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Carbon Emissions from air-Conditioning

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Abstract: This paper explores electricity consumption and carbon emissions associated with air-conditioning. The total heat load of a room fitted with air conditioner of 1.5 ton capacity has been calculated by calculating conduction and ventilation losses. Solar heat gain and internal gain were taken as the other two parameters for the total heat calculation.

Keywords: *Heat gain, absorptance, transmittance, coefficient of performance.*

I. INTRODUCTION

As the average temperature of the planet rises every year we also have started using the air conditioner more. The result is that we are heating up the environment even more. What happens is, whenever we turn on the air conditioner, it releases carbon into the air. And carbon has been identified as the element that insulates our planet and is a major contributor in global warming The average world temperature of the Earth has increased by 1 degree Fahrenheit in just the last century. Compared to most other electric devices, the air conditioner consumes much more energy. We had considered a room of 6.7 m length, 5.5 m width and 3 m height. The room was maintained at 22^{o}C temperature by an air-conditioner. Under the steady state approach (which does not account the effect of heat capacity of building materials), the heat balance for room air can be written as [1]:

$Q_{total} = Q_c + Q_s + Q_i + Q_v$…………………………………….(1)

1.1 Conduction

The rate of heat conduction (Q_c) through any element such as roof, wall or floor under steady state can be written as

$Q_c = AU\Delta T$ ……………………………………………...…. (2)

where,
A = surface area (m^2)
U = thermal transmittance (W/m^{2}K)
ΔT = temperature difference between inside and outside air (K)
Mean hourly values of data for various places in India are available in the handbook by Mani [2].

1.2 Ventilation

The heat flow rate due to ventilation of air between the interior of a building and the outside, depends on the rate of air exchange. It is given by:

$Qv = \rho Vr\, C\Delta T$……………………………………….... (3)

where,
ρ= density of air (kg/m^3)
Vr = ventilation rate (m3/s)
C = specific heat of air (J/kgK)
ΔT = temperature difference (To–Ti) (K)

1.3 Solar Heat Gain

The solar gain through transparent elements can be written as :

$Qs = \alpha_s \Sigma A_i S_{gi} \tau_i$…………………………………….…. (4)

where,

α_s = mean absorptivity of the space

A_i = area of the ith transparent element (m^2)

S_{gi} = daily average value of solar radiation (including the effect of shading) on the ith transparent element (W/m^2)

τ_i = transmissivity of the ith transparent element

1.4 Internal Gain

The heat generated by occupants is a heat gain for the building; its magnitude depends on the level of activity of a person. Table 1.1 shows the heat output rate of human bodies for various activities [3]. The total rate of energy emission by electric lamps is also taken as internal heat gain. The heat gain due to appliances (televisions, radios, etc.) should also be added to the Qi.

Table 1. Heat production rate in a human body [3]

Activity	Rate of heat production	
	(W)	(W/m^2)
Sleeping	60	35
Resting	80	45
Sitting, Normal office work	100	55
Typing	150	85
Slow walking (3 km/h)	200	110
Fast walking (6 km/h)	250	140
Hard work (filing, cutting, digging etc.)	More than 300	More than 170

Qi = (No of people × heat output rate) + Rated wattage of lamps + Appliance load……… (5)

We have the following data available [3]:

Place: Solan (Himachal Pradesh)

Month: May

Ventilation rate: 2 h^{-1}

Artificial light: 18 Tubelights of 20 W each are continuously used

Occupants: Four persons (normal office work; 8hours occupancy)

Window: (1.8m X 4.8m) on South wall, single glazed

Window: (1.2m X 1.8m) on West wall, single glazed

Door: (0.9m X 3m) on South wall

Door: (0.9m X 3m) on West wall

$U_{glazing}$ = 5.8 W/m^2K [4]

U_{wall} = 3 W/m^2K

U_{roof} = 2.3 W/m^2K [3]

Daily average outside temperature in May: 28.2 ºC

Absorptance of external wall surfaces: 0.6

Outside heat transfer coefficient: 22.7 W/m^2K

Inside design temperature: 22 ºC

Mean absorptivity of the space: 0.6

Transmissivity of window: 0.8

Density of air: 1.2 kg/m^3

Specific heat of air: 1005 J/kgK

Using equations (2), (3), (4) & (5) in equation (1), we get

$Q_{total} = Q_c + Q_s + Q_i + Q_v$

Q_c = 3 (16.2–11.3) [(28.3–22)] + 3 x 19.8 [(26.9-22)] + 3 x 16.2 [(27.4–22)] + 3 x (19.8-4.9) [(27.8–22)] + 2.3 x 35.6 [(26–22)] + 5.7 x 4.5 [(33.0–23.3)]

= (3 x 4.9 x 6.3) + (3 x 19.8 x 4.9) + (3 x 16.2 x 5.4) + (3 x 14.9 x 5.8) + (2.3 x 35.6 x 4) + (5.7 x 4.5 x 9.7)

= 92.6 + 291.1 + 262.4 + 259.3 + 327.5 + 248.8

= 1481.7 W

Q_s = 0.6 x [(11.3 x 111.3) + (4.9 x 155.2)] 0.8

= 0.6 x (1257.7+760.5) x 0.8
= 0.6 x 2018.2 x 0.8
= 968.7 W

Q_i = 4 x 100 + 18 x 20
= 400+360
= 760 W

Q_v = 1.2 x 1005 (2 x 6.7 x 5.5 x 3/3600) (28.2–22)
= 1.2 x 1005 x 0.02 x 6.2
= 149.5 W

Thus, Q_m = 1481.7 + 968.7 + 760 + 149.5
= 3359.9 W
= 33.6 kW

It represents that total heat entering the building is 33.6 kW.

The COP of a standard window air conditioner of 1.5 tons cooling capacity is about 2.8 [3]. So the power required is 12 kW (i.e.,33.6 kW/2.8). Suppose the machine was to be used for 8 hours a day; then it would consume 12 kWh per day (12 kW×8 hours = 96) or 96 units (One kWh is equivalent to one unit) of electricity supplied by the power company [3]. At a rate of Rs. 2 per unit, expenses would amount to Rs. 192/- per day. The carbon component emitted by the use of 96 kWh hydroelectric power is 384 g [5] whereas per day emission of carbon by this ac is 5344 g [6]. Total carbon produced by using 1.5 ton AC is 5728 g=5.7 kg per day, therefore per annum it will be 1368 kg if the air conditioner works for 20 days per month as an average [7].

II. CONCLUSION

Till the day we can use alternative forms of energy in a wide scale, turning on the air conditioner will always mean that the earth will be affected. The only way to limit the damage is by using high energy efficient air conditioners which require less power to run, and to keep the use of the air conditioners to the minimum level possible. Increasing awareness of environmental issues has led to development of a large number of energy conservation technologies for buildings, especially in more developed countries [6]. Energy savings potential (ESP) is a very important indicator for developing these technologies.

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