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Energy & Environment Linkages

V. Raghuraman

Energy is closely linked to economic development and environment quality. Though India ranks sixth in the world so far as the total energy consumption is concerned, it still needs much more energy to keep pace with its development aspirations. Energy scarcity is becoming a major barrier and could obstruct the stream of development. This paper critically examines the general as well as sectoral energy-economy linkages and prescribes policy measures in order to make the growth path sustainable. It also outlines the Clean Development Mechanism (CDM) potential in India, the exploration of which could fetch economy wide benefits by increasing the foreign direct investment, technology transfer and employment generation.

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In neo-classical production function, energy is considered to be a factor of production along with capital and labour. In global perspective, energy consumption and economic growth follow a vicious cycle, but increased energy consumption also leads to a negative externality – environmental pollution. Several empirical studies have established that for India, energy consumption uni-directionally causes economic growth (Masih & Masih, 1996; Adjaye-A, 2000; Ghosh, 2002) via the indirect channel of effective aggregate demand, improved overall efficiency and technological progress. So, proper policy framework needs to be evolved in the energy sector in terms of more investment, improved efficiency of use, diversification of energy supplies and cost-effectiveness of resource utilization for sustainable economic growth in an environmentally responsible manner.

Though India is rich in coal and abundantly endowed with renewable energy sources, its hydrocarbon reserve is really small (0.4 per cent of world's reserve). India, like many other developing countries, is a net importer of energy whose more than 25 per cent of primary energy needs is met through imports mainly in the form of crude oil and natural gas. The rising oil import bill has been the focus of serious concerns due to the pressure it places on scarce foreign exchange resources and it is also largely responsible for energy supply shortages. The sub-optimal consumption of commercial energy adversely affects the productive sectors, which in turn hampers economic growth.

If we look at the pattern of energy production, coal and oil account for 54 and 34 per cent, respectively, with natural gas, hydro and nuclear contributing to the balance. In terms of Co_2 emission, coal, oil and gas contribute 64, 30 and 6 per cent, respectively.

In the consumption front, industrial sector in India is a major energy user followed by transport and domestic sector. Low levels of income coupled with large disparities among various user groups and poor energy

Table 1: Ownership and Mode-wise Pattern of Installed Capacity (MW)

(As on 31-3-2002)

Ownership/Mode	Hydel	Steam	Gas	Diesel	Wind	Nuclear	Total	% Share
State	22636.02	36302.00	2661.70	582.89	62.86	0.00	62245.47	59.33
Central	3049.00	21417.51	4419.00	0.00	0.00	2720.00	31605.51	30.12
Private	576.20	4411.38	4082.40	551.94	1444.60	0.00	11066.52	10.55
Total	26261.22	62130.89	1163.1	1134.83	1507.46	2720.00	104917.50	100.00
% of Installed Capacity	25.03	59.22	10.64	1.08	1.44	2.59	100.00	

Source: Planning Commission

infrastructure have rendered India as one of the lowest per capita energy-consuming countries in the world as shown in Fig. 1.

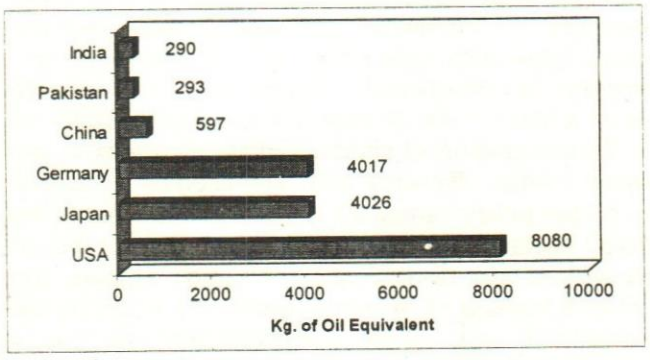

Fig. 1. Per capita energy consumption

Environmental pollution is the result of unsustainable economic activities of production and consumption. The five major environmental problems causing serious concern in India are air pollution, water pollution, pollution due to the disposal of industrial and municipal solid wastes, deforestation and soil degradation. All these problems are primarily caused due to the upward trends in mining, consumption of fossil fuels, industrialization and vehicle use. According to Central Pollution Control Board (CPCB) Data, air in most of the Indian cities has become highly polluted and the concentration of certain harmful pollutants exceeded World Health Organisation's (WHO) safety limits by large margins.

Sector-wise energy-environment linkages

Power Sector

Total Installed Capacity of electric power generating stations under utilities was 104917.5 MW as on 31-03-2002 consisting of 26261.22 MW hydro, 74428.82 MW thermal, 2720 MW nuclear and 1507.46 MW wind, detailed break up of which is given in Table 1. Indian power sector is facing challenges and despite significant growth in terms of technological sophistication and capacity addition over the years, it has been suffering from shortage and supply constraints. High transmission and distribution (T&D) losses and lack of demand side management (DSM) further aggravate the situation.

Power from coal

Widespread need of electric power generation has created the need for a cheap and readily available commercial fuel for generating electricity at low cost. Coal was the first to be selected in India as a commercial fuel in early thermal power stations and is still the king of the power market as shown in Table 1.

But coal is a messy and dirty fuel to handle and transport. It contains less energy per unit weight than oil and gas. Further, burning of coal creates a host of serious environmental problems requiring emission control and waste disposal. In India, the poor quality coal poses problems in design, operation and maintenance of the power plant equipment. The high ash percentage (35 per cent and above) of Indian coal demands high level of performance from electrostatic precipitators in order to keep the pollution of the surroundings by fly ash at acceptable levels. The low calorific value due to high ash content of the coal also creates problems in start-up and flame stabilization in the boiler and needs continuous addition of the secondary fuel (oil) which is very expensive. The high abrasive nature of the ash due to its high silica and alumina content leads to severe erosion of the equipment.

Total ash generated in India from power plants is presently about 95 million tonnes per year. Management of such huge quantity of ash would call for quantum jump in ash utilization from the present level of about 10-15 per cent. Norms for emission and disposal of fly ash should be structured liberally for the next 5 to 10 years till the power supply conditions improve. Environment concerns are no doubt vital but timing can be configured such that each phase of development matches the aspiration for a cleaner environment.

Ministry of Environment and Forests (MOEF), Govt. of India (GOI) brought out a notification requiring existing power stations to achieve full ash utilization in 15 years time and new units in 9 years time. Achieving full utilization level of ash in such a time frame is a big challenge before the power plants.

Power stations will gain a lot if they use beneficiated coal for power generation. MOEF through its notification has made mandatory the use of beneficiated coal having ash less than 34 per cent for all power stations, located at a distance of 1000 km from the mine and/or located in sensitive/critically polluted zones. The power plants using Fluidized Bed Combustion (FBC) and Integrated Gasification Combined Cycle (IGCC) technologies are exempted from using beneficiated coal, irrespective of their locations. CPCB has also suggested third party and pithead coal washing. It is estimated that pithead coal washing will increase the cost only by 2 to 3 per cent.

Power stations will gain a lot if they use beneficiated coal for power generation.

In 2001-02, energy and peak load shortages were 7.5 and 12.6 per cent, respectively, and according to Central Electricity Authority (CEA) estimates these shortages will be ballooning day by day as GDP growth accelerates to an ambitious 8 to 10 per cent. Under such circumstances, imaginative repositioning of the power sector is the need of the hour to double the existing capacity by 2012 in order to meet the higher growth trajectory and also accomplish the targeted mission of "Power for All" by 2012.

The Ministry of Power (MOP) has drawn up a Blueprint of action to realize the targets. The notable feature of the strategy is the marked deviation from the traditional supply side bias with undue stress on adding generation capacity to an integrated development encompassing all the aspects of generation renovation, modernization, transmission, distribution, demand side management and energy conservation. The action plan also includes private sector participation and thereby brings competition by restructuring the monolithic State Electricity Boards (SEBs) to enable consumers to get best service at affordable prices.

Future choice of technology for power generation crucially depends on current and future trends of environmental regulations, availability of low-cost fuel on a long-term basis, plant efficiency and costs of the technology. Since India has a vast coal reserve, it is expected that power generation from coal will continue to maintain its share in future. But in order to achieve higher thermodynamic efficiency, minimizing environmental impact and cost effective utilization of high ash Indian coal, MOP is focussing on coal benefeciation, pit head power generation, cheap imported coal for coastal power plants, super critical technologies, IGCC, heat rate improvement programme in the power plants, fly ash management and scaling up of the power plants. Power generation from other environmentally clean sources like Compressed Natural Gas (CNG). Nuclear and Renewables are also getting proper emphasis.

Table 2: India's Perspective Plan for Electric Power for Zero Deficit Power by 2011/12

(power on demand)

	Thermal (Coal) (MW)	Gas/LNG/ Diesel (MW)	Nuclear (MW)	Hydro (MW)	Total
Installed capacity as on March 2001	61,157	Gas: 10,153 Diesel: 864	2720	25,116	100,010
Additional capacity	53,333	20,408	9380	32,673	115,794
Total capacity as on March 2012	114,490 (53.0%)	31,425 (14.6%)	12,100 (5.6%)	57,789 (26.8%)	215,804

Source: Planning Commission

Hydropower

Share of hydropower, despite being recognized as clean and economically cheep source of energy, has been declining over the years due to large gestation periods, environmental problems associated with big dams, interstate dispute, resettlement problems of the local inhabitants, NGO protests etc. So far, only 15 per cent of the hydro potential have been harnessed and 7 per cent is under various stages of development. Thus, remaining 78 per cent of the potential remains untapped. The utilization of hydropower in India is much lower than in countries like Norway (58%), Canada (41%) and Brazil (31%). MOP has taken proactive role to accelerate the capacity addition from hydroelectric projects.

Renewables & Rural Electrification

Being a tropical country, India is abundantly endowed with renewable energy sources in the form of solar, wind, biomass and small hydro. Now-a-days, several renewable technologies are not only commercially available, but are also economically viable in comparison to the fossil fuels, particularly when the *negative environmental externalities* associated with the fossil

fuels are taken into account. With a strong industrial base and successful commercialization of technologies in wind, solar photovoltaics, solar thermal, small hydro and bio-energy, India today is in the forefront of international effort to harness renewable energy resources.

In the area of power generation about 3 per cent power-generating capacity based on renewable energy has been installed in the country and 90 per cent of the investments have come from the private sector. The potentials of various renewable energy sources with the current figures are outlined in Table 3.

Table 3: Renewable Energy Potential & Achievement

Source/Technologies	Unit	Approximate Potential	Status
Power from Renewable:			
Wind	MW	45,000	1,507
Small Hydro	MW	15,000	1663
(upto 25 MW)			
Biomass/	MW	19,500	343
Bagasse based co-generation			
Solar PV Power	MW/Sq. Km.	20	47
Energy Recovered from Wastes:			
Urban & Industrial	MWe	1700	15.15
Waste			
Energy for Rural Area:			
Biogas Plants	Nos.	12 Million	3.128 Million
Improved Chulha	Nos.	120 Million	32.89 Million

Source: Ministry of Non-conventional Energy Sources (MNES) & Planning Commission.

India is planing to add about 12,000 MW power generating capacity from renewables by the end of the 11th Plan. Almost half of it will come from wind, 3500 from biomass and 2000 MW from small hydro. Renewables can play a major role in rural electrification. In India, 80,000 villages are not electrified as of now, 18,000 of such villages, mostly in remote far-flung areas, can only be electrified by using renewable resources since it is not economically viable to connect through conventional grid system.

Rural people are often not in a position to afford the cost of electricity and they meet their basic energy needs through the use of energy sources like firewood, cow dung, agricultural residue and kerosene. However, inefficient exploitation of these resources led to environmental degradation. Power from renewables would reduce the consumption of kerosene (for lighting) and diesel (for lighting and irrigation) used in rural areas, leading to reduction in imports, which have macro-economic benefits.

There exists a close linkage between carbon trading and renewable energy market development. Analysis shows that renewable energy technologies are among the low cost options for carbon mitigation. In the next decade carbon trading could push renewable technology.

There exists a close linkage between carbon trading and renewable energy market development.

Transmission & Distribution

In the T&D side, it is believed that establishment of national grid, higher distribution voltage line (11 KV and above), distribution circuit phase balancing and installation of energy efficient distribution transformers like amorphous core transformers would reduce the various technical and non-technical losses in the system. Higher emphasis should be given on demand side management to reduce the wastage of electricity by introducing policies for promoting sustainable markets for energy efficient appliances; removing subsidies in agriculture and domestic sector; labeling and benchmarking of appliances; 100 per cent metering for all consumers combined with utility and information management system and electronic metering system for time of day metering. All these measures could significantly reduce the demand for electricity and thus level of environmental pollution due to the avoided power plants without affecting the end-use benefits.

Industrial Sector

India, like many other developing countries, has been experiencing a high pace of industrialization. The industrial sector in India is a major energy user, accounting for about 52 per cent of the commercial energy consumption.

Energy Intensity

The historical data on energy intensity for some of the developed countries (e.g. Germany, France, UK, USA etc.) revealed that initially, these countries' energy intensity had increased because of the development of heavy industries and infrastructure, then peaked and finally began to decline due to

- shifting from non-commercial to commercial energy;

- more efficient use of commercial energy;
- substituting fossil fuels by electricity in many cases and
- shifting emphasis to the service sector

In most of the developing countries, energy intensity has been increasing as expected, since they have embarked on the path of growth and relied heavily on the development of infrastructure and heavy industries. Unfortunately, energy intensity in India is one of the highest in comparison to other developed and developing countries. For example, it is 3.7 times of Japan, 1.55 times of USA, 1.47 times of Asia and 1.5 times of world average. Thus, there is a huge scope for energy conservation and efficiency improvement programmes in the country.

Energy Efficiency

Energy efficiency involves efficient utilization of resources, which is a key to sustainable development. It is a measure of productivity provided per unit of energy consumed. Improving energy efficiency increases productivity, significantly reduces Green House Gas (GHG) emissions, reduces solid waste production and thermal pollution.

Policies and programmes that have been used in countries worldwide to improve efficiency in the energy sector can be classified as:

- Good house keeping practices
- Regulation and/or Standards
- Industrial cogeneration
- Fuel switching
- Fiscal policies like taxes, tax rebates, subsidies etc.
- Agreement/Targets
- Benchmarking
- Energy audits
- Information dissemination and demonstration and
- Research and development.

Industrial sector in India, despite *Win-Win* situation, did not pay much attention to the energy efficiency improvement programme due to three main reasons:

- Most of the manufacturing units still depend on old machinery
- Relatively high cost of capital as compared to European/USA standards.
- Uncertainty about the long-term growth of the particular industrial sector.

In India, energy intensive industries namely fertilizers, aluminum, textiles, cement, iron and steel, pulp and paper, and chlor-alkalis consume around 65 per cent of total industrial energy. A recent World Bank report shows that Indian Industry has the potential to save 20 to 30 per cent of total energy consumption. Table 4 indicates the average energy conservation potential in various energy intensive industries.

Table 4: Energy Saving Potential

Industry	Energy Saving Potential
Iron & Steel	10%
Fertilizers	15%
Textiles	25%
Cement	15%
Chlor-alkali	15%
Pulp & Paper	25%
Aluminium	10%
Ferrous Foundry	20%
Petrochemicals	15%
Glass & Ceramics	20%
Refineries	10%

Source: CII Newsletter, Dec. 2000

On the pollution control front, CPCB had identified a total of 1551 medium and large industrial units under the seventeen highly polluting industrial sectors (as of June 30, 2000). Of these about 77 per cent were predominantly water polluting, 15 per cent predominantly air polluting and remaining 8 per cent of the industries were potentially both air and water polluting. Out of 1551 units, 1324 have provided the requisite pollution control facilities, 165 units have closed and 62 units are defaulting.

Energy Conservation Act

The enactment of the Energy Conservation Act, 2001, spells out the roadmap for the country to move up the energy efficiency ladder and would radically change the approach towards energy conservation efforts. The Energy Conservation Act aims to focus on the enormous potential for reducing energy consumption by adopting energy efficiency measures in various sectors of the economy.

Table 5: Projection for Energy Demand for Cooking & Lighting

Fuel	2006/07	2011/12
LPG (in MT)	9.62	13.23
Superior Kerosene Oil (MT)	6.69	5.57
Coal (MT)	1.98	2.22
Charcoal	2.76	3.13
Nat. Gas (MCM)	304	347
Fuel wood (MT)	174.34	171.14
Dung cake (MT)	97.44	100.04
Crop waste (MT)	63.16	67.87
Biogas (MCM)	1902	2274

Source: Planning Commission

The Act provides statutory measures to establish a statutory authority called the **Bureau of Energy Efficiency**. The Bureau will be established by merging the existing Energy Management Centre to effectively coordinate with designated consumers and agencies for performing functions necessary for efficient use of energy and its conservation.

The Act also confers upon the Central Government, State Governments and the Bureau, certain powers to enforce measures for efficient use of energy and its conservation. There is provision for compulsory annual energy audit of large consumers.

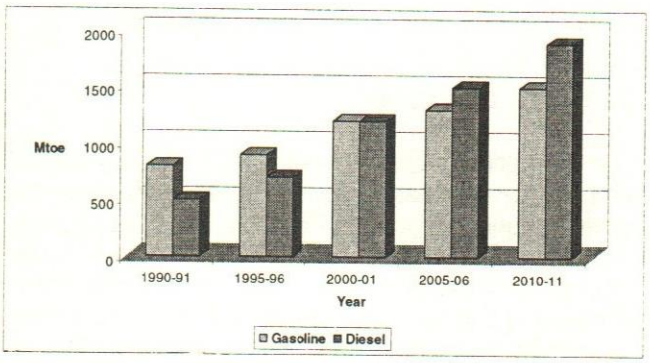

Fig. 2. Fuel-Wise consumption in transport sector

Transport Sector

The projected energy demand in four Indian cities viz. Delhi, Kolkata, Mumbai and Bangalore are 1614, 343, 711 and 663 mt respectively in 2010-11 (Bose, 1998). Fuelwise consumption pattern is depicted in Fig. 2. The Indian metropolises are facing major environmental crisis due to the growing air pollution and Green House Gas (GHG) emissions caused by fuels used in vehicles.

It is reported that transport sector contributed most of the pollution load (27 per cent No_x, 74 per cent carbon monoxide [CO], 11 per cent Volatile Organic Compound and 100 per cent lead) in the urban areas (Parikh & Parikh, 2000). Vehicular emission load in selected metropolitan cities is given in Table 6.

Table 6: Estimated Vehicular Emission Load in Selected Metropolitan Cities

Name of the city	Vehicular pollution load (tonnes per day)					
	Particulates	Sulphur dioxide	Oxide of the Nitrogen	Hydrocarbons	Carbon monoxide	Total
Delhi	10.30	8.96	126.46	249.57	651.01	1046.30
Mumbai	5.59	4.03	70.82	108.21	469.92	659.57
Banglore	2.62	1.76	26.22	78.51	195.36	304.47
Calcutta	3.25	3.65	54.69	43.88	188.24	239.71
Ahmedabad	2.95	2.89	40.00	67.75	179.14	292.71
Pune	2.39	1.28	16.20	73.20	162.24	255.31
Chennai	2.34	2.02	28.21	50.46	143.22	226.25
Hyderbad	1.94	1.56	16.84	56.33	126.17	202.84
Jaipur	1.18	1.25	15.29	20.99	51.28	88.99
Kanpur	1.06	1.08	13.37	22.24	48.42	86.17
Lucknow	1.14	0.95	9.68	22.50	49.22	83.49
Nagpur	0.55	0.41	5.10	16.32	34.99	57.37
Grand Total	35.31	29.84	422.88	809.96	2299.21	3597.20

Source: Central Pollution Control Board, New Delhi "Urban statistics", October, 1996, Town and Country Planning Organisation, Ministry of Urban Affairs and Employment, Government of India.

Following are the main factors of vehicular pollution:

- Many vehicles are in poor condition, creating more particulates and burning fuel inefficiently. Certain types of engines, such as two-stroke engines are inefficient with respect to four-stroke engines and emit hydrocarbon and smoke at a much higher rate.
- Lower quality fuel used, lead to the emissions of far greater quantities of pollutants.
- Motor vehicles are concentrated in a few large cities.
- Lack of public transport and travel demand management and shifting from rail to road transport
- Bad road condition and poor infrastructure

Important steps taken for vehicular pollution control are as follow (PARIVASH, 2001)

Vehicle Technology & Emission Norms

- Bharat Stage-II emission norms for new private non-commercial vehicles were made effective in Mumbai from 01.01.2001 and in Chennai and Kolkata from 01.07.2001.
- Bharat Stage-II emission norms for new commercial vehicles implemented in NCT-Delhi, Mumbai, Kolkata and Chennai from October 2001.
- Introduction of 4-stroke two wheelers replacing 2-stroke two wheelers increased in 2001.

Fuel Quality

- Gasoline sulphur content reduced to 0.05 per cent from 0.1 per cent max. in Greater Mumbai from 01.01.2001 and in Chennai from 01.07.2001.
- Diesel sulphur content reduced to 0.05 per cent in NCT-Delhi from 01.03.2001, in NCR from 30.06.2001, in Greater Mumbai from 01.01.2001, in Kolkata and Chennai from 01.07.2001.

Alternative fuels & Vehicles

- Emission norms for CNG & LPG powered vehicles notified during 2001.
- Number of CNG dispensing stations increased to 87 in Delhi.
- Number of registered CNG vehicles in Delhi increased during the year.

Auto Fuel Policy

- An Inter-Ministerial Task Force on Vehicular Emission Norms & Fuel Quality, headed by the Chairman, CPCB, submitted its report in March 2001. The Task Force recommended that Bharat Stage-II emission norms be implemented all over the country and Bharat Stage-III norms be implemented in seven mega cities by 2005. Also, the Task Force recommended that time limit for extending Bharat Stage III (EURO-III equivalent) norms throughout the country may be decided within one year.
- An Expert Committee on "Auto-Fuel Policy" was constituted during November 2001 under the Chairmanship of Director General, Council of Scientific & Industrial Research. The Committee submitted its interim report on 31.12.2001. The Committee recommended that Euro-II/Bharat Stage-II norms be implemented throughout the country and Euro-III norms be implemented in seven mega cities from 2005 and Euro-III norms be enforced all over the country by 2010.

Following policy prescriptions need to be implemented for efficient and environmental friendly transport system:

- Travel demand management
- Introducing efficient mass transport
- Discouraging private transport
- Integration and co-ordination among road, rail and water transport
- Clearance of road encroachment
- Adequate supply and proper infrastructure development for clean fuels
- Stringent emission norms leaving choice of fuel on market forces
- Periodic road maintenance
- Energy efficient engines
- Traffic signals synchronization
- Creation of high occupancy vehicle lanes
- Congestion charges and area licensing to reduce vehicular density in core areas

Residential Sector

In 1998, the average per capita income in India was only 430 dollars with respect to the world average of 4890 dollars. Commercial fuels meet around 60 per cent of the residential energy needs while the remaining 40 per cent continues to be met by traditional energy forms.

Energy demand in the residential sector has been increasing significantly in India as a result of higher disposable income, changing lifestyle and patterns of energy consumption. Energy consumption patterns vary widely not only among rural and urban areas but also across various income categories. The levels and forms of fuel consumed by the households depend on income level, location, price, availability and accessibility of fuels, and efficiency of the end-use equipment. It is generally observed that with higher per capita income, households tend to move towards cleaner, more expensive, convenient and efficient fuels. Energy gadgets are becoming more and more popular in the households for recreation and comfort. Setting energy consumption standards along with energy labeling in these gadgets and appliances proposed in Energy Conservation Act will set the trend. Table 5 gives projected energy

demand for households, cooking and lighting in 2006-07 and 2011-12.

The poor are major victims of environmental degradation and at the same time they pay substantially higher price for energy services than any other group in the society in terms of time, labour and health. Since poor are largely dependent on natural resources for their survival, depletion of natural resources, large population growth and lack of income generating activities further increases poverty.

Indoor Air Pollution

It was estimated that 82 per cent of So_2, 38 per cent of No_2, 88 per cent of volatile organic compound (VOC) and 96 per cent of particulate matter emission in India come from the household sector (Parikh & Parikh, 2000). Women, children and older generation, who spend most time indoors, are badly affected. Major reasons for indoor air pollution are inefficient burning of inferior fuels like cow-dung, agricultural residue, coal and fuel wood, along with poor ventilation system inside the house. The use of agricultural residue and dung as energy sources instead of fertilizers also reduce the soil nutrient level. According to a Tata Energy Research Institute (TERI) study, particulate matter concentrations in kitchens due to the burning of bio-fuels are known to be as high as 30 times the WHO standards while concentrations at the workplace for primary workers can be as high as 12 times the WHO standard. The outdoor concentrations of particulate matters are about 2.5 times the WHO standard in urban and rural India, and 8 times the standard in slums in India.

Particulate matter concentrations in kitchens due to the burning of bio-fuels are known to be as high as 30 times the WHO standards.

Indoor air pollution from traditional fuels causes at least four major categories of illness: acute respiratory infections in children; chronic obstructive lung diseases such as asthma and chronic bronchitis; lung cancer; and still births and other problems at birth.

Using total exposure method, which is supposed to be a superior measure, Saksena & Dayal (1997) predicted that the health impacts due to PM10 (respirable particulate matter) are likely to be 4 times higher at the national level and 2.5 times higher in Delhi than those predicted by an earlier study using ambient concentration levels. If the WHO standard for air quality is met, they estimated that the economic gains for each urban dweller would range from $17 to $43 and could be as high as $57 to $211 for each slum dweller.

The only solution to get rid of indoor air pollution could be interfuel substitution from inferior fuels to cleaner fuels like kerosene and LPG. Although kerosene and LPG are highly subsidized to meet certain social objectives, the access to these commercial fuels is still poor due to lower income and inadequate distribution network. Government should strengthen the PDF system for kerosene and innovative financing mechanism for LPG for better access. Government should also reorient and widen the improved cook-stoves and community size biogas programme. Solar lighting could be a clean option for remote rural households. This will result in an estimated saving of Rs 26758 million annually on subsidy to kerosene, which can be used to subsidize solar lanterns, according to a study conducted by TERI.

Some Policy Issues

Establishment of market determined prices for energy is critical if financing is to be made available to maintain facilities, establish new capacity in the energy sector and to support effective transport mechanisms to move energy to users in a sustainable manner. Energy prices in India have been under the administered regime that was based on covering the cost of supply plus a specified rate of return to products. The Administered Pricing Mechanism (APM) has led to distortion and inefficiency in the use of different sources of energy. Government has taken serious steps to deregulate the energy price from APM regime. The prices of coal and petroleum have already been deregulated. In the electricity sector, most of the SEBs have started reform measures and regulatory commissions have been set up to determine tariffs based on economic rationale.

Since energy sector in India is dealt with by several ministries, there is a need for coordination and integration among these ministries. Reform in power sector, for example, is suffering from the lack of progress in coal reforms while coal movement suffers from the lack of tariff rationalization in the railways. For smooth operation of the energy sector, there should be a well-established institutional framework consisting of regulatory agencies, the rules and regulations of the sector and policy guidelines. The regulatory agency should have international experience, independence (free from political pressure and from market forces), accountability, autonomy and expertise on technology, economics, law and accounting.

Macroeconomic policies sometimes encourage environmental degradation. Environmentally harmful subsidies reduce the private costs of producers and consumers resulting in over-utilization of natural resources. Energy subsidies in India, which is approximately 1 per cent of national income, lead to energy intensive economic structures and technologies, and wasteful management practices (Ghosh, 2001). In petroleum sector subsidized prices of diesel and kerosene encourage fuel adulteration and diesel power generation, which ultimately contribute to environmental pollution. It has been estimated that the elimination of energy subsidy worldwide would reduce global carbon emission by 9.5 per cent. A study by the International Energy Agency of the OECD in 1999 on the under pricing of electricity in China, India, Indonesia, Iran, Kazakhasthan, Russia, South Africa and Venezuela, found that reducing price subsidies in India would reduce primary energy consumption by 13 per cent, increase GDP through higher economic efficiency by 1 per cent, lower CO2 emissions by 16 per cent, produce domestic environmental benefits including lower local air pollution. Further, a World Resources Institute (WRI) study says that by the late 90's, bilateral banks made up largely of Export Credit Agencies (ECAs) which accounted for 31 per cent of all long-term financing received by developing countries, appeared to be investing heavily in projects resulting in long-term consumption and ultimately associated with environmental degradation.

On pollution control front, India has relied heavily on Command and Control (CAC) techniques. However several empirical studies have demonstrated that CAC instruments are cost inefficient and sub-optimal in terms of social welfare maximization, i.e., they do not in general yield production-pollution-abatement outcomes which equate the social marginal benefit of abatement with its social marginal cost. As a result, direct regulations are being gradually supplemented by Market Based Instruments (MBI) and taxation is increasingly used with the purpose of achieving environmental improvements. MBI may also create incentives for finding least cost technologies and measures for prevention and control of pollution (Mehta et. al., 1997). However, in most of the cases, due to the influence of industry lobby group the taxes are set too low to have any desired effect.

CAC instruments are cost inefficient and sub-optimal in terms of social welfare maximization.

More recently while countries in Europe have introduced MBIs mainly in the form of charges, the USA has gone ahead with economic instruments in the form of tradable pollution permits (Stavins 2002).

USA Experience

1. The lead-trading programme, developed in the 1980s, allowed gasoline refineries greater flexibility in meeting emission standards at a time when the lead-content of gasoline was reduced to 10 per cent of its previous level. The programme was successful in meeting its environmental targets and EPA estimated cost savings of about $250 million per year. Furthermore, the programme provided measurable incentives for cost saving technology diffusion.
2. The most important application made of a market based instrument for environmental protection has arguably been the So_2 allowance trading programme for acid rain control, established under the Clean Air Act, 1990, and intended to reduce emission by 10 million tonnes below 1980 levels. A robust market of bilateral So_2 permit trading has emerged, resulting in cost saving on the order of $1 billion annually, compared with the costs under some CAC regulatory alternatives.

It should be noted that regardless of the choice of the instruments or any combination of them, all require monitoring and enforcement. Unfortunately, the enforcement of environmental regulations in most developing countries is generally weak, frequently relying on self-regulation and warnings.

Clean Development Mechanism (CDM)

Sectoral share of Co_2 emissions in India is depicted in Fig. 3. India is among the top 10 contributors to GHG emissions, despite its per capita emissions being only one-sixth of the world average. Since coal, which has the highest Co_2 emission coefficient, will dominate its share in the future, India needs to adopt clean and energy efficient technologies to reduce its GHG emissions. But there is a problem in getting finance for these technologies. CDM, included in the Kyoto Protocol can help a lot to overcome the situation.

India has significant CDM potential in hydro and biomass energy; cleaner fuels in transport; energy efficiency projects; forestry; development of natural gas infrastructure and co-generation projects. Credit Rating Information Services of India Limited (CRISIL) conducted a study to examine the range of possibilities and investment potential or CDM in India. The top-down analysis shows that CDM could account for between 397-503

MMtC of emissions reduction in 2010. The corresponding CDM flows could be between $5.2-17.4 billion. India could collect between 7-12 per cent of the total global market for CDM-led investment (Joshi, 2001).

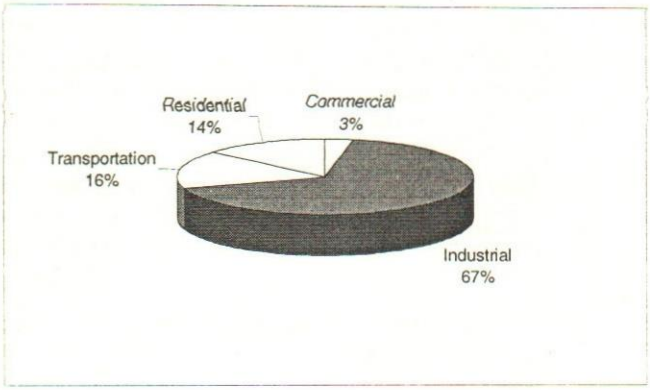

Fig. 3. Sectoral share of Co_2 emissions

To initiate a process of learning by doing, India has hosted several Activity Implemented Jointly (AIJ) projects, which has been supported by several foreign governments, especially from the USA, Norway, Japan and the Netherlands. This shows the interest of developed countries to explore the sub-continent's great CDM potential. The USA has announced a $ 45 million programme for clean energy and global climate change in India despite Washington's unwillingness to ratify the Kyoto Protocol.

The framework of CDM enshrined in the Kyoto Protocol gives Indian industry the opportunity to achieve reduction in greenhouse gas emissions taking advantage of the markets for trading reductions in such emissions. A number of trading systems are active in North America and Europe and a variety of mechanisms for trading carbon emissions have been emerging worldwide.

Conclusion

Energy is closely linked to economic development and environment quality. Significant growth in energy consumption in developing countries will be both essential and inevitable in the coming decades in order to support their development aspirations. But increased energy consumption will also lead to the degradation of environment, which should be taken as a matter of serious concern. A proper understanding of linkages among energy, environmental activities and macro-economic variables is crucial for the planning and implementation of a nation's future sustainable strategy. In this regard, it is important to isolate and calculate the environmental costs associated with energy related activities and include that cost in the price of energy. In the absence of such internalization, energy pricing will not reflect its true cost.

Market determined energy pricing would significantly restructure the energy consumption basket towards a clean and efficient energy mix. India needs proper initiatives to promote its energy portfolio diversification, integrated resource planing and energy conservation and efficiency improvement programmes, which will not only meet the country's future energy demand for rapid economic growth, but also protect the environment in a sustainable manner.

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Technology Cooperation in Energy Efficiency

S. Padmanaban

This article deals with the complex precesses involved in technology cooperation and transfer. Stress is laid on the need for hard research on the factors leading to successful energy efficiency programmes. Measures are proposed for improving technology cooperation in energy efficiency.

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Technology Co-operation

Technology cooperation and transfer mechanisms vastly depends upon the status of the technology under consideration. Energy efficient, environmentally sound technologies span a broad spectrum, ranging from embryonic and pre-commercial systems to economically viable and commercially proven technologies. Market-oriented policy and regulatory reform are key to the adoption of technology cooperation and transfer mechanisms. The variety of technology cooperation methods is illustrated by choosing embryonic technologies requiring innovative cost and risk sharing mechanisms to accelerate their transition from the laboratory to the market place such as advanced combustion systems, superconductivity, fuel cells and the hydrogen economy; recently commercialized systems with limited market penetration such as efficient lighting, heat pumps and energy management control systems; and, commercially available, proven and economically viable hardware such as co-generation, waste heat recovery systems and efficient electrical motors.

A process of technology cooperation and transfer will require that the gains to all parties are seen as mutually beneficial and that partnerships are symmertrical. The foundation of these partnerships should be grounded in the realities of the marketplace. Nonetheless, market barriers and imperfections abound, and market reforms, both international and locally, will take years to accomplish. Technology cooperation and transfer mechanisms should address barriers such as inadequate capital, distorted pricing, and lack of knowledge and information. Fortunately, there have been significant lessons learned from over two decades of experience in technology transfer and cooperation.

Energy Efficiency: Scope and Potential

The energy sector in India is a good example to

demonstrate technology development and commercialisation including partnerships that foster technology cooperation between developed and developing countries. Furthermore it is critical to economic development and its impact on the local and global environment. Currently India generates approximately 547 billion kWh of electricity from an installed capacity of over 108, 150 MW. Annual coal production is 230 million tonnes and oil production is approximately 23 million tonnes. Annual production of natural gas, a very recent entry into the country's energy supply picture, is approximately 18 billion cubic metres. Future energy demand in India is substantial as the numbers below indicate for the year 2012 – barely a decade away:

- A 120 per cent increase in annual oil production at 50 million tonnes;
- Almost 250 per cent increase in annual coal production at 600 million tonnes;
- Doubling of natural gas production at 100 million cubic metres per day

This extraordinary growth in demand will place great pressure on the financial, managerial and physical resources of the country, creating capital and energy shortages as well as environmental problems. The latter has important global climate change implications since India is the sixth largest emitter of green house gas emissions in the world while having the second largest emissions growth rate. Notwithstanding this, the country's per capita carbon emissions are relatively low. In 1999, India emitted 0.25 metric tons of carbon per person, approximately one quarter of the world average and 22 times less than the United States. However, the intensity of energy use, defined as the amount of energy consumed per unit of product value added in many sectors of Indian industry is high by international standards. This signifies the need and potential for energy conservation in the Indian economy.

Industrial Sector

Industries account for over 50 per cent of the total commercial energy consumed in India. The total industrial energy consumption, including non-energy uses, grew from 45.7 MTOE (million tones of oil equivalent) in 1984/85 to 113.1 MTOE in 1996/97. Of the commercial sources of energy, coal and lignite contribute about 57 per cent, oil and natural gas 33 per cent, hydroelectric power 3 per cent, and nuclear power 0.2 per cent. More than two-thirds of the total industrial energy is consumed in the steel, caustic soda, textiles and the paper industry sub-sectors. In addition it is estimated that these sub-sectors are also responsible for about 40 per cent of the total national environmental impact.

Several reports published since the early eighties have identified the need to improve energy efficiency in the industrial sector. This would have the twin impact of reducing specific energy consumption and limiting the impact of industrial activity on the environment.

Iron and steel

The iron and steel industry is the largest consumer of energy in the industrial sector accounting for almost 10 per cent of the total energy in the country. Energy costs constitute 30 - 35 per cent of the total production costs of iron and steel. The process of making iron in blast furnaces accounts for nearly 70 per cent of the total energy consumption at the plant. Although substantial energy conservation measures have been adopted in integrated steel plants in India, their performance is sub-standard compared to other countries. The phasing out of open-hearth furnace for steel making, and the more rapid introduction of continuous casting plants will improve the energy efficiency in the sector. In the case of mini-steel plants, the small size of furnaces and erratic power supply has led to high electricity consumption which range from 500 to 880 kWh/tonne of crude steel.

The iron and steel industry is the largest consumer of energy in the industrial sector.

Chlor-alkali

The Chlor-alkali industry companies comprise mainly caustic soda, soda ash and chorine manufacturing plants. At present, there are 40 caustic soda and 7 soda ash plants operating in India. Out of these, 17 plants have the membrane cell process, 9 plants have the mercury and membrane cell processes, 12 plants have only the mercury cell process, and 1 has the diaphragm process, which is being phased out. Energy accounts for 50 - 65 per cent or more of the total cost of production. The overall specific energy consumption of Indian caustic soda industry has varied from 2.3 to 3.5 giga calories per tonne, which is substantially higher than international norms.

Textiles

The textile industry account for 9 per cent of the total commercial energy-use in India. With a total installed capacity of 21 million spindles, energy in the form of coal, electricity, and furnace oil accounts for an

estimated 12 - 15 per cent of the total cost of production. Coal and furnace oil are used for process heat requirements and an estimated 80 - 90 per cent of the electricity used in textile industry is motive power for spinning mill drives.

Pulp and paper

The pulp and paper industry is the sixth largest energy consumer in the country with energy costs constituting 30-35 per cent of total manufacturing costs. As compared to the larger mills, which are more efficient and have low costs of production, the smaller mills do not have chemical recovery systems and cogeneration, thus making them less efficient and increasing the production costs.

Aluminum

Aluminum production is a highly energy intensive process, with energy accounting for nearly 40 per cent of the production cost. While electricity constitutes 80 per cent of total energy-use, coal and fuel oil are also used. The ninth plan projected a 8 per cent growth in demand for aluminum in response to which installed capacity in the country increased from 670,000 tonnes to 714,000 tonnes.

Cement

India is the third largest cement producing country in the world. Energy accounts for about 40 per cent cost of production with coal as the main source of energy for cement production. For dry process plants, the thermal energy consumption ranges between 720 and 1000 kcal/kg of clinker and the power consumption is 86-143 kcal/tonne of cement. Energy consumption norms in Indian cement industry compare very favourably with international companies.

Domestic Sector

Forty per cent of India's household energy needs are met by traditional bio-fuels and 90 per cent of rural households depend primarily on these fuels. In urban households, particularly in the higher income classes, there is a decline in consumption of bio-fuels which is accompanied by growth in consumption of LPG (liquefied petroleum gas), kerosene, and electricity by about 9 per cent, 3 per cent and 11 per cent a year, respectively. Around 40 per cent of the energy needs of Indian households continue to be met by traditional energy forms. This is particularly true of rural households, 90 per cent of which are still dependent on biomass fuels like fuel-wood, cow dung, and agricultural residue.

However, in terms of useful energy consumption, energy use per capita in the high-income group is higher by 112 per cent when compared with the low-income group. This is largely due to the much higher efficiencies of end-use devices (cooking stoves) used by the high-income group. The high-income group consumes significantly more electricity for televisions, radios, etc. It is observed that there is an increasing trend in the purchase of electrical appliances such as televisions, refrigerators, washing machines, ceiling fans, electrical irons and geysers. The increase of refrigerators and geysers is particularly significant: from 0.56 million in 1985/86 to 1.47 million in 1993/94 for refrigerators and from 76,000 to 249,00 in the case of geysers between 1989/90 and 1993/94.

Energy use per capita in the high-income group is higher by 112 per cent when compared with the low-income group.

Transport

The contribution of the transport sector to the gross domestic product has grown annually by 7.12 per cent between 1993/94 and 1997/98. Of total transport GDP during 1997/98, road transport contributed 60 per cent, railways 22 per cent, water transport 13 per cent, and air transport 5 per cent. High-speed diesel and petrol contribute to 98 per cent of the energy consumed in the transport sector.

Energy Efficiency Market Drivers and Size

The new Energy Conservation legislation provides a policy framework for the development of energy efficiency market. This legislation seeks to implement energy efficiency policies that lead to widespread market development though better standards for appliances and equipment, energy efficiency labeling, rational cost-of-service based tariffs, mandatory energy audits, awareness and training, financial and fiscal incentives (ex. 100 per cent accelerated depreciation).

While the energy intensive industries are in the large and organized sectors, several of the industries that produce energy consuming equipment, such as electrical appliances, are in the small and unorganized sectors. The potential for energy savings could be achieved by improving housekeeping practices, small investments in production facilities, and major changes in technological processes. The percentage energy saving

potential in different sectors are given in Table 1.

Table 1: Percentage energy saving potential in different sectors

Sector	Saving Potential
Iron & Steel	10%
Fertilizer	15%
Textile	25%
Cement	15%
Pulp & Paper	25%
Aluminum	10%
Sugar	20%
Petrochemicals	15%
Glass & Ceramics	20%
Refineries	10%
Agriculture Sector Efficient Pump sets	30%
Domestic/Commercial Sector Lighting (CFL vs Filament Lamp)	76%

Source: International Conference on Strategies for Energy Conservation in the New Millennium; FICCI, August 2002.

The total energy saving potential for major industries is about 14500 to 15500 MW. The energy saving potential of major industries is given in Table 2.

Table 2: Energy Saving Potential of Major Industries

Sector	Saving Potential (MW)
Aluminum	59
Caustic Soda	394
Coke Owen	200
Cotton Textiles	506
Distilleries	2900
Iron & Steel	362
Paper & Pulp	850
Plywood	50
Sponge Iron	225
(Incl. Co-gen)	5200
Sulphuric Acid Plant	74-125
Breweries	250-400
Cement	78-100
Commercial Sector	175-350
Dairies	70
Fertilizer	850-1000
Man Made Fiber	523
Petro Chemicals	250-500
Refineries	232
Solvent Extraction	220-350
Tyre Plants	160-200

Source: International Conference on Strategies for Energy Conservation in the New Millennium; FICCI, August 2002.

Energy Technology Cooperation and Transfer

Technology is often thought as only equipment or "hardware", but when viewed in an age where services, information and techniques are gaining importance, the definition of technology must be considerably broadened. It must also include policy, regulatory/legal, institutional or financial/economic concepts or approaches and new market-based techniques that permit efficient delivery of energy services. This non-hardware, or "software", area of technology is becoming an integral part of energy efficiency cooperation.

One of the critical lessons of the past decade has been that the transfer of hardware by itself rarely succeeds. With countries moving aggressively toward market-based economies virtually the world over, economic growth and competitiveness are becoming more a function of the marketplace of ideas, knowledge and information than of the marketplace of commodities. Transferring such software to developing countries has become as important as transferring hardware. These software advances include planning models such as integrated resource planning and demand-side management, policy and regulatory reforms for cogeneration and independent private power, energy labeling, codes and standards, pricing theory and practice, and others. (See Annex A for a list of applicable software and hardware technologies).

Technology must be transferred into a receptive environment, where the policy, regulatory and market forces support its adaptation and continued use, and where training is sufficient to support both local manufacture and repair of the technology. Many of the technological advances in promoting energy efficiency in recent years, in fact, have come as much on the software side as the hardware. Several examples are available to demonstrate the application of energy efficiency software and hardware technologies as vehicles for technology cooperation between industrialised and developing countries. The examples presented below do not cover the wide gamut of potential areas in energy efficiency; rather they are meant to serve as illustrations of the methods and mechanisms through which technology cooperation can be effected. Given the importance of

Technology must be transferred into a receptive environment, where the policy, regulatory and market forces support its adaptation and continued use.

both software and hardware in promoting environmentally sound energy production and use, the examples provided embody both these facets of technology.

Embryonic and Pre-Commercial Technology

There exist several examples of energy technologies that require development/adaptation, testing and validation in developing countries before they can be commercialised. Examples range from those in energy supply, such as clean coal technologies like fluidised bed combustion or coal gasification combined cycle systems, to advanced energy transportation and storage systems to end-use systems that utilise superior materials, advanced controls and software. In many of the developing countries, current financing for technology development and commercialisation is inadequate with the result that many innovative technologies are not developed and the markets are not field tested. Unfortunately, most multilateral development banks and international financing institutions are technologically risk-averse.

A financing facility could be created for joint venture technology development and commercialisation involving enterprises from developed and developing countries. The primary concern expressed by firms from developed countries in technology development and commercialisation ventures is the level of risk associated with product development and commercialisation, particularly when investing in developing countries.

Such financing mechanisms will reduce the level of risk associated with new product development, and will provide incentives for bringing efficient technology into the market-place. It therefore follows that there is a strong case to be made for promoting cost-shared, market-driven research in critical energy technology areas. The development and commercialisation process could involve consortia that include electric utilities, manufacturers, universities, and national laboratories to tap the private sector for innovative technology. A hallmark of this approach is that developing countries participate directly in the development and adaptation of innovative technologies, and thus are able to influence the outcome so that these technologies are also appropriate to the developing country situation.

The Program for the Acceleration of Commercial Energy Research (PACER), an Indian/USAID collaborative science and technology initiative launched in 1987 is a good example of a successful consortium of this type. The purpose of PACER was to foster innovation in the Indian energy/power sector, in part by establishing consortia that link the industrial, commercial, R&D, and government sectors.

Commercial Technology: Limited Market Penetration

Efficient Lighting and Refrigeration Systems

Lighting is the single largest user of electricity in commercial offices and residential buildings in developing countries and accounts for, typically, 10 to 15 per cent of total electricity use in a developing country. The lighting technologies currently used in developing countries, such as India, are for the most part obsolete and inefficient and mirror the diversity of the problem itself: incandescent lamps at homes, a mixture of standard fluorescent lamps and incandescents in offices and factories, restaurants, retail stores and a small but growing proportion of high-intensity sodium vapor lamps for public lighting.

Incandescent lamps that provide the most lighting in India are also the least efficient. These are simple to install, cheap to manufacture, familiar to consumers, and widely available. Their disadvantages are short life (typically 1000 hours) and very low energy efficiency (typically 18 lumens per watt, far lower than other technologies).

Incandescent lamps that provide the most lighting in India are also the least efficient.

Fluorescent lamps are about four times more efficient than incandescent lamps, but their use in residences has been limited by their higher first costs, unattractive light, and inability to fit in incandescent fixtures. The compact fluorescent lamp, introduced in 1984 in the U.S., provides reasonably attractive light, fits regular incandescent fixtures yet using the efficient fluorescent technology. The compact fluorescent achieves an efficiency of 61 lumens per watt, or 3.8 times the efficiency of a comparable incandescent. This means that a compact fluorescent can provide the same light as a standard incandescent with just one-fourth of the energy and power. In addition, the life of a compact fluorescent is typically about 10,000 hours, about 10 - 13 times as long as a standard incandescent.

These new and innovative illumination technologies can significantly reduce the electric power capacity required to deliver lighting services in a country where

peak power capacity shortfall is about 22 per cent. Since evening peaks (6-9 pm) are most pronounced in Indian cities and towns and largely comprise lighting loads, any shift to efficient lamps would be advantageous in bridging the peak shortfall. However, these technologies come at an increased first cost which is a major constraint to their widespread acceptance. Electric utilities that provide compact fluorescent bulbs at low cost recover the benefits through energy and capacity savings at the point of consumer use. For example, in Washington, D.C., the power company provides consumers with coupons that allow them to purchase a variety of CFLs at greatly reduced cost. These bulbs are readily available in hardware stores in the area.

Another example is EPA's Green lights program, designed to encourage America's largest companies to implement profitable lighting efficiency improvements in 90 per cent of their facilities over the next five years. It addresses a number of issues that are equally relevant in developing countries: information dissemination on lighting technologies and potential profitability, decision support systems that allow companies to rapidly analyse their options for installing energy-efficient lighting, financing energy efficient lighting and product testing. In spite of these incentives, efficient lighting systems in developed countries are still in their infancy. However, lessons learned from the US Green Lights programme and other programmes such as the ILLUMEX programmes in Mexico and the ELI programme in Poland could facilitate a programme of technology cooperation on efficient lighting technologies between India and these nations.

Efficient lighting systems in developed countries are still in their infancy.

Refrigerators, both residential and commercial, appear to be inefficient in many developing countries. In addition, the stock of refrigerators in these countries is rapidly rising, making refrigeration and air-conditioning a major end-use application. For instance, a typical Indian refrigerator (6.8 cubic feet capacity) uses 540 kWh per year as compared to 240 kWh/year for a South Korean model or 410 kWh/year for an equivalent Brazilian model. With refrigerator stock in India at about 8 million in 1992/93 and annual production at 1.25 million units (1990/91), increasing at a rate of over 20 per cent per year, it is projected that the refrigerator stock and annual production will increase to over 110 million and 13 million, respectively, by 2010. At that time, the overall penetration of refrigerators in Indian residences will be less than 60 per cent.

The energy efficiency of food refrigeration equipment has improved tremendously in the last 10 to 20 years, yet considerable potential for further improvement remains. Improvements can be achieved by the use of more efficient compressors and fans, use of more and better insulation and by reducing the wattage of the anti-sweat heater. The Typical U.S. refrigerator is an 18 cubic feet, top-mount, automatic defrost unit using about 900 Kwh/year. While this is far below that of typical units sold in the 1970s, it is "technically feasible" to build a refrigerator using less than 500 Kwh per year that retains the features expected by consumers—including 18 cubic feet interior volume and automatic defrost. A 16 cubic feet manual defrost refrigerator using about 280 Kwh/year is already commercially available in the U.S. The 1992 U.S. standards required refrigerators to consume 700 Kwh/year for a n 18 cubic feet model. Current standards have been revised to as low as 300-400 Kwh/year.

Incentives in the U.S. to promote efficient refrigerators include rebates to customers who buy the most efficient models. A golden carrot incentive programme was initiated in the early nineties in which a consortia of utilities pledged to provide $30 million to the first manufacturer who can commence commercial production of a super-efficient refrigerator which exceeds U.S. efficiency performance standards by an estimated 20 per cent.

Opportunities exist for similar "golden carrot" programmes through fostering joint venture partnerships between private sector manufacturers in developed and developing countries for the introduction and adaptation of superior energy efficient refrigerators. Such opportunities could be realised through innovative financing mechanisms with costs shared among developed and developing countries.

Commercially Proven Technology

Industrial Cogeneration

Industrial cogeneration of process heat/cold and by-product electric power merit very serious consideration as a means to achieve energy efficiency and to augment the availability of electrical power. The opportunities for cogeneration are wide and varied: biomass cogeneration possibilities in industry such as sugar mills, pulp and paper and agro-industry such as rice milling; in the modern industrial chemical complexes—refineries, petrochemicals, fertilisers and drugs/pharmaceuticals; in the traditional industries such as textiles, jute and food-processing; and in modern residential/commercial complexes and hotels.

The potential for cogeneration is dependent largely on the extent and profile of the industrial base of the country and could amount to 10 to 25 per cent of the country's installed generation capacity. The technology varies from the traditional boiler-steam turbine configurations, to diesel engines with waste heat recovery to the sophisticated combined cycle systems fuelled by natural gas or distillate fuels. Cogeneration systems come in two basic varieties: packaged or engineered systems. Packaged systems are typically generator sets which come already designed to provide hot water, heat recovery or air-conditioning. The thermal energy is generally in the form of hot water or low pressure steam. These systems can be as small as 6 kw up to 1,000 kw, skid mounted and require minimal on-site engineering. Systems larger than 1000 kw are typically engineered systems, where engine, generator set and thermal configuration are custom designed and integrated to balance thermal and electric loads.

The application of cogeneration in developing countries has been constrained by a number of institutional and policy barriers. For instance, in many developing country there is no provision for the sale of power to the utility grid which reduces the ability of a co-generator to optimise a thermally intensive process. Many utilities have been reluctant to pay attractive prices for co-generated power for fear of losing a steady high tariff bulk power market. These factors have joined to limit the development of cogeneration.

Recent interest in developing countries in independent private power (IPP) stimulate cogeneration and dictate the ultimate size and speed with which the market develops. Current and future fuel and electricity prices as well as the cost of cogeneration equipment will continue to dictate the economics of cogeneration along with policy and regulatory measures. The latter assumes critical importance and relates to the development and negotiation of power purchase and fuel supply contracts, pricing of co-generated power and issues related to stand-by and interconnection. In the U.S., the Public Utilities Regulatory Policy Act (PURPA), 1978, makes it mandatory for utilities, subject to certain conditions, to purchase power from co-generators and IPPs at the utilities full avoided cost of generation. The application of similar instruments in developing countries, taking into consideration local conditions, situations and regulatory policies, assumes significance if cogeneration is to rapidly develop in these countries.

Recent interest in developing countries in independent private power (IPP) with stimulate cogeneration.

Another crucial factor is the high degree of technical expertise required to design an appropriate cogeneration system, interface it with existing production facilities and negotiate fuel purchase and electricity sell back arrangements. In the U.S., develpment and packaging companies have sprung up to integrate the many diverse talents required to design, build, finance and operate a successul cogeneration project. The development of this segment of business in developing countries will help overcome traditional barriers of industry to cogeneration.

Several studies in Brazil, India, Mexico, Philippines and Thailand, as well as experience in other parts of the world, point to the sugar industry as a prime candidate for cogeneration. Advantages include relatively low capital requirements, renewable, indigenous waste material as a fuel, and sugar mills of sufficient number and size to make a measurable contribution to power supplies. A prerequisite for the rapid commercial growth of biomass cogeneration in developing countries is the presence of a regulatory and policy climate and financial incentives that permit co-generators to sell power to the utility grid. Implicit in this is the need to broaden the technology cooperation framework in biomass technologies to include the contractual procedures and regulatory systems that enable their implementation and operation.

A prerequisite for the rapid commercial growth of biomass cogeneration in developing countries is the presence of a regulatory and policy climate and financial incentives.

The need for financing mechanisms and organisational structures for biomass power projects in developing countries is essential for the rapid growth and development of the market. Such structures are required to actively promote, co-finance and deploy cost-effective decentralised biomass-power conversion technologies in the rural areas of developing countries.

Critical Factors Affecting Technology Cooperation and Transfer

Technology cooperation and transfer are complex processes and thus there are many factors that may influence the success of any particular effort. The impact

of these factors also varies with the degree of commercial and technical maturity of the technology, as discussed earlier. Identifying critical factors is further complicated by the lack of sufficient research in the area of technology cooperation and transfer, particularly in the energy sector. Without adequate research, factors may not be correctly identified and as a result, resources may be misapplied. While further research is needed, the discussion which follows is based on the best available research and review of practical experience.

Many factors affecting technology cooperation and transfer are generic with respect to the degree of technical and commercial maturity of the technology as well as being common to both the holders and users of the technology, such as the price of energy, access to capital and access to information. Other factors only become critical at specific stages of market development – such as factors involving programmes to accelerate the market penetration of recently commercialised technologies.

Generic Factors

Energy Pricing

Rational energy pricing is fundamental to technology cooperation and transfer. The price of energy will directly affect the level of investment which is financially feasible, the size of potential markets, and the willingness of firms and individuals to both development and commercialise new technologies as well as their willingness to buy and install them. Without prices that reasonably approximate true costs, ultimately including the costs of mitigating local undesirable environmental impacts, investments among competing energy sources, including efficiency and renewable sources, will be misallocated. This, unfortunately, is currently the case in many developing countries. Thus, any effort to accelerate technology cooperation and transfer must begin with the reform of energy pricing.

More than two decades of experience in promoting energy efficient technologies has demonstrated, however, that energy pricing alone is not sufficient to lead to technology development and adoption. Multiple barriers exist to adoption of energy efficient technologies of which price is predominant but not exclusive. Many other factors affect adoption, as discussed below.

Multiple barriers exist to adoption of energy efficient technologies of which price is predominant.

Access to Capital

Capital markets in many developing countries and countries with economies in transition are poorly developed. This results in underinvestment in general and in energy efficiency spcifically. A variety of programmes have been implemented in both industrialised and developing countries to provide greater access to capital to finance energy efficiency measures. Key lessons learned from a review of the programmes are:

- programmes design is critical
  - energy conservation financing cannot take place in isolation
  - financing programmes must be flexible and attractive
  - selection of the appropirate "delivery mechanism" or intermediary is critical
  - the programmes must be aggressively marketed
- concessionary financing is generally necessary, particularly in the early stages of the introduction of a new technology
- most developing countries do not have mature enough capital markets and other necessary institutional infrastructure for innovative financing, such as third party financing
- energy companies, particularly utilities, should play a major role in energy conservation financing

With the opening up of markets in India, foreign direct investments are becoming an increasingly important source of investment. Efforts to encourage private investment such as reducing trade barriers, encouraging competition, opening up markets to foreign collaboration, reducing corporate taxes, progressive currency convertibility and other market reforms and sector restructuring (such as power sector reforms and restructuring including electricity distribution reforms) are likely to have a substantial impact on improving access to capital for new technologies. Donor funds should be targeted to leverage this private investment, provide incremental incentives in the early stages of technology adoption, and assist in the critical process of project design and evaluation.

Related to the capital issue is the fact that energy audits in India routinely identify 10-20 per cent energy savings that have no or low cost. The adoption of these measures is not influenced by the access to capital. Capturing these savings must be accomplished by ad-

dressing other barriers to adoption, including training, information, and enlightened corporate management.

Access to Information

"The incomplete and poorly functioning information markets for energy conservation increase the perceived risk and uncertainty associated with energy conservation investments". Perceived technical risk was identified in a recent study as the single greatest factor influencing the adoption of energy conservation technologies. The study covered 243 firms in 12 developing countries and a total of 1,470 measures.

Perceived technical risk was identified in a recent study as the single greatest factor influencing the adoption of energy conservation technologies.

Access to information is now one of the most important factors limiting the transfer of energy efficient technologies. The accelerating pace of technological development means that developing countries are falling further behind. The rapid transfer of information will allow developing countries to keep pace with technological developments around the world. Because economies of scale exist in information markets, governments and donor agencies can often provide information at a much lower cost than an individual or firm could.

Market Conditions

Unlike many other environmentally sound technologies whose adoption is often driven by regulation, the adoption of energy efficient technologies is largely market driven and thus market conditions will influence the rate of their development and adoption. India is moving toward the adoption of policies and regulations that promote competition and more open markets, and is thus positively influencing the adoption of energy efficiency technologies. Nonetheless, the adoption of energy efficient technologies face numerous market impediments and failures. Some of the most significant market barriers and steps to address them, include:

Consumer discount rates many times higher than societal discount rates. In industrialized countries, this has meant that incentives have been required to get consumers to adopt new technologies, even when they are clearly already in their own financial interest to do so. Similar or possibly even stronger incentives will be required in developing countries like India.

Absence of financial intermediation by banks and other lending institutions to promote and develop energy efficiency lending; the relative lack of private sector energy efficiency service delivery machanisms such as ESCOs. In summary, there is insufficient understanding and assessment of the risks and benefits that accrue to the parties in an energy efficiency transaction.

Most new commercial buildings are not occupied by the owner – they are rented. The builder's objective is to construct the building for the lowest initial cost; the renters also have no incentive to invest in efficiency improvements in a property they do not own. A similar market failure exists for residential rental property. Most industrialised countries have adopted energy efficiency building codes to overcome this barrier and there is now strong interest among developing countries to do the same. The adoption of building energy codes by developing countries could be greatly accelerated if a global programme were designed to assist the interested countries and to share information and experiences. A public-private sector partnership model that USAID/India is facilitating with key Indian stakeholders is the certification of "green buildings" through a process and rating system adopted from the US Green Building Council's LEED programme.

Failure by the power sector to treat energy efficiency on the same economic basis as new capacity. This market barrier is being addressed in industrialized countries by adopting integrated resources planning (IAP) techniques, and by designing and implementing demand-side management (DSM) programmes. In India, following upon the experience of power sector reforms in a few Indian states involving unbundling of the vertically integrated power utilities, there is growing interest in these "software" innovations aimed at improving the quality, reliability and efficiency of power supply and end-use.

Institutional and Technical Capacity

Efforts to research, develop and commercialise energy efficient technologies are hampered in many developing countries by inadequate capacity at virtually every level. In-country research and development institutions are poorly funded, making the countries dependent on imports for state-of-the-art technology. Primary and secondary education, usually does not include curricula on energy efficiency, thus placing a large burden on both the public and private sectors to educate the populace on the benefits of energy efficient technologies. Adult and post-secondary institutions also usually lack courses relevant to energy efficiency. And practicing engineers and technicians need easy access to education courses that help them understand the

new technologies. Efforts should focus especially on upgrading knowledge and managerial skills in large industrial plants which often account for one-third to one-half of total commercial energy consumption in many developing countries. Without education and training at all levels, technology adoption will be greatly slowed.

The funds required to upgrade training and education in this area are small relative to other demands for funds, such as for electricity generation capacity. And investment in education and training can yield large benefits, particularly in creating the indigenous capacity to develop and manufacture energy efficient technologies. Yet in spite of the small funding requirements an their large impact, funds in this area are in extremely short supply. Because technology transfer is critically dependent upon trained and knowledgeable producers and consumers, investment in human resource capacity building must be an essential component of any technology cooperation and transfer programme.

Factors Affecting Recently Commercialised Technologies

Most of the targeted efforts to promote, facilitate and finance technologies that have been recently commercialised but have limited market penetration take place within the centext of specific programmes. Although there have been relatively little hard research on the factors leading to successful energy efficiency programmes, there is nonetheless a wealth of experience and many reasonably thorough evaluations of that experience to draw upon. Three of the most critical programmatic factors of success are discussed below.

Comprehensiveness

Experience with energy conservation programmes has demonstrated repeatedly that the singular, isolated effort rarely succeeds. Yet many financing programmes have been established without assuring industry interest or trained energy auditors; conversely, audit programmes have been conducted without assuring the availability of financing. The lesson has been that programmes must be as comprehensive as possible; that programme elements such as awareness campaigns, training, energy audits and financing are interdependent and must be designed and implemented in a Well-orchestrated sequence. Indeed, a sequence of eight essential and interdependent steps, known as "total energy management", has been widely accepted as a standard energy conservation programme guide (See Annex B).

Scale

Many technology transfer projects have not succeeded because the design involved a single transfer project, or "demonstration" project, and did not proceed to successively larger scales of implementation. Typically, in the demonstration type of project, which has been the predominant approach to technology transfer, the bulk of the funding goes into the hardware, with few funds allocated to the dissemination of results or to follow-on efforts. The project remains an isolated event, is often not replicated within the country, and does not achieve commercial viability or significant, national impact.

Table 3: Typical Energy Efficiency Technology Cooperation/Transfer Time Periods in Developing Countries

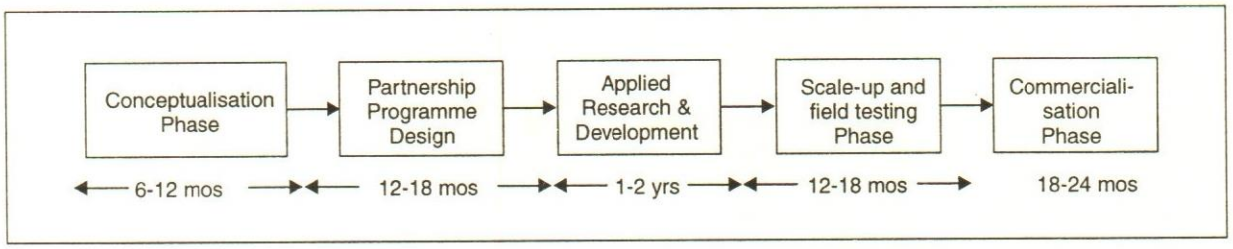
Software	Period
National energy conservation law	Long-term
Building energy code	Long-term
Appliance efficiency standards	Long-term
National energy conservation centre	Medium-term
College-level energy efficiency courses	Medium-term
Elementary school energy modules	Short-term
Energy efficiency workshops	Short-term
Demand Side Management programmes	Long-term
Hardware	
Nationwide boiler replacement	Medium-term
Electronic combustion analysis	Short-term
High efficiency industrial motors	Medium-term
High efficiency industrial motors	Medium-term
Combined cycle gas turbines	Long-term
Compact fluorescent lamps nationwide	Long-term

Short-Term = Less than 2 years; Medium-term = 2-4 years; Long-term = 4-10 years

Source: RCG/Hagler, Bailly, Inc., (now PA Consulting Group), 1992

To be successful, technology transfer projects must be designed at the outset to achieve a large-scale impact. In practice, this will mean that both the project's duration and funding level will have to be significantly increasd over what many donor agencies and others normally provide. It will also mean the virtual elimination of the isolated demonstration project approach. Instead, projects should be designed with time frames that cor-

Project's duration and funding level will have to be significantly increasd.



Technology Co-operation Model

respond to the entire period of time it takes for technology transfer to become sustainable. Typical time periods are suggested below.

To achieve large-scale impact as well as commercial viability, many technology transfer projects will need to proceed in phases, where each phase is implemented at a larger scale until nationwide impact is achieved. The figure below shows a conceptual model for this type of successive scale-up.

Leveraging

With many competing demands being made on limited donor grant and loan funds, it will become increasingly important to design programmes where the funds leverage larger activities and funding. Leverage can be accomplished in both the software and hardware areas. In the software area, donor grant funds can be used to assist indigenous efforts to develop policy and regulatory reforms; on the hardware side, grant funds can be used to assist local energy conservation agencies or other design programmes or conduct preinvestment studies that can leverage multilateral development bank loan funds. Loan funds, on concessionary terms, can then be used for the direct procurement or the financing of procurement of the new technologies. In either case, leveraging has become an essential programmes design factor that is needed to maximise the impact of donor assistance.

Financing Technology Cooperation and Transfer for Improved Energy Efficiency

It is clear that developing countries will need financial and other assistance in order to take advantage of the new technologies available to improve their energy efficiency. The experience in both developed and developing countries in energy efficiency programmes over the past decade points to the need for financial incentives to promote technology cooperation and transfer, particularly for technologies in the precommercial and commercial-with-constrained-markets categories. Nonetheless, many of these programmes have met with mixed success, thus a much better job needs to be done to understand consumer preferences and the decision-making process of those acquiring new technologies.

Promote Public–Private partnerships in Energy Efficiency Technology Development and Commercialisation

Any successful technology cooperation regime must recognise the primary role of the private sector not only in developing and commercialising energy efficiency technologies, but also in providing the necessary technical assistance, training and know-how. Many corporations have initiated aggressive programmes to promote energy efficient environmentally sound technologies within their own operations and to outside parties. Developed countries can play a more direct role in promoting the role of the private sector, thereby improving competitiveness while supporting international efforts to further energy efficiency.

Developed countries should use existing as well as new and additional bilateral and multilateral resources to create institutional facilities for developing public-private partnerships aimed at promoting and developing environmentally sound energy efficient technologies. The Green Business Center (GBC) at Hyderabad is a good example of a partnership between the state government of Andhra Pradesh, the Confederation of Indian Industry and USAID, devoted to showcasing of energy efficient technologies, dissmination of information on "green" technologies and providing green certification. Planned to be located in India's first Green Building on land donated by the A.P. state government, the GBC could prove to be a replicable model to catalyse technology cooperation between India and the USA. Refer to Annex C for a brief description on the GBC project.

Proposed Actions to Accelerate Technology Cooperation in Energy Efficiency

- Conduct a detailed assessment of the current level of funding for energy efficiency assistance to developing countries from bilateral, multilateral and other sources. Funding should be

broken down by country, sector, funding source, type of programme and other relevant factors.

- Promote the establishment of programmes along the lines of the PACER-programme for joint venture technology development and commercialisation involving enterprises from developed and developing countries.
- Promote the establishment of "Golden Carrot" programmes (modeled after the U.S. EPA programmes) to provide incentives for the joint development and/or adaptation of new energy efficient technologies for developing country markets.
- Foster public-private partnerships to create institutional capacity, such as the Green Business Centre in Hyderabad, to advance green technologies and systems.
- Design and finance the implementation of programmes that are universal in application and global in reach for implementing technically promising and economically viable energy efficiency projects in the following areas:
  - industrial combustion efficiency
  - waste heat recovery
  - building energy codes
  - appliance efficiency standards, etc.
  - efficient power distribution technologies, and
  - IT based advanced metering and measurement
  - Support energy sector policy, regulatory and pricing/tariff reforms that encourage the development and adoption of energy efficient technologies and systems such as industrial cogeneration and natural gas combined cycle private power facilities.

Conclusion

Energy efficient, environmentally sound technologies span a broad spectrum, ranging from embryonic and pre-commercial systems to economically viable and commercially proven technologies. A process of technology cooperation and transfer will require that it be driven by common interests and mutual needs; that the gains to all parties are seen as mutually beneficial and that partnerships be symmetrical. The foundation of these partnerships should be grounded in the realities of the marketplace. Nonetheless, market barriers and imperfections abound, and market reforms, both international and local, will take years to accomplish. Technology cooperation and transfer mechanisms should address barriers such as inadequate capital, distorted pricing, and lack of knowledge and information.

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Annex-A

Technologies for Energy Efficiency – Software and Hardware

A. Software

Legal/Regulatory: Where imperfact markets exist, legal or regulatory measures have been adopted by many countries to protect the environment, to capture unmonetized societal benefits, or to protect consumers. Some of the more common measures include:

- Appliance efficiency standards
- Building energy codes
- Efficiency standards for existing residential rental housing
- Appliance and equipment energy efficiency labeling
- Mandatory energy audits and commercial/industrial energy managers
- Energy information reporting
- Integrated resources planning
- Utility demand-side management programmes

Institutional: Many countries have reorganised national governments, and often state and local governments as well, to provide management capability over the energy sector and energy efficiency and renewable energy in particular. Some of the common institutional innovations include:

- A national department of energy with a bureau or office for energy efficiency
- A national energy conservation centre or agency
- Regional energy efficiency centres or a nationwide energy extension service
- Expansion of R&D capabilities, such as the creation of energy efficiency or solar energy research centres
- Establishment of non-profit professional associations for energy efficiency such as the Association of Energy Engineers, the Association of DSM Professionals, the Association of State Energy Officials, or the National Association of Energy Service Companies

Economic/financial: A wide variety of innovative techniques have been created in developed countries that could have widespread applicability in developing countries. Some of these include.

- Concept of utilities as energy service providers, not retailers of electricity or gas
- Privatisation of the power industry and commercial sectors. Restructuring of the power sector to include economically based regulation, privately owned generation, transmission and distribution systems, and full and open competitive access to independent power producers including ESCOs
- Tax incentives favouring efficiency and renewable energy, such as tax credits, accelerated depreciation
- Pricing techniques, such as the use of marginal cost pricing, time-of-use pricing, interruptible tariffs, the inclusion of environmental externalities, and most importantly, the elimination of subsidies and cross-subsidies Performance-based contracting as a means of using projected savings as a basis for securing financing
- Low-interest loan programmes for energy audits and retrofits

Information/education: Fundamental to the improvement in efficiency in developed countries was a change in attitude on the part of the populace. Much of this change was brought about through intensive information and education programmes, many beginning at the grade school level and continuing on through adult and post-secondary levels. Some of the innovations in this area include:

- Introduction of curriculum modules in K-12 grades on energy issues and efficiency
- Creation of masters and PhD programmes in energy
- A vast array on continuing education courses and programmes aimed at retraining technicians and professionals in efficiency

- Creation of data bases, both public and private, and other information resources to quickly convey results and provide a rich source of data for research of large numbers of energy efficiency technologies, projects and programmes

B. Hardware

Hardware technologies can be divided into two application categories: (1) households and small commercial facilities (micro-enterprises); and (2) small commercial and industrial facilities. The technologies for each of these categories are presented below. In considering the application of these technologies, several points are important

- Lower cost investments and less highly technological applications have been found to be more successful in industrial applications in developing counties; it should be expected that this will be even more the case for residential and small industrial applications.
- Local capability in the development and application, as well as the long-term maintenance of the technology is key to ensure success in the installations. Participation of local institutions and companies in the identification, design, implementation and maintenance of the equipment must be ensured.
- Among the technologies listed, there is none (except perhaps CFLs) with wide universal applications in all countries in all residential and small industrial sectors. As a result, a portfolio containing a variety of the technology possibilities described here must be considered in order to ensure energy saving results.

Technologies for households and small commercial facilities

There are only 4 major technology areas where developed-country technologies find applications in households and small commercial facilities in developing countries. Of these, lighting is by far the most applicable, followed by refrigeration.

High efficiency lighting: Compact fluorescent lamps (CFL) can directly replace incandescent lamps, providing the same light output at a 75 per cent savings in energy consumption. Initial costs of CFL lamps are high. However, as these lamps become more widespread, their costs are being reduced, and their performance on power circuits with poor quality (voltage fluctuations) is being improved.

Efficient refrigeration: Energy-efficient refrigerators, refrigerator-freezers, and freezers are in a continuous state of development. Energy consumption for current refrigerator-freezer models has been reduced by about 25 per cent compared to models of 10 years ago (which represent typical models available in developing countries). The 1993 U.S. standards call for an additional 20 per cent reduction in consumption. Using a variety of additional improvements, including improved foam insulation in walls and doors, greater compressor efficiency, and reduced fan consumption, an additional 25-30 per cent over the 1993 standards consumption can be saved.

High efficiency air conditioners—The efficiency of air conditioners has improved considerably since the 1970s, from a typical EER (energy efficiency ratio, Btu/Kwh) of 6.0 to a 1990 U.S. standard of 9.0 when new. The most efficient commercially available units on the market have EERs of over 12. Improvements have been obtained through higher efficiency compressors, larger heat exchangers, and better fan designs. In developing countries, it can be supposed that the EERs of air conditioners are close to the low end of the EER range. In addition, the EERs cited here are for new equipment; old equipment can have significantly lower efficiencies depending on the maintenance and operating conditions.

Efficient hot water heating systems: A number of technologies exist to reduce energy consumption in domestic hot water heating; however, the majority do not apply to developing countries due to mild outdoor temperatures and low number of tank heaters. For example, a more efficient hot water tank (energy factor 0.95 instead of 0.88) can save approximately 5 per cent of annual energy consumption for a 4-person household in the Pacific Northwest. Similarly, heat pump water heater with heat recovery ventilation provide savings of approximately 50 per cent in new construction applications, and "hot water savers' (devices that push hot water from the pipes back into the tank after hot water use) provide savings of 10-15 per cent.

Windows: Double-glazed windows have provided important energy savings in both cold and hot climates. In typical developing country applications, such windows can reduce air conditioning loads.

Locally developed technologies: A number of local low-cost measures in developing countries can be spurred through technology cooperation. These measures can be developed in conjunction with local agencies and through local experience, and include measures such as the following:

- **building insulation:** application of building insulation within the context of local building techniques
- **efficient fans:** use of high efficiency motors and lightweight plastic materials can reduce cooling fan consumption
- **solar water heaters:** development of locally manufactured and maintained solar water heaters
- **efficient building designs:** design of buildings to take advantage of passive heating and cooling techniques, using local experience, or complemented with computer models
- **low power electric showerheads:** replacement of existing locally made instantaneous hot water showerheads used in various countries, with reduced-power showerheads sized for optimum water flow.
- **efficient water pumps:** a combination of an energy efficient motor, an optimally designed pump and minimum piping losses can provide significant (30%) savings in water pumping systems.

Technologies for large commercial and small industrial facilities

The technologies listed above for residential and small commercial facilities also apply to non-residences, such as larger commercial and small industrial facilities. Furthermore, the following additional technologies apply specifically to commercial and small industrial facilities.

Mirrorised lighting reflectors: Improved reflectors, applied especially to fluorescent fixtures, can provide savings of 30-50 per cent with paybacks of 2-3 years at an electricity cost of US$ 0.05/Kwh.

High efficiency magnetic and electronic lighting ballasts: While high efficiency magnetic ballasts for fluorescent lamps offer savings of 5-10 per cent a small cost premium electronic ballasts can save as mush as 20-25 per cent of that lamp energy consumption. Both types of ballasts result in paybacks of 3-4 years at an electricity cost of US$ 0.05/Kwh. While electronic ballasts are sensitive to power line voltage fluctuations, continuous technology improvements will reduce this problem, and continue to bring down costs.

Window film: Window film treatments to reduce the amount of solar radiation entering an air-conditioned building can be applied to certain larger buildings. Savings depend on window size and orientation, and can often be eliminated or minimised through intelligent design of the building as described above.

Timers, sensors and controls: Savings and payback from lighting controls such as timing switches and occupancy sensors depend to a large degree on the specific application; typical applications can be found in most commercial and industrial facilities. Increasing use of these controls in the U.S. is spurring new types of products, and reducing their costs.

Energy management control systems: Typical applications of energy management control systems, which use electronic programming and sensors to control energy consuming equipment such as building fans, pumps, and lights, result in savings of 15 per cent with paybacks of 3-5 years. The recent trend toward direct digital controls has reduced prices and multiplied the capabilities of such systems.

High efficiency motors: In small sizes (less than 5 Kw) energy-efficient motors can offer saving of up to 5 per cent, with paybacks of 3-5 years depending on electricity cost and number of operating hours per year. Small engine cogeneration—natural gas and diesel fueled engine generators in the 50-500 Kw range can provide hot water needs for commercial and industrial processes. The need for relatively constant and high hot water loads limits the number of applications, but the high efficiencies (60 - 70%) make these systems attractive in specific cases.

Annex-B

Essential Energy Conservation Programme Functional Areas

1. **Management Support:** This refers to the development and maintenance of organisational structures, managerial systems, staffing and staff development. It includes such tasks as developing an annual work plan, determining staff complement, preparing position descriptions, hiring and training staff, and administrative tasks such as fiscal management, procurement and contracts management.
2. **Planning:** This is an integrative function, drawing upon policy analysis, engineering and special studies, and programmatic experience to arrive at policies, strategies and multi-year implementation plans. It can include the setting of national conservation targets, planning and budgeting of sectoral programmes, development of legislative

and regulatory initiatives, identification of training and educational needs and other national level planning.

3. **Data Acquisition and Management:** This function is the collection, assembly and analysis of data to provide information necessary to carry out energy conservation planning, policy development, programme design, implementation and monitoring.

4. **Engineering Analysis:** Audits, Feasibility Studies – This function involves the onsite identification and subsequent engineering and financial analysis of energy conservation opportunities. It is usually the area to which the most resources are devoted but is intimately dependent upon the other areas for achieving savings.

5. **Training:** Training refers to short-term instruction in narrowly proscribed subjects for specific audiences. The educational function involves institutionalising energy conservation instruction within academia through curriculum development, teacher training or the development of new courses and degrees.

6. **Information and Outreach:** Energy conservation begins with awareness. Outreach and information are the tools by which awareness is generated and knowledge transmitted through person-to-person contact or using various media.

7. **Financing:** The financing function is essential for the implementation of any sizable energy efficiency capital improvements. It is usually external to the national conservation centre and therefore requires close coordination for programme success.

8. **Monitoring and Evaluation:** This function provides feedback on all other functions. It serves not only to help make mid-course corrections but also to document success and help garner financial and political support for the centre.

Annex-C

The Green Business Center – An Indo/US Technology Cooperation Partnership

Background

The challenge of ushering in environmentally sound energy efficient technologies, products and services is a global one and depends on new methods and ways of engendering technology cooperation between developed nations such as the US and developing nations such as India. Recognizing thus the need for sustainable development, the Confederation of Indian Industry (CII), India's premier private sector industry association and the State Government of Andhra Pradesh (GoAP), the country's leading reformist state, have established the Green Business Center (GBC), with critical strategic planning and design support from USAID.

The concept of the GBC was first formally mentioned in the March 2000 Joint Statement on Energy & the Environment between U.S. and India. This statement entrusted the USAID to support the establishment of the GBC with the CII and was a natural culmination of Indo-US bilateral initiatives that CII had been privileged to host. Under USAID sponsorship, CII led activities aimed at enhancing energy efficiency, environment protection and the commercial development of renewable technologies. CII is also the designated centre for USAID's Global Climate Change Awareness & Outreach programme aimed at promoting business partnerships to reduce GHG emissions.

The Partnership

The GBC is a unique partnership between three agencies with clearly defined roles. CII, as the implementing agency is responsible for the administration, staffing, management and financing of the GBC and its activities. The GoAP, as the first Indian state with a growing track record in introducing economic reforms, has extended its unstinted support and patronage to the centre. With a state GDP of over US$ 18 billion, India's 4th largest state economy, a large pool of scientific and technical manpower, abundant natural resources and fairly well-developed infrastructure, the AP region has the potential for sustained progress. USAID as the first bilateral donor invited to participate has been engaged in providing specific and targeted assistance to support the GBD in its formative stages. Over the past 18 months since the programme began, the partnership has yielded tangible results. In January 2001, the GBC was inaugurated by the Vice President of India for which a 5 acre plot of prime land in the business centre of Hyderabad was provided as an outright grant by the GoAP. Since then, the CII has raised over US$ 1 million for the GBC from the Indian corporate sector, hired an architect firm to prepare a state-of art building design incorporating energy efficient features and organized two major international conferences on "green" (i.e. environmentally cleaner) themes – International Congress on Green Buildings and as International Conference on Green and micro- power. In all of these CII was supported by USAID. A USAID funded strategic business plan for the GBC enabled CII to prepare documentation for its successful fund-raising efforts; a study

tour to the US in late 2000 helped in developing the basic concept and architectural features of the GBC building, and the participation of US experts at the two green conferences lent prestige and credibility to the effort.

Objectives of the GBC

The partners are in agreement on the objectives of the centre. It will advance the public policy goals of sustainable development, efficiency and environmental protection through catalysing private sector businesses. To this end, the GBC will follow two guiding principles. First, it will assist Indian businesses create the demand for clean energy systems and environmentally sound industrial processes. For instance, in AP state the GBC could assist in addressing the problem of disposal of over 60,000 tons per annum (TPA) of hazardous wastes, the recycling of over 40,000 TPA of recyclable wastes and the reduction of industrial air pollution estimated to comprise 25 per cent of the state's carbon and sulphur dioxide emissions. Second, the private sector will be the primary means of technology transfer through international trade in goods, services and investment. This would entail fostering partnerships and joint ventures between Indian and foreign companies in clean energy and environmental technologies and services.

It is envisaged that the GBC will promote private sector businesses in the state of AP and the rest of India through:

- increased environmental awareness and outreach;
- the showcasing of clean energy technologies, products and processes;
- provision of green business technology incubation facilities and services;
- development of the system of green certification based on best environmental and social practices;
- educated and facilitated interaction between prospective business clients, facility managers and financiers on green technologies; and,
- promote Indo-US joint ventures in green technology transfer, development and commercialisation. □

I do not feel obliged to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forgo their use.

– Galileo Galilei

Challenges to Demand Forecasting for Electricity

Tanusree De

Information is vital for any forecasting exercise. To predict the future one needs to have knowledge of the past and the present. The accuracy of a forecast depends not only on the specified model for forecasting but also to a large extent on the inputs to the model. The purpose of this paper is twofold: it explores the necessary information required for undertaking studies on demand forecasting, particularly for electricity, and also makes an attempt to research various uncertainty factors associated with forecasting, their sources, and possible treatment.

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Information plays a crucial role in forecasting and a detailed discussion on the same is therefore imperative. The purpose of this paper is to explore the necessary information that is required for undertaking studies on demand forecasting, particularly for electricity. An attempt is also being made to research on various uncertainty factors associated with demand forecasting, their sources, and possible treatment.

Information Requirement for Electricity Demand Analysis

Electricity is one of the basic inputs in the functioning of an economy and plays a decisive role in various aspects of development such as industrialization, agricultural mechanization, urbanization, and so on. Electricity is in fact considered to be a crucial indicator of economic development. It is therefore imperative for an economy to maintain a balance between the demand and supply of electricity. Since electricity, unlike other energy products, cannot be stored and must be generated and delivered on the spot as needed, accurate forecasting of the electricity requirement is crucial, especially for purposes of planning the generation. Also an in-depth analysis of factors affecting electricity consumption would indicate what policy measures are needed to adjust electricity demand in the context of macro objectives. There are several methods of demand forecasting, application of any of which is possible only if sufficient data are in hand. To discuss data requirement, macro and sectoral demand analysis are distinguished as two major approaches of electricity demand analysis.

Macro analysis is an aggregate level analysis, where the aggregate electricity demand of an economy is explained by macroeconomic variables such as the GDP (gross domestic product), population, per capita income, prices, urbanization index etc. All data required for macro analysis are aggregated data. Some of the

commonly applied techniques of macro analysis are listed below:

- Estimating the elasticity of electricity consumption with respect to GDP, by fitting a log-linear relationship between the two, through regression analysis.
- Computing the electricity consumption per unit of real GDP (GDP at constant prices) over time and interpreting the results with respect to an increase or decrease in the electricity-GDP ratio.
- Establishing the relationship of electricity consumption with socio-economic and technological factors such as level of income, population size, urbanization index, prices, efficiency of end-use devices and other relevant variables through multiple regression modelling.

Thus three types of data are generally required for macro analysis, viz., consumption data, price data, and macroeconomic variable data such as, the GDP, population, urbanization index.

In addition to macro demand analysis, which provides general and global information useful for policy direction, electricity demand analysis needs to be undertaken from the sectoral perspective as well in order to facilitate in formulating specific energy policies. Factors and variables determining electricity demand and the behavioural relationships among them vary from one sector to another. Electricity demand by the residential sector, for example, is for a final commodity, which is disposed for consumption purposes. On the other hand, electricity demand by industry is for an intermediate product, which is used in the production of other commodities. Hence the factors and variables determining electricity demand are likely to differ in the two sectors. For sectoral analysis of electricity demand, the economy of a country is conventionally classified or disaggregated into the industry, residential, agricultural and commercial sectors with further disaggregation of each of these sectors. However, sector classification of the economy for electricity demand analysis should be done on the basis of similarities and differences in the structure of the electricity demand and its principal determining factors. For practical purposes of analysis, however, the disaggregation is done on the basis of data availability. Sectoral demand analysis can be undertaken either at an aggregate or a disaggregate level. The various approaches are discussed in detail in the subsequent sections to provide an idea of the data requirement for sectoral demand analysis.

Industry Sector

Electricity is consumed by industry as an intermediate input to produce other commodities. In a very basic sense, industrial electricity consumption is the product of electric intensity (i.e. electricity content per unit of industrial output) and total output, which can be expressed in equation form as:

$$IC_t = Q_t \times I_t$$

where IC_t is the aggregate electricity consumption of the industrial sector in period t, Q_t is the level of output of the sector in period t, expressed either as value added or as value of output at constant prices, and I_t is the electricity intensity that measures electricity consumption per unit of value added or value of output in period t. The equation is an identity that is valid at any level of aggregation: sector, industry, or individual customer.

The aggregate output level can be taken either from the planning figures of the government or from econometric analyses or scenario studies. Econometric analysis refers to the use of regression analysis to establish a functional relationship between the future level of output and its various driving factors such as number of factories, persons employed in factories, productive capital, price of raw materials, technology etc. provided data on these variables are available. The aggregate electricity intensity can be calculated for the base year by dividing the total industrial electricity consumption by the total output of the sector in the base year. Holding the intensity constant over the forecast period, the aggregate industrial electricity requirement for a given future year can be simply determined by multiplying the pre-determined output level by the constant electricity intensity. This will represent the business-as-usual scenario. One may also consider alternative scenarios making assumptions of variation in the intensity.

However, an aggregate does not properly account for the changes in the product mix and the differences in conservation potential existing among the product groups. A disaggregate approach can improve upon these disadvantages of the aggregate approach. For disaggregate analysis the industry sector is further decomposed into sub-sectors or product groups such as food, textile, chemicals, metal and metallic products, non-metallic mineral products, rubber, paper and so on. The underlying assumption for the disaggregation is that the nature and structure of electricity consumption and electricity intensity of each product are the same or atleast similar. For practical purposes of analysis, however, the disaggregation is done on the basis of data availability. Once the industrial sector is decomposed into product groups, the output level and electricity in-

tensity are to be estimated for each group or sub-sector so as to estimate the electricity requirement of the respective group or industrial sub-sector.

Then, aggregating the individual sub-sectoral demands over all the sub-sectors, one can arrive at the total industrial demand.

To calculate the electricity intensity for the base year a further level of disaggregation would be to assess the consumption of electricity (in the base year) by each product group through an end-use analysis. The end-use method is based on the premise that energy is required for the service that it delivers and not as a final good. The following relation defines the end methodology for a sector.

$$E = S \times N \times P \times H$$

where E is the energy consumption of an appliance in kWh (kilowatt-hour),

S is the penetration level in terms of number of such appliances per customer,

N denotes the number of customers,

P is the power required by the appliance in kW (kilowatt), and

H denotes the hours of appliance use.

This, when summed over different end-uses in a sector, gives the aggregate energy demand. This method takes into account improvements in the efficiency of energy use, utilization rates, inter-fuel substitution, etc., in a sector as these are captured in the power required by an appliance (P). In the process the approach implicitly captures the price, income, and other economic and policy effects.

In industries the end-use service needs for which electricity is required are extremely heterogeneous because of the diversity of industrial activities and products. At a general level they can be grouped into five major end-uses, viz, (1) motor drive, (2) process heating, (3) electrolytes, (4) space conditioning and (5) lighting and other end-uses for illuminating work surfaces.

The main difficulty often faced in analysing electricity demand in the industrial sector as well as in any other sector is the availability of data, especially of end-use breakdowns of electricity consumption. A research has to take recourse to consumer surveys in order to collect such data. Due to the lack of data, a simple approach would be to regress aggregate industrial electricity demand on aggregate industrial output and price of electricity. Again in the absence of data on aggregate industrial output, an alternative is to consider industrial contribution of GDP as a proxy for industrial output. The above discussion provides an indication of the data requirements for the analysis of electricity demand in the industrial sector.

Commercial Sector

Electricity demand in the commercial sector can also be analyzed either at an aggregate or a disaggregate level. Econometric methods are a common analytical tool employed for the aggregate approach while end-use analysis can be used for the disaggregate approach. Aggregate electricity demand in the commercial sector can be expressed as a function of the sector's contribution to real GDP, price of electricity, number of commercial buildings, level of urbanization, etc.

On the other hand for disaggregate analysis, the commercial sector is decomposed into sub-sectors, on the basis of economic activities, like trade, hotels and restaurants, transport, communication, storage and warehousing, offices, educational institutes, and medical institutes. The demand for electricity in each of these sub-sectors is estimated separately and then aggregated to obtain the sectoral demand. For commercial sector analysis one may consider intensity either in terms of consumption per unit floor area or in terms of consumption per employee. Thus one may adopt any one of the following models given the availability of relevant data.

Model I

Electricity demand (kWh) = electricity reference surface X Electricity intensity (kWh/m^2)

Model II

Electricity demand (kWh) = Employment level * Electricity (kWh/employee) intensity

Again for calculation of intensity, an end-use analysis as described earlier can be undertaken for which the consumption of electricity by each commercial establishment can be broken down into several end-uses like lighting, space conditioning, water heating, cooking, refrigeration, medical appliances, and office equipment.

Residential Sector

Electricity consumed by the residential sector is a final demand. In general, electricity is used by the residential sector for end-uses very similar to those in the commercial sector such as lighting, space conditioning, water heating, and refrigeration. Again the ap-

proach of forecasting may be either aggregate or disaggregate. Aggregate electricity demand can be expressed as a function of real GDP, electricity price, population, and changes in fuel efficiency. Econometric methods can be employed as a tool for forecasting. The disaggregate approach estimates total electricity demand in the residential sector by summing up the end-use electricity demands for lighting, space conditioning, water heating, refrigeration, and use of electrical appliances. Thus, each end-use demand has to be determined separately to arrive at a forecast for the total electricity demand by the sector. Each end-use demand is influenced by various factors such as income, penetration of appliances, number of rooms in a house, size of rooms, climatic conditions and several other factors.

Econometric methods can be employed as a tool for forecasting.

Another approach may be tc estimate the number of households and the average consumption of electricity per household and to calculate total electricity demand by multiplying the two estimates. Change in average electricity consumption per household is influenced by the expected changes in average size of homes and in fuel efficiency. Therefore information on these factors are needed for such an analysis.

Agriculture Sector

The agriculture sector, like the industry sector, consumes electricity as an intermediate product. Electricity is used in the agriculture sector mainly for pumping water for the purpose of irrigation. Electricity demand for irrigation can be projected in a number of ways. One approach may be to estimate the electricity consumption for irrigation per unit area and then multiply this norm by the total area under irrigation. However, the estimate of the norm would differ for different regions and crop types as the water requirement is not the same for all crops and the depth of the water table is not uniform in all regions; the greater the depth, the higher will be the horse power requirement of a pumpset for that region. So it is better to adopt a disaggregate analysis where the level of aggregation might be crop types and regions classified by depth of water table. Such an approach would necessitate a huge amount of information such as crops grown, hours of irrigation pertaining to a particular crop in a particular region, number of times of irrigation in season, area under irrigation for a particular crop in a particular region, number of cropping cycles, and the depth of the water table in a particular region. However such information are not generally documented and a researcher has to take recourse to sample surveys of agricultural consumers. Otherwise, given the availability of data on the agriculture sector's contribution to the GDP, number of pumpsets energised, gross irrigated area, etc. the aggregate electricity demand of the agriculture sector can be projected by fitting a regression. The drawback with the aggregate approach, as has already been discussed earlier, is that it does not properly account for the change in electricity demand caused by changes in various factors such as, in case of agriculture sector, shifts in patterns of crop, changes in depth of water table, and other relevant factors.

Uncertainty in demand forecasting

The success of a forecast lies in its proximity to the actual. But, due to a number of uncertainly factors forecasts may go haywire. To minimize the forecast error a forecaster's primary aim should be to detect the cause of uncertainty. Uncertainties may crop up due to technical failure in modelling as well as inadequate projection of socio-economic evolution and/or technological advancement. Another big reason behind unreliability of forecast lies in the shortcomings associated with the data.

Problems with data

Poor quality of data

In practice, the success of an analytical study depends on the availability of appropriate data. However, it is often found that the quality of data is not that good. There are several reasons for this. First, most economic and social science data are non- experimental in nature and therefore there is the possibility of observational errors, either of omission or commission. Second, even in experimentally collected data, errors of measurement arise from approximations and rounding off. Third, in questionnaire type surveys, the problem of non-response can be serious; analysis based on partial responses may not truly reflect the behaviour of the respondents who did not respond thereby leading to sample selectivity bias. Bias may also arise because of the substitution of a selected unit by another. For example, in a house-to-house survey, the next house is interviewed if no reply is forthcoming from the selected house. Then there is the further problem that those who respond to the questionnaire may not answer all the questions, especially questions of a financially sensitive nature, thus leading to additional sensitivity bias. Again, bias may arise due to negligence or carelessness on the part of investigators in asking questions, or inaccuracies in recording, or false recording by dishonest investigators without actually visiting the sample.

Non-availability of data

Non-availability of data is a chronic problem, mostly in developing countries. Generally there is scarcity of data at a disaggregated level. Most economic data are available at a highly aggregate level, therefore economic models are often estimated using aggregate, consumer class data. Again, unless all consumers in a particular class have identical preferences, or unless the preferences of each consumer can be represented by simple linear relationships, parameter estimates obtained from aggregate consumer class data will not yield accurate estimates of consumer preferences regarding electricity use. Thus the more disaggregate the data, the better the model specification will correspond to the underlying economic theory.

There is scarcity of data at a disaggregated level.

Data inconsistencies and gaps

Definitional inconsistencies: It is often found in public documents that disaggregated data on a particular variable are clubbed and presented as a single data series. Also, mostly, the items clubbed for the initial years do not match the items clubbed for the later years. In such a situation the entire series cannot be considered and, therefore, the number of observations available for study gets reduced, which in turn diminishes the reliability of the estimates. A similar problem is that in case of two variables that can be related functionally, data may be available at a certain level of disaggregation for one variable while for the other, variable data may not be available at the same level of disaggregation. In this case the two variables cannot be related at the desired disaggregated level. For all such data related problems certain assumptions are made which may lead to unreliable forecasts. Another problem arises when data are reported under the category 'others' without any definition of the categories provided.

Numerical inconsistencies: When a data series has to be obtained from two different issues of the same publication, the data of the overlapping time period(s) in many cases do not match. Decision making in such cases is a difficult task and is entirely based on the forecaster's choice and the end result is an unreliable forecast. Inconsistency also arises if data on a particular variable are reported in different units for two different years in the same series by mistake. Also if the data are actually calculated values, as often happens in case of survey data, data reliability is significantly affected. Moreover, data are also plagued by errors of approximation.

Missing observations: It is fairly common that a data series may have gaps or missing observations. In some cases it is due to lack of timeliness in collection of data, and, sometimes, data are actually collected at long intervals. For example, the census of population is conducted every 10 years in our country. Now if there is a need to obtain data for some year within the inter-census period, the common practice is to interpolate on the basis of some ad hoc assumptions. All such techniques might impose upon the data a systematic pattern which might not exist in the original data.

Problems with models

The basic objective of regression modelling is to explain as much of the variation in the dependent variable as possible. A model is judged good if this explanation as measured by the R^2 (coefficient of determination) is as high as possible. However, a high R^2 only attests to the predictive power of a model within the given sample. Now, whether a high R^2 would entail the same high explanatory power beyond the sample period or not is uncertain. Also forecasts are driven by future estimates of exogenous variables, which themselves are estimates with known or unknown probability distributions. Uncertainties in forecasts may also arise due to errors in the model specification. One important aspect of model specification is the incorporation of an optimal number of variables that explain the pattern of electricity demand. Suppose we arrive at the following, which we accept as a good model.

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + u_t \qquad (1)$$

where Y is the dependent variable, X_i 's (i = 1, 2, 3) are the independent/explanatory variables and u is the stochastic disturbance or error term.

Now suppose a researcher decides to use the following specification.

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_t \qquad (2)$$

then if (1) is the correct form, (2) involves a specification error in the omission of the relevant variable X_3.

On the other hand, suppose the following specification is used.

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + u_t \qquad (3)$$

Again if (1) is the true formulation, (3) will constitute a specification error, the error here being inclusion of an

unnecessary or irrelevant variable (X_4) in the sense that the true model assumes the coefficient beta sub 4 to be zero.

Another aspect of model specification is the choice of an appropriate functional form to describe the mathematical relationship between electricity demand and a specified set of explanatory variables. In general, suppose with the objective of finding a relation between the same variables Y and X, a researcher postulates the following model

$$\log Y_t = \beta_0 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + u_t \qquad (4)$$

In relation to the true model (1), (4) would constitute a specification bias, in the use of the wrong functional form. The correct specification involves a linear relationship unlike the log-linear relationship specified in (4).

One of the reasons behind committing such errors is that even if a researcher knows the correct model, the non-availability of necessary data may prevent implementation. In such cases, the particular variable, though relevant, has to be excluded from the analysis. Another reason is that one may know what variables to include in the model but may not know the exact functional form to use.

Whatever the sources of the specification errors, in consequence a researcher is misled in drawing conclusions about the statistical significance of the estimated parameters. When legitimate variables are omitted from a model, OLS (ordinary least squares) estimators of the variables retained in the model are not only biased but inconsistent as well. Moreover, the variances and the standard errors of these coefficients are incorrectly estimated thereby vitiating the usual hypothesis testing procedures. On the other hand, including irrelevant variables in the model hampers neither the unbiasedness and consistency of the coefficient estimates of the relevant as well as 'irrelevant' variables nor the estimated error variance but the only problem is that the estimated variances of the parameters tend to be larger, thereby making precise estimation difficult. In other words, the confidence intervals tend to be much wider, leading to the acceptance of the 'null hypothesis' more readily.

There is still another kind of uncertainty associated with forecast error which is the discrepancy between the actual and the forecasted value.

Suppose a model is hypothesized as

$$Y_t = \beta_0 + \beta_1 X_t + u_t$$

where u_t is the stochastic disturbance or error term which captures the impact of other determinants which are not included in the relationship.

Applying OLS regression to the above model, we obtain estimates of β_0 and β_1 as b_1 and b_2 respectively. Setting the error term equal to its mean value of zero (according to the classical linear regression model assumptions underlying the methods of least squares), the forecasts of the dependent variable (Y) are obtained as

$$y_t = b_1 + b_2 X_t$$

where, y_t is the forecasted value of Y_t.

The discrepancy between the actual and forecasted value, i.e. $(Y_t - y_t)$ provides the forecast error which is a measure of the accuracy of a forecast. Now the disturbances or error terms in the equation are unknown for the forecast period and are replaced with their expected values. While the expected value of each residual is zero, the actual value may be non-zero. Therefore, the larger the variation between the expected and actual values of the residuals, the greater the overall error in the forecasts.

Treatment of uncertainty

The uncertainty associated with forecasting can be minimized through proper treatment of the causes and utilizing information from past forecast errors. In the subsequent section some remedies for the problems associated with the data and the model are suggested.

Remedies for problems with data

The problems associated with the data can be redeemed by improving the data collection procedures and through proper maintenance of the database. In order to ensure high level data reliability the collection procedures must be consistent and rigorous. Consistency requires that the data be collected using the same definitions. Timeliness is a very important factor in maintaining a database. Information collection is not a one-time exercise. It needs to be conducted regularly and whenever new information becomes available it should be recorded in the current database without delay to ensure that there is no missing data. In the context of electricity demand forecasting study, it is to be ensured that data on variables required for such an analysis (as has been discussed earlier) are available. If no data is available on some required variable(s), then the information must be collected so that the variable can be added to the existing database.

For the purpose of electricity demand forecasting

more importance is to be given to creating a pooled database in order to capture the behavioural dynamics of electricity consumers. To create a pooled database, information needs to be collected from electricity consumers in a region for some consecutive time periods. The changes in norms can be best estimated if a pooled database is available. Otherwise, various scenarios of the changes in the norm value have to be considered, which in turn is subject to uncertainty. In the case of surveys using questionnaires, the format, design, and content of the questionnaire should be tested and revised through discussions and mock interviews. An important suggestion is that the database provides details of the data collection procedure as well as the definitions used, so that a researcher might not have any confusion in selecting the data.

Changes in norms can be best estimated if a pooled database is available.

Remedies for problems with model

Procedures exist to detect the presence of model specification errors, so that a mis-specified model can be rejected. Examination of the residuals is a diagnostic test for detecting model specification errors such as the omission of an important variable, and incorrect functional form specification as discussed earlier. If in fact there are such errors, a plot of the residuals will exhibit distinct patterns. Besides, there are two distinct tests for detecting model specification errors.

1. Ramsey's RESET (regression specification error test) test suggests introducing the estimated dependent variable in some form as additional regressor(s) in the original model and re-runing the regression. If the R^2 for the new formulation is higher than the R^2 for the original model and the difference is statistically significant (in terms of the F-statistic) one may conclude that the original model was mis-specified.
2. The Durbin-Watson test for detecting model specification error(s) requires, first, the calculation of the Durbin-Watson d-statistic from the OLS residuals of the assumed model. If it is believed that the assumed model is mis-specified because it excludes a relevant explanatory variable (Z) from the model, then the residuals are to be ordered according to increasing values of Z. The omitted explanatory variable (Z) could be some function of the explanatory variables already present in the original specification or it may be completely unrelated. The next step is to compute the d-statistic from the ordered residuals by the usual formula. If the estimated d-statistic value is significant (according to the Durbin-Watson tables) then the hypothesis of model mis-specification is accepted.

The above two tests only suggest the rejection of a model if it is detected to be mis-specified. Though this is not a solution because knowing that a model is mis-specified does not necessarily help in choosing a better alternative, at least the tests give an indication to improve upon the selected model.

The problem of forecast errors (as discussed in the earlier section) can be dealt with by comparing forecasts for the same series across different models. The forecast error statistics used as relative measures to compare forecasts for the same series across different models are the root mean squared error and the mean absolute error. The criterion is that the smaller the error, the better the forecasting ability of the model. Given Y_t, y_t, the actual and the forecasted value of the dependent variable Y in period t respectively, and given that $t = s$, $s + 1$, ..., $s + h$, we get

$$\text{root mean squared error} = \sqrt{\frac{1}{h+1}\sum_{t=s}^{s+h}(y_t - Y_t)^2}$$

$$\text{mean absolute error} = \frac{1}{h+1}\sum_{t=s}^{s+h}\left|y_t - Y_t\right|$$

The mean squared forecast error can be decomposed as

$$\frac{1}{h}\sum_{t=s}^{s+h}(y_t - Y_t)^2 = (\bar{y} - \bar{Y})^2 + (s_y - s_Y)^2 + 2 \times (1 - r) \times s_y \times s$$

where $\bar{y}$ and $\bar{Y}$ are the respective means of the forecasted and actual series, and s_y and s_Y are the standard deviation of y and Y respectively, and r is the coefficient of correlation between y and Y.

The proportions are then defined as

$$\text{bias proportion} = \frac{(\bar{y} - \bar{Y})^2}{\frac{1}{h}\sum_{t=s}^{s+h}(y_t - Y_t)^2}$$

$$\text{variance proportion} = \frac{(s_y - s_Y)^2}{\frac{1}{h}\sum_{t=s}^{s+h}(y_t - Y_t)^2}$$

$$\text{covariance proportion} = \frac{2^{*}(1-r)^{*}s_y{}^{*}s_Y}{\frac{1}{h}\sum_{t=s}^{s+h}(y_t - Y_t)^2}$$

The bias proportion tells us how far the mean of the forecast is from the mean of the actual series. The variance proportion shows the disparity between the variation of the forecast and that of the actual series. The covariance proportion measures the remaining unsystematic forecasting error.

The bias, variance and covariance proportions add up to unity. The forecast is supposed to be 'good' if the bias and variance proportions are small so that most of the bias is concentrated in the covariance proportion. If the bias proportion is large it indicates that the mean of the forecast does a poor job of tracking the mean of the dependent variable.

The discussion, so far, mainly depicts the technical aspects of modelling. However, the difficulty in predicting electricity demand lies in the fact that such an exercise has to take into consideration the behaviour of millions of individual consumers whose decisions influence the consumption of electricity. For example, a household's decision to purchase an electric air- conditioner is partly determined by whether its income is sufficient. Predicting the growth in air-conditioner sales thus requires that income be predicted, in addition to possessing knowledge about the probability of the consumer's decision to purchase the air-conditioner given a certain income level. Several variables other than income level are also known to have a strong influence on individual customer behaviour. A very important variable is the price of electricity. Again, prices of energy sources that compete with electricity (e.g. natural gas for space heating and water heating) influence these decisions. Finally, the forecaster must predict how the technologies themselves change. This can again influence future levels of electricity consumption in two ways. First, as industrial processes and appliances become more efficient the consumption per appliance falls. Second, the introduction of new technologies might contribute to increased purchases of appliances. The concern here is that in anticipating the future evolution of the determinants of electricity some degree of uncertainty is involved and a forecaster's challenge lies in finding alternative ways to account for the uncertainty in the forecasting process.

The forecaster must predict how the technologies themselves change.

Conclusion

The challenge of forecasting lies in improving forecast model by developing an explicit notion of uncertainty. So apart from addressing uncertainties due to technical errors in modelling and problems associated with data, a forecasting exercise should also take into consideration various socio-economic phenomena and explore the possible uncertainties associated with anticipation on the basis of assumptions about the future evolution of the socio-economic system. A common practice is to use historical relations to comprehend the dynamic character of the socio-economic system. Such relations may be able to accurately depict, in a global manner, the past correlation of certain dependent and independent variables but this may not necessarily help infer the causality in these relations. A model may appear to have grasped the essential dynamics of society (without actually doing so), simply because other factors were temporarily stable in the past or worked in unison with the independent variables. However, dynamic factors like technological progress and structural changes are bound to have substantial impact, particularly in the context of electricity demand forecasting. One way of dealing with such uncertainties is to consider different scenarios and conduct an analysis for each. Scenarios are basically alternative cases that reflect the range of the possible futures while they should essentially reflect the contrast in assumptions. Generally, three scenarios are chosen, high, low, and expected development. However the scenarios too, being developed on the basis of a set of assumptions, are generally biased in the sense that one always foresees a better future while making assumptions. The problem of uncertainty in forecast modelling is indeed too enigmatic and begs the conclusion that the subject receives more attention.

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Promoting & Financing Renewable Energy

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The renewable energy programme in India is presented in the light of the potential of renewable energy in the country. The achievements in renewable energy exploitation are outlined as well as future plans for the same.

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Renewable Energy technologies based on inexhaustible resources of sunlight, wind, water and biomass are considered to offer sustainable energy alternatives to a world beset by serious environmental problems and volatile fossil fuel politics. Despite the somewhat checkered progress of renewables in the last three decades, they continue to hold a prominent place in various national and international agendas, including the global climate change negotiation processes, as choices that could lead the world towards sustainable development. Throughout human civilisation, energy has been one of the prime movers of economic development. An increasing share of global energy needs is expected to be met by renewables in the years ahead. Energy forecasts for the European Union and the United States indicate this share to reach about 12% by the year 2010. International estimates suggest that renewables would contribute about one-quarter to half of the world's primary energy supply by 2050; and by that year, two of the world's largest petroleum companies expect renewables to account for over 50 per cent of their turnover. Renewables have enormous potential to meet the growing energy requirements of the increasing population of the developing world, while offering sustainable solutions to the global threats of climate change.

Energy scenario in India

India has the second largest population in the world with a billion people, and is considered a rapidly growing economy. Being a developing country, the energy technology base in India is relatively inefficient and has a slow turnover; consequently, the economy is highly energy-intensive. India's commercial energy system is heavily dependent on coal with oil and natural gas being the other major sources of primary energy among the commercial fuels. The traditional biomass fuels of fuelwood, animal waste and crop residues play an important role, especially in the rural areas where they meet a large proportion of the energy requirements. While the share of commercial energy from fossil fuels, is seen to be increasing every

year, the traditional fuels are estimated to still contribute over one-third of the total energy.

The total installed capacity in India is 105,000 MW as on 31st March 2002 including Thermal, Hydel, Nuclear and Renewables. However, there is demand supply gap of 7.8 per cent and peak load demand of 13 per cent. This has got accentuated by non-decentralised nature of power generation with a vast area in the rural segment not connected by grid for reliable and quality power.

Potential of Renewable Energy in India

India is generously endowed with renewable energy resources viz. Solar Energy, Wind Energy, Biomass and Small Hydro, widely distributed across the country, which can be utilised through commercially viable technologies to generate power/energy. Increasing use of these sources will also be instrumental in simultaneously achieving environmental objectives. Renewable Energy technologies fit well into a system that gives due recognition to decentralisation and local participation.

Table 1: Potential of Renewable Energy technologies in India

Sector	Potential
Biogas Plants	12 Millions
Improved wood stoves	120 Millions
Wind	45,000 MW
Small Hydro	15000 MW
Biomass Power/Co-generation	19,500 MW
Solar PV	20 MW/sq.km.
Waste of Energy	1700 MWe
Solar Water Heating (collector area)	140 Million sq.m.

Source: Ministry of Non-conventional Energy Sources (MNES)

Table 2: Cost of Installation and Generation of Some Renewable Energy Technologies

Sector	Capital Cost (Million Rupees per MW)	Cost of Generation (Rupees per kWh)
Small Hydro	30 to 60	1.00 to 2.00
Wind Energy	35 to 40	2.00 to 2.75
Biomass Power	30 to 40	1.75 to 2.00
Bagasse Co-generation	25 to 30	1.75 to 2.00
Biomass Gasification	25 to 30	1.25 to 1.50
Solar PV	250 to 300	1.00 to 12.00

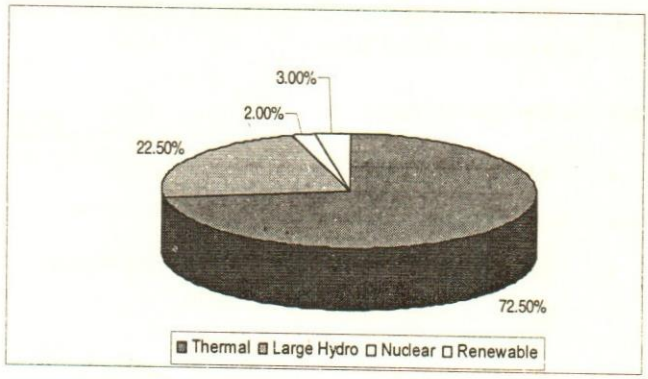

Fig. 1. Indian Energy Scenario

The Renewable Energy Programme in India

In India, the systematic Renewable Energy programme began with the constitution of a Commission for Additional Sources of Energy (CASE) under the Department of Science & Technology, with the responsibility of formulating programmes for the development of Renewable Energy, coordinating and intensifying R&D activities and ensuring the implementation of all government policies in this regard.

Appreciating the importance of developing the NRSE in a larger framework, the Government of India created the Department of Non- conventional Energy Sources (DNES) in 1992, which later has been converted to a full fledged Ministry of Non-conventional Energy Sources (MNES).

Taking into account the limitations of the conventional banking approach and to accelerate the momentum of development and large scale utilisation of renewable energy sources and primarily for promoting and developing and financing NRSE technologies, the Indian Renewable Energy Development Agency Limited (IREDA) was incorporated in March, 1987. Within this institutional framework the renewable energy technologies have been promoted through research and development, demonstration projects, programmes supported by government subsidies, programmes based on cost recovery supported by IREDA and private sector projects.

Policy Framework for Renewables

A favourable fiscal/policy environment exists in India for development of renewable energy sources economically. In the last 10 years, Renewable Energy Technologies in India have been promoted through R&D, demonstration projects, dissemination projects/

programmes supported by Government subsidies and fiscal incentives outlined below:

From Central Government

- Income Tax Holiday
- Accelerated Depreciation
- Concessional Custom Duty/Duty Free Import
- Capital/Interest Subsidy

From State Governments

- Energy buyback, power wheeling and banking facilities
- Sales Tax concession benefits
- Electricity Tax exemption
- Demand cut concession offered to industrial consumers who establish power generating units from renewable energy sources
- Capital Subsidy

Achievements in Renewable Energy Exploitation

India is implementing one of the world's largest programme on renewable energy. This cover an entire gamut of technologies, including improved woodstoves, biogas plants, biomass gasifiers, solar thermal and solar photovoltaic systems, wind farms, wind mills, biomass based co-generation, small and micro hydel systems, energy recovery from urban, municipal and industrial wastes, hydrogen energy, ocean energy, fuel cells etc.

However, in the national energy scene, the present output from Renewables being less than four per cent of the installed capacity, it has not matured into a major alternative, but a viable supplementary energy, especially for niche applications like decentralised power generation for captive consumption. The National Energy Plan includes specific emphasis on Renewable Energy Development with the main motto of environmental benignness and meeting decentralised energy needs. The Government is also in the process of formulating and enacting a comprehensive Renewable Energy Policy and Legislation, which will dovetail the application and use of Renewable Energy with conventional energy in the above applications.

The National Energy Plan includes specific emphasis on Renewable Energy Development.

The achievement made in exploitation of renewable energy sources in India can be assessed from the following:

Table 3: Cumulative Achievements in Renewable Energy Sector (as on March 31, 2002)

Sector	Achievement
Biogas Plants	3.3 Million No.
Improved wood stoves	35 Millions
Wind	1617 MW
Small Hydro	1438 MW
Biomass Power/ Co-generation	381 MW
Biomass Gasifiers	51 MW
Solar PV	85 MWp (including 30 MWp exported)
Waste of Energy	22 MWe
Solar Water heating (collector area)	0.6 Million sq. m.

Renewable Energy Plan 2012

The Government has proposed draft renewable energy policy and programme interventions required to achieve the goals of meeting the minimum rural energy needs, providing decentralised off-grid energy supply and generating grid quality power based on renewables. The draft also sets medium term goals to be achieved till the year 2012, which are:

- Achieving a 10 per cent share for renewables in the new power capacity projected upto 2012. In absolute terms, this would translate to setting up of about 10,000 MW through Renewables.
- Deployment of Solar Water heating systems in one million homes
- Electrification by renewables of at least one quarter of 18,000 unelectrified villages
- Deployment of 5 million solar lanterns and 2 million solar home lighting systems
- Coverage of 30 million households through improved wood stoves
- Setting up of further 3 million family size biogas plants

The Renewable Energy Plan 2012 aims at more

women participation in Renewable Energy programmes for their employment and empowerment; availability of minimum cooking energy to all households; to provide cost effective energy for water pumping, irrigation, drinking and for rural electrification and all round rural development through Integrated Rural Energy Programme.

Barriers in Renewable Energy Development

The main bottlenecks for large-scale development of Renewable Energy includes:

- Risks involved in the transformation of technologies from novelty to mainstream
- Distortions in energy market and easy availability of conventional energy with established networking arrangements
- Stiff competition from subsidised conventional energy and its universal applicability
- Lack of large scale production facilities
- High capital investment and marginal commercial viability
- Lack of marketing mechanisms
- Less number of major players in the industrial segment
- Lack of awareness
- Lack of adequate capital at affordable cost
- Limited access to financial resources and high cost of finance
- Lack of micro and retail financing
- Lack of adequate polity and institutional framework
- Lack of trained manpower

India has good know-how and technical knowledge in many commercially viable Renewable Energy technologies. However, the infrastructure for large-scale development and deployment are not available in comparison to conventional forms of energy, which were developed over a number of years. The natural advantage available to conventional energy due to its high level of maturity in all spectrums of its development and usage is not available to Renewable Energy technologies.

In India, there should be a judicious mix of large scale and small scale installation and production of Renewable Energy depending upon the technology and usage and niche applications. For example, many grid power technologies can have medium or large-scale installations with long-term viability options, which will supplement the grid with quality and uninterrupted power. However, decentralised utilisation of Renewable Energy can be developed as niche applications in remote areas.

Decentralised utilisation of Renewable Energy can be developed as niche applications in remote areas.

Market For Renewable Energy

Market for Grid Power from renewables is well appreciated through policies and programmes of State Utilities. The shortage in power generation and the decentralised and captive use of small-scale power generation provide ample investment opportunity in the sector.

Whereas, in the off-grid applications like Solar Photovoltaic Power there are four distinct segments for tapping:

- Government Market
- Government Driven Market
- Cash Market and
- Loan Market

Most manufacturers and developers are focussing attention towards safe and secure Government Markets and not aggressively pursuing cash and loan markets. The absorption capacity of cost of funds and a market-based commercialisation is yet to be fully developed in the loan market category.

The consumer market in India for various products provides good opportunity for economically viable technologies in Solar Energy products. A study conducted by the National Council for Applied Economic Research concluded the following characteristics of Indian Consumer Market:

- The rural markets are already large and growing fast
- People are graduating from the lowest to the higher income groups
- There has been a surge in the purchase of consumer products by households, and the ownership of consumer durables

- Hire purchase and loans are about 10 per cent of the ownership

The structure of the Indian Market shows over a million households as very rich consumer segment and about 30 million households in the next stratum of consuming class. Over 50 million households are already on the climbing steps and a similar number of households are aspiring to become the consuming class. These opportunities are to be tackled with innovation marketing models and user friendly products with reliability and service facilities.

Industrial Infrastructure

A few years ago not many entrepreneurs would have thought of making a foray into the renewable energy sector. But today an increasing number of them are looking at this sector as quite promising for investment. Annual turnover of renewable energy industry in the country has reached a level of more than Rs. 25 billion. There are about 15 companies manufacturing different models of wind turbines of unit capacity 225 kW and above. There are 9 firms engaged in the manufacture of solar cells and 21 in producing PV modules. In addition, 50 firms mostly in the small-scale sector are engaged in manufacturing a variety of PV systems. In the biomass power and sugar mill co-generation sectors, there are about 9 leading boiler manufacturers and about 7 turbine manufacturers in India. In the field of small hydropower generation, there are about 9 companies manufacturing turbines and generators, while there are few others who offer technical consultancy services and are themselves independent power producers.

IREDA Model in Renewable Energy Financing

Affordable financing is one of the crucial factors inhibiting the usage of renewable energy, especially at the small-user level. This inhibition has been capitalised through the institutional model of IREDA, which is a unique model globally. Commercial projects based on cost recovery principles are supported by IREDA, predominantly in the private sector.

IREDA'S Mission is to be a pioneering, participant friendly and competitive institution for financing and promoting self-sustaining investment in energy generation from renewable sources and energy efficiency for Sustainable Development. IREDA operates a Revolving Fund to develop and promote commercially viable NRSE technologies in the country. A major role of IREDA is to provide both renewable energy users, manufacturers and producers credit that initially feature concessional terms but progressively approach commercial market rates as the technology gains wider acceptance. By financing new ventures in renewable energy, IREDA helps to create performance track records for NRSE technologies, facilitating their transition from novelty to mainstream status.

IREDA operates a Revolving Fund to develop and promote commercially viable NRSE technologies in the country.

IREDA's Achievements as on 31.03.2002

Number of projects approved	1570
IREDA's loan commitment	Rs. 53,000 Million
Loan disbursement	Rs. 27,500 Million
Power Generation Capacity sanctioned	1900 Mega Watt
Conventional Fuel Replacement (MTCR: Metric Ton Coal Replacement)	950,000 MTCR/Year

Commercially viable technologies in Solar Power, Biomass, HydroPower, Wind Energy and Co-generation are already making rapid progress in our country. Besides international assistance, enhanced budgetary support and wide-ranging incentives offered to private sector energy entrepreneurs have created the right climate for an accelerated development of renewables.

IREDA's Main Objectives

- To operate a revolving fund for promotion, development and commercialisation of new and renewable sources of energy (NRSE)
- To assist in upgradation of technologies
- To extend financial support to energy efficiency and conservation projects/schemes

IREDA's Lending Activities

IREDA's mandate covers a wide spectrum of financing activities including those that are connected to energy conservation and energy efficiency. At present, IREDA's lending is mainly in the following areas:

- Solar Energy Technologies – Manufacture & Utilisation of Solar Thermal and Solar Photovoltaic systems

- Wind Energy – Setting up grid connected Wind Farm projects
- Small Hydro – Setting up Small, Mini and Micro Hydel Projects
- Bio-Energy Technologies – Support to biomass based co-generation and power generation projects, biomass gasification, energy from waste and briquetting projects
- Hybrid systems
- Energy Efficiency and Conservation – End users, DSM and ESCO
- New and Emerging Technologies – Fuel Cell, Battery Powered Vehicles, Bio-fuels

The maximum extent of assistance extended by IREDA is determined by IREDA's exposure limit, which is set according to the client's credit worthiness and the security/guarantees offered for the loan term. The highlights of financing norms are:

Debt instruments

- Project financing schemes
- Equipment financing schemes
- Manufacturing loans

Quantum of Assistance

- Upto 75 per cent under project financing schemes
- Upto 85 per cent under equipment financing schemes

Rate of interest

- Up to 14.5 per cent per annum

Moratorium

- Upto 3 years

Repayment Period

- Upto 10 years

In addition to debt instruments, IREDA also operates Non-Conventional Energy Technology Commercialisation Fund (NETCOF), which is a venture capital fund for providing support for commercialisation of NRSE technologies by way of equity participation, loan, grant-in-aid, debentures etc.

Promotional Activities

Apart from the role of a Financial Institution, IREDA also conducts various promotional initiatives through business meets, seminars and workshops etc. IREDA also does entrepreneurial development through its various Entrepreneurship Development Programmes (EDPs), a number of them exclusively devoted to women. It also encourages more and more women participation. IREDA also takes critical care to ensure environment friendliness and better eco-balance. The agency also encourages rural development, self-employment and self-reliance through decentralised NRSE programmes.

International Assistance

IREDA's track records of achievements have also attracted global attention. Renowned multilateral and bilateral agencies have come forward to join this global movement for sustainable development. Details of international assistance tied and in the pipeline are given below:

International Assistance Received

Government of Netherlands	18 Million Dutch Guilders
Asian Development Bank	100 Million US Dollars
The World Bank-I Line of Credit (IDA/GEF/SDC/GON)	145.50 Million US Dollars
DANIDA	4 Million US Dollars
KfW	Germany
The World Bank-II Line of Credit (IDA/IBRD/GEF)	135 Million US Dollars

Corporate Plan and Vision

IREDA's activities form an integral part of the National Five-Year Plans and annual plans and are particularly dovetailed to the Five-Year Plans of the MNES. During the 10th Five Year Plan (2002-2007), IREDA'S proposal envisages ambitious targets for sanction of Rs. 63350 million for setting up renewable energy and energy efficiency projects. It is envisaged to support installation of power generation capacity to the tune of 1700 MW and generate energy equivalent to 200,000 MT of coal through these projects.

IREDA's Corporate Plan Targets for 1997-98 to

2009-10 envisages to support installation of power generation capacity to the tune of 2993 MW and generate energy equivalent to 976,000 MT of coal through renewable resources. Apart from this, 11,65,000 Square Metres of Solar Collector Area is expected to be installed during this period with IREDA's Assistance.

The Future

A recently concluded study has projected that with a medium incentives/support by the Government, the installed renewable energy capacity in India can increase to around 16,000 MW by 2015, thereby achieving a share of about 8 per cent for renewable energy technologies in total power generation capacity. Such a development in renewable energy in India would need an investment of about Rs. 1575 billion within the 20 years period of 1995-2015. This would present a very challenging opportunity for IREDA and other national financial institutions, which need a substantial pool of resources. These resources would be a mix of internal borrowings from UN, multilateral and bilateral programmes and private sector investment.

The installed renewable energy capacity in India can increase to around 16,000 MW by 2015.

Towards this end, any strategy to enhance the utilisation of renewables should include:

- Providing Renewable Energy Projects equal access to investment capital by providing a level playing ground in terms of fund mobilisation, institutional support, tariff formulation, continuing financial incentives in the form of tax rebates etc. in view of their environmental virtues.
- Priority sector lending status for renewables.
- Instituting a "Renewable Energy Act" to address the concerns of renewables so as to bring them on a fast track development frame.
- Increasing the awareness of the advantages of decentralised stand-alone energy systems operating on renewable sources.
- Devising a policy package for the country to enhance private sector participation and to increase the involvement of rural based co-operatives in electricity generation.
- Entrepreneurship development in renewable energy.
- Intensification of R&D efforts to improve technology and to reduce costs.
- Energy Efficiency and Conservation.

Conclusion

It may also be noted that Commercialisation of Renewable Energy Technologies for sustainable development need appreciation and analysis of realizable potential and development of innovative models for market penetration. A multi-model approach based on the socio-politico-economic-cultural situation in the country is necessary.

Once a proper institutional mechanism is in position, the barrier of energy pricing distortions is rationalised and adequate resource allocation is available, this has to be followed-up by the industry with sustained movement along learning curves in manufacturing and operation, greater production economies and technical innovations. Only with this, the Renewable Energy Movement, which has already begun, will gain momentum. The Renewable Energy Community has a greater challenge ahead. IREDA invites your participation in this global movement paving the way for a sustainable human development in the new millennium. □

Anyone who proposes to do good must not expect people to roll stones out of his way, but must accept his lot calmly if they even roll a few more upon it.

— Albert Schweitzer

Sustainable Energy Supply in India: Vision 2020

Pradeep Chaturvedi

This article outlines the energy resources of our country at present and goes on to discuss how we can meet our future demands for energy by sustainable means. The characteristics of growth in the energy sector are discussed within this perspective and policy measures for meeting these goals are suggested.

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India has significant renewable coal oil resources, but it also faces significant energy poverty and urban energy challenges. Energy accessibility, the meaningful and affordable access to commercial energy for everyone, has become a national goal. This goal is not just a social or moral challenge—it has business implications in terms of energy security, trade and shareholder value. This calls for setting a goal of energy availability in terms of continuity of supply and quality of energy services on which all the state governments have to work with the central government.

Energy Security is gaining significance as terrorism is on the increase. Too much dependence on imported fuel—mainly oil—can jeopardise India's energy security at any point of time. Failure to attract foreign and private investment in the energy sector has resulted in a setback to the government's plans of oil and gas production; coal production and power production targets. That has also affected the growth of other economic sectors. However, a roll back to the public funded energy sector targets are likely to result in ground reality results.

In order to achieve sustainable energy development, measures need to be taken to increase the efficiency of energy production and consumption, and to switch to non-fossil fuels. It will include introducing rapidly advanced (and clean) fossil fuel technologies and nuclear power technologies and developing new and renewable sources of energy technologies to facilitate switching to renewable energy in the long run. Particular attention is needed to introduce modern technologies in the use of biomass, a major and widely used renewable energy source in the region. Further, improvements in cooking stoves have the potential of raising combustion efficiency and in reducing air pollution. With regard to industrial and transportation sectors, effective national policies need to be formulated and implemented to reduce material and energy intensity of production and consumption.

The prime challenge before the country is to provide minimum energy services to allow the poor people to achieve a decent standard of living. By 2020 the provision of modern energy services can be ensured either as a connection to a reliable, sustainable electricity supply grid, or as a stand alone electricity system which may not be grid connected.

Demographic Trends

A discussion on trends at the turn of the millennium will bring up various issues. India's population reached one billion on May 11, 2000, which means 16 percent of the world's population is living on 2.4 per cent of the world's land area. If the current trend in population growth continues then India may overtake China in 2045, to become the most populous country in the world. The population in the decade of March 1991-March 2001 grew from 846.3 million to 1012.4 million. Projections made by the National Population Commission in 1999 indicate that India's population at the end of 2020 would be around 1250 million (extrapolated from the figure of 1107 million in 2010). This will be feasible only when the National Population Plan 2000 becomes fully operational.

It is estimated that in 1999 about 31 per cent of the population was in the urban areas and 69 per cent in the rural areas. As per the Census of India projections; by the year 2020, 47 per cent of the population will be in the urban areas and 53 per cent in rural areas. That means, by the year 2020, the urban population would have jumped from the present 310 million to 537 million and the rural population would have marginally increased from 690 million to 713 million. Such a paradigm shift will lead to major shifts in the development process and corresponding energy consumption patterns as the rural population will stabilise around the present day figure but the urban population will almost double.

Such a change in demography and growth patterns will lead to new consumption patterns. Energy supply and consumption will be attuned to emerging patterns of development. That means the consumption pattern in 2020 will be quite different from the present and may call for exploitation of all possible primary energy sources.

The consumption pattern in 2020 will be quite different from the present and may call for exploitation of all possible primary energy sources.

Commercial Energy Resources

Primary Energy Resources and Regional Distribution

Coal and hydroelectric resources are the mainstay for India's primary resource support. Oil and natural gas resources of the country are limited. Nuclear resources, on the other hand, are modest. The coal resources are of poor quality having high ash content. Besides, the distribution of the primary resources in various regions is rather skewed. While the eastern region accounts for 70 per cent of the total coal resources, the western region accounts for over 70 per cent of the hydrocarbon reserves, and over 70 per cent of the total hydro potential of the country is concentrated in the northern and north-eastern region. The southern region which has only 6 per cent of the coal reserves and 10 per cent of the hydroelectric potential, possesses most of the lignite deposits of the country.

Refer to Table 1 for regional distribution of the primary commercial energy.

Table 1: Primary Commercial Energy Resources (March 1999)

Regional	Coal (BMT)	Lignite (BMT)	Crude Oil (MMT)	Natural Gas (BCM)	Hydro Capacity(x) MW	Electricity Energy TWh
Northern	1.1	1.1	–	4	30135	225.00
Western	48.2	0.5	584	497	5679	31.40
Southern	13.1	25.9	–	–	10763	61.80
Eastern	141.4	–	–	–	5590	42.50
North-Eastern	0.9	–	148	159	31857	239.30
All India	204.7	27.5	732	660	84044	600.00

Ref.: Planning Commission, Government of India (1998); and ONGC (1999)

BMT = Billion Metric Tonnes MMT = Million Metric Tonnes
BCM = Billion Cubic Meter (x) at 60% LF.

Note: Gas reserves are identified at 717.3 BCM (at the end of 1998) - Under control of ONGC - 525 BCM; OIL - 94.5 BCM; & Joint Ventures/Private companies - 97.5 BCM.

Non-Conventional Energy Sources

The country is endowed with a large potential of non-conventional energy resources as given in Table 2.

Indigenous Primary Energy Production

India's energy requirements are met from traditional as well as modern forms of energy. The share of traditional forms of fuels is diminishing, and in 1996-97 these contributed to over 34 per cent of the annual energy

Table 2: Renewable Energy Potential and Exploitation

Source/technology	Potential Availability
Biogas Plants	12 Million
Biomass-based Power	17,000 MW
Efficient Woodstoves	120 Million
Solar Energy	5 ×10 Whr/Year
Small Hydro	10,000 MW
Wind Energy	20,000 MW
Energy Recovery from Urban & Industrial Wastes	–
Ocean Thermal	50,000 MW
Sea Wave Power	20,000 MW
Tidal Power	9,000

Ref.: Ministry of Non-Conventional Energy Sources, Govt. of India, Annual Report 2001-2002.

SPV = Solar Photovoltaic SWH = Solar Water Heater
SC = Solar Cooker

consumption. The usage is largely restricted to domestic fuels in semi-urban and rural areas at very low efficiencies. Current trends in production are given in Table 3.

Table 3: Trends in Indigenous Production of Commercial Primary Energy

Year	Coal Mt	Lignite Mt	Crude oil mt	Natural Gas mt	Hydro TWh	Nuclear TWh	Wind TWh
1953-54	33.0	–	0.26	–	2.52	–	–
1960-61	55.67	0.05	0.45	–	7.84	–	–
1970-71	72.95	3.39	6.82	1.4	25.25	2.42	–
1980-81	114.1	4.80	10.51	2.4	46.54	3.00	–
1990-91	211.73	14.07	33.02	18.0	71.66	6.14	0.03
1996-97	288.65	22.54	33.87	22.9	68.63	9.01	0.85
1997-98	295.9	23.05	33.86	26.40	74.5	10.00	1.00
1998-99	292.2	23.42	32.7	27.43	82.7	11.90	1.00
1999-00	299.97	22.12	31.9	28.45	80.6	13.3	1.00
2000-01	309.63	22.95	32.4	29.48	74.5	16.9	1.00

Ref: Planning Commission, Government of India (1998); Indian Economic Survey 2001-2002.

Total power utility generation capacity installed on March 31,2001 was 101,600 MW as indicated in Table 4. These plants generated a total of 499.5 bkwh of electricity in 1998-99 comprising of thermal - 408.1 bkwh, hydro - 74.6 bkwh and nuclear - 16.9 bkwh. Thermal plants account for 81.8 per cent, hydroelectric plants for 14.8 per cent and nuclear plants for 2.4 per cent of power generation. This recorded a growth of about 4 per cent over the previous year. In addition, 15,400 MW capacity also existed in non-utilities and captive power units.

Table 4: Installed Plant Capacities and Electricity Generation (March 2001)

Source	Installed Capacity	Generation
Utilities		
Hydro	25,100 MW	74.6 Bkwh
Thermal	73,600 MW	408.1 Bkwh
Nuclear	2,900 MW	16.9 Bkwh
Sub-Total	101,600 MW	499.5 Bkwh
Non-Utilities	15,400 MW	55.00 Bkwh
Total	117,000 MW	554.4 Bkwh

Ref: Indian Economic Survey 2001-2002.

Energy Imports

Energy imports are largely in the form of crude oil and oil products. The import/export of other commercial energy forms, viz, coal and secondary electricity, has been rather limited. The import of crude oil and oil products in the year 2000-01 has been 74.1 mt and 4.2 mt (crude equivalent) respectively. India also exported petroleum products equivalent to 1 mt making net imports of oil products at 3.2. Import of coal during 2000-01 was 20.38 mt.

Primary Energy Supply

Total supply of energy (both of commercial, and non-commercial forms excluding draught animal power) increased from 89.6 mtoe in 1953-54 to about 421 mtoe in 2000-01. Share of non-commercial fuels declined from 74 per cent 1950-51 to about 30 per cent in 2000-01. Fuelwood continues to maintain its primacy in non-commercial energy supply (largely in the household sector). Changes in the pattern of primary energy supply since India's planned development in 1952 is reflected in Table 5 below:

Supply (also considered consumption) of non-commercial fuels in the year 2000-01 is estimated at 173 mt of fuelwood, 95 mt of dung cakes and 53 mt of agro wastes.

Energy Consumption

Share of commercial energy in the final energy consumption increased from 28.4 per cent to 70 per cent in this period, while that of non-commercial energy sources declined from 71.6 per cent (in 1953-54) to 30.0 per cent (in 2000-01). See Table 5.

Energy Sector Growth

Following characteristics of growth have been ob-

Table 5: Changes in the Pattern of Primary Energy Supply (mtoe)

Commercial Primary Energy Production	1953-54	1960-61	1970-71	1980-81	1990-91	1996-97	1997-98	1998-99	1999-2000	2000-2001
Coal	23.62	35.64	36.48	56.96	94.68	122.79	127.2	125.63	128.95	133.09
Lignite	–	0.01	0.18	1.23	3.34	5.04	5.15	5.23	5.17	5.13
Crude Oil	0.19	0.46	7.01	10.79	33.92	33.9	33.9	32.70	31.90	32.40
Natural Gas	–	–	0.60	1.41	11.73	20.05	26.40	27.43	28.45	29.48
Hydro Power	0.24	0.67	2.17	4.00	6.16	5.90	6.39	7.10	6.90	6.38
Nuclear Power	–	–	0.63	0.78	1.60	0.78	0.85	1.02	1.14	1.45
Wind Power	–	–	–	–	–	0.07	0.10	0.10	0.10	0.10
Total	24.05	36.78	47.67	75.19	151.43	187.53	193.64	199.2	202.6	208.03
Net Imports	2.20	6.04	12.66	24.63	31.69	51.16	57.16	64.3	65.7	86.2
St. Changes (–)	0.24	2.87	0.69	3.80	5.37	2.38	2.38	2.38	2.38	2.38
Intl. Bunkers (–)	0.53	2.50	0.24	0.21	0.14	0.17	0.17	0.17	0.17	0.17
Total Commercial Energy Supply	25.48	39.45	59.40	95.81	177.61	241.08	254.35	266.05	270.75	296.78
Non-Commercial Primary Energy Supply	64.13	74.38	86.72	108.48	122.07	127.50	127.50	127.50	127.50	127.50
Total Primary Energy Supply	89.61	103.83	146.12	204.29	299.68	368.58	381.85	393.55	398.25	421.28

Ref.: Planning Commission, Government of India (1998). Indian Economic Survey 2000-2991, Government of India and Date Base of IEI

served in different sectors of energy:

(a) Power generation has not developed as envisaged, mainly due to lack of enabling environment, foreign and private investment.

(b) Not only the generation capacities have not been added, the transmission and distribution losses have been on the increase.

(c) Coal consumption and production has been lower than projected due to lower additions of power generation capacities.

(d) Oil consumption has been high, as a large number of captive power plants were installed and larger transport activities took place and the service sector developed. As domestic crude production stagnated, the import of crude oil increased. However, due to recent recession, oil consumption has stagnated.

(e) Contribution of new and renewable sources of energy has been lower than projected, except for biomass (in traditional form) and wind power. Lack of policy on use of renewables and hidden subsidies for conventional sources have been mainly responsible for the same.

(f) Natural gas use has been on the increase. Combined cycle gas turbine, utilising natural gas for base load, has been projected as a potential front-runner in the country for future additions of power capacities. Option of Naptha and LNG based power plants were considered but not found favourable. CNG had been introduced in the transport sector. However, the gas supply does not match the requirement even in major cities. Lack of infrastructural facilities for local transportation/transformation, mainly the port facilities, is delaying decision.

(g) Nuclear power has registered significant growth, mainly due to rehabilitation of the Rajasthan Atomic Power Plant and improvement in plant availability factor at 85 per cent and over. Systematic work on safety, waste management and environment management have raised the level of public confidence. Environment management control have earned the ISO 14000 certification to the nuclear power plant.

(h) The refining capacity has gone up to 102 mt per year in 1999-2000. This has no doubt lowered the import of petroleum products (but increased import of crude oil)

(i) UN Framework Convention on Climate Change, in 1992; and Kyoto Protocol, in 1997, have resulted in wider awareness of environmental is-

sues relating to energy use. Local and regional pollution as well as greenhouse gas emissions have received wide political attention. Adverse impact of greenhouse gas emissions on air pollution and health, has been under scrutiny.

Issues in Perspective

The Indian Member Committee of the World Energy Council, in 1996, projected energy demand in 2020, as the demand pattern over the 25 year time frame can be understood within the known technology regime. The conclusions of the 17th Congress of the World Energy Council, at Houston, in September 1998 also emphasised on suitability of present technologies for application upto 2020, thereafter, the emerging technologies will take over.

The energy demand is likely to be influenced in the following manner:

(i) The combined effect of increase in population, higher energy consumption and introduction of efficiency measures can result in increasing the household energy demand by almost 2.5 to 3.0 times, during the 20 year period.

(ii) Also with better network of road and rail, and introduction of rapid mass transport system under an integrated transport policy, the increase in transport sector energy consumption will be decoupled from increase in man and freight movement. The IT revolution will lead to the concept of 'home and work place' resulting in lower energy consumption for private transport.

(iii) Environmental concerns, mainly the global and trans-boundary issues involved in energy sector emissions, will lead to higher utilization of cleaner coal conversion technologies; and utilization of cleaner energy sources – mainly the renewable energy sources.

There is a growing perception that environment protection and conservation would have to be adequately internalised in the growth of the energy sector.

Energy Demand 2020

A few model studies were made by experts in the recent past for projecting energy demands for the period up to 2020. The Study by E.A.S. Sarma, J.N. Maggo and A.S. Sachdeva has been considered at discussions organised by The Institution of Engineers and other professional groups and found generally acceptable. This paper also refers to the same approach, incorporating charges as considered appropriate. The Study indicates the overall energy demand perspectives for three different scenarios as follows:

(i) a reference-able scenario (BAU) – in which the business as usual, (BAU) would be allowed to continue.

(ii) an efficiency oriented scenario (EFF) – considering the scope for reduction in the energy intensity based on induced efficiency through technology and management adaptations, and

(iii) an environmentally constrained scenario (ENV) – considering the implications for emphasis on minimisation of adverse environmental impacts in augmenting the energy supply system.

Projections were made under three different scenarios for different sectors of consumption and for three terminal years viz. 1999, 2009 & 2019.

In the presentation in 1996, the authors made projections under the "business as usual" scenario. It indicated that the total demand by 2019 would go up to 39,107 peta joules (934.0 mtoe) as compared to 9,727 peta joules (232.3 mtoe) in 1989 (corresponding figure for 1997-98 is 390 mtoe). However, looking from the point of view of environmental sustainability and huge investment required, energy conservation and energy efficiency programmes would have to be focused on. Their successful implementation can reduce the demand substantially.

Table 6: Future Demand for Commercial Energy in India (BAU Scenario)

		1991-92	1996-97	2009-10	2020-21*
1.	Electricity TWH	231	336	725	1350 (1745)**
2.	Coal mt	229	311	690	#1400
3.	Petroleum mt Products	57	81.2	165	335
4.	Natural bcum Gas	18.6	30.2	65	130

Ref: Planning Commission, Government of India - September 1995 & September, 1996 and India's National Paper on Energy Scene 1998 presented at the 17th Congress of the World Energy Council, at Houston in September 1998.

* Projections to 2020-21 made on the basis of 'Business as Usual' – J.N. Maggo - R&D Needs for Energy Sector - September, 1996.

** Electricity generation capacity of 1745 TWH will be required to take care of T&D losses and Plant Load Factor. Corresponding installed generation capacity will be 385,000 MW at present day PLF and T&D loss level (1998).

\# R.K. Sachdev – International Conference on Coal - June 1996. Projection of requirement of Coal in 2020-21 was also revised in 1998.

Expert consultations agreed on these energy demand projections for India. The details are given in Table 6.

In order to meet the level of final energy demand projected in the BAU Scenario, the installed capacity in power generation will need to increase to nearly 3,85,000 MW in the year 2020. The coal and oil requirement will correspondingly be 1,400 mt and 335 mt respectively.

Demand for non-conventional energy sources, mainly biomass fuels, will remain around the same figure at about 113 mtoe (as in 1998-99) due to interfuel substitution and population migration from rural to urban areas.

Demand Side Efficiency Driven Scenario

Globalisation and competitiveness of Indian economy is creating a scenario wherein efficient and cleaner technologies will be introduced. Introduction and adaptation of such technologies will be slow for reasons of outdated equipment and plants and lack of financial capital. Therefore, it is expected that the combined impact of these measures can lead to at least 10 per cent lowering of energy demand in 2020, compared to BAU Scenario (except gas). Thus, applying this assumption to BAU scenario, the commercial energy demand will work out to about 36,000 peta joules (850 mtoe).

Thus the sectorwise energy demand projection under environmentally sound and, efficiency driven use scenario will be as given in Table 7.

Correspondingly, the final energy demand in environmentally sound and demand side efficiency supported scenario will need an installed capacity in power generation of 3,50,000 MW in the year 2020. The coal and the oil requirement will correspondingly be 1,260 mt and 300 mt respectively. The natural gas demand will be 130 bcum.

Table 7: Future Demand for Commercial Energy in India (Env. & Demand Side efficiencies Scenario)

Source Unit	1991-92	1996-97	2009-10	2020-21
1. Electricity TWH	231	336	725	1215 (1570)
2. Coal mt	229	311	690	1260
3. Petroleum mt Products	57	81.2	165	300
4. Natural bcum Gas	18.6	30.2	65	130

Demand for non-conventional energy sources is expected to remain at 113 mtoe.

Demand Side and Supply Side Efficiency Driven Scenario

If the supply side power sector interventions are taken into consideration, then the advantage of PLF improvement and T&D loss reduction will reduce the power generation capacity requirement by almost 10 per cent. Correspondingly the installed capacity required in 2020 will be 3,20,000 MW for a delivered energy supply of 1215 TWH/year from 1,400 TWH/Year generated power. Correspondingly the coal requirement will come down to about 1150 mt. However, a number of future power plants are to be based on liquid or gas fuels. Some coal experts project that the demand of coal can be reduced to just 800-810 mt if power generation from hydel, nuclear and renewable sources of energy can be organised appropriately. The demand for non-conventional energy sources is likely to be 140-150 mtoe in view of power generation from biomass.

Contribution of Different Sources

Power Sector

The Central Electricity Authority has carried out an extensive exercise to project power demand up to the year 2012-22. They have also developed the demands in the hydro thermal and nuclear sectors considering different levels of introduction of hydro at 25 per cent, 30 per cent, 35 per cent and 40 per cent. These projections are shown as below.

Table 7: Future Demand for Commercial Energy (Env & Demand and Supply Side Efficiency scenario)

Source Unit	1991-92	1996-97	2009-10	2020-21
1. Electricity TWH	231	336	725	1215 (1400)
2. Coal mt	229	311	690	(810)*1150
3. Petroleum mt Products	57	81.2	165	300
4. Natural bcum Gas	18.6	30.2	65	130

* Coal requirement will be 1150 mt in 2020, if the power generation from thermal power will be 75 per cent of the total. However, since contribution of nuclear power at 20,000 MW; renewable energy power at 20,000 MW and power import from Nepal and Bhutan at 20,000 MW are also considered, the requirement of thermal power will reduce to 190,000 MW (about 110,000 MW additional power over the present capacity of about 80,000 MW thermal power in utilities and non-utilities combined) or about 60 per cent of the required installed capacity of 320,000 MW, and the overall coal requirement will be only about 810 mt. Some part of additional thermal power will come from gas and liquid fuels.

Table 8: Provisional Power Sector Demand Projection up to 2021-22 (in MW)

	Hydro	Thermal	Nuclear	Total
Installed generating capacity I.C. (as on 31.3.1999)	22438	68586	2225	93249
Derated capacity (as on 31.3.1999)	22298	67273	1840	91411
Additional capacity identified in the CEA's Paper on Demand Supply (2011-12 - end of 11th Plan)	35490	78642	10226	124392
End of 12th Plan (2016-17) – Peak demand forecast under BAU Scenario – Consumption at the consumer end and excluded auxiliary consumption and T&D losses (and not the generation requirement) - 207809 MW. Total installed generating capacity at the end of 12th Plan (2016-17)				
Scenario Hydro: 25%	68061	190185	17000	272246
Total share Hydro: 30%	81673	175573	17000	272246
at the end Hydro: 35%	95268	160960	17000	272246
of 12 th Plan Hydro: 40%	108898	146348	17000	272246
13th Plan 2021-22 Peak demand forecast under BAU Scenario - 279298 MW. Total installed generating capacity at the end of 13th Plan (2021-22) - end of 31st of March 2022.				
Scenario at Hydro: 25%	91476	252427	22000	365903
the end of Hydro: 30%	109771	234132	22000	365903
13th Plan Hydro: 35%	128066	215837	22000	365903
Hydro: 40%	146361	193542	22000	365903

Note: Liquid fuel use beyond 2007 precluded.

Hydro-Scenario changes reflect the additional use of natural gas, imported coal and decentralised biomass generation at 35200 MW - 2020-21.

An important point to note is that the total power sector demand projected under CEA Study is at 3,65,903 MW.

CEA Study – (Provisional results)

The CEA Study has taken into effect the possibility of nuclear power generation of 22,000 MW installed capacity. The Ministry of Non-Conventional Energy Sources have been discussing the idea of setting a target of at least 10 per cent power generation from renewable energy sources in the additional capacities in future. If that be so then the renewable energy sector is also expected to contribute to the extent of 20,000 MW installed capacity. Since hydro can be considered a renewable source of energy, not necessarily decentralized, therefore, the power generation capacity from renewables can be clubbed with hydro power. Achieving the level of hydro power capacities at 25 per cent appears to be a feasible option but 30 per cent may not be obtainable for reasons of opposition to large dams by the environmentalists.

The CEA figures for 2021-22 (moderated for 2020) will also correspond to the figures expected under the study mentioned above. The suggested intervention will be that hydro at 30 per cent should read as hydro and other renewables. Thus the break-up will be as follows:

(i)	Thermal Power	2,34,132 MW
(ii)	Hydro Power	91,476 MW
(iii)	Biomass and Wind Power	20,000 MW
(iv)	Nuclear Power	20,000 MW
	Total	3,65,608 MW

Nuclear Power

The Vision 2020 of the Department of Atomic Energy has projected that the nuclear capacity in India can reach up to 20,100 MW(e). A tentative programme is as follows:

Present Operating Base	2280 MWe
Additions:	
PHWRs (Pressurised Heavy Water)	8320 MWe
FBRs (Faster Breeder Reactors)	2500 MWe
LWRs (Light Water Reactors)	7000 MWe
Total	20,100 MWe

Petroleum Sector

The Working Group on Hydro Carbon has made projections in the petroleum sector up to the year 2024-2025. From the figures presented in the Report the intermediate stage of 2020 has been worked out and it indicates the estimated crude requirement to be at 300 mt. Incidentally, this figure is similar to what has been projected for the year 2020 in the Study mentioned earlier. Projection for Supply/Demand of petroleum products is given in Table 9.

Table 9: Supply/Demand – Petroleum Products (in million tonnes)

Year	Demand (without meeting gas deficit)	Demand (with meeting gas deficit)	Estimated refining capacity	Estimated crude requirement
1998-1999	91	103	69	69
2001-2002	111	138	129	122
2006-2007	148	179*	167	173
2011-2012	195	195**	184	190
2024-2025	368	368	358	364
2019-2020	305	305	300	300

* Assuming 15 MMTPA to LNG import by 2007.

** Assuming that by 2012, adequate gas is available through imports and domestic sources.

Source: Hydro Carbon Vision 2025, Government of India – Report of the Sub-group on development of refining, marketing, transportation and infrastructure requirements (1999).

Policy Actions

Speedy Implementation of Market Reforms

Different governments have supported the concept of Energy Sector Reforms announced in 1992. They have been slow in creating the enabling environment to attract private and foreign equity and financing. Liberalisation, trade, privatization and customer choice are the four elements for market based energy systems. Market reforms should take into account the growing link between the final form of energy i.e. gas, liquid and electricity and primary sources of energy.

As power sector reforms focus has shifted from generation to transmission and distribution, it is necessary to focus on new players from the private sector.

Government's Role in Energy Sector

The market principles indicate that the governments need not be directly involved in managing energy markets and should restrict their role to laying down sound rules to be administered by impartial regulators. In India, the energy markets being largely under the control of government owned companies/boards the government will continue to control and dictate energy markets for a long time. Thus, innovative instruments will have to be introduced that will allow joint-sector of mixed PSU/private sector operation.

All Energy options are to be Effectively Developed

Renewables in every form, including the traditional biomass and new renewables need to be pursued vigorously to attain the future goals of 2020. Conversion of solid biomass into gaseous and liquid fuels and electricity will open new opportunities for wider use in the country. Also, urban and industrial wastes including the municipal solid wastes will become a major source of energy availability and their disposal has to be taken care of by municipal authorities. Wind power for megawatt scale power supply and photovoltaic power for small stand-alone systems will be critical. These sources can supplement the domestic energy needs in rural areas and urban slums. Specific policy interventions will be necessary for attaining this goal.

Urban and industrial wastes including the municipal solid wastes will become a major source of energy availability.

Recent advances in nuclear power sector in the country indicate improvements in fuel processing, waste management and environment control over the total nuclear fuel cycle. Contribution of nuclear power can contribute to meet the base load requirement.

Ensure an Enabling Climate for Investment

The case of capital investment is directly affected by currency devaluation, changes in fiscal regime and barriers to benefit of repatriation, among others. A major shift has been observed in the approach of most of the foreign companies seeking collaboration for setting up infrastructure sector projects. They are concentrating on being managers of projects under the 'build, operate and transfer' concept. Thus, the onus of financing is back on the Indian partners and Indian Financial Capital Markets. The government will have to ensure that all regulatory frameworks are in place at an early date, and reasonable profits are allowed to future investors.

Energy Prices to Cover Cost and Ensure Payment

Energy so far has been treated basically as a social good in the country. Multiple layers of prices have been decided based on cross-subsidies in an effort to reduce the burden of high energy price to agriculturists and the rural population, but without any concern for the environmental costs. This has not worked satisfactorily. The externalities such as energy security and environmental impact have to be internalised in the pricing structure.

Since the next focus has to be on meeting the energy needs of the poor, two sectors come in focus for tackling energy prices. The first of these is the agriculture sector and the other is rural household sector, basically for electrification. The present system of supplying kerosene or diesel at subsidised rates in the rural areas need to be gradually replaced by electricity supply through reliable and stable grid or decentralised supply system. It may even be observed that reduction in kerosene supply will result in substantial savings for the government in terms of the subsidy on kerosene. This saving can substantially augment project capital cost for establishing electricity networks.

Reduction in kerosene supply will result in substantial savings for the government in terms of the subsidy on kerosene.

Encourage Energy Efficiency

Energy efficiency policies that use direct or indirect price mechanisms (for example removing subsidies, incorporating externalities) are the most effective in lowering energy consumption trends. However, even without changing the overall price, environment energy efficiency policies should be pursued. Energy efficiency standards contribute to increased GDP growth by enhancing the marginal productivity of energy or because they provide the same energy for an increase in well being, both in economic and environmental terms.

Legal standards and an adequate payment systems for energy are essential to energy efficiency goals.

Financing Partnerships linked to Environmental Goal

In the context of climate change mitigation all countries are obliged to take domestic action. Given the enormous need for new capital stock in developing countries, international mechanisms with the potential to stimulate capital flows, linked to clean and safe energy projects in developing countries, are valuable supplementary approaches which should be a high priority of governments. Proper mechanism for quantifying such benefits should be evolved to have larger number of projects funded for reasons of environmental advantage.

Affordable Energy for the Poor

Ensuring affordable energy for the poor is directly linked to the purchasing capacity of the poor. Therefore, it is very difficult to say what will be the affordable level of energy supply and how it should be priced. The economic and social policies aimed at equitable income distribution are the most effective means of improving the purchasing capacity of the poor.

To make energy affordable for the poor, the government will have to shoulder the following responsibilities to:

(i) Absorb part or all of the sunk cost of energy infrastructures needed to serve the poor.

(ii) Support/favour decentralised or renewable energy systems for rural areas where their life cycle cost is comparable to or lower than the extension of grid.

(iii) Support/favour nuclear power systems for base load grid supply as they offer a low cost power generation system.

(iv) Build the capacity of local energy enterprises by training managers and other personnel, technically and commercially, to run the different aspects of the business, including local maintenance.

Larger Fund Support for Research & Development

The public funded R&D programmes will be ideally suited for sectors that tackle the energy supply to the poor. As R&D can not be made critical only on the market mechanism, there will be no incentive for the private sector to invest in equipment and product research. Such research will have to be supported largely through public funds either to the public institutions or to private sector organisations.

Following R&D programmes need to be funded on a large scale; and linkages with regional and international R&D programmes need to be established:

(i) Energy efficiency in production, supply and end-use.

(ii) All renewables at the development stage; mainly for higher technology introduction into the biomass sector.

(iii) Carbon sequestration in underground reservoirs/aquifers or at a depth in ocean storage.

(iv) Cleaner fossil fuel systems.

(v) Integrated decentralised energy systems, as well as buffer systems designed to accommodate short power variations.

(vi) Nuclear fuel storage, waste treatment and disposal on evolutionary power plants, including light water reactors and fast breeder reactors.

Promotion of Regional Trade in Energy

Long term collaborative projects should be encouraged to tap hydro resources in Bhutan and Nepal and gas resources in Bangladesh. Such a collaborative effort will help funding of respective energy projects as counter guarantees will be easily available. This will also ensure long term energy security.

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two ways i.e. upgradation of quality of the existing fuels through reformulation or additional processing in the short to medium term and introduction of new non-petroleum based clean fuels in the long term.

Quality Upgradation

The petroleum industry has started marketing fuels that emit less hydrocarbons, nitrogen oxides, carbon monoxide, sulphur dioxide and toxics than conventional fuels. In India, oil companies have implemented major programmes for upgradation of auto fuel (petrol and diesel) quality during the Ninth Plan. Lead has been removed from petrol in phases and from 1.2.2000, only unleaded petrol is being supplied in the entire country. Petrol octane number has been increased and sulphur content reduced from 0.20 per cent max. to 0.10 per cent max. in the entire country from 1.4.2000. In addition, the 4 metro towns and National Capital Region (NCR) are being supplied petrol of 0.05 per cent max. sulphur content. The sulphur content in diesel has been reduced from 1.0 per cent max. to 0.25 per cent max. in the entire country during the period 1.4.1996 to 1.1.2000. Further, in the 4 metro towns sulphur content in diesel has been reduced to 0.05 per cent max. Diesel Cetane number has been increased from 45 to 48 from 1.4.2000. Improvements have been made in the distillation specifications of diesel from 1.4.2000. The improvements in petrol and diesel quality has facilitated adoption of India 2000 (Euro-I equivalent) emission norms in the entire country and Bharat stage-II (Euro-II equivalent) emission norms in the 4 metros. For this purpose, an amount of Rs. 10,000 crore was spent over the Ninth Plan period.

Presently, the product quality requirements in India are ahead of most of the countries in the Asia Pacific and the Middle East regions. In order to enable adoption of Bharat Stage-II vehicular emissions standards throughout the country and Euro-III equivalent emission norms in seven mega cities from April 2005, quality of petrol and diesel would need to be further improved. For this purpose, measures such as further reduction of sulphur content need to be taken in a time bound manner. Accordingly, Indian refineries would need to invest in secondary and tertiary processing facilities to ensure that the quality of products conforms to the appropriate specifications.

New Fuels

Natural Gas

Natural gas can be used in vehicles in either compressed (CNG) or liquid form (LNG). Although some vehicle tests have been done using LNG, development of CNG vehicles is far more advanced.

(i) *Compressed Natural Gas (CNG):* Compressed Natural Gas (CNG) vehicles emit low levels of toxic and ozone-forming emissions. CNG has already been established as a clean & environment friendly fuel. CNG vehicle for public transport has emerged as a near term solution to the problem of urban transportation and its use in metro cities is increasing in India. However, the long term usage of CNG as an alternative fuel for automobiles has to be viewed in the light of pollution reduction vis-à-vis electric vehicles, hydrate vehicles and fuel cell vehicles and the availability of natural gas in India.

(ii) *Liquefied Natural Gas (LNG):* Liquefied Natural Gas (LNG) is delivered by tanker trucks from remote liquefaction plants. Highly insulated tanks are installed on board the vehicle to store the fuel. Technology for LNG fuel tanks has evolved quite considerably over time. Although, safe self-service fueling stations have recently become available, refueling vehicles with LNG requires knowledge and expertise.

On an energy-equivalent basis, the price of LNG can be higher or lower than gasoline or diesel fuel. The price is very much dependent on geographic location, purity, transportation and quantity. India is planning to import LNG in the near future. The feasibility of using LNG as a vehicle fuel needs to be examined.

Advantages and Disadvantages of Natural Gas

Natural gas offers potential environmental and economic benefits. It has a higher octane number and cleaner burning than gasoline. Natural gas does not need to be vapourised before being injected into the combustion chamber as do liquid fuels because of its gaseous state. Therefore, it does not require any fuel enrichment during cold starting or in transient operating conditions, which result in considerably lower carbon monoxide emissions than gasoline engines. Another advantage related to the gaseous state of natural gas is the elimination of oil contamination by unburned fuel during cold operation, which contributes to less engine wear compared to gasoline engines.

The main disadvantage of natural gas vehicles are acquisition costs than comparable gasoline or diesel vehicles, limited refuelling infrastructure, as well as the fact that they can travel only about one-half as far as comparable gasoline vehicles before re-fuelling.

A limiting factor in the growth of the natural gas vehicle market is on board storage of fuel. Compared to

The main disadvantage of natural gas vehicles are acquisition costs.

gasoline or diesel, on-board storage of natural gas requires larger and heavier storage tanks. CNG, which is usually stored at 3000 psi, requires roughly 5 times the amount of space as the amount of gasoline having the same energy content. LNG requires about 1.5 times the storage volume of gasoline.

Since natural gas must be stored in pressure vessels, the weight of traditional steel storage tanks is considerably higher than the weight of gasoline or diesel tanks. For example, a steel natural gas storage vessel that contains the equivalent of 19 litres of gasoline weighs about 85 kg, compared to about 15 kg for a 19 litres gasoline tank. Because of the weight, volume and cost of natural gas storage tanks, the fuel storage capacity of a natural gas vehicle must be carefully matched to its daily operating range in order to be practical.

Liquefied Petroleum Gas (LPG)

The use of LPG as an auto fuel aims at introducing yet another cleaner and eco-friendly fuel. LPG produces lesser CO emissions compared to diesel and petrol, and also produced lower emission of highly toxic nitrogen oxides. The Government of India has allowed the use of LPG as an auto fuel. As the country is still deficient in LPG, the requirement of auto LPG would have to be met mainly from imports.

Bio-Fuels

Bio-Fuels include alcohols, ethers, esters and other chemicals made from cellulosic biomass such as herbaceous and woody plants, agriculture and forestry residues. The term bio-fuel can refer to fuels for electricity and fuels for transportation. The bio-fuels for transportation include bio-ethanol, bio-methanol and pyrolysis oils. Two most common types of bio-fuels that are presently used are bio-ethanol and bio-diesel.

Ethanol

Fuel ethanol is used mainly as a blend component in gasoline at levels ranging from 10 per cent to 85 per cent in USA, Canada and Brazil. The use of blended ethanol gasoline has various benefits such as

- Serve as both an octane booster and Oxygenated additive.
- Is renewable.
- Reduces dependence on imports of petroleum products.
- Improves market opportunity for agricultural crops.
- Contributes to rural economic development.
- Displaces dangerous and er vironmental damaging components in gasoline, like benzene.

Ethanol is produced from various agro residues, which contain starch like molasses in case of sugarcane crop, spoiled grains, palm etc. U.S.A. has based its ethanol programme on corn while Brazil utilizes sugarcane crop for this purpose. In India, ethanol programme has been approved on sugarcane/molasses. The Government has recently mandated the use of Ethanol in petrol in 13 States producing sugarcane, which is a renewable source of energy and its use will enhance the income of sugarcane farmers and mills that are currently nursing huge stock of unsold sugar. In this direction, the Government has allowed blending of five per cent Ethanol with MS in the country. However, in the first phase, this programme will be taken up in nine States, from January 1, 2003, when five per cent blending with ethanol will become compulsory. This programme will require around 320 million litres of ethanol annually.

Currently, the Bureau of Indian Standards (BIS) permits blending of five per cent of ethanol with petrol. However, blending up to 10 per cent can be done without any modification in the engines and efforts are on to get the BIS standards modified to allow 10 per cent blending in petrol. Research is being conducted to study feasibility of blending of ethanol with High Speed Diesel (HSD). An MOU has been signed between the Government of Brazil and India for cooperation in this field as Brazil is the world leader and has been practicing this technology (of ethanol blended petrol) for over 75 years.

Research is being conducted to study feasibility of blending of ethanol with High Speed Diesel (HSD).

Advantages & Disadvantages

Ethanol is highly soluble and will disperse rapidly. It is readily biodegradable, and will evaporate quickly if spilled on land. Also, contamination of drinking water supplies is less of an issue than for gasoline because

ethanol is less toxic to humans in equal concentrations.

Compared to gasoline, ethanol has lower volatility, a higher flammability limit, lower vapour density, lower combustion heat, and a higher heat for vaporisation, which means an ethanol spill is less likely to ignite compared to gasoline. Furthermore, if it ignites, it will burn more slowly and less violently than a gasoline fire.

Ethanol contains considerably less energy per litre than gasoline, and vehicles fueled with 85 per cent ethanol blend consumes between 15 and 30 per cent more fuel per km. than gasoline-powered vehicles, on an energy equivalent basis. Therefore, at about twice the volume of 85 per cent ethanol, fuel economy is comparable to gasoline.

Bio-Diesel

Bio-diesel is the name of a clean burning alternate bio-fuel, produced from vegetable oils, recycled cooking oil and tallow. Bio-diesel is made through a chemical process called trans-esterification whereby the glycerin is removed from the fat or vegetable oil. The diesel programme in most of the countries is based on Soya and Rapeseed. However, the main sources identified for bio-diesel in India are Jatropha curcas (Ratanjyot), Pongamia Pinnata (Karanj), Calaphyllum Inophyllum (Nagchampa), Hevea Brasiliensis (Rubber) etc. Bio-diesel contains no petroleum, but it can be blended at any level with diesel to create a bio-diesel blend or can be used in its pure form. It can be used in compression-ignition (diesel) engines with no major modifications. This bio-diesel is simple to use, biodegradable, non-toxic, and essentially free of sulphur and aromatics.

The physical characteristics of bio-diesel compare very well with the low sulphur diesel produced by Indian Refineries. The road map for emission norms in India is under consideration wherein Euro III & IV equivalent emission norms will be applicable in 7 mega cities w.e.f April 2005 and April 2010. In order to meet this emission requirement, a drastic reduction in sulphur content and higher cetane number will be required. Bio-diesel meets these two important specifications and would help in improving the lubricity of low sulphur diesel. The present specification of flash point for diesel in India is 35 deg. C which is lower than other countries in the world (55 deg. C). Bio-diesel will help in raising the flash point from point of view of safety.

Bio-diesel can be used as a pure fuel or blended with petroleum diesel in any percentage. B20(a blend of 20 per cent by volume bio-diesel with 80 per cent by volume diesel) has demonstrated significant environmental benefits in USA with a minimum increase in cost for fleet operations and other consumers. Bio-diesel is registered as a fuel and fuel additive with the US Environmental Protection Agency and meets the clean diesel standards established by the California Air Resources Board. Neat (100 per cent) bio-diesel has been designated as an alternative fuel by the Department of Energy and the Department of Transportation of USA.

Bio-diesel can be used in any diesel engine with little or no modification to the engine or the fuel system. Essentially no engine modifications are required, and bio-diesel maintains the payload capacity and range of diesel. Bio-diesel has a solvent effect that may release deposits accumulated on tank walls and pipes from previous diesel fuel storage. The release of deposits may clog filters initially and precautions should be taken. Pure bio-diesel is not compatible with natural rubber hoses and gaskets. This is not a problem with B20 blends (20 per cent biodiesel/80 per cent diesel).

Electric Vehicles

The primary difference between an electric vehicle and a internal combustion engine vehicle is an electric motor replaces the engine; a battery pack and management system sits in place of a fuel tank; electronic controls are used instead of an ignition system; and a high-voltage system is used in addition to low-voltage system. Electric vehicles can have quicker acceleration because electric motors produce maximum torque at lower speeds than internal combustion engines.

The two major types of electric drive systems are alternating current (AC) and direct current (DC). AC motors typically are more efficient over a large operating range, but the complicated electronics make the controllers more expensive. DC motors typically require a less complicated controller system and are less expensive, but they tend to be larger and heavier. Both technologies are used in today's electric vehicles.

Battery-powered vehicles give off virtually no pollution and offer one of the best options for reducing motor vehicle emissions in polluted cities. Power plants that produce electricity do pollute. But these plants are often in rural areas where the emissions do not drive pollution levels above health standards. Also, efficient emission controls can be installed and maintained more easily on individual power plants than on millions of vehicles. The driving range of today's electric cars is limited by the amount of power the battery can provide. Current batteries take hours to recharge and the cost of electric vehicles is high. Recent developments in electric vehicle technology show much promise for the future.

Battery-powered vehicles offer one of the best options for reducing motor vehicle emissions in polluted cities.

Electric vehicles are convenient as these can be charged at home. Charging systems can also be made available at worksites. This home or workplace-based recharging is not only convenient but also cost efficient. Most electric vehicles will recharge during off-peak hours or overnight. Off-peak recharging makes efficient use of electric power plant capacitv that normally would be idle.

Only legislation and regulations will ensure that electric vehicles are introduced on a larger scale to reduce pollution in city areas. Regulations have been introduced in California and other States in the USA and these have resulted in research and development programmes for advanced batteries, largely funded by the US Advanced Battery Consortium and the Advance Lead Acid Battery Consortium. At present, the best techno-economic choice for electric vehicles is the lead acid battery. However, the travel range of these batteries is 100-150 km. To address the consumers' need for an extended travel range in electric vehicles, some manufacturers have been offering nickel-metal hydride batteries. This battery has extended the range from an average 100-150 km. on a single charge to 200-320 km.

Bringing down the cost of the battery packs has become a recent focus. Important measures are being implemented to further improve battery technology. The goal is to increase battery sales that would lower the cost of the battery packs used in electric vehicles, thus making electric vehicles more affordable to the average consumer.

Fuel Cell Vehicle

The fuel cell is a power-generating system for electric vehicles that converts the chemical energy of hydrogen and combines it with oxygen to produce electric energy, heat and water. It is restored with chemical energy rather than electric recharging. Because many components used in electric vehicles are also found on fuel cell vehicles, they can be considered a type of hybrid electric vehicle. However, fuel cells differ from batteries because they do not store energy but use energy stored in a fuel carried on a vehicle.

Fuel cells have emerged in the last decade as a potential replacement for the internal combustion engine (ICE) in vehicles. Unlike commonly used dry cell batteries, which store definite amount of energy in their electrodes, fuel cells can run as long as fuel and oxidants are supplied till the components of the cells degrade. The fuel cell converts the chemical energy of the fuel directly to electrical energy without the intermediate of thermal energy; its conversion efficiency is not subject to Carnot limitation and can theoretically reach a very high value. But actually the slow reaction of oxygen at the cathode limits the efficiency to 45 to 60 per cent. This is better than today's internal combustion engine.

Fuels that are directly used in fuel cells are difficult and costly to produce and distribute. Transportation of fuels carries the responsibility of safe handling: impact of impurities and accidental ingestion must be well understood to common man. Several types of fuels like Hydrogen, Natural gas, LPG, Methanol, Ethanol, Ethane, Butane, Toluene, Coal, Biogas etc. have been used as source of fuel in fuel cells. Most of these fuels offer reduced levels of emissions and better fuel consumption, ensuring their own choice of fuels by way of employing convenient feedstock. The challenge is to supply these fuels in adequate quantity and their production in pure form, infrastructure development for distribution and refueling aspects of these fuels.

Expert opinion indicates that first commercial FCV would be based on gasoline or diesel with on board reforming technology, currently under development. A methanol concept is also regarded as being likely. These opinions are based on the argument that the existing fuel distribution infrastructure is available for these fuels. Methanol and gasoline have both their own advantages and disadvantages. One has to look carefully regarding health and safety when methanol is being considered as fuel. Direct use of dry hydrocarbon fuels like methane, ethane, butane, butane and toluene in solid oxide fuel cells is also being considered.

While fuel cell vehicles may not be commercially available for several years, they can play a pivotal role in displacing conventionally fueled internal combustion engines with more efficient zero emission or near zero emission vehicles. To accomplish this benefit, significant cost reductions must be realised. Space restrictions and weight barriers must also be addressed. Over the long term, fuel cell vehicles can have an important and beneficial impact.

Significant efficiency gains can be achieved, depending on the specific technology and fuel used. In addition to air quality and energy efficiency improvements, fuel cell vehicles offer the potential to move away from petroleum based and other fossil fuels.

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Conclusion

Transport Sector consumes about 45 per cent of the petroleum products in the country. Their use is mainly responsible for producing harmful emission and pollution. Thus, the situation warrants a switchover to cleaner fuels. Clean fuels for transportation are available today. Their widespread use in the near future is feasible. To enable the transition, technologies must be refined so that vehicles can achieve optimum performance and emission characteristics. Consumers must accept the new vehicles and fuels, and government and industry must cooperate to ensure their availability. It requires a concerted effort by all sections of the society, but a switch to clean fuels may be the most viable way for many cities to attain clean and healthy air.

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It is, in fact, nothing short of a miracle that the modern methods of instruction have not entirely strangled the holy curiosity of inquiry.

– Albert Einstein

Indian Power Sector – A Diagnosis of Inefficiency

Vijayamohanan Pillai N.

This study analyses the inefficiency syndrome of the State power sector in India in the present context of restructuring. It is argued that what the system requires is not any market-oriented restructuring, but internal reforms that can remove the problems that stand in the way of the SEBs' improved performance.

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The power sector in India is on the threshold of a radical restructuring, that in some of the States has assumed significant dimensions. What was once in the realm of a vertically integrated public sector monopoly undertaking has now become functionally unbundled and independent corporations/companies. In the present study, we discuss the possible explanation of what in their functional trends have warranted restructuring of the State Electricity Boards (SEBs) in India. Though the SEBs were statutorily required to function as autonomous service-cum-commercial corporations, they were in effect changed into promotional agencies of the Governments in the pursuit of their socio-economic policies and hence never felt the requirement to break even or to contribute to capacity expansion programs. This unaccountability culture in turn led to gross inefficiency at all levels – technical, institutional and organisational, as well as financial, which in turn got reflected in avoidable cost escalations. This in the face of an irrational and uncompensated subsidised pricing practice left the SEBs in general with negative internal resources. At the same time, the traditional sources of investment funds – Government loans and subventions – were fast draining, and the so-called 'fiscal crisis' at the turn of the nineties facilitated the ushering in of the ideologies of restructuring. Funds have now begun to flow into the Indian power sector from a number of leading international financial institutions on stringent conditionalities of restructuring. The present paper in this context shows that the problems confronting the SEBs are just internal to them, and hence what the system requires is not any market-oriented restructuring, but an essence-specific reform that can remove the impediments that stand in the way of the SEBs' improved performance.

Falling Growth Rates

On the whole, the growth of the system from a mere 1.7 thousand MW of installed capacity (IC) in 1950 to

Table 1: Growth of the Indian Power Sector

	Installed Capacity (MW)				Generation (MU)				Sales (MU)			
	1970-71	1980-81	1990-91	1998-99	1970-71	1980-81	1990-91	1998-99	1970-71	1980-81	1990-91	1998-99
Andhra Pradesh	608	2240	4130	6214	2937	7319	18249	30805	2195	5223	15508	24956
Assam	180	228	537	622	369	465	1206	1066	298	640	1545	1753
Bihar	499	941	1549	1988	1372	2281	2964	4225	1886	4103	7344	10984
Delhi	252	276	552	654	1027	1313	2063	1894	1157	2308	6334	7951
Gujarat	907	2197	4395	6973	416	9363	19875	34357	3326	7573	17685	30525
Haryana	504	1141	1780	1780	1848	4289	6938	8302	939	2793	6134	8932
Himachal Pradesh	51	129	272	299	62	245	1262	1484	165	433	1778	2525
Jammu & Kashmir	40	206	262	374	168	768	875	713	170	515	1477	2904
Karnataka	878	1470	2970	3973	4754	6392	12430	17182	4052	5575	12178	15953
Kerala	547	1012	1477	1816	2126	5242	5491	7602	1859	4451	5296	9162
Madyha Pradesh	727	1631	3298	4094	2754	5952	12937	20562	2328	4583	21364	26434
Maharashtra	2119	3992	8705	11589	9134	17664	36439	56639	7660	14399	31958	53035
Orissa	564	923	1612	1698	1766	3137	5792	6358	1917	2624	4910	6178
Punjab	680	1536	3049	3929	2365	6483	14618	20880	2192	5197	12654	20904
Rajastan	541	810	1722	2235	1509	3393	6717	11964	982	3002	8299	16302
Tamil Nadu	1966	2329	4098	5988	5638	7372	13202	23279	5261	8881	16970	28739
Uttar Pradesh	1351	3612	5527	6085	5725	10190	19688	24938	4509	8142	19781	27312
West Bengal	1212	1726	3071	4131	4056	5563	9001	15883	4228	5747	9227	16003
All India	14709	30214	66086	93294	55828	110844	264329	448544	43724	82409	190419	310004
SEBs	9478	23456	40727	41526	34200	83411	157032	188546				
Central Sector	1441	2198	14740	25500	5399	8480	69001	151488				
Private sector	1488	1382	2742	8259	6266	6730	12947	32804				

Source: CMIE (2002)

102,907 MW by October 2001 (a 60.5-fold increase, at an annual growth rate of about 8.5 per cent) appears quite impressive. So does the growth of energy generated also – about 98 times increase from 5.1 billion kWh in 1950-51 to 499.6 billion kWh in 2000-01 (at an annual rate of about 10 per cent). Electrification has been accomplished in over 5 (out of more than 6) lakh villages in India; 13 out of 25 States have achieved cent per cent rural electrification, and in 22 States the rate is above 70 per cent (Planning Commission 1999). Despite this seemingly tremendous growth, the per capita consumption of electricity in India, one of the leading indicators of the living standard of a people, still remains one of the lowest in the world. In 1997, it was just 363 kWh against 714 kWh of China, 1634 kWh of Argentina, 2011 kWh of Chile, 2352 kWh of Malaysia and 1459 of Mexico, and was nearly one-tenth of the World average (World Bank 2000: Table 5.10). As per 1991 Census, only 42 per cent of the Indian households had electricity facility, with about 71 per cent in the rural and 24 per cent in the urban areas remaining unelectrified.

It can be seen that the impressive growth at the aggregate national level is not evenly distributed across the regions. Power development, placed in the concurrent list of the Indian Constitution, is a joint responsibility of the regional States and the Centre. There was pervasive enthusiasm for power development in the States during the 1960s (generating capacity growing at an annual growth rate of over 12 per cent per annum) and the 1970s (with an annual growth rate of nearly 10 per cent). During the next decade, this regional zeal, however, further evaporated to drive the growth rate down to

The impressive growth at the aggregate national level is not evenly distributed across the regions.

Table 2: Annual Average Growth Rates %

	Installed Capacity			Generation			Sales		
	1970s	1980s	1990s	1970s	1980s	1990s	1970s	1980s	1990s
Andhra Pradesh	13.93	6.31	5.24	9.56	9.57	6.76	9.06	11.50	6.13
Assam	2.39	8.94	1.85	2.34	10.00	–1.53	7.94	9.21	1.59
Bihar	6.55	5.11	3.17	5.21	2.65	4.53	8.08	5.99	5.16
Delhi	0.91	7.18	2.14	2.49	4.62	–1.06	7.15	10.62	2.88
Gujarat	9.25	7.18	5.94	8.41	7.82	7.08	8.58	8.85	7.06
Haryana	8.51	4.55	0	8.78	4.93	2.27	11.52	8.19	4.81
Himachal Pradesh	9.72	7.75	1.19	14.73	17.81	2.05	10.13	15.17	4.48
Jammu & Kashmir	17.81	2.43	4.55	16.41	1.31	–2.53	11.72	11.11	8.82
Karnataka	5.29	7.29	3.7	3.00	6.88	4.13	3.24	8.13	3.43
Kerala	6.35	3.85	2.62	9.44	0.47	4.15	9.12	1.75	7.09
Madyha Pradesh	8.42	7.3	2.74	8.01	8.07	5.96	7.01	16.64	2.70
Maharashtra	6.54	8.11	3.64	6.82	7.51	5.67	6.51	8.30	6.54
Orissa	5.05	5.73	0.65	5.91	6.32	1.17	3.19	6.47	2.91
Punjab	8.49	7.1	3.22	10.61	8.47	4.56	9.20	9.31	6.48
Rajastan	4.12	7.83	3.31	8,44	7.07	7.48	11.82	10.70	8.81
Tamil Nadu	1.71	5.79	4.88	2.72	6.00	7.35	5.38	6.69	6.81
Uttar Pradesh	10.33	4.35	1.21	5.94	6.81	3.00	6.09	9.28	4.11
West Bengal	3.60	5.93	3.78	3.21	4.93	7.36	3.12	4.85	7.13
All India	7.46	8.14	4.40	7.10	9.08	6.83	6.54	8.74	6.28
SEBs	9.48	5.67	0.24	9.33	6.53	2.31			
Central Sector	4.31	20.96	7.09	4.62	23.32	10.33			
Private sector	–0.74	7.09	14.78	0.72	6.76	12.32			

Source: Estimates based on CMIE (2002)

5.7 per cent per annum, and commensurately there was a significant shift in the weight of capacity addition from the States of the Central sector, the latter registering an annual growth rate of about 21 per cent in the 1980s (Tables 1 & 2). The share of the Central sector in the ownership of the total IC increased from 9.8 per cent in 1970-71 to 22.3 per cent in 1990-91 and then to 27.3 per cent in 1998-99, and the share of the SEBs fell from about 64.4 per cent in 1970-71 to 44.5 per cent in 1998-99; (the share of the private sector increased only from 4.15 per cent in 1990-91 to 8.85 per cent in 1998-99). This in fact helped the whole system to keep up the tempo of power development, at an annual growth rate of about 3.14 per cent, despite the deceleration in the States. However, a further shift in the policy of capacity addition towards the private sector in line with the liberalisation drives of the 1990s has left this whole decade 'wasted', with very little investment actually coming on stream in all the three sectors, Central, State and private. Consequently, during 1990-91 to 1999-2000, the total power generating capacity increased (from 66086 MW to 97846 MW) at an annual rate of about 4.4 per cent only. It should be added that only 53.8 per cent of the Eighth Plan target of 30538 MW could be achieved – the target achievement of the three sectors being Central: 65 per cent, State: 46 per cent and private: 45 per cent.

Energy Shortage

The low consumption profile that has always characterised Indian power sector directly implies low availability of electricity, which in turn suggests a shortage situation. For example, the energy deficit grew worse from 7.8 per cent in 1991-92 (beginning of the 8th Plan) to 11.5 per cent by the end of the 8th Plan (1996-97), and the peak period deficit almost stayed at 18 per cent during the period. In 1999-2000, the energy deficit was 6.2 per cent and the peaking shortage 12.4 per cent. Energy deficit indicates two possible causative

factors: (i) capacity deficiency, and (ii) operational inefficiency, given capacity.

Inadequate Capacity Additions

It is widely recognised that it is the inadequate capacity additions, in the face of an exponentially growing demand, that have in cumulation plunged the country into chronic energy deficit. In no Plan period the target in installed capacity (IC) could actually be achieved, the cumulative slippage between the target and the achievement remaining well over 20 per cent. During the 8th Plan period, the achievement was only 53.8 per cent of the target of 30,538 MW; in all the sectors the actual achievement fell well short of the 8th Plan target – Central sector: 65.2 per cent, State sector: 45.8 per cent, and private sector: 45 per cent. Pinching financial constraints have been the main crippling factors of such inadequacy. Even though the power sector outlay was steadily increasing over time in absolute terms, its percentage share in most of the Plan periods was much less than 20 per cent. The fall was drastic during the 1990s – the share of power sector in the total annual Plan outlay progressively decreased from 18.5 per cent in 1992-93 to 13.4 per cent in 1996-97. During the same period, the share of power sector in the total outlays by the States also declined from 27 per cent to 19.1 per cent on an average. The reason was clear: 'Neither the State Governments nor the Central Government have the resources to provide substantial funds for augmenting generating capacity through budgetary support to meet increasing demand'. (Government of India 2000: 1). In the face of the stark reality of the financial inability of the State and Central governments, the responsibility for financing the capacity additions in the power sector was naturally shifted to the concerned State Electricity Boards (SEBs), which however were equally or more cash-strapped.

It should be stressed here that the performance of the SEBs was largely determined for a long time by the assertions and defenses of their statutorily intended promotional role in power development. The SEBs were to subserve the socio-economic policies of the State and hence expected not to view every aspect of developmental activities exclusively from the point of view of profit or return, as highlighted by the Venkataraman Committee of 1964. Thus there was no compulsive requirement, till the late seventies (till the 1978 amendment of the Section 59 of the Electricity (Supply) Act, 1948), for the SEBs to break even, as also even to provide for full depreciation and/or interest payable on Government loans, both of which could, under the Statute, be provided for only if there were adequate surpluses after meeting all other obligations. Thus there seemed to be no idea, let alone requirement, of the SEBs contributing internal resources to expansion programmes. The SEBs, still remaining under that spell of unaccountable, non-commercial performance, continue to have in general negative internal resources. This fact thus lends the required rationale and strength to the assertions for inviting private sector participation in investment in the Indian power sector.

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The very validity of the above argument emanates from the assumption that identifies energy shortage solely with capacity inadequacy; that a shortage also follows from inefficient and insufficient operation of the given capacity is somehow overlooked here. It is not difficult to find that the latter's role in the shortage situation is all the more significant in that it stands not only as a complementary factor, but at times as the primary causative itself. This we discuss in the following section.

Operational Inefficiency

Utilisation of the installed capacity in the Indian power sector has never been up to the mark. In 1970-71 it was about 43 per cent only, and in 1998-99, about 45 per cent of IC remained unutilised (Table 3). As many as 11 (out of 18) SEBs had a use factor much less than the all-Indian average in that year, including Karnataka, Kerala and Tamil Nadu in the South, and only two (as well as the Central Sector with about 68 per cent) had a rate higher, though very minimal, than 60 per cent. It should however be noted that for a hydro-power dominant system, such as in Himachal Pradesh, Meghalaya, Kerala, and, to some extent now, Karnataka, utilisation efficiency of the hydro-power plants should be evaluated with respect to firm power capacity (the always available and dependable capacity corresponding to the minimum stream flow and storage) rather than with respect to IC. Thus, taking into account the hydel firm power capacity of 750 MW of Kerala State Electricity Board (KSEB) in 1999-2000, the actual capacity utilisation comes out to be 6,410.65 KWh/KW or about 73 per cent. However, a distressing question that comes up here is about the wide gap of 'waste' between the IC and the dependable power of the hydro-plants; the latter being just 43 per cent of the hydel IC in Kerala in 1999-2000. This in turn calls for meticulous planning and execution efforts on firm power augmentation projects along with the IC additions of hydro power.

Table 3: Technical Performance Indicators

	Capacity Utilisation (PLF) %				T & D loss %				Sales out of Generation %			
	1970-71	1980-81	1990-91	1998-99	1970-71	1980-81	1990-91	1998-99	1970-71	1980-81	1990-91	1998-99
Andhra Pradesh	55.14	37.30	50.44	56.59	25.42	22.60	22.40	33.56	74.74	71.36	84.98	81.01
Assam	23.40	23.28	25.64	19.56	17.68	19.30	24.10	38.73	80.76	137.63	128.11	164.45
Bihar	31.39	27.67	21.84	24.26	22.85	22.10	21.10	16.53	137.46	179.88	247.77	259.98
Delhi	46.52	54.31	42.66	33.06	11.07	18.40	24.90	50.55	112.66	175.78	307.03	419.80
Gujarat	52.56	48.65	51.62	56.25	14.52	19.80	23.70	25.34	79.65	80.88	88.98	88.85
Haryana	41.86	42.91	44.49	53.24	27.94	22.60	27.50	35.33	50.81	65.12	88.41	107.59
Himachal Pradesh	13.88	21.68	52.96	56.66	12.23	19.30	21.50	26.33	266.13	176.73	140.89	170.15
Jammu & Kashmir	47.95	42.56	38.12	21.76	21.66	48.10	42.30	47.98	101.19	67.06	168.80	407.29
Karnataka	61.81	49.64	47.78	49.37	14.62	24.60	20.10	30.57	85.23	87.22	97.97	92.85
Kerala	44.37	59.13	42.44	47.79	12.80	14.20	21.60	17.69	87.44	84.91	96.45	120.52
Madyha Pradesh	43.24	41.66	44.78	57.33	14.69	22.30	24.90	21.05	84.53	77.00	165.14	128.56
Maharashtra	49.21	50.51	47.79	55.79	13.67	16.20	18.10	17.82	83.86	81.52	87.70	93.64
Orissa	35.74	38.80	41.02	42.74	6.15	19.20	25.30	43.20	108.55	83.65	84.77	97.17
Punjab	39.70	48.18	54.73	60.67	22.38	19.60	19.00	17.98	92.68	80.16	86.56	100.11
Rajastan	31.84	47.82	44.53	61.11	13.11	26.60	25.90	29.41	65.08	88.48	123.55	136.26
Tamil Nadu	32.74	36.13	36.86	44.38	17.67	19.10	18.70	16.75	93.31	120.47	128.54	123.45
Uttar Pradesh	48.37	32.20	40.66	46.78	24.49	15.60	26.90	30.28	78.76	79.90	100.47	109.52
West Bengal	38.20	36.79	33.46	43.89	10.18	13.70	21.80	22.89	104.24	103.31	102.51	100.76
All India	43.33	41.88	45.66	54.88	17.55	20.60	22.90	26.50	78.32	74.35	72.04	69.11
SEBs	41.19	40.59	44.02	51.83								
Central Sector	42.77	44.04	53.44	67.82								
Private sector	48.07	55.59	53.90	45.34								

Source: Estimates based on CMIE (2002)

One important causative factor of such low capacity utilisation is the poor technical efficiency, reinforced by an inability to attain and assimilate significant technological progress over time (Kannan and Pillai 2002: 29). Technical efficiency in generation in general is primarily determined by plant availability (which in turn is determined by forced outages), and by plant load factor (PLF). Forced outages occur when a unit is thrown out of service due to unexpected causes such as breakdown, equipment malfunction, etc., and are usually of a random nature. These outages generally occur on the operation side in generators, boilers, turbines, and their auxiliaries. There are also electrical and mechanical forced outages, due to poor quality of fuel, wet coal being supplied, and lack of timely and proper maintenance practices that cause Grid system faults, which are always avoidable. Units are also shut down at times for planned preventive maintenance, intended to ensure their proper running conditions, and also due to lack of adequate system load and of water in reservoirs in the case of hydro plants. Considerations of plant availability factor and PLF are usually associated with analyses of technical efficiency only of thermal power plants. Hydro plants are generally expected to be open always and at maximum subject to firm power capacity constraints. However, the hydro plants in Kerala stand an exception to this expected rule, and also smart for higher forced outage rates (FORs) and loss of load probability (Pillai 1991, 1999a). The FORs of the hydro system in Kerala (41 units of 11 plants) on an average were as high as 17.71, 22.59, and 13.12 per cent, respectively, for the three years of 1982-83 to 1984-85. In 1996-97, it was 8.96 per cent, while the all-India average for thermal plants was 12.8 per cent. The planned maintenance rate of the hydro-power system in Kerala on an average was 12.88 per cent in the same year, and the reserve shut down rate, 11.87 per cent, the latter being largely due to lack of water in storage. The thermal systems of the other Southern States had much lower FORs. Bihar, Assam, Uttar Pradesh, Haryana, and

Table 4: Technical Performance Indicators of Thermal Power Systems (%)

	Operating Availability	Growth	Forced Outage Rate	Growth	Plant Load Factor	Growth	1990-91	1999-2000	Rate
Andhra Pradesh	78.06	89.8	1.57	12.36	5.9	–7.89	65.84	83.2	2.63
Assam	48.06	31.4	–4.62	28.26	52	7.01	24.62	18.2	–3.30
Bihar	42.87	36.5	–1.77	22.6	40.6	6.73	23.98	19.7	–2.16
Gujarat	75	77.8	0.41	12.18	12.9	0.64	57.71	64.3	1.21
Haryana	56.33	69.2	2.31	35.4	26.3	–3.25	34.53	53	4.88
Karnataka	87.89	87.4	–0.06	3.08	2.8	–1.05	76.15	82.3	0.87
Madyha Pradesh	72.98	79	0.88	11.19	10.6	–0.60	57.38	69	2.07
Maharashtra	75.68	85.1	1.31	12.69	9.2	–3.51	58.12	71.7	2.36
Orissa	53.32	92.5	6.31	32.88	1.6	–28.53	33.93	85.6	10.83
Punjab	79.77	82.7	0.40	10.22	9.5	–0.81	52.96	74.7	3.90
Rajastan	54.04	86.5	5.37	23.63	3.7	–18.62	42.77	82.3	7.54
Tamil Nadu	69.35	81.7	1.84	18.51	10.9	–5.71	58.28	72.3	2.42
Uttar Pradesh	64.33	64.3	–0.01	26.5	25.6	–0.38	52.08	50.6	–0.32
West Bengal	53.26	68.1	2.77	35.03	31.6	–1.14	30.91	39.8	2.85
Average	71.7	73.7	0.31	16.49	17.4	0.58	53.89	61.9	1.55

Source: Estimates based on CMIE (2002)

Orissa (till 1994-95) are some of the States with higher FORs and hence much lower availability of capacity (Kannan and Pillai 2002).

The availability factor is defined as unity less planned maintenance rate (PMR) less forced outage rate (FOR); i.e., availability = 1 – (PMR + FOR). In 1999-2000, the availability of thermal plants of the SEBs in India in general was 73.7 per cent, with only a marginal improvement over 1990-91. Nine SEBs had availability higher than this average, including all the three neighbours of Kerala in the South. The worst affected were the SEBs of Bihar and Assam, with very high FORs (Table 4).

Load factor is generally defined as the ratio of average load to maximum (or peak) load. More exactly, it is also defined as the ratio of energy consumed (average load) in a given period to energy which would have been consumed, had the maximum demand been maintained throughout that period. Extended thus to a generating unit, plant load factor (PLF) then refers to the ratio of the actual generation of that plant to its maximum possible generation during a period (one year). While the plant availability remained about 75 to 79 per cent in the 8th Plan period, the average PLF of the thermal plants had a distinct improvement from about 54 per cent in 1990-91 to 67.7 per cent in 2000-01. In that year, the PLF in the Central sector was 72.2 per cent, and in the Private sector, 76.4 per cent, while the all-SEBs average was only 64.3 per cent.

In addition to this technical inefficiency in energy generation is the higher level of auxiliary consumption at the generation end that eats into the energy available for transmission. Auxiliary consumption in the power station depends upon its layout, operation conditions, automisation, and design of various equipment. Though taken to be of the order of 3 to 5 per cent in a modern thermal plant and 0.5 per cent in a hydro plant, auxiliary consumption in India has been nearly 10 per cent over the years. Reported as a weighted average of thermal and hydel plants in the State sector, it remained in the range of around 7 per cent in the 8th Plan period. Bihar, Orissa, and West Bengal have had always much higher auxiliary consumption – more than 10 per cent.

Another very significant inefficiency factor functions in the transmission and distribution (T & D) network that fritters away the energy sent out, net of auxiliary consumption, to such a substantial extent that by the time it reaches the sales point, it would often be only a smaller fraction of the net generation. About 111,484 million units of electricity were reportedly lost in T & D in various States in India in 1998-99. The losses reportedly increased from 17.5 per cent in 1970-71 to 26.5 per cent in 1998-99 (Table 3). These are very high by international standards – compared with less than 10 per cent in most of the developed economies and with less than 15 per cent in many developing countries such as China (7 per cent), Thailand (10 per cent), Argentina (12 per cent), and Chile (11 per cent) (Rao, et. al 1998-99). In

almost all the States the losses remain very high, from 16.5 per cent in Bihar to 50.6 per cent in Delhi, followed by Jammu and Kashmir (48 per cent). Orissa (43.2 per cent), Haryana (35.3 per cent). Assam (38.7 per cent), Andhra Pradesh (33.6 per cent), Karnataka, Uttar Pradesh, and Rajasthan (about 30 per cent each).

Table 3 showed that the total losses (auxiliary and transit consumption) were on the rise over time – only about 69 per cent of the generation went into sales in 1998-99. In the States, sales include, besides generation, energy import also, such that sales as a proportion of generation will be above cent per cent. However, it is distressing to find (Table 3) that in a number of States, the total losses went to the high extent of eating into the whole energy imported plus a part of the generation itself. For example, in Andhra Pradesh, the whole energy purchased and about 19 per cent of its own energy were lost in 1998-99.

The neglect of the T & D sector, especially the transmission sector, in terms of adequate investments in capacity and maintenance, and the lack of systematic T & D planning over the years are the major technical factors contributing to the high level of T & D losses. Defective metering, unmetered supply and pilferage are the main non-technical factors. There has been over the years a pronounced bias in investment in favour of augmenting generation capacity to the utter neglect of the 1:1 norm in investment in generation and T & D sectors. Despite the increased funds allocation given to T & D sector in the recent past, out of the belated recognition of the compounded effects of neglect, under-utilisation or diversion of funds (meant especially for transmission capacity augmentation) into generation and/or distribution sector still plagues the system. Increase in demand by an increasing number of consumers vis-à-vis inadequate T & D capacity has resulted in heavy overload on the system, causing substantial line losses. During the period 1970-71 to 1998-99, the number of consumers increased by 7.3 per cent per annum, and IC, though restricted, by about 7 per cent, while the annual growth in transmission lines was 4.44 per cent and distribution (low tension, LT) lines, 6.11 per cent. The ratio of the length of transmission lines to the length of distribution lines dropped from 7.73 per cent in 1970-71 to 4.96 per cent in 1998-99. Evidently, the imbalance between the two has been on the rise, worsening the overload problem. Since a predominantly low voltage network characterises the Indian power sector in general, higher technical line losses and poor quality of electricity at user ends are an inescapable fact. In fact, the low-voltage-low-frequency profile common in many States is an easy route for mitigating the power deficit, which would get aggravated with any attempt to raise the voltage level in the basic system without adequate generation. In this respect, the tie up of a State Grid with a Regional Grid that operates at low system frequency due to overload, further reduces quality. For example, the Southern Grid, with which Kerala is tied up, runs at a low frequency up to even 47.5 Hz instead of the normal 50 Hz. The low voltage conditions in turn lead to the use of step-up transformers or voltage stabilisers by consumers, which in turn induces a high inductive load and further worsens the conditions.

Increase in demand by an increasing number of consumers vis-à-vis inadequate T & D capacity has resulted in heavy overload on the system.

There is little doubt that even these high figures of T & D losses are only underestimates that find a suitable cover-up in the overestimates of agricultural consumption. In most of the States, agricultural consumption is largely unmetered, and the SEBs, in their eager to record reduced transit losses, find this situation a convenient 'dump' for a good part of the unaccounted for energy. Kannan and Pillai (2001 a) have attempted a rough estimate of such diversion and arrived at the conclusion that the so-called agricultural consumption in India is over-estimated by as much as 30 to 40 per cent. The actual T & D loss in India, inclusive of this then, amounts to about 36 to 33 per cent, instead of the reported 26.5 per cent in 1998-99. It should be pointed out here that some of the reforming States have recently come out with revised and alarming levels of T & D losses. 'For example, before restructuring its power sector, Orissa reported only 23 per cent as T & D losses. After restructuring, the T & D losses are shown to be 51 per cent. In the State of Andhra Pradesh, where the T & D losses were of the order of 25 per cent before restructuring, it is now estimated to be 45 per cent after restructuring. Other reforming States like Haryana have now estimated its losses at 40 per cent and Rajasthan at 43 per cent against earlier level of 32 per cent and 26 per cent respectively.' (Government of India 2000: 35).

The above discussion thus serves the purpose of identifying three possible sources of avoidable operational inefficiency, viz., under-utilisation of capacity and higher levels of auxiliary consumption and T & D losses, equivalent to three possible sources of a large potential for energy and capacity savings. If the SEBs were able to improve their operational efficiency and thus increase their net generation for sales, it could yield an effective short-term remedy for the shortage problem. This we illustrate below for 1998-99.

Table 5: Prime-Mover-Wise Technical Performance of the SEBs in 1998-99

	Installed Capacity (MW)		Generation (MU)		Capacity Utilisation %		Purchase Net (MU)	Available Energy MU	Sales MU	T & D Loss MU
	Hydro	Thermal	Hydro	Thermal	Hydro	Thermal				
Andhra Pradesh	2657	3052	7353	20543	31.59	76.84	9473	37369	24351	13018
Assam	2	595	0	926	0	17.77	1935	2861	1753	1108
Bihar	150	1394	140	2567	10.65	21.02	6573	9280	6902	2378
Delhi	0	654	0	1894	0	33.06	14720	16077	7951	8126
Gujarat	547	4020	1346	21798	28.09	61.9	10606	33750	26209	7541
Haryana	884	896	4576	3726	59.09	47.47	5477	13779	8900	4879
Himachal Pradesh	299	0	1484	0	56.66	0	1486	2970	2083	887
Jammu & Kashmir	190	184	699	14	42	0.87	4728	5441	2798	2643
Karnataka	2646	1328	10451	6731	45.09	57.86	5579	22761	15796	6965
Kerala	1695	109	7305	253	49.2	26.5	3407	10965	9052	1913
Madyha Pradesh	848	3228	2851	17701	38.38	62.6	11646	32198	25601	6597
Maharashtra	1565	6293	3932	40431	28.68	73.34	7239	51602	41092	10510
Orissa	1277	420	3554	2804	31.77	76.21	1012	7370	3386	3984
Punjab	1799	2130	9966	10914	63.24	58.49	3098	23978	19396	4582
Rajastan	972	1264	4426	7538	51.98	68.08	10557	22521	15730	6791
Tamil Nadu	1963	3119	4918	17224	28.6	63.04	11180	33322	27527	5795
Uttar Pradesh	1505	4574	6196	18741	47	46.77	13274	38211	26391	11820
West Bengal	142	1132	361	3274	29.02	33.02	7878	8118	3395	11513
All India	22479	70815	82923	353699	42.11	57.02		421488	310004	111484
SEBs	12070	29456	44646	143900	42.23	55.77				
Central Sector	2365	23135	10916	140573	52.69	69.36				
Private sector	477	7782	1440	31363	34.46	46.01				

Source: CMIE (2002); Capacity utilisation figures are estimates.

Potential Savings from Efficiency Improvement

Table 5 presents the structure of SEB-wise electricity supply, along with the prime-mover-wise PLF in 1998-99. The PLF of the thermal power plants on an average for the Indian power sector in that year was only 59 per cent, while for the hydro plants, just 42.1 per cent. It goes without saying that if the SEBs could plan and execute an efficient operational strategy, the capacity could be made available and then utilised at a higher level. For example it might not be impossible for the SEBs to improve their performance such that the average thermal PLF increases up to, say, 70 per cent (which implies for instance a utilisation rate of 87.5 per cent at an availability of 80 per cent) and the average hydro PLF up to, say, 55 per cent (implying utilisation of nearly 80 per cent at 70 per cent availability). This possibility (at an overall PLF of 66.4 per cent, about 20 per cent more than the actual 55 per cent in 1998-99) would then yield a gross generation of 542,535.27 MU of energy instead of the actual 448,545 MU. Accounting for a minimum of 7 per cent auxiliary consumption, this would leave an available (net) energy of 504,557.8 MU, far exceeding the (unrestricted) energy requirement of 446,584 MU, against the actual availability of 421,488 MU. Not only that there would not be any energy shortage in this efficient scenario, but the per capita energy consumption would also rise substantially. With a minimum 15 per cent T & D loss, the potential consumption would be 423,177.5 MU, about 1.4 times the actual one.

The increase in generation thus achievable represents an installed capacity of 16,161 MW at a PLF of 66.4 per cent. This then means that if the Indian power sector could improve its operational efficiency to some possible extent, by increasing the present low level PLF by a minimum 20 per cent and reducing the energy loss in auxiliary and transit consumption, it could help the system dispense with the need for adding about 16,160

MW to the total installed capacity, saving highly in investment and working expenses. That this saving is in addition to the potential increase in revenue from the additional sales as well as in the standard of living of the people in general highlights the immensity of the problem of the operational inefficiency in the Indian power sector.

In the above estimation, we have assumed a T & D loss factor of 15 per cent only. Now just reflect upon a drop in T & D losses to the ideal 10 per cent norm. It must, however, be noted here that the non-technical energy losses due to theft, etc., cannot be converted into energy and capacity savings, but can only be included in revenue savings. Though theft of electricity has been made a cognizable offence, with deterrent punishment of up to 3 years imprisonment, since 1986 under the Indian Electricity Act, 1910, this has had no effect on the theft problem. On an average, in 1996-97, an estimated quantum of about 1,332 units of electricity was lost per case of theft/misuse detected in 13 States, the total losses being 614.71 MU (Government of India 1996-97). Though under-estimates, these figures do represent a big drain on the SEBs' revenue stream. The estimated revenue loss for the 13 States in 1996-97 in this respect amounted to Rs. 100.19 crores at an average rate of Rs. 1.63/unit, and for Punjab alone, Rs. 29.63 crores, at Rs. 1.36/unit. Data are unavailable/withheld on the estimates of Energy loss in theft in some SEBs, where in fact pilferage is a major problem, for example, in Delhi, with no rural electrification commitment that involves high T & D loss.

Demand Side Management

A proper diagnosis of a shortage situation (excess of demand over available supply) requires a close look into the relevant correlates on both the sides: demand and supply. That the demand actually pressing against the system capacity is not out of any extravaganza facilitated by cheap availability should be primarily ensured. That is, the demand we should consider is one of 'rational' use; and unfortunately this is not the actual fact in our country. There remains much to be desired in respect of energy conservation, with tremendous scope at every end-use point. For example, the almost free electrical energy, whenever available, is just lavishly burnt out in the agricultural sector. And we know well that even the highly educated and socially conscious among us are not free from the careless forgetting that leaves lights and fans 'switched on' even when not in need in offices and other public places, though we may be keen to conserve energy at home. It goes without saying that the present energy crisis could to a good extent be solved by conscious efforts of energy conservation, the significance of which was acknowledged in India long back. The case for energy conservation is recognised to rest 'on the solid fact that conservation measures are cost-effective, require investments which are much smaller than what would be needed to produce additional energy equivalent to the energy they save and above all, have very short gestation periods, unlike energy supply projects which take years to plan and implement'. (Government of India 1986: 7).

There remains much to be desired in respect of energy conservation, with tremendous scope at every end-use point.

The Eighth five-year plan of India envisaged a demand reduction of 4,600 MW through demand side management (DSM) measures (i.e., of energy conservation and efficiency of use at the consumer end). A study undertaken at Indira Gandhi Institute of Development Research (IGIDR), Mumbai, (Parikh et al. 1994) has shown that a demand saving of 2235 MW (excluding cogeneration) is possible over a 20-year plan period ending with 2012 AD at a cost of Rs. 10,907 million (in 1993-94 figures), and an energy saving in the terminal year of 6,835 Giga Watthour (ibid.: xxiv). Extending the results to all-India level, Reddy (1995) shows a saving potential of 25,000 MW over a period of 15 years and 100 billion kWh in the 15th year (quoted in Parikh 2001). A DSM study of low tension consumers in Kerala (Unnikrishnan et al. 1997) gives a peak load saving of 1094 MW and an energy saving of 1048 MU. Many of the DSM options, once adopted by the consumers, help recover their investment in two to three years. However, a number of institutional barriers to adoption (such as information availability, cognitive skills, risk and uncertainty and capital market accessibility; see Pillai 1999 b) stand in the way of reaping the full potential.

Despite the importance given and measures undertaken, the social behavioural pattern has not been much affected to effect any perceptible result in energy conservation, through better housekeeping, proper maintenance and better controls of instruments, and adaptation of latest technologies.

Financial Inefficiency

Apart from the impacts of the technical inefficiencies, the government policies have also adversely affected the financial health of the power system. Since the responsibility of power development was originally

shouldered by the government, as in the case of other infrastructure sectors with high capital intensity and long lead time, the power sector has been expected to subserve the social, political and economic policies of the State. The patronising policies of the governments have created avenues for excessive employment, especially at the non-technical, establishment and administration level, involving unwarranted cost increases. Moreover, the little energy available after the low capacity utilisation and very high T & D loss itself has been sold out at subsidised rates, irrespective of considerations of costs, under compulsion of government policies. For instance, the gross subsidy involved in electricity sales was Rs. 7449 crores in 1991-92 (accounting for 1.1 per cent of GDP) and Rs. 33814 crores in 1999-2000 (accounting for 1.7 per cent of GDP). The gross subsidy of the state power sector as a percentage of gross fiscal deficit of state governments was about 36 per cent in 1999-2000 (Government of India 2001: 175). And the commercial losses rose from Rs. 4117 crores in 1991-92 to Rs. 24920 crores in 1999-2000—a six-fold increase.

To ensure financial health of SEBs, it should be ensured in turn that the prescribed tariffs are adequate for the purpose and are reviewed periodically and revised, whenever necessary, consistent with the trend of the operational parameters, input costs, etc. In addition, and more importantly, it should also be ensured that the sales revenue these tariffs yield is collected regularly and the outstanding dues are kept to the minimum possible. As revenue arrears accumulate, the very purpose of tariff revision gets defeated; and sadly this is so in almost all the States. The uncovered revenue dues outstanding against different consumers in the State power sector was always on the increase over time, for example, from Rs. 6,720 crores in 1992-93 to Rs. 11,535 crores in 1996-97, growing at an annual rate of 14.5 per cent. Accounting for about 26 to 36 per cent of the annual sales turnover, these arrears represent about 4 months' sales revenue being locked up with the consumers at any point of time, against the maximum allowable norm of two months' sales revenue. States like Bihar and Jammu and Kashmir have revenue arrears of up to 183 per cent (in 1996-97) and 228 per cent (in 1995-96), respectively, of their annual sales, equivalent to about 22 and 27 months' sales revenue respectively, while it is at the lowest in Tamil Nadu with 2 to 4 per cent (i.e., 7 to 15 days' sales) only. Assam, Delhi, Uttar Pradesh, and West Bengal had often more than 50 per cent turnover of revenue arrears, i.e., more than 6 months' sales, while for Kerala, 23 to 43 per cent, i.e., about 3 to 5 months' sales. In 1997-98, it was about 41 per cent for Kerala, nearly 5 months' sales. Regular and timely collection of all receivables could increase the liquidity available with the SEBs and arrest the excessive dependence on loans. For instance, if all the SEBs could limit the revenue arrears receivable to nearly two months' sales norm, additional revenue collected of Rs. 4,490 crores would be available with them in 1996-97, which in turn means that they could dispense with additional loans of the order of about Rs. 4,500 crores in that year or be relieved of some of the old loans. In other words, this is the cost of inefficiency in the management of sundry debtors in 1996-97. For 1995-96, this amounts to Rs. 7,567 crores. That every year such huge cost of liquidity restriction is left to be incurred explains the financial inefficiency of the SEBs.

Regular and timely collection of all receivables could increase the liquidity available with the SEBs and arrest the excessive dependence on loans.

Thus the receivables to the SEBs have been mounting, often representing more than 4 months' sales revenue being locked up with the consumers at any point of time, against the maximum allowable norm of two months' sales revenue. And all these inefficiencies have left the system with little internal resources for sustainable development. Partly the SEBs were reared, as already mentioned above, in such an unaccountability culture—the SEBs were to subserve the socio-economic policies of the State and hence expected not to view every aspect of developmental activities exclusively from the viewpoint of profit (as highlighted by the Venkataraman Committee of 1964), there was no compulsive requirement (till the 1978 amendment of Section 59 of the Electricity (supply) Act of 1948) for the SEBs to break even, or to contribute internal resources to expansion programmes. In addition to Plan outlays allocated to the power sector, government subventions were also on the way in.

Conclusion

It is in this backdrop of the cumulative internal inefficiencies, that the apparent 'fiscal crisis' at the turn of the 1990s has stood to usher in 'the much desired' reform process in the power sector. The reforms and restructuring of the Indian power sector, commenced at the initiation of the World Bank, has also lit up an informed atmosphere of debates and discourses. A number of SEBs are now on the reform/restructuring path. So far sixteen States (Andhra Pradesh, Arunachal Pradesh, Delhi, Goa, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal) have either constituted or notified the constitution of

SERC. The SEBs of Orissa, Haryana, Andhra Pradesh, Karnataka, and Uttar Pradesh have already been unbundled/corporatised. The first move towards such reform process was initiated in Orissa, even before the formulation of the CERC at the Centre. Orissa Electricity Regulatory Commission was the first of its kind in the country, designed as an independent regulatory commission to regulate the power sector in the State. Again, Orissa is the only State to have fully privatised the distribution business of its ESI in the State. The World Bank has sanctioned a loan of 350 million dollars to Orissa for its power sector reforms.

The new scenario has lit up an informed atmosphere of debates and discourses. Despite the clear signal of the need for an internal, efficiency improving reform, most of the State Governments have gone for an all out restructuring of the power sector, with little regard that the irreversible actions might lead to disastrous results (Government of Kerala 1998:6). A possible explanation for this can be found in the attraction of the Central assistance and of soft loans offered by the international financial agencies as a package with reforms as also of the selling out of public assets that has captured the political economy of corruption that governs the prodigal Governments (Kannan and Pillai 2001b).

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Feature

TQM Practices in the Indian Automobile Sector

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The paper presents the survey result and analysis of TQM practices being followed by Indian automobile sector. The survey focused on twelve key variables including seven enablers (leadership, strategic planning, information management, human resource focus, customer and market focus, supplier focus and process management) and five results (impact on society, human resource satisfaction, customer satisfaction, supplier satisfaction and organisation specific business results). This paper reveals that Indian automobile sector is still not responding fast, even after liberalisation, to the changing needs of the market scenario and concludes that implementation of TQM philosophy is a must for its survival and growth.

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The Indian Automobile sector is contributing only 5 per cent of the country's industrial output compared to the 8-10 per cent range in developing countries like Mexico and Brazil and a much higher (15-17 per cent) range in developed countries like USA and Germany (The Economic Times, 2000). India's contribution in car production as a percentage of the market share in world wide production is negligible, at around 0.9 per cent of the total world's car production as against 20.8 per cent, 19.7 per cent, 5.6 per cent, 5.2 per cent and 4.3 per cent of USA, Japan, Germany, France, Canada and U.K. respectively. India's car production is only 6.25 per 1000 against 532, 514, 489 and 430 of Italy, USA, Germany and France respectively (Murad, 2000).

One of the major reason for this dismal performance in the world market may be attributed to the poor quality management systems (Ulrich, 2000). Japan's automobile industry started out several decades behind the USA's but in 1980 it overtook the USA's and became the biggest in the world [5] due to its reputation for high and dependable quality and reliability. Literature reveals that 8,424 people from 96 countries have come to study Japanese Total Quality Control (TQC) at the Japanese Union of Scientists and Engineers alone (Parth, 1996). It is astonishing to note that the competitiveness of India has been ranked very low (41 out of 49 counties) as per world competitiveness yearbook report 2001. Since the Indian automobile sector is a vital sector of the Indian economy, it is felt important to take stock of TQM practices being followed by Indian automobile sector that includes automobile manufacturers, suppliers and sub-contractors.

Research Methodology

A comprehensive questionnaire was designed to survey TQM practices being followed in the Indian

automobile sector. The survey questionnaire primarily based on the Malcolm Baldrige National Quality Award Model focuses on twelve key variables including seven enablers – leadership, strategic planning, information management, human resource focus, customer and market focus, supplier focus and process management and five results (impact on society, human resource satisfaction, customer satisfaction, supplier satisfaction and organisation specific business results). All the seven enablers and five results were further classified into sub-categories and respondents were asked to evaluate each factor on 5-point Likert scale as per practices being followed in their company. For the purposes of our survey the 5-point Likert scale has been defined as shown in Table 1.

Table 1: Relationship of Score with Organisational Maturity

5 point scale	Characteristics	Description
5	World class quality performance	Excellent approaches, full deployment, processes continuously improved sustained results
4	Superior quality accomplish-ment	Good systematic, effective approaches have been refined and are deployed throughout most of the company. Results are good to excellent in most key areas. Continuous improvement in place. Positive improvement trends.
3	Strong quality implementation	Strong, systematic and effective approach to quality. Good results and/or improvement trends in most key areas. No major gaps in deployment.
2	Quality awareness	Organisation is aware and needs to begin to formalise its quality efforts. No systematic approaches, results are weak and poor.
1	Traditional find and fix	Main emphasis is on quarterly profit maximisation, cost containment and reduction.

The survey questionnaire was validated based on sample data from automobile manufacturers, suppliers (first tier) and sub-contractors (second tier and above). In addition to the survey personal visits to companies were made to get first hand information.

The survey questionnaire was mailed to 350 automobile companies including 66 automobile manufacturers, 227 suppliers and 57 sub-contractors. The analysis is based on the responses received from 48 companies including 12 automobile manufacturers, 26 suppliers and 10 sub-contactors. The 48 responses were collected after making more than one personal visit and holding a series of detailed discussion with the practicing TQM managers of the companies.

Survey Result and Analysis

TQM: A Guiding Philosophy

Results show that 83 per cent of automobile manufacturers and 73 per cent of suppliers claim to follow TQM as a guiding philosophy whereas only 30 per cent of sub-contactors believe in TQM as shown in Fig. 1.

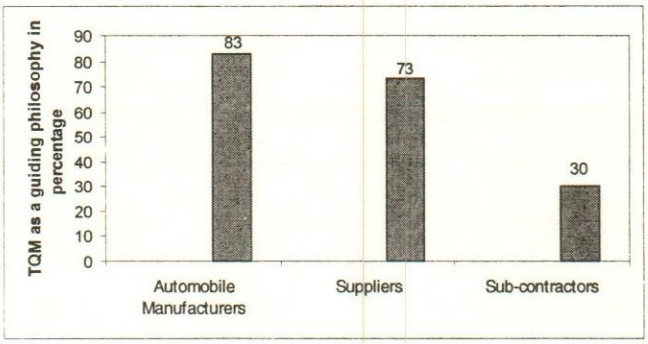

Fig. 1. TQM as a guiding philosophy in percentage

Automobile manufacturers and suppliers are convinced that TQM can bring the desired results however the sub-contractor category does not recognise this fact. This will affect India's overall competitiveness in the world market.

It was analysed that 15 per cent of the automobile sector were following TQM philosophy in the pre liberalised era and it improved to 47 per cent after liberalisation. However, 38 per cent of the organisations have still not started TQM. The effect of the same can be seen on on-time delivery status, cost reduction programme, rejection and cost of quality status. As per world standard the Indian automobile sector is still for behind. Fifty two per cent of the automobile organisations are working for cost reduction for more than 5 per cent reduction as percentage of sale, whereas it is very alarming that 48 per cent of the organisations have not taken up cost reduction as a percentage of sale. However, world-class organisations are working to identify non value added activities to reduce cost as percentage of sales.

World-class organisations are monitoring their rejections in ppm (parts per million) whereas 83 per cent of automobile sector claim to be having rejection more than 4 per cent that is very high. This shows that automobile sector has to go a long way in achieving that kind of performance and much more serious efforts are required for process control in order to achieve ppm rejection levels.

Harrington observed that the complexity of today's business environment has made it necessary for or-

ganisation to evaluate all the alternatives before committing resources to an improvement process. He proposed the use of quality cost concepts (cost of poor quality) to avoid ambiguity and improve understanding of quality improvement. But unfortunately only 10-15 per cent Indian automobile organisations are using quality cost as a measure of their quality performance thus loosing an opportunity to identify critical areas for improvement. That is probably the reason why inspite of 52 per cent of the Indian automobile sector claiming to be working for cost reduction, it fails to achieve the desired results.

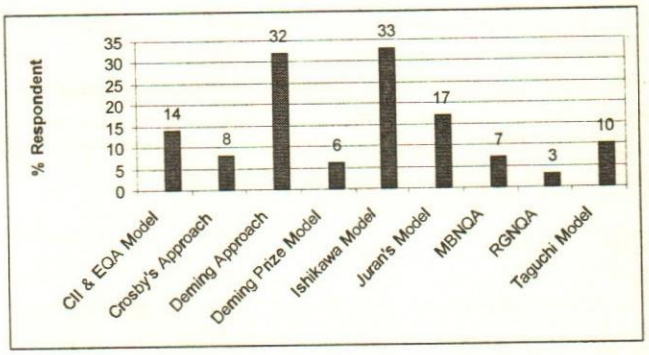

Fig. 2. Category wise Quality Model Used in percentage by Respondent Organisation

Therefore, world class organisations offer products and services capable of capturing and retaining worldwide market share; on the basis of superior performance and lower price, besides exceeding customer's expectations and India lags behind in capturing a reasonable market share globally.

Quality Models and Tools used

Quality model

TQM models are based on a premise that quality improvement requires an enlightened and influential leadership, which drives quality movement forward. The success of the Deming Prize acted as a catalyst for spreading quality awareness in Japan, the Malcolm Baldrige National Quality Award model in America, the Australian Quality Award Model in Australia and European Quality Award Model in European countries. These National models gave momentum to organisations in achieving performance excellence in their respective countries. This zeal however seems missing in the automobile sector. The popular models in the In-

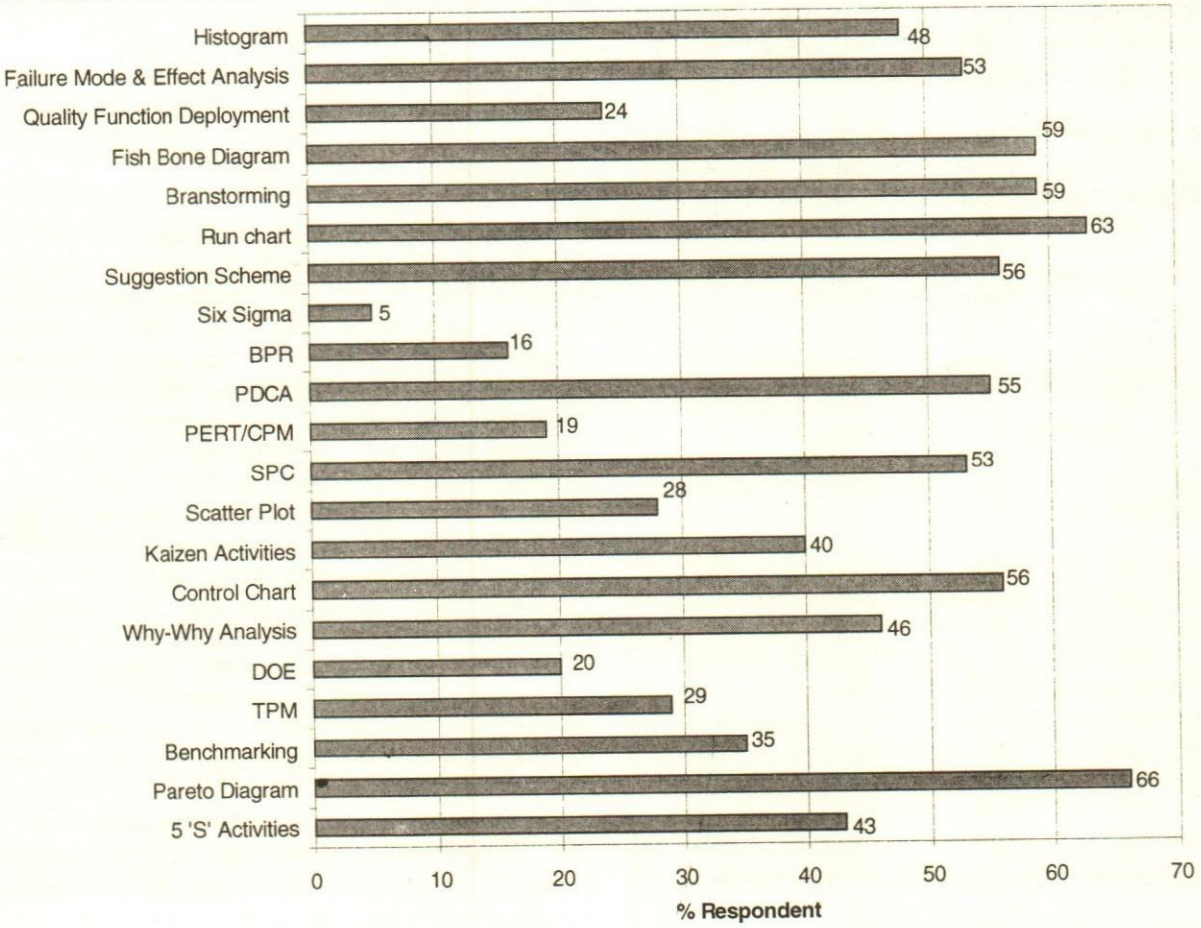

Fig. 3. Tools Employed by Respondent Organisation (in percentage)

dian automobile sector are Deming's approach and Ishikawa model whereas Deming Prize model, European Quality Award model, Malcolm Baldrige National Quality Award model, CII-EXIM Award model and Rajiv Gandhi National Quality Award model are not being used much as shown in Fig. 2.

Quality Tools

In automobile sector 5'S' Activities, Pareto Diagram, Why-Why Analysis, Control Charts, Kaizen Activities, SPC, PDCA Cycle, Suggestions Scheme, Run Chart, Brainstorming, Fish Bone Diagram, Failure Mode Effect Analysis and Histogram are very popular and are being used for improving house keeping and solving quality related problems whereas the area of concerns are Benchmarking, TPM, DOE, Scatter Plot, PERT/CPM, BPR, Six Sigma and Quality Function Deployment are also very essential for continuous improvement as shown in Fig. 3.

TQM Variables

Twelve TQM variables have been identified based on modification of Malcolm Baldrige National Quality Award Model as appropriate to Indian conditions. Seven variables have been identified as enablers and five variables have been identified as results.

The model recognises that there has to be good enablers for better results. A pictorial representation of the Business Excellence model has been shown in Fig. 4.

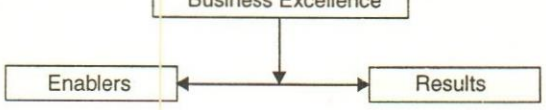

Fig. 4. Business Excellence Model

TQM Enablers

Considering the Indian socio-culture values seven enablers have been identified as Leadership; Strategic Planning; Human Resource Focus; Customer and Market Focus; Supplier Focus; Process Management and Information Management. Information Management provides the foundation on which all enablers rest and information acts as a glue. Pictorially these are depicted in Fig. 5.

As discussed above there are seven enablers that were considered in the survey questionnaire, the overall average score of all the seven enablers are presented in Table 2.

Table 2: TQM enablers overall average score

TQM Enablers	Overall Average Score in Automobile Sector
Leadership	2.52
Strategic Planning	2.64
Information Management	2.44
Human Resource Focus	2.36
Customer and Market Focus	2.47
Supplier Focus	2.10
Process Management	2.35

The results of all the seven enablers have been analysed below.

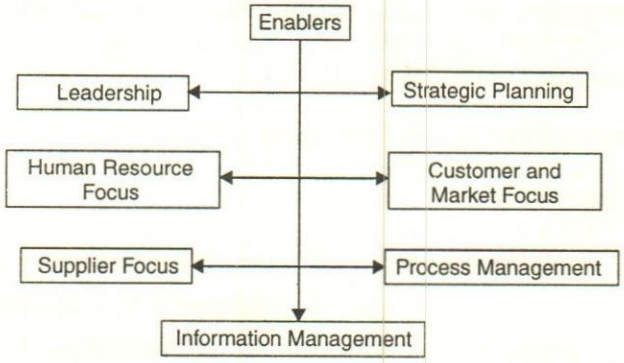

Fig. 5. Identification of TQM Enablers

Leadership

The success of TQM depends upon the visionary quality of leadership, however the overall average score of 2.52 on a 5-point scale indicates that in general the responding organisations do not have a strong leadership as shown in Table 2. In this survey three areas i.e. leadership of top management, top management commitment and change management process were focused. For top management leadership the top management's personal visible involvement in all aspects of quality management is very important, however the average score of 2.78 does not corroborate the same. It is equally important for the top management to provide and receive training for updating the knowledge, however the average score of 2.48 contradicts this. Timely recognition and appreciation of individual's / team's contribution brings out optimum contribution from the individual and teams, however the average score of 2.51 does not show this.

Other important factors for the success of TQM in any organisation is to set high performance goals and provide appropriate resources, give effective consideration to quality of work in appraisal system, top management encourages core team to monitor and

evaluate the level of performance and assess its effectiveness, respect and value all employees and encourage open communication and enhance innovativeness and creativeness in each individual, the top management is supportive and pay sufficient attention to the needs of the people and shows trust and confidence in their subordinates and empower them to take decisions, however the average score of 1.98, 2.51, 2.57, 2.58, 2.44 and 2.60 does not corroborate the same and thus are the weakest areas. The average of overall top management leadership is 2.49, which is quite low when compared on a 5-point scale.

Top management commitment is also weak as is evident from an overall average score of 2.81 on a 5-point scale.

The ability to change quickly that stems from the ability to assimilate and transfer new ideas to action faster are the key factors for the success of any organisation, however overall average score of change management is 2.31 which is very low when compared on a 5-point scale.

Strategic Planning

To remain competitive, a set of measurable goals and a long-range view of the future must guide each and every organisation. These measurable goals emerging from the strategic planning, serve to align the work of every one in the organisation, however the overall low average score of 2.64 does not corroborate the same as is evident through Table 2. The area of concerns are to the questions "the top management is committed to spend enough time for understanding the changing business scenario and its implications", "the organisation is ready to create a high level vision and mission in the changing business scenario, "the organisation's strategic planning incorporates the needs of customers after a thorough understanding of their needs", "the profile of the organisation's strengths, weaknesses, opportunities and threats forms the basis of strategies", "efforts are made to integrate quality i.e., quality planning, quality control and quality improvement with business strategies" and "the organisation's strategies are targeted for quantified measurable improvement in quality, cycle / response time and waste reduction", "long-term perspective is more important than short-term gains". The low average score of 2.67, 2.68, 2.67, 2.51, 2.64, 2.65 and 2.56 on a 5-point scale reflects the same. "Commitment of resources for new facilities, process improvements and training is done considering long-term objectives" is a comparatively strong area with an average score of 2.72.

Information Management

The success of any organisation depends upon taking decisions based on facts and figures and not on the basis of intuition or gut feeling. Effective information management improves decision quality. In this survey two areas of information management were focused on i.e. information technology and shared information.

The area of concern is information technology and shared information with low overall average scores of 2.19 and 2.56 on a 5-point scale, respectively. The overall average of information management is also a matter of concern with a low average of 2.44 on a 5-point scale as shown in Table 2. For effectiveness of information technology it is very important to use it to improve the co-ordination and information access across various departments, it should transform unstructured processes into routine transactions through shared databases, transform information rapidly and easily across large distances, connect two parties (internal or external) within a process that would otherwise communicate through intermediaries and this technology is used to spread information and to reduce time lag, however 2.30, 2.17, 2.10, 2.17 and 2.17 does not corroborate the same.

Decision based on shared information is very important for effectiveness of any organisations. For shared information it is very important that organisation's working system and procedures promote easy upward flow of information, employees the feel free to share information with their managers and / or colleagues, the organisation uses information on product performance, customer feed back / complaints etc. for quality improvement, the organisation reviews and updates data before integrating it in process improvement plans, however scores of 2.48, 2.45, 2.91 and 2.52 speaks to the contrary. Equally important factors are organisation use supplier performance related data for quality improvement efforts, organisation's information management system is easily accessible throughout the organisation, organisation uses past performance data to improve understanding of processes, organisation periodically evaluates and improves its processes so as to further improve overall performance and organisation gives priority to product quality improvements decision vis-à-vis financial performance, however, low scores of 2.58, 2.39, 2.51, 2.61 and 2.67 shows that this does not happen.

Human Resource Focus

The success of TQM depends upon the full use of the potential of all employees through the processes of recruitment, training, development, motivation and in-

volvement. In this survey three areas were focused on human resource development, employee involvement and shared information. For human resource development the organisation's business plan should consider human resources capabilities for addressing quality leadership opportunities and invest in education and training considering employees' and business needs, however, low score of 2.39 and 2.52 on a 5-point scale speak to the contrary. Equally important factors are whether the employees are encouraged to write, follow and improve upon the standard operating procedures, employees are empowered to reduce the non value adding activities and employees are encouraged to be involved in and participate in decision making of major policy changes that soften the resistance to change, however these are the areas of concern with low scores of 2.38, 2.67 and 2.23. There were low average scores of 2.51, 2.19, 2.41, 2.52, 1.24 and 2.46 against the questions are employees encouraged to develop multi skills and capabilities, the organisation evaluates and improves its human resources planning using employee's feedback, whether the organisation encourages employees to bring their problems without any hesitation to the seniors for resolution, does the organisation make efforts to integrate employees job performance with key quality improvement targets and business results, does the organisation offer stress control programmes for the employees so as to improve quality of their work life and is the organisation concerned about its employees well being (health, safety and ergonomics). The overall average score of 2.38 for human resource development is the weakest area when compared on a 5-point scale.

Employees involvement is very important for the success of TQM programme in any organisation, they should support the vision of the organisation, each and every employee must contribute significantly and employees must maintain motivation, safe working condition, however low average scores of 2.39, 2.52 and 2.48 does not support this and the overall score of employees involvement is quite low at 2.46.

For shared information and for the success of any organisation, efforts are made to recognise and reward the accomplishment of the employees, it should be timely and sincere, efforts are made to recognise and reward team oriented behaviour and efforts are made to understand the family and home life of the employees, however the low average score of 2.39, 2.07, 2.19 and 1.75 show these as areas of concern. The overall score of shared information is 2.10 which shows that information is generally not shared among employees which is very detrimental for TQM implementation.

The overall low score of human resource focus i.e. 2.36 indicates that if human resource focus is not sustained systematically, it will become difficult to survive and grow and present good business results cannot be sustained in the future.

Customer and Market Focus

For the success of any organisation it is very important to understand the concept of internal and external customers. Where appropriate, customer and supplier partnerships should be promoted on the basis of added value and joint strategies, however, the overall average score is 2.47. In this survey two areas were focused as far as customer and market focus is concerned i.e. customer knowledge and customer relationship.

Organisations are required to regularly determine customer's requirements and expectations, select customer groups / market segments with the intention of adding quality conscious customers, determine specific product features and their relative importance using customer listening techniques like QFD etc. and organisation analysis and uses information on customer loss / gain and product performance to develop future strategies. These areas are still weak as is evident by low average scores of 2.81, 2.51, 2.07 and 2.48 respectively. Equally important factors for effective TQM implementation are that the organisation addresses future needs taking into account competitors, customers and changing market segments and regularly evaluates and improves upon its processes based on changing customer expectations, however the low average score of 2.45 and 2.67 does not support sufficient efforts being made by the Indian Automobile sector. The overall average score of customer knowledge is low with an average score of 2.49.

To cement strong relationships with customer, commitment like guarantee / warranty etc should be simple and should be effectively communicated to the customers, organisation should regularly evaluate and improves their communication for service performance to match customer expectations, however, low average scores of 2.37 and 2.54 show lack of efforts by the Indian Automobile sector in this direction. Globally, organisations regularly follow-up with customers on product performance and build long term relationships, have an effective system to reward and motivate customer-contact employees and regularly evaluates and uses the customer feedback to improve performance standards, however these are weak areas as far as the Indian automobile sector is concerned which is evident with low averages of 2.63, 1.95 and 2.70, respectively. The overall customer relationship is quite low with average score of 2.44 on a 5-point scale.

There is a need to work significantly in this area of customer and market focus. Due to protected markets in the past customer was neglected. Now the situation is changing fast after liberalisation and there is a need to change old habits as early as possible.

Supplier Focus

For the success of TQM it is very important that suppliers should be treated as partners in the process of improvement. Supplier rating system, supplier training and development, understanding of supplier's need etc. should be an ongoing activity; it has been emphasised by QS-9000 (Quarterly System, Requirements, 1998). But the overall average score of 2.10 speaks to the contrary as shown in Table 2. It is very important that members of the major supplier's should work jointly in teams on issues like new product development, resource saving and energy conservation, the organisations should share the resources and systems with major suppliers like financial and accounting system, financial resources, information system, production planning system, quality system, technical expertise, however the low scores of 2.04, 1.63, 1.74, 2.07, 2.37, 2.39, 2.32 and 1.82, respectively, are cause for concern.

Thus there is a greater need to share resources for mutual benefits and improving quality, lowering cost and delivery. This could become an effective basis for implementation of JIT.

The low average score of 2.64 on a 5-point scale does not indicating growing need of vendor rating system implementation (based on quality, price and delivery). Another area of concern against the question does the organisation aim to develop suppliers was low average score of 2.60 on a 5-point scale.

In the surveyed organisations the supplier focus is low. Thus there is a need to improve supplier focus in the Indian automobile sector. Suppliers should be considered as business partners and given due and appropriate focus. This is the need of the hour under today's liberalised economy for survival and growth. Literature survey revealed that no study has been carried out to analyse the impact of supplier quality management (Froker, 1997).

Process Management

The Success of TQM depends upon the effective implementation of process management. These include project activity, corrective and preventive action, opportunities for using SQC techniques, cost of quality, supplier auditing, competitive benchmarking and measured customer satisfaction and dissatisfaction. Effective use of the PDCA circle helps in continuous improvement.

Overall average of 2.35 score on a 5-point scale does not corroborate increasing awareness of the need for process management. In this survey two areas are focused i.e. product management and process control. Organisations are still weak in product design considering customer's implied and future needs. This is evident by low average score of 2.32 on a 5-point scale. For the success of any organisations it is very important that organisations should validate their product design taking into account performance, process, and supplier capabilities and organisations should evaluates and improve their design and design processes so as to improve product quality and cycle / response time however, the low average score of 2.26 and 2.25, respectively, are cause for concern. The average score of 2.42 does not indicate the area of strength either against a question do organisations determine the cause of variations, make corrections and integrate them into the process using statistical techniques etc. The overall low average of 2.31 indicates a weak area as far as product management is concerned.

For effective process control it is very important that the organisation should regularly evaluate and maintain the key business process, their requirements, quality, and operational performance, however, low score of 2.56 does not corroborate the same. Benchmarking is generally not done which is evident by the average score of 2.38.

Benchmarking being weak can be very detrimental to sustaining quality in the long run by the Indian automobile sector. The average low score of 2.30 also indicates that organisations are not effectively using alternative technology, process research and testing for business process improvement.

Overall there is a need for improving process control for getting better results. Since there is not effective process management, some problems keep recurring. Thus present efforts for process management / improvements are not adequate.

Results

The results are the measures of the level of output and outcome. Results are emphasised in all the award models. In the result category; Impact on Society; Human Resource Satisfaction; Customer Satisfaction; and Supplier Satisfaction are considered over and above the Company Specific Business Results as shown in Fig. 6.

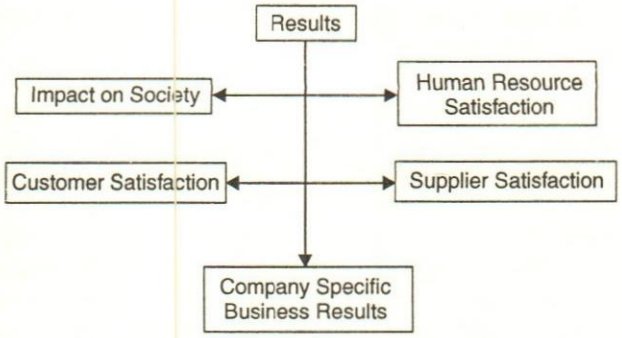

Fig. 6. Identification of TQM Variables of Results

As discussed above there are five results that were considered in the survey questionnaire, the overall average score of all the five results are presented in Table 3.

Table 3: TQM Results overall average score

TQM Results	Overall Average Score in Automobile Sector
Impact on Society	2.26
Human Resource Focus	2.29
Customer Satisfaction	2.49
Supplier Satisfaction	2.27
Organisation Specific Business Results	2.55

Impact on Society

It is very important for effective implementation of TQM that all employees should value and promote their organisation within the community. The organisation should balance its societal responsibilities with the demands of its shareholders. The organisation should have well-established prevention-based systems for environmental management. The organisation should also make all regulatory requirements mandatory. Automobile manufacturers are encouraging their suppliers to go far ISO 14001 environmental management system.

Some organisations have started taking an interest in societal responsibilities, but generally there is a total lack of awareness towards promoting this. This is evident by the overall low average score of 2.26 on a 5-point scale as shown in Table 3. Very few organisations are effectively satisfying the needs and expectations of the society at large, effectively evaluating possible impacts of its products and operations on society and making adequate efforts towards the alignment of work plans with the available resources. This is evident by low average score of 2.45, 2.28 and 2.37 on a 5-point scale respectively. Other areas of concern are lack of effort on the part of organisations to effectively promote ethical conduct in all its activities ensuring the organisation's Ad-campaigns are truthful and reflects facts, effectively considers quality of work life while deciding service conditions of employees and effectively considers energy conservation and preservation of global resources / raw materials. This is evident through low score of 2.57, 2.07 and 2.33 respectively on a 5-point scale. For positive impact on society it is very important that organisations should consider utilisation of the recycled materials and makes effective efforts to improve upon it and impart education and training to community / neighbourhood at large with respect to its products and services, however this is not reflected the low score of 2.21 and 1.78 on a 5-point scale.

Human Resource Satisfaction

The success of TQM depends upon the full use of the potential of all employees in an organisation. In this survey four areas were focused as far as human resource satisfaction is concerned i.e. human resource satisfaction monitoring, teamwork, value system and individual relationship. Human resource satisfaction monitoring is very important, however, this is not reflected by the overall low average of 2.15 as shown in Table 3.

For full use of the potential of employees it is very important that employees satisfaction level should be regularly reviewed and corrective action taken, existing system of incentive and reward should be adequate for maximisation of employees individual contribution, efforts must be made to improve job skills, maintain employees motivation level at high level and attract the best talent from market, however this is not reflected by the low score of 1.93, 2.07, 2.37, 2.14 and 2.23 respectively.

The other important factor for human resource satisfaction is to provide a conducive atmosphere for employees to work as a team, however, the overall low average score of teamwork i.e. 2.25 on a 5-point scale does not reflect the same. For an effective team working climate the important things are that the team members should trust one another, team members should appreciate constructive criticism, there should be intense communication within the teams to generate ideas, team members should be exposed to training on benchmarking and other tools and techniques to carry out changes successfully and the team members should create a performance measurement system, however the low scores of 2.37, 2.26, 2.22, 2.25 and 2.16 respectively on a 5-point scale does not corroborate the same.

Value system of an organisation is another important factor for human resource satisfaction. The overall

low average score of the value system is 2.30.

The conducive value system lacks where employees in the organisation don't understand that each and every job is essential and important and every individual makes a difference, employees don't believe in accepting the responsibility for problems to solve them, employees don't believe that we succeed or fail together as a team not as individuals and employees don't believe in superior quality and service. The same is reflected by low score of 2.30, 2.30, 2.17 and 2.42, respectively.

Individual relationship plays an important role as far as human resource satisfaction is concerned. There is a growing need to maintain cordial and good individual relations between the labour and management and sort out the differences and pending issues across the table. This is evident through a comparative better score of 2.64 and 2.73 respectively and their overall average score 2.69 also reflect the same.

Customer Satisfaction

For the survival and growth of any organisation, customer satisfaction is a must under today's liberalised economy. Customer satisfaction means the internal and external customers are satisfied, customer base is improving and market share is growing. Customer needs are reflected in products and services. Customer complaints are systematically monitored and properly addressed. Competition among different automakers is growing day by day. They are trying to woo the customers with better quality and services, providing different range of models, offering finance at very competitive rates. All of a sudden customer satisfaction is a must for brand loyalty and for the growth and survival of the organisation, still this is not reflected through a overall low average score of 2.49 on a 5-point scale as shown in Table 3.

Very important factors for achieving customer satisfaction are that the organisation effectively determines customer satisfaction and makes effective efforts to improve it further, also compare satisfaction level effectively with that of key competitors based on in-house scientific studies and by using independent surveys, customers feedback is collected and used to improve the products and customer service and efforts are made to anticipate the customer's needs, requests and probable complaints that will enable the organisation to respond in real time, however, the low score of 2.77, 2.09, 1.96, 2.76 and 2.45 does not reflect the same.

There is a need for the management team to discuss and interact regularly with customers on key policy issues, which is also not evident by a low score of 2.55 on a 5-point scale. Top management executives do not base their decisions on previous experience in business. This is evident by low score of 2.52. It is very important for customer satisfaction to have a 'single point of contact' in the organisation for customers, service to internal customer is improved by actively involving different functional departments and units and organisations collect and analyse the data on customer dissatisfaction concerning organisation's service and products. The low average scores of 2.64, 2.51, 2.39 and 2.73, respectively, does not corroborate the same.

Supplier Satisfaction

A TQM system does not support receiving inspection but this would work only if the process of the supplier is under control to produce consistent quality and thereby suppliers parts are self-certified. For the success of any automobile manufacturer it is very important to receive components from suppliers at right quality, lower cost and timely delivery. Therefore many automobile manufacturers have programmes to improve the supplier's performance. These includes supplier quality system audits, supplier rating and qualification systems, training and supplier recognition programmes. Many automobile manufacturers encourage their suppliers to go for QS-9000 / ISO 14001 certification. Inspite of these efforts effective measures to involve the supplier as a business partner are not there. This is evident through the overall low average score of 2.27 as is shown in Table 3.

To achieve supplier satisfaction it is very important for the organisations to compare performance of their supplier with the suppliers of their key competitors and make constantly endeavours for development of capabilities of its suppliers. This is not evident through a low average score of 2.22 and 2.33 respectively. 45 per cent of respondent organisations are making efforts for development of their suppliers.

Thus there is an overall need to improve supplier satisfaction for getting better results. However present efforts for supplier development is not satisfactory. Ishikawa has credited the meticulous quality control practice by Japanese suppliers as one of the most important reasons for the high level of Japanese product quality (Ishikawa, 1985).

Organisation Specific Business Results

A balanced view of the organisation specific business result is important to understand whether the organisation is becoming good or merely looking good. An assessment against this criterion confirms the

organisation's TQM approaches have successfully ingrained the core values into the mainstreams of the enterprise. The results should present balanced interest of all stakeholders however the overall average score of 2.55 does not corroborate the same. It is very important for the success of any organisation to enjoy product quality leadership for the range of products it deals with however the low score of 2.49 is a matter of concern. A comparatively better score of 2.80 show that organisations' efforts are yielding better product quality over the last financial year. To achieve better business results it is very important to reduce the product cost significantly and organisations have significantly improved the product from the view point of production cycle / response-time over the last financial year, however, the low average score of 2.38 and 2.51, respectively, is not very encouraging.

Where to Go from Here: Emerging Issues

The analysis given above implies that the Indian automobile sector is aware of the need for improving quality, however systematic approaches are not yet in place and efforts for improvement are not yielding sufficient results, though many organisations claim to be TQM organisations and many more are taking ISO 9000/QS-9000 certification as a route to implement TQM philosophy. Many executives actually believe that the mere accreditation of the organisation to ISO 9000 and QS 9000 quality standards will bring about an overall improvement in its quality levels. The result of the survey does not corroborate this. ISO 9000 and QS-9000 certification is a journey towards TQM but not an end in itself. It seems many Indian organisations become complacent after receiving the certification. This would require a change in the mind-set of the management. The analysis has shown many areas for improvement to be globally competitive which requires serious involvement, deliberations and implementation by the top management to remove weaknesses.

The response analysis indicates that the automobile sector is still not responding to the changing needs of the market scenario and major steps have not been initiated for cost reduction. The overall processes are unstable and corrective and preventive actions are not effective thus leading to very high rejections. The cost of quality has not been understood as a very important analytical tool to drive continuous improvement in a prioritised manner and thus there is no systematic tool to assess TQM endeavours.

The overall awareness of quality models lack in depth. In many organisations people are trained for quality tools but the software part of the quality integration i.e. quality culture and team working has not been developed. However, there is a passion to know about quality tools but a lack of depth in using them, as a result, teams even if they are operational can not function effectively.

Another weak area is top management involvement in training the members of the core team which is reflected by the low morale of the people, which is detrimental to the implementation of TQM philosophy. The strategic planning is generally not done on the basis of the organisation's strengths, weaknesses, opportunities and threats and by and large lacks an effective monitoring system.

Though the information management system has been developed, information sharing among employees is very weak and is not easily accessible throughout the organisation. Thus mangers take more decisions based on intuition rather than on facts and figures. The top management also sets too many priorities resulting in a lack of focus. There is generally a lack of communication of goals throughout the organisation. Past performance data are not shared in setting objectives and goals, nor is it effectively deployed.

In many organisations a conducive environment is not created to make full use of potential of employees and there is lack of transparency in award and recognition of employees.

Lack of customer techniques like quality function deployment is a weak area and thus customer and market focus lacks depth. Consequently, roles for all levels of management and technical staff in quality improvement based on customer perception are not developed.

Suppliers are generally not treated as business partners in the process of improvement. Thus primary objective of improving quality, lowering cost and timely delivery lacks direction and organisations are forced to keep an inventory to ward off these problems.

Processes are generally not benchmarked to drive a continuous improvement culture.

It has been observed that there is a general lack of interest in societal responsibilities. Very few organisations effectively evaluate possible impacts of its products and operations on society.

TQM programmes cannot achieve the desired results unless everybody right from top to bottom are involved. The analysis reveals that inspite of weaknesses the overall quality scenario in the automobile sector is improving. More and more organisations are

focusing on TQM as a strategy to survive and grow. But as far as overall improvement and customer satisfaction is concerned the automobile sector has a long way to go.

Organisations have to develop better methods for identifying poor quality and eliminate the associated cost of poor quality. In fact, organisations will more than double their profits without capital investment. Cycle-time reduction, zero rejection, zero breakdown and zero accident should be the aim.

Organisations have to continuously benchmark their quality performance against those of their competitors and leading organisations in other industries.

The limitation of this study has been low response rate of 13.71 per cent i.e. analysis and interpretation of findings are based on the response received from 48 automobile organisations out of 350. Statistically, it may appear to be just about adequate with a 10 per cent response. However to overcome low response limitation, the sample sise was randomly selected to represent the automobile sector fairly well and was followed up by a series of detailed discussions with the practicing managers and chief executives to understand the status more objectively and to avoid contradictions in the findings.

Concluding Remarks

Before liberalisation the growth of the Automobile sector in India was relatively slow. A dramatic change in the scenario was witnessed in the year 1983 when Maruti was taken over by the Government of India; Maruti entered into a joint venture agreement with Suzuki of Japan, and thus began the revolution in the Indian Automobile sector.

The policy of economic liberalisation initiated by the Government of India in the year 1991, gave a further impetus to the growth of the Auto sector. Major car manufacturers such as General Motors, Hyundai, Fiat and Honda set up their manufacturing bases in India.

With liberalisation, the Automobile sector is realising the competition ahead and feels the necessity of improving quality for survival and growth. In fact, the actual TQM activities started in the automobile sector after liberalisation. Since TQM philosophy is founded on continuous improvement, team work, cultural change and customer satisfaction and it fortifies an organisation's competitive stance while it also cuts product cost through reduced waste, enhanced productivity and elevated employee morale. TQM practices assume a vital role for survival and growth of any organisation.

Though there has been a steady growth in the Automobile sector India is still a player of no consequence in the world auto market production. Though there is greater system emphasis, more market orientation / customer focus, continuous improvement culture but the analysis shows no significant progress. Since the growth of automobiles in any country is an indication of the overall economy, a lot to be done by the automobile sector in implementing TQM philosophy. Various National Quality award models can help in achieving the same.

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Feature

Quality Function Deployment in an Educational Institution

S.S. Mahapatra

Now-a-days, the service organisations are widely adopting the principles of Total Quality Management (TQM) with a view to improve the service quality and productivity at various levels in the organisation. The change in the mindset and attitude of the people involved in the quest for improvement plays a vital role for organisation-wide improvement. Although, manufacturing organisations have accepted TQM principles as a competitive weapon, the implementation level in service organisations is not encouraging. In this paper, an attempt has been made to define the customers in an educational setting and to apply Quality Function Deployment (QFD), an important tool of TQM, for collecting the voice of customer.

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Total Quality Management (TQM) has become a way of life not only in production but also in the service departments of manufacturing organisations. Although, the growth rate of buyers of services is increasing as much as the manufactured products, the level of TQM implementation in service organisations is not encouraging. The services the customer wants to buy, range from medical assistance, specialized education and urban transit through mail-order supplies, fast food restaurants and recreational facilities. With reference to the education establishments, particularly technical institutions, play a vital role in educating the students on TQM principles as well as on implementing these concepts for their own survival and improvement. Many institutions and universities in the west have implemented or are implementing either quality improvement practices in their administrations or quality related courses in their curricula or both (Rubach, 1994). The measurement of customer satisfaction is regarded as one of the greatest challenges by educators as educational institutions deal with multiple levels of customers (Cloutier and Richards, 1994). A particular strait for educators is the role of the students as customers, who should be heard, yet they are not fully formed skilled adults, capable of judging whether their education is being properly imparted and delivered.

The purpose of this paper is to demonstrate how Quality Function Deployment (QFD) can be used to measure customer satisfaction in an educational institution. QFD is nothing but a matrix method of translating the customer attributes into engineering characteristics necessary at the design stage of the product/system. Essentially, the "voice of customers" contains ambiguity and multiplicity of meaning. The objects of adjectives, particularly, are not clearly specific, and are vague in terms of breadth of meaning. "The product designed must be able to last for a long time" and "part size must be small" are examples. The ambiguity concerning the durability of the product designed and the part size come from the adjectives *long* and *small* respectively.

Fuzzy sets (Zadeh, 1988) has become an effective tool to deal with ambiguity in the system. In this work, an approach centered on the application of possibility theory and fuzzy arithmetic has been used to address the ambiguity in QFD operation. However, the methodology can be used in any service organisation.

Review of Literature

Educational establishments require a customer-driven focus as the key to success for any organisation is to provide goods or services that meet or exceed customer requirement in the context of today's business world (Marchese, 1993). Nevertheless, the basic question lies in the identification of customers in an educational setting. Brower treats the students as primary customers and emphasises on building of partnership between faculty and students in a discovery and learning process (Brower, 1994) whereas Marchese is reluctant to define the student as the primary customer (Marchese, 1991). However, there is an all-round feeling that education is too process centred and not sufficiently student-centred (Rhodes, 1992). The student-centred view allows treating the students as customers when they are recipients of services like registration, parking, library or food. But, the customer analogy seems to be inappropriate when applied to students as recipients of education. The student becomes the raw material of a specific process of production. In other words, the educational institutions provide the added value between the suppliers of students and the employers of their students (Ewell, 1993). Since students are both customer and product, they are valuable export to employers and community. It is likely that customers of educational institutions, particularly technical education, include students, alumni, employers, the academic disciplinary community, the professional community, and the economic areas and regions served by the technical institutions. Each will have their own definition of satisfaction, and each definition must be known and effectively addressed.

Quality Function Deployment

Quality Function Deployment (QFD) is a matrix-method, developed by Y.Akao, for converting the voice of customers into engineering characteristics required for the development of a product or service to suit customer requirements. Normally, the customers express their requirements in vague linguistic terms, which are difficult to understand. However, the application of QFD using fuzzy data eases out the process of translating customer attributes into engineering or quality characteristics. The fundamental steps of QFD process are:

(i) To identify the customer.

(ii) To identify what the customer wants; and

(iii) To fulfil what the customers want.

A cross-sectional team consisting of representatives from each of the major work groups within the organisation is formed to guide and implement the QFD process. In identifying the customers, the organisation must objectively determine the group or groups that best describe its current desired customer base and their wants or requirements. These wants are commonly referred to as the "whats" and can be derived through the interview/questionnaire survey. Once the "whats" are established, the QFD team then determines the mechanisms that would satisfy the "whats". These mechanisms are commonly referred to as the "hows". Whereas the "whats" are expressed in customer terms, the "hows" are expressed in technical terms. With the "whats" and "hows" in place, the QFD team then establishes relationships between them. They assign a strength value of very weak, weak, moderate, or strong to each relationship. Furthermore, the team will also assess each "how" with respect to its interaction with the other "hows" to determine if there is positive, negative, or no correlation. The QFD team incorporates all this information on a graphical display known as the "House of Quality". This house provides a framework that guides the team through the QFD process. It is a matrix that identifies the "whats", the "hows", the relationship between them, and criteria for deciding which of the "hows" will provide the greatest customer satisfaction. The peak of the house identifies the inter-relationships between the "hows". Sometimes organisations need to carry this process further by using multiple houses of quality. In such cases, the "hows" of the first house become the "whats" of the second house, and the process repeats itself. When the house of quality is complete, the QFD team can then analyze and use it to achieve a product/service realization that will allow the organisation to enjoy greater customer and employee satisfaction, improved product performance, and enhanced profitability.

The QFD team incorporates all this information on a graphical display known as the "House of Quality".

The Case Study

As technical educational establishments are mushrooming these days, the institutions must strive to impart quality education to have competitive edge over

	is essential.
Capability to attract Companies for Campus Interview	It includes better Hospitality for the Interviewers, Emphasis on Software Training, Rigorous Practical Training, Industrial Visits, Industry Based Project Works, Mastery of in Core Subjects, Knowledge of state-of-the-art Technology, Development of Managerial and Communication Skills, Concept of Team-work, General Knowledge and Etiquette.

A house of quality is formed as shown in Fig. 1. and various entries in it are obtained from the selected group of students through questionnaire survey. The following cases are considered in this study.

Case I: Crisp Approach

The initial ratings for various customer needs and rating scale are as follows:

others for their own survival. Recently, the government funding to academic institutions has largely diminished. The institutions are advised to generate funds from various sources for meeting their expenses towards infrastructure development and recurring expenditures. The ways the institutions can be self-supporting is through the development of methodologies for improving the quality of education/research and establishing a brand of their own. Sometimes, the apathetic attitude of the administration to meet the requirements of the students and faculty gives rise to dissatisfaction among them. This results in failure to achieve the institutional objectives resulting in loss of "Credibility of the Or-

- Specific Problems associated with imparting Quality Education.
- Policies need to be formulated to alleviate the identified limitations.

The students and faculty are highly dissatisfied with the prevalent academic activities and the facilities.

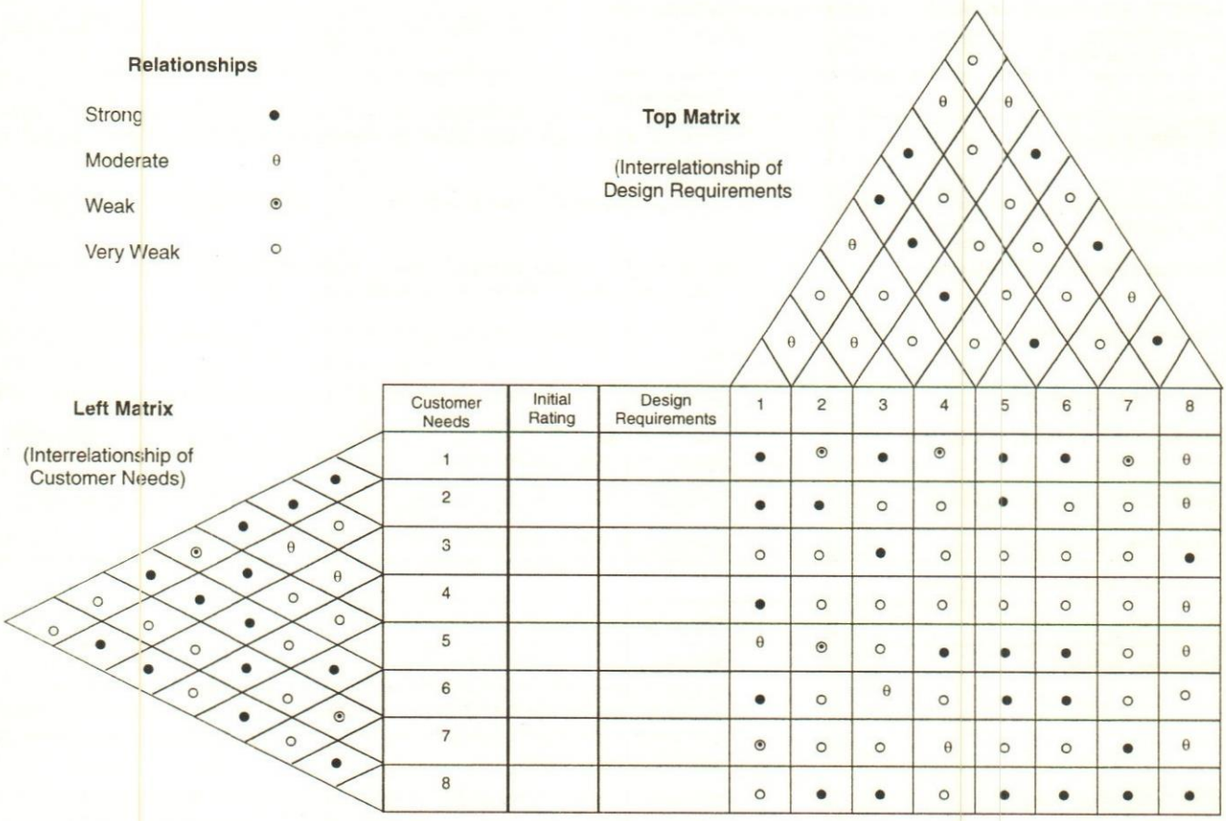

Fig. 1. The House of Quality

Rating Scale		Customer Needs	Initial Rating
Strong	0.8	1	10
Moderate	0.6	2	8
Weak	0.4	3	6
Very Weak	0.2	4	6
		5	6
		6	7
		7	6
		8	7

Case II: Fuzzy Approach with uncertainty level 0.1 for initial rating

The initial ratings are obtained by varying at 0.1 around the mean as mentioned in Case I. A similar method is adopted for assigning fuzzy intervals of linguistic variables of rating scale.

Rating Scale		Customer Needs	Initial Rating
Strong	[0.7, 0.9]	1	[9.9,10.1]
Moderate	[0.5, 0.7]	2	[7.9, 8.1]
Weak	[0.3, 0.5]	3	[5.9, 6.1]
Very Weak	[0.1, 0.3]	4	[5.9, 6.1]
		5	[5.9, 6.1]
		6	[6.9, 7.1]
		7	[5.9, 6.1]
		8	[6.9, 7.1]

Case III: Fuzzy Approach with uncertainty level 0.5 for initial rating

The uncertainty level is maintained at 0.5 around the mean for initial ratings given in Case I. The rating scale is same as in Case II.

Case IV: Fuzzy Approach with uncertainity level 0.15 for rating scale

The rating scale is obtained by varying at 0.15 around the mean as mentioned in Case I. The initial rating is same as in Case II.

First, the revised customer ratings for the attributes/needs are determined from the left correlation matrix of Fig. 1.

$$\text{Customer Rating} = Z_i + \left[\frac{1}{(n-1)}\right] * \sum_{j \neq i}^{n} B_{ij} Z_j \qquad \ldots(4)$$

where B_{ij} denote the relationship between customer needs i and j expressed as interval of symmetric TFN $[\beta_{1ij}, \beta_{2ij}]$ and Z_i the initial customer rating.

The revised rating for the second customer need is calculated as follows;

For Case I, the revised rating for the second customer need is calculated as follows when the initial rating is 8,

$$\text{Revised Rating} = 8 + \frac{1}{(8-1)} * [10 * 0.8 + 6 * 0.2 + 6 * 0.6 + 6 * 0.8 + 7 * 0.8 + 6 * 0.2 + 7 * 0.8] = 12.28572$$

For Case II, the revised rating for the second customer need is calculated as follows when the initial rating is [7.9, 8.1]

$$\text{Revised Rating} = [7.9, 8.1] \oplus \left(\frac{1}{(8-1)}\right) \otimes (\{[9.9,10.1] \oplus [0.7,0.9]\} \otimes \{[5.9,6.1] \oplus [0.1,0.3]\} \otimes \{[5.9,6.1] \oplus [0.5,0.7]\} \otimes \{[5.9,6.1] \oplus [0.7,0.9]\} \otimes \{[6.9,7.1] \oplus [0.7,0.9]\} \otimes \{[5.9,6.1] \oplus [0.1,0.3]\} \otimes \{[6.9,7.1] \oplus [0.7,0.9]\}) = [11.45000, 13.14143]$$

The individual rating of each Design Requirement is obtained using the following relation.

$$\text{Individual Rating}_i = \left(\frac{1}{n}\right) \otimes \left(\sum_{j}^{n} A_{ij} X_j\right) \qquad \ldots(5)$$

Where A_{ij} and X_j denote the relative importance of the i^{th} characteristic with respect to the j^{th} customer need in the relationship matrix and the importance of the j^{th} customer need perceived by customer i.e. customer rating and n is the number of customer needs. A_{ij} and X_j are expressed as TFNs.

For Case I, Individual Rating of design requirement$_1$ =

$$\left(\frac{1}{8}\right) * (13.80000 * 0.8 + 12.28572 * 0.8 + 9.82857 * 0.2 + 9.60000 * 0.8 + 9.94286 * 0.6 + 11.14286 * 0.8 + 9.08571 * 0.4 + 10.62857 * 0.2) = 6.39429$$

For Case II, Individual Rating of design requirement$_1$ =

$$\left(\frac{1}{8}\right) \otimes (\{[12.99571,14.62429] \otimes [0.7,0.9]\} \oplus \{[11.45000,13.14143] \otimes [0.7,0.9]\} \oplus \{[8.97286,10.70429] \otimes [0.1,0.3]\} \oplus \{[8.74714,10.47286] \otimes [0.7,0.9]\} \oplus \{8.74714,10.47286] \otimes [0.5,0.7]\} \oplus \{[10.29571,12.01000] \otimes [0.7,0.9]\} \oplus \{[7.89857,9.60714] \otimes [0.3,0.5]\} \oplus \{[9.78429,11.49286] \otimes [0.1,0.3]\}) = [4.88261, 8.00218]$$

Then revised rating for each design requirement is calculated in a similar fashion as it is calculated for customer needs using Equation 4. The final ratings of design requirements are normalized by dividing each rating with the maximum available rating.

The normalised refined ratings are obtained in fuzzy intervals for Cases II, III. & IV. The fuzzy intervals are defuzzified using the strategy proposed by Mabuchi (Mabuchi, 1993) so as to obtain the crisp values for ranking purpose.

For defuzzifying an interval $[x_L, x_R]$, consider Z as the distance from the true defuzzified value x^*, then

$$Z(x ; x^*) = \left|x - x*\right|$$

Defuzzification $\hat{x}$ is such that

$$\underset{\hat{x},\, x^* \in [x_L, x_R]}{\text{min. max.}} \left|\hat{x} - x^*\right| = \underset{\hat{x},\, \in [x_L, x_R]}{\text{min.}} \left[(\hat{x} - x_L) \vee (x_R - \hat{x})\right] \qquad \ldots(6)$$

This leads to Defuzzification

$$\hat{x} = \frac{1}{2}(x_L + x_R) \qquad \ldots(7)$$

The final ratings are tabulated in Table 2. Using the normalized ratings, the design requirements are prioritized as per the importance of design requirements. These are shown in Table. 3. The numbers shown in the bracket are the defuzzified values of the fuzzy intervals obtained using Equation 7.

As mentioned earlier, four cases have been considered in this work. In Case I, crisp numbers are used whereas in other cases fuzzy numbers are used to reflect the imprecision involved in making judgements. Using fuzzy approach, the ambiguity of assigning crisp rating values can be avoided. Case II can be treated as the base

Table. 2: Refined Ratings of Design Requirements

Case I			Case II		
The Customer Rating	The Design Requirements	The Refined Ratings	The Customer Rating	The Design Requirements	The Refined Ratings
113.80000	6.39429	9.23092	[12.99571, 14.62429]	[4.88261, 8.00218]	[6.54063, 12.30545]
9.82857	4.93929	7.39094	[8.97286, 10.70429]	[3.55750, 6.46621]	[4.97661, 10.26955]
9.60000	4.42286	5.89173	[8.74714, 10.47286]	[3.01804, 5.88661]	[3.69974, 8.44800]
9.94286	6.49286	9.92031	[8.74714, 10.47286]	[4.98161, 8.10032]	[7.11941, 13.15914]
11.14286	5.57143	8.11402	[10.29571, 12.01000]	[4.12286, 7.11471]	[5.63441, 11.00645]
9.08571	4.32643	6.34902	[7.89857, 9.60714]	[2.63725, 5.41782]	[3.74310, 8.68935]
10.62857	6.42786	9.39859	[9.78429, 11.49286]	[4.88486, 8.05043]	[6.63287, 12.52102]
Case III			Case IV		
The Customer Rating	The Design Requirements	The Refined Ratings	The Customer Rating	The Design Requirements	The Refined Ratings
[12.40714, 15.29286]	[4.61018, 8.44232]	[6.17447, 12.98463]	[12.67214, 14.95786]	[4.24398, 8.83677]	[5.54989, 14.02888]
[10.85000, 13.82143]	[2.94857, 6.27214]	[4.44855, 10.58135]	[11.11214, 13.48929]	[2.54386, 6.71736]	[3.73991, 11.64601]
[8.40714, 11.35000]	[3.35507, 6.82536]	[4.69497, 10.83978]	[8.62071, 11.06643]	[2.96146, 7.25696]	[4.00920, 11.87699]
[8.19286, 11.10714]	[2.83732, 6.22304]	[3.48075, 8.92615]	[8.39500, 10.83500]	[2.42920, 6.66991]	[2.84247, 9.91216]
[8.19286, 11.10714]	[4.70661, 8.54304]	[6.72353, 13.88286]	[8.39500, 10.83500]	[4.34352, 8.93437]	[6.00024, 14.95520]
[9.70714, 12.67857]	[3.89286, 7.50643]	[5.31929, 11.61393]	[9.95071, 12.36500]	[3.51011, 7.92268]	[4.65129, 12.62886]
[7.37857, 10.20714]	[2.48339, 5.72339]	[3.52628, 9.17680]	[7.54643, 9.96929]	[2.06655, 6.18248]	[2.84553, 10.21154]
[9.20714, 12.15000]	[4.60143, 8.50357]	[6.25110, 13.22174]	[9.43929, 11.84786]	[4.23636, 8.89514]	[5.54342, 14.27550]

Table 3: Ranking of Design Requirements

The Design Requirements	The Normalised Refined Ratings				Ranks
	Case I	Case II	Case III	Case IV	
Motivated faculties	0.93051	[0.49704,0.93513] (0.71608)	[0.44475,0.93530] (0.69003)	[0.37110,0.93806] (0.65458)	3
Fast Computing, Networking & E-mail Facilities	0.72010	[0.35807,0.76201] (0.56004)	[0.32043,0.76219] (0.54131)	[0.25007,0.77873] (0.51440)	6
Industry Institute Interaction	0.74503	[0.37819,0.78041] (0.57930)	[0.33818,0.78080] (0.55949)	[0.26808,0.79417] (0.53113)	5
Visual Teaching Aids & Computer Simulation Packages	0.59391	[0.28115,0.64199] (0.46157)	[0.25072,0.64296] (0.44684)	[0.19007,0.66279] (0.42643)	8
Opportunity for Knowledge Upgradation	1.00000	[0.54102,1.00000] (0.77051)	[0.48430,1.00000] (0.74215)	[0.40121,1.00000] (0.70061)	1
Library Modernisation	0.81792	[0.42817,0.83641](0.63229)	[0.38315,0.83657] (0.60986)	[0.31101,0.84445] (0.57773)	4
Firm Policy on Academic Indiscipline	0.64000	[0.28445,0.66033] (0.47239)	[0.25400,0.66102] (0.45751)	[0.19027,0.68281] (0.436554)	7
Capability to Attract Companies for Campus Interviews	0.94741	[0.50405,0.95151] (0.72778)	[0.45027,0.95238] (0.70133)	[0.37067,0.95455] (0.66261)	2

results for the fuzzy approach where the uncertainty level is fixed at ±0.1 both for the initial ratings and rating scale. In Case III, the uncertainty level is changed to ±0.5 for the initial ratings whereas in Case IV the uncertainty level of rating scale is changed to ±0.15. From Table 3, it is observed that the rankings of design requirements for all the four cases remains the same. Results show that the variations in uncertainty have no effect on the trend exhibited. This is logical and demonstrates the robustness of the method used in this work. It is further observed in Table 3, that crisp approach (Case I) tends to produce ratings that are close to the upper limits of the ranges

registered by the fuzzy approach. This might not be desirable, as the ratings would be inflated through the normalisation process and possibly affect the selection of critical design requirements. The ratings generated by the fuzzy approach, however, are expressed in terms of ranges of values. This would provide an overall picture about the design requirement concerned and could ensure that the decision made in the subsequent selection process would not be biased. As an example, the design requirement, "Fast Computing, Networking & E-mail Facilities" has a rating of 0.35807-0.76201. Qualitatively, this suggests that it is moderately important but far from being a critical requirement. However, a crisp rating of 0.72010 generated by the crisp approach may imply differently.

The ratings generated by the fuzzy approach are expressed in terms of ranges of values.

Conclusion

The factors that need to be considered while formulating organisation-wide policies are listed in the following in consultation with the management.

Enhancing the Knowledge of the Individuals

It includes up-gradation of knowledge about the state-of-art technology, development of general knowledge, exposing to the students the facilities available and intensifying their urge to know more.

Thrilling the Guests

Proper treatment to guests, particularly, the interviewers, have a great impact on them and helps in enhancing the campus selection statistics.

All Round Development of the Individuals

Cultural activities, sports events, technical seminars etc. create a sense of versatility and help in all-round development of individuals. These may help to develop communication skills, presentation skills, sporting ability etc. of the students.

Faculty Promotions

Promotions and recognition to deserving faculty motivates them to strive for excellence. Therefore, the promotion policies need to be reviewed.

Recommendations of the Library Advisory Board

Many a change, are required for proper functioning of a library and hence a recommendation of the library advisory board is necessary.

Developing Partnership with Industries

It helps to provide the students with practical oriented teaching, practical training and above all, a good partnership with industry results in more campus selection. Even projects can be taken up by students to solve industrial problems. The areas of partnership in testing, consultancy and training need to be evolved and reserved for fund generation.

Continuous improvements in TQM must be incorporated in an organisation to succeed in today's competitive environment. QFD serves as a powerful process, which is highly successful in eliciting the strengths and areas that require attention. The steps for improvements, thus concluded, should be practised for overall improvement of the Education (Technical) setting.

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Feature

Quality Management Practices in Indian Industries

Raj Kumar & Dixit Garg

Quality has changed its connotations from safety, prompt delivery, and value for customers' money to total quality, which also encompasses product design, customer delight and environmental protection. Total Quality Management (TQM) concepts are being implemented and practiced in world-class companies. This study has considered six main factors which have a vital role in TQM implementation and also examined a variety of industries to see the importance of TQM at each level. The present study is expected to be beneficial for respondent companies and numerous other companies who are in the process of TQM implementation.

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Customers are to decide the destinies of organisations in the present age. A globally competitive environment has made organisations realize the value and importance of customer satisfaction. Definition of quality evolved, according to Murthy (2000), from focus on 'conformance to specifications' to focus on 'customers delight', and beyond. The hottest quality buzzword now days is 'the quality is not an accident'. It is the effort of scientific management and ingenuity of skill. Quality system not only provides customers consistently high quality products/services, but also a driver for efficiency and effectiveness of all aspects of organisation. Campbell et al, (2000) describes it as rebuilding the thought patterns of an organisation and it requires great determination and farsightedness on the part of the 'Top Team'. Of late, Indian companies have also realized that the desired improvement in quality can be achieved if they understand not only what the various quality opinions are, abut also the time when a particular approach should be applied. Under the banner of quality, Total Quality Management (TQM) can be described, as the art of continuous improvement with customers' requirements, the measurement of standard. Continuous improvement of work process is the method of facing the competition.

TQM is a progressive process by which considerable growth and reliance on the role of quality can take place. It is a way of creating a discipline in a business organisation both internally and externally. Its tools and techniques help in measuring performance of process. TQM cultivates the culture of necessary improvements to achieve better results and doing everything right first time and every time. The Indian companies have to un-

TQM is highly beneficial but very tough to implement.

derstand the fact that TQM is highly beneficial but very tough to implement. The study deals with the current status of TQM practices and their implementation in Indian Industries.

Literature Review

The development of quality activities has spanned the entire 20th century. Curiously, significant changes in the approach to quality activities have occurred almost every 20 years. Quality activities have traversed a long path from operator inspection (1900s) to verification of quality by superior (1920s) to establishment of quality control departments and 100 per cent inspection (1940s) to statistical quality control (1960s) to Total Quality Management and Statistical problem solving (1990s). The TQM gurus were charismatic individuals whose concepts and approaches to quality in business and life in general, have made a major and lasting impact (Ghobadian et al, 2001).

Many different slogans, catch words and acronyms are used to refer to the philosophy of TQM, including employee involvement, continuous process improvement, Just-In-Time, quality circles, empowerment, Kaizen, Self directed work groups and world class quality (Rao et al, 1994).

Relevant Past Studies Outside India

More than a decade ago, an empirical study based upon a question "what is really gong on in quality control?" was carried out (Chaudhry, 2000). The students of a production and operations management course contacted companies in New York to ask a set of quality-related questions. The study found that the firms did have a formal quality improvement process but the firms failed to use the reports generated. Again a study was carried out but now in Japan that is known as synonymous with the word quality (Olikar, 1992). The study reveals that quality is an issue that is now taken for granted by both producers and consumers. Quality is equally important in service and manufacturing and the major focus is customers' satisfaction.

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HO (1999) reveals TQM as business excellence. He develops a TQMEX (Total Quality Management Excellence) model that can be used as a process/system for achieving quality awards. This TQMEX model is a step-by-step guide for the companies who want to achieve TQM. Various steps to achieve TQM are Japanese 5-S practice, Business Process Re-engineering, Quality Control Circle, ISO-9000 & Total productive Maintenance. In recent years increasing number of organisations in both developed and developing countries have started implementing different forms of TQM towards maintaining customer satisfaction, increasing productivity through waste reduction and improving the reliability of all work processes. Different forms of TQM are Customers Satisfaction, Employee Involvement, Continuous Process Improvement, Supplier Partnership and Performance measures. Ways to achieve these various tools and techniques are: statistical process control, ISO 9000 Series, Bench marking, Quality function deployment, Quality by design, Taguchi's Quality Engineering, Failure mode and Effect analysis (FMEA), Total productive maintenance and management tools (Nirmala et al, 1998).

Japanese describe a state development process in going from traditional management to participative management.

A case study was carried out in England in a sister concern of Ford Motor Company (European Division) to measure how TQM is helpful to achieve Quality-1 rating from Ford Motor company (Olikar, 1992). One of the key out growths of TQM principles is the involvement of employees in the decision making process and now a days this is defined as employee empowerment. It requires a commitment on the part of management to open up the process to employees. It is very difficult to switch from traditional, top-down management style to a style of total participative management. Silos (1999) suggested three systems to aid in successful implementation but this was not sufficient so the Japanese describe a state development process in going from traditional management to participative management. The three state are Commitment of management, Education and training of workers, Focus on economic and business benefits.

A case study with the question "Do employee involvement teams make a measurable difference in solving problems than traditional management intervention". The outcome of the study showed that the results of the employee involvement team were

measurably greater than the results of traditional management intervention in solving the problems (Silos 1999). This study which was carried out to show the importance of employee involvement is not only one example but there are several studies in the past which were carried out on the same theme, out of those some were:

1. During World War II by General Motor.
2. In 1990 by New York City Department of Parks and Recreation.
3. By Spring Field Remanufacturing Corporation.
4. In 1986, by Internal Revenue Service.

From the above discussion we can see the importance of employee involvement but cannot conclude that employee involvement is every thing because it is just a practice in TQM.

About 75 per cent to 80 per cent US companies are practicing TQM for managing quality. Regarding this, a survey has been conducted to see the extent to which they used quality management practice. This survey Kanna (2000) was sent to about 1465 quality directors and vice-presidents of US Companies, which included automotive, chemical, computer, electronics, pharmaceutical, semiconductor and tele-communication industries. Response rate was 21.5 per cent and results show that the strongest part is management commitment to quality strategy. The functioning of active quality departments indicate that organisations are providing training in quality awareness and also providing training to use various quality control techniques. Another work by Rao (1994) shows that companies which are using TQM achieve higher customer satisfaction but more stress on work culture, continuous quality improvement depends upon the best use of the talents and abilities of a companies' work force by empowering the workers and providing them with the best work culture through training, employee participation and involvement.

Mahapatra (2001) is credited with initiating the Quality function deployment (QFD) system. The first application of QFD was at Mitsubishi, Heavy Industries Ltd. in the Kobe Shipyard, Japan, in 1972. Again in 1977, Toyota successfully implemented it in production of minivans. QFD is in fact a planning tool used to fulfill customers' expectations or requirements.

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Relevant Past studies in India

One of the biggest challenges witnessed by the Indian industries the in post liberalisation era has been the increasing customer demand to deliver value at competitive cost. Quality is no longer an isolated and independent function confined to the domain of the quality professional only. It has spread from the corporate boardroom to become an essential requirement of all business processes and activities from concept to after market (Arya, 2000). Although it is a widely acknowledged philosophy and culture for improving the organisational performance, only a few Indian organisations are ready to implement it. Nirmala (1998) revealed that workers and managers, including the top management, are the crucial elements in impacting the change. In case of Indian workers it was found that workers are linked tightly with their deep-rooted psyche of helplessness, personalised relations and family centredness. On the other hand, Japanese workers work with dedication, harmony, group thinking decision process, pride of belongingness to the company, high level motivation and high level of literacy.

Hierarchy boundedness among the Indian managers is yet another roadblock for bringing about culture change.

At managerial level, hierarchy boundedness among the Indian managers is yet another roadblock for bringing about culture change in the organisation (Nirmala, 1998). To implement TQM at this level (managerial), a high degree of commitment is required with the help of which they are able to change the mind setup of workers, and can align structures and systems with TQM culture. Total customer satisfaction is possible, provided various members of the organisations support each other and everybody is involved in the process, bringing in continuous improvement in their work. An approach of this kind merely leads to TQM. In this context, empowerment of individuals, teams and organisations has become extremely important. In order to create empowerment three conditions are necessary:

1. Every one must understand the need for change.
2. The system needs to change to a new paradigm.
3. The organisation must enable its employees for quick and effective decision making.

Murthy (2000) studied the cases of three Indian Companies in order to know how Indian companies rejuvenated themselves with organisational restructuring and employee empowerment. They concluded that TQM couldn't be implemented without empowerment of individuals, teams and organisations.

Quality circle is simple, with cheap and best techniques for bringing incremental improvement in the organisations.

Certain Indian Industries have taken into account factors which can influence implementation of TQM such as Quality circle, quality control techniques, System tools like Kaizen, BPR, QS 9000 and ERP. Quality circle is simple, with cheap and best techniques for bringing incremental improvement in the organisations. It arrived in India about two decades back and has still not lost its relevance in industries (Patnaik and Kumar, 2000). Quality circle refers to a small group of people who meet together regularly and voluntarily to identify and solve problems pertaining to quality, performance and enrichment of their work life. A few points to the success of a quality control programme are:

1. Quality control must work on the right problems.
2. Employees should be motivated to contribute their talents.
3. The participants must have the necessary problems solving skills.

A case study was conducted (2000) in the Dye house of a Spinning hill of West Bengal and in this a Quality circle under study consisted of a leader and ten workmen. In the first meeting they identified the problems. In the second meeting they discussed the problem in detail and then using Pareto Technique found that the reason for low productivity was machine stoppage. Then the Quality Circle team found the reasons responsible for machine stoppage and made cause and effect diagrams which clearly elaborated the various reasons. Next step in this field by Quality Circle is data collection regarding reasons and then expanding the various reasons one by one and finding out solutions. When Quality Circle team finds the root cause of the problem, they submit recommendations and suggestions which solve the problems one by one and move the industry towards increasing profits and improves productivity (Das, 2000).

Many electrical and electronics industries in India are also praticising TQM to satisfy customers and to meet their daily needs. Due to increasing quality awareness among customers, quality has become the qualifying factor. Keeping this under consideration, a case study has been conducted in an electrical company that is one of the top five in India in the electrical equipment manufacturing sector. The theme of the case study was how to overcome problems like loose fasteners, riveting, etc. which were identified by verification after testing and then using quality techniques like Taguchi and Ishikawa diagrams the solutions were find out which approximately affected 40 per cent of Quality (Kannan et al, 2000). Another case study was carried out in an electronic industry to find out supplier buyer relationship and suppliers' internal practices to improve quality. These types of studies help us to know better what is going on for Quality in Indian Industries. Quality management practices are also going on in small and medium scale industries in India. There are many approaches but the commonly used approach is ISO 9000 series registration that is playing a catalytic role in Indian Industries (Sohrab, 2001). A general survey shows that while nearly 77 per cent of companies have a quality control department, 62 per cent of them are using traditional quality control approaches for managing quality.

Nearly 77 per cent of companies have a quality control department, 62 per cent of them are using traditional quality control approaches.

A survey has been carried out to see how Indian industries understand TQM and how they are implementing it. As it is too costly and time consuming to collect information from each industry a structured questionnaire survey followed by personal interviews were used for data collection. The questionnaire was divided into three sections:

1. The companies' introduction and brief background i.e. product manufactured, strength of employees, mission statement, annual turnover and net profit.
2. Importance of various factors in TQM implementation.
3. Detailed questioning on top management commitment, continuous improvement, customer focus and satisfaction, statistical process control, education and training and recognition and rewards. The industries chosen for study were from various fields such as automobile, poly product, electronics, rubber, milk products and

technical institutions. The questionnaire was sent to 25 industries and response was received from 13 industries. Details of introduction were given in Table 1, which shows that all industries are taking ISO seriously.

Table 1: ISO Certification, N = 13

Industrial	Number of Respondents	ISO Certified	Percentage
Automobile	4	4	100
Poly Products	3	2	67
Electronics	3	3	100
Institutions	3	2	67

Table 2 indicates 77 per cent industries are implementing TQM vigorously and 24 per cent (apx.) are taking it moderately. There are many factors that play a vital role during TQM implementation. It was found that there are six main factors which industries feel can put tremendous effect on TQM implementation. Total 37 factors were identified and a question was asked in the form of 'very important', 'average' and 'not so important'. It was observed that none of the 37 factors is marked as 'not so important' by any industry. Top management leadership and commitment, continuous improvement, customer focus and satisfaction, ISO 9000 certification, SPC, education and training, recognition and rewards, house keeping, vendor development etc. were taken as very important, and seven quality control tools, employee empowerment, team work, quality circles, bench marking, working environment, quality process planning, Taguchi method, design of experience etc are taken as important factors and a few like total employee involvement, JIT, waste elimination QFD etc are taken as average factors. On the basis of this, six main factors were chosen for detailed study.

Table 2: Extent of TQM Implementation, N = 13

Extent	Number of Respondents	Percentage
Vigorously	10	76.923
Moderately	3	23.077
Rarely	–	–

Factor - 1: Top Management Leadership and Commitment

Without genuine commitment from organisation's top management, TQM cannot succeed. The behaviour and action of managers at all levels provide the necessary leadership, set the power tone and demonstrate the examples for successful implementation of Total Quality. It is the management's leadership and commitment to Total Quality that lays the foundation upon which pillars of TQM strategy can be built. It has been observed that most of the respondent companies have treated top management leadership and commitment as the foundation for their TQM implementation programmes.

Respondent companies have treated top management leadership and commitment as the foundation for their TQM implementation programmes.

The top management of Indian Companies proclaim a vision for their companies. The staff in these companies are excited and motivated. Commitment and willing co-operation, praise, encouragement, developing team work, creating the conditions for excellence, are all examples of sound leadership in these companies. The top management in its leadership style encourages staff to adopt a preparedness to innovate, experiment and improve.

Table 3: Percentage of various industries that feels vigorously Top Management Leadership and Commitment will help in TQM implementation. N = 13

Industry	Vigorously	Moderately	Rarely	Percentage Vigorously
Autombile	3	1	–	75
Poly Products	2	1	–	67
Electronics	3	–	–	100
Institutions	2	1	–	67

Table 4: Percentage of various industries feels vigorously that continuous improvement will help in TQM implementation

Industry	Vigorously	Moderately	Rarely	Percentage Vigorously
Automobile	3	1	–	75
Poly Products (3)	2	–	–	100
Electronics (3)	2	1	–	64
Institutions (2)	1	2	–	34

One of the distinguishing features of the Indian companies dedicated to TQM is the positive atmosphere that pervades the organisation. To practice TQM, the top management believes in delegating as much of the decision-making as possible to its employees. Employees are able to take responsibility for their jobs and are involved in the decision-making process. Com-

munications are free flowing, suggestions and innovations are frequent, data collected from sample companies show that about 77 per cent companies consider top management leadership and commitment very important for successful implementation of TQM.

Factor - 2: Continuous Improvement (KAIZEN)

KAIZEN is a Japanese word used for describing the philosophy of continuous improvement. The philosophy defines management's role in continuously encouraging and implementing small improvement involving total employees. It is a system of small but continuous improvement that makes the process more efficient, effective, under control and adaptable to local conditions.

Table 5: Percentage of the respondent industries feels vigorously that customer focus satisfaction will help in TQM implementation

Industry	Vigorously	Moderately	Rarely	Percentage Vigorously
Automobile (4)	4	–	–	100
Poly Products (3)	3	–	–	100
Electronics (3)	3	–	–	100
Institutions (3)	1	2	–	67

Table 6: Percentage of the respondent industries feels vigorously that education and training will help in TQM implementation

Industry	Vigorously	Moderately	Rarely	Percentage Vigorously
Automobile (4)	4	–	–	100
Poly Products (3)	3	–	–	100
Electronics (3)	3	–	–	67
institutions (3)	1	2	–	34

In Kaizen, a complex process is first broken down into simple sub-processes and then each simple subprocess is examined for improving and innovating. The improvement under Kaizen involves very little expense because of the involvement of local employees and resources. About 69 per cent feel that their Kaizen philosophy is working vigorously and rest feels that it is working moderately. But simultaneously it is observed that the interest of institutions is less towards continuous improvement.

Factor - 3: Customer focus and Satisfaction

Customer is the basis for existence and growth of any organisation. Broadly, there are two types of customers viz. external and internal. Both internal and external customers are important for quality improvement.

External customers are ultimate users of the product or services provided by the organisations. Internal customers are people (workers-employees) within the organisation. For the satisfaction of external customers, it is necessary to satisfy the internal customer at every stage.

It is highly appreciable to note that (85%) of all the respondent companies consider customer focus and satisfaction as their most important goal. They feel increased customer satisfaction and retention and attraction of new customers as the major mission of their organisation.

Factor - 4: Education and Training

The new demands for quality, changing job patterns and advances in technology have created new needs for education and training. Today quality is considered vital to improve productivity and to sustain competitiveness. Making employees conscious of quality related areas is the first challenge that many Indian companies face as they strive hard to be world class and global producers. The quality of improvement depends upon the environment, system, education and training, roles, responsibilities and cost of quality. All quality gurus in their teaching emphasise education and training to improve quality and productivity.

In Indian industries research has revealed that education is not how much to memorise or even how much to know. It's being able to differentiate between knowing and not knowing. Education and training require practice, patience and desire to learn or achieve. To be educated and trained it requires time, money and energy. Data collected from sample industries indicate high importance to education and training, at about 77 per cent. But its responding institution is comparatively very low i.e. 34 per cent approximately.

Factor - 5: Statistical Process Control

The study of statistics can be of great help in facing problems of quality, productivity and presentation of data in tabular formats and charts to facilitate decision making in uncertainties. For improving productivity and quality in any organisation the key techniques are based on quantitative data. These techniques are called statistical process control. This facilitates decision-making on improvements in the process for better productivity, quality efficiency and cost effectiveness.

In industries statistical data plays an important role in planning, controlling and improving processes. Variations in data for any particular item from standard norms provides managers and supervisors an indication of the item needing attention and they take decisions on priority basis.

Statistical data plays an important role in planning, controlling and improving processes.

Factor - 6: Quality Awards

Discussion with various chief executives, managers and workers at different levels during the course of the study indicates that people get involved in what get recognised and rewarded by their organisation. According to them, recognition and rewards are necessary for employees' effective and continuous involvement, quality focus and creation of TQM culture. Awards motivate people to contribute their best for achieving excellence in quality and high productivity. Recognition and rewards are powerful tools for letting employees know and feel an asset to the organisation.

Table 7: Percentage of the respondent industries feels vigorously that statistical process will help in TQM implementation

Industry	Vigorously	Moderately	Rarely	Percentage Vigorously
Automobile (4)	2	2	–	50
Poly Products (3)	2	1	–	670
Electronics (3)	2	1	–	67
Institutions (3)	–	2	1	00

Table 8: Percentage of the respondent industries feels vigorously that quality awards will help in TQM implementation

Industry	Vigorously	Moderately	Rarely	Percentage Vigorously
Automobile (4)	2	2	–	50
Polk Products (3)	2	1	–	67
Electronics (3)	2	1	–	67
Institutions (3)	1	2	–	34

Data collected in Table 8 clearly shows that all industries feel that awards are important for motivation of employees but discussions with some of the managers suggest that recognition and rewards system should be based on following considerations:

1. Relating rewards to achievement.
2. Frame Certificates.
3. Presentations of rewards by the appropriate level of management.
4. Make mechanism for publicity in family and friends.
5. Vary the method of presenting rewards.
6. Diversify the rewards.
7. Present rewards in appropriate surrounding and occasion.

As the TQM is a continuous process, so industries have to work continuously to achieve the required level of quality.

Table 9: Industries Implementing TQM vigorously

Industry	TML	CI	CFS	ET	SPC	QA	Total	Mean	%
Automobile	3	3	4	4	2	2	18	3	75
Poly. Prod.	2	3	3	3	2	2	15	2.5	83
Electronics	3	2	3	2	2	2	14	2.33	78
Institutions	2	1	1	1	–	1	6	1	33

Conclusion and scope for future work

In the context of globalisation of the Indian economy it can be expected that India will emerge as an economic force by the next decade. Helping the industry in becoming world class, TQM seems to be holding the promise. TQM has therefore to be implemented with a sense of urgency. TQM cannot be implemented without the help of top management commitment and leadership, continuous improvement, customer focus, education and training, quality awards and other such effective factors.

Major findings of the study are:

1. Eighty five per cent of surveyed industries are ISO certified.
2. Seventy six per cent of surveyed industries are implementing TQM vigorously and other 24 per cent are moving moderately.
3. Although the respondent industries adopt varied practices for TQM implementation, majority of these companies consider management leadership and commitment, continuous improvement, customer focus and satisfaction, education and training, statistical process control and quality awards as the major determinants of TQM implementation.

During the course of this study, it has been observed that TQM implementation is an increasingly complex and cumbersome exercise. Since the complete results of TQM implementation are visible after a long time period, the organisations and people involved feel frustrated in view of money, time and energy which is invested in its implementation. The present study has examined six factors to understand TQM implementation. It is advisable to undertake detailed study of other factors like quality circle, total employees' involvement, team work, BPR, JIT, waste elimination, ISO 9000 quality system standards, bench marking, management tools, house keeping, Taguchi method, Total productive maintenance, Six Sigma, 5 S etc.

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Feature

Reduction of Material Waste in a Manufacturing Industry

T.P. Singh & Janpreet Singh Gill

Globalization and liberalization has brought with it immense degree of competition in the manufacturing sector. Manufacturing industry, for its survival and growth, is now trying to do everything possible to reduce the cost of manufacture. At this point, resource waste reduction assumes a great importance. Further, materials being one of the most important resources has a great potential for cost reduction and hence need a special focus. This paper presents a case study of a manufacturing organisation, carried out to identify and reduce material waste existing at various stages of manufacture. Input-output-waste analysis has been used for the purpose. Pareto analysis has been carried out in order to identify critical areas of waste. Root cause analysis of these prominent areas indicates the causes responsible for excessive waste. In order to reduce material waste in the future, suggestions and recommendations have been made as a direct outcome of the exercise of finding out the root causes.

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With globalization business has cut across national boundaries resulting in cut throat competition in the manufacturing sector. Natural resources are becoming scarce and the cost of resources of material, energy, manpower etc. has increased. Industry can no longer dictate the prices of products in direct proportion to the rise in cost. Rather the cost of production has to be brought down to maintain prices in the competitive range. To survive and achieve some growth, industry cannot afford wastage of resources. Appropriate opportunities for reducing wastage of resources need to be found out.

Waste can be defined in many ways. However, two comprehensive definitions of Waste are given below:

> "Waste is any unnecessary input to or any undesirable output from a system". [Sushil, 1990].
>
> "Any cost that does not enhance value is termed as waste". [Robinson & Schroeder, pp. 37-42, 1992].

Scrap produced, useless outcomes of the processes, using costlier materials than required, cost involved in achieving higher standards than required, procuring materials in advance, over production and it's inventory are all examples of waste. The wastage in industry occurs in resources like materials, energy, capital and manpower. Materials constitute the most important resource going into the manufacture of any item. In certain cases, material cost is above 50 per cent [Bindra, 1991] of the total cost of manufacture. So a small fraction of reduction in material waste will result in high monetary savings. Material waste results in great financial loss for industry, not only because of its own cost, but it also causes wastage of energy, manpower, equipment, time etc. which are spent on its transformation from raw material to in-process and finished goods. This study concentrates on the area of material waste in the manufacturing industry.

Material waste in industry occurs in following ways: Use of more expensive material than required, rejected goods (scrap), rework, excessive chips formed, trim loss [Venkateswarlu, 2001], pilferage, spillage, over consumption of indirect materials, damages during handling and movement of materials, damage, deterioration or obsolescence during storage and unrecognized components in storage [Singh, 1994].

Case Study

A case study has been conducted in a leading auto-components manufacturing unit from August to October 2001. The products manufactured in this company find their use as original equipments in most of the engines manufactured in India. The company makes a large variety of products in order to meet the demands of a wide range of engine and automobile manufacturers. The products manufactured in the company are classified into four categories: Product A, Product B, Product C and Product D. They vary from one another with respect to their shape and size. Within each category, there is again a large variation of sizes of products. Bi-metallic strip is used for the manufacture of all these products. Figure-1 shows the flow of material in the industrial unit.

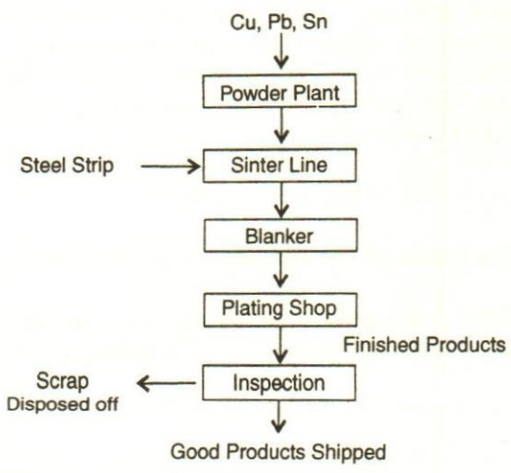

Fig. 1. Material flow

In this case study, the powder plant has not been included for the analysis and the study is confined to Sinter line and the subsequent operations. The system is divided into two sub-systems: (i) Sanding and Sintering. (ii) Auto line and Plating. For both the sub-systems input-output analysis has been carried out independently. Fig. 2 shows the details of the operations done in sinter line.

In Auto-Line blanking is the first operation. After that different sets of operations are carried out. The flow chart of operations done in Auto line is given in Fig. 3.

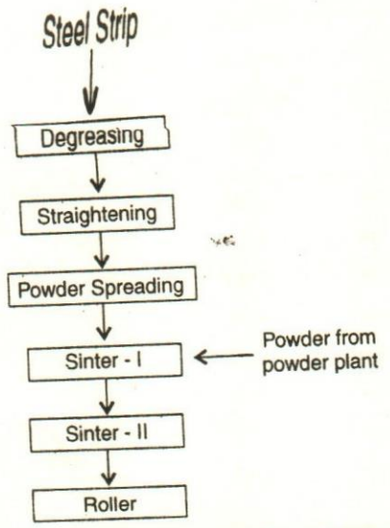

Fig. 2. Detail of the process in sanding and sintering plant

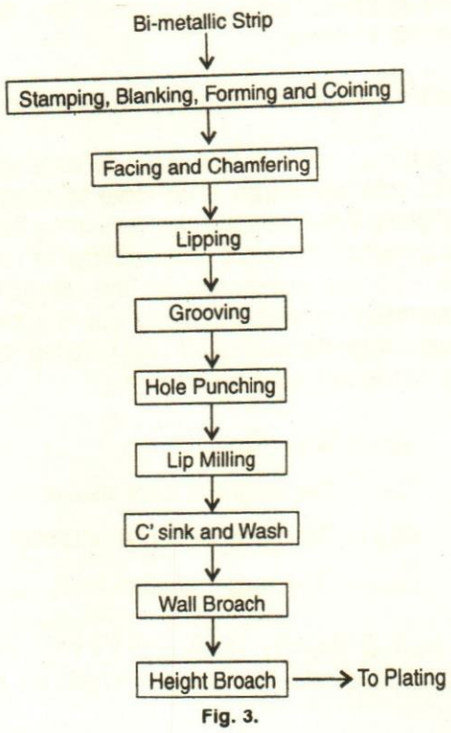

Fig. 3.

The data of inputs and outputs of the major subsystems of the Sinter line and Auto line has been compiled and analysed to find out material waste. Pareto-analysis has been conducted to find out the critical areas contributing towards material waste. A comparison of the actual scrap and the reported scrap has been made. A classification of waste based on various defects has been made and the amount and quantity of scrap due to each type of defect have been worked out. A second round of pareto analysis at this stage reflects the vital areas of scrap and rework. This is followed by a root cause analysis of each vital area of scrap and rework. The causes of waste analysed through the root cause analysis directly point out the remedial measures.

Table 1: Input-Output Analysis for Sanding and Sintering Plant

Steel Coil Code (Steel Type Xt Xw)	Steel Issued (Kg)	Steel Returned (Kg)	Steel Used (Kg)	Equivalent Length (M)	Expected Output for Given Input	Actual Output (M)	Scrap (Difference) (M)	Percentage of Scrap on Output
3 × 1.57 × 130	1198	0	1198	622.3	659.65	597	62.65	10.49
1 × 2.62 × 148	1391	500	891	292.34	309.88	265	44.88	16.94
1 × 2.49 × 148	2163	900	1263	436.03	462.19	427	35.19	8.24
1 × 2.75 × 142	1675	400	1275	415.40	440.32	416	24.32	5.85
3 × 1.70 × 156	1102	435	667	319.98	339.18	322	17.18	5.33
1 × 2.90 × 118	733	300	433	160.99	170.65	163	7.65	4.64
1 × 3.15 × 124	1412	220	1192	388.26	411.28	399	12.28	3.07
1 × 2.13 × 122	1353	600	753	368.67	390.79	382	8.79	2.30
Total				3003.98	3183.94	2971	212.94	7.167%

These have been found out and recommended to reduce scrap in future.

Input output analysis for Sanding and Sintering

The input material at this stage is steel strip. The steel strip coils are issued from store to sanding and sintering plant. After sanding the remaining steel strip coil is returned to the store. The records of issue and return of strip are maintained by the company. This record has been referred and made use of in the study. The actual weight of steel used (Q_{SL}) during the study period is calculated using equation (i).

$$Q_{SU} = Q_{SI} - Q_{SR} \quad \text{...(i)}$$

Where, Q_{SI} = The weight of steel issued.

Q_{SR} = The weight of steel returned.

Q_{SU} = The weight of steel used.

The input of steel by weight (kg) for each steel strip coil is converted into the units of length by applying equation (ii).

$$l_{SL} = \frac{Q_{SU}}{(w \times t \times \rho_S)} \quad \text{...(ii)}$$

Where, l_{SU} = length of steel coil in metres

Q_{SU} = weight of steel coil in kg

w = width of the steel strip used

t = thickness of the steel strip used

r_s = specific density of the steel used

Powder is sintered on the steel strip and then the bimetallic strip is rolled. It has been found from past experience that the strip gets extended in length by 6% on an average after it undergoes rolling operation. Therefore the maximum expected output from Sinter line ($O_{SL(M)}$) is calculated using equation (iii).

$$O_{SL\,(M)} = l_{SL+}\left(0.06 \times l_{SL}\right) \quad \text{...(iii)}$$

After the sintering and rolling operation the bimetallic strip is coiled. The length of the coiled strip is automatically measured by an instrument installed for the purpose. This is referred to as actual output ($O_{SL(A)}$). The difference between the maximum expected output and the actual output reflects material waste in this subsystem. The quantity of material waste (W_{SL}) is worked out from equation (iv).

$$W_{SL} = O_{SL(M)} - O_{SL(A)} \quad \text{...(iv)}$$

The results of the analysis are given in Table 1.

Table 2 presents a pareto analysis carried out to identify major contributors to waste in this sub-system.

Table 2: Pareto Analysis for Sanding and Sintering Plant

Steel Coil Code	Quantity of Scrap on Output	Cumulative Quantity of Scrap	(Cumulative Quantity of Scrap/212.94) X 100 (%)
3 × 1.57 × 130	62.65	62.65	29.42
1 × 2.62 × 148	44.88	107.53	50.49
1 × 2.49 × 148	35.19	142.72	67.02
1 × 2.75 × 142	24.32	167.04	78.44
3 × 1.70 × 156	17.18	184.22	86.51
1 × 2.90 × 118	7.65	191.87	90.10
1 × 3.15 × 124	12.28	204.15	95.87
1 × 2.13 × 122	8.79	212.94	100

Table 3: Input-Output Analysis for Auto line and Plating

S.No.	Part Number	Coil No. Used for Blanking	Length of the Coil (M)	Actual Pieces Blanked	Final Output	Actual Scrap	% Age of Actual Scrap on Input	% Age of Actual Scrap on Output
1	E,M,I,G	C-1790	87 M	3358	2746	612	18.22	22.28
2	B,F	C-1752,53	1784 M	55741	46292	9449	16.95	20.41
		C-1839,40,41						
3	L	C-1838	45 M	1406	1338	68	4.83	5.08
4	H	C-1832	42 M	1312	1152	160	12.19	13.88
5	A	C-1846,47	427.40 M	12981	11830	1151	8.86	9.72
6	C	C-1849	125 M	3797	3010	787	20.72	26.14
7	K,J	C-1853	63 M	1913	1660	253	13.22	15.24
8	D	C-1819		4100	3404	696	16.97	20.44
	Total			84608	71432	13176	15.57%	18.45%

It has been found that for the critical coils as identified through pareto analysis, the scrap is mainly due to three types of defects: improper bond between steel and powder, inaccurate thickness of bimetallic strip, inaccurate slit width. These three defects taken together are referred to as Sinter line problems. Further, a root cause analysis has been conducted to find out the reasons and root causes of the sinter line problems. Causes of waste are categorised into four categories: man, machine, method and material. Figure 4 shows the root cause analysis.

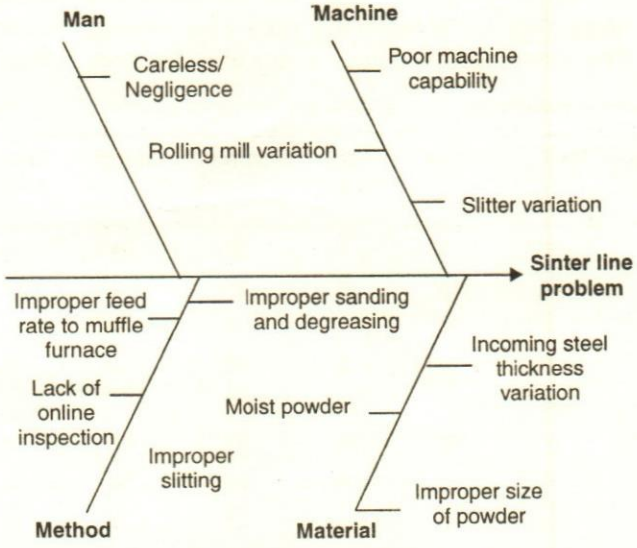

Fig. 4. Root Cause Diagram for Sinter line Problems

Following recommendations are made for reducing waste by removing the root causes:

(i) Proper degreasing and sanding of strip before sintering

(ii) Use of dry powder for sintering

(iii) Accurate control of feed rate of strip in the furnace

(iv) Proper maintenance of recommended temperature in the furnace

(v) Employ skilled operator

(vi) Proper setting of thickness of loose powder

(vii) Ensure uniform thickness of incoming steel

(viii) Ensure rust free steel strip before sintering

(ix) Proper care by operator by slitting

(x) Maintain recommended rolling pressure.

Work instructions pertaining to the above should be established displayed on the respective equipment and the concerned personnel should be instructed/educated to follow these.

Input-output analysis for Auto line and Plating

The input material at this stage is the bimetallic strip. The data of respective coil numbers of bi-metallic strip used for blanking of pieces of different part numbers is taken from the records. Actual observations have also been made to record inputs and outputs.

From the dimensions of each part taken from the drawings, the number of pieces ($I_{AL(A)}$), which can be blanked from the used length of the coil are calculated using equation (v). This is referred to as the actual input to Auto-line (in number of pieces).

$$I_{AL\,(A)} = \frac{L_S}{W_B} \qquad ...(v)$$

Where, $I_{AL(A)}$ = actual number of pieces which can be blanked

L_s = length of the coil used for blanking

W_b = width of blank

The reported numbers of pieces blanked ($I_{AL(R)}$) are also noted from the daily production records, which is referred to as the reported input. The good pieces sent after the final inspection, are referred to as the final output (O_{AL}) from the Auto-line and plating. This is taken from daily inspection reports and also from actual observations on the shop floor. The quantity of material waste is calculated by using equation (vi).

$$W_{AL(A)} = I_{AL(A)} - O_{AL} \quad ...(vi)$$

The results are presented in Table 3.

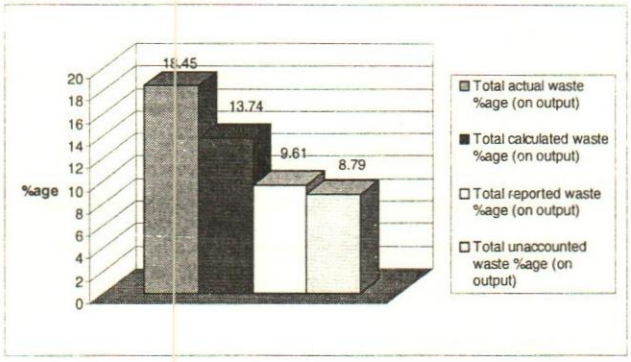

Fig. 5. Comparison of Actual Scrap, Calculated Scrap, Reported Scrap and Unaccounted Scrap

The quantity of scrap is also calculated by taking the difference of final output (O_{AL}) and the reported input noted from daily production report and is referred to as the calculated scrap ($W_{AL(C)}$) and is given in Table 4.

Table 4: Calculated scrap based on Reported Input

Part Number	Reported Quantity Blanked	Final Output	Calculated Scrap	% Age of Calculated Scrap (on Input)	% Age of Calculated Scrap (on Output)
A	12600	11830	770	6.11	6.5
B	50950	44414	6536	12.83	14.71
C	3700	3010	690	18.64	22.92
D	4100	3404	696	16.97	20.44
E	1300	981	319	24.53	32.51
F	2200	1878	322	14.63	17.14
G	1000	829	171	17.1	20.62
H	1250	1152	98	7.84	8.5
I	500	436	64	12.8	14.67
J	600	527	73	12.16	13.85
K	1200	1133	67	5.58	5.91
L	1350	1338	12	0.88	0.89
M	500	500	0	0	0
Total	81250	71432	9818	12.08%	13.74%

$W_{AL(C)} = I_{AL(R)} - O_{AL}$...(vii)The quantity of reported scrap ($W_{AL(R)}$) is taken from the daily rejection reports. The difference of actual scrap and reported scrap is

Table 5: Quantities (no. of pieces) and % ages of each type of defect for all part numbers

Part No.	Damages	Strip Defect	Blanking	Forming and Coining	Face and Chamfer	Punch Press	Milling	C'sink	OD/F Height	Final Wall	Plating	Sinter Line
G	2	0	12	20	15	11	25	0	5	30	24	0
M	0	0	0	4	0	0	0	0	0	26	0	0
I	0	0	0	0	0	0	0	6	2	0	0	0
E	13	2	0	3	11	22	9	21	2	219	12	0
B	110	113	106	616	96	100	185	0	418	1979	538	285
F	22	15	0	58	0	0	4	0	23	27	72	0
L	0	7	0	12	3	0	4	0	24	11	0	0
H	12	0	0	3	4	1	1	0	5	24	0	0
A	8	12	13	48	24	37	175	0	100	239	80	22
C	0	28	21	73	9	7	69	0	50	31	0	19
K	0	6	0	22	0	0	4	0	8	37	0	0
J	0	3	0	4	0	0	3	0	0	28	0	0
D	0	10	12	29	26	39	18	26	25	128	0	0
Total	167	196	164	892	188	217	497	53	662	2779	726	326
% Age	2.43%	2.85%	2.39%	12.99%	2.74%	3.16%	7.24%	0.77%	9.64%	40.47%	10.57%	4.75%

taken to calculate unaccounted scrap ($W_{AL(U)}$). The comparison of total percentage of actual scrap, calculated scrap, reported scrap and unaccounted scrap is given in Fig. 5 in order to highlight the difference.

In each part-number the total scrap is due to various defects. The data regarding scrap due to individual defect has been compiled for each part number. Scrap due to each defect in all the part numbers taken together has also been calculated and shown in Table 5 as well as in Fig. 6.

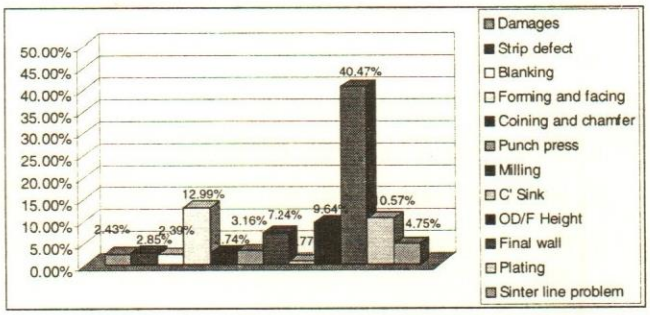

Fig. 6. Types of defects and their percentages

Further, to find out the critical part numbers causing material waste, a pareto-analysis has been conducted as shown in Table 6.

Table 6: Pareto-analysis (by quantity)

Part No.	Reported Quantity	Good Quantity	Scrap	Cumulative Scrap	(Cumulative Scrap/ 9818) × 100 (% Age)
B	50950	44415	6536	6536	66.57
A	12600	11830	770	7306	74.41
C	3700	3010	690	7996	81.44
D	4100	3404	696	8692	88.53
E	1300	981	319	9011	91.78
F	2200	1878	322	9333	95.06
G	1000	829	171	9504	96.80
H	1250	1152	98	9602	97.79
J	600	527	73	9675	98.54
I	500	436	64	9739	99.19
K	1200	1133	67	9806	99.87
L	1350	1338	12	9818	100
M	500	500	0	9818	100

On the basis of this pareto analysis B, A, C, and D are the critical part numbers contributing towards waste. For these critical part numbers, again, a pareto analysis for the types of defects is carried out. This is shown in Table 7.

Table 7: Pareto analysis for various defects

Type of Defect	Quantity (Pcs)	Commulative Quantity	(Commulative Quantity/6376) × 100
Final Wall	2626	2626	41.18
Forming & coining	789	3415	53.56
Plating	654	4069	63.82
O/d & final height	600	4669	73.23
Milling	481	5150	80.77
Sinter line problem	326	5476	85.88
Punch press	210	5686	89.18
Face & chamfer	181	5867	92.02
Strip defect	165	6032	94.60
Blanking	164	6196	97.18
Damages	133	6329	99.26
C'Sink	47	6376	100

The above analysis shows that final wall, forming and coining, plating and O/D and final height are the critical defects. Root cause analysis for all these critical defects is carried out. This is presented in the Figs. 7-10.

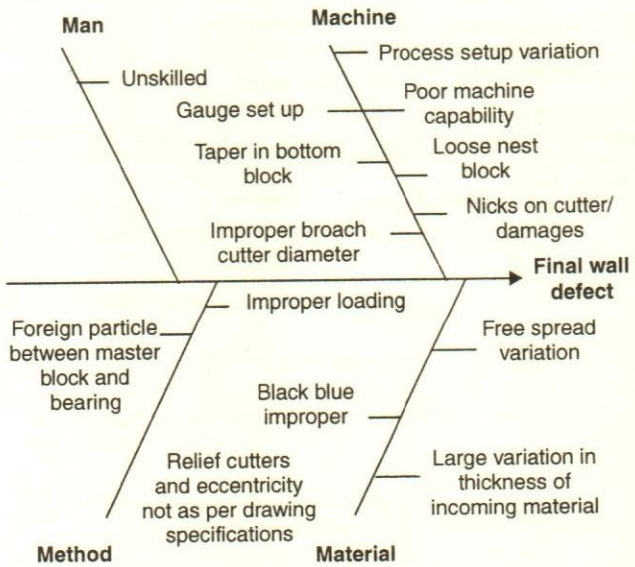

Fig. 7. Root Cause Diagram for Final Wall Defect

The causes of occurrence of these defects, as found out from the cause and effect analysis, are summarized as common causes and special causes depending upon the nature of defect. These common and special causes found out from the analysis are:

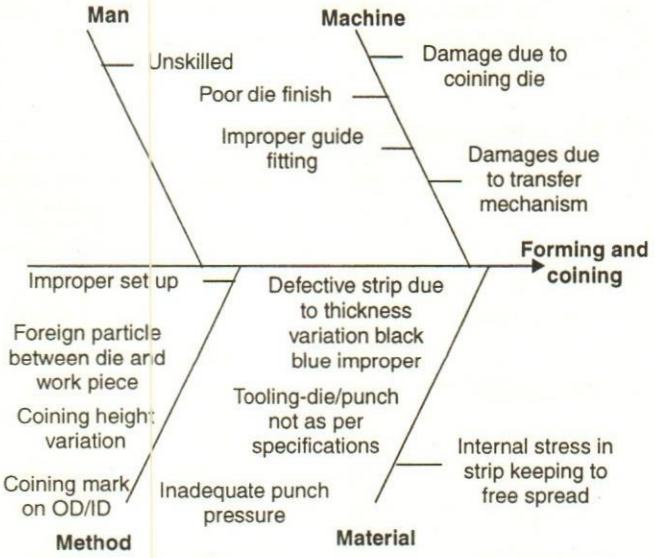

Fig. 8. Root Cause Diagram for Forming & Coining Defect

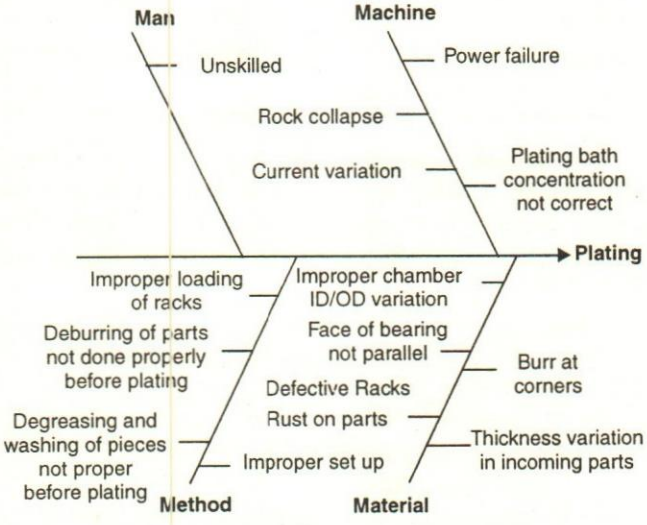

Fig. 9. Root Cause Diagram for Plating Defect

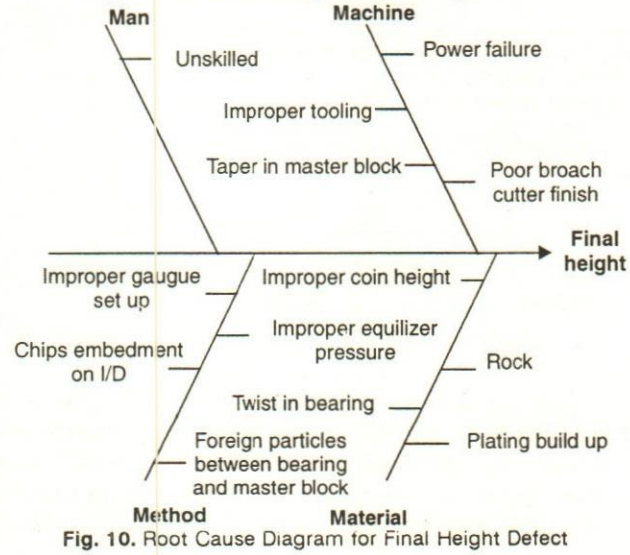

Fig. 10. Root Cause Diagram for Final Height Defect

Common causes

- Unskilled operator
- Large variation in gauge reading in case of some instruments by operators
- Carelessness/negligence by operator
- Process setup variation
- Poor machine capability
- Variation in thickness of incoming material
- Special Causes
- Final Wall

i. Taper on the bottom block
ii. Broach cutter diameter not proper
iii. Nicks on cutter/damages
iv. Foreign particle between master block and bearing
v. Relief cutter and eccentricity not as per drawing specifications
vi. Variation in free spread of work piece
vii. Back blue not proper

Forming and Coining

i. Damages due to coining die
ii. Poor die finish
iii. Guide fitting of die and punch not proper
iv. Damages caused by transfer mechanism
v. Forign particle between die and work piece
vi. Variation in coining height
vii. Coining mark on OD/ID
viii. Improper setup
ix. Tooling – die/punch not as per specifications
x. Inadequate punch pressure
xi. Improper back blue
xii. Free spread variation due to internal stresses in the strip

Plating

i. Interrupted power supply
ii. Plating bath concentration not proper
iii. Current variation during plating process

iv. Rack collapse

v. Deburring, degreasing and washing of products not done properly before plating

vi. Loading of racks not proper

vii. Defective racks

viii. Improper setup

ix. Improper chamfer on OD/ID

x. Burr at corners of products

xi. Thickness variation in incoming parts

xii. Faces of products not parallel

xii. Rust on parts

Final Height

i. Improper tooling

ii. Taper in master block

iii. Poor broach cutter finish

iv. Chips embedment on ID

v. Fareign particle between bearing and master block

vi. Improper gauge setup

vii. Improper equalizer pressure

viii. Twist in products

ix. Improper coin height

x. Rocking action in workpiece

Recommendations

Based on the defects, their causes and other features and characteristics of the systems, following recommendations are made to reduce waste:

Common Recommendations to All

- The operator should be properly trained and skilled
- The Thickness of incoming material should be uniform.

Specific Measures for Reducing Each Defect

Final Wall

i. Clean the master block periodically to ensure that there is no foreign particle between bearing and master block.

ii. Loading to be done properly.

iii. Ensure no damages or burrs on the cutter.

iv. Ensure flatness of the bottom block.

v. The broach cutting diameter should be accurate

vi. Minimize process set-up variation of the machine.

vii. Control and minimise the free spread variation in material.

Forming and Coining

i. Ensure proper finishing of the die.

ii. Check and ensure accurate fitting of the die and punch.

iii. Clean the die frequently.

iv. Ensure the tooling to be exactly as per drawing specifications.

v. Ensure that the punch pressure is properly set.

vi. Minimize variation in the coining height.

Plating

i. Properly clean the work piece before plating.

ii. Ensure that the parts are rust free.

iii. Ensure proper loading of racks.

iv. Periodically check and maintain required concentration in plating bathe.

v. Ensure uninterrupted power supply to plating.

vi. Properly set and maintain the parameter of current.

vii. De-bur the parts before plating.

viii. Ensure that racks used for plating are not defective or damaged.

ix. Faces of products should be parallel.

x. Ensure proper chamfering on ID and OD of the products.

Final Height

i. Check and maintain the flatness of the master block.

ii. Ensure the broach cutter to be in good condition to give required finish.

iii. Ensure that the faces of products are flat to avoid rocking effects.

iv. Ensure that the equalizer pressure of cutters on both the ends of products is exact.

v. Clean the master block and ensure that it is free from any foreign particle.

For reducing material waste in this organisation it is necessary that the above listed recommendations and measures be employed. To ensure that these are used, it is recommended that work instructions be established and displayed on all work centres. Check lists should also be developed which are to be filled by the concerned operators and supervisors. This is expected to go a long way in reducing waste.

Conclusions

Many types of wastes have been found in the industry. Major waste is the scrap products. There are many reasons and root causes of waste identified in the study. It has been seen that better management and compliance to already laid down norms and ways of working rather than technological innovations and upgradations are required to reduce waste. This is an inexpensive option and must be exercised. High variety needs an accurate planning of the resources, their quantity and timing. It is seen that in this organisation the area of production planning needs strengthening. As the study has revealed appreciable amount of wastages, it is recommended that such studies be regularly conducted. Through these, targets must by set for the future and monitored regularly.

Acknowledgement

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The secret of joy in work is contained in one word—excellence. To know how to do something well is to enjoy it.

— Pearl S Buck

Feature

Gaining Competitive Advantage by Personalising Customer Interfaces

Hemant Kumar Sabat

Customers' perception of value of a product or service decides the success of the offering. To gain competitive advantage in a fiercely competitive marketplace, this paper describes a strategic roadmap for personalisation of customer interfaces like Web, physical retail outlet and direct mail order. Further, to devise marketing strategies by benchmarking companies' efforts at personalizing their customer interfaces, this paper offers a personalisation diagnostic instrument, and provides a perspective on its implementation.

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To grasp a customer's value system, customer orientation is increasingly becoming an integral part of business. In a successful customer-oriented business, a business manager has many tools to understand the value system of customers. These tools are based on many market research methods like conjoint analysis, cluster analysis, etc. (Sabat, 2001). A critique of three modern marketing strategies to manage customer relationships, namely, one-to-one marketing, brand loyalty management, and market research and product engineering, has been provided in an earlier paper (Sabat, 2001).

Two external or environmental factors have increased the marketing manager's endeavour to make an offering successful: one, increased competition across all industries due to a concrete move towards globalisation of the world economy, and two, dramatically altered economic environment due to the evolution of the internet, which augments and boosts the efficiency of traditional channels. Internet is making it increasingly difficult for companies to control customers' access to information in the marketspace (Evans & Wurster, 1997). A marketplace can be defined as a virtual realm where products and services exist as digital information and can be delivered through information-based channels (Rayport and Sviokla, 1995). The traditional value chains are being dis-intermediated and reintermediated into a virtual value chain with more efficient electronic intermediaries (Rayport & Sviokla, 1995).

The shift in market power to the customer and the unleashing of the value chain's potential due to information flow to and from the customer puts the customer at the center of companies' success. Then, with billions of revenues at stake, it is startling to see that businesses are still losing from 15 per cent to 35 per cent of their customers annually – usually due to poor sales or service interactions. In the U.S., it has been estimated that cutting customer defections by just 5 per cent can

boost profits by over 25 per cent (Jones & Sasser, 1995; Reichheld, 1996). The incremental profits can be even higher if the most profitable customers are identified and retained (Reichheld & Teal, 1996a).

Many companies have invested in technologies and skills to advance one-to-one marketing and Customer Relationship Management (CRM). Companies have been automating critical front office business processes across all customer touch points, including the web, telephone, email, chat, fax, etc. Businesses are also seeking ways to analyze the data collected during customer interactions, and act on that information to sell, service and market better to each customer as an individual. At the same time, growing business pressures on the bottomline of many companies have been forcing them to outsource customer contact services. Due to demands for process automation and customer-profitability analytical applications to meet customer contact outsourcing needs, venture capitalists are investing in first as well as subsequent rounds of CRM services. e4e, a venture capital firm, has looked at the CRM space to build one of its companies, iSeva. CRM product companies like TriVium and Talisma; services companies like QSupport, CustomerAsset, 24x7Customer and iSeva; system integrators like Planetasia; consultants like Infosys and Orbit-e; and even a specialist direct marketing company Wunderman Cato Johnson have populated the CRM market. A McKinsey-NASSCOM study expects the current US$ 88 million CRM services market to reach US$ 3.7 billion in 2008 (Duttagupta, 2001).

Further, technology-intensive customer interfaces (Internet, e-mail, Electronic Data Interchange or EDI, etc.) allow companies to develop customer-oriented products, channels, and management processes thereby helping businesses to increase profits and to retain customers. By allowing companies to engage customers in a dialogue that helps understand customers' preferences and profiles, the Internet has provided opportunities to strengthen customer relationships developed through all other channels. So, technology-intensive customer interfaces are assuming a prime role in one-to-one-marketing.

Technology-intensive customer interfaces are assuming a prime role in one-to-one-marketing.

Companies are increasingly focusing on real-time personalisation and customisation of channel offerings to aid efficient management of their customer relationships through improved service-quality. To facilitate adoption of this new paradigm by companies, this paper introduces personalisation as the modern implementation doctrine of relationship marketing strategy. The genesis of personalisation is described by highlighting the business drivers of evolution of marketing strategy continuum. Drawing from leading thoughts on personalisation, the paper offers a strategic roadmap for businesses to help companies personalise their customer interfaces. To measure the extent of personalisation of three customer interfaces – Web, physical store and direct mail order – the paper offers a personalisation diagnostic instrument that is developed from an understanding of the demand and operational efficiency parameters in implementing customer interface strategy. The tool was validated in the U.S. apparel retail industry. Using this tool, companies can benchmark their efforts at personalisation across each stage of the purchase cycle. The paper, then, elaborates on how to implement this instrument and its utility in developing customer interface strategies to effectively devise marketing strategies.

The genesis of personalisation

At one end of the marketing strategy continuum is a transaction-based, product-centric business model. Don Peppers and Martha Rogers (1999a) state that transaction-based approach to marketing strategy is the reason behind adversarial relationship between a buyer and a seller. This is because in a single, solitary transaction that is the only interaction between the buyer and the seller, the two have no relationship prior to the purchase, and have no relationship following it. So, the buyer wants to buy the most of the product at the lowest price from the seller, and the seller wants to sell the buyer the least of the product at the highest price.

The roots of modern management lie in the 'machine age' of the nineteenth century. Today's organisations remain modelled on the tenets of first business revolution – the principle of division of labour industrial work should be dissected into its simplest and most basic tasks described by Adam Smith in 1776. Frederick Taylor's 'scientific management'– the principle built around specialisation and division of labour – grew from Smith's fundamentals. Then, in order to increase productivity and efficiency, and reduce prices in order to generate sales, the genius of Henry Ford stepped in to pioneer the mass production techniques centred on specialisation and division of labour. Next, Alfred P. Sloan Jr. (Sloan, 1963) took what Ford had achieved on the factory floor and sought to apply it to managers and the organisation as a whole through a new organisational form, called the multi-divisional form.

Sloan's management machine was a twin component of Ford's corporate machine. The systems championed by Taylor, Ford and Sloan carved out the *corporate man.* Ford's assembly-line systems – the corporate machine – supported mass production and mass marketing. However, the paradox of mass-produce, mass-market products was that they were usually bland, vanilla, inoffensive and uninspiring to the customer (Sabat & Karunes, 1996; Sabat, 1998).

Today's marketing focus is technology-enabled relationship building with the customer. To increase customer satisfaction, develop customer loyalty, and contain the high costs associated with new customer acquisition and customer support, businesses are increasingly turning their attention to one-to-one marketing and mass customisation of products.

The explosive rise of global competition has shifted commercial opportunities from economies of scale to economies of scope. This means that instead of making single products for huge markets to generate economies of scale, companies have been forced to make many subtly differentiated products for increasingly fractional market niches. While serving these fractional market niches, companies have evolved significantly differentiated businesses. Integrated into a company, these niche businesses generate economies of scope by allowing companies to secure a larger mindshare (mindshare means share of a customer's purchase) of a customer or customer segment.

Global competition has shifted commercial opportunities from economies of scale to economies of scope.

Combining the two drivers – globalisation and the Internet – now the big trick has become, as Christopher Locke (2000a) has pointed out, how to identify in advance what the new micro-markets want. With the advent of technology-intensive customer interfaces, like the Web, EDI, e-mail, etc., the challenge is no longer just to predict the wants and needs of fragmented micro-markets, but – as Regis McKenna (*Relationship Marketing,* 1993), Joseph Pine (*Mass Customization,* 1993a), Don Peppers and Martha Rogers (The *One-to-One* series, 1997a & b, 1999a & b), and Seth Godin and Don Peppers (*Permission Marketing,* 1999) have pointed out – to predict the wants and needs of markets-of-one. This end of marketing strategy continuum, known as relationship marketing, is diametrically opposite to the transaction-based approach. After McKenna (1993) popularized the term 'relationship marketing,' contributory streams such as customer relationship management, mass customisation (Pine *et al,* 1993b), one-to-one marketing (Peppers & Rogers, 1997a & b, 1999a & b) and permission marketing (Godin & Peppers, 1999) appeared in the business world to form the whole concept, which is called *personalisation.* In mass customisation, processes and people reconfigure perpetually to produce exactly what customers want and need.

Direct marketing, mail order, and database marketing are based on the same concept. Terms like 'relationship marketing' and 'target marketing' were used in direct marketing to describe the importance of understanding the needs and interests of market segments, and then communicating to those market segments in ways that impacted those individuals. Unfortunately, the economics of traditional print media had made it very expensive to do even the most rudimentary personalisation of customer interfaces. While marketers have known the value of a personal relationship with customers, it had been uneconomical for businesses to personalise their products. Thus, while direct marketing, target marketing, database marketing, etc. form the dossier of traditional relationship marketing implementation doctrines, personalisation is the modern implementation doctrine of relationship marketing.

The driving principle of personalisation is getting to know the customer. Establishing a dialogue and a sense of community with customers create a bond between the company and the individual customer. The ultimate objective is to own a piece of the customer's mindshare and to provide customized services to each customer according to his or her own personal preferences – whether expressed or inferred. All this must be done while protecting customers' privacy and giving them a sense of power and control over the information they provide. Personalisation allows the vendor to identify and to take advantage of the moment when a customer's purchasing decision is most likely to occur and to be prepared for that moment, one step ahead of the competition.

Peppers and Rogers (1997a) explain that what is needed for this is not just targeted marketing, but a complete overhaul of the way customers are treated. In addition to tailoring marketing messages to individuals, Peppers and Rogers recommend that a company adopt mass customisation – the manufacturing and service technique of personalisation strategy – in order to meet each customer's unique needs and interests. When these are combined with systematic approaches to implementation, the personalisation concepts form a near-perfect fit with technology-intensive customer interfaces, like the Internet.

Further, in the business world, personalisation is often confused with customisation. But the two differ from each other. As Web marketers begin to evolve their Web sites from static, unchanging Web pages to database-driven dynamic pages that are created 'on the fly,' features are added to allow Web visitors to select how certain pages will be displayed. This is customisation. For example, Dell's Web site allows a visitor to pick and choose from existing options to provide the information the visitor wants to be displayed on the Web site. By contrast, when a Web visitor expresses an interest and the site responds with information, graphics, and other content that lead the individual into a new experience, then the site is moving towards the true conversational potential of personalisation. For instance, if the visitor identifies himself or herself as a novice golfer on the Web site and the site responds with educational material that the visitor did not expect, then the visitor has experienced Web personalisation. The techniques used by the site to identify novice golfers could include: observe what pages the visitor selected, and use that as an indicator of the visitor's interests and preferences; use forms to explicitly request such information; or use customer purchase history data to determine the visitor's profile. Whichever method is used to obtain the data, it is collected and stored in the customer's profile.

Personalisation is often confused with customisation.

Thus, while customisation allows the user to control and manipulate the selection, format, and order of existing content in a Web site according to his/her preferences, personalisation allows the supplier (Web site) to add new content based on stated and observed preferences of the customer. With this, customisation appears to be more mechanical than personal, and personalisation strives to offer a new experience to the user. Then, personalisation is much more evolved doctrine of relationship marketing strategy than customisation.

Adapted and modified from Gronroos' marketing strategy continuum (1991), Table 1 is a visual summary of how personalisation, as the modern implementation doctrine of relationship marketing strategy, differentiates itself from transaction-based approaches to marketing.

Table 1: Marketing strategy continuum: transaction marketing vs. relationship marketing

Transaction marketing	Factors	Relationship marketing
One-off exchanges	Focus	Ongoing exchanges
Level pricing	Pricing	Differential pricing
Brand management	Marketing management	Customer management
Insignificant use of technology	Role of technology	Interactive technology as enabler
Short-term focus	Time perspective	Long-term focus
Mass communications	Primary communication	Personal communications
Isolated market research	Customer feedback mechanism	Ongoing dialogue
Mass markets or market segments	Market size	Markets-of-one
Market share	Criterion for success	Mindshare of customer
Mass marketing	Marketing	Customised products and services
Same for all customers	Customer interface	Personalised interface
Mass production	Production system	Mass customization
Push system	Manufacturing system	Pull system

Note: Adapted and modified from Gronroos, C. (1991). The marketing strategy continuum, Management Decision, January.

Strategic Roadmap

Based on an analysis of the literature on personalisation (Peppers & Rogers, 1997a & b; 1999a & b), and author's discussions with Martha Rogers, Partner, Peppers and Rogers Group (PRG) a preeminent customer relationship management consulting and training firm that helps clients shift from mass marketing to individualised (or relationship or one to one) marketing and Larry light, CEO of Arcature Systems, LLC, a marketing consulting frirm based in Boston, a three-stage strategic roadmap for companies to personalise their customer interfaces has been developed. The strategic roadmap recommends the companies

1. To *survive* by generating *traffic* (or revenue stream) leads
2. To *succeed* by identifying and differentiating customers by their value to the company's business and by retaining *profitable customers,* and
3. To *prosper* by earning *business loyalty* of customers, employees and investors

Figure 1 is a visual description of the roadmap.

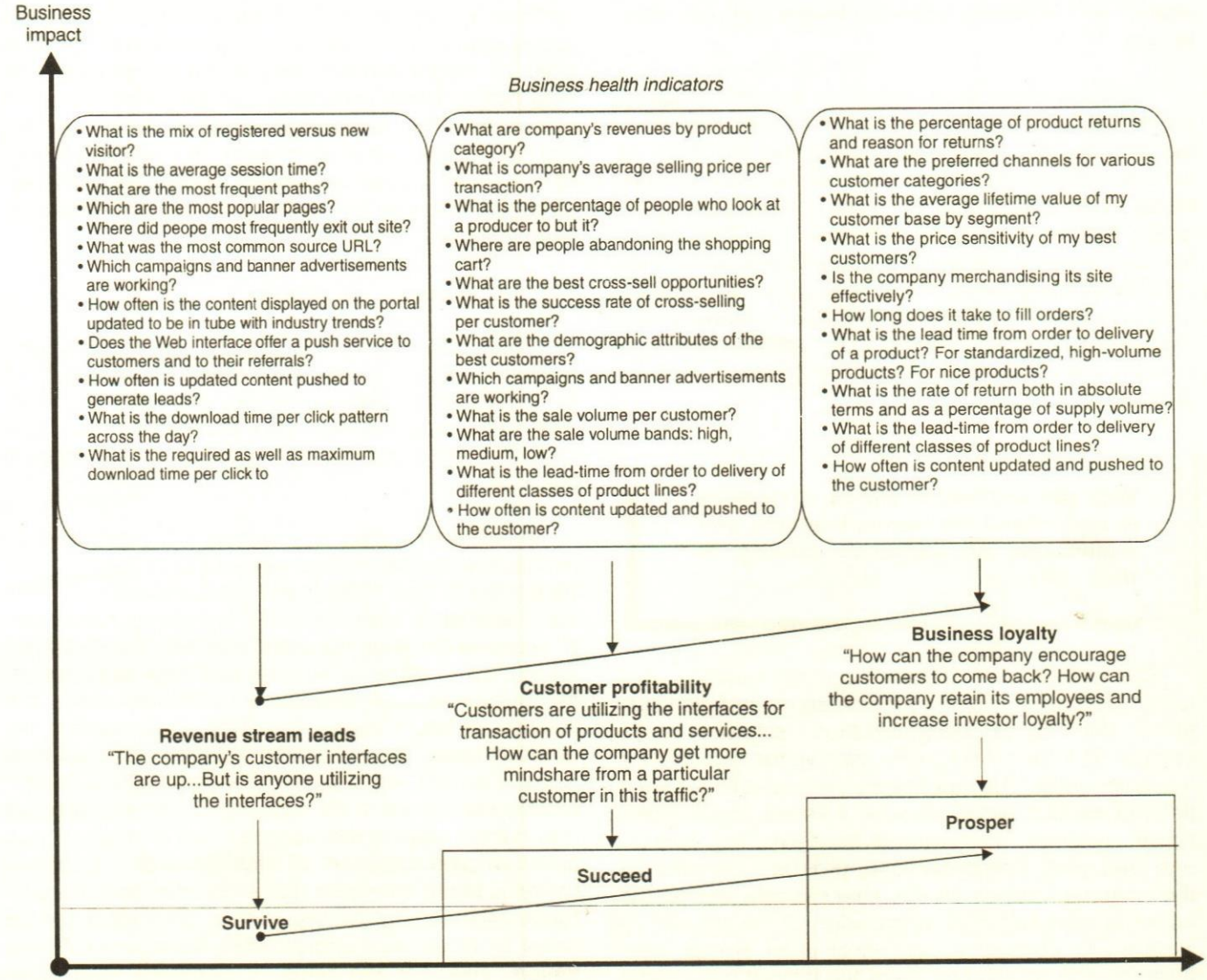

Fig . 1. Roadmap for personalisation of customer interfaces

Survive: traffic or revenue lead generation

In the first phase, businesses must focus on traffic, or revenue lead generation. A business manager must identify parameters to select probable customers, and then develop and implement marketing programmes to generate leads. Leads are generated by securing information about customers. The purpose is getting to know the customer. The key to any successful personalised marketing is the quality of information about the customer. The better information that a firm has about a particular customer, the more value that firm will potentially be able to provide to that customer.

The quality of information is predicated on three components: accuracy, timeliness and relevance. Companies adopt multiple methods to acquire quality customer data. Most companies spend on advertising, affiliate relationships, incentive programs, etc. to generate leads. Conceptually, information-gathering techniques range from unobtrusive to intrusive. Intrusive means could employ tagging through cookies to generate educated guesses about consumer preferences, demographics, etc. (e.g., MathLogic, Inc.). Unobtrusive means of gathering information could request the customer to engage in some type of self-disclosure (e.g., New York Times, The Wall Street Journal, customisable Web sites).

Companies resort to multiple marketing media to implement their information-gathering methods. It could be mail order, physical interview, phone, chat, e-mail, fax, etc. However, corporations are increasingly challenged to create compelling Web experiences for various stakeholders or users (employees, customers, investors, etc.) that will lead to higher site traffic, repeat

visitors, and ultimately increased loyalty and user satisfaction.

Although there are a variety of services (content, news, data, analysis, etc.) that will drive site traffic, leading organisations unanimously agree that the ability to provide a personalised experience will be a key success factor. While it is difficult for most companies to reengineer their manufacturing processes, the Web allows for easy implementation of the one-to-one techniques on a mass basis (Allen, 2000). Web personalisation allows companies to understand the needs, interests, and motivations of individuals coming to their sites, and then to tailor Web content based on the profile of each individual.

Web personalisation allows companies to understand the needs, interests, and motivations of individuals coming to their sites.

Using data from multiple sources, including customer databases, clickstream data and transaction systems, and using personalisation software tools, companies interactively profile each visitor to build their real-time profile. The tool selects the best offer for each point of contact based on what it knows about a particular customer. The customer interfaces, e.g., one-to-one Web sites, then dynamically provide information to the customers based on the latter's profile and on the business rules specified by providers of the site and its services. In contrast to traditional push or pull technologies, this avoids end-users the difficult and painful task of finding their way through overloads of information to find the relevant data nuggets. A step further, as individuals accept or decline offers, the personalisation engine adjusts and incorporates that information into future offers. No other marketing medium has ever provided the opportunity for marketers to communicate with such a pinpoint accuracy as the Web does while emulating the personal selling experience of a company's best salesperson.

However, to capitalise on the opportunity that the Web offers, businesses require software applications that exceed the capabilities of currently available Web software products, many of which were designed for publishing static content, or 'brochureware.' The new software applications incorporate analytical modules that are designed to track and mine customer data. Logically, the analytical applications capture demand-side and supply/operational efficiency information across the purchase cycle that is enabled by the company's supply chain. Typical demand-side and supply/operational efficiency parameters provide strategic insight into the state of the company's business health. These parameters can be benchmarked to personalise the technology-intensive Web interface thereby improving business health. To measure efficiency of revenue lead generation efforts through personalised Web interface, a few of these parameters are listed in Figure 1.

Succeed: customer profitability

While customers have different needs, they also represent different levels of value to a firm (Peppers *et al,* 1999b). After obtaining information about the probable customers, the next step is to differentiate customers by value and identify the profitable customers in the pack.

A customer's value to a company is predicated on two factors: his/her lifetime value (LTV) to the company (Reichheld & Teal, 1996b), and the company's share of the customer. A customer's LTV represents the stream of expected future profits associated with that customer, discounted at some appropriate rate back to its current net present value. A customer's profitability status is a function of future transactions with the customer, acquisition costs, price premium, referrals, cost savings, revenue growth, etc. (Reichheld & Teal, 1996b). Further, a company's share of the customer is the ratio of actual (i.e., current value to the enterprise that is obtained from an information database) to strategic value (i.e., potential value to the enterprise that is obtained from the customer itself). Using the two factors, customers can be tiered as: Most valuable customers, Most growable customers, Third tier, Big zeros. A successful relationship marketing firm leverages this customer knowledge to determine how to allocate its resources. The first category is to be retained, the second is to be grown, the third is to be served through mass marketing, and the fourth is to be gotten rid of in a very nice way so as not to turn them into public relations terrorists. This enables the firm to concentrate its efforts on providing the greatest amount of benefits to those customers that represent the greatest amount of value. Thereafter, identify the needs of the customer. In sum, this phase involves the following: tier customers by business value, detect anomalies, and differentiate customers by their needs.

Personalised Web interface could provide the above information about customers, thereby enhancing a company's understanding of customer profitability. These interfaces allow the company to identify its customers by extracting and aggregating customer data from all existing enterprise systems. Companies can

then use another set of analytical applications in the software system to differentiate their customers. For this, companies can use powerful data mining technologies designed to profile and segment customers. This helps build knowledge about the customer. A few demand-side and operational efficiency parameters to measure effectiveness of personalisation in identifying profitable customers are listed in Fig. 1.

Prosper: business loyalty

Once a customer has been brought to the company's interface and served an offering, he/she must be engaged and encouraged to return. A customer returns if he/she was delighted with its first 'buy-and-use' experience with the company's offering. Translated, a customer will be delighted if its expectations about benefits from the products are exceeded. A business manager must seek means to understand the value system of the targeted customer, and then design the offering. Market research tools, like conjoint analysis and cluster analysis, can be employed to understand the value system of the customer. The ability to elicit repeat customers by understanding their value system can be increased manifold if businesses effectively leverage the core asset of the customer interface: *relevant, person-specific* content. That is, the customer interface can be used to convert a first-time customer into a repeat one by interacting with customers more cost efficiently and effectively, and personalising the marketing mix.

Customer interface can be used to convert a first-time customer into a repeat one.

Leveraging the acquired dynamic customer profiles, companies can plan how best to interact with their customers by designing and executing one-to-one marketing campaigns. As companies gain a comprehensive understanding of each customer, they can then use real-time, fact-based predictive modeling and execution to personalise every customer interaction. This step – personalisation of the marketing mix – is a four-fold one:

- Personalising products and services

This step includes creating what the customers want through mass customisation (or creative outsourcing), remembering what customers want, and anticipating what customers want.

- Customising communications (banner ads, e-mail, experiential marketing, viral marketing, etc.)
- Customising channels
- Personalising pricing and versioning

In a nutshell, companies must integrate analytical applications into their customer interfaces that enhance customer profiling and segmentation, increase campaign effectiveness, personalise content, analyze revenue by product-line and channels and identify cross-sell opportunities. By providing relevant, person-specific content, customer interfaces have made this step less formidable than it appears.

The customer's experience with a company's offering can be made delightful by using the knowledge learnt about the customer in devising the offering ahead of competition. The result will be customer loyalty. This loyalty reduces costs of retaining and managing the current profitable customer even while eliminating the unnecessary endeavour to acquire new ones, unless required, to maintain enterprise profitability. Since acquiring a new customer is more expensive than retaining an existing one, customer loyalty helps companies earn higher margins. Customer loyalty, along with investor loyalty and employee loyalty, contributes to business loyalty (Reichheld & Teal, 1996a).

Web-based analytical applications have been developed to seek information about customers, investors and employees. This information is being analysed through analytical applications, and is being used to develop customer interface strategy in order to measure the components of business loyalty, customer loyalty, investor loyalty and employee loyalty. To measure effectiveness of Web personalisation in generating business loyalty, a few indicators are listed in Fig. 1.

To evaluate extent of personalisation *(personalisation index)* of three customer interfaces – Web sites, physical store and direct mail order – a diagnostic tool has been developed (Table 2). This instrument has been developed based on the following studies:

- A survey conducted to develop marketing strategy for a high-end U.S. retailer in January-April 2000 by Customer Interface Strategy Group at the Kelley School of Business, Indiana University, U.S.A.
- Evaluation of personalisation characteristics of customer interfaces of a company that is an IT leader travel and transportation industry
- Peppers and Rogers Group's report (2000) on the best practices of top one-to-one sites on the Web

Table 2: Customer interfaces personalisation measurement tool

Step I. Calculate personalisation index of individual customer interfaces.

	Criteria	Rating	Weight factor	Weighted rating = Rating x Weight factor
a. Personalisation of Web site				
General criteria				
The site	The technology is cost effective and sustainable in the long term			
	Coordinates ad integrates all the touch-points to give a single view to the customer			
	Is not hard to implement That is, even non-technical managers can configure and maintain a site that is personalised for each user on a real-time basis			
	Is easy for customers to use			
	Is robust, yet has fully customisable shopping application, featuring shopping carts, browsing, price locking, tax calculation and inventory management			
	Offers a significant number of enticements per site to attract customers			
	Has prominent privacy statements and clear privacy policies			
	Has the ability to link individuals into related groups of buyers			
Registration/recognition				
The site	Clearly explains the benefits of registering at a site so customers can be recognised			
	Clearly explains its privacy policy, describing how information collected by the site will be used			
	Allows customers to quickly customise (configured through company's applications) for interactive selling and marketing services on the Internet			
	Is able to distinguish between registered and new visitors			
Content design				
The site	Allows the customer to customise the look and/or feel of the Web site			
	Provides individualized information to users, such as displaying the user's name and/or changing what information is displayed			
	Is organised around customer needs rather than products			
	Updates content to be in tune with industry trends			
Marketing design				
The site	Offers collaborative filtering (making recommendations based on the shopper's past purchases and the purchases of other, similar shoppers) or rules-based recommendations (marketers makes recommendations)			
	Presents campaigns and banner ads that are customised to the needs of the customer			
	Provides benefits to consumers in proportion to the amount of information they share			
	Provides cross-sell opportunities			
	Personalises cross-sell recommendations			
	Records frequency of cross-selling			
	Provides service enhancements to most valuable customers			
Configuration				
The site	Can be configured for each user on a real-time basis			
	Provides an online product configurator so shoppers can custom-design the products and services they want			
Transaction				
	The site fills the order on a real-time basis for customers			

11. The weight factor of a personalisation characteristic is assigned out of a total of 100% for all personalisation characteristics across all customer interfaces.

(Contd.)

	Criteria	Rating	Weight factor	Weighted rating = Rating x Weight factor
Underwriting				
	The site interfaces with popular bill payment systems like Checkfree and Intuit			
Customer interaction				
The site	Provides online order tracking			
	Provides individualised customer service			
	Offers users the ability to determine how they want to access and store content			
	Offers the option of pre-fill data for customers			
	Offers "one-click" ordering capability			
	Display community-building features			
	Provides search engines that are more accurate in finding the right products or answers, and are more fault-tolerant to user uncertainty or error			
	Offers the best e-mail response in terms of speed and quality			
	Offers online order histories			
	Offers personalised "wish lists" as a convenience-oriented feature			
Delivery/shipping				
The site	Offers multiple delivery/shipping options			
	Offers the provision of product return easily			
	Records lead time from order to delivery of standard, high-volume products			
	Records lead time from order to delivery of fast flow product lines			
	Records lead time from order to delivery of niche, specialty product lines			
Data mining/analysis				
The site	Collects information on the interests, preferences and needs of individual customers			
	Allows users to save multiple customer profiles, so they can tailor the site to different events or usage occasions (such as gift purchase versus personal purchase)			
	Has advanced profiling capabilities • Allows users to create multiple profiles for different users within a single account • Recognizes the same individual with different business and personal profiles			
	Tracks the most common source URL of the best customers			
	Tracks the most frequent exit site of a user and presents him/her with alternatives in the next session			
	Tracks the price sensitivity of the best customers			
	Tracks demographic attributes of the best customers and offers services accordingly			
	Tracks the average selling price per transaction			
	Tracks average lifetime value of a customer base by segment			
	Tracks the percentage of product returns and reason for returns			
	Tracks most frequent paths followed by a user and presents them as highlights in the next session			
	Integrates offline and online databases			
		Personalisation index of Web site	W (say)	

(Contd.)

	Criteria	Rating	Weight factor	Weighted rating = Rating x Weight factor
b. Personalisation of direct mail order				
The company	Customises product provision in its catalogues			
	Offers customised services such as bill payment, delivery Provides customised promotions including cross selling			
	Offers multiple channels for customers to contact the company such as telephone, fax, mail, and email			
	Facilitates customised fax communications for its retail operations			
	Communicates with its customers through customized e-mail			
	Provides customised phone service based on customer personal information			
	Collects individual customer information including purchasing pattern, consuming preferences, interests, needs			
	Conducts customer analysis such as segmentation based on collected individual customer information			
	Records lead time from order to delivery of standard, high-volume products			
	Records lead time from order to delivery of fast flow product lines			
	Records lead time from order to delivery of niche, specialty product lines			
	Updates content to be in tune with industry trends			
	Personalisation index of direct mail order			D (say)
c. Personalisation of a physical store				
The store	Distinguishes repeat and new customers through electronic image recognition devices			
	Offers personalised customer services based on customer recognition and following customer information retrieved from database			
	Uses kiosks to guide purchasing process via personalized product information, personalised promotions, personalised recommendations, etc.			
	Uses discount card/store credit card to collect customer information, track customer purchasing pattern and promote merchandise to selected customer group			
	Chooses cost-effective personalisation technology			
	Has trained customer service representatives to help individual customers on a customised basis			
	Records lead time from order to delivery of standard, high-volume products			
	Records lead time from order to delivery of fast flow product lines			
	Records lead time from order to delivery of niche, specialty product lines			
	Updates content to be in tune with industry trends			
	Has customer service representatives who are friendly and customer-service oriented			
	Personalisation index of physical store			P (say)

Step II. Calculate combined personalisation index of customer interfaces.

Personalisation of customer interfaces of the company			
• Personalisation index of Web site	W	w_1[12]	W x w_1
• Personalisation index of direct mail order	D	w_2	D x w2
• Personalisation index of physical store	P	w_3	P x w_3
Personalisation index of customer interfaces of the company			(W x w_1) + (D x w_2) + (P x w_3) = Final index

12. $w_1 + w_2 + w_3 = 100\%$

Index: Personalisation rating of a customer interface

Degree of personalisation characteristics	Rating
High	4
Above average	3
Average	2
Below average	1
None	0

A business manager can use this tool to accomplish the many business health diagnostic and strategic studies, like

- Determine the extent of personalisation of the company's customer interfaces
- Establish industry-wide as well as segment-specific benchmarks by evaluating customer interface effectiveness of industry and business-unit-specific (or segment-specific) leading companies
  If there are only a few players in an industry or if there are only a few high-visibility category leaders, comparable industries can be searched for benchmarks
- Benchmark against company's business units that are leaders in personalisation
- Perform correlational studies between business performance indicators (like revenues, earnings, margins, return on investment, etc.) and personalisation indices of customer interfaces to gain valuable insight into effectiveness of distribution channels in the industry
- Set, using a rigorous business judgment process, segment-specific benchmarks for growth of business units of the company

The results from the above diagnostics can be used by the business managers to devise customer-specific marketing strategies.

The proposed personalisation diagnostic instrument was used to measure personalisation characteristics of companies in the U.S. apparel retail sector. This study was sponsored by one of the companies in the retail sector. The sponsor of the research used the survey findings to devise its customer interface strategy, which was implemented in its U.S. units.

Generally, catalogue selling is a mass-marketing method that tries to provide to customers as much information of products and services as possible. It aims to increase exposure of different product categories and generate traffic. So, it is not a one-to-one marketing method. Due to the nature of catalogue selling process (high volume), its personalisation is a difficult proposition. No company, however, was using customer information to facilitate its call centre service. In reality, the degree of data mining and analysis of different companies may vary, which, in turn, may affect the degree of customisation and personalisation. How to use customer personal information from data mining and analysis to facilitate the call centre service then becomes an important task for retailers to improve their customisation and personalisation activities.

Last, little personalisation of retail outlets was evident among the retailers. This is because in a commoditised channel, like retail outlet, the return on investing in differentiation features is meagre.

Companies can follow two approaches to implement the roadmap and measure personalisation effectiveness of their interfaces: collaborative filtering and rules-based. While collaborative filtering approach attempts to discover correlations in large bodies of data and use the results to predict likely affinities, rules-based approach uses generally-understood patterns of behaviour to propose appropriate matches.

Collaborative systems are based on the premise: customer relies on the information provided by other the customers. The customer makes a purchase. While buying a product, the customer also gives information on other products too. Collaborative systems fit the customer into a group. Then it collates buying patterns across a large number of customers. Based on similarity in backgrounds of different customers, the computer recommends to the customer. Sites that say, "people who have bought this product also bought these other products" are probably using collaborative filtering techniques that use the purchase behaviour of many other people to recommend products to a particular customer.

By contrast, in rules-based systems, the seller uses specific information about the individual buyer to personalise the experience and precisely tailor the content provided. The marketer takes the customer information and says "if you purchase this, I will give information on X." In this case, then, the marketer determines the messages that are delivered to the customer. This might take the form of offering a selection of silk ties to someone purchasing an expensive suit, or discounted psychotherapy to someone buying Windows 98.

So, while collaborative systems focus on the buyer, rules-based systems let the marketer set the personalisation rules. Table 3 provides a comparative evaluation of the two approaches.

Table 3: Comparative evaluation of the two approaches to personalisation

Collabcrative filtering systems	Factors	Rules-based systems
Discover correlations in large bodies of data and use the results to predict likely affinities	Logical basis	Use generally-understood patterns of behaviour to propose appropriate matches
Focuses on the buyer	Marketing power	Centred on the seller; the marketer sets the personalisation rules
Recommendations are generated by collating buying patterns across a large number of customers	Basis of recommendations	Web sites that use specific information about individual visitors to personalise the Web experience usually use rules-based personalisation to precisely tailor the content displayed
Works well in a consumer environment where little is known about the needs and interests of the individual Web visitor, especially for distributors and aggregators of content	Favourable business environment	Works well where a company sells a product or some number of products
• Net Perceptions' Recommendation Engine (RE) The RE, which is used by Amazon.com, CD-Now, Wine.com, Garden.com, and JCPenney.com, recommends products to you based on what other customers with similar tastes have purchased • Firefly's software also belongs to this category	Example	One-to-One product suite from BroadVision

Sources: www.netperceptions.com, www.broadvision.com, www. firefly.com, www.vignette.com, www.vantive.com, www. epiphany.com

A company's choice of personalisation approach depends on the form of personalisation it wants to pursue. There are four basic technological forms of personalisation. The most basic form is name recognition, wherein names of users are recognised and are used to address them on the Web site. Check-box personalisation involves personalisation of content based on user-provided information. Input comes from questionnaires, surveys, registration forms, etc. Segmentation and rules-based personalisation involves using demographic and psychographics information to segment people into groups. Specific content is then delivered to a 'group' of people based on "if this, then that" type rules. The final technological form is real-time personalisation. It offers the ability to modify the response to a user based on the changing perceptions of the user throughout the interaction. It is a more advanced, real-time version of preference-based personalisation where the behavioural preferences of a user are analysed and content is delivered accordingly.

Regardless of the personalisation-form a company opts for, both the buyer and seller stand to benefit. But these benefits can be realized only if the personalisation paradigm is adopted in the way it was conceived. In the enthusiasm for the potential of personalisation, the companies should not be naive and fall into the denial that can result from the domino effect acting through blind technology boosterism.

Personalisation's potential cuts two ways—both positively and adversely. Though personalisation has the potential to completely revolutionise market relationships, the success of personalisation is predicated on multiple factors. While some of these are centred on the concept, others are operational issues.

In many marketing situations, a transaction strategy is the most appropriate. In the transaction approach, the firm focuses on single exchanges, and profits are expected to follow these exchanges. To the extent that a firm has a long-term perspective, the emphasis is on image development and brand management. The primary means for communicating with customers is through mass media; the primary means of obtaining feedback is through traditional market research. Markets tend to be large, and a stable or rising market share is a key criterion for success. However, in other contexts, a relationship-building approach makes for a better (i.e., more profitable) strategy. In this approach, the time perspective is much longer; the profitability of single exchanges may be negative but justified as paying off in the long run. The emphasis is on customer management through personal communications and ongoing interactions with each customer. The Customer's mindshare is the key criterion to generate higher margins. This is often reflected in customer retention rates.

The transition from transaction-based marketing to personalised marketing is a paradigm shift for companies. It requires that companies move from "branding a product" to "branding a relationship" and generate loyalty. Not only is the paradigm shift is challenging, but also to holistically implement it in a company requires a cultural shift.

Personalised marketing is a win-win situation for both. Customers benefit from personalised and ap-

propriate products at the best price, delivered in the most convenient manner while requiring minimal search and acquisition costs. They get easier access to products they care about, and get personalised service that reflects their individual preferences without making them feel that their privacy is in jeopardy. This gives them a sense of power and confidence. As they experience the benefits of increased personalized service, they become more willing to provide further information, resulting in a feedback loop that continues to increase the benefits to both the company and customer. Finally, customers get better value because the company, by generating higher profit margins, will be able to offer better prices and offer higher quality of service.

In the short-term, personalisation will lead to larger sales per transaction, more frequently returning customers, and hence, more frequent sales for companies. The biggest benefit to the seller is a long-term relationship with the customer (customer loyalty) though. Customer loyalty contributes to business loyalty (Reichheld & Teal, 1996a). Business loyalty generates sustainable revenues and profitability (Sabat, 2001).

On its part, the customer has developed a deep awareness of irreplicability of the firm's value in meeting its needs and wants. The result is that it is in both parties' interests to continue the relationship, and it becomes difficult for another firm to duplicate the level of personalisation inherent in the offerings.

The challenge is that the partners should be able to see the tangible and intangible value in the relationship. The intangible value is derived from the customer's mindshare. In many cases, it may be costly to calculate LTV precisely for any particular customer. However, rough LTV analyses can be sometimes sufficient to make comparisons between customers, allowing firms to focus on those that represent greater LTV to the firm. However, there is a limit to using customer's mindshare to grow the business. This is because of two reasons: one, limited purchasing power of the customer caps the revenue stream from a customer to a company; and two, beyond a certain point, understanding a customer's new needs may turn out to be more expensive than acquiring another customer (Sabat, 2001).

Implementation of the personalisation paradigm requires significant organisational resources to be committed to training the human capital of the company, and of the extended enterprise (like channel partners, among others). Commitment of significant resources demands executive sponsorship. The reality is while a personalised marketing concept is the key to long-term sustainability of the firm's profitability, the firms are preoccupied mostly with achievement of short-term goals, like cash flow, return on investment, etc.

On the customer front, the key is to convince them that they engage in a win-win situation when they disclose personal information. Disclosing personal information is a sensititve issue. Personalisation ends up in a classic trade-off morass. The benefits of obtaining a personalized service is to be viewed vis-à-vis the potential problems of surrendering personal information by a customer to a third party. The questions about individual privacy and which companies should have access to profile data collected at Web sites are vital (Locke, 2000b).

By contrast, personalisation lives up to its true promise when companies use it to better understand and serve their markets in substantive, concrete ways. For this, it is important to recognize that personalisation methods differ in kind from traditional marketing approaches, and often follow entirely different principles (see Table 1 discussed earlier). They can also be used to accomplish far more than the marketing agenda called for in the past—ultimately, connecting customers in such a way that they benefit from each other's accumulated experience, knowledge, interests, inclinations and tastes. When this approach is taken, privacy will rarely become an issue.

Given that there is a premium set on the quality of information acquired about customers in the "identification and learning about customer" steps, how a company goes about acquiring quality customer data is a real challenge. A firm's strategic imperative to acquire information about its customers by either means—unobtrusive and intrusive—comes into direct conflict with customers' concerns about privacy. This is why a critical factor in successful knowledge acquisition strategies is trust. Thus, firms that view privacy concerns as an inconvenience run the risk of sabotaging the primary goal of cultivating enduring relationships with customers—to mutual detriment though.

A critical factor in successful knowledge acquisition strategies is trust.

Collaborative filtering systems, such as those used in software applications from Firefly and NetPerceptions, might be more in tune with the idea of customer's trust. However, a collaborative filtering makes recommendations to a customer based on the preferences this customer has declared to the Web site

and thanks to the opinions of other customers with similar tastes. Two issues arise then. What if the customer cannot explicitly express the expected benefit it is looking for in the form of features of products and services? Further, no two customers expect an identical set of benefits from the same product. These challenges can be surmounted if the marketing manager exercises due diligence to facilitate this step even while not losing leads to relevant information.

It is equally important that the meaning and importance of trust is to be viewed in terms of objectivity of seller's recommendations, and relevance of information about the customer. Different personalisation approaches are suitable for different situations. For rule-based systems, one has to ask how objective and effective are the modes to customise the products and services. Collaborative systems may be viewed as being more objective than rules-based systems because in the collaborative case the customer relies on other anonymous customers, while in the rules-based case, the marketing manager determines messages that are to be delivered.

Further, the information obtained from one customer may not be as relevant to the other; thus, reducing the cumulative impact of personalisation to the customer. How relevant is such information is an important factor to be considered, especially for collaborative filtering systems. Collaborative filtering is valuable in a limited range of domains like low-price commodities (buying books at Amazon, buying CDs from CD-Now), but may provide irrelevant leads regarding goods that are high-end or that are more person-specific like stocks (depends on investment profile of an individual).

Collaborative filtering is valuable in a limited range of domains like low-price commodities.

Even in domains related to taste, a customer tends to trust an expert. Moreover, taste could be also domain-specific so that the model that a company builds for movies does not really work for music. So, unless the customer does not care about the validity of the recommendations, or the recommendation does not impact a big financial decision, collaborative filtering will be relatively less relevant. At the same time, in a rules-based system, the expertise provided by the marketing manager could be driven by myopic business concerns.

Then, collaborative filtering is more suitable for distributors (like Amazon) and aggregators of content (like Yahoo!). However, rules-based is more useful to companies that have a product to sell or some number of products to sell.

In order to develop learning relationships between the buyers and sellers of products, companies need to create an atmosphere of trust and respect for customers' privacy. If privacy concerns are adequately addressed, people will volunteer additional information about themselves to companies they trust in order to use that information on their behalf and for their benefit. Imagine a car company that offered to connect owners of a specific vehicle, enabling them to talk about what they like and dislike about the product. Or, imagine a company that offered to connect people having a particular taste in films, or books, or software, or who practised certain trades or professions. How much would it cost to collect these attitudes and opinions via old-school 'market research?' However, without trust, no information will be disclosed and the system will not work.

A company can gain its customers' trust by disclosing what the company does with customer data. One institutional structure that has been established to address privacy concerns is the non-profit TrustE consortium, which consists of Web sites and privacy advocates that seek to enhance privacy relationships on the Web. To display the TrustE seal, sites must subit to an audit by TrustE, which guarantees to the public that the site adheres to the policies they post.

Customers will disclose accurate personal information if they believe they will benefit. That will happen if and only if they feel that they have total control over the information they provide, if they have something to gain in return for releasing the information, and if they know the purpose for which the information is being collected and, to some extent, the way the information will be used.

The customers need to be in control of what information they give out, when, and to whom. Businesses have begun to give users a chance to choose what type of personal information will be collected and how that information will be used. Personalisation technology should and now can make privacy controls available. With current technology, personalisation systems have been able to provide privacy covers for customers with the help of privacy tools like anonymous identifiers and by the use of aggregated data. This method is called *anonymous personalisation.* This method of personalisation helps Web visitors receive tailored information without disclosing personal information. When a customer decides to make a purchase or request contact by the company, they explicitly choose to give up their anonymity in return for perceived product benefits or the specific information they have requested.

Established brand equity of business, and adequate customer data management issues (security, accuracy and reliability) could sway things in favour of the seller. Customers also trust reliable brand names; so, establishing brand recognition early on is crucial. Further, adequate security of online personal data and data warehousing capabilities (data storage, data accuracy, and data mining) helps earn customer's trust.

While the role of interactive technologies in the development of relationship marketing cannot be more emphasised than the concept, strategy and tactical implementation, the success of this concept is heavily predicated on the efficient and effective use of interactive technologies. Technology has made outsourcing to customers at the mass customisation step (creating what the customers want) a reality. The idea is to leverage the collective knowledge of the entire customer base to anticipate the preferences of each customer. The real power of this system lies not only in its ability to anticipate preferences, but in its ability to link relationships among its user base, which consists of millions of users.

Many firms, especially the largest, most well-established ones, find it difficult to adapt to these technologies. They are the ones who typically stand to lose the most by sabotaging traditional sales channels. As a result, many large companies have been slow to respond to the opportunities afforded by the Web. In doing so, they risk being "Amazon'ed" by start-up firms that have no qualms about bypassing traditional channel structures. This is an important consideration that might become a hindrance for companies to switch to individualised marketing which has its fulcrum on interactive technologies.

Another challenge is while interactive technology is creating new opportunities for differential pricing (through personalised pricing and versioning), it can also make such pricing strategies more difficult when it is used to provide customers with better information about their choices. Indeed, customer ignorance or information secrecy has been traditionally a source of profit for companies. Today, however, online shopping agents can perform automatic price and feature comparisons for the customers leading to information democracy. There is a need to balance the use of twin radical forces of information secrecy and information democracy as weapons in personalisation.

In rules-based system, the marketing manager determines the messages that are delivered to the customer. If the company is plagued by the 'law of inertia,' it continues to inadvertently practice the adversarial business-as-war outlook that is a hangover from the days of mass production and mass marketing. In collaborative filtering, the seller has no control on the recommendations made to the buyer; the black box receives inputs from the customers which formulates recommendations based on patterns.

While based on many individual decisions in collaborative filtering, the larger pattern that emerges is much more than the sum of its parts. Because the filtered pattern is averaged against biases of many customers, this larger pattern is more objective, and hence, more dependable than the idiosyncrasies of personal taste. When applied correctly, what surfaces through this kind of correlation is the largely unconscious process by which social communities assess and measure value. This represents an instance of what complexity theorists call the 'emergent behavior' of complex systems. In emergent behaviour, the organisation and coordination take place without explicit planning or premediation. This gives 'tacit knowledge' – knowledge one has, but do not know that he/she has, or cannot adequately express. Though these clues are not infallible, comprehensive or definitive, these represent a lot more information than one can get from walking into a physical store. This is because this information is an output of a network of tacit knowledge embedded within a community. This tacit knowledge, in fact, defines a community that may not even exist as such in the non-virtual world.

Information is an output of a network of tacit knowledge embedded within a community.

Collaborative filtering enables companies like Amazon, CD-Now, Levi Strauss and others to collect and correlate data that constitutes tacit knowledge emerging across large online communities of interest, which are themselves only just emerging. It can improve a company's ability to bring widely distributed intellectual capital to bear on current business opportunities, and to affect such pairings in real time (Locke, 1999). Communities of interest, thus, enrich the marketing and customer knowledge base of the company. Companies can reap long-term benefits from this learning relationship, as discussed earlier in the paper.

While both of the personalisation approaches use the same database for the purpose, neither of these approaches necessarily depends on personal information. While collaborative filtering can be applied only to a limited number of domains, likely in an unreliable way, and in a business-wise inefficient mode, it has the prime on building communities that will help increase brand

equity and hence, generate revenue leads without stretching the bottomline

The key to successful personalisation is striking a balance between the company's business interests in boosting the topline and the service or advice it wants to give to customers to generate revenue leads and to build brand equity. Whether a company has been successful at its personalisation efforts or not can be assessed by asking three questions:

- *Does it offer true real-time personalisation to optimize every interaction?*

Traditional analytic and campaign management systems operate only in a batch mode and are, therefore, incapable of providing fact-based personalisation in real time when a customer visits the Web site, sends an email, or calls a call centre.

- *Does it provide a single view of the customer to the company, and to the customer of the company's offering?*

Most information technology (IT) environments are heterogeneous, with multiple disparate systems automating discrete business processes. To create a single view of the customer and of the offering, the software must be capable of drawing data from, and integrating with, all existing enterprise systems such as e-commerce servers, business-to-business exchanges, existing client/ server CRM applications, Enterprise Resource Planning (ERP) systems and data warehouses.

- *Does its customer interface strategy integrate all customer touch-points?*

The company should have a robust software application designed to address a full range of customer interactions across all touch-points, including the Web, telephone, email, on-line chat, fax, etc. Now businesses can not only capture information about every customer interaction, but also provide consistent interactions with each customer, regardless of the point of interaction.

Companies can use multiple Web personalisation commercial solutions incorporating the analytical modules discussed in the roadmap that have sprung up in the market to implement the roadmap and measure the personalisation index of their customer interfaces. To provide a personalised experience, these solutions use a number of techniques, namely, search, dynamic publishing, database triggers, and independent agents. Robust personalisation techniques often go far beyond being simple standalone tools; most are fully integrated environments that are significantly enhanced or limited by the overall Web architecture.

Conclusion

Drawing from leading thoughts on personalisation, the personalisation roadmap has been developed. This can provide companies a strategic perspective to generate business loyalty. Developed from an understanding of the demand and operational efficiency parameters in implementing customer interface strategy, the personalisation diagnostic instrument can help companies measure and benchmark the effectiveness of their interfaces' personalisation against that of industry-leaders. This will help serve the dual purpose of understanding the customer and of equipping the marketing manager to create favorable perceptions in customer minds. Because customer's perception of value of a product decides the success of the offering, favourable perceptions bring in successful offerings, which, in turn, will lead the company to business prosperity. By elaborating on how to implement this instrument and its utility in developing customer interface strategies to effectively devise marketing strategies, the challenges associated in its implementation are highlighted.

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Society, community, family are all conserving institutions. They try to maintin stability, and to prevent, or at least to slow down, change. But the organization of the post-capitalist society of organizations is a destabilizer. Because its function is to put knowledge to work—on tools, processes, and products; on work; on knowledge itself—it must be organized for constant change.

— Peter F. Drucker

Feature

Intranet Services for Competitive Advantage

M.P. Gupta & Gaurav Saxena

A survey of select Indian IT firms was carried out to understand the organisation wide information needs that intranet services can fulfill, and benefits these services can deliver. Following the survey, we suggest a flexible framework that managers can use to organize their thinking about corporate Intranets. A closer inspection reveals that there are different software applications neatly interwoven in intranet infrastructure that enables different intranet services. Each application service fulfills information needs with varying level of benefits and therefore, certain intranet services are more advantageous than others. The major problem that organisations face is, therefore, of identifying the critical services without which the intranet loses significance. The framework helps the management decide what Intranet based services should be developed for the company by identifying the information needs of the organisation and assessing the benefits associated. This helps organisations to select development plans for the appropriate applications and services leading to higher efficiency and effectiveness in operational and strategic measures to gain competitive advantage.

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Business and IT managers both recognize the potential for providing intranet support for a wide variety of business processes. Especially as corporate managers increasingly use publicly available Intranet and Web services on a daily basis, and cost for initiating corporate web pages, portals, authoring tools, databases and e-commerce infrastructures continue to drop. An intranet is a company-wide information distribution system that uses Internet tools and technology. It is a smaller version of the Internet that only the members of an organisation can see. Companies can create, within their walls, a manageable, secure version of the World Wide Web. Intranets enable work-flow management and project management, and are a platform for process redesign [Curry 1997; James, 1996]. It has been appreciated as the solution to organisational technology issues as far reaching as faster information systems development, access to legacy system data, integration of incompatible systems [Rettenmayer and Berry 1996], and progress towards the paperless office. Intranets facilitate collaborative expertise to develop, as engineers brainstorm and give each other feedback in discussion groups, and share product specifications and product test result queries [Cronin 1997, Stein and Zwass 1995].

Intranets have found wide applications in the medical [HLC 1996], legal, engineering, training, travel [Bittle 1996], technical, computer-related and manufacturing industries [Cronin 1997, Kotlas 1996]. Besides the increasing interests and applications of Intranet in organisations, theoretical research has been lacking. Evidence of the business value of the Intranet has been convincing [Ryan and Martin 1997]. On the other hand, some studies highlight on hidden costs [Gantz 1996], performance limitations [Dennis and Pootheri 1996], and organisational resistance [Bhattacherjee 1997, Cortese 1996]. These are explained by political and organisational learning theories that some gain and others lose when there is organisational change associated with IT implementation [Markus 1983, Orlikowski 1993, Robey 1995, Garvin 1993, Gill 1995, Sitkin 1996, Stein and Zwass

1995]. Scott (1998) suggested a theoretically-based model relating organisational knowledge to the Intranet phenomenon by extending the inductive concepts and analyzing examples of enabling conditions and organisational knowledge creation modes on intranets, using Nonaka's [Nonaka 1994, Nonaka and Takeuchi 1995] theory of organisational knowledge creation as a guide.

As companies face the management challenge of running the business competitively, the need to find the right combination of Intranet applications and tools, either off-the-shelf or developed in-house, to help do that job has increased. A plethora of products and software applications are available; choosing the best means for analyzing company systems, needs and goals and working within those parameters. Aligning Intranet services with corporate business objectives requires that support for one or more of the company's business objectives be demonstrated by planned Intranet services, specially with growing expenses.

We conducted a survey of select leading Indian IT firms in order to understand the benefits delivered by intranet services and applications. The research has been conducted in the IT industry segment as these organisations have been early adopters of Intranet and still, of all industrial segments, IT service companies has maximum intranet installation base. The learning helps us to suggest a flexible framework that managers can use to organize their thinking about corporate Intranets and decide what Intranet based services should be developed for the company.

The framework provides a rational basis for selecting the appropriate services by identifying the Information needs of the Organisation and prioritizing them on the basis of estimated benefits. This helps Organisations select development plans for the appropriate Applications and Services leading to higher efficiency and effectiveness in operational and strategic measures to gain competitive advantage. In IT industry, with larger survey base and experienced IT managers to opine about the benefits from Intranet, the quality of data gathered was expected to be better while using the framework. Further, due to the lack of previous work in this area, the research results are formative in nature rather than definitive.

Approach to Research

Sampling strategies were of major concern given the choice of methodology selected for this project. The results from this study were used for generalization of applicability of framework, therefore it mattered that the sample selected was a true, representative sample of the population under investigation.

Sampling was done for the following two categories of subject:

- iT managers: Since these experts are using and closely evaluating these services for extent of usage and benefits applicable to the Organisation as a whole, they have sufficient experience with corporate intranets to be able to answer questions regarding intranet use. Further, demands from Services cannot be expected to be consistent for all Organisations across industries as they have different procedures, operations and job roles. True service benefits yielded are a collective measure of technology benefits and extent of usage of that technology, which as explained above is a trait of industry where technology is put to use. Hence, the expert opinion had to be formulated for a industry by taking opinions from multiple experts and evaluating the consensus.
- Managers: Since the top managers are aware of Organisation wide context of different user needs, their opinion is a more unbiased, collective opinion on service requirements that organisations have from the central internal Web systems. Instead of biased opinion from a user who has a given role where needs are repetitive and bias creeps in, managers are expected to have better idea of usage/needs for different services/applications.

Given that the importance of a truly representative sample mattered to this research, random sampling was desired, but due to constraints of time and lower willingness of respondents to participate in research, convenience sampling was resorted to. However, since the problem construct defined the highly homogeneous population universe (IT managers taking care of Intranet systems), where all experts were expected to respond alike about Intraned benefits, the results from convenience sampling are expected to be no different than true random samples. Similar argument holds for the homogeneous IT user population where all IT users were expected to opine on relative level of needs from different intranet applications/services.

In such confirmatory questionnaire research the sample used for this project would almost certainly raise issues of sample bias and would therefore question the reliability and validity of the data collected. Hence, brainstorming sessions were conducted with fellow researchers to determine appropriateness of the assump-

tions in sampling, and the selection of population itself as true representative of subject. This was further validated for appropriateness by industry experts and faculty.

Data collection methods

Since the research topic was on new technology and mass opinion was required to form conclusions, the observation method was ruled out. As explained in sampling, convenience sampling was resorted to, with Questionnaire as Survey instrument. All constructs were carefully explained before asking for feedback from a respondent to ensure that thoughts of respondent are aligned with the research.

For this study we have administered two types of questionnaire for collecting information on two independent variables highlighted in the Literature review – Benefits & Needs. The "Expert survey for Benefit analysis" questionnaire was to asses the collective opinion of experts on benefits currently seen from intranet services. The other questionnaire was a standard "User survey for Need Analysis" designed to assess the level of independent variable need as seen for each service in the IT organisations.

Questions related to these areas were generated by brainstorming. A mind map was drawn up and using multi-nodal links a wide variety of topics and questions of interest were produced for the parameters highlighted in the literature review. These topics were then "siphoned" off into relevant categories for question generation. The Questionnaire collected the information on a 5- point scale (a Likert like scale). This also represented perceptual information in the minds of senior managers, and quantification was not possible:

- Very Low
- Low
- Moderate
- High
- Very High
- Can't Say

A mind map was drawn up and using multi-nodal links a wide variety of topics and questions of interest were produced.

In questionnaire 1, for each type of benefit resulting in overall organisation wide performance improvement, different traits as established in literature review were used to gauge the relative importance of each service at the workplace. These are Economic Measures (Relative Growth rate, ROI, Relative Market share), Organisational Measures (Decision-making, alignment of goals, job enrichment, conditions at work, relationship and Flexibility).

In questionnaire 2, the relationship of questions to needs from service is given in Table 1.

Table 1: Parameters in Questionnaire 2

Questions	Intranet Service
1-7	Information dissemination Service
8-15	Collaboration Service
16-23	Transaction Services
24-31	Process Services
32-37	Knowledge Management Services

For each service, different traits as established in literature review were used to gauge relative importance of each service at the workplace.

Information Dissemination Services: Ease of access, frequency of document distribution, frequency of changes in document, impact of delays in document delivery, cost of document creation and distribution, wastages in document printing, disparate systems.

Collaboration Services: Real time and offline need, multimedia enriched communication channels, high frequency of interaction with co-workers, centralized project management, shared resources managed between teams, frequent need to spread out Cross functional teams, decisions taken with Informal communication, idea sharing and discussion forums are appreciated.

Transaction Services: Frequent raising of requisitions, delay in requests is critical for projects, centralized data management, tracking of response on requests is critical, need to consolidate MIS on requests/responses, Routine decisions are data dependent, reports are required to be generated, fly based on current data, stress on automation of routine tasks and self help.

Process Services: Business processes are defined in a workflow as sequential steps, high volumes of information processing job, centralized data management for consistency, job scheduling efforts for synchroniza-

tion between members is high, more number of persons participating in the Information process, need to consolidate MIS on requests/responses, decisions taken on Report that is generated fly based on current data, Impact of delays and update in information are crucial, Disparate systems.

Knowledge Management Services: Learning and updation of skills is integral to job, requirement of problem sharing and solving, need to access and accumulate organisational tacit-explicit and cultural knowledge, frequency of decision on varied topics is high, cost of information re-creating is very high, usage of statistical modeling on past data for trend analysis.

Where relevant, portions of the research that discussed systems and observations were sent using e-mail to the respective interviewees for their confirmation that analysis and descriptions of observed models were correct. This ensured that what was stated in the research was factual and accurate. Through the use of SPSS the reliability test of questionnaire for Intranet Benefits and Service needs was conducted. The two test undertaken showed a high degree of reliability and these have been shown in the output given in Tables 2 and 3.

- Reliability: Benefit Analysis

Table 2: Reliability of Questionnaire 1

Reliability Analysis-Scale (Alpha)	
Number of Cases: 32	No of Items: 8
Reliability Coefficient	Alpha = 0.58 for all the 5 Services

- Reliability: Need Analysis

Table 3: Reliability of Questionnaire 2

Reliability Analysis Service 1: Information Dissemination	
Number of Cases: 46	No of Items: 7
Reliability Coefficient Alpha = 0.54	
Reliability Analysis Service 2: Collaboration	
Number of Cases: 46	No of Items: 8
Reliability Coefficient Alpha = 0.65	
Reliability Analysis Service 3: Transaction	
Number of Cases: 46	No of Items: 8
Reliability Coefficient Alpha = 0.65	
Reliability Analysis Service 4: Process	
Number of Cases: 46	No of Items: 8
Reliability Coefficient Alpha = 0.65	
Reliability Analysis Service 5: Knowledge Management	
Number of Cases: 46	No of Items: 6
Reliability Coefficient Alpha = 0.65	

As can be seen from the above findings that the reliability (value of alpha) of all tests are high and this means that the scales used in the tests are highly dependable.

Data Collection

This questionnaire was administered to the eight organisations, which are known names in Indian IT industry (Table 4).

Table 4: List of Sites Surveyed

Name of Company	Operations	Respondents	
		IT Managers	Users
Network Program India Ltd.	Telecom Software	5	5
DSQ Software Limited	Telecom Software	4	10
SoftEdge Solutions	Web Software Development	1	3
CoFuture	Software Services	3	8
Magic Software	Web Software	7	6
MCI WorldCom	Links	3	4
Servion Global Ltd.	CRM Software	3	3
Tata Telecom Ltd	Business Communications	6	7
		32	46

In all these organisations the questionnaire was used for feedback by IT managers and users across the functional departments. The employee strength of the organisation under study varied from 30 employees to 200 employees at the present location. For DSQ, and Servion, there are multiple locations but separate Intranets exist for each local centre as the remote offices are not networked. MCI provides true centralized Intranet to its employees across the globe. As all the above companies are in IT areas, the population was fairly consistent and qualifies for both kinds of replications. Thus, it helped to have a faithful data, which could support or contrast the opinions in a strong manner. The information of most relevance to the research was that which enabled a picture to be built identifying the distinct needs and benefits of each Intranet service. Table 5 summarizes the Respondents Profile. As we see the major respondents are in 5-10 years that is, high experience domain, the results can be expected to be valid and good indicator of gross benefit.

Table 5: Profiles of IT Managers Surveyed

Experience of IT managers	Experience (Years)
< 5 years	13
5-10 Years	17
> 10 years	2

Data Analysis

In order to make sense of the data collected, analysis of information collected as responses to questionnaires was performed. This involved the transcription of responses properly organized and categorized into Excel spreadsheets and usage of appropriate statistical method for drawing trends from data. SPSS and Microsoft Excel were used for carrying out Statistical Analysis while Microsoft Word was used for Documentation. Following analysis were carried out:

- Analysis of Benefit from different Intranet Services
- Analysis of Information Needs
- Analysis of Dependent Variable

Analysis of Benefit from different Intranet Services

For analysis of economic benefits and Organisation benefits the central tendency of rated benefits (mean value) and standard deviation of all questions is calculated. After calculating means of all questions an overall mean and standard deviation is calculated separately for Economic benefits and Organisational benefits. The overall means are then ranked to infer the overall ranking of organisations in terms of benefits as given in Table 6 below:

Economic Benefits

Table 6: Analysis of Economic Benefits from different Intranet Services

Service	Mean of Economic Benefits	Rank
Information Dissemination	4.1	2
Collaboration	3.6	4
Transaction	4.3	1
Process	4.0	3
Knowledge Management	1.5	5

From the above table, we see that Simple Transaction services yield maximum returns as per the experts and is ranked 1st amongst all services. This is in line with literature survey where database access with simple front end screen have been seen as a powerful tool relieving many persons from mundane task of data review and recreation in some other form for further use, thereby confirming low cost-high benefit nature of Transaction service. The information dissemination service which by far is the most commonly adopted service is ranked 2nd, while the process services follow closely at 3rd position. The collaboration services have been ranked 4th in terms of cost savings analysis and knowledge management applications are seen as very poor re-coverer of investment and is ranked 5th.

For all the responses, the z-value is in excess of 1.28 for higher side and lesser than ö1.28 for lower side, which marks the critical value in single tail z-test for given alpha of 0.10 (for 90% population opinion) level of significance. Here we had tested that mean value computed from the sample is away from the hypothesized mean 3 using single tailed z-test and conclude that population have rated the service as highly beneficial or otherwise. Thus, we can say with surety that the stipulated mean value is no different from the mean.

The interesting observation is that Transaction services, which require little business logic to create front end to database yields maximum returns. The cost incurred in these services is definitely not the lowest, but by eliminating mundane tasks, it benefits the organisation maximum in terms of cost/benefit ratio. All data logging and assimilation activities are a regular part of everyone's job and if taken seriously, can eat up a lot of precious time, which is eliminated by simple database operations in intranet. Also, the quality of data gathered is expected to be better as simple rules imposed to log data on time, comparing data entered with master records etc can be used to bring high accuracy in monitoring and predicting future course of action. Since the organisations covered were involved in some form or other in development of intranet, these custom developments were rated high showing more faith in adaptation of simple activities on Intranet.

Transaction services, which require little business logic yields maximum returns.

Information dissemination service is ranked 2nd with mean weight quite close to the 1st one and this result was also expected, as the Information dissemination is one of the most visible and tangible advantages of the Intranet. With intranet acting as documentation repository, the information is just a click away. Since,

now the employees have faster access to more accurate information, they can take better decisions and work with greater effectiveness. With better knowledge, employees will become empowered to go out and create better relationships with customers, suppliers and distributors. Better relationships will lead to greater revenue and lower costs. All this is visible in day-to-day activities in form of increased sales calls, better quality documentation and service calls closure rate. Since this is one of the cheapest services, the cost/benefit ratio is high.

The process services definitely improve the operational efficiency much better than transaction services, as they cover wider range of tasks and bind them together. However, given the high costs of all such applications (ERP, SCM, CRM etc), the benefits get overshadowed and the experts opine that cost/benefit ratio is less than transaction services.

Surprisingly, the collaboration services have been ranked low at level 4, whereas this is one of the most widely adopted services. The possible reasons suggested were that it has now become an indispensable service as there are few comparative technologies and also most of customers/vendors have adopted these and all information internally moved also needs to be compatible with those standards. The costs of mail servers with hundred of Gigabytes of disk spaces and high up time raises the cost significantly and again the benefits gets overshadowed. Also, discussion forums etc are not that widely used till date and their lower acceptance reduces the yield.

The knowledge management services have been ranked last and is the only service where economic losses are predicted, as these services require very heavy investments in creation of knowledge repository in form of data warehouses and embedding data mining in Web servers to dig out trends. More than technology, the success of this service depends on accumulation of past experiences and maintenance of those for supporting future works. As the organisations are relatively newer, and other than basic search engines, nothing much have been implemented, the real benefits extracted are lower and this remains an hyped application.

Knowledge management services is the only service where economic losses are predicted.

As seen from Fig. 1, most of the experts have opined about definite ROI from most of the Intranet services as well as high growth rate, which are the internal competitive advantages. The experts are not very confidently advocating the impact on increase in relative market share, which is an external attribute.

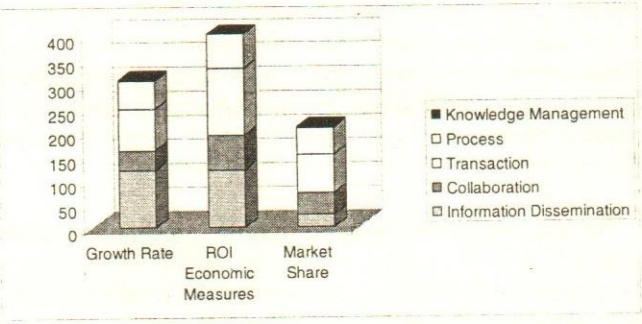

Fig. 1. Economic measures which gets maximum impacted from Intranet

Table 7: Analysis of Organisational Benefits from different Intranet Services

Service	Mean of Organisational Benefits	Rank
Information Dissemination	4.0	2
Collaboration	4.2	1
Transaction	3.7	3
Process	3.2	4
Knowledge Management	2.5	5

From Table 7, we see that Collaboration service yield maximum organisational benefits as per the experts and is ranked 1st amongst all services. This also is in line with literature survey where free communication is deemed as major contributor in creating positive culture and facilitating other soft benefits. The information dissemination service is ranked 2nd here also as these are standard services used in top-down communication. The transaction services follow closely at 3rd position. The process services have been ranked 4th in terms of soft benefits while knowledge management applications are ranked 5th as these are not very popular in context other than decision making and few IT managers have even indicated "can't say" as established benefits are not visible.

For all the responses, the z-value was checked to be in excess of 1.28 or lower than –1.28, which marks the critical value in single tail z-test for given alpha of 0.10 (for 90% population opinion) level of significance. Here we had tested that mean value computed from the sample is away from the hypothesized mean 3 using single tailed z-test and conclude that populations have rated the service as highly beneficial or otherwise. Thus, we can say with surety that the stipulated mean value is no different from the mean if entire population opinion

would have been collected. However, only for information dissemination and collaboration services the z test gave the confident rating of being high and significantly away from central value 3. For process services and transaction services, the z test didn't show the mean being higher or lower with significance of .1. For knowledge management, the z test showed population significantly of the opinion that knowledge management services presently are not yielding organisational benefits either.

As was expected, collaboration services have been ranked first, as free communication is the most important influencer in getting soft benefits. This explains perhaps why this is one of the most widely adopted services and has now become indispensable with most customers/vendors organisations also having adopted these and further forcing the information internally moved also to be compatible with those standards.

Information dissemination service is ranked 2nd with mean weight quite close to the 1st one and this result was also expected, as Information dissemination is one of the most visible and tangible advantages of the Intranet. Till date, papers were used to broadcast information and now intranet is doing it in a more effective way, where the information can be accessed at convenience, anytime. With intranet acting as documentation repository, the information is just a click away. For all Top down messages, bulletin boards and static Web pages have been widely used and since, now the employees have faster access to more accurate information, they can take better decisions and work with greater effectiveness leading to greater revenue and lower costs.

The interesting observation is that transaction services have also been recognized as major contributor in Organisational benefits and is ranked 3rd for its contribution in job enrichment, alignment of goals and decision-making. The mundane tasks of data logging and assimilation activities are a regular part of everyone's job and can eat up a lot of time, which is eliminated by simple database operations. And simple automation of such tasks yields significantly in boosting employee morale by freeing him to focus on more creative and beneficial tasks.

The process services are seen more as part of job roles with some contribution to relationship building and better work conditions resulting from well-managed data. Since the adoption is low, these services have not been fully evaluated and soft benefits are yet to be fully explored. The z-value close to zero is more representative of less critical usage and lack of informing opinion.

The knowledge management services have again been ranked last as these organisations are relatively newer, and nothing much have been implemented, the real benefits extracted are lower and this remains an hyped application. All the managers have opined strongly against the current level of benefits from these services, but in the future, with more and more complex work conditions, these services may be needed more and possible benefits may also get enhanced.

As seen from Fig. 2, most of the experts have opined about increased decision-making, better alignment of goals, and enrichment in job in most of the intranet services. They have also reposed faith in enhancement in relationship with all external parties and increase in flexibility/risk management.

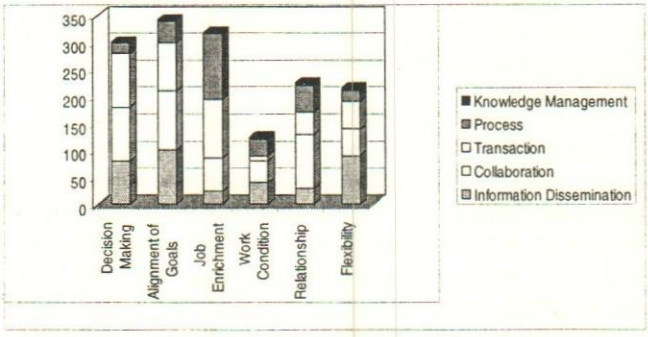

Fig. 2. Economic measures which gets maximum impacted from Intranet

Overall benefits from different Intranet Services

Though it is the Organisation's choice to compare economic benefits vs Organisational benefits and quantify them as weights for overall prioritization, as there are no strict rules and a poorly doing company use economic criteria as first and foremost, while cash rich companies are not interested in sole economic measures and give more weightage to Organisational benefits. Both set of factors are significant determinants of a firm's performance, and these two are roughly independent and Organisational factors explain more variance in profit rates than economic factors. Still, for modeling purpose we want a cumulative figure, which is indicative of joint effect of both the variables.

Table 8: Analysis of overall Benefits from different Intranet Services

Service	Mean of Overall Benefits	Rank
Information Dissemination	4.05	1
Collaboration	3.9	3
Transaction	4.0	2
Process	3.6	4
Knowledge Management	2.0	5

Here, for sake of simplicity, we have taken the weights equal, and computed the mean weight as overall benefit score. For organisations that have clearly laid out importance/weights for both these benefits, the rank may differ. From Table 8, as we see, Information dissemination service slightly outweigh transaction services and have been ranked at number 1 position. The transaction services stand 2nd while collaboration services are ranked at 3rd position in gross benefit scores. Further, process services obtain 4th position in overall score, while knowledge management services are ranked 5th.

This result, oblivious of the needs of different users represents the gross benefits that organisations having same traits as IT industry are able to harness from internal Web based systems. If the organisation is not too sure of its needs, then these results alone can be used as guides for selecting appropriate services.

Analysis of Information Needs

For analysis of Information needs, the mean value and standard deviation of each service related question is calculated for overall population. After calculating means of all questions an overall mean and standard deviation is calculated to represent information need score of each Intranet service. The overall means are then ranked to infer the overall ranking of organisations in terms of information needs as given in Table 9 below:

Table 9: Analysis of Information needs from different Intranet Services

Service	Mean of Overall Benefits	Rank
Information Dissemination	4.1	1
Collaboration	3.8	3
Transaction	2.5	5
Process	3.3	4
Knowledge Management	4.0	2

From the above table we deduce that maximum user information needs can be serviced by deployment of Information dissemination services which is ranked 1st by users. The users have indicated a strong inclination for Knowledge management needs and rated it 2nd most required service. This probably is attributed to high rate of obsolescence and need for continuous technology update required by users in IT domain. The collaboration service needs have been ranked as 3rd service. There is very less difference between gross weights of these three services, which indicates nearly equal relevance of each service and in future, even with slight changes in job roles, the sequence may change. Process Service needs have been ranked at 4th position while Transaction services have been ranked at 5th position. This may be attributed to the fact that people feel more attracted to fully automated and integrated processes when compared to intermediate simple database services.

Users have indicated a strong inclination for Knowledge management needs and rated it 2nd most required service.

For all the responses, the z-value is in excess of 1.28 for higher side and lesser than ö1.28 for lower side, which marks the critical value in single tail z-test for given alpha of 0.10 (for 90% population opinion) level of significance. Here we had tested that mean value computed from the sample is away from the hypothesized mean 3 using single tailed z-test and conclude that population have rated the service as highly needed or otherwise. Thus, we can say with surety that the stipulated mean value is no different from the mean if entire population opinion would have been collected.

Information dissemination service which is one of the most visible is also most needed and is ranked 1st by the users. In IT industry, nearly all the job roles require continuous reading and updation as changes happen pretty fast. For all the different aspects of static information broadcast like ease of access, frequency of document distribution, frequency of changes in document, impact of delays in document delivery, cost of document creation and distribution, wastages in document printing, Disparate systems, the respondents have unanimously opined that z value suggests significantly higher requirement of document management system.

The knowledge management services have been ranked 2nd due to a growing complex environment and more diverse nature of problems coming up demanding solution in a short span of time, which requires extensive knowledge of past trends and collective decision making. For all the different aspects of knowledge management like learning and updation of skills being integral to job, requirement of problem sharing and solving space, need to access and accumulate organisational tacit-explicit and cultural knowledge, high frequency of decision on varied topics, higher cost of information re-creation, usage of Statistical modeling on past data for trend analysis, the respondents have unanimously opined significantly higher requirement and this gets reflected in z value.

substantially in a beneficial manner and rank 1, which suggests that this should be the first service to be adopted by new divisions/organisations looking for intranet deployment. This is closely followed by collaboration services which is again ranked 2nd with good overall need and benefit score, and explains the dominant adoption of such services. The Process service achieves the 3rd rank overall with good perceptible fulfillment of organisation wide task integration. The Transaction service as well as Knowledge Management service are ranked 4th though experts rate Transaction service high on benefit score.

Selection of Services if both the benefits matter

This analysis applies to all general Organisations that are interested in Organisation as well as economic benefits from any investment in technology.

Table 12: Overall Benefits and Information needs for prioritizing Intranet Services

Service	Mean of Economic Benefits	Mean of Information needs	Overall Weights of Intranet Services	Rank
Information Dissemination	4.05	4.1	8.15	1
Collaboration	3.9	3.8	7.7	2
Transaction	4.0	2.5	6.5	4
Process	3.6	3.3	6.9	3
Knowledge Management	2.0	4.0	6.0	5

Table 12 incidentally is same as that in case of economic benefits as determining criteria. It highlights that Information dissemination service fulfils information needs substantially in a beneficial manner and get rank 1, which suggests that this should be the first service to be adopted by new divisions/organisations looking for intranet deployment. This is closely followed by collaboration services which is ranked 2nd with good overall need and benefit score, and explains the dominant adoption of such services. The Process service achieves the 3rd rank overall with good perceptible fulfillment of organisation wide task integration. The Transaction service is ranked 4th though experts rate it high on benefit score whereas knowledge management is ranked 5th i.e. it forms the last choice on service comparison list.

For Intranet services to benefit the company they should have direct impact on how management and staff work. Management should ask questions such as:

- What business decisions (e.g., day to day, operational, strategic) would benefit Most for improved Intranet based services? Why?
- What business decisions (e.g., day to day, operational, strategic) would benefit Least for improved Intranet based services? Why?
- Who can provide insight into these management decisions? Who are they? Where are they?
- What is the best way to involve these corporate business leaders and process owners in the definition of required services?

It helps to classify decision making into different categories where each category can have an impact on defining an appropriate Intranet service. Decisions associated with planning, product development, research, or merger/acquisition activity may be complex, distributed over long periods of time, and difficult to model or define rule sets. The best set of services would be therefore, ones that by virtue of technology deliver maximum values, and also are needed most by the organisation to solve its problems on a regular basis (Fig. 3).

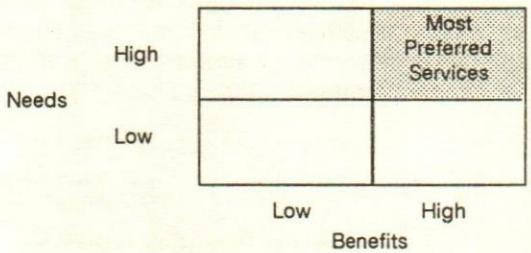

Fig. 3. Identifying most value adding services on Intranet

The model of the decision making process where the choice depended on individual score of each service based on

$$Y(x) = N(x) + M(x)$$

where,

Y(x) = Preference weight for Service x.

N(x) = User provided weight for Needs from Service x.

M(x) = Expert provided weight for Benefits from Service x.

And Further,

Best Service = max(Y(x) for x = 1 to n)

Since, the Gross benefits accrued from the service

depends not only on technology but also the extent of usage of technology/service, we may define the overall benefits in terms of both as–

Overall Service deployment Benefits	=	Savings per transaction from specific Intranet service over comparative technology	×	Repetitive usage extent of the service/application

These benefits are usually projected at the time of making project plans for any capital budgeting decision when budgets are approved. Later, with the working systems, IT managers track the usage to determine how effectively the resources are being utilized and make strategies for increasing benefits from investments. Similarly, the need assessment can be best done by users from different functional departments as Intranet finally is going to serve their work related needs only.

All the above results have been computed based on the above model of the decision making process. Further to have a better representation of the entire data collected, we used the 2 dimensional plot of Information needs vs Benefits accrued and identify those services (figure 4), which collectively takes care of most information needs while ensuring maximum benefits from the investment in each of these services.

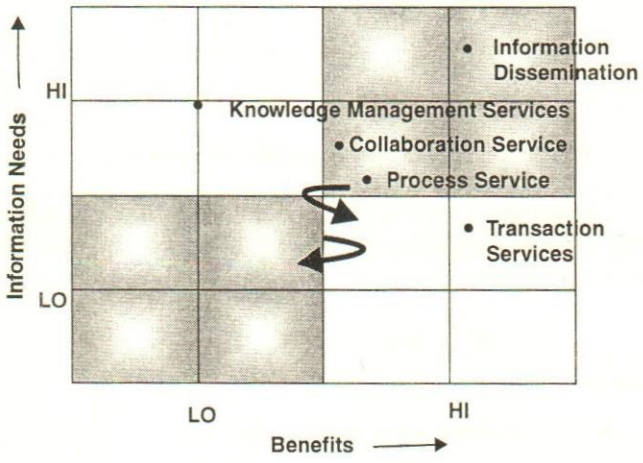

Fig. 4. Preferred Intranet Services identified in Survey

Since Information dissemination, collaboration service and process service lies in "most Preferred Quadrant", these set of services must be adopted first by any IT organisation planning to setup Intranet or expand/evolve its intranet. After these services, Organisations must target those services where information needs are high i.e. knowledge management services as they are required by work staff and finally the transaction services.

The results were largely in conformance with Meta Group's research that identified database access applications (same category as Transaction services) only in use at 7 per cent of the surveyed businesses but offered a remarkable 68 per cent return on investment. For using intranet for publishing documents–such as the company newsletter, events calendar, and similar material, the return on investment for publishing information, ranged between 10 per cent to as high as 100 per cent (in Sun Microsystems case). The process services like Inventory-management applications calculated to have a 52 per cent ROI, were exceptionally unusual: only two companies of those surveyed had it.

In the report, Meta Group officials said that the results of the study show that companies that carefully select applications for intranet deployment, and that have the cooperation of product managers, would benefit the most from intranet technology. The second aspect is not covered in this study.

The ideal way of going about deployment of services is–

(i) Select those services that have both needs and benefits as high

(ii) Then select those services that have needs as high, benefits as low

(iii) Then select those services that have needs as low and benefits as high

(iv) Finally, select those services that have both needs and benefits as low.

Representing this in the graphical model (Fig. 5),

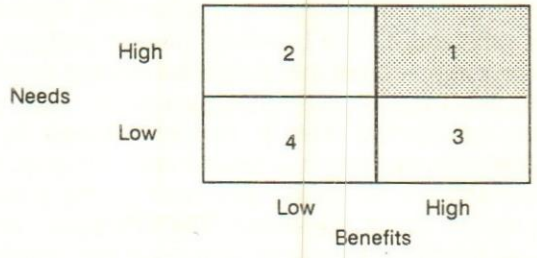

Fig. 5. Defining the order of services on Intranet

There are some limitation of the study. A larger sample size gives more faithful representation. Instead of convenience sampling, true random sampling would have yielded better quality data. The literature reviewed made reference to increased communication and knowledge sharing as a potential benefit that intranet bring to a corporation. The organisations observed had not been successful at communication and knowledge

sharing. Research into the disparity between the literature claims and the actual manifestation of this facet would be useful. It would be interesting to expand this research to other industries also. A widespread study over a longer period of time using a larger sample size that ensured stronger reliability and validity measurements would make an interesting contribution to the information management literature.

Concluding Remarks

In this paper, the business benefit of the Intranet is evaluated in terms of its' significance to senior management, primarily: who decides to invest, overall return on investment expectation; it's association with business strategy; it's current and planned deployment over the next short-term strategy period. Analysis of the survey responses also identifies both the tangible and intangible benefits currently being experienced by those with existing Intranet Web sites, and envisaged by those who plan to expand/launch their internal Web using their past experiences of this technology. It is found that Information dissemination services, Collaboration services and Process services in IT industry are the most worthy and should be adopted first, followed by Knowledge Management and Transaction services. Most companies tend to approach intranet implementation as a technology issue rather than a business issue. This tends to increase implementation costs, as new and incompatible technologies for security, access and application design are built and deployed, rather than reusing existing solutions. Intranet system is an Investment too, and like any other technology, must be evaluated on its merits. Part of the reason for the large interest and deployment of intranet is attributed to the benefits an intranet can bring to a corporation but not each organisation can expect to avail same level of benefits from the Intranet services and hence finding the "best fit" is crucial to Intranet development strategy. The IT managers can use the framework to evolve their thinking about Intranet and form Intranet development plans.

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Feature

Measuring Concentration in Indian Cement Industry

Pushpa Kumari

The present paper measures the concentration in the Indian cement industry during 1990-2001, the liberalised period. It is measured in both the ways, absolute and relative, using the data on cement capacity and cement production. By all the measures Concentration Ratios, Herfindahl Index and Gini Coefficient concentration in the cement industry is found to be high. It is still higher in cement production than capacity and is growing at a faster pace in the case of production. Industry was fully deregulated to increase competition, which normally requires reduced concentration. Somehow this has not come about in practice.

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Indian cement industry has remained for long in the limelight as a few dominant players of the industry are said to have exercised market power. They are said to have formed a cartel to affect the supply and price of the cement. In industrial economics market power is generally associated with the industries, which are highly concentrated in the hands of a few players. One school of thought led by Bain (1956) during the 1960s established this market-power based view and suggested that more concentrated industries tend to be more collusive and therefore non-competitive. There is another school of thought led by Demsetz (1973), which established efficiency-based view and put forward that owing to a small number of larger firms in a concentrated industry, firms tend to be more competitive and therefore efficient. Yet positive correlation between seller concentration and market power has come to stay in the recent empirical findings. In this background, it is interesting to investigate the seller concentration in the Indian cement industry. However, present paper does not attempt to find out whether or not seller concentration and market power are correlated. In the first part of the paper current scene of Indian cement industry and in the second concentration measures will be described briefly. Third part will be on the measurement of concentration in the Indian cement industry.

Current Scene of Indian Cement Industry

Cement industry of India experienced full decontrol in 1989 and delicensing in 1991. These policy-shifts have led to several factors which include, for instance, large scale consolidation and restructuring, declining share of public sector either as a producer or bulk buyer, free entry of cement MNCs, better management, and use of marketing skills etc. Because of government's focus on physical infrastructure and expansion of real estate and housing sector, demand for cement is bound to increase in the construction sector as a whole. On the other hand, supply side has now

been characterized by factors like excess supply and intermittent overcapacity, no imports, low exports (between 2-4 per cent), efficient technology (e.g. dry process technology switched from wet or semi-dry technology, usage of cheaper and high caloriffic imported coal, installation of energy efficient balancing equipment, sea transportation, split locational plants, etc.).

Demand and supply side position of the cement industry as a whole is shown in Table 1. When demand, production and capacity figures are taken together, also shown in Graph 1, these show oversupply and excess capacity in the industry. During 2000-01 demand, production and capacity were 90.3, 99.66 and 130.41 million tonnes, respectively. Low level of per capita cement consumption for India as compared to that for world, for instance 99 kg. as against 263 kg. during 2001, indicates that a huge consumption gap exists for India which will be bridged as the economy grows. Per capita consumption has grown at an average annual rate of 5.79 per cent for India as compared to 1.96 per cent for the world during 1990-2001. Thus, it again reflects the huge growth potential for Indian cement industry.

Concentration Measures

Concentration generally meaning production/capacity/sales etc. under the control of 'a few' or 'dominant few' is in fact measured in two ways: (a) absolute concentration, where a few firms' domination is measured; and (b) relative concentration, which measures inequality in size distribution of firms in an industry. A change in one may affect the other, however, both are distinct concepts with a different significance and different uses in analysis. Absolute concentration may be high, for example, and relative concentration very low, for absolute concentration indicates nothing about the size distribution of firms within the group. For instance, if an entire industry contains two firms only, the industry will be highly concentrated in the absolute sense, but if the two firms are of equal size it will show perfect equality. Conversely, relative concentration is not indicative of absolute concentration; former may decrease while latter increases when smaller firms leave an industry, an extensive merger may reduce relative concentration but cannot reduce absolute concentration (Penrose, 1995).

In the present paper concentration is measured in both the ways, absolute and relative to find out whether industry is dominated by a few; and also whether cement industry in India is equally or inequally distributed in firms. Most common concentration measures will be used, namely, concentration ratio (CR), Herfindahl Index (HI) [both absolute concentration measures] and Gini Coefficient (G) [relative concentration measure]. Concentration ratio will be calculated for the top 4, 8 and 12 players and will be denoted as C4, C8, and C12 respectively.

Concentration Measurement in Indian Cement Industry

Gopinath Pradhan (1992) estimated concentration in the Indian cement industry after the change in government policy in 1982. He compared two periods: period of total control (till 1982) and period of partial control (1982-1989; though he covered the period upto 1986 in his study); He found that the rate of decline of concentration slowed down after 1982 and thus established that in contrast to the earlier trend the post 1982 period has experienced an increasing control of production by a few big producers.

The rate of decline of concentration slowed down after 1982.

After this study two major events occurred, industry was fully decontrolled and then delicenced. Hence there have been no regulations since 1991 regarding entry, exit, pricing, production and distribution. What has happened to the concentration during the 1990s is studied in this paper.

All the measures, CRS (C4, C8, C12), HI and G, are calculated using the data on cement capacity and cement production during 1990-2001 (1990-2000 for production because data were available only for that period at the time of study).

Both the sectors, public and private, are included. To capture the actual concentration of the market players, it is preferred to take data on various business groups (in case of groups, otherwise data on companies will be considered). Since, similar to Indian manufacturing sector as a whole, cement industry is dominated by large business groups. Cement industry, being a capital-intensive industry, might have attracted these groups to take advantage of their investible capital (Pradhan, 1992).

Cement industry of India is dominated by large plants. The large plants contribute more than 90 per cent cement capacity/production. Table 1 shows that mini plants' average share in the industry's capacity/production was about 7 per cent during 1990-

2001/1990-2000. As data is not available for mini plants, Herfindahl Index (HI) and Gini coefficient (G) cannot be calculated for all the plants because data on each group/company is required in their calculation. However, Concentration ratios (CRs) may be calculated for all the plants taken together since in their calculation, data on shares of top players are required. Therefore, HI and G are calculated only for large plants though CRs (C4, C8, C12) are calculated for both, all plants and large plants. Results on CRs, HI and G for cement capacity/production during 1990-2001/1990-2000 are shown in Table 2/Table 3. Graphs 2 to 5 also present CRs for cement capacity/production.

Table 1: Cement Industry at a Glance (1990-2001)

(Million tonnes unless otherwise indicated)

Year	Total Demand	Production	Capacity	Per Capita Consumption (kg)*	
				India	World
1990-1991	45.8	48.90	64.36	57	217
1991-1992	50.5	53.61	66.56	63	216
1992-1993	49.9	54.08	70.19	61	225
1993-1994	52.9	57.96	76.88	62	233
1994-1995	56.6	62.35	83.79	65	243
1995-1996	62.9	69.63	95.76	72	254
1996-1997	68.2	76.22	105.26	78	257
1997-1998	73.9	83.36	110.51	82	263
1998-1999	79.8	87.91	118.97	85	261
1999-2000	92.1	100.45	119.1	97	263
2000-2001	90.3	99.66	130.41	99	263

Source: Centre for Industrial & Economic Research, Industrial Databook 2000-01; CMA, Cement Statistics 2001; K.D. Gadhok, Cement Industry in Millennium-Vision, 2001.

* Year-wise data, starting from 1990 till 2001.

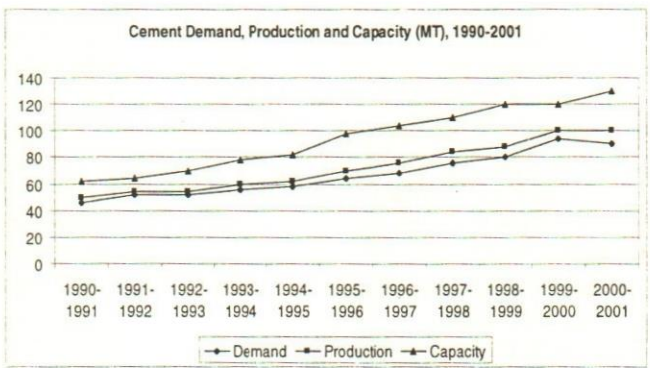

Fig. 1. Graph 1

Table 2 and Graph 2 show that more than 50 per cent of the industry's total cement capacity is concentrated in top four players; it was 51.67 per cent during 2000-01 that increased from 48.5 per cent during 1990-91. C4 has grown though at a low average annual rate of 0.70 per cent during 1990-2001. Next four players held about 17 per cent of total capacity (making C8 to be 68.71 per cent during 2000-01 from 66.45 per cent during 1990-91). Only about 9 per cent of total capacity was controlled by the four groups/companies falling between the rank of 9 and 12 (making C12 77.57 per cent in 2000-01 from 74.81 per cent in 1990-91). This is how total capacity in cement industry is concentrated in a few hands, as also clearly indicated by the largest bottom block and then by smaller subsequent blocks in Graph 2. Situation is even worse in the case of cement capacity of large plants as shown in Table 2 and Graph 3. C4, C8 and C12 during 2000-01 were 55.35, 73.61

Table 2: Share of Mini Plants in Industry's Capacity/Production

Year	Mini plants' Capacity as % of Total	Mini Plants' Production as % of Total
1990-91	7.83	6.43
1991-92	7.59	5.60
1992-93	7.20	6.21
1993-94	7.05	6.68
1994-95	6.56	6.40
1995-96	9.19	7.24
1996-97	8.37	8.18
1997-98	7.97	7.94
1998-99	7.40	6.93
1999-00	5.10	6.21
2000-01	6.50	–
Average	7.34	6.78

Source: Gadhok, K.D., Cement Industry in Millennium – Vision, 2001.

Note: Calculated as difference of total and large plants' capacity/production of cement.

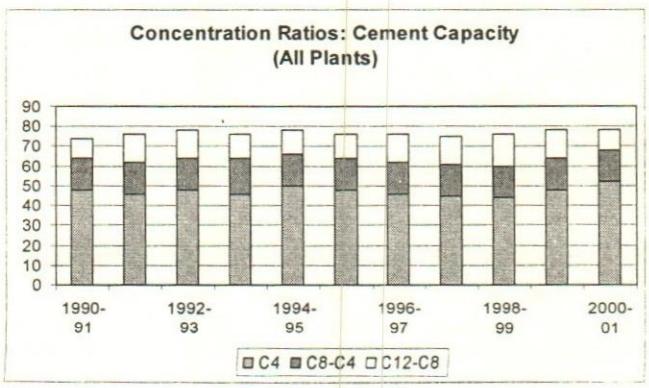

Fig. 2. Graph 2

Table 3: Concentration Measures: Cement Capacity

Year	Concentration Ratios						Herfindahl Index	Gini efficient
	All Plants			Large Plants				
	C4	C8	C12	C4	C8	C12		
1990-91	48.51	66.45	74.81	52.81	72.34	81.44	546.81	0.57
1991-92	48.07	65.87	75.75	52.19	71.51	82.24	533.92	0.57
1992-93	48.90	67.13	76.79	52.86	72.57	83.01	535.40	0.57
1993-94	46.64	65.13	75.28	50.31	70.27	81.22	503.55	0.56
1994-95	49.65	67.83	77.31	53.27	72.78	82.95	547.56	0.59
1995-96	48.46	67.73	76.12	53.49	74.76	84.01	565.63	0.60
1996-97	46.97	66.61	75.83	51.37	72.84	82.92	550.00	0.60
1997-98	46.23	65.93	74.71	50.33	71.78	81.33	532.88	0.59
1998-99	49.17	68.23	76.38	53.19	73.81	82.63	567.74	0.60
1999-00	50.42	69.71	77.86	53.23	73.59	82.19	570.52	0.61
2000-01	51.67	68.71	77.57	55.35	73.61	83.10	595.64	0.62
Average Annual Growth Rate (%) during 1990-2001	0.70	0.36	0.38	0.53	0.20	0.21	0.96	0.86

and 83.10 per cent (52.81, 72.34 and 81.44 during 1990-91) in large plants as compared to 51.67, 68.71 and 77.57 per cent (48.51, 66.45 and 74.81 during 1990-91) in all plants, respectively. In the sample of 43 groups/companies operating on large plants, top 12 control about 83 per cent and another 31 players controlled remaining 17 per cent of the capacity during 2000-01.

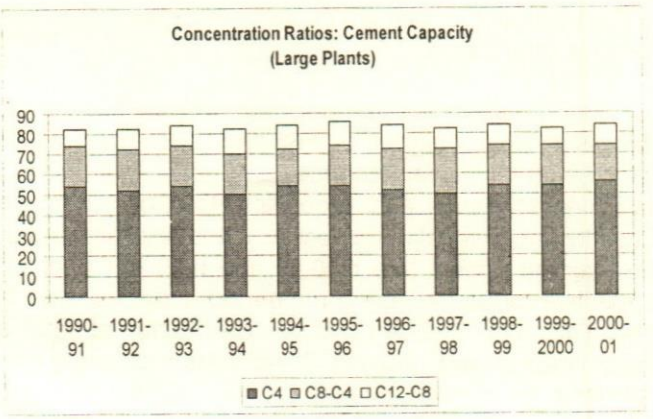

Fig. 3. Graph 3

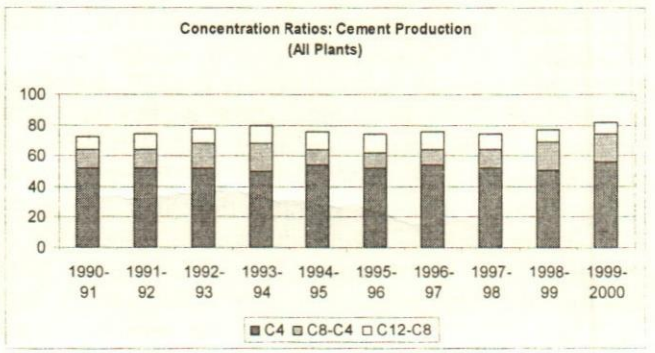

Fig. 4. Graph 4

So far as cement production in the industry/all plants is concerned, it is more concentrated and also growing at a higher rate than that of cement capacity as indicated in Table 3, Graphs 4 and 5. C4, C8 and C12 in percentage in 1999-2000 were 54.99, 74.76 and 82.01 (increased from 51.15, 64.14 and 71.94 in 1990- 91), which grew at average annual growth rates of 0.85, 1.75 and 1.50 per cent respectively during 1990-2000. As indicated in Graph 4, top four players held 54.99 per cent, another four 19.77 per cent and yet another four only 7.32 per cent during 1999-00 (against 51.15, 12.99 and 7.80 per cent respectively during 1990- 91). Regarding production in large plants, concentration is still higher. During 1999-00 four players held 59.72 per cent (56.23 in 1990-91) share, another four players next 21.47 (14.28 in 1990-91) and yet another four only 7.95 per cent (from 8.57 per cent in 1990-91) as shown in Graph 5. Thus as much as 59.72, 81.19 and 89.15 per cent shares of production in large plants were controlled by the top 4, 8 and 12 business groups/companies during 1999-00 (as compared to 56.23, 70.52 and 79.09 during 1990-91) respectively. These shares were growing at 0.71, 1.60 and 1.35 per cent average annual growth rates, respectively, during 1990-2000. Also C8 growing at a higher

Table 4: Concentration Measures: Cement Production

Year	Concentration Ratios						Herfindahl Index	Gini efficient
	All Plants			Large Plants				
	C4	C8	C12	C4	C8	C12		
1990-91	51.15	64.14	71.94	56.23	70.52	79.09	1095.34	0.65
1991-92	51.28	64.48	72.80	56.04	70.47	79.56	1119.97	0.64
1992-93	51.35	65.24	73.11	56.40	71.65	80.30	1164.35	0.65
1993-94	50.85	65.53	74.03	55.91	72.04	81.39	1231.73	0.66
1994-95	51.95	66.26	74.17	57.01	72.70	81.38	1243.15	0.65
1995-96	51.32	65.23	73.21	56.86	72.27	81.12	1213.49	0,62
1996-97	52.22	66.02	73.53	58.46	73.91	82.32	1271.70	0.65
1997-98	51.18	66.78	73.96	56.78	74.10	82.07	1229.27	0.66
1998-99	50.72	69.74	76.64	55.82	76.75	84.35	1113,75	0.66
1999-00	54.99	74.76	82.09	59.72	81.19	89.15	1290.75	0.70
Average Annual Growth Rate (%) during 1990-2000	0.85	1.75	1.50	0.71	1.50	0.71	1.60	1.35

rate shows that players between the rank of 5 and 8 are becoming more powerful, obviously not at the cost of the top four but smaller players. Table 2 and 3, Graphs 2 to 5 indicate that concentration in actual production in both, all plants and large plants, is higher as compared to that of capacity. If this trend is extrapolated, it apparently implies that concentration is going to increase in the production of cement in the industry.

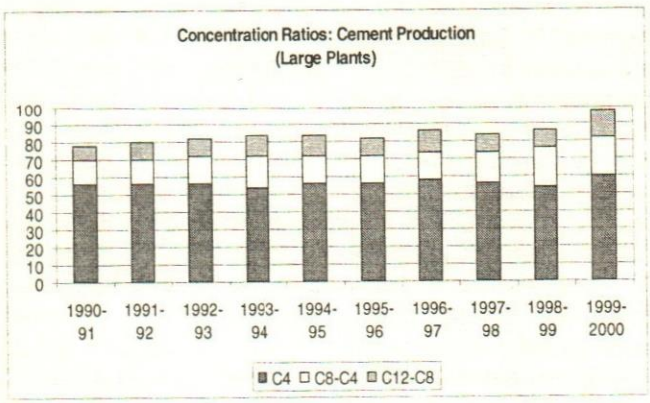

Fig. 5. Graph 5

About Herfindahl Index, cement industry in India seems to be moderately concentrated if the following classification based on US Department of Justice 1982 Merger Guidelines are followed: HI 1000: unconcentrated; 1000 HI 1800: moderately concentrated; and HI 1800: highly concentrated. As Table 2 shows average Hi for cement capacity is 1036.36 and for cement production 1197 during 1990-01 (1990-00 in case of production). HI is growing at an average annual rate of 0.96 per cent for cement capacity whereas at 2.05 per cent for production.

Gini Coefficient, measuring the relative concentration, is also very high; it is 0.62 and 0.70 during 2000-01/1999-00 for cement capacity/production. Whereas G ranging between 0 and 1 coefficients show complete equality and inequality respectively. It is also growing at an average annual rate of 0.86 and 0.89 per cent for capacity/production during the period under consideration. Thus high G shows that size distribution of firms is fairly unequal and growing G indicates increasing inequality in the cement industry.

By all the measures, concentration in the cement industry is high. It is still higher in cement production than capacity and is growing at a faster pace in the case of production. Because of existing excess capacity across all the plants installed during 1993-97, especially during 1995-97, indices may show slightly low concentration in the cement capacity. In fact building up capacity on the basis of projections is different from that in sustaining production, which is directly linked to the sales in the market. Thus production data show the effective position of the players in the real market place and therefore concentration in production may be seen as a better indicator in the prevailing situation. Top 4 players controlling 55 per cent and top 8 holding 75 per

cent and further top 12 as much as 82 per cent share of the total industry production (respective 60, 81 and 89 per cent share in case of large plants production) during 1999-2000 is really high concentration by any standard. Herfindahl index growing at 2.05 per cent average annual rate during the decade of the 1990s indicates high concentration trend in production. Gini coefficient of 0.7 too shows high inequality in the size distribution of firms so far as cement production is concerned. Yet, it is a matter of research whether or not such a high concentration has led to the use of market power in practice. However, with no regulation on prices, the possibilities for the exercise of such market power in matters like pricing of cement cannot be ruled out. Moreover, there is no doubt that the Indian cement industry has experienced high and also growing concentration during the 1990s. The liberalization policies were meant to increase competition, which normally requires reduced concentration. Somehow this has not happened in the case of cement industry.

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The longer I live, the more convincing proofs I see of this truth, that God governs in the affairs of man; and if a sparrow cannot fall to the ground without his notice, is it probable that an empire can rise without his aid?

– Benjamin Franklin

Feature

Indian Livestock 2020: The Next Food Revolution

Akram A. Khan & Farhad Shirani Bidabadi

A demand driven revolution in livestock consumption and production is taking place in most of the developing countries and regions, which has great impact on nutrition, health, environment, and national and international agricultural marketing and research system. Livestock Revolution is happening in all developing regions and countries, but it is more evident in case of China, India, and Brazil, because of sheer size of these countries. While China and Brazil have a dominant role in meat part of Livestock Revolution, it will not be limited to China and Brazil and to just meat. The near doubling of aggregate milk consumption as food in India between the early 1980s and the late 1990s suggests that the Livestock Revolution goes beyond just meat and beyond China and Brazil. Now the question before economic managers and planners in developing countries like India is not whether the Livestock Revolution is manifest in their country or not? But the question is how poor people and small holders can play a part in the revolution that forms future of global and national food markets in coming decades.

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When incomes begin to rise in traditional low-income societies, one of the first things people do is diversify their diets, consuming more livestock products (Brown et al, 1999). When households or individuals become better off, they consume a wider variety of food; a diverse diet is a valid welfare indicator in its own right. The nutrition literature is placing increasing emphasis on importance of consuming a wide variety of foods so as to enhance dietary quality in addition to longer standing concerns regarding quantities of consumption. A recent document of International Food Policy Research Institute (IFPRI), attribute the increase in demand for fruits, vegetables, and animal products to both income growth and shifts in taste and preference (See Oshaug and Haddad, 2002).

As a result of increased income and urbanization a demand driven livestock revolution is underway in developing world, with profound implications for global agriculture, health, livelihoods, and environment. From the beginning of the 1970s to the mid 1990s, consumption of meat in developing countries increased by 70 million tons, almost triple the increase in developed countries, and consumption of milk by 105 million tons of Liquid Milk Equivalent (LME), more than twice the increase that occurred in developed countries. The market value of that increase in meat and milk consumption totaled approximately 155 billion (1990 US $), more than twice the market value of increased cereal consumption under the better known Green Revolution in wheat, rice, and maize (Delgado et al 2001).

The population growth, urbanization, and income growth that fueled the increase in meat and milk consumption are expected to continue well into the new millennium, creating a veritable Livestock Revolution. Many people's diets will change, some for the better, but others for the worse, especially if food contamination is not controlled. Farm income could rise dramatically, but smallholders and landless agricultural workers who need it most would still be undermined. The environmental and

public health impact of rapidly rising livestock production in close proximity to population centres also need attention (Delgado, et al, 1999a, 1999b).

Unlike Green Revolution Livestock Revolution is a demand driven revolution, which has profound impacts on food and nutritional security, and on the national and international agricultural research system.

Now question for India is, will it participate actively in Livestock Revolution or become only a passive receiver of changes in the international food market, which are outcomes of Livestock Revolution? What kinds of policies are now in place? And what are those policy actions that must be implemented in order to make India an active participant in Livestock Revolution rather than a passive receiver? This paper tries to find out answers for these crucial questions.

Characteristics of the Livestock Revolution

Truly it is not inappropriate to use the term livestock Revolution to describe events in world agriculture in the next 20 to 25 years. Like the well-known Green Revolution, the label is a simple and convenient expression that summarizes a complex series of interrelated processes and outcomes. As in the case of cereals, the stake for the poor in India is enormous. Not unlike the Green Revolution, the Revolutionary aspects come from the participation in transformation that had previously occurred in temperate zones of developed countries. And like the gradually but steadily rising cereal yields in the 1970s and 1980s that typified the Green Revolution, the Livestock Revolution started off gradually and increased its rate of growth. But the similarities end there.

The Green Revolution for cereal was a supply side phenomenon; it rested on fundamental technological change and adaptation and extension of seed and fertilizer innovations in developing countries. The Livestock Revolution is demand driven. With notable exceptions for milk and poultry in the developed countries, where technological progress arguably preceded and precipitated changes in demand through lower prices, the supply side of the Livestock Revolution until now has mostly responded (often under distorted incentives) to rapid increase in demand (Delgado, et al, 1999).

The livestock revolution has seven specific characteristics, each of which offers both dangers and positive opportunities for human welfare and environmental sustainability. The seven are:

i. Rapid worldwide increases in consumption and production of livestock products;

ii. A major increase in the share of developing countries in total livestock production and consumption;

iii. Ongoing change in the status of livestock production from a multipurpose activity with mostly no tradable output to food and feed production in the context of globally integrated markets;

iv. Increased substitution of milk and meat for grain in the human diet;

v. Rapid rise in use of cereal based feeds;

vi. Greater stress on grazing resources along with more land intensive production closer to cities and;

vii. The emergence of rapid technological change in livestock production and processing in industrial system.

Livestock Revolution and Incomes of the Poor

Livestock are central to livelihood of the rural poor in developing countries in at least six ways (Livestock in Development, 1998). First they are an important source of cash income. Second, they are one of the few assets available to the poor, especially poor women. Third, livestock manure and draft power are vital to the preservation of soil fertility and sustainable intensification of farming systems in many developing areas facing population density. Fourth, livestock allow the poor to exploit common property resources, such as open grazing areas, in order to earn income. Fifth, livestock products enable farmers to diversify incomes, helping to reduce income variability. Sixth, livestock provide a vital and often the only source of income for the poorest and and most marginal of the rural poor, such as pastoralists, sharecroppers, and widows.

Livestock products enable farmers to diversify incomes, helping to reduce income variability.

A broad variety of anecdotal evidence from case studies in Africa, Asia, and parts of Latin America shows that the poor and landless derive a higher share of their household income from livestock source than do the relatively better-off in the same rural communities. Estimates of the share of household income coming from livestock for households with different income levels, farm size,

Table 1: The Place of Livestock in the Income of the Rich and Poor

Country	Poverty Indicator	Stratum	Percent of Household Income from Livestock	Period	Source
Brazil	Household income stratum	Lowest1/5 Highest 1/5	37 64	1994	Vosti et al 1998
Ethiopia	Household income stratum	Very poor Poor	6 24	1988- 89	Webb and Von Braun 1994
Philippines	Household income stratum	Lowest 1/5 Highest 1/5	23 10	1984-85	Bouis 1991
Pakistan	Household income stratum	Lowest 1/5 Highest 1/5	25 9	1986-89	Adams and He 1995
Egypt	Landholdings	Landless or near landless Largest landholders	63 14	1976-77	Fitch and Soliman 1983
India (Andhra Pradesh and Maharashtra	Landholdings	Lowest 1/5 of land distribution Highest 1/5 of land Distribution	5 6	1977	Kerr 1998
India (Andhra Pradesh and Maharashtra)	Landholdings	Landless Largest landholders	7 15	1975-78	Singh Askon and Walker 1982
Brazil	Dietary Adequacy	Malnourished Not Malnourished	32 27	1984	Von Braun Pandya-Lorch 1991
Pakistan	Dietary Adequacy	Malnourished Not Malnourished	16 14	1986-87	Von Braun Pandya-Lorch 1991
Philippines	Dietary Adequacy	Malnourished Not Malnourished	10 9	1983-84	Von Braun Pandya-Lorch 1991
Sri Lanka	Dietary Adequacy	Malnourished Not Malnourished	4 1	1984	Von Braun Pandya-Lorch 1991

Source: Delgado et al, 1999.

and dietary adequacy from all over the world are presented in Table 1. In Pakistan in the late 1980s, for example, Adams and He (1995) found that about 25 per cent of the income of the poorest 20 per cent of rural households in their sample came from livestock. The richest 20 per cent received only 9 per cent of their income from livestock. In Egypt in the mid 1970s Fitch and Soliman (1983) found that an average of 63 per cent of income of landless or near landless households came from livestock. Only 14 per cent of the income of large landowners came from livestock. Von Braun and Pandya Lorch 1991, identify four countries where the malnourished get more of their incomes from livestock than those who are not malnourished. Vosti, Witcover, and Carpentier (1998) show an exception to this trend in their study of Brazil. In parts of Latin America, such as the Amazon and Argentina Pampas, successful animal grazing requires control of large amounts of land.

Poor people have a few opportunities to increase their incomes because of limited access to land and capital. Small-scale and backyard livestock production enables the poor to earn income from animals grazed on common property pastures or fed household waste. Livestock production offers one of the few rapidly growing markets that poor, rural people can join even if they lack substantial amounts of land, training and capital (Delgado et al, 1999).

The importance of livestock for women's incomes in developing countries has been widely emphasized (Quisumbing et al, 1995; Valdivia, Dunn and Sherbourne 1995). Dairy cooperatives have in fact been a major means of bringing women in poor areas successfully into case economy in East Africa (Brkken and Seyoum 1992). India (Schneider 1995), Bolivia (Valdivia, Dunn, and Sherbourne 1995).

A pattern that shows that the poor earn a higher share of their income from livestock than do the wealthy raises the possibility that the Livestock Revolution will be good for the poor. The revolution offers two main reasons for optimism. First, the poor can more easily improve their incomes if they have a major stake in a sector that is growing. Second, the current rapid intensification of animal production comes at a time when the rural poor desperately need higher returns to their shrinking land than field crops alone can offer.

About half a billion pastoralists depend on livestock for their livelihood, and at least 200 million smallholder

farm families in the developing world derive most of their income from livestock. As livestock production increases smallholders will increasingly walk away from poverty (Fritschel and Mohan, 2001).

Recent Trends in Livestock Product Consumption

People in developing countries are increasing their consumption from the very low levels of the past, and they have a long way to go before coming near the developed country average. In developing countries people consumed an annual average in 1996-98 of 25 kg/capita meat and 51 kg/capita milk, one-third of the meat and one-fifth of the milk consumed by people in developed countries. Nevertheless, the caloric contribution per capita of meat, milk and eggs in developing countries in the late 1990s was still only a quarter that of the same absolute figure for developed countries and, at 10 per cent accounted for only half the share of calories from animal sources observed in developed countries, as shown in Table 2.

Table 2: Annual Per Capita Human Food Consumption (Kg) and Percent of Calorie from Selected Livestock Products, 1973 and 1997

	Developed	Countries	Developing	Countries
Commodity	1973	1997	1973	1997
Beef	26(3%)	23(3%)	4(1%)	6(1%)
Mutton and Goat	(1%)	2(0%)	1(0%)	2(0+%)
Pork	26(4%)	28(5%)	2(2%)	10(4%)
Poultry	11(1%)	21(3%)	2(0%)	7(1%)
Eggs	13(2%)	14(1%)	2(0%)	7(1%)
Milk products excluding butter	18(9%)	245(9%)	29(2%)	51(3%)
Four Meats	67(10%)	75(10%)	11(3%)	25(6%)
Four Meats Eggs and Milk	26(20%)	334(20%)	42(4%)	83(10%)

Source: Calculated from Data in FAO, 2000.

Per capita consumption is rising fastest in regions where urbanization and rapid income growth result in people adding variety to their diets. Across countries, per capita consumption is significantly determined by average per capita income (Cranfield et al, 1998). Aggregate consumption grows fastest where rapid population growth augments income and urban growth (Rae 1998; Delgado and Courbios, 1998). Since the early 1980s, total meat and milk consumption grew at 6 and 4 per cent per year, respectively, throughout the developing world. In East and Southeast Asia where income grew at 4-8 per cent per year between the early 1980s and 1998, population at 2-3 per cent per year, and urbanization at 4-6 per cent per year meat consumption grew between 4 and 8 per cent per year (Delgado, et al, 2001).

The Livestock Revolution has been most evident in East Asia, as illustrated by per capita figures for China in Table 3.

Table 3: Per Capita Meat and Milk Consumption by Region, 1983 and 1997

Region	Meat (Kg)		Milk (Kg)	
	1983	1997	1983	1997
China	16	43	3	8
Other East Asia	22	31	15	19
India	4	4	46	62
Other South Asia	6	9	47	63
Southeast Asia	11	18	10	12
Latin America	40	54	93	112
WANA	20	21	86	73
Sub-Saharan Africa	10	10	32	30
Developing world	14	25	35	43
Developed World	74	75	195	194
United States	107	120	237	257
World	30	36	76	77

Source: Calculated from data in FAO 2000, Values are moving average centered on the year shown

Between 1982/84 and 1996/98, the share of the world's meat consumed in developing countries rose from 37 to 48 per cent, and their share of the world's milk rose from 34 to 44 per cent (Table 4).

Table 4: Food Consumption Trends of Various Livestock Products, 1983 and 1997

Region	Total consumption (million tons)		% of World total	Per Capita consumption (KG)	
	1983	1997	1997	1983	1997
Developed World					
Beef	32	30	52.2	27	25
Pork	34	36	43.4	29	28
Poultry	19	28	49.1	16	20
Meat	88	98	46.9	74	76
Milk	233	251	56.4	195	192
Developing World					
Beef	16	27	47.4	5	5
Pork	20	47	56.6	6	9
Poultry	10	29	50.9	3	5
Meat	50	111	53.1	14	21
Milk	122	194	43.6	35	40

Source: Calculated from data in FAO, 2000.

Pork and poultry accounted for 76 per cent of the large net consumption increase of meat in developing countries from 1982/84 to 1996/98. Conversely, both per capita and aggregate milk and meat consumption stagnated in the developed world, where saturation levels of consumption have been reached, and population growth is small. Nine-tenths of the small net increase in meat consumption that occurred in developed countries over the same period was from poultry.

Table 5: Food Consumption of Meat and Milk by Region, 1983 and 1997

Region	Total meat consumption (million tons)		Total milk consumption (million tons)	
	1983	1997	1983	1997
China	16	53	3	10
India	3	4	34	60
Other East Asia	1	2	1	1
Other South Asia	1	3	11	21
Southeast Asia	4	9	4	6
Latin America	15	26	35	54
Of which Brazil		11		20
WANA	5	7	21	25
Sub-Saharan Africa	4	6	12	17
Developing world	50	111	122	194
Developed World	88	98	233	251
World	139	208	355	445

Source: Calculated from data in FAO, 2000,

The dominant role of China and Brazil in the meat part of Livestock Revolution is shown in Table 5. However, the near doubling of aggregate milk consumption as food in India between the early 1980s and the late 1990s suggests that the Livestock Revolution goes beyond just meat and beyond China and Brazil.

At 60 million tons of Liquid milk Equivalent (LME) in 1996/98, Indian milk consumption amounted to 13 per cent of the world's total and 31 per cent of milk consumption in all developing countries. The high milk consumption of Latin America in 1996-98, at 112 kg/Capita is half way between the developing world as whole (43 kg/capita) and the developed countries (194 Kg/Capita), because of the very high level (75%) of urbanization in Latin America.

Future Consumption and Production Trends

For 1996/98 to 2020 periods, International Food Policy Research Institute projects developing country aggregate consumption growth rates of meat and milk separately to be 2.9 per cent per year each, compared to 0.7 and 0.6 per cent respectively, in the developed countries. Aggregate meat consumption in developing countries is projected to grow by 102 million tons between the late 1990s and 2020, whereas the corresponding figure for developed countries is 16 million tons (Table 6).

As the growth rates in Table 7 suggest, high growth in consumption is spread throughout the developing world and in no way limited to China, India, and Brazil, although the sheer size and vigour of those countries

Table 6: Projected Food Consumption Trends of various Livestock Products to the Year 2020

Region	Projected Annual Growth of Consumption % per year	Total Consumption million tons		% of world total	Per capita Consumption (kg)	
	1997-2020	1997	2020	2020	1997	2020
Developed World						
Beef	0.5	30	34	39.5	23.3	24.8
Pork	0.4	36	39	32.8	27.9	28.8
Poultry	1.3	28	38	36.2	21.7	27.6
Meat	0.7	98	114	34.9	75.3	84.0
Milk	0.6	251	276	42.6	193.6	202.9
Developing World						
Beef	2.9	27	52	60.5	6.0	8.5
Pork	2.4	47	80	67.2	10.4	13.1
Poultry	3.7	29	67	63.8	6.5	11.1
Meat	2.9	111	213	65.1	24.6	34.9
Milk	2.9	194	372	57.4	43.2	61.1

will mean that they will continue to increase their dominance of the world market for livestock products. Experience for individual commodities will vary widely among different parts of the developing world, with China leading the way on meat with a near doubling of the total quantity consumed; the increments are primarily poultry and pork. India and other South Asian countries will drive a large increase in total milk consumption.

Table 7: Projected Food Consumption Trends of Meat and Milk, 1997-2020

	Projected annual growth 1997-2020 % per Year		Total consumption in 2020 (million tons)		Per capita consumption in 2020 (kg)	
	Meat	Milk	Meat	Milk	Meat	Milk
China	3.0	3.5	104	23	71	16
India	3.5	3.2	9	132	7	104
Other East Asia	3.2	1.7	4	4	54	29
Other South Asia	3.3	3.0	6	42	12	78
Southeast Asia	3.3	2.9	19	12	29	18
Latin America	2.4	1.8	45	82	69	127
Of which Brazil	2.3	1.7	19	30	92	142
WANA	2.6	2.2	13	42	26	83
Sub-Saharan Africa	3.2	3.3	11	35	12	37
Developing world	2.9	2.7	213	372	35	61
Developed World	0.7	0.4	114	276	84	203
World	2.0	1.5	327	648	44	87

Source: Total and per capita meat and milk consumption for 1997 are annual averages of 1996-98 values, calculated from FAO 2000. Projections are from October 2000 version of IFPRI's IMPACT.

Production patterns generally follow consumption patterns, as suggested by projected growth rates in production in Table 8 that are similar to the growth rate in consumption in Table 6. Because of the relatively high cost of handling perishable final products and taste factors, most meat and milk will be produced where it is consumed, aided by increase in feed imports. By 2020, people living in developing countries are projected to produce on an average 38 per cent more meat and 37 per cent more milk per capita than in the late 1990s.

International Trade

The actual trade situation for livestock products and feed cereals, and the projected situation for 2020, are shown in Table 9.

Table 8: Projected Production Growth of Various Livestock Products, to the Year 2020

Region	Projected Annual Growth of Production % Per Year	Total production million tons		Per Capita Consumption (Kg)	
	1997-2020	1997	2020	1997	2020
Developed					
Beef	0.56	31	35	23.7	25.6
Pork	0.49	36	41	28.0	29.9
Poultry	1.39	30	41	22.9	30.0
Meat	0.81	100	120	77.1	89.0
Milk	0.53	339	382	261.1	281
Developed					
Beef	2.76	27	51	6.0	8.3
Pork	2.29	47	79	10.4	12.9
Poultry	3.54	29	64	6.4	10.5
Meat	2.77	110	206	24.5	33.9
Milk	2.73	208	386	46.3	63.3

Source: Total and per capita production for 1997 are annual averages calculated from FAO, 2000. Projections are from the October 2000 version of IFPRI'S IMPACT.

Several striking conclusions emerge. First, the big trade flows that equilibrate rapidly growing livestock demand with supply in developing countries occur primarily in the feed cereals market. Developing countries as a whole increase their net imports of cereals for all purposes by 98 million tons to a total of more than 200 million tons of net annual imports from the developed countries. Maize, sorghum and minor cereals (i.e., excluding rice and wheat) accounted for 42 million tons of net cereal imports into the developed countries (from developed countries) in 1996/98 and are projected to account for net imports of 97 million tons in 2020. Thus, 55 million tons or substantially more than half of the projected increase in annual net imports of cereals to developing countries from developed countries between 1996/98 and 2020 are likely to be used for feed. The most impressive increase is projected for China (40 million tons extra net imports of cereals for all purposes), but the rest of southern and eastern Asia adds another 27 million tons in net imports.

Changes in meat trade to 2020 tend to be more modest, even if adjusted to value terms. Net imports of beef by developing countries are projected to increase by 1.0 million tons by 2020, while the figures for pork and poultry are 1.4 and 2.5 million tons, respectively. Latin America is the only developing region projected to increase its net exports of meat. This is especially striking for beef (an additional 1.3 million tons of net ex-

Table 9: Net Exports Imports of Various Livestock Products by Location in 1997 and Projections to Year 2020 (million tons)

	Beef		Pork		Poultry		Milk		Cereals	
Region	1997	2020	1997	2020	1997	2020	1997	2020	1997	2020
China	–0.042	–0.608	–0.159	–1.182	–0.155	–2.231	–1.369	–2.917	–7.760	–47.60
India	0.158	0.072	0	–0.064	0	–0.041	0.048	–0.539	1.701	–6.417
Other East Asia	–0.185	–0.487	0.007	–0.135	–0.038	–0.502	–0.195	–0.553	–13.58	–19.43
Other South Asia	–0.22	–0.128	0	–0.006	–0.001	–0.088	–0.759	–3.584	–4.972	–15.04
Southeast Asia	–0.197	–0.830	–0.008	0.109	0.158	0.280	–4.663	–8.837	–5.704	–8.645
Latin America	0.500	1.823	–0.105	0.049	–0.060	0.588	–5.767	–4.539	–15.35	–3.489
WANA	–0.377	–0.744	–0.006	–0.016	–0.459	–0.905	–4.885	–7.864	–45.23	–73.10
Sub-Saharan Africa	0.011	–0.063	–0.043	–0.092	–0.127	–0.214	–2.279	–4.596	–12.53	–27.34
Developing world	–0.152	–1.156	–0.007	–1.402	–0.701	–3.155	–20.01	–33.70	–104.1	–202.1
Developed World	0.152	1.156	0.007	1.402	0.701	3.155	20.01	33.70	104.1	202.1

Source: Projections are based on production minus consumption in the years shown for the commodity and region. Figures for 1997 are annual averages calculated from FAO 2000. Projections are from October 2000 version of IFPRI's IMPACT.

Table 10: Share of Expenditure on Food Grains, Fruits/Vegetable, Milk, Meat, Egg, & Fish in Total Food Expenditure

NSS Round	Expenditure on Food Grains		Expenditure on Fruits & Vegetables		Expenditure on Milk, Meat Egg & Fish	
	Rural	Urban	Rural	Urban	Rural	Urban
27th Round	63.1	42.02	10.15	9.92	13.44	19.53
32nd Round	58.01	40.83	9.95	10.67	16.17	21.67
38th Round	55.34	38.75	11.43	12.01	16.01	21.66
43rd Round	47.81	33.16	12.66	13.83	18.59	23.23
50th Round	44.78	31.63	14.4	14.99	20.25	24.13
55th Round	44.11	31.81	14.48	15.59	20.37	24.53

Source: Indian Economic Survey, 2001-02.

Table 11: Total and Per Capita Consumption of Livestock Products 1997-2020

Region	Total Consumption of 1997 (million tons)		Total Consumption of 2020 (million tons)		Per Capita Consumption 1997 (Kg)		Per Capita Consumption 2020 (Kg)		Annual Consumption Growth (Per cent)	
	Meat	Milk	Meat	Milk	Meat	Milk	Meat	Milk	Meat	Milk
India	4	60	9	132	4	62	7	104	3.5	3.2
China	53	10	104	23	43	8	71	16	3.0	3.5
Developing World	111	194	213	372	25	45	35	61	2.9	2.7
Developed World	98	251	114	276	75	194	84	203	0.7	0.4
World	208	445	327	648	36	77	44	87	2.0	1.5

Source: 1997 data from FAO, 2000, 2020 projections are from October 2000 version of IFPRI's IMPACT model.

ports), but is also the case far pork and poultry. Developing countries are expected to add another 13.7 million tons in milk imports by 2020, with net imports growing noticeably in most parts of the developing world. By contrast, India is an exception; despite its size and rapid growth in milk consumption, net imports are only projected to grow by 0.6 million tons by 2020 because of strong growth in production.

Is Livestock Revolution Evident in Case of India?

There are evidences to suggest that Indians have begun to consume less food grains per capita by substituting a wider variety of foods. This downward shift in demand for food grains can basically be attributed to changing consumer taste and preferences as a result of increasing availability of a wide variety of food items other than food grains. Data from National Sample Survey Organisation (Government of India) shows the upward trends in expenditure on livestock products is at the expense of reduction in expenditure on food grain. While share of expenditure on food grains both in rural and urban areas of India decreased from 63 and 42 per cent to 44 and 31 per cent respectively, the share of expenditure on livestock products increased from 13.44 per cent and 19.55 per cent in rural and urban areas to 20.37 per cent and 24.53 per cent, respectively, between the 27th and 55th round of National Sample Survey (Table 10).

The expenditure data supported by consumption data for India between 1997 and 2020 (Table 11), suggest that Livestock Revolution is also happening in India.

Concluding Remarks

Livestock Revolution in developing countries like India will continue well into the next decades and will increasingly drive world markets for meat, milk and feed grains. While it is more evident in China in case of meat, in India it is evident in case of milk and milk products.

The ongoing nutritional transformation in India driven by income, population, and urban growth leaves little room for policy to alter the widespread increase in demand for animal products. Policy can, however, help make the form of the revolution as beneficial as possible to the overall well-being of the poor.

There are four broad based pillars on which to base a desirable livestock development strategy for developing countries like India. These are: (1) removing policy distortions that artificially magnify economies of scale in livestock production; (2) building participatory institutions of collective action for small-scale farmers that can be vertically integrated with livestock processors and input suppliers; (3) creating the environment in which farmers will increase investment in ways to improve productivity in the livestock sector; and (4) promoting effective regulatory institutions to deal with the threat of environmental and health crisis stemming from livestock. To do this, policy makers will have to focus on four key issues:

Small-scale producers have to be linked vertically with processors and marketers of perishable products. The poor find it difficult to gain access to productive assets such as credit and refrigeration facilities and to information such as knowledge about microbial infection prevention. The integration of small-scale livestock producers and larger-scale processors would combine the environmental and poverty alleviation benefits of small-scale livestock production with the economies of scale and human health benefits that can be had from large scale processing.

Policy can help facilitate the incorporation of smallholders into commercial production by remedying distortions that promote artificial economies of scale, such as subsidies to large-scale credit and grazing. Success in this effort will require political commitment as well as public and private partners to develop the technologies and practices necessary to minimize risks from animal disease that are inevitable when animals from large numbers of small-scale producers are mixed in a single finishing or processing facility. Much greater attention should be given to livestock productivity and health issues, including postharvest processing and marketing.

Regulatory mechanisms for dealing with the health and environmental problems arising from livestock production need to be developed. Technologies that address environmental and public health dangers will not work unless regulatory enforcement backs them up. Such institutional developments will likely occur when the political demands for better regulation become strong.

Above all, small-scale producers need to be included in the response to this dynamic opportunity. Lack of policy action will not stop the Livestock Revolution, but it will ensure that the form it takes is less favourable for growth, poverty alleviation, and sustainability.

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Don't curse the darkness – light a candle.

– Chinese proverb

Feature

Nature & Behaviour of Tea Prices: The Spectral Approach

C. Hazarika & H. Gogoi

Tea industry is of considerable importance in the national economy. Price is an important instrument for molding production towards the desired goal. This paper, attempts to study the nature and behaviour of domestic and international tea prices for the period 1980-81 to 2000-01. Domestic tea price exhibited a half-yearly cycle as well as seasonality in production and market supply of tea in Assam. There exists very little association between supply and price of tea both in the long and short run periods. Market price lagged behind market supply in annual cycles. In the annual cycle international price had a significant bearing on domestic price.

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Tea is the most popular of all the beverages in the world. Tea industry is one of the largest organised sectors and provides direct employment to over one million people and indirectly to another one million by way of ancillary occupation. It has been an important export item for many decades. The area under tea in the world is about 2.419 million ha which produces a total quantity of 2.922 million tonnes at an average productivity of 1,208 kg per hectare during 1997. India continues to be one of the leading producers of tea accounting for 29.79 per cent of the global output followed by China with 21.39 per cent, Kenya (10.07 per cent) and Sri Lanka (9.61 per cent) during 1997-98. Tea industry in of considerable importance in the national economy of India. India remains the largest producer and consumer and a consistent exporter of tea. Production of tea in India has increased from 283 million kg in 1950-51 to 870 million kg in 1997-98 registering an annual compound growth rate of 2.50 per cent. The total export earnings from tea increased from Rs. 122.25 crores in 1960-61 to Rs. 1945.32 crores in 1997-98, the share of earnings from tea export to total export earnings declined during the same period. Assam is the leading state is the country in tea industry. Tea is not only the most important cash crop but also a major source of revenue, employment and the most important industry of Assam. Assam has an area of 2.29 lakh hectare which is 52.76 per cent of all India acreage during 1997. The annual production of tea in Assam is valued at over Rs. 3422 crores at an average annual auction price of Rs. 80.51 per kg during 1998. Assam contributes around 80.00 per cent of the total tea exported from India during 1999. Although India holds the leading position in production and export the current position of tea trade revealed that its share in world production and export has been declining steadily over the past three decades. The share of major producing countries viz., India, Sri Lanka, and Bangladesh in world production declined, while the share of China and Kenya increased. India's share in total production declined from 39.70 per cent to 29.79 per cent between 1954 and 1998 and the share in export

declined from 40.65 per cent to 16.39 per cent during the same period. While one section of the economists argued that the decline in export in developing nations was due to slow expansion in the world market for the primary commodities exported by them, others argued that it was due to the relatively inelastic export supply coupled with rapidly expanding domestic market. Uncertainty of international and domestic prices due to excess supply in the world market is one of the major reasons, apart from relatively new suppliers entering the international market with advantage of vintage in production and technology resulting in cost advantage. Price is a quite effective instrument in the hands of the policy formulators for molding production towards the desired goal. In this paper an attempt has been made to analyze the nature and behaviour of domestic and international tea prices over time.

Methodology

Monthly price data for the period 1980-1981 to 2000-2001 were collected and used. For this analysis, two auction markets i.e. Guwahati and London were selected due to their volume of transactions. Data on monthly tea prices and quantity of tea offered for sale in various auction markets were collected from Guwahati Tea Auction Centre and the Regional office of J. Thomas and Co. Pvt. Ltd., Guwahati. The spectral approach extends the traditional decomposition of time series into trend, cycle, seasonal, and erratic movement which is based on a rigorous foundation by decomposing a stationary time series into many uncorrelated components each associated with a period or frequency (Rausser and Cargill, 1970). In general, spectral analysis is concerned with the examination of time series from the point of view of a frequency domain. The units of measurement are frequency and density, plotted on the X and Y axis respectively. Frequency (N^{-1}) indicates the number of cycles per unit and the period (N) describes the time required for one complete cycle.

It is assumed that X(t) is normal stationary time series whose covariance function is

$$R(V) = E\left[x(t)\, x(t+v)\right]$$

which satisfy in the discrete case

$$\sum_{-\infty}^{\infty} V^2 \left| R(V) \right| < \infty$$

R(V) is called the auto-covariance function x(t) and it depends solely on V, the length of the lag. This is the consequence of the assumption of stationary. The auto-covariance function R(V) determines the probability structure of the zero mean stationary Gaussian random function X(t).

Given a sample of size n, the sample co-variance function R(V) is defined by

$$R(V) = \frac{1}{n} \sum_{t=1}^{n-|v|} X(t)\; X(t+|v|)$$

$$v = 0, 1, \ldots\ldots \pm (n-1)$$

$$= 0 \quad v = \pm n, \pm (n+1), \ldots\ldots$$

Where X becomes a function of time X(t), m and σ^2 is not sufficient to characterize X. Due to the serial dependence of X values the covariance between X(t) and its 'n' lagged values will have to be computed resulting in $\frac{n}{2}$ additional values. If any meaningful headway is to be made in the statistical analysis of X(t), as a minimum requirement it is necessary to assume stationarity of the series. A non stationary series is one where the variance changes with time.

Once the trend is removed the number of co-variance terms to be estimated reduces to (n-1) and is called auto co-variances. If the assumption of normality holds for the variable X(t) then the joint distribution is a multivariate normal distribution and μ, σ^2 and R(V) are sufficient to characterize the behaviour of X(t) completely.

The variance σj^2 of the frequency component centered on frequency W(j) is called the spectrum of the random function X(t).

$$X(t) = \sum_{j=1}^{n} (aj \cos wjt + bj \sin wj\, t)$$

denoted in its complex form as $X(t) = \int_{-\infty}^{\infty} e^{iwt}\, dz(w)$

$$f(w) = \frac{1}{2\pi n} \left| \sum_{t=1}^{n} e^{itw} X(t) \right|^2 \quad -\pi \leq w \leq \pi$$

where,

$$e^{iwt} = \cos wt + i \sin wt$$

and $i = \sqrt{-1}$

thus, $\cos wt = \dfrac{e^{iwt} - e^{iwt}}{2}$

$$\sin wt = \frac{e^{iwt} - e^{-iwt}}{2}$$

Therefore, $f(w) = \frac{1}{\pi}\left[1 + 2\sum_{V=1}^{\infty}\rho(V)\cos WV\right]$

$$\varnothing \leq W \leq \pi$$

The relationship between the auto–covariance function R(V) and the spectral density function f(w) is called the Weiner-khintchine relation.

The relationship can be written as:

$$f(w) = \frac{1}{2\pi}\sum_{V=T}^{T} e^{-ivw} \quad R(V)$$

$$= \frac{1}{2\pi} R(\varnothing) + \frac{1}{\pi}\sum_{V=1}^{T} \cos vw \; R(V)$$

Thus, the relation between the spectral density function f(w) and the auto–covariance function R(V) is a fourier transformation of one another. Rather than estimate f(w), the spectral densities, one might want to estimate σ^2 f(w) the power spectrum, in which case the auto–correlation r(V) function:

$$f(w) = \frac{1}{\pi}\left[1 + 2\sum_{V=1}^{\infty}\rho(V)\cos WV\right], \quad \varnothing \leq W \leq \pi$$

Usually the spectral densities are estimated over a frequency band rather than at a particular frequency. This is done because individual estimates of the spectral density may be subject to large sample fluctuations. Several authors concur with this procedure. The main reason for estimating average spectral densities over relatively broad frequency bands is to assure moderately stable estimates. The process of averaging reduces the variance of the spectral estimates and are normally estimated over a band width of the extent of 2 h and is given by

$$B(w) = \frac{1}{\pi}\left[1+2\sum_{V=1}^{\infty} r(V) \cos w\frac{\sin vh}{Vh}\right]$$

In a truncated estimate of f(w) the band width is inversely related to the number of lags m that are considered. The truncation point (no. of lags) is proportional with variance of the estimate whereas bias is inversely proportional with the truncation point. Thus, a balance has to be struck between stability and resolution.

Cross Spectral Analysis

The cross lag covariance of the two series is represented as:

$$R\,xy(V) = E[Y(t)\; x(t+v)]$$

$$= \int_{-\infty}^{\infty} e^{iwv}\,\frac{d\,Fxy(w)}{2}$$

$$= \frac{1}{2}\int_{-\infty}^{\infty} e^{iwv}\, f\,xy(w)\,dw$$

Unlike the auto covariance where the coefficients are the same regardless of the direction of the lag, i.e., r(k) = r(–k), the cross covariance yields different values depending on whether X or Y leads, for instance $X_t\, Y_{t+1}$ and $Y_t\, X_{t+1}$ respectively. Hence frequency by frequency examination and the relationship of corresponding components of X and Y is found. The spectral component of each frequency of one series is related to the corresponding component of the other series by two values, namely, the corramplitude and the relative phase.

A function similar to a regression co-efficient called the gain spectrum is defined as

$$Gyx(f) = \frac{Axy(f)}{Px(f)}$$

Where Px(f) is the spectral density of the X Series. There is another function of frequency called coherence which varied between zero and 1 and is similar to the square of the correlation co-efficient. It is computed as:

$$P^2\; Yx(fi) = \frac{|P(xy)(fi)|^2}{Px(fi)\,Px(fi)}$$

The phase measured the extent to which each frequency component leads the other. The phase shift could be converted into time units by dividing phase ø (f) by $2\pi f$.

$$\frac{-\varnothing(f)}{2\pi f} = Tau$$

If the phase is negative, series x(t) leads series Y(t). But this could be interpreted only when the phase showed either a positive or a negative trend. The variance of the phase is proportional to $(1–P^2)/P^2$, P^2 is the coherence. When coherence is low their variance of the phase will be large. Thus the phase is interpretable only at frequencies of high coherence. The significance of the coherence is tested using the method suggested by Koopmans (1974).

Spectral Analysis of domestic price

To study the behaviour of domestic tea price the

monthly tea auction price at Guwahati market was subjected to spectral analysis. The results of the analysis are presented in Table 1. It showed the extent of spectral density at the relevant peak and its harmonics for the first difference price series. An examination of the detrended series revealed the presence of relative peaks at 6.34, 4.06 and 2.53 months. It may be noticed that even though the first peak appeared at 6.34 month the subsequent peak did not pin point the exact harmonics but fell at the neighborhood of the respective harmonics. The value of the estimated spectra at 6.34 months was 22.41 (2.08 per cent) which was maximum indicating the dominance of half yearly cycles relative to other cycles. It could be seen that short term fluctuations were not much pronounced and there was complete absence of long term cycles. Fluctuations shorter than two months could not be identified, since the Nyquist frequency was 0.50 cycle per month which corresponded to two month period. Figure 1 gives a better understanding of the domestic price which showed the presence of relative peaks at the neighbourhood of the harmonics of half yearly cycles explained above.

Table 1: Spectral Estimates and Cycle Lengths for Auction Price at Guwahati Market of Tea with Parzen Weights

Lag	Cycle length (month)	Spectrum (density)	Percentage Spectrum
1	203.00	4.52	0.42
2	101.50	4.52	0.42
3	67.66	4.49	0.41
4	50.75	4.44	0.41
8	25.37	3.90	0.36
17	11.94	4.84	0.45
20	10.15	6.32	0.59
24	8.45	10.70	0.99
28	7.25	17.92	1.66
32	6.34	22.41	2.08
33	6.15	22.31	2.07
36	5.63	18.91	1.76
40	5.07	12.74	1.18
44	4.61	13.42	1.25
50	4.06	20.58	1.91
56	3.62	12.00	1.11
60	3.38	7.16	0.67
64	3.17	5.71	0.53
68	2.98	5.01	0.47
72	2.81	6.42	0.59
76	2.67	10.26	0.95
80	2.53	12.51	1.16
84	2.41	12.05	1.12
88	2.30	11.83	1.09
92	2.20	10.90	1.01
96	2.11	8.66	0.80
100	2.03	7.47	0.69

Thus, the result of the auto spectrum of the domestic tea price series indicated that the half yearly cycle was prominent followed by the presence of four months and 2.53 months cycles. Further, the study failed to show any evidence of short run fluctuations and also ruled out the possibility of long term cycles in the behaviour of domestic tea prices.

This kind of seasonal price fluctuations could be mainly attributed to market supply conditions. In this context, it may be mentioned that tea in Assam is mainly harvested for eight months only. During the peak periods of production when the market supply is more, the price will decline and in the lean season when the production recedes, market arrivals decrease resulting in price increase constituting an half yearly price cycle. Thus, it is evident that tea prices are characterised by only seasonal cycles and are free from violent fluctuations.

Spectral Estimates of Supply of Tea in Guwahati Market

The estimated spectra of tea supply are presented in Table 2. From an examination of the first difference series, it could be seen that the first peak occurred at 11.94 months and relative peaks at 4.22, 2.98 and 2.30 months. This indicated the seasonality in production and market supply of tea in Assam. In addition to annual cycles, there was reason to believe the existence of short term fluctuations also as there was concentration of power at higher frequencies. The maximum peak was at the cycle length of 2.03 months which contributed 2.62 per cent of the overall variance. Figure 2 provides a clear indication of the seasonal peaks and also the nature of fluctuation in the supply of tea in Assam.

The annual component in supply was mainly explained by the seasonality in production. Even though tea is a perennial crop and plucking could be done through its economic life once it attains maturity, the plucking is not uniform within the year due to climatic factors. The production is generally lowest in December due to the dormant nature of tea in Assam during winter. Again in summer plucking is interrupted by heavy summer showers. Thus, production exhibited heavy seasonality as compared to price.

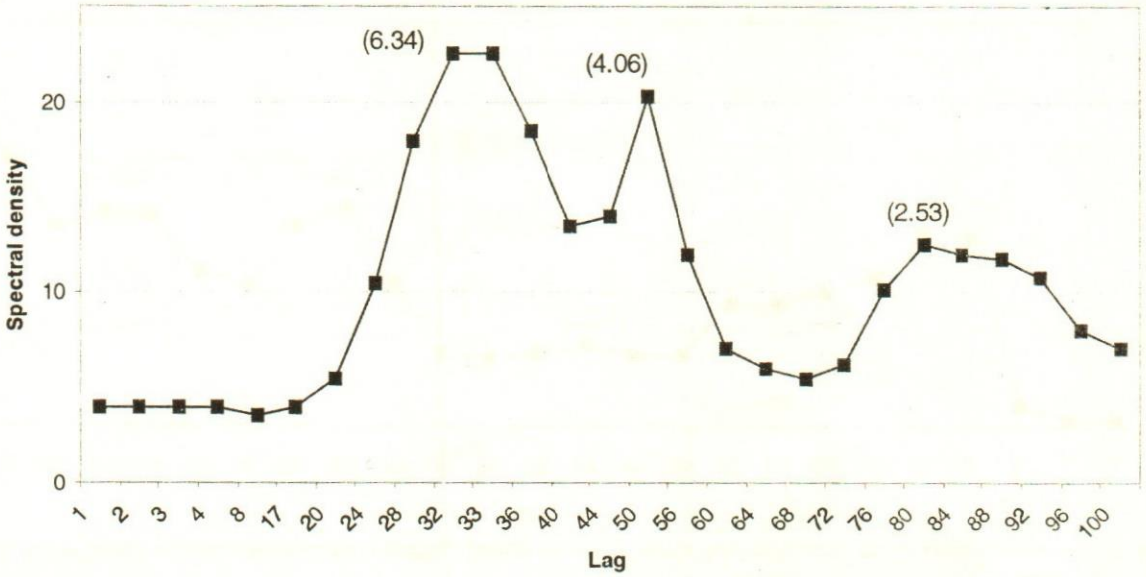

Fig. 1. Spectral estimates of the monthly prices of tea, Guwahati Market (Figures in parentheses indicate cycles in months)

Table 2: Spectral Estimates and Cycle Lengths for Supply of Tea in Guwahati Market with Parzen Weights

Lag	Cycle length (month)	Spectrum (density)	Percentage Spectrum
1	203.00	441315.9	0.02
2	101.50	457143.2	0.02
4	50.75	542293.2	0.02
8	25.37	2995966.1	0.15
16	12.68	26079985.2	1.28
17	11.94	27171080.0	1.34
20	10.15	23225689.7	1.34
34	5.97	19188877.0	0.94
36	5.63	17180101.5	0.85
40	5.07	11238445.8	0.55
44	4.61	11128291.8	0.55
48	4.22	13069709.7	0.64
52	3.90	11768174.1	0.58
56	3.62	9588089.2	0.47
60	3.38	11768174.1	0.58
64	3.17	22342559.4	1.09
68	2.98	33301905.3	1.64
72	2.81	30305464.7	1.49
76	2.67	21948353.5	1.08
80	2.53	24360373.6	1.19
84	2.41	32136959.4	1.58
88	2.30	32887118.1	1.62
92	2.20	30106380.1	1.48
96	2.11	39220132.3	1.93
100	2.03	53308981.0	2.62

Relationship between Supply and Price

Price fluctuation could also be due to the supply side of production. The general belief is that in a free economy price fluctuation adjusts to simultaneous changes in supply. However, such adjustment is not instantaneous in the case of agricultural commodities because of lagged supply response. But, in a dynamic sense supply itself is dependent on price.

Cross-spectra provides a convenient method of investigation of the relationship between economic time series. Cross spectral analysis between price and supply series was made and the important measures such as coherence, gain and phase (Tau) with respect to important cycles are presented in Table 3.

The coherence is similar in concept to R^2 of correlation and is bound by zero and one. The test criteria for coherence as suggested by Parikh (1971) was followed and a value more than 0.30 was considered as significant. The phase statistics provide an estimate of average lead or lag of one series over another at each frequency hand under study. The gain statistics is analogous to the regression co-efficient which explains the scalar by which the amplitude of one series at some frequency must be multiplied to produce a component of the amplitude at which this frequency appears in another series.

From the Table, It could be seen that the coherence value of the half-yearly component (6.34 months) was highest i.e., 0.49. The coherence is significant in the medium term frequencies, ranging from 12.68 months to 5.07 months. The remaining values at very low frequencies as well as higher frequencies are relatively low sug-

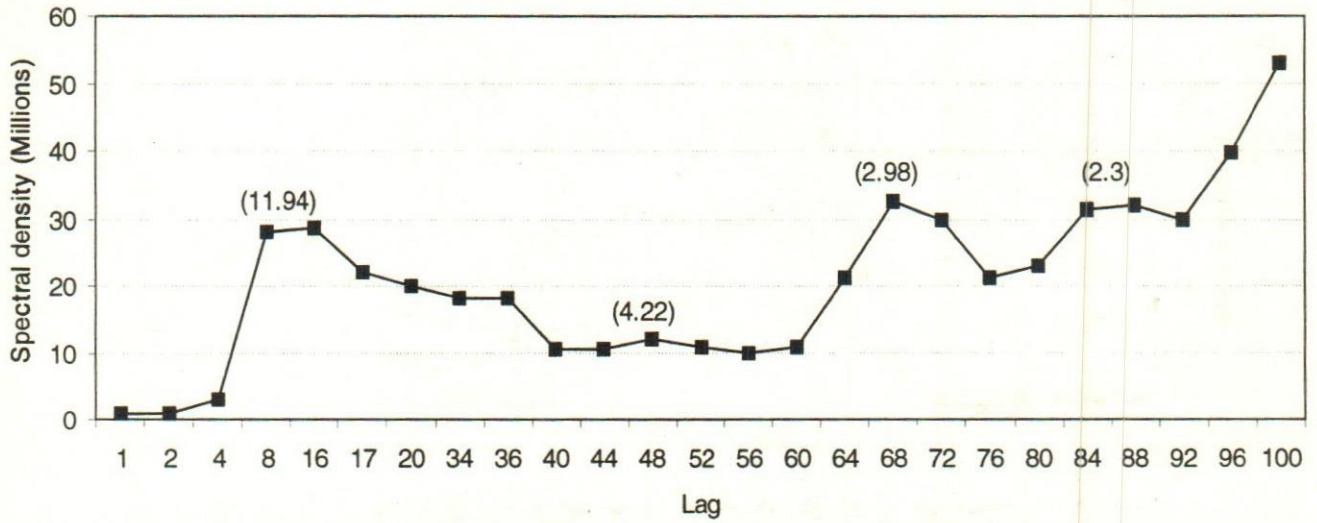

Fig. 2. Spectral estimates of the monthly supply of tea, Guwahati Market (Figures in parentheses indicate cycles in months)

Table 3: Cross-Spectral Statistics with Parzen Weights for Monthly price and Arrivals of Tea in Guwahati Market

Lag	Cycle Length (month)	Cohe-rence	Gain	Phase	Tau
1	203.00	0.053	71.99	-3.04	-98.21
2	101.50	0.041	64.73	-2.95	-47.65
4	50.75	0.011	38.02	-2.91	-23.50
8	25.37	0.056	208.58	1.20	4.84
16	12.68	0.322	1366.52	1.19	2.40
17	11.94	0.300	1297.60	1.19	2.26
20	10.15	0.193	843.02	1.23	1.99
24	8.45	0.156	424.35	1.43	1.92
28	7.25	0.360	494.35	1.55	1.79
32	6.34	0.490	640.59	1.58	1.59
36	5.63	0.470	658.80	1.67	1.49
40	5.07	0.310	523.45	1.80	1.45
44	4.61	0.198	405.22	1.31	0.96
48	4.22	0.230	394.41	0.81	0.54
52	3.90	0.168	320.93	0.66	0.41
56	3.62	0.039	178.59	1.18	0.68
60	3.38	0.025	201.91	2.54	1.37
64	3.17	0.005	145.34	-0.53	-0.28
68	2.98	0.063	649.56	-0.55	-0.26
72	2.81	0.014	262.21	-0.11	-0.05
76	267	0.083	421.60	1.86	0.79
80	2.53	0.147	536.52	2.14	0.86
84	2.41	0.068	427.25	2.83	1.09
88	2.30	0.104	538.89	-2.47	-0.90
92	2.20	0.098	522.01	-2.14	-0.75
96	2.11	0.012	237.14	-1.05	-0.35
100	2.03	0.043	556.47	-0.03	-0.01

gesting that there was very little association between supply and price of tea both in the long and short run periods. The table also indicated the extent to which the corresponding components in the two series are related. It generally decreased as the period became shorter. The medium-term cycles were apparently more related when compared to the long-term and short-term cycles. Further, it is also evident that the coherence for annual component and its first harmonics were significantly different from zero. This suggested that the annual cycles of price and market supply were closely interrelated.

The results further showed that the market price lagged behind market supply in the annual cycles and in most other frequencies. However the relationship was in the opposite direction at higher as well as lower frequencies. The positive phase values at annual cycles as well as other significant frequencies showed price lagged supply at the annual cycles and medium-term cycles.

The gain statistics analogus to the regression co-efficient when quantities were regressed on price appeared to be high for all the significant cycles. This implied that at annual cycles supply had a significant bearing on price. The annual cycles were highly interrelated (1366.52 and 1297.60 for 12.68 and 11.94 months cycles respectively) because of the existence of marked seasonality in production. So, during the peak production period prices tend to fall and during the lean period prices tend to rise establishing a negative relationship between supply and price of tea.

The results of cross spectral analysis revealed that annual cycles of market supply and price of tea in Assam were closely interrelated. However in the short run as well as in the long run there was a total absence of association between arrivals and prices. The analysis also indicated that prices were lagging behind market

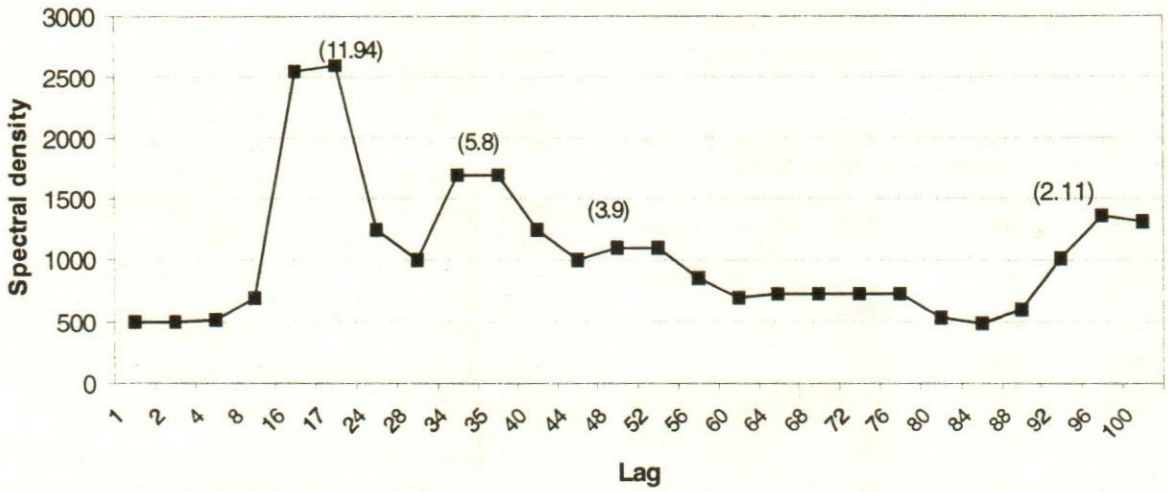

Fig. 3. Spectral estimates of the monthly prices of tea, London Market (Figures in parentheses indicate cycles in months)

supply in the annual cycles. The very low frequency components as well as high frequency components were not significantly correlated. This implied that except for seasonal price variation, long term and short term price variations were perhaps absent or explained by factors other than market supply. This seems quite plausible because the price of tea at the auction centre is influenced by the price prevailing at the international market.

International Tea Prices

Having examined the domestic market price of tea, an attempt was made to study the price behaviour at a London tea auction centre. In order to identify the international price structure, the detrended series of tea prices in London market was subjected to spectral analysis using parzen weights. The result of spectral analysis is furnished in Table 4. There is evidence for a cyclical behaviour of 12 months duration. The maximum peak was noticed at 11.94 months (2.40 per cent) which emphasised the importance of this component in explaining the price movement. Other peaks were obtained around the neighbourhood of six months, four months, three months and two months. The cause for such fluctuation might be the changes in demand in the short and medium term, including seasonal fluctuations in supply. The spectral densities were rather low at higher frequencies implying that short term fluctuation had significant impact in explaining the tea price in the international market. Fig. 3 provides a clear indication of the seasonal peaks and also the nature of fluctuation in the international tea price.

Relationship between Domestic and International Prices

The domestic and international prices of tea were

Table 4: Spectral Estimates and Cycle Lengths for Tea Price at London Market with Parzen Weights

Lag	Cycle length (month)	Spectrum (density)	Percentage Spectrum
1	203.00	479.64	0.43
2	101.50	489.70	0.44
4	50.75	520.87	0.47
8	25.37	715.49	0.65
16	12.68	2555.97	2.31
17	11.94	2656.16	2.40
24	8.45	1254.64	1.14
28	7.25	1010.80	0.91
34	5.97	1693.97	1.53
35	5.80	1697.99	1.54
40	5.07	1230.14	1.11
44	4.61	1008.25	091
48	4.22	1119.03	1.01
52	3.90	1111.50	1.01
56	3.62	858.95	0.78
60	3.38	714.36	0.65
64	3.17	784.18	0.71
68	2.98	810.59	0.73
72	2.81	770.92	0.69
76	2.67	741.65	0.67
80	2.53	582.41	0.53
84	2.41	438.65	0.39
88	2.30	648.70	0.59
92	2.20	1083.83	0.98
96	2.11	1275.23	1.15
100	2.03	1219.48	1.10

subjected to cross spectral analysis to find out the nature of relationship between these two prices. The results are provided in Table 5.

Table 5: Cross-Spectral Statistics with Parzen Weights for Monthly Prices of Tea in Guwahati and London Market

Lag	Cycle Length (month)	Coherence	Gain	Phase (W)	Phase T Tau (months)
1	203.00	0.356	6.14	.057	1.84
2	101.50	0.364	6.28	.107	1.73
3	67.66	0.373	6.47	.145	1.56
4	50.75	0.375	6.63	.173	1.39
8	25.37	0.197	6.02	.418	1.69
16	12.68	0.209	10.89	1.815	3.66
17	11.94	0.198	10.43	1.800	3.42
20	10.15	0.129	6.91	1.710	2.76
24	8.45	0.074	2.96	1.990	2.68
28	7.25	0.154	2.95	2.970	3.43
32	6.34	0.272	4.31	–2.800	–2.83
34	5.97	0.293	4.79	–2.640	–2.51
36	5.63	0.276	4.92	–2.480	–2.22
40	5.07	0.160	3.93	–2.080	–1.68
44	4.61	0.080	2.45	–1.330	0.98
48	4.22	0.173	3.16	–0.850	–0.57
52	3.90	0.244	3.75	–0.784	–0.49
56	3.62	0.080	2.39	–0.734	–0.42
60	3.38	0.008	0.91	1.890	1.02
64	3.17	0.011	1.27	2.370	1.19
68	2.98	0.27	2.12	–2.860	–1.36
72	2.81	0.146	4.19	–2.670	–1.19
76	2.67	0.233	4.10	–2.850	–1.21
80	2.53	0.216	3.17	2.960	1.19
84	2.41	0.121	2.09	2.210	0.85
88	2.30	0.025	1.19	1.040	0.38
92	2.20	0.022	1.49	0.142	0.05
96	2.11	0.026	1.98	0.133	0.05
100	2.03	0.027	2.12	0.065	0.02

The coherence values for all the frequencies except for the very low frequencies were very low and insignificant. The highest coherence value (0.375) was located at 50.75 months cycle. The extent to which the corresponding components in the two series are related generally decreased as the period become shorter. The phase and Tau statistics showed that the domestic price lagged behind international price both in the long run and short run. The reverse was experienced in medium cycles (the statistics was negative). The gain statistics was higher (10.89) at the annual cycles. This implied that in the annual cycle international price had a significant bearing on domestic price. The spectral analysis exhibited very little relationship between domestic and international price. The domestic price remained more or less isolated and moved out of the line from the world price.

There was neither significant association nor fixed pattern of lead or lag relation among domestic and international price of tea. The price change in one market was reacted upon by other market prices at seasonal cycle, but the flow of information was not efficient. Therefore the value of coherence and gain were low in a large number of instances. As a result, the traders in the domestic market exploited the short run situation to their benefit.

From the foregoing discussion it could be inferred that the cycles in the tea price series were not very stable but changing from one period to another. This phenomenon is the characteristic of a random walk model. Speculative markets are those which cannot produce price series having predictable components, barring the ones which are seasonal. The production of tea is seasonal. Buying is also cyclic since certain buyers operate at regular intervals in order not to increase their stocks beyond a certain level because of deterioration in quality and high interest burden. It is also difficult to postulate a simple demand explanation for commodity price because of the extraneous or exogenous factors influencing internal price. This is particularly true in respect of most commodities which are internationally traded.

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Feature

Growth Trends in Food Grains Production

Jagdeep Kaur Gill, Manish Sharma & Arshad Mahmood

This article analyses the total production of food grains in the country by examining the time series data on area, production and productivity of food grain for the period 1950-51 to 2000-2001. Methods to attain self-sufficiency in food grain production are discussed.

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India holds a premier position in terms of food grains acreage and production in the world. It is one of the leading producers of rice, wheat, maize etc. Still, the yield of most of the food grain crops is less than the world average level. About two-third of food grain production comes from irrigated areas like Punjab, Haryana, Western Utter Pradesh, part of Andhra Pradesh and Tamil Nadu. In our country, there are wide regional variations in production and productivity of food grains. These variations are also in terms of availability per capita in the region.

Apart from the food grains demand for direct human consumption, an increasingly important component is the indirect demand for seed, feed, industrial uses and wastages. Mostly feed demand is met by food grains (51%), oil cakes (33%) and cotton seed (11%). Demand of food grain is projected to be 14-23 mt in the year 2020. While the industrial use of food grains in year 2000 was about 5 million tonnes it is projected to grow to 6.6 mt during the year 2020. This wastage allowance also includes grains not fit for human consumption and which are later to be used as feed. The total indirect demand for food grains is estimated to be 20-22 mt, 25-29 mt and 29-38 mt in the years 2000, 2010 and 2020, respectively. [The domestic demand for total food grains will grow at the rate of 2.14-2.18 per cent in the short term (1995-2000) and 1.91-1.96 per cent in the long term (2000-2020) (Perspective Plan and Vision 2020, Ministry of Agriculture, Government of India)].

On the other hand, it is after two successive years of high record that the total food grains of the country's production has slid to a dismal 196.13 millions tones. According to G. Venkataraman, the average growth rate of total food grains production during 1994-95 to 2000-2001 was dismal (0.8 per cent). Rice production during the period grew at 1.11 per cent and wheat production rose by 2.24 per cent. The nutritious cereals (millets) recorded a growth rate of 0.02 per cent during the period, and pulses registered a negative growth rate of minus 1.55 per cent during the period. This trend has to

be reversed, and the agricultural development in the country should be put on a faster track to meet the food grains demand of the future. Several studies reveal that food productions will have to increase substantially over the next few decades to feed the increasing population (World Bank, FAO). By the year 2020, India would have to produce 400 million tonnes of food grains annually to feed its population (Abdul Kalam, 2000). It is, therefore, desirable to examine the trends in growth in area, productivity and their interaction to increase the total production of food grains during the different phases of agricultural development in the country.

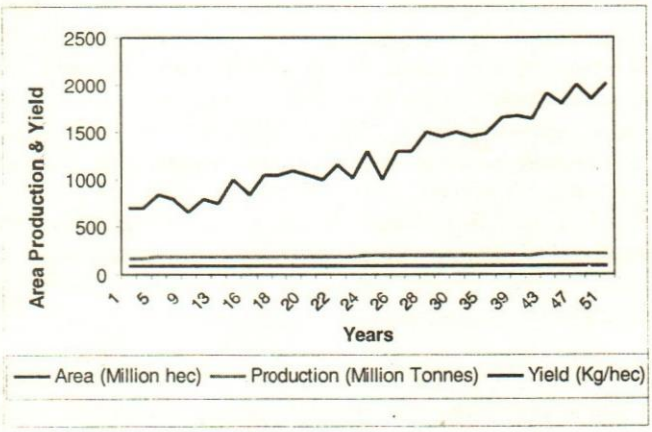

Fig. 1. Trends in Area, Production & Yield of foodgrains in India

Material and Methods

The time series data on area, production and productivity of food grain for the period 1950-51 to 2000-2001 were utilized to study the trend (Fig 1). The data was taken from the various issues of Statistical Abstract at a Glance. The time period has been divided into three different Phases as:

(a) Pre-Green revolution era	1950-51 to 1965-66
(b) Green Revolution era	1966-67 to 1975-76
(c) Post-Green revolution era	1976-77 to 2000-2001

To judge the best model, for measuring the growth trends in area, production and productivity of food grains, on the basis of coefficient of determination, the linear as well as non-linear models were used, namely

(a) Linear Function	$y = a + bx$
(b) Quadratic Function	$y = a + bx + cx^2$
(c) Exponential Function	$y = a\, e^{bx}$
(d) Power Function	$y = a\, x^b$
(e) Compound Growth Function	$y = a\, b^x$
(f) Logarithmic Function	$y = a + b \log x$

Where y is the dependent variable viz., area, production and productivity, and x is the time variable. Compound growth rates (r), expressed as percentage were calculated for production, area and productivity of food grains for different phases of agriculture in India by using the formula r = (b – 1) *100. The growth rates were tested statistically for their significance through t-test as given below:

$$t = \frac{r}{S.E(r)} \sim t_{\alpha,\, n-2}$$

Where,

$$SE(r) = \frac{b\sqrt{(\Sigma logy^2 - (\Sigma logy)^2/n - logb)^2\,(\Sigma x^2)}}{0.43429\,(n-2)\,(\Sigma x^2)} \times 100$$

To test the significance of the difference of regression co-efficient (b) of different decades, the test statistic that was used is as follows:

$$t = \frac{b_i - b_j}{SE\,(bi - b_j)} \qquad (i, j = 1, 2, 3)$$

Effect of area, yield and their interaction in increasing the food grains production was examined by using differential equations given by Sharma (1977). The change in the production of food grains between any time period can be expressed as,

$$\Delta P = Y_0\,\Delta A + A_0\,\Delta Y + \Delta A\,\Delta Y$$

Where, $\Delta A = A_n - A_0$, $\Delta Y = y_n - y_0$, $\Delta P = p_n - p_0$.

A_0, Y_0, P_0 are the area, productivity and production in base year, whereas A_n, Y_n and P_n, are area, productivity and production in current year and ΔA, ΔY, ΔP are the change in area, productivity and production, respectively.

First, second and third term on the right hand side of the equation are the effect of area, productivity and their interaction respectively, on production for the already mentioned period.

The contribution of area productivity, and their interaction to total differential production of food grains were obtained separately for each of the period under study as also for total period of study (1950-51 to 2000-2001). For comparing the variability in data of food grains area, productivity and production during various era of agriculture as well as for the whole study period, the coefficient of variation (%) has been calculated. The data having greater coefficient of variation (CV) is said

to be more variable than the others and the data having lesser coefficient of variation (CV) is said to be more consistent than others.

To study the correlation co-efficient between production and percentage coverage under irrigation in case of food grains in India, the Karl-Pearson correlation method was used by applying the following formula as given below:

$$r = \frac{n\sum xiyi - \sum xi \sum yi}{\sqrt{n \sum xi^2 - (\sum xi)^2}\ \sqrt{n\sum yi^2 - (\sum yi)^2}}$$

To work out the impact of percentage coverage under irrigation on food grains production, both linear and log linear function were fitted

$Y = a + b_1x_1 + \text{----------} + u$ (Linear form)

$Y = ax_1^{b1}.u$ (Cobb-Douglas form)

Where, Y = production of food grains

a = constant

b_1 = regression coefficient

x_1 = percentage coverage under irrigation in case of food grains crops

The linear function was selected on the basis of econometric consideration such as higher co-efficient of multiple determination, appropriateness of signs associated with estimated co-efficient and statistical significance of coefficients.

Similarly, the impact of production on net per capita availability of food grains was also worked out by using linear and log linear function, and the final equation was selected on the basis of already mentioned criteria. Moreover, to study the trend in case of net capita availability of food grains, the annual compound growth rate was worked out.

Results and Discussion

Growth trends in area under food grains:

The area under food grains in the country has increased from 97.32 to 119.71 million hectares during 1950-51 to 2000 - 2001 (Fig. 1). The growth trend in the food grains area, as expressed by different equations for the periods 1950-51 to 2000-2001, are given in Table 1 along with their statistical coefficient values. From Table 1, it is clear that the value of the coefficient of determination (R^2) is maximum (0.86) for exponential function compared to other functions fitted for food grains area over time. Also the coefficient of determination (R^2 = 0.894) is statistically significant. This indicates that the best trend in area is quadratic in nature. The quadratic equation fitted for the area is as follows:

Table 1: Different functions estimating food grain area in Jammu and Kashmir

Model	a	b	c	R^2
Linear function	110.047*** (1.523)	0.389*** (0.051)		0.544***
Quadratic function	99.143*** (1.432)	1.624*** (0.101)	–.0237*** (0.0019)	0.894***
Exponential function	109.814*** (1.467)	0.061 (0.00126)		0.539***
Power function	97.296*** (1.388)	0.071*** (0.005)		0.826***
Compound growth function	109.814*** (1.467)	1.003*** (0.00048)		0.539***
Logarithmic function	96.392*** (1.692)	7.96*** (0.543)		0.814 n.s

Note: *** denotes significant at one per cent level of significance & n.s denotes non-significant

$$A = a + bx + cx^2 \qquad (R^2 = 0.894)$$

Where A is total food grains area thousand hectares, x is time variable.

$$A = 99.143 + 1.624x - 0.0237\,x^2$$

The co-efficient of the square term in the quadratic equation is negative i.e. (–0.0237), which is significant.

Growth trends in food grains production

Table 2: Different functions estimating food grain production in Jammu and Kashmir

Model	a	b	c	R^2
Linear function	398.289*** (25.915)	22.848*** (0.867)		0.934***
Quadratic function	576.608*** (21.766)	2.661*** (1.931)	0.388*** (0.036)	0.981***
Exponential function	513.135*** (9.161)	0.0231*** (0.001)		0.916 (23.1183)
Power function	337.988*** (29.033)	0.340*** (0.028)		0.974 (42.1196)
Compound growth function	513.135*** (9.161)	1.023*** (0.001)		0.968***
Logarithmic function	319.32*** (33.136)	38.071*** (103.24)		0.655 n.s

Note: *** denotes significant at one per cent level of significance & n.s denotes non-significant

In India the production of food grains increase as a

result of increase in productivity of food grains. The values of mathematical function for growth of food grains production over the period of 51 years (1950 – 51 to 2000–2001), as estimated by exponential function has maximum value of coefficient of determination (R^2 = 0.981). Also this value of R^2 is statistically significant at one percent level (Table 3). This indicates that the trend in food grain production is exponential in nature and is given as,

$$Y = a + bx + cx^2 \qquad (R^2 = 0.981)$$

Where Y is food grains productivity in millions tonnes.

$$Y = 576.608 + 2.661x + 0.388\,x^2$$

In the above quadratic expression for food grain production, the co-efficient of the square term (0.388) is positive and statistically significant at one percent level. This indicates that there is acceleration in food grain production in India over the years.

Growth trends in food grain productivity

Table 3: Different functions estimating food grain productivity in Jammu and Kashmir

Model	a	b	c	R^2
Linear function	41.221*** (2.794)	3.065 (0.094)		0.956***
Quadratic function	55.874*** (3.331)	1.406*** (0.295)	0.0319*** (0.006)	0.974***
Exponential function	56.344*** (1.159)	0.026*** (0.001)		0.968***
Power function	32.882*** (2.661)	.410*** (0.026)		0.836***
Compound growth function	56.344*** (1.159)	0.026*** (0.001)		0.968***
Logarithmic function	–11.448*** (12.398)	44.289*** (3.979)		0.717***

Note: *** denotes significant at one per cent level of significance & n.s denotes non-significant

The food grain yield in the country has increased from 522 to 1638 Kg/hac during 1950-1951 to 2000-2001 (Fig. 1). Table 2 revealed that the best expression for growth in food grains productivity among the fitted function was found to be Quadratic function in nature with coefficient of determination (R^2 = 0.974). Also the value of coefficient of determination (R^2) was found to be significant at one per cent level. The fitted power equation for food grains productivity is as,

$$Y = a + bx + cx^2 \qquad (R^2 = 0.974)$$

Where Y is food grains productivity, kg/hac.

$$Y = 55.874 + 1.406\,x + 0.0319x^2$$

In the above quadratic expression, the coefficient of the square function is positive (0.0319) and statistically significant. This shows that food grain productivity is accelerating in the country during the study period.

Table 4: Compound growth rate (per cent) of area, production, and productivity during different phases of agriculture in India

Era	Area	Production	Productivity
Pre-Green revolution (1950-51 to 1965-66)	1.227*** (0.166)	2.980*** (0.493)	1.716*** (0.349)
Green revolution (1966-67 to 1975-76)	0.645** (0.272)	3.186*** (0.999)	2.515*** (0.769)
Post green revolution (1976-77 to 1999-2000)	–0.191***	2.523***	2.719***
1950-51 to 1999-2001	0.339*** (0.045)	2.679*** (0.071)	2.333*** (0.061)

Note: *** and ** denote significant at five and one percent level of significance respectively.

The compound growth rates of area, production and productivity of food grains during the pre-green revolution period, green revolution, post-green revolution as well as for the total period were calculated and their significance were tested statistically. This is given in Table 4. It revealed that in case of area under food grains, the maximum growth was observed during the pre-green revolution period i.e. 1.227 per cent per annum. After that it started to decline. The growth rates of food grain production (2.960 to 3.186 per cent) and productivity (1.716 to 2.515 per cent) have gone up from the pre-green revolution period to the green revolution period. The growth rates of area, production and productivity of food grains were worked out to be significant during the pre-green revolution, the green revolution and the post-green revolution periods. During the green revolution period, instead of area, more emphasis was given on production side. So during that period the maximum growth in food grain production was at the rate of 2.515 per cent. The growth rates of area (0.645 to –0.191 per cent) and production (3.186 to 2.523 per cent) have declined during the post green revolution period from the green revolution period. The growth rate of food grains productivity has increased significantly during the post-green revolution period from 2.515 to 2.719 per cent. For the total period (1950-51 to 2000-2001), growth rates of area (0.339 give per cent), production (2.679 per cent) and productivity (2.333 per cent) were found to be positive and significant. It is obvious from Table 4 that growth rates of food grain production during the pre-green revolution

period was affected by both area and productivity of food grains but during the green-revolution and the post-green revolution periods it was highly affected by the productivity factor only. This was because of the introduction of high yielding varieties, better technology etc.

Table 5: Effect of change in area, productivity and their interaction in differential production of food grains in India

Period	Differential production ΔP	Area effect $\Delta A\, y_o$	Productivity effect $\Delta y \Delta_o$	Interaction effect $\Delta A \Delta y$
Period I Pre-green revolution period (1950-50 to 1965-66)	22827.69	10344.4 (45.32)	10984.62 (48.11)	1498.67 (6.57)
Period II Green revolution period (1966-67 to 1975-76)	50406.07	1016.13 (20.16)	38117.52 (75.62)	2125.39 (4.22)
Green revolution period (1976-77 to 2000-2001)	78206.44	–8007.54 (–10.23)	82329.54 (105.27)	3884.43 (4.96)
Over-all period (1950-50 to 2000-2001)	135103.6	13026.5 (9.69)	114568.6 (84.8)	7508.49 (5.56)

Note: Figure within brackets is percentage contribution.

Relative contribution of area, production and their interaction in increasing food grains production in the country during the total study period (1950-51 to 2000-2001) as well as during each intervals viz.1950-51 to 1965-66; 1966-67 to 1975-76 and 1976-77 to 2000-2001 were examined by sub dividing the total change in the food grains production due to area, productivity and their interaction effect i.e. Production as differential function of area and Productivity (Table 5). Table 5 indicates that area effect has declined while productivity effect has increased in recent years. It varied from 48.11 per cent in the pre-green revolution period to 75.62 per cent and 105.27 per cent in the green and the post green revolution periods, respectively. For the total period, a higher productivity effect (84.8 per cent) was observed compared to area (9.64 per cent) and interaction effect (5.56 per cent). Hence, from the results of the present study it can be easily concluded that productivity plays a major role on differential production function during the pre and post green revolution periods. But for all three periods under consideration productivity effect remained greater than area and interaction effect. During the post-green revolution period acreage effect has worked out to be negative. So the right method to increase production further is to increase productivity at the world level rather than by increasing the area.

The coefficient of variation for food grain production in India varies from 11.39 per cent to 18.22 per cent, indicating that there is a lot of variation in food grain production during different periods. The value of co-efficient of variation was 14.96 per cent before the green revolution, which reduced to 11.39 per cent during the green revolution period. It again increased to 18.22 per cent. This variation in food grain production indicates that stability in food grain production has not been obtained in the country. Moreover, this variability is due to the variability in food grain productivity. So in the case of productivity of food grains, the co-efficient of variation was 9.65 per cent during the pre-green revolution which reduced to 8.97 per cent during the green revolution. This again increased to 35.07 per cent during the post-green revolution period. So our main motive should be to increase production by stabilizing the variations in the yield of food grains. This would mean that concentrated research efforts are required for developing adaptable high yielding variations across different agro-climatic regions.

Table 6: Co-efficient of variation (per cent) for area, production and productivity in India

Era	Area	Production	Productivity
Pre-green revolution period	6.09	14.96	9.65
Green revolution period	2.86	11.39	8.97
Post-green revolution period	2.33	18.22	19.35
Total Period	6.47	38.15	35.07

Table 7: Common correlation coefficients between production and percentage coverage under irrigation in case of food grains in India

Era	Co-efficient of correlation
Pre-green revolution era (1950-51 to 1965-66)	0.598*
Green revolution era (1966-67 to 1975-76)	0.658***
Post-green revolution era (1976-77 to 2000-2001)	0.949***
Over-all period	0.980***

Note: *, *** denote significant at ten and one percent level of significance.

Apart from various inputs like quality of seeds, fertilizers etc. the main input that affects the production of any commodity is irrigation. The co-efficient of correlation between production of food grain and percentage coverage of food grain under irrigation for various era i.e. pre-green revolution era, green revolution era, post-green revolution era as well as for the over all period has been presented in Table 7. During all the periods

under study, the correlation coefficient was worked out to be positive as well as significant, which means that increase in irrigation facilities leads to increase in production of food grains. But in India on an average only 26.87 per cent of food grain acreage is irrigated. So in the future increases in irrigation facilities would yield better results on the production front.

Table 8: Regression coefficient of food grain production with respect to percentage coverage under irrigation

S.No.	Parameter	Regression
1.	Intercept	3.829*** (0.134)
2.	Percentage coverage under Irrigation	0.140*** (0.019)
3.	R^2	0.520***

Note: (a) *** denotes significant at one per cent level of significance.

(b) Figure in the parenthesis is the standard error of the estimated regression coefficients.

Table 9: Net availability of food grains (per day) in India from 1951 to 2000. (grams per capita per day)

Year	Net availability of Food grains
1950-51	394.9
1960-61	468.7
1970-71	468.8
1980-81	454.8
1990-91	510.1
1994-95	495.3
1995-96	476.2
1996-97	505.5
1997-98	450.3
1998-99	470.4
1991-2000	458.6
C.G.R from 1950-51 to 1999-2000	0.2335***
Standard error	(0.051)
Coefficient of Variation	6.15

Source: Statistical Abstract at a Glance – 2001.

Note: 1. For calculation of per capita net availability, the figure of net imports from 1981 to 1994 is based on imports and exports on Govt of India account only. Net imports from 1995 onwards are, however, based on the exports and imports (both Government and Private accounts).

2. *** denotes significant at one percent level of significance.

Table 8 shows the impact of percentage coverage of food grain under irrigation for the period of 51 years from 1950-51 to 1999-2001 in India. The linear form of the equation was found to have an edge over the log linear form in explaining the variation in production of food grains in the country. The coefficient of multiple determination (R^2) came out to be 0.52 indicating that about 52 percent of the production was explained by the explanatory variable included in the equation. The variable, which affects the production of food grains the most, is the percentage coverage under irrigation. The regression coefficients of percentage coverage under irrigation was worked out to be (0.140) positive significant at one per cent level of significance, which means that one percent coverage under irrigation would lead to an increase in the production of food grains by 0.14 million tonnes. Keeping in mind these positive effects, more efforts should be given to increase irrigation facilities, so that more area under food grains should be covered by irrigation.

Table 9 shows the net availability of food grains (per day) in India from the period 1950-51 to 1999-2000. According to the results obtained in Table 9, the per capita net availability of food grains (per day) was 394.9 grams during the period 1950-51. Now it has increased to 458.6 grams during the year 2000. Overall the compound growth rate in case of per capita net availability of food grains was worked out to be 0.234 per cent per annum. This increase is not sufficient. The variations in the per capita net availability of food grains were also worked out to be 6.15 per cent.

Table 10: Regression coefficient of per capita net availability of food grains with respect to production of food grains in India

Parameter	Regression
Intercept	–10.636*** (2.029)
Production	2.907*** (0.424)
R^2	0.49***

Note: *** denotes significant at one per cent level of significance.

Table 10 shows the impact of food grains production on net per capita availability of food grains in India. From the results shown in table 10, it is concluded that while keeping other variables like population etc. constant the one per cent increase in population of food grains would lead to an increase in the per capita net availability of food grains by 2.91 per cent per annum.

The supply of any commodity depends upon total production of any particular commodity is the country, its previous stock (export-Import of that particular commodity).

Conclusion

During all the periods' i.e. pre-green revolution,

green revolution, post-green revolution period and for the over all period, the growth in food grain production and productivity trends in India have increased while food grains acreage has shown a decreasing trend during the post-green revolution period. But rates of growth of production were low during the post-green revolution period (2.523 per cent) compared to the green revolution period (3.186 per cent). In the case of area, growth rate has declined by 0.191 per cent, but the rate of growth in productivity of food grains has shown an increasing trend. So the further increase in food grain production is possible by increasing the productivity of food grains instead of food grains acreage. The present study shows a significant impact of green revolution in the country in increasing the productivity of food grains. Moreover, the results of the study also highlighted the fact that irrigation has a positive impact upon the production of food grains. So in order to enhance the production of food grains in the country, there is a great need to develop infrastructure especially irrigation facilities. Further increases in food grains must come primarily from increasing biological yields rather than from area expansion. We should also draw up an innovative, farmer friendly policy in order to catch up with other devolving countries in food grain production and emerge as the leader in farm production in the coming years.

Apart from these during the current years huge stocks of food grains, procured by various state agencies and stocked in the open, will remain exposed to a vigorous monsoon, which is likely to break over. No specific arrangements to save the food stocks from the rain have been made any where by any of the state or central agencies, including the Food Cooperation of India (FCI) as a results the food grains stocks become unfit for human consumption. Exposed to the vagaries of the weather and lying unprotected from rodents the stocks have started discoloring. At places, there is decaying. So the proper storage of food grains is equally important.

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Kind words can be short and easy to speak, but their echoes are truly endless.

– Mother Theresa

Feature

Institutional Developments & Agricultural Productivity in Punjab

Manjeet Kaur & M.K. Sekhon

The impact of institutional developments on agricultural productivity in Punjab has been studied by constructing a composite index of the institutional inputs like farm size distribution, financial institutions, the general infrastructure, cropping intensity, the degree of progressiveness of the farmers, the development status of the districts and education at four different points of time i.e. triennium ending 1971-72,1981-82, 1991-92 and 1998-99. Institutional Index for all the districts improved over the period, which is a clear sign of infrastructure development among districts. The regression coefficients of Institutional Index variable were positive and significant at 1 percent level. A broad comparison of regression coefficients with and without Institutional Index as a variable also showed its increasing significance. The coefficient of Institutional Index variable clearly pointed to improvements in the institutional structures and infrastructure, not only in the lagged districts but also for the state as a whole.

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Punjab is known for its agricultural development in terms of manifold increase in productivity during the last five decades, particularly after the introduction of high yielding varieties (HYVs) in the mid nineteen sixties. A study on the trend in value productivity among districts in Punjab found that the value productivity increased in all the districts (at constant prices) and the gap between them decreased over the period. It has also been found that the districts with higher productivity in the base period of the study continued in general to be on the higher ladder (Kaur & Kaur, 2002). The value productivity gaps among different districts show the potential to raise the productivity in the lagging areas and help in identifying the causal factors thereof. Various institutional variables such as consolidation of holdings, more equitable farm size distribution, access to financial institutions, metalled roads, market developments, education etc. have played complementary role as important determinants of productivity growth. However, these variables have themselve not progressed uniformly across districts/regions in the state. This has led to inequitable growth in productivity in different districts of the state. There are two corollaries: one, how far these variables determine the productivity growth, and two, how far these determine the productivity variation across districts? The paper is divided into three sections. First section deals with the construction of a composite Institutional Index capturing the variation and growth in various institutional variables over the period 1969-70 to 1998-99. Second section deals with the aggregate production function analysis with Institutional Index as the important determinant variable. The last section presents concluding observations of the study.

Institutional Index

This section deals with construction of Institutional Index of various institutional variables such as farm size distribution, density of financial institutions, metalled roads, literacy ratio and the progressiveness of the

farmers which directly or indirectly influence productivity of the region. Although in some studies only education has been considered as a catch-all variable (Griliches, 1964 & Singh 2000), but it is the sum total of all the institutional variables, on account of their complementarity and not the education variable alone that determines the aggregate productivity. This is more vividly captured in our data, for instance, the percent literacy was the highest in the Hoshiarpur district but because of the lag of other institutional variables, the institutional index as well as the productivity in this district were very low.

Data and Variables

The data on variables considered for constructing the Institutional Index were taken from the Statistical Abstract of Punjab (Government of Punjab). The Institutional Index for 1971-72, 1981-82, 1991-92 has been taken from our earlier study (Singh, Kaur and Kaur, 1996). Following the same approach, following institutional variables were considered for developing the Institutional Index for 1998-99.

Development Status of the District

There are many economic indicators defining the development status of a district. However, the present study concentrates on the variables expressed through gross and net area sown as per cent of geographical area as the most important determinant in the development of the district.

Farm Size Distribution

The economic farm size range considered for constructing this index was above four hectares, notwithstanding the controversy over the optimum size of the farm. District wise data related to the number of operational holdings for different size categories was available for the year 1995, which was assumed to be the same as for 1998-99 because the changes in this variable are rather slow to come about.

Intensity of land use

The intensity of land use reflects the overall infrastructural developments in an area. The cropping intensity was used to capture the variation across districts.

Pogressiveness of the farmers

This variable was expressed by percentage of area under HYVs of wheat and rice to gross cultivated area.

Education

Several studies using field level survey data have shown a significant positive relationship between education and productivity of crops (Singh 1974; Chaudhri 1979; Ram 1980; Pudasaini 1983; Duraisainy 1992). Education measured as a per cent of rural literacy was available for the 1971, 1981, 1991 census. The growth rates for per cent literacy for each district were estimated separately. These growth rates were used for interpolations/extrapolations of the per cent literacy between these years, for developing estimates for some years, whenever required.

General Infrastructure

General infrastructure which includes number of regulated markets and metalled roads have an important role to play in agricultural development. Almost all the markets in the state are regulated, hence much variation was not observed among districts. So the metalled roads as kilometres per thousand geographical hectares were expressed as the variable indicating general infrastructure of the district.

Financial Institutions

The role of financial institutiosn in agricultural development is well recognized. The variable was taken as credit outstanding by various central cooperative banks for agriculture as a close proxy of the variation in credit advanced to agriculture in different districts by institutional sources.

Weights were assigned to these variables for construction of Institutional Index, which were the averages of the expert opinion obtained through a structural schedule. The indices of institutional variables have been constructed for the period ending 1971-72, 1981-82, 1991-92 and 1998-99. The details of methodology for each district have been given for the period around 1998-99 in Appendix-II. It may be noted that the maximum (theoretical) value of the Institutional Index at any point of time was placed at 100 because the dispersion in each of the institutional variables at any point of time has been considered from the maximum and not from the averages.

Institutional indices for almost all the districts improved over time (Table 1). During 1971-72 the maximum index was 80.8 points i.e. for Ludhiana district (Details of institutional variables showed that very high value for Ludhiana district during 1971-72 was due to very high credit outstanding in that year). It declined (relatively) later on and hence the Institutional Index. Excluding Ludhiana for 1971-72, it was found that there

was an increasing trend of maximum and minimum Institutional Index over time. The highest value of Institutional Index increased from 70.4 points in 1971-72 to 84.4 points in 1991-92 and further to 87.9 points in 1998-99. Similarly the lowest value of Institutional Index increased from 52.6 points in 1971-72 to 66.6 points in 1998-99. The improvement in Institutional Index is an indicator of infrastructure development across the districts.

Institutional indices for almost all the districts improved over time

Table 1: Relative Institutional Index of different districts

District	1971-72	1981-82	1991-92	1998-99
Gurdaspur	62.1	75.5	67.2	73.2
Amritsar	69.2	65.6	77.9	79.0
Kapurthala	70.4*	71.1	74.8	81.1
Jalandhar	70.4	71.0	74.8	81.5
Hoshiarpur	54.8	63.6	60.9	68.6
Ropar	52.6	58.3	62.9	74.9
Ludhiana	80.8	73.0	80.3	87.9
Ferozepur	60.1	69.2	75.5	79.5
Faridkot	60.1	74.2	80.3	82.9
Bathinda	61.3	71.8	80.4	72.9
Sangrur	66.6	71.4	84.4	81.5
Patiala	65.9	74.8	81.3	84.2
Max	80.8	74.5	84.4	87.9
Min.	52.6	58.3	60.9	66.6
Gap	28.2	17.2	23.5	21.3

* Figure next to maximum value of index number.

Institutional Index as a Determinant of Production Surface

Production function approach was adopted to analyse the role of institutional developments in productivity. Cobb-Douglas type production function was used for estimation purpose. Two specifications of the production function have been employed to relate institutional development with productivity; i.e. without and with Institutional Index as an independent variable in the production function for different time periods. Aggregate agricultural production functions based on the cross-district and time series data were estimated for different periods.

The dependent variable (y) was gross return computed by aggregating the value of different crops at 1980-81 prices. The crops considered in this estimation are wheat, rice, cotton, bajra, maize, sesamum , linseed, dry chillies, potato, massar and sugarcane which together account for about 90 per cent of the total cropped area in the state. The data on the production of fruits and vegetables were not available district-wise and hence, could not be considered. The value productivity was estimated at four different points of time. Since the weather and other natural factors vary from year to year, a three years average was considered i.e. average of triennium ending 1971-72, 1981-82, 1991-92 and 1998-99.

The independent variables considered were; Net area sown in thousand hectares (X_1) basically, required to convert all the other variables at the district level to per unit area basis. Labour in thousand workers (X_2); female workers were converted into male equivalents (one female worker equal to 0.67 male worker). Fertiliser in thousand kgs of nutrients (X_3). The number of tractors were considered to represent machinery (X_4). Electric motors (X_5) per thousand hectares was used as the measure of relative electric power used in a district. Per cent of net sown area irrigated (X6) reflects the inter-district differences in land quality and hence accounts for the difference in productivity. Finally Institutional Index (X_7) was quantified to account for a number of institutional variables.

The regression results are reported in Table 2. During the 1969-72 green revolution period, the production elasticities of labour, fertiliser and machinery were significant at 5 per cent whereas for irrigation variable, taken as per cent area irrigated, it was significant at 1 per cent level of significance. All these variables were important determinants of productivity during the early phase of the green revolution period. During 1979-82 and the subsequent periods thereafter up to 1996-99, the regression coefficient of fertiliser and labour became non-significant (equation nos. 3, 5 & 7) due to decline in variation in use of these variables across districts over time. The coefficient of machinery for which the number of tractors per thousand hectares was used as a close proxy, improved over the period and remained significant at 1 per cent level of significance, inspite of increase in number of tractors over this period. This shows that the input of intensive agriculture can accommodate more intensive mechanisation and has played active role as a determinant of aggregate productivity.

Electric motors were not included during 1969-72, but had become a very important variable by 1979-82 and continued to be so. Its coefficient remained significant in all the equations. This is precisely the pointer

Table 2: Impact of Institutional Index on the aggregate agricultural production function (Cobb- Douglas), Punjab, 1969-72 to 1996-99.

Period	No. of obs.	Regression Coefficient of							
		Intercept	Labour	Fertiliser	Machinery (Tractors)	Electric Power	Irrigation	Institutinal Index	R^2
1969-72	33	2.2305	1.0421** (3.7594)	0.0632** (2.0387)	0.1780** (2.9132)	–	0.5178*** (5.3658)	–	0.8105
1969-72	33	0.8159	0.7355** (2.1799)	–0.0071 (0.0715)	0.0877** (2.2710)	–	0.0721 (0.4498)	1.1840*** (3.3560)	0.8414
1979-82	36	1.4421	0.0234 (1.4124)	0.1322 (0.2996)	0.2077*** (5.3393)	0.1540*** (4.3380)	0.0975 (1.2728)	–	0.8629
1979-82	36	–1.4241	–0.0712 (0.9621)	–0.0324 (0.3375)	0.2095*** (6.1799)	0.2272*** (5.9321)	0.0575 (0.8481)	0.8135*** (3.248)	0.8995
1989-92	36	–02191	0.0184 (0.1762)	0.0624 (0.8667)	0.2853*** (3.3644)	0.1359*** (3.8718)	0.5027*** (3.7127)	–	0.8291
1989-92	36	-4.0888	0.0021 (0.0353)	0.0290 (0.7039)	0.2042*** (4.1366)	0.2197*** (9.7212)	-0.5811** (3.7131)	2.0452*** (7.9611)	0.9463
1996-99	36	1.2271	–0.1586 (-0.8168)	0.1261 (0.9559)	0.2894** (2.2463)	0.1908*** (4.2484)	0.1022 (0.4405)	–	0.6716
1996-99	36	–1.7845	–0.1447 (–0.8172)	–.0228 (1.2735)	0.1511 (1.1766)	0.1144** (2.2889)	–0.3462 (1.2804)	2.1648** (2.6639)	0.7362

Note: ***,** and * denote significance at 1,5 and 10 percent respectively. Figures in paranthese are the t-values.
All the R^2 values are significant at 1 percent level.

towards majority of the farmers even small and marginal ones, going in for their own electric motors.

The impact of institutional developments has been studied by incorporating Institutional Index as an independent variable in regression equations. The regression coefficient of the Institutional Index variable was positive and significant in all the regressions.

During the period 1969-72 to 1979-82, its value decreased marginally but remained highly significant at 1 per cent level of significance. During 1979-82 to 1989-92 and further in 1996-99, its value increased considerably from 0.8135 to 2.0452 and further to 2.1648. The increasing value of the coefficient of the Institutional Index during the 1990s is of even more significance in pointing out its role in the changed economic scenario of globalisation and WTO. Although this was not directly included in the model, and so far (up to the period of this study) it was only a starter, it does indicate that infrastructure and institutional developments in the state would go a long way in pushing up the agricultural productivity.

Infrastructure and institutional developments in the state would go a long way in pushing up the agricultural productivity.

A broad comparison of the regression coefficients, without and with Institutional Index as an independent variable also showed its changing, rather increasing significance. Though during 1969-72, the statistical significance of the variables decreased with the inclusion of institutional index as an independent variable but during 1989-92, the Institutional Index showed more significant impact on production along with the other variables. The same was true for 1996-99, when the coefficient of Institutional Index was the highest at 2.1648. The number of holdings in the economic farm-size range, cropping intensity and education, determined the diffusion of new technology at a faster rate (particularly varieties), coupled with the availability of institutional finance and other factors. The increased output is to be marketed, the movement of technical inputs like fertilisers etc. is to be facilitated from nodel points to villages and farmers. Here the road network was used as the best approximation. This complex framework of the institutional variable is, therefore, very important and the improvements in its various components and also their maintenance have now come to be obviously related with economic development. The coefficient of Institutional Index variable, which improved over time clearly pointed to improvements in the institutional structures and infrastructures, not only in the lagged districts but also for the state as a whole.

Conclusions and Policy Implications

From the above analysis it is concluded that various

institutions and infrastructural developments played a considerable role in the productivity growth and is determining the variation in productivity amongst various districts of the Punjab state. The improvement in institutional indices over the period among districts on one hand and declining gaps in value productivity on the other hand is a pointer towards potential capital investments in infrastructures and institutional development which build up productivity in relatively low productive areas. Although the productivity gaps between districts declined over time their ranking remained somewhat the same thereby indicating more potential in low productive areas, which demands more of capital investments, infrastructural developments and improvement of the institutional variables. It was further vindicated in the production functions analysis, wherein the Institutional Index was found to be a strong determinant of aggregate agricultural productivity over time. Not only the coefficient of Institutional Index improved over time and even more so during the 1990s, but its complementarity with other variables also became of greater significance. This is a strong pointer for further improving the institutional environment and building up the additional infrastructure not only in the lagged districts but also for the state as a whole.

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Appendix I

Coefficients used to standardize data for the original 12 districts

New District	Original district	Proportion of the different variables of the new district merged with the original district.
Nawan Shahar	Jalandhar	0.60
	Hoshiarpur	0.40
Mukatsar	Faridkot	1.00
Moga	Faridkot	1.00
Mansa	Bathinda	1.00
Fatehgarh Sahi	Patiala	0.83
	Ludhiana	0.17

Appendix II

Constructing the Institutional Index,1996-99

Disst	Development Status (Area sown as per cent of total geographical area Trienn. Ending 1998-99)		Farm Size Distibution (Per cent of holdings >4 ha. 1995)	Intensity of Land Use (Cropping intensity Trienn. Ending 1998-99)	Progressive-ness (per cent area under HYV of wheat and rice Trienn Ending 1998-99)	Education (Per cent of rural literacy-projected as per growth rates	Infrastructure (Metalled roads maintained by PWD and Local Bodies Trienn. Ending 1998-99)	Financial Institutions (Credit outstanding by Central Cooperative Bank Trienn. Ending 1998-99)	Institutional Index
	Gross	Net					Index: Max.,16.14 kms/000 geographical ha. = 100	Index: Maxi. Rs.4563.44 / sown ha. = 100	
Weights	0.1	0.06	0.24	0.12	0.16	0.11	0.07	0.14	1.00
Gurdaspur	135.21	80.99	12.62	174.33	73.65	76.98	58.41	46.59	73.20
Amritsar	159.06	88.06	22.20	190.00	72.51	54.22	48.97	63.19	79.00
Kapurthala	163.8	84.87	18.45	184.67	75.42	71.82	60.89	64.02	81.14
Jalandhar	152.38	92.98	23.29	175.67	69.23	78.10	69.67	68.87	81.48
Hoshiarpur	104.9	62.06	14.87	167.00	52.44	92.90	62.81	55.23	68.61
Roopnagar	95.68	56.79	9.98	178.67	60.63	76.74	98.30	100.00	74.99
Ludhiana	163.22	83.15	26.55	190.00	81.57	77.24	100.00	73.76	87.90
Ferozepur	163.21	87.66	32.03	184.67	69.42	51.16	42.67	60.15	79.55
Faridkot	169.21	88.89	39.33	184.00	69.66	52.02	44.27	63.34	82.88
Bathinda	157.98	89.22	31.36	176.33	55.52	47.97	40.44	43.91	72.93
Sangrur	182.2	87.92	27.59	189.67	79.45	53.95	45.51	47.83	81.53
Patiala	157.88	80.71	29.32	187.33	81.69	60.76	72.92	70.34	84.16

□

I find television very educating. Every time somebody turns on the set, I go into the other room and read a book.

– Groucho Marx

News & Notes

Table 1: Productivity Scorecard: Major Countries in the World 2002 (US Dollars)

Countries	At Current Exchange Rates				
	GDP per person employed per hour	GDP per person employed	GDP per person employed in agriculture	GDP per person employed in industry	GDP per person employed in services
Australia	23.06	40331	27666	47389	39240
Brazil	3.37	6508	2156	12084	6475
Canada	24.58	46478	35697	60170	42706
China	0.80	1587	489	3693	2014
Denmark	35.23	59440	35346	62659	59904
Finland	29.83	51404	26475	52812	52232
France	34.58	54885	42115	51497	56743
Germany	29.88	50433	18854	42723	55714
Hong Kong	22.82	49780	14722	44152	51006
India	0.52	1095	403	2465	2570
Indonesia	0.69	1435	527	3853	1440
Italy	29.22	50603	22817	47726	54353
Japan	34.67	64625	17799	64081	68122
Korea	9.53	19763	8436	29775	17318
Malaysia	4.15	9203	4443	12621	8626
Netherlands	31.78	53578	54544	77002	50450
Norway	41.98	72631	27649	102734	66230
Russia	2.61	4769	2466	5958	6173
Singapore	21.05	41846	14767	53787	37631
Spain	22.85	39398	23580	35486	43349
Sweden	26.83	49912	43767	59053	47192
Switzerland	33.62	62367	23423	68923	62279
United Kingdom	27.81	50968	48480	50954	47175
USA	39.30	75386	55802	89711	71722

Table 2: Productivity Scorecard: Major Countries in the World 2002 (US Dollars)

Countries	At Purchasing Power Parity terms				
	GDP per person employed per hour	GDP per person employed	GDP per person employed	GDP per person employed in agriculture	GDP per person employed in industry
Australia	31.57	55218	37878	64882	53726
Brazil	8.87	17119	5672	31785	17030
Canada	30.37	57436	44113	74356	52775
China	3.72	7375	2271	17158	9359
Denmark	32.39	54641	32492	57599	55067
Finland	32.06	55239	28450	56752	56129
France	38.55	61171	46938	57395	63242
Germany	33.58	56685	21191	48019	62621
Hong Kong	24.12	52605	15558	46658	53901
India	2.97	6237	2296	14033	14633
Indonesia	3.53	7286	2674	19569	7312
Italy	37.24	64495	29082	60828	69274
Japan	28.31	52779	14536	52334	55635
Korea	19.11	39617	16911	59688	34717
Malaysia	10.05	22273	10754	30545	20875
Netherlands	34.55	58249	59300	83716	54849
Norway	34.94	60445	23010	85497	55118
Russia	10.80	19697	10184	24609	25497
Singapore	22.60	44934	15857	57757	40408
Spain	31.03	53492	32015	48179	58856
Sweden	27.81	51718	45350	61189	48899
Switzerland	28.43	52747	19810	58292	52672
United Kingdom	28.00	51325	48819	51310	47505
USA	37.47	71858	53191	85513	68366

Table 3: Overall Ranking & Competitiveness: Major Countries in the World

Countries	1998	1999	2000	2001	2002
Australia	12	11	10	11	14
Brazil	35	34	31	31	35
Canada	8	10	8	9	8
China	21	29	30	3	31
Denmark	10	9	13	15	6
Finland	6	5	4	3	2
France	22	23	22	25	22
Germany	15	12	11	12	15
Hong Kong	5	6	12	6	9
India	38	42	39	41	42
Indonesia	40	47	44	49	47
Italy	31	30	32	32	32
Japan	20	24	24	26	30
Korea	36	41	28	27	29
Malaysia	19	28	27	29	26
Netherlands	4	4	3	5	4
Norway	11	16	17	20	17
Russia	43	46	47	45	43
Singapore	2	2	2	2	5
Spain	26	20	23	23	23
Sweden	16	14	14	8	11
Switzerland	9	7	7	10	7
United Kingdom	13	19	16	19	16
USA	1	1	1	1	1
Total Countries considered for Ranking	46	47	47	49	49

Source: Based on World Competitiveness Year Book, 2002

Compiled by
K.P. Sunny
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Book Reviews

Managing Productivity in the Apparel Industry *by Rajesh Bheda,* Professor–NIFT, CBS Publishers & Distributors, New Delhi, First Edition 2003, Price: Rs. 295.

The book presents various aspects related to productivity in Apparel industry in India as well as at the global level. Probably one of the few books dedicated to productivity improvement in the apparel industry. Chapter 1-9 of the book takes a novice as well as practitioners in the Industry from concept to intricacies of factors effecting productivity in the Apparel Industry.

It starts with an overview of the global apparel industry. This chapter discusses the stages of development in the textile and lists major exporting & importing countries of Apparel with their trade volumes. It also gives an overview of technology in apparel manufacturing. The author has presented an encouraging future outlook for the world trade in apparel specially after the much awaited quota out by Dec. 2004. The author discusses that while cost of manufacturing is not the most important, it is and will remain a significant factor. India is cost competitive, but trading blocks, lead time, transportation costs and non-tariff barriers will continue to alter this cost competitiveness.

Chapter 2 deals exclusively with the Indian Apparel Industry and provides a basis for productivity level in the country that is further discussed in Chapter 5. It thus establishes a useful link between the practices and the results.

In Chapter 2, the author discusses the technology status of apparel manufacturing in India and presents a data indicating presence of sophisticated imported machines mainly in cutting and specialised sewing. Quoting an important research study undertaken by NIFT in 1999, the author discusses that even though future investments would be made to Chapter 8 & 9 discusses the strategies for productivity improvement as phase I and II. It is observed by the author that factories rely more on past performance to set production targets, than calculate the work content of operations using established procedures like time and motion study or use pre-determined time standards. The author also suggests productivity measurement system for apparel industry. In phase II (Chapter 9) of the strategy, the book concentrates on quality system, safety and work environment, technology up-gradation and incentive schemes etc. The author also gives due importance to development of information system.

The book is strongly recommended for all the officers in operations and productivity enhancement related functions in the apparel industry expand production capacity, the relative importance of productivity and technology improvement was increasing.

Chapter 3 explains the concept of productivity, different approaches to productivity improvement, calculation of productivity index and how productivity is lost in the apparel industry. The author also gives some useful tips for calculation and interpretation of productivity and identifies and discusses major factors influencing productivity performance such as absenteeism, incentives etc.

Chapter 4 outlines "Apparel productivity in the Western world" and focuses on productivity achievements in U.S. and European union and presents a global comparison in productivity. It emphasises the role of industrial engineering principles to bring in improvement such as methods improvement, introduction of incentive, increased use of work aids etc.

Chapter 5 discusses at length, the apparel productivity in India and quotes McKinsey global Institute (MGI) finding that has estimated productivity level of the India apparel manufacturers for exports at 35% and of the Chinese manufacturers at 55% of the productivity levels achieved in USA while the performance achieved by Indian Apparel manufacturers in the domestic market at further lower level. It also gives the industry perception of the world standard productivity level vis a vis actual productivity performance.

Chapter 6 has brought out the factors associated with productivity in apparel manufacturing. A close look at these factors indicates that majority of the factors can be altered or controlled by management with relative ease to improve the productivity level. Chapter 7 draws out different cases for Benchmarking. The cases are drawn from the organisations specializing in various apparel products. However this chapter only limits itself in providing data on certain indicators. The author could have gone one step further in backing up the cases with prevailing practices and enabling elements as the data indicating results is only a consequence of the latter.

Neeraj Chopra
Deputy Director
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Urban Fringe Agriculture, published by APO, 2002, p. 246.

This book contain reports on the presentations by different country participants, resource speakers on the seminar on Urban Fringe Agriculture organised by Asian Productivity Organisation (APO) in Tokyo during May 2000 with the objectives to discuss the present situation of Urban Fringe Agriculture in Asia and Pacific and to identify issues and constraints affecting its development and suggest measures for enhancing its contribution to the economy.

Urban fringe agriculture has recently becomes an important policy concern, particularly in light of the rapid growth of cities and other urban centers in many parts of Asia and the consequent need to feed the growing population in these areas. Urban fringe or peri-urban agriculture involves farming near or around cities and towns with the use of intensive methods to produce mainly vegetables and other horticultural and livestock products on a semi-or full commercial basis. Due to their proximity to their markets, urban fringe farmers are able to enhance the freshness of their perishable products and to minimise their post harvest losses. Urban Fringe Agriculture also offers opportunities for productive employment, particularly in the commercial livestock sector in which rapid growth in recent years has also spurred the expansion of food processing activities in areas near urban centers.

Urban Fringe Agriculture, however, can pose risks to public health and the environment. The inappropriate or excessive use of inputs such as chemical fertilisers and pesticides can contaminate soil and water and can cause air pollution. The improper disposal of animal waste can also lead to public health problems. Thus, the sustainability of urban fringe agriculture needs to be more intensively studied as the development of more environment-friendly technologies and formation of appropriate policies will require the balancing of the benefits from a further expansion of this type of faming with its potential impact on the larger environment.

Urban Fringe Agriculture has to be seen as a business not only benefiting those sectors directly involved, such as producers and vendors, but also consumers who will be positioned for better food sourcing. Equally important to a city's deployment and its society is its social and environment characteristics. Policy- makers, agricultural and urban development institutions, farmers' associations, and non-government and community based organisations have to recognise and be informed of the capacity, benefits and present pitfalls of urban fringe agriculture and horticulture.

Agriculture still remains an important industry in Asia-pacific region. Its contribution to the national economy has actually declined significantly in the past two decades in many of the region. However, its role continues to be critical, particularly in the context of growing concern over food security, as well as the continuing need to provide employment opportunities to an increasing number of people.

Urban Fringe Agriculture in the participating countries has several characteristics that distinguish it from rural agriculture. The characteristics, which basically stem from urban fringe agriculture's proximity to urban areas, include land-use policy/regulations that are relatively more critical to urban fringe agriculture, general need for more intensive types of farming activities, often involving rapidly maturing crops that exhibit higher productivity due to the technology adopted for urban fringe agriculture, it is more demand driven and involves the production of more high quality produce, as required by its urban markets, product marketing that is usually done in a more direct way to consumers and wider and more serious impact of urban fringe agriculture activities on the environment and public health of community.

The environment impact of urban fringe agriculture is perhaps the most important aspect in terms of sustainability, since environmental pollution resulting from the indiscriminate use of agro-chemical could restrict its future expansion. As development in urban areas proceeds, competing uses of land will also be a major factor limiting urban fringe agriculture. These two factors highlight the importance of land-use planning, environmental protection and coordination of all development efforts at the local and national levels.

The more common crops grown in urban fringe agriculture are vegetables, particularly the leafy type,

flowers and ornamental plants, livestock (mostly poultry and pigs), and aquacultural products. Due to its nearness to the urban population, urban fringe agriculture in a number of countries has also combined the farm business with leisure agriculture or agro-tourism. The farmlands in urban and urban fringe areas are either owner-operated or rented/leased from other landowners/government. Cultivation is done in open fields or under protective shelters/greenhouses. The latter method is most prevalent in the case of vegetable growing where protection of the plant from pests and diseases is most critical. Chemical-free farming practises such as integrated pest management (IPM), diversified cropping, crop rotation and use of organic waste materials by composting is becoming more widespread in urban fringe agriculture. Organic farming systems are also increasingly being promoted in order to meet the growing demand among urban consumers for safe and healthier foods. More advanced technologies such as hydroponics are also being applied in order to improve productivity and quality of the produce.

In a few countries, agro-technologies parks have been established to enhance the suitability of urban fringe agriculture in terms of ensuring more permanent/secure areas of which to engage in farming for urban communities. Such parks provide essential infrastructure and comprehensive support services, and promote integrated farming systems.

In some other countries, urban agriculture has specifically been in order to pursued to achieve poverty alleviation objectives through home or community garden activities. Because of limited space, this type of farming makes maximum use of resources, particularly land, and promotes the utilisation of recyclable materials.

While urban fringe agriculture, in general remains relatively small in many of the participating countries, it is expected to grow more significantly in the future as urban communities further expand and the need to feed the growing number of people become more urgent. Its future expansion, however will be constrained by greater competition for land and other resources resulting from continued urbanisation and industrialisation. It is expected that cities will continue to grow as more and more inhabitants migrate from rural areas to urban centres. As land becomes limited and food scarcity get worse, preventive measures will need to be taken. In that context, urban fringe agriculture can play an important role in addressing the problems of food security and providing employment and income opportunities, production of quality and safe foods, environmental enhancement, the preservation of biodiversity, improvements in the quality of life, the development of agro-tourism and education and better utilisation of idle space.

The papers from all the participants recommended some actions for application in urban fringe agriculture such as organic waste management, integrated pest management, irrigation and water productivity, community gardening, school gardening, community law and regulations for urban agriculture, the integration of small livestock, fish ponds and vegetable growing and other such actions for application in urban fringe agriculture and a number of basic considerations/requirements need to be taken into account. In the development of urban fringe agriculture these include among others a well defined land use policy, optimal use of resources, particularly land, environment protection, an effective marketing strategy and appropriate technology. In addition, urban fringe agriculture should not be developed in competition with rural agriculture, but should concentrate on crops where it has a comparative advantage.

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