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Computation of Space Heating Energy Requirements and Comparative Analysis of Three Cold Desert Region of Jammu and Kashmir (India)

-A Case Study for Solar System Designs-

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Abstract: The aim of this study is to determine and present heating degree days for three locations in Jammu and Kashmir province of India for solar system designs. The heating energy requirement of a typical residential building of floor area ~100 m^2 in Jammu and Kashmir, has been determined and the heating degree days have been calculated for various base temperatures and are presented in tabular form. The numerical results show that the heat loss from a typical structure in the state is in huge quantity and that can be a significantly reduced in the heating load using well fitted doors and windows.

Keywords: Heating degree days, Heating load, Space heating energy, Variable base temperature

1. Introduction

The aim of this study is to determine and present heating degree days for three arid and desert locations in Jammu and Kashmir province of India for solar system designs. Jammu and Kashmir state constitutes the northern most extremity of India comprising Jammu, Kashmir and Ladakh. The total area of the province is 222236 km^2 of which 19% is under Jammu region, 11% of Kashmir and 70% of Ladakh. The three regions have distinct climate and topography. Jammu has 26293 km^2 of total area. It is situated between the outer hills and has mostly sub-tropical climate. Temperature sometimes touches 45 ˚C. There are no snowfalls and the lowest temperature seldom reaches 0 ˚C. The valley of Kashmir is situated among the outskirts of the Himalayas in the Pir-Panjal range. Its area is 15948 km^2. The topography of Kashmir valley can be classified into three terrains-mountainous, sub-mountainous and plain. The climate of three terrains varies from moderate summer to severe winter. The valley of Kashmir has temperate climate. The summer lasts only a couple of months generally from June to August. During winters the valley experiences heavy and frequent snowfalls and total average rainfall in the region is ~1000 mm. Ladakh region experiences extreme weather condition with temperature dipping to – 40 ˚C. However, the whole region receives average daily solar radiation of 5-7 kWh/day and there are about 300 clear sunny days per year (Mani and Rangarajan, 1982).

In the present study, heating degree-days have been calculated for three locations in Jammu and Kashmir State namely Jammu, Srinagar and Pahalgam. Due to non availability of temperature data of Ladakh region, it has not been considered in this study. Srinagar is the summer capital of Jammu and Kashmir. Pahalgam is the famous tourist resort and is the coldest place in the valley of Kashmir. The daily ambient temperature data since 2003 has been used to determine heating degree-days for the three locations under study. Computations indicate that there is tremendous opportunity to use solar energy for space heating.

2. Degree-Day method

The calculations of seasonal energy consumption are of vital importance in any building design for heating or cooling purposes. In literature several methods are available to estimate energy requirements of buildings (Marx and Stamber, 1995). There are some computer simulation models which simulate the hourly envelope dynamic heat transfer process as well as the dynamic behaviour of the heating system and equipment. These models are based on thermodynamic principles which are solved numerically using initial and boundary conditions and also the architectural geometry of the usable spaces of a building. These models are not practically realistic as they require certain assumptions because of unpredictable

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nature of weather conditions. These methods are known as dynamic methods and require hourly data for simulation. Some simpler steady state methods are also available which require less data but provide lesser degree of information. Degree day or degree hour method is developed for this area to estimate heating and/or cooling load of buildings. The methodology is less data intensive than dynamic methods and more accurate than steady state methods. During heating season, windows of buildings are usually closed and the air exchange rate is fairly constant. Thus there is not a significant difference among the results using degree day and degree hour method as shown by Papakostas and Kyriakis (2005). The degree day method has been used by a few researchers to estimate the monthly and annual heating and cooling energy requirements of specific buildings in different climatic conditions. Traditionally, degree days are calculated based on a base temperature of 18.3 ˚C for a typical none insulated building (Martinatis, 1998).

Table 1. Geographical details of locations under study.

Station name	Type of climate	Latitude (˚N)	Longitude (˚N)	Altitude AMSL(m)
Srinagar	Temperate	34.05	74.50	1588
Pahalgam	Temperate	32.0	75.20	2310
Jammu	Sub-tropical	32.40	74.50	356

The daily ambient temperature data since 2003 has been used for determining heating degree-days for the three locations under study. These data were taken from India Meteorology Department, Rambagh, Srinagar. The geographical detail of locations under study is shown in **Table 1**. The monthly maximum and minimum dry bulb temperatures were computed using the recorded daily weather data **Table 2**. The base temperature is not necessarily constant and differs because of various factors like increased insulation levels, a reduction in set point temperature or large solar gains etc. the heating degree days are therefore calculated for various base temperatures. The buildings in Jammu and Kashmir state are observed to be non insulated. The heating load is determined based on a base temperature of 18.3 ˚C, however the variable base degree days can be used for all types of houses using proper insulation and with all types of their usage. The monthly heating degree days (HDD) can be expressed as,

$$HDD=\Sigma(T_b-T_{av})_{daily} \quad (1)$$

where, T_b is base temperature (˚C) and T_{av} is the average temperature of the day.

2.1. Heating Load

The physical characteristics of building parameters of a typical residential building in the Jammu and Kashmir is shown in **Table 3** (Sharma, 1984). The total heat loss coefficient of the building is expressed as,

$$L_h = \Sigma UA+N\,(\rho C_p)_{air}\,V/3.6 = \Sigma UA+N\,V/3 \quad (2)$$

where, A is area, N is air exchange rates per hour or air changes per hour (1/h), L_h is heat loss coefficient (W/^{0}C), U is thermal transmittance (W/m^2 ^{0}C), V is volume of air (m^3), ρ is density (kg/ m^3), $(\rho C_p)_{air}$ is volumetric thermal capacity of air and its numerical value is 1.2 kJ/ m^3 ^{0}C and C_p is specific heat at constant pressure (kJ/ kg^{0}C). The monthly heating energy requirement for the building in terms of number of hours in a day (N_h) can be expressed as,

$$Q\,(J) = 3600N_hL_h\,(HDD) = 86400L_h\,(HDD) \quad (3)$$

3. Results and Discussion

The heating degree day for a location depends upon the severity of the climatic conditions at that place. **Table 4** shows that Srinagar and Pahalgam has heating degree days in all month except

Table 2. Monthly max (1) and min (2) DBT temp (^{o}C) of three locations under study.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	6.3	10.9	17.4	20.8	25.3	28.2	29.7	29.4	28.0	22.0	15.9	9.5
	-0.4	1.7	5.2	7.6	11.3	14.7	18.0	17.4	12.8	10.0	1.4	-1.3
Pahalgam	3.4	7.4	13.6	17.6	21.8	23.7	25.2	25.1	24.3	18.8	13.2	7.1
	-5	-2.2	1.4	3.3	6.3	9.2	13.1	13.1	9.0	3.3	-1.0	-4.1
Jammu	18.2	22.6	28	33.9	38.0	38.6	34.4	33.3	32.6	30.7	26.3	21.1
	8	11.5	15.6	20.9	25.3	26.4	25.2	24.6	23.6	18.7	13.1	8.7

July-August. Space heating is the major energy consuming end-use in the household sector of Kashmir valley. In Jammu region space heating is required only for three months November, December and January, the heating degree days in the rest of months is zero. The energy consumption for space heating in a typical residential building of state (floor area ~ 100 m^2) has been calculated using Eq. 3. **Figure 1** shows the energy consumption for space heating in three different climatic conditions. The maximum space heating requirement is in the month of January (25 GJ). The present buildings have poor insulation levels and loosely fitted doors and windows, so the infiltration load has been calculated using two air changes per hour **Figure 2** shows the variation of heating load of a building with different air exchange rates, there can be a significant reduction in the heating load by using well fitted doors and windows.

4. Conclusion

The calculation results show that the heat loss in a small residential building is enormous. A number of steps can be taken to reduce the heating load in pre-existing buildings. The wall and roof insulation should be incorporated in the buildings. Efforts should be put forth to classify the better insulating envelope in different climatic conditions of the state. In order to maximize benefits from solar radiation, buildings should be designed using passive solar heating techniques. The site specific Energy Conservation Building Codes should be developed and these building codes need to be enforced to motivate the implementation of energy conscious building design.

Table 3. Physical characteristics of building parameters and heat loss coefficient.

Description	Area (m^2)	U-factor $W/m^2\ ^\circ C$	Heat loss factor ($W/\ ^\circ C$)
Walls	69.50	2.32	161.24
Ceiling	71.11	2.34	166.46
Windows	13.67	4.86	66.42
Doors	11.46	3.76	43.12
Floor	Perimeter 38.51m	1.29 $W/m\ ^0C$	49.98
Infiltration loss*	Vol. of air $173.39m^3$	0.33 $W/m^3\ ^0C$	115.48
Total heat loss Coeff.	---	---	602.7

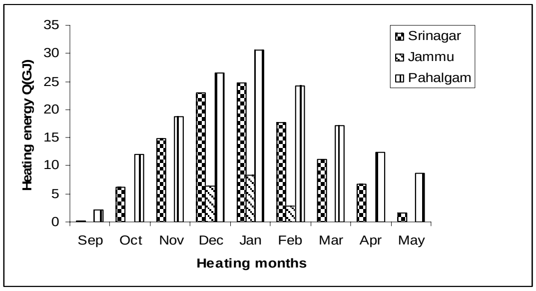

Fig. 1. Energy consumption for Space Heating vs. heating months in a typical Residential building.

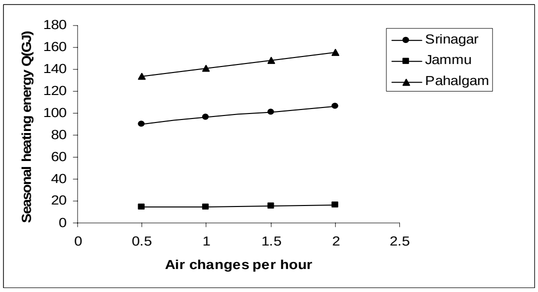

Fig. 2. Seasonal Energy Requirement vs. Air exchange rate for a typical Residential building.

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Table 4. HDD for various base temperatures for Srinagar, Jammu and Pahalgam.

Station	T_b	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Srinagar	19	502.6	358.3	236.7	151.2	50.6	9.9	0	0	11.9	140.6	304.8	463.0	2229.6
	18.3	475.9	338.6	215.0	130.2	32.1	0	0	0	3.4	119.1	284.2	441.3	2040.2
	18	466.6	330.0	205.7	121.2	22.2	0	0	0	0	109.9	267.8	432.0	1955.7
	17	435.6	301.8	174.7	91.2	11.9	0	0	0	0	79.2	237.8	401.0	1733.5
	16	404.6	273.5	143.7	61.2	1.5	0	0	0	0	48.6	207.8	370.0	1511.2
	15	373.6	245.2	112.7	31.2	0	0	0	0	0	22.7	177.8	339.0	1302.5
	19	155.5	72.8	0	0	0	0	0	0	0	0	0	120.9	349.2
	18.3	160.7	56.8	0	0	0	0	0	0	0	0	0	99.6	317.1
Jammu	18	151.5	51.1	0	0	0	0	0	0	0	0	0	90.5	293.1
	17	120.8	32.1	0	0	0	0	0	0	0	0	0	60.2	213.1
	16	90.1	18	0	0	0	0	0	0	0	0	0	29.9	138.0
	15	59.5	8.9	0	0	0	0	0	0	0	0	0	6.6	75.0
	19	607.6	485.7	352.7	257.6	189.3	76.6	8.7	1.5	63.5	254.2	383.3	534.1	3214.8
	18.3	585.9	466.1	331.3	236.6	167.6	55.6	0	0	42.5	232.9	362.3	512.4	2993.2
Pahalgam	18	576.6	457.7	322.2	227.6	158.3	46.6	0	0	33.5	223.7	353.3	503.1	2902.6
	17	545.6	429.7	291.7	197.6	127.3	16.6	0	0	8.4	193.2	323.3	472.1	2605.5
	16	514.6	401.7	261.2	167.6	96.3	0	0	0	0	162.7	293.3	441.1	2338.5
	15	483.1	373.5	230.7	137.6	65.3	0	0	0	0	132.2	263.3	410.1	2095.8