# Research Agenda *for* Energy Sector 2009-2012

Bogor Agricultural University

# RESEARCH AGENDA FOR ENERGY SECTOR 2009-2012

**Bogor Agricultural University**
**2009**

**Research Agenda for Energy Sector 2009-2012**


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# Content

# List of Tables

# List of Figures

# Foreword

Indonesia is still facing numerous problems regarding the closely linked sectors of food, energy and environment. These problems have indirect impacts on the economic, socio-cultural and political conditions in Indonesia. The considerable environmental degradation and natural resources depletion that are occurring are due to natural resources utilization such as forest, sea, agricultural lands, minerals and water that overlooked ecological sustainability, production sustainability and social impacts. To overcome these problems, Bogor Agricultural University (IPB) offers new perspectives for agricultural-based national development in a broader term that are based on sovereignty, impartiality and sustainability principles.

Agricultural development in Indonesia, in a broader term, requires a new paradigm to ensure bigger control of natural resources by the people. Resource control at local scale, *i.e.*, the household unit, has higher potential to produce food than control at higher scale. This condition will boost the production and diversification of food at local level that corresponds with local ecosystem and culture. On the other hand, bigger resource control by the people will improve people's welfare which in turn will impact the purchasing power of the people themselves. In general, these situations will push food sovereignty and security at local and national levels.

As an academic institution with competence in agricultural development research, IPB should always drive the achievement of balance between renewable energy development specifically bio-energy or biomass energy and food production. Some breaks through in research are required to optimize biomass utilization for energy production which will have positive impacts on increases of production and access to food. Aggregately, energy sufficiency is expected to increase productive economic activities and increasing people's income. Therefore, concrete systematic steps are necessary. Through various research, seminars and workshops, IPB has formulated the Strategic Research Agenda related to energy problems.

This Strategic Research Agenda is organized with the objectives to: 1) provide direction for optional policies that should be taken by IPB, 2) provide foundations for research programmes compilations that are realistic and inspiring for stakeholders. We hope that this Research Agenda for Energy Sector can be use as guidelines for all IPB's academic society and other institutions in carrying out future research activities within energy sector.

Bogor, March 2009

Rector,

Prof. Dr. Herry Suhardiyanto

# I Introduction

## 1.1. Background

Indonesia's dependence on oil fuels or other type of fossil fuels is currently facing the heaviest challenge. About 65% of final energy needs in Indonesia is still dependent on oil fuels, which mostly use for transportation sector. On the other hand, Indonesia's oil reserve is only nine trillion barrels (DESDM, 2005) which is expected to be exhausted after 18 years with average production rate of 500 million barrel annually. This has turned Indonesia from being an oil exporter country to net importer country since the past few years. The challenge that faces Indonesia is very heavy due to the current high dependence on crude oil and imported fuels that keep increasing. Policy on subsidy that has been applied has burdened government's expenditures, although these subsidies are gradually decreased through various policy instruments. This will have great impacts on agricultural development, including plantation and fisheries, as development sectors that are very important for Indonesia's economic development. Agriculture, including plantation, husbandry and fisheries are economic sectors that are highly dependent on the availability of oil fuels and other energy sources.

Based on the data from "Handbook of Energy Economics Statistic, 2006", the intensity of energy (commercial) in agriculture, plantation and fisheries sectors are still low, that is only 0.012 SBM/million rupiahs in 2006 from 0.008 SBM/million rupiahs in 1990. For comparison purpose, Indonesia's energy intensity is 0.31 SBM/ million rupiahs in 2006. Such low energy intensity indicates inefficiency in energy utilization, that is low inputs of commercial energy in agriculture, plantation and fisheries. Energy inputs in agriculture comprise of four categories, embodied energy on agricultural inputs (seeds, fertilizers, agrochemicals, other maintenance including energy for packaging and transportation), direct used energy, labour energy (including transport of labour), and energy embodied in agricultural equipments/machineries (capital energy).

Various studies show that energy inputs, in relation to technological level, still provide positive significant impacts on agricultural productivity. For example, the impact of energy on rice production in Java and outside Java (Abdullah, 2007) are given below:

| | | | |
|---|---|---|---|
| Java | : Rice field | : 18.01 GJ/ha, | Yield : 2.95 tonnes/ha |
| | Dryland | : 10.41 GJ/ha, | Yield : 1.56 tonnes/ha |
| Outside Java | : Rice field | : 11.48 GJ/ha, | Yield : 2.41 tonnes/ha |
| | Dryland | : 3.50 GJ/ha, | Yield : 1.03 tonnes/ha |

Similar conditions are also experienced by other agricultural crops, plantation, husbandry and fishery sectors. Therefore, the uncertainty of energy provision will have great impacts on agricultural development in Indonesia.

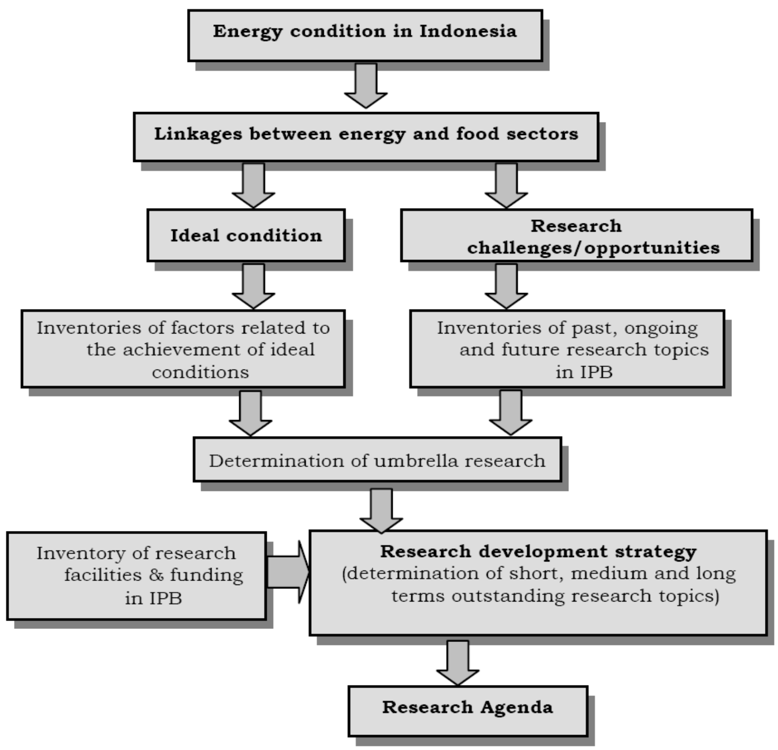
In relation to the energy provision embodied in agricultural inputs, there are still unbalance competitions between agriculture and non-agriculture. For example, the obstacles in the provision of natural gas for fertilizer industry have caused uncertainty of inputs and fertilizer's price, which in turn influence agricultural productivity and farmers' income. Furthermore, uncertainty in oil fuel supply to rural areas (agriculture) due to distribution interference and unreachable prices will impede direct energy supplys to agriculture, plantation and fisheries, as well as for rural household consumptions.

Agriculture and rural areas cannot be separated. Hindrance in agricultural development will have impact on rural development and vice versa. The low energy input in agriculture is also followed by the low energy consumption of rural households. As an illustration, a survey conducted by Directorate General for Electricity and Energy Development (1986, 1989, and 1990) observes that the energy consumption for cooking purposes in rural Java, Sumatra and Sulawesi range between 0.2-2.5 GJ/person/year, which is still below the figure given by WHO for cooking energy requirement. Fuelwood remains the main energy for cooking in Indonesia's rural areas, followed by kerosene. Indonesia has more than 70,000 villages and 45 percent are categorized as "backward villages". Low access of electricity in rural areas is one factor that intricate poverty alleviation programmes in rural areas.

Study of data based on National Socioeconomic Survey (Susenas) reveals that up to 150 % of people living above poverty line utilize fuelwood and thus are more sensitive to increasing fuelwood and kerosene consumptions. This indicates that fuelwood is a main alternative to kerosene. Government's plan to replace kerosene with gas seems to be showing a failure in rural areas, due to low purchasing power and low acceptance of technological change. On the other hand, this plan could increase the consumption of fuelwood. Meanwhile, uncontrolled use of fuelwood for energy is feared to have impacts on the ecological balance, especially in Java, which already undergone some critical conditions.

The various energy related problems as discussed above have influenced the macro economic condition of Indonesia due to the diverse energy-dependent sectors. The long term solutions is by producing alternative energy through the available local natural resources such as sun, wind and other sources of energy. The development of these types of energy should be taken with consideration so as not to cause any contradictories between energy and food importance. In this regard, IPB's role is necessary to enhance utilization of various natural resources especially flow resources to produce sustainable energy sources.

One important step that should be taken by IPB is to formulate a Strategic Research Agenda for energy sector with the following systematic:



## 1.2. Objectives of Research Agenda Formulation

This Strategic Research Agenda is expected to provide strategic framework to:

1) direct the formulation of realistic and inspiring research programmes that will be able to mobilize stakeholders;
2) provide direction for policy options that should be taken by IPB; and
3) ensure that IPB with its competence as leader in bio-energy sector in Indonesia.

# II Situational Analysis

Analysis of national agricultural situations and conditions, especially with regard to energy sector, suggests that immediate responses are required through various research by IPB through studies of the following aspects:

a. Current Indonesia's energy condition and role of agricultural sector
b. Comparison of such condition with regional and global conditions
c. Specific linkages between agricultural and energy sectors in Indonesia, and the impacts on other sectors such as environment, food and economy.
d. Direction of national research policy and research in IPB to date, and other influencing factors

Studies of each of the above aspects are justified in more details below.

## 2.1. Current Indonesia's energy condition and comparison with other countries

Current Indonesia's energy condition and its linkage with other agricultural sectors can be perceived based on situational portrait of the potential available sources of energy, energy supply-demand pattern and their projections on each user (including agricultural sectors), regulations and policies on energy, policy implementation and real situations, and factors related to requirement level and national and sectoral energy provision system.

The following tables and figures illustrate the potential sources of energy available in Indonesia, development policies, supply-demand energy pattern for each sector, and factors affecting policy implementation in field.

Table 2.1. Position of Indonesia's major fossil energy (2007)

| Type of fossil energy | Resources | Reserve | Production | Ratio of Reserve/ production (year) *) |
|---|---|---|---|---|
| Oil | 56.6 trillion barrel | 8.4 trillion barrel**) | 348 million barrel | 24 |
| Natural gas | 334.5 TSCF | 165 TSCF | 2.7 TSCF | 61 |
| Coal | 93 trillion tonnes | 18.7 trillion tonnes | 250 million tonnes | 75 |
| Coal bed Methane | 453 TCF | | | |

**) under the assumption of no new discovery*
***) including Cepu block*
*Source: Departemen ESDM (2008)*

Table 2.2. New and renewable energy potentials in Indonesia (2007)

| Non fossil energy | Resources | Equivalent | Installed capacity |
|---|---|---|---|
| Water power (hydro) | 845.00 million BOE | 75.67 GW | 4.2 GW |
| Geo-thermal | 219.00 million BOE | 27.00 GW | 1,042 GW |
| Water power (Mini/ microhydro) | 0. 5 GW | 0.5 GW | 0.084 GW |
| Biomass | 49.81GW | 49.81 GW | 0. GW |
| Sun power | 4.80 kWh/m$^2$/day | – | 0.008 GW |
| Wind power | 9290 MW | – | 0.0005 GW |
| Uranium (Nuclear)*) | 24,112 tonnes | 3 GW for 11 years | - |

**) only in Kalan, West Kalimantan*

*Source : Dept. ESDM, 2008*

Table 2.3. Final energy consumption per sector (2007)

| Sector | Consumption (thousand BOE) | (%) |
|---|---|---|
| Industries (including agriculture) | 323,493 | 37 |
| Transportation | 179,936 | 21 |
| Household | 314,688 | 36 |
| Commercial | 26,589 | 3 |
| Others | 27,959 | 3 |
| TOTAL | 872,665 | 100 |

*Source: Dept. ESDM, 2008*

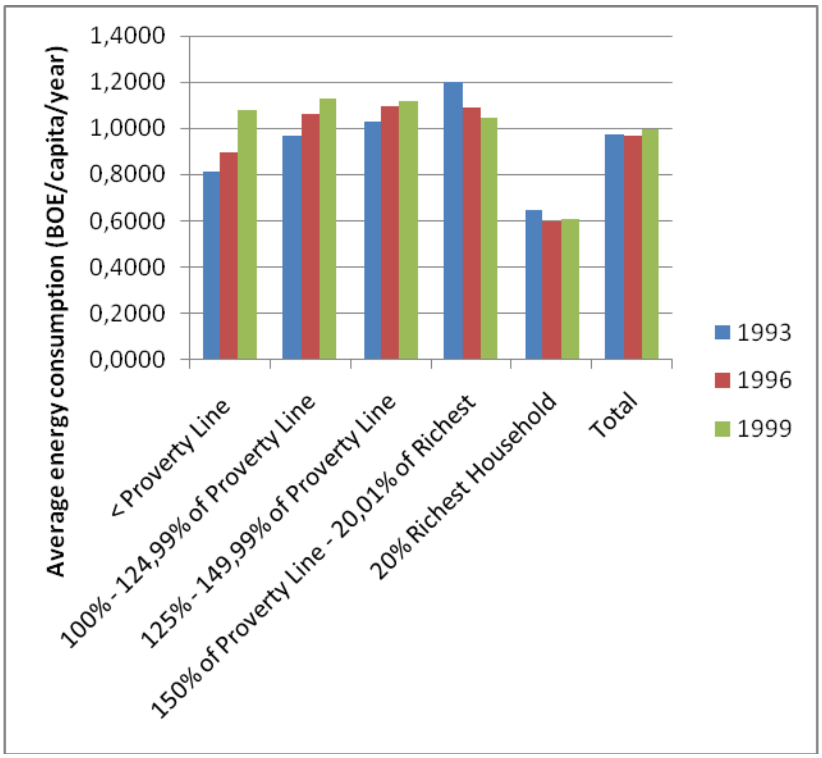
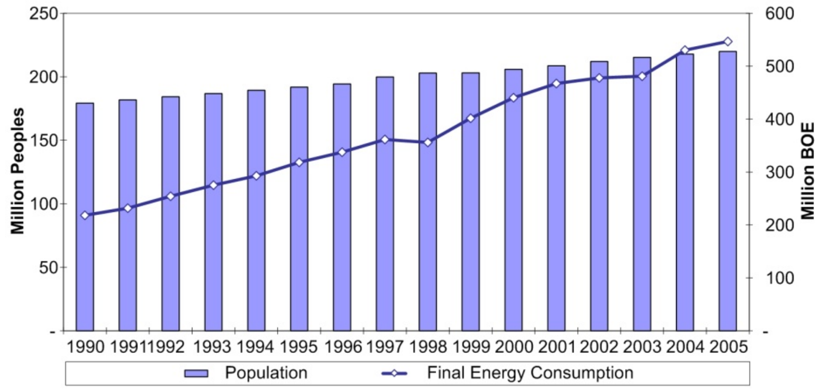


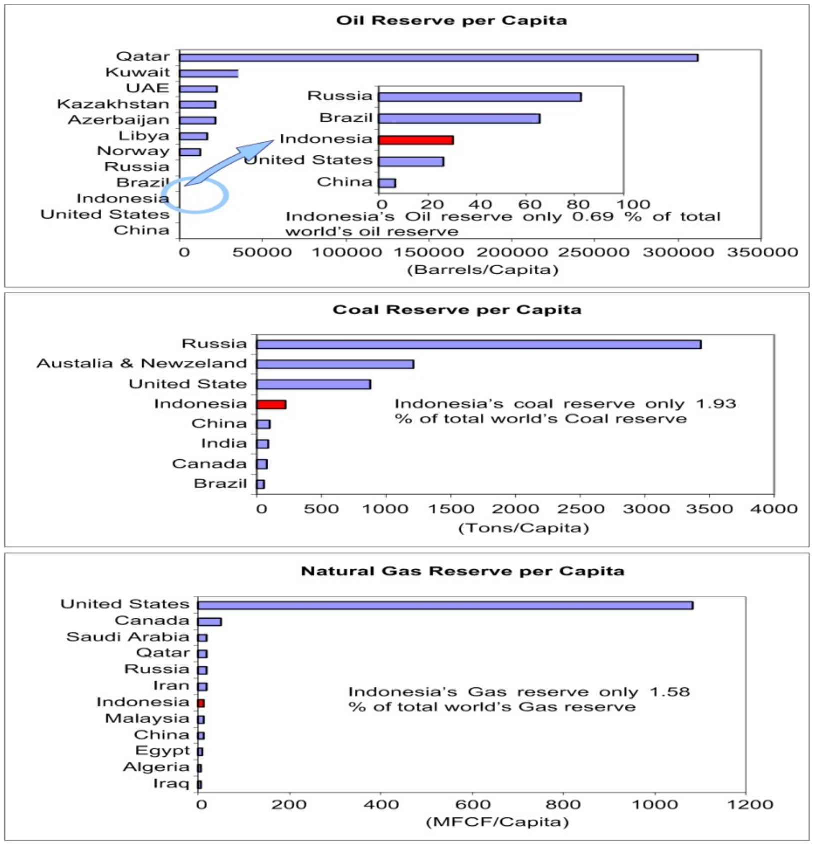

Figure 2.1. Final energy consumption for household sector (Simangunsong, et al., 2008)




*Source: Handbook Energy Economics Statistic, 2006*

Figure 2.2. Comparison of population increase with energy consumption increase

The above data suggests that the major energy sources in Indonesia come from fossils. Dependence on fossils energy is not easy to be reduced since substitution with non-fossil energy sources is very low and slowly taking place. On the other hand, Figure 2.3 compares Indonesia's energy potentials and reserves with other countries. The figure shows that Indonesia needs to alter its energy utilization policy by shifting from export-oriented policy to that which is oriented towards increasing domestic energy supply requirement, especially if related to the energy-mix programme (Figure 2.4) where the target is to shift dependence on fossil fuels toward other primary energy sources such as coal, gas and renewable energy.




*Source: Indonesian Energy Economics Review*

Figure 2.3. Comparison of Indonesia's fossil energy reserves with other countries

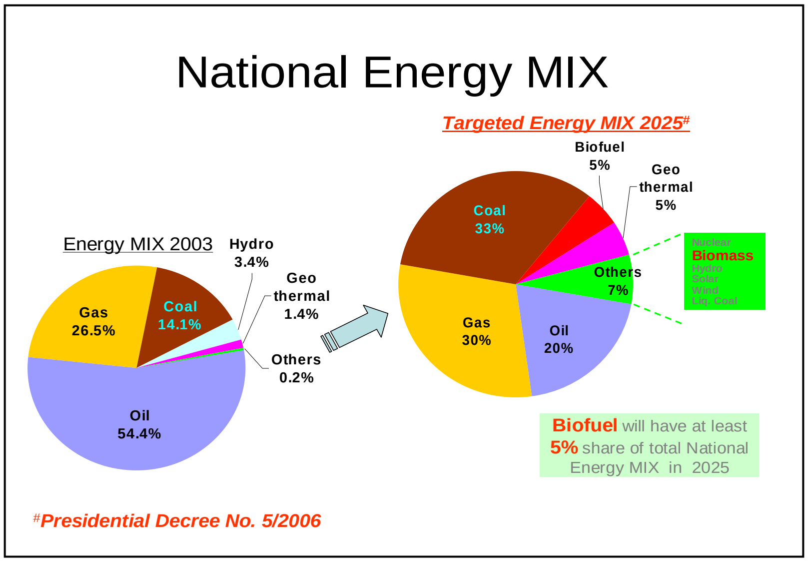



Figure 2.4. National Energy-Mix programme

## 2.2. Linkages between energy and food sectors

Every activity can be conducted if there is energy, including agriculture. Agriculture sector in a broader term (including fisheries, husbandry, plantation and forestry) requires energy inputs for each of its activity. Energy is required from land preparation, seed provision, planting, maintenance, harvesting, handling of harvest products, processing of products to distributing products to final consumers. Therefore agriculture is a sector that is full of energy inputs.

On the other hand, agriculture is the main sector for food provision, for human, livestock and fish that are part of the agricultural cycle itself. Other than influenced by technology, agricultural productivity is also influenced by energy inputs. Similar to other energy users, agriculture also produces negative outputs, such as biomass wastes and emissions due to utilization of fuels. Therefore, energy analysis for production process of agricultural products is necessary to be conducted for the development of production technology that is more efficient and environmentally friendly.

Based on the targets for energy sector as stated in the Act no. 30 of 2007 on national energy, the role of agricultural sector has been shifted not only as energy user but also as energy supplier. Agricultural sector is expected to provide some energy inputs, in the form of solid and liquid biomass fuels and bio-fuels (bio-diesel, bio-ethanol, and bio-kerosene) as substitutes for oil fuel. Table 2.4 and Table 2.5 provide information on bio-fuel requirements based on the targets from energy-mix programme.

Table 2.4. Bio-fuel demand estimation (million litre)

| | **Diesel** | | **Gasoline** | |
|---|---|---|---|---|
| | **2007** | **2010** | **2007** | **2010** |
| Total oil demand | 30.40 | 34.89 | 33.34 | 38.27 |
| Substitution 5% bio-fuel | 1.52 | 1.74 | 1.67 | 1.91 |
| Substitution 10%bio-fuel | 3.04 | 3.48 | 3.34 | 3.82 |

Table 2.5. Target for biomass fuel utilization (in million kilo litre)

| **Substitution target** | **2010** | **2015** | **2020** | **2025** |
|---|---|---|---|---|
| Bio-diesel (solar substitute) | 2.41 | 3.18 | 4.60 | 10.22 |
| Bio-ethanol (gasoline substitute) | 1.48 | 1.95 | 2.83 | 6.28 |
| Kerosene substitute | 0.96 | 1.27 | 1.83 | 4.07 |
| Fuel oil substitute | 0.4 | 0.53 | 0.76 | 1.69 |
| **TOTAL** | **5.25** | **6.92** | **10.02** | **22.26** |

Source : DJLPE,2006.

In order to fulfil such target, agricultural sector must conduct various “reformation” and “revolution”, since currently there are deficiencies of data and research related to energy utilization in agriculture (energy requirement, intensity and efficiency) Similar is the development of technology as source of energy, both for the conversion of main products and wastes, that is still far from reaching the national targets. Table 2.6, 2.7, and 2.8 show data on the potentials of agriculture as national energy supplier, while Figure 2.5 shows the choices of conversion technology to convert biomass to various forms of energy that are applicable within the agricultural or agro-industrial sectors.

Table 2.6. Target for biomass fuel substitution as source of alternative and renewable energy, and required raw materials

| Type of biomass fuels | Utilization | Raw materials |
|---|---|---|
| Bio-diesel | Solar substitute (petrol-diesel) | Vegetable oil (CPO, Jatropha oil, etc) |
| Bio-ethanol | Gasoline substitute | Starch/Sugar (sugar cane, tuber, sago, sorghum, etc) |
| Bio-oil | Kerosene substitute for HSD | Vegetable oil biomass (with pyrolysys process) |
| Biogas | Kerosene substitute | Biomass/biomass liquid waste (livestock wastes, agro-industrial wastes, etc) |

Source: DJLPE , 2006

Specifically for bio-diesel raw material, Indonesian current production of CPO is 16-17 million tonnes/year and only 3.5 million tonnes that are absorbed by domestic markets (for various food & non-food industries) while the rest are exported (Indonesia is the number 1 exporter of CPO). Therefore, the use of CPO for bio-diesel raw material in Indonesia does not upset food market shares and domestic industries. The availability of CPO as industrial material in Indonesia (food & non-food) will be disturb if demand of CPO in the global market increase drastically with high price, which will cause producers to sell CPO to global market instead to domestic markets, including materials for bio-diesel. The current bio-diesel production capacity is 1.2 million tonnes, which will increase to 2.4 million tonnes in 2009. In 2020 it is estimated that the production will reach 4 million tonnes. Table 2.7 shows data on the potentials and locations of bio-diesel production in Indonesia.

Table 2.7. Bio-diesel potentials and production in Indonesia

| No | Company | Location | 2008 | | 2009 | |
|---|---|---|---|---|---|---|
| | | | Capacity KL/Yr | Domestic KL/Yr | Capacity KL/Yr | Domestic KL/Yr |
| 1. | Energi Alternatif Indonesia PT. | Jakarta | 300 | 300 | 1,000 | 1,000 |
| 2. | Eterindo Wahanatama Tbk | Gresik & Cikupa | 120,000 | 120,000 | 240,000 | 240,000 |
| 3. | Ganesha Energy Group | Medan | 3,000 | 3,000 | 10,000 | 10,000 |
| 4. | Indo Biofuels Energy PT. | Merak | 60,000 | 60,000 | 160,000 | 100,000 |
| 5. | Multikimia Intipelangi PT. | Bekasi | 5,000 | 5,000 | 10,000 | 10,000 |
| 6. | Musim Mas Group | Medan | 50,000 | 10,000 | 350,000 | 100,000 |
| 7. | Permata Hijau Group | Duri | 200,000 | 75,000 | 200,000 | 120,000 |
| 8. | Sumi Asih PT | Bekasi & Lampung | 100,000 | 50,000 | 200,000 | 100,000 |
| 9. | Wilmar Group | Dumai | 700,000 | 300,000 | 1,000,000 | 300,000 |
| | **Jumlah yang tersedia** | | **1,238,300** | **623,300** | **2,171,000** | **981,000** |

Source : APROBI

Table 2.8. Potential of biomass energy from agricultural wastes (crops, plantation and forestry

| No | Products or commodities | Type of biomass waste | Potential |
|---|---|---|---|
| 1. | Paddy | Straw | 5000 kg/tonnes of paddy |
| 2. | Rice | Rice husk | 280 kg/tonnes of paddy |
| 3. | Cassava | Stalks | 800 kg/tonnes of cassava |
| 4. | Corn | Corn cobs | NA |
| 5. | Coconut | Fibre/husk | 280 kg/tonnes of coconut |
| 6. | Coconut | Coconut shell | 150 kg/ tonnes of coconut |
| 7. | Rubber | Wood (replanting) | 1500 m3/Ha replant |
| 8. | Cacao | Cacao shells | NA |
| 9. | Palm oil | Wood (replanting) | 74.5 tonnes /Ha replant |
| 10. | Palm oil | Fronds | 24.84 tonnes /Ha |
| 11. | Palm oil | FEB | 200 kg/tonnes FFB |
| 12. | Palm oil | Fibre and shell | 420 kg/tonnes CPO |
| 13. | Processed wood | Saw dust | 203 041.6 m3/year |
| 14. | Processed wood | Other wood wastes | 1 827 373.7 m3/year |
| 15. | Sugar cane | Bagasse | 280 kg/tonnes of sugar |

Source : Endah Agustina, 2007

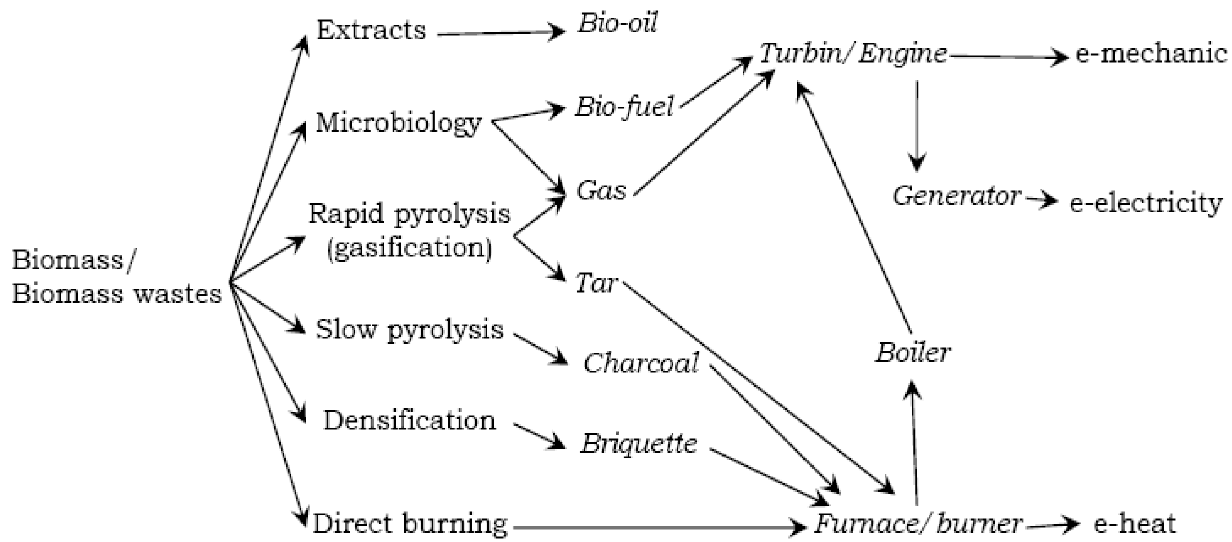



Figure 2.5. Technology choices for conversion of biomass/biomass wastes to energy

Table 2.9. Utilization of various biomass and biomass wastes

| Type of biomass/ Biomass wastes | Current utilization | Promotion as source of energy |
|---|---|---|
| Crude palm Oil (CPO) | Raw material for food and cosmetic industries | Bio-diesel |
| Palm press fibre | Boiler fuel (co-gen system) | Boiler fuel |
| Palm oil shell | Active charcoal, liquid smoke, road aggregate, boiler fuel | Feed materials for gasification (combustible gas) |
| Empty fruit bunch (EFB) | Compost/fertilizer, mulch | Boiler fuel (co-gene), compost |
| Palm oil sludge | Cattle feed | Bio briquette |
| Crude palm oil wastewaters | ---- | Methane gas power |
| Bagasse | Boiler fuel, fertilizer | Boiler fuel, bio briquette |
| Molasses | Raw material for ethanol industry and cooking ingredients | Bio-ethanol |
| Corn | Food, livestock feed | Bio-ethanol |
| Corn cob | Furnace fuel | Furnace fuel, briquette |
| Rice husk | Furnace fuel, packaging material, livestock feed | Boiler fuel (co-gen), feed materials for gasification, bio briquette, charcoal husk briquette. |
| Coconut | Food, medicine | Fuel oil, bio-diesel |
| Coconut fibre | Packaging material & furniture | Bio briquette, boiler fuel |
| Coconut shell | Furnace fuel, active charcoal, household appliances, crafts | Feed materials for gasification, furnace fuel. |
| Waste of slaughter house | | Biogas |
| Vegetable waste | Compost | Biogas |
| Jatropha oil shell | ---- | Furnace fuel |
| Jatropha oil waste | --- | Briquette |
| Gum | --- | Fuel |

Source : Agustina,S.E (2005)

Table 2.10. Calorie value (kJ/kg) of several types of bio-briquette

| No. | Type of bio-briquette and biomass | Calorie value (kJ/kg) |
|---|---|---|
| 1. | Palm oil sludge briquette | 10896 |
| 2. | Corn cob briquette | 15455 |
| 3. | Corn cob charcoal briquette | 20174 |
| 4. | Bagasse briquette | 17638 |
| 5. | Jatropha oil waste (from West Nusa Tenggara) | 17550 |
| 6. | Jatropha oil briquette (from B2TE-BPPT)/ Tracon | 16399 / 16624 |
| 7. | Jatropha oil gum | NA |
| 8. | Fuel wood (acacia) | 17270 |
| 9. | Charcoal husk briquette | 13290 |

Source : Agustina, S.E (2007)

Agricultural wastes have been used for commercial energy power as shown in Table 2.11. Furthermore, several agricultural-based industries have tried to use their production wastes as energy sources for their production activities, which is driven by the high price of fuels and electricity for industrial sector. While for palm oil and sugar cane processing industries, utilization of processed wastes as boiler fuels has become part of the energy production package.

Table 2.11. Renewable energy power ready for operation

| RE | Capacity (kWatt) | Location | Operation Status | Operator |
|---|---|---|---|---|
| Palm oil waste | 12500 | North Sumatra | Evaluation | Private company |
| Palm oil waste | 10500 | Riau | Evaluation | Private company |
| Rice husk | 10000 | Lampung | Evaluation | Private company |
| Bagasse | 7000 | Lampung | Evaluation | Private company |
| Rice husk | 20000 | Bali | Evaluation | Private company |
| Municipal waste | 42000 | Jakarta | Evaluation | Private company |
| Hybrid, solar & diesel | 40 | West Kalimantan | 2004 | PLN |
| Wind energy | 6 x 250 | NTB | 2007 | PLN |

Wet rice field areas are generally rich in water resources. Based on the statement on Act No. 30, the utilization of renewable energy including water (hydro) is very much recommended. Therefore, rivers in rural areas and wet rice fields are very potential to be used as water power energy through microhydro technology. This will also support the achievement of energy-self sufficient village programme (see 2.13, Villages without electricity). If such program is conducted, then environmental conservation will be achieved due to the cheap and accessible source of energy for the community. Nevertheless, the use of water through microhydro can generate conflicts, such as sectoral conflicts due to the minimum water availability, especially in Java. Table 2.12 shows several locations for microhydro energy power that are ready to be operated in Indonesia.

Table 2.12. Locations of microhydro power ready for operation

| NO | PLTM | Propinsi | Unit-Kapasitas (MW) | Kapasitas Terpasang (MW) |
|---|---|---|---|---|
| 1 | Parlilitan | Sumatera Utara | 2 x 5,000 | 10.000 |
| 2 | Pakat | | 2 x 5,000 | 10.000 |
| 3 | Hutaraja | | 2 x 3,000 | 6.000 |
| 4 | Parluasan | | 2 x 2,100 | 4.200 |
| 5 | Telanai 1 | Sumatera Barat | 2 x 5,000 | 10.000 |
| 6 | Telanai 2 | | 2 x 5,000 | 10.000 |
| 7 | Telanai 3 | | 2 x 2,500 | 5.000 |
| 8 | Kambalan | | 2 x 2,500 | 5.000 |
| 9 | Pinti Kayu | | 2 x 5,000 | 10.000 |
| 9.1 | Lawugunung | | 2 x 5,000 | 10.000 |
| 9.2 | Simonggo | | 2 x 8,000 | 18.000 |
| 9.3 | Lawuorbi | | 2 x 5,000 | 10.000 |
| 9.4 | Doloksanggul | | 2 x 5,000 | 10.000 |
| 9.5 | Lawujabi | | 2 x 2.000 | 4.000 |
| 10 | Tuile | | 2 x 5,000 | 10.000 |
| 11 | Bayang | | 2 x 5,000 | 10.000 |
| 12 | Telunberasap | Jambi | 2 x 5,000 | 10.000 |
| 13 | Aurgading | Bengkulu | 2 x 2,000 | 4.000 |
| 14 | Lebong | | 4 x 3,000 | 12.000 |
| 15 | Manna | | 2 x 4,000 | 8.000 |
| 16 | Cikotok | Banten | 2 x 1,650 | 3.300 |
| 17 | Ciparay | | 2 x 3,000 | 6.000 |
| 18 | Suakan | | 2 x 3,000 | 6.000 |
| 18.1 | Cibareno 1 | | 2 x 3,000 | 6.000 |
| 18.2 | Cibareno 2 | | 2 x 4,000 | 8.000 |
| 18.3 | Ciberang | | 2 x 1,000 | 2.000 |

Table 2.12. Lanjutan

| NO | PLTM | Propinsi | Unit-Kapasitas (MW) | Kapasitas Terpasang (MW) |
|---|---|---|---|---|
| 19 | Girimukti 1 | Jabar | 2 x 3,000 | 6.000 |
| 20 | Girimukti 2 | | 2 x 4,000 | 8.000 |
| 21 | Panyairan | | 2 x 0,750 | 1.500 |
| 22 | Marasap | Kalimantan Barat | 2 x 0,750 | 1.500 |
| 23 | Santong | NTB | 2 x 0,750 | 1.500 |
| 24 | Pakatan | | 2 x 0,750 | 1.500 |
| 25 | Manipi | Sulawesi Selatan | 1 x 3,500<br>1 x 6,500 | 10.000 |
| 26 | Rante Bala | | 2 x 1,200 | 2.400 |
| 27 | Bungin | | 2 x 0,800 | 1.600 |
| 28 | Matarin | | 2 x 0,750 | 1.500 |
| 29 | Batang | | 2 x 0,750 | 1.500 |
| 30 | Rongi | Sulawesi Tenggara | 2 x 1,500 | 3.000 |
| 31 | Mempuweno | Sulawesi Tengah | 2 x 1,000 | 2.000 |
| 32 | Wawopada 1 | | 2 x 1,000 | 2.000 |
| 33 | Wawopada 2 | | 2 x 1,000 | 2.000 |
| 34 | Kalumpang | | 1 x 1,000 | 1.000 |
| 35 | Hangahanga 2 | | 2 x 1,000 | 2.000 |
| 36 | Pagimana | | 2 x 1,000 | 2.000 |
| 36.1 | Lobu | | 2 x 4,000 | 8.000 |
| 36.2 | Lambangan | | 2 x 3,000 | 6.000 |
| 37 | Pilolahunga | Sulawesi Utara | 2 x 1,000 | 2.000 |
| 38 | Milangodaa 1 & 2 | | 4 x 1,000 | 4.000 |
| 39 | Bakida | | 2 x 0,750 | 1.500 |
| 40 | Duminanga | | 2 x 1,000 | 2.000 |
| 41 | Pinolosian | | 2 x 1,000 | 2.000 |
| 42 | Mobuya | | 3 x 1,000 | 3.000 |
| 43 | Ranoketangtua 1 | | 2 x 1,000 | 2.000 |
| 44 | Ranoketangtua 2 | | 2 x 1,000 | 2.000 |
| 45 | Lobong | | 2 x 0,800 | 1.500 |
| 46 | Mongango | | 2 x 0,800 | 1.600 |
| 47 | Goal | Maluku Utara | 2 x 0,750 | 1.500 |
| 48 | Ngoali | | 2 x 0,600 | 1.200 |
| 49 | Ira | | 2 x 0,500 | 1.000 |
| 49.1 | Ibu | | 2 x 0. 750 | 1.500 |
| 50 | Prafi | Papua | 2 x 1,500 | 3.000 |
| 51 | Amai | | 2 x 0,750 | 1.500 |
| TOTAL | | | | 303.800 |

Source : Associaton of Indonesian Development Microhydro

Table 2.13. Number of villages with electricity

| No. | Province | Number of Village | Villages with Electricity |
|---|---|---|---|
| 1. | Nanggroe Aceh Darussalam | 5.530 | 4.782 |
| 2. | North Sumatra | 4.834 | 4.079 |
| 3. | West Sumatra | 1.769 | 1.510 |
| 4. | Riau | 1.249 | 534 |
| 5. | Jambi | 1.049 | 745 |
| 6. | South Sumatra | 2.407 | 1.786 |
| 7. | Bengkulu | 1.060 | 852 |
| 8. | Lampung | 1.955 | 1.261 |
| 9. | Bangka Belitung | 208 | 167 |
| 10. | West Kalimantan | 1.363 | 938 |
| 11. | Central Kalimantan | 1.181 | 543 |
| 12. | South Kalimantan | 2.207 | 1.937 |
| 13. | East Kalimantan | 1.248 | 619 |
| 14. | North Sulawesi | 980 | 948 |
| 15. | Gorontalo | 282 | 262 |

Source : APSI,2008.

# III Ideal Conditions and Policy Direction

### 3.1. Ideal Conditions

The ideal conditions for agricultural sector as the sector that is expected to provide significant role to support the national energy program, are:

a. Able to use energy efficiently
b. Produce high productivity
c. Able to contribute significantly in national energy provision
d. Does not generate negative impacts for other sectors such as environmental pollution and diseases.
e. Provide positive impacts on socio-culture and economic capabilities of the farmers, traders, industries etc.

In order to achieve such ideal conditions, various factors are necessary to be carried out, from plant cultivation to distribution of final products to consumers. Therefore, all factors related and impacted on each activity for every production step through distribution must be consider and should be combine in one harmonious production system. Hence, research and studies on energy sector related to agricultural system must be conducted from upstream (agricultural cultivation) to downstream (product distribution to final consumers), including studies and research on supporting or influencing factors, and must be conducted with integration.

## 3.2. Direction for Policy

Within energy sector, the new paradigm is reflected on the shift of energy development orientation from centred to scattered, and from supply driven to demand driven that results in the appropriateness between needs and energy sources, both in scale and type of energy. Through this new paradigm, it is possible to develop energy diversification and achieve self sufficiency, as well as to overcome dependence on fossil energy. The implication of such paradigm will be on the increase of people's access to energy and drive local abilities in producing energy through local technology innovation.

Several new policies that are required include:

1) Energy planning strategy in rural areas need to be integrated to achieve three things, namely (i) energy provision for production activities, (ii) fulfilment of energy requirement to increase rural welfare, including village electricity, especially in agricultural sector, and (iii) energy internalization in agriculture and rural development. Both agriculture and rural areas must be able to perform as energy suppliers not just users. This strategy can be achieve through:
    a. Protecting commercial energy supplys for agricultural purposes, in the form of direct and indirect energy, with appropriate policy so that it can be more accessible (in price and availability) to the farmers and initiate diffusion of renewable energy conversion technique to rural areas.
    b. Developing energy planning system that puts more emphasis on renewable energy development that is integrated with agricultural development to ensure rural welfare.
    c. Devolution of rights of energy provision and utilization to local communities to achieve energy self sufficient and diversification for agricultural and

rural development.

2) Direction for the development of renewable energy:
   a. Developing and utilizing agricultural products as Bio-fuels to prevent forfeit of food production and ecological imbalance. Economic, fiscal, and spatial plan policies are effective instruments to be use.
   b. Developing new and renewable energy based on local natural resources (energy from sun, wind, microhydro, ocean and tide).
   c. Devolution of rights of new and renewable energy to local communities and institutions.
   d. Strengthening the local communities and institutions capacities in supplying and managing new and renewable energy.

## 3.3. Research Challenges

Research challenges and opportunities of IPB in relation to energy and linkage to agriculture include:

- Inefficient use of energy on all sectors including agriculture
- Deficiency in energy research in agriculture
- Ability of supply products as source of energy in great amount as substitutes for fossil fuel especially oil fuel
- Realization of food self sufficient and self sufficient village programmes
- Development of agricultural products /agricultural wastes conversion technology to energy
- Development of bio-product for stimulant in various industries
- Impact on environmental quality (local and global) and biodiversity.

To carry out this research agenda to provide answers to real challenges, there need to be some short, medium and long-term scenarios. These scenarios must be formulated based on research challenges/opportunities and values of the strategies for IPB, as well as IPB's capabilities (human resources, supporting facilities and funding availability) and results of inventory of research activities in each unit in IPB (faculties, research /study centres and other specific units). Therefore, after determination of « outstanding research topics » as umbrella topic, grouping of research topics are necessary to be determined to establish target and period of conduction of research and to plan strategies to support such research (formulation of experts, facilities provision, funding provision, and research task division between units in IPB). Therefore, it is expected that research will be carried out with efficiency, synchronize, complementary, and have national strategic values.

# IV Research and Development

The research agenda for energy sector is based on research priorities identified by representatives of various departments and research centre within IPB. Based on priority, this research agenda is divided into two groups based on the position of agriculture as energy consumers and producer.  The first group is Agricultural Energy Planning and the second group is Development of Bio-diesel.

## 4.1. Agricultural Energy Planning

Research agenda for agricultural energy planning is formulated based on agricultural system:

a. Planning of Energy Production
b. Planning of Energy Processing

The word agriculture in this agenda has a broader term that includes plant and animal agriculture.

**A. Energy Production Planning**

Research agenda for energy production planning include:

1. Energy planning for agricultural production facilities (fertilizer, seed, agrochemicals)
2. Energy conservation of crop production system
3. Development of renewable-based energy tools and machineries.

**B. Energy Processing Planning**

Research agenda for energy processing planning include:

1. Development of renewable-based energy post-harvesting machineries
2. Development of energy audit system for agricultural processing industry

## 4.2. Development of Bio-energy

Research agenda for bio-energy development is formulated based on production chain sequence as follows:

a. Provision of Biomass Raw Materials
b. Development of Processing Technology
c. Development of Biosurfactant to Increase Production of Gasoline
d. Supply Chain management and Sustainability
e. Impacts of Biofuel development on Growth of Agriculture, Food security, Poverty and Environment
f. Utilization of Surface Wave and Ocean Wind Energy

The research agenda is formulated for the period of 2009-2012 to provide contribution for national target, that is, the utilization of 5 % bio-energy from the total national needs for energy in 2025 and to enhance production increase and shift the exhaustion period of Indonesia's gasoline. This period is related to available technology development to be implemented as well as new technology that still needs to be developed.

**A. Provision of Biomass Raw Materials**

The provision of biomass raw materials can be enhanced through optimization of production system, diversification of raw materials and improving the existing natural resources management both from supply and demands by considering sustainability criteria. The use of biomass for energy source can be said as carbon neutral, because plants absorb CO2 during photosynthesis. Nevertheless, carbon emission from fossil fuels can still occur during biomass production, conversion process and transportation. If during conversion process, carbon can be recapture, collected and stored in a permanent base (*Carbon Capture and Sequestration*, or CCS) there will be a negative carbon balance of CO2 extraction from atmosphere. CCS can also be obtained from agricultural products if the excess biomass is returned to ground as compost to enrich soil organic material.

**1. Energy producing plants**

Energy producing plants are plants that are traditionally or new species specifically breed and cultivated to produce energy. Research are directed towards plant breeding, increase productivity and characteristics of end result quality of the produced energy. The commodities are focussed on Jatropha oil and sea plants such as macroalgae and microalgae. Most of these energy producing plants can thrive on marginal and dry lands, hence it is expected that there will be no competitions with food requirements.

**Research and Development 2009-2012**

a. Development of Jatropha oil plant from plant breeding with biotechnology, cultivation technique, post harvesting handling, by products processing as well as social, economic and management aspects. Target of breeding is the achievement of new variety of Jatropha oil that has a productivity of 15 tonnes/hectare/year (in 2018), formulation of regulation technique for harvesting period to obtain uniform harvesting time and increasing of plant tolerance on biotic and abiotic stresses.

b. Increase of Jatropha oil production efficiency through LEISA (*less input sustainable agriculture*) cultivation technology and yield stability on various cultivation conditions.
c. Sorghum breeding to produce varieties that are tolerant to dryness and acid soil, and produce high yield.
d. Development of rapid propagation technique of superior cassava with productivity over 60 tonnes/hectare/harvest to ensure availability of seed/cutting propagation.
e. Multi-location tests for high yield transgenic sugar cane.
f. Development of potential macroalgae variety for bio-ethanol raw material.
g. Development of potential microalgae strain for bio-diesel raw material, development of microalgae cultivation technology, harvesting and aeration, and study of microalgae characteristics of biofuel.
h. Utilization of microalgae for nutrasetikal (chlorophyll, omega-3) raw material.

## 2. Agricultural and Forestry Wastes

Agricultural wastes in Indonesia originate from paddy crop, corn, palm oil and others such as husk, husk charcoal briquette, corn cob, palm oil empty fruit bunch, palm oil shell, cake of pressed peanuts, saw dust etc. These types of waste can be use for cooking fuels and energy power for electricity and boiler for industrial purposes, both directly and after going through densification process into briquettes or pellets. The current use of agricultural wastes has not reached a commercial level. Researchers from IPB have initiated the use of such wastes as fuels by designing and producing husk charcoal furnace for cooking purposes. If this type of technology that uses various biomass wastes can continually developed, testing of waste characteristics and burning ability should be tested, followed by development of logistics and infrastructures to handle bulky and diverse materials so that cost per unit can be minimized.

**Research and Development 2009 - 2012**

a. Development of data on raw material qualities (physical, chemical) and availability, for processing purposes (desizing, densification and mixing) to produce quality that are required by the users (size, homogeneity and calorie).
b. Technical study of agricultural and forestry biomass waste supply system comprising of biomass waste production, collection, sorting and logistic to fulfil the needs for processing industry and consumers of biomass fuel.
c. Study of forest biomass supply cost (wood and waste) as function of processing, storage, period of storage and price on various conditions and production scales to fulfil biofuel industrial needs.
d. Development of silvicultural technology and discovery of new rapid growth forest plant (including grasses and shrubs) to increase biomass supply and sustainable reduction of cost, keeping in mind that forest is a carbon sink.
e. Study of biomass utilization impact based on the best available technology, from agricultural waste and forest products.

**B. Development of Processing Technology**

Development of processing technology is aim to produce biofuel from various raw materials. Integrated approach or biorefinery concept where all materials are processes to obtain optimum additional values, must be considered together with development focus on certain area. The long term objectives and technological development are to produce highly competitive price for fuels compare to fossil fuels or to improve carbon efficiency process by reducing fossil fuel inputs.

**1. Bio-diesel production from bio-oil**

Development of bio-diesel processing technology is required due to the diversity of raw materials as well as requirement to reduce production price and addition of glycerol added value and bio-diesel by products to increase oxidative stability, resistance to cold temperature and reducing the values of CFPP (cold filter plugging point), cloud point and pour point from tropical oil.

**Research and Development 2009-2012**

a. Use of cleaning agent on bio-diesel refining process to increase efficiency in bio-diesel production process.
b. Improvement of methanol recovery and catalyst and improvement of phase separation technology.
c. Development of transesterification reaction through non catalytic, solid catalyst, utilization of ultrasonic and micro wave methods.
d. Glycerol purification and its utilization as additive raw material, surfactant, polymer and other products.
e. Increasing additional values of by products, such as cake of pressed oil, residues of degumming oil and soapstock from bio-diesel process.
f. Technological development of pure bio-fuel oil for fuels (bio-kerosene).
g. Technological development to improve oxidative stability, cold flow properties and other qualities of bio-diesel and oil fuel.
h. Use of bio-ethanol as reactant on bio-diesel process.
i. Technological development of bio-diesel process from microalgae.

j. Development of bio-diesel standardization method and quality assurance.
k. Development of post harvest facilities and aeration tools for cost effective aeration using solar energy.

## 2. Development of Bio-ethanol Processing Technology

Currently, most bio-ethanol production uses waste from sugar or sugar cane industry for raw materials. Other sources of sugar such as palm sugar, coconut sugar, sugar cane, etc, can be use as raw materials that are easily processes although the availability are still limited due to the competition with food industries. Starchy raw materials especially cassava and sorghum have been initiated, because cassava and sorghum able to grow on marginal land, have high productivity and easily cultivated. Moreover, raw material from starch and cellulose such as macroalgae have been researched. By product of ethanol processing still contain high organic materials that can be use for livestock feed, fuels and easily digested inside digester to produce biogas. The resulting biogas can be use for energy sources in bio-ethanol industry. Multiplication of scale is a critical point from technological development. Funding supports from government, industry and community are necessary to produce community scale bio-ethanol plant as demonstration and training facilities.

**Research and Development 2009-2012**

a. Development of bio-ethanol processing technology made from cassava, sorghum and macroalgae.
b. Development of new enzyme for starch hydrolysis and sacarification from potential local microbe isolate.
c. Development of efficient lignocellulose hydrolysis technique (thermal pre-treatment, acid hydrolysis,

thermochemical, and enzymatic).
d. Development of microbe isolates, optimization of cultivation condition, gene mutation technique and genetic engineering to increase cellulytic enzyme production.
e. Development of potential new microbe isolates (single culture, mixture) for bio-ethanol fermentation of pentose sugar (C5) and hexos (C6) mixture.
f. Development of local adsorbent molecular sieve material as and design of small scale continue distillation-dehydration process.
g. Processing of solid waste fermentation by products through improving nutritional value and formulation into livestock feed.
h. Factory planning to increase energy efficiency through the use of biogas, biomass or thermal recirculation and water retrenchment through recycling.
i. Biogas production and characterization from bio-ethanol wastes.
j. Utilization of fusel oil for chemical raw materials (acid, aldehyde, other alcohol).

### 3. Development of Biogas Technology

Development of biogas technology is very much required, considering the high biodigester installation investment cost for farmers. Therefore there is a need to reduce production costs and increase biogas production and by products. Increasing biogas quality is also important, especially to increase pressure and biogas calorie value.

**Research and Development 2009-2012**

a. Development of biodigester design
b. Increase of biogas production through the development of microbe isolate decomposer
c. Increase of biogas calorie value through biogas

purification development

d. Development of biogas utilization through improvement of gas distribution system to increase gas pressure.
e. Quality increase of biogas by product for fertilizer

## C. Development of Biosurfactant to Increase Crude Oil Production

One of the chemical materials that is use in Enhanced Oil recovery (EOR) process to increase gasoline production is surfactant. Surfactant reduces interface tension (IFT), altering wettability, reducing viscosity and stabilizing dispersion to ease the flow of oil from reservoir and reducing oil saturation. To support the national oil industry, development of bio-oil based local biosurfactant is necessary. One such product that has been developed and formulated by researchers from IPB for EOR requirement is Methyl Ester Sulfonate (MES) Testing of IFT and oil recovery from core in laboratory produces a very good results. Therefore, IPB will develop anionic surfactant using $SO_3$ to be more effective. This MES surfactant is suitable for sand stone, but not suitable for carbonate rocks that requires cationic surfactant. Therefore, development will be broadened for cationic and anionic surfactants as well as their formulation for various types of rocks. If through the use of biosurfactant, crude oil production in Indonesia can increase by 10%, there will be an increase of income about USD 9.7 million/day.

**Research and Development 2009- 2012**

a. Study of anionic, cationic and nonionic surfactants production process
b. Production scale multiplication of bio-oil based surfactant
c. Formulation of surfactant for application of oil well stimulation, huff and puff and flooding.

d. Testing of surfactant formula on laboratory scale for sand stones and carbonate rocks for application of oil well stimulation, huff and puff and flooding.
e. Test field of biosurfactant for the application of oil well stimulation, huff and puff and flooding

## D. Supply Chain Management and Sustainability

### 1. Supply Chain Management

Study of biomass supply as future source of energy requires a complex analysis from local natural resources and agricultural condition, and its interactions with development of food, fibre, energy and international trade requirements. There is no single model that can overcome this problem directly. There need to be a model of energy-resource that can be locally and globally applied including effects of policies, such as WTO, CDM, REDD, and biofuel policy in various countries.

**Research and Development 2009- 2012**

a. Identification and benchmarking of various regional supply systems, intermarket dependence, transportation and international trade.
b. Analysis of supply and demand system for biomass raw materials and the impacts on trade policy and biofuel utilization.
c. Synergy/conflict analysis between bio-energy production and environmental protection.

### 2. Sustainability

Sustainability scheme comprises of various criteria that covers three aspects, i.e. environment, social and economy. Valuation of sustainability requires indicators and methods to measure the criteria for environment, social and economy. Having done these, field valuation and monitoring are conducted that involve data collection and analysis to produce recommendation and improvement on sustainability aspect, such as land competition and utilization between energy-producing plant and biomass, deforestation, increase of food commodity price at level that out of reach, need for product certification, etc.

**Research and Development 2009- 2012**

a. Identification of sustainability indicators based on current conditions and difference of technological situations, end consumers and local obstacles
b. Methodological improvement for measuring technical, economical, environmental and social aspects such as LCA (Life Cycle Analysis) and Socio-Eco-Efficiency-balance.
c. Analysis of data on the whole biofuel chain such as need for fertilizer, amount of soil organic material, agricultural mechanization, $N_2O$, $SO_2$, VOC emissions, satellite data (land, water), new variety, commercial scale factory and plantation, compare to its reference, *i.e.*, fossil fuel chain.
d. Development of agroforestry in Gunung Walat Educational Forest, to produce synergy between energy production and other forest products by considering environmental protection.
e. Study of human behaviour in energy utilization that comprise of increase energy efficiency through environmental management, renewable energy utilization, energy retrenchment (4R: *reduce, reuse, recycle* and *replace*) and development of social capital in community – based energy production and utilization.

## E. Impacts of Biofuel Development on Growth of Agriculture, Food Security, Poverty and Environment

Theoretically, development of bio-fuels is a dynamic process. When there are changes in economic, environmental, politic and social conditions, where all interact with economical sectors, all agricultural sector dynamics will also experience change. Other than that, household activities, business activity and private sector will also be influenced.

Currently, the Indonesian government has various food and energy policies. However, between the two aspects there are no synergy thus the resulted impact is still partial and incomprehensive. Related to the social economic problems faced by Indonesia, now is the right momentum to conduct synergy between policies for food and energy to provide benefits for the community in big scale, such as reducing unemployment and poverty. Therefore, development of biofuel is an important agenda to be applied.

Several studies need to be conducted to obtain information that can benefit as inputs in policy formulation that are synergy between food and energy. Research on the development of biofuel can be conducted in a big framework “Impact of Biofuel Growth on Agricultural Development, Food Security, Poverty and Environment. Afterwards, the research framework can be developed into several related studies. Nevertheless, each topic covers greater and more comprehensive matters, hence each topic should be divided into several sub-topics.

**Research and Development 2009-2012**

a. Analysis of benefits and development cost for biofuels.
b. Incentive structure study of biofuel supply.

c. Social economic study towards “switching” to biofuel energy
d. Impact of energy conversion on social economic conditions of people.

### F. Utilization of Surface Wave and Ocean Wind Energy

**Research and Development 2009- 2012**

a. Perfection of buoy prototype, instalment and direct measurement of wind and real time.
b. Development of buoy prototype for meteorology and oceanography purposes.
c. Instalment of additional buoy : scatterometer (satellite) data validation
d. Development and perfection of wave converter prototype and wind-energy converter
e. Testing and operationalization of surface wave and wind energy utilization.

## 4.3. Research Capacity Building

Many individuals and institutions in IPB are working individually or together to find solutions for energy development especially conversion of biomass into biofuel through an economical and sustainable means, through self funding or external support from industries and government. The research objectives vary from basic research for scientific publication, patent, applied research and commercial application research, according to the area of study. This research agenda is oriented toward the development of technology that is appropriate and relevant to the personal ability, facilities and available resources. Good communication between users and strong individual competition, should be followed by tight collaborations between researchers.

Therefore, there need to be some formulation of several important activities to support enhancement of research capacity from expertise of researchers and supporting facilities.

**A. Establishment of Networks and Collaborations among Researchers and Research Centres**

Significant benefits can be obtained through establishment of networks between researchers and research centres in industries, universities and research and development centre. This is important to prevent duplication of research and HKI ownership problem. Direct and on line networking can be developed through similar objective framework, similar competence, formation of excellence centres, information exchange and best practice. Creativity and ability to understand each other are very important to start networking between domestic and foreign institutions. Collaboration can be established through exchange of researchers and collaboration proposals.

**Research capacity building 2009-2012**

a. Establishment of networks between bio-energy research centres especially in Jatropha oil development (International Jatropha Research Coordination) between SBRC IPB, Sichuan University, China and Agrobiotechnology (ABI) MOSTI and MIGHT, Malaysia.
b. Establishment of international postgraduate programme on Bio-energy Technology and Management
c. Establishment of Indonesian Association of Bio-energy Profession
d. Publication of international scientific journal on bio-energy

## B. Collaboration in Research and Development Facilities Management

Research and development facilities can be developed and enhanced to support certain research activities. Funding and facilities supports can be derived from central and regional government, education foundation, industry and member of community. Individual researcher or from other centres can use the available facilities through research collaboration and analysis services. Development of pilot plant and infrastructure on pilot scale are required to validate technology. The main problem for biofuel technology is the difficulties in scale multiplication from pilot to commercial scales. For small scale, "Proof-of-Principle" (PoP) is required to prove its suitability according to theory, while for pilot scale "Proof-of-Concept" (PoC) is required to prove that the design concept can be carried out technically, and "Proof-of-Feasibility" (PoF) is required for demonstration scale to show that the process can be carried out technically and economically.

**Research capacity building 2009-2012**

a. Establishment of collection and experiment garden for Jatropha oil, cassava, sorghum and sugar cane
b. Establishment of microalgae cultivation laboratory and pilot plant (open pond and photobioreactor)
c. Establishment of small scale cassava bio-ethanol plant and superior cassava cultivation field
d. Establishment of pilot plants for bio-diesel, biopellet and bio-diesel by products industry
e. Establishment of experimentation laboratory and pilot plant surfactant production
f. Establishment of biosurfactant experimentation laboratory for EOR and pilot plant for cationic, anionic and non-ionic biosurfactant production with scale of 1 tonne/day

g. Establishment of biogas pilot plant toward energy self sufficient Faculty of Husbandry campus
h. Commercialization of household scale biogas plant for breeders and fishermen.

## C. Deployment Strategy and Improving Public Acceptance

The objective of formulating this strategy is to identify non-technical problems including regulation and market instruments (product quality standard, certification), funding, incentive and responsibility to use biofuel (mandatory), that are important for the achievement of sustainable biofuel utilization. Introduction of technology or new product to the communities requires time and depend on several factors such as the nature of the technology, role of government, economical situation, environmental impact and other social aspects. The use of biofuel as alternative energy has several advantages apart from its drawbacks. Promotion of new bio-energy plant variety that is still on research level, undeveloped application of technology, unproven suitability of economical calculation, must be clearly informed to the communities to avoid misperception and disappointments. Various opinions regarding the increase of food commodities prices showed the importance of in-depth study and public discussions. If well disseminated, public acceptance on technology and new products will increase, despite some doubts during the introduction.

**Research capacity building 2009-2012**

a. Socialization of energy research results through scientific publication, seminars, workshops, trainings and community facilitation
b. Determination of priority and promotion of biofuel to reduce glass house emission, energy diversification job opportunities and rural economy development

c. Effort to standardized regulations between regions and perceptions on biofuel production and administration, especially on bio-ethanol production and tax regulation, bio-ethanol denaturing regulation and regulation on mixture of biofuel and fossil fuel to prevent misuse.

## 4.4. Timeline for Research and Development

Table 4.1. First priority Activities

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| **I. PROVISION OF BIOMASS RAW MATERIALS** | | | | | | | |
| **A. Energy Producing Plants** | | | | | | | |
| 1. Development of Jatropha oil with expected target of achieving new variety that has a productivity of 15 tonnes/hectare/year (year 2018) | Basic | Local | | | | | |
| 2. Development of rapid propagation technique for superior cassava (productivity > 60 tonnes/ hectare/harvest) | Applied | Local | | | | | |
| 3. Increasing Jatropha oil production efficiency and stability on various conditions. | Basic | Local | | | | | |
| 4. Multi-location tests on transgenic sugar cane | Applied | Local | | | | | |

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 5. Development of microalgae cultivation technology, harvesting and aeration | Basic | Local | | | | | |
| **B. Agricultural and Forestry Wastes** | | | | | | | |
| 1. Development of data on raw materials qualities and availability for processing purposes and users' needs | Applied | Local | | | | | |
| 2. Technical study of agricultural and forestry biomass wastes supply system | Applied | Regional | | | | | |
| **C. Fisheries** | | | | | | | |
| 1. Study and identification of fresh and salt water biota as potential source of bio-energy | Basic | Local Regional | | | | | |
| **II. DEVELOPMENT OF PROCESSING TECHNOLOGY** | | | | | | | |
| **A. Bio-diesel Production from Bio-oil** | | | | | | | |
| 1. Use of cleaning agent on bio-diesel refining process | Applied | Local | | | | | |

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 2. Development of transesterification reaction through non catalytic, solid catalyst, utilization of ultrasonic and micro waves methods | Applied | Local | | | | | |
| 3. Increasing additional values of by products (cake of pressed peanuts, residues of degumming and soapstock | Applied | Local | | | | | |
| 4. Use of bio-ethanol as reactant on bio-diesel processing | Applied | Local | | | | | |
| 5. Development of standardization method and quality assurance of bio-diesel | Applied | Local | | | | | |
| 6. Development of cost efficient post harvest facilities and raw material aeration that are with the use of solar energy | Basic | Local<br>Local | | | | | |
| **B. Development of Bio-ethanol Processing Technology** | | | | | | | |
| 1. Development of bio-ethanol processing technology made from cassava, sorghum and macroalgae | Applied | Local | | | | | |

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 2. Development of efficient lignocellulose hydrolysis technique | Basic | Local | | | | | |
| 3. Development of microbe isolates, optimization of cultivation condition, gene mutation technique and genetic engineering to increase cellulytic enzyme production | Basic | Local | | | | | |
| 4. Development of potential new microbe isolates for fermentation of sugar C5 and C6 mixture | Applied | Local | | | | | |
| **C. Development of Biogas Technology** | | | | | | | |
| 1. Development of biodigester design | Applied | Local | | | | | |
| 2. Increase of biogas production through the development of microbe isolate decomposer | Applied | Local | | | | | |
| 3. Increase of biogas calorie value through biogas purification development | Basic | Local | | | | | |

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 4. Development of biogas utilization through improvement of gas distribution system to increase gas pressure. | Applied | Local | | ▬ | ▬ | ▬ | ▬ |
| 5. Quality increase of biogas by product for fertilizer | Applied | Local | | ▬ | ▬ | ▬ | ▬ |
| **III. DEVELOPMENT OF BIOSURFACTANT TO INCREASE GASOLINE PRODUCTION** | | | | | | | |
| 1. Production scale multiplication of bio-oil based surfactant | Applied | Local | ▬ | ▬ | ▬ | | |
| 2. Test field of biosurfactant for the application of oil well stimulation, huff and puff and flooding | Applied | Local | | | | ▬ | ▬ |
| **IV. SUPPLY CHAIN MANAGEMENT AND SUSTAINABILITY** | | | | | | | |
| 1. Analysis of supply and demand system for biomass raw materials and its impacts on trade policy and biofuel utilization | Applied | Local | | | ▬ | ▬ | |

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 2. Synergy/conflict analysis between bio-energy production and environmental protection | Basic | Local | | | | | |
| **V. ESTABLISHMENT OF NETWORKS AND COLLABORATIONS AMONG RESERACHERS AND RESERACH CENTRES** | | | | | | | |
| 1. Establishment of international networks between bio-energy research centres especially n Jatropha oil development (International Jatropha Research Coordination) | Applied | Regional | | | | | |
| **VI. COLLABORATION IN RESEARCH AND DEVELOPMENT FACILITIES MANAGEMENT** | | | | | | | |
| 1. Establishment of collection and experiment garden for castor oil, cassava, sorghum and sugar cane | Applied | Local | | | | | |

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 2. Establishment of microalgae cultivation laboratory and pilot plant (open pond and photobioreactor) | Applied | Local | | | | | |
| 3. Establishment of pilot plants for bio-diesel, biopellet and bio-diesel by products | Applied | Local | | | | | |
| 4. Establishment of small scale cassava bioethanol plant and superior cassava cultivation field | Applied | Local | | | | | |
| 5. Establishment of biogas plant pilot toward energy self sufficient Faculty of Husbandry campus | Applied | Local | | | | | |
| 6. Commercialization of household scale biogas plant for breeders and fishermen | Applied | Local | | | | | |

| FIRST PRIORITY ACTIVITIES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| **VII. DEPLOYMENT STRATEGY AND IMPROVE PUBLIC ACCEPTANCE** | | | | | | | |
| 1. Socialization of energy research results through scientific publication, seminars, workshops, trainings and community facilitation | Applied | Local | | | | | |
| 2. Determination of priority and promotion of biofuel for environment, energy diversification and rural economy development | Applied | Local | | | | | |
| 3. Effort to standardized regulations between regions and perceptions on biofuel production and administration | Applied | Local | | | | | |

Table 4.2. Second Priority Activities

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| **I. PROVISION OF BIOMASS RAW MATERIALS** | | | | | | | |
| **A. Energy Producing Plants** | | | | | | | |
| 1. Sorghum breeding to produce varieties that are tolerant to dryness and acid soil, and produce high yield | Basic | Lokal | | | | | |
| 2. Development of potential macroalgae variety for bio-ethanol raw material | Basic | Local | | | | | |
| 3. Development of potential microalgae strain for bio-diesel raw material and study of microalgae characteristics of biofuel | Basic | Local | | | | | |
| 4. Utilization of microalgae product for nutrasetikal raw material | Basic | Local | | | | | |
| **B. Agricultural and Forestry Wastes** | | | | | | | |
| 1. Study of forest biomass supply costs on various conditions and production scales to fulfil biofuel industrial needs | Applied | Local | | | | | |

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 2. Development of silvicultural technology and discovery new rapid growth forest plant for biomass production | Basic | Local | | | | | |
| 3. Study of biomass utilization impacts on regional ecology, climate, production chain and supply | Applied | Local | | | | | |
| **C. Fisheries** | | | | | | | |
| 1. Conservation and protection of potential sea biota for bio-energy source | Basic | Local Regional | | | | | |
| **II. DEVELOPMENT OF PROCESSING TECHNOLOGY** | | | | | | | |
| **A. Bio-diesel Development from Bio-oil** | | | | | | | |
| 1. Improvement of methanol recovery and catalyst and improvement of phase separation technology | Applied | Local | | | | | |
| 2. Glycerol purification and its utilization as additive raw materials, surfactant, polymer and other products | Applied | Local | | | | | |

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 3. Technological development of pure bio-oil for fuel (biokerosene) | Applied | Regional | ■ | ■ | ■ | | |
| 4. Increase of oxidative stability, cold flow properties and other qualities from bio-diesel and oil fuel | Applied | Local | | ■ | ■ | ■ | |
| 5. Technological development of bio-diesel processing from microalgae | Applied | Local | | | → | → | → |
| **B. Development of Bio-ethanol Processing Technology** | | | | | | | |
| 1. Development of new enzyme sources for starch hydrolysis and sacarification from potential local microbe isolate | Basic | Local | | → | → | → | → |
| 2. Development of local adsorbent molecular sieve material and small scale continue distillation-dehydration tool | Basic | Local | | ■ | ■ | | |
| 3. Processing of solid waste fermentation by product through improvement of nutritional value and formulation into livestock feed | Applied | Local | | | ■ | ■ | |

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 4. Factory planning to increase energy efficiency through the use of biogas, biomass and thermal and water recirculation | Applied | Local | | | | | |
| 5. Production and characterization of biogas from bio-ethanol wastes | Applied | Local | | | | | |
| 6. Utilization of fusel oil as chemical raw material | Applied | Local | | | | | |
| **III. DEVELOPMENT OF BIOSURFACTANT TO INCREASE CRUDE OIL PRODUCTION** | | | | | | | |
| 1. Study of anionic, cationic and non-ionic surfactants production process | Applied | Local | | | | | |
| 2. Formulation of surfactant for application of oil well stimulation, huff and puff and flooding | Applied | Local | | | | | |
| 3. Testing of surfactant formula on laboratory scale for sand stones and carbonate rocks for application of oil well stimulation, huff and puff and flooding | Applied | Local | | | | | |

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| **IV. SUPPLY CHAIN MANAGEMENT AND SUSTAINABILITY** | | | | | | | |
| **A. Supply Chain Management** | | | | | | | |
| 1. Identification and benchmarking of various regional supply systems, intermarket dependence, transportation and international trade | Basic | Local | | | | | |
| **B. Sustainability** | | | | | | | |
| 1. Identification of sustainability indicators based on current conditions and difference of technological situations, end consumers and local obstacles | Applied | Local | | | | | |
| 2. Methodological improvement for measuring technical, economical, environmental and social aspects such as LCA (Life Cycle Analysis) and Socio-Eco-Efficiency-balance | Applied | Local | | | | | |
| 3. Analysis of whole biofuel chain data compare to fossil fuel | Applied | Local | | | | | |
| 4. Development of agroforestry in Gunung Walat Educational Forest | Applied | Local | | | | | |

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 5. Study of human behaviour in energy utilization that comprise of increased energy efficiency through environmental management, renewable energy, energy retrenchment (4R) and development of social capital in community – based energy production and utilization | Applied | Local | | | | | |
| **V. IMPACTS OF BIOFUEL DEVELOPMENT** | | | | | | | |
| 1. Analysis of benefits and development cost for biofuels | Applied | Local | | | | | |
| 2. Incentive structure study of biofuels supply | Applied | Regional | | | | | |
| 3. Social economical study towards "switching" to biofuel energy | Applied | Regional | | | | | |
| 4. Impact of energy conversion on social economic conditions of people | Applied | Regional | | | | | |
| 5. Development of and perfection of wave converter and wind-energy converter prototypes | Applied | Local | | | | | |
| 6. Testing and operationalization of surface wave and wind energy | Basic | Local | | | | | |

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| **VI. ESTABLISHMENT OF NETWORKS AND COLLABORATIONS AMONG RESERACHERS AND RESEARCH CENTRES** | | | | | | | |
| 1. Establishment of Indonesian Association of Bio-energy Profession | Basic | Local | | | | | |
| 2. Publication of international scientific journal on bio-energy | Basic | Regional | | | | | |
| 3. Establishment of international postgraduate programme on Bio-energy Technology and Management | Basic | Regional | | | | | |
| **VII. COLLABORATION OF RESEARCH AND DEVELOPMENT FACILITIES MANAGEMENT** | | | | | | | |
| 1. Establishment of experimentation laboratory and pilot plant for surfactant production | Applied | Local | | | | | |

| SECOND PRIORITY ACTIVITES | Research Status | Research Scale | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| 2. Establishment of biosurfactant experimentation laboratory for EOR and pilot plant production of cationic, anionic and nonionic biosurfactant on scale of 1 tonne/day | Applied | Local | | | | | |

Table 4.3. Additional Research Agenda Activities

| ACTIVITIES | Research Status | Research Status |
|---|---|---|
| **I. PROPOSED MAIN RESEARCH ACTIVITIES** | | |
| 1. Establishment of husk furnace plant pilot toward energy self sufficient Faculty of Mathematics and Science | Applied | Local |
| 2. Commercialization of husk furnace plant on household and small industry scales | Commercialization | Local |
| 3. Establishment of biophysics-based sun cell pilot plant | Basic | Regional |
| 4. Crystal photonic based biocentral | Basic | Local |
| 5. Development of integrated pest control for Jatropha oil plant | Applied | Regional |
| 6. Development of environmental friendly and sustainable bio-energy plant protection technology | Basic | Regional |
| 7. Identification of appropriate insecticides application for Jatropha oil plantation | Applied | Regional |
| 8. Embryogenesis of Jatropha oil to produce large scale seed production | Basic Applied | Local |

| ACTIVITIES | Research Status | Research Status |
|---|---|---|
| 9. Genetic improvement of Jatropha oil through genetic engineering | Basic | Regional |
| 10. Development of methanotroph bacteria to convert methane to methanol | Basic<br>Applied | Local |
| 11. Study of energy-based management system to achieve self sufficiency in energy | Basic | Applied |
| 12. Development of entrepreneurship at village level for energy based business | Basic | Applied |
| 13. Study of organization reinforcement of energy–based business to achieve self-sufficiency in energy | Basic | Applied |
| 14. Development of *Calophylum inophyllum* as source of energy | Applied | Local |
| 15. Inventory of renewable energy from forest trees | Applied | Local |
| 16. Development of traditional wisdom-based energy sources | Applied | Local |
| 17. Development strategy for bio fuel energy | Applied | Regional |
| 18. Study of effective and efficient oil fuel administration | Applied | Regional |
| 19. Mapping of national energy requirement | Basic | Regional |
| 20. Study of self sufficient energy village model | Applied | Local |
| 21. Economical study of agricultural products utilization as alternative sources of energy | Applied | Local |
| 22. Grafting technique for Jatropha oil | Basic<br>Applied | Local |
| 23. Development of natural pigment as photon trap (for sun power ) | Basic | Local |
| 24. Alternative for utilization of Jatropha oil solid wastes as raw material for medicines, growth supplements and bio-pesticides | Basic<br>Applied | Local<br>Regional |
| 25. Utilization of microorganisme to degrade crude oil wastes | Basic<br>Applied | Local<br>Regional |

| ACTIVITIES | Research Status | Research Status |
|---|---|---|
| 26. Sail design for various types of fishermen's boat – reducing the use of oil | n.a | n.a |
| 27. Study of forest conservation and its relation to potential microhydro | n.a | n.a |
| 28. Planning of microhydro energy power for various water discharges | n.a | n.a |
| 29. Development of business design for provision of rural energy | n.a | n.a |
| 30. Development of bio fertilizer to support the production of bio-energy producing plant (*gatropha* ) | n.a | n.a |
| **II. PROPOSED SUPPORTING RESEARCH ACTIVITIES** | | |
| 1. Development of sun sensor from biomaterial | Basic | Regional |
| 2. Development of chlorophyll-based sun cell | Basic | Local |
| 3. System dynamic simulation modelling of nerve cells propagation | Basic | Local |
| 4. Development of composites making methods from egg shell | Basic | Local |
| 5. Optikal *biosentor based on photomic crystal with gaussian pulse* | Basic | Regional |
| 6. Bio-ecology of mealybug on Jatropha oil plant | Basic | Local |
| 7. Development of intercrop on Jatropha oil plantation | Applied | Regional |
| 8. Development of integrated pest control technology for bioeternal producing cassava | Applied | Regional |

# V Conclusions

In order to become the *World Class University*, IPB must organize itself, and one such way is through the formulation of research. The Research Agenda for Energy Sector is formulated to organize and direct research conducted by IPB academic society, to be more integrated and sustainable in order to provide meaningful contribution for development of Indonesia.

This Research Agenda for Energy Sector is built upon various aspects that are more than just development of inputs and technology processes, but also taking into account policy and economic aspects. This research agenda is expected to strengthen collaboration among study units and research centres to conduct integrated research to minimize overlapping research. Furthermore, this research agenda will be very helpful in allocating research funds and establishing research targets terms.

We hope that these thoughts contribution will benefit the development and strengthening of research among IPB's academic society.

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