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The Second Pacific Basin

BIOFUELS WORKSHOP

Volume 1: Report

Kauai, Hawaii, U.S.A
April 22-24, 1987

Hawaii Natural Energy Institute
University of Hawaii at Manoa

THE SECOND PACIFIC BASIN BIOFUELS WORKSHOP

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Volume 1: Report

Hawaii Natural Energy Institute

In cooperation with:
Nitrogen Fixing Tree Association
United States Agency for International Development
Hawaii Department of Planning and Economic Development
Hawaiian Sugar Planters' Association
Coral Industries Chair for Renewable Energy Resources
Solar Energy Research Institute

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Introduction

Biomass is the most flexible renewable energy resource in Hawaii. Today it provides the state with cost-effective fuel for electrical generation and for thermal energy used in sugarcane processing; tomorrow it will provide feedstock to produce liquid and gaseous fuels, which will help meet Hawaii's transportation energy needs. Hawaii's dependency on imported oil costs the state more than $2 billion annually; increased use of biomass would not only help diminish this cost but would keep Hawaii green, provide jobs and economic development opportunities, and build a stronger state tax base and trade balance. With optimal growing conditions year round and a strong economy based in part on sugarcane and pineapple cultivation, Hawaii is an ideal place to develop fuels from biomass.

In November 1984, the Hawaii Natural Energy Institute (HNEI) held the First Pacific Basin BioFuels Workshop. It was attended by 40 members of Hawaii's biomass R&D community, which includes local industry, university, and government officials, and 20 guests from the continental United States and foreign countries. The Plan for Action resulting from this workshop led to significant new program efforts that addressed the advancement of biomass research, development, and use.

The Second Pacific Basin BioFuels Workshop was held at the Kauai Resort Hotel in Kapaa, Kauai, April 22-24, 1987. Ninety people participated, including thirty visitors from Thailand, the Philippines, the Republic of China, the People's Republic of China, Japan, the Dominican Republic, Jamaica, Puerto Rico, Czechoslovakia, Hungary, Africa, the Federated States of Micronesia, and the continental United States. Before and after the workshop, HNEI conducted field visits to biomass energy facilities and test sites on Hawaii, Maui, Oahu, and Kauai. The workshop consisted of presentations, discussion groups, and plenary sessions on growth and yield, conversion, end use, institutional issues, and other topics. The final session focused on recommendations for a Plan for Action update.

Field Visits

Thirty workshop attendees participated in the field visits. They were conducted by HNEI staff and affiliates from April 19 to April 21, 1987, and on April 25, 1987.

HAWAII

BioEnergy Development Corporation

On the island of Hawaii, one of seven BioEnergy Development Corporation (a subsidiary of C. Brewer and Co.) test sites was visited. The BioEnergy Development project studies fast-growing eucalyptus and is in its eighth year of operation, thanks to major funding from the U.S. Department of Energy (USDOE), cost sharing by C. Brewer, and additional support from the U.S. Department of Agriculture (USDA) Forest Service, Pacific Southwest Forest and Range Experiment Station. Seven studies indicated that the optimum spacing for eucalyptus growth is between 1m x 2m and 1m x 3m (3m to $6m^2$). Phosphorus fertilizer was helpful in maximizing growth during the first year, but nitrogen fertilizer, when applied frequently and in sufficient quantity, proved to be most effective. Other research conducted at the site examines superior phenotypes (one promising clone is from Brazil), harvesting, coppicing, regional analysis, and other growth related factors.

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Tree growing costs are approximately $4 per green ton; harvesting and delivering costs are $9 per green ton. To reduce expenses further, more research is needed in feedstock preparation for conversion.

Hilo Coast Processing Company

The Hilo Coast Processing Company's sugar mill is equipped with a 24-MW high pressure (1200 psi) steam boiler-generator. The use of a stack-heat recovery system to pre-dry bagasse from approximately 47% to 35% moisture content improves operating efficiency by nearly 10% and enables the boiler to operate more reliably. The system is available for most of the 48 weeks of mill operation; coal and oil are used as backup fuel during periods of insufficient bagasse supply. The sugar mill uses an average of 6 MW of power for its own needs and has a firm or scheduled power contract with the electric utility for 12 MW; the utility also receives surplus power from the mill when it is available.

Hamakua Sugar Company

Workshop participants visited the Hamakua Sugar Company's Haina mill, which is expanding to incorporate the company's Ookala mill to reduce operation costs. Hamakua Sugar's efforts to densify surplus bagasse into pellets (10% moisture content) are continuing. These pellets can be readily stored and used as backup fuel when bagasse is unavailable (during those periods when cane is not being processed). Because the Haina mill and the electric utility have a firm power contract stipulating that the mill provide seven days of producing power per week for 10 1/2 months, Hamakua Sugar's energy research efforts have been diverse and creative. Besides pelletizing (the company holds the world patent on the system), it has also explored cubing bagasse, which saves on energy costs and the cost of the die replacement for the pelletizer. While workshop participants toured the mill, a series of steam turbine-generator sets was operating at various steam pressures, illustrating what can be done when components from several defunct mills are integrated and developed into a cost-effective operation.

Hawaii Sugar Planters' Association (HSPA) Field Trial, Mountain View

Supported by the state and operated by HSPA, the Mountain View field test site is located on abandoned Puna Sugar Company lands at an elevation of 1300 feet. The area is characterized by acid soil and low insolation. The cane variety grown in this area, *Saccharum* spp. Hybrid (68-1158), recently produced 1.1 tons per acre per month when harvested in the eighth month. Several tree species were also planted; *Eucalyptus saligna* and *E. grandis* have been doing particularly well. This field test will continue for the next five years at several sites throughout Hawaii.

Puna Mill

Puna Mill was the last site visited by workshop participants on the island of Hawaii. The mill no longer processes sugar, but a long-term contract requires that it provide 8 MW of power to the utility. (The mill routinely provides 14 MW.) The main feedstock is eucalyptus wood chips, which are supplied by the BioEnergy Development Corporation and State Forestry Division lands. The chips are shredded to a consistency similar to bagasse and then fed into a boiler. Coal and oil are used for backup fuel when there is an insufficient supply of wood chips.

MAUI

Hawaii Commercial and Sugar Company (HC&S), Puunene

The HC&S (a subsidiary of Alexander and Baldwin, Inc.) ethanol plant was originally built by Seagrams to produce rum from molasses. The plant is no longer in operation but could someday be brought back on-line. Molasses was piped from the adjoining Puunene Sugar Mill, and a batch system produced about 600,000 gallons of rum a year. The sugar mill was operating during the field visit, and participants observed the off-loading of sugarcane.

HSPA Field Trial, Puunene

A second HSPA field trial was visited. Waste water, which was used to wash sugarcane, is pumped from Puunene Sugar Mill and is used to cultivate *Eucalyptus grandis*, *Leucaena leucocephala*, *Casuarina equisetifolia*, and *Saccharum* spp. Hybrid (73-6110). The trees had been planted about nine months before and were doing well.

OAHU

University of Hawaii (UH) Waimanalo Research Station

The UH College of Tropical Agriculture Waimanalo Research Station is the world headquarters of the Nitrogen Fixing Tree Association (NFTA). Nitrogen fixing trees offer a good source of fuel wood and feedstock for biofuels and, because they produce nitrogen naturally, do not require costly nitrogen fertilizers. Work in nitrogen fixing is of critical importance in developing countries where population is increasing and tropical forests are decreasing at an accelerating rate. Mixing nitrogen fixing trees with other forest and agricultural crops can also increase growth potential at low cost. The experiment station is also developing new hybrid tree species that are insect- and disease-resistant.

HSPA Headquarters and Laboratory

The HSPA headquarters and research station on Oahu are considered the most advanced facilities of their kind in the world. Owned and operated by HSPA, they employ outstanding researchers in all areas of sugar production and utilization. Visitors who work in the sugar industry were given an excellent opportunity to aquaint themselves with research and researchers in the Hawaii sugar industry.

KAUAI

UH Wailua Experiment Station

The UH Wailua Experiment Station uses nearly 300 acres of abandoned pineapple lands. With the support of UH College of Tropical Agriculture and Human Resources scientists, the station staff have greatly improved growing conditions for several plant species. Several species of nitrogen fixing trees and nineteen-month-old Chinese tallow trees, which were beginning to bear liquid oil containing seeds, were viewed by workshop participants. The station is the proposed site for the Hawaii Tropical BioFuels Research Center,which will conduct large-scale field trials, and feedstock preparation R&D for short rotation tree crops (six months to one year once coppicing trees are established).

HSPA Field Trial, Lihue

A third HSPA field trial, also on abandoned cane land, was visited. Eucalyptus trees, well-fertilized with nitrogen, were doing best. The USDA Forest Service has conducted ten-month field trials with various spacing at the same location. Tour members were impressed with the more than 100 acres planted in this area for boiler fuel by Lihue Plantation.

Presentation Summary

The Second Pacific Basin BioFuels Workshop convened at the Kauai Resort Hotel in Kapaa, Kauai, on Wednesday, April 22, 1987. Throughout the workshop, papers were presented by researchers, academicians, and representatives in government, utilities, and industry from Brazil, China, Japan, Puerto Rico, the Dominican Republic, Thailand, Jamaica, and the United States (see Volume 2 for papers presented). David E. Yount, UH Vice President for Graduate Research and Education, opened the conference by welcoming attendees. Yount commented that Hawaii is an ideal setting for an international conference on biofuels from biomass because of its location in the Pacific, multi-ethnic population, and tropical climate (see Appendix C for Yount's address).

The opening address, given by HNEI's director Patrick K. Takahashi, followed. Many biofuels research issues noted by the director were the same as those presented at the first workshop, but Takahashi placed a new emphasis on methanol rather than ethanol research. Research on items outlined in the 1984 workshop's Plan for Action has begun. Total systems, transportation fuels, and international cooperation were introduced as topics requiring particular attention in the future. The workshop's keynote paper, prepared by Congressman Daniel K. Akaka, is included in Appendix B.

Several USDOE representatives gave presentations at the Wednesday morning session. Each spoke about his division's goals, objectives, and projects, and the role of government was touched on by all USDOE speakers. The government supports research with high R&D potential; such research is often long-term, has high technical risk, and has a low payback ratio, making it insupportable in the private sector. The government also undertakes projects that recognize people's concern over public spending and environmental, health, and safety issues. A secure and adequate energy supply obtainable at reasonable cost is a primary goal of the present administration. On a percentage basis, renewable energy is currently the fastest growing source of new energy supplies and has the added attraction of not being subject to the international political crises that have, in the past, adversely affected the nation's supply of imported oil. Research efforts instigated by government agencies in cooperation with private industry, however, are particularly successful because industry is involved in research development for the marketplace; a key to success in future biofuels R&D lies in establishing closer ties with industry.

John J. Berg, Principal Deputy Assistant Secretary for USDOE's Office of Conservation and Renewable Energy, pointed out that transportation is a key energy issue because of its heavy reliance on petroleum (see Appendix D for Berg's presentation).

Don Walter, Director of USDOE's Biofuels and Municipal Waste (BMW) Technology Division, outlined critical technological, economic, and market issues: feedstock productivity, biotechnology, and scale-up; matching feedstock to conversion and market; increased feedstock production, control of nutrient rates, and dealing with wastes; improvement of conversion costs through increased efficiency and use of byproducts; and

the effects of unstable energy prices, competition for other feedstock uses, market interface, and land availability and use.

Eugene Ecklund, Manager of USDOE's Engine Technology Programs, compared the qualities of liquid and gaseous fuels. High octane alcohol, a liquid, makes a car run better than conventional gasoline. Maximum benefit is derived from neat alcohol, which permits use of higher compression engines. Methanol, however, offers a flexible resource base and is nearly price-competitive when made from natural gas; it is also easy to transport, store, and transfer. Methanol has the best overall vehicle-related characteristics and is the auto industry's fuel of choice. Only minor component changes are needed to produce cars that use methanol, ethanol, or gasoline.

Overviews of other institutes' work were presented. James B. Sullivan, Director of the U.S. Agency for International Development's (USAID) Energy Division, spoke about his agency's focus on indigenous energy supplies. Countries working with USAID tend to be poor in petroleum resources but rich in biomass resources.

Sinya Yokoyama of the National Research Institute for Pollution and Resources, Agency of Industrial Science and Technology under Japan's Ministry of International Trade and Industry (MITI), presented an overview of MITI's biomass conversion technology research. A biochemical approach to biomass conversion is involved in this research, using ethanol fermentation and anaerobic digestion.

Stan Bull, Director of the Solar Energy Research Institute's (SERI) Solar Fuels Research Division, discussed SERI's biofuels program. The program includes research on aquatic species, biochemical conversion, and energy from municipal wastes. Price competitive energy products are crucial for the success of biofuels in the marketplace, and Bull presented several technologies in which the gasoline equivalent price has dropped dramatically through research achievements. Should oil prices return to a higher level, these technologies could be even more cost effective.

Dick Neill, HNEI's Program Coordinator and coordinator of the workshop, outlined Hawaii's biofuels program. HNEI has undertaken and supported a variety of projects: a biomass resource assessment, field trials of promising fast-growing tropical trees and herbaceous crops, harvesting and feedstock preparation, conversion technologies, an assessment of hydrogen production from renewable energy, and a utilization program.

James Brewbaker followed with a summary of the workshop's goals and objectives. A professor of horticulture at the University of Hawaii, Brewbaker is also President of the Nitrogen Fixing Tree Association (NFTA). Brewbaker charged workshop attendees with developing a plan that deals directly with problems and avoids the academic definitions that often get the most attention.

Wednesday's afternoon session focused on an integrated approach to biofuels development, and the day concluded with a special session on research given by Sinya Yokoyama. Overview papers were presented on growth and yield issues at the Thursday morning session. A workbook distributed to attendees prior to the workshop noted that the workshop's focus was the production of rapid growth/high yield tropical species of biomass crops. Identifying critical growth yield issues was one of the goals of Thursday's morning discussion groups. Responses resulting from these discussions were gathered

and later sent to workshop participants, who were then asked to rank the importance of each issue (see Appendix E). Items judged to be "most important or critical" were:

(1) selecting species with high yield potential;
(2) varying the use of wood crops for greater market accessibility;
(3) breeding and integrating multi-purpose biomass systems that combine fuel, food, chemicals, and other products and that have, as a result, greater economic potential than pure biofuels systems, especially in the near-term;
(4) increasing the use of available agricultural land;
(5) cost-effective harvesting and feedstock preparation;
(6) identifying markets for viability;
(7) involving the commercial sector in prioritizing crops/end uses;
(8) encouraging greater awareness in developing biomass systems that meet people's needs;
(9) developing processing technologies and markets to increase biomass product value in areas other than energy;
(10) securing economic viability of large biomass-fueled power plants;
(11) determining minimum size of gasifier/methanol plants, alternate sizes and relative costs, and related land/energy plantation requirements; and
(12) conducting economic analyses.

Thursday afternoon began with a plenary session covering that morning's discussion group reports and recommendations; presentations on biomass conversion/end use technologies followed. Institutional issues and recommendations for an updated version of the Plan for Action, which was developed at the First Pacific Basin Biofuels Workshop in November 1984, were debated on the last day of the workshop. Participants were later asked to rank the recommendations (see Appendix F). Those given the highest ranking were:

(1) developing tree crops from highest value products first;
(2) continuing to give serious attention to species identified as promising biofuels crops at the first workshop: sugarcane, sorghum and sudan-sorghum crosses, Napier, Guinea, and California grasses, and pineapple;
(3) continuing the cane and cogeneration program;
(4) producing methanol by gasification of biomass;
(5) making biomass energy more economically competitive by increasing yields through vegetative outputs and by increasing the value of these outputs;
(6) developing practical plans in addition to those technologically interesting or technically possible;
(7) assessing adequately environmental issues related to any program or project; and
(8) focusing on smaller projects to demonstrate systems and gain experience before upscaling or adding systems.

Conclusion

The seven recommendations listed above form the basis of a sound biofuels development plan for Hawaii and the Pacific. If the state is committed to reducing future energy supply interruptions, biofuels offer a viable energy alternative that can help reduce significantly Hawaii's dependence on imported oil. Government officials must provide the leadership and funding to support a realistic biofuels program. The discussions conducted at this workshop clearly show that biofuels R&D is not without its problems; they also show, however, that a variety of possible solutions do exist to solve these problems. In

addition to greater energy security, the benefits of biofuels include economic development and job creating opportunities, a cleaner environment, a stronger state economy and tax base, and more efficient use of the state's natural resources. Private industry must do most of the work but, to accelerate the process, public action and support are needed. Industry, government, and the research community can work together to advance biofuels and thus lead the way to greater energy independence for Hawaii.

Appendix A

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The following abbreviations are used:
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Appendix B

Keynote Speech by Congressman Daniel K. Akaka, U.S. House of Representatives

The islands of Hawaii hold as much charm and beauty today as they did when the English voyager, Captain James Cook, first "discovered" the lush shores some two hundred years ago.

Despite enormous challenges posed by a post-statehood development boom, Hawaii has managed to preserve the pristine, almost incandescent, green aura that causes observers to denote the islands, "paradise."

How has the state preserved this lush environment? Well, as Hawaii's representative to Congress from the 2nd District--a district which includes rural Oahu and the neighbor islands--I know that the anwer lies in one simple word: agriculture. And, during my tenure in Congress, agriculture--particularly our sugar industry--has certainly been one of my priority concerns.

Hawaii's sugar industry, unfortunately, is on the decline. And, while our pineapple industry had a reasonably good year in 1986, it too is on the decline. We cannot, however, allow these businesses to fail. For, as major contributors to our economy--balance-of-trade, profits and tax revenues--they represent the number three source of jobs for our people.

The green environment created by our agricultural industry contributes, furthermore, to our island well-being by removing carbon dioxide from the air, and reducing the greenhouse effect. Likewise, being in a green environment is a naturally pleasant experience, and this aids our biggest money maker--tourism. Our agricultural industry, thus, helps to both preserve the environment and shore up the economy.

This brings me to my main message tonight, and your primary mission at this improtant workshop: How can we best ensure the solvency of our agricultural base?

The answer to that question lies in biomass. As has been earlier stated, biomass is our most flexible renewable energy resource. The world's oil supply is dwindling, and future crises are certain. The only question is: When? The dedication of only a small amount of our land to biomass, for biofuels, can totally satisfy our ground transportation requirements. In Hawaii, we have sufficient renewable biomass to totally replace imported oil.

As a member of the House Appropriations Committee, I have consistently backed legislation that paves the way for energy plantations and research on biofuels. I see this effort as not only utilizing the abandoned cane and pineapple lands, therefore aiding our agricultural industry, but as an important component to the energy security of our state and nation.

Hawaii is indeed a model for the transition to a renewable energy economy. Biomass is already making a major contribution through the burning of bagasse to produce electricity and thermal energy for sugar cane processing. But, in the future, biomass will need to be used as the feedstock for the production of liquid and gaseous fuels, and chemicals.

The scale-up gasifier plant proposal recently submitted to the Department of Energy--to be located at the Lihue Plantation sugar mill--will help provide an important step to the commerciali-zation of biomass to a medium BTU gas. This gas can, in turn, be converted to methanol or hydrogen, the former to replace gasoline, and the latter to take the place of jetfuel. I understand that Exxon Oil overcharge funds will be set aside by our Department of Planning and Economic Development to initiate a statewide program for the transition to methanol.

There is a growing realization that our renewable energy R&D policy has primarily served to improve our ability to generate electricity. While research must be continued on photovoltaics, windpower, OTEC and geothermal energy, the fact of the matter is that less than one-third of all energy goes to produce electricity. The big problem, as the gasoline lines of 1973-74 and 1979 revealed, is transportation fuel.

Furthermore, very little oil, with Hawaii being a notable exception, is now used in power plants. The next energy crisis will almost surely occur before the year 2000, and again, national transportation fuel supplies, not electricity production, will be hardest hit.

As conferees, you have a monumental task at hand, as you must develop a compelling case to convince government and industry to get serious about renewable transportation fuel. I have for several years now inserted biofuel funds for research. I am prepared to upgrade this program, but need your help.

The first Pacific Basin Biofuel Workshop set the stage for initiating a biofuels program. I look forward to the fruits of this workshop, for your recommendations can help bring the Pacific Basin into a more energy secure 21st century. Let us hope that we are wiser and can develop a balanced plan to accommodate the full spectrum of energy needs.

Thank you for joining me tonight. Let us work together for a greener Pacific Basin. Aloha.

Appendix C

Welcoming Address by David E. Yount, Vice President for Research and Graduate Education, University of Hawaii

On behalf of President Albert J. Simone and the University of Hawaii, I would like to welcome all of you to this Second Pacific Basin Biofuel Workshop. It is a special pleasure to welcome such an illustrious group of distinguished leaders from the mainland. We are also pleased with the strong participation of our foreign neighbors from Thailand, the Philippines, the Dominican Republic, Jamaica, the People's Republic of China, Taiwan, and Brazil. We appreciate the financial support of the U.S. Agency for International Development (USAID), the Hawaii Department of Planning and Economic Development (DPED), the Nitrogen Tree Fixing Association (NTFA), and the Hawaiian Sugar Planters' Association.

We at the University of Hawaii feel that one of the most important contributions we can make is to foster cooperative international research programs and to create sharing opportunities, such as this workshop. President Simone and our Board of Regents have made the area of international cooperation one of our highest priorities. We feel that our setting in the middle of the Pacific, our harmonious multi-ethnic population, and our many foreign students, especially in our graduate programs, all contribute to the special role that we can play for Hawaii and the Pacific Basin.

This workshop is particularly appropriate because our University is a leader in biomass and tropical agriculture research. We are the only state in a tropical setting and the only state with a special distinguished professorship devoted to biofuels.

The Hawaii Natural Energy Institute (HNEI) in the past ten years has contributed greatly to the advancement of renewable energy alternatives. Of all of the indigenous options, biomass is the most flexible renewable energy resource. It presently provides fuel for generating over 600 million kwh a year, mainly from bagasse, a sugarcane processing byproduct, plus about double this level of thermal energy for the processing of sugarcane itself. But probably more important to the Pacific Basin's energy future, biomass is the best near-term feedstock for liquid and gaseous fuels.

Our College of Tropical Agriculture and Human Resources (CTAHR), a land-grant college, is the only one in the U.S. based in a tropical location. It has been playing a leading role in all aspects of tropical crops, including genetics, horticulture, agronomy, soils, agricultural economics, and agricultural engineering. One area of cooperation between HNEI and CTAHR is the land resource data bank that was initially made possible by support from our Representative Daniel Akaka, who I am pleased to announce will be the banquet speaker tomorrow night. When completed, the computerized land resource data bank will tell you all you ever wanted to know about what will grow best on a given piece of land and produce the most biomass feedstock for the least cost. You will hear more about this project from key scientists in the program.

Ag-engineering is also cooperating with HNEI in developing the harvesting and feedstock preparation component of the integrated biofuel program. The Conference Co-Chairman, Dr. James Brewbaker from CTAHR, is considered to be one of the world's leading authorities on nitrogen-fixing trees.

It is this kind of cooperation among disciplines that makes a university great, or at least more effective, both in training its students and in providing leadership in the advancement of science.

As with the first Pacific Basin BioFuel Workshop, held two and a half years ago, this workshop today joins leaders from different disciplines, both within and without Hawaii, and in all areas related to biofuels. In brief, the combination of production, conversion, and utilization, together with the realities of economics and institutional concerns, must be effectively addressed if the great potential of biofuels is to be realized.

A recent study by HNEI, in cooperation with the Florida Solar Energy Center, funded by the U.S. Department of Energy through the Solar Energy Research Institute, on the production of hydrogen from renewable energy, concluded that biomass was the clear winner. In brief, this study showed that the least costly way of produce hydrogen today from renewable energy is by gasification of biomass into a medium Btu gas. The gas can then be converted either to methanol or to pure hydrogen. The cost of hydrogen conversion is close to the present-day cost of producing hydrogen from natural gas (which is what fuels our space program).

Methanol, which can be viewed as a carrier of hydrogen, appears to be the leading candidate to displace gasoline. Just three percent of our State's land area, 140,000 acres would be enough to provide the feedstock needed to produce 440 million gallons of methanol a year, and this is enough methanol to replace all the fuel now used by our automobiles, about 300 million gallons a year.

One of the products of that first Pacific Basin Biofuel Workshop was an action plan consisting of a series of recommendations that has resulted in an integrated approach. Resource assessment, the land data bank, field trials, conversion experimentation, and end use applications are being handled by HNEI and CTAHR, complementing the work of DPED through their support of the Hawaiian Sugar Planters' Association and USDOE's earlier funding of the BioEnergy Corporation.

I am pleased to note that thanks to Representative Akaka and Senator Inouye, Congress has maintained continuity for this effort by making $500,000 available to HNEI. In addition, HNEI has worked with the Pacific International Center for High Technology Research in the preparation of a $9 million proposal to the USDOE for a biofuel Gasified Scaleup Plant project. Finally, HNEI is securing a grant from DPED via the Exxon Oil Overcharge Fund to develop a statewide methanol program. Indeed, biofuel is coming of age.

We look forward to the findings and recommendations of this workshop to advance the critical field of biofuels for Hawaii, the Pacific Basin, and the world. Again, I am impressed with the high technical and decision-making level of the participants present. The discussion groups hold the key to identifying possible problem areas, determining strategies to resolve these problem areas, and making recommendations to advance a realistic plan for biofuels.

While the next energy crises could be just around the corner, be it three to six years away as predicted recently by former USDOE Secretary Donald Hodel or a bit longer, we cannot afford to wait. We need to move forward and complete the research and development that will enable Hawaii, the Pacific Basin, and indeed the world, to be less dependent, and eventually independent of the dwindling supply of oil.

Thank you very much for joining us on the lovely island, in the midst of considerable biomass, to plan for a greater utilization of this wonderful renewable resource.

Appendix D

Opening Address by John J. Berg, Principal Deputy Assistant Secretary, Conservation and Renewable Energy, U.S. Department of Energy

Good morning. It is indeed a pleasure for me to be here in the island paradise of Hawaii. If you've ever lived through a Minnesota winter, as I have, you can understand why they call our 50th state a paradise.

Workshops like this provide an important opportunity for members of the biomass community to exchange ideas and discuss mutual problems facing the industry and I'm pleased to see that there are attendees from many diverse backgrounds here today. I understand that representatives from the federal government, municipalities, industry, academia and the national laboratories as well as from other countries will be participating in your presentations and workshops and I know that there will be positive results from this conference.

Developments in Biofuels and municipal waste technology have been moving ahead and I'm delighted to be able to discuss some of the results with you.

Let me state first, that the Reagan administration is committed to promoting a mixed and balanced energy resource base for this country and to making certain that we will never again face the economic and energy chaos we experienced a decade ago.

Although the United States has significantly improved its energy position, there can still be no doubt that securing an adequate supply of energy at a reasonable cost will remain a crucial national priority.

This administration is dedicated to that goal. Our ideal is an economically efficient, flexible energy system which is not dependent on any single source. This means the aggressive development of all available sources of energy--from conventional sources such as our domestic fossil fuels--to nuclear to every form of renewable energy.

Indeed, through research, continued technological advances and market expansion, renewable energy can be expected to become increasingly cost-competitive in the future. Department of Energy projections suggest that supplies from renewable technologies will continue to increase throughout the rest of this century and will represent more than 13 percent of domestic energy supplies by the year 2010. Is is a fact, that on a percentage basis, renewable energy is currently the fastest growing source for new energy supplies.

As many of you are aware, the recent energy security report to the president of the United States, which was released March 17th in Washington, D.C. by secretary of energy John Herrinton, notes that the United States and the world will, in time, come to rely largely on energy sources that are essentially inexhaustible. The combination of solar, wind, geothermal, water and biomass energy represents as extremely large resource base that over the long term, could become a major new source of energy supply. It will be the rate of technological progress and the forces of the energy market which will determine the extent to which this resource potential can be developed. However, even with the progress made to date, a number of years of research challenges still remain.

The approach to achieving renewable energy's potential contribution is through a realistic, far-sighted effort to improve the technology base from which private enterprise can make development and investment decisions for the future.

Strategies to help the renewable potential emerge as reality include continued research, active international energy collaboration, and a continued federal leadership role. The DOE's renewable energy research program is structured to provide the private sector with the technology base it will need to develop competitive technologies in the critical areas required to reduce system costs, improve performance, and lengthen the operating lives of systems.

According to the energy security report, perhaps the greatest advantages of the "new" renewables over the long haul is simply that they are based on technology, rather than on insecure commodity resources. The resources that underlie them (including innovative ideas) are indigenous. They are not subject to politically induced disruptions and their costs are likely to drop rather than rise.

A prime example of these "new" resources is one of the most versatile of the renewables--biofuels. The technology in this field ranges from commercial systems such as the direct combustion of wood and MSW, which now supplies nearly 3 quads of our energy, to technologies that are yet in the preliminary research states, such as alcohol from cellulostic materials and oil bearing micro-algae. Consequently, biomass offers alternatives that could reduce oil dependency in one area of special interest and that is in the transportation field. There can be no doubt, however, that the energy contribution from biofuels technologies has the potential for significant impact.

To realize the tremendous potential of biofuels, current research is laying the groundwork for the development of advanced, innovative biofuels technologies that can compete in conventional energy markets. By using the newest biotechnology and genetic engineering techniques, researchers can improve the energy characteristics of the trees, plants and micro-algae that are vital feedstocks for liquid and gaseous fuel production.

I should also point out, that innovative R&D will in the future, produce inexpensive biocrude oils and refine them to gasoline or diesel substitutes: enzymes from biological systems will be able to produce alcohol fuels from inexpensive grasses and wood, and recombinant DNA approaches are being employed to improve micro-organisms for fuel ethanol and methane gas production.

We believe that the key to success in biofuels lies in cooperation with industry. We are aware that our research efforts will only be successful to the extent that industry is involved in our research and develops it for applications in the marketplace.

Let me stress that the biofuels community has an excellent record in cooperating with the federal biofuels program, both in participation in cooperative R&D projects and in its willingness to consult with and advise the department on optimum R&D planning.

Through a partnership among federal, state and local governments, and the private sector, we are establishing the technology base for the development of advanced technologies to produce liquid and gaseous fuels from biomass. The Department of Energy's Biofuels and Municipal Waste Technology Division has now focused its research efforts of five fuel cycles, all of which produce liquid or gaseous fuels. Later this morning, Don Walter will describe these cycles, as well as our overall research strategy for biofuels. In addition, the Federal Biofuels Program conducts research on increasing supplies of biomass feedstocks, such as short rotation woody crops. The department is

also supporting research done by the Hawaii Natural Energy Institute in woody and herbaceous crops, aquatic plants, and appropriate conversion processes. The ultimate goal of the Federal Biofuels Program is to provide the data necessary to allow the private sector to make informed decisions concerning the ultimate commercialization of biofuel technologies.

There is evidence that this approach is beginning to pay off. One of the department's projects in Hawaii has been a cooperative undertaking with Bioenergy Development Corporation. This research project, begun in 1978, has focused on improving the energy production of eucalyptus trees through genetics and short rotation forestry techniques. We are now seeing the first commercial applications of this research: a privately-funded, commercial short rotation wood energy plantation on the island of Molokai is in the planning stages. Another project of note is the first energy from municipal waste project under construction on Oahu. A joint venture of Amfac, Combustion Engineering, and the city of Honolulu, this project will turn a disposal problem into an energy asset. Hopefully, these projects are the first wave of a number of private projects which will help Hawaii to meet its energy goals.

It should be noted, also, that biofuels is not the only renewable energy resource making an impact on Hawaii. The department has supported a geothermal energy project on the Big Island and ongoing research projects in Hawaii include DOE's efforts to harness the potential of ocean thermal, wind and hydrogen energy systems. Renewable energy is ready and able to play a large role in Hawaii's drive to strengthen its energy security.

In closing, let me say that if we in the United States are to achieve our goal of energy non-dependence, we must explore every possible way to broaden our sources of energy and to make the most of what we have. The Department of Energy enthusiastically recognizes that renewable energy is an inherently secure source of supply for the United States overall, and for the future. With the U.S. projected as being able to count more on renewable technology options, including geothermal, wind, solar, photovoltaics, most assuredly biofuels, and even energy from the ocean, it means special significance for Hawaii as well as specific areas of the U.S. mainland.

The domestic renewable energy resource base is enormous--perhaps hundreds of times larger than current domestic energy consumption and far above projected national energy requirements--and the use of renewable energy is expected to increase rather steadily. I want to commend all of you here at this conference today for making that possible by actively working on the research and experimentation in this field.

Thank you for inviting me to be here with you today.

Appendix E

Participants' Concerns: Growth and Yield Issues

Workshop attendees rated the following issues on a scale of 4 ("Most Important/Critical") to 1 ("Less Important").

Technical Issues

4 Selection of species with high yield potential.
3 A methodology to select between herbaceous and woody biomass.
3 Interspacing of nitrogen fixing trees.
2 Monoculture with fertilizer.

Tree Crops

4 Multiple uses of wood crop in light of lack of access to markets.
1 Plant oils do not seem promising in terms of economics or end use in engines.

Grasses

3 Sugar's superior photosynthetic activity in converting sun energy to biomass as an energy crop.
3 Cane trash study in economics and harvesting (decide the percentage of costs) and comparative advantages of byproducts from bagasse and trash (emphasize trash, as there is 10 times more trash than bagasse).

Conversion

4 Importance of evaluating multipurpose biomass systems which have much better economic potential than pure biofuels systems, especially in the near-term, which combine food, chemicals, and other products as well as fuels. Need to focus on breeding and integrating such systems.

Program Policy Issues

4 Lack of systems for harvesting and feedstock preparation cost-effectively.
4 Utilization of underused or abandoned agricultural lands.
3 Intensive vs. extensive production (yield per acre vs. total acres).
3 Determine critical long-term soil and fertility requirements; maintain the balance of payments. Eucalyptus, for instance, is highly demanding of nutrients. Emphasize high production of market driven end-uses of cane, e.g., sugar vs. energy material.
3 Species selection process: technical concerns should be paramount, but R&D requirements are great, i.e., in areas of breeding, cultivation practices, conditions, etc. Who decides what species should be emphasized?
3 Technology transfer methods and cooperative ventures to transfer principles and techniques from industrialized countries to other areas.
2 Apply existing data on many crops and biomass systems from industrialized countries to developing areas.

General Concerns

4 Identify end uses (markets) for viability.
4 Involve the commercial sector to prioritize crops/end uses.

Social

4 Look at all aspects of the situation, not just fuel. The biomass system must meet the real needs of people.
3 Consideration to overall social factors in planning systems, as some products are detrimental to society even though economically viable. Biomass systems in developing countries are labor intensive and provide significant rural employment.
2 Information on thelabor intensiveness for site specific projects is needed, as well as the capital intensiveness, in evaluating systems for a variety of Pacific Basin countries, rather than just summary amortized cost information.
1 Saving sugar in many countries because economies depend on it.

Impact

1 Noise and visual pollution from movement of chip-carrying trucks on highways and from chipper, due to large scale activity.

Water and Land Use

3 Concern of natural forest harvesting for biomass energy.
2 "Triple mining" of land: i.e., (a) use oil for machinery in planting, harvesting, hauling,processing, and petrochemical fertilizers; (b) s(oil) erosion (mining soil); (c) water depletion (mining water: depleting watershed, ground water).
2 The reality of land availability. (How much of the one million acres designated as viable forest land really is?)
2 Quantities of land not available for biomass methanol program--much land is not suitable for intensive energy production.
1 Overuse of limited world resources (soil, water, chemicals, oil).

End Use

4 Increasing the value of outputs by increasing the number of products. Higher value products from biomass other than energy, such as chemicals. will be possible when processing technologies and markets develop.
2 Use of coconut shells, other available biomass, or other waste products in developing countries.
2 Methanol (and other biofuels) utilization based on the availability and cost of natural gas, potential from coal and decisions by the automotive industry and a national market.
2 Long-term sustainability of intensive wood farming.
1 Ethanol expense (3 to 4 times that of methanol and 2 or more times that of methanol from coal). Ethanol is not likely to survive without high subsidies.

Institutional Concerns

4 Economic viability of large biomass-fueled power plants.
4 Minimum size of a gasifier/methanol plant, alternate sizes and relative costs, and related land/energy plantation requirements.
3 Introduction of new biomass crops to existing operations such as the sugar industry (will remain prone to concentrate on cane).
3 Importance of breeding; need for government public sector commitment to long-term research.
3 Problem of petroleum security--how real is it?
2 Methanol plant economies of scale: combined with limited and dispersed land availability, is biomass methanol less attractive than fermentation/distillation of sugarcane or some other fermentable product?
2 Fuel distribution system accomodation of both alcohol and petroleum fuels. Influence from government commitment to long-term research, incentives, and tax subsidies on land.

Energy Plantations

2 High transport costs: forming large enough clusters (less than 25-mile radius around each plant) to serve each methanol plant.

Economics and Financing

4 Importance of economic analysis.
2 High costs of establishing tree plantations.
2 High production costs.
2 Economics of sugar as an energy crop TODAY.

Appendix F

Participants' Recommendations: Plan for Action Update

Workshop attendees rated the following recommendations on a scale of 4 ("Most Important/Critical") to 1 ("Less Important").

Technical Issues
Tree Crops

4 Develop tree crops for highest value products first, i.e., pulp. Developmental programs from the beginning should include multiple uses, i.e., energy and feeds from leaf and small branch fibers.

3 Pursue eucalyptus production, because 100 years of worldwide experience has shown this to be an attractive, high-growth, low-input biomass crop, with emphasis on improving productivity of species and testing within genus.

3 Nitrogen fixing trees.

3 Continue serious attention to species identified as promising biofuels crops in the First Pacific Basin Biofuels Workshop: *Eucalyptus grandis, E. globulus, E. saligna, E. robusta, Acacia mangium, A. mearnsii, Albizia falcataria,* and *Casuarina equisetifolia.*

3 Continue development of the energy components and techniques for recovering these from sugarcane where presently grown, within economic constraints. The high moisture of most grasses will inhibit development of other grasses for energy.

3 Market analyses in Hawaii for tree crops by different end uses:
- convert biomass to low Btu for electrical generation;
- convert biomass to methanol
  - automobiles;
  - electrical generation;
  - energy bridge.

2 Eucalyptus energy plantations.

2 Eucalyptus/nitrogen fixing trees grown together.

2 Need for the production of nitrogen fixing trees in developing countries through short-rotation energy plantations and agroforestry plots to help mee the needs (particularly) of the rural populations.

Grasses

4 Continue serious attention on species identified as promising b. fuels crops in the First Pacific Basin Biofuels Workshop: sugarcane, sorghum and sudan-sorghum crosses; Napier grass (*Penisetum* sp.); Guinea grass (*Panecum maximum*); California grass (*Brachiaria* sp.); and pineapple for liquid fuels.

4 Go with what we have now--cane and cogeneration.

3 Breed cane for both sugar and energy--greatest gains have been made in plant breeding.

3 Research the productive potential of grasses such as:
- Napier;
- Guinea;
- others;
- (name)

3 Convert whole crop cane to produce ethanol and furfural plus Btu value residue for burning.
3 Market analyses in Hawaii for grass crops by different end uses:
- convert biomass to low Btu gas for electrical generation;
- convert biomass to methanol
  - automobiles;
  - electrical generation;
  - energy bridge.
1 Develop a sugarcane factory energy balance.
-- Sugarcane is best energy crop because of alternate end uses.

Conversion Technologies

4 Methanol by gasification of biomass.
3 Importance of work on chemicals to provide added revenue.
3 Keeping current on advances in all biomass conversion technologies, including ethanol (not cost effective today without subsidy in comparison with methanol, but advances in technology R&D could change this in the future).
2 Charcoal's importance to provide domestic fuel in many developing countries and a potential added source of revenue in others.
2 Other conversion technology R&D.
1 Charcoal's possibilities as a biofuel.
1 Development of small-scale charcoal systems.
1 Charcoal's importance as an intermediate product/source for a variety of markets (dependence shifts between Hawaii and developing countries).

R&D
Pilot Plants

3 Develop small-scale methanol plants. One large methanol plant (or several) is not feasible for Hawaii because of dispersed land availability.
3 Demonstration project of biomass gasification for gas turbine electrical generation.
3 Develop a versatile gasifier program (one input → one output; one input → multiple outputs; multiple inputs → one output; multiple inputs → multiple outputs.
3 Compare herbaceous to tree crops/fuel costs. Feasibility studies and pilot projects in the medium range must be funded to find out actual costs.
2 Conduct a demonstration project of biomass gasification for gas turbine electrical generation, which could also lead into biofuels-methanol production
dual system (e.g., by upgrading the gas to a medium Btu level for methanol coversion).

End Use

3 Prioritize crops/end uses by their economic potential--commercialization.
3 Create end-product markets, multiple-use, high value products.

Financial and Economic

4 Make biomass energy more economically competitive:

- increasing yields through vegetative production, using the local expertise.
- increasing the value of outputs by increasing the number of products derived.

3 Market analyses in Hawaii for tree crops by different end uses (methanol--electricity or automobiles, direct combustion--for electrical production, indirect fuel displacement).

3 Focus on highly flexible conversion systems where the output product mix can be easily changed according to current requirements, as future energy and economic situations are highly uncertain.

3 Develop shorter rotation crops that can provide an earlier financial return to the landowner/investor.

3 Complete market assessment for biofuels end uses and other products.

3 State legislature adoption of a state tax basis on the basis of Btu content, not gallons, for an easier transition to methanol (which has half the Btu content or about two-thirds the net energy level).

3 State tax exemption for "gasohol" from the excise tax be extended to neat methanol (providing a sizable tax incentive).

2 Complete economic models on land use; growth and yield; harvesting; feedstock preparation; conversion; and end use.

2 Smaller scale power plants:
- co-products;
- state and federal tax incentives;
- domestic uses.

2 Ship wood to Japan for pulp at $60/ton (marginally economic from $10-$20/ton--bbl oil value).

2 Develop economic models to provide needed decision making information for various biomass feedstock, production, harvest and conversion/end use cost implications.

2 Identify market niches in the state of Hawaii, as virtually any biomass crop seems to grow well.

1 Federal oil import tariff on oil.

Institution and Support

4 Develop practical plans, not merely technologically interesting or technically possible.

4 Adequate addressing of possible environmental issues related to any program or project.

4 Focus on small size projects to get project going (farms, energy plantations, conversions systems) to demonstrate systems and gain experience, then scale-up or add systems.

3 Carefully evaluate physiology and genetics of plants in response to stresses such as poor soils, insufficient nutrients, drought. (Needed information to design plants to match the varied and often marginal areas available for bioenergy plantations.)

3 Near-term uses of biomass resources are critical. Economics are key, i.e., electric power cogeneration is commercial today in existing operations.

3 Include energy marketing company representatives at future meetings to address the near-term implementation issues rather than just long-term theoretical aspects.

3 Give more attention to appropriate collection systems and densification methods for both large- and small-scale operations. Transportation and handling remain major limitations and cost factors.

3 Total systems approach: identify high-value products without destroying Btu value.

3 Encourage greater utility company commitment to biomass fuel for electrical generation.

3 Integrate biofuels programs with:
- other renewable components;
- food production;
- w[illegible]ction or extended use;
- se[illegible] waste disposal;
- milita[illegible]plications, funding possibilities;
- tourisn[illegible]ications (methanol buses).

3 Develop a biofuels program with energy plantations that stresses job opportunities for impacted or displaced workers; energy security (reducing impact of future oil supply interruptions).

3 Avoid native ecosystems and watersheds.

3 Collaborate with researchers in other countries where there are common interests and potential.

2 Emphasize the situation in developing countries; the primary energy crises today are the firewood and power shortages. (Most workshop presentations related to high intensity management and cropping on good quality soils. Most developing countries' bioenergy systems are labor intensive on poor soils, where the best land is used for food production).

2 Need for high level public relations to allay resistance and to consolidate support for bioenergy. Increase biomass technology awareness by involving targeted institutions and groups in workshops and seminars and through media coverage.

2 Develop a graduate program in tropical forestry research and plant breeding.

2 Initiate a transition to methanol transportation fuel program as soon as possible using imported methanol until the time that it becomes possible to produce methanol from biomass.

2 Identify possible institutional barriers and develop and implement a program to remove the same, especially to reduce possible risks. This would involve a strong state and local government commitment if it is to be successful.

2 Develop cogeneration opportunities for biofuels.

2 Get the oil companies involved.

1 Develop an intensive public relations program on biofuels possibilities.

1 Assist local development corporations in Hawaii.

1 Establish one or two faculty positions in tropical forestry.

1 Mix recreation and production in green belt areas around cities and resort communities.

Assessment (Resource)

3 Complete computerized Land Data Bank program of all known relevant growth and yield factors.

3 Realistically assess land resources for biomass production (including ownership, availability, costs, possible problems, etc.) and identify the most productive trees and grasses for each type of land/growing condition that may be available (with use of computer model for growth and yield as well as economics).

2 Quantify resource potential, market supply and constraints, and size of demand.

1 Lay out the overall process in each country based on the spectrum of possible uses if sugar in each country is to guide the country's program:

1. Evaluate economics.
2. Recognize error bars (confidence level) qualitatively for each option.
3. A preliminary spectrum of potential uses:
   a. Sugar/food (small error bar [EB]);
      - beverage alcohol (small EB);
      - fuel alcohol (moderate EB);
      - chemicals--furaldehydes (large EB);
   b. Bagasse and field waste;
      - fuel--electricity (small EB);
      - paper (small EB);
      - gases for electricity (moderate EB);
      - gases for methanol (moderate EB);
      - sugar for ethanol (moderate EB);
      - sugars for chemicals--furaldehydes (large EB);
      - charcoal (moderate EB).

1 Include ocean biomass in future consideration of biofuels. (Hawaii's ocean area is one-third of the U.S. mainland, and OTEC will provide nutrient-rich water.)

1 Analyze all biofuels feedstock at various age for basic factors (moisture, cellulose, hemicellulose, lignin, etc.).

Needed R&D

3 Develop research and development of harvesting and feedstock preparation for utilization of various conversion technologies.

2 Research Ni-fixation (applying symbiotic bacteria directly to crop species), photosynthesis.

2 Future research: genetic engineering crops (less water, less lignin, more biomass, etc.).

1 Find near-term research (less than five years) for first payoff.

1 Direct R&D programs toward reducing error bars in cases where the option could be justified.

Test Planting and Evaluation

2 Develop renewable tree farms to store energy for later use.

2 Continue work on increasing biomass yield per acre to reduce future land requirements for methanol production.

2 Consider available land and species, the type of final product and economic, environmental, and social uses

2 Develop a breeding program for increasing the dry matter yield per acre.

Harvesting/Feedstock Preparation

3 R&D in reducing costs of harvesting and feedstock preparation of both wood and grass crops.

1 Long-range harvest of seeds and saps from perennial liquid fuel (hydrocarbon) plants.

1 Combination of long and short rotation.

Appendix G

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Sinya Yokoyama, National Research Institute for Pollution and Resources, Agency of Industrial Science and Technology, Ministry of International Trade and Industry, Japan

Alternative Transportation Fuels Programs
E. Eugene Ecklund, Office of Transportation Systems, USDOE

Workshop Objectives and Overview
James L. Brewbaker, UH and Nitrogen Fixing Tree Association

Jamaica Cane/Energy Project: The Determination of Cogeneration Feasibility and the Economics of Steam-Electric Production from Sugarcane Wastes
John P. Keppeler, General Manager, Jamaica Cane/Energy Project, USAID

Rating Land for Biomass Production
Tung Liang and M. Akram Khan, Department of Agricultural Engineering, UH

Plant Sciences and Biofuels Production
J.W. Ranney and J.H. Cushman, Biofuels and Municipal Waste Technology Division, USDOE

Harvest and Preparation Technology for Biofuels
Allan L. Phillips, Department of Agricultural Engineering, University of Puerto Rico

An Overview of Thermochemical Technologies for Biomass Gasification
Michael J. Antal, Jr., Coral Industries Professor of Renewable Energy Resources, HNEI, UH

Multi-purpose Biomass in Development Strategy
Lewis L. Smith, Director, Puerto Rico Office of Energy (Paper presented by William Allison)

Liquid Fuel Production from Biomass and Waste by Thermal Chemical Conversion
Sinya Yokoyama, National Research Institute for Pollution and Resources, Agency of Industrial Science and Technology, Ministry of International Trade and Industry, Japan

Comparative Yield Trials with Tree and Grass Energy Crops in Hawaii: A Preliminary Report on Current Research.
R.V. Osgood and N.S. Dudley, HSPA

Alternative Uses of Sugarcane for Puerto Rico
William F. Allison, Consultant/Agriculture Engineer, Land Authority, Puerto Rico

Electricity: End Use for Biofuel
Kelvin L. Kai, Kauai Electric Division, Citizens Utilities Company

New Prospects for Cogeneration in the Cane Sugar Industry
Eric D. Larson, Joan M. Ogden, and Robert H. Williams, Center for Energy and Environmental Studies, Princeton University

Electrothermal Wood Gasification
José R. Moreira, Companhia Energética de São Paulo

Mathematical Modelling of the Pyrolysis Region of an Electrothermal Gasifier
José R. Moreira, Departamento de Física Experimental, Instituto de Física da Universidade de São Paulo

Current Status of Biomass Gasification for Production of Heat, Electricity and Fuel
Thomas B. Reed, Colorado School of Mines

Methanol Production from Biofuels
Earl C. Nelson, Consultant

The California Methanol Program: Commercial Demonstration and a Practical Challenge
Kenneth D. Smith and Peter F. Ward, Synthetic Fuels Office, California Energy Commission

Eucalyptus Plantations for Energy Production in Hawaii
Thomas E. Crabb, BioEnergy Development Corporation

Chinese Tallow Tree Program: Hawaii Progress, December 1986
Robert Boom, Director of Hawaiian Operation, The Mason Research Foundation

Plan for Action: A Conversion Technology Option
Robert Bloom, Director of Hawaiian Operation, The Mason Research Foundation

Biofuels in Hawaii: Mass or Morass?
Robert A. Merriam, Resource Management Forester, Division of Forestry and Wildlife, Hawaii Department of Land and Natural Resources

Conference Summary and Agenda for Action: A Transportation Fuels Perspective
Daniel Sperling, Department of Civil Engineering and Division of Environmental Studies, University of California, Davis