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Relating between Sustainable Heritage Conservation and Domestic Energy use of Historic city of Jaipur

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Abstract:
Concerns regarding energy efficiency and energy conservation have been made world over. Sustainable use of our resources will define whether our future is comfortable or a struggle for survival. One of the important sectors for energy consumption is household electrical consumption. This consumption is primarily based on architectural construction of the house. This paper is a review of literature available on the historic section of Jaipur – the walled city of Jaipur and its energy consumption. The paper focuses on the importance of historic residential buildings regarding energy consumption.

Keywords: Energy efficiency, thermal comfort, historic conservation, Jaipur, residential buildings

1.0 Introduction

Concerns about the energy sustainability of the existing built stock and changes in both climatic conditions and comfort requirements, in recent years, have put a lot of research focus on energy performance evaluation of our constructions. Around 17.5% of the world's population resides in India in which the urban population is larger than the entire US population (372 million) (Sunita Bansal, 2019).

Thus, India is among the major energy consumers in the world with a total primary energy demand of 933Mtoe in 2018. Although still developing, India faces monumental challenges related to energy sustainability and urbanization. c (IEA, n.d.). We need to address the problem of energy sustainability in all aspects of development including heritage conservation.

The walled city of Jaipur was developed in 1727 and is known to be the first planned city of North India. The construction and planning of this city promoted sustainable development (Ar. Vibha Upadhyaya, 2015). In 2018, Jaipur was nominated by UNESCO as a world heritage city post which various heritage conservation and development plans were conceived. However, there is a noticeable lack of energy conservation measures and thermal comfort concerns in these plans. This paper establishes the need for energy and comfort studies to be included in conservation measures for a sustainable development and protection of our heritage.

2.0 History

Documented History states that Jaipur primarily belonged to Dhoondhar region roughly comprising of current districts of Jaipur, Dausa and Tonk which was under the Kachchwaha Dynasty of Rajputs. This region prospered due to political alliance with Mughals as well as it fell under the shortest trade route between north India and rich port cities of Gujarat and Malabar with Amer as the initial capital of this region between 1179 and 1216 AD. Sawai Jai Singh II laid the foundations of Jaipur in 1727 with the help of the famous counsellor Vidyadhar.

In 19th Century Sawai Ram Singh II extended the city beyond the fort walls with inclusion of modern facilities like railways, street lamps and proper drainage system. In 1947 Jodhpur, Jaisalmer, Bikaner and Jaipur which were the largest Rajput dominions of Rajasthan joined the secular India making Rajasthan with Jaipur becoming the capitol attracting further economic and administrative activities. A brief description of the historic timeline is provided in the table below (Jain, 2011) (Megna, 2012).

Table 1 Brief historic timeline of Jaipur

Timeline	Description
10th century onwards,	the district of Dhoondhar, comprising of Jaipur, Dausa,Tonk ,Mewat, Hadauti and Mewar.
In Aryan epics, Dhoondhar region (called Matsya Desh/ Mina Wati)	it fell on the trade route between north India and port cities of Malabar and Gujarat
11th century onwards	Kachchwaha dynasty of Rajputs
967 AD	As per popular chronicles, Dulha/Dhola Rai (1006-1036 AD) of Kachchwaha clan,

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	laid the foundation of Dhoondhar kingdom in 967 AD and made Dausa his capital.
1036 AD	Kakil Dev (1036-1038) of Kachchwaha clan layed the foundations of the Amber Fort and the temple of Ambikeshwar Mahadev. Capital shifted from Dausa to Amber
16th - 17th century	Raja Man Singh (1590-1614) and Mirza Raja Jai Singh (1622-1667) of Kachchwaha clan increased political alliance with Mughals.
18th century (Jaipur established)	Sawai Jai Singh II (1700 – 1743) laid foundation of Jaipur with the help of counsellor Vidyadhar
Late 18th century	Sawai Pratap Singh further developed Jaipur through addition of Hawa mahal and several other temples.
19th century, (Sawai Ram Singh II (1835 – 1879))	Extended city beyond the old city walls, introduced railways, started using gaslights on the streets and adopted modernized drainage and piped water supply system. New Indo Saracenic buildings constructed such as the Mubarak Mahal within the Palace Complex, the Naya Mahal or Vidhan Sabha and the Maharaja's College in 1873 (now Rajasthan School of Arts); and the Ramniwas Bagh.
20th century (Sawai Man Singh II (1922 – 1969))	(Mirza Ismail then prime minister of Jaipur) restoration work of the city walls and gates, conversion of the inner temporary houses into more permanent structures; new colonies such as the Bani Park constructed outside the walled city
1947	Rajasthan joins secular India with Jaipur becoming the capital of Rajasthan attracting administrative and economic activities leading to population growth and increase in city boundaries.

3.0 Jaipur Design Concept

There are two significant reasons responsible for the origin of the city: Amber built on a hill with no scope of growth was getting congested and Sawai Raja Jai Singh wanted his capital to display a strong political statement at par with Mughal cities. The city was planned in a gridiron Pattern using the then prevalent sawaya system of measurement. Although features of the mandala plan are often connected with the city plan of walled city, its direct application seems improbable as the initial plan only consisted of six blocks or chowkaris as opposed to prescribed nine. Jaipur location was planned in the valley surrounded on three sides by hills for security reasons while also lying on the trade route to Delhi and Agra. Details of concept are provided in the table below (Vibhuti Sachdev, 2002).

Table 2 Jaipur design concept

Title	Description
Origin theories (need)	Amber built on a hill with no scope of growth was getting congested and Sawai Raja Jai Singh wanted his capital to display a strong political statement
Physical planning	Planned in the gridiron pattern east-west axis of the town was divided by three perpendicular roads into eight portions with the central ones of equal size and the outer ones as per the remaining dimensions till the Chand Pol in the west and Suraj Pol in the east A Sawaya (a quarter extra) system of measurement was used which were then prevalent dimensional norms.
Ancient texts referred	Although the direct application of the mandala in the plan of Jaipur seems improbable due to there not existing 9 blocks during conception, parallels can be found between the Jaipur planning principles and traditional texts on spatial organization such as Rajvallabha, the regional 15th century text written by the sutradhar Mandan.
Geographical context and terrain	The site selected was a valley located south of Amber and the plains beyond. The terrain was the bed of a dried lake with dense forest cover to the north and the east of the city. The physical constraints included the hills on the north with the fort of Jaigarh and the Amber palace beyond, and the hills on the east, housing Galtaji temple.
Drainage and water supply	Jaipur district lies in the Banas River basin with seasonal rivers of which Banganga, Dhundh and Bandi are prominent. Darbhavati river in the north was dammed to create the Jai Sagar and Man Sagar (that later housed the Jal Mahal) lakes to facilitate water supply to the city and for recreational purposes. Later Jhotwara river in the north-west was diverted through the Amani Shah Nallah and a number of canals were channelized through Brahmapuri and Jai Niwas to supply water to the city. Today the city is supplied water through Bilaspur dam.

4.0 Geography, Climate and Demographics

Jaipur city population according to 2011 census is 3.04 million people. With a total area of 467 square km the city has a population density of 6500 residents/ sq km. (Review, 2019) The walled city was initially designed to house the population of 50,000 but it currently has a density of over 58,207persons/sq. km. (Md. Fuzail Jawaid, 2014) The population density of walled city is almost nine times that projected for Jaipur making it a very densely populated area (JMC).

According to NBC, Jaipur comes under Composite climate with mean temperatures ranging from 15 oC to 34 oC with an avg. relative humidity between 20%-60% (Figure 1 and 2). Thermal Cooling is the primary requirement for this climate although heating is required for the months of Dec, Jan and Feb as shown in the below images using climate consultant (Figure 1).

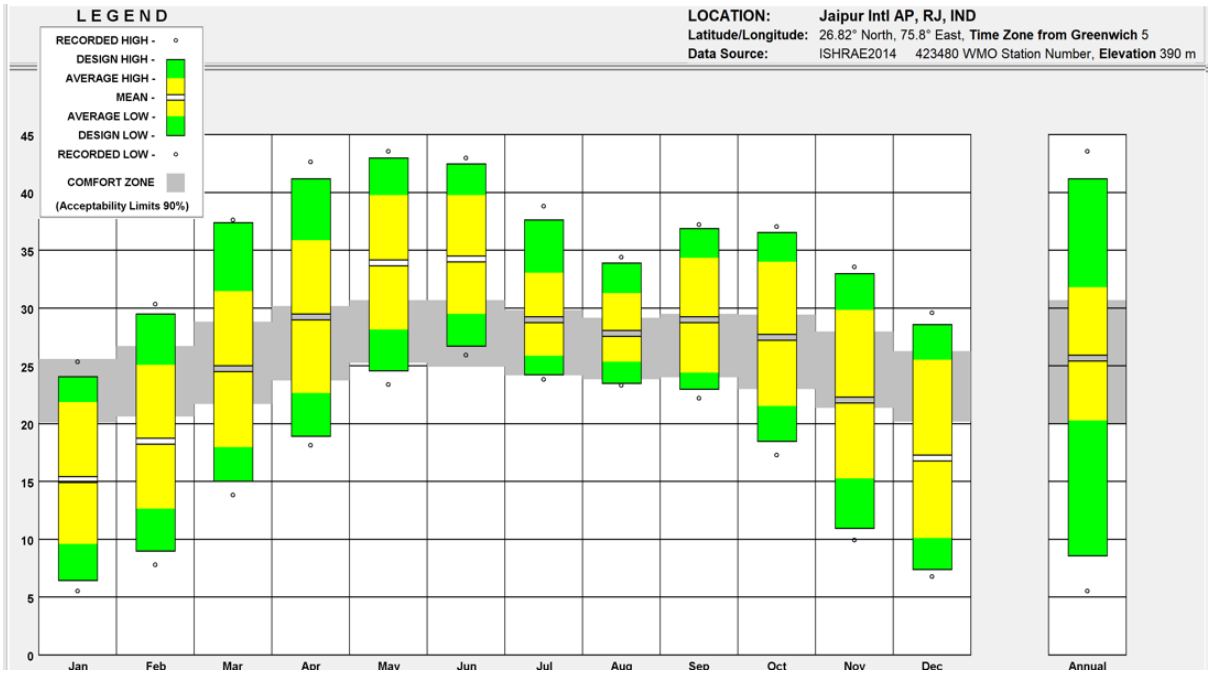

Figure 1 Temperature chart of Jaipur using climate consultant depicting thermal comfort band

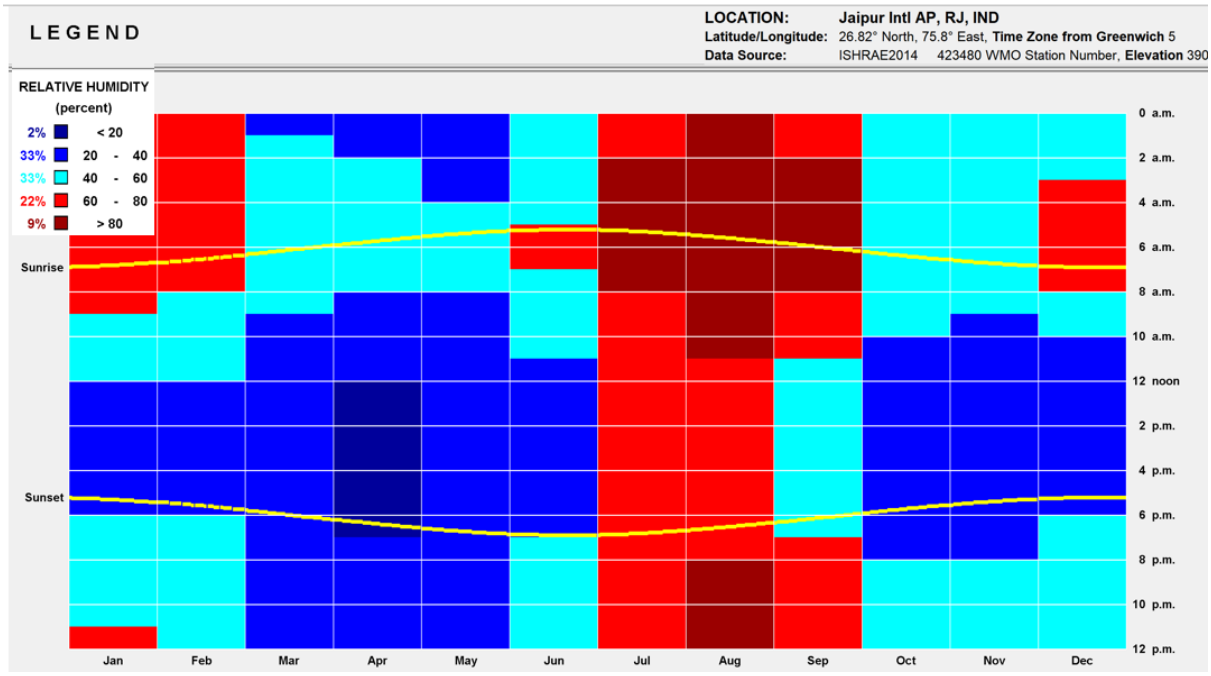

Figure 2 Relative humidity chart of Jaipur made using climate consultant by the author

5.0 Conservation byelaws and practices

The Municipalities Act of 2009 (amendment) and Jaipur Building Byelaws 1970 guide the architectural control on urban character of Jaipur which has helped in retaining the original architectural form of the bazaars (Shikha Jain, 2019). Besides these, Jaipur city has also developed specific architectural control guidelines for its various bazaars recognizing the distinct features of each bazaar. The World Heritage Site of Jantar Mantar, including major urban monuments of Jaipur such as the Hawa Mahal, the City Palace, the Jaleb Chowk and the Town Hall in the buffer area, is protected and managed through its Site Management Plan, which is also a component of the Jaipur City Master Plan (INTACH 2015, "Jaipur Heritage Management Plan" in Compendium of Good Practices, Urban Heritage in Indian Cities by NIUA, p. 20–25, New Delhi, NIUA, 2015).

The control of development in the walled city of Jaipur was thought of by as early as 1971. Since then the recognition of the architectural heritage value of Jaipur city as well as study of built heritage within the city was begun. Various organisations were involved over the years (Ar. Vibha Upadhyaya, 2015). The government bodies involved are:

- JAIPUR MUNICIPAL CORPORATION- responsible for cleaning and maintenance, painting public buildings and monuments, Enforcement of building byelaws, declaring buildings unsafe and maintaining roads.

- THE JAIPUR DEVELOPMENT AUTHORITY- prepares and executes plans, projects and schemes for integrated development of Jaipur region. Also prepares Master Development Plans.
- PUBLIC WORKS DEPARTMENT – provides for road infrastructure, departmental building works, conservation of historical monuments and buildings
- Rajasthan Urban Infrastructure Development Project (RUIDP) – provides urban infrastructure like sewage line and water supply. Also involved in repair and restoration works of the heritage buildings
- JHERICO (JAIPUR HERITAGE COMMITTEE) - guide the growth of historic core and heritage area in the city
- JAIPUR METRO RAIL CORPORATION LTD. (JMRC)- provides public transport
- ASI / State Archaeology – As per the "Ancient Monuments and Archaeological Sites and Remains Act, 1958", "The Rajasthan Monuments, Sites and Antiquities Act 1961", "The Rajasthan Monuments Archaeological sites and Antiquities Rules 1968", the monuments in Jaipur fall under the Jurisdiction of ASI or State Archaeology.
- THE DEPARTMENT OF TOURISM, RAJASTHAN

There is also an involvement by private sectors on international as well as national level like:

- INTACH- National NGO, in 2001 it initiated the identification of Modikhana Chowkry to raise awareness on civil heritage conservation and participation issues based on which JDA provided a budget for restoration.
- JAIPUR VIRASAT FOUNDATION- A citizen forum committed to build community awareness and participation. In 2003, in collaboration with Rajasthan state and JMC it created Heritage festivals of handicrafts as well as Jaipur heritage week.
- ASIA URBS- Funded by European Union for capacity building of JMC in terms of Urban Conservation.
- ASIAN DEVELOPMENT BANK- Provided around 500 million rupees for restoration and conservation works in Jaipur walled city in 2005. Also assisted in implementation of Jaipur Metro Rail.

Policies and interventions for development of Jaipur walled city including Conservation and urban renewal initiatives in Jaipur is briefly mentioned in the below table (Table 3) with timeline since independence of India in 1947 (S. Jain and R. Jigyasu) (Shikha Jain, 2019) (Ar. Vibha Upadhyaya, 2015).

Table 3 A timeline of Policies and interventions for the development of Jaipur walled city

Year	Organisation responsible	Walled city renewal initiative
1947	U.P. Municipalities" Act of 1916	State of Rajasthan was constituted and adopted this act
1951	Rajasthan town municipalities' act	Precursor of Rajasthan municipalities act.
1959	RAJASTHAN MUNICIPALITIES ACT	Act passed and updated again as Rajasthan Municipal act 2009 and again amended as The Rajasthan Municipalities (Amendment) Ordinance, 2010
	THE RAJASTHAN URBAN IMPROVEMENT TRUST ACT	The preparation of masterplans and urban improvement trusts for urban improvement is processed and carried out by state government.
	JAIPUR MUNICIPAL CORPORATION	The Jaipur Nagar Nigam functions under "the Rajasthan Municipalities Act, 1959" responsible for regular cleaning and maintenance of walled city, Painting public buildings and monuments, Enforcement of building byelaws, repair and maintenance of roads, sewerage, buildings and old water tanks in walled city.
1961	The Rajasthan Monuments, Archaeological Sites and Antiquities Act 1961	The monuments in Jaipur area fall under the jurisdiction of ASI or State Archaeology and hence are protected
1971-1991	Town planning dept of Rajasthan (Under Urban improvement act)	First masterplan prepared. Further Byelaws were formed in terms of Height regulations, setbacks, use of colours, advertisements etc.
1982	THE JAIPUR DEVELOPMENT AUTHORITY (J.D.A. ACT)	JDA established on 5 August 1982 to secure integrated development of rapidly expanding Jaipur city. Also responsible for preparing Masterplans (1991-2011, 2025). Decongestion of walled city and gates. Development of MI Road.
1985	Ford Foundation and JDA	Study of heritage buildings within the walled city
1991	MASTER PLAN FOR JAIPUR 1991-2011	Reduce density with height limitation, limit commercial expansion and keep dwelling functions, take out wholesale and noxious activities, improve the transportation system and maintain mixed land use
1995	Avas Vikas Sansthan and Department of Tourism	Conservation and restoration work of heritage structures
1998	JDA	Master Plan, 2011 addressing the needs of the walled city
2001	JMC (Jaipur Municipal Corporation)	Operation Pink, removal of encroachments in main commercial streets of the walled city
2001	INTACH (Indian National Trust for Art	Heritage Walk in Chowkri Modikhana

	and Cultural Heritage) and JVF (Jaipur Virasat Foundation)	
2001	ADB (Asian Development Bank) and JMC	The Asian Development Bank project of infrastructure – reuse of wells and repair work in the walled city/installation of sewage pipes
2002	JMC, JDA and CTP (Country and Town Planning)	Multi-storeyed parking options within the walled city
2003	JVF	Jaipur Heritage International Festival
2004	Asia Urbs	A revitalization proposal for Chowkri Modikhana
Since 2005	Government of Rajasthan	Conservation of city gates, Amber Palace, Jaleb Chowk in City Palace and Ghat Ki Guni heritage zones, lighting of several monuments, making of Heritage Acts and Laws and Empanelment of Conservation Architects to prepare conservation proposals for grade I and II monuments
2006-07	JHERICO (Jaipur Heritage Committee), JMC	JHERICO formed. Heritage Management Plan prepared with 1096 listed structures and conservation project of Amber Fort and Hawa Mahal
2007-08	ADMA (Amber Development and Management Authority) and Department of Archaeology & Museum, Rajasthan	Conservation project of Jaleb Chowk, Jantar Mantar and Ghat ki Guni
2009-10	ADMA and Department of Archaeology and Museum, Rajasthan	Architectural Control Guidelines (initiated) and inscription of Jantar Mantar as World Heritage Site
2011–2013	JDA, DLB (Department of Local Self Government), JMC	Heritage Management Plan included in Jaipur Master Plan 2025 and Documentation of Crafts as part of UNESCO dossier
	ADMA, JMC	Conservation of Jaipur Bazaars, Ghat ki Guni and Jantar Mantar buffer zone
2015	RAJASTHAN HERITAGE CONSERVATION BILL, 2015	Introduced in Rajasthan Legislative Assembly but yet to be passed
2014–2016 onwards	JMC and Jaipur Smart City Ltd.	Jaipur SMART City Plan includes Walled city, Heritage Management Plan (Best Practice 2015) and bazaars conservation
	ADMA, Department of Archaeology & Museum, Rajasthan	Conservation projects of Heritage Walk, Jantar Mantar Interpretation Centre
	Department of Archaeology & Museum, Rajasthan and JMC	Jaipur city on Tentative List and Jaipur designated as UNESCO Creative City
2018	Jaipur Municipal Corporation	Jaipur historic city nominated for World Heritage
	MASTER DEVELOPMENT PLAN- 2025	identified Walled City as Special area/ heritage zone and a Heritage and Conservation plan is proposed to prepare for this

While the policies and government interventions on municipal level had already been devised as far back as 1947, yet policies concerning conservation only began in 1985 with a collaborative study between Ford Foundation and Jaipur Development authority. It has been over 25 years since then, however, proper implementation of these policies has faced the following setbacks:

- There are various government bodies competing for Jurisdiction over the same area making it difficult to implement any intervention without smooth interdepartmental transfer of information and permissions.
- Despite many acts and policies, there is lack of detailed analysis and recommendations regarding built form, materials, built proportions, wall thicknesses etc concerning historic residential built forms in the city.
- Lack of climate and comfort analysis of historic residential built forms in the walled city.

6.0 Built form and typology

Geographically, Jaipur is located at the entrance of the thar desert which has hot arid climate. Jaipur is, on the other hand known to have composite climate. Accordingly, shading and cooling strategies are an inherent form of the built structure. The dimensions of central courtyard, parapet walls, 'Chatris' and 'Chajjas' are all catering to this need. Broadly, the built form of the house may be influenced by the following: climate and geography, Construction, Customs and rituals, Family structure, Assets owned. Traditionally the relationship of the house with open space is also opposite of the conventional western relationship. In terms of typology, we may consider the classification of the residential buildings in Jaipur on the basis of various reasonings-

• Status in the social hierarchy (Location based on ownership): the social strata defined the location of the house as well as status of the urban area. Monetary aspects may have been related with social and cultural activity of residents influencing the haveli built structure (Megna, 2012).
• Number of courtyards: Havelis may also be segregated on the basis of number of courtyards and their subsequent effect on form and function of the building (Shuji Funo, 2002).
• Evolution: Another way to categorise is evolution of the house from its initial phase when an I shape dwelling block is built to the final stage when dwelling blocks are gradually built to enclose a courtyard (Shuji Funo, 2002).
• Neighbourhood Quarter and streets: In Jaipur, the neighbourhood residential quarter is known as 'rasta' or 'marga'. A residential quarter is made up of several lanes which are called 'galli' in Hindi. A neighbourhood could be defined by rasta or marg and penetrated by gali. Neighbourhood structure differs from one neighbourhood to the next and houses may be classified according to neighbourhoods (Shuji Funo, 2002).
• Building mode: Another way of classification of the buildings may be based on whether they are completely naturally ventilated, air-conditioned or mixed mode buildings. Thermal comfort preferences, expectations and adaptations would differ from one mode to another (Sanyogita Manu, 2016).
• The Jaipur havelis not only provide a wide range and scale of this archetype but also present two unique typological variations of the haveli i.e., the haveli temple type found as courtyard temples (with no shikhara) on the main commercial streets as well as inner residential streets of Jaipur and secondly, the garden haveli type found on the Ghat Ki Guni valley stretch located on the Jaipur Agra highway (Jain, 2011)

7.0 Jaipur energy statistics

Heritage conservation in contemporary practice involves aesthetic, social, economic and functional aspects within its purview. Energy sector has yet to become associated with the field of conservation in India. This section discusses the need to involve comfort and energy studies in heritage conservation practices through a case study of Jaipur walled city. The consumers of electricity have been classified as follows by Jaipur Vidyut Vitran Nigam Ltd. who supplies electricity to the entire Jaipur city : Domestic line (DL), Non-Domestic line (NDL), Public street light (PSL), Agriculture Flat/ Metered(AG (FLAT/Mtrd.)), Small Industrial Power (SIP), Medium Industrial Power (MIP), High tension and railway (HT+Rly.), Waterworks (small+medium+high) (W/W (S+M+H), Bulk supply(Figure 3).

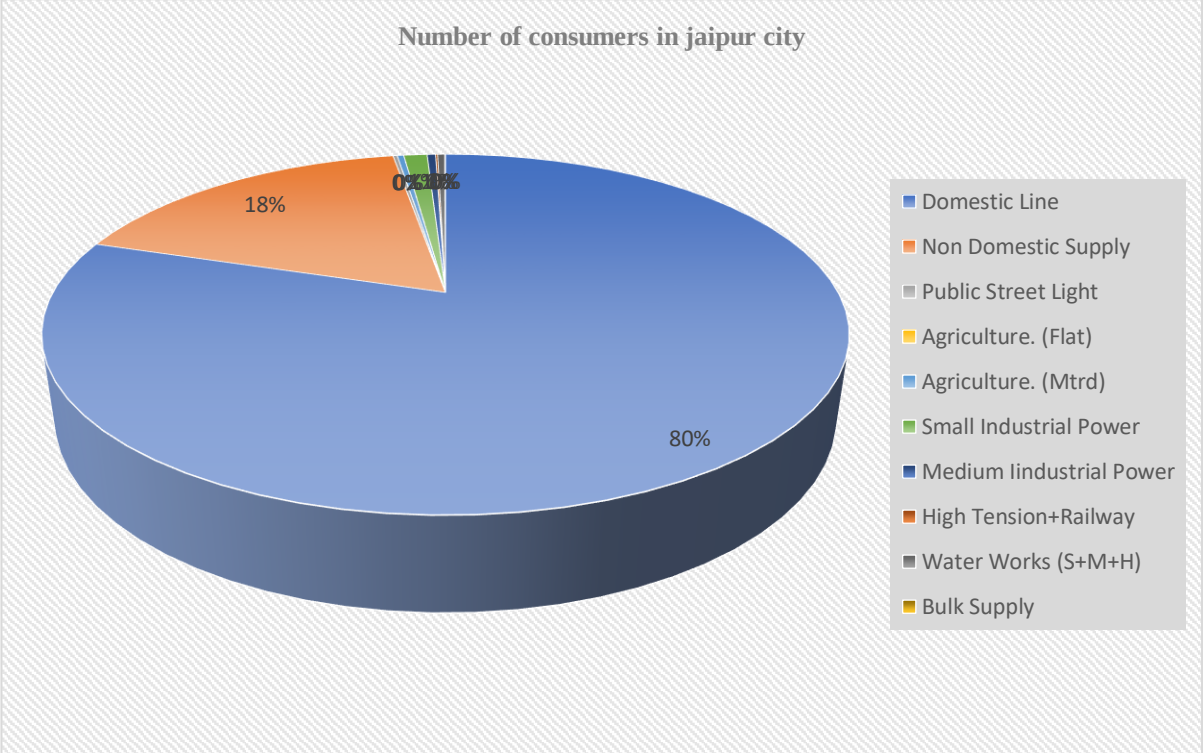

Figure 3 Electricity consumption classification based on consumer types (made by author based on data collected from JAIPUR VIDYUT VITRAN NIGAM LTD, March 2018- 2019)

Electricity consumption data was collected of Jaipur Walled city as well as Jaipur Circle which includes the entire Jaipur municipal boundary as shown in Table 4 and Table 5. The data considered was of one year period between March 2018 – March 2019. This data was analysed further.

HISTORIC WALLED CITY					
	Category	No of consumers	energy billed in one year (LAKH UNITS)	Unit billed per KW	Total energy KW
1	DL	194333	2227.49	1182.70	188339.4
2	NDS	138456	1612.17	1130.53	142603
3	PSL	32	0.03	12399.42	0.241947
4	AG. (Flat)	0	0	0.00	0
5	AG. (Mtrd)	1	0.01	1920.00	0.3125
6	SIP	4377	72.61	789.00	9202.788
7	MIP	290	16.11	1079.72	1492.053
8	HT+Rly	2	7.85	1832.25	428.435
9	W/W(S+M+H)	1305	76.96	2870.14	2681.402
10	Bulk Supply	151	39.94	2016.60	1980.561
Total Billed		338947	4053.166		346728.2

Table 4 Electricity consumption data of walled city (made by author based on data collected from JAIPUR VIDYUT VITRAN NIGAM LTD, March 2018- 2019)

JAIPUR CIRCLE					
	Category	No of consumers	energy billed in one year (LAKH UNITS)	Unit billed per KW	Total energy KW
1	DL	661404	19595.74	1182.70	1656865
2	NDS	144702	12053.07	1130.53	1066143
3	PSL	1726	654.17	12399.42	5275.8
4	AG. (Flat)	0	0.00	0.00	0
5	AG. (Mtrd)	2690	282.13	1920.00	14694.12
6	SIP	9732	789.75	789.00	100095
7	MIP	3507	1949.87	1079.72	180590.1
8	HT+Rly	848	7469.63	1832.25	407675.1
9	W/W(S+M+H)	2951	1217.89	2870.14	42432.99
10	Bulk Supply	336	905.86	2016.60	44920.08
Total Billed		827896	44918		3518692

Table 5 Electricity consumption data of Jaipur city (made by the author based on data collected from JAIPUR VIDYUT VITRAN NIGAM LTD, March 2018- 2019)

Value	**Unit**	**Description**
467	Km^2	area of Jaipur
7.09	Km^2	area of Historic walled city
459.91	Km^2	Considered area of Jaipur (minus walled city)
6896.922	KW/Km^2. year	energy consumed / unit area Jaipur per yr
48903.84	KW/Km^2. year	energy consumed / unit area walled city per year
3.144117	KW/consumer. Year	energy consumed / domestic consumer in an yr (Jaipur)
0.969158	KW/consumer. Year	energy consumed / domestic consumer in an yr (walled city)

Table 6 Data analysis of table 4 & table 5

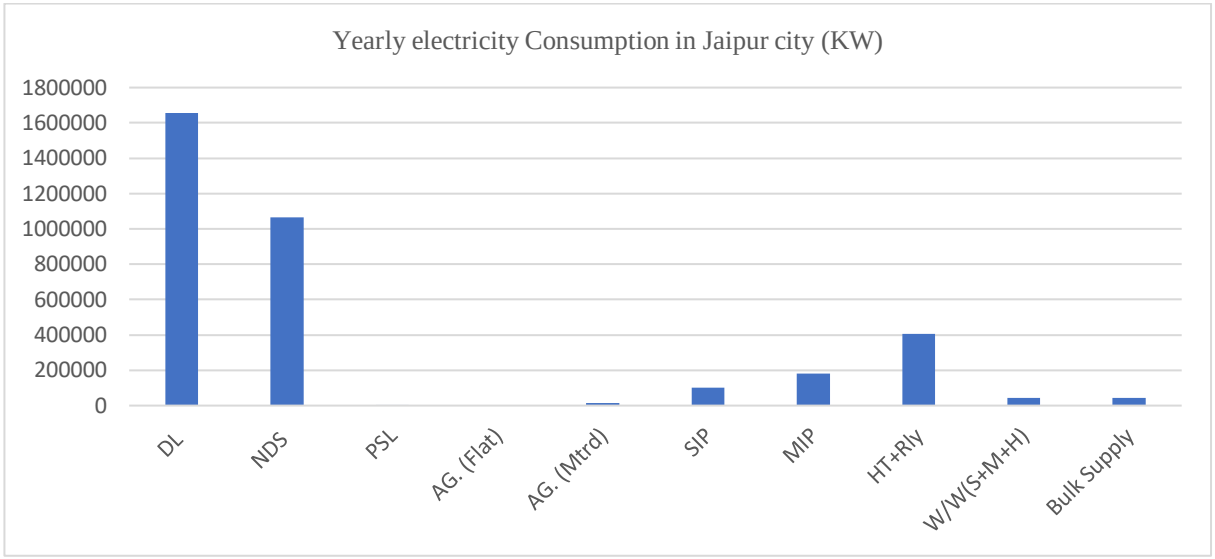

Figure 4 Electricity consumption data chart (made by author based on data collected from JAIPUR VIDYUT VITRAN NIGAM LTD, March 2018- 2019)

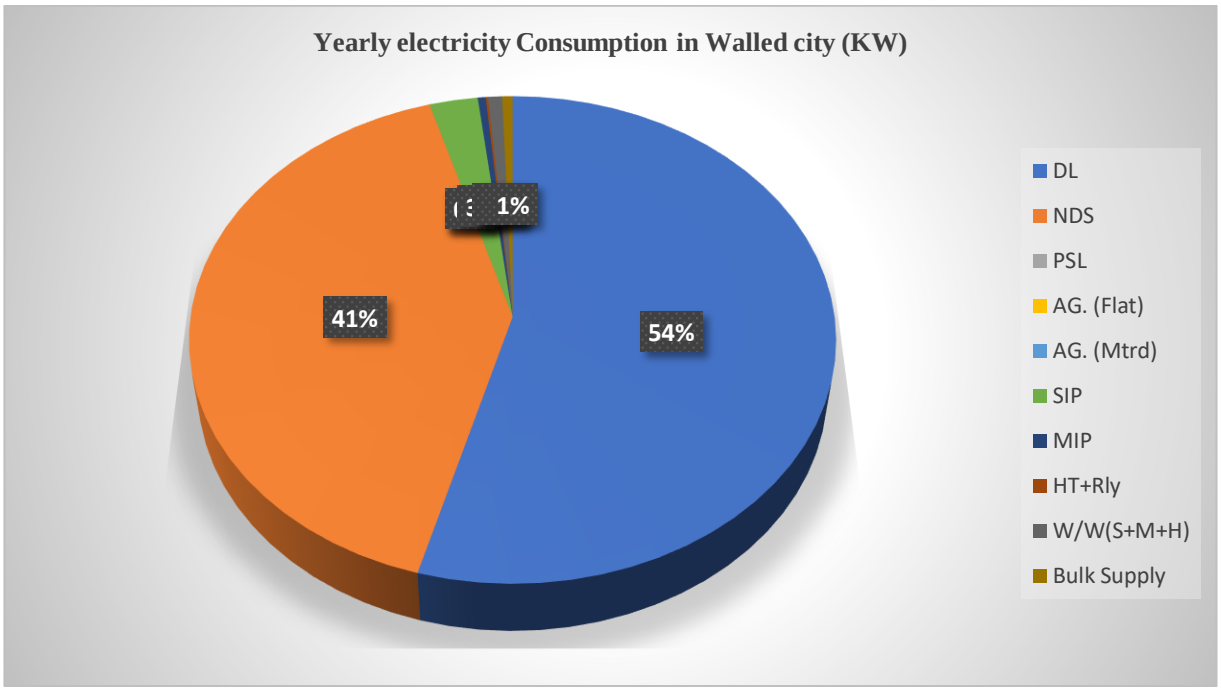

Figure 5 Electricity consumption chart (made by author based on data collected from JAIPUR VIDYUT VITRAN NIGAM LTD, March 2018- 2019)

As we can see from figure 3, the number of domestic consumers is more than ¾ th of the total number of electricity consumers. In terms of electricity consumed, the domestic sector is the largest consumer having 1.6 GW (figure 4) as compared to nondomestic units consuming around 1GW while the rest are comparatively negligible. Thus, residential buildings in the city are an important sector in terms of energy use. Even in terms of electrical consumption in the walled city, the residential sector consumes more than 50% (figure 5) of the total electricity consumption within the walled city. The area of Jaipur city is around 467 Km^2 ((Greater), n.d.)while that of walled city is around 7.09 Km^2. The energy consumed per unit area in a year in the walled city of Jaipur is 48903.8 KW/Km^2.The energy consumed per unit area in a year in the rest of Jaipur city is 6896.9 KW/Km2. This is understandable as the walled city is much more congested as compared to the rest of Jaipur and also contains many small-scale traditional industries which Jaipur is famous for. The energy consumed per domestic consumer in the walled city in a year is 0.97 KW/consumer while the same for the rest of Jaipur city is 3.14 KW/consumer. The data might be affected by the size of residential units as walled city houses smaller units as compared to newly constructed units in the rest of the city. The over-all living standard of residents also may affect the electricity consumption.

Domestic energy consumption of Jaipur city is over 8 times that recorded of walled city alone. The area of the city is more than 65 times the area of the walled city. The population of Jaipur is 11 times that of walled city. The total number

of domestic units in the walled city are around 20% that of the Jaipur city whereas they consume only around 10% of total domestic electricity consumption of Jaipur (Figure 6 and 7).

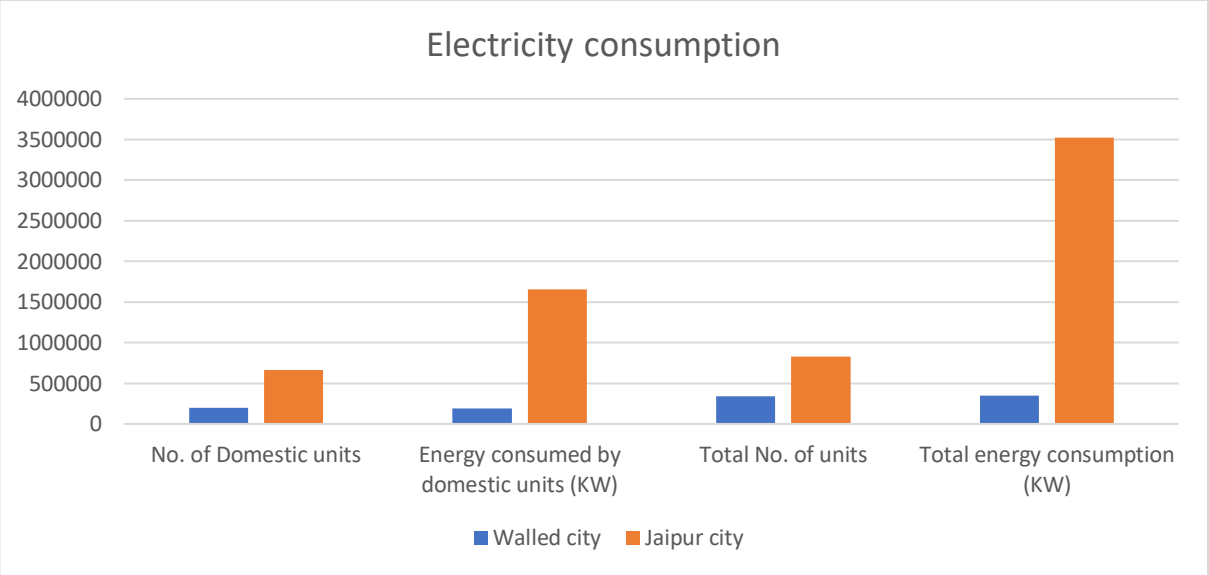

Figure 6 Comparison between walled city electricity consumption and the rest of Jaipur city consumption (made by author based on data collected from JAIPUR VIDYUT VITRAN NIGAM LTD, March 2018-2019)

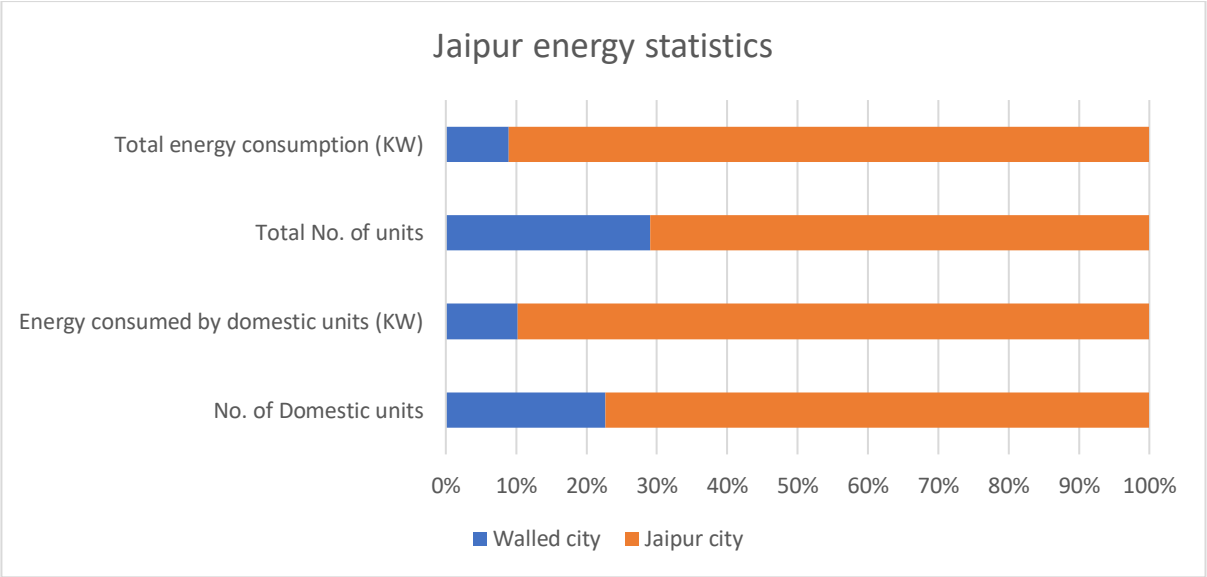

Figure 7 Comparison between walled city and rest of Jaipur city in percentage (made by author based on data collected from JAIPUR VIDYUT VITRAN NIGAM LTD, March 2018- 2019)

Thus, from this data, we may conclude that domestic sector is an important consumer of energy in terms of electricity in Jaipur. There is a large gap noticeable within the domestic electricity consumption pattern of walled city of Jaipur and the rest of Jaipur city. This gap may be due to the difference in density of population or perhaps the mean standard of living. Or it may be due to climate sensitive historic residential architecture present and still in use in the old city. Whichever may be the case, energy is definitely an important factor that should be studied in relation to the architecture of the city. Today, Jaipur being a world heritage city, requires extensive conservation work within the walled city and we must address sustainable development perspective within the conversation of conservation.

8.0 Impact of COVID situation on energy use

A nationwide lockdown in India began on 24 March 2020 where the directives included minimal movement in the public space except for essential services. In terms of domestic electricity consumption, as per data collected from JVVNL Circle office(shown in Figure 8) There was a peak in annual domestic electricity consumption after which there was a slight fall. This means that even though there was a lockdown, there was less than expected electricity used. This may be because of population migration during the lockdown, where students, labourers, and other people who had come to the city for work, during lock-down they returned to their respective hometowns leaving only the permanent residents behind. Similar

trends were seen in the data collected from sub-offices C1 and C2 which represent different areas in the walled city.

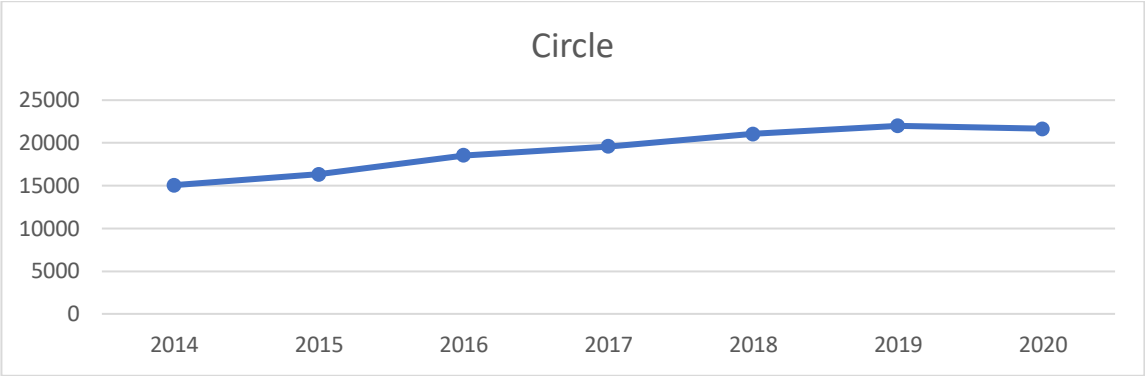

Figure 8 City Domestic electricity consumption, as per data collected from JVVNL Circle office

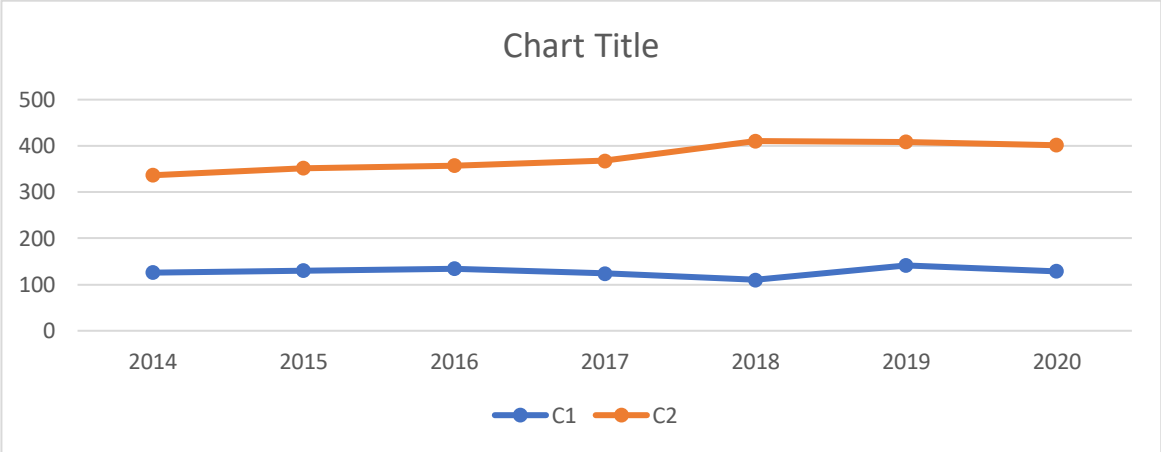

Figure 9 Parts of Walled city; Domestic electricity consumption, as per data collected from JVVNL sub-offices

9.0 Conclusion

Energy and comfort studies are directly related to each other. A dwelling is built to cater to comfort and in a sustainable development, comfort needs to be catered to while decreasing overall energy consumption. Historic buildings have immense amount of embodied energy making conservation primarily a sustainable option. It is also noticed that historic buildings are energy efficient and thermally comfortable as compared to modern buildings. In the case of Jaipur city, the total number of domestic units in the walled city are around 20% that of the Jaipur city whereas they consume only around 10% of total domestic electricity consumption of Jaipur. We may thus infer that the residences in the walled city are consuming less electricity as compared to the rest of the Jaipur city and we need to find out why? Thus, a detailed study of energy and comfort implications in historic residential buildings needs to be performed and included in the heritage conservation and development of historic cities.

10.0 References

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