Imposing an energy balance about the heat source, one can write:

$$\dot{m} = \frac{Q_{in}}{\int_{T_o}^{T_i} C_p(T)dT} \qquad (1)$$

Consider an infinitesimal element in the primary radiator. Applying energy conservation:

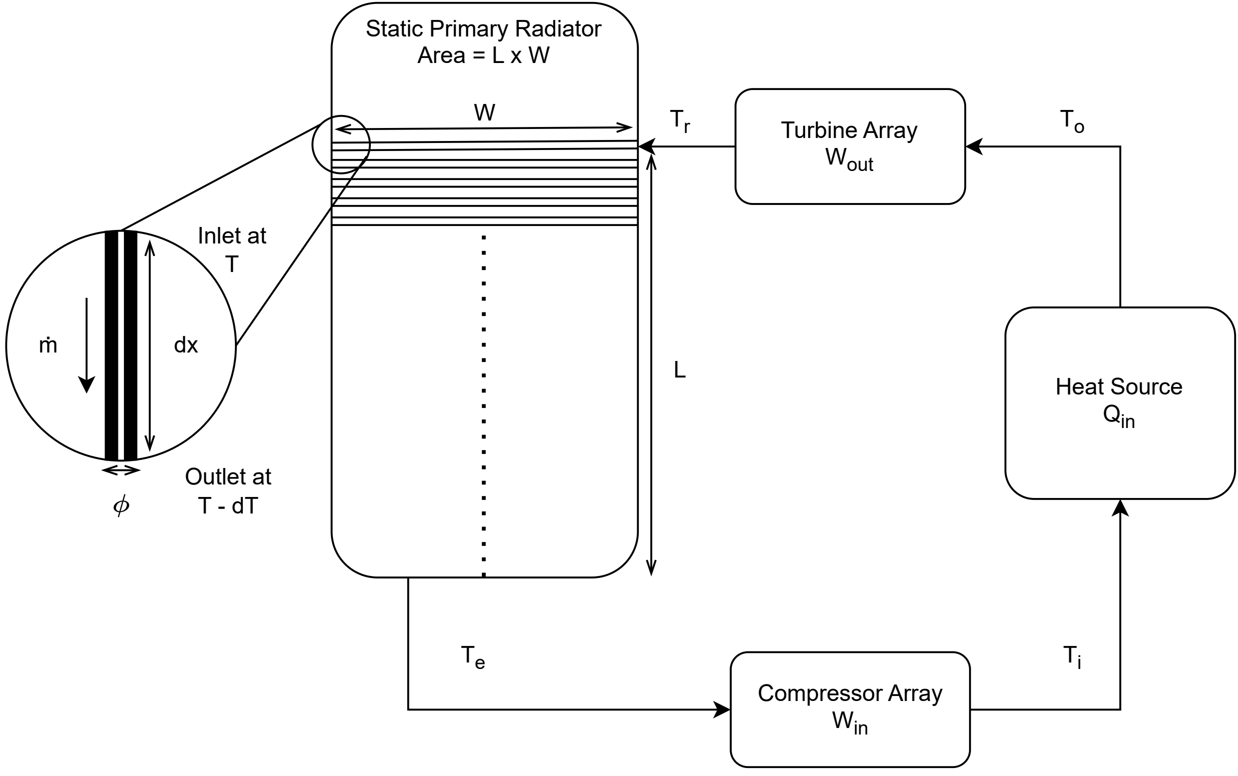
$$dQ = \dot{m}C_p(T)dT = \epsilon\sigma_b\phi(T^4 - {T_a}^4)dx \qquad (2)$$

Where T_a is the ambient temperature and ϵ is the surface emissivity coefficient

The above equations in $\dot{m}$ and T can be numerically solved if $C_p(T)$ is known. The maximum thermal to electrical conversion efficiency is then:

$$\eta_{th} = \eta_{gen}\frac{W_{out} - W_{in}}{Q_{in}} \qquad (3)$$

Where η_{gen} is the generator's efficiency



For He-Xe cooled systems, $C_p = 2.5\frac{R}{MM}$ and it is constant for $T > 400K$. The constant C_p value leads to simpler solutions for $\dot{m}$ and T. Rearranging (2):

$$\int \frac{dT}{T^4 - {T_a}^4} = \frac{\epsilon\sigma_b\phi}{\dot{m}C_p}\int dx \qquad (4)$$

However, $T_a << T$ in space, which simplifies the LHS. The limits for the LHS integration are from T_r to T_e. For the RHS, using an assumption that the radiator is a single long tube folded into N sections of W length and ϕ apparent diameter, one has $\phi\int dx = \phi NW = \phi\frac{L}{\phi}W = LW$. Putting that result and (1) in (4):

$$\left[\frac{1}{3{T_e}^3} - \frac{1}{3{T_r}^3}\right]\left[\frac{1}{T_o - T_i}\right] = \frac{\epsilon\sigma_b LW}{Q_{in}} \qquad (5)$$

If the pressure ratio (PR) is isentropically defined as the ratio of the outlet to the inlet temperature raised to $\frac{\gamma}{\gamma-1}$, the pressure balance in the system is:

$$CPR = \frac{F_p}{TPR} \qquad (6)$$

Where CPR is the compressor array pressure ratio, TPR is the turbine array pressure ratio and F_p is a pressure factor to account for pressure losses in the cycle from phenomena like friction and fluid expansion.

If one defines T_o, TPR and F_p, that results in:

$$T_r = T_o(TPR)^{\frac{\gamma-1}{\gamma}} \qquad \& \qquad T_i = T_e\left[\frac{F_p}{TPR}\right]^{\frac{\gamma-1}{\gamma}}$$

Substituting for T_r and T_i in (5) enables one to find T_e via numerical solution.

Finally, one can express the system's conversion efficiency using an energy balance: $\eta_{th} = \eta_{gen}\frac{T_o - T_r - T_i + T_e}{T_o - T_i}$. Substituting for T_r and T_i yields:

$$\eta_{th} = \eta_{gen}\frac{T_o\left[1 - (TPR)^{\frac{\gamma-1}{\gamma}}\right] - T_e\left[\left(\frac{F_p}{TPR}\right)^{\frac{\gamma-1}{\gamma}} - 1\right]}{T_o - T_e\left(\frac{F_p}{TPR}\right)^{\frac{\gamma-1}{\gamma}}} \qquad (7)$$