OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

RESTRICTED

17538

SEPTEMBER 1988

ENGLISH

CHARCOAL PRODUCTION AND WOOD GASIFICATION

DP/URU/87/027/11-01

TECHNICAL REPORT *

Prepared for the Government of Uruguay
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

Based on the work of Mr. Huub Stassen

Biomass Technology Group (BTG)

University of Twente

The Netherlands

Backstopping Officer: R O. Williams, Chemical Industries Branch

United Nations Industrial Development Organization

VIENNA

---

* This document has been reproduced without formal editing

TABLE OF CONTENTS

ACKNOWLEDGEMENT

The author wishes to thank UNIDO for inviting him to undertake this mission. Dr. Robert Williams (Vienna), Ms. Liz Taylor (Vienna), Mr. A. Sojit (Montevideo) and Ms. A. Emery (Montevideo) are thanked for their kind assistance in preparing and executing this mission.

Ing. Rosario Pou, Ing. Jorge Barbot and Ing. Oscar Schmidt of the Ministery of Industry and Energy (National Energy Directorate) assisted consultant during the mission both by providing usefull written and oral information and facilities, as well as by active participation in discussions. Without their generous co-operation, this mission would not have been possible.

EXECUTIVE SUMMARY AND RECOMMENDATIONS

Recently, the Directorate of Energy of the Ministery of Energy in Uruguay completed a comprehensive study quantifying the natural and wood resource base in the country. Following this Authorities have now embarked on a programme to investigate the extent to which the available wood may be used as an indigeneous energy source. One of the technologies under consideration is wood gasification.

Objective of this mission was to inform the Directorate as well as other interested parties about different aspects (current status, applications, operation and maintenance, manufacturers) of the biomass gasification technology, as well as to provide an input to the Uruguayan Gasification Evaluation Programme that is currently under consideration.

The first objective was met by executing a 4 day course in Montevideo, that dealt with a wide range of technical and economic aspects of the technology. A comprehensive set of course notes was made available to the Directorate. Beside, this report presents a list of wood gasifier manufacturers (mainly from Europe), under ANNEX 1.

Discussions with respect to a Uruguayan Gasifier Evaluation programme led to the conclusion that the following applications are of potential interest in the Uruguayan context:

- small/medium decentralized power generation
- industrial/domestic heatgas supply
- automotive power

It was concluded that the latter application at present has little priority.

An overview of commercial gasification technology presently available in Uruguay revealed that the following gasifiers types are presently commercially operated in Uruguay:

- small/medium size up-draft wood power gasification
- large size up-draft wood heatgas gasification
- small size cross-draft charcoal gasification

Gasifier types of potential interest not available in the country are:

- small/medium size down-draft wood gasification
- small medium size "open core" gasification

Based on the above considerations the following recommendations are made:

1. The Directorate of Energy should embark on a gasifier monitoring and evaluation programme incorporating technology already available in-country as well as new systems to be installed under the programme. The programme must be designed along the lines proposed in the "UNDP/WB Guidelines for Gasifier Performance Monitoring". To this effect the Directorate should be provided with monitoring equipment and technical assistance on monitoring procedures from project funds. Specified gasifier monitoring equipment is to be found under ANNEX 2.

2. In order to enable evaluation of the scope of down-draft wood power gasifiers, such a system should be bought abroad under project funds and installed at an agricultural research station for irrigation purposes. Specifications of such a system are to be found under ANNEX 3. It is proposed that the system be locally installed and commissioned and that some technical assistance in training and installation be made available from project funds. The outline of a personnel training programme is to be found under ANNEX 4.

   After careful evaluation of the rice husk resource base, a second phase of the project could involve installation and analysis of an "open core" rice husk power gasification system.

3. Apart from the above, within the Gasification Evaluation Programme, the Directorate of Energy should start a study to quantify the importance of the small/medium size decentralized power sector as well as the heatgas sector in Uruguay.

1. INTRODUCTION

1.1 Introductory Remarks

This mission was executed by Ir. H.E.M. Stassen, Director Biomass Technology Group (BTG), Enschede, The Netherlands, during the period 09 - 23 July 1988.

In accordance with his Terms of Reference, the consultant provided the Ministry of Industry and Energy as well as selected interested persons outside the Ministery with information as to:

- Current worldwide status of biomass gasification
- Applications of gasifier technology
- Operation and maintenance of gasifier systems

This transfer of knowledge was effectuated by means of a four day formal biomass gasification technology course which was held from 19 - 22 July 1988. The Directorate of Energy was provided with an extensive set of course notes, on a wide range of subjects relating to technical and economic aspects of the biomass gasification technology. Partial selected copies of those notes were distributed among the participants of the course.

In order to deal with the fourth aspect of his Terms of Reference (an overview of suppliers of small gasification systems), consultant includes a manufacturers list in this report under ANNEX 1. Part of the manufacturers listed have been discussed during the mission in Montevideo.

1.2 Limitations of this report

During the last day of the mission, while on official visit to a gasifier system, consultants official car was burglared and all information, papers and notes that were collected during the mission were stolen. For this reason this report is of necessity weak on background and country information. Also the description of the different gasification systems that were visited in Uruguay had to be done from memory, and therefore may be weak with respect to hard data and figures.

The latter will have little influence on the recommendations for further activities and the specification of the gasification systems to be installed, as those were discussed intensively at the Ministery and consultant is convinced that no major data or considerations are lacking in this respect.

1.3 Uruguayan biomass energy situation

Under the preparatory assistance project DP/URU/83/011, the forest resources (natural and plantation) within the Uruguayan territory were quantified by interpretation of IMI/LANDSAT image data in conjection with ground surveys. Maps of the plantations and natural forests at a scale of 1:100,000 were prepared and compiled into one sheet at a scale of 1:1,000,000.

This work has resulted in the conclusion that the forest area in Uruguay constitutes about 3 % of the total land area. Plantations on cattle raising farms and meant to provide shelter to the animals, constitute about 24 % of the total forest. Volumes of standing stock of pine and eucalyptus plantations were estimated at 3.5 million and 24 million cubic meters respectively.

Having completed this survey, Project Authorities have now embarked on a programme to investigate the extent to which the available wood may be used as an energy source, both in power as well as in heat applications. One of the technologies under consideration is wood gasification.

As in the North-Eastern part of the country irrigated rice cultivation becomes increasingly important, consultant is of the opinion that the other biomass resource possibly available in sufficient quantity to warrant further investigation as a gasification fuel is rice husk.

1.4 Gasification Programme

In 1986 the National Energy Directorate decided to embark on a programme to evaluate the possibilities of biomass gasification, in co-operation with UNDP, UNIDO and the Government of Brasil. The executing agency on the Brasilian side is CETEC.

The programme aims at installation and technical/ economic/financial evaluation of 3 pilot gasification installations i.e.:

- one charcoal gasification system coupled to an existing Diesel engine (dual fuel operation) to be installed for rice irrigation purposesat an agricultural research station,
- one charcoal gasification system coupled to an existing Diesel engine (dual fuel operation) to be installed for rice irrigation purposes at a private rice farm,
- one wood gasification system coupled to an adapted Otto engine (full gas operation) for installation at a sawmill.

1.5 Scope of Report

The objective of this report is twofold:

- to assess the suitability of technologies, locations and applications proposed in para. 1.4,
- to detail specifications of gasification systems to be installed at suitable locations.

2. FACTORS IN BIOMASS GASIFICATION INTRODUCTION

2.1 Technical Aspects

2.1.1 Biomass gasification technology

Figure I presents a schematic diagram of a biomass gasification system. Prepared fuel and air enter the reacter where the thermo-chemical conversion into a combustable gas takes place. The gas is subsequently cooled and cleaned (removal of dust, tarry materials and condensates), after which it is suitable for operation in an internal combustion engine. Tar cleaning and gas cooling may not be necessary in case the gas is directly used for heating purposes by means of a gasburner.

2.1.2 Biomass gasifiers

At present various types of biomass gasifiers are offered by manufacturers from both developed and developing countries.

2.1.2.1 The simplest and oldest type is the fixed bed up-draft or countercurrent system. Gasification air is entered at the bottom, fuel is entered over the top and the gas leaves over the top of the reactor (Figure II).

Major advantage of this system is its simplicity and insensivity to differing fuel characteristics (moisture content and size).

Major drawbacks are:

- the relatively high tar content of the gas which gives rise to considerable quantities (0.10-0.25 kg/kg fuel) of tarry residues from the gascleaning section and (in absence of a condensate treatment plant) to potential harmfull environmental effects,
- the volume of the gascleaning section, which makes the technology unsuitable for mobile applications.

Nevertheless the system has been in operation succesfully for decades both in developing as in developed countries on relatively "difficult" fuels like sawmill (bark, chips, sawdust and planing shavings) and agricultural residues (cotton ginnery trash, maize cobs, straw briquets) and possibly its developing country implementation possibilities have been overlooked in recent times.

2.1.2.2 In co-current or down-draft fixed bed gasifiers (Figure II), fuel is entered over the top of the equipment and gasification air is introduced at an intermediary level. The producergas leaves over the bottom of the reactor. As a result of this procedure tar containing pyrolysis products, that are generated in the upper part of the equipment, pass through a hot zone where they are combusted and/or cracked. The advantage of a well-operating down-draft gasifier is the production of a tar-free gas, which after dust cleaning can be directly used in an internal

Figure I Biomass gasification system

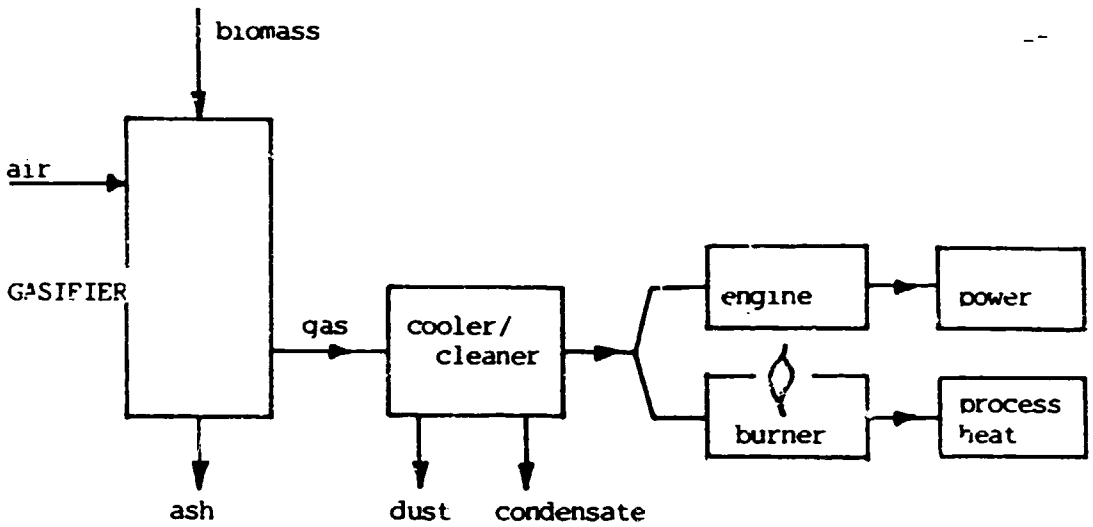
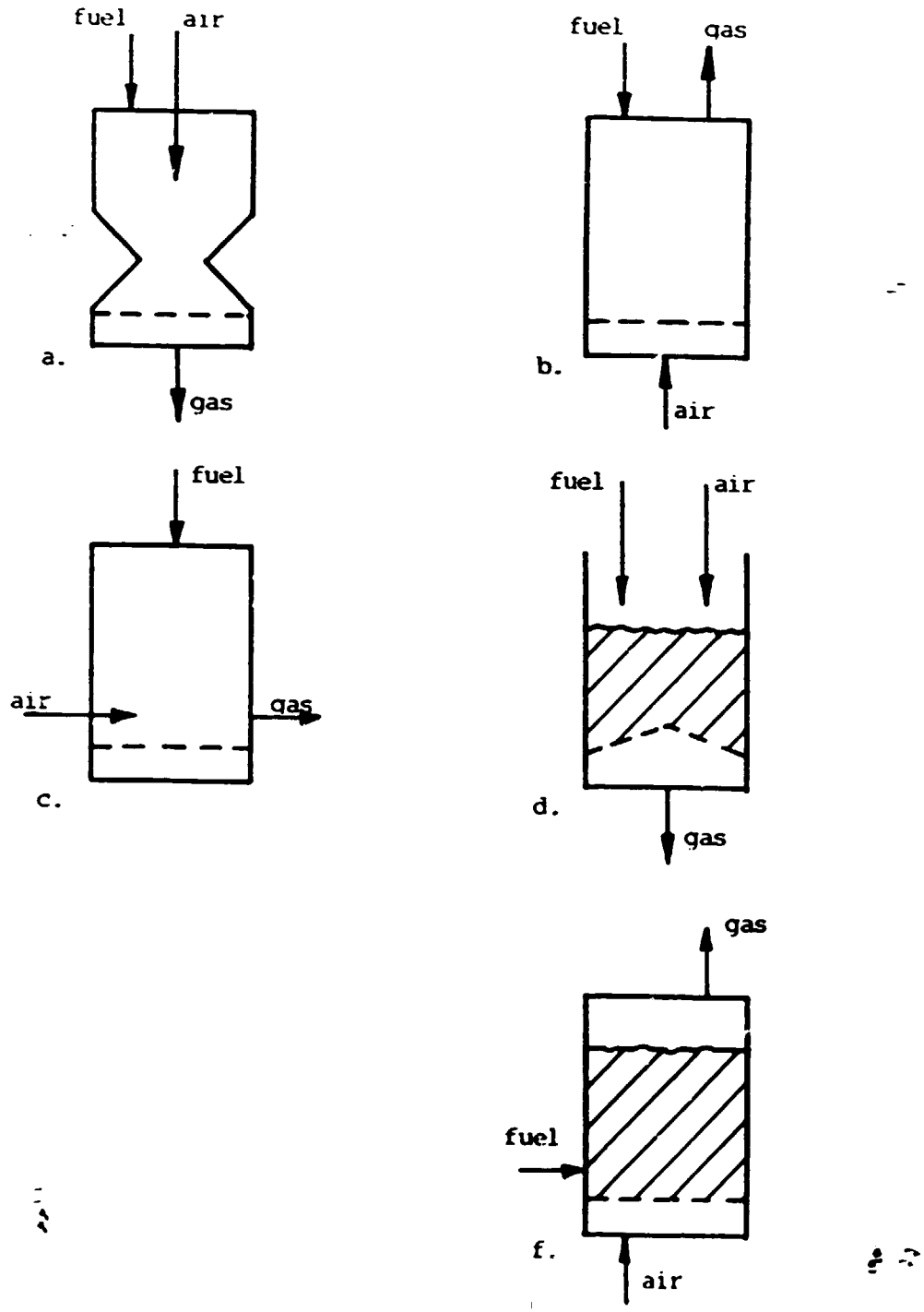


Figure II Biomass gasifier types



combustion engine. Because of the relatively small volume of the gascleaning section, this system was especially popular in mobile applications. The disadvantage of the system lies in its sensitivity to fuel specifications (moisture content, ash content, size and size distribution, bulk density) and load fluctuations. Variations in both can easily result in the production of a tar-containing gas, which (in the absence of an adequate tar-cleaning system) will lead to increased engine maintenance.

2.1.2.3 Cross-draft gasifiers (Figure II) are only suitable for charcoal and are almost exclusively used for transport and small (below 50 kW) power applications. No problems are reported in operation on good quality charcoal (low moisture content, low volatile content, specified size).

2.1.2.4 "Open core" gasifiers (Figure II) are a relatively recent development. Fueled on wood residues and used for domestic heating purposes, they have found a ready market in the USA. An analogous power generating system of Chinese design, fueled by rice husks and equiped with gascleaning section and adapted gasengine has been in succesfull operation for 15 years both in China and Mali.

2.1.2.5 Pyrolysis gas removing/recycling gasifiers (Figure II) are in operation generation in a number of countries. The technically most succesfull equipment is probably to be found in Ivory Coast, where two co-generating installations fueled by coconut husks have been in operation for several years.

2.1.2.6 Fluidized bed gasifiers (Figure II) are especially suitable for fine-grained or pulverized fuels. Air is blown through a bed of inert solid particles at a sufficient velocity to keep the bed in a state of suspension. The bed is externally heated and feedstock is introduced as soon as the gasification temperature is reached. The major advantage of a fluid bed gasifier is easy temperature control which allows operation below the melting/fusion temperature of the ashes. Drawbacks are the relatively high gas tar content and poor response to load changes. The latter difficulty makes the installation of sophisticated (and expensive) control equipment necessary. For this reason implementation of small fluidized bed gasifiers is generally considered not economic.

2.1.3 Producergas quality

Engine quality producer gas must have a sufficient heating value (above 4,200 kJ/m^3), be free of tars and dust and be as cold as possible in order to maximize engine gas intake and power output. Gas cleaning can present problems. In general the gas is passed through a series of cyclones, scrubbers, fibre and/or electro-static filters in order to remove all tars, ashes and soot. Insufficient gas cleaning is the major reason for unsatisfactory operation of gasifier power plants.

2.1.4 Gasifiers for heat production

In principle all above mentioned gasifier types may be used for heat production by means of a producergas burner. Gas quality requirements with respect to tar content are usually less strict in this application. In practice often updraft gasifiers are used.

Heat gasifiers compete with direct combustion furnaces or boilers. In some cases gasifiers can be used to retro-fit existing oil fired burners. Where a small capacity loss (5-15 %) due to the application of moist, low BTU gas is of little concern, this procedure may be much more economic then investing in a new biomass fueled furnace. Heat gasifiers are also the only solid fuel based option in processes where precise furnace temperature control is of importance or where heat (gas) distribution over limited distances is a necessity.

2.1.5 Producergas engines

All spark-ignited internal combustion engines may be run on producergas, however a decrease of about 50 % in maximum continuous power output must be taken into consideration. Maximum efficiencies are realized by adapting the ignition timing.

Diesel engines may be run at maximum continuous power output on mixtures of approximately 15 % diesel oil and 85 % gas. At lower engines loads the injected diesel oil quantity (necessary for mixture ignition) remains constant. As a result of this savings in diesel fuel tend to become increasingly less at sub-maximum engine power outputs and are effectively insignificant at engine power outputs below 30 %.

2.2 Application Aspects

2.2.1 Wood vs. charcoal gasifiers

Engine contamination due to use of tar-containing gas is a major failure factor in power gasifiers. For this reason a cross draft charcoal gasifier using good quality (low tar content) charcoal may be preferred over a down-draft gasifier using wood, especially in applications where low reactor gas loads may occur regularly. In case of varying engine loads, low reactor gas loads of down-draft wood gasifiers tend to be more serious in dual fuel systems then in full gas systems.

In heat applications the choice between wood and charcoal is mainly a matter of convenience. If the gas can be burned hot there is no advantage in using charcoal. However in case the gas is to be piped over a distance there may be an advantage in using a charcoal gasifier instead of an up-draft wood gasifier, as in the latter case the gas must be extensively cleaned resulting in heavy expenditure in gascleaning equipment as well as the production of substantial quantities of tar on-site.

2.2.2 Dual fuel vs. full gas engines

Apart from the disadvantage mentioned in para. 2.6, actual diesel fuel savings in duel fuel operation depend to a large extend on the average engine load i.e. regular low engine loads lead to disappointing savings.

2.3 Economic/financial aspects

The basic advantage of gasifier power plants as compared to diesel units is in the low biomass fuel cost vs. liquid fossil fuel. The major disadvantage is in the comparatively higher equipment cost. Therefore in general economic and financial analyses of gasification plants reveal that the prime factors influencing the economic feasibility of gasifiers are:

- the ratio (per unit energy) of diesel fuel costs and wood fuel costs. A high ratio widens the gap between fossil fuels and biomass (wood) fuels and therefore favours gasifiers.

  In Uruguay the cost of diesel fuel is 160 NP/l (ca. 0.5 US$/l) or about 0.0132 US$/MJ. The cost of (wet) wood (estimated heating value 11 MJ/kg) in- and outside Montevideo amounts to respectively 20 US$/ton (0.0018 US$/MJ) and 10 US$/ton (0.0009 US$/MJ).

  A fuel energy ratio in the range of about 15 to 7 as is the case in Uruquay in theory should be attractive for gasifier application.

- the total annual power output of the plant under consideration as a fraction of the maximum annual power output: high annual number of operating hours and high plant load factors "spread" equipment costs over a larger number of produced energy units, therefore resulting in a lower "equipment cost fraction" per energy unit.

2.4 Social Aspects

Prospective users of gasifiers should be aware that gasifier operation is very much dependant on quality and motivation of the operating manpower. All gasification systems demand continuous supervision. Cleaning tasks that must be performed are often dirty. Succesful projects are characterized by well trained personel, good organisation on-site, a structured division of tasks as well as an incentive system for motivating the operating personel.

In this respect it may be worth mentioning that human nature being what it is, full gas systems that have no possibility of operating on liquid fuel, often in the long run perform better than dual fuel systems.

3. BIOMASS GASIFICATION EXPERIENCE IN URUGUAY

3.1 Introduction

Largely unknown to the rest of the world there exists considerable experience in biomass gasification in Uruguay. Consultant was able to visit a number of operating installations in different parts of the country. However, as mentioned in para 1.2 consultant's notes were lost, therefore the description of the different systems below is of necessity somewhat weak and lacking in hard data.

3.2 Dual Fuel Up-draft Wood Power Gasifier

The system is located at a sawmill situated along the shore of the Rio de la Plata, approximately 80 km's East of Montevideo. The sawmill is mainly producing sawn timber from a local pine variety.

The gasifier is manufactured by AVIMEC, Rio Grande do Sul, Brasil. The system consists out of an updraft wood gasifier in which gasification air is introduced at a pressure of about 1.5 ata by means of an electric compressor. Wood is introduced over the top of the equipment by means of a vertical valve system. Ashes are batchwise removed by hand over the bottom of the equipment. The tar containing gasification/pyrolysis gas is passed through a sawdust filter where the majority of the tarcontaining condensates are removed from the gas stream. Next the gas is passed through a water cooled disc-cooler, followed by a cyclone and a final sawdust filter for removing remaining tars. From here the gas is piped through a long (70 m) upward sloping pipeline, passed through a final cyclone, mixed with combustion air. This gas/air mixture is fed to 2 diesel gensets (80 kW) each powering the sawmill.

The gasifier is fuelled by sized pinewood waste (slabs, off-cuts etc.). of approximately 60-70 % moisture content. Average wood waste consumption amounts to about 250 kg/hr.

The Diesel engines are run in a part fuel (gas/diesel) mode, in such a way that the base load of the sawmill is taken up by the producer gas and the load variations are controlled by adapting the diesel fuel amounts. Before gasifier installation, average power plant diesel fuel consumption amounted to about 16 l/hr. At present in part fuel mode the power plant consumes about 5 - 7 l/hr of diesel fuel.

The gasifier plant has been in operation for over 2 years. Initially gas cleaning problems leading to sticking engine valves where encountered. Those problems have been overcome by introducing some modifications especially in the lay-out of gas and mixture lines. At present only occasional engine knock problems (in case of exceptionally low engine loads) are encountered. From a technical and economic point of view, the system is working to the satisfaction of the sawmill owner, although it will be dismantled as soon as the central power grid

reaches the sawmill site (possibly in 1 year time).

Presently the owner is looking into a useful application (wood preservative ?) for the relatively large amounts (25 - 50 kg/hr) of tarry condensates produced in the tarcleaning section.

3.3 Up-draft Wood Heat Gasifier

The system is located at the ceramics factory "Metzen y Sena S.A." in Pando, approximately 30 km's North of Montevideo. The factory (personnel approx. 1,500) is producing a large diversity of ceramic tiles and earthenware under the brand name "Olmos". A considerable part of the production is exported.

The system was build by a West-German engineering firm, and consists of 3 large (height about 12 m) parallel reactors. Wood fuel is introduced over the top of the reactor by means of a double valved filling sluice or (in a newer version) a rotary valve. Compressed air is introduced over the bottom of the reactor. Ashes are removed through the water seal at the bottom of each unit. The gas is first cooled in a water scrubber and than passed through a stainless steel centrifugal tar seperator. Part of the tars separated in this device are reinjected thus assisting in the separation action. Next the gasses are passed through a stainless mesh wire fixed bed tar separator followed by cleaning and neutralizing in a "raschig ring" water scrubber. The alkalic ashes produced from the reactors are used as a neutralizing agent. The clean and cool gas is subsequently piped to the different furnaces and ovens in different parts of the factory.

The gasifiers are fuelled by hogged and partially dried eucalyptus wood. Average wood fuel consumption amounts to about 100 m^3/hr. With this wood consumption the system must be one of the biggest gasification systems currently operating world-wide. At present the wood is bought from different ranches in the surroundings. However "Metzen y Sena S.A." has taken measures to ensure wood supply through company owned plantations which will become productive in the near future.

The system was installed in 1982, and after some initial problems (mainly due to corrosion), is now working technically and economically to the satisfaction of the user. It was mentioned to the consultant that even at current low petroleum prices, the pay out time of the units will be not more than 7 years. The technical lifetime of the equipment was estimated at approximately 25 years.

Major problem with the system to date is the considerable tar production, which over the years has resulted in the build-up of a "tar lake" on the premisses of the factory. Presently the management is considering possibilities to convert this tar into a marketable product or alternatively to carbonize the tar and use the resultingcarbon as additional gasifier fuel. However, realisation of either one of those options seems to be in a very preliminary stage.

3.4 Full Gas Cross Draft Charcoal Power Gasifier

The unit is installed at a small sawmill near the coast, approximately 130 km's East of Montevideo. The mill specializes in the manufacture of fencing poles for ranches mainly from pinewood.

The gasifier was build by "Julian Berges S.A." of Montevideo after a design provided by the National Oil Company of Uruguay. The consultant recognised the system as a copy of a World War II system which t that time was manufactured by "Mercedes" and meant for mobile applications. The unit is of cross-draft design. Charcoal is manually introduced over the top of the reactor and ashes are manually removed over the bottom. Gasification air is sucked in by the engine through a watercooled air inlet tuyere. A provision for adding steam to the gasification air is available. The gas is sucked through subsequently a cyclone, a gas cooler and a heated (about 80 ^{0}C) cloth filter, after which it is mixed with combustion air and fed to the 80 hp full gas spark ignited engine. The engine is equiped with a manually adjustable ignition timing and is directly coupled by means of a gear box to the circular saw. The system is started up by means of a small hand-operated fan.

The unit is fed by on-site produced charcoal made from wood waste. For this purpose a locally manufactured charcoal kiln of TPI design is available.

The gasifier has been in operation at this site for over one year. The owner is exceptionally pleased with the unit both from a technical as from an economic point of view. Since installation of the equipment no major problem causing unforeseen maintenance or repair has occurred.

3.5 Conclusions

Contrary to prevailing in-country beliefs there exists considerable experience in biomass (especially wood and small-scale charcoal) gasification in Uruguay.

Both the medium and the large up-draft gasification systems described in para 3.2 and 3.3 can be considered more or less State-of-the-Art for this type of technology. A technical and economic evaluation of this existing equipment should provide the Directorate of Energy with sufficient information to formulate a policy with respect to implementation possibilities. Care should be taken that especially the environmental implications of up-draft gasifier application are sufficiently taken into consideration.

The small-scale cross draft charcoal gasification technology currently available and manufactured in Uruguay, though of old design can in no way be considered inferior to equipment currently manufactured in Brasil, Phillipines or Thailand. In fact (World War II) operating experience (resulting in "debugged" equipment) with the type of unit currently in use in Uruguay, is relatively speaking enormous, as compared to equipment of more

modern design. For this reason it does not seem necessary to import foreign equipment in order to evaluate the technical and economic implementation possibilities of this technology.

Gasifier types currently not available in Uruguay and of potential use for the country are:

- medium scale down-draft wood power gasification,
- medium scale "open core" rice husk power gasification.

4. URUGUAYAN GASIFIER EVALUATION PROGRAMME

4.1 General

Biomass gasification can theoretically play a role in the following sectors:

- small/medium size decentralised power
- industrial/domestic heatgas supply
- automotive power

The power supply situation in Uruguay is characterised by wide-spread availability of grid electricity in all major and medium-size population centres . As a result of this the role of decentralized power supply through wood and charcoal power gasification systems is probably fairly limited. Nevertheless (as described in Chapter 4) there are a number of isolated sites and situations like sawmills and irrigation water pumping stations where wood/charcoal gasifiers are presently used, and it seems worthwile to evaluate the advantages, disadvantages and subsequently the scope of both the charcoal cross-draft and the wood down-draft technolgy for sites of this type. In case an evaluation should reveal that a sufficient resource potential of rice husks exists in Uruguayan rice growing districts, as a second priority, the role of medium size rice husk gasification in decentralized power supply should be evaluated.

In Uruguay already one company is operating a large size wood gasifier for heatgas supply. Apart from environmental problems, for which possible solutions exist, technical and economic experiences with this equipment are satisfactory. For this reason it is worthwile to further evaluate the scope for this technology in Uruguayan industry. One possible application that could be studied is the possibility to supply the Montevideo towngas network (partly) with producergas.

In view of the additional expenditure necessary for gasifier service and maintenance, owners of the big trucks used for interregional transport are not likely interested in converting to producergas drive. The situation may be somewhat different with respect to the old small lorries often seen in urban Montevideo traffic. Here there may be a potential for automotive charcoal gasifiers that may warrant further investigation. In the agricultural sector experiments in Brasil have shown that the powerloss associated with producergas drive is generally considered unacceptable by the user. Based on the above, consultant comes to the conclusion that evaluation of biomass gasification introduction possibilities in the automotive sector is not a first priority.

4.2 Evaluation of systems

4.2.1 Technologies and applications

In accordance with the above it is proposed that the Directorate of Energy as a first phase of the project execute technical and economic evaluations of following units:

- the "Julian Berges S.A." small scale full gas cross draft charcoal system currently operating at a sawmill East of Montevideo,
- a dual fuel down draft wood gasification system to be purchased under the project and to be installed at a selected site (see below),
- the up-draft wood heatgas gasifier currently operating at "Metzen y Sena" ceramics factory North of Montevideo.

After careful analysis of the resource base, as a second phase of the project, an evaluation of a rice husk gasification system (to be purchased from project funds) may be included.

4.2.2 Evaluation methodology

It is proposed that the above evaluations are performed in accordance with the "UNDP/WB Guidelines for Gasifier Performance Monitoring". A copy of those "Guidelines" specifying actual measurements to be performed during initial gas quality and efficiency tests as well as providing suggestions for logbook management during operational monitoring has been sent to the Directorate of Energy.

For the initial measurements, the Directorate of Energy must be provided with gasifier monitoring equipment. A basic set of measuring equipment is specified in ANNEX 2. It is proposed to purchase this equipment from project funds and to provide initial technical assistance in order to familiarize Directorate of Energy staff with equipment and measurements.

4.2.3 Down-draft wood gasification system

Evaluation of the usefulness of this technology requires a suitable site as well as the availability of a unit in Uruguay.

The Directorate of Energy proposes to install this equipment at an experimental rice growing research station of the Ministery of Animal Husbandry, Agriculture and Fisheries, near Treinta y Tres in the Nortern part of the country. The unit is to be used for irrigation purposes at a site where at present a 80 kW diesel fuelled waterpumping station is operated. According to information gathered on site the pumping station is operated approximately 120 days per year for periods varying between 15 and 20 hours per day. The station is permanently manned by personnel from the research station. Eucalyptus wood fuel can be easily provided from nearby plantations.

From a point of view of operational hours and unit load factor the research station site is well suited for installation of a pilot wood gasification project. The quality of the manpower at the station seems to be such that no serious problems with respect to training of personnel or service and maintenance of the gasifier unit are expected. Attention however should be paid to the managerial and social aspects of the project. It is the consultant's experience that gasifier installation at sites where formerly diesel units were employed, can easily lead to complaints about enhanced workload and demotivation of operators. The latter is especially the case in circumstances in which no possibilities of additional incentives for the operating personnel exists. The consultant appreciates that the latter is the case at the site under consideration, and therefore emphasises the necessity of strong management in order to warrant correct gasifier operation and maintenance procedures.

It is proposed to tender the wood gasification unit among selected manufacturers from the list provided in ANNEX 1. A technical specification of such a system is provided in ANNEX 3.

In order to minimize equipment costs it is proposed that only the gasifier system and gascleaning system be purchased abroad. The Diesel dual fuel engine and water pump to be chosen from existing equipment available at the research station.

In order to minimize installation costs it is proposed that the system be mainly installed and commissioned by local manpower. Some additional technical assistance in installation of equipment and training of personnel will be necessary and must be provided from project funds. An outline of a personnel training programme as provided as a matter of routine by BTG (Biomass Technology Group) is incorporated under ANNEX 4. In the consultant's opinion it is feasible to combine installation advice, training in operation and maintenance as well as training in measuring and monitoring procedures (see para 4.2.2) in one mission.

4.3 Analysis of scope for biomass gasification

Apart from the above activities the Directorate of Energy must embark on a study in order to quantify the importance of the decentralized power and heat gas sectors in Uruguay. As a first step the number of sawmills, waterpumping stations and gas/liquid fuel burning industrial equipment should be established c.q. estimated, including when possible maximum installed capacity and annual fuel consumption. Based on such an overview and in combination with additional visits to selected sites it will be possible to get a clearer idea about the role biomass gasification can possibly play within the overall Uruguayan energy sector.

ANNEX 1. LIST OF DOWN-DRAFT WOOD GASIFIER MANUFACTURERS

1) BECE (Biomass Energy Consultants & Engineers) B.V.
Attn. Dr. F.G. van den Aarsen
P.O.Box 498
7600 AL Almelo
The Netherlands

2) CHEVET S.A.
Attn. Mr. R. Chevet
40 Rue de Paris
77200 Croissy Beaubourg
France

3) IMBERT ENERGIETECHNIK GMBH & CO. KG
Attn. Mr. O. Zerbin
Bonnerstrasse 49
5354 Weilerswist
Germany (FR)

4) NEI FLUIDYNE (NZ) LTD.
Attn. Mr. D. B. Williams
2 Rabone Street
Henderson
Auckland
New Zealand

4) ETS. TOUILLET
Attn. Mr. G. Touillet
Division Gazeification MARTEZO
237 Route de Paris
86010 Poitiers
France

5) S.E.S. (Soft Energy Systems) SPA
Attn. Mr. C. Gloria
Via Cuneo 20
Torino
Italy

ANNEX 2. MONITORING EQUIPMENT

In order to enable the Directorate of Energy to perform some basic measurements with respect to gasquality and efficiency of gasification systems, following basic set of monitoring equipment is proposed:

1) Gas composition and gas heating value

Orsat apparatus (including chemicals)

2) Gas tar/dust content

THT tar/dust sampling system (including auxiliary equipment and chemicals)

3) Gas flow

2 venturi gas flow meters (including calibration graphs and pressure indicators)

4) Gas temperature

1 thermocuople (0 - 200 ^{0}C)
1 thermocouple (0 - 700 ^{0}C)

including mV meter and calibration graphs

ANNEX 3. SPECIFICATION OF DOWN-DRAFT WOOD GASIFICATION SYSTEM

1. Scope of supply

The supply shall include the following:

- The supply of a 80 kW(mech) eucalyptus wood fuelled gasification system (exclusive diesel engine and irrigation pump) for rice irrigation purposes.

- The seaworthy packaging and transport to Montevideo, Uruguay of above wood gasification system.

2. Design Requirements

2.1 General

- The Buyer requests one single 80 kW mech unit.

- Supplier to take note that there is no auxiliary electricity supply on-site.

- All equipment and materials used for the entire plant shall be new, unused and suitable for operation in a sub-tropical climate.

- The equipment shall be designed to permit rapid and economical maintenance.

- The arrangement of the equipment, including piping and auxiliaries shall provide adequate clearance and safe acces for operation and maintenance.

- The Supplier shall ensure that all sub-contracted ancillary equipment is of high quality and compatible with the rest of the plant.

2.2 Gas generator

- The supplier shall deliver a fixed bed down-draft wood gasification plant. The unit shall be capable of producing adequate quantities of clean gas, with a heating value above 4,300 kJ/Nm^3, for producing a minimum maximum power output of 80 kW(mech) by means of a dual fuel (gas/diesel) Diesel engine.

- The plant shall be fuelled by hogged eucalyptus wood. Supplier to state maximum acceptable wood moisture content, maximum and minimum acceptable wood size and maximum acceptable wood ash content for efficient operation of the plant.

- The fuel feeding system and ash removal system of the plant will be manually operated

- The fuel bunker of the plant will be of such a size that under circumstances of full load only once in every two hours fuel feeding will be required.

- The gasifier shall be able to start up and come to full performance within a period of half an hour from the beginning of starting procedures.

- The gasifier shall be capable of responding to load changes from 20 to 80 kW mech within 3 minutes.

- The gas generator will be equiped with sufficient and adequate instrumentation to quickly discern and diagnose malfunctioning and its cause(s).

- Any ancillary equipment like for instance air compressors (for cleaning bag filters), axial blowers (for gas cooling), start-up fan etc. shall be included in the supply.

- The plant shall work efficiently requiring only routine maintenance by unskilled labour. Supplier to state operation and maintenance requirements in manhours per plant operating hour.

- Supplier to include all necessary equipment for gas cooling and cleaning.

- The gas cleaning/cooling section will be equiped with sufficient and adequate instrumentation to quickly discern and diagnose malfunctioning and its cause(s).

- Supplier to state and guarantee:

  - gas heating value
  - gas tar content at engine inlet manifold
  - gas dust content at engine inlet manifold

  under load conditions of resp. 80, 40 and 20 kW mech.

- Supplier to deliver a control system for the dual fuelled Diesel engine.

- Supplier to state and guarantee engine diesel fuel consumption (l/hr) under conditions of:

  - full load (80 kW mech)
  - half load (40 kW mech)
  - quarter load (20 kW mech)

- The equipment shall come with a complete set of spare parts for an operational period of two years.

- Supplier to include all special tools necessary for gasifier service and maintenance in the supply.

- Supplier to include following documentation:

  - plant outline dimension drawing and arrangement drawing,
  - cross-sectional drawings of all equipment with part list,
  - instruction manual for installation, operation and maintenance, including technical data sheets for all equipment and tarining manual,
  - spare part list.

ANNEX 4. OUTLINE OF PERSONNEL TRAINING PROGRAMME

1) Fuel preparation

- Best way of fuel preparation to eliminate waste.
- Effect of fuel size variations on gasifier performance and gas quality.
- Effect of fuel moisture content on gasifier performance, gas heating value and gas contamination (tars).
- Effect of fuel moisture content on engine performance and engine maintenance.
- Practical instruction in:

    - fuel sizing
    - fuel storage

2) Gasifier Operation

Theoretical Aspects:

- Basics of thermo-chemical processes involved in the generation of producer gas from wood.
- Factors effecting gasifier performance and gas quality.
- Gas treatment: cooling, cleaning.
- Gas/air mixing: factors effecting mixture homogeneity and combustion.

Practical Aspects:

- Visual assessment of gas quality from test flame colour.
- Essential discipline in efficient and safe gasifier operation:

    - pre-start plant inspection
    - operation
    - post shut-down service and plant inspection
- Operating technique, observations and fault diagnosis.
- Refuelling
- Ash removal
- Plant cleaning, routine periodic service, minor repairs, replacement of parts.
- Logbook keeping

3) Engine operation

Theoretical Aspects:

- Operating principles of dual fuelled Diesel engines
- Operating principles of engine governor
- Operating principles of gas/air mixer
- Effect of engine load on gasifier performance and gas quality

Practical Aspects:

- Use of manufacturer's operating and maintenance manuals,
- Routine servicing of engine (lubrication oil inspection, oil filter, air filter),
- Engine start-up, operation, shut-down,
- Engine instrumentation,
- Engine operation safety procedures,
- Engine logbook keeping.

4) Gasifier/engine instrumentation

Theoretical Aspects:

- Relations between instruments read-out and operating efficiency of individual systems,
- Instruments as aids in plant and system fault diagnosis.

Practical Aspects:

- Operation,
- Protective systems,
- Instrument read-outs,
- Instrument adjustment,
- Maintenance
- Operating safety procedures,
- Logbook keeping.

5) Health, safety and first aid

In addition to instruction in safety procedures applicable to the operation of the plant in general and of particular items of plant and equipment, the training includes general instructions in health, safety and first aid appropriate to a plant which produces and utilizes producergas.

This aspect of the training shall give particular emphasis to gas leak prevention, gas detection, carbonmonoxyde poisoning symptoms and remedial action, as well as fire prevention, protection against skin burns and their treatment, precautions against cuts and the treatment of cuts and bleedings.

6) Standard of operating competance and discipline

Throughout the progress of the training programme, trainees shall be called upon to demonstrate a satisfactory level of knowledge and skills in the safe and efficient exercise of the particular tasks in which they are being trained and also to demonstrate awareness of their role and responsabilities in ensuring safe and efficient functioning of other operating personnel and of the plant in general.

ANNEX 5. ITINERARY

09 July 1988	Departure Enschede, The Netherlands
10 July 1988	Arrival Montivideo, Uruguay
11 July 1988	Initial Discussions Ministry of Energy and Industry, Directorate of Energy
12 July 1988	Detailed Discussions Directorate of Energy
13 July 1988	Visit Wood Gasifier Powered Sawmill
14 July 1988	Visit UNDP Office
	Visit Wood Gasifier Fuelled Ceramics Factory
15 July 1988	Visit Charcoal Gasifier Powered Sawmill
	Visit Experimental Research Station "Trente y Tres"
16 July 1988	Evaluation Of Visit Results
17 July 1988	Sunday
	Preparation Course "Aspects of Biomass Gasification"
18 July 1988	National Holiday
	Preparation Course "Aspects of Biomass Gasification"
19 July 1988	Course "Aspects of Biomass Gasification"
20 July 1988	Course "Aspects of Biomass Gasification"
21 July 1988	Course "Aspects of Biomass Gasification"
22 July 1988	Course "Aspects of Biomass Gasification"
	Evaluation of Course
	Evaluation of Mission Results and Tentative Recommendations
23 July 1988	Departure Montevideo, Uruguay
24 July 1988	Arrival Enschede, The Netherlands