Sustainable Biomass Residues Utilization in Indonesia Palm Oil Industries,

an Effort toward Net Zero Emission

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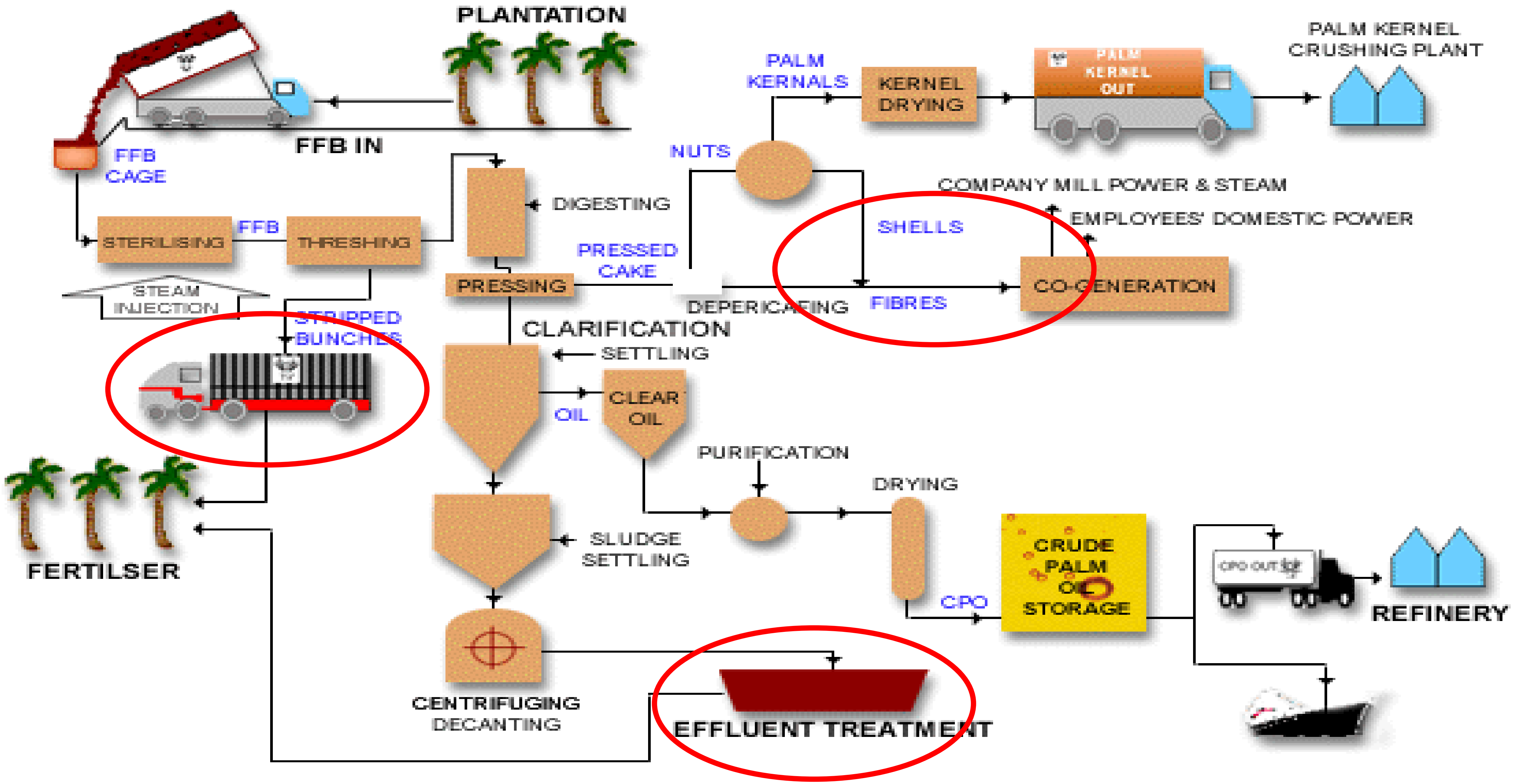
FLOW PROCESS IN PALM OIL INDUSTRY



Palm Oil Mill By-products

POME

60-100 %

Solid by-products

EFB
20-23 %

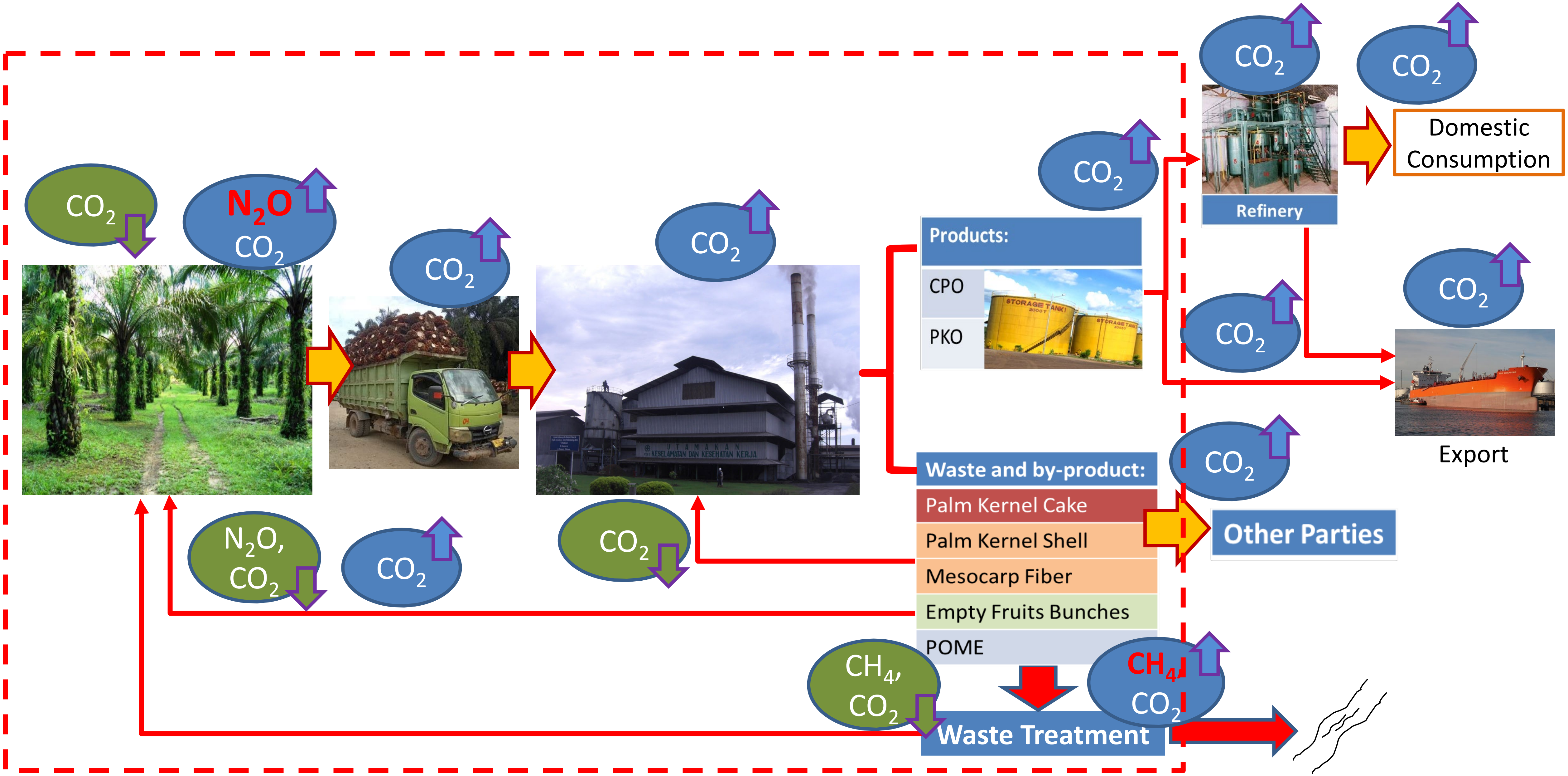
Fiber
12-13 %

Shell
5-6 %

Boiler Ash
2.5 %

Solid Decanter
3.5% (optional)

GHGs Emission Potential from Palm Oil Industry

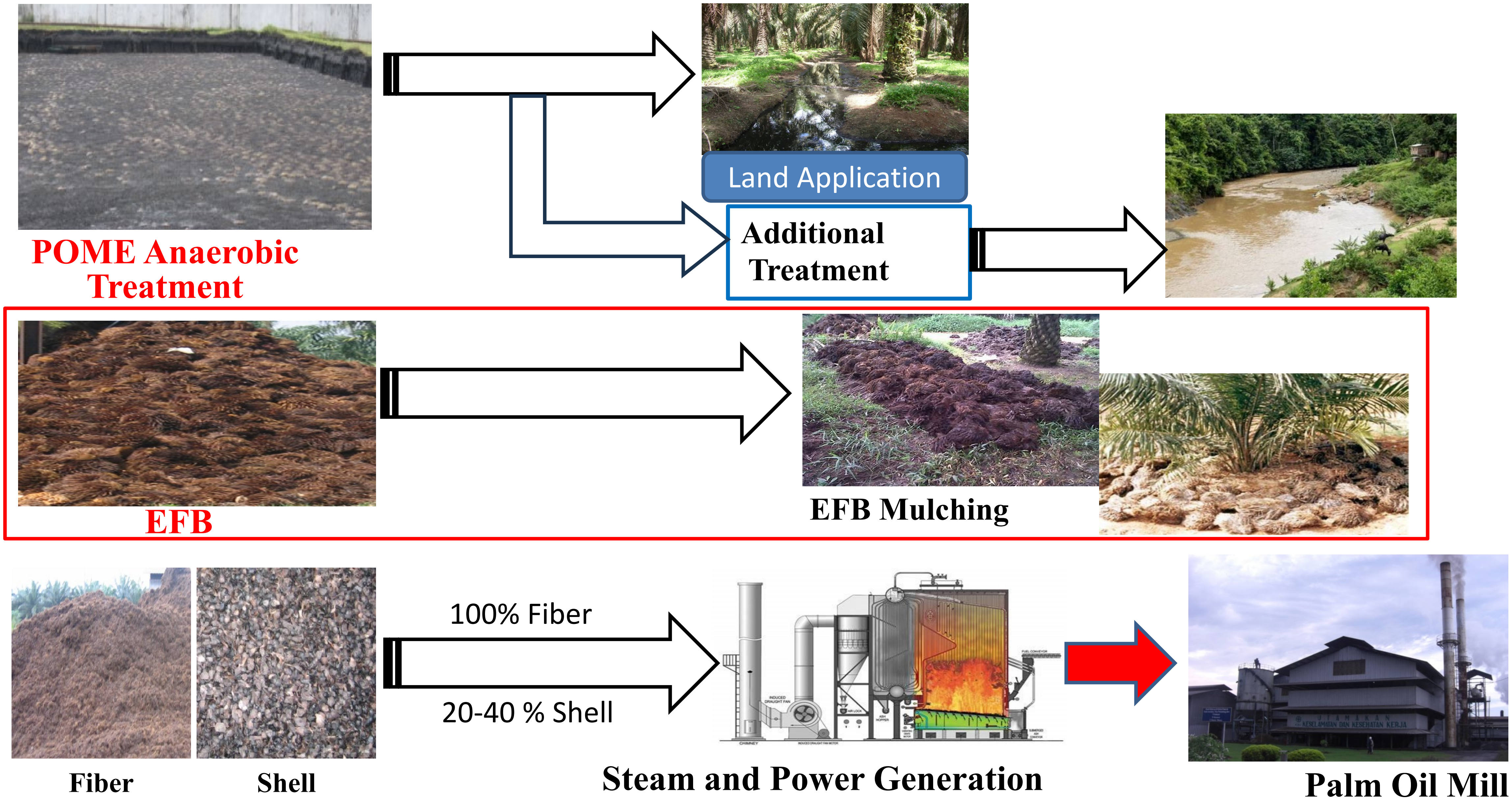


The Main Potential Sources of GHGs Emission from Palm Oil Industry

- **Oil Palm Plantation**
  - ✓ **Utilization of Fertilizer and other chemicals (Herbicide, Pesticide, etc.)**
  - ✓ Organic matters decomposition
  - ✓ Utilization of fossil fuels for plantation operation

- **Palm Oil Mill**
  - ✓ **POME treatment**
  - ✓ Utilization of fossil fuels for mill operation

COMMON PRACTICES OF WASTE MANAGEMENT IN PALM OIL INDUSTRIES



EFB Utilization in Palm Oil Industries

POM with Plantation

EFB

EFB Mulching

Increasing C-organic and minerals concentration in soil BUT Very costly, labor intensive, and plant disease risk

POM without Plantation

EFB

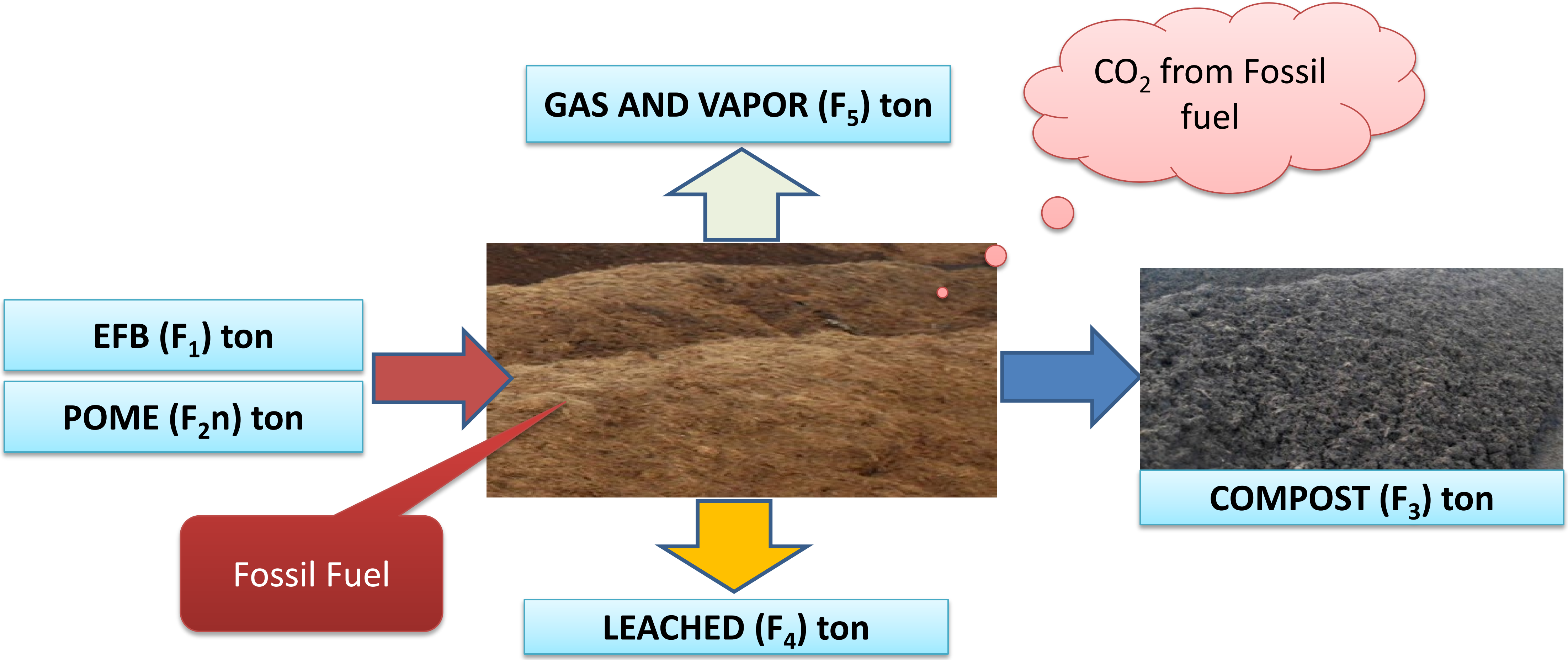
EFB Burning

Resources Loss

Aerated Bunker Composting System

Open Windrow Composting System

ESTIMATION OF GHG EMISSION FROM CO-COMPOSTING OF EFB AND POME USING CARBON BALANCE



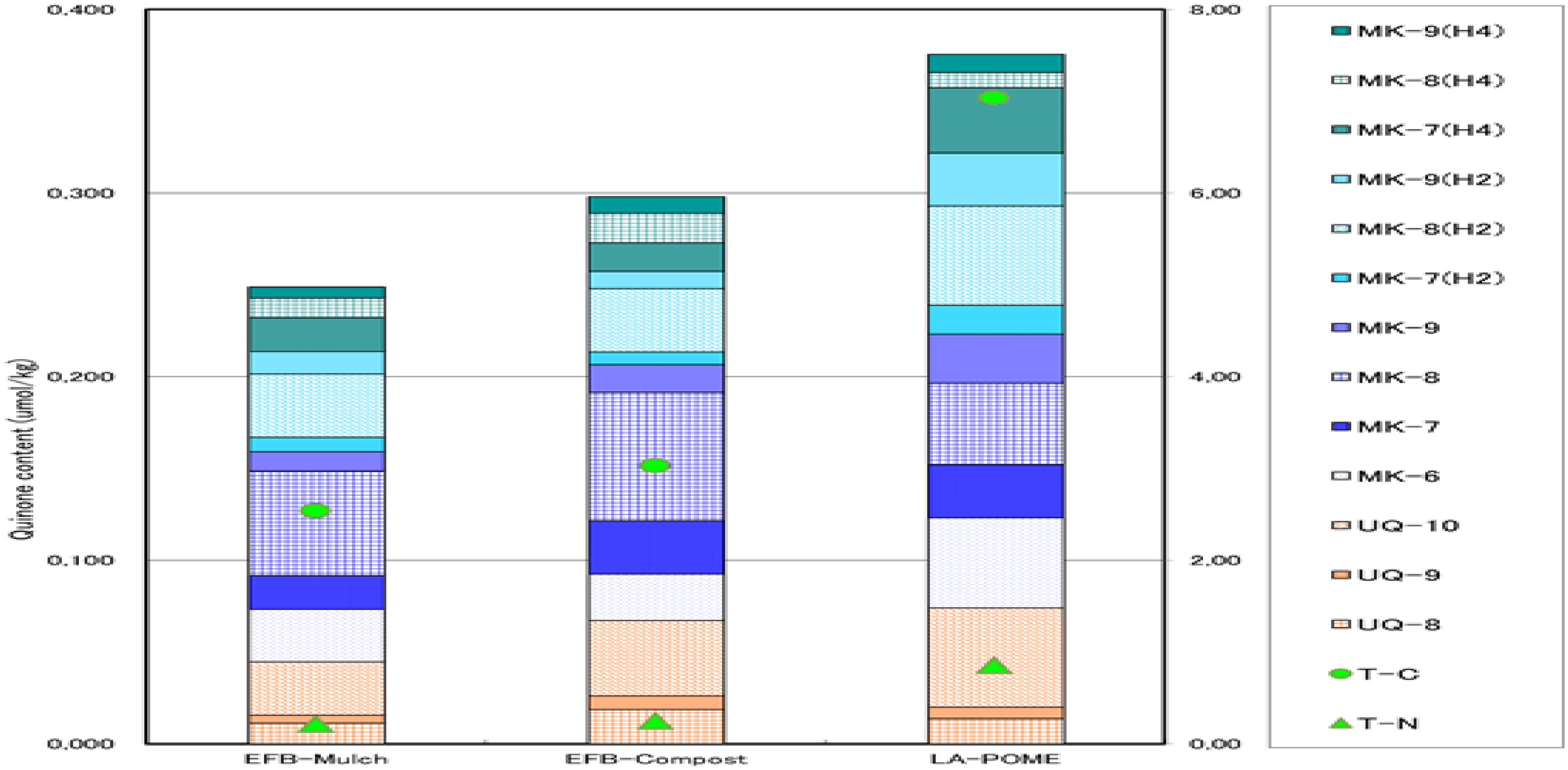
$$F5.C5 = F1.C1 + F2.C2(n) - F3.C3 - F4.C4$$


TAMU

Summary of GHG emission estimation

	Unit	**30 days**	**70 days**
Baseline emission value (E_0)	$kgCO_{2e}$/ton FFB	301.48	301.48
Fraction of POME used for composting (X)	%	43.18	78.04
Methane emission from composting pile (E_C)	$kgCO_{2e}$/ton FFB	13.98	42.72
Fuel emission for composting process (E_F)	$kgCO_{2e}$/ton FFB	0.30	0.70
Greenhouse gas mission reduction (GHG_R)	$kgCO_{2e}$/ton FFB	115.89	191.86
	%	38.44	63.64

Microbial Quinone Content, Quinone species, Carbon and Nitrogen content in the Soils



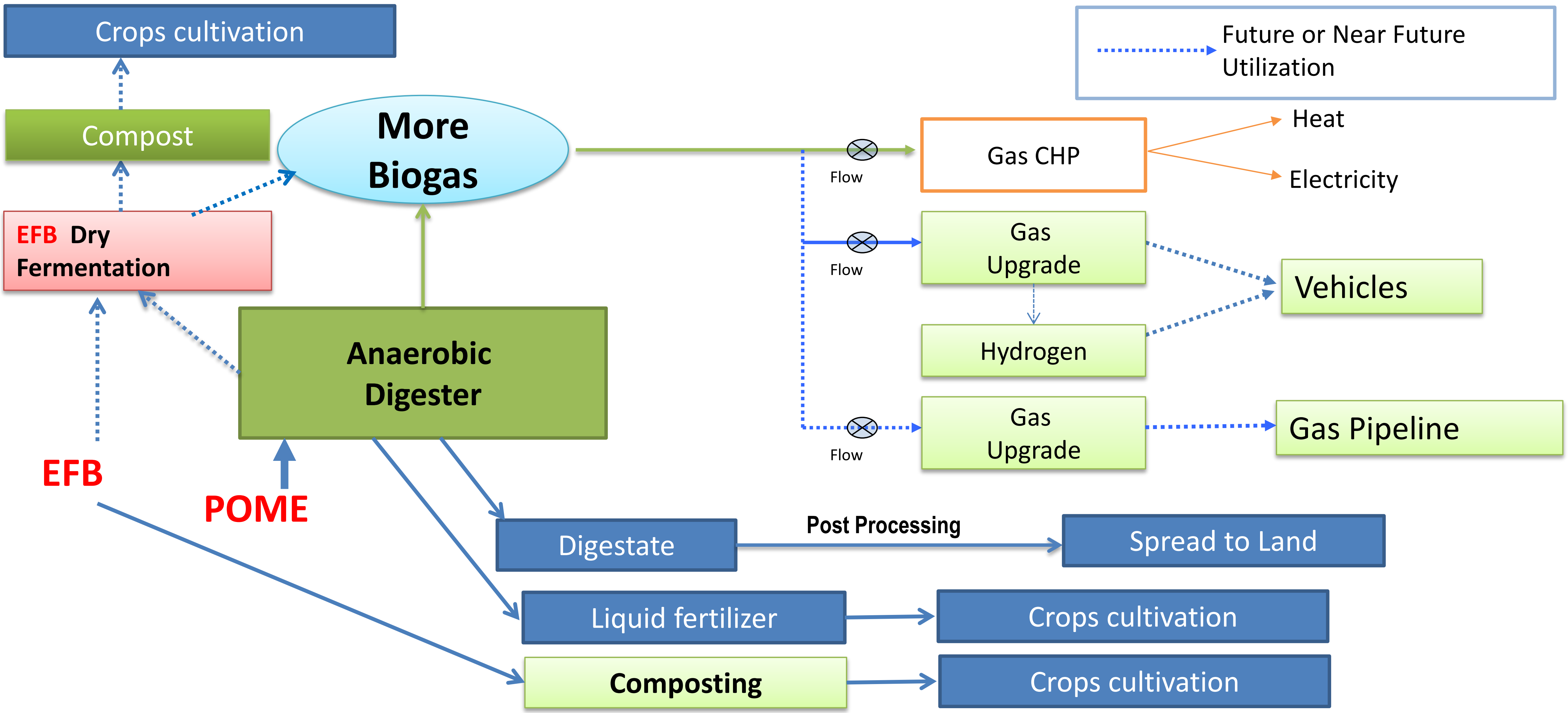
Co-Composting EFB and POME

- Reduce G…G emission
- Reduce water po… …nd increase soil fertility and oil palm productivity
- Carbon and nu… …oil with better m…
- Smaller amount o… plantation for lan…

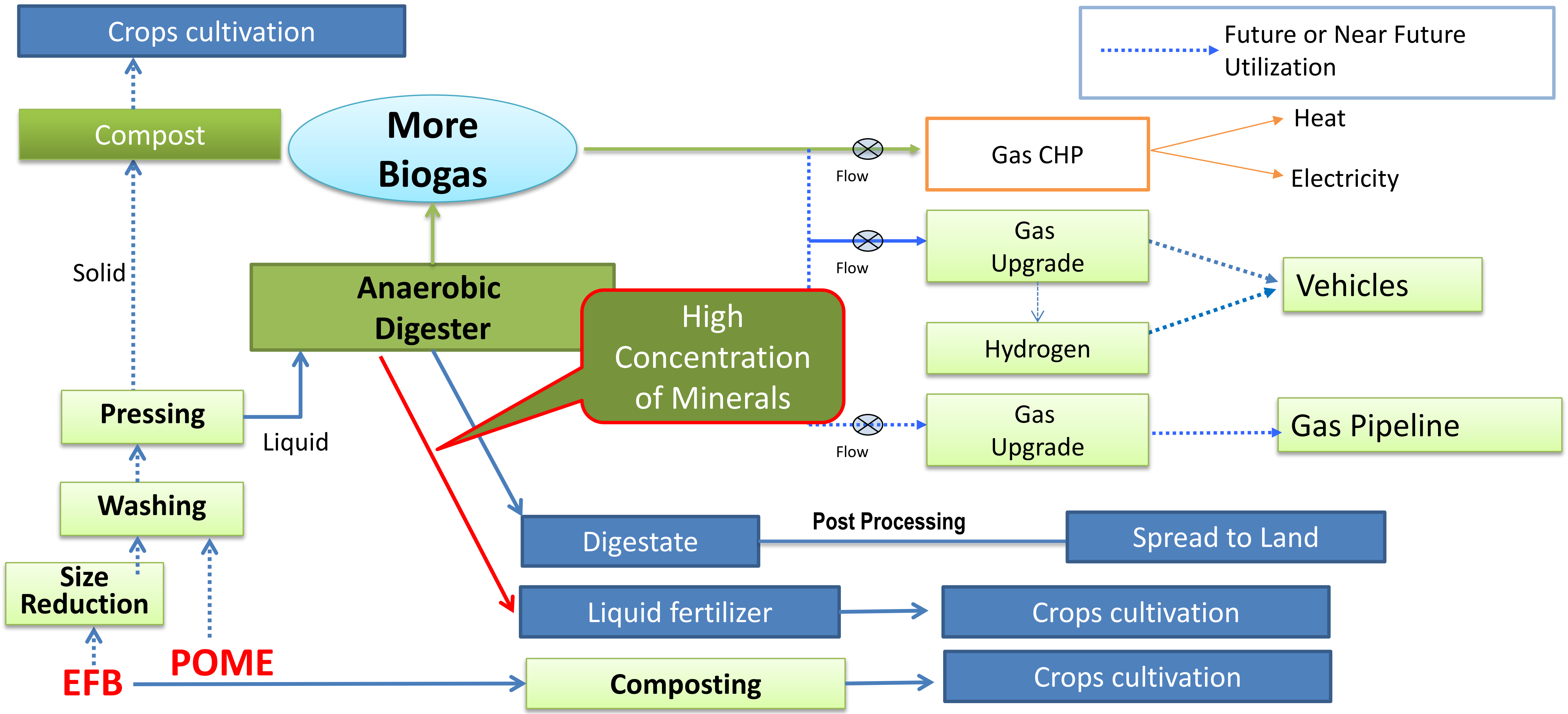
Support GHG emission reduction and oil palm production through soil quality improvement

But, we can not get renewable energy

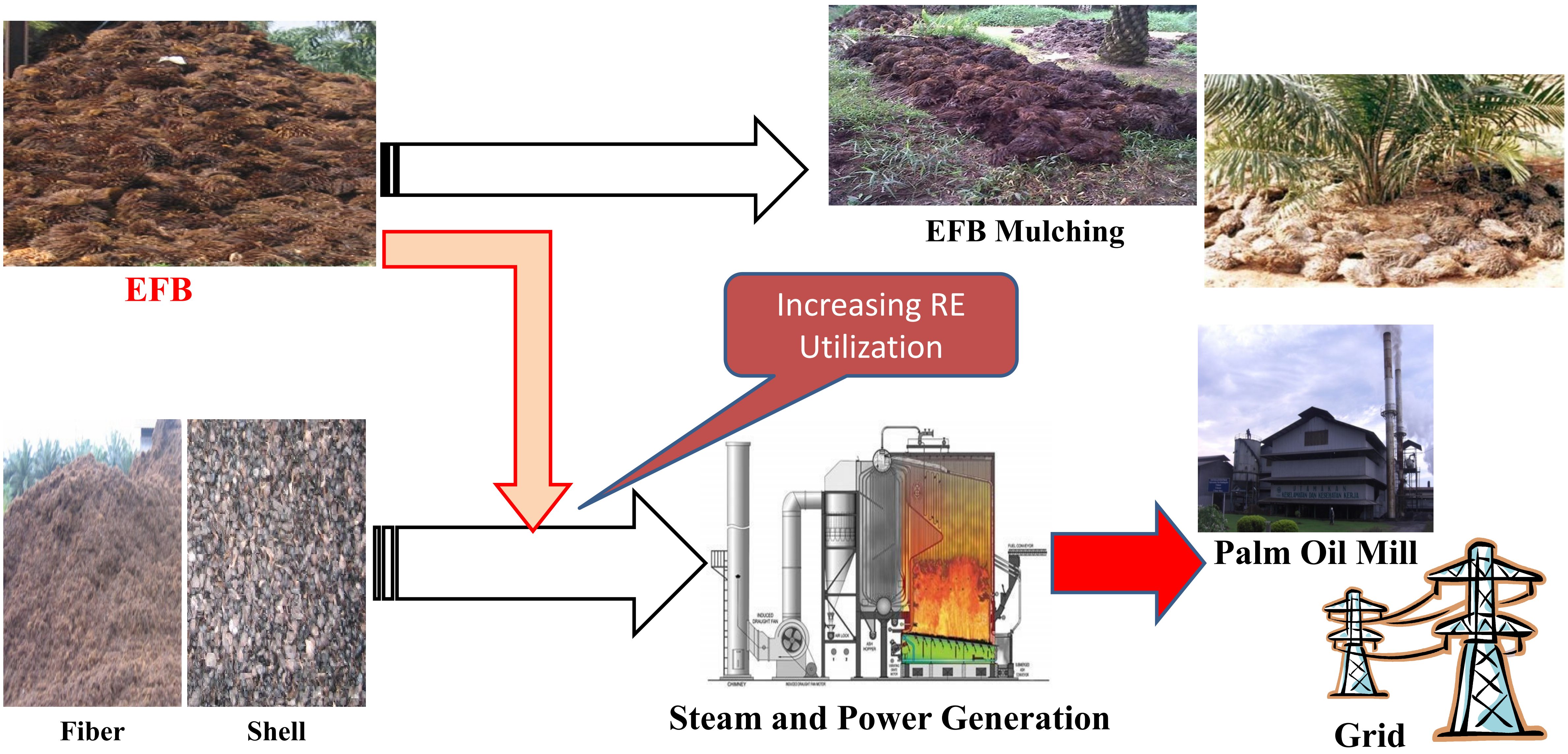
Co-Digestion of POME + EFB



Co-Digestion of POME + EFB



PALM OIL MILL SOLID BIOMASS WASTE UTILIZATION

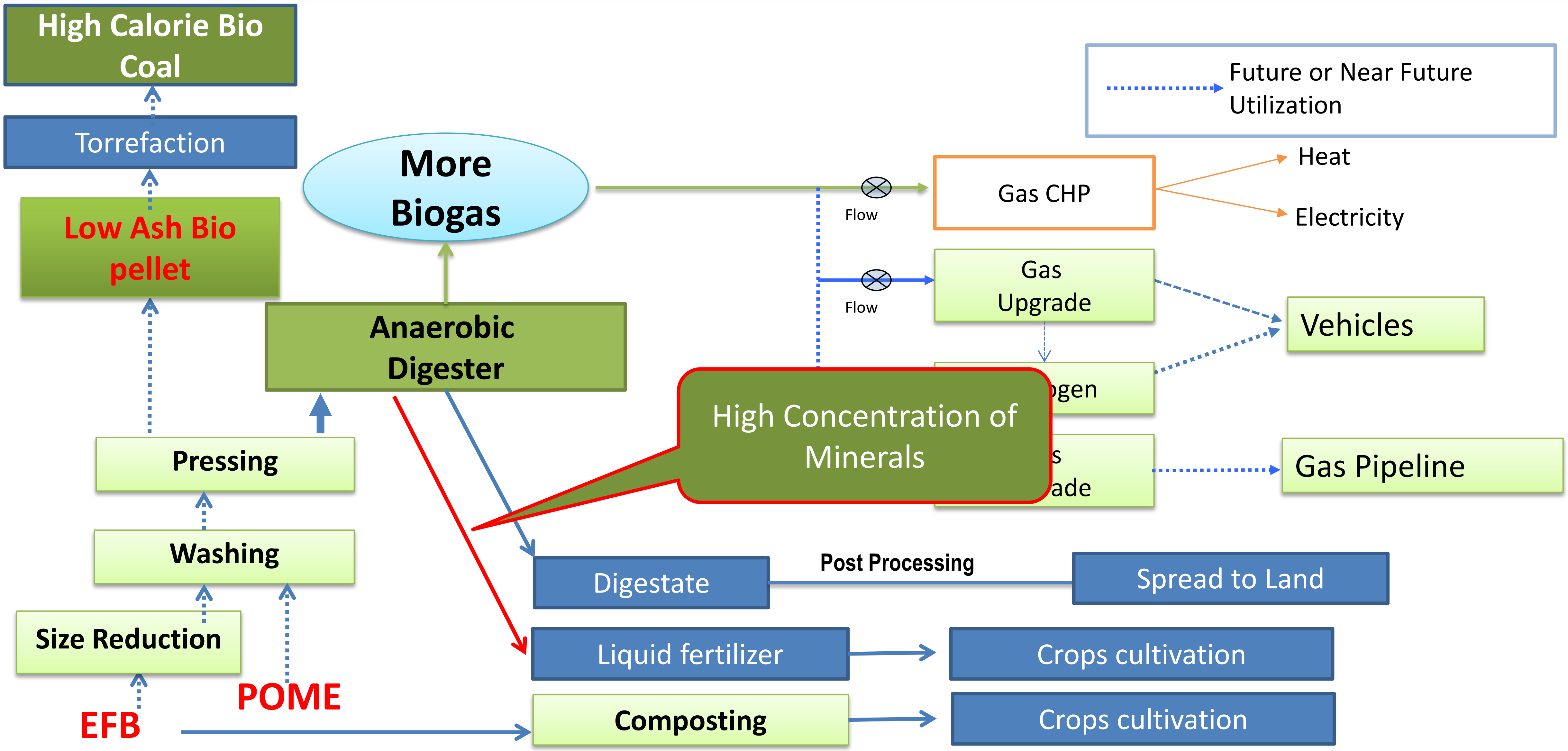


Problems:

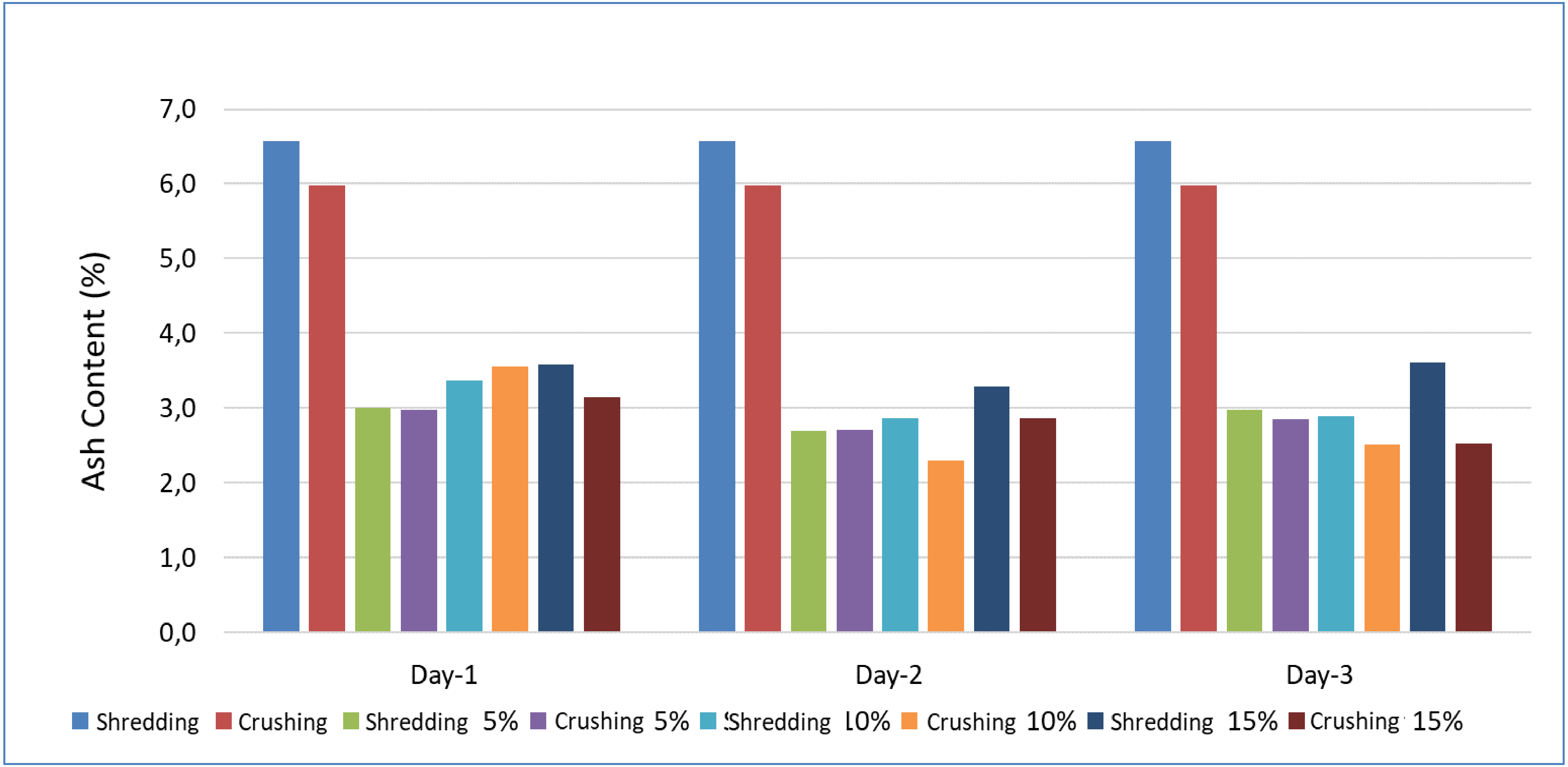
Element	Unit	EFB
Ash	**%**	**7**
MgO	%	1,212
Al_2O_3	%	--
SiO_2	**%**	**10,446**
P_2O_5	%	2,457
SO_3	%	3,57
Cl	%	6,592
K_2O	**%**	**51,584**
CaO	%	17,71
TiO_2	%	0,193
Cr_2O_3	%	0,314
MnO	%	0,353
Fe_2O_3	%	5,08
ZnO	%	0,733
Rb_2O	%	0,22

- Returned torrefied EFB pellet (biochar) to oil palm plantation has potential to keep C-organic and minerals content in high level
- Utilization of EFB pellet for energy need pretreatment (washing) to reduce ash content and returned the ash (minerals) to the soil of oil palm plantation

Co-Digestion of POME + EFB



Effect of Washing on Ash Content of EFB



With Washing

Without Washing

BIOMASS PELLET

Bio-Pellet from Empty Fruit Bunches

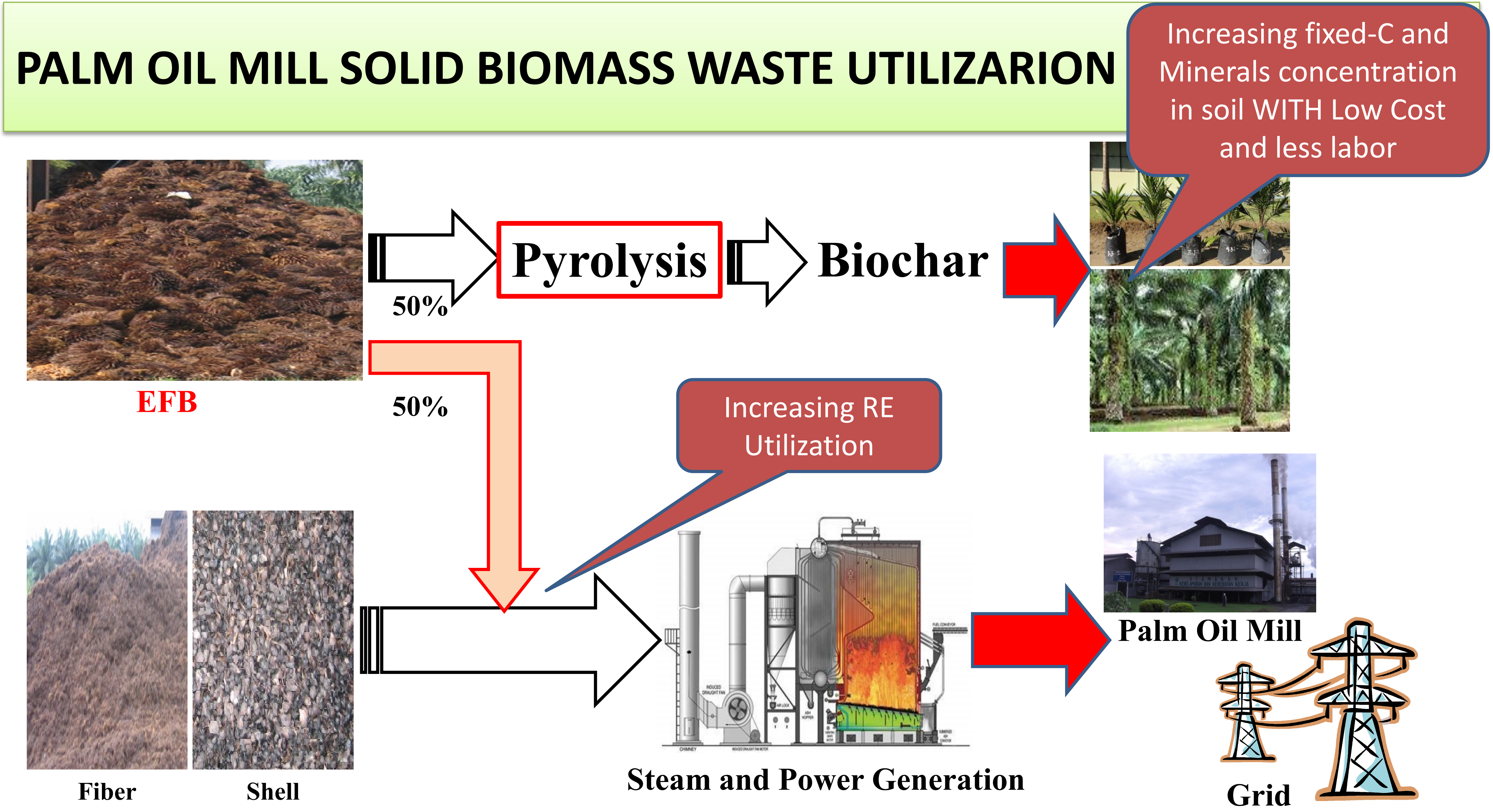
EFB (1 ton)

- **Washing,** Pressed and shredded
- Conveyor Dryer (116ºC, 20m)
- Rotary Dryer, (90ºC, 20m)
- Cutting Mill
- PRESSED (55 kg/cm^2)

EFB Pellet (0.4 ton)

EFB Pellet Potential about 22 mil Ton/year

- Renewable, Environmentally friendly, clean and easy to used, and low GHGs Emission
- Bio-pellet Characteristics:
  - ✓ Diameter = 6-10 mm and Long = 10-50 mm
  - ✓ Average bulk density > 650 kg/m3 (1,5m3/ton)
  - ✓ Ash Content = 0,5-3%
  - ✓ Energy content about 4,7 kWh/kg



PALM OIL MILL SOLID BIOMASS WASTE UTILIZARION
Increasing fixed-C and Minerals concentration in soil WITH Low Cost and less labor
Pyrolysis
Biochar
50%
50%
EFB
Increasing RE Utilization
Fiber
Shell
Steam and Power Generation
Palm Oil Mill
Grid

EFB PRODUCTION IN INDONESIA

Year	CPO Production (Million Tons)
2019	47.180
2020	47.034
2021	46.888
2022	46.729

OER = 20%

Year	FFB Production (Million Tons)
2019	235.900
2020	235.170
2021	234.440
2022	233.645
Average	**234.789**

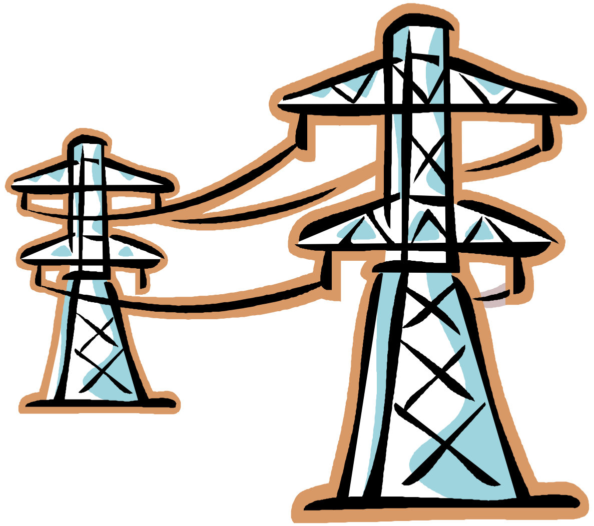
EFB Production
± 54 Million Tons/year

50% converted to bio-pellet

± 10 Million tons

Electricity Production and GHG Reduction Potential from EFB Utilization for Energy

± 10 Million tons
≈ 7.38 Million tons of medium range of Coal

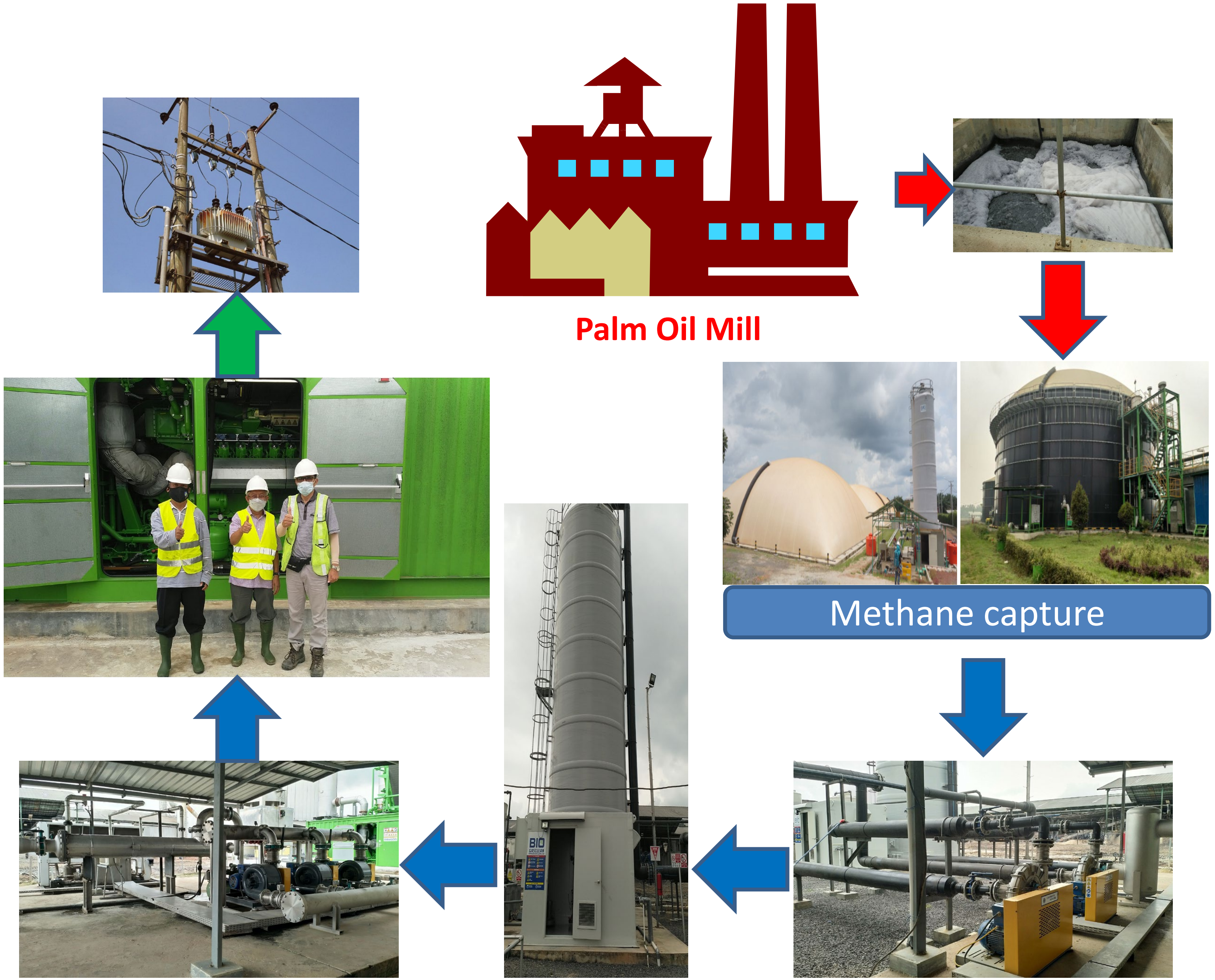


± 1420 MW

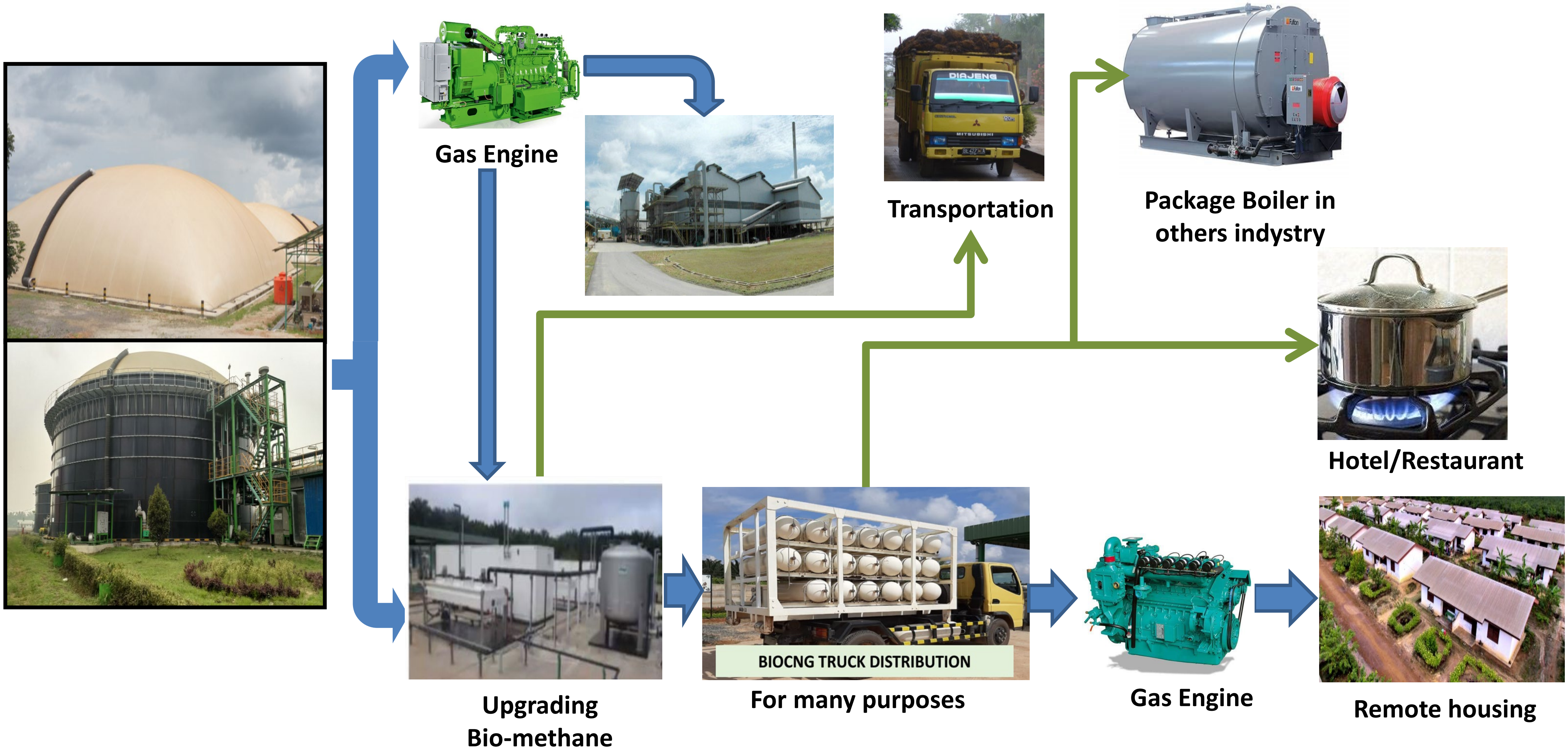
Emission Factor
= 1.140 kg CO2e/kWh

14,2 million tons of CO_{2e} per year

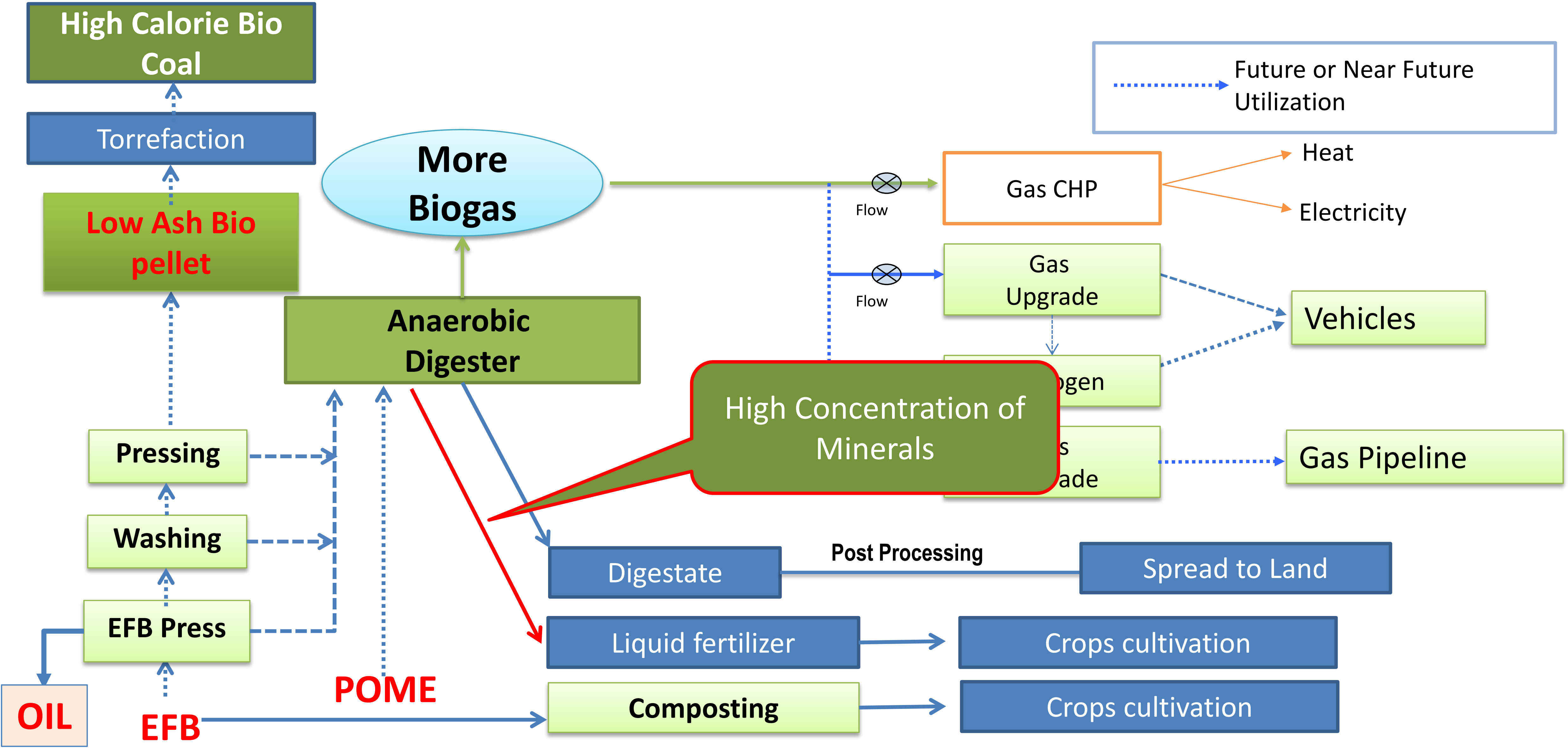
Biogas Power Plant



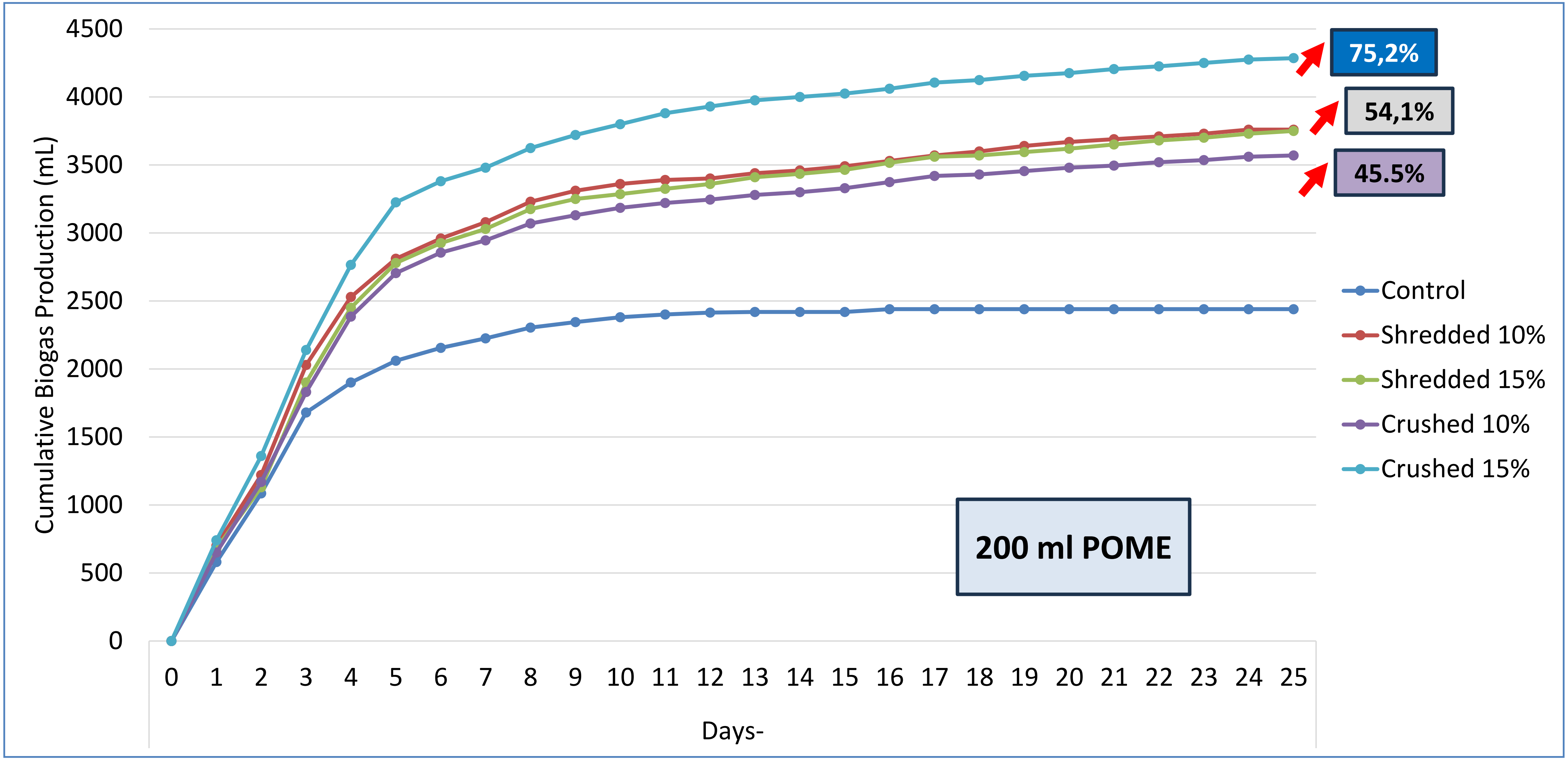
Utilization of Biogas and Bio-Methane



Co-Digestion of POME + EFB to increase Biogas Production



Cumulative Biogas Production



Estimation GHGs from POME

Parameters	Unit	Value
COD of fresh POME	mg/l	60,000
COD of treated POME	mg/l	10,000
POME production	m^3/ton FFB	0.70
Oil Recovery	ton CPO/ton FFB	0.21
COD removal	kg/ton CPO	166.7
IPCC default value*)	kg CH_4/kg COD removal	0.25
CH_4 production	kg/ton CPO	41.7
GWP potential of CH_4*)	kg CO_2e/ kg CH_4	27
GWP potential	kg CO_2e/ton CPO	1,125

*) IPCC, GHG protocol, sixth assessment report(AR6), 2024

IPCC Global Warming Potential Values

Version No.	Date	Description of amendment
2.0	August 7, 2024	Updated with AR6 values

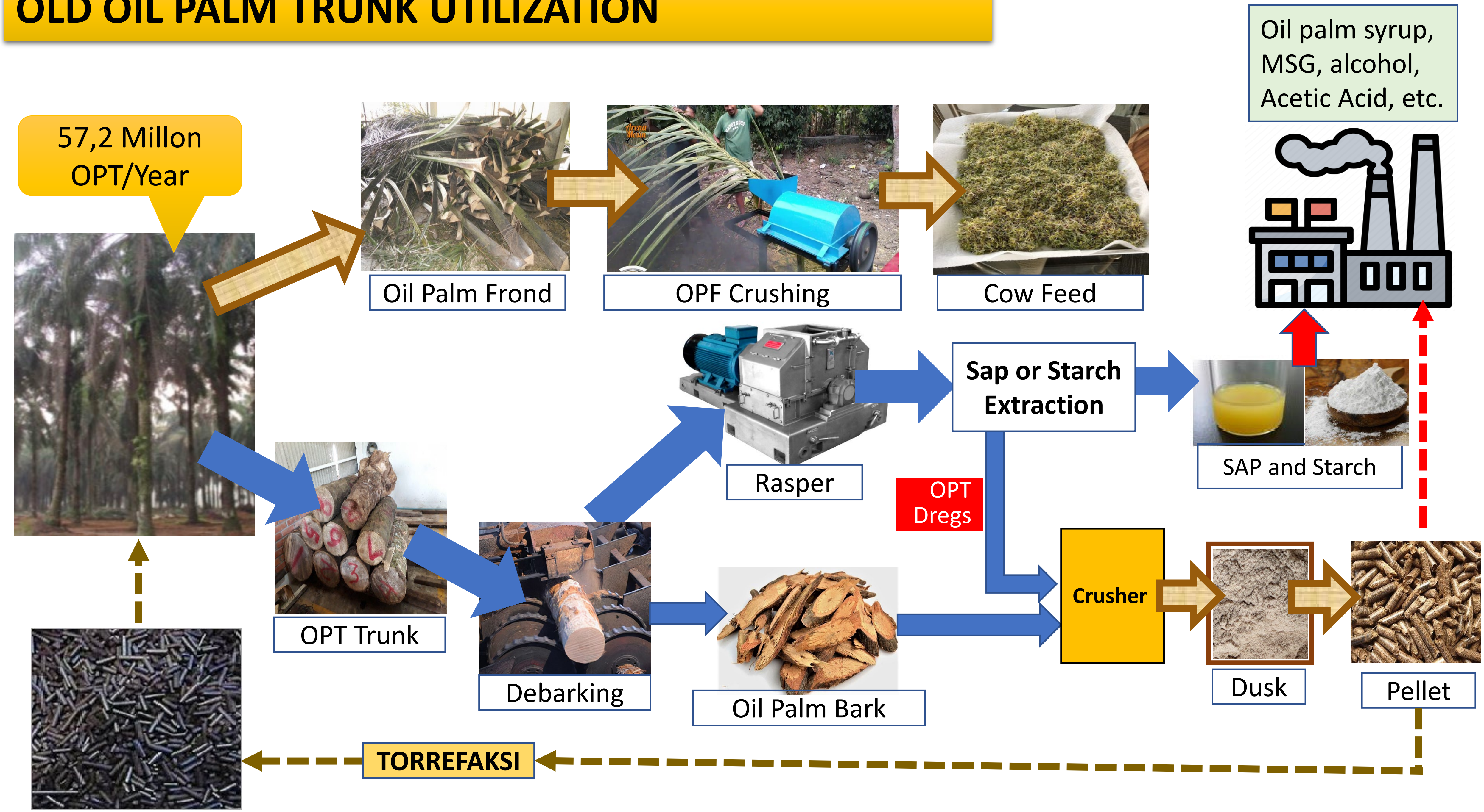
GREENHOUSE GAS PROTOCOL

IPCC Global Warming Potential (GWP) values relative to CO_2

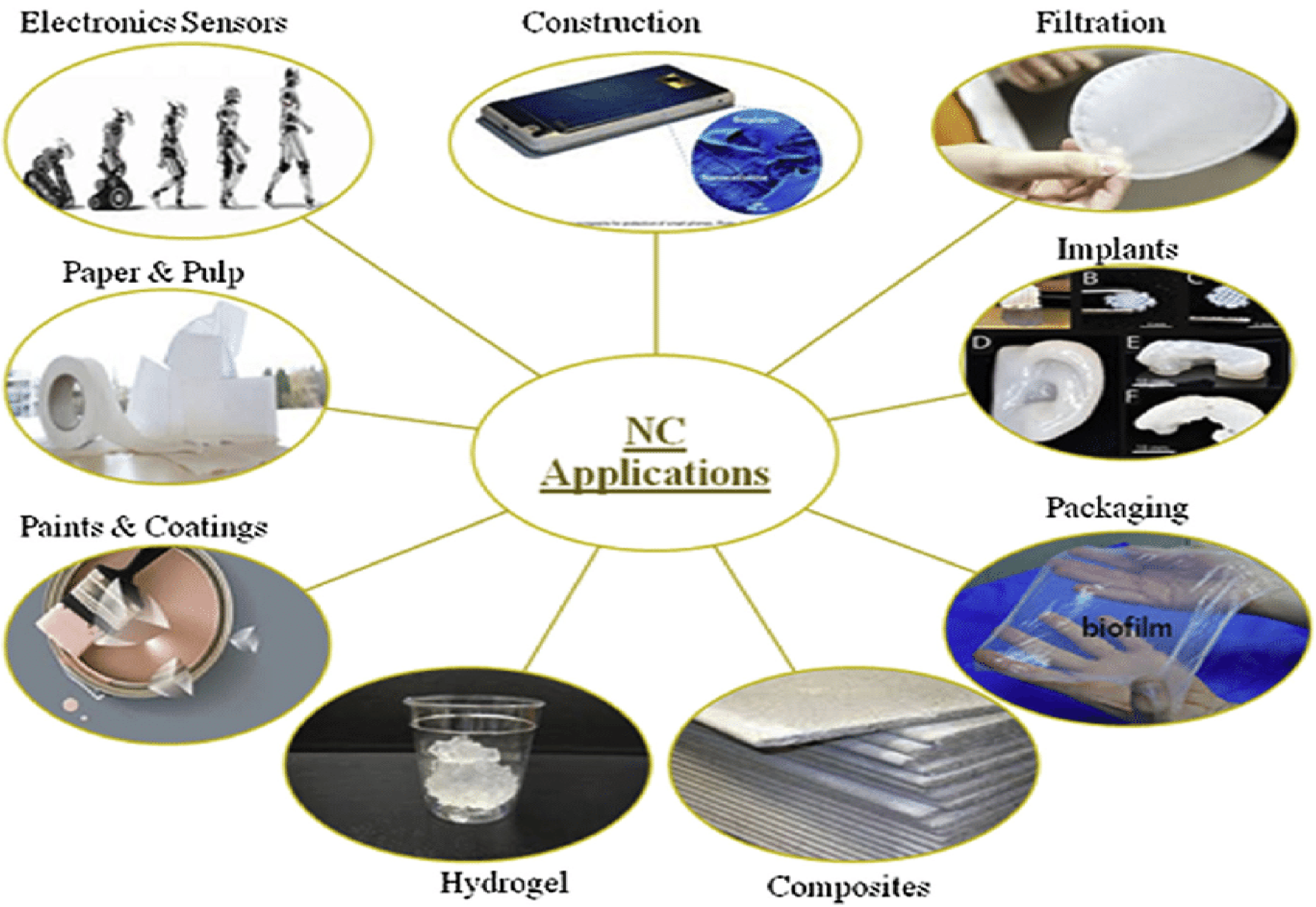
Common chemical name or industrial designation	Chemical formula	GWP values for 100-year time horizon		
		Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)	Sixth Assessment Report (AR6)
Major Greenhouse Gases				
Carbon dioxide	CO_2	1	1	1
Methane – non-fossil	CH_4	25	28	27.0
Methane – fossil	CH_4	N/A	30	29.8
Nitrous oxide	N_2O	298	265	273
Nitrogen trifluoride	NF_3	17,200	16,100	17,400
Sulfur hexafluoride	SF_6	22,800	23,500	24,300

CPO Production (M-ton/Year)	Emission Reduction Potential (M-ton CO2e/Year)
50.07	56.32

OLD OIL PALM TRUNK UTILIZATION



The Potential of OPT Dregs Utilization

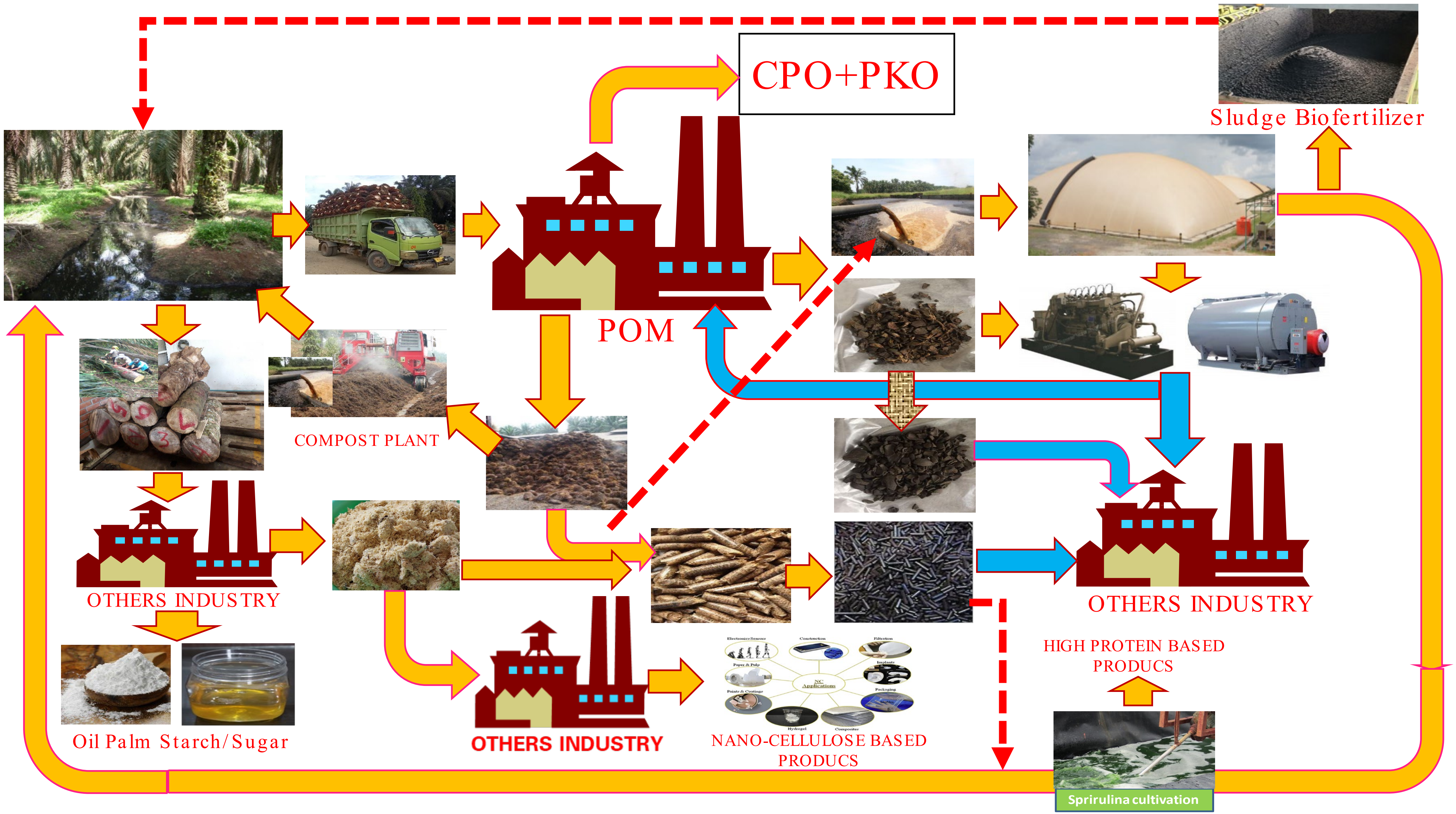


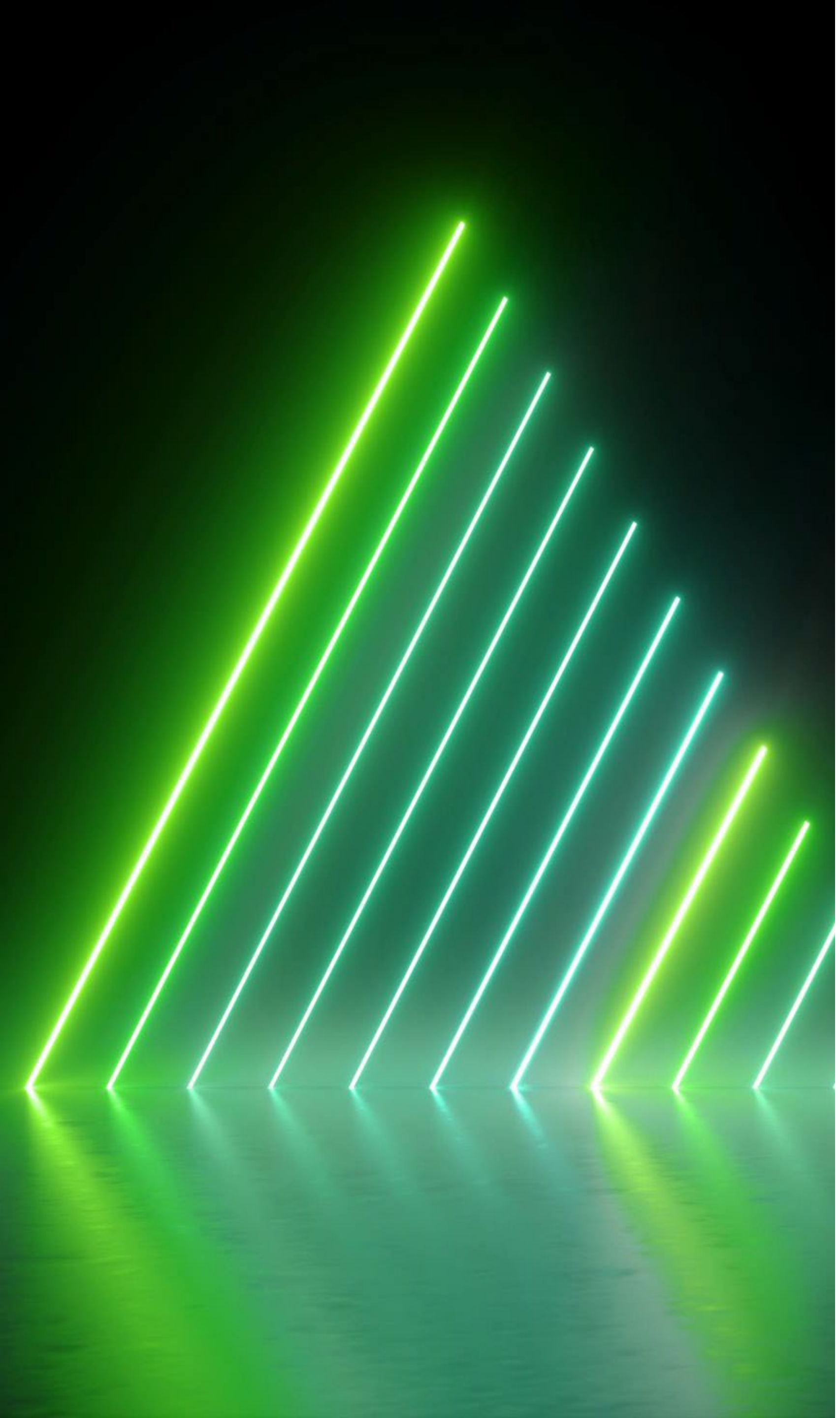
OPT dregs

Cellulose	47.6 ± 0.2 %
Hemicellulose	25.7 ± 0.8 %
Lignin	7.2 ± 1.6 %

Nano Cellulose based Industries

Model of Sustainable Bio-refinery in Indonesia Palm Oil Industries





The Future Challenges in Indonesia Palm Oil Industries

- Waste management in palm oil industry should be develop to increase the added value and at the same time minimize GHGs emission and environmental pollution load
- Development of Low Emission Conversion Technology is very much important to utilize palm oil mill biomass residue, improve their value added, and ensure the sustainability of palm oil industries.
- **Collaboration is very much important to accelerate the implementation of Net Zero Emission in commercial stage.**

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Thank You