Boilers, Furnaces, etc.

- How to reduce operating costs (save $)
  - Turn it off!
  - Reduce heat loss (insulate hot surfaces)
  - Preheat water (for boiler)
  - Preheat fuel
  - Preheat Air
  - Recover waste heat from stack
    - Air preheater
    - "Economizer" → water preheater.
    - Condensing economizer allows
      $T_{\text{stack}} \leq 200^\circ\text{F}$ or less (Built to withstand condensation.)
  - Minimize excess air (O₂) in stack.
    - ~3% - 5% is very good
    - 25% O₂ on a dry basis
    - 8% is good for non-modern controls
    - >8% → room to improve
Combustion:

\[
\begin{align*}
H & \rightarrow H_2O \\
C & \rightarrow CO_2 \\
S & \rightarrow SO_2 \\
N_2 & \rightarrow N_2 \\
\end{align*}
\]

Look at CH₄ combustion:

\[
CH_4 + (1+EA) \frac{1}{2} (O_2 + 3.76N_2) \rightarrow \frac{1}{2} (O_2) + \frac{1}{2} (3.76N_2)
\]

% O₂ in products? "EA" moles of O₂ in products

products: \( M_{O_2} = EA \times 32 \)

\[
\begin{align*}
M_{\text{products (not water)}} &= EA \times 32 + \frac{1}{2} \times 44 + (1+EA) \times 2 \times 3.76 \times 28 \\
&= \frac{EA \times 32}{EA \times 32 + 44 + (1+EA) \times 2 \times 3.76 \times 28}
\end{align*}
\]

% O₂ products = \( \frac{EA \times 32}{EA \times 32 + 44 + (1+EA) \times 2 \times 3.76 \times 28} \)

\[
\frac{A}{F} = (\text{molar A/F}) = \frac{(1+EA) \times 2 \times 4.76}{1}
\]

\[
A = \frac{A}{F} \frac{M_{\text{air}}}{M_{\text{sulf}}} = \frac{(1+EA) \times 2 \times 4.76 \times Z8.97}{1 \times 16}
\]