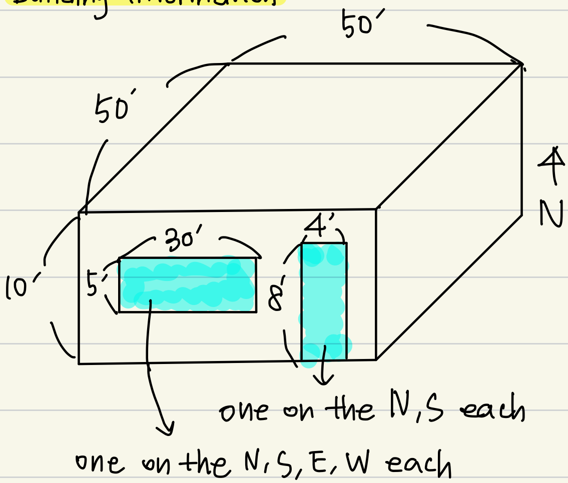
Assignment #2
Seungmin Lee

- Building information



- $T_{room} = 68\,°F$
- T_{oA} (Charlotte) $= 22\,°F$
  T_{oA} (Denver) $= 1\,°F$
  T_{oA} (Washington) $= 17\,°F$
- $(UA)_{tot}$ (Charlotte) $= 1{,}104.55$ Btu/F·hr
  $(UA)_{tot}$ (Denver) $= 1{,}154.84$ Btu/F·hr
  $(UA)_{tot}$ (Washington) $= 1{,}116.14$ Btu/F·hr

- Calculations

1. 1-1) ① $T_{b,JAN}$ (Charlotte, NC)

$Q_{Heat} \rightarrow 0,\quad 1{,}104.55\ \text{Btu/F·hr} \times (68°F - T_b) - Q_{int} = 0$

$$T_b = 68°F - \frac{Q_{int}}{1{,}104.55\ \text{Btu/F·hr}}$$

Q_{int} { People (1.6 Btu/hr·ft²)
Lights (2.0 Btu/hr·ft²)
Equipment (1.0 Btu/hr·ft²)
Solar (944 Btu/day·ft²)

$$Q_{int} = \underbrace{((1.6+2.0+1.0)\ \text{Btu/hr·ft}^2 \times 2{,}500\ \text{ft}^2 \times 9/24)}_{4{,}312.50\ \text{Btu/hr}}$$
$$+ \underbrace{(944\ \text{Btu/day·ft}^2 \times 600\ \text{ft}^2 \times \text{day}/24\text{hr})}_{23{,}600\ \text{Btu/hr}}$$
$$= 27{,}912.50\ \text{Btu/hr}$$

$$T_{b,JAN} = 68°F - \frac{27{,}912.50 \text{ Btu/hr}}{1{,}104.55 \text{ Btu/F·hr}} = 68°F - 25.27°F = 42.73°F$$

② $T_{b,JAN}$ (Denver, CO)

$$Q_{int} = 4{,}312.50 \text{ Btu/hr}$$
$$+ (1{,}465 \text{ Btu/day·ft}^2 \times 600 \text{ ft}^2 \times \text{day}/24 \text{ hr})$$
$$= (4{,}312.50 + 36{,}625) \text{ Btu/hr} = 40{,}937.50 \text{ Btu/hr}$$

$$T_{b,JAN} = 68°F - \frac{40{,}937.50 \text{ Btu/hr}}{1{,}154.84 \text{ Btu/F·hr}} = 68°F - 35.45°F = 32.55°F$$

③ $T_{b,JAN}$ (Washington, DC)

$$Q_{int} = 4{,}312.50 \text{ Btu/hr}$$
$$+ (793 \text{ Btu/day·ft}^2 \times 600 \text{ ft}^2 \times \text{day}/24 \text{ hr})$$
$$= (4{,}312.50 + 19{,}825) \text{ Btu/hr} = 24{,}137.50 \text{ Btu/hr}$$

$$T_{b,JAN} = 68°F - \frac{24{,}137.50 \text{ Btu/hr}}{1{,}116.14 \text{ Btu/F·hr}} = 68°F - 21.63°F = 46.37°F$$

1-2) ① $Q_{heat,JAN}$ (Charlotte)

$$\begin{cases} HDD\,50 = 255 \text{ (from table)} \\ HDD\,22 = 0 \\ HDD\,42.73 = x \end{cases}$$

$$\frac{42.73-22}{50-22} = \frac{x-0}{255-0}, \quad x = 188.79$$

$$Q_{heat,JAN} = (UA)_{tot} \times HDD_{42.73} \times 24$$

$$= \underbrace{1,104.55}_{Btu/F \cdot hr} \times 188.79 \times 24 = 5 \text{ MM Btu/JAN}$$

② $Q_{heat,JAN}$ (Denver)

$$\begin{cases} HDD\,50 = 623 \\ HDD\,1 = 0 \\ HDD\,32.55 = x \end{cases}$$

$$\frac{32.55-1}{50-1} = \frac{x-0}{623-0}, \quad x = 401.14$$

$$Q_{heat,JAN} = 1,154.84 \text{ Btu/F}\cdot\text{hr} \times 401.14 \times 24$$

$$= 11.12 \text{ MM Btu/JAN}$$

③ $Q_{heat,JAN}$ (Washington)

$$\begin{cases} HDD\,50 = 555 \\ HDD\,17 = 0 \\ HDD\,46.37 = x \end{cases}$$

$$\frac{46.37-17}{50-17} = \frac{x-0}{555-0}, \quad x = 493.95$$

$$Q_{heat,JAN} = 1{,}116.14\ Btu/F\ hr \times 493.95 \times 24$$
$$= 13.23\ MMBtu/JAN$$

1-3) ① $Q_{heat,use,JAN}$ (charlotte)

$$= [(UA)_{tot} \times (HDD_{42.73} \times 24)] / K$$

K = boiler efficiency = 80% = 0.8

$$Q_{heat,use,JAN} = [1{,}104.55 \times 188.79 \times 24] / 0.8$$
$$= 6.26\ MMBtU/JAN$$

② $Q_{heat,use,JAN}$ (Denver)

$$= [1{,}154.84 \times 401.14 \times 24] / 0.8 = 13.90\ MMBTU/JAN$$

③ $Q_{heat,use,JAN}$ (Washington)

$$= [1{,}116.14 \times 493.95 \times 24] / 0.8 = 16.54\ MMBtU/JAN$$

1-4) ① $Q_{cost,JAN}$ (charlotte)

6.2 MMBtU / 100 kBtU = 62 Therms

$$= 62\ Therms \times \underset{\text{gas price}}{\underline{\$1/Therms}} = \$62$$

② $Q_{cost,JAN}$ (Denver)

$= \underbrace{139 \text{ Therms}} \times \$1/\text{Therms} = \$139$

↳ 13.9 MMBtu / 100kBTU = 139 Therms

③ $Q_{cost,JAN}$ (Washington)

$= \underbrace{165 \text{ Therms}} \times \$1/\text{therms} = \$165$

↳ 16.5 MMBtu / 100kBTU = 165 Therms

2. 2-1) ① Washington = 13.23 MM BtU/JAN

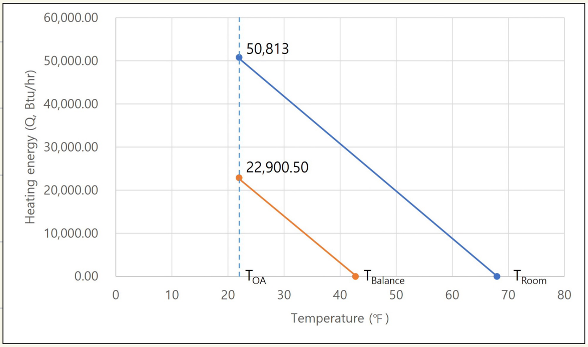
② Denver = 11.12 MMBtU/JAN

③ Charlotte = 5 MMBtU/JAN

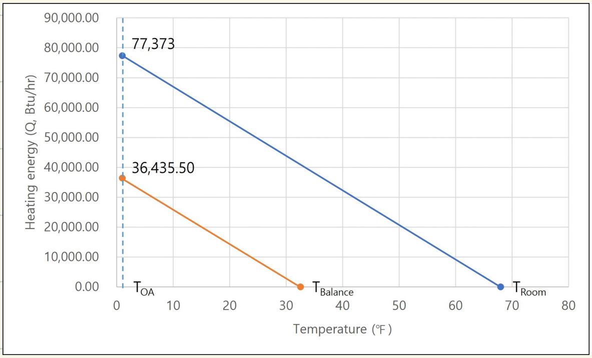
→ I think the heating energy calculated in Q.1 was influenced by HDD_{T_b}. T_b is the outside air temperature when heat loss and heat gain are balanced in the building, so the balance point temperature is different in each region. When HDD is calculated based on this temperature, the results are HDD. Here, Washington = 434.95, Denver = 401.14, Charlotte = 188.79. Therefore, Washington has the highest heating energy, and Charlotte has the lowest heating energy requirements.

2-2)

Charlotte



Denver



Washington