Decentralized Biomass & Wind Power Systems for Energy Self-Sufficient Rural Communities in the Philippine Islands

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Think Green & Smart

- The Philippines is an archipelago .
- 7,107 islands covering a total land area of 299,764 square km.
- Coastline is 17,500 km long, with the Pacific Ocean on the east, the South China Sea on the west and north, and the Celebes Sea on the south.
- This position accounts for much of the variations in geographic, climatic and vegetational conditions in the country.
- Climate is tropical with relatively abundant rainfall and gentle winds. Three pronounced seasons: Wet or rainy season from June to October, cool, dry season from November to February, and hot, dry season from March to May.

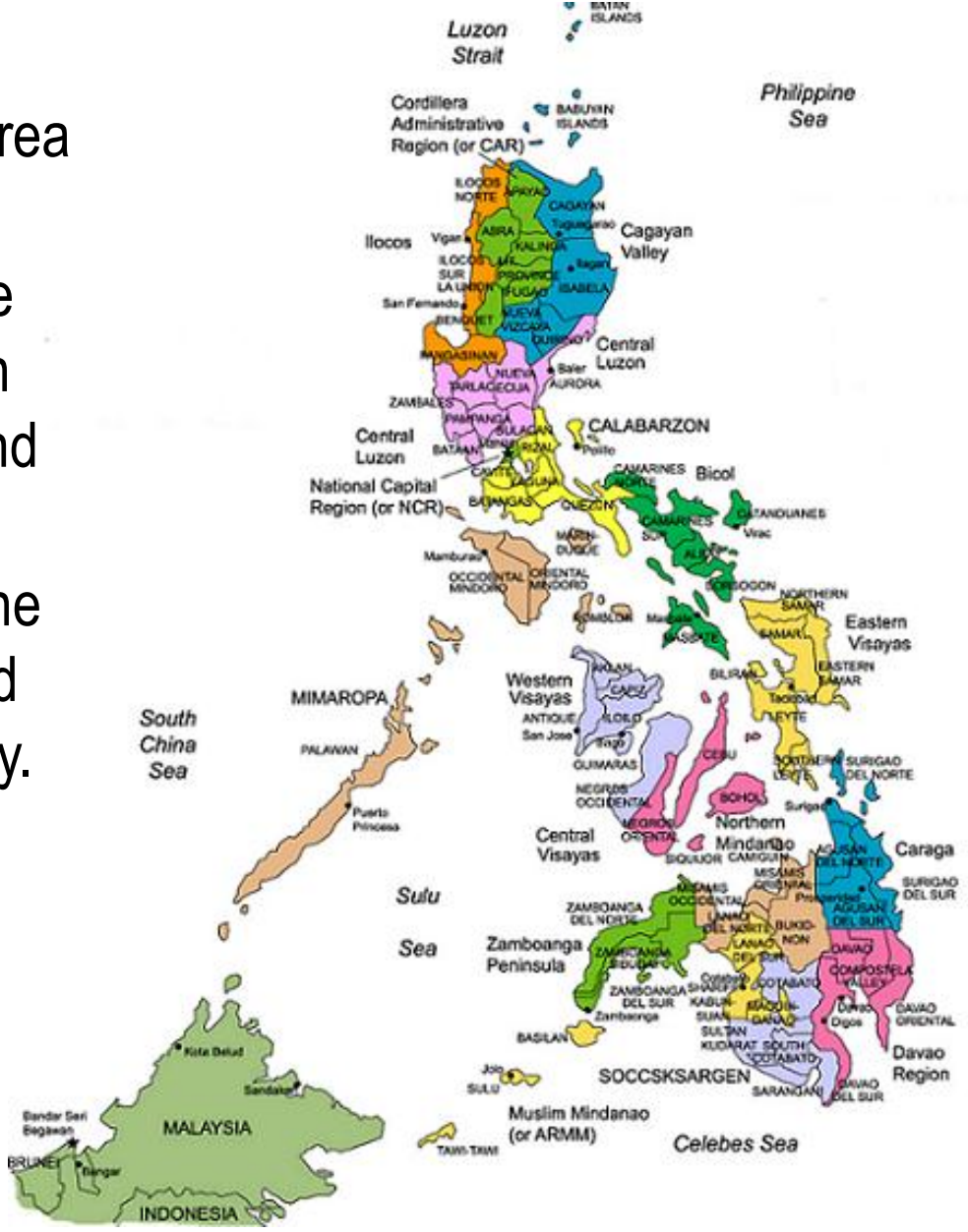
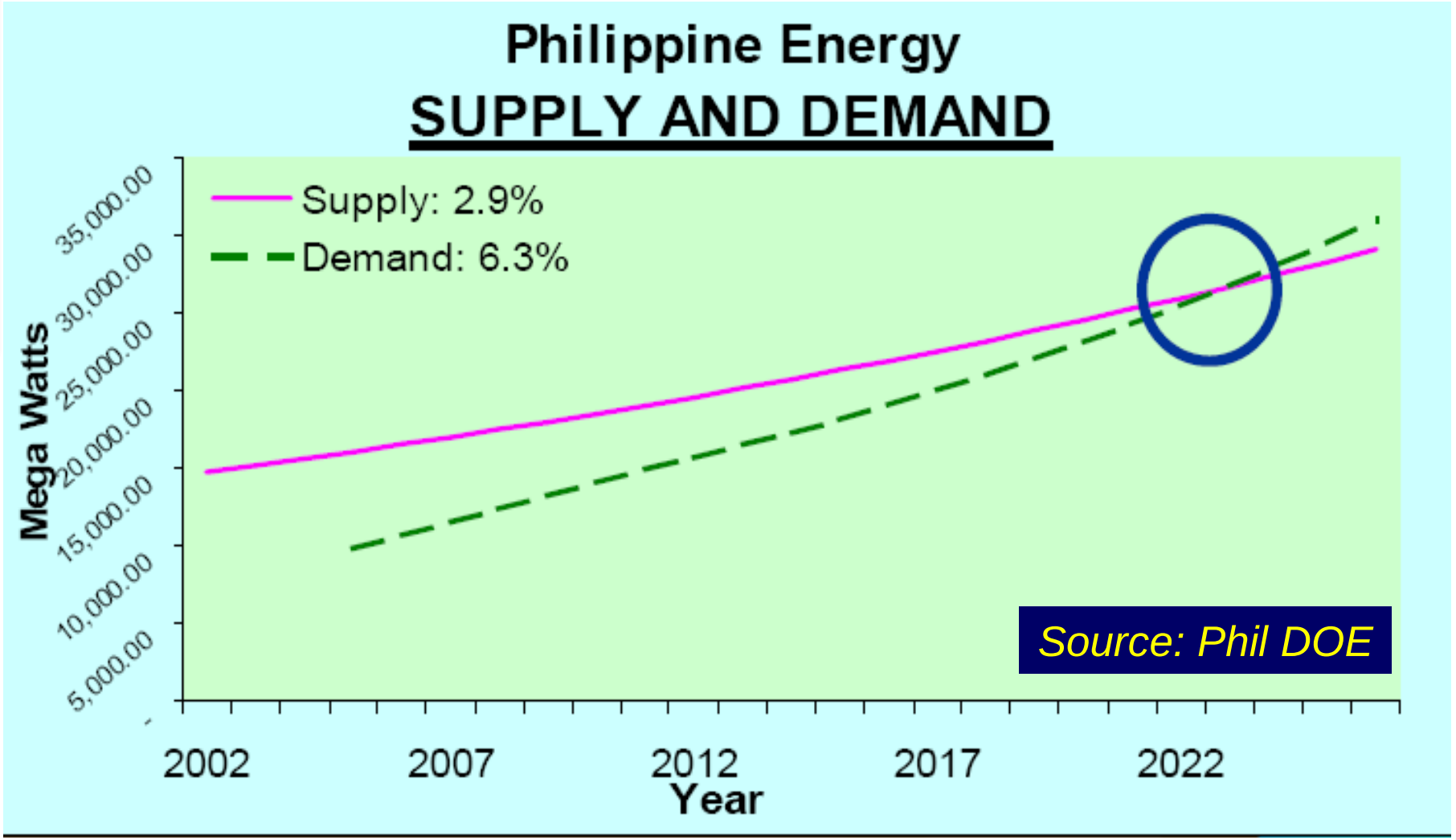


Figure 1. The Philippine Archipelago

Republic Act 9367 or the Biofuels Act of 2006 mandates the blending of minimum 10% (E10) motor fuel grade (anhydrous), eventually locally-sourced bioethanol and 2% biodiesel and other biofuels made from biomass and primarily used for motive, thermal and power generation. All water effluents, such as but not limited to distillery slops from the production of biofuels used as liquid fertilizer and for other agricultural purposes are considered "reuse" and are therefore, exempt from wastewater charges under the Clean Air Act (RA 9275).

Republic Act 9513 or the Renewable Energy Act of 2008 establishes the framework for the accelerated development and advancement of renewable energy (RE) resources (biomass, solar, wind, run-off river hydro), and the development of a strategic program to increase its utilization. It gives direction and support (fiscal and non-fiscal incentives) to RE developers, suppliers, fabricators/manufacturers authorized to operate in the Philippines. On-grid policy mechanisms are Renewable Portfolio Standards (RPS); Feed-in-Tariff System (FiT), Renewable Energy Market (REM), Green Energy Option, and Net Metering.

The Need for Energy…



Biomass

Biomass resources refer to non-fossilized, biodegradable organic material originating from naturally occurring or cultured plants, animals and micro-organisms.

Include 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.

Biomass energy is carbon-neutral but is of low energy density.

Energy for/from Rice Farming

"**We must learn to synthesize materials for every human need from the things that grow**." – George Washington Carver

Rice – one of the most versatile crops

- ✓ Food for humans;
- ✓ Feed for livestock/poultry;
- ✓ Fiber for paper-making; and
- ✓ **Energy** for industry

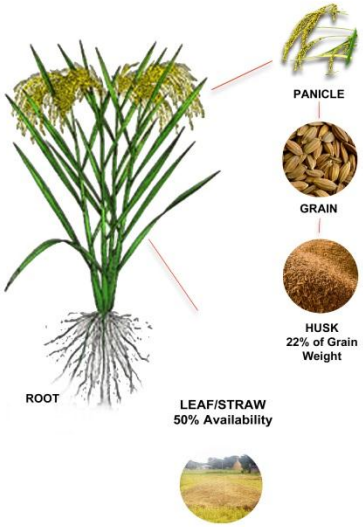
- Harvesting **energy** from the sun through green vegetation photosynthesis – a new paradigm for agriculture (Buchanan et al. 2008).

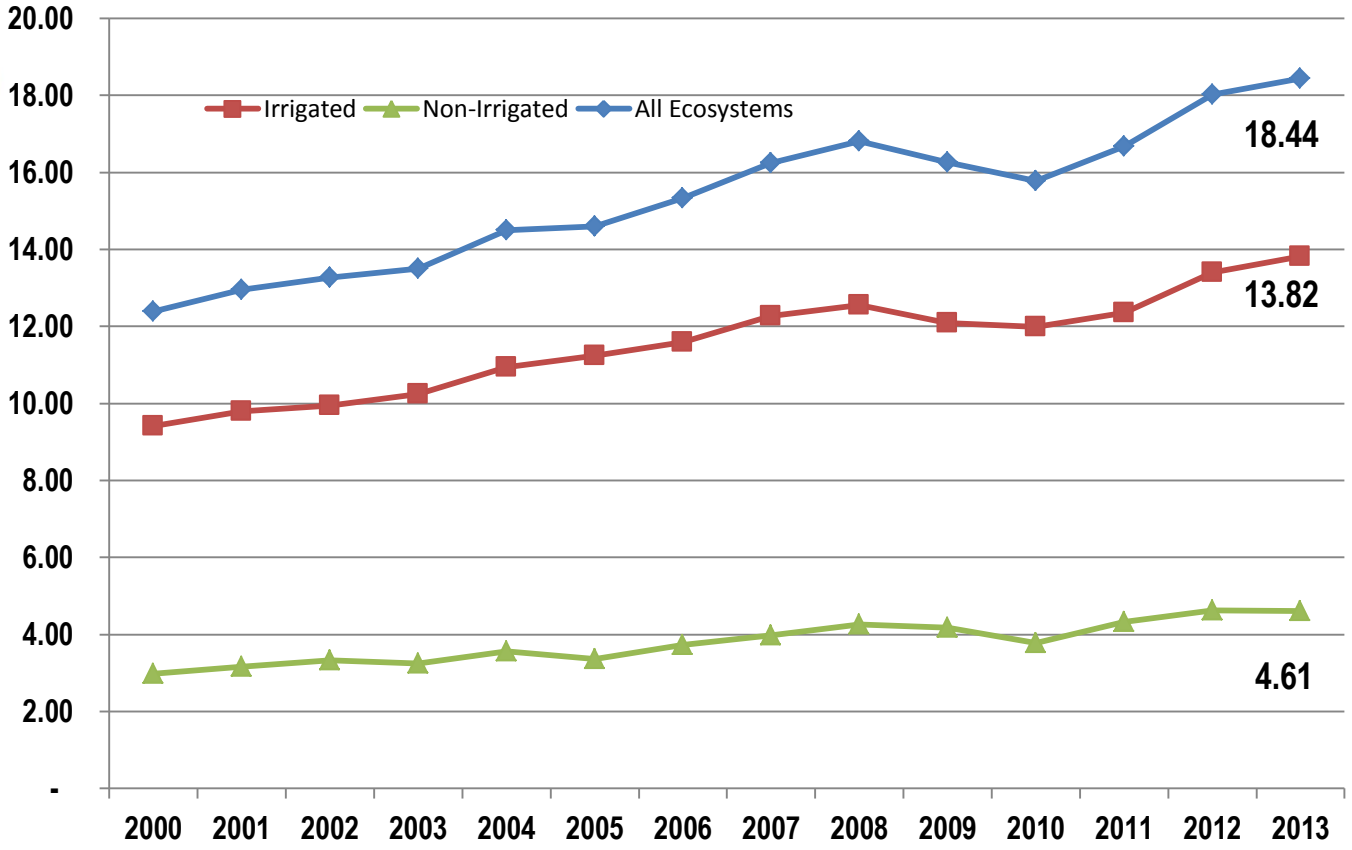
Theoretical and technical residue volume of major crops in the Philippines, 2012

Crop/Animal	Production[1]	Agricultural Residues	RPR[2] %	Theoretical tons	Recover ability[5], %	Technical tons
1. Rice	18,032,422	Rice husk	22.5	4,057,295	95	3,854,430
		Rice straw	100.0	18,032,422	50	9,016,211
2. Corn	7,406,830	Corn cob	27.0	1,999,844	95	1,899,852
		Corn stalk	400.0	29,627,320	50	14,813,660
3. Coconut	15,862,386	Coco husk	33.3	5,282,175	90	4,753,958
		Coco shell	15.0	2,379,358	95	2,260,390
		Coco frond	197.7	31,359,937	50	15,679,968
4. Sugarcane	26,295,553	Bagasse	29.0	7,625,710	95	7,244,425
		Cane trash	10.0	2,629,555	50	1,314,778
5. Poultry (birds)	164,192,253	Chicken manure	4.5[3]	55,414,885	75	41,561,164
6. Hog (heads)	11,863,021	Pig manure	2.0[4]	355,890,630	70	249,123,441

Sources: (1) Bureau of Agricultural Statistics (BAS): rice, corn, coconut, sugarcane production are in tons while poultry in number of birds weighing 1.5 kg each, and hog in number of heads weighing 100 kg each; (2) Department of Agriculture (DA), PhilRice, Philippine Coconut Authority (PCA), Sugar Regulatory Administration (SRA), Philippine Sugar Millers Association (PSMA);(3) 4.5% daily chicken manure production effectively for 5 days per harvest; (4) 2.0% daily pig manure production effectively for 15 days per harvest; (5) Philippine Association of Renewable Energy Centers (PAREC), Full Advantage Phils International, Inc. (FA)

Paddy Production, 2000-2013





Total paddy production was 18.44 Million metric tons in 2013. Based on residue percentage and recoverability factor, rice husk and straw technical volumes would reach 3.94 and 9.22 million metric tons, respectively

Rice Husk Biomass

Chemical composition of rice husk

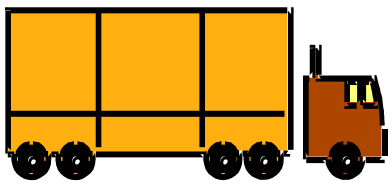
Components	Weight%
C	38.5
H	5.7
O	39.8
N	0.5
Ash(SiO_2)	15.5

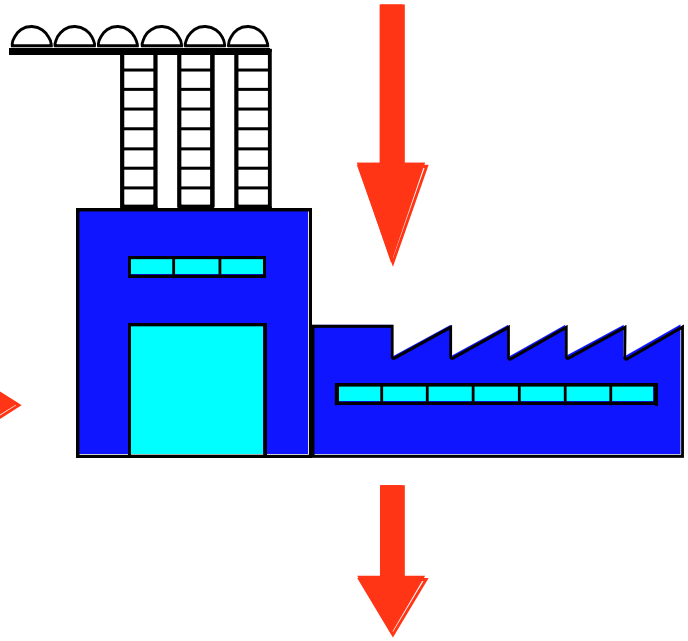
Rice husk has a high heating value, w/c ranges from 10,000–20,000 kJ/kg, making it an important energy source in agriculture

Rice Husk Energy Potential

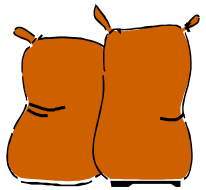
Process energy required:
Paddy milling and drying: 30-60 kWh/tonne paddy

1 tonne of Paddy





650-700 kg White rice



Waste:
220 kg Husks ~ 90-125 kWh

Power Generation from Agricultural Wastes

Technical Power Potential, 2012

Agricultural Residues	Technical Volume tons	Electricity Generation(1) kWh/kg	Power Potential(2) MWe	Current Practices(3)
Rice husk	3,854,430	0.627	315	Power generation, heat for drying, cooking
Rice straw	9,016,211	0.774	909	Field burning, fodder, organic fertilizer,
Corn cob	1,899,852	0.932	231	Power generation, heat for drying, cooking
Corn stalk	14,813,660	0.872	1,682	Soil incorporation, fodder
Coco husk	4,753,958	1.398	865	Power generation, heat for drying, cooking
Coco shell	2,260,390	1.758	517	Activated carbon, charcoal for cooking
Coco frond	15,679,968	1.139	2,325	Heat for cooking
Bagasse	7,244,425	0.316	298	Combined heat and power generation
Cane trash	1,314,778	0.545	93	Field burning, soil incorporation
Chicken Manure	41,561,164	0.240	1,299	Organic fertilizer, soil incorporation
Pig Manure	249,123,441	0.030	973	Biogas, organic fertilizer, soil incorporation
Total			9,507	

Sources: (1) Averages from different sources (energy generation rate is dependent on the biomass heating value and moisture content, and electric efficiency of certain technologies) as mentioned in the following studies: Energy Efficiency and Power Generation in the Philippine Agro-Industries by Full Advantage Co. Ltd. for the International Finance Corporation; Biomass Resource Assessment in the Philippines by Philippine Association of Renewable Energy Centers (PAREC) for GEF=UNDP-DOE-CBRED Project. (2) Based on a 320-day annual operation. (3) Full Advantage Phils International, Inc.

- Problems exist in consolidation, transportation, storage and biomass fuel preparation before feeding into a power facility (boiler), except when the residue is a product of a processing center such as rice husk from rice mill and bagasse from sugar mill where the power plant can be embedded within the milling facility.

- Rice straw and cane trash consolidation may be solved by a baling system. The widely dispersed coconut residue should be prepared as feedstock using a shredding facility.

- Supply of raw materials for centralized large-scale biomass power plants in the order of 10 – 20 MWe might be compromised by shortfalls in production brought about by natural and man-made calamities, shift to other crops, and farm land conversion to other uses.

- Decentralized and diversified biomass power plants in the range of 100 – 500 kWe for rural communities might be more sustainable and practical in the future considering supply shortages, logistical constraints, and energy generation and distribution efficiencies.

Utilization of Rice Hull in the Philippines

Rice hull is now a traded commodity due to increasing demand in power plants and cement factories. Rice hull is owned by rice millers, a portion is left soiled on the ground or wasted, decomposing and cannot be hauled anymore.

Other portions are used as garden beddings, biochar for soil conditioning, and fuel for cooking and drying

Batch-Type Rice Husk Gasifier Stove

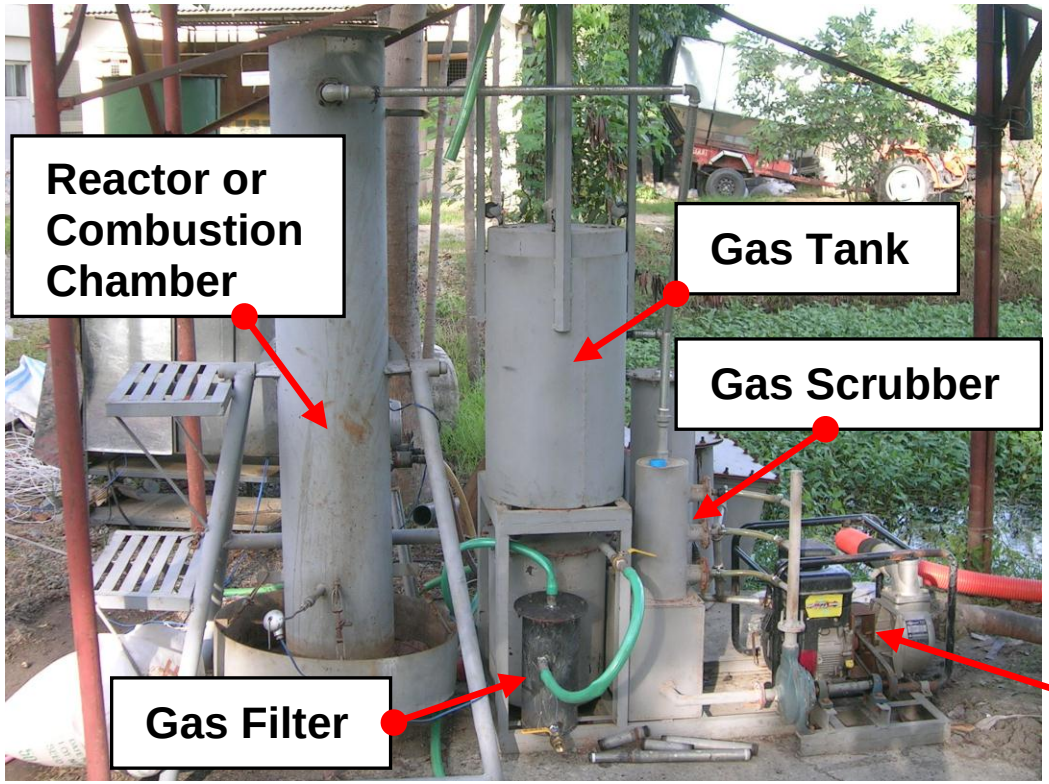
OUTSTANDING FEATURES

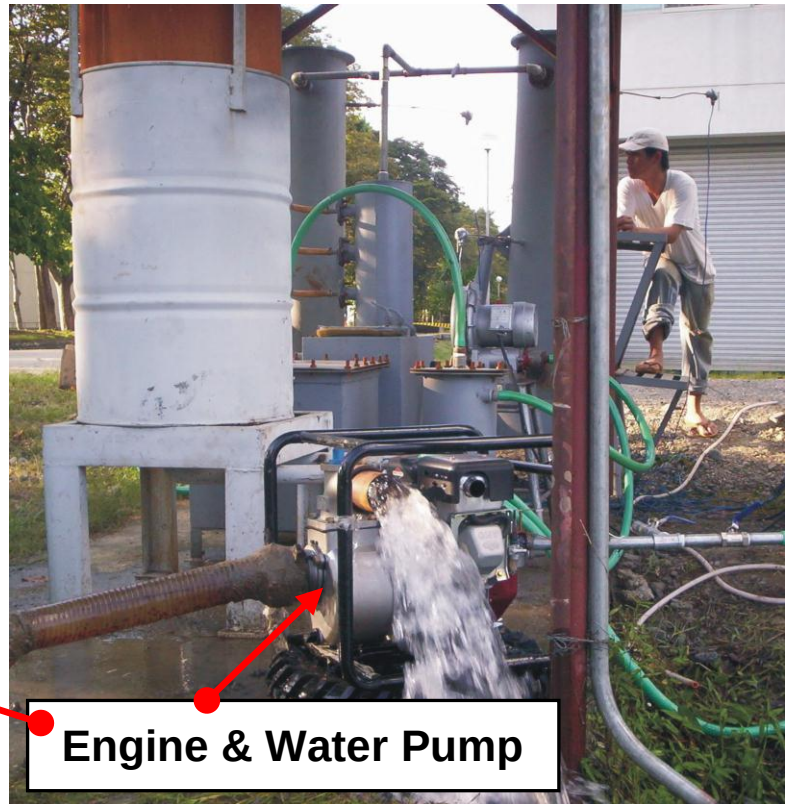
- Uses agro-waste rice husk as fuel
- Easy to start and generate gas
- Almost no smoke during operation
- Low CO_2 and black carbon emission
- Efficient and low parasitic load
- Locally developed and produced
- Women friendly and easy to operate
- Affordable and short payback period

SPECIFICATIONS

Model	:	RHGS 14D-60
Fuel	:	rice husk
Fuel consumption rate	:	0.8 kg per load
Flame color	:	blue to pink
Power output	:	3.1 to 4.7 kW
Fan	:	9 watt, 12 volt DC
Start-up time	:	1 min.
Time to Boil Water	:	8.5 to 11 min. for 2 liters of water and 14 to 15 min. for 3 liters of water
Thermal efficiency	:	up to 76%
Operating time	:	27 to 30 min per load
Overall Dimension	:	23cm W x 30 cm L x 80cm H
Price as of April 2013	:	PhP2,500 (GI sheet model) or PhP4,500 (stainless steel model)

Stationary rice hull gasifier-engine-pump system





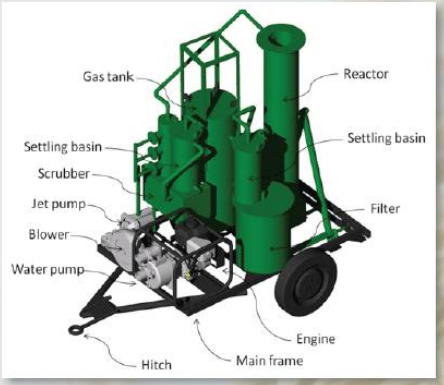
Mobile Rice Hull Gasifier Engine System

OUTSTANDING FEATURES

- Utilizes rice hull biomass as source of energy altering conventional petrol fuels
- Can save 37-44% on fuel cost being used for irrigation
- Simple design and locally manufactured
- Mobile; able to transfer from one location to another
- Can perform in different application such as water pumping, rice milling, and power generation
- Sustainable and environment friendly
- With CRH as waste, can be used as substrate for organic fertilizer among others

SPECIFICATIONS

Rice husk load requirement	:	4 kg per batch
Firing time	:	3.0 minutes
Start up time	:	3.0 minutes
Operating time:	:	80 minutes
Discharge rate	:	5-7 liters per sec
Temperature inside the reactor	:	350 - 800°C
Engine rating	:	6.5 hp
Pump size	:	3.0 inches diameter
Labor requirement	:	1 person



10-20 kW Gasification, Carbonization & Combined Heat & Power Generation Setup

Smoke vinegar

Carbonized Rice Hull (CRH)

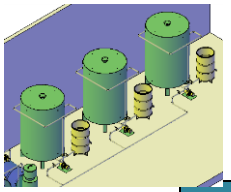
- Develop modular small scale cleaner production resource recovery systems
- Produce gas, heat, mechanical and electrical power
- Produce by products such CRH and liquid materials for soil conditioning, organic fertilizer, and natural pesticide (smoke vinegar), among others.

Rice hull gasifier for 100 kW electric power generation

Rice hull gasifier as heat source for batch recirculating grain dryer

Nipa, sweet sorghum, coconut, etc

Sap



Fermentation

Uses a yeast to produce ethanol from the feedstock

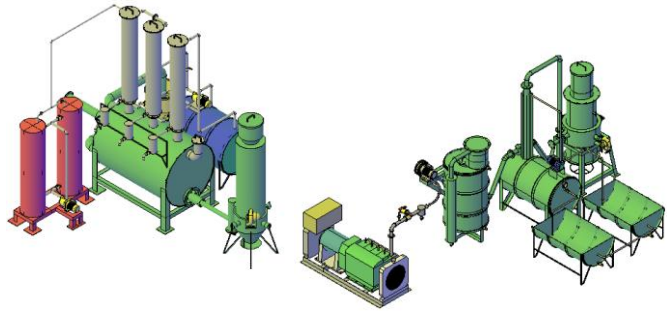
Boiling the mixture of water and alcohol in the fermented material to produce around 35% ethanol

First Phase Distillation (Crude Bioethanol)

Second Phase Distillation (Hydrous Bioethanol

Heating crude bioethanol at around 70 to 80 C to vaporize and condense producing up to 95% bioethanol

Hydrous ethanol (95%) as fuel for spark ignition engine without the need of gasoline



Hydrous Bioethanol Production from Nipa and Utilization for Farm and Fishing Boat Engines and Motorcycles

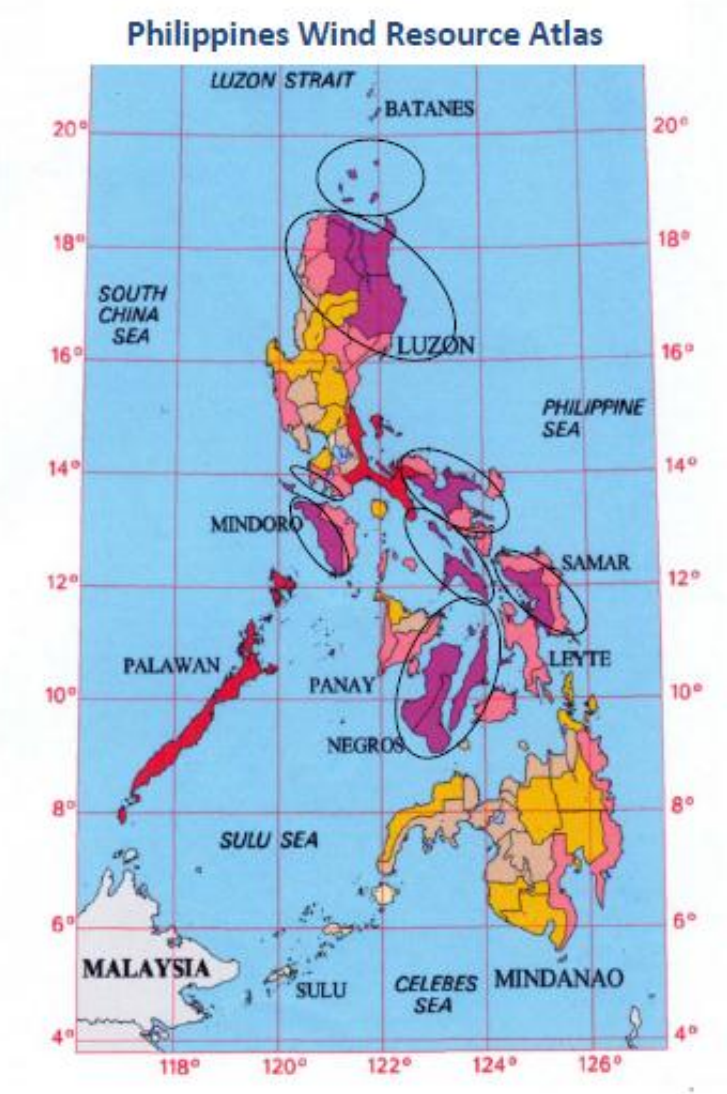
Bioethanol distiller plant that can produce 35% hydrous bioethanol from nipa sap with an output of 30 liters per batch at 3 hours operation.



Proprietary ethanol fuel injection system was also designed for spark igintion engines to enable it to run using only 95% hydrous bioethanol as fuel without gasoline blend.

750 MW of Wind Power Potential

- Existing Capacity: **33 MW**
- Currently, the biggest wind power producer in SE Asia
- Wind Regions:
  - Batanes and Babuyan Island
  - Northwest tip of Luzon (Ilocos Norte)
  - Higher interior terrains of Luzon, Mindoro, Samar, Leyte, Panay, Negros, Cebu, Palawan, Eastern Mindanao
  - East-facing coastal locations from N. Luzon southward to Samar
  - Wind corridor between Luzon and Mindoro
  - Between Mindoro and Panay



Merritt Partners

33 MW BANGUI BAY WIND ENERGY PROJECT

		Phase I	Phase II
Plant Configuration	-	15 x 1.65 MW	5 x 1.65 MW
Plant Capacity	-	24.75 MW	8.25 MW
Annual Generation	-	74,482 MWh	24,600 MWh
WT Arrangement	-	single row	
Spacing	-	326 meters apart	
Orientation	-	North	

The turbines are oriented facing the sea effectively eliminating windbreaks and achieving terrain roughness of class 0

Prevailing Wind Direction - Northeast

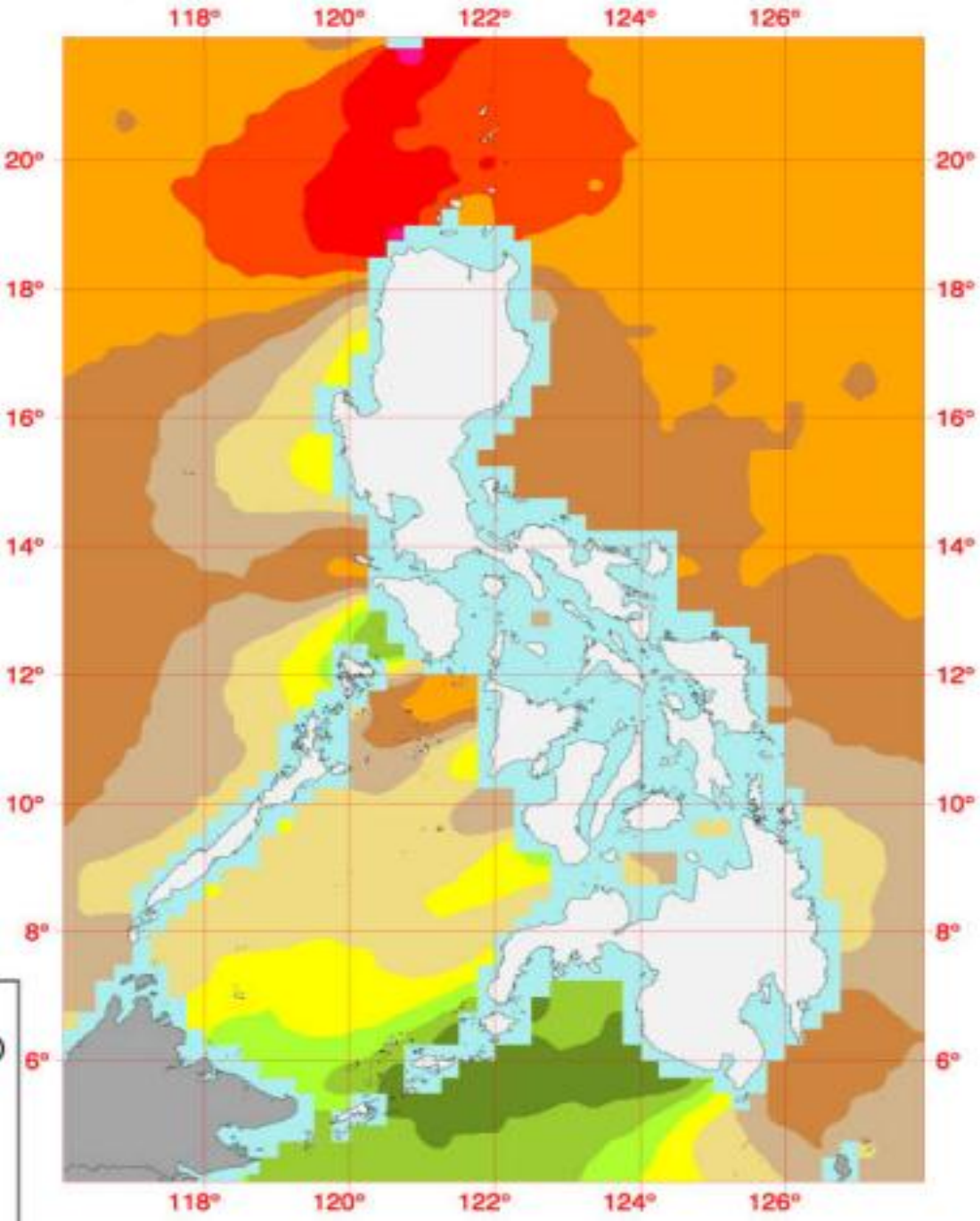
Micro Wind Power

Microgeneration technologies defined as windpower-generation technologies with capacity of below 100-kilowatt (kW) or 50-kW

Advantages of Micro Wind Power

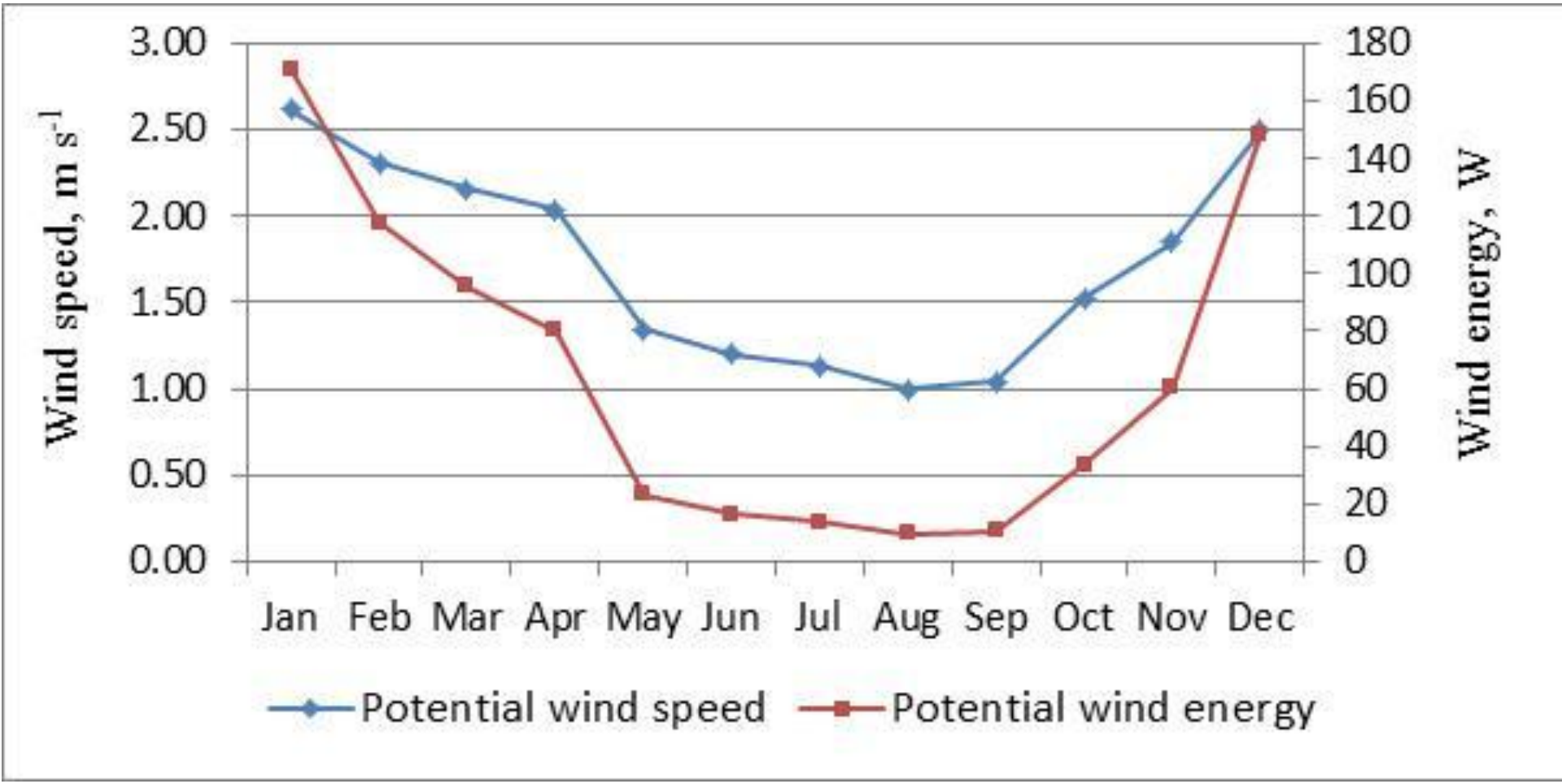
1. Suitable for rural and island communities
2. Minimal transmission costs and losses
3. Low construction cost
4. Power at night and day
5. Combines well with other energies

Loopwing turbine
Loopwing Co. Ltd., Japan
(Alimario 2009)



Wind speed computed from satellite ocean wind data (Source: Elliott et al. 2001)

Wind speed and wind energy:



WindPump Irrigation System

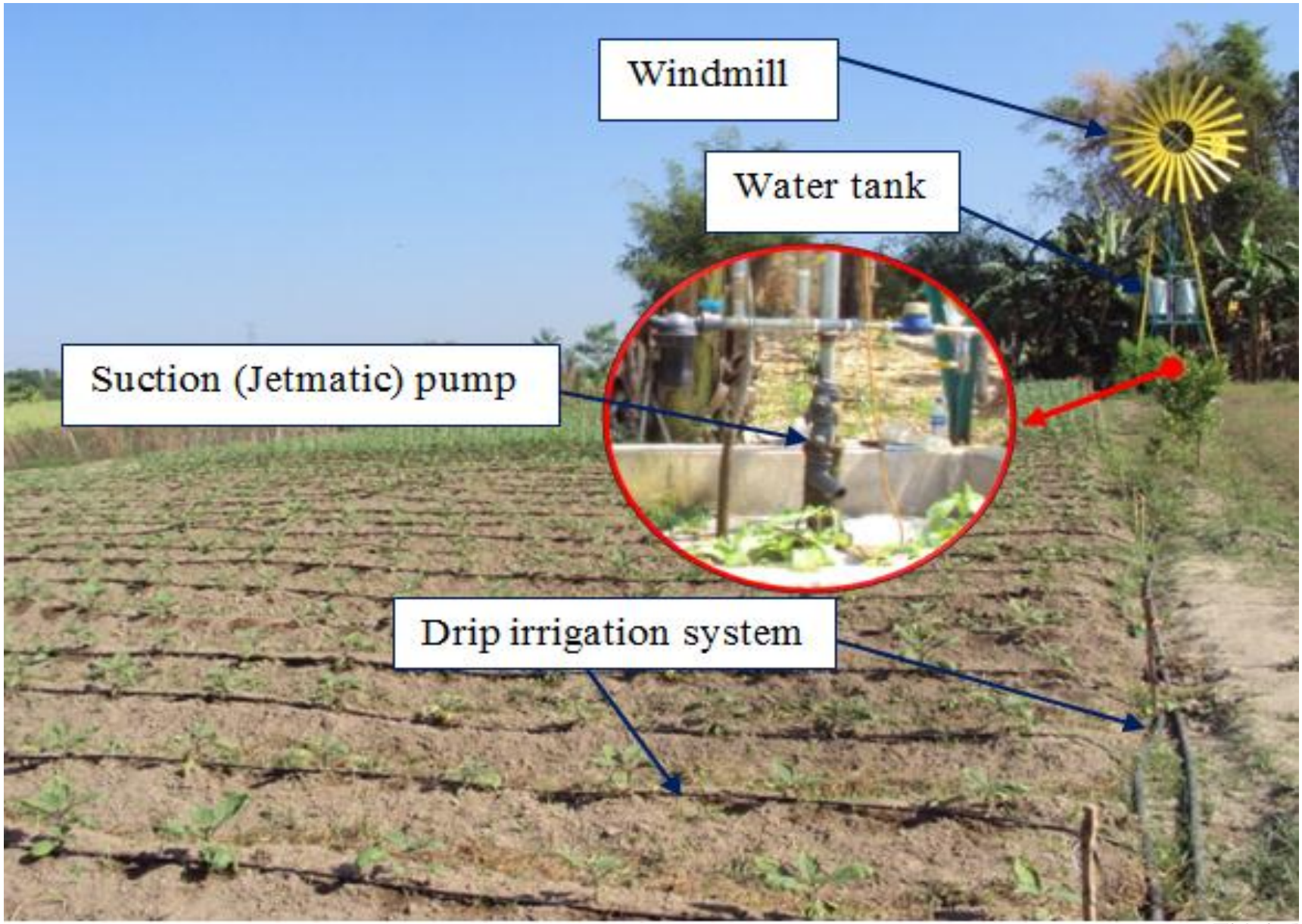
OUTSTANDING FEATURES

- ***Environment-friendly.*** This clean technology does not use or burn fossil fuels.
- ***Efficient windmill design.*** Rotor will operate at wind speeds as low as 2 m/s.
- ***Versatile***. Suitable for gravitational, drip or micro sprinkler irrigation of rice-based crops and for village water supply.
- ***Easy and safe to operate and maintain.*** With minimal maintenance it pumps water without much attention needed.

SPECIFICATIONS

Original Design	:	Central Philippine University (CPU)
Model	:	CPU WP - 24450
Rotor diameter	:	4.5 meters
Number of blades	:	24
Control mechanism	:	Side vane and main hinge vane
Tower height	:	10 meter, four-legged type tower
Start-up speed	:	2 meters per second (7kph)
Cut-out speed	:	7 meters per second (25 kph)
Pump	:	1 ¾-in Clayton Mark deep well pump or modified 4-in jetmatic pump
Typical output	:	250-400 ml/s on pressure-compensating drip emitters or 10-20 m^3/day at 6-12 m suction head

• Windpump-Drip Irrigation System



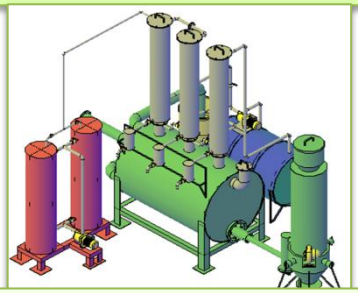
Energy in Rice-based Farming Conceptual Framework

Developing renewable, clean fuels & other energy sources for farm mech.

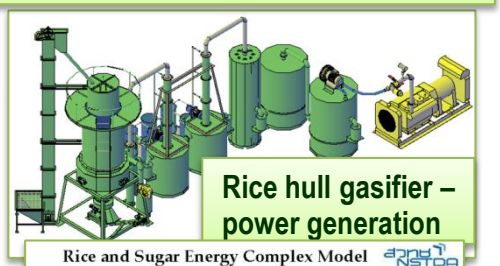
Improving energy resource-use efficiency in rice-based farming systems production

Life cycle analysis of production & post-production systems

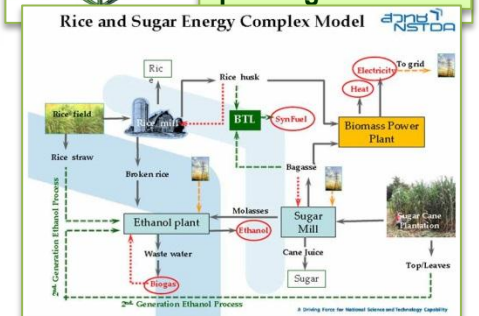
Sustainable & competitive rice production systems



Village-level bioethanol distillation



Rice hull gasifier – power generation



Renewable Energy Resources

- Biomass Waste
- Wind
- Sun
- Water
- Plants
- Algae

Think Green
& Smart.

Be Riceponsible…
Always.

Thank you very much…