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Universitas Bandar Lampung
20 - 21, June 2012
Lampung, Indonesia

PREFACE

The activities of the International Conference is in line and very appropriate with the vision and mission of the UBL to promote training and education as well as research in these areas.

On behave of the First International Conference of Engineering and Technology Development (ICETD 2012) organizing committee; we are very pleased with the very good responses especially from the keynote speakers and from the participants. It is noteworthy to point out that about 45 technical papers were received for this conference

The participants of conference come from many well known universities, among others: Universitas Bandar Lampung, International Islamic University Malaysia, University Malaysia Trengganu, Nanyang Technological University, Curtin University of Technology Australia, University Putra Malaysia, Jamal Mohamed College India, ITB, Mercu Buana University, National University Malaysia, Surya Institute Jakarta, Diponogoro University, Unila, Universitas Malahayati, University Pelita Harapan, STIMIK Kristen Newmann, BPPT Lampung, Nurtanio University Bandung, STIMIK Tarakanita, University Sultan Ageng Tirtayasa, and Pelita Bangsa.

I would like to express my deepest gratitude to the International Advisory Board members, sponsors and also welcome to all keynote speakers and all participants. I am also grateful to all organizing committee and all of the reviewers which contribute to the high standard of the conference. Also I would like to express my deepest gratitude to the Rector which give us endless support to these activities, such that the conference can be administrated on time.

Bandar Lampung, 20 Juni 2012

Mustofa Usman, Ph.D
ICETD Chairman

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UNIVERSITAS BANDAR LAMPUNG
Bandar Lampung,Indonesia
June, 20-21 2012

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Indonesia's Challenge to Combat Climate Change Using Clean Energy

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Abstract— **Indonesia as the biggest archipelago country and situated in equator is very vulnerable to the adverse effect of climate change. There are two main categories of efforts to handle the issues in climate change; that are how to mitigate it and how to adapt to the change. One of the main culprits of climate change is the emission of carbon gas due to fossil fuel energy utilization contributing 302 million tonnes CO_2 equivalent.President of the Republic of Indonesia in 2009 in the G-20 Meeting, Pittsburgh, USA, and in 2010 in COP 15 UNFCCC, Copenhagen, Denmark issued the national voluntary target to reduce greenhouse gas emission by year 2020 as much as 26% from business-as-usual by national domestic efforts. This emission reduction will further be improved as much as 41% from business-as-usual by international supports. The Government of Indonesia issued a national action plan to reduce greenhouse gases emission which is enforced by Presidential Regulation No. 61/2011. To achieve this target in energy sector,REFF-Burn (Reducing Emission from Fossil Fuel Burning) concept has been proposed by Sumiarso. Based on REFF-Burn Technology Portfolio, reducing emission from fossil-fuel burning is categorized in three different stages, which are pre-combustion, during combustion and post-combustion. In pre-combustion stage, utilization of clean energy is one of the wise choices. The perspective of the clean energy resources and utilization in Indonesia is discussed in this paper.**

Keywords— **Climate Change, Greenhouse Gas, Carbon, REFF-Burn, Clean Energy, Renewable Energy, Energy Security, Feed-in Tariff.**

I. INTRODUCTION

According to Christensen, Anthony and Roth[1], the future world will be dominated by four main issues, which are food security, affordable quality healthcare, energy security and environment. The issue in environment includes the issue in climate change. It has been widely aware that climate change is an imminent threat to the world civilization. Among other adverse effects of climate change is rising of sea level, habitat destruction, uncured diseases due to new strains of bacteria and viruses, crop and agricultural problems, availability of drinking water, natural disaster and the chemistry of ocean [2]- [5].

Indonesia as the biggest archipelago country and situated in equator is very vulnerable to the adverse effect of climate change [6]. For example, rising of sea level will shrink our islands, contaminate our drinking water reservoir, and swamp our low level cities, such as Jakarta. It is also predicted that climate change will change the pattern of fish migration in the ocean which eventually will sadden our traditional fisheries. It is also hypothesized that current inclination of natural disasters, such as hurricane, typhoon, flood, and longer and drier drought seasons, related to climate change [7]-[9].

It requires globally orchestrated efforts to avert the devastating impact of climate change to living creatures on earth.There are two main categories of efforts to handle the issues in climate change; that are how to mitigate it and how to adapt to the change. The main culprit of climate change is the emission of carbon gas which is mainly contributed by sectors of forestry utilization, energy utilization and waste. In Indonesia, forestry sector releases the largest amount of greenhouse gas emissions [10]. It contributes about 1,232 million tones CO_2 equivalent from land use, land use change and peat land. While the energy sector and wastecontribute the second and third largest of greenhouse gas emissions, respectively. Energy sector contributes about 302 million tones CO_2 equivalent. However, by 2030 it is estimated that the energy sector will become the largest greenhouse gas emission in Indonesia, due to economic development and implementation of REDD+ (*Reducing Emission from Deforestation and Forest Degradation*)in forestry activities. Indonesia energy consumption increases approximately 7% yearly. Globally, burning fossil energy and fuels have contributed over 40% of the global green house gas (GHG) emissions causing the global warming and climate change.

Although, Indonesia is not listed in Annex I of Kyoto Protocol, President of the Republic of Indonesia in 2009 in the G-20 Meeting, Pittsburgh, USA, and in 2010 in COP 15 UNFCCC, Copenhagen, Denmark issued the national

voluntary target to reduce greenhouse gas emission by year 2020 as much as 26% from business-as-usual by national domestic efforts. This emission reduction will further be improved as much as 41% from business-as-usual by international supports. To achieve this target, the Government of Indonesia issued a national action plan to reduce greenhouse gases emission (RencanaAksiNasionalPenurunanEmisi Gas RumahKaca – RAN-GRK), which is enforced by Presidential Regulation No. 61/2011 [11]. It is the guidance to plan, execute, monitor and evaluate the reduction of greenhouse gas emission from sectors of agriculture, forestry, energy and transportation, industry and waste management. In 2007, Ministry of Environment issued National Action Plan/Mitigation Adaptation Climate Change.

If in forestry we already have REDD (Reducing Emission from Deforestation and Degradation) then extended to be REDD+ as an international mechanism to provide incentive to the successful countries in reducing greenhouse gas emission due to deforestation and forest degradation, we have not had similar mechanism for energy sector. The condition stimulated Sumiarso [12]to develop REFF-Burn (Reducing Emission from Fossil Fuel Burning) concept, when he was a General Director of New Energy,Renewable and Energy Conservation, the Ministry of Energy and Mineral Resources of the Republic of Indonesia.

II. WHAT IS REFF-BURN?

REFF-BURN concept is mirror that of REDD for the forestry sector. Sumiarso is continuing to develop its REFF-BURN concept in his new office, as the chairman of International Institute for Clean Energy and Climate Change (IICECC) to be REFF-BURN+. Fossil fuel burning here is defined as burning coal, oil and/or gas fuels which produce greenhouse gas emission. In REFF-BURN concept, Sumiarso[12], [13] describes REFF-Burn Technology Portfolio, REFF-Burn Scheme and REFF-Burn Mechanism. Based on REFF-Burn Technology Portfolio, reducing emission from fossil-fuel burning is categorized in three (3) different stages, which are pre-combustion, during combustion and post-combustion.

Pre-fossil combustion stage is to avoid using more fossil fuel burning in the energy industry that lead to greenhouse gas emissions, through (1) efficient energy technology; (2) renewable energy technology, such as hydro-energy, geothermal-energy, bio-energy, solar-energy, wind-energy, and ocean energy; and (3) low carbon power generation technology. During fossil combustion stage is to reduce greenhouse gas emissions from fossil fuel utilization, through (1) clean coal technology; (2) clean oil technology; (3) clean gas technology; and (4) clean energy utilization technology in household sector, industrial sector, transportation sector and commercial sector. Post fossil combustion stage is to remediate the emitted greenhouse gas emissions from fossil fuel burning, through (1) carbon capture technology; (2) carbon storage technology; and (3) carbon utilization technology.

To ensure the implementation of the Low-Carbon Technology Platform, Sumiarso[12]-[14] developed policy and regulations in the package of REFF-Burn Schemes, which are categorized into four policy instruments: (1) legal instrument, (2) fiscal instrument, (3) financial instrument, and (4) institutional instrument. These four instruments cannot be a standalone, but they must be together in one package to create the right atmosphere in the country. Similar to the idea of REDD+ in the forestry sector, the aim of REFF-BURN is to provide financial reward to developing countries that can demonstrate emission reductions in the energy sector. Hence, the basic principle of the REFF-Burn mechanism is to provide funds to developing countries for reducing emissions from burning fossil energy or fuels [12]-[14].

III. CLEAN ENERGY

Clean energy is not always renewable energy, but renewable energy is always clean energy. For example, nuclear energy is not a renewable energy, but considered as a clean energy, because it does not release CO_2 as much as burning fossil fuels. However, unfortunately, nuclear power plant is dangerous, if disasters occur. Let alone, its wastes release hazardous nuclear radiation for very long time. Clean energy becomes increasingly important in the new paradigm of current economic development which stress not only on the growth, but also sustainability (green economics or green growth).

The office of Ministry of Energy and Mineral Resources of the Republic of Indonesia has strong commitment, not only to achieve the goal of RAN-GRK, but more than that of, which is to secure the availability of domestic energy (energy security). The energy security means the ability to respon to the dynamic global energy changes (external) and the ability to secure the energy supply in appropriate prices (internal) [15]. With the average annual economic growth 7% and highly depending on energy from fossil fuels, such as oil and gas, the energy sector in Indonesia requires innovative way to reduce domestic greenhouse gas emissions but at the same time to secure energy national. According to a release from the office of Ministry of Energy and Mineral Resources (ESDM) [16], the Republic of Indonesia as shown in Fig 1, fossil fuels contributed about 95% of Energy-Mix in Indonesia in 2010.It consisted of oil (48%), coal (19%) and natural gas (28%), while hydropower and geothermal contributed only 3% and 2%, respectively. Actually, Indonesia has diversity of renewable energy resources, but they have not been extensively utilized. So, it is not too ambitious for the Directorate General of New Energy, Renewable and Energy Conservation of the Republic of Indonesia to set the target 25% renewable energy in energy-mix by 2025 as depicted in Fig 2 [13]. This goal is famously called 25/25. On the other hand, theGovernment of Indonesia sets the target 17% renewable energy in national energy-mix by 2025 (17/25) [17]. There are two main strategies used to achieve the vision 25/25, which are conservation of energy and diversification of energy.

Among renewable energy resources are geothermal, wind, hydro, bio-energy, ocean and solar. Tables 1 and 2 showing

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the reserve and production of energy in Indonesia clearly indicate that Indonesia is rich renewable country, but not optimally utilized

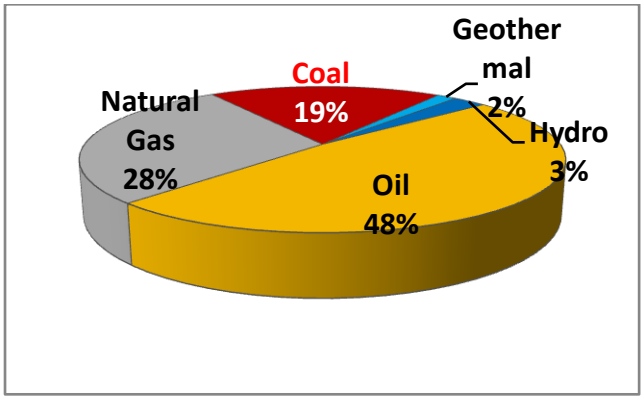
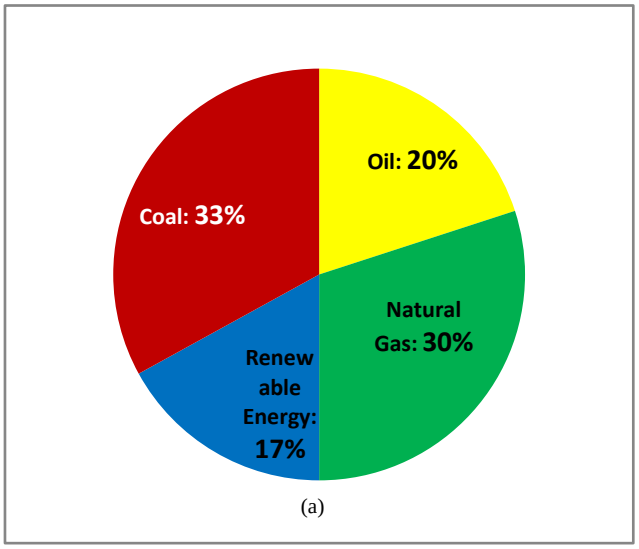
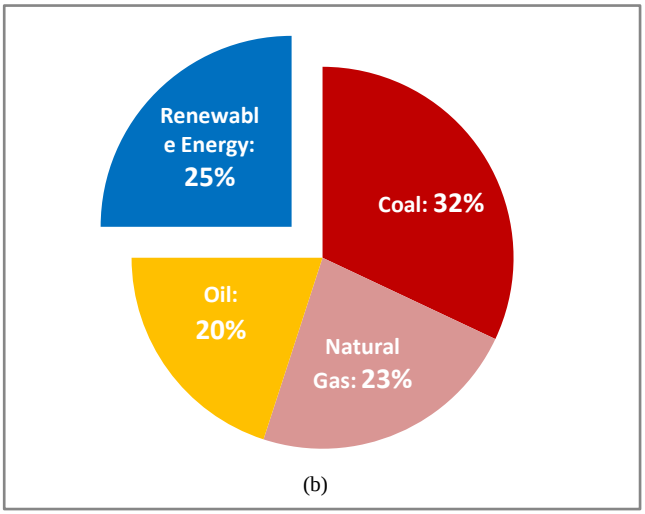


Fig.1 Energy-Mix Indonesia in 2010. [16]



(a)



(b)

Fig. 2 (a) Indonesia Energy-Mix by 2025, 17/25 [17] (b) Vision of Directorate General of New Energy, Renewable and Energy Conservation 25% renewable energy in Indonesia Energy-Mix by 2025, 25/25.[13].

A. *Hydro (small and large hydro)*

Hydro power is one of very clean energy, because it does not emit green-house gases, such as CO_2. Working principle of hydro power plant in general is almost similar to conversion of kinetic energy of water into electricity. It can be in the form high-head through water fall or water damn, low-head hydro, or water current. In Indonesia, it is considered two types of hydro power plants, large and small hydro power plants. Usually, less than 10 MW capacity is called a small one, which can be mini, micro (below 1 MW), or pico (below 0.1 MW). Among large hydro power plants in Indonesia are PLTA Balambano (South Sulawesi) – 140 MW, PLTA Cirata (West Java) – 1008 MW, PLTA Musi (South Sumatera) – 210 MW, PLTA Saguling (West Java) - 712 MW.

TABLE 1
NON-RENEWABLE ENERGY PROSPECT IN INDONESIA [13], [17]

Non-Renewable Energy	Resource (SD)	Reserve (CAD)	Ratio (CAD/SD) (%)	Production (PROD)	Ratio CAD/PROD (Year)
Oil (billion barrels)	56.6	7.99*)	14	0.346	23
Natural Gas (TSCF)	334.5	159.64	47.7	2.9	55
Coal (billion tons)	104.8	20.98	20	0.254	83
Coal Bed Methane (TSCF)	453	-	-	-	-

*) = Including Cepu Block

TABLE 2
CLEAN ENERGY PROSPECT IN INDONESIA [13], [17]

Clean Energy	Resource (SD)	Installed Capacity (KT)	Ratio (KT/SD) (%)
Hydro	75,670 MW	5,705.29 MW	7.54
Geothermal	28,543 MW	1,189 MW	4.17
Mini/Micro hydro	769.69 MW	217.89 MW	28.31
Biomass	49,810 MW	1,618.40 MW	3.25
Solar	4.80 kWh/m^2/day	13.5 MW	-
Wind	3 – 6 m/s	1.87 MW	-
Uranium	3.000 MW (e.q. 24,112 ton) for 11 years*)		

*) = only in Kalan, West Borneo

Table 2 indicates that Indonesia still has large resource of hydro power potential, including large scale ones, to fulfil our increasing electricity needs. According to Table 3, it is predicted by 2025 that hydro power contributes at least 2% in Indonesia energy-mix. Although, hydro power does not contribute to the greenhouse gases, however, over a decade, environmentalists have been critical to the negative impact of development of large hydro powers involving large dams to store the power. Building large dams do not only change the

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ecosystem in the location, but also not rare lead to social problems resulting from relocation of vast number of inhabitants living in the project are, which can be long time miseries for the affected people [18]. This concern makes small hydro power plants (up to 10 MW), particularly micro hydro power plants (below 1 MW) become wise choices. Another positive side of micro hydro power plants is they are considered to contribute to poverty alleviations and community empowerments. Tri Mumpunifrom Indonesia has introduced stand-alone installation of micro hydro power plants combined with the community based system, which is able to create economic incentives for sustainable rural development [18].

TABLE 3
INDONESIA PRIMARY ENERGY PROJECTION [17]

Type of Energy	2005*)	2010*)	2015*)	2020*)	2025*)
Oil	524.0	550.7	578.0	605.8	638.9
Coal	160.4	210.3	349.7	743.8	1099.4
Natural Gas	212.8	363.7	382.5	477.1	832.0
Coal Bed Methane	0.0	0.0	23.0	74.6	127.8
Hydro Power	34.0	41.7	56.6	60.5	65.8
Geothermal	23.7	23.7	61.8	115.8	167.5
Nuclear	0.0	0.0	0.0	27.9	55.8
Other Renewable Energy	1.6	3.5	7.4	11.7	17.4
Biofuel	0.0	32.5	89.0	102.4	166.9
Liquefied Coal	0.0	0.0	14.2	47.4	80.5
Total	956.5	1226.1	1562.1	2266.9	3252.2

*) = Million of SBM

B. Geothermal

Geothermal is a clean energy since it emits greenhouse gases very insignificant. Hence, it does not contribute to the global climate change. Geothermal energy utilization is an effort to utilize the energy stored in the hot rock beneath the earth surface in the form of thermal energy. Under high pressure, this thermal energy is transferred to the liquid to form hot water or steam. On the surface, the existence of this energy usually appears as hot springs, fumarole and steaming grounds. However, for electricity generations, high pressure and high temperature geothermal fluid, above 200^{o}C, is required, which usually can be tapped by drilling the geothermal well at the potential geothermal energy locations.

Fig 3 shows that Indonesia is among only a handful of countries having abundant geothermal energy resources, spanning from Sumatera, Java, Bali, Nusa Tenggara until Sulawesi [19]. Indonesia has 40% of world geothermal resources, the highest in the world. It is the consequence of Indonesia's geographical location sitting on the ring of fire. However, Indonesia's geothermal resources are still underutilized, even still lagging behind the Philippine. Installed capacity of Indonesia's geothermal power plant is only 1,226 MW [20] Among of them are PLTP Kamojang (Pertamina) – 200 MW, PLTP Salak (Chevron) – 375 MW, PLTP Darajat (Chevron) – 255 MW, and PLTP Wayang Windu (Star Enery) – 227 MW. Indonesia wants to develop urgently 4000 MW of geothermal power plant as part of the second 10,000 MW accelerated electricity production programme [21]. To achieve the Directorate General of New Energy, Renewable and Energy Conservation's vision 25/25 (25% renewable energy in Indonesia Energy-Mix by 2025), it was proposed to have geothermal energy power plant output 12 GW by 2025 [22].

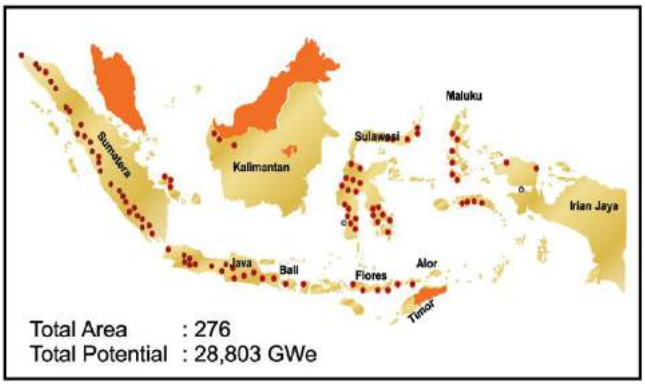

Fig.3.Geothermal energy potential in Indonesia. [19]

C. Bioenergy

Bioenergy is a renewable energy source coming from biomass, living creatures. There are many types of bioenergy technologies, but mainly based on thermochemical conversion, biochemical conversion and extraction. Biogas, biomass gasification, and biofuel are among others. People have used wood chips for cooking and heating system since the existence of human and biogas has been used long before the invention of oil. In many countries, wood is still used daily for cooking and heating. Hence, bioenergy is one of the oldest and widely used source of energy. According to Table 2, so far Indonesia utilizes only about 3% of its biomass resource. Table 3 also shows that Indonesian government expect that the contribution of biofuel to the national energy-mix about 5% by 2025. That is why the Indonesian government has issued President Instruction (Inpres), No. 1 in 2006 about bioenergy program, especially biofuel [23].

Biogas is mainly methane gas produced by the digestion of organic waste, such as animal waste and organic domestic waste. Methane is a more dangerous greenhouse gas than CO_2. If not utilized, the methane from cow dung and land fill will be released to the atmosphere and contribute to the global warming. Hence, utilization methane gas helps mitigate the global warming. While biomass gasification is the process of producing gas by burning biomass in side controlled O_2. Both energy generated by biogas and biomass gasification can be used for electricity generation and heating.

Biofuels are fuels produced from living things which can substitute fuels from oil. There two most popular biofuels, bioethanol and biodiesel. Bioethanol can be blended with

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gasoline. This liquid fuel is made from corn, sugarcane, or other crops. Two of the world's major ethanol producers are the United States and Brazil. Gasoline sold in Brazil is blended with ethanol. Vehicles can also run on biodiesel. This fuel is made from vegetable oils, such as palm oil, coconut, algae and jathropa, or animal fats. It can be used as a substitute or replacement for diesel fuel made from crude oil. In Indonesia, most of biodiesel are made from palm oil. Current locations of biodiesel producers in Indonesia are mainly in Sumatera and Java islands [24]. Many people believe that migrating from fossil fuels to biofuels as energy sources for vehicles is much easier as compared to other alternative energy sources, such as hydrogen and electric cars, because utilization of biodiesel and bioethanol does not require big changes on the infrastructure of fuel distribution and vehicle technologies. Biomass is the only renewable energy which can replace fossil fuels, because other renewable energies, such as solar, wind, hydro and wave, can be easily used to generate electricity only. Biofuels also can be produced by small/medium enterprises using a simple and compact system as shown in Fig.4 for example. Hence, biofuels can be convenient fuels to bridge the transition between fossil fuel era and the era of new type of vehicles, such as electric cars and hydrogen cars.

Biofuels contain carbon. So do fossil fuels. In fact, biofuels and fossil fuels are often called carbon-based fuels. Hence, it can be understood some people argue that biofuels are not clean energies. Do biofuels contribute to global warming? Some scientists say no. Mining and burning fossil fuels release carbon that has been buried and locked for many million years. Then, this carbon enters the atmosphere as CO_2 because of fossil fuel burning and contributes to the global warming. Because biofuels come from living things, they, too, contain carbon. When biofuels are burned, this carbon is released into the atmosphere. However, as a whole process of biofuels utilization does not contribute to the global warming. The explanation for this is based on the carbon cycle. Biofuels release CO_2 as they burn, but biofuel crops use CO_2 as they grow. As long as people continue to plant biofuel crops, some or all of the CO_2 that is released by biofuel burning will be absorbed by the growing biofuel plants. Hence, if people continue to grow biofuel plants from year to year, the CO_2 net due to biofuel can be zero.

In order to foster bioenergy, the Government of Indonesia has issued few policies related to biofuels. President regulation 5/2006 sets the target that the biofuel will contribute at least 5% in Indonesia energy-mix by 2025 [25]. President instruction 1/2006 [23] regulates all the ministries and local governments in order to enhance the bioenergy utilizations. Decision of Ministry of Energy and Mineral Resouce of the Republic of Indonesia 32/2008 is about the mandatory of transporation sector, power plant and industry [26]. The last but not the least, President regulation 45/2009 stated that biofuel is one of subsidised fuels by the government [27]. In 2009, government subsidised biofuel Rp 1000/litre, and then 2010 and 2011 the subsidy was increased to Rp 2000/litre. However, biofuel producers were only able to absorp the budget of government subsidy about 18% and 28% in 2009 and 2010, respectively [28].

On the other side, some environmentalists have an issue in massive use of bioenergy, particularly biofuel. Biofuel crop plantation needs to clear the large land which may cause deforestation, while forest is very important to absorp the green house gases. Some food scientists and experts also have concern that biofuel production may threaten food security. Theoretically, all seed, stems and roots of crops containing oil or hydrocarbon can be used to produce bioenergy. However, they must not compete with the food source. Ideally, the crops used to produce for biofuels must not edible crops and can be planted easily in marginal lands.

Fig. 4 Continuous ultrasonic biodiesel reactor designed by Untoro and Dimyati, suitable for small scale and medium biodiesel plant.

D. Solar

There are two types of popular solar energy utilizations, through solar thermal and solar photo voltaic (solar cell). Solar thermal is mainly used for drying and heating. However, there are also some researchers which use solar thermal to

generate electricity by concentrating sun light to heat the liquid to turn the turbine [29], [30]. Currently, solar photovoltaic is the most popular techniques to generate electricity using solar energy. In many countries, such Germany, USA and Malaysia, many solar photovolatics are installed in houses and buildings and the excess of electricity generated by solar photovolatic is sold to utilities companies through the grids. When people have excess of electricty, they can sell it to the utility company and when they shortage of electricity they can buy from the uitlity company. This mechanism will avoid people to require battery as energy storage. The price of electricity sold to the utilities company is adjusted according to FIT (Feed-in Tariffs). Feed-in tariffs typically make use of long-term agreements and pricing tied to costs of production for renewable energy producers. This mechanism by offering long-term contracts and guaranteed pricing will attract people to participate in electricity generation because they feel safe from some of the inherent risks in renewable energy production. Hence it will promote for more diversity in energy technologies and people participation.

Indonesia naturally benefits from its geographical position at equator. We receive abundant of sun light along the year. Table 2 indicates that our solar energy intensity is 4.80 kWh/m^2/day. However, the installed capacity of solar energy contribution to the national energy-mix until 2011 was still insignificant. Why is solar photo voltaic (PV) in Indonesia still not popularly used? Highly oil subsidy makes generating electricity using solar PV is still considered not economically interesting by energy investors. In many countries, such as Malaysia, Italy, China and Germany, growing of solar PV installed is triggered by the government policy on Feed-in Tariffs. For example, Respati[31] reported that China's Feed-in Tariff policy has stimulated 14 GW solar PV project pipeline. Last year, it was also reported that triggered by generous Italian Feed-in Tariff policy, Italy surpassed Germany on solar PV installation [32]. Malaysia also proves that Feed-in Tariff increases consumer participations in solar PV installation, and helps develop the domestic solar PV industries [33]. Indonesia Renewable Energy Society (METI) has proposed solar PV Feed-in Tariff to the government, and currently the government of Indonesia is considering a special pricefor PT PLN (the state owned Indonesia electricity company) to purchase electricity generated from solar energy. It is expected that this special purchasing price will attract the investors.

Good news was reported by Respati[34] that PT PLN in the next decade plans to deploy about 200 MWp solar PV to produce electricity in remote areas, particularly remote islands. This ambition is triggered by long term rising oil prices and awareness that using more renewable energy reduces oil dependency and greenhouse gas emission. Given its geographic archipelago containing more than 17,000 islands, most of them remote and small, PLN has had difficulty to provide electricity nationwide. PLN has been trapped since founded for more than 50 years ago balancing two contradictory missions. One is as the government's social tool as mandated by constitution to provide electricity need to people. The other is growing pressure to operate as full fledge profitable enterprise [34]. Many remote areas/islands are very far from big power plants and not feasible to connect them to main grids. Currently, costly diesel plants growing constantly are mainly used in remote areas/islands. To reduce growing running cost, PLN must substitute such diesel plants with a new form of energy source, such as solar PV.

E. Wind

Wind energy is one of the cleanest energy, because it does not emitt greenhouse gases. Actually, wind energy is a product of solar energy. Because different parts of the globe receive the intensity of sun light differently, the temperature of earth is uneven which causes air pressure gradient. Wind is the movement of air from higher pressure to lower pressure. Hence, wind energy is conversion of kinetic energy of air into electricity

According to Ivannanto [35], Indonesia has only 6% of the world's wind energy resources, which is equal to 9,29 GW only. Even so, of that potential, Table 2 shows that the installed capacity of wind turbine in Indonesia is only 1.87 MW. Let alone, it is also questioned whether they are still in ful operation or not. Hence, Indonesia's wind energy resources are still underutilized. Although due to its geographical position at equator, Indonesia does not have big potential for wind energy, small wind turbines are still economically feasible in many places. It is believed that small wind turbines may be a good choice to electrify remote islands and waterfront villages in Indonesia. The timing of wind makes its good choice to tandem it with solar PV. Stronger wind usually blows during evening and night when the solar PV can not produce electricity. Hence, wind turbine and solar PV may complement one and another.

Some people may worry about noise produced by wind turbines. Unlike large wind turbines which are installed alot in Europe, USA and other countries, small wind turbines do not make annoying noise. Mini and micro wind turbines do not require big space either. Hence, they are suitable installed in the resident areas. Open spaces like parking lots in office, resident and shopping mall complexes are suitable places for mini and micro wind turbines, as examples shown in the Fig 5. Similar to solar energy sector, to attract the investors, METI has also proposed wind energy Feed-in Tariff to the government. The government of Indonesia is also considering a special price for PT PLN (the state owned Indonesia electricity company) to purchase electricity generated fromwind energy.

F. Nuclear

Using nuclear technology to generate electricity has been controversial for a long time. Nuclear power may save the country from energy shortage [36]. Its energy resource is clean, but it has problems in depositing its waste which ultimately impact human health if not well managed. Safety of nuclear reactors are also people's concerns. Japan's Fukushima nuclear meltdown in April 2011 which was considered by some experts even more severe than

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Chernobyl's nuclear accident, triggered by a great earthquake and the ensuing large tsunamy, causes some contries to revisit their nuclear plants policy. Germany, for example, stops its nuclear plants. Safety concerns on a nuclear power plant and its waste management cause developing a nuclear power taking long time and requiring huge capitals which may make this source of electricity energy become less economically feasible. Indonesia has become interested in nuclear power plant for many years. As shown in Table 3 [8], Indonesian government made projection about Indonesia nuclear energy. Many Indonesians, particularly from BATAN (Indonesia Nuclear Agency), have been sent to study nuclear power plant technolgy overseas. Many places such as Belitung island and Muria, have been considered safe places for a nuclear plant. Table 2 also shows that Indonesia has proven uranium resouce in West Borneo. However, many elements of people, like environmentalists, oppose such plans. Considering the geographical position of Indonesia sitting on the ring of fire, which is vulnerable to earthquake and tsunamy, they worry of nuclear power plant accidents, like what happened to Japan's Fukushima nuclear power plant recently. Hence, if Indonesia wants to develop nuclear power plants, social engineering to educate and inform the people correctly should be the first priority [37].

(a)

(b)

Fig. 5. (a) 100 kW wind turbine installed at the car park of Surya Research & Education Centre, Serpong, Indonesia; (b) Wind turbine at a car park in Jeju Island, South Korea

IV. Conclusions

It has been widely aware that climate change is an imminent threat to the world civilization, including Indonesia. Because Indonesia is an archipelago country and situated in equator, it is very vulnerable to the adverse effect of climate change. For example, rising of sea level will shrink our islands, contaminate our drinking water reservoir, and swamp our low level cities, such as Jakarta. It is also predicted that climate change will change the pattern of fish migration in the ocean which eventually will sadden our traditional fisheries.

One of the main culprits of climate change is the emission of carbon gas due to fossil fuel burning which contributes about 302 million tones CO_2 equivalent. To reduce the greenhouse gas emission due to fossil fuel burning, REFF-Burn concept has been issued by the General Director of New Energy, Renewable and Energy Conservation, the Ministry of Energy and Mineral Resources of the Republic of Indonesia. REFF-Burn concept is categorized in three (3) different stages, which are pre-combustion, during combustion and post-combustion. One of the pre-combustion stages is utilization of clean energy, like geothermal, solar, wind, hydro, bio-mass and nuclear. Luckily, Indonesia is a clean energy rich country having abundant opportunities to explore clean energy resource. However, those clean energy resources are still underutilised. One of the key factors to foster clean energy utilization is to apply Feed-in Tariffs to some renewable energy resources, such as solar, wind, bio, hydro and geothermal.

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