

UNEP-DTIE-IETC
Waste Biomass
Demonstration Project



Largest province in Central Luzon Region; highest rice-producing province in the country



Cabiao has 5,749.90 has. (436,364 cavans @ 95 cavans per hectare)

Rice straw: 209MT (2009)

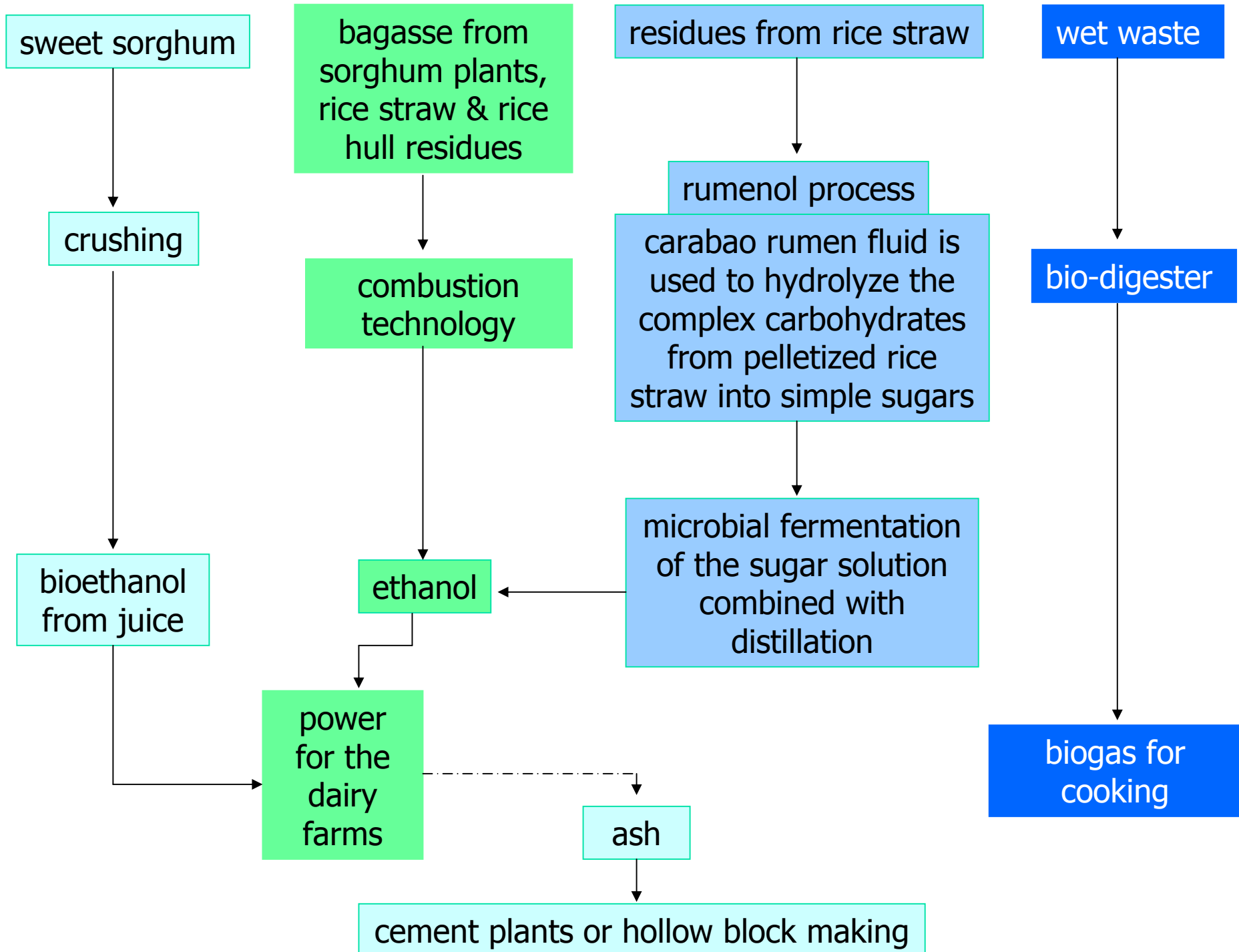
- Pilot demonstration project

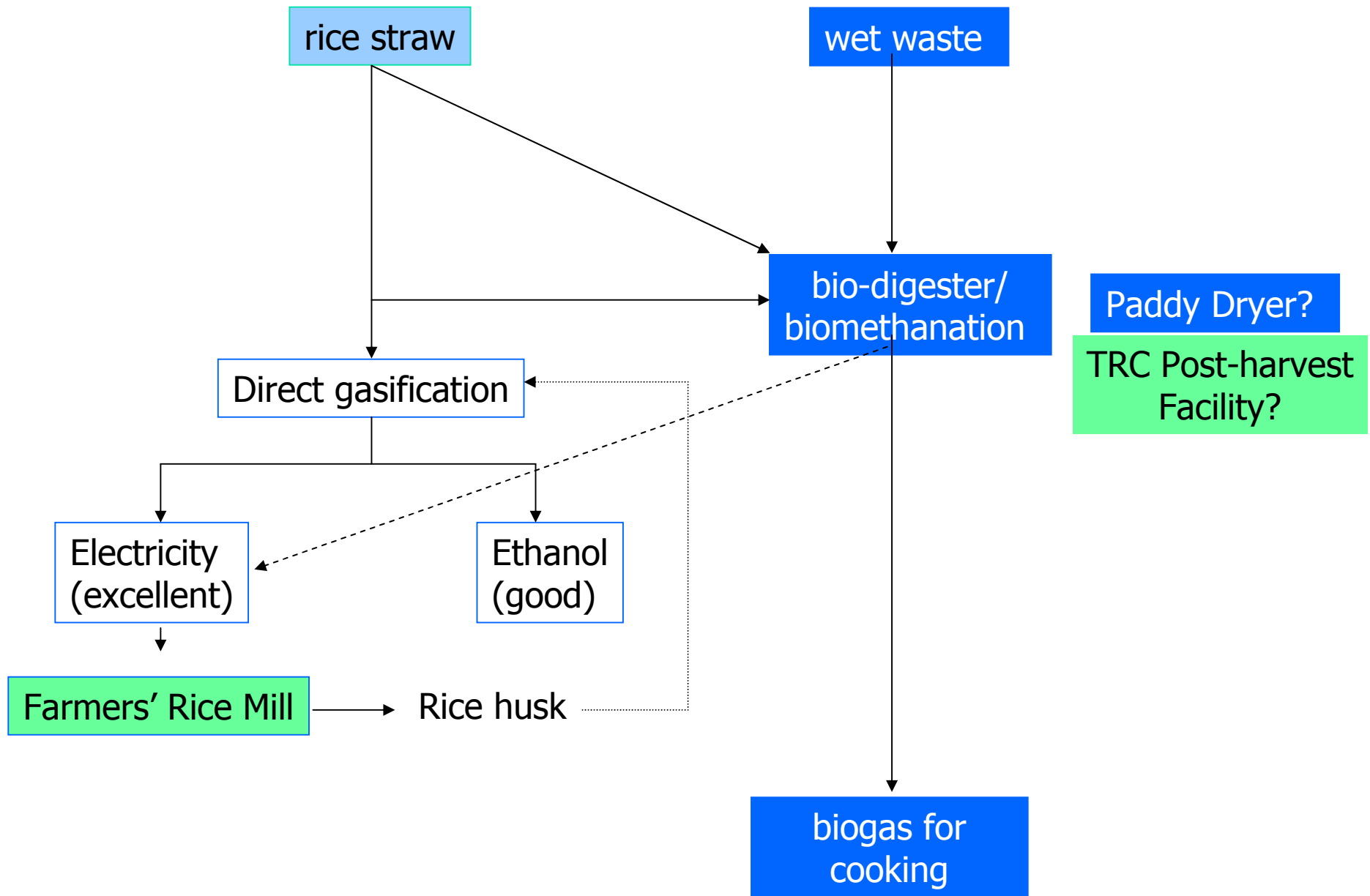
- utilizing biomass waste

- sweet/grain sorghum
- rice straw
- rice hull

- Poverty incidence reduction
- Reduction of GHG emissions
- More awareness & knowledge





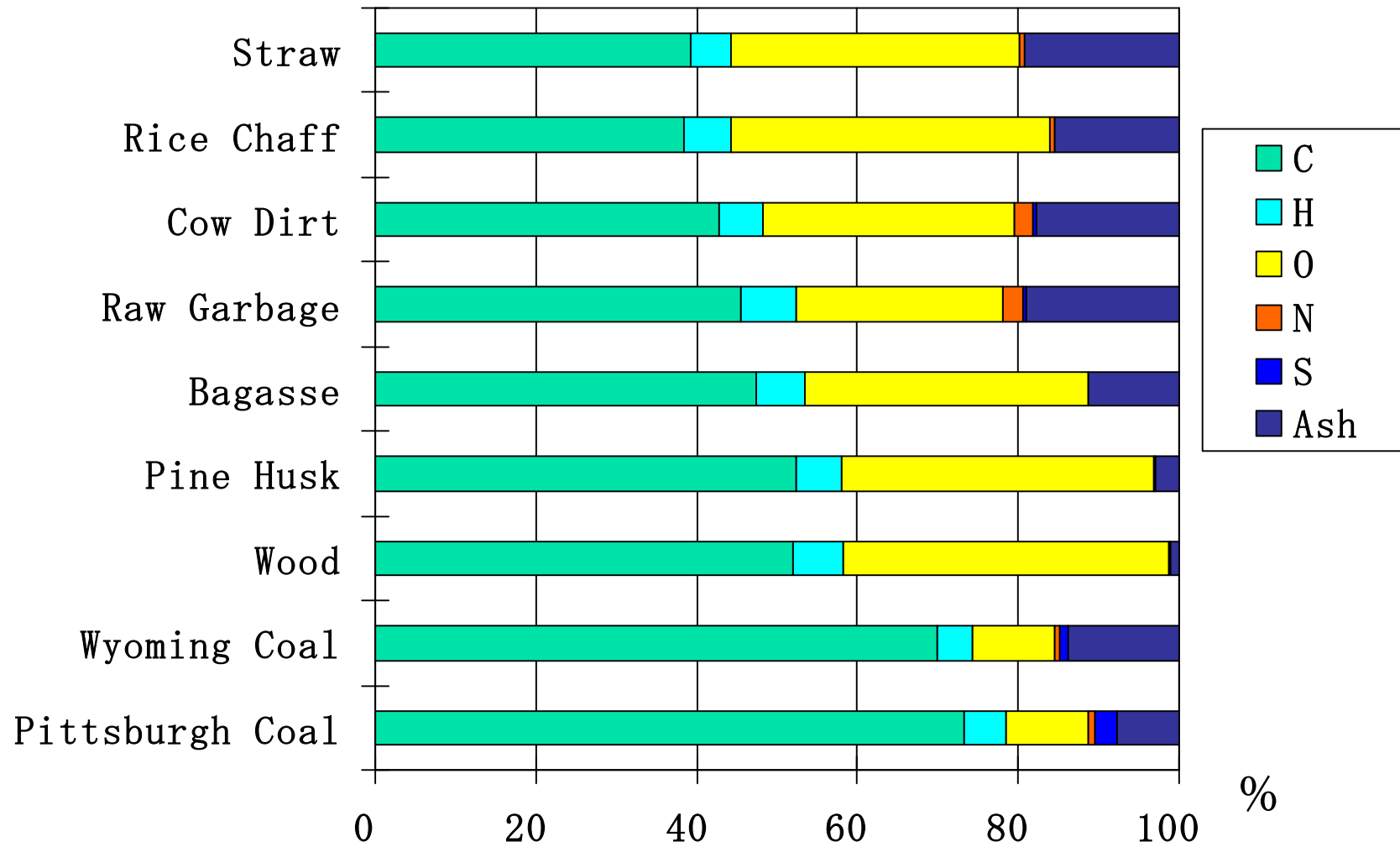


- (>100 gallons/ton of rice straw)
- Floyd Myers Marsh Power Plant convert about 200,000 tons of rice hulls and straw a year to 29 megawatts of electricity

Rice Straw

- 668 t could produce theoretically 187 gallons of bioethanol
- Low feedstock quality primarily determined by a high ash content (10–17%) & high silica content in ash
- Advantage: relatively low total alkali content (Na₂O and K₂O typically comprise <15% of total ash)
- If exposed to precipitation in the field, alkali & alkaline compounds are leached, improving the feedstock quality.
- Moisture content should be <10% for combustion technology

Element Composition of Various Fuels



Rice straw ash

Proximate analysis (% dry fuel)

Fixed carbon: 15.86

Volatile matter 65.47

Ash 18.67

Total 100.00

Elemental composition of ash (%)

SiO₂ 74.67

CaO 3.01

MgO 1.75

Na₂O 0.96

K₂O 12.30

Producing electric power and heat from rice straw

- Combustion (electricity, and heat)
- Anaerobic digestion (biogas)
- Pyrolysis (bio-oil) *
- Gasification (syngas) *

Combustion Methods

- Most well-known conversion method
 - Boiler coupled to heat exchanger, steam turbine
- Options for rice straw combustion:
 - “Stand-alone” , small-scale for electricity and heat
 - Co-combustion with coal or other fuels (co firing)
- Challenges for rice straw combustion:
 - High ash content (up to 20%)
 - Troublesome inorganic elements (K, Cl)
 - Need to densify fuel for optimal logistics

Solutions for ash & related problems of rice straw

- Combine rice straw with other fuels that are lower in alkali and chlorine
- Lower temperatures in combustion systems
- Remove troublesome components prior to combustion (“leaching”)

- Increasing the melting point of ash through addition of limestone indirectly reduces sulfur (especially SO₂) emissions
- The high alkali content of straw at high temperature results in increased corrosion & fouling problems in the superheater - adverse effects can be mitigated through controlled boiler temperature & special coating on the superheater surface.
- Alkali & alkaline compounds are leached when straw is exposed to precipitation in the field. This improves feedstock quality by increasing the melting temperature of ash
- Silica content of rice straw ash is around 75%, which has a low melting point.
 - feeding limestone onto the furnace bed & controlling the temperatures inside the boiler is essential to prevent the melting of silicon dioxide (SiO₂)

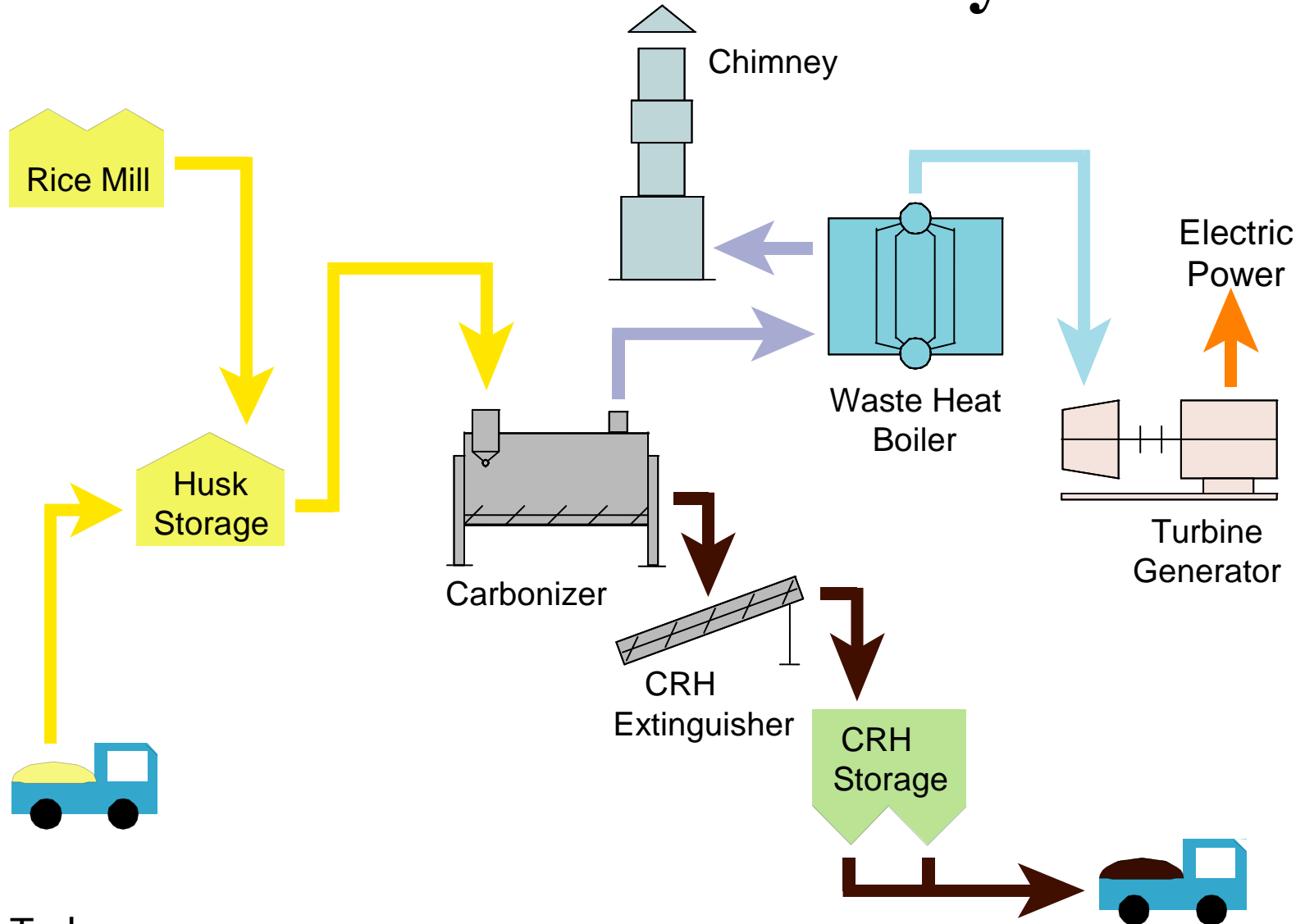
Anaerobic digestion

- Well-proven technology for various agricultural waste
 - Low maintenance; technology not complicated
 - Small-scale: short transportation distance
- Two applications for Biogas:
 - Direct use: use biogas for cooking and heating
 - Indirect use: biogas into engine for electricity generation
- Straw is digested together with other biomass types
 - For Rice straw common substrates are Animal manure, or other organic wastes

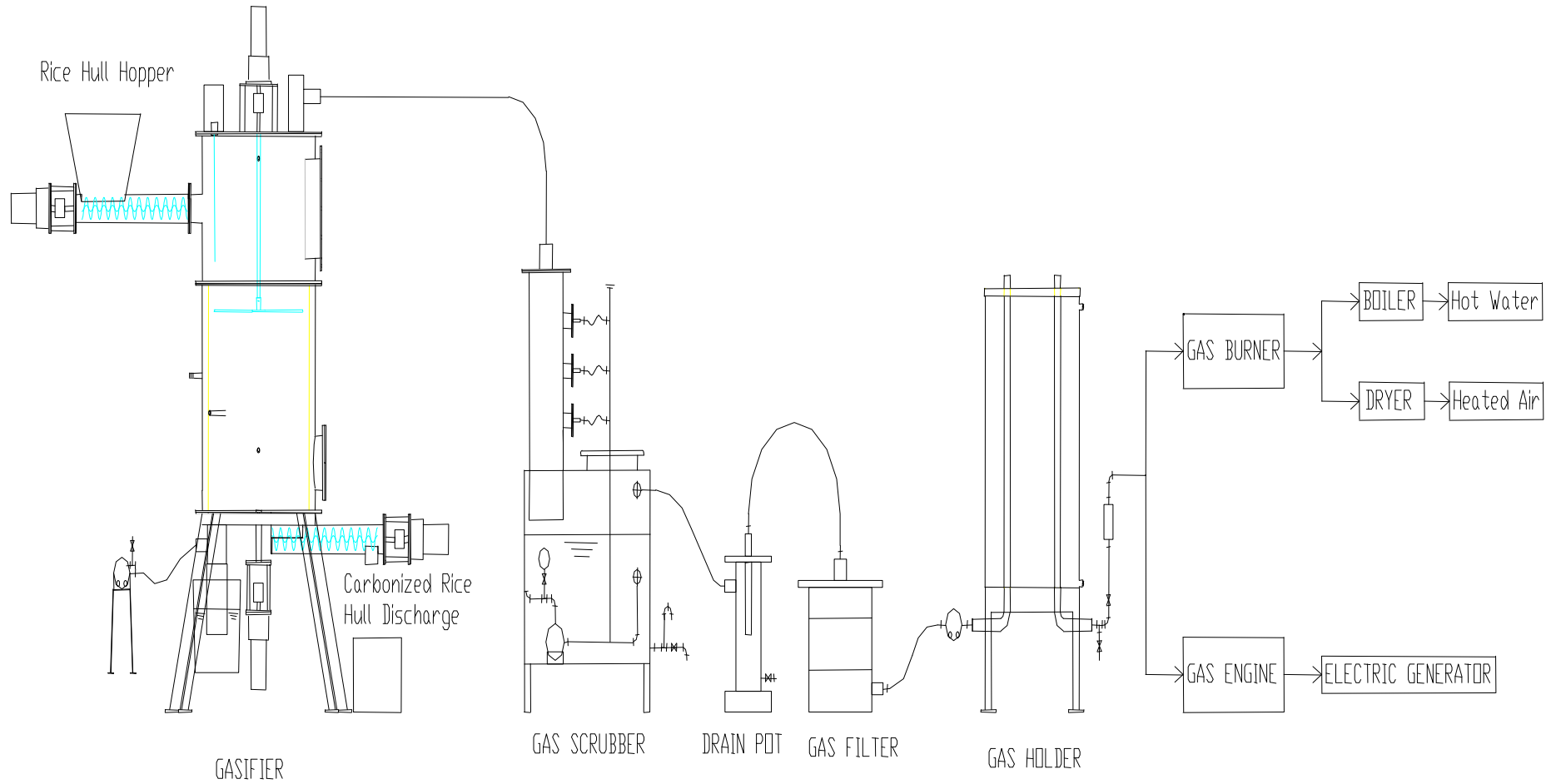
Major challenges that are encountered with straw

- Many technologies are available for producing electricity and heat from rice straw
- Up to now, potential of rice straw has not been realized
- This is in contrast with energy applications from rice husks, which in general are quite successful
- Technological: rice straw composition
- Organizational: logistics of straw collection
- Economics: cost of straw versus revenue

Automated Carbonization System



The Gasification System



Performance Indices of the Gasification System

Hour of operation	8 h
Total input of rice husk	431 kg
Feed rate	53.9 kg/h
Total discharge of CRH	92.6 kg
Discharge rate of CRH	11.6 kg/h
CRH conversion ratio	21.5 %
Temperature of combustion zone	600-750 °C
Gasification efficiency	46 %
Power generation	13 kW
Generation efficiency	9.2 %

Small-scale Rice Milling Machines

- Model 1 (China)
 - Power - 5.5 kw
 - Productivity – 400-600 kg/hr
 - Cost – USD320-340
- Model 2 (China)
 - Power – 11 kw/hr
 - Productivity – 500-650 kg/hr
 - Cost – USD320-340
- Model 3 (Australia)
 - Power – 7.5-11 kw/hr
 - Productivity – 500-900 kg/hr
 - Cost – USD800++

Resource Efficient Agricultural Production (REAP)

- Assess the Philippine resource base for biomass production
- Estimates for recoverable biomass materials available for energy production for sugarcane, corn and rice
- Distributed in Negros couple of hundreds of rice hull cookstoves

REAP Project

- Rice straw has high silica content, low heating value and high moisture content
- Probably the best use for rice straw is to incorporate it in the fields to maintain soil organic matter levels and to fix Nitrogen during the decomposition process

Gasification of Rice Straw

1. straw - received at a moisture level of 15- 65% and ground to particles of 3/16" or less and then dried to approximately 15% water content
2. processed rice straw - is injected into the gasifier/reformer with super-heated steam. The super-heated steam also contains some recycled water and other alcohols from storage tanks.

3. gasifier - indirectly heated by burning natural gas, so that the product gas is not diluted by nitrogen from the natural gas combustion product stream

- feeder, the gasifier and all downstream components operate at a pressure high enough to result in a substantial reduction in the size of piping, vessels and other components)
- Silica, metal oxides, traces of elemental C and higher molecular weight hydrocarbons are collected as ash.

4. hot, raw syngas - cooled in the steam production/heat recovery system
5. partially cooled gas then passes through a cyclone to remove particles that are greater than 5-10 μm in size and then through a High Efficiency Particulate Air (HEPA) filter to remove particles down to about 0.5 μm .
 - It then passes through a counter-current water scrubber where water-soluble components are removed.

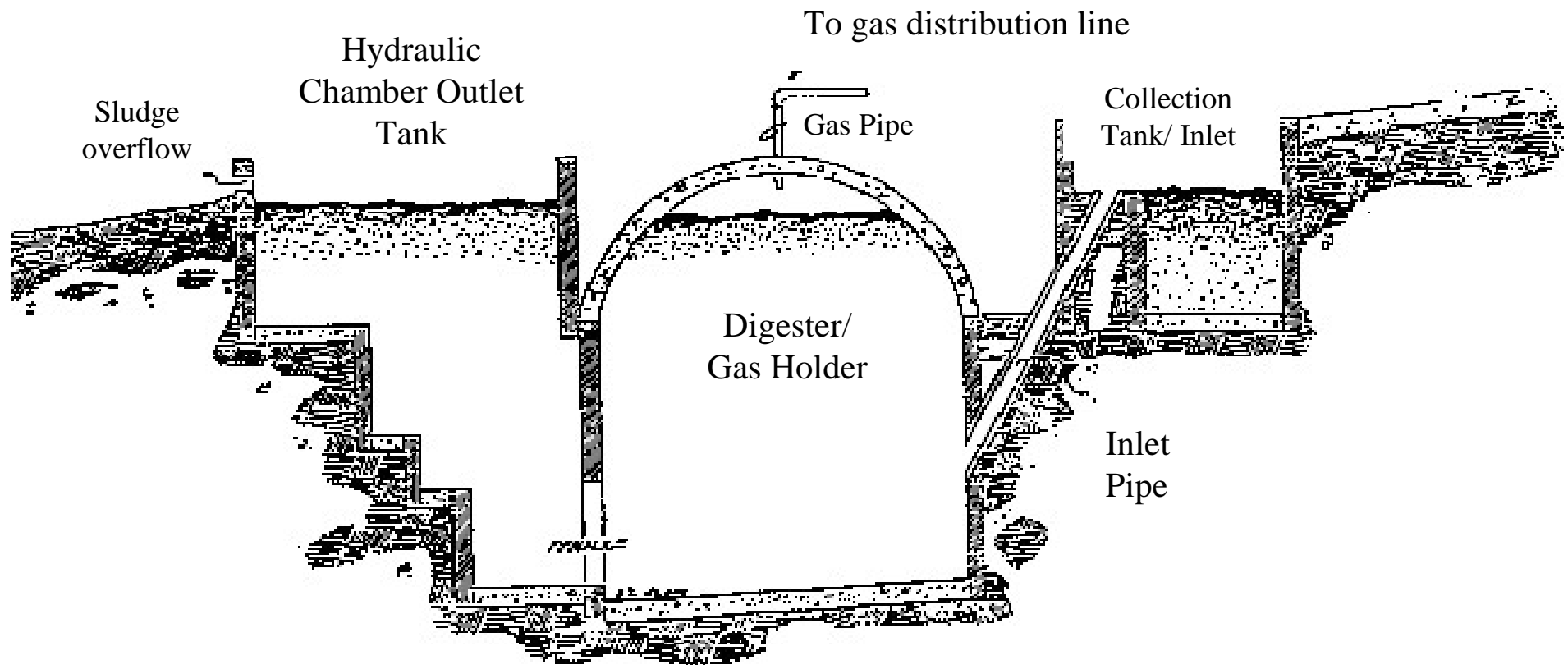
6. cooled syngas gas -- further cleaned by scrubbing with a circulating stream of light petroleum oil, which absorbs BTX and heavier hydrocarbons that may have been formed during gasification.
7. small amount of oil - periodically sent to the gasifier to keep the oil from becoming saturated with BTX and higher molecular weight hydrocarbons. (clean, dry gas is about half CO₂ by weight, the rest being a mixture of H₂, CO, methane and ethane)
 - to increase the yield of ethanol, it is necessary to separate the products (methanol) by distillation and re-introduce the methanol with the H₂ and CO at the compression stage (nearly complete conversion of the methanol to ethanol may require recycling up to 7 or 8 times)
 - products are cooled and collected in a condenser and fractionated using a distillation column into three fractions: 1) methanol, 2) ethanol (95%) and an aqueous solution of the remaining alcohols
 - excess H₂ and CO is separated from the aqueous phase and recycled back to the compressor

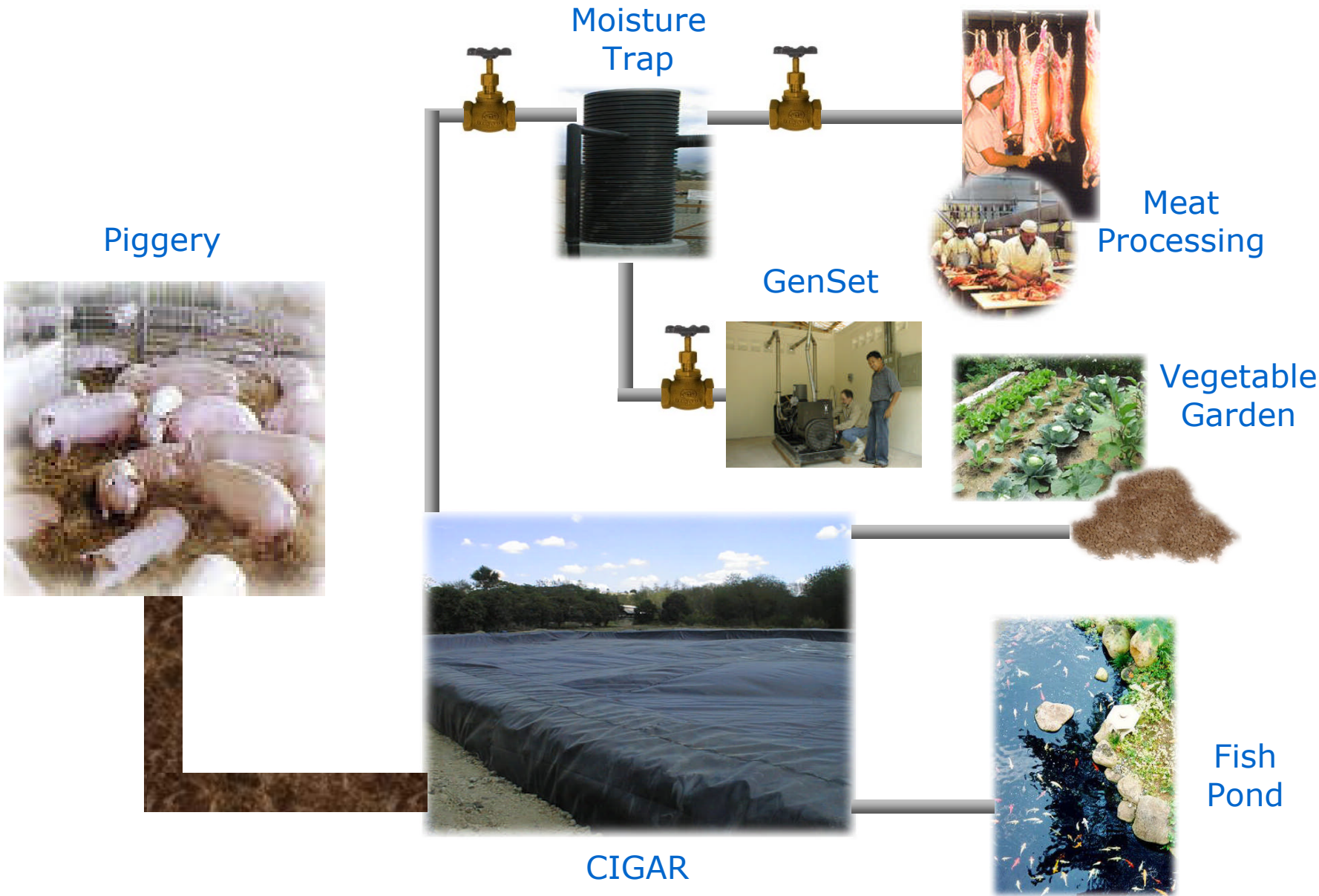
Biomass Advantage Compared Renewable Energy by EU Evaluation

Power Generation	Solar Cell	Wind	Biomass
Total Investment (million US\$)	1,830	12,700	6,300
Facility Scale (kW/year)	1,000,000	10,000,000	10,000,000
Yearly Operation Rate (%)	12	20	70
Yearly Electricity Generation (million kWh)	1,100	17,500	61,300
Unit Investment (US\$/kW)	1.66	0.72	0.10

“21 Century by Biomass Energy”, Sakai Masayasu

CAVSU Biogas Digester





Commercial Technologies

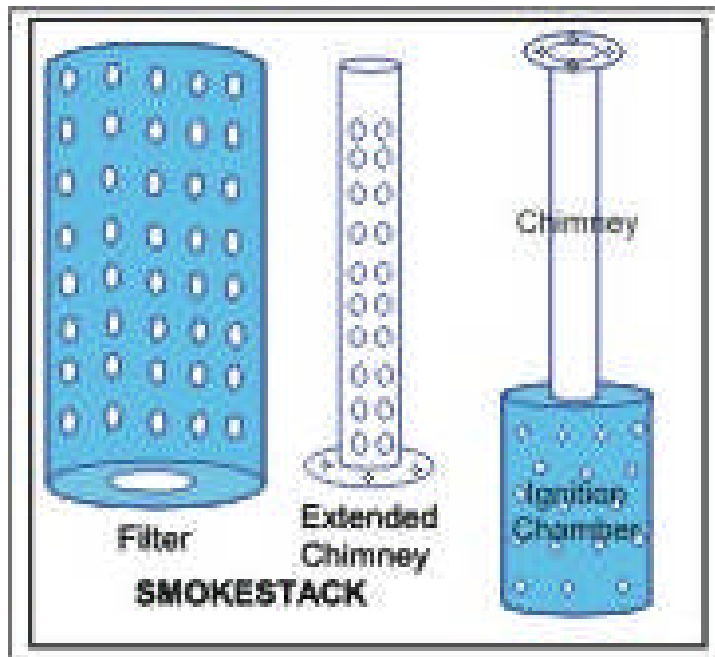
1. *Maligaya Flatbed Dryer (1992-95)*



- 2-3, 4 & 6 tons/batch models
- Multi-crop drying capability
- 20 manufacturers trained
- More than 200 units installed
- PhP350K – 500K per unit

Commercial Technologies

3. *Rice Hull Carbonizer (2003-04)*



- 1500 L rice husks to 1000 L CRH in 4-5h
- Quality of CRH: 98% black/dark colored
- PhP700 – 800 per unit

Pilot-scale Technology

1. 10-20 kW Rice Husk Gasifier, Carbonizer & Cogen System (2003-07)



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 as CRH and liquid materials for soil conditioning, organic fertilizer, and natural pesticide (smoke vinegar), among others.



Upcoming Technology

1. *Rice Hull Gasifier –Engine –Pump System (2006-07)*

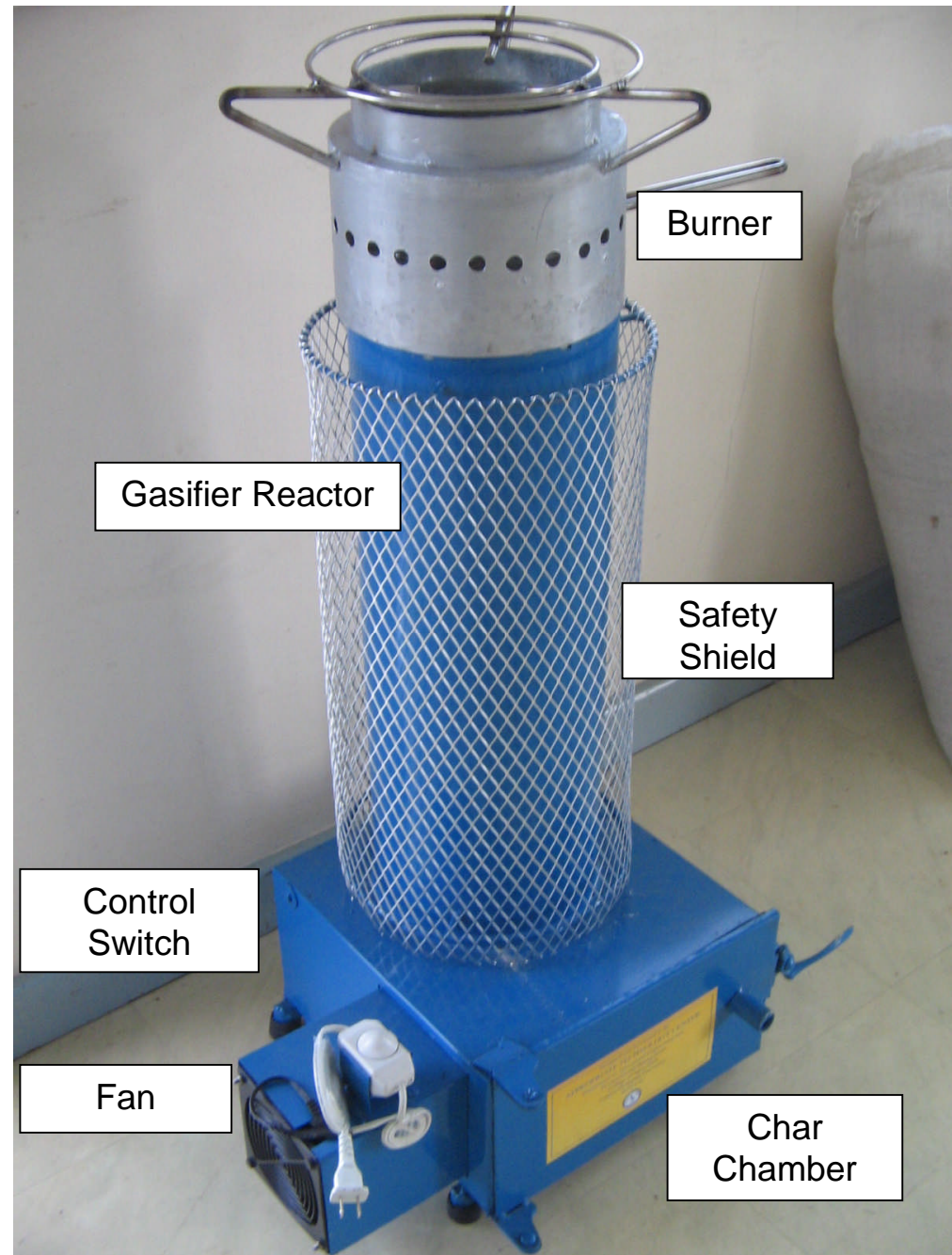


- 6.5 kg RH load/batch; 1.5h operation
- 6 min start-up & firing time
- 3-in pump; 6.5 hp engine; 6-9 L/s



Rice Husk Gas Stove

Engineer Alexis T. Belonio,
an Associate Professor and
Chairman of the Department
of Agricultural Engineering
and Environmental
Management, College of
Agriculture, Central
Philippine University (CPU),
Iloilo City, Philippines



Technology Resource Center Post-Harvest Facility in Cabiao

- Constructed in late 1980s
- Unable to take off
- White elephant
- What it can do?
 - Rice milling
 - Solar drying
 - Boiler for drying (electricity?)
 - Storage

Public-Private Partnership

- Partners:
 - Technology Resource Center
 - Ecological solid waste advocate NGO
 - Local entrepreneur, organic farmer
 - DAP as technical support provider
- Main Purpose:
 - Waste conversion cum organic fertilizer plant
- Secondary Purpose:
 - Rehabilitate the paddy dryer & rice mill

Capacity of the Post-Harvest Facility

- Paddy dryer
 - Output: 2,400 cavans of 50 kgs./day
 - Fuel: rice husks/hull
- Multi-Pass Rice Mill
 - Output: 1,000 cavans of 50 kilos/day
- By-product: Carbonized Rice Hull (CRH)

CRH as Soil Conditioner

- Retains heat from sunlight
 - increases soil & water temperature
- High air permeability
 - ability to replenish air in the soil
- Enhances water retention
- Sterilized & free from pathogens
- Excellent host for beneficial microorganisms
- Excellent ingredient for bio-organic fertilizer
- Reduces the population of golden apple snail in flooded rice fields (Source: PhilRice)

