Energy sustainability innovation: searching for an appropriate biomass plant species for sustainability energy production in the future

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Outline Presentasi:

- ❑ Indonesian National Policy on New Renewable Energy
- ❑ Global issue on biomass feedstock production
- ❑ Potential biomass energy from lowland community forest
- ❑ Potential biomass energy from plantation forest

UN CLIMATE CHANGE CONFERENCE UK 2021

IN PARTNERSHIP WITH ITALY

Jokowi reveals Indonesian policy in the field of economic and energy transition

It the energy sector, Indonesia also continues to move forward with the development of the electric car ecosystem and the construction of the largest solar power plant in Southeast Asia. Apart from that, Indonesia is also utilizing new renewable energy, including **biofuel/bioenergy**, as well as developing clean energy-based industries, including the construction of the largest green industrial area in the world in North Kalimantan.

PRIORITY FOR NATIONAL ENERGY DEVELOPMENT

Based on national energy policy

Maximizing the use of renewable energy

Minimizing the use of petroleum

Optimizing the use of natural gas and new energy

Using coal as the main source of national energy

Utilizing nuclear as a last option

Courtesy: Sutijastoto - ESDM (2020)

Development of bioenergy power plants

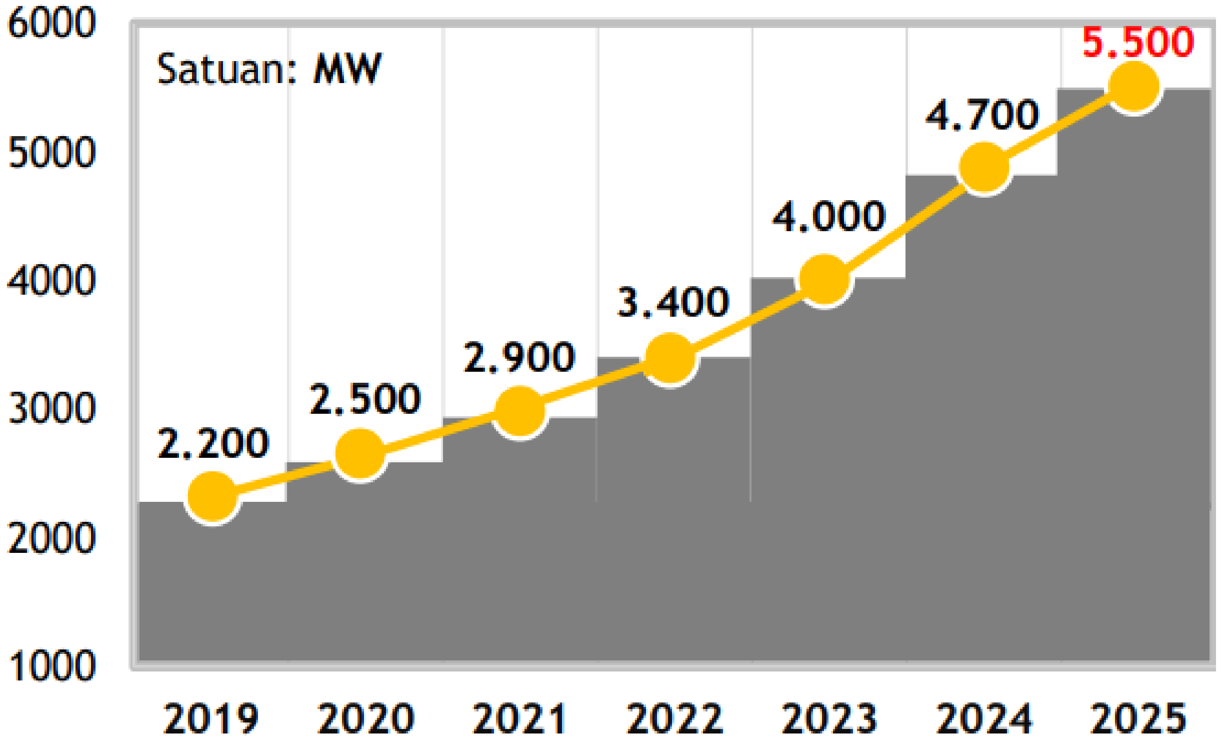
(Programs and national target)

Bioenergy power plant development program

- Biomass power plant
- Biogas power plant
- Natural oil power plant

- Municipal waste power plant

Development target of bioenergy power plants



Courtesy: Sutijastoto - ESDM (2020)

Domestic Biomass Energy Needs

PLN

The State Electricity Company (PLN), which initiated corporate action through the co-firing method, explained that to meet the need for **1% cofiring** at PLTUs in Indonesia, biomass of **17,470 tons per day or 5 million tons of wood pellets per year** is **needed.**

Indonesia's wood pellet production capacity ±1.1-1.2 million tons/year

±25 million tons of wood pellets are needed (5% Cofiring at PLTU)

IDR 25 T

Currently there are three types of steam power plants in Indonesia (PLTU):

- 43 PC (Pulverized Coal) type PLTUs with a total capacity of 15,620 MW require a mixture of 1-5% biomass
- 38 types of CFB (Circulating Fluidized Bed) with a total capacity of 2,435 MW requiring 1-5% biomass
- Meanwhile, 23 types of STOKER with a capacity of 220 MW use

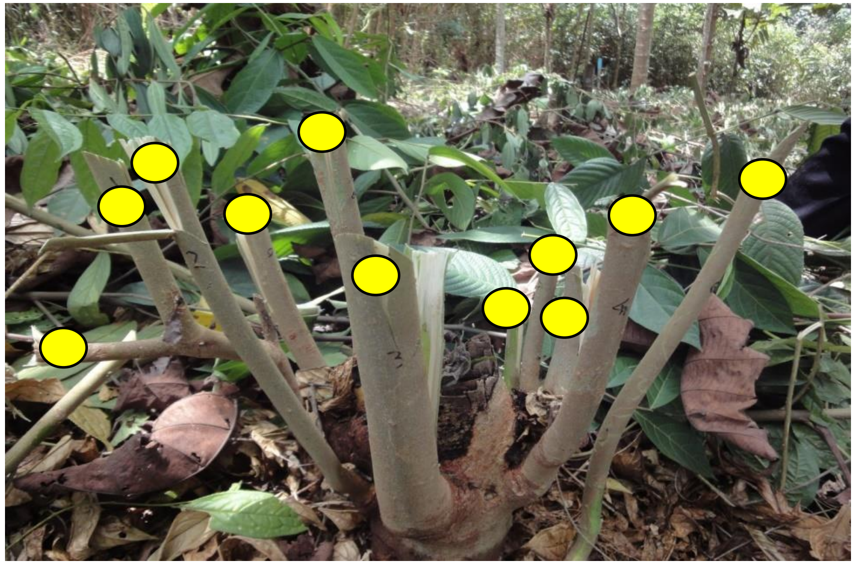
Global issue on biomass feedstock production

Recently, much attention has been focused on identifying suitable biomass species, which can provide high-energy outputs, to replace conventional fossil fuel energy sources. **Short Rotation Coppice (SRC)** or **Short Rotation Woody Crops (SRWC)** is one option for increasing the supply of woody biomass. Shorter rotation cycles allow higher planting densities and thus, higher biomass yields per unit land area (Dillen et al., 2013; Ghaley and Porter, 2014).

SRC planting process

What is short rotation coppice (SRC)?

Some fast growing tree species can be cut down to a low stump (or stool) when they are dormant in winter and go on to produce many new stems in the following growing season (in European forest). The woody shrub plant species such as Willow, Salix, Poplar, Black Locust and also Acacia and Eucalyptus trees were commonly used on SRC system in Denmark, Germany, Poland, Italy, New Zealand and others European countries (Sims et al. 2001; Sims and Venturi 2004; Fiala and Bacenetti 2012; Dillen et al. 2013; Ghaley and Porter 2014; Hauk et al. 2014; Haverkamp and Musshoff 2014; Krzyzaniak et al. 2015). .



Symplocos – East Kalimantan

Willow - UK

How about SRC/SRWC development in EK (Indonesia)

How about SRC/SRWC in Indonesia? In general speaking, there is no information available for SRC/SRWC and the woody plant species used for the energy-electricity production in Indonesia as far. In Indonesia we only knew and have a conventional concept of the forest plantation for the wood construction and pulp and paper production as well.

FP – Energy/Fuel

FP – Pulp and Paper

FP – Wood Construction

Google images

Evaluation of biomass energy potential from lowland community forest in East Kalimantan, Indonesia: a preliminary study

Forest plant species (wood biomass)

Thirty one samples of tropical plant species consists of tree and wood shrub with diameter about 2-10 cm and their leaves and branches were collected from community forest located at Telaga Village, East Kutai District, East Kalimantan Province, Indonesia. The leaves of plant samples were identified at the Laboratory of Forest Dendrology, Faculty of Forestry, Mulawarman University

Physico-chemical and energy potency

Analysis of forest plant species The physico-chemical and energy potency analysis of forest plant species were performed according to the American Society for Testing and Material (ASTM)

Diversity of plant species

Table-1. Plant species collected from the sampling plots located at community forest of Telaga Village, East Kutai

No.	Plant species		Plant Category	Local Use	Revegetation
	Latin Name	Local Name			
1	*C. glaucan*	Bengalon	Tree	Construction	Natural
2	*Prunus sp.*	Tembelas	Tree	Construction	Natural
3	*L. splendens*	Kacang	Tree	Construction	Natural
4	*M. sericea*	Telenggawi	Tree	Construction	Natural
5	*P. azurea*	Mutun	Tree	Construction	Natural
6	*A. cadamba*	Jabon	Tree	Construction	Artificial
7	*M. gigantea*	Serkong	Tree	Fire wood	Natural
8	*M. tanarius*	Mahang	Tree	Fire wood	Natural
9	*G. arborea*	Gmelina	Tree	Pulp and paper	Artificial
10	*A. mangium*	Akasia	Tree	Pulp and paper	Artificial
11	*P. falcataria*	Sengon	Tree	Pulp and paper	Artificial
12	*A. saman*	Trembesi	Tree	Fire wood	Artificial
13	*F. racemosa*	Kopi-kopian	Shrub	Fire wood	Natural
14	*V. trifolia*	Vitex	Shrub	Fire wood	Natural
15	*V. amygdalina*	Sambung Nyawa	Shrub	Herbal tea	Artificial
16	*M. malabathricum*	Karamunting	Shrub	Herbal tea	Natural
17	*G. sepium*	Gamal	Shrub	Fire wood	Artificial
18	*P. aduncum*	Sirih hutan	Shrub	-	Natural
19	*H. capitata*	Kayu wangi	Shrub	Herbal tea	Natural
20	*A. clypearia*	Kelayung	Shrub	-	Natural
21	*B. tementosa*	Berduri	Shrub	Fire wood	Natural
22	*C. calothyrsus*	Kaliandra	Shrub	Fire wood	Artificial
23	*V. arborea*	Hamirung	Shrub	Fire wood	Natural
24	*Nauclea sp*	Bengkal	Shrub	Fire wood	Natural
25	*B. purpurea*	Kupu-kupu	Shrub	-	Artificial
26	*V. pinnata*	Laban	Shrub	Fire wood	Natural
27	*Timonius sp*	Sebulu	Shrub	Fire wood	Natural
28	*S. fasciculata*	Simplocos	Shrub	-	Natural
29	*F. septica*	Awar awar	Shrub	Fire wood	Natural
30	*H. populneus*	Homalantus	Shrub	Fire wood	Natural
31	*T. orientalis*	Kalamboto	Shrub	Fire wood	Natural

Figure 2. Leave shape variations of plant species collected from the community forest of Telaga Villlage, East Kutai District, East Kalimantan, Indonesia

Wood density of woody biomass

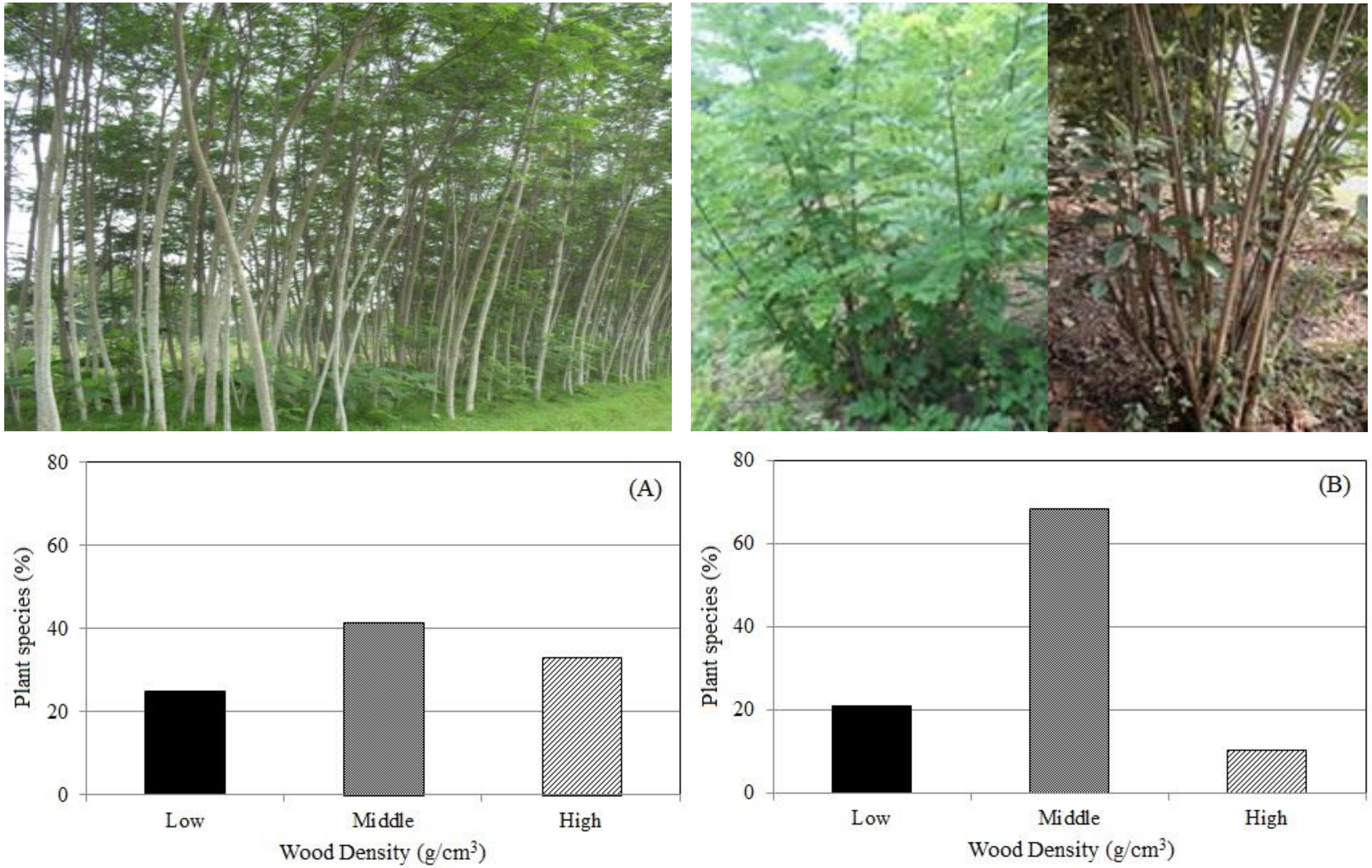


Figure 3. Wood density among (A) trees and (B) wood shrubs plant species collected from the community forest of Telaga Villlage, East Kutai, Indonesia

Potential SRC – Biomass Energy Plant Species

C. calothyrsus

S. fasciculata

V. amigdalina

G. sepium

P. aduncum

B. purpurea

V. pinnata

G. arborea

Potential SRC – Biomass Energy Plant Species

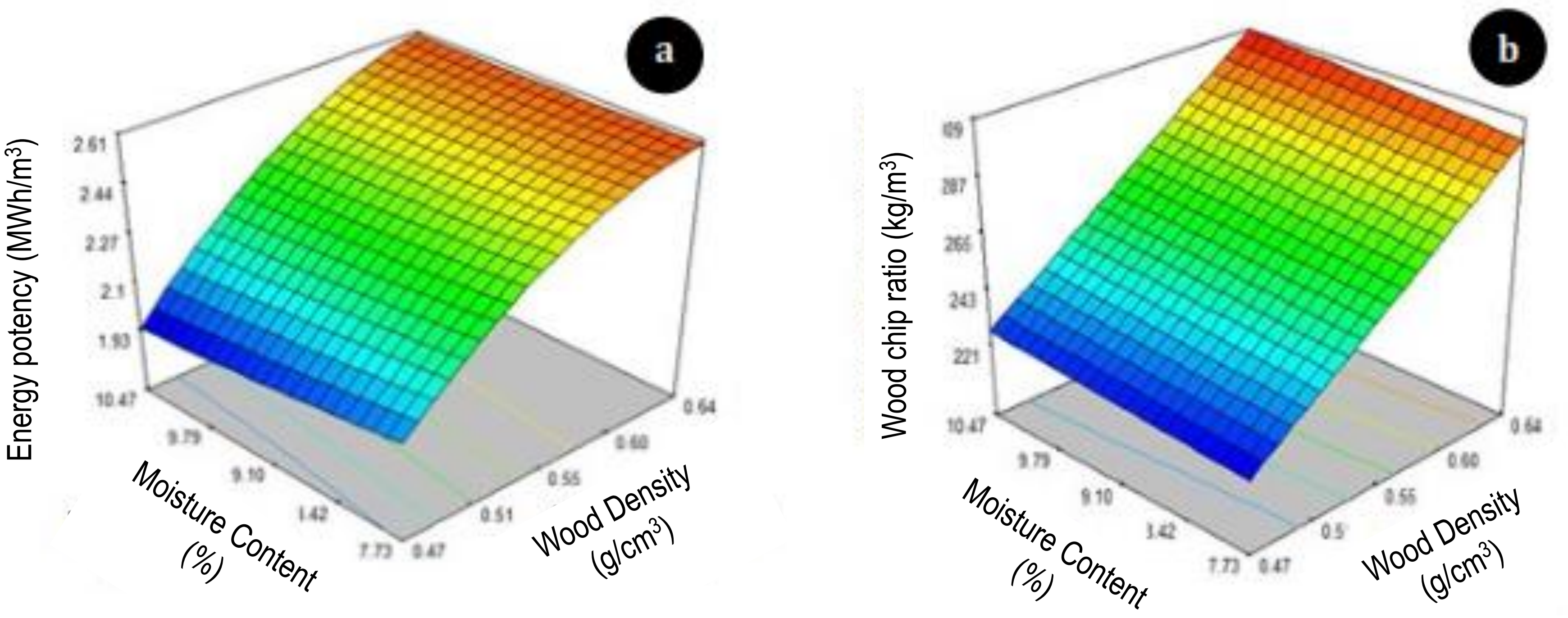
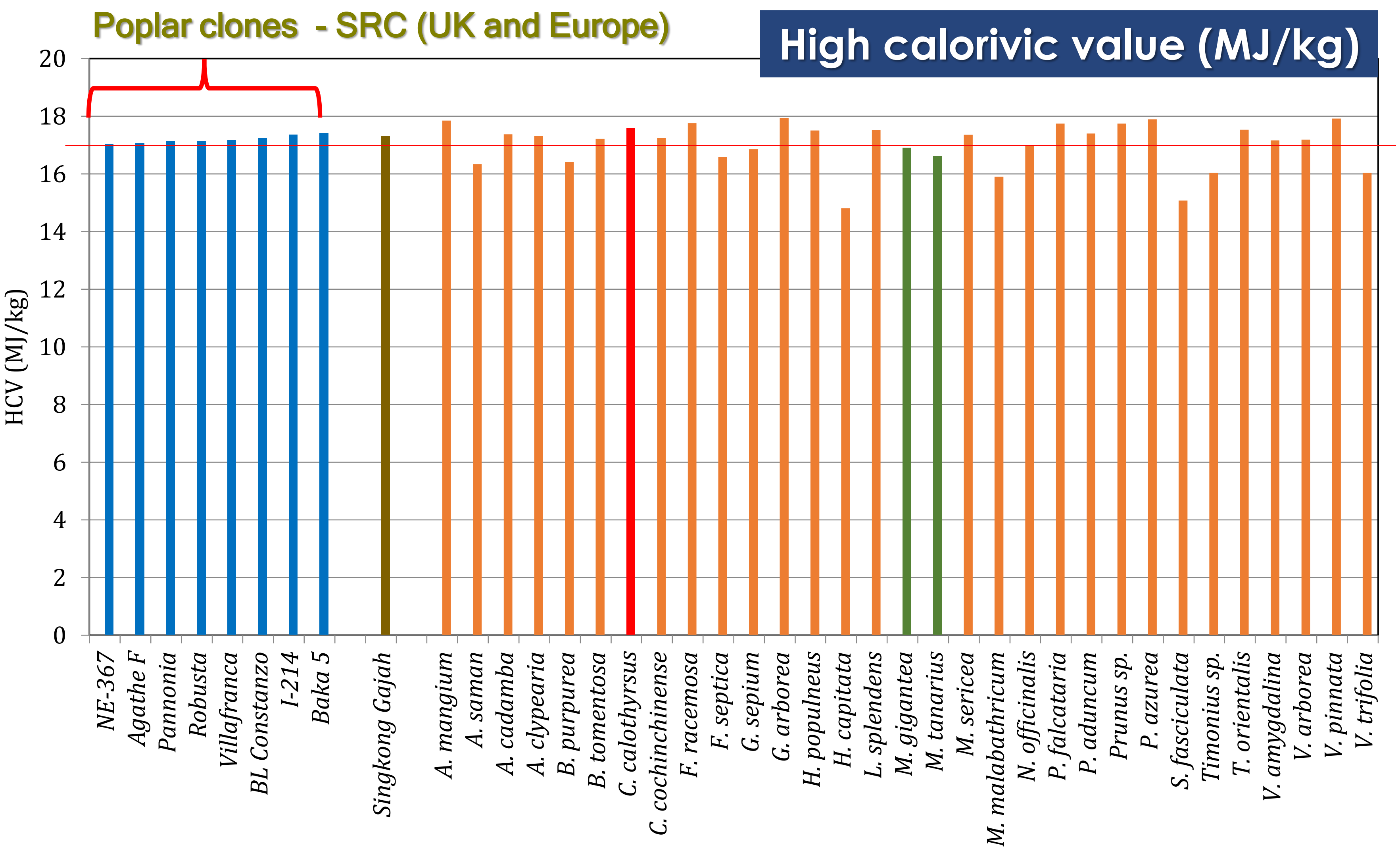


Figure 4. Surface response analysis of short rotation coppice (SRC) plant spesies from tropical lowland community forest in East Kalimantan, Indonesia

Energy potency of Tropical Wood to SRC-Poplar



Amirta R, Yuliansyah, Angi EM, Ananto BR, Setiyono B, Haqiqi MT, Septiana HA, Lodong M, Oktavianto RN. 2016. **Plant diversity and energy potency of community forest in East Kalimantan, Indonesia: Searching for fast growing wood species for energy production**. Nusantara Bioscience 8: 22-30.

Tropical Forest Resources – Macaranga

Fig. *Macaranga tanarius*

- *M. gigantea* and *M. tanarius* have been used as firewood species by local people in East and North Kalimantan Provinces, instead of the higher density wood species such as *Vitex pinnata, Nephelium lappaceum, Blumeodendron kurzii* and *Dipterocarpus* sp. (Yuliansyah et al. 2012).
- The dried root and fresh leaves of *Macaranga* was also used to cover wounds to prevent inflammation, as an emetic agent, antipyretic, antioxidant and antitussive in Thailand and Malaysia (Chulaborn et al. 2002; Lim et al. 2009).
- The bioactive compound *of M. tanarius* was reported effective to be used as an antidiabetic (Puteri and Kawabata 2010).
- Macaranga was also traditionally used by Dayak people in East Kalimantan as the natural plant indicator to determine the end of the recovery period of forest land after ground fire or shifting cultivation activities (Slik et al. 2003, 2005).

Growth ability of Macaranga

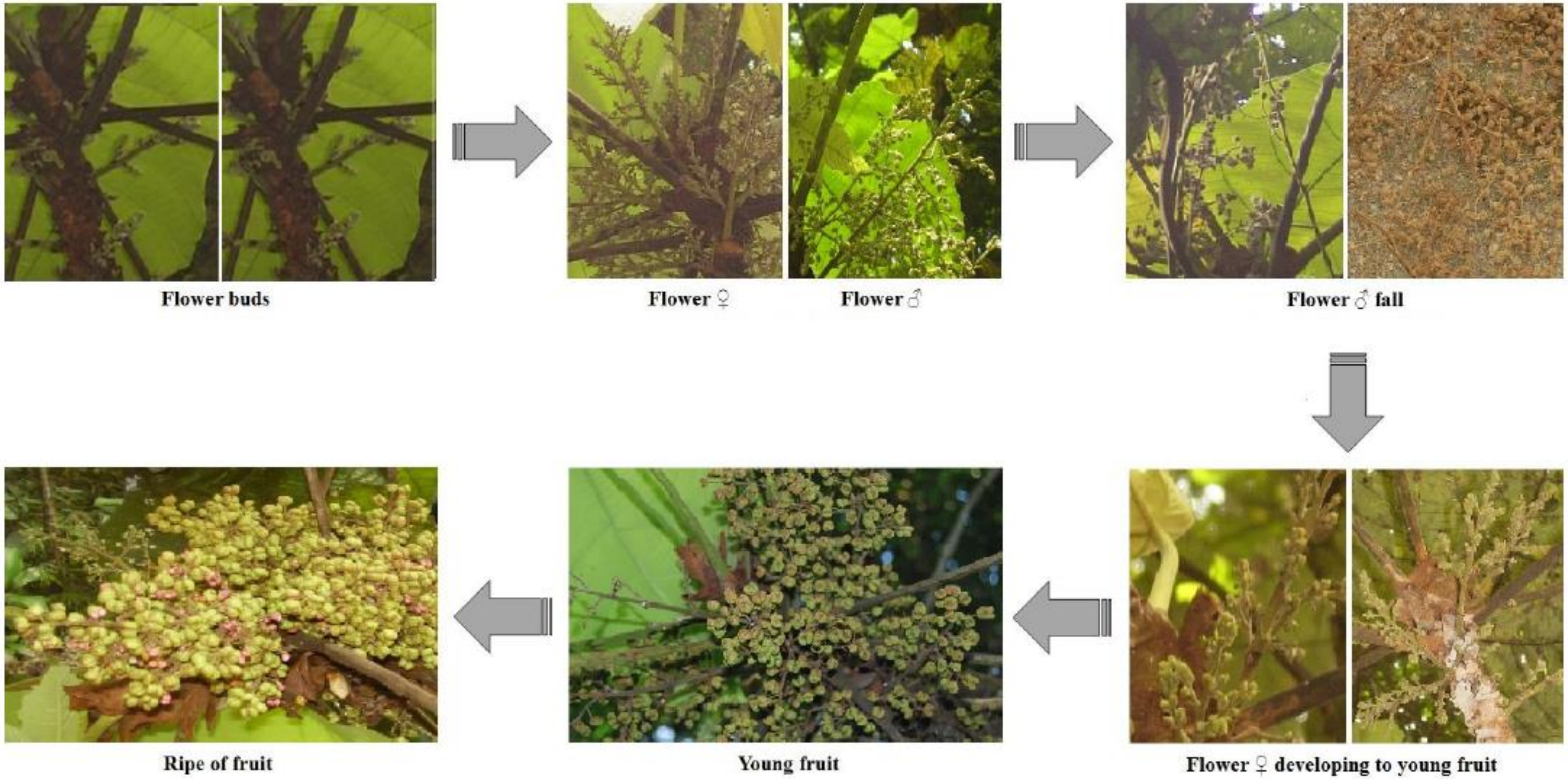


Fig. Developmental stages of *Macaranga gigantea* flowers and fruits

Susanto D, Ruchyat D, Sutisna M, **Amirta R**.. 2016. **Flowering, fruiting, seed germination and seedling growth of *Macaranga gigantea*. Biodiversitas, 17 (1): 192-199.**

Growth ability of Macaranga

Fig. Morphology of fruits and seeds *Macaranga gigantea*: A. Ripe fruit, B. Seeds

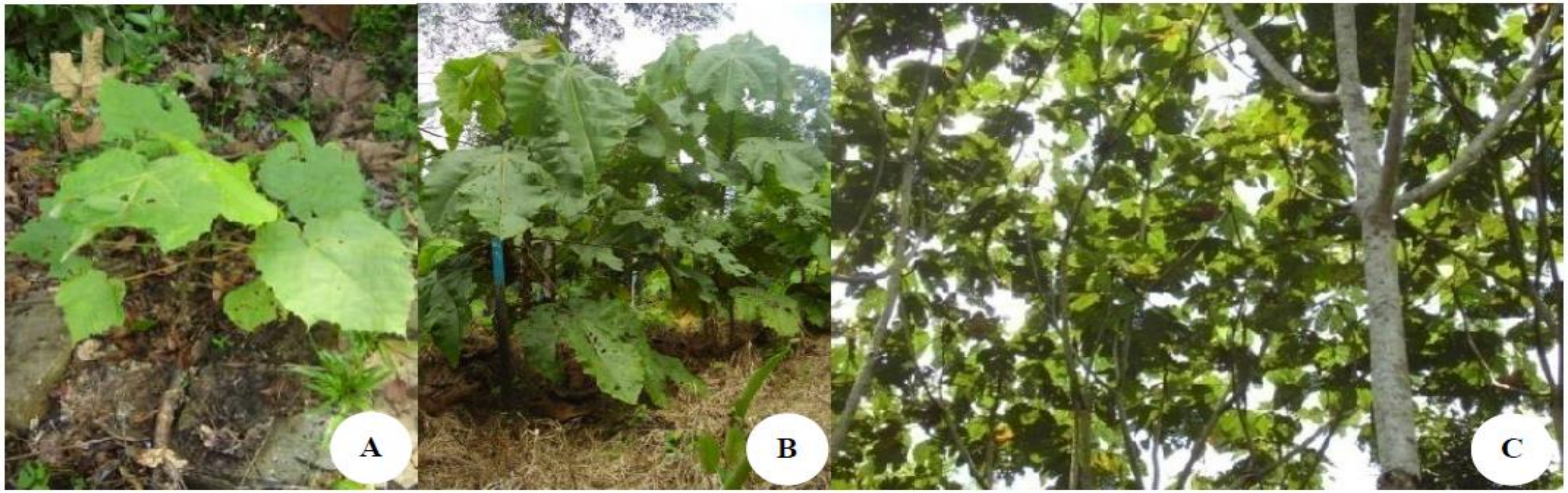


Fig. *Macaranga gigantea* plants: A. seedling, B. sapling, C. mature trees

Susanto D, Ruchyat D, Sutisna M, **Amirta R**.. 2016. **Soil and leaf nutrient status on growth of *Macaranga gigantea* in secondary forest after shifting cultivation in East Kalimantan, Indonesia. Biodiversitas, 17 (2): 409-416.**

Fast Growing Pioneer Woody Biomass

Pioneer species in tropical forest ecosystem with very fast growing ability

Fig. Description of fast growing ability of *M. gigantea*. (A) 1st year, (B) 2nd year, (C) 3rd year

Gowth indicators	1st year	2nd year	3rd year
Plant density (g/cm^3)	-	0.30 ± 0.05	0.33 ± 0.07
Plant diameter (cm)	3.41 ± 0.53	9.70 ± 0.25	11.50 ± 2.10
Plant high (m)	1.76 ± 0.34	7.51 ± 1.60	9.00 ± 1.70
Plant biomass (kg/ha dry wood biomass)	1,297	17,154	26,119

Amirta R, Mukhdlor A, Mujiati D, Septia E, Supriadi, Susanto D. 2016. **Suitability and availability analysis of tropical forest wood species for ethanol production: a case study in East Kalimantan**. Biodiversitas,17 (2): 544-552.

Fig. Growth comparasion between poplar (Left: 4 years plant - German) and Macaranga (3 years – Samarinda, Indonesia)



East Kalimantan has abundant resources of biomass:

- Forest plantation of *Eucalyptus*. *Acacia Falcataria*. etc.
- Palm oil plantation

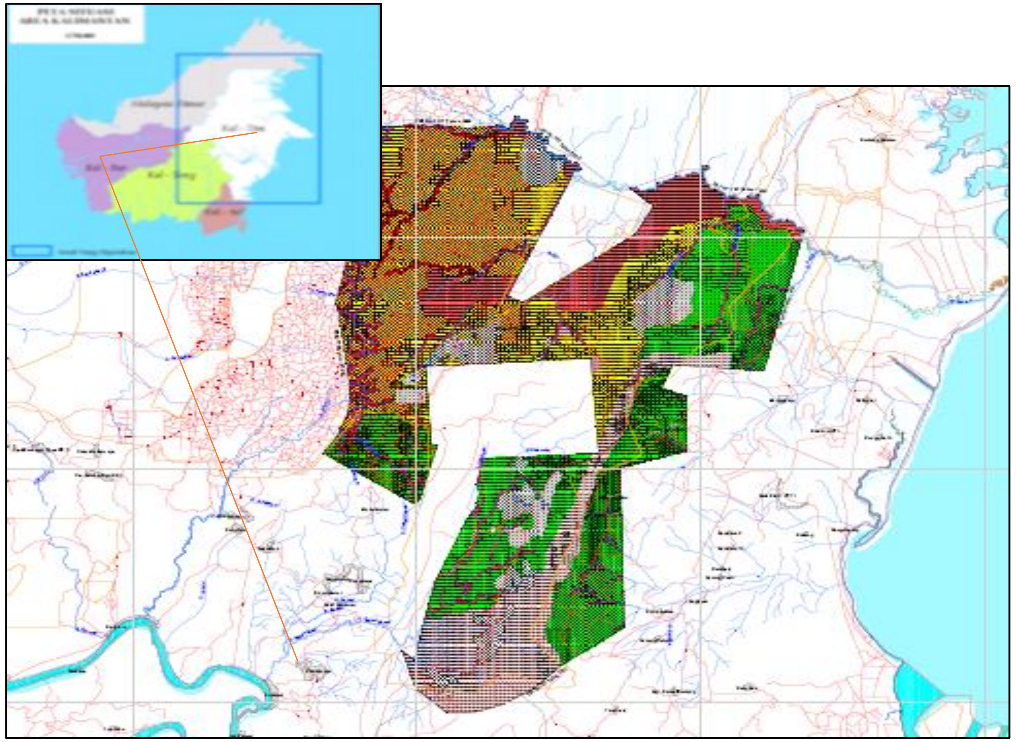
Eucalyptus is the major species used widely in the plantation forest of Indonesia (for fiber production to supply pulp and paper industries)

Evaluation of biomass energy potential from plantation forest of *Eucalyptus pellita*

Research purpose

Therefore herein this paper the potential of biomass energy production from plantation forest in East Kalimantan. Indonesia particularly that located at district Sebulu and Sei Mao managed by Sumalindo Hutani Jaya Ltd (Sinar Mas Group) was analyzed toward supplying the green electricity for rural and remote area

Electricity



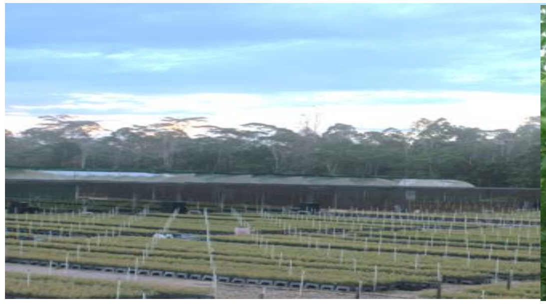
Research Location

Plantation forest of *Eucalyptus pellita* (EP). located at Site Sebulu and Sei Mao, Kutai Kertanegara – East Kutai, East Kalimanta,. Indonesia (PT. Sumalindo Hutani Jaya Ltd – Sinar Mas Group)

Evaluation:

The evaluation was focused on:

- The growth rate and total biomass production of main species planted, *E. pellita* (EP) in different ages of plant.
- The proximate, ultimate & conversion ratio of log to chip and also energy potential from the plantation forest were also studied.





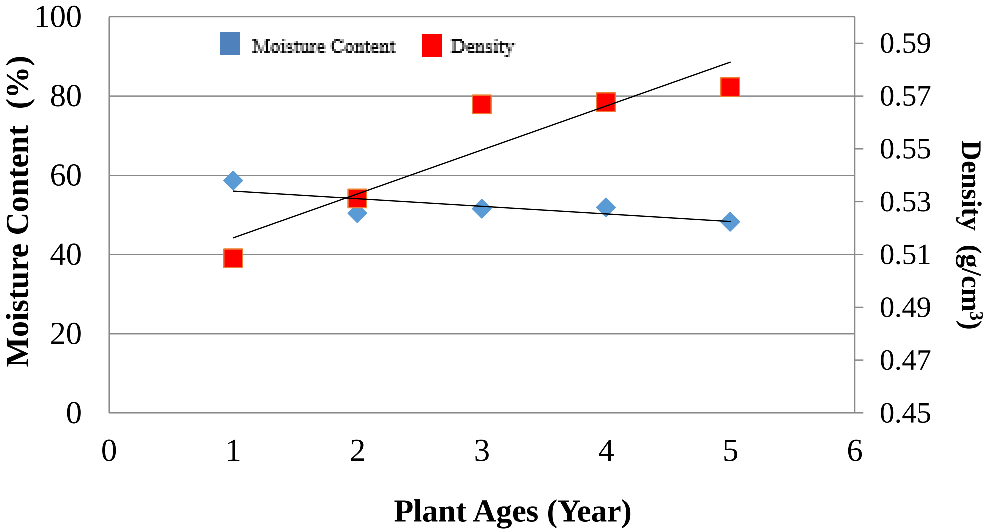
Growth rate and biomass potency of *E. pellita*

Plant Ages (year)	High (m)	Diameter (cm)	Plant Density (n/ha)	Volume (m^3/ha)
1	6.48	5.13	1146	11.65
2	12.12	8.62	1085	58.30
3	14.93	10.25	1019	95.40
4	16.58	11.18	947	116.94
5	17.65	11.77	862	125.77

Growth rate and biomass potency of *E. pellita*

Plant Ages (Year)	Wood Density		Rasio Solid-Chip (m^3/ton)	Volume per Ha (m^3/ha)	Biomass Potency (ton/Ha)
	g/cm^3	kg/m^3			
1	0.51	508.52	4.75	11.65	5.92
2	0.53	531.25	4.61	58.30	30.97
3	0.57	566.83	4.34	95.40	54.08
4	0.57	567.73	4.34	116.94	66.39
5	0.57	573.40	4.33	125.77	72.12

Relationship between plant ages. moisture content and density of *E. pellita*



Wood components of *E. pellita*

Plant Ages (Year)	Lignin (%)	Holocellulose (%)	Cellulose (%)
1	25.35 ± 0.42	68.54 ± 1.13	41.86 ± 1.24
2	28.12 ±1.15	66.60 ± 0.88	40.08 ± 0.04
3	28.47 ± 0.94	66.84 ± 0.79	40.37 ± 0.21
4	28.87 ± 0.31	66.02 ± 1.23	39.79 ± 0.25
5	29.90 ± 0.78	67.49 ± 0.15	37.70 ± 0.46

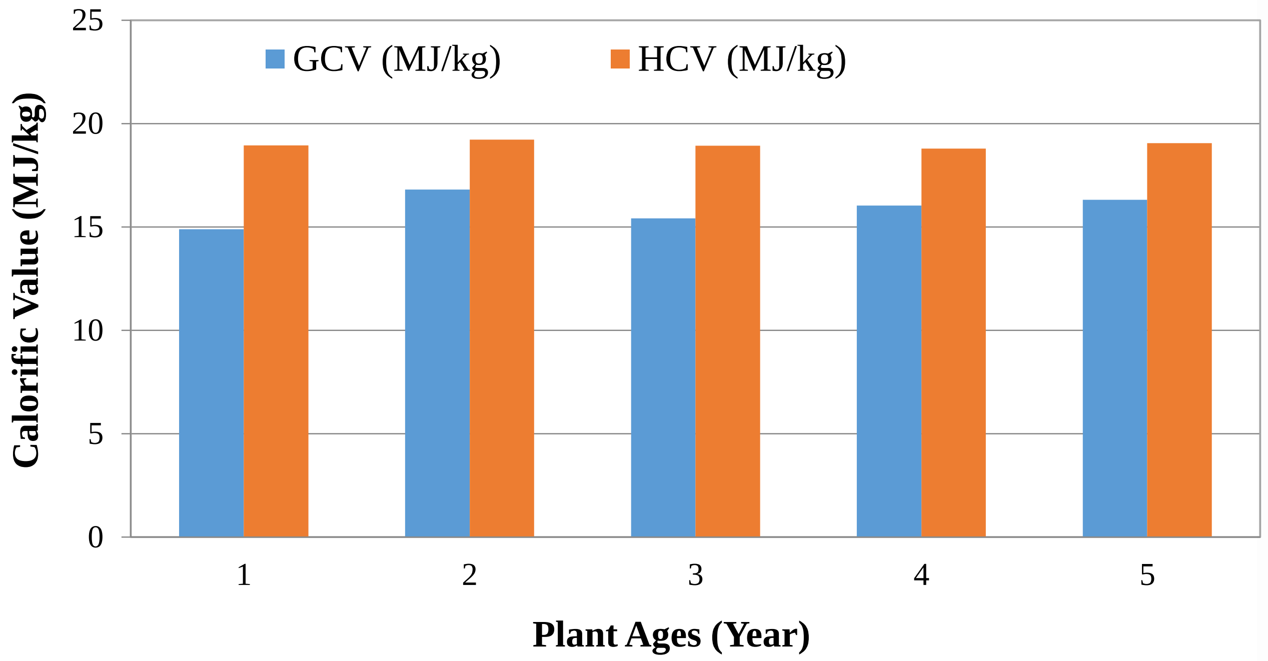
Proximate data of *E. pellita*

Plant Ages (Year)		Proximat Data	
	Volatile Matter (%)	Fixed Carbon (%)	Ash (%)
1	81.89	17.48	0.63
2	80.58	18.85	0.57
3	82.24	17.27	0.49
4	83.07	16.51	0.42
5	82.10	17.71	0.19

Ultimate data of *E. pellita*

Plant Ages (Year)	Ultimate Data		
	Carbon (%)	Hydrogen (%)	Oxygen (%)
1	48.39	5.99	44.29
2	48.67	5.98	44.03
3	48.42	6.00	44.40
4	48.32	6.01	44.56
5	48.64	6.01	44.46

Potential energy of *E. pellita*



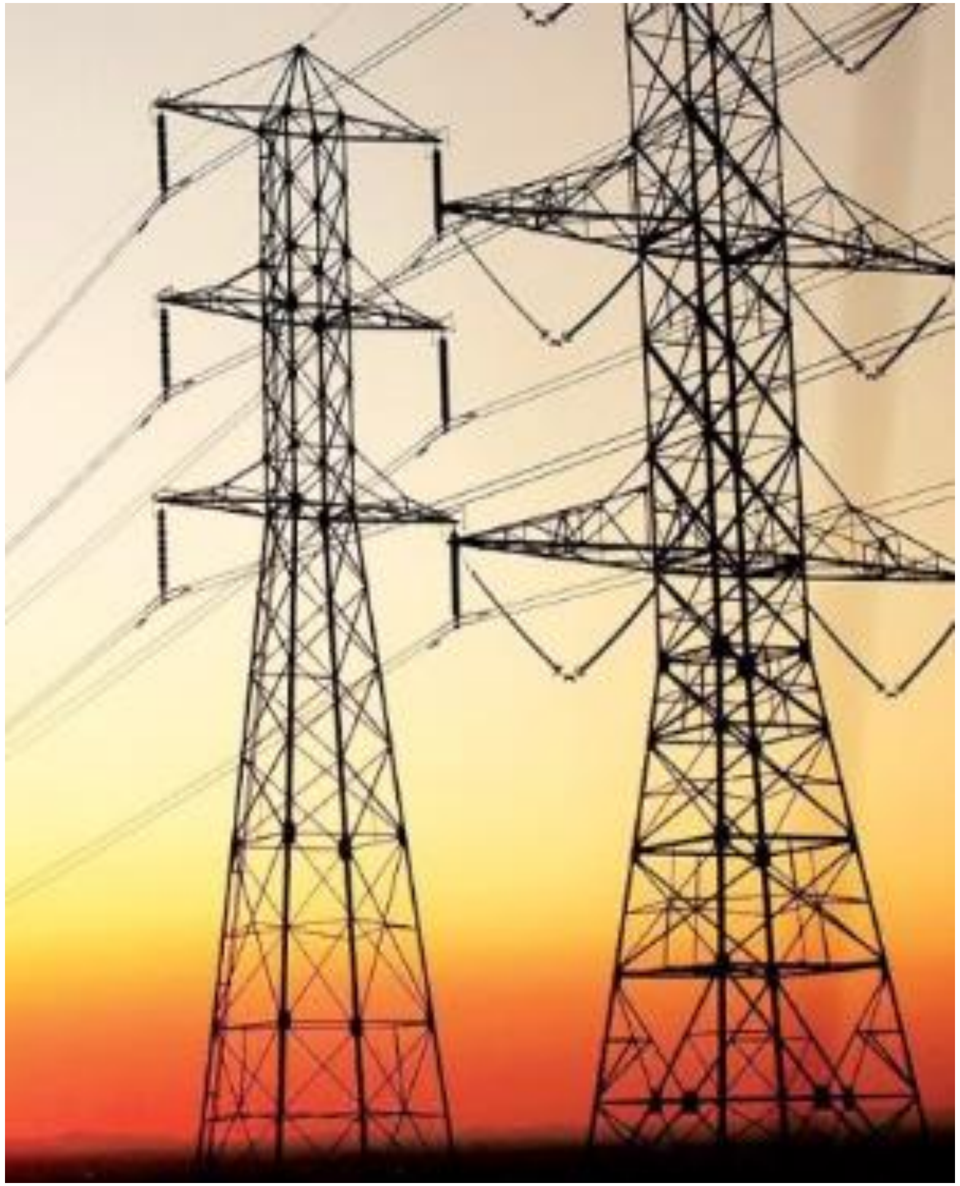
Annual biomass production
745,296 tons

20% of annual biomass production
149,059 tons

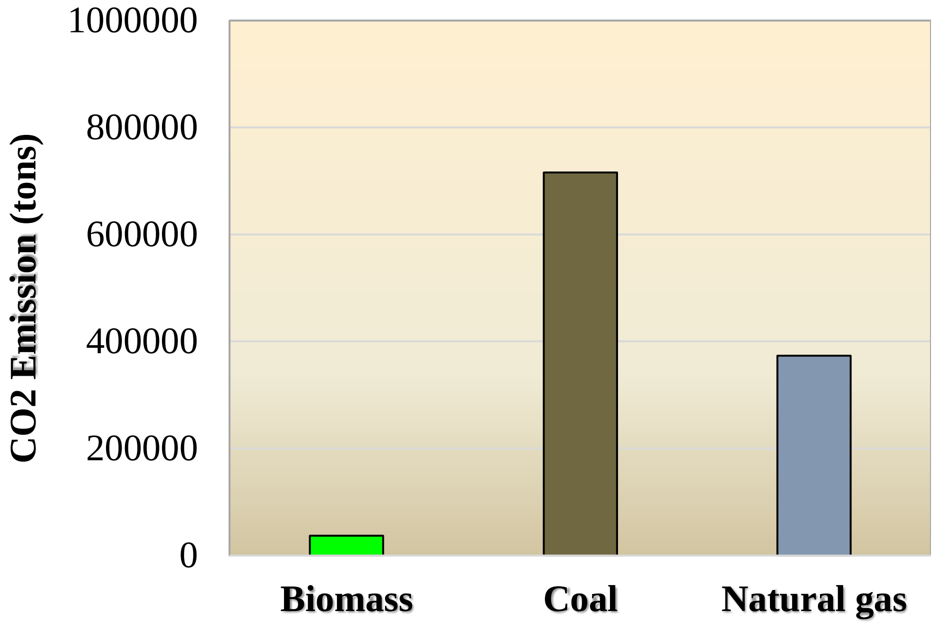
Equal to
2,864,918 GJ of energy

Power plant efficiency ratio 25%
8000 hours per year of operation

Potential electricity supply
24.87 MW



Comparasion of CO_2 emission

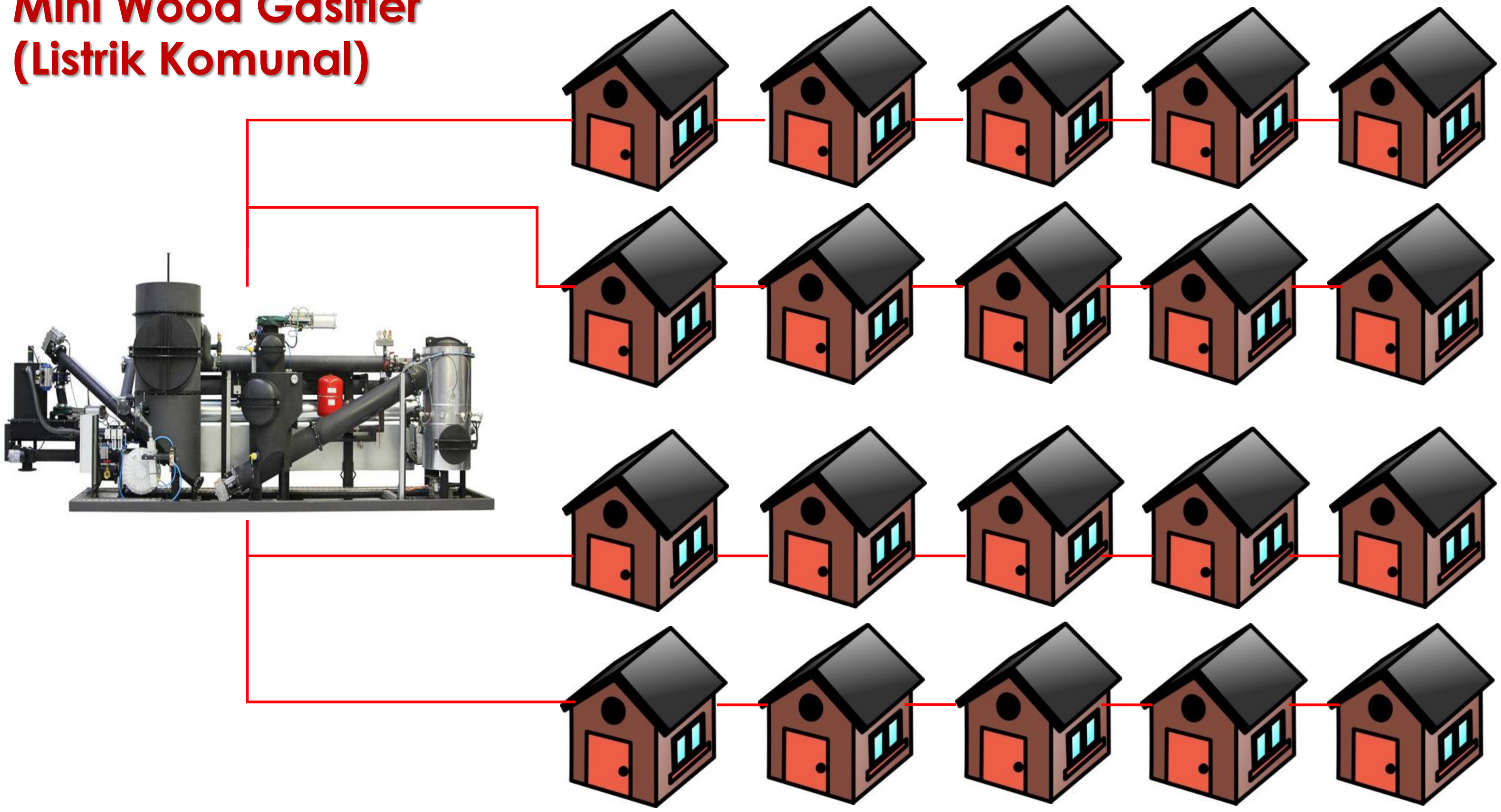


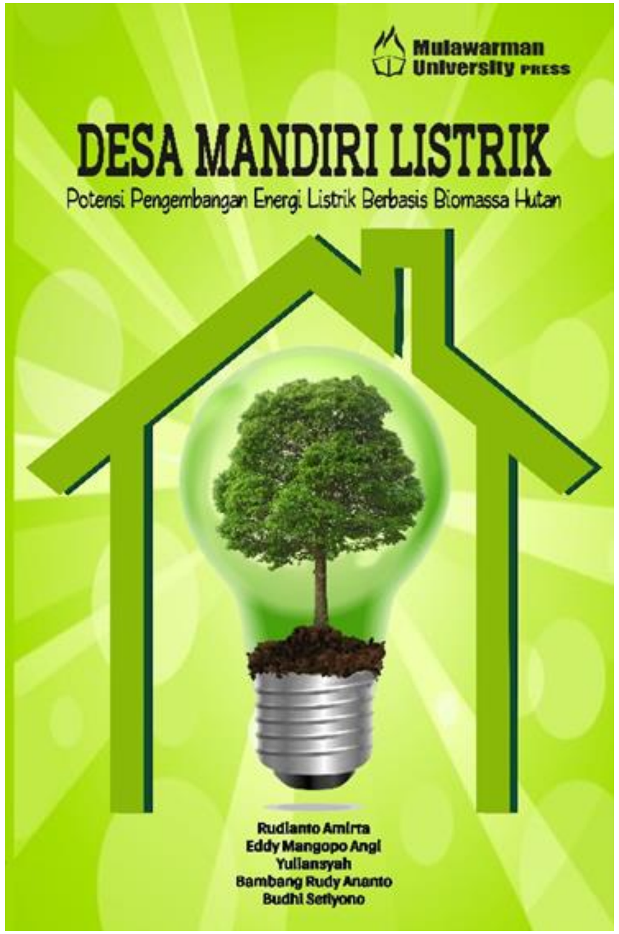
Potential CO_2 emission reduction on prdoction of ± 795,810 MWe

Conclusions

1. We found the biomass production was linearly increased due to increase of plant ages (maturity) to reached 11.65 m^3/ha. 58.30 m^3/ha. 95.40 m^3/ha. 116.94 m^3/ha and 125.77 m^3/ha for 1-5 years of plantation. respectively
2. The biomass production was equal to 5.92-72.12 tons/ha of dry material with the range of higher calorific value (HCV) was 18.79-19.22 GJ/ton.
3. 745.296 tons of biomass potentially produced annually. which is 20% of them could be used as energy feedstocks (equal to 149.059 tons of biomass or 2.864.918 GJ of energy).
4. If this energy potential is applied at a power plant with efficiency ratio of 25% and 8000 hours per year of operation. this has potential of 24.87 MW of electricity.
5. This fact was not only good for the sustainable production of biomass and green electricity supply issues but also link with the significant CO_2 emission reduction potential (±716.229 ton CO_{2e}) that could be achieved from replacement of coal power plant to biomass in this area.

Mini Wood Gasifier (Listrik Komunal)

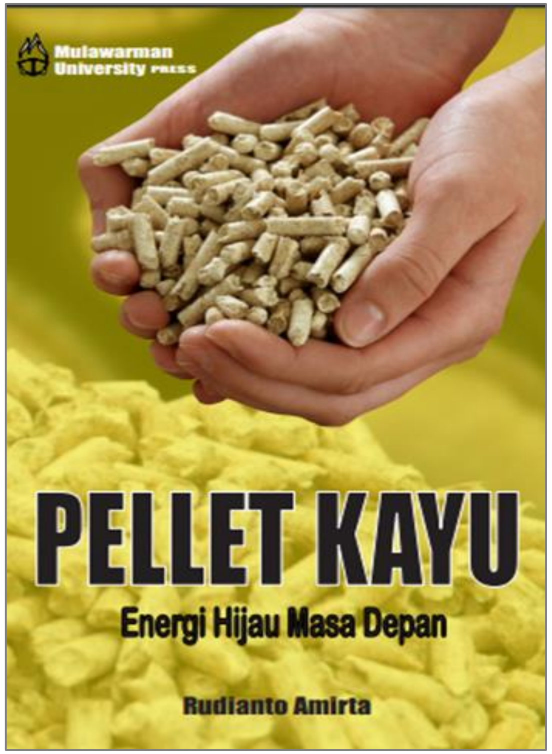


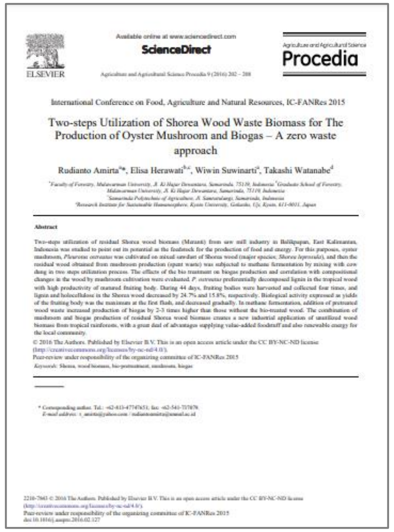


MP3EI

MASTERPLAN PERCEPATAN DAN PERLUASAN PEMBANGUNAN EKONOMI INDONESIA 2011-2025

45 KW electricity for 100 houses @ 450 watt power and 115 KW heat power for chilling and drying

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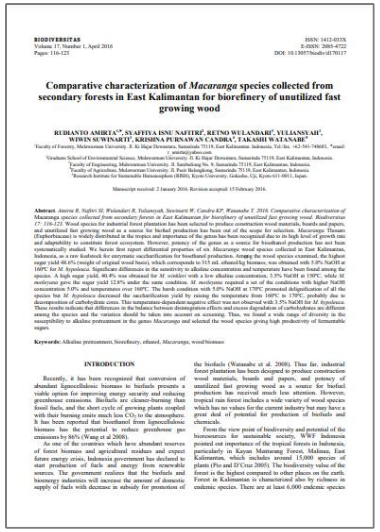
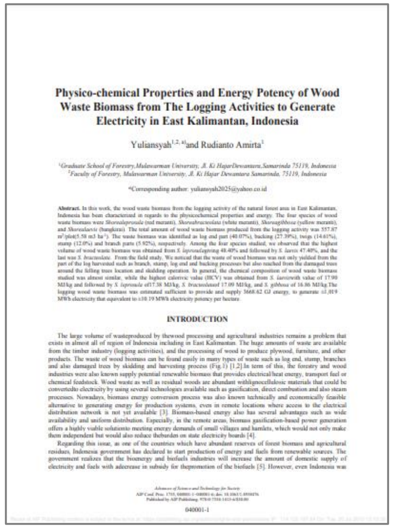
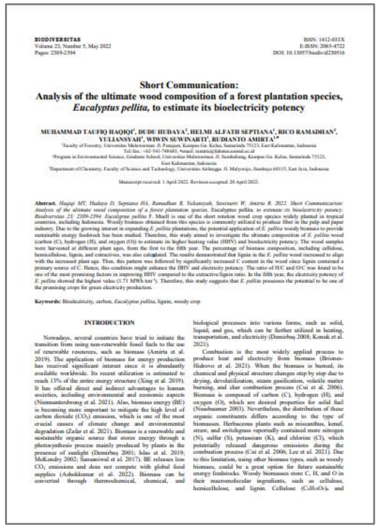
International Conference on Food, Agriculture and Natural Resources, IC-FANRes 2015
Two-steps Utilization of Shorea Wood Waste Biomass for The Production of Oyster Mushroom and Biogas – A zero waste approach
Rudianto Amirta, Elisa Herawati, Wiwin Suwinarti, Takashi Watanabe


BIODIVERSITAS
Comparative characterization of *Macaranga* species collected from secondary forests in East Kalimantan for biorefinery of unutilized fast growing wood

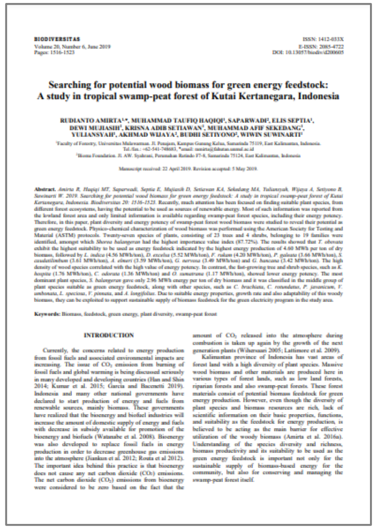

BIODIVERSITAS
Suitability and availability analysis of tropical forest wood species for ethanol production: a case study in East Kalimantan


NUSANTARA BIOSCIENCE
Plant diversity and energy potency of community forest in East Kalimantan, Indonesia: Searching for fast growing wood species for energy production


Physico-chemical Properties and Energy Potency of Wood Waste Biomass from The Logging Activities to Generate Electricity in East Kalimantan, Indonesia
Yuliansyah and Rudianto Amirta
INTRODUCTION


BIODIVERSITAS
Short Communication:
Analysis of the ultimate wood composition of a forest plantation species, *Eucalyptus pellita*, to estimate its bioelectricity potency


BIODIVERSITAS
Fast-growing native tree species to the secondary forest of East Kalimantan, Indonesia: Physicochemical properties of woody materials for bioelectricity feedstocks


BIODIVERSITAS
Searching for potential wood biomass for green energy feedstock: A study in tropical swamp-peat forest of Kutai Kertanegara, Indonesia

POME biogas potency in East Kalimantan

Parameter	Unit	Value
CPO production	Tonnes	5,221,016
POME generated[a]	m^3	15,663,048
COD level in POME[b]	mg/L	798,815
COD converted[c]	Tonnes	639,052
CH_4 produced[d]	Tonnes	159,763
Energy rate[e]	MJ	7,988,154,480
	MWh	2,218,932
Diesel equivalent[f]	L	227,297,817
Electricity generated[g]	MWh	887,573
Power plant capacity (gas engine) [g]	MW	**111**

[a]Assume that $3 m^3$ POME generated per tonne CPO produced.; [b]COD of POME based on mean value given by Malaysia Palm Oil Board (MPOB); [c]Assume that digester efficiency is 80%.; [d]Theoretical methane conversion factoris 0.25 kg CH_4 per kg COD [66]. [e]Calorific value of CH_4 is 50MJ/kg. [f]Calorificvalueofdieselis35.144MJ/L. ; [g]Assume the gas engine operating 8000 hr/yr and with efficiency of 40%. (Ji et al., 2013)