WEC's Energy for Mega Cities Study

Delhi case study

Demographics, Economics and City Shape

Delhi is located in northern India between the latitudes of 28°-24'-17"and 28°-53'-00"North and longitudes of 76°-50'-24"and 77°-20'-37"East. Delhi shares its border with the States of Uttar Pradesh and Haryana. Delhi has an area of 1483 sq km, out of which urban area is 925 sq km. Its maximum length is 51.90 km and greatest width is 48.48 km.

Mythologically, the city of Delhi belongs to the period of the Mahabharata[1]. It is said to be built on the site of the epic Indraprastha, where the legendary palace and court of the Pandavas[2] were located. Going by history alone, Delhi became historically important for the first time in the 11th century as a city of the Rajputs (A warrior clan from central India). Over the years Delhi became the site of seven cities[3], most of them belonging to the more recent Muslim period of Indian history.

Delhi was a small town in the beginning of twentieth century with a population of 0.4 million. Delhi's population started increasing after it became the capital of British India in 1911. During the Partition of the country in 1947, a large number of people migrated from Pakistan and settled in Delhi. Migration into the city continued even after Partition. As per 2001 Census, NCT of Delhi (National Capital Territory of Delhi as it is known now for administrative records) had a total population of 13.8 million with 3.85% annual growth rate and 47.02% decennial growth rate during 1991-2001. Delhi's population in 2007-08 was 16.9 million. Delhi is highly urbanized with 93.18% of its population living in urban areas as against the national average of 27.81%. While it may not be possible to make an accurate forecast, the expectation is that the population of Delhi may range between 22 to 23 million in the year 2021.

According to Census 2001, the density of population is worked out at 9340 persons per sq km as against 6352 person in 1991. Density of population at All-India level has been worked out at 324 persons per sq km in 2001. The density of population in Delhi is the highest among all States/Union Territories in the country.

Planning for the city is taken up on National Capital Region (NCR) Basis[4]. The National Capital Region (NCR) comprises of a total area of 33,578 sq. km. including areas of Delhi (1483 sq. km), Haryana (13,413 sq. km), Uttar Pradesh (10,853 sq. km) and Rajasthan (7829 sq. km). There has been an increase in natural growth from 55.80% in 1981 to 59.21% in 1991 and 60.18% in 2001 and decrease in the net migrants from 44.20% in 1981 to 40.78% in 1991 and 39.82% in 2001. However, a reduction in the rate of natural growth and increase in migration between 2001and 2021 is envisaged. Table-1 gives the population projections for Delhi and NCR up to 2021.

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[1] The Mahabharata is one of the world's most well known Sanskrit epics and is recognised as the longest epic-poem ever written, set somewhere around 2500 BC

[2] The story of the Mahabharata revolves around two families, the Pandavas and the Kauravas who were cousins.

[3] The rulers of Delhi established new cities through the centuries. Seven principal cities were chiefly created by different rulers.

[4] The concept of NCR is described later under multilevel governance

Table 1 : Population projections of NCR and Sub-regions (in million)

Year	NCR Total	NCT- Delhi		Haryana		Rajasthan		Uttar Pradesh	
		Population	% to total	Population	% to total	Population	% to total	Population	% to total
2001	37.10	13.85	37.33	8.69	23.42	2.99	8.06	11.57	31.19
2011	48.62	17.99	37.00	11.76	24.18	3.79	7.80	15.08	31.02
2021	64.14	23.49	36.62	16.02	24.97	4.81	7.49	19.83	30.92

Source: Census 2001, Census of India and Study Group Report on Policy zone, demography and settlement pattern; page 26, Table 4.12, Regional plan-2021, National Capital region by NCRPB (National Capital Region Planning Board), Ministry of urban development, Government of India

Demographic features

- Estimated number of households in Delhi was about 3.63 million, and out of which 167,000 were in rural and 3.46 million in urban areas.
- Average household size in rural, urban and Delhi worked out to 5.30, 4.51 and 4.55 persons per household respectively.
- 69.05% of dwellings were estimated to be owned, 28.50% rented and 2.45% as other category.

Energy consumption pattern

- 98.74% of the total households were dependent on Electricity for their lighting needs.
- 85.14% households were using LPG, 1.82% firewood as the primary source of cooking in Delhi

Consumer expenditure pattern[5]

- Delhi ranked first in both urban and rural Monthly per capita expenditure (MPCE) among 26 states/UTs
- Average monthly per capita expenditure of Delhi worked out to Rs.1838.47 (US$ 40.8)
- The monthly per capita expenditure (MPCE) was Rs.1304.27 (US$28.97)for rural and Rs. 1972.19 (US$ 43.82)for urban Delhi.
- Rs. 697.40 (US $15.5) (37.93%) was spent on food items and Rs.1141.07 (US$ 25.35) (62.07%) on nonfood items.
- Average monthly consumer expenditure per family was estimated as Rs.8554 (US$ 190.09)
- Major heads of expenditure included: miscellaneous consumer services accounted for 20.87%, milk and milk products 10.67% , conveyance 9.41%, cereals 6.66%, rent 5.35%, clothing 5.27%, fuels & lighting 8.97%, education 6.71%, beverages 6.02% of the MPCE.

Urban Sprawl

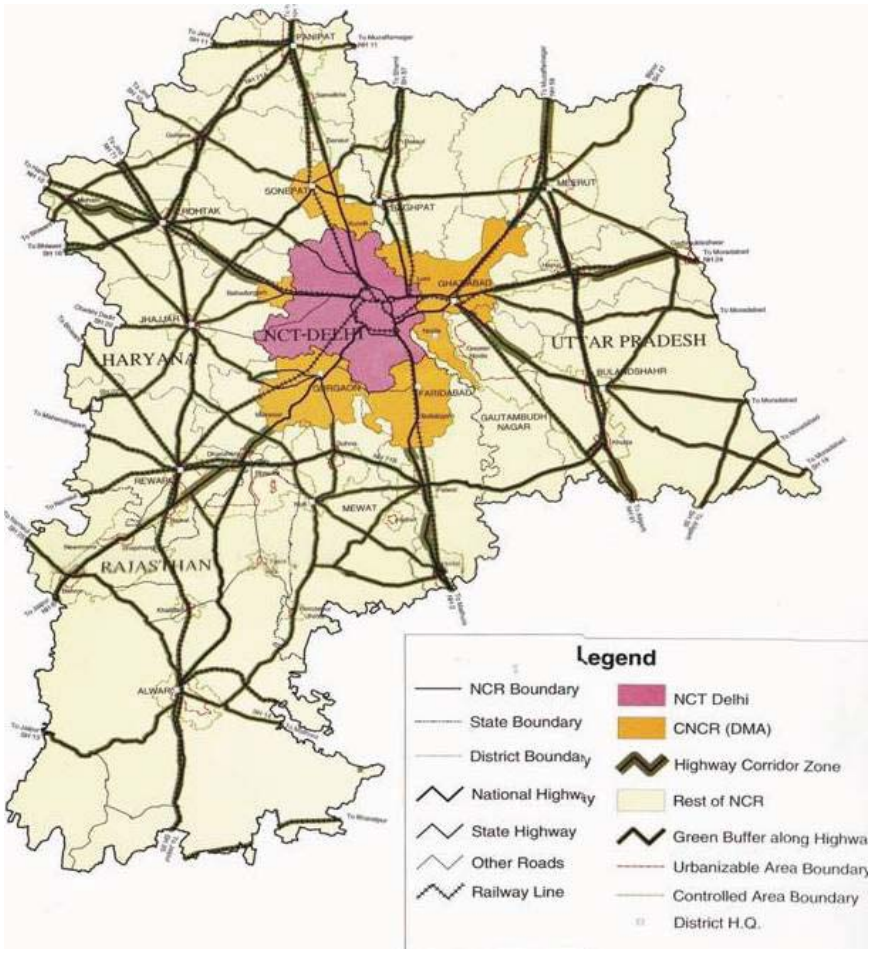
The government realized that growth and development of the city of Delhi has to be planned by linking to the development of surrounding areas-which are really the greater Delhi, but have been categorized under specially planning zones as National Capital Region. The administration of these areas remains the responsibility of respective federal states in whose geographic territories the area lies.

[5] Level and Pattern of Household Consumer Expenditure in Delhi ,Based on N..S..S.. 63rd Round, July 2006 – June 2007

The process of planned development of the National Capital began with the enactment of the Delhi Development Act 1957, followed by the promulgation of the Master Plan of Delhi in 1962 (MPD-62). The Central Government enacted the National Capital Region Planning Board Act, 1985. The National Capital Region (NCR) Planning Board, constituted under the Act, is charged with the responsibility of coordinating the efforts of the adjoining States through the instrumentality of Regional and Sub-Regional Plans. The Regional Plan 2021 has been drawn up with reference to the following **four Policy Zones** –

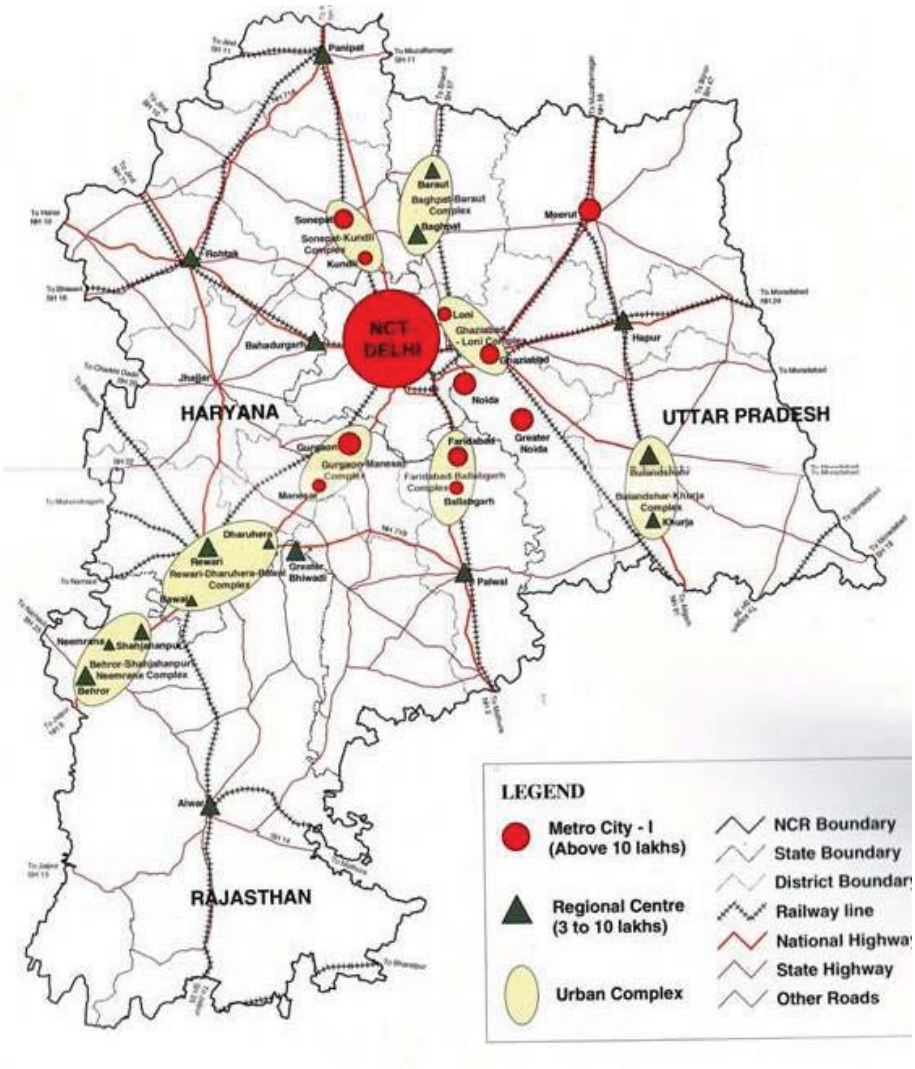
i. **NCT of Delhi (NCTD):** The City of Delhi
ii. **Central National Capital Region (CNCR) :** The Central NCR (earlier the Delhi Metropolitan Area) as defined in the Regional Plan – 2021 and shown in Map-1, comprises of the notified / controlled development areas of the neighboring towns of Ghaziabad - Loni, NOIDA, Gurgaon-Manesar, Faridabad- Ballabhgarh, Bahadurgarh and Sonepat-Kundli, and the extension of the ridge in Haryana, having an area of about 2000 sq km.
iii. **Highway Corridor Zone** :The NCR Plan has proposed promotion of planned and regulated development along the National Highways.
iv. **Rest of NCR** :In the Rest of the NCR (approximately 29,795 sq km), the basic policy of the Regional Plan - 2021 is aimed at accelerated development of the urban and rural areas.

MAP 1 : National Capital Region



Source: Map 3.1, page 19, Regional plan-2021, National Capital region by NCRPB (National Capital Region Planning Board), Ministry of urban development, Govenmant of India

MAP 2 : Proposed Settlement Pattern 2021



Source: Map 4.2, page 33, Regional plan-2021, National Capital region by NCRPB (National Capital Region Planning Board), Ministry of urban development, Govenmant of India

Economy of Delhi

Gross State Domestic Product (GSDP) of Delhi at current prices was of the order of Rs.1252.82 billion (US$ 27.84 billion) during 2006-07 depicting 18.4 % growth over the previous year. GSDP (Provisional) of Rs.1439.11 billion (US$ 31.98 billion) for 2007-08 indicated 14.9% annual growth at current prices. GSDP at 1999-2000 prices is expected at Rs.1092.01 billion (US$ 24.27 billion) for 2007-08 with real annual growth of 12.5% over the previous year as against all India figure of 9.0%. However in real terms the annual growth for the year 2006-07 was 15.1% as compared to 9.7% at the national level. Table-2 summarizes the growth picture of GSDP of Delhi over last five years both at current and 1999-2000 prices.

Table 2 : Growth of Gross Domestic Product of Delhi (in percentage)

		2003-04	2004-05	2005-06	2006-07	2007-08
GSDP	At Current Prices	11.4%	15.8%	14.9%	18.4%	14.9%
	At 1999-2000 Prices	5.7%	11.7%	11.0%	15.1%	12.5%
NSDP[6]	At Current Prices	11.3%	14.5%	15.1%	18.6%	15.3%
	At 1999-2000 Prices	5.4%	10.8%	11.4%	15.4%	13.0%

Source: Economic Survey of Delhi, 2008-09, page 12, statement 2.1, Chapter 2, State Domestic Product

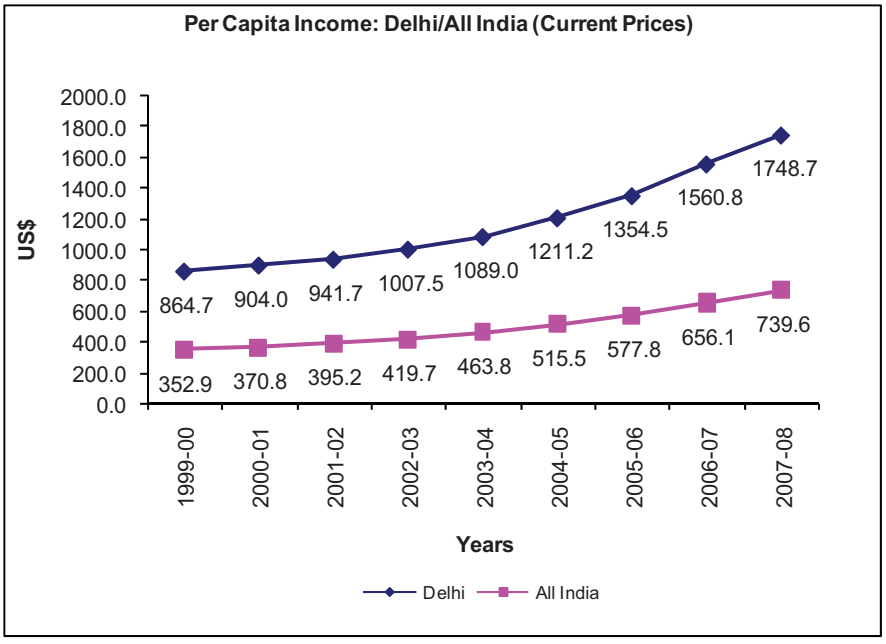
The comparative picture of Delhi vis-a-vis All India with reference to Percentage Annual Compound Growth Rate (Between 1999-2000 & 2007-08) is depicted in Table-3.

Table 3 : Growth Rate of Delhi compared to National Growth Rate

		Delhi	All India
GSDP/GDP	At Current Prices	12.72%	11.67%
	At 1999-2000 Prices	8.90%	7.26%
NSDP/NNP[7]	At Current Prices	12.56	11.42
	At 1999-2000 Prices	8.85	7.11

Source: Economic Survey of Delhi, 2008-09, page 13, statement 2.2, Chapter 2, State Domestic Product

According to the present series, the per capita income of Delhi at current prices is Rs.78,690 (US$ 1,749) in 2007-08 compared to Rs.70238 (US$ 1561) in 2006-07 and Rs.60951(US$ 1355) in 2005-06. The annual growth rates are 11.8%, 15.2% and 12.0% for 2005-06 ,2006-07 and 2007-08 respectively. Delhi's per capita income is more than double the national average, both at current and constant prices as indicated below:



The analysis of sector wise growth in Gross State Domestic Product reveals that contribution of primary sector (comprising of agriculture, livestock, forestry, fishing, mining & quarrying) is showing az declining trend, where as the contribution of secondary sector (comprising manufacturing,

[6] Net State Domestic Product
[7] Net National Product

electricity, gas, water supply and construction) and the contribution of tertiary sector, also called the service sector (comprising trade, hotels and restaurants, transport, storage, communication, financing & insurance, real estate, business services, public administration and other services) are showing a mixed trend in the economy of Delhi. The contribution of primary sector which was 1.38% during 1999-2000 has come down to 0.69% in 2007-08 at current prices. The contribution of secondary sector recorded at 18.26% during 1999-2000 has enhanced to 20.26% in 2007-08. The contribution of the tertiary sector worked out to 80.36% in 1999-2000 declined to 79.05% in 2007-08.

The broad reasons for change in the sectoral composition of Delhi's economy may be attributed to the rapid urbanization and consequential reduction in agricultural and allied activities on one hand; and substantial increase in activities pertaining to the secondary as well as services sector on the other hand.

Regular monitoring of environmental degradation by different Government agencies on the directives of Supreme Court of India and subsequent closure of polluting industrial units has restricted the growth of the secondary sector.

Energy

Delhi peak energy demand in 2008-09 was 4,034 MW and the energy consumption was 21,738 million kwh. Delhi has the highest per capita power consumption of electricity among the States and Union Territories of India. The per capita consumption of electricity in Delhi has increased from 1259 units per annum in 2000-01 to 1615 units in 2007-08. (National average was 717 units in the year 2007-08.)

Electricity tariff in Delhi is the lowest as compared to all Metros. Current Tariff is Rs. 1.20 (2.67 US Cents) for monthly consumption less than 200 Units in peak months and less than 150 units in non peak months[8]; as compared to Rs. 2.18 (4.84 US Cents) in Mumbai (BEST), Rs. 4.32 (9.6 US Cents) in Kolkata and Rs. 3.50 (7.78 US Cents) in Chennai. Low tariff encourages lower energy consumption and protects weaker sections.

The power purchase price has increased by 25% since 2002. However there is a disconnect between consumer prices and electricity supply price. Cost of consumable goods has increased by 55% whereas actual tariff being paid by consumers consuming up to 200 units per month has been brought down by 15% by 2007-08. Load shedding has been brought down to 0.6% (2007-08) from abnormally high 4.9% in year 2000-01. Peak demand deficit of Delhi is low around 1.5% against the national average of 12.3%. Table-4 depicts the electricity supply position over the years:

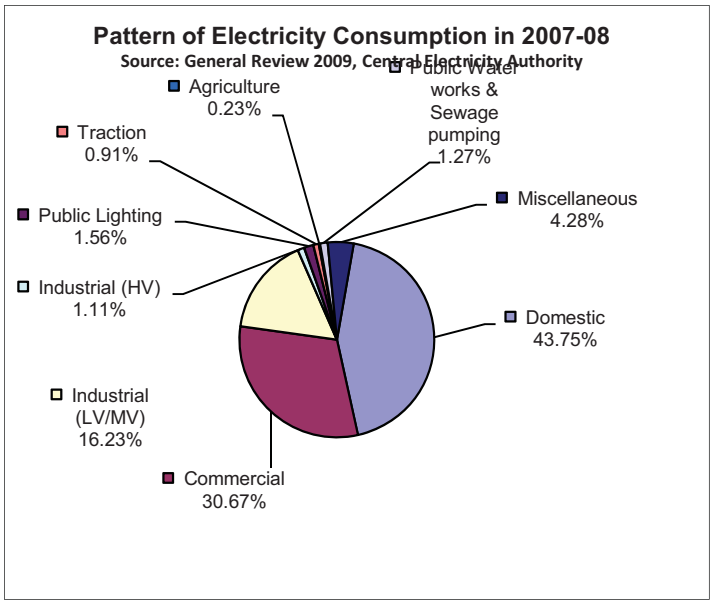
[8] Summer peak months: May, June, July and August; Winter peak months: December and January; Feb, March, April, Sept., Oct. and Nov. shall be taken as non-peak months. Ref : BSES / DERC guidelines

Table 4 : Electricity supply in Delhi (2004-2009)

Year	2004-05	2005-06	2006-07	2007-08	2008-09
Peak Demand met in MW	3490	3626	3736	4030	4034
Energy Consumption in MUs	20810	21184	21977	22372	21768
Load Shedding in MUs	176	322	411	136	128
Load Shedding as % of energy consumption	0.84	1.5	1.87	0.61	0.61
Transmission Losses(%)	1.30	0.72	0.83	0.95	
System availability (in %)		97.71	98.87	98.50	

Source : Economic Survey of Delhi, 2008-09, page 125, statement 11.3, Chapter 11, Energy (Delhi Transco Ltd)

Delhi consumed 16328 Gwh of electricity in 2007-08. The pie chart shows the sectoral consumption of electricity in Delhi in the year 2007-08.



From 1st July, 2002 under the Delhi Electricity Reforms Act, DVB[9] was unbundled into Six companies comprising of a Generation Company, a Transmission Company, three distribution companies and one holding company. The Generation and Transmission functions are performed by the two companies i.e. Genco and Transco as wholly State Government owned companies. The distribution functions have been entrusted to two private companies viz BSES and TATA Power Ltd. BSES has taken up two distribution companies namely; BSES Rajdhani Power Ltd (BRPL) and BSES Yamuna Power Ltd. (BYPL), while the third company is with TATA Power which has been named as New Delhi Power Ltd. (NDPL). Transmission company also supplies bulk power to New Delhi Municipal Corporation (NDMC) and Military Engineering Serices (MES) for distribution in their respective areas. As in 2007-08, Delhi had a total consumer base of 3.33 million.

[9] Delhi Vidut Board

The position of electricity supply has marginally improved over the past five years. Delhi Transco Ltd. has significantly improved its system availability and reduced load shedding as given in Table-4.

The position of Aggregate Technical and Commercial Losses (AT & C losses) has also improved from 52% in pre-reform period to around 25% in 2007-2008. The losses have further reduced in the year 2009. Yearwise position in respect of each private distribution company is given in Table-5.

Table 5 : Yearwise status of AT&C losses for private distribution companies in Delhi (In percentage)

Distribution Company	Opening levels of AT & C loss		2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
BYPL[10]	57.2	Target	56.45	54.70	50.70	44.65	39.95	34.77
		Achievement	61.89	54.29	50.12	43.88	39.03	29.82
BRPL[11]	48.1	Target	47.55	46.00	42.70	36.70	39.10	26.69
		Achievement	47.40	45.06	40.64	35.53	29.92	27.17
NDPL[12]	48.01	Target	47.60	45.35	40.85	35.35	31.10	22.03
		Achievement	47.79	44.86	33.79	26.52	23.54	18.31

Source : Annual Report of DERC 2007-08 and Public notice of ARR Petitions of Discoms, Economic Survey of Delhi, 2008-09, page 132, statement 11.8, Chapter 11, Energy

Such remarkable achievement in loss reduction has been possible through a systematic and planned development of distribution network post reforms and privatisation. Electrification of unelectrified colonies and Jhuggi Jhopdi[13] clusters, augmentation of old transformers, replacement of aged feeders, high voltage distribution system, bare conductor replacement by aerial bunched conductors are some of the initiatives taken in this direction. IT has played a major role in our endeavor to continually improved customer care. Most of the customer oriented services are IT based with many avenues for bill payment and web based services. World class distribution control system based on latest available technologies like SCADA, GIS, SAP, Prepaid metering, Automatic Meter Reading, etc. have been adopted.

Energy Peaks and Explanation

In 2009 the variation in peak demand (from lean to peak month) was about 1500 MW, which is 34 % of the annual peak of 4408 MW. This depicts the extent of variation in peaks with the changing weather conditions. Delhi has experienced a whopping 9% rise in peak demand in 2009 during summers.

Key reasons leading to this increase are:-

1. Increasing consumer base of Delhi.
2. Large number of infrastructure development projects has been taken up and are in progress in different part of Delhi due to upcoming Commonwealth Games.
3. Huge commercial establishments like malls and shopping complex and housing societies have been developed.
4. Rising demand from Delhi Metro Rail Corporation (DMRC) and Delhi International Airport Ltd. (DIAL).
5. Increased income levels that have propelled higher energy consumption in Delhi and NCR region.

[10] BSES Yamuna power limited
[11] BSES Rajdhani Power Limited
[12] North Delhi Power Limited
[13] Slums and temporary shelters

6. Extreme weather conditions

The distribution companies in Delhi have effectively implemented element of **smart grid**. They have successfully deployed Automated Meter Reading (AMR), Grid Substation Automation System (GSAS), Supervisory Control and Data Acquisition System (SCADA), Distribution Management System (DMS), System Application and Product (SAP), Geographical Information System (GIS) and few other projects like Distribution Automation (DA), Outage Management System (OMS) are under implementation. These projects are enabling NDPL to move forward speedily towards "SMART GRID".

In addition, several projects like Smart Feeder, Advanced Meter Infrastructure (AMI), Advanced Communication Infrastructure, Broadband over Power Line (BPL), Mobile Workforce Management (MWM), DR(Demand Response) Management, DER(Distributed Energy Resources) Management, Advanced Asset Management (AAM), Enterprise Application Integration (EAI), etc, are lined up for future execution in a phase wise manner in the coming five years.

Transport

Road transport is the major travel mode in Delhi, though some shift has come with expansion of Metro Rail service in Delhi and NCR. Table-6 shows the consumption of petroleum products in Delhi and NCR for the years 2007-08 and 2008-09. Consumption of petrol has increased by 2-4% over this period; however, consumption of diesel has come down by massive 12.4% in Delhi though in NCR as a whole it has remained unchanged. Increased penetration of LPG is reflected in the 6% growth figures of LPG as well reduction of consumption of kerosene by over 10%. Public transport has been shifted to CNG fuel in a big way and this reflects in the increased consumption of CNG by around 20% in Delhi. Now other NCR towns are going the CNG way, which is likely to increase the CNG consumption further. This has been adopted as policy measure and ensures a cleaner environment.

Table 6 : Consumption of petroleum products in Delhi and NCR [Metric Tonnes]

Product	Area	2007-08	2008-09	Difference	Growth
Diesel	Delhi	1,394,204	1,221,288	-172,916	-12.40%
	NCR	2,905,000	2,904,000	-1,000	-0.03%
Petrol	Delhi	748,887	762,469	13,582	1.81%
	NCR	960,000	998,000	38,000	3.96%
CNG[14]	Delhi	386,220	459,546	73,326	18.99%
	NCR	390,000	464,000	74,000	18.97%
Kerosene	Delhi	165,844	141,647	-24,197	-14.59%
	NCR	228,000	201,000	-27,000	-11.84%
LPG[15]	Delhi				
	NCR	872,000	923,000	51,000	5.85%

Source : Inputs from Petroleum Planning & Analysis Cell (PPAC), Ministry of Petroleum & Natural Gas, Government of India

The number of vehicles has grown exponentially from 3.033 million in 1997-98 to 5.627 million in 2007-08 at an annual compound growth rate of 6.42%. Decennial growth rate is substantially higher in case of private vehicles (92.53%) as compared to commercial vehicles (13.41%). In the category of private vehicles, cars & jeeps have registered a decennial growth rate of 126.14%, which is highest among all the categories of vehicles followed by two wheelers (i.e. scooter, motorcycle & moped) with

[14] Compressed Natural Gas
[15] Liquefied Petroleum Gas

79.62%. In the commercial category of vehicles, Taxies, have registered highest decennial growth rate (82.35%) followed by Buses including light, medium and heavy Passengers vehicle (43.75%). Auto rickshaws have registered a negative decennial growth rate of (-) 6.25%. The same trend has been observed if data is compared to compound annual rate of growth. It is expected that with expansion of Metro and better bus transport the growth of private individual vehicles will be controlled.

Table 7 : Growth of Motor Vehicles in Delhi up to 2007-08

S.No.	Category	No. of Vehicles		% Share in 2007-08	Decennial growth rate % [1997-98 to 2007-08]	Annual Compound Growth Rate %
		1997-98	2007-08			
A.	**Private Vehicles**					
i.	Four Wheelers [Cars, Jeeps Wagon]	765,000	1,730,000	30.74%	126.14%	8.73%
ii.	Two Wheelers [Scooter, Motorcycle]	1,992,000	3,578,000	63.59%	79.62%	6.03%
	Sub Total	**2757000**	**5308000**	**94.33%**	**92.53%**	**6.84%**
B.	**Commercial Vehicles**					
iii.	Auto Rickshaw	80,000	75,000	1.33%	(-)6.25%	(-)1.15%
iv.	Taxis	17,000	31,000	0.55%	82.35%	6.24%
v.	Buses	32,000	46,000	0.82%	43.75%	4.33%
vi.	Goods Vehicle+ Tractors	147,000	161,000	2.86%	9.52%	0.02%
	Sub Total	**276,000**	**313,000**	**5.56%**	**13.41%**	**0.81%**
	Total	**3,033,000**	**5,627,000**	**100%**	**85.41%**	**6.42%**

Source : Economic Survey of Delhi, 2008-09, page 137, statement 1, Chapter 12, Transport

In Delhi, the number of vehicles per 1000 persons has grown from 247 in 1997-98 to 332 in 2007-08, giving a 34.41% decennial growth rate. During the same period, four wheelers in Delhi have increased from 765000 to 1.73 million giving a decennial growth rate of 126%. Delhi had 102 four wheelers per 1000 population in 2007-08 (Decennial growth of 64% during 1997-98 to 2007-08) of which 85 were private cars. Overall, car penetration in India, however, continues to remain low at 8 cars per 1000 population. Car density in Delhi is more than 10 times of national average.

Delhi is predominantly dependent on road transport, with the railways (circular Rail) catering to only about 1% of the local traffic. Till 2003, buses constituted about 1% of the total number of vehicles, but catered to 60% of the total traffic load, while personalized vehicles accounted for 93.73% of the total vehicles but catered to only 30% of the total traffic load. Such a huge share of private vehicles in Delhi, while serving a relatively limited purpose in terms of the transportation modal split, obviously creates tremendous pressure on road space, parking, and pollution directly and through congestion. Delhi has a ring rail network which is grossly underutilized. However, with commencement of Metro in Delhi, public transport in Delhi has witnessed perceptible change. With all three corridors of phase-I of MRTS and some lines of phase-II becoming operational, about one million passenger trips are being covered by Metro. Table-8 gives transport demand forecast up to the year 2025 in urban areas of NCT- Delhi.

Table 8 : Transport Demand Forecast in Urban Areas of NCT- Delhi

S. No	Item	2005	2011	2025
1	Intra city trips (million)	16.04	21.54	26.06
2	Modal split – Public transport (%)	82.00	82.00	82.00
3	Mass transport trips (million)	13.15	17.66	21.37
4	MRTS (Mass rapid transport systaem) (million)	4.32	5.80	7.1
5	Surface Rail (million)	1.42	1.90	2.30
6	Bus (million)	7.41	9.96	11.97
7	Peak hour factor (%)	10.00	10.00	10.00
8	Peak direction factor (%)	60.00	60.00	60.00

Source: Identification of Rail Projects for Commuter Traffic for Delhi and NCR, RITES, March 1999, page 196, annexure 6/III, Regional plan-2021, National Capital region by NCRPB (National Capital Region Planning Board), Ministry of urban development, Govenmant of India

Any discussion of public transport ends up being a debate about buses and trains. Oddly and luckily, the simplest and most widely used form of transport is “walking” (and its sister mode “cycling”). A 2008 study of 30 Indian cities showed that almost 40% of all trips in urban India involved no motorized vehicles at all, 28% walked and 11% cycled[16]. The proportion was sharply higher in smaller towns since distances were usually small and the roads less congested. However, in bigger cities, the proportion of people using conventional public transport was high, and consequently commuters walked the last mile. For instance, in cities with more than 8 million population: 22% walked all the way, 8% used cycles and 44% used public transport. This adds up to 74% of people who rely on non-motorized transport for at least part of the commute.

It is difficult to obtain complete data about non-motorized vehicles and animal-driven vehicles as there is no proper mechanism to register them. Moreover, the number of unregistered vehicles are estimated to be more than those registered with the local bodies. Registered non-motorized vehicles and animal-driven vehicles constitute about 1.87% of the total vehicle population in Delhi out of which about 99.31% are cycle rickshaws. Since registration of cycle rickshaws has been discontinued, the exact number of cycle rickshaws in the city may not be known.

[16] Study by by Wilbur Smith Associates for ministry of urban development, Government of India, June 2008

GHG emissions

As per the Expert Report titled "Inventorization of Green House Gases – Sources and Sinks in Delhi", inventory of green house gases in Delhi has been estimated as given in Table-9.

Table 9 : Inventorization of Green House Gases – Sources and Sinks in Delhi

Sector	CO2 emissions (2007-08) MMT	Remarks
Road Transport	7.66	Using the bottom-up approach CO2 emission was estimated to be 8.17 MMT. Ambient CO2 concentration varies from 484 to 587 ppm. The trend is directly proportional to the traffic volume with maximum concentration in the morning peak hour from 9:30 to 10:30 am.
Power Plants	9.76	Delhi has five thermal power plants. Out of these three are coal based. Recently one of the power stations has been shut down owing to very large emissions
Industry	1.37	Power consumption alone contributed 1.21 MMT while contribution from fossil fuel combustion in industrial processes was 0.01 MMT and contribution from DG set (operation in industrial area) was estimated to be 0.15 MMT. Average concentration of CO2 monitored at the industrial areas ranged from 512 to 559 ppm.
Commercial	1.87	Power consumption contributed 1.69 MMT. Contribution from the combustion of fossil fuel in the DG sets was 0.177 MMT.
Domestic Sector	5.3	LPG is the most commonly used cooking fuel (68.4%) followed by kerosene (24.4%) while biomass is also used in 3.9% households.Average CO2 emission from domestic sector of Delhi in the year 2000-2008 was 4.56 MMT. biomass is used as a cooking fuel, it is carbon neutral and therefore its contribution to the total CO2 emissions has not been included in this approach
Total	**25.96**	

Source: Executive Summary of Inventorization of Green House Gases – Sources and Sinks in Delhi Sponsored by Department Of Environment, Government of Delhi

2.POLICIES

2.1 General Presentation of the Objectives

The Integrated Energy Policy of the Government of India was announced in December 2008. This Policy directs all sectors of energy at the Central Government level to ensure energy sufficiency at national and local levels. However, the Federal States have the opportunity to take their actions suiting local needs. The 'broad vision' behind the energy policy is to reliably meet the demand for energy services of all sectors at competitive prices. Further, lifeline energy needs of all households must be met even if that entails directed subsidies to vulnerable households. The demand must be met through safe, clean and convenient forms of energy at the least cost in a technically efficient, economically viable and environmentally sustainable manner. Considering the shocks and disruptions that can be reasonably

expected, assured supply of such energy and technologies at all times is essential to provide energy security for all. The policy directs that all available fuel options and forms of energy, both conventional and non-conventional be pursued. Further, India must seek to expand its energy resource base and seek new and emerging energy sources. Finally, and most importantly, India pursues technologies that maximize energy efficiency, demand side management and conservation. Coal shall remain India's most important energy source till 2031-32 and possibly beyond.

The Integrated Energy Policy has also laid down a firm basis for the following:

i) Wherever possible, energy markets are to be competitive. However, competition alone has been shown to have its limitations in a number of areas of the energy sector and independent regulation becomes even more critical in such instances. Whereas the central regulator provides neutral all-country guidelines for regulation of a sector, every state level regulator has its autonomy to decide appropriate regulation at the State level. In case of electricity supply in Delhi, the Delhi Electricity Regulatory Commission takes specific decisions.

ii) Pricing and resource allocations are to be determined by market forces under an effective and credible regulatory oversight. Though this is a desirable goal, but whereas in the power sector this is fully applicable in coal, oil and gas sector, major steps have been taken by the government, so that the market determines the prices.

iii) Transparent and targeted subsidies for the poor, mainly below poverty line for electricity, kerosene and gas are being ensured.

iv) Improved efficiencies across the whole energy chain has been mandated and that includes supply side and demand side. The demand side management is broadly regulated through Energy Conservation Act 2001, which is applicable at the Centre as well as at the State levels.

v) Environmental externalities have to be treated uniformly and internalized.

The Integrated Energy Policy is in the implementation mode and lays quidelines for actions at national, city and local levels. The Central National Capital Region of city of Delhi (CNCR) covers the satellite towns and villages and urbanized villages. Therefore, this region has characteristics of an urbanized society as well as the rural society and includes poor and even below poverty line.

2.2 MULTILEVEL GOVERNANCE

The NCR is a planning concept and entity and is not a single administrative or political unit. The area under CNCR comes under different federal states that have their own administrative boundaries, but they have a common National Capital Region Planning Board, which helps in coordinating their development plans. However, within the region, there are agencies under the Central Government, State Governments and local bodies and village level bodies. Actions of all four have to be coordinated, which is not an easy task.

2.3 THREE MAIN POLICY DOMAINS

Energy efficiency and GHG emissions reduction: Energy efficiency is looked at as an important element for GHG emissions reduction. Energy efficiency policies are administered through the Bureau of Energy Efficiency at the Central level and through the State level wing of the Bureau of Energy Efficiency for the city of Delhi. GHG emissions reduction targets

have not been specifically laid down by the city of Delhi, but various administrative decisions and Court orders have ensured actions like, introduction of CNG vehicles, solar equipment, high efficiency DSM equipment. Some of the actions were mainly to curtail air and water pollution, but have also resulted in containing GHG emissions.

Combating Energy Poverty: Integrated Energy Policy lays down the norms for market oriented approach through regulations and reforms of various energy sectors to combat energy poverty and even fulfill the lifeline energy needs of the poor. At the city level the government has action so that there is redundancy in the energy sector. Recent commitment of the local government to the court ensures power sufficiency and surplus even during the peak summer seasons, thereby ruling out any brown outs or black outs during 2010-2012.

Adaptation of the Energy and Related Systems to Climate Change: The Government of India has announced its 'Energy Efficiency Mission' and 'Solar Mission' as major government directives for climate change mitigation and adaptation measures. These missions have been appropriately funded and provided fiscal support in the budget for the next year i.e. 2010-11. All such measures are expected to result in environmentally clean energy services: at least 20% efficiency improvement by 2020. Capacity addition of 20,000MW by2022 is envisaged in National Solar ission. NVVN (NTPC Vidut Vyapar Nigam[17]) a wholly owned subsidiary of NTPC limited has been appointed the Nodal Agency for sale and purchase of 33 kV and above Grid connected Solar Power under Phase -I of the NSM by Ministry of Power. These initiatives are expected to result in corresponding reduction of GHG emissions. Acceptability of the two missions encourage us to believe that the targets will be well surpassed and India will be on the promised low carbon economy path. Rooftop solar heating systems are being aggressively pursued. Through the first MYT[18] (Multi year Tariff) order, the DERC (Delhi electricity regulatory Commission) has asked the Discoms to achieve 1% of their total power purchase from renewable sources for promoting use of clean fuel and mitigating pollution.

2.4 NATIONAL PLANS AND POLICIES

Expressed Emission Reduction Objectives: The Government of India has committed to UNFCCC that it will voluntarily endeavour to reduce carbon intensity and thereby the GHG emissions by atleast 20% by the year 2020 as compared to 2005.

Short–term and Long-term National Policies Towards Energy and Climate Change: The Integrated Energy Policy lays down the future energy growth in the country as a sustainable pathway ensuring energy security at the national level as well as the individual poor level in urban and rural areas.

The National Action Plan on Climate Change has laid down seven principles to achieve a sustainable development path that simultaneously advances economic and environmental objectives. These are:

i) Protecting the poor and vulnerable sections of society through development strategies, that is sensitive to climate change.

[17] NVVN translation in English : NTPC Electricty Trading Corporation
[18] Annual report 2007-08 of DERC

ii) Achieving national growth objectives through a path leading to further mitigation of GHG emissions.
iii) Devising efficient and cost effective strategies for end use DSM.
iv) Deploying appropriate technologies for both adaptation and mitigation at an accelerated pace.
v) Engineering new and innovative forms of markets and regulatory and voluntary mechanism to promote sustainable development.
vi) Effecting implementation of programmes through unique linkages with civil society and through PPP.
vii) Promoting international cooperation for research and development.

The short-term and long-term specific measures toward energy and climate change are defined by Integrated Energy Policy and National Action Plan on Climate Change.

2.5 LOCAL PLANS AND POLICIES

Delhi has a unique character and constitution. It is surrounded by other states and therefore has also to influence the policies being followed in these states, primarily in the area of environment. As the conglomerate of Delhi is growing so are the pressures on amenities and environment. Therefore planning for Delhi is not considered in isolation but as a planning concept for the region. An entity NCR (National Capital Region) has been established, which is not a single administrative or political unit. Development in this region is guided by a common planning board, the NCR Planning Board. It was constituted in 1985 upon enactment of the National Capital Region Planning Board Act by the Union Parliament, with the concurrence of the participating States of Haryana, Rajasthan and Uttar Pradesh. In this backdrop, the local polices and plans can be devided in two parts- one relating to overall development of NCR and second relating to Delhi City. These are described under Roadmaps.

3. ROAD MAPS

Spread and expanse of the city

Delhi as the National Capital has a distinct and unique character. It is a growing and expanding magnet of attraction for people from all across the country and also a hub for the region surrounding it. Planning for a metropolis like Delhi, therefore, cannot be limited within its boundaries. In recognition of this the Regional Plan 2021 has been drawn up with reference to the following **four Policy Zones**:

i. **NCT of Delhi (NCTD[19]):** In the National Capital Territory of Delhi, the basic policy is to achieve environmentally sustainable development/ re-development considering the limitations of land and water with significantly improved quality of infrastructure.
ii. **Central National Capital Region (CNCR) :** The Central NCR (earlier the Delhi Metropolitan Area) as defined in the Regional Plan – 2021 and shown in Map-1, comprises of the notified / controlled development areas of the neighbouring towns of Ghaziabad - Loni, NOIDA, Gurgaon-Manesar, Faridabad- Ballabhgarh, Bahadurgarh and Sonepat-Kundli, and the extension of the ridge in Haryana, having an area of about 2000 sq. kms. The opportunities presented by the Central NCR are being perked up to enable it to compete effectively with the NCT of Delhi, offering comparable

[19] National capital territory of Delhi

employment, economic activities, comprehensive transport system, housing, social infrastructure and quality of life and environment.

iii. **Highway Corridor Zone**: The NCR Plan has proposed promotion of planned and regulated development along the National Highways. The identified Highway Corridor Zones will be notified by the respective State Governments with appropriate regulations for their development. Uttar Pradesh has already created Yamuna Expressway Industrial Development Authority (YEA) for development along the expressway from NOIDA to Agra.

iv. **Rest of NCR**: In the Rest of the NCR (approximately 29,795 sq. km), the basic policy of the Regional Plan - 2021 is aimed at accelerated development of the urban and rural areas. It is felt that this will make them more attractive for locating economic and allied activities and for attracting private sector investment.

STRATEGIES FOR DEVELOPMENT OF SETTLEMENT SYSTEM

Strategy being adopted for the development of settlement systems (Map-2) is to harness the growth impulse of Delhi and to integrate the urban and rural functions in the region. These are to be attained by means of a more balanced and mutually reinforcing system of central places and bringing a series of necessary functions to the actual reach of the rural population. Cluster approach of settlement is one key thrust area, meaning thereby that the settlements will be a mix of residential, commercial, institutional, educational and industrial sectors. Following steps have been proposed to achieve these objectives:

1. It is proposed to identify four or five Metro Centres or Regional Centres or any other suitable townships for development by attracting investment and generation of employment, creation of high- quality infrastructure, robust transport and communication linkages, high-quality residential areas, industrial and commercial complexes. The proposed new townships would be nodes along the key transport corridors, proposed expressways, orbital rail corridors and other suitable locations on virgin land.
2. Development of small and medium towns in the region as Sub- regional centres or service centres. These towns would play an important role in supporting the socio-economic development in their rural hinterland by providing access to education and health facilities, agricultural extension services and agro-industries based on local products.
3. Rural development to be encouraged by providing facilities and services in appropriate hierarchy which stimulates production and increases income of the rural population, diversify the economy, make villages attractive to live and work and check migration to urban centres.

The effort in planning settlements is focused to ensure that optimum socio-economic development becomes possible with minimum movement. It is expected that the laying metro lines will bring about a shift of settlement density on both the sides of metro lines. Better facilities in the mega city will also mean larger influx of masses from the hinterland as well as smaller citires in search of better income generation opportunity. A balanced growth for settlement is planned in eco-friendly manner.

Development of counter magnet areas

Migration has been playing a crucial role in increase of population of Delhi. In percentage terms share of migration in population increase has dropped in recent years; however, in absolute terms the number of migrants has been continuously increasing. In this background, it has been suggested that:

i) As per NCR Plan, no new Central Government and Public Sector Undertaking offices should be located in NCTD. However, this would be possible only after a time bound action plan is prepared together with suitable incentives and disincentives.
ii) Industrial growth in Delhi should be restricted to high-tech with emphasis on units, which require skill, less manpower and energy and do not create pollution / nuisance.
iii) Legal and fiscal measures should be adopted to restrict employment in industries and distributive trade.
iv) Major regional transport corridor and communication network needs to be strengthened to enhance economic development within the region and decentralization of the distributive trade.

Efforts are on to develop counter magnet areas in the surrounding and nearby states. The counter magnet areas that have been identified are Patiala in Punjab, Hissar in Haryana, Gwalior in Madhya Pradesh, Kota in Rajasthan and Bareilly in Uttar Pradesh.Recent policy intervention and administrative actions have resulted in industrial and commercial activites improving in counter magnet areas and therefore the pressure of migration in Delhi in expected to be controlled.

Connectivity

A phenomenal increase in the growth of vehicles and traffic has been seen in Delhi in recent years. Based on the rate of increase in the number of trips between 1981 and 2001, it is estimated that the total trips would rise to 28 million by the year 2021, including 25.7 million motorized trips and 2.3 million non-motorized trips. In addition to intra-city trips, distance of which has been increasing over the years, inter city trips from neighbouring towns put an additional burden on already stressed roads of Delhi. Table-10 shows the projected travel demand for intercity trips in NCT- Delhi and NCR in the coming years.

Table 10 : Daily Transport demand projections (intercity) up to 2025

Mode	Daily Transport Demand (in million)		
	2005	**2011**	**2025**
Rail	1.311	1.672	3.403
Bus	1.377	1.756	3.573
Other modes	0.59	0.752	1.532
Total	**3.278**	**4.180**	**8.508**

Source: Identification of Rail Projects for Commuter Traffic for Delhi and NCR, RITES, March 1999, page 196, annexure 6/III, Regional plan-2021, National Capital region by NCRPB (National Capital Region Planning Board), Ministry of urban development, Govenmant of India

Apart from the problems and requirements of transportation at the macro level, there are special problems in specific areas, particularly the old city, which has narrow roads and streets, which deserve special attention. Issue of inadequacy of public transport has already been previously discussed. High dependency on personlised vehicles leads to congestion on roads with associated wastage of fuel. Central Road Research Institute (CRRI) and Petroleum Conservation Research Association (PCRA) had undertaken a study in 1996 to estimate loss of fuel due to idling of vehicles at the traffic intersections. The study concluded that in Delhi, with over 466 signalized intersections at that time, 3,21,432 litres of Petrol and 1,01,312 litres of Diesel were being burnt every day due to the idling of vehicles.PCRA has been regularly creating awareness through campaigns. Though no study has been conducted but it is considered that the amount of fuel burnt at crossings has come down by switching off engines rather than idling at crossings.

Traffic enforcement and education measures have been identified as two most important elements to influence personal behaviour. The following technical interventions have been suggested -

i. Synergy between land use and transport
ii. Preparation and operationalisation of an integrated and mutually complementary multi-modal transportation and traffic plan comprising the Road, Rail and Metro-rail network, so that work centers / residences are within a walkable distance.
iii. The multimodal system will be integrated with safe facilities for pedestrians, bicyclists, disabled persons and Intelligent Transport System (ITS) enabled taxis and three-wheeled scooter rickshaws (TSR).
iv. Optimal use and utilisation of the existing road network and full development of ROW by removing all impediments. All arterial roads will be restructured to allow for smooth and safe flow of buses and non motorised transport to minimize pollution and congestion.
v. Expansion and restructuring of the existing network through expressways, arterial roads, elevated distributors and relief roads with a view to creating alternate access ways and reducing congestion on the existing roads to the extent possible. Urban Relief Roads should also be identified as additional or alternative link roads, wherever possible, to reduce congestion. Diverting traffic not meant for Delhi through peripheral expressways and restriction of heavy traffic during peak hours are other initiatives that have been taken.

The proposed Integrated multi-modal transit system (IMTS) project envisages various models such as Bus rapid Transit (BRT), light rail, monorail and metrorail. The project has 43 corrdors in addition to the metro rail and has been approved for implementation by 2020Delhi Metro is expected carry 10.8 million passengers daily with an average trip of 15 km by 2021

vi. Planning of new road network in such a manner as to prevent possibilities of future congestion by modifying road sections to promote use of public transport, which would reduce use of private transport modes.
vii. Planned and targeted expansion of the Metro-rail network.
viii. Expansion and strengthening / restructuring of the Ring Rail System and sub-urban rail system.
ix. Developing an integrated relationship between the bus, rail and metro-system to provide for seamless multimodal transport, through provision of additional stations, park and ride facilities, introduction of single multi-modal ticketing, etc. The choice of technology for the multimodal public transport system (Bus Rapid transit System, Metro, Mono-Rail, Light Rail) be based on comparative cost-effectiveness analysis studies to ensure rapid development of public transport and to ensure judicious use of public funds.
x. Development of a comprehensive parking policy in line with the broad aims of the Plan for transportation mentioned earlier, including measures for linking new vehicle registration with owner parking facilities.
xi. Establishment of a quick and efficient transport network between the NCR and the NCT of Delhi.
xii. Provision of directional Goods and Passenger Terminals with adequate infrastructure.
xiii. Review of the licensing policy and systems, and effective arrangements for training of drivers / transport operators.
xiv. Other methods of reducing congestions have been suggested, viz., Congestion taxes, ERP (Electronic Road Pricing) as in Singapore, intelligent traffic signaling, incentives for using public transport etc have been suggested.
xv. Walkability should become an important element of urban transportation planning.

Many of the recommendations listed above are being in the process of implementation, which includes, Delhi Metro Rail, Bus Rapid Transit system, Provision of flyovers etc. Intelligent traffic management system is under implementation. Delhi has also shifted to CNG transport in a big way and has the world's largest fleet of CNG driven buses. These initiatives have not only improved traffic condition but also have had a marked impact on environment and consumption of petroleum

products. DMRC (Delhi Metro Rail Corporation) had commissioned a study to estimate impact of Delhi Metro on consumption of motor fuels. As per study done by CRRI, the benefits of Phase –I (74.55 km line length on three routes with 67 stations) has been estimated as given in Table-11.

Table 11 : Fuel type wise Reduction in the quantity of fuel Consumed in tonnes

FUEL	2007	2011	2021
CNG	14309.67	19772.28	29252.30
Diesel	1410.58	2312.12	4336.07
Petrol	8971.60	14705.58	27578.41
ALL	**24691.85**	**36789.98**	**61166.78**

Source: Inputs given by DMRC (Delhi Metro rail Corporation)

The proposed Integrated multi-modal transit system (IMTS) project envisages various models such as Bus rapid Transit (BRT), light rail, monorail and metrorail. The project has 43 corrdors in addition to the metro rail and has been approved for implementation by 2020[20].

The Metro Rail System is the most important, component, of a Mass Rapid Transport System (MRTS) in the City. The Metro Rail network for the entire city has been identified in various phases, which comprises of a network of underground, elevated and surface corridors aggregating to approximately 250 Km, and is expected to carry 10.8 million daily passengers with an average trip length of 15 Km by 2021.

It is expected that about 60% of the urban area will be within 15-minute walking distance from the proposed MRTS stations, after full development of the system. Additional areas could come within easy access and connectivity with the Metro Rail through inter-linkages with other transport modes. About 15% of urban area of Delhi is likely to be directly affected, and may undergo a dramatic impact and change. Further, due to development of economic activities along the Metro Corridors and optimization of connectivity provided by it, the rider ship on the Metro is expected to grow substantially over time. Correspondingly, it is expected that vehicular trips may also progressively shift from road-based transport to MRTS, particularly, with reference to the longer trip lengths (greater than 10 Kms) within the city. Recent BRT initiative in Delhi is seeing development of separate dedicated lanes for cycles and pedestrians, making the roads safer for the users.

Delhi Metro has introduced a unique scheme for renting of bycycles for last mile connectivity. Presently the scheme is operational in some of the stations. These Metro stations have bicycles available on rent. The commuters have to provide a photo identity proof for availing the facility.

[20] Request for qualification and proposal for operation of private stage carriage service, March 2010

Environmental and social benefits of MRTS in Delhi.	
Saving in travel time	The annual cost saved by Metro passengers on account of reduced travel time will be Rs 9.47 billion (US$ 221 million) in 2009.
Fuel cost saving	The annual saving on account of reduced fuel consumption will be Rs 1.81 billion (US$ 40 million) in 2009
Vehicle cost saving	The annual vehicle (capital and operating) cost saving will be Rs 2.76 billion (US$ 61 million)
Reduction in emission of greenhouse gases	The increasing use of the Metro will result in prevention of emission of 131,395.34 tonnes of greenhouse gases such as carbon dioxide and nitrogen oxide from being emitted into Delhi's atmosphere up to 2009.
Emission cost saving	The emission cost saving will be Rs 410 million (US$ 9 million) in 2009.
Number of Road accidents avoided	The Metro will help avoid a total of 255 accidents, including 51 fatalities, in 2009.
Road Accident cost saving	The cost saving on account of accidents will be Rs 93.5 million (US$ 2 million)
Improvement in road journeys	Due to increase in average speed of road vehicles, the annual cost saved by road passengers on account of reduced travel time will be Rs 2.40 billion (US$ 53 million) in 2009.
Source: Inputs by DMRC based on a survey conducted by Central Road Research Institute	

Apart from the Metro Rail System, buses will continue to be other major public transport in the city. Buses carry about seven million passengers per day, of which 1.7 million are on the state owned DTC (Delhi transport corporation) buses (1952 on road every day) and 5.5 million on private buses (3849 buses)[21]. Even after the introduction/ expansion of the Metro, major dependence will continue to be on Bus Transport as a form of comfortable and convenient public movement within the city. BRTS (Bus Rapid transit system) has been experimented in one of the routes of the city. It has increased the average speed of travel of the buses ; however, the public response in general has been mixed due to other bottlenecks. A different model is planned for next phase of BRT.

To bring about a large cale shift to public transport, the number and quality of buses is being increased. DTC has already introduced low floor non AC (Air conditioned) and AC buses. Over the next two years DTC is expected to increase the number of non AC buses to 6600. DTC will also operate about 1000 Air-conditioned buses. It is proposed ta have about 11000 buses. The balance buses are proposed to be inducted through private route. The private buses cuurently plying in Delhi, called as blueline buses, are owned by individuals and operate on the sanctioned routes. The service provided by

Delhi has Delhi has the world's largest fleet of CNG driven buses. More than 17000 buses of different types have been given permits by Delhi transport department. The city bus service is being revamped and around 11000 new low floor buses are to be inducted in next two years.

[21] Page-10, Request for qualification and proposal for operation of private stage carriage service, March 2010

the private bus operators has not been satisfactory, both on passenger comfort and safety aspects.To phase out Blueline buses from city roads, the Delhi government has decided to divide the city into seventeen clusters and award each cluster to private operator. Each private operator will deploy designated number of buses in the cluster. The buses will operate as per unified time table of Delhi and if rquired, will be fitted with special devices such as global positioning system to track the buses, monitored by a government agency. The buses will be run by the operator but the revenue will go to the government, which will pay to the operator on agreed per kilometer rate basis. The first such agreement has been recently signed with a private bus operator, Star Bus Services Private Limited, which will deploy 250 low-floor buses to cover 32 routes in cluster 1 in South Delhi[22].

Power

The population of the city of Delhi in 2021 will be 23 million and that of CNCR will be 64 million. As such future plans for meeting the energy needs are being considered keeping the above demographic structure.

The present total availability of power is 3170 MW. The existing power generation stations within Delhi have installed capacity of 1699 MW and maximum generation capacity of 1435 MW. Delhi's own generation installed capacity is 994.5 MW. Nearly 28% of Delhi's power needs are met by its own plants and BTPS[23] and remaining 72% by import from NTPC and other sources. Central Electricity Authority has estimated Power requirement of about 11,000 MW in the 17th Annual Survey (March 2007) for the year 2021. However, the actual demand may be higher in view of the realistic growth related to Commonwealth Games 2010. To meet this demand; there is a need to augment the Power Generation, Transmission, Sub-Transmission & Distribution Capacity within the State.

Since the projected load demand is expected to reach 11,000 MW by 2021, the existing generation capacity in Delhi including the proposed additional 2000 MW capacity at Pragati Ph.II, Pragati Ph. III and Replacement units at I.P. will not be sufficient and the gap between the core generation and the load demand will further increase. Also, since coal based generation in Delhi is not permitted due to environmental and ash disposal constraints only gas based Power Plants are envisaged to be installed in Delhi and all thermal power plants located in the NCT of Delhi will be gradually converted to gas based plants.

To reduce this gap, at least three generating stations each of 1000 MW capacity shall be required. About 40 hectares of land would be required for each of such facilities. This could be compacted by going for higher generation for each of such facilities. This could be compacted by going for higher generation in one place provided gas is available as required. Balance supply could be brought from outside Delhi from plants like Jhajjar, DVC[24], THDC[25], Dadri etc. Delhi is keen to have higher contribution from enviornmentally benign renewable hydro-electricty. However, that carries the risk of variable availability due to monsoon variability and water table variablility in catchment areas, mainly in the Uttaranchal.

Further, even though 400 KV D/C Transmission Ring around Delhi has been established to draw power from the Northern Grid, this Transmission Network is inadequate to draw required Power from

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[22] One of the seventeen clusters
[23] Badarpur Thermal Power Station
[24] Damodar Valley Corporation
[25] Tehri Hydro Development Corporation

Northern Grid to meet the load of about 11,000 MW keeping in view the N-1 Criteria[26] at outage of one largest Transformer in each Sub-Station and other redundancies as per planning norms of Central Electricity Authority. Thus, in order to draw power from the Northern Grid to meet the expected Load requirement and to keep contingencies and margins, 4 new 400KV Grid Stations would be required to be established. In addition, in feeds from 765 KV proposed ring in NCR Region would also be required to be established. Further, keeping in view the long-term requirements of Power in Delhi provision of at least two 765/800 KV Grid Stations would also be required. Correspondingly, 220 KV Grid Stations and down stream 66KV/11KV Grid Station would also require to be established to meet the load requirement of newly developed areas and increasing demand in the existing developed areas. About 40 numbers of 220/66KV and 220/33KV Grid Stations would be required while at present only 22 Stations are existing. As such land would be required for at least 20 more 220KV Grid Stations. In Zonal Plans of Narela, One 400 KV Grid station, Five 220KV Grid Stations and 20 66KV Grid Stations shall be required and in Rohini Zonal Plans, two 220KV Grid Stations and twenty 66KV Grid Stations shall be required.

The loss level reduction of AT & C losses targeted by DERC (Delhi Electricity Regulatory Commission) in the Multi Year Tariff (MYT) regulations for the distribution Companies by the end of control period (2007-08 to 2010-11) and the annual loss reduction target during the control period as stipulated by DERC for the Discoms is as given in Table-12.

Table 12 :Target of Aggregate technical and Commercial (AT&C) Loss reductions

Discoms	By 2010-11	Annual Target
BRPL	17%	3.23%
NDPL	17%	1.65%
BYPL	22%	4.26%
NDMC	10%	0.38%

Source: MYT (Multiyear tariff) order 2007-08 to 2010-2011 of DERC (Delhi electricity regulatory commission) for distribution companies

In order to improve the overall power situation in the National Capital Region for the perspective year 2021 for the harmonized and balanced development of the region, following strategies and policies have been proposed:

1. **New power plants:** New power plants have been planned in the region and/or to have share for NCR in allocation of power expected to be generated by the newly proposed power plants under the Central sector power projects including mega-projects. Initiatives have been taken to enhance the installed capacity of power generation in Delhi. IPGCL[27] & PPCL[28] are setting up new power plants for augmentation of Delhi's core generation and to meet the demand of power during the Commonwealth Games, 2010 and beyond. Two Gas Based Combined Cycle Power Projects of 1500 MW capacity at Bawana and 750 MW capacity at Bamnauli respectively are set up in Delhi by Pragati Power Corporation Ltd. A 1500 MW coal based Power Project is being set up by Aravali Co. Pvt. Ltd. (a JVC[29] of NTPC, IPGCL & HPGCL[30]) in Distt. Jhajjar, Haryana.

[26] "n-1" i.e. to withstand a single contingency with little negative effect. This means the most severe fault or tripping of a critical generator, transformer or line should not result in instability of the system

27 Indraprastha Power Generation Co. Ltd.

[28] Pragati Power Corporation Limited

[29] Joint Venture Company

30 Haryana Power Generation Company Limited

2. **Load Management:** Modern techniques are proposed for Load Management to flatten the load curve and reduce the peak demand in the system to a manageable proportion, vis-à-vis the availability in the grid e.g. smartgrids.
3. **Improvement in transmission and Distribution:** Transmission and distribution system is being improved. The momentum in controlling AT&C losses will be further geared up so that leakages and losses are totally controlled.
4. **Promotion for Non- Conventional Energy Resources:** Emphasis is being given for promoting non-conventional energy resources such as solar energy plants on roof top etc. in big hotels, institutions, commercial buildings, group housing etc; to meet a part of the power demand. WEC-IMC has taken initiative of taking solar water heater to Delhi homes through a joint exercise with MNRE, financial institutions, manufacturers and RWAs (Resident welfare associations).
5. **Public-Private Partnership:** Keeping in view the huge investment required, which amounts to approximately Rs. 933.8 billion (US$ 20.75 billion) for the power generation and Rs.583.6 billion (US$ 12.97 billion) for transmission and distribution till 2021, public-private partnership are being encouraged.

Energy Efficiency

Energy Efficiency Bureau of Delhi under Delhi Transco has developed a comprehensive plan. Delhi has adopted a holistic approach combining the issues and actions at various levels of planning, design, construction and end use with an aim to usher in a sustainable and energy efficient regime. Integrated mass transport system, traffic and transit operation and management, better telecommunications, promoting bicycles and NMV (Non motiorised vehicle) transport are some areas which have the urgent attention of the administration. The introduction of energy audit and design of energy efficient buildings by site planning, heights, form, construction and materials and reducing energy demand by passive micro-climatic design approach, intelligent energy controls, heat recovery, landscape, opening design, furnishings, etc., are the critical considerations that have been identified. The identified actions include the following-

1. Encouraging Energy Conservation Building code (ECBC) compliant new commercial buildings complexes having a connect load of 500 KW or 600 KVA .This code provide norms and standards of energy consumption expressed in terms of per metre of the area wherein energy is used taking into account, location of the building and provides minimum requirements for the energy-efficient design and construction of commercial buildings. Compliance with this code may reduce the specific energy consumption of a commercial building complex by up to 20 to 25%.Even though the codes are presently in the voluntary stage, awareness through continuous outreach programmes is being spread to bring about market transformation towards high performance commercial buildings in the capital .This code also form an integral part of the green building ratings like GRIHA.
2. Solar energy is being encouraged for all establishments with floor area of more than 300 sqm.
3. Solar panels are promoted for public advertising, lighting in open areas, public utilities, streets, etc.
4. Load Management Techniques are being introduced
5. Tariff restructuring and improved metering arrangement are initiated to minimize power thefts/losses
6. Private Sector Participation in different stages of power generation, transmission and distribution is being enhanced
7. Energy savings and use of energy efficient gadgets are being incentivised
8. Public awareness, capacity building and training is being undertaken

The following initiatives have been launched in Delhi-

- **Bachat Lamp Yojana (BLY):** Replacement of low efficiency incandescent lamp with high efficiency fluorescent tubes (CFLs) without compromising with the lumens output. Lamps are being distributed at the cost of GLS lamps under Bachat Lamp Yojana (BLY). Scheme announced by MOP (Ministry of Power) seeks to replace estimated 400 million incandescent bulbs in household sector by CFLs- could save 6000 MW to 10,000 MW.
- **Labelling Programme:** The Objectives of Standards &Labeling Program is to provide the consumer an informed choice about the energy savings, and thereby the cost saving potential of the marketed household and other equipment. The scheme was launched by the Hon'ble Minister of Power in May,2006 and is currently invoked for equipments/appliances (Frost Free(No-Frost) refrigerator, Tubular Fluorescent Lamps, Room Air Conditioners, Direct Cool Refrigerator, Distribution Transformer, Induction Motors, Pump Sets, Ceiling Fans, LPG, Electric Geysers and Colour TV). Addition of new equipments and appliances is to be rolled out. Voluntary labeling of motor vehicles has been introduced.
- **Star rating of buildings:** A voluntary star rating programme for buildings fully occupied for more than one year has been introduced by BEE (Bureau of Energy Efficiency), a statutory body of Government of India. Energy audit studies in buildings have shown large potential for energy savings both in government and commercial office buildings. Study of the available data has shown that there is an urgent need for improved energy efficiency of buildings. The Star Rating Program for buildings is expected to create a demand in the market for energy efficient buildings based on actual performance of the building in terms of specific energy usage. The buildings having a connected load of 100 kW and above are to be considered for BEE star rating scheme. The Bureau will work towards creating a market for energy efficient buildings through awareness and education.
- **Commonwealth Games, New Delhi 2010 and Energy Efficiency:** The Delhi Development Authority (DDA), Central Public Works Department (CPWD), Government of Delhi, Sport Authority of India and other organizations have taken up various projects for the prestigious 19th Commonwealth Games, to be held in Delhi during October 2010. All the venues have been planned as 'Green Projects', which include Commonwealth Games Village (DDA), Competition and Training Venues, Transport and other infrastructure. Energy efficiency is a key concern, which involves a synergy combining the various levels of planning, design, construction and maintenance, leading to a sustainable and energy efficient regime. These have been implemented right from the site analysis and concept planning stage, and throughout the design and specification process and construction.
- **Green Buildings:** Delhi government has approved a proposal for the implementation of the Energy Conservation Building Code (ECBC) in new government buildings and building complexes on a mandatory basis in government buildings.
- **Energy Audit of buildings:** Energy audits within the existing government buildings and implementing the audit recommendations through BEE empanelled Energy Service Companies (ESCOs) through Performance Contracts has been taken up. Energy Audit recommendations have indicated a huge energy saving potential of as high as 40 % in the existing government buildings. With the intent of handholding the ESCO business and encouraging energy efficiency implementation through performance contracting, the BEE entered into a Memorandum of understanding with the Power Trading corporation under which six utilities in Delhi have been identified for taking up of energy efficient measures on performance contracting mode , these are AIIMS (All India Institute of Medical Sciences), Safdarjung Hospital, ESIC (Employees State

Insurance Corporation) Hospitals at Rohini & Jhilmil, Presidents Estate and Ram Manohar Lohia Hospital .Under this MoU M/s PTC[31] would fund the implementation of the audit recommendations and get back its investments through annual savings achieved in these utilities. Success of this model will enable replication in rest of the state.

- Encouraging new technologies like Trigeneration and Heat Pumps specially in the government hospitals and hotels in the capital to reduce the HVAC energy consumption by as much as 40%.

Environment

Delhi is one of the Greenest Capital Cities in the world. Green cover of Delhi increased from 30 sq km to 300 sq. km in last 10 years, which at present is about 20% of the Delhi's geographical area. Actions have been taken towards afforestation as detailed below-

- 5000 Acres of denuded mine land, developed with plantation of 700,000 trees with the help of Eco-Task Force, a unit of the Territorial Army.
- 4 existing City Forests densified, 9 new city forest created in the year 2007-08 and 9 more new city forest added during the year 2008-09.The forest department plans to creates another 10 City Forest in this year.
- Two Biodiversity parks namely Yamuna Bio-Diversity Park and Aravali Bio-diversity Park are being developed.

Despite various initiatives and measures taken over the past few years, like introduction of CNG and EURO II norms etc., the air quality in the city, in terms of pollution levels, has continued to be a matter of concern. The three main sources of air pollution in Delhi are–

i. Vehicular emissions (around 70 percent)
ii. Industrial emissions (around 20 percent) with a major element of this coming from the three thermal power plants, and
iii. From other sources such as diesel generator sets and domestic cooking, burning of biomass, etc.

Delhi Metro is providing a mode of fast and comfortable journey thus resulting in shifting of users from roads to Metro. Delhi metro has not only resulted in reduction in fuel consumption of the city but has also given environmental benefits. It is the first Railway project in the world to be registered by the United Nations under the Clean Development Mechanism (CDM), which will enable it to claim carbon credits. It has been estimated that DMRC may earn 400,000 CERs for a 10-year crediting period beginning December 2007 when the project was registered by the UNFCCC, which translates to Rs. 12 million (US$ 267,000) per year for 10 years.

Many of the polluting industries have been relocated outside the city and restriction has been put on setting up of new industrial units. One of the oldest power plants has been shut down to control emissions. Delhi has recently published Climate Change agenda for Delhi 2009-2012. Delhi is one of the first cities to have its own Climate Change Agenda and Action plan. The document stresses on the need of “putting in place small efforts which are encapsulated in a framework which makes it possible for each Delhite to become a part of the process of change which is globally acceptable for the future generations”. The Climate Change Agenda for Delhi 2009-12 adopted by the Government

[31] Power trading corporation

of NCT of Delhi put forth several action items that the Government intends to undertake in the coming years. Areas like Air, Water, Noise, Municipal waste management and greening with clear cut target for 2009 and 2012 and the responsible departments have been clearly identified. In fact 65 agenda points for action on various sectors have been identified. Over and above the mandatory Energy Conservation Building Code adoption in Government buildings and in all new construction projects applied for Environmental Clearance, Delhi Cabinet has decided to upgrade energy efficiency of existing Government Buildings through retrofitting to be carried out by energy service companies in a performance contracting mode. The objective is to ensure that Government Buildings can achieve at least rating of one star from BEE under their office building labeling programme.

The industrial wastewater generated in Delhi is about 40 MGD. All industrial units have been directed to ensure linkage to conveyance system in 11 Common Effluent Treatment Plants (CETPs). These are also being checked for their water quality every month and necessary corrective measures also being ensured. More than 1200 industrial units have installed eight ETPs to treat industrial wastewater.

Latest estimates indicate that about 6500-7000 Tonmes of Municipal Solid Waste is being generated each day in Delhi at present. Estimated generation of Municipal Solid Waste by 2010 is 9000 Tonnes per day. The management of solid waste in Delhi is being improved through various measures adopted by concerned agencies. The Govt. of India has notified Municipal Solid Waste (Management & Handling) Rules, 2000 with the objective of collection, segregation, storage, transportation and processing and disposal of Municipal Solid Waste. Implementation of these rules is being taken care by concerned local bodies in their respective areas.

Besides the above, the Municipal Corporation of Delhi, which is managing the solid waste, has taken the following policy level decision to improve the management system:

i. Private Sector Participation in transportation of solid waste in six zones has already been awarded and for other four and a half, it is in the process of award.
ii. Setting up of processing facilities through private entrepreneurs.
iii. Infrastructure development at the local level collection and at the terminal processing level for segregation of wastes.

Delhi Pollution Control Committee has granted consent for following projects for generation of power from garbage (waste to energy project):

i. Timarpur Project: 650 tons per day MSW[32] with output of 255 tons per day RDF(Refuse Derived Fuel).
ii. Okhla plant: 1300 tons per day MSW will process 450 tons RDF, from which 16 MW power will be generated.
iii. Ghazipur: 1300 tons per day MSW with output of 450 tons RDF. Electricity generation capacity is 10 MW.

The following Waste to compost Projects are operational:

i. Compost plant of 500 TPD capacities at Bhalaswa Sanitary Landfill site.
ii. Okhla Compost Plant of MCD (Municipal Corporation of Delhi) has been upgraded to 200 TPD

[32] Municipal Solid waste

iii. Existing 125 TPD Compost Plant of APMC[33] has been upgraded to 200 TPD.

Green Commonwealth Games

The infrastructural developments leading to Commonwealth Games to be held in Delhi in October 2010 are according to the overall philosophy of the Delhi Governement to reduce carbon footprints to the extent possible. Some of the initiatives are-

1. Games Village: All common areas of all towers of the games village and more than 50 percent of external lighting is to be powered by solar panels. Energy efficient lighting shall only be used. Variable Refrigerant Flow system provided for air conditioning of residential flats is expected to reduce energy consumption towards air conditioning. Waste water recovery has been planned through sewage treatment Plant, effluent water treatment plant and phytorid treatment. Rain water harvesting system has also been provided.
2. The venues being constructed for the XIX Commonwealth Games 2010 Delhi are being built keeping in mind the Green vision of the Games. Measures in terms of energy efficiency, water conservation, etc., have been taken to reduce the carbon emissions from Games related activities.
3. Thyagaraj Stadium, one of the games venues, is constructed on green building concept. It uses solar energy for lighting purposes. The Stadium will generate 650 KVA electricity from Solar panels on the roof, providing 18% of the 100% standby arrangement.

Adaptation to climate change

Government of Delhi is the first federal state to have adopted a Climate Mitigation and Adaption Plan within the broad outlines of National Action Plan on Climate Change. Commonwealth Games have proved an impetus for Delhi to adopt a number of environment friendly measures. Green development strategy to project Green Games has introduced new norms in construction and operations that will have exponential spin-off effect that cannot be quantified at this stage. Commitment of local leadership and support of business academics and media will be crucial in future green development in the city. Various orders of the Supreme Court have also helped the government to take strict measures for greening of Delhi. Current indications are that the City of Delhi will adopt energy efficiency measures, and thereby, reduction in emissions is expected at a very rapid pace - over 20% by 2020.

Combating energy poverty

Delhi is in true sense a cosmopolitan city, which is a safe haven for people coming from all federal states. As the economic growth in Delhi and satellite towns has been at a pace higher than at national level, large number of migrant labour is always adding to the city. During the last three decades the population has always overshot the projections. Upgradation of infrastructure in preparation to Commonwealth Games will make Delhi a magnet Mega City. Prediction of growth pattern is difficult; therefore, planning for energy supply to meet 100 percent energy needs will always remain a ‘pipe dream’. However, all the measures undertaken by the government are targeted towards making energy available and affordable to each category. A periodic review of energy pricing will ensure planned sufficiency. In a unique initiative, Indian Member committee of World Energy Council distributed Solar Lanterns to poor households not having access to electricity in Sangam Vihar locality of Delhi.

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[33] Agricultural Produce Marketing Committee

Integrated Planning for Energy

Delhi needs integrated planning for energy supply; energy management and energy consumption pattern. This means supply of all forms of energy: coal, oil, gas, firewood, LPG must be planned in an integrated manner and their uninterrupted flow in sufficient quantities should be administered and managed through an institutional arrangement. City gas was introduced more than 10 years back but the coverage is marginal. At present Delhi does not have an integrated structure for supply of energy services.

On the demand side management traffic management and regulation will form on important part of transport sector. Long term planning of surface trains, metro trains, city buses and taxies and other public transport has to evolve in an integrated manner for inter-city transport to satellite towns around Delhi and intra-city transport in Delhi. An integrated Transport and Traffic Policy will have to evolve. Realty sector is another sector which will need long term policy planning for energy efficient buildings and construction- including commercial buildings, residential buildings, public buildings and all public works of roads, flyovers etc.

Electricity supply in Delhi has received special attention due to Commonwealth Games 2010. Working on the principle of at least 60% requirement should be met through load centered generation, the electricity supply is planned through expansion of NTPC's Dadri Plant; Badarpur Plant and Power Plants being set-up in Jhajhar and a few gas plants in Delhi. This integrated planning will result in Delhi having redundancy in power supply.

Above mentioned elements form components of integrated planning. But, such planning and implementation will need proper institutional structure.

Institutional Structure for Energy Planning & Implementation

Delhi has a complex administrative pattern and the government cannot take decision on every issue on its own. As such, there is no clear cut institutional arrangement for energy planning and administration. Overall the Department of Energy is supposed to oversee all actions.

In the electricity sector Delhi has the regulator, generating companies, transmission company and the distribution companies. By and large, Delhi Transco Ltd. is responsible for transmission, demand side energy efficiency programmes and use of renewable sources.

Energy Architecture far slums

Energy use pattern in slums is a mix of commercial sources and woody biomass and cow dung. Delhi has two kinds of settlements that can be described as poor man's habitat. Permanent slum colonies and the temporary construction worker clusters - popularly known as Jhugi-Jhopri or JJ Colonies. The energy architecture for these two slums differ substantially as follows:

i. In case of permanent slums - residents use electricity supply metered or otherwise; LPG supply and also limited personal transport.
ii. In case of temporary slums- Residents depend mainly on firewood for cooking and kerosene lamps for lighting. Streetlights and community centre are normally non-existent.

Markets in both the cases have local shops lit by kerosene lamps or PV panels in some cases.

As construction in Delhi and neighbouring cities will be an ongoing process, the temporary clusters will continue to be the permanent feature. The government has to build a partnership model with construction developers to create local lighting and cooking energy devices that can move from place to place.

The numbers in slums are likely to increase with time. With them the rural habits will also be transferred to Delhi.

Academic institutions, NGOs and energy companies will have to be networked under the government umbrella so that a mix of energy supply for cooking based on firewood, LPG and kerosene is arranged through efficient cooking devices. Also low energy consuming electric lights will have to be promoted.

The energy architecture for urban slums will have to evolve over time.

GENERAL COMMENTS AND CONCLUSIONS

Delhi is a unique case study of a Mega City which grows exponentially accommodating low skilled and high skilled manpower. Delhi is not only a seat of power but also a major commodity wholesale market. Being surrounded with satellite industrial townships, the city remains a place of attraction for two-way daily movement of masses that causes challenge of traffic on highways and arterial roads, Delhi has to import electricity from other federal states and as such has to depend on large scale electricity transmission which often fails either for demand in neighbouring states or tripping of national grid. Uncertain monsoon and erratic hydro electric supply is also a major cause of concern.

Delhi has successfully brought down its AT&C cases from 62% to around 20% in seven years since privatization of distribution network. These losses are expected to further reduce annually by 2 to 4% and may be down to about 17% in another one year. The Smart Grid concept has been tested and when fully implemented will further optimize electricity supply.

Delhi electricity demand has been growing at 8% every year for which supplies are being arranged. Energy Efficiency Mission and Solar Mission are expected to bring down this increase to about 5%. Inspite of best efforts in the scenario of unplanned large scale influx of migrants it will always remain a challenging task to create redundancy in electricity supply. The government has shown political determination and submitted affidavit to the Supreme Court of India that supply redundancy will be maintained by 2012. That has still to be tested. Since large part will not be generated in Delhi, the city as such will not have concerns about resulting pollution from power plants. Pollution due to transport sector has been curtailed initially by the order of the Supreme Court that makes it mandatory for all commercial vehicles including buses, taxies and autorikshaws to use CNG fuel. Starting in April 2010 only the automobiles conforming to EURO IV standards will be registered in Delhi. Metro Rail has been a major facelift to public transport in Delhi and has reduced transport pollution considerably. The combined impact of regulated traffic; smoother roads and more fly-overs, smart traffic control; improved rapid mass transport will all have an integratd impact which can only be assessed a year later, But the fact is that this growth pattern has been developed and optimally funded though budgetary allocation reassures that an environmentally sustainable transport system will be in place in Delhi.

Public consciousness about energy efficient pollution free habitat is supporting realty sector growth in conformity with new building codes including Energy Conservation Building Code; and adherence to Green Building Ratings is ensuring optimum energy efficiency of existing buildings and new buildings

after one of full occupany and operation. Whereas these codes and ratings are mandatory only for a small category of designated users, a large number of environmentally conscious people are voluntarily adopting these standards.

Delhi has to face formidable challenge of containing rising energy demands but the options, technology and funding available to the city give hope of sustainable development of the city.

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18. STUDY TEAM MEETINGS

Study team meetings were held on the following dates-

- 1st Meeting : 08 December, 2009
- 2nd Meeting : 18 August, 2009
- 3rd Meeting : 28 August, 2009
- 4th Meeting : 10 September, 2009
- Final meeting : 19th April, 2010

The first meeting of the study team was held on 08/12/2008. This was the introductory meeting in which the participants were apprised about the WEC study on “Energy for mega cities”, its scope and terms of reference. Mr. Anil Razdan chaired this meeting attended by wide cross section of administrative, transport, environment, Energy sector departments and organisations. In this meeting, WEC-IMC requested the participants for their inputs.

Draft report was prepared based on inputs received from study team members and 2021 plan documents for Delhi and NCR.

The second meeting of the study group was called on 18th August, 2009 to discuss and review the draft report. Deliberations led to certain new inputs relating to consumption of petroleum products, Delhi Metro and its impact on consumption of petroleum products.

In the third meeting held on 28th August, 2009, inputs were sought from Bureau of Energy efficiency regarding the Energy conservation building code and inputs were also requested from BSES (A distribution company supplying power to part of Delhi) regarding electricity supply distribution. Suggestions on transportation and densification of cities also emerged.

The fourth meeting held on 10th September, 2009 focussed on Energy efficiency interventions, Energy Conservation Building code and transportation plan. Participants agreed to give inputs on these aspects.

The final meeting called for final thoughts and viewpoints on the draft prepared based on the suggested template by WEC London

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