Supplementary data:

- The calculations of the CO_2 eq./year for all (ENZ vs CHEM/AUT) processes due to **thermal energy** consumption were calculated as follows:

Given:

- *From table 7_AUT, the daily steam consumption (CHEM/AUT) is equivalent to 22700 MJ*

- *1 GJ of thermal energy generates 55.82 kg of CO_2*

1. $C\text{onverting MJ to GJ (diving by 1000)} = 22700/1000 = 22.7 \text{ GJ}$

2. Converting energy consumption in terms of GJ to the quantity of CO_2 eq.

$\text{daily generation of CO2 (kg CO2 eq./d)} = (22.7 \times 55.82) = 1267.1 \text{ kg CO2 eq}$

$dividing\ by\ 1000$

$\text{Daiy generation of CO2 (t CO2 eq.)} = 1267.1/1000 = 1.267 \text{ t CO2 eq}$

$\text{Annual generation of CO2} = 1.267 \times 330 = 418 \text{ t CO2 eq. (table 7)}$

- *From table 7_ENZ, the daily steam consumption is equivalent to 1713 MJ*

- *1 GJ of thermal energy generates 55.82 kg of CO_2*

1. $C\text{onverting MJ to GJ (diving by 1000)} = 1713/1000 = 1.713 \text{ GJ}$

2. Converting energy consumption in terms of GJ to the quantity of CO_2 eq.

$\text{daily generation of CO2} \left(\text{kg CO2} \frac{\text{eq}}{\text{d}}\right) = (1.713 \times 55.82) = 95.62 \text{ kg CO2 eq}$

$dividing\ by\ 1000$

$\text{Daiy generation of CO2 (t CO2 eq.)} = 95.62/1000 = 0.0956 \text{ t CO2 eq}$

$\text{Annual generation of CO2} = 0.0956 \times 330 = 31.55 \text{ t CO2 eq. (table 7)}$

- The calculations of the CO_2 eq./year for both processes due to **electrical energy** consumption were calculated as follows:

- Given_ 1 kWh equivalent to 438.64 g CO_2 eq (Mata et al., 2018)
- Given in table 7_AUT/CHEM, the daily electrical energy consumption is 1800 kWh

Daily generation of t CO_2 = (1800 × 438.64) / 1000000 = 0.7895 t CO_2
Annual generation of t CO_2 = 0.7895 × 330 = 260.55 t CO_2 (see table 11)

- Given in table 7_ENZ, the daily electrical energy consumption is 125 kWh

Daily generation of t CO_2 = (125 × 438.64) / 1000000 = 0.05483 t CO_2
Annual generation of t CO_2 = 0.05483 × 330 = 18 t Co2 (see table 11)

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t CO_2 due to lauric acid production _AUT, given that the energy consumption to produce 1 tone of lauric acid is 500 kcal (source is Oleo Misr Company)

= 11.595 × 330 × 500 kcal = 1,912,680 kcal

Divide by 238.8 to convert from kcal to mj = 1,912,680 kcal / 238.8 = 8009 mj (equivalent to 147 t CO_2 equivalent)

t CO_2 due to lauric acid production _AUT, given that the energy consumption to produce 1 tone of glycerin is 700 kcal (source is Oleo Misr Company)

= 5.208 × 330 × 700 = 1203048 kcal

Divide by 238.8 to convert from kcal to mj = 1203048 kcal / 238.8 =5038 mj (equivalent to 92.8 t CO_2 equivalent)

t CO_2 due to palm kernel transportation _AUT, given that lauric acid quantity is multiplied by 1.05 to convert it to total fatty matter, and the distance between Egypt and Malaysia is 7925 km

11.595 × 330 × 1.05 × 0.133 / 1000 = 4380 t CO_2

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t CO_2 due to lauric acid production _ENZ, given that the energy consumption to produce 1 tone of lauric acid is 500 kcal (source is Oleo Misr Company)

= 10.868 × 330 × 500 kcal = 1,793,220 kcal

Divide by 238.8 to convert from kcal to mj = 1,793,220 kcal / 238.8 = 7509 mj (equivalent to 138 t CO_2 equivalent)

t CO_2 due to lauric acid production _ENZ, given that the energy consumption to produce 1 tone of glycerin is 700 kcal (source is Oleo Misr Company)

= 4.883 × 330 × 700 = 1127973 kcal

Divide by 238.8 to convert from kcal to mj = 1127973 kcal / 238.8 =4723 mj (equivalent to 87 t CO_2 equivalent)

t CO_2 due to palm kernel oil transportation _ENZ, given that lauric acid quantity is multiplied by 1.05 to convert it to total fatty matter, and the distance between Egypt and Malaysia is 7925

$10.866 \times 330 \times 1.05 \times 0.133 / 1000 = 3608$ t CO_2

t CO_2 due to enzyme transportation _ENZ, and the distance between Egypt and Denmark is 3688 km

2.5 ton of enzyme $\times 3688 \times 0.133$ x $1000 = 1.2$ t CO2