LOW CARBON DESIGN FOR A NEIGHBOURHOOD IN NORTH INDIA

A DISSERTATION

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

of

MASTER OF ARCHITECTURE

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which is presented in the dissertation entitled " LOW CARBON DESIGN FOR A NEIGHBOURHOOD IN NORTH INDIA ", in partial fulfillment of the requirements for the award of the degree of MASTER OF ARCHITECTURE, submitted in the department of Architecture and Planning, INDIAN INSTITUTE OF TECHNOLOGY ROORKEE, ROORKEE is an authentic record of my own work carried out for a period of about one year from July 2010 to June 2011 , under the supervision of Ms. Rita Ahuja and Dr.P.S. Chani, Department of Architecture and planning, INDIAN INSTITUTE OF TECHNOLOGY ROORKEE, ROORKEE, INDIA.

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

Dated: 30/6/2011

Place: Roorkee

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CERTIFICATE

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

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(DIVYANSHI CHOPRA)

ABSTRACT

The construction sector is a major consumer of energy hence; produce a lot of carbon release in the environment. This released carbon has two classifications. One is the embodied energy and second is operating energy. To reduce carbon content of any neighbourhood it is necessary to lower these values.

The aim of this study is to make a low carbon design for a neighbourhood in North India.

The literature survey reveals that the percentage of resource consumption is high in construction sector. Also one of the highest percentages of construction takes place in residential sector. Therefore if we can establish any change in this area which will result in lesser carbon release then its effect will be considerable.

The methodology adopted for this study is that an existing neighbourhood is studied and its embodied energy and operating energy is found out. Then these values are carefully analyzed and it is observed that which areas can be curtailed to reduce the carbon content. Then another new neighbourhood is proposed on the same site with the suggested changes. And now the values of the existing neighbourhood and the proposed neighbourhood are compared. Also some other methods are suggested which play their role in reduction of the carbon content both directly and indirectly. This helps us to analyze that how much is the reduction possible in this case and whether is it effective.

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CHAPTER 1 : INTRODUCTION

1.1 INTRODUCTION

The term "Low Carbon neighbourhoods" can be interpreted as Low, means lesser than the normal or existing; Carbon means a non-metallic element occurring in nature and a neighbourhood means a geographically localized community within a larger city, town or suburb. Neighborhoods are often social communities with considerable face-to-face interaction among members.

Therefore, Low carbon neighbourhood is a neighbourhood that has lesser amount of carbon emission and which have lesser embodied energy compared to the existing neighbourhood.

This study is specific to the region of plains of Northern India in Indian subcontinent of Asia.

1.2 NEED FOR STUDY

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs requiring huge investments to meet them.
Economic growth is desirable for developing countries, and energy is essential for economic growth.
However, the relationship between economic growth and increased energy demand is not always a straightforward linear one. For example, under present conditions, 6% increase in India's Gross Domestic Product (GDP) would impose an increased demand of 9 % on its energy sector.

Power consumption in India:--

Generation Installed Capacity (Mw) Of Power Utilities In States/Uts As On 31.07.2006

i. Northern region (Total Installed Capacity--->34,207.15)

ii. Western region (Total Installed Capacity--->37,099.86)

iii. (Total Installed Capacity--->36,569.32)

iv. Eastern region (Total Installed Capacity--->16,477.78)

v. North-easter region (Total Installed Capacity--->2,404.17)

vi. Islands

Installed capacity (in MW) of power utilities in the States/UTS located in northern region including allocated shares in joint & central sector utilities as on 31.07.2006

Can go to Ath

States	Sector	HYDRO	THERMAL				RES	NUCLEAR	
			COAL	GAS	DIESEL	TOTAL			
Delhi	State	0.00	320.00	612.40	0.00	932.40	0.00	0.00	932.40
	Private	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.07
	Central	457.78	1896.98	204.30	0.00	2101.28	0.00	47.08	2606.14
	Sub-Total	**457.78**	**2216.98**	**816.70**	**0.00**	**3033.68**	**0.07**	**47.08**	**3538.61**
Haryana	State	946.26	1602.50	0.00	3.92	1606.42	0.30	0.00	2553.36
	Private	0.00	0.00	0.00	0.00	0.00	7.06	0.00	7.06
	Central	393.80	364.02	532.04	0.00	896.06	0.00	76.16	1365.77
	Sub-Total	**1340.19**	**1966.52**	**532.04**	**3.92**	**2502.48**	**7.36**	**76.16**	**3926.19**
Himachal Pradesh	State	323.00	0.00	0.00	0.13	0.13	49.08	0.00	372.21
	Private	386.00	0.00	0.00	0.00	0.00	0.01	0.00	386.01
	Central	740.24	89.32	60.89	0.00	150.21	0.00	14.08	904.53
	Sub-Total	**1449.24**	**89.32**	**60.89**	**0.13**	**150.21**	**49.09**	**14.08**	**1662.75**
Jammu &Kashmir	State	309.15	0.00	175.00	8.94	183.94	10.59	0.00	503.68
	Private	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.52
	Central	583.76	183.68	127.09	0.00	310.77	0.00	68.00	962.53
	Sub-Total	**892.91**	**183.68**	**302.09**	**8.94**	**494.71**	**11.11**	**68.00**	**1466.73**
Punjab	State	2470.52	2130.00	0.00	0.00	2130.00	115.25	0.00	4715.77
	Private	4.20	0.00	0.00	0.00	0.00	29.70	0.00	33.90
	Central	608.97	516.18	259.72	0.00	775.90	0.00	151.04	1535.91
	Sub-Total	**3083.69**	**2646.18**	**259.72**	**0.00**	**2905.90**	**145.95**	**151.04**	**6285.58**
Rajasthan	State	1008.84	2420.00	113.80	0.00	2533.80	233.29	0.00	3775.93
	Private	0.00	0.00	0.00	0.00	0.00	90.18	0.00	90.18
	Central	370.31	548.88	217.74	0.00	766.12	0.00	469.00	1605.43
	Sub-Total	**1379.15**	**2968.38**	**331.54**	**0.00**	**3299.92**	**323.47**	**469.00**	**5471.54**
Uttar Pradesh	State	518.60	4280.00	0.00	0.00	4280.00	11.40	0.00	4810.00
	Private	0.00	0.00	0.00	0.00	0.00	114.37	0.00	114.37
	Central	712.54	2308.84	541.16	0.00	2850.00	0.00	203.72	3766.26
	Sub-Total	**1231.14**	**6588.84**	**541.16**	**0.00**	**7130.00**	**125.77**	**203.72**	**8690.63**
Uttranchal	State	986.93	0.00	0.00	0.00	0.00	32.77	0.00	1019.70
	Private	200.0	0.00	0.00	0.00	0.00	0.00	0.00	200.00
	Central	181.23	225.24	68.25	0.00	293.49	0.00	16.28	491.25
	Sub-Total	**1368.16**	**225.24**	**68.25**	**0.00**	**293.49**	**32.77**	**16.28**	**1710.70**
Chandigarh	State	0.00	0.00	0.00	2.00	2.00	0.00	0.00	2.00

	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Central	40.69	25.04	15.07	0.00	40.11	0.00	4.84	85.64
	Sub-Total	**40.69**	**25.04**	**15.07**	**2.00**	**42.11**	**0.00**	**4.84**	**87.64**
	Central – Unallocated	268.93	682.32	285.73	0.00	968.05	0.00	129.80	1366.78
Total Northern Region	State	6563.68	10752.50	901.20	14.99	11668.69	452.68	0.00	18685.05
	Private	590.20	0.00	0.00	0.00	0.00	241.91	0.00	832.11
	Central	4358.00	6840.00	2311.99	0.00	9151.00	0.00	1180.00	14689.99
	Grand Total	**11511.88**	**17592.50**	**3213.19**	**14.99**	**20820.68**	**694.59**	**1180.00**	**34207.15**

Buildings account for a large amount of land use, energy and water consumption, and air and atmosphere alteration. Considering the statistics, reducing the amount of natural resources buildings consume and the amount of pollution given off is seen as crucial for future sustainability, according to EPA (Environmental Protection Agency). The building sector alone accounts for 30-40 percent of global energy use. Over 80 percent of the environmentally harmful emissions from buildings are due to energy consumption.

Of which housing forms a large percentage as per use zoning.

Residential zone	40 to 50%
Commercial zone	2 to 5%
Industrial zone	5 to 20%
Civic zone	2 to 3%
Institutional zone	1 to 2%
Recreational zone	15 to 20%

Table 1 Zonning

In year 2000, India had the production capacity ot manufacture more than 10000 crore bricks through local kilns in unorganized sector.It is understood that about 65% of bricks go into dwelling and the balance in commercial, industrial and institutional

Housing scenario in the Indian Building industry:--

India: Summary

Table S00-005: DISTRIBUTION OF CENSUS HOUSES BY PREDOMINANT MATERIAL OF WALL

		Total	%	Rural	%	Urban	%
	Total number of houses	249,095,869	100.0	177,537,513	71.3	71,558,356	28.7
F	Material of wall:						
F.1	Grass, Thatch, Bamboo, Wood, etc.	24,737,121	9.9	22,162,932	12.5	2,574,189	3.6
F.2	Plastic, Polythene	721,776	0.3	477,498	0.3	244,278	0.3
F.3	Mud, Unburnt Brick	73,799,162	29.6	65,807,212	37.1	7,991,950	11.2
F.4	Wood	3,196,992	1.3	2,363,200	1.3	833,792	1.2
F.5	G.I., Metal, Asbestos sheets	1,998,678	0.8	876,677	0.5	1,122,001	1.6
F.6	Burnt Brick	111,891,629	44.9	62,715,919	35.3	49,175,710	68.7
F.7	Stone	25,481,817	10.2	20,347,899	11.5	5,133,918	7.2
F.8	Concrete	6,540,338	2.6	2,253,979	1.3	4,286,359	6.0
F.9	Any other material	728,356	0.3	532,197	0.3	196,159	0.3

Source: Table H-3B India : Census of India 2001

Office of the Registrar General, India
http://www.censusindia.net/

Figure 1: Predominantly used wall material

Energy and Environment

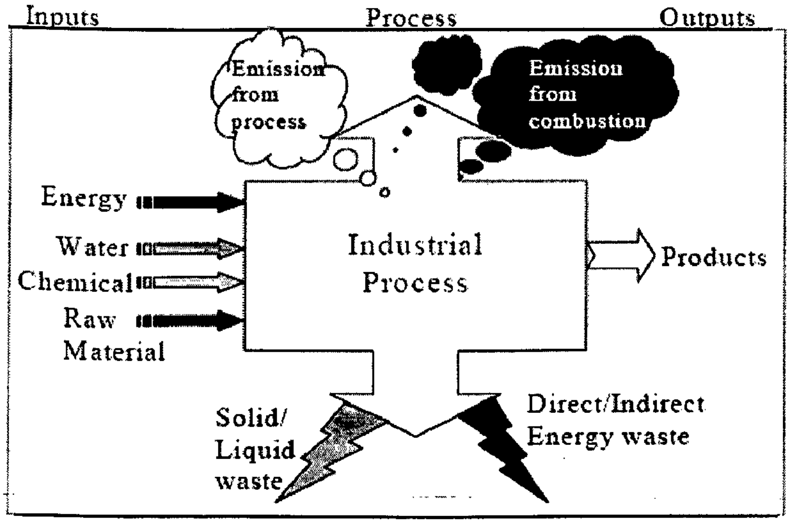


Figure 1.10 Inputs & Outputs of Process

Figure 2: Input & output process

The usage of energy resources in industry leads to environmental damages by polluting the atmosphere. Few of examples of air pollution are sulphur dioxide (SO_2), nitrous oxide (NO_X) and carbon monoxide (CO) emissions from boilers and furnaces, chloro-fluro carbons (CFC) emissions from refrigerants use, etc. In chemical and fertilizers industries, toxic gases are released. Cement plants and power plants spew out particulate matter. Typical inputs, outputs, and emissions for a typical industrial process are shown in Figure 1.10.

So if we could make these buildings energy efficient we could save a lot of energy in the process. And making low carbon neighbourhoods is a step in this direction.

1.3 AIM

Making a low carbon neighbourhood in plains of North India .

1.4 OBJECTIVES

- To analyze & compute comprehensive energy.
- To study retrofitting solutions for selected case studies.
- To evolve a neighbourhood design based on these inferences.

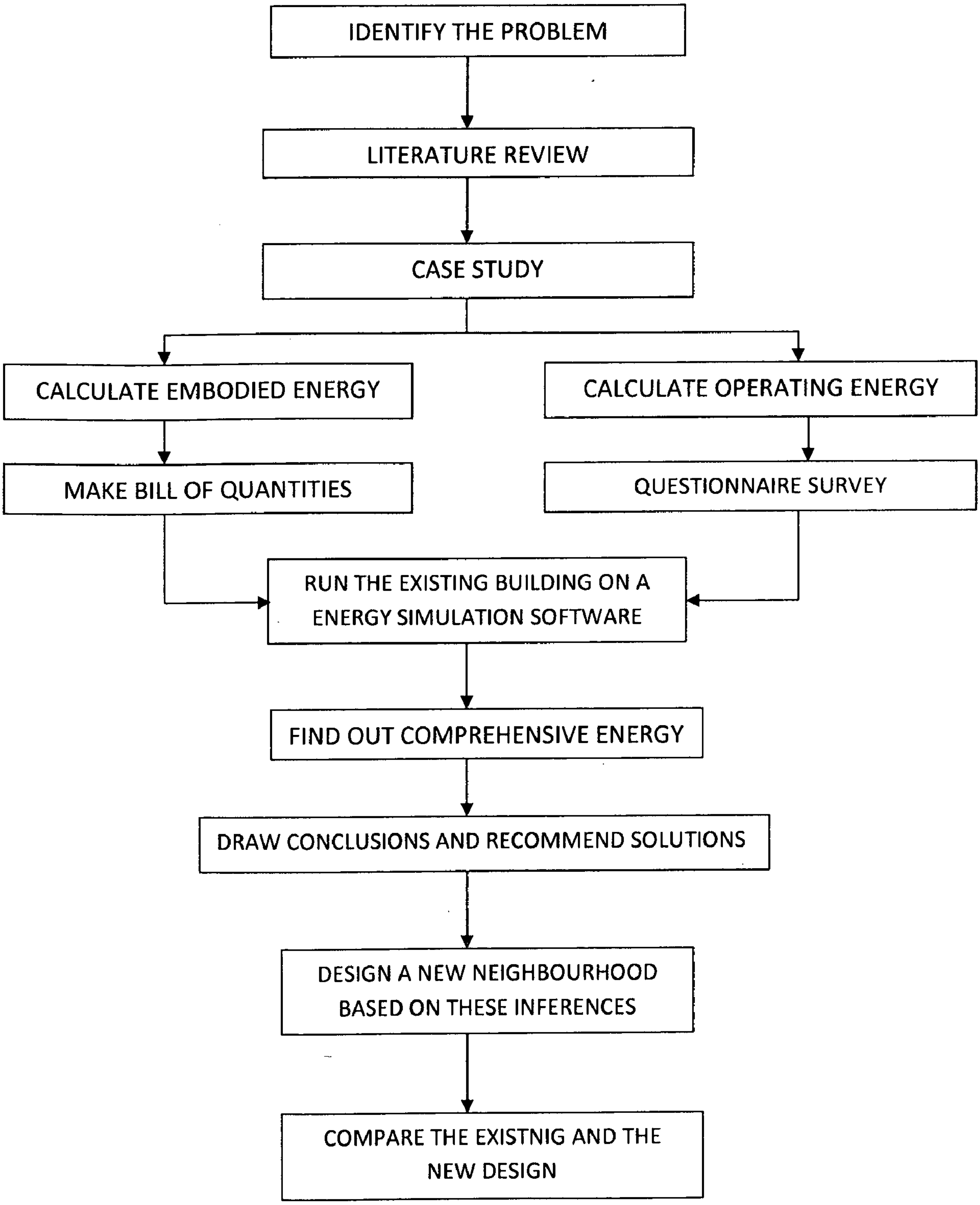
1.5 SCOPE

- The scope of this study is Design of low rise neighbourhoods in the plains of northern India having composite climate.

1.6 LIMITATION

- This study has to be limited to data that can be put under the category of: Embodied energy and Operational energy. Also only the tabulated data shall be taken for the study.

1.7 METHODOLOGY:--



CHAPTER 2:LITERATURE REVIEW

2.1 ENERGY RESOURCES AND CONSUMPTION

In 2008, total worldwide energy consumption was 474 exa-joules (474×10^{18} J) with 80 to 90 percent derived from the combustion of fossil fuels. This is equivalent to an average power consumption rate of 15 terawatts (1.504×10^{13} W). Not all of the world's economies track their energy consumption with the same rigor, and the exact energy content of a barrel of oil or a ton of coal will vary with quality.

Rate of world energy usage in terawatts (TW), 1965-2005

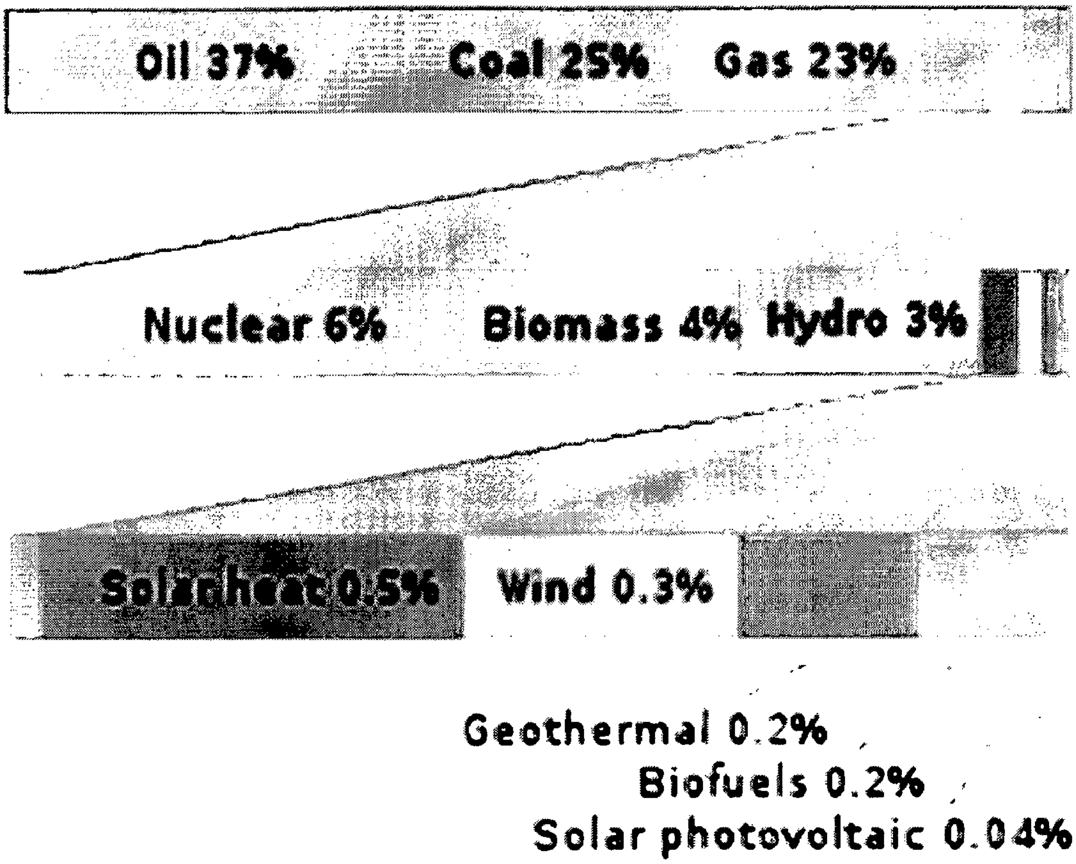


Figure 3:Fuel usage

Global energy usage in successively increasing detail (2005)

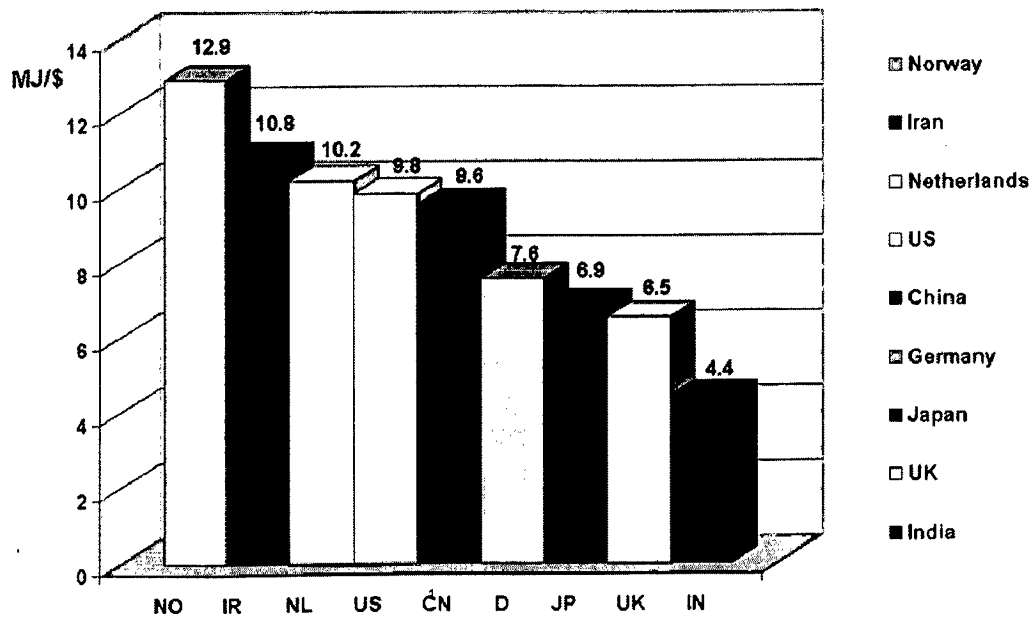


Figure 4:comparison of energy usage in various nations

But the scenario in the emerging economy is different from the economies which are already developed.

Comparison of energy intensity of India with mature and emerging economies (British thermal unit per dollar GDP as in 2000)

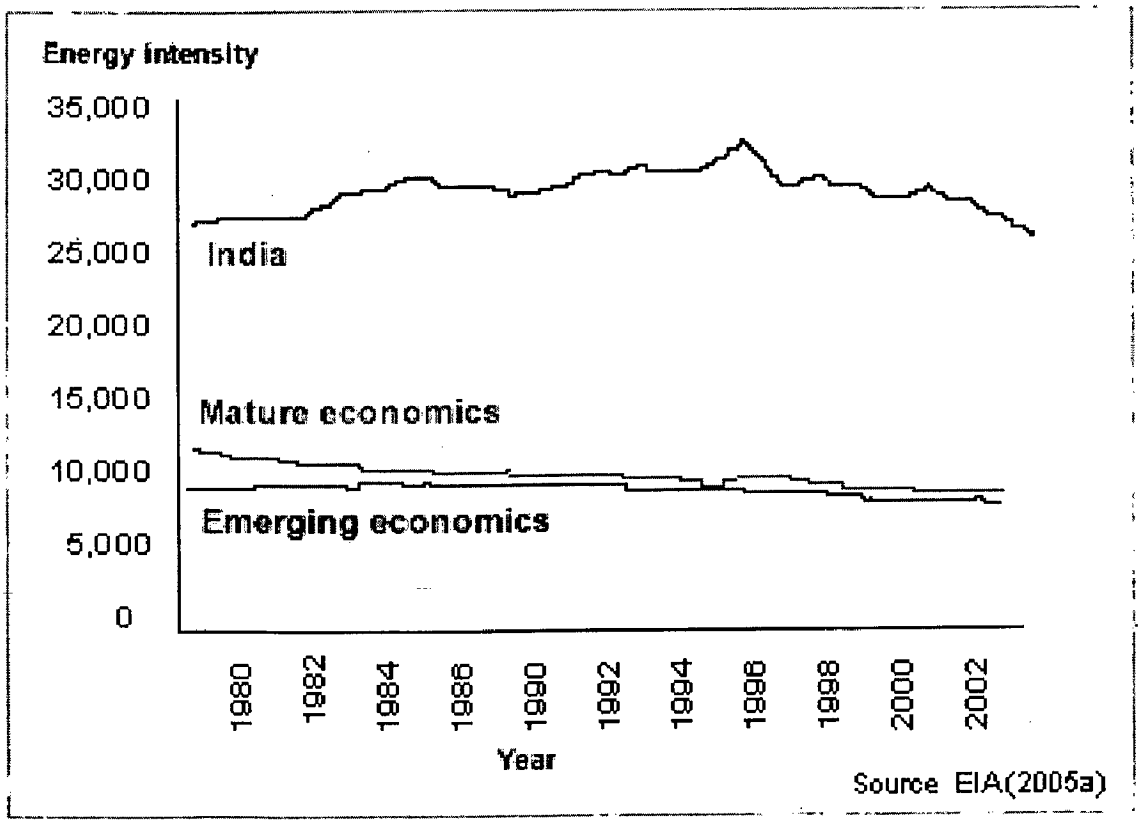


Figure 5:Energy consumption in India

Therefore, it leads to two consequences. These upcoming economies have an opportunity to utilize the energy in better ways as well as it becomes their responsibility to conserve energy in current scenario.

*1 ft^3 approximately equal to 1,000 Btu
or
*1 ft^3 gas = 1,000 Btu = 1 MBtu

2.2 LITERATURE STUDY

1.7.2.1 Sector wise Energy Consumption in India

The major commercial energy consuming sectors in the country are classified as shown in the Figure 1.5. As seen from the figure, industry remains the biggest consumer of commercial energy and its share in the overall consumption is 49%. (Reference year: 1999/2000)

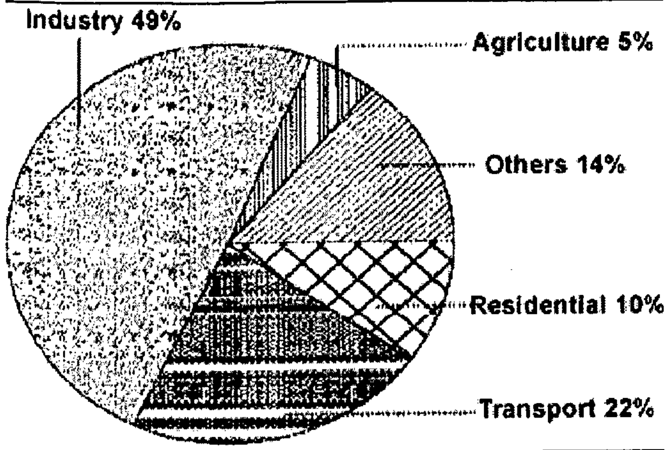


Figure 6: Sector wise energy consumption

Long Term Energy Scenario For India

Coal

Coal is the predominant energy source for power production in India, generating approximately 70% of total domestic electricity. Energy demand in India is expected to increase over the next 10-15 years; although new oil and gas plants are planned, coal is expected to remain the dominant fuel for power generation. Despite significant increases in total installed capacity during the last decade, the gap between electricity supply and demand continues to increase. The resulting shortfall has had a negative impact on industrial output and economic growth.
However, to meet expected future demand, indigenous coal production will have to be greatly expanded. Production currently stands at around 290 Million tonnes per year, but coal demand is expected to more than double by 2010. Indian coal is typically of poor quality and as such requires to be beneficiated to improve the quality; Coal imports will also need to increase dramatically to satisfy industrial and power generation requirements.

Oil

India's demand for petroleum products was expected to rise from 97.7 million tonnes in 2001-02 to around 139.95 million tonnes in 2006-07, according to projections of the Tenth Five-Year Plan.

The plan document puts compound annual growth rate (CAGR) at 3.6 % during the plan period. Domestic crude oil production is likely to rise marginally from 32.03 million tonnes in 2001-02 to 33.97 million tonnes by the end of the 10^{th} plan period (2006-07). India's self sufficiency in oil has consistently declined from 60% in the 50s to 30% currently. Same is expected to go down to 8% by 2020. Around 92% of India's total oil demand by 2020 has to be met by imports.

Natural Gas

India's natural gas production was expected to rise from 86.56 million cmpd in 2002-03 to 103.08 million cmpd in 2006-07. It is mainly based on the strength of a more than doubling of production by private operators to 38.25 mm cmpd (cubic meter per day).

Electricity

India currently has a peak demand shortage of around 14% and an energy deficit of 8.4%. Keeping this in view and to maintain a GDP (gross domestic product) growth of 8% to 10%, the Government of India has very prudently set a target of 215,804 MW power generation capacity by March 2012 from the level of 100,010 MW as on March 2001, that is a capacity addition of 115,794 MW in the next 11 years

This excessive demand for energy to meet the need of our fast growing economy has striking impact on the environment that supports the existence of mankind and other life forms.

Climatic change

Human activities, particularly the combustion of fossil fuels, have made the blanket of greenhouse gases (water vapour, carbon dioxide, methane, ozone etc.) around the earth thicker. The resulting increase in global temperature is altering the complex web of systems that allow life to thrive on earth such as rainfall, wind patterns, ocean currents and distribution of plant and animal species

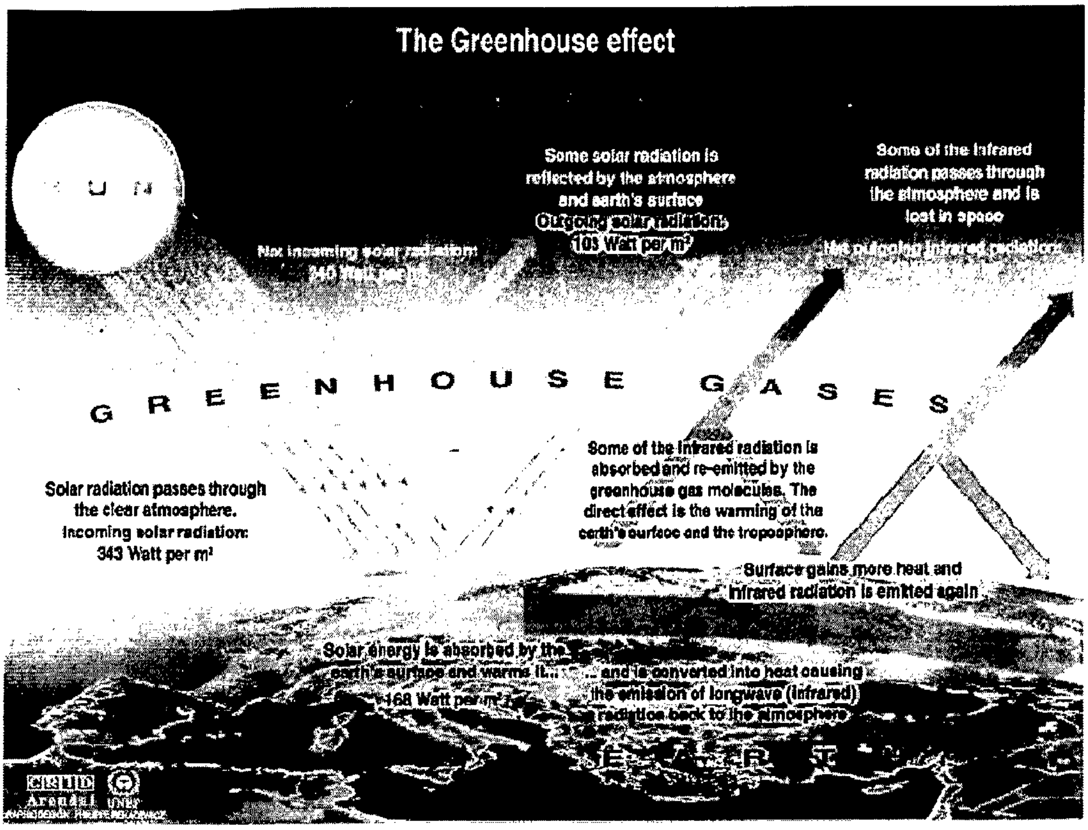


Figure 1.11 The Greenhouse Effect

Figure 7: The Green house effect

Future Effects

Even the minimum predicted shifts in climate for the 21st century are likely to be significant and disruptive. Predictions of future climatic changes are wide-ranging. The global temperature may climb from 1.4 to 5.8 degrees C; the sea level may rise from 9 to 88 cm. Thus, increases in sea level this century are expected to range from significant to catastrophic. This uncertainty reflects the complexity, interrelatedness, and sensitivity of the natural systems that make up the climate.

This change in the environment has a very critical impact on various life forms on the planet. And the life forms include mankind , so when the issue of saving the environment is raised the it essentially talks about preserving the delicate equilibrium in which the various life forms can be sustain.

As building industry also contributes substantially to this damage to our environment, it becomes important for this industry to analyze and assess ways which can reduce the effect on the environment.

This process of understanding, analyzing, and finding an appropriate solution to consumption of energy in efficient way is called energy efficiency.

Low carbon neighbourhoods a step towards energy efficiency.

Energy Intensity

Energy intensity is energy consumption per unit of GDP. Energy intensity indicates the development stage of the country. India's energy intensity is 3.7 times of Japan, 1.55 times of USA, 1.47 times of Asia and 1.5 times of World average.

Why do it?

Encouraging local communities to lead the way in cutting carbon has proved successful in other areas. It is also an excellent way of making the most of London's diversity to create innovative approaches to CO2 savings that can then be applied throughout and beyond the capital.

The overall aim of the Low Carbon Zone project is to achieve a lasting reduction in our city's carbon footprint. The Low Carbon Zones (LCZ) should produce short-term carbon savings from the buildings in the zones and develop models to drive future change throughout London.

The ten pilot LCZs will receive funding and support up until 2012, when it is hoped that sustainable solutions achieved in these areas can be rolled out to other parts of London. These local areas will be forging a way to create sustainable communities and act as role models in carbon reduction.

A locally organised approach has many advantages in delivery carbon saving programmes and it also offers communities real freedom to tailor-make plans to fit with the specific challenges and opportunities in their neighbourhood.

By allowing communities to design and manage their plans to reduce carbon emissions, they can better integrate services and deliver more meaningful behaviour change. A local approach also provides economies of scale in terms of raising funds and speeding up delivery by partners. Alongside the main objective of reducing carbon emissions, the LCZs should also have other positive impacts. Other beneficial side effects that have been identified include a reduction in fuel poverty, support for more sustainable lifestyles and the development of regional skills.

The local delivery of carbon saving programmes has already proved successful with Warm Zones area-based programmes, British Gas Green Streets and low carbon zones in Shropshire and Wales.

What the user can do ?

Users can all do their bit in the development of a low carbon London. There are many ways that both individuals and organisations can reduce CO_2 emissions.

Key areas in which carbon savings can be made include:

- Switching to greener transport – walk, cycle, use public transport. If you must use a car, go electric if possible.
- Turning appliances off – leaving electrical items on standby uses as much energy as when they are switch on.
- Use energy efficient bulbs – these last up to eight times longer than standard bulbs.
- Improve insulation – this will save on heating bills.
- Recycling more – sixty per cent of what we use can be recycled, and means less waste going to landfill.
- Green purchasing – buy locally and sustainably produced goods where possible.

2.3 LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN (LEED)

LEED is an internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies intended to improve performance in metrics such as energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts.

LEED CRITERIA FOR LOW CARBON EMISSIONS:--

ND Credits Affecting CO_2 Emissions

SMART LOCATION & LINKAGE	NEIGHBORHOOD PATTERN & DESIGN	GREEN INFRASTRUCTURE & BUILDINGS
p1: Smart Location	p1: Walkable Streets	p1: Certified Green Building
p2: Imperiled Species and Ecological Communities	p2: Compact Development	p2: Minimum Building Energy Efficiency
p3: Wetland and Water Body Conservation	p3: Connected and Open Community	p3: Minimum Building Water Efficiency
p4: Agricultural Land Conservation	c1: Walkable Streets	p4: Construction Activity Pollution Prevention
p5: Floodplain Avoidance	c2: Compact Development	c1: Certified Green Buildings
c1: Preferred Locations	c3: Mixed-Use Neighborhood Centers	c2: Building Energy Efficiency
c2: Brownfield Redevelopment	c4: Mixed-Income Diverse Communities	c3: Building Water Efficiency
c3: Locations With Reduced Automobile Dependence	c5: Reduced Parking Footprint	c4: Water-Efficient Landscaping
c4: Bicycle Network and Storage	c6: Street Network	c5: Existing Building Reuse
c5: Housing and Jobs Proximity	c7: Transit Facilities	c6: Historic Resource Preservation and Adaptive Use
c6: Steep Slope Protection	c8: Transportation Demand Management	c7: Minimized Site Disturbance in Design and Construction
c7: Site Design for Habitat or Wetland and Water Body Conservation	c9: Access to Civic and Public Spaces	c8: Stormwater Management
c8: Restoration of Habitat or Wetlands and Water Bodies	c10: Access to Recreation Facilities	c9: Heat Island Reduction
c9: Long-Term Conservation Management of Habitat or Wetlands and Water Bodies	c11: Visitability and Universal Design	c10: Solar Orientation
	c12: Community Outreach and Involvement	c11: On-Site Renewable Energy Sources
	c13: Local Food Production	c12: District Heating and Cooling
	c14: Tree-Lined and Shaded Streets	c13: Infrastructure Energy Efficiency
	c15: Neighborhood Schools	c14: Wastewater Management
		c15: Recycled Content in Infrastructure
		c16: Solid Waste Management Infrastructure
		c17: Light Pollution Reduction

Figure 8: LEED ND Crediting

2.4 CASE STUDY

Neighbourhoods of Chandigarh are being taken as case studies for this project.

Chandigarh is situated in northern India. As the first planned city of India, Chandigarh is known internationally for its arc hitecture and urban planning

Chandigarh has a humid subtropical climate characterized by a seasonal rhythm: very hot summers, mild winters, unreliable rainfall and great variation in temperature (-1 °C to 41.2 °C). In winter, pieces of snow sometimes occur during December and January. The average annual rainfall is 1110.7 mm. The city also receives occasional winter rains from the west.

Each neighbourhood unit (sector) is 1200x800 mts. and has a population ranging from 5000 – 35000. Northern sector has less density than Southern Sectors.

Primarily the standardized 800x1200 meter 'sector' and hierarchical circulation resulting from Le Corbusier theory of 7Vs resulted into a well ordered matrix of this generic completing itself into two phases 'sector 1-30' in first phase and development up to 47 sectors in second phase. The 'sector' itself was a self sufficient, introvert unit, enclosed by fast moving V3 road running NW-SE.

Controls

Urban Control in Chandigarh were to operate at three levels, The Periphery, The Master Plan and Architectural control on 7Vs, city centers and housing (conceived areas include two majoV2 roads (Madhya and Jan Marg) the city center (Sec 17 and Sec.34) and neighborhood shopping on V4

Clause no.4 of the Capital of Punjab (Development and Regulation) Act, 1952 reads as follows:-

(1) For the purpose of proper planning or development of Chandigarh, the State Government or the Chief administrator may issue such directions, as may be considered necessary, in respect of any site or building either generally for the whole of Chandigarh or for any particular locality thereof, regarding any one or more of the following matters, namely:-

a) Architectural features of the elevation or frontage of any building:
b) Erection of detached or semi-detached building or both and the area of the land appurtenant to such building:
c) The number of residential buildings which may be erected on any site in any locality:

d) prohibition regarding erection of shops, workshops, ware-houses, factories or buildings of a specified architectural character or buildings designed for particular purposes in any locality:

e) Maintenance of height and position of walls, fences, hedges or any other structural or architectural construction:

f) Restrictions regarding the use of site for purposes other than erection of buildings.

2) Every transferee shall comply with the directions issued under sub-section (1) and shall, as expeditiously as possible, erect any building or take such other steps as may be necessary to comply with such directions.

Chandigarh to Chandigarh Metropolitan Region

- Phase I Population 150000

  Sector 1-30

  Density: 40 persons/ha

  Total area: 43sq.km.

- Phase II Population 350000

  Sector 31-47

  Density: 144 persons/ha

  Total area: 70sq.km.

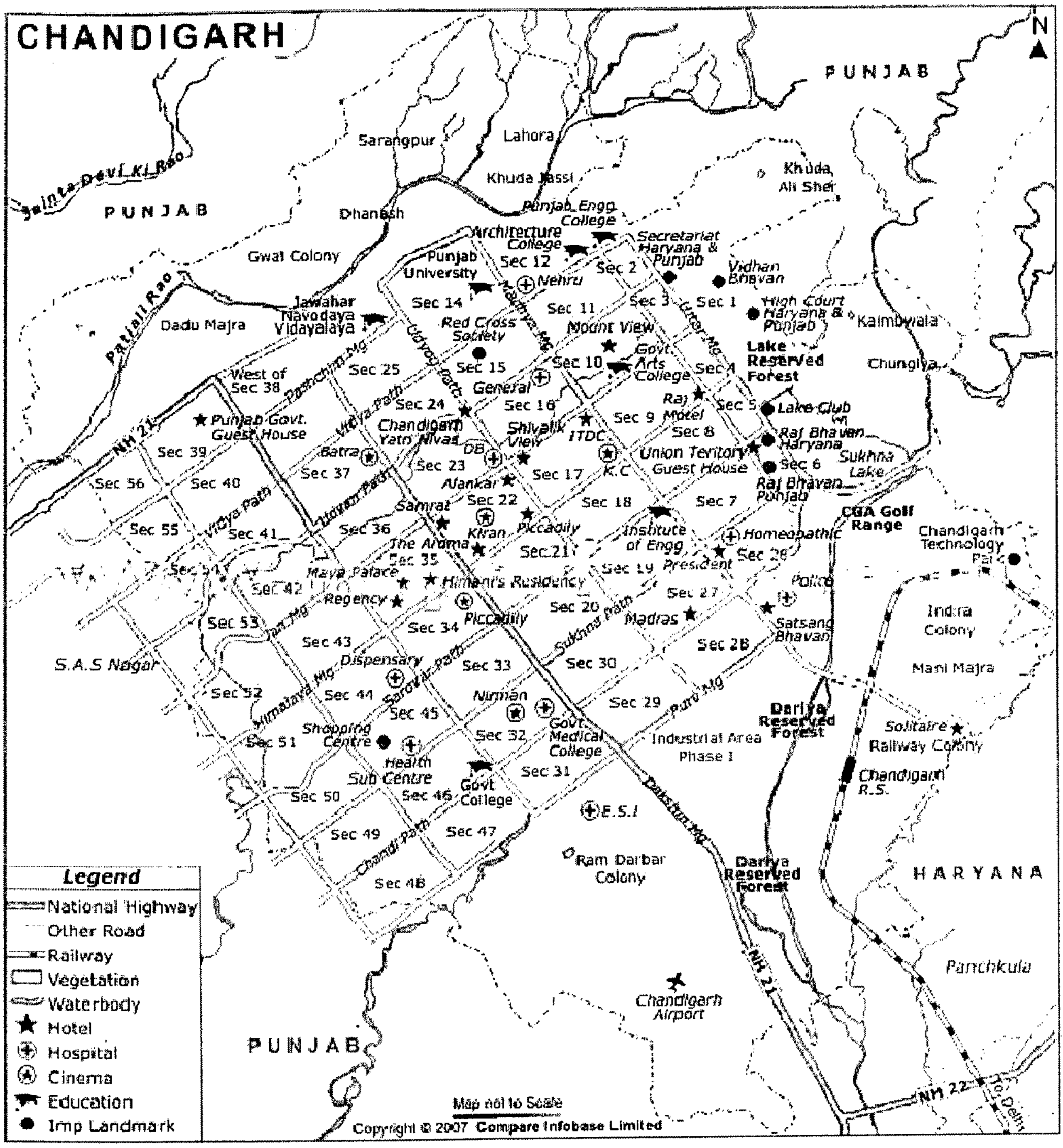


Figure 9: Plan of Chandigarh

Various neighbourhoods selected for the study are:--

- SECTOR-20

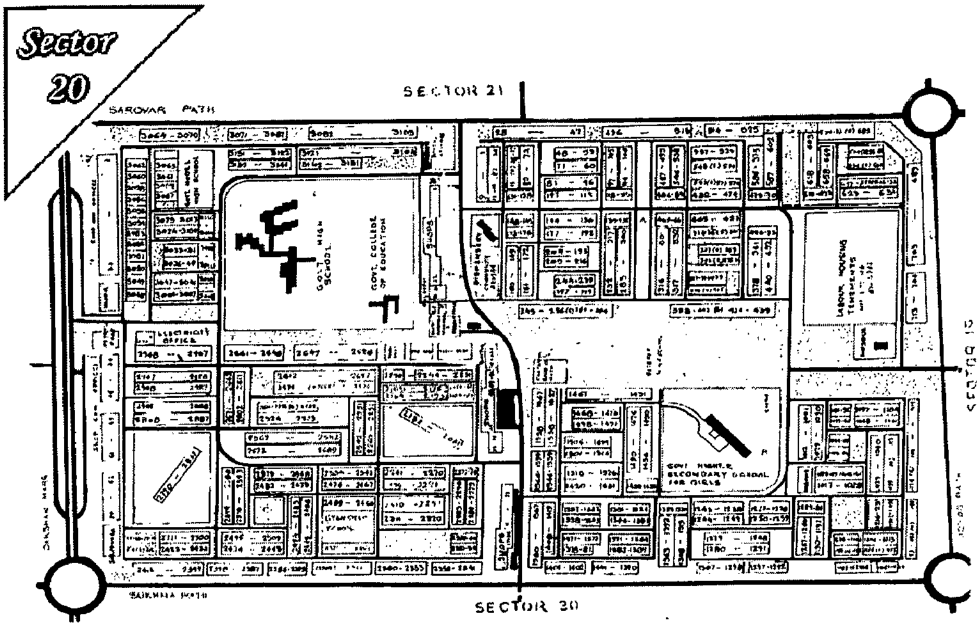


Figure 10: Plan of sec-20 chd.

- SECTOR 22

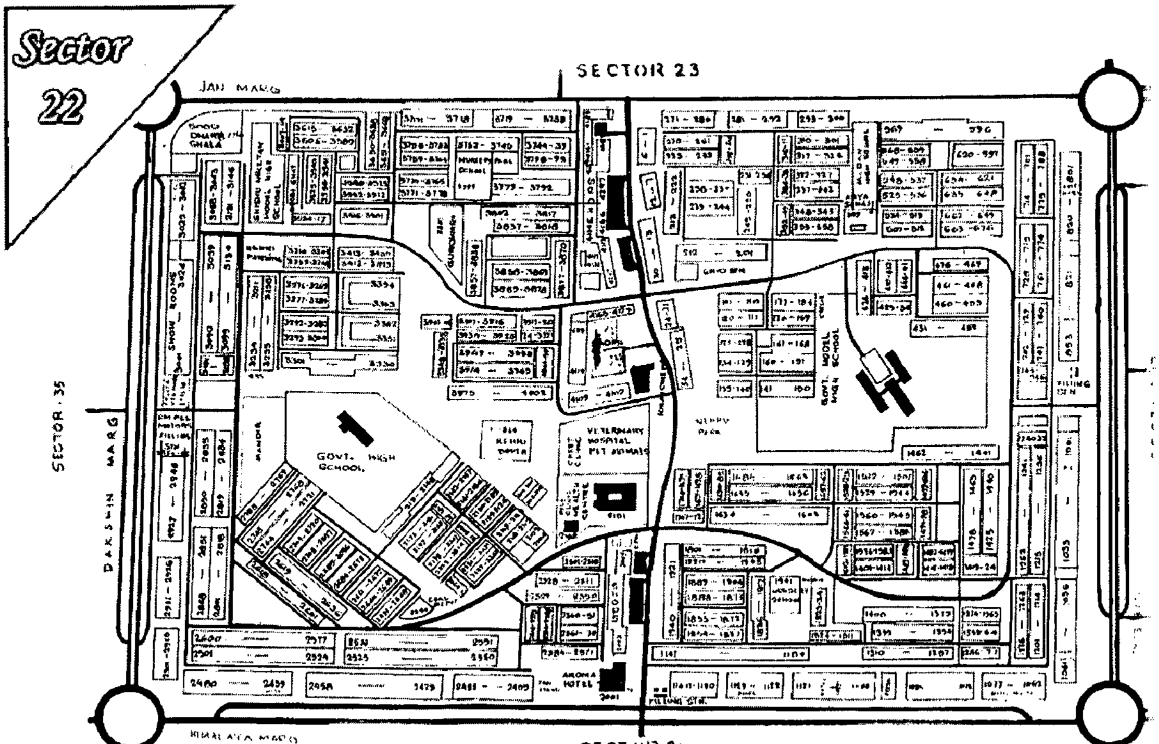
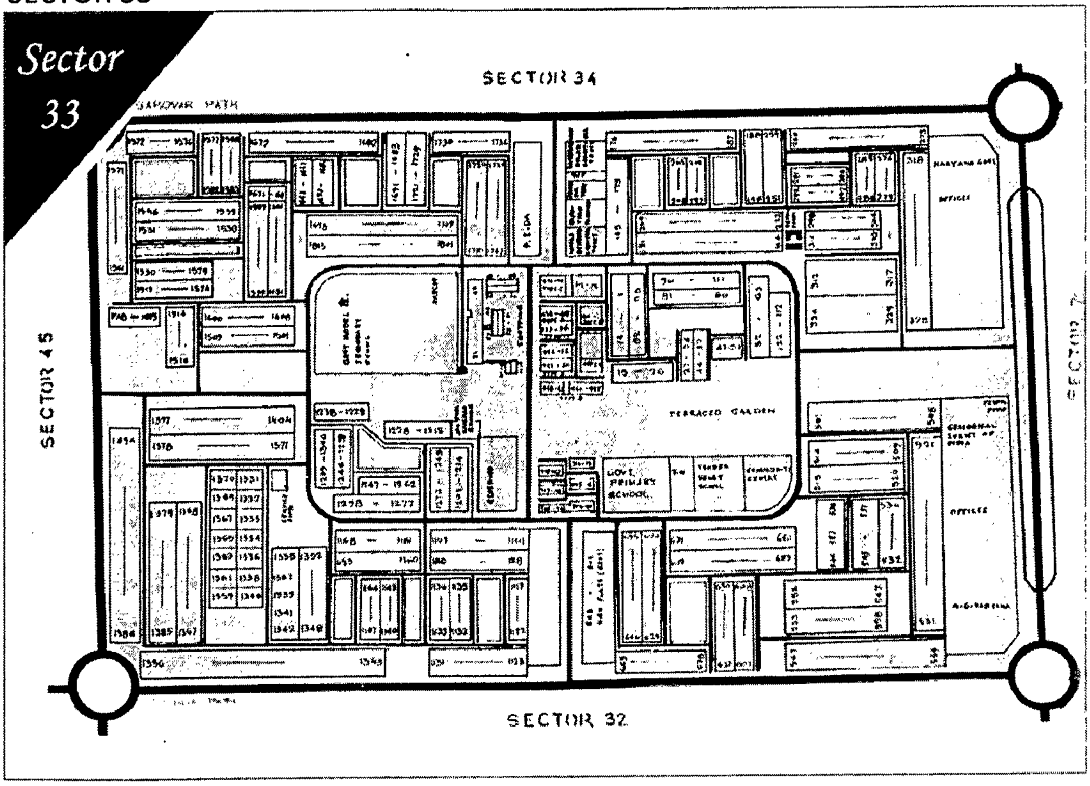


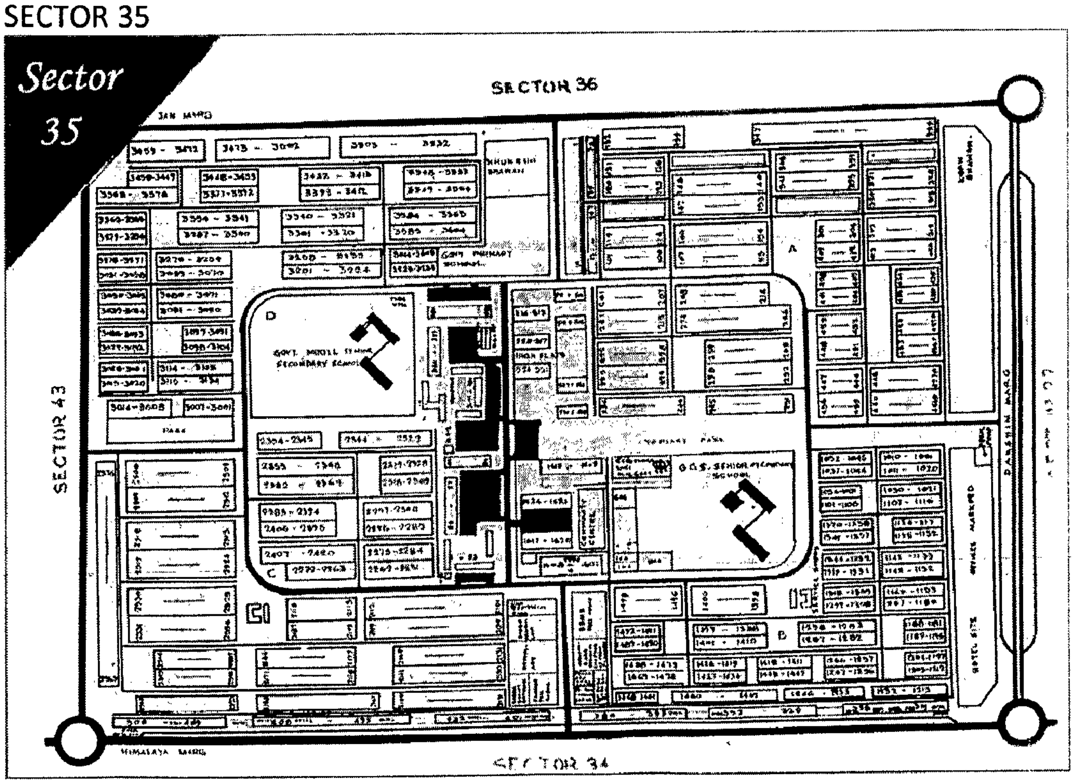
Figure 11: Plan of sec-22 chd.

- SECTOR 33



ure 12:Plan of sec-33 chd.

- SECTOR 35



ure 13:Plan of sec-35 chd.

- SECTOR 36

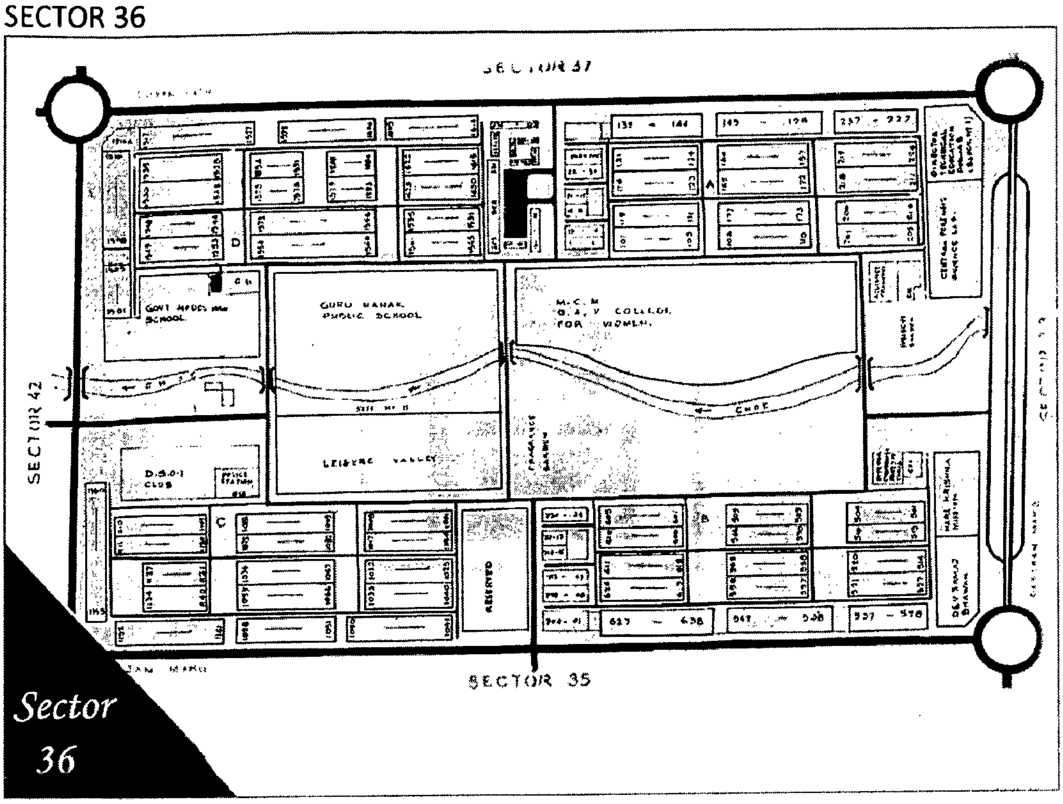


Figure 14:Plan of sec-36 chd.

- SECTOR 38

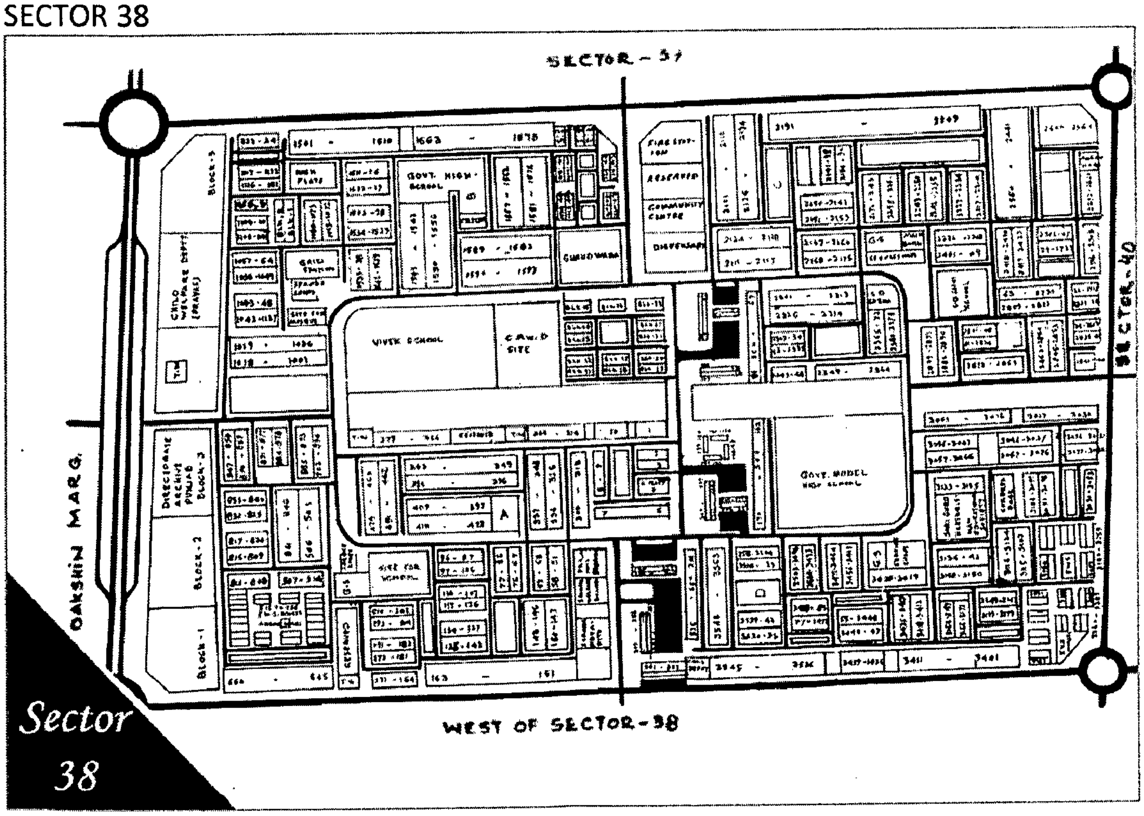


Figure 15: Plan of sec-38 chd.

- SECTOR 44

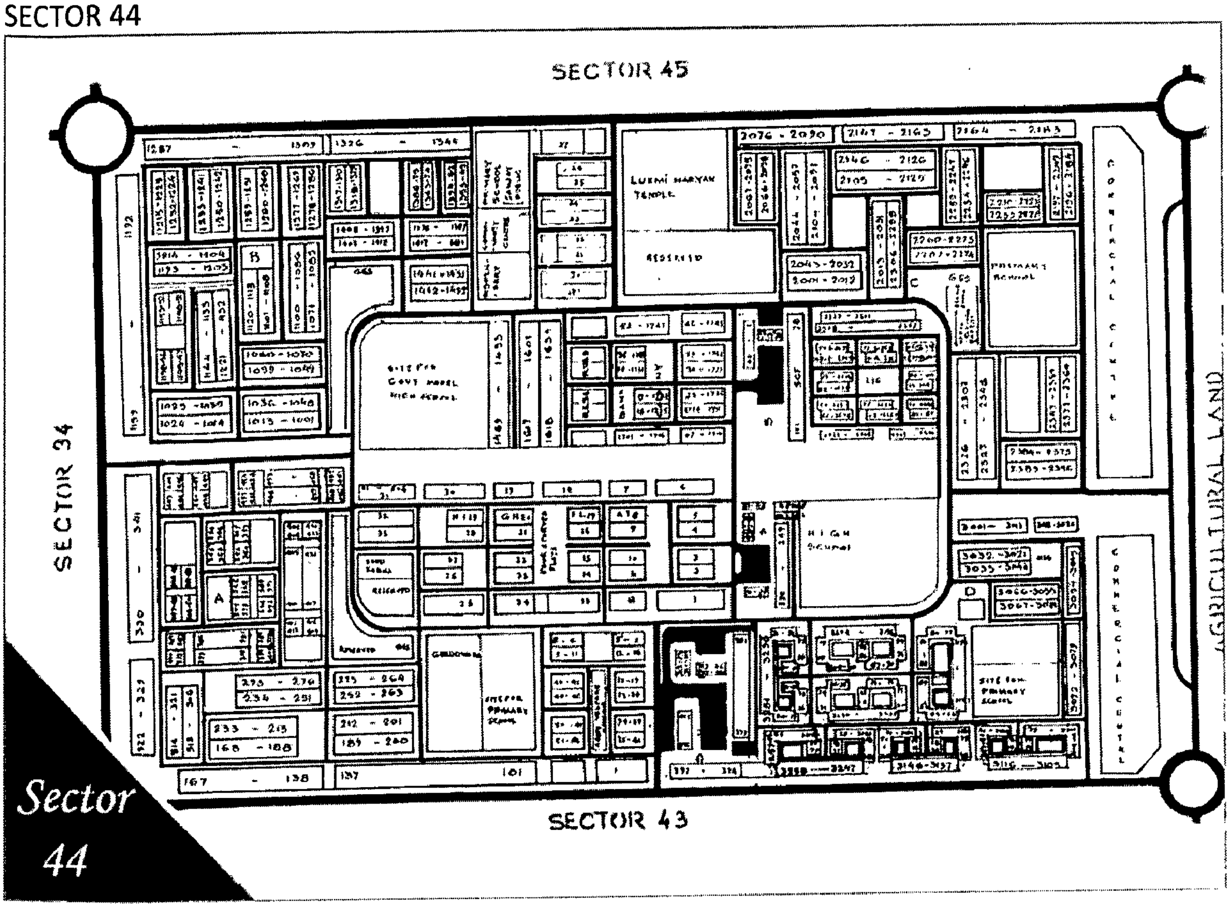


Figure 16:Plan of sec-44 chd.

These sectors have neighborhood planning concept so target would be to calculate the embodied energy and operating energy for one such neighbourhood. And then try to reduce these energy values in the design.

CHAPTER 3: SITE SELECTION

.1 INTRODUCTION

- Neighbourhood of The Central Building Research Institute, Roorkee, India
- Since it's inception in 1947, the C.B.R.I. has been assisting the building construction and building material industries in finding timely, appropriate and economical solutions to the various problems.
- It is a neighbourhood designed to facilitate the employees of Central Building Research Institute, Roorkee.
- Area of site is 63 acres.

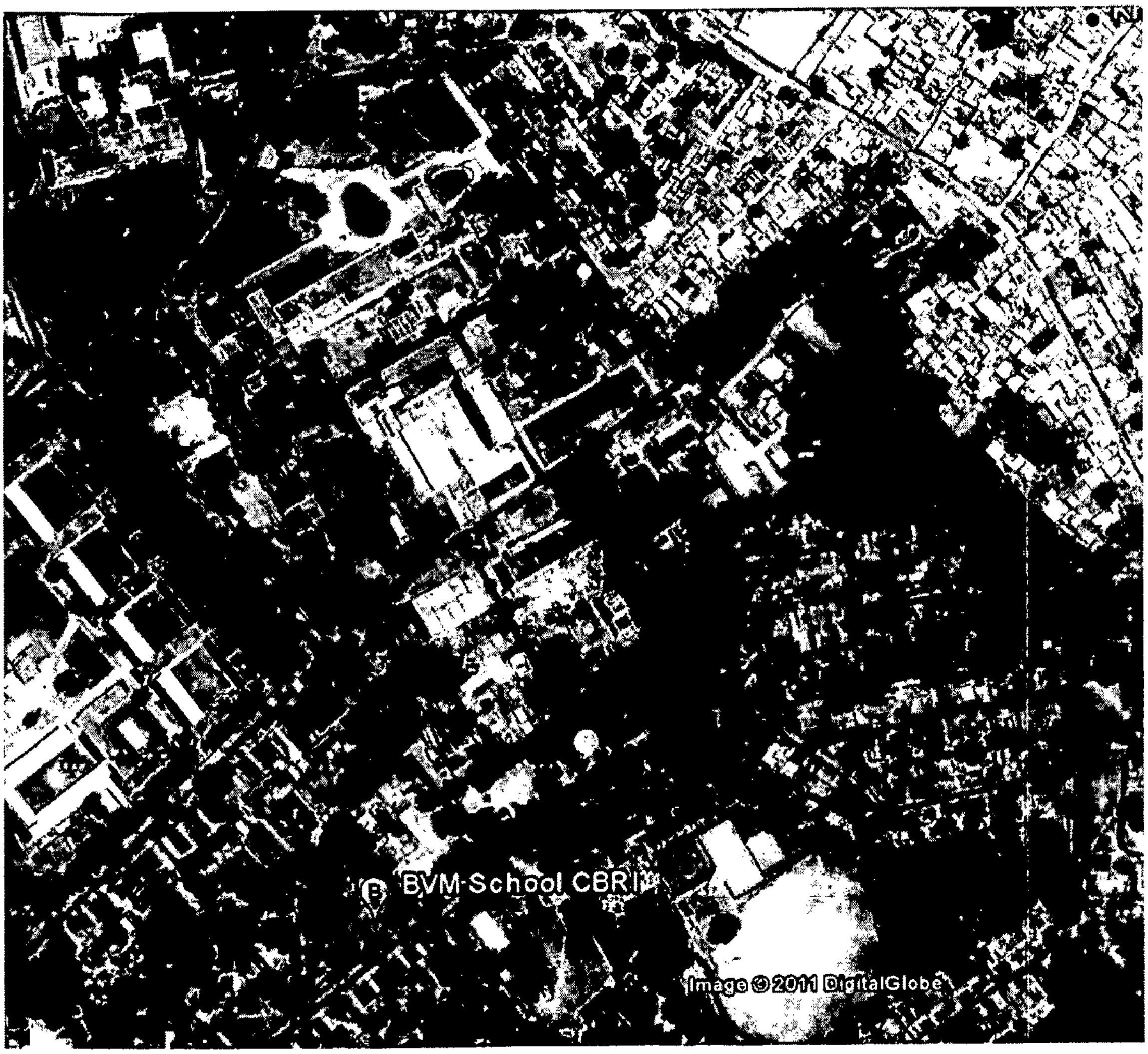


Figure 17: Aerial view

3.2 BUILDING TYPES EXISTING ON SITE

This neighbourhood has various house types and other amenities:--

1. House type A1 to A 10
2. House type A 12 to A 15
3. House type A18 to A 25
4. House type A26 to A43
5. House type B5 to B36
6. House type D18 to D29
7. House type E1 to E 62
8. House type E65 to E68
9. Bank
10. Dispensary
11. Shops
12. School

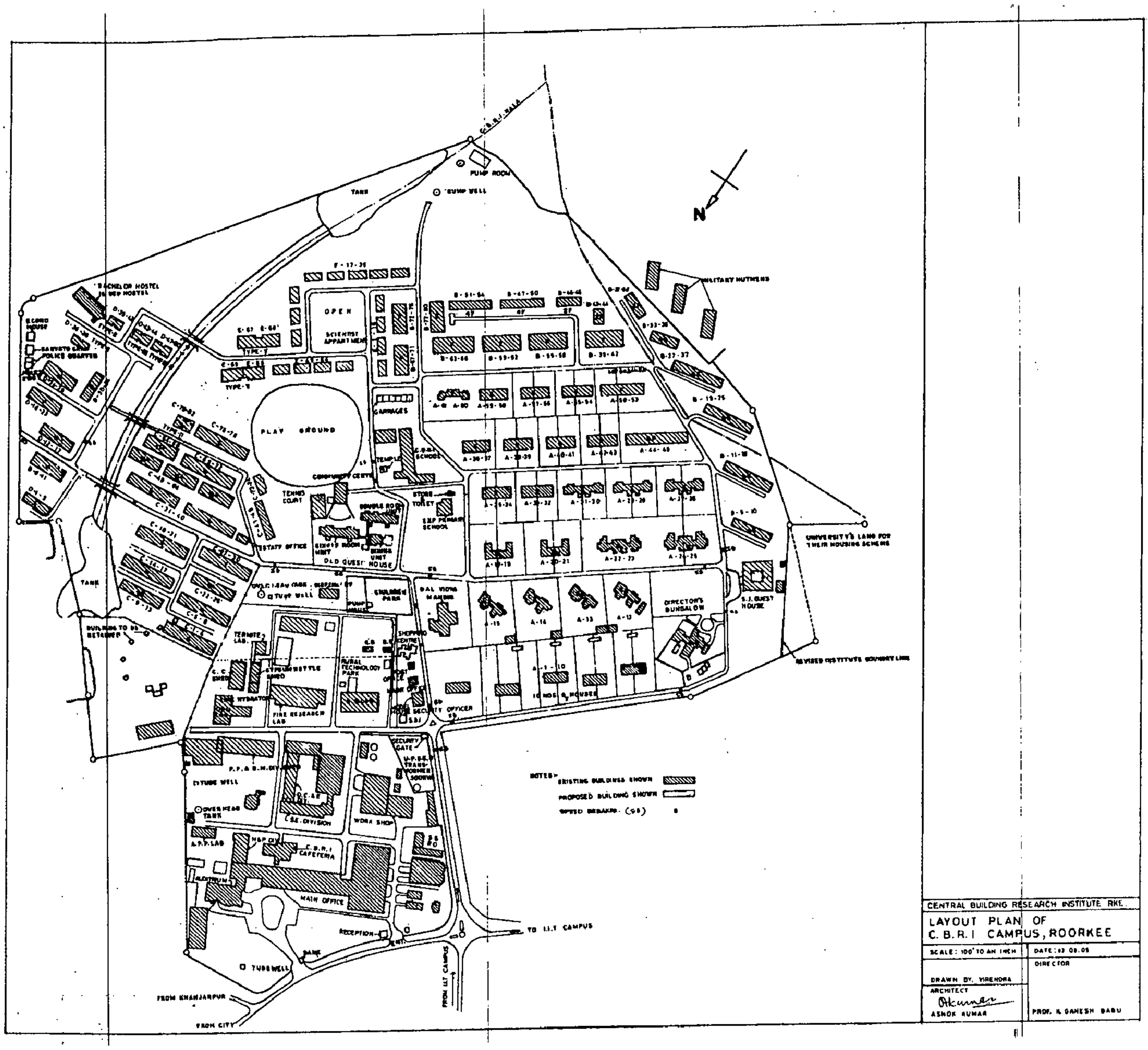


Figure 18: CBRI Existing Site plan

CHAPTER 4: EMBODIED ENERGY

4.1 INTRODUCTION

Embodied energy is defined as the commercial energy (fossil fuels, nuclear, etc) that was used in the work to make any product, bring it to market, and dispose of it. Embodied energy is an accounting methodology which aims to find the sum total of the energy necessary for an entire product lifecycle. This lifecycle includes raw material extraction, transport, manufacture, assembly, installation, disassembly, deconstruction and/or decomposition.

Different methodologies produce different understandings of the scale and scope of application and the type of energy embodied. Some methodologies account for the energy embodied in terms of the oil that supports economic processes.

The total amount of energies, direct and indirect, for the entire amount of production was called the *embodied energy*. Energy embedded in all building materials in a constructed structure

4.2 EMBODIED ENERGY METHODOLOGIES

Embodied energy analysis is interested in what energy goes to supporting a consumer, and so all energy depreciation is assigned to the final demand of consumer. Different methodologies use different scales of data to calculate energy embodied in products and services of nature and human civilization. International consensus on the appropriateness of data scales and methodologies is pending. This difficulty can give a wide range in embodied energy values for any given material.

4.3 EMBODIED ENERGY IN THE C.B.R.I. NEIGHBOURHOOD

The neighbourhood taken for the study i.e. the C.B.R.I. neighbourhood has various types of house and other amenities like bank, shops etc. Embodied energy for these buildings was calculated using bill of quantities.

The bill of quantities was calculated using the available drawing. And an abstract of quantities is framed using the same.

- Dwelling unit type – A 1 to A 10

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 43.20329 cu. m
2. Lime concrete in foundation = 20.555 cu. m
3. Brickwork in foundation and plinth= 27.1282 cu. m
4. Damp proof course 2.5 cm thick = 23.5332 sq. m
5. First class brickwork in super structure= Ground floor: 40.0689 cu. m + First floor: 31.4890 cu. m=71.5549 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = Ground floor: 13.853361 cu. m + First floor: 13.4890 cu. m=27.5542 cu. m.
7. Mild Steel work including bending in steel reinforcement = Ground floor: 10.8748 quintals + First floor: 10.755 quintals=21.6298 quintals.
8. Bitumen Isolation layer of 2 coats on roof = Ground floor: 88.0077 sq. m. + First floor: 86.3686 sq. m=174.3768 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. =Ground floor: 75.412 sq. m + First floor: 73.883sq. m=149.295 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion = Ground floor: 229.65 sq. m + First floor: 395.236 sq. m=624.886 sq. m.

Embodied energy in A 1 to A 10

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	20.555 cu. m.	1288.25 MJ/cu. m.	26479.97
2.	Brickwork in foundation & plinth	27.1282 cu. m.	2641.75 MJ/cu. m	69002.51
3.	Damp proof course 2.5 cm thick	23.5332 sq. m	2601.35 MJ/sq. m	61218.08

4.	Ist class Brickwork in super structure	71.5549 cu. m.	2641.75 MJ/cu. m	189030.15
5.	R.C.C. Work	27.5542 cu. m.	3114.82 MJ/cu. m	85826.37
6.	Mild steel work	21.6298 quintals	--	--
7.	Flooring	149.295 sq. m.	211.48 MJ/sq. m.	31572.90
8.	Cement Plaster in wall 12 mm. thick	624.886 sq . m.	24.12 MJ/sq. m	15072.25
			TOTAL=	451722.26 M.J.

Table 2: Embodied energy A1 to A10 house

- Dwelling unit type – A 12 to A 15

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 117.4491 cu. m
2. Lime concrete in foundation = 31.2522cu. m
3. Brickwork in foundation and plinth= 40.4032 cu. m
4. Damp proof course 2.5 cm thick= 40.801 sq. m
5. First class brickwork in super structure= 60.3307 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 32.2692 cu. m.
7. Mild Steel work including bending in steel reinforcement = 25.331 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 204.612 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 165.836 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 460.309 sq. m

Embodied energy in A 12 to A 15

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	31.2522 cu. m.	1288.25 MJ/cu. m.	40260.64
2.	Brickwork in foundation & plinth	40.4032 cu. m.	2641.75 MJ/cu. m	106735.15
3.	Damp proof course 2.5 cm thick	40.801 sq. m	2601.35 MJ/sq. m	106137.68
4.	Ist class Brickwork in super structure	60.3307 cu. m.	2641.75 MJ/cu. m	159378.62
5.	R.C.C. Work	32.2692 cu. m.	3114.82 MJ/cu. m	100512.74

6.	Mild steel work	25.331 quintals	--	--
7.	Flooring	165.836 sq. m.	211.48 MJ/sq. m.	35070.99
8.	Cement Plaster in wall 12 mm. thick	460.309 sq . m.	24.12 MJ/sq. m	11102.65
			TOTAL=	559199.00 M.J.

Table 3:Embodied Energy A12 to A15

- Dwelling unit type – A 18 to A 25

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 88.8053 cu. m
2. Lime concrete in foundation = 29.738 cu. m
3. Brickwork in foundation and plinth= 38.2874 cu. m
4. Damp proof course 2.5 cm thick= 38.943 sq. m
5. First class brickwork in super structure= 64.971 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 26.3876 cu. m.
7. Mild Steel work including bending in steel reinforcement = 20.7 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 169.2289 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 134.0303 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion=596.6305 sq. m.

Embodied energy in A 18 to A 25

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	29.738 cu. m.	1288.25 MJ/cu. m.	38309.97
2.	Brickwork in foundation & plinth	38.2874 cu. m.	2641.75 MJ/cu. m	101145.73
3.	Damp proof course 2.5 cm thick	38.943 sq. m	2601.35 MJ/sq. m	101304.37
4.	Ist class Brickwork in super structure	64.971 cu. m.	2641.75 MJ/cu. m	171637.13
5.	R.C.C. Work	26.3876 cu. m.	3114.82 MJ/cu. m	82192.62

6.	Mild steel work	20.7 quintals	--	--
7.	Flooring	134.0303 sq. m.	211.48 MJ/sq. m.	28344.72
8.	Cement Plaster in wall 12 mm. thick	596.6305 sq . m.	24.12 MJ/sq. m	14390.72
			TOTAL=	537325.26 M.J.

Table 4: Embodied Energy in A18 to A25 houses

- Dwelling unit type – A 26 to A 43

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 70.1765 cu. m
2. Lime concrete in foundation = 23.3897 cu. m
3. Brickwork in foundation and plinth= 30.2257 cu. m
4. Damp proof course 2.5 cm thick = 31.7904 sq. m
5. First class brickwork in super structure= 54.4563 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 23.3374 cu. m.
7. Mild Steel work including bending in steel reinforcement = 18.314 quintals.
8. Bitumen Isolation layer of 2 coats on roof = 110.736 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 94.2633 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion =440.9365 sq. m.

Embodied energy in A 26 to A 43

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	23.3897 cu. m.	1288.25 MJ/cu. m.	30131.78
2.	Brickwork in foundation & plinth	30.2257 cu. m.	2641.75 MJ/cu. m	79848.74
3.	Damp proof course 2.5 cm thick	31.7904 sq. m	2601.35 MJ/sq. m	82697.95
4.	Ist class Brickwork in super structure	54.4563 cu. m.	2641.75 MJ/cu. m	143859.93
5.	R.C.C. Work	23.3374 cu. m.	3114.82 MJ/cu. m	72691.80

6.	Mild steel work	21.6298 quintals	--	--
7.	Flooring	94.2633 sq. m.	211.48 MJ/sq. m.	19934.802
8.	Cement Plaster in wall 12 mm. thick	440.9365 sq . m.	24.12 MJ/sq. m	10635.38
			TOTAL=	439800.3904 M.J.

Table 5:Enbodied energy in A26 to A43

- Dwelling unit type – B 5 to B 36

Here is the abstract of quantities:--

1. 1.Earthwork in excavation in foundation= 34.4677 cu. m
2. Lime concrete in foundation = 11.490.738 cu. m
3. Brickwork in foundation and plinth= 14.661 cu. m
4. Damp proof course 2.5 cm thick= 15.4438 sq. m
5. First class brickwork in super structure= Ground floor: 26.370 cu. m + First floor: 26.5982 cu. m=52.9682 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = Ground floor: 9.1132 cu. m + First floor: 9.8113 cu. m=18.924 cu. m.
7. Mild Steel work including bending in steel reinforcement =. Ground floor: 7.1539 quintals + First floor: 7.7018 quintals=14.855 quintals.
8. Bitumen Isolation layer of 2 coats on roof= Ground floor: 59.0065 sq. m + First floor: 59.0065 sq. m=118.01 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. =Ground floor: 49.5833 sq. m + First floor: 37.5948 sq. m=87.1781 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion=. Ground floor: 158.4 sq. m + First floor: 147.685 sq. m=306.085 sq. m

Embodied energy in B 5 to B 36

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	11.490 cu. m.	1288.25 MJ/cu. m.	14801.99
2.	Brickwork in foundation & plinth	14.661 cu. m.	2641.75 MJ/cu. m	38730.69
3.	Damp proof course 2.5 cm thick	15.4438 sq. m	2601.35 MJ/sq. m	40174.72

4.	Ist class Brickwork in super structure	52.9682 cu. m.	2641.75 MJ/cu. m	139928.74
5.	R.C.C. Work	18.924 cu. m.	3114.82 MJ/cu. m	58944.85
6.	Mild steel work	14.855 quintals	--	--
7.	Flooring	87.1781 sq. m.	211.48 MJ/sq. m.	18436.42
8.	Cement Plaster in wall 12 mm. thick	306.085 sq . m.	24.12 MJ/sq. m	7382.77
			TOTAL=	318400.18 M.J.

Table 6:Embodied energy in B5 to B 36 houses

- Dwelling unit type – D 18 to D 29

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 33.9458 cu. m
2. Lime concrete in foundation = 11.3162 cu. m
3. Brickwork in foundation and plinth= 14.528 cu. m
4. Damp proof course 2.5 cm thick= 13.9508 sq. m
5. First class brickwork in super structure= 24.2086 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 7.037 cu. m.
7. Mild Steel work including bending in steel reinforcement = 5.524 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 44.4808 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 32.266 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 167.91 sq. m

Embodied energy in D 18 to D 29

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	11.3162 cu. m.	1288.25 MJ/cu. m.	14578.09
2.	Brickwork in foundation & plinth	14.5200 cu. m.	2641.75 MJ/cu. m	38358.21
3.	Damp proof course 2.5 cm thick	13.9508 sq. m	2601.35 MJ/sq. m	36290.91
4.	Ist class Brickwork in super structure	24.2086 cu. m.	2641.75 MJ/cu. m	63953.06
5.	R.C.C. Work	7.03700 cu. m.	3114.82 MJ/cu. m	21918.98

6.	Mild steel work	5.524 quintals	--	--
7.	Flooring	32.266 sq. m.	211.48 MJ/sq. m.	6823.61
8.	Cement Plaster in wall 12 mm. thick	167.91 sq . m.	24.12 MJ/sq. m	4049.98
			TOTAL=	185972.84 M.J.

Table 7:Embodied energy in D18 to D29 houses

- Dwelling unit type – E 1 to E 64

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 46.5317 cu. m
2. Lime concrete in foundation = 15.51148 cu. m
3. Brickwork in foundation and plinth= 20.77707 cu. m
4. Damp proof course 2.5 cm thick = 19.7986 sq. m
5. First class brickwork = 33.69567 cu. m
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 16.277 cu. m
7. Mild Steel work work including bending in steel reinforcement = 12.777 quintals
8. Bitumen Isolation layer of 2 coats on roof = 67.0850 sq. m
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 60.7549 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion = 325.1749sq.m

Embodied en ergy in E 1 to 64

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	15.51148 cu. m.	1288.25 MJ/cu. m.	19982.66
2.	Brickwork in foundation & plinth	20.77707 cu. m.	2641.75 MJ/cu. m	54887.63
3.	Damp proof course 2.5 cm thick	19.7986 sq. m	2601.35 MJ/sq. m	51503.08
4.	Ist class Brickwork in super structure	33.6956 cu. m.	2641.75 MJ/cu. m	89015.35
5.	R.C.C. Work	16.2775 cu. m.	3114.82 MJ/cu. m	50701.48

6.	Mild steel work	12.777 quintals	--	--
7.	Flooring	60.7579 sq. m.	211.48 MJ/sq. m.	12849.08
8.	Cement Plaster in wall 12 mm. thk.	325.1749 sq . m.	24.12 MJ/sq. m	7843.21
			TOTAL=	286782.49 M.J.

Table 8: Embodied Energy in E1 to 64 houses

- BANK in existing C.B.R.I. neighbourhood

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 47.004 cu. m
2. Lime concrete in foundation = 15.668 cu. m
3. Brickwork in foundation and plinth= 20.309 cu. m
4. Damp proof course 2.5 cm thick= 21.612 sq. m
5. First class brickwork in super structure= 38.1332 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 19.6599 cu. m.
7. Mild Steel work including bending in steel reinforcement = 15.433 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 126.054 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 87.2658 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 167.91 sq. m

Embodied energy in BANK

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	15.668 cu. m.	1288.25 MJ/cu. m.	20210.06
2.	Brickwork in foundation & plinth	20.309 cu. m.	2641.75 MJ/cu. m	53651.30
3.	Damp proof course 2.5 cm thick	21.612 sq. m	2601.35 MJ/sq. m	56220.37
4.	Ist class Brickwork in super structure	38.1332 cu. m.	2641.75 MJ/cu. m	100738.38
5.	R.C.C. Work	19.659 cu. m.	3114.82 MJ/cu. m	61234.24

6.	Mild steel work	15.433 quintals	--	--
7.	Flooring	87.2658 sq. m.	211.48 MJ/sq. m.	18454.97
8.	Cement Plaster in wall 12 mm. thick	194.09 sq . m.	24.12 MJ/sq. m	4681.45
			TOTAL=	315190.77 M.J.

Table 9:Embodied energy in bank

- SCHOOL in existing C.B.R.I. neighbourhood

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 338.114 cu. m
2. Lime concrete in foundation = 112.6818 cu. m
3. Brickwork in foundation and plinth= 146.0682 cu. m
4. Damp proof course 2.5 cm thick= 152.336 sq. m
5. First class brickwork in super structure= 253.9261 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 149.3679 cu. m.
7. Mild Steel work including bending in steel reinforcement = 117.253 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 977.02 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 894.239 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 2062.565 sq. m

Embodied energy in SCHOOL

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	112.6818 cu. m.	1288.25 MJ/cu. m.	145162.32
2.	Brickwork in foundation & plinth	146.068 cu. m.	2641.75 MJ/cu. m	385875.13
3.	Damp proof course 2.5 cm thick	152.336 sq. m	2601.35 MJ/sq. m	396279.25
4.	Ist class Brickwork in super structure	253.926 cu. m.	2641.75 MJ/cu. m	670809.01
5.	R.C.C. Work	149.367 cu. m.	3114.82 MJ/cu. m	465251.318

6.	Mild steel work	117.253 quintals	--	--
7.	Flooring	894.329 sq. m.	211.48 MJ/sq. m.	189132.69
8.	Cement Plaster in wall 12 mm. thick	2062.56 sq . m.	24.12 MJ/sq. m	49748.94
			TOTAL=	2302258.66 M.J.

Table 10:Emboded energy in school

- SHOPS in existing C.B.R.I. neighbourhood

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 77.4593 cu. m
2. Lime concrete in foundation = 25.8309 cu. m
3. Brickwork in foundation and plinth= 33.4845 cu. m
4. Damp proof course 2.5 cm thick= 37.248 sq. m
5. First class brickwork in super structure= 67.9331 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 22.1704 cu. m.
7. Mild Steel work including bending in steel reinforcement = 17.403 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 21.483 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 132.2898 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 321.205 sq. m

Embodied energy in SHOPS

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	25.8309 cu. m.	1288.25 MJ/cu. m.	33276.65
2.	Brickwork in foundation & plinth	33.4845 cu. m.	2641.75 MJ/cu. m	88457.67
3.	Damp proof course 2.5 cm thick	37.248 sq. m	2601.35 MJ/sq. m	96895.08
4.	Ist class Brickwork in super structure	67.9331 cu. m.	2641.75 MJ/cu. m	179462.26
5.	R.C.C. Work	22.1704 cu. m.	3114.82 MJ/cu. m	69056.80

6.	Mild steel work	17.403 quintals	--	--
7.	Flooring	132.2898 sq. m.	211.48 MJ/sq. m.	27976.64
8.	Cement Plaster in wall 12 mm. thick	321.205 sq . m.	24.12 MJ/sq. m	7747.46
			TOTAL=	502872.56 M.J.

Table 11:Embodied energy in shops

- <u>DISPENSARY in existing C.B.R.I. neighbourhood</u>

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 77.6628 cu. m
2. Lime concrete in foundation = 25.8876 cu. m
3. Brickwork in foundation and plinth= 33.558 cu. m
4. Damp proof course 2.5 cm thick= 35.472 sq. m
5. First class brickwork in super structure= 68.8367 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 30.5367 cu. m.
7. Mild Steel work including bending in steel reinforcement = 23.971 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 198.731 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 172.3834 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 375.915 sq. m

<u>Embodied energy in DISPENSARY</u>

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	25.887 cu. m.	1288.25 MJ/cu. m.	33348.92
2.	Brickwork in foundation & plinth	33.558 cu. m.	2641.75 MJ/cu. m	88651.84
3.	Damp proof course 2.5 cm thick	35.472 sq. m	2601.35 MJ/sq. m	92275.08
4.	Ist class Brickwork in super structure	68.836 cu. m.	2641.75 MJ/cu. m	181847.50
5.	R.C.C. Work	30.5367 cu. m.	3114.82 MJ/cu. m	95116.32

6.	Mild steel work	23.971 quintals	--	--
7.	Flooring	172.3834 sq. m.	211.48 MJ/sq. m.	36455.55
8.	Cement Plaster in wall 12 mm. thick	375.915 sq . m.	24.12 MJ/sq. m	9067.06
			TOTAL=	536762.28 M.J.

Table 12:Embodied energy in dispensary

TOTAL EMBODIED ENERGY IN C.B.R.I. NEIGHBOURHOOD

SR. NO.	BUILDING TYPE	NUMBER	EMBODIED ENERGY(M.J.)	QUANTITY (M.J.)
1.	Dwelling unit-A1 to A10	10	451772	4517220
2.	Dwelling unit-A12 to A15	4	559199	2236796
3.	Dwelling unit-A18 to A25	8	537325	4298600
4.	Dwelling unit-A26 to A43	18	439800	7916400
5.	Dwelling unit-B5 to B36	32	318400	10188800
6.	Dwelling unit-D18 to D29	12	185972	2231664
7.	Dwelling unit-E1 to E64	64	280066	17924224
	TOTAL	151		49313704
8.	Bank	1	315190	315190
9.	School	1	2302258	2302258
10.	Shops	1	502872	502872
11.	Dispensary	1	536762	536762
	TOTAL			52970786 M.J.

Table 13: Total embodied energy in existing CBRI

Covert Mega Joule to Kilowatt-hours

If, 1 M.J. =0.2777 KW-hrs,

Then 52970786 M.J. = 52970786 x 0.2777 KW-hrs = 14709987.27 KW-hr

To convert Kilowatt-hours to Kilograms of CO_2

Factor for Industrial Coal = 0.32227 Kg of CO_2

So, 14709987.27 x 0.32227 = 4740587.598 Kg of CO_2 => 4740.587 tons of CO_2

CHAPTER 5: OPERATING ENERGY

5.1 INTRODUCTION

Operating energy is can be as defined energy needed for heating, cooling, lighting and operating the building. Basically all the energy required for running a building.

5.2 OPERATING ENERGY IN THE C.B.R.I. NEIGHBOURHOOD

The neighbourhood taken for the study i.e. the C.B.R.I. neighbourhood has various types of house and other amenities like bank, shops etc. Operating energy for these buildings was calculated using software called 'Design builder' version 1.6.9.003. Also to make certain that there value was within the range of realistic energy usage a survey was conducted in neighborhood on E type dwelling units.

Each building type was modeled in this software. These buildings were preconditioned like their existing counter parts and were the simulated. The results we got gave us CO_2 release annually of each building and various other values. This helped figure out the annual CO_2 release of this neighbouhood. This value when coupled with the embodied energy gives the comprehensive energy assessment.

Dwelling unit type – A 1 to A 10

Here are the images of simulation model for Dwelling Unit type A-1 to A-10 showing results.

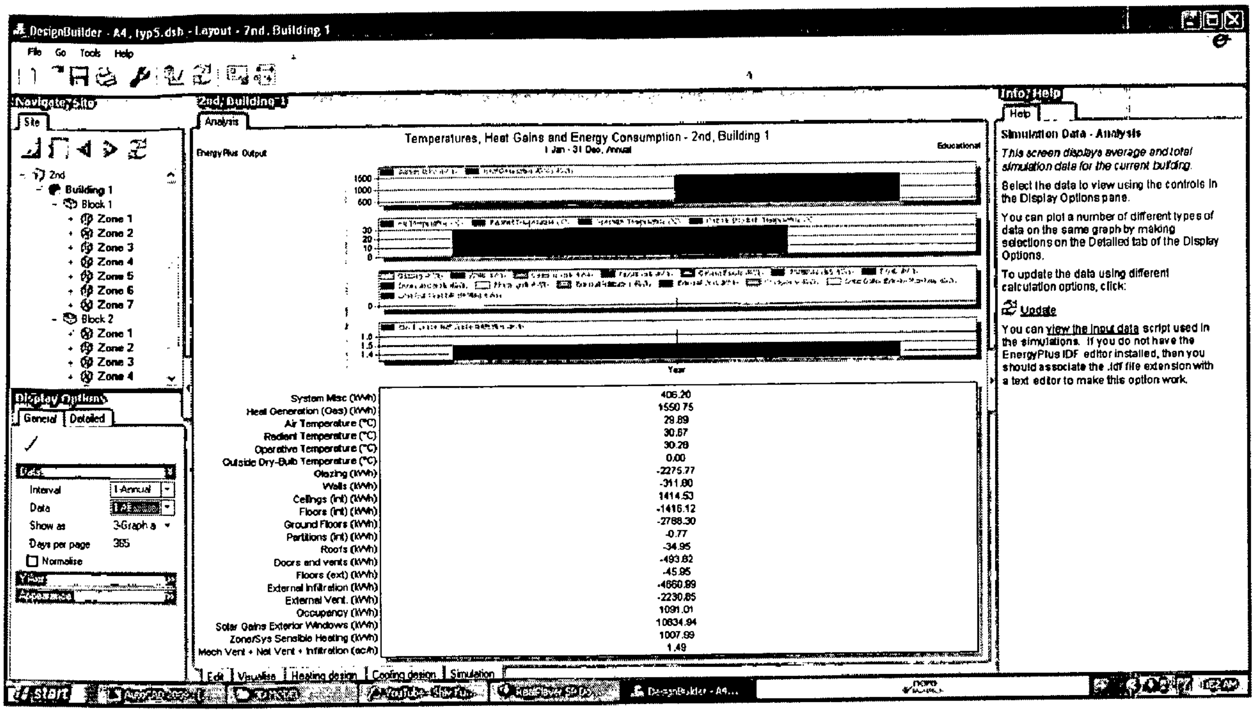


Figure 19: showing simulation result for A1 to A10

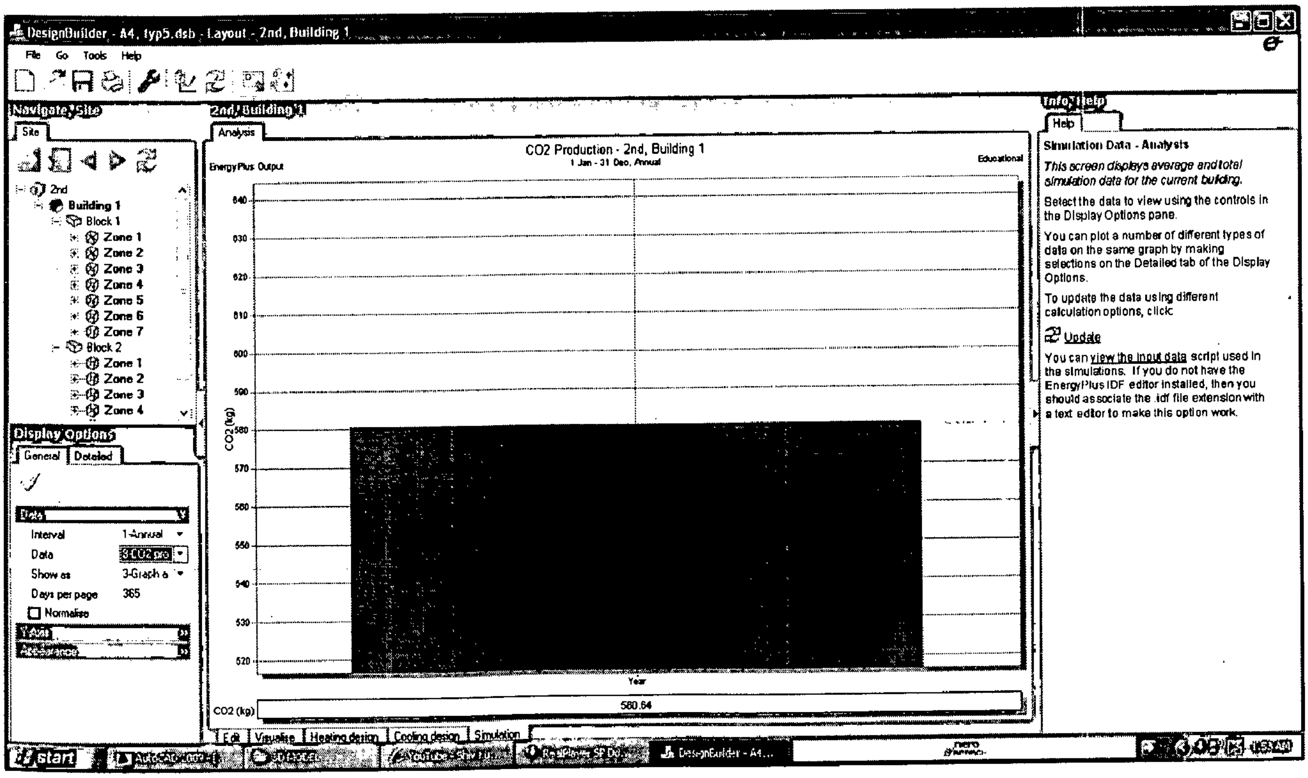


Figure 20: Showing CO2 consumption of A1 to A10

Operating energy in A 1 to A 10

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units A1 to A10 type	2490	5918	3491.71

Table 14:Operating energy in A1 to A10

Dwelling unit type – A 12 to A 15

Here are the images of simulation model for Dwelling Unit type A-12 to A-15 showing results.

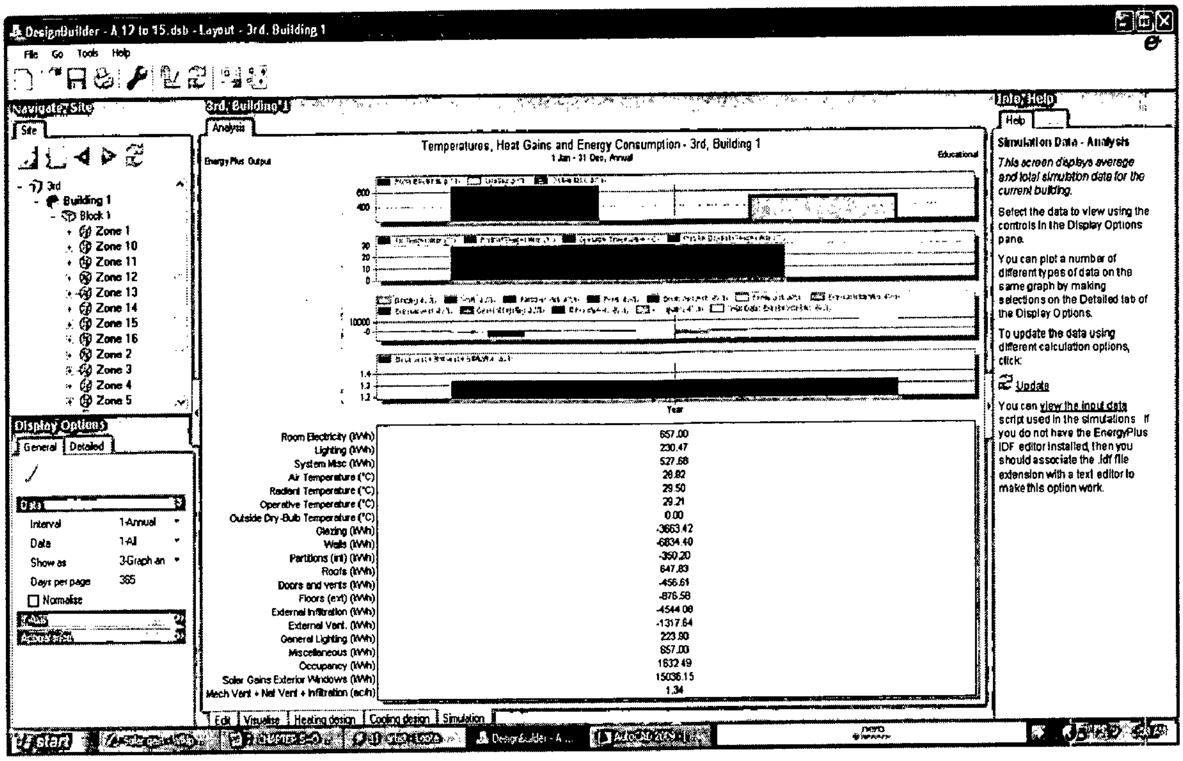


Figure 21: Showing simulation result for A12 to A15

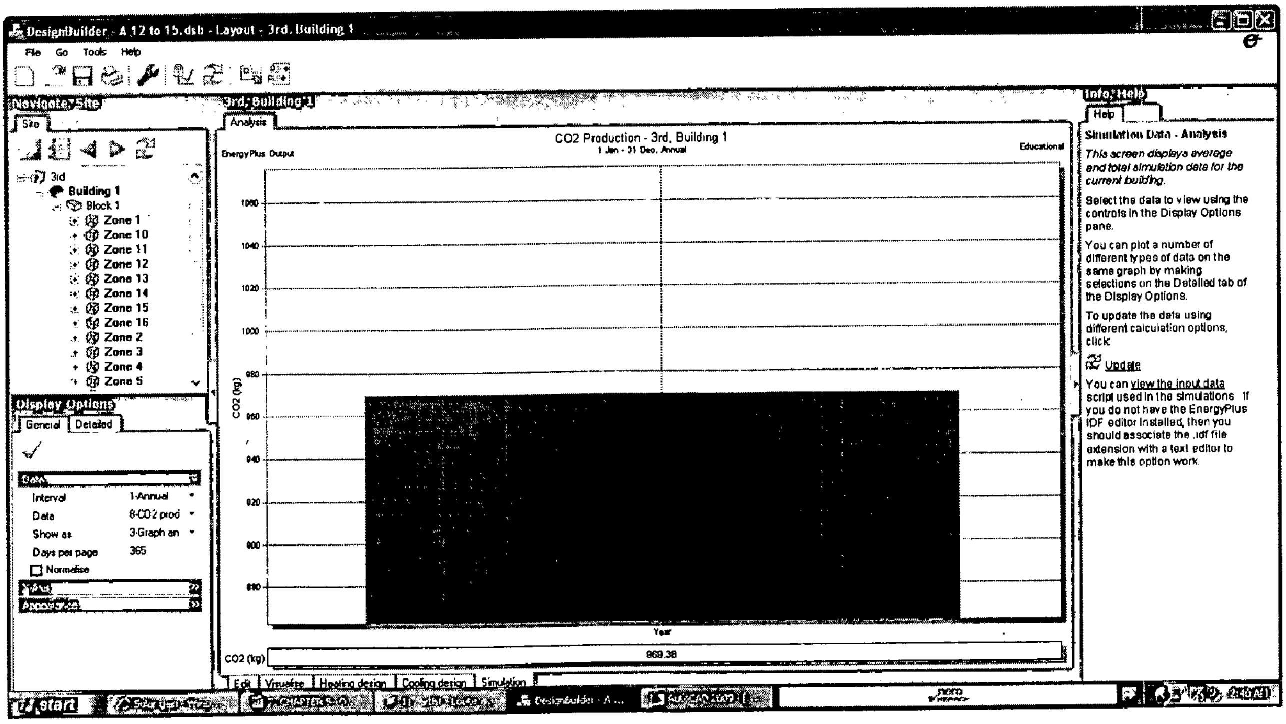


Figure 22: Showing CO 2 consumption for A12 to A15

Operating energy in A 12 to A 15

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units A12 to A15 type	969.38	15036.15	1415.15

Table 15:Operating energy in A12 to A15

Dwelling unit type – A 18 to A 25

Here are the images of simulation model for Dwelling Unit type A-18 to A-25 showing results.

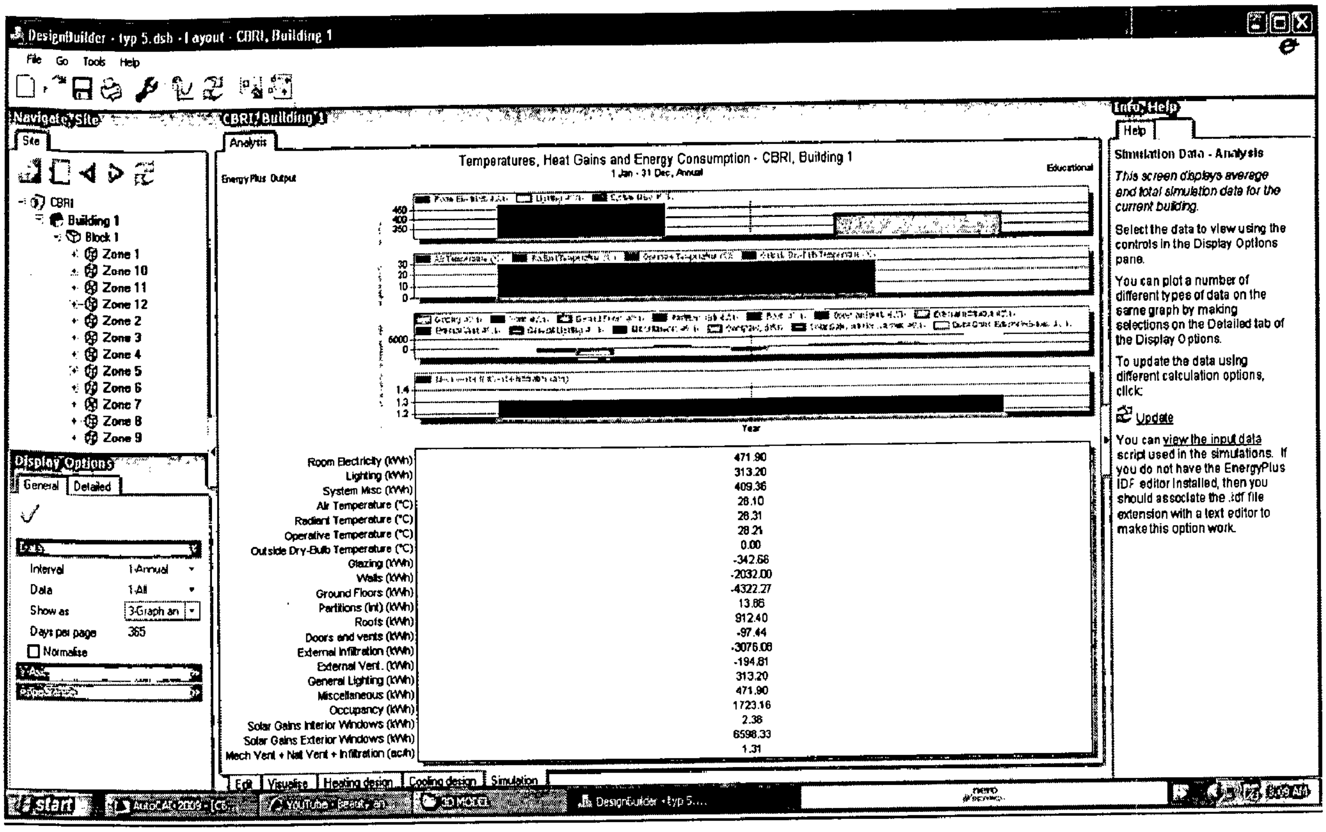


Figure 23: Showing simulation result for A18 to A25

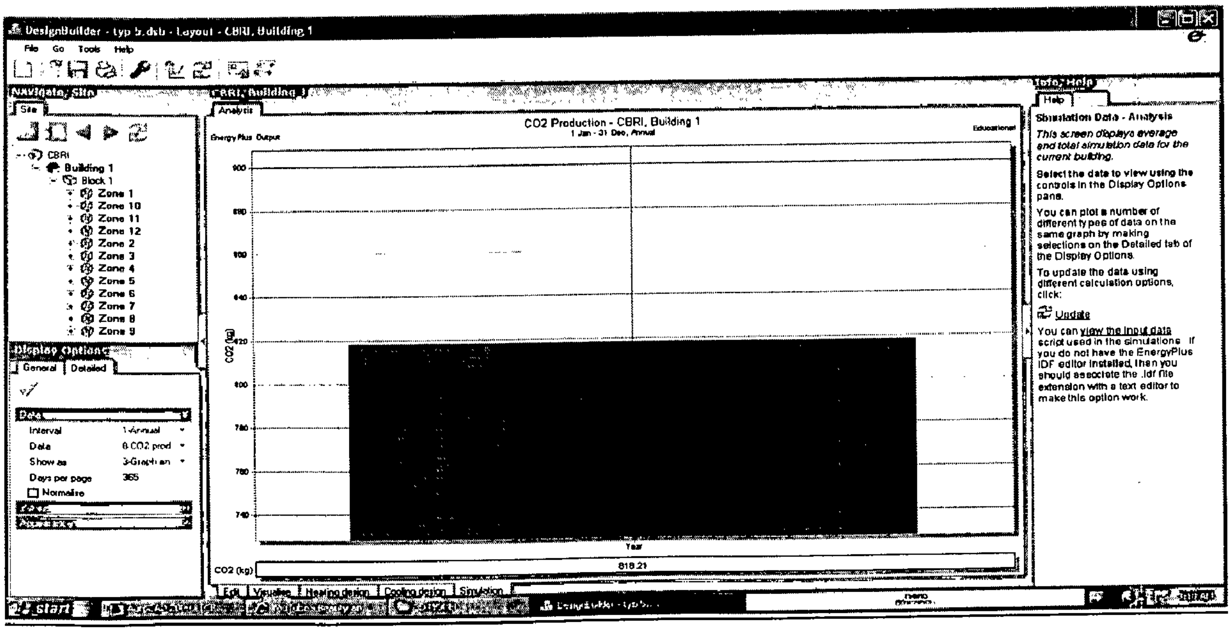


Figure 24: Showing CO2 consumption for A18 to A 25

Operating energy in A 18 to A 25

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units A18 to A25 type	818.21	6598	1194

Table 16:Operating energy in A18 to A25

Dwelling unit type – A 26 to A 43

Here are the images of simulation model for Dwelling Unit type A 26 to A 43 showing results.

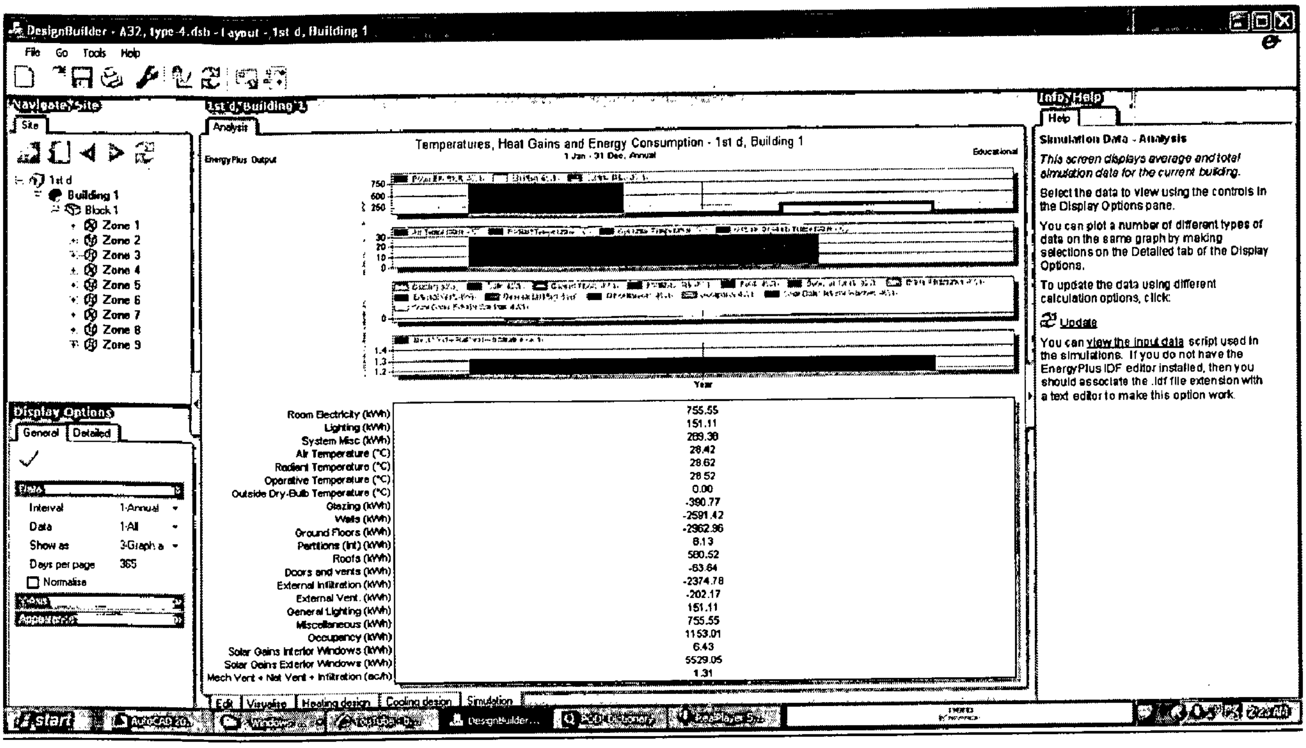


Figure 25: Showing simulation results for A26 to A 43

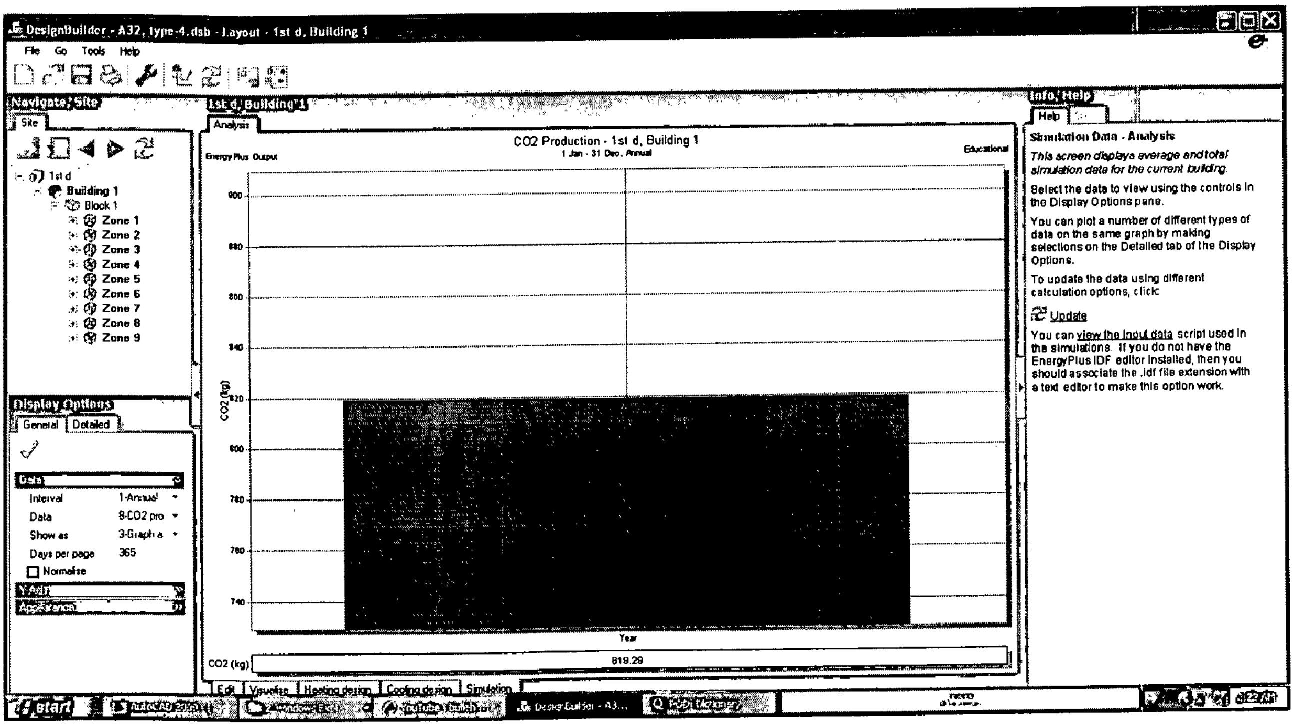


Figure 26: Showing CO2 consumption for A26 to A43

Operating energy in A 26 to A 43

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units A18 to A25 type	819.29	5529.05	1196.04

Table 17:Operating energy in A26 to A43

Dwelling unit type – B 5 to B 36

Here are the images of simulation model for Dwelling Unit type B 5 to B 36 showing results.

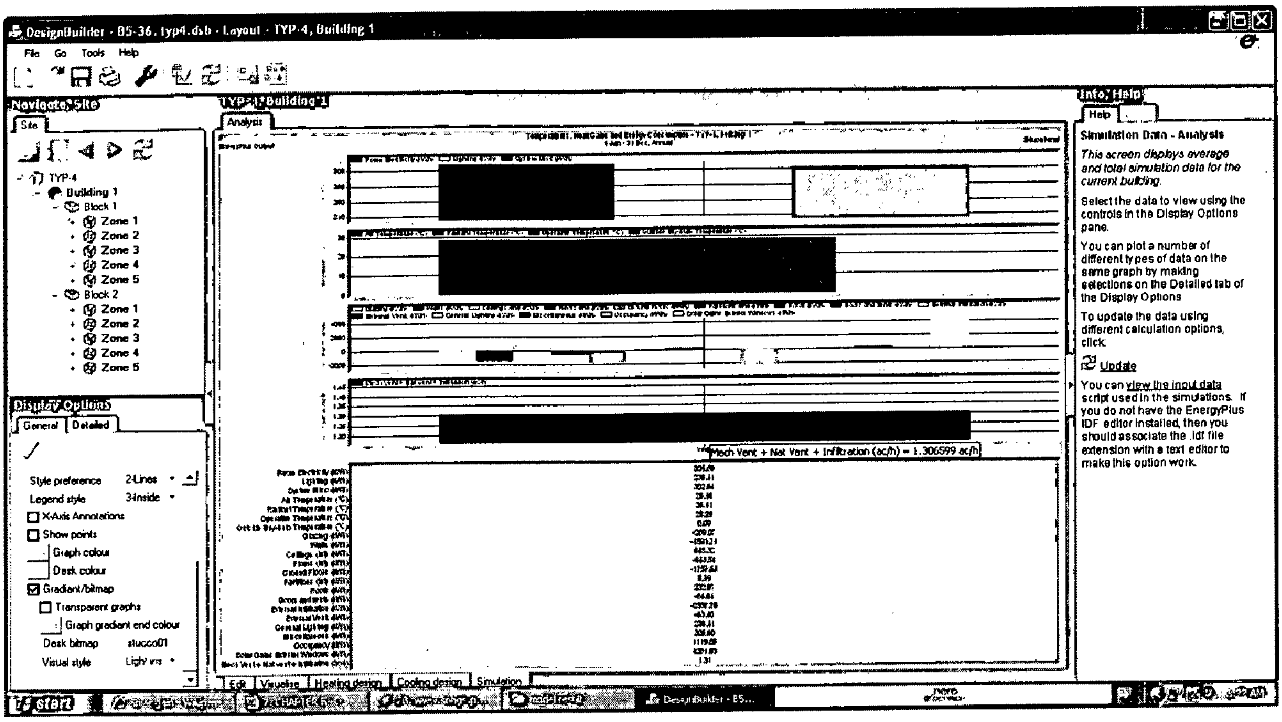


Figure 27: Showing simulation result for B5 to B 36

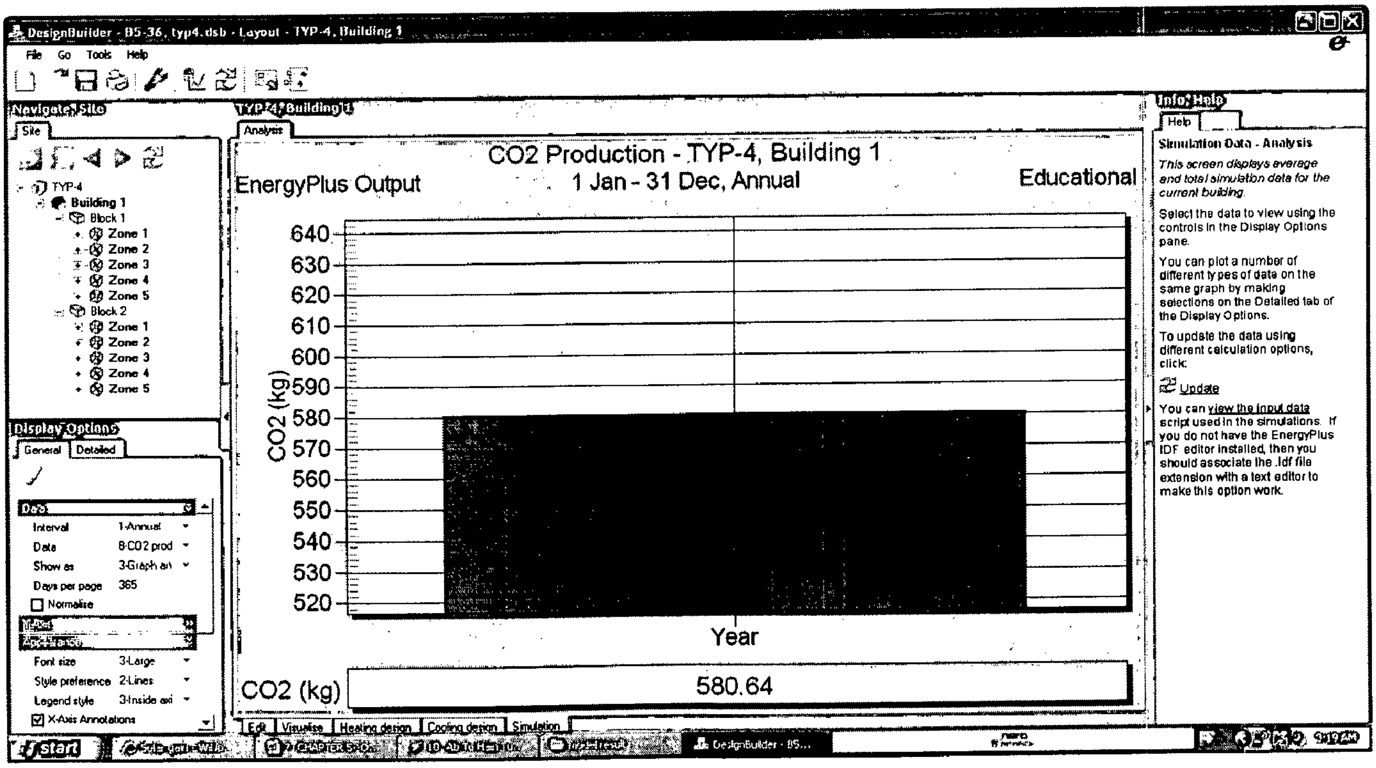


Figure 28: Showing CO2 consumption for B5 to B36

Operating energy in B 5 to B 36

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units B 5 to B 36 type	580.64	4201.93	847.65

Table 18:Operating energy in B5 to B36

Dwelling unit type – D 18 to D 29

Here are the images of simulation model for Dwelling Unit type D 18 to D 29 showing results.

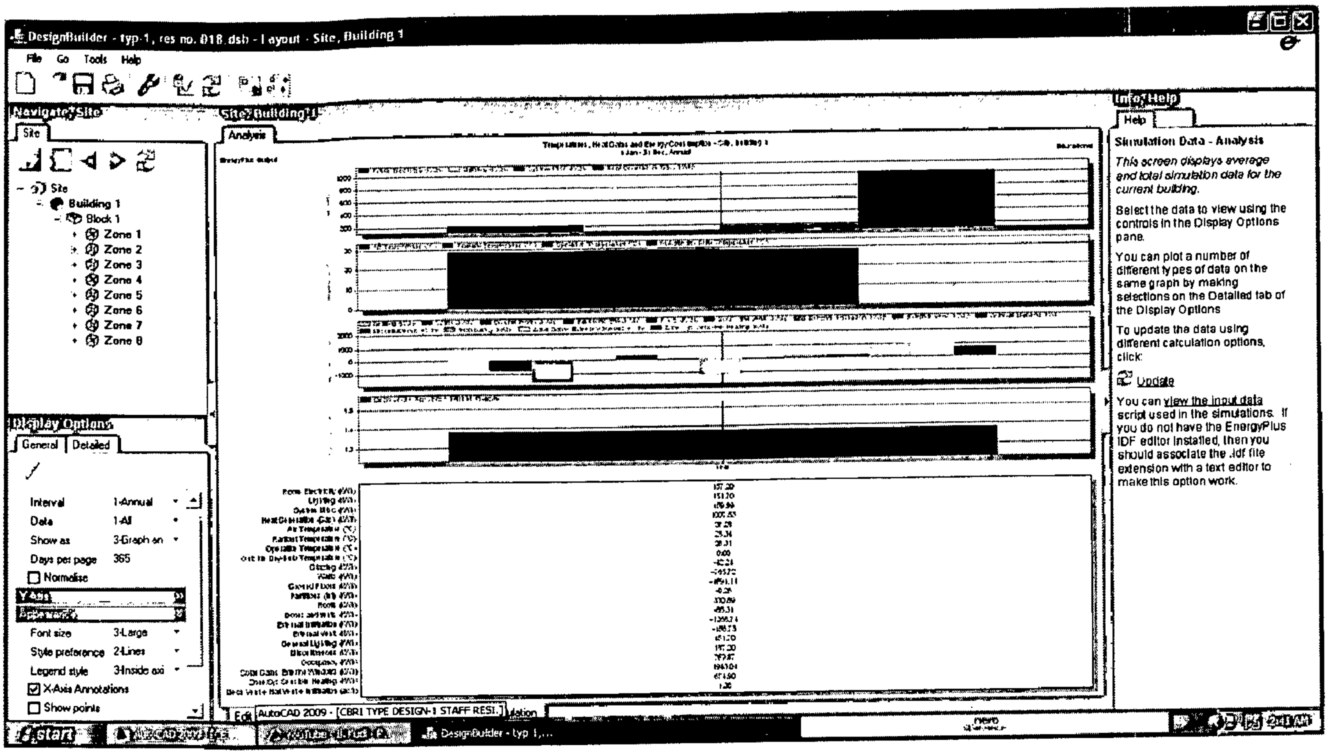


Figure 29: Showing simulation for D18 to D29

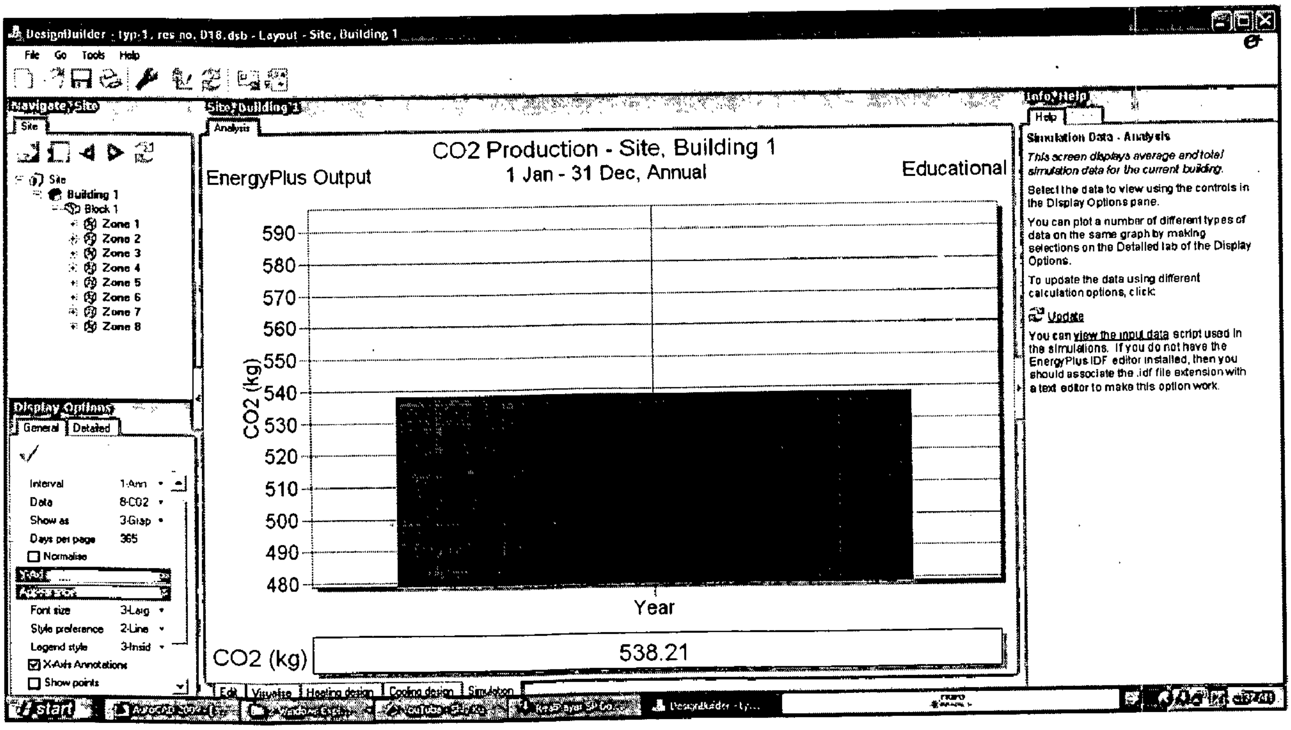


Figure 30: Showing CO2 consumption for D18 to D29

Operating energy in D 18 to D 29

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units D 18 to D 29 type	538.21	1943.04	498.90

Table 19:Operating energy in D18 to D29

Dwelling unit type – E 1 to E 64

Here are the images of simulation model for Dwelling Unit type E 1 to E 64 showing results.

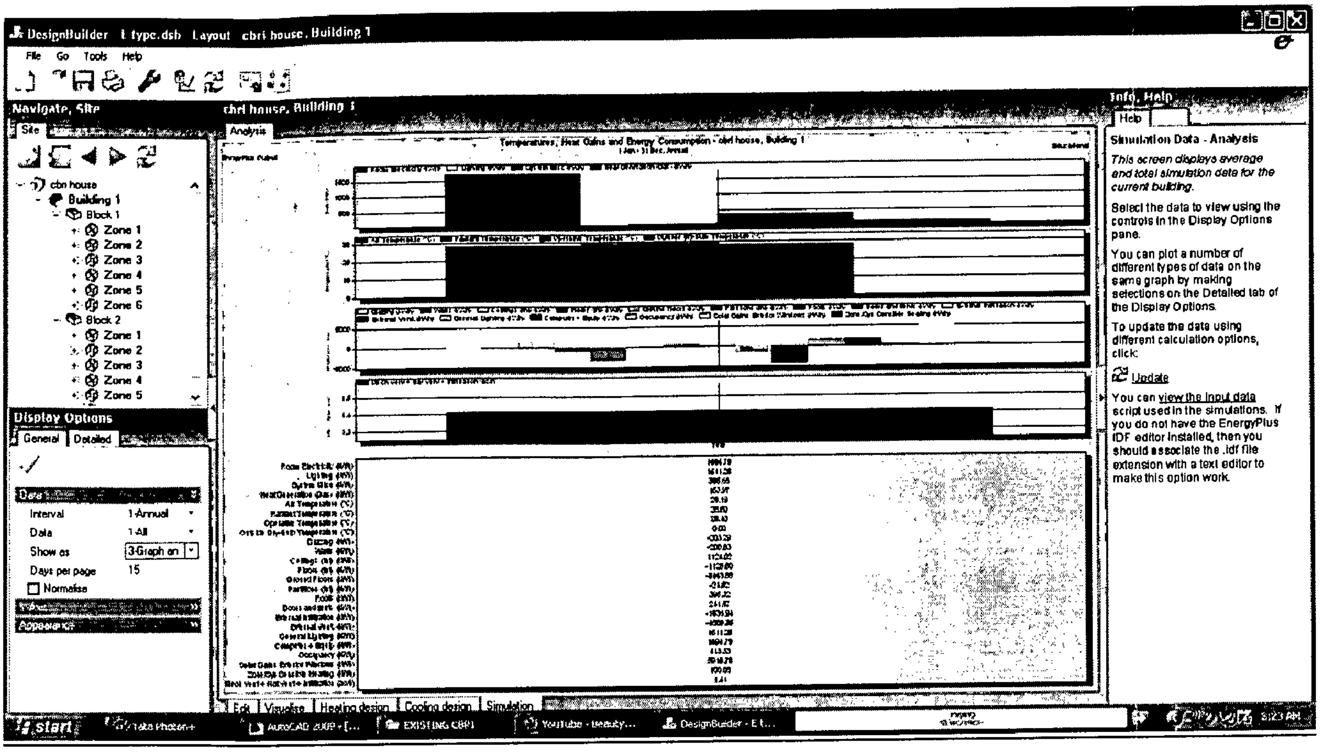


Figure 31:Showing simulation results for E1 to E64

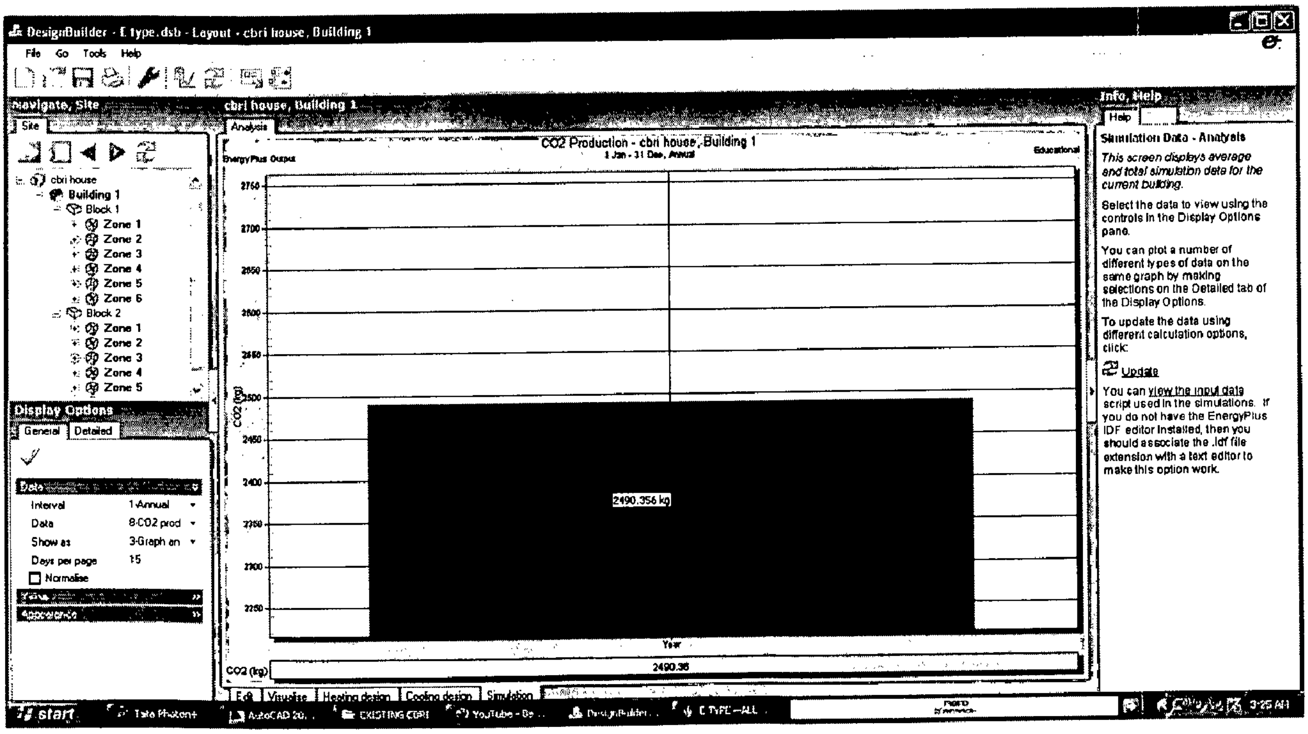


Figure 32: Showing CO2 consumption for E1 to E64

Operating energy in E 1 to E 64

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units E 1 to E 64 type	2490	5918	3491.71

Table 20:Operating Energy in E1 to E64

BANK in existing C.B.R.I. neighbourhood

Here are the images of simulation model Bank showing results.

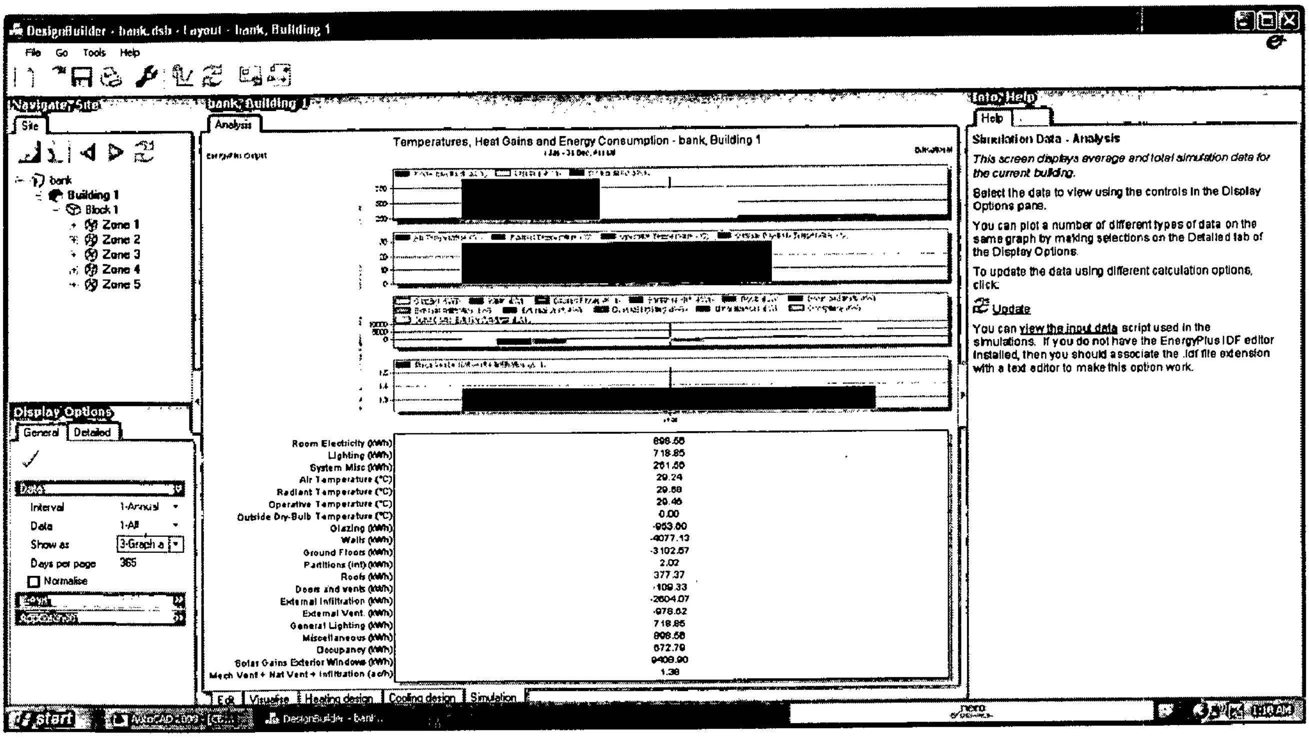


Figure 33:Showing simulation for bank

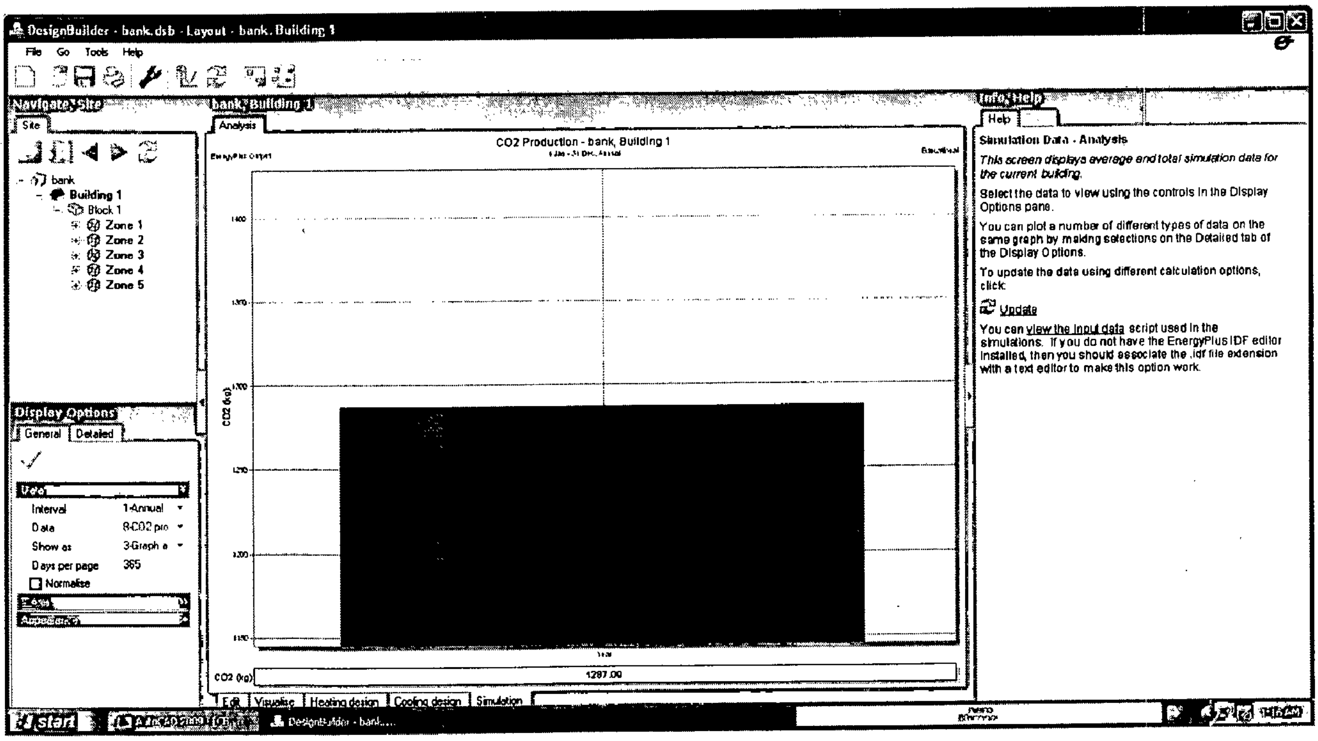


Figure 34:showing CO2 consumption for bank

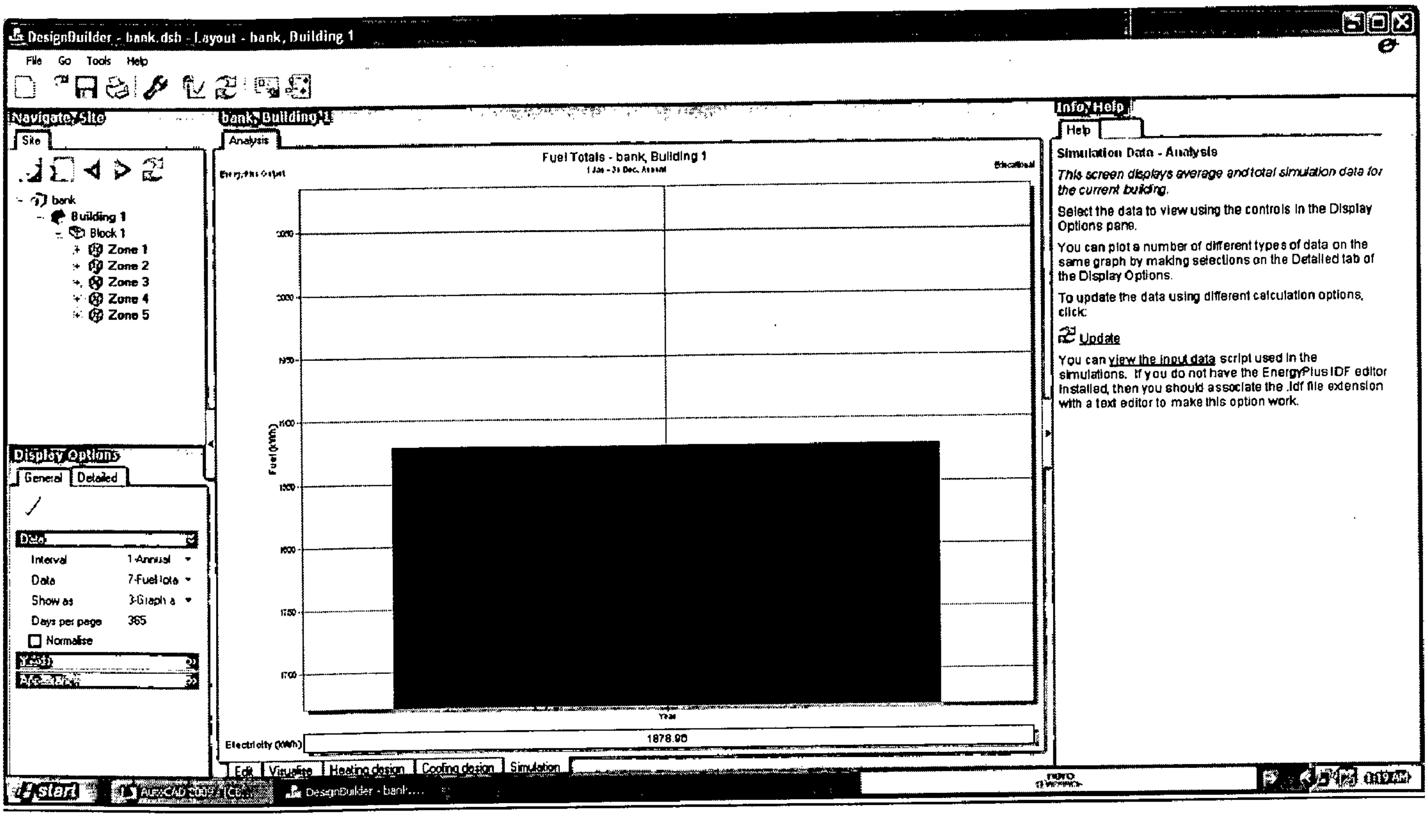


Figure 35:showing electricity consumption for bank

Operating energy in Bank

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Bank	1287.09	9408.90	1878.96

Table 21:operating energy in Bank

SCHOOL in existing C.B.R.I. neighbourhood

Here are the images of simulation model school showing results.

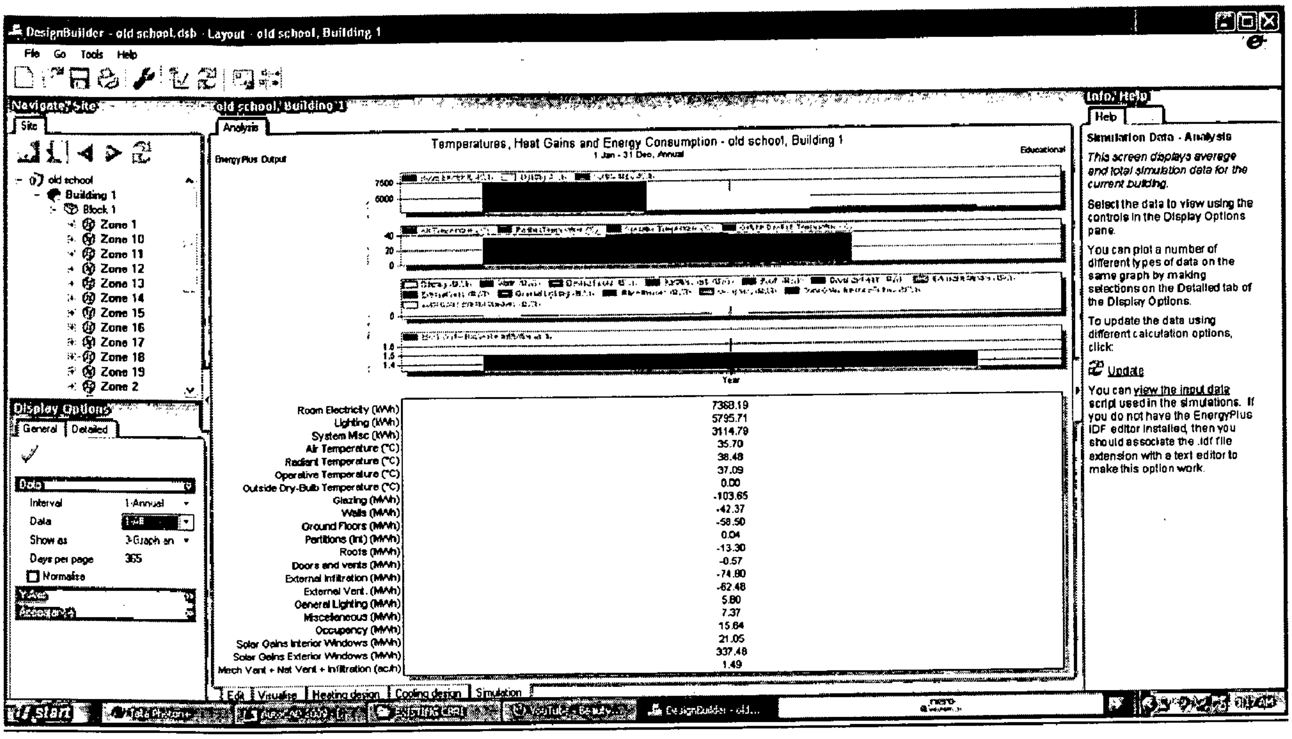


Figure 36: Showing simulation for

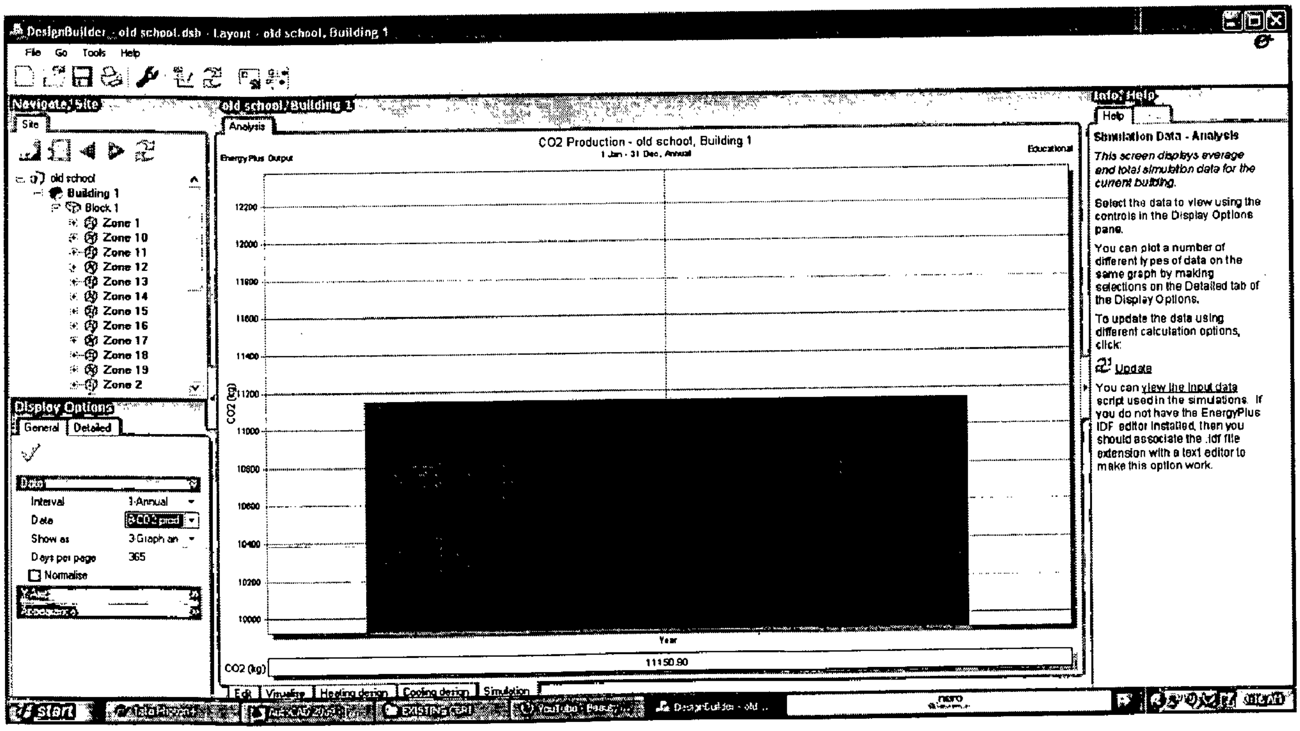


Figure 37:showing CO2 consumption for bank

Operating energy in School

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
School	11150.90	337.48	16278

Table 22:Operating energy in school

SHOPS in existing C.B.R.I. neighbourhood

Here are the images of simulation model Shops showing results.

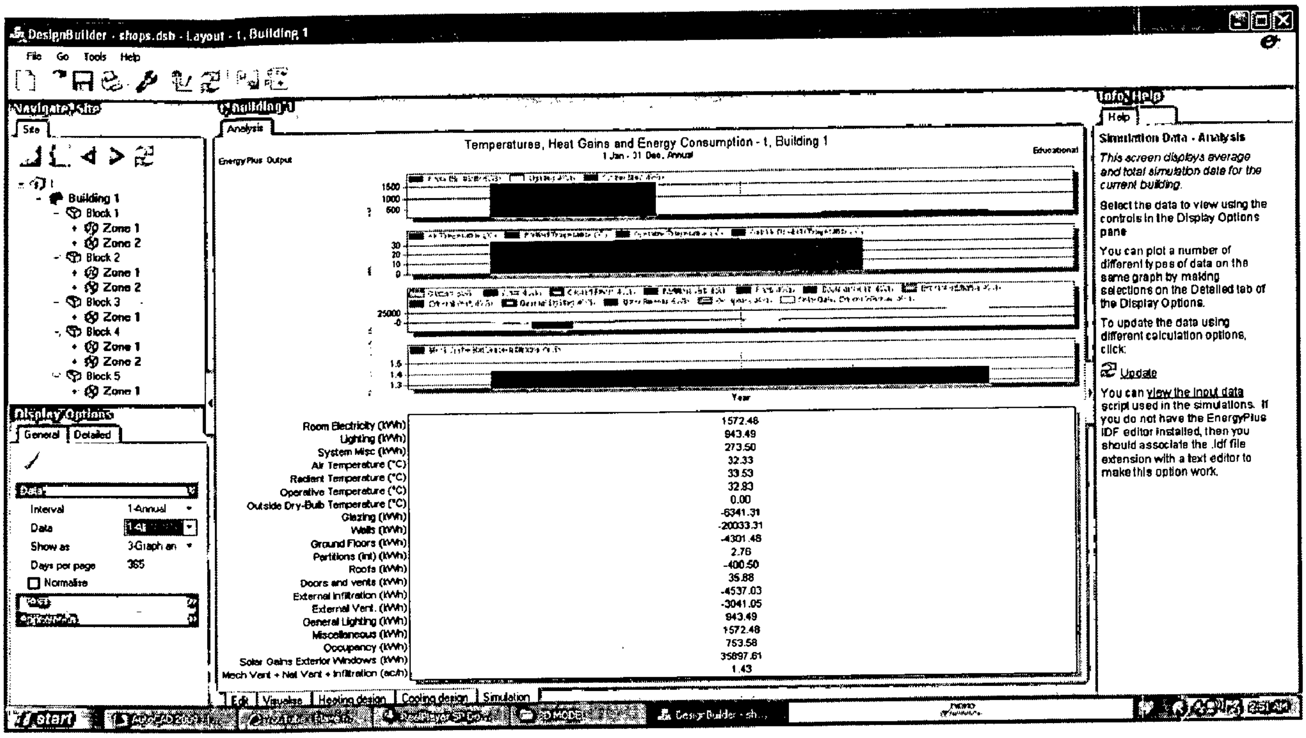


Figure 38: Showing simulation for shops

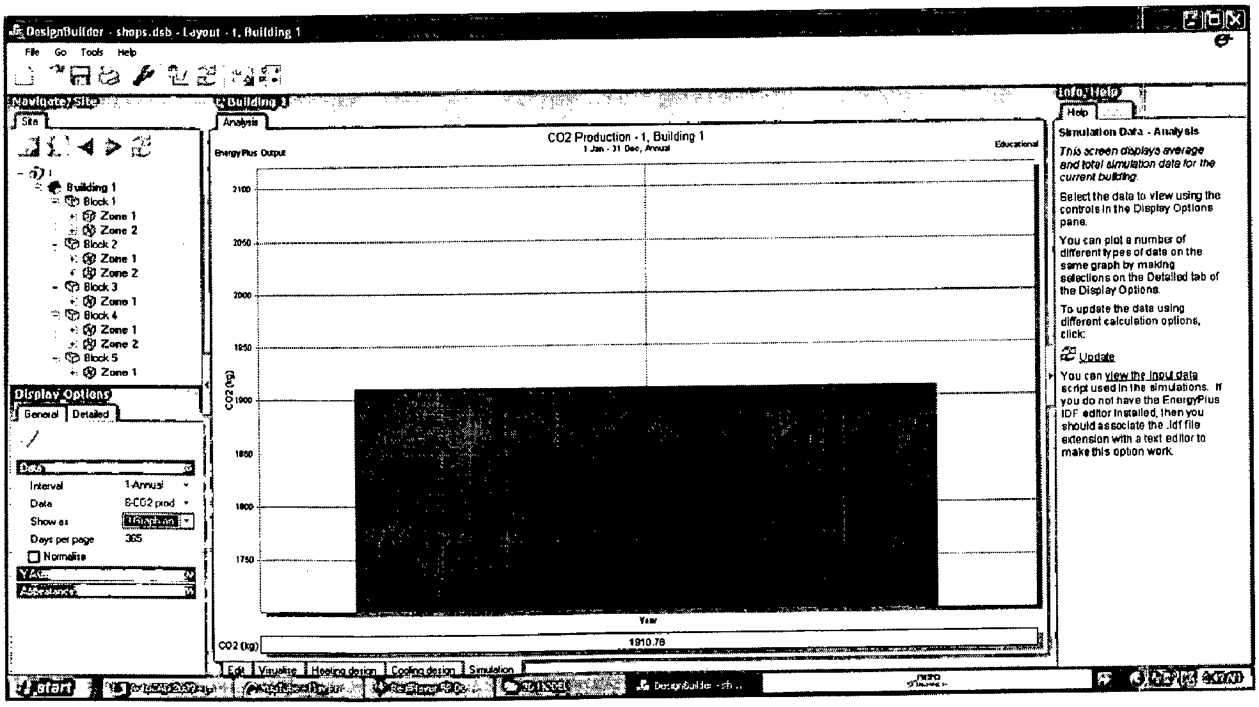


Figure 39:showing CO2 consumption for shops

Operating energy in Shops

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Shops	1910.78	35897	2786.49

Table 23:operating energy in shops

DISPENSARY in existing C.B.R.I. neighbourhood

Here are the images of simulation model Shops showing results.

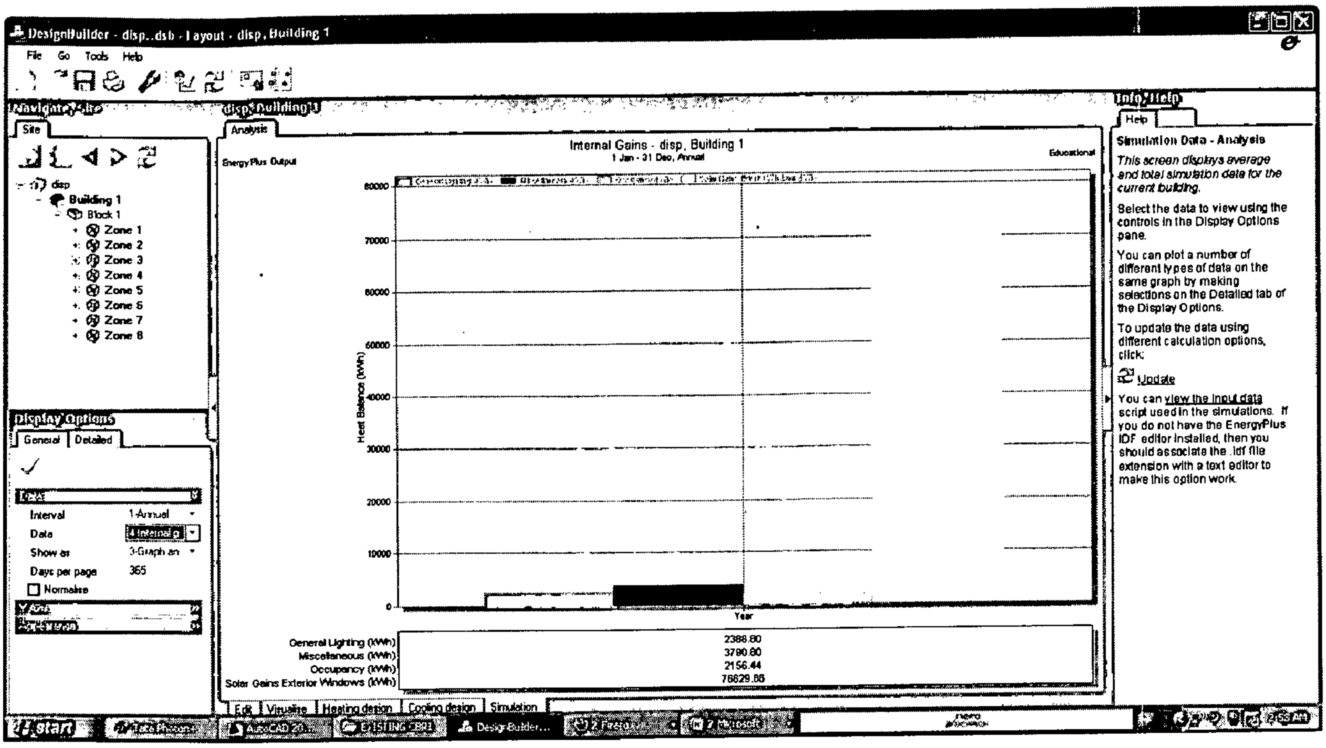


Figure 40: Showing simulation for dispensary

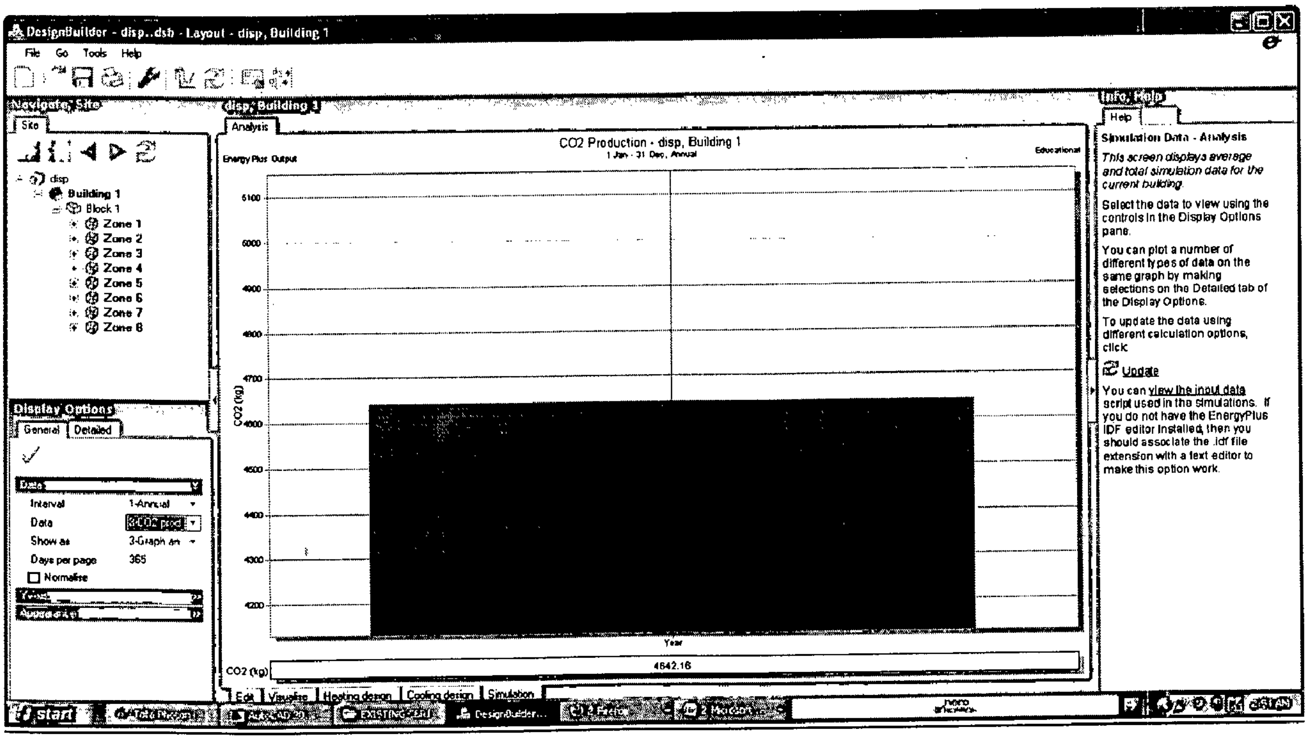


Figure 41:showing CO2 consumption for dispensary

Operating energy in Dispensary

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dispensary	4642.16	76629	6776.87

Table 24:Operating energy in Dispensary

TOTAL OPERATING ENERGY IN C.B.R.I. NEIGHBOURHOOD ANNUALLY

BUILDING TYPE	NO.	OPERATING ENERGY (CO_2 IN KG.)	SOLAR GAINS (KW-h)	ELEC. (KW-h)	TOTAL OPERATING ENERGY (CO_2 IN KG	TOTAL SOLAR GAINS (KW-h)	TOTAL ELEC. (KW/h)
Dwelling unit-A1 to A10	10	580.64	10834.94	406.20	5806.4	108349.4	4062.0
Dwelling unit-A12 to A15	4	969.38	15036.15	1415.15	3877.52	60144.6	5660.6
Dwelling unit-A18 to A25	8	818.21	6598	1194	6545.68	52784	9552
Dwelling unit-A26 to A43	18	819.29	5529.05	1196.04	14747.22	99522.9	21528.72
Dwelling unit-B5 to B36	32	580.64	4201.93	847.65	18580.48	134461.76	27124.8
Dwelling unit-D18 to D29	12	538.21	1943.04	498.90	6548.52	23316.48	5986.8
Dwelling unit-E1 to E64	64	2490	5918	3491.71	159360	378752	223469.44
TOTAL	151				215465.82	8573311.1	297384.36
Bank	1	1287.09	9408.90	1878.96	1287.09	9408.90	1878.96
School	1	11150.90	337.48	16278	11150.90	337.48	16278
Shops	1	1910.78	35897	2786.49	1910.78	35897	2786.49
Dispensary	1	4642.16	76629	6776.87	4642.16	76629	6776.87
TOTAL					234456.75	8695583.4	325104.68

Table 25:Total operating energy in existing CBRI

CHAPTER 6: PROPOSAL ON THE SAME SITE

6.1 PROPOSED NEIGHBOURHOOD

This neighbourhood constitutes of various house types, a school, a bank, a market place, dispensary, plaza, park, carbon sink, area for solar panels, site for religious place, area for food production, area for future expansion of neighbourhood and area for future expansion of C.B.R.I.

6.2 LEED CRITERIA

The proposal on the same site has been proposed, with an objective of reducing the carbon release. This proposal tries to incorporate the LEED criteria for the low carbon neighbourhood.

ND Credits Affecting CO_2 Emissions

SMART LOCATION & LINKAGE
p1: Smart Location
p2: Imperiled Species and Ecological Communities
p3: Wetland and Water Body Conservation
p4: Agricultural Land Conservation
p5: Floodplain Avoidance
c1: Preferred Locations
c2: Brownfield Redevelopment
c3: Locations With Reduced Automobile Dependence
c4: Bicycle Network and Storage
c5: Housing and Jobs Proximity
c6: Steep Slope Protection
c7: Site Design for Habitat or Wetland and Water Body Conservation
c8: Restoration of Habitat or Wetlands and Water Bodies
c9: Long-Term Conservation Management of Habitat or Wetlands and Water Bodies

NEIGHBORHOOD PATTERN & DESIGN
p1: Walkable Streets
p2: Compact Development
p3: Connected and Open Community
c1: Walkable Streets
c2: Compact Development
c3: Mixed-Use Neighborhood Centers
c4: Mixed-Income Diverse Communities
c5: Reduced Parking Footprint
c6: Street Network
c7: Transit Facilities
c8: Transportation Demand Management
c9: Access to Civic and Public Spaces
c10: Access to Recreation Facilities
c11: Visitability and Universal Design
c12: Community Outreach and Involvement
c13: Local Food Production
c14: Tree-Lined and Shaded Streets
c15: Neighborhood Schools

GREEN INFRASTRUCTURE & BUILDINGS
p1: Certified Green Building
p2: Minimum Building Energy Efficiency
p3: Minimum Building Water Efficiency
p4: Construction Activity Pollution Prevention
c1: Certified Green Buildings
c2: Building Energy Efficiency
c3: Building Water Efficiency
c4: Water-Efficient Landscaping
c5: Existing Building Reuse
c6: Historic Resource Preservation and Adaptive Use
c7: Minimized Site Disturbance in Design and Construction
c8: Stormwater Management
c9: Heat Island Reduction
c10: Solar Orientation
c11: On-Site Renewable Energy Sources
c12: District Heating and Cooling
c13: Infrastructure Energy Efficiency
c14: Wastewater Management
c15: Recycled Content in Infrastructure
c16: Solid Waste Management Infrastructure
c17: Light Pollution Reduction

Figure 42: LEED ND criteria

SMART LOCATION & LINKAGE

P 1: Smart location

The chosen site was the closest to the work place of the residents in this particular case.

P 2: Imperiled Species and Ecological Communities

The large open and green areas provide enough space for flora and fauna to flourish.

C 1: Preferred Location

Due to close proximity to the work place of the residents living in this area.

C 3: Location with reduced automobile Dependence

This is because; again the workplace, the school, and other amenities are nearby and are well connected through the pedestrian path.

C 4: Bicycle Network and Storage

This neighbourhood has pedestrian and cycle paths which connect the whole neighbourhood, i.e. the residential, commercial and institutional zones.

C 5: Housing and job proximity

Since this neighbourhood is closer to workplace of the users of this neighbourhood i.e. the employees of C.B.R.I. it matches this parameter.

NEIGHBOURHOOD PATTERN & DESIGN

P 1: Walkable Streets

All the streets in this neighbourhood are provided with 1.5 m wide side walk on the either sides.

P 2: Compact Development

The whole layout for this neighbourhood is on a grid-iron pattern. This prevents the wastage of space resulting in a compact development.

P 3: Connected and Open Community

The neighbourhood has been connected to its various parts using pedestrian paths. Open green areas around the house provide an open community for people of various age groups to interact.

C 3: Mixed Use Neighbourhood Center

This neighbourhood has a mixed use neighbourhood center which supports a school, a bank, a dispensary and shops.

C 4: Mixed-Income Diverse Community

It is a mixed income diverse community because it provides residences for the employees of C.B.R.I., which has a range of various income groups.

C 9: Access to civic and public spaces

There is an easy access to all the civic and public spaces through streets and pedestrian paths.

C 10: Access to recreational spaces.

It is provided through the streets and pedestrians.

C 11: Visibility and Universal design

There is enough visibility of open spaces and streetscapes from the house and vice-versa thus providing a holistic view. Also the design is such that it can be used on some other site with similar climatic and topographical conditions with suitable changes.

C 12: Community outreach and Involvement

There is a provision for a central plaza in the market place which can be developed further for holding public forums and space for discussions. Also the placement of the park is centrally located such that it is equidistant from all the residential units. This acts as a space for children to play, youngsters to recreate and adults to interact.

C 13: Local food Production

The area for local food production has been marked out. These sites can be leased out on a seasonal basis or on annual basis and either the profit or the yield can be shared by the residents.

C 14: Tree lined and shaded streets

The neighbourhood has been provided with streets and path which have been lined with trees on both the side.

C 15: Neighbourhood School

There is a school provided in the central part of the neighbourhood so that the children don't have to cross any major streets in reaching the destination.

6.3 SOME OTHER CHARACTERISTICS OF THIS NEIGHBOURHOOD

Grid iron pattern has been used for the site so as to ensure least wastage of land.

This grid iron pattern has been aligned with the wind direction of the site.

The orientation of the buildings is such that it captures the wind.

6.4 CARBON SINK

A **carbon sink** is a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period. The process by which carbon sinks remove carbon dioxide (CO_2) from the atmosphere is known as carbon sequestration. Public awareness of the significance of CO_2 sinks has grown since passage of the Kyoto Protocol, which promotes their use as a form of carbon offset.

A **carbon sink** is anything that absorbs more carbon that it releases, whilst a **carbon source** is anything that releases more carbon than is absorb

A carbon sink created on this site has 3300 deciduous tree ranging from a diameter of 3m to 6m. So if one tree can absorb 2.6 tons of carbon every year, then this carbon sink can absorb 8580 tons of carbon-dioxide annually, i.e. 8.580×10^6 kg of CO_2. Also these carbon sinks can be mangroves or orchards, this way it can bring monetary gains to the inhabitant/managers/local bodies of this neighbourhood. The money raised from this carbon sink and area for local food can be used for improvement and maintenance of neighbourhood.

6.5 SOLAR PANELS

It has been found by simulation modeling of the proposed house that the amount of electricity needed by this neighbourhood is 159424 KW/hr annually. This need has been fulfilled by providing solar panels so that this much load could be lifted off the grid.

Specifications: --

- Size of the panel=1m x 1m

- For 8 hours a day

- It can produce 100 W/sq. m. of electricity

- Efficiency varies from 5% to 20%

Solution: --

One panel in one day can produce= 100 W/sq. m. x 8 =800 W/ sq. m.

If efficiency is 10% then = 10/ 100 x 800= 80 W/sq. m. for each panel a day.

So annually one panel can produce=80 x 365=29200W/sq. m.

But, we have the annual requirement of energy= 159424KW/hr=159424000W/hr

So number of panels needed are= 159424000/29200=5459.7 ~ 5500 panels

These panels have been provided to provide electricity to the neighbourhood.

6.6 AREA FOR LOCAL FOOD PRODUCTION

Instead of providing small individual kitchen gardens, this neighbourhood is provided with two farms of a considerable size of 9829.379 sq. m. and 11660.566 sq. m. these farms can be leased out annually or seasonally by the local governing bodies.

6.7 CONNECTIVITY IN NEIGHBOUHOOD

This neighbourhood has been divided into various zones i.e. residential, institutional, commercial, carbon sink and area for solar panels. In this case area such as commercial or area for food production which have to deal with people not only from the neighbourhood but also from the outside are kept near the entrance to neighbourhood. The residential area is on the rear side and so is the school. Though school is on rear side it is so placed that it is at a walkable distance from the houses.

These zones have been connected through a peripheral road that runs around these areas making them approachable for the vehicles. And the internal dynamics of these zones has been so kept that the all the houses are connected to each other, commercial area, park/green and the school through a pedestrian/cycling path. Also they have been lined with the trees on both sides for shade. Cycling sheds have been provided at suitable places for parking cycles.

A green space or a park is provided centrally so that children do not have to cross any street to reach there and there is a visual connectivity between the residential and recreational zone this provides a sense of security to the user and makes the space more approachable.

6.8 STREET LIGHTS AND FURNITURE

All the streets are to be lined with street lights powered by solar panels. Also all the street furniture should be of wood because it is product which will not consume fossil fuel for its extraction from ores. It can be regenerated by planting more trees. Thus an eco-friendly and biodegradable product.

6.9 FUTURE EXPANSION

The scope for future expansion is left for the housing or commercial in the neighbourhood. Also scope for future expansion for C.B.R.I. is left too.

6.10 GREEN ROOF

A **green roof** is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane.

All the roofs are provided with green roof so that it reduces the carbon footprint of all the buildings.

6.11 EMBODIED ENERGY

Embodied energy was calculated for various building types in the proposal. Here is the detail of those building types:-

Dwelling unit type – 1 B.H.K.

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 35.87 cu. m
2. Lime concrete in foundation = 11.95 cu. m
3. Brickwork in foundation and plinth= 15.49 cu. m
4. Damp proof course 2.5 cm thick = 15.37 sq. m
5. First class brickwork in super structure= 25.96 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel =11.7487 cu. m.
7. Mild Steel work including bending in steel reinforcement = 9.222 quintals.
8. Bitumen Isolation layer of 2 coats on roof = 75.833 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. =57.345 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion = 233.07 sq. m.

Embodied energy in 1 B.H.K.

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	11.95 cu. m.	1288.25 MJ/cu. m.	15395
2.	Brickwork in foundation & plinth	15.49 cu. m.	2641.75 MJ/cu. m	40920
3.	Damp proof course 2.5 cm thick	15.37 sq. m	2601.35 MJ/sq. m	39982.7
4.	Ist class Brickwork in super structure	25.96 cu. m.	2641.75 MJ/cu. m	68579
5.	R.C.C. Work	11.748 cu. m.	3114.82 MJ/cu. m	36593

6.	Mild steel work	9.222 quintals	--	--
7.	Flooring	57.345 sq. m.	211.48 MJ/sq. m.	12129
8.	Cement Plaster in wall 12 mm. thick	233.07 sq . m.	24.12 MJ/sq. m	5621.64
			TOTAL=	219219 M.J.

Table 26: Embodied energy in proposed 1 BHK

For Ground Floor=219219 M.J.

For First Floor= 122922 M.J.

For Second Floor= 122922 M.J.

For 3 Dwelling units (i.e. G.F.+F.F.+S.F.) = 465064 M.J.

For 6 Dwelling units in one block = 930129 M.J.

Dwelling unit type – 2 B.H.K.

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 67.06 cu. m
2. Lime concrete in foundation = 22.35 cu. m
3. Brickwork in foundation and plinth= 33.94 cu. m
4. Damp proof course 2.5 cm thick = 29.81 sq. m
5. First class brickwork in super structure= 49.149 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel =24.467 cu. m.
7. Mild Steel work including bending in steel reinforcement = 19.206 quintals.
8. Bitumen Isolation layer of 2 coats on roof = 158.70 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. =126.87 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion = 467.48 sq. m.

Embodied energy in 2 B.H.K.

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	22.35 cu. m.	1288.25 MJ/cu. m.	28792.38
2.	Brickwork in foundation & plinth	33.94 cu. m.	2641.75 MJ/cu. m	89661
3.	Damp proof course 2.5 cm thick	29.81 sq. m	2601.35 MJ/sq. m	77547
4.	Ist class Brickwork in super structure	49.149 cu. m.	2641.75 MJ/cu. m	129839
5.	R.C.C. Work	24.467 cu. m.	3114.82 MJ/cu. m	76210

6.	Mild steel work	19.206 quintals	--	--
7.	Flooring	126.87 sq. m.	211.48 MJ/sq. m.	26830
8.	Cement Plaster in wall 12 mm. thick	467.48 sq . m.	24.12 MJ/sq. m	11275
			TOTAL=	440155 M.J.

Table 27:Embodied energy in proposed 2BHK

For Ground Floor= 440155 M.J.

For First Floor= 244154 M.J.

For Second Floor= 244154 M.J.

For 3 Dwelling units (i.e. G.F.+F.F.+S.F.) = 928463 M.J.

For 6 Dwelling units in one block = 1856926 M.J.

Dwelling unit type – 3 B.H.K.

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 79.04 cu. m
2. Lime concrete in foundation = 26.34 cu. m
3. Brickwork in foundation and plinth= 34.15 cu. m
4. Damp proof course 2.5 cm thick = 35.13 sq. m
5. First class brickwork in super structure= 58.01 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel =26.67 cu. m.
7. Mild Steel work including bending in steel reinforcement = 20.94 quintals.
8. Bitumen Isolation layer of 2 coats on roof = 172.529 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 143.921 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion = 466.292 sq. m.

Embodied energy in 3 B.H.K.

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	26.34 cu. m.	1288.25 MJ/cu. m.	33932
2.	Brickwork in foundation & plinth	34.15 cu. m.	2641.75 MJ/cu. m	90216
3.	Damp proof course 2.5 cm thick	35.13 sq. m	2601.35 MJ/sq. m	91385
4.	Ist class Brickwork in super structure	58.01 cu. m.	2641.75 MJ/cu. m	153248
5.	R.C.C. Work	26.67 cu. m.	3114.82 MJ/cu. m	83072

6.	Mild steel work	20.94 quintals	--	--
7.	Flooring	143.921 sq. m.	211.48 MJ/sq. m.	30436
8.	Cement Plaster in wall 12 mm. thick	466.292 sq . m.	24.12 MJ/sq. m	11246
			TOTAL=	493536 M.J.

Table 28:Embodied energy in proposed 3 BHK

For Ground Floor= 493536 M.J.

For First Floor= 278002 M.J.

For Second Floor= 278002 M.J.

For 3 Dwelling units (i.e. G.F.+ F.F.+S.F.) = 1049540 M.J.

For 6 Dwelling units in one block = 2099080 M.J.

Building Type – SHOPS

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 79.04 cu. m
2. Lime concrete in foundation = 26.34 cu. m
3. Brickwork in foundation and plinth= 34.15 cu. m
4. Damp proof course 2.5 cm thick = 35.13 sq. m
5. First class brickwork in super structure= 58.01 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel =26.67 cu. m.
7. Mild Steel work including bending in steel reinforcement = 20.94 quintals.
8. Bitumen Isolation layer of 2 coats on roof = 172.529 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 143.921 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion = 466.292 sq. m.

Embodied energy in SHOPS

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	30.88 cu. m.	1288.25 MJ/cu. m.	39781
2.	Brickwork in foundation & plinth	40.03 cu. m.	2641.75 MJ/cu. m	105749
3.	Damp proof course 2.5 cm thick	37.35 sq. m	2601.35 MJ/sq. m	97160
4.	Ist class Brickwork in super structure	66.46 cu. m.	2641.75 MJ/cu. m	175570
5.	R.C.C. Work	32.74 cu. m.	3114.82 MJ/cu. m	101979

6.	Mild steel work	25.707 quintals	--	--
7.	Flooring	191.04 sq. m.	211.48 MJ/sq. m.	40385
8.	Cement Plaster in wall 12 mm. thick	345.9 sq . m.	24.12 MJ/sq. m	8343.108
			TOTAL=	568967 M.J.

able 29:Embodied energy in proposed Shops

Building Type – SCHOOL

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 221.23 cu. m
2. Lime concrete in foundation = 59.73 cu. m
3. Brickwork in foundation and plinth= 95.59 cu. m
4. Damp proof course 2.5 cm thick = 100.25 sq. m
5. First class brickwork in super structure= 196.25 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel =92.76 cu. m.
7. Mild Steel work including bending in steel reinforcement = 72.82 quintals.
8. Bitumen Isolation layer of 2 coats on roof = 604.37 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 534.5 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion = 1050.43 sq. m.

Embodied energy in SCHOOL

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	59.73 cu. m.	1288.25 MJ/cu. m.	76947
2.	Brickwork in foundation & plinth	95.59 cu. m.	2641.75 MJ/cu. m	253423
3.	Damp proof course 2.5 cm thick	100.25 sq. m	2601.35 MJ/sq. m	260135

4.	Ist class Brickwork in super structure	196.25 cu. m.	2641.75 MJ/cu. m	518443
5.	R.C.C. Work	92.76 cu. m.	3114.82 MJ/cu. m	288930
6.	Mild steel work	72.32 quintals	--	--
7.	Flooring	534.5 sq. m.	211.48 MJ/sq. m.	113036
8.	Cement Plaster in wall 12 mm. thick	1050.43 sq . m.	24.12 MJ/sq. m	25326
			TOTAL=	1536240 M.J.

For Ground Floor= 1536240 M.J.

For First Floor= 945735 M.J.

TOTAL for both floors = 2481975 M.J

BANK in existing C.B.R.I. neighbourhood

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 47.004 cu. m
2. Lime concrete in foundation = 15.668 cu. m
3. Brickwork in foundation and plinth= 20.309 cu. m
4. Damp proof course 2.5 cm thick= 21.612 sq. m
5. First class brickwork in super structure= 38.1332 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 19.6599 cu. m.
7. Mild Steel work including bending in steel reinforcement = 15.433 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 126.054 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 87.2658 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 167.91 sq. m

Embodied energy in BANK

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	15.668 cu. m.	1288.25 MJ/cu. m.	20210.06
2.	Brickwork in foundation & plinth	20.309 cu. m.	2641.75 MJ/cu. m	53651.30
3.	Damp proof course 2.5 cm thick	21.612 sq. m	2601.35 MJ/sq. m	56220.37
4.	Ist class Brickwork in super structure	38.1332 cu. m.	2641.75 MJ/cu. m	100738.38
-.	R.C.C. Work	19.659 cu. m.	3114.82 MJ/cu. m	61234.24

		15.433 quintals	--	--
7.	Flooring	87.2658 sq. m.	211.48 MJ/sq. m.	18454.97
8.	Cement Plaster in wall 12 mm. thick	194.09 sq . m.	24.12 MJ/sq. m	4681.45
			TOTAL=	315190.77 M.J.

DISPENSARY in existing C.B.R.I. neighbourhood

Here is the abstract of quantities:--

1. Earthwork in excavation in foundation= 77.6628 cu. m
2. Lime concrete in foundation = 25.8876 cu. m
3. Brickwork in foundation and plinth= 33.558 cu. m
4. Damp proof course 2.5 cm thick= 35.472 sq. m
5. First class brickwork in super structure= 68.8367 cu. m.
6. RCC work excluding steel and its bending but including centering, shuttering and binding steel = 30.5367 cu. m.
7. Mild Steel work including bending in steel reinforcement = 23.971 quintals.
8. Bitumen Isolation layer of 2 coats on roof= 198.731 sq. m.
9. Flooring 2.5 cm. C.C 1:2:4 over and including 7.5 cm. L.C. = 172.3834 sq. m.
10. Cement plaster 12 mm thick in 1:6 proportion= 375.915 sq. m

Embodied energy in DISPENSARY

Sr No.	Particular	Quantity	Embodied Energy Rate	Embodied Energy (M.J.)
1.	Lime Concrete in foundation	25.887 cu. m.	1288.25 MJ/cu. m.	33348.92
2.	Brickwork in foundation & plinth	33.558 cu. m.	2641.75 MJ/cu. m	88651.84
3.	Damp proof course 2.5 cm thick	35.472 sq. m	2601.35 MJ/sq. m	92275.08
4.	Ist class Brickwork in super structure	68.836 cu. m.	2641.75 MJ/cu. m	181847.50
5.	R.C.C. Work	30.5367 cu. m.	3114.82 MJ/cu. m	95116.32

6.	Mild steel work	23.971 quintals	--	--
7.	Flooring	172.3834 sq. m.	211.48 MJ/sq. m.	36455.55
8.	Cement Plaster in wall 12 mm. thick	375.915 sq . m.	24.12 MJ/sq. m	9067.06
			TOTAL=	536762.28 M.J.

TOTAL EMBODIED ENERGY IN C.B.R.I. NEIGHBOURHOOD (PROPOSED)

SR. NO.	BUILDING TYPE	NUMBER	NUMBER OF BLOCKS	EMBODIED ENERGY OF 1 BLOCK (M.J.)	QUANTITY (M.J.)
1.	Dwelling unit- 1 B.H.K	54	9	930129	8371107
2.	Dwelling unit- 2 B.H.K.	54	9	1856926	16712334
3.	Dwelling unit- 3 B.H.K.	54	9	2099080	18891720
	TOTAL	162			43975161
4.	Bank	1		315190	315190
5.	School	1		2481975	2481975
6.	Shops	1		568967	568967
7.	Dispensary	1		536762	536762
	TOTAL				47878055 M.J.

overt Mega Joule to Kilowatt-hours

If, 1 M.J. =0.2777 KW-hrs,

Then 52970786 M.J. = 52970786 x 0.2777 KW-hrs = 13295735.87 KW-hr

To convert Kilowatt-hours to Kilograms of CO_2

Factor for Industrial Coal = 0.32227 Kg of CO_2

So, 13295735.87 x 0.32227 = 4284816.8 Kg of CO_2 => <u>4284.816 tons of CO_2</u>

6.12 OPERATING ENERGY

Operating energy is can be as defined energy needed for heating, cooling, lighting and operating the building. Basically all the energy required for running a building.

The neighbourhood proposed has three types of house and other amenities like bank, shops etc. Operating energy for these buildings was calculated using software called 'Design builder' version 1.6.9.003.

Each building type was modeled in this software. These buildings were preconditioned like their proposed counter parts and were the simulated. The results we got gave us CO_2 release annually of each building and various other values. This helped figure out the annual CO_2 release of this neighbourhood. This value when coupled with the embodied energy gives the comprehensive energy assessment.

Dwelling unit type – 1 B.H.K.

Here are the images of simulation model for Dwelling Unit type- 1 B.H.K. showing results.

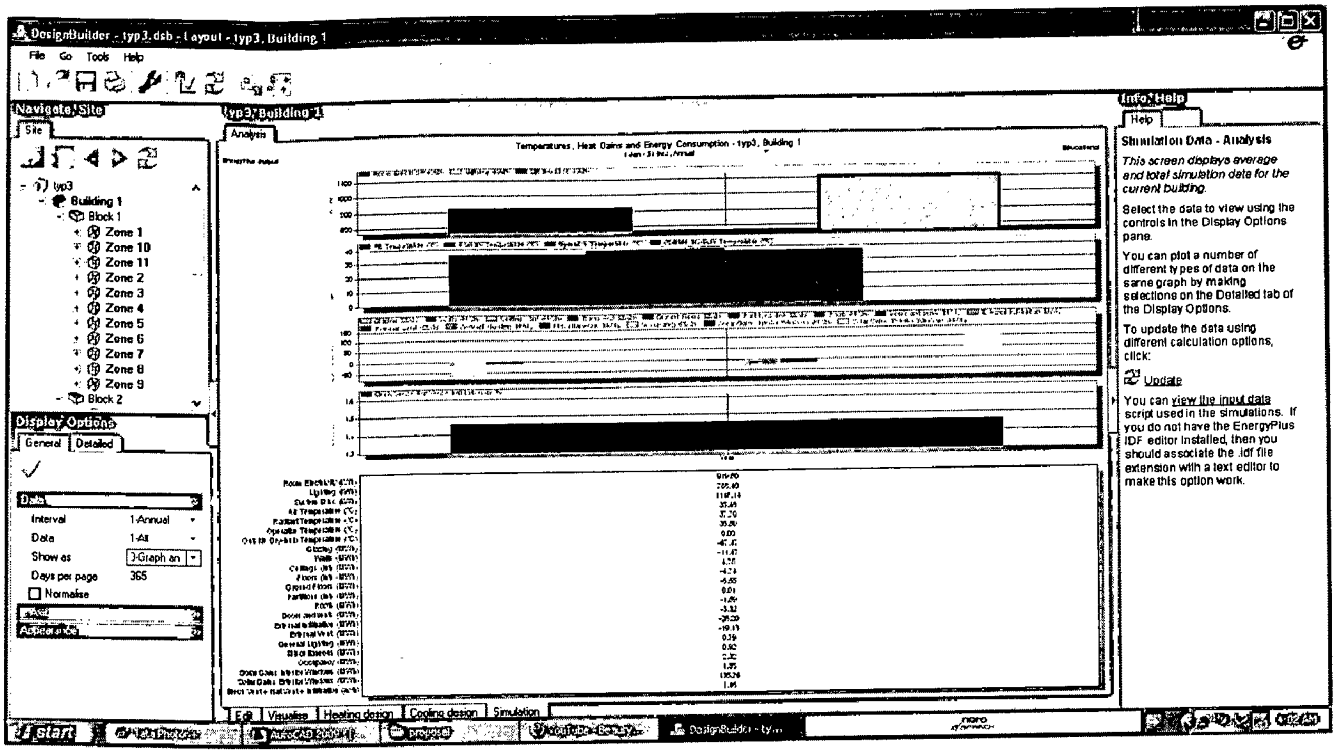


Figure 43: Showing simulation in 1 BHK

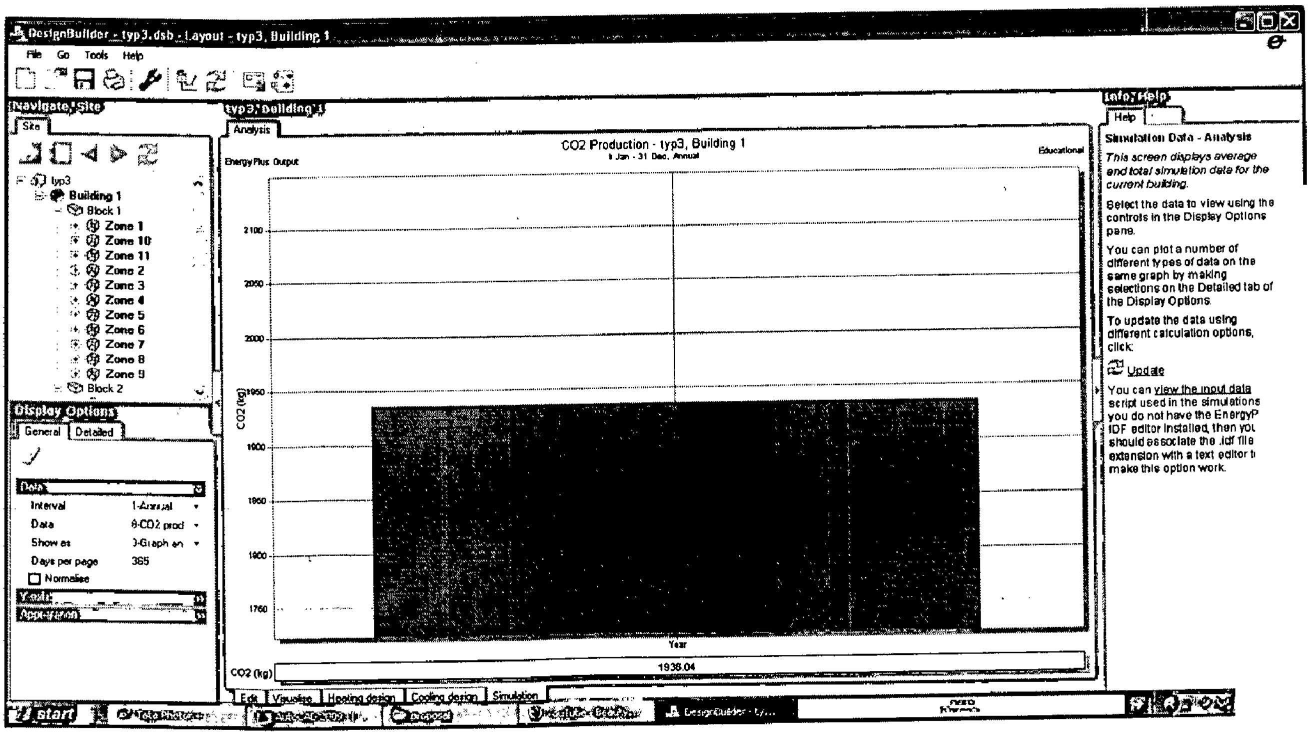


Figure 44:Showing CO2 consumption in 1 BHK

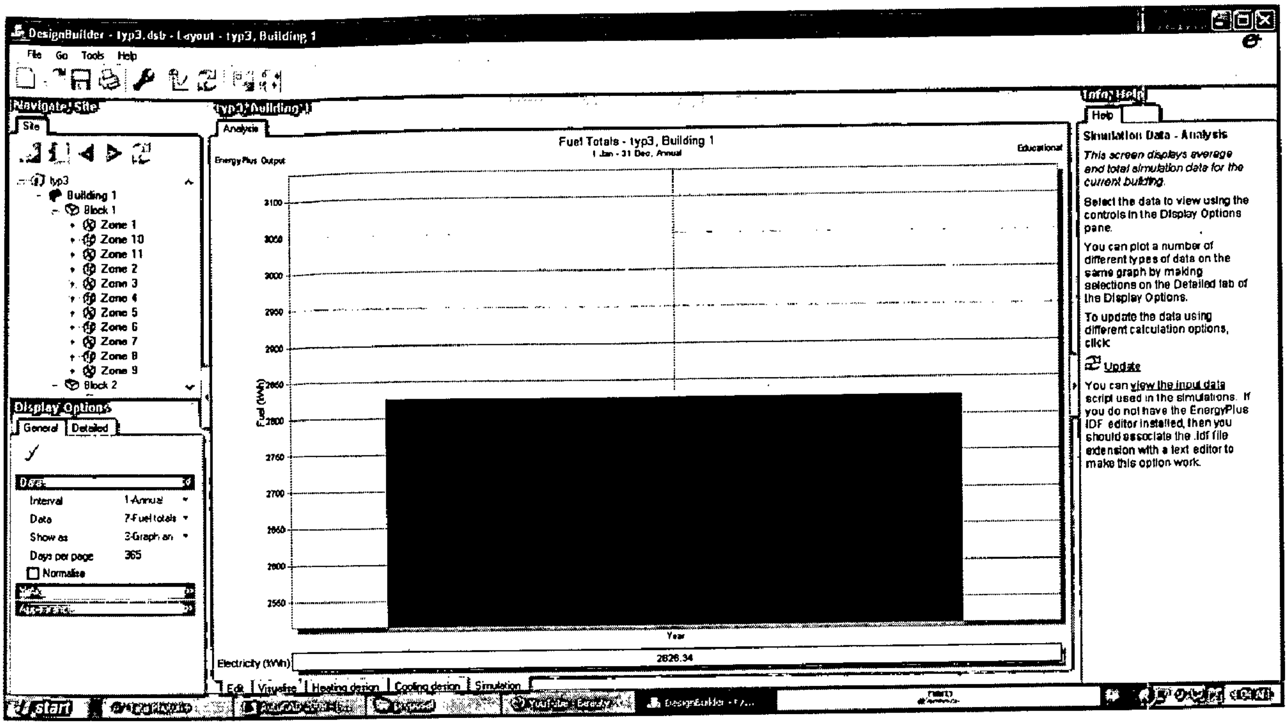


Figure 45: Showing electricity consumption in 1 BHK

Operating energy in 1 B.H.K.

Building type	NUMBER OF BLOCKS	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units type- 1 B.H.K.	1	1936	135	2826

Table 30:Operating energy in proposed 1 BHK

Dwelling unit type – 2 B.H.K.

Here are the images of simulation model for Dwelling Unit type- 2 B.H.K. showing results.

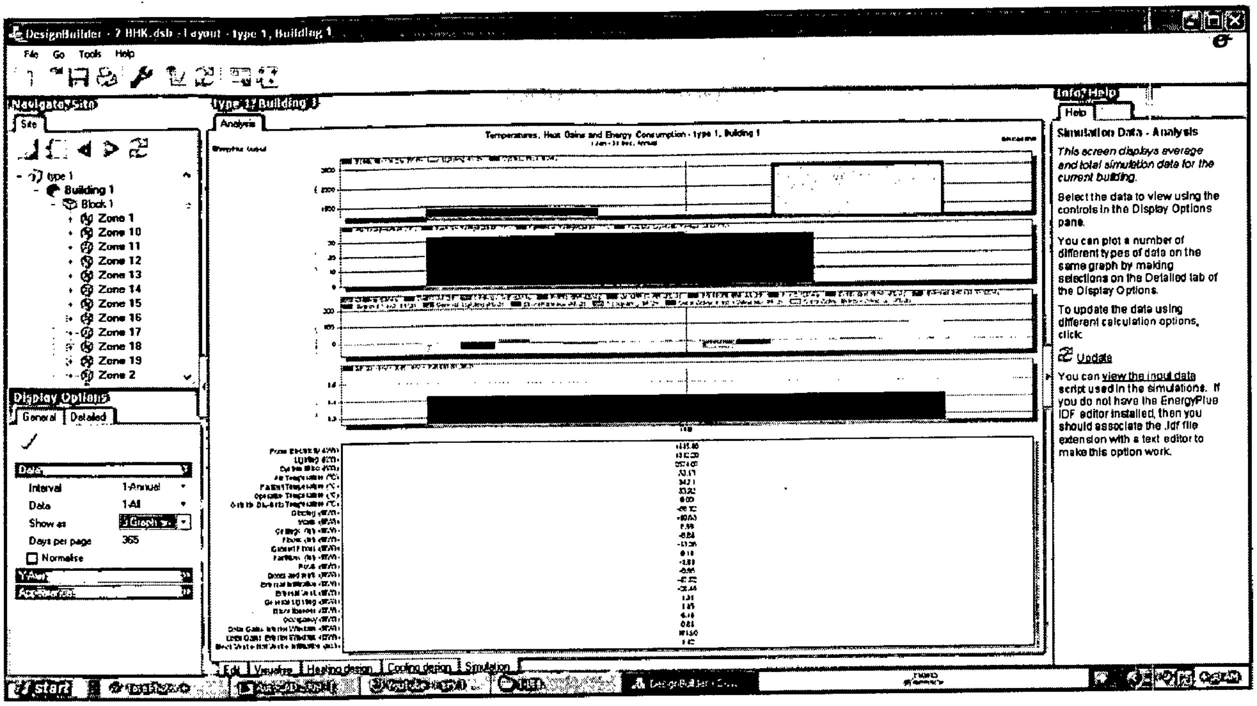
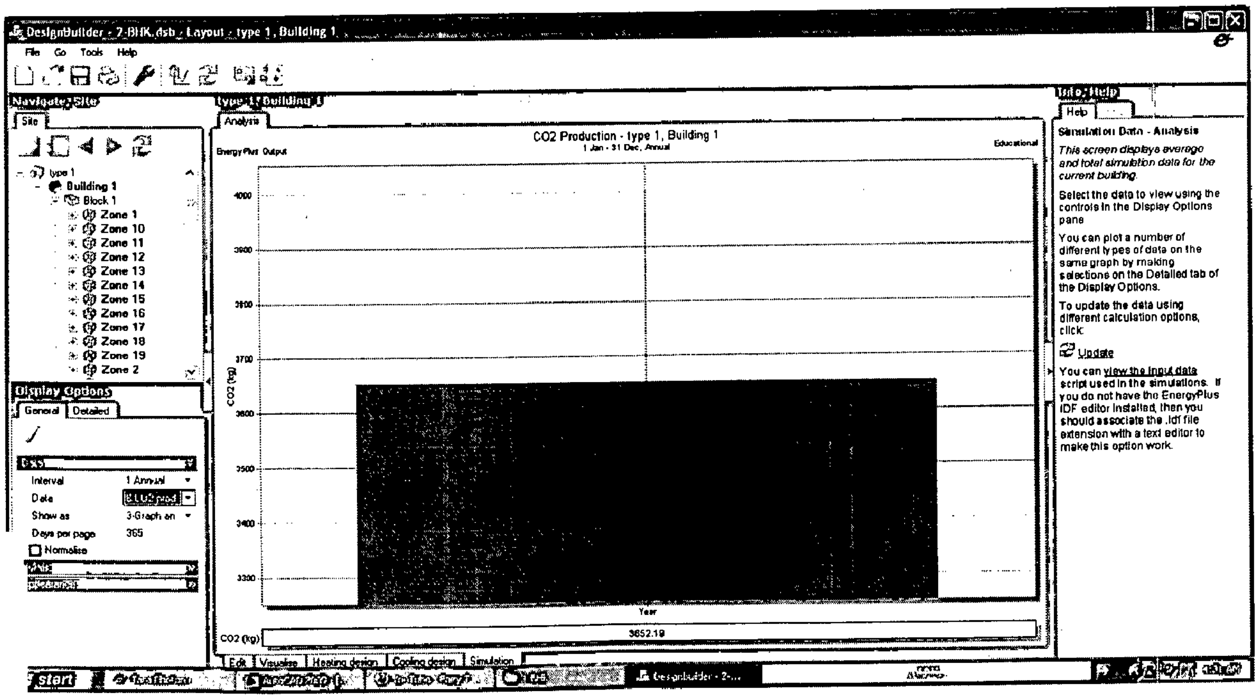


Figure 46: Showing simulation in 2 BHK



gure 47:Showing CO2 consumption in 2 BHK

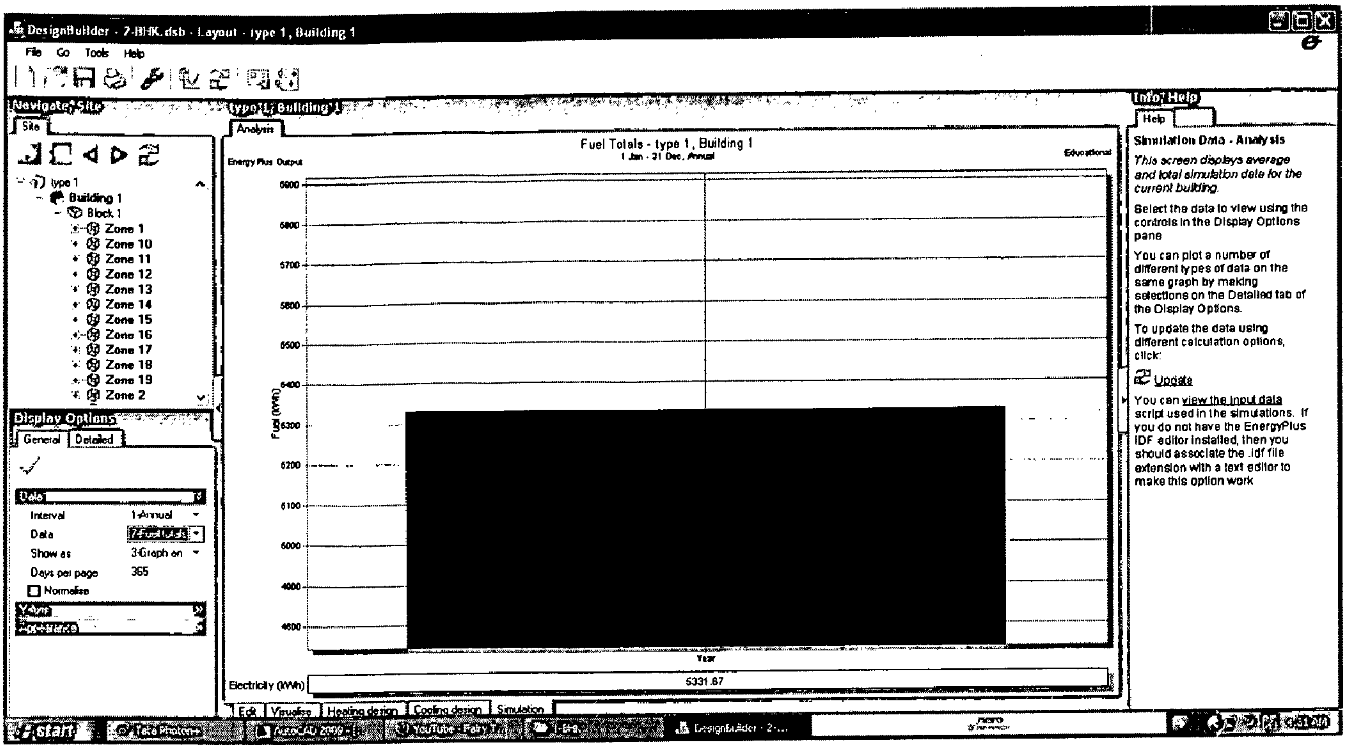


Figure 48:Showing CO2 consumption in 2 BHK

Operating energy in 2 B.H.K.

Building type	NUMBER OF BLOCKS	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units type- 2 B.H.K.	1	3652	184	5331

Table 31:Operating energy in proposed 2BHk

Dwelling unit type – 3 B.H.K.

Here are the images of simulation model for Dwelling Unit type- 3 B.H.K. showing results.

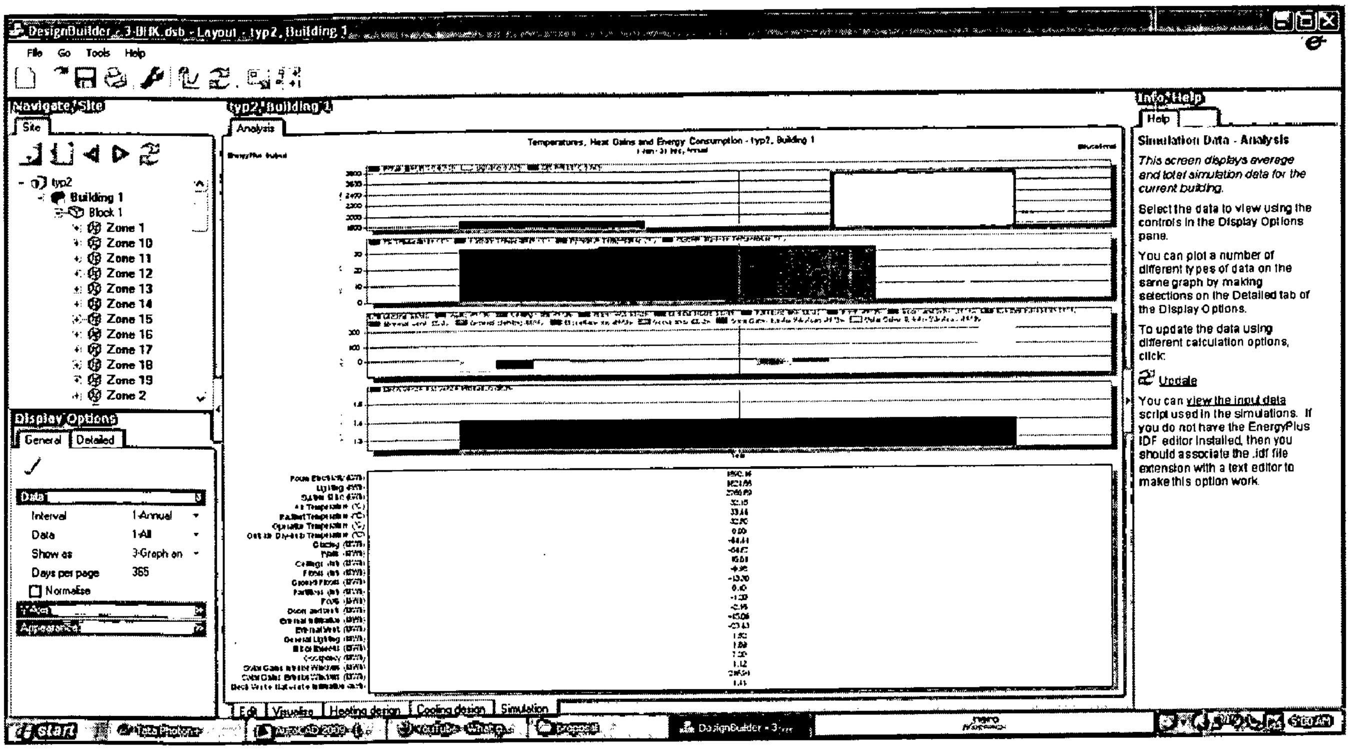


Figure 49: Showing simulation in 3 BHK

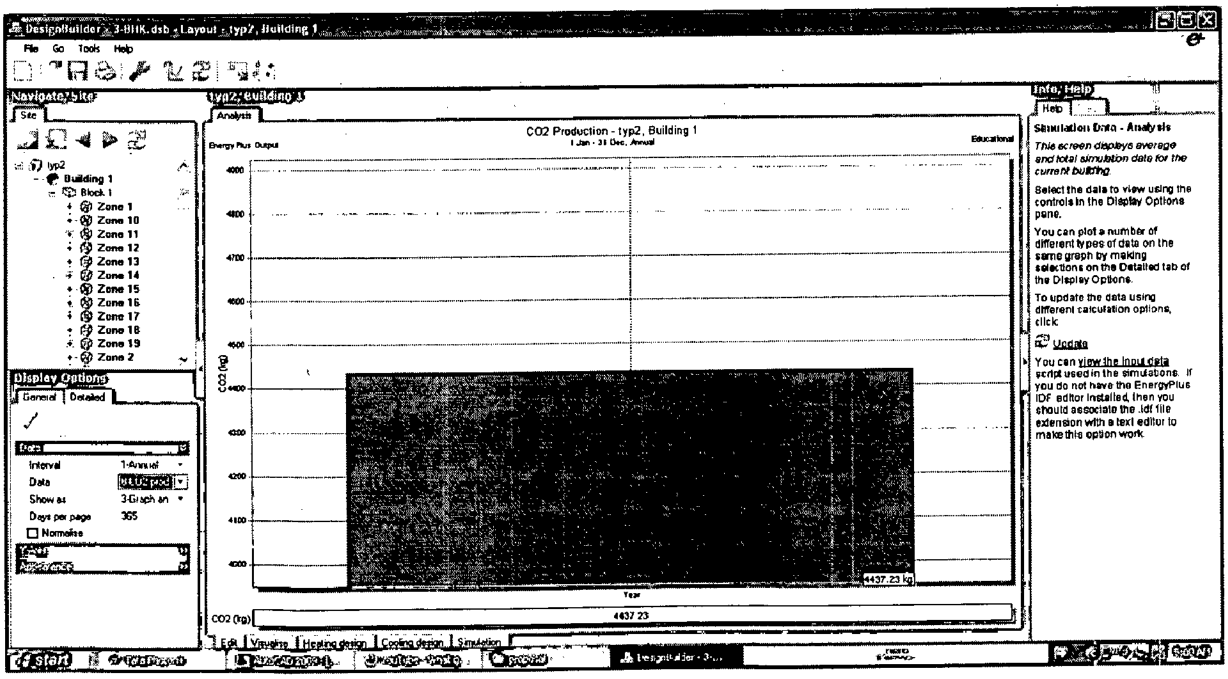


Figure 50:Showing CO2 consumption in 3 BHK

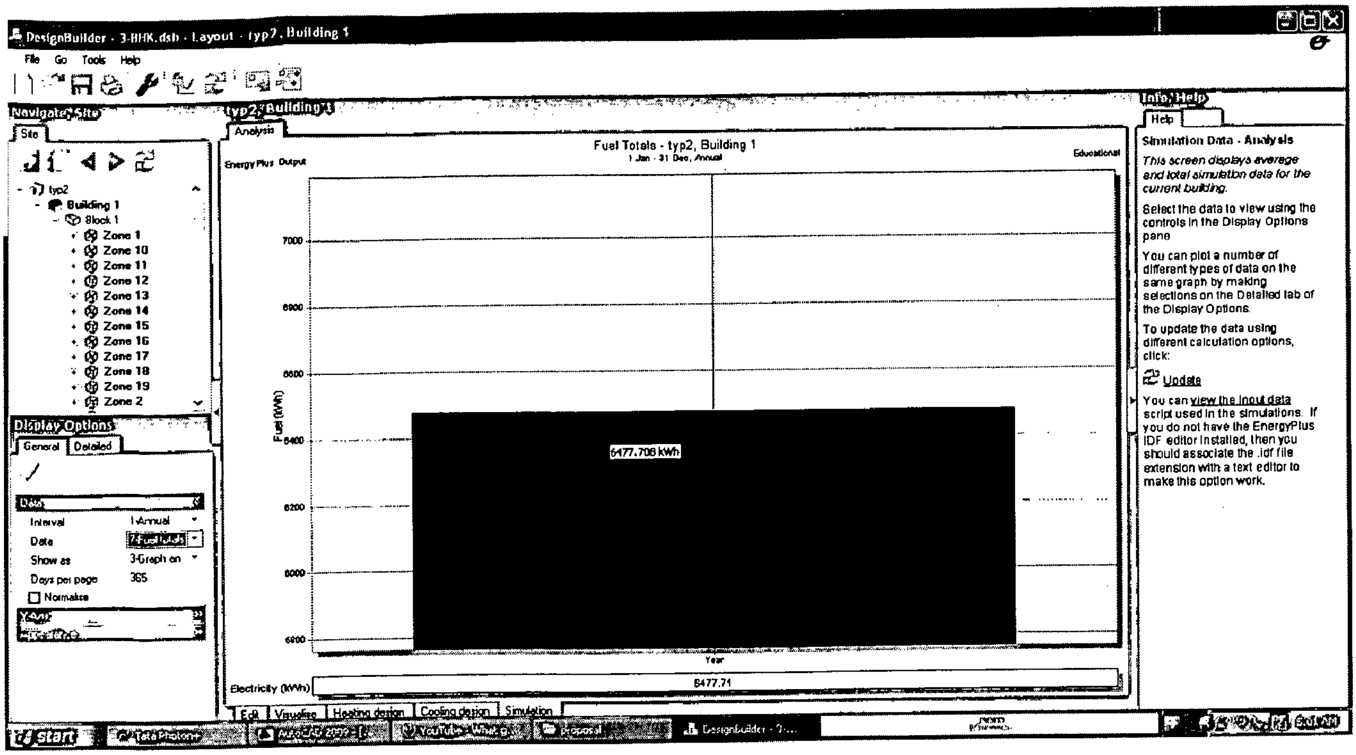


Figure 51: Showing electricity consumption in 3 BHK

Operating energy in 3 B.H.K.

Building type	NUMBER OF BLOCKS	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dwelling units type- 3 B.H.K.	1	4437	216	6477

Table 32:Operating energy in proposed 3 BHK

BANK in existing C.B.R.I. neighbourhood

Here are the images of simulation model Bank showing results.

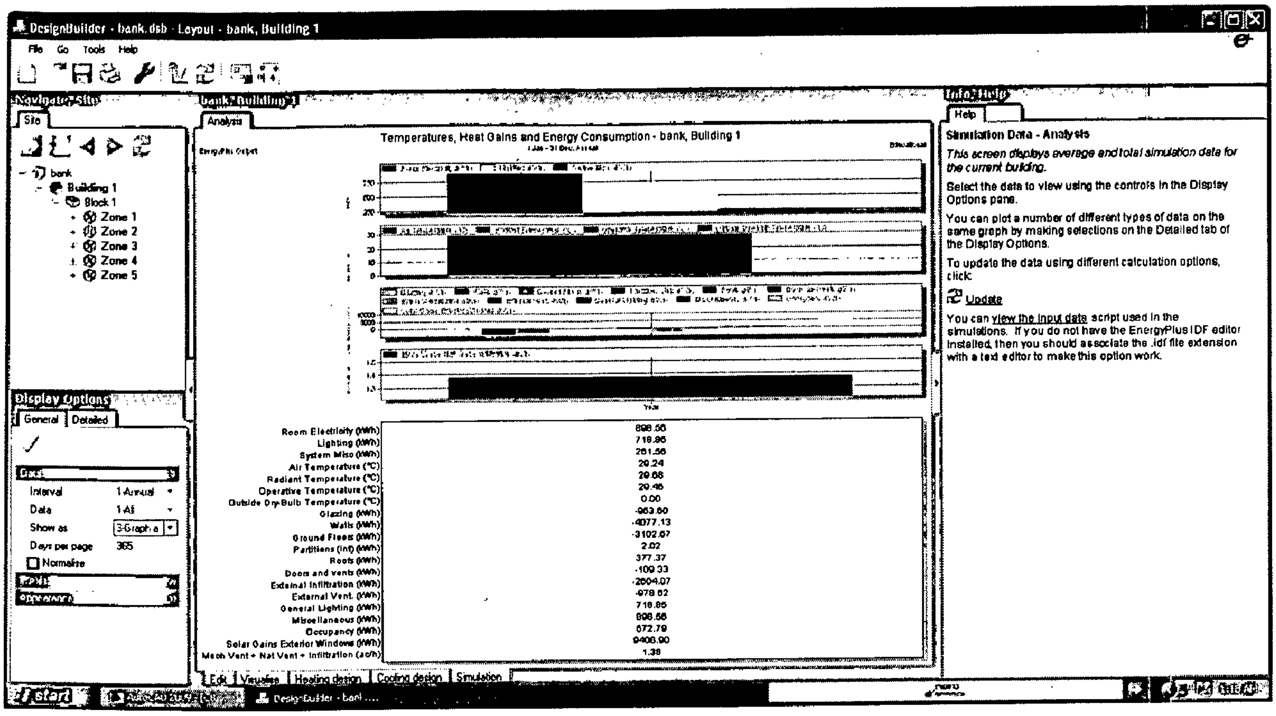


Figure 52: Showing simulation in bank

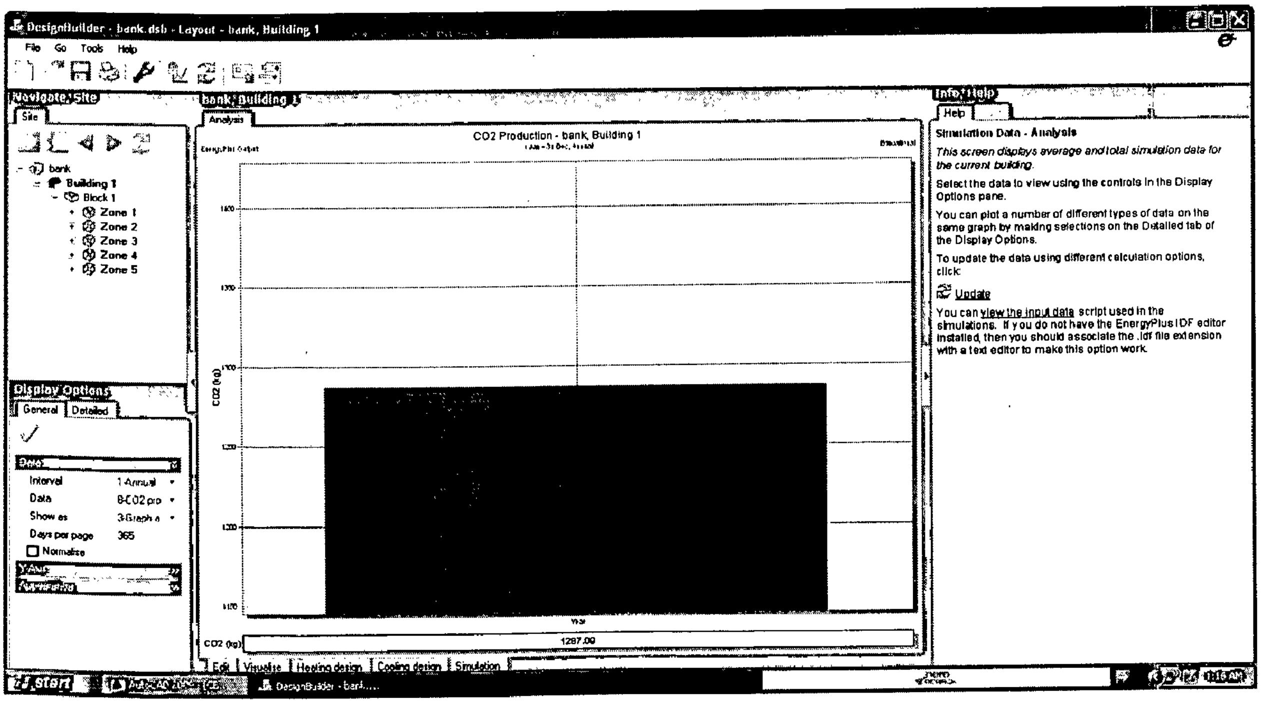


Figure 53: showing CO2 consumption in bank

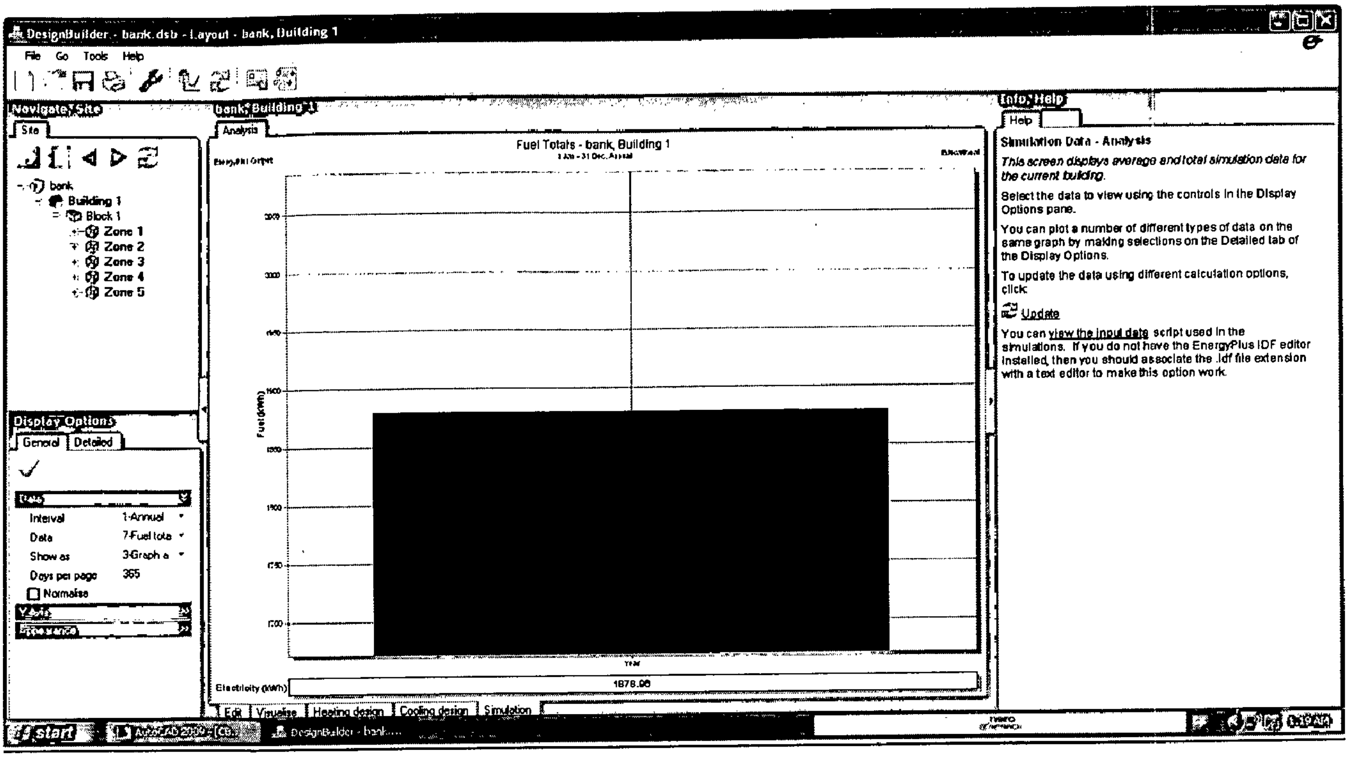


Figure 54: Showing electricity consumption in bank

Operating energy in Bank

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Bank	1287.09	9408.90	1878.96

Table 33: Operating energy in bank

SHOPS in existing C.B.R.I. neighbourhood

Here are the images of simulation model Shops showing results

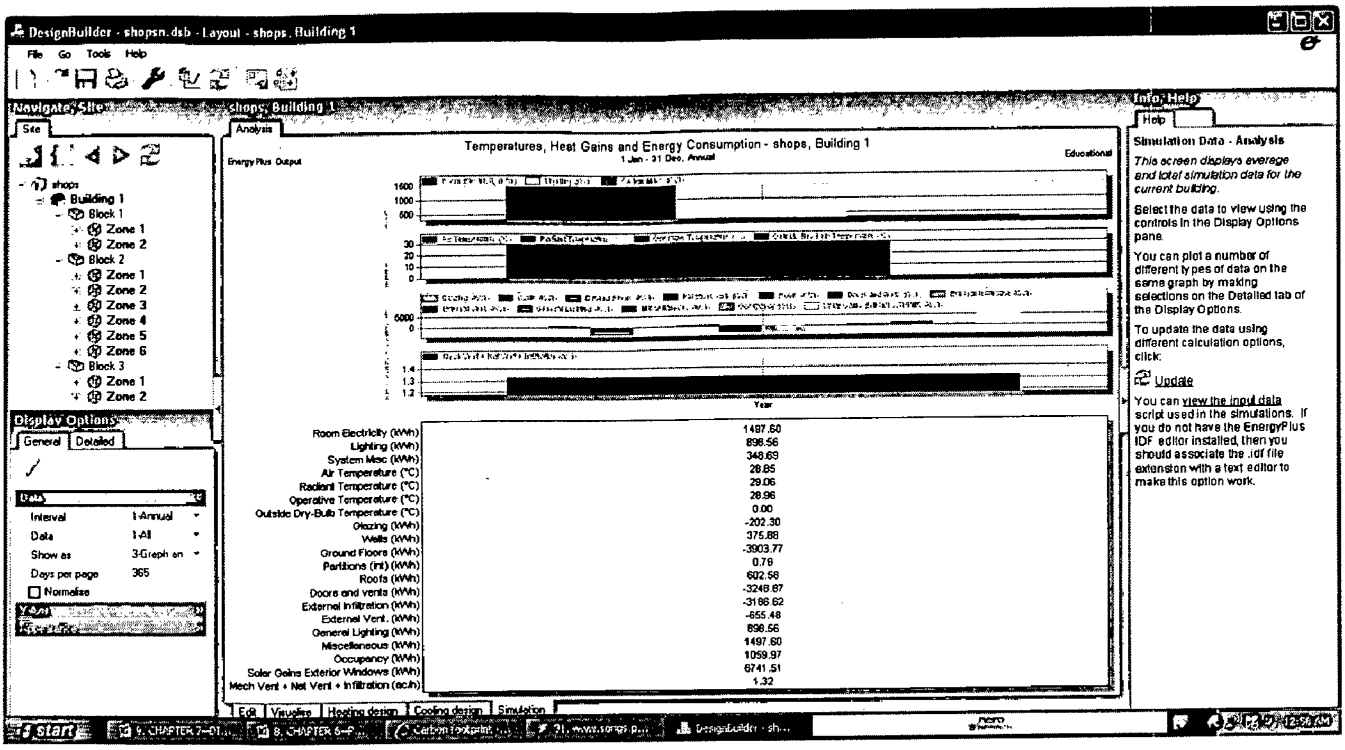


Figure 55: Showing simulation in shops

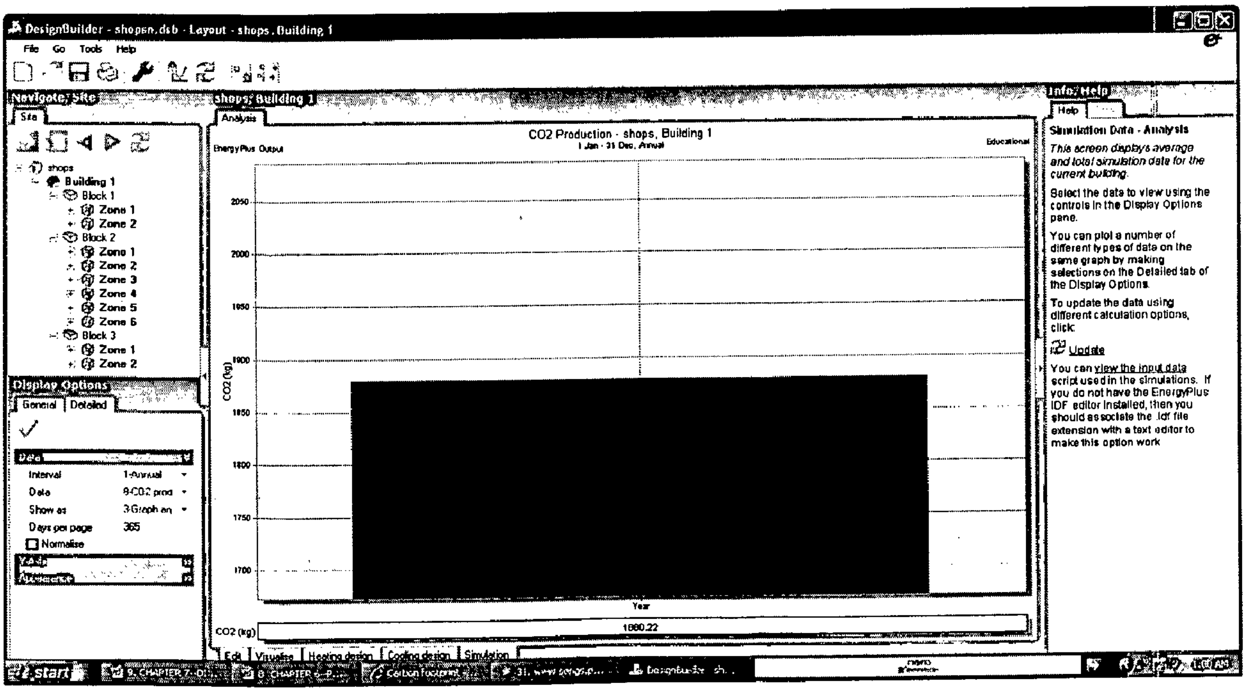


Figure 56:Showing CO2 consumption in shop

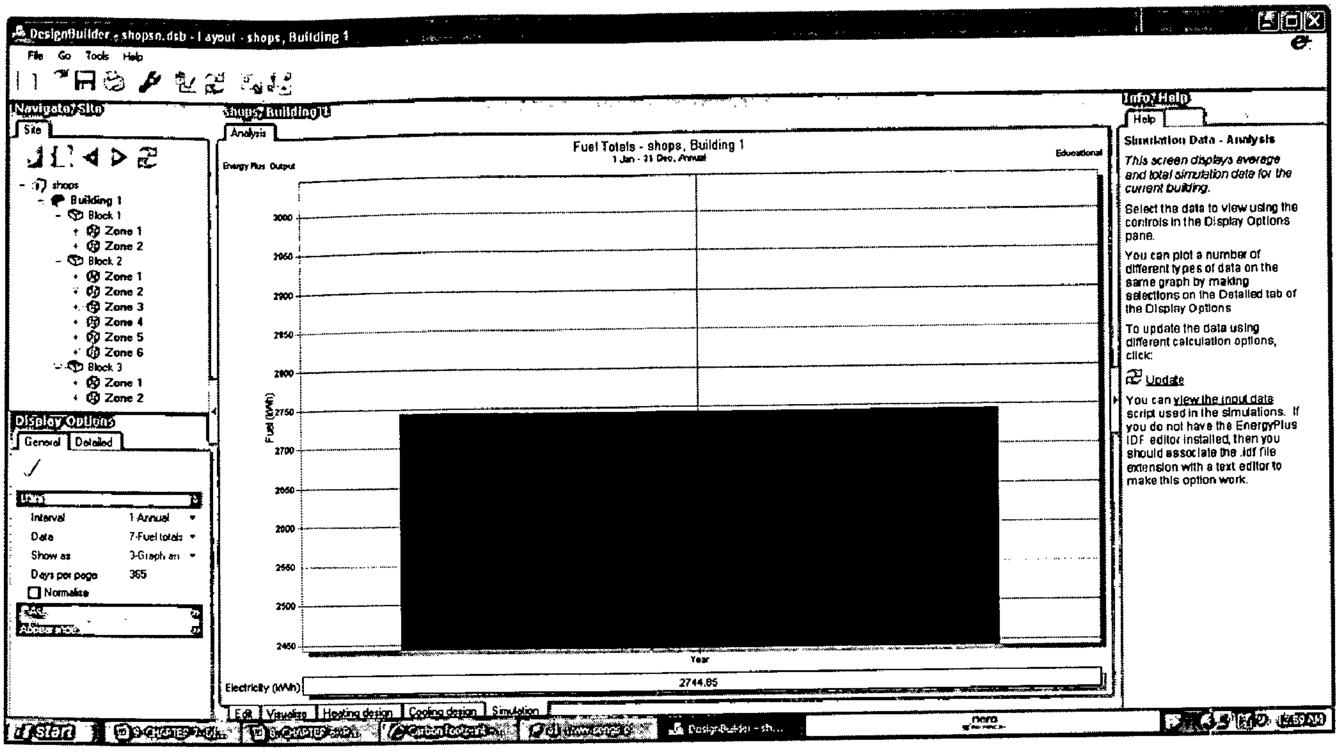


Figure 57: Showing electricity consumption in shops

Operating energy in SHOPS

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Shops	1880	6741.51	2744.85

Table 34: Operating energy in proposed shops

DISPENSARY in existing C.B.R.I. neighbourhood

Here are the images of simulation model Shops showing results.

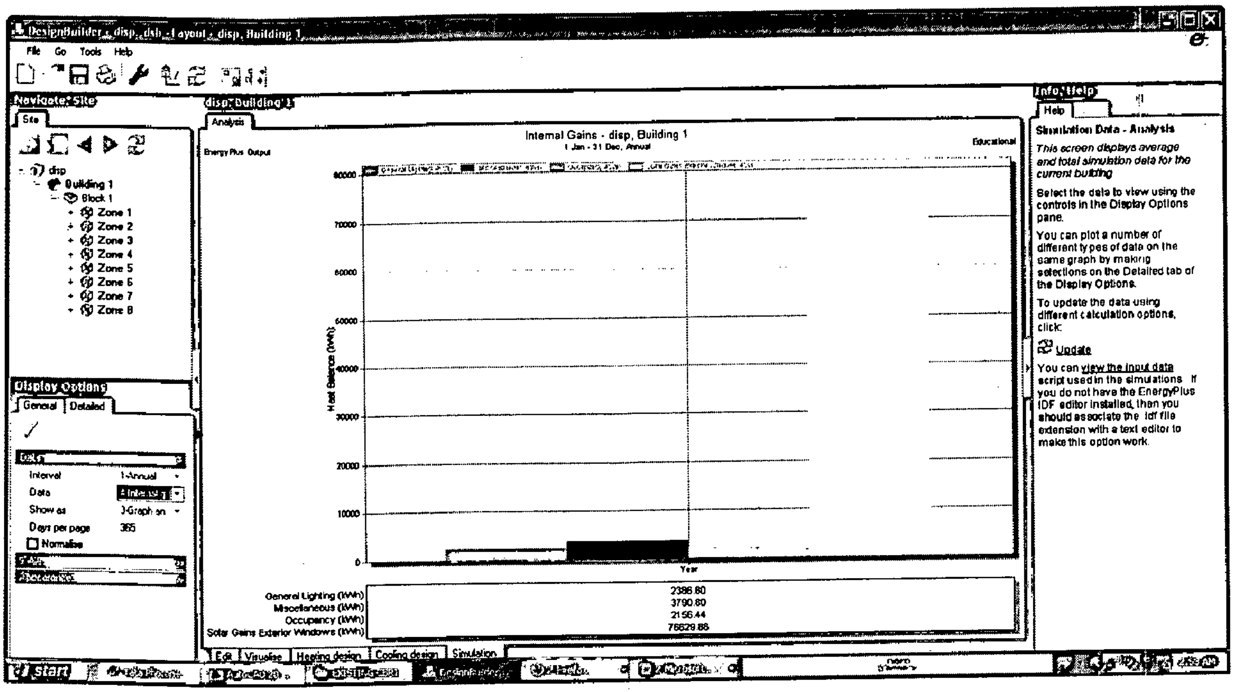


Figure 58: Showing simulation in dispensary

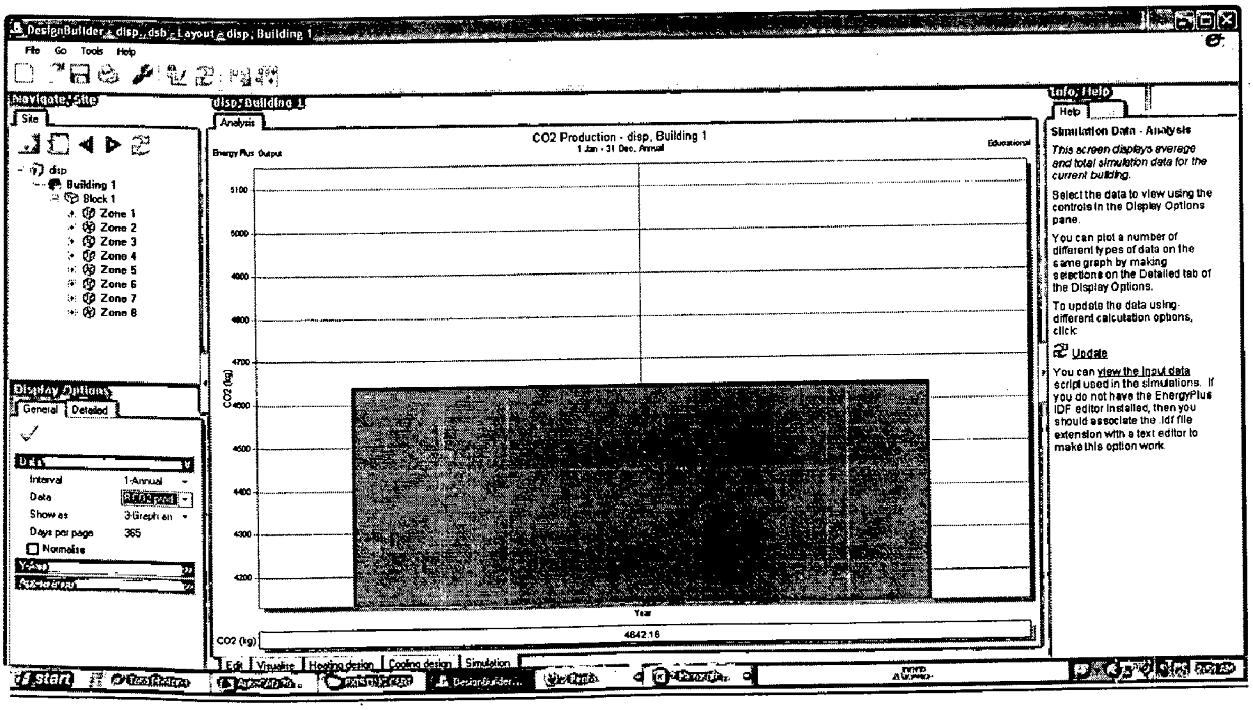


Figure 59:Showing CO2 consumption in dispensary

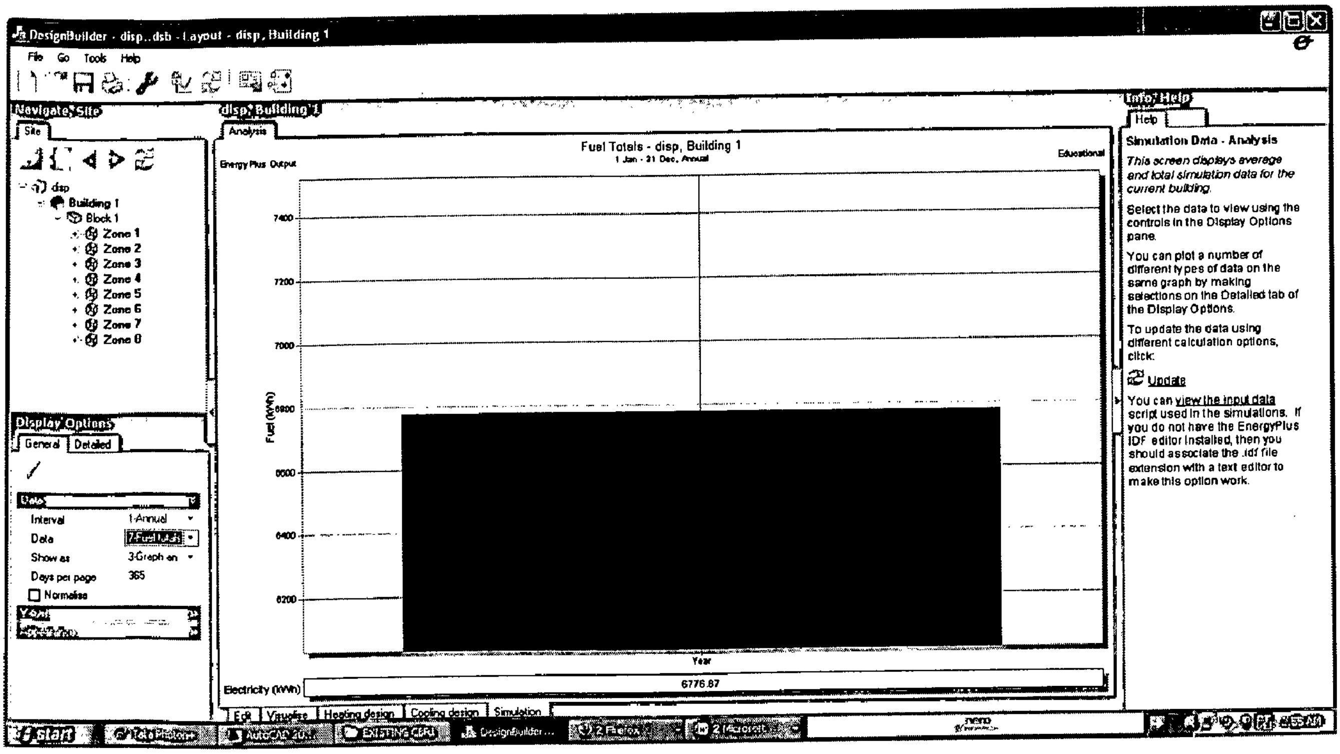


Figure 60: Showing electricity consumption in dispensary

<u>Operating energy in Dispensary</u>

Building type	Operating energy-CO_2 in kg	Solar Gain (KW h)	Electricity (KW/hr)
Dispensary	4642.16	76629	6776.87

Table 35: Operating energy in dispensary

TOTAL OPERATING ENERGY IN C.B.R.I. NEIGHBOURHOOD (PROPOSED)

BUILDING TYPE	NO. OF BLOCKS	OPERATING ENERGY (CO_2 IN KG.)	SOLAR GAINS (KW-h)	ELEC. (KW-h)	TOTAL OPERATING ENERGY (CO_2 IN KG	TOTAL SOLAR GAINS (KW-h)	TOTAL ELEC. (KW-h)
Dwelling unit-1 B.H.K.	9	1936	135	2826	17424	1215	25434
Dwelling unit-2 B.H.K.	9	3652	184	5331	32868	1656	47979
Dwelling unit-3 B.H.K.	9	4437	216	6477	39933	1944	58293
TOTAL	162 D.U.				90225	4815	131706
Bank	1	1287.09	9408.90	1878.96	1287.09	9408.90	1878.96
School	1	11150.90	337.48	16278	11150.90	337.48	16278
Shops	1	1880	6741.51	2744.85	1880	6741.51	2744.85
Dispensary	1	4642.16	76629	6776.87	4642.16	76629	6776.87
TOTAL					109185.15	97931.89	159384.68

Table 36: Total operating energy in proposed neighbourhood for CBRI

CHAPTER7: DISCUSSION OF RESULTS

7.1 INTRODUCTION

This chapter discusses the results of both the neighbourhood i.e. the existing and the proposed on the site of C.B.R.I. neighbourhood. It also brings to light the various techniques that have been used to reduce the carbon emissions in this neighbourhood.

7.2 EMBODIED ENERGY

This shows the savings in carbon emissions and embodied energy that can be made on the same site with additional dwelling units.

SR. NO.	PARTICULARS	EMBODIED ENERGY (M.J.)	CO_2 IN METRIC TONS
1.	Existing neighbourhood	52970786	4740.587
2.	Proposed neighbourhood	47878055	4284.816
	TOTAL DIFFRENCE	5092731	455.771

Table 37: Comparison of embodied energy & savings in proposed and existing neighbourhood

So, it is found that the proposal results in saving 455.771 MT of carbon vis-a-vis the existing neighbourhood, even though the proposed project has 11 more dwelling units compared to the existing neighbourhood. This happens because the houses are stacked one over the other up to G+ 2 levels. So it is seen that in each block that has 6 dwelling units the foundation calculation comes out only for two in the ground floor. And the house on first floor and second floor end up relying on that itself.

SAVINGS IN EACH DWELLING UNIT ON FIRST & SECOND FLOORS:--

- 1 B.H.K 96297 M.J.
- 2 B.H.K. 196000 M.J.
- 3 B.H.K. 215533 M.J.

7.3 OPERATING ENERGY

This shows the savings in carbon emissions that can be made on the same site with more dwelling units in operating energy.

SR. NO.	PARTICULARS	CO_2 IN METRIC TONS ANNUALLY	TOTAL SOLAR GAINS ANNUALLY (KW-h)	TOTAL ELECRICITY CONSUMPTION ANNUALLY (KW/h)
1.	Existing neighbourhood	234.45675	8695583.4	325104.68
2.	Proposed neighbourhood	109.18515	97931.89	159384.68
	TOTAL DIFFRENCE	125.2716	8597651.51	165720.00

Table 38: Comparison of operating energy in existing and proposed neighbourhood

It is found that due to stacking of houses one over other result in lesser solar gains. This happens because the direct intake of heat from roof in this is affecting only top two dwelling units and the lower floors have indirect or diffused effect of solar heat gains from roof. But it is also suggested that house should not go beyond this because then they lose out on the shading effect of the trees, which may result in increase of solar heat gain from walls. It will result in more usage of electricity to nullify the effect of solar radiation in summers and more usage of electricity for heating dwelling units in winters as trees will not be there at that height to act as a barrier for cool winds.

7.4 SOLAR PANELS

It has been found by simulation modeling of the proposed house that the amount of electricity needed by this neighbourhood is 159424 KW/hr annually. This need has been fulfilled by providing solar panels so that this much load could be lifted off the grid.

Specifications: --

- Size of the panel=1m x 1m

- For 8 hours a day

- It can produce 100 W/sq. m. of electricity

- Efficiency varies from 5% to 20%

Solution: --

One panel in one day can produce= 100 W/sq. m. x 8 =800 W/ sq. m.

If efficiency is 10% then = 10/ 100 x 800= 80 W/sq. m. for each panel a day.

So annually one panel can produce=80 x 365=29200W/sq. m.

But, we have the annual requirement of energy= 159424KW/hr=159424000W/hr

So number of panels needed are= 159424000/29200=5459.7 ~ 5500 panels

These panels have been provided to generate electricity for the neighbourhood.

7.5 CARBON SINK

A carbon sink created on this site has 3300 deciduous tree

There diameter ranges from 3m to 6m.

One tree can absorb 2.6 tons of carbon every year.

Then, 3300 x 2.6 tons = 8580 M.T. of CO_2

This carbon sink can absorb 8580 tons of carbon-dioxide annually, i.e. 8.580×10^6 kg of CO_2.

Also these carbon sinks can be mangroves or orchards, this way it can bring monetary gains to the inhabitant/managers/local bodies of this neighbourhood. The money which will be raised from this carbon sink and area for local food can be used for improvement and maintenance of neighbourhood and solar panels.

7.6 AREA FOR LOCAL FOOD PRODUCTION

Instead of providing small individual kitchen gardens, this neighbourhood is provided with two farms of a considerable size of 9829.379 sq. m. and 11660.566 sq. m. these farms can be leased out annually or seasonally by the local governing bodies.

As it is found that most of the plant species that do photosynthesis convert or break down some amount of CO_2 in the process.

Some carbon fixing food crops are maize, sugar cane, millet, and sorghum. Sugar cane is best suited in this case because the site falls in the most sugar cane yielding regions of north India.

7.7 GREEN ROOF

A **green roof** is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane.

All the roofs are provided with green roof so that it reduces the carbon footprint of all the buildings.

7.8 LANDSCAPING

It is suggested that even the plants that are going to be used for landscaping should fall into the category of that help in carbon fixation.

Some suggested plants are The Asteraceae or Compositae, also referred to as the aster, daisy, or sunflower family. Many members of the family are grown as ornamental plants for their flowers and some are important ornamental crops for the cut flower industry. Some examples are *Chrysanthemum, Gerbera, Calendula, Dendranthema, Argyranthemum, Dahlia, Tagetes, Zinnia* and many others.

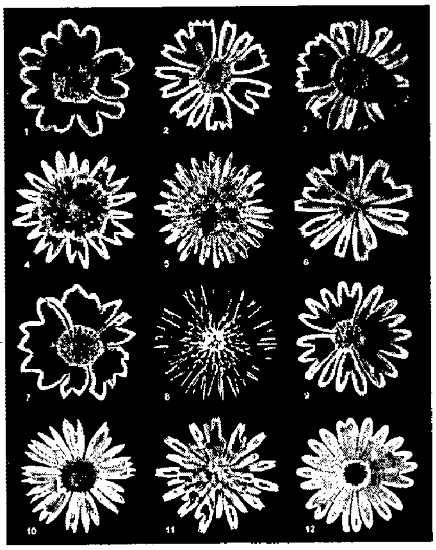


Figure 61: Flowerings plants which do the process of carbon fixation

.AINING OF CO_2 IN THE SUBSTRATA OF EARTH

If solar panels are used for the generation of electricity then it means that we are reducing the load from thermal power plant. This will cause reduction extraction of coal from substrata of earth. Thus helping us retain carbon in natural form deep inside the earth and preventing i from being released to the environment.
Sources conflict on the number of pounds of coal to create 1 kWh of electricity:

- Dept. of Energy: 2.1 lbs.
- Arizona Public Service Company: 1.1 lbs.
- CoalEducation.org: 0.8 lbs

1 pound = 0.45359237 kilograms

- Dept. of Energy =2.1 X 0.45359237=0.952543977 KG
- Arizona Public Service Company =1.1 X 0.45359237=0.498951607 KG
- CoalEducation.org =0.8 X 0.45359237=0.362873896 KG

So, usage of solar panels in new proposal will result in saving of coal and retaining it in substrata of earth as well. This figure will come out to be following as per various institutions

- Dept. of Energy =0.952543977 KG x 159384.68=151820.917 kg annually
- Arizona Public Service Company =0.498951607 KG x 159384.68= 79525.242 kg annual
- CoalEducation.org=0.362873896 KG x 159384.68= 57836.539 kg annually

7.10 PEDETRIAN / CYCLING PATHS

The design of the neighbourhood is such that it encourages the user to walk or cycle through the neighbourhood. All the internal links are provided specially through pedestrian paths / cycling tracks. These are lined with trees on either sides of the road thus encouraging the user to walk from one place to other instead of use of a vehicle. Also it can be noted that some distances come out to be closer if travelled on foot instead of using a vehicle. This is because vehicular movement is on the periphery of the neighbourhood providing longer travel distances.

'.11 LEED CRITERIA

'he proposal on the same site has been proposed, with an objective of reducing the carbon elease. This proposal tries to incorporate the LEED criteria for the low carbon neighbourhood.

MART LOCATION & LINKAGE

1: Smart location--The chosen site was the closest to the work place of the residents in this articular case.

2: Imperiled Species and Ecological Communities--The large open and green areas provide nough space for flora and fauna to flourish.

C 1: Preferred Location--Due to close proximity to the work place of the residents living in this area.

C 3: Location with reduced automobile Dependence--This is because; again the workplace, the school, and other amenities are nearby and are well connected through the pedestrian path.

C 4: Bicycle Network and Storage--This neighbourhood has pedestrian and cycle paths which connect the whole neighbourhood, i.e. the residential, commercial and institutional zones.

C 5: Housing and job proximity--Since this neighbourhood is closer to workplace of the users of this neighbourhood i.e. the employees of C.B.R.I. it matches this parameter.

NEIGHBOURHOOD PATTERN & DESIGN

P 1: Walkable Streets--All the streets in this neighbourhood are provided with 1.5 m wide side walk on the either sides.

P 2: Compact Development--The whole layout for this neighbourhood is on a grid-iron pattern. This prevents the wastage of space resulting in a compact development.

P 3: Connected and Open Community--The neighbourhood has been connected to its various parts using pedestrian paths. Open green areas around the house provide an open community for people of various age groups to interact.

C 3: Mixed Use Neighbourhood Center--This neighbourhood has a mixed use neighbourhood center which supports a school, a bank, a dispensary and shops.

C 4: Mixed-Income Diverse Community--It is a mixed income diverse community because i provides residences for the employees of C.B.R.I., which has a range of various income groups.

C 9: Access to civic and public spaces--There is an easy access to all the civic and public spaces through streets and pedestrian paths.

C 10: Access to recreational spaces.--It is provided through the streets and pedestrians.

C 11: Visibility and Universal design--There is enough visibility of open spaces and streetscapes from the house and vice-versa thus providing a holistic view. Also the design is such that it can be used on some other site with similar climatic and topographical conditions with suitable changes.

C 12: Community outreach and Involvement--There is a provision for a central plaza in the market place which can be developed further for holding public forums and space for discussions. Also the placement of the park is centrally located such that it is equidistant from all the residential units. This acts as a space for children to play, youngsters to recreate and adults to interact.

C 13: Local food Production--The area for local food production has been marked out. These sites can be leased out on a seasonal basis or on annual basis and either the profit or the yield can be shared by the residents.

C 14: Tree lined and shaded streets--The neighbourhood has been provided with streets and path which have been lined with trees on both the side.

C 15: Neighbourhood School--There is a school provided in the central part of the neighbourhood so that the children don't have to cross any major streets in reaching the destination.

CHAPTER8: CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

This chapter helps us conclude this study on 'Low Carbon design for a neighbourhood in north India'. Also it brings to light some recommendations while executing this study.

8.2 CONCLUSIONS

Following things can be concluded from this study:

- Stacking of dwelling units reduced the embodied energy because of savings in foundation work.
- Stacking of dwelling units also reduces over all operational energy of a neighbourhood because of reduction in the solar heat gains.
- Carbon sink in a neighbourhood will absorb the carbon-dioxide into the environment, at the same time it can generate revenue for the maintenance of neighbourhood and also this can also be used in carbon trade-offs by creating tie-ups with local industry.
- Solar panels will reduce the load on the grid. Also it will help in retaining some amount of carbon in its natural state in the substrata of the earth.
- Pedestrian path interconnectivity helps in safety of the users of neighbourhood and also encourages pedestrian movement resulting in reduction of usage of vehicles preventing burning of fossil fuel.

8.3 RECOMMENDATIONS

Following things are recommended while executing the study on any other site:--

- Using the templates of site on which the building is proposed.
- Orientation of buildings should be done keeping in mind the wind directions to reduce electric loads.
- It is recommended that stacking should not go beyond 3 storey because then the shading effect of trees is loses its effect for upper storeys.

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APPENDIX-I

Questionnaire for the user of housing colony

Name of the resident: ______________________________

Address: ______________________________

1. Amount of electricity used in a household

    1. Number of fans
        - 0-5
        - 6-10
        - 10-15
        - Any other specific number__________
    2. Number of lamps: --- incandescent
        - 0-5
        - 6-10
        - 10-15
        - Any other specific number__________

          ---Fluorescent
        - 0-5
        - 6-10
        - 10-15
        - Any other specific number__________

    3. Laptops
        - No
        - Yes: (no.)____________

    4. Computers
        - No
        - Yes: (no.)____________

    5. Kitchen appliances:

        I) Mixer/juicer
        - No
        - Yes

        II) Food processor

- No
- Yes

III) Dish washer

- No
- Yes

IV) Microwave

- No
- Yes

V) Oven/grill

- No
- Yes

VI) Toaster

- No
- Yes

VII) Refrigerator

- No
- Yes: (no.)________________

VIII) Exhaust fan

- No
- Yes

IX) Electric chimney

- No
- Yes

x) Electric kettle

- No
- Yes

xi) Coffee maker

- No
- Yes

6. Air conditioner
    - No
    - Yes: (no.)________________

7. Air Coolers
    - No
    - Yes: (no.)________________

8. Geysers
    - No
    - Yes: (no.)________________

9. Hair dryers
    - No
    - Yes

10. Room heaters
    - No
    - Yes: (no.)________________

11. Washing machine
    - No
    - Yes

12. Vacuum cleaner
    - No
    - yes

13. Mobile phone charger
    - No
    - Yes: (no.)________________

14. DVD /CD player
    - No
    - Yes

15. TV
    - No
    - Yes

Type	Number
# Picture tube type	

#Liquid crystal diode	
#Plasma screen	
#Any other type	

16. Inverter
    - No
    - Yes: (no.)________________

17.electric iron: yes no

2. Average Water bill paid in the terms of INR per month
    - 0-50
    - 51-100
    - 100-150
    - Any specific amount-___________

3. Members in the dwelling unit:

Name	Occupation	Place of work	Means of transportation

4. Number of vehicles in a house hold
    - 1
    - 2
    - 3
    - 4
    - Any other number--_____________________

Type	Number	Fuel used : petrol/diesel/CNG	Average

• Two wheeler			

Type	Number	Fuel used : petrol/diesel/CNG	Average
• Four wheeler			

5. Number of LPG cylinders used in a household
   - 1
   - 2
   - 3
   - Any other number--____________

7. Living Pattern:-

1. fire place
   - no
   - yes

2. number of cigarette smokers in a dwelling unit
   - 1
   - 2
   - 3
   - Any other (no.)--__________

3. Number of cigarettes smoked per day
   - 0-5
   - 6-10
   - 10-15
   - Any other number--__________

4. Number of match boxes used per month
   - 0-5
   - 6-10
   - 10-15

- Any other number--__________

5. Number of incense/fragrance stick boxes used per month
    - 1
    - 2
    - 3
    - Any other number--__________

6. burning of lamp in household temple(hydrocarbon)

Number of lamps	Time duration for which they are burnt(hrs.)	Fuel used: mustard oil/ghee/ any other

7. water purifier
    - no
    - yes
    - type:______________________________

Any other alternate source of energy (if any)

SITE PLAN

C.B.R.I. NEIGHBOUHOOD--PROPOSED

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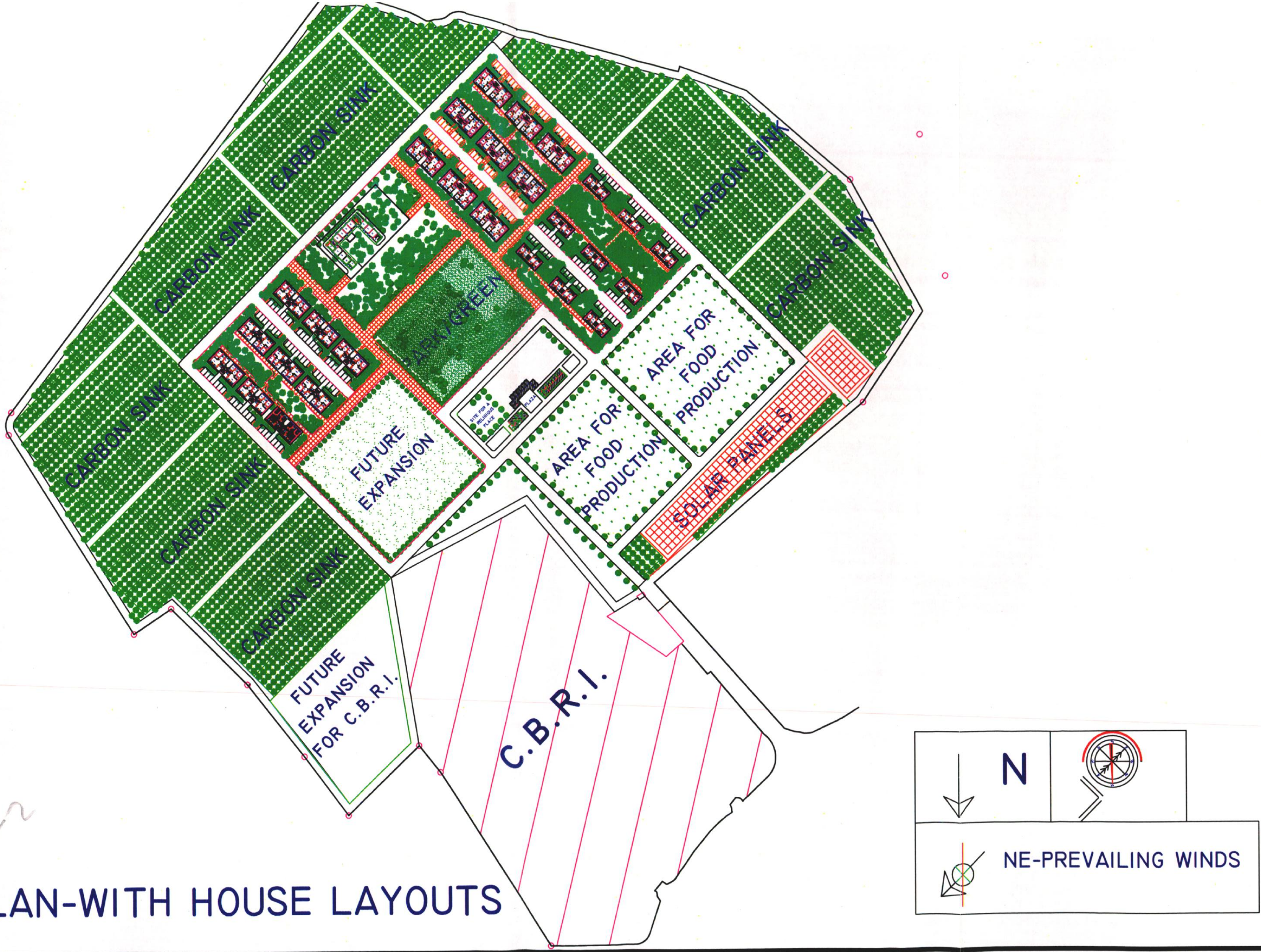
DIVYANSHI CHOPRA
09510003
M.ARCHITECTURE
ARCHITECTURAL DESIGN



SITE PLAN-WITH HOUSE LAYOUTS

C R R I NEIGHBOUHOOD--PROPOSED

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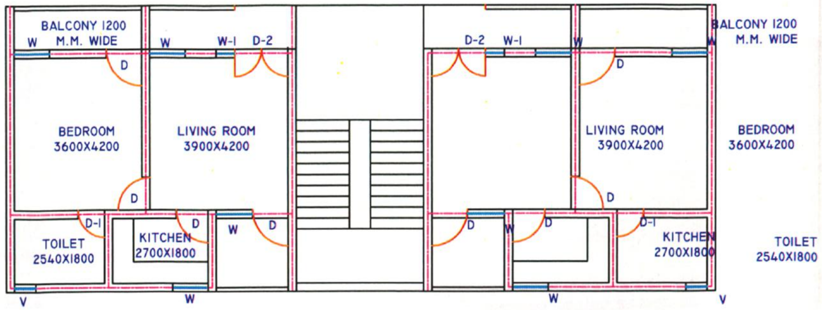
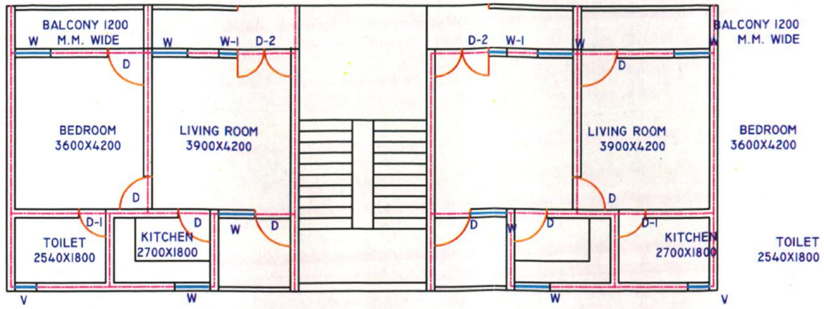
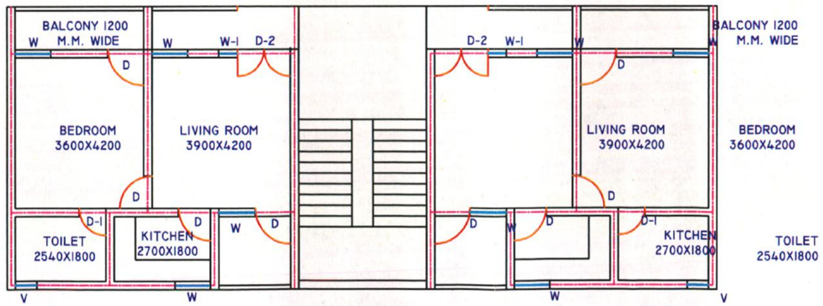


I B.H.K-- GROUND FLOOR PLAN



I B.H.K-- SECOND FLOOR PLAN



I B.H.K-- FIRST FLOOR PLAN

OPENNING SCHEDULE

	PARTICULAR	SYMBOL	SILL	LINTEL	NUMBER	SIZE		
1.	DOOR	D	0	2100	4	900X2100	1.89	D
2	DOOR	D-1	0	2100	1	750X2100	1.575	D-1
3	DOOR	D-2	0	2100	1	1500X2100	3.15	D-2
6	window	W	900	2100	4	1000X1200	1.2	W
7	window	W-1	900	2100	1	530X1200	0.636	W-1
12	Ventilator	V-1	2100	2700	1	1000X600	.6	V-1

C.B.R.I. NEIGHBOUHOOD--PROPOSED

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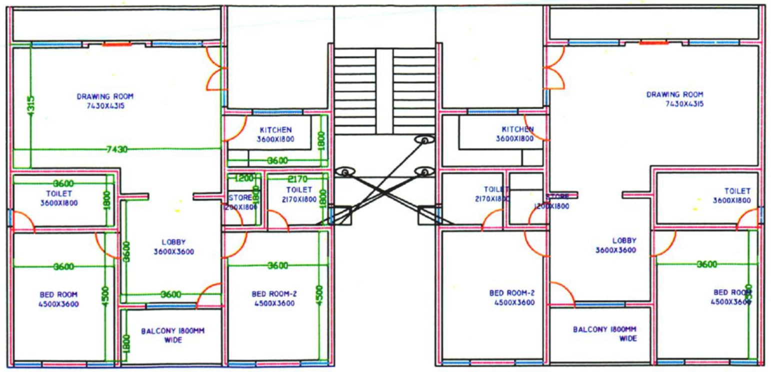
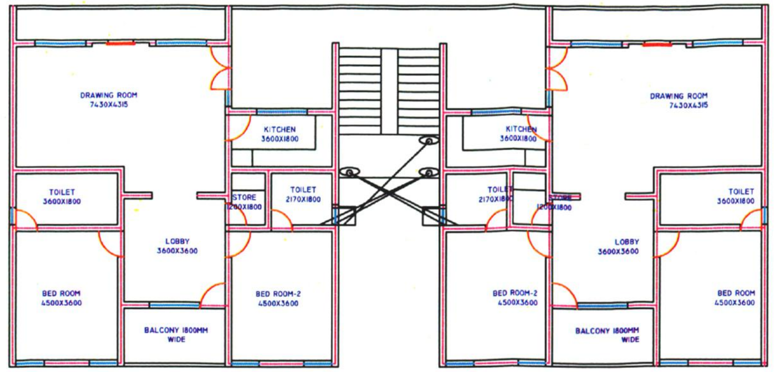
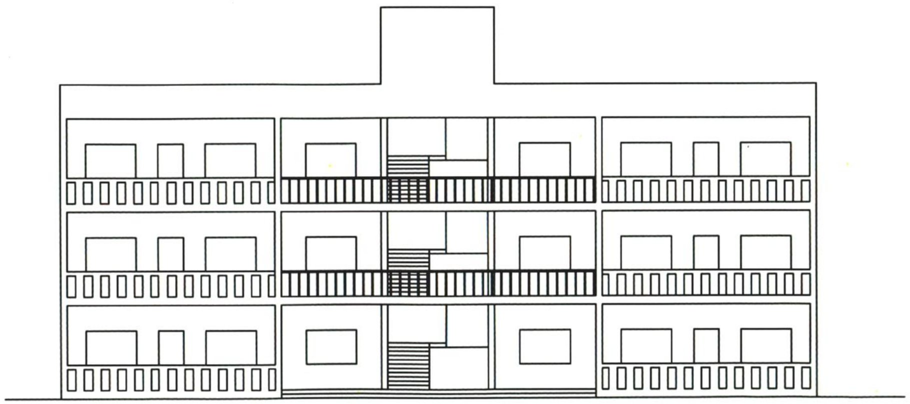
N.E. FACADE



2 B.H.K-- GROUND FLOOR PLAN



2 B.H.K-- SECOND FLOOR PLAN



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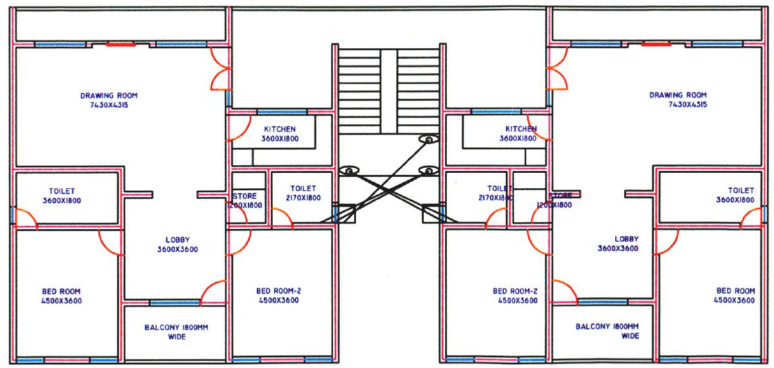

2 B.H.K-- FIRST FLOOR PLAN

OPENING SCHEDULE TO TYPICAL DWELLING UNIT

	PARTICULAR	SYMBOL	SILL	LINTEL	NUMBER	SIZE	AREA
1.	DOOR	D	0	2100	4	900X2100	1.89
2	DOOR	D-1	0	2100	3	750X2100	1.575
3.	DOOR	D-2	0	2100	1	1500X2100	3.15
4.	DOOR	D-3	0	2100	1	900X2100	1.89
5.	window	W	900	2100	4	1000X1200	1.2
6.	window	W-1	900	2100	1	600X1200	0.72
7.	window	W-2	900	2100	4	1800X1200	2.16
8.	Ventilator	V	2100	2700	1	600X600	0.36

C.B.R.I. NEIGHBOUHOOD--PROPOSED

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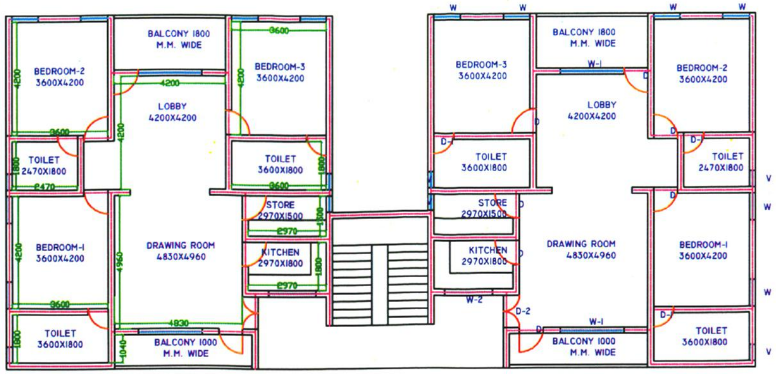
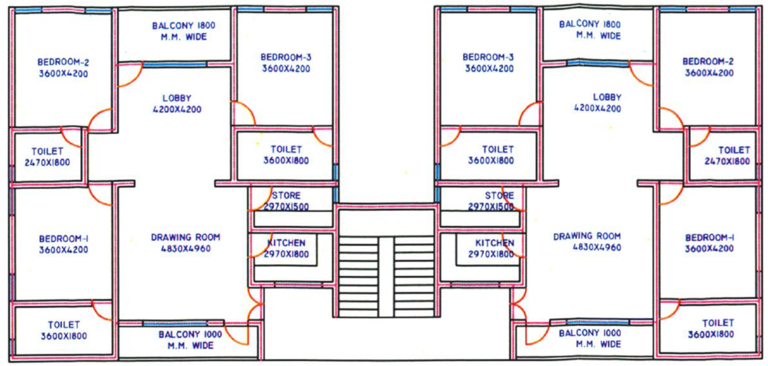


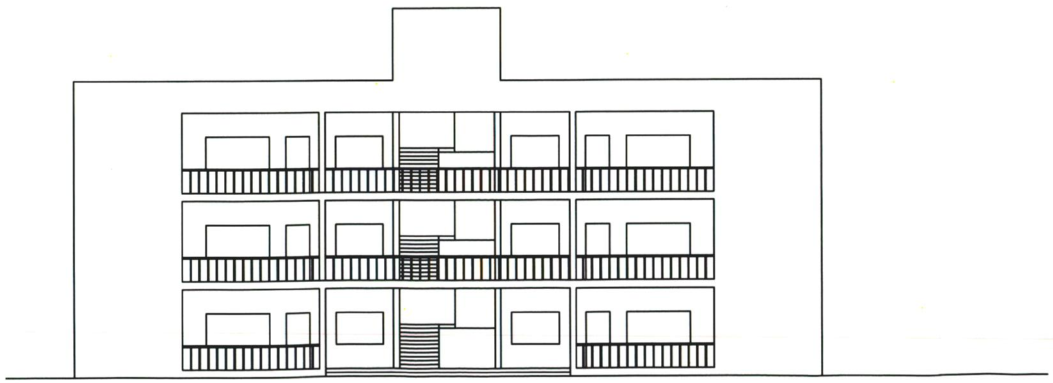
3 B.H.K-- GROUND FLOOR PLAN

N.E. FACADE

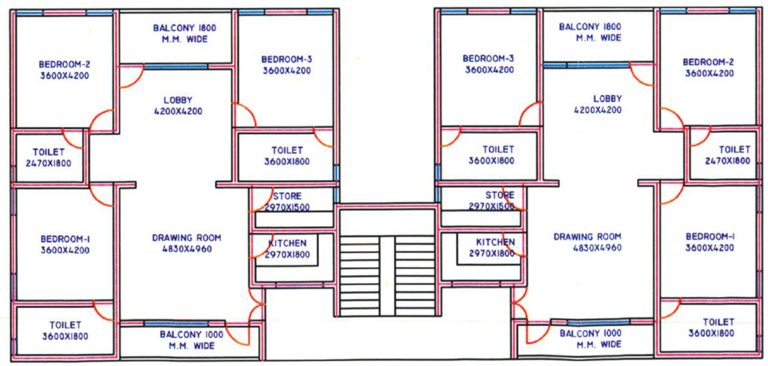


3 B.H.K-- SECOND FLOOR PLAN

N.E. FACADE

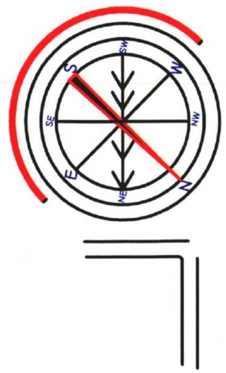


OPENING SCHEDULE TO TYPICAL DWELLING UNIT						
PARTICULAR	SYMBOL	SILL	LINTEL	NUMBER	SIZE	AREA
1. DOOR	D	0	2100	7	900X2100	1.89
2. DOOR	D-1	0	2100	3	750X2100	1.575
3. DOOR	D-2	0	2100	1	1200X2100	2.52
5. window	W	900	2100	6	1000X1200	1.2
6. window	W-1	900	2100	2	2400X1200	2.88
7. window	W-2	900	2100	1	1800X1200	2.16
8. Ventilator	V	2100	2700	4	600X600	0.36



3 B.H.K-- FIRST FLOOR PLAN

N.E. FACADE



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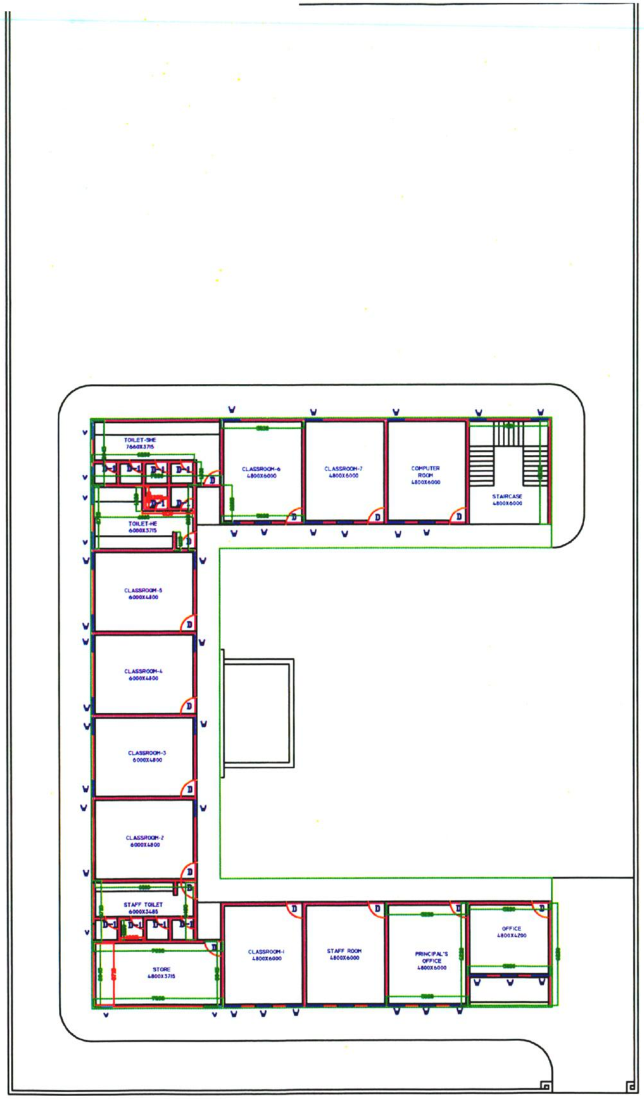
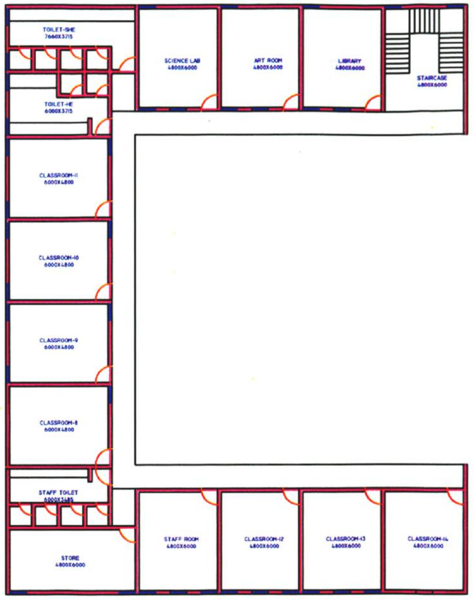
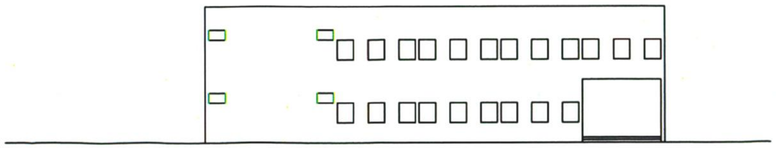
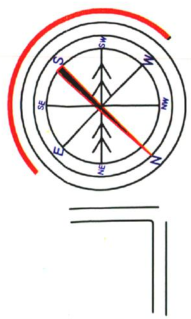


SCHOOL-- GROUND FLOOR PLAN



SCHOOL-- FIRST FLOOR PLAN





	OPENING SCHEDULE TO TYPICAL school floor						
	PARTICULAR	SYMBOL	SILL	LINTEL	NUMBER	SIZE	AREA
1	DOOR	D	0	2100	15	1000X2100	1.89
2	DOOR	D-1	0	2100	10	750X2100	1.575
5	window	W	900	2100	35	1000X1200	1.2
8	Ventilator	V	2100	2700	7	1000X600	0.6

C.B.R.I. NEIGHBOUHOOD--PROPOSED

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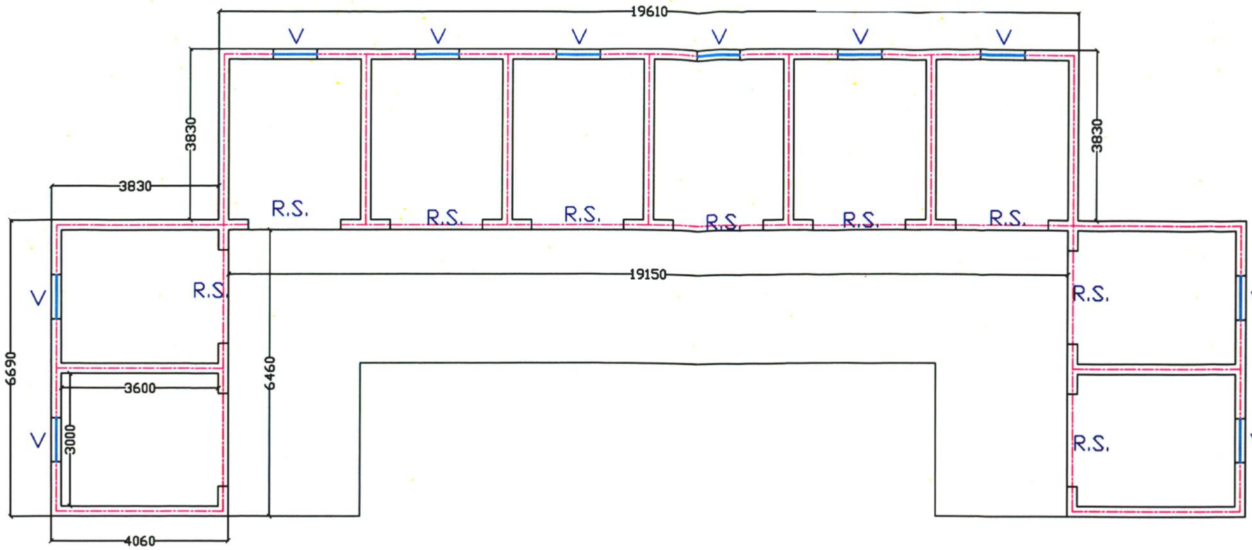
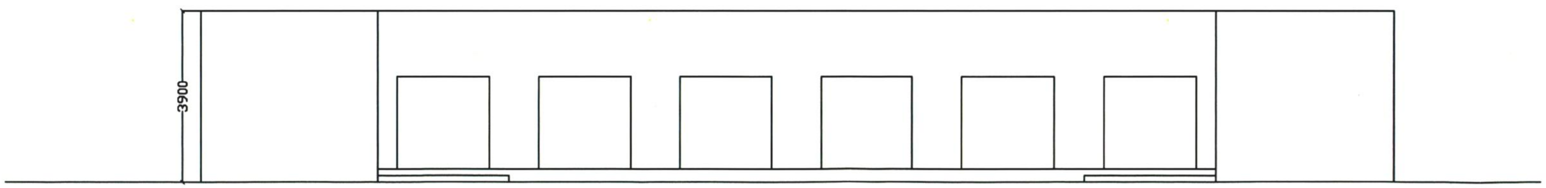
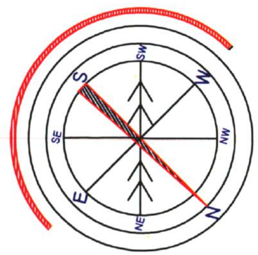
DIVYANSHI CHOPRA
09510003
M.ARCHITECTURE
ARCHITECTURAL DESIGN



PLAN



ELEVATION



OPENING SCHEDULE TO TYPICAL school floor							
	PARTICULAR	SYMBOL	SILL	LINTEL	NUMBER	SIZE	AREA
1.	Rolling Shutter	R.S.	0	2100	10	2100X2100	4.41
2.	Ventilator	V	2100	2700	10	1000X600	0.6

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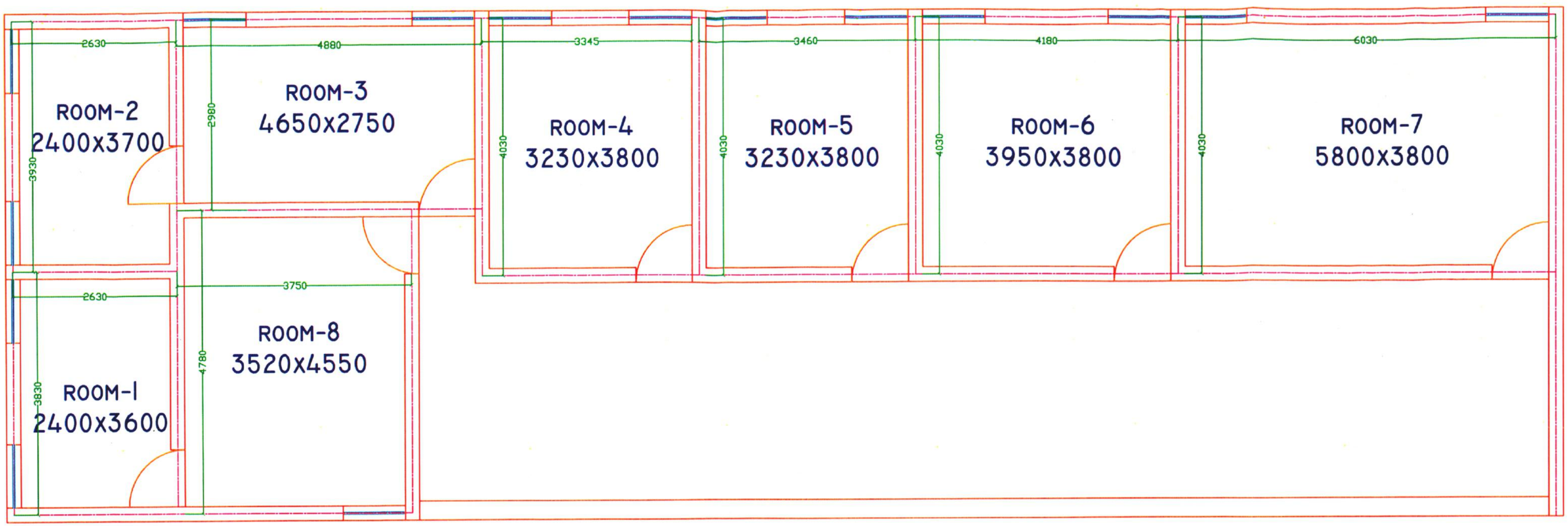

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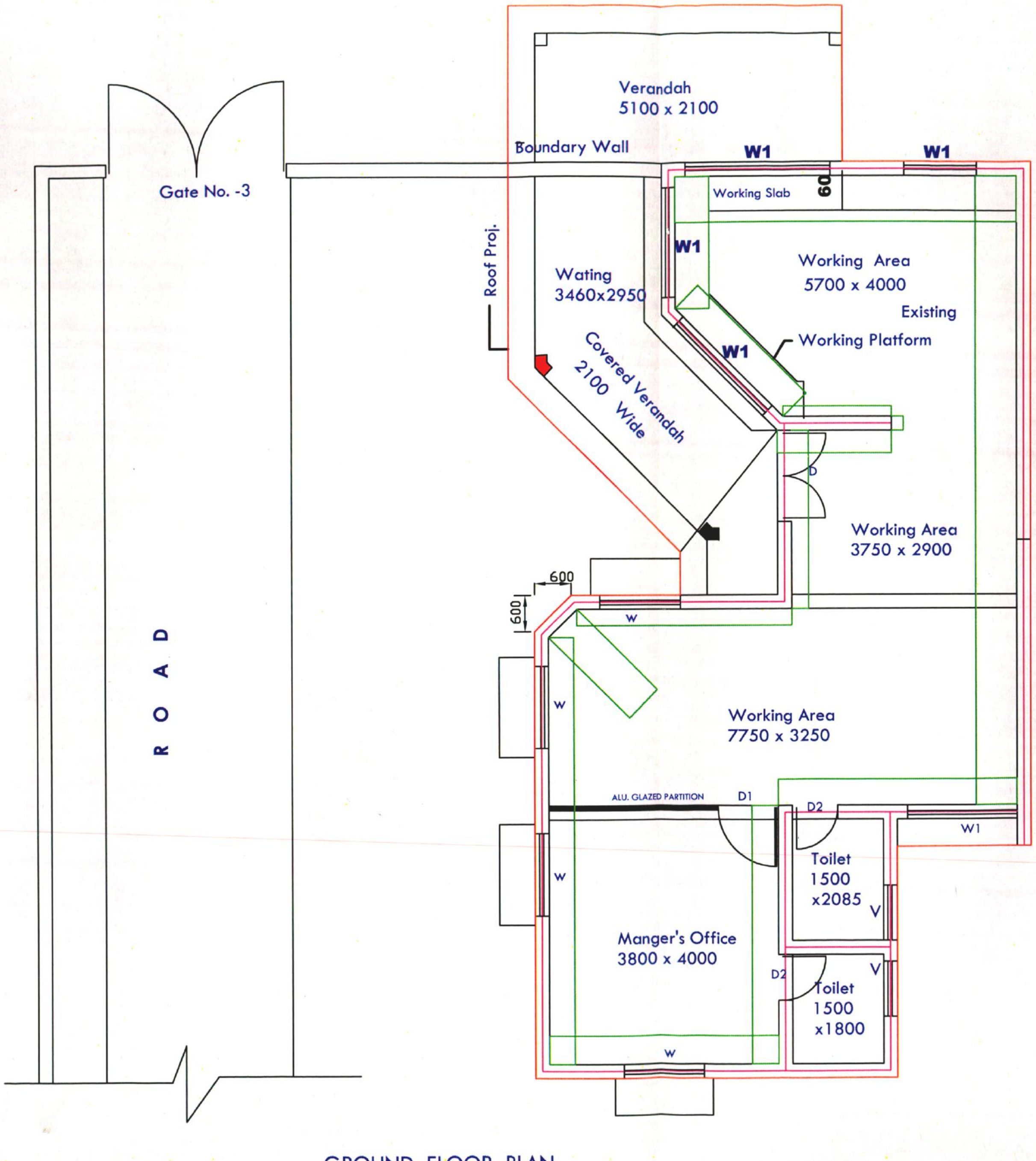

GROUND FLOOR PLAN

NOTES :

1. ALL THE DIMENSIONS ARE IN MM.
2. DO NOT SCALE THE DRG. FOLLOW WRITTEN DIMENSIONS ONLY.
3. FOR ALL RCC WORK M-20 GRADE CONCRETE SHALL BE USED.
4. ALL THE MASONRY WALLS SHALL BE BUILT IN 1:4 CEMENT MORTAR.
5. FOR STR. DRAWINGS & EARTHQUAKE BANDS REFER STRUCTURAL DETAILS.
6. DISCREPANCY, IF ANY SHOULD BE ARCHITECT / ENGINEER.

AREA DETAILS

EXISTING AREA = 24.96 SQ.M.
COVERED VERANDAH = 25.96 SQ.M.
PROPOSED AREA = 66.86 SQ.M.
TOTAL COVERED AREA = 117.78SQ.M.

EXISTING WORK

PROPOSED WORK

SCHEDULE OF DOORS, WINDOWS & VENTS.

S. NO.	ITEM	SIZE	REMARKS	
1.	D	1500 x 2550	1	3.825
2.	D1	1000 x 2550	1	2.550
3.	D2	750 x 2100	2	1.575
4.	W	1350 x 1650	4	2.2275
5.	W1	1800 x 1650	5	2.970
6.	V	900 x 450	2	0.405

PROPOSED DESIGN FOR STATE BANK OF INDIA C. B. R. I. ROORKEE

GROUND FLOOR PLAN

SCALE : 1:50	DRAWN: JAIPAL	CHECKED: MANOJ
ARCHITECT	ENGINEER	DIRECTOR
S . K . Negi		Prof. S.K.Bhattacharyya

CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE