BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING

Institute of Process Engineering

# Innovative Method for Fuel Saving Calculation Related to Energy Retrofit of Thermal Waste Processing Units

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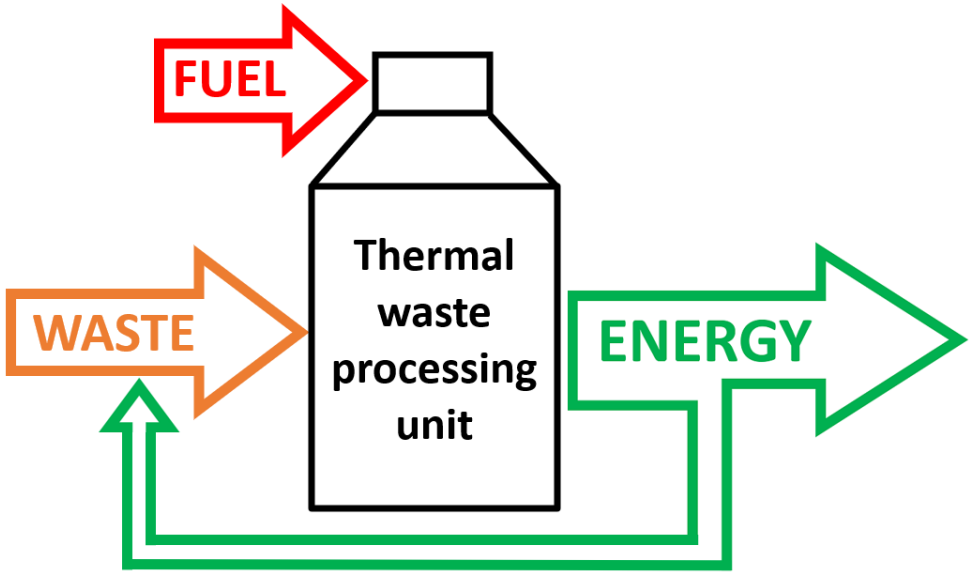
Ph.D. student
Researcher

**Dr. Zdeněk Jegla**
Associate professor

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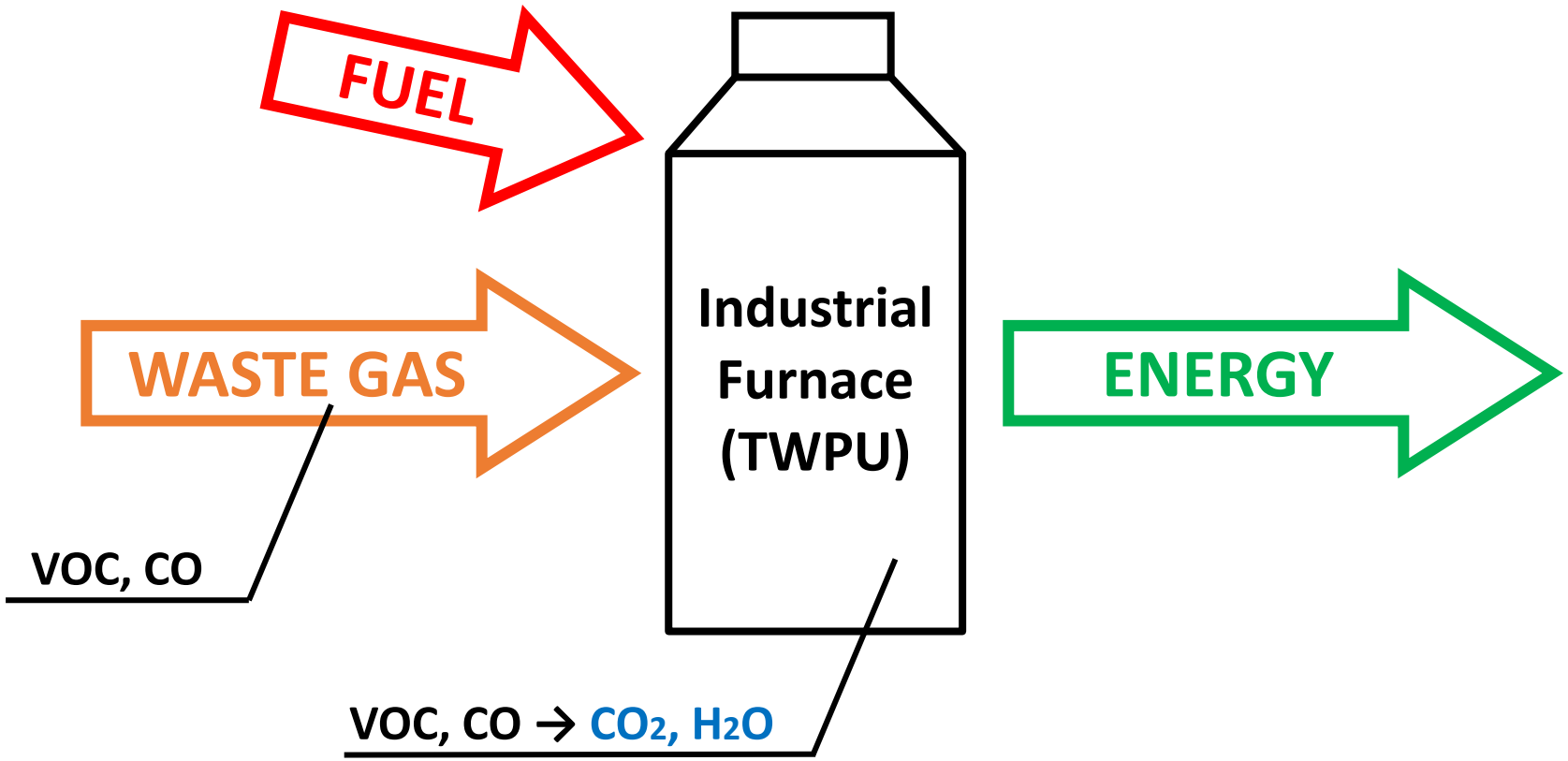

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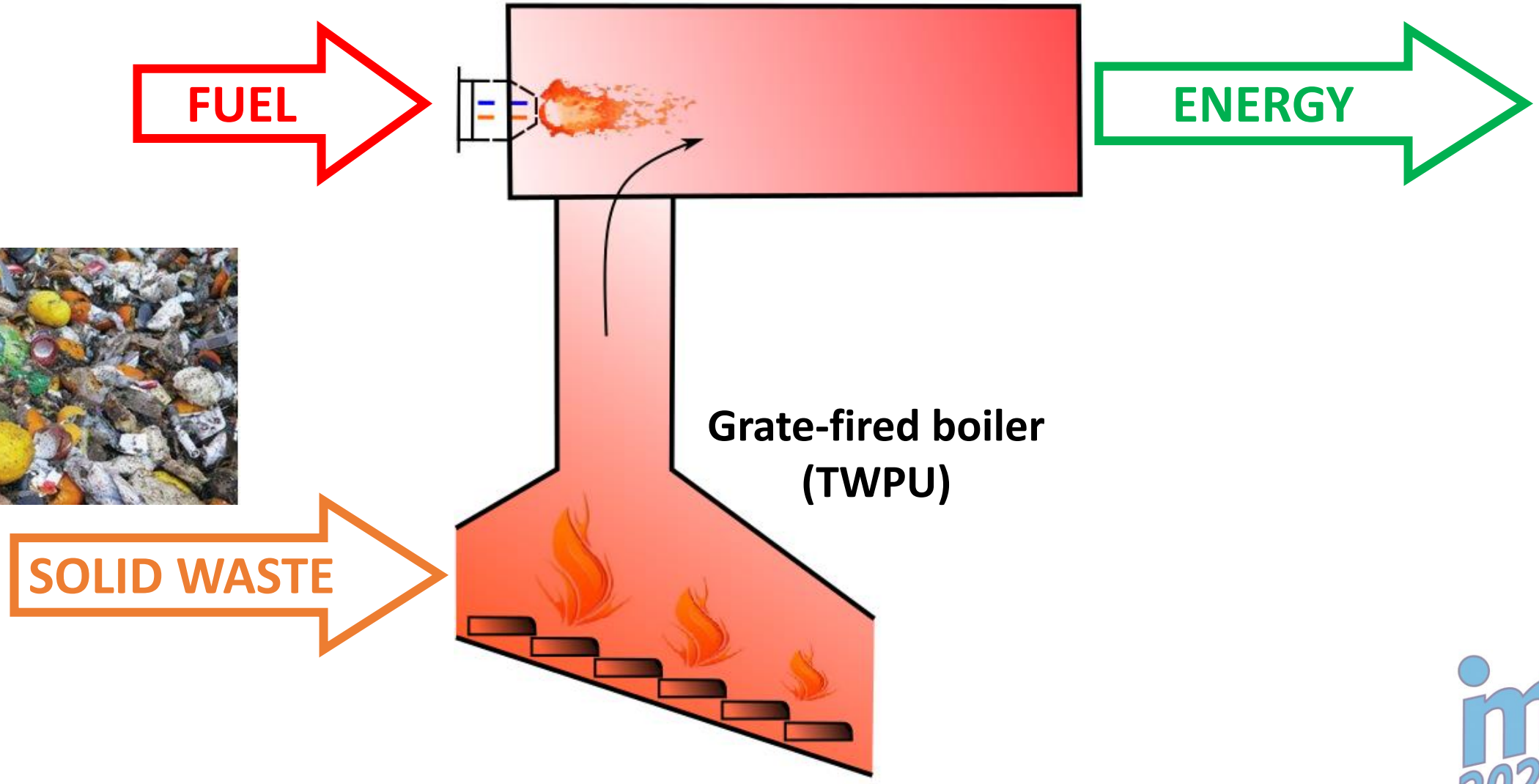

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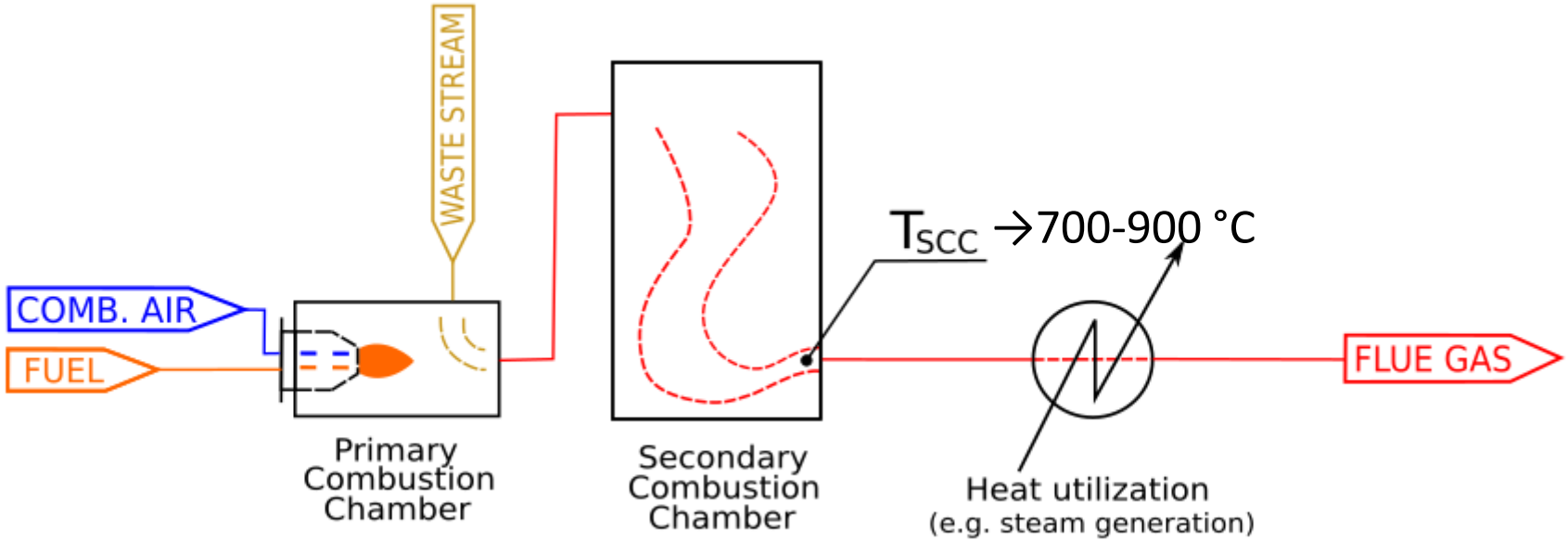

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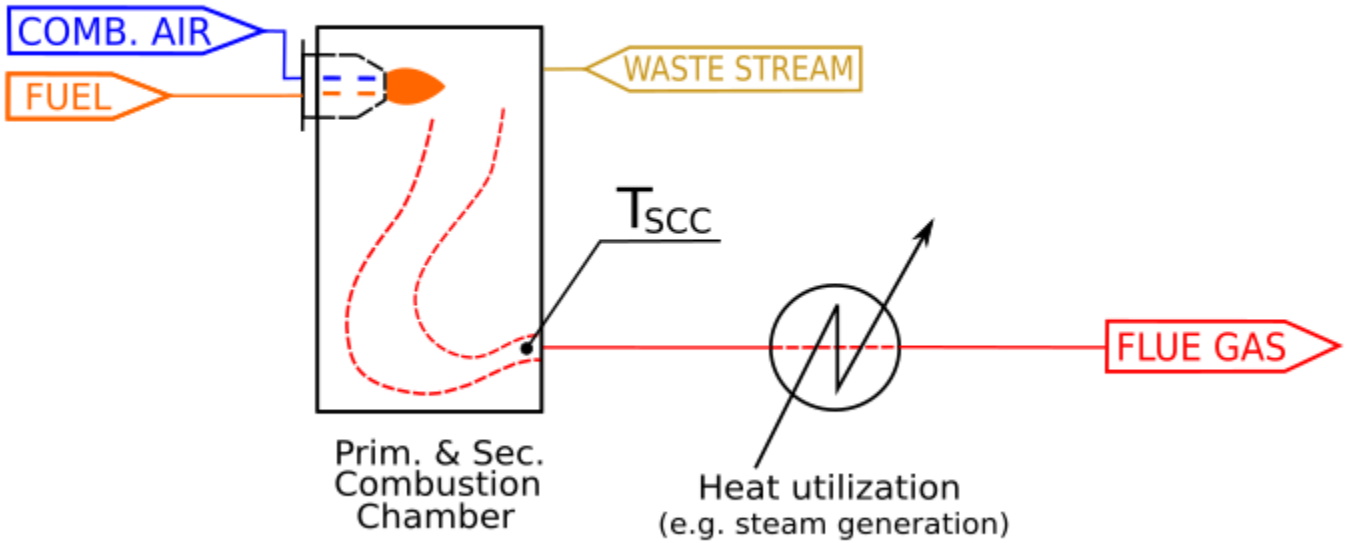

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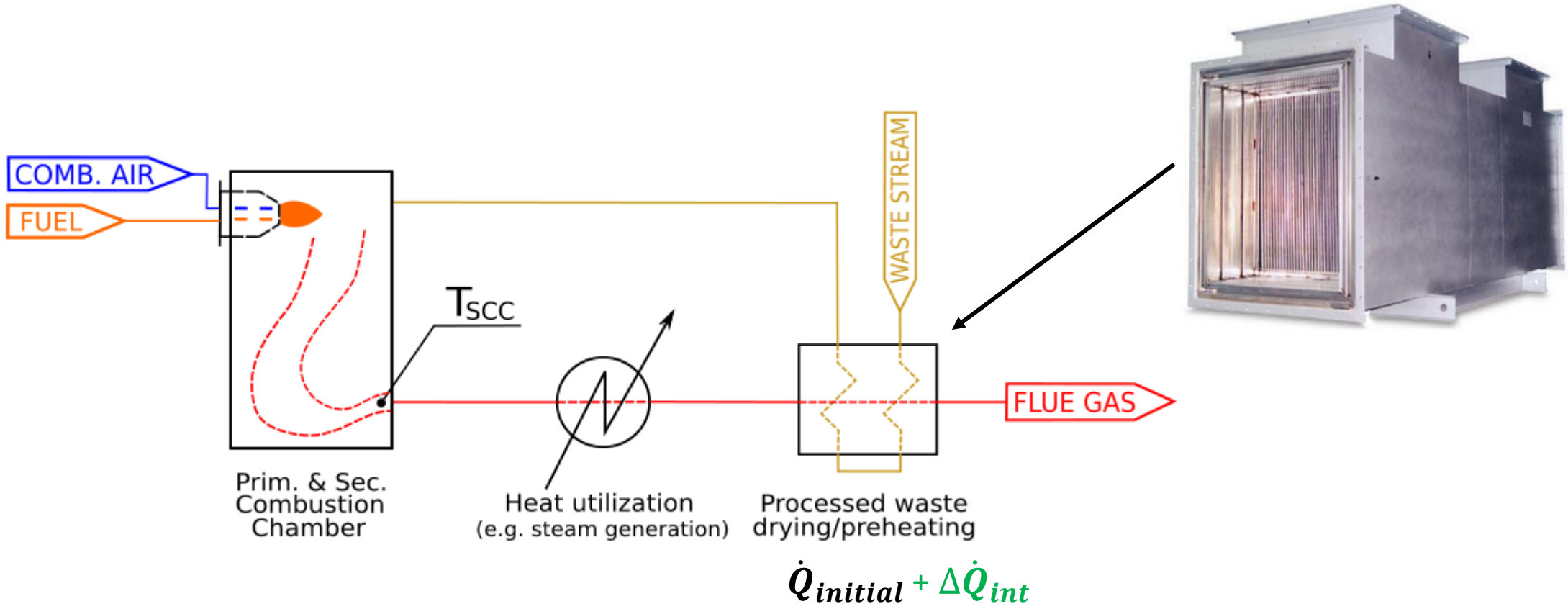

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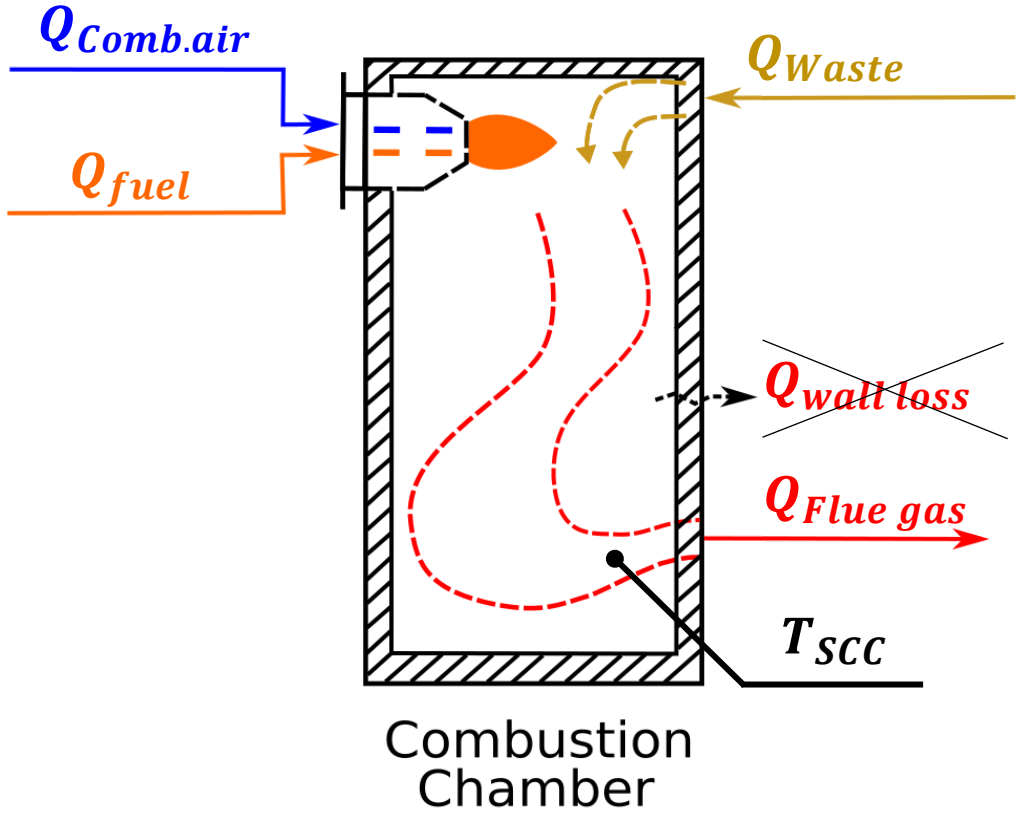


## ENERGY BALANCE

$$\Delta\dot{Q}_{int} + Q_{Waste} + Q_{fuel} + Q_{Comb.air} = Q_{Flue\ gas}$$

$$Q = f(T; \dot{m}; composition) \qquad Q = f(T; \dot{m})$$

**How could be fuel saving calculated using $\Delta Q_{int}$?**

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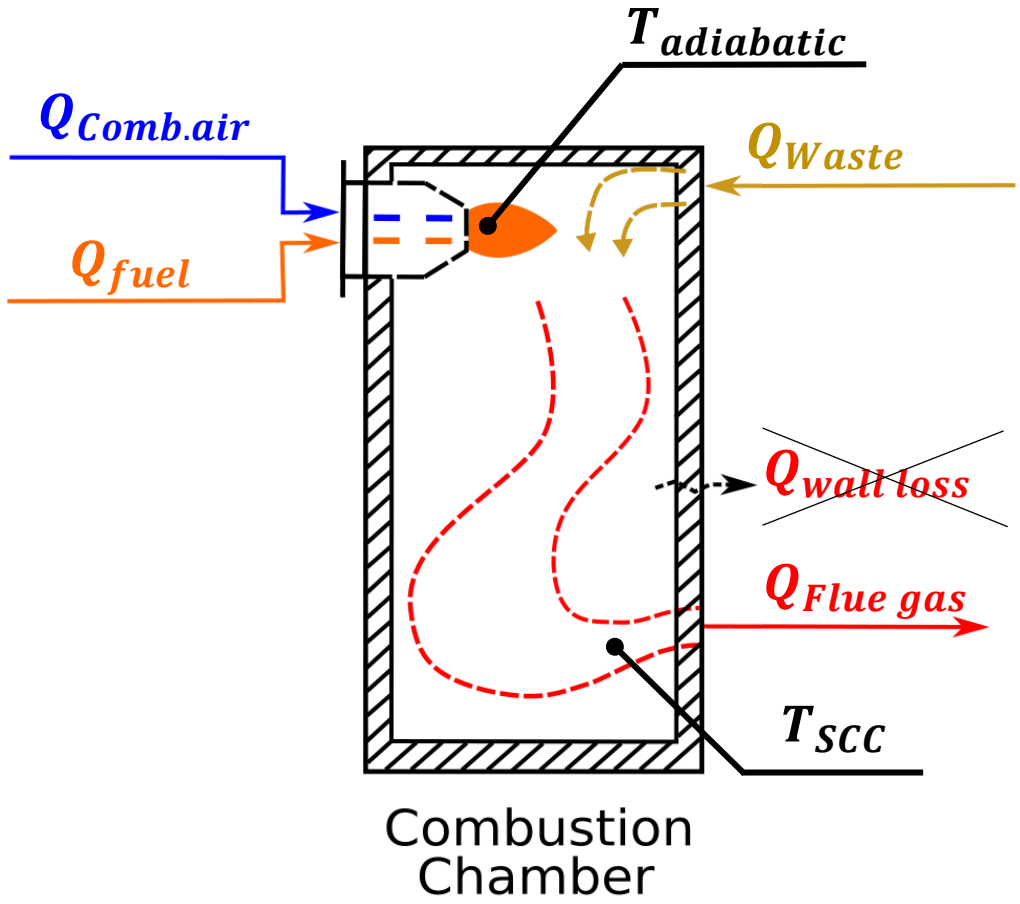
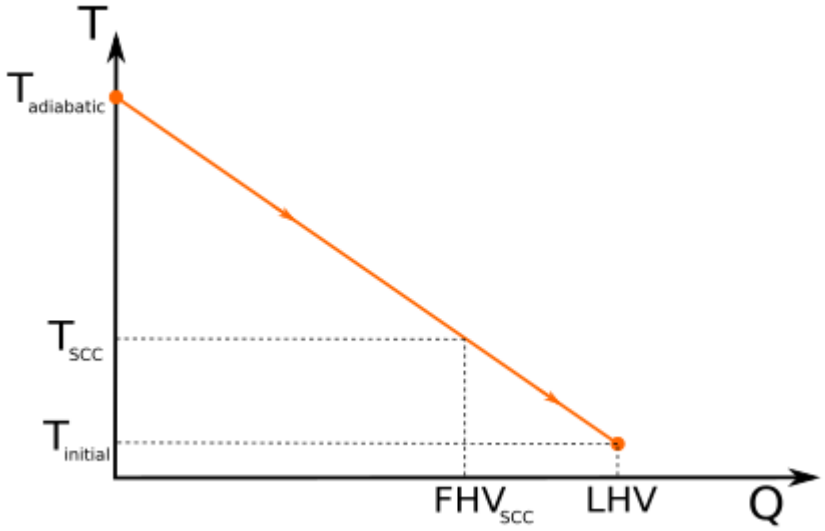



**How could be fuel saving calculated using $\Delta Q_{int}$?**

**By application of LHV (Lower Heating Value).**



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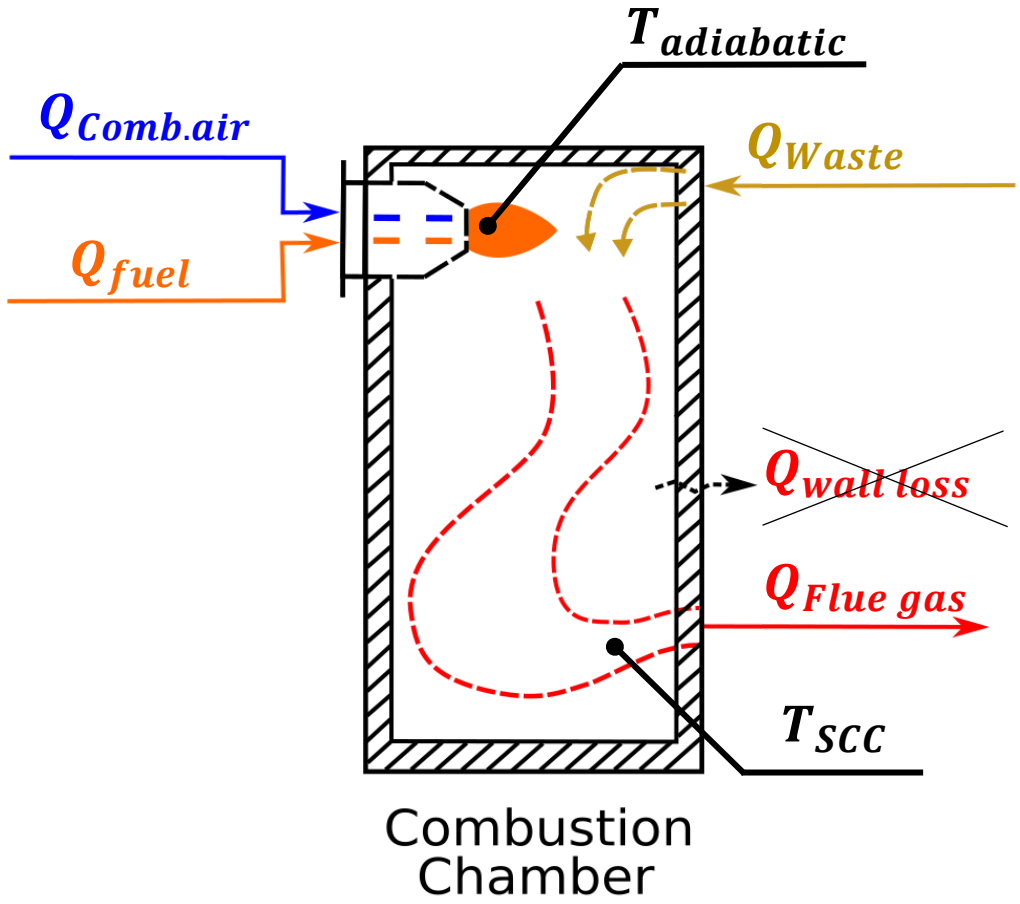


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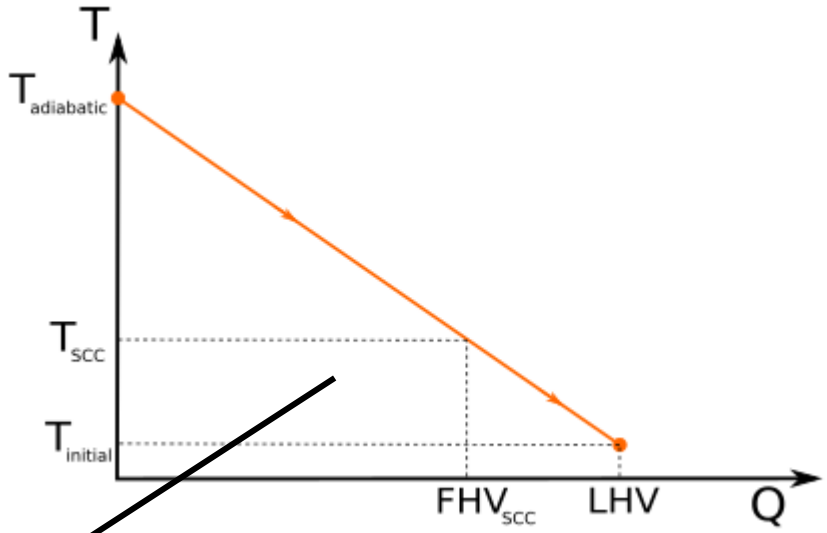


$$\frac{LHV}{T_{adiabatic} - T_{initial}} = \frac{FHV_{SCC}}{T_{adiabatic} - T_{SCC}}$$

$$FHV_{SCC} = LHV \cdot \frac{T_{adiabatic} - T_{SCC}}{T_{adiabatic} - T_{initial}}$$

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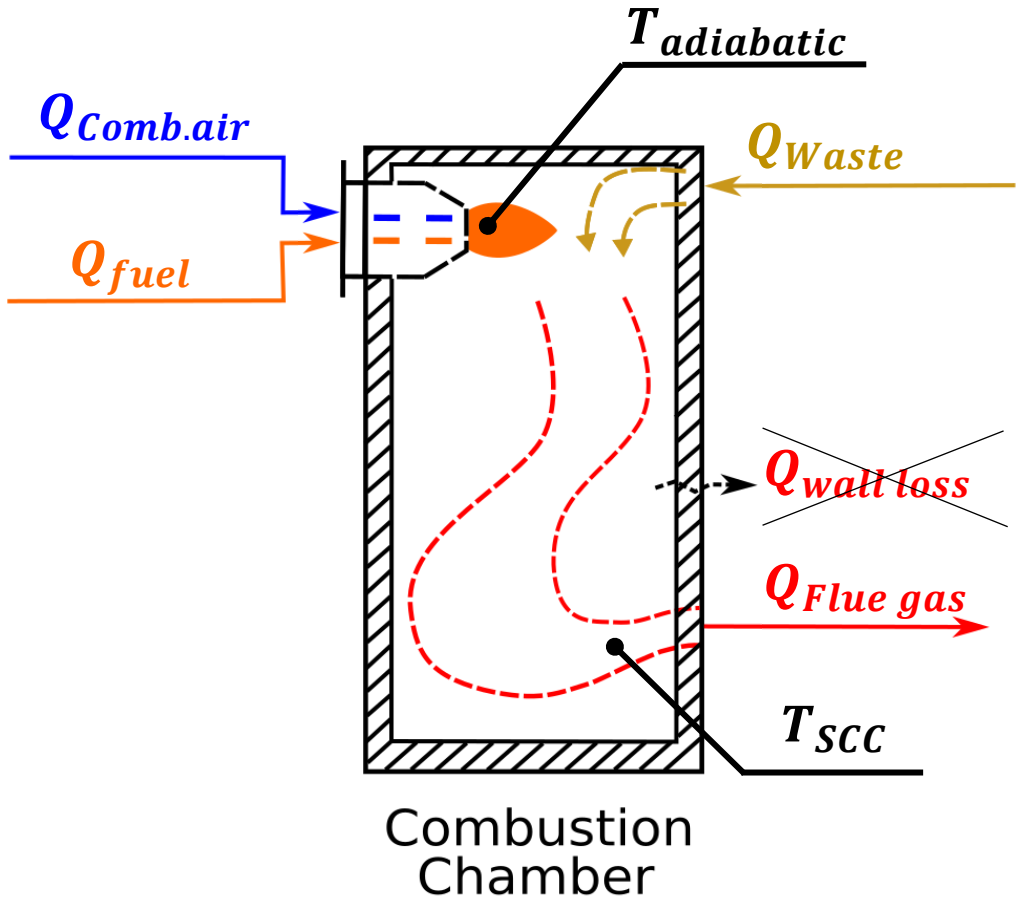


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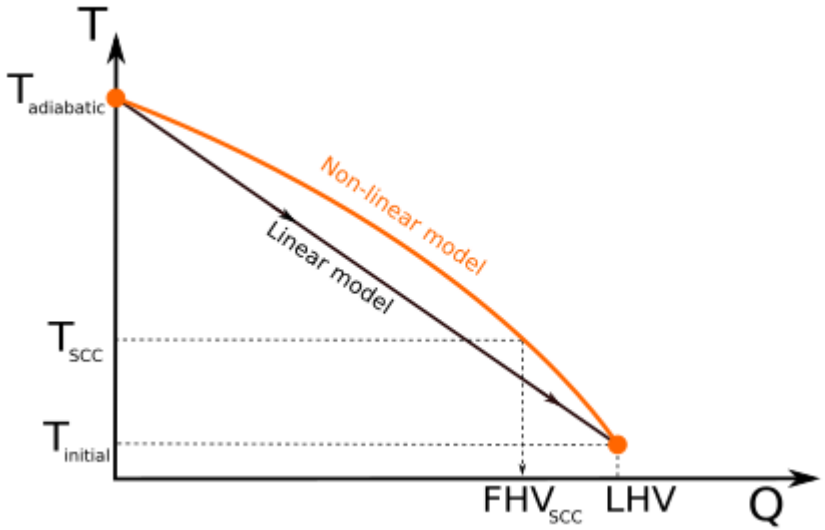



$$n_c = 1,07 - 1,09$$

$$FHV_{SCC} = n_c \cdot LHV \cdot \frac{T_{adiabatic} - T_{SCC}}{T_{adiabatic} - T_{initial}}$$

$$\Delta f_s = \Delta Q_{int} / FHV_{SCC}$$

# Developed equations:

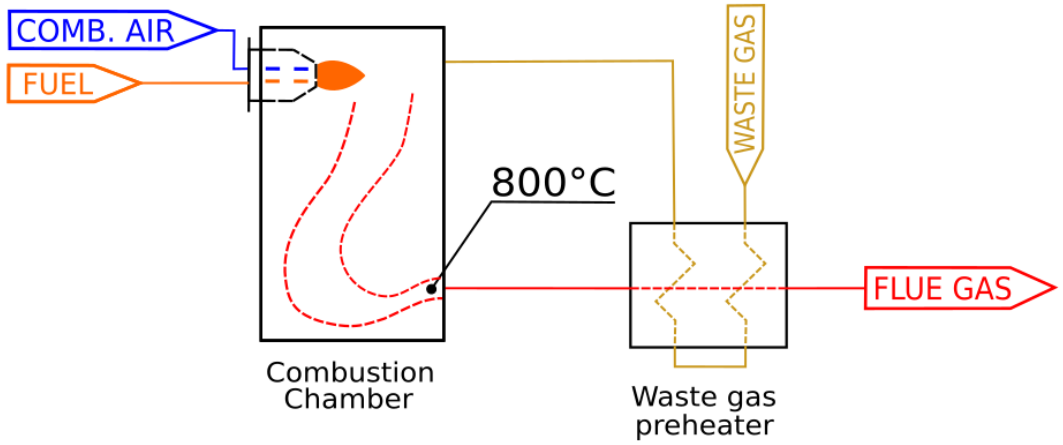
$$FHV_{SCC} = n_c \cdot LHV \cdot \frac{T_{adiabatic} - T_{SCC}}{T_{adiabatic} - T_{initial}}$$

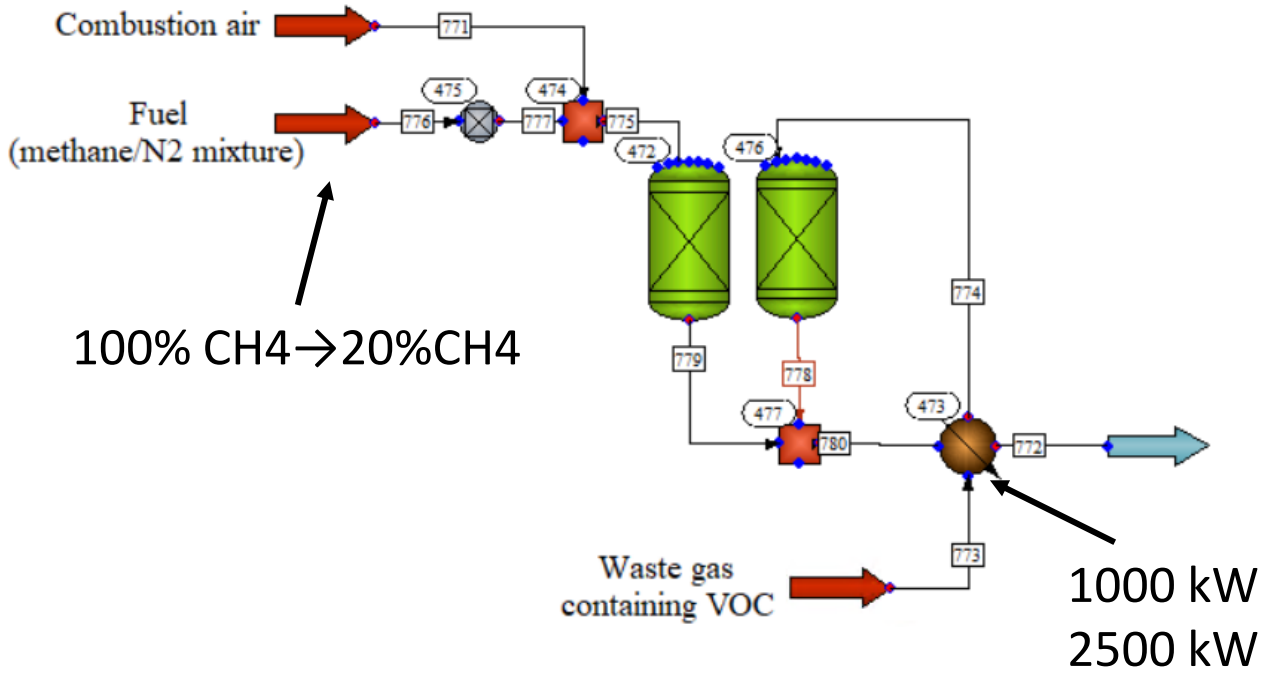
$$n_c = 1,07 - 1,09$$

$$\Delta f_s = \Delta Q_{preheat} / FHV_{SCC}$$

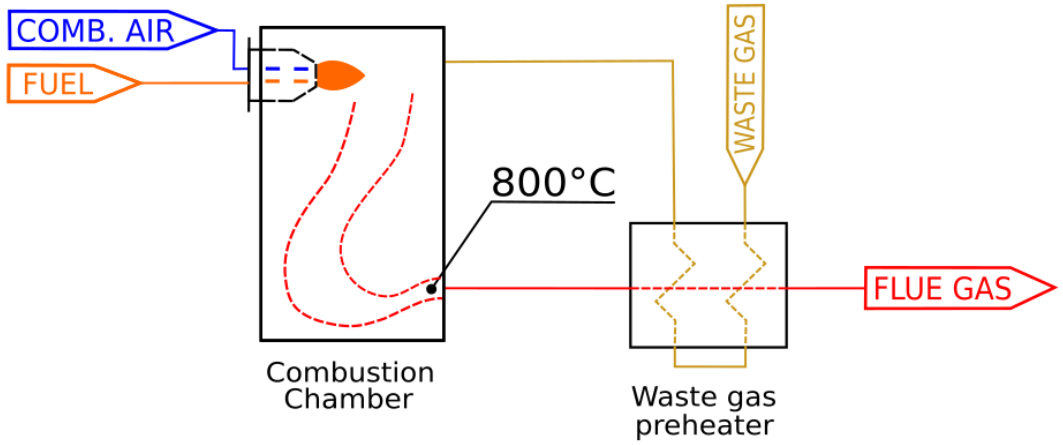
**It is simple, but is that accurate?**

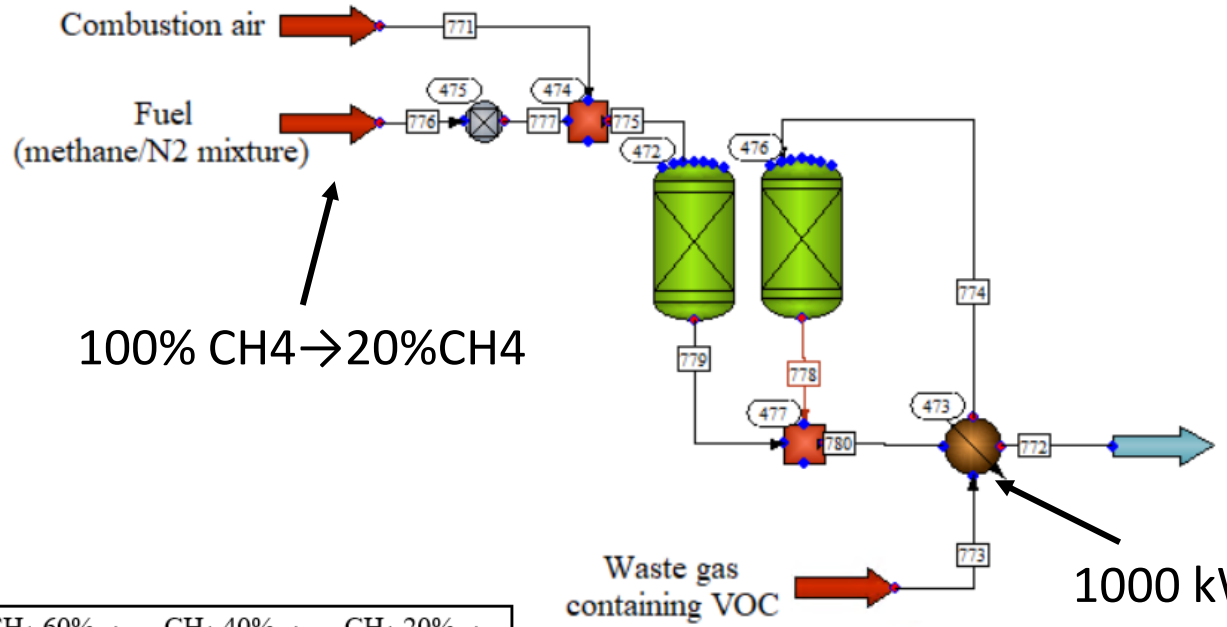
# Case study


COMB. AIR
FUEL
800°C
WASTE GAS
FLUE GAS
Combustion Chamber
Waste gas preheater


Combustion air
Fuel (methane/N2 mixture)
100% CH4→20%CH4
Waste gas containing VOC
1000 kW
2500 kW

# Case study




| Fuel | $CH_4$-100%$_{vol}$ $N_2$-0%$_{vol}$ | $CH_4$-80%$_{vol}$ $N_2$-20%$_{vol}$ | $CH_4$-60%$_{vol}$ $N_2$-40%$_{vol}$ | $CH_4$-40%$_{vol}$ $N_2$-60%$_{vol}$ | $CH_4$-20%$_{vol}$ $N_2$-80%$_{vol}$ |
|---|---|---|---|---|---|
| $T_{adiabatic}$ [°C] | 1 909 | 1 877 | 1 825 | 1 730 | 1 499 |
| LHV [kJ/kg$_{fuel}$] | 50 000.0 | 34 805.7 | 23 104.0 | 13 814.9 | 6 261.9 |
| | WASTE GAS IS SLIGTLY PREHEATED – $Q_{WG\ preheat}$ = **1 000 kW** | | | | |
| $\Delta f_{FHV\_SCC}$ [kg/h] | 114.6 | 166.7 | 256.4 | 447.8 | 1 136.8 |
| $\Delta f_{NLP}$ [kg/h] | 115.0 | 167.3 | 257.0 | 448.3 | 1 136.0 |
| Deviation [%] | -0.33 | -0.37 | -0.21 | -0.11 | 0.07 |
| | WASTE GAS IS INTENSIVELY PREHEATED – $Q_{WG\ preheat}$ = **2 500 kW** | | | | |
| $\Delta f_{FHV\_SCC}$ [kg/h] | 286.5 | 416.7 | 641.1 | 1 119.5 | 2 842.1 |
| $\Delta f_{NLP}$ [kg/h] | 287.5 | 418.0 | 642.6 | 1 120.8 | 2 838.5 |
| Deviation [%] | -0.33 | -0.32 | -0.23 | -0.12 | 0.13 |

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# *Thank You for attention and watching!*

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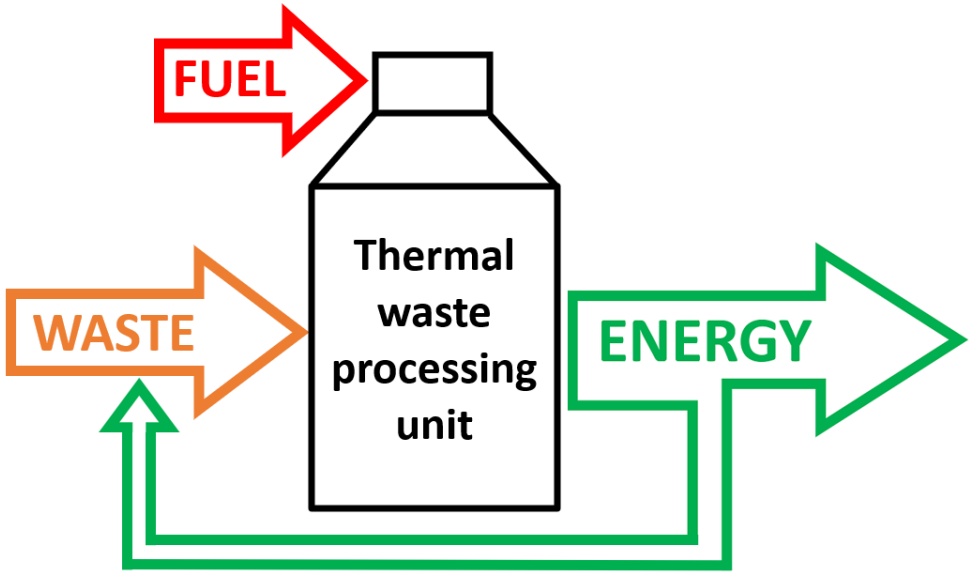


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