

Heat engines Carnot efficiency $\eta = (T_h - T_c) / T_c$

Combined heat and power CHP efficiency

$$\eta_{\text{CHP}} = \frac{\text{net power output} + \text{heat recovered}}{\text{energy input}}$$

U-value - the rate at which heat flows through an area of 1m^2 when the temperature change across it is 1°C . From the heat equation

$$J = -\kappa \frac{\Delta T}{\Delta x}$$

$$\text{obtain } U = \frac{J}{\Delta T} = -\frac{\kappa}{\Delta x}$$

$$\frac{1}{U} = \frac{1}{h_{in}} + \sum_j R_j + \frac{1}{h_{out}}$$

Fabric loss $P = UA(T_{in} - T_{air})$

Ventilation $P = V(\rho C_P)(n/3600)(T_{in} - T_{air})$

Noise $L_P = 10 \times \log \left(\frac{P_{\text{rms}}^2}{P_{\text{ref}}^2} \right) = 10 \times \log \left(\frac{I_{\text{rms}}}{I_{\text{ref}}} \right)$

Passive solar heat an absorbing wall

$$m_{\text{wall}} C_{\text{wall}} \frac{dT_{\text{room}}}{dt} = taSA - UA(T_{\text{room}} - T_{\text{surr}})$$

In steady state, $taSA = UA(T_{\text{room}} - T_{\text{surr}})$.

Domestic heating - capture efficiency

$$n = ta - U \frac{T_{\text{out}} - T_{\text{in}}}{S}$$

Photovoltaics sunlight creates electron-hole pairs in semiconductor.

Solar concentrators towers & furnaces. Parabolic troughs or paraboloid mirrors. Cannot use diffuse radiation.

Maximum power in fluids: $\frac{1}{2}\rho u^3$ per unit area.

Hydropower Power = ρQgh where $Q = uA$ is the flow rate at the top

Impulse turbine Water passes through nozzles; jets hits cups on wheel perimeter and deflected by 180° . $u(\text{Turbine}) = u/2$

Tidal power Maximum energy per tide $(\rho AR)g(\frac{R}{2})$ where R is the tidal range. Mean power $\bar{P} = \rho AR^2g/2\tau$

Wave power Water column (and air above) oscillates in cavity. Air forced past turbine as waves come in and out.

Wind power

$$P = \frac{1}{2} C_P \rho A_1 u_0^3$$

where $C_P = 4a(1 - a)^2$ and $a = 1 - u_1/u_0$ (Betz limit). Greatest value about 59%
Arrays of turbines in wind farms.

Nuclear power In *fission reactors*, U (or Th, Pu) nuclei broken up by neutron bombardment releasing energy and excess neutrons. In *fusion reactors* hoped to use deuterium-tritium reaction to get power.