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PROCEEDINGS

OF

INTERNATIONAL SEMINAR ON CHEMICAL ENGINEERING

in conjunction with

Seminar Teknik Kimia Soehadi Reksowardojo (STKSR) 2016

27-28 October 2016
Institut Teknologi Bandung, Indonesia

Organized by:

Supported by:

Sponsored by:

Department of Chemical Engineering
Faculty of Industrial Technology
Institut Teknologi Bandung

PROCEEDING

International Seminar on Chemical Engineering
in conjunction with
Seminar Teknik Kimia Soehadi Reksowardojo (STKSR)
2016

"Sustainable Food, Energy, and Water"

ISSN: 2353-5917

27-28 October 2016
West and East Hall
Institut Teknologi Bandung
Jl. Ganesha 10 Bandung INDONESIA

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Organized by

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Faculty of Industrial Technology
Institut Teknologi Bandung

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MESSAGE

First of all, deep gratitude is dedicated to Allah the Almighty which gives His blessing to the Chemical Engineering Institut Teknologi Bandung which this year evenly becomes 75 years old. The journey of 75 years for Chemical Engineering ITB as the oldest Chemical Engineering program in Indonesia and one of the oldest program in ITB is a long journey with all the hurdles which creates the Chemical Engineering ITB becomes a reputable program.

We gladly overcome the presence of "75 Tahun Teknik Kimia untuk Indonesia" book, as a track record of the contributions of Chemical Engineering ITB and its alumni in advancing Indonesian society. The family of Chemical Engineering ITB and its alumni have been proven to be able to build a strong connectivity among the higher education, Science and technology development, and industrial escalation especially in chemical industry. Therefore, the contribution of Chemical Engineering ITB is unquestionably substantial in showing the objective of Indonesian society to achieve food independency and energy sovereignty. It is highly expected that this book can pass those ideas to the society, especially the young generation which will advance the development of Chemical industry in Indonesia.

We would like to congratulate anew this 75th year Commemoration of Chemical Engineering Higher Education in Indonesia. We hope that the family of Chemical Engineering ITB can be continuously actively contribute in generating intellectual works which are affluent in advantages, as a contribution to the Indonesian society. Especially for the alumni of Chemical Engineering ITB, we hope that can keep the good relation with the alma mater, also to keep working, accomplishing, and being the "energy" for ITB to keep carrying on the credence of the higher education.

Bandung, October 2016

Prof.Dr.Ir. Kadarsah Suryadi, DEA.

Rector of Institut Teknologi Bandung (ITB)

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MESSAGE

Assalamu'alaikum Warahmatullahi Wabarakatuh

Warm Greetings for us all

Ladies and Gentlemen,

Chemical Engineering program in ITB cooperates with Chemical Engineering ITB alumni foundation and the alumni themselves are conducting series of events which consist of the Education Seminar about Chemical Engineering dedicated to High School teachers and students, especially for Science program, on October 26th 2016 and the International Seminar on Chemical Engineering in Conjunction with Seminar Teknik Kimia Soehadi Reksowardojo 2016 on 27-28 October 2016.

The seminar this year is focusing on the topic of Energy, Food and Water. Those three topics were chosen in relation to the scarcity of these three aspects which are starting to give impacts and need a special attention. The chemical engineering bachelors can be involved much in those three sectors, and so the academia, practitioneers and the government in order to harness this moment to share knowledge for the sake of advancement of Republik Indonesia.

For the participants who are actively involved and the invited speakers, the sponsors and Institut Teknologi Bandung who already gave us permission to utilize the facilities, we express our deep gratitude.

Hopefully this seminar can give benefits for us all.

Wassalam

Dr.Ir. Irwan Noezar, MS

Chairman of 75th year Commemoration of Chemical Engineering

Higher Education in Indonesia

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MESSAGE

Dear Colleagues,

On behalf of the Organizing Committee of the International Seminar on Chemical Engineering, I am honorable to welcome you all to Institut Teknologi Bandung, Bandung, Indonesia. This year, Department of Chemical Engineering – Institut Teknologi Bandung is celebrating the 75th year of Chemical Engineering Education in Indonesia. One of the main events is holding this Seminar in conjunction with Seminar Teknik Kimia - Soehadi Reksowardojo (STKSR) 2016 with the topic of 'Sustainable Energy, Food and Water'. Globally and at national level as well, we are aware of the challenges to meet the needs of energy, food and water for all in sustainable ways.

Those topics will be addressed by leading engineers/scientists from 9 countries, either in plenary lectures or parallel sessions. In each session, an invited speaker will address a certain topic with a depth insight and ample of time to discuss the issue with the participants, hopefully they will learn more from an expert in the field.

We have also prepared several social functions, so that delegates may meet one another and experience the Indonesian culture with Bandung pleasant weather and warm hospitality. Finally, the committee is most grateful to all sponsors and ChemEng-ITB Alumni for providing funds. I also thank all International/Technical Committee members, all the plenary and invited speakers and all oral/poster presenters for their kind efforts and contributions in making this conference a success.

Thank you

Prof. Tjandra Setiadi, Ph.D.

Chairman of STKSR 2016

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GENERAL PROGRAM

Day 1: Thursday, October 27th 2016

TIME	PROGRAM	
	WEST HALL	**EAST HALL**
07.30 – 08.00	Registration	
08.00 – 09.05	Opening Ceremony of Commemoration of 75 Years Higher Education of Chemical Engineering in Indonesia • Safety Induction: Dr. Hary Devianto • Report presentation from Programme Advisor: Assoc. Prof. Irwan Noezar • POKJA Presentation	
09.05 – 09.15	Referral of POKJA document to Rector of Institut Teknologi Bandung	
09.15 – 09.30	Opening and Welcoming Speech by Rector of Institut Teknologi Bandung: Prof. Dr. Ir. Kadarsah Suryadi, DEA.	
09.30 – 10.00	Photo session and coffee break	
10.00 – 10.15	Opening ceremony of STKSR 2016: Prof. Tjandra Setiadi	
	Keynote 1: Prof. Koichi Fujie. **Yokohama National University, Japan.** **" Design and Evaluation of Biomass Residue Recycle System for Sustainable Crop Cultivation based on Material Flow Analysis "**	
10.45 – 11.15	**Keynote 2: Prof. Hamdani Saidi** **Universiti Teknologi Malaysia, Malaysia**	

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TIME	PROGRAM			
	WEST HALL	EAST HALL		
	" Renewable Energy – Emerging opportunities for Chemical Engineers "			
11.15 – 11.45	**Keynote 3: Prof. Johan Sanders** **Wageningen University, The Netherlands** **" Small Scale Biorefineries for Food and Non Food Application "**			
11.45 – 12.15	Flash Poster Presentation			
12.15 –13.30	LUNCH BREAK			
	PARALEL I : 1st SESSION			
	ROOM 1	**ROOM 2**	**ROOM 3**	**ROOM 4**
13.30 – 13.50	E06*	F06	W11*	O12*
13.50 – 14.05	E01	F05	W10	O01
14.05 – 14.20	E05	F03	W05	O02
14.20 – 14.35	E07	F16	W08	O05
14.35 – 14.50	E20		W03	O07
15.00 – 15.30	Coffee Break			
	PARALLEL I: 2nd SESSION			
	ROOM 1	**ROOM 2**	**ROOM 3**	**ROOM 4**
15.30 – 15.50	E03*	F29	E43*	W13*
15.50 – 16.05	E08	F08	E31	O10
16.05 – 16.20	E10	F10	E34	O11
16.20 – 16.35	E11	F13	E38	O13
16.35 – 16.50	E14	F14	E39	
19.00 – 21.00		**GALA DINNER**		

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Day 2: Friday, October 28th 2016

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“ Wastewater – Still one of the most important engineering challenges ”</td><td colspan="2"></td></tr>
<tr><td>14.00 – 14.30</td><td colspan="2">Keynote 5: Prof. Subagjo
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TIME	PROGRAM	
	WEST HALL	EAST HALL
	" Biorefineries: from biomass to green energy,biofuels and biobased chemicals."	
15.00 – 16.00	Studium Generale by Indonesian Minister of National Development Planning: Prof. Bambang Permadi Soemantri Brodjonegoro	
16.00 – 16.30	Closing remarks Award announcement: best presenter, best paper, best poster, and young scientist award	
16.30 – 17.00	Coffee Break	

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WASTE TREATMENT AND UTILIZATION IN INDONESIAN PALM OIL INDUSTRY

Udin Hasanudin*[1], Julfi R. Amelia[2], Agus Haryanto[3], Ryo Murakami[4], and Koichi Fujie[4]

[1]Dept. of Agro-industrial Technology, University of Lampung, Email: udinha@fp.unila.ac.id,
[2]Dept. of Agro-industrial Technology, Bogor Agricultural University,
[3]Dept. of Agricultural Engineering, University of Lampung,
[4]Graduate School of Environment and Information Sciences, Yokohama National University.

Indonesia CPO Production

2013:

27.64 Million tons.

2015 :

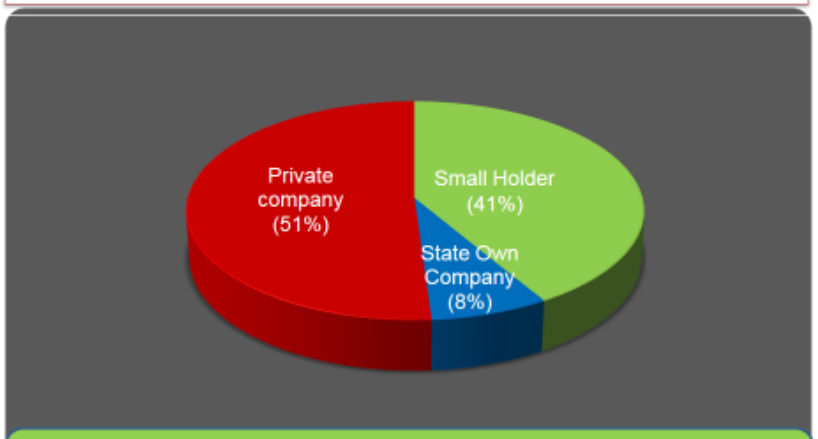
32.36 Million tons.

2020 was estimated

43.93 Million tons (GAPKI 2014).

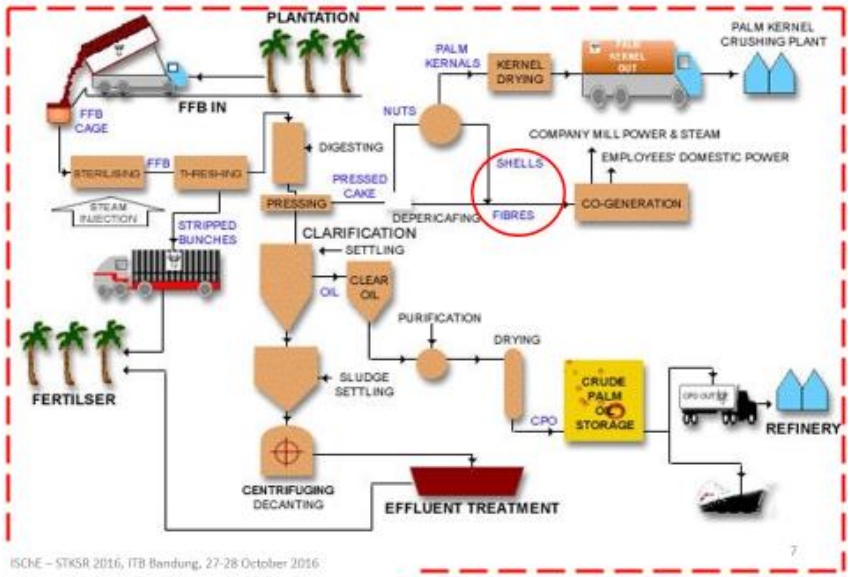
Number of Palm Oil Mills more than 750 unit (some of mills have no plantation)

Owner of Oil Palm Plantation in Indonesia



Small holder farmers usually have no mill, it should be considered on waste treatment and utilization policy

Crude Palm Oil Milling Process



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Estimation of Waste Potential from Indonesian Palm Oil Mills

Type of Waste	Waste Production		
	2013	2015	2020
POME (10^6 m^3)	84,12	98,49	133,70
Mesocarp Fiber (10^6 Ton)	14,42	16,88	22,92
Palm Kernel Shell (10^6 Ton)	6,01	7,03	9,55
EFB (10^6 Ton)	24,03	28,14	38,20
Boiler Ash (10^6 Ton)	3,00	3,52	4,78

Waste Treatment and Utilization Approach

- *minimization of waste,*
- *total utilization of resources*, and
- *increase of total productivity*

AGROINDUSTRY ⇨ **ZERO WASTE**

COMMONS PRACTICES OF WASTE TREATMENT AND UTILIZATION IN INDONESIAN PALM OIL INDUSTRIES

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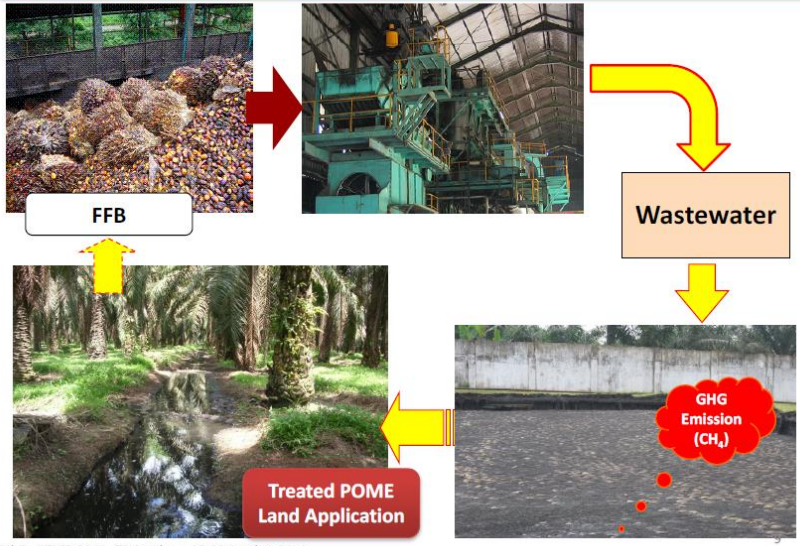
Conventional POME Treatment and Utilization



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REQUIREMENT FOR LAND APPLICATION OF TREATED POME

Decree of Minister of Environment No. 28 and 29, 2003.

- ❑BOD max. 5000 mg/l
- ❑ pH 6-9
- ❑prohibited to apply in peat land
- ❑Soil permeabilty > 1,5 cm/h and < 15 cm/h
- ❑Water table > 2 m
- ❑Conducted a research in the LA area before applying the treated POME

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What the impact of Treated POME Land Application to the soil environment ?

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The Important of Land Application

- Wastewater (POME) = 0,6-1 m3/ton of FFB
- **COD fresh POME = 40.000-100.000 mg/l**
- Effluent standard in palm oil industry:

Parameters	Max. Concentration (mg/l)	Max. Pollution Load (Kg/Ton CPO)
BOD_5	100	0,25
COD	350	0,88
TSS	250	0,63
Fats and Oils	25	0,063
Nitrogen Total (as N)	50	0,125
pH	6-9	
Max. Flow rate	2,5 m^3 per ton product (CPO)	

Very costly if the objective POME treatment is only for fulfilling the effluent standard

Nutrient Content in Each Stage of POME Treatment

Stage of Treatment	BOD (mg/L)	N (mg/L)	P (mg/L)	K (mg/L)	Mg (mg/L)
Fresh POME	25.000	950	150	1.960	345
After Anaerobic Treatment					
- Mixed	1.300	900	120	1.800	300
- Liquid	450	450	70	1.200	180
- Slurry	190	320	40	1.495	260
- Sediment	1.000-3.000	3.350	1.180	1.390	1.510
After Aerobic Treatment					
- Liquid	100	50	12	2.300	540
- Sediment	150-300	1.495	460	2.380	1.000

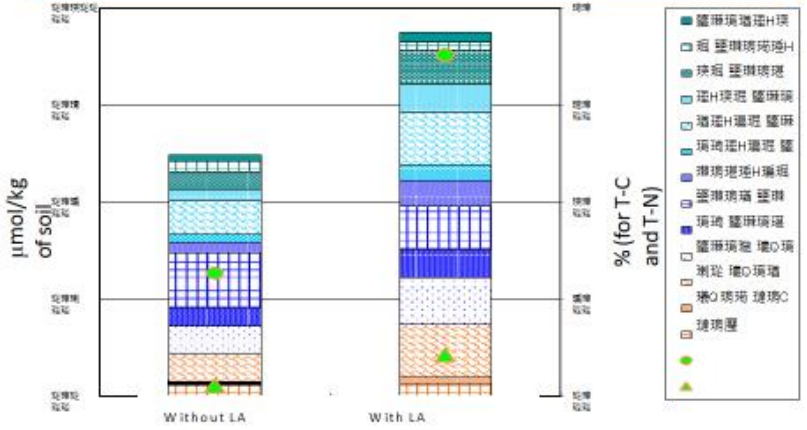
Land Application is related with SOIL QUALITY and PRODUCTIVITY as main indicators of SUSTAINABILITY in agricultural sectors

Soil Quality Indicator:

GBEP : considered Soil Organic Carbon
ISCC : soil erotion, soil organic matters, soil structure
RSPO : soil fertility → optimal and sustained yield

SOIL QUALITY has integrated meaning

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



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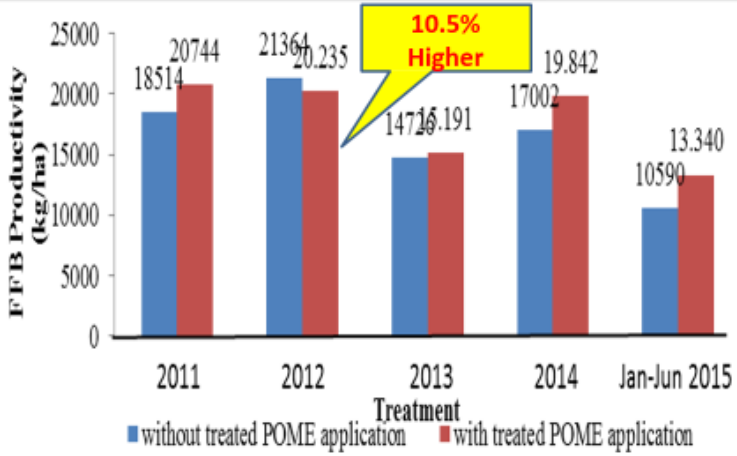
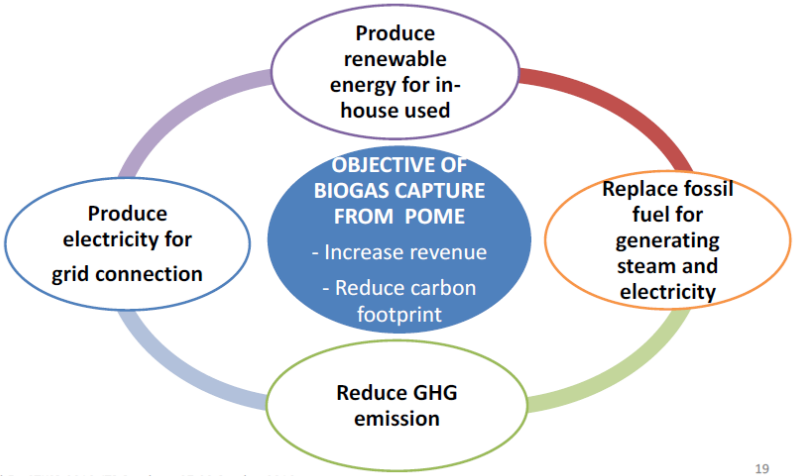
FFB productivity in the block with and without treated POME Application



Methane Capture dan Land Application

The Objective of Methane Capture



Biogas Production from POME

Cover In Ground Anaerobic Reactor (CIGAR)

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Estimation of GHG emission potential from POME

Parameter	Unit	Value	
		Min	Max
COD of fresh POME	mg/l	43,375	60,400
COD of treated POME	mg/l	5,500	9,000
POME production	m^3/ton FFB	0.55	0.65
COD removal	kg/ton FFB	20.83	33.41
IPCC default value*)	kg CH_4/kg COD removal	0.25	
CH_4 production	kg/ton FFB	5.21	8.35
IPCC default value*)	m^3 CH_4/kg COD removal	0.35	
CH4 production potential	m^3 CH4/ton FFB	7.29	11.69
GWP potential of CH_4*)	kg CO_2e/ kg CH_4	21	
GWP potential	kg CO_2e/ton FFB	109.41	175.35

*) IPCC, 2006

Based on methane production potential, the energy production from POME is estimated about:
25.3-40.6 kWh/ton FFB.
Using this value, palm oil mill with 45 ton FFB/hour or 900 ton FFB/hour has potential to generate
0.95 to 1

Energy Consumption in Palm Oil Mill:
17 kWh/ton FFB

Based on CPO production at 2015, the potential of energy production from POME in Indonesia is estimated more than **750 MW.**

Co-Composting EFB and POME

Co-Composting EFB and POME

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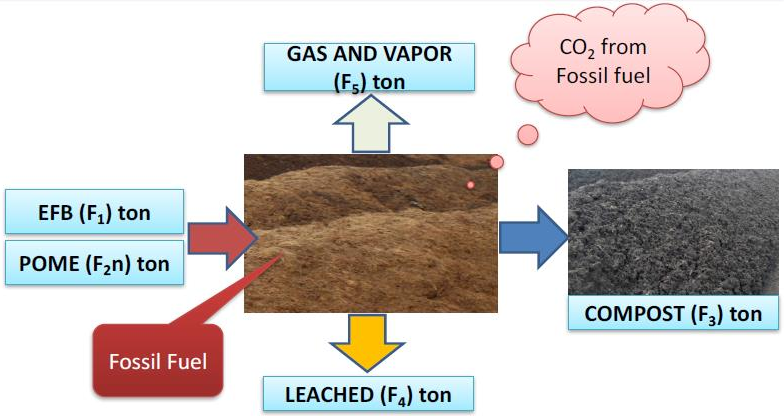
- Compost is important to maintain soil carbon and improving soil structure
- In between reversal period, it has potential to to occur anaerobic condition. Methane will realease during this period

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



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

Summary of calculation for GHG emission

	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

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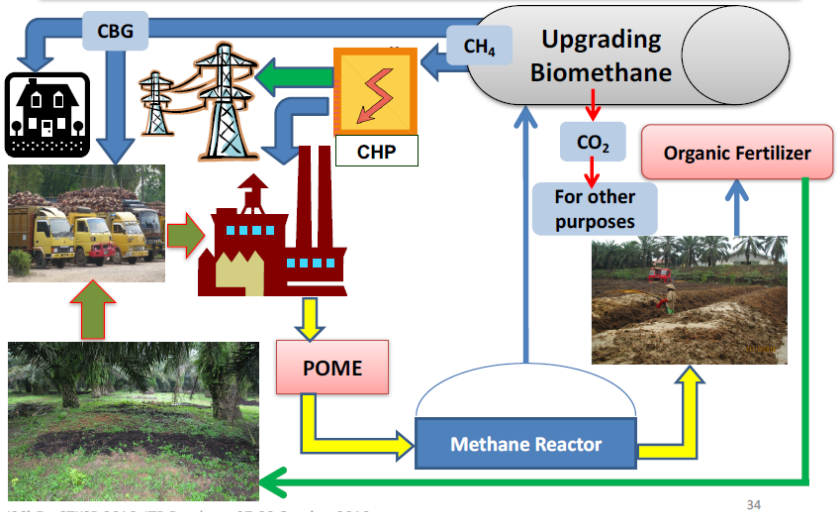
Co-Composting EFB and POME

- Reduce GHG e…sion
- Reduce water pollu… …d increase soil fertility and oil …
- Carbon and nu… return to the s…
- Smaller amount of … return to the plant

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

But, we can not get renewable energy

Propose Sustainable Palm Oil Waste Treatment



CONCLUSIONS

- Palm Oil Mill WASTE treatment has potential to support the sustainability of palm oil industry
- Sustainable Palm Oil Mill WASTE treatment has potential to:
  - ✓ Produce Renewable energy and increase energy diversity,
  - ✓ Reduce GHGs emission
  - ✓ Reduce environmental pollution
  - ✓ Improve soil quality
  - ✓ Increase oil palm productivity
  - ✓ Create new jobs in bioenergy and other sectors

Sawit Indonesia More Sustainable Than Ever

Thank you for your kind attention

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