**Energy Units:**

1. Joule (J)
2. Watt-hour (Wh)
3. Calorie
4. British Thermal Unit (BTU)

**Relations Between Energy Units:**

Table 1: Relation between the energy units and the SI energy unit (Joule)

|  |  |
| --- | --- |
| 1 Calorie | 4.18 J |
| 1 kWh | 3.6 MJ |
| 1 BTU | 1055 J |

Table 2: Relation between kWh and BTU

|  |  |
| --- | --- |
| 1 kWh | 3428 BTU |

**Energy formulas:**

Table 3: Energy formulas

|  |  |  |
| --- | --- | --- |
| Kinetic Energy |  | m: mass  v: velocity |
| Heat Energy |  | m: mass  Ch: specific heat (J/K) |
| Potential Energy |  | m: mass  g: gravity constant  h: height |

**Renewable Energy Formulas:**

Table 4: Renewable Energy formulas

|  |  |  |
| --- | --- | --- |
| Capacity Factor | ∴ | C: Rated capacity of the generator  H: working period |

**Example 1 (Unit Converging):**

A marathon runner burns 2,000 calories during the race (26.2 miles). The race was completed in 4 hours. How many kWh does he burn? What is the average output power?

Answer:

1. Energy calculation:
2. Converting the calories into Joules:

1 calorie = 4.18 J from Table.1

2000 calorie = 2000 x 4.18 = 8.36 kJ

1. Converting from Joules into kWh:

3.6 MJ = 1 kWh from Table.1

8.36 kJ = 0.00232 kWh

1. Power calculation:
2. Power is the energy over the time period

P = 0.00232/4 = 580 mW

**Example 2 (Kinetic Energy):**

A wind turbine converts with 30% efficiency the kinetic energy of the air mass that passes through its rotor area. Assume the air is travelling at a speed of 10m/s, the density of air is 1.2 kg/m^3 and the rotor diameter is 90 m. How much electric energy, in kWh, does the wind turbine produce during one hour?

Answer:

To get the kWh energy of the wind turbine we should find the Joule energy that the air causes using the kinetic energy formula.

The mass of the air is unknown but its speed is. To get the mass we should use the density equation:

The volume of the air can be calculated as the volume in **one second** considering a cylindrical shape for the air mass passing through the turbine blade.

where *l* is the length of the air mass passing through the turbine in **one second** and *r* is the radius of the rotor blades.

The question is asking for the energy generated in one hour so the length of the air mass in one hour is:

Now the mass can be found as:

The kinetic energy can be formulated as:

Finally substituting the values of the variables, we get:

Converting the Joules energy into kWh gives:

3.6 MJ = 1 kWh

13741.2 MJ = 3817 kWh

Finally, the efficiency of the turbine is 30% so the final energy is:

Total Energy = (3817) x 0.3 = 1145.1 kWh.

**Example 3 (Temperature and heat):**

You plan on using large mirrors to reflect sunlight onto a container to heat your shower water. You will use 30 liters of water in your shower at a temperature of 120 °F, the unheated water is at 60 °F. How much energy must be applied to the water in kWh? Ignore the presence of the container in the calculation.

• Note: 𝐶ℎ = 4186 J/K for water, 1L weighs 1 kg.

Answer:

To get the kWh energy that must be supplied to the water we should find the Joule energy that is needed to heat the water to the 120 ℉ from 60 ℉ using the thermal equation.

where T is in Kelvin.

Converting the ℉ temperatures to kelvins gives:

60 ℉ = 288.706 K

120 ℉ = 322.039 K

Therefore, the temperature difference can now be calculated as:

The next step is to find the heat transfer in joule:

Finally, we convert the joules into kWh using Table.1

3.6 MJ = 1 kWh

4.186 MJ = 1162.7 kWh