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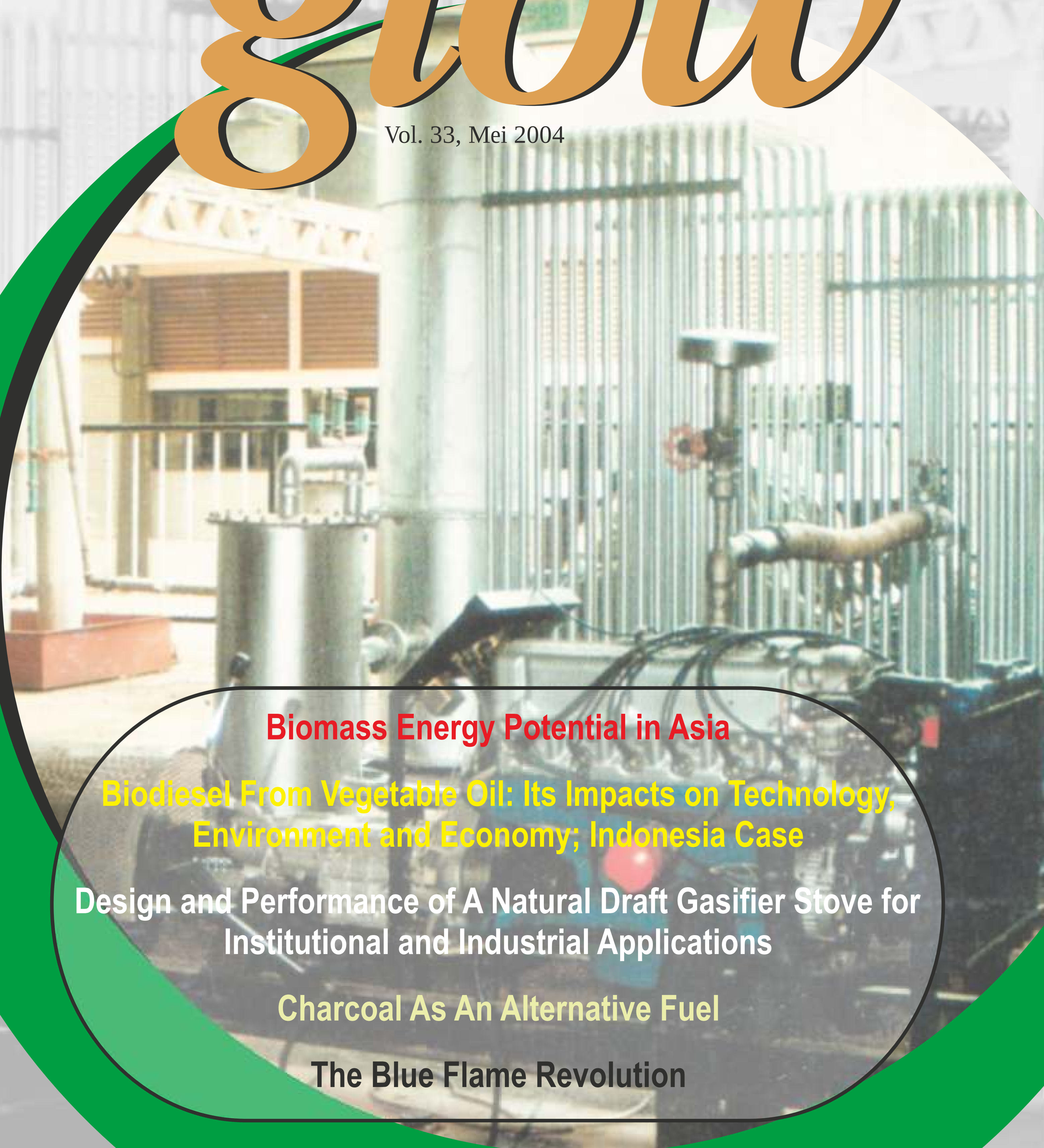

Biomass Energy Potential in Asia

Biodiesel From Vegetable Oil: Its Impacts on Technology, Environment and Economy; Indonesia Case

Design and Performance of A Natural Draft Gasifier Stove for Institutional and Industrial Applications

Charcoal As An Alternative Fuel

The Blue Flame Revolution

glow

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The Asia Regional Cookstove Program (ARECOP) is a forum for voicing the concerns of improved cookstove programs in the Asia Region. It influences and facilitates effective and efficient programs in improved cookstove issues.

## Dear Readers

One of the objectives of ARECOP is to enhance the viability of biomass fuel as a manageable and environmentally sound energy resource for households, small scale industries and institutions in Asia. In this efforts, ARECOP network strives to answer through activities related to biomass fuel upgrading.

The present situation that energy supply and use is still heavily dependent on the fossil energy has resulted on some worries such as the ultra-rapid CO2 emissions and also the limited stock of the fossil fuels itself. To cope with the global warming issue as well as the future energy crisis there is a need to decrease energy consumption derived from fossil fuels resources and to increase the use of natural energies. Biomass is one of the natural and renewable energy resource that are abundantly available in most countries in Asia.

At present however, the fact shows that the use of biomass fuel is still making use of traditional conversion and or combustion devices that often are not optimized resulting in various types of emissions and inefficiencies. This has also been the main reason that biomass energy is considered as traditional fuel and not attractive enough to policy makers to be considered as main fuel resource. There is therefore a need to take action to develop better and cleaner combustion devices that will help make biomass energy more viable in the eyes of policy makers and also can be proven as viable and renewable source of natural energy.

In this endeavor ARECOP in collaboration with Yayasan Dian Desa and the Asian People's Exchange jointly organized an international seminar on “Appropriate Technology for biomass derived fuel production”. The seminar is meant to share thoughts, experiences and information on various technologies developed and used to produce cleaner fuel from biomass and to seek for alternatives technology utilizing biomass appropriate to the conditions of Asian countries.

Considering that some of the technologies may be of relevant and important information for the ARECOP network, this issue of GLOW is specially dedicated on sharing some of the technologies on biomass derived fuel production shared during the seminar. The articles are summarized from some of the papers that are considered interesting and important for the readers to know.

In case anyone of you are interested and would like to have a complete information on the seminar or in one particular technology, you may contact the ARECOP secretariat for more information.

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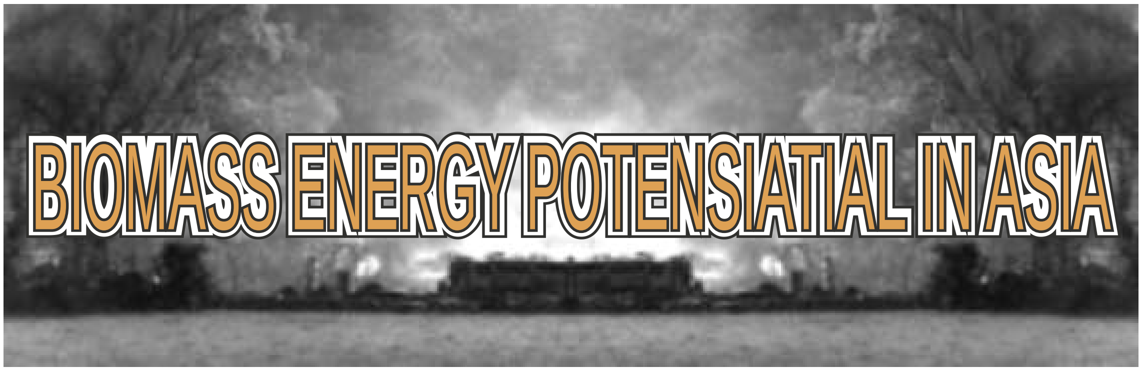

# BIOMASS ENERGY POTENSIATIAL IN ASIA

Auke Koopmans
*Former Chief Technical Advisor FAO-Regional Wood Energy Development Programme*

In Asia, biomass is still and will be an important source of fuel and as major biomass energy consumers. In general biomass fuel source is divided into three types namely, wood and wood product like charcoal, agro-residues (corn, husk, corn cobs, palm leaves, straw, etc.), and other biomass (dung, aquatic weeds, etc.). The importance of biomass energy is shown in some countries like Lao, Cambodia, and Myanmar, where biomass energy consumption is as high as 80 -90%. Despite the fact that it is difficult to get accurate data on biomass energy use, fact shows that biomass energy is still and will be an important source of energy and its consumption is still increasing with time.

Discussion on how important biomass as a source of energy in the world and in Asia, data shows that in the year 2000, biomass (or combustible Renewable and Waste) accounted for about 11% of all primary energy used, that is equal to about 3  4 billion tons. This has put biomass as the fourth largest source of energy after Oil (37.2%), coal (23.5%) and Gas (21.1%). While in Asia, about 26% of all primary energy used in 1999, consisted of biomass that was equal to 1.7  1.8 billion tons. In Asia, biomass is the second most important source of energy after coal (>40%) and closely followed by oil (>24%) and gas (>6%). Unfortunately, there is insufficient information available to provide breakdown of which sectors are the largest consumers. However, in general, based upon small-scale studies, the domestic sector generally accounts for about 70 80%, while the industrial sector consumes the remaining 20 30%.

Biomass, if used in a sustainable manner  as much is grown as is used, can be carbon neutral  or in other words can be good for the local and global environment  assuming that the biomass is converted and or combusted properly e.g. complete combustion.

At present however, the fact shows that in practice a major part of the biomass is converted by making use of traditional conversion and/or combustion devices, which often are not optimized, and resulting in various types of emissions and inefficiencies. Such condition has made biomass less attractive compared to other fuel especially fossil fuels. Yet, in some countries fossil fuels is getting less and prices are getting higher and higher. On the other hand, availability of biomass waste that can be utilized as fuel source is abundant.

There is therefore need to take action by either improving the combustion devices or replacing them with more efficient and/or cleaner combustion equipment. Consequently there appears to be scope for gasification and other technologies in order to improve the situation and to make biomass a viable source of energy.

BIODIESEL FROM VEGETABLE OIL:

# ITS IMPACTS ON TECHNOLOGY, ENVIRONMENT AND ECONOMY;

INDONESIA CASE

Prof. Dr. Tatang Hernas Soerawidjaja

*Director of Center of Research and Development of Sea Resources and Terrestrial*

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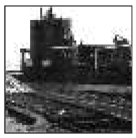
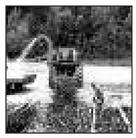
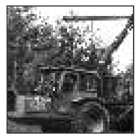
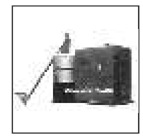






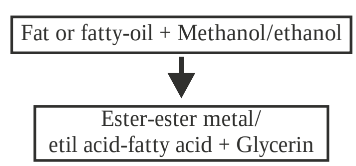


*Biodiesel is ester Metil or etil acid vegetable oil from triglyceride oil that undergone transesterification with methanol or ethanol. Biodiesel can be used as neat oil or blended with diesel oil. The benefit of using biodiesel oil in Indonesia is for improvement of environment, alternative for liquid fuel, reduce import of diesel oil, strengthen security of supply of diesel fuel, employment creation, and reduces gaps in income among regions, potential for new export commodity.*

*The problem of biodiesel development in Indonesia mainly lies on the price that is still higher than the diesel oil so that the competition is not balanced. The utilization of biodiesel is still very limited and the local technology to produce biodiesel is not yet proven. In addition there is no political support for its development and lack understanding on the importance of utilization of renewable energy. Therefore it is suggested that the roadmap to the utilization of biodiesel in Indonesia should be through the application of standardization of biodiesel, market development and the development of biodiesel industry including the diversification of its resource materials.*

*This article was abstracted from his presentation on International Seminar on Appropriate Technology for Biomass Derived Fuel Production, 3 October 2003, Yogyakarta, Indonesia.*

Scientifically biodiesel means fuel for diesel engine derived from various biomass resources. Yet, at present it is more popular as fuel for diesel engine that consists of ester-ester metal (or etil) of fatty acid. It is usually produced through the reaction of metanolysis (or etanolysis) of vegetable or animal fatty-oil and alcohol (methanol or ethanol); the side product of this reaction is glycerin, a kind of chemical material that has a good market potential.




Biodiesel was first introduced about 20 years ago in Austria by Mittelbach et.al. (1983) who tried ester metal of canola (rapeseed) oil. At present, there have been a number of countries that have produced and utilized biodiesel commercially by utilizing the vegetable oil that is abundantly available in their area. Countries like Germany, French, and Austria used biodiesel derived from canola (rapeseed) that grows well in sub-tropical area. While America used soybean, Spain use olive oil, Italy uses sunflower oil, Mali and South Africa use physic nut, Philippines uses coconut oil, and Malaysia uses palm oil; in addition, a number of cities in developed countries utilized used frying oil.

Indonesia as a country with vast number of population and also rich of natural resources is in transition period from net exporter to become net exporter of oil. Indonesia should actually be able to utilize and get the same benefit as what have been done in other countries.

This paper is meant to explain on the benefit of having technologies, environment improvement, and community economy development that can be achieved by the Indonesian community through the production and commercial use of biodiesel in the country.

## Characteristics of Biodiesel as Fuel

Table 1 shows the comparison of the most important characteristics of vegetable oil, biodiesel ester metal, and diesel oil, as fuel. The viscosity data and setana number shows the role and objective of the conversion of fatty-oil to ester metal (biodiesel): increasing the figure of setana and decreasing viscosity in order to fulfill the requirement of biodiesel for diesel engine fuel.

The melting point and density of biodiesel in most cases already fulfill the requirement of diesel fuel in Indonesia (as presented in the last row of table 1). The net calorific value (LHV=Low Heating Value) of biodiesel or vegetable oil is lower than diesel oil (only 90%), but it is compensated by the easiness of both to burn completely in the combustion chamber at lower rate ratio between air and fuel.

Biodiesel can be used as neat or blended with diesel oil without any significant modification needed to be done to the vehicle engine. Its fluid characteristic so that it can be easily mixed with diesel oil at any rate, is an important characteristic of biodiesel: because for commercial use it will not need special marketing infrastructure because it can utilize existing diesel oil infrastructure (gas station, trucks, dispenser, etc.)

## Benefit of Having the Technologies

The technology to produce biodiesel from various vegetable oil is practically the same and relatively simple because it only involves:

1. The reaction between vegetable oil and excessive alcohol with bases catalyst
2. Separation of glycerin as side product, and the excess of alcohol from the biodiesel product.

The production phases does not need a very tight operational control system so that it is quite easy to be developed and applied by local people. The operational condition is also

| Vegetable oil (VO) | Viscos (cSt) | | Setana figure | | Melting point ( C) | | Dens (kg/l) | | LHV (MJ/kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MN | Ester | MN | Ester | MN | Ester | MN | Ester | MN | Ester |
| Kanola | 37.0 | 4.2 | 37.6 | 60 | -31.7 | < -20 | 0.911 | 0.882 | 39.7 | 37.2 |
| Soya bean | 32.6 | 4.5 | 37.9 | 45 | -12.2 | -7 | 0.914 | 0.885 | 39.5 | 37.1 |
| Coconut | - | 2.7 | - | 63 | ≈25 | - | 0.93 | 0.872 | 37.3 | 35.3 |
| Palm | 24.3 | 4.4 | 37 | 62 | 15 | 18 | 0.899 | 0.870 | 39.6 | 40.1 |
| Physic nut | 52 | 4.8 | - | 51 | - | - | 0.92 | 0.879 | ≈39.5 | ≈37 |
| Diesel oil (ADO) | 1.6 | 5.8 | ≥45 | | ≤18 | | 0.82 - 0.87 | | 45.3 | |

Table 1 The comparison of important characteristics of vegetable oil, biodiesel ester metal, and diesel oil as fuel (Source: Soerawidjaja dkk., 2001, 2003)

quite mild (temperature is <150C, atmospheric pressure, pH and corrosives level is moderate, so that the necessary equipments to produce bio-diesel can be locally produced at local workshops. Figure 1 shows the diagram of the typical process route of biodiesel ester. Production operation can also be done by batch system up to 10,000 m3 /year or as continuous system in larger production system.

Indonesia is very rich in vegetable resources that produces fatty-oil, either edible fatty oil or non edible fatty oil either those that have been commercialized or still underutilized:

- Edible: Palm, Coconut, Peanut, *Moringa oleifera*, *Adenanthera pavonina*, *Carthamus tinctorius*, etc.
- Non-edible: *Jatropha curcas*, *Azadirachta indica*, *Calophyllum inophyllum*, *Schleichera oleosa*, *Bombax malabaricum*, *Jatropha multifida*, *Jatropha gossypifolia*, etc.

The fact that biodiesel can be made of vegetable oil using practical and simple technology will encourage Provinces or districts or even islands in Indonesia to cultivate trees that produce vegetable oil that have been locally grow in the respective areas. They can establish their own biodiesel manufacture, if not for large commercialization, at least it can serve their own province or district needs.

The above description shows that establishment of biodiesel industry in Indonesia will have a positive contribution towards the development of agricultural technology and industry in Indonesia.

## Benefit of Biodiesel for Environment Improvement

Because biodiesel is made of vegetable of animal fatty oil or renewable, the $CO_2$ emission from the engine that uses biodiesel as fuel is not classified as $CO_2$ emission that causes global warming, unlike the $CO_2$ produce when fossil fuel is used.

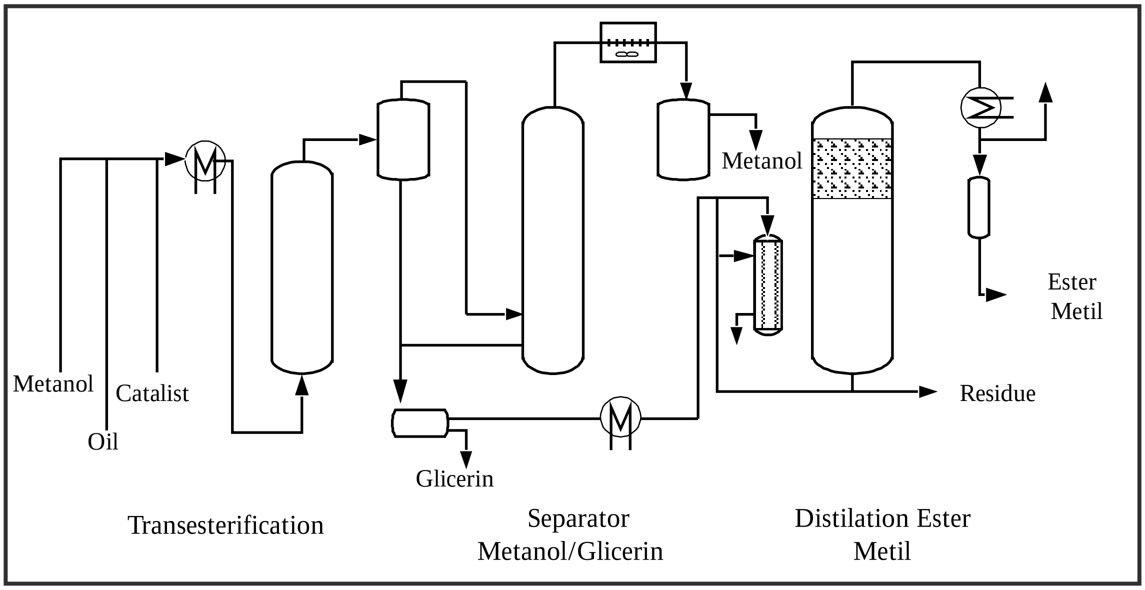



Figure 1 Route diagram of biodiesel production process

In addition:

- Biodiesel contains oxygen particles, which is bound in its compound structure (ester-ester fatty acid) so that the combustion inside the engine is almost complete that the air-to-fuel ration is small. Thus the Carbon non $CO_2$ is low and the engine is more efficient.

- The viscosity of biodiesel is higher than the diesel oil so that biodiesel has a better lubricant character and has a positive impact on the durability of the engine that uses biodiesel.
- The sulfur contents of biodiesel is too low and sometimes zero. Tyson (2001) mentioned that the average sulfur content of biodiesel is 0  24 ppm but in general it is <15 ppm (compared to sulfur content of diesel oil in Indonesia which is 1500  4100 ppm). Thus the SO2 emission and particulate (SPM=Solid Particulate Matters) from engine that uses biodiesel is almost zero (sulfur is known to be the cause of the formation of SPM).

At present the requirement of vehicle engine emission is tougher and requires that the sulfur content on diesel fuel is reduce or completely zero, yet diesel oil is known that the lubricant capacity is lower if the sulfur is less. As one alternative to fulfill such requirements and yet still maintain the lubrication capacity of the fuel, many countries now utilize biodiesel as blending component to diesel oil with high sulfur content (300 - 500 ppm) or low (≈50 ppm). The blend XX%-vol of biodiesel with (100-XX%-vol of diesel oil is commonly known as biodiesel BXX. For example, B5 is a mixture of 5%-vol biodiesel and 95%-vol diesel oil and B20 is a mixture of 20%-vol biodiesel and 80%-vol diesel oil. World-Wide Fuel Charter (WWFC) December 2002 volume has implicitly admitted b5 as a formal fuel for diesel engine by admitting diesel fuel to contain 5%-vol FAME (Fatty Acid methyl Esters or biodiesel).

In Indonesia especially producers of fuel should have taken the positive impact of the use of biodiesel as in other countries by producing and using biodiesel in Indonesia (Soerawidjaja and Tahar (2003b)). The fact that diesel oil in Indonesia has a very high sulphur content (1500 - 4100) ppm), and to modify petroleum refinery to produce diesel oil with low sulfur content would need big investment, should consider biodiesel as alternative.

## Benefit of biodiesel to the strength and the country economy

The benefit of commercial production and use of biodiesel in Indonesia is as follow:

- Develop the liquid fuel resource
- Reduce import of diesel oil (ADO = Automatic Diesel Oil)
- Strengthen the security of diesel oil supply
- Employment creation
- Reduce the gap of individual income as well as province or district
- Potential new export commodity

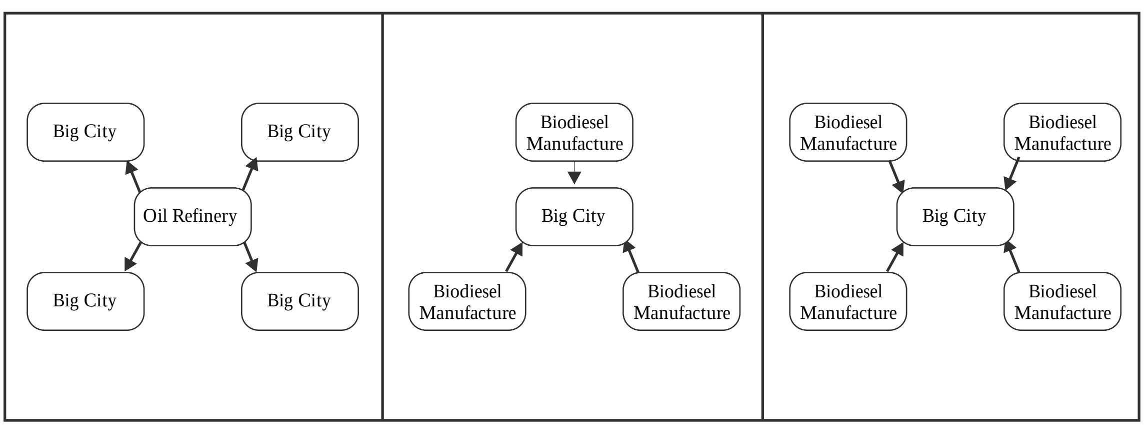



Figure 2 Comparison of production and supply system of diesel oil and biodiesel

## Biodiesel Development Activities in Indonesia

Based on the belief that the establishment of biodiesel production and use in Indonesia will have positive impact, in February 2002, activists and researchers of biodiesel development in Indonesia formed the Forum Biodiesel Indonesia (FBI). The objectives of the forum are to promote the development and use of biodiesel in Indonesia. The forum also identifies obstacles towards the realization of the establishment of biodiesel industry in Indonesia, namely,

- The price of biodiesel is still higher than diesel oil
- Unfair competition between biodiesel and other fossil fuel.
- Quality and benefit of product: that biodiesel is compatible to the requirement of vehicle engine is not yet widely proven in the community
- The management infrastructures as well as commercial infrastructure have not existed yet because biodiesel have not attracted investors on transportation fuel.
- Commercial Scale Technology application (by Indonesian) and the stability of the raw material supply at reasonable cost have not been proven
- Policy makers and investors have not realized the macroeconomy benefit of biodiesel glow

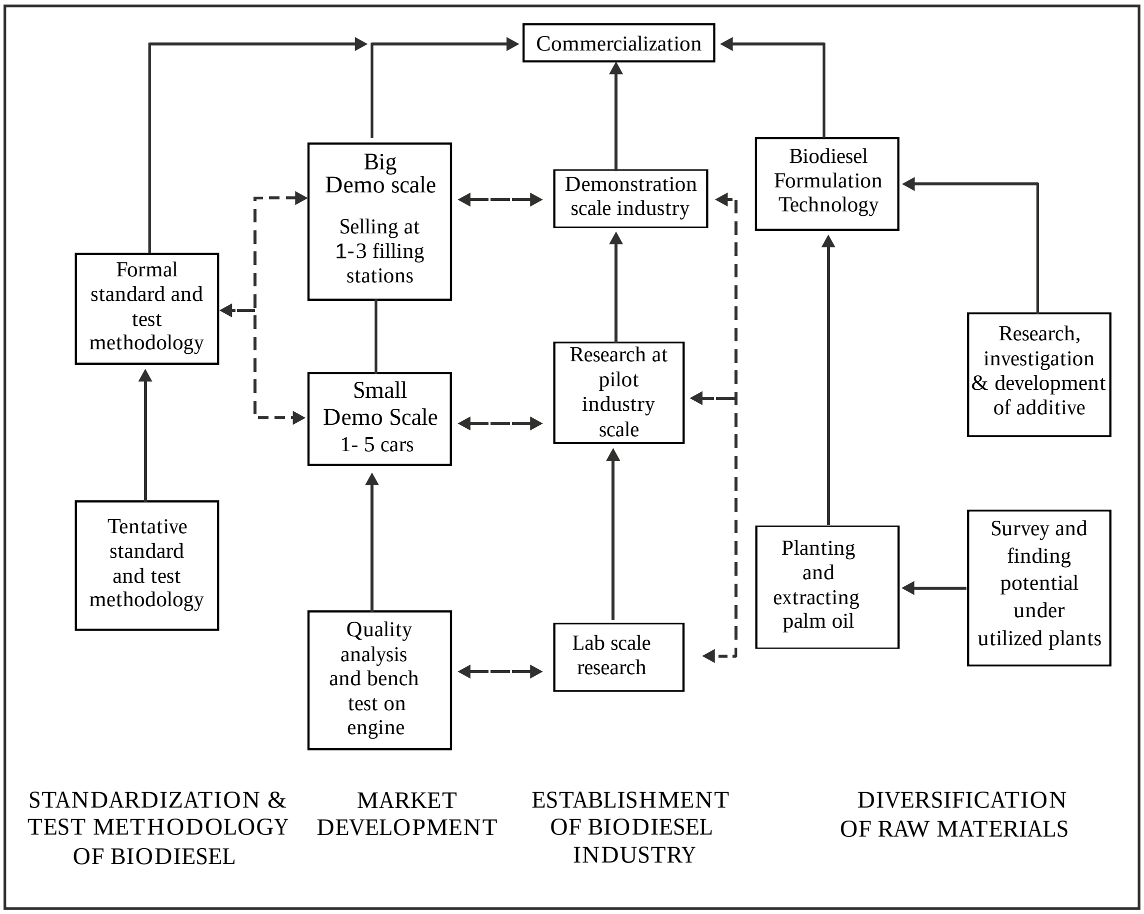



Figure 3 Roadmap of biodiesel commercialization Indonesia

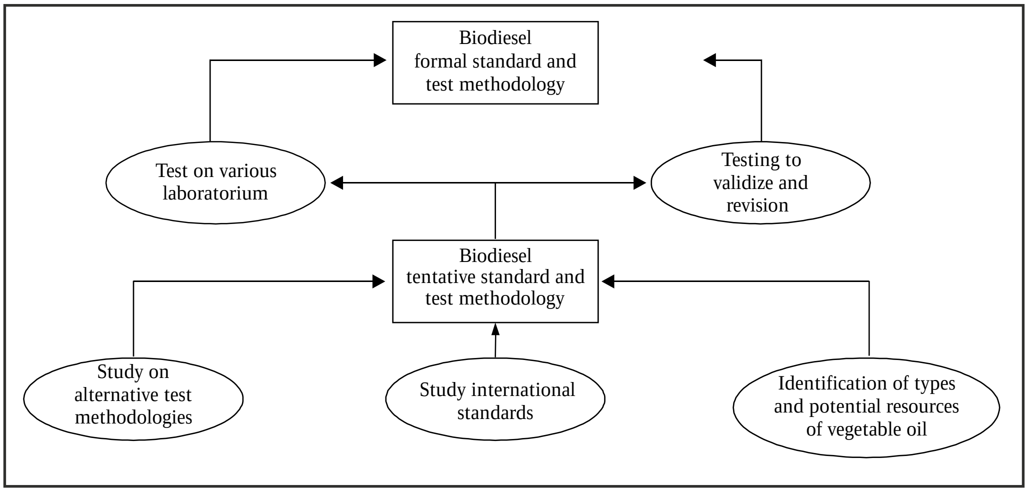



Figure 4. Roadmap to biodiesel standardization in Indonesia

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# Design and Performance of A Natural Draft Gasifier Stove for Institutional and Industrial Applications

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Gasification of biomass provides cleaner, more efficient and more convenient cooking option than direct combustion of biomass. Gasifier stove appears to be promising alternative for community use as this type of stoves have high power (wattage) to size ration, and it can be operated continuously if necessary, does not require much attention, and produce little smoke. To fulfill such needs, in June 2000 AIT under the framework of a regional research and dissemination program , RETs in Asia, funded by the Swedish International Development Cooperation Agency (Sida) has developed an improved briquette or wood-fired gasifier stove suitable for small institutional kitchens. The stove, named IGS-2, uses rice husk briquettes and wood chips as fuel. THE IGS -2 was developed such that it can be used in commercial establishment such as restaurants, small-scale industrial applications such as cottage industries, as well as for community-type cooking.

The IGS-2 stove is essentially a natural draft cross-flow gasifier, with a burner, pot support and a chimney attached to it. Producer gas is generated in the reaction chamber of the gasifier, and the gas is burned in a gas burner with secondary air supplied appropriately. The hot flue gases from the gas burner pass through a pot support, which houses two cooking pots. A chimney attached to the second pot support produces the required draft and can direct the exhaust gases out of the room in case of indoor applications.

A review of the performance of the IGS-2 shows that in a two-pot configuration, IGS-2 offered water boiling efficiency of about 17.1% with rice husk briquettes. Yet, when tested with other biomass fuels, the stove offered an average efficiency of 27.8% and 22.2% for wood chips (eucalyptus) and wood twigs respectively in water boiling test with two-pots.

For operating the IGS-2, it requires 10 15 minutes for start up, meaning that it took about 10 15 minutes for the stove to generate combustible gases at the gas burner which can sustain a flame, from the time a flame torch is used below the grate to start the process of gasification. During the start-up period of 10 -1 5 minutes, a considerable quantity of smoke is released through the gas burner. Yet, since the stove is equipped with chimney, the smoke safely exists through the chimney. And, once the flame start, the emissions from the stove is quite low and therefore the stove is suitable for indoor use as it is healthier compared to direct combustion stove.

## Technical Design Detail

From the results of a series of controlled experiments conducted on IGS-2, it was concluded that the stove wattage and efficiency could be enhanced by increasing the reaction chamber volume and the gasification rate, as well as by providing a third pot. The gasification rate can be increased by suitably increasing the primary air supply into the reaction chamber. The design details of the new stove are presented as follows :

The stove consists of four main parts i.e. fuel chamber, reaction chamber, primary air inlet and gas burner. Different parts of the stove can be attached together by bolts and nuts. The design configuration of each part is shown in Figure 2.

*Fuel chamber:* The fuel chamber is designed to store the biomass fuel for operating the stove over extended periods of time with a single fuel loading. The stored fuel is fed into the reaction chamber by gravity while fresh charge of fuel can be loaded by opening a lid at the top. Made of 1.5 mm thick mild steel sheet, the 78 cm high conical shaped fuel chamber is located above the reaction chamber. Conical shape was chosen to reduce the chances of fuel bridging inside the fuel chamber, and to improve the fuel flow during stove operation. The lower part has a diameter of 40 cm while the upper part, 35-cm. A water seal is provided at the fuel chamber top. A cup-type lid is used at the top, for easy loading of fuel. The water seal consists of a water rail fixed on the outer edge of the hopper at the top, and is filled with water. With the lid in place, the water seal prevents gas leakage from the joint during stove operation.

*Reaction chamber:* This is the section where the biomass fuel is pyrolysed, and the related reactions take place, to generate the producer gas. The reaction chamber has a rectangular outer shell made of 1.5 mm thick mild steel sheet, with a cross section of 56 cm x 56 cm, and a height of 56 cm (outer dimensions). The chamber is lined inside with clay bricks, mortared together using refractory cement CASTABLE-13, to form a cylindrical chamber in the middle. A rectangular grate is fixed at a height of 30 cm from the top of the reaction chamber.

Above the reaction chamber is *the fuel hopper,* from where fuel flows down by gravity. The grate is made of 10 mm diameter round parallel steel bars with 2.5 cm spacing in between. Ash from the reaction chamber could fall down freely through the grate and accumulate in the ash pit. An ash scraper is fixed below the grate to remove ash occasionally. A mild steel door (21 cm x 18 cm) is provided below the grate at one side of the ash pit for removing the accumulated ash. The ash scraper is particularly useful while using ricehusk briquettes as fuel since ricehusk contains ash often in excess of 20%.

*Primary air inlet manifold:* Primary air required for gasification of the biomass enters the reaction chamber through the inlet manifold. It is in the shape of inverted 'L', made of 1.5 mm thick mild steel sheet and attached on one side of the reactor. A slider gate is provided to control the amount of primary air supply into the reaction chamber. The rectangular cross sectional area of the primary air inlet measures 25 cm x 36 cm.

*Gas Burner:* The producer gas from the reaction chamber is burnt in the gas burner, using secondary air supplied through a series of secondary air holes. The burner has two parts: the rectangular support at the bottom or gas burner base, and four cylindrical burner pipes, which are fitted over the base. The gas burner base is insulated with a 2-cm layer of refractory cement (CASTABLE 13) on its entire inner surface. The insulation reduces the heat loss from the gases exiting from the reaction chamber before it is burnt in the gas burner.

The design of the gas burner in the Commercial Gasifier Stove is slightly different from that in IGS-2. The single cylindrical burner designed in the IGS-2 prototype has been replaced with four smaller burners, with secondary air holes provided in each cylinder. Each of the four burner pipes is 12 cm in diameter, and 35 cm high, and has forty eight number of 10 mm dia. holes drilled on it in six rows, through which secondary air flows in, for combustion of the producer gas. To reduce heat losses, the surfaces below and above the secondary air holes in all the four burner pipes are together insulated with rockwook and clad with 1mm thick GI sheet.

*Pot Supports:* A two-pot and a three-pot configuration were fabricated for the experimentation. Each pot hole could accommodate a circular pot of

36 cm outer diameter. To increase the heat transfer surface area, the pot supports are designed in such as way that the pots 'sink' into the pot holes, with only the top 2 cm height of the pot (with handles) staying outside the pot hole.

The pot supports are modular in construction, and are fabricated using 1.5-mm thick mild steel sheets. A two-pot configuration can be converted into a three-pot configuration simply by attaching a third pot before the chimney. The first pot hole base has a central circular hole in the middle, through which hot flue gases from the gas burner enter. After transferring some of their heat to the first pot, the gases leave the first pot hole through an opening at one side, and enters the second pot hole, also through an opening in its side. The first and second (and third in the case of 3-pot support) potholes are connected together using flanges. Flue gas exits from the last pot hole through a chimney, which is also connected with a flange.

Each pothole is provided with tertiary air holes at its lower part, of 1cm diameter each, to aid complete combustion of flue gases. The first pot hole is provided with ten tertiary air holes, while the second and third pot holes were provided with six holes each. A central-air pipe of 1cm diameter is fitted to each combustion column to supply air to the center of the gas stream and to enhance the mixing of gas and air.

All the three potholes are insulated inside with a 20mm thick layer of CASTABLE-30 refractory cement, to reduce thermal losses. The chimney exterior is insulated with fiberglass wool and clad with aluminum foil.

## Fuel Use for IGS-2 Stove

IGS-2 was originally designed for rice husk briquettes and wood chips as fuels. But, experiments proved that wood twigs and coconut shells can also be used and are also suitable for IGS-2. The only limitation of fuel use for IGS-2 is that the fuel should be sized before loading into the fuel chamber. An average size of 25-40 mm is acceptable size for the fuel.

## Stove Operation

The biomass fuel is loaded into the metallic hopper from the top. The lid of the hopper is then placed in position, and some water is filled into the water seal to prevent gas leakage from the top. To start the gasification process, a flame torch is held below the grate by opening the ash pit door. During the start-up, consider-

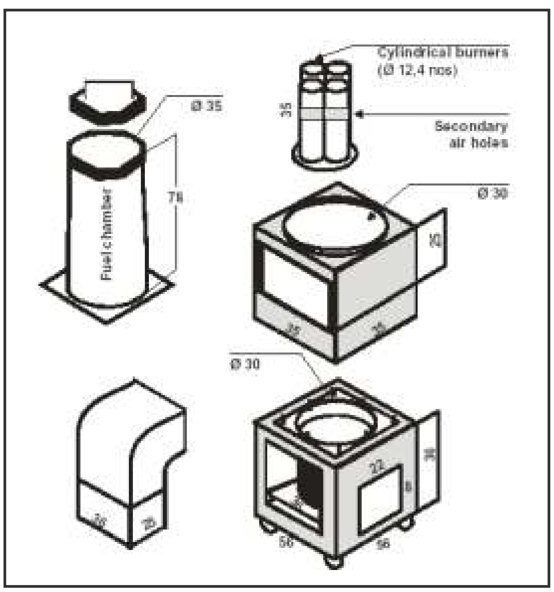


Figure 2 Exploded view of CGS, with dimensions marked

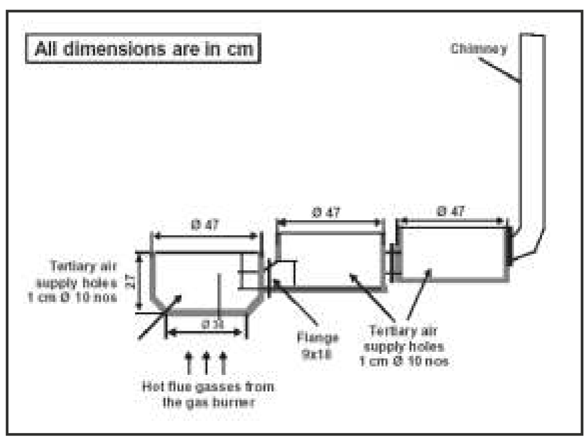


Figure 3 Pot support design (three-pot configuration)

able amount of smoke is generated from the stove; in about fifteen to twenty minutes, the fuel inside the reaction chamber starts producing a combustible gas, known as the producer gas. The gas can then be ignited at the gas burner by holding a flame torch near the secondary air holes. Once the gas gets ignited, the stove operates with practically no smoke. The gas mixes with secondary air entering from the sides of the combustion chamber and generates a strong flame.

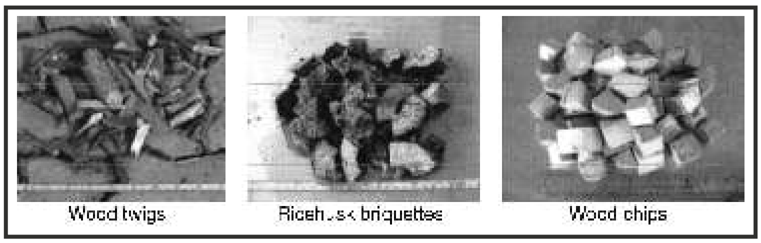


Figure 4 Fuels for the gasifier stove

Accumulated ash should be removed by operating the ash scraper occasionally, typically every 10-15 minutes while using ricehusk briquettes as fuel. A single fuel loading could last for about two hours of continuous stove operation. Additional fuel could be added afterwards, to continue the operation further, to any number of hours.

## Conclusions

A commercial/industrial type gasifier stove (CGS), based on the IGS-2 design, was designed, fabricated and tested. Experimental results using ricehusk briquettes as fuel indicate an average water boiling efficiency of 17.7% with two-pot configuration. The efficiency increased to 19.1% with a three-pot configuration. With wood chips as fuel, the stove offered an average efficiency of 24.1% for a two-pot configuration, and 28.9% with a three-pot configuration. A maximum efficiency of 31.8% was achieved with wood as fuel in a three-pot configuration. CGS offers a heat power of about 8.2 kW with ricehusk briquette as fuel (with a fuel consumption of 13 kg/hour), and 11.5 kW with wood chips as fuel (with a fuel consumption of 11 kg/hour).

Although designed to operate efficiently with ricehusk briquettes as fuel, the stove is versatile, allowing different fuels such as wood chips, wood twigs and coconut shells to be used in it. The gasifier stove is also versatile, smoke-free, and provides continuous steady operation for extended periods of time, offering itself as a good alternative to other traditional stoves using conventional fuels for similar applications. glow

## Acknowledgement

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# Charcoal As An Alternative Fuel

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## Introduction

Charcoal has been known throughout the world for thousands of years. All ethnic groups have knowledge and experience in regards to the production and use of charcoal as fuel or heat energy. For many years the production of charcoal has been carried out on a small-scale (household scale), medium scale and large scale such as for industry.

Since the time of our great great grandparents there has existed the knowledge to producing charcoal from a number of different basic resources, the main resource being wood. From experience it is known that only a few types of wood are preferred and chosen for producing charcoal. The reason for this choice of wood is that the quality of the charcoal produced depends heavily upon the type of wood used.

One aspect of producing high quality charcoal that requires careful attention is the production technique. The methods of producing charcoal have developed from very simple methods to what are now far more technical methods. A very simple method to produce charcoal is to burn biomass in an open area until glowing hot and then douse with water thus producing charcoal. A more technical way of producing charcoal is to use an earth or steel kiln, with this method the charcoal fuel source is not directly burnt but the space within which it is placed is continually heated producing step by step carbonisation and in turn producing charcoal.

## Types of Basic Charcoal Material

In principle all types of botany (plants) can be said to be raw material source for producing biomass. But on the other hand the quality of the charcoal depends highly upon the raw material used, technique and process used in production. Generally raw material used for producing charcoal is solid fibre hardwood. Besides wood a number of waste materials are also used such as coconut shells and fibres, rice husk, ear/stem of corn, rubber plant seed, straw (dried rice stalks), twigs, grass leaves and waste from fruits. For certain particular requirements animal bones and cockleshells can also be used for producing charcoal. Generally materials used for producing charcoal can classified as below.

*Wood:* mangrove, Leban, jambu klutuk, rubber tree, coffee plant, forest hard wood etc.

*Bamboo:* experience has shown that all types of bamboo can be used to produce charcoal.

*Waste:* industrial wood waste, farming waste, plantation waste (shells and coconut fibres, shell and stem used for producing coconut oil, rice husk, ear/stem of corn, grass, twigs, straw)

*Fruits* (decorative/ceremonial charcoal): banana, rambutan(lychee), durian and manggis etc.

## Types of Charcoal

All types of charcoal are black in colour. Nevertheless many individuals that produce charcoal believe that it is the actulisation of cultural art. Charcoal is not only a commodity to meet daily energy needs but also forms an artistic commodity. The ability of an individual to produce high quality charcoal brings with it a feeling of pride as the produced charcoal is formed from culture beliefs and a high work ethos. The quality of the charcoal produced will also determine how the charcoal will be used. For example, bincho charcoal in Japan is well known as the world's number one charcoal for roasting eel meat. Besides this there is also charcoal produced especially for use in tea drinking ceremonies that have great cultural significance in Japanese society.

Types of charcoal:

*Normal charcoals* (black charcoal): hard, produces high level of heat energy and is smoke free.

*White charcoal* (bincho charcoal): very hard, produces high level of heat energy, smokeless, sounds like steel if dropped, not all basic charcoal material can be used for producing white charcoal. In Japan there is a special wood named "Ubamegashi" used to produce the bincho charcoal.

*Charcoal briquette:* black charcoal that is ground and then formed into the required shape, Industry produced.

*Charcoal stick:* long pieces of intact wood charcoal, this is usually sold in the form of sticks.

*Powder charcoal:* this is charcoal that is reduced to powder for a specific reason or was actually produced from powder such as sawdust.

*Active charcoal:* black charcoal that is activated to increase quality for its intended usage

Figure 1 Wood as a raw material for charcoal making

## Quality of Charcoal Raw Materials

Not all the raw materials used to produce charcoal will result in a high quality charcoal product. To produce charcoal of a high quality not only the production technique and firing of the charcoal must be good but also the quality of the raw material.

Good quality raw materials must have the following properties:

1. If the raw material is wood, it must be a type of compact fibre hard wood
2. Rotten wood or other raw material can not be used
3. The raw material must have a normal water content, not too much but also not too dry, this water content is required in the carbonisation and drying stages of the charcoal process. The best method of drying the raw material is by exposure to air/wind.

## High Quality Charcoal

Not all produced and sold/ marketed charcoal is of a high quality. Charcoal that can be categorised as high quality must have the following things:

1. Chosen raw material (hard, not rotten)
2. Processed using good and correct technique (following the steps: drying, cellulose carbonisation, hemi cellulose and lignin, and completed with finishing steps).
3. After charcoal is produced (removed from kiln and stored)
4. Has a fixed carbon content of above 75%
5. Low water content (maximum 8%)
6. Ash content below 5%
7. Volatile mater content (gas) of less than 15%
8. Is not polluted by waste, stones, sand etc.
9. Charcoal is hard, shiny and has a ringing sound/tone
10. Smokeless once alight
11. Charcoal remains at constant high temperature
12. Charcoal burns continually for long period of time (not easy to put out)

## Technique for Producing Charcoal

Making charcoal is not a job that is too difficult. On the other hand producing high quality charcoal that is appropriate to its end use means that the task of making charcoal is no longer as simple as burning raw materials so as to produce the finished charcoal. There are many techniques for producing good quality charcoal. A technique for burning one kind of raw material is not defiantly suitable or appropriate for the burning of another kind of raw material. This means that the operation of a kiln for firing charcoal is not always the same. Beside this each kiln is also designed to produce charcoal of a fixed quality. The production of charcoal whether using a simple or more technical method must be done using the following steps.

## Working Steps for Producing Charcoal

1. Identify types of available raw material
2. Determine the type of kiln or firing method for producing the charcoal
3. Determine the appropriate location with good supply of raw materials and transportation for producing the charcoal.
4. Construct and prepare all the requirements for producing charcoal
5. Collect raw materials
6. Prepare all the require work tools
7. Place the raw materials in the kiln

## Firing Steps

1. Initial firing, this is the burning of wood to start the drying process. In larger kilns the burning of wood fuel must be constantly controlled so as for the whole of the drying process the fire does not go out.
2. Drying process, this process is to remove the water content from the raw material before beginning the carbonisation process. The drying process in a large kiln can take between 8 to 12 hours to complete with the

Figure 2 Arranging the wood in the kiln before ignition

internal temperature of the kiln reaching temperatures between 70 to 80% Celsius.

3. Carbonisation, the carbonisation step is one of the most important steps in the charcoal producing process. The carbonisation process should happen naturally. The increased temperature in the kiln will no longer come from the burning of the wood fuel but will instead come from the heat transfer that will start to burn the raw materials in the kiln. There are three different steps in the carbonisation process, these are carbonisation cellulose, carbonisation hemi cellulose and carbonisation lignin. During this carbonisation process, the charcoal producer will usually retain the smoke for the process of collecting wood vinegar. During the carbonisation process the temperature in the kiln will naturally reach temperatures between 80 to 100 degrees Celsius for around 20 hours.
4. Finishing process, all production of high quality charcoal requires a finishing stage. This step is carried out once the carbonisation step has been completed. The aim of this finishing step is to increase the temperature within the kiln to as high as possible so as to remove all the gas and tar content form the charcoal. This process also helps to completely bake all the parts of the charcoal that may not have been fully baked. This finishing step takes around 3 hours but if the step is carried out for too long the charcoal can burn into ash.
5. Cooling stage, After the finishing stage the kiln is completely sealed to prevent air entering having the effect that the fire will eventually pitter out. the waiting time to remove the charcoal from the kiln is what is known as the cooling stage. This cooling process lasts between 2-3 days depending upon the type of kiln used.

## Removal of Charcoal

After the cooling process has finished the charcoal producer can now open the kiln and remove the charcoal. The method for removing charcoal depends highly upon both the type of kiln and the type of charcoal produced. For example; charcoal produced in a drum kiln is easier to remove than charcoal produced in an Iwate kiln. To remove the charcoal from an Iwate kiln the charcoal producer must actually enter the kiln in a crouched position, as the kiln is small. When this operation is carried out the interior of these kilns still hot.

Another thing to be aware of is the risk of fire. There is always a possibility that charcoal removed from the kiln still contains some live embers. Because of this when the charcoal comes in contact with air/oxygen it may well re-ignite, so it is therefore best to avoid placing newly produced charcoal close to homes. Beside avoiding the risk of fire also try to store the charcoal in a dry place that will not be effected by rain as this will effect the quality of the charcoal.

## Why Charcoal

Generally speaking charcoal is used to meet burning energy (fire) needs. Charcoal as an alternative fuel has a number of advantages over other biomass fuels that have not been converted to charcoal. The advantages of charcoal as a fuel can be seen as:

1. Raw materials for charcoal are available in surrounding environment (especially in rural areas)
2. Technique for producing charcoal can be easily learnt, especially for very simple production techniques.
3. The cost of charcoal is still relatively cheap compared to other fuels such as gas, diesel or kerosene.
4. The amount of charcoal required is relatively low compared to other biomass fuels that have not been converted to charcoal.
5. Burning charcoal embers do not produce smoke.
6. Charcoal that has been produced using the finishing technique, no longer contains gases that can cause stinging eyes or are dangerous to health.

7. Heat energy produced by charcoal is healthier especially for cooking (food cooked using charcoal has a more pleasant aroma)

## Other Uses for Charcoal

Besides its usual use as a fuel charcoal has been developed for use in other sectors such as farming, plantations, forestry, animal husbandry, waste treatment and the mineralisation of rain water. In a number of regions charcoal is also being used to help to repair the environment. These other uses relate to the fact that charcoal contains many pores which, hold and release air/oxygen into the ground soil. Besides this charcoal can also can trap harmful gases or poisons, condition farming land for planting, stimulate the growth of both micro organisms and plant roots in the ground, helps with the process of metabolic growth in livestock and also maintain the health condition of livestock during the change in seasons from wet to dry or visa versa.

A positive aspect of these numerous uses for charcoal is the fact that the price of charcoal should remain competitive in comparison to other fuels. Another aspect is that the need for charcoal should continue to increase as long as there are the raw materials available to produce it. One worrying factor is that the push to produce charcoal is already to high and there is not enough development in the cultivation of raw materials which in turn could lead to the degradation of forest areas. Because of this it is recommended that there should be a push to produce charcoal from waste such as farming, plantation and forestry waste materials. For regions that still have large areas of land, it is recommended that the cultivation of raw materials would be an astute move.

## Close

What has been expressed above is formed from the experiences of the writer in developing charcoal as an alternative fuel. In daily experiences the use of charcoal in the farming, plantation, animal husbandry and forestry sectors is far more developed as this has a direct link to the environment and crop production. Communities that live close to forest areas are yet to see the importance of charcoal as an alternative fuel, this is because within their own area there is still an abundance of biomass that can be used directly as fuel.

From experience gained it can be said that the use of charcoal as a cook fuel will become more effective with the development of appropriate cookstoves. In conclusion the use of charcoal can not stand alone without the technical development of other appropriate technologies at the same time. glow

# The Blue Flame Revolution

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*Abstract*

*Indoor air pollution, caused mainly by wood-burning traditional cookstoves, kills an estimated 500,000 women and children annually in rural India. Kerosene and LPG burn cleanly but they are costly and non-renewable. Biogas is non-polluting, renewable, cheap and CO2-neutral. But the present, cattle dung based technology, apart from being useful only to families owning at least 6 to 8 heads of cattle, is not user-friendly. Its 2000 litre fermenter is bulky and costly (US$250). Filling daily 100 litres dung slurry into the fermenter and disposing of daily 100 litres effluent is arduous and bothersome. The author has developed an innovative 400 litre domestic fermenter, costing only US$30. It requires daily just 1kg starchy or sugary feedstock (e.g. damaged seed, spoilt tubers, oilcake of non-edible oilseeds, leftover food, tree seeds, spoilt fruits, etc.) and it produces only 1 to 5 litres effluent. This technology, which can be used by any rural or urban family, would also create new rural enterprises, based on producing feedstock from locally available starchy waste for the domestic biogas fermenter. Dissemination of the this fermenter in rural India would save trees, reduce indoor air pollution, and improve the health of rural housewives and children.*

## Introduction

According to an estimate by the World Health Organisation, about 3 million people in the world die every year as a consequence of exposure to suspended particulate matter in the outdoor or indoor air, and that 85% of the deaths are due to indoor air pollution (Schwela, 2002). Considering India's share in the world population, the number of estimated deaths due to indoor air pollution in India comes to about 500,000. Although acute respiratory infection is the single largest category of deaths in children under 5 years of age (Smith & Mehta, 2000), indoor air pollution remains a neglected topic in India, because the number of persons killed annually by polluted water is much higher than that killed by polluted air. It must however be emphasised, that while polluted water can be made potable by filtration, chlorination, boiling, reverse osmosis, distillation, etc. there is no simple treatment to purify polluted air before breathing it in. It is therefore necessary to reduce the pollutant load in the air at the source itself.

Indoor air in rural households gets polluted mainly by emissions from traditional cookstoves, operated in poorly ventilated kitchens. The fuel used in these stoves consists of wood, agricultural waste and dung cakes. It does not burn cleanly.While burning, it always releases large quantities of volatile organic compounds, collectively termed as tar. The yellow colour of the flames is caused by the burning organic volatiles, which do not burn completely. As the flames rise, the unburnt volatiles cool and condense to form particles of tar, which, together with unburnt particles of carbon, form the pollutant fraction called suspended particulate matter (SPM). Carbon monoxide (CO) is another pollutant that is often produced by burning biomass, but studies conducted in 2002 by Appropriate Rural Technology Institute, Pune (India), showed that CO was not a major pollutant in the case of biomass burning cookstoves. The CO concentration was relatively high only during the first 10 to 15 minutes of lighting the stove. Once the fire got going strongly, the CO level in the kitchen atmosphere came down, but that of SPM remained high throughout the period of cooking and also for several hours afterwards. The SPM causes not only temporary discomfort like smarting of eyes, but also serious chronic diseases like trachoma and cataract of eyes, and diseases of the respiratory system, such as cough, asthma, bronchitis, emphysema and cancer.

In 1984, the Government of India launched a programme called the National Programme on Improved Cookstoves. Under this programme, rural households were supplied with improved chulhas (biomass burning cookstoves). These improved cookstoves not only burned biomass more efficiently, but they also led the smoke and flue gases out of the kitchen with the help of a chimney. But for some reason or other, the rural housewives were not convinced of the benefits of the improved chulhas, and because this programme failed to make a significant impact, it was terminated in the year 2002. Among factors suggested as being the cause for failure of this programme, were apathy on the part of the implementing agencies, emphasis on fulfilling the targets rather than on satisfying the needs of the users, emphasis on subsidies instead of on commercialisation, etc. The author however feels, that the housewives no longer wanted to use unprocessed biomass as domestic fuel and that they aspired for cleaner and more user-friendly fuels.

## The Problem

One of the pointers towards this aspiration of the housewives was the spread of liquified petroleum gas (LPG) throughout India without any promotional effort. LPG burns with a blue flame. It does not produce any smoke or soot, and it allows finger-tip control of the flame intensity, including instantaneous ignition and extinction. The high degree of acceptance of LPG was mainly due to its user-friendliness and because it offered housewives freedom from smoke and soot. In the early days of LPG, there were complaints that cooking systems based on LPG were not suitable for cooking some of the ethnic foods, but the convenience of using LPG far outweighed this negative aspect. Instead of giving up LPG, housewives readily gave up their traditional ways of cooking and traditional utensils in favour of those that were LPG-compatible.

In an Editorial to the Journal "Science", Kirk Smith (2002) has strongly argued in favour of LPG. According to him, use of LPG by additional 2 billion people in the developing world, who currently used biomass as domestic fuel, would add less than 2% to the global greenhouse gas. He has argued further that this increase could be entirely offset, if the automobiles in the world were to increase their efficiency by just 0.5% per year over the next ten years.

The above suggestion is very attractive, but the practical difficulty in its implementation is that the investment cost of LPG based cooking systems, about Rs.5000 (US$ 100) per unit, and the cost of LPG itself, Rs.20 (40 US Cents) per kg, are high by Indian rural standards. The cost of LPG is likely to increase in future. In addition, LPG must be transported, in cylinders, from a central processing factory to each and every rural household. The logistics, the difficulty of maintaining an efficient supply network, and the cost of transport, would make it impossible to supply every rural household in India with LPG.

Biogas is the renewable and carbondioxide neutral alternative to LPG. It too produces a blue flame, and offers finger-tip control of the flame intensity. It is cheaper than LPG, because it is produced locally from local raw material. But in spite of the technology having been in existence for more than 50 years, it failed to find wide acceptance in India, because of some serious drawbacks. The basic flaw in the present system is that it uses cattle dung, the nondigestible end-product of the process of digestion of animals. Since the bacteria used in the biogas fermenter are the same as those normally found in the alimentary canal of animals, it is obvious that they cannot easily digest dung. As a result, the rate of methane production per unit of dung is very low and the reaction time is very long, requiring very bulky and costly biogas plants, which are basically unsuitable for domestic use. The present domestic biogas system for a family of 6 to 8 persons requires daily 40 to 50 kg dung (from about 6 to 8 heads of cattle) and because it takes several weeks for the dung to get converted into methane, the present domestic biogas systems are huge. The smallest domestic unit consists of a 2000 litre fermenter and a 200 litre sump for collecting the effluent slurry. The system costs about Rs.12,000 (US$240), which is too high for a rural Indian family. Because of its large size, it cannot be placed in the kitchen, and in villages, where the houses are clustered close together, even the space outside the house is often not enough for accommodating a biogas plant of these dimensions. Underground installation of the biogas plant is generally not feasible in peninsular India, because of the presence of hard rock about a meter below the ground level. Mixing daily 40 to 50 kg of cattle dung with an equal quantity of water, pouring the slurry into the fermenter, and disposing of daily about 80 to 100 litres of effluent slurry, are considered bothersome by users of this system.

Owing to these factors, the present biogas technology remains restricted to households that not only possess the requisite number of cattle, but that also have sufficient space in or near the house to install the fermenter and enough money to pay its price. At the present moment, the number of households using biogas as domestic fuel is therefore even smaller than that using improved cookstoves.

## The Solution

The Author has developed and successfully tested a domestic biogas fermenter that is much more user-friendly than the one described above. Instead of using cattle dung, the new fermenter uses material containing starch or sugar. 1 kg of starchy or sugary biomass can produce about 800 litres of biogas, which is enough for cooking a day's meals for a family of 5 to 6. The new system consists of a cylindrical fermenter having a diameter of 60 cm, height of 170 cm, and a total internal volume of about 400 litres. The reaction time for converting starchy or sugary biomass into methane is about six hours. Because of its small size, the system can be easily acommodated inside the kitchen. It generates daily from 1 to 5 litres of effluent, which does not pose any problem of disposal. The prototype fermenter, in continuous operation for a year, has been successfully tested with various feedstocks such as flour collected from the floor of a flour mill, sugarcane juice, macerated sugarcane, left over food, flour of non-edible seeds and powdered oilcake of non-edible oilseeds.

The technology is now ready for transfer to potential users. A mass-produced fermenter would cost about Rs.1,500 (US$ 30), which is about half of the cost of a domestic LPG system and almost one eighth that of a biogas fermenter using cattle dung. It is planned to replace the smokey and sooty yellow flames in the rural kitchens by the blue flames of biogas, ushering into rural India, the blue flame revolution.

## Novelty of the Technology, Its Drawbacks and Advantages

Biomethanation is considered all the world over primarily as a means of treating organic wastes such as animal dung, human faeces, distillery effluents, paper factory waste, municipal solid waste, etc. The biogas generated in this process is considered as a useful by product. The author, having the production of biogas as his primary objective, searched for feedstocks that would produce the maximum amount of biogas. Waste products, such as animal faecaes, effluents from a paper factory, or distillery effluents, have low digestibility, and therefore, biogas systems based on them are always extremely bulky and basically unsuitable for domestic use. The concept of using starch, sugars or fats as a substrate for domestic biogas generation was novel. It led to the development of a compact and user-friendly domestic biogas system. Because it required a very small quantity of feedstock and also because of the shorter reaction time, the size of such a fermenter could be reduced to about 400 litres. A fermenter of this size can be easily acommodated inside the kitchen. The new biogas plant uses cattle dung only as a source of bacteria, but right from the first day, it uses exclusively starchy or sugary feedstock. The feedstock consists of ground or pulped starchy or sugary material that is mixed with water to form a slurry. It is converted into biogas within about 4 to 6 hours. Taking into consideration the small size of the fermenter, the feedstock is fed into the fermenter in three doses of about 300 g each. Fresh feedstock is added before the cooking starts, so that while the accumulated gas is being used for the current cooking operation, new gas is already being generated for the next one. The total daily requirement of starch or sugar is about 1 kg. The amount of feedstock to be introduced at a time into the fermenter should be adjusted to replenish the gas used up in that particular cooking operation. It must be kept in mind, that this fermenter cannot accommodate more than 200 litres of gas. Introduction of fresh feedstock slurry into the fermenter forces a corresponding amount of spent material out of the fermenter, which drops into a bucket kept below the outlet duct. The total quantity of effluent produced by this fermenter does not exceed 5 litres per day. It contains all the minerals in the original feedstock, so that it can be used as manure for potted plants or in the kitchen garden.

There can be two objections to this technology. The first of them could be that products meant for consumption by humans or animals would get diverted to methane production. The answer to this objection is that this technology would be using waste material, like spoiled grain, spoiled rhizomes and tubers, starchy crop residues like rhizomes of banana, roots of buffalo gourd, nonedible seed of various tree species (Tamarindus indicus, Syzygium cumini, Leucaena leucocephala, Sesbania spp, Pithecolobium dulce, mango kernels, etc.) non-edible rhizomes and tubers (e.g. arums, cannas, dioscoreas and nutgrass), rejected seed from seed processing plants, sweepings from the floor of a flour mill, misshapen and damaged fruits that cannot be sold, and leftover food. India also produces non-edible oil from the seed of about 10 species of trees, generating annually about 3.5 million tonnes of oilcake, that is currently used only as manure. This oilcake too can serve as feedstock for the new biogas fermenter. Farmers generally have at least some quantity of rain damaged and mouldy grain (cereals, legumes and oilseeds), that cannot be sold in the market. Similarly, weevil-infested and damaged grain can be procured cheaply from grain merchants. Because sugars can also serve as feedstock in this fermenter, non-edible wild fruits as well as spoiled, damaged, overripe or misshapen edible fruits (banana, papaya, pineapple, mango, guava, zapota, melons, tomato, etc.) can be used for biogas production in this fermenter.

The second objection could be that the new biogas technology would have to compete with traditional domestic fuels like dung cakes and agrowaste, which are available to the villagers free of cost. One of the reasons for non-adoption of processed fuels like kerosene or LPG by rural households is the fact that agrowaste is available to them free of cost, whereas the processed fuels have to be purchased. To answer this objection, it is emphasised, that most of the items mentioned as potential feedstock for the new biogas technology are easily accessible to rural inhabitants. Most rural families would be able to lay their hands on at least some quantity of non-edible starchy or sugary material without having to pay for it. If they were to experience a shortage of such material, they can grow crops that would supply their households with the requisite amount of starchy or sugary material. It is only a matter of a few hundred kilograms of material per family. The author has developed a nutrient flow system consisting of sand filled channels, in which rhizomes and tubers can be grown by using domestic waste water. As stated above, the starchy or sugary material needed for the new biogas plant would be mostly free of cost, but even if some of it has to be purchased by the users, bviogas produced from them would still be much cheaper than kerosene or LPG. Identifying local sources of starchy or sugary waste biomass and processing (mainly drying and powdering) it to produce feedstock for the new biogas system, can offer self-employment to a large number of rural inhabitants.

The negative points mentioned above are however of a hypothetical nature. They are offset by a number of positive points. Biogas is a renewable and carbondioxide neutral fuel. Its widespread use would save trees, reduce indoor air pollution and improve the health of rural women and children. The Author places his confidence in the success of the new biogas technology on its user-friendliness and covenience of use, the very two characteristics that made LPG popular among the urban Indian housewives. The new technology would replace the smokey and sooty yellow flames in the rural kitchens by the blue flames of biogas, and it would also support new rural enterprises producing feedstock from locally available starchy waste. glow

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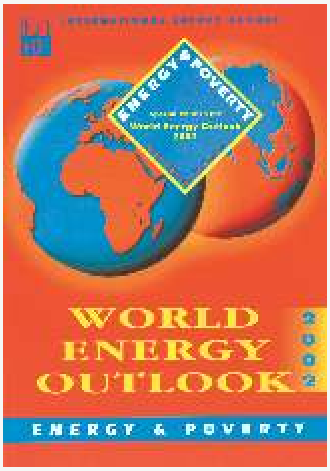
# RESOURCES




## World Energy Outlook

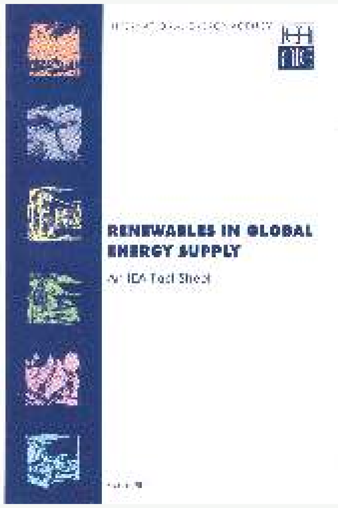
“Energy and Poverty” is a Chapter 13 of the International Energy Agency's World Energy Outlook 2002 to be released at the Ministerial Meeting of the Consumer-Producer Dialogue (International Energy Forum) in Osaka, Japan on 21 September. Since energy poverty is a key topic at the World Summit on Sustainable Development meeting in Johannesburg, IEA Member countries decided to make this study available in advance.

The chapter includes new, country-by-country data on electrification rates worldwide and provides regional projections to 2030. It also includes estimates on the use of traditional biomass energy sources in developing countries over the same period. The chapter sets out a quatitative framework for poverty alleviation strategies.

## Renewables in Global Energy Supply

An IEA Fact Sheet

Renewables were at the center of the energy discussion at the World Summit on Sustainable Development in Johanesburg in the year 2002. Differences in definition and lack of adequate data compilated the discussion between participants on this key issue. The International Energy Agency believes that this fact sheet can be of the use to all in order to facilitate the debate on the past, current and future place and role of renewables in total energy supply.
This pamphlet presents as objectively as possible the main elements of the current renewables energy situation. The definitions and coverage of national statistics vary between countries and organizations. In this leaflet, we define renewables to include combustible renewables and waste (CRW), hydro, geothermal, solar, wind, tide, wave energy.




## The Brilliance of Bioenergy in Business and in Practice

Ralph E H Sims

The time for modern biomass has come. The increasing abundance of well-designed, successful bioenergy projects around the world is creating new interest in this renewable, sustainable and low emission-producing source of energy.

*The Brilliance of Bioenergy* covers all the main resources and technologies, principles, practice, social and environmental issues as well as the economics involved.