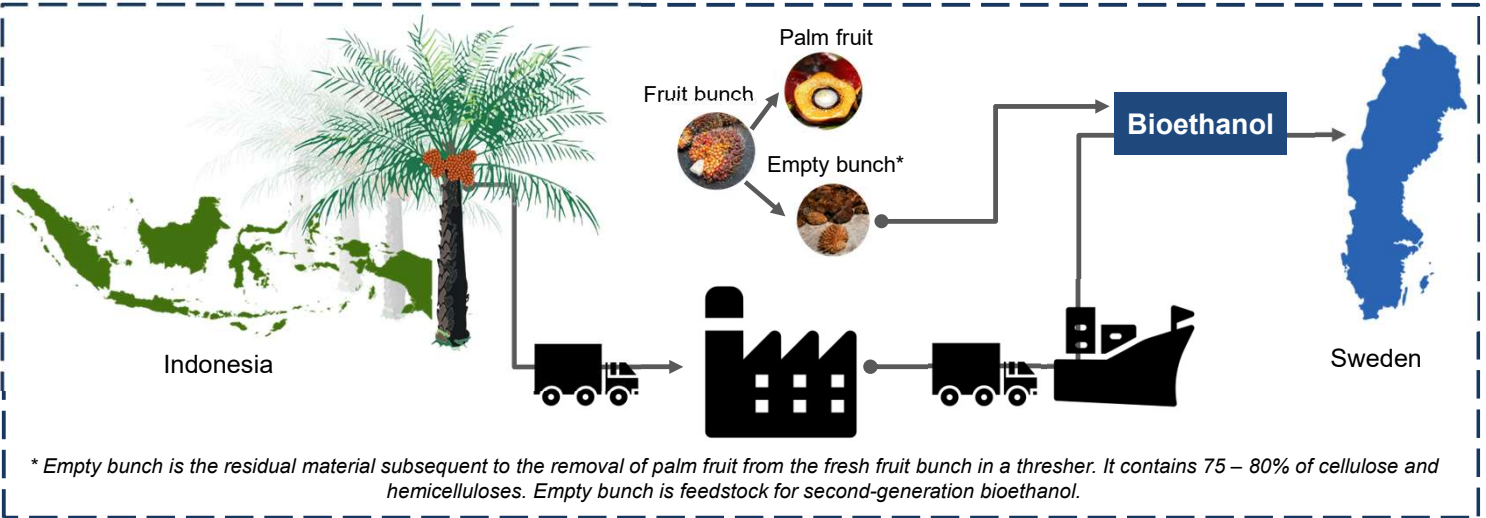


Sustainability of second generation palm-based ethanol production in Indonesia for transport sector in Sweden

Fumi Harahap, Jagruti Thakur, PhD*

Division of Energy Systems, Department of Energy Technology, KTH Royal Institute of Technology, Sweden

* Corresponding author: jrthakur@kth.se



Emergy analysis is used to investigate the sustainability of bioethanol from empty bunch. Emergy is the total available energy of one kind (usually solar) directly and indirectly used up to drive a process and generate a product or a product flow (Odum, 1996).

Calculating emergy of a process

$$\text{Emergy (seJ)} = \text{Available energy (J)} \times \text{Transformity (seJ/J)}$$

Emergy Indicators

Emergy Yield Ratio (EYR)

The higher EYR, the greater the system yield per purchased input emergy

- Yield (Y) = R + N + F
- EYR = Y/F

Environmental Loading Ratio (ELR)

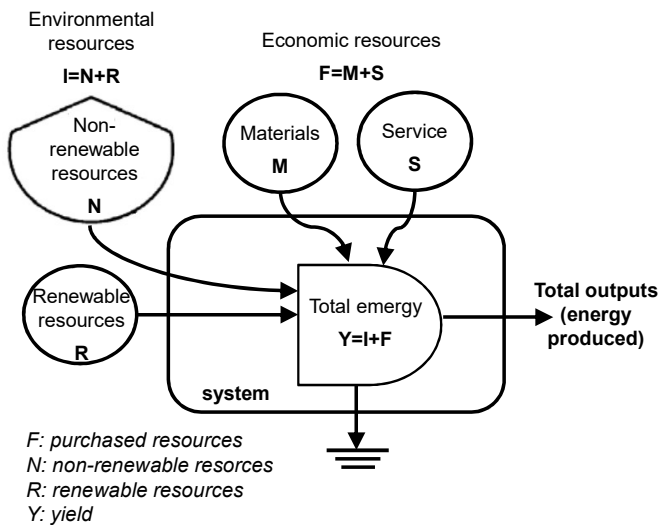
ELR ≤ 2 (low environmental impacts), 2 < ELR < 10 (moderate environmental impacts), ELR ≥ 10 (large environmental impacts)

- ELR = (F+N)/R

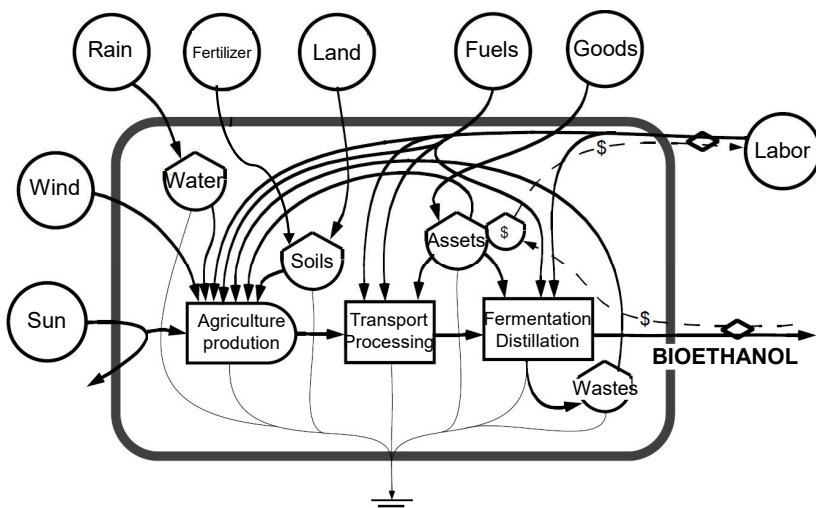
Emergy Sustainability Index (ESI)

ESI < 1 (the system is not sustainable in the long run), 1 < ESI < 10 (the system has development vigor & potential), ESI > 10 (the system is undeveloped)

- ESI = EYR/ELR



Emergy Flow: palm-based bioethanol



PRELIMINARY RESULTS

Indicator	Palm-based bioethanol	Other type of biofuels
EYR	1.00055	1.055 – 1.106
ELR	0.175	0.12 – 5.64
ESI	5.716	0.19 – 9.16

- The system is sustainable from ELR but there is huge improvement potential based on ESI
- Scope of improvements to be further investigated (e.g., waste management)
- The findings are comparable to other existing studies on liquid biofuels