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A Review of Sustainability Challenges of Biomass for Energy: Focus in the Philippines

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Abstract Biomass as one source of renewable energy, as a whole, is challenging us to address the 3 interrelated indicators of sustainability: ecology, economy and society. On ecology- instead of just serving as pollutants as in animal manure, biogas production arrests odor, considerably reduce the pollution loading (BOD, COD) in the environment .Instead of just simply burning them, crop residues (bagasse, rice husks) are now used to produce power. However, the biomass taken out as fuel for the power plants corresponds to nutrient out. To maintain soil fertility, nutrient taken out should be replenished by external source of fertilizer or Nutrient in= Nutrient out. Rice straws and sugarcane trsh are best left in the field. Bagasse fired boiler for COGEN doubles the previously-one major product sugarcane industry. This rekindles the hope of one's sunset but now transformed into sunrise sugar industry. Same is true for rice husks-fired power plant. But feedstock ownership is now questioned. Feedstock production for COGEN starts in the field where the crops are grown. Farmers deserve share to the "gift" of the new technology. This generation and the next deserves "happy" living and enjoying available, dependable, affordable and renewable energy. There are many options. Biomass to energy is one of them. Technologies for 2nd generation biofuel are developing fast up to commercial level as systems for cellulosic ethanol are now optimized. The sleeping resource- the sea- will also give rise to algal-biodiesel, But the sustainability challenges of biomass for energy in the Philippines (technical, economic, social and political concerns) must be addressed.

Keywords: algae, bagasse ,biomass, COGEN, cellulosic ethanol, energy, renewable energy, rice husks, napier grass, solar, sustainability, sugarcane bagasse

Introduction

The past century can be characterized mainly by logarithmic growth in population and development. Capitalizing on Edwin Drake's discovery of oil, a

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non-renewable fossil energy*, many human needs were addressed as briefly described and listed below.

…"about 92 percent of the average barrel of oil is made into various products that are burned, ; 3 percent consisting of asphalt for roads; 3 percent as feedstock for the chemical manufacture of plastics and other 2 percent into useful oil-derived materials crucial in modern life listed alphabetically : Ammonia; anesthetics; antihistamines; antiseptics; awnings; balloons; ballpoint pens; bandages; boats; cameras; candles; candy wrappers; car battery cases; carpeting; car sound insulation; cassettes; caulking; clotheslines; cold cream; combs; contact lenses; cortisone; crayons; credit cards; curtains; deodorant; detergents; dishwashing liquids; dice; disposable diapers; dresses ; drinking cups; dyes; electrician's tape; dolls; eyeglasses; fan belts; false teeth; faucet washers; fertilizers; fishing boots; fishing lures; fishing rods; floor wax; food preservatives; ink; garden hoses; glue; golf bags; golf balls; guitar strings; hair curlers; hair dyes; hand lotion; heart valves; house paint; ice buckets; ice chests; ice cube trays; identification cards; insecticides; insect repellent; life jackets; linoleum; loudspeakers; luggage; model cars; mops; motorcycle helmets; movie film; nail polish; nylon stockings; oil filters; paint brushes; paint rollers; pajamas; panty hose; perfume; permanent press clothes; petroleum jelly; photograph film; pillows; plastic wood; plywood adhesive; purses; putty; refrigerator linings; roller-skate wheels; roofing; rubber cement; rubbing alcohol; safety glass; salad bowls; shampoo; shoe polish; shoes; shopping bags; shower curtains; shower doors; slacks; soap dishes; spandex tights; sports car bodies; sun glasses; sweaters; synthetic rubber; telephones; tennis rackets; tents; tires; toilet seats; tool racks; toothbrushes; toothpaste; toys; transparent tape; trash bags; TV cabinets; umbrellas; unbreakable dishes; upholstery; VCR tapes; vitamin capsules; water pipes; wire insulation; X-ray film; yarn, throwaway plastic bags and containers that litter the landscape"(Rodolfo, 2004).

So useful is oil that humanity became addicted to its use. At present, all the people on Earth use 80 million barrels a day, or about 29 billion barrels annually. This means that humanity, in one year, consumes what earth stored in nine million years since the Silurian period (Rodolfo, 2004). The use of fossil fuels since the Industrial Revolution of the late 19th Century to the

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*Oil or Fossil fuel energy is non-renewable energy because the cycling or formation time required is greater than 3.5 million years. The CO_2-GHG emission is thus acknowledged to promote global warming climate change (Rodolfo,2004).

Renewable energy as in biomass – organic matter from trees, crops, animals and sea biomass , are called renewable energy because their recycling time is few months (years) to few decades (5 decades). Any CO_2-GHG emissions are recycled back or captured in the next crop photosynthesis.

present is largely responsible for warming Earth's surface environments. CO_2-GHG (green house gas) emission due to oil contributes some 70-80% of the total GHG emission causing global warming and climate change (IPCC 2006, 2009, 2010). But *'Many of our world's most serious environmental and socioeconomic problems are caused by the continued reliance on dirty and----for many----unaffordable and non-renewable fossil energy (NRFE)'*

The oil-powered and technology-led industrial revolution had been identified as the main driver of non-inclusive growth where owners and controllers of technology became richer (among and within nation states) and the basis of neocolonialization .Crisis breeds change. It is hoped that in this century, there will be a massive shift to sources and uses of renewable energies [*] that are dependable, reliable; that are less CO_2-GHG emitting. Moreover, the use of renewable energies may lead to achieving the target emission reduction; address the world's most serious environmental and socioeconomic problems caused by the continued reliance on these dirty and non-renewable fossil energy(NRFE); and that will lead to the promotion of inclusive growth among and within the countries.

The Philippines is a country not well-endowed with fossil fuel energy. About 59% is imported. It means that 41 % of the primary energy mix was contributed by renewable energy sources in 2011(geothermal at 21.7%, biomass at 12.4% and hydro at 6%). It is claimed that the country can be 100% dependent on renewable energy (geothermal, wind, solar, hydro, biomass). Except for natural gas due to the Malampaya, the country's other oil resources are yet to be discovered or uncovered (the Spratlys island cluster is believed to be endowed with deep sea soil). *(The Malampaya has an output of 3.7-trillion cubic feet of natural gas and 85-million barrels of condensate that can generate 2,700 MW until 2022, A newly found source in Isabela, the Mangosteen field has a recoverable resource potential of 71-billion cubic feet of natural gas reserves that could contribute 60 megawatts to the Luzon power grid for more than 15 years(Esplanada,2015*).

Objectives: Covering all the sources/ types of renewable energy is not the scope of this paper. Mainly, the review covers 2 parts; the first is a report on the current situation of biomass for energy under the Philippine situation and the

[*]) "Biomass resources" refer to non-fossilized, biodegradable organic material originating from naturally occurring or cultured plants, animals and micro-organisms, including agricultural products, by-products and residues such as, but not limited to, biofuels except corn, soya beans and rice but 0sugarcane and coconut, rice hulls, rice straws, coconut husks and shells, corn cobs, corn stovers, bagasse, biodegradable organic fractions of industrial and municipal wastes that can be used in bioconversion process and other processes, as well as gases and liquids recovered from the decomposition and/or extraction of non-fossilized and biodegradable organic materials. Sect4b of RA 9513. Renewable Energy Act of 2008.

second part is an assessment of the sustainability of biomass for energy along 3 indicators, namely: economy, ecology and society.

Biomass for Energy in the Philippines

Potential Power from Biomass

As defined in Sect.4b of RA 9513, the Renewable Energy Act of 2008, *"Biomass resources"* refer to non-fossilized, biodegradable organic material originating from naturally occurring or cultured plants, animals and micro-organisms, including agricultural products, by-products and residues such as, but not limited to, biofuels except corn, soya beans and rice but including sugarcane and coconut, rice hulls, rice straws, coconut husks and shells, corn cobs, corn stovers, bagasse, biodegradable organic fractions of industrial and municipal wastes that can be used in bioconversion process and other processes, as well as gases and liquids recovered from the decomposition and/or extraction of non-fossilized and biodegradable organic materials.

Philippines is providing incentives for renewable energy which started in March 27th, 2013 under the feed-in tariff system (Table 1). Section 7 of RA 9513 provides a feed-in tariff system (FITS) for electricity produced from wind, solar, ocean, run-of-river hydropower and biomass to accelerate the development of emerging renewable energy resources, The “feed-in tariff” guarantees energy companies an extra amount of money above the market rate for every kilowatt of clean power they sell. It was the spirit of 2008 renewable energy law to spur investment and see 50% of the country’s energy come from renewable sources by 2030, compared with about 39 percent currently. http://business.inquirer.net/114493/philippine-clean-energy-tariffs-to-start-next-year-government.

Table 1 **Feed-In Tariff Rates for Renewable energy.Source:Tadeo,2015)**

RE	ERC	Digression
Wind	P8.53	0.5% after 2 yr
Biomass	P6.63	0.5 after 2 yr
Solar	P9.68	6% after 1 yr
Hydro	P5.90	0.5 after 2 yr

FIT payment guidelines	ERC Res #24, s 2013
FIT rate	ERC Res # 10, s 2012
FIT rules	ERC Res #16, s 2010

The estimated potential power available from biomass in the Philippines is about 4,667.0 megawatts (MW) (Table 2) distributed in the 3 major islands. (The Philippines is composed of 7,100 islands.) Of the three major islands: Luzon has the most at 1,215 MW while Visayas and Mindanao have almost the same amount at 1,137 MW and 1,316 MW, respectively. There are 4 dominant crops (rice, corn, coconut, sugarcane) that occupy about 80% of the 10M ha agricultural lands . These 4 crops produce biomass (crop - industrial residues) that can provide feedstock to potentially produce 96% of the total 4,667.0 MW.

Table2.Potential Power from Available Biomass (Philippines, in MW)

(Amarra,2015)

Crop	Biomass Resources	Luzon	Visayas	Mindanao	Total
Palay	Rice Hull	126.00	8.60	20.58	155.18
	Rice Straw	207.60	79.30	142.72	429.62
Corn	Corn Cobs	116.29	3.60	14.63	134.52
	Corn Stalks	1,187.89	23.30	295.03	1,506.22
	Corn Leaves		11.30		11.3
Coconut	Coconut Shell	154.30	2.10	22.13	178.53
	Coconut Husk	345.10	2.10	63.62	410.82
	Coconut Frond	77.60		550.61	628.21
Sugarcane	Bagasse	0.10	842.30		842.4
	Cane Leaves / Cane Trash	0.30	87.80	58.44	146.5
	Waste Water		26.80		26.8
	Filter Cake		16.60		16.6
Oil Palm	Empty Fruit Bunch			3.88	3.8
	Shell			1.37	1.37
	Husk			2.56	2.56
	Frond			38.74	38.74
	Hogs/Swine Manure		19.60	1.56	21.16
	Chicken Manure		14.40	3.19	17.59
	MSW			27.12	27.12
Sawmill	Sawmill Slabs			63.52	63.52
	Sawmill Dust			6.73	6.73
	Total	**2,215.18**	**1,137.80**	**1,316.43**	**4,669.41**

1,032.34 MW for Sugarcane

Note: For Visayas, we used CEST and UASB Technologies
CEST (Condensing Extracting Steam Turbine)
UASB (Upflow Anaerobic Sludge Blanket Digestion)

The potential power (in MW) from the agro-industrial residues of the 4 crops are summarized as follows:

1.	Corn:	Corn stalks	=	1,500	(33.67%)
		Corn cobs	=	134.52	(2.88%)
		Corn leaves	=	11.3	(0.24%)
		TOTAL	=	1,652.04	(35.38%)
2.	Coconut:	Coconut shell	=	178.53	(3.82%)
		Coconut husk	=	410.82	(8.80%)
		Coconut frond	=	628.21	(26.08%)
3.	Sugarcane:	Bagasse	=	842.4	(18.04%)
		Cane leaves/ trash	=	146.54	(3.14%)
		Waste water	=	26.8	(0.58%)
		Filter cake	=	16.6	(0.36%)
		TOTAL	=	1,032.34	(22.1%)
4.	Rice	Rice hull	=	155.18	(3.32%)
		Rice straw	=	429.62	(9.20%)
		TOTAL`	=	548.8	(12.52%)

Shown in Table 2 are the potential biomass considered for firing power plants generated in terrestrial or land-based ecosystems. But lots of potentials equally exists on water-based (sea water, fresh water) or aquatic ecosystems.

Potential Power from algae

There are two forms of algae: *micro* which includes single-celled organisms, and *macro* which includes larger species such as seaweeds. In the US, it has been predicted that algae-derived biofuel could displace 70 billion litres per year of fossil fuels in road transport and aviation fuels by 2030 (http://www.carbontrust.co.uk/emerging -technologies/current-focus-areas/algae-biofuels-challenge/pages/algae-biofuels-challenge.aspx 33.).

In the Philippines, interests are high on sea-derived biomass or algae for energy. The Philippines has 220,000 ha coastal and marine areas where some areas could be tapped for sea weed (crop) farming. Eroding soils rich in nutrients and heavy use of fertilizers jointly flow to the river and lakes and finally to the seas. This leads to nutrient overload in these bodies of water leading to algal bloom or eutrophication. In fresh water lakes, growth of water lilies is so abundant and luxuriant causing lake eutrophication and fish death due to toxins emitted and high BOD, COD of decomposing biomass of water lilies not to mention the high organic matter and nutrient load coming from domestic wastes. Sea weeds could grow well in these quatic ecosystems.

"If there's an untapped potential sustainable energy resource, it is algae. Our efforts should be focused on realizing that potential. Algal R&D should become a national priority" (Angara, Chair of the Congressional Commission on Science, Technology and Engineering (COMSTE). " COMSTE had proposed the establishment of the Philippine Institute for Algae Research and Commercialization (PINARC), which will become an innovation cluster -- a three-way partnership between government, the academe and industry in algal R&D.(http://biofuels.carboncapturereport.org/cgi-in//profiler?key=Philippine_Institute_For_Algae_Research&pt=3#sthash.aUdC8EHA.dpuf). Biofuel policies as in corn ethanol in US were a major factor in food price spikes in 2008 (>100 million tons of corn are converted to ethanol). Thus, effort to find alternatives to fossil fuels should not compete with human foods," Seaweeds or algae for biofuels does not use arable lands . But lots of R&D needs to be conducted before algal biofuels become cheap as fossil fuels. Presently, algae are already utilized for nutraceuticals and animal feeds, for their proteins and omega-3 fatty acids. Subsidies for algal R&D for biofuels are not necessary because a processed algae industry in the country may already be

lucrative in itself,"(Angara,2014 http://biofuels.carboncapturereport.org/cgi-in//profiler?key=Philippine_Institute_For_Algae_Research&pt=3#sthash.aUdC8EHA.dpuf).

University –based Filipino scientists have been conducting extensive research on the use of algae as feedstock for biodiesel. The team of Professor Emeritus Milagros R. Martinez-Goss of the University of the Philippines Los Baños are researching algae as feedstocks for biodiesel.Promising species of freshwater microalgae such as *Chlorella vulgaris*, *Scenedesmus obliques* and *Nitzschia palae* are being tested as biodiesel feedstock. A larger R& D program which aims to characterize, optimize and genetically and physiologically modify microalgae for mass cultivation to be used for biodiesel production is also being done by UPLB in cooperation with the Ateneo de Manila University and the University of Santo Tomas.

At the University of Santo Tomas' Faculty of Engineering, Dr. Maria Natalia Dimaano in cooperation with the state-run Philippine National Oil Co.-Alternative Fuels Corp. (PNOC-AFC) are doing R&D on Algae as feedstock of biodiesel . "The algae are grown with sunlight, water and carbon-carrying emissions from power plants. Algae are harvested and turned into biodiesel fuel," "The algae growth rates increase in the presence of the carbon dioxide that would otherwise be emitted into the atmosphere."(Dimaano, 2008).

On the private sector side, there is at present an algae research and development being done by SECURA's network of Biotechnology Systems . The process and engineering design for a small-scale commercial production of 32 ponds of 16 cubic meters each are now in operation at Bgy. Tagpako, Gingoog City, Misamis Oriental, Mindanao , Philippines. (Manayaga,2015). The initial results from their pilot plant photobioreactors showed very encouraging data.

A review of second generation biofuels as in algae has been done (FAO ,2008) and the review points are summarized as follows :

>The cultivation of algae does not require land for food crops e.g. cultivated, forested. But cultivation areas of 1000ha may mean that algal production is not open to small holders as it requires a large area. *This could be remedied by group or Coop algal farm.*

> Can use wastewater as a source of nutrient input for algae cultivation. Algae removes nitrogen and phosphorus from effluents reducing eutrophication in the natural environment. *This is advantageous for many coastal areas in the Philippines.*

> Where wastewater is not available, application fertilizers will be required. The production of synthetic fertilizers is highly energy-intensive (ie. N-at 1.8 li diesel oil/kg).

> Algae have high oil or starch content (15-75% dry weight) resulting in a high biofuel yield (360 barrels/ha/yr). But No current reviews of the quality of final algae biodiesel – potential problems associated with their ability to grow at low temperatures and also degradability. This not a problem in the tropics like the ASEAN.

> Algae can be cultivated in saltwater and does not require a source of freshwater. Large-scale water consumption and the wastewater produced from algae cultivation requires treatment before discharge.

> Under optimal conditions, algae can double their biomass in 6-12 hours. Algae do not have a seasonal harvest unlike land-based crops .Tropical temperature is optimal for algal growth rates .

> Elevated levels of CO_2 are required to optimize growth. Algae can grow directly using combustion gas. Algae remove CO_2 and utilise it during biomass production. Requires large quantities of CO_2 restricting cultivation location close to source. Some sources of CO2 may require cleaning to remove toxic substances which is an expensive process. High quantities of CO2 in water cause a drop in pH.

> Research and development, construction, maintenance etc will create jobs.

> Although the potential for algae as second-generation biofuel production may exist in developing countries, the capital necessary to develop and install these technologies may not be available. Only a limited number of countries(Brazil, China and India) have started to invest and establish pilot projects on second generation biofuels(*Discussed further in 2.2.4.Biomass for Cellulosic ethanol*)

Status of Using Biomass (Agro-Industrial residues) for Energy in the Philippines

Corn and Coconuts

As shown above (Table 2), corn and coconut are the two dominant crops in the Philippines generating the highest potential biomass for energy. But no power plant is constructed or planned to utilize the residues of the 2 crops for power. This could be surprising to many. Let's examine the reasons.

For corn

In rural corn-farming communities, corn stalks is a treasured feed for carabao or cattle that are used for land preparation and power for transport. (This is fast eroding when Bt-corn was introduced and planted to about 0.8 M ha). Corn grain threshing by mobile-small threshers is done mostly in the farm where corn is planted and harvested.

There are few big mills but not big enough to accumulate cobs sufficient to supply the cob-fired power plant. Corn cobs is 65% by volume, hence, so bulky to transport. Farmers prefer to thresh the grain and leave behind cobs on-farm. Some farmers know already that once decomposed, they are good organic fertilizer. Logistics–wise, it is too costly to locate, and haul the voluminous corn cobs in long distance. The energy for hauling (2 li oil /Km of 5t/truck) may not be offset with the power (electricity) generated and sold to the grid even with the Feed-in-Tarrifs [3].

While the potential power that can be produced from corn stalks is huge (1,500 MW; 32.6% of the total 4,667 MW); it runs counter to the current use by the corn farming communities. It is no longer free. At present, corn farmers hardly share their corn stalks to fellow farmers. They are experiencing shortage of forage to feed their own carabaos or cattle especially during the dry season.

In summary, while corn co-products (leaves, stalks, cobs) top the list of potential biomass for power generation (35.38% of total), it is difficult to assure a dependable, reliable and adequate supply to meet the requirement of the power plant. Their current uses (corn stalks) and way of generating them (corn cobs) including collection and the energy needed in transporting bulky materials to the power plant must be weighed relative to the energy or electrical power that could be generated.

For coconuts

There are about 300 million coconuts planted mostly in hill sides and upland rolling topographies of the 3.0M ha of lands throughout the country. Coconuts are mostly grown in Southern Luzon, Visayas and Mindanao where there is almost even distribution of rainfall and affected by the sea breeze spray rich in NaCl. (*Clorine is an important element in coconut nutrition* [4]). This will contextualize the operationalization of the potential power from coco co-products (coconut shell, husks, fronds).

3Philippines' main incentive scheme for renewable energy finally come after a long regulatory struggle, Philippine clean energy tariffs to started March 27th, 2013 under the feed-in tariff system .The so called "feed-in tariff" guarantees energy companies an extra amount of money above the market rate for every kilowatt of clean power they sell.It was one of the main planks of a 2008 renewable energy law to spur investment and see 50% of the country's energy come from renewable sources by 2030, compared with about 39 percent currently. http://business.inquirer.net/114493/philippine-clean-energy-tariffs-to-start-next-year-government

[4]*Chlorine enhances root absorption and translocation of cations (Calcium, Magnesium, Potassium) in the plant system, increase photosynthesis,enhances leaf production , increase stem girth, minimizes leaf spots fungus disease, increase resistance to drought*
involve in osmotic regulation and fruiting, coco-meat formation- increases thickness and weight of meat or heavier copra weight. For optimum fruiting, chlorine is required up to 249 kg/ha (Quevier & Ouchs, 1978 as cited by Magat, 1999).

Coconut frond and husks

Coco-husks make the coconut so bulky and heavy to transport where the available way is through horse's back or man-carried traversing long, winding and variable up & down-slopes due to streams and river pathways. Pricing or cost of coco- husks collection for bulk transport near road sides of main highways is the main consideration. Same logic applies to coconut fronds. When coconuts with the husks are dehusked in the communities where people stay (hence, cooked their meals), coconut husks are used to fuel their biomass (wood) stove.

The increase in the price of LPG, charcoal, or firewood elevated the importance of coconut husks for rural household fuel for cooking. At present, even coco coir factories are finding difficulties in collecting (they are now buying) coconut husks to satisfy their factory requirement for viable operation and to meet the demand for coco coir fiber and dusts. Planning to construct coco husks/frond- fired power plant, while theoretical estimates for husks/frond residues are high. But the challenge of collecting/hauling dispersed husks and coco frond should be considered.

Coconut shell is now a treasured coconut co-product. Coco shell has high heating value (households knew this all along). In the market where coconut is being sold for coco-milk extraction termed "gata" , coco-shells are used as fuel for cooking. In communities where there are still sources of firewood, coco shells are sold, and made into coco-charcoal, then sold to buyers. A number of enterprising people are into processing coco shell into "activated carbon."
For coco shell-fired power plant (potential power generation = 178.53 MW) , investors and stockholders/financiers need to address the following:

1) Collecting sufficient volume of coco shells by out-competing the current users i.e. households, charcoal makers – sellers, entrepreneurs making activated carbon.
2) Costs of collecting/ hauling dispersed coco shells assuming the price offered is acceptable so coconuts with husks will be transported instead of just being left on-site to lighten the load of

carrying them and/or higher price could be offered than current users .

Coconut co-products ranks second to corn in generating potential power from biomass (26.08% of the total). The uniqueness of coconut, considered as *'tree of life'* presents a formidable challenge for would-be investors to finance/construct a coco-husks/shell-fired power plant. The place where coconuts are grown where their co-products (coco fronds, shells , husks,shells) will be so hard and expensive to collect .

Sugarcane

Bagasse fueling for power has been done in the sugar industry since its inception (100 years or more in the Philippines) starting from the muscovado sugar (direct fired-vat) to concentrate the juice to the centrifugal method of sugar manufacture. Raw sugar processing and power generation are interdependent (Amarra, 2015). This makes the sugar industry, the premiere industry in the country to be external power neutral or it can even be a supplier. However, it was only recently that the sugarcane industry could export or sell extra-power to the grid.

Due to changing policies (feed-in-tariff incentives as shown in Table 1), a growing number of sugar mills had installed COGEN in their factory. There are now 3 sugar mills [First Farmers (21 MW), Crystal (9MW), CASA (8MW)] where COGEN facilities are installed, generating a total 38 MW. There are still 5 more sugar mills that will operate soon, their COGEN facility generating about 122 MW (Amara, 2015). Their excess COGEN power after sugar processing could now be sold to the grid. Thus, a president of one sugar mill said *"Cogen is evolving as the 2nd industry within the sugar industry"*. This makes sense if the feed-in-tarriff for biomass COGEN could be maintained at P6.33/kWhr. With increasing costs of cane production, and raw sugar processing, additional revenues through COGEN by the industry partners (planter, miller) is necessary for sustained economic viability .

But COGEN in the sugar mill undoubtedly, has also some problems which should be attended to. In the earlier set-up , bagasse fueling of boilers do not yield extra income, though the mills realized reduced costs as bunker oil is minimally used. Many mills simply used bunker oil for start up operations but once bagasse is available, source of fuel is automatically shifted to bagasse . High priced oil made other mills to altogether forego using bunker oil and instead, they use biomass (wood, napier grass, baled trash and stored bagasse).The lack of share in COGEN revenues emanated from the existing sharing system under the law (R.A. 809) as only the main product (sugar) and co-product (molasses) are shared. This should be extended to the other by-products (mudpress, mill ash) including bagasse as the mill is earning from COGEN from bagasse. This is especially true for purely private-owned mills (except the coop-owned mills). Thailand is into cane purchase system (CPS), thus, the mill owned all the canes. This may not be true also as the planters will soon demand higher price of their canes. Earlier, the price was indexed to the amount of sugar that could be processed per ton of cane. With COGEN, they could also compute the extra-income (less the energy for raw sugar processing) generated from COGEN. Obviously, they will demand add-on price to their canes.

Everybody recognizes the changing and more difficult production environment (climate change, increasing cost of production – high priced oil fertilizer and other inputs, high priced labor) and free-trade relations (due to globalization, AEC in the region). Both partners of the sugar industry, will be happy if both realized benefits from COGEN. The planters grow/produce the feedstock. Simply stated *" COGEN starts from the field*". The Philippines has 100 M population Philippines. The optimum area (0.41-0.43 ha/person, CIA, 2003, Mendoza, 2008) had been exceeded 3.3 times. Because of this, the 62,000 sugarcane planters will grow sugarcane continuously if they perceived they earn more by planting sugarcane, or they may palnt other higher income generating crops.

The initial assessment that COGEN shall ensure the economic viability of the 2-major products of sugarcane-based industry (food sugar and COGEN power) is a big boost to the current 2 billion dollar (USD) earnings of the industry directly supporting/employing 0.700 million people and indirectly employing 5 million more. If all the mills in the Philippines will construct COGEN plant (High pressure system @ ~ 65 bar, with excess power 55 kWh/tonne cane) revenues alone from the feed-in-tariff at P6.63/kWhr amounts to PhP2.655 billion (Table 3) on a per day basis. Even if only half of the 27 sugar mills will install COGEN facilty ,at an average 116 milling days, the gross revenue shall be about 154 billion pesos (3.5 billion USD).

Table 3. Estimated Exportable Power Potentials of the Sugar Mills (in kWhr)

Location	Capacity, TCD	Cogeneration System			FITs(P6.63/kW)
		Low Pressure	Medium Pressure	High Pressure	Potential Income
Luzon	35,500	11,833	41,417	75,931	503423
Negros	93,200	31,067	108,733	224,263	1486864
Panay	3,500	1,167	4,083	7,486	49632
E. Visayas	8,000	1,000	3,500	7,219	47862
Mindanao	40,000	13,333	46,667	85,556	567236
Total	180,200	58,400	204,400	400,453	2655003
		Low pressure system @ ~ 30 bar, with excess power in kWhr/tonne cane=10	*Medium pressure system @ ~ 45 bar, with excess power in kWh/tonne cane=35*	*High pressure system @ ~ 65 bar, with excess power in kWh/tonne cane =55*	

Source :Amarra,2015

Rice

Power generation from rice co-product is a recent phenomenon in the Philippines. There are 4 rice husk fired-power plants in the Philippines (Table 4). Three (3) of them are located in Nueva Ecija and one in Isabela province producing a total power of 49 MW or 44.1 MW net power after deducting parasitic load. All the power plants employ high boiler steam pressure (65 bar) and high temperature (485C). The average investment per MW = 2.073 million US dollar and 1.459 tCO_2/year/MW GHG emission reduction. Just like the "COGEN" for the sugar industry, "the main proponent and private company installing rice husks - fired power plant claim… *"Biomass to Energy is a sunrise Industry*" (Tadeo, 2015).

Just like bagasse, rice husks (20-22% of unmilled rice) is not yet "treasured" or valued co-product of rice milling. Hence, it is simply treated as wastes or "noxious" by-product unworthy of retrieval. Likewise, the current set-up is that the big rice traders (buyers) are also the owners of the big rice mills. These big rice mills either co-own or they are the major stockholders (President, Chair of the Board) of the rice husks-fired power plants. Similar to sugarcane bagasse, the rice farmers also do not put value to their rice hull when selling their rice harvests . But when the net income from the power generated from their rice husks are known and accounted for, they will demand payment.

Similarly, there is the question of "what is the best use of rice husk?" for power generation or for increasing the soil organic carbon where rice is grown? Currently, all rice soils (and all other crops – corn, sugarcane, pineapple) have low soil organic carbon or soil organic matter (Alaban *et al*.,1990). Rice husks has 70% fiber and 10-20% silica(Thenabu,1979). Rice straws contain 50g-61g Si per kg straw (De datta,1980;Lian 1976 and Lian *et al*., 2006)(Low SOM is related to decreased buffering capacity of the soil, low exposed hydroxyl sites for holding cations, low water holding capacity ,high bulk density, difficult to till the heavy/clayey soils. Decomposition of organic matter provides C and energy to N-fixing bacteria, food for the bacteria synthesizing plant growth hormone, solubilizing phosphorus, allowing more root proliferation and growth. This is also true for the other co-products i.e. rice straws which is 45-50% of grain yield, are identified or perceived as voluminous that could generate 429.63 MW. Again, same question could be raised on *what is the best use of rice straw* considering their potential to generate power is 3 times higher than rice husks at 155.18MW only.

Putting back rice husks or rice straws (instead of burning them) increases the organic matter. But under anaerobic decomposition, methane emission increase (which has 25 times higher GWP relative to $CO_{2)}$. In a recent study methane emission accounted for 70% of all the GHG emission in rice from production – to-post production (cooking). But CH_4 emission could be reduced significantly by alternate wetting drying, moist soil only irrigation management, or mid-season drained paddy fields, collecting rice straws and partially decomposing them aerobically using aerobic compost-enhancing-bacteria(Taghavi ,2015).Back to the question "where to best use the co-products (rice hull, rice straw)?" *This is discussed in the final section " Addressing the biomass sustainability issue on technical, economic, social and political"*

Forest and other biomass

From 15Mha in the early 1900, it is down to 8Mha of secondary growth and a little primary/virgin forests (1.8 ha). By products of few sawmills processing planted fast growing tree species (falcata, mahogany, eucalyptus) could not generate sufficient mill waste – fired power plant. Besides, saw mill wastes have many uses (for household wood stove, mulch for lawn and garden), source of carbon for producing organic fertilizers.Altogether , this transformed the label will waste to mill co-products (It is PhP10/30kg bag! 1USD = PhP47).

The paper and particle board requirement of the Philippines require huge area to be planted to fast growing tree species. Using trees to fuel power plants requires that tree-planters should earn equally or more by selling their harvestable trees to provide the fuel requirements of power plants instead of selling them to paper mills or plywood manufacturers , and furnitures-makers. With the current price of oil($30/barrel),using trees to fuel power plants will not be competitive.

In the 70s, the Philippines tried a wood fired-power plant using *Leucaena leucocephala* (Giant Ipil-ipil). It did not prosper since the power plant ceased operation when jumping psylid, a damaging insect infested Ipil-ipil trees. While Ipil-ipil plants recovered after 5 years, it dampened the interests and enthusiasm of growing them in large scale. The stigma and fear of psylid infestation coming-back had stick into the mind of people.

Almost a decade ago, large scale planting Jatropha trees whose fruits could be processed into biodiesel had rekindled interests of both tree-enthusiasts and mill investors. This eventually died down since the promised yield of 5.0 t/ha was not realized even in small scale planting. The claim that Jatropha could be planted in marginal areas/soil ,thus, it will not compete with foods crops lands was also not proven. Planted in marginal soils , Jatropha yielded low yield (500-700 kg/ha) hence, low biodiesel yields/ha. Large areas (hilly lands) should be planted to satisfy the seeds for feedstock requirement of the Jatropha factory where road infrastructure (including bridges) are not yet built. Low yield means low income for the farmers. Who will plant them ? A farmer provided a bench mark income of PhP100,000/ha (2,275 USD/ha) or more to make a new crop out compete other crop options in a land scarce country like the Philippines.

Animal Wastes (Manure)

Production of biogas (methane) from animal manures (hogs, poultry, cattle) is about half century old in the Philippines. Livesctock raisers, especially hog or swine growers are pressured to go biogas due to economic, social, environmental reasons. The decomposing manure emits more than 200 compounds, most dominant are hydrogen sulfide and methane which when combined produce obnoxious and stinky odor that irritate communities .Plus the houseflies that quickly reproduce on the highly nutritious but bad smelling manure flies out the poultry farms and spread out profusely in nearby houses . Manure disposed in rivers lead to high BOD/COD and nutrient overload once used in rice paddies for irrigation water makes rice plants grow tall and lodge. Yields are low to nothing in excessively manure fertigated (fertilized + irrigated) rice fields. Laws are there (Clean Air Act, Water Act and Ecowaste Management Act) but observance or obedience is another. Monitoring and enforcement officers are inadequate.

Livestock/hog raisers can now avail of incentives and credit for biogas plant installation. The Land Bank of the Philippines environmental program co-financed the installation of biogas power plants (biogas → mechanical → electrical energy). Incentives come in the form of rebates provided through the CDM (clean development mechanism). But the interests died down when the premium was reduced and collection became extra difficult.

Biomass for Cellulosic ethanol

The world's oil supply is estimated to last for 4 t0 5 decades at the current rate of usage (Rodolfo, 2008).Due to this , there was vigorous efforts to produce liquid biofuel (bioethanol & biodiesel from crops). They are called the 1st generation of biofuel which draws a lot of criticisms as the feedstocks directly compete with human food. Come the 2nd generation of biofuel- the feedstock from cellulose- an abundant compound found within plants and trees . It consists of long chains of glucose molecules and once broken down , it can form cellulose ethanol.

Many years ago, it was just a dream to process cellulosic biomass into ethanol. Way back in 1975, Patrick Foody Sr. initiated work on a "steam explosion" process to improve cellulose digestibility for use as animal feed . In 1978 – US DOE investigated the performance of steam explosion for energy production. The process was found to deliver superior results compared with the prior state of the art pretreatments. 1980 – The company initiates research on enzymes and biotechnology.In 1982, the company built an integrated 1 tonne per day cellulosic ethanol pilot plant, using wood as a feedstock. In 1990, Iogen enters the commercial enzymes business, focusing on producing enzymes that digest natural fiber. In 2013, Iogen sold its commercial enzyme business to Novozymes.1991 – Iogen forms an alliance with Amoco for the development of cellulosic technology, ending in 1995 when Amoco terminated alternative fuels development. 1999, $15.8 million investment from Petro Canada and $10 million from Technology Partnerships Canada, Iogen initiated construction of the world's first demonstration-scale plant. By 2002, Shell made an initial commitment of $46 million to invest in developing Iogen cellulosic biofuel technology. In 2004, Iogen initiated commercial sale of cellulosic ethanol from its demonstration plant. Over the following years, Iogen invested in several rounds of demonstration plant upgrades, solving production scale-up issues. By 2006, Goldman Sachs invested $40 million in Iogen; 2007 – Volkswagen invested $10 million in Iogen, and studies the German potential. In 2010, Shell and Cosan announced that they were forming a Brazilian joint venture, and Shell transfered its holdings in Iogen Energy to Raízen. By 2012, Shell announced the termination of its pursuit of a cellulosic ethanol project in

Canada. By 2013, Raízen begun the construction of their $US100 million "biomass-to-ethanol" facility in their Costa Pinto sugar cane mill in Piracicaba, São Paulo, Brazil. Their facility is capable of converting sugar cane bagasse and straw into 40 million litres per year of advanced, second generation cellulosic biofuel. Their target is to produce 1 billion liters of advanced, second generation cellulosic biofuel by 2024 (Lane, 2014).

The bagasse-to-ethanol of producing cellulosic biofuel has unique features as follows: it uses feedstock delivered to the mill, shares existing equipment and facilities, and it enables the mill to extend their operating systems. The reported production coefficients (Lane, 2014) are: 80-100 gal (300-400 li) of ethanol /tonne of bagasse. Sugarcane on dry basis has 1/3 sugar, 1/3 bagasse and 1/3 tops+trash. Using these coefficients, 125 million (dry) tonne annual Brazilian cane harvest produces around 41 million tonnes each of bagasse and tops/cane trash. At 80-100 gallons per tonne (if all of it will be used) , 6.5- 8.2 billion gallons of ethanol, or 26-32.8 billion liters. At 40 % use of biomass for ethanol (the remainder shall be used as biomass in the field for nutrient purposes, or burned for power generation), the ethanol that could be produced will be 10.4-13.12 billion li of ethanol (Lane ,2014).

Cellulose ethanol is an alternative to fossil fuels. But it has also some disadvantages as follows:1) the average fuel economy of E85 was tested at 13.5 miles per gallon, which is lower than the 18.3 miles per gallon (0.73) obtained with gasoline; 2) cellulose ethanol absorbs water and is also a corrosive substance. This makes current pipelines incompatible with ethanol transportation, although modifications could be made in the future. There will be higher cost of transport through the use of railways or trucks; and 3) ethanol-containing fuels are hygroscopic (absorb 50 times more water than conventional fuels). E10, an ethanol-blend fuel, has a shelf life of approximately three months and fuel in tanks should be replaced every two to three weeks to avoid alcohol- and water-related engine problems (Samuel Markings, 2014).

Assessing the Sustainability of some Biomass for Energy in the Philippine Context

Sugarcane bagasse –fired boiler has been with us for the last 100 years. It sustained the sugar industry energy needs, made juice concentration easy and cheap. Bagasse is a co-product after juice extraction (20-22% of cane weight). Costs of hauling and producing are passed on items. Bagasse disposal when used as fuel is no longer a problem compared to other residues. Ever since, centrifugal mills use steam converted into power to supply the electrical energy needs of the several moving parts of the mill. On the average, only 50% or less of the potential power is utilized by the mill. The current policies allowing COGEN to be sold to the grid altered the once financially challenged centrifugal sugar mills. COGEN offers life line to a new sun rise industry within the industry employing 0.7 million and another 5 million indirectly and infusing about 2 billion dollar (USD) income into the Philippines economy. The challenge is how to spread the benefits (inclusive growth principle). It is true that the mill owners are the investors (equity + loan). But the feedstock (sugarcane → raw sugar + bagasse + molasses+ mudpress + mill ash) is produced by the 62,000 planters. Only sugar and molasses are being shared. COGEN is a new experience or young co-industry in the sugar industry. Thus ,the law (R.A. 809) that stipulates sharing of sugarcane product and co-products does not include COGEN power sold to the grid.

Sugarcane trash, the other co-product is voluminous as well (12-15% of tonnage). The problem is hauling or collection. It is so bulky and lots of energy is also needed in baling and hauling if the source is far from the mill. (Small baling machines are available but big baling machines will not fit the small lots and rugged terrain where many sugarcane farms are located). Earlier, the use of sugarcane trash was well studied. It was found that trash be allowed to decompose in the fields. The present agricultural practices can be likened to “mining the soil” as they are so “extractive" (Mendoza 1989;). As such, the soils are impoverished (Alaban et al 1990) attributed mainly to non- crop residues recycling as they are simply burned in the farms where they are harvested. Mendoza *et al.,* (2003) presented a summarized benefits of trash farming in sugarcane.

Rice and sugarcane occupy only about 30% of the 10 million ha agricultural lands but 50% of all fertilizers in the country are used by these crops (Briones 2014).There are other utilization option for the crop residues as in biofuel or feedstock for gasification or for 2nd generation ethanol but recycling them back in the farm where they are produced is still the best utilization option (Lal, 2005; Mendoza and Samson, 2006; Parr *et al*. ,1986). The positive merits of crop residue recycling are well studied and documented. The causes and/or reasons why rice straws and sugarcane trashes are burned (Mendoza, 2015) despite the known merits and long term positive effects of crop residue recycling on soil fertility and productivity are summarized below:
For rice

Prevent farther spread of disease inoculums (RTV in rice). Short turnaround time, rice straws abstract land preparation suing small machines. Cattle raisers are afraid of the insecticides residues. Rice straws are hiding *place for rats. Yellowing of transplanted seedlings with rice straws. Duck raisers burn rice straws. Rice straws are burnt by passersby near the road. Fertilizers are cheap due to government subsidy. Extension agents and sales representatives are given incentive proportional to fertilizer rates.*

For sugarcane trashes **:** *1956 (Pineda) sugarcane soils were still fertile and fertilizers were cheap. Burning cane fields easily transfer in non-burnt canes during hot and windy days. Cigarette butts are thrown by passersby. Harvesting non-burnt canes slows down work by 40%. Weedy fields is difficult to harvest and the fear of snakes biting the harvester. Trashes obstruct tillage for ratoon and plant cane establishment. Piling trashes is laborious, labor demand coincides with peak harvesting High risks that piled trashes between rows would be burned including the actively growing canes.*

Rice husks- fired power plants are soon to operate (3 of them) but one is already operational. The interests are high in using rice husks-fired power plants due to the following reasons:

1) The current government policy allowing private sector to invest/construct renewable energy-power plants and sell it to the grid. Before, this was not allowed.
2) There is feed-in-tariff (FIT) incentives to participants or investors/owner.
3) Burn them to generate power is meritorious. Mountains of rice husks are available. Disposal is expensive. Where to find disposal site is difficult or far from where it is produced.
4) The dominant view is that rice husks is just burnt for easy and quick disposal although health and environmental hazards due to burning rice straws are well studied(Gadde *et al*.2009)

There are 2 interrelated concerns and they are:

What is the best use of rice husks *for fuel* or *rice husks for recycling in the farm.* A growing body of evidence indicates that adequate uptake of silicon (Si) can substantially increase the tolerance of rice (Oryza sativa L.), sugarcane (Saccharum officinarum L.) and other crops to both abiotic and biotic stresses (Dantoff *et. al*., 2001; Ma and Takahashi, 2002).CRH (Biochar) mixed with animal manure makes good quality organic fertilizer. At present , many farmers know already how to carbonize rice husk (CRH) producing what is popularized as “biochar.” It is a good soil conditioner.

CRH applied underneath poultry/broiler houses, check-off odor and houseflies multiplication .Feed conversion efficiency, average daily gain of broilers increase and overall weight increased at harvest and quality organic fertilizer is also produced after harvesting the birds. Poultry and duck raisers are buying rice husks already.

Rice husks used for fuel is common. Rice husk stoves are available. When it was still free in the province of Laguna, many households use rice hull stove for cooking meals.

The view that rice husks is abundant and free is not true in many provinces. Rice mill are selling rice hulls already. Will it be lower or higher in the future? Used as feedstock to produce power, farmers will eventually claim ownership of the co-products. What is the just pay or price of rice husks? In Bay, Laguna, rice hull is sold at P10/20kg. The buyer own the sack. It suggests that rice hull is priced at P0.50/kg (1.136 US cents/kg). Will the rice husks-fired power plant run economically viable at this price of rice husks.

Rice husks- fired power plants could still earn additional income from RHA. Rice husk ash (RHA) has many uses.

RHA has numerous applications in silicon based industries. Substantial research has been carried out on the use of RHA as a mineral admixture in the manufacture of concrete. RHA in amorphous form can be used as a partial substitute for Portland cement and as an admixture in high strength and high performance concretes. Due to its refractory properties, crystalline RHA is the most wanted material for steel industries, ceramic industry and for the manufacture of refractory bricks [Prasad et al., 2000 and Bronzeoak, 2003]. Basha et al., (2005) examined the possibilities of improving residual soil properties by mixing RHA and cement in suitable proportions as stabilizing agent. Indian Space Research Organization has successfully developed a technology for producing high purity silica from RHA that can be used in silicon chip manufacture [Bronzeoak, 2003]. Naito (1999) introduced a low cost technology for controlling insect pests in Soya beans by using RHA. The insects are irritated by the high levels of silicon and the needle like particles. Saha et al., (2001) studied the possibility of using RHA for manufacturing activated carbon, and confirmed its usefulness in water purification. (Source : http://shodhganga.inflibnet.ac.in: 8080/jspui/bitstream/10603/5599/10/10_chapter%202.pdf)

Biogas production from hog manure solves social , environmental and public health problems of odor, pollution of water ways and rivers used for bathing/swimming; kill fishes or make them unable to reproduce. The bank financed construction of biogas-power plant should be expanded. They should also qualify under the FITS being a renewable energy source. CDM had been widely criticized including in the recently released 182 pages ecclesiastical paper of Pope Francis. FIT is the way to go rather than CDM. Heavy GHG emitters should not be made free from their acts because they can pay or underpay excessively their environmental baggage. The Philippines has more than 5 decades experience on biogas. Maramba et al. had optimized the process of biogas in the 70's (http://journeytoforever.org/biofuel_library/biogasPhilippines.pdf)

Meat lovers should join the campaign on environmental clean-up and stop methane GHG emission from animal manures. One best practice is biogas. It helps alleviate energy and environmental problems. Moreover, it is socially-positive and economically viable.

General interrelated issues / concerns regarding Biomass –to- Energy

Supply of biomass

As shown in table 1, potential supply of biomass in the Philippines is enormous. As proposed by Tadeo (2015) , there are at least 4 ways of estimating biomass potential supply. *First, is the theoretical biomass potential* (Bth) – the maximum volume of biomass based on the accepted residue-to-product (RPR) ratio ; *second is the technical biomass potential* (Bte) - the volume of biomass left from the theoretical after factoring the recoverability factor (RF) of each biomass resource, *third* is the *realistic biomass potential* (Bre) - the volume of biomass left from the technical potential after deducting the competing uses (CU), including the biomass for own use and *finally*, the *available biomass potential* (Bav) - the volume of biomass left from the realistic potential after deducting the biomass feedstock requirements of planned and existing power projects based on the survey and published DOE's pending and awarded biomass renewable energy operating contracts (BREOC)Tadeo, 2015).

The estimates of available biomass based on the survey and published by DOE's pending and awarded biomass renewable energy operating contracts (BREOC) may still be an over estimate since it does not include the local uses of biomass. It may be correct for the time being while the farmers in the locality have not found better and practical uses for their crop residues – the competing uses. In Laguna, there are many competing uses for rice husks(*for balut making, fuel for bakeries, noodle manufacture, potting media for ornamentals, mulching materials, carbonized to mixed in making organic fertilizer etc.).* Yes, it is burned but for cooking and baking. Where there are rice husked-fired power plant, it is accepted that it is treated as *'wastes'* and burned for easy and quick disposal. But a growing numbers of farmers are realizing the many uses of their crop residues. This relates to the next issue or concern.

Pricing of biomass for fueling power plant

Prices of any commodity is influenced by many factors (basic economics, 'the supply and demand'). Earlier, the term crop residues (biomass) or wastes is replaced by the term co-product. Why? Once society recognized the utility value of any material, it suddenly assumes financial or monetary value. Examples :*sugarcane bagasse* - for cogen power,particle board , cellulose for ethanol;rice husks - for power,fuel for bakeries,potting media,"balut" making

The question is the "just price" for the farmers/producers and the users/factory owners. It will not be an issue for those factory owners who also own the farm, hence, they also own the co-products. Example is the coop-owned mill by sugarcane planters in Negros Occidental, Philippines. Their decision is to go COGEN and it is working to their advantage and benefits, financially. In the case of Central Azucarera de Tarlac, when they were using baled trash for fueling their sugar mill boilers, they have no problem at that time. It is not the same anymore as Hacienda Luisita had been redistributed to their workers.

The pricing issue of the co-products remains to be settled. The following may serve as benchmark for the co-product price estimates.

1) For bagasse used in COGEN, the net sales after the computed/actual payback period. Under the law that govern sugar product sharing (R.A. 809), there are at least 3 tiers: 60:40, 65:35, 70:30 for planters and millers, respectively. Pricing of bagasse per ton may be started based from the R.A. 809 that stipulated sharing between the planters and millers on sugarcane products and co-products. The actual monetary (peso) price can be computed from the power sales to the grid as a function of COGEN power (kWH) per ton of bagasse after the pay back period.

For rice husks, there are recent developments that must be anticipated. Consumers (rice eaters) are beginning to realize the merits of "brown" or simply dehulled rice. Brown rice is more expensive than well-milled rice. Brown rice milling is currently done in small rice mills. Big rice mills can re-trofit the needed attachment to dehull rice into brown rice as the end-produced. What is the merit of pointing this development? Rice husks, once dubbed as voluminous "wastes" in rice milling will be dispersed in small mills which will reduce the available unmilled rice for milling (brown rice or well-milled rice) in the big rice mills. Then, aside from the energy /financial costs of hauling, there will be "buying" costs from the "owners". In Bay, as stated earlier, rice husk is priced at P10/20kg bag or at P.50/kg. At this price, it should be asked whether the feedstock price is still profitable to run the husked-fired power plant?

Napier grass or any tree grown for fueling power plants. To avoid the society's concern of prioritizing energy over foods, it is being suggested that these crops shall be grown in marginal soils or areas which are not grown to food crops. Incidentally, in the Philippines whose land area (30M ha) is so dense in relation to the population (100 million), it is difficult to locate such areas to be planted to biofuel crops that will not compete to food crops. From agronomic point of view, "marginal soil" is relative. Soils are marginal because they are eroded, acidic, and low in soil nutrients , and rainfed. Once nutrients and irrigation water are provided, it is not marginal anymore . The soil becomes favorable for any crops to be grown. Consider soils in Israel which were made so productive through drip-fertigation technology.

In Thailand, napier grass is being grown by farmers and regularly cut and sold to cattle growers-fatteners. Napier grass grown for cattle fattening can serve as benchmark price for growing napier as fuel for power plant (Thailand farmers and agronomists know more about this!).

In Mindanao, Philippines, there are increasing number of farmers planting fast growing tree species for paper and plywood manufacturing. The purchase price of log grown for this purpose can also serve as benchmark price for wood to be used in firing power plants (PhP2,500/m^3).

The agronomy of biomass production for power

Crisis propels change…… scarcity is the mother of invention…… biomass energy is a sunrise industry!..

Crisis propels change is similar to *scarcity is the mother of invention* . When there was food crisis, agronomists were challenge to develop high yielding technologies. When Malthus predicted in the later portion of the 19th century that there will be massive food shortage because food production is increasing arithmetically and population increases exponentially, not only agronomists responded but the whole multitude of disciplines. Human kind was able to produce more than enough food through chemical/industrial or green revolution agriculture although there are still many who are hungry now (820 million). Why these brief history was mentioned ? So the mistakes or the pitfalls of green revolution – chemical agriculture will not be remembered as we pursue dual objectives in crop production – food and energy.

Crop production is simply management of crop photosynthesis where the basic equation could be describe below:

$Y = G + E + (G \times E) + M$

Where :*Y = yield ;G =genotype – crop or tree species and the variety within species;E =the environment which refers to the soil (soil quality, location, topography) and climate ;M =management which refers to selection/ identification of best adapted species/variety for the soil/location, time of crop establishment, inputs tools/ equipment used or the level of management or input application (low, medium, high).*

From the simplified equation, it denotes that crop production is technology and knowledge – intensive if we are to get high yield. This is especially true at this time – climate change, increasing prices of inputs, migrating rural labor to the cities.

When the sun rise, there are lots of energy in the light spectrum for crop photosynthesis. But the yield equation described above must be satisfied. In plain language, it is equal to seeds, inputs, machines, tools, equipment, capital, roads, credit and the bottom line profit for the farmers growing the crops. Benchmark income cited by a farmer: a farmer should earn at least P100,000 per ha per year. Can a farmer growing napier or fast growing tree species for energy earn at least P100,000/ha per hear?

Addressing the biomass sustainability should include the technical, economic, social and political

Finally, the biomass sustainability issue is a complex issue to tackle. It is *technical, economic, social and political.* On *technical*, the yield equation described earlier presents directly and indirectly technical parameters of sustainability. On soil fertility, sustaining soil fertility means nutrients absorbed must be balanced by nutrients applied (or $N_{in}= N_{out}$). Taking out biomass for power goes with it the nutrients absorbed. Where will nutrients come from? From Haber-Bosch manufactured N-fertilizer which used 1.8 li diesel oil per kg (Pfeiffer,2003; Mclaughlin *et al*. 2000). Production of energy from biomass consumed also energy across the chain starting from land preparation, fertilizer application, harvesting, hauling, processing. To increase yield, chemical N fertilizer are applied but soil becomes acidic with time (lessons from green revolution agriculture). For sugarcane, per ton cane produced, 1.5, 0.75, 2.0 kg of N, P, K are absorbed. With time, when soil organic matter declined, fertilizer use efficiency declined. *(The agro-ecological importance of humus is summarized in* Mendoza *et al., 2003*[5] *).*This led to increased application of fertilizer to achieve same yield level(high energy bill from fertilizer).

[5]*Agro-ecological importance of humus as summarized by Mendoza et al.,2004*

•Humus gives the top soil a dark or brownish color, indicative of a fertile soil
•Humus serves as stock of nutrients for higher plants
•Humus provides several active agents, plant hormones and antibiotics
•Humus supports nitrogen fixing organisms
•Humus enhances the physical and chemical properties of soil by: 1.enhancing soil cation exchange capacity;2.improving the soil water holding capacity (4 to 5 x more than clay, humus absorbs water 80- 90% of its weight);3.acting like glue to link mineral soil particles to so-called clay-humus complexes, thus improving soil particle aggregation
•Humus reacts with many substances to form complexes. For example, humus:1.Reacts with oxides of iron and aluminum to form a stable aggregate, thus reducing toxic metal concentrations ;2.Reacts with herbicides applied in the soil ;3.Serves as buffer system for the pH value in the soil

The basic equation of photosynthesis is … $CO_2 + H_2O \rightarrow CHO_n + O_2$
CO_2 is non-limiting but water is. In general, 1 ton of dry biomass consumes 3,000 tons of water. Growing crops (biomass) for power shall require tremendous amount of water. This happen at a time that fresh water supply for irrigating food-agriculture and household (existing industry-use) is already limiting or reaching scarcity level. Furthermore, conversion of biodiverse forestlands to –single monocrops have multiple effects on water/hydrologic cycle, biodiversity habitat, soil erosion etc. is a common knowledge now.

Brazil plans to expand sugarcane areas from the current 9.5milion ha to 17 million ha for bio ethanol. Between 2000 and 2010, three million Brazilian hectares were converted to sugarcane cultivation areas. More than 70% of this land consisted of pastures, and 25% had been used for growing grains (http://phys.org/news/2014-07-payback-soil-carbon-pasture-conversion.html#jCp). In Germany, Oil World expects the EU's rapeseed production to take a hit from the current hot and dry weather. Production is estimated to reach only 21.8 million metric tons, down from more than 24 million tons in 2014 (http://www.biofuelsdigest.com/bdigest/2015/07/01/oil-world-expects-dry-hot-weather-to-hit-eu-rapeseed-production-further/).

The technical issue of crop production for biomass $\rightarrow$ power… extends now to economic, social and political.

It becomes very political when there are brownouts due to power shortage.

It becomes very political when there is no water for household use and the media portrayed communities on long-files waiting for their turn to fetch water.

Moreso, *it becomes very politically explosive when food staple is scarce or there is perceived shortage.*

"Biomass to energy is a sun rise industry!" Yes, but we know that the sun rises in the morning if only to set again in the evening! Can we avoid the sun rotating from its own axis?

How can the biomass to energy evade the universal rule "What comes up will come down?"

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