Energy Consumption, Heat Transfer, and Efficiency Calculations

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To determine energy consumption, it is essential to take into account the following parameters: the type and size of a house, the day and night occupancy, cooling and heating nature, weather, location, window area, external wall area, occupants' status and lifestyle, the effectiveness of lighting and appliances, as well as the levels of loft insulation, floor, and walls.

To approximate the lighting/heating consumption of a residence, it's imperative to consider the temperature difference inside and outside the home. Thus, the heat losses of a particular house can be determined by the ventilation and fabric heat losses (John, 2014).

To calculate the fabric heat loss, the first step is to examine the total surface of uncovered external walls and then compute the U-values of every element. The heat lost through ventilation is dependent on air changes for each hour through windows and other means of infiltration that may be available, as well as the cubic volume of every room.

Movement of heat by convection

Losses of energy by convection in a house can be stated as negligible in a home without wide-ranging calculations. For instance, in every piping system, air spaces exist between the insulation and the walls. The air gaps are estimated to be less than one-tenth of an inch. The spaces prevent the smooth flow of air, hence limiting heat loss through convection.

Movement of heat by radiation

Heat loss by radiation is a result of the transmission of heat through waves by extremely energized molecules. Heat loss through this medium requires the hotter surface to be above the ambient temperature.

Relationship between Radiation, Convection, and

Conduction

Practically, radiation and convection account for only 10% of the total energy lost in a system (Kokin, 2013). In light of the information from (Kokin, 2013), a general formula for calculating heat loss through the three mediums can be developed.

Movement of heat by conduction

Conduction denotes the transfer of heat through solids. In a house, the loss of heat by conduction is through the floor, ceiling, and walls. Conduction is the most considered mode of heat transfer. Heat tends to move from higher-temperature solids to lower-temperature ones. However, heat loss through conduction can be controlled through insulation.

The general equation of heat loss by conduction is,

$Q = A/R \times \Delta T$, where Q refers to heat flow, A refers to area, and R refers to the resistance commonly known as the R-factor, and ΔT is the temperature difference (James, 2017).

Calculations

The house in question is a 3-bedroom terraced house made of two external walls and two walls with separate neighbors. The apartment consists of a ground floor, a first floor, and a loft.

Heat loss via walls

The total area of the walls is,

(10m ×5m) × 2 (walls) =100m2

(10m × 5 m) × 2 (walls) = 100m2

The floor area is 10m × 10m = 100m2

Thus, the total surface area is 300 with an R-value of 0.7 K/ (m2W)

Calculating total heat loss during winter

Night

300m2/0.7 K/ m2W× (6 × 12×30) days × (21-0 + 273.15) k= 272mj

Day

300m2/0.7K/M2W × (6×12×30) days × (21-7 + 273.15) k = 265.83 mj

Summer

300m2/0.7K/ (M2W × (6×12×30) days × (21-20 +273.5) k = 254.12 mj

300m2/0.7K/ (M2W × (6×12×30) days × (21-13 +273.5) k = 270.01 Mj

Therefore, the total heat loss (in a year) of the walls that are not insulated is 265.83 +254.12 +270.01 +272 =1061.96 mj

Heat loss through the roof

The area of the roof is 10m by 10m, which is 100 m2. The R-factor is 0.7 K/ (m2W)

Calculating heat loss during winter

Night- 100m2/0.7 K/ m2W× (6 × 12×30) days × (21-0 + 273.15) k= 90.76 mj

Day- 100m2/0.7K/M2W × (6×12×30) days × (21-7 + 273.15) k = 88.61 mj

Summer

Day- 100m2/0.7K/ (M2W × (6×12×30) days × (21-20 +273.5) k = 84.71 mj

Night- 100m2/0.7K/ (M2W × (6×12×30) days × (21-13 +273.5) k =90.00 Mj

Heat loss via windows and doors

Winter- Day-2m2 /3.5 K/(m2w) × (6×12×30) × (21-7 + 273.15) k + 1m2 /3.5 K/(m2w) × (6×12×30) × (21-7 + 273.15) k=1.01 mj

Night-2m2 /3.5 K/(m2w) × (6×12×30) × (21-0+ 273.15) k + 1m2 /3.5 K/(m2w) × (6×12×30) × (21-0 + 273.15) k=0.54mj

Summer

Day-[2m2×3 /3.5 K/(m2w) ×3× (6×7×30) × (21-20 + 273.15) k] + [1m2 /3.5 K/ (m2w) ×4 × (6×12×30) × (21-20 + 273.15) k]=0.53 mj

Night-[2m2×3 /3.5 K/ (m2w) ×3× (6×12×30) × (21-13 + 273.15) k]+ [1m2 /3.5 K/ (m2w) × (6×12×30) × (21-13 + 273.15) k] =0.53

Heat loss through uninsulated pipe

Winter

Day-(3.14×0.015×0.001) m2/500× (80-7+273.5) × (6×12×30) =0.18 mj

Night (3.14×0.015×0.001) m2/500× (80-0+273.5) × (6×12×30) =0.17 mj

Day-(3.14×0.015×0.001) m2/500× (80-20+273.5) × (6×12×30) =0.17 mj

Night-(3.14×0.015×0.001) m2/500× (80-13+273.5) × (6×12×30) = 0.18 mj

Heat loss through radiators

In this case, the R-factor of the walls will be considered

The number of radiators is 5

Winter

Day-[1m2 /0.7 K/ (m2w) ×4 × (6×12×30) × (21-7 + 273.15) k]= 3.5 mj

Night-[1m2 /0.7 K/ (m2w) ×4 × (6×12×30) × (21-0 + 273.15) k]=3.63 mj

Summer

Day-[1m2 /0.7 K/ (m2w) ×4 × (6×12×30) × (21-20 + 273.15) k] =3.38 mj

Night-[1m2 /0.7/ (m2w) ×4 × (6×12×30) × (21-13 + 273.15) k]=3.60 mj

Heat loss through light bulb

Winter

Day-20×60 ×6×3×30×(21-7 + 273.15) k]= 185.43 mj

Night-20×60 ×6×2×30×(21-0 + 273.15) k]= 195 mj

Summer

Day-20×60 ×6×3×30×(21-20 + 273.15) k]= 178.12

Night-20×60 ×6×2×30×(21-13 + 273.15) k]=181.76

The total loss is, therefore, the sum of all the heat and light lost, which sums up to

2172.63 megajoules annually when the surfaces are not insulated.

Using Kokin's (2013) finding that convection and radiation account for only 10% of the total heat loss, then the total heat loss is,

2172.63 × 100/90 = 2414.03 MJ

The budget available for insulation and change of lighting appliances to more efficient bulbs is £2500 (streambank, 2014).

The cost of 5.53 m2 of rock wool is £361.25 per roll with a total surface area of 200m2 rocks. After calculating the total cost involved in the insulation process, total energy consumption is lower by 23%.

Conclusion

There is excellent potential for energy savings in apartments. An approach to energy conservation is to note the surfaces of the house that lose the most energy. The determination of the energy in the 3-bedroom apartment was to illustrate the surfaces losing the most energy. The walls, windows, and electrical appliances contributed to the highest heat loss. Insulation of surfaces is the best approach to conserving energy, as exemplified in the determination of energy loss in the calculation.

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