National Renewable Energy Laboratory

Alternative Fuels Division

Ethanol Program

External Review Panel Report

November 8 & 9, 1994

TABLE OF CONTENTS

INTRODUCTION 2

Background
Methodology
Report Structure

EXECUTIVE SUMMARY 5

ANALYSIS OF CURRENT CONDITION 6

Goals
Deployment of Ethanol Technology
- On-Target
- Off-Target

STRATEGIC RECOMMENDATIONS 11

Overview
Strategic Recommendations of the Review Panel

CONCLUSION 14

INTRODUCTION

Background

On November 8 and 9, 1994, a collaborative and independent Review Panel visited the Alternative Fuels Division of the National Renewable Energy Laboratory (NREL) in Golden, Colorado, to review the Ethanol Program. The Panel consisted of the following members:

James A. Doncheck, P.E. (Chairman), Executive Vice President
Bio-Technical Resources, Manitowoc, Wisconsin

James C. Craig, Research Leader, Engineering Science Research Unit
Agricultural Research Service, USDA, Philadelphia, Pennsylvania

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Chevron Research and Technology Company, Richmond, California

Steven Shaffer, Senior Agricultural Biologist
California Department of Food and Agriculture, Sacramento, California

We, the Panel, recognize that the Ethanol Program at NREL is important to the overall energy program of the United States and should be supported and developed further. Also, we are aware that the technology developed in the Ethanol Program is at a critical stage—moving from the laboratory into commercial production. Our two-day review focused on gaining an understanding of the Ethanol Program's current condition and then guiding Program managers as they develop a marketing and business plan for private sector deployment of their scientific developments.

Thus, the purpose and scope of this review were to:

- provide an independent assessment of the Ethanol Program.
- assess the clarity of the Program's goals and purpose.
- evaluate its current direction and projected growth.
- recommend strategic directions for the Program.

From information presented to us by Program managers—Program objectives, activities, and plans—we developed our own versions of the Program's goals, examined where deployment efforts were on- and off-target, and then developed some strategic recommendations. On November 9, we provided branch and Program managers an overview of our interpretation of the Program along with our recommendations for improving the overall Program. A highlight of the Panel's visit was a guided tour of the recently completed Process Development Unit (PDU).

The purpose of this report is to provide the Ethanol Program, NREL, and the Department of Energy (DOE) a summary of the findings and recommendations of the Review Panel.

Methodology

By their very nature, review and strategic planning processes are governed by the amount of time available and the depth of information provided. Time constraints create a challenge for both the presenters and reviewers. Within a given time frame, presenters must communicate as much information as possible, which forces them to include only what is most important and relevant. Review Panel members must attempt to grasp where the Program is today, observe its strengths, and make some worthwhile strategic recommendations.

To coordinate information given by the presenters with information needed by the Review Panel, the Program's managers were available throughout the meeting to answer any questions we Panel members had. This format enabled us to make educated assumptions, maintain an open dialogue, and draw informed conclusions. Nevertheless, we responded only to what we heard, saw, and read. All of the comments and recommendations contained in this report were taken from the information provided during the review meeting.

Please note that we recognize some of our recommendations may not be relevant in view of Ethanol work not reported to the Review Panel. However, without information to the contrary, all of the following responses and suggestions should be taken into consideration.

Report Structure

The report is divided into three categories—Executive Summary, Analysis of Current Condition, and Strategic Recommendations.

Executive Summary	• Summarizes the Ethanol Program's current conditions and strategic direction as noted by the Review Panel.
Analysis of Current Condition	• Focuses on how the Program is developing and deploying its technology: which decisions and activities are on-target, which are off-target.
Strategic Recommendations	• Presents the Panel's suggestions for the strategic direction of the Ethanol Program.

EXECUTIVE SUMMARY

On November 8 and 9, 1994, NREL program managers and staff reviewed the Ethanol Program with a seven-member Panel representing industry, government, and academia. The review process was structured to provide an overall review of the Program, including project goals, objectives, business strategy, technology status, financial and resource analyses, and deployment and commercialization plans. The review process was interactive, with Program managers providing an overview of their various activities and panelists asking questions and offering insight into various issues. The review meeting ended with the Panel providing DOE and NREL Program managers with their impressions of the overall Program, which are also documented in this report.

The Panel feels strongly that the overall goals of the Ethanol Program should continue to be to:

- develop efficient technologies for conversion of a lignocellulosic material to ethanol.
- construct a plan to deploy NREL's technologies in the industrial sector.
- position NREL to be the global leader in biomass-to-ethanol conversion technology.

The Panel believes the Program is making good technical progress, as evidenced by the work on improving the cellulase enzyme complex and ethanol production by Zymomonas, plus the filing of patents. The building of the PDU was a logical next step in the overall development of the technology and is essential to demonstrate and optimize each processing step and the conversion process as a whole. The considerable interest generated in the business sector is further evidence of the perceived value of NREL's technology.

We believe that the biggest weakness in the Program is the lack of a visible, comprehensive, proactive plan to broadly deploy the NREL technology. Research and development efforts have progressed to a stage where substantially more effort should be devoted to developing commercialization plans. Intellectual property, patent, and technology licensing strategies also need to be examined before marketing NREL's technology and capabilities to targeted audiences.

ANALYSIS OF CURRENT CONDITION

Goals

We Panel members spent some time crafting our own version of the Ethanol Program's goals so that we could better understand what the Ethanol Program does and wants to do:

- Develop technology, while acknowledging environmental constraints, that leads to making ethanol as efficiently as possible out of lignocellulosic material
- Develop and communicate an implementation plan for the transfer of this technology to industry
- Establish the results of NREL research in the industrial sector
- Position NREL to be the leader in biomass-to-ethanol conversion technology

Agreement upon these goals gave us a context for understanding the Ethanol Program's current condition and suggesting strategic directions. We feel that while goals are dynamic, they should accurately reflect an organization's current status as well as its future direction.

The Ethanol Program's mission statement differs from our version somewhat and is presented below for comparison:

ETHANOL PROGRAM MISSION STATEMENT

The mission of the ethanol project is to identify and develop environmentally acceptable and safe conversion technologies for the production of ethanol from renewable resources at prices that will allow ethanol to compete with conventional blending agents and fuels. This must be accomplished while maintaining the highest regard for health and safety during the entire development process. The ethanol project has the responsibility to deploy these technologies to industry such that three billion gallons of ethanol are commercially produced by the year 2010. Completion of this mission will result in improved national security, environmental quality, and economic competitiveness for the United States.

Finally, while Panel members were not given sufficient information to evaluate the status of the *development* of ethanol technology—the review focus being the *deployment* of that technology—we heard nothing to indicate that technology development is not proceeding well and according to plan.

Deployment of Ethanol Technology

The Ethanol Program is entering a new, critical stage in the development of ethanol from biomass—deploying this technology in the private sector. Two of the biggest challenges that Ethanol Program managers face with deployment are:

- developing economically viable technology for producing ethanol from renewable feedstock sources.

- transferring the technology developed in the laboratories of NREL and its subcontractors, and in its CRADAs, to the commercial sectors for production and industrialization.

We, the Review Panel, noted what the Ethanol Program is doing to successfully meet these challenges as well as where we think the Program might not be on course.

On-Target

The following activities and capabilities noted by the Panel constitute where the Program is on-target with its deployment goals as the leader in ethanol-from-biomass technology. These are fundamental elements from which strategic recommendations can be created.

Developing Its Marketing Plan

The following market drivers, used to determine market demand, are important in understanding the potential demand for ethanol fuels:

- Energy diversity
- Balance of trade
- Energy security
- Rural economic development
- Renewable/sustainable energy source
- Reduction of CO_2 emission
- Waste utilization

Commercialization

The Program has generated substantial interest in creating business partnerships for the deployment of its technology by using CRADAs, Requests for Proposals (RFP), and other agreements. The CRADAs with New Energy Corporation and AMOCO support the development of this technology and its transference to the private sector. Four responses to a recent RFP seeking support of the newly built, bench-scale Process Development Unit (PDU) indicates significant interest in this stage of development. An important component of this RFP was asking respondents to provide information about what technology they would contribute.

Technology Transfer/PDU

NREL and the Ethanol Program are positioning themselves as the experts in biomass-to-ethanol technology; in fact, they are taking the lead. Building the PDU has been an important step. The Program's focus on pretreatment and cellulose conversion, particularly improving enzyme economics and developing analytical expertise and standardized methods, is also important. The Panel was impressed by the Program's continuing scientific efforts:

- Improving the cellulase/enzyme complex
- Establishing standard analytical methods for biomass composition
- Showing significant progress on Zymomonas organism
- Identifying thermo-tolerance and concentration tolerance
- Ensuring that process engineering methodology is on target
- Continuing work on fungal systems while developing bacterial enzyme systems

Planning

There were three key planning issues that the Panel thought were the foundation blocks for the deployment program: (1) focusing on waste products as near-term energy resources; (2) planning for the logical extension of the research and creating a timetable for developing commercial units; and (3) filing and receiving U.S. patents.

Off-Target

Navigating an uncharted course in an effort to commercialize a developing science requires not only scientific expertise to monitor and improve the technology but also business acumen to ultimately achieve the goal of commercialization of the technology on a broad scale. Within the Ethanol Program, highly skilled, scientific personnel are being asked to market what they have developed, a task that can be as challenging as developing the technology itself. The Panel recognizes this and wants to assist Ethanol Program managers in developing a marketing and deployment plan by guiding them with the questions and concerns that were generated by the information presented.

Developing a Marketing Plan

The Panel didn't understand what criteria, if any, Program managers were using to develop their deployment plan. Members were concerned that the choice of which plant to commercialize first may be random rather than planned. Members questioned how the Program was evaluating potential plant sites.

Also, the Panel was concerned with the emphasis on certain market drivers. By highlighting air quality and oxygenated gasoline, the Ethanol Program may lose credibility with some audiences.

Commercialization

As the Program moves towards commercialization, the Panel noted two issues which need to be monitored. First, procurement must be streamlined. The private sector will not tolerate inefficient methods of acquiring necessary equipment to improve production, especially if the marketplace demands that changes be made. Second, some Panel members felt that there are not enough industrial subcontractors at this time and that obtaining industrial subcontractors now will help the Program transition later.

Technology Transfer/PDU

Panel members questioned why certain entities are coming to NREL; their apprehension is that the motive is "dollars, not technology." One panel member asked, "If NREL's charter is to transfer technology, why are partners asked to *bring* technology?" Another asked, "Is the PDU being used to develop someone else's technology?" All members agreed that PDU should be used to transfer and license NREL technology. They noted three other concerns:

- How does NREL give out its exclusive rights? Freely granting exclusive rights would be extremely harmful.
- One demonstration plant won't facilitate the investment in another. Each is site-specific with individual economic and technological issues.
- The Florida CRADA may be off-target because it lacks a good "technical fit" with the Ethanol Program and because of the potential environmental impact.

Planning

The crux of the problem that Ethanol Program managers face in deploying this technology is the lack of a strategy to bridge the gap between a demonstrable technology and multi-plant production.

A second critical issue is the lack of a proactive approach to business planning. One panel member asked, "How will they implement a good business plan?" Without a plan, Members felt that managers could not proactively choose and target specific industries for partnership. Furthermore, Panel Members thought the time projections are too optimistic.

Finally, the Panel pointed out that the Ethanol Program and this review were operating with "tunnel vision." Members haven't seen a Master Energy Plan from the DOE and are concerned that one does not exist. One Member asked, "How does this Program fit into the overall energy program of the United States?"

Data

Panel members noted some incongruities in data and the development of it. Most important, they were concerned about the approach used to develop the Program's technological goals. Setting cost goals and then adjusting the technology to meet these goals may be the wrong approach. For example, setting a target of $.67 per gallon and then developing a technology development schedule to meet that goal seems backwards. In addition, some of the economic figures seem rather "rosy" and "fuzzy."

There also appeared to be a contradiction between biomass feedstock quantities projected and actual; between the number of plants and the number of gallons produced. Some members were also skeptical about the BTU balance presented.

STRATEGIC RECOMMENDATIONS

Overview

The Ethanol Program has already committed time and money to deploy the ethanol-from-biomass technology. Assembling this Review Panel to provide strategic recommendations exemplifies this commitment. Using recommendations from the Panel, managers of the Ethanol Program should be able to develop a strategic marketing plan to steer the deployment efforts of this technology into the marketplace.

Recommendations by the Review Panel

Developing a Marketing Plan

A strategic marketing and deployment plan is essential for the successful commercialization of this technology. Some critical steps that Program managers should consider follow:

- Establish criteria for developing demonstration projects. These criteria need to be linked to NREL's technologies and the development of them. Feedstock availability, conversion technology, and local economics are interrelated and need to be considered simultaneously.
- Develop clear criteria for demonstration plant project selection. These criteria need to be linked to NREL's technologies.
- Focus initially on feedstocks that are easiest to use (e.g. the purest cellulose—corn fiber or pulp). Panel Members would like to see a list of the most-developed to least-developed conversion technologies, based on pilot plant data. Many questioned why the Program is using waste woods first.
- Create criteria/policy for licensing the technology. Clarify intellectual property and patent strategies.
- Establish a substantive break between ethanol-from-corn and ethanol-from-biomass. Continue pursuing waste feedstock and choosing some geographic locations out of the Midwest (e.g. Hawaii is a clear break).

In terms of market drivers, Panel members recommend that the Program consider the following:

- Use air quality selectively. It weakens the argument with some audiences.
- Use life-cycle CO_2 emissions, rather than air quality as an environmental driver.
- Include the following drivers in Program presentation:
  - Development of this technology in the United States and exportation to the Third World
  - Recent progress and DOE's expertise in biomass conversion
  - U.S. rural economic development/jobs

Planning

For the development of the PDU and demonstration plants, the Panel recommends that Program managers should:

- select their next steps carefully.
- improve the accuracy of the selection process and deployment timetables.
- develop a plan involving the commercialization of feedstocks in a parallel manner rather than one after another.
- attempt better coordination among government agencies funding biomass conversion.
- align NREL with other sources of funding: SBIR programs, DOD, USDA, EPA, and state agencies.
- improve coordination among the economists doing projections. (Some of the numbers in the presentations were inconsistent.)

For the development of an ethanol market, Program managers should bridge the gap between demonstrating the technology and multi-plant deployment. To do this, they should:

- develop a comprehensive deployment plan—visible, well-understood, and proactive.
- expand their thinking about how the market will evolve.
- involve industry in planning this market evolution.

Finally, the Panel would like to see DOE's Master Energy Plan and how ethanol fits into the overall U.S. energy program.

Technology Transfer/PDU

In terms of transferring this developing ethanol technology, Panel members recommend that Program managers:

- work closely with an experienced technology licensing team.
- develop licensing criteria which limit exclusivity or access to broad technology rights. For example, if AMOCO has the rights to fuels from waste paper, it should not be given the rights to fuels developed from wood chips.
- negotiate profit splits when exclusive rights are granted.

Members also recommend that the Program:

- explore opportunities that might generate money by working with industrial partners.
- use the PDU to further the transfer and optimization/development of NREL's technology.
- explore cooperative relationships. For example, consider using other existing pilot plants as alternative PDUs. The Panel pointed out that the Tennessee Valley Authority, Proctor & Gamble, and the Idaho National Engineering Labs each has one that might be available.

Commercialization

The Panel strongly urges that pressure to commercialize be reduced by identifying realistic cost and time objectives. This would involve performing more rigorous and realistic sensitivity analyses on process economics and justifying how these technical goals can be achieved. For example, managers should complete a total life-cycle mass and energy balance and make these numbers available to Panel members.

In addition to developing a realistic commercialization plan, the Program should:

- continue developing its base technology and be sensitive to broadening this technology to include other oxygenated products (e.g., make sure that the wording of patent filings is inclusive).
- actively market capabilities to targeted audiences (e.g. oil, pulp and paper, wood, and sugar industries; the regulatory and governmental community, too).
- place more emphasis on the adverse environmental impact of commercial and demonstration plants. Develop a plan for handling air, water, and solid waste pollutants to ensure compliance with environmental regulations.

CONCLUSION

The Review Panel recognizes the role that the Ethanol Program plays in and the impact it already has on the development of Ethanol biofuels. In fact, we believe that this Program is of strategic national interest and that the pilot plant will emerge as the nation's premier biomass-to-fuel facility.

Overall, we feel that the Ethanol Program is strategically important and producing good results. The Program also faces many substantial financial, market, and deployment challenges. We assessed the Program's current condition—where its technology and deployment strategies are on-target—and to build from these, we developed strategic recommendations to help guide this Program through its immediate, short- and long-term deployment goals. We also noted where we believe the Program has strayed from these goals and have made appropriate recommendations. It is our hope that the Ethanol Program will use this encouragement from an independent, yet concerned, viewpoint to enhance an already strong Program and to further its growth.

We wish to thank the Ethanol Program managers for the opportunity to assess the Program's current status and collaboratively suggest strategic directions for its continuing growth and upcoming technology deployment.