large potential in the country. The average solar insolation in the country is 6 kWh/meter square/day. This can be exploited in many direct thermal applications such as for cooking or heating or in photovoltaic cells that directly convert sunlight to electricity. The present conversion efficiency of commercial available photovoltaic cells is less than 15%. With this efficiency, the potential of covering just 5 million hectares of land with photovoltaic cells is 1,200 mtoe / year. The photovoltaic technology is proven but expensive and the cost of electricity exceeds Rs 20 / kWh at present. Potential to reduce costs and increase efficiency exists and a technology mission for it is highly desirable. (Planning Commission, 2005)

Solar thermal is economical for water heating. Much of its potential is yet to be exploited. Appropriate policies need to be designed to accelerate the exploitation of this potential. Solar thermal generation has not found acceptance globally, though the potential to use it in hybrid systems may be there.

Hydrogen is seen as the new energy carrier. Development of hydrogen technology is being pursued in many countries. India also has set up a Hydrogen Development Board to promote development of technologies for producing, transporting, storing and distributing hydrogen as well as in the field of fuel cells for efficient end use of hydrogen. Hydrogen can also be burnt directly in internal combustion engines. The overall efficiency of the hydrogen cycle remains in doubt. Hydrogen production, liquefaction or compression, transportation and storage and final dispensation, all entail huge amount of energy consumption and loss. Hydrogen can be produced using hydrocarbons, bio mass and splitting water with the use of solar, hydro, wind or nuclear energy and through certain microbial processes. However, significant barriers relating to financial and technological viability remain in widespread use of hydrogen in automotive or stationary applications. Metal hydrides that store hydrogen and release it for direct combustion have been developed for powering two / three wheelers in the country but not yet commercialized. Stationary applications or automotive applications using fuel cells are still relatively uncompetitive.

Another emerging technology of interest is liquefaction of coal. South Africa leads the world in this technology based on Sasol process. This can substitute petrol in cars. One tonne of oil requires 6 tonnes of relatively high quality (5,500 + kcal / kg) coal. The technology was commercially proven in South Africa and has been in use there for a number of decades. At current prices of oil, this technology may be viable even for Indian coals and should thus be pursued. Sasol is reportedly considering investing $ 1 billion, rising ultimately to $ 5.8 billion, for a project to convert Indian coal into petroleum products. Sasol has reportedly asked the Government of India to buy its output at $ 45 per barrel, if the world price falls below that level. (Aiyar, 2006) This project has signaling value in terms of FDI and a pilot project. The proposed Sasol investment of $ 5.8 billion will be the biggest single foreign investment by far in India. Yet such a plant will take five years to build and will produce no more than 4 MMT of oil per year. More plants could be built, but scaling up will not be simple. Apart from the high cost and time involved, Sasol has found that the yield of oil in the coal to liquid process is highly sensitive to the quality of coal. This means that only a small fraction of India's large coal reserves may be suitable for conversion. So, while converting coal to oil looks an important and worthwhile prospect, it can play only a limited role in meeting India's future energy needs.

Among new energy resources that have yet to be proved are gas hydrates and nuclear fusion. India has large deposits of gas hydrates (which are methane gas trapped inside ice) off the coast in the sea. The technology to exploit it is yet to be developed. Fusion power which requires fuels that can be obtained from sea water offers virtually unlimited power. The technology of controlled fusion with positive energy gain in an economic way is also yet to be developed.

2.1.5 Supply Scenario of Renewable Energy Resources

The demand scenario outlined above assumes certain factors with regard to macro economic development, technological development leading to availability of various fuels and inter fuel substitution. Each assumption, as outlined below, has some degree of probability and has got some basis.

- Electricity generation will be based on full development of hydro and nuclear potential of the country and use of gas to the extent of 20%.
- Possible fuel wise substitution will take place. In respect of oil for transport use, it cannot easily be replaced in significant quantities, unless there are technological breakthroughs or large scale shifts to public transport in place of personal vehicles or to freight movement by rail in place of trucks.
- Natural gas demand for other than power generation is in the production of fertilizers and chemicals where it cannot be economically substituted.
- In respect of coal and natural gas, there is a clear substitution possibility. Such a substitution will depend on the relative availability and price of coal and gas.

To explore the consequences of different alternatives and their quantitative significance, a number of scenarios have been developed by Planning Commission, using a multi-sectoral, multi period optimizing linear programming model. The scenarios are designed to assess the importance of critical policy options for meeting energy requirement. (Planning Commission, 2005)

2.1.6 Reforms in the Energy Sector

In line with economic reforms, various initiatives and strategies have been suggested for India's energy sector. The following action plan summarizes India's reform strategy in the energy sector.

- To initiate a shift from the existing non-renewable sources of energy to renewable sources and provide wider access for the rural and urban poor to adequate energy supplies at affordable costs;

- To ensure efficiency in the use of energy in all production process;

- To review the use of all energy intensive materials and provide for substitution of less energy intensive materials through R & D;

- To ensure efficiency in the use of equipment in the energy sector; this applies specially to capacity utilization in thermal and nuclear power generation through improved plant availability;

- To initiate measures aimed at reducing energy intensity in different sectors, through changes in technology / processes;

- To optimize inter fuel substitution. This would involve the substitution of oil by coal wherever feasible and within the oil sector, of oil products like diesel and furnace oil by natural gas;

- To propagate renewable resources based on decentralized and environmentally benign non conventional technologies. There is special need in this context to reduce the cost of new energy technologies;

- To maximize the availability of indigenous energy resources such as oil, natural gas, coal and hydro electric power, as well as, non conventional energy by way of bio gas, solar energy and wind energy.

2.1.7 Energy Policy

With growth in economy, a structural transformation in GDP takes place. Similarly, there would also be a structural change in energy use itself. It has been the experience, that at very low levels of economic activity, nearly the entire energy is consumed in the residential sector, essentially for heating and cooking. During that initial stage of economic development, bio mass (including fuel wood, switch grass, cow dung etc) account for typically more than half of total final energy use; its comparatively inefficient combustion also contributes to the residential sector's high share in energy use. The share of direct energy use of households in India is about 40% of the total direct commercial and non-commercial indigenous energy use. If, in addition, one takes into account the indirect or embodied energy in all goods and services purchased by households, then about 70% of the total energy use of the economy can be related to the household sector. (Pachauri, 2004)

With the onset of industrialization and build up of energy efficient infrastructure, industrial energy use arises more strongly, causing the share in household energy use to decline. Once the basic infrastructure is set up and the economy is beginning to be saturated with basic durable consumer goods, industrial energy consumption begins to saturate at 40 – 60 percent of total final energy use at GDP per capita level of roughly US $ 5000 (1985). Finally in a post industrial economy, the share in the final energy consumed by the industry sector decreases due to continuous decline in industrial energy intensity and rapid increase in service sector energy.

While the main goals of energy policy would remain identical, i.e., secure, reliable and affordable energy supply, rational energy use, meeting environmental constrains etc, the sector of application changes with economic development. Due to the high share of household energy use, energy policy should primarily focus on affordable, efficient and clean use of residential energy at low levels of economic development. With continuous economic development and the onset of industrialization, the energy policy focus would necessarily shifts towards more energy efficient industrial processes.

Mukhopadhyay *et al* (2000) has studied the pattern of changes in energy consumption during reform period, i.e., 1991-92 to 1996-97 based on input output model and have recommended the following energy policy.

- Government shall have to provide fiscal incentives linked to energy savings and tax concessions, rather than subsidies.
- Government shall have to develop an energy conservation act to enforce punitive action under the law and ensure strict implementation.
- Government should adopt a policy that promotes growth of less energy intensive components of final demand.
- The cost of new technologies has to be reduced.
- Optimize inter fuel substitution. In particular, this would involve the substitution of oil by coal wherever feasible and within the oil sector, of oil products like diesel and furnace oil by natural gas.

- To introduce technological innovation and diffusion. This together with supportive institutional changes will have a powerful role to play in promoting sustainable energy development and use.
- Appropriate energy pricing needs to be formulated.

Section 2.2 - Energy Consumption and Economic Growth: Empirical Evidences

All consumption and production activities involve energy as an essential input. It is the key source of economic growth, industrialization and urbanization. On the other hand, economic growth, industrialization and urbanization may induce use of more energy, particularly commercial energy. India has been passing through economic reform since 1991, the general aim of which is to quadruple its economic growth and remove the problem of poverty and unemployment. One of the obstacles to achieve these objectives has been frequent occurrence of energy shortage in the economy. In India, commercial energy consumption overtime has grown at a compound annual growth rate (CAGR) of about 6% which is more than CAGR of GDP during last 2 decades. It is noteworthy to observe that past trend in energy consumption does not fully represent the growth of energy demand. To a large extent it reflects the net availability.

The direction of causation between energy consumption and economic growth has significant implication. If for example, there exists unidirectional causality running from economic growth to energy consumption, it may be implicit that energy conservation policies may be implemented with little adverse or no effects on economic growth. On the other hand, if unidirectional causality runs from energy consumption to income, reducing energy consumption could lead to fall in income. The finding of no causality in either direction, the so called 'neutrality hypothesis' would imply that energy conservation policies do not effect economic growth.

The empirical findings on the causal issue between energy consumption and economic growth in India have been mixed or conflicting. The reason for this lies in the variety of approaches, time frame considered and testing procedures employed in the analysis.

Cheng (1999) has applied Johansen-Hsiao's version of the Granger causality method on the Indian data for the time period 1952 -1995. The study finds that energy consumption, economic growth, capital and labor are co-integrated and the direction of causality runs from economic growth to energy consumption both in the short run and in the long run. No causal relation is found from energy consumption to economic growth.

The modeling strategy adopted in Asafu – Adjaye (2000) is based on the Eagle and Granger (1987) methodology. He used 3 variable: commercial energy use, real income and energy prices proxied by the consumer price index for the period 1973 – 1995 and found unidirectional Granger causality running from energy consumption to economic growth both in the short run and in the long run. This discrepancy in results between Cheng (1999) and Asafu – Adjaye (2000) may be due either to the choice of the sample period or to the measure of the variables or to the choice of the methodology.

Paul and Bhattacharya (2004) have tested the causality between energy consumption and economic growth in India using annual data covering the period 1950 – 1996. Their study, using standard Granger causality test reveal a unidirectional causality from energy consumption to economic growth. This process does not show any causal effect from economic growth to energy consumption. However, use of Eagle – Granger co-integration process exhibits unidirectional long run causality from GDP along with capital to energy consumption. No short run relation is found. The results of the Eagle – Granger approach combined with the standard Granger causality process indicate that there is bidirectional causality between energy consumption and economic growth. The long run causal relation runs from GDP to energy consumption and the short run causal relation runs from energy consumption to GDP. The same results are obtained by using Johansen multivariate approach on the different combination of variables. These results are at variance with the results obtained by Cheng (1999) and Asafu – Adjaye (2000).

The interpretation of this short run and long run divergence in causal relation between energy consumption and economic growth can be given as follows:

In the short run, energy, particularly commercial energy acts as an engine of economic growth. It is a very important primary input in the aggregate production function. In the context of a less developed country like India, the substitution of non commercial energy by commercial energy is likely to be limited in the short run. But in the long run, with the growth of income and technological progress, it is likely that more and more non commercial energy will be substituted by commercial energy.

The gravity of environmental degradation observed at the local, national and global level attracted the concern of energy analysts and policy makers towards the environmental side effects of energy use and related social welfare.

Policies for reducing energy use alone may not be enough to ensure a certain desired level of economic growth and social welfare. The qualitative dimension of energy use is becoming increasingly important for sustainable development. One important question in this context and in the context of global climate change is how one can achieve the separation of greenhouse gases (GHG) emission from economic growth and energy consumption.

Several gases, collectively labeled, GHG, contribute to the global warming process. The largest contribution to the greenhouse effect comes from carbon dioxide emission. Anthropogenic activities, primarily the combustion of fossil fuels and the resultant carbon emission cause significant warming of the global climate.

In absolute terms, India is the world's sixth largest emitter of energy related carbon dioxide gas. Indian share of emission amounts to 909 million metric tones which is about 3.8% of the world total emission of 23838 million tones. However, measured on per capita basis, India's per capita carbon dioxide emission is very low (it was 1 tonne per person in 1995). It is 4 times below the world average of 4 tonnes per person. 98% of carbon dioxide emission in India is accounted for by energy related activities and out of this, 48% is contributed by bio-mass combustion and the balance by the combustion of fossil fuel.

Paul & Bhattacharya (2004) have determined contribution of the factors which influence energy related carbon dioxide emission in India by using complete decomposition technique. The factors that led to changes in carbon dioxide emission are: a) pollution coefficient effect, b) energy intensity effect, c) structural effect and d) economic activity effect.

Empirical results reveal that in India, economic growth is the most important component of carbon dioxide emission changes during 1980-1996. Energy intensity reduces carbon dioxide emission in the industrial and transport sector. The pollution coefficient component shows a reduction in carbon dioxide emissions in industrial and transport sectors after 1985. The decrease in the pollution coefficient is dependent on the fuel switching of fuel cleaning technologies. The results imply that the current technological conditions and fuel use patterns may limit decreases in the pollution coefficient to a significant extent in agricultural and other sectors. The relative share of agricultural sector in Indian economy has been falling gradually since 1980. Thus, while the structural component shows to increase carbon dioxide emissions in all the sectors, in the agricultural sector this component leads to a decline in carbon dioxide emission. The carbon dioxide emission is the lowest in other sectors after 1990. This is likely to be because of the reduction in energy intensity (improvement in energy efficiency) particularly in residential sectors.

It thus seems that the need to abate green house gas (GHG) and to realize the objective of development draw attention of energy policy of developing countries more towards favorable energy intensity changes of economic activity or GDP. In this context, one policy in terms of reducing carbon dioxide emission would be to enhance technical improvement (endogenously or through international transfer) that would enhance energy efficiency. Whenever feasible, energy conservation and reduction of output share of energy intensive sectors are also important strategies for reducing energy intensity.

Ramanathan (1999) made a study of demand for gasoline in India. Results have shown high long run income elasticity (2.682) and low price elasticity (- 0.319). Application of the error correction model has shown a smaller short run elasticity (1.178) and price elasticity (- 0.209). The error correction term was found significant with an adjustment coefficient of 0.284. It indicates that, if gasoline demand drifts away from its long run equilibrium level, it restores itself to the long run equilibrium at a relatively slow rate, with about 28% of the adjustments occurring within the first year.

The elasticities obtained in the study provide valuable policy level information. The higher long run income elasticity compared to the short run income elasticity means that the response of gasoline demand to income will be larger in the long term than in the short term. High levels of long run income elasticity indicate that gasoline demand in India is likely to increase quite sharply as the GDP increases. Even the short run elasticity is more than unity, indicating a faster increase in gasoline demand as GDP in India increases. Gasoline demand is inelastic to price changes, both in the long run and in the short run.

Consumption of gasoline in India has been growing at a very high rate at about 6.5 percent per year during last 30 years (1975-76 to 2004-05). It has grown at 7.2 percent per year during last decade (1995-96 to 2004-05). Road passenger transport using personalized vehicles, which is the main consumer of gasoline, is increasing at a very rapid rate. However, from a sustainable development point of view, it is necessary to promote mass transport instead of the gasoline consuming personalized passenger transport. Increasing the price of gasoline is considered as one policy option. However, the empirical results indicate low price elasticity even in the long run. This means that over pricing of gasoline as a policy instrument is not likely to be very influential on future gasoline demand in India.

Section 2.3 - Indian Oil Industry in a Growing Economy

India's consumption of petroleum products is increasing at a rate 5.6 percent per annum during last 30 years (1975-76 to 2004-05). It has grown at 5.5 percent per year during last decade (1995-96 to 2004-05). In 2003-04, net of exports, India consumed 116 MMT of petroleum products. Domestic production of crude oil has been between 30 to 34 MMT. Not only that the domestic production has stagnated, reserves of indigenous Oil have been hovering between 700 MMT and 750 MMT during this period. The proved reserve to production (R/P) ratio was 22 in 2003-04. India now import 76% consumption and country's import dependence is growing rapidly. This raises serious concerns about India's energy security.

Till 1997, oil and gas exploration was mainly done by public sector firms. Progressive liberalization of exploration, licensing policy has attracted some private and foreign firms. The success of these explorations has been marginal in enhancing oil reserves. However, a sizeable gas reserves amounting to 680 mtoe (176 mtoe by Reliance and 504 mtoe by GSPC) have been reported recently. More work is needed to estimate the extractable potential. Despite one of the most liberal exploration licensing regimes, India has failed to attract any oil majors to explore in India. This might be an indication of their assessment of the potential in the Indian sedimentary basins, as they typically prefer to work on large fields. Given the rising preference for gas as fuel and feedstock, India is also seeking to significantly raise gas imports through LNG and through transnational gas pipelines. Oil diplomacy is currently seen as a major tool for ensuring India's energy security along with acquisition of equity oil and gas overseas.

Total demand for petroleum products has grown at the rate of 5.4% per annum between 1980-81 and 2003-04. However, the demand growth has moderated to 2.8% per annum over last five years (2000-01 and 2004-05). Demand for petrol and diesel has grown at 7.4% and 5.7% per annum, respectively during 1980-81 and 2003-04. This is the outcome of growth of personal motorized transport and the rise in share of road haulage. The numbers of two wheelers have grown from 575,893 to 41,478,136, three wheelers from 36,765 to 1,881,085, cars from 539,475 to 5,717,465, buses from 93,907 to 552,899 and trucks from 343,000 to 2,088,918 over the period between 1970-71 and 2001-02. The vehicle population has continued to grow at higher than historical rates. However, in the last 5 years, (2000-2005), growth in consumption of petrol and diesel has been far more moderate at 6.9% and 3.1%, respectively. This reflects improved efficiency of vehicles and better roads. In 2003-04, Petrol and Diesel in transport sector accounted for 25.6% of our total oil consumption.

Currently, the refining capacity in the country is more than the domestic requirements (127 MMT capacity vis-à-vis 116 MMT consumption), making India a net exporter of petroleum products. The projected addition of refining capacity both in public and private sector will far exceed the demand and export of petroleum products could become India's largest export.

The oil sector remains largely in the hands of the Central Public Sector Units (CPSU). The exception is refining wherein some 26% of capacity is now in private hands. Oil product prices were set by the Government under administered pricing mechanism (APM), which was dismantled in April 2002. The prices of inputs and the products are now determined on the basis of import parity principle even for products wherein India is a net exporter. However, the prices are fixed collectively by the public sector oil companies and there is no price competition at the refinery gate or retail outlets. The Government of India, through the Ministry of Petroleum and Natural Gas, has frequently deviated from the import parity principle in fixing the effective price of domestic crude as well as the price of petroleum products at the retail level.

The above pricing methodology when coupled to the fact that there are differential customs duties on crude and product, differential excise duties and central levies on products, differential state taxes and a pooling of the transport costs leads to multiple distortions. These distortions and their impact on profitability of CPSUs and the private refiners are further compounded by the subsidies on LPG and Kerosene, which is exclusively marketed by CPSUs. This has restrained the growth of private sector retailers who find it simpler to sell to the CPSU marketing companies at import parity price. Other barriers to private sector's entry into retailing include a minimum investment hurdle of Rs 2,000 crores and the absence of common carrier principle in the use of distribution and marketing sectors. A feature of the distorted market is the large scale adulteration of petrol and diesel with subsidized kerosene. The LPG and Kerosene subsidies are not reaching the intended beneficiaries.

The challenges facing the petroleum and natural gas sectors include: a) ensuring crude oil and gas supplies in a constrained world market amidst rising prices, b) demand management of petroleum products; c) rational pricing of petroleum products and natural gas; d) removal of entry barriers for private players in distribution and retail business for creating real market competition; e) regulation of upstream and downstream sectors, f) improving administration of LPG and Kerosene subsidy and g) environmental management through product up-gradation.

India's import dependence is projected to rise to 75% of total consumption requirement in XI Plan. The feature of import dependence brings out mainly two issues: one, India's ability to buy so much oil at foreign currency at the prevailing price; and second, the issue of security of oil supply at the time of exigencies like war or natural calamity. The two issues together throw up challenging tasks like managing risk of volatile oil prices in international market, foreign exchange reserve management, managing uninterrupted supply line, optimization in logistics and inventory holding. It has been estimated that a 20% increase in diesel price and 10% increase in petrol price can result in 0.5% reduction in GDP. Even when the oil price increase is not passed on to consumers, it has an adverse impact. Government or pool account has to finance it and that puts pressure on Government budget. Government investment may go down leading to reduction in demand.

Section 2.4 - Oil Industry and India's Balance of Payment

Oil Industry is net import dependent. In 2004-05, India imported 96 MMT of Crude Oil at a cost of Rs 116,806 Crores, constituting 73% India's Crude Oil consumption. Therefore, Oil Industry plays a significant impact on India's balance of payment, as all imported oil is paid in US dollars.

Goldar and Mukhopadhyay (1990) have estimated import demand function of petroleum products, taking time series data 1970 – 1986.

$$\ln M = \underset{(.34)}{0.49} + \underset{(6.37)}{0.94} \ln EXD - \underset{(-1.30)}{0.04} \ln IPC + \underset{(1.96)}{0.06} \ln FEX \quad \dots (1)$$

$R^2 = .91$, $\bar{R}^2 = .88$, DW = 1.61, F = 30.65

$$\ln M = -.46 + .80 \ln EXD - .04 \ln IPC + .08 \ln FEX + .23 \ln M(-1) \quad \dots (2)$$

$R^2 = .93$, $\bar{R}^2 = .90$, h = .67, F = 38.23

M = Total import of petroleum products (expressed in crude oil equivalent)

EXD = Total excess demand for petroleum = the gap between the quantity of crude oil required to meet domestic demand for petroleum products and the domestic production of crude oil

IPC = Foreign price for crude oil deflated by domestically produced crude oil price = the import price of crude oil as a ratio to domestic cost of production of crude oil

FEX = Foreign exchange reserve (expressed in month's import) in previous year

M (-1) = Previous year's import of petroleum products

The estimates of the import function presented above indicate that the domestic demand and supply gap in petroleum products is the main determinant of imports of crude oil.

The results suggest a proportional relationship between the gap and the imports of petroleum products.

The international price of crude oil is found to have a negative relationship with crude oil imports. But the value of the coefficient is very small, indicating low elasticity of import demand for petroleum products with respect to the price prevailing in international market.

The coefficient of the foreign exchange availability variable is positive and statistically significant.

The results are somewhat better, when petroleum imports with one year lag is introduced as an explanatory variable. It appears from the result that import demand for petroleum responds to change in domestic demand – supply gap, international price of petroleum and foreign exchange availability with a lag.

Section 2.5 – India's External Sector Development and Oil Industry

While India underwent reform process since 1991, two developments swept the international economic landscape. First, there was acceleration in the pace of growth of international trade in goods, services and financial assets. At the global level, this encompasses the growth spurts in key emerging market economies, notably China and India. Globalization has also overlapped the economic and financial deregulation in India along with information technology revolution. Second, oil prices have risen sharply since 2003, driven both by strengthening global demand and most recently by concerns about future supply.

2.5.1 Globalization and National Inflation

With a view to understand the effect of globalization on inflation, we will review the main broad channels through which globalization affect national inflation.

a) **Policy incentives**: Determined monetary policy efforts aimed at reaching and maintaining low inflation have been a major factor in the global decline in inflation and inflation volatility during the 1980s and 1990s. These efforts have reflected on a number of factors. Policy makers have learned from the mistakes of the 1970s. Financial deepening, improved fiscal policies and smaller disturbances have also played a role. Globalization may have played a subtle role in the strengthened conduct of monetary policy by changing the incentives of policy makers. In particular, globalization may reduce their ability to temporarily stimulate output and / or may increase the costs of imprudent macro economic policies through the adverse response of international capital flows. Central banks in industrial countries are unlikely to lower their inflation targets further despite continued globalization. This is because of concerns about the adverse consequences of targets that are too close to zero at times of weak aggregate demand conditions. However, in many developing and emerging market countries, globalization is likely to continue to affect inflation through its impact on central banks' inflation objectives.

b) **Trade integration and price level declines**: Globalization and the associated rise in trade integration have reduced the barriers to market access by foreign producers. This tends to bolster price competition in domestic markets and increase imports. It has also led to the relocation of production of many internationally traded goods and to a much smaller extent, of services to the most cost-efficient firms in the countries with a comparative advantage. As a result, the prices of affected goods or services typically decline compared to the general price level – in other words, their relative price declines. A case in point is the observed fall in the relative prices of many manufactured goods, such as textiles, that has accompanied the rapid integration of emerging market economies into the world trade system. Because such good prices are a component of consumer prices, their fall has, to some extent contributed to low overall inflation. In addition to such direct effects, increased competition may also have indirect effects by moderating domestic producer prices, input prices and markups in some industries more generally, given the availability of close substitutes produced abroad.

c) **Productivity growth, aggregate supply and relative prices**: Globalization can raise productivity growth, reflecting increased pressure to innovate and other forms of non-price competition. By increasing aggregate supply, such productivity gains typically lower prices, which may affect aggregate inflation, with the effects possibly amplified by positive feedback from low inflation to productivity growth. Clearly, globalization related productivity increases have overlapped with increases due to other factors, including the information technology revolution.

d) **Inflation response to domestic output fluctuations**: Globalization may have affected the strength of the cyclical response of inflation to output fluctuations for a number of reasons. For example, prices of many items that are produced or consumed at home are increasingly determined by foreign demand and supply factors rather than local factors. This is reinforced by the effects of financial integration, which allows for larger trade balance deficits or surpluses and, thereby, weakens the relationship between domestic output and demand.

With the growing share of international trade, prices of many items that are produced or consumed at home are increasingly determined by foreign demand and supply factors. Similarly, stronger foreign competition may reduce the pricing power of domestic corporations, limiting their ability to raise prices during booms. Consequently, prices become less sensitive to the domestic cycles and the business cycle volatility of inflation decreases.

Of course, openness is not the only factor that could have weakened the co-movement of output and inflation. The strengthened conduct of monetary policy over the past two decades is likely to have contributed as well for at least two reasons. First, in low-inflation environment, firms re-price their production less often. Second, increasing policy credibility increases the weight that price setters put on expected inflation or inflation targets when they set their prices.

However, certain factors related to globalization and the associated push for structural reforms may have acted in the opposite direction, effectively raising the sensitivity of inflation to output. In highly competitive markets with very low margins, producers respond faster to changes in their cost structure and may become more sensitive to demand fluctuations if production costs vary with volumes over the cycle. Co-movements between output and inflation could therefore increase when economies become less regulated, more competitive and more flexible. Trade openness appears to be the key factor behind the reduced sensitivity of prices to output. Reduction in labour market rigidities (as measured by an index of centralization and coordination in wage bargaining) in some countries has partly offset the effects of openness by raising the price sensitivity, but this effect tends to be small.

Trade integration, notably with developing countries and emerging markets, has been accompanied by a rapid decline in the prices of certain goods and services.

To date, the impact of higher oil prices on the global economy has been more moderate than generally expected, in part because inflationary expectations have remained well anchored, and the shock has been driven by strong global demand. Looking forward, however, there are three reasons for concern. First, the full effects of the recent shock may not yet have been felt, especially if producers and consumers are still treating it as temporary, rather than largely permanent in nature. Second, with excess production capacity still very low, the market remains vulnerable to shocks. Third, with prices increasingly driven by supply side concerns, the adverse impact is likely to be greater than in the recent past. This would be of particular concern for oil importing developing countries like India, which would not in these circumstances benefit from an offsetting rise in non-fuel commodity prices.

2.5.2 Phases of India's External Sector Development

An overview of India's external sector development and policies since independence with special reference to Oil sector presents three distinct phases:

i. From independence to the end of 1970s when the current account deficit widened sharply, but then returned to balance, and the deficits were mainly financed from concessional flows;

ii. The 1980s to 1991, when the first step toward external liberalization began, but the current account deficit widened substantially and its financing moved towards shorter term private debt financing; and

iii. The period since 1991 when more substantial steps toward liberalization occurred, the current account deficit narrowed and capital flows shifted more towards equity financing.

In the period following independence, economic policies focused on the rapid industrialization of the economy with the aim of achieving self-sufficiency. This goal manifested itself in a trade system where all imports including Oil imports were controlled through comprehensive exchange controls, quantitative trade restrictions, canalization, which was supplemented by a complex tariff structure with high and differentiated rates. There was no scope for export of Oil as India's Oil consumption was growing at the rate of 8.5% during 1950s, 9.7% in 1960s and 5.9% during 1970s, reflecting a very high income elasticity of demand for Oil at the rate of 2.21, 2.42 and 1.6 during the respective decades. In 1960-61, India's domestic production of Crude was 448 TMT and Indian refineries processed 6,130 TMT Crude. In 1965-66 and 1970-71, Crude production increased to 3,473 TMT & 6,822 TMT and refinery processing to 10,233 TMT & 18,379. India's domestic Oil scenario entered into a different phase with the beginning of off-shore production in 1976-77 (406 TMT), which got a boost in 1982-83 (12,877 TMT).

The large investments in capital goods and other materials essential for industrialization, and the continued need to import many essential consumer items including Oil and food resulted in strong import growth in late 1950s and early 1960s. With export performance remaining poor, the trade deficit widened and the current account deficit increased to around 2.5 percent of GDP as the surplus on the invisible account also narrowed. However, improved export performance of non-Oil goods in the late 1960s and 1970s, aided by the expansion of world trade and a depreciation of the real exchange rate, led to an improvement in the current account position. While this was temporarily reversed in the aftermath of the oil price shock of 1973, a tightening of import controls and restraint of domestic expenditure quickly brought import growth down. Remittances also increased strongly during the 1970s as the number of Indians employed in the oil producing nations of the Middle East increased. During this period the current account was almost entirely financed by concessional aid flow which increased from 1 percent of GDP in the early 1960s to a peak of 2.5 percent of GDP in the middle of the decade.

The second oil price shock in 1979 brought about deterioration in current account of 1980s. Imports rose, exports slowed in response to the world wide recession and the appreciation of real exchange rate and the current account moved back into deficit. As reserves fell critically low, India entered into a program with IMF in 1981. However, unlike after the first oil price shock, no significant current account adjustment followed, and with large macroeconomic imbalances developing in the second half of the 1980s, the current account deficit rose to a peak of 3 percent of GDP in 1990-91. While trade deficit remained in 2 – 2.5 percent of GDP range, the surplus on invisible account narrowed and moved into small deficit in 1990-91. External financing shifted away from concessional finance towards higher-cost debt. With the rise in Oil prices and decline in remittances following the crisis in the Gulf region, reserves declined, India was brought into a brink of default in January 1991. This was avoided by purchases through the IMF's Compensatory Financing Facility and by the adoption of an IMF program in October 1991.

2.5.3 How did India deal with successive Oil Shocks?

Trends in 1970s

India's balance of payments remained comfortable in 1970s despite the first oil shock of 1973-74. During this decade, volume growth in exports was 6.8 percent per annum, while the growth in imports was limited to 6.7 percent per annum. Foreign exchange reserves in US dollar terms increased nearly seven times from US $ 1,095 million to $ 7,361 million during this period. Reserves at the end of the decade formed 7.4 months of imports in that year.

The economy was able to adjust to the first oil shock in a remarkably short time. Import bill rose by over 50 percent within a year, but this was soon compensated by a strong growth in exports and demand for labor from neighboring oil exporting countries. The current account of balance of payments which was in deficit of Rs 644 crore in 1974-75 turned into a surplus of Rs 294 crore in 1975-76, reaching a record surplus of Rs 1,735 crore by 1977-78. The current account continued to be in surplus until 1978-79, although it declined from the high levels reached in the previous two years. During 1975-76 to 1978-79, the current account surplus aggregated Rs 3,727 crore which more than offset the deficit of Rs 644 crore in 1974-75. The current account as a proportion of GDP turned from a deficit of 0.9 percent in 1974-75 to a surplus of 1.8 percent by 1977-78, though the surplus came down to 0.2 percent by 1978-79. It was only in 1979-80, when the economy experienced the second oil shock that current account showed a deficit, *albeit* small, of 0.2 percent of GDP.

The swift adjustment to the first oil shock was due to a combination of factors. There was basically a strong growth in exports of 11 percent in 1975-76 and of 19 percent in 1976-77 in volume terms due partly to a sharp increase in exports to oil exporting countries. The international trade environment was also supportive as the value of world trade rose by over 7 percent in SDR terms in these two years. In volume terms, world trade declined by 4 percent in 1975 but rebounded next year with a rise of 11 percent. Thereafter the growth in world trade was in the region of 5 to 6.5 percent per annum. India's export effort was also aided by the fact that after the sharp increases in prices during 1973-74 and 1974-75, price increases were modest in the following four years. The average rate of increase in wholesale prices during 1975-76 to 1978-79 was only 2.2 percent per annum.

The balance of payment adjustment was also helped by large inward remittances from Indian workers in the Middle East, consequent on the large migration of Indian labor to oil rich countries of West Asia. Receipts by way of private transfers rose sharply from Rs 220 crore in 1974-75 to Rs 1,472 crore in 1979-80 and further to Rs 2,149 crore in 1980-81. These amounted to a total of Rs 4,380 crore during the post first oil shock period 1975-76 to 1979-80 and were equivalent of nearly 80 percent of the trade deficit during this period. At the same time, imports after an initial rise, remained more or less unchanged up to 1976-77, partly because of improved domestic oil production and only a modest rise in consumption. Aid receipts were reasonably buoyant. India drew various fund facilities including the Oil facility during 1973-74 to 1975-76, but over the next three years, by the time of the second oil shock, India had already repurchased all the Fund drawings. Further, during the period 1975-76 to 1979-80, reserves were built up by as much as SDR 4,780 million.

1978-82

The scenario was in many ways different in the early 1980s. With the sharp escalation of crude oil prices brought on by the second oil shock in 1979, the pressure on the balance of payments intensified. Between 1978-79 and 1981-82, while imports increased by Rs 6,489 crore, POL imports increase by Rs 3,512 crore, accounting for a little over half of the overall increase in imports during the period. The deceleration in export growth further exacerbated the external payment position. Volume growth of exports was restricted to 3.3 percent, partly reflecting the severe international recession of 1980-83 and the accompanying stagnation of world trade. In value terms, exports rose by Rs 2,221 crore during 1978-82 and could finance only 34 percent of the increase in imports during the period. As a result, the trade deficit widened by more than three times from Rs 1,843 crore in 1978-79 to Rs 6,121 crore in 1981-82. Net invisible receipts continued to provide a measure of support to the balance of payments, aided by the sustained buoyancy of private transfer receipts and earnings from tourism. However, unlike the earlier period, these could not offset the deficit on the merchandise trade account. Consequently, there was a turnaround in the current account balance from a surplus of Rs 173 crore in 1978-79 to a deficit of Rs 2,317 crore in 1981-82. The ratio of current account deficit rose to a peak of 1.5 percent of GDP in 1981-82. Thus while the current account turned surplus within two years after the first oil shock, the deficit increased substantially in the two years after the second oil shock.

To meet the difficult balance of payments situation, India borrowed from the IMF Rs 274 crore under the Compensatory Financing Facility and Rs 545 crore from the IMF's Trust Fund in 1980-81. Although at the end of 1980-81, reserves level was comfortable (over 5 months of import), in order to meet any unforeseen calamities, India negotiated with the IMF an extended Fund Facility of SDR 5 billion in November 1981.

1982-83 to 1984-85

The period 1982-83 to 1984-85 saw a marked improvement in the external situation. From 1982-83 onwards, there was a progressive improvement in the balance of payments. The pressure emanating from a burgeoning import bill eased to some extent. The volume growth of imports fell from the average rate of 14.7 percent ruling during 1978-82 to a little over 2 percent during 1982-85. In SDR terms, imports remained stable at around SDR 15 billion. The period also witnessed replacement of energy imports at an accelerated pace. Domestic production of crude oil spurted from 16.2 million tones in 1981-82 to 29 million tones. As a result, the share of domestic production in meeting consumption requirement rose form a little under 50 percent to 75 percent in 1984-85, representing a major success in import substitution. Net oil imports, (net of crude oil exports which commenced in 1981-82), therefore declined by more than one third from SDR 4,807 million in 1981-82 to SDR 3,009 million in 1984-85. On the other hand, with the maintenance of a stance of selective liberalization, the category of non-POL imports rose at an average rate of 7 percent in SDR terms.

Export performance, however, was depressed and fell far short of Plan projections. In volume terms, exports rose at an annual average rate of 3.2 percent during 1982-85. The sluggishness in export growth was due to a combination of adverse external and internal developments.

The share of invisibles in financing the trade deficit progressively declined. Interest payments on external debt recorded a sharp increase. Remittances from expatriate Indian workers showed only modest increase. While interest payments increased four fold from Rs 362 crore in 1981-82 to Rs 1,312 crore in 1984-85, net invisible receipts which had financed as much as 92 percent of the trade deficit in 1978-79, could finance only 55 percent of the trade deficit, on an average, during 1982-85. As a result, recourse to external financing was of a relatively larger order. During the period, 65 percent of the current account deficit was met by way of foreign loan and credits, 24 percent by way of non-resident deposits and 45 percent through use of Extended Fund Facility (EFF) drawings. The current account deficit remained more or less unchanged in rupee terms during 1982-83 to 1984-85. In SDR terms, the current account deficit declined. India did not fully utilize the EFF facility of SDR 5 billion negotiated with the IMF and surrendered the use of SDR 1.1 billion thereof. Foreign exchange reserves which were drawn down by SDR 1.939 million in 1980-82 were built up by SDR 2,060 million so that the level of reserves at SDR 6,004 million at the end of March 1985 stood cover for over 4.5 months of imports during 1984-85. The current account deficit as a proportion to GDP declined from 1.5 percent in 1981-82 to 1.2 percent in 1984-85. However, it needs to be noted that whatever improvement that was noted in the balance of payments during this period was due mostly to reduction in the oil import bill arising from the sharp increase in the domestic production of crude. Thus, the adjustment was limited and the position started deteriorating once the oil import bill started increasing.

1985-86 to 1988-89

The balance of payment came under pressure in 1985-86, the first year of VII Five Year Plan. The current account deficits continued to remain at high levels over the last four years. As a percentage of GDP, the current account deficit during this period averaged around 2.2 percent as against the Planning Commission's estimate of 1.6 percent for the Plan period. Between end March 1985 and January 1990, foreign exchange reserves declined by US $ 2,480 million and by SDR 3,393 million. The use of reserve was minimized because of substantial inflows of capital by way of external assistance, commercial borrowings and deposits by non-resident Indians for financing the large current account deficits. But as a result, India's medium and ling term debt and NRI deposit liabilities taken together more than doubled from nearly Rs 40,000 crore at the end of March 1985 to Rs 83,835 crore by the end of March 1989. This pushed up the country's debt service ratio from 13.6 percent in 1984-85 to around 25 percent by 1988-89.

In 1985-86, imports increased by Rs 2,484 crore (by 13.3 percent), while exports declined by Rs 381 crore, so that the trade deficit widened over the year by Rs 2,865 crore. Exports stagnated in 1985-86, due to a virtual cessation of crude oil exports.

Oil imports, net of oil exports, in SDR terms went up from SDR 3,009 million in 1984-85 to SDR 3,361 million in 1985-86. There was a sharp drop to SDR 1,554 million in 1986-87 ranging around a little over SDR 2,000 million in 1987-88 and 1988-89. Thus, between 1985-86 and 1988-89, the saving in oil import bill was of the order of 1.4 billion. Although the consumption of POL has shown an annual increase of 6 to 7 percent and domestic production seems to have reached a plateau in recent years, the fall in crude oil prices helped to contain the oil import bill, not withstanding a growth in volume of imports. Net oil imports increased from 12.3 million tonnes in 1984-85 to 19 million tonnes in 1987-88. Crude oil prices plummeted from an average of $ 28 per barrel in 1984-85 and $ 25 per barrel in 1985-86 to $ 14 per barrel in 1986-87. Prices increased somewhat to $ 17 per barrel in 1987-88, but came down again to around $ 14 per barrel in 1988-89.

The saving in oil imports arising from the fall in prices enabled an expansion in non-oil imports which rose by nearly 105 percent in rupee terms and by 26 percent in SDR terms over the four year period. In two out of four years, non oil imports went up sharply by over 15 percent in SDR terms, which more than offset the fall of 6 percent in the other two years taken together.

High Oil Price Regime Beginning 1999

Looking back it is clear that the broadly successful management of external sector pressures in 1997 to 1999 was greatly aided by the largely fortuitous coincidence of low international prices for Oil. Oil prices declined throughout 1997 and 1998 from a previous peak above $ 20 per barrel in late 1996 to a little over $ 10 per barrel at the end of 1998. As a result, India's Oil import bill declined from over $ 10 billion in 1996-97 to $ 8.2 billion in 1997-98 and $ 6.4 billion in 1998-99. The extra leeway of nearly $ 4 billion in 1998-99 was probably crucial to the successful management of the problems of contagion, sanctions and confidence during the year.

This good fortune changed in 1999. For a variety of largely unpredicted reasons, Oil prices rebounded vigorously in 1999 and continued to surge upwards throughout 2000, rising above $ 30 per barrel in the later half of the year. The implications for India's Oil import bill were equally dramatic. Oil imports rose above $ 10 billion in 1999-2000 and to nearly $ 16 billion in 2000-01. Compared to 1998-99, India was paying $ 800 million per month extra in 2000-01 for its Oil imports. As these payments mounted inexorably, foreign exchange reserves dropped from $ 38 billion at the beginning of the fiscal year to $ 35 billion in October and the rupee depreciated from Rs 43.30 per dollar to Rs 46.40 per dollar. The problem of waning confidence feeding speculative pressures again surfaced in the summer of 2000.

Faced by this rising Oil import bill, the government followed a three pronged strategy to deal with the problem. First, to prevent Oil import payment pressures from being transmitted into a large additional fiscal problem via Oil Pool Account deficits, the administered prices of petroleum products were revised upwards in three tranches within a twelve months period: in October 1999, in March 2000 and in September 2000. On two of these occasions, the government courageously broke a long standing taboo and raised the price of kerosene. Second, recognizing that increases in domestic prices of Oil were unlikely to bring about the necessary adjustment in the trade deficit (essentially because of the low price inelasticity of Oil demand) and that the adjustment would have to come from other imports and exports, the authorities did not resist unduly the market driven depreciation of the exchange rate that occurred between April and November. Third, since adjustment takes time, the government mobilized exceptional balance of payment financing to generate the necessary 'breathing space' and tackle the emerging confidence problem. The mean deployed was the Indian Millennium Deposit (IMD) scheme, which closely paralleled the earlier RIB venture. Launched in late October and closing in early November, the IMD scheme mobilized $ 5.5 billion of five year funds at 8.5 percent interest in dollars. Although deemed unduly expensive by some observers, these resources certainly solved the confidence problem and helped take foreign exchange reserves to a new peak of $ 42.4 billion by end of 2000-01. Aside from expense, the IMD issue may have been 'too successful' in the sense that it prevented the rupee from depreciating enough to facilitate the economy's adjustment to higher Oil prices (and to the lifting of the final tranche of quantitative restrictions on imports that occurred in 2000 and 2001).

2.5.4 Impact of increase in Oil Prices on Inflation and Output in India

Studies have been made to examine the impact of an increase in oil prices on prices of other commodities and output in India. (Bhattacharya, Kaushik, *et al*, 2001) In the Indian context, the possible impact of petroleum price hike, which are administered, often generates debate among the public. The postponement of adjustment in administered prices may delay the build up of inflation pressure in the short run, but subsequently gets translated into an invariably bigger shock. Any hike in such prices, apart from a direct impact, has an indirect impact on the prices of those commodities which use them as inputs and can lead to a wage price spiral as evidenced during oil shock of the 1970s. However, the impact could be nullified through appropriate and judicious use of monetary policy instruments, provided the origin of the inflationary pressure in the economy is clearly delineated and policy perspectives are drawn accordingly.

IMF indicated that in Indian context, a sustained US $ 5 per barrel increase in the price of oil leads to 1.3 percentage point increase in inflation after a year and reduces the annual GDP growth by 0.1 percentage point. However, it is acknowledged that the magnitude of such an impact crucially depends on the degree of monetary tightening and the extent to which consumers seek to offset the decline in the real income through higher wage increases and producers seek to restore profit margin.

Conventional wisdom suggests that any oil shock in the domestic market could lead to increase in prices of other commodities in two distinct phases. The first phase is an immediate one and occurs as a result of hoarding of commodities in anticipation of a future price rise. In the second phase, a price rise in petroleum products generates a cost-push effect whose impact is felt only after the completion of an average production cycle in the economy. International evidence seem to suggest that for administered commodities, in general, the impact tends to peak after eight months from the date of the initial price rise. To gauge the possible impact of a hike in the administered prices of petroleum products over short, medium and long term, the interactions of oil prices with key macroeconomic and policy indicators need to be studied more intensely,

Using monthly data from April 1994 to December 2000, a four equation vector auto-regression model has been used to study the interaction of inflation in oil with non-oil inflation and growth in money and output. (Bhattacharya, Kaushik, *et* *al*, 2001) Attempt has been made to study the transmission mechanism of an increase in petroleum prices on the prices of other commodities and output in India. It is attempted to identify the lag structure in which a rise in the prices of oil begins to affect the prices of other commodities and output. The nature and extent of feedback in such a transmission mechanism is examined and evidence is obtained in favor of bi-directional causality between oil and non-oil inflation in India.

The study revealed that the process of transmission of oil prices to other commodities occurs in two phases. In the first phase, price rise in other commodities is small and is based on expectations. This phase typically occurs within the first quarter of the oil shock. In the second phase, prices of other commodities start to rise steeply after a production cycle in the economy is over. The response is at its peak after five to seven months. During this period, a 3.8 percentage point positive shock in 'inflation in oil', *ceteris paribus*, translates into additional 0.25 point inflation in other commodities. Thus if the *ceteris paribus* shock in 'inflation in oil' is increased by 20 percentage points, 'inflation in other commodities' is likely to increase by 1.3 percentage points after five to seven months after the shock. The response, however, is crucially dependent on the output scenario and monetary policy. A dampened output scenario reduces the impact of the oil shock, obviating the need for monetary tightening. However, if output shock is also positive at the same time and control of inflation is the major policy objective, the situation demands monetary tightening to some extent. It also reveals that following an oil shock, inflationary tendencies persists for about two years, although the magnitude of the impact reduces considerably by the end of the period. A *ceteris paribus* 20 percentage point shock in 'inflation in oil' leads to an increase of 1 percentage point in 'inflation in other commodities' after a year.

In an import dependent country like India, the rise in world oil prices worsens the trade balance, leading to a higher current account deficit and a deteriorating net foreign asset position. At the same time, higher oil prices tend to decrease private disposable income and corporate profitability, reducing domestic demand; along with a depreciation of the exchange rate, this acts to bring the current account back into equilibrium over time. The speed and output cost of adjustment depends on factors such as the degree of trade openness, structural flexibility and central bank credibility, as well as the shock's expected persistence and the speed with which it is allowed to feed through into domestic fuel prices. Among other things, these determine the extent to which rising oil prices raise inflationary pressures, necessitating a monetary tightening that could lead to a more pronounced slowing in growth.

Reserve Bank of India in its Annual Report 2004-05 makes a mention that India is the sixth largest consumer of petroleum products in the world, up from 14th position in 1993. India's share in global oil consumption has risen to 3.2 percent in 2004 from 2.2 percent in 1993 and 1.2 percent in 1981. India's oil demand grew by 4.7 percent in 2004 (1.3 percent in 2003), higher than the growth of 3.4 percent in world oil demand. India's import basket of crude oil comprises 43 percent of sweet crude and 57 percent of the sour variety. Average crude oil prices facing India escalated by 40 percent from US $ 27.8 per barrel in 2003-04 to US $ 38.9 per barrel in 2004-05. The Indian basket price increased further during April July 2005 and stood at US $ 50.8 a barrel or about 47 percent higher over the corresponding period of the previous year. In the absence of any countervailing policy intervention, every US dollar increase in crude oil prices could potentially add 15 basis points to WPI inflation as a direct effect and another 15 basis points as an indirect effect.

Section 2.6 - Consumption of Petroleum Products

Petroleum products are composite product, processed out of Crude Oil through a process of distillation and blending. Crude Oil is the raw material that is processed and the output is the stream of products of various distillation range and calorific value. It is the refined petroleum products, which are used by the consumers. Petroleum products are used as fuel, inputs for industrial production as well as household consumption item. Primarily, the refined products are classified under 3 categories, viz, Light distillates, Middle distillates and Heavy ends, as the Table 2.10 presents. Consumption of petroleum products has been consistently rising year by year on average at 5.5 percent.

Table 2.10: Consumption of Petroleum Products

Figures in million tonnes

	1975-76	1980-81	1985-86	1990-91	1995-96	2000-01	2005-06
Light Distillates	**3.60**	**4.39**	**6.78**	**9.80**	**13.70**	**29.27**	**33.50**
LPG	0.34	0.40	1.24	2.41	3.92	7.15	10.30
Petrol	1.27	1.52	2.27	3.54	4.68	6.61	8.65
Naphtha & NGL	1.84	2.32	3.11	3.45	4.15	11.68	12.26
Middle Distillates	**11.65**	**17.06**	**23.95**	**33.11**	**46.08**	**53.47**	**54.20**
ATF	0.90	1.12	1.45	1.68	2.08	2.25	3.30
Kerosene	3.10	4.23	6.23	8.42	9.93	11.31	9.36
Diesel	6.60	10.34	14.89	21.14	32.26	37.96	40.15
Heavy Ends	**7.20**	**9.45**	**10.15**	**12.13**	**15.05**	**17.29**	**24.22**
FO	4.28	5.41	3.81	4.46	6.50	7.66	8.84
LSHS	1.38	2.07	4.09	4.52	4.19	4.99	**3.89**
Bitumen	0.69	1.06	1.13	1.58	2.00	2.71	3.51
Coke	0.15	0.14	0.16	0.29	0.32	0.41	4.43
Lubes Oil	0.44	0.59	0.70	0.89	0.96	1.04	2.10

Source: Energy, CMIE, February 2007

2.6.1 Changes in Oil Consumption during Reform Period (1991-92 to 1996-97) – Analysis with Input Output model

Mukhopadhyay *et al* (2000) has studied the pattern of changes in energy consumption during reform period, i.e., 1991-92 to 1996-97 based on input output model.

In this study, 3 energy sector and 19 non energy sector have been used. The 3 energy sectors are: (a) coal, (b) crude petroleum and natural gas & (c) electricity. Empirical results of input-output study and structural decomposition analysis of energy consumption are the following for 'crude oil and natural gas' sector:

During 1991-92 to 1996-97, India's total commercial energy consumption increased by 5.7% per annum; oil and gas sector recorded growth of 5.5% per annum.

During the first half of the 1990s, oil production has increased at an annual rate of less than 1%. The 19% increase in production during 1994-95 arrested the declining trend. Aggregate production during the 5 year period was 157.71 MMT. VIII Plan envisaged a promising contribution from the private sector. However, during the last 2 years of the Plan, it was able to contribute only 1.12 MMT. The shortfall is on account of: a) uncertain reservoir behavior in Bombay off shore basin; b) problems in the north eastern region and c) delay in implementation of joint venture projects.

On the consumption front, it reflects a moderate increment of 5.5% per annum during 1991-92 to 1996-97. The natural gas consumption was peaking gradually during the period by 6 percent per annum. Out of it, 56 percent of gas was utilized for energy purpose, mainly for power generation and 44 percent was used as feedstock, mainly for fertilizer plants.

More remarkable changes occurred during 1995-96 to 1996-97; consumption of crude oil picked up at 75.4 MMT. It was 10.8 percent higher than in 1994-95.

This spurt in growth matches with a pick in industrial activity during 1995-96. High speed diesel (HSD), kerosene, fuel oil, petrol and LSHS accounted for over 75 percent of the consumption of crude oil during 1996-97. HSD accounted for 43 percent of the total consumption of petroleum products in the economy during 1995-96. During 1991-92 to 1996-97, the consumption of HSD increased at a rate of 7.3 percent per annum.

2.6.2 Reasons for the changes in Energy consumption

Technical Change

During 1991-92 to 1996-97, moderate technical changes was observed, which helped to reduce crude oil and natural gas consumption by 41.86 mtcr (million tonne coal replacement) or 2 percent annually. The slight technical improvement in case of oil and natural gas sector has been possible due to the flaring of associated gas minimization, to arrange for the off take of natural gas, also for the minimization of the risks of exploration both by an optimal mix of exploration in different basins in India and for vigorous energy conservation and inter fuel substitution. (Mukhopadhyay *et al*, 2000)

Splitting the effect of technical change into 3 forms as (i) changes in energy input coefficient; (ii) changes in non energy input coefficient and (iii) interaction term of the two, the following picture emerges.

Changes in energy input coefficients save energy from the improvements in energy efficiency over the period. There was reduction in direct energy input coefficient in crude oil and natural gas sector by 221.46 mtcr or 8.7 percent per annum. However, changes in non energy portion of production technology increased energy consumption in crude oil and natural gas sector by 215.74 mtcr or 8.47 percent per annum.

To minimize flaring, Government had undertaken a major gas flaring reduction program. Consequently, it is observed that in 1996-97, flaring was reduced to a minimum technical level.

In case of crude oil, capacity creation moved rather lowly in the 1980s; capacity utilization improved substantially particularly in early 1990s. During the period 1991-92 to 1996-97, both creation of capacity and its utilization improved substantially. While capacity increased by 9 percent, utilization clocked 106 percent in 1995-96, which was 100 percent in 1989-90. Due to technical improvement in capacity utilization, the growth rate of crude throughput also performed well at 58.6 percent in 1995-96, which was 4 percent higher than 1991-92.

Changes in final demand structure

Changes in final demand structure have been an important force behind the increase in energy consumption during 1991-92 to 1996-97. The findings reveal that the final demand changed by 336.89 mtcr or 6.9 percent per annum. The share of individual sectors are: 109.65 mtcr or 9.13 percent per annum for coal, 138.59 mtcr or 5.44 percent for crude oil and natural gas and 88.35 mtcr or 7.85 percent per annum for electricity in this respect.

The final demand structure was split into 5 heads like: a) macro structure of final demand; b) effects of changes in domestic demand; c) effects of changes in the structure of non energy exports; d) non energy imports and e) non energy change in stocks. The study observes that lions share goes to macro structure of final demand, i.e., 194.56 mtcr or 3.9 percent annually and the next immediate share leveled by the effects of change in the structure of domestic demand, i.e., 138.54 mtcr or 2.8 percent per annum. The positive effects of changes in the structure of domestic final demand on energy consumption has far reaching significance, as the growth of Indian economy is becoming more domestic demand driven. In case of coal sector, macro structure of final demand is greater (75.74 mtcr) than the structure of domestic demand (36.94 mtcr). But in case of crude oil sector, opposite consequences happened, i.e., 83.16 mtcr in domestic demand and 49.89 mtcr in macro structure of final demand.

The study notes that LPG is extracted from crude oil as well as from natural gas. LPG consumption grew at a rate of 14 percent per annum during 1985-86 to 1990-91, but the rate has declined to 9.7 percent in early 1990s. But during 1995-96, its consumption touched 3.84 MMT, which is 11.7 percent higher than the consumption in 1994-95. During 1996-97, the consumption of LPG touched

4.32 MMT. LPG production from natural gas is increased sharply. At present its share has increased to 52.7 percent. LPG is the most sought after cooking fuel in urban India. The domestic sector accounts for about 85 percent of LPG consumption in the country.

Sectoral Contribution

The total energy content of final demand consists of two components: (a) the direct deliveries of total energy sources of final demand; and (b) the energy content which is hidden in all goods and services of final demand.

On the crude oil side, the entire consumption of petrol is in the automobile sector, i.e., in cars and three or two wheelers. During 1995-96, consumption of petrol at 4.70 MMT was 0.56 MMT or 13.5 percent higher than 1994-95. During 1995-96, 3.44 lakh cars and 26.58 lakh two wheelers were sold in the country. Petrol consumption grew at a rate of 5.8 percent per annum during 1991-92 to 1996-97. Consumption of kerosene increased at an annual rate of 1.6 percent during the period 1991-92 to 1996-97. Diesel consumption in the country almost doubled in the 10 years during 1986-87 to 1996-97. It performed a growth of 7.3 percent per annum during this period. In 1996-97, diesel consumption at 36.35 MMT was 14.5 percent higher than the consumption in 1995-96. Retail sale of diesel accounts for three fourth of the total sales in the country. Diesel sold directly to railways, state road transport, defence and bulk sales to industry was around 25 percent of the total during 1996-97. Consumption of lubes and greases grew by almost 5 percent per annum. However, the first half of nineties witnessed a downward trend in lubes and grease consumption. The decline in consumption could be attributed to the marginal growth in production of lube oil by Indian refineries and the decline in imports.

Product group like textile product, petroleum products, chemical, basic metal etc. are the most leading sectors that increased energy consumption. Chemical, construction, transport, trade, basic metal, metal product and machinery textile increased the consumption of crude petroleum sector. The share of commercial energy consumed in the transport sector to the total commercial energy consumed has increased steadily, i.e., 110.28 mtcr. Consumption of oil in the transport sector gradually increased, i.e., 101.50 mtcr, mainly because of greater use of private modes of transport. Also oil gradually replaced coal as a fuel. This is evident from the declining share of coal from about 30% in 1970-71 to 5% in 1994-95, whereas the share of oil increased from 30% to 95% in the same period. This change is attributed to greater dependence on road transport, rail transport and shift from steam traction to diesel and electric traction. The share of oil products used directly for energy purpose is steadily declining while the use of oil for non-energy uses is increasing.

Change in Energy Imports

The reduction of energy consumption resulting from changes in energy imports was very small. It covers 4 mtcr during 1991-92 to 1996-97. The major portion was due to crude oil and natural gas sector in this respect. The gross import of petroleum during 1995-96 was at 20.30 mt which was 46 percent lower than 1994-95. This was the highest increase observed in recent years.

The decline in crude oil production since 1989-90 had resulted in higher imports. With the arrest of declining trend in domestic production in 1993-94, the growth in import of crude oil was also reduced. However, the share of imports in total availability peaked at 53.3 percent during the year. During 1994-95 and 1995-96, import of crude oil at 27.35 mt was 11.3 percent lower than the import in 1993-94. The share of imports too declined to 43.7 percent during 1996-97. During 1995-96 average import price of crude oil was 12 percent higher than that during the year 1996-97. Though imports during 1996-97 were similar in physical terms, they were higher by 13 percent in value terms.

Import of high speed diesel increased by 49 percent and that of LPG by 15 percent. In value terms, the POL imports at Rs 12578 cr was Rs 5056 cr. or 67 percent higher than the imports in 1994-95. Dependence on imports to fulfill the rising domestic demand for petroleum products saw a steep rise in the early 1990s. During 1990-91, the share of imports was 15 percent in the total consumption of petroleum products. This increased to 27 percent in 1995-96.

Kerosene is a deficit product; more than 54 percent of the requirements of the country were met by imports during 1996-97. During the year, consumption of kerosene was about 10.26 mt. Out of this about 5 mt was imported by public sector oil companies. The private sector imported 0.6 mt of kerosene during the year. Actually import of kerosene increased at an annual rate of 2 percent during the period 1991-92 to 1996-97.

Changes in Energy Stocks

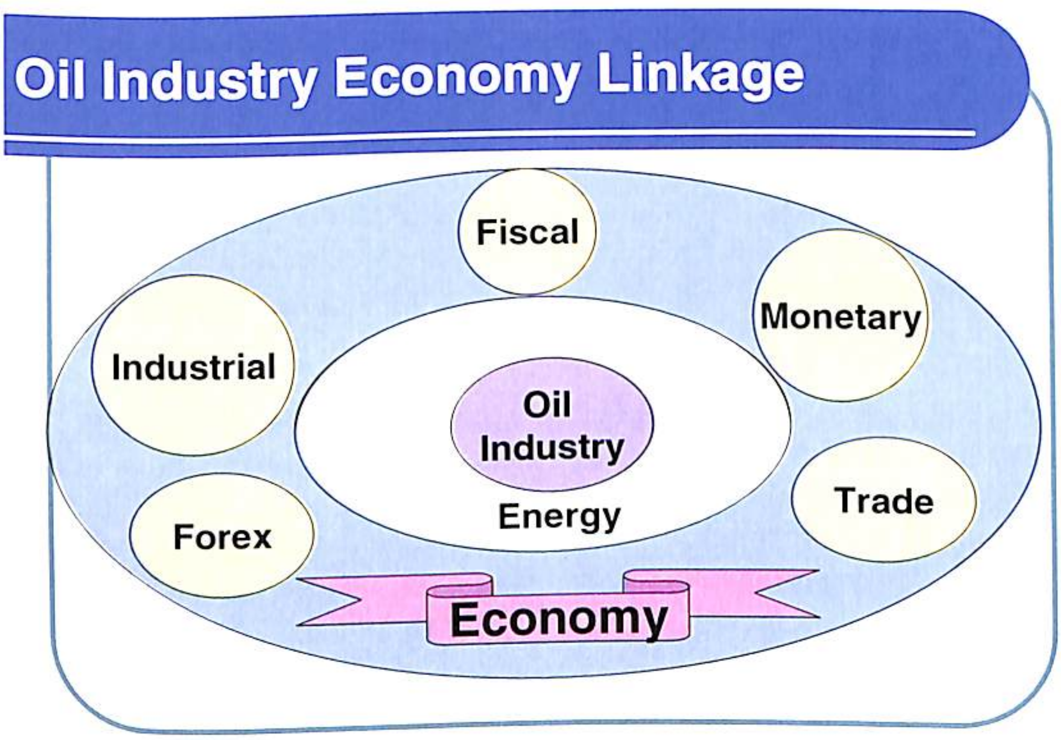
Change in energy stocks response in a similar fashion like imports. It had decreased energy consumption by 1.64 mtcr during 1991-92 to 1996-97. More or less an equal share observed in coal and electricity, but crude petroleum shared a little bit higher, i.e., 1.05 mtcr during the period.

Interaction Term of Technological Change and Final Demand Shift

The interaction term between technical changes and changes in final demand structure in 1991-92 to 1996-97 has increased energy consumption by 34.68 mtcr or reduced energy saving from the efficiency improvement. Major contribution is shared by crude petro sector as 49.99 mtcr or 1.96 percent per annum; but the other two sectors like coal and electricity reduced energy consumption by 12.27 mtcr and 3.32 mtcr respectively during the study period. As the final demand structure in case of crude petroleum sector helps to increase energy consumption but technical change follows an opposite path by reducing energy consumption and finally the latter one is entirely offset by the previous one. Thus a positive response in energy consumption is derived. (Mukhopadhyay *et al*, 2000)

Summary

Exhibit - 3



National policy documents treat 'oil industry' as one of the economic infrastructures. 'Refining' is a manufacturing activity. 'Transportation' and 'marketing' of oil are in the service sector.

To summarize, the functional and managerial knowledge of Oil Industry is very deep and there is a huge base of knowledge available in the Industry. The policy and strategy pertaining to Oil Industry is formulated, taking of course the ground level realities of the Industry on the one hand and macro economic policy direction on the other.

This chapter provides a very exhaustive review of literature on the Oil Industry from the perspective of policy and strategy, linking it to energy sector and national economy. This Chapter brings out linkage between oil price variation and inflation by highlighting the transmission mechanism of oil price variation. The Chapter also reviews India's response (in terms of monetary policy and balance of payment management) to series of oil price shocks experienced from 1970 onwards. This chapter thus provides the background to get further into the Oil Sector on policy front.

There is no comprehensive and consolidated work on the reform process in Oil Industry. No research has been undertaken to assess the impact of oil sector reform on the economy as a whole. There is little explicit analysis in published literature to explain the cause and consequence of reforms process in Oil Industry. Reforms in Oil Industry so far have not attracted academic interest. This thesis attempts to focus on these areas, where no analytical work has been done. Recently the Economic Advisory Council of Prime Minister was assigned to work on pricing of Oil & Gas, as the issues assumed the proportion of a crisis for the country.

This thesis attempts to build a framework where issues pertaining to oil sector reforms have been systematically and chronologically analyzed through the principles of economics and their consequences have been weighed against national economic interests. This thesis is therefore an addition to the literature on the subject, which would facilitate research based policy analysis and direction in the downstream oil sector in India.

Recap: Chapter II

Energy Consumption & Economic Growth

Energy consumption and economic growth are co-integrated. The long run causal relationship runs from GDP to energy consumption and the short run causal relation runs from energy consumption to GDP.

In the short run, commercial energy acts as engine of economic growth. It is a very important primary input in the aggregate production function.

Consumption of petroleum products is increasing at a rate of 5.6% per annum during last 30 years (1075 – 2005). It grew at 5.5% per annum during last decade (1995 – 2005), further got moderated to 2.8% per annum during last 5 years (2000 – 2005).

Trend in Consumption of Major Petroleum Products
(Percentage Annual Average Growth)

Period	No. of years	Petrol	Diesel	LPG	Naphtha
1975 – 2005	30	6.5	6.4	13.0	8.2
1995 – 2005	10	6.6	3.6	11.6	16.2
2000 – 2005	5	7.1	0.3	9.7	5.3

Impact of Oil price rise

20% increase in diesel price and 10% increase in petrol price can result in 0.5% reduction in GDP. Even when the oil price increase is not passed on to consumers, it has an adverse impact. Government or pool account has to finance it and that puts pressure on Government budget. Government investment may go down leading to reduction in demand.

A sustained US $ 5 per barrel increase in the price of oil leads to 1.3 percentage point increase in inflation after a year and reduces the annual GDP growth by 0.1 percentage point. However, the magnitude of such an impact crucially depends on the degree of monetary tightening and the extent to which consumers seek to offset the decline in the real income through higher wage increases and producers seek to restore profit margin.

A 3.8 percentage point positive shock in 'inflation in oil', ceteris paribus, translates into additional 0.25 point inflation in other commodities. Thus if the ceteris paribus shock in 'inflation in oil' is increased by 20 percentage points, 'inflation in other commodities' is likely to increase by 1.3 percentage points after five to seven months after the shock. The response, however, is crucially dependent on the output scenario and monetary policy. A dampened output scenario reduces the impact of the oil shock, obviating the need for monetary tightening. However, if output shock is also positive at the same time and control of inflation is the major policy objective, the situation demands monetary tightening to some extent. Following an oil shock, inflationary tendencies persists for about two years, although the magnitude of the impact reduces considerably by the end of the period. A 20 percentage point shock in 'inflation in oil' leads to an increase of 1 percentage point in 'inflation in other commodities' after a year.

In the absence of any countervailing policy intervention, every US dollar increase in crude oil prices could potentially add 15 basis points to WPI inflation as a direct effect and another 15 basis points as an indirect effect.

Oil Industry and External Sector Management

India's balance of payments remained comfortable in 1970s despite the first oil shock of 1973-74. The swift adjustment to the first oil shock was due to a combination of factors. There was basically a strong growth in exports of 11 percent in 1975-76 and of 19 percent in 1976-77 in volume terms due partly to a sharp increase in exports to oil exporting countries. The international trade environment was also supportive as the value of world trade rose by over 7 percent in SDR terms in these two years.

The scenario was in many ways different in the early 1980s. With the sharp escalation of crude oil prices brought on by the second oil shock in 1979, the pressure on the balance of payments intensified. Between 1978-79 and 1981-82, while imports increased by Rs 6,489 crore, POL imports increase by Rs 3,512 crore, accounting for a little over half of the overall increase in imports during the period. The deceleration in export growth further exacerbated the external payment position. Volume growth of exports was restricted to 3.3 percent, partly reflecting the severe international recession of 1980-83 and the accompanying stagnation of world trade.

The period 1982 to 1985 saw improvement in the external situation, when the import bill eased. The growth of imports fell from 14.7% during 1978-82 to a little over 2% during 1982-85. Domestic production of crude oil spurted from 16.2 MMT in 1981-82 to 29 MMT.

The balance of payment came under pressure in 1985-86. Oil imports, net of oil exports, in SDR terms went up from SDR 3,009 million in 1984-85 to SDR 3,361 million in 1985-86. There was a sharp drop to SDR 1,554 million in 1986-87 ranging around a little over SDR 2,000 million in 1987-88 and 1988-89. Although the consumption of POL has shown an annual increase of 6 to 7 percent and domestic production reached a plateau, the fall in crude oil prices helped to contain the oil import bill.

The successful management of external sector pressures in 1997 to 1999 was greatly aided by the coincidence of low international prices for Oil. Oil prices declined throughout 1997 and 1998 from a previous peak above $ 20 per barrel in late 1996 to a little over $ 10 per barrel at the end of 1998. India's Oil import bill declined from over $ 10 billion in 1996-97 to $ 8.2 billion in 1997-98 and $ 6.4 billion in 1998-99.

This good fortune changed in 1999, when Oil prices rebounded and continued to surge upwards, rising above $ 30 per barrel in the later half of 2000. Oil imports rose above $ 10 billion in 1999-2000 and to nearly $ 16 billion in 2000-01. Faced by this rising Oil import bill, the government followed a three pronged strategy. 1st, prices of petroleum products were revised upwards in three tranches within a twelve months period: in October 1999, in March 2000 and in September 2000. 2nd, recognizing that increases in domestic prices of Oil were unlikely to bring about the necessary adjustment in the trade deficit (essentially because of the low price inelasticity of Oil demand) and that the adjustment would have to come from other imports and exports, the authorities did not resist unduly the market driven depreciation of the exchange rate that occurred between April and November. 3rd, Government mobilized exceptional balance of payment financing. The mean deployed was the Indian Millennium Deposit (IMD) scheme. These resources certainly solved the confidence problem and helped take foreign exchange reserves to a new peak of $ 42.4 billion by end of 2000-01.

Challenges facing Oil & Gas Sector

a) ensuring crude oil and gas supplies in a constrained world market amidst rising price;
b) demand management of petroleum products;
c) rational pricing of petroleum products and natural gas;
d) removal of entry barriers for private players in distribution and retail business for creating real market competition;
e) regulation of upstream and downstream sectors,
f) improving administration of LPG and Kerosene subsidy and
g) environmental management through product up-gradation.