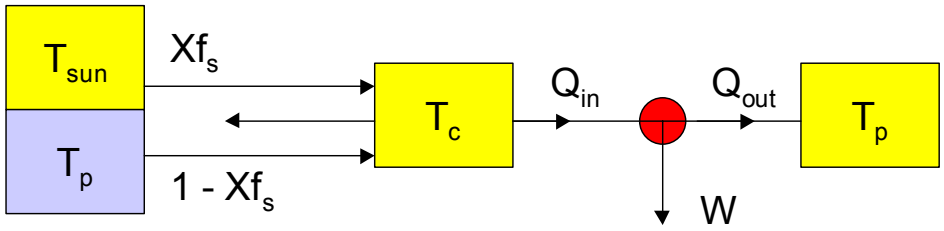
Lecture 18: Solar thermal energy conversion

Analysis of solar thermal converter:



Balance radiative power at converter: $\dot{Q}_{in} = Xf_s \sigma T_{sun}^{\ 4} + (1 - Xf_s)\sigma T_p^{\ 4} - \sigma T_c^{\ 4}$

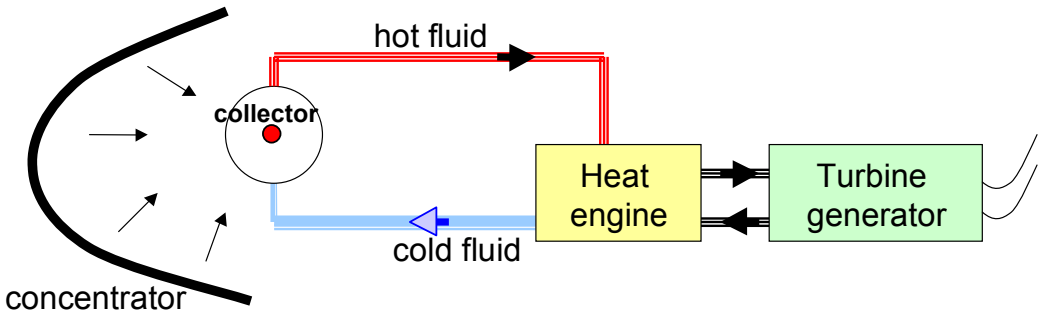
Conservation of energy: $\dot{W} = \dot{Q}_{in} - \dot{Q}_{out}$

Conservation of entropy in Carnot cycle: $\frac{\dot{Q}_{in}}{T_c} - \frac{\dot{Q}_{out}}{T_p} = 0$

Power conversion efficiency: $\eta = \frac{\dot{W}}{Xf_s \sigma T^4}$

$$\eta = \left\{1 + \frac{1 - Xf_s}{Xf_s}\left(\frac{T_p}{T_{sun}}\right)^4 - \frac{1}{Xf_s}\left(\frac{T_c}{T_{sun}}\right)^4\right\}\left(1 - \frac{T_p}{T_c}\right)$$

Elements of solar thermal electric system



Concentrator: parabolic dish or array of heliostats (2D) ($X \leq 800$); parabolic trough (1D) ($X \leq 80$)

Collector: thermal fluid (water, oil, molten salt) inside evacuated tube. T_c up to 580 °C

Heat engine: Rankine (steam) or Brayton (gas) engine