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Workshop on Ethanol as an Alternative Source of Fuels

Jakarta, Indonesia

January 14-21, 1981

Jointly sponsored by

Agency for Development and Application of Technology (BPPT)
Government of the Republic of Indonesia

and

Board on Science and Technology for International Development
Commission on International Relations

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National Research Council
United States of America

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This is a staff-prepared summary of the Workshop on Ethanol as an Alternative Source of Fuels, held in Jakarta, Indonesia, January 14-21, 1981, under joint sponsorship of the Agency for Development and Application of Technology (BPPT), Government of the Republic of Indonesia, and the National Research Council (NRC) of the United States. Participation by the NRC was made possible through funds provided by the U.S. Agency for International Development Jakarta under contract AID 497-79-100.23.

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

PREFACE

The Workshop on Ethanol as an Alternative Source of Fuels, held in Jakarta, Indonesia, January 14-21, 1981, reviewed Indonesian government plans for a rural pilot plant to produce alcohol fuel from root crops. Workshop participants included scientists, engineers, economists, and administrators.

Indonesia's Agency for Development and Application of Technology (BPPT), the Indonesian sponsoring organization, invited the Board on Science and Technology for International Development (BOSTID) to jointly sponsor the meeting and provide a counterpart group of specialists. BOSTID participation was made possible through a 3-year cooperative project sponsored by a science and technology loan program from the U.S. Agency for International Development (AID) to the Government of Indonesia. The project calls for 2-3 annual activities such as workshops or provision of small advisory groups.

This report was prepared by BOSTID staff and was reviewed by the chairman of the BOSTID participants and the chairman of the Indonesian workshop organizing committee.

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INTRODUCTION

BACKGROUND

Indonesia's Ministry of Research and Technology has asked the Agency for Development and Application of Technology (Badan Pangkajian dan Penarapan Teknologi, or BPPT) to develop a pilot plant for the production of alcohol fuel. This project is related to a broad energy strategy that has been formulated in Indonesia.

Although Indonesia is an oil exporter and a member of the Organization of Petroleum-Exporting Countries (OPEC), it is, nevertheless, a large, populous country that requires a great deal of capital to finance its economic and social development. As a result, the Indonesian government is seeking to diversify its domestic energy sources as much as possible to sustain maximum oil exports. The national energy policies stated in the current 5-year plan (REPELITA III) amplify these objectives:

a. To guarantee a continuous energy supply which meets national demands in both quality and quantity, at a reasonable price, to generate a well-distributed increase in the standard of living of the Indonesian people and the achievement of a high economic growth rate.

b. To guarantee that, apart from fulfilling national needs, the energy supply also provides export commodities in order to support the balance of payments.

c. To guarantee that the development of energy resources is accompanied by an efficient and wise management of a life support environment structure in order to achieve a better quality of life for the Indonesian people.

d. To make every effort to ensure that the overall supply and management of energy resources increases the capability and strength of the Indonesian people to face the future.

In discussing steps to be taken in achieving national energy objectives, the development plan specifically recommends that there should be "a reduction in the domestic utilization of crude oil and the promotion of crude oil as a prime export commodity through an extensive diversification program that increases the utilization of other energy resources."

Indonesia's population is predominantly rural but is heavily concentrated on a few islands such as Java and Bali. For this reason, the government established a "transmigration" program to provide land on less densely settled islands such as Sumatra and Borneo to settlers who are willing to emigrate from crowded areas. However, the cost of the energy necessary to provide an infrastructure and develop new agricultural lands in the outlying islands is high because of transportation costs from the major commercial centers.

Indonesian scientists and planners considering alternative energy sources and the needs of rural development have found the use of biomass resources of particular interest. Indonesia is a tropical country with high rainfall and abundant biomass, including natural vegetation, crops, and crop residues. A variety of projects are now investigating how these resources might be used in providing energy.

ALCOHOL PRODUCTION TECHNOLOGIES

Among the biomass energy alternatives under consideration is the production of alcohol from root crops. The technologies for producing alcohol through yeast fermentation of sugar are well known and adaptable to various levels of production and complexity. For root crops, the process essentially involves cleaning and pulverizing the feedstock, cooking the starch and perhaps using liquefaction enzymes to break down the long starch chains, converting starch to sugar with a saccharification enzyme, and fermenting the sugar to produce ethanol.

Root crops have interesting possibilities for ethanol production in Indonesia. Indonesian farmers are experienced in growing crops such as sweet potato and cassava that do well in many of the areas where transmigration or other rural development projects are located; however, there are often major problems in marketing cassava and sweet potatoes in these areas. Sugar cane is also a good crop for alcohol production, of course, but is not generally grown by small farmers in Indonesia. Morever, Indonesia currently imports sugar to meet its domestic needs.

A good deal of experience has been amassed in the use of ethanol as a fuel for internal combustion engines, particularly in Brazil and the United States. With modifications, spark ignition-type engines can operate entirely on alcohol fuel. However, mixing ethanol (at least 190 proof) with gasoline has become a more widely used practice; mixtures of up to 20 percent alcohol with gasoline have been used, and experience indicates that most automobiles run without carburetor adjustment on mixtures of 10 percent ethanol (provided the alcohol remains well above 190 proof). Ethanol can also be mixed with diesel fuel, although the technical factors are somewhat more complex. Thus it is technically feasible to use alcohol as fuel for automobiles, trucks, motorcycles, agricultural implements, generators, pumps, and other rural uses involving internal combustion engines. With appropriate modifications for safety, alcohol might also be used for cooking and lighting.

The production of ethanol from sugar or starch crops can be adapted to rural conditions. Indigenous fuels or perhaps even solar energy can be used for cooking and distillation. Some parts of the processing plant can be simplified or can be made using indigenous materials, and certain stages of processing can be changed--settling tanks and filter presses can replace use of a centrifuge, for example.

In relation to national energy strategy and rural development needs, Indonesian officials have developed a concept of building ethanol plants in transmigration areas with populations of 4,000-5,000 families. The ethanol produced by these plants would be used locally for a variety of agricultural and transportation needs or for domestic purposes. Annual production for such plants might be on the order of 10 million liters, based on growing of sweet potatoes or cassava on the quarter-hectare garden plot provided each family. This concept of small-scale alcohol production is aimed not only at energy diversification but also at the need to increase rural incomes by providing extra jobs and additional markets for farm products.

PILOT ETHANOL PLANT

The Minister of State for Research and Technology has established a National Alcohol Committee to examine the broad implications of alcohol fuel production, and has decided to build a pilot ethanol plant suitable for alcohol production in rural areas, thus providing Indonesia with technical and operational experience. The pilot project will be located in a transmigration area at Tulang Bawang in Lampung province, southern Sumatra. Using sweet potato and cassava as feedstock, the plant will be designed for an annual production capacity of 5 million liters of ethanol.

The BPPT, an Indonesian government agency chaired by the Minister of State for Research and Technology, is responsible for designing, constructing, and operating the 5 million liter per year pilot plant to be built with Indonesian funds. Some initial design assistance was provided by a German firm, but the BPPT is drawing on the experience of other countries as well. Because a mechanism existed that permits BOSTID and Indonesia to cooperate on science and technology, and because of the considerable U.S. experience with ethanol plants (mainly using grain as the feedstock), a workshop was planned to review the ethanol pilot plant project and to suggest ways in which it might be strengthened.

The review of plans for the pilot plant project was intended to be broad in scope. BPPT had already collected much information and staff members had visited ethanol projects in several countries. The workshop provided an exceptional opportunity, however, to bring together the BPPT staff and members of the National Alcohol Team and representatives of other ministries and agencies that have an interest in the project or play some role in its implementation. Participation by the BOSTID group was intended not only to provide an exchange of experience but also to inject the perspective of outside views into the discussions.

A number of complex, varied issues have implications for the pilot plant project. Naturally, the production capacity of the plant has implications for design and construction, but it is not a figure that can be arrived at arbitrarily. It depends upon a steady supply of feedstock, the ways the alcohol will be used, and the potential market for such uses. These uses of course, are inseparable from questions of agricultural practices, transport and marketing of crops, maintenance and repair of plant equipment, possible modification of machinery and equipment that uses the fuel, pricing policies of food and petroleum fuels, and other equally important issues.

The staff members of the BPPT concerned with the pilot plant project are fully aware of the complexity of the issues concerned and are anxious to make a careful examination of the nontechnological as well as the technological questions. The Indonesian participants in the workshop reflected this awareness, and expressed interest in possible workshop follow-up which is described in the next section.

Given the formidable social and economic questions involved, and lack of experience with the specific technical problems, it would be relatively easy for the Indonesians to defer their own examination of the potential for production and use of alcohol fuels. The Minister of State for Research and Technology and the staff of the BPPT believe, however, that they must seize the opportunity to develop first-hand experience, strengthen their capability to analyze the

relevant multidisciplinary problems, and adapt experience and information from a wide variety of sources to the particular conditions and opportunities in Indonesia.

Over time, the possibility of establishing a second pilot plant has arisen from financial assistance provided by the Japanese government. In addition, the U.S. Agency for International Development is supporting a program in Indonesia to investigate a variety of alternative energy technologies, and a small, laboratory-scale plant using sago as feedstock is planned for the program.

Procurement related to construction of the first pilot plant at Tulang Bawang is scheduled to begin in April 1981 with the goal of beginning ethanol production at the end of 1982.

FOLLOW-UP TO THE WORKSHOP

The National Alcohol Committee's report on the potential for alcohol fuel production in Indonesia, due by the end of 1981, will address some important issues related to policy matters such as alcohol price subsidies, economic issues related to the agricultural production of feedstock, and marketing issues. The BPPT staff working with the national committee feel they would benefit from assistance in analyzing these complex issues, particularly in designing studies and determining the kinds of information required.

In discussing Indonesia's ongoing activities with the alcohol project, BOSTID staff and the USAID/Indonesia Science and Technology Advisor William Littlewood agreed with BPPT that BOSTID would help identify two advisors to help with the planning and analysis of economic and marketing issues for the national committee study. One advisor will make an initial visit to Indonesia in late May 1981 for a planning session. Both advisors will make a second visit in August or September to help review work in progress, and will make a third and final visit toward the end of 1981. It should be emphasized that the advisors will serve as resource persons and that the conclusions of the report will be entirely the responsibility of the National Alcohol Committee.

The workshop may also contribute to another activity in BOSTID's cooperative program with Indonesia. In 1979, a Workshop on

Technologies for Increasing Rural Productivity was held with two primary objectives:

1 To raise agricultural productivity to the level at which a small percentage of families can provide enough food and other agricultural products for themselves and for large numbers of nonfarming families at a higher level of per capita consumption than now prevails.

2 To generate enough improvement in support of higher agricultural productivity and in other projects to absorb the families not directly engaged in agricultural production.

It has been agreed that a follow-up workshop will focus on specific projects that can be implemented in selected villages as a means of assessing their feasibility and suitability in achieving the two broad objectives. An Indonesian workshop committee has now identified three villages in which pilot projects might be conducted, and discussions are under way concerning plans for the second workshop which would outline specific projects and suggest a plan of implementation. The pilot ethanol plant project should be an important complement to this effort.

OPENING ADDRESSES

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Wardiman Djojonegoro, Chairman
Workshop Organizing Committee

Assistant (Planning) to the Minister of State
for Research and Technology
Republic of Indonesia

On behalf of the Organizing Committee, I would like to welcome you to the Workshop on Ethanol as an Alternative Source of Fuels.

On December 11, 1978, an agreement between the governments of the United States of America and the Republic of Indonesia to cooperate in the field of science and technology development was signed by representatives of both countries. This workshop not only helps to realize the science and technology cooperation agreement, but also continues more than a decade of cooperation with the American scientific community through the National Academy of Sciences (NAS). The workshop topic selected is considered important by both Indonesia and the United States. On the occasion of Minister Habibie's visit to the United States, it was decided to hold the workshop in the framework of scientific cooperation.

Today we are very happy that this workshop can take place in Jakarta and will open shortly. We are thankful to the American government, especially for the support provided by the U.S. Agency for International Development to the National Academy of Sciences, the foremost private scientific organization in the United States; to the BPP Teknologi; and to Minister Habibie for his full sponsorship and support.

This workshop is organized by the Agency for Development and Application of Technology (BPP Teknologi). It will address (1) problems that should be solved as soon as possible to realize the

introduction of ethanol as an alternative fuel in Indonesia; (2) studies that should be undertaken to facilitate expansion of supply and demand capacities; and (3) administrative efforts needed to support the alcohol program. The topic will be scrutinized from four points of view: (1) agriculture and agronomy, (2) technology and engineering, (3) economy, and (4) transmigration and social impacts.

The workshop's program will also include study-tours to the transmigration site in Lampung where the first pilot plant will be built, and to small sweet potato farms in Kuningan, West Java, where small farmers have succeeded in raising sweet potato with an average yield of 20 tons per hectare.

This workshop is part of a national effort by the Indonesian government to stimulate the use of ethanol as a fuel in conjunction with the national energy policy aimed at diversifying energy sources. The objectives of the workshop are:

- To provide a forum for exchange of knowledge and experience between scientists of both countries regarding studies and experiments on the sources of production and use of alcohol as an alternative fuel and on energy farming to produce ethanol in transmigration areas from agricultural products, especially sweet potato

- To assess the relevance of suggested approaches to individual and institutional needs and problems

- To assess studies related to the possibilities for ethanol production in Indonesia

The Indonesian participants in this workshop, who total more than 40, are from the National Team on Alcohol, recently appointed by the Minister. This team consists of persons from various departments, universities, and scientific institutions. The eight participants from the NAS, coordinated by John Hurley, are from different universities, institutions, and companies. Particularly to this group of experts who are donating their time to the workshop, I would like to extend a hearty welcome to Indonesia.

Elmer L. Gaden, Jr., Chairman
BOSTID Participants

Department of Chemical Engineering
University of Virginia
United States of America

It is both a privilege and an honor for me and my colleagues from the United States to visit your country and to examine with you the very vital question of alcohol as a potential fuel.

It is a credit to the foresight and good sense of the Government of the Republic of Indonesia, and especially its technical community, that rather than resting in your favorable position as a major petroleum producer, you are looking at alternatives to petroleum, which will not be as readily available in the future.

Our task at this workshop is to work with you in every sense. We will offer you the benefit of our experience where we can, but, we will also learn from you. I note that the structure of your ethanol fuel program gives the concern for social impacts equal place with the more obvious questions of agronomy, technology, and economics. More and more Americans are coming to recognize that technological developments that fail to meet the deeper needs of society are inherently flawed and unlikely to survive in the long term. It is in this area that we especially seek exposure to your knowledge, wisdom, and patience.

I want to thank you for all you have done to make us welcome and all that I know you will do to make our visit productive and satisfying.

Edward E. Masters

U.S. Ambassador to the Republic of Indonesia

It is a great pleasure to participate in the inauguration of this very important bilateral activity involving participants from Indonesia and the United States.

The subject of alternative sources of energy--in this particular case ethanol--is one that is of great importance to all of us, and Indonesia is certainly to be commended for its foresight and initiative, in particular under Dr. Habibie's leadership, in moving ahead so aggressively in finding alternative sources despite its own favorable energy situation.

This is actually the sixth workshop that has been held involving the U.S. National Academy of Sciences. Workshops have covered such fields as food and nutrition, industrial research, natural resources, technology for rural development, and now this very crucial field of alternative fuel resources. This workshop brings together some of the very best people in the technical fields, the university sector, government, and private industry from the United States to discuss with their Indonesian counterparts matters in which we have a mutual and a very important interest. This continues the tradition of cooperation between our two countries which goes back a long way and which both have found mutually beneficial.

We are very pleased at this cooperation. We are also very happy that the science and technology agreement, signed during Dr. Habibie's visit to Washington in December 1978, is being implemented so effectively and aggressively by both sides. This agreement is not just a piece of paper, but is a living document that is being put into effect for the mutual benefit of the people and the government of both of our countries.

The subject that you are to consider is of great importance. I certainly wish you well, and I hope that this is a very successful conference and that there is continued follow-up and cooperation between our two governments and between scientists in both countries.

B.J. Habibie

Minister of State for Research and Technology
Head, Agency for the Development and Application of Technology
Republic of Indonesia

I am honored to have the opportunity to open this workshop and address you about Indonesia's ethanol project. Ethanol has attracted the interest of many countries, including Indonesia.

During the next few days, we will conduct very open, informal discussions on problems concerning the development of ethanol in Indonesia. Although this workshop with its limited time cannot provide a comprehensive analysis of all the problems, a deeper insight will likely result that will benefit all of us.

For my Indonesian scientist colleagues, I hope this workshop will stimulate further research and development on ethanol, in such areas as improving the sugar content of raw materials, using other raw materials instead of sweet potato or cassava, and assessing economic, social, and cultural impacts. This workshop will also expand the capabilities of our personnel in this area as a result of the exchange of knowledge and experience.

For my fellow scientists from either America (NAS) or other countries, this workshop will provide an overall description of Indonesia's ethanol problems, in particular the situation and condition of the future sites (transmigration areas) of the ethanol plants. This information will enable you to support us in analyzing the prospects for ethanol in this country and to share more of your experience and R&D results with us and our guests from other countries. Informal and open discussions, combined with field trips to potential sites for ethanol production will facilitate closer personal contacts between us.

As you know, the Indonesian Government is presently embarked on a transmigration program aimed at dispersing the congested population of Java to the less-populated islands, and increasing and equalizing the prosperity of the people. In other words, transmigration is one way to increase the quality of life and the welfare of the Indonesian people by participating in int grated national development.

Transmigrants receive money from the government to start their new lives, and it is hoped that after a year, they begin to improve their standard of living. If this is not the case, then we have only transferred poverty from Java to the outer islands; this must not happen.

Because most of the transmigration areas are in remote and isolated locations, transmigrants have difficulty selling their agricultural products, which are generally not saleable in the surrounding districts, because nearly all families cultivate the same crops. Selling agricultural products to other villages or cities requires money for transportation, which is, of course, impossible for them. The only remaining solution is to sell through a jobber, resulting in a very low price for the products, although this is better than letting the crops spoil.

By locating simple ethanol plants in transmigration areas, farmers could sell their products at a reasonable price either as fuel or as raw material to the plants through the Rural Cooperation Unit (KUD). This would increase farmers' incomes and mean better income distribution, and would create new job opportunities in the area.

INDONESIA AS AN OIL-EXPORTING COUNTRY

As you are all aware, a recent OPEC meeting resulted in another increase in the price of oil. It is assumed that the price will continue to increase.

Indonesia, with an economic growth of 6-7 percent a year and a population growth of about 2.3 percent a year, requires substantial funds to finance its national development programs. Over the past few years, most of this money has come from crude oil export earnings. To maintain this flow of funds, we must take steps toward stabilizing the domestic use of oil fuels through conservation, diversification, etc. If such steps are not taken immediately and domestic fuel oil consumption continues to increase rapidly, we may see Indonesia change from an oil-exporting to an oil-importing country. This must be prevented. Crude oil should be exported to

obtain funds needed to finance national development programs, and domestic fuel requirements should be fulfilled through diversification of energy resources, in particular the use of ethanol as an automotive fuel. Even ethanol could become an export commodity should it become abundant.

ENERGY FARMING

Indonesia is endowed with a tropical climate and vast areas of potential agricultural lands, ideal conditions for developing ethanol production through energy farming. In doing so, many problems will arise, however, and we must study every aspect of these problems. Through a team I recently formed, study and research will focus on four sectors most involved in the development of biomass ethanol production: (1) agriculture and agronomy, (2) technology and engineering, (3) economy and marketing, and (4) transmigration and social impacts.

From the agriculture/agronomy point of view, the problems encountered will concern the raw materials for ethanol production. In Indonesia, cassava and sweet potato are being considered in the first phase of the project. We must study these crops further. We know that cassava contains a cyanide acid in its outer layers that prevents attack by plant diseases. Sweet potato does not have this shield and is more easily infected. On the other hand, sweet potato can be harvested three times a year, but cassava only once. Studies must also be made of cultivation of these crops in order to increase their yields, and of the possibility of using other raw materials, such as wood, which are abundant in Indonesia.

From the technical and engineering points of view, we will study the techniques of ethanol production and of installation of ethanol plants in transmigration areas. Ethanol production techniques are well known, but we must adapt them to local conditions. For maximum efficiency, we will not simply buy or copy ethanol plants already established in other countries. Indonesia must be able to make her own plants, even though in the early stages, we will be working with other countries. We must think seriously about developing a standard plant model as we intend to establish small plants with capacities of about 5,000-10,000 kiloliters per year in many regions. Bigger plants would cause problems in transporting raw materials, especially if cellulose were used.

In addition to technical feasibility, is ethanol production economically feasible? If not, why, and what steps must be taken? We must find out what kind of economic impacts are justified. We

might conclude, for example, that while locating an ethanol plant in Java is not economically feasible because of the high distribution costs and the low price of oil fuels, an ethanol program might be more feasible in outer regions, especially transmigration areas.

Finally, the social impacts of an ethanol production program must be carefully considered. Technology should serve mankind, and this program, in particular, is conceived as a means of improving the lives of rural people. We must insure that it is carried out in a way that fits into their patterns of life and work in a positive and useful way.

This workshop, then, will help begin exploration of these important topics. The ethanol pilot plant to be established at a transmigration site will provide further information on the problems involved and build experience in solving these problems. We hope that the results of these efforts will expedite raising the quality of life of rural people and diversifying Indonesia's energy supply.

Mr. Chairman, ladies and gentlemen, let me reemphasize our gratitude that you are willing to share your knowledge and experience with us in this important task, and our pleasure at the opportunity to make new friendships. I trust that your deliberations will be fruitful, that our foreign friends will have a pleasant stay, and that the ideas raised at this meeting will play an important role in developing approaches to the application of technology to economic and social development in Indonesia.

PRESENTATIONS

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THE PROSPECTS FOR ETHANOL IN INDONESIA

Koeswandi Wasito
Agency for the Development and Application of Technology (BPPT)
Republic of Indonesia

Many countries are currently considering the use of renewable sources of energy as a substitute for fossil fuels. In this vein, Indonesia is studying the use of ethanol as an alternative to increasingly expensive fossil fuels, and as a tool for solving national development problems.

As an OPEC member and an oil-exporting country, Indonesia has not experienced an oil crisis. Crude oil exports are a source of government income and of foreign exchange income. Even now, oil supports almost 60 percent of the national development investments.

However, energy consumption is increasing rapidly. For 1979 alone, more than 80 percent of the energy consumed was in the form of crude oil. It is estimated that by the year 2000 Indonesia will remain an oil-exporting country only by properly managing the balance between demand and supply of oil.

One step taken by the government to achieve national energy targets is promoting the development of alternative energy resources, particularly renewable, through the use of new technologies that help increase oil exports, thereby increasing foreign exchange. In this regard, Indonesia is now undertaking a project that will utilize various crops easily grown in Indonesia (e.g., sweet potato and cassava) as feedstock for an ethanol plant. Through this program, it is hoped that some of Indonesia's urgent development problems can be improved.

ENERGY FARMING

Energy farming requires land, manpower, and technology. Indonesia's vast agricultural lands are ideal for the development of energy farming, along with development of its transmigration areas. Such approaches could help reduce the congested population in Java and encourage use of underutilized land in outer islands, as well as provide job opportunities, increase the standard of living of transmigrants and farmers, and promote development of supporting industries. Employment opportunities are a high government priority, since it is estimated that the labor force will grow from about 54.8 million in 1978 to about 61.3 million in 1983.

Developing an Ethanol Plant Through Energy Farming

The production of ethanol in Indonesia would have a number of advantages:

- Ethanol is environmentally clean; it can be blended with gasoline and used as a motor fuel, and it is easy to transport
- Ethanol can be produced from farm products as well as from hydrocarbon products
- Alcohol fermentation does not require sophisticated technology or substantial investment
- Alcohol production is considered to be fully in accord with Indonesia's current situation and goals

Many sectors, such as agriculture, transportation, industry, and commerce, are involved in implementation of an energy farming program. Thus planning and developing this program would require close coordination among these sectors and consideration of related manpower requirements.

Implementation will also involve solving transmigration problems. It is estimated that during the Third National Five-Year Plan (1979-1984), 500,000 persons will transmigrate to regions outside of Java. Approximately 250 housing areas for 2,000 persons each will have to be built to accommodate these transmigrants.

The construction of ethanol plants in these areas will motivate farmers to cultivate sweet potato or cassava, which can be sold to ethanol plants as feedstock. Thus farmers will have little

difficulty in selling their products nearby, which solves the transportation problem. This would also encourage transmigrants to cultivate the rest of their land with major food crops, such as rice or corn, which will fulfill their everyday requirements and supplement the national food supply. The impact of these activities on regions surrounding transmigration areas would also be considerable. In addition, ethanol production will promote new activities in the industrial sector, especially the development of alcohol-powered machines and vehicles, which will, in turn, provide employment opportunities related to services such as maintenance and repair.

POSITION OF ALCOHOL FUELS IN THE LONG-TERM FORECAST FOR ENERGY DEMAND AND SUPPLY IN INDONESIA

It is estimated that by the year 2000 Indonesia's per capita energy consumption will reach an equivalent of about 2.7 barrels of oil per year. Experts also estimate Indonesia's potential energy resources at 50 billion barrels of crude oil, 30,300 billion cubic feet of natural gas, 18 billion tons of coal, 31,000 megawatts (MW) of hydropower, and 8,000-10,000 MW of geothermal power, in addition to nuclear energy and vast resources of nonconventional energy.

In 1979, Indonesia's alcohol production was approximately 25,000 kiloliters (kl) per year (70 kl/day), low production when considering alcohol as an alternative energy source. A large amount of the alcohol produced is used in chemical solutions or medicines.

It is hoped that alcohol production in Indonesia will reach 30,000-60,000 kl/day, equal to one-third to one-fourth of the country's crude oil production. If alcohol production shows sufficient promise, plans might call for building a number of small-scale plants in rural areas with capacities of from 5,000 kl to 10,000 kl. Long-range goals in alcohol production could reach 20 million kl/year by the year 2000.

Along with undertaking alcohol production, the government must also initiate quality standards, establish distribution systems, develop and install the necessary technology, and review the energy taxation system. Otherwise, an effective demand will not be forthcoming nor will suppliers take a positive stance toward investment.

Alcohol could also become an important export commodity. For example, it is estimated that Japan will need 1 million kl of alcohol for use as fuel by 1985.

DEVELOPMENT OF AN ETHANOL PILOT PLANT

Current plans call for constructing an ethanol pilot plant with a capacity of 5,000 kl/yr (15,000 l/day) in the Tulang Bawang transmigration area, Lampung, Sumatra. This will be followed by 5- to 10-year studies of the agronomic, technical and engineering, economic and social/transmigration aspects of the program.

This plant is intended to serve as a model for plants to be built later in other areas, a training center for managers and technicians, and a research center for studies related to the development of biomass ethanol production.

The site selected for the pilot plant satisfied the following criteria:

- Presence of transportation network systems, especially roads
- Sufficient land to ensure continuous supplies of raw materials to the plant and sufficient number of farmers/transmigrants to cultivate crops and operate the plant
- Proximity to a Pertamina depot for more efficient fuel distribution
- Proximity to a harbor for easier exporting or domestic marketing
- Sufficient water for processing

An Indonesian team, with the help of the Salzgitter Industriebau Gmbh of West Germany, is now in the process of designing the pilot plant. This design must be simple, require a low capital investment, and be easily maintained. Indonesian industries will undertake manufacturing the equipment and other components required, which will, consequently, increase the skill and production volume of the local metals industry.

Cassava and sweet potato will serve as raw material for the pilot plant because:

- It is possible to produce these crops in barren land
- Unlike cane sugar, which requires an estate production system, these crops can be raised by independent small-scale producers

- Traditionally, these crops have been raised by the Indonesian people

- Adverse effects on food markets are expected to be minimum

In the future, emphasis will be given to using sweet potato as a raw material because of its advantages over cassava: (1) it has a shorter growing period than cassava, and thus can be harvested twice a year instead of once like cassava; (2) its yield per hectare is higher than that of cassava; and (3) sweet potato can be harvested mechanically. However, compared with cassava, the sweet potato is easily affected by plant diseases because it lacks cyanide acid in its outer layer.

Thirty thousand tons of sweet potato per year would be needed to supply a plant with a capacity of 5,000 kl/yr (15,000 l/day). This is based on the assumption that 1 liter of alcohol is equivalent to 6 kilograms (kg) of sweet potato. If sweet potato is harvested twice a year, each harvest with a production of 15 tons per hectare (ha), then 1,000 ha would be required to cultivate the above requirements. If a transmigrant only used a quarter hectare of his land to cultivate sweet potato, 4,000 farm families would be needed in the area where the pilot plant will be built. The rest of their lands can be used to cultivate other important crops, such as rice and corn.

Until the transmigration area can provide sweet potato for the ethanol plants, feedstock will have to be obtained from experimental farms.

Research and studies on the development of this pilot plant in particular and the project in general will be conducted by the National Alcohol Committee, recently formed by the Minister of State for Research and Technology and made up of individuals from various institutions and agencies. The team will study agronomic and production techniques and the economic and social impacts of ethanol production.

LONG-TERM PLANNING FOR ETHANOL PRODUCTION

Long-term plans for this program call for building future plants (5,000 kl/yr) in other transmigration areas that support at least 4,000 farm families. This calculation is based on estimates of fuel oil substitute requirements.

Research and studies are needed on the:

- Agronomy sector: problems connected with developing and managing energy farming and efforts to raise crop yields, including soil fertility, cultivation techniques, plant breeding, plant diseases, starch content, and other development efforts.

- Production sector: improving the energy balance, increasing efficiency by improving the production process, and solving technology transfer problems.

- Economic sector: the marketing system, including pricing and distribution; evaluation of energy farming; monopoly of selling alcohol; incentives for alcohol plants; potential of alcohol as a substitute fuel for diesel oil and kerosene.

- Transmigration/social sector: the social impact of the ethanol program on farmers/transmigrants and all of the Indonesian people; the most suitable types of energy farming and the development of energy farming or farm management in transmigration or surrounding areas.

Alcohol production technology will likely be transferred from developed countries by means of seminars; collaboration among scientists, engineers, foreign firms, and scientific institutions; technical assistance; student exchange; etc., all of which will accelerate development of Indonesia's alcohol industry.

Most development efforts will focus on:

- Developing a continuous fermentation technology to yield a higher alcohol concentration (up to 12 percent alcohol content instead of the 8-10 percent currently possible)

- Improving the energy efficiency of ethanol production through more efficient distillation and heat recovery designs, using engineering concepts proven commercially by other chemical industries

- Using agricultural wastes for feedstock and/or fuel purposes

- Developing alternative species of crops that will serve as sources of energy to reduce reliance on crude oil

THE ECONOMICS OF ETHANOL IN INDONESIA

H. Soetono
National Alcohol Committee

When compared to the consumption rates of coal, wood, water, and geothermal gas, Indonesia's rate of oil consumption is too high. Oil is almost the only source of energy used.

A national policy that includes energy conservation and diversification is necessary to develop other sources of energy in Indonesia. In this connection, this country is exploring the possibility of producing alcohol at a relatively low price to replace oil. Presently, the alcohol produced in Indonesia for commercial use is made from molasses, a by-product of sugar processing. Thus we must determine, from the economic point of view, to what extent alcohol made from molasses can serve as a substitute for fuel oil.

It is estimated that Indonesia's rate of energy production will increase 15 percent per year between 1980 and 1984. Energy consumption for 1976 is shown below:

	Total energy consumption (10 TCE*)	Oil consumption (kiloliters)
Electricity generation	1,788	837,342
Industry	6,133	3,501,261
Transportation	6,284	4,920,241
Households		5,302,722

*TCE = tons of coal equivalent

Energy needed for transportation is supplied by oil and coal, the latter used for rail transportation only. In 1977, this use amounted to 35.4 million barrels, or 7.1 million TCE for oil and 43,000 TCE for coal. It is estimated that in 1980 transportation will consume 61 million barrels of oil. Of this, road transportation will account for 63.8 percent; railway transportation, 0.8 percent; river, lake, and ferry transportation, 12 percent; sea transportation, 17.3 percent; and air transportation, 6.1 percent. Clearly, since road transportation consumes the most oil (19.1 percent of the total domestic use of oil), it should be given the first priority in any study of alcohol as a substitute for petroleum.

PRODUCTION OF ALCOHOL AS A FUEL

Between 1974 and 1980, the average production of alcohol and spirits in Indonesia was about 30 million liters a year.*

A survey of seven alcohol factories in Java between 1974 and 1977 showed that these factories produced substantially less than their full capacity; in 1977, total production was only about 50 percent of full capacity. Thus existing alcohol factories are not operating efficiently and selling prices could be lower.

No data are presently available on the costs of alcohol production. Surveys of alcohol factories should be conducted to obtain this information, particularly for methanol which can be substituted for fuel oil.

Alcohol is distributed directly from the factory to retailers. The only expense incurred by the factory is for transportation, which amounts to 25 rupiahs (Rp)** per liter of alcohol.

Factories charge approximately Rp 496.75 per liter. This price includes a sales tax of 2.5 percent, other taxes of 2 percent, and a BKS (alcohol association) premium of Rp 1.50 per liter of spirits. In 1980, the alcohol and spirits factory in Mojokerto exported its 12 million liters at a "on-the-port" price of Rp 855.50 per liter.

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* This number does not represent total production, as data were not available for some factories.

** Approximately Rp 625 = US$1.00.

Substituting Alcohol for Fuel Oil

The following analysis shows that the substitution of alcohol fuel from molasses for petroleum is profitable for the government of Indonesia. Some Indonesians are of the opinion that this substitution is not profitable based on the fact that the cheapest alcohol (Rp 500 per liter) is more expensive than fuel oil (gasoline = Rp 150 per liter).

Some of the figures used below are only assumptions because of limited data. According to the data obtained from a local corporation, B.P. Pasuruan, the price of molasses is approximately Rp 70,000 per ton. If 250-300 liters of alcohol can be obtained from one ton of molasses, the base price of alcohol should not be less than Rp 233-280 per liter.

The following assumptions have been made about the production and export prices of Indonesian oil: (1) the export price of 1 liter of oil is Rp 168.75, or Rp 177.63 per 10^4 kilocalories (kcal); (2) the production cost of oil is Rp 50.01 per liter or Rp 52.64 per 10^4 kcal.

If the substitution of alcohol for oil is successful, the government of Indonesia will profit by the increased export of oil using the following formula:

Rp 177.63 (export price) - Rp 52.64 (production cost) =
Rp 124.99 per 10^4 kcal (profit)

The following is a rough estimate of the economy of substituting alcohol for gasoline.

Government subsidy (for domestic gasoline consumption) avoided:

Export price (US$43/barrel)	Rp 177.63/10^4 kcal
Domestic price (Rp 101.95/l)	Rp 107.32
Government subsidy saved	Rp 70.31/10^4 kcal

Increase in G.N.P. (value added) due to increase in alcohol production:

Selling price (Rp 496.75/1)	Rp 764.00/10^4 kcal
Raw material (Rp 280/1)	Rp 430.64
Overhead (15% of raw material)	Rp 64.60
Value added (Selling price, less raw material and overhead)	Rp 268.76/10^4 kcal
Total value added to the state (Government subsidy saved plus value added)	Rp 339.07/10^4 kcal

Notes: 1 barrel = 158.99 liters US$1.00 = Rp 625
1 liter of gasoline = 9,500 kcal

Government subsidy to promote consumption of alcohol as a fuel is necessary because of its relatively higher cost. Based on 1980 data, this would amount to Rp 656.68 per 10^4 kcal. This subsidy is not included in the calculation of the above value added because it is a government transfer payment.

It is clear from these calculations that if the substitution of alcohol for oil is successfully implemented, the government will profit. This profit will grow as alcohol factories come up to full production capacity, thus lowering the cost of production. If the substitution is not carried out, there will be a loss that will continue to grow as oil supplies become scarcer and more expensive in the future.

Indonesia's capability of satisfying its growing need for fuel oil is likely to become more limited. In order to use oil exports to raise the national income, Indonesia must promote oil conservation and the production of energy from renewable resources. From this analysis, it is clear that it is important to conduct more concrete research in Indonesia to gain experience in producing and using alcohol fuels.

WORKING GROUP DISCUSSIONS

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Four working groups met to discuss four principal aspects of the pilot plant project: agriculture and agronomy, technology and engineering, economics and marketing, and transmigration and social impacts. Participants reviewed the directions proposed by the Indonesian project planners, exchanged information on relevant experience with ethanol projects in the United States and elsewhere, and raised issues and questions that may require further thought and study by the Indonesian project team.

The working groups did not meet in isolation; a number of participants in the discussions spent time in more than one group. In addition, the four groups met in plenary session at the end of their two days of discussions to air their thoughts and to consider interrelated issues.

As an overall perspective, BOSTID participants emphasized their view that the proposed pilot plant project is an important and useful undertaking. The technological factors are fairly straightforward, and the pilot plant can be and should be designed and built in Indonesia. This will provide valuable hands-on experience and should also increase the attention given to process and plant adaptations required by local climatic and environmental conditions, manufacturing capabilities, and the rural setting in which the plant will be located. Although reliable and efficient operation is important, the plant should not be over-designed; the process, materials, and equipment should be simplified wherever possible, consistent with effective operation.

Perhaps of greater complexity than the technological factors are the agricultural, economic and marketing, and social issues. Providing a steady flow of feedstock for an ethanol plant involves organizational and logistical problems that require a broad examination of the local agricultural system. The ethanol that is produced has to fit into a system of marketing that has been planned

with attention to such questions as how the alcohol will be used, where it will be used, and how much it will cost the users. An especially important issue is whether the government will provide a subsidy for ethanol as it does for petroleum products. Finally, the production and use of alcohol fuel involves social and cultural behavior patterns that must be taken into account when planning the pilot project and seeking information related to long-range possibilities for alcohol production.

Because the discussions emphasized exchange of ideas and experience, highlights of the major issues raised in each group are presented here rather than detailed minutes of the discussions.

AGRICULTURE AND AGRONOMY

The indigenous production capability for producing the 90 tons of raw materials (sweet potato and cassava) needed daily to meet the initial needs of the pilot alcohol plant is presently available in Indonesia. For example, cassava growing is well known in the province of Sumatra where the pilot plant will be located; Lampung has eight large automated starch factories and about 20 small ones with a total cassava feedstock capacity of about 3,750 t/day.

Sweet potato growing on a large scale is not as common in Lampung. Therefore, to meet the schedule for the pilot project, a sweet potato crop should be planted in the production plots at the site of the plant about 5 months before it starts up. The size of the crop can be adjusted according to the amount of cassava available in the area. In addition, specific plans for providing farmers with fertilizer and sweet potato plants must be made so that they can begin to plant their crops about the same time.

Because decisions about crop varieties must be made as soon as possible, experimental studies and training of personnel needed in the areas of crop varieties, soil cultivation and fertility, crop rotation, plant protection, and climatic affects must begin now. This would allow approximately one and a half years to develop the specific production details necessary for the transmigration area. A strategy of selection and breeding should be developed that is appropriate to the type of feedstock desired. For example, if maximum alcohol production is sought, a variety with high dry matter content is desirable. If a crop will be used for food as well as alcohol production, other characteristics will be sought.

One major production problem is coordinating crop harvests so that the alcohol plant has sufficient raw material for full production without shortages or large excesses. Some storage of the sweet potato crop can even out its availability, but probably should not be relied on extensively. Farmers must be encouraged to provide steady supplies.

The scheme followed for taro in Hawaii could serve as a model. Under this plan, the production area is divided into units. Each unit has a specified quota for the amount of the crop it must deliver weekly to the plant, which allows the farmer flexibility in planning his harvest.

TECHNOLOGY AND ENGINEERING

This group was primarily concerned with all aspects of the design and construction of the proposed pilot alcohol plant. The discussion began with a description of the general process of converting starch to alcohol, which includes:

1 Processing the feedstock (cleaning, crushing, separating the cellulose, producing the starch slurry, etc.)

2 Cooking and saccharifying the input starch

3 Fermenting the slurry

4 Distilling the alcohol

In discussing the overall process, emphasis was placed on: (1) keeping the plant simple and easy to maintain, (2) maintaining a positive energy balance, and (3) handling a variety of feedstocks.

Initially, cassava will be chiefly used as a feedstock. Later, sweet potatoes, or even other starch inputs such as taro or sago palm, may be used.

Specific technical issues discussed included:

- Cooker designs: Is it necessary to cook the slurry at a pressure of from 2 to 7 atmospheres and at a temperature of up to 130° C for half an hour? Many existing plants process starch at 98° C, at atmospheric pressure, with excellent results. Is there a significant difference between starch from grain and starch from sweet potato or cassava? These issues should be carefully, but quickly, examined.

- Fermenter designs: Do fermenters need to be internally or externally cooled? What is the proper tank design for adequate cooling, and what special cooling problems are presented by Indonesia's ambient temperatures and high humidity? What other mechanisms can be used for controlling fermentation temperatures?

- Requirements for raw materials (feedstock and fuel): Feedstock requirements were stated roughly as 90 t/day to produce 15,000 liters of ethanol per day. Other requirements, such as special enzymes, were also discussed.

- Equipment for proper treatment of input feedstock: The chippers used for cassava in starch plants in Indonesia may not be optimum for sweet potatoes, which are fibrous. It was suggested that hammer mills might be more appropriate for sweet potatoes.

- New varieties of feedstocks and the time required for such developments: The need to start immediately on field trials to select the most appropriate feedstock varieties, well before the plant is constructed, was stressed.

- Overall system energy balance, and how it is affected by different fuel inputs, boiler efficiencies, and the addition of heat recovery systems: To the extent possible, adaptations should be made to the production process and to the plant in order to achieve efficient use of energy for feedstock preparation, distillation, and fermentation.

- Yeast cultivation: Various methods of increasing yeast quantity over time were discussed including the percent seeding of a culture, cultivation times between steps, and the number of steps required.

- Controlling fermentation time and heat release: All agreed that minimizing the heat generated per unit time is essential, and that it would, therefore, be desirable to ferment longer and at a slower rate than is the practice in plants in other parts of the world. In slower fermentation, however, the danger of contamination is somewhat higher.

In each of the above areas, no clear-cut, "correct" answers were forthcoming. At the same time, however, no unsolvable dilemmas were presented. Each issue is a matter of making specific value judgments for each feedstock, each plant location, each set of operating

conditions, and each kind of indigenous fuel that might be used. A major issue affecting the above areas is the value of substituting renewable, locally generated fuels for nonrenewable fuels that can be exported.

ECONOMICS AND MARKETING

The primary objectives of Indonesia's ethanol project are to diversify energy sources, specifically by producing alcohol as a substitute for petroleum-derived energy sources, and improve the quality of life of transmigrants by improving their income. The long-run objective is to improve the quality of life of all rural Indonesians, not only transmigrants.

The project is an experiment in providing a base for a national policy on the diversification of energy sources. Pilot alcohol plants, located in transmigration areas, are laboratories for this purpose. Even if this experiment fails, alternative ways of diversifying sources of energy should be sought.

The following important issues related to this project should be studied:

- The impact of the project on food supply and prices
- The impact of the project on land-use planning for various commodities
- The feasibility of alcohol as a substitute for petroleum fuel, including:
  - -- What are the current markets for alcohol?
  - -- What are the future markets for alcohol as a substitute for gasoline, or as a substitute for kerosene?
  - -- Should the market be developed on a local/regional basis, or as a controlled market (such as military use) that does not interact with the overall market?

-- What is the projected price of gasoline in the international market?

-- What are the blending problems?

-- What are the distribution problems?

-- What are the pricing problems? Should a tax exemption/subsidy be given to the alcohol industry? Should an agricultural production incentive/subsidy be given to the farmer?

-- What kind of adjustment is necessary for facilities currently using gasoline/kerosene that are expected to use alcohol?

- o Socioeconomic effects of farming in the transmigration areas
- o Two concepts of implementation: the centralized concept and the small cooperative concept

ROUGH PROJECTION OF THE ECONOMY OF THE ALCOHOL PROJECT

Raw material (sweet potato) @ 8 kg/1 x Rp 20/kg	Rp 160
Processing cost	Rp 150
	Rp 310
Marketing cost	Rp 25
Total cost of 1 liter of alcohol	Rp 335

Currently, the price of gasoline in the international market is Rp 250 per liter. Assuming the price of gasoline increases 5 percent per year, alcohol would be competitive with gasoline by 1986.

TRANSMIGRATION AND SOCIAL IMPACTS

The outcome of this group discussion is presented in two sections. The first is concerned with the pilot project to be set up at the Tulang Bawang (Lampung) transmigration site, and the second addresses the longer-term aspects of Indonesia's alcohol fuels program.

RECOMMENDATIONS FOR THE TULANG BAWANG PROJECT

1 Detailed plans for the Tulang Bawang alcohol production facility should be closely coordinated with overall plans for this transmigration site being made by the Department of Public Works, especially with regard to a transportation network.

2 Project plans should include specific incentives and means for motivating farmers to devote part of their land to the production of crops (e.g., sweet potato) needed as raw material for the alcohol plant. A well-designed educational effort will be required, including emphasis on other opportunities, such as nonfarm employment and new business opportunities, which the alcohol plant will provide.

3 Attention should be given to providing mechanisms that will:

-- Provide farmers with investment credits to cover the initial costs of cash crop farming and to aid in recovery from disasters (e.g., insect infestion)

-- Assist individual farmers in marketing their cash crops and in obtaining supplies, such as fertilizer, control chemicals, etc.

-- Permit resolution of the inherent conflict between the interests of farmers, who want to obtain the highest possible price for their crops, and the alcohol plant management, who wish to pay the lowest possible price for raw materials. One possible approach is establishing long-term contracts between the alcohol plant and the farmers. The basis for the infrastructure needed here may already be available in the village unit cooperative system.

RECOMMENDATION FOR THE LONG-TERM DEVELOPMENT OF THE ALCOHOL FUELS PROGRAM

1 Studies should be implemented as soon as possible to define and develop opportunities for additional cooperative activities between the alcohol plant and the local farming community. Utilization of distillery wastes for local poultry or cattle production would be one example.

2 Studies should be undertaken to develop mechanisms for simultaneously improving the quality of life and encouraging the use of alcohol fuels in rural areas. For example, farmers could be offered incentives to purchase alcohol fuel made from the crops they have produced, or special credits could be offered for the purchase of alcohol-powered equipment and arrangements made for the repayment of these credits with crops rather than with cash.

TULANG BAWANG PROJECT ASSESSMENT

Although these recommendations are concerned with "transmigration and social impacts," there are much broader issues involved. In this context, it is recommended that this pilot project (Tulang Bawang) be carefully monitored to determine:

- Whether real improvements in the economic status of rural farmers have in fact been achieved
- The nature and degree of social change arising from the introduction of rural alcohol production
- How the land allocated to transmigrants has actually been used, requiring an inventory of current land use at the site so that changes following the introduction of alcohol production can be evaluated quantitatively and qualitatively

- The full nature and extent of ecological changes at the site resulting from the introduction of alcohol production and the accompanying agricultural activities

Finally, it is recommended that the alcohol team consider mechanisms for the continued management of the national alcohol fuels program following completion of the pilot project at Tulang Bawang.

APPENDIXES

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APPENDIX A

Workshop Participants

The eight individuals representing the BOSTID workshop were chosen for their personal experience with energy production from biomass resources and with the agricultural, economic, and technological factors relating to ethanol production.

Indonesian participants in the workshop included staff members of the BPPT who are involved with the pilot plant project, staff members of the Ministry of State for Research and Technology, and representatives of other relevant ministries and agencies. A list of the participants follows.

BOSTID PARTICIPANTS

Dr. Elmer L. Gaden, Jr., Professor, Department of Chemical Engineering, University of Virginia (Chairman)

Dr. Ramon de la Pena, Superintendent, Kauai Branch Station, College of Tropical Agriculture and Human Resources, University of Hawaii

Dr. Otto C. Doering, III, Associate Professor, Agricultural Economics Department, Purdue University

Dr. Donald I. Hertzmark, Senior Analyst, Agriculture and Transportation Group, Solar Energy Research Institute

Dr. William Hughes, Director, Energy Engineering Laboratory, Oklahoma State University

Dr. Alfred Jones, Research Geneticist, U.S. Department of Agriculture

Dr. Paul R. Middaugh, Alcohol Fuel Consultant, Northwest Pacific Energy Company, Inc.

Dr. Antonio Moreira, Assistant Professor, Department of Agricultural and Chemical Engineering, Colorado State University

INDONESIAN PARTICIPANTS

Department of Agriculture

Ir.* Jafri Jamaluddin, Direktur, Bina Produksi Tanaman Pangan
Ir. Kasmo, Ka. Subdit. Palawija, Ditjen Tanaman Pangan
Ir. H. Moh. Soenaryo Hardjodarsono, Direktur, Lembaga Penelitian Hasil Hutan
Wargiono, B.Sc., L.P.P.P., Bogor
Mr. M. Sayuti
Drs.* Hartoyo, Lembaga Penelitian Hasil Hutan
Ir. Lina Rusliana, Lembaga Penelitian Hasil Hutan

Department of Defense

Otty Soekotjo, Ka. Puslitbang Hankam

Department of Finance

Dr. H. Hutabarat, Ka. Pusat Penelitian
Muhadar Hardi, Ka. Subdit Bea Cukai
Sarudin

Department of Industry

Ir. Santoso Kismomihardjo, Ka. Subdit. Industri Agrokimia, Dit. Evaluasi dan Standardiasi Industri Kimia Dasar
Ir. Silaen, Subdit Industri Agrokimia

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*Ir. (Insinyur), Drs. (Doctorandus), and Dra. (Doctoranda) are academic titles used in Indonesia.

Department of Manpower and Transmigration

Kadarusno, Dirjen Transmigrasi
Ir. Amir Hasan Muthalib, Direktur Binagram, Ditjen Transmigrasi
Ir. Asfian, Subdit. P.B.L.N., Ditjen Binagram
Ir. Zuberdi M., Subdit. Binagram
Ir. Ani S., Subdit. Binagram
Dra. Tuti Kustur

Department of Mining and Energy

Prof. Dr. Samaun Samadikun, Dirjen Ketenagaan
Dr. F. Tambunan, Ka. Subdit, Ditjen Ketenagaan
Ir. M. Panjaitan, Ka. Subdit, Ditjen Ketenagaan
Ir. T. Sitanggang, Ka. Subdit Petrokimia, Dirjen Minyak dan Gasbumi
Ir. Endang Lestari, PPTMGB Lemigas
Ir. Irzal Chatab

Department of Public Works

Ir. Syarifuddin Akil, Dirat Tata Kota dan Tata Daerah

Ministry of Research and Technology

Ir. Wardiman Djojonegoro
Ir. Koeswandi Wasito
Ir. Kumhal Djamil

University of Brawijaya

Prof. Dr. H. Soetono, M. Agr.
Ir. Salyo Sutrisno

University of Gajah Mada

Dr. Ir. Bambang Suhendra
Drs. B. Sudibya, MBA, AK

University of Indonesia

Sardjono Jatiman, S.H., Fak. Ilmu-ilmu Sosial
Dr. Na Peng Bo, Fak. I. Ilmu Pasti dan I. Alam
Dipl. Ing. N. Soenarto, Fak. Mesin

Institute of Agriculture Bogor

Dr. H.H. Sitompul

Institute of Technology Bandung

Prof. Dr. Ir. H. Kho

B.P.P. Teknologi

Dr. S. B. Joedono
Ir. Dwipurwo Pangaroo
Ir. Sofyan Rasyad
Ir. Trihono
Dra. Susanti
Dipl. Ing. Todo Tambunan
Ir. Darmawan
Ir. A. Rafiq
Ir. Komaruddin
Dra. Comaria S.
Dra. Endang S.
Ir. Iman Sudarwo
Ir. Ibrahim
Ir. Hari Suharyono
Dr. Soerya Harto
Dra. Ina Miryanti
Ir. Tri Setya Budi
Ir. Didie Herkamto
Ir. Joko Prihastoto
Ir. S.H. Nasution
Ir. Cecilya Malik
Ir. M. Rasyid
Ir. Endang Suwarna
Ir. Enang Supena
Ir. Prihadi Waluyo
Dr. L. Pangabean
Ir. Fritz. S.
Ir. Budoyo

PERTAMINA

R. Lucas, Dit. Perbekalan Dalam Negeri
Nyoman S., Ka. Bid Ekonomi, Litbang
Ir. Pramono, Litbang
Poerwoto
Nurani, M.

Alcohol Association

Drs. Untung Basuki, Direktur, BKS
Ir. N.K. Nurai, Direktur, P.S. Madukismo
Mr. Suyoto

APPENDIX B

Organization of the Workshop

Organization of the workshop in Indonesia was the responsibility of a committee headed by Wardiman Djojonegoro, director of the ethanol pilot plant project. Other members of the committee were Koeswandi Wasito, Surya Harto, Ina Miryanti, and Ibrahim. In the United States, the coordinator for workshop activities was John Hurley of the Board on Science and Technology for International Development of the National Research Council, assisted by Elizabeth McGaffey. Detailed arrangements for the workshop were made when Mr. Hurley visited Jakarta in early October 1980. Further plans were developed during brief visits to Washington, D.C. by Mr. Koeswandi in late October 1980, and by Mr. Wardiman in late November 1980.

In planning the workshop, the Indonesian organizers stressed the importance of including a visit by BOSTID participants to the probable site for the pilot project. In no other way, they felt, could the group obtain a sharp perspective of both the human and geographical factors involved.

Accordingly, the workshop schedule began with an initial day in Jakarta in which Indonesian participants provided presentations on the background and objectives of the pilot plant project, and BOSTID participants provided a brief overview of the state of the art in alcohol production and the important issues and questions related to the pilot project. Four days of field visits then followed, including a two-day trip to the Tulang Bawang transmigration area in the province of Lampung, southern Sumatra, likely site of the pilot plant, and a two-day visit to Kuningan in west central Java to see agricultural practices there, especially sweet potato cultivation. Key Indonesian participants in the workshop took part in the field trips so that there was a valuable opportunity for informal interaction between the two groups during the trips.

After the field trips, a final two days of meetings were held in Jakarta during which participants discussed the alcohol project in four working groups: (1) agriculture and agronomy, (2) technology and engineering, (3) economy and marketing, and (4) transmigration and social impacts. Brief reports of the discussions of each group are provided.

Following the final session of the workshop, Minister Habibie met with representatives of the BOSTID and Indonesian participants for a briefing on their views. He expressed the hope that there would be continuing cooperation as the project evolves and stressed his belief that it is important for Indonesian scientists, engineers, and administrators to get personal experience in the project and to be allowed to learn the practical lessons that ultimately lead to better understanding and capability.