Event 470: PM removal (1) vs. processes in series?

There is an instructive analogy between energy conversion systems and PM 'collectors' in series:

Chemical energy

\[ E_1 = 0.98 \]


\[ E_2 \approx 0.40 \]

\[ E_3 \approx 0.98 \]

\[ \Rightarrow E_{\text{overall}} = E_1 E_2 E_3 = (0.98)(0.40)(0.98) \leq 0.40 \] (12)

\[ \text{RDS} \]

:: Efficiency of a power plant is lower (or at least equal to) that of the lowest-efficiency component!

PoC with lots of PM

\[ \begin{aligned}
0.75 & \quad \rightarrow \quad 0.75 \\
\eta_1 & \quad \rightarrow \quad \eta_2 \\
\end{aligned} \]

\[ \text{PoC with (much?) less PM} \]

\[ \eta_{\text{overall}} = (0.75)(0.75) = 0.94 \] (12)

:: Efficiency of collectors in series is higher than that of any one of individual collectors!? (For parallel collectors: \( E_1 < E_{\text{overall}} < E_2 \))

\[ \text{Demonstration?} \]
Yet another version of Ohm's Law!? 

(⇒ can make PM removal VERY efficient!)

\[ \eta = \text{efficiency of process} \]
\[ \text{e.g., degree of conversion, particle capture, etc.} \]

Series

\[ \eta_1 = 1 - \frac{C_1}{C_i} \Rightarrow \frac{C_i}{C_1} = (1 - \eta_1) \]
\[ \eta_2 = 1 - \frac{C_2}{C_1} \Rightarrow \frac{C_2}{C_1} = (1 - \eta_2) \]
\[ \eta_{\text{overall}} = \left( 1 - \frac{C_f}{C_i} \right) = \left( 1 - \frac{C_2}{C_1} \right) = \left( 1 - (1 - \eta_1) \right) \left( 1 - \eta_2 \right) \]

Parallel

\[ \eta_1 = \frac{Q_1 C_i - Q_1 C_1}{Q_1 C_i} = 1 - \frac{Q_1 C_1}{Q_1 C_i} \]
\[ \eta_2 = \frac{Q_2 C_1 - Q_2 C_2}{Q_2 C_i} \]
\[ \eta_{\text{overall}} = \left( 1 - \frac{Q_f}{Q_i} \right) = 1 - \frac{Q_1 C_i + Q_2 C_2}{Q_i} \]

\[ \text{vs.} \]

\[ \Rightarrow \]

\[ \text{Series} \]

\[ \text{Parallel} \]