"economic factors provide the strongest argument for considering gasification "

Philippine Experience in the Commercial Production of Gasifiers*

By

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Background

Serious efforts at promoting the use of gasifier technology in the Philippines were initiated in 1981. [1] At that time, gasifier use was seen as a solution to the problem of high fuel costs in small pump irrigation systems and other rural-based industries. Today, however, in view of the encouraging results of the past two years' activities, the gasifier technology is seen as a vital component of the Philippine Government program for energy self-reliance. This program is anchored on the use of biomass resources abundant in the Philippines for energy generation.

The commercialization of gasifiers for vehicles and stationary engines is occurring on a significant scale in Brazil and the Philippines. The number of technical reports generated, as well as conferences held [2], highlighting both Philippine and Brazilian gasifier experience, attest to the growing worldwide interest in gasifier technology. The Philippines likewise had been honored with the visit of international scientists interested in seeing for themselves actual field installations and manufacturing facilities.

Evidently, a wide body of knowledge already exists on gasifier technology, which is available to developing countries. The level of appreciation of the technology is expectedly high, in light of earlier technical presentations. The Philippine experience is fairly known to most of our colleagues here, such that this paper shall concentrate in addressing the following issues: (a) an update on Philippine gasifier program experience (June 1982 up to the present), highlighting potential for applications in equipment used for food production; (b) implementing a national bioenergy program – its vital issues; and (c) critical factors in commercial gasifier

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[1] The detailed experience in gasifier technology development in the Philippines are highlighted in the paper "Gasifier Manufacture in the Philippines: Status and Prospects", presented during the first FAO expert consultation on agricultural waste utilization for energy use in farms, held in China and the Philippines in June 1982.

[2] Technical reports are cited in the Bibliography. Conferences include: (a) First FAO expert consultation, June 1982; (b) First International Producer Gas Conference, Sri-Lanka, November 1982; and (c) International Conference on Bio-energy Approaches in National Development, Manila, March 1983.

production. It is hoped that a discussion of the above issues will result in better appreciation of the far-reaching implications of the gasifier technology in a country's development efforts.

The Philippine Bioenergy Program: An Approach to Energy Self-reliance

The bioenergy program in the Philippines has obtained recognition from the national leadership as reflected in several presidential decrees which primarily directed the accelerated research, development and utilization of indigenous energy resources. This is a step to enable the country to achieve greater energy self-reliance. The regional dispersal approach with the rural areas composing the major market of the bioenergy program aims at developing lagging regions. The same approach aims to maximize the use of land, considering the fact that the Philippines is geographically rich in natural resources.[3] Further, the bioenergy programs are in line with the national goal of managing the environment, particularly to make the idle lands productive as well as to tap alternative energy resources that are less pollutant. Currently, it is estimated that there are some five million hectares of underutilized foothill land in the Philippines much of which is entirely suitable for cultivation of fast-growing tree species. These lands can provide the needed biomass resources (woodfuel and forestry wastes). which could supply various non-conventional energy technologies including dendro-thermal and hydrocarbon producing plants, gasifier installations, biogas generators and alcohol and coco-fuel oil production.

The bioenergy program offers the country unparalleled opportunities to: (a) employ a significant number of farm families in biomass production thereby enhancing their income and spurring development of lagging regions, resulting into a more equitable distribution of income in the national economy; (b) convert expenditures from oil import to incomes for rural producers; and (c) encourage reforestation of denuded land.

The hallmark of successful bioenergy systems is an early and primary emphasis on systems organization, coupled with the national commitment to the development of a bioenergy system. Thus, a critical issue in bioenergy program planning and implementation is the design of management and delivery systems.

Figure 1 presents the conceptual framework of the bioenergy program. Technological research and skills development, as well as institutional development, are seen as key inputs which provide momentum to bioenergy technology development. Government serves as catalytic agent in development of bioenergy enterprises (both fuel-related and technology-related), in terms of providing initial capital requirements.

Figure 2 illustrates the operational framework for the bioenergy program, which highlights the forward and background integration of bioenergy technology development and utilization, from raw materials production and processing to marketing and technology diffusion.

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[3] The potential biomass energy available can fill the country's need for imported oil, if all of it were used. Domestic agricultural and forestry waste has an estimated yearly energy potential equivalent to about 68 million barrels of oil as against last year's oil imports estimated at 64.4 million barrels.

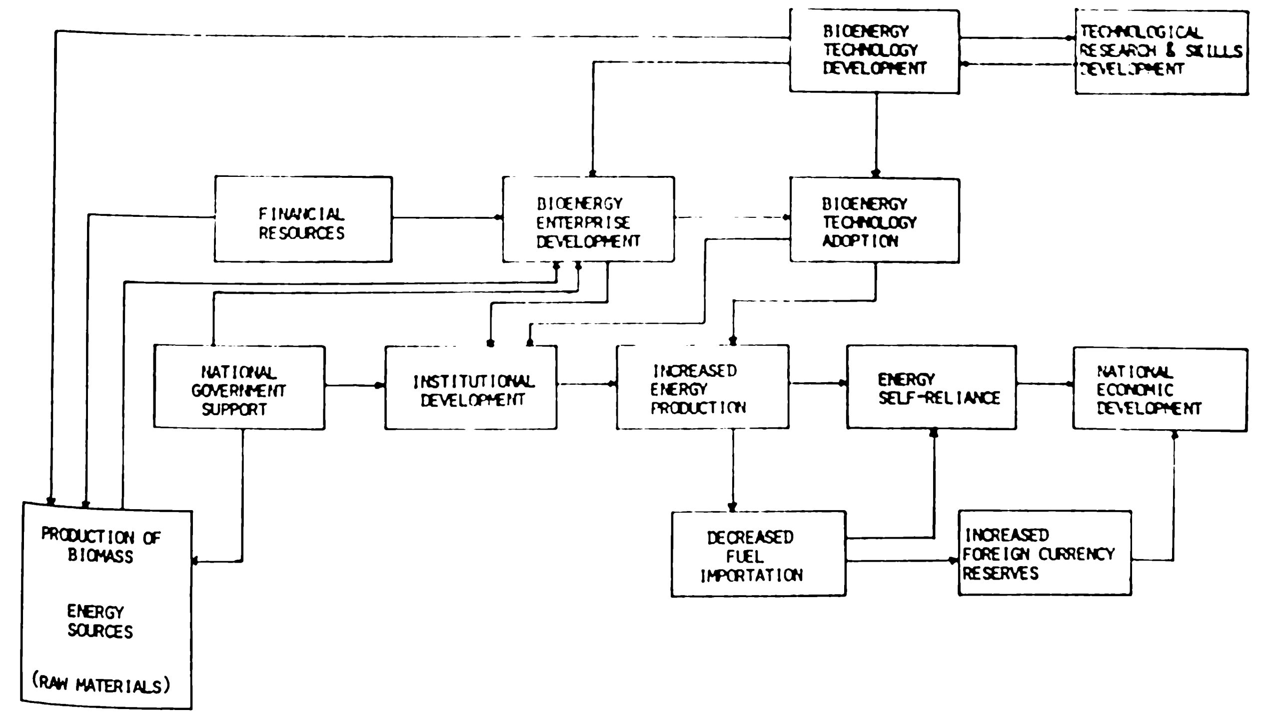


Figure 1. Bioenergy Development Conceptual Framework

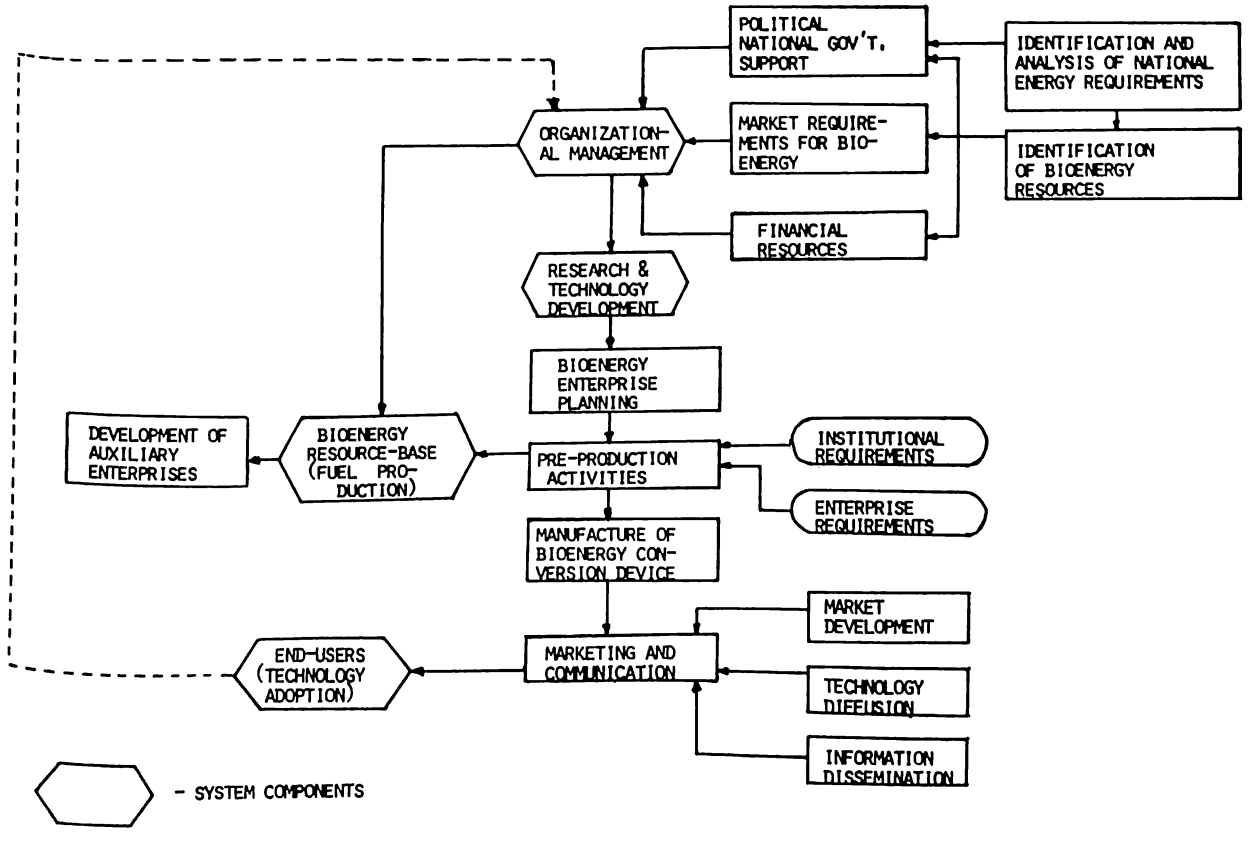


Figure 2. Bioenergy Development Operational Framework

The major components of the bioenergy program are defined as follows, with the corresponding Philippine government agencies responsible for their implementation:

Fuel Development

Energy Plantations

1. National Dendro Development Corporation (NDDC) – For tree planting programs at the municipal level

2. National Electrification Administration (NEA) – For dendro-thermal fuel requirements

3. Farm Systems Development Corporation (FSDC) – For provincial level plantations and for irrigation gasifier requirements

Woodfuel/Charcoal Production and Marketing

– NDDC

Agricultural and Forestry Waste Processing (R & D)

– Forest Products Research and Development Commission (FORPRIDE-COM)

– University of the Philippines at Los Baños (UPLB)

Bioenergy Technology Development and Diffusion

Gasifier Technology

– FSDC/GEMCOR

Dendro-Thermal

– NEA

Biogas, Alcohol and Coco-fuel

– Energy Research and Development Center (ERDC) under the Philippine National Oil Company (PNOC)

Table 1 shows the physical targets of the Philippine bioenergy program for the seven-year program period (1983-1989). Fuel development programs are concentrated in the setting up of plantations using fast-growing tree species such as the giant Ipil-Ipil (Luecaena Leucocephala). All the bioenergy technology development programs have the combined effect of increasing the share of biomass and other non-conventional energy sources from the present 15% to 30% at the end of the plan period, reducing dependency on conventional resources, particularly oil to 70%.

The Gasifier Program

The relevance of gasification technology to the developing countries is the question this report specifically addresses. Under the combined pressures or rising oil prices, balance of payments difficulties, and unreliable fuel supplies, many developing countries find themselves in a position similar to that of a war-time siege economy (a condition under which gasifiers flourished in the 1940s.) The incentive to develop alternative fuel sources is strong, and gasification of biomass is one amongst a range of possible choices.

Table 1

Physical Targets of the Philippine Bioenergy Program, CY 1983-1989

	1983	1984	1985	1986	1987	1988	1989	TOTAL
I. FUEL DEVELOPMENT								
A. Tree Plantation for Gasifiers (in thousand hectares)	85	150	140	150	150	75	–	750
B. Charcoal Production (in thousand tons)	38	90	165	195	225	300	375	1,343
II. TECHNOLOGY DEVELOPMENT								
A. Gasifier Production (in thousand units)	5	25	80	90	100	100	100	500
B. Dendrothermal Program (in million watts)	26	32	35	38	40	*	*	171

* Dendrothermal program targets have been project only up to the year 1987.

Justification for Gasifier use

Under present conditions, economic factors provide the strongest argument for considering gasification. In many situations, particularly where the local price of petroleum fuel is high, or where supplies are unreliable, a strong economic case can be made for using gasifiers, provided a suitable biomass feedstock is available. The capital cost of the gasifier and the price of the fuel being replaced are the two most important variables affecting the economics. Capital costs vary widely – by a factor of 10, among the gasifier systems currently on the market, based on the Earthscan (6) report. Those being made in Brazil and the Philippines are available for $75 per kilowatt, or less. Sophisticated European designs, in contrast, can cost up to $800 – $1,000/kw.

Earthscan concludes that where shaft-power gasifiers can be supplied at prices below $200/kw, there is substantial economic scope for their use. Savings in power costs of 10-40% will generally be obtainable, with payback periods on the gasifier equipment of between six months and two years. Table 2 shows that Philippine-made gasifiers for various applications are well within these limits derived in the Earthscan report.

Table 2

ECONOMICS OF DIFFERENT GASIFIER APPLICATIONS

APPLICATION	CAPITAL COST ($/KW)	% SAVINGS IN OPTG. COST	PAYBACK PERIOD (YRS. OR MOS.)
A. Irrigation	40-75	25	1.28 years
B. Power Generator	60-85	23	9 months
C. Ricemill	60-85	44	2.48 years
D. Iceplant	60-85	71	5 months
E. Thresher/Dryer	50-75	63	6.58 months
F. Vehicle	55-75	69	2.70 months

* 1 U.S. $=11 Philippine pesos (1983 costs)

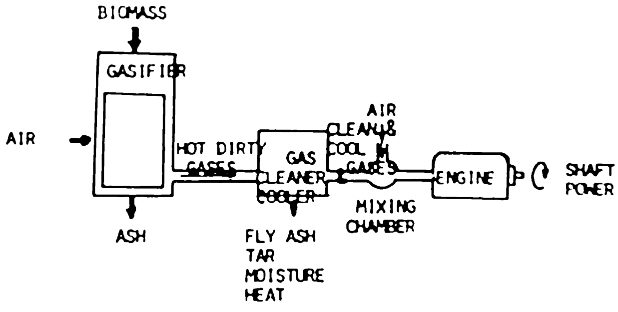
Gasifier Applications

Gasifier applications are divided into two main categories: (A) Shaft-power applications, where the gas is used to run engines, and (B) Direct-heat applications, where it is burnt directly in a boiler, furnace or kiln to provide heat. These two applications are different in many respects. One of the principal differences is that very clean gas is required for shaft-power applications – because of the strict fuel-quality demands for most engines. This is one of the biggest problems designers face, and makes effective gas cleaning devices an essential part of shaft-power gasifier systems. It also places limitations on their flexibility of operation and on the types of fuels they can use.

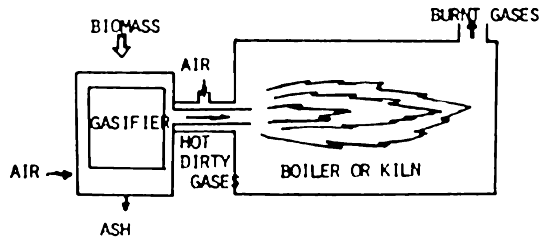
When the gas is used in direct-heat applications, its quality is usually much less crucial. The technology of direct-heat gasifiers therefore tends to be simpler and the cleaning equipment can often be omitted entirely. Figure 3 shows schematically the difference between these two alternatives.

In the Philippines, experience on gasifier use is mostly on the shaft-power applications. These include the following applications requiring the use of internal combustion engines:

1. Transport vehicles such as jeepneys and trucks, mostly gasoline-engine driven, up to 150 HP capacity;
2. Small fishing boats (10-15 meters long, with outriggers), using 10-20 HP gasoline engines;
3. Irrigation pumps using gasoline or diesel engines of up to 130 HP capacity, including turbo-charged engines;
4. Farm machineries such as rice threshers, palay driers, portable irrigation pumps and portable generator sets (5 kw) powered by 10-20 HP gasoline or kerosene engines;
5. Ricemills of either *cono* or *kiskisan* type with 25-30 HP diesel engines;
6. Small ice plants (up to 2 ton/day capacity) driven by 80 HP automobile engines (gasoline);
7. Specialized applications such as diesel locomotives and large fishing boats, requiring special designs and installation schemes.



1. SHAFT-POWER GASIFIER SYSTEM



2. DIRECT-HEAT GASIFIER SYSTEM

Figure 3: Schematic Representation of Shaft-Power and Direct-Heat Gasifier Systems

The status of gasifier use in these applications is discussed in a later section.

In direct-heat gasifier applications, GEMCOR has started commercializing gasifiers for use in limestone kilns and driers requiring up to 3.15 GJ/HR. Two installations are presently undergoing testing; in both cases agricultural residues such as coconut shells and husks and bagasse briquettes are being used as fuel, displacing the use of bunker oil. Updraft gasifiers are used in these installations.

Gasifiers can be economically justified in a host of other applications apart from the ones earlier mentioned. However, for some, there are practical constraints limiting gasifier use. A number of general observations can be made regarding the type of factors taken into account in evaluating gasifier suitability for certain applications. Firstly, for technical reasons, most gasifiers used for shaft-power operate best under steady-state conditions, particularly when using wood as fuel. Gasifier operation becomes complex in applications where engine-running is intermitent, or where loads are highly variable. Secondly, the local level of technical skills is also crucial. Gasifier technology requires a reasonable level of technical competence if it is to be operated efficiently and safely, in view of the relative complexity of operations and the increased number of routine maintenance tasks. Clearly, where the technical demands of ordinary gasoline or diesel engines are beyond the available local skills, the use of gasifiers is inappropriate. Thirdly, as far as vehicles are concerned, the additional complexity of a gasifier, and its dependence on suitable fuel puts an additional element of unreliability into vehicle operation. Major constraints on all vehicle applications are therefore availability of fuel and access to the necessary service facilities.

The technical problems involved in designing and running direct-heat gasifiers are less severe than with shaft-power systems. The fact that the need for cleaning systems is reduced or eliminated makes the system cheaper and simpler to operate. The main problems arise in maintaining thermal quality of the gas and ensuring a stable flame at the burner, requiring careful regulation of fuel and air feed rates and control of fuel characteristics. The biggest potential for direct-heat gasifiers in the immediate future is in retrofitting existing oil-fired furnaces, and boilers, opening up a large number of possible uses.

The Seven-Year Gasifier Program (1983—1989)

Considering the strong economic justification for gasifiers, and mindful of the constraints inherent in their use in some applications, the Philippine government has mapped out an ambitious seven-year gasifier program as a component of the bio-energy program earlier discussed.

Based on an estimate of the application potential for shaft-power gasifiers alone (a survey of industries requiring process heat is now being undertaken to determine market potential for direct-heat gasifiers in the Philippines), there are close to a million possible applications for shaft-power gasifiers. Table 3 shows the breakdown of this total market potential. Mobile gasifiers represent approximately 97% of this potential, with stationary gasifiers accounting for the remaining 3%.

Table 3
Total Market Potential for Shaft-Power Applications (1980)

A. Stationary Application	
1. Irrigation or water supply pumps [A]	5,000
2. Electric Generators [B]	2,000
3. Ricemills [C]	16,000
4. Ice Plant	1,000
5. Abaca Stripping Plants	1,000
6. Driers [C]	3,000
7. Other Engine Driven Processing Equipment	4,000
B. Mobile Applications	
1. Land Transport Vehicles [D]	
A. Cars	355,000
B. Jeepneys	88,677
C. Trucks	288,178
D. Buses	18,016
2. Water Transport Vessels [E]	
A. Motorized Bancas	148,000
B. Baby Trawls	3,000
C. Trawlers	2,000
D. Tugboats	1,000
3. Agricultural Machinery [F]	
A. Hand Tractor	10,000
B. Four-Wheel Tractor	5,000
TOTAL	950,871

[A] FSDC, NIA, NWRC
[B] NEA, MINING AND LOGGING ASSOCIATION
[C] NFA
[D] BLT
[E] PHILIPPINE COAST GUARD
[F] FSDC, NFA, AMMDA

The seven-year gasifier program for the period 1983-1989 has for its target the production and installation of 500,000 gasifier units. To support these gasifiers with fuel, 750,000 hectares of land will be planted to fast-growing trees. Some 75,000 kilns with a capacity of one ton charcoal per week will be put up, requiring some 350 million clay bricks.

In terms of gasifier manufacturing, the target production is expected to be realized with the establishment of regional gasifier plants as well as with the active participation of the private sector. GEMCOR for its part will account for 72,000 units or 14% out of the total target. This shall be accomplished through the setting up of three (3) satellite regional gasifier plants in addition to its original Carmona, Cavite plant. To accelerate gasifier production for vehicular applications, another government-supported gasifier corporation, the Philippine Dendro Gasifier Corporation (PDGC) has been organized earlier this year, with roughly three times the productive capacity of GEMCOR when fully operational. Table 4 shows GEMCOR's target seven-year production on a per application basis.

Table 4

Gasifier and Equipment Manufacturing Corporation Production Target Per Application, CY 1983-1989 (In Units)

APPLICATION	1983	1984	1985	1986	1987	1988	1989	TOTAL
A. Small engine (thresher/pumps/gen-set/mixer)	1,200	2,000	4,000	4,800	5,600	5,600	5,600	28,800
B. Banca	750	1,250	2,500	3,000	3,500	3,500	3,500	18,000
C. Large Stationary/ Engine								
C.1 Genset/ Ricemill/ Ice Plant	450	750	1,500	1,800	2,100	2,100	2,100	10,800
C.2 Irrigation	250	400	800	960	1,120	1,120	1,120	5,760
D. Vehicle (Jeep/ Truck)	360	600	1,200	1,440	1,680	1,680	1,680	8,640
TOTAL	3,000	5,000	10,000	12,000	14,000	14,000	14,000	72,000

The gasifier program is expected to provide direct employment to roughly 240,000 families in terms of the tree planting, charcoal production, brick production and gasifier manufacturing enterprises to be set up. The breakdown is shown below:

Tree plantation	–	150,000 families
Charcoal production	–	75,000 families
Brick making	–	5,000 families
Gasifier Manufacturing	–	10,000 families
Total	–	240,000 families

Additionally, some 500,000 gasifier users will benefit from lower operating costs in their livelihood activities, benefitting a total of 740,000 families from the gasifier program.

Commercial Gasifier Production in the Philippines

Status of Program Implementation

The gasifier program thus far has shown modest accomplishments in terms of its physical targets. In all likelihood, however, the initial years' targets may not be met inasmuch as not all of the program components have been put in place as per program plan. What cannot be quantified, however, is the growing appreciation in the rural areas of the gasifier technology as a solution to prevailing economic problems affecting livelihood activities.

Physical Accomplishments

As of 30 June 1983, a total of 1,661 gasifier units have been manufactured, 331 of which had been installed in various project sites in the country. GEMCOR accounts for 100% of total commercial production so far. Table 5 shows a detailed breakdown of physical accomplishments of the program.

Table 5

Status of Gasifier Production & Installation by Application as of 30 June 1983

Application	Units Produced	Units Installed
Irrigation	452	140
Banca	726	27
Generator Set	20	6
Ricemill	2	2
Mobile (Luv, Truck)	226	152
Thresher	230	1
Direct Heat	2	1
Dryer	1	1
Ice Plant	2	1
Total	1,661*	331**

* Some Custom-ordered Projects not included
** Excluding 50 Demo Units: Banca – 44 and thresher – 6

In terms of fuel development, the various plantation programs being implemented by several government agencies are under different stages of growth and development, with the planted trees now at an average of approximately 2 years. In view of this, the fuel requirements of the program are supplied from existing sources. Generally, gasifier fuel requirements have been filled at the local level without disturbing the supply situation. However, in some areas, fuel scarcity has been experienced, resulting in a moderate increase in prices.

Gasifier Performance and Acceptance

Gasifier end users have been trained on gasifier operation, maintenance/troubleshooting and operations monitoring prior to turn-over to them of the installed gasifier equipment. Through this system, it had been hoped that an adequate volume of performance data could be generated for technical evaluation purposes.

Due however to a variety of reasons (non-use due to seasonality of equipment use, inoperational due to drought conditions, irregularity or non-submission of report, etc.), a limited amount of operating data have been generated from which conclusive findings can be derived. The data presented herein on gasifier performance, therefore, are culled from actual test results obtained from field installations. Table 6 contains some data on various installations.

Table 6

Performance Data of Installed Gasifier Units

Application	Specs of Unit Tested	No. of Hours operation	Fuel consumption kg/hr	Fuel type	Liquid fuel dis-placement	% cost savings
GENSET	Gasoline engine 125-HP	480	30	Wood charcoal	100%	69%
GENSET	Diesel engine 146-HP	1,800	15	Wood charcoal	60%	39%
LUV	Gasoline engine 53-HP	624	8	Cocoshell charcoal	100%	69%
BANCA	Gasoline engine 16-HP	326	2.5	Cocoshell charcoal	100%	85%
IRRIGATION	Diesel engine 30-HP	200	8	Wood charcoal	50%	44%
RICEMILL	Diesel engine 46-HP	3,840	8	Cocoshell charcoal	61%	28%

The data shown on Table 6 point to the fact that gasifier use can indeed result in savings in operating costs for all applications involved. Fuel consumption ranges from 0.7 to 1.5 kg/kw-hr, which is typical of the experience in other countries. The magnitude of cost savings is a function of the type and cost of fuel used. Wood charcoal in general yields the highest percentage savings in operating cost, followed by coconut shell charcoal. Based on these findings, therefore, the initial field experience on gasifier use is very encouraging, although some installations may not be realizing the expected operating cost savings. (It is to be noted, however, that performance is directly related to the condition of the engine prior to gasifier retrofit.)

To be sure, existing gasifier installations are not without problems. Feedbacks received from the field have indicated some operational problems which are indicative of some changes that will have to be made with regard to gasifier installation schemes, operation and maintenance procedures, operator training and fuel specification and preparation. Some of these problems are listed in Table 7, with the corresponding analysis and actions taken. Most of the problems are centered on the gas cleaning and cooling system and the way it is maintained, rather that on the gasifier itself. From all of these findings, two conclusions can be drawn: (a) the sensitivity of gasifier operation and reliability to fuel quality; and (b) the crucial role of the operator – his attitude and his skills, in the successful operation of the gasifier system. The need for enhancement of gasifier design through the introduction of instrumentation (temperature indicators, fuel-level indicators, etc.) is likewise indicated in the problems noted. All of these problems have been addressed and the appropriate corrective measures are being implemented. The above-mentioned conclusions, however, have implications on some policy issues, detailed discussion of which are reserved for a later section of this paper.

Table 7

Summary of problems noted on existing gasifier installations with corresponding analysis and solutions per application

Application problems noted	Causes	Solution/action taken
A. Luv		
1. Cracking/Tearing of some Gasifier components/ Pipings (e. g., Bumper Cooler, Butterfly Valve, etc.)	1. Due to vibration on rough roads	1. Strengthened materials used and provided flexible hose at critical piping locations
2. Reduced speed and pay load	2. Due to gasifier weight and lower heating value of producer gas	2. Reduced total gasifier weight, and operated on dual fuel at unfavorable travel conditions
B. Irrigation System		
1. Sucking of diesel fuel oil and water from the wet filter	1. Due to high suction of the engine (in high HP engines)	1. Added moisture trap and water spray barrier
2. Tar and moisture observed in piping especially in using wood		2. (a) Added moisture trap (b) Use only charcoal for the irrigation model
C. Generator Set		
1. Voltage/Frequency fluctuation during (a) charcoal reloading and (b) high loads	1. (a) Caused by the entry of more air into the reactor during fuel reloading which changes quality and quantity of gas (b) Caused by slower response to load changes of gasifier reactor (or compared to diesel or gasoline)	1. (a) Ran the engine on 100% diesel or gasoline during fuel reloading (b) Added an automatic governor to the engine to control the voltage and frequency fluctuation
2. Moisture/Tar observed after cleaning units when using damp charcoal or wood	2. Fuel used has more than tolerable moisture content (greater than 20%)	2. Use dry fuels only
D. Banca		
1. Poor engine performance after 1-1/2 – 2 hours of operation	1. Low level of fuel inside the reactor	1. Reload after every 1-1/2 hours of operation
2. Reduced speed for payload capacity	2. Heavy overall gasifier weight and large space occupied (for earlier models)	2. Reduced the size and weight of the gasifier system

Over and above the problems noted (which can be expected of a program as new and revolutionary as the gasifier program) is the confidence in the viability of the technology that has been retained by both program implementors and gasifier end-users. It is generally felt that problems encountered are minor enough so as not to cast serious doubts on the technology. These problems can be technically solved given the right attitude and perseverance. Evidences of this sentiment are some occasions where gasifier end-users themselves have proposed and implemented changes in some of the gasifier components which resulted in more efficient and reliable operation. The important factor keeping the program going is the credibility enjoyed by the program implementors (FSDC and GEMCOR) in the rural areas, and the quick action taken on problems brought to their attention.

In terms of technology acceptance, it could be said that the gasifier technology is gradually but surely gaining acceptance in the rural areas, as evidenced by the sustained increase in volume of sales of GEMCOR gasifiers (to be discussed in a later section). Several factors affect the level of acceptance of the gasifier technology, which definitely limited the accomplishments that the program would have realized. These are: (a) the need for sustained information campaigns on the gasifier technology intended to create awareness of the technology and its benefits; (b) lack of a financing program for gasifier acquisition, which is considered essential inasmuch as targetted end-users are from the low-income sectors (farmers/fishermen); and (c) scarcity of fuel in some areas which inhibited investments on the gasifier for fear that charcoal prices might go up sharply, negating whatever cost advantages the gasifier may have over the present system. Also, it cannot be denied that to a certain extent, gasifier acceptance may have been affected by awareness of problems encountered in existing installations. In recognition of all of these factors, promotional strategies are being implemented that are geared towards fostering a clear and objective understanding of the gasifier technology, taking into account its advantages as well as its disadvantages.

The GEMCOR Experience

Organization and Status of Operations

The Gasifier and Equipment Manufacturing Corporation (GEMCOR) is one of only two companies in the Philippines formally engaged in gasifier manufacture, the other being the newly-organized Philippine Dendro Gasifier Corporation (PDGC) as earlier mentioned. PDGC shall concentrate its efforts in servicing the country's gasifier needs for vehicular and mass transport applications, while GEMCOR shall specialize on stationary gasifiers, both for shaft-power and direct-heat applications. Other companies and organizations in the country are known to have produced gasifiers in non-commercial quantities using either foreign-acquired designs or original designs. GEMCOR is included in all facets of gasifier development, from product development, to manufacture, up to marketing. GEMCOR produces and markets gasifier products under the "*LIKAS* gasifier" brand, (the term '*LIKAS*' means indigenous in the Filipino language, referring to biomass as a cheap and locally abundant source of energy.)

Four (4) main models comprise the GEMCOR products lines, namely: (a) the stationary engine model; (b) the small engine model; (c) the direct-heat gasifier model; and (d) the vehicle gasifier model (limited to truck applications). These main models come in different sizes, each capable of servicing a range of engine horsepower (for shaft-power) or process heat flow requirements. Table 8 lists the different *LIKAS* gasifier models and sizes and applications for which they are suited. The stationary engine model can be used for irrigation (a specific design or sub-model is used solely for diesel engine-driven irrigation pumps) and other stationary engine applications such as electric generators, ice plants, ricemills and the like. The small engine model is good for both stationary and mobile engines of from 10-20 HP capacity, applicable for bancas (small fishing boats) and small farm and industrial machinery such as threshers, dryers, portable irrigation pumps, gen-sets and cement mixers. The small machinery applications are serviced by a portable 'wheel-barrow-mounted' gasifier model.

Table 8

GEMCOR PRODUCT LINES

MODEL	APPLICATION	SIZES
1. STATIONARY	Irrigation	10-30 HP
		31-60 HP
	Power Generator/	30-80 HP
	Ice Plant	81-150 HP
	Ricemill/Dryer	10-30 HP
		31-60 HP
2. SMALL ENGINE	Small GENSET	10-20 HP
	Thresher	10-20 HP
	Banca	10-20 HP
3. MOBILE	Light truck	101-150 HP
4. DIRECT HEAT	Kilns, boilers, furnaces and dryers	Up to 3 million BTU/Hr.

From its inception in July 1981 up to June 1983, GEMCOR has accomplished the following:

(A) Gasifier Production : 1661 units
(B) Sales : 973 units
(C) Installation : 331 units

Table 9 presents the breakdown of production, sales and installation on a per application basis. The following sections discuss the highlights of 1982-83 (1st sem) operations.

Table 9

Production, sales and installation status per application/model (July 1981 to June 1983)

APPLICATION/MODEL	PRODUCTION (UNITS)	SALES/PURCHASE (ORDERS CLOSED)	INSTALLATION (UNITS)
IRRIGATION	452	421	140
RICEMILL	2	2	2
POWER GENERATOR	20	20	6
THRESHER	230	5	1
DRYER	1	1	1
ICE PLANT	2	2	1
BANCA	726	318	27
JEEPNEY, LIGHT TRUCK	226	202	152
DIRECT HEAT	2	2	1
TOTAL	1,661*	973	331

*Some custom-ordered projects not included

Manufacturing Aspects

In an effort to attain the projected production schedule for 1982 and develop a balanced production capability, the expansion of plant facilities was undertaken. This expansion included the construction of an additional 384 sq.m. production bay, a test laboratory as well as raw materials and finished goods storage at its Carmona, Cavite plant.

Likewise, the three-shift schedule had been operationalized, enabling plant production to increase to 5 units per day or an aggregate monthly production of 123 units for varied applications. Installation and commissioning of newly purchased capital equipment was also undertaken.

Rationalization of the product lines, as well as parts standardization across different models,have likewise been undertaken. This has resulted in the increased versatility of existing models, in terms of the number of applications to which they are applicable. Also, parts interchangeability has been made possible, effectively reducing manufacturing costs for these parts, and resulting in lower inventory costs for spare parts.

A semi-line type of production has been developed and implemented, whereby parts and sub-assembly fabrication are done on job order basis, while assembly finising and testing are done on a production line basis.

Marketing Aspects

Gross sales revenues of ₱6.57 million representing sales of 499 units have been realized during the period July 1982 – June 1983. Institutional sales for projects of various government programs for farmers and fishermen constitute the bulk of sales closed. Government accounts represented 82% of actual sales of gasifier units and 18% were sales made to the private sector.

Creating product awareness in the rural areas was the major goal of GEMCOR's marketing efforts during the past year. GEMCOR actively participated in various exhibits of both government and private sectors. Various trainings, symposia, seminars on the gasifier technology for various entities were also conducted. Participation in the World's Energy Fair in Knoxville, Tennessee, U.S.A., was the corporation's major exposure in the international arena. In this fair, GEMCOR's model for jeepney, banca and power generator earned international recognition.

A major move in the gasifier marketing effort was the finalization of the regional distributorship agreement between GEMCOR and 13 farmers' federations known as *KAISAS*. The *KAISAS* are professionally-managed provincial aggrupations of farmer cooperatives known as *ISAS*, supervised by the Farm Systems Development Corporation (FSDC), which engage in rural-based enterprises. These distributors are strategically located in each of the country's 13 regions. This scheme thus laid the groundwork for the effective nationwide dispersal of gasifiers in the ensuing years.

Installation of gasifier unit of various applications was undertaken by GEMCOR and its duly appointed distributors (which have trained and accredited gasifier mechanics) as well as by cooperating agencies such as the National Electrification Administration (NEA).

Product Development Efforts

GEMCOR vigorously pursued its product development program through the improvement of existing gasifier models and the development of gasifiers for new applications. A total of eight (8) new and modified gasifier models have been developed for commercialization or market introduction. Rigid testing of products is being done using newly acquired test equipment and instruments. Patents for two innovative gasifier designs have been applied with the Philippine Patent Office.

Gasifier models for two-ton ice plant and 30 KW generator set have been developed and existing models have been modified. Some work had likewise been done toward developing other gasifier-driven equipment. A prototype rotary drier for ipil-ipil leaves (for animal feed) had been fabricated. The latest product development effort during the early part of 1983 was the development of the direct-heat gasifier.

In response to suggestions and recommendations of GEMCOR's clientele, refinement of existing models has been continually underscored. Greater attention was focused into design of parts and components to increase reliability of the finished product.

Some Related Issues

Fuel Supply Issues

It was mentioned in the earlier part of the paper that existing biomass resources in the Philippines can theoretically be used to completely substitute for imported oil in supplying the company's energy requirements. Table 10 shows the energy potential of agricultural wastes in the Philippines. This shows that rice, coconut and corn crop wastes alone account for more than 70% this total potential. However, with the exception of coconut shell charcoal, and possibly corn cobs, these agricultural wastes have not gotten off the pilot testing level as reliable fuels for gasifiers both in the Philippines and in other countries, outside of wood and charcoal. Add to this the fact that the use of problematic fuels like rice hull and sawdust in shaft-power gasifiers entails additional sophisticated gas cleaning equipment which greatly complicates gasifier operation and casts serious doubts on the reliability of such systems when used in the rural areas, where the level of technical skills is low. This is not to say, however, that R & D work should not be pursued in utilizing proven suitable fuels for shaft-power applications. Research and development work is important in applying as many types of agricultural wastes as gasifier fuels, because their energy potential is still usable, especially for a wide variety of direct-heat applications.

Charcoal and wood are still the only biomass fuels which can be confidently recommended for use in gasifiers. The choice between the two is largely a question of economic and wood availability. Charcoal is a more straightforward fuel in most respects. Charcoal gasifiers produce a cleaner gas, and so do not require such an elaborate cleaning system as wood-fuelled systems, and therefore tend to be cheaper. They are also better able to respond to changes in the load on the gasifier, which is particularly important in vehicle applications. The main disadvantages of charcoal are its greater expense and the fact that it is a less energy-efficient fuel than wood, owing to the large amount of energy lost in its manufacture.

Therefore, given the task of promoting the wide-spread use of gasifier technology in the rural areas, and having set for itself hard targets to be accomplished within a short time-frame, the Philippine gasifier program opts for the use of the most ideal fuel – charcoal (wood or coconut shell) in shaft-power gasifiers being

Table 10

Potential of Agricultural Wastes in the Philippines

	MT*	MBOE**	MBOE	(%)
Coconut Shell	2,320,402	6,926	20,119	(23.1)
Coconut Husk	5,152,548	13,193		
Rice Hull	1,655,472	3,713		
			28,200	(32.4)
Rice Straws	10,116,773	24,487		
Corn Cobs	1,113,270	3,043		
			14,092	(16.2)
Corn Stalks	4,042,476	11,049		
Bagasse	6,350,909	10,479	10,479	(12.0)
Firewood	43,189	130		
			136	(0.2)
Wood Charcoal	1,302	6		
Logging Wastes	1,169,435	1,760		
Sawmill Wastes	2,949,169	7,723	14,054	(16.1)
Veneer and Plywood Wastes	1,745,847	4,571		
Total of Agri-wastes	36,660,792	87,080	87,080	(100.0)

*Metric tons
**Thousands of barrels of oil equivalent

Sources: Bureau of Agricultural Economics
Ministry of Agriculture
Bureau of Forest Development
Philippine Sugar Commission

dispersed in the rural areas. This will simplify operation, reduce capital costs, increase reliability and will result in better appreciation and faster acceptance by the end-users of the benefits to be derived from gasifier technology.

The policy decision on the use of charcoal as gasifier fuel of choice necessarily gives rise to the issue of fuel availability and the dangers of forest depletion and its consequences. This is where the complementary programs of tree planting, tree farming and charcoal production and distribution become relevant. These programs should closely dovetail the gasifier program to insure stable supply and acceptable prices of charcoal in the market.

Technology Diffusion and Acceptance Issue

Field experience on gasifier use as earlier discussed indicated that gasifier reliability and therefore gasifier acceptance at the grassroots level relies heavily on two (2) critical factors, namely: (a) fuel quality; and (b) the skills and attitude of the gasifier operators. The impact of the first factor was amply discussed in the earlier section, such that the issue on operator skills and attitude will now be tackled.

The gasifier operator – how he acts, his ability to assimilate new methods, his perception of the gasifier equipment (whether a boon or a bane) – holds the key to the success of any government effort at promoting the technology. In the Philippines, there are three categories of gasifier users, namely: (a) the individual owner-user; (b) the cooperative-type user; and (c) the corporate-type user. The individual owner-user necessarily possesses the right attitude and skills on the gasifier, because the decision to use a gasifier came after a thorough analysis of the pros and cons; he has decided on the gasifier and he stands to directly benefit from the results. The gasifier operator of the cooperative-type user may be a member of the cooperative, compensated for his additional tasks as operator of the conventional equipment (irrigation pump and engine, ricemill, etc.) The operator of the corporate-type user, on the other hand, is a hired employee with a specific task of operating and maintaining equipment. These two, therefore, are in a different situation compared to the owner-user, on the following grounds: (a) they are not direct beneficiaries of the results of gasifier use; (b) the decision to use gasifiers may not have been theirs; and (c) they tend to relate compensation to the amount of work they do – additional work means additional pay. Considering this and the fact that gasifier use necessarily entails additional inconvenience on the part of the operator, there is therefore a built-in disincentive on the gasifier's use on the part of the operator working against the incentive on the part of the owner which led to the decision to acquire the gasifier. The result: the operator is not concerned about efficient gasifier operation, neglects required fuel specifications, looks for reasons not to use the gasifier or doesn't use it at all. This has been the experience in a good number of installations until the proper remedies were instituted.

The remedy came in the form of additional incentives for the operator. These incentives were tied in with the frequency or level of gasifier usage: the longer hours logged on gasifier operation, or the bigger savings generated, the bigger the compensation. Cooperative and corporate users are encouraged to grant incentives to their gasifier operators from out of the operating cost savings generated from the gasifier's use. This way operators are now possessed with the proper attitude and will take steps to ensure attainment of maximum benefits through gasifier use, by proper operation and maintenance, monitoring and immediate feedback of problems noted. Through these moves, and with owners bringing down to the operator level a clearer understanding of the gasifier, gasifier technology stands a good chance of flourishing and gaining more adherents.

The mechanism through which feedback, analysis and solutions to problems noted can be generated is made operational through different gasifier program committees set up among user groups, such as government cooperating agencies and private users' groups. These committees, composed of representatives from GEMCOR and the different users meet regularly to share experiences, assess problems and formulate solutions to these. Both gasifier maker and gasifier user are therefore part of the 'Gasifier Movement'.

Manufacturing Capability Build-up Issue

With the demand for gasifiers expected to rise as a result of government's promotional efforts, and with production requirements rising to the levels projected in the gasifier program, the issue shifts to one on manufacturing capability build-up. The question necessarily crops up: Do we go for centralized manufacturing plants and mass produce gasifiers to achieve economics of scale, or do we set up regionally dispersed plants with capacities proportional to the market potential in these areas?

The Philippine decision is to disperse plant facilities. This is based on the following grounds: (a) gasifier fabrication is relatively simple, easily implementable in areas with existing light metal industries; (b) raw materials for gasifier production are locally available, with the only possible exception being the refractory cement (which can however be substituted with local materials, given ample studies); (c) skilled labor is available in the major regions of the country; (d) reduced shipping cost resulting in lower unit cost compared to centralized scheme; and (e) service/installation facilities are within easy reach of the users.

Concluding Remarks

Judging from the fruitful experiences of GEMCOR over the past two years in the promotion of gasifier technology and in commercial gasifier production, it can be said that gasifier technology has bright prospects in the Philippines. Within the next year or two, when the energy plantations and the fuel supply infrastructure would have been fully operational, the technology's impact will be fully felt, and the gasifier will be a regular fixture in irrigation systems and other projects in the rural areas.

International conferences and discussions such as this which we are having are excellent venues for exchange of information and sharing of experiences in the gasifier technology. The compilation of the wealth of data and information that are generated from these international gatherings, which is what FAO is doing, will facilitate implementation of bioenergy-related programs in interested developing countries. The next logical step will be to organize some sort of users' network, through which information as well as expertise can be availed of by countries interested in pursuing research projects or development programs on gasifier technology or bioenergy in general. Multilateral agencies such as the U.S. Agency for International Development (USAID) are actively working along these lines.

Insofar as monitoring of gasifier field experience in developing countries which have gone beyond the R & D stage on the use of this technology, the Philippines, as one of those countries, welcomes this move. Notwithstanding the fact that our gasifier program employs its own system of monitoring technical performance and socio-economic impact, we believe that a global monitoring project which will evaluate gasifier performance based on a uniform set of criteria and standards is a laudable undertaking. The World Bank and the UNDP are undertaking one such project, and the Philippines is honored to be a cooperating country in this project.

Bibliography

1. *ANNUAL REPORT*, (1982) of the Gasifier and Equipment Manufacturing Corporation (GEMCOR), Manila.
2. ASCOUGH, W.J. (1981) *Producer Gas for Automotive Use*. Seminar on alternative fuels for internal combustion engines. Imperial College, Department of Mechanical Engineering.
3. CRUZ, I.E. (1977) *Utilization of Agricultural Wastes as Producer Gas for Power Generation,* University of the Philippines Research Conference Proceedings.
4. DENTON, F. (1982) *Energy Use in the Philippines,* (unpublished), Manila.

5. DUMOL, P. (1983) *Proceedings of the Conference on Bioenergy Approaches in National Development,* Manila

6. FOLEY, G. AND BARNARD, G. (1983) *Biomass Gasification for Developing Countries (Earthscan Technical Report No. 1)* Earthscan, London.

7. GOSS, J.R. AND KAUPP, A. (1981) *State of the Art for Small-Scale (to 50 Kw) Gas Producer Engine Systems,* Final report to USDA forest service.

8. REMULLA, J.A. (1982) *Gasifier Manufacture: Status and Prospects.* Technical consultation on agricultural waste utilization and solar technologies for energy needs in farms. Philippines and China.

9. REMULLA, J.A. (1983) *Green Realm of Progress: The Philippine Bioenergy Experience,* Bioenergy Users' network discussion meetings. Washington, D.C.

10. Various reports, data files and brochures of the Gasifier and Equipment Manufacturing Corporation (GEMCOR), Manila.

ANNEX

Profile of various gasifier models of GEMCOR

Gasifier components for irrigation

Reactor – where charcoal is burned to produce combustible gases.

Cyclone separator – removes solid impurities in the gas by centrifugal action.

Gas scrubber – removes other impurities and condensable gases at the same time cools the gas.

Wet filter – collects condensable gases and impurities that might have passed thru the gas scrubber.

Mixing box – where the combustible gases is mixed with air before the gas enters the engine intake manifold.

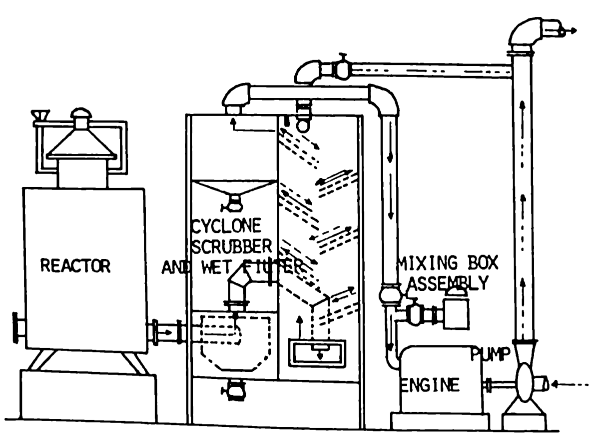
Technical Features

- Downdraft reactor with six (6) air holes in the mid-section and equipped with an ash port to facilitate cleaning
- Modified gas scrubber which incorporates the cyclone separator, gas scrubber and wet filter
- Space occupied: 2 Sq.m.
- Fuel used: cocoshell charcoal; wood charcoal. Fuel used should have a moisture content of 20% or less

LEGEND :

GAS FLOW

WATER FLOW



Schematic Diagram of a Gas Producer Installation for Irrigation

TECHNICAL FEATURES

- Cylindrical downdraft reactor with peripherally distributed air nozzle and tangential entry preheated air.

DIMENSION

0.5 Ø x 2.70M

- GAS CLEANING TRAIN DIMENSIONS

Primary cyclone

0.30 Ø x 1.0 M

Gas Cooler

0.30 Ø x 0.91 M

Secondary Cyclone

0.23 Ø x 1.65 M

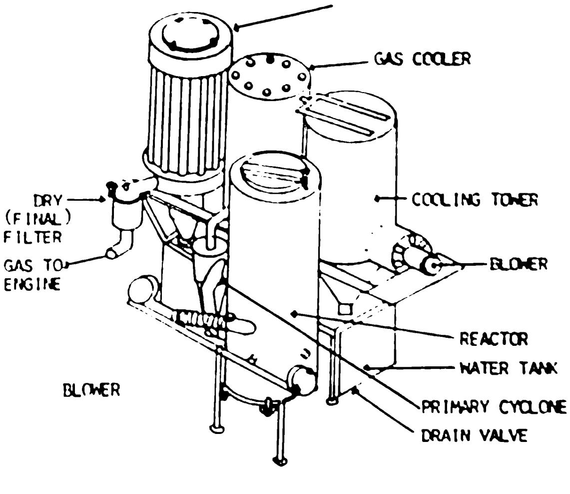
Primary filter with condensate trap:
0.25 Ø x 1.3 M

Final Filter

0.1 Ø x 0.25 M

System Weight 328 kg

- All fuel used should have a moisture content of 20% or less



Schematic Diagram of IS Model

IS-150 components

Reactor – where the woodchips or charcoal is burned to produce combustible gases.

Primary Cyclone removes solid impurities in the gas by centrifugal action.

Gas cooler assembly cools down the gas that passes thru the tubes by the water wetting the outer surface of the tubes.

Secondary cyclone separator removes solid impurities in the gas that passed through the primary cyclone by centrifugal action.

Primary filter – removes filter particles that passed through the cyclone separator.

Condensate trap - filters out the finest impurities before the gas enters the engine.

Mixing box (not shown) – where the combustible gases is mixed with air before the gas enters the engine.

BM-20 components

Reactor – where charcoal or wood is burned to produce combustible gases.

Cyclone separator – removes solid impurities in the gas by centrifugal action.

Primary filter – removes finer particles that passed through separator.

Cooler/Heat Exchanger – cool down the gas at the same time removing condensable gases and very fine solid impurities.

Mixing box – where the combustible gases is mixed with air before the gas enters the engine intake manifold.

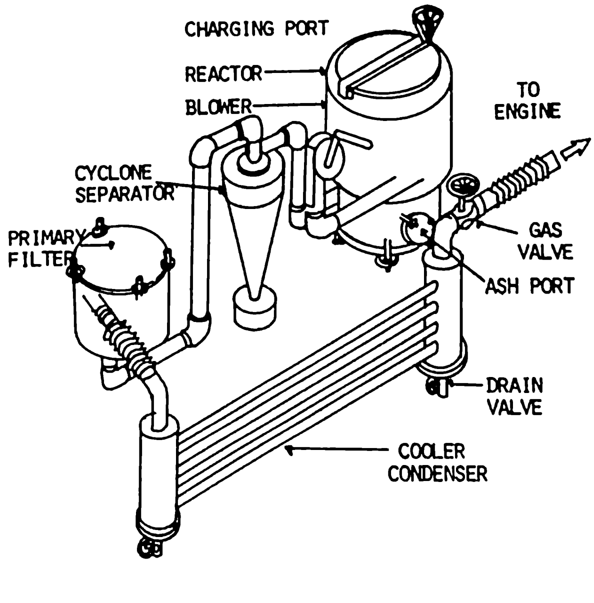
Technical Features

- **Downdraft reactor with peripherally distributed air nozzles and air pre-heating chamber.**

DIMENSION

0.387 MØ x 0.775 M

- **Gas Cleaning Train**
  1. Cyclone separator
     0.178 MØ x 0.565 M
  2. Primary filter
     0.279 MØ x 0.5 M
  3. Side mounted cooler/ heat exhanger
     0.317 MØ x .16 M x 1.359 M
- System Weight: 85 Kgs.
- Fuel: cocoshell charcoal, wood charcoal, cocoshell, woodchips. Fuel used should have a moisture content of 20% or less.



Gasifier Assembly for Banca.

TM-150 components

Reactor – where the wood or charcoal is burned to produce combustible gases.

Condensate trap – condenses the condensable gases.

Cyclone separator – removes solid impurities in the gas by centrifugal action.

Primary Filter – removes finer particles that passed through the cyclone separator.

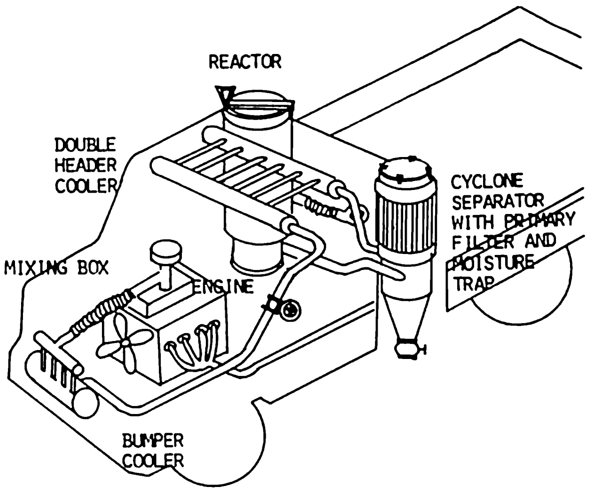
Double Header Cooler and Bumper Cooler/Filter – cool down the gas at the same time removing condensable gases and very fine solid impurities.

Mixing box – where the combustible gases is mixed with air before the gas enters the engine intake manifold.

Technical Features

- Downdraft reactor with peripherally distributed air nozzles and air pre-heating chamber.

  Dimension
- Gas cleaning train
  •Cyclone separator with primary filter and condensate trap
  •Double header Cooler
  •Bumper Cooler/filter
- System Weight
- Fuel Used: cocoshell, charcoal, wood charcoal, cocoshell, woodchips
- All fuel used should have a moisture content of 20% or less



Gasifier Assembly for Truck

Features

Economy – saves up to 50% of existing fuel cost.
– One full load reactor runs from 2-3 hours.

Simple – easily adapted to boilers, kilns, furnaces, dryers, etc.

Installation – compact unit occupying minimum installation space.

Easy operation – easily operated by operator with minimum training, short start up time.

Safety – provided with heat insulations.
– Flame produced is cleaner than that of bunker or diesel oil.

Specifications

Reactor – top loading, batch fed cylindrical updraft with peripherally distributed air nozzles, rotating grate and air pre-heating chamber.

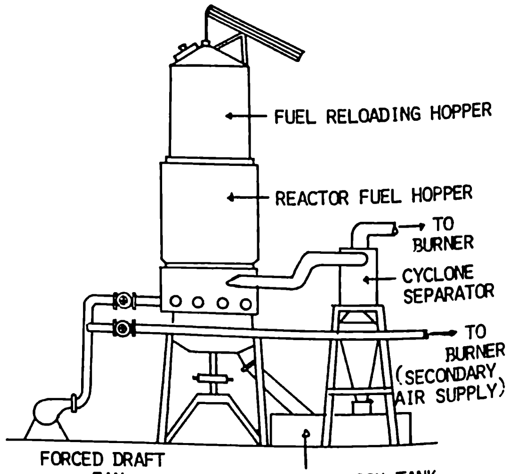
Cyclone Separator – conventional single cyclone, tangential gas entry, with easy-to-detach dust hopper.

Burner – made of high quality steel.

Forced Draft Fan – heavy duty fan driven by sturdy three-phase motor.

ECONOMICS OF 3 M BTU/HR MODEL DHS USING DIFFERENT FUELS

	Gasifier Fuel			
	Bunker Oil	Cocoshell	Cocoshell Charcoal	Wood Refuse
Fuel consumption	80 LI/HR	210 kg/jr	150 kg/hr	230 kg/hr
Fuel substitution	–	100%	100%	100%
Annual operating cost	P960,000.00	P618,000.00	P865,000.00	P667,000.00
Annual savings	–	P342,000.00	P 95,000.00	P293,000.00
Percent savings	–	35,6%	10%	30.5%
Payback period	–	1,260 hrs.	4,500 hrs.	1,485 hrs.



Schematic Diagram of Direct Heat Gasifier