ENERGY MANAGEMENT IN LUCKNOW CITY

A DISSERTATION

Submitted in partial fulfilment of the requirements for the award of the degree of

MASTER OF URBAN AND RURAL PLANNING

By

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CERTIFICATE

Certified that this report titled **"Energy management in Lucknow city"**, which has been submitted by Ms. Hina Zia, in partial fulfillment of the requirements for the award of Post Graduate degree in Master of Urban and Rural Planning in the Department of Architecture and Planning, Indian Institute of Technology Roorkee, is the student's own work carried out by her under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree.

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in this thesis titled **"Energy management in Lucknow city"**, in partial fulfillment of the requirement of the award of the degree of **Master of Urban and Rural Planning** submitted in the Department of Architecture and Planning, of the Indian Institute of Technology Roorkee, Roorkee, is an authentic record of my own work carried out during the period from August 2001 to February 2002 under the supervision of ***Prof. Rajesh Chandra***, Assistant Professor, Department of Architecture and Planning, Indian Institute of Technology Roorkee, Roorkee.

The matter embodied in this thesis has not been submitted by me for the award of any other degree.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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PREFACE

Man's history is a living testimony to his growth from a mere medium-sized mammal to his present position as the earth's dominant species by harnessing and manipulating energy at each stage of his evolution. The modern society grew without realizing the extent of its dependence on energy. The complex edifice of industrial civilization, with its endless catalogue of achievement and conquest of the physical world, has so impressed people that they failed to see the fragility of supports received from the environment. Fossil fuels were regarded as free resources with infinite availability. Exponential growth in population, increasing urbanization and industrialization aggravated the problem further leading to grave consequences.

The later part of the last decade saw the sudden realization of this great fault of *Homo sapiens* by the leading economies of the world and thus, started an era of attempts to switch over to "sustainable development". A sustainable system delivers services without exhausting resources. It uses all resources efficiently both in an environmental and economic sense. Our country, one of the fastest growing economies of the region, seems to have been left behind inspite of its rich heritage, which was based on sustainable development.

Despite years of oil and electricity conservation efforts, India's electricity intensity remains very high- for 1996/97 it was 0.91 kWh/ US$ of GDP(Gross domestic product)- one of the highest in developing Asia and almost twice that of small countries like Taiwan and Malaysia. A number of Demand-side-management measures have been found on the top of the energy policy change list for many years, but the desired results are not yet achieved.

There is a major lacuna as far as implementation of various programs is concerned. There is a need to shift the focus from top-to-bottom to bottom-to-top approach in all aspects of planning and administration. With regard to energy management, little has been achieved so far on account of various reasons. The problem has not yet been taken up holistically. The present study had made an attempt in this regard to design an energy management plan at city level. Lucknow City, the capital of Uttar Pradesh, has been chosen for conducting this present investigation.

On account of resource and time constraints, only domestic and transport sectors have been dealt with in detail. The existing consumption pattern suggests a gap between the supply and demand. This gap is bound to increase manifolds in future if the same situation prevails, indicating an urgent need to look at the problem.

Viewing the energy scenario from the aspects of supply, production, end-use and environment, and thus presents a gloomy picture. Therefore, for a sustainable use of energy and its resources few timely steps to be taken include mass awareness regarding energy resources and their limitations, judicious use and environmental concerns; appropriate understanding of the population, energy and environmental triangle in policy planning; development of energy efficient tools and adoption of other conservation measures. All these have been attempted in the proposed energy management model for the city.

The study also paved the way for further research in this regard to make sustainable development a reality.

ABSTRACT

Our inevitable reliance on energy in some form or other is a ubiquitous yet unrealized truth. Seeing the short supply of energy with respect to increasing demand, management of energy in all systems- urban as well as rural remains a challenge. Very little effort has so far been done in this regard in the country inspite of the many hullabaloos given to energy sector in the national policy. There is dearth of efforts at lower levels- cities, towns and villages.

The present study aims to evolve an energy management model for optimal utilization of energy in Lucknow city- the capital of Uttar Pradesh. Domestic and Transportation sectors have been taken for detailed investigation. Survey research method has been employed, and random sampling technique has been used in this investigation. The data, thus collected has been worked upon using tools like MS Excel, correlation, projection and trend analysis. The study highlights the existing energy gap in terms of electricity, petrol and petroleum products and LPG. The demand and supply projections in future (taken upto year 2005) show an increasing energy gap in all the sectors.

Accordingly, a detailed energy management model has been worked upon to reduce this increasing energy gap and to augment the supply employing various innovative methods. The model suggests for the setting of an energy management cell at city level. A detailed feasibility study has also been undertaken for the setting up of a proposed municipal solid waste based plant. A general framework for an urban energy database and the administrative set-up at various levels has also been given in the study.

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I have received a lot of assistance in the form of library support from number of institutions, such as, TERI, CEPT, IIT Delhi, IREP Training center, NEDA, etc. I am obliged to the residents of Lucknow for providing me the primary information in the form of questionnaire.

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Dated: **Hina Zia**

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

There is no substitute for energy; the whole edifice of modern life is built upon it. Although energy can be bought and sold like any other commodity, it is not 'just another commodity', but the preconditions of all commodities, a basic factor equally with air, water and earth.

E.F.SCHUMACHER,
'Energy supplies-the need for conservation'
Energy International, Sep 1964

A quarter century ago hardly anyone imagined that energy would become virtually overnight a major nemesis in the worlds affair. The availability, type, use, abuse and price of energy touch nearly all the dimensions of human life more or less. The prosperity and stability of industrial state, the economic and social aspiration of developing countries, food production, population and economic growth, environmental balance, the promise and limits of technology, the growing militarization of the world economics. The alternatives to a conscious search for solution are quite simply drift, periodic "crisis storm" and chaos as E. F Schumacher has put the case for energy, it is impossible to over emphasise its certainty. It might be said that energy is for the mechanical world and no consciousness to human world. **IF ENERGY FAILS, EVERYTHING FAILS** [29].

Indeed, it is man's incredible ability to copy the natural ecosystem and evolve his own 'fuel-powered' system (rural or urban). However, in this unchecked and uncontrollable quest for power he lost the foresight and as a consequence a lot of environmental and ecological degradation took place, bringing a crisis for not only other organisms but also his very own existence.

He failed to fully copy the natural ecosystem. Similar to the cybernetics observed in nature, man's 'fuel-powered' system also needs some negative feedback in the form of a proper management plan to avoid the major energy crisis looming ahead in the near future to achieve an orderly and sustainable growth.

1.2 PROBLEM IDENTIFICATION

1.2.1 ENERGY, A PIVOT FOR DEVELOPMENT

Energy is the quintessential necessity of life. It is required both as a means of production and to contribute to quality of life. Infact, a country's Gross domestic product (GDP) is a direct reflection of the paramount role of energy as input in the economic development. The pivotal role played by the energy sector in the economic growth and development of a nation was brought to the fore by none other than the two oil price shocks of 1973 and 1979/80 bringing an end to the era of cheap, abundant energy for most countries, developed and developing alike.

The deep impact of energy on the economy, environmental and international relation is now more evident. Infact, the economic disparities among regions very well reflect the disparities in energy availability. The richest 20 per cent of the world's population use 55 per cent of the total final and primary energy, the other 80 per cent of the global population using only the rest 45 per cent of final energy (***fig no:1.1***). An absence of proper energy planning and management at macro and micro levels may therefore, result in becoming a possible bottleneck for successful economic and social development.

Energy is the basic element for the development of any country (***fig no:1.2***). It has a major economic and political role, as an important raw material traded world-wide. The energy sector activities include extraction, conversion, transportation and consumption, and conservation of energy.

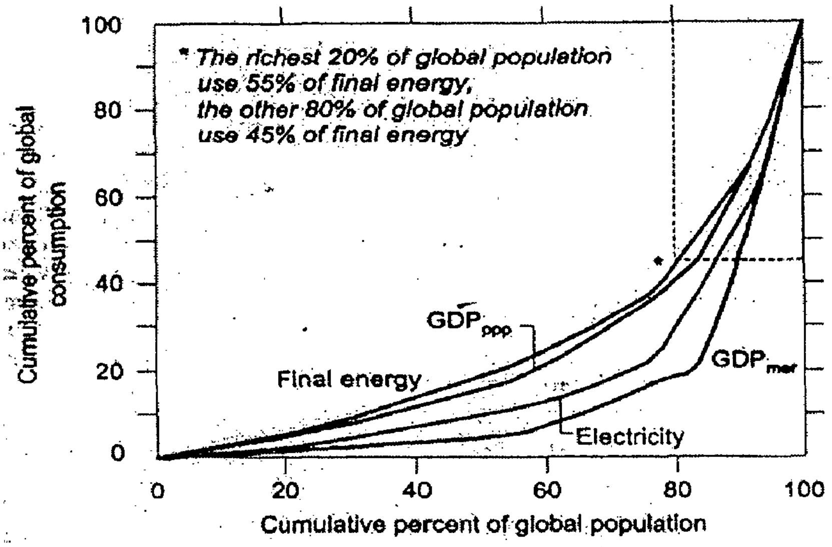


Fig 1.1 Disparities in economic activity and energy consumption in 1990.Cumulative percentage of global economic product, Gross domestic product (GDP), and consumption of final energy and electricity by percentage of cumulative global population.

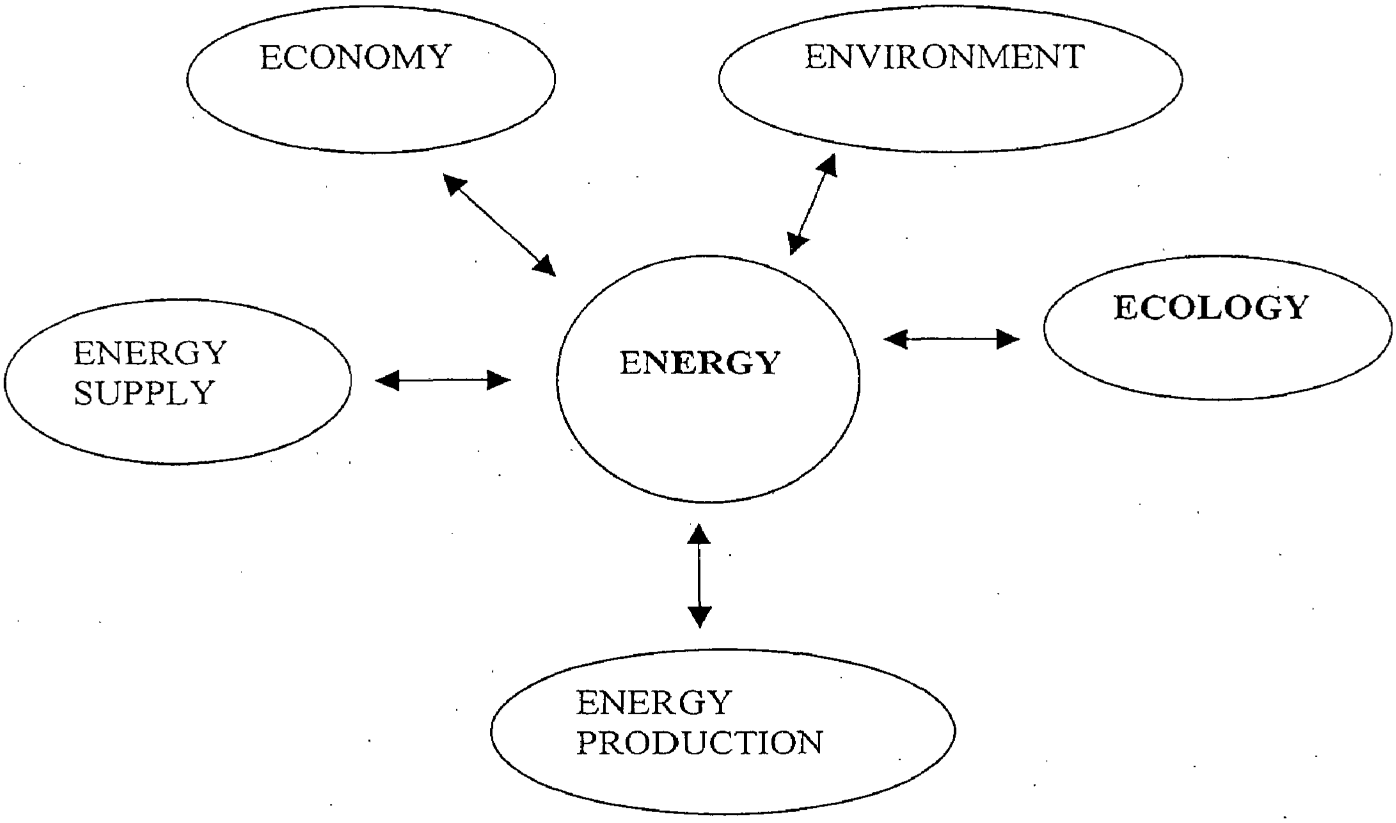


Fig 1.2 ENERGY: the very essence of life depicted as a pivot in the development of any society (Similar to sun in the solar system)

1 2.2 GLOBAL ENERGY SCENARIO

Energy is a very crucial input in the process of any economic development. Some of the complexities that characterise the global energy scene today, are the variable in the magnitude of the energy resources, differing mix of the energy resource profiles, lack of adequate resources of the fossil fuel in many nations, dispersed geographical location of energy resources within the nation of the world.

Energy is at present derived largely from fossil fuels. Major sources of conventional energy at present are crude oil, natural gas and coal, which are constantly depleting. The changing shares of different primary energy sources in the global energy supply, the long transition away from traditional renewable energy forms towards fossil fuels is shown in ***fig no:1.3***.

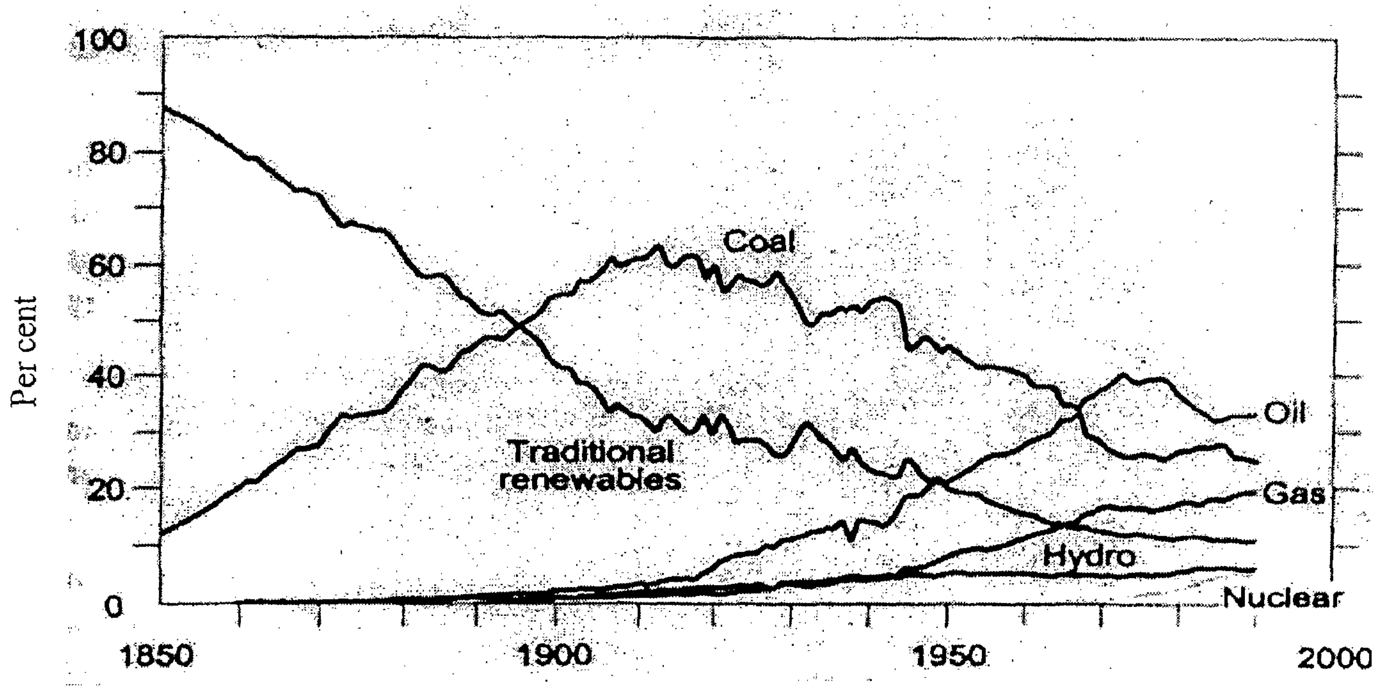


Fig 1.3 World primary energy shares from 1850 to 1990, in per cent.

The following ***table no 1.1*** shows the energy reserve situation in the world as well as in the Asian and pacific region as of the end of 1995.

	Oil		Natural gas		Coal	
	Amt. (billions of tons)	Reserves/ production ratio (in yrs)	Amt. (trillions of cu. Ft)	Reserves/ productio n ratio(yrs)	Amt. (billions of tons)	Reserves/ productio n ratio(yrs)
World	138.3	42.8	4933.6	64.7	1031.6	228
Organisation for economic cooperation & development (OECD)	14.0	14.7	403.6	14.4	424.4	248
Organisation of petroleum exporting countries (OPEC)	105.8	79.5	--	--	--	--
Asia & Australia (excluding China but including mid-east)	6.1	17.0	328.6	45.8	311.5	158
China	3.3	22.0	59.0	94.9	114.5	88
Middle east	89.2	92.3	1597.2	>100	--	--

Source: BP Statistical Review of World Energy 1996, June 1996

Proven reserves are generally taken to be those quantities whose geological and engineering information indicates with reasonable certainty that they can be recovered in the future from known reservoirs under existing economic & operating conditions

Reserve/production ratio: if the reserves remaining at the end of any year are divided by the production in that year, the result is the length of time that those remaining reserves would last if production were to continue at the then current level

1.2.3 REGIONAL ENERGY SCENARIO

Analysis of the aggregate energy scene does not reflect the individual situation at the country level. Nevertheless, it highlights the general trend of energy demand, which influence the energy market and pricing. The region (Asian-Pacific) as a whole remained a net energy importer for a long time and the gap between energy consumption and production has generally been rising. As of 1994, the commercial energy consumption was 2069.7 MTOE compared to the production of 1893.3 MTOE (million tonne oil equivalent). ***Table no: 1.2*** shows the energy demand situation and demand pattern in the region.

Table 1.2 Energy demand pattern in Economic & Social Commission for Asia & the Pacific (ESCAP) region

	1980	1985	1990	1993	1994	Average annual growth rates (percentage)		
						1990/ 1980	1990/ 1970	1994/ 1993
World	5891.5 (1339)	6449.1 (1326)	7605.2 (1442)	7702.2 (1385)	7880.6 (1395)	2.6	2.7	2.3
ESCAP region	1038.0 (430)	1296.8 (478)	1723.2 (576)	1937.0 (615)	2069.7 (649)	5.2	5.2	6.9
Developed economies of the ESCAP region	363.2 (2700)	402.9 (2899)	496.8 (3455)	520.8 (3576)	543.6 (3719)	3.2	3.2	4.4
Developing economies of the ESCAP region[a]	674.9 (295)	894 (347)	1226.4 (431)	1416.2 (472)	1526.2 (502)	6.2	6.3	7.8
Central Asian & Turkey				209.60 (3276)	196.10 (3017)			6.4

Source: United Nations, Energy Statistics Yearbook, 1995

Note: The figures in parenthesis show the per capita energy consumption

[a] Excluding the Central Asian republic and Turkey

The consumption in the industrialised economies of the region during the period 1970-1990 increased by about 3.2 per cent a year, that of the developing economics increased at an average annual rate of 6.3 per cent.

Despite this impressive growth in developing economics, the current energy consumption level in developing economics remained quite low compared to the industrialised countries.

These developing countries require huge quantity of energy for the economic growth and development. Since energy is a scarce commodity, this will put extra pressure on satisfying the energy demand in these countries.

As far as the Renewable energy technologies (RETs) are concerned, the market share of new and renewable energy technologies has increased significantly in Asia since the early 1990s. The current status of the level of Renewable energy technologies (RETs) in selected Asian Countries is as given in the ***table no:1.3***

Table 1.3 Renewable energy technology in selected Asian countries as of December 2000: CEERD (Centre for Energy-environment Research & Development), 2001

Country	Solar thermal system (1000m^2	PV system (MWp)	Wind power plants (MW)	Small/ micro hydel plants (MW)	Power plants (MW)	Biogas plants (1000 units)	Improved cookstoves (1000units)
Bangladesh	0.15	-	-			1	82
China	5000	6.00	344	20,000	800	6800	180,000
India	476	50	1167	217	272.74	3000	32,000
Indonesia	-	5	0.5	54	178	-	-
Japan	57	3.6	75	-	-	-	-
Korea	-	0.48	-	5	-	-	-
Malaysia	-	2	0.15	24	200	-	-
Nepal	10	1.08	0.02	11.46	-	49.28	250
Pakistan	-	0.44	-	20	-	4.13	68
Philippines	-	0.52	0.06	70	-	-	-
Sri Lanka	-	-	3	6	-	4	-
Thailand	50	5	0.2	128	1230	10	500
Vietnam	-	0.47	0.1	95	-	3.08	-

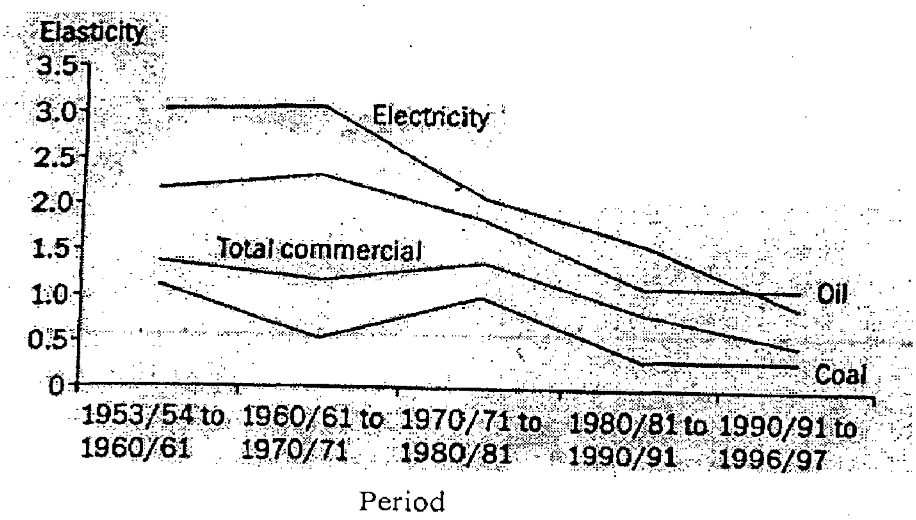
Source:Renewable ENERGY World. July-August 2001

1. 2.4 INDIAN ENERGY SCENARIO

In 1998/99, commercial energy consumption in India was estimated at 195.11 million tones of oil equivalent, indicating a 75 per cent growth over a decade. India's per capita consumption, however, continues to be much lower than the global average of about 1684 kilograms of oil equivalent and is 5-10 per cent that of developed economies like Japan, France and USA (World Bank 2000).

Energy-Economy Linkages

- The energy sector in India is closely linked to the developments in the economy as elsewhere in the world. Between 1970 and 1995, energy consumption and Gross Domestic Product were highly correlated (0.97).
- The energy-Gross domestic product elasticity has been falling in spite of economic development due to changes in technology and in demand patterns for various energy sources.



Source: Bhattacharya and Gupta (1998)

Fig 1.4 Elasticity of Final energy consumption with gross domestic product

- Energy intensity of India's GDP has begun to decline as well. Despite this, India is about thrice as energy intensive as the world on an average.

Energy Supply and consumption

India is the third largest producer of coal, with nearly seven per cent of the world's reserves. ***Table no:1.4*** gives the reserves and production scenario of the fossil fuel-coal, oil and natural gas.

Table 1.4 Fossil fuels scenario in India

	Coal (million tones)	*Oil (million tones)*	*Gas (billion cu. Meters)*	*Power*
Reserves	211 593.6	715	675	-
Production/ generation	292.27	32.72	27.43	451 billion units
Installed capacity	-	-	-	97837 MW

Source: TERI Energy Data Directory & Yearbook (2000-01)

India's commercial energy consumption is just one-fourth (195.11 Million tonne oil equivalent) of that of the world average (795.25 Million tonne oil equivalent). The consumption of commercial fuels is steadily rising throughout the Indian economy, with coal continuing to be the most prominent energy source.

➢ **Sector wise consumption of primary commercial energy**

The sectorwise consumption of primary energy is as shown in ***table no: 1.5*** ,the industrial sector being the major consumer of energy closely followed by the transport sector.

Table 1.5 Sectorwise energy consumption in India

S.No.	*Sector*	*Percentage*
1.	Household	12.10
2.	Agriculture	9.00
3.	Industries	41.9
4.	Transport	22.3
5.	Others	14.7

Source: Mid-term evaluation of 9th Five year plan, Planning Commission, 2001

- **Sectoral energy consumption by fuel**

Coal continues to meet over 70 per cent of industry's needs, but petroleum products and power are gradually replacing coal in small quantities. The use of power has gone up. The consumption of petroleum products has increased following a sevenfold increase in registered motor vehicles between 1981 and 1997.

The country faces 18 per cent peak power shortage and about 7 per cent average power. It is a fact that the power shortage continues to persist. To merely keep pace with the current shortages, India needs an additional capacity of 1,40,000 MW in the next 15 years, according to the 15th Electric power Survey.

- **Energy Imports**

The demand for energy in India has been rising and it continues to be a net importer of energy. India imported 39.81 MT (million tons) of oil and 17.38 MT (million tons) of petroleum products in 1998/99. Projection of crude imports indicates that import dependence, which is 66 per cent at present, will rise to 80 per cent by 2010 and a continued rise in the country's balance of payment.

- **Energy Security**

Our country is not blessed either with high quality fuel or with a wide range of energy choices, adversely affecting our energy sufficiency and energy security. Energy security is not limited to ensuring a smooth supply of energy in a manner that is least damaging to the environment and promotes sustainable development.

1.2.5 STATE ENERGY SCENARIO

- Power is one of the capital intensive and long gestation sectors, which requires huge amount of money either by private or by public sectors. The following organisations are engaged in power related programs in Uttar Pradesh. They are:

  a) U. P. State Electricity Board;

b) Jal Vidyut Nigam whose activities are confined to survey, investigation, and construction of small hydro projects between 3-15 MW only.

- The installed capacity of Uttar Pradesh including Uttaranchal stood at 6170.79 MW in 1998-99[3]. After the coming up of Uttaranchal state, the current power generation in the state stood at 2100 MW.
- Supply from the central sector is 2100 MW. Thus, the total supply to the state is around 4900 MW against a demand of 6200 MW during peak hours, energy gap being 1300 MW.
- During the day, rostering is being done for 762 MW and at night as the demand increase making the total shortfall to about 1300 MW.
- The state is currently facing huge quantity of power shortage resulting in losses to the economy, as there are strong economy-energy linkages. Most of the cities, towns and villages are facing power supply cut from 3 to 12 hr on daily basis.
- Average per capita consumption of energy is an accepted strong indicator for measuring the prosperity of the society. The per capita consumption in 1995-96 for Uttar Pradesh was 207 KWh against an All India average of 336 KWh. The more prosperous states account for per capita consumption as high as 760 KWh (Punjab) and 671 KWh (Gujarat)[3].
- In transport sector, there has been an increase in the total number of vehicles in all modes of transportation sectors posing an increasing demand of energy supply. The average fuel consumption has also increased as given in ***Table no:1.6***

Table 1.6 Number of vehicles & average fuel consumption, U.P.

	1984-85	1998-99	1999-2000
Registered vehicles	116,360	450,397	460,355
On-road vehicles	809,889	4,027,378	4,492,111
Average fuel consumption (km/litre)	4.15	4.60	4.69

Source: Statistical diary-2000, Uttar Pradesh

The consumption of petrol and petrol products in the transport sector account for 493 TMT (thousand metric tones), 1999.

- At present the total number of large and medium industries in Uttar Pradesh are 2281 while the number of I.E.M/LOI issued till 1998 is 3821. This low pace is mainly because of inadequate power availability, which is essential for industry and inadequate infrastructure facilities.
- A separate agency namely Non-Conventional Energy Development Agency (NEDA) under the department of Additional sources of energy, Government of Uttar Pradesh, also functions with the following objectives:
  - To promote renewable energy among various classes of users, as well as, planners, government officers and development organisation.
  - To evaluate the performance of various renewable energy devices and systems developed under field condition and make improvement in these systems/devices based on the feedback.
  - To provide various kinds of subsidies and other incentives.

A brief of various Renewable energy technologies (RETs) installed so far and the potential is as given in ***Table no:1.7***

Table 1.7 Status of RETs in Uttar Pradesh

Technology	Potential	Installed capacity
SOLAR BASED	20 MW/km^2	
Non-grid connected solar power plant		179 KW
Grid connected PV power plants		225 KW
Solar cookers		46,000 units
Solar lanterns		64,00 units
Solar home lighting systems		65,000 units
BIOMASS BASED		
Community biogas plants	-	70
Night soil based biogas plants	-	700
Bagasse based cogeneration	1000 MW	40 MW
HYDRO BASED		
Small hydropower development on canal falls	153 MW	-

Source: Report by Non-conventional energy development agency NEDA, 2001

1.2.6 CITY LEVEL ENERGY SCENARIO

About Lucknow city

Some of the problems related to energy supply and energy consumption in Lucknow city are as under:

- Frequent power supply cut for as long as 3-4 hours in day in the city brings huge losses to the economy, besides inconvenience and discomfort.
- Frequent fluctuations in supply voltage decreases the appliance efficiency, which is already very low.
- Increasing gap between energy demand and supply.
- Inconvenience in getting LPG cylinder for domestic consumption
- Increasing dependence on captive power generation using diesel, petrol, and kerosene due to the non-availability of uninterrupted power supply, thus increasing the energy cost, besides the huge amount of carbon emissions further aggravating the environmental degradation
- Tremendous increase in vehicle ownership powered by diesel or petrol, low efficient engines, and absence of an efficient public transportation system increases the consumption of secondary energy.
- High cases of power theft and meter tampering.
- The last decade has seen a tremendous increase in the rate of urbanisation not only in India but also around the globe. There is an increasing concern with regard to keep pace with the increasing energy demand in urban system as the latter is a great consumer of energy, due to its strong and dynamic interaction between urbanisation and energy consumption.
- The need to meet the energy crunch and to reduce the deterring environmental impacts of energy consumption need efforts not only at global, regional and national level but also at micro level (urban and rural system).
- Measures like demand side management, energy conservation, efficient transport policy, use of new and renewable energy sources and

technologies-all need to be integrated with urban and land use planning. The need of the hour at all levels is "preparation and effective implementation of scientific energy planning".

1.3 OBJECTIVES

The present study has the following objectives:

1. To assess the energy resources available in the system;
2. To assess the energy consumption pattern in the system;
3. To analyse the technology and techniques applied in energy consumption;
4. To forecast the demand and supply of energy for the year 2005 in the system;
5. To identify the feasibility of Municipal Solid Waste based energy plant;
6. To evolve a set of policy guidelines for optimal energy management in the system.

1.4 SCOPE

The present study aims at preparing a set of policy guidelines and making plausible recommendations so that the energy resource can be managed in Lucknow city in a rational manner.

1.5 CONCEPT

Urban system functions with energy interaction. In an urban system, almost all the subsystems, such as, household, industries, transport, trade and commerce, and other infrastructure services are consuming more quantity of energy rather than they produce. More quantity of energy is required to satisfy the requirement of human wants since energy is the basic element for any development, and development is a continuing process. The present investigation aims at to investigate energy consumption at various sub-systems level in the urban system and to evolve a feasible energy management system for Lucknow city.

1.6 RESEARCH DESIGN

Survey research methods have been employed in this present investigation.

1.6.1 DATA

Two sources of data, such as, secondary and primary are used in this present investigation. They are:

Secondary sources:

Both published and unpublished literature in this particular field from the concerned departments and organisations, research and educational institutions, journals, symposium proceedings and various energy related websites have been collected and reviewed.

Primary sources:

Primary survey has been conducted at the household level for obtaining the required data by using pretested relevant schedules and questionnaire.

1.6.2 SAMPLING TECHNIQUES

Random sampling technique has been employed for this present investigation to identify the sample respondent for data collection.

1.6.3 SURVEY TOOLS AND TECHNIQUES

Appropriate survey tools and techniques, such as, schedules and questionnaires have been employed in this present investigation.

1.6.4 ANALYTICAL TOOLS AND TECHNIQUES

Relevant statistical tools and techniques have been employed to analyse the data. Various software packages like MS Excel, MS -Word; and statistical techniques like correlation, regression, projection, trend analysis, etc. have been employed in the present study.

The methodology that has been adopted in this investigation is given in ***fig no: 1.5 & 1.6***.

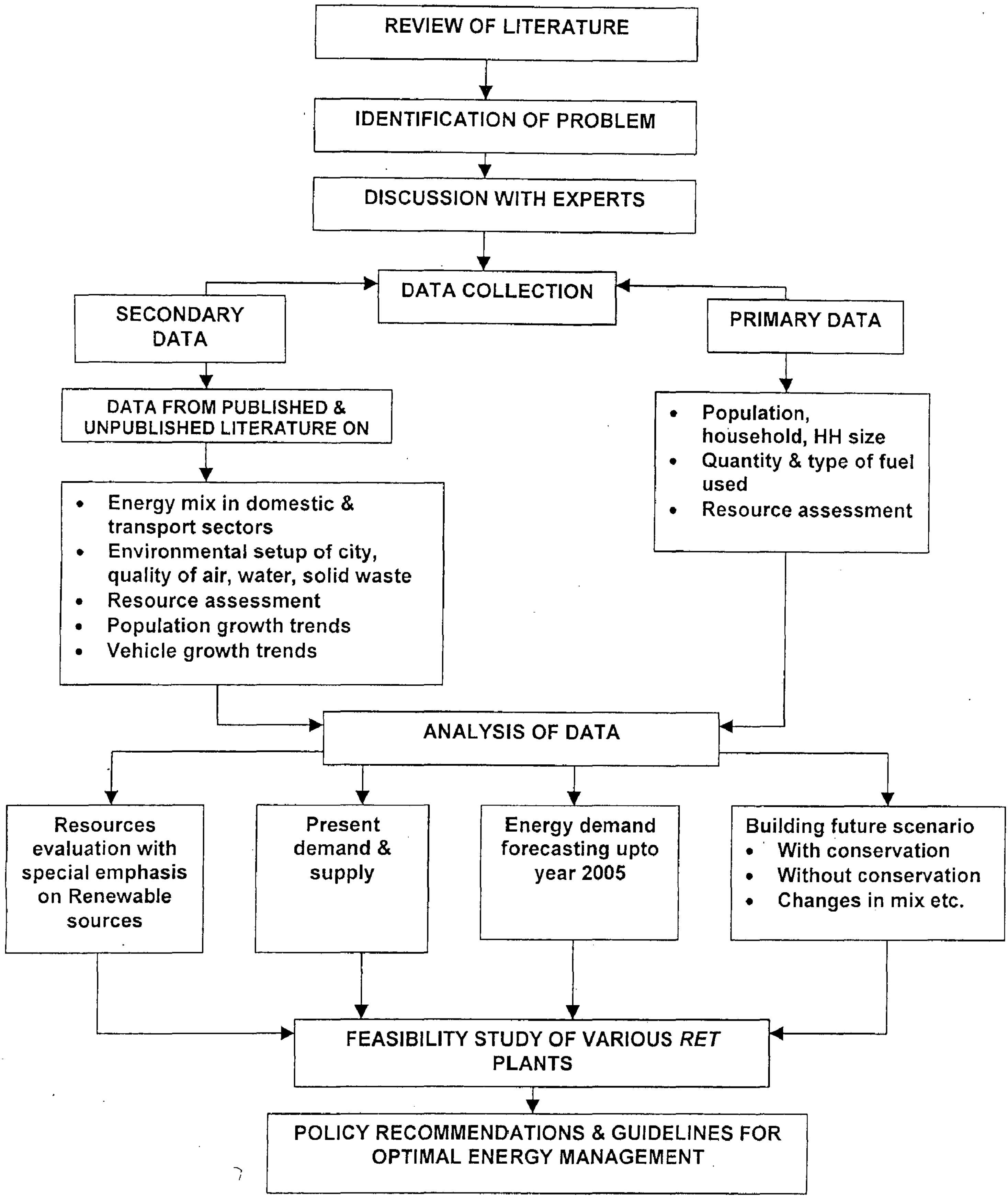


FIG 1.5 FLOW CHART SHOWING METHODOLOGY

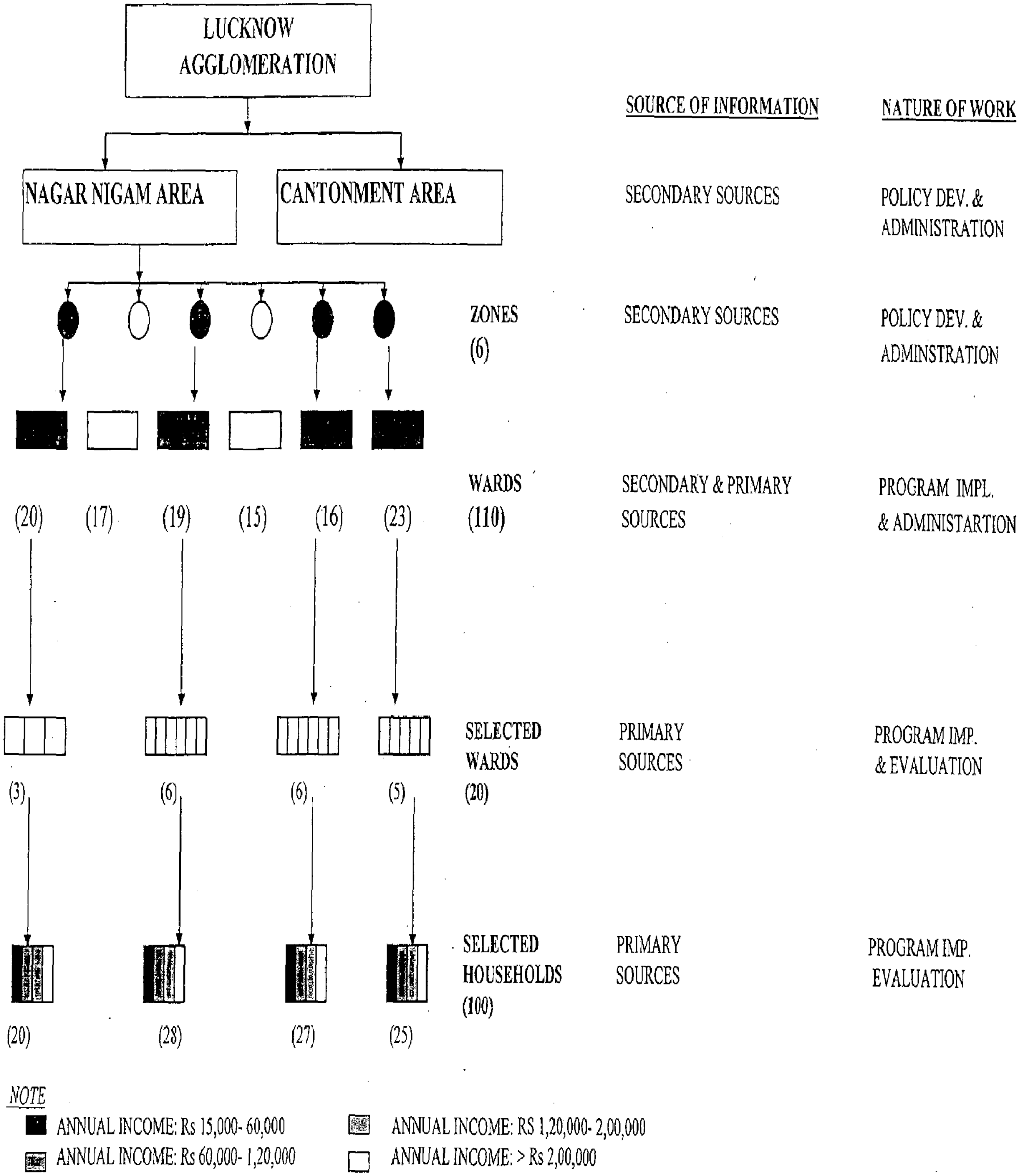


Fig.1.6 FLOWCHART SHOWING METHODOLOGY(2)

1.7 RESULTS AND DISCUSSIONS

Results and discussions are done, based on the outcome of the analytical work.

1.8 LIMITATIONS

The following limitations are envisaged:

1. On account of the resources (monetary and human) and time constraints, the study is limited to the Municipal Corporation area (Nagar nigam) of Lucknow city.
2. Exclusive study has been done only for domestic and transport sectors.
3. In the transport sector, the study is limited to arterial and sub-arterial streets only.
4. In the domestic sector, the economically weaker sections residing in slums have been excluded in this investigation.
5. Feasibility study could not be carried out for all the subsystems due to time and resource constraints.

Certain baseline assumptions have been made for calculation of energy consumption and emissions by various modes of transport, due to the unavailability of required data.

CHAPTER 2
LITERATURE REVIEW

Literature review is an important aspect of the study as it often provides the necessary information required on the latest issues and concerns, related to the problem in various contexts and background. It, thus, acts as a prop and helps in better understanding of the various aspects related to the investigation.

A number of publications, books, journals, technical papers, seminar proceedings, newsletter, unpublished project reports, Ph.D. Thesis, M.E. thesis, etc. have been studied in this regard. The whole study has been dealt with under three sections.

SECTION A

This section essentially deals with the various energy linkages, technological advancements in the field of energy, energy conservation measures and its significance. The discussion has been aggregated under various sub-heads :

2.1 ENERGY CONSUMPTION

Man's dependence on commercial/non-commercial energy is increasing day by day with increasing urbanization and population growth. The latest trend of consumption of all forms of commercial primary energy in the Asia –Pacific region and aggregate world trends indicate that regional primary energy consumption has been increasing at an average annual rate of 5.2 per cent over the last two decades; the world average growth rates were only 2.9 and 2.6 per cent during the same period. Whereas, the consumption in the industrialized economies of the region during 1970-1990 increased by about 3.2 per cent a year, that of the developing economies increased at an annual rate of 6.3 per cent. Despite this impressive growth in the developing economies, the per capita consumption is still very low as compared to the developed economies.

In India, Industrial sector consumes more than half of the total final commercial energy, followed by transport sector. The energy intensity in all the sectors is very high as compared to the developed economies. Energy consumption pattern in the residential sector varies widely not only among the rural and urban areas, but also across various income classes. The heterogeneity of the social fabric and disparity in lifestyles result in a wide range in the standards of living and ways of satisfying energy requirements.

Myriad factors like economic output and structure, technological progress, personal income, energy prices, lifestyles, and energy and environmental policies drive energy consumption. The links among the factors are complex, and any changes in these are dependent on the type of energy service, stage of economic development, existing infrastructure, political system, availability of energy resources, climate and geographic conditions, and culture [12, 21, 30].

2.2 ENERGY RESOURCE ASSESSMENT

India is the third largest producer of coal, with nearly seven per cent of the world's coal reserves. Non-coking coal makes up 86 per cent of the total reserves of 21159.3 Million tones (MT). Indian coal has generally low calorific value and high ash content.

In the oil and natural gas sector, despite a continuous decline in balance recoverable reserves, India continues to be one of the least explored regions with just 30 per cent of its estimated reserves so far. ***Table no: 2.1*** show the reserves of fossil fuels in the country.

Table 2.1 Fossil fuel reserve & production in the country

	Coal (Million tones)	*Oil (Million tonnes)*	*Gas (billion cubic meters)*
Reserves	211593.6[a]	715	675
Production/ Generation	292.27	32.72[b]	27.43

a Coal reserves upto depth of 1200 m

b Crude oil production only, petroleum products production 64.55 Mt.

Source: TEDDY (TERI Energy Data Directory & Yearbook), 2000-01

Besides these conventional energy sources, India has an abundance of renewable energy sources, e.g. the sun, wind, biomass, and hydro. ***Table no: 2.2*** give an estimate of the technical potential of the renewable energy by sourcewise and technologywise [30, 35].

Table 2.2 Renewable energy status in India

Source/System	Approximate potential	Current status
Biogas plants	12 million units	3 million units
Improved cookstoves	120 million units	32 million units
Small hydro power	1000 MW	1134 MW
Biomass energy	17, 000 MW	-
Bagasse cogeneration	-	235 Mwe
Gasifiers	-	35 Mwe
Solar energy	20 MW/km^2	-
Solar water heating	-	0.5 million m^2
Solar cookers	-	0.49 million
Solar photovoltaic	-	58 MWp
Wind energy	45,000 Mwe	-
Windelectric generators	-	1175 Mwe
Wind pumps	-	651
Waste to energy	1700 Mwe	15.12 Mwe

Source: Ministry of Non-conventional energy sources (MNES), Government of India,Year 2000

2.3 ENERGY AND ECONOMY

The intricate links between energy and the different sectors of the economy, is a well-accepted fact today. Modern industrialized or developing societies cannot function without the use of large quantities of inanimate energy. The aftershock of energy crisis of 1970s and 80s has given a strong impetus to this linkage. Infact, the history of economic development is to a very large degree the history of the increasing use and substitution of inanimate for human or animal energy.

The correlation between per capita energy use and real per capita income throughout the world is striking. On an aggregate basis, higher use implies higher income and vice versa. It is only at a much-disaggregated level that significant variation in this relationship become apparent.

An increase in energy costs results in adverse impact on the economies of practically all countries, except those of the oil exporters, in terms of reduced growth rates and output, employment and per capita income. The direct effects of energy crisis results in worsening of balance-of-payments, increase in the external debt burden and fall in real income. Investment and economic growth fall off following a major energy price increase, because of uncertainty in the market regarding costs, interest rates, and profits, and the complementarily between capital and energy in short run.

The strengthening interest in promoting energy efficiency, energy conservation, and demand management, the search for new technological advances and replacement of fossil-fuel based energy system by employing alternate renewable sources, policy measures and the huge investments in this direction by economies worldwide highlight this quintessential role of energy in the economic growth and development [7, 19, 21, 30, 33].

2.4 ENERGY AND ENVIRONMENT

Energy has strong socio-economic and environmental linkages. Most of the environmental problems that confront mankind today are connected to the use of energy in one way or another. There is a discernible human influence on global climate. Some of the most important energy-related areas of perceived risks or actual accidents are listed below:

- On-shore and off-shore blow-outs, explosions and fires due to the production, treatment, transport and use of oil and gas, such as fires at refineries, oil rigs, gas storage tanks, explosions of pipelines etc.;

- Maritime pollution due to oil tanker accidents, as well as soil and water pollution due to oil spills from rail and road tankers;
- Radioactive releases resulting from nuclear accidents in the course of the production of nuclear energy or the transport, treatment or storage of radioactive materials (fuel or waste);
- Hydroelectric dam failure causing flooding and landslides;
- Land subsidence and landslides due to mining activities as well as explosions in mines;
- Spontaneous combustion of stored coal or spoil dumps as well as explosions due to methane build-up in refuse dumps and coalmines.

Increasing water pollution, maritime pollution, air pollution, acid deposition, and stratospheric ozone depletion- all environmental concerns are directly or indirectly related to energy production, transportation and consumption, posing serious threat to ecological balance.

Some of the major indicators of environmental degradation related to energy in Indian context are:

- Between 1963 and 1991, toxic releases from industries grew sixfold, though industrial output grew only fourfold; industries with particularly worrisome air pollution levels include thermal power, sugar, paper and pulp, and distillery;
- While two and three wheelers contribute heavily to emissions of hydrocarbons and oxides of nitrogen, petrol-driven vehicles account for 85 per cent of total carbon monoxide emissions and diesel driven vehicles contribute over 90 per cent of emissions of oxides of nitrogen in metropolitan cities; the Central Pollution Control Board estimates that only 1.6 per cent of the total polluted water gets treated;
- Rapid increase in Municipal solid wastes (MSW) in most Indian cities; per capita waste generation increasing at the rate of 1.33 per cent. Mega metropolitan cities generate about 1500-5300 tonnes of municipal wastes

everyday, most of which is scattered as wastes heaps in cities or is transported to landfill sites, which are seldom managed in an environmentally acceptable manner.

Energy development and environment need to be integrated and not seen as adversaries to find a way towards sustainable energy development [10, 12, 30].

2.5 ENERGY AND TRANSPORTATION

Two salient features highlighting the modern civilization are the ever-growing process of urbanization and industrialization. Urban hubbubs are attractive magnets for the surrounding rural areas due to the presence of better employment opportunities, living standards, educational and health facilities. All the countries around the world are facing rapid urbanization. In India, around 31 per cent of the total population live in urban areas (1998-99). Increasing urbanization among other things bring with it an increased pressure on infrastructure. An efficient transport network becomes an inevitable necessity and one of the biggest challenges to the authorities for any urban area. Bigger the level of urbanization and economy, greater is this challenge. Transport does play a significant role in the overall development of a nation's economy. However, this sector also accounts for substantial and growing proportion of air pollution in cities. This sector is a major consumer of petroleum fuels. Almost half of the total consumption of petroleum products in India is attributed to the transport sector mostly in the form of gasoline and HSD (High-speed diesel) [33 million tonnes of oil equivalent in 1994/95].

Energy consumption in the transport sector increased at the rate of 3.1% per annum between 1970/71 and 1980/81. It grew even faster, at the rate of 4.9% per annum between 1980/81 and 1990/91, and at 4.5% per annum between 1990/91 and 1995/96. This emphasizes the strong linkage between energy and transport.

Transport demand can be classified under three broad categories depending on the lead distances, namely urban and suburban transport, regional and national transport, and international transport. The first two categories are more important with regard to energy consumption and environmental impacts. Transport services are provided through several modes, the more important ones being road, rail, shipping, waterways, and pipelines. The modes vary in terms of their infrastructure requirements, carrying capacity, capital and operating cost, energy consumption and environmental impacts.

Factors like absence of good transport system, railways failing to meet the increasing freight and passenger travel demand and increased mobility has led to increasing pressure on personalized transport (which is many times more energy intensive besides the extra environmental costs). Supply security, congestion and substantial air pollution in urban area calls for an urgent need to make the transport policy sustainable and energy-efficient. Various case studies taken in CEE/CIS (Central & eastern Europe countries/ Commonwealth of Independent countries) countries and metropolitan cities of India suggest this dire requirement.

Moving towards more energy intensive path put severe strains on the balance of payments, the rising net oil import bill and the decline in indigenous oil production, for a net importing country like India. Three mutually reinforcing policies need to be considered for reducing energy consumption and pollution from the transport sector. These include efficient transport system management, promotion of clean fuels and improved technologies, and improvement of the pricing structure with appropriate regulatory and enforcement mechanisms. The inter-modal mix needs to be determined on the basis of analysis of resource costs of main modes of transport and fuel pricing. The interventions should, however, be selective, enforceable and affordable.

There cannot be a single solution to the problem. The gravity and complexity of the problem calls for a rational mix of policy and appropriate measures or it might result in the mess created by the government in Delhi (public transport getting costlier and less available after the CNG crisis, the gains in pollution scenario being offset by the increase in privatized vehicles)

Since the contribution of transport sector in energy consumption is increasing rapidly throughout the globe and its environmental effects, a renewed interest is being given to this aspect but still, energy is not likely to become the major consideration in transportation policy [2, 8, 27, 31, 34].

2.6 ENERGY DEMAND ANALYSIS AND FORECASTING

A reasonable knowledge of present and past energy consumption and likely demands are essential requirements for energy planning. An accurate energy demand forecasts is required for following reasons:

- Timely and reasonable reliable availability of energy supplies is vital for functioning of a modern economy;
- Expansion of energy supply system usually requires many years; investments in such systems are highly capital intensive (on an average it accounts for some 30 per cent of gross investments in most countries)

Errors in demand projections lead to shortages of energy, which may have serious repercussions on economic growth, and development of a nation.

Demand forecasts can be made either on the basis of statistical evaluation and projections of past consumption or on the basis of specific micro studies. Some of the more popular methodologies employed in energy demand forecasts are:

1.Trend analysis

It is the most commonly used approach. BAU (Business-As-Usual) scenario is based on this only. It consists of the extrapolation of past growth trends assuming that there will be a little change in the growth pattern determinants of demand, such as, incomes, prices, consumer tastes etc., trends being usually estimated by a least square fit of past consumption data or by using some similar statistical methods [12, 21, 26].

2. Econometric multiple correlation forecasting

It is a more sophisticated technique. In this, past energy demand is first correlated with other variables, such as, prices and incomes, and then future energy demands are related to the predicted growth of these other variables. Time series data are required for doing the same [21].

3. Macroeconomic and input-output models

This is more applicable in the developed economies on account of availability of detailed and reliable sets of data. Basically, it connects a number of energy variables with various driving variables. However, lack of detailed data set restricts its usage [21].

4.Survey

Surveys potentially provide a direct and reliable tool of demand analysis and forecasting, and is quite popular at micro level studies or major energy consumers like medium-to large size industrial plants, large transportation companies, etc. due to the limitations of other forecasting methods [21].

2.7 ALTERNATE ENERGY SOURCES AND TECHNOLOGIES

Energy is an essential component for economic development and social progress of any nation. The economic and political security of developing countries greatly depends on their access to a secure supply of fossil fuel energy at reasonable costs. India, a developing economy with a large agricultural base and a growing industrial infrastructure is facing this energy crunch with increasing oil import bills along with increasing gap between energy supply and demand.

Undoubtedly, non-conventional/renewable energy technologies have a role to play in socio-economic development. It is necessary to use Renewable energy technologies RETs for two reasons:

- Inability of conventional systems to meet the growing energy demands in an equitable and sustainable manner; and
- Large scale adverse impacts of conventional energy production and consumption on the physical and human environment.

Renewable energy scenario in India

India is the only country in the world with an independent ministry, Ministry of Non-conventional Energy Sources (MNES) established in 1992, for the promotion of Renewable Energy technologies (RETs) in the energy economy of the country. The ministry was restructured in 1993 on the basis of end-use applications of technologies through the horizontal integration of various technologies, into following sectoral groups:

- Rural energy
- Urban/industrial energy
- Power generation

Besides, the extra impetus was provided with the formation of the Indian Renewable Energy Development (IREDA) as a financial arm of the MNES.

The key issues facing renewable energy technologies depend on their level of technological maturity and the kind of market that they face. Following presents a classification of technologies based on these two parameters:

1. Technically mature Renewable Energy Technologies (RET) systems

- Grid connected electricity generating technologies (wind, solar PV, and cogeneration)
- Stand-alone electricity generating technologies (wind, solar PV, and biomass based cogeneration systems); and
- Stand-alone thermal systems (solar water heating systems, solar cookers, cogeneration, and biogas)

2. New and emerging RET systems

- Grid-connected electricity generating technologies (solar thermal, geothermal, tidal, and Ocean thermal energy conversion (OTEC);
- Stand-alone (or decentralized grid-interactive) electricity generating technologies (hybrid systems, fuel cells, and biomass gasifiers based generation);and
- Stand-alone thermal systems (solar ponds and geo-thermal)

Some of the key issues in the sector are related to high initial cost of Renewable energy technologies (RETs), pricing of conventional energy, lack of indigenous R & D demonstration and product development, identification of niche markets, lack of public awareness, lack of requisite infrastructure, multiplicity of institutions with no integration, etc. [1, 2, 6, 13, 16, 17, 22, 24, 25, 27, 32, 35]

2.8 ECONOMICS OF DIFFERENT ENERGY TECHNOLOGIES

Along with the technological feasibility for the introduction and successful implementation of a new or alternate energy technology equally important is to find its economic and social feasibility. Requirements for techno-economic feasibility of different projects vary with site location, resource availability, income generated, payback period etc. on account of several economic constraints and the massive investments required [34].

Feasibility has been studied from various journals and project reports on bagasse based co-generation, municipal solid waste based power generation, small and micro-hydel power development on canal falls and irrigation canals, vegetable market solid waste based biogas production, etc.

2.9 ENERGY CONSERVATION AND DEMAND SIDE MANAGEMENT

Energy conservation in its most general sense is defined as the deliberate reduction in the use of energy below some level that would prevail otherwise. Usually, such reduction requires some tradeoffs in terms of comfort, convenience, or the use of additional capital or labour.

There are two aspects of conservation; one in which less energy is used with no sacrifice on the part of the individual questions of economy and technology. The second aspect of energy conservation involves some sacrifice on the part of the user [8, 31]. There is however, a limit beyond which conservation measures may become too costly in terms of foregoing other resources or useful outputs, thereby causing more harms than good.

Energy conservation is the demand of the time and a means to save the man's 'fuel-powered' ecosytem. Improvement in energy efficiency brings "win-win" solution, in that they bring environmental and economic benefits at the same time. It weakens the link between energy demand and economic growth, and delays the need for new capacity.

Different sectors need different sets of regulations to meet the desired objective [4, 7, 21]. In residential and commercial sectors, well known solutions are to improve pricing and billing of energy, use of efficient building materials, energy-efficient equipment and appliances, design buildings with passive or hybrid cooling, passive solar and day lighting design techniques, integrate buildings with local environment so as to optimize transportation, waste management and water management, etc. [4, 8, 9, 11, 15, 19, 20, 21, 23, 28, 31]. Similarly, practices like energy audit, general housekeeping and maintenance program, energy management and accounting systems, improved equipment and procedures for existing production methods, new and better production methods, waste hat recovery and cogeneration, recycling and recovery of waste materials etc. may be employed in the industrial sector.

Demand side management is a broad term often used in place of energy-efficiency and vice versa. It covers all means of influencing the magnitudes and patterns of energy consumption. Two types of tools namely hard and soft are used in this. The hard policy tools like physical controls technical methods and directed investments are more effective in the short run. While the soft policy tools including pricing, financial incentives, education and propaganda have a greater impact in the long run. Both the techniques need to be carefully coordinated [21]. SEBs (State Electricity Boards) can successfully use the approach in mitigating the current situation of power shortage as demonstrated in a case study done by the TERI, 1997 for Gujarat Electricity Board [15, 31].

Organizations like PCRA (Petroleum and Conservation Research Agency) need to be encouraged. It is involved in multi-media awareness and educational campaigns, networking with various R & D institutes, in the field of conservation of petroleum products. Energy Conservation Center (similar to those in Japan, China, Indonesia, etc.) need to be encouraged in our country as well to carry out the basic functions – educating public about the benefits of energy conservation, conducting energy audits, feasibility studies for large business, and training professionals such as engineers and plant managers whose work has a direct impact on energy use [8].

SECTION B

ENERGY MANAGEMENT IN INDIA AND ABROAD

2.10 ENERGY MANAGEMENT MEASURES ABROAD

1.Japan

Amongst the countries which had worked on this problem, it can be said that Japan has one of the most comprehensive set of regulatory measures for energy management. The objective of this policy is to reduce to the maximum extent possible, the growth of energy demand without affecting development. The law pertaining to the rationalization in the use of energy provides for several measures that assist energy management as pertinent to factories, building machinery and apparatus. Mixtures of technical and penal regulations are in force together with appropriate Japanese Industrial Standards (JIS).

The key roles are being played by several agencies, particularly the Energy Conservation Center (ECC) in the management of Japan's conservation program. It is also evident that the program is comprehensive which could serve as model case, and that can be introduced in India after having thorough investigation.

2.Denmark

The government of Denmark currently implements several energy efficiency programs. Initiatives targeting private consumers include energy conservation campaigns and various subsidy schemes. Labeling of electrical appliances is being introduced to encourage consumers to purchase low-energy appliances.

The Dutch Energy Agency administers a scheme launched in 1997 to energy-label all buildings so that buyers know the energy condition of a building when contemplating a purchase. Furthermore, systematic energy management has been introduced in most public institutions and energy consultants encourage trade and industry to save energy by means of energy auditing schemes.

Each year the Energy Agency draws up a framework for the Electricity Saving fund, which was established in 1997 and is administered by an independent Board. The objective of the Fund is to increase energy-saving efforts and make them more efficient.

3.United Kingdom

In the UK, the Department of Environment, Transport and the Regions is the government agency responsible for implementing energy efficiency programs.

- Standards of performance

The Office of Electricity Regulation (OFFER) recognized that utilities did not have incentives to pursue energy efficiency programs. OFFER elected to include £1 annual allowance per account for the period from 1994-98 in the supply price control mechanism for the franchise market. The funds so collected are used for DSM and low-income programs implemented by Regional Electricity companies (RECs) as a requirement to improve their "standards of performance" by achieving energy savings.

- Energy Saving Trust

As a means to stabilize its CO_2 emissions, the UK government formed a non-profit organization, the Energy Saving Trust (EST), to assist OFFER in overseeing DSM program design and activities implemented by the UK's 12 Regional Electricity Companies(RECs). The EST also established a network of Local energy Advice Centers (LEACs), which is currently managed by the

National Energy Foundation, an independent educational charity based in the UK.

4.Korea

During the nineteen eighties, Korean energy conservation policy was first implemented in many end-use sectors. For industry, the Korean Energy Management Corporation (KEMCO) was an important organization in implementing energy conservation policy through collecting energy data, providing technical education and information. The government activated financial policy instruments in all sectors to promote installation of energy-efficient equipment. Mandatory regulation was the main policy tool involving sectors, i.e.; government introduced obligatory insulation of new houses and submission of five-year conservation plans for energy-intensive industries in this period.

" Energy Efficiency Management System in Korea- Standards and Labeling", a program sponsored in 1992 by the government of Korea is one of the most successful programs implemented in the country. The program includes efficiency standards, efficiency labeling and rating labeling.

5.Canada

The industry leaders have devised a voluntary program for implementing energy conservation in Canada, through which industry commits itself to a program and seeks to promote off-the-job consciousness. The Federal Government provides assistance and support. Over 100 million dollars per year of federal funds are currently allocated for such ventures.

6.Philippines

Energy supply, efficient uses of fuels and environmental protection form the basis of the energy program in Philippines. The Bureau of Energy Development (BED) and The Bureau of Energy Utilization (BEU) regulate energy business, monitor supply and demand and conservation.

7.New Zealand

New Zealand has two notable energy efficiency programs: the Energy Saver fund and the Energy-wise Companies Campaign (EECA, 1999).

- Energy Saver fund

The Energy Efficiency and Conservation Authority (EECA) is the national organization responsible for energy efficiency issues under the Ministry of Energy. EECA has established a five-year $18 million pool of funds to be awarded as grants for residential energy efficiency programs. Projects are solicited periodically, and are required to meet the following criteria for approval: obtain large energy savings at low cost; develop effective methods to market and deliver efficiency after the funds are exhausted; target sectors where barriers are high; have high success potential; and involve activities that would not have occurred without the ESF.

- Energy efficiency in business

EECA initiated an Energy-wise Companies campaign, which includes over 700 companies. It supported energy management practices through training and publications. It also supported technology and behavioral change programs in commercial and industrial businesses. It is developing and reviewing 21 voluntary CO_2 agreements with major industries.

7.Indonesia

The Indonesian Govt. has adopted a 'General Policy' on energy to substitute oil with non-oil sources wherever possible. The conservation policy includes public campaign and dissemination of information, technical guidance to the needy and regulations relating energy as presidential promulgation.

8.Netherlands

Energy efficiency and conservation became a policy issue in the Netherlands after the first energy crisis in 1974. The current National Environmental Policy plan (NEPP) contains a quantitative goal of 3 per cent CO_2 emission reduction by the year 2000 compared with the 1990 level (174 million tones, Mt). The general policy approach to energy conservation emphasizes voluntary agreements with relevant groups in society. Groups that signed covenants with the Ministry of Economic affairs aiming at CO_2 emission reduction include several branches of industrial end-users and distribution utilities.

In 1990, the distributors issued an Environmental Action Plan (called MAP) as a result of an agreement with the ministry. It contained measures to be taken by the distribution companies that would result in 17 Mt of CO_2 emission reduction by the year 2000. The introduction of combined heat and power plants is expected to contribute to major emission reductions, augmented by a whole range of demand-side management measures to stimulate energy conservation by end-users. In addition, distributors agreed to the goal of supplying 3 per cent of total electricity demand in 2000 from renewable sources.

It was stipulated in the agreement that distributors could charge a so-called "MAP levy" of upto 2.5 per cent on the KWh price to end-users in order to finance these efficiency measures. Since 1996, an additional "Eco-tax" has been charged to end-users. Contrary to the MAP levy this is a regulatory levy not meant to generate funds for energy efficiency activities and is returned indirectly to energy users via compensatory tax measures.

It is difficult to conclude whether the MAP levy is a successful mechanism to stimulate demand management. Distributors claim that their environment action plans- and hence the levy- are successful, while others argue that the energy efficiency activities are mainly a continuation of actions carried out already before the plans and the levy were established.

9. Thailand

The energy policy of Thailand primarily focuses on the objective of reducing dependency upon energy imports by ways of developing sustainable energy supply and promoting energy efficiency. The former entails the implementation of demand-side-management (DSM) programs to promote more efficient use of energy by the end-users.

The Thai government has also created an energy conservation fund to support energy efficiency promotion. The National Energy Policy Office (NEPO) controls distribution of money from the fund. The Department of Energy Development and Promotion (DEDP) also contributes to the government's "top-down" approach by setting energy efficiency standards and codes for designated buildings, factories, equipment, and household appliances. The Electricity Generating Authority of Thailand (EGAT) follows up with a "bottom-up" approach by working directly with end-users by providing subsidies and incentives through its Demand-side-management (DSM) programs.

2.11 ENERGY MANAGEMENT MEASURES IN INDIA

India's energy demand, fueled by economic growth projected at 6 per cent per year or more, is one of the two fastest growing economies in the world. India's key energy policy goal in the next decade is to improve energy management. Success in this effort will buy time for expanding sources of supply, a task that requires both deft diplomacy and a more user-friendly business environment in India.

Management of electricity:

India's strategy for improving energy management focuses chiefly on the State electricity boards that supply power around the country. The electricity sector is by law entrusted chiefly to India's State Electricity Boards (SEBs), all of which have been in financial trouble. Indian government figures show SEB transmission and distribution losses at 23 per cent in 2000, but experts suspect losses are underreported. The World Bank estimates that in 1997-1998 commercial losses of the SEBs and state generating companies came to $3 billion.

India's 2001 budget highlighted power sector reforms, which center chiefly on restructuring the SEBs, eventually privatizing some parts of their operations; improving fee collection; and tackling the " third rail" of Indian politics, subsidies to consumers. Most states are exploring "unbundling" the state power corporations into more manageable and efficient units. Maharashtra's energy review committee has recommended splitting its SEB into separate, state-owned transmission, distribution, and generation companies. That move followed similar "corporatisation" of SEBs in Orissa, Andhra Pradesh, Uttar Pradesh, Haryana, and Karnataka.

Rajasthan, one of the poorest states, aims to install meters at all feeders by November of this year and to have 100 per cent metering by June 2002. Tamil Nadu has formed " anti-power theft squads", bringing many theft cases to court. An aggressive audit program in the city of Ahmedabad in Gujarat, recovered $3.12 million in 1999-2000 from power theft cases. Karnataka, known for its electronic industry, is installing 4 million electronic meters and decentralizing payment collection. Uttar Pradesh lags behind; one-third of its consumers are unmetered. Reform involves political risks. According to 1998-1999 budget estimates, India's power subsidies amounted to $4.2 billion. Analysts argue that farmers would willingly pay if power supply were more reliable. Even in the reform-oriented Andhra Pradesh and Tamil Nadu, however, political leaders are reluctant to take that chance. Those who steal electricity are often well-connected, making energy audits and elimination of theft difficult. The central government has offered incentives for SEB reform, but the process will be slow and uncertain.

Of lately, the Power Grid Corporation of India has given a 4 year, $33 million contract to GE Harris Energy Control Systems of Melbourne, Florida, to provide an **Energy management and Supervisory Control and Data Acquisition System** to improve the reliability and quality of electric power delivery in the Southern region of India. The company will supply and integrate its state-of-the art, Energy management systems in order to control over 18,000 megawatts of power generated by various power plants in the region. The system will enable Power grid to better control power frequency fluctuations and frequent power interruptions that currently plague the region and cause damage to industrial, office and home electronics.

Energy management services in India:

Estimates by the Indian ministry of Power estimate average national energy loss at 21 per cent and peak power shortage at more than 12 per cent. With these figures, one would have expected India to be the hotbed of energy management services (EMS) market. Even with the early 90s, the growth of the EMS market has been anything but impressive. The focus on capacity addition as a part of power sector reforms has clearly eclipsed the importance of energy efficiency and management. The opinion of policy planners and decision makers are currently skewed in favor of adopting centralized and costly power generation through ' Augmentation' only route and a cost-effective and eco-friendly 'Optimisation-Augmentation' options have been ignored.

International Energy Services Company (INTESCO) of U.S.A has been the first to enter the EMS market in India, through its joint venture with the Bhoruka group. Other players like Thermax-Energy Performance Services (TEPS), DCM-Shriram and Saha Sprague were quick to follow. Apart from TEPS, an equipment manufacture affiliated service provider, others are relatively small players in India's energy industry Enron, which had plans to enter into the contract energy management market, has put it on hold after the Dabhol controversy.

Industry associations like the Confederation of Indian Industries (CII) and Federation of Indian Chamber of Commerce & Industry (FICCI) have their own energy management cells that double up as ESCOs, albeit with a limited mandate of advising the member organisations on energy management. The onus of implementation lies with the organisations themselves.

The market is thus split between independent service providers, industry association affiliated consultants and energy management divisions of large industrial organisations, each addressing their own niche segments. Such fragmentation has not helped the development of industry standards. Lack of benchmarks has thus discouraged smaller end users from outsourcing energy management, for fear of not getting a fair deal.

Most of the ESCOs adopt performance-contracting route. The banking institutions and lending agencies are, however, not familiar with the structuring and financing of performance-based contracts. This, combined with the high interest rates, is a major impediment for financing and implementing energy conservation projects.

Energy Efficiency Bill:

In what is billed as a major effort in energy efficiency and conservation, the Government of India has tabled the Energy Efficiency Bill 2000, in the Parliament. This bill, the first of its kind in India, seeks to maximise the energy efficiency in the country through a systematic approach through:

- Provision for creation of a central Energy Conservation Fund(ECF),
- ECF to meet costs of implementing the bill and take responsibility for information dissemination on use of energy efficient systems and practices
- Provision for creation of a Bureau of Energy efficiency (BEE) to recommend energy standards, energy labels,
- Powers to the central government to establish energy standards for buildings , industrial processes and equipment, and
- Powers to state governments for amending energy standards for buildings in accordance with site conditions.

When ratified, this could act as a major driver for kick-starting the energy management services market.

2.12 THE LEGISLATIVE FRAMEWORK

India is a union of 29 states. Consequently, the legislative authority under article 246 of the constitution of India is split between the Union and States with concurrent jurisdiction of both over some subjects. The seventh schedule of the Constitution provides three lists. Recently, vide the 73rd and the 74th amendments in 1991, devolution of authority, in the selected subjects, including those related to energy, has been recommended from the states to the village level panchayats and urban Municipalities. However no state has so far given effect to such devolution to bodies of local self-government.

Of subjects reserved for the Union, the following relate to energy:

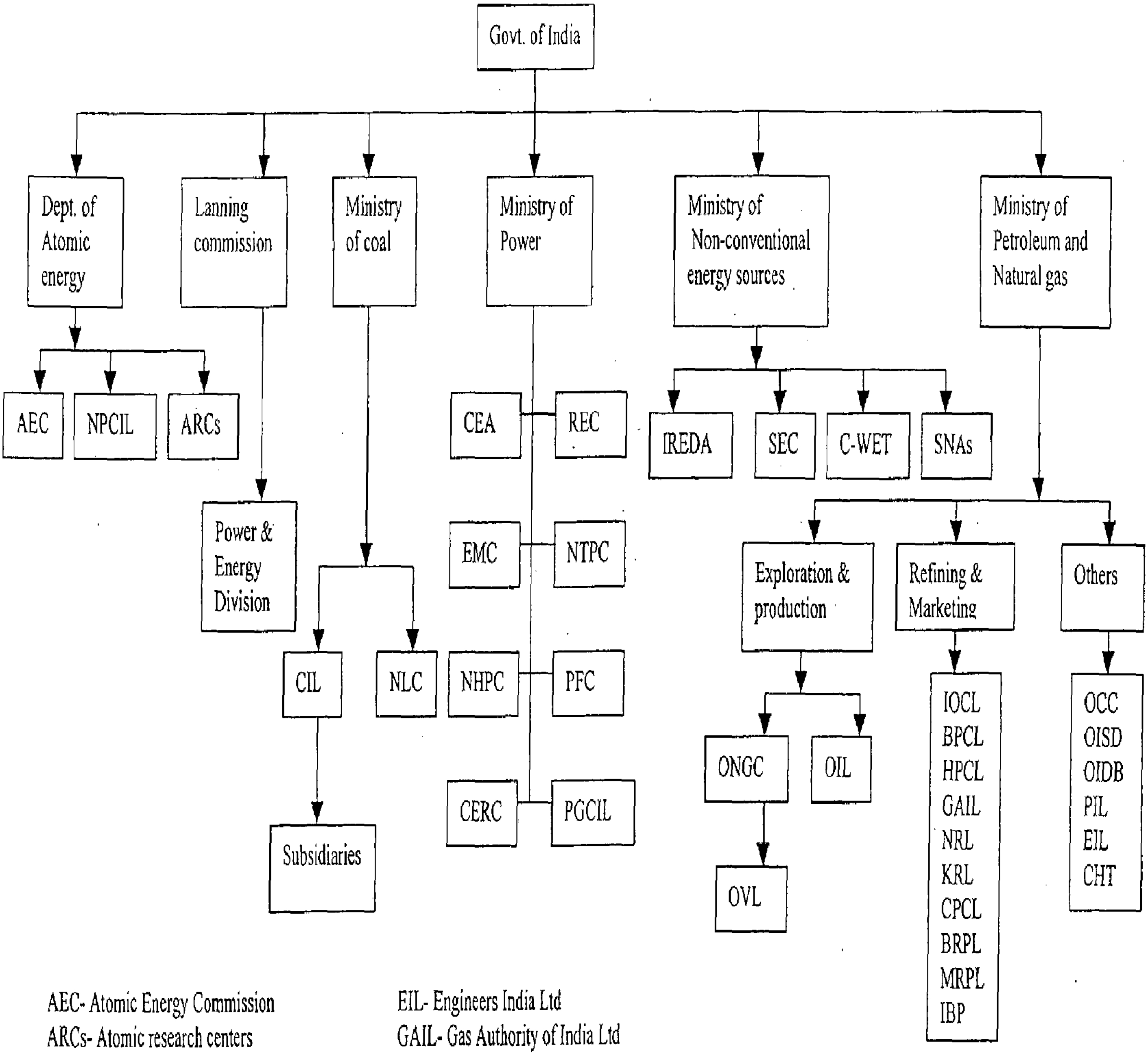
1. Atomic energy, and mineral resources necessary for its production.
2. Regulation and development of oil fields, mineral oil resources, and petroleum and petroleum products.
3. Regulation of mines and minerals development as declared by the Parliament.
4. Regulation of labor and safety in mines and oil fields.
5. Regulation and development of inter- state rivers.

The concurrent list mentions only one energy-related subject, i.e., electricity. This skewed distribution of legislative powers explains the dominant role of the Union Government in the energy sector. In general, the States have no role in regulation, promotion, or conservation of atomic, petroleum, or coal based energy sources, which continue to be the preserves of the Union Government. Their main involvement has been in the electricity sector and, more recently, in the promotion of new renewable forms of energy.

2.12.1 Energy related organization of the Union government

There are multitudes of ministries and organizations vested with disparate functions concerning energy development (***fig. no: 2.3***). The forums and the structure for coordinate action amongst all these separate centers are not well defined. Three forums for coordinated planning and thinking for energy development can, however, are identified.

1. Parliament and its committees.
2. The Union Cabinet and its committees.
3. The Power and Energy division of Planning Commission.



AEC- Atomic Energy Commission
ARCs- Atomic research centers
BPCl- Bharat Petroleum Corporation Ltd
BRPL- Bongaigaon Refinery & Petrochemicals Ltd
CEA- Central Electricity Authority
CERC- Central Electricity Regulatory Commission
CHT- Centre for High technology
CIL- Coal India Ltd
CPCL- Chennai Petrochemicals Corporation Ltd
C-WET- Centre for Wind Energy Technology
EMC- Energy Management Centre
NTPC- National Thermal Power Corporation
OIL- Oil India Ltd
EIL- Engineers India Ltd
GAIL- Gas Authority of India Ltd
HPCl- Hindustan Petroleum Co. Ltd
IOCl- Indian Oil Co. Ltd
IREDA- Indian renewable Energy development agency
IBPl- Indo-Burma petroleum company Ltd
KRL- Kochi Refineries Ltd
MRPl- Mangalore refinery & petrochemicals Ltd
NHPC- National Hydroelectric Power Corporation
NLC- Neyveli Lignite Corporation
NRL- Numaligarh refineries Ltd
OCC-Oil Coordination Committee
OIDB- Oil Industry Development Board
OVL- ONGC Videsh Ltd
PFC- Power Finance Corporation
PGCIL-Power Grid Corporation of India Ltd
PIL- Petroleum India International
REC- Rural Electrification Corporation
SEC- Solar Energy centre
SNAs- State nodal agencies
ONGC- Oil & Natural gas corporation
OISD- Oil Industry Safety Directorate

Fig. 2.3 Organisation of the Energy sector

Source: TEDDY,2000/2001

2.13 ENERGY MANAGEMENT AT CITY LEVEL

No efforts have yet been adopted for a holistic and integrated management of energy at city level. The measures so far taken are found to be piecemeal and taken for various subsystems of the urban system separately. Some noticeable measures taken so far are by agencies like Alliance to Save energy, Conserve (an NGO based in Delhi).

The Alliance to Save Energy in India

The Alliance to Save Energy began working in India in 1996 and has made remarkable progress within its first five years. With support from the United States Agency for International Development (USAID), Department of Energy (DOE), W. Alton Jones Foundation, the United States-Asia Environmental Partnership (US-AEP), Honeywell Foundation, and in-country non-governmental organizations (NGOs), the Alliance has helped to implement projects to address India's growing energy demand.

A significant portion of this work falls under USAID and USAEP's **Sustainable Cities Initiative (SCI)**, which uses innovative market- based solutions to address urban energy and environmental problems. To complement this work under SCI, the Alliance has created the **Council of Energy-Efficiency Companies of India (CEECI)**, a non-profit trade association that will promote the interests of India's emerging energy efficiency industry. The Council provides an avenue for the emerging energy efficiency industry to establish and promote its interests in policy, educational, media, and business circles throughout India. It also provides technical and policy guidance to the Ministry of Power and the State Electricity Boards.The Alliance is also implementing energy education programs and promoting efficient lighting in Indian schools.

Ahmedabad is the Alliance's first sustainable city in India. With few energy resources and electricity demand rising by 5-6 percent annually, the city's utility could not keep pace with demand. The Alliance provided technical assistance to Ahmedabad and reaped impressive results. Along with Hagler-Bailly Services Inc. and USAID, the Alliance worked closely with the city to build support for an energy management program at the local utility, hired a full time in-country coordinator to be a liaison, and introduced the concepts of lease financing and energy service companies.

As a result of these efforts, the city government has established an official energy management cell and agreed to increase staff and funding for this new institution. To date, Ahmedabad has reduced peak electricity demand by 11 per cent, saved over $300,000 in energy costs, and reduced carbon dioxide emissions (a primary greenhouse gas) by 4,650 tons.

In 1998, the SCI program expanded the program to two more cities—**Chennai** and **Pune**. The SCI team worked with the local utility and municipality to implement energy and environmental management initiatives. In Chennai, the SCI team is worked with the state utility, the Tamil Nadu Electricity Board (TNEB), to implement a demand side management (DSM) pilot project. In Pune, the alliance provided assistance in the development of an Energy management Cell and also creation of an energy monitoring and management system. Subsequently, the Alliance has extended its work to the city of Indore.

SECTION C

CASE STUDIES

In the absence of any model energy managed city in India, the case studies are chosen on various aspects of energy management and have been found useful in framing of a set of guidelines for an optimum energy management plan in Lucknow city.

2.14 ENERGY SUPPLY AND CONSUMPTION SCENARIO IN AHMEDABAD CITY

The case study chosen helps in understanding the methodology for assessing the existing energy scenario of a city for different sectors- Residential, commercial, transport, industrial and public sector, the city here being a capital city- Ahmedabad.

ENERGY SUPPLY PROFILE FOR THE CITY OF AHMEDABAD

➢ **Origin & growth of Ahmedabad**

Founded by Sultan Ahmed Shah in the year 1411 AD, the city has undergone various phases of development since. In order to give the city a good economic base, the setting done of the merchants, weavers & the craftsman were encouraged by the founder. The city entered an industrial phase after 1857 with the formation of a local body. Among the industries, the textiles have a strong hold, inspite of the steady decline of the industry over the years. It consumes approximately, 40 to 50 per cent of the major fuels consumed by the industrial sector.

The city area is 190.84 sq. km and a population of 28,76,710(1991 census). The density of the population is 15074 per sq. km. The population of the city is increasing rapidly and was 20.79 per cent from 1981 to 1991.

Spatially, the city can be divided into three zones,

a) The Western Zone- on the western bank of river Sabarmati,

b) The old city-the central Zone-the walled city areas and

c) The eastern Zone- i.e. excluding the old city.

Western zone is predominantly residential interlaid with commercial establishments and is the so-called rich Ahmedabad, characterized by higher income group settlement, broad road and no industries. The old city is the formerly founded city, characterized by low and middle income group settlement, high density, narrow roads congestion, high pollution and facing conversion of residential to commercial land use with specific industries.

Eastern Ahmedabad which now includes the industrial estates of Odhav, Narodav and Vatva is characterized typically as an industrial area, whereas other areas in the zone are a mix of residential, commercial, with the commercial basically on a supporting basis for the residential units and a mix of middle and low income groups.

➢ Present energy Profile-Supply side

Table No: 2.3 give the position of the total supply of various fuels across the major energy-consuming sector in the city of Ahmedabad for the year 1992-93.

➢ Sectors of energy consumption

RESIDENTIAL SECTOR

Households in Ahmedabad consume energy like electricity, kerosene, LPG, firewood, and charcoal. The non-commercial fuels like firewood, cowdung and charcoal are mostly consumed by the lower income group settlements, and there is shift from the noncommercial to the commercial energy as the income category goes up. Mostly the higher income groups consume LPG for cooking and even kerosene consumption in the higher settlement is extremely low.

In the residential category maximum utilization is of kerosene which accounts for 40.8% of the total energy for the sector; which is 69.44% of the total kerosene supplied to the city. Kerosene in the lower income groups is used at the rate of 6.0 lts per family per month. This is followed by LPG, which accounts for 40.3% for the sector & represent 98.7% of the total supply to the city. Electricity contributes 16.88% for the sector, which represent 18.2 % of

Table 2.3 Energy supply in Ahmedabad City, 1992-93

Source of fuel	Residential	Commercial	Industrial	Transport	Public amenities	Total	% of fuels
Electricity(M.Kwh	366.67	204.46	1339.52	0	103.02	2031.67	
In MTCR	256669	143122	937664	0	72114	1409569	27.90
Coal (M. tons)	0	0	579480	0	0	579480	
In MTCR	0	0	579480	0	0	579480	11.50
Kerosene(Klts	90000	36000	3600	0	0	129600	
In MTCR	628200	251282	25128	0	0	904616	18.00
LPG(M. tons)	60500	605	145.2	0	0	61250.2	
In MTCR	620125	6201	1488.3	0	0	627815	12.40
Petrol (Klts)	0	0	0	90000	0	90000	
In MTCR	0	0	0	691200	0	691200	13.70
Diesel (Klts)	0	0	2400	33600	0	38000	
In MTCR	0	0	21600	302400	0	324000	6.40
Lignite(M. tons)	0	0	360000	0	0	360000	
In MTCR	0	0	166320	0	0	166320	3.30
FO+LSHS(Klts)	0	0	36000	0	0	36000	
In MTCR	0	0	72000	0	0	72000	1.40
Other FO +Petro products (Klts)	0	0	74400	0	0	74400	
In MTCR	0	0	148800	0	0	148800	3.00
Firewood(M.tons)	26646	13323	4441	0	0	44410	
In MTCR	18852	9326	3109	0	0	31087	0.60
Cowdung(M.tons)	34075	0	0	0	0	34075	
In MTCR	10222	0	0	0	0	10222	0.20
Charcoal(M.tons)	2364	0	0	0	0	3940	
In MTCR	4255	0	0	0	0	7092	0.14
Animal Energy							
In MTCR	0	0	0	80850	0	80850	1.60
Total (MTCR)	1538123	409931	1955589	1074450	72114	5053051	100.00
SHARE OF SECTOR	30.44%	8.11%	38.70%	21.30%	1.45%	100.00%	

Source: Statistical Outline of Ahmedabad city, Ahmedabad Municipal Corporation, 1992-93

Note: FO- Fuel oils; MTCR- Metric ton coal reserves; Klts- Kilo liters the total units supplied to the city. The other fuels, firewood accounts for 1.2% of the supply for the sector followed by cowdung 0.33%.

Total amount of energy consumed in the residential sector is 15,38,123 MTCR, which accounts for 0.53 MTCR/CAPITA or 2.8 MTCR/HHs (by 1991 census)

COMMERCIAL SECTOR

The commercial sector is broadly divided as

a) Shops

b) Commercial establishment includes the business establishments, offices, wholesale, stockists etc.

c) Residential hotels & lodges

d) Residential, all eating joints without boarding and lodging

(As enumerated by the shops & Establishments department of the Municipal Corporation)

Total amount of energy consumed in the commercial sector is 409,931 MTCR, which account for 8.11% of the total energy consumed in the city.

61% of the energy comes from kerosene which represent 27.8% of the total kerosene supplies to the city, 35% from electricity which represent 10.15% of the total units of electricity consumed in the city and 2.3% from fire wood, assumed to be 30% of the total fire wood consumed/supplied in the city. Nowadays a shift has been observed in the consumption of firewood & charcoal to LPG & more of kerosene. LPG contributes 1.5% of the total energy for the sector, which is 1% of the total LPG supplied to the city. A small amount of charcoal is also consumed which are approximately 20% of the total consumed in the city. But yet has not yet been accounted for a suitable estimates are not available.

The total number of people employed in this sector is 3,91,230 (1991 Census) and hence MTCR/WORKER in this category accounts for 1.05 & MTCR/unit is 1.75.

INDUSTRIES

Industries consume energy from various fuel types and the amount consumed depends not only on the type of the industry and the product but the technology adopted and the size of the industry. Various other factors affect the consumption in the industries and hence it is difficult to determine the energy utilized per unit directly.

However, the energy consumption figures here, represents the approximate amount consumed by the industries in the city of Ahmedabad only.

Total energy consumed by the industries is 19,55,589.3 MTCR & accounts for the maximum energy consuming sector i.e. 38.7% of the total supplied energy to the city.

Textiles, the major energy consuming units amounting for 42.3% of the total energy consumed in the industrial sector.

TRANSPORT SECTOR

The total number of motor vehicles on road upto 31st Mar 1989 is as given below in ***table no: 2.4***

Table 2.4 Motor vehicles in Ahmedabad

S.No	*Type*	*1980*	*1988*	*1989*	*1990*	*1991*	*1992*
1.	2-wheeler	109360	133504	186310	225435	272776	330060
2.	Motorcars	26747	21900	27614	28481	29375	30298
3.	Taxi/cabs	572	636	753	849	958	1080
4.	Rickshaw	20917	20563	22515	24467	26588	28893
5.	Truck	5200	5222	5660	6098	6570	7078
6.	others	3006	4126	4111	4440	4795	5179
	Total	***165802***	***185951***	***246963***	***289770***	***341062***	***402588***

Source: Statistical Outline of Ahmedabad city 1999-89, Ahmedabad municipal corporation

In addition to the above there are about 612 AMTS buses, approximately 2200 GSRTC buses & 152 Ambulance & other vans plying on the roads.

Overall it is found that approximately 9% increase is there per year in total vehicles registered

AMTS: (1991-92)

Fleet of buses	732
Avg. buses on Routes	612
Daily avg. of bus kms	1,14,973
Daily avg. of Passengers	7,19399

A major bulk of travel is met by the intermediate transport i.e. the auto rickshaws, which also contribute a major portion of the pollution more recently due to the utilization of kerosene in the autos. According to the auto drivers nearly 20 to 30% of the autos fill petrol at the rate of only 1-2 liters of petrol and the rest is filled with kerosene. However they do not ply in the walled city due to strict traffic police control.

Among the private vehicles, two wheeler, are the maximum preferred by the majority of the middle income group households. Besides, it is easy to ply in the walled city area due to the maneuverability in the narrow and the congested areas. There are much more numbers of cars in the western zone due to the high and middle income group settlements.

A major source of energy for the transport also comes from the animal energy. Considering 2000 camel carts and 10,000 donkeys, the animal energy accounts to 80850 MTCR.

The transport sector consumes 10,74450 MTCR & thus represents 21.3% of the total energy supplied to the city. Out of the total 92.48% is contributed by the petroleum products i.e. by the petrol & diesel.

PUBLIC AMENITIES

Consumption by the Municipal Corporation for the services accounts for only 1.43% of the total energy consumed which is mainly in the form of electricity i.e. 103.02 M.KWh, mainly for street lighting, traffic signals, sewerage and water pumping and other amenities like power consumption in the hospitals, schools, swimming pools, theatres etc. run by the corporation. The vehicles run for the public services i.e. AMTS, fire brigade, ambulances and others are accounted for in the transport sector.

2.15 ENERGY AND TRANSPORT RELATION IN THE FOUR METROPOLITAN CITIES: DELHI, MUMBAI, CALCUTTA AND BANGALORE

The case study gives a comparative analysis of the two popular strategies adopted:

(1) Reducing urban congestion by strengthening public transportation system;

(2) Promoting efficient engines by phasing out two-stroke technologies and the effect on energy consumption and automotive emissions.

INTRODUCTION

In India, with the technology import liberalization policy of the Government, and the establishment of several international collaborations, the automobile policy in 1985 allowed the manufacturers to produce any type of vehicle, from passenger cars to heavy commercial vehicles. There was constraint on engine size or any attempt at obtaining an appropriate mix of vehicles from the view point of fuel efficiency, pollution, axle load, chassis configuration and with a view to minimize transportation costs.

The rapid increase in two-wheeler and private car population is making unregistered claims on valuable road space and of energy resources, particularly in urban areas. While on the one hand, the vehicle mix in urban areas has aggravated congestion and air pollution, on the other, specifically production of buses and their design for urban mass transportation has not received adequate attention in the national automobiles and are confined to the large size cities. Over two-third of the total registered fleet in large size cities comprises of two wheelers of which over 90% run on two-stroke engines, while the remaining are four-stroke. The advantages of 4-stroke engines in terms of energy consumption and emissions are enormous. Conversion of two-stroke can reduce HC emission considerably and attain higher fuel economy.

The study analyzes the extent to which the two most discussed policies:

(1) Gradual penetration of new and clean technologies of two-wheelers, and

(2) Strengthening of public transport system (to reduce urban traffic congestion) are expected to offset the growing demand of energy and emission by 2000-01 in the four cities-Delhi Calcutta, Bombay and Banglore.

Energy demand estimates and resultant emissions of five criteria pollutants viz., CO, HC, NO_x, SPM and SO_2 are estimated for different modes and their respective technologies. Results are obtained under three scenarios.

Scenario 1-the " business-as usual" (BAU)-assumes the different type of vehicles in each city will continue to grow as per their present trends without any policy interventions in during the five-year period (1995-2000).

Scenario 2 assumes strengthening of public transport system to reduce urban congestion.

While *scenario 3* assumes phasing out of two-stroke technologies and replaced with four-strokes, to promote clean and efficient engines.

Results of scenario 2 and 3 are compared separately with the BAU case to estimate the likelihood reduction/additions in energy demand and emissions.

SCENARIO CONSTRUCTION AND ASSUMPTIONS

Three scenario are considered to study the impact of different urban transport policy initiatives that would reduce total energy requirement and emission in the road based passenger transportation in the four cities-Delhi, Calcutta, Bombay and Bangalore. These scenarios are defined below:

Scenario 1: Business-as-usual

This scenario assumes that the present trends of growth in registration of vehicles in each of the four cities will continue, while the present fuel efficiency norms, occupancy level and vehicle utilization patterns for different modes will remain unchanged until 2001-01.

Scenario 2: Increasing the share of buses

It is assumed that, with incentives for greater investment in and use of bus, in each city a 20% shift in the estimated total passenger travel demand in 2000-01 will be towards use of bus with a corresponding decline in usage of personal vehicles like two wheelers (viz., scooter, motor-cycle and mopeds) and passenger cars and jeeps. With greater use of buses in scenario 2, congestion of traffic will decline and the overall efficiency of passenger movement will increase. More specifically, (1) total passenger travel demand in each city during 2000-01 would remain at the same level as obtained in the BAU scenario, (2) modal spilt-distribution of travel demand catered by different modes—for bus during 2000-01 in each city would increase by 20%. With this, the modal spilt for bus in Delhi would increase from about 61% in BAU to 73% in scenario 2. The corresponding increase in Calcutta would be from 67% to 80%, while in Bombay and Bangalore from 71% to 85%, and (3) contribution of travel demand by two-wheelers, three-wheelers and cars, jeeps and taxis together would decline in Delhi by 25%; 45%; 30%, Calcutta 25%: 40%: 35%, Bombay 25%:42%:33% and Bangalore 49%: 25%: 25% respectively.

Scenario 3: Phasing out of two-stroke engines

This scenario assumes that by 2000-01, in each city 45% of the total two-wheeler fleet (only scooters) which otherwise would have run on two-stroke engines will be phased out and would be replaced with four-stroke engines. In other words, scenario 3 envisages introduction of clean technologies in a phased manner to attain higher efficiency of energy utilization and consequent reduction in emission for certain pollutants.

RESULTS AND ANALYSIS UNDER BAU SCENARIO

Growth of motor vehicles

Table 2.5 gives growth in total number of registered vehicles, their composition and annual growth rates for each of the four cities. Delhi has the largest number of registered motorized vehicle in the country (2.34 million in 1995-96) which is more than the total number of vehicles in Calcutta, Bombay and Bangalore taken together (2.02 million).

Currently, Delhi and Bangalore is experiencing a higher annual growth rate (around 8%) of all vehicles together as compared to Calcutta and Bombay where the corresponding figures is nearly 7%. In terms of vehicular composition in 1995-96, share of bus with respect to the total registration of fleet is between 1 and 2% in the four cities, while the corresponding share of personal modes (two-wheelers, car and jeep) is between 80 and 90%. Delhi and Bangalore has relatively a higher share of two-wheelers (71% and 80% respectively) as compared to cars and jeeps (19% and 12% respectively), while in Bombay and Bangalore the corresponding share is 48% and 45% respectively for two-wheelers (71% and 80% respectively) as compared to cars and jeeps (19% and 12% respectively), while, in Bombay and Bangalore the corresponding share is 48% and 45% respectively for two wheelers, and 34% and 39% respectively for cars and jeeps. Share of three-wheeler and taxi is relatively higher (around 5% and 4% respectively) in Bombay and Calcutta as compared to Delhi and Bangalore (3.5% and 0.4% respectively). Nearly one-third of the total vehicles registered in 1995-96 in each city is likely to be added to the fleet stock by 200-01, without much of a deviation in the existing vehicular composition (table2.5).

Passenger travel demand and model split

Table no: 2.6 give the estimated travel demand and its distribution by various and their respective technologies for 1995-96 and 2000-01. In Delhi,

e 2.5 Growth of registered vehicles, its composition and projections in the BAU scenario

	Financial year (March-April)	Total vehicles registered (million)	Changes in vehicle composition (%)						Annual growth rate over the last five years (%)					
			2-wh	3-wh	car & jeep	taxi	bus	goods	2-wh	3-wh	car & jeep	taxi	bus	goods
i	1990-91	1.59	72.18	3.50	18.14	0.47	0.81	4.90	14.8	16.9	23.3	9.0	11.6	15.4
	1995-96	2.34	71.01	3.39	19.49	0.44	0.84	4.82	7.7	7.4	9.6	6.6	8.9	7.7
	2000-01	3.14	70.03	3.36	20.59	0.42	0.83	4.77	5.7	5.8	7.2	4.8	5.6	5.8
:utta	1990-91	0.39	46.58	4.55	35.00	3.61	2.28	7.98	12.9	41.8	10.8	13.3	26.6	7.7
	1995-96	0.55	47.93	5.25	33.53	3.61	2.26	7.42	7.5	10.0	5.9	6.8	6.7	5.3
	2000-01	0.71	48.39	5.83	32.92	3.65	2.30	6.91	5.5	7.6	4.9	5.6	5.7	3.8
ıbay	1990-91	0.52	43.80	6.68	37.71	4.89	1.05	5.88	10.5	2.0	11.1	5.6	9.6	7.3
	1995-96	0.71	44.55	5.31	38.99	4.54	1.01	5.59	6.9	1.8	7.3	5.0	5.9	5.5
	2000-01	0.90	44.92	4.56	39.75	4.31	1.01	5.46	5.0	1.7	5.2	3.7	4.7	4.3
galore	1990-91	0.52	80.26	3.15	12.08	0.34	0.90	3.27	17.4	14.4	13.9	12.6	11.3	12.9
	1995-96	0.76	79.44	3.81	11.66	0.30	0.81	3.99	7.7	12.1	7.1	5.2	5.5	12.3
	2000-01	1.01	79.56	3.85	11.46	0.29	0.75	4.10	6.0	6.2	5.6	4.8	4.6	6.5

Data on vehicles registered for the period 1984-85 to 1993-94 (excluding pre 1973-74 vehicles) are considered for the time trend Eq.(1) using reference no. 9

le 2.6 Passenger travel demand & its distribution by different modes & their technologies in the BAU scenario

	Financial year (March - April)	Distribution of travel demand catered by different types of technologies (%)										Total travel deman (bpkm)
		2-wheelers (gasoline)				3-wheeler (gasoline)	Car, jeep & taxi (gasoline)			Car, jeep & taxi (diesel)	Bus (diesel)	
		2-stroke			4-stroke		Pre-1984	Post-1984	Catalytic convertor			
		scooter	m-cycle	moped	m-cycle							
i	1995-96	12.13	1.82	0.46	0.76	7.55	0.78	12.95	0.31	1.56	61.67	81.07
	2000-01	12.04	1.05	0.45	1.51	7.53	0.83	5.78	7.44	2.48	60.89	108.00
utta	1995-96	2.75	2.75	0.40	0.81	6.39	2.02	11.95	0.40	5.87	66.65	28.94
	2000-01	2.54	2.80	0.40	0.93	6.99	1.57	3.34	8.85	5.90	66.68	38.13
bay	1995-96	2.18	2.77	0.66	0.99	6.84	3.30	7.93	0.33	4.96	70.04	35.67
	2000-01	2.02	2.96	0.54	1.21	5.94	3.01	1.17	7.53	5.02	70.58	44.58
jalore	1995-96	4.90	2.52	4.34	2.24	5.83	0.39	5.03	-	2.32	72.44	31.82
	2000-01	4.85	2.06	5.00	2.79	6.18	0.32	4.86	-	2.79	71.16	40.54

currently bus meets nearly 62% of the travel demand, which is expected, to decline marginally in 2000-01. Travel demand being met by bus in Calcutta and Bombay is around 67% and 70% respectively, which are likely to increase marginally during 2000-01. In Bangalore, almost 72% of the travel demand are catered by bus in 1995-96, which is expected to decline, though marginally.

In the case of two-wheelers, the travel demand to be catered by two-stroke engines (which are highly fuel inefficient due to incomplete combustion) will continue to be higher than that of four strokes. The three-wheeler autorickshaws is expected to meet between 6 and 8 per cent of the travel demand in the four cities.

Energy demand

Total energy demand and its contribution by various modes and technologies is estimated for 1995-96 and 2000-01 in each city (***Table no: 2.7***).

Total energy demand for passenger transportation in Delhi is highest relative to the other cities.

The introduction of new cars with catalytic converter in 1995 (which can run only with unleaded gasoline) only in the four metropolitan cities viz., Delhi, Calcutta, Bombay and Madras to reduce lead emissions, would result in a high growth in demand of unleaded gasoline over the next couple of years in these cities. (***Table no: 2.7***)

Emissions

Emission factors of the five criteria pollutants viz., CO, HC, NOx SPM and SO_2, with respect to the different range of technologies considered in our analysis have been compiled and presented in ***Table no: 2.8.***

Table no: 2.9 gives estimated daily emissions of these pollutants in the four cities during the last decade.

ıle 2.7 Energy demand & breakup of demand structure across different technologies & modes in the BAU scenario

	Financial year (March-April)	Total energy demand (thousand toe)			Share of demand by various technologies and mode (%)								Diesel	
					Gasoline									
		Gas.	Diesel	Total	2-wheelers				3-wh	Car, jeep & taxi			Car, jeep & taxi	Bus
					2-stroke			4-st.	2-st.	Pre-1984	Post-1984	Post-1994 catalytic conv.		
					scooter	m-cycle	moped	m-cy.	auto					
	1995-96	475	364	840	10.82	1.58	0.36	0.50	14.53	2.01	26.24	0.57	4.38	39.[illegible]
	2000-01	614	509	1123	10.70	0.91	0.36	1.00	14.43	2.12	11.66	13.53	6.92	38.[illegible]
ıtta	1995-96	147	191	338	2.18	2.11	0.28	0.48	10.91	4.78	22.17	0.68	15.09	41.[illegible]
	2000-01	186	252	437	2.04	2.19	0.29	0.56	12.15	3.79	6.32	15.11	15.46	42.[illegible]
ıay	1995-96	228	246	473	1.52	1.87	0.41	0.51	10.28	11.33	21.37	0.80	18.50	33.[illegible]
	2000-01	267	310	577	1.44	2.05	0.34	0.65	9.15	10.60	3.24	18.79	19.22	34.[illegible]
alore	1995-96	112	164	276	5.22	2.60	4.11	1.78	13.39	1.19	12.19	-	7.80	51.[illegible]
	2000-01	145	212	356	5.10	2.10	4.67	2.19	14.00	0.97	11.61	-	9.23	50.1

e 2.8 Emission factors & fuel consumption of different modes by type of technology under a typical driving cycle

of technology ıode	Average emission factors across different technologies (g/km)					Fuel cons. (km/l)	Type of technology and mode	Average emission factors across different technologies (g/km)					Fuel cons. (km/l)
	CO	HC	NO_x	SPM	SO_2			CO	HC	NO_x	SPM	SO_2	
ı984 car[a]	28.9	6.2	2.3	0.33	0.12	10.5	2-stroke scooter[a]	3.38	3.06	0.05	0.15	0.02	54.11
	(4.6)	(5.6)	(52.9)	-	-	(4.8)		(61.37)	(14.49)	(82.56)	-	-	(12.56)
984 car[a]	9.5	1.5	1.9	0.25	0.08	13.36	4-stroke motorcycle[a]	1.9	0.72	0.39	0.08	0.03	72.6
	(18.3)	(14.1)	(35.1)	-	-	(13.5)		-	-	-	-	-	-
994 car[b] lic conv.)	2.6	0.3	0.6	0.08	0.06	14.8	2-stroke moped[a]	4.5	3.2	0.07	0.08	0.02	60.81
	(33.7)	-	-	-	-	(9.3)		(36.6)	(24.0)	(53.4)	-	-	(12.4)
car[c]	1.1	0.28	0.99	2.0	0.39	11.0	3-wheeler auto[a]	9.0	7.5	0.26	0.3	0.02	21.38
	-	-	-	-	-	-		(58.3)	(14.8)	(21.1)	-	-	(14.7)
e cycle[a]	2.48	3.18	0.053	0.15	0.02	55.762	Diesel heavy duty vehicle[c]	12.7	2.1	21.0	3.0	1.5	3.5
	(40.13)	(19.57)	(111.31)	-	-	(8.91)		-	-	-	-	-	-

. [a]IIP. 1994. Vehicle emissions and control perspectives in India - a state of the art report. Engines Laboratory, Indian Institute of Petroleum, Dehradun. [b]Rao onal communications on June 24, 1996), Engineering Division, Research and Development, Maruti Udyog Limited, Gurgaon. [c]Biswas D. 1994. Vehicular ı: combating the smog and noise in cities. In *Hindu - Survey of the Environment*, p.43.
igure in parentheses are estimated coefficient of dispersions, expressed in percentage.

2.9 Total emissions and its contribution by various modes

Year	Total daily emissions (t/d)	Share of loading by different modes (%) Motor gasoline 2-wheelers 2-st.	4-st.	3-wh	Car, jeep & taxi	Diesel Bus	Total daily emissions (t/d)	Share of loading by different modes (%) Motor gasoline 2-wheelers 2-st.	4-st.	3-wh	Car, jeep & taxi	Diesel Bus	Total daily emissions (t/d)	Share of loading by different modes Motor gasoline or gasoline 2-wheelers 2-st.	4-st.	3-wh	Car, jeep & taxi	D B
	Carbon monoxide (CO)						Hydrocarbons (HC)						Nitrogen oxides (NO_x)					
90-91	230	19.97	0.76	23.17	42.89	13.22	116	38.04	0.58	41.93	15.13	4.32	68	1.33	0.53	2.16	22.47	73
95-96	314	21.24	0.67	24.20	39.05	14.84	164	39.70	0.50	42.61	12.47	4.72	104	1.27	0.43	2.04	21.87	74
00-01	364	23.26	1.53	27.79	30.55	16.88	205	39.73	1.05	45.27	8.98	4.96	129	1.30	0.91	2.18	16.73	78
90-91	98	7.36	0.38	14.57	63.04	14.65	35	19.95	0.41	37.44	35.41	6.79	32	0.42	0.24	1.22	24.93	73
95-96	108	8.57	0.74	21.34	50.90	18.45	44	21.80	0.70	47.80	22.25	7.46	44	0.41	0.38	1.46	22.83	74
00-01	115	10.21	1.06	28.74	37.24	22.75	55	22.30	0.85	55.04	13.93	7.86	53	0.43	0.48	1.73	15.92	81
90-91	168	5.49	0.34	16.47	67.65	10.05	60	14.20	0.37	42.52	38.23	4.68	43	0.40	0.28	1.79	32.36	65
95-96	175	6.26	0.69	17.32	62.87	12.86	64	17.52	0.73	43.26	32.70	5.80	56	0.38	0.46	1.51	30.70	66
00-01	172	7.71	1.07	19.13	55.60	16.48	68	20.34	1.05	44.23	27.50	6.88	63	0.41	0.62	1.45	23.13	74.
30-91	72	26.11	1.17	18.14	32.94	21.65	35	44.88	0.92	33.83	13.06	7.29	30	1.12	0.59	1.21	10.81	86.
35-96	90	26.55	2.71	25.71	22.37	22.60	50	42.06	1.89	42.41	6.89	6.75	39	1.10	1.30	1.63	10.35	85.
)0-01	116	27.12	3.33	26.78	20.88	21.80	65	41.33	2.29	43.61	6.34	6.43	49	1.14	1.64	1.75	10.44	85.

Year	Total	2-st.	4-st.	3-wh	Car, jeep & taxi	Bus	Total	2-st.	4-st.	3-wh	Car, jeep & taxi	Bus
	Total suspended particulate matter (SPM)						Sulphur dioxide (SO_2)					
10-91	14	15.00	0.51	13.84	20.91	49.74	5	5.92	0.57	2.80	17.62	73.09
5-96	23	13.96	0.40	12.62	24.26	48.76	8	5.59	0.44	2.57	19.16	72.24
0-01	30	12.95	0.78	12.43	26.30	47.55	10	5.17	0.86	2.52	21.18	70.25
0-91	8	4.02	0.20	6.79	46.00	42.98	3	1.73	0.23	1.40	32.22	64.43
5-96	11	4.22	0.32	8.01	43.81	43.64	4	1.76	0.36	1.66	30.26	65.96
0-01	14	4.25	0.38	9.09	40.95	45.33	5	1.74	0.42	1.85	28.84	67.15
0-91	10	3.56	0.24	10.24	46.58	39.37	3	1.67	0.28	2.16	35.59	60.30
5-96	15	3.43	0.34	7.52	53.53	35.18	5	1.56	0.41	1.67	39.67	56.69
0-01	18	3.59	0.44	6.88	51.77	37.32	6	1.56	0.51	1.47	38.60	57.86
0-91	6	10.11	0.60	8.14	19.96	61.19	2	4.54	0.59	1.47	12.75	80.64
5-96	9	9.90	1.21	10.07	22.88	55.93	3	4.44	1.27	1.93	14.39	77.97
-01	11	9.46	1.47	10.36	25.39	53.33	4	4.46	1.57	2.03	15.95	75.99

RESULTS AND ANALYSIS UNDER THE TWO STRATEGIES

Energy demand and emission are also estimated for 2000-01 under the two alternative scenarios 2 and 3 in each of the four cities. Results of each scenario are compared with the BAU scenario results discussed above.

Scenario 2

By facilitating a shift towards use of public buses, each city would save considerable oil in 2000-01 for passenger transportation. This would also lead into reduction in urban traffic congestion and emission of CO, HC and SPM. However, emission of NO_x and SO_2 would rise. A 20% increase in bus share in the total travel demand in 2000-01 would lead to about 15% saving of oil for passenger transportation in Delhi (170696 toe) and Calcutta (67298 toe), 17% in Bangalore (59452 toe) and 22% in Bombay (128671 toe). The other advantages that ensue are 22% reduction of total vehicles on Delhi roads, 39% in Calcutta, 41% in Bombay and 47% in Bangalore respectively. Emissions of CO and HC would decline considerably in each city. In Delhi, CO and HC emission would reduce by 35% and 45% respectively. While in Calcutta drop would be 46% and 62% Bombay 54% and 73% and in Bangalore 39% and 51% respectively. SPM emission would also decline in each city, with maximum drop in Bombay by about 18% and least in Calcutta by 8%. However, emission of NO_x and SO_2 would rise marginally in each city (with only exception being Bombay where SO_2 emission would fall by around 3%). Rise in emission of NO_x would lie in the range of 3% in Bombay and 10% in Bangalore. While that of SO_2 emissions would increase by around 5.5% in Delhi, Calcutta and Bangalore.

Scenario 3

Introduction of four-Stroke two-wheelers by phasing out 45% two-strokes scooters in 2000-01 under scenario 3 would lead to a marginal reduction in total demand in each city when compared with the BAU case. Though the reduction in gasoline demand by two-wheelers would be substantial. Similar trend is observed for emission reduction for CO, HC and SPM. In scenario 3, the total gasoline demand in Delhi would decline by around 1.2% (13364 toe). Total CO emissions in Delhi would decline by little less than 4%, Calcutta 2%, Bombay 1% and Bangalore 3% respectively. Similarly, emissions of total HC would reduce by 12% in Delhi, 6% in Calcutta, 5% in Bombay and 10% in Bangalore. Total SPM emissions would also drop in Delhi by 2%, Calcutta 0.7%, Bombay 0.6% and Bangalore nearly 2% emissions. Emissions of the other two pollutants-NO_x and SO_2 would increase in the former case, the range of increase would be 0.8% in Bombay to 2.7% in Delhi. While for SO_2 the rise would be in the range of 0.3% in Calcutta and Bombay to 1% in Delhi. High potential exists for stabilizing/reducing emissions of CO, HC and SPM with more buses on City roads. While, rate of decline in emissions is less when introduction of only clean technology as supply side intervention is considered. Thus, an increased reliance on demand management measures, complimented with supply intervention would help in improving the urban air quality

CONCLUSIONS

The study illustrates the effect on emission of two much discussed possibilities for improving economic efficiency while reducing energy demand and emission in the four major metropolises in India:-

(a) reducing urban congestion by facilitating a shift towards use of public transport, and
(b) introduction of clean technologies.

The physical benefits in terms of oil savings and reduction in emission have been quantified. Reduction in energy demand and emission is substantial with more buses on road as compared to the gradual introduction of improved engine technologies. This suggests that the **technological fix alone is not sufficient**

The current air quality strategy in developed economies is based primarily on a search for technological fix, which is a supply side option. However, in a rapidly growing developing economy like India, there are limitations to a strategy focused primarily on affecting automotive technology. With growing traffic congestion and inadequate investment in road development, demand management is critical and needs to be more vigorously used than at present, having usually failed due to: lack of public transport alternatives, lack of staff for design and enforcement; and political unwillingness to implement and enforce. It is desirable therefore, **to complement the supply side interventions with demand management measures, if the ultimate objective is to secure improved levels of air quality.**

2.16 SOLID WASTE TO ENERGY RECYCLING FACILITY—SWERF

The case study deals with a unique system called SWERF developed by Brightstar Environmental, Australia. It is a fully integrated and unique Municipal solid waste management system, providing dual solution to the problem of treating the ever increasing urban waste and producing electricity and farm yield manure as well.

Despite efforts to recycle with sources separation and collection of dry recyclable being fairly well developed of the household level, commercial centers and institutional areas, the quantity of municipal waste requiring disposal continues to increase and there is upto 94 per cent of material still being land filled in India. As pointed out by the Central Pollution Control Board (CPCB), most of the cities have acquired land for landfilling years ago, and now these sites are over-used. Acquisition of the new sites is a tough task for authorities.

There are also a number of environmental problems associated with land filling waste such as odor, wind blow litter, vermin, leachate (contaminated water and greenhouse gas emission).

There is an immediate need to find solution, which provide environmentally sustainable methods for processing of household and commercial/industrial waste.

The needs for this evolution are accentuated given the United Nations statistics showing that in 1995 India had an urban population which consisted of 26.8 per cent of the total population with an urban MSW generation of 0.46kg per capita per day. By comparison, it is estimated that by 2025, the urban population of India will have increased to 45.2 per cent of the total population with an urban MWS generation of 0.7 kg per capita per day. Based on an estimated population of 1.2 billion people in 2025, the urban MSW generation will be more than 300 million metric tonnes per annum.

Brightstar Environmental

Brightstar Environmental is a member of the Energy Developments Group of companies. Energy developments is an Australian company and is one of the world's leading renewable power producers with projects in Australia, North America, Europe, United kingdom and Asia.

In response to the needs for the solid waste management Brightstar Environmental has developed a Solid Waste Energy and Recycling Facility (SWERF) which is a fully integrated and unique Municipal Solid Waste (MSW) management system. SWERF was developed to maximize levels of recycling and resource recovery from either unsorted or source separated household and commercial/industrial waste and to minimize the amount of material being landfilled.

At SWERF, waste is handled and processed inside buildings rather than outside, thus giving greater control on odors. Minimizing the exposure of waste to the open air also assists in controlling wind blown litter and vermin. The conversion of waste into electricity reduces green house gas emission because of reductions in methane generation from landfill and the offset of the use of fossil fuels for electricity generation. It also recovers more resources than current recycling systems. Most importantly SWERF saves nature resources by utilizing an alternative fuel source. This reduces our reliance on fossil fuels such as coal, oil and natural gas.

The world's first SWERF is located in Wollongong, Australia. It has the potential to process upto 150,000 tonnes of MSW annually, which will produce enough electricity for approximately 24,000 households.

The technology

SWERF generates its own gas, known as syngas, directly from Municipal Solid Waste and eliminated the need to place waste in a landfill.

The SWERF process accepts daily deliveries of municipal and selected commercial/industrial wastes which are "cooked" in the first stage of the process before beings separated into an organic stream, recyclable, and an inert residual stream. The organic stream is dried using waste heat from the process and palletizes for storage and final drying. The dry pellets are then heated in a pressurized oxygen free process to around 950^0 C, where the basic elements in the waste material revert to a gaseous form (syngas). The gas is cooled and further processed to remove contaminants before being converted into electricity in a spark ignition generation set.

The SWERF process consists of three integrated components:

1. **Pre-processing of MSW**

Pre processing involves receival of the MSWs, sterilization with steam in an autoclave and mechanical separation. Steel aluminum and plastics are recovered for recycling and a pulp is produced from the organic material.

2. **Gasification**

The pulp is fed into a high temperature gasifier, which breaks down the solid pulp into gaseous compounds consisting mainly of carbon, hydrogen and oxygen. These elements are reformed into a clean, dry synthetic fuel gas (syngas). The gasification process operation in sealed pressurized units with a low volume of emissions and heats the waste in an oxygen free environment to produce a clean gas which is used to produce renewable electricity, during the gasification process, the solid waste is not burned as it is during incineration. Thus, it is an environmentally sound and superior alternative to waste combustion.

3. Electricity generation

The syngas is used to derive highly efficient internal combustion engines to produce renewable electricity, which is supplied to the local electricity distribution network for use in homes and businesses in the area. The combustion of clean syngas is very similar to the combustion of natural gas or LPG in that, as it is a clean gas it avoids the air emissions usually associated with combustion (incineration) of solid waste. In addition, as syngas is not a fossil fuel this reduces reliance on using non-renewable resources such as coal for the generation of electricity.

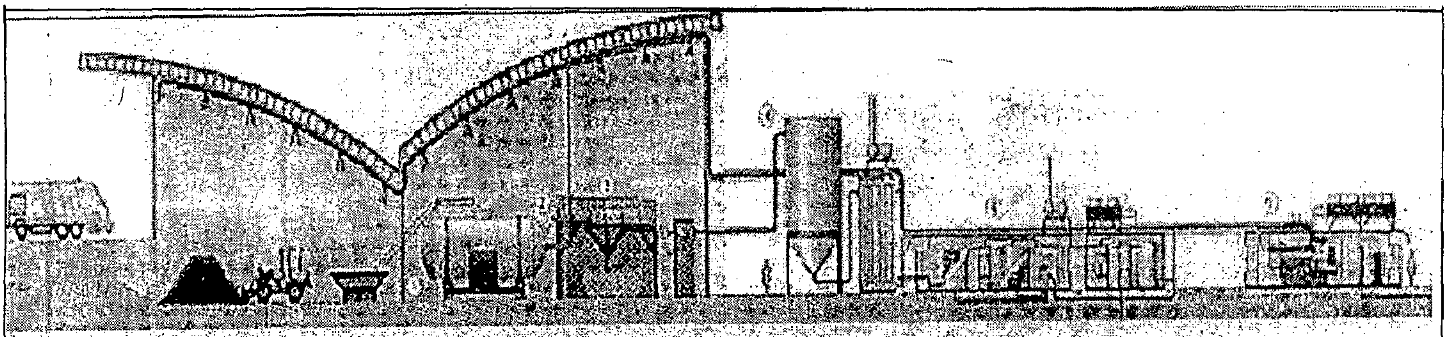
ADVANTAGES OF SWERF

- Substantial recovery and reuse of resources with 90% of household waste diverted from landfill thus, mitigating health and environmental effects of landfill.
- Adaptability to the local community as SWERF is able to be sized and adopted to meet the needs of the area in which it is located.
- Value adding operations to recycling such as metals, plastics and glass by extracting more recyclable from the waste stream and producing clean, de-labeled materials improving commercial viability.
- Low visual impact, designed to operate close to neighbors without causing nuisance through noise or odour.
- Environmental benefits of reducing greenhouse gas emissions associated with landfills and production of green electricity, which reduces the use of fossil fuels for electricity generation.
- Minimal emissions which comply with the most stringent regulatory requirements. The clean syngas is used to fire both the gasification process and power plant, with water and waste heat recovered and reused throughout the process.

CONCLUSION

SWERF can make a major contribution to rectifying the problem of MSW. This technology is "'world first' and has tremendous potential internationally to eliminate waste and reduce Greenhouse Gas (GHG) emissions. SWERF has the potential to reduce the level of MSW going to landfill by up to 90 percent. SWERF provides a benefit of 2.7 tonnes of avoided GHG emissions for every one tonne of waste processed.

SWERF can also play an integral role in rectifying the massive health and sanitation problem caused by MSW.



A view of the SWERF plant

(1) Waste Reception, (2) Autoclaving of waste, (3) Mechanical source separation of recyclables, (4) Organic pulp washing, drying and storage, (5) Gasification of organic pulp to create syngas, (6) Electricity generation from syngas

Fig. 2.4 A view of the SWERF plant

STUDY AREA PROFILE

3.1 GENERAL

Lucknow , the capital city of the state of Uttar Pradesh has been selected for the present investigation. It lies on the banks of the river Gomti that divides the city into two unequal halves, the southern half being larger than the northern.

It is believed that Lucknow derives its name from Lakshmana, the brother of *Lord Rama*. This theory is supported by the presence of a mound called *Lakshman Tila* which lies on the north-west border of the city. Another story attributes the name of the city to an architect called *Lakhna* who constructed a fort for the Sheikh rulers under whose reign the region was during the 15th century. However, the fort, which was known as *Lakhna Qila*, no longer exists.

Lucknow is in fact one of the few traditional Indian cities that has been home to the full glory of Mughal and British architecture in India. Associated with the lavish culture of the *nawabs*, this city is a capsule of styles depicting a distinct aesthetics of scale, proportion, and ornamentation. However, a visit to the city projects the stark callousness on the part of the city planners who have failed to guide urban growth and to preserve the precious heritage.

The urban fabric of the city is unique .On one hand is seen the *chowks* of the yesteryears as the centers of hub-hub, emanating a sensitive spirit of the bygone days. On the other side, are the new district nodes and growth centers that portray an utter lack of character or identity. The steps taken up the government to reinforce the crumbling infrastructure seems to be more concerned with only cosmetic treatments. To understand the present profile of the city, the discussion is done under the following headings:

3.2 PHYSICAL CHARACTERISTICS OF LUCKNOW

3.2.1 GEOGRAPHICAL LOCATION AND REGIONAL SETTING

The region lies in eastern Uttar Pradesh along the adjoining areas of Kanpur, Faizabad, Sitapur and Rae Bareilly (***map no:3.1***). The region is rich in agricultural produce, which forms the basic backbone of the economy. The industrial inputs come mainly from Kanpur, which during the time of the British was called the Manchester of the east.

The city lies in the center of the Indo-Gangetic plains on the bank of the river Gomti between 26.53 degree north latitude and 80.56 degree East longitude with an average height of 120 m above mean sea level (MSL).

3.2.2 PHYSICAL FEATURES

The city lies on the banks of river Gomti and is divided by it into two unequal halves. A large part of the city situated on the banks of the river is low lying.

3.2.3 CLIMATE

The climate is sub-tropical monsoon type. The change between summer and winter is quite abrupt. As a result the area do not experience long springs and autumns.

The mean monthly maximum temperature is around 40 degree centigrade while the minimum recorded is 1.7 degree centigrade. The city experiences an annual rainfall of 1016.5 mm. The wind moves along North-westerly direction or westerly direction in winters. During the summers, the winds move in the east.

3.2.4 LANDUSE PATTERN

The land use plan of Lucknow city as proposed in the master plan 1965 is as shown in ***map no: 3.2***.The Master plan-1965 was a verbatim translation of the untested planning theories being propagated at that time with a strong reflection of the Delhi model. The thrust being rigid zoning to achieve an

ordered land use pattern. The approach was to keep the existing city as the hub and expand in all directions amorphously without any considerations for the urban dynamics, form and socio-economic aspirations of the society.
The land use pattern is as shown in the ***table no: 3.1***

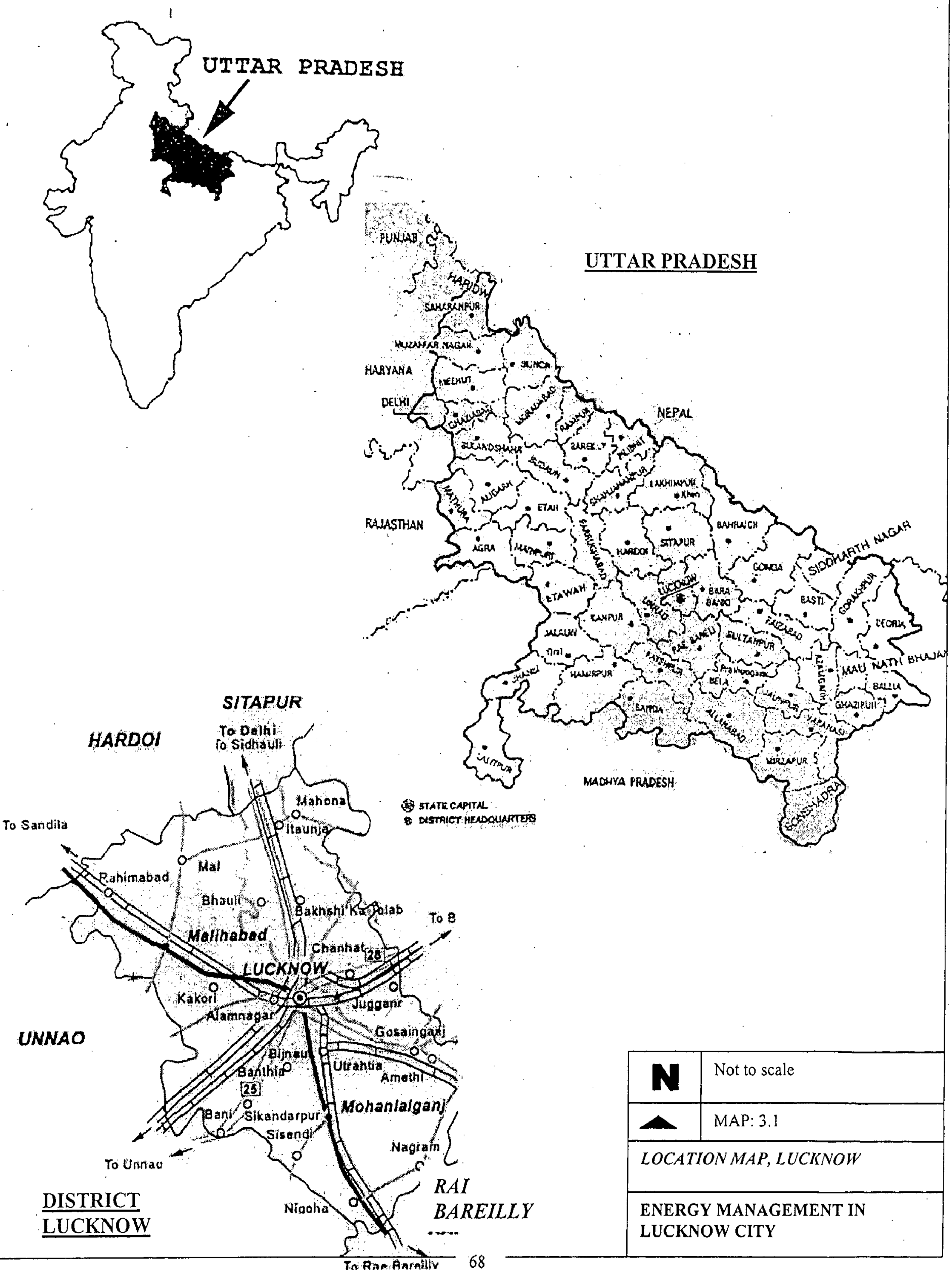
Table 3.1 Landuse pattern

Land use	*Before Master plan 1965(%)*	*Proposed in Master plan 1965-95(%)*	*Existing In 1987(%)*	*Proposed in master plan 2001(%)*
Residential	19.36	52.22	48.91	67.20
Commercial	01.27	03.80	02.43	04.10
Official	03.30	02.59	05.20	01.70
Industrial	02.16	08.71	06.50	03.10
Facilities	07.63	06.11	09.83	06.50
Recreational	02.62	09.97	03.78	07.90
Transportation	08.91	12.95	10.38	09.50
Open spaces	20.14	00.65	12.97	-
Agriculture	34.61	-	-	-

Source: Revised master plan, Lucknow, 2001, Town & Country Planning Department

3.3 TRENDS OF GROWTH

River Gomti formed the backdrop to the major activities during the hey-day of the Nawabi rule .The initial growth of the city started from the west in an area known as Chowk and gradually spread south and south eastwards. It was only in the early part of the nineteenth century that the city started to grow towards the east with major colonial inputs in terms of the cantonment by the British in the post 1857 mutiny period and the railway station to the south.

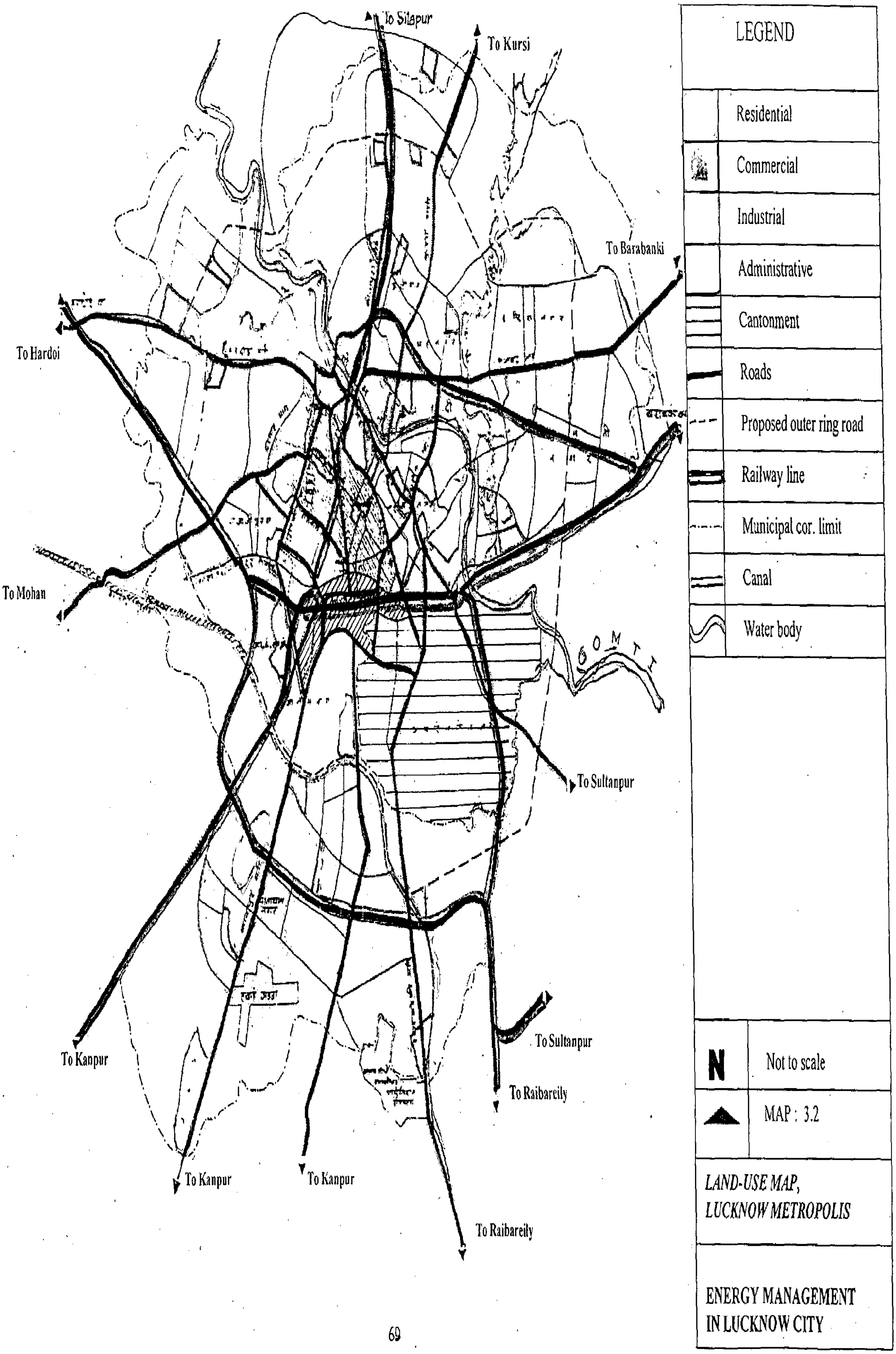


N — Not to scale

MAP: 3.1

LOCATION MAP, LUCKNOW

ENERGY MANAGEMENT IN LUCKNOW CITY



To Sitapur
To Kursi
To Barabanki
To Hardoi
To Mohan
GOMTI
To Sultanpur
To Kanpur
To Sultanpur
To Raibareily
To Kanpur
To Kanpur
To Raibareily
LEGEND
Residential
Commercial
Industrial
Administrative
Cantonment
Roads
Proposed outer ring road
Railway line
Municipal cor. limit
Canal
Water body
N
Not to scale
MAP : 3.2
LAND-USE MAP,
LUCKNOW METROPOLIS
ENERGY MANAGEMENT
IN LUCKNOW CITY

During the post-independence and post-partition period, a large migration population settled in the southern part of the city along the Kanpur road. The sixties and seventies saw the easterly growth of the city and the eighties saw the development of the southeasterly part of the city.

3.4 DEMOGRAPHIC PATTERN

The growth trends of Lucknow have been phenomenal, especially in the last decade or so. In the decade 1981-91, a growth rate of 65.66 per cent was registered, whereas in the preceding two decades the growth rate had been 22.36 per cent and 24.13 per cent respectively. In the current decade, the trend is no different and a growth rate of over 60 per cent has been found.

3.4.1 Area and population

The Urban agglomeration has an area of 337.5 sq. km out of which the area under the Municipal Corporation limits is 310.1 sq km while the rest 27.4 sq km comes under the Cantonment (***map no:3.3***). The population of the area under city limits is 23 lacs as per 2000 census. The city shows an amorphous multi-nodal urban configuration.

Three types of density pattern are seen in the 110 municipal wards.

- High density / saturated wards with over 600 persons per hectare density in the central core areas of the city.
- The periphery wards show low to medium density between 100 to 350 persons per hectare.

3.4.2 Sex ratio

The female to male ratio is 860 females per 1000 males, which is close to states ratio.

3.4.3 Literacy

The overall literacy rate is 60.4 per cent higher than the state average of 57.36 per cent while the female literacy is 53 per cent against the state average of only 42.98 per cent (as per census 2001)

3.4.4 Employment scenario

The employment scenario in various sectors is as shown in ***Table no:3.2***

Table 3.2 Employment scenario in Lucknow city

S.No.	Employment sector	No. of persons
1.	Manufacturing, processing, servicing & repairs in other than household industries	60,721
2.	Construction	22,441
3.	Trade & commerce	104,950
4.	Transport, storage & communications	35,311
5.	Other services	183,136
6	Marginal workers	3,012
7.	Non-workers	1,268,185
	Total	1,677,756

Source: Census Abstract,1991

3.5 ECONOMIC BASE

As per Lucknow Master Plan 2001, Lucknow urban agglomeration has failed to attract appreciable quantity of industrial units. Consequently, work force in industrial area continues to be negligible. Hence as State capital, it continues to be the administrative center commanding and influencing a vast region. It is an important educational and commercial center of the State, and fast assuming the function of an important trade and commercial centre.

3.6 SOCIO-ECONOMIC BASE

The old city of Lucknow largely on the south of river Gomti is highly dense, having a very traditional cultural background and a mixed economic profile whereas the new developments have taken place on the periphery of the old city in post independence period where the people have relatively better economic condition.

Slum and low-income communities

30 per cent of the city population lives in slums or in low-income settlements. These households have inadequate housing and infrastructure facilities. The access to urban services in these settlements is extremely limited.

Scheduled Caste

The population of scheduled caste in the city is about 10 per cent, which is relatively low as compared to the scheduled caste population of the state which, is about 21 per cent.

3.7 INFRASTRUCTURE FACILITIES

For a balanced and sustainable growth, an optimum balance between need to be made between the growing population and the available infrastructure facilities. The infrastructure facilities can be grouped under two heads as follows:

A PHYSICAL INFRASTRUCTURE

3.7.1 Water supply

Piped water supply network exists in most of old Lucknow area but low-income settlements depend on water supply stand posts and hand pumps.

3.7.2 Electricity

The city is well fed by the northern grid. Most of the electricity is supplied to the city by the Sarojini nagar substation besides the other three sub-stations.

3.7.3 Sewerage and drainage

The sewerage network extends to large part of eastern CIS Gomti area however, 44,000 service latrines/nalli discharge latrines exist in the city mainly in the low and middle-income settlements. Open defaction is common in certain parts of the city. Large part of old Lucknow has either open pucca or covered drains. The drainage services are most deficient in areas inhabited by low-income population. In the newly developed peripheral areas, majority of the households has piped water supply and sewerage facility. The low-income settlements and slum pockets in the peripheral areas also depend on community facilities having a problem of open defaction and lack of basic amenities.

B SOCIAL INFRASTRUCTURE

3.7.4 Health and education

The city is full of educational institutes and hospitals, though the distribution is not even.There are 715 educational institutions and some 75 health centres and hospitals.

3.8 TRADE AND COMMERCE CENTRES

Old: Hazratganj, Aminabad, Chowk, Kaiserbagh, Alambagh

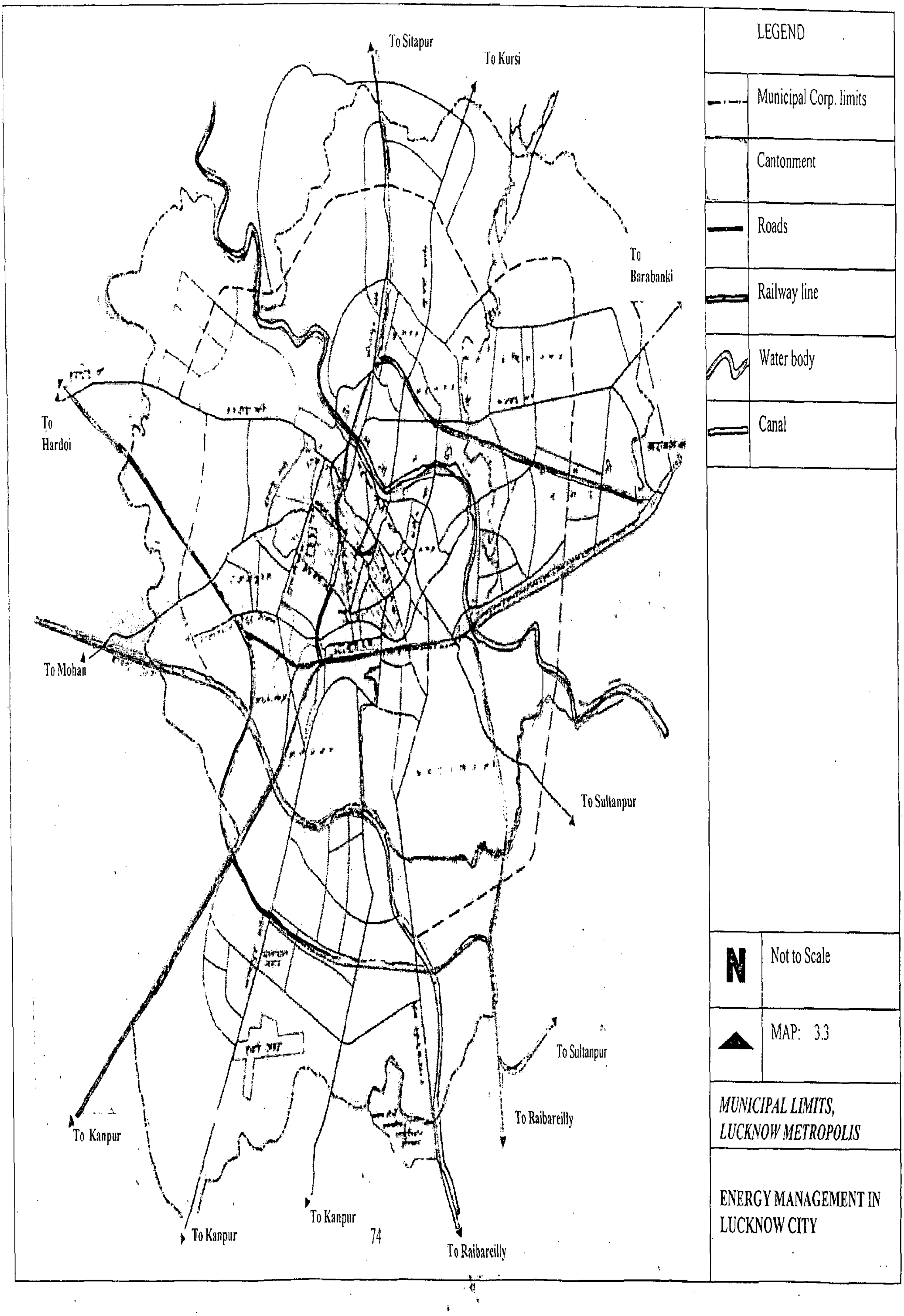
Recent: Kapoorthala complex, Bhootnath market

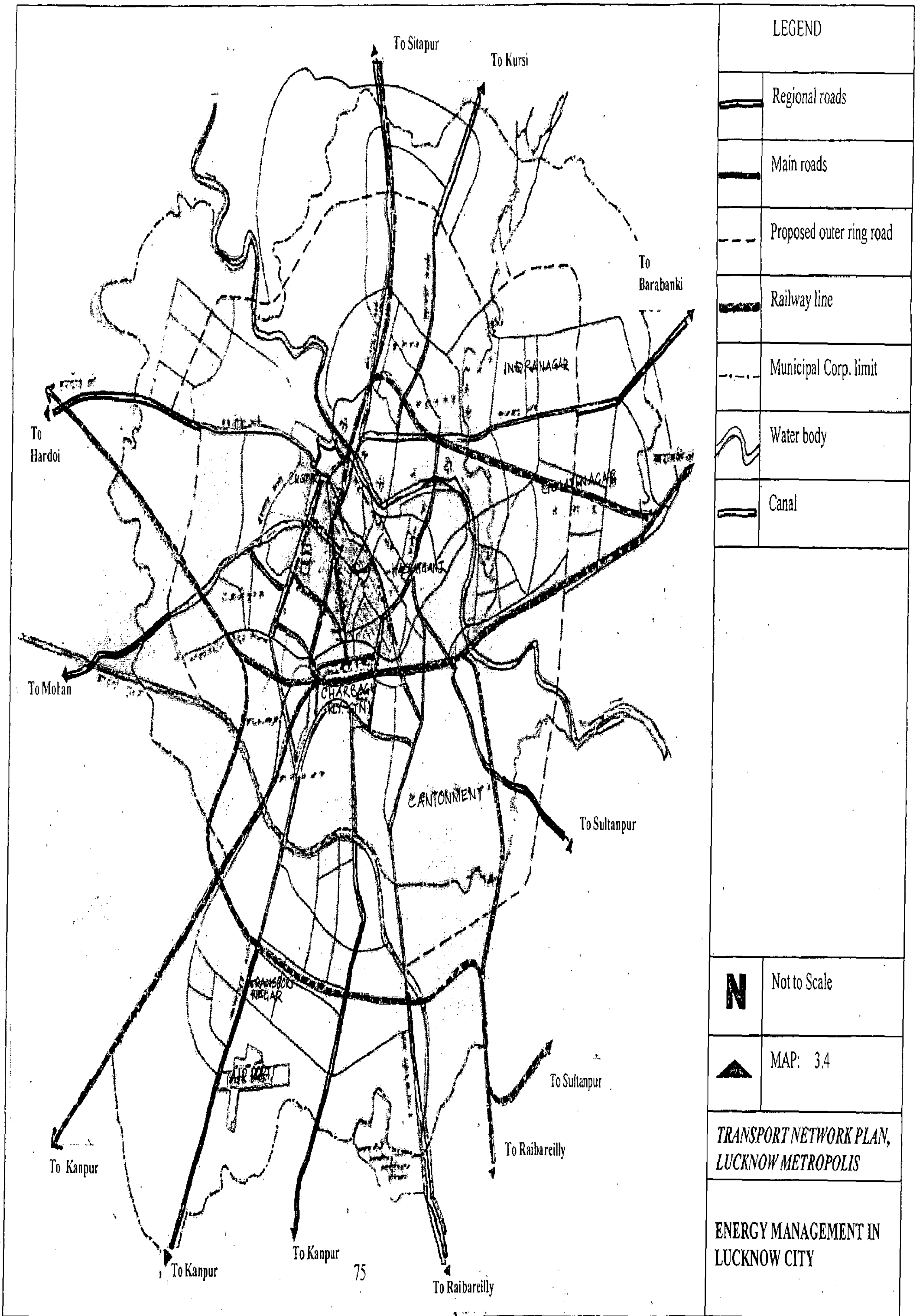
New coming: Gomtinagar, Ashiana colony, Janakipuram, Vikasnagar

Up

3.9 TRAFFIC AND TRANSPORTATION

Lucknow is well connected to all the major places in the country as well as state by rail, air, road due to which there is a continuous flow of passengers and travelers throughout the year. The city is served by three national highways (NH-25, NH- 28, NH- 56) and five provincial highways and a good number of local highways. Lucknow is an important railway station of Northern and North-Eastern railways as well. There is also a domestic airport at Amausi. The transport network plan is as shown in ***map no: 3.4***.


LEGEND
Municipal Corp. limits
Cantonment
Roads
Railway line
Water body
Canal
Not to Scale
MAP: 3.3
MUNICIPAL LIMITS, LUCKNOW METROPOLIS
ENERGY MANAGEMENT IN LUCKNOW CITY
To Sitapur
To Kursi
To Barabanki
To Hardoi
To Mohan
To Sultanpur
To Sultanpur
To Raibareilly
To Raibareilly
To Kanpur
To Kanpur
To Kanpur


To Sitapur
To Kursi
To Barabanki
To Hardoi
To Mohan
To Sultanpur
To Sultanpur
To Raibareilly
To Raibareilly
To Kanpur
To Kanpur
To Kanpur
INDRANAGAR
CHARBAGH RLY. STN.
CANTONMENT
AIR PORT
LEGEND
Regional roads
Main roads
Proposed outer ring road
Railway line
Municipal Corp. limit
Water body
Canal
N
Not to Scale
MAP: 3.4
TRANSPORT NETWORK PLAN, LUCKNOW METROPOLIS
ENERGY MANAGEMENT IN LUCKNOW CITY

ASSESSING THE AVAILABLE ENERGY RESOURCES

Urban system is comprised of many sub-systems, such as, domestic, transport, commercial and industrial. Each sub-system is dependent on a variety of energy sources and a continuous supply of the required energy is a necessity to make the system function. A misbalance occurs when this steady supply is not able to meet the demand. In order to have a clearer picture of this demand and supply lies the need to assess the available energy sources, which is required for the function of all the sub-systems.

Different types of energy have been used at different levels in order to satisfy energy requirement. The types of energy use also changes in accordance with the usage, technology adoption at the end user level, availability of energy resources at the end users level, tariff rate of energy, etc. Energy use at the local level are classified into fuelwood, charcoal, coal, petroleum products, and electricity. These types of energy are transported and distributed by various agencies (Central government agencies, State government agencies, private contractors, etc.) for using the same in domestic, commercial, industrial and transport sectors.

It is observed that fuelwood and charcoal are distributed by private contractors. These are mostly used by the poor people. The market system for the same is highly unorganized for these biofuels. Hence, assessing the supply for the same in the system becomes a great difficulty. Petroleum products constitute motor-oil, diesel, kerosene, LPG, etc. These are controlled by the Central government organizations and the market is rather organized, hence making the assessment of the total supply to any urban system is easier. As far as electricity is concerned, it is supplied by the respective State Electricity Boards to the end-users through grid. However, a lot of theft is reported on account of absence of meters on feeder lines and meter tampering. This makes the assessment of electricity supplied to the system rather difficult. It is, thus, clear that there are various constraints in assessing the exact availability of energy sources in any system.

With this background, the assessment of available energy sources has been done for Lucknow city. Owing to the great difficulties in getting data for bio-fuels (firewood, chips, charcoal, etc.) and kerosene consumption, they have not been considered for assessment in this present investigation.

4.1 PRESENT ENERGY RESOURCES

This is one of the most important parts in this present investigation, since it assesses the present energy resources that are in use. This helps to understand the nature and type of energy use in the city, and the energy resources that are in demand and used more frequently. ***Table no: 4.1*** show the power development in Uttar Pradesh.

The various types of conventional energy resources in the city, considered for assessment are:

1) Electricity
2) Petrol
3) Diesel
4) LPG

Table 4.1 Power Development in Uttar Pradesh

S no.	*Item*	*Unit*	*2000-01*
1	Installed capacity	MW	2800
2	Supply from central sector	MW	2100
3.	Plant load factor	Percent	48.6
4.	T & D losses	Percent	26
5.	Power requirement	MW	6200
6.	Peak hr power surplus (+)/ deficit (-)	MW	-1300
7.	Domestic	Percent	17.3
8.	Agriculture	Percent	28.4
9.	Industry	Percent	42.0
10.	Commercial	Percent	5.8
11.	Others	Percent	4.3
12.	Per capita consumption		252
13.	Profit / loss of state electricity board	Rs./ million	-546.8

Source: Annual report, State Electricity Board

4.2 AVAILABILITY OF RESOURCES

4.2.1 Electricity

The authority responsible for supplying electricity to the city is Uttar Pradesh State Electricity Board (UPSEB). The city receives its supply from the Singrauli thermal power plant of the Northern grid.

The requirement of electricity in the city is not as high as the neighboring Kanpur city as the city lacks a sound industrial base as compared to the latter.

As far as sectorwise consumption of electricity is concerned, the Domestic and Commercial sectors are the main consumers of electricity followed by the industrial sector.

The yearwise electricity consumption in the city is as shown in **Table no: 4.2**

Table 4.2 Electricity consumption (MU) pattern in Lucknow city

S.No.	*Sector*	*1995-96*	*1998-99*	*1999-00*	*2000-01*
1.	Commercial	110	179	198	235
2.	Domestic	326	685	802	899
3.	Small/Medium ind.	33	46	66	49
4.	Large & heavy ind.	56	117	128	113
5.	Public tubewells	45	106	66	101
6.	Street light	17	40	29	41
7.	Jal Sansthan	15	60	60	63
8.	State tubewells& pump canals	13	15	15	15
9.	World Bank tubewell	5	4	4	4
	Total	***620***	***1252***	***1368***	***1520***

Source: LESA (Lucknow Electricity Supply Authority), Lucknow

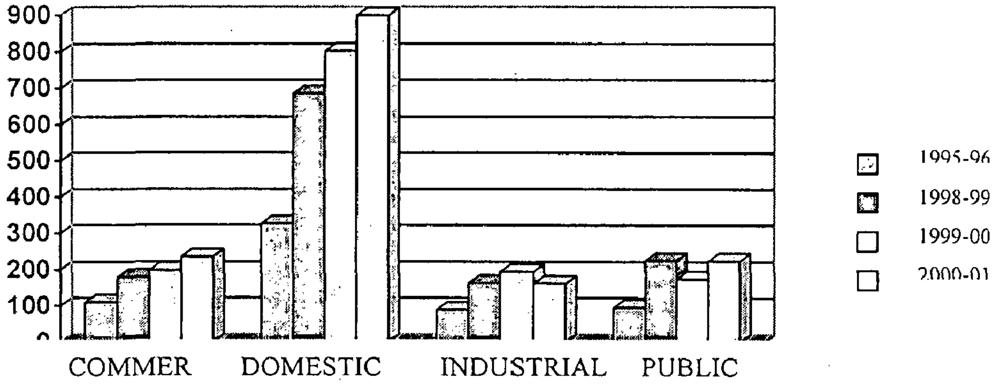


Fig.4.1Graph showing electricity consumption pattern for different years

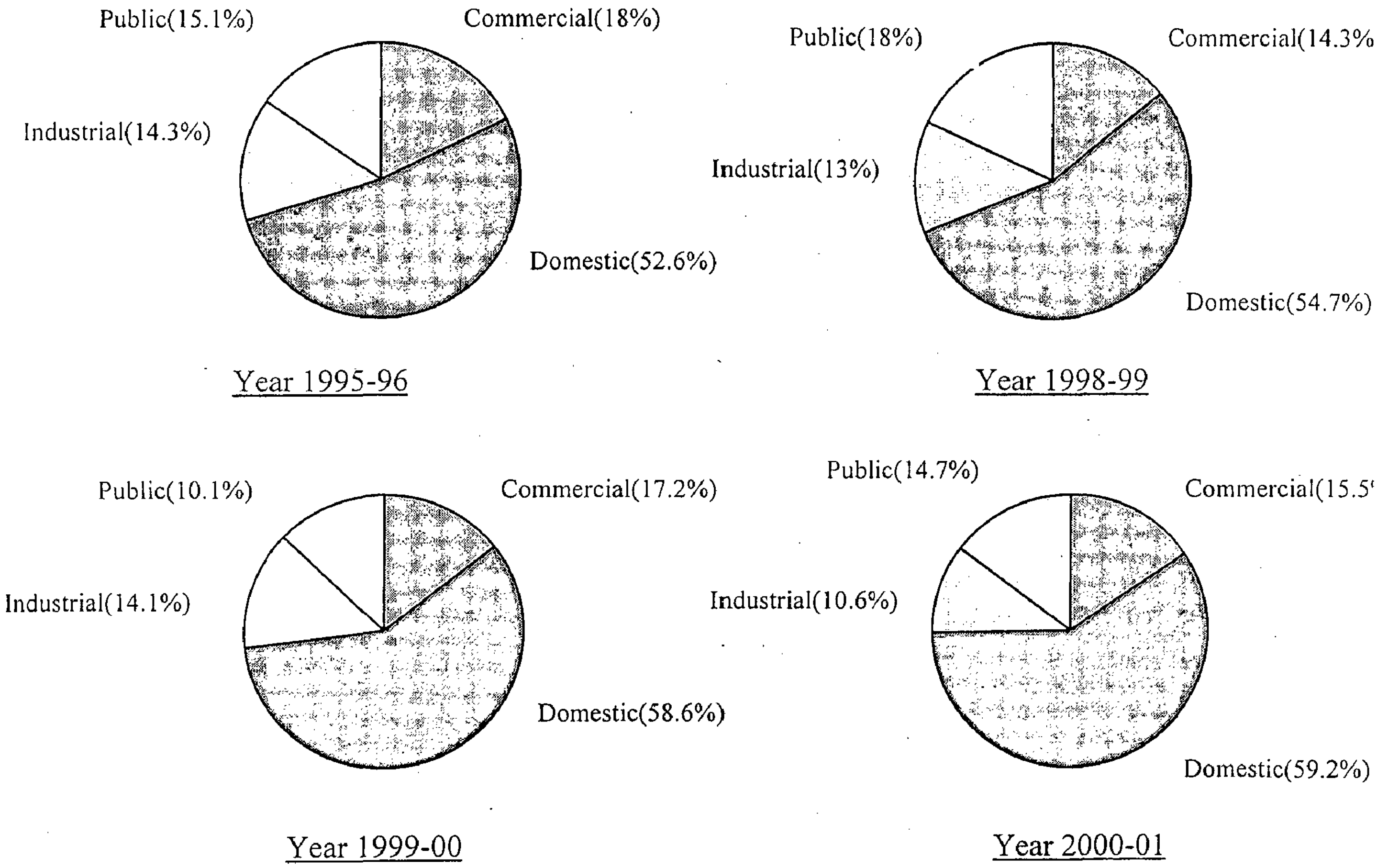


Fig.4.2Pie-chart showing sectorwise electricity consumption in Lucknow city

The annual energy receipt data shows that the electricity consumption shoots up by 12 percent in the months of May, July and August as shown in ***Table no: 4.3***

Table 4.3 Monthly energy receipt (2000-01) (in M.U.)

Year	April	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1999 -00	170.1	190.5	180.9	191.8	185.4	174.1	169.7	150.1	161.3	173.5	153.9	157.1
2000 -01	173.9	199.3	185.9	196.8	201.7	185.6	184.8	156.0	168.4	182.8	148.9	165.3

Source: Lucknow Electricity Supply Authority LESA, Lucknow

4.2.2 Petrol

The city is supplied with petrol from four oil companies viz:, Indian oil Corporation, Bharat Petroleum, Hindustan Petroleum, and Indo-Burma Petroleum. Requirement for petrol in the city is fully satisfied and the petrol pumps are spread all over the city.

At present, the city is supplied 71755 KL (kiloliter) or 53809 kgoe(Kilogram oil equivalent) of petrol from the various oil companies to the petrol pumps, which is sufficient for the present requirement of the city.

The annual supply of petrol by different oil companies in the year 2000-01 is as shown in ***Table no: 4.4***

Table 4.4 Annual supply of petrol (2000-01)

S.No.	*Oil Company*	*Petrol Supply (KL)*
1.	Indian Oil Corporation (IOC)	23958
2.	Bharat petroleum Corporation(BPC)	20340
3.	Hindustan Petroleum Corporation (HPC)	16010
4.	Indo-Burma Petroleum (IBP)	11447
	Total	***71755***

Source: Sales data Divisional office, Indian Oil, Lucknow

The demand has been found to be increasing @ 6 per cent per annum.

4.2.3 Diesel

The aforementioned four oil companies also supply diesel to the city. The consumption of diesel is low as compared to petrol in the domestic sector as people are having more number of vehicles run by petrol than by diesel, but if one sees the total scenario of consumption pattern of diesel it is much higher than petrol. The main reason behind this is that heavy vehicle like buses trucks, etc. and the locally plying Tata Sumos, jeeps etc. use diesel as fuel and as their requirement is high so the consumption level is also high. Besides, diesel is also used in industries.

The annual supply of diesel by different oil companies in the year 2000-01 is as shown in ***Table no: 4.5***

Table 4.5 Annual supply of diesel (2000-01)

S.No.	*Oil Company*	*Diesel Supply (KL)*
1.	Indian Oil Corporation (IOC)	62213
2.	Bharat Petroleum Corporation(BPC)	24962
3.	Hindustan Petroleum Corporation (HPC)	25931
4.	Indo-Burma Petroleum (IBP)	23725
	Total	***136831***

Source: Sales data Divisional office, Indian Oil, Lucknow

The annual demand of diesel has been found to be increasing at the rate of 10 per cent per annum.

4.2.4 Liquid petroleum gas (LPG)

The city is supplied LPG from oil companies viz., Indane and Bharat Petroleum. The present requirement for LPG in the city is fully satisfied. At present, there are 35 gas agencies spread all over the city. The city is supplied 96821 MT of LPG from the various companies to the gas agencies. The present quantity of LPG is sufficient for the city's requirement.

4.2.5 Solid Waste (Generation and collection)

Waste is defined as " *the goods, which is not suitable to use for productive purpose*". But, unfortunately, the resource, which is left out after major use, is considered as waste in India and thrown out in public places.

Wastes have been considered as a resource in the present investigation. Hence, this part has been found helpful in collecting various information of waste in the city like the type of waste produced, the total amount of waste production, composition of waste etc., based on which the technical feasibility for using waste as a resource could be assessed.

Basically, there are following three types of waste:

1. municipal waste
2. Industrial waste
3. Hospital waste

Industrial and Hospital waste come under the category of Hazardous waste and are being managed and disposed by their respective organisations whereas the responsibility for collecting and disposal of municipal waste lies on the Municipal Corporation (Nagar nigam).

4.2.5.1 Waste generation

The per capita/day waste generation is estimated at 650 grams and daily waste generation rate of the city is estimated to be 1500 Metric Tons, out of which about 900 to 1050 tons of waste is claimed to be collected by the Municipal Corporation, which includes domestic, trade, institutional and construction waste. 50% of the waste generated is organic in nature and principally comprises of food and other putreciable waste. The quantity of construction waste is quite significant and estimated at 230 tons per day.

4.2.5.2 Waste collection efficiency

On an average 70% and 75% is served through solid waste management services as claimed by the municipal Corporation. The survey, however, indicates that the waste collection is much lower and is around 50%.

4.2.5.3 Storage of waste at source

System of storage of waste at source has not developed and in absence of the facility of primary collection of waste from the doorstep or community bins close-by, most of the households, shops and establishments throw their waste on the streets, open spaces, surface drains, etc. treating the streets as receptacle of waste.

4.2.5.4 Segregation of recyclable waste

The city has active informal sector of kabadiwalas and rag pickers who purchase/collect recyclable waste from the doorstep and from the storage bins respectively. The households, shops and establishments do segregate the sellable recyclable material such as newspapers, plastic paper, glass, metals, etc. and sell it to waste purchaser/kabadiwals. Yet, the citizens throw quite a big quantity of the recyclable waste material on the streets, in the drains or nallas leading to blocking the flows of wastewater. It is estimated that there are over 10000 people engaged in collection of recyclable material in an informal sector. 2000 of them are kabadiwalas and rest 8000 are rag pickers and they collect about 200 Metric tons of recyclable material from the city.

4.2.5.5 Primary collection of waste

There is no system of door to door primary collection of waste. The citizens are expected to take the waste to the dustbins, which are quite away from the households, besides they are ill designed. Absence of adequate and conveniently placed dustbins result in deposition of waste on the streets, open spaces, drains, etc. No facility is even provided for collection of waste from hotels, restaurants, construction sites, etc.

4.2.5.6 Waste storage depots

The city has very poorly designed waste storage depots. This facility is also very inadequate. Most of the sites are open, unhygienic, attracting stray cattle. The City corporation has also constructed masonry waste storage depots at several locations, which are also ill-designed. More waste is found outside such bins than inside them.

At 500 locations, the city corporation has provided open containers from which waste is collected by refuse collector vans and at some places larger containers are also kept. The waste storage system is not synchronised with the primary collection system resulting in deposition of waste outside the bins, defeating the very idea of placing the containers.

4.5.2.7 Disposal of waste

The waste is disposed of at two landfill sites, namely Motijhil and Purania in CIS-Gomti and Trans-Gomti area respectively. Total capacity of both these sites is 1.6 million cmt. Taking into consideration waste generation rate of 1500 Metric Tons per day and average density of 500 kg/cmt. in initial month and later about 800 kg. cmt after appropriate compaction and decay of waste, the present sites would not last for more than two and a half years if all the waste were brought at these landfill sites. The City Corporation is thus, having inadequate landfill sites to meet the future requirements. The waste is not subjected to any treatment at the disposal site and it is just spread with the help of bulldozers from time to time.

The waste at the landfill site is not covered properly. The animals and rag pickers are found on the landfill site. The system of crude dumping of waste resorted to by the City Corporation is adversely affecting the environment and poses a threat to the health of the people nearby. Besides, groundwater is also likely to be contaminated on account of unscientific disposal of waste at the land fill site.

The typical composition of Municipal solid waste in the city is shown in ***Table no: 4.6***

Table 4.6 Typical composition of MSW in Lucknow

1.	Total quantity of waste generated	1500 Ton/day
2.	Collection	65-66 %
3.	Moisture content	25-30 %
4.	Solid content	70-75 %
5.	Organic content	40-45 %
6.	Nitrogen	0.2 - 0.6
7.	Phosphorous	0.8 - 6.8
8.	Fe, Cu, Zn	Traces
9.	Structure	Fibrous

Source: Non-conventional Energy Development agency (NEDA), Lucknow

CHAPTER 5

ASSESSING THE ENERGY CONSUMPTION PATTERN

A typical Indian urban system is a heterogeneous mix of varying energy consumption pattern amongst various sections of society and in different sectors. Greater is the size of urban center, greater is its energy requirement. Even among the urban centers of same size and population, great variations are found with regard to energy consumption. A number of factors are responsible for this, such as, urban form, type of transport system and management, extent of modern technology adoption, price of fuels, economic base, economic status of people, lifestyle, awareness regarding energy-environment linkages, etc.

In domestic sector, energy consumption pattern varies widely across various income groups in urban areas. Disparity in income, heterogeneity of social fabric, price of fuels, availability and accessibility to modern commercial fuels, efficiency of the end-use equipment used are some of the factors responsible for variations in energy consumption in this sector. It is observed that with an increase in per capita income, households tend to switch over to cleaner and more efficient fuels. High-income groups consume more electricity for lighting, water heating and other electrical appliances, Whereas, the low-income groups consume most of energy for cooking and lighting. The use of bio-fuels in these groups has also been found decreasing due to their dwindling supply. The overall scenario with regard to energy consumption in this sector, however, is found to be increasing manifold.

In transport sector as well, the trend of energy consumption is found increasing. An absence of good public transport system, increasing use of private vehicles, increasing trip-length due to increased distances between home and work places and lack of transport management are some of the reasons for tremendous increase in energy demand in this sector.

This increasing demand for energy has to be met with for a system to survive. Problems crop up when this energy gap between demand and supply widens as the supply is limited. Each system has its own peculiarities with regard to energy consumption. With this background, an attempt has been made to study the energy consumption pattern of Lucknow city for domestic and transport sectors.

5.1 DOMESTIC SECTOR

In this section, energy consumption pattern in domestic sector has been discussed under the following sub-heads, on the basis of the primary survey done.

5.1.1 TREND OF ENERGY USE

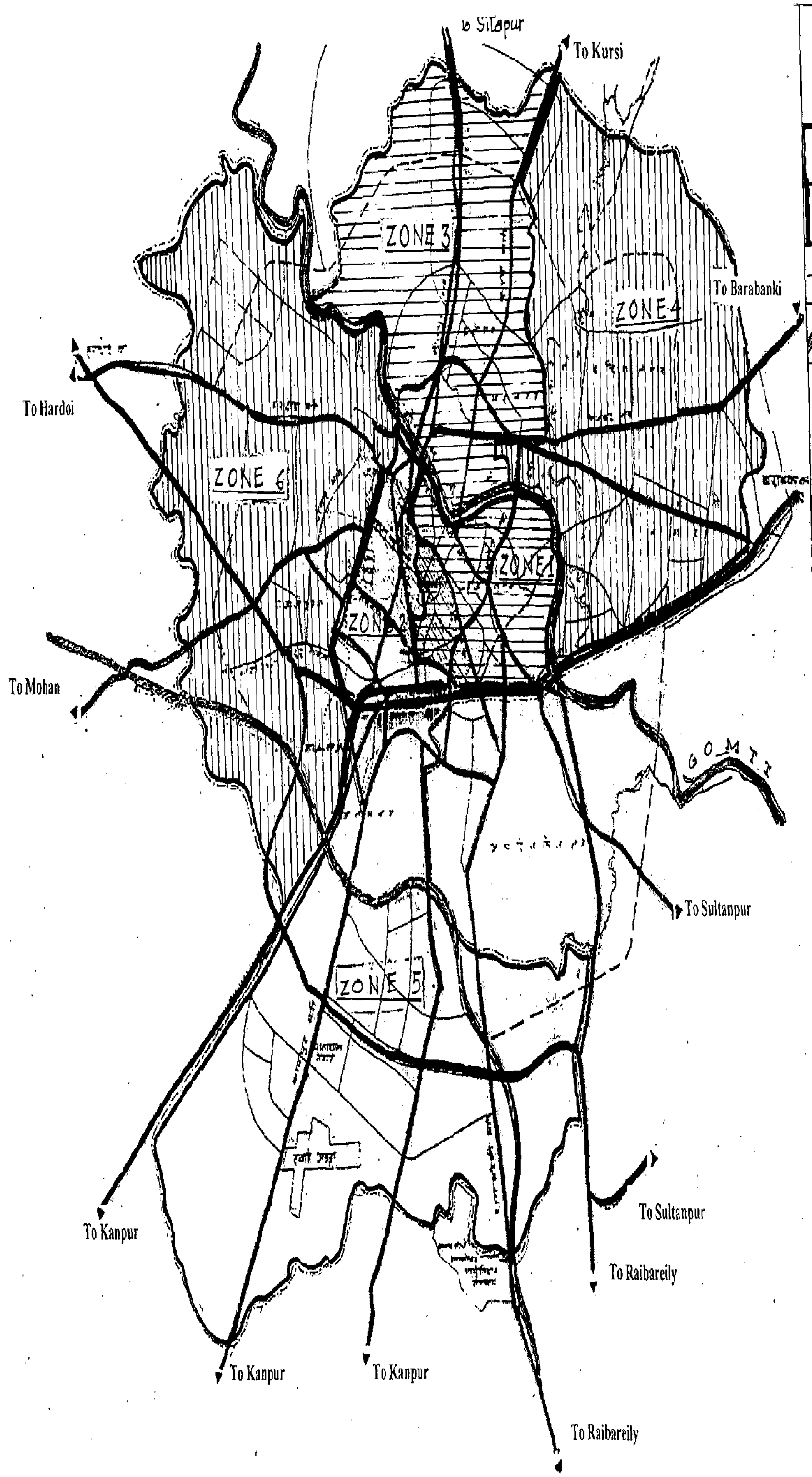
It gives the details of the trend of energy consumption pattern in the city. The energy consumption pattern and the sources of energy are very important as it is directly related to income, living standard and various other factors, which will be of great help for arriving at plausible recommendations in later part of the study. It will also help us in knowing that what is the trend of use of various types of the resources available in the system.

5.1.2 NUMBER OF HOUSEHOLDS

Identification and selection of households at the grassroot level for conducting the survey in the study area is one of the most important tasks.

In the present investigation, 100 households have been surveyed from different parts of the city (***map 5.1***). The surveyed schedules are classified and grouped into four groups on the basis of their income, such as, annual household income upto Rs. 60,000, Rs. 60,000- 1.2 lacs, Rs.1.2 –2.0 lacs, and greater than 2.0 lacs, for analysis, and the results are presented in ***Table no: 5.1***.

The table indicates that maximum number of households is confined in the income range of 0.6 to 1.2 lacs and 1.2 to 2.0 lacs per annum i.e. 27 per cent. An attempt has been made in the survey to get an equitable representation of people from different income categories.



LEGEND

	Planning zones
	Selected zones
	Municipal Corp. limit
	Water body

N Not to scale

MAP : 5.1

ZONES SELECTED FOR HOUSEHOLD SURVEY

ENERGY MANAGEMENT IN LUCKNOW CITY

Table 5.1 Number of households (Income in Rs/year)

S.No.	Income	Total no. of Household	%age
1.	< 60,000	21	21.0
2.	60,000 to 1.2 lacs	27	27.0
3.	1.2 to 2.0 lacs	27	27.0
4.	> 2.0 lacs	25	25.0
	Total	100	100.0

5.1.3 POPULATION DISTRIBUTION

Population is one of the most important criteria in a study, as everything is directly related to it. Thus the distribution of population according to various income groups of the sample households are studied very carefully, and the results are presented in ***Table no:5.2*** and ***5.3*** respectively.

The table illustrates that maximum number of people are confined in the income range of 0.15 to 0.60 lacs i.e. 27.5 percent of the total population, although the segment covers only 21 percent of the total sample household. The highest income range i.e. greater than 2.0 lacs per annum follows this, which shows 25.6 percent of the total population. It is interesting to note that the least number of people are confined in the income range of 0.6 to 1.2 lacs and 1.2 to 2.0 lacs per annum.

The size of household is maximum, i.e., 6.05 in the income range of 0.15 to 0.60 lacs per annum, followed by 4.72 in the income range of greater than 2.0 lacs per annum. The household size is lowest i.e., 3.78 in the income range of 0.6 to 1.2 lacs per annum.

Table 5.2 Population distribution (Income in Rs/year)

S.No	Income	Population	%age	Household size
1.	< 60,000	127	27.5	6.05
2.	60,000 to 1.2 lacs	102	22.0	3.78
3.	1.2 to 2.0 lacs	115	24.4	4.25
4.	> 2.0 lacs	118	25.6	4.72
	Total	462	100.0	

Table 5.3 Composition of population

S.No	Income	No. of males	%age	No. of Females	%age	Total	%age
1.	< 60,000	53	22.0	74	33.3	127	27.5
2.	60,000 to 1.2 lacs	64	26.8	38	17.1	102	22.1
3.	1.2 to 2.0 lacs	58	24.2	57	25.7	115	24.9
4.	> 2.0 lacs	65	27.0	53	23.9	118	25.5
	Total	240	100.0	222	100.0	462	100.0

5.1.4 EDUCATIONAL STATUS

Education is considered as the most important parameter, which has the power to control various activities of the system, even the other parameters are directly related to it, like income, quality of life, etc. education is the parameter which is directly related to the awareness regarding various matters.

Thus, in this present investigation, the educational status of the people is studied very carefully, and the results are shown in ***Table no: 5.4***. The level of education is divided into five groups they are:

- Primary education
- Secondary education
- Graduation
- Post graduation
- Technical/Professional education

Table 5.4 Educational status (Income in Rs/year)

S.No	Income	Primary (%age)	Sec. (%age)	Grad. (%age)	Post grad. (%age)	Tech. (%age)	Total (%)
1.	< 60,000	39 (49.4)	17 (17.5)	1 (1.1)	0 (0.0)	0 (0.0)	57 (14.7)
2.	60,000 to 1.2 lacs	15 (18.9)	37 (38.1)	29 (32.2)	8 (15.7)	12 (16.9)	101 (26.0)
3.	1.2 to 2.0 lacs	10 (12.8)	21 (21.7)	32 (35.6)	22 (48.1)	27 (38.0)	112 (28.9)
4.	> 2.0 lacs	15 (18.9)	22 (22.7)	28 (31.1)	21 (41.2)	32 (45.1)	118 (30.4)
	Total	79 (100.0)	97 (100.0)	90 (100.0)	51 (100.0)	71 (100.0)	388

It is observed that of the total population i.e., 462, 84 per cent of them are literate; and of which only 23.2 per cent are graduates and 18.3 per cent have technical/professional qualification, whereas it is seen that there are 20.4 per cent of people having an education upto 10^{th} standard.

Further studying the educational status of the various income groups, it is observed that major part of them i.e. 30.4 per cent belong to the income range of greater than 2.0 lacs per annum, followed by the next higher income group people. Thus, it is seen that educational status has a great correlation with the income. Although, the lowest category show a high percentage (49.4 per cent) of people studied upto 10^{th} standard, they lack in higher education; the level of post-graduation and technical education is high in the higher income groups of 1.2 to 2.0 lacs and greater than 2.0 lacs per annum.

5.1.5 STATUS OF EMPLOYMENT

Status of employment is one of the most important factors, which decides the functioning of the system. If more number of people is employed, then the system will fetch more income, which leads to more spread effect. It is the deciding factor in the issues like accruing more income, quality of life, saving, etc. It is observed that generally most of the population is engaged in the service sector followed by tertiary sector.

The status of employment has been studied very carefully among the sample households and presented in ***table no: 5.5***

Table 5.5 Status of employment (Income in Rs/year)

S.No.	Income	No. of People Employed	Percentage
1.	< 60,000	40	26.0
2.	60,000 to 1.2 lacs	30	19.5
3.	1.2 to 2.0 lacs	37	24.0
4.	> 2.0 lacs	47	30.5
	Total	154	100.0

The table indicates that one-third of the total population of the sample households is employed. It has been observed that the highest income group has maximum employed persons i.e. 30.5 per cent, while the income group 0.6 to 1.2 lacs have minimum number of employed persons i.e., 19.5 per cent. It is also observed that the higher income groups are more engaged in organized sector, which goes well with the non-industrial base of the city.

Thus, it can be inferred that the status of employment is increasing with the increase in the income range. The higher income group people are able to get better and higher education, whereas in lower income group, the people are not able to get good education and therefore, show a lower rate of employment.

5.1.6 VEHICULAR DISTRIBUTION

India has started to have open market economy since 1991, which resulted in large number of multinational companies' flow in the sub continent. There are few multinational companies setup their small car production, which lead to an increase in small car production at considerable level. The higher income group started to have more than one car, and the usage of cars have been increased to a larger extent. As a result, the demand of fossil fuels has increased manifold, which is an unfavorable sign for this country as India is importing fossil fuels from other countries and huge amount of money is spend in this regard.

Lucknow, being the capital state is an administrative city but it lacks a good public transportation system, thus the people prefer using personal vehicles. The distribution of vehicles in the different income groups of the sample household is given in ***Table no: 5.6***

Table 5.6 Number of vehicles (Income in Rs/year)

S. No.	Income	Total no. of HH.	No. of Cars	Per HH.	No. of 2-Wheelers	Per HH.
1.	< 60,000	21	0	0	4	0.19
2.	60,000 to 1.2 lacs	27	0	0	28	1.04
3.	1.2 to 2.0 lacs	27	18	0.67	37	1.37
4.	> 2 lacs	25	29	1.16	43	1.72
	Total	100	47		112	

It has been observed that the households own a total of 159 vehicles, of which 30.1 per cent are cars and 69.9 per cent are two-wheelers. The ownership of four-wheelers as well as two-wheelers show increasing trends along with increase in income.

It is also found that the higher income groups i.e., 1.2 to 2.0 lacs and greater than 2.0 lacs per annum, prefer four-wheelers for going to work place and nearby towns, whereas for market they prefer using two-wheelers. The lower income group people are more dependent on two-wheelers and public transportation.

5.1.7 TYPE OF HOUSING

House is one of the basic necessities just after food and clothing. House is a shelter where one gets protection against sunlight, rain, extreme weather conditions like cold, summer, other such odds, besides providing privacy and comfortable living conditions. Thus owning a house is the final dream of everyone.

In the present conditions the situation has become very complex as the land is becoming scarce with each passing day. This has also resulted in the sky rocketing prices of land. Therefore, a person owns a house depending upon his means.

In the present investigation, the houses belonging to each of the household of a specific income class are classified into four groups for analysis namely:

- Detached
- Semi detached
- Row housing
- Apartments.

Among the sample households, the different types of houses available in the system is studied very carefully, and presented in ***Table no: 5.7.*** The table shows that of the total households surveyed, detached and row houses together represent more than two-third (73 per cent) of the total and the rest are confined in Row and apartment housing system.

Table 5.7 Type of housing (Income in Rs/year)

S.No	Income	Detached (%age)	Semidetached (%age)	Row (%age)	Apartment (%age)
1.	< 60,000	3 (7.9)	2 (13.3)	16 (45.7)	0 (0.0)
2.	60,000 to 1.2 lacs	4 (10.5)	4 (26.7)	12 (34.3)	7 (58.3)
3.	1.2 to 2.0 lacs	13 (34.2)	3 (20.0)	7 (20.0)	4 (33.3)
4.	> 2.0 lacs	18 (47.4)	6 (40.0)	0 (0.0)	1 (8.4)
	Total	38 (100.0)	15 (100.0)	35 (100.0)	12 (100.0)

Of the total Detached housing type, half of the total number of houses are confined with the highest income range i.e., greater than 2.0 lacs per annum, followed by the next higher income group i.e., 1.2 to 2.0 lacs per annum.

In the semi-detached housing type, again a little more than half of the households are confined in the highest income range and the rest is almost evenly distributed.

As one move to the next type of housing i.e., Row housing, it is observed that all the houses are confined in the lower income groups of 0.15 to 0.60 lacs and 0.6 to 1.2 lacs respectively. Thus, it is inferred that the lower income group people cannot afford the luxurious Detached and Semi-detached housing and can afford only this category.

Another interesting thing to be noted is that inspite of the affordability, the higher income group people prefer detached houses in the older areas and the newly formed posh areas of the city to luxurious apartments. The people in the income category of 0.60 to 1.2 lacs per annum mostly occupy apartments.

Thus, most of the middle income group people are living in row houses followed by detached type housing.

5.1.8 AVAILABILITY OF WATER

Drinking water supply is one of the most important aspects linked with man's day to day life. If water supply is affected almost all the subsystems of the urban system would be affected, and the urban system as a whole would be paralyzed because water supply is the parameter, which is considered equal to blood in the human immune system. In Indian metro cities and cities, polluted water is also supplied often due to various reasons. The polluted water supply directly affects the human system. One can very easily understand from that how much water is important for the survival of human being.

The deficiency of water supply at the household level causes scarcity and polluted water supply, causes several diseases, such as, diarrhea, dysentery, entire figures, infectious skin, eye diseases and certain louse borne infections, etc. The availability of sufficient quantity of water for different purposes, such as, bathing, cleaning, and laundry are thus of great importance.

Water is one of the basic necessities needed for human survival just as we need air. We not only need water for drinking purpose but also for washing, bathing, etc.

Therefore, in the present investigation the availability of water supply is carefully studied in the surveyed households and shown in ***Table no: 5.8***

Table 5.8 Availability of water (Income in Rs/year)

S.No	Income	Yes			No	Total
		Metered (%)	Non-met. (%)	Total (%)	(%)	
1.	< 60,000	5 (6.9)	13 (52.0)	18 (18.6)	3 (100.0)	21
2.	60,000 to 1.2 lacs	23 (31.9)	4 (16.0)	27 (27.8)	0 (0.0)	27
3.	1.2 to 2.0 lacs	27 (37.5)	0 (0.0)	27 (27.8)0	0 (0.0)	27
4.	> 2.0 lacs	25 (34.7)	0 (0.0)	25 (25.8)	0 (0.0)	25
	Total	72 (100.0)	25 (100.0)	97 (100.0)	3 (100.0)	100

The table illustrates all households are having water supply save for 3 households which belong to the lowest income category. The supply is metered in the higher income groups i.e., 1.2 lacs to 2.0 lacs and greater than 2.0 lacs per annum respectively. Most of the households in the lowest income group are unmetered (illegal connections). Few households in the income range of 0.60 to 1.2 lacs per annum have also been found to have illegal connections.

5.1.9 AVAILABILITY OF ELECTRICITY

Electricity is one of the most important infrastructure facilities required for any development. Its absence may cause lot of problems in day to day life, as one has become dependent on it. Though it is so important, often the desired level of requirement is not been fully met. It is not only required for household activities, but also a considerable quantity is required for industrial and commercial activities. Since the requirement is not fulfilled, it affects the growth of the economy. Earlier there were not many appliances being run by electricity at the household level, but now the number is unlimited, thus causing increased dependence. It has come to the stage that failure in supply of electricity disrupts the entire life of a city.

Therefore, in this present investigation, the availability of electricity supply at the household level is very carefully studied in the sample households and presented in ***Table no: 5.9***.

The table illustrates all households in the sample households are having electric supply, and most of the electrical connection is metered. The households having illegal connection belong to the lower income category; 3 households belonging to the lowest income category. There is only one household in the next higher category having non-metered connection; the house happens to belong to the one working in electricity department. The economic status of the particular households in the lowest income category was found to be bad.

Table 5.9 Availability of electricity (Income in Rs/year)

S.No	Income	Yes			No	Total
		Metered (%age)	Non-met. (%age)	Total (%age)		
1.	< 60,000	18 (18.8)	3 (75.0)	21 (21.0)	0	21
2.	60,000 to 1.2 lacs	26 (27.0)	1 (25.0)	27 (27.0)	0	27
3.	1.2 to 2.0 lacs	27 (28.1)	0 (0.0)	27 (27.0)	0	27
4.	> 2.0 lacs	25 (26.1)	0 (0.0)	25 (25.0)	0	25
	Total	96 (100.0)	4 (100.0)	100 (100.0)	0	100

5.1.10 NUMBER OF APPLIANCES

Application of appliances is one of the important factors, which vary in accordance with their income. The person earning higher amount of income used to have more quantity of sophisticated appliances at their household level, such as, air conditioners, fridge's, computers, higher quality of audio systems, televisions, ovens, washing machines, etc. Whereas, it is a dream to have these appliances those who have little amount of income. Moreover, these appliances consume more quantity of energy for their functioning. The investigator has therefore, carefully studied the availability of different types of appliances at the household level in the selected samples. The results are presented in ***Table no. 5.10.1, 5.10.2, 5.10.3, 5.10.4, and 5.10.5.*** The tables illustrate that twelve types of appliances are very commonly used in the system.

They are:

- Fridge's
- Immersion rods
- Air conditioners
- Mixers
- Computers
- Audio systems

- Television's
- Geysers
- Ovens
- LPG stoves
- Washing machines.
- Generator

It has been observed that the number of appliance availability is increasing along with increase in income in their respective strata of income category. Though the availability of all appliances discussed earlier is having increasing trend along with income, the availability of sophisticated appliances, such as fridge, A/c, computers, audio system, T.V, geysers, etc, are found in higher number among the higher income group category, whereas immersion rods (common man's water heater) is found only at the lower income group category. Out of curiosity, the investigator inquired about the utilization of the sophisticated appliances and found that though the higher income group people have more number of sophisticated appliances, their application are more or less under utilized.

Table 5.10.1 **No. of appliances** (Income in Rs/year)

S.No	Income	No. of Fridge	Per HH.	No. of immersion rod	Per HH.	No. of A.C.	Per HH.
1.	< 60,000	1	0.05	11	0.52	0	0
2.	60,000 to 1.2 lacs	30	1.11	14	0.51	2	0.07
3.	1.2 to 2.0 lacs	32	1.19	10	0.37	6	0.22
4.	> 2.0 lacs	45	1.80	0	0	24	0.96
	Total	108		35		32	

Table 5.10.2 No. of appliances (Income in Rs/year)

S.No	Income	No. of Geysers	Per HH.	No. of Computer	Per HH.	No. of Stereo	Per HH.
1.	< 60,000	0	0	0	0	13	0.62
2.	60,000 to 1.2 lacs	4	0.15	8	0.29	27	1.00
3.	1.2 to 2.0 lacs	24	0.89	12	0.44	32	1.19
4.	> 2.0 lacs	28	1.12	20	0.80	30	1.20
	Total	56		40		102	

Table 5.10.3 No. of appliances (Income in Rs/year)

S.No	Income	No. of T.V.	Per HH.	No. of Mixer	Per HH.	No. of oven	Per HH.
1.	< 60,000	18	0.86	1	0.04	0	0
2.	0.6 to 1.2 lacs	28	1.04	20	0.74	7	0.26
3.	1.2 to 2.0 lacs	36	1.33	30	1.11	16	0.59
4.	> 2.0 lacs	45	1.80	29	1.16	18	0.72
	Total	127		80		41	

Table 5.10.4 No. of appliances (Income in Rs/year)

S.No	Income	No. of washing machine	Per HH.	No. of L.P.G stove	Per HH.	No. of Toaster /Griller	Per HH.
1.	< 60,000	0	0.00	20	0.95	0	0.00
2.	60,000 to 1.2 lacs	17	0.63	27	1.00	13	0.48
3.	1.2 to 2.0 lacs	26	0.96	28	1.04	23	0.85
4.	> 2.0 lacs	25	1.00	27	1.08	28	0.92
	Total	68		102		59	

Table 5.10.5 No. of appliances (Income in Rs/year)

S. No.	Income	No. of Cooler	Per HH.	No. of Generator	Per HH.
1.	< 60,000	18	0.86	0	0.00
2.	60,000 to 1.2 lacs	55	2.04	0	0.00
3.	1.2 to 2.0 lacs	64	2.37	6	0.22
4.	> 2.0 lacs	32	1.28	12	0.48
	Total	169		18	

Table 5.10.6 Average time of usage of electric appliances

S.No.	Appliances	Average usage per day(hours)
1.	Lights	8.54
2.	Fans	14.95
3.	Heaters	2.58
4.	Coolers	4.70

5.1.11 CONSUMPTION PATTERN OF ELECTRICITY

Electricity is one of the most widely used commercial energy in urban system. It is available in refined form and hence it is very easy to use, as compared to other energy resources. Thus, one can be able to use it for various purposes in his/her house for lighting, heating, cooking, etc. As the technology is improving day by day more electrical energy based appliances are being used.

Therefore, consumption of electricity at the household level has been carefully studied among the sample households and presented in ***Table no: 5.11.***

The table illustrates that the per capita electricity consumption is increasing along with the increase in income. Moreover, it is also observed that it is very low in the lowest income strata and it is the highest among the highest income strata. This very clearly explains that income is the basic control parameter, which decide the consumption of electricity at the household level.

Thus from the above observations, it is inferred that the higher income range people, since they have more resources, are able to afford various luxuries in terms of modern electrical appliances, hence they are the main consumers of electricity. Whereas, people belonging to the lower income groups are not able to afford these luxuries and hence show less per capita electricity consumption.

Table 5.11 Consumption pattern of electricity (Income in Rs/year)

S. No.	Income	Qty. of electricity used (units/month)	%age	Per capita consumption (units/month)
1.	< 60,000	1155	4.9	9.09
2.	60,000 to 1.2 lacs	5960	25.8	58.43
3.	1.2 to 2.0 lacs	7175	30.9	62.39
4.	> 2.0 lacs	8900	38.4	75.42
	Total	23190	100.0	

5.1.12 CONSUMPTION PATTERN OF PETROL

As urbanization is increasing day by day, resulting into expansion of cities. Thus, one has to travel for longer time, and larger distances to reach his/her destination. This has caused the increasing number of vehicles, which resulted in increasing the consumption of petrol. Petrol is one of the most widely used fossil fuel in the world. The main consumer of petrol is the transportation sector. This increase in vehicle number has caused accelerated environmental degradation.

Lucknow city has radial pattern, similar to Delhi. The work nodes are centered so people have to come from far off places to these central nodes. The problem becomes more acute due to the lack of an efficient public transportation system.

The consumption pattern of petrol in the sample household is shown in ***Table no: 5.12.***

Table 5.12 Consumption pattern of petrol (Income in Rs/year)

S.No.	Income	Consumption of petrol/ month (liters)	%age	Per capita consumption (liters/month)
1.	< 60,000	80	3.3	0.63
2.	60,000 to 1.2 lacs	560	23.3	5.49
3.	1.2 to 2.0 lacs	852	35.5	7.41
4.	> 2.0 lacs	908	37.9	7.69
	Total	2400	100.0	

The table explains that the per capita consumption of petrol is increasing along with an increase in income. It has been observed that the per capita consumption of petrol is more than six times in the highest income group category compared to that in the lowest income group.

Thus, there is an increasing trend in the consumption along with increasing income ranges. The main reason for high consumption of petrol in the higher income ranges is because these households have higher number of two-wheeler and four-wheeler ownership, while lower income range households have more number of two-wheelers only, so consumption is found very low at the lower level of income category.

5.1.13 CONSUMPTION PATTERN OF DIESEL

Diesel is also one of the important fossil fuels used in transportation sector, but it is mostly used by heavy vehicles like trucks and buses, and a very little quantity of it is used in small vehicles like cars, as most of the cars are being run by petrol. Diesel consumption although, very less in domestic activities has been studied very carefully, and presented in ***Table no: 5.13.***

It is interesting to observe that there is absolutely no consumption of diesel in all the income groups except for the income range 1.2 to 2.0 lacs per annum which shows two households using diesel. Thus, this shows that in the household sector the consumption of diesel is very less as compared to petrol, although in terms of sales the consumption of diesel is more than petrol.

Table 5.13 Consumption pattern of diesel (Income in Rs/year)

S. No.	Income	Consumption of diesel/month(liters)	%age	Per capita consumption (liters/month)
1.	< 60,000	0	0.0	0.00
2.	60,000 to 1.2 lacs	0	0.0	0.00
3.	1.2 to 2.0 lacs	64	64.0	0.56
4.	> 2.0 lacs	0	0.0	0.00
	Total	64	100.0	

5.1.14 CONSUMPTION PATTERN OF L.P.G

Liquefied Petroleum Gas is another important source of energy, which is used, in the day to day life. LPG is mainly used for cooking purpose. The use of LPG has helped us to switch over from older methods of cooking, like earlier coal, cow dung, etc. to cleaner and more efficient fuels. Thus, LPG is a safer and environmental friendly energy. Now day's people have also started using LPG cylinders in their cars as an alternative to fuel.

The consumption pattern of LPG in the sample households is shown in the ***Table no: 5.14.***

Table 5.14 Consumption pattern of L.P.G (Income in Rs/year)

S. No.	Income	No. of L.P.G Cylinders used/month	%age	Per capita consumption (kgs/month)
1.	< 60,000	12.65	11.5	1.41
2.	60,000 to 1.2 lacs	29.00	26.0	4.04
3.	1.2 to 2.0 lacs	32.80	29.5	4.05
4.	> 2.0 lacs	36.70	33.0	4.42
	Total	111.15	100.0	

The table illustrates that the per capita consumption of L.P.G is increasing along with increase in income, i.e., the per capita consumption of L.P.G is higher in higher income segment and lower in lower income segment. The reasons are the higher income people have more affordability, the wastage is also more. Besides, it has also been found that although the higher income groups have more electronic gadgets like ovens, microwave etc. but they don't use it very often.

5.1.15 ENERGY CONSERVATION

Energy conservation can play a very important role in view of the current energy crisis. In the domestic sector, the use of appliances like solar cooker, pressure cooker, compact fluorescent lamps etc. are all extensions of this concept. The presence and extensive use of these appliances are good indicators of the level of awareness among the general public regarding energy conservation.

The presence of these appliances has therefore, been carefully studied in the sample households and presented in ***Table no: 5.15.***

Table 5.15 Energy conserving appliances (Income in Rs/year)

S.No	Income	HHs having pressure cooker(%)	HHs having solar cooker (%)	HHs having solar heater (%)	HHs having C.F.L (%)
1.	< 60,000	21 (21.0)	0 (0.0)	0 (0.0)	0 (0.0)
2.	60,000 to 1.2 lacs	27 (27.0)	1 (20.0)	0 (0.0)	4 (44.4)
3.	1.2 to 2.0 lacs	27 (27.0)	2 (40.0)	1 (100.0)	3 (33.3)
4.	> 2.0 lacs	25 (25.0)	2 (40.0)	0 (0.0)	2 (22.3)
	Total	100 (100.0)	5 (100.0)	1 (100.0)	9 (100.0)

Inspite of Lucknow being the nodal center of Non conventional Energy Development Agency (NEDA), it has been found that the level of use of energy conserving appliances, save for the exception of pressure cooker, is very low. Only 11 households (belonging to the higher income groups) out of the total 100 sample households show the presence of these energy conserving / renewable energy using appliances.

5.1.16 SOLID WASTE GENERATION

Having the importance of garbage management in the urban system, the investigator has included garbage management also as one of the parameters in this present investigation. Literature pertaining to the garbage management are collected and reviewed and careful inferences are drawn.

A study of the solid waste generated gm/capita/day in the various income groups of the surveyed household is shown in ***Table no: 5.16.***

The table indicates that the maximum generation of solid waste is observed in the highest income groups, which has the income range of 2 lacs and above per annum, which is 620.51 gm/capita/day, followed by 523.48 gm/capita/day in the income range 1.2 lacs to 2.0 lacs per annum. Whereas in the low-income range of 0.15 lacs to 0.60 lacs it is lowest i.e. 350.52 gm/capita/day. Thus, from the above observation it has been found that the solid waste generation is increasing along with increase in the income level. Thus, it is inferred that the major contribution of waste generation is of the higher income group segment.

Table 5.16 Amount of waste generated / per capita / day

(Income in Rs/year)

S. No.	Income	Waste generated per capita/ day in gm	%age
1.	< 60,000	350.52	17.8
2.	60,000 to 1.2 lacs	475.63	24.2
3.	1.2 to 2.0 lacs	523.48	26.5
4.	> 2.0 lacs	620.50	31.5
	Total	1970.13	100.0

5.2 TRAFFIC AND TRANSPORTATION PROFILE OF LUCKNOW CITY

This section deals with another important aspect –transportation. There are strong linkages of transportation and energy. The analysis is done in this section with this regard .The discussion is done under the following sub-heads:

5.2.1 TERRAIN

The city is situated in the center of the Indo-Gangetic plains. The main urban area of Lucknow is situated on the southern banks of river Gomti. A large part of the city is developed on low-lying land. In the denser part of the city, the terrain is mostly plain.

5.2.2 ROADS

5.2.2.1 Road network

- Nine regional roads coverage to the city:
  - From Kanpur, two roads
  - From Faizabad, one road
  - From Sitapur, one road
  - From Hardoi, one road
  - From Rae Bareilly, one road
  - From Sultanpur, one road
  - From Kursi, one road
  - From Mohan, one road
- The road network is radial in nature.
- The outer ring road is incomplete and broken at many places.
- The inner ring road consists of Station road, Vidhan Sabha Marg , M.G. Marg.

5.2.2.2 Traffic scenario/problems *(map no: 5.2 & 5.3)*

- Ring road network consisting of all major roads viz. Hardoi, Kanpur, Faizabad, Sitapur, etc. originate from city center or converge to the city from different directions.

- Overloading on Inner ring road consisting of Station road, Vidhan Sabha marg, M.G. marg.
- Incomplete outer ring road causes bypassable traffic from Kanpur road to Raibareilly road, Raibereilly road to Sultanpur road, Sultanpur road to Faizabad road and Hardoi road to Sitapur road pass through the city.
- Inadequate right-of-way of almost all roads in the central area poses a constraint for capacity expansion.
- Non-confirming and mixed landuse causing large-scale road side encroachments on Aminabad road, Tulsidas marg, Nadan Mahal road and Aishbagh road.
- Iron bridge, Hanuman setu, Daliganj bridge, Rekabganj bridge major bottlenecks due to heavy load.
- Gomti barrage, Hanuman setu and Nishatganj bridge over utilised.
- Main junctions/ intersections - Nishatganj, Naka hindola, Rakabganj, Alambagh, Lalbagh, Kaiserbagh, Chowk overloaded; Medical college crossing, VIP crossing and many other crossing within the city overloaded.
- Heterogeneous traffic mix on major roads.
- Absence of pedestrian footpaths, slow moving traffic lanes and other facilities on major arterial and sub-arterial roads.
- lack of parking facilities.
- Presence of rail/road level crossings in the busy corridors of city like Tulsidas marg, Nirala nagar , Daliganj, etc.
- Lack of proper control and traffic management measures.
- Heavy encroachment on main and secondary streets.
- Obstruction to traffic from electric and telephone poles on carriageway.
- The intersection geometrics are poor and control system inadequate.

5.2.2.3 Problematic areas and causes of traffic problems

- Heterogeneous mix of slow and Fast traffic on

  Station road

  Subhash marg

Ashok marg
Vidahn Sabha marg
Gautam Budha marg
Aishbagh road
Nadan Mahal road
Ganga Prasad road
M.G. marg
University road
Cantt. road
Guru Gobind Singh marg
Tulsidas marg
Tal katora road
Alambagh- Charbagh road
Jagat narain road

Percentage of slow vehicles vary between 60 to 70% and needs immediate attention

- Disorganised on-street parking and shortage of off-street parking

Charbagh railway station
Bus terminal Charbagh
Gurugovind Singh marg
Hazratganj
Janpath market
Lalbagh
G.P.O
Kaiserbagh
Aminabad
Chowk
Latouch road
Khunkhunji marg(intersection)
Koneshwar chowk

- Intersections causing congestion and traffic bottlenecks (Inadequate geometric and complete lack of road and traffic sign/ signals except for Hazratganj)

Nishatganj
I.T. college
Hazrat ganj
G.P.O
Khunkhunji
Chowk
Lal bagh
Natha Chowk
Naka Hindola
Cantt
Husain ganj
Kaiserbagh
Halwasia
Allahabad bank
Novelty cinema
Valmiki marg
B.N. road
Aminabad
Ganga Prasad
Jhande wala park
Latouch road
Charbagh railway station
Vidhan Sabha marg
Nehru crossing
Nadan Mahal
Tulsidas marg

- Lack of pedestrian facilities

Charbagh station
Halwasia intersection
Aminabad
Kaiserbagh
G.P.O intersection
Nishatganj intersection
Chowk

- Rail/road level crossings; Traffic bottleneck and total traffic chaos

Sadar
Langra phatak crossing
M.G. marg
Nirala nagar
Talkatora road
Daliganj
Aliganj (sector-J)

- Lack/Absence of road traffic signs
- Traffic signals and manual management not synchronized (Hazratganj- G.P.O etc.)
- Encroachment of road space(Conversion of residential use to commercial; reduction in road capacity)

Aminabad
Tulsidas marg
Subhash marg
Chowk
Gautam Budha marg
Nadan Mahal road etc.

- Encroachment of walkways/corridors/footpaths

  Aminabad, Kaisarbagh, in and aroud Hazratganj
- Road side vegetable/ fruit/ grain/ Tahbazari trading

Kaiserbagh (fish market)	Tulsidas marg
Rekabganj (grain market)	Aminabad(fruit market)
halwasiya	Alambagh
Narahi	Hardoi road

- Waiting, loading / unloading of passengers by tempos or rickshaws, buses, Tata Sumos on intersections.
- Poor traffic management and enforcement upon Aminabad, Aishbagh, Chowk, IT college, Nishatganj.
- Lack of public awareness about traffic regulation and rules.
- Goods vehicles have increased 6 times whereas cars, 2-wheelers have increased 1-3 times.
- Being a capital city and a centrestage of state politics, a lot of rallies and processions carried out by various political parties take place in the central core area (M.G.marg, G.P.O. park,etc.) causing further disruption in traffic.

5.2.2.4Transport modes and growth of vehicles

- Main public modes—City bus, Tempo, cycles, rickshaw ,carts (tonga)
- Heterogeneity of traffic with as many as 14 modes, from a hand pulled cart loaded with heavy weight to heavy trucks or buses
- Predominance of slow moving vehicles nearly 70 %; cycles share 59.20%
- Private modes—both slow and fast predominant over the public modes
- Share of public slow mode is higher than the public fast mode
- Public transportation by corporation city buses is highly inefficient and time consuming; Tata Sumos and tempos provide a better service
- Slow vehicle like cycle rickshaw and carts (tongas) may not resister further growth but their present number plying on road is quite disturbing
- Growth of vehicle population high as shown in the ***table no: 5.17***

Table 5.17 Growth of vehicle population in Lucknow (1990-2001)

Year	Total no. of registered fast vehicles(as percentage)
1990-91	22,246
1991-92	19,877(-10.6)
1992-93	13,866(-30.2)
1993-94	16,124(16.3)
1994-95	18,883(17.1)
1995-96	22,521(19.3)
1996-97	26,244(16.5)
1997-98	28,910(10.1)
1998-99	33,618(16.3)
1999-00	41, 733(24.1)
2000-01	44,977(7.8)
Total	2,88,999(102.2)

Source: R.T.O , Transport Nagar, Lucknow

5.2.2.5 Road accidents *(map no: 5.4)*

- Fatality rate has gone up from 0.20 in 1989 to 0.25 in 1995 as the total number of accidents have increased from 790 (1989) to 1033(1995).
- Some accidental prone areas are:

  G.T.I crossing at Faizabad road, Junction of Ring road and Sitapur road, Badshah nagar crossing on Faizabad road, Ashok marg crossing at Faizabad road under flyover, junction of ashok marg and Nishatgang market roads, Mawaiya crossing at Kanpur road, eagress and ingress junctions of Aishbagh flyover, Bapu bhawan crossing, Gomti barrage junction at Uptron and Prem Narain road, etc.

5.2.2.6 Speed and Delay

- By observation, it can be stated that there is low journey speeds of traffic stream particularly in the core area of the city; on an average 5-10 km / hour during peak hours.
- Stretches where average speed (peak hour) is 5-10 km /hr

  Vidhan Sabha marg(near G.P.O)

  Nadan Mahal road (Rakabganj, Tulsidas marg)

Gautam Budha marg (Near G.P.O)

Ganga Prasad marg (Aminabad, Rakabganj)

- Stretches where average travel speed greater than 15-20 km/hr but less than 30 km/hr

  Ashok marg

  Station road (near K.K.C College)

  M.G marg

  Kanpur road (Tehri pulia - Alambagh)

- Reasons for low speeds:
  - High volume of slow traffic
  - Inadequate carriageway
  - Encroachment along the roads
  - Poor road surface
- Speed in newly developing parts of the city like Mahanagar, Indira nagar, Gomti nagar, etc. comparatively higher

5.2.2.7 Bus terminals

- Inter city bus system has a high load factor of 67%
- Existing bus depots at Charbagh, Kaiserbagh and Amausi are inadequate
- Intra city bus system is highly inefficient; very time consuming
- Kaiserbagh bus depot located in highly congested area
- Inadequate parking facilities at the bus depots
- No stations for the intracity city bus facility

5.2.2.8 Emission from vehicles

Vehicular emissions are assuming alarming proportions in urban area. The different factors causing this tremendous increase in emissions are the types of engines used, the age of vehicles, increase in number of vehicles, poor road conditions, congested traffic, type of fuel used etc.

Emissions causing concern are carbon dioxide, oxides of nitrogen, unburnt hydrocarbons, and particulates. Emission factors of the five criteria pollutants viz., CO, HC, NO_x, SPM and SO_2, with respect to the different range of technologies considered in the analysis is presented in ***Table no: 5. 18***

Table 5.18 Emission factors & Fuel consumption of different modes by type of technology under a typical urban driving cycle in India

S.No	*Type of technology & mode*	*Average emission factors across different technologies(g/km)*					*Fuel cons.*
		CO	*HC*	*NO_x*	*SPM*	*SO_2*	*(km/l)*
1.	Pre-1984 car	28.9	6.2	2.3	0.33	0.12	10.5
2.	Post-1984 car	9.5	1.5	1.9	0.25	0.08	13.36
3.	Post-1994 car	2.6	0.3	0.6	0.08	0.06	14.8
4.	Diesel car	1.1	0.28	0.99	2.0	0.39	11.0
5.	2-stroke motor cycle	2.48	3.18	0.053	0.15	0.02	55.762
6.	2-stroke scooter	3.38	3.06	0.05	0.15	0.02	54.11
7.	4-stroke motor cycle	1.9	0.72	0.39	0.08	0.03	72.6
8.	2-stroke moped	4.5	3.2	0.07	0.08	0.02	60.81
9.	3-wheeler auto	9.0	7.5	0.26	0.3	0.02	21.38
10.	Diesel heavy duty vehicle	12.7	2.1	21.0	3.0	1.5	3.5

Source: IIP. 1994. Vehicle emissions and control perspectives in India- a state of the art report. Engines laboratory, Indian Institute of petroleum, Dehradun

Annual emissions of five criteria pollutants Co, HC, NO_x, SPM, and SO_2 by different modes and technologies of transport are estimated by using the following equation,

$$P = N_{ij} * E_i * EF_i$$

where, P denotes emissions expressed in gms/day

N_{ij} denotes vehicles of type i in year j

E_i denotes effective kms traveled per day per vehicle

EF_i emission factors (gm/km) of vehicle of type i

And is shown in ***table no : 5.19***

Table 5.19 Estimated emissions of pollutants from vehicles, year 2000-01

S.No	***Type of Pollutant***	***Total daily emission(t/day) (%)***	***Share of loading by different modes in t/day***	
			Gasoline driven ***Vehicles(%)***	*Diesel driven* ***vehicles (%)***
1.	CO	38.3 (46.4)	30.8 (58.8)	7.5 (28.0)
2.	HC	23.1 (28.0)	21.6 (41.2)	1.5 (5.6)
3.	NOx	12.5 (15.2)	2.0 (3.8)	10.5 (39.2)
4.	SPM	7.0 (8.5)	1.2 (2.3)	5.8 (21.6)
5.	SO_x	1.6 (1.9)	0.1 (1.9)	1.5 (5.6)
	Total	***82.5 (100.0)***	***52.4 (100.0)***	***26.8 (100.0)***

It is observed that gasoline driven vehicles are a major source of CO emissions contributing about 80 per cent of the total CO emissions; diesel driven vehicles contribute 85 per cent of emissions of oxides of nitrogen.

5.2.2.9 Energy consumption by different modes of transport

The petrol and diesel consumption in the city are calculated using the following equations:

$$V_{ij} = N_{ij} * E_i * 365$$

$$F_{ij} = V_{ij} / FE_i$$

Where , N_{ij} denotes vehicles of type i in year j

E_i denotes effective kms traveled per day

V_{ij} denotes no. of kms traveled annually by vehicles of type i

FE_i denotes fuel efficiency of vehicle (kms/ litre)

F_{ij} denotes fuel consumed by vehicles of type i in year j

Fuel efficiency of different vehicles is as shown in ***table no: 5.18***

The total energy demand by various vehicles in the year 2000-01 is estimated using the above formulae and presented in ***Table no: 5.20***

Table 5.20 Estimated energy demand by various technologies and modes (2000-01)

S. No.	*Energy type*	*Type of vehicles*	*Energy demand by various tech. & mode (KL)*	*%age of the total*
1.	Gasoline (petrol)	2-wheeler	31740.5	15.2
2.		3-wheeler	12098.0	5.8
3.		Car, jeep & taxi	27910.5	13.4
		Total	**71755.0**	
4.	Diesel	Car, jeep & taxi	77048.1	36.9
5.		Bus, mini bus	40921.7	19.6
6.		Others	18862.0	9.1
		Total	**136831.0**	
	Total		***208586.0***	***100.0***

5.2.2.10 Design capacity and level of service of major arterial and sub-arterial roads

When a road is carrying traffic equal in volume to its capacity under ideal roadway and traffic conditions, the operating conditions become poor. Speed drops down and the delay and frequency of stops mount up.

The **capacity flow** or the maximum possible flow on a roadway or a traffic lane is attained at a particular optimum speed, the flow decreases at higher as well as lower speed values. Capacity flow is reached when all the vehicles flow as a stream at this optimum speed with no opportunity for overtaking; at this speed the level of service is considered to be fairly low when the volume of the road reaches the capacity or the volume to capacity ratio approaches a maximum possible value of 1.0.

The Highway Capacity Manual (HCM) has introduced the concept of "**Level of Service**" to denote the level of facility one can derive from a road under different operating characteristics and traffic volumes. The concept of level of service is defined as "a qualitative measure describing the operational conditions within a traffic stream, and their perception by motorists and/or passerby"[14].

Various factors are considered for the evaluation of level of Service like operating speed, travel time, traffic interruptions, freedom of maneuver, driving comfort, safety, economy etc. However, to simplify the concept HCM considers two factors:

- The ratio of service volume to capacity
- The operating or travel speed

The characteristics of different levels of service for urban arterials and sub-arterials are summarised below:

Level of service	**Operating characteristics**
A	The average overall travel speed is 80 K.P.H or more. Relatively free flowing, with service volume capacity ratio of 0:60 or less.
B	Stable flow. Average overall travel speed drops down to 40 K.P.H. or more. Slight delay is common. Service volume/capacity ratio is 0.70 or less.
C	Stable flow, with acceptable delays. Average travel speed drops down to 30 K.P.H. or more. Service volume/capacity ratio is 0.80 or less.
D	approaching unstable flow, with tolerable delay. Average overall travel speed drops down to 25 K.P.H. Service volume/capacity ratio about 0.90 or less.
E	Unstable flow with congestion and intolerable delay. Average overall travel speed about 25 K.P.H. Service volumes are at capacity, or nearabouts.
F	Forced flow, with jammed conditions. Average overall travel speed below 15 K.P.H. Demand volume /capacity ratio may well exceed 1.0.

For design purposes, a level of service of C is perhaps suitable for urban streets.

Peak hour volume count was done for arterial and sub-arterial streets of the city, on the basis of which average hourly traffic volume was calculated. The level of service was later calculated by taking the service volume to design capacity ratio. The P.C.U. factor of vehicles and the design capacity standards are given in ***table no: 5.21*** and ***table no:5.22*** respectively.

Table 5.21 P.C.U. Factor of vehicles

S.No.	Vehicle	P.CU. factor
1.	Car	1.0
2.	Bus / Truck	2.2
3.	Auto-rickshaw	0.5
4.	Two-wheeler	0.4
5.	Pedal cycle	0.7
6.	Bullock cart	4.6
7.	Hand cart	4.6
8.	Cycle rickshaw	1.5

Table 5.22 Design-service volume for urban roads

			P.C.U/hours	
S.No	Types of carriageway	Arterial	Sub-arterial	Collector
1.	2 lane one way	2400	1900	1400
2.	2 lane two way	1500	1200	900
3.	3 lane one way	3600	2900	2200
4.	4 lane undivided	3000	2400	1800
5.	4 lane divided	3600	2900	-
6.	6 lane undivided	4800	3800	-
7.	6 lane divided	5400	4300	-
8.	8 lane divided	7200	-	-

Source: Indian Road Congress. 1980

The Average hourly traffic and the level of service of major roads in the city is as shown in ***Table no: 5.23*** and ***map no: 5.5***

5.2.2 RAILWAYS

5.2.3.1 Railway Network *(map no: 5.6)*

Lucknow is an important railway station of Northern and North-Eastern railways; the major railway lines being:

- Lucknow-Kanpur
- Lucknow-Gorakhpur
- Lucknow-Delhi
- Lucknow-RaeBareilly-Allahabad-Varanasi

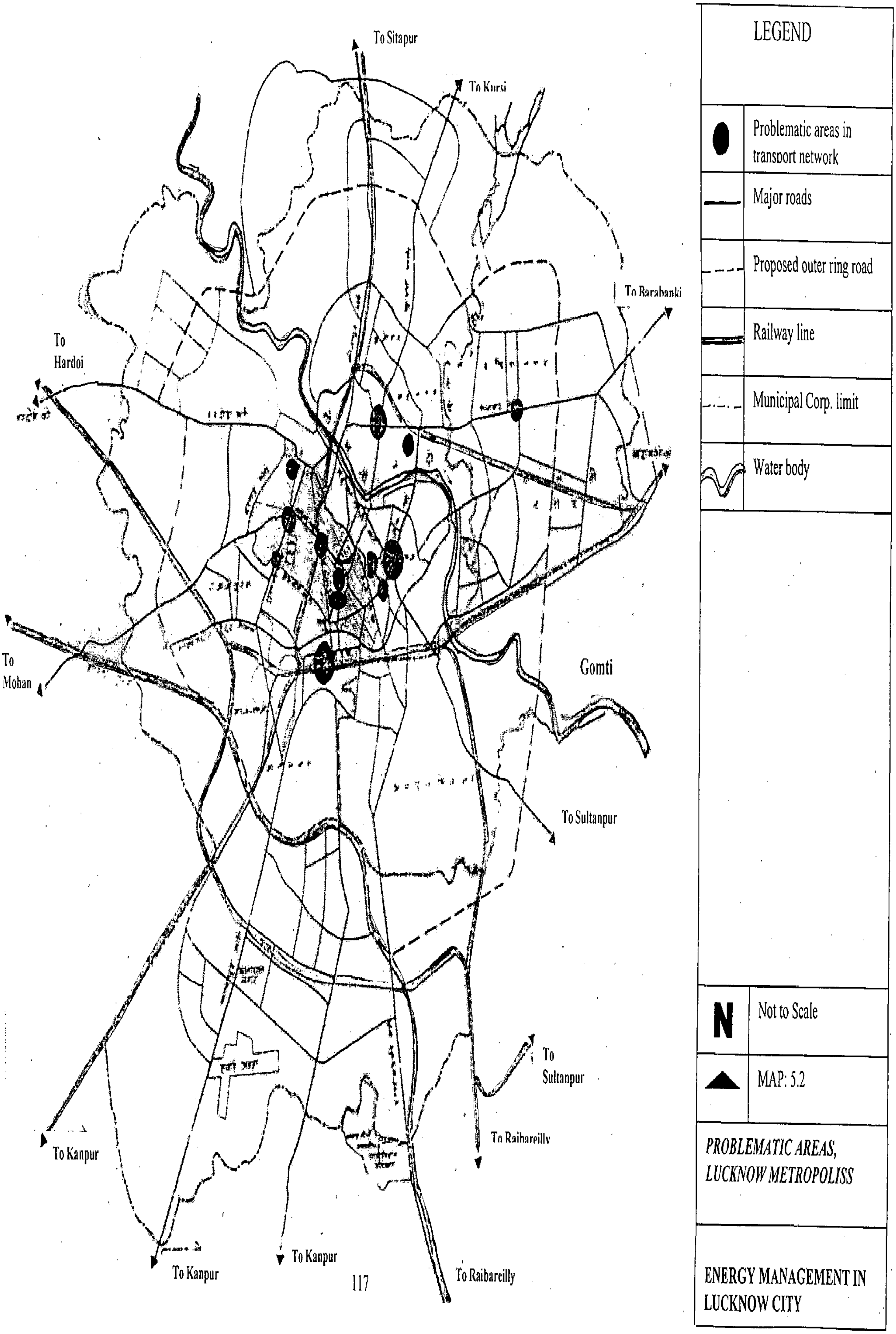
The two railway corridors of the Northern (NR) and North-eastern (NER) railways pass through the whole city, cutting old parts as well as newly developed areas. There is great potential of using it for intra city transport.

Stations:

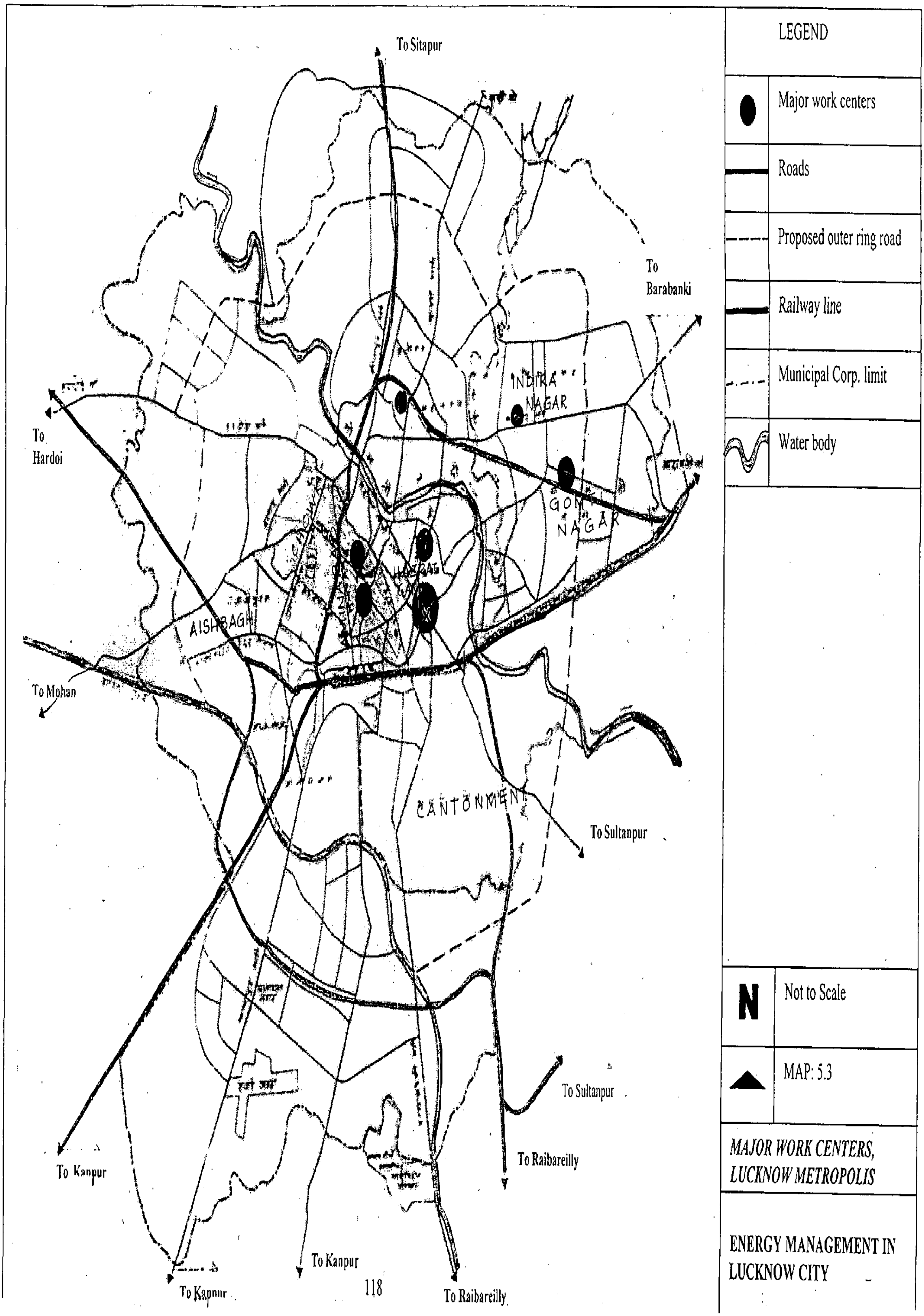
The NER line has got six stations in the city, while the NR line has got three stations.

Table 5.23 Average hourly traffic (AHT) & Level of service of major roads

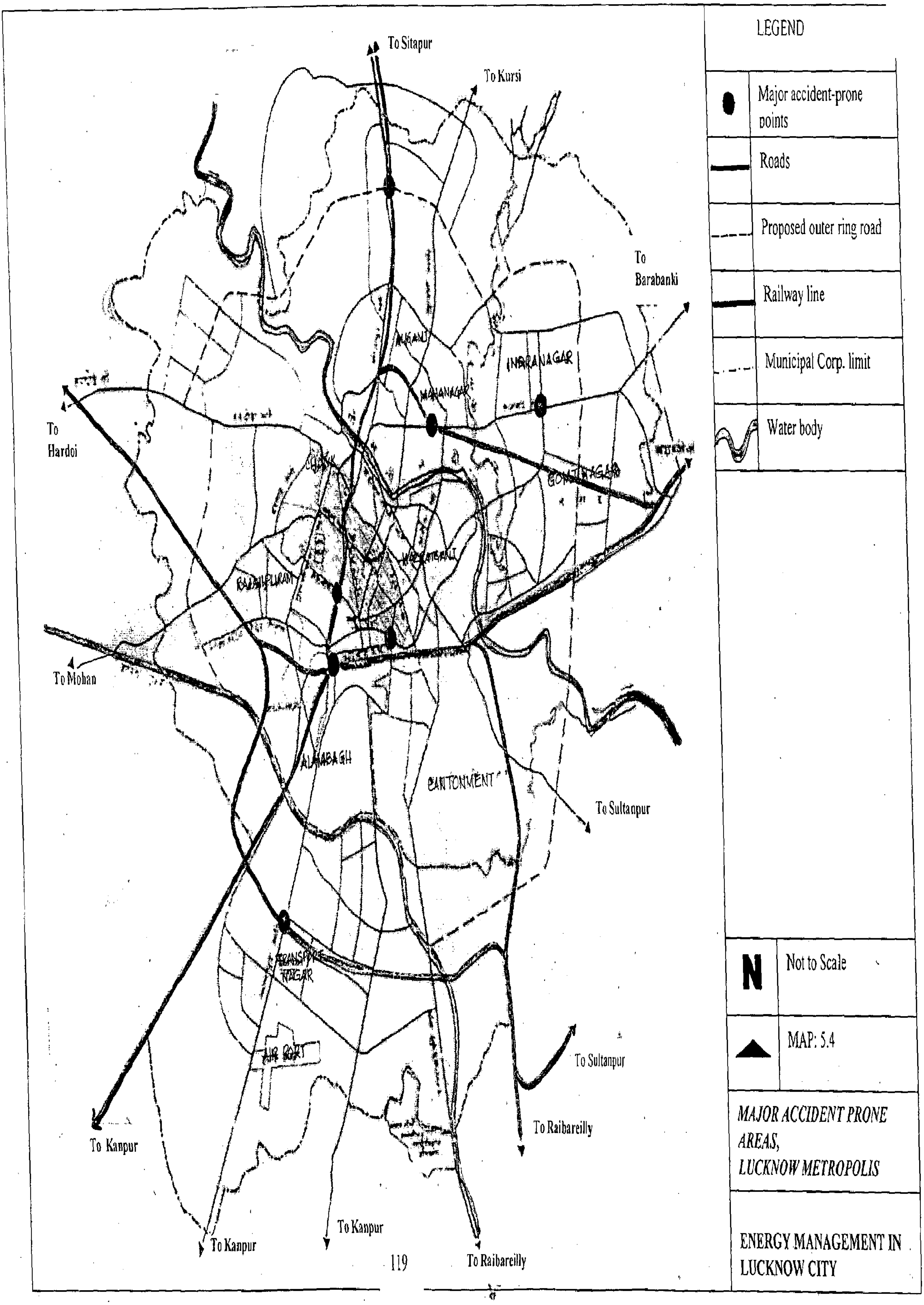
S.No	*Road*	*AHT(in P.C.U)*	*Service volume/design capacity*	*Level of service*
1.	Nishatganj marg & Ashok marg	3265	1.09	F
2.	Vidhan Sabha road	4315	1.4	F
3.	Station road	7309	2.03	F
4.	Tulsidas marg	2263	0.6	A
5.	Subhash marg	2631	0.9	D
6.	Aishbagh road	1987	0.8	C
7.	M.G.marg	7539	2.0	F
8.	Gautam Buddha road	1790	1.0	F
9.	University road	2415	0.8	C
10.	Kalidas road	983	0.5	A
11.	Sitapur road	1450	0.5	A
12.	Kanpur road	2495	0.8	D
13.	Faizabad road	1260	0.9	D



To Sitapur
To Kursi
To Barabanki
To Hardoi
To Mohan
Gomti
To Sultanpur
To Sultanpur
To Raibareilly
To Raibareilly
To Kanpur
To Kanpur
To Kanpur
LEGEND
Problematic areas in transport network
Major roads
Proposed outer ring road
Railway line
Municipal Corp. limit
Water body
N
Not to Scale
MAP: 5.2
PROBLEMATIC AREAS, LUCKNOW METROPOLISS
ENERGY MANAGEMENT IN LUCKNOW CITY

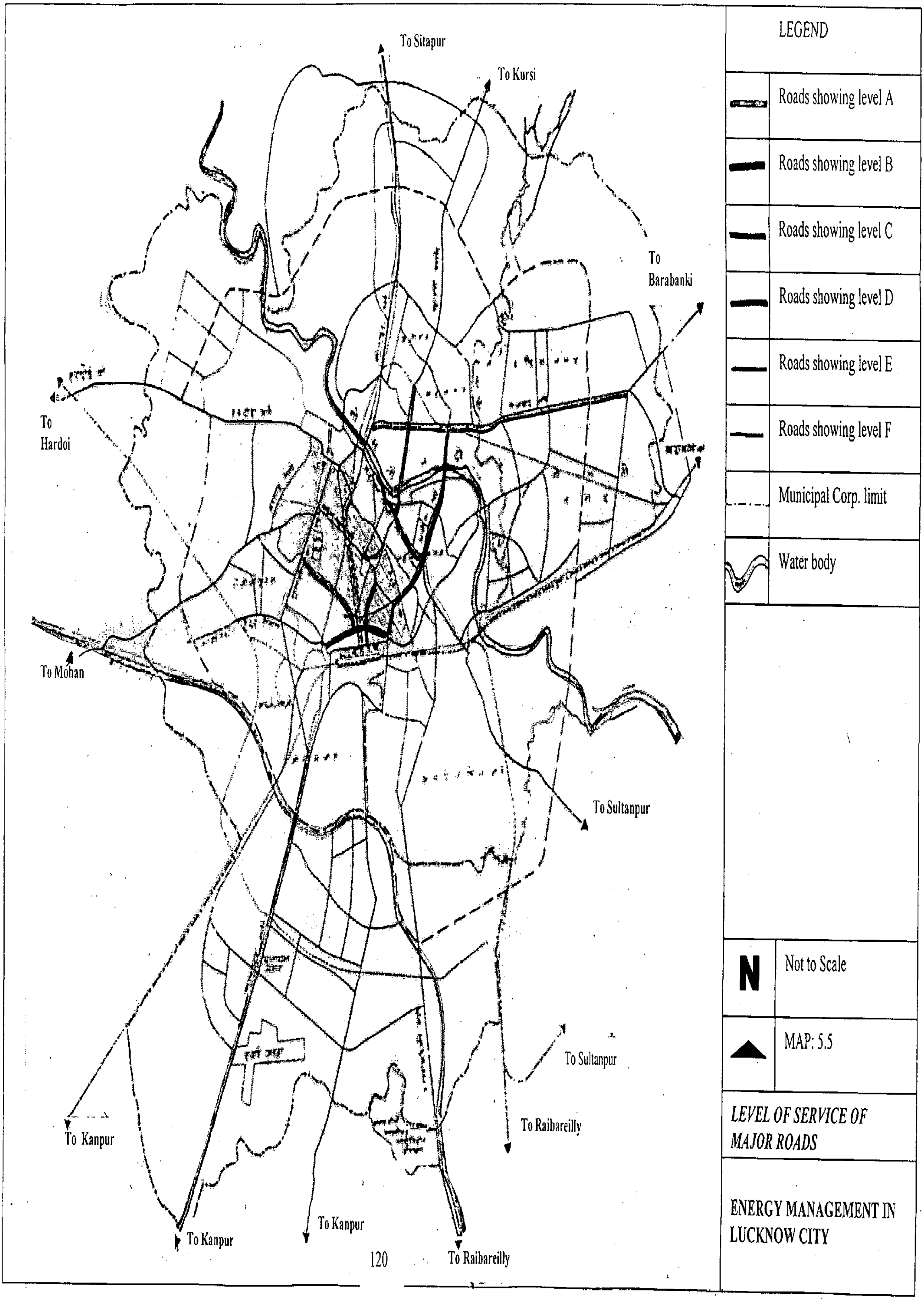


MAJOR WORK CENTERS, LUCKNOW METROPOLIS



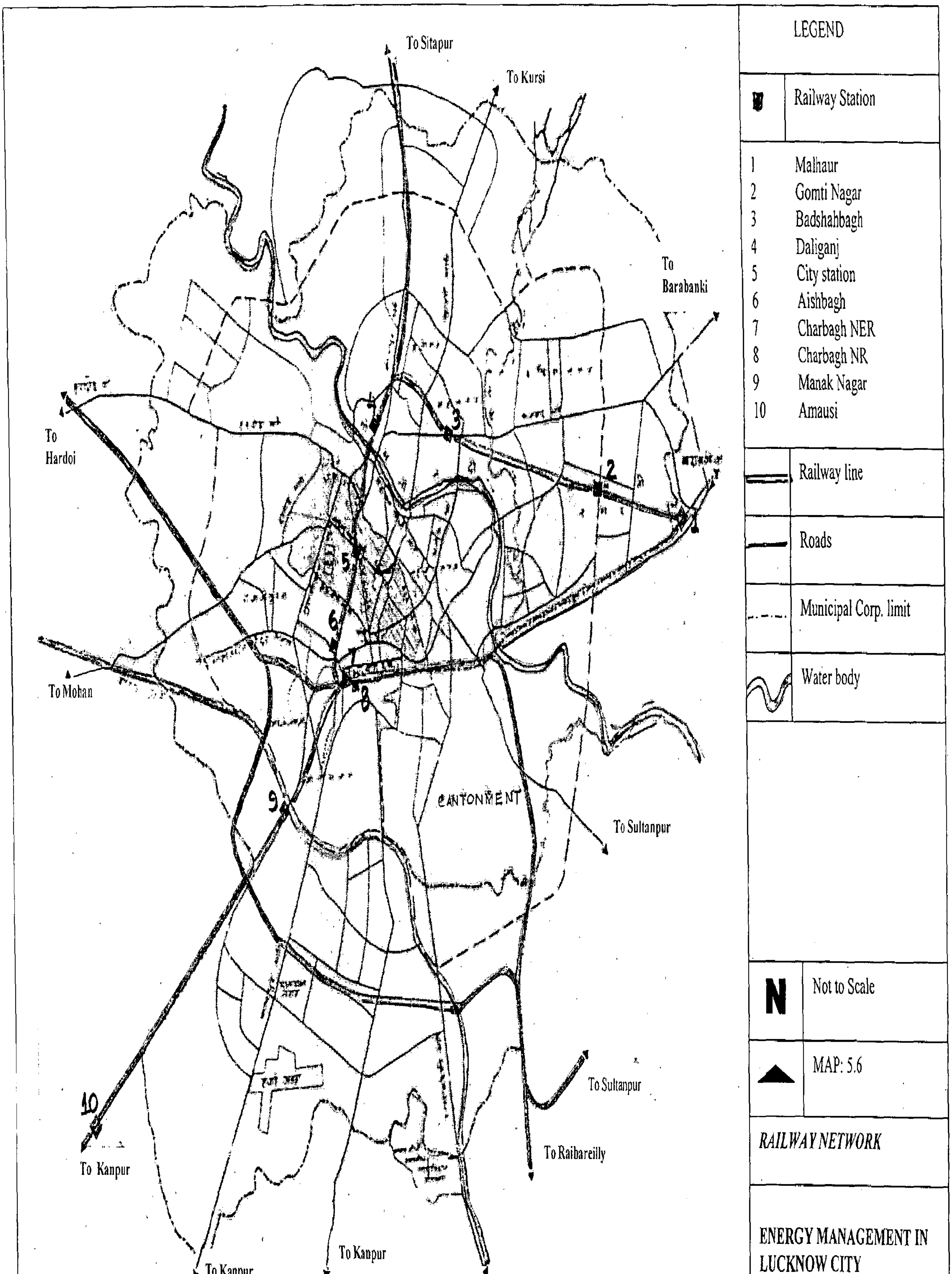
MAJOR ACCIDENT PRONE AREAS, LUCKNOW METROPOLIS

ENERGY MANAGEMENT IN LUCKNOW CITY



LEVEL OF SERVICE OF MAJOR ROADS

ENERGY MANAGEMENT IN LUCKNOW CITY



LEGEND
Railway Station
1 Malhaur
2 Gomti Nagar
3 Badshahbagh
4 Daliganj
5 City station
6 Aishbagh
7 Charbagh NER
8 Charbagh NR
9 Manak Nagar
10 Amausi
Railway line
Roads
Municipal Corp. limit
Water body
N
Not to Scale
MAP: 5.6
RAILWAY NETWORK
ENERGY MANAGEMENT IN LUCKNOW CITY
To Sitapur
To Kursi
To Barabanki
To Hardoi
To Mohan
To Sultanpur
CANTONMENT
To Sultanpur
To Raibareilly
To Kanpur
To Kanpur
To Kanpur
To Raibareilly

CHAPTER 6

FORECASTING THE DEMAND AND SUPPLY OF ENERGY

Any future plans cannot be made unless the potential growth of population is not known. Forecasting is therefore, an important aspect of the study as based on its accuracy proposals shall be made. Owing to the rapid rate of change due to various factors, the forecasting has been done only for the next five years (2000-05). Statistical tools like Business-As-Usual (BAU)/ Trend analysis has been used for forecasting.

6.1 POPULATION

This is the focal point of the study as based on the forecasts of this section is related all the other sub-sections.

Total population of the city in the year 1991 = 1,619,115

Total population of the city in the year 2001 = 2,350,126

Using Geometric increment method,

$$P_n = P_o (1+r)^n$$

Where, P_n = Forecasted population of n years

P_o = Population at present

n = number of years

R = rate of growth

To find r,

$$P_{2001} = P_{1991} (1+r)^{10}$$

$$(1+r)^{10} = 2350126/ 1619115$$

$$= 1.45$$

Therefore, r = 1.0378 – 1

= 0.038

Therefore, the total population in the year 2005 shall be,

$$P_{2005} = P_{2001}(1+r)^5$$

$$= 2350126(1+ 0.0378)^5$$

$$= 2,829,172$$

Therefore, increase in population = 2,829,172 – 2,350,126

= 479,046

6.2 ELECTRICITY

Through the survey conducted in the selected sample households, the average per capita consumption of electricity is 49.76 units per capita per month.

Thus, the present requirement of electricity is,

Electricity required = 2350126* 49.76 KWh/month

= 116942269.8 KWh/month

= 116942.27 MWh/month

Therefore yearly consumption = 116942.27*12

= 1403307.2 MWh/year

Now, taking the same trend (BAU scenario) and assuming an increase in per capita consumption at the rate of 10 percent, the future requirement has been calculated.

The present per capita consumption is 49.76 KWh/month

Taking 10 percent growth rate per annum, per capita consumption in 2005 will be 72.85 KWh/month

Future requirement of electricity,

Electricity required = 2829172*72.85 KWh/month

= 206105180.2 KWh/month

= 206105.18 MWh/month

Therefore, yearly consumption = 206105.18 * 12

= 2473262.2 MWh/yr

Increase in demand in the year 2005,

= 2473262.2 – 1403307.2

= 1069955 MWh

At present, the annual quantity of electricity supplied to the domestic sector in the city is 899091 MWh

The present shortfall for supply of electricity in the city is,

= 1403307.2 – 899091

= 504216 MWh

Future shortfall in the year 2005 (Assuming BAU scenario),

= 504216+1069955

= 1574171 MWh

6.3 PETROL

Through the survey conducted in the sample households, the average per capita consumption of petrol is 3.01 litres per capita per month

Thus, the requirement of petrol in the domestic sector is,

= 2350126 * 3.01

= 7073879.3 litres/month

= 84886.55 KL/ year

The sales figure indicates an increase in per capita consumption at the rate of 10 per cent. Now taking the same trend the future requirement for petrol in the year 2005 has been calculated

The per capita consumption of petrol in the year 2005 (@ 10 per cent growth) will be 4.406 litres/ month.

Future requirement of petrol in the year 2005,

= 2829172 * 4.406

= 12465331.8 litres/ month

= 149583.98 KL/year

Increase in demand in the year 2005,

= 149583.98 – 84886.55

= 64697.4KL

Present supply of petrol = 71755 KL

Present shortfall of petrol = 84886.6 – 71755

= 13131.6 KL

Future shortfall of petrol in the year 2005,

= 13131.6 + 64697.4

= 77829 KL

6.3 DIESEL

In the domestic sector, the survey indicates there's hardly any consumption of diesel. However, the sales data show that the consumption of diesel is much greater than gasoline (petrol) in the city. The reason being diesel is widely used by heavy vehicles, public transportation and industry.

The consumption of diesel indicates that there is a growth of 10 per cent. Following this trend, forecasting has been done for future requirements of diesel in the city.

Present requirement and supply,

= 136831 KL per year

Future requirement (in the year 2005)

= 200333 KL

Future shortfall of diesel,

= 200333– 136831

= **63502 KL**

6.4 L.P.G

Through the survey conducted in the selected sample households, the average per capita consumption of L.P.G is 3.4 kg per capita per month.

Thus, the present requirement of L.P.G is,

= 2350126 * 3.4 kg/month

= 7990428.4 kg/month

= 7990.43 MT/month

or 95885.1 MT/year

Future requirement of L.P.G assuming the same per capita consumption (trend analysis),

= 2829172 * 3.4

= 9619184.8 kg/month

= 9619.18 MT/month

or 115430.2 MT/year

The increase in demand in the year 2005,

= 115430.2-95885.1

= 19545 MT/year

Present supply of L.P.G,

= 96821 MT/year

Thus, present excess in L.P.G supply,

= 96821- 95885.1

= 935.9 MT

Future shortfall of L.P.G supply,

= 19545-935.9

= **18609.1 MT**

6.5 SOLID WASTE GENERATION

Through the survey conducted in the selected sample household, the average per capita per day waste generation is estimated at 650 grams.

Present waste generation,

= 2350126 * 0.650 kg/day

= 1527581.9 kg/day

= 1527.6 T or 1552 Metric tons per day

Present waste collection,

= 900 M. tons per day

Present backlog in waste collection,

= 1552-900 M. tons per day

= 652 M. tons per day

Future waste generation assuming the same per capita waste generation (2005),

= 2829172 *0.65 kg/day

= 1838961.8 kg/day

= 1838.9 T /day or 1868.4 M.tons /day

If the waste collection by the Municipal Corporation remains same, the **future backlog in the year 2005,**

= 1868.4-900 M.tons/day **or 968.4 M. tons/day**

FEASIBILITY STUDY

Solid wastes have been taken as an alternate source for energy recovery in the present investigation. Biomethanisation technique is proposed to be adopted for the purpose as it ensures minimal stress on ecology. It is a technique, which anaerobically digests the organic fraction of the waste, to recover biogas and organic manure.

The biogas could be connected with a gas engine to recover valuable electrical and thermal energy. The electrical energy could be fed to the state electricity grid. The residue following digestion being rich in nutrients could be used as organic manure and could be an effective substitute for synthetic fertilizer.

A feasibility study has, therefore, been attempted to ensure for a municipal solid waste treatment (MSW) plant in this present investigation. Economic and technical feasibility analyses have been carried out in this regard.

7.1 ECONOMIC FEASIBILITY

To conduct the economic feasibility, incurring costs to the plant, and the benefits obtained is worked out. If the benefit to cost-ratio is greater than unity, then the project is considered to be economically feasible.

Taking 300 tons per day of assured Municipal Solid waste (MSW) supply by the Municipal Corporation and using any competent Biomethanisation technology, following has been found.

Daily feed = 300 TPD

Organic content = 40-45 % or approx. 116 TPD

Biogas generation = 49137 m^3

(@0.42 m^3 from 1 kg of volatile solids)

Total power expected to be generated from biogas = 129488 kWh/day

(@ 2.2 KWh of electrical energy and 3.1 KWh of thermal energy from $1m^3$ of biogas)

Internal consumption of power = 14477 KWh/day

Surplus power to grid = 115011 KWh/day

Bio-fertiliser production (after drying) = 71 TPD

Incurring costs

Incurring costs include the plant setup costs, infrastructure costs, operation and maintenance costs. ***Table no: 7.1*** and ***Table no: 7.2*** give an estimation of the estimated incurring costs.

Table 7.1 Initial plant setup cost

S.No.	*Item*	*No.*	*Unit cost in Rs (in lakhs)*	*Total cost in Rs (in lakhs)*
Mechanical				
1.	Weighing machine	1	5	5
2.	Wheel loaders	3	30	90
3.	Press	4	200	800
4.	Conveyor belt system	1	60	60
5.	Mechanical pulper	3	220	660
6.	Agitators	3	40	120
7.	Feeding pumps(to digester)	2	15	30
8.	BIMA internal parts, heating tubes & control system	6	80	480
9.	Screw press feed pumps	2	8	16
10.	Screw press	2	60	120
11.	Press water feed pumps	1	4	4
12.	Drying equipment tiller, heating tubes & conveyor belt	1	350	350
13.	Bagging machine	1	20	20
14.	Gas holder	1	150	150

15.	Protection silo	1	40	80
16.	Blowers	1	35	35
17.	Gas engines	3	520	1560
18.	Boiler & steam turbine	1	500	500
19.	Flare	1	30	30
20.	Conveyor	1	30	30
21.	Tractor &Trailer	1	6	6
22.	Tippers	2	14	28
23.	Forklift	2	12	24
24.	DM plant	1	10	10
25.	Electrical, lab equipments, piping, instrumentation etc.		600	600
26.	Preoperative expenses, engineering, experts' visits, training of staff etc.		assuming 5% of the total cost	385
27.	BIMA Digester	6		2040
28.	Civil work including construction of building, infrastructure etc.)		Assuming 31.5% of the total cost	2429
	Total			**7717**

Table 7.2 Operation and maintenance costs

S.No.	*Item*	*Total cost per annum (in lakhs)*
1.	Spares (per year)	49.1
2.	Lubricants	39.2
3.	Mechanical/electrical maintenance	28.9
4.	Reserve per year for major overhaul of engine /8 yrs.	97.4
5.	Diesel	16.5
6.	Bags for organic manure (3502 bags /day @ Rs 0.5697/bag)	7.1
7.	Laboratory chemicals	5.8
8.	Stationary	0.6
9.	Telephone/fax	5.8
10.	Grit removal	51.8
11.	Land	0.2
12.	Salary	51.1
13.	Royalty(to the Municipal Corporation)	14.5
	Total	**370**

<u>Revenue generated</u>

The benefits include the tariff generated by selling of electricity generated and other by-products (organic manure) produced.

Power tariff taken as Rs2.86/KWh (2001 prices) as fixed by the Ministry of Non-conventional Energy Sources, MNES, an agency of Government of India, with 5 per cent escalation in revenue for the first 12 years and by 4, 3, and 2 per cent respectively for the next six years.

Revenue from the sale of organic manure would be at the rate of Rs. 3000/ton, with 5 per cent escalation in revenue each year, for the first 12 years and by 4, 3 and 2 per cent for the next six years.

Calculation of Pay-back period

Scenario 1: without any subsidy and taking 18 per cent as the rate of interest by the financial agency on the amount taken

Investment cost + operation & maintenance cost = 7717 + 370

= 8087 lakhs

In the **first** year,

Revenue generated by selling of power = 115011*2.86*360

= 1170 lakhs

Revenue generated by selling of organic manure = 3000*71*360

= 766 lakhs

Total revenue generated = 1936 lakhs

Taking 10 per cent as net profit of the entrepreneur = 193.6 lakhs

Interest to be paid in 1st year = 1455.6 lakhs

Therefore, the amount left to be paid at the end of 1st year

= (8087+1455.6)-(1936-193.6)

= 7800.2 lakhs

In the **second** year,

Revenue generated by selling of power = 115011*3.00*360

= 1229 lakhs

Revenue generated by selling of organic manure = 3150*71*360

= 805 lakhs

Total revenue generated = 2034 lakhs

Taking 10 per cent as net profit of the entrepreneur = 203.4 lakhs

Interest to be paid in 2nd year = 1404 lakhs

Therefore, the amount left to be paid at the end of 2nd year

= (7800.2+1404)-(2034-203.4-370)

= 7743.6 lakhs

In the **third** year,

Revenue generated by selling of power = 115011*3.15*360

= 1291 lakhs

Revenue generated by selling of organic manure = 3307*71*360

= 845 lakhs

Total revenue generated = 2136 lakhs

Taking 10 per cent as net profit of the entrepreneur = 213.6 lakhs

Interest to be paid in 3rd year = 1393.8 lakhs

Therefore, the amount left to be paid at the end of 3rd year

= (7743.6+1393.8)-(2136-213.6-370)

= 7585 lakhs

In the **fourth** year,

Revenue generated by selling of power = 115011*3.30*360

= 1352 lakhs

Revenue generated by selling of organic manure = 3472*71*360

= 887 lakhs

Total revenue generated = 2239 lakhs

Taking 10 per cent as net profit of the entrepreneur = 223.9 lakhs

Interest to be paid in 4th year= 1365.3 lakhs

Therefore, the amount left to be paid at the end of 4th year

= (7585+1365.3)-(2239-223.9-370)

= 7305.2 lakhs

In the **fifth** year,

Revenue generated by selling of power = 115011*3.46*360

= 1418 lakhs

Revenue generated by selling of organic manure = 3645*71*360

= 931 lakhs

Total revenue generated = 2349 lakhs

Taking 10 per cent as net profit of the entrepreneur = 234.9 lakhs

Interest to be paid in 5th year = 1314.9 lakhs

Therefore, the amount left to be paid at the end of 5th year

= (7305.2+1314.9)-(2349-234.9-370)

= 6876 lakhs

In the **sixth** year,

Revenue generated by selling of power = 115011*3.63*360

= 1487.9 lakhs

Revenue generated by selling of organic manure = 3827*71*360

= 978.2 lakhs

Total revenue generated = 2466.1 lakhs

Taking 10 per cent as net profit of the entrepreneur = 246.6 lakhs

Interest to be paid in 6th year = 1237.7 lakhs

Therefore, the amount left to be paid at the end of 6th year

= (6876+1237.7)-(2466.1-246.6-370)

= 6264.2 lakhs

In the **seventh** year,

Revenue generated by selling of power = 115011*3.81*360

= 1561.7 lakhs

Revenue generated by selling of organic manure = 4019*71*360

= 1027.2 lakhs

Total revenue generated = 2588.9 lakhs

Taking 10 per cent as net profit of the entrepreneur = 258.9 lakhs

Interest to be paid in 7th year = 1127.6 lakhs

Therefore, the amount left to be paid at the end of 7th year

= (6264.2+1127.6)-(2588.9-258.9-370)

= 5431.8 lakhs

In the **eighth** year,

Revenue generated by selling of power = 115011*4*360

= 1656.3 lakhs

Revenue generated by selling of organic manure = 4220*71*360

= 1078.6 lakhs

Total revenue generated = 2734.9 lakhs

Taking 10 per cent as net profit of the entrepreneur = 273.4 lakhs

Interest to be paid in 8th year = 977.7 lakhs

Therefore, the amount left to be paid at the end of 8th year

= (5431.8+977.7)-(2734.9- 273.4-370)

= 4318 lakhs

In the **ninth** year,

Revenue generated by selling of power = 115011*4.2*360

= 1739 lakhs

Revenue generated by selling of organic manure = 4431*71*360

= 1132.6 lakhs

Total revenue generated = 2871.6 lakhs

Taking 10 per cent as net profit of the entrepreneur = 287.1 lakhs

Interest to be paid in 9th year = 777.2 lakhs

Therefore, the amount left to be paid at the end of 9th year

= (4318+777.2)-(2871.6- 287.1-370)

= 2880.7 lakhs

In the **tenth** year,

Revenue generated by selling of power = 115011*4.41*360

= 1825.9 lakhs

Revenue generated by selling of organic manure = 4652.6*71*360

= 1189.2 lakhs

Total revenue generated = 3015.1lakhs

Taking 10 per cent as net profit of the entrepreneur = 301.5 lakhs

Interest to be paid in 10th year = 518.5 lakhs

Therefore, the amount left to be paid at the end of 10th year

= (2880.7+518.5)-(3015.1- 301.5-370)

= 1055.6 lakhs

In the **eleventh** year,

Revenue generated by selling of power = 115011*4.63*360

= 1917.2 lakhs

Revenue generated by selling of organic manure = 4885.2*71*360

= 1248.7lakhs

Total revenue generated = 3165.9 lakhs

Taking 10 per cent as net profit of the entrepreneur = 316.5 lakhs

Interest to be paid in 11th year = 190 lakhs

Therefore, the amount left to be paid at the end of 11th year

= (1055.6+190)-(3165.9- 316.5-370)

= -1233.8 lakhs

Thus, the **payback period** comes out to be **10 and a 1/2-year.**

Scenario 2: With a subsidy of 5 per cent and taking 18 per cent as the rate of interest by the financial agency on the amount taken

Investment cost + operation & maintenance cost = 7717 + 370

= 8087 lakhs

In the **first** year,

Revenue generated by selling of power = 115011*2.86*360

= 1170 lakhs

Revenue generated by selling of organic manure = 3000*71*360

= 766 lakhs

Total revenue generated = 1936 lakhs

Taking 10 per cent as net profit of the entrepreneur = 193.6 lakhs

Interest to be paid in 1st year = 1051.3 lakhs

Therefore, the amount left to be paid at the end of 1st year

= (8087+1051.3)-(1936-193.6)

= 7395.9 lakhs

In the **second** year,

Revenue generated by selling of power = 115011*3.00*360

= 1229 lakhs

Revenue generated by selling of organic manure = 3150*71*360

= 805 lakhs

Total revenue generated = 2034 lakhs

Taking 10 per cent as net profit of the entrepreneur = 203.4 lakhs

Interest to be paid in 2nd year = 961.5 lakhs

Therefore, the amount left to be paid at the end of 2nd year

= (7395.9 + 961.5)-(2034-203.4-370) = 6896.8 lakhs

In the **third** year,

Revenue generated by selling of power = 115011*3.15*360

= 1291 lakhs

Revenue generated by selling of organic manure = 3307*71*360

= 845 lakhs

Total revenue generated = 2136 lakhs

Taking 10 per cent as net profit of the entrepreneur = 213.6 lakhs

Interest to be paid in 3rd year = 896.6 lakhs

Therefore, the amount left to be paid at the end of 3rd year

= (6896.8+896.6)-(2136-213.6-370)

= 6241 lakhs

In the **fourth** year,

Revenue generated by selling of power = 115011*3.30*360

= 1352 lakhs

Revenue generated by selling of organic manure = 3472*71*360

= 887 lakhs

Total revenue generated = 2239 lakhs

Taking 10 per cent as net profit of the entrepreneur = 223.9 lakhs

Interest to be paid in 4th year= 811.3 lakhs

Therefore, the amount left to be paid at the end of 4th year

= (6241+811.3)-(2239-223.9-370)

= 5407.2 lakhs

In the **fifth** year,

Revenue generated by selling of power = 115011*3.46*360

= 1418 lakhs

Revenue generated by selling of organic manure = 3645*71*360

= 931 lakhs

Total revenue generated = 2349 lakhs

Taking 10 per cent as net profit of the entrepreneur = 234.9 lakhs

Interest to be paid in 5th year = 702.9 lakhs

Therefore, the amount left to be paid at the end of 5th year

= (5407.2+702.9)-(2349-234.9-370)

= 4366 lakhs

In the **sixth** year,

Revenue generated by selling of power = 115011*3.63*360

= 1487.9 lakhs

Revenue generated by selling of organic manure = 3827*71*360

= 978.2 lakhs

Total revenue generated = 2466.1 lakhs

Taking 10 per cent as net profit of the entrepreneur = 246.6 lakhs

Interest to be paid in 6th year = 567.6 lakhs

Therefore, the amount left to be paid at the end of 6th year

= (4366+567.6)-(2466.1-246.6-370)

= 3084.1 lakhs

In the **seventh** year,

Revenue generated by selling of power = 115011*3.81*360

=1561.7 lakhs

Revenue generated by selling of organic manure = 4019*71*360

= 1027.2 lakhs

Total revenue generated = 2588.9 lakhs

Taking 10 per cent as net profit of the entrepreneur = 258.9 lakhs

Interest to be paid in 7th year= 400.9 lakhs

Therefore, the amount left to be paid at the end of 7th year

= (3084.1+400.9)-(2588.9-258.9-370)

= 1525 lakhs

In the **eighth** year,

Revenue generated by selling of power = 115011*4*360

= 1656.3 lakhs

Revenue generated by selling of organic manure = 4220*71*360

= 1078.6 lakhs

Total revenue generated = 2734.9 lakhs

Taking 10 per cent as net profit of the entrepreneur = 273.4 lakhs

Interest to be paid in 8th year = 198.3 lakhs

Therefore, the amount left to be paid at the end of 8th year

= (1525+198.3)-(2734.9- 273.4-370)

= - 368.2 lakhs

Thus, the **pay back period** is coming to be **seven and a half-year** in this case.

The **financial models** showing the financial feasibility of the project is shown in ***Table no: 7.3, 7.4, 7.5 and 7.6*** respectively.

7.2 TECHNICAL FEASIBILITY

Factors to be considered for ensuring the technical feasibility of the plant include, the contents of the solid wastes, the amount of MSW (municipal solid waste) produced daily, the amount which can be provided by the corporation, composition of the waste, and the minimum daily feed required for the proper running of the plant.

Table no: 7.7 give the composition of MSW and the assured daily feed by the Municipal corporation.

Table 7.7 Typical composition of MSW in Lucknow

1.	Total quantity of waste generated	1500 Ton/day
2.	Collection	65-66 %
3.	Moisture content	25-30 %
4.	Solid content	70-75 %
5.	Organic content	40-45 %
6.	Nitrogen	0.2 - 0.6%
7.	Phosphorous	0.8 - 6.8%
8.	Fe, Cu, Zn	Traces
9.	Daily feed	300TPD(113-120 TPD of organic part)

Source: Non-conventional Energy Development agency (NEDA), Lucknow

WITHOUT SUBSIDY & INTEREST RATE OF 18%

	Year 1	2	3	4	5	6	7	8	9	10	11	
COSTS (in lakhs)												
Initial cost (Plant setup)	7717											
Operation & Maintenance	370	370	370	370	370	370	370	370	370	370	370	
Interests	1455.6	1404	1393.8	1365.3	1314.9	1237.7	1127.6	977.7	777.2	518.5	190	
Total costs	*9736.2*	*1977.4*	*1977.4*	*1959.2*	*1919.8*	*1854.3*	*1756.5*	*1621.1*	*1434.3*	*1190*	*876.5*	*26302.7*
BENEFITS (in lakhs)												
Revenue by sale of power	1170	1229	1291	1352	1418	1487.9	1561.7	1656.3	1739	1825.9	1917.2	
Revenue by sale of manure	766	805	845	887	931	978.2	1027.2	1078.6	1132.6	1189.2	1248.7	
Total benefits	*1936*	*2034*	*2136*	*2239*	*2349*	*2466.1*	*2588.9*	*2734.9*	*2871.6*	*3015.1*	*3165.9*	*27536.5*
Net profit taken by private Investor	193.6	203.4	213.6	223.9	234.9	246.6	258.9	273.4	287.1	301.5	316.5	
Net cash flow (in lakhs)	7800.2	56.6	158.6	279.8	429.2	611.8	832.4	1113.8	1437.3	1825.1	2289.4	16834.2

Table 7.3 Costs- benefits of the Municipal solid waste based plant(Case 1)

1. Payback period:
   Without subsidy and at an interest rate of 18%; 10 & ½ years

2. Accounting rate of return (ROI)
   Calculation of the rate of return from an investment by adjusting cash inflows produced by the investment for depreciation. Approximates the accounting income earned by the investment.

$$\frac{\text{(Total benefits- Total costs- depreciation)/ useful life}}{\text{Total initial investment}} = \frac{(27536.5-16566.5-9736.2)/11}{9736.2} = 1.15\%$$

3. Cost-benefit ratio

$$\frac{\text{Total benefits}}{\text{Total cost}} = \frac{27536.5}{26302.7} = 1.05$$

4. Net present value (NPV)
   The amount of money an investment is worth, taking into account its cost, earnings and the time value of money
   Present value of the benefits = $27536.5* \frac{1-(1+18)^{-11}}{18}$ = 1529.8 lakhs

   Net present value = Present value – initial investment cost
   = 8206.4 lakhs
   Thus, the net present value of the investment is 8206.4 lakhs over a period of eleven years

5. Profitability index
   NPV/ Investment = 1529.8/9736.2 = 0.15

Table 7.4 Financial models to determine the financial basis for the Municipal solid waste based plant (Case

WITH A SUBSIDY OF 5% & INTEREST RATE OF 18%

	Year 1	2	3	4	5	6	7	8	
COSTS (in lakhs)									
Initial cost (Plant setup)	7717								
Operation & Maintenance	370	370	370	370	370	370	370	370	
Interests	1051.3	961.5	896.6	81.3	702.9	567.6	400.9	198.3	
Total costs	*9138.3*	*1534.9*	*1480.2*	*1405.2*	*1307.8*	*1184.2*	*1029.8*	*841.7*	*17922.1*
BENEFITS (in lakhs)									
Revenue by sale of power	1170	1229	1291	1352	1418	1487.9	1561.7	1656.3	
Revenue by sale of manure	766	805	845	887	931	978.2	1027.2	1078.6	
Total benefits	*1936*	*2034*	*2136*	*2239*	*2349*	*2466.1*	*2588.9*	*2734.9*	*27536.5*
Net profit taken by private investor	193.6	203.4	213.6	223.9	234.9	246.6	258.9	273.4	
Net cash flow (in lakhs)	7202.3	499.1	655.8	833.8	1041.2	1281.9	1559.1	1893.2	14966.4

Table 7.5 Costs- benefits of the Municipal solid waste based plant(Case 2)

1. Payback period:
   Without subsidy and at an interest rate of 18%; 7 & ½ years

2. Accounting rate of return (ROI)
   Calculation of the rate of return from an investment by adjusting cash inflows produced by the investment for depreciation. Approximates the accounting income earned by the investment.

   (Total benefits- Total costs- depreciation)/ useful life = (27536.5-8783.8-9138.3)/8 = 13.2%
   -- = ----------------------------
   Total initial investment 9138.3

3. Cost-benefit ratio
   Total benefits 27536.5
   ------------- = -------- = 1.5
   Total cost 17922.1

5. Net present value (NPV)
   The amount of money an investment is worth, taking into account its cost, earnings and the time value of money
   Present value of the benefits = $27536.5 * \frac{1-(1+13)^{-8}}{13}$ = 2118.2 lakhs

   Net present value = Present value – initial investment cost
   = 7020.1 lakhs
   Thus, the net present value of the investment is 7020.1 lakhs over a period of eight years

6. Profitability index
   NPV/ Investment = 2118.2/9138.3 = 0.23

Table 7.6 Financial models to determine the financial basis for the Municipal solid waste based plant (Case 2)

CHAPTER 8

POLICY GUIDELINES FOR OPTIMAL ENERGY MANAGEMENT IN LUCKNOW CITY

8.1 POLICY GUIDELINES FOR OPTIMAL ENERGY MANAGEMENT IN LUCKNOW CITY

The following set of policy guidelines are evolved and recommended for optimal utilization of energy in Lucknow City. As the study has been done in detail for domestic and transport sectors only, specific recommendations are given for the same: general recommendations are also given to the rest of the sectors.

8.1.1 METHODS OF SUPPLY AUGMENTATION

This section primarily deals with augmentation of electricity supply through non-conventional technologies and innovative methods.

- **Setting up of a 5 MW Municipal Solid Waste (MSW) based power plant**

Municipal solid waste has been considered as a resource in this present investigation. The city generates huge quantity of solid waste everyday i.e., 1500 tonnes per day of which the collection is about 900 tonnes per day (60%). These solid wastes have been found technically feasible to be used as a resource for production of electricity by using Biomethanisation technology.

A detailed Feasibility study (economic and technical) has been carried out as presented in Chapter 7. The project is thus, found to be a good choice for serving the dual purpose of solving the ever increasing problem of waste treatment on one hand, and for producing 5 MW electricity per day (41,403.9 MWh/year) on the other.

This will serve to reduce the present energy gap by 8.2% and the future gap (year 2005) by 2.6%, as the electricity produced is proposed to be sold to the Electricity Board for supply to the Grid.

- **Night soil based power plants for Domestic and Street lighting**

Twin objectives can be achieved based on these plants, such as, producing methane gas and generating electricity, and reducing the intensity of accumulating the quantity of night soil in the system. This will help in reducing the load on other commercial energy, thus will be effective and also will require low maintenance cost. For example, in Banares, and in Mumbai night soil based plants are working perfectly, and the output are being supplied to the household either for cooking, space heating or for lighting.

- **Mini hydel at Thermal power plant cooling water tail-ends**

Mini hydel potential at Thermal power plant cooling water tail ends is a potential source of energy retrieval, efficiency and conservation. A large thermal mini-hydel hybrid system symbolically fulfills non-fossil fuel obligations by the generation of conventional power.

Studies have been conducted by UPSEB (Uttar Pradesh State Electricity Board) and some potential thermal power plants have been found for the purpose. Singrauli, Rihand and Unchahar thermal power plants are found to hold a potential of 3.0, 1.50 and 0.25 MW respectively.

This will reduce the present energy gap by 7.6% and the future energy gap(year 2005) by 2.5%.

- **Power generation from co-generation projects**

A cogeneration facility is defined as one, which simultaneously produces two or more forms of useful energy such as electric power and steam, electric power and shaft power, etc. Cogeneration facilities, due to their ability to utilise the available energy in more than one form, use significantly less fuel input to produce electricity, steam, shaft power or other forms of energy than would be needed to produce them separately. Thus, by achieving higher efficiency, cogeneration facilities can make a significant contribution to energy conservation.

Sugar industry is a potential source of bagasse based cogeneration. The combined potential of the working sugar mills and the proposed new sugar mills in the state were estimated to be about 600-700 MW during 1994-95.

Even if 10 per cent of this is achieved in five years, supply augmentation will be of the order of 60 MW (1,336,500 kWh or 1336.5 MWh/day or 481,140 MWh/year) and thus, can fill *a major portion of the city's present energy gap (of 504,216 MWh/yr, 2001) by 95% and the future energy gap (year 2005) by 30.5%.*

There is a huge potential of cogeneration in other industries also like paper & pulp, cement, chemical, pharmaceutical, etc. But attempts have not been made yet to find the estimated potential.

- **Promotion of market development and infrastructure development for propagation of Renewable energy technologies**

The city has nodal agency, Non-conventional Energy Development Agency (NEDA). Inspite of this, the household survey reveals that only one household employed these technologies. The Renewable energy Technologies (RETs) has a great potential to lessen the energy gap and shall be very effective as a long-term measure for reducing the energy gap.

The barriers to their commercialisation like lack of user confidence, information dissemination, unreliable after-sales service, lack of credit infrastructure, poorly developed markets, etc. need to be removed.

Solar Photovoltaic (PV) and Solar thermal have a good potential in the area and the technologies should be made more popular. To increase the market penetrability of these Renewable energy technologies (RETs), subsidy should be directed for promoting market development and infrastructure development at the local level.

8.1.2 ENERGY EFFICIENCY AND CONSERVATION MEASURES/DEMAND SIDE MANAGEMENT(DSM)

Energy efficiency and conservation are very much essential tools for energy management. It buys time for expanding sources of supply. Infact, *every MW of energy saved/conserved is equivalent to a MW generated.*

a) Identification of Energy efficient technologies (EETs) in the Domestic sector

Energy efficient technologies (EETs) seek to provide the same output levels as the conventional technologies, but at a lower rate of energy consumption. Though these Energy efficient technologies (EETs) cost more than the conventional technologies, the increased cost is usually more than compensated through the energy savings achieved over the lifetime of the equipment.

Various energy efficient technologies (EETs) were studied in the given urban context and only those have been selected for implementation in the short run, which are economically feasible as well as have low pay back period.

- **Replace incandescent lamps with circular fluorescent lamps**

The average no. of 60 W bulbs and 100 W bulbs per capita as found in the household survey conducted is 0.8 and 0.84 respectively.

Total energy requirement for old technology (60W)= 2350126*0.80*0.06*2000 (average yearly use per unit is taken as 2000hrs)= 225612096 kWh

Energy requirement for new technology (22W)= 2350126*0.80*0.022*2000
= 142887660.8 KWh

Therefore, annual energy saving = 82724.4 MWh

Total energy requirement for old technology (100W)
= 2350126*0.84*0.100*2000
(Ave. Yearly use per unit is taken as 2000 hrs) = 394821168.8 KWh

Energy requirement for new technology (22W)= 2350126*0.84*0.022*2000
= 86860657.14 KWh

Therefore, annual energy saving = 307,960.5 MWh

If 15% of the total is replaced in 5 years period annual energy saving is cumulated to be **58,602.7 MWh**

(which is sufficient to fill the current energy gap of the city itself)

- **Replace TL fluorescent tubes with TLD fluorescent tubes**

(TL fluorescent tubes have a diameter of 1.5" and are rated at 40 watts. The TLD lamps have a diameter of 1.25" and are rated at 36 watts)

The average no. of TL fluorescent per capita as found in the household survey is 0.94.

Total energy requirement for old technology (40W)= 2350126*0.04*2000*0.94 (average yearly use per unit is taken as 2000hrs)= 176729475.2 KWh

Energy requirement for new technology (36W)= 2350126*0.94*0.036*2000
= 159056527.7 KWh

Therefore, annual energy saving = 17,672.9 MWh

If 15 % of the total is replaced in five years period *annual energy saving is cumulated to be = 2,650.9 MWh*

- **Replace Ceiling fan with efficient fan motor**

The average no. of Ceiling fan per capita as found in the household survey is 1.01.

Total energy requirement for old technology (70W)= 2350126*1.01*0.07*4000 (average yearly use per unit is taken as 4000hrs)= 664615632.8 KWh

Energy requirement for new technology(60W)= 2350126*1.01*0.06*4000
= 569670542.4KWh

Therefore annual energy saving = 94,945 MWh

If 15 % of the total is replaced in five years period *annual energy saving is cumulated to be = 14,241.7 MWh*

- **Replace standard efficiency cooler with high-efficiency cooler**

The average no. of cooler per capita as found in the household survey conducted is 0.38.

Total energy requirement for old technology (230W)

= 2350126*0.38*0.23*1200

(average yearly use per unit is taken as 1200hrs)= 246481214.9 KWh

Energy requirement for new technology (184W)= 2350126*0.38*0.184*1200

= 197184971.9KWh

Therefore annual energy saving = 49,296.2 MWh

If 15 per cent of the total is replaced in five years period, *annual energy saving is cumulated to be = 7394.4 MWh*

- **Refrigerators**

Refrigerators account for about 16 per cent of the total electricity use by the domestic sector. Efficiency of refrigerators used in India is very low. Efficient refrigerators can save 30-35 per cent energy and are cost-effective too, though they have high initial cost. Even with 15 per cent replacement, some 11,167.8 MWh electricity can be saved per year.

Currently, high efficiency refrigerators are not available in the Indian market as they use a different design of compressors, which are very sensitive to the quality of power supplied. Since the technology is not available in India, the option has not been considered.

2) Energy Efficient technologies (EETs) in the Industrial sector

Some of the most economically viable EETs in the industrial sector with small pay back period are:-

- replacement of standard efficient motors with high efficient motors
- replacement of standard efficient industrial pumps by high efficient industrial pumps

- replacement of magnetic ballast by electronic ballast
- TL fluorescent by TLD fluorescent

However, the possible net energy saving could not be worked out due to lack of data.

Good housekeeping and use of Energy management and control systems can bring rich dividends. Energy audit should be made mandatory for all industries. For this, bigger industries or a group of small industries can have an Energy management committee, which can review energy consumption once in every month. This procedure can save a considerable amount of oil and electricity.

The measures can thus be broadly grouped under the following categories:

- General housekeeping and maintenance programs;
- Energy management and accounting systems;
- Improved equipment and procedures for existing production methods; and
- New and better production methods

3) Energy efficient technologies (EETs) in the Commercial sector

The commercial sector mainly uses electricity and petroleum products to meet its demand for lighting, cooking, space conditioning, etc. It is the second largest consumer of electricity next to the domestic sector in the city. The sector offers a large scope for efficiency improvements in electrical appliances, such as, bulbs, fans, air-conditioners, refrigerators as well as oil-based stoves and small generator sets used by shops, hotels and *dhabas.*

Since, a detailed study has not yet been carried out in this sector the exact potential of Energy efficient technologies (EETs) in the sector cannot be analysed. However, even by replacement of incandescent lamps by CFLs, use of A.C.s with higher energy efficiency ratio can result in substantial savings. Provision of cost-effective Energy management and Control system in big commercial centres and institutions (like hospitals, college etc.) can bring huge dividends in terms of saving energy.

Incentives may be given to the commercial centres in the form of tax benefits, etc. for making energy-efficient buildings or it could be made mandatory through introduction of building codes.

4) Energy efficient technologies(EETs) in Agriculture sector

Surveys carried out to measure the efficiency of pumpsets reveal poor operating efficiencies of both electric and diesel pumpsets. Nearly 90 % of the agriculture pumpsets installed are found to be faulty and consume 150-200% more electricity than that required for properly selected pumpsets. Reasons for high electricity consumption in agriculture pumpsets include:

- Improper selection of pumpset size
- Improper selection of foot valves, undersized delivery pipes, improper pipe fittings etc. causing high frictional losses
- Use of pumps with low efficiency

Some of the reasons for no efforts done in connection with energy-efficiency in this sector are:

- Lack of information and knowledge on part of the farmers
- Lack of standardisation, ineffective monitoring and control on the part of the financial institutions
- Highly subsidised flat tariff structure results in shadow pricing. Such a pricing system provide no incentive to limit the hours of operation or to improve pump efficiency

The major efficiency measures to be taken in this direction are:

1. Pump metering , which can reduce electricity use by 5%
2. Rectification of existing pumps, which can reduce electricity use by 30-50%
3. High efficiency pumpsets can bring atleast 20% savings
4. Change in tariff structure by the utility and removal of subsidies
5. Proper dissemination of information regarding Energy efficient technologies (EETs) to the farmers

Table 8.1 Energy saving by Supply augmentation & Demand side management measures

Supply augmentation	Production of energy (per day)	Reduction of energy gap Present (2001)	Future (2005)
1. 5- MW Municipal solid waste (MSW) based power plant	5 MW	8.2%	2.6%
2. Night soil based power plants for Domestic & Street lighting	NA	--	--
3. Mini hydel at Thermal power plant cooling water tail-ends (Singrauli, Rihand & Unchahar)	4.75 MW (3.0, 1.5 & 0.25 MW)	7.6%	2.5%
4. Power generation from c0-generation projects • Sugar industry based co-generation	60 MW	95%	30.5%
5. RETs • Solar photovoltaic • Solar thermal	20 MW/km^2 20 MW/km^2	NA	NA

Demand side management (DSM) measures					
Type of measure	Energy requirement (W) Present tech.	Future tech.	Energy saving (MWh)	Reduction in energy gap (%age) Present (2001)	Future (2005)
1. EETs in the Domestic sector • Replace incandescent lamps with circular fluorescent lamps	60 100	22 22	58,602	11.6	3.7
• Replace TL fluorescent tubes with TLD fluorescent tubes • Replace ceiling fans with efficient fan motors • Replace Standard efficiency cooler with high-efficiency cooler	40 70 230	36 60 184	2,650.9 14,241.7 7,394.4	0.5 2.8 1.5	0.2 0.9 0.5
2. EETs in the industrial sector • Replace standard efficient motors with high efficient motors • Replace standard efficient industrial pumps by high efficient industrial pumps • Replace magnetic ballast by electronic ballast • TL fluorescent by TLD fluorescent	NA	NA	NA	NA	NA
3. EETs in the Agriculture sector • Pump metering • Rectification of existing pumps • Use of high efficiency pumpsets	NA	NA	5% 30-50% 20%	NA	NA

Note: NA --Not available; EET—Energy efficient technology

5) Transport sector

Transportation sector accounts for major part of the city's fossil fuel consumption. The energy consumption in this sector is found to be increasing at the rate of 10 per cent per annum and this demand is bound to increase (as analysed in chapter 6) in future. Given the increasing energy crunch, there is an urgent need for introducing energy-efficiency and energy conservation measures in this sector. The framework suggested to improve the transport in Lucknow city is as shown in ***fig no: 8.1***

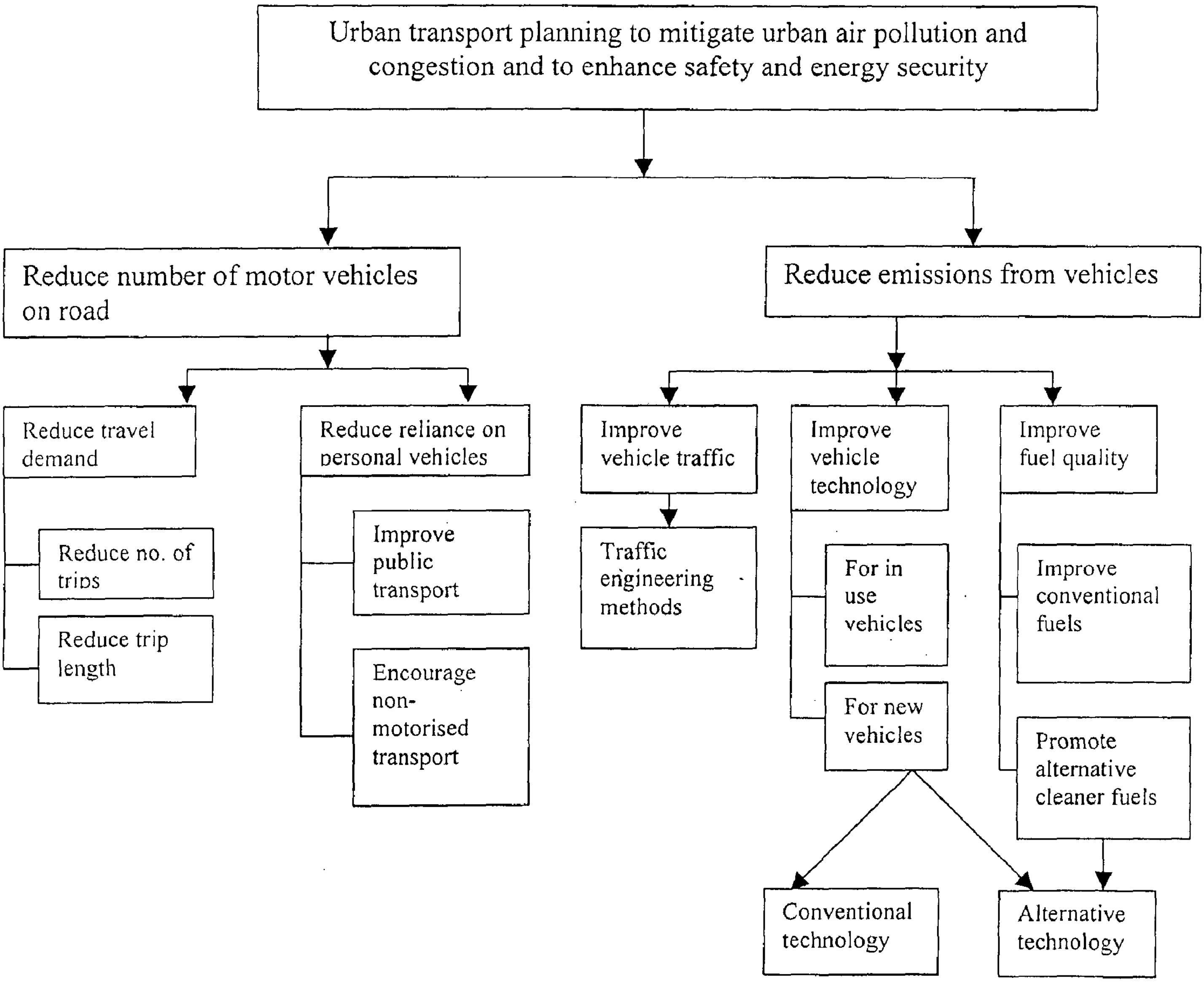


Fig 8.1 Framework to improve transport in Lucknow

There are five principal ways to influence transport systems efficiency and reduce energy consumption:

- Urban land-use planning
- Modal mix
- Behavioural and operational aspects(occupancy of vehicles, driver behaviour, system characteristics)
- Vehicle efficiency and fuel choice
- Traffic management

Urban Land-use planning

Urban land-use planning can optimise transportation activity by allowing public transportation to play a substantial role. This is a LONG-TERM measure.

Lucknow city is following the concentric model of Delhi for development, which is proving suicidal with increasing population. There are a few major nodes occupying the central part of the city. Everybody has to commute from far-off places to these central nodes. The problem being further compounded by the absence of an efficient mass transportation system. If the present system prevails, very soon citizens will be wasting 50 per cent of their working time on streets negotiating to reach their destinations. Thus, the restructuring of urban pattern is a must to make it compatible for the operation of an efficient mass transport system. The switching over of the intra city transportation system from predominately privately owned slow moving modes to efficient mass transport system is a must for every metropolis, and Lucknow is no exception.

Lucknow has the inherent potential to grow as a linear configuration with the railway line as the spinal corridor since it has the natural dynamics to grow along the Lucknow-Kanpur corridor on one side and along the Lucknow-Barabanki corridor on the other. This corridor, which has railway lines and the roads running almost parallel, is the potential spine for making the city dynamic ***(map no: 8.1)***.

To exploit this potential, it is required to freeze the development, which has been planned along the Sitapur road, Rae-Bareily road, and along Hardoi road on the north-west. Incidentally, the development has not responded well on all these sides. Real estate market can play a substantial role in this.

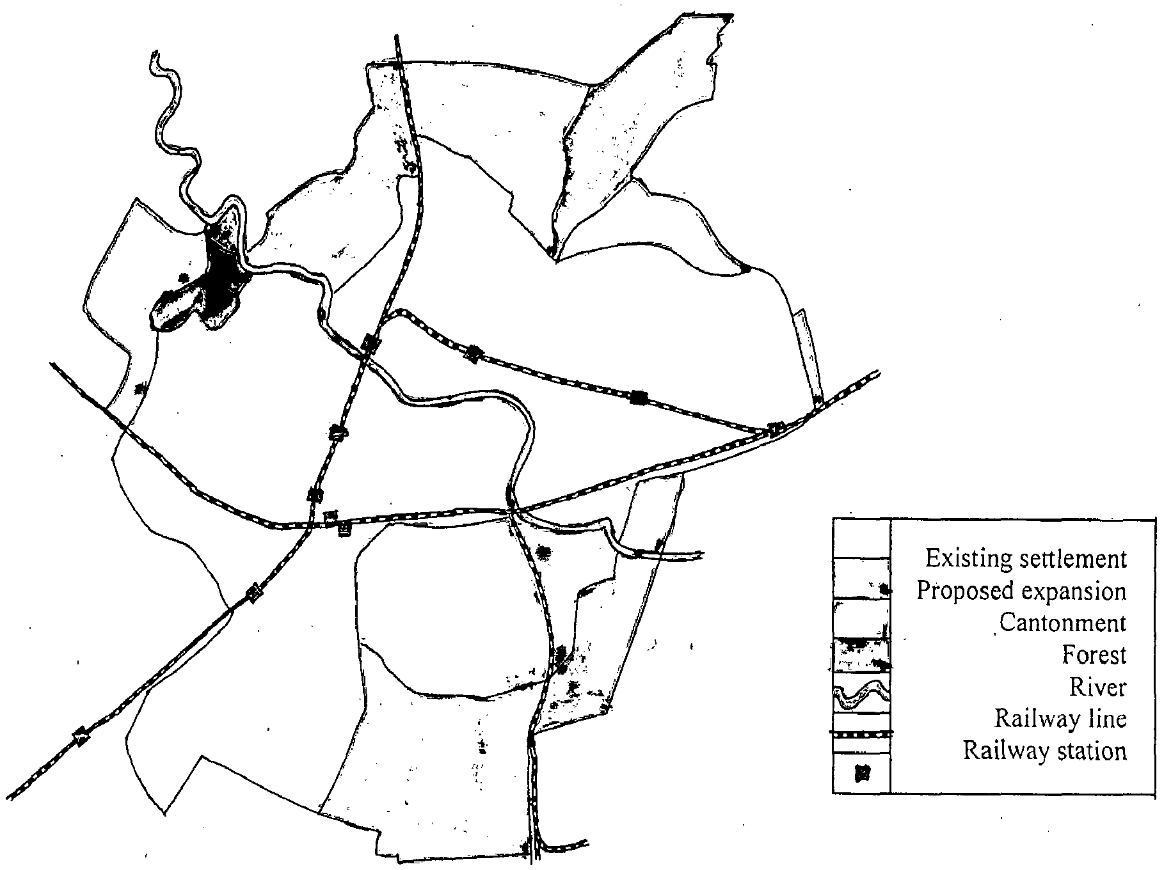
The two railway corridors of the northeastern railway NER and northern railway (NR) could be adopted for intracity traffic- a mass transport medium on account of following reasons:

- The corridors touch different points in the core areas while on the periphery they come together and merge in a single corridor.
- The corridors have a double line traction except for a short stretch
- The major electricity source-Sarojini nagar substation is also located along this corridor making the erection of the transmission lines for energising the EMU cost effective
- The mega activity centers can be located on the Kanpur side, thus, shared and sustained by both Kanpur and Lucknow City making the proposal more viable in economic point of view.

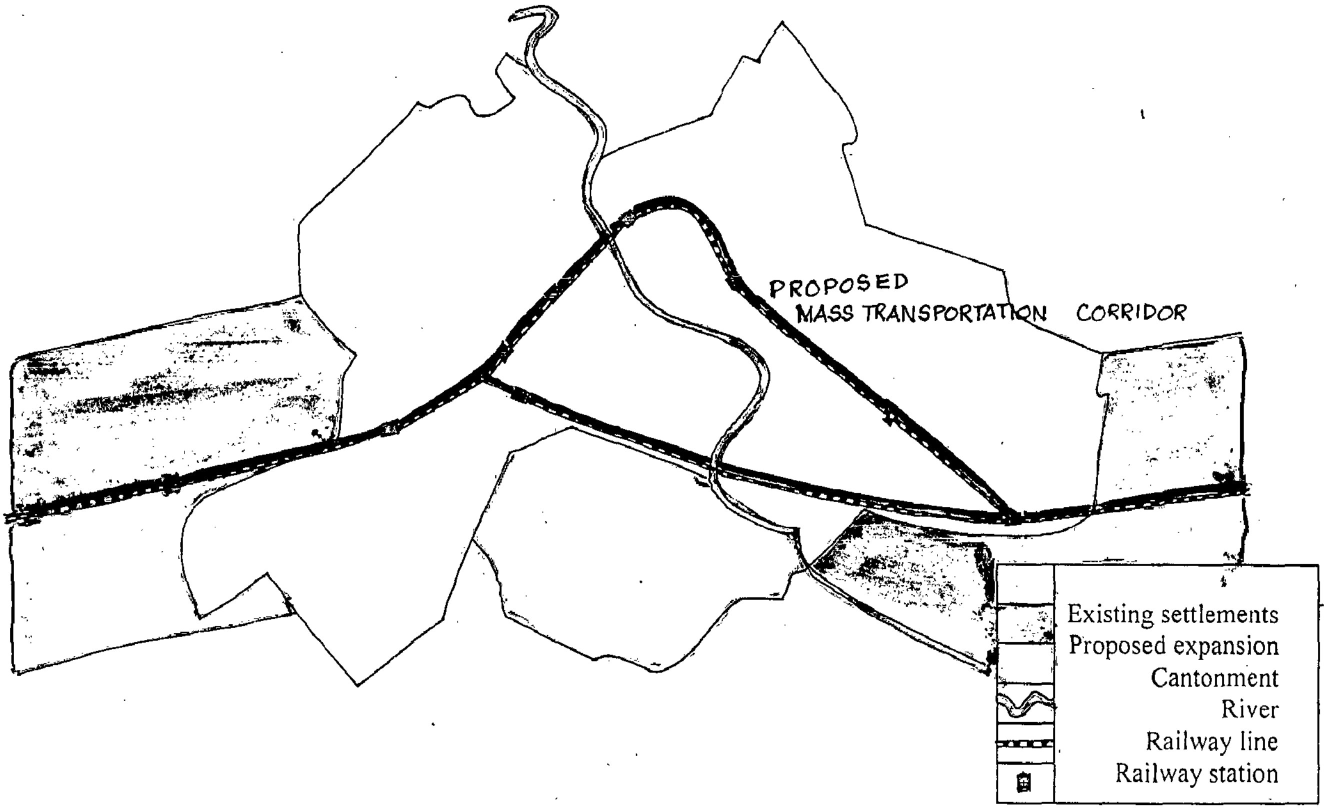
Modal mix

The differences in specific energy consumption per passenger-km for the different modes of motorised travel clearly indicate that the car and two-wheeler consume about two to three times more quantity of energy on a direct and indirect basis than the collective land transport modes.

The efficiency potential thus makes it very clear that public transport need to be given patronage. Efficient use of intermediate public transport (IPT) combined with mass transportation system will reduce the use of private vehicles, definitely.



LUCKNOW MASTER PLAN- 2001



ALTERNATE MASTER PLAN

Map 8.1 Proposed land use with respect to mass transportation

Behavioral and operational aspects

These are mainly non-technical and non-vehicle related influences on the actual fuel consumption of a vehicle, such as, driving behavior, road conditions and traffic flow. Driving behavior, in particular, can be correlated by making the driver visually aware of the (excessive) fuel consumption. Increasing congestion, however, diminishes possible gains in vehicle fuel efficiency (whatever little is there).

Vehicle efficiency and fuel choice

Relatively old vehicle stock and low maintenance vehicle efficiency is found to be much lower. The older technologies like two-stroke engines need to be gradually replaced.

Switching to alternative motor fuels (natural gas, LPG, biofuels) does not generally provide benefits in terms of energy efficiency, rather its benefits are in terms of abating atmospheric pollution or supply security if a domestic resource can be used. The potential even in the better sense is often limited since their introduction requires particular fuelling infrastructure and sometimes considerable changes to vehicles, both at substantial cost.

This option is thus suitable as a long-term measure for private vehicles. Fuels like (Compressed natural gas CNG or preferably Ultra Low sulphur diesel ULSD) are recommended for public mode of transport like bus fleet.

Traffic management

To achieve a sustainable and energy efficient urban transport, the traffic management has to be made effective. Some of the recommendations in this regard for Lucknow city are:

1. To distribute the traffic volume on main corridors, it is suggested the timings of office, schools, financial institutions, commercial establishments should be segregated as follows:
   - Schools 7.30 a.m. – 2 p.m.

- Colleges 8 a.m. – 3 p.m.
- Financial institutions 9 a.m. - 4 p.m.
- Private offices 9.30 a.m. – 4.30 p.m.
- Government offices 10 a.m. – 5 p.m.
- Commercial establishments 11 a.m. – 8 p.m.

2. Chartered buses can be introduced from different directions upto core area of city.
3. Terminal facilities for Public transport to be planned at outer cordon areas
4. Kaiserbagh bus terminal is located in a very congested area and it needs to be shifted to the outer area, where it is feasible.
5. The existing parking facility on all major roads and commercial areas is highly inefficient. An in-depth study need to be done in this regard and accordingly, a holistic plan to be made and implemented to increase the parking facility in major areas. Some proposals in this regard are:
   - The corner of D. N. Park facing Novelty cinema rotary occupied by Water works department can be utilised for the parking of two-wheelers
   - A parking lot is proposed in front of Nishat cinema from National Herald building to Dr. Arora clinic
   - An underground parking is proposed in Daya Nidhan park to fulfill the parking demand in Lalbagh area
   - The road stretch near Bapu Bhawan intersection should be made free from any parking
6. The existing public transport system and IPT intermediate public transport is very inefficient and time consuming. There are no well-designed terminals and the buses stop anywhere. People, especially those using two-wheelers are willing to use public transport if the latter is made efficient.
7. The six -seater Vikrams are major sources of pollution, besides being energy consuming, and need to be removed immediately.

8. Two-way movement is suggested on Vidhan sabha marg, Cantt. Road, Lal Bahadur Shastri marg and Darbari Lal marg. The Sarojini Naidu marg only from Cantt. road "T" junction upto Kabir marg crossing should be made two-way.
9. A railway overbridge is proposed on sadar railroad crossing.
10. All the intersections are recommended to be equipped with computerised digital signal system.

    Information technology can be effectively used for optimal utilization of the existing transport infrastructure with optimum efficiency, enhanced safety, reduced pollution and less congestion. Systems like Advanced traffic management System (ATMS) is recommended for the city. Such systems aim at improving the traffic flow, identify congestion points and accident locations. It can evolve dynamic traffic signal plans to optimise the traffic flow over a network.
11. Wholesale activities in Chowk, Aminabad areas need to be shifted in well-planned phases.
12. The outer ring road provide a by pass to through traffic between major National and State highways and, if completed can greatly reduce the congestion in the core areas. Besides, there can be considerable saving in energy as well, inspite of the increased distance as the vehicle speed in the inner areas varies between 5 to 25 km/h, resulting in a lot of energy wastage and time delay.

    The project therefore, needs to be completed on a priority basis.
13. Water transport

    River Gomti is passing through mid of the city and also connects the major traffic routes like Sitapur road, Kursi road, Ashok Marg, etc. Ferrying starting from ring road at Sardar Patel Bridge to barrage can reduce the traffic load on inner road of the city during peak hours. The feasibility study needs to be done in this regard for viability of the project.

8.1.3 POLICY MEASURES TO BE TAKEN BY THE UTILITY

Some of the broad measures to be taken by the Uttar Pradesh State Electricity board (UPSEB) are as listed below:

- The ***Board should evaluate the Demand and Load curve analysis***. Accordingly, load shifting can be done specially in the industrial and agricultural sectors. There is a considerable scope of energy savings by flattening the system load curve.
- ***Electricity pricing structure***

  The state has one of the lowest tariff rates. Agricultural and low-income residential sectors are highly subsidized, not reflecting the true cost of power generation, transmission and distribution. This results in apathy on the part of end users with regard to energy conservation.

  Subsidies need to be removed from agricultural and domestic sectors whereas curtailable/interruptible rates (These rates credit customers for reducing demand, upon notice from the utility, to a predetermined level. Credits can be based upon the probability of interruption or curtailment) may be targeted at industrial and commercial sectors and feasibility study is recommended to be carried out in these lines.

  A properly devised pricing policy can defer investment in new generation capacities by creating incentives to shift load from peak to off-peak hours as well as inducing users to invest in energy efficient measures.
- ***Metering system***

  The state has a very poor metering system; one-third of its consumers is unmetered. Theft rates are also observed high. Metering should be done at all the feeders and electronic meters that combine high accuracy, anti tamper, multi-tariff billing and communication capabilities (similar to Orissa model) can be employed. This would increase the Board's revenue collection as well, and an improved revenue collection would eventually result in proper maintenance of the existing power plants and further augmentation in supply.

Automated meter reading (AMR) and Power Line Carrier technologies (PLC) (as used in China) can also be worked out in the long run.

- The Board should work with appropriate State and Central government agencies and develop efficiency standards for appliances and equipment. Proper energy labelling need to be made mandatory.
- Various building codes relevant to the area can result in energy-efficient buildings.
- An ***Energy Management Cell*** should be constituted at the Electricity board level, which will look after the demand side management (electricity). It's first two priorities being establishment of Energy Service companies (ESCOs) throughout the state (atleast one in each district headquarter and important towns) and information campaigns on Energy efficient technologies (EETs) and good housekeeping practices.

8.2 ENERGY MANAGEMENT MODEL AT CITY LEVEL

The objective of the study is having efficient energy management system of Lucknow city. Thus, an energy management model has been prepared, in which formation of a managing body is proposed. The body will have all the necessary information –the overall energy scenario- with regard to production, supply, present requirements and future requirements of the city. A database is also proposed to be prepared for this, as it will act as a useful tool for the managing body.

The structure of the managing body is as shown in ***fig no: 8.2***

1. At the highest level of the body, there will be a Chief Managing Director. He will monitor the functions of the body and will keep a track on various activities of the body.
2. The body will be divided into three sections, each headed by a Deputy Chief Managing director
   A) Electricity
   B) Petroleum products
   C) Renewable Energy Technologies(RETs)/Non-conventional methods

A) ELECTRICITY

The section will have three departments; each headed by a Managing Director.

a. Research & Design

The section will deal with carrying out research in developing indigenous technologies with regard to metering system, setting tariff, load curve analysis, modification of imported technology in accordance with suitability at the local level and the likes.

b. Supply

The section will keep a track on the electricity requirements of the city in various sectors, the energy gap, collection of bills, power theft, faults in transmission lines, etc. Thus, it will maintain a complete record of the supply of electricity in the city. The section will have three teams for different areas of the city; each team covering two planning zones.

c. Demand Side Management

This section will have a very important role to play. The section will have following divisions:

- Public Relations/communications
- Market research, technical assessment, planning and program evaluation
- Program design and implementation
- Industrial sector
- Commercial sector
- Domestic sector
- Agricultural sector
- Sales

All the above divisions will support each other for launch of programs from conception to implementation and program evaluation.

B) PETROLEUM PRODUCTS

The section will have three departments; each headed by a Managing director.

a. Research & Design

The section will deal with carrying out feasibility study of new fuel types (like CNG or ULSD); change in engine design, improved cooking stoves, methods of replacing diesel with less polluting fuels in industrial sector etc.

b. Supply

This section will keep a track on the city's requirements in various sectors for petrol, diesel and L.P.G. It will interact with Petrol pumps and gas agencies. It will also keep into account the probable future requirement of the petroleum products in each sector. The section may have 3 teams; each covering two planning zones of the city.

c. Demand side management

The section will be headed by a Managing Director and will have 3 divisions; each headed by a DSM manager. The three divisions will be for:

I. ***Petrol***

II. ***Diesel***

III. ***L.P.G. and Kerosene***

Each division will have a DSM group with following sub-divisions:

- Public Relations/communications
- Market research, technical assessment, planning and program evaluation
- Program design and implementation
- Industrial sector
- Commercial sector
- Domestic sector
- Agricultural sector
- Sales

C) RENEWABLE ENERGY TECHNOLOGIES(RETs)/ NON-CONVENTIONAL METHODS

The section will have 4 departments as follows:

a. Production

This section will look after new ways of producing energy through Solid waste based power plant, night soil based plant, biogas based power, and the likes.

b. Research & design

This will deal with finding out as to which RETs are suitable for application in the city and coming up with indigenous technologies of energy production and also modification of imported technology in accordance with suitability at the local level. The section can cover the whole district.

c. Supply

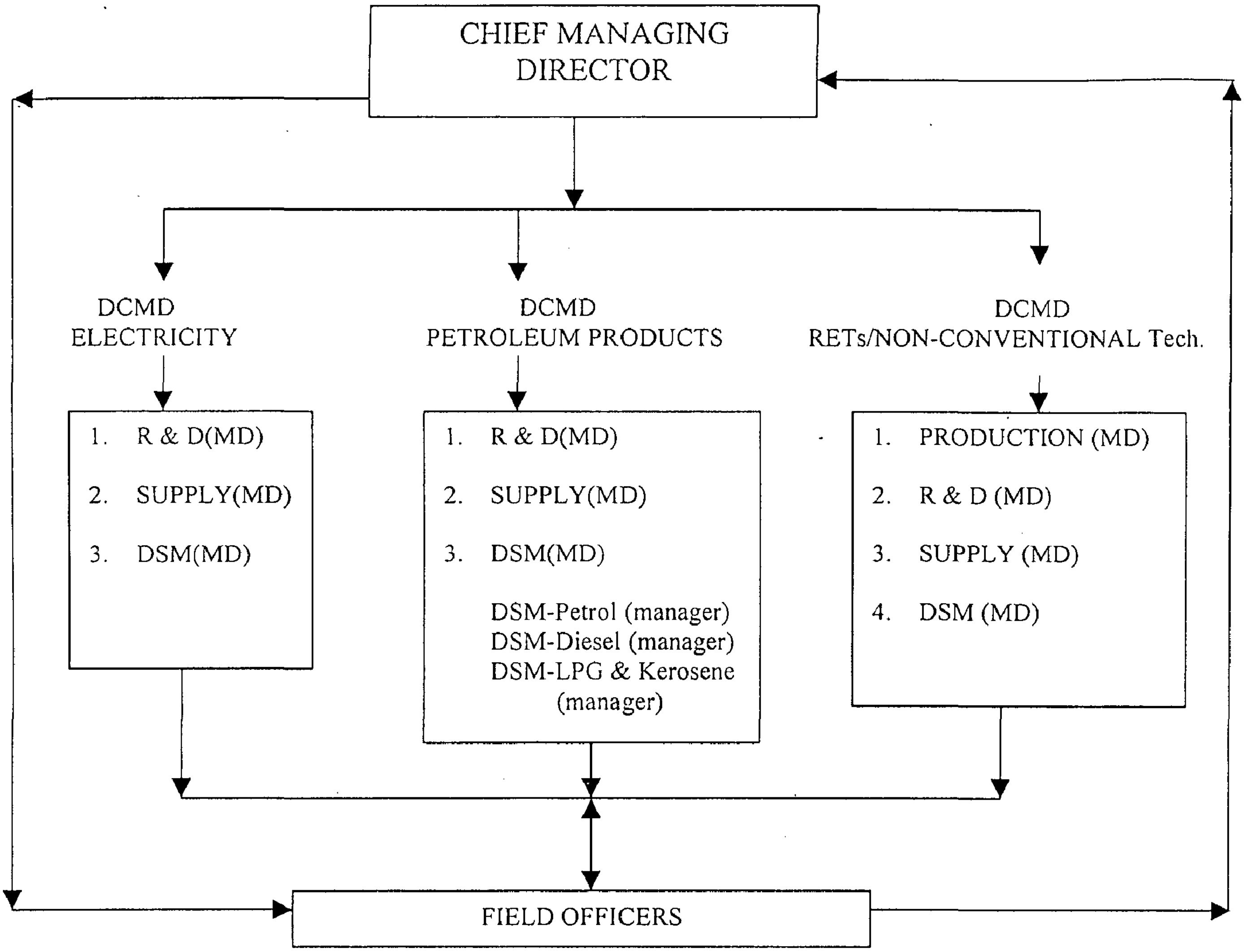
This will look into the supply of various RETs based appliances, develop proper market infrastructure, service shops and credit infrastructure.

d. Demand side management

The section will aim at to improve the market penetrability of various RET based technologies in various sectors. It will have following divisions:

- Public Relations/communications
- Market research, technical assessment, planning and program evaluation
- Program design and implementation
- Industrial sector
- Commercial sector
- Domestic sector
- Agricultural sector
- Sales

The Sales staff in all the DSM groups in each section would be assigned to develop key customer accounts and strong working relations with local allies including equipment suppliers, consultants, contractors, architects etc. The staff will be extensively trained in Energy efficient technologies. The staff will have Field officers at the end users level that will give a feedback directly to the Chief managing director with regard to the implementation of various programs.



Each DSM (Demand side management) will have following divisions:

- Public relations/communications
- Market research, technical assessment, planning, program evaluation
- Program design and implementation
- Industrial sector
- Commercial sector
- Domestic sector
- Agricultural sector
- Sales

Note: DCMD-Deputy Chief managing director
MD-Managing director

Fig 8.2 ENERGY MANAGEMENT MODEL, LUCKNOW CITY

8.3 INFORMATION SYSTEM

An information system can be defined as, "a set of interrelated components that collect (or retrieve), process, store, and distribute information to support decision making and control in an organization. In addition to supporting decision making, coordination, and control, information systems may also help managers and workers analyze problems, visualize complex subjects, and create new products" [18].

By information we mean data that have been shaped into a form that is meaningful and useful to human beings. Data, in contrast, are streams of raw facts representing event occurring in an organization or the physical environment before they have been organized and arranged into a form that people can understand and use.

Three activities in an information system produce the information organization need for making decisions, controlling operations, analyzing problems, and creating new products or services they are:

1) Input
2) Processing
3) Output

Input captures or collects raw data from within the organization or from its external environment. *Processing* converts this data into more meaning full form. *Output* transfers the processed information to the people or activities where it will be used. Information system also requires *feedback*, which is output returned to appropriate members of the organization to help them evaluate or correct the input stage.

From a management perspective, information systems are far more than input output process in a vacuum. It is an organizational and management solutions based on the information technology, to a challenge posed by the environment.

An efficient information system, preferably a formal, organized computer based information system (CBIS) can be of major help for the successful functioning of the proposed energy management model, in view of the huge amount of information requirement.

Functions of Information System model

An information system based flow model is evolved for having proper energy management system in the study area and is presented in ***fig. no: 8.3***

Different kinds of systems are required at different levels of the proposed energy management model (energy management cell). No single system can provide all the information required by the organization, as shown in the flow model.

Thus, following types of information systems are required for this particular purpose:

1. Executive Support Systems (ESS):

These are the information systems at the strategic level of the energy management cell and shall be used by the Chief managing director. It shall be designed to address unstructured decision making through advanced graphics and communications. The system shall be designed to have direct access with field workers to get the exact picture of the matters at the end users' level.

2. Decision Support System (DSS):

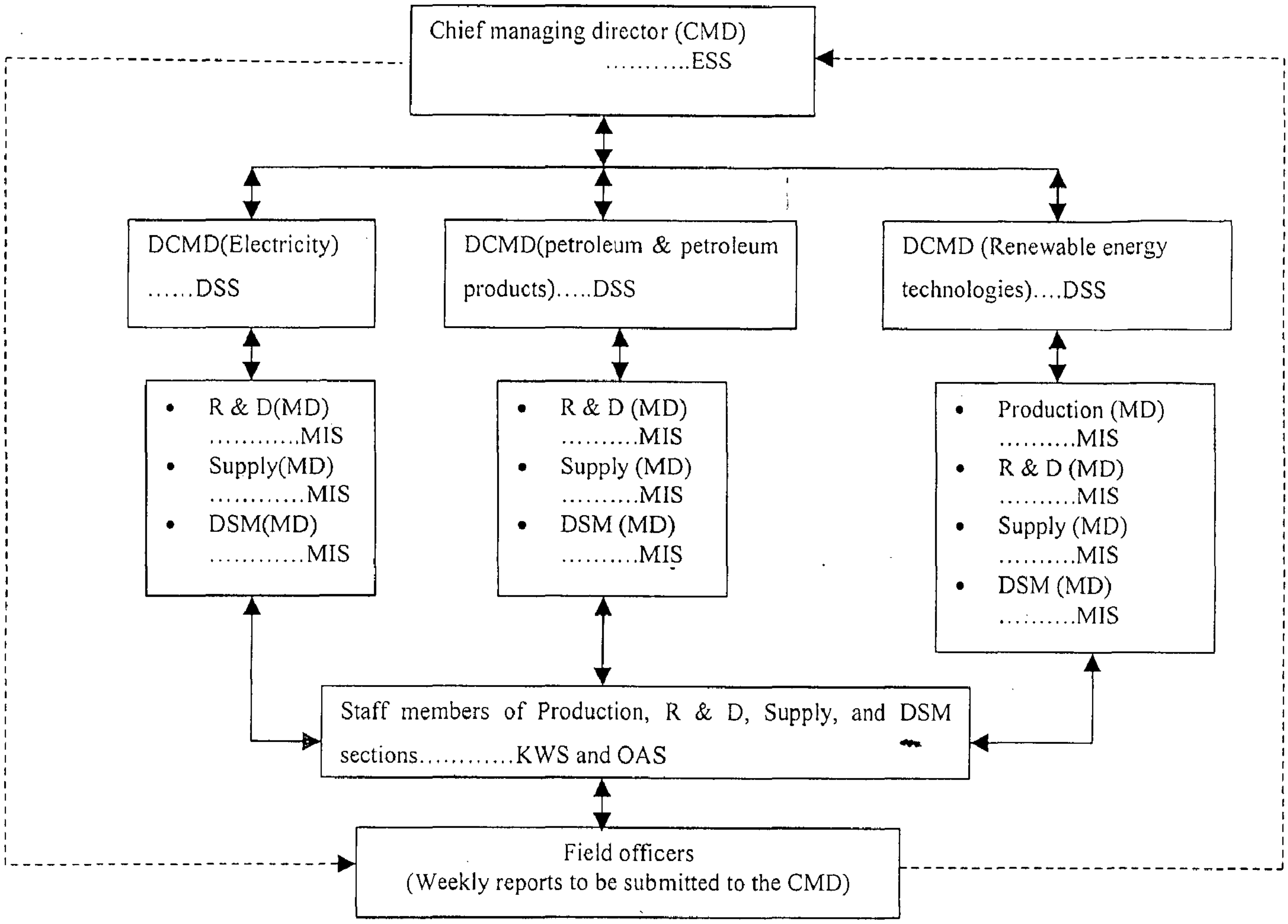
The Deputy Chief managing director of the respective field (Electricity, Petroleum and petroleum products, and Renewable energy technologies) shall use Decision support system. The system will combine data obtained from the Managing directors (MDs) of Research & Design, Supply and Demand-side management (DSM) group, and sophisticated analytical models to support semi-structured and unstructured decision making.

3. Management information system (MIS):

A Management Information system (MIS) shall be designed for use by the Managing directors' of Research & Design, Supply and Demand-side management (DSM) section. The system shall serve the functions of planning, controlling and decision making by providing routine summary and exception reports. These reports shall be further forwarded to the respective Deputy Chief managing director (DCMD).

4. Knowledge work systems(KWS) and Office automation systems(OAS):

The staff of the Research & Design, supply and Demand-side management (DSM) section shall be provided with Knowledge work systems and Office automation systems, meant for providing primary aid to the workers. It shall keep a daily record of the daily supply, consumption of electricity, petroleum and petroleum products, the daily sales report of the Renewable energy technologies etc., collected at the field level. Besides, it shall also keep an account of payroll, employee record keeping and the likes.



Note:
ESS: Executive support sys.
DSS: Decision support sys.
KWS: Knowledge work sys.
OAS: Office automation sys.
DCMD: Deputy chief managing director
MD: Managing director

Fig 8.3 Flow of information in the proposed energy management model

8.4 URBAN ENERGY MANAGEMENT MODEL AND DATABASE

8.4.1 URBAN ENERGY MANAGEMENT MODEL

The following ***fig no: 8.4*** gives a general layout of the proposed urban energy management model.

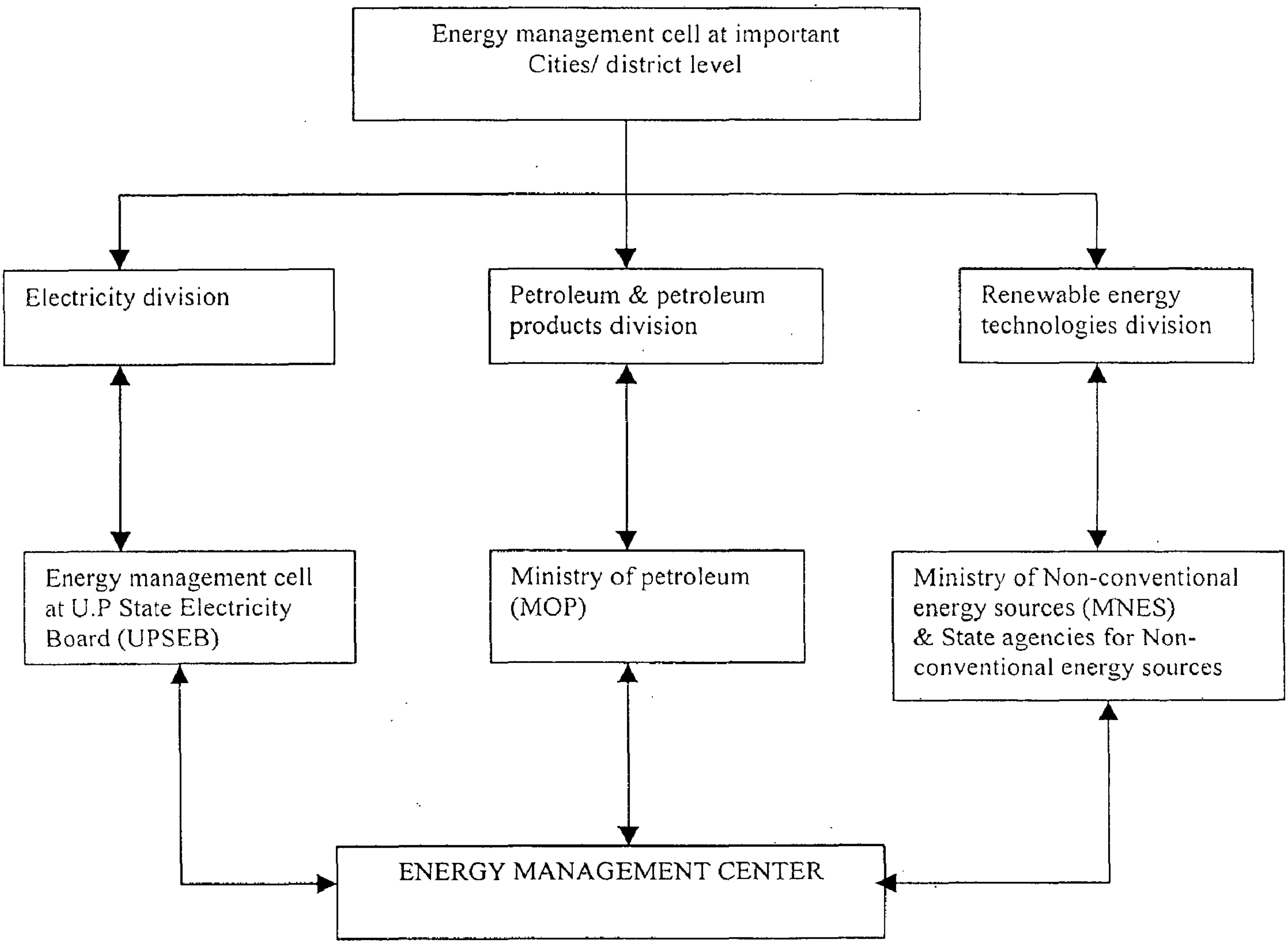


Fig. 8.4 Flowchart showing the proposed general energy management model

8.4.2 URBAN ENERGY DATABASE

A reliable and comprehensive database is a prerequisite for successful implementation of any program at various levels. In the field of energy, a comprehensive database, both rural and urban, is currently lacking leading to the necessity of developing an energy database. An urban energy database is therefore proposed. The proposed urban energy database shall be based on various planning actions pertaining to its structure and location confirming to different levels of planning. The functional utility of the database will be maximized when the interconnections between its various components are well established. The following ***fig. no. 8.5*** and ***8.6*** show these interconnections in terms of vertical layers and horizontal modules at each layer.

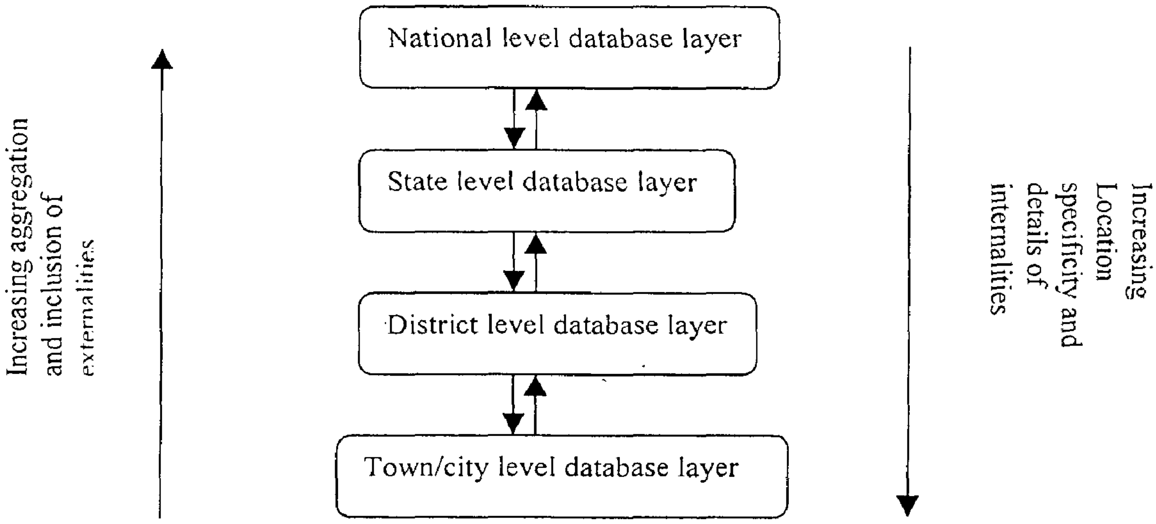


Fig. 8.5 Vertical layers of the proposed urban energy database

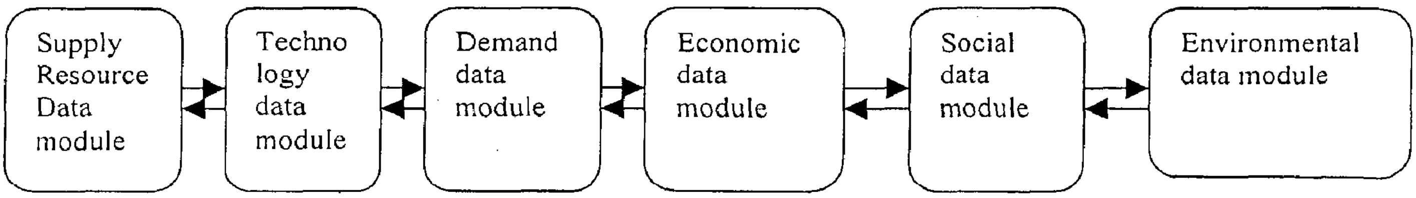


Fig.8.6 Horizontal modules of the proposed energy database

The present investigation, with an objective of evolving an optimal energy management plan for Lucknow city, studies all the sectors with special focus on domestic and transport sectors. The energy consumption pattern, supply and demand for various fossil fuel based energy, has been extensively studied in the investigation. Based on the existing trend, energy supply and demand in future (upto year 2005) has been predicted. Accordingly, a management model has been presented for optimum utilization of energy in the city. Methods have been suggested for taking supply augmentation measures as well as demand-side measures. Supply-side management measures shall be taken by the utility. A general framework is also proposed at state level in this regard. The proposed framework promises to make the system function properly from top to bottom.

The model presented, if implemented by the proposed administration promises to encourage energy savings and make optimum utilization of the available resources in the city.

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QUESTIONNAIRE

IDENTIFICATION

Name of person____________________ Age Sex occupation

Household particulars:

No.	Name	Age	Sex	Occupation	Education	Employed/Unemployed	Income (p.m.)	Workplace

HOUSING PATTERN

Type:

Detached..... Semidetached...... Row housing.... Apartments.......

Class:

HIG....... MIG....... LIG............ EWS.......

No of Rooms..... No. of floors...... plot area.........sq./mt ....sq./ft

Availability	Yes	No	Metered	Non metered
Water				
Electricity				

OWNERSHIP OF VEHICLES:

Type & no of vehicles

	Put no.		Years of use	Frequency of use Daily	Alternate days	once in a week
(1)Four wheeler	....	Petrol..../Diesel.....	....	......	.....	......
(2)Two wheeler	....	Scooter...	....	....	......	......
		/Motorcycle....	....	....	......	......
(3)bicycle	....	Geared/non-geared	....	....	......	......

CHOICE OF VEHICLE:

	Four-wheeler	two-wheeler	bicycle	pedestrian	public transport
(1) Going to workplace	....	....	....	....	....
(2) Going to market	....	....	....	....	....
(3) nearby towns/other areas	....	....	....	....	....

MODE OF TRANSPORT for given range of distance (in km per day)

	4-wheeler	2-wheeler	bicycle	pedestrian	public transport
(1)1-4	....	....	....	....	....
(2) 5-10	....	....	......	....	....
(3)11-20	....	....	......	....	....
(4) >20	......	....	......	....	....

QUANTITY OF FUEL(LITRE/WEEK)

	Petrol	diesel	L.P.G.
(1) Less than 5	......	.....	....
(2)between 5- 10	......	.....	....
(3) between 10-15	......	.....	....
(4) > 15	......	.....	....

HOUSEHOLD APPLIANCES: (NO.)

Refrigerators....Stove...... A.C......... Mixer....... Computer....... Geysers........TV....... Stereo system...... Immersion rod....... Oven..... washing machine....... Cooking gas....... Toaster/griller...... Cooler.... Generator......

Tubelights.... Bulb(40 W)..... Bulb(60W)...... Bulb(100W).... Bulb(200W)....... Fan.....

ENERGY CONSUMPTION: (QTY. PER MONTH other than in transportation)

Electricity...... units LPG...... kerosene...... diesel...... petrol.....

Total time of usages(hrs per day)

Lighting...... fans...... heating..... cooling.......

ENERGY CONSERVATION(no.)

Pressure cooker..... solar cooker.... Solar heating..... C.F.L......

WASTE MANAGEMENT

Types of wastes	organic	inorganic	Place of disposal
(kg per day)	....	....	....

TOTAL HOUSEHOLD INCOME (Rs per month)

0-5000 .... 5000-10,000...... 10,000-15,000....... 15,000-20,000.......

20,000-25,000....... 25,000-30,0000.... Above 30,000.......

TRANSPORT RELATED PROBLEMS

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

LIST OF VARIABLES

A	NO OF FAMILY MEMBERS
B	NO OF MALES
C	NO FEMALES
D	NO OF EMPLOYED MEMBERS
E	ANNUAL INCOME (1) 15,000-60,000 (2) 60,000-1,20,000 (3) 1,20,000-2,00,000 (4) >2,00,000
F	HOUSING PATTERN (1) DETACHED (2) SEMIDETACHED (3) ROW HOUSING (4) APARTMENTS
G	NO. OF ROOMS (1) 1-3 (2) 4-6 (3) 7-9 (4) >9
H	NO. OF FLOORS
I	AVAILIBILITY OF WATER (1) YES (2) NO
J	(1) METERED (2) NON-METERED
K	AVAILIBILITY OF ELECTRICITY (1) YES (2) NO
L	(1) METERED (2) NON-METERED
M	NO. OF FOUR-WHEELERS
N	YEARS OF USE (1) 0-5 (2) 6-10 (3) >10 (4) 1+2 (5) 2+3 (6) 1+3
O	FREQUENCY OF USE (1) DAILY (2) ALTERNATE DAYS (3) ONCE IN A WEEK
P	NO. OF TWO-WHEELERS
Q	YEARS OF USE (1) 0-5 (2) 6-10 (3) >10 (4) 1+2 (5) 2+3 (6) 1+3
R	FREQUENCY OF USE (1) DAILY (2) ALTERNATE DAYS (3) ONCE IN A WEEK
S	NO. OF BYCYCLE
T	YEARS OF USE (1)0-5 (2) 6-10 (3) >10 (4) 1+2 (5) 2+3 (6) 1+3
U	FREQUENCY OF USE (1) DAILY (2) ALTERNATE DAYS (3) ONCE IN A WEEK
V	CHOICE OF VEHICLE FOR GOING TO WORKPLACE (1) 4-WHEELER (2) 2-WHEELER (3) BICYCLE (4) PEDESTRIAN (5) PUBLIC TRANSPORT (6) 1+2 (7) 3+4 (8) 4+5 (9) 2+5 (10) 3+5 (11) 1+5 (12) 2+3 (13) 2+4
W	CHOICE OF VEHICLE FOR GOING TO MARKET (!) 4-WHEELER (2) 2-WHEELER (3) BICYCLE (4) PEDESTRIAN (5) PUBLIC TRANSPORT (6)1+2 (7) 3+4 (8) 4+5 (9) 2+5 (10) 3+5 (11) 1+5 (12) 2+3 (13) 2+4
X	CHOICE OF VEHICLE FOR GOING TO NEARBY TOWNS/OTHER AREAS (1) 4-WHEELER (2) 2-WHEELER (3) BICYCLE (4) PEDESTRIAN (5) PUBLIC TRANSPORT (6)1+2 (7) 3+4 (8) 4+5 (9) 2+5 (10) 3+5 (11) 1+5 (12) 2+3 (13) 2+4
Y	MODE OF TRANSPORT FOR DISTANCE 1-4 KMS (1)4-WHEELER (2) 2-WHEELER (3) BICYCLE (4) PEDESTRIAN (5) PUBLIC TRANSPORT
Z	MODE OF TRANSPORT FOR DISTANCE 5-10 KMS (1)4-WHEELER (2) 2-WHEELER (3) BICYCLE (4) PEDESTRIAN (5) PUBLIC TRANSPORT
AA	MODE OF TRANSPORT FOR DISTANCE 11-20KMS (1)4-WHEELER (2) 2-WHEELER (3) BICYCLE (4) PEDESTRIAN (5) PUBLIC TRANSPORT
AB	MODE OF TRANSPORT FOR DISTANCE >20 KMS (1)4-WHEELER (2) 2-WHEELER (3) BICYCLE (4) PEDESTRIAN (5) PUBLIC TRANSPORT
AC	CONSUMPTION OF PETROL IN TRANSPORT (LITER/WEEK) (1) <5 (2) 5-10 (3) 11-15 (4) >15
AD	CONSUMPTION OF DIESEL IN TRANSPORT (LITER/WEEK) (1) <5 (2) 5-10 (3) 11-15 (4) >15
AE	NO. OF REFRIGERATORS
AF	NO. OF STOVE
AG	NO. OF A.C.
AH	NO. OF COMPUTER
AI	NO. OF GEYSERS
AJ	NO. OF T.V.

AK NO. OF STEREO SYSTEM
AL NO. OF IMMERSION ROD
AM NO. OF OVEN
AN NO. OF WASHING MACHINE
AO NO. OF COOKING GAS
AP NO. OF TOASTER/ GRILLER
AQ NO. OF COOLER
AR NO. OF GENERATOR
AS NO. OF TUBELIGHTS
AT NO OF BULBS (40 W)
AU NO. OF BULBS (100 W)
AV NO. OF BULBS (200 W)
AW NO. OF FANS
AX ELECTRICITY CONSUMPTION PER MONTH(UNITS)
AY L.P.G CONSUMPTION PER MONTH(NO. OF CYLINDER)
AZ KEROSENE CONSUMPTION PER MONTH (LITRE)
BA DIESEL CONSUMPTION OTHER THAN IN TRANSPORTATION (PER MONTH , LITRE)
(1) 0 (2) 1-10 (3) 11-20 (4) >20
BB PETROL CONSUMPTION OTHER THAN IN TRANSPORTATION (PER MONTH , LITRE)
(1) 0 (2) 1-10 (3) 11-20 (4) >20
BC TOTAL TIME OF USAGE (HRS PER DAY)---LIGHTING
(1) 1-5 (2) 6-10 (3) 11-15 (4) 16-20 (5) >20
BD TOTAL TIME OF USAGE (HRS PER DAY)---FANS
(1) 1-5 (2) 6-10 (3) 11-15 (4) 16-20 (5) >20
BE TOTAL TIME OF USAGE (HRS PER DAY)---HEATING
(1) 1-5 (2) 6-10 (3) 11-15 (4) 16-20 (5) >20
BF TOTAL TIME OF USAGE (HRS PER DAY)---COOLING
(1) 1-5 (2) 6-10 (3) 11-15 (4) 16-20 (5) >20
BG NO. OF PRESSURE COOKER
BH NO. OF SOLAR COOKER
BI NO. OF SOLAR HEATER
BJ NO OF C.F.L.(COMPACT FLOUROSCENT LAMP)
BK QTY. OF ORGANIC WASTE (KG PER DAY)
BL QTY. OF INORGANIC WASTES (KG PER DAY)
BM PLACE OF DISPOSAL
(1)COMMUNITY BINS (2) ON STREETS (3) COLLECTION FROM HOME
BN NO. OF MIXER
BO EDUCATIONAL STATUS: PRIMARY EDUCATION
BP EDUCATIONAL STATUS: SECONDARY EDUCATION
BQ EDUCATIONAL STATUS: GRADUATION
BR EDUCATIONAL STATUS: POST-GRADUATION
BS EDUCATIONAL STATUS: TECHNICAL/ PROFESSIONAL
BT EMPLOYMENT SECTOR: (1) AGRICULTURE & MINING (2) MANUFACTURING (3) SERVICES[ORGANISED SEC] (4) TRADE & COMMERCE (5) 3+4 (6) SERVICES[INFORMAL SEC] (7) 2+3 (8) 4+6