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ABSTRACT

With the aggressive promotion of hybrid rice in the country, production level is expected to increase. On the other hand, the effect of global warming and climate change gave rise to unpredictable weather conditions like heavy downpour and flooding. With this situation, the problem of drying harvested paddy becomes more acute if not properly addressed.

Increasing the utilization rates of mechanical dryers (recirculating batch-type) by retrofitting them with biomass furnaces would be a logical solution to the problem, as this would lower drying cost and eventually entice more farmers to use mechanical dryers. Along with this, PHilMech has developed an indirect-fired biomass furnace utilizing rice hull and other biomass materials as alternative fuel.

To cushion the effect of the rising cost of fuel, reduce the cost and losses of drying operation and encourage utilization of mechanical dryers, PHilMech implemented the project "Promotion of Biomass Furnace Retrofitted to Mechanical Dryers". The project established strategic pilot technology demonstration sites nationwide to showcase the benefits of the retrofitting system that would eventually boost the utilization of mechanical drying facilities which are underutilized due to high drying cost. These serve as demonstration and showcase centers for interested adopters and manufacturers of the technology.

Establishment of techno-demo sites was done in partnership with DA-RFUs and organized farmer groups (cooperative/organization), LGUs as cooperators and licensed manufacturers. The PHilMech biomass furnace was retrofitted to the recirculating batch-type mechanical dryer of identified cooperators and seasonal utilization level was monitored and documented for a period of two years.

Generally, data collected revealed significant increase in mechanical dryer utilization (number of bags dried) and decrease in drying fee collected (peso per bag). Utilization level of the mechanical dryer tripled in terms of number of bags dried and this is attributed to the decrease in drying fee collected by almost 50 percent. Also, findings showed that the sustained utilization of biomass fed furnace is hinged on the collaborative efforts of both public and private entities.

INTRODUCTION

Rationale

Postharvest losses in palay can reach as high as 32 percent of the total production. Drying loss accounts for the largest portion of these postharvest losses. Generally, some 30 percent of the total postharvest losses were attributed to drying operation (as high as 8.70 percent of total production), 21 percent in milling operation, 18 percent in storage and 15 percent during threshing operation (BPRE, 1995). These loss estimates only relate to quantity losses and do not include the quality losses such as grain yellowing, molding, etc., which are similarly very significant.

Drying operation is so critical that inefficiencies in this operation (i.e. the inability to dry palay immediately and properly) would affect the efficiencies in the subsequent chain of postharvest operation (i.e. shorter storage life of palay and poor milling recoveries). Drying is commonly done through sun drying, the efficiency of which is very much affected by the unpredictability of weather. These contribute to a significant reduction on the nation's food supply and serious economic losses to our producers and processors.

In recognition of the critical role of promoting proper drying operation, the government promoted the use of mechanical dryers to farmer cooperatives. Various schemes of financial assistance were provided to them in the acquisition of mechanical dryers. Data from the National Food Authority (NFA) and PHilMech revealed that around 1,000 units of mechanical dryers (recirculating batch-type) were distributed to various cooperatives and local government units under the drying support program of DA in 1997. In spite of this, the use of mechanical dryers remains to be very minimal and most farmers continue to rely on sun drying to dry their produce.

In a survey conducted by PHilMech on the rate of utilization of distributed mechanical dryers, only about 50 percent of dryer – recipients operated their dryers at an average of 10 percent of their rated capacities. The other 50 percent have either used them at lower utilization rates or not at all. The high operating cost of these dryers is primarily the reason for the low utilization rate. Energy cost accounts for as much as 50 percent of the total operating cost. Most of the dryers distributed to farmer cooperatives are equipped with kerosene burners as the main source of heat and the continued increase in prices of fossil-based fuels such as kerosene has aggravated the problem. However, the use of biomass as heat source of drying could reduce drying cost by around 30 percent.

With the aggressive promotion of hybrid rice in the country, production level is expected to increase. On the other hand, the effect of global warming and climate change gave rise to unpredictable weather conditions like heavy downpour and flooding. With this situation, the problem of drying harvested paddy becomes more acute if not properly addressed. Increasing the utilization rates of these distributed recirculating dryers by retrofitting them with biomass furnaces would be a logical solution to the problem. This would lower drying cost and eventually entice more farmers to use mechanical dryers. Along with this, PHilMech has developed two models of indirect-fired furnaces; one using ricehull as fuel and the other using corncobs and other biomass source.

Biomass such as ricehull, corncobs, wood chips, sugarcane bagasse and many others are abundant in the Philippines. If these will be tapped as alternative fuel, the drying cost will be significantly reduced. Biomass is a renewable energy source because we can always grow more trees and crops, and waste will always exist. According to Wikipedia “Biomass is part of the carbon dioxide. Carbon from the atmosphere is converted into biological matter by photosynthesis. On death or combustion, the carbon goes back into the atmosphere as carbon dioxide. This happens over a relatively short timescale and plant matter used as a fuel can be constantly replaced by planting. Therefore, a reasonably stable level of atmospheric carbon results from its use as a fuel. The US-Energy Information Administration also stated that burning biomass fuels does not produce pollutants like sulfur that can cause acid rain. When burned, biomass does release carbon dioxide. But when biomass crops are grown, a nearly equivalent amount of carbon dioxide is captured through photosynthesis.

With the above premises, it has been recognized that there is a need to commercialize the biomass furnace technologies developed by PHilMech to fully realize its benefits. The Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) defines commercialization as the mass production of a mature technology for the use of a large number of people (end-users) significant enough to create impact directly or indirectly on the technology generator, manufacturer, distributor, end-users and other beneficiaries in the technology transfer system. It has a profit motive.

On the other hand, Peter Drucker, the modern-day management guru, briefly said, “In the final analysis, the ultimate test of a research result lies not in its novelty, scientific content or cleverness. It lies in its success in the marketplace.”

OBJECTIVES

General: This project aimed to promote the commercial utilization of the biomass-fed furnace in mechanical drying.

Specific: It aimed to

1. promote the utilization of biomass-fed furnace through the establishment of technology demonstration sites,
2. harness the skill and capabilities of the manufacturing sector in the commercialization of the biomass-fed furnace, and
3. enhance the awareness level of farmer-groups, agri-technologists, manufacturers, and grain traders/processors on the benefits of biomass-fed furnace in mechanical drying.

REVIEW OF LITERATURE

Majority of farmers in the country still prefer sundrying their harvested grains even though there are many mechanical dryers available in the market. The reason for this is primarily the high cost of fuel to operate mechanical dryers. The high cost of fuel limits the utilization of mechanical dryers resulting to very expensive operation that contribute in reducing the quality and quantity of farmer's harvest.

Recently, the development and introduction of good biomass furnaces like the models designed by PHilMech reduced significantly drying cost making mechanical drying a very attractive option in drying harvested grains. These furnaces feature automatic fuel-feeding mechanism and are equipped with temperature controls therefore easier to operate than previously available manually fuel-fed and controlled furnaces (Bulaong, 2008; Flores, 2008).

Batch Recirculating Dryer

The batch recirculating crossflow dryer (Figure 1.a) is the most commonly used mechanical grain dryer in the Philippines. Wet grains are loaded to the intake hopper of the elevator that conveys grains to the drying bin. The top portion of the drying bin is the tempering section, occupying about 90 percent of the total bin volume. The bottom portion is the drying section composed of four drying columns made of perforated metal sheets. Below each drying column is a metered discharge system that unloads grains at a constant rate (PHilMech, 2011).

Air is drawn into the dryer by an axial fan. The air is heated by a kerosene burner or a biomass-fed furnace before it enters the dryer. Grains moving down the drying columns are exposed to hot air and moisture is removed as hot air passes across the drying columns. The exhaust moist air is sucked by the fan out of the dryer. On the other hand, discharged grains are conveyed by the auger to the elevator and are recirculated to the top portion of drying bin. Very minimal drying occurs as the grains remain in the tempering section. The time within which the grains remain in the tempering section is termed as 'tempering time' while the time elapsed for grains to move down the drying section is the 'grain residence time'.

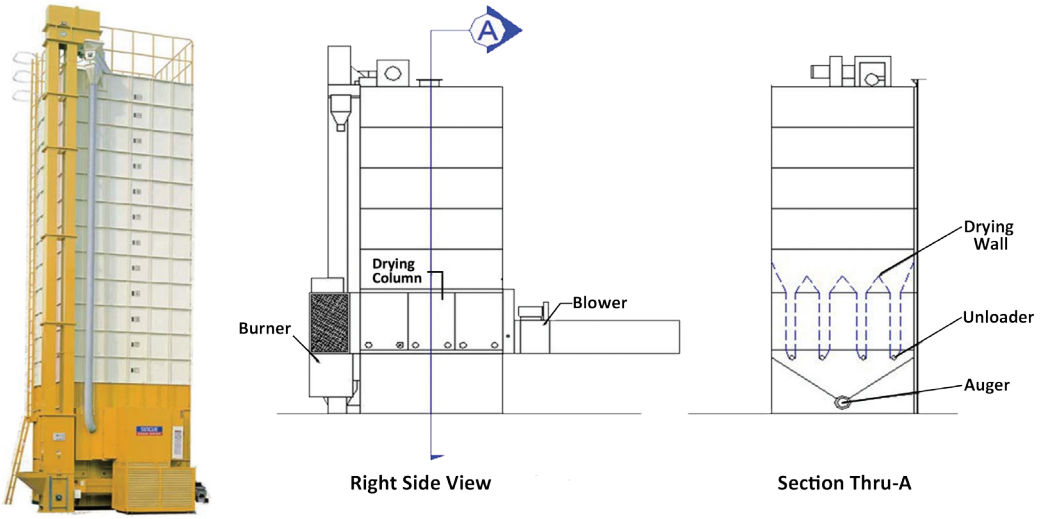

Figure 1.a Typical batch-type recirculating crossflow dryer.

PHilMech Rice Hull-Fed Biomass Furnace

The rice hull-fed furnace (RHF) system uses biomass as an alternative source of heat for mechanical dryers. The RHF technology was developed primarily to reduce the energy cost and address concerns on labor requirement, drudgery of operation and contamination of ash to the grains being dried (BPRE, 2007). The furnace uses rice hull as fuel and indirectly supplies heated air to the grains being dried through heat exchangers which prevents ash and flue gases from mixing with the grains. The furnace is also equipped with an automatic fuel feeding device thus, requiring minimal labor and substantially reducing drudgery. Figure 1.b shows the basic parts of the rice-hull fed furnace.

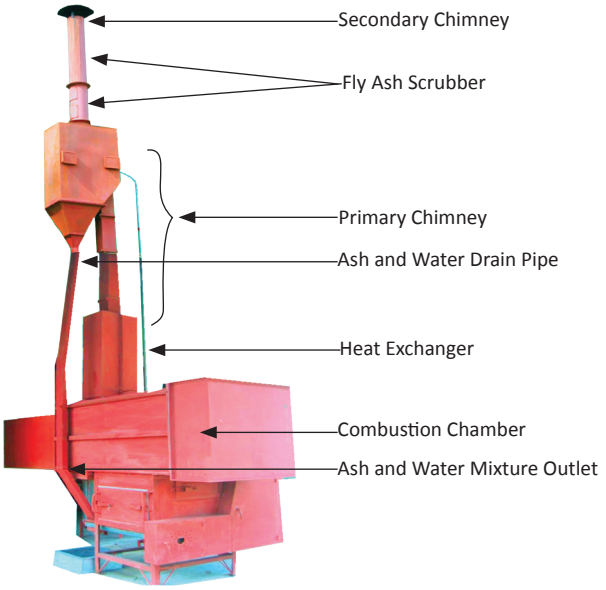

Figure 1.b The basic parts of the rice hull-fed furnace

Figure 1.c shows the diagram of operation of the rice hull-fed biomass furnace. The burning of the rice hull inside the combustion chamber heats the fire tubes inside the heat exchanger. Through a suction force from the blower of the mechanical dryer, ambient air enters the heat exchanger and passes inside the fire tube that is heated by the flue gas passing in between the fire tubes. Through a temperature controller, the recommended temperature setting is attained and maintained by regulating the feeding of rice hull into the combustion chamber. Flue gas escapes out into the chimney after passing the fly-ash scrubber system. Trapped fly ash is flashed down to a discharge tube by the water from the spray nozzle inside the scrubber system.

The technical specifications and features of the rice hull-fed furnace is shown in Table 1.

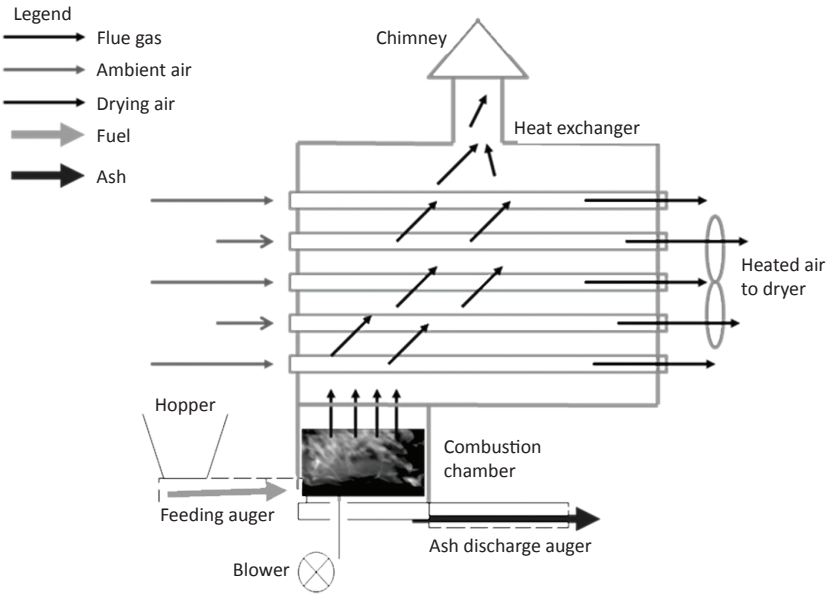

Figure 1.c Diagram of the indirect-fired PHilmech biomass-fed furnace/heater system (flue gas passes inside fire tubes of the heat exchanger).

Table 1. Specifications of the rice hull-fed furnace/heater system

Total Power	1.125 KW, single phase, 220 v
Fuel Consumption	> 23-24 kg/hr for 1 batch recirculating dryer
	> 40.7-47.5 kg/hr for 2 batches recirculating dryer
Dimension	1,524 mm x 1,269 mm x 1,789 mm
Type of Furnace	Indirect-fired (through the use of heat exchanger)
Drying Temperature	60°C – 70°C for batch recirculating dryer
Labor Requirement	1 operator
Features	> simple to operate
	> fully-automated operation
	> clean air output
	> with excellent temperature control system
	> with ash scrubber system
	> two in one machine (as heater and rice hull carbonizer)

Components of the Rice Hull-Fed Furnace

The rice hull-fed furnace consists of four major components, namely: the combustion chamber, heat exchanger, fly-ash control system and prime mover with temperature controller.

Combustion Chamber

Burning of the biomass fuel takes place inside the combustion chamber. Rice hull is fed into the combustion chamber through the automatic feeding mechanism attached to the loading hopper which moves eccentrically and pushes the rice hull to the combustion area. The chamber is metal in construction and lined with refractory fire bricks on its inner side walls equipped with an inclined step grate made of cast iron and agitator that automatically removes burned rice hull. An auger discharges the ash from the combustion chamber to the ash outlet.

Heat Exchanger

The heat exchange is made up of 68 pieces of seamless boiler tubes with two inch diameter and 3.4 millimeter thickness. The heat exchanger is located on top of the combustion chamber, with the drying air flowing through the horizontal pipes while the hot flue gas flowing up in between the pipes and exit the chimney. The heated air is forced through the mechanical dryer by a suction blower.

Fly Ash Control System

The rice hull-fed furnace is provided with a chimney for the exit of flue gas. Cleaning of flue gas prior to discharge to the atmosphere is done through the fly ash control system. The fly ash control system is a box attached to the chimney composed of baffles and faucet fitted with spray nozzles capable of spraying mist to “scrub off” fly ash and goes down the chimney through a discharge tube.

Temperature Controller and Prime Mover

The temperature control system allows for the automatic setting and maintenance of the desired level of air drying temperature. The desired drying temperature is set based on the initial moisture content of grains to be dried. The temperature control system automatically activates or de-activates the operation of the biomass fuel feeding mechanism regulating flow of rice hull to the combustion chamber.

The rice hull-fed furnace system requires a total power requirement of 1.12 kilowatt for the single phase electric motor prime mover.

PHilMech Multi-Fuel Biomass Furnace

The multi-fuel biomass furnace of PHilMech optimizes the use of mechanical dryers because it uses rice hull and corn cobs as fuel. It can provide the heat requirement for mechanical dryers, sufficient enough to dry grains from 31 percent to 14 percent moisture content in six to eight hours. It is equipped with temperature controller and an automatic feeder. Figure 1.d shows the basic parts of the multi-fuel biomass furnace.

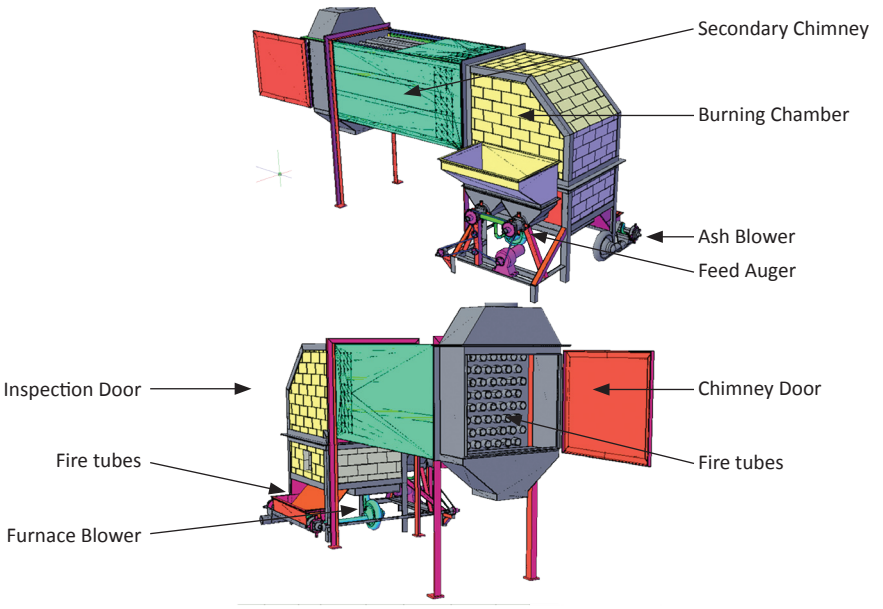

Figure 1.d Basic parts of the PHilMech multi-fuel biomass furnace

The multi-fuel biomass furnace operates in the same principle as the rice hull-fed furnace except that it is dry-type (without ash scrubber system) and flue gas enters the heat exchanger inside the fire tubes. Also, drying air is heated as it passes in between the fire tubes and is forced by the suction force of the blower to the drying column of the mechanical dryer. The schematic diagram of the operation of the multi-fuel biomass furnace is shown in Figure 1.e.

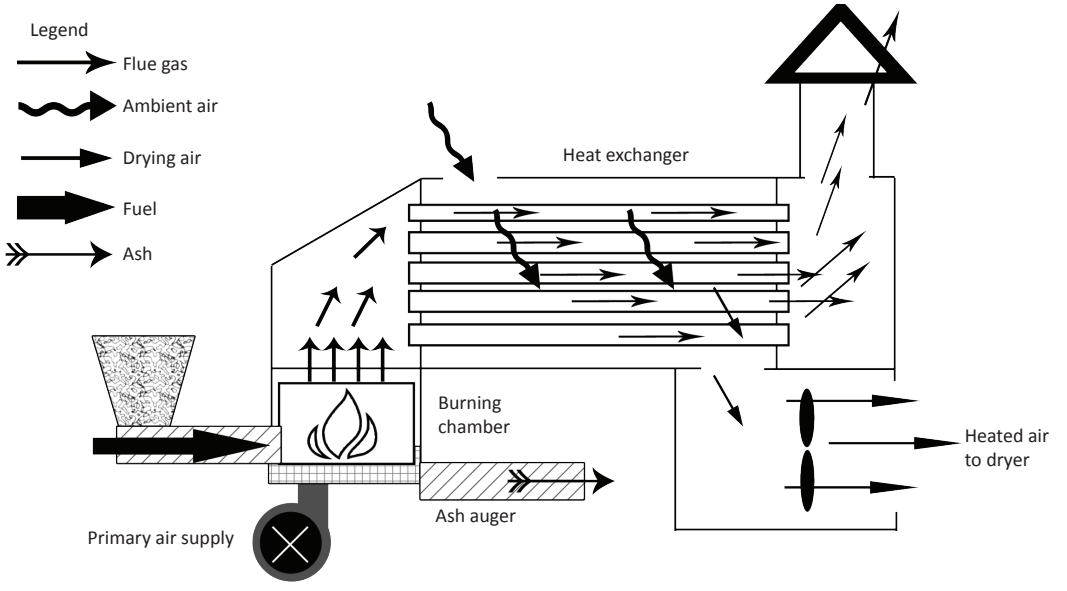

Figure 1.e Diagram of the indirect-fired PHilMech multi-fuel biomass furnace (flue gas passes inside fire tubes of the heat exchanger). (Source: Dr. Manolito Bulaong presentation, Grain Drying Principles)

Table 2 shows the technical specification and features of the PHilMech multi-fuel biomass furnace.

Table 2. Specifications of the multi-fuel biomass furnace.

Power Requirement	1.98 kw, single phase, 220 v
Heating System	Indirect-fired
Heat Exchanger Material	Fire tubes
Furnace Material	Refractory bricks
Fuel Feed	Twin auger
Temperature Control	Proportional Integral Derivative (PID) connected to fuel motor
Ash Disposal	Auger and pneumatic system
Fuel	Corn cobs or rice hull
Dimensions	Approximately 3m x 1m x 2m (L x W x H)

CONCEPTUAL FRAMEWORK

Figure 2 shows the conceptual framework of the project. Concepts from the general systems theory (GST) was used as the framework to illustrate how the project, *"Promotion of Biomass Furnace Retrofitted to Mechanical Dryers,"* works as a system and interacts with a greater system (supra system), its environment and to its sub - systems. The systems approach views the organization as a unified, purposeful system composed of interrelated parts. It shows that the activity of any part of an organization affects the activity of all other parts (Wallonick, 2007).

Adopting a linear proposition, inputs refer to the human, hardware, technological and financial resources. The transformation process includes establishing partners and networks, technology promotion and management, information and knowledge management and project monitoring and evaluation. Outputs will be the outcome of the project. The output is to pump prime the sustainable utilization and commercialization of mechanical dryers using biomass fed furnaces at farmer cooperatives and traders or processors.

Inputs are holistic in nature as these provide the whole continuum of a technological intervention/change, the hardware (facility), software (technology), humanware (manpower), organoware (organization) and financial requirements (Angeles, 2003). These inputs which come from within or outside the system will be infused into the system to work interrelatedly and interdependently in a transformation process to produce results as output of the system.

The Promotion of Biomass Furnace Retrofitted to Mechanical Dryers project as a system being implemented by PHilMech envisioned the promotion of commercial utilization of the biomass-fed furnace in mechanical drying. It comes as a venue for the availability of biomass furnace technologies in the market, which will eventually lead to improving the utilization of mechanical dryers, hence, postharvest development. This will ultimately contribute to the national economy, its supra system.

The inputs in the project consist of the human, hardware, technological and financial resources which interact with the project system. With the input - process interaction, commercialization of PHilMech designed biomass furnaces and their utilization for mechanical dryers are expected to be the results or outputs.

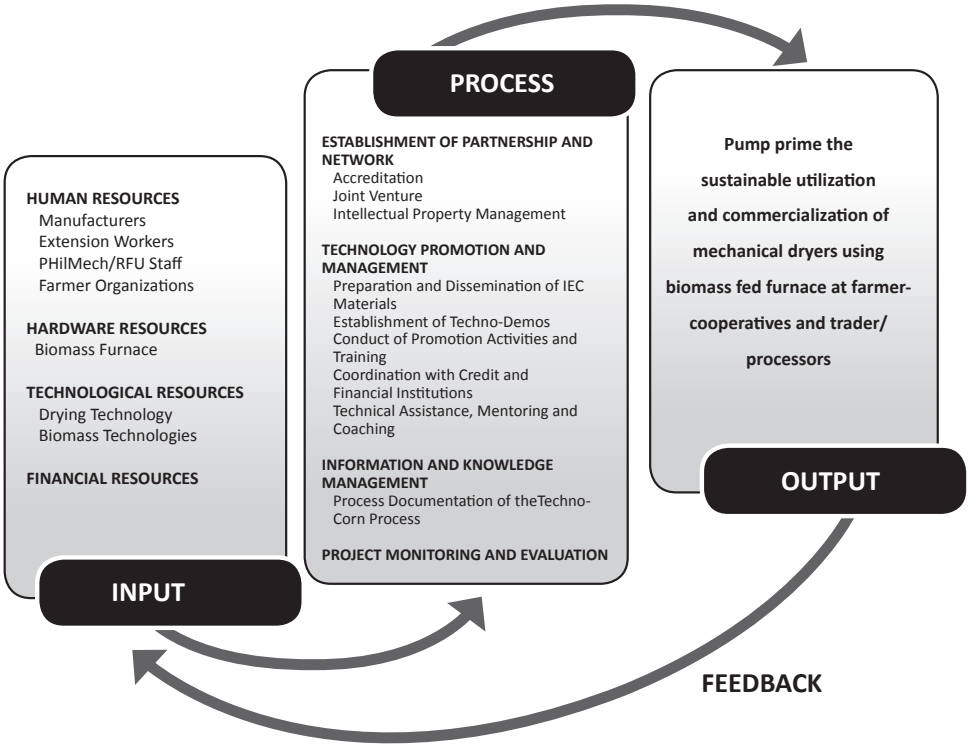

Figure 2. Conceptual framework on the technology utilization and commercialization of the PHilMech biomass furnace technology.

As inputs, the variations in the human resources (e.g. the staff of manufacturers, extension workers from LGUs, PHilMech and DA-RFUs staff and the members of the farmer organizations), hardware resources (e.g. biomass furnaces and its attributes), technological resources (e.g. the drying technology, biomass technologies and other related technologies), and financial resources (i.e. the funds to be used in the implementation as well as the payment for the purchase of furnaces) are assumed to influence the implementation of the project or the transformational processes.

Transformational process includes (1) Establishment of partnership and network through accreditation, joint venture and IPR management; (2) Technology promotion and management through preparation and dissemination of information, education and communication (IEC) materials, establishment of techno-demos, conduct of promotional activities and training, coordination with credit and financial institutions and provision of technical assistance, mentoring and coaching; (3) Information and knowledge management by conducting the documentation of the commercialization and utilization processes; and (4) Project monitoring and evaluation.

The result of these processes pump-prime the sustainable utilization and commercialization of mechanical dryers using the PHilMech designed furnaces. The effects to manufacturers, farmer cooperatives/associations, grain traders/processors and other adopters served as the yardstick of output from the process.

The comments and responses on the utilization and commercialization of biomass furnace from the industry stakeholders served as feedback and provided reference for further improvement to research, development and extension (RD&E) of the furnaces.

METHODOLOGY

Information Campaign

The production of information, education and communication (IEC) materials on biomass-fed furnace was the initial major step in promoting and increasing the awareness level of the stakeholders. These IEC materials were distributed during techno demonstrations in the vicinity of the techno-demonstration sites for prospective adopters.

Conduct of Seminars and Workshops

Seminars, workshops and technical symposium on the biomass furnace technology for extension workers, farmer-cooperatives, manufacturers, traders/processors, government officials and policy makers were conducted. These activities were done in collaboration with the DA-Regional Field Units, Local Government Units and local machinery manufacturers.

Establishment of Partnership and Networks

Licensing of machinery manufacturers

The manufacturer who initially manufactured the technology demonstration units of PHilmech furnaces were licensed/accredited following PHilMech's Licencing Protocol. The accreditation was coordinated with the PHilMech Industrial Promotion Program (PIPP) of the Technology Management and Training Division (TMTD).

Setting of the minimum requirements to license local agricultural machinery manufacturers was undertaken. On the crafting of criteria, some of the matters that were taken into considerations were the available shop equipment, human resource and financial capability, physical assets, track records and legal compliance documents.

Setting the minimum standard requirements for the technology was based from the original prototype of PHilMech, Philippine Agricultural Engineering Standards (PAES) and the clean air act implementing guidelines. Standards on the burning efficiency, combustion efficiency, smoke emission, and the standard specifications of the furnace were considered in the minimum standard requirements.

The list of the Agricultural Machinery Manufacturers Distributors Association (AMMDA) members and list of existing PHilMech accredited manufacturers for mechanical dryers were secured as reference and were considered in the screening and accreditation for the fabrication of the PHilMech designed furnaces. Letters and information materials were sent to manufacturers inviting them to join the screening and licensing process for the furnace.

Benchmarking/profiling of manufacturers as potential fabricators for the commercialization of the PHilMech biomass furnaces was conducted. The manufacturer's profile that were submitted and the results of the plant inspection and validation were used as basis for the licensing of local manufacturers.

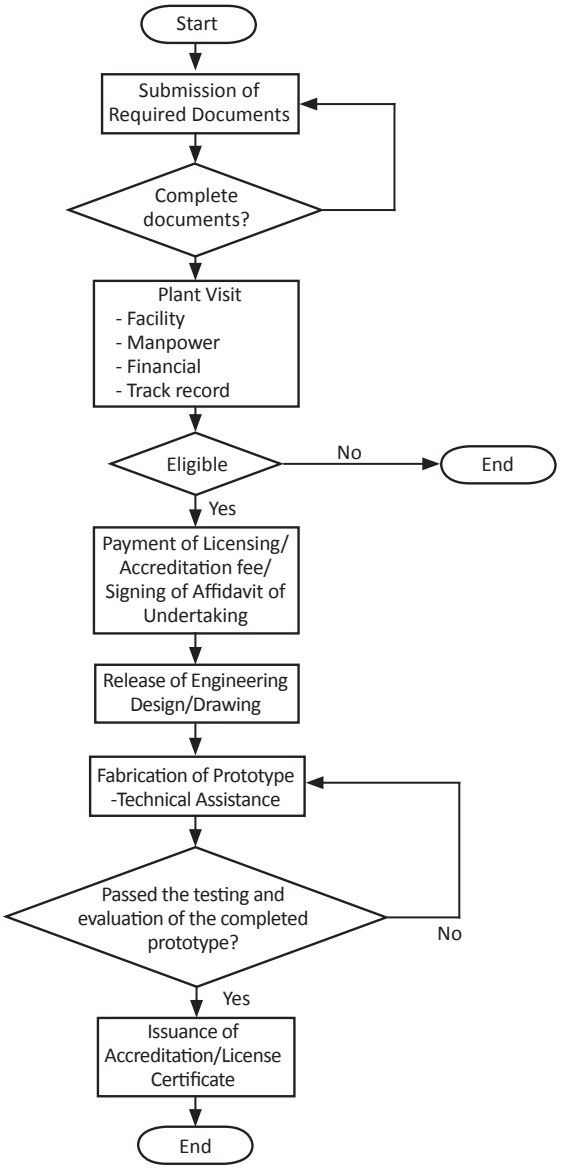

Figure 2. PHilMech licensing protocol process flow

Plant inspection and validation were conducted to assess if the prospective manufacturers have satisfied the minimum requirements for licensing. These activities were carried out to determine the manufacturing capability and compliance of the company to the required business permits. After passing the plant inspection and validation, an Affidavit of Undertaking (AOU) was signed by the manufacturers and PHilMech. The AOU is an assurance that the manufacturer shall treat the blueprint of the technology issued by PHilMech with utmost confidentiality. Technical assistance was also provided to the manufacturers in the course of developing the prototype model.

Testing and evaluation of the fabricated prototype was also conducted. The testing was carried out to determine its operating performance and verify the material specifications, workmanship, conformity with PHilMech design specifications, fuel consumption rate, heating efficiency and exhaust emission of carbon dioxide and nitrogen. If the fabricated prototype passes the testing and evaluation and other administrative requirements, a license certificate to manufacture is issued for commercial production of the technology. The manufacturers are considered responsible for the after-sales service, maintenance and quality control of the commercial units.

Intellectual property management

As a sign of recognition on the importance of Intellectual Property Rights (IPR), the project followed guidelines prepared by the PHilMech IPR Committee incorporated in the PHilMech's Technology Licensing Protocol. Under its terms and conditions, the manufacturer shall pay PHilMech an earned royalty of three percent (3%) of the completed net sales of products arising from the license. Payment of license fees and royalties shall be paid to the PHilMech Cashier at the specified dates. Also, the licensee shall at all times commit to the highest standards of workmanship in the fabrication of the licensed intellectual property. On the other hand, the concerned technology developers and contributors shall be entitled to a share in the License Fees and royalty payments.

Technology Promotion Management

Establishment of techno-demo center

Techno-demonstration sites were established to showcase the benefits derived from the biomass furnace technology. The project established one techno-demonstration center per region. Establishment of techno-demo sites was done in partnership with DA-RFUs and organized farmer groups (cooperative/organization), LGUs as cooperators and licensed manufacturers.

One of the preliminary activities undertaken was the preparation of criteria for the selection of technology demonstration (techno-demo) cooperators. On crafting the criteria, parameters taken into considerations were the presence of a functional recirculating dryer equipped with kerosene/diesel burner, location of the drying plant, financial status of the cooperative, receptivity, technical requirements and administrative concerns.

The records of active groups, organizations, cooperatives and LGUs engaged in grain drying activities with functional recirculating dryer were secured from the database of PHilMech and were requested from the DA-Regional Offices. The short list of cooperatives and LGUs with recirculating dryers were recommended and submitted by DA-RFUs as possible cooperators for the establishment of techno-demo sites. The submitted list of cooperatives and LGUs were evaluated and an on-site validation was conducted.

Gathering of data was done using a structured questionnaire. The questionnaire includes details on the location, organization, management, technical aspects, and administrative matters of potential cooperators. The target sites selected for the project were the major rice-or corn producing areas in the country.

Actual inspections of the drying plant of the would-be cooperator were conducted. This is to inspect the status and type of the mechanical dryer, plant lay-out, possible waste disposal and surroundings of the plant. Field validations were conducted to determine the appropriateness and potential advantages of the PHilMech biomass furnace to the potential cooperator.

Based on the information gathered and evaluation conducted, the project implementers and collaborators have identified the most qualified possible cooperators per region.

During the installation of techno-demo units, technical assistance was provided to the local machinery manufacturer suppliers. This is to ensure quality, correctness and proper fabrication and installation of the facility. Debugging, trail run, testing and evaluation were also carried out to determine its operating performance and verify the material specifications, workmanship, conformity with PHilMech design specifications, fuel consumption rate, and heating efficiency of furnace delivered and installed. Any problems encountered on the operation during testing were immediately reported to the supplier.

Technical symposium and technology demonstration

Technical symposium and technology demonstrations were conducted to enhance the awareness level of the participants on the benefits of biomass-fed furnace in mechanical drying. This was also a way of coming up with action plans replicating retrofitting projects in their respective areas.

Technical assistance, coaching and mentoring

Deliberate site visitation and immersion with the beneficiaries were conducted. This was to assist the beneficiaries in the operation of the hardware/technology. Coaching and mentoring were done with the beneficiaries to ascertain sustainability and utilization of the facilities. This focused on technical, social and organizational aspect of operation. It was conducted in collaboration with the DA-RFUs.

Information and Knowledge Management

Process documentation

Since there were several processes that needed to be undertaken in the course of utilization and commercialization of the biomass furnace technology, processes involved were documented. This ensured that the dynamics of utilization and commercialization of the technology are properly documented. The results will become the basis for future strategies and thrusts concerning biomass furnace.

Project monitoring and evaluation

Regular monitoring and evaluation were conducted to ascertain the status of the project that will become the basis in providing guide and direction to project implementers. The project implementers spearheaded the monitoring and evaluation of the project.

Monitoring forms were left to the cooperators to record/monitor the utilization of the dryers as well as problems encountered on the operation of the furnace. Also, utilization forms were used to monitor the drying fee collected and other technical parameters such as temperature, initial moisture content, final moisture content, number of drying hours, purpose of grain to be dried, initial and final weight or number of bags. This served as the basis of assurance if the furnace is operated correctly, if the drying cost is reduced, and if the utilization of mechanical dryers is increased.

RESULTS AND DISCUSSION

Development of IEC materials

The IEC materials were developed and disseminated to create awareness and heighten interest among prospective users of the biomass furnace technology. Table 2 shows the different IEC materials that were developed, reproduced and disseminated to the intended users.

Postharvest newsletters were sent to stakeholders through mail. Regular subscribers of the PHilMech newsletters are the manufactures, SCUs representing the academe, DA-attached and line agencies, regional and provincial DA extension offices. The last quarter issue of 2007 Volume 14 of the postharvest newsletter featured the PHilMech designed biomass furnace.

The manual of operation was provided to the accredited / licensed manufacturers for reproduction and dissemination along with the promotion and marketing of the furnace.

Table 2. IEC materials produced and disseminated, 2009

Type of Publication	No of Copies/ Publication	Intended Audience
Manual of Operation	4.000 copies	Operators and drying plant managers
Leaflet	5,000 copies	General public
Flyers*	100 copies	Prospective adopters
Video presentation*	1 presentation	Prospective adopters
Calendar	1,500 copies	General public
Poster	2 sets	General public
Newsletter	1,500 copies	General public
Press Releases	4 times at national dailies	General public

Seminars, Workshops and *Tekno-Talakayan*

A National-Seminar Workshop on Rice Hull Non-Power Applications in the Philippines was conducted at PHilMech, Science City of Munoz, Nueva Ecija on October 24 to 25, 2006. The activity was organized by PHilMech in collaboration with the Philippine Rice Postproduction Consortium (PRPC) and DA-Regional Field Unit III. The seminar-workshop brought together 62 participants from all over the country. During the seminar, updates about the past and present rice hull research and development activities and projects of PRPC member agencies (NFA, UPLB, PhilRice, BPRE, NAFC and IRRI) were presented and discussed. Action plans/proposals towards the formulation of extension-promotion activities for PHilMech-designed biomass furnace by DA-RFU's were crafted. The participants were composed of the Regional Rice Coordinators, Regional Agricultural Engineering Group (RAEG) chiefs, researchers, rice millers, manufacturers and other rice postharvest stakeholders.

Series of "Rice and Corn Information Caravan" were conducted nationwide. There were 15 batches conducted in 15 regions. The caravans were conducted from January 2007 to February 2007. The caravan aimed to create awareness on the recently developed production and postharvest technologies on rice and corn. One of the technologies that were highlighted in the said activity was the PHilMech-designed biomass furnace, flat bed dryer and moisture meter. Advantages, features, and specifications of these postharvest technologies were among the

contents of the topics discussed. Participants to the caravan were farmer-cooperative-leaders, extension workers from the LGUs, processors and other stakeholders. From the 15 batches conducted there were around 6,000 participants who attended the caravans, averaging to 400 participants per caravan. The caravan was spearheaded by the DA-Central Office in coordination with DA-RFUs and other agencies under the Department of Agriculture like PHilMech.

The PRPC conducted the 5th National Grains Postproduction Conference on July 18 to 19, 2007 at the Royal Mandaya Hotel, Davao City. One of the topics presented in the conference was the technical performance of the PHilMech Biomass Furnace/Heater System. Other furnaces developed by the PRPC member agencies were also presented in the conference. The conference also defined biomass and other possible sources; biomass utilization; biomass power generation; biomass non-power technology and biomass profitability and environmental sustainability. Participants were farmers, farmer-groups or cooperatives, millers, processors, manufacturers, LGUs, R & D institution, SCUs representatives and other agencies with current efforts on biomass utilization. There were around 300 participants to the conference.

Three batches of *Tekno-Talakayan* on postharvest technologies were conducted by PHilMech for the farmers and agricultural technicians. The objective of the *tekno-talakayan* was to discuss mature and emerging grains postharvest technologies, among which, is the PHilMech designed biomass furnace. A *talakayan* is an innovation of the seminar. The lecture was shortened to give more time for discussion. An anchor facilitated the *talakayan* and the resource persons answered the questions of the participants.

The *Tekno-Talakayan* on Rice Postharvest Technologies was held on November 12, 14 and 16, 2007 with around 95, 90, 60 participants, respectively. This was held at the Department of Agriculture, Diliman, Quezon City in recognition of the Rice Awareness Month 2007 celebration. Farmer leaders from regions 3, 4A and 4B attended on the first and second day, Extension workers of DA bureaus and line agencies participated on the third day.

The PHilMech displayed exhibit materials of the two models of furnaces at the 5th National Grains Postproduction Conference on July 18 to 19, 2007 in Davao City. The agency also participated in the Rice Awareness Month exhibit in November 2007 at the DA Central Office. One of the technologies featured was the biomass furnace technology.

On May 23, 2008 the bureau conducted a seminar workshop for manufacturers regarding PHilMech Biomass / Rice hull furnace and orientation on the technology licensing protocol.

Although the designs of biomass furnaces, the direct-fired furnace is already out in the market. Several manufacturing firms have signified their interest to fabricate the PHilMech-designed biomass furnace. Table 3 shows the manufacturers who are interested to fabricate the PHilMech designed furnaces. Other manufacturers were invited to participate in the screening and accreditation process.

Manufacturer's Promotional Strategy

The accredited manufacturers of PHilMech biomass-fed furnace have been aggressively doing promotional activities. They had printed several copies of flyers on PHilMech biomass-fed furnace. The flyers were given to their prospective adopters. Agri Component Corporation and Suki Trading Corporation have also developed video presentation of the PHilMech Multi Fuel Biomass Furnace. The video was shown to those who inquired directly at their office. Their staff had compiled a list of prospective clients who have recirculating dryers. They visited their prospects and presented the

economic benefits, advantages, features and cost benefit analysis of the technology as compared to their existing heat source or drying system. They have also informed their dealers about the technology. Manufacturers have now their own marketing and promotional strategies.

Technology Early Adopters

The experiences of the implementers and manufacturers in commercializing the PHilMech biomass furnaces confirms the statement of Roger (1983) "when a technological innovation is introduced, not everyone adopts it at the same moment. Rather, there will be innovators and there will also be laggards".

Many have heard and known the technology. Many got interested and signified their interest There were eight initial adopters that purchased the PHilMech Multi Fuel Biomass-fed Furnace. Table 3 shows the list of early adopters of the biomass furnace technology.

Table 3. List of early adopters of the PHilMech biomass furnace technology. 2009

Name	Address	Remarks
Mr. Bello Miguel	Villaluz, Benito, Soliven Isabela	Grain processor
Mr. Bong Tapales	Poblacion, Benito Soliven, Isabela	Grain processor
Mr. Jinggoy Samano	Poblacion, Baler, Aurora	Grain processor
Northern Aurora MPCI	Dinalongan, Aurora	Grain processor
Ms. Lolita Ganet	Bunton, Tuguegarao, Cagayan	Grain processor
Mr. Antonio Barrientos	Buenavista, Maddela, Quirino	Cooperator of the Pilot-demo prototype
Mr. Leo Condoya	Poblacion, Maddela, Quirino	Grain processor
MAC TRACK Company	Tagum, Davao City	Supplier/dealer

Licensing of Manufacturers

Benchmarking/profiling of interested manufacturers was conducted and 10 manufacturers were considered. A questionnaire was developed and was used in the profiling of prospective manufacturers.

On-site plant inspections were conducted at the Agri Component Corporation, ACT, Suki Trading Corporation, HG Agri Machineries, Golden RAM Merchandising, Tropics-Agro Industries, Inc., PI Farms Products, Morallo Industries, Mechaphil Corporation and Agustin General Engineering Services.

The Affidavit of Undertaking and other administrative arrangements with the interested manufacturers like coordination meetings were also conducted with Agri Component, ACT, Suki Trading, Golden RAM Merchandising, Hg Agri Machineries, PI Farms, Mechaphil Corporation and Tropics Agro Industries Inc.

Technical assistance and coaching were provided to Agri Component Corporation, Suki Trading Corporation, Golden RAM Merchandising and P.I. Farms Products Inc. during the fabrication of the prototype. The concerned technology generator spearheaded the activity.

Testing and evaluation of the fabricated prototype of Agri Component Corp., PI Farms Products, Suki Trading Corp. and Golden RAM Merchandising were conducted. Sample test results of the performance and smoke emission test of the prototype of Agri Component Corporation for PHilMech Multi Fuel Biomass-fed Furnace showed that the heating system efficiency (HSE) using ricehull as fuel, was around 67.55 percent while the HSE using corncob as fuel was 57.15 percent. The HSE of the prototype surpassed the PSAE standard allowable minimum value of 50 percent.

The smoke emission of the prototype was also tested and analyzed. The testing was done using a gas analyzer. The smoke emission was tested at 0.25 meter around the exhaust of the chimney. Using ricehull as fuel at stable operation of the furnace, the exhaust smoke had an average carbon monoxide content of 317.10 mg/m^3 and 10.5 mg/Nm^3 nitrogen. Using corncob as fuel, the exhaust smoke had an average of 166.63-mg/m^3 carbon monoxide and 6.6 mg/Nm^3 of nitrogen. The prototype emitted lesser amount of carbon dioxide and nitrogen than the DENR maximum allowable amount of carbon monoxide which is 500 mg/m^3 and nitrogen 500 mg/Nm^3.

The same procedures of testing and evaluation were conducted at the other accredited/ licensed manufacturers of PHilMech biomass furnaces (Table 4).

Table 4. List of accredited manufacturers and with on-going fabrication of prototype model, 2010

PHilMech Designed Furnace	Name of Manufacturer	Address	Accreditation Certificate No.	Status (as of 2010)
PHilMech Multi Fuel Biomass-fed Furnace	Agri Component Corporation	Cauayan, Isabela	08-1BF	Licensed manufacturer
	Suki Trading Corporation	Cebu City	09-2BF	Licensed Manufacturer
	HG Agri Machineries	Bukidnon	-	On-going fabrication of prototype
	Agustin General Engineering Services	Midsayap, North Cotabato	-	On-going fabrication of prototype
	P.I. Farms Products Inc.	Valensuela	-	On-going fabrication of prototype
	Ulip Welding Shop	Oriental Mindoro	-	On-going fabrication of prototype
PHilMech Biomass Furnace/Heater System	P.I. Farms Products Inc.	Valenzuela	10-2BF	Licensed manufacturer
	Suki Trading Corporation	Cebu City	10-3BF	Licensed manufacturer
	Golden RAM Merchandising	Negros Occidental	09-1BF	Licensed manufacturer

Technology Modification and Innovation

There is no sense in developing a machine that nobody uses. Technology verification and assessment would permit evaluation for developing, modifying, or entirely stopping the development of a technology. The study established the potential of the technology and revealed possible modifications to further enhance its performance and acceptability. (Paras et al. 2004)

With the continued technology generation and the growing capability of our local machinery manufacturers, licensed manufacturers modified the PHilmech biomass-fed furnace to satisfy the need of other applications of the technology. Adopting the basic technical principles of operation of PHilmech biomass furnace, they came up with the design the could suit the need of high value crops drying, fish drying, cocopeat drying, high capacity mechanical dryers and even in solid waste management applications.

Agri Components Corporation, one of the accredited manufacturer of PHilMech multi fuel biomass-fed furnace came up with a scaled-up design that could satify the requirement of mechanical dryers with a maximun air flow rate of 50,000 cfm (Figure 3).

On the other hand, Suki Trading Corporation, also a licensed manufacturer of PHilMech multi fuel biomass-fed furnace came up with a scaled-down design of the furnace that can be used as supplemental heater to cabinet type dryers for fish products (Figure 4).

Figure 3. Scaled-up design of the multi-fuel biomass furnace (manufactured by Agri Component Corporation) retrofitted to the 30 tons capacity batch type recirculating dryers

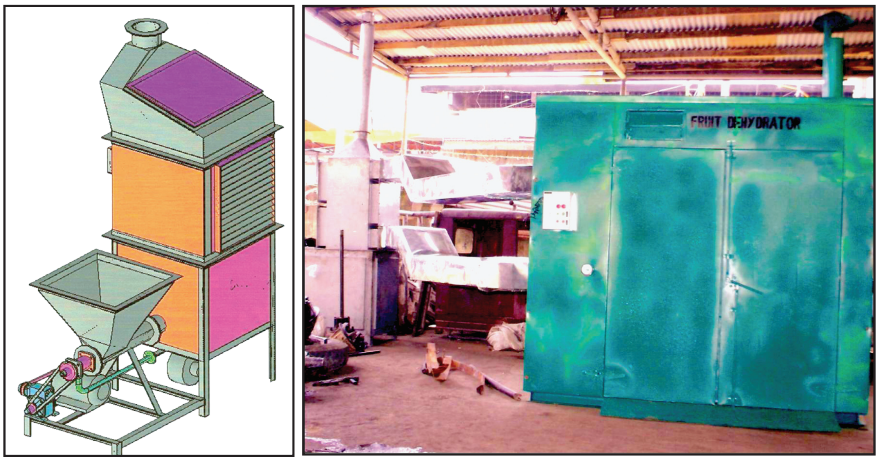

Figure 4. Scaled- down design of the multi-fuel biomass-fed furnace (manufactured by Suki Trading Corporation) retrofitted to cabinet type dryers for mango.

Establishment of Techno-Demo Center

Based on the information gathered and evaluation conducted, the project implementers and collaborators have identified the most qualified possible cooperators per region. Figure 5 shows the selected cooperators for the technology demonstration sites for the promotion of the PHilMech designed biomass-fed furnace. Unfortunately, no qualified cooperator was identified in Region I and CAR during the conduct of evaluation. The units allotted for these regions were recommended for CARAGA and Region V instead.

Two units of PHilMech biomass furnace/heater system were delivered and installed in Regions III and IV-A in June 2010 by PI Farms Products Incorporated under the DA-Rice 2007 fund. Three units of PHilMech multi fuel biomass-fed furnace were also delivered and installed in Region VI, IX and X in July 2010 by Suki Trading Corporation under GMA-Rice 2008 fund.

Under the 2009 DA-Rice Program, additional 12 units of PHilMech biomass-fed furnace were delivered and installed. Six units of these (PHilMech multi fuel biomass-fed furnace) were installed in Regions VIII, XI, XII and CARAGA in December 2010 by Suki Trading Corporation. Meanwhile six units of PHilMech biomass-fed furnace/heater system were delivered and installed in Regions II, IV-A, IV-B, V, and VII by P.I. Farms Product Incorporated. Trial run, debugging, testing and evaluation were also conducted for the 12 techno-demo units of PHilMech biomass-fed furnace.

Based on the testing and evaluation, the furnaces conformed to the minimum specifications specified by PHlMech. The heating system efficiency obtained by the furnaces also passed the minimum HSE set by PAES.

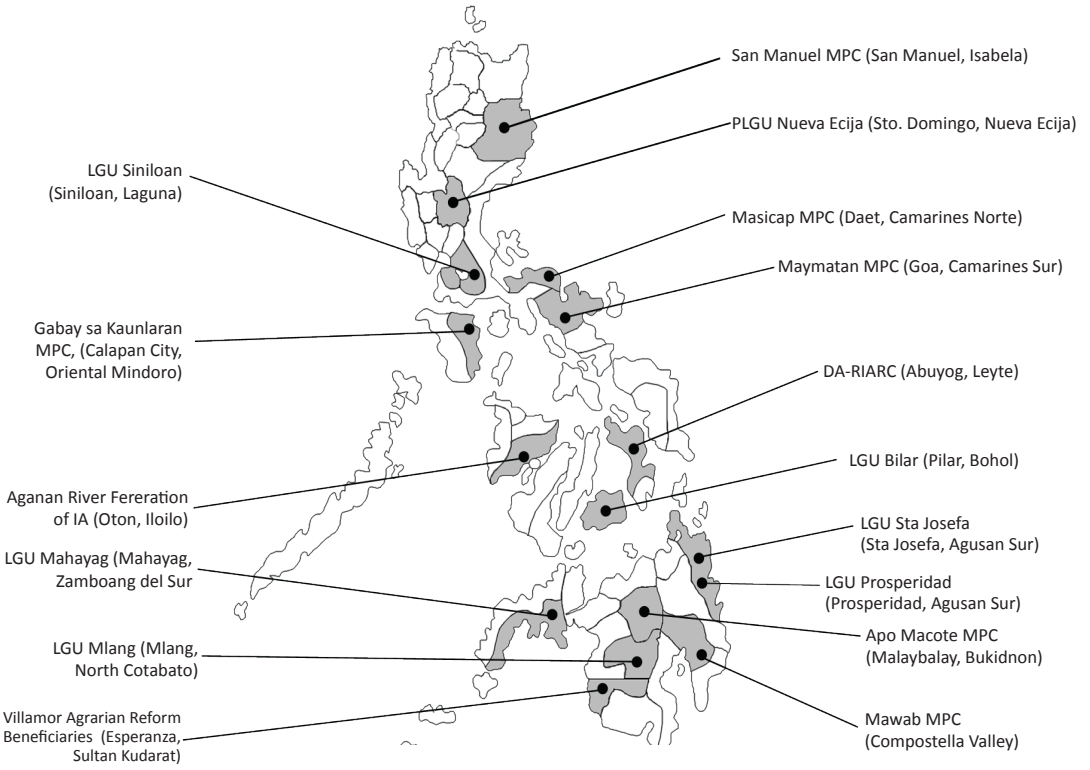

Figure 5. Technology demonstration sites and cooperatives for the project, 2009

Retrofitting the Furnace

The mechanical dryers of the identified cooperators were initially assessed prior to retrofitting the furnace. The biomass furnace was retrofitted either to one or two units of mechanical dryers. Retrofitting the furnace to two mechanical dryers was done for the rice hull-fed furnace system in two demo sites while five demo sites for the multi-fuel furnace model. On the other hand, retrofitting the furnace to a single mechanical dryer was done in five and two sites for the rice hull-fed and multi-fuel biomass furnace system, respectively.

Testing and Evaluation

Actual testing of the biomass retrofitting system was conducted using the freshly harvested paddy to determine the conformity in material specification, design, workmanship and drying performance. Method of test conducted and drying performance evaluation was based on the heating system efficiency standards set under the Philippine Agricultural Engineering Standards (PAES).

Heating system efficiency is the ratio of the amount of heat supplied for drying to the total amount of heat available from the fuel, expressed in percent. Table 5 shows the heating system efficiency (HSE) for the demo units in the project sites.

Table 5. Heating system efficiency attained by techno-demo units during the conduct of performance testing and evaluation, 2009-2011

Region	Cooperators/techno-demo sites	Heating System Efficiency (%)
II	San Manuel Multi -Multi Purpose Cooperative	66.55
III	Grain Drying Center of Nueva Ecija	78.57
IV-A	Local Government Unit of Siniloan, Laguna	78.88
IV-B	Gabay sa Kaunlaran Multi-Purpose Cooperative	79.30
V	Masicap Multi-Purpose Cooperative	73.61
	Maymatan Multi-Purpose Cooperative	69.73
VI	Aganan River Federation of Irrigators Association	72.00
VII	Local Government Unit of Bilar Bohol	67.52
VIII	DA-Regional Integrated Agricultural Research Center	66.55
IX	Local Government Unit of Mahayag, Zamboanga del Sur	76.06
X	Apo Macote Multi-Purpose Cooperative	79.68
XI	Mawab Multi-Purpose Cooperative	76.77
XII	Villamor Agrarian Reform Beneficiaries Cooperative	63.39
	Local Government Unit of M'lang	69.04
XIII	Local Government Unit of Santa Josefa	79.36
	Local Government Unit of Prosperidad	86.10

Conduct of Technical Symposium and Technology Demonstration

Five batches of technical symposium and technology demonstration on PHilMech Multi Fuel Biomass-Fed Furnace and PHilMech Biomass-fed Furnace/Heater System were conducted (Table 6). These activities were attended by the Postharvest Specialist Network from the PLGUs and DA-RFUs, municipal agriculturists and municipal planning officers. The activity aimed to enhance the awareness level of the participants on the benefits of biomass-fed furnace technology in mechanical drying and come-up with action plans and retrofitting projects in their respective areas.

During the conduct of technical symposium, technical overview and socio economic benefits of PHilMech biomass furnace retrofitted to mechanical dryers were presented. Actual operation of PHilMech biomass furnace was also demonstrated to the participants. A total of 120 participants attended the five batches of technical symposium and demonstration activities. Action plans prepared per region were monitored and technical assistance was provided to adopters of the technology.

Table 6. Technical symposia and demonstrations of PHilMech biomass-fed furnace conducted, 2010-2011.

Activity	Date	Venue	Type of Participants	No. of Pax
Technical Symposium and Technology Demonstration of PHilMech Biomass Furnace	08/29-30 /2010	Pagadian and Mahayag, Zamboanga del Sur	DA-RFU staff, PLGU PAEG and LGUs Municipal Agriculturist and Planning Officer (Region IX and XII)	35
	10/09-10/2010	PHilMech, Science City of Muñoz, Nueva Ecija	DA-RFU staff, PLGU PAEG and LGUs Municipal Agriculturist and Planning Officer (Region III, IV-A, IV-B and V)	17
	10/17-18/ 2010	Iloilo city	DA-RFU staff, PLGU PAEG and LGUs Municipal Agriculturist and Planning Officer (Region VI, VII and VIII)	25
	05/16-18/2011	Prosperidad, Agusan Sur	DA-RFU staff, PLGU PAEG and LGUs Municipal Agriculturist and Planning Officer (Region X, XI, XIII)	38
	11/9-10/2011	PHilMech, Science City of Muñoz, Nueva Ecija	DA-RFU staff, PLGU PAEG and LGUs Municipal Agriculturist and Planning Officer (Region CAR, I, II)	25

Turnover activities for the operation and technology demonstrations were also conducted. Farmers' cooperatives and association leaders as well as private millers, local manufacturers and local officials were invited during the said activity. Technology demonstration was conducted at every techno-demo site (Table 7).

A total of 355 participants attended the series of on-site technology demonstration conducted. Benefits, technical briefing and actual operation of the furnace were presented and demonstrated. The objectives was to familiarize and orient the participants on the PHilMech developed technology. Possible partnership with local manufacturer in the region for the fabrication and commercialization of the technology was also explored. Table 7 shows the list of turnover and techno-demo activities conducted per site.

Table 7. Turn-over and technology demonstration activities conducted per site. 2011.

Activity	Date	Venue	Type of Participants	No. of Pax
Turn-over and technology demonstration site of PHilMech Biomass Furnace	April 12, 2011	Mawab, Compstella Valley	LGUs, manufacturer, farmers, private millers and traders	20
	April 14, 2011	Malaybalay, Bukidnon	LGUs, manufacturer, farmers, private millers and traders	44
	April 19, 2011	San Manuel, Isabela	LGUs, manufacturer, farmers, private millers and traders	24
	April 26, 2011	Bilar, Bohol	LGUs, manufacturer, farmers, private millers and traders	23
	April 28, 2011	Abuyog, Leyte	LGUs, manufacturer, farmers, private millers and traders	20
	May 03, 2011	Calapn City, oriental Mindoro	LGUs, manufacturer, farmers, private millers and traders	34
	May 04, 2011	Siniloan, Laguna	LGUs, manufacturer, farmers, private millers and traders	17
	May 05, 2011	Daet, Camarines Norte	LGUs, manufacturer, farmers, private millers and traders	39
	May 06, 2011	Goa, Camarines Sur	LGUs, manufacturer, farmers, private millers and traders	51
	September 21, 2011	Oton, Iloilo	LGUs, manufacturer, farmers, private millers and traders , NIA	48
	October 05,2011	Malaybalay, Bukidnon	LGUs, manufacturer, farmers, private millers and traders	25
	November 20, 2011	Calabanga, Camarines Sur	LGUs, manufacturer, farmers, private millers and traders	36

Technology Adopters

As an offshoot of the aggressive promotion, and awareness campaign of the project, the local manufacturers, techno-demo cooperators, collaborators, farmers, traders and private millers started to recognize the importance and benefits of having the PHilMech biomass-fed furnace retrofitted to their mechanical dryers. As of December 2011 the reported biomass furnace purchased by the adopters from the licensed manufacturers totaled 222 units nationwide. The 63.06 percent of the adopters are from Luzon, 8.10 percent from Visayas and 28.82 percent from Mindanao.

In addition, there were interested adopters who visited PHilMech. Other interested stakeholders inquired through phone calls and letters.

The municipal mayor, municipal agriculturist and municipal administrator from Umingan, Pangasinan personally visited PHilMech to seek assistance and see the actual unit of mechanical dryers retrofitted with PHilmech biomass furnace.

The San Enrique Multi-Purpose Cooperative in Negros Occidental learned from PLGU staff about the PHilMech biomass furnace. The coop sent letter to PHilMech requesting for technical assistance to retrofit their existing batch-type recirculating dryers with biomass furnace.

The DA-RFU V allocated four units of PHilMech biomass furnace from their 2011 projects. These were retrofitted and installed to unutilized batch-type mechanical dryers distributed during their previous drying support program.

Private traders and millers from Laguna and Pangasinan inquired and asked for licensed manufacturers referral and the nearest locations that could be visited to see the actual unit of PHilMech furnace.

DA-West VIARC in Iloilo and Villa Luna MPC in Isabela visited the techno-demo units of PHilMech biomass furnace in their area and sent letters to PHilMech requesting technical assistance in assessing their mechanical dryers proposed for retrofitting. The provincial local government of Nueva Ecija started its assessment of 71 units of batch-type mechanical dryers located in several municipal grain drying centers. The technical assessment activity was conducted by PHilMech in collaboration with DA-RFU III. To determine the extent of damage and repair requirements of the mechanical dryers that can still be retrofitted with biomass-fed furnace.

Moreover, the Rice Mechanization Program of the Department of Agriculture incorporated the retrofitting of existing mechanical dryers with PHilMechs biomass furnace as component of their drying support projects.

Monitoring and Evaluation

Initial monitoring and evaluation and the gathering of comments and responses on the utilization of the technology from the adopters under DA-Rice 2006 and 2008 were conducted.

Based on the monitoring and evaluation, all units were functional and operational. However, it was observed that some problems have been encountered on the operation of the furnace. Cracks were observed on the combustion chamber after a few drying operations. Excessive heat exposure at the walls of the combustion chamber, clog the ash scrubber, fuel feeding system and ash discharge part of the heart system model. Feedbacks and recommendations from the operators

and cooperators were also gathered. The identified problems were then appropriately consulted to the technology generators and manufacturers.

Accordingly, improvements and corrective measures were undertaken by the manufacturers upon consultation with technology generators. Improvements on the PHilMech multi-fuel biomass furnace were incorporated on the additional technology demonstration units delivered under the 2008 funds.

Monitoring of the additional 12 techno-demo units was also conducted to assess the problems encountered on the operation thus assuring continuous operation. These problems were immediately reported to the manufacturers and technology generators. Continuous monitoring and evaluation on the techno-demo units were conducted for the next cropping season for further assessment of the technology.

Process Documentation

To establish the success of the project and determine immediate impact to the cooperators and adopters, monitoring and documentation activities were conducted for every techno-demo cooperator / site. Questionnaires and forms were developed to gather the data needed. Figures 6 and 7 show the significant levels of improvement in terms of decrease in drying fee collected and the increase on the rate of utilization of retrofitted mechanical dryers as compared to its original configuration with a kerosene-fed burner.

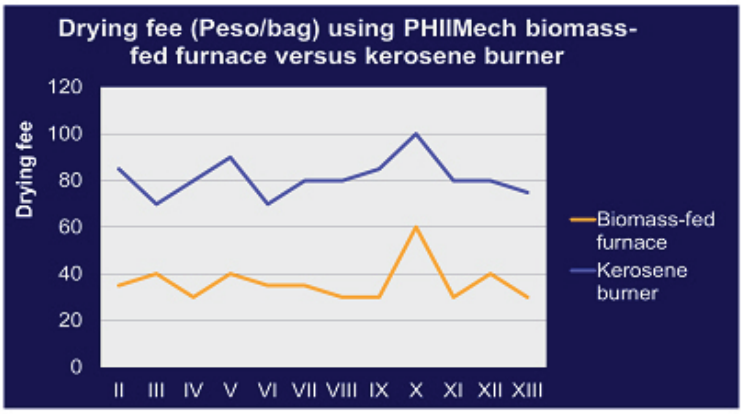

Figure 6. Drying fee collected (peso/bag) using PHilMech biomass-fed furnace versus kerosene burner, 2011-2012

Before the intervention with the PHilMech biomass furnace technology, the level of utilization (in terms of number of bags dried) of mechanical dyers was very minimal. The high operating cost of operation reflected on the drying fee collected was primarily the reason for the low utilization level. Cooperatives, farmers association and local government units recognized the importance of mechanical dryers in their area. However, because of the continuous increase of fuel prices (kerosene) the drying fees collected also increased significantly, discouraging farmer members in utilizing the mechanical dryers.

With the intervention of PHilMech biomass-fed furnace and utilizing alternative biomass material as fuel, triggered significant increase in the use of mechanical dryers by reducing drying cost by around 50 percent. This gave positive economic effect on the part of the users. Cooperators

acknowledged the importance and the opportunities that the biomass furnace contributed to avail of mechanical drying services from the techno-demo cooperators.

A good example is the case of the Local Government Unit (LGU) of Siniloan, Laguna. The drying fee collected using kerosene burner was around 65 to70 pesos per bag, but actual expenses incurred in drying were around 80 pesos. The 10 to 15 pesos deficit was subsidized by the LGU. With the intervention of the PHilMech furnace, the drying fee collected was significantly reduced to 40 pesos per bag. The drying fee collected was reduced by around 50 percent. Presently, the LGU generates around 10 pesos income per mechanically dried bag of grains.

The rate of utilization of mechanical dryers increased because of marked decrease in drying fees charged or collected. The farmers are now encouraged to use the mechanical dryer especially during rainy season. This translates to reduction in losses incurred in drying by farmers.

Farmers, traders and processors who utilized the mechanical dryers retrofitted with PHilMech biomass furnace were interviewed. Feedbacks showed that the farmers, traders and processors were satisfied on the output of the palay or corn dried in mechanical dryers retrofitted with biomass furnace. They were very grateful to the Department of Agriculture and PHilMech in particular, for these projects in their respective areas.

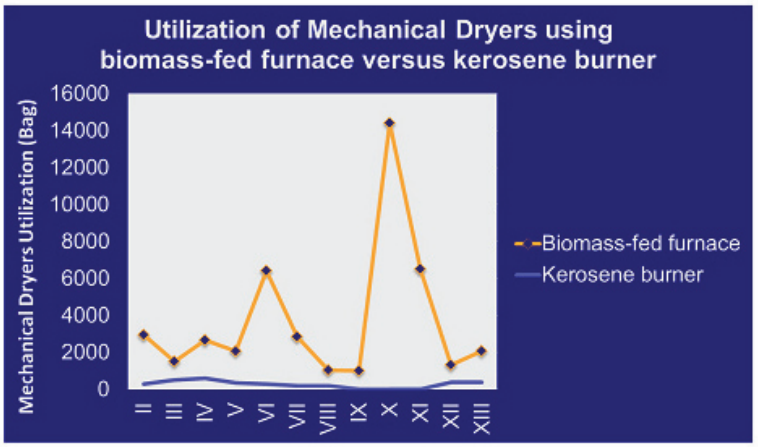

Figure 7. Utilization in terms of number of bags dried of mechanical dryers using PhilMech biomass-fed furnace versus kerosene burner, 2011-2012

Continuous documentation was conducted for the next cropping season especially for cooperators who encountered problems and beneficiaries whose mechanical dryers retrofitted with biomass furnace were not fully utilized.

Based on the feedback gathered from the techno-demo cooperators particularly for the ricehull-fed/heater system furnace design, maintenance of the heat exchanger from ash accumulation was a major concern during continuous drying operation. It was observed that ash accumulated in between the fire tubes that block entry of heated air to the dryer. Frequent cleaning was required, after three batches of operations that affected continuous drying operation. The said observations were documented and presented to the PHilmech management committee. It was decided that the commercialization of the ricehull-fed/heater system furnace would be deferred.

Technical Assistance, Coaching and Mentoring

During the installation and debugging of furnace, the manager and three possible operators of the mechanical dryer were immersed on actual operation and maintenance orientation. PHilMech engineers facilitated the orientation and actual demonstration on the operation of the furnace. Also, site visits and immersion with the cooperators in collaboration with DA-RFUs were conducted to sustain the utilization of the technology.

Technical assistance was provided to the adopters of the technology. Actual demonstration of operation, and communication materials like brochure, operation and maintenance manual were given to the interested farmer-traders and processors. Technical assistance through site inspection and validation to address the request of farmers association, attached agencies and trader and processors were also provided.

The Villa Luna MPC in Isabela and DA WESVIARC were among the interested adopters provided with technical assistance. Site visit and assessment were conducted in their areas.Reports were prepared and their retrofitting proposal were forwarded to DA-RFUs for funding. Interested cooperatives, farmers association, private millers and traders expressing interest to avail and purchase the PHilMech biomass furnace were linked to licensed manufacturers. Training on the operation and maintenance and after sales service was provided by the licensed manufacturers.

SUMMARY AND CONCLUSION

Through aggressive promotion and awareness campaign of PHilMech, the industry stakeholders (e.g. manufacturers, farmers, traders and processors millers) recognized and acknowledged the importance and benefits of the biomass-fed furnace technology.

As of December 2012, around 300 multi-fuel biomass furnace purchases were reported by PHilMech licensed manufacturers nationwide. The Rice Mechanization Program of the Department of Agriculture has also recognized the potential of the technology and has incorporated the multi-fuel biomass furnace retrofitting as a component project of the program in promoting mechanical drying assistance in the countryside.

The rate of utilization of mechanical dryers increased because of the significant decrease in drying cost. Farmers are now encouraged to use the mechanical dryers, especially during rainy season. This translates to reduction in drying losses and additional income among farmers.

Sustained utilization of biomass fed-furnace is hinged on the collaborative efforts of both public and private entities. Manufacturers have a big role in the commercialization of technologies developed by R&D institutions like PHilMech because the agency has no mandate in mass fabricating its developed technologies.

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ABOUT PHILMECH

The Philippine Center for Postharvest Development and Mechanization, known then as the National Postharvest Institute for Research and Extension (NAPHIRE), was created on May 24,1978 through Presidential Decree 1380 to spearhead the development of the country's postharvest industry.

As a subsidiary of the National Grains Authority in 1980, the agency's powers and functions were expanded in line with the conversion of NGA to the National Food Authority.

In 1986, PHilMech moved to its new home at the Central Luzon State University compound in Muñoz, Nueva Ecija.

The agency was transformed from a government corporation into a regular agency through Executive Order 494 in 1992. It was renamed the Bureau of Postharvest Research andExtension (BPRE).

For years now, PHilMech is engaged in both postharvest research, development and extension activities. It has so far developed, extended and commercialized its research and development outputs to various stakeholders in the industry.

With Republic Act 8435 or Agriculture and Fishery Modernization Act (AFMA) of 1997, PHilMech takes the lead in providing more postharvest interventions to empower the agriculture, fishery and livestock sectors.

Pursuant to Executive Order 366 or the government's rationalization program in November 2009, BPRE became the Philippine Center for Postharvest Development and Mechanization (PHilMech) with twin mandates of postharvest development and mechanization.

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