

Oil palm mill residue oils

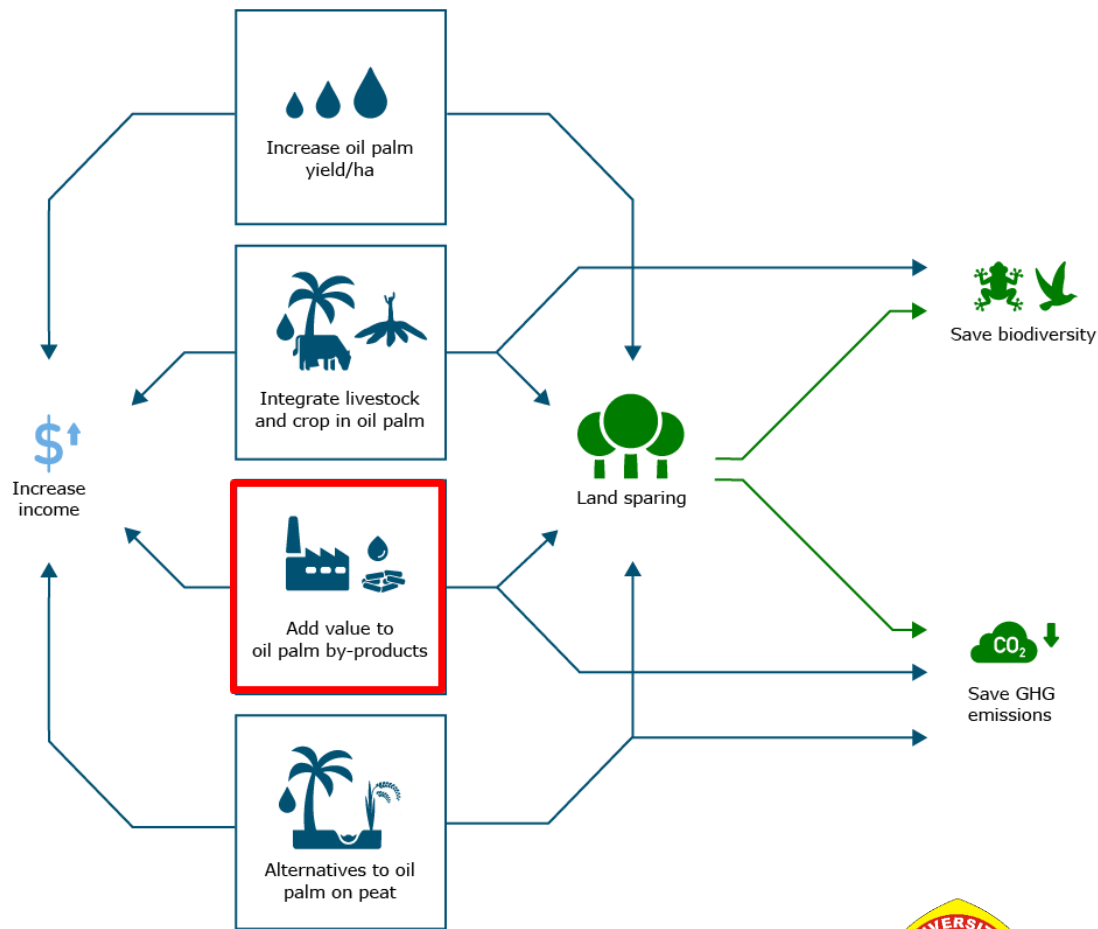
Wolter Elbersen

Workshop Trust in POME biofuels, 6 October 2025



Agenda

- Palm production system and residue oils:
 - POME (Palm Oil Mill Effluent) oil
 - EFB (Empty fruit bunch) oil
 - *MF (Mesocarp fibre) / PPF (Palm Press Fibre) oil*
- Suggestions for next steps to assure authenticity and understand how the system works or should work
- Follow-up



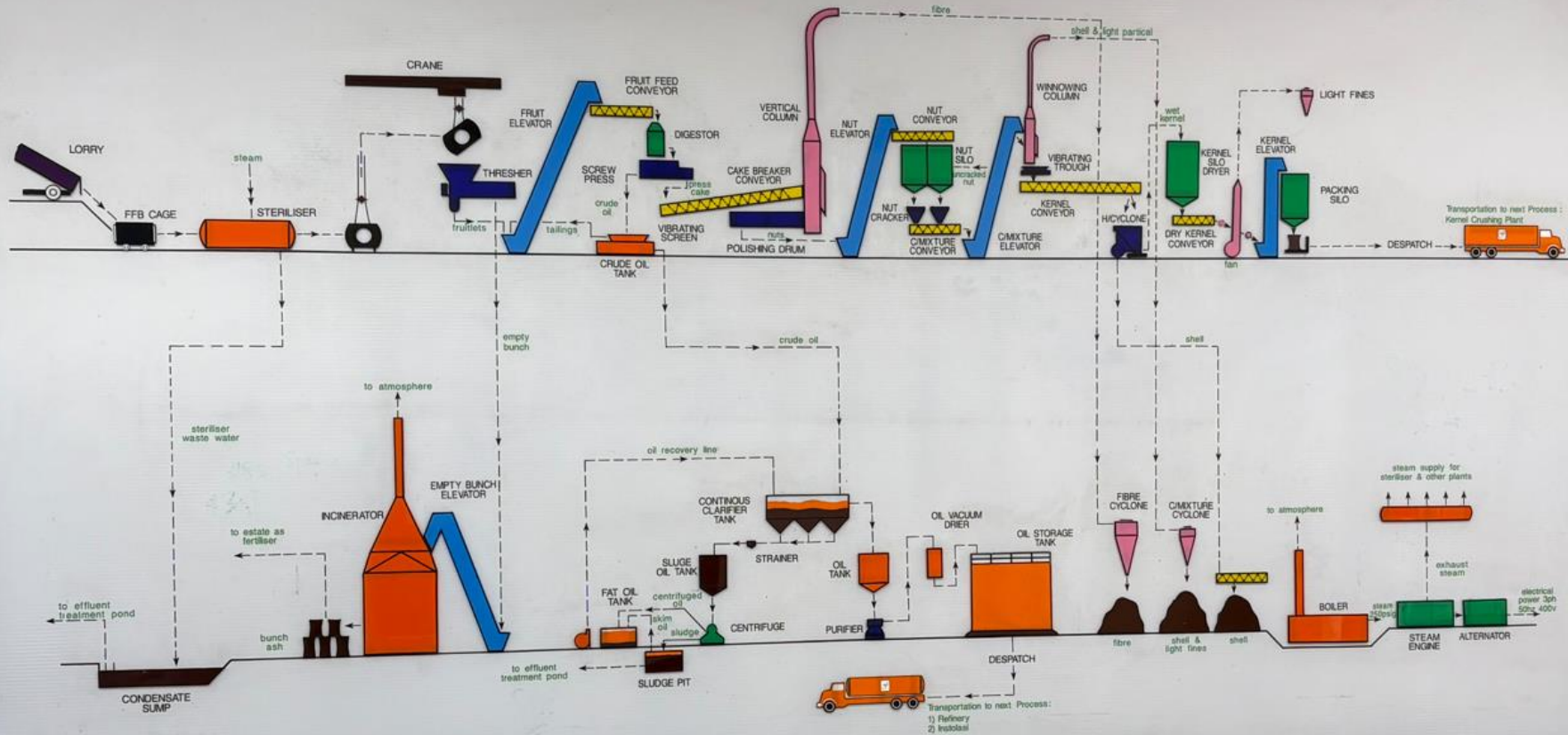
SustainPalm: Implementing more sustainable practices in palm oil industry in Indonesia

Oil palm mill 20 to 120 ton FFB/hr = 3.000 to 15.000 ha per mill



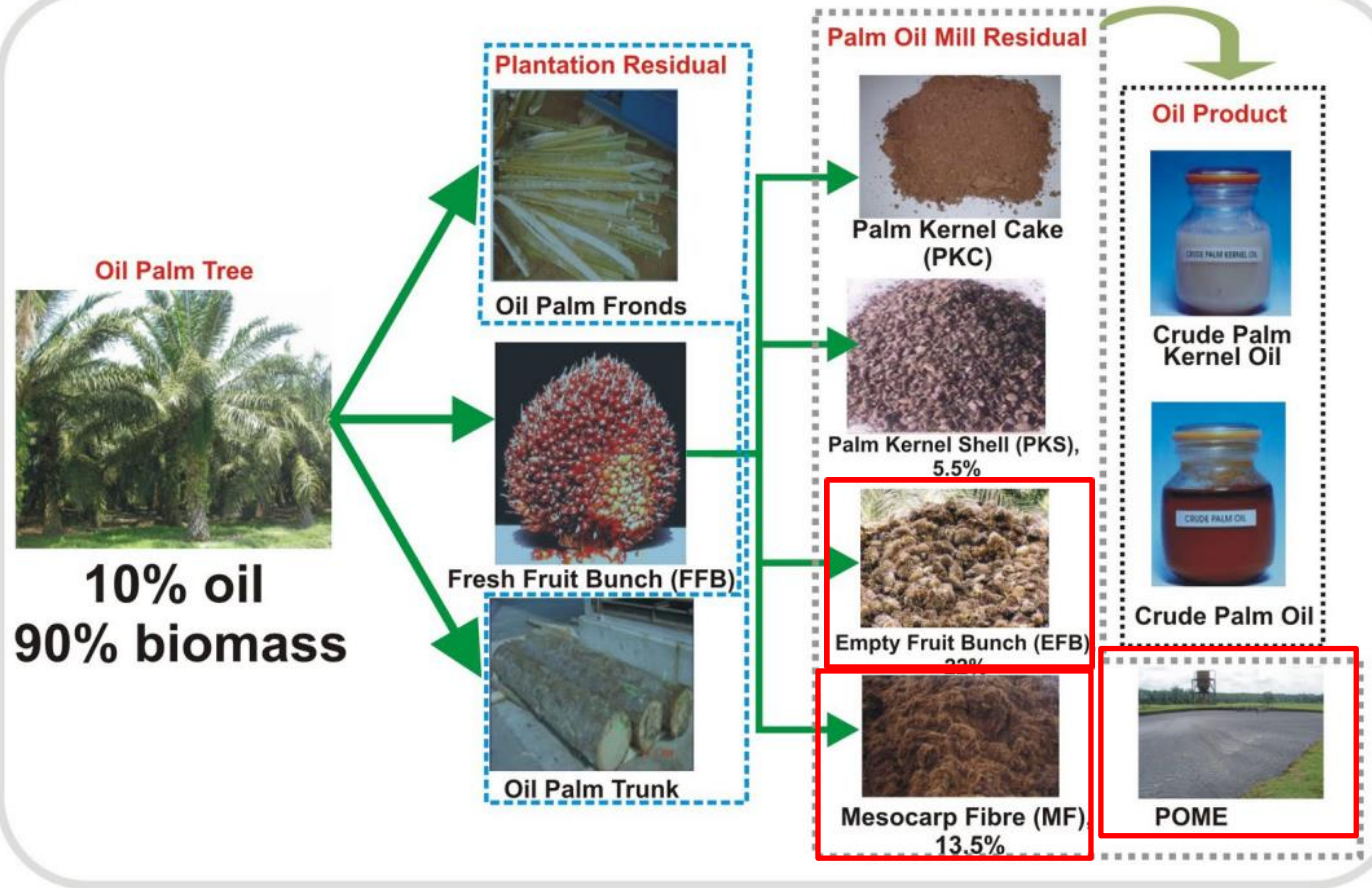


SCHEMATIC FLOW DIAGRAM OF PALM OIL MILL

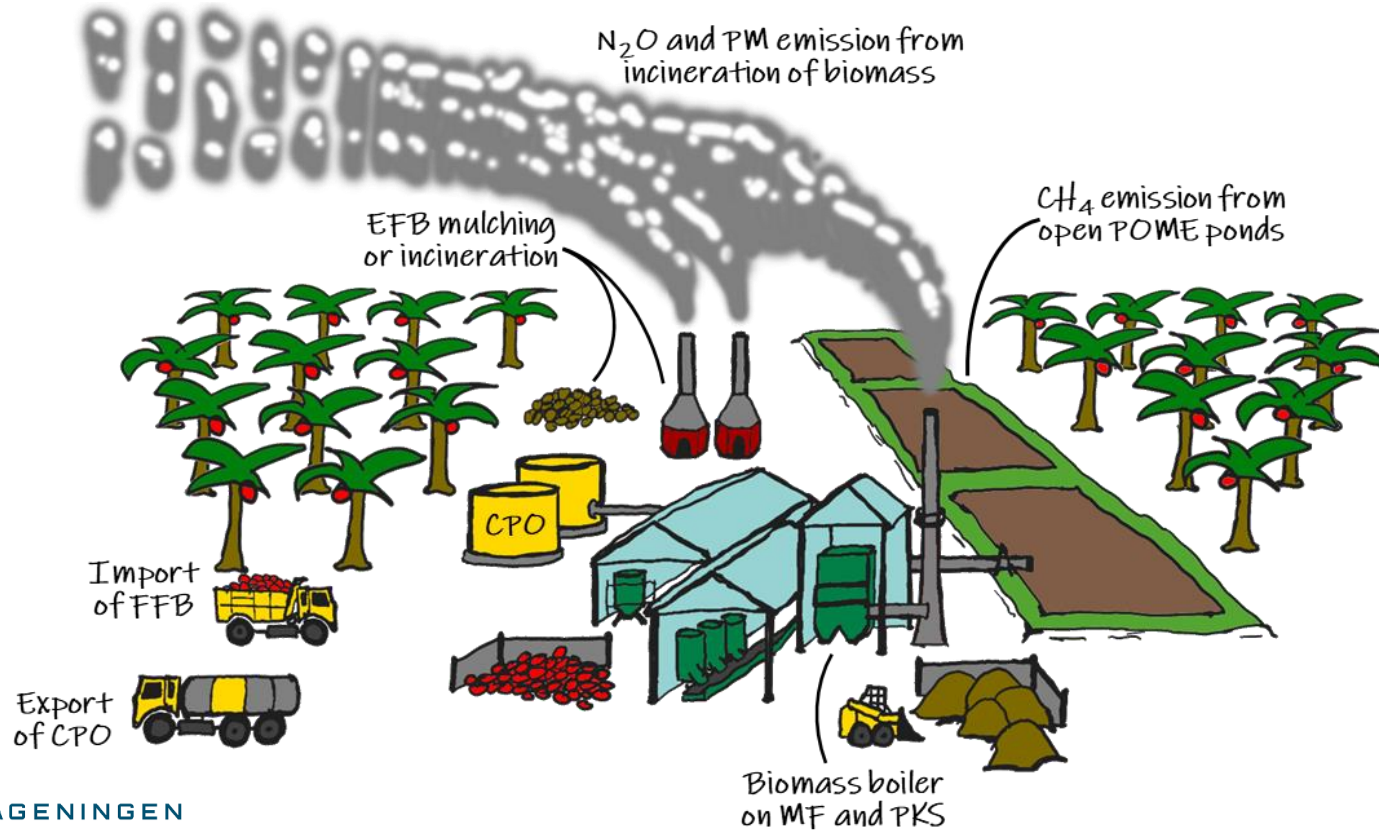


Oil Palm
produces 3 to 4
tons of oil per
ha/yr

Also residues

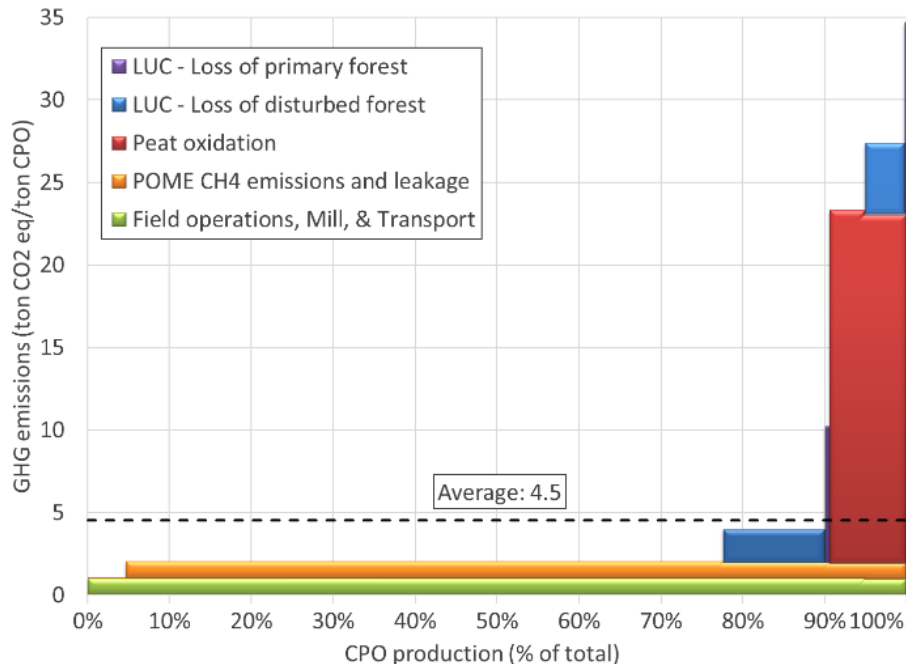


Current (Indonesia)

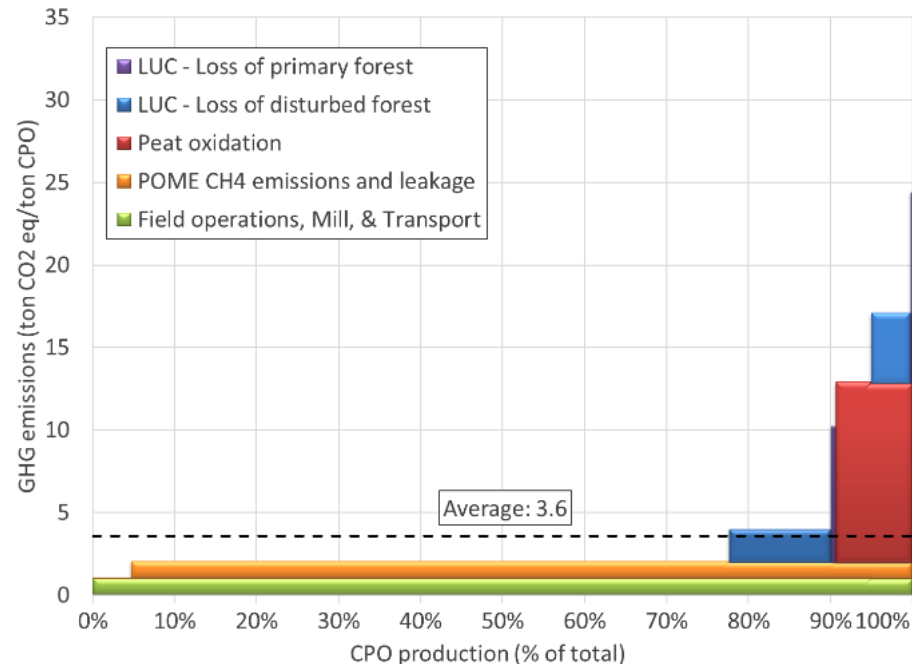


Current (2020) GHG emissions for CPO production in Indonesia

Assuming 80 tons CO₂-eq/ha peat emissions



Assuming 40 tons CO₂-eq/ha peat emissions



Residual oil in oil palm mill residues in Indonesia and the world

	Oil production	Oil as % of CPO	Indonesia	World
	% of FFB	% of CPO	Million ton per year (2023)	
CPO (Crude Palm Oil)	21,0%	100%	47	76
POME (Palm Oil Mill Effluent)	0,60%	2,86%	1,34	2,17
EFB (Empty Fruit Bunch)	0,60%	2,86%	1,34	2,17
MF (Mesocarp Fibre)	0,60%	2,86%	1,34	2,17
Total	22,8%	109%	51	83

In 2024 15,4 Mton FAME + HVO used in EU

8,5 Mton from “waste”

→ Oil palm residue oil potential is significant

What part of this potential can be mobilized?

*conversion from oil to biodiesel is not 100%

POME oil in Indonesia

- POME is processed anaerobically in ponds generating methane
- >90% of methane is emitted
- Removing all oils from POME can reduce methane emission by ~**31%**
- Skimming can extract max 50% to 60% of POME oil = 0,36% of OER = 1,3 Mton worldwide
- What part of sludge oil is really recovered?
- Improved oil recovery systems are in development, see “bubble technology”
- Distinguish POME/sludge oil? free fatty acids, short chain fatty acids?
- What happens downstream?



POME – Sludge oil composition?

Table 1 Characteristics of SPO used in this study and crude palm oil (CPO) for comparison

Parameters	SPO ^a	CPO
Total carbon content (%)	87.8	–
Lipid content (wt%)	94.9	–
Free fatty acid content (%)	82.2	5.6 ^b
Saturated fatty acid (%)	82.3	54.1 ^c
Acid number (mgKOH/g)	180.3	6.9 ^c
Moisture content (%)	2.68	0.02 ^c
Ash content (%)	0.33	–
Unsaponifiable matter (%wt)	0.75	0.19–0.44 ^d
Peroxide value (meq/kg)	<0.10	–
P-Anisidine value	22	–
Melting temperature (°C)	45.5	33.8–39.2 ^d
Total nitrogen (%)	0.07	–
Total protein (%)	0.41	–

^aFrom this study

^bResults from Melero et al. [45]

^cResults from Crabbe et al. [36]

^dData from MS814:2007

Table 2 Fatty acid composition of SPO and crude palm oil (CPO) as comparison

Fatty acid	SPO ^a (%)	CPO ^b (%)
Caproic acid (C6:0)	3.7	–
Enanthic acid (C7:0)	0.8	–
Caprylic acid (C8:0)	0.5	–
Lauric acid (C12:0)	0.9	0.5
Myristic acid (C14:0)	2.1	1.2
Palmitic acid (C16:0)	64.5	47.8
Palmitoleic acid (C16:1)	0.1	0.04
Stearic acid (C18:0)	9.2	4.2
Oleic acid (C18:1)	14.4	37.0
Linoleic acid (C18:2)	2.6	9.1
Linolenic acid (C18:3)	–	0.3
Arachidic acid (C20:0)	0.6	0.3
Others	0.6	–

^aFrom this study

^bData from Crabbe et al. [36]

Empty Fruit Bunch oil

- >90% EFB is burned or mulched
- EFB stored on heaps before burning or mulching → methane emissions
- What is the oil yield in case of pressing?
- How common is EFB pressing for EFB liquor/juice production? →
- EFB oil has lower quality compared to CPO
- “EFB liquor is recycled and ends up in (lower grade) CPO”
- “EFB liquor mixed with sludge oil”
- Why so little EFB oil used for biodiesel compared to POME oil?
- How to distinguish EFB oil from CPO? - higher chlorine? FFA?



EFB juice

Palm Press Fibre = Mesocarp Fibre + some crushed kernel

- PPF >95% burned as fuel for steam production
- Hexane extracts 80% of PPDF oil Realistic yield is $0,6 \times 0,8 = 0,48\%$ of OER
- 76 Mton CPO in world $\times 0,48/21 = \underline{1,74 \text{ million ton worldwide is capacity}}$
- Alternative fuel for steam? → Yes, extracted PPF + some EFB fibre
- Or: biogas from POME + clean PPF → Additional benefit: trigger POME biogas systems → all CH_4 emission avoided
- PPF oil is not on the list of allowed biodiesel feedstocks - but should be -
- Expansion of hexane extraction is needed



How many PPF oil extraction plants?

- Hexane extraction also used for Palm Kernel Cake (PKC) extraction
- Indonesia 1030 oil palm mills
- Malaysia approx. 450 palm oil mills
- Current use of PPFOil?
- "I will build a hexane plant if 90% of CPO price is guaranteed for the PPF oil"
- How can the demand for biofuels trigger investments in PPF extraction plants?

Malaysia 15?

Country	No	Contracted Party	Site	Year	Description	Status
Malaysia	1	Kim Loong Palm Oil Mills Sdn Bhd (Kim Loong Resources Berhad)	Kota Tinggi	2007	288 TPD PFOE	Completed
	2	Sungei Kahang POM Sdn Bhd	Sg Kahang	2009	360 TPD PFOE	Completed
	3	Bell Biochem Sdn Bhd (Bell Group of Companies)	Yong Peng	2010	288 TPD PFOE	Completed
	4	Desa Kim Loong Palm Oil Mill Sdn Bhd (Kim Loong Resources Berhad)	Keningau	2010	80 TPH FFB	Completed
	5	KKSL Nutri Oil Sdn Bhd (Kilang Kelapa Sawit Lekir Sdn Bhd)	Setiawan	2010	360 TPD PFOE	Completed
	6	Endau Palm Oil Mill (Ultimate Palms Sdn Bhd)	Endau	2011	252 TPD PFOE	Completed
	7	Rompin Palm Oil Mill (Ultimate Palms Sdn Bhd)	Rompin	2011	252 TPD PFOE	Completed
	8	Gunong Pertanian Sdn Bhd (KLK Berhad)	Paloh, Johor	2011	120 TPH FFB	Completed
	9	Sungkit Enterprise Sdn Bhd (Kim Loong Resources Berhad)	Kota Tinggi	2012	120 TPD PKC	Completed
	10	Bell Sri Lingga Sdn Bhd (Bell Group of Companies)	Melaka	2012	288 TPD PFOE	On-hold
	11	CP Hexchem Sdn Bhd (Charuk Putting POM Sdn Bhd)	Temerloh	2012	90 TPH FFB	Completed
	12	KLK Premier Oil Sdn Bhd (KLK Berhad)	Lahat Datu	2014	900 TPD Kernel	Completed
	13	ST Solvent Sdn Bhd (ST Palm Oil Mill Sdn Bhd)	Teluk Intan	2014	90 TPH FFB	Completed
	14	Melewar Properties S/B (JC Chang Group)	Lahad Datu	2015	90 TPH FFB	Completed
	15	Asia Ecogreen S/B (JC Chang Group)	Lahad Datu	2015	90 TPH FFB	Completed
	16	KS Felcra Seberang Perak (Felcra Berhad)	Seberang Perak	2017	60 TPH FFB	Completed
	17	Sedenak Palm Oil Mill (Kulim (Malaysia) Berhad)	Kulai, Johor	2022	90 TPH FFB	Completed

18

Indonesia 2?

Country	No	Contracted Party	Site	Year	Description	Status
Indonesia	1	PT Bangun Jaya Alam Permai (PT Best Agro Group)	Kalimantan Tengah	2012	388 TPD PFOE	Completed
	2	PT Adei Plantation & Industry (KLK Berhad)	Mandau, Riau	2018	504 TPD PKC	Completed
	3	PT Inti Indosawit Subur Ukui 1	Pekan Baru, Riau	2021	268 TPD PFOE	Completed

15

PPF oil

- Not food grade – cannot be mixed with CPO.
- High in vitamins and Ox stability, phosphorus, but also
- High in FFA,, Cl, Hexane
- Can vitamins be extracted for feed use before biodiesel production?

TABLE 1. INITIAL QUALITIES OF CRUDE PALM OIL (CPO) AND SOLVENT-EXTRACTED PALM PRESSED-FIBRE OIL (PPFO) FROM DIFFERENT COMMERCIAL PLANTS

	CPO (this study)	PPFO commercial I (this study)	PPFO commercial II (Ummi Kalsum and Rohaya, 2019)	PPFO commercial III (Nur Sulihatimarsyila <i>et al.</i> , 2019)	MS 814:2007 specification (Farah Khuwailah <i>et al.</i> , 2019; Parveez <i>et al.</i> , 2019)
FFA (%)	3.1 - 4.5	5.38 - 8.26	5.09 - 10.6	5.30 ± 0.19	<5%
DOBI value	2.43 - 2.83	1.62 - 2.02	1.15 - 2.17	2.02 ± 0.18	>2.3
Oxidative stability (hr)	14 - 17	18 - 25	-	-	-
Iodine value (ppm)	49.11 - 51.22	51.96 - 53.22	-	-	52 ± 0.66
Phosphorus content (ppm)	16 - 27	214 - 247	217 - 1063	633 ± 83	<10
Chloride content (ppm)	1.95 - 10.89	23.41 - 127.23	207.62 - 379.58	-	<2.5
Carotene content (ppm)	537 - 572	1258 - 1750	1025 - 1913	1467 ± 35	500 - 600
Vitamin E (ppm)	771 - 1108	1686 - 2600	1574 - 2999	1527 ± 73	-
Hexane concentrations (ppm)	*N/A	111 - 4046	-	-	-

Remarks: The solvent-extracted PPFO samples were retrieved from a number of solvent extraction plants in Peninsular Malaysia: (I) eight, (II) nine (III) one. Results of oil samples were tabulated in mean ± standard deviation (n = 3).

*N/A = not applicable

Palm Press Fibre = Mesocarp Fibre + some crushed kernel

- This explains the difference in composition between CPO and PPF oil. PPF oil contains C12:0 and C14:0 acid from palm kernel



Table 3. Fatty acid composition in palm pressed fiber, crude palm oil and RBDPOo via various extraction methods

Free Fatty Acids	CPO, %	RBDPOo, %	PPF,%		
			Cold extraction	Soxhlet	Reflux
C12:0	-	-	5.89 ±0.17	7.12 ±0.13	9.09 ±0.09
C14:0	0.55 ± 0.05	0.60 ±0.11	2.62 ±0.12	2.91 ±0.15	3.43 ±0.05
C16:0	46.93 ±0.02	46.30 ±0.04	39.34 ±0.09	40.70 ±0.06	37.01 ±0.08
C18:2	6.29 ±0.02	6.70 ±0.03	10.00 ±0.04	9.48 ±0.09	8.00 ±0.11
C18:1	42.94 ±0.10	42.79 ±0.07	37.74 ±0.08	36.51 ±0.14	39.01 ±0.05
C18:0	3.14 ±0.08	3.37 ±0.13	3.58 ±0.10	3.27 ±0.09	3.45 ±0.02

Samples of CPO and mill residues



Next Steps?

- Know how it works in practice
- Anticipate irregularities
- Include physical checks
- Develop a library of CPO and residue oils → (fast) detection methods
- Check feedstock on arrival in NL
- Assess readiness at mills level for mobilizing residue oils – what infrastructure is available? Pressing? Skimming? Bubble? Hexane extraction?
- How can investments be triggered in the needed infrastructure?
- *Course on biomass feedstock supply for biofuels? Interested?*

Thank you!

wolter.elbersen@wur.nl

johan.vangroenestijn@wur.nl

puneet.mishra@wur.nl



MesOil project

