SUMMER INTERNSHIP REPORT

ANALYSING & FORECASTING ENERGY DEMAND FOR A SUSTAINABLE LIVING: A CASE STUDY OF MUMBAI

UNDER THE GUIDANCE OF

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At
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Declaration

I, Saurabh Srivastava, Roll no. / Semester III / Class of 2011-13 of the **MBA (Power Management)** programme of the National Power Training Institute, Faridabad hereby declare that the Summer Training Report entitled

Analysing & Forecasting Energy Demand for Sustainable living :A Case Study of Mumbai is an original work and the same has not been submitted to any other Institute for the award of any other degree.

A Seminar presentation of the Training Report was made on ………………….. and the suggestions as approved by the faculty were duly incorporated.

Presentation In charge
(Faculty)

Signature of the Candidate

Countersigned

Director/Principal of the Institute

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Abbreviations

MMR- Mumbai Metropolitan Region

ICMA- International City/Country Management Association

USAID- United States Agency for International Development

NIPFP- National Institute of Public Finance & Policy

CPCB- Central Pollution Control Board

PJ- Peta Joule

TJ- Tera Joule

NDDP- Net District Domestic Product

PKM- Passenger Kilometer

ICLEI - International Council for Local Environmental Initiatives

MCDM- Multi Criteria Decision Modelling

SDI- Sustainable Development Indicators

ICMA- International City/Country Management Association

SME- Small & Medium Enterprises

Institute's Profile

➢ About IGIDR

History/Backgrouds

Indira Gandhi Institute of Development Research (IGIDR) is an advanced research institute established and fully funded by the Reserve Bank of India for carrying out research on development issues from a multi-disciplinary point of view.

IGIDR was registered as an autonomous society on November 14, 1986 and as a public trust in January 1987. On December 28, 1987 the campus was inaugurated by Late. Shri Rajiv Gandhi, the then Prime Minister of India.

Subsequently, the Institute was recognized as a Deemed University under Section 3 of the UGC Act. Since then it has been awarded the highest National Assessment and Accreditation Council (NAAC) rating of A++ (under the old methodology) given to Indian academic institutions.

Starting as a purely research institution, it rapidly developed into a full-fledged teaching cum research organisation when it launched a Ph.D. program in the field of development studies in 1990. The objective of the Ph.D. programme is to produce researchers with diverse disciplinary backgrounds who can address issues of economics, energy and environment policies. In 1995, the institute initiated the M. Phil programme. The M.Sc. programme commenced in 2003 to introduce students to the world of research at an earlier stage.

At present the Institute has about 150 employees and students that include about 26 full time faculty members, 24 non-academic staff and about 90 M.Sc./M.Phil/Ph.D students.

➢ Prof. S. Mahendra Dev, Director (Vice Chancellor)

Following is an excerpt from a detailed information about Prof. S Mahendra Dev.

"Since its existence in 1987, IGIDR has been committed to excellence in teaching and research. It is an advanced research institute established by the Reserve Bank of India for carrying out research on development issues from a multi-disciplinary point of view.

Subsequently it was recognized as a deemed university. The former directors of the institute Prof. Kirit Parikh, Prof. R. Radhakrishna and, Prof. D.M.Nachane have helped in maintaining high standards in both research and teaching. I also acknowledge the contributions of faculty, staff and students for the growth of the institute over the years.

My task is to continue the past good practices and face new challenges in future. Dr. Bimal Jalan Committee had given several recommendations on teaching, research, infrastructure and governance for further development of IGIDR as an Institute of high international standing. We will try to achieve some of these ambitious goals in future.

The research agenda of the Institute is guided by policy concerns, by individual faculty members' research interests and projects by sponsors. However, there is a need to strengthen and diversify the research in keeping with the changing needs. While individual scholars would continue to have the freedom to choose topics for research, there is a need to expand the frontiers of knowledge in order to keep with the emerging challenges.

There have been many changes in macro economic policies due to paradigm shifts in development strategies consequent to globalization. Also, there is a need to understand better the role of structural and cyclical factors in growth and development. Shocks due to globalization are increasing now. The recent examples are four ‘F’s: food, fuel, fertilizer and financial shocks.

There is also a perception that economics as a profession failed to predict the financial crisis and some advocate the need for new thinking on economics. For example, an institute sponsored by George Soros on new economic thinking has been established in the U.S.

More research may be needed to understand the changes at global level particularly in macro policies like monetary policies, fiscal policies, external and internal debt management, exchange rate management, financial sector reforms, and trade policies. It is known that financial sector is an instrument to help the real sector. Financial sector policies have to be tuned in such a way that real sector improves.

Similarly, with globalization, the role of the state and market has to be redefined to address the development issues. New actors like non-governmental organizations have emerged with the decline in the role of the state. There is also an increasing emphasis on decentralized governance taking governance to grass roots level. Inclusive growth approach being followed by government of India also implies the need to look at challenges in the divides in economy and society viz, sectoral, regional and social.

New concerns on human development, social dimensions of globalization, social security and insurance, gender, sustainability of natural resources, climate change, livelihoods, water, biotechnology also need some attention. In this context, the Prime Minister of India Dr. Manmohan Singh had suggested that IGIDR should also focus on issues relating to topics such as monetary policy, water management and climate change.

For a deemed university, teaching is an important component of the Institute’s activities.

Teaching programme has been very good at IGIDR. The students of MSc, M.Phil and Ph.D have got jobs in reputed corporate firms, banks and research institutes and universities. It reflects the quality of teaching at IGIDR. However, as mentioned by Dr. Jalan Committee, there is a need to relook at the curriculum, method of teaching, incentives to faculty etc.

Teaching programmes can be upgraded to international standards through appropriate curricula revisions and academic collaborations involving faculty and student exchange programmes. There is also a need to focus on infrastructure development including hostel facilities for students.

The vision of IGIDR in the next decade is to further develop it as an Institute of high international standing and join the league of world class centres of excellence in theoretically informed applied research and teaching in development studies. It can be done by strengthening the present areas of research and diversifying its research and teaching to new areas to address the development challenges in tune with the changes in development paradigms, economy and society. The intellectual ambience of openness to ideas and plurality of perspectives have to be continued and strengthened."

Vision & Values

The aims and objectives of the Institute are to promote and conduct research on developmental issues from a broad inter- disciplinary perspective (economic, technological, social, political and ecological). It aspires to gain insights into the process of development and alternative policy options and to further disseminate the knowledge acquired.

The primary objectives of the Institute are :

- To promote and conduct research on development from a broad inter-disciplinary perspective.
- To promote co-operative endeavour and interaction between research scholars and institutions in India and abroad.
- To undertake projects or activity which renders itself useful for the furtherance of development and social welfare.
- To carry out training for advanced degrees viz. Master's and Doctorate award.

Special emphasis is laid on the following areas:

- The comparative study of development and policy in different regions and countries.

- The growing interdependence among nations in the world economy and its impact on development strategies and policy options.
- The influence of international trading, financial and economic systems on countries.
- The examination of energy, technology and environment problems in global setting.
- The analytical foundations of the positions adopted by India and other developing countries in international forums and negotiations.
- Economic and technological cooperation among developing countries and India's development experience and policies.
- Planning techniques and methodology.
- Issues in the choice of technology and social well being.
- The role of innovation and diffusion of technology in development.
- Resource utilisation and environment implications of technological alternatives.
- Social, legal, organisational and institutional aspects of development.

The Institute also serves as a centre for promoting co-operative endeavour and interaction in research activities between Indian scholars and institutions as well as between Indian and foreign scholars and institutions

Executive Summary

A sustainable city is a city designed with consideration of environmental impact, inhabited by people dedicated to minimization of inputs of energy, water and food, and waste output of heat, air pollution - CO_2, methane, and water pollution.Although, there is no completely agreed upon definition for what a sustainable city should be ,generally experts agree that a sustainable city should meet the needs of the present without sacrificing the ability of future generations to meet their own needs. Reduction of the impacts of cities on global sustainability requires them to reduce and contain their spatial, resource, pollution, climate and ecological footprints. Alternatives need to be found to urban sprawl. The liveability, aesthetic, social and economic attractiveness and safety of the cities' more dense urban centres need to be enhanced, and so does the efficiency of the cities' energy usage.

This study takes up Mumbai as a case. Starting with a detailed description of the region, the report discusses various problems faced by the district. Visits to a number of organizations were carried out for data collection related to the energy supply & demand patterns of the place. Other primary details as Population ,income distribution , district domestic product were found using secondary data sources . Chapter 4 discusses the analysis of data at hand. A comparative analysis over the years reflects the change in Energy Intensity due to Electricity consumed to generate Industrial Output & similarly for the commercial output (both in monetary terms). Tariff rates comparison shows the impact of a change in variables on the price of utility desired. In the later part recommendations for a sustainable living (in terms of energy consumption) have been given.

Chapter 5 forecasts the trend for some attributes in different business scenarios.

Development of alternative energy sources, replacement of hydrocarbons as urban transportation fuels, recycling materials, water conservation, production within or near the cities of resources they need are among the imperatives for cities.

As the intersection of two enormously complex and far from well understood problems, urbanization and sustainability, the challenge of urban sustainability should be placed in a broad framework that views the city as an interacting and self-adapting system consisting of living organisms, social organizations and cultures, and technological artifacts (machines, broadly defined). Linkages among these components, their synergies and trade-offs, and their interactions with the environment, are critical factors in determining the sustainability of a city.

1 .Chapter 1- Significance & focus of Study

1.1 Significance of the Study

Mumbai's aspiration is to become a world-class city in the next 10-15years. In order to achieve this, it needs to be distinctive on the dimension of economic growth and above average on quality of life. It will, therefore, need to step up economic growth to 8-10 percent by becoming one of Asia's leading services hubs, with a fast-growing manufacturing base in the hinterland. On the quality of life dimension, comparing it to the benchmark cities revealed that it needed to move from average to above average on mass transport, from poor to above average on private transport, housing, safety/ environment, financing and governance. It will also need to make improvements in the remaining areas, i.e., go from being average to above average in water/sanitation and education and from above average to world-class in healthcare. [1]

Mumbai needs to develop on both fronts- economic growth and quality of life. Mumbai contributes significantly to the State Domestic Product as well as India's GDP.

1.1.1 Energy

1.1.1.1 Transportation

Significant improvement is required to both mass and private transportation, it is imperative to ensure that the traveling population per rail car is kept down to 220 people and there is at least one bus for every thousand people. At present suburban rail congestion is such that during peak hours there are more than 570 people per rail car in certain sectors. For private transportation, increasing the average speed of travel, tripling the freeways/expressways and increasing the number of public parking spaces by order of magnitude is essential.

1.1.1.2 Electricity

Growing demands of Electricity asks for much efficient electricity supply through out the district & usage of energy efficient equipments in Industry.

1.1.2 Housing

Bringing down the number of people living in the slums from the current 50-60 percent. Mumbai also needs to increase housing affordability by, for instance, bringing down housing rental costs from their current 140percent of per capita income to about 50percent.

[1] Vision Mumbai,2003

1.1.3 Other infrastructure (safety, environment, water, sanitation, education & healthcare)

Environment stability,water availability & its conservation,education ,healthcare,sanitation & safety are other areas Mumbai needs to keep a vigil on for a sustainable living.

1.2 Focus of the study

The energy requirements of Mumbai have been increasing at a rapid rate owing to increase in the GDP ,the population of the city, rise in income per capita, increased infrastructural activities as real estate development, telecom infrastructure development .

Energy basically consists of resources as Electricity, Oil,Gas & Coal. These resources power up the energy requirements of any city .

The inputs in the form of these resources lead to a production of outputs in several forms. Of all these outputs,there are useful outputs & then there are the wastes. For a city like Mumbai to become sustainable in the coming future ,it becomes imperative to reduce the wasted material (energy,water etc.) to a minimum. The waste when fed back to the original system improves the efficiency to a great extent.

So the focus of this study is to analyse the trends & patterns of consumption of Energy/Electricity with the varying parameters of the Greater Mumbai region. It also tries to forecast the energy demand for upcoming periods.

2 . Chapter 2- Literature Review,Research Methodology & Limitations

2.1 Review of existing literature

Singh et al(2012) mentioned in his study that India's economic growth in the last decade has raised several concerns in terms of its present and future resource demands for materials and energy. While per capita resource consumption is still extremely modest but on the rise, its sheer population qualifies India as a fast growing giant with material and energy throughput that is growing rapidly . If such national and local trends continue, the challenges for regional, national as well as global sustainability are immense in terms of future resource availability, social conflicts, pressure on land and ecosystems and atmospheric emissions. Using the concepts of social metabolism and material flow analysis, his paper presented an original study quantifying resource use trajectories for India from 1961 up to 2008. He argued for India's need to grow in order to be able to provide a reasonable material standard of living for its vast population. To this end, the challenge is in avoiding the precarious path so far followed by industrialized countries in Europe and Asia, but to opt for a regime shift towards sustainability in terms of resource use by building on a host of promising examples and taking opportunities of existing niches to make India a trendsetter.

Bertaud et al(2009), said in his study that Urban productivity is dependent on people's mobility within a metropolitan area. GHG emissions, however, are only weakly linked to the number of kilometers traveled per person because there are such large variations between the emissions per km passenger between different transport mode and between the carbon content of the various energy sources used for transport. To reduce urban GHG emissions due to transport, it is therefore important to look at all the parameters that contribute to emissions. People's mobility depending on the choice of an urban transport mode is based on criteria of speed, cost, comfort, convenience, and reliability. Transport mode shifts that could reduce GHG would be possible only if all the demand factors are taken onto account. A supply driven approach to GHG reductions will have little chance of success if consumers' demand is ignored. He has reviewed the three concurrent strategies that could contribute to reducing GHG emissions due to urban transport: technology change within mode, mode shift, and land use strategy allowing the spatial concentration of jobs. However, none of these strategies are likely to succeed if not supported by an energy pricing policy directly linking energy price to carbon content.

ICLEI (2009), in its study on Sustainable planning mentioned that, as financial and environmental impacts soar, the real costs of resource inputs and of waste generation need to increasingly be taken into account. These factors are making efficiency, conservation, reuse, recycling and renewable energy sources primary considerations for a healthy economy. In an attempt to reduce resource inputs and environmental impacts, some developed nations have managed to 'decouple' economic growth from energy consumption – essentially resulting in energy inputs that decrease with economic growth. This has been achieved through technology and behaviour change to improve efficiency, and by closing the energy loop in production (e.g. recapturing heat energy released in the production process to then power production). Implementation of high energy efficiency and the use of renewable resources are also evident in energy-poor developing countries such as the island states of Reunion and Mauritius. As such, under conditions of necessity, pursuing efficient and renewable energy paths is possible. There is potential to greatly improve energy efficiencies and reduce carbon emissions in many upper-middle income developing countries which have a substantial industrial base. For example, South Africa produces a mere US$1.06 in economic value for every 1 kWh of electricity consumed – Brazil manages twice and Mexico four times this level of energy efficiency.

Economist Intelligence Unit(2011) mentioned in its paper that half a century ago, only one-third of people lived in urban areas; now it is over half, and by 2050, the United Nations (UN) expects worldwide urbanisation to reach 70%. Given that both rapid urbanisation and strong population growth are concentrated in poorer countries, the UN estimates that cities in emerging markets will see their populations more than double to 5.2 billion by 2050, from 2.5 billion in 2009. Rural populations are moving to the city to seek improvements to their quality of life—most notably through better economic opportunities. Cities generate around 80% of world gross domestic product (GDP), and accordingly attract the bulk of investment and create the lion's share of new jobs. Yet, whilst the wave of urbanisation is strongest in developing countries, it is cities in these countries that appear least prepared to respond to this rapid urban growth. Far from being a luxury for small, wealthy cities, urban sustainability is a vital part of managing rapid city growth in poorer countries.Indeed, cities in developing countries have the opportunity not only to *work*, but to *work better* than cities in developed countries.

Phdungsilp(2006) said in his study that cities throughout Asia have experienced unprecedented economic development over the past decades. In many cases this has contributed to their rapid and uncontrolled growth, which has resulted in a multiplicity of problems, including rapid population increase, enhanced environmental pollution, collapsing traffic systems, dysfunctional waste management, and rapid increases in the consumption of energy, water and other resources.The significant energy use in cities is not very well perceived in Asian countries. Although a number of studies into energy consumption across various sectors have been conducted,most are from the national point of view. Energy demand analysis is not considered important at the level of the city. This thesis focused on the dynamics of energy utilization in Asian mega-cities, and ultimately aimed at providing strategies for maximizing the use of renewable energy in large urban systems. The study aimed at providing an in-depth understanding of the complex dynamics of energy utilization in urban mega-centers. An initial general analysis was complemented by a detailed study of the current situation and future outlook for the city of Bangkok, Thailand. An integrated approach applied to the study included identification of the parameters that affect the utilization of energy in mega-cities and a detailed analysis of energy flows and their various subsystems, including commercial, industrial, residential and that of transportation. The study investigated and evaluated the energy models most commonly used for analyzing and simulating energy utilization. Its purpose was to provide a user-friendly tool suitable for decision-makers in developing an energy model for large cities. In addition, a Multi-Criteria Decision-Making (MCDM) process had been developed to assess whether or not the energy systems meet the sustainability criteria. A metabolic approach has been employed to analyze the energy flow and utilization in selected Asian mega-cities, including Bangkok, Beijing, Shanghai, and Tokyo. The approach is applied to measure the majority of indirect energy flows or the energy embodied in the flows of goods and services involving the residents of those cities. Since the function of cities is to serve the lives of the residents, indirect energy consumption could be regarded as being of equal importance as that of direct energy use. The essence of embodied energy is that an indirect reflection upon behavior following direct energy consumption. It can illustrate how a city relies on the outside, for example other cities, countries, etc. and provides some interesting information that cannot be easily drawn from the direct energy demand. The study reveals that the indirect energy demand is more significant than the direct energy demand in Bangkok, Shanghai, and Tokyo, while direct energy demand is greater than the indirect energy demand in Beijing. This can be explained by the fact that Bangkok, Shanghai, and Tokyo have a greater reliance upon the outside in terms of energy demand.

Schremmer et al(2011) discussed in his study about how future urban systems can be designed to be consistently less damaging to the environment and particularly to climate change than in the present. The FP7-funded SUME project (Sustainable Urban Metabolism for Europe) is focusing on the way urban development scenarios linked with an agent-based urban metabolism model will try to demonstrate the potential to build and rebuild existing (European) cities in ways which will extract much less of specific energy and material resources from the environmental system, thereby reducing green house gas emissions and improving the climate change performance of urban systems. The built environment – in a systems logic the stocks of the urban system – is using a substantial portion of resource flows to be built and maintained. On the other hand, the spatial qualities of the built urban systems, the so-called “urban form”, have an impact on quantities and qualities of resources needed to maintain urban life. That impact will be estimated and conclusions for future urban development strategies be drawn.

Parikh et al(2005) talked about the energy demand growth. In this paper, econometric models are developed for the various petroleum products separately with the aim of capturing variables that are specific to the individual fuel. This study projects the demand of fuels up to 2011–2012, end period for the 11th Five Year Plan, under two scenarios of annual gross domestic product (GDP) growth of 6% and 8%. The demand of petroleum products for the year 2011–2012 is estimated to be 147 and 162 million tons in the business as usual scenario of 6% and optimistic scenario of 8% GDP growth, respectively. Similarly, the demand of natural gas for the year 2011–2012 has been estimated to be 46 and 49 billion cubic meters for 6% and 8% growth, respectively. The projections suggest the level of preparedness that will be required from the oil and gas sector to enable India achieve the GDP growth target that it aims to.

Phdungsilp(2009) said in his study ,city can be regarded as an ecosystem which is a self-organized system and governed by the same laws of thermodynamics. By looking at city as a whole and analyzing the pathways along which energy and materials including pollutants move, it is possible to conceive of management systems and technologies that allow for the reintegration of natural processes, increasing the efficiency of resource use, the recycling of wastes, and the conservation of energy. Based on the thermodynamic point of view and metabolism approach, this paper aims to quantify the flows of direct and indirect energy at a city level. The study employs a thermodynamic framework through an economic Input-Output (IO) analysis to estimate the direct and indirect energy uses based on the embodied energy analysis in economic sectors. It also makes an attempt in comparing the direct and indirect energy consumption in Bangkok with other Asian cities, including Beijing, Shanghai and Tokyo. This study provides important information about energy use patterns, material cycling, waste management, and infrastructure in urban systems.

Reddy et al(2008) stated in his study,provision of modern energy services for cooking (gaseous fuels) and lighting (electricity) is an essential component of any policy aiming to address health, education or welfare issues; yet it gets little attention from policy–makers. Secure, adequate, low-cost energy of quality and convenience is core to the delivery of these services.His study analyses the energy consumption pattern of Indian domestic sector and conceptualizes availability, accessibility, and affordability indicators of modern energy services to households and describes the practical ways of evaluating them. A comprehensive analysis is done to estimate the cost for providing modern energy services to everyone by 2030. A public–private partnership-driven business model, with entrepreneurship at the core, is developed with innovative institutional, financing and pricing mechanisms for diffusion of energy services. This approach facilitates large–scale dissemination of energy efficient and renewable technologies like small–scale biogas/biofuel plants, and solar water heating systems to provide clean, safe, reliable and sustainable energy to rural households and urban poor. It is expected to integrate the processes of market transformation and entrepreneurship development involving government, NGOs, financial institutions and community groups as stakeholders.

Nathan et al (2011a) proposed a Multi-view Black-box (MVBB) framework for development of sustainable development indicators (SDIs) for an urban setup. The framework is flexible to be applied to any domain or sector of urban system. In this paper the proposed MVBB framework is applied for transportation sector of Mumbai city. The paper begins with a discussion on transportation sector and its unsustainability links and trends. It outlines the concept of sustainable transportation system and reviews some of the prominent sustainable transportation indicator initiatives. In order to formalize sustainable development indicators (SDIs) for transportation sector, the study collates the indicators from literature, placed them in Mumbai's context and classified them into the three dimensions of urban sustainability—economic efficiency, social wellbeing and ecological acceptability.

Dhakal in his study on "Urban Energy Use and Greenhouse Gas Emissions in Asian Mega-Cities" said that cities in rapidly industrialising regions of Asia are confronted with multiple tasks for economic development and environmental protection. They tend to give priorities to immediate and local issues, and consider global warming as a far-away issue. The nature of energy use and greenhouse gas emissions from cities is not well understood in Asia. In fact, municipal policies to reduce energy consumption bring multiple benefits to the community. It helps to solve air pollution and traffic congestion, and also facilitates the reduction of CO2 emissions. Energy management at city level was neither a priority nor an important issue until recently because energy related decisions are made at the national level. These days, city policy makers are under growing pressure to incorporate greenhouse gases, especially CO_2 emissions into consideration while planning. But any policy measure solely for CO_2 reduction is a distant possibility for cities in Asia, with the exception of selected and relatively developed cities. Integrating energy consideration into policies, either by integrating energy concerns to overall urban development or by synergising measures to reduce air pollution and CO_2 emissions, is important. Therefore, efforts should be directed towards providing support to cities in generating knowledge and in building their capacity to understand the problem and to find possible measures for implementing policies. The prerequisite for systematic action is the analysis of CO_2 emission budgets of cities, their drivers and associated policy analyses. In this context, this lecture presents results of a study which quantifies CO_2 emissions from energy use and analyses their driving factors for selected Asian Mega-Cities--Tokyo, Seoul, Beijing and Shanghai. It presents discussions on the nature of future challenges and highlights the needs for taking into account the overall energy and CO_2 "footprint" of cities. It presents policy challenges and identifies major opportunities and barriers for integrating CO_2 considerations into local environmental policies.

Bombay First and McKinsey & Company(2003) published a report offering a vision for transforming Mumbai into a world class city, developed through a collaborative process with Mumbai’s business leadership. The Government of Maharashtra then established an interagency Task Force, with a strong Citizens Advisory Group, to design and implement a strategy that would elaborate the vision and translate it into reality. The task force operates through five subgroups: strategic planning, housing, economic growth, physical infrastructure, social infrastructure and governance. This report was prepared for the subgroup on economic growth. It offers an analysis of conditions and trends in the economy of the Mumbai Metropolitan Region (MMR) and offers recommendations for actions to remove barriers and stimulate growth in key economic sectors;provides findings and recommendations on themes increasingly recognized as critical to the region’s economic health: workforce development and mainstreaming the informal sector. It created a calibration for a city’s performance on each parameter – hence, a city’s performance could range from “poor” the lowest end of the spectrum, and then move up one notch to “average”, then to “above average” and, finally, “world-class”. We calibrated each notch/rating based on the difference between the city’s performance and international benchmark levels (defined as the average of all the international cities in our sample). So, for example, we defined Mumbai as “world-class” on a particular parameter if the gap between international benchmarks and its performance on that parameter was less than or equal to 10 per cent of the benchmark.

USAID(2005) commissioned the Urban Institute and International City/Country Management Association (ICMA) to conduct a study on rejuvenating economic growth of Mumbai Metropolitan Region (MMR) as part of USAID's India Urban Initiatives project.
As per the report effective strategies for economic growth involve two themes:
1. Improving the local investment climate; i.e. reducing the general costs of doing business in the city
2. Providing specialized support to key growth industries

Grubler(2004) mentioned the change in patterns of energy use since the onset of the industrial revolution in terms of both energy quantities and energy quality. These changing patterns of energy use, where energy quantities and quality interact in numerous important ways, are referred to in this article as energy transitions and are described from a historical perspective as well as through future scenarios. Far from being completed, many of these transitions are continuing to unfold in industrial and developing countries alike. Energy transitions are described in terms of three major interdependent characteristics: quantities (growth in amounts of energy harnessed and used), structure (which types of energy forms are harnessed, processed, and delivered to the final consumers as well as where these activities take place), and quality (the energetic and environmental characteristics of the various energy forms used).

Rees et al(1996) mentioned in his study that Urbanization represents a human ecological transformation.Understanding the dramatic shift in human spatial & material relationships with the rest of nature is a key to sustainability. He described a novel approach to assess the ecological role of cities and to estimate the scale of impact they are having on the ecosphere. The analysis shows, that as nodes of energy & material consumption ,cities are causally linked to global ecological decline & are not by themselves sustainable. At the same time,cities and their inhabitants can play a major role in helping to achieve a global sustainability.

Stern (April 2003) surveyed the relation between energy and economic growth and more generally the role of energy in economic production. The principal finding is that energy used per unit of economic output has declined, but that this is to a large extent due to a shift in energy use from direct use of fossil fuels such as coal to the use of higher quality fuels, and especially electricity. When this shift in the composition of final energy use is taken into account, energy use and the level of economic activity are found to be tightly coupled.

Phadke et al (Novemeber 2005) in a study on “Economic benefits of saving electricity” mentioned that resale of saved electricity to electricity-short businesses can increase their production and generate additional revenue for the State Electricity Board. Curtailment of electricity to businesses lowers their economic output, and reduces their tax payment to governments at all levels. Restoring electricity supply to such businesses can increase their production and tax payments. Such increased tax revenue has the potential to reduce state’s fiscal deficit by more than 15%.

2.2 Research Methodology

This project is based on the basic concept of research methodology. The following concepts are directly or indirectly used while doing this project.

•This study is an exploratory research to understand more about the Energy Issues in Mumbai.

•The universe in this case is the Greater Mumbai region.

•The sample taken is the electricity related parameters & energy data over the years.

•Data collection is an intensive part of this study since very less data is available in public domain. Oil& Gas data was procured from Indian oil Corporation Ltd. Data for coal consumed in Mumbai was obtained from Coal India Ltd. Mumbai Metropolitan Region Development Authority (MMRDA) was approached for data related to the basic attributes of Mumbai like population, income distribution. Some of this data is available in State's economic survey report but for data over a no. of years MMRDA's library was referred. Electricity data specific to Greater Mumbai region was obtained by visiting the offices of BEST, Tata & Reliance Energy Ltd.

•Data analysis is done by comparative study of consumption of electricity in different sectors over the years that varies with variation in different parameters as GDP,income distribtution, population.

Forecasting of energy demand has been done for different scenarios.

2.3 Limitations of study

There are several resources for consumption as useful products in Mumbai . Many studies have been done on different socio-economic aspects of Mumbai but the resource utilization & sustainable development aspects of Mumbai have neither been studied nor are any relevant data available in public domain.

This study is just an analysis of the Energy/Electricity issues and does not propose to suggest any solutions to those issues. Limitation of the availability of concerned data lead to a constrained analysis & forecasts.

To solve the issues of unsustainability accurately, it is important to know about all the Energy resources of Mumbai in detail, which itself is a time demanding process.

The study provides an initial step for understanding the Energy Utilization aspects of Mumbai region.

At instances where data available were insufficient or lacking in completeness, some figures have been used on the basis of extrapolation.

2.4 Background

The concept of urban metabolism provides a means of understanding the sustainable development of cities by drawing analogy with the metabolic processes of organisms. The parallels are strong: "Cities transform raw materials, fuel, and water into the built environment, human biomass and waste". The study of an urban metabolism requires quantification of the inputs, outputs and storage of energy, water, nutrients, materials and wastes.[2]

Urban metabolism can be defined as "the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste". The metabolism of an ecosystem involving the production, via photosynthesis, and consumption, by respiration, of organic matter is often expressed by ecologists in terms of energy. A few studies of urban metabolism have focused on quantifying the embodied energy in cities, while others have more broadly included fluxes of nutrients and materials, and the urban hydrologic cycle.

First applied by Wolman to a hypothetical American city of 1 million people, there have been about ten metabolism studies of actual cities worldwide. These include studies in the 1970s of Tokyo, Brussels and Hong Kong, and then from the 1990s: Vienna, Sydney, London, Toronto, Cape Town and part of the Swiss lowlands. The regions of these studies are typically greater metropolitan areas, including rural or agricultural fringes around urban centers.

There are a variety of practical reasons for studying the urban metabolism. Firstly, the metabolism parameters provide suitable measures of the magnitude of resource exploitation and waste generation to be used as sustainability indicators. The metabolism provides measures of resource efficiency and the degree of circularity of resource streams, and may be helpful in identifying opportunities to improve these measures. As well as providing a comprehensive accounting of the stocks and flows through cities, urban metabolism also provides a context to understand critical processes such as rising or falling groundwater tables, urban heat islands, accumulation of nutrients, and the long-terms impacts of hazardous materials stored in the building stock. It is pertinent for urban policy makers to understand the metabolism of their cities, to consider to what extent their nearest resources are close to exhaustion and, where necessary, develop appropriate strategies to slow exploitation. Several factors influence the metabolism of cities. Urban form, including density and morphology, and the evolution of transportation technology can influence both energy and material flows. Sprawled, low-density cities have higher per capita transportation energy requirements than compact cities. Climate also has an impact on the metabolism; for example, cities with interior continental climates will

[2] Phdungsilp, A Thermodynamic framework for urban energetic metabolism

expend more energy on winter heating and summer cooling than those with temperate climates. Application of technology, appropriate use of vegetation, policies such as building codes, and the costs of energy may also influence energy consumption. Similarly, climate, choice of technology, e.g., for recycling, policies supporting demand management, and social attitudes will impact the flows of water and nutrients. The age of a city, its overall infrastructure, and its stage of industrial development might also impact its urban metabolism.

Studies from cities around the world show that urban metabolism is increasing. Certainly this is the case in absolute terms, where the population of cities is increasing with urbanization. Even in per capita terms, trends are generally upwards. In Hong Kong, for example, per capita food, water and materials consumption increased by 20%, 40% and 149%, respectively from 1971 to 1997. Studies also show that Hamburg and Vienna have become more material intensive. Water and wastewater flows were typically greater for cities in the 1990s than those in the early 1970s. Energy inputs to Sydney increased over the same period, although in Toronto per capita energy use showed signs of levelling off during the 1990s. Changes in waste streams are mixed. Emissions of sulphur dioxide (SO2) and particulates have decreased in several cities, while nitrogen oxides (NOx) have increased. Through implementation of large-scale recycling, many cities have seen reductions in residential waste disposal, in absolute terms, but outputs of commercial and industrial waste are possibly on the increase. The implication of increasing metabolism, with today’s predominant technologies, is accelerated consumption of natural resources; greater loss of farmland, forests and species diversity; as well as more traffic and more pollution.

3 .Chapter 3- Energy Demand Variables & Issues at stake

3.1 Determinants of energy use in cities

Energy has long played a central role in the development and function of the economy. It is an essential input for economic activities. Reliance on energy will obviously continue to grow with increase in populations and improvements in the standards of living, especially in cities. History has shown that increased mechanization and energy use brings its own burdens upon the environment. As regards urbanization, it is no doubt that energy has no conflict with it in regards to the population pattern and type of infrastructure. Cities open up many opportunities for the efficient utilization of energy.

Pattern of urban settlements

The compactness of urban settlements influences the energy demand in regards to transportation and for other energy utilization areas such as heating and cooling for space conditioning. Another factor related to urban planning is the urban spatial structure and functions. They all affect energy use as they influence the demand for the mobility of the urban dwellers

Income level and lifestyle

As mentioned earlier, cities are the engines for the economic growth of a region or even country. They actually are the development engines of their own countries. Studies on the relationship between income and energy use have clearly demonstrated that there is a strong correlation between per capita energy consumption and GDP. It is generally accepted that energy use per capita increases with income, but at some point it may decrease. A higher income is associated with a better lifestyle and more consumption, which affects energy use within and beyond the borders of cities.

Energy efficiency technologies

Energy efficiency is defined as the energy needed to produce a unit of energy service. Since energy demand is for service purposes, energy efficiency can directly improve or worsen energy consumption. Energy technologies dominate consumption within a city, including the automobile along with household and commercial appliances used for lighting, heating, cooling, and cooking. Improving energy efficiency is a function both of the technology itself and of the patterns of energy utilization. There is significant untapped potential for improving energy efficiency in almost all energy applications. Improving energy efficiency is often highly profitable, but there are still some barriers that remain.

Industrial processes

These issues are related to energy efficiency technologies; however, separating the discussion aims to give an overview of disaggregated sectors, including the transportation and building sectors. The energy efficiency of all industrial production processes affects the energy use in the city too. Asian mega-cities are rapidly relocating their primary industries either to sub-urban areas or to areas outside the cities' borders, leaving cities increasingly dominated by the tertiary sector.

Transportation systems

The energy consumed by the transport sector is influenced by its systems. Transportation systems are very important, for mobility is a key aspect of urban life. Historically, cities have moved from non-motorized to rail-based and then gradually to automobile-dominated transportation.

3.2 Factors driving energy consumption

Modern forms of energy empower human beings in countless ways by reducing drudgery, increasing productivity, transforming food, providing illumination and transportation, powering industrial processes, conditioning space for households and buildings, facilitating electronic communications and computer operations, etc. Patterns of energy use vary dramatically, in ways that reflect and intensify social and economic inequities

In the previous sections some of the physical determinants of energy used in the cities, as well as impacts, were outlined. At the city level, similar to the national level, there is a need to understand the mechanisms of the driving forces behind energy consumption.

Urban demographic changes

There is no question as to whether or not population and the sizes and numbers of households affect energy use in the city. Much of this population growth is attributable to migrants. The number of households is obviously increasing primarily due to the rapidly decreasing size of the average household

Income growth and social change

It is well recognized that rapidly industrialized countries as well as those in economic transition like India and China yield high economic growth. The financial collapse in Thailand during 1992-93 had obvious implications for Mumbai, but India has regained growth rates of the GDP on an average 7% per year since 2001. Economic growth in the city has led to an increase in income, which in turn affects the lifestyles of residents. For they can afford to consume more material goods, follow fashions, and pursue leisure activities. Hence, they use more energy.

Lifestyle and the level of consumption

Lifestyle and the level of consumption regarding goods and services are significant factors that can either increase or decrease energy consumption in the residential sector. A number of determinants, particularly the scale and intensity of cooking, lighting, electrical appliances and space conditioning devices, influence the use of energy in a household.

Structure of economic activities

In cities like Mumbai & Delhi, the growing population, high population density, noise and environmental problems related to primary industries are forcing industries to relocate away from city centers to the outskirts and sub-urban areas. Therefore, these cities dominated by service industries and are becoming a commercial city. The primary industries have been moved from the inner area to the city's outskirts, but there are still many SMEs in the city centre.

3.3 Major Energy Issues in Mumbai

3.3.1 Electricity

There are 3 distribution licensees supplying electricity to Mumbai.

- BEST : Established in 1873, the BEST operates one of India's largest fleets of buses. Originally setup as a tramway company: Bombay Electric Supply & Tramways Company, the BEST set up a captive thermal power station at Wadi bunder, Bombay in November 1905 to generate electricity for its trams. That positioned it to also supply electricity to the city of Bombay.

Since 1926, the BEST has been sourcing its power from Tata Power, part of the Tata Group conglomerate. The power cables are laid underground, which reduces pilferage and other losses that plague most other parts of India. Unlike the transport company, the electricity department services only the Mumbai City area, and not the suburbs. It provides power to over a million residential and commercial establishments and over 33,000 street lights within the city limits. As of 2000, BEST supplies a total of 700 MW (938,715 hp), with a consumption of 3,216 GWh (11,578 TJ).

- Tata Power Company: The Tata Power Company Limited (TPC) is a company established in 1919, which undertakes the supply of energy to the public in its Mumbai License Area and to supply energy in bulk to Licensees, under a license by the Government of Maharashtra(dated July 12, 2001). Currently TPC provides electricity to the three distribution Licensees viz. REL, BEST and TPC itself, through own generation and power purchases from external sources using the transmission lines owned by TPC. Also, TPC, as a distribution licensee, distributes the power so received through its distribution network to retail consumers.

Certain features as they exist today, are unique to Mumbai. The generating entity is making power available for the area from own generation and power purchases. To that extent, it has entered into agreements for purchase of power to meet the requirements of the Licensees.

- Reliance Infrastructure Limited (formerly Reliance Energy Limited), referred to as RInfra is an integrated Utility engaged in Generation, Transmission and Distribution of electricity in suburban areas of Mumbai. Under the provisions of the Electricity Act, 2003 and in terms of MERC (General Conditions of Distribution License) Regulations 2006 and MERC (Specific Conditions of Distribution License) Regulations 2008, RInfra is a Distribution Licensee .

RInfra-D sources its requirements of energy for supply to its consumers, from its Dahanu Thermal Power Station (RInfra-G), allocation in TPC-G, Bilateral Contracts. For receiving the energy, the distribution system of RInfra-D is connected to the transmission system of RInfra-T and TPC-T, which is connected to the transmission system of MSETCL, and together the transmission systems of RInfra-T, TPC-T and MSETCL constitute the Intra-State Transmission System (InSTS).

RInfra-D is currently catering to electricity needs of over 2.7 million consumers in its licensed area (in and around suburbs of Mumbai) spread over 384 Sq. Kms with energy input requirement of about 8.8 billion units and coincident Max. Demand of above 1400 MVA.

Licensees →	RInfra	BEST	Tata Power
License Area	Mumbai Suburbs	Island City	City & Suburbs
Area	384 Sq Km	70 Sq Km	454 Sq Km
Population Served	~ 120 Lacs	~40 Lacs	~ 2.0 Lac
Total No of consumers	28 Lac	10 Lac	50, 000
No of Low end consumers*	22 Lac	6 Lac	Negligible

Figure 1: The 3 Distribution Utilities of Mumbai ***(Source: RInfra)***

RInfra distributes in Mumbai Suburbs that has an area approx. 384 Sq Km with population of 120Lacs. The number of consumers with RInfra as on 2011 is 28 Lac of which a majority constitutes the low end consumers. More than 75% of the low end consumers of Mumbai are served by Reliance Infra. BEST serves the Mumbai city that has an area approx.70Sq Kmwith a population of 40Lacs. The no. of consumers with BEST as on is 10Lac.

Tata Power serves the city & suburbs region. The company has a very low number of low end consumers. The majority being the industrial consumers & a major portion of its power goes to Railways.

As shown in the graphs the 3 discoms used to share equal deficit of power owing to a limited generation capacity in the region.Subsequently Tata Power Company –distribution saw an increase in its own consumers & the power allocation thereafter is a bit skewed with RInfra left to a deficit of 2662MW in FY09. By FY2010 the deficit of RInfra grew to approx. 2719MW with the other 2 discoms going in surplus.

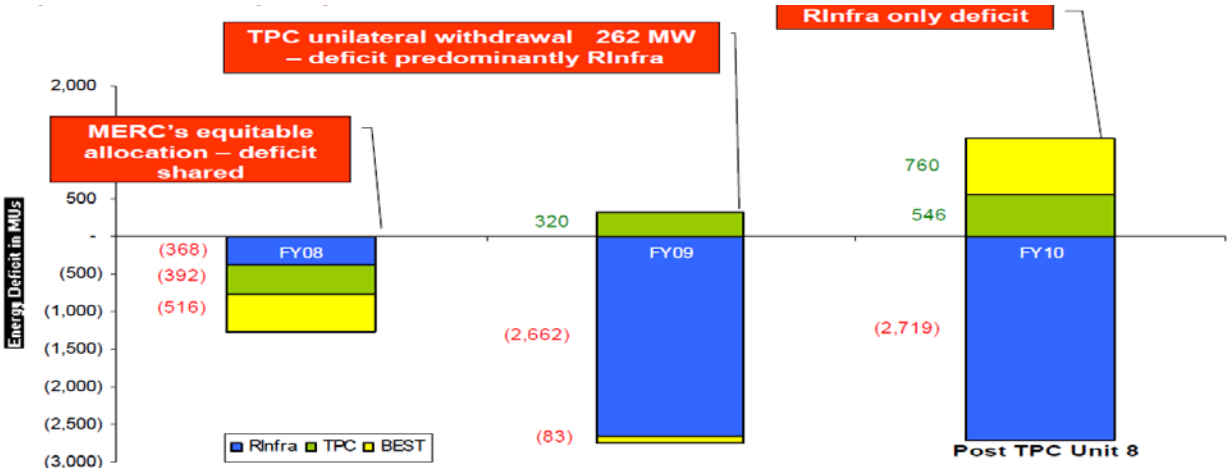

Chart 1: Power Allocation*(Source: RInfra)*

Migration of consumers from Reliance Infrastructure to Tata Power in the city's vibrant power sector has picked up slowly but steadily. On an average, Tata Power, with customer base of 300,000, daily receives around 300 to 350 consumer applications for changeover. In 2011-12 alone, around 120,000 customers changed over to Tata Power. The changeover customers span across all three segments -- residential, commercial and industrial. The residential segment accounts for a major part (88%) of the changeover, followed by the commercial segment (11%) and the Industrial segment (1%).

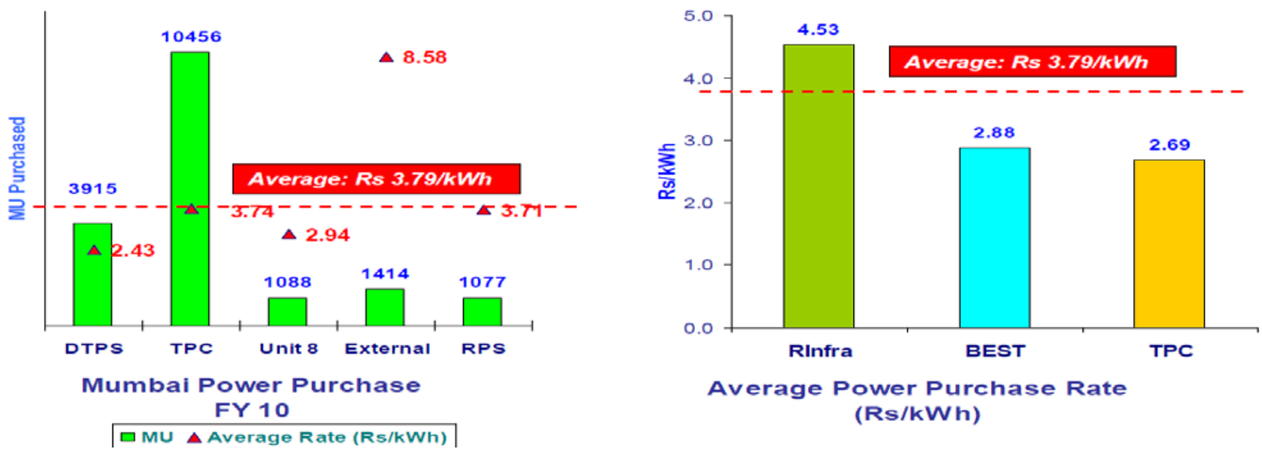

Chart 2:Power Purchase Rates *(Source: RInfra)*

Tata Power's competitive tariff has been the leading factor for the surge in migration rate. According to the tariff proposals filed with the Maharashtra Electricity Regulatory Commission, the average billing rate of Reliance Infrastructure's distribution wing comes to Rs 7.06 per unit compared with Tata Power's distribution arm of Rs 5.20 per unit in 2010-11.

However, what is Tata Power's gain is turning out to be a loss -–both physical and financial-- to Reliance Infrastructure, which has a customer base of over 2.8 million. Due to the migration of the cross-subsidised consumer from Reliance Infrastructure to Tata Power (75% of the migrated sale is from cross-subsidised categories) it is resulting in a cross-subsidy loss of over Rs 600 crore a year. This burden is getting accumulated and will be have to be borne by subsidised low-end consumers. This is because there are hardly any cross subsidizing consumers left in Reliance Infrastructure and if the burden gets passed on to the few in this segment who are still with us, it could result in a cascading effect of further migration.

Moreover, the tariff difference between the two companies is primarily driven by the power purchase price and consumer mix. Despite having competent power purchase price, Reliance Infrastructure continues to lose consumers to Tata Power. The company has unfavourable consumer mix having cross-subsidy in excess of Rs 1,000 crore, it is supplying 2.2 million low-end consumers (75% of low end consumers stay in Mumbai) who receive supply at a tariff much lower than cost of supply, whereas Tata Power has negligible number of such consumers.

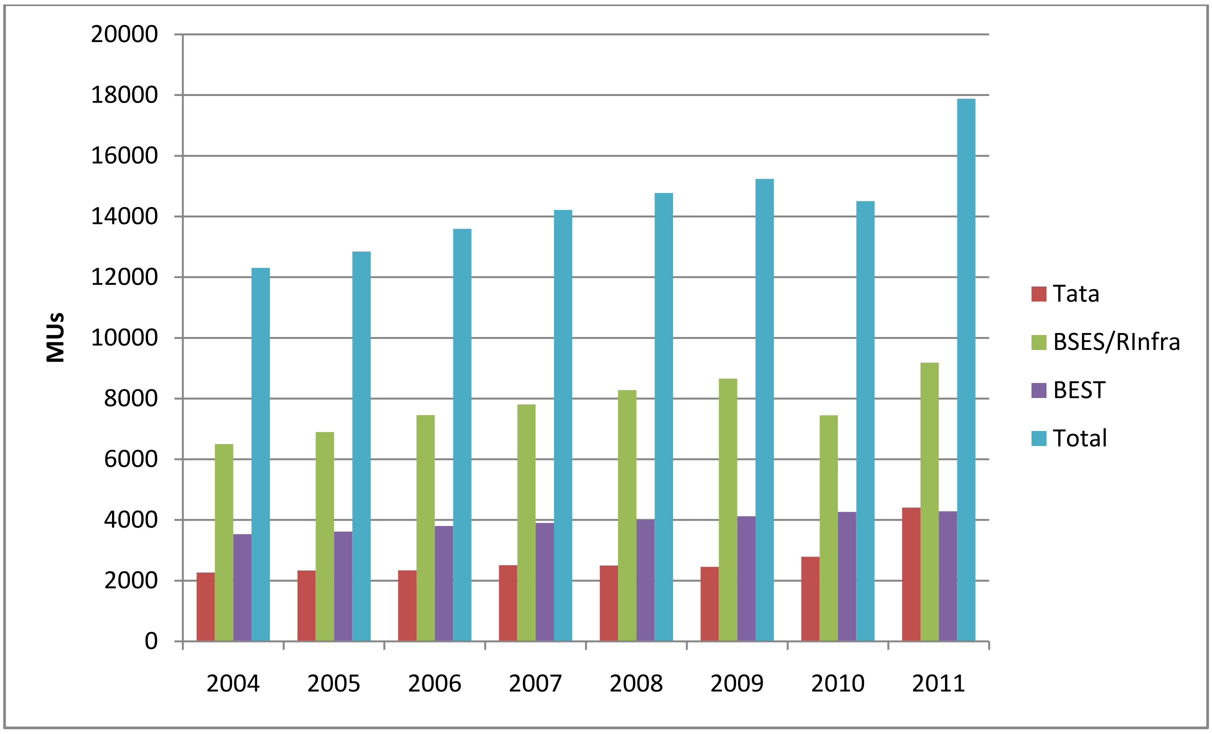

Chart 3:Units supplied *(Source: TPC,RInfra,BEST)*

3.3.2 Transportation

Mumbai is equipped with both bus and train services, which is considered superior compared to other Indian cities . The popular and environmentally clean mode of public transport is electrically operated suburban railways; it is punctual and purposeful, but overcrowded .

The rail network consists of two suburban systems, namely, Central Railway and Western Railway, spanning for 319 km and carrying close to 700,000 population daily . The environment friendly suburban rail transport has a big question mark on the safety and security of the passengers with approx 4,000 people dying every year on travel .The BEST (Bombay Electric Supply & Transport) operates 3,587 buses on 370 routes carrying 43,000 passengers daily .

With inputs from various studies by leading organizations like World Bank, UNEP/WHO, TERI, CPCB has reported that for Mumbai transportation sector contributes 92% of the carbon monoxide (CO), 60% of nitrogen oxides (NOX), up to 16% of particulate matter and up to 4% of sulphur dioxide (SO2) to the city. The large population base, high population density, land and infrastructural constraints, road congestions, overcrowding in trains, and safety and security challenges of the commuters makes Mumbai as an interesting case study for transportation sustainability. The socio-economic characteristics of the city make it all the more interesting. Mumbai is the financial capital having majority of populace as slum dwellers; it exults its wealth and at the same time faces the impact of urban poverty, dwarfing other major India cities in its extent and complexity .

The total number of motor vehicles on road in the State as on 1st January, 2012 was 188.27 lakh (i.e. 16,578 vehicles per lakh population), showing an increase of 10.8 per cent over the previous year. The number of vehicles per km road length in the State is 78. Of the total vehicles in the State, about 19.79 lakh vehicles (10.5 per cent) were in Brihanmumbai. The number of vehicles per km of road length in Brihanmumbai is 647, which has assumed alarming proportions and is a cause of concern.[3]

Due to the geographical spread of the population and location of business areas, the rail network is the principal mode of mass transport in Mumbai. Two zonal railways, the Western railway (36 stations) and the Central railway (62 stations) operate the Mumbai suburban railway system. The Harbour line (38 stations) is part of the Central Railway. The Mumbai Suburban Railway is a mass transit system spread over 465 route km. serving the MMR. The suburban services are run by electric multiple units (EMU's). A fleet of 191 rakes (train sets) of 9 car, 12 car and 15 car composition are utilized to run 2,342 train services, carrying 6.94 million passengers per day. It has the highest passenger densities of any railway system in the world. The suburban

[3] www.indiastat.com, Mumbai Human Development Report ,2009

railway system operates on 1,500 volt DC/25,000 volt AC power supply from overhead catenary lines.

3.4 Energy flow Representation

An energy flow diagram is normally a flow diagram showing the energy gains and energy losses of a given process. This type of diagram is often used to show the efficiency of a given system or lack thereof. It also helps in evaluating a city's energy consumption performance.

The Energy flow charts illustrate the flow of primary fuels from home production and imports to their eventual final uses. Charts show them in their original state, and after being converted into different kinds of energy by the secondary fuel producers. Widths of the bands approximately proportional to the size of the flow they represent.

It was developed over 100 years ago by the Irish engineer RiallSankey to analyse the thermal efficiency of steam engines and has since been applied to depict the energy and material balances of complex systems. The Sankey diagram is the maintool for visualizing industrial metabolism and hence is widely used in industrial ecology.The use of Sankey diagrams has long been standard practice in science and engineering. The diagrams are described as graphical heat balances, heat balance diagrams, energy flow charts or simply Sankey diagrams .The diagrams frequently focus on energy flow and its distribution to various sources or sinks, represented by arrows, the width of which indicates the amount of energy flow.If one looks at basic articles on industrial ecology or life cycle assessment (LCA), it becomes apparent that they frequently use Sankey diagrams to show the complexity of industrial "metabolism."One could almost believe that Sankey diagrams are the visual language of industrial ecology. Graedel pointed out that industrial ecology addresses the budgets and cycles of input and output streams and tries to optimize them. He went on to say that the key concepts of industrial ecology include conservation of mass and conservation of energy.

With their intuitive readability and transparency, they are ideal for interpreting complicated sets of resource flows. It is therefore not surprising that such diagrams were repeatedly used in the past to explain significant findings to a broad public and to launch technical or social measures.

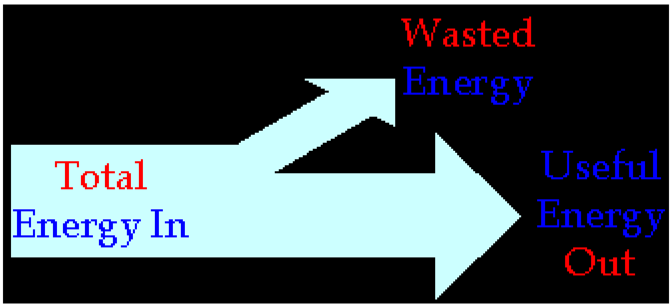

Figure 2:Energy Flow Diagram

Energy flow diagrams have different colours depicting different sources of energy e.g. black for coal, green for petroleum products etc. On the left hand side of the diagram there are different basic sources of energy i.e. Coal, Gas, Petroleum Products & Renewable sources (Wind, Biomass and Hydro etc.). These basic sources are either converted in more usable form like electricity or directly consumed by end users. Right hand side of the diagram represents the end users. Through these diagrams we can easily calculate the waste & useful part of total energy, thereof computing the efficiency of the system.

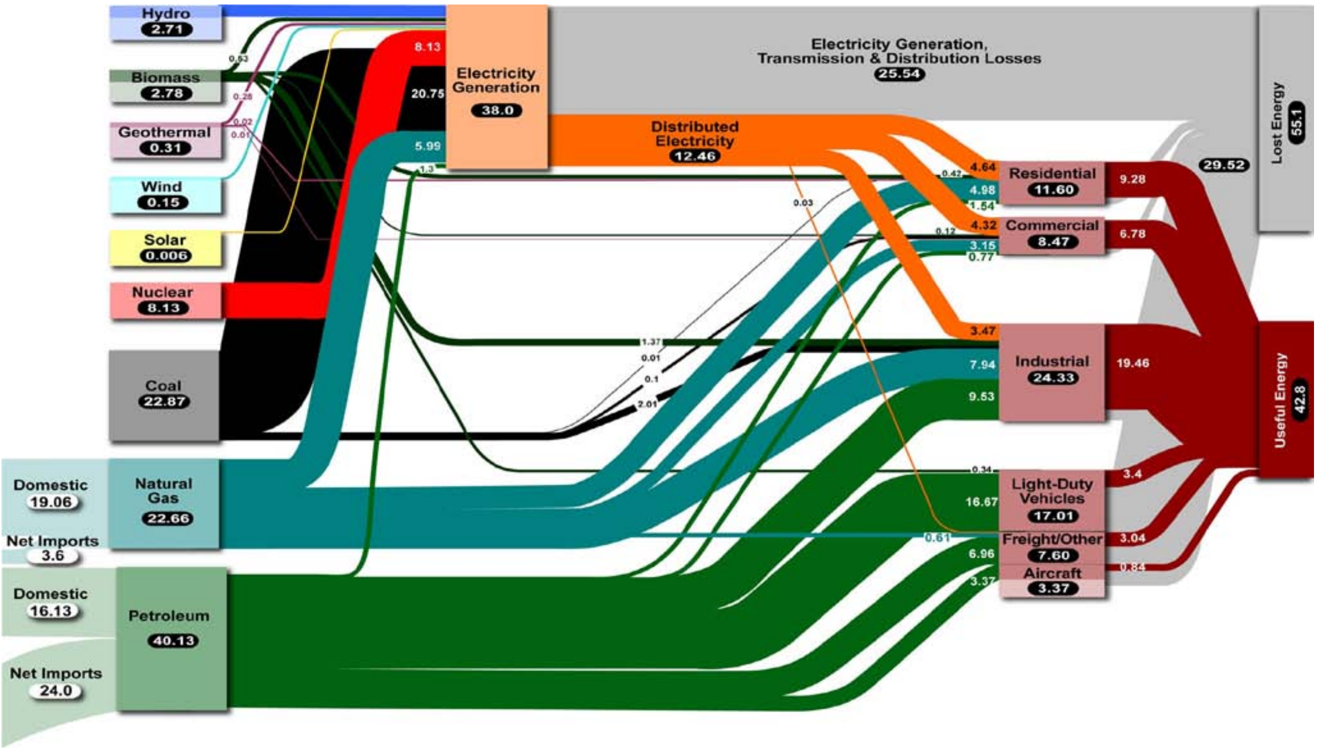

Figure 3:Energy Flow Diagram ***(Source : www.sankey-diagrams.com)***

Shown is a generalized view of such a diagram with different resources of generating electricity and in transportation.

Of every 39 units of electricity generated ,a hefty 26 units are lost and approx. 29 units are lost in conversion process of other energy resources to useful form.

Thus by tracing the flows of water,energy ,nutrients & materials through an urban system,it can be designed to close loops, thus reducing the inputs of resources and output of wastes.

3.5 Description of the Region

3.5.1 Location

Mumbai consists of two distinct regions: Mumbai City district and Mumbai Suburban district, which form two separate revenue districts of Maharashtra.The city district region is also commonly referred to as the *Island City* or South Mumbai. The total area of Mumbai is 603.4 km^2 (233 sq mi). Of this, the island city spans 67.79 km^2 (26 sq mi), while the suburban district spans 370 km^2 (143 sq mi), together accounting for 437.71 km^2 (169 sq mi) under the administration of Brihanmumbai Municipal Corporation (BMC). The remaining area belongs to Defence, Mumbai Port Trust, Atomic Energy Commission and Borivali National Park, which are out of the jurisdiction of the BMC.

3.5.2 Demographic Data

According to the 2011 census, the population of Mumbai was 12,479,608. The population density is estimated to be about 20,482 persons per square kilometre. The living space is 4.5sq metre per person. As Per 2011 census, Greater Mumbai, the area under the administration of the BMC, has a literacy rate of 94.7 %, higher than the national average of 86.7%. The sex ratio was 838 (females per 1,000 males) in the island city, 857 in the suburbs, and 848 as a whole in Greater Mumbai, all numbers lower than the national average of 914 females per 1,000 males. The low sex ratio is partly because of the large number of male migrants who come to the city to work.

YEAR	Total Pop.	Population growth rate
1961	4152056	-
1971	5970575	43.80%
1981	8243405	38.07%
1991	9925891	20.41%
2001	11978450	20.68%
2011	12478447	4.17%

Table 1:Population Trend ***(Source: MMRDA)***

What is driving Population Growth in Mumbai?

The population increase in Greater Mumbai from about 3 million in 1951 to 11.9 million in 2001 is partly a result of natural increase in population and partly due to migration. The share of migration in the total increase in population was 36.8% in 1991-2001, lower than in earlier decades, except for 1991-2001, which is being debated as an underestimate.

Such a sharp increase in population definitely puts pressure on the civic infrastructure of the region,especially the housing stock. As a result, unauthorized dwellings get developed in the form of slums due to the region's inability in this period to provide affordable housing to the burgeoning population.[4]

3.5.3 Employment in Mumbai

Until the 1970s, Mumbai owed its prosperity largely to textile mills and the seaport, but the local economy has since been diversified to include engineering, diamond-polishing, healthcare and information technology. As of 2008, the Globalization and World Cities Study Group (GaWC) has ranked Mumbai as an "Alpha world city", third in its categories of Global cities. Mumbai is the 3rd most expensive office market in the world. Mumbai was ranked among the fastest cities in the country for business startup in 2009.

State and central government employees make up a large percentage of the city's workforce. Mumbai also has a large unskilled and semi-skilled self employed population, who primarily earn their livelihood as hawkers, taxi drivers, mechanics and other such blue collar professions. The port and shipping industry is well established, with Mumbai Port being one of the oldest and most significant ports in India. In Dharavi, in central Mumbai, there is an increasingly large recycling industry, processing recyclable waste from other parts of the city; the district has an estimated 15,000 single-room factories.

Mumbai has been ranked 48th on the Worldwide Centres of Commerce Index 2008. In April 2008, Mumbai was ranked seventh in the list of "Top Ten Cities for Billionaires" by *Forbes*magazine, and first in terms of those billionaires' average wealth.

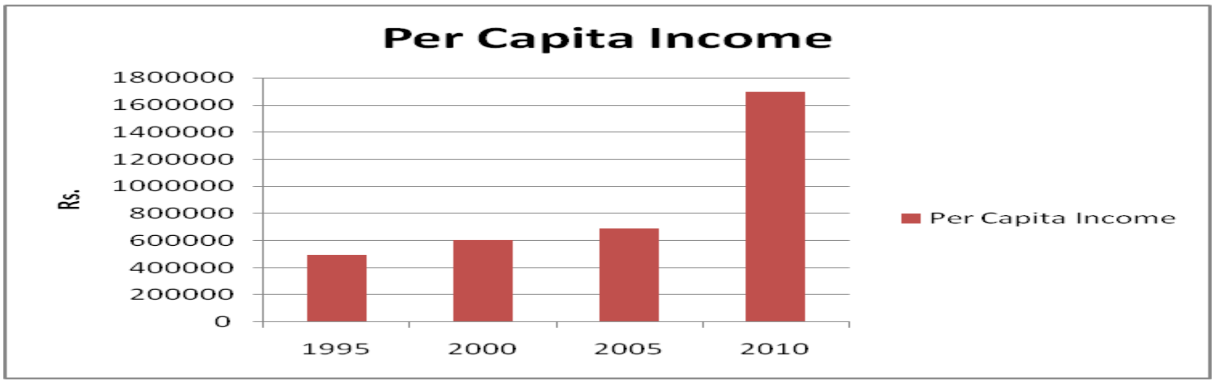

Chart 4:Per Capita Income of Mumbai

[4] USAID ,2007

Per capita income has increased over the years .Between 1995 and 2010 ,the increase of per capita income has been at a CAGR of 24.8% . This's been due to an improvement in the quality of services,employment and effective overall growth.

YEAR	GDP(Rs Cr.)	Growth Rate
1993-94	28752	
1998-99	41388	44%
2003-04	46026	11%
2009-10	191555	316%

Table 2:GDP growth trends

The GDP of Mumbai has seen a tremendous rise over the years. Between 2003 and 2009 it increased 3 folds

Year	Primary	Secondary	Tertiary	Total NDDP(Rs lakh)	Growth Rate
1993	31385	908769	1576083	2516237	
1994	36434	952921	1844704	2834059	12.63%
1995	50688	1160794	2249189	3460671	22.11%
1996	78910	1279723	2444587	3803220	9.90%
1997	80310	1512119	2785168	4377597	15.10%
1998	85297	1506436	3188942	4780675	9.21%
1999	90358	1512025	3011686	4614069	-3.48%
2000	89362	1261544	3113637	4464543	-3.24%
2001	85399	1380249	3520397	4986045	11.68%
2002	91739	1544207	3917949	5553895	11.39%
2003	91539	1934093	4503534	6529166	17.56%
2004	114549	2148224	5341526	7604299	16.47%
2005	74337	2204877	5394049	7673263	0.91%
2006	126344	2570342	6276828	8973514	16.95%
2009	165751	4098571	11029978	15068276	
2010	207742	4674196	12654954	17311838	14.89%

Table 3:Contribution of different sectors to NDDP of Mumbai. ***(Source: DES Data)***

In Mumbai 74% of the income is generated in the tertiary sector while the secondary sector accounts for about a quarter of the total . Despite being an urban area there is a contribution of 1% from the primary sector notably from fisheries. This predominant status of the service sector as a contribution to the economy is in line with the national trend. These proportions have been approximated as per the trend over last few years shown in Table 1.3.

The primary sector’s share in 1993-94 was 1.25% ,now just around 1%. The secondary sector’s share declined from 36% to 25% ,the decline being rapid since the year 2000 when the share of the tertiary/service sector ,both formal and informal jumped to around 74%.

This shift towards services is a result of several factors and has significant implications for employment generation. It’s also due to dynamic fields coming into play such as IT,electronic services,banking etc.

This shift has been very encouraging for the district’s economy but at the same time has required the provision of efficient energy consumption in order to maintain the sustainability of growth.

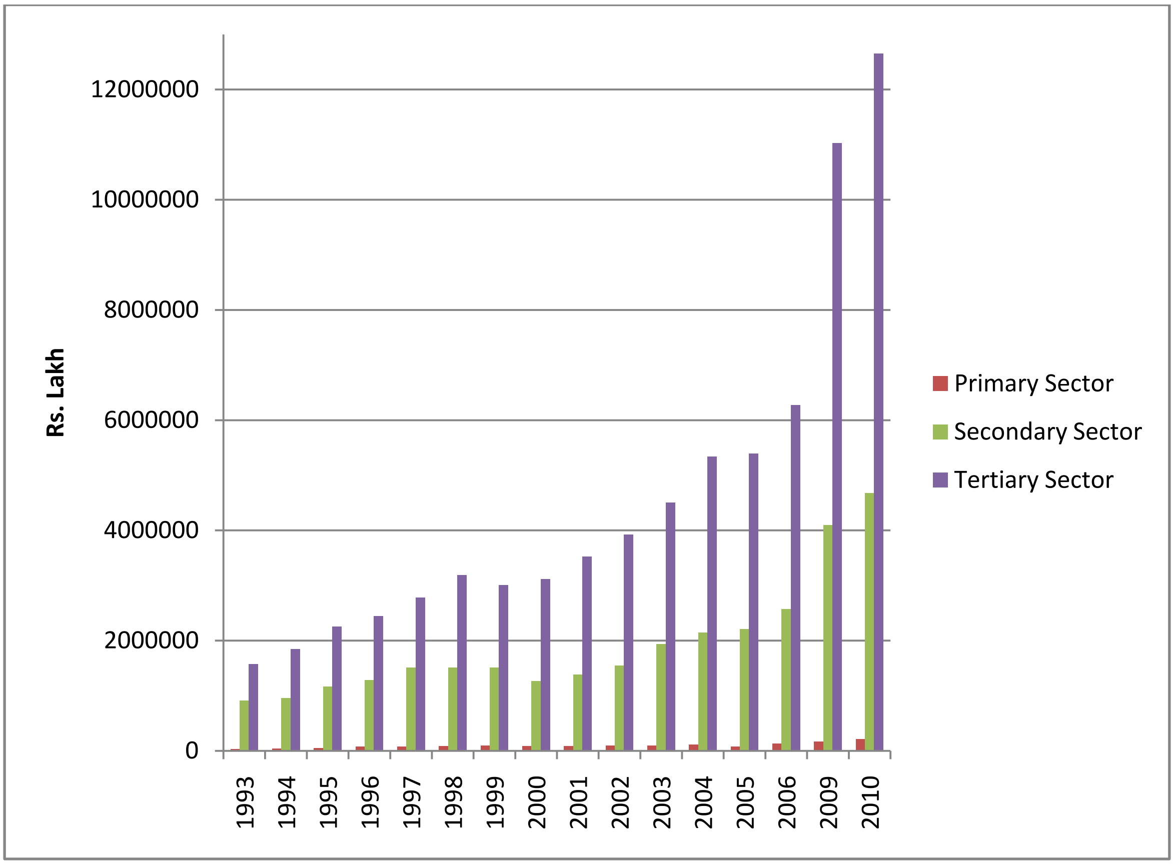

Chart 5:Contribution of different sectors to the district’s income

4 .Chapter 4 -Analysis & Recommendations

4.1 Analysis

4.1.1 Energy Intensity

Is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per unit of GDP.

- High energy intensities indicate a high price or cost of converting energy into GDP.
- Low energy intensity indicates a lower price or cost of converting energy into GDP.

Many factors influence an economy's overall energy intensity. It may reflect requirements for general standards of living and weather conditions in an economy. It is not atypical for particularly cold or hot climates to require greater energy consumption in homes and workplaces for heating (furnaces, or electric heaters) or cooling (air conditioning, fans, refrigeration). A country with an advanced standard of living is more likely to have a wider prevalence of such consumer goods and thereby be impacted in its energy intensity than one with a lower standard of living.

Energy efficiency of appliances and fuel economy of vehicles, vehicular distances travelled, better methods and patterns of transportation, capacities and utility of mass transit, energy rationing or conservation efforts, 'off-grid' energy sources, unexpected new sources, efficient uses of energy or energy subsidies may all impact overall energy intensity of a nation.

Thus, a nation that is highly economically productive, with mild and temperate weather, demographic patterns of work places close to home, and uses fuel efficient vehicles, supports carpools, mass transportation or walks or rides bicycles, will have a far lower energy intensity than a nation that is economically unproductive, with extreme weather conditions requiring heating and cooling, long commutes, and extensive use of generally poor fuel economy vehicles. Figures of energy consumption used in statistics are energy sources marketed through major energy industries. In countries, which do not have such developed energy industries or people with highly self energy efficient life style, report smaller energy consumption figures.

The same way the concept of Energy Intensity is applicable to a State,District or a City.

We analyse the Energy/Electricity Sustainability of Mumbai by analysing its Energy Intensity for different sectors.

Two basic approaches are used to express industrial energy intensity

1)Physical energy intensity (eg. PJ/Tonnes)

2)Energy used per unit of monetary value of output (eg. PJ/Rs Billion)

Physical intensities are suitable for time series comparison of a single product but are not preferred for the entire industrial sector as comparison of the units of physical output is difficult across sectors. Even in the same industry ,different products are produced which may be valued differently and may have different units. In such cases ,it is not possible to develop an aggregate measure of physical energy intensity.

So ,in this analysis the economic energy intensities are used.

The actual consumption is converted to energy in Joules and the output of corresponding sector known in Rs. The energy intensity is thus expressed as Joule/ Rs.

- **Industrial Sector**

Comprises of all of the secondary sector & the mining & quarrying activities of primary sector. But mining & quarrying activities in Mumbai are close to nil ,so we consider secondary sector contribution to be that of the industrial sector.[5]

Registered/Unregistered Manufacturing , Construction, Electricity generation and Mining & quarrying have been considered in the Industrial Sector here.

Year	Industrial Output(Rs Billion)	Energy Consumption(TJ)	Energy Intensity(TJ/Rs Bn)
2005	220	8531.90	38.69
2010	467	6696.78	14.32

Table 4:Energy Intensity in Industrial sector due to electricity consumption*(Source: DES)*

From 2005 to 2010 ,there has been a decrease in Energy Intensity as shown in Table 1.4 . This is due to shift of city's economical output from industrial to service based. This also reflects the energy(electricity) conservation measures being taken by existing industries.

- **Tertiary Sector**

[5] Estimates prepared by Directorate of Economic Statistics,Govt. Of Maharashtra

Is the one comprising several services . Here the commercial sector has been considered to include Railways, Transport by other means, Communication , Hotels,Restaurants,Banking & Insurance, Real Estate ,Public Adminstration. So,the commercial output of Mumbai has been approximated from that of the tertiary sector.

The income generated by this sector & corresponding Energy Intensity is as shown in Table 1.5

Year	Commercial Output(Rs Billion)	Energy Consumption(TJ)	Energy Intensity(TJ/Rs. Bn)
2005	546	14893	27.23
2010	1286	19498	15.15

Table 5:Energy Intensity in commercial sector due to electricity consumption

From 2005 to 2010 the energy intensity has decreased . Table 1.5 shows the trend. This is due to a shift to many renewable energy sources coming in which have not been taken into account here. Also the energy conservation incentives and training programs have shown some effect.

Overall ,the electrcity consumption has increased at a fairly lower rate than the increase in Commercial Output of Mumbai(in monetary terms).

- **Transportation Energy**

Year	Total(BnPKM)	Energy(PJ)	MJ/PKM
2001	31.88	15.04	0.471769134
2005	37.55	16.97	0.451930759

Table 6:Transportaton Energy Intensity due to all energy consumption (petrol, diesel, electricity)

Table 6 shows the mobility energy intensity. Mobility energy intensity is the amount of energy associated with the movement of people from one point to another.

The Table shows a drop in the mobility energy intensity of Mumbai ,which is because of an increasing support of public transport services in the district.

It has been observed that public transport consumes significantly lower energy than private transport.

- **Per Capita Consumption**

Year	Population	Energy Consumed(TJ)	Energy Intensity(TJ/Person)
2010	12265895	81990.98576	0.006684468

Table 7:Energy consumed per person(petrol,diesel,electricity)

This energy Consumed figure consists of energy derived from gasoline,diesel & electricity. It represents the total energy consumed by the region through all kind of activities i.e industrial, commercial & household chores. The individual figures for the 3 products stand as 194 Mtoe, 517 Mtoe & 14506 MUs respectively. Considering other uses too, the energy intensity per capita could in no case exceed 8GJ/person. Megacities around the world have shown consumption trends of more than 15GJ/person a year.[6]

- **Analysing the Electricity Consumers pattern**

Year	BEST('000)	Tata	R-Infra('000)
2008	950	23630	2630
2011	996.983	487378	2805

Table 8: No. of Consumers

The no of consumers of BEST has not increased much .The growth is merely at a CAGR of 1.5% . Reliance has seen tremendous outflux of consumers as Tata has been on an expansion spree. Consumer CAGR of RInfra has been 2.1%. Tata's consumers have increased manifold due to lower tariff rates and also because it has a large no of industrial consumers. It witnessed a CAGR of approx. 174% from 2008 to 2011.

Stakes are high with the ongoing changes in the sector and Mumbai is a playing field for the competition between Reliance and Tata at the national level. This has led to a number of conflicts between the two operators. The main one is related to the strategy of Tata to woo (and supply) large Reliance customers. Reliance has argued in front of the regulatory commission, with positive outcomes that without its limited commercial and industrial base, its consumer mix will grow to be even more unbalanced (they claim 1.7 million slum consumers out of a 2.2 million consumer base) and will undermine the sustainability of the company. Besides this Tata

[6] World Energy Insight ,2010

versus Reliance battle, the Electricity Act offers the possibly of authorising the granting of second licences. In Mumbai, Reliance has already requested a second license in the BEST area. As a counterstrategy, BEST is also considering applying for a second license in the Reliance area.

At the level of the metropolitan region, the Maharashtra State Electricity Board was unbundled in June 2005 with the creation for the distribution segment of Mahadiscom (the Maharashtra State Electricity Distribution Company Ltd.). Very recently, Mahadiscom started a policy of franchise in the metropolitan region for some of the zones it administers. By the end of 2003, both Reliance and Tata had applied for a second license in the two Mumbai wards covered by Mahadiscom but also in other profitable urban and industrial areas of Maharashtra.

Consequences are mostly played at the regional level with the arrival of new players with the franchise policy, the granting of multiple licenses and its potential outcome of cherry-picking. The regulatory commission favours this policy as it considers that it will boost industrial growth and competitiveness and will drive prices down. It is clearly inscribed in a policy shift from integrated monopolies internalising evening out mechanisms to a competitive model based on economic efficiency.

- **Electricity Tariff Growth Rate Analysis:**

Category	Units(MU)	Fixed charges/Demand charges(Rs./KVA/month)		Growth Rate(%)	Energy charges(Rs./Unit)		Growth Rate(%)
		2006	2012		2006	2012	
BPL		3	3	0.0%	0.5	0.44	-12.0%
LT-1 (Residential)	0-100	10	40	300.0%	0.75	2.06	174.7%
	101-300	10	75	650.0%	2.15	3.81	77.2%
	301-500	50	75	50.0%	4.65	5.36	15.3%
	>500	50	100	100.0%	4.65	6.86	47.5%
LT-2a(Commercial)	0-300	150	250	66.7%	4.15	5.5	32.5%
	301-500	150	250	66.7%	5.15	5.5	6.8%
	501-1000	150	250	66.7%	5.15	8.16	58.4%
	>1000	150	250	66.7%	6.3	8.16	29.5%
LT-3 (Industrial)	0-300	300	325	8.3%	3.4	5.21	53.2%
	301-500	300	325	8.3%	4.65	5.21	12.0%
	501-1000	300	425	41.7%	4.65	7.28	56.6%
	>1000	300	425	41.7%	6.15	7.28	18.4%
HT-Commercial		300	200	-33.3%	4.35	6.35	46.0%
HT-Industry		300	200	-33.3%	2.7	5.9	118.5%

Table 9:BEST's Tariff Rate Comparison for 2006-2012 *(Source: BEST Tariff Petition 2008-09)*

As it appears from the table,the residential tariff rates have seen the largest increase during the period. The growth rate in fixed charges being a maximum of 600% while the energy charges growth occurred to a maximum of approx. 170%.

Category	Units(MU)	Fixed charges/Demand charges(Rs./ KVA/month)		Growth Rate	Energy charges(Rs./Unit)		Growth Rate
		2006	2012		2006	2012	
BPL		3	3	0.0%	0.4	0.4	0.0%
LT-1 (Residential)	0-100	30	30	0.0%	1.6	1.05	-34.4%
	101-300	50	50	0.0%	3.6	2.5	-30.6%
	301-500	50	50	0.0%	5.75	4.4	-23.5%
	>500	50	100	100.0%	5.75	5.3	-7.8%
LT2a(Commercial)	<15 HP	150	150	0.0%	4.6	4.25	-7.6%
	>15 HP	374	150	-59.9%	3.5	4.9	40.0%
LT-3 (Industrial)	<15 HP	150	150	0.0%	4.6	4.5	-2.2%
	>15 HP	374	150	-59.9%	3.5	5.1	45.7%
HT- Commercial		374	150	-59.9%	3.15	5.2	65.1%
HT-Industry		374	150	-59.9%	3.15	5	58.7%

Table 10:TPC Tariff Rate comparison for 2006-2012 ***(Source: TPC Tariff Petition2006-07)***

Tata Power Company has seen a mixed kind of growth/ decrease in percentage terms over the period. The maximum growth of fixed charges moving upto 100% for >500 Million Units consumption in Residential Sector. The energy charges witnessing a maximum growth of approx. 65%,while there is a also a significant decline in fixed & energy charges for some categories.

On comparing the trends of tariff growth rate of BEST & TPC ,we see a clear distinction of tariffs of the 2 utilities. Neglecting the minute details ,we can see that BEST has not witnessed a major reduction of tariff rates,which has happened in the case of TPC.

This’s obviously due to Tata Power’s own generation facility.

Almost same has been the case with R-Infra. Lower tariff rates of TPC give it the upper hand when it comes to the no. of consumers, which has increased manifold over last few years.

Consumer Category	Energy Charge (Rs./unit)		
	RInfra	TPC	BEST
LT – Residential			
0-100	1.72	1.30	1.80
101-300	4.02	2.70	3.70
301-500	7.02	4.20	5.90
Above 500	8.27	4.90	7.90
LT- Commercial	6.52 (0-20 kW)	3.85 (0-20 kW)	5.10 (0-300)
LT-Industrial (<20KW)	6.32	4.10	4.30 (0-300)
HT – Housing	4.02	3.80	4.37
HT – Industry	6.32	4.10	6.42
HT- Commercial	8.77	4.35	6.90

*Note: Tariff as per stay order 15th Jul 2009

Table 11:A comparison of Tariff Rates of 3 utilities in Mumbai as in july,2009.*(Source: RInfra)*

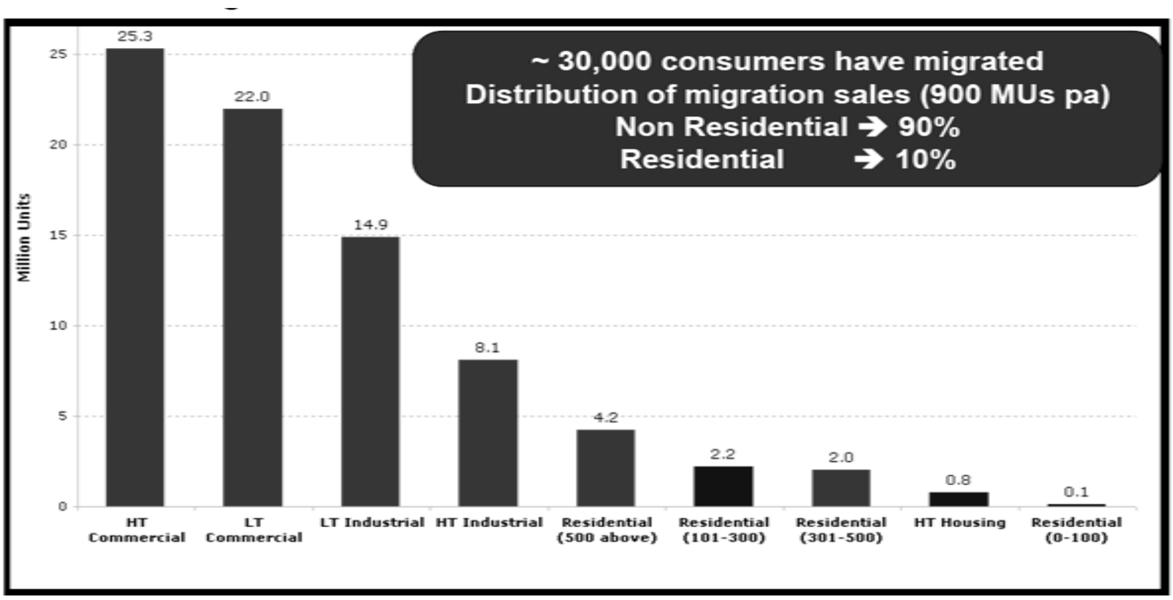

Chart 6:Migration of Consumers from R-infra to TPC as on March 29,2010.*(Source: RInfra)*

4.2 Recommendations

- Incentivize the off peak hour commuters and the mass transit systems.

Owing to the growing demands of fuel(Petrol,Diesel,Natural Gas,Electricity etc.) for transportation purpose in Mumbai(or any other district per se), and the insufficient supply/availability of resources ,it's important that a suitable initiative be adopted to promote transportation in a sustainable manner.

One way could be to incentivize the commuters who travel in personal 4 wheelers during off peak hours of traffic & to penalize in some way those who use 4 wheelers during peak hours. This could ensure that more people make use of the public transit system & thereby causing lesser pollution on road & also reduced traffic jams.

In Singapore transit mode share declined from 55% of commuters in 1990 to 52.4% in 2000 (Singapore Census, 2000). This decrease is striking as Singapore has had the most consistent transport policy over 2 decades favoring transit, including strict limits on car ownership and has been a world pioneer for congestion pricing using advanced technology. [7]

Congestion pricing and parking pricing,aim at adjusting the price of using a highway or of a parking space to reflect its real economic value, including externalities due to congestion.

For instance, a toll charge on a highway may not reduce congestion if it is set too low. Congestion pricing, as practiced in Singapore, consist of increasing tolls until the desired decrease in congestion is achieved. Congestion pricing consists in increasing or decreasing prices until reaching equilibrium between supply and demand is reached. Congestion pricing does not aim at recovering the cost of a highway, but at limiting traffic volume to obtain a desired speed. Pricing parking at market price is equivalent to congestion pricing: the operator will increase the price of parking until all the parking spaces are filled.

- More energy efficiency improvement programs should be initiated. Specially for low-consumption households that consume 50 kWh of electricity or less per month. These are in most cases low-income consumers, who have high discount rates, and often don't have the initial capital required to buy energy efficient end uses devices, such as CFLs. These consumers also tend not to be well educated and informed, and rarely use energy efficient appliances. Utilities could overcome the initial high cost and information barriers by a targeted leasing program for energy efficient appliances especially CFLs. The cost of the CFLs could be recovered from the consumer bill over a period of time. The program could be designed in such a way that a consumer's monthly electricity bill remains unchanged (a bill-neutral program)

[7] Bertaud (2009),Urban Research Symposium

until the full cost of the CFL is recovered, and subsequent savings are passed on to the consumer. Beyond the benefits to the residential consumer, the utility would benefit by reselling the saved energy to its high end consumers, and by reducing the amount of subsidy given to the low consumption (low income) residential consumers.[8]

Eg: average monthly bill of a 60W incandescent bulb @Rs.2/kWh

= 2*4hours/day*30*0.06kW

=Rs.14.4/month

Average bill of a 15W CFL which replaces the 60W bulb =Rs.3.8

Reduction in the bill= Rs 10 per month

If a 15W CFL costs Rs. 150 ,the cost of CFL can be recovered in 15 months.

The utility can thus make a conservative estimate of the bill saving as a result of using one CFL. When it leases a CFL to the consumer,it could add to his bill,the amount saved by the use.This'll ensure the consumer's bill remains almost the same. This addition will be in effect until the cost of CFL is recovered ,after which the savings would be passed on to the consumers.

The increased /sufficient energy supply to the high end industrial consumers ultimately leads to additional revenue generation due to increased production . This in turn ,generates more tax revenues for the district/state. The saved energy can also be traded with the deficit regions to earn some revenue.

- Awareness is another very important issue. It's ironical that whereas on one hand more & more industries are realizing the importance & cost benefits of energy conservation, the individuals have become more unconcerned about the same. While industries respond rapidly to market forces, through efficient use of energy, households are much slower to respond, for a variety of reasons. One reason may be that low-income households under-invest in energy efficiency technology, partly because they face formidable information barriers, partly because they cannot observe many of the costs of energy they use.

So in essence, this point goes in tandem with the first one. The sensibility to create a sustainable living environment should've dawned on the people and rather than the need of any incentive ,they should have gone for energy conservation methods which includes efficient electricity usage, bills payment, theft prevention, avoiding travelling alone in a 4 wheeler & following other traffic rules.

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[8] Stern (April 2003),Energy & Economic Growth

5 .Chapter 5-Forecasts & Conclusion

5.1 Forecasts

Forecasting of Energy Consumption has been done for the years 2015 & 2020 on the basis of the data available for 2005 and 2010.

For the purpose of forecasting, 3 different business environments have been considered.

5.1.1 Business as Usual Scenario:

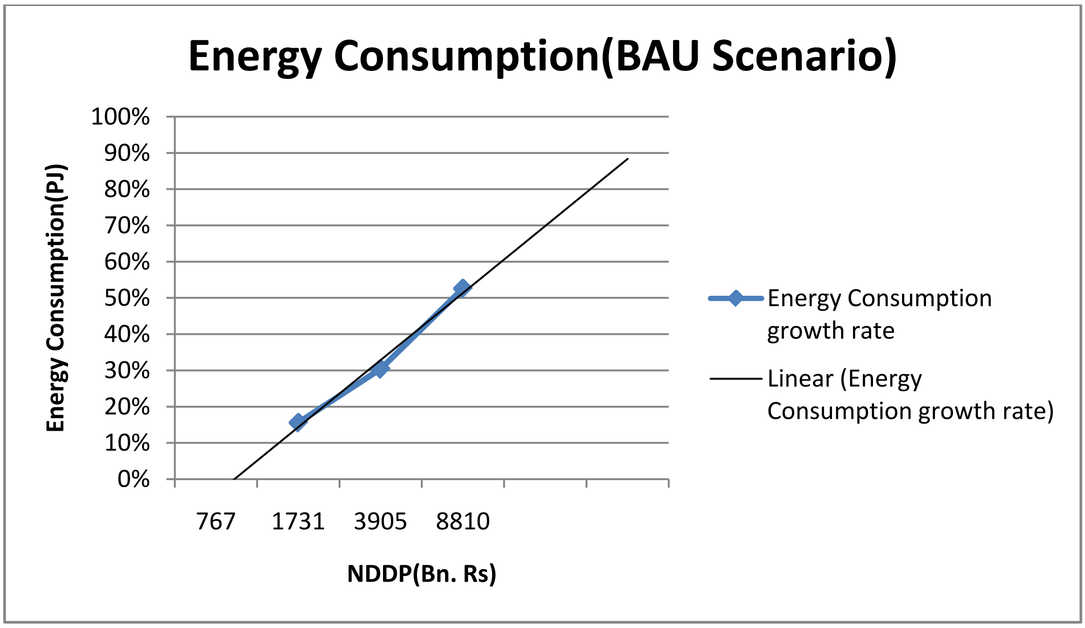
Here ,the business of the district proceeds at a normal rate i.e business as usual scenario.

The Net District Domestic Product growth rate has been assumed to be 17.67% ,which is same as the Compound Annual Growth Rate of NDDP between the years 2005 & 2010.

So a linear relationship has been shown in the graph as Energy Consumption comes out to be 106.91PJ & 163.13PJ for the respective years.

Year	Total NDDP(Bn Rs)	CAGR(%)	Energy Consumption(PJ)	Growth Rate(%)
2005	767		70.94	
2010	1731	17.67%	81.99	15.58%
2015	3905	17.67%	106.91	30.39%
2020	8810	17.67%	163.13	52.59%

Table 12:Business as Usual Scenario



Graph 1:BAU Scenario

5.1.2 High Growth Scenario:

Here ,the business of the district proceeds at a high rate i.e High Growth scenario.

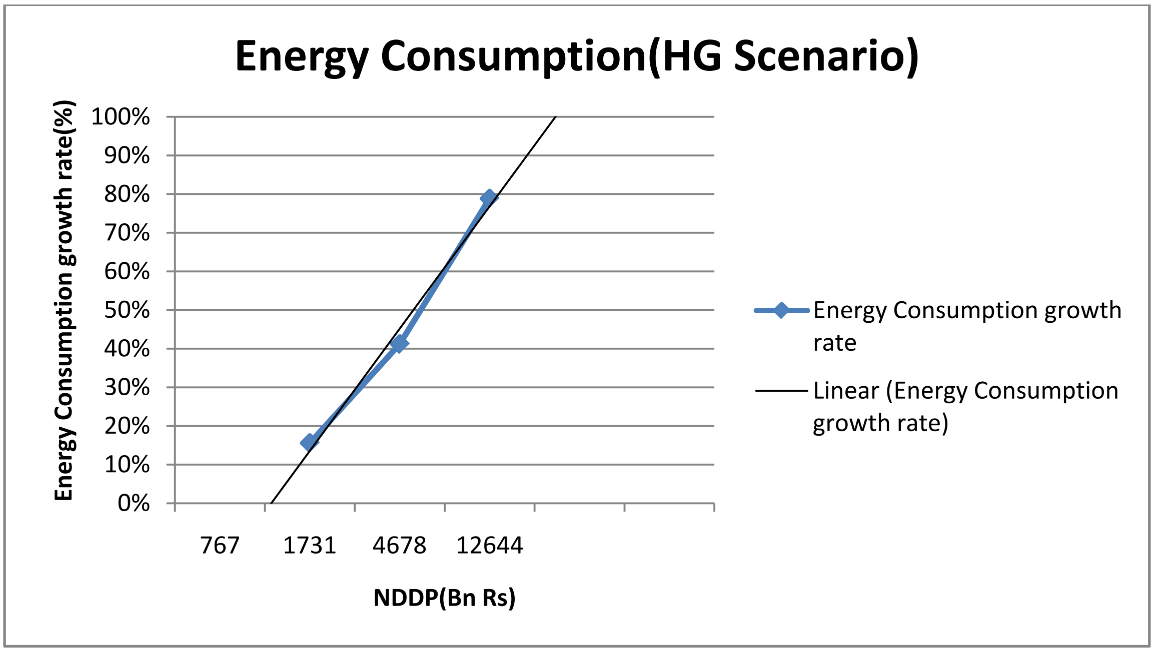
The Net District Domestic Product growth rate has been assumed to be 22% ,which is higher as compared to the Compound Annual Growth Rate of NDDP between the years 2005 & 2010.

So a linear relationship has been shown in the graph as Energy Consumption comes out to be 115.77PJ & 207.99PJ for the respective years.

As seen the with higher growth rate of NDDP,the energy consumption increases at a very high rate.

Year	Total NDDP(Bn Rs)	CAGR(%)	Energy Consumption(PJ)	Growth Rate(%)
2005	767		70.94	
2010	1731	17.67%	81.99	15.58%
2015	4678	22%	115.77	41.21%
2020	12644	22%	207.09	78.87%

Table 13:High Growth Scenario



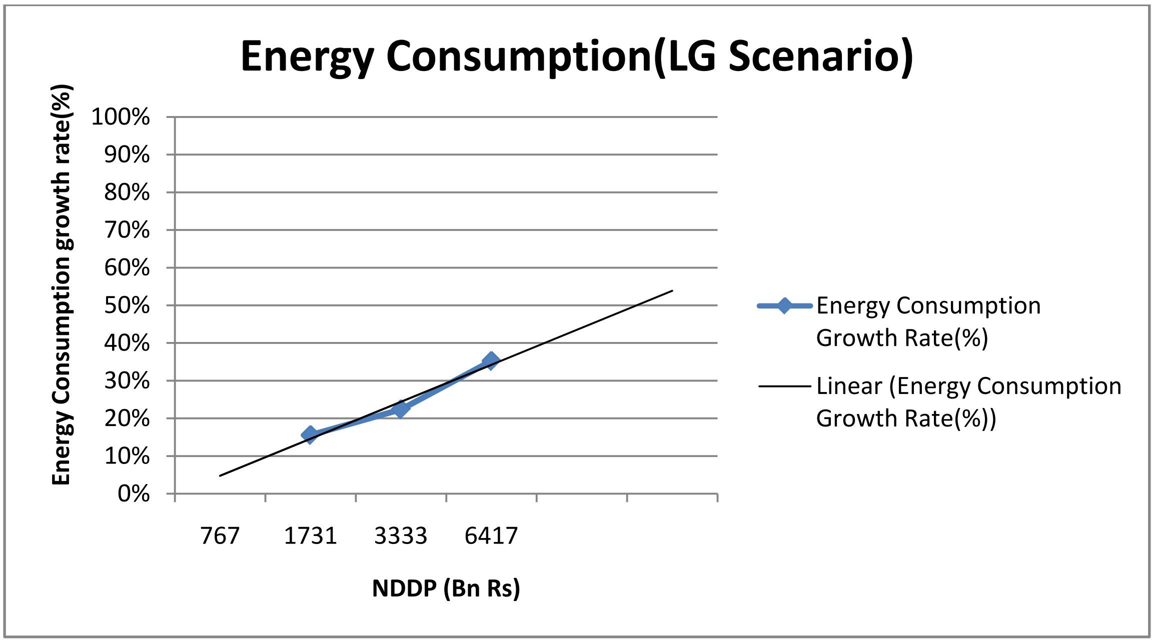
Graph 2:HG Scenario

5.1.3 Low Growth Scenario:

Here ,the business of the district proceeds at a lower rate i.e Low Growth scenario.
The Net District Domestic Product growth rate has been assumed to be 12% ,which is lower as compared to the Compound Annual Growth Rate of NDDP between the years 2005 & 2010.
So a linear relationship has been shown in the graph as Energy Consumption comes out to be 100.35 PJ & 135.71PJ for the respective years.
As seen the with a low growth rate of NDDP,the energy consumption increases at a lower rate.

Year	Total NDDP(Rs Lakh)	CAGR(%)	Energy Consumption(PJ)	Growth Rate(%)
2005	767		70.94	
2010	1731	17.67%	81.99	15.58%
2015	3333	14%	100.35	22.40%
2020	6417	14%	135.71	35.23%

Table 14:Low Growth Scenario



Graph 3:LG Scenario

5.2 Conclusions

A full urban metabolism with respect to energy, materials, water, and nutrients needs to be quantified to get the complete picture of sustainability aspects of a region.There are practical reasons for understanding urban metabolism. The vitality of cities depends upon its spatial relationships with its surrounding and global resources. Metabolic processes that threaten the sustainability of cities are identified. It is useful for all the stakeholders to know if they are using energy, water, materials and nutrients efficiently, and how this efficiency compares to other cities.

NDDP of Mumbai has grown by almost 18% between the year 2005 and 2010. During the same period Per capita income of Mumbai has grown at a CAGR of 19.7% .

As seen from the figures, the improved economy of the district seems to arise from the fact that more and more employment has grown in service sector & with improved economic & social conditions for people ,the Industrial & Commercial output has risen with not so serious increase in the Energy Intensity. It also signifies the importance of sustainable development to the economic growth of a region. As is evident,efficient energy utilization leads to an increased revenue generation for the region.

Also the rapid increase in the no. of consumers of different utilities in a skewed manner brings to the fore the importance of providing value added services like incentives for energy saving, troubleshooting & complaint resolving sessions ,ease of payment etc. along with supplying electricity at a reasonable & competitive tariff and passing on the savings owing to a reduced overall price of electricity to consumers (if any).

Although this study has analysed only the Energy Consumption in the form of Electricity ,it provides for further study into different Energy Resources consumption patterns.

Glossary

- **Net District Domestic Product (NDDP)** : which is also commonly known as District Income, is a measure, in monetary terms, of all goods and services produced (without duplication) within the geographical boundaries of the district during a given period of time (generally, one year).

- **Gross District Domestic Product (GDDP)** : When the consumption of fixed capital is added to NDDP, it is termed as Gross District Domestic Product.

- The IEA/OECD define one toe to be equal to 41.868 GJ [1] or 11.63 MWh. Some organisations use other definitions of toe, for example:

  - 1 toe = 11,630 kilowatt hours
  - 1 toe = 41.87 gigajoules
  - 1 t diesel = 1.01 toe
  - 1 m^3 diesel = 0.98 toe
  - 1 t petrol = 1.05 toe
  - 1 m^3 petrol = 0.86 toe

  1 MWh = 0.086 toe (therefore 1 toe = 11630.0 KWh)

Annexure 1

Electricity supplied to Mumbai District(Discom Wise)

Electricity Supplied in Mumbai District(MU)				
	Organisations			
Year	**Tata**	**BSES/Reliance**	**BEST**	**Total**
1960		121	560	681
1970		540	1003	1543
1980		1316	1389	2705
1990		2899	2147	5046.4
1991		3100	2248	5347.98
1992		3400	2290	5689.95
1993		3700	2387	6087.17
1994		4000	2443	6443.4
1995		4212	2636	6847.81
1996		4381	2724	7104.94
1997		4645	2884	7528.55
1998		4950	2951	7901.22
1999		5168	3145	8312.96
2000		5250	3176	8425.81
2001		5676.00	3216	8892.35
2002		5880.00	3319	9198.53
2003		6117.00	3387	9504.31
2004	2269	6502.00	3535	12306.05
2005	2336	6895.00	3615	12845.69
2006	2342	7454.00	3800	13596
2007	2510	7807.00	3900	14217
2008	2501	8276.00	4000	14777
2009	2458	8659.00	4121	15238.17
2010	2790	7472.56	4267	14529.67
2011	4406	9186.00	4286	17878

Table 15:Electricity Supplied in Mumbai District(MU)

Year	Residential	Commercial	Power	Others	Total
1980-81	508.49	473.87	380.55	26.48	1389.39
1990-91	831.79	884.93	395.01	35.67	2147.40
1991-92	883.96	961.65	366.94	35.43	2247.98
1992-93	921.03	954.90	377.76	36.26	2289.95
1993-94	960.00	1005.00	386.17	36.00	2387.17
1994-95	989.55	1044.98	372.65	36.22	2443.40
1995-96	1085.55	1136.57	366.55	47.14	2635.81
1996-97	1125.30	1191.52	359.83	47.29	2723.94
1997-98	1214.20	1249.37	355.29	64.69	2883.55
1998-99	1273.34	1270.56	356.28	51.04	2951.22
1999-00	1349.35	1379.89	359.83	55.89	3144.96
2000-01	1394.20	1390.35	343.05	48.21	3175.81
2001-02	1437.35	1402.97	324.83	51.20	3216.35
2002-03	1511.38	1442.84	312.72	51.59	3318.53
2003-04	1554.75	1452.81	326.31	53.44	3387.31
2004-05	1620.57	1534.01	328.59	51.88	3535.05
2005-06	1651.25	1590.12	321.30	52.02	3614.69
2009-10	1726.13	2035.77	295.67	63.60	4121.17
2010-11	1745.17	2154.21	296.24	71.49	4283.35
2011-12	1763.05	2143.28	302.68	77.04	4286.05

Table 16:BEST's electricity supply to different sectors in Mumbai

Year	Residential	Commercial	Industrial	Total
1995-96	2196.00	791.00	1225.00	4212.00
1996-97	2296.00	909.00	1176.00	4381.00
1997-98	2467.00	1023.00	1155.00	4645.00
1998-99	2707.00	1101.00	1142.00	4950.00
1999-00	2834.00	1184.00	1150.00	5168.00
2001-02	3132.00	1344.00	1200.00	5676.00
2002-03	3283.00	1417.00	1180.00	5880.00
2003-04	3232.00	1758.00	1127.00	6117.00
2004-05	3554.00	1889.00	1059.00	6502.00
2005-06	3799.00	2147.00	949.00	6895.00
2006-07	4028.00	2591.00	835.00	7454.00
2007-08	4107.00	2724.00	976.00	7807.00
2008-09	4397.00	2834.00	1045.00	8276.00
2009-10	4653.00	3076.00	930.00	8659.00
2010-11	4463.00	2380.00	606.00	7472.56

Table 17:RInfra(erstwhile BSES) supply to different sectors in Mumbai

Year	Residential	Commercial		Indusrial	Traction	Misc.	Total
		LT	HT				
2006-07	66.00	321.00	117.00	1073.00	765.00	0.00	2342.00
2007-08	72.00	344.00	192.00	1101.00	801.00	0.00	2510.00
2008-09	74.00	357.00	597.00	655.00	818.00	0.00	2501.00
2009-10	79.00	261.00	575.00	719.00	824.00	0.00	2458.00
2010-11	105.00	290.00	592.00	958.00	825.00	20.00	2814.38
2011-12	334.00	735.00	989.00	1486.00	821.00	41.00	4406.00

Table 18:Tata's electricity supply to different sectors in Mumbai

Year	Gasoline(Mtoe)	Energy(PJ)
2005-06	170	7.1179
2010-11	194	8.12278

Table 19:Energy corresponding to Gasoline consumed

Year	Diesel(Mtoe)	Energy(PJ)
2005-06	420	17.5854
2010-11	517	21.64679

Table 20:Energy corresponding to diesel consumed

Year	Electricity(MUs)	Energy(PJ)	Total Energy(PJ)=(Gasoline+ Diesel+ Electricity)
2005-06	12845.69	46.24397	70.94727017
2010-11	14506.11	52.221416	81.99098576

Table 21:Energy corresponding to electricity consumed

YEAR	Per Capita Income(monthly)
1980-81	4221
1984-85	5550
1989-90	10050
1991-92	25350
1992-93	28028
1993-94	33596
1994-95	36244
1995-96	40952
1996-97	43902
1997-98	43519
1998-99	42037
1999-2000	45861
2000-01	50548
2001-02	57536
2005-06	57229
2006-07	65361
2008-09	110000
2009-10	125000
2010-11	141138

Table 22:Per capita income of Mumbai

Quantity of Petroleum Products demand from 1990-2010 in Mumbai.

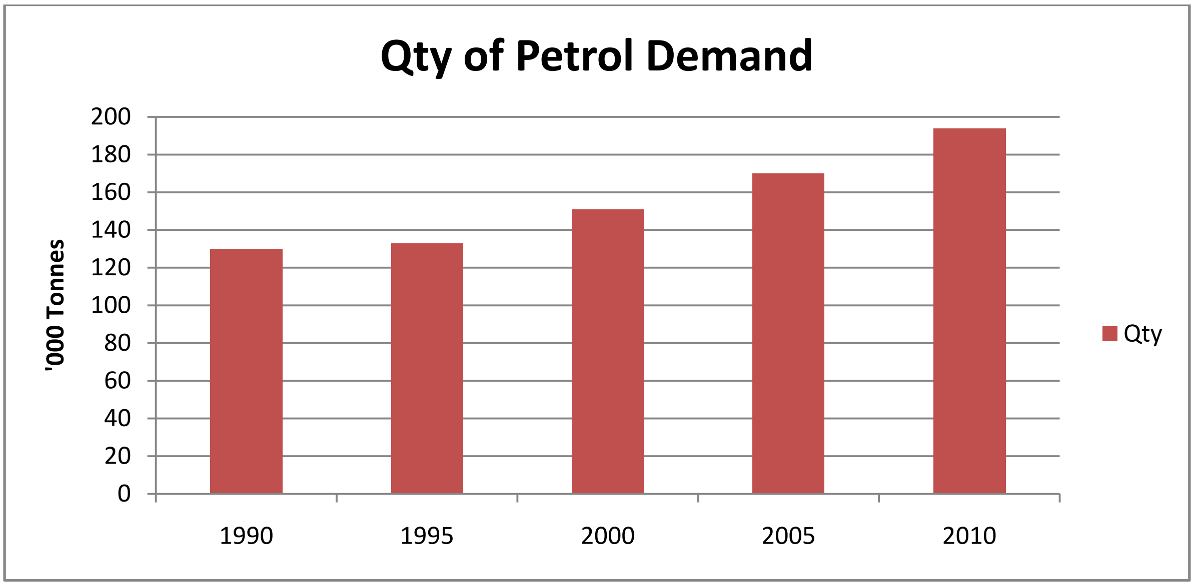


Chart 7:Petrol Demand in Mumbai

Chart 1.7 shows the approx. quantity of gasoline demand over the years. The demand has increased from 1990 to 2010 at a CAGR of 2.02%.

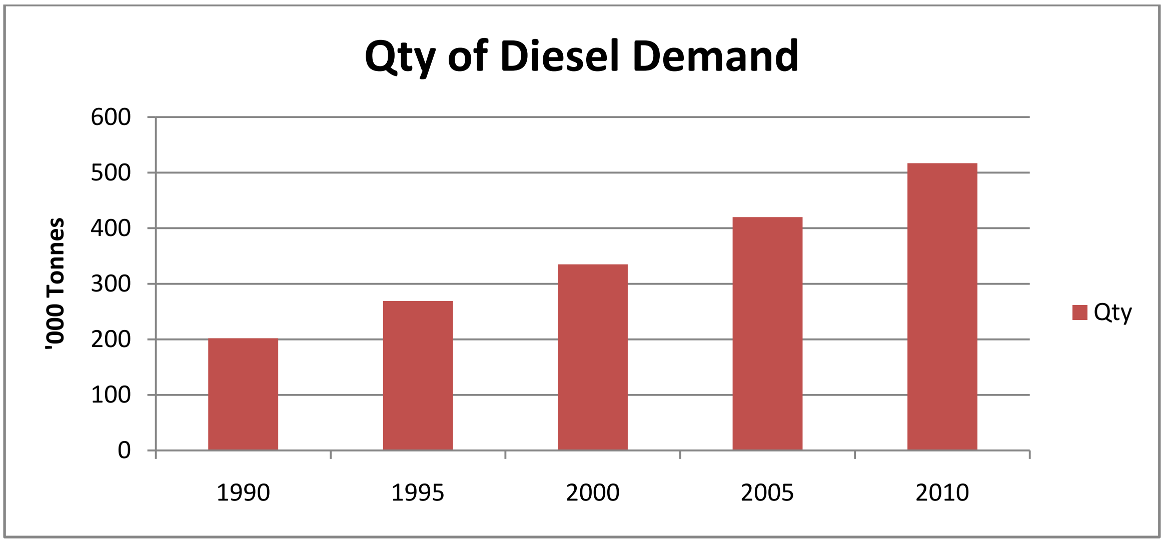


Chart 8:Diesel Demand in Mumbai

Table shows the approx. quantity of diesel demand over the years. The demand has seen a CAGR of 4.08% from 1990 to 2010.

<u>Prices of different Petroleum Products in Mumbai</u>

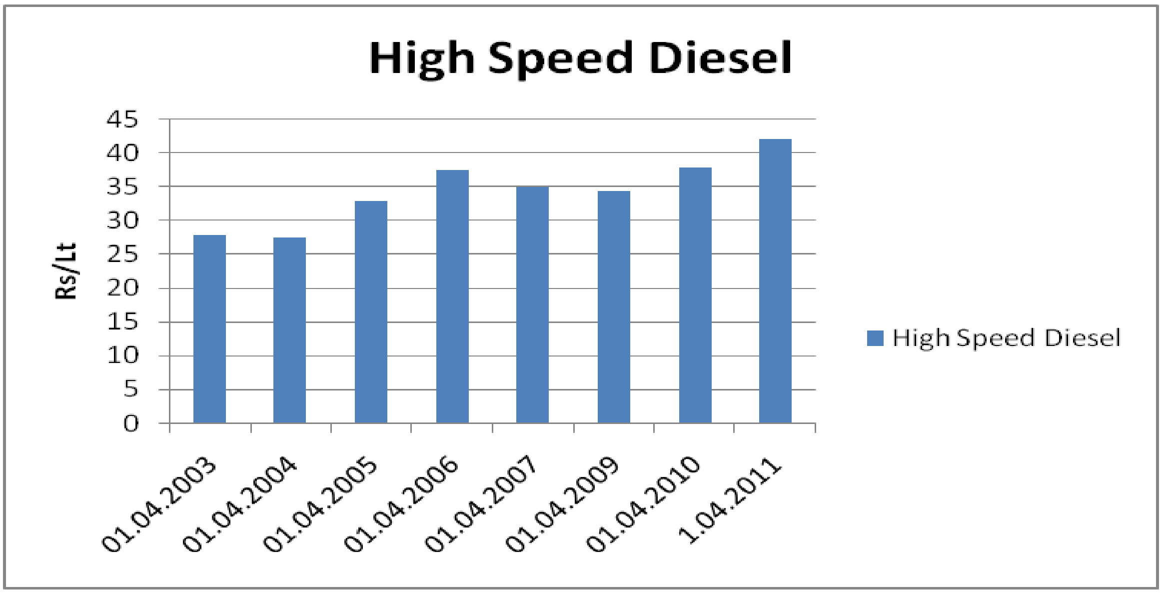


Chart 9:Price of High Speed Diesel

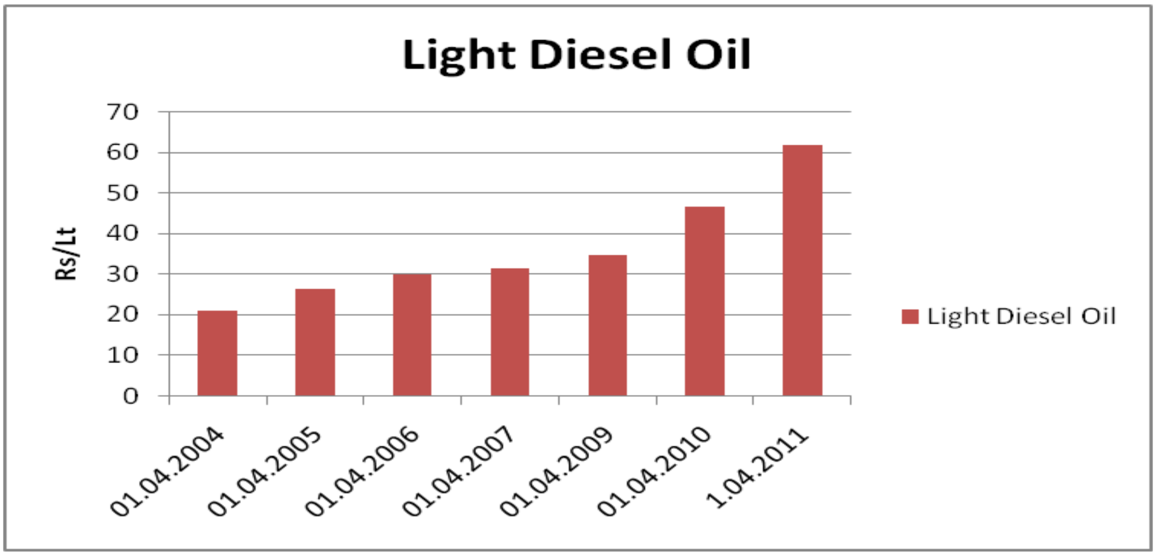


Chart 10:Price of Light Diesel Oil

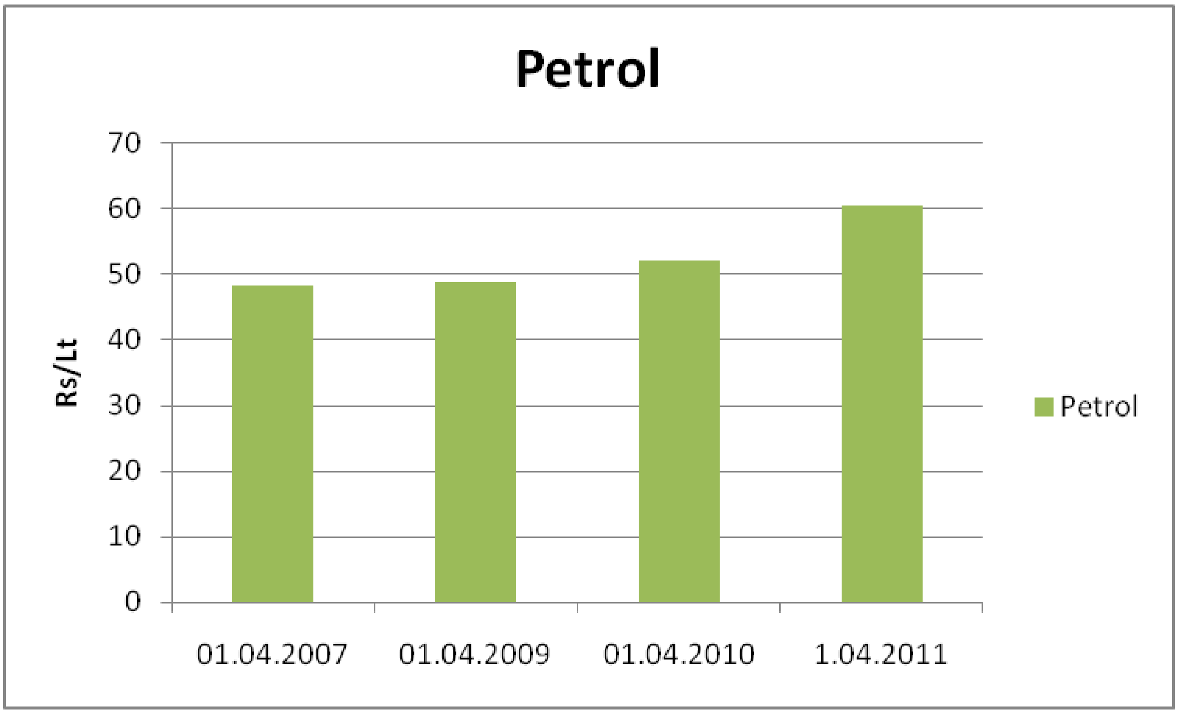


Chart 11:Price of Petrol

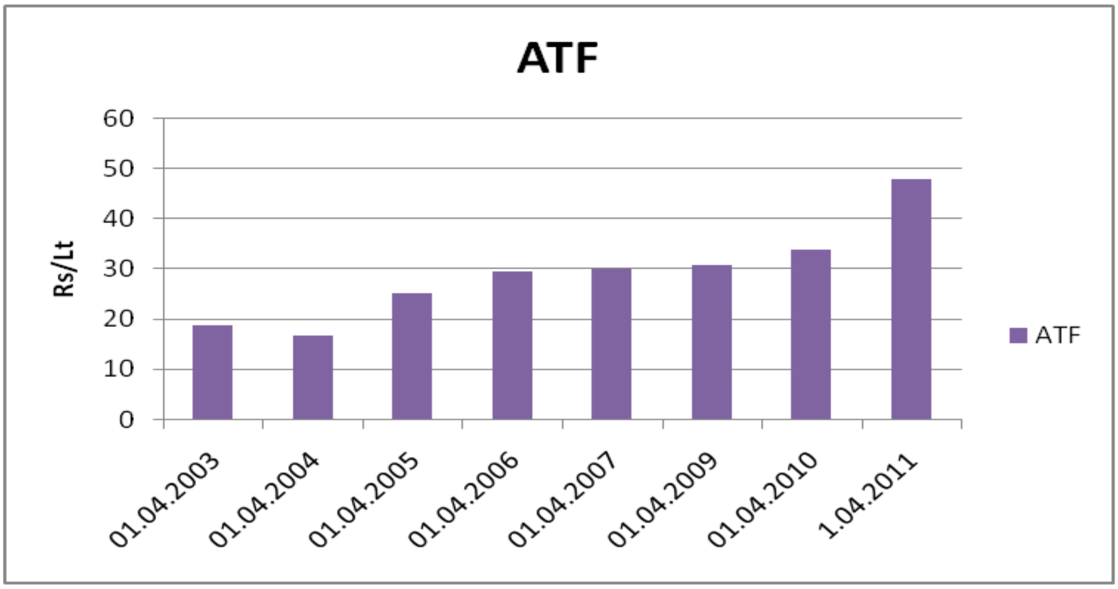


Chart 12:Price of Aviation Turbine Fuel

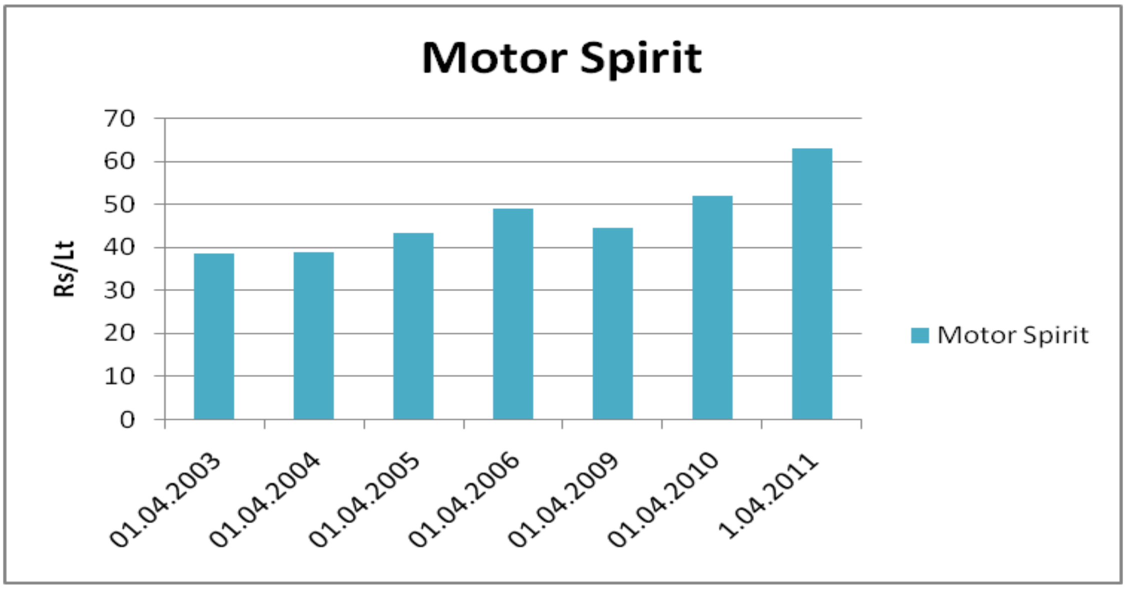


Chart 13:Price of Motor Spirit

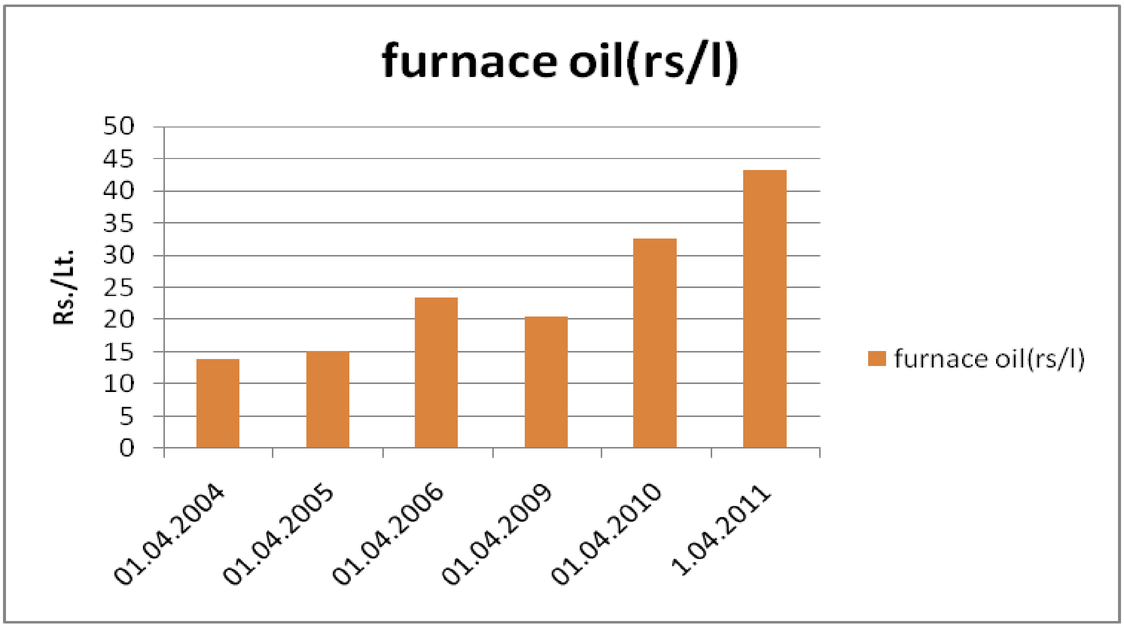


Chart 14:Price of Furnace Oil

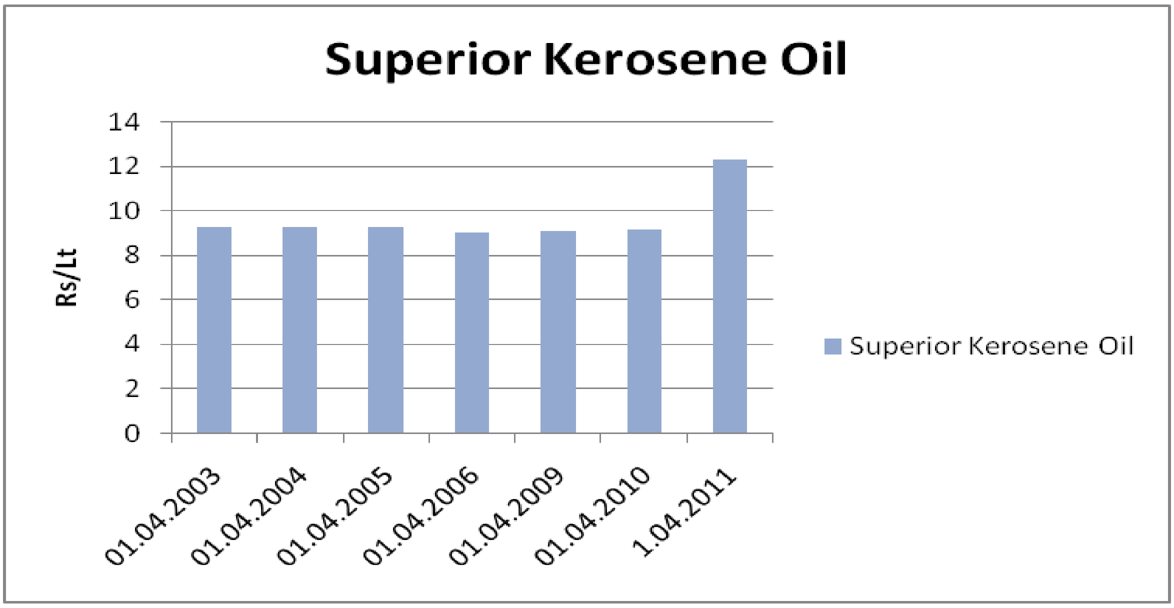


Chart 15:Price of Superior Kerosene Oil

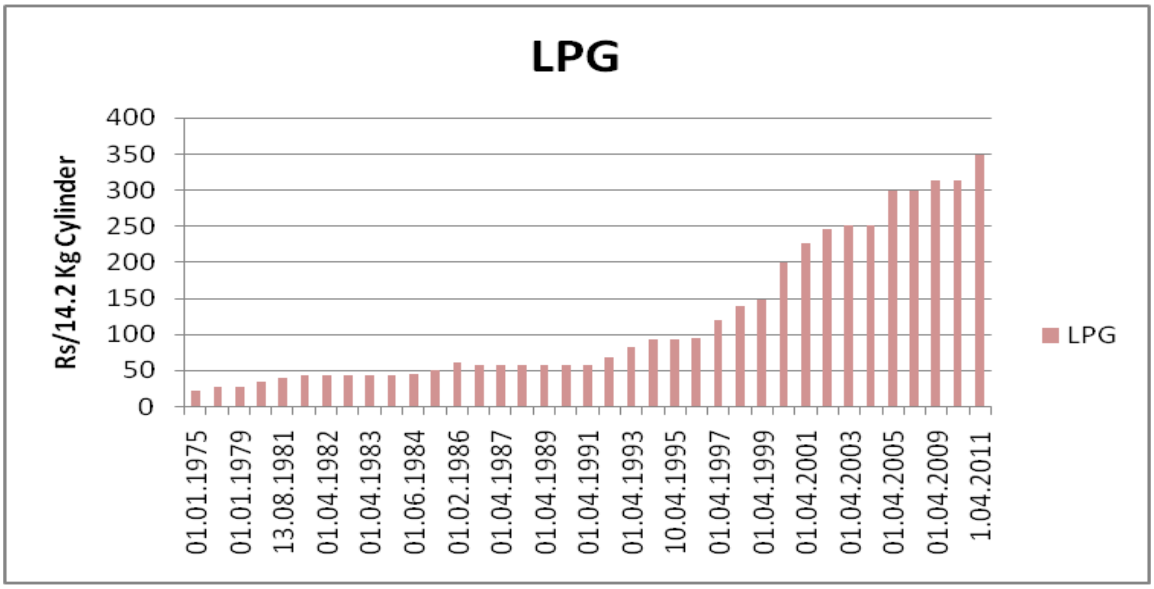


Chart 16:Price of LPG

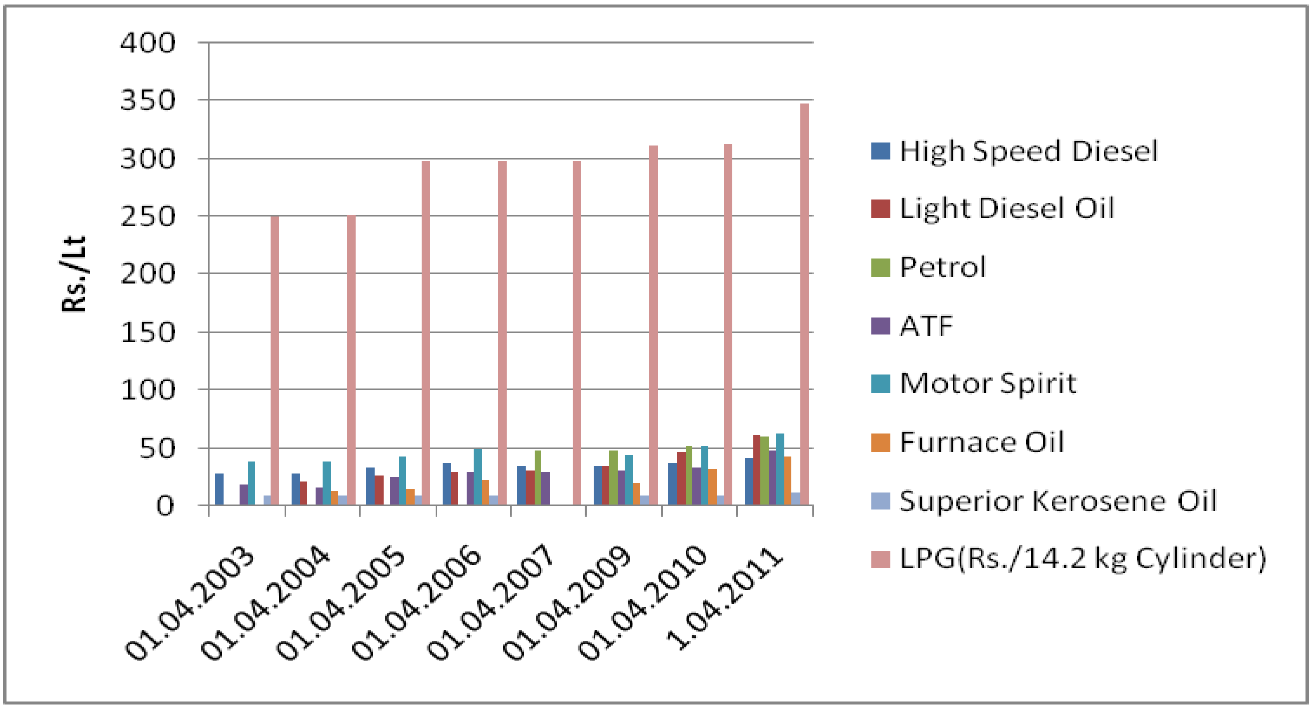


Chart 17:Combined Representation of Prices of Petroleum Products

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