インドネシアにおけるバイオマスのエネルギー利活用の可能性調査

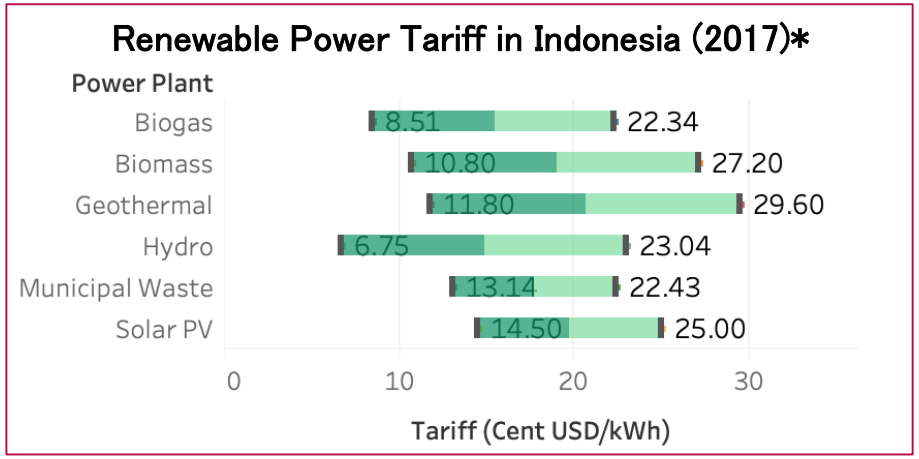
Study of Biomass Potential for Energy Use in Indonesia

1. Background

1. Background

1 – 1. Overview of Biomass

- **Biomass** is any organic matter produced through photosynthetic processes, both in the form of products and waste of recently living plant or animal origin. It is available in many forms such as agricultural products, forestry products, municipal and other waste.
- **Bioenergy** is derived from biomass to generate electricity and heat, or to produce liquid fuels for transport. It can be used indirectly by converting it into fuels or directly through combustion to generate heat, or it can be converted to methane gas or transportation fuels like ethanol and biodiesel.
- The carbon dioxide (CO_2) released from biomass during production of bioenergy is from carbon that circulates the atmosphere in a loop through the process of photosynthesis and decomposition → production of bioenergy does not contribute extra CO_2 to the atmosphere like fossil fuels.
- Another advantages:
  - ✓ Reducing greenhouse gas emission
  - ✓ Unlike most other renewable source, it generating heat and electricity
  - ✓ Biodegradable and provide better air quality
  - ✓ Regional and rural economic development and employment
  - ✓ Supporting agricultural and food- processing industries
  - ✓ Less landfill & alternatives to prescribed forest burning



Source: Minister of Energy and Mineral Resources Regulation No. 12 of 2017
*) Tariff depends on capacity, power plant area and Commercial Operating Date

- Indonesia has a huge abundant of biomass in the form of standing vegetation/crops, agricultural residues, municipal waste, etc.

バイオマスは、バイオエネルギーを生み出す資源となり得るが、巨大なバイオマスを擁するインドネシアにとって、利用価値が高く、しかも大部分が未利用の資源である。 → 本調査では、バイオマス由来の、特に廃棄物由来のバイオエネルギーに焦点を当てる。

2. Policy of Energy and Biomass

2. Policy of Energy and Biomass

2 – 1. Biomass Policy History

インドネシアにおけるエネルギー関連政策の歴史①：増加するエネルギー需要への対応

World's oil shock 1970s → Indonesia took initiative to resolve the problems and to answer future energy supply challenges → **Presidential Instruction No. 9/1982**: First policy that focus on energy conservation → Directing all ministries & state-owned agencies-enterprises for **energy conservation**.

In 2000: Ministry of Mines and Energy **Reformed** → Ministry of Energy and Mineral Resource (ESDM)

Four dominant policy objectives in energy sector: (1) **Energy diversification**; (2) **rational energy pricing**; (3) **energy sector reform** and (4) **rural electrification**

---------- As energy demand (electricity) continue to increase, PT PLN (national electricity company) currently cannot provide enough supply ----------

In 2005: **Government Rule No. 3 on Supply of Electricity**

- To supports Law No. 15/1985 on electricity, that was reenacted in 2005;
- To regulate partnership between independent power producers (IPPs) partnered with PLN to develop electricity projects;

exception is given to companies that generate power to be use by their own or those **who are using renewable energy** → they can set up plants independently without PLN.

Blueprint of National Energy Implementation Program 2005–2025 issued by Minister of Energy and Mineral Resources

- To enhance **security of energy** supply;
- To provide road-maps that cover **renewable** & non-renewable energy sectors;
- To design programs to phase out subsidies and improve energy efficiency.

In 2006: **Presidential Regulation No. 5 on National Energy Policy**

- To set energy diversification **targets for 2025**; where renewables contribute more than 15% of the total energy mix; including **5-10% from biomass energy**;
- To set an energy conservation target of reducing energy intensity by 1% per year.

2. Policy of Energy and Biomass

2 – 1. Biomass Policy History

インドネシアにおけるエネルギー関連政策の歴史②：再生可能エネルギーへの転換

In 2006:	**Presidential Decree no. 1 on Supply and Use of Biofuel**	■ To set targets for biofuel utilization; ■ To set guidance for multi-sector coordination in biofuel development.
	Ministerial Regulation No. 2 on Medium Scale Power Generation from Renewable Energy Sources	■ To extend similar price guidelines as Ministerial Decree No. 1122/2002 for projects from 1 MW to 10 MW.
In 2007:	**Energy Law (Law No. 30/2007)**	■ To regulate renewable energy development and energy efficiency policy, particularly by increasing utilization of renewable energy and provide incentives for renewable energy developers within a certain time period.
In 2010:	**Electricity Law (Law No. 30/2010)**	■ To invite more private sectors to be involve in electricity supply; ■ To provide higher priority for the use of renewable energy and clean technology in electricity supply; ■ To boost increase of utilization of small-scale power generation from renewable sources such as from biomass energy

2. Policy of Energy and Biomass

2 – 2. Current Policy of Bioenergy

現在のバイオエネルギー関連政策①：エネルギー鉱物資源省による再生可能エネルギー振興策

E S D M **Formed** → 4 Directorates:
1, 2, 3,…

Directorates of New and Renewable Energy and Energy Conservation (EBTKE)

to formulate and implement new and renewable energy policies and regulations
→ biomass energy sector (& other renewable sectors) is expected to have institutional & policy support.

In 2012:	**Ministerial Regulation No. 4/2012**	■ To set the Feed in Tariff for electricity generated from biomass
In 2014:	**Ministerial Regulation No. 27/2014**	■ Increase portion of renewable energy to 23% by 2025 & 31% by 2050; ■ Utilization of biomass is focused for electricity & transportation; ■ Using feed-in-tariff for renewable energy; ■ To boost government & private sectors using biomass as fuel for power plant; ■ To increase electricity tariff from biomass fueled power plant.
In 2015:	**Ministerial Regulation No. 44/2015**	■ The process of generating municipal solid waste based on sanitary landfill, anaerobic digestion, and thermochemical technologies; ■ Power Purchase Agreement (PPA) is valid for a period of 20 (twenty) years starting from COD.; ■ The purchase price of electric power with high voltage, medium voltage and low voltage respectively 16.55, 16.55 and 20.16 (cent USD / kWh).

2. Policy of Energy and Biomass

2 – 2. Current Policy of Bioenergy

現在のバイオエネルギー関連政策②：固定価格買取制度等

In 2016: **Ministerial regulation No. 21/2016**

- The purchase price of electricity from the biomass and biogas power plant by considering: the capacity, the voltage and the area of the power plant;
- Power Purchase Agreement (PPA) is valid for a period of 20 (twenty) years starting from COD and can be extended;
- The results of verification of the feasibility study document to the Business Entity within a maximum period of 30 (thirty) working days from the submission of the request for verification;
- The purchase price of electricity from the biomass and biogas power plant by considering the capacity, voltage and the area of the power plant;
- The power plant capacity is divided into up to 20 MW, 20 MW to 50 MW and above 50 MW.

In 2017: **Ministerial regulation No. 12/2017**

- PT PLN is obliged to buy electricity from power plants that utilize renewable energy sources;
- The purchase of electricity from biogas and biomass by PT PLN with a capacity of up to 10 MW is carried out using a benchmark price, while the capacity of more than 10 MW is done through a direct selection mechanism;
- The benchmark price of purchasing electricity from biogas and biomass power plants is the highest at 85% of the Basic Cost of Generating Power in the local electricity system;

2. Policy of Energy and Biomass

2 – 2. Current Policy of Bioenergy

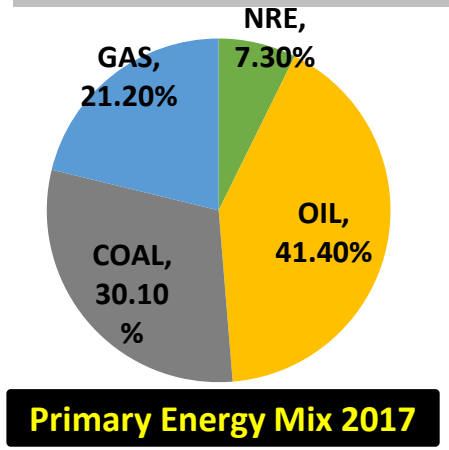
2014年、インドネシア国会は国家エネルギー政策を改訂し（NEP14）、2006年の同計画を刷新し、政令2014年第79号として公布した。
これによってバイオマス由来エネルギーの基礎が改訂された。

Government Regulation No. 79/2014 (National Energy Policy /NEP14)

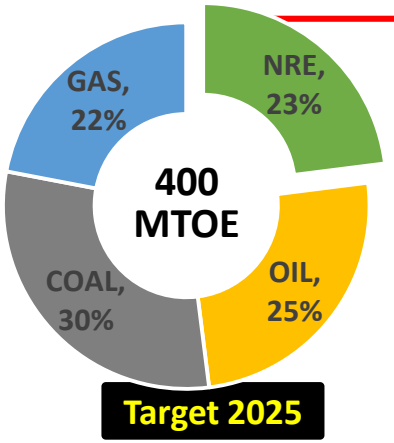
Priority of National Energy Development

- Maximizing renewable energy utilization;
- Minimizing fossil oil utilization;
- Optimizing natural gas & new energy utilization;
- Utilizing coal as a reliable national energy supply;
- Utilizing nuclear as the last option.

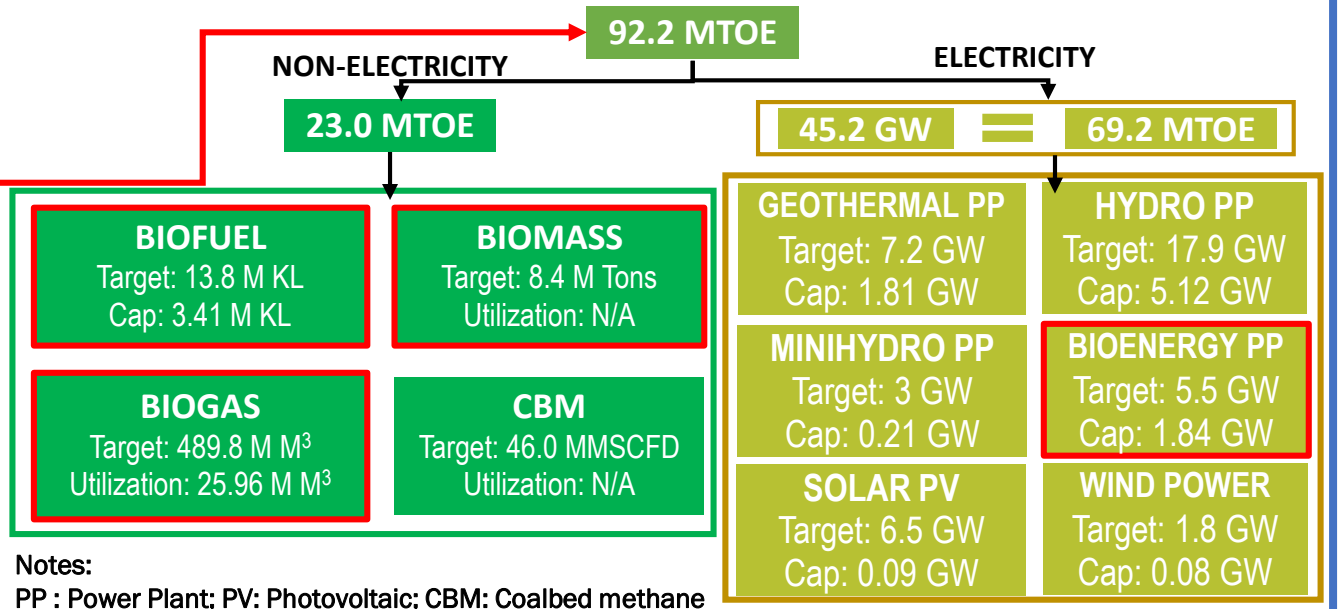
- Increase portion of renewable energy to 23% by 2025 & 31% by 2050; with around 10% from biomass energy
- Utilization of biomass is focused for electricity & transportation;
- Using feed-in-tariff for renewable energy;
- To boost government & private sectors using biomass as fuel for power plant;
- To increase electricity tariff from biomass fueled power plant.



Primary Energy Mix 2017



Target 2025



Notes:
PP : Power Plant; PV: Photovoltaic; CBM: Coalbed methane

2. Policy of Energy and Biomass

2 – 3. Existing Biomass Projects

バイオマスを原料とする発電所の実例を紹介する。カリマンタン島とスマトラ島にある発電所は、両方とも民間企業によって所有・運営されており、それぞれ2017年、2018年に操業を開始した。

Biomass Power Plant Siantan

- Location: Desa Wajok Hulu, West Kalimantan
- Commercial Operating Date: April 23rd, 2018
- Production Company: PT. Rezeki Perkasa Sejahtera Lestari
- Capacity: 10 – 15 MW (IPP: 10 MW)
- Feedstocks: Palm and wood shells, rice husks, corncobs, bagasse
- Capital: Rp 290,000,000,000,-

Source: Ministry of Energy and Mineral Resources, http://ebtke.esdm.go.id/ (2018).

Biomass Power Plant Bambu Siberut

- Location: Saliguma, Madobag, West Sumatera
- Commercial Operating Date: March 20th, 2017
- Production Company: PT. Charta Putra Indonesia
- Capacity: 700 – 1,300 KW
- Feedstocks: Bamboo
- Capital: US$ 12.4 million

Source: Ministry of Energy and Mineral Resources, http://ebtke.esdm.go.id/ (2018).

2. Policy of Energy and Biomass

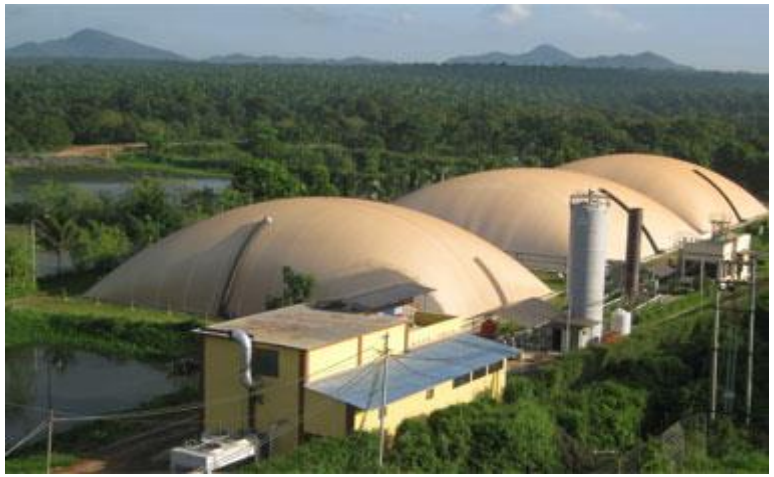
2 – 3. Existing Biomass Projects

その他の発電所で、バイオマスを原料とするものとしては、発電量10MWのものが北Malukuに、Belitung島にはPOMEを原料とする発電所が2016年以来稼働している。

Biomass Power Plant Sofifi

- Location: Tidore City, North Maluku
- Commercial Operating Date: April 2nd, 2019
- Production Company: PT. Bersih Halmahera
- Capacity: 10 MW
- Feedstocks: Gamal plant
- Capital: No data

Source: Ministry of Energy and Mineral Resources, http://ebtke.esdm.go.id/ (2018).



Biogas Powerplant Jangkang

- Location: Jangkang Village, Dendang, East Belitung
- Commercial Operating Date: January 2016
- Production Company: PT. Austindo Aufwind New Energy
- Capacity: 1.8 MW
- Feedstocks: Palm Oil Mill Effluent (POME)
- Capital: Rp. 43.82 Trillion

Source: Austindo Nusantara Jaya Group, https://anj-group.com/ .

2. Policy of Energy and Biomass

2 – 3. Existing Biomass Projects

PTPN VとBPPTによって設立された発電所がリアウ州にあり、 POMEを原料とし、発電量は700KWである。北スマトラ州には、Pertamina（国営石油公社）とPTPN IIIによって建設されつつある発電所があり、その発電量は2.4MW、原料はパーム由来のバイオマスである。

Biogas Power Plant Terantam

- Location: Terantam, Tapung Hulu, Riau
- Commercial Operating Date: March 4th, 2019
- Production Company: PT. Perkebunan Nusantara V and BPPT
- Capacity: 700 KW
- Feedstocks: Palm Oil Mill Effluent (POME)
- Capital: Rp. 27,000,000,000,-

Source: http://www.aprobi.or.id .

Biogas Power Plant Sei Mangkei

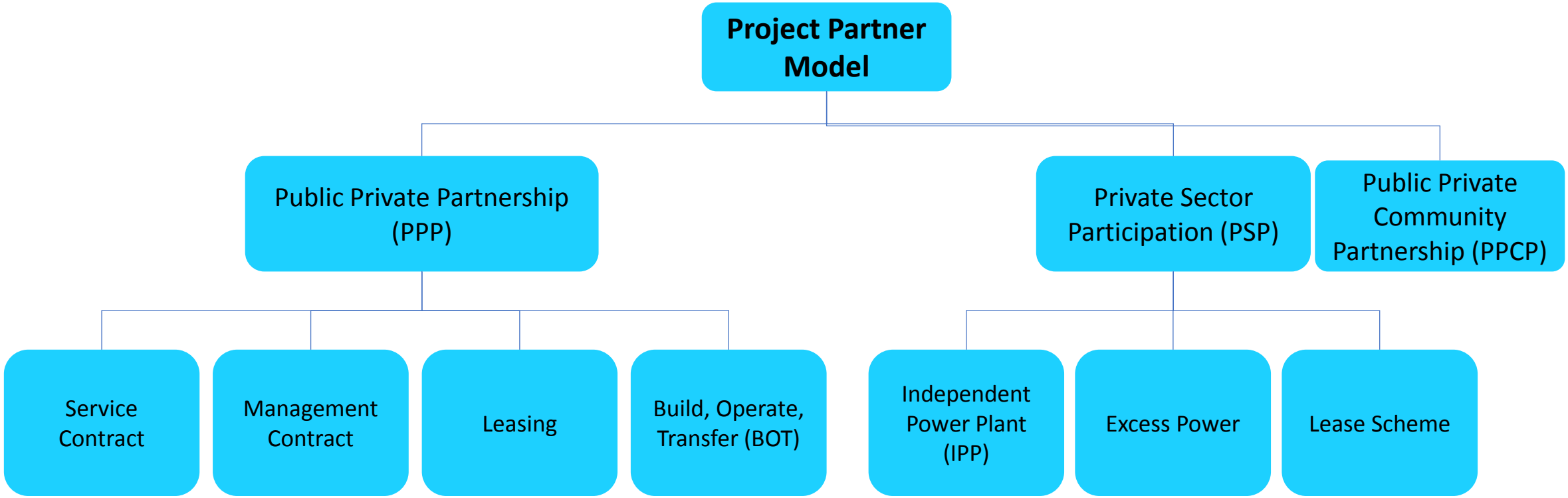
- Location: Sei Mangkei, North Sumatera
- Commercial Operating Date: December 2019 (Plan)
- Production Company: PT. Pertamina Power Indonesia and PTPN III
- Capacity: 2.4 MW
- Feedstocks: Palm
- Capital: No data

Source: https://pertaminapower.com/pltbg-sei-mangkei-24-mw

2. Policy of Energy and Biomass

2 – 4. Collaboration Scheme

国家のエネルギー安全保障に関して、民間セクターは重要な貢献をなし得るが、政府機関との直接的パートナーシップを組む場合とそうでない場合が考えられる。究極の目的は、地域の経済成長に貢献することである。



Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

2. Policy of Energy and Biomass

2 – 4. Collaboration Scheme

PPP（*Public Private Partnership*）のプログラムは、事業スキームとしてBOT（*Build-Operate-Transfer*）を奨励している。BOT以外にも、IPPとしての事業参加とPPCP（*Public Private Community Partnership*）という事業スキームがある。

Public Private Partnership (PPP) is a contractual agreement between the private and the government, both of which are joined in a partnership to use the expertise and ability of each to improve services to the public.

Independent Power Producer (IPP) is a cooperation scheme in which the private sector to generate electricity at the power plant that had to be sold to PLN.

Public Private Community Partnership (PPCP) is a form of cooperation between government, private sector and communities together to cooperate in the development and/or management of infrastructure and facilities.

BOT "Build-Operate-Transfer" is a term for a pattern or structure that uses private investment for infrastructure construction work or public sector. There are several advantages in BOT projects, namely:

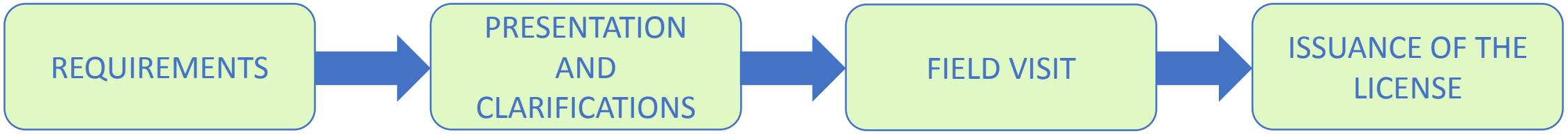
a. Obtain new source of capital from the private sector, in order to reduce government loan and direct spending.
b. Accelerates the project construction without waiting to have a sizeable fund.
c. The involvement of private sponsors and experienced commercial lenders.
d. The government does not need to control the project unnecessarily, because it has been handed over to the private sector until the end of the concession period.
e. Technology transfer and training of local personnel.

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

2. Policy of Energy and Biomass

2 – 4. Collaboration Scheme

バイオ燃料分野への投資を行うためには、企業はバイオ燃料分野のビジネスライセンスを保有する必要がある。当該ライセンスの取得手続きには、標準的手続きとして以下のものが含まれる。



1. Administrative requirements
   - Documents relating to the legality of the companies

2. Technical requirements
   - technical documents on the production process, technical specifications, and feasibility

Enterprises held a presentation for data clarification and explain the business plan.

Team of Directorate General of New Renewable Energy and Conservation Energy conduct a review of the plant site for verification of data and technical. Also checks the production facilities at the plant site.

Issuance of permits by Directorate General of New Renewable Energy and Conservation Energy.

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

2. Policy of Energy and Biomass

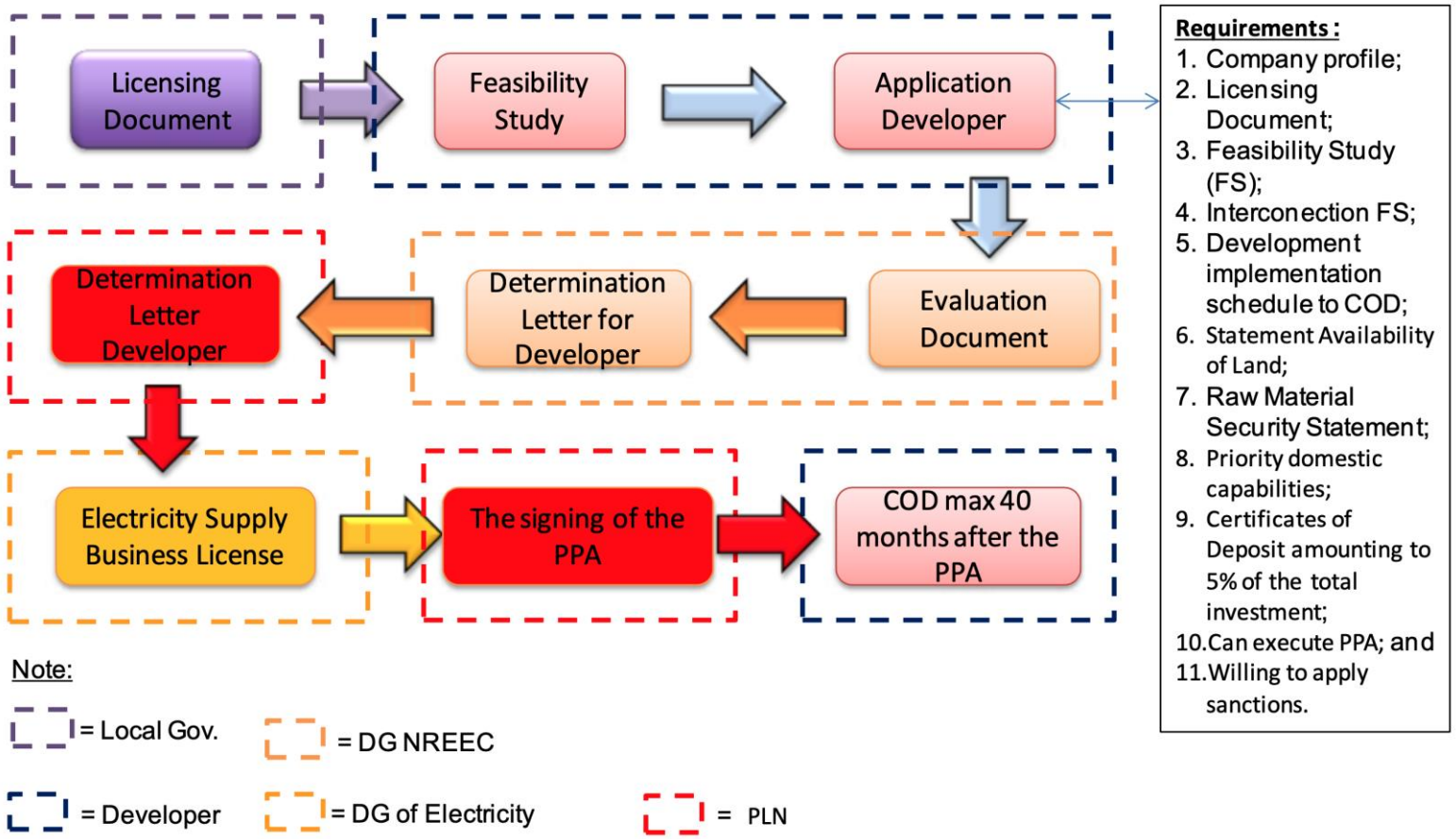
2 – 4. Collaboration Scheme

エネルギー鉱物資源省・省令No. 27/2014により、バイオマス利用、又はバイオガス利用の発電所の建設のための投資手順は以下のように定められている。

Biomass and biogas-based power plant according to the Minister of Energy and Mineral Resources Regulation No. 27 Year 2014: Submission of development biomass/biogas power plant scheme.

Furthermore, as the guidelines can be divided into three (3) parts, namely:

- Location Selection
- Administration of Authority
- Power Purchase Agreement (PPA)



Requirements :

1. Company profile;
2. Licensing Document;
3. Feasibility Study (FS);
4. Interconection FS;
5. Development implementation schedule to COD;
6. Statement Availability of Land;
7. Raw Material Security Statement;
8. Priority domestic capabilities;
9. Certificates of Deposit amounting to 5% of the total investment;
10. Can execute PPA; and
11. Willing to apply sanctions.

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

2. Policy of Energy and Biomass

2 – 4. Collaboration Scheme

電力購入契約（*Power Purchase Agreement*、*PPA*）は、民間の電力事業者とPLN（電力公社）との間で締結される法律文書である。電力供給のパターンには、独立電力事業者（*Independent Power Producer*）、余剰電力販売（*Excess Power*）、オフグリッドの三種類がある。

Production Pattern	Selling Price	Funding	Power Purchase Agreement (PPA)	Consumer
Independent Power Producer (IPP)	Ministerial Regulation of MEMR No. 27 of 2014	Enterprises shall reach financial close maximum of 12 months from PPA	20 Year After the COD	PLN
	Ministerial Regulation of MEMR No. 44 of 2015	- Enterprises shall reach financial close maximum of 15 months from PPA - Manufacture certificate deposit of 5% of the total investment of 20-year since the COD		
Excess Power	Ministerial Regulation of MEMR No. 27 of 2014 and No. 44 of 2015	Developer	1 Year and Extendable	PLN
Off Grid	Arranged by the Regional Planning Board	Developer Government	-	Community

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

3. Mapping of Potential Biomass

3. Mapping of Potential Biomass

3 – 1. Biomass Production

バイオマスは、主産物として生産される場合と副産物として生産される場合がある。エネルギー目的に最も広く利用されているバイオマスは、パーム油生産過程から出る副産物である。

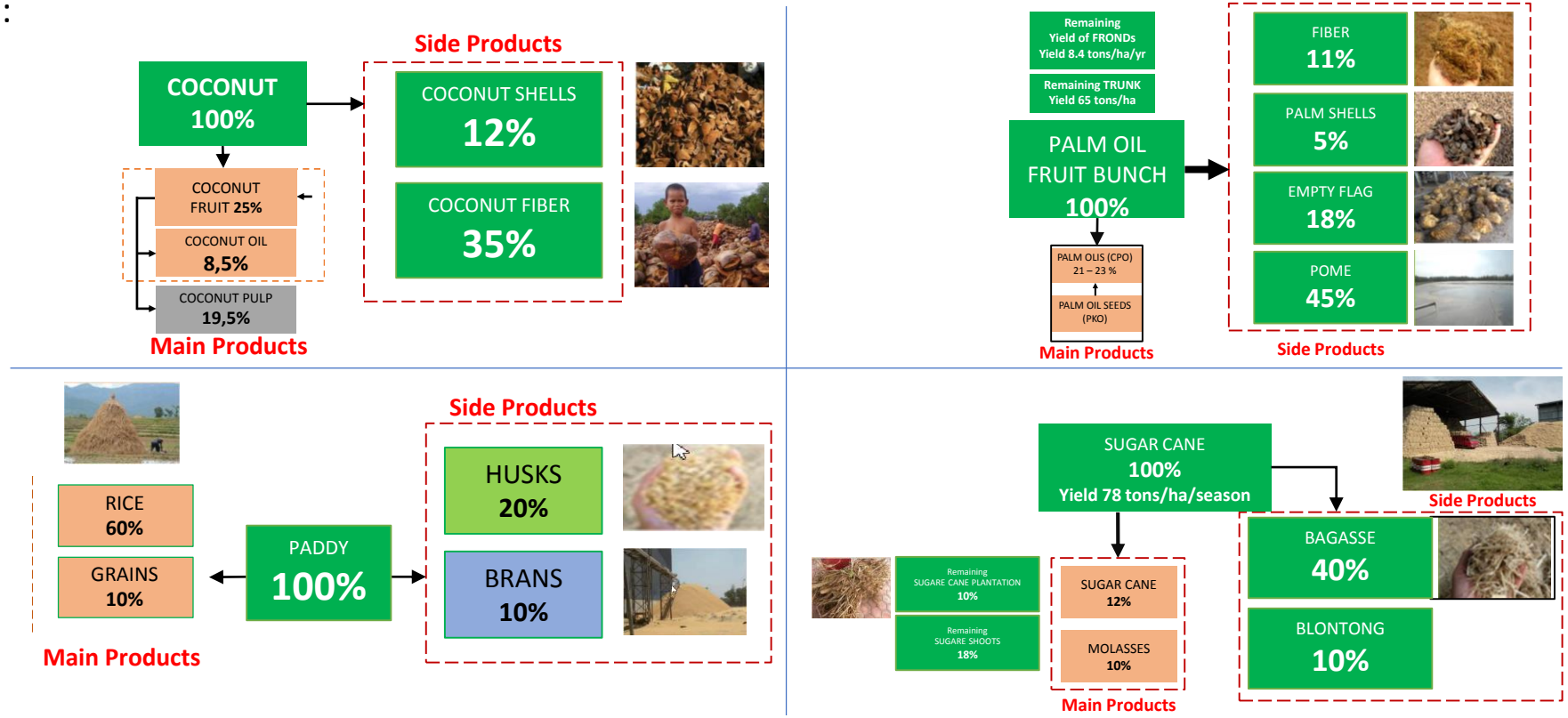
List of Biomass that have huge potential and been used to produce energy in Indonesia, are:

Estate Crops Sub-sector
Tea
Tobacco
Sugar Cane
Cocoa
Clove
Pepper
Coffee
Rubber
Palm Oil
Coconut
Cashew-nut
Cotton
Sago

Food Crops Sub-sector
Paddy
Maize
Soybean
Peanut
Cassava
Sweet-Potatoes

Source : http://balitkabi.litbang.pertanian.go.id/

Calculation of raw material for biomass from plantation products can be done using the Mass Balance approach, of course the mass balance is different for each raw material.



3. Mapping of Potential Biomass

3 – 1. Biomass Production

バイオマスとしてのコーヒーの利用は、生産工程で産出される副産物によって大きく異なる。キャッサバも炭の形態で発電に利用される。

List of Biomass that have huge potential and been used to produce energy in Indonesia, are:

Estate Crops Sub-sector
Tea
Tobacco
Sugar Cane
Cocoa
Clove
Pepper
Coffee
Rubber
Palm Oil
Coconut
Cashewnut
Cotton
Sago

Food Crops Sub-sector
Paddy
Maize
Soybean
Peanut
Cassava
Sweet Potatoes

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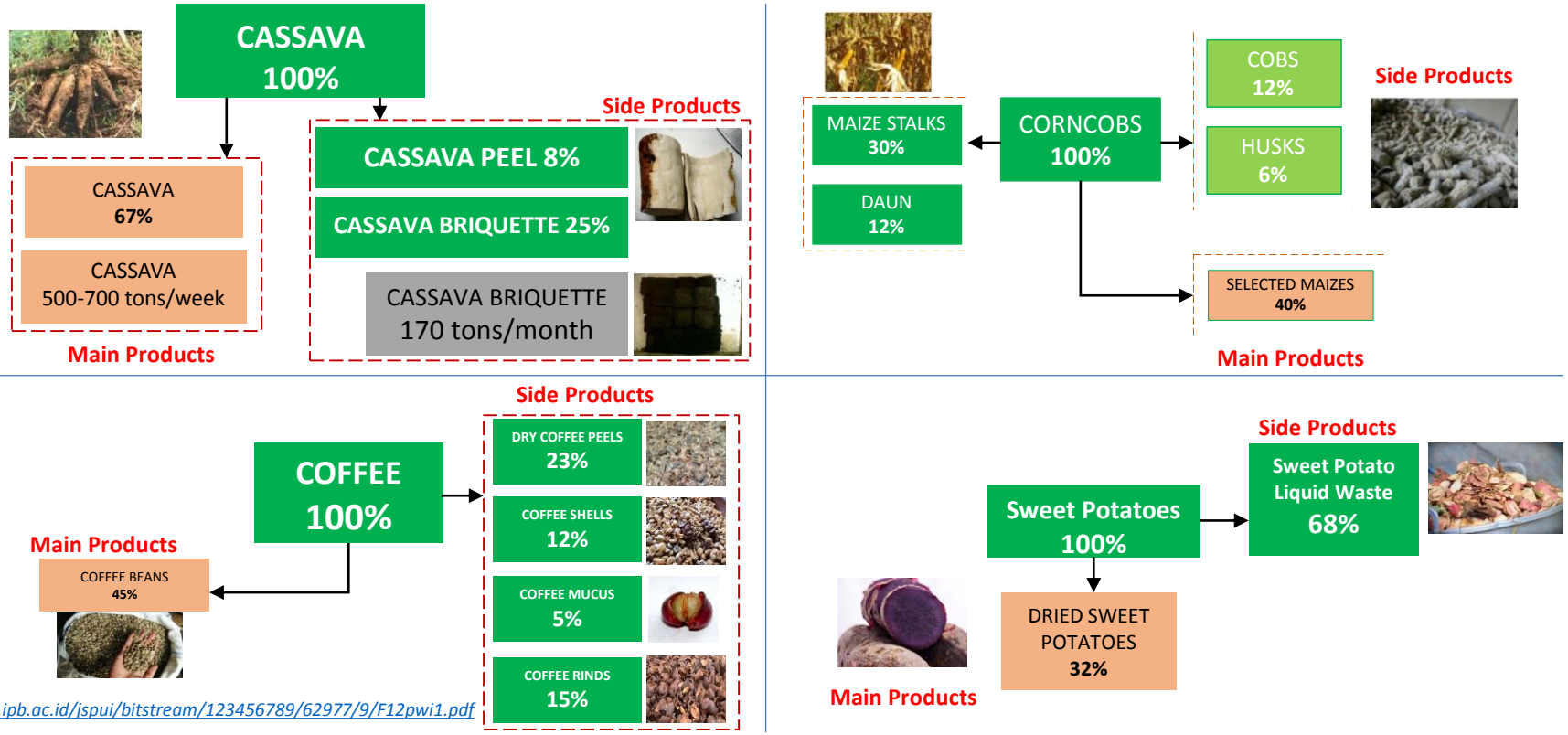

Source : http://balitkabi.litbang.pertanian.go.id/ and https://repository.ipb.ac.id/jspui/bitstream/123456789/62977/9/F12pwi1.pdf

3. Mapping of Potential Biomass

3 – 1. Biomass Production

サゴヤシ、カカオ、天然ゴムの生産過程で産出される副産物も広く利用されている。

List of Biomass that have huge potential and been used to produce energy in Indonesia, are:

Estate Crops Sub-sector
Tea
Tobacco
Sugar Cane
Cocoa
Clove
Pepper
Coffee
Rubber
Palm Oil
Coconut
Cashewnut
Cotton
Sago

Food Crops Sub-sector
Paddy
Maize
Soybean
Peanut
Cassava
Sweet Potatoes

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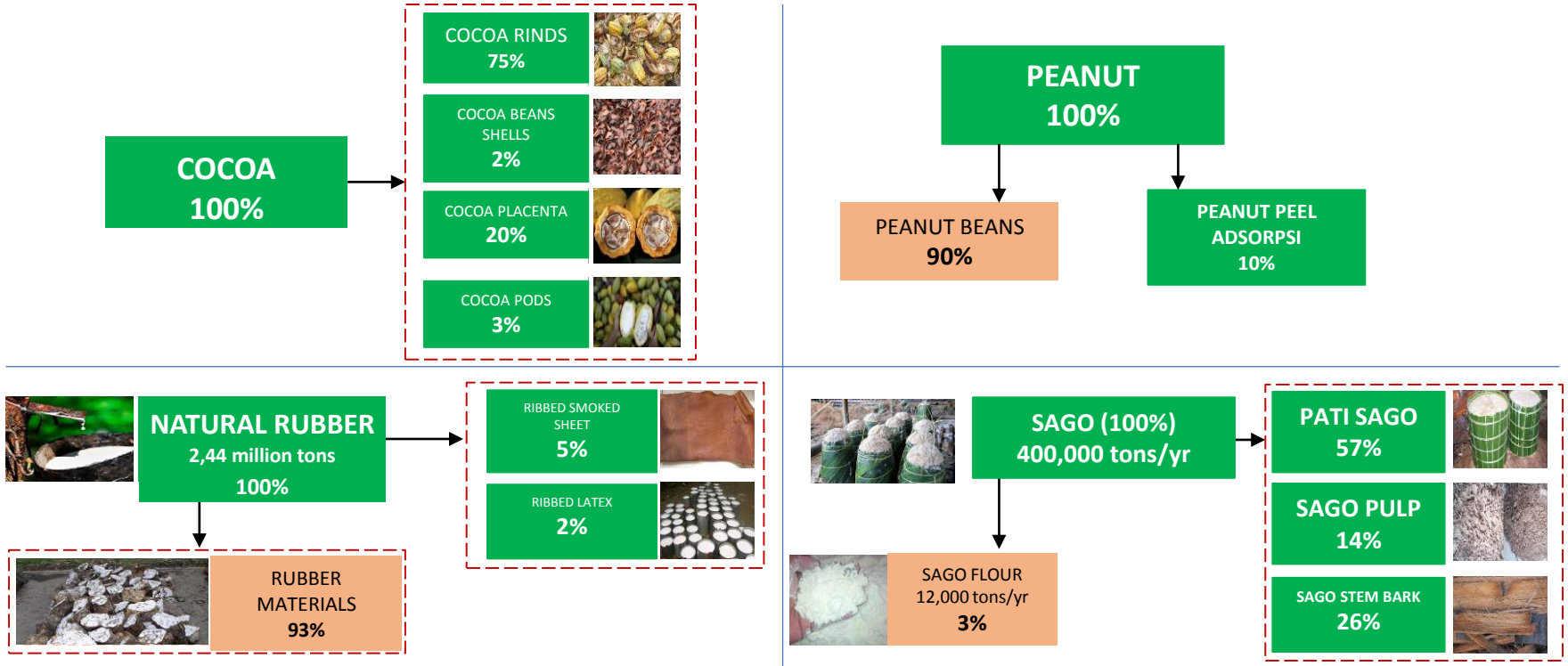


Source : https://repository.ipb.ac.id/jspui/bitstream/123456789/40875/11/2008tpu.pdf and ejournal.puslitkaret.co.id

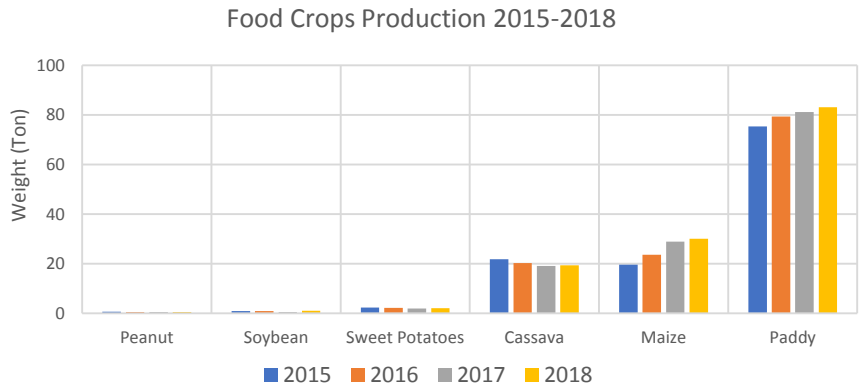
3. Mapping of Potential Biomass

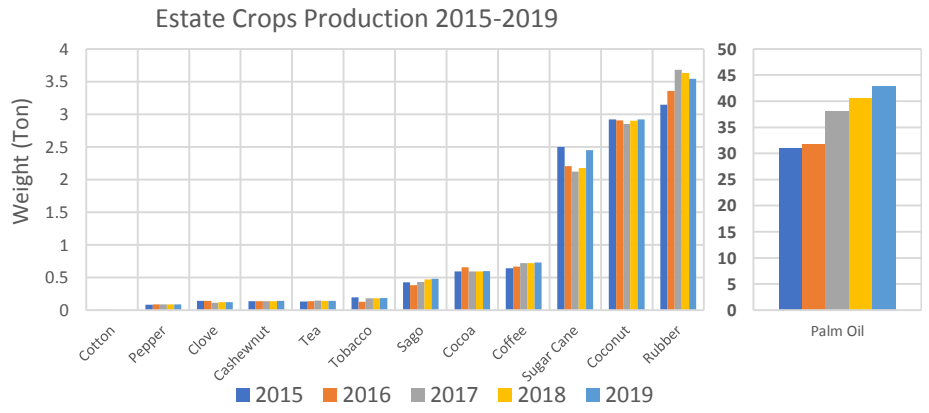
3 – 1. Biomass Production

2018～19年の生産状況について、プランテーション・セクターに関しては、パーム油が、食用作物セクターに関しては、米の生産が突出している。2017年のパーム油の生産は、前年比19.17%の増加であった。

Biomass in Indonesia is from agriculture sector including crops plantation. According to the data from Ministry of Agriculture, here are the crops production in Indonesia:

- Palm oil production is still very dominant in estate crops sub-sector follow by rubber and coconut (Graph separated).
- The palm oil growth significantly in 2017 over 2016 is 19,17%. This means the demand of palm oil every year is increasing.
- Paddy, Maize and Cassava as the food crops shows as the highest production in last four years.
- Their growth were increasing, paddy growth in 2017 over 2016 is 2,26%, follow by Maize is 3,91% and Cassava is 1,51%.





Food Crops Sub-sector	2015 (Ton)	2016 (Ton)	2017 (Ton)	2018* (Ton)	2019** (Ton)
Paddy	75397841	79354767	81148594	83037150	-
Maize	19612435	23578413	28924015	30055623	-
Soybean	963183	859653	538728	982598	-
Peanut	605449	570477	495447	512198	-
Cassava	21801415	20260675	19053748	19341233	-
Sweet Potatoes	2297634	2169386	1914244	2029353	-

Estate Crops Sub-sector	2015 (Ton)	2016 (Ton)	2017 (Ton)	2018* (Ton)	2019** (Ton)
Tea	132615	138935	146251	141341	141252
Tobacco	193790	126728	181142	181308	183360
Sugar Cane	2497997	2204619	2121671	2174400	2450000
Cocoa	593331	658399	590684	593833	596477
Clove	139641	139611	113178	123399	123766
Pepper	81501	86334	87991	88715	89671
Coffee	639412	663871	717962	722461	729074
Rubber	3145398	3357951	3680428	3630268	3543171
Palm Oil	31070015	31730961	37965224	40567230	42869429
Coconut	2920665	2904170	2854300	2899725	2922190
Cashewnut	137580	137094	135575	136402	139968
Cotton	759	932	332	417	170
Sago	423946	383613	432913	470883	478361

Source: BPS – Statistics Indonesia and Ministry of Agriculture (2019)

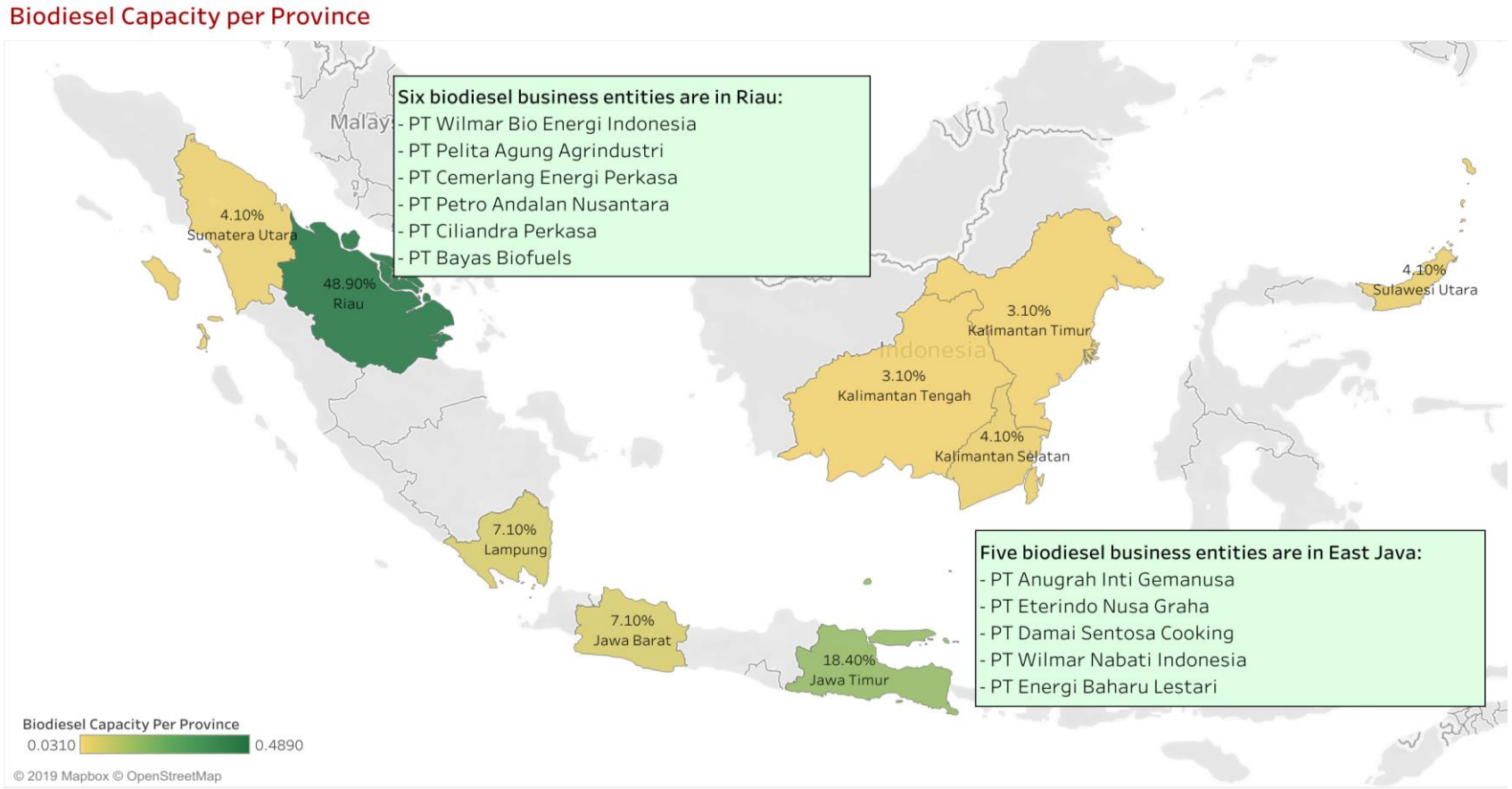
3. Mapping of Potential Biomass

3 – 2. Biomass for Energy Utilization

バイオディーゼルの生産事業者が比較的多く所在している州は、リアウ州の6社、東ジャワ州の5社である。スマトラ島とジャワ島以外には、カリマンタン島とスラウェシ島に事業者が立地している。

From the previous slide, here is the distribution of biodiesel business entities per province in Indonesia.

- Please note that this map only represent capacity per province, not the area covered or dominate by business entities.
- Majority of biodiesel business entities with large capacity placed in Riau (48,90%) and East Java (18,40%).



Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

3. Mapping of Potential Biomass

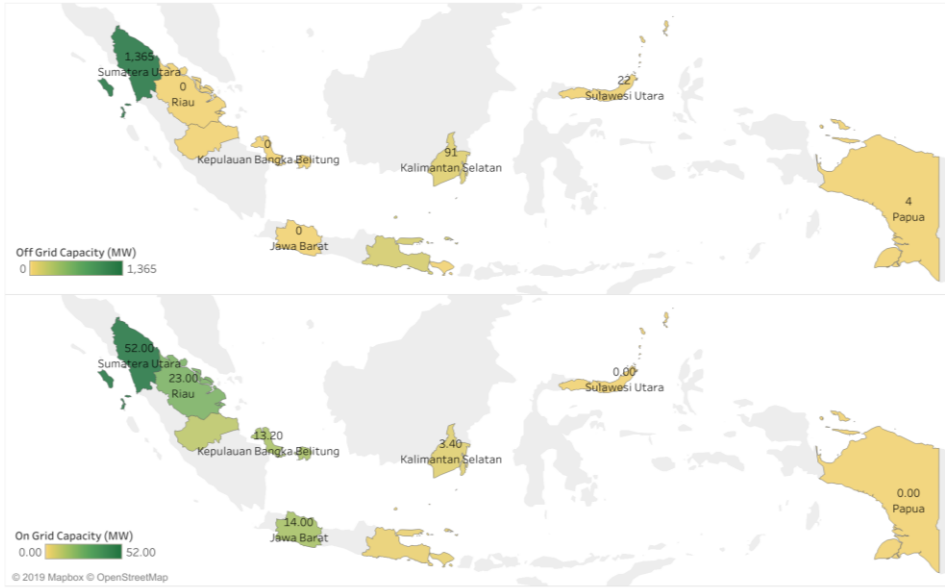
3 – 2. Biomass for Energy Utilization

バイオ燃料を利用した発電に関しては、オフグリッドの発電量がオングリッドのそれを上回っており、発電所の多くはスマトラ島に位置している。オフグリッド、オングリッド共に北スマトラ州が、最大の発電量を誇っている。

For the power plant capacity is divided into two pattern: On Grid and Off Grid.

- On grid consumer is PLN, means the owner must sell power to PLN. While off grid consumer is regional community and do not have to sell power to PLN.
- Majority of power plant placed in Sumatera, and off grid power plant dominate the power supply across Indonesia.

On and Off Grid Biomass Power Plant Capacity



Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

Biomass **Off Grid** Capacity

Province	Feedstocks	Capacity (MW)
East Java	Palm Waste	2
East Java	Sugar Cane	142
South Kalimantan	Palm Waste	91
North Sumatera	Palm Waste	335
North Sumatera	POME	9
North Sumatera	Sugar Cane	66
North Sumatera	Paper	955
North Sulawesi	Palm Waste	11
North Sulawesi	Sugar Cane	11
Papua	Palm Waste	4
TOTAL		1626

Biomass **On Grid** Capacity

Province	Feedstocks	Capacity (MW)
Bali	MSW	2
Bangka Belitung Island	Palm Waste	5
Bangka Belitung Island	POME	1,2
Gorontalo	Corncob	0,4
Jambi	Palm Waste	10
West Java	MSW	12
West Java	MSW	2
East Java	MSW	1,6
South Kalimantan	POME	1
South Kalimantan	POME	2,4
South Kalimantan	Palm Waste	0
Bangka Belitung Island	Palm Waste	7
Riau	Palm Waste	10
Riau	Palm Waste	3
Riau	Palm Waste	10
North Sumatera	Palm Waste	9
North Sumatera	Palm Waste	10
North Sumatera	Palm Waste	10
North Sumatera	Palm Waste	10
North Sumatera	Palm Waste	3
North Sumatera	Palm Waste	10
TOTAL		119,6

3. Mapping of Potential Biomass

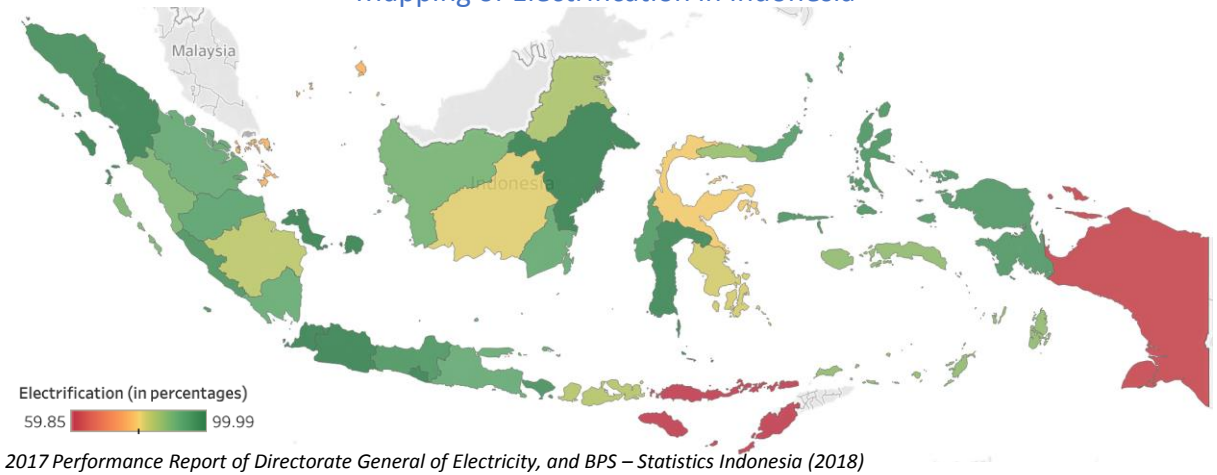
3 – 2. Biomass for Energy Utilization

インドネシア全体の電化率は、95.35%であるが、国の西側が電化率が高く、東南部と東部で電化率が低い。国家の標準電化率（95.35%）を下回る州は19州ある。

Electricity access refers to the percentage of people in each area that have relatively stable access to electricity. It can also be referred to as the electrification.

- The electrification rate reaches almost 100% (colored with green) in the western part of the country (i.e. DKI Jakarta, Banten and West Java), and the lowest at 59.85% (colored with red) in the southeastern part (i.e. NTT) of the country.
- The average electrification rate in Indonesia is currently 95.35%. With these standards, there are still around 19 provinces that are still below the national electrification standard.

Mapping of Electrification in Indonesia



Source: 2017 Performance Report of Directorate General of Electricity, and BPS – Statistics Indonesia (2018)

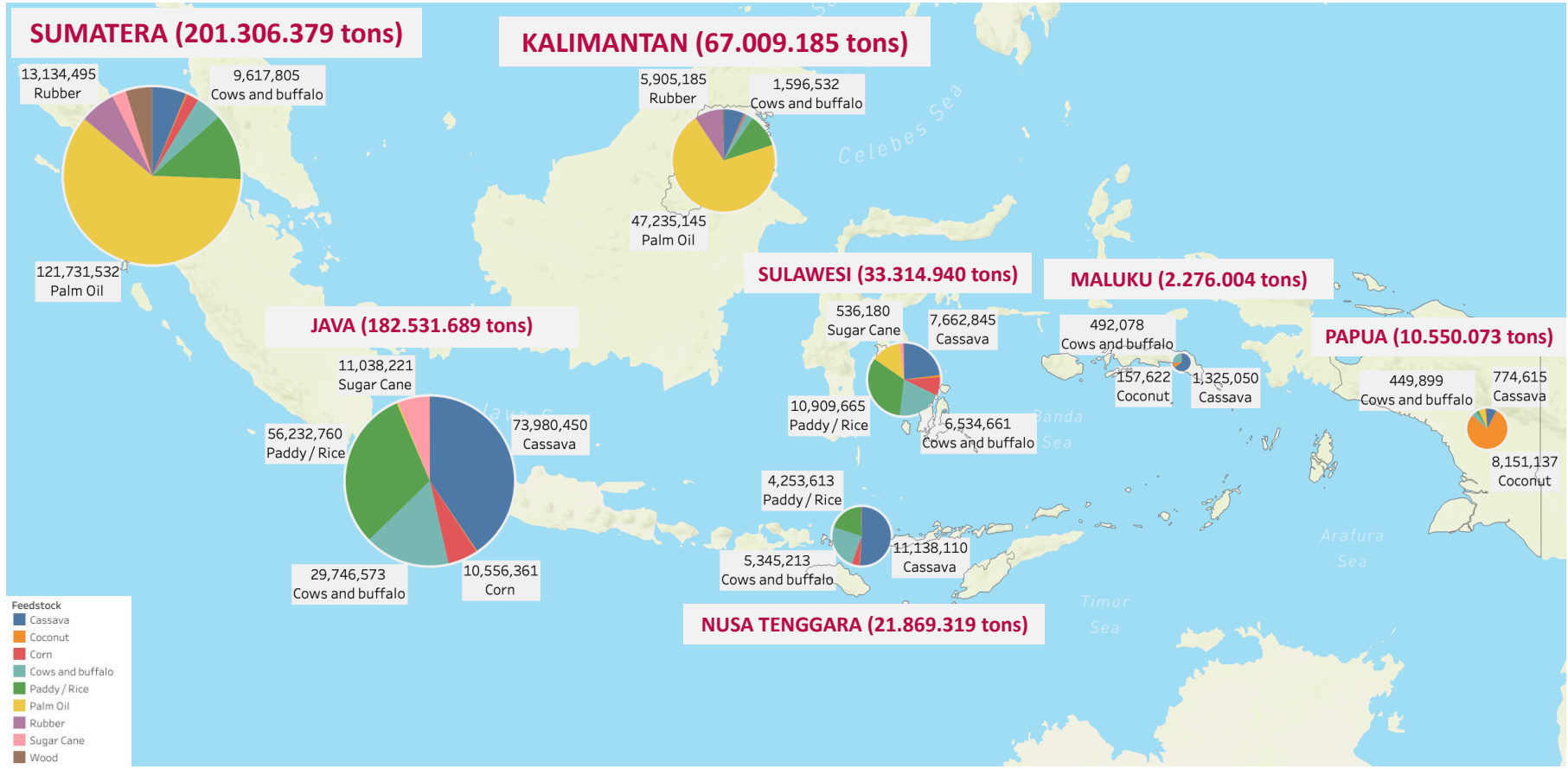
Province	Electrification (in percentages)	Electricity Generated (GWh), 2017	Demand Electricity (GWh)
Aceh	97,68	568,20	13,50
North Sumatera	99,90	18544,99	18,56
West Sumatera	89,15	89,28	10,87
Riau	92,25	1032,83	86,77
Jambi	93,68	124,19	8,38
South Sumatera	83,38	16955,88	3379,79
Bengkulu	96,49	80,73	2,94
Lampung	91,96	40,60	3,55
Bangka Belitung Island	99,99	974,12	0,10
Riau Island	76,97	2275,74	680,92
DKI Jakarta	99,99	16070,82	1,61
West Java	99,99	37801,93	3,78
Central Java	96,30	39579,73	1520,72
DI Yogyakarta	99,99	No data	No data
East Java	92,03	53868,24	4665,11
Banten	99,99	46111,50	4,61
Bali	97,12	3564,45	105,70
West Nusa Tenggara	84,11	1563,41	295,36
East Nusa Tenggara	59,85	600,32	402,72
West Kalimantan	89,93	1609,28	180,20
Central Kalimantan	80,82	369,11	87,60
South Kalimantan	92,12	3933,49	336,47
East Kalimantan	99,99	3769,59	0,38
North Kalimantan	84,78	184,58	33,14
North Sulawesi	94,56	1937,36	111,46
Central Sulawesi	79,31	1720,51	448,84
South Sulawesi	99,12	5878,51	52,19
Southeast Sulawesi	81,54	873,80	197,82
Gorontalo	86,56	115,76	17,97
West Sulawesi	95,28	44,25	2,19
Maluku	87,39	620,77	89,57
North Maluku	96,09	238,21	9,69
West Papua	95,70	713,88	32,08
Papua	61,42	805,28	505,82

3. Mapping of Potential Biomass

3 – 3. Potential Waste Mapping

バイオ燃料の原材料として、量的に最も多く利用可能なのは、パーム油生産過程の副産物であり、地理的にはスマトラ島とカリマンタン島に集中している。量的にこれに続くのは、稲の残渣である。それぞれ、プランテーション・セクターと食用作物セクターの代表的作物である。

- Sumatera has the biggest potential feedstocks in Indonesia, followed by Java and Kalimantan;
- Palm oil waste is the largest feedstocks in Indonesia, and mostly placed in Sumatera and Kalimantan;
- Even though every island have potential waste, but only a few of them utilize the waste.



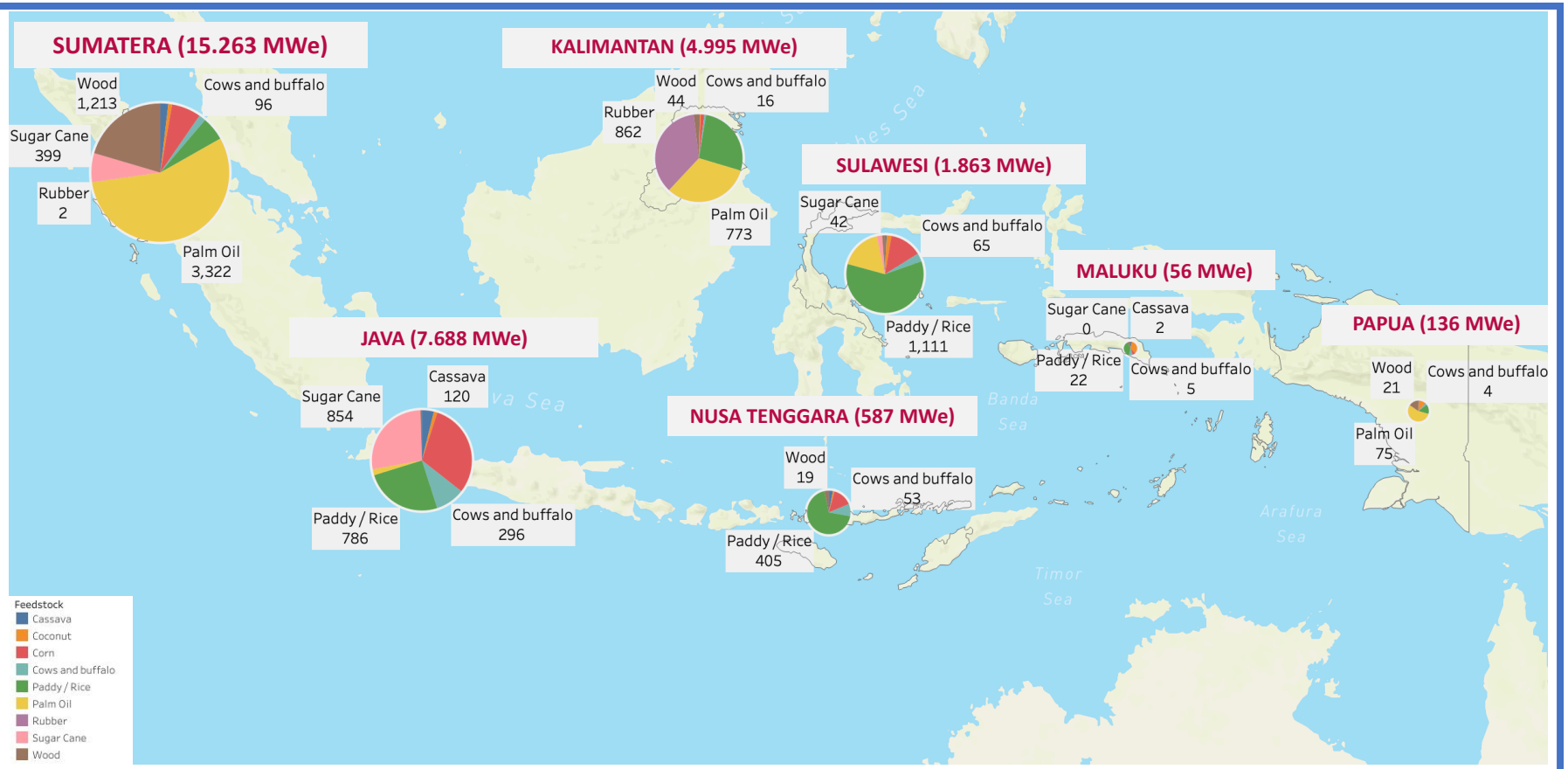
Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

3. Mapping of Potential Biomas

3 – 4. Potential Energy Conversion Mapping

インドネシアの幾つかの地域で、未利用残渣の活用は可能なエネルギー源であり、量的には油ヤシが最も多く、それに稲が続く。

- Sumatera has the biggest potential electricity in Indonesia, followed by Java and Kalimantan.
- For the potential energy, palm waste still the top feedstocks and currently use for now.
- From the previous slide of power plant distribution compare to this data, we can say only a few resources already used to generate electricity.



Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

4. Biomass Energy Utilization

4. Biomass Energy Utilization

4 – 1. Biomass Power Plant Process

インドネシアにおける現在のバイオエネルギーの利用形態は、以下の3種類に分類できる：①バイオエネルギーによる発電、②バイオ燃料プログラム、③植物由来の廃棄バイオマスのエネルギー利用

INDONESIA BIOENERGY DEVELOPMENT PROGRAM FROM BIOMASS
(Which is currently spearheaded by waste/residue from palm oil)

01

BIOENERGY FOR ELECTRICTY

Power Plants from biomass, biogas, municipal sewage and waste, and CPO

02

BIOFUEL PROGRAM

Mandatory of B20, B30, E2, biodiesel for aviation and green fuel

03

ENERGY FROM PLANT-BASED WASTE-BIOMASS

Utilize residue or waste from various plants in agricultural, plantation and forest lands as well as degraded land

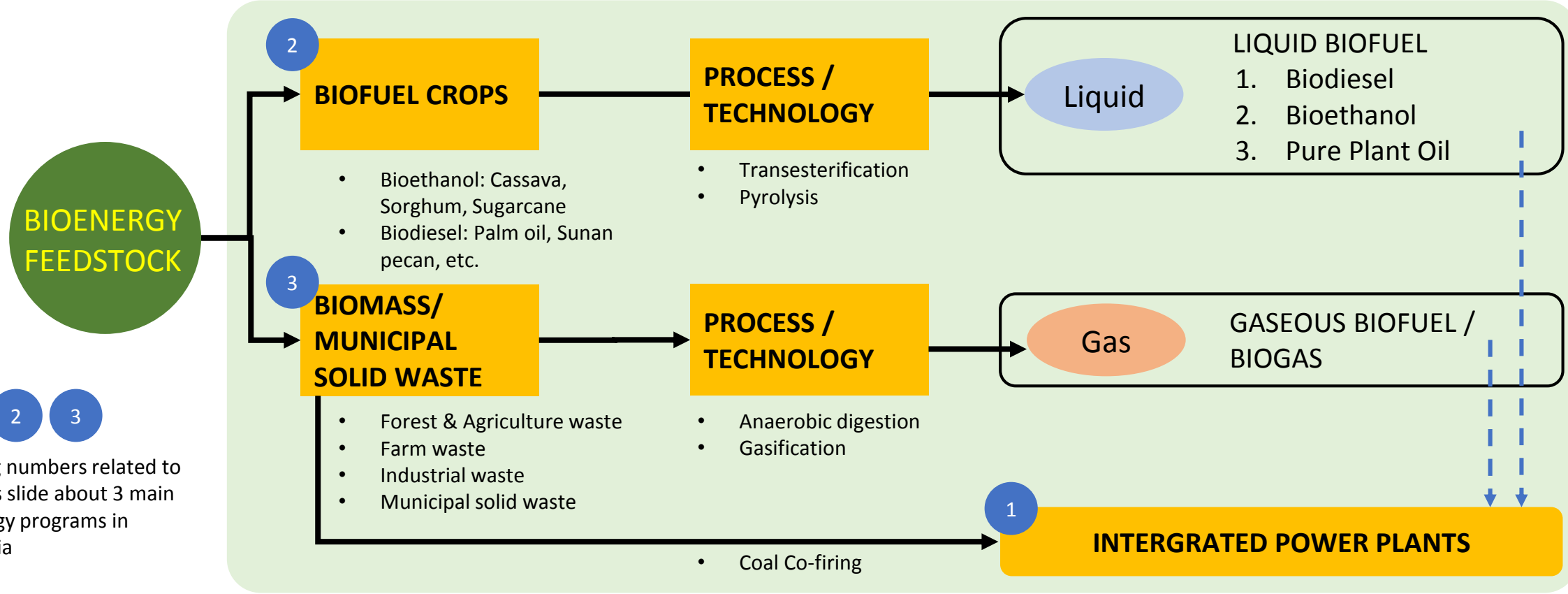
After establishing power plant from biomass, biofuel program of B20 had been started since 2016, then with B30 program had been started since 2019; then next target is B40 program that is plan to be started in early 2021 plus increase optimization of biomass in form of waste and residues in the form of plant-based waste from agriculture and plantation activities. According to MEMR (2018) that in line with our findings, the most significant amount of plant-based waste are from palm oil then follow by rice-paddy and sugarcane. Another significant waste are from corn, rubber & cassava.

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

4. Biomass Energy Utilization

4 – 1. Biomass Power Plant Process

バイオマスは、様々なテクノロジーを利用することで、様々な種類のバイオエネルギーに変換できる。バイオ燃料の生成にはエステル交換、バイオガスの生成には嫌気性消化処理、バイオマス統合型の発電には石炭との混焼が利用される。



Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

4. Biomass Energy Utilization

4 – 1. Biomass Power Plant Process: Mixed Feedstocks

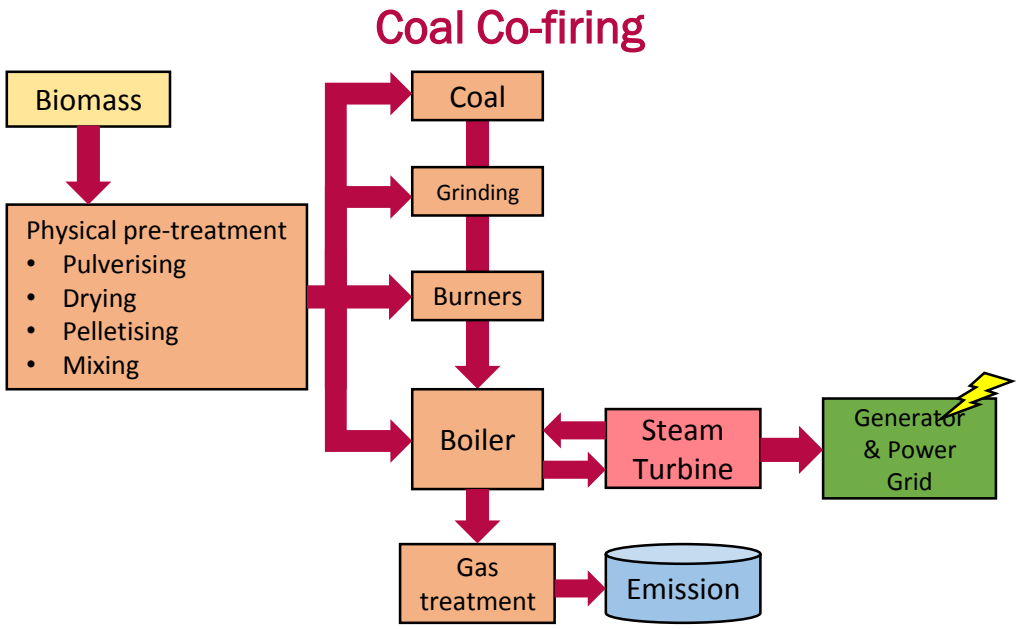
バイオマスは、既存の石炭火力発電所において混焼される場合があるが、この形態は、発電所を新しく建設する必要が無い点、エネルギー含有量の低い石炭の場合に含有量を向上させる可能性がある点が利点である。ただし、大量のバイオマスと大規模な発電所が共に必要とされる。

Co-firing is the combustion of two (or more) different types of materials at the same time. Biomass is sometimes co-fired in existing coal plants instead of new biomass plants. The advantages of coal co-firing is:

- Existing coal plants can be used to burn a new fuel, which may be cheaper or more environmentally friendly (cut emissions from coal-fueled generation).
- Used to improve the combustion of fuels with low energy content.
- However, co-firing requires large amounts of biomass and typically works best at large coal-fueled plants.

Biomass Power Plant Siantan

- Location: Desa Wajok Hulu, Kecamatan Siantan, Kabupaten Mempawah, West Kalimantan.
- Commercial Operating Date: April 23rd, 2018
- Production Company: PT. Rezeki Perkasa Sejahtera Lestari
- Capacity: 10 – 15 MW
- Feedstocks: Palm waste and wood shells, rice husks, corncobs, bagasse, sawdust and other agriculture waste.



Flowchart of the Coal Co-firing process

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2018)

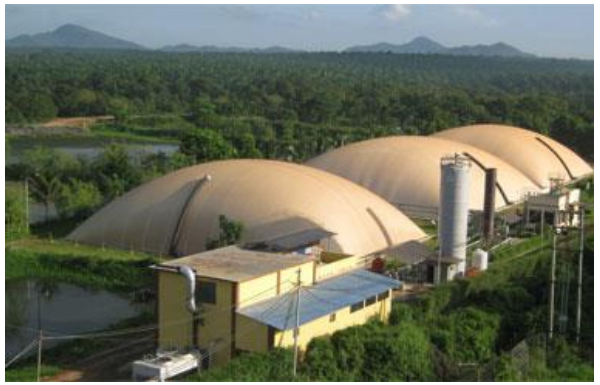
4. Biomass Energy Utilization

4 – 1. Biomass Power Plant Process: Biogas Product

バイオガスは、嫌気状態での有機物分解から生成するが、大気を汚染せず、堆肥を生み出すという利点を持つと同時に、現状のバイオガスプラントは非効率で、金属を腐食させる不純物をプロセスから排除できていない、という技術的課題を抱えている。

Biogas is the mixture of gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from agricultural waste, manure, municipal waste or food waste. The advantages of biogas are:

- Gas generated through bio-digestion is non-polluting; no combustion takes place in the process (except incineration as an old process).
- The by-product of the biogas is enriched organic (digestate), which is a substitute for chemical fertilizers.
- An unfortunate disadvantage of biogas today is that the systems used in the production of biogas are not efficient; biogas still contains impurities that can corrode the metal parts of the engine; need optimal temperature around 37℃, and less suitable for dense metropolitan areas.

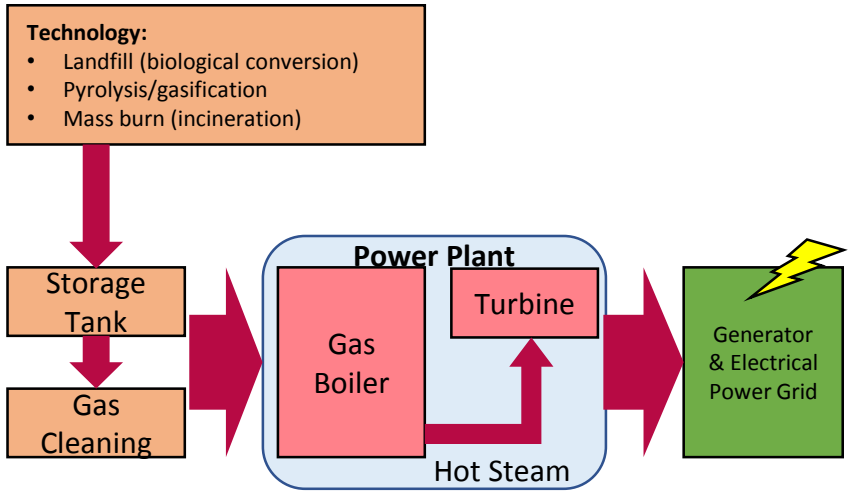


Biogas Power Plant Austindo Nusantara Jaya

- Location: Desa Jangkang, Belitung Timur.
- Commercial Operating Date: January 2016
- Production Company: PT. Austindo Aufwind New Energy (AANE)
- Capacity: 1,8 MW
- Feedstocks: Palm Oil Mill Effluent (POME), Methane gas waste

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

Biogas Production Process



Flowchart of the Biogas Production Process

4. Biomass Energy Utilization

4 – 2. Biofuel Process: Overview

バイオ燃料は、活用する技術とその原料に基づいて、以下のような「世代」に分類されている。現時点のインドネシアで活用されている技術は、基本的に「第2世代」に属するものである。

CURRENT TECHNOLOGY

1st

- First-generation biofuels are directly related to a biomass that is generally edible
- Feedstocks: waste oil, animal fats, vegetable oil, sugar (sugar beet, sugarcane), and starch (corn, wheat)
- Products: Biodiesel and Bioethanol
- Process: Transesterification

2nd

- Second-generation biofuels are defined as a fuels produced from a wide array of different feedstock, raging from lignocellulosic feedstocks to municipal solid wastes
- Feedstocks: wood, organic waste, food waste and specific biomass crops
- Products: Biomethane and Bio-syngas
- Process: Anaerobic digestion, Gasification and Pyrolysis

3rd

- Third-generation biofuels are, at this point, related to algal biomass but could to a certain extent be linked to utilization of CO_2 as feedstock
- Feedstocks: algae, agricultural residues (stalks, leaves, husk)
- Products: Biodiesel
- Process: Hydro-Thermal Liquefaction (HTL), Cellulosic Bioethanol

Source: Research Gate – Chapter 20 Biofuel Production (March 13th, 2018)

4. Biomass Energy Utilization

4 – 2. Biofuel Process: Transesterification

エステル交換プロセスは、バイオマス由来の油脂とアルコールからバイオディーゼルを生成する。この技術には、反応時間が短いという利点があり、現在既に使われている技術である。

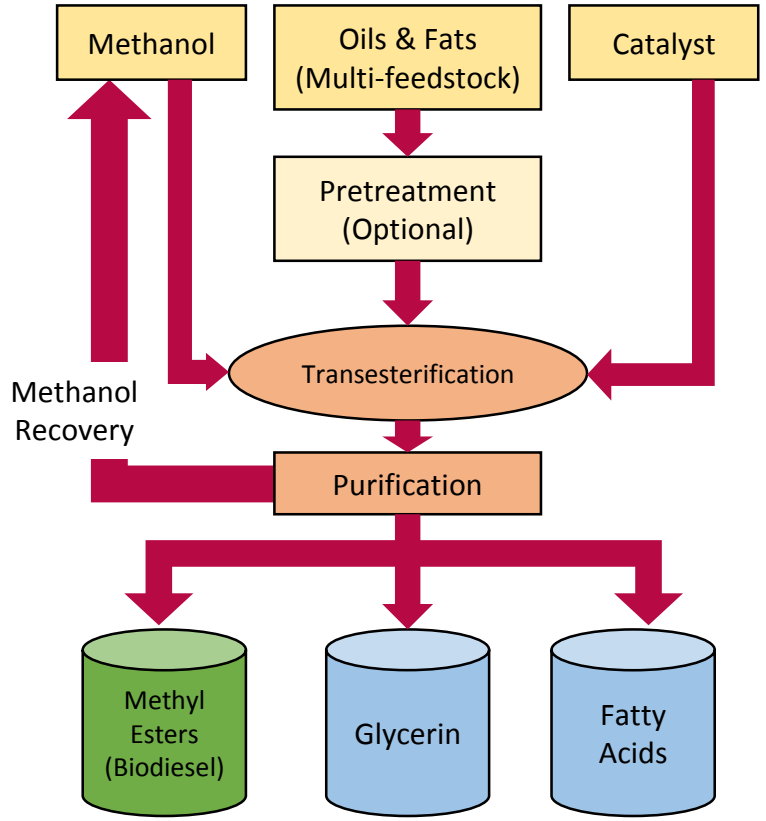
Biodiesel can be produced through transesterification process between oil or fat and alcohol. The process can be carried out with or without a catalyst. The advantages and disadvantages of the process depends on type of chemical reaction and catalyst:

- Short reaction time, mild reaction temperatures and atmospheric pressure.
- Some catalyst are reusable.
- Produce high yield of biodiesel.
- However, some method need high energy consumption and requires pre-treatment, such as the to remove water content from feedstocks or high temperature.

PT. Wilmar Bioenergi Indonesia

- Location: Kw. Industri Dumai, Pelintung, Medang Kampai, Kota Dumai, Riau.
- Commercial Operating Date: January 30th, 2007
- Total Plant: 5 biodiesel plants
- Capacity: 1.050.000 MT/year
- Feedstocks: Palm Oil

Source: Field Study Report, 2018, Atmajaya Yogyakarta University Journal



Flowchart of the esterification process

4. Biomass Energy Utilization

4 – 2. Biofuel Process: Anaerobic Digestion

嫌気性消化法は、液化とガス化の二段階プロセスでバイオガスを生成する。生成過程で、副産物として繊維質の肥料を産出するが、肥料の悪臭は処理されていない廃棄物の悪臭を下回る。大規模農場であれば利用可能な技術である。

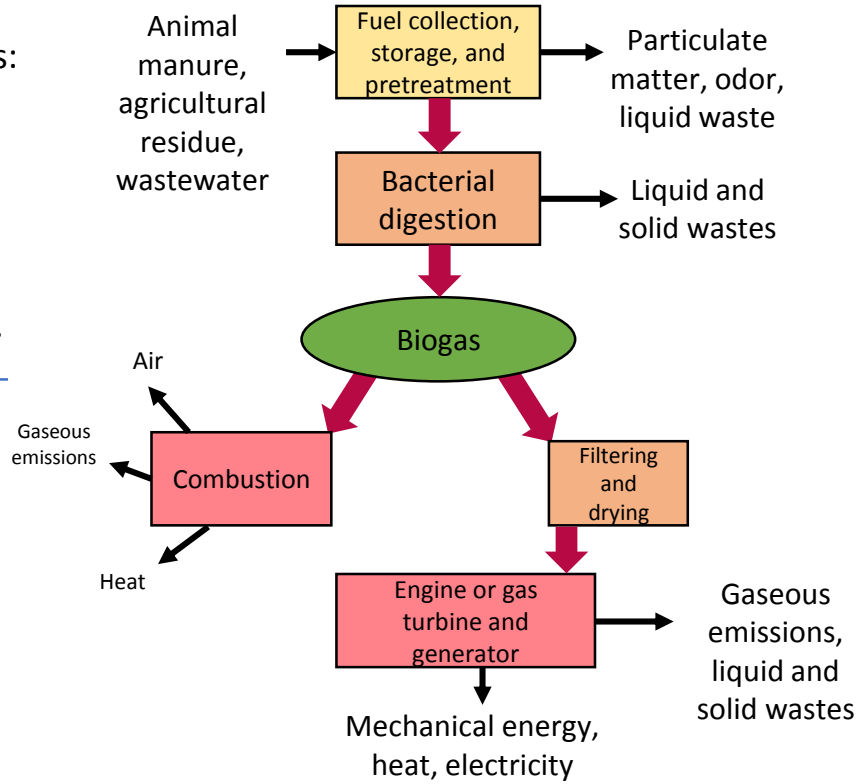
Anaerobic digestion is a series of biological processes in which microorganisms' breakdown biodegradable material in the absence of oxygen. The advantages of anaerobic digestion process is:

- It produces renewable energy in the form of biogas and a fibrous fertilizer.
- Reduces odor below unprocessed waste odor levels.
- Help to remove phosphorous and other metals from the waste products.
- Unfortunately, the installation costs of the process can be prohibitive since it requires some massive financing to set it up. Also the maintenance cost are costly.
- It is economically feasible for large farm and must have a constant source of the raw materials.

PT Molindo Raya Industrial

- Location: Jl. Sumber Waras 255, Lawang, Malang, East Java
- Commercial Operating Date: 2012
- Production Company: PT. Rezeki Perkasa Sejahtera Lestari
- Capacity: 7800 MT/year

Source: www.molindo.co.id



Flowchart of biogas production via the anaerobic digestion process

4. Biomass Energy Utilization

4 – 2. Biofuel Process: Pyrolysis

熱分解は、材料を高温で、石油留分とバイオエタノールに分解するプロセスである。この技術は様々な原材料に適用できる。

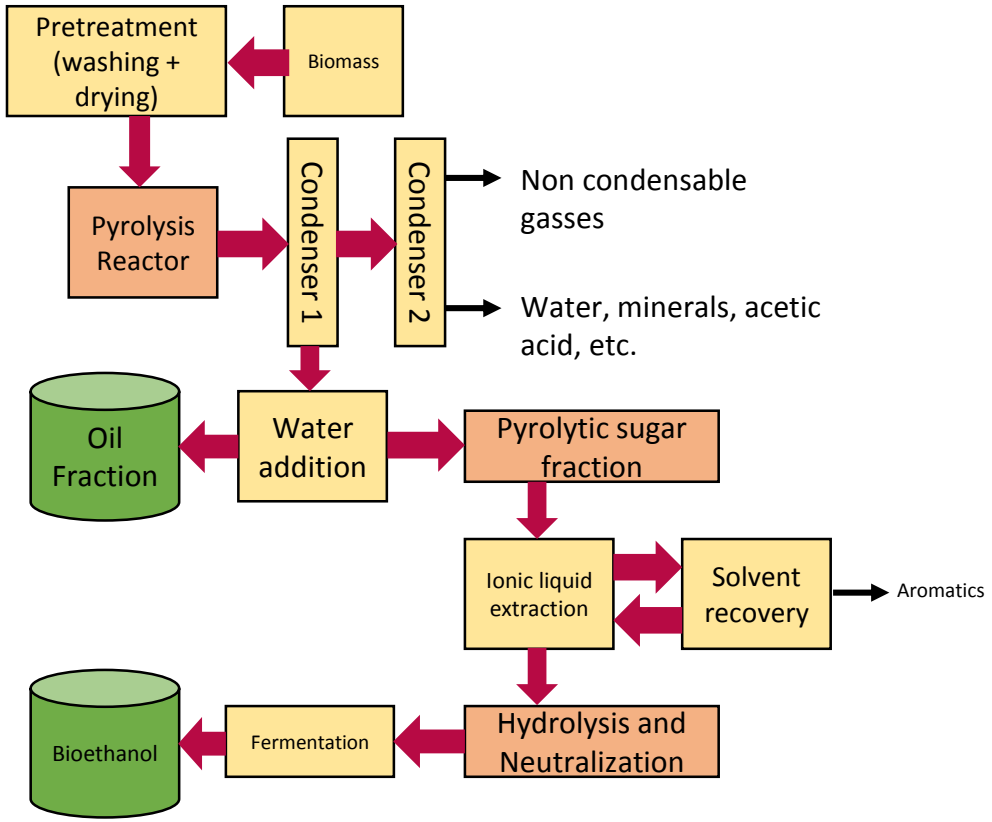
Pyrolysis is the thermal decomposition of materials at elevated temperatures in an inert atmosphere. The advantages of pyrolysis process is:

- Toxic components and pathogens are degraded using high temperatures. Also reduce water volume.
- This technology for processing a wide variety of feedstocks.
- However, the process is complex, need high temperature and high operating costs.

GempolKerep Bioethanol Plant

- Location: Jl. Suko Sewu, Gempolkrep, Mojokerto, East Java
- Commercial Operating Date: June 3rd, 2013
- Production Company: PT. Energi Agro Nusantara
- Capacity: 23.400 MT/year
- Feedstocks: Molasses

Source: www.ptpn10.co.id and www.enero.co..id



Flowchart of bioethanol production via the pyrolysis process

4. Biomass Energy Utilization

4 – 2. Biofuel Process: Gasification

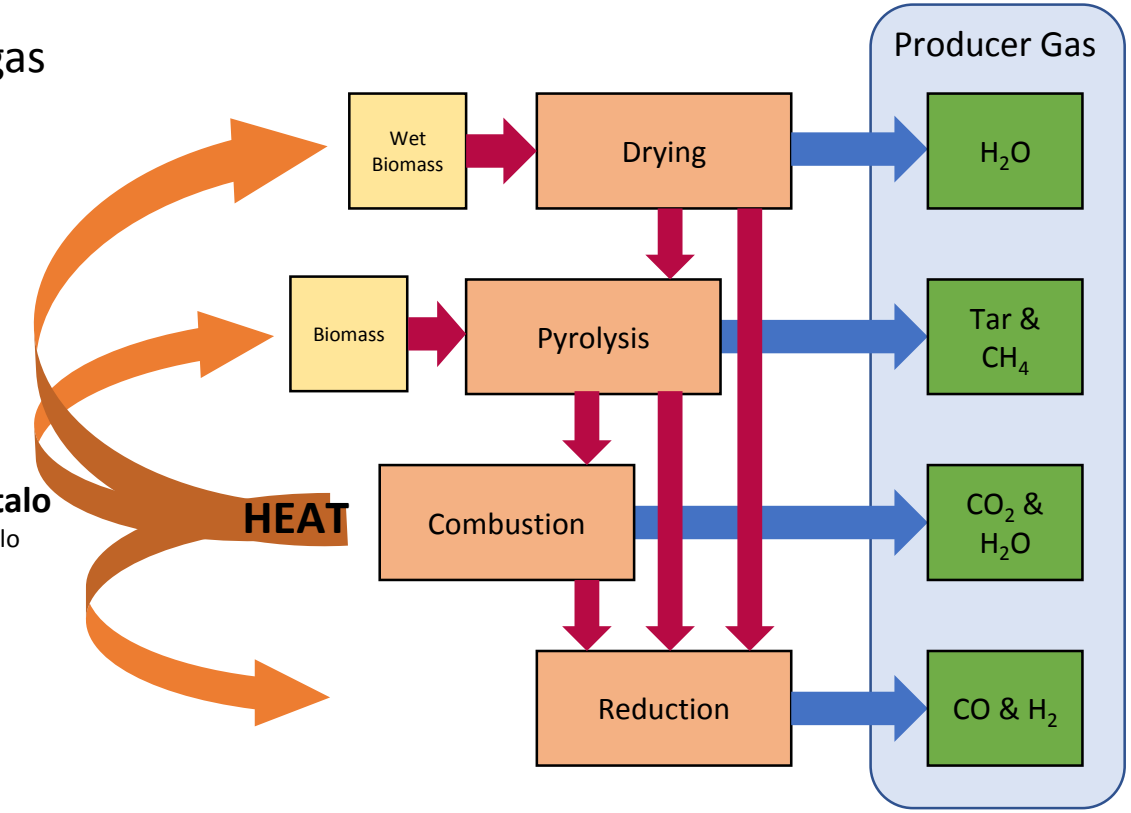
ガス化はバイオマス原料から電気とバイオ燃料を生産するための技術で、現在既に利用されている。しかしながら、プロセスの中で有害なタールとチャー（未燃炭素と灰分からなる微小粒子）が相当程度発生するので、その対策が必要になる。

Gasification is a technology that converts carbon-containing materials, including coal, waste and biomass, into synthetic gas which in turn can be used to produce electricity and biofuel.
The advantages of gasification process is:

- Simple and inexpensive process, high carbon conversion efficiency, and high thermal efficiency.
- However, the process produce high tar and char, and unsuitable for coarse particles (need pre-treatment).

Biomass Powerplant Pulubala Gorontalo

- Location: Dusun Tumba Km 40, Pulubala, Gorontalo
- Commercial Operating Date: 2014
- Production Company: PT. PLN
- Capacity: 500 kW
- Feedstocks: Corncobs



Schematic representation of biomass gasification

Source: Analysis of Power Plant Biomass Based Corn Cobs, Ichsan Gorontalo University, August 2018

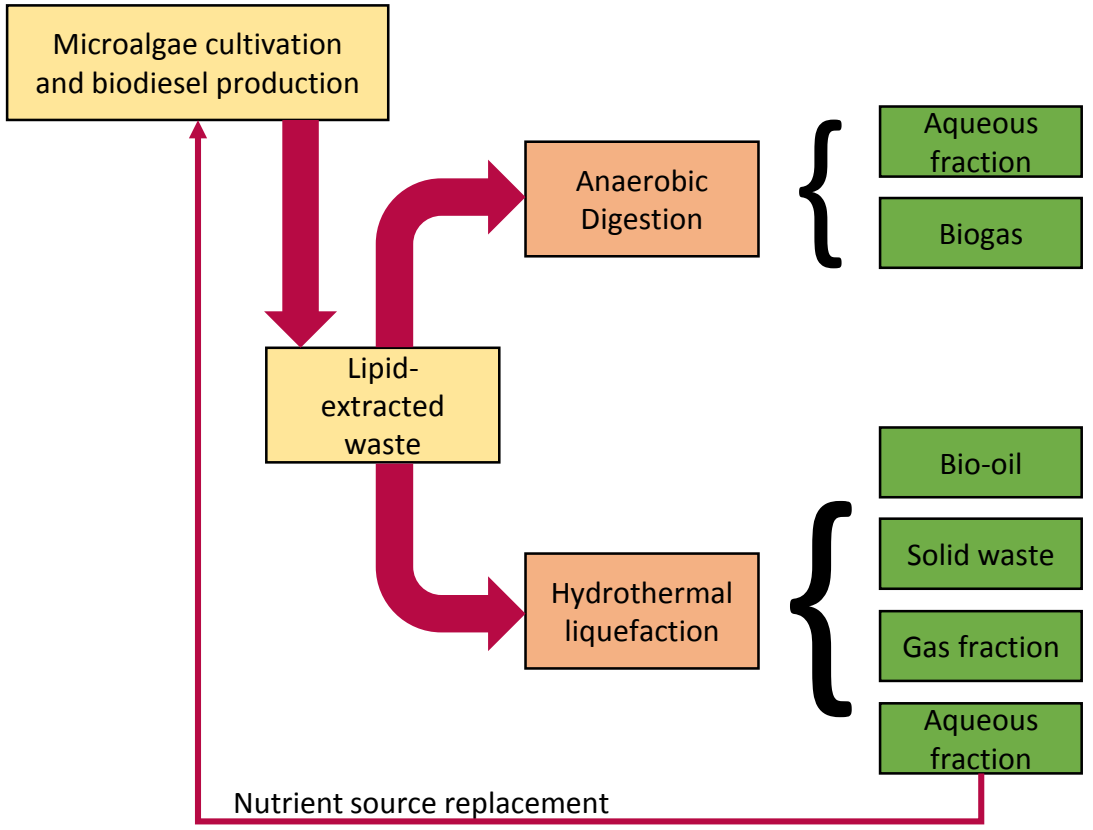
4. Biomass Energy Utilization

4 – 2. Biofuel Process: Hydrothermal Liquefaction (HTL)

水熱液化は、バイオマスを高温高圧の熱水で改質することにより、直接液状オイルを得る方法であり、乾燥の前処理を必要としないので、水分含有量の大きなバイオマスに適用できる技術である。

Hydrothermal Liquefaction (HTL) is a direct liquefaction process where biomass is converted into liquid oil with the presence of a solvent at moderate temperatures of 200-350℃ and high pressures of 100-250 bar. The advantages of this process is:

- For wet biomasses HTL is a promising method, because there is no drying of wet biomasses required (such as algae).
- HTL delivers a high energy bio-crude that is lower in oxygen and moisture content compared to pyrolysis.
- Corrosion in the subcritical water environment is a critical issue. Also salt deposition in the reactor if the amount of minerals in the feedstocks is very high, can lead to reactor clogging.
- There are no factories that use this technology in Indonesia. This technology is only at the research stage and has not yet been implemented.



Schematic representation of production of bio-oil from HTL

Source: www. sciencedirect.com, Yusuf Chisti, in Biofuels from Algae (Second Edition) (2019)

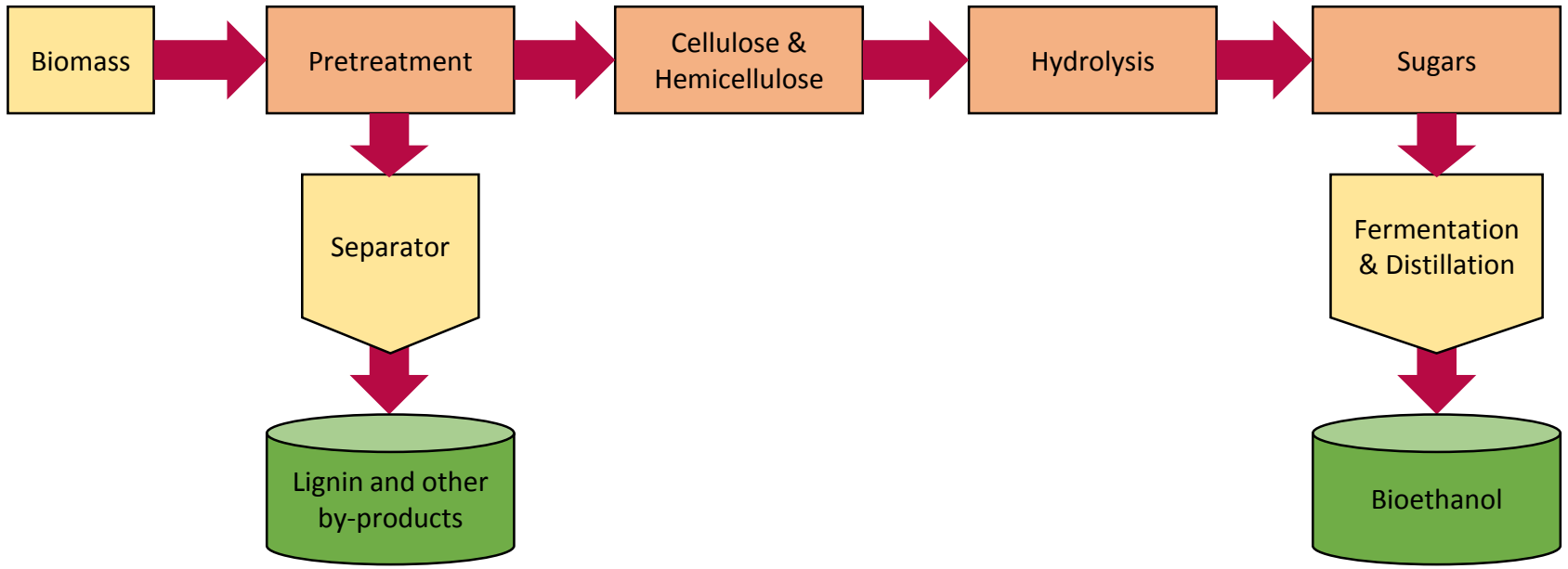
4. Biomass Energy Utilization

4 – 2. Biofuel Process: Cellulosic Bioethanol

セルロース系エタノール、つまりセルロースから生成されるエタノールは、将来有望なエネルギー源である。この技術には、草木、藻類、及び他の木質バイオマスが利用でき、温室効果ガスの削減率を現行技術の85%から94%に高めることが可能である。

Cellulosic ethanol is ethanol produced from cellulose (the stringy fiber of a plant) rather than from the plant's seeds or fruit. It is a biofuel produced from grasses, wood, algae, or other plants. Cellulose ethanol is a viable alternative to fossil fuels, here is the advantages:

- Enhances greenhouse gas reduction by 85% to 94%.
- Has an estimated positive net energy balance of 2 to 12 times.
- However, a fuel that is generated is expected to have a reduced fuel efficiency compared to gasoline.
- There are no factories that use this technology in Indonesia. This technology is only at the research stage and has not yet been implemented.



Schematic representation of production of bioethanol from cellulosic biomass

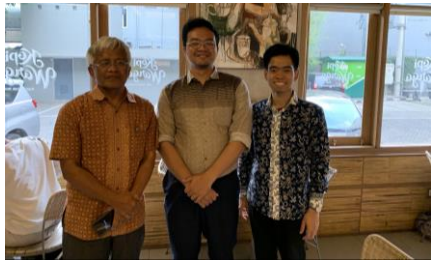
Source: https://web.extension.illinois.edu/ethanol/cellulosic.cfm, The Future of Ethanol: Cellulosic (March 2019)

5. Expert Comments

5. Expert Comments

5 – 1. Expert Profile

2019年11～12月に専門家インタビューを実施し、バイオエンジニアリング及びバイオテクノロジー関連分野専攻の有識者（大学、政府機関）からヒアリングを行いました。

Dr. Ahmad Agus Setiawan Head of Renewable Energy Laboratory, Gadjah Mada University	
Dr. Robert Manurung Associate Professor of Bioengineering, Bandung Institute of Technology	
Renna Eliana Warjoto, SSi, MSc. Head of Biotechnology Faculty, Atma Jaya Catholic University	

Ir. Widi Pancono Head of KOPETINDO (Indonesia Renewable Energy Coop)	
Duncan Kuncara, MSc. President Director of PT. Rezeki Perkasa Sejahtera Lestari (Biomass Power Plant Company)	
Dr. Indri Badria Adilina **Dr. Euis Hermiati** Researcher for Chemistry, LIPI (Indonesia Institute of Science)	

5. Expert Comments

5 – 1. Expert Profile: Dr. Ahmad Agus Setiawan (Gadjah Mada University)

我々が今までに試したバイオマスは、パーム糖と炭化したココナツヤシ殻である。インドネシア国全体で、再生エネルギーの比率を10%に高めるには、太陽光発電施設を大量に増設する必要がある。

Questions	Answer
• Can you explain your current expertise and research activities?	• Now I am the head of a renewable energy laboratory. Generally this laboratory is used for final project research. • My expertise is in the field of renewable energy in general. Now it is developing hybrid, mini grid and microgrid power plants.
• Is there any biomass research and technology trend that you see growing in the past two year in Indonesia?	• A few months ago we held a training for teachers on pyrolysis technology which is currently being used and developed.
• Is there any global research and technology trend happen right now?	• In Germany there is a biomass power plant using raw materials of wood pellets with a combine cycle system. • In Denmark it uses coal-fired generation technology, where charcoal is made from biomass raw materials.
• Is there any other biofuel crops that potential for bioenergy?	• We conducted a study in Klaten to produce biomass products from unused sugar palm fibers using pyrolysis. • We have also tried using coconut shells to make biomass charcoal.
• Can you tell us about other renewable energy trend in Indonesia?	• The achievement of renewable energy in Indonesia has not reached 10% until early 2020. Currently, solar power plants are being intensified.

5. Expert Comments

5 – 1. Expert Profile: Dr. Robert Manurung (Bandung Institute of Technology)

バイオエタノールは、ジャワ島以外の島でキャッサバ及びサゴヤシなど種々の異なる原料を利用して生産可能なので、非常に可能性のある分野である。将来有望なバイオマスとしては藻類がある。何故なら、藻類は粗パーム油の10倍の脂質レベルを有するからである。

Questions	Answer
• Can you explain your current expertise and research activities?	• My expertise is in bioengineering. Has facilitated Japanese companies, such as Mitsubishi. I have also developed biomass products in rural areas in Indonesia.
• Is there any biomass research and technology trend that you see growing in the past two year in Indonesia?	• In my opinion bioethanol must be produced outside of Java, and it is very possible. The cost of transportation of fuel such as to Papua is too expensive. Bioethanol can be produced from a variety of raw materials.
• Is there any global research and technology trend happen right now?	• Currently in Europe, precisely in Germany is developing algae as a biomass feedstock to become bioethanol. This research was initiated by prof. dr. ir. RH (Rene) Wijffels. • Algae is very potential if it can be developed properly because of the 10x lipid level of CPO.
• Is there any priority scale in developing renewable energy technology?	• All regions in Indonesia have the potential to utilize biomass, not only as biofuels or electricity but can be a by-product.
• Is there any other biofuel crops that potential for bioenergy?	• Sago in Papua is very abundant. • I used cassava to produce bioethanol. The level of sugar in cassava is 30%, so that for 100 tons of cassava can produce 30 tons of sugar. My research has been tried in Sudan. • When compared with Brazil which uses sugar cane with only 10% sugar content, cassava produces bioethanol 3 times that of sugar cane. • Rice also has potential because it is seen from the size of the land. But it is still a food ingredient.
• Is there any other biofuel processing technology trend right now?	• Pyrolysis and gasification have started to be used. • Now it is developing into solar power plants.

5. Expert Comments

5 – 1. Expert Profile: Renna Eliana Warjoto, SSi, MSc. (Atma Jaya University)

微生物燃料電池（MFC）と呼ばれる技術は、微生物を分解して発電することが可能である。パーム油は、バイオディーゼルの原料となる可能性を持っている。

Questions	Answer
• Can you explain your current expertise and research activities?	• I am the head of student affairs at the biotechnology faculty. I teach bioreactors and other biotechnology courses.
• Is there any biomass research and technology trend that you see growing in the past two year in Indonesia?	• The research that I have done is Microbial Fuel Cell (MFC) which already exists in Indonesia but is not as popular as abroad. • MFC is a bio-electrochemical system where we utilize the ability of microorganisms to degrade complex organic compounds. Then it produces electrons so that it can produce electrical energy. • Technology trends that have begun to be seen in Indonesia: fermentation, feedstock, castor oil, palm oil, pyrolysis, microalgae
• Is there any priority scale in developing renewable energy technology?	• Biodiesel in Sumatera has the potential for investment because oil palm is still abundant.
• Is there any other biofuel crops that potential for bioenergy?	• Palm oil is still potential in Indonesia.
• Is the price of biofuel affordable?	• Expensive because there are chemical reagents that are used up and are still exported. Need to think about processing biodiesel byproducts.
• How is the development of bioenergy from Jatropha?	• Research on Jatropha is quite a lot but lack of implementation.
• What is the procedure for cooperation with surrounding communities in the field of renewable energy?	• Lecturers can submit proposals to DIKTI or LIPI. • As for students through the Program name *Kreativitas Mahasiswa* (University Students Creativity).

5. Expert Comments

5 – 1. Expert Profile: Ir. Widi Pancono (KOPETINDO)

再生可能エネルギーのための協同組合は、インドネシアの誇りである。ガス化技術は実践されてはいるものの、オペレーション・コストが高すぎるのが実情である。

Questions	Answer
• Is there any biomass research and technology trend that you see growing in the past two year in Indonesia?	• Co-firing technology by mixing coal with wood. Being tried to replace coal by 5%. • Producing low grade oil from rotten fruit in Sumatera and Bangka.
• Is there any global research and technology trend happen right now?	Algae is also potential but is more economical to be a protein material compared to biofuel.
• Is there any priority scale in developing renewable energy technology?	In general, bioenergy, solar power plants, hydroelectric power plants are the backbone of renewable energy in Indonesia. Biomass is being promoted by the government, such as the construction of biomass plants.
• Is there any other biofuel crops that potential for bioenergy?	Palm oil still has the potential to become a biodiesel feedstock but requires a large investment.
• Is there any other biofuel processing technology trend right now?	Gasification technology is trending, but operational costs are still relatively expensive.
• Is the price of biofuel affordable?	The price of bioethanol set by the government is still low, it should be exported directly. Process costs are still too high because of the raw material from sugar.
• How is the development of bioenergy from Jatropha?	Jatropha does not develop in Indonesia. Production costs are expensive because the harvest method is still manual.

5. Expert Comments

5 – 1. Expert Profile: Dr. Indri Badria Adilina (LIPI)

インドネシア科学院（LIPI)は、科学的研究を統括するインドネシアの政府機関である。その傘下には、47の研究センターがあり、社会科学から自然科学に至る様々な分野の研究を主導している。バイオエタノールについてはコストの高さが問題である。

Questions	Answer
• Is there any biomass research and technology trend that you see growing in the past two year in Indonesia?	Palm oil and sugar cane can be the raw material for bioethanol currently in Indonesia.
• Is there any priority scale in developing renewable energy technology?	Development priorities at LIPI are based on requests from the community and local government.
• Is there any other biofuel crops that potential for bioenergy?	There are various variants of algae. In my opinion, algae which have high lipid content can be a raw material for biofuels.
• Is there any other biofuel processing technology trend right now?	Pyrolysis and gasification have begun to be implemented.
• How is the development of bioenergy from Jatropha?	Previously there was a Jatropha study, but it did not develop because operational costs were still expensive.
• Is the price of biofuel affordable?	Bioethanol production costs are still expensive because of the many chemical reagents as catalysts that can be completely reacted.

6. Matrix Feedstocks and Technology

6. Matrix Feedstocks and Technology

Composition based on preference

考慮すべき要因：廃棄バイオマスの利用可能量、現行のあるいは将来可能な技術、施設の立地・場所

No.	Type of Unused Plant based-biomass	Distribution	Total Quantity (ton/year)	Potential energy conversion (Joule/Year)	Current technology used	Location of current used technology	Country origin of current Technology	Potential technology that can be used	Country origin of potential technology
1.	**PALM OIL Residues**								
	Fiber	Sumatera, Kalimantan, Java, Sulawesi, Papua	12.752.453	1.231	Transesterification	Sumatera, Kalimantan, Java	Belgium	Pyrolysis	Many European countries
	Shell		6.136.541	758					
	EFB		23.841.538	828					
	POME		47.876.339	431					
	Stem		75.517.083	330					
	Re-planting		8.412.853	977					
2.	**SUGAR CANE Residues**								
	Bogasse	Sumatera, Java, Sulawesi	9.559.394	582	Fermentation	East Java	Brazil	Pyrolysis and Cellulosic Bioethanol	Many European countries
	Sugar Cane Leaves and Shoot		7.154.404	713					

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

6. Matrix Feedstocks and Technology

Composition based on preference

No.	Type of Unused Plant based-biomass	Distribution	Total Quantity (ton/year)	Potential energy conversion (Joule/Year)	Current technology used	Location of current used technology	Country origin of current Technology	Potential technology that can be used	Country origin of potential technology
3.	**RUBBER Residue**								
	Re-planting	Sumatera, Kalimantan	19.039.680	864	Transesterification	-	Belgium	Pyrolysis	Many European countries
4.	**COCONUT Residues**								
	Coconut Fiber	Sumatera, Kalimantan, Java, NT, Sulawesi, Maluku, Papua	2.271.600	118	Transesterification	-	Belgium	Pyrolysis	Many European countries
	Coconut Shell		7.261.864	58					
5.	**RICE-PADDY Residues**								
	Husk	Sumatera, Kalimantan, Java, NT, Sulawesi, Maluku, Papua	12.987.573	1.431	Transesterification	-	Belgium	Cellulosic Bioethanol	United States
	Straw		90.166.385	1.885					

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

6. Matrix Feedstocks and Technology

Composition based on preference

No.	Type of Unused Plant based-biomass	Distribution	Total Quantity (ton/year)	Potential energy conversion (Joule/Year)	Current technology used	Location of current used technology	Country origin of current Technology	Potential technology that can be used	Country origin of potential technology
6.	**CORN Residues**								
	Corncob	Sumatera, Kalimantan, Java, NT, Sulawesi, Maluku, Papua	4.263.117	496	Fermentation	Sumatera, Java	Brazil	Pyrolysis and Cellulosic Bioethanol	Many European countries
	Stems and leaves of corn		14.920.906	1.239					
7.	**CASSAVA Residue**								
	Liquid waste	Sumatera, Kalimantan, Java, NT, Sulawesi, Maluku, Papua	111.796.967	270	Fermentation	-	Brazil	Pyrolysis and Cellulosic Bioethanol	Many European countries

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

6. Matrix Feedstocks and Technology

Composition based on preference

No.	Type of Unused Plant based-biomass	Distribution	Total Quantity (ton/year)	Potential energy conversion (Joule/Year)	Current technology used	Location of current used technology	Country origin of current Technology	Potential technology that can be used	Country origin of potential technology
8.	**WOOD Residues**								
	Black Liquor	Sumatera	7.967.045	955	-	-	-	Pyrolysis, Co-firing	Many European countries
	Wood Waste	Sumatera, Kalimantan, Java, NT, Sulawesi, Maluku, Papua	2.678.781	381	-	-	-		
9.	**COWS AND BUFFALO Manure**								
	Manure	Sumatera, Kalimantan, Java, NT, Sulawesi, Maluku, Papua	53.782.761	535	-	-	-	Anaerobic Digestion	Germany

Source: Bioenergy Investment Guidelines, Ministry of Energy and Mineral Resources (2016)

7. Conclusion: A Recommendation Scheme

7. Conclusion

Recommendable Schemes

可能な事業スキームについては次ページに示したが、最善のビジネスモデルをただ一つ特定することは困難である。NEDOが出版した「戦略的次世代バイオマスエネルギー利用技術開発」とインドネシアの技術の現状に基づき、最も有望なR＆D分野として以下のようなものが考えらえる：

Currently have been developed in Indonesia	Product	R&D fields NEDO has recently committed
Biomass Power Plant Process: Mixed Feed stock (Example: Biomass Powerplant Siantan)	Electricity	Combination of Rice Husk Power Plant in combination with Poultry and other agricultural sectors
Biomass Power Plant Process: Biogas Product (Example: Biogas Powerplant Austindo Nusantara Jaya)	Electricity	Development of High-performance and Clean-Gasification System and Low temperature and Low-Pressure FT Synthesis for Total BTL System Construction
Gasification (Example: Biomass Powerplant Pulubala Gorontalo)	Electricity and Biofuel	Advanced Biomass Co-gasification Next-generation Biomass Liquid Fuel Technology
Transesterification (Example: PT Wilmar BI), Anaerobic Digestion (Example: PT Molindo RI), Pyrolisis (Example: GempolKerep BP), Hydro-Thermal Liquefaction (HTL-under development)	Biofuel	Development of Biomass Conversion Process for Producing High-quality Biofuel Using Hydrothermal Pretreatment and catalytic Reforming with Zeolite; Development of Hydrogenation Hybrid Process for High-grade Fuel Production from Biomass
Cellulosic Bioethanol (Under development)	Biofuel	Development of Innovative Technology for Direct Liquefaction of Cellulosic Biomass

7. Conclusion

Recommendable Schemes

前頁では有望なR&D分野を提示したが、以下ではNEDOプロジェクトによって商業化フェーズまで開発された技術でインドネシアに適用可能なものを、可能な事業スキームと共に示す。

Commercialization Technology Development (developed by NEDO) that we can adopt:

- Mixed Feedstock: Development of valuable Energy Recovery Technology and a Suitable Utilization System from Feedstock
- Re-use Coal Powerplant: Development of a New Solid Biomass Fuel for Co-firing at Coal Power Station
- Gas Commercialization: R & D on Cost Reduction of Primary Equipment for dry Anaerobic Digestion technology and effective Purification of Biogas and Practical Use of Gas Utilization

Then using these three different scheme that demonstrates a balanced composition between affordability and preference.

Public Private Partnership	**Build, Operate, Transfer (BOT)**
Private Sector Participation	**Independent Power Producer (IPP)**
Public Private Community Partnership	**Arranged by Regional Planning Board**

Palm Oil

- Palm oil growth in 2017 over 2016 is 19,17%
- Accelerates the project construction without waiting to have a sizeable fund

Biogas Power Plant

- The capacity of palm oil is 30 tons/hour that can generate 1 MW electricity through gasification process.
- Own a power plant, however, still need to sell power to PLN
- KOPETINDO support can be expected.

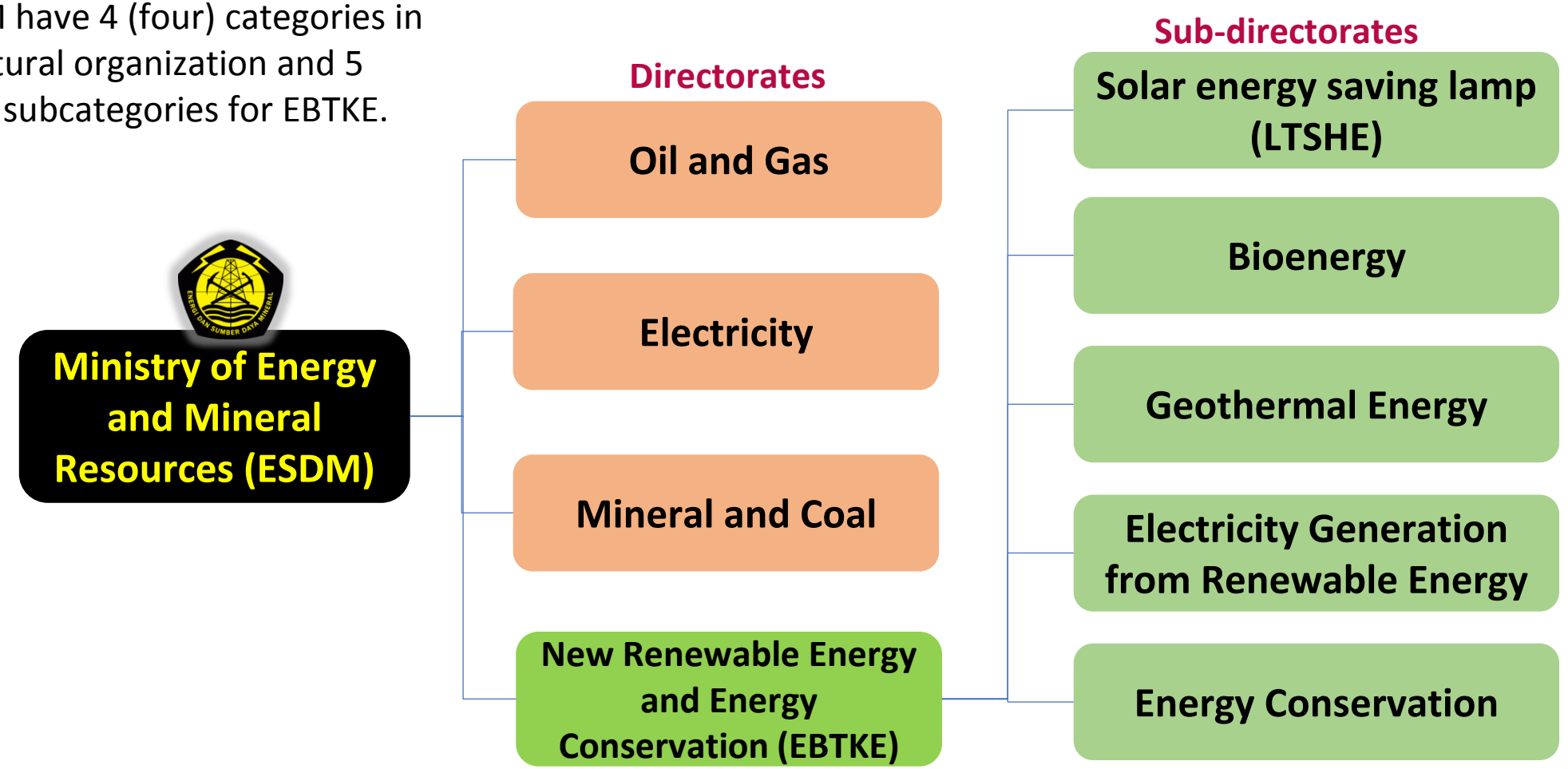
This scheme is open for any feedstocks and technology. However, the scheme usually by request from regional government, and collaboration with LIPI can be expected. This scheme is an off-grid pattern and doesn't need to sell power to PLN.

8. Appendix

8. Appendix

8 – 1. Renewable Energy Regulation: 再生エネルギー関連の規制は、エネルギー鉱物資源省の新･再生エネルギー及び省エネ総局が管轄している。

ESDM have 4 (four) categories in structural organization and 5 (five) subcategories for EBTKE.



8. Appendix

8 – 2. Renewable Energy Regulation: 地熱エネルギー関連の規制

Year	Regulation
2012	Regulation Of The Minister Of Energy And Mineral Resources Number 18 Of 2012 Concerning Guidelines For Conducting Geothermal Business Activities
2013	Regulation of the Minister of Energy and Mineral Resources No. 14 of 2013 concerning the Status of Ownership of Geothermal Assets Derived from Joint Operation Contracts (Joint Operation Contract)
2014	Regulation of the Minister of Energy and Mineral Resources Number 17 of 2014 concerning Purchasing Electricity from Geothermal Power Plants and Geothermal Steam for Geothermal Power Plants by PT. State Electric Company (Persero)
	Law Number 21 of 2014 concerning Geothermal Energy
2015	Regulation of the Minister of Energy and Mineral Resources Number 14 of 2015 concerning Procedures for Imposing, Collecting, and Depositing Non-Tax State Revenues Derived from Geothermal Activities at the Directorate General of New, Renewable Energy and Energy Conservation
2016	Government Regulation Number 28 Year 2016 concerning the Amount and Procedure for Giving Geothermal Production Bonuses
	Minister of Energy and Mineral Resources Regulation No. 44 of 2016 concerning Procedures for Placement and Disbursement of Geothermal Exploration Commitments

Year	Regulation
2017	Government Regulation Number 7 of 2017 concerning Geothermal for Indirect Use
	Regulation of the Minister of Energy and Mineral Resources No. 21 of 2017 concerning Management of Mud Waste and Drill Cutting in Geothermal Drilling
	Regulation of the Minister of Energy and Mineral Resources Number 23 Year 2017 concerning Reconciliation, Depositing, Imposition and Procedure for Determining the Percentage of Producing Areas for the Amount of Geothermal Production Bonuses
	Minister of Energy and Mineral Resources Regulation Number 36 Year 2017 concerning Preliminary Survey Assignment and Preliminary and Exploration Survey Assignment
	Minister of Energy and Mineral Resources Regulation No. 37 of 2017 concerning Geothermal Working Areas for Indirect Utilization
2018	Minister of Energy and Mineral Resources Regulation No. 33 of 2018 concerning Management and Utilization of Geothermal Data and Information for Indirect Utilization
	Minister of Energy and Mineral Resources Regulation No. 37 of 2018 concerning Geothermal Working Areas, Geothermal Business Assignment and Geothermal Permit Issuance.

8. Appendix

8 – 2. Renewable Energy Regulation: 再生可能エネルギーの電力利用に関する規制

Year	Regulation
2012	Minister of Energy and Mineral Resources Regulation No. 6 of 2012 concerning Assignments to PT. Perusahaan Listrik Negara (Persero) to Carry out Construction of the Upper Cisokan 4x260 MW Water Pump Power Plant
2014	Regulation of the Minister of Energy and Mineral Resources No. 35 of 2014 concerning Delegation of the Authority to Provide Electricity Business Licenses in the Context of Implementing One-Stop Integrated Services to the Head of the Investment Coordinating Board
2015	Regulation of the Minister of Energy and Mineral Resources No. 44 of 2015 concerning Purchases of Electric Power by PT. Perusahaan Listrik Negara (Persero) from Municipal Waste Based Power Plant

Year	Regulation
2017	Regulation of the Minister of Energy and Mineral Resources Number 10 of 2017 concerning Principles in Electricity Purchase Agreement
	Regulation of the Minister of Energy and Mineral Resources Number 14 of 2017 concerning Delegation of the Authority for Electricity Business Licensing in the Framework of Implementing One-Stop Integrated Services to the Head of the Investment Coordinating Board
	Regulation of the Minister of Energy and Mineral Resources Number 49 Year 2017 concerning Principles in Electricity Sale and Purchase Agreements
	Minister of Energy and Mineral Resources Regulation Number 50 Year 2017 concerning Utilization of Renewable Energy Sources for Electric Power Supply
2018	Regulation of the Minister of Energy and Mineral Resources Number 49 of 2018 concerning Use of Roof Solar Power Generation Systems by State Electricity Company (PLN) Consumers
	Regulation of the Minister of Energy and Mineral Resources No. 53 of 2018 concerning Utilization of Renewable Energy Sources for Electric Power Supply
	Regulation of the Minister of Energy and Mineral Resources Number 30 of 2018 concerning Delegation of the Authority to Provide Electricity Business Licenses in the Framework of Implementing One-Stop Integrated Services to the Head of the Investment Coordinating Board

8. Appendix

8 – 2. Renewable Energy Regulation: 太陽光発電照明とバイオエネルギーに関する規制

Year	Regulation
2017	Regulation of the Minister of Energy and Mineral Resources Number 33 of 2017 concerning Procedures for Providing Energy-Saving Solar Lights for Communities that Have Not Gained Electricity Access
	Presidential Regulation Number 47 Year 2017 concerning Provision of Energy-Saving Solar Lights for Communities that Have Not Gained Electricity Access
2018	Minister of Energy and Mineral Resources Regulation No. 5 of 2018 concerning Procedures for Providing Energy-Saving Solar Lights for Communities that Have Not Got Electricity

Year	Regulation
2013	Regulation of the Minister of Energy and Mineral Resources Number 25 of 2013 concerning Provision, Utilization, and Commerce of Biofuel as Other Fuels
2014	Regulation of the Minister of Energy and Mineral Resources Number 20 of 2014 concerning Provision, Utilization, and Commerce of Biofuel as Other Fuels
2015	Regulation of the Minister of Energy and Mineral Resources No. 12 of 2015 concerning Provision, Utilization and Business Administration of Biofuel as Other Fuels
2018	Regulation of the Minister of Energy and Mineral Resources Number 41 of 2018 concerning Provision and Utilization of Biodiesel-Type Biofuel in the Framework of Financing by the Palm Oil Plantation Fund Management Agency

8. Appendix

8 – 2. Renewable Energy Regulation: 省エネルギー、その他に関する規制

Year	Regulation
2011	Minister of Energy and Mineral Resources Regulation No. 4 of 2011 concerning Energy Awards
2012	Regulation of the Minister of Energy and Mineral Resources Number 14 of 2012 concerning Energy Management
2014	Regulation of the Minister of Energy and Mineral Resources No. 18 of 2014 concerning Affixing Energy Saving Sign Labels for Swablast Lights
2017	Minister of Energy and Mineral Resources Regulation Number 57 Year 2017 concerning Application of Minimum Performance Standards and Inclusion of Energy Saving Sign Labels for Air Conditioning Devices

Year	Regulation
2017	Minister of Energy and Mineral Resources Regulation No. 3 of 2017 concerning Operational Instructions for the Implementation of Special Allocation Funds for the Assignment of Small Scale Energy Fields
	Regulation of the Minister of Energy and Mineral Resources No. 39 of 2017 concerning the Implementation of Physical Activities in the Utilization of New and Renewable Energy and Energy Conservation
	Ministerial Regulation Number 48 Year 2017 concerning Supervision of Businesses in the Energy and Mineral Resources Sector
2018	Regulation of the Minister of Energy and Mineral Resources No. 9 of 2018 concerning Revocation of the Regulation of the Minister of Energy and Mineral Resources Related to Activities in the Field of New, Renewable Energy and Energy Conservation
	Minister of Energy and Mineral Resources Regulation No. 12 of 2018 concerning the Implementation of Physical Activities for the Utilization of New and Renewable Energy and Energy Conservation
	Regulation of the Minister of Energy and Mineral Resources Number 36 of 2018 concerning Operational Instructions for the Implementation of Special Physical Allocation Funds for Small Scale Energy Sector

8. Appendix

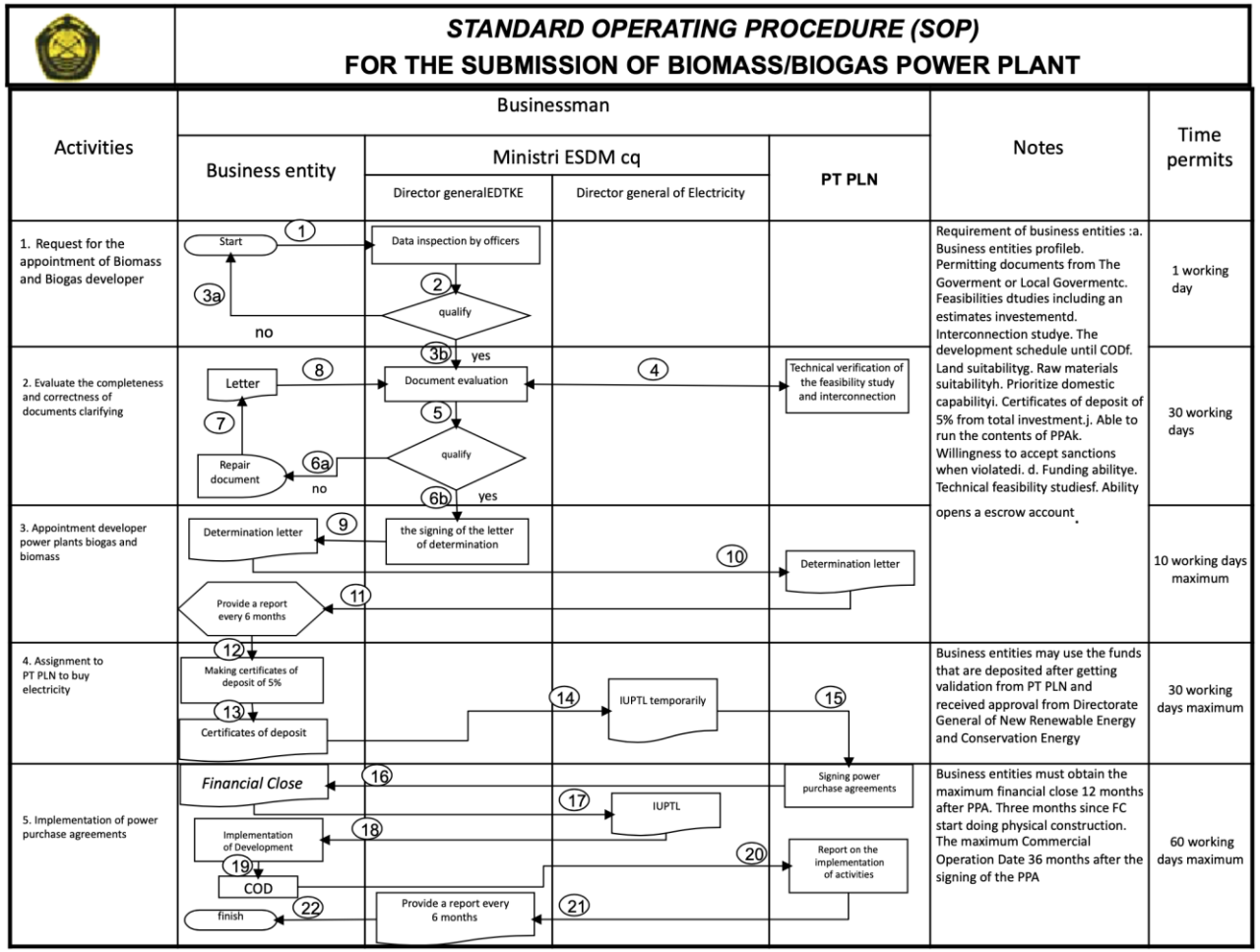
8 – 3. Standard Operating Procedure (SOP): バイオ燃料に関連する営業ライセンス

	STANDARD OPERATING PROCEDURE (SOP) COMMERCIAL LICENSE FOR BIOFUEL	Nomor : 01/SOP/DEB/02/2012 Tanggal : 13 Agustus 2012 Unit : Direktorat Bioenergi Revisi : 00

Activities	Businessman				Time permits
	Business entity	Director General of Renewable Energy and Conservation Energy	Bioenergy Director	Sub Directorate Bioenergy Business Services and Supervision	
1. Biofuels Commercial license application	start → 1 Data inspection by officers → 2 qualify? → 3a no / 3b yes				1 working day
2. Evaluate the completeness and correctness of documents	letter → 9 → disposition → 4 → document evaluation → 5 qualify → no 6a letter → 7 → repair document → 8				10 working days
3. SOP Commercial License for Biofuel	6b yes → Presentations and Clarification of data → 10 → invitations presentation → presentation materials → 11				1 working day
3. Repair dokuments	12 The suitability of documents and business activities → 13a no → Repair document → 14 / yes 13b				10 working days
5. Fiedwork	13b → sighting location letter → 15 → sighting location				1--3 working days

8. Appendix

8 – 3. Standard Operating Procedure (SOP): バイオマス／バイオガスを利用した発電所



STANDARD OPERATING PROCEDURE (SOP)
FOR THE SUBMISSION OF BIOMASS/BIOGAS POWER PLANT

Activities	Businessman			Notes	Time permits
	Business entity	Ministri ESDM cq	PT PLN		
		Director generalEDTKE / Director general of Electricity			
1. Request for the appointment of Biomass and Biogas developer	Start (1) → Data inspection by officers (2) → qualify; (3a) no; (3b) yes			Requirement of business entities :a. Business entities profileb. Permitting documents from The Goverment or Local Governmentc. Feasibilities dtudies including an estimates investementd. Interconnection studye. The development schedule until CODf. Land suitabilityg. Raw materials suitabilityh. Prioritize domestic capabilityi. Certificates of deposit of 5% from total investment.j. Able to run the contents of PPAk. Willingness to accept sanctions when violatedi. d. Funding abilitye. Technical feasibility studiesf. Ability opens a escrow account	1 working day
2. Evaluate the completeness and correctness of documents clarifying	Letter (8) (7) Repair document (6a) no; (6b) yes	Document evaluation (5) qualify	(4) Technical verification of the feasibility study and interconnection		30 working days
3. Appointment developer power plants biogas and biomass	Determination letter (9)	the signing of the letter of determination	(10) Determination letter		10 working days maximum
4. Assignment to PT PLN to buy electricity	Provide a report every 6 months (11) (12) Making certificates of deposit of 5% (13) Certificates of deposit	(14) IUPTL temporarily	(15)	Business entities may use the funds that are deposited after getting validation from PT PLN and received approval from Directorate General of New Renewable Energy and Conservation Energy	30 working days maximum
5. Implementation of power purchase agreements	*Financial Close* (16) Implementation of Development (18) (19) COD (22) finish	(17) IUPTL; Provide a report every 6 months (21)	Signing power purchase agreements; (20) Report on the implementation of activities	Business entities must obtain the maximum financial close 12 months after PPA. Three months since FC start doing physical construction. The maximum Commercial Operation Date 36 months after the signing of the PPA	60 working days maximum

8. Appendix

8 – 3. Standard Operating Procedure (SOP): BOT事業スキームの組織図