Influence of Extreme Temperature on Electricity Demand in Madhya Pradesh (India)

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Abstract: **The climate is defined as 'the general or average weather conditions of a certain region, including temperature, rainfall, and wind'. The earth's climate is most affected by latitude, the tilt of the Earth's axis, the movements of the Earth's wind belts, and the difference in temperatures of land and sea, and topography. Human activity, especially relating to actions relating to the depletion of the ozone layer, is also an important factor. Urban centers heavily depend upon electricity for their existence, with increase in temperature electricity demand for space cooling also increases. Climate Change induced temperature rise also affect electrical generation at power plants. Due to excessive cooling demand many cities in India has to overdraw the electrical power from the grid, while the other not so important has to bear the power cuts due to increased demand by others. Urban areas are continuously growing larger creating huge demand of electricity for their smooth functioning; Rapid urbanization and improved lifestyle also adds further increase in the electrical demand of the city. This study attempts to improve upon an existing forecasting model indicating a quadratic Relationship between temperature and peak electricity demand whereby peak electricity load increases exponentially with increasing temperature based on previous analysis.**

I - INTRODUCTION

1.1 CLIMATE CHANGE, IMPACTS, AND ADAPTATION

Climate affects societies in many ways, and climate variability and change are important factors for societal development. Over the past century (1906-2005), global average surface temperatures have increased by 0.74 ± 0.18 °C (IPCC, 2007a). Based on observations of global air and ocean temperatures and changes in (among others) snow/ice extent and sea level, the Intergovernmental Panel on Climate Change (IPCC) concluded that it is 'unequivocal' that the climate system has warmed (IPCC, 2007a).

Most of the warming since the middle of the 20th century is very likely (subjective probability of >90%) to be due to the human-induced increase of atmospheric greenhouse gas concentrations (IPCC, 2007a). Various impacts on physical and biological systems have been observed (IPCC, 2007b). Changes can however differ strongly at the regional level. For example, the observed Western European temperature trend over the past decades is much larger than the global average.

Regional climate effects (changes in atmospheric circulation) and other regional environmental changes (lower aerosol concentrations) are believed to have played a role in this difference (e.g. PBL, 2009a).Temperature projections for the end of the 21st century range from 1.1 to 6.4°C, compared to end-20th century, based on the 'Special Report on EmissionScenarios' (SRES) scenarios for greenhouse gas emissions (IPCC, 2000, 2007a).

These changes in the global average temperature have a wide variety of effects on global,regional and local levels, such as: changes (average and extremes) in temperature, sealevels, precipitation and river runoff, drought, wind patterns, food production,ecosystem health, species distributions and phenology, and human health (IPCC,2007b). The impacts of these will differ per region andsometimes per season.

1.2 POPULATION GROWTH

The statistics for India is of serious concern. Between 1901 and 1951 India's population grew from 238 million to 361 million, an increase of 52 per cent in 50 years. Between 1951 and 1981 it expanded from 361 to 685 million. Post-Independent India in 35 years (1947- 1981) literally added a second India i.e., doubled its population. At present, it has exceeded 1 billion marks (2000 May), close to China. We have been overwhelmed by population explosion since 1980.

Distribution: For historical and other reasons, world population is not uniformly distributed. USA andCanada have a population of 250 million; South America and the Soviet Union (CIS) have the same population. Africa and Western Europe have about 500 million people; East Asia,i.e., China, Japan and Korea have more than 1 billion while South Asia is the most populousregion with 1.5 billion population

(India, Pakistan, Bangladesh). India is adding every yearthe population of Australia (16 million).
Table 1.1 Trends of Population and Urbanization given by the Census of India in 2006.

Year	Population (000 person)	Urbanization % of urban population in Total
2006	1,112,186	28.9
2007	1,128,521	29.1
2008	1,144,734	29.3
2009	1,160,813	29.6
2010	1,176,742	29.8
2011	1,192,506	30
2012	1,208,116	30.2
2013	1,223,581	30.5
2014	1,238,887	30.7
2015	1,254,019	30.9
2016	1,268,961	31.1
2017	1,283,600	31.4
2018	1,298,041	31.6

1.3 ASPECTS OF CLIMATE CHANGE

The awareness of the extent to which change of climate can affect the environment, society, and economy is increasing.Long-term climate change has been observed at continental, regional, and ocean basin scales, due to increasing concentration of greenhouse gases particularly carbon dioxide. These include changes in precipitation amounts and timings, arctic temperatures, wind patterns, and aspects of extreme weather like heavy precipitation, drought, and heat waves (IPCC,2007).The pattern of precipitation is not distributed evenly across the world and is governed by atmospheric circulation patterns and moisture availability.

These two factors are impacted by temperature so the pattern of precipitation is expected to change due to changing temperature. The changes include the type of precipitation, the amount, the intensity and the frequency. Precipitation as increased in eastern NorthAmerica, southern South America, and northernEurope and decreased in the Mediterranean, most of Africa, and southern Asia (Trenberth, K.E et al.,2007)

1.4CONSUMPTION PATTERN OF ELECTRICITY IN RURAL AND URBAN AREAS

Electricity was introduced in Greek. William Gibert, an English physician, physicist and natural philosopher was the first to coin the term “electricity” derived from the Greek word for amber. The combinations of qualities and quantities act of community orhuman group’s use of resources for survival, needs, comfort and enjoyment is called consumption pattern.

With the help of electricity many diseases are today cured by electric treatment. Surgeons will not be able to carry on operations as their instrumentsand machines are operated by it. X-ray machine which enables the doctor to take the photograph of the internal parts of the body can be operated only with its help. Briefly speaking, many men will meet their death much earlier without it. In the present period many big and heavy machines are been used to run machines.

But these machines can run only through help of electricity. In many progressive countries, like Japan, electric power is used in small scale and cottage industries. In our own country we find flour mills, crushers, saw mills, etc. functioning withelectricity. The use of such small machines in our village has helped in improving the condition of the villagers. Thus, electric power is helping in the growth of industries.

Figure 1.1 Increment of electricity consumption in India as per the report of World Bank.

1.5 SECTORAL BREAKDOWN OF ELECTRICITY DEMAND IN INDIA

This section provides the broadest view of electricity usage in India by looking at estimates of residential demand in relation to other energy demand sectors in the country. A number of studies were collected to compare electricity use estimates and the general methods toward achieving those estimates.

The two main approaches to constructing energy usage estimates are top-down and bottom-up. In the 2002 paper from the International Energy Agency (IEA), Electricity in India: Providing Power for the Millions, a more top-down method was used. IEA generated much of its own data for itsestimates, which werelargely done by collecting data from power generation facilities. Using survey results from those generators, IEA calculated various energy estimates for Indiaand for other global regionsincluding electricity usage. [2] Stephane de la Rue du Can et al. used a bottom-up approach in their research paper from the Lawrence Berkeley National

Lab (LBNL) in 2009, Residential and Transport Energy Use in India: Past Trend and Future Outlook.

1.6 UNDERSTANDING TIME VARYING TEC

A hypothetical temperature-electricity curve (TEC) as represented in Fig.1.2 In thisU-shaped curve, the minimum point is called the threshold. TEC is influenced by a largenumber of structural socio-economic developments, such as the growth in incomes, extent ofelectrification, energy efficiency improvements, cultural habits, and prevailing climatic conditions. Hekkenberg et al. (2009) argues that over time temporal dynamics could influencethe slopes as well as the threshold temperature of the TEC. For instance, increased internalheat gains in commercial buildings from increasing use of computers or decreasing tolerancefor heat, leads to a general shift towards lower heating demand and higher cooling demand.

With increasing electricity access and rising income level, the number of householdsowning temperature control devices (such as air conditioners and air coolers) is increasingvery rapidly in India. According to National Sample Survey Organization surveys (50th,61st, 66th) the number of households owning an air cooler or an air conditioner doubledfrom 32.9% in 1993 to 60% in 2009 in urban Delhi (which represents 97.5% of total Delhipopulation as per census 2011) and increased from 20.6% to 26% in rural Delhi. In the caseof refrigerators, the upward trend was even more impressive; saturation went from 29% in1993 to 61.3% in 2009 in urban Delhi and from 17.7% to 38% in rural areas.

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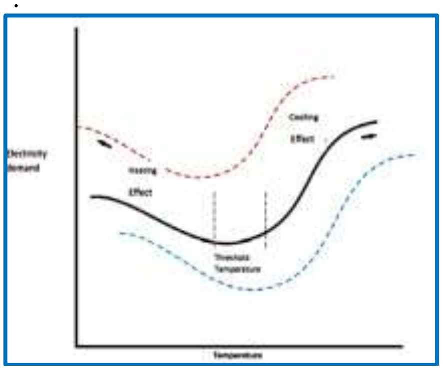

Figure 1.2 Temperature Electricity Demand Curve

1.7 AIM OF THE STUDY

The fundamental aim of the study is to carry-out a methodology for evaluation of Climate change induced warming and cooling impacts on urban built environment.

For an improved energy management, the government of India is implementing the 12th Five-Year Plan, which is cheering clean energy production and CO_2 emissions control. Therefore, the investigation oftheinfluence of urban temperature on energy consumption will benefit energy conservation

II - LITERATURE REVIEW

In developing countries, there is a influential positive association among wealth and energy particularly electricity utilization. Though, the method of electricity production and consumption may generate air pollution and greenhouse gas which results global warming (Lee and Chiu, Ferguson).

Forecast model reveals that the electricity consumption (EC) and mean monthly maximum temperature areincreasing with the passage of time.

In India, there are various codes, standards, guidelines and rating systems launched tomake energy intensive and large sized buildings energy efficient whereas independent residentialbuildings are not covered even though they exist most in numbers of total housing stock. ***Aniket Sharma and Bhanu M. Marwaha***presents a case study methodology for energy performance assessment of existing residential stock of Hamirpur that can be used to develop suitable energy efficiency regulations.

Wendy S. Jaglomet. al. analyzes the potential impacts of changes in temperature due to climate change on the U.S. power sector, measuring the energy, environmental, and economic impacts of power system changes due to temperature changes under two emissions trajectories—with and without emissions mitigation. It estimates the impact of temperature change on heating and cooling degree days, electricity demand, and generating unit output and efficiency. These effects are then integrated in to a dispatch and capacity planning model to estimate impacts on investment decisions, emissions, system costs, and power prices for 32U.S. regions.

From an engineering perspective, climate change can affect the energy sector in a number of ways, such aschanges in the efficiency of power plants and increases in peak demand due to higher cooling demand in hottersummers. ***Juan-Carlos Ciscar, Paul Dowling*** reviews how integrated assessment models have estimated the impacts of climate in the energy sector, including the modelling of adaptation.

Rory V. Jonesa, Kevin J. Lomasprovides an analysis of the appliance ownership and use factors contributing to high electricalenergy demand in UK homes. The data were collected during a large-scale, city-wide survey, carriedout in Leicester, UK, in 2009–2010. Annual electricity consumption and appliance ownership and usewere established for 183 dwellings and an odds ratio analysis used to identify the factors that led tohigh electricity consumption.

HOU Yi-Ling, MU Hai -Zhen used the data of daily electricity consumption and temperature for the period 2003-2007 in Shanghai, the variationof energy consumption and the correlations between energy consumption and temperature are analyzed. The resultsindicate that winter and summer are the two peak seasons of energy consumption due to the urban residential heating and cooling demand.

To investigate the link between rising global temperature and global energy use, ***Sebastian Petrick, KatrinRehdanz and Richard S. J. Tol*** estimate anenergy demand model that is driven by temperature changes, prices and income. The estimation isbased on an unbalanced panel of 157 countries over three decades. Authors limit the analysis to theresidential sector and distinguish four different fuel types (oil, natural gas, coal and electricity).

Studies on many countries are few***. Bigano et al. (2006)*** investigate the energyconsumption of the residential, industrial and service sectors of up to 26 OECDcountries, distinguishing between five different fuel types. They find significantimpacts of temperature only for residential energy demand. Energy use of theindustrial and service sectors are not significantly influenced by temperaturechanges. ***Bessec and Fouquau (2008)*** focus on total electricity use in the EU-15and do not differentiate between specific sectors.

Delson Chikobvu and Caston Sigauke (2013) discusses the modeling of the influenceof temperature on average daily electricity demandin South Africa using a piecewise linear regressionmodel and the generalized extreme value theoryapproach for the period - 2000 to 2010.

MeLike E BILDIRICI investigates the relationship between electricity consumption and economic growth by using Autoregressive Distributed Lag (ARDL) bounds testing approach and vector error-correction models (VECM) in Cameroon, Cote D'Ivoire, Congo, Ethiopia, Gabon, Ghana, Guatemala, Kenya, Senegal, Togo and Zambia for period 1970-2010.

III RESEARCH METHODOLOGY

The State of Madhya Pradesh is centrally positioned and is frequently called as the "Heart of India". The State is home to a rich artistic heritage and has virtually everything; uncountablememorials, large hill, remarkable mountain ranges, twisting rivers and miles and miles of opaque forests offering a exclusive and exciting view of wildlife in sylvan surroundings.

Madhya Pradesh, India's succeeding largest state, which subjugates 9.38% of the country's area,in terms of its mineral resourcesit is the second richest state. Mainly, it has an agricultural and countrified economy. Industrial development is mainlyfocused in the additionalprogress districts like Indore, Bhopal, Gwalior and Jabalpur.

As the four districts Indore, Bhopal, Gwalior and Jablpur has the major industrial growth in last two decade in Madhya Pradesh. We have considered for the study these entire four districts as they can give the proper effect of urbanization on the climate change.

Figure 3.1 Geographical Position of Madhya Pradesh

3.1 Data:

In this study, the daily and monthly mean temperature data for 2005-2015 were obtained from the India Metrological Department, Bhopal. Total four meteorological observation stations have been established in urban area of all the district.Thisnetwork provides daily, hourly and even more detailedmeteorological observations.

A time series of daily electricity consumptionE (in 10^6 kWh), spanning the period 2005-2015, has been used. This data comprises the electricity consumption in all economic sectors for Madhya Pradesh and wasderived from thedata.gov.in, an official website for data of India.

Figure 3.2 Four District Considered for the Study in Madhya Pradesh

3.2 Methods

Degree-days are fundamentally the summation of temperature differences over time, and therefore they confine both limit and period of outdoor temperatures. The temperature difference is between an orientation temperature and the outdoor air temperature. The reference temperature is known as the base temperature which, for buildings, is a balance point temperature, i.e. the outdoor temperature at which the heating (or cooling) systems do not need to run in order to maintain comfort conditions.

The Cooling Degree Days can be defined as the number of degrees that a day's average temperature is above 65^o F and persons start to use air conditioning to cool their houses. Heating degree days are indicators of home energy expenditure for space heating. It was establishing that for a normal outdoor temperature of 65 degrees Fahrenheit; nearly all buildings require heat to keep up a 70 degree temperature inside.

Monthly CDD and HDD are calculated based onthe subsequent formula (HOU Yi-Ling et. al.)

$$CDD = \sum_{i=1}^{M}(T_i - T_{base}) \quad (for\ T_i \geq T_{base}) \ldots\ldots \quad (3.1)$$

$$HDD = \sum_{i=1}^{M}(T_{base} - T_i) \quad (for\ T_i \leq T_{base}) \ldots\ldots \quad (3.2)$$

Where M is the number of days in a month,
Tiis daily mean temperature of day i and
T_{base} is the base temperature which will be determined later. Here the base temperature is 65F.

For each state, a centered average monthly meantemperature was calculated at the center of each gridcell for each month in each run year, plus the 2010 baseline.After that, the monthly total HDD and monthly total CDD is calculated for each month in each run year for eachclimate model grid cell using Equation (3.1) and (3.2)

IV RESULTS & ANALYSIS

4.1 Climate Results

In spite of of the state, future temperature increases aregenerally projected to decrease HDD and increase CDD. Absolutedecreases in HDD are greater in magnitude than absolute increasesin CDD. And also the percent increases in CDD are lower thanpercent decreases in HDD. Figure 4.1 depicts the changes in HDD and CDD value as the average of the entire four districts.

Figure 4.1 % Changes in HDD and CDD

When the outdoor temperature is lower the base temperature, the heating system requiresproviding heat. The increment of cooling degree days shows the requirement in increasing the energy demand for heating the space, while in the case of increment in heating degree days indicates the increment in energy requirement for cooling the space.

4.2 Relationship between temperature and electricity consumption

During 2011-2015, the monthly mean temperature of Madhya Pradesh has a considerable seasonal cycle (Figure 4.2), with the highest in May 2011 (94F), and thelowest in month of January of all the years (65F).From 2005 to 2015, the electricity consumptionpracticed a regular seasonal modification like to the temperature. During the summer season, there is a max out in electricity use due to high cooling demand. Additionally, a relatively lower max out in electricity use is found during winter season generally because of the increase in heating demand.

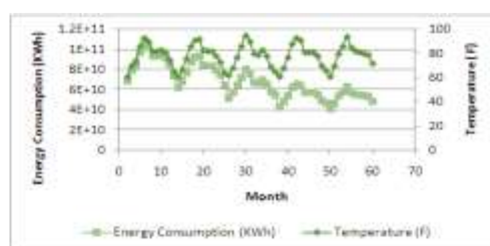

Figure 4.2 Variation of monthly electricity consumption (E) and monthly mean temperature (T) in Madhya Pradesh from 2011 to 2015

Figure 4.3 shows the 5-year mean (2011-2015)monthly temperature and electricity consumption.According to the results the variation inelectricity consumption is not responsive to temperaturewhen the mean temperature range between 15ºC and25ºC. Based on this, the months from April to June are regarded as the warm months in which cooling would be requisite to realize thermal ease in Madhya Pradesh, while December to February are amorphous aswintry months when heating might be requisite. Mutual with the local climate of Madhya Pradesh and the design standard for energy efficiency of housing buildings in warm summers and chilly winters (CABR, 2001),a base temperature of 10ºC is amorphous for heating and22ºC for cooling.

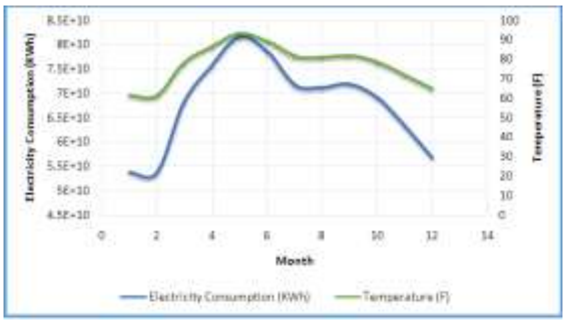

Figure 4.3 Monthly electricity consumption and temperature and related base temperature zones (2011-2015 mean)

4.3 Observed trends in HDD and CDD

Table 4.1 Average Temperature, HDD and CDD for year 2011

Sr. No.	Month	Average Temp (F)	HDD	CDD
1	January	61	141.5	23
2	February	70	4	134.5
3	March	80	0	461
4	April	88	0	642.5
5	May	94	0	911
6	June	85	0	510.5
7	July	82	0	511
8	August	81	0	483
9	September	80	0	400
10	October	79	0	420.5
11	November	72	0	212.5
12	December	64	78	44

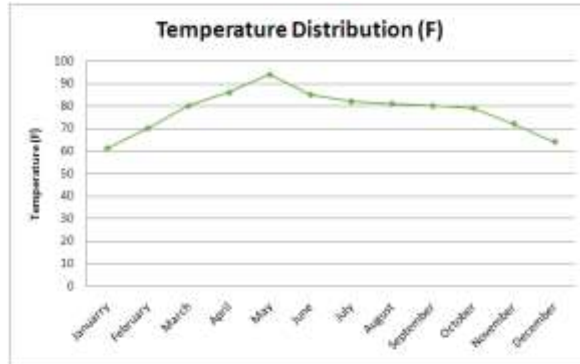

Figure 4.4Temperature Distribution for year 2011

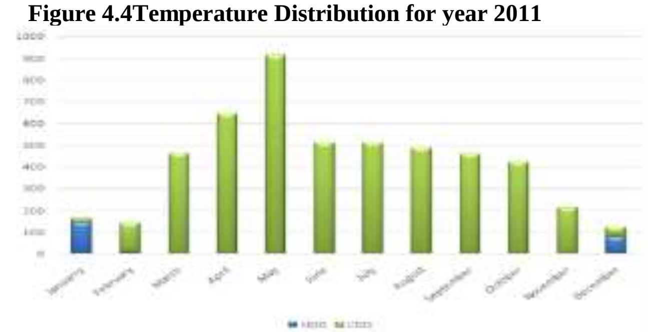

Figure 4.5 HDD and CDD distribution for the year 2011

Table 4.2 Average Temperature, HDD and CDD for year 2012

Sr. No.	Month	Average Temp (F)	HDD	CDD
1	January	61	132	8.5
2	February	68	41	111
3	March	77	0	384
4	April	88	0	681
5	May	93	0	868
6	June	91	0	788
7	July	81	0	496
8	August	81	0	442.5
9	September	81	0	487.5
10	October	78	0	481.5
11	November	70	0	188.5
12	December	66	90.5	91

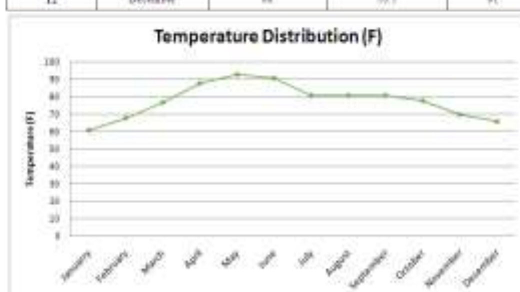

Figure 4.6 Observed trend in Temperature variation for the year 2012

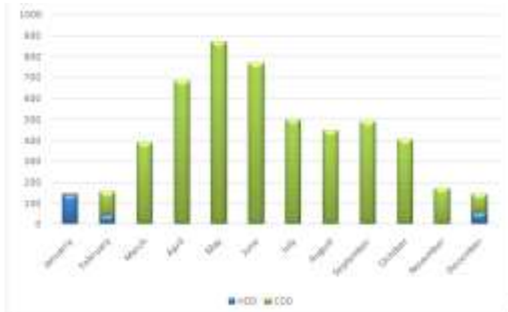

Figure 4.7 HDD and CDD distribution for the year 2012

Table 4.3 Average Temperature, HDD and CDD for year 2013

Sr.No	Month	Average Temp	HDD	CDD
1	January	61	136.5	4
2	February	70	4	158
3	March	74	0.5	308
4	April	88	0	627.5
5	May	93	0	883
6	June	90	0	736.5
7	July	82	0	541
8	August	82	0	529.5
9	September	83	0	543
10	October	81	0	490.5
11	November	75	0	308
12	December	65	61.5	68.5

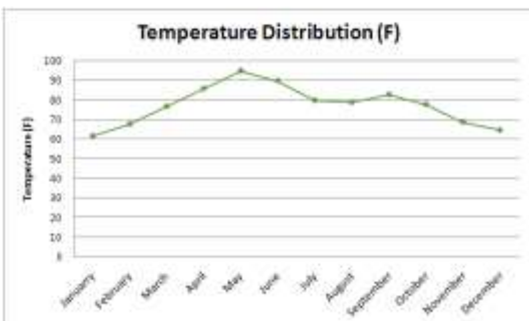

Figure 4.8 Observed trend in Temperature variation for the year 2013

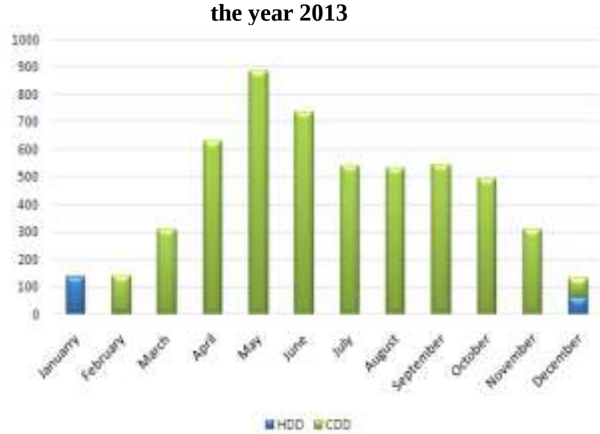

Figure 4.9 HDD and CDD distribution for the year 2013

Table 4.4 Average Temperature, HDD and CDD for year 2014

Sr. No.	Month	Average Temp (F)	HDD	CDD
1	January	61	81.5	28
2	February	67	33	88.5
3	March	76	1	330
4	April	85	0	629.5
5	May	91	0	814.5
6	June	92	0	795
7	July	83	0	562
8	August	82	0	522.5
9	September	82	0	495.5
10	October	78	0	410.5
11	November	73	0	209.5
12	December	64	83	48.5

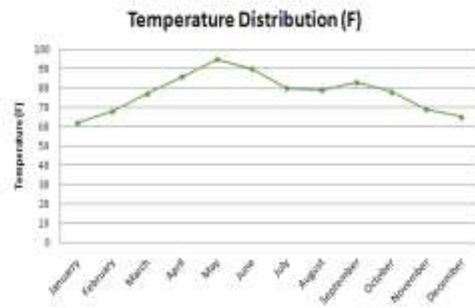

Figure 4.10 Observed trend in Temperature variation for the year 2014

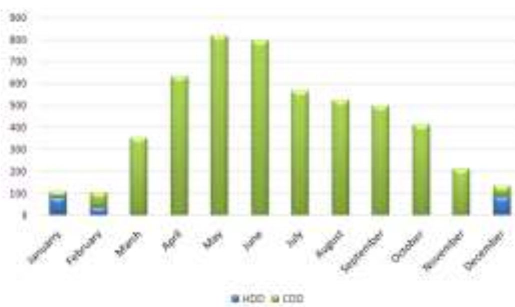

Figure 4.11 HDD and CDD distribution for the year 2014

Table 4.5 Average Temperature, HDD and CDD for year 2015

Sr. No.	Month	Average Temp	HDD	CDD
1	January	62	171	42
2	February	68	8.5	91.5
3	March	77	0	381.5
4	April	88	0	818
5	May	95	0	918.5
6	June	90	0	580.5
7	July	80	0	487
8	August	79	0	439.5
9	September	83	0	527.5
10	October	78	0	395.5
11	November	69	0	125.5
12	December	65	23.5	32

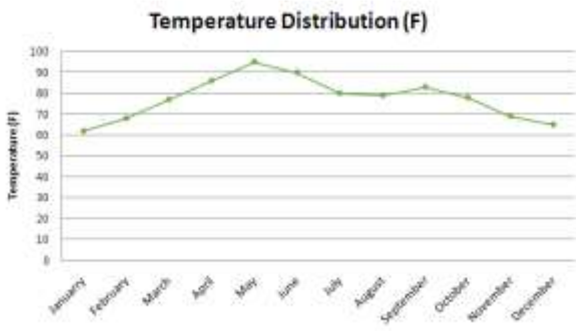

Figure 4.12 Observed trend in Temperature variation for the year 2015

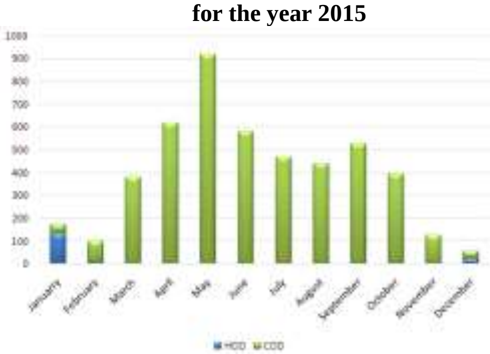

Figure 4.13 HDD and CDD distribution for the year 2015

Table 4.1 to 4.5 shows the observed trends in distribution of average temperature and degree day's distribution. It is observed that there is the increment in Cooling as well as Heating degree days. It is above from all of the above figures from 4.4 to 4.13 that there variation in cooling as well as heating degree day. There is large fluctuation of temperature from the comfortable zone.

4.4 The Projected Trends for HDD and CDD

For the period of 2005 to 2020, the annual CDDand HDD of Madhya Pradesh are generated by calculatingthe average values of the grid points within the area

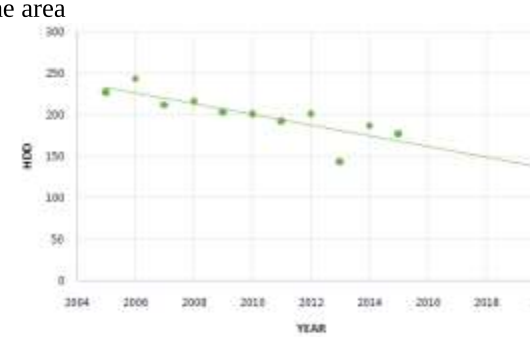

Figure 4.14 Projected Trends for HDD for Madhya Pradesh

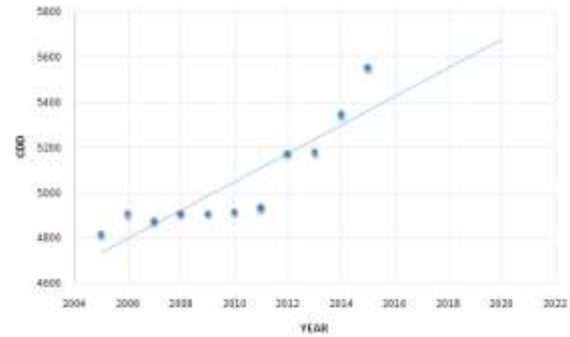

Figure 4.15 Projected Trends for CDD for Madhya Pradesh

The variations in the annual CDD and HDD during 2004-2020 are shown in Figure 4.14 and 4.15. Inwarm months, the CDD would increase at a rate of 10% d per year, while the HDD would decrease at arate of 3.1% d per year in cold months.

4.5 CALCULATING HOME HEATING ENERGY

Heat transfer from residential houses can take place by conduction, convection and radiation process. It is classically modeled in terms of conduction, while infiltration from side to side walls and around windows can contribute a significant additional loss if they are not well closed.

Table 4.6 Resistance of Different Types of Wall

Thickness	Material	Conductivity	Resistance=thickness/conductivity
-	outside surface	-	0.04 K·m²/W
0.10 m	clay bricks	0.77 W/m·K	0.13 K·m²/W
0.05 m	glass wool	0.04 W/m·K	1.25 K·m²/W
0.10 m	Light concrete blocks	0.30 W/m·K	0.33 K·m²/W
(Bridge, 7%)	Mortar between concrete blocks	0.88 W/m·K	0.11 K·m²/W
0.01 m	plaster	0.57 W/m·K	0.02 K·m²/W
-	inside surface	-	0.13 K·m²/W

For a 107.63 square foot room as it is per capita space in Madhya Pradesh in the year 2005 with a 10 foot ceiling, with inside temperature 65°F and outside temperature 90°F at the summer season (Average of 10 Years Mean Temperature):

$$\text{Heat loss Rate} = \frac{Q}{t} = \frac{\text{Area}\times(T_{\text{inside}} - T_{\text{Outside}})}{\text{Thermal Resistance of wall}} \ldots (4.1)$$

$$\text{Heat loss Rate} = \frac{Q}{t} = \frac{10\times(90-65)}{0.13} \quad \text{…. (4.2)}$$
= 1.923KJ/Sec
= 46.15 KJ/day
The loss per day with a one degree difference between inside and outside temperature.

$$\text{Heat loss Rate} = \frac{Q}{t} = \frac{10\times 1}{0.13}$$
= 0.07692 KJ/S
= 1.846 KJ/day

For a 143.5 square foot room as it is per capita space in Madhya Pradesh in the year 2015 with a 10 foot ceiling, with inside temperature 65°F and outside temperature 90°Fat the summer season (Average of 10 Years Mean Temperature):

$$\text{Heat loss Rate} = \frac{Q}{t} = \frac{13.34\times(90-65)}{0.13} \quad \text{…………. (4.3)}$$
= 2.565KJ/Sec
= 61.56 KJ/day
The loss per day with a one degree difference between inside and outside temperature.

$$\text{Heat loss Rate} = \frac{Q}{t} = \frac{13.34\times 1}{0.13}$$
= 0.102 KJ/S
= 2.4627 KJ/day
The Increment in Energy Demand per capita due to 1 degree difference in Temperature
= (2.4627-1.846) KJ/Day
= 0.6167 KJ/Day 0r 25.04% increment per day

It is depicted from the above calculation that due to the rapid growth and urbanization there is substantial increment in per capita energy demand for degree days. The increment of CDD plays vital role in Madhya Pradesh as it is in the region where weather is having very hot summer days.

V CONCLUSION

In this work, the correlation between electricityconsumption and daily mean temperature in Madhya Pradeshwas investigatedover the definition of the base temperature of CDD and HDD in warm months and coldmonths. Electricity demand shows substantial seasonalvariations.

The variations of electricity demand due to temperature are compared. In summer season,a high peak occurs in electricity consumption due togreat cooling demand as having very hot summer days. The comparativelylesser peak inelectricity use is found in winter season especially in the month of December and January, and it is due to thegrowth in heating demand.

The distribution of CDD and HDDclearly shows the urbanization effects. By the effect of urbanization, the state area experienceslarger CDD in summer and lower HDD in winter. Due to the Urbanization there is increment of cooling load demand about 25% during the summer season. These results could be useful in the decision making of the electricity demand.

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