Summary:

Biomass Research & Development Technical Advisory Committee Meeting February 13-14, 2007

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Day 1 - February 13, 2007

I. Welcome and Introduction

Committee Chairman Tom Ewing called the meeting to order and introduced Bill Hagy, U.S. Department of Agriculture (USDA) liaison to the Committee from the Office of Rural Development.

II. Update on USDA Activities

Mr. Hagy began his talk by requesting that Committee members interested in participating in the March 1-2, 2007 Agricultural Outlook Forum contact staff. Input from industry and academia will be a valuable part of the Forum (Attachment A). Jim Martin asked whether USDA would consider any of the Committee planning publications. Mr. Hagy responded they would not, but that the updated *Roadmap for Biomass Technologies in the United States,* due to be published this spring, is anticipated to be influential in the year-round planning for the next forum. Harry Baumes, from the USDA Office of Energy Policy and New Uses, stated that a policy paper on energy strategy was published a few months ago, but his office has not yet considered the updated *Vision* and *Roadmap* documents. Mr. Martin asked whether the USDA strategy paper would undergo Committee review. Mr. Hagy answered that Farm Bill theme papers were introduced to the Committee in 2006.

Mr. Hagy gave a presentation (Attachment B) regarding USDA bioenergy and Committee-related activities. The fiscal year 2006 USDA – Department of Energy (DOE) joint biomass research and development (R&D) solicitation has been significantly delayed due to the Office of Management and Budget (OMB)'s request that administrators publish a reporting burden package which requires 60 days for comment. The package was delivered to OMB February 13, 2007. Doug Hawkins asked whether the FY 2007 joint solicitation would include any changes in technologies funded, or funding provided. Mr. Hagy responded that funding levels are legislated in the Energy Policy Act of 2005. The legislation may change again as part of the 2007 Farm Bill. Eric Larson asked how many years the $50 million of authorized joint solicitation funds would last. Mr. Hagy answered that the Secretary's proposed $50 million in joint solicitation funding would last for ten years, totaling $500 million, about double the 2002 funding level. Tom Binder asked whether Mr. Hagy had any indication of funding increases or decreases for USDA and DOE. Mr. Hagy stated that Farm Bill funding categories would be changed, and include a greater emphasis on renewable energy technologies. Fewer funds overall will be available in this version, and guarantee programs, costing taxpayers less, will be favored.

Chairman Ewing introduced Neil Rossmeissl of the DOE Office of the Biomass Program (OBP). Mr. Rossmeissl is the Committee's Designated Federal Officer (DFO).

III. Update on Committee Action Items

Mr. Rossmeissl gave a presentation (Attachment C) on the status of Committee action items. At this time, Congressional and administration interest in the Biofuels Initiative and complementary legislation is very high.

John Hickman asked whether the Energy Policy Act of 2005 (EPACT 2005) section 932 Integrated Biorefinery solicitation would be funded, given the uncertain status of Continuing Resolution approval. Mr. Rossmeissl stated that all budget priorities have focused on funding the 932 solicitation, including cost estimates and the number of possible project selections. If more funding is available, more projects can be selected.

Jim Martin asked whether the EPACT 2005 section 942 Reverse Auction language defines cellulosic ethanol, or provides guidance on required feedstocks for ethanol production. Mr. Rossmeissl answered that EPACT 2005 includes at least nine definitions of biomass and ethanol. Reverse Action activities have taken a broad perspective, including hemicellulose, cellulose, and perhaps the cellulosic segment of corn feedstocks. What is under debate is the incentive price, which must be arrived at through transparent analysis.

The Committee broke for ten minutes.

IV. Presentation on DOE Feedstock Analysis

Committee Chairman Tom Ewing introduced Dr. Richard Hess of Idaho National Laboratory, the laboratory relationship manager for DOE. Dr. Hess gave a presentation (Attachment D) regarding feedstocks analysis work at the laboratory and elsewhere by DOE.

Rodney Williamson asked whether certain feedstocks can be produced most easily at ten dollars. Dr. Hess responded that forest logging residues, some corn stover, and cereal grains, all produced in a dry system configuration, require less pre-processing and pre-treatment, reducing costs. John McKenna asked for a definition of pre-processing. Dr. Hess explained that feedstock size reduction and quality assurance in wet mill and fractionation processes are the major functions of pre-processing. Scott Mason asked whether the $1.07 per gallon cost target for cellulosic ethanol was defined in 2002 dollars, which Dr. Hess confirmed.

Eric Larson asked whether a wet system works for logging feedstocks. Dr. Hess stated that the “wet” or “dry” designation is usually a factor of moisture levels being above 50 percent, or below 15 percent, respectively. Feedstocks with between 15 and 50 percent moisture can face decomposition or fire hazards, due to property instabilities. John Hickman asked whether wet systems could exclude drying costs entirely. Dr. Hess stated that storing wet feedstocks would require consideration of some drying activity. Materials with between 15 and 50 percent moisture must either be dried, or have moisture added to create silage. Neil Rossmeissl asked what percentages of the 1.3 billion-ton national feedstock supply would be considered wet and dry. Dr. Hess displayed a stover moisture map, detailing the variety of moisture contents nationally for one feedstock. He expressed the opinion that producers would benefit in the long-term from a functioning wet system. Dry systems tend to incur greater plant risk. Doug Hawkins asked whether wet systems lower costs. Dr. Hess explained that wet systems allow producers to take advantage of natural post-harvest physiology, including pre-treatment and some free sugar recovery. These benefits would allow for higher feedstock payments to farmers. Bob Sharp asked why Dr. Hess assumed producers would have to pay for residual feedstocks. He answered that rotation and compaction issues create some difficulty for growers, meaning residues, which are not necessarily wastes. John McKenna asked why switchgrass cannot be provided at ten dollars per ton. Dr. Hess explained that switchgrass yields per acre are finite due to soil sustainability and other issues. Harry Baumes added that farmers will require equal payments for energy crops and corn. Dr. Hess agreed, and explained that producers should not be paying the 75 percent spot price for feedstocks. The 45 to 55 percent payment is more sustainable.

Dr. Hess presented a sample farmer's budget spreadsheet as an example of crop rotation and residue harvest considerations. Nutrients lost by harvesting residues between rotations must be replaced by costly fertilizers. Farmer payments for energy crop production must compensate for this loss.

Jim Martin asked whether producers are yet able to convert mixed-stream feedstocks. Dr. Hess stated that, due to limited supply streams, dedicated feedstock-type plants do not yet exist. Plants must use barley and wheat straws, or wheat straw, corn stover, milo stover, and cotton gin trash from throughout the local growing region to obtain enough volume for sustained production. Producers ask farmers to grow any and all energy crops, and can use all the feedstock. This approach may change as plant size increases.

Chairman Tom Ewing suggested producers advocate farming marginal land, just as CRP areas currently not cultivated. Dr. Hess agreed, and added that farmers and the soil would benefit from greater crop variety in the Midwest, so that some corn acres should be converted to alternate energy crops. Also, if producers could access 40 percent of corn stover, there would be enough feedstock for 64 ethanol plants. Adding switchgrass as an augmentation to current corn acres would about double the number of plants supported to 126.

John McKenna asked whether farmers are yet interested in long-term energy crop contracts, a risk-mitigation measure that would attract investors. Dr. Hess agreed that long-term contracts are desirable, and stated that a clear demarcation between producer and farmer processing responsibilities would facilitate contracting. Handling responsibilities, pricing, baling or fractionation activities, and other "farm gate" considerations should be standardized.

Tom Binder recommended that future analysis use a more realistic feedstock cost than ten dollars per ton, an amount that is only profitable for corn as cattle feed. Dr. Hess responded that the ten dollar figure is not supposed to be a point where industry will build. Instead, the analysis aims to identify efficiency measures, and R&D needs to lower conversion costs. Supply system efficiencies could also lower feedstock costs.

In response to Chairman Tom Ewing's assertion that cellulosic ethanol plants must be sited close to energy crop land, Dr. Hess asked Neil Rossmeissl whether section 932 solicitation awards are expected to be sited near cellulosic crops. Mr. Rossmeissl explained that the biggest issue in the solicitation has been a "replication" criterion, where applications had to justify their feedstock selection, and detail how their methods could be duplicated nationwide. He then stated that DOE is considering a cost target different from the $1.07 goal.

Ralph Cavalieri asked what would happen to the 1.3 billion tons of available feedstock if feedstock costs rose above ten dollars per ton. Dr. Hess explained that demand for all feedstocks will drive up feedstock prices to at least an average of 25 dollars per ton.

Committee Chairman Tom Ewing thanked Dr. Hess for his time, and moved to the next item on the agenda, discussion of the updated *Roadmap* draft, and a timetable for publication.

V. Discussion of Updated *Roadmap* Draft

Vision and *Roadmap* subcommittee chairman Tom Binder stated that summaries of the four *Roadmap* sections have been posted to the Committee's internal website for review. Members should post comments there, or submit them for posting. The sections should be collated for analysis of regional differences, and alignment with the original *Roadmap* structure. Michael Manella of BCS, Incorporated suggested a four-week window for comment submission, followed by a focus group review. The compiled draft with comments is expected to be ready by early March. Staff will contact Committee members with this information. This timeline will be posted to the internal website.

Tom Binder asked the Committee to consider carbon reduction issues for inclusion in the updated *Roadmap.* The reason for this discussion arises partly from agencies' current focus on liquid fuels. Biofuels have a clear greenhouse gas (GHG) emissions reduction advantage over coal-to-liquid plants. Eric Larson agreed that the carbon reduction issue should be emphasized in all four major benefits of biofuels: renewability, energy security, rural development and environmental protection.

Handouts titled "Greenhouse Gases and Energy: Ethanol Relative to Gasoline," and "Food versus Fuel" were distributed (Attachments E and F).

John McKenna stated that the financial community is excited about the environmental and investment possibilities of biofuels. Climate change should be one focus of the *Roadmap*.

Mark Maher asked that, in view of the recent European Union Carbon Dioxide emissions per Kilometer standard, and activity in Canada and Japan, the Committee would welcome an update from Michael Wang of Argonne National Laboratory regarding net energy balance analysis. Neil Rossmeissl noted that the Committee has requested such presentations in the past. Meetings planned for the rest of 2007 include presentations from Michael Wang, the DOE Office of Science regarding fundamental research for a stable GHG strategy, and the DOE Office of Fossil Energy. John McKenna asked for additional information on how well biofuels and biomass technologies compete with other carbon reduction technologies. Charles Kinoshita asked that presentations focus on non-corn feedstocks' GHG effects. Mark Maher asked that Michael Wang's presentation include recommendations for laboratory resources to achieve necessary R&D.

The members further discussed how to focus on carbon reduction benefits in the updated *Roadmap*. Mark Maher stated that the carbon dioxide reduction benefit of biofuels and bioproducts should be presented as a secondary effect. Doug Hawkins thought GHG recommendations might be out of place in the *Roadmap's* R&D recommendations. John McKenna stated that the secondary GHG reduction objective should be explained in a preamble to the R&D recommendations. Mr. Hawkins added that a preamble should advocate government support of studies on certain GHG factors. Neil Rossmeissl suggested that companies or universities submit supporting documents upon publication. Tom Binder reiterated that the original *Roadmap* structure used for the updated document does have a policy section. Tom Ewing asked that written proposals for GHG additions to the *Roadmap* be submitted using the Committee's internal website.

Chairman Ewing suggested that the *Roadmap* include a discussion of the food versus fuel issue, and Mr. Sharp added that it might also mention the competition between paper and fuel. Mr. Rossmeissl voiced concern that, in light of all the suggested additions, biofuels may be in danger of becoming a secondary issue. He then noted that there are food versus fuel issues that should be addressed, and that the OBP was in the process of assessing the fluctuating market price of corn. Dr. Binder contributed the idea that if the price of corn does not rise, there would be no market incentive to develop cellulosic ethanol technologies.

Jim Martin continued the discussion of corn prices by mentioning that some technological challenges remain regarding feeding livestock ethanol byproduct. The feed industry is currently blending a variety of proteins together in the feed; however, the cost of this process is still high. Mr. Rossmeissl asked if this issue should also be included in the *Roadmap*, and Mr. Martin replied that it should be incorporated into the "strategy" section, along with input from industry experts.

Harry Baumes offered a brief explanation of market behavior and the effect of corn price on other commodities. Mitch Peele asked whether or not economists can predict the impact of U.S. corn prices on the international market, or vice versa. Dr. Binder agreed that the *Roadmap* should address the cause, effect, and possible remedies of higher international prices for corn.

The Committee broke for lunch.

VI. Public Comment

Tom Ewing announced an amendment to the agenda and opened the floor for public comment. Mr. Ewing recognized Ryan Weston, a former staff person for the House Agricultural Subcommittee, currently representing sugar cane growers in Florida, Texas, and Hawaii.

Mr. Weston gave a presentation (Attachment G) regarding the bioenergy potential of sugar cane in the United States. Cost figures in the presentation are from when corn was two dollars per bushel. In Hawaii, farmers find it beneficial to grow sugar cane due to better conversion economics than corn, a state tax credit for growers, and higher petroleum prices than in other states. Mr. Weston referred to sugar cane bagasse and venasse. Bagasse is fibrous material left over after cane crushing, which is dried to low moisture (less than 50 percent), then crushed and used in power generation. Venasse is the pure liquid left over. Year-round operations in Hawaii have the edge over seasonal work in Florida and Louisiana.

Dr. Cavalieri asked for a comment on the possible role of sugar beets. Mr. Weston noted that the research into processing sugar beets is not as advanced as that for sugar cane, although the Brazilians and Australians are researching their cellulosic potential. Beets have a pulp that is similar to paper mill pulp, and there is not currently a more expedient or more cost effective method of conversion than for cane. Mr. Weston also added that beets have no burnable byproducts.

Doug Hawkins asked what the value of burning bagasse for electricity versus sugar cane production is. The Committee was unsure if a study had been done, and Harry Baumes suggested mandating a study. Jim Martin postulated that bagasse might produce ten Btus/ton, which would make it more cost effective to burn than coal, and worth investigating further.

Mr. Weston also noted that sugar crops often compete for land with perennial switchgrasses and the cane must be milled in close geographical proximity to the processing site. There is a narrow harvest window for sugar cane, which can affect the processing costs. There was agreement that more information was needed regarding the energy versus sugar issue.

VII. Reports from the Subcommittees

Analysis Subcommittee

Mr. Rossmeissl introduced Ralph Cavalieri, who gave the Analysis Subcommittee report. Dr. Cavalieri notified the group that he had received a list of analytical reports from DOE, from which foundational documents were selected for evaluation. Harry Baumes was asked to do the same for the USDA.

Mr. Baumes commented that all three arms of the USDA have gone through various types of professional review, and Dr. Cavalieri suggested that Mr. Baumes evaluate those documents as well. Additionally, the 30 x ‘30 and National Biofuels Action Plans may available for subcommittee review by the September 2007 meeting.

Jim Martin asked if the analysis committee has looked at the “Billion Ton Study”, and Dr. Cavalieri replied that they had.

Mr. Rossmeissl stated that the original Policy Gap Analysis was intended to be published and made available to USDA to support Farm Bill analysis and deliberations.

Mr. Baumes noted that the Farm Bill theme papers were recently released, and that they identify various government policies. Mr. Ewing asked if these would be available for the committee’s May meeting, and Mr. Baumes responded that it was likely to be available then.

Mr. Hagy said that in the next two weeks he well communicate with the Committee on policy suggestions for the newest Farm Bill negotiations. Bob Sharp recommended including the cost of transportation issue. He suggested a provision allowing for those transporting agricultural products with six axle vehicles to be subject higher weight limit on highways, providing an opportunity for efficient transport of farm freight. EPA regulations have decreased transport efficiency simultaneous to increases in the price of fuel.

Committee Chairman Tom Ewing agreed that policy suggestions from the revised Policy Gap Analysis (Attachment H) would be provided to USDA for Farm Bill consideration. Ed White replied that the document could also be made available to other groups for greater impact. He has already discussed its contents with state forestry representatives. Tom Ewing asked Committee staff to make a revised document available for Committee discussion the next morning. Doug Hawkins stated that the document, with editorial comments, could undergo an approval vote. He asked that the version voted on not include his comments regarding funding, which were intended merely to spur debate, but suggested that Eric Larson’s comments regarding price floors and carbon taxes should be included.

Policy Subcommittee

Committee Chairman Tom Ewing followed discussion of the Policy subcommittee's Policy Gap Analysis document by requesting discussion of the subcommittee's activities since the last meeting. Neil Rossmeissl announced that subcommittee chairman Jim Barber was unable to attend, and that Doug Hawkins would instead discuss a report on a fuel tax.

Mr. Hawkins began by saying that policy makers are good at proposing tax incentives, capital investment, and research and development funding. He stated that although tax increases are not popular, he proposes implementation of a five cent per gallon tax on all non-renewable fossil fuel and liquid transportation fuels. Scott Mason inquired when in the supply chain the tax would be implemented, and Mr. Hawkins clarified that the tax would be at the refinery level. Mr. Mason stated the tax did not sound like a policy that politicians would be able to support. Committee Chairman Ewing then suggested a tax on imported oil, a carbon tax, to spur domestic production. Eric Larson mentioned that rather than framing the issue as a tax, it could be framed as floor on the price of oil. In response, Chairman Ewing said that a similar idea had been floated around the Aspen Institute a year ago.

Chairman Ewing stated that renewable fuels do have some of the same problems as gasoline. Mark Maher agreed, noting the loss in volumetric fuel economy with E85 use. Swedish tax policy has assured that the price of E85 accounts for its loss in energy density, and Brazilians price E100 fuel 30 percent lower than gasoline. The loss of energy density of gasoline blended with E10, however, is very small. The purpose of such price controls is to assist in infrastructure development, or creation of consumer demand. Mr. Baumes agreed that tying an objective to a cost can be beneficial.

Mr. Hawkins said that he did not believe that a five cent or even a ten cent per gallon tax would cause an adequate increase in the research and development of renewable fuels. Mr. Rossmeissl asked if anyone had considered a modified carbon tax that would be tied to the cleanness of the fuel and the efficiency of its use. Mr. Hawkins questioned if such a tax would be any easier to manage.

Bill Hagy thought that Senator Harkin had proposed a tax similar to the ones being discussed, and Mr. Rossmeissl confirmed this. The purpose of Senator Harkin's proposed tax was to increase biorefinery investment.

Mr. Mason touched on some of the tricky economic issues of pricing. When stores serve E10 customers with free E85, the price is no longer correct. He confessed that he was uncomfortable with some of the funding issues at hand and would like to see the Committee focus on an appropriate course of action.

Mr. Larson observed that a common objective was clearly to increase the market penetration of biofuels, and that the Committee has the expertise, ideas, contribute to that end. The Committee should look at the low-carbon fuels standard from California that is similar to renewable portfolio standards (RPS) for electricity, because existing policies provide a ready market for low-carbon fuels, biofuels, and other renewables.

Mr. Rossmeissl introduced a draft white paper by Committee member John McKenna for discussion. The white paper was not for distribution, though discussion was public. Regarding his proposals in the white paper, Mr. McKenna stated that public market models like SASOL, a South African synfuels operation, are his recommendation for future investment. SASOL is an example where government can invest in or help establish an industrial operation initially. Once it becomes self sustaining, the entity can become independent or go private. SASOL is now a world leader in synfuels production. Many investment clients seek innovative technologies, which come with risk. Mr. McKenna asked whether the government could augment research and development funds to jump-start commercialization.

Mr. Rossmeissl replied that he understood Mr. McKenna's sensitivity about financial aspects of policy documents. He noted that some options, including loan guarantees, did not work well when they were first experimented with in the 1970s. The administration is open to new ideas, and Mr. Rossmeissl asked the Committee to consider suggesting alternatives. Mr. McKenna said that his concern is that non-economists are dabbling in economic matters and that they run the risk of deteriorating credibility, as well as diluting the effect of experts' information. Mr. Rossmeissl reminded everyone that the policies in place are not working and they require analysis. Mr. McKenna recommended that any Committee discussion with government representatives should revolve around a list of agreed-upon issues, and Lou Honary agreed, saying that it would make their message more accessible.

Mr. Smith commented, saying that he thought that high energy costs are better in the long run for agriculture. There are transition problems, but as the country moves toward a more biobased economy, agriculture and forestry will be in the perfect position to capture the market.

Committee Chairman Ewing stated that Mr. McKenna's concerns are understandable, but there may not be a big difference between recommending additional funds for biofuels incentives, and recommending a specific tax. Recommending a tax will create a situation where one recommendation becomes the only item a document is known for, overshadowing other issues. If the Committee suggested that more funds be infused into the system, that would tell legislators that something needs to happen.

Mr. Larson suggested that there be a hybrid between the tax and funding suggestions. David Anton proposed including an appendix to the Committee's Policy Gap Analysis, listing the funding mechanisms discussed, noting that there was a lack of consensus, excluding a recommendation. Mr. McKenna agreed with Mr. Anton, saying that the goal is to provide people with factual information that they can use.

Communications Subcommittee

Committee Chairman Ewing moved in the agenda to an update from the newly-formed Communications Subcommittee, of which he is also the chair. He stated that the result of subcommittee discussions is a suggestion to request that the Secretaries of Agriculture and Energy work with the Committee on publicizing its documents. Bill Hagy asked whether joint announcements should be made by the Secretaries at Committee meetings, and Chairman Ewing responded that the Committee would like to make announcements with the support of the agencies. Committee staff will need to maintain communication with the Secretaries' communications offices.

Neil Rossmeissl introduced a discussion of the biofuels initiative and made a presentation (Attachment I). Charles Kinoshita asked if there was a list of replicable feedstocks, and Mr. Rossmeissl responded that a list would be based on a criteria set forth by reviewers, and that such a list does not yet exist. David Anton asked what level of funding the upcoming ten percent validation solicitation will receive, and Mr. Rossmeissl said the awards will be made as a fifty-fifty cost share with industry recipients. Eric Larson asked how many awards will be made, to which Mr. Rossmeissl responded that no appropriation has yet been made by Congress to fund the awards. Mr. Larson followed by asking whether national replication discussed in the presentation will conflict with regional feedstocks efforts. Mr. Rossmeissl answered that DOE approaches feedstock R&D as a process integration and efficiency issue. John McKenna asked whether the Biomass Program's goals assume bioprocesses will all be consolidated. Mr. Rossmeissl answered that the goals assume aggressive conversion efficiency, and that bioproducts are incorporated in the National Biofuels Action Plan. David Anton stated that he disagrees with all cost target numbers. Doug Hawkins asked how Committee members can comment on the National Biofuels Action Plan. Mr. Rossmeissl answered that the Committee can make recommendations in their Annual Report to the Secretaries and Congress.

John Hickman asked whether the 30 x '30 goal analysis document was no longer scheduled for Committee review. Mr. Rossmeissl replied that the document was being finalized for publication, and could be to the Committee in two weeks. The draft NBA Plan is due for interagency discussion on March 16, 2007.

VIII. Adjournment – Day 1

Committee Chairman Tom Ewing adjourned the meeting for the day.

Day 2 - February 14, 2007

Committee Chairman Tom Ewing called day two of the meeting to order and began discussion of Committee recommendations to the Secretaries for fiscal year 2007.

IX. Recommendations to the Secretaries

To begin the discussion, Doug Hawkins made a presentation of the revised Policy Gap Analysis, including several policy recommendations (Attachment I). Eric Larson and Bob Sharp's comments were integrated. John McKenna moved to strike certain language. Tom Binder seconded the motion, which did not carry. Mark Maher moved that the previous edit should be removed, but that amendments to paragraph two should remain. Rod Williamson seconded the motion. John McKenna stated that equal support for all incentives in the report will limit actual incentive activity. Mark Maher's comments on paragraph two were integrated in the document. The comments were approved by majority vote. Mitch Peele's changes to paragraph three were unanimously approved. Eric Larson's changes to paragraph four were unanimously approved.

X. Public Comment

There was no public comment.

XI. Presentation on Biomass Public Policy R&D Project

Larry Biles made a presentation on the Southern Forest Research Partnership, Inc. (SFRP) (Attachment J). SFRP work is funded in part by an award made by the Biomass Initiative USDA-DOE joint solicitation in fiscal year 2004. He also provided for review the SFRP Handbook, due to be published in a few weeks. The presentation advocated the inclusion of forestry in the research titles of the Farm Bill, as well as the facilitation of university partnerships.

Bob Sharp commented that there are 41 million dry tons of available feedstocks in the South, which converts to about 300 million dry tons and 82 billion total wet tons. He believes that energy will compete with the paper industry for these feedstocks, and it will be important to understand the trade-offs. We should know what the total energy potential would be if paper residue were added, and how much residue could be added. He postulated that available residue may total 300 million tons. Specifics should be determined in regard to the portion used for paper, and how much can be reallocated to energy. Larry Biles agreed that calculations must be done. Ralph Cavalieri suggested obtaining grant money and pursuing university partnerships to begin analysis. Dr. Biles said that there is no current university investment.

Dr. Cavalieri asked how much woody feedstock there is in northwestern forests, and Dr. Biles answered that a great deal of material is available; however, harvesting technologies are different in the western mountains and the volume of material and species vary. Mr. Sharp noted that some southern materials have to be harvested at certain seasonal times, while the national average is a bit longer. It was agreed that the SFRP handbook could be oriented more toward a national audience.

Dr. Biles suggested that SFRP plans to communicate with USDA's Natural Resources Conservation Service, soil and water offices, and timber harvesters. Bill Hagy asked if the forest service would continue to support the SFRP's work, and Dr. Biles said that even more support was necessary.

John McKenna inquired into the project's position on thermochemical conversion, and Dr. Biles said that SFRP documents identify processes around thermochemical and biochemical conversion, and let readers decide which to pursue.

XII. Presentation on Bioconversion R&D Project

Chairman Ewing introduced K.T. Shanmugam of the University of Florida – Gainesville, who gave a presentation regarding his office's R&D project (Attachment K). The project is funded in part by part by an award made by the Biomass Initiative USDA-DOE joint solicitation in fiscal year 2003.

Mr. Shanmugam began by talking about the creation and development of enzymes. Sugar is produced by a pretreatment and is fermented into fuel ethanol. Some streams produce butanol, and other byproducts such as lactic, pyric, and sacilic acids. Organisms are developed which match cellulase enzyme activity. Science needs to find a way to reduce cellulase, which is a high cost component of the conversion process.

Tom Binder asked what ethanol's tolerance of the microbe is at 55 degrees, and Mr. Shanmugam responded that it was 4.5 percent. Mr. McKenna asked if the E. coli solution was licensed to BC international/Celunol, and Mr. Shanmugam replied that it was already commercial. John McKenna asked whether Mr. Shanmugam's work is separate from these companies'. Mr. Shanmugam stated that the university is using non-proprietary enzymes, which are probably available to companies such as Celunol.

Eric Larson asked how specific to feedstocks the organisms are, and Mr. Shanmugam said that it should not make a difference. Organisms find sugars, and then ferment glucose, manose, lactose, arabinose, and xylose, which are all found in cellulosic biomass. Mr. Larson clarified that the difference lies mainly in sugars' production, then asked about a National Renewable Energy Laboratory study, which states that the cost of conversion cellulase is nine percent. He asked whether the cost can be eliminated. Mr. Shanmugam explained that rural economics was not his area of specialty, but that the assumption of cost is about eight to twenty cents per gallon, which could be reduced to five cents per gallon, using the same cost structure as corn ethanol. Dr. Cavalieri asked what the challenges to achieving that price would be, and Mr. Shanmugam responded that converting to being an ethanol producer is a big step. He continued, explaining that there is more than one pathway to success in developing effective organisms. In the next few years, the production of organisms should be well-established, and ethanol-producing organisms should be ready by next year. In response to a question by Mr. Larson, it was articulated that, even with more research and development funding, the process of organism development could not be made much faster. Yeast can tolerate alcohols at up to fifteen percent, while this organism can only tolerate up to five percent. The difference may not be a problem, but Mr. Shanmugam is concerned.

XIII. Discussion of Agenda for Next Meeting

Committee Chairman Tom Ewing thanked Mr. Shanmugam for his presentation, and began Committee discussion of items for the next meeting, scheduled for May 15-16, 2007.

Doug Hawkins asked if Michael Wang from Argonne National Laboratory would be on the agenda, as previously discussed. Neil Rossmeissl affirmed this, and stated that representatives of the DOE Office of Science have also been invited.

Lou Honary suggested that he would like to invite someone to make a presentation regarding biobased lubricants, to which Chairman Ewing agreed.

Bill Hagy stated that if a USDA R&D strategy plan is developed by May, it should be presented.

Mr. Rossmeissl brought up the issue of the Policy Gap Analysis, and Charles Kinoshita suggested having an assessment of agency and congressional response to the recommendations.

Chairman Ewing stated that Committee member Mark Maher has invited the group to hold its meeting at GM facilities in Detroit in September. The group could also tour several fuel testing and proving facilities. Jim Martin inquired whether any biobased products are currently used in GM car manufacturing, and Mr. Maher said that he would investigate the answer.

John McKenna asked whether the Policy Gap Analysis will be made available to the public on the Committee website. Neil Rossmeissl answered that since the document, as revised, has received Committee approval, it will be posted, and submitted to DOE and USDA. In addition, it will be included in the Committee's annual report to Congress. Jeff Serfass asked whether Policy Gap Analysis recommendations will become part of the annual report section containing overall Committee recommendations to the agencies. Mr. Rossmeissl suggested that the Policy Gap Analysis and the annual report remain separate documents. If recommendations from the former are extracted to become part of the latter, the Committee must discuss them separately. He understood that Jim Martin wants a number of the Policy Gap Analysis items developed for inclusion in the FY 2007 annual report.

Committee Chairman Tom Ewing asked when the final version of the *Roadmap for Biomass Technologies in the United States* will be available. Mike Manella of BCS, Incorporated stated that a timeline would be emailed to Committee members. Tom

Binder said that it would probably be submitted to the Biomass R&D Board in July 2007. Chairman Ewing requested that the Committee receive a draft of the *Roadmap* at the May meeting. Doug Hawkins said that it would be possible after comments were received from focus teams on May 11, assuming there were not many revisions to be made at that point.

XIV. Adjournment – Day 2

Chairman Ewing thanked Mr. Rossmeissl for his efforts and adjourned the meeting.

ADDENDUM A

Biomass Research & Development
Technical Advisory Committee Meeting
February 13-14, 2007

ATTENDEES

Committee Members Present

Tom Ewing – Committee Chairman
David Anton
Tom Binder
Ralph Cavalieri
Doug Hawkins
John Hickman
Lou Honary
Charles Kinoshita
Eric Larson
Mark Maher
Jim Martin
Scott Mason
John McKenna
Mitch Peele
Jeff Serfass
Bob Sharp
Read Smith
Ed White
Rodney Williamson

Committee Members Not Present

Jim Barber
Tom Binder
Butch Blazer
Bob Dinneen
Alan Kennett
Ed McClellan
Larry Pearce

Federal Employees Present

William Hagy III - USDA
Neil Rossmeissl – DOE
Harry Baumes - USDA

Total Attendees: 27
Total Members of the Public: 3

ADDENDUM B

Agenda

Public Meeting of the
Biomass Research and Development Technical Advisory Committee
February 13-14, 2007

Doubletree Hotel Orlando
Dade/Florida Keys Room
At the Entrance to Universal Orlando
5780 Major Boulevard
Orlando, FL 32819

Day 1 **February 13, 2007**

7:30 – 8:30 Continental Breakfast

8:30 – 8:40 Welcome to the Public and Overview of Meeting Agenda – *Committee Chairman Thomas Ewing*

8:40 – 9:10 Presentation on the Status of USDA – DOE Biomass R&D Collaboration – *Bill Hagy, Rural Business-Cooperative Programs, USDA liaison to the Committee*

- Status of the FY 2007 USDA – DOE Joint Biomass R&D Solicitation
- Update on the October 10-12, 2006 USDA - DOE Advancing Renewable Energy Conference
- Update on the USDA Energy Council Activities
- Update on USDA study on benefits of prior year awards under Farm Bill Section 9008
- Update on NOFA for Section 9006, Renewable Energy Systems/Energy Efficiency Improvements Program

9:10 – 9:40 Presentation on the Status of DOE Biomass R&D Efforts – *Neil Rossmeissl, Office of the Biomass Program (OBP), Designated Federal Officer (DFO), DOE*

9:40 – 10:50 Presentation on Feedstocks Analysis Efforts – *Dr. Richard Hess, Laboratory Relationship Manager, Idaho National Laboratory*

10:50 – 12:00 Discussion of the draft updated *Roadmap for Biomass Technologies in the U.S.*
- Discuss draft timeline
- Discuss carbon reduction issues which can be integrated into the Roadmap
- Discuss Food vs. Fuel

12:00 – 1:00 Lunch (*to be provided*)

1:00 – 2:30 Subcommittee Discussions

1:00 – 1:15 Analysis Subcommittee progress and 2007 goals – *Ralph Cavalieri, subcommittee chairman*

1:15 – 1:30 Policy Subcommittee progress and 2007 goals– *Jim Barber, subcommittee chairman*

1:30 – 1:45 Communications Subcommittee progress and 2007 goals – *Tom Ewing, subcommittee chairman*

1: 45 – 2:00 Discussion

2:30 – 2:45 Public Comment

2:45 – 3:00 Break

3:00 - 4:00 Discussion of FY 2007 Biomass R&D Planning – *Neil Rossmeissl, OBP, DFO, DOE*
- National Biofuels Action Plan
- Biomass Technologies Investment Strategy

4:00 – 4:15 Additional Discussion

4:15 – 4:30 Additional Public Comment

4:30 Adjourn

Day 2	**February 14, 2007**

7:30 – 8:00	Continental Breakfast
8:00 – 9:30	Discussion of Recommendations to the Secretaries for Fiscal Year 2007
9:30 – 10:15	Discussion to Update 2007 Work Plan
10:15 – 10:30	Public Comment
10:30 – 10:45	Break
10:45 – 11:30	Presentation on FY 2004 Biomass Public Policy R&D project: "Sustainable Forestry for Biobased Energy and Biobased Products" – *Dr. Larry Biles, Southern Forest Research Partnership*
11:30 – 12:15	Presentation on FY 2003 Bioconversion R&D project: "Engineering Thermotolerant Biocatalyst for Biomass Conversion to Products" – *K.T. Shanmugam, UFRF Professor, Department of Microbiology and Cell Science, University of Florida*
12:15 – 12:30	Discussion
12:30	Adjourn

Attachment A

Release No. 0014.07 Contact: Brenda Chapin (202) 720-5447 USDA ANNOUNCES SPEAKERS FOR MARCH 1st OUTLOOK FORUM *"Agriculture at the Crossroads: Energy, Farm & Rural Policy"*

WASHINGTON, Jan. 25, 2007 - The U.S. Department of Agriculture today confirmed plenary speakers for USDA's 83rd annual Agricultural Outlook Forum, "Agriculture at the Crossroads: Energy, Farm and Rural Policy," March 1 and 2 at the Crystal Gateway Marriott Hotel in Arlington, Virginia. Agriculture Secretary Mike Johanns delivers the keynote address on Thursday, March 1.

"USDA's 2007 Agricultural Outlook Forum explores renewable energy's future in biofuels, cellulosic, methane, and wind," said Johanns. "The Forum's national conversation about agriculture centers on the fascinating opportunities and challenges of renewable energy in the next farm bill and beyond."

"Renewable Energy - Inroads to Agriculture," the Forum's plenary panel, includes Archer Daniels Midland President and CEO Patricia Woertz; Cargill Chairman and CEO Warren R. Staley; American Petroleum Institute President and Chairman Red Cavaney; and CHS, Inc. President and CEO John Johnson. Scott Kilman, of the Wall Street Journal, will moderate the panel.

Forum dinner speaker, Indiana Governor Mitch Daniels will explore "21st Century Economic Development - A Renewed Focus on Agriculture."

"U.S. Potential for Biofuels," is addressed by Robert Dinneen, President of the Renewable Fuels Association. William A. Frey, DuPont's Global Business Director for Biofuels, explores the marketplace for biobutanol.

Chief Economist Keith Collins provides an overview of U.S. agriculture's economic outlook, with individual USDA sessions to address major commodities.

Discussion of the next farm bill features panelists Bob Stallman, President, American Farm Bureau Federation; Ralph Grossi, President of the American Farmland Trust; Howard Vincent, President and CEO of Pheasants Forever; and Ambassador Tom Nassif, President and CEO of the Western Growers Association and Co-Chairman of the Specialty Crop Farm Bill Alliance. The discussion will be moderated by Bruce Gardner, Distinguished University Professor of Agriculture and Resource Economics at the University of Maryland.

Mark Keenum, Under Secretary for Farm and Foreign Agricultural Services presents USDA's farm bill perspective with specialized insight from Thomas Dorr, Under Secretary for Rural Development; Bruce Knight, Under Secretary for Marketing and Regulatory Programs; and Mark Rey, Under Secretary for Natural Resources and Environment. The moderator will be Arlen Lancaster, Chief of Natural Resources Conservation.

Examining the options and challenges of risk management are Roger Bernard of Pro Farmer and Dave Juday of World Perspectives.

Deputy Under Secretary for Farm and Foreign Agricultural Services A. Ellen Terpstra will address international agricultural trade. Stanford University's Tim Josling and William Cline of the Peterson Institute for International Economics discuss trade with developing countries. Addressing agricultural exports is William C. Motes of Informa Economics. Our trading partners also bring viewpoints from Sweden, Brazil, Japan, Australia, New Zealand, Mexico, Belgium, and France.

A full roster of speakers, program preview, and registration are available at www.usda.gov/oce/forum Registration is $300 until February 5 and $350 thereafter.

Plenary speeches are Webcast after 3:30 p.m. EST on March 1, with speech and PowerPoint presentations posted online at the end of each day's session.

Writers, reporters and editors may call Press Room Coordinator Priscilla Smith at 202-694-5022 or Forum Coordinator Brenda Chapin at 202-720-5447 for more details.

#

From Earth Policy Institute

Lester R. Brown, **“Beyond the Oil Peak”** and **“Stabilizing Climate”** in **Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble** (New York: W.W. Norton & Company, 2006).

Lester R. Brown, **Outgrowing the Earth** (New York: W.W. Norton & Company, 2005).

Lester R. Brown, “Exploding U.S. Grain Demand for Automotive Fuel Threatens World Food Security and Political Stability,” **Eco-Economy Update**, 3 November 2006.

Lester R. Brown, “Supermarkets and Service Stations Now Competing for Grain,” **Eco-Economy Update**, 13 July 2006.

Lester R. Brown, “World Grain Stocks Fall to 57 Days of Consumption: Grain Prices Starting to Rise,” **Eco-Economy Indicator**, 15 June 2006.

Lester R. Brown, “The Short Path to Oil Independence: Gas-Electric Hybrids and Wind Power Offer Winning Combination,” **Eco-Economy Update**, 13 October 2004.

From Other Sources

American Coalition for Ethanol (Ethanol.org), "**Ethanol Plants**," at http://www.ethanol.org/productionlist.htm.

BBI International, **Ethanol Producer Magazine**, "**Plant List**," at http://www.ethanolproducer.com/plant-list.jsp.

Keith Collins, Chief Economist, USDA, **Statement Before the U.S. Senate Committee on Environment and Public Works**, 6 September 2006.

F.O. Licht, **World Ethanol and Biofuels Report**, at http://www.agra-net.com.

Renewable Fuels Association, “**Ethanol Biorefinery Locations**," at http://www.ethanolrfa.org/industry/locations.

Heather Schoonover and Mark Muller, **Staying Home: How Ethanol Will Change U.S. Corn Exports** (Minneapolis, MN: Institute for Agriculture and Trade Policy, December 2006).

U.S. Department of Agriculture, Office of the Chief Economist, World Agricultural Outlook Board, **USDA Agricultural Baseline Projections to 2015** (Washington, DC: February 2006).

LINKS

American Coalition for Ethanol
http://www.ethanol.org

BBI International, **Ethanol Producer Magazine**
http://www.ethanolproducer.com

Food and Agricultural Policy Research Institute (FAPRI)
http://www.fapri.org

F.O. Licht, **World Ethanol and Biofuels Report**
http://www.agra-net.com

Renewable Fuels Association
http://www.ethanolrfa.org

United States Department of Agriculture
http://www.usda.gov

Attachment B

Committed to the future of rural communities.

Biomass R&D Technical Advisory Committee Meeting

Orlando, Florida

February 13, 2007

William F. Hagy III

Deputy Administrator, Business Programs

USDA Rural Development

Biomass Initiative Update

- Update on USDA's Fiscal Year (FY) 2006 Awards
- Update on FY 2007 Solicitation
- Update Section 9008 Portfolio Analysis
- Update on USDA – DOE Advancing Renewable Energy Conference
- Secretary's Energy Council
- FY 2007 Section 9006 NOFA
- Ag Outlook Forum

USDA's FY '06 Section 9008 Awards

Rural Development

Committed to the future of rural communities.

- Notice to Awardees/Non-awardees – 10/13/06
- 14 Awardees – Grant Closing Package – Issued 11/24/06
- Deadline for Return of Executed Grant Agreement – 60 days
- 8 of 14 Awardees – Grant Agreements have been signed.

FY '07 Section 9008 Solicitation

- *Federal Register Pre-application Notification*
- *Deadline for Pre-applications – 45 days*
- *Merit Review Committee Panel – 30 days*
- *Notification of Pre-application Review – 60 days*

Total = 135 days

FY '07 Section 9008 Solicitation
(continuation)

- Full Application due – 45 days
- Merit Review Committee Panel – 30 days
- Announce Awards – 60 days

Total – 135 days

Committed to the future of rural communities.

Advancing Renewable Energy

An American Rural Renaissance Conference

- 1350 Attendees
- Results / Next Steps
- http://www.usda.gov

  Spotlights! Renewable Energy

USDA'S Energy Council

Committed to the future of rural communities.

- Purpose: Coordinate Department Collaboration and Leveraging of Resources for Renewable Energy/Energy Efficiency Development.

- Three Committees
  - Research & Development (R&D)
  - Commercialization
  - Marketing / Outreach
  - International Energy Collaboration

USDA'S Energy Council (Con't)

Rural Development

Committed to the future of rural communities.

- R&D Committee
  - R&D Plan

- Commercialization Committee
  - Matrix
  - Intra-agency Coordination

- Marketing / Outreach Committee
  - Renewable Energy Conference

- International Energy Collaboration
  - Coordination of USDA Participation in numerous international related energy initiatives.

Section 9006 Funding Activity FY 2003 thru 2006
Renewable Energy/Energy Efficiency
Renewable Energy Systems

	No.	Amount	Leveraged
Biomass	171	$73,007,579	$287,428,389
Wind	168	33,506,152	489,345,477
Solar	40	2,224,639	5,924,634
Geothermal	15	921,282	2,763,869
Hybrid	11	2,021,236	182,159,526
Totals	405	$111,680,888	$967,621,898

Energy Efficiency Improvements: 426 - $10,043,959; Leverage Funds $30,046,333

Guaranteed Loans: 19 - $34,258,862; Leverage Funds $37,441,264

Grand Total: 850 - $155,983,709 Leveraged Funds $1,035,109,495

Committed to the future of rural communities.

Questions

USDA

Rural Development

Committed to the future of rural communities.

THE END

Attachment C

The Biomass R&D Technical Advisory Committee

Update on Action Items

February 13, 2007

Neil Rossmeissl

Annual Report

- The FY 2006 Report has been delayed due to OMB review and comments. Received OMB comments on February 9, for incorporation this week

- This document is due to Congress by December 20.

Membership

- 2006 Nominee package was held up in concurrence.
- It was signed on February 12.
- 6 Nominees and a Co-Chair were submitted.

Biofuels Initiative

- EPACT 932 Solicitation
  - 24 Proposals submitted and reviewed
  - 4 awards were selected for negotiation
  - Total Cost $630 million
  - Awards expected to be announced this week
- Ethanologen Solicitation
  - Proposals under review
  - Awards still anticipated in April

Biofuels Initiative

- EPACT 942
  - No Budget Authority - CR
  - Determination of incentive payment
  - Estimated 96 million gallons may apply
  - Reverse Auction scheduled for August 2008

Questions?

You can contact the Biomass Initiative at:
harriet.foster@ee.doe.gov
202-586-4541

Attachment D

Cellulosic Biomass Feedstocks and Logistics for ETOH

FACA Meeting
February 13-14, 2007
Orlando, FL

Richard Hess, Kevin Kenney, Chris Wright, Corey Radtke
Idaho National Laboratory
Bob Perlack
Oak Ridge National Laboratory

Idaho National Laboratory

OAK RIDGE NATIONAL LABORATORY

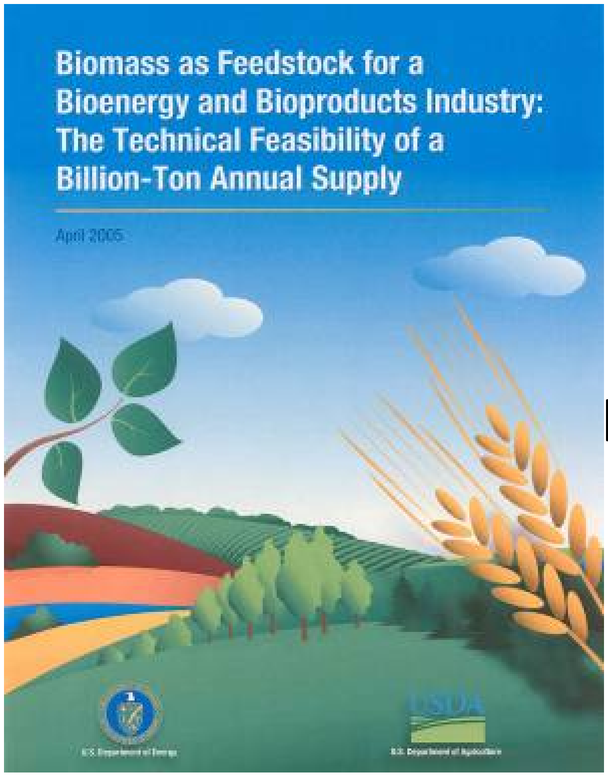
U.S. Department of Energy
Energy Efficiency and Renewable Energy

U.S. Department of Agriculture

DOE Biorefining Industry 2030 Goals

biomass program

Displace a significant fraction of gasoline demand ~ 60 billion gallons/year by 2030



http://bioenergy.ornl.gov

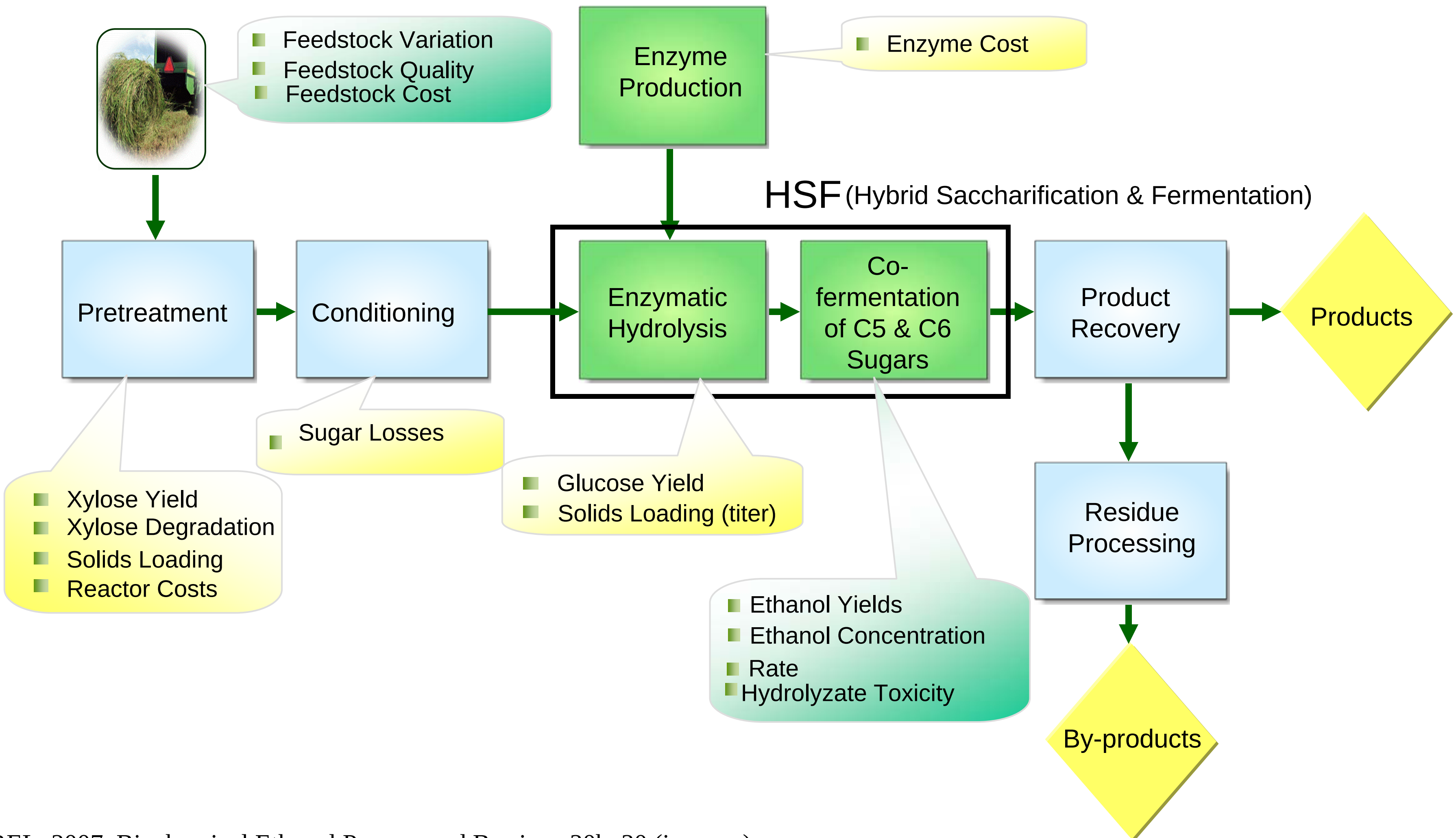
~1.3 Billion tons/yr Biomass Potential in the U.S.

Sugar Platform

Syngas Platform

Including Corn Grain, an <u>Estimated 600 – 700 Million Tons</u> of Biomass per Year is Needed for 60 B gal of ethanol.

Biochemical Conversion

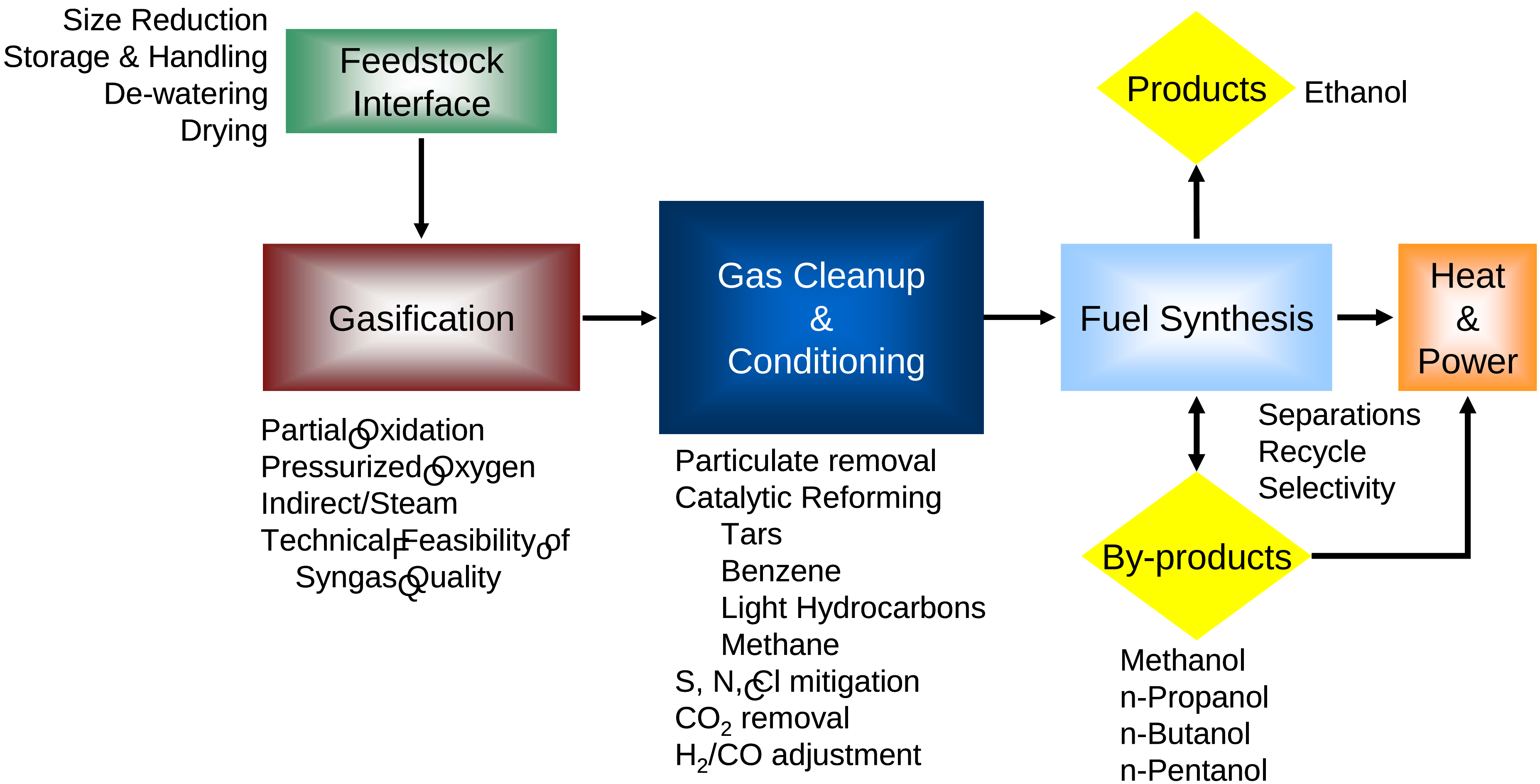


NREL. 2007. Biochemical Ethanol Process and Barriers. 30by30 (in press)

U.S. Department of Energy
Energy Efficiency and Renewable Energy
U.S. Department of Agriculture

Thermochemical Conversion

biomass program



NREL. 2007. Thermochemical Ethanol Process and Barriers. 30by30 (in press)

What is the Time-Frame for Required Feedstock Tonnages?

2012 – 2015 Time Frame:

- Grain Ethanol 7-8 billion gal.
- Cellulosic Ethanol 3-4 billion gal. (estimated 35-45 M tons)

2030 Time Frame:

- Grain Ethanol 13-14 billion gal.
- Cellulosic Ethanol 40-50 billion gal. (estimated 400-500 M tons)

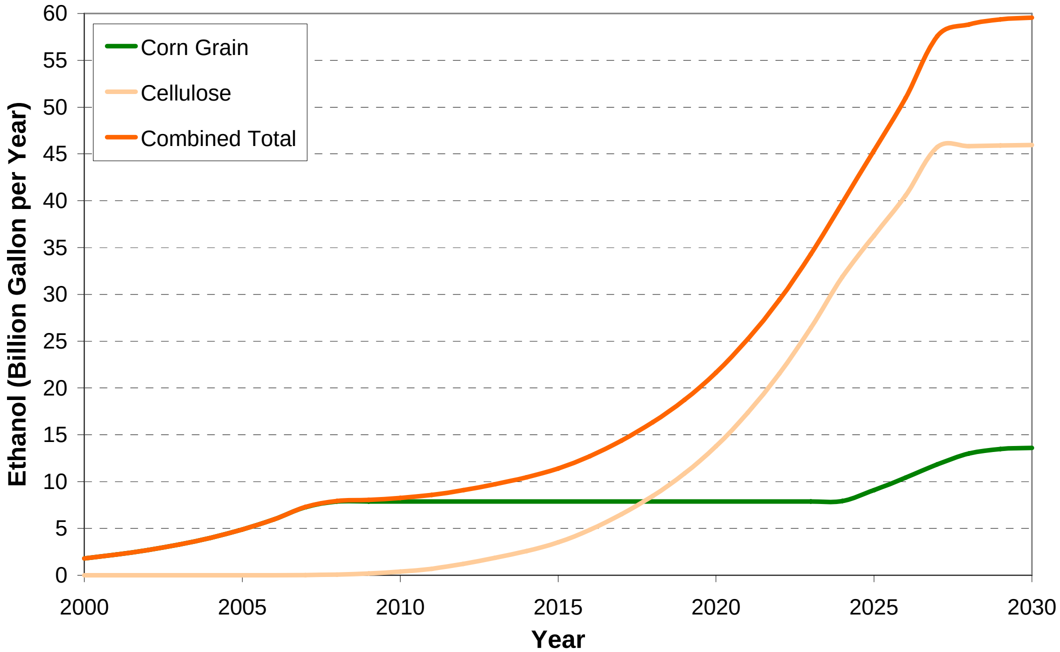
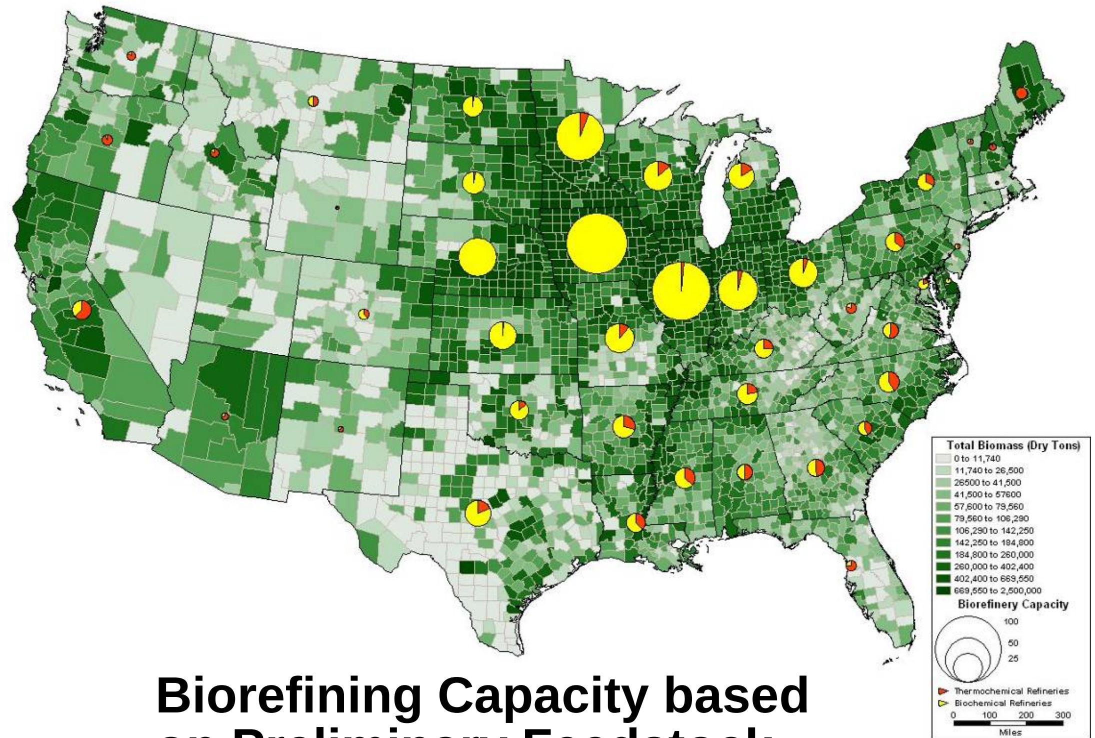


Chart representing ethanol volumes predicted from the high oil case using the transition model for the 30x30 NREL report. Date: 09/05/06, contact – Bob Wooley, National Renewable Energy Laboratory

Feedstock R&D to Achieve Ethanol Production Goals

Feedstock Supply must Answer:

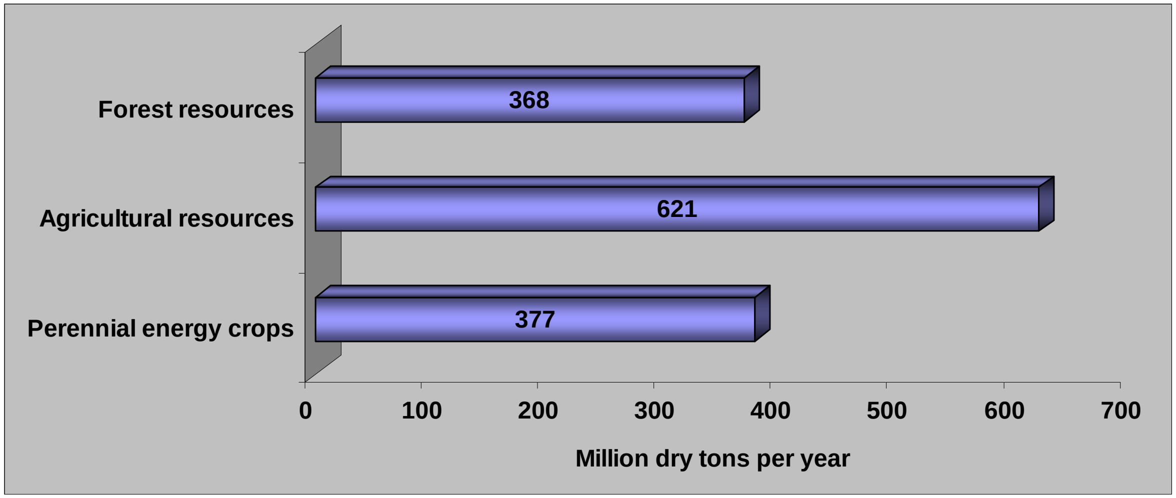
- *What are the Feedstocks?*
  - Feedstock and characteristics
  - Location
- *What are the Feedstock Tonnages and Costs?*
  - Supply potential
  - Availability and demand
- *What are the feedstock locations' opportunities / constraints?*
  - Production practices
  - Infrastructure constraints
- *What are the feedstock supply options and costs?*
  - Regional engineering designs
  - Dry, wet, and woody



Biorefining Capacity based on Preliminary Feedstock Resource Estimates – Map developed by Bob Perlack, ORNL, October 2006

Biomass Feedstock Resource Base

- US land resources can provide a sustainable 1.3 billion ton annuals biomass supply and still meet food, feed, and export demands
- Estimates are reasonable given trends and time for biorefinery scale-up/deployment



- **Forest resources**
  - **Logging residues**
  - **Forest thinnings (fuel treatments)**
  - Fuelwood
  - Primary wood processing mill residues
  - Secondary wood processing mill residues
  - Pulping liquors
  - Urban wood residues
- **Agricultural resources**
  - **Crop residues**
  - **Grains to biofuels**
  - **Perennial grasses**
  - **Perennial woody crops**
  - Animal manures
  - Food/feed processing residues
  - MSW and landfill gases

Biomass Feedstock Cost Target and Metrics

$$\$/\text{ton} = \left(\text{Grower Payment } [\$/\text{ton}]\right) + \left(\frac{\text{Efficiency } [\$/\text{hr}]}{\text{Capacity } [\text{ton/hr}]} + \text{Quality } [\$/\text{ton}]\right)$$

Therefore

\$35/ton = \$10-\$50/ton + \$25/ton

2012 Industry initiation/low demand Cost Target (2002$)

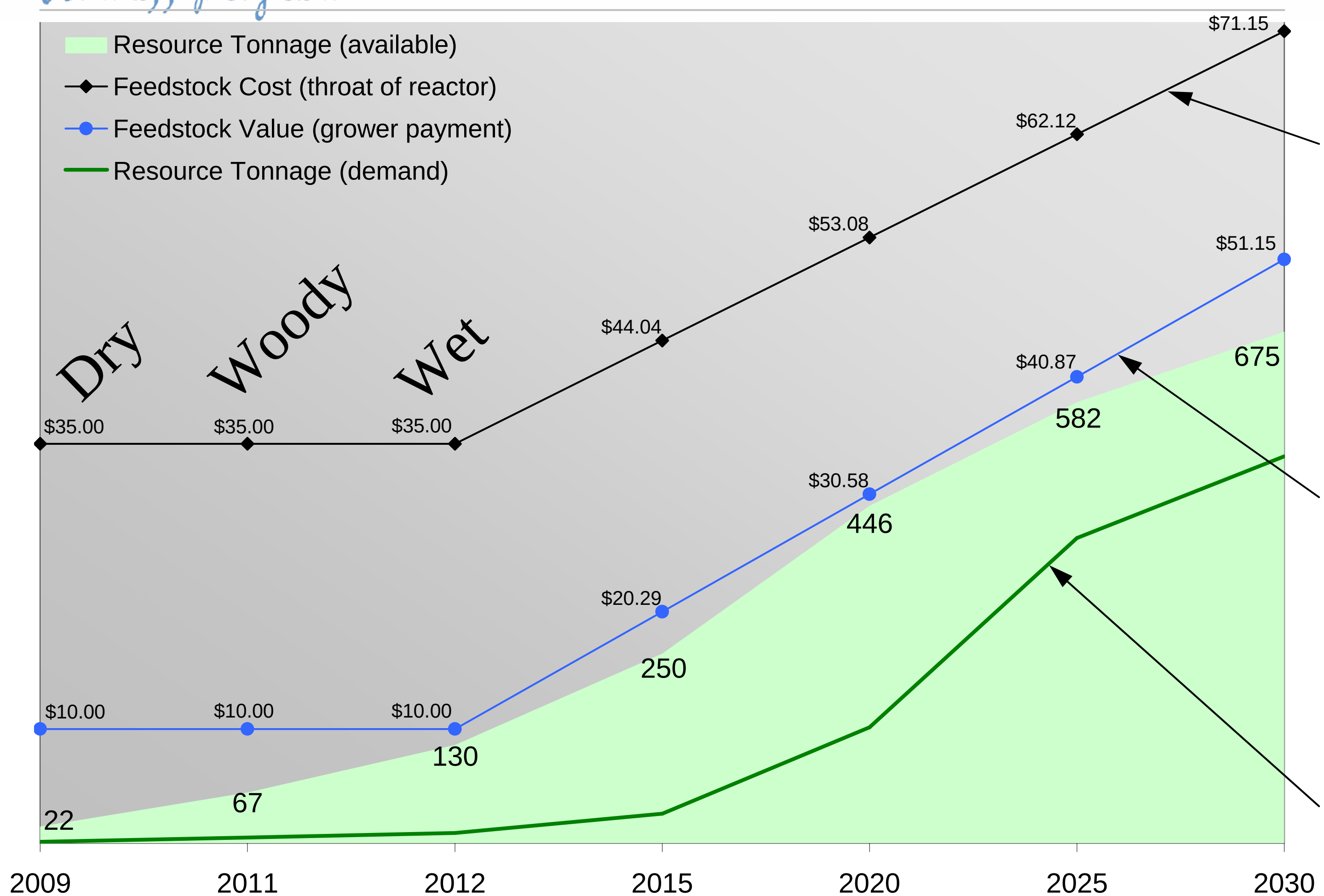
Feedstock Resource R&D Plan Contributes:

- Analysis and characterization
- Projections based on technology development and supply demand assumptions
- Technology development through "Regional" and "Office of Science" Partnerships

Feedstock Supply System R&D Plan Contributes:

- Engineering Designs
- Technology Development

Characterize Feedstock Tonnages and Costs? (Resource Assessment)



Price determined by what the conversion process can pay for feedstocks

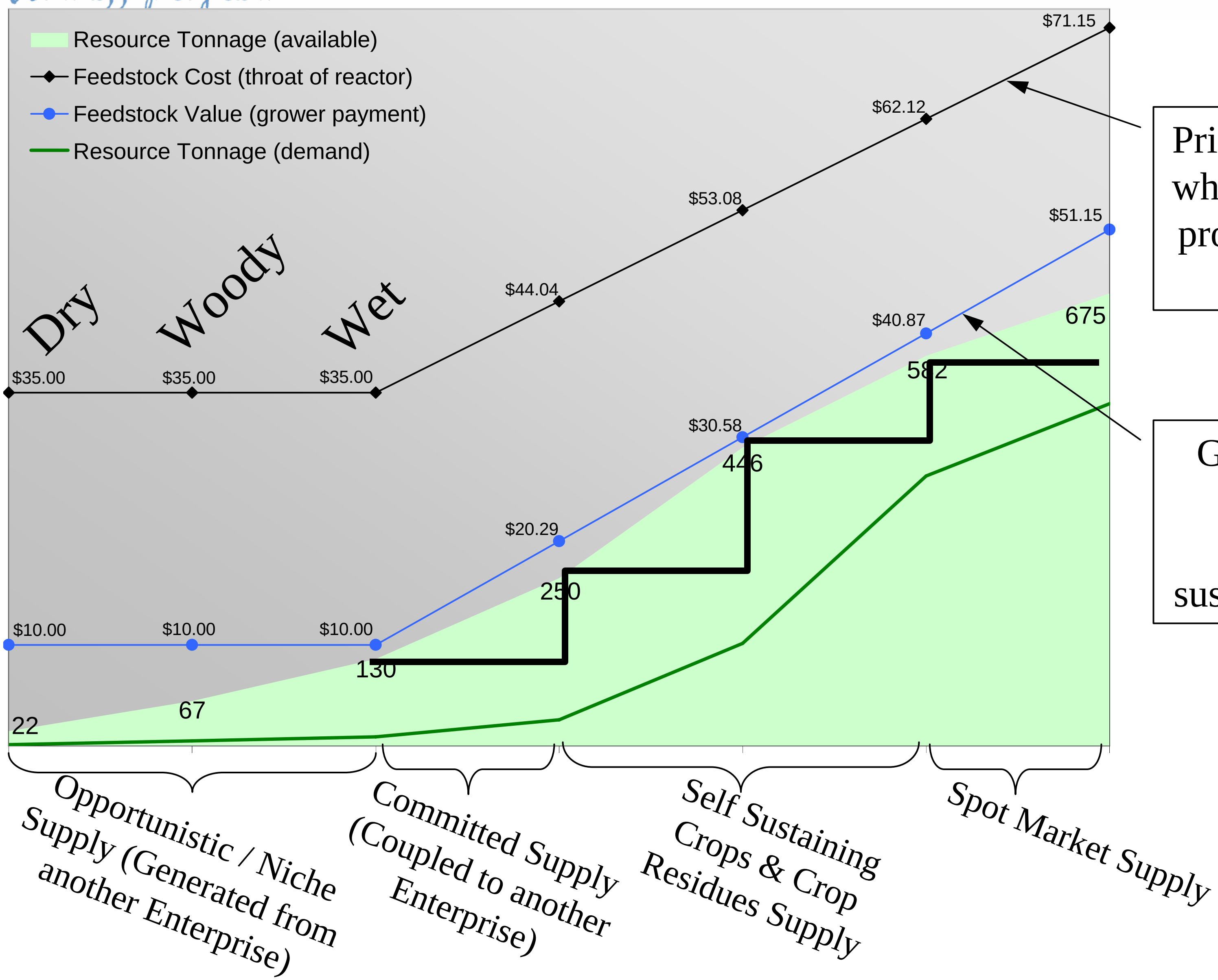
Grower Payment influenced by production / sustainability issues

Line represents tonnage needed for projected yearly ethanol demand

Increased tonnage due to advances in supply system technologies

Increased tonnage due to improved supply / conversion technologies (or policies) so that more can be paid for the feedstock resource

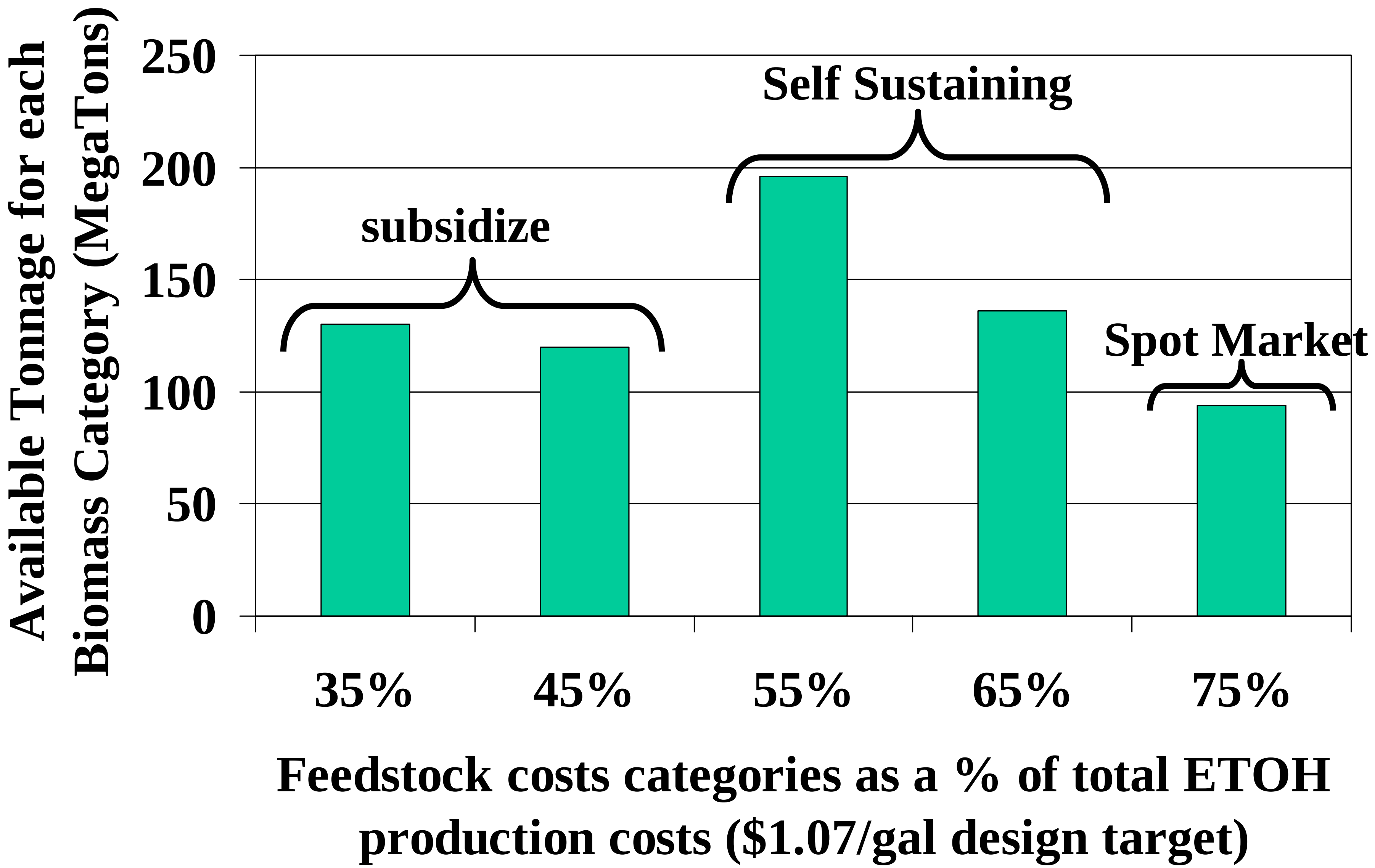
Characterize Feedstock Tonnages and Costs? (Resource Assessment)



Price determined by what the conversion process can pay for feedstocks

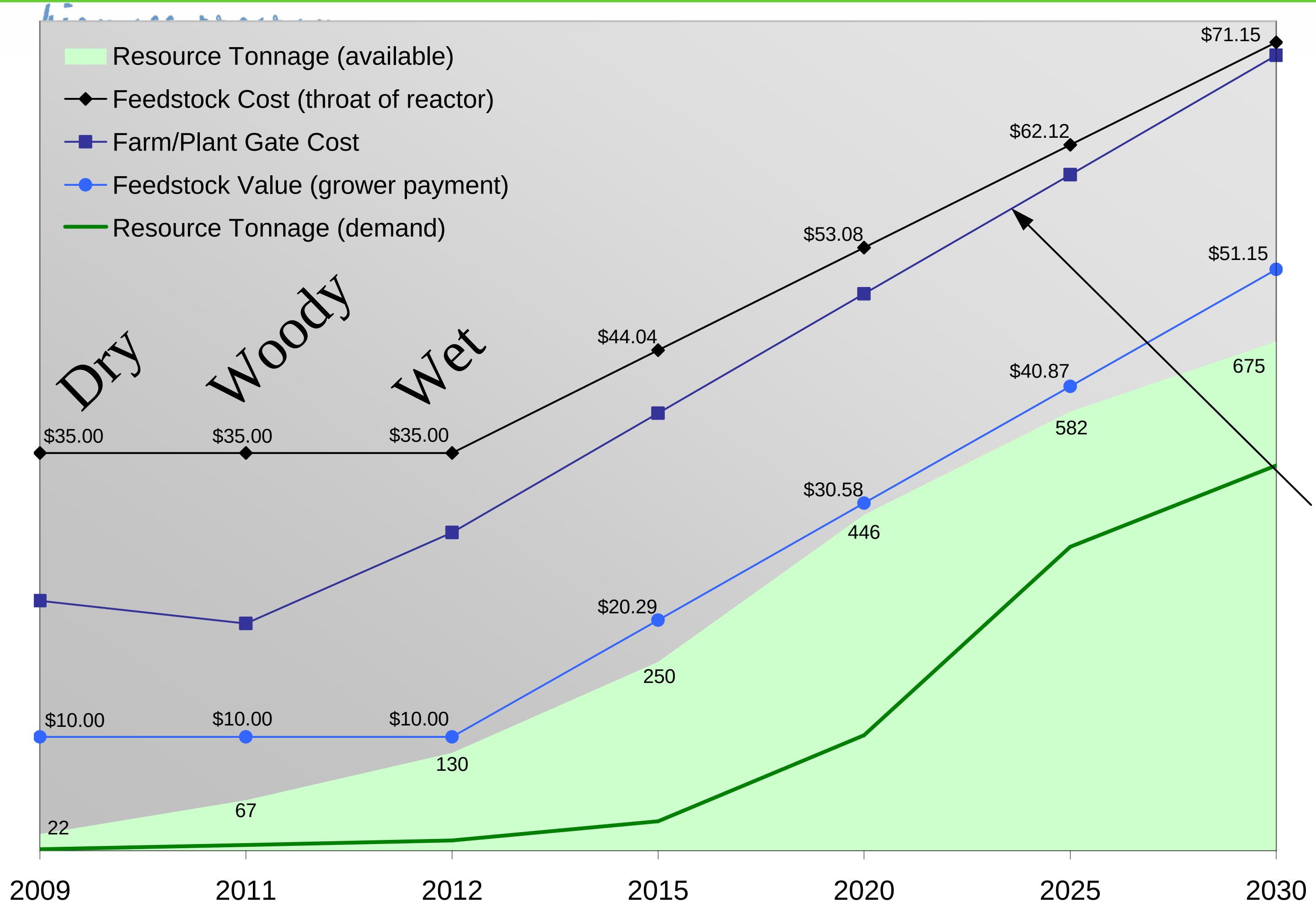
Grower Payment influenced by production / sustainability issues

Feedstock Categories and Characteristics



What are the Feedstock Tonnages and Costs?

U.S. Department of Energy
Energy Efficiency and Renewable Energy
U.S. Department of Agriculture



Price changes with different supply system technologies or configurations.

Lignocellulosic Feedstock Supply Types

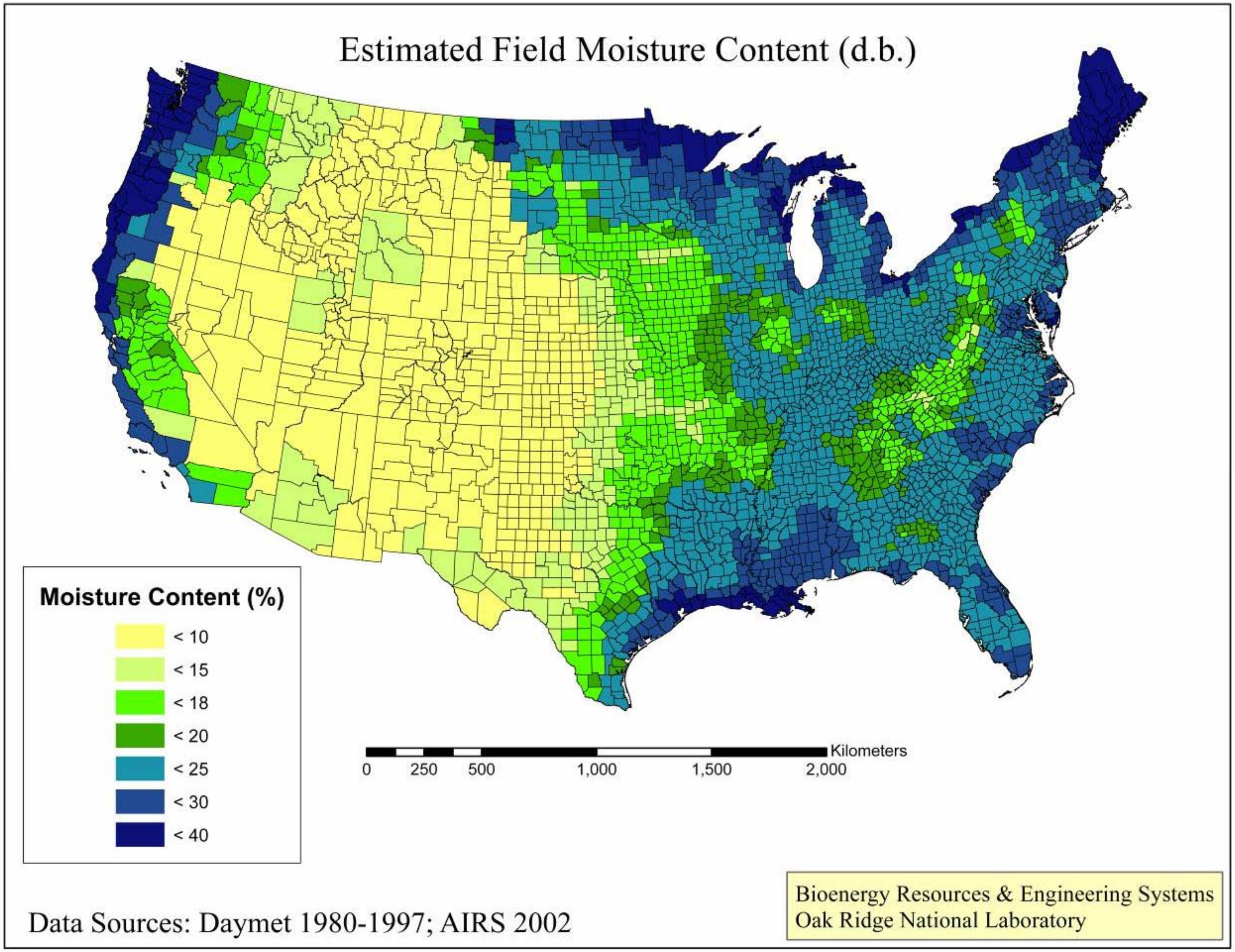
- Dry Herbaceous – Agriculture Residues/Crops at less than 15% moisture

- Wet Herbaceous - Agriculture Residues/Crops greater than about 50% moisture

- Energy Crops – Wet, Dry, and Woody

- Woody – Forest resources and woody energy crops

Estimated Field Moisture Content



Biomass Feedstock Cost Target and Metrics

$$\$/\text{ton} = \left(\text{Grower Payment } [\$/\text{ton}]\right) + \left(\frac{\text{Efficiency } [\$/\text{hr}]}{\text{Capacity } [\text{ton/hr}]} + \text{Quality } [\$/\text{ton}]\right)$$

Therefore

$35/ton = $10-$50/ton + $25/ton

2012 Industry initiation/low demand Cost Target (2002$)

Feedstock Resource R&D Plan Contributes:

- Analysis and characterization
- Projections based on technology development and supply demand assumptions
- Technology development through “Regional” and “Office of Science” Partnerships

Feedstock Supply System R&D Plan Contributes:

- Engineering Designs
- Technology Development

Feedstock Supply System Barriers and Interface Point

Performance Metrics:

- Efficiency ($/hr)
- Equipment Capacity (ton/hr)
- Biomass Quality ($/ton)

Biomass Production
- Agricultural Resources:
  - Crop Residues
  - Energy Crops
- Forest Resources:
  - Logging Residues
  - Harvested for Energy

Harvest and Collection → Storage → Preprocessing → Transportation → Handling and Queuing at the Biorefinery → Feedstock Interface Boundary

Harvest and Collection:
- Equipment Capacity
- Compositional Impacts
- Pretreatment Impacts

Storage:
- Shrinkage
- Compositional Impacts
- Pretreatment Impacts
- Soluble Sugar Capture

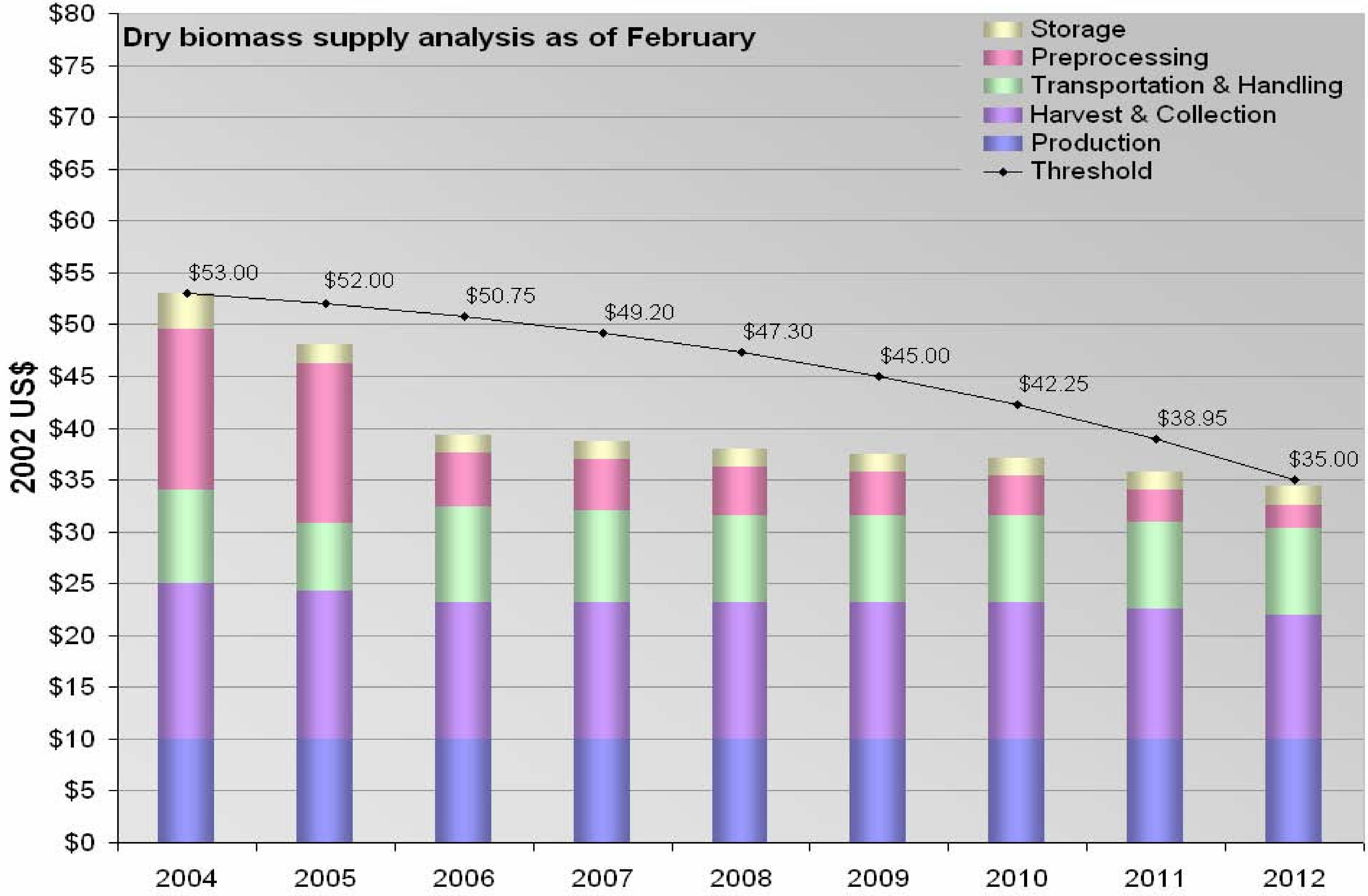
Preprocessing:
- Equipment Capacity
- Material Bulk Density
- Compositional Impacts
- Pretreatment Impacts

Transportation:
- Truck Capacity
- Loading compaction
- Loading efficiencies

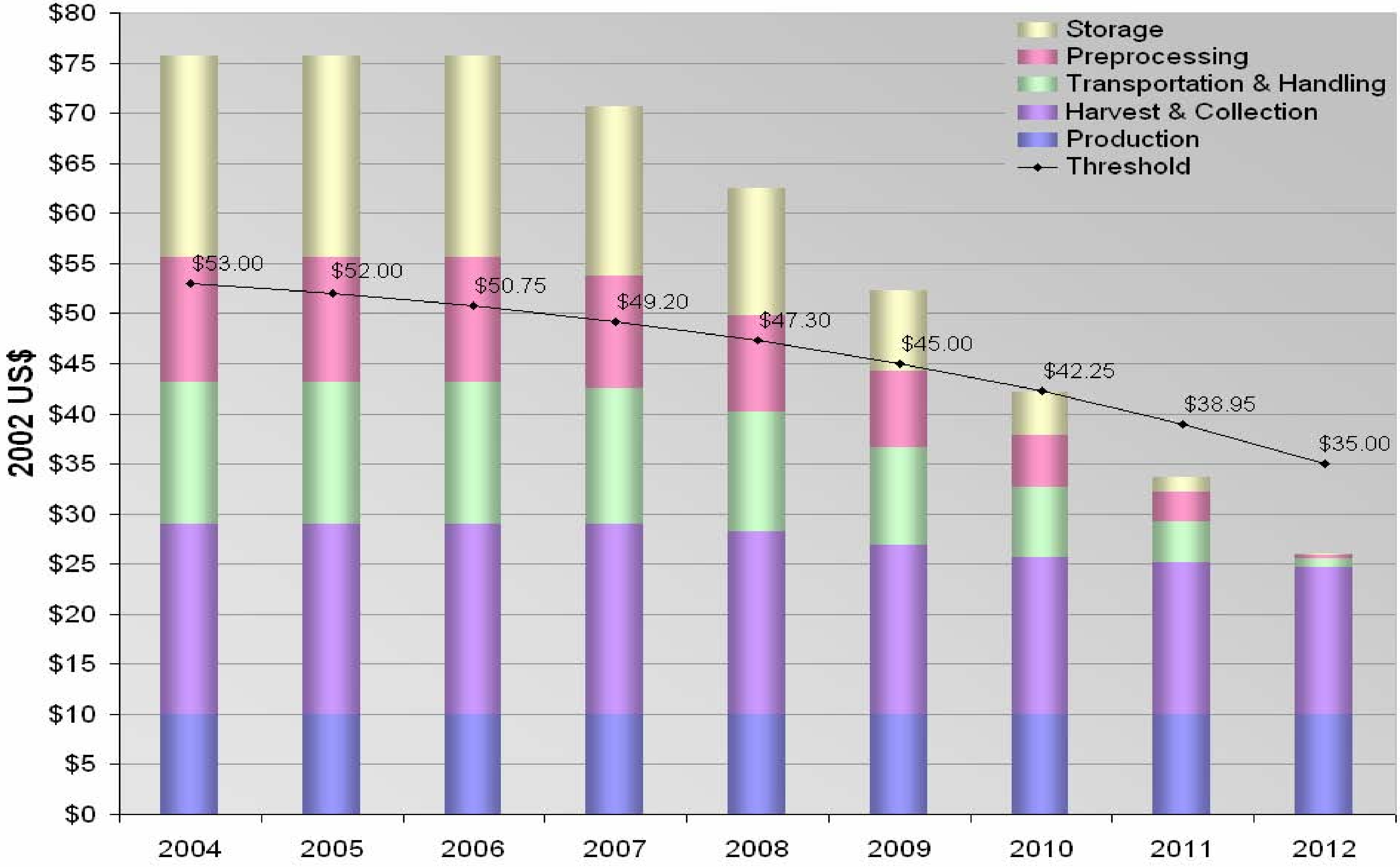
Handling and Queuing at the Biorefinery:
- Handling efficiencies
- Handling compaction
- Material Bulk Properties

Conversion Pathway's Reactors:
- Agricultural Residues
- Energy Crops
- Forest Products

Feedstock Cost Reduction by Cost Elements (Dry)



Feedstock Cost Reduction by Cost Elements (Wet)



Feedstock Supply System Models and Business Elements

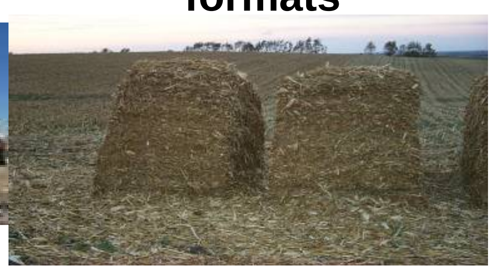
Distributed On-farm Storage

Bale-Based Feedstock Supply System

Agriculture

Bulk Feedstock Supply System

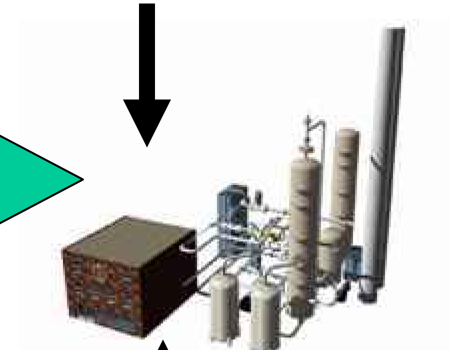
Bales or other formats



Farm Gate

Centralized Agri-business Storage

Agri business



Harvest and Collection

Location	Capital Investment	Capital Costs	Operating Costs	Labor Costs	Feedstock Costs
Idaho $35 Straw	$45.44	$5.37	$4.08	$1.05	$10.50
Kansas Straw	$33.67	$5.41	$4.42	$2.18	$12.02
Kansas Stover	$49.45	$7.79	$6.78	$3.60	$18.17
Kansas $35 Stover	$14.51	$1.57	$1.01	$1.29	$3.87

Description:

- ID Straw: combine, bale (4’x4’x8’), roadside
- KS Straw: combine, (4’x4’x8’), roadside
- KS Stover: combine, ***swath***, bale (4’x4’x8’), roadside

Explanation of Difference: ***Logistics***

- Swathing cost for stover
- Equipment utilization (ID: 1 crop, KS: 3 crops)
- Roadside distance (ID: 0.5 mi., KS: 5 mi.)




- Costs in $/dry ton, 2002 $
- Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Harvest and Collection (Continued)

Location	Capital Investment	Capital Costs	Operating Costs	Labor Costs	Feedstock Costs
Idaho $35 Straw	$45.44	$5.37	$4.08	$1.05	$10.50
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Kansas Stover	$49.45	$7.79	$6.78	$3.60	$18.17
Kansas $35 Stover	$14.51	$1.57	$1.01	$1.29	$3.87

Needed Improvements:

- Single-Pass/Selective Harvest – full bulk system
- Eliminate swathing ($5.78/dTon)
- Eliminate baling ($8.52/dTon)

Sweet Corn Harvester

(Photo Not Available)

- Costs in $/dry ton,, 2002 $
- Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Management Strategy Studies; Fractional Single-Pass vs. Mow and Rake

- Single-pass High cut harvested 72% of stover produced (i.e., 12% more stover collected per acre than billion ton study assumptions), so
- 70% removed with combine
  - Low moisture
  - Reduced pretreatment severity
  - Short soil half-life (Kumar and Goh, 2000; Eiland et al. 2001)
- 30% of stalk left behind
  - High moisture
  - Highly recalcitrant
  - Long soil half-life
- 40% removed with mow and rake – mostly stalk material

Agronomic Factors Limiting Corn Crop Potential

Limiting factor	*Issue(s)-addressed section 2.0*	*Proposed solution – addressed section 3.0*	*Guideline – addressed section 2.0*
Loss of soil carbon	Supply/replenish SOC Soil quality Future production capacity	Restrict stover removal to the amount exceeding that needed to maintain SOC. Develop situation specific guidelines and tools to estimate the amount of stover needed to maintain SOC. That is, create a "RUSLE" for SOC/soil quality management. Fractional or selective harvest.	This is the meat of work. Must be strong, but not long. We need to inform, not bore, a "lay" audience.
Soil erosion	Water erosion and runoff management Wind erosion management Off-site effects	Restrict stover removal to the amount exceeding that needed to keep soil loss to less than T, use RUSLE/RUSLE2 and NRCS guidelines and procedures to identify practices	Keep this short. NRCS has this covered. It's not our main issue, but we have to cover it for completeness.
Loss of plant nutrients	Increased fertilizer application and production costs	Retain stover Improve nutrient use efficiency Return ligneous conversion by-product or boiler ash to land (??). Fractional or selective harvest.	Secondary issue. May need to find some data on indicate how quickly nutrients in stover are cycled into plant-available forms.
Soil Compaction	Compaction of soil due to increase field traffic for residue removal and/or transition to no-till cropping system	Agronomic solutions?? Single pass harvesting systems	Reduce or eliminate harvest operations to reduce field traffic.
Soil Water and Temperature	Retains soil seasonal moisture / residue prevents rapid soil warming	Maintain stover cover to retain moisture or remove stover cover to reduce moisture and raise soil temp.	Need driven by climatic conditions.
Environmental degradation	Off-site erosion impacts Nutrient loss to surface water	These "issues" seem linked to the erosion limiting factor. If nothing new to add here we should discuss under erosion	May need to write this as part of other topic. If so, best delay until next version

Single-Pass and Selective-Harvest

McLeod Harvester (Dry system example)

- Single-pass, selective harvester for cereal grains/chaff
- Single flow system: collects crop, separates grain and chaff from straw, returns straw to the field, collects and transports both grain and chaff together, separated grain and chaff in a stationary mill (locate at a depot)

Sweet Corn Harvester (photo not available)

- Single-pass harvester for corn/stover
- Single flow system, picks cob, billets stalk, collects and transports both grain and residue together

Task R&D Details:

- Evaluate grain and residue combining/packing factors and requirements for achieving bulk density targets in single-flow harvester
- Evaluate and develop methods for separating the grain, residue and residue fractions at target capacities and efficiencies
- Evaluate rheological properties of single-flow biomass stream

Storage

Location	Capital Investment	Capital Costs	Operating Costs	Labor Costs	Feedstock Costs
Idaho $35 Straw	$0	$0	$1.69	$0	$1.69
Kansas Straw	$1.30	$0.36	$7.53	$0	$7.89
Kansas Stover	$1.30	$0.36	$7.85	$0	$8.20
Kansas $35 Stover	$0.70	$0.18	$5.43	$0	$5.61

Description:

- Costs include shrinkage, insurance, land rent for stack, stack maintenance, and cover

Explanation of Difference: ***Location (Environment)***

- ID: Low precipitation , no cover needed
- KS: Higher precipitation, bale wrap for loss mitigation
- KS Stover: Higher harvest & collection cost results in higher shrinkage cost

Needed Improvements:

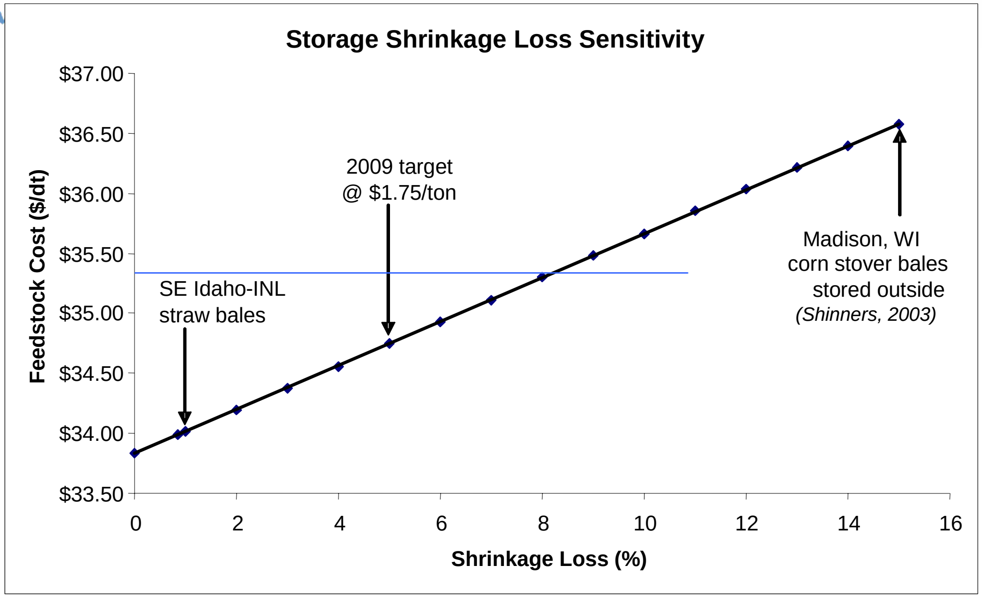
- GIS/weather-data based method for determining loss mitigation requirements. 100% mitigation is not necessary – KS $35 Stover assumes 50% of feedstock inventory does not need cover.

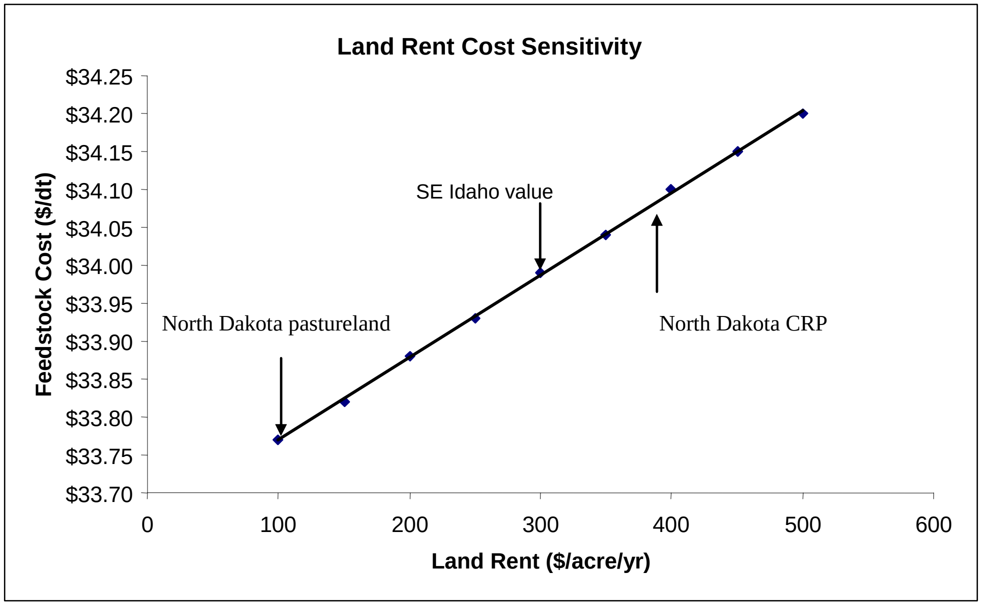
- Costs in $/dry ton, 2002 $
- Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

U.S. Department of Energy
Energy Efficiency and Renewable Energy

U.S. Department of Agriculture

Dry Storage



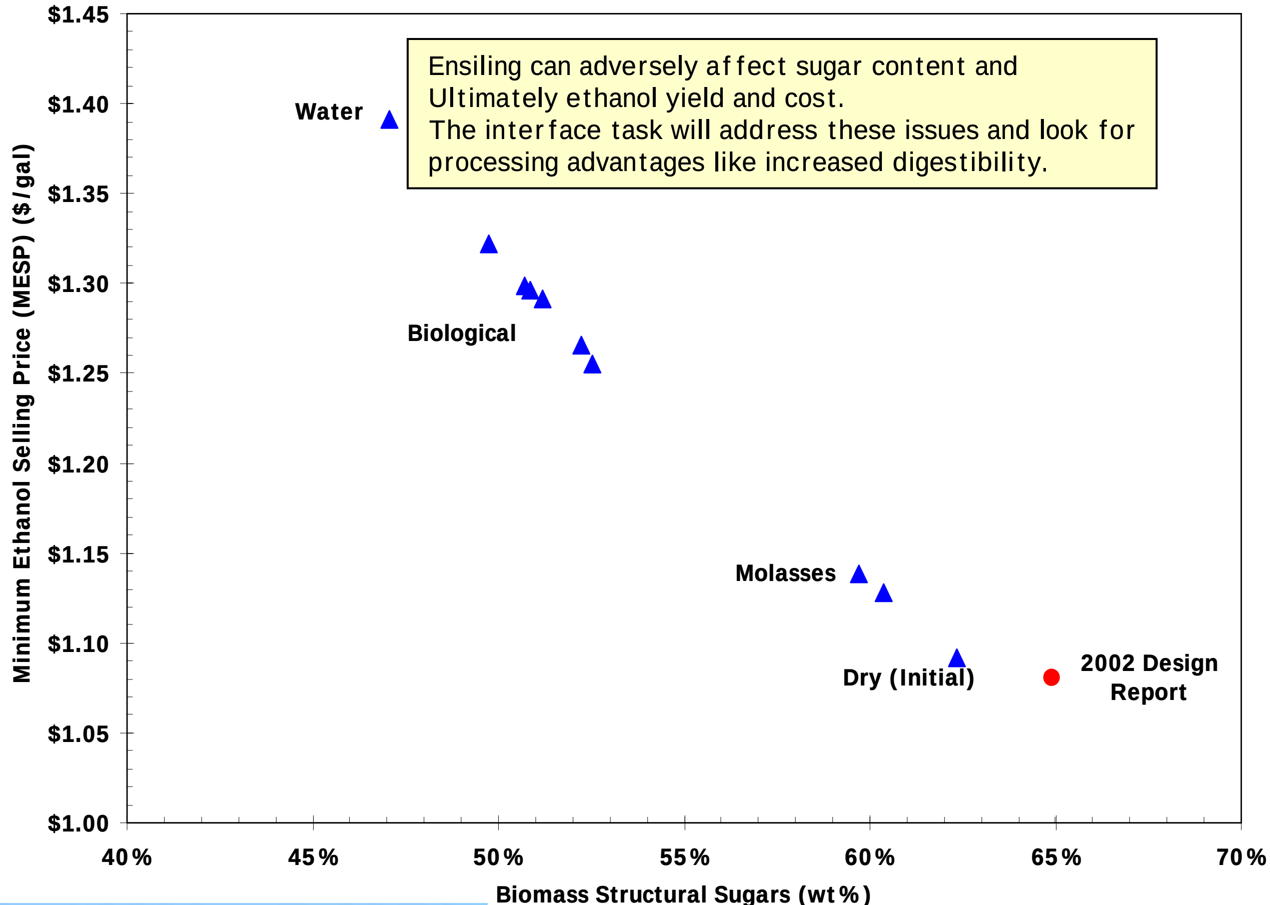


Feedstock/Process Interface
Quantify changes in wet storage

R&D Details:

- Verify ensiled biomass value
- Verify values of biomass fractions
- Measure levels of inhibitors
- Screen with upgraded SSF system

Sugar Losses in 3 different wet storage scenarios



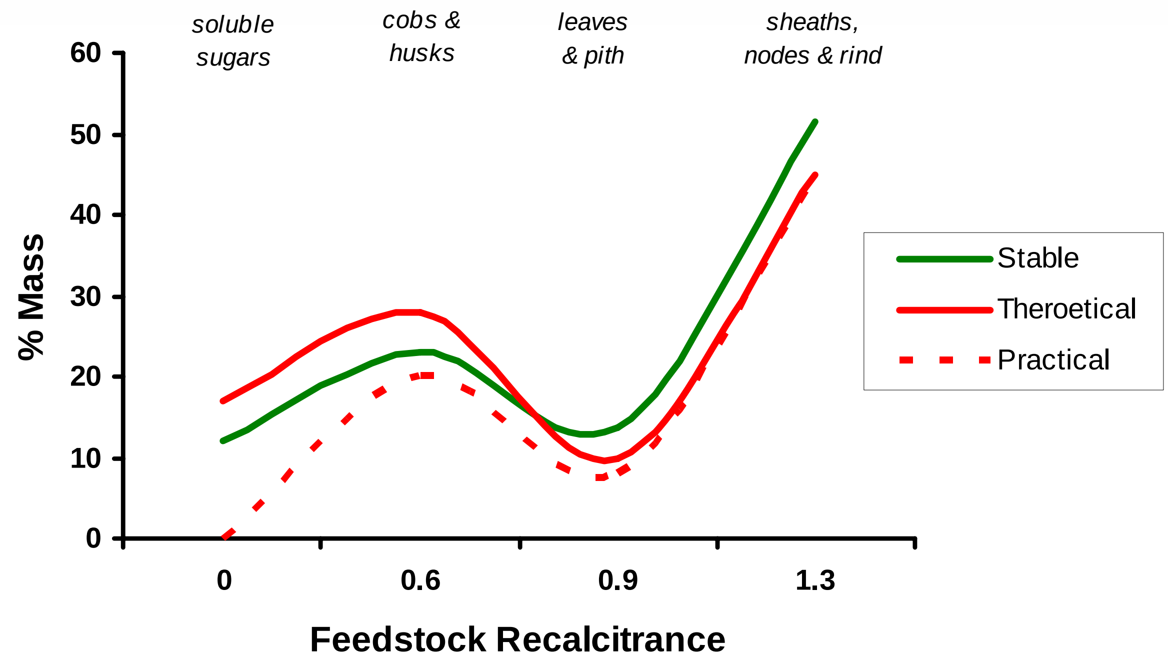
Radtke, INL
Ibsen, NREL

Storage and Queuing R&D

R&D Details:

- Assess soluble sugar capture systems
- Expand wet design concepts for $35 target
- Assess performance of key storage systems
- Investigate function / composition tradeoffs *(i.e., can we stabilize & destabilize together?)*

- Extend dry systems for use in wet climates



Biomass	**Compositional Quality** % structural sugars (Δ $/ton)	**Functional Quality** % xylan yield (Δ $/ton)
Unstored Whole Stover	60.8% (baseline)	ND
Bunker-Most Stable	51.9% (- 10.3)	ND
Bunker-High Least Stable	47.9% (- 16.0)	ND
Unstored Cobs	71.7% (baseline)	70.0% (baseline)
Cobs	69.3% (-2.21)	73.5 ($1.35)
Unstored Leaves	75.3% (baseline)	72.1% (baseline)
Leaves	59.3% (-16.0)	69.4% (-$1.04)
Unstored Stalks	64.9% (baseline)	52.7% (baseline)
Stalks	59.2% (-6.5)	56.8% ($1.57)

Distributed Grinding

Location	Capital Investment	Capital Costs	Operating Costs	Labor Costs	Feedstock Costs
Idaho $35 Straw	$6.93	$1.01	$1.61	$1.59	$4.21
Kansas Straw	$8.18	$1.12	$1.59	$1.62	$4.33
Kansas Stover	$8.18	$1.12	$1.59	$1.85	$4.56
Kansas $35 Stover	$8.18	$1.12	$1.59	$1.85	$4.56

Description:
- Grinding occurs at the stack
- Current grinder performance: Capacity = 26 tons/hr, Bulk Density = 8 lbs/ft^3,

Explanation of Difference: ***Economies of Scale***
- Equipment utilization (grinders are under-utilized in KS scenario)

Needed Improvements:
- Increase grinder capacity 25% (32.4 tons/hr)

- Costs in $/dry ton, 2002 $
- Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Preprocessing, Handling and Transport Design Targets

Dry Weight Characteristics and Cost

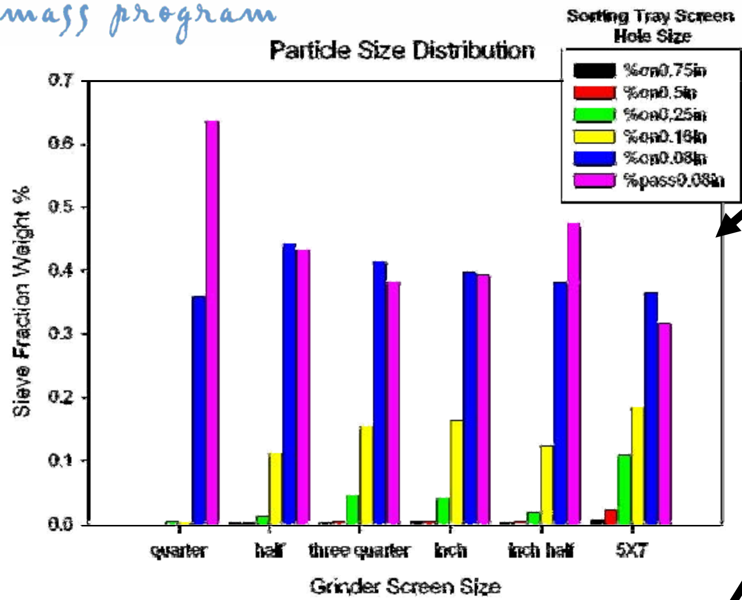
R&D Year	Cost Method	Screen Sizes (inches)	Moisture (%)	Capacity [a] (dry ton/hr)	Bulk Density [b] (dry lbs/ft^3)	Particle size geo. mean (in)	Grinding ($/dry ton)	Transport ($/dry ton)
FY05	Estimate	0.25 x 0.19	10.3	7.37	8.72	0.048	***14.65*** [c]	***7.57*** [c]
FY06	Model	0.25 x 0.19	10.3	7.37	8.72	0.048	***13.30*** [de]	***8.33*** [de]
FY06	Model	1.5 x 1.0	8.47	25.9	7.40/11.5+ [f]	0.069	***4.89***	***6.87***

a. at the specified moisture content
b. based on supersack volumes
c. based on FY05 estimate incl. $2.25/gal fuel
d. FY05 data in terms of FY06 techno-economic analysis
e. includes field efficiency factor not in FY05 estimate and $0.85/gal fuel
f. Based on full-scale loaded tractor-trailer unit

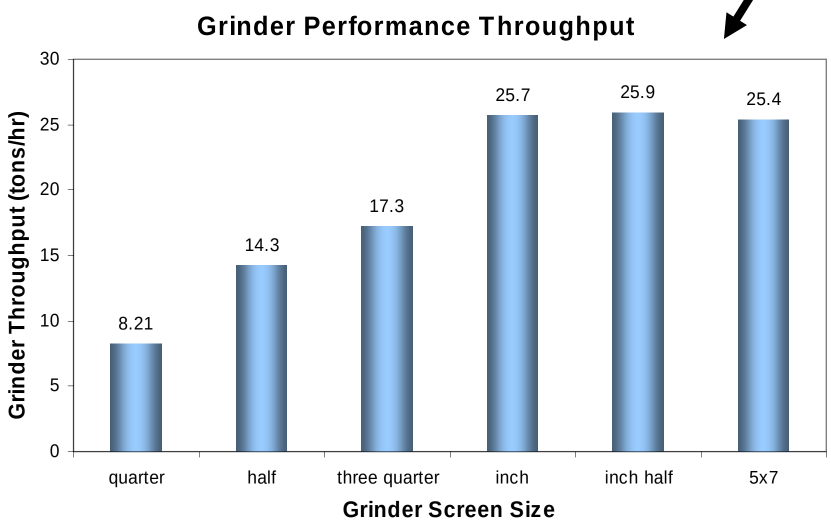
- **Capacity increase = 251%**
- **Bulk density change = -15%**
  - **Projected bulk density improvement using compression data = 32%**
- **Preprocessing (grinding) cost savings = 64%**
- **Transportation savings (bulk density contribution) = 19%**

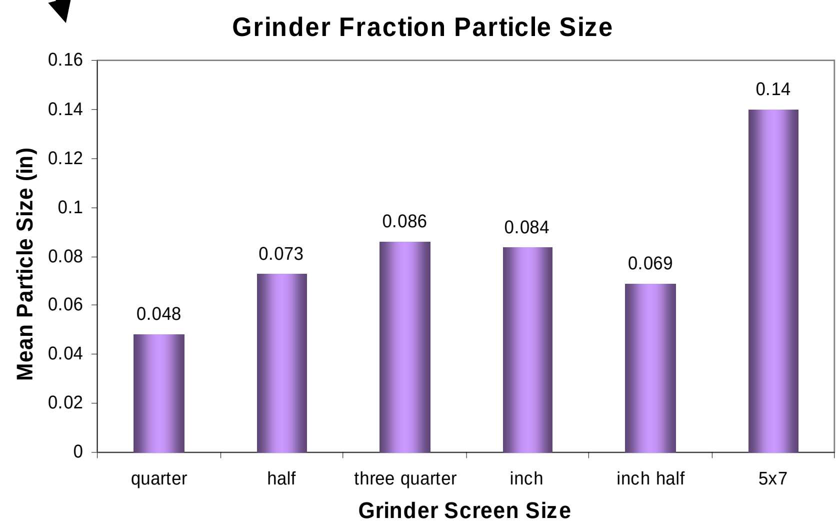
Improvements have been shown with models and must be validated by implementing design changes identified from the work performed in this project

Preprocessing Deconstruction Characteristics



- Different screen sizes cause a differential rate of deconstruction of the material
- Screen geometry directly affects throughput (particle escape) and spearing (loss of size reduction)





Bulk Biomass Handling and Transportation

Location	Capital Investment	Capital Costs	Operating Costs	Labor Costs	Feedstock Costs
Idaho $35 Straw	$8.38	$1.00	$1.75	$3.11	$5.85
Kansas Straw	$9.84	$1.20	$2.16	$4.06	$7.42
Kansas Stover	$9.84	$1.20	$2.16	$4.62	$7.98
Kansas $35 Stover	$8.37	$1.03	$1.87	$4.00	$6.90

Description:

- Self-unloading belt trailers, trailer configuration varies to maximize load

Explanation of Difference: ***Location (State Regulations)***

- State road limits:

  Idaho: 105 ft., 115,500 GVW

  Kansas: 85 ft., 85,500 GVW

Needed Improvements:

- Increase truck-loaded densities to 14 lb/ft^3 to gross-out trucks (increase by 25%)
- Increase conveyor-loaded densities to 10.4 lb/ft^3 (increase by 100%)

- Costs in $/dry ton, 2002 $
- Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

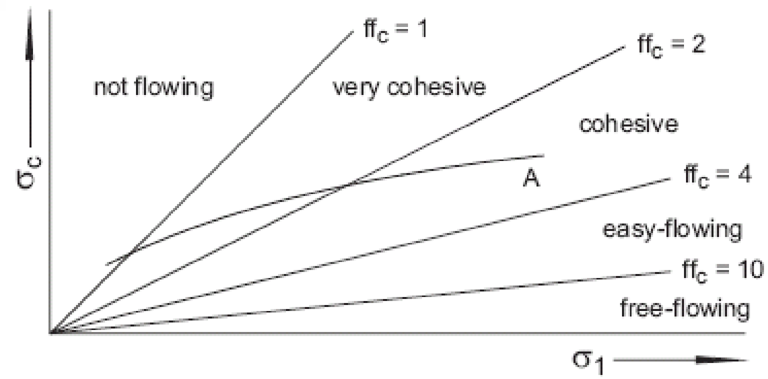
Biomass Compressive Characteristics in Transport and Handling

Non-Elastic material

- Relatively low compressive forces cause compaction with very little rebound
- Rheological data confirms plant material has high cohesive strength

Example:

- Grind material to 1/4”- (12.9 lb/ft^3)
- Pelletize (19.8 lb/ft^3)
- Re-grind through 1/4” screen (~28 lb/ft^3)
- Final product is in a highly compressed granular form



The ffc ranges is 0.45 to 1.36 after 72-hrs

Figure courtesy of Diamondback Technology, Inc.

Bulk Receiving and Handling

Location	Capital Investment	Capital Costs	Operating Costs	Labor Costs	Feedstock Costs
Idaho $35 Straw	$13.90	$1.04	$0.40	$0.33	$1.77
Kansas Straw	$21.87	$1.64	$0.59	$0.52	$2.75
Kansas Stover	$21.87	$1.64	$0.59	$0.52	$2.75
Kansas $35 Stover	$21.87	$1.64	$0.59	$0.52	$2.75

Description:

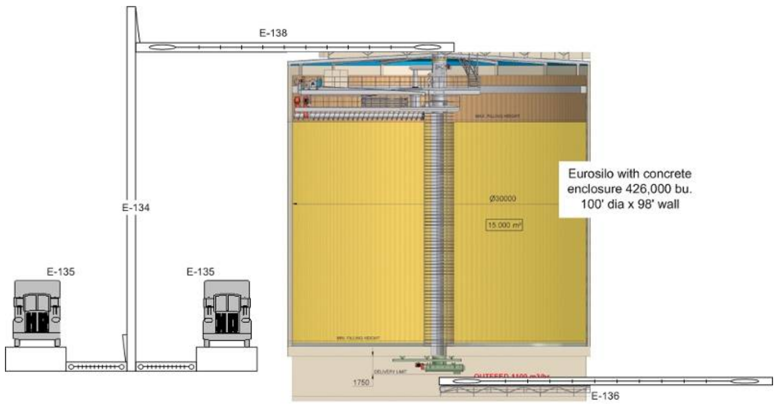
- 72-hr inventory
- Eurosilo storage
- Conveyor density 5.2 lb/ft^3, bin density 14.1 lb/ft^3

Explanation of Difference: ***Economies of Scale***

- Economies of scale favor larger Idaho biorefinery
- Idaho: 95 tons/hr; 943,000 ft3 inventory
- Kansas: , 38 tons/hr; 389,000 ft3 inventory

Needed Improvements:

- Increase conveyor-loaded bulk density
- Improve rheological properties

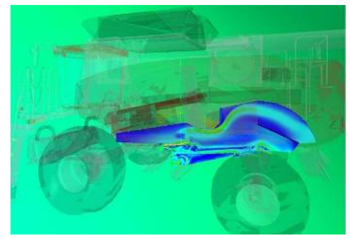


- Costs in $/dry ton, 2002 $
- Cost per ton estimates can vary based on yield, feedstock type and operational size assumptions.

Biochem Feedstock Fractions Quality

Wet Storage

Dry Storage



Selective Harvest

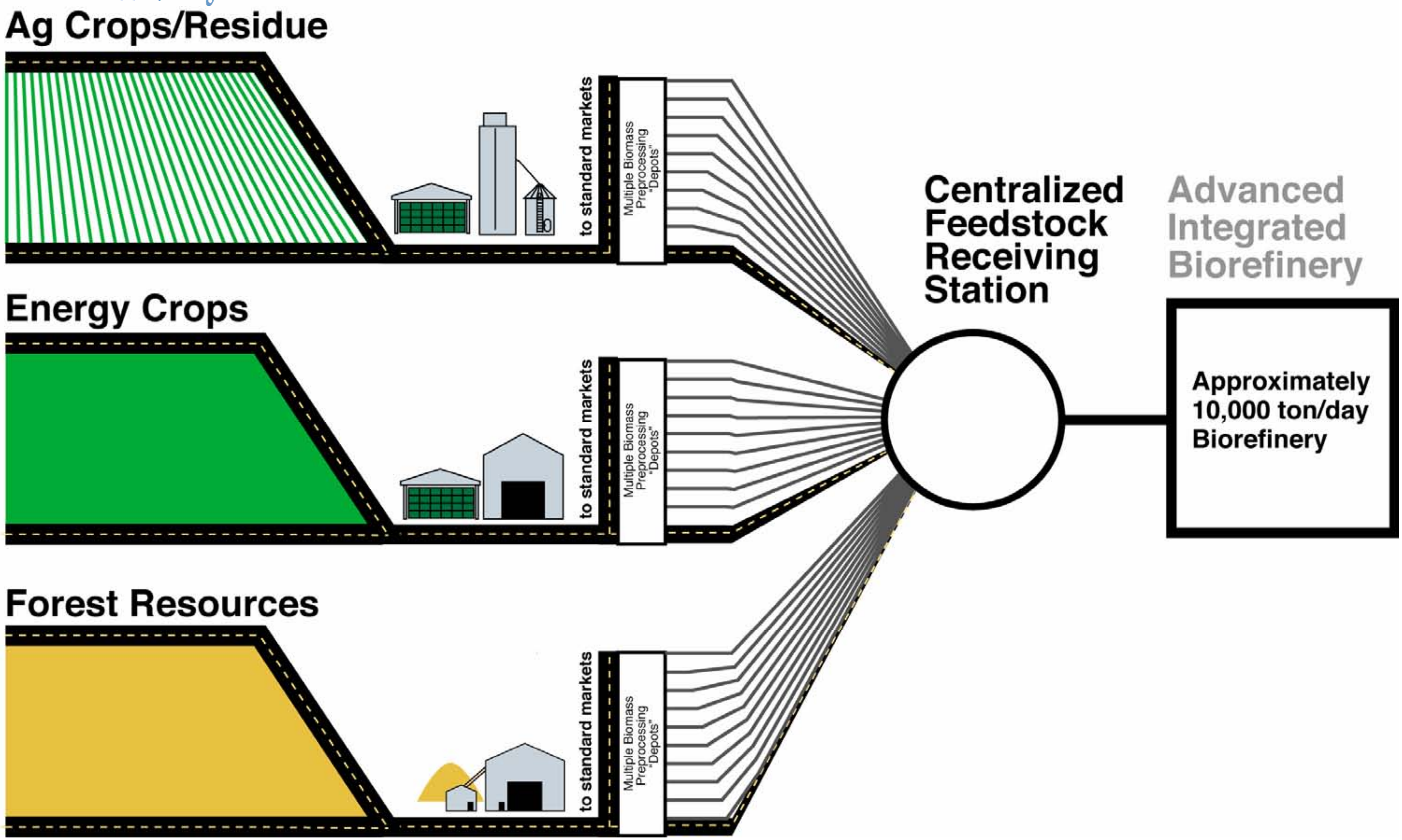
Preprocessing

Feedstock value for $1.07/gal cost target:

- Wet storage conditions affecting composition changes created a $28* range in feedstock value
- Dry storage conditions affecting composition changes created a $22* range in feedstock value
- Selective harvest composition changes created a $10* range in feedstock value
- Mechanical Preprocessing and fractionation composition changes created a $12* range in feedstock value

*Value estimations based on NREL Aspen model analysis

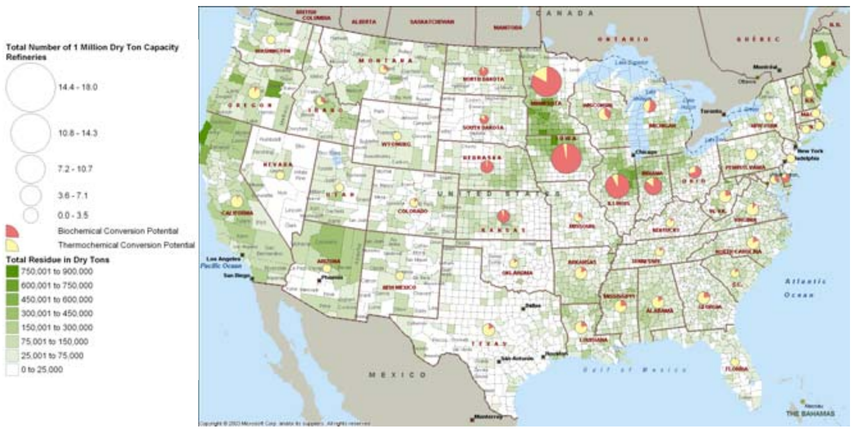
Multiple Feedstock Biorefining Industry OR "Feedstock Country Elevator System"



Critical Partnerships Needed to Validate Feedstock Milestones

Regional Partnerships (*Sun Grant Init., Universities, States, Commodity Groups, etc*.) are needed to answer:

- What are the Feedstocks?
- What are the Feedstock Tonnages and Costs?
- What are the feedstock locations' opportunities / constraints?



Industrial Partnerships (*Biorefining Companies, Growers, Equipment Mfg., Agribusiness, etc*.) are needed to answer:

- What are the feedstock supply options and costs?

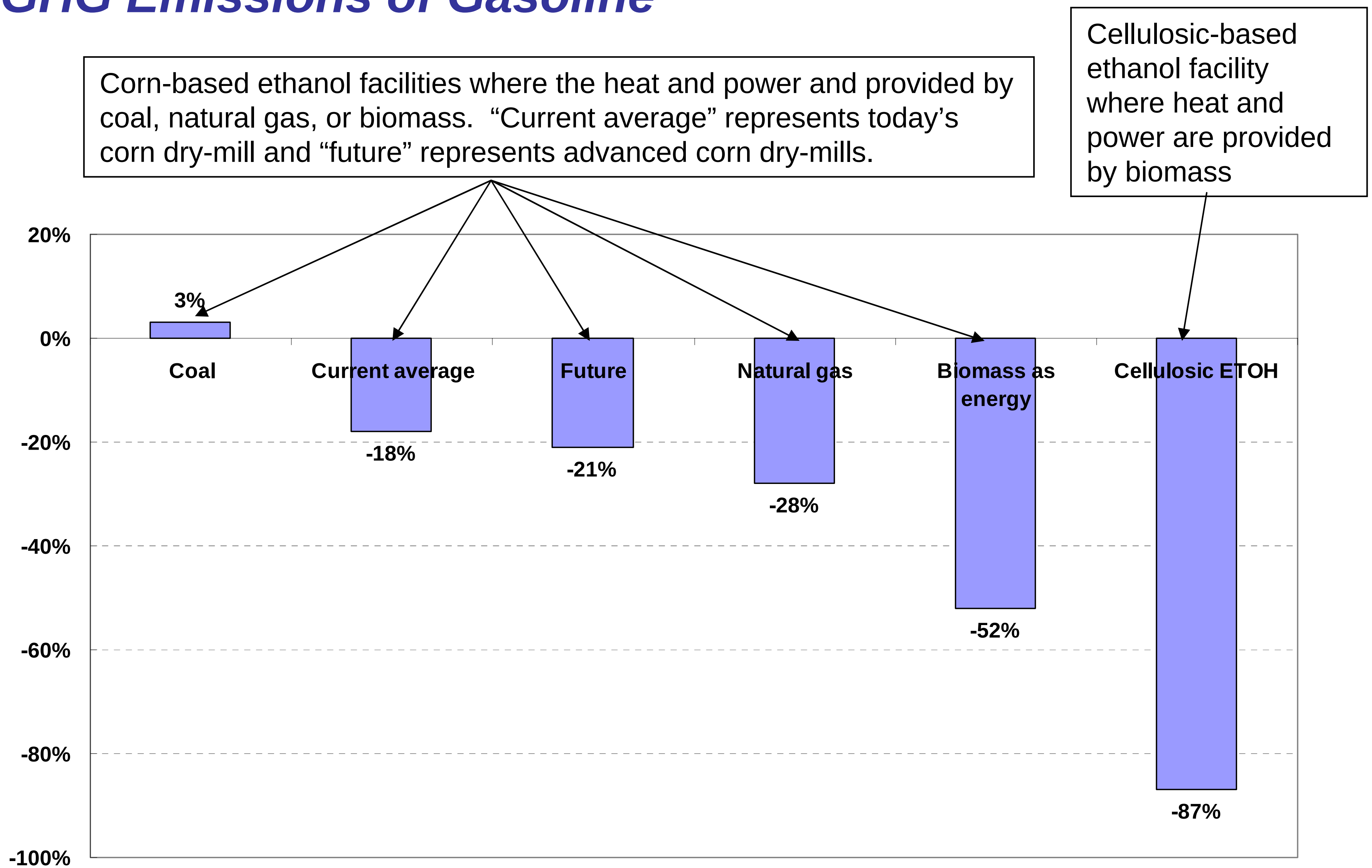
U.S. Department of Energy
Energy Efficiency and Renewable Energy

USDA U.S. Department of Agriculture

Biorefining Depends on Feedstock

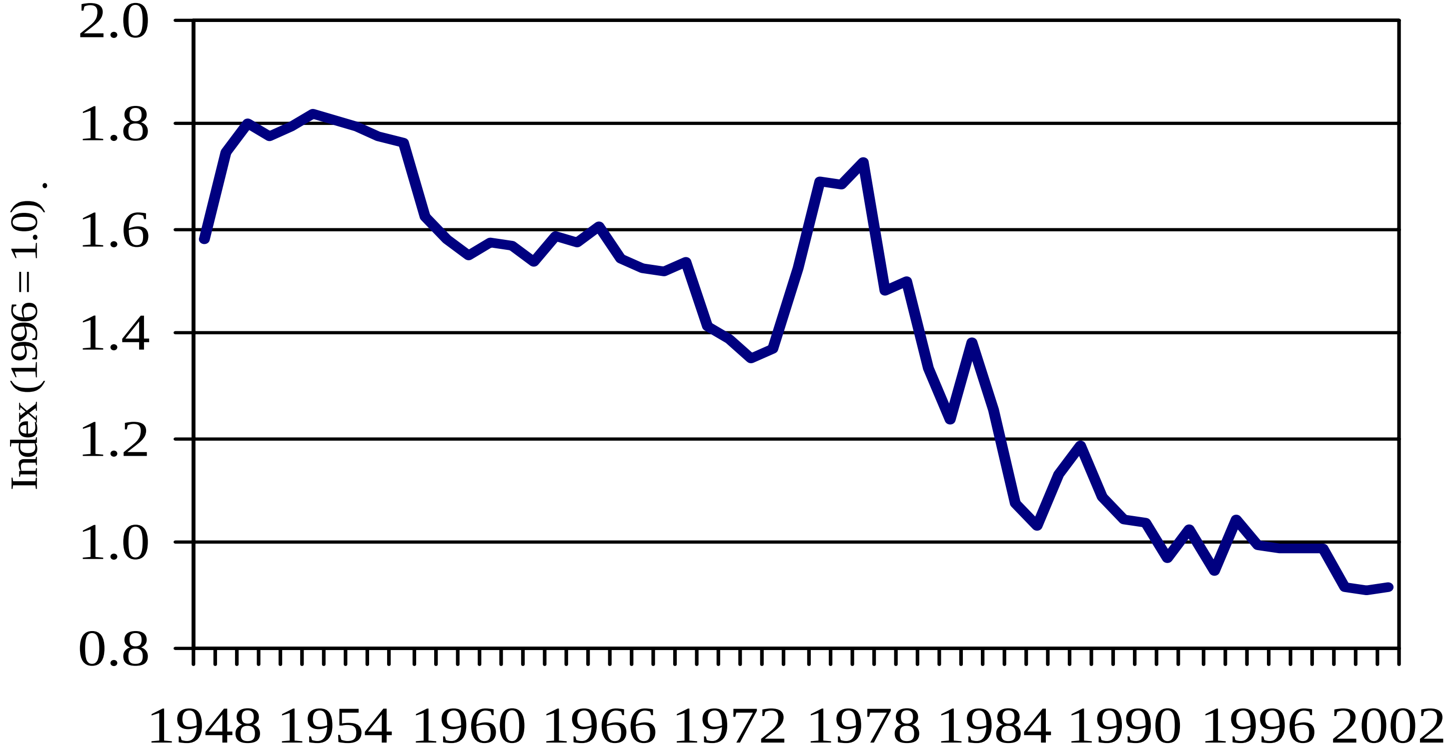
Attachment E

GHG Emission Changes by Corn Ethanol Relative to GHG Emissions of Gasoline



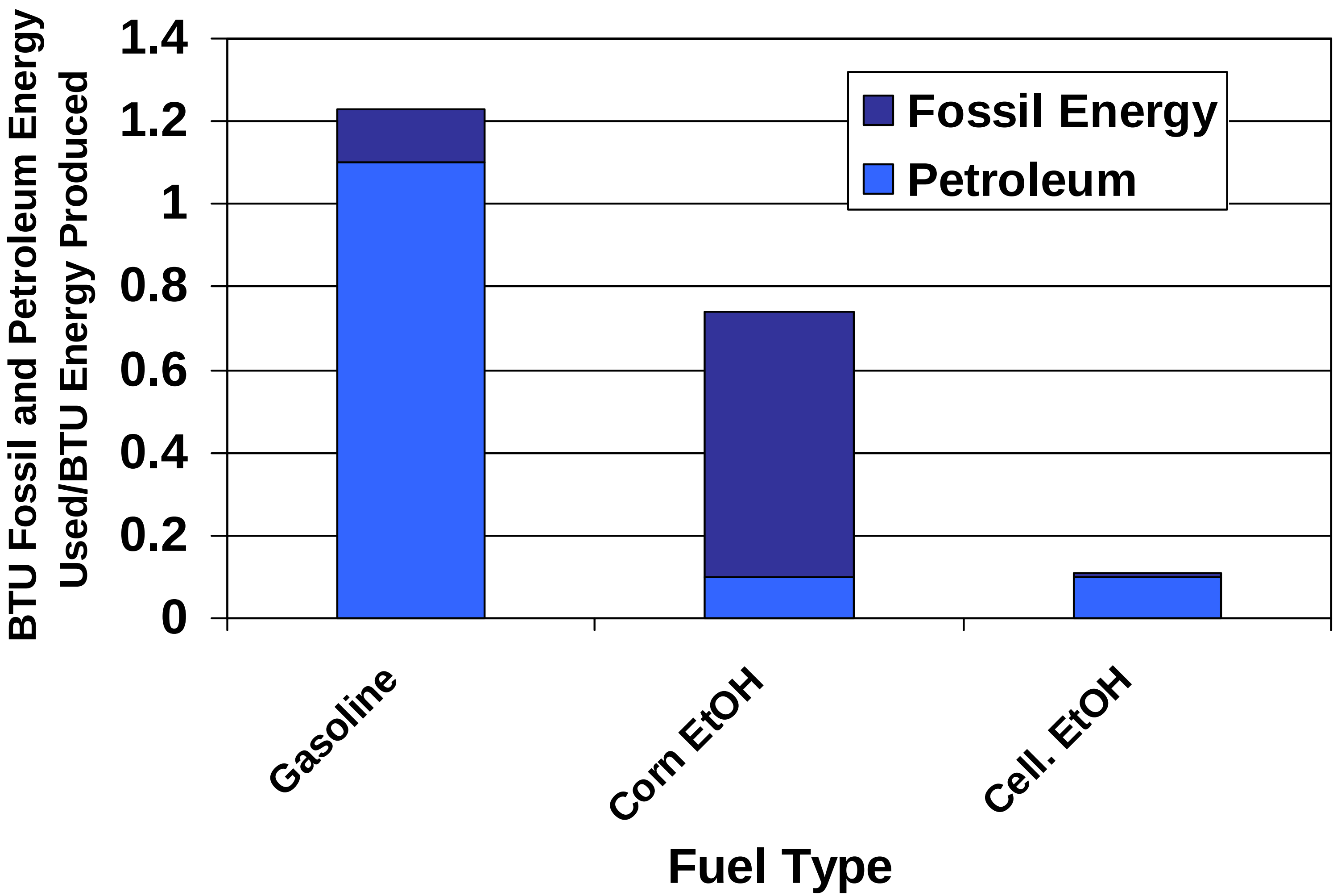
Source: M. Wang, Argonne National Laboratory

Energy Use Per Unit of Farm Output Has Fallen Over the Last 50 Years

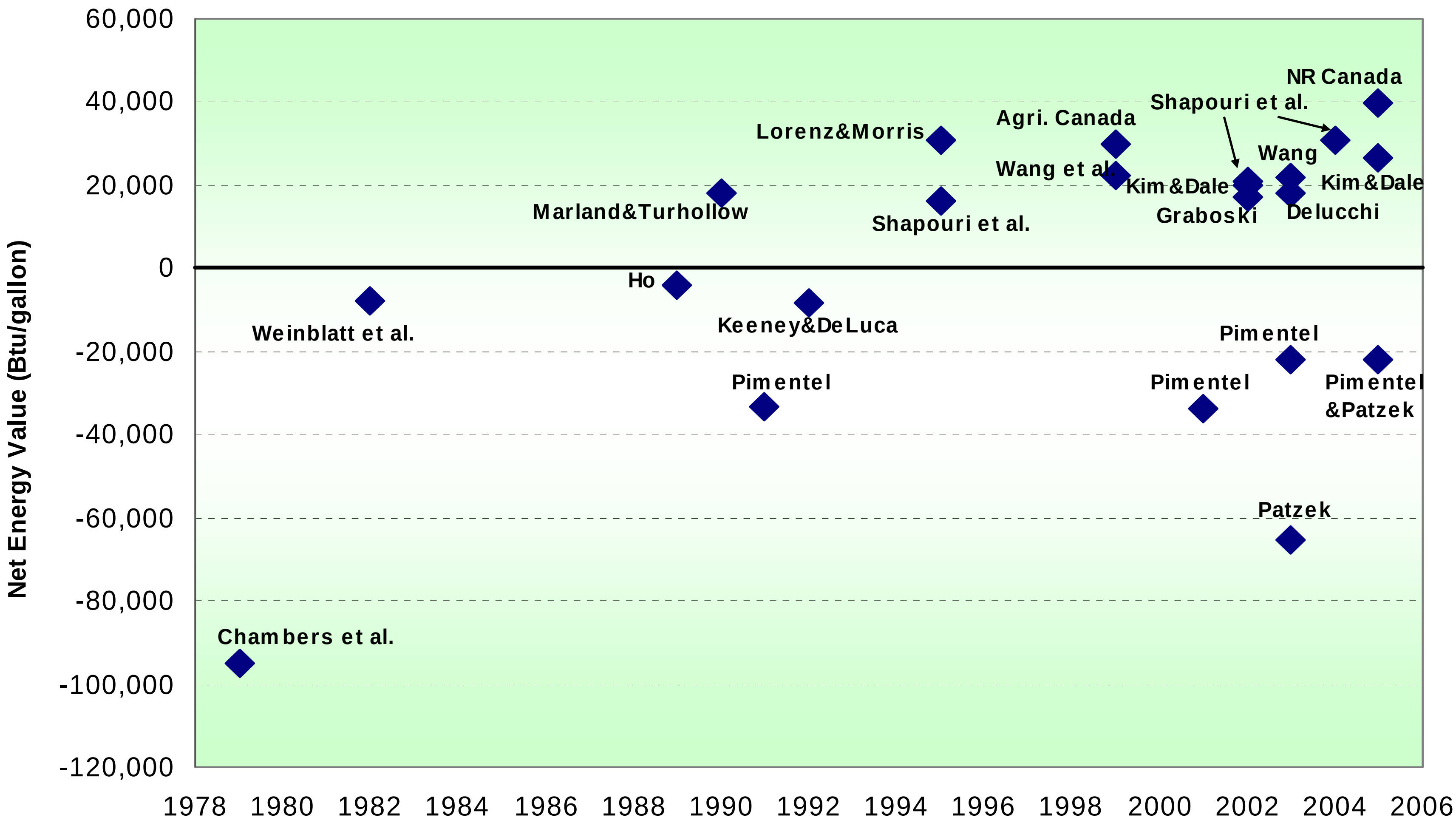


Source: USDA, 2007 Farm Bill Theme Papers, Chapter 4, Energy and Agriculture, pp. 85 - 86

Total BTU of Fossil and Petroleum Energy Required to Produce 1 BTU of Gasoline and EtOH Available at the Pump



Most Recent Studies Show Positive Net Energy Balance for Corn Ethanol



- Energy balance here is defined as Btu content a gallon of ethanol minus fossil energy used to produce a gallon of ethanol

- For additional information: Alexander E. Farrell, et. Al., “Ethanol Can Contribute to Energy and Environmental Goals”, **Science**, Volume 311, January 27, 2006, at http://www.sciencemag.org

Summary

- Corn derived ethanol requires only about 60% of the fossil energy required to deliver a gallon of liquid transportation fuel on an energy equivalent basis compared to gasoline.

- The fossil energy savings for corn derived ethanol continues to improve with improved agronomic practices, increased yields, improved nitrogen/water utilization, and improved conversion technology.

- Cellulosic derived ethanol requires only 40% of the fossil energy required to deliver a gallon of liquid transportation fuel on an energy equivalent basis compared to gasoline.

- Corn derived ethanol has the potential to reduce greenhouse gas emissions by 15-26% over petroleum based fuels.

- Cellulosic ethanol has the potential to reduce greenhouse gas emissions by as much as 87%.

Attachment F

Recent Press on the Food vs. Fuel Debate

1. *Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble* was published by the Earth Policy Institute (EPI: http://www.earth-policy.org/index.htm) on January 23, 2006. The book is an update of Lester Brown's 2003 book of the same title. Lester Brown has 50 years of experience as an agricultural economist, policy advisor, and environmentalist, and founded both the EPI and the Worldwatch Institute.

   In both books, Brown:
   - Advocates for improved conservation, sustainable agriculture, renewable energy, and recycling practices to combat the negative combined effects of population growth, peak oil (and overall diminishing resources), and global warming.
   - States that the negative environmental symptoms indicate global economic deterioration.
   - Argues that a sustained rise in food prices corresponding to demand from corn-based ethanol production could be the only factor to finally effect policy change.
   - Advocates that construction of all corn-based ethanol plants cease.

   The updated book's release has generated extensive, continuous press coverage, including articles in *The New York Times, The Guardian (UK), Business Week, the Wall Street Journal, United Press International, Science News, and U.S. News and World Report,* and ongoing radio and television interviews. A rise in the price of corn throughout the year has seriously affected tortilla prices throughout Latin America, generating spin-off coverage.

2. In the June 25, 2006 issue of the *Proceedings of the National Academy of Sciences*, researchers from the University of Minnesota published the results of their study, titled "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels". A full text of the study is attached.

   The results included the following conclusions:
   - Confirmed ethanol's positive net energy balance, while noting biodiesel's higher energy yield.
   - Stated that biofuels production, especially without development of cellulosic conversion technologies, can have a significant negative environmental impact.

3. On January 4, 2007, the Earth Policy Institute website published an article by Lester Brown titled "DISTILLERY DEMAND FOR GRAIN TO FUEL CARS VASTLY UNDERSTATED: World May Be Facing Highest Grain Prices in History".

   The article declared:
   - That USDA and industry association (RFA, BBI, ACE) numbers for ethanol plants' feedstock supply are too low.
   - That unforeseen demand from excess production facilities would drive corn prices correspondingly higher.

   A document from the DOE Office of the Biomass Program responding to his main points, and the full article text, are attached.

4. USDA Chief Economist Keith Collins testified before the Senate Committee on Agriculture, Nutrition, and Forestry January 10, 2007 regarding renewable energy markets, biofuels issues, and related current USDA activities. The full testimony is attached.

   Among his statements on corn prices were the following:
   - "With ethanol fueling a push for more corn acres, major crop prices are generally expected to be higher over the next couple of years than in the recent past."
   - All livestock and poultry producers' profits would decrease with higher corn feed prices.
   - The price of ethanol is expected to decline.
   - "If ethanol is to continue its expansion beyond 10 percent of U.S. gasoline use, higher blend levels and E85 will have to become far more pervasive than they are today, and, given corn production constraints, cellulosic ethanol will have to become economically feasible."
   - "If corn prices continue to stay strong and ethanol demand growth slows, ethanol profitability would decline and expansion could slow appreciably in several years. While this scenario would take pressure off the acreage adjustments and commodity prices in agriculture, it would diminish the ability to reduce U.S. energy dependence on fossil fuel.

From the Cover: Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels

Jason Hill, Erik Nelson, David Tilman, Stephen Polasky, and Douglas Tiffany

PNAS 2006;103;11206-11210; originally published online Jul 12, 2006;
doi:10.1073/pnas.0604600103

Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels

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Departments of *Ecology, Evolution, and Behavior and †Applied Economics, University of Minnesota, St. Paul, MN 55108; and ‡Department of Biology, St. Olaf College, Northfield, MN 55057

Contributed by David Tilman, June 2, 2006

Negative environmental consequences of fossil fuels and concerns about petroleum supplies have spurred the search for renewable transportation biofuels. To be a viable alternative, a biofuel should provide a net energy gain, have environmental benefits, be economically competitive, and be producible in large quantities without reducing food supplies. We use these criteria to evaluate, through life-cycle accounting, ethanol from corn grain and biodiesel from soybeans. Ethanol yields 25% more energy than the energy invested in its production, whereas biodiesel yields 93% more. Compared with ethanol, biodiesel releases just 1.0%, 8.3%, and 13% of the agricultural nitrogen, phosphorus, and pesticide pollutants, respectively, per net energy gain. Relative to the fossil fuels they displace, greenhouse gas emissions are reduced 12% by the production and combustion of ethanol and 41% by biodiesel. Biodiesel also releases less air pollutants per net energy gain than ethanol. These advantages of biodiesel over ethanol come from lower agricultural inputs and more efficient conversion of feedstocks to fuel. Neither biofuel can replace much petroleum without impacting food supplies. Even dedicating all U.S. corn and soybean production to biofuels would meet only 12% of gasoline demand and 6% of diesel demand. Until recent increases in petroleum prices, high production costs made biofuels unprofitable without subsidies. Biodiesel provides sufficient environmental advantages to merit subsidy. Transportation biofuels such as synfuel hydrocarbons or cellulosic ethanol, if produced from low-input biomass grown on agriculturally marginal land or from waste biomass, could provide much greater supplies and environmental benefits than food-based biofuels.

corn | soybean | life-cycle accounting | agriculture | fossil fuel

High energy prices, increasing energy imports, concerns about petroleum supplies, and greater recognition of the environmental consequences of fossil fuels have driven interest in transportation biofuels. Determining whether alternative fuels provide benefits over the fossil fuels they displace requires thorough accounting of the direct and indirect inputs and outputs for their full production and use life cycles. Here we determine the net societal benefits of corn grain (*Zea mays* ssp. *mays*) ethanol and soybean (*Glycine max*) biodiesel, the two predominant U.S. alternative transportation fuels, relative to gasoline and diesel, the fossil fuels they displace in the market. We do so by using current, well supported public data on farm yields, commodity and fuel prices, farm energy and agrichemical inputs, production plant efficiencies, coproduct production, greenhouse gas (GHG) emissions, and other environmental effects.

To be a viable substitute for a fossil fuel, an alternative fuel should not only have superior environmental benefits over the fossil fuel it displaces, be economically competitive with it, and be producible in sufficient quantities to make a meaningful impact on energy demands, but it should also provide a net energy gain over the energy sources used to produce it. We therefore analyze each biofuel industry, including farms and production facilities, as though it were an "island economy" that is a net energy exporter only if the energy value of the biofuel and its coproducts exceeds that of all direct and indirect energy inputs (see Tables 1–6 and *Supporting Text*, which are published as supporting information on the PNAS web site).

Biofuel production requires energy to grow crops and convert them to biofuels. We estimate farm energy use for producing corn and soybeans, including energy use for growing the hybrid or varietal seed planted to produce the crop, powering farm machinery, producing farm machinery and buildings, producing fertilizers and pesticides, and sustaining farmers and their households. We also estimate the energy used in converting crops to biofuels, including energy use in transporting the crops to biofuel production facilities, building and operating biofuel production facilities, and sustaining production facility workers and their households. Outputs of biofuel production include the biofuels themselves and any simultaneously generated coproducts. For purposes of energy accounting, we assign the biofuels themselves an energy content equal to their available energy upon combustion. Coproducts, such as distillers' dry grain with solubles (DDGS) from corn and soybean meal and glycerol from soybeans, are typically not combusted directly; rather, we assign them energy equivalent values.

Results

Net Energy Balance (NEB). Despite our use of expansive system boundaries for energy inputs, our analyses show that both corn grain ethanol and soybean biodiesel production result in positive NEBs (i.e., biofuel energy content exceeds fossil fuel energy inputs) (Fig. 1; see also Tables 7 and 8, which are published as supporting information on the PNAS web site), which reinforce recent findings (1–5). Although these earlier reports did not account for all of the energy inputs included in our analyses, recent advances in crop yields and biofuel production efficiencies, which are reflected in our analyses, have essentially offset the effects of the broad boundaries for energy accounting that we have used. Our results counter the assertion that expanding system boundaries to include energetic costs of producing farm machinery and processing facilities causes negative NEB values for both biofuels (6–8). In short, we find no support for the assertion that either biofuel requires more energy to make than it yields. However, the NEB for corn grain ethanol is small, providing ≈25% more energy than required for its production. Almost all of this NEB is attributable to the energy credit for its DDGS coproduct, which is animal feed, rather than to the ethanol itself containing more energy than used in its production. Corn grain ethanol has a low NEB because of the high energy input required to produce corn and to convert it into ethanol. In contrast, soybean biodiesel provides ≈93% more energy than is required in its production. The NEB advantage of

Conflict of interest statement: No conflicts declared.

Abbreviations: NEB, net energy balance; GHG, greenhouse gas; EEL, energy equivalent liter; DDGS, distillers' dry grain with solubles.

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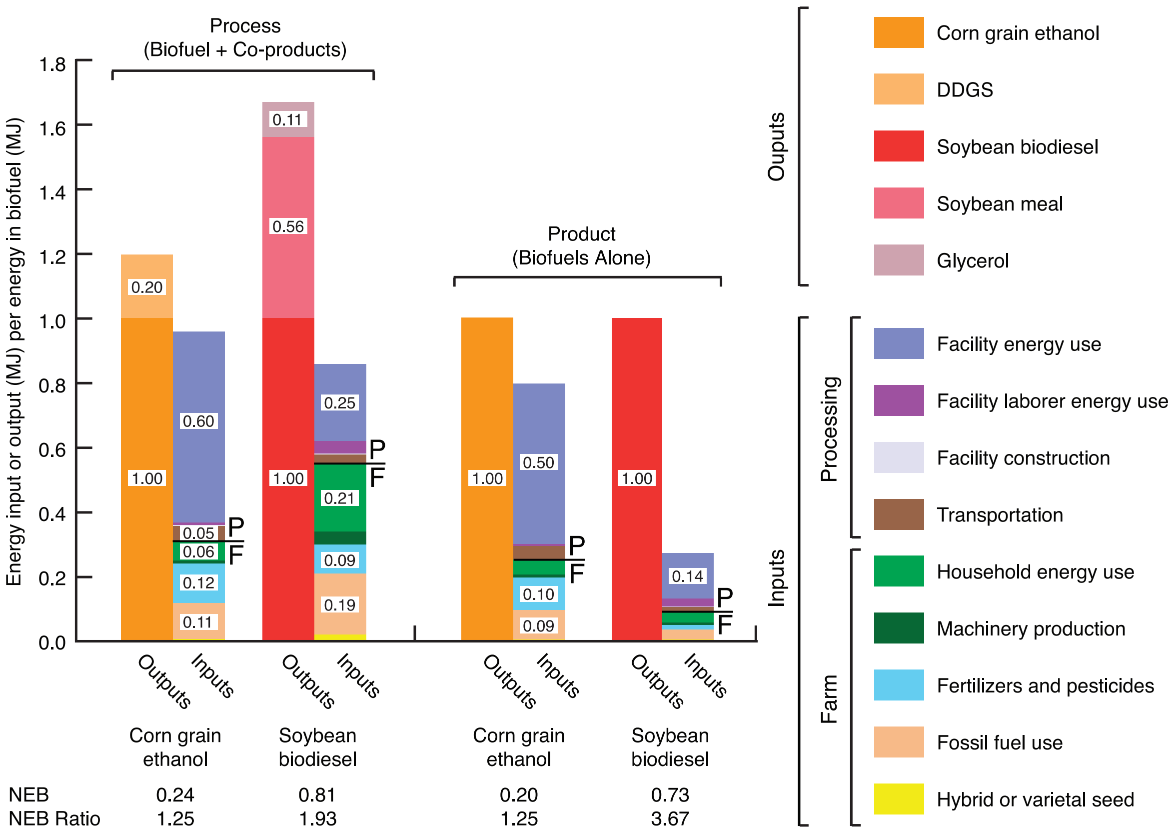

Fig. 1. NEB of corn grain ethanol and soybean biodiesel production. Energy inputs and outputs are expressed per unit energy of the biofuel. All nine input categories are consistently ordered in each set of inputs, as in the legend, but some are so small as to be nearly imperceptible. Individual inputs and outputs of ≥0.05 are labeled; values <0.05 can be found in Tables 7 and 8. The NEB (energy output − energy input) and NEB ratio (energy output/energy input) of each biofuel are presented both for the entire production process (*Left*) and for the biofuel only (i.e., after excluding coproduct energy credits and energy allocated to coproduct production) (*Right*).

soybean biodiesel is robust, occurring for five different methods of accounting for the energy credits of coproducts (see Table 9, which is published as supporting information on the PNAS web site).

Life-Cycle Environmental Effects. Both corn and soybean production have negative environmental impacts through movement of agrichemicals, especially nitrogen (N), phosphorus (P), and pesticides from farms to other habitats and aquifers (9). Agricultural N and P are transported by leaching and surface flow to surface, ground, and coastal waters causing eutrophication, loss of biodiversity, and elevated nitrate and nitrite in drinking-water wells (9, 10). Pesticides can move by similar processes. Data on agrichemical inputs for corn and soybeans and on efficiencies of net energy production from each feedstock reveal, after partitioning these inputs between the energy product and coproducts, that biodiesel uses, per unit of energy gained, only 1.0% of the N, 8.3% of the P, and 13% of the pesticide (by weight) used for corn grain ethanol (Fig. 2*a*; see also Table 10, which is published as supporting information on the PNAS web site). The markedly greater releases of N, P, and pesticides from corn, per unit of energy gain, have substantial environmental consequences, including being a major source of the N inputs leading to the "dead zone" in the Gulf of Mexico (11) and to nitrate, nitrite, and pesticide residues in well water. Moreover, pesticides used in corn production tend to be more environmentally harmful and persistent than those used to grow soybeans (Fig. 2*b* and Table 10). Although blending ethanol with gasoline at low levels as an oxygenate can lower emissions of carbon monoxide (CO), volatile organic compounds (VOC), and particulate matter with an aerodynamic diameter ≤ 10 μm (PM10) upon combustion, total life-cycle emissions of five major air pollutants [CO, VOC, PM10, oxides of sulfur (SO_x), and oxides of nitrogen (NO_x)] are higher with the "E85" corn grain ethanol–gasoline blend than with gasoline per unit of energy released upon combustion (12). Conversely, low levels of biodiesel blended into diesel reduce emissions of VOC, CO, PM10, and SO_x during combustion, and biodiesel blends show reduced life-cycle emissions for three of these pollutants (CO, PM10, and SO_x) relative to diesel (5).

If CO_2 from fossil fuel combustion was the only GHG considered, a biofuel with NEB > 1 should reduce GHG emissions because the CO_2 released upon combustion of the fuel had been removed from the atmosphere by plants, and less CO_2 than this amount had been released when producing the biofuel. However, N fertilization and incorporation of plant biomass into soil can cause microbially mediated production and release of N_2O, which is a potent GHG (13). Our analyses (see Table 11, which is published as supporting information on the PNAS web site) suggest that, because of the low NEB of corn grain ethanol, production and use of corn grain ethanol releases 88% of the net GHG emissions of production and combustion of an energetically equivalent amount of gasoline (Fig. 2*c*). This result is comparable with a recent study that estimated this parameter at 87% using different methods of analysis (1). In contrast, we find that life-cycle GHG emissions of soybean biodiesel are 59% those of diesel fuel. It is important to note that these estimates assume these biofuels are derived from crops harvested from land already in production; converting intact ecosystems to production would result in reduced GHG savings or even net GHG release from biofuel production.

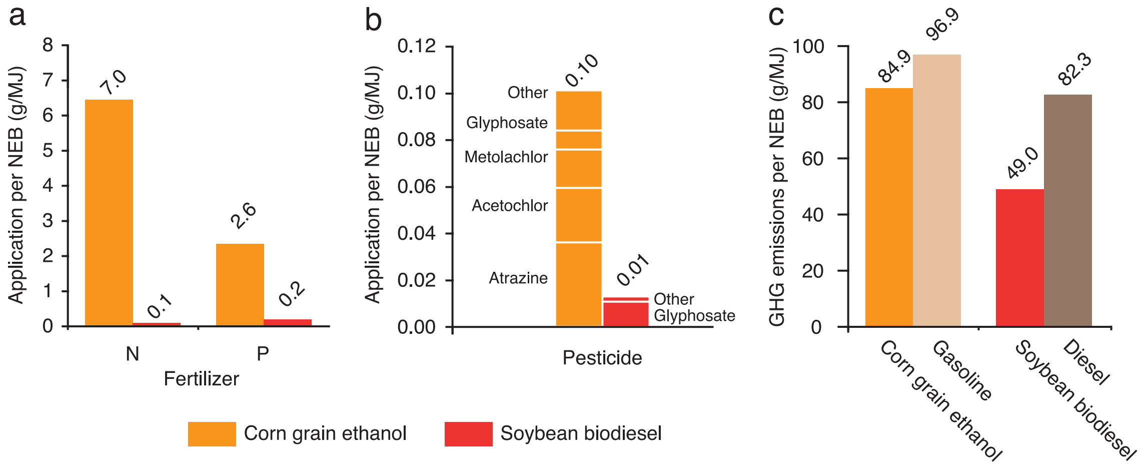

Fig. 2. Environmental effects from the complete production and combustion life cycles of corn grain ethanol and soybean biodiesel. (*a* and *b*) Use of fertilizers (*a*) and pesticides (*b*) per unit of net energy gained from biofuel production (Table 10). (*c*) Net GHG emissions (as CO_2 equivalents) during production and combustion of biofuels and their conventional counterparts, relative to energy released during combustion (Table 11).

Economic Competitiveness and Net Social Benefits. Because fossil energy use imposes environmental costs not captured in market prices, whether a biofuel provides net benefits to society depends not only on whether it is cost competitive but also on its environmental costs and benefits vis-à-vis its fossil fuel alternatives. Subsidies for otherwise economically uncompetitive biofuels are justified if their life-cycle environmental impacts are sufficiently less than for alternatives. In 2005, neither biofuel was cost competitive with petroleum-based fuels without subsidy, given then-current prices and technology. In 2005, ethanol net production cost was \$0.46 per energy equivalent liter (EEL) of gasoline (14–16), while wholesale gasoline prices averaged \$0.44/liter (17). Estimated soybean biodiesel production cost was \$0.55 per diesel EEL (16, 18), whereas diesel wholesale prices averaged \$0.46/liter (17). Further increases in petroleum prices above 2005 average prices improve the cost competitiveness for biofuels. Even when not cost competitive, however, biofuel production may be profitable because of large subsidies. In the U.S., the federal government provides subsidies of \$0.20 per EEL for ethanol and \$0.29 per EEL for biodiesel (19). Demand, especially for ethanol, also comes from laws and regulations mandating blending biofuels in at least some specified proportion with petroleum. Ethanol and biodiesel producers also benefit from federal crop subsidies that lower corn prices (which are approximately half of ethanol production's operating costs) and soybean prices.

Potential U.S. Supply. In 2005, 14.3% of the U.S. corn harvest was processed to produce 1.48×10^{10} liters of ethanol (20, 21), energetically equivalent to 1.72% of U.S. gasoline usage (22). Soybean oil extracted from 1.5% of the U.S. soybean harvest produced 2.56×10^8 liters of biodiesel (20, 23), which was 0.09% of U.S. diesel usage (22). Devoting all 2005 U.S. corn and soybean production to ethanol and biodiesel would have offset 12% and 6.0% of U.S. gasoline and diesel demand, respectively. However, because of the fossil energy required to produce ethanol and biodiesel, this change would provide a net energy gain equivalent to just 2.4% and 2.9% of U.S. gasoline and diesel consumption, respectively. Reaching these maximal rates of biofuel supply from corn and soybeans is unlikely because these crops are major contributors to human food supplies through livestock feed and direct consumption (e.g., high-fructose corn syrup and soybean oil, both major sources of human caloric intake).

Discussion

Among current food-based biofuels, soybean biodiesel has major advantages over corn grain ethanol. Biodiesel provides 93% more usable energy than the fossil energy needed for its production, reduces GHGs by 41% compared with diesel, reduces several major air pollutants, and has minimal impact on human and environmental health through N, P, and pesticide release. Corn grain ethanol provides smaller benefits through a 25% net energy gain and a 12% reduction in GHGs, and it has greater environmental and human health impacts because of increased release of five air pollutants and nitrate, nitrite, and pesticides.

Our analyses of ethanol and biodiesel suggest that, in general, biofuels would provide greater benefits if their biomass feedstocks were producible with low agricultural input (i.e., less fertilizer, pesticide, and energy), were producible on land with low agricultural value, and required low-input energy to convert feedstocks to biofuel. Neither corn grain ethanol nor soybean biodiesel do particularly well on the first two criteria: corn requires large N, P, and pesticide inputs, and both corn and soybeans require fertile land. Soybean biodiesel, however, requires far less energy to convert biomass to biofuel than corn grain ethanol (Fig. 1) because soybeans create long-chain triglycerides that are easily expressed from the seed, whereas in ethanol production, corn starches must undergo enzymatic conversion into sugars, yeast fermentation to alcohol, and distillation. The NEB (and perhaps the cost competitiveness) of both biofuels could be improved by use of low-input biomass or agricultural residue such as corn stover in lieu of fossil fuel energy in the biofuel conversion process.

Nonfood feedstocks offer advantages for these three energetic, environmental, and economic criteria. Switchgrass (*Panicum virgatum*), diverse mixtures of prairie grasses and forbs (24, 25), and woody plants, which can all be converted into synfuel hydrocarbons or cellulosic ethanol, can be produced on agriculturally marginal lands with no (24, 25) or low fertilizer, pesticides, and energy inputs. For cellulosic ethanol, combustion of waste biomass, such as the lignin fractions from biomass feedstocks, could power biofuel-processing plants. Although gains may be somewhat tempered by higher transport energy requirements, higher energy use for construction of larger and more complex ethanol plants, and possibly greater labor needs, resultant NEB ratios may still be >4.0 (26, 27), a major improvement over corn grain ethanol with its NEB ratio of 1.25 and soybean biodiesel with its NEB ratio of 1.93. Cellulosic ethanol is thought to have the potential to become cost competitive with corn grain ethanol through improved pretreatments, enzymes, and conversion factors (28, 29). The NEB ratio for combined-cycle synfuel and electric cogeneration through biomass gasification (30) should be similar to that for cellulosic ethanol and may convert a greater proportion of biomass energy into synfuels and electricity than is possible with cellulosic ethanol. In total, low-input biofuels have the potential to provide much higher NEB ratios and much lower environmental impacts per net energy gain than food-based biofuels.

Global demand for food is expected to double within the coming 50 years (31), and global demand for transportation fuels is expected to increase even more rapidly (32). There is a great need for renewable energy supplies that do not cause significant environmental harm and do not compete with food supply. Food-based biofuels can meet but a small portion of transportation energy needs. Energy conservation and biofuels that are not food-based are likely to be of far greater importance over the longer term. Biofuels such as synfuel hydrocarbons or cellulosic ethanol that can be produced on agriculturally marginal lands with minimal fertilizer, pesticide, and fossil energy inputs, or produced with agricultural residues (33), have potential to provide fuel supplies with greater environmental benefits than either petroleum or current food-based biofuels.

Methods

Energy Use in Crop Production. We use 2002–2004 U.S. Department of Agriculture data on fertilizer, soil treatment, and pesticide application rates for corn (Table 1) and soybean (Table 2) farming. Our estimates of the energy needed to produce each of these agrichemical inputs are derived from recent studies (2–7). We also estimate per-hectare (ha) energy use for operating agricultural equipment, for manufacturing this equipment and constructing buildings used directly in crop production (Table 3), and for producing the hybrid (corn) or varietal (soybeans) seed planted. We transform these estimates of per-hectare energy use into per-biofuel-liter energy use based on crop to biofuel conversion efficiencies of 3,632 liters/ha for corn grain ethanol and 544 liters/ha for soybean biodiesel. Because this island industry cannot operate without laborers, we also estimate the per-biofuel-liter energy use to sustain farm households (Table 4).

Energy Use in Converting Crops to Biofuels. We estimate the energy used to build the facilities used to convert crops to biofuels (Table 6), transport crops to these facilities, power these facilities, and transport biofuels to their point of end use (Table 5). As with farm labor, we estimate the energy used by households of industry laborers (Table 4).

Energy Yield from Biofuel Production. The energy output of biofuel production includes the combustible energy of biofuels themselves and energy equivalent values for coproducts that typically have uses other than as energy commodities (Table 5). We assign coproduct credits as follows. For DDGS and glycerol we use an "economic displacement" method whereby we calculate the energy required to generate the products for which each serves as a substitute in the marketplace (i.e., corn and soybean meal for DDGS and synthetic glycerol for soybean-derived glycerol). For soybean meal, which does not have an adequate substitute in the marketplace based on both its availability and protein quality, we estimate its coproduct energy credit by a "mass allocation" method as the fraction of energy, based on the relative weight of the soybean meal to the entire soybean weight processed, used to grow soybeans and produce soybean meal and oil. We also apply alternative methods of calculating coproduct credits including issuing energy values based on caloric content and market value (Table 9).

We determine the NEB of a biofuel by subtracting the value of all fossil energy inputs used in producing the biofuel from the energy value of the biofuel and its coproducts. Similarly, we calculate the NEB ratio by dividing the sum of these outputs over that of the inputs.

Environmental Effects. When measuring the life-cycle environmental impacts of each biofuel, we expand the island industry model to include total net emissions from biofuel combustion as well as production. Given the NEB of each biofuel and current fertilizer and pesticide application rates, we calculate for each biofuel the amount of each agricultural input applied per unit of energy gained by producing the biofuel (Table 10). For our estimates of GHG savings in producing and combusting each biofuel in lieu of a fossil fuel, we first calculate the life-cycle GHG savings from displacing the fossil fuel (i.e., from the energy gained in producing the biofuel) and then add to this amount the net GHG emissions released on the farm.

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Office of the Biomass Program and DOE Response to the Lester Brown Article

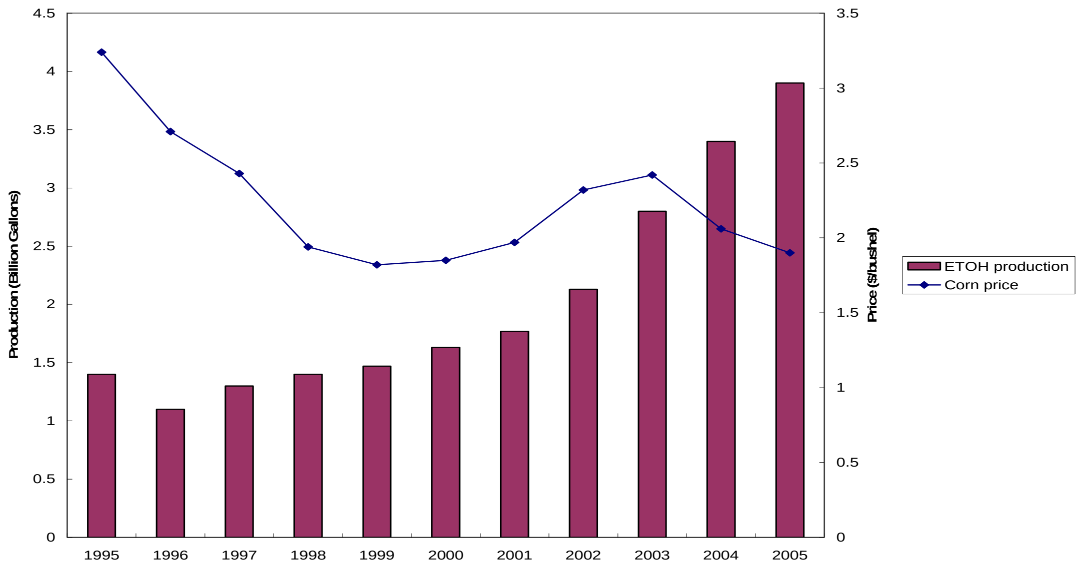
The Lester Brown article takes a short-term snapshot of U.S. agriculture and ethanol production. It is probable that we will see significant fluctuations in corn prices over the next three years as an unprecedented expansion in ethanol production takes place. Eventually, the growth in ethanol production will be mediated by corn prices and other construction and operating costs. A longer term more rational view suggests that corn production will be able to keep pace with ethanol production through 2015. For example, the National Corn Growers Association is estimating that the average per acre corn production in 2015 will be 180 bushels based on historic yield increases. This increase over 2006 would allow the production of 6.7 billion gallons of ethanol without taking any additional corn out the current system. In addition, there are currently 35 million acres in the Conservation Reserve Program. If 50% if this acreage was brought back into corn production, this would produce enough corn to supply an additional 9 billion gallons of ethanol. All of these decisions will be driven by the marketplace supply and demand. Figure 1 shows historical data on corn prices and ethanol production.

Lester Brown Article & Detailed DOE Response

Lester Brown Point	DOE Response
In 2008, corn demand for ethanol will reach 139 million tons. He argues that this will lead to price levels for world grain prices that have never been seen before.	▪ Historically we have seen corn prices at levels that have exceeded $4.00/bushel, but these prices have quickly come back down to historic averages as the market adjusts to increased demand. The 139 million tons of corn represents about 40% of the current corn crop, which is twice of what we are currently using for ethanol production. ▪ While ethanol will create significant demand for corn, the most important feed components (protein and fat) are not taken out of the feed system. Therefore, as the markets adjust to availability of different feeds, corn prices will be rationalized. ▪ The agricultural community will respond with production increases (both in acreage and in yield, which is projected to increase 2.5% per year) as the demand for corn increases with ethanol production. This increase in supply will bring corn prices back in line with historic averages. ▪ Ethanol production is still driven market demand and corn will need to be priced competitively to continue the increased growth in ethanol production.
The numbers of ethanol plants under construction are under estimated by RFA, BBI, Licht and ACE. 200 plants are in the planning stages at the end of 2006.	▪ DOE references the RFA list for ethanol plants under construction because of the strict requirements that RFA maintains when identifying those plants that will actually be constructed. ▪ If the market dynamics change, especially with regard to the long term price of corn, many of these ethanol facilities will not go into construction.
The U.S. corn crop, accounting for 40 percent of the global harvest and supplying 70 percent	▪ The US exports only about 20% of its crop or about 2 billion bushels annually. While this represents a significant portion of the global export for corn, other

of the world's corn exports, looms large in the world food economy. Substantially reducing this export flow would send shock waves throughout the world economy.	countries are continuing to increase domestic supply. ▪ Distillers dried grains (DDGS), the protein rich byproduct of ethanol production could be used to substitute directly for corn in many export markets. ▪ The potential to export DDGS or a modified DDGS may in fact facilitate the growth of ethanol in the US.
Converting the entire U.S. grain harvest to ethanol would satisfy only 16 percent of U.S. auto fuel needs.	▪ While this is a true statement, it has never been the intent of DOE to attempt to displace the entire US liquid transportation fuel needs with ethanol. ▪ DOE believes that while corn will make a significant contribution to ethanol production, cellulosic ethanol will be required to meet our goal of 30%. ▪ DOE estimates, based on the biomass scenario model, that by 2030 corn could contribute about 15 billion gallons of ethanol production and that this level is balanced with other food and feed uses for corn.
The equivalent of the 2 percent of U.S. automotive fuel supplies now coming from ethanol could be achieved several times over, and at a fraction of the cost, by raising auto fuel efficiency standards by 20 percent.	▪ DOE agrees that a multifaceted approach is essential for meeting our demands for liquid transportation fuels. ▪ DOE manages several programs that are developing technologies for improving energy efficiencies in the transportation sector. These include lightweight vehicles, fuel cell technology and improved battery technology for plug in hybrids. ▪ DOE is also supporting engine development technology for improving the engine efficiency of ethanol based (E85) vehicles.
It is time for a moratorium on the licensing of new distilleries, a time-out, while we catch our breath and decide how much corn can be used for ethanol without dramatically raising food prices.	▪ DOE believes that the market will dictate the rate at which ethanol capacity is added. ▪ A national moratorium on licensing would not be in interest of either the agricultural community or the ethanol industry as a whole. ▪ DOE strongly supports the development and deployment of new technologies that would support expanding the ethanol industry with additional feedstocks beyond corn.

Figure 1. Corn Price and Ethanol Production



Sources: USDA, NASS, ERS, NCGA, and Renewable Fuels Association

January 4, 2007 - 1

DISTILLERY DEMAND FOR GRAIN TO FUEL CARS VASTLY UNDERSTATED
World May Be Facing Highest Grain Prices in History

Lester R. Brown

Investment in fuel ethanol distilleries has soared since the late-2005 oil price hikes, but data collection in this fast-changing sector has fallen behind. Because of inadequate data collection on the number of new plants under construction, the quantity of grain that will be needed for fuel ethanol distilleries has been vastly understated. Farmers, feeders, food processors, ethanol investors, and grain-importing countries are basing decisions on incomplete data.

The U.S. Department of Agriculture (USDA) projects that distilleries will require only 60 million tons of corn from the 2008 harvest. But here at the Earth Policy Institute (EPI), we estimate that distilleries will need 139 million tons—more than twice as much. If the EPI estimate is at all close to the mark, the emerging competition between cars and people for grain will likely drive world grain prices to levels never seen before. The key questions are: How high will grain prices rise? When will the crunch come? And what will be the worldwide effect of rising food prices?

One reason for the low USDA projection is that it was released in February 2006, well before the effect of surging oil prices on investment in fuel ethanol distilleries was fully apparent. Beyond this, USDA relies heavily on the Renewable Fuels Association (RFA), a trade group, for data on ethanol distilleries under construction, but the RFA data have lagged behind movement in the industry.

We drew on four firms that collect and publish data on U.S. ethanol distilleries under construction. RFA is the one most frequently cited. The other three firms are Europe-based F.O. Licht, the publisher of *World Ethanol and Biofuels Report*; BBI International, which publishes *Ethanol Producer Magazine*; and the American Coalition for Ethanol (ACE), publisher of *Ethanol Today*.

Unfortunately, the lists of plants under construction maintained by RFA, BBI, and ACE are not complete. Each contains some plants that are not on the other lists. Drawing on these three lists and on biweekly reports from F.O. Licht, EPI has compiled a more complete master list. For example, while we show 79 plants under construction, RFA lists 62 plants. (We welcome any information that will improve this list, which can be viewed at www.earthpolicy.org/Updates/2007/Update63_data.htm.)

According to the EPI compilation, the 116 plants in production on December 31, 2006, were using 53 million tons of grain per year, while the 79 plants under construction—mostly larger facilities—will use 51 million tons of grain when they come online. Expansions of 11 existing plants will use another 8 million tons of grain (1 ton of corn = 39.4 bushels = 110 gallons of ethanol).

In addition, easily 200 ethanol plants were in the planning stage at the end of 2006. If these translate into construction starts between January 1 and June 30, 2007, at the same rate that plants did during the final six months of 2006, then an additional 3 billion gallons of capacity requiring 27 million more tons of grain will likely come online by September 1, 2008, the start of the 2008 harvest year. This raises the corn needed for distilleries to 139 million tons, half the 2008 harvest projected by USDA. This would yield nearly 15 billion gallons of ethanol, satisfying 6 percent of U.S. auto fuel needs. (And this estimate does not include any plants started after June 30, 2007, that would be finished in time to draw on the 2008 harvest.)

This unprecedented diversion of the world's leading grain crop to the production of fuel will affect food prices everywhere. As the world corn price rises, so too do those of wheat and rice, both because of consumer substitution among grains and because the crops compete for land. Both corn and wheat futures were already trading at 10-year highs in late 2006.

The U.S. corn crop, accounting for 40 percent of the global harvest and supplying 70 percent of the world's corn exports, looms large in the world food economy. Annual U.S. corn exports of some 55 million tons account for nearly one fourth of world grain exports. The corn harvest of

Iowa alone, which edges out Illinois as the leading producer, exceeds the entire grain harvest of Canada. Substantially reducing this export flow would send shock waves throughout the world economy.

Robert Wisner, Iowa State University economist, reports that Iowa's demand for corn from processing plants that were on line, expanding, under construction, or being planned as of late 2006 totaled 2.7 billion bushels. Yet even in a good year the state harvests only 2.2 billion bushels. As distilleries compete with feeders for grain, Iowa could become a corn importer.

With corn supplies tightening fast, rising prices will affect not only products made directly from corn, such as breakfast cereals, but also those produced using corn, including milk, eggs, cheese, butter, poultry, pork, beef, yogurt, and ice cream. The risk is that soaring food prices could generate a consumer backlash against the fuel ethanol industry.

Fuel ethanol proponents point out, and rightly so, that the use of corn to produce ethanol is not a total loss to the food economy because 30 percent of the corn is recovered in distillers dried grains that can be fed to beef and dairy cattle, pigs, and chickens, though only in limited amounts. They also argue that the U.S. distillery demand for corn can be met by expanding land in corn, mostly at the expense of soybeans, and by raising yields. While it is true that the corn crop can be expanded, there is no precedent for growth on the scale needed. And this soaring demand for corn comes when world grain production has fallen below consumption in six of the last seven years, dropping grain stocks to their lowest level in 34 years.

From an agricultural vantage point, the automotive demand for fuel is insatiable. The grain it takes to fill a 25-gallon tank with ethanol just once will feed one person for a whole year. Converting the entire U.S. grain harvest to ethanol would satisfy only 16 percent of U.S. auto fuel needs.

The competition for grain between the world's 800 million motorists who want to maintain their mobility and its 2 billion poorest people who are simply trying to survive is emerging as an epic issue. Soaring food prices could lead to urban food riots in scores of lower-income countries that rely on grain imports, such as Indonesia, Egypt, Algeria, Nigeria, and Mexico. The resulting political instability could in turn disrupt global economic progress, directly affecting all countries. It is not only food prices that are at stake, but trends in the Nikkei Index and the Dow Jones Industrials as well.

There are alternatives to creating a crop-based automotive fuel economy. The equivalent of the 2 percent of U.S. automotive fuel supplies now coming from ethanol could be achieved several times over, and at a fraction of the cost, by raising auto fuel efficiency standards by 20 percent.

If we shift to gas-electric hybrid plug-in cars over the next decade, we could be doing short-distance driving, such as the daily commute or grocery shopping, with electricity. If we then invested in thousands of wind farms to feed cheap electricity into the grid, U.S. cars could run primarily on wind energy—and at the gasoline equivalent of less than $1 a gallon. The stage is set for a crash program to help Detroit switch to gas-electric hybrid plug-in cars.

It is time for a moratorium on the licensing of new distilleries, a time-out, while we catch our breath and decide how much corn can be used for ethanol without dramatically raising food prices. The policy goal should be to use just enough fuel ethanol to support corn prices and farm incomes but not so much that it disrupts the world food economy. Meanwhile, a much greater effort is needed to produce ethanol from cellulosic sources such as switchgrass, a feedstock that is not used for food.

The world desperately needs a strategy to deal with the emerging food-fuel battle. As the leading grain producer, grain exporter, and ethanol producer, the United States is in the driver's seat. We need to make sure that in trying to solve one problem—our dependence on imported oil—we do not create a far more serious one: chaos in the world food economy.

Data:

Fuel Ethanol Distilleries in Production and under Construction in the United States by State (table)

Fuel Ethanol Distilleries in Production in the United States (table)

Fuel Ethanol Distilleries under Construction in the United States (table)

Fuel Ethanol Distilleries under Expansion in the United States (table)

U.S. Corn Production and Use for Fuel Ethanol, 1980-2006, with Projection to 2008 (figure and table)

U.S. Corn Use for Fuel Ethanol and for Export, 1980-2006 (figure)

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FOR ADDITIONAL INFORMATION

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Lester R. Brown, "Exploding U.S. Grain Demand for Automotive Fuel Threatens World Food Security and Political Stability," **Eco-Economy Update**, 3 November 2006.

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LINKS

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http://www.ethanol.org

BBI International, **Ethanol Producer Magazine**
http://www.ethanolproducer.com

Food and Agricultural Policy Research Institute (FAPRI)
http://www.fapri.org

F.O. Licht, **World Ethanol and Biofuels Report**
http://www.agra-net.com

Renewable Fuels Association
http://www.ethanolrfa.org

United States Department of Agriculture
http://www.usda.gov

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STATEMENT OF KEITH COLLINS
CHIEF ECONOMIST, U.S. DEPARTMENT OF AGRICULTURE
BEFORE THE U.S. SENATE COMMITTEE ON AGRICULTURE,
NUTRITION AND FORESTRY

January 10, 2007

Mr. Chairman, thank you for the opportunity to discuss renewable energy in relation to U.S. agriculture. While biomass energy from wood and waste have long been important sources of renewable energy, biofuels from agricultural crops are a rapidly growing source of renewable energy, with exciting prospects for the future. I will provide a brief status report on renewable energy focusing on biofuels, then discuss emerging issues related to the rapid growth in biofuels, and conclude with a brief summary of USDA activities in renewable energy.

U.S. consumers want an adequate, clean and affordable supply of energy. Renewable energy can help achieve that goal by utilizing naturally occurring sources such as wind and biomass. Renewable energy can reduce our dependence on fossil fuels, diversify energy sources, improve the trade balance, reduce environmental impacts, and generate income for farmers, ranchers, rural areas and others who harness these natural sources of energy. The Department of Agriculture (USDA) has programs that support renewable energy production, including research, technical assistance, loan and loan guarantee programs, and competitive grants. For example, Section 9006 of the 2002 Farm Bill, the Renewable Energy Systems and Energy Efficiency Improvements Program, has provided $73 million in grants and loans from 2003 to 2006. This program makes loans, loan guarantees, and grants to farmers, ranchers and rural small businesses to purchase renewable energy systems and make energy efficiency improvements. USDA works closely with the Department of Energy (DOE) and other Federal agencies to efficiently coordinate and implement programs to increase renewable energy production.

Overview of Energy Markets

The Energy Information Administration's (EIA) AEO 07 Reference case projections released in December 2006 place U.S. energy consumption at 101 quadrillion Btus (quads) in 2006, eight times the level at the beginning of the last century. Renewable energy consumption in 2006, including hydropower, is estimated at about 6.4 quads, less than four times the level at the start of the last century. U.S. energy use is projected to increase by 30 percent by 2030: from 101 to 131 quads. This means renewable energy production must also increase by 30 percent over the period simply to maintain its current small share of total energy use. The expected growth in energy demand represents a significant challenge if our nation is to reduce its dependence on fossil fuels. However, this growth in total U.S. energy demand also represents an enormous potential for renewable energy, including renewable fuels, with critical implications for agriculture, forestry, and rural America.

The AEO 07 EIA Reference case projects that the real price (2005 dollars) of crude oil will slowly decline from $62 per barrel in 2006 to $46 per barrel by 2012. Oil price and many other factors will influence future demand for ethanol.

Biofuels

Ethanol. In 2000, about 1.6 billion gallons of ethanol were produced in the United States, with ethanol utilizing about 6 percent of the 2000 corn harvest. In 2006, an estimated 5 billion gallons of ethanol were produced, and ethanol accounted for 20 percent of the 2006 corn harvest. Renewable Fuels Association data indicate there are now 110 ethanol plants with total capacity of 5.4 billion gallons and another 73 ethanol plants under construction and another 8 facilities expanding. When construction and expansion are completed, ethanol capacity in the United States will be 11.4 billion gallons per year, which is likely to occur during 2008-09. To provide an indication of how rapidly this expansion is occurring, in August 2006, just 6 months ago, the capacity of known plants and those under construction and expansion was 7.4 billion gallons, some 4 billion less than current estimates. The rapid expansion has been facilitated by high oil prices, the 51 cent per gallon tax credit provided to blenders, low corn prices until this fall, the ethanol import duty of 54 cents per gallon, the Renewable Fuels Standard (RFS), and the elimination of ethanol's main oxygenate competitor, methyl tertiary butyl ether (MTBE).

Another factor supporting ethanol production has been improving production economics. Ethanol production costs declined between 1980 and 1998 due to higher yields of ethanol per bushel of corn, lower enzyme costs, and production automation which lowered labor costs. Energy input costs also fell over this period. U.S. Department of Agriculture (USDA) surveys indicate that between 1998 and 2002 the average cost of producing ethanol (excluding capital costs) remained at about 95 cents per gallon. Since 2002, the cost of producing ethanol has increased to the range of $1.45 per gallon due the increased cost of energy (electricity and natural gas) and corn. Each $1 increase in the per bushel price of corn adds about 36 cents per gallon to the production cost of ethanol, assuming no change in the price of co-products and 24 cents per gallon assuming the prices of co-products increase proportionally with the price of corn. While corn prices have risen, the price of ethanol has been quite volatile. The Chicago futures price for January 2007 delivery fell from over $2.50 per gallon last June and July to about $1.70 in late September and then rose most recently to about $2.40, suggesting a fairly good return on average at the ethanol plant.

Various industry analysts believe there are many more ethanol plants in different stages of planning in addition to the plants currently under construction or expansion. Projected ethanol production capacity currently falls in the range of 13 to 15 billion gallons by 2012, which could change if there is a collapse in the price of ethanol.

Biodiesel. U.S. biodiesel production was very small until USDA initiated the Bioenergy Program in Fiscal Year (FY) 2000 that encouraged biodiesel production through cash payments to producers. Mostly due to this incentive, biodiesel production increased from a half million gallons in 1999 to 28 million gallons in 2004 and 91 million gallons in 2005. The Bioenergy Program authorization ended in FY 2006, but the up to $1 per gallon biodiesel tax credit was extended until 2008 by the Energy Policy Act of 2005. High diesel prices and new tax incentives continue to spur production. USDA estimates U.S. biodiesel production reached 250 million gallons in 2006, a 173-percent increase from 2005. For the 2005/06 crop year, biodiesel production accounted for 8 percent of soybean oil use; for 2006/07, biodiesel is expected to account for 2.6 billion pounds of soybean oil or 13 percent of total domestic soybean oil use. The 2.6 billion pounds equals the oil extracted from 229 million bushels of soybeans or 7 percent of estimated U.S. soybean production in 2006.

As of November 2006, the National Biodiesel Board indicated there were 87 U.S. biodiesel plants, varying markedly in size, with a total annual production capacity of about 582 million gallons. Most plants have an annual production capacity below 6 million gallons. The National Biodiesel Board reports that there were also 65 new plants under construction and 13 under expansion that are expected to add another 1.4 billion gallons to annual capacity. While soybean oil is the most common feedstock, one plant under construction that will have an annual expected capacity of 85 million gallons plans to use canola oil.

The cost of producing biodiesel depends heavily on feedstock and processing costs. Soybean oil has a higher cost than other feedstocks, but other feedstocks, such as yellow grease and beef tallow, cost more to process. The processing cost per gallon of biodiesel made from soybean oil—which currently accounts for over 90 percent of biodiesel production—including materials, labor, energy, plant depreciation, and interest is about $0.50 per gallon for a 5 million gallon per year plant. The cost of the feedstock is by far the largest production expense item. For example, soybean oil at current prices would cost over $2.00 for one gallon of biodiesel, resulting in a total production cost (excluding capital costs) of about $2.50 per gallon. With low sulfur spot diesel selling at Gulf ports for about $1.66 per gallon in late December, even with the $1.00 per gallon tax credit and a $0.10 per gallon small producer tax credit for biodiesel, the margin above costs at the biodiesel plant is thin.

Judging from the capacity that is currently being built by investors, biodiesel production is expected to continue growing rapidly over the next few years. Given the thin margins in biodiesel production and projections for declining real crude oil prices, biodiesel production is expected to be sharply higher but below 400 million gallons in 2007. Even so, biodiesel could account for 20 percent of U.S. soybean oil production for the 2007/08 crop year. For perspective, 400 million gallons of biodiesel equals about 1 percent of expected highway diesel use in 2007 according to EIA. So while any displacement of fossil fuels with biofuels is generally beneficial for the nation, it is clear that we cannot grow our way to energy independence, but agriculture can make an important contribution.

Other Renewable Energy. Other renewable energy sources, while still small, are growing rapidly and offer important opportunities for participation by U.S. farmers, ranchers, and rural areas. Electricity generation from wind increased from 0.06 quads in 2000 to 0.146 quads in 2005, up 160 percent. EIA's preliminary reference case projects wind power to rise to 0.48 quads by 2010, up 230 percent from 2005. Several factors have stimulated the expansion, including high natural gas prices, the Federal wind production tax credit of 1.9 cents per kilowatt hour for the first 10 years of a project's production, regulatory policies promoting greater access to the electricity grid by wind power producers, state incentives and mandates for renewable electricity use, improved turbine efficiency and reliability, declines in production costs that now put wind power costs similar to gas combined-cycle and coal in areas where wind turbines can operate at high levels of capacity, and the emergence of marketing programs for green power.

The leading wind power state is California, however, wind power is also growing in Midwestern states from Minnesota to Texas. Many Midwestern and Western states have the wind resources to produce much more wind power. U.S. farmers and ranchers are providing land to turbine owners, and in some cases, owning the turbines. The major decision factors considered by potential wind developers are having sufficient wind for economically feasible electricity production, having access to transmission lines, and estimating whether construction can be completed in time to be eligible for the Federal wind production tax credit.

Another small but increasingly important source of renewable energy for agriculture is electricity from methane. Anaerobic digestion of animal wastes breaks down the wastes into biogas and other co-products. The biogas is usually used to generate electricity on the farm and may be sold onto the electricity grid. The effluent is used as a fertilizer and solids extracted from the effluent are used as animal bedding material. New, large digester complexes that utilize manure from multiple farming operations are scrubbing the biogas and piping it as a natural gas substitute. Most digesters are on dairy or hog operations and the number of digesters has increased sharply in recent years.

The Environmental Protection Agency's (EPA) AgStar program, with support from USDA and DOE, promotes digesters to reduce methane emissions and achieve other benefits.

Most direct financial support for digesters has come from USDA programs, although many states provide grants, loans, or technical assistance. The economics of digesters are complex and feasibility depends on many factors, including the supply of manure, the ability to use or sell power generated, and the efficiency of the digester. Farms using digesters successfully benefit from electricity generation, better manure and fertilizer management and reduced costs, less potential for water contamination, better odor and fly control, reduced herbicide use as the applied effluent may contain fewer weed seeds than manure, and reduced methane emissions, a potent greenhouse gas.

Emerging Biofuels Issues

The rapid growth of biofuels production has stimulated much enthusiasm about the prospects for ethanol and biodiesel making substantial inroads in reducing gasoline and diesel fuel consumption. Yet, the rapid growth has generated many questions about its sustainability and the current and potential impacts of this evolving industry. This section reviews some of these issues.

Acreage. The increase in corn production used for ethanol has set in motion an expectation of a substantial adjustment in U.S. field crop production for 2007. As more corn moves to more ethanol plants, corn prices have risen signaling the market’s need for more corn acreage and production. For 2006/07, USDA forecasts the total use of U.S. corn will be equivalent to the production on 85.6 million acres. Yet, only 78.6 million acres were planted in 2006. Corn supplies are expected to meet demand because of large carryin stocks of corn, which are expected to be reduced by more than half. During August 2006, prior to the start of the 2006/07 crop year, the average price received by farmers for corn was $2.09 per bushel. By December 2006, after a corn harvest that was slightly below summer expectations and a growing awareness that ethanol production capacity is coming on line at a very rapid rate, U.S. farm-level corn prices averaged $3.01 per bushel, an increase of 44 percent from the August level.

As corn farmers ponder spring planting decisions, they will likely consider corn and soybean futures prices. The Chicago Board of Trade December 2007 corn futures contract recently traded at about $3.75 per bushel. The ratio of the November 2007 soybean futures price to the December 2007 corn futures price has been about 2 to 1, well below the August soybean-to-corn farm price ratio of 2.5 to 1. With market prices shifting in favor of planting corn at the expense of soybeans and other crops, a sharp increase is expected in corn acreage this spring. The prospective increase in corn acreage is already having ripple effects on agricultural commodity markets. For example, despite having a high level of stocks at the start of the 2006/07 marketing season and record-high production this fall, soybean prices have increased in anticipation of reduced soybean planted area this spring.

Looking ahead to the 2007 crop of corn, it is quite likely, based on current ethanol plant construction, that corn used in ethanol production will rise by more than 1 billion bushels from the 2.15 billion bushels of the 2006 corn crop expected to be used for ethanol. Use of 1 billion bushels, at a trend yield of 152 bushels per acre, would require an additional 6.5 million acres of corn, if corn consumed in other uses remains unchanged from this year's projected levels. With corn stock levels already being reduced this year, another large drawdown in stocks for the 2007-crop marketing year will not be available to meet the rising demand, thus the higher corn prices that are signaling more planting. Beyond 2007, to achieve steady increases in ethanol production from corn will require ever more acreage or higher corn yields per acre, or both.

A related issue is the implication of farming substantially more corn acres. These implications include the possible environmental consequences of more nitrogen fertilizer use, and the potential that more marginal lands may come into production having greater vulnerability to erosion, nutrient runoff, and leaching. To meet the demand for biofuels, some corn acreage could return to production from land in the long-term Conservation Reserve Program (CRP) as contracts mature, but that land may be environmentally sensitive and would need to be properly farmed. In addition, former CRP land may have lower yields and take some time before such land can be made suitable for crop production. The productivity of cropland and the environmental challenges may be addressed at least partially by the programs of the Farm Security and Rural Investment Act of 2002, which greatly increased financial support for conservation programs. In addition, farm management is steadily improving and the 2007 Farm Bill could also address these challenges.

Corn yields. Research was the founding role for USDA and has continued to be a fundamental function of the Department for nearly 150 years. Research, whether performed and supported by USDA, or by others, has enhanced agricultural productivity, increased agricultural output, and expanded agricultural exports, all while less cropland is being farmed. Productivity measures the ability to produce more output from a given set of inputs. Technology advances that have raised productivity have been a critical source of income growth, wealth creation, and international competitiveness. In fact, virtually all the growth in U.S. agricultural output over the last 50 years is explained by growth in productivity. Growth in inputs used, such as land, has been quite modest.

Research and the resultant productivity gains could potentially solve much of the acreage challenge facing corn ethanol production. Since 1948, corn yields have increased four-fold, from 40 bushels per acre to 160 bushels in 2004 due to fertilizers, better management, technology, and improved crop genetics. It appears corn yields in the past couple of years have moved above the long-term trend and may continue to do so in coming years as well, helping to meet biofuel demand and reduce pressure on corn prices and acreage. Acreage planted to genetically engineered corn varieties has increased from 25 percent of corn acres in 2000 to 61 percent this year. Over the past few years, new generation root worm resistant corn has been introduced and is showing strong yield increases in many areas. Over the next couple of years, drought-tolerant varieties of corn are expected to become commercially available. As we look out over the next decade, USDA trend projections suggest U.S. corn yields per acre rising to 168 bushels by 2015, however, at least one seed company projects yields that are more than 20 bushels per acre above that level. Each 5 bushel increase in yield above the current trend level would be the equivalent of adding around 2.5 million acres to corn plantings, enough to produce an additional one billion gallons of ethanol each year.

Effects on crop consumers. With ethanol fueling a push for more corn acres, major crop prices are generally expected to be higher over the next couple of years than in the recent past. Soybeans, while facing competition from ethanol feed co-products, such as Distillers Dried Grains (DDG), are still likely to face higher prices over time, as lower expected soybean acreage offsets the lower soybean meal demand and more soybean oil is demanded for biodiesel production.

Livestock and poultry profitability declines under higher corn feeding costs. For example for hogs, which are heavily dependent on corn and limited in the level of DDGs that can be put into feeding rations, a $1 per bushel increase in the price of corn would raise the cost of producing hogs by about $6 per cwt. With hogs selling for a U.S. average of $43 per cwt in December 2006, the cost of production increase would be about 10 percent of the market price. The farm level value of hogs was about 29 percent of retail value of pork in November 2006, so if the higher feed costs were fully passed on to retail over time, a $1 per bushel increase in the price of corn would translate into about a 3 percent increase in the consumer price of pork. This increase could be more or less depending on how much pork production declines, the speed of market adjustments, the extent to which DDGs substitute for corn and soybean meal, and how other users adjust demand in response to the increase in corn prices. Poultry producers, also heavy users of corn would be similarly affected. Cattle producers overall face a smaller impact than hog and poultry producers, because of their heavier reliance on hay, rangeland, and pasture for weight gain and cattle can accommodate a higher portion of DDGs in their rations.

USDA forecasts that choice cattle prices in 2007 will average $85 per cwt, about the same in 2006 as beef production expands modestly. Hog prices are expected to decline 13 percent as production increases by nearly 4 percent over 2006. The lower hog prices and higher feed costs will likely slow expansion beyond 2007. Broiler prices are expected to increase in 2007 as production grows more slowly due to reduced prices in 2006 and higher feed costs.

Despite higher corn and soybean prices this year, exports for both commodities remain strong. In the future, to the extent that corn and soybean prices continue to rise, exports would be expected to decline as foreign livestock produces cut back on feed use and purchase feed from other sources, such as Brazil and Argentina.

Profitability of ethanol. How the growth of corn ethanol and its effects on agricultural producers unfolds in the future depends importantly on the profitability of producing ethanol. As ethanol production expands beyond regulated markets, such as reformulated gasoline, and beyond the market for ethanol as an octane enhancer, the long-standing price premium of ethanol over gasoline is likely to decline toward ethanol’s energy equivalent with gasoline.

Can ethanol's rapid production gains outstrip demand growth? If the 140 billion gallons of gasoline now consumed was E10, or 10 percent ethanol, roughly 14 billion gallons of ethanol would be used. However, the practical limit on E10 would be less than that as it would be very difficult to distribute and blend E10 everywhere. Unless E85 and flex-fuel vehicles become much more pervasive or blend levels above 10 percent are used in conventional engines (which requires regulatory approval and engine warranty coverage), demand growth for ethanol is likely to slow in several years as the E10 market approaches its limit. In the face of continued production increases, the price of ethanol could even fall below its energy equivalent to gasoline. If corn prices continue to stay strong and ethanol demand growth slows, ethanol profitability would decline and expansion could slow appreciably in several years. While this scenario would take pressure off the acreage adjustments and commodity prices in agriculture, it would diminish the ability to reduce U.S. energy dependence on fossil fuel. If ethanol is to continue its expansion beyond 10 percent of U.S. gasoline use, higher blend levels and E85 will have to become far more pervasive than they are today, and, given corn production constraints, cellulosic ethanol will have to become economically feasible.

Cellulosic ethanol. A key challenge facing renewable fuels is in the area of alternative feedstocks. Even with higher corn yields, corn ethanol alone cannot greatly reduce U.S. crude oil imports. Nearly 60 percent of U.S. crude oil use is imported. In 2006, ethanol production on an energy content basis was equivalent to only 1.5 percent of U.S. crude oil imports and a little over 2 percent of gasoline consumption. Despite ethanol's small share of gasoline demand, it already claims a large share of corn production. Ethanol could account for over 25 percent of the 2007 crop of corn, compared with 20 percent for the 2006 crop. Clearly, developing biofuels from alternative feedstocks will be necessary for long-term expansion of biofuels.

Cellulosic ethanol appears to be the best biofuel alternative for reducing crude oil imports, but making it commercially feasible on a wide scale is a formidable challenge. Information from investors and potential producers suggest some technologies are close to being economically viable but need demonstration plants to prove the efficiency on a larger scale and secure low-cost financing. The capital requirement per gallon of ethanol is much higher for ethanol produced from cellulose than for corn ethanol. Ethanol yield is lower per ton of feedstock and conversion is complex, requiring enzymes that cost substantially more than for corn ethanol. Harvesting, bailing, storing, and transportation of biomass are expensive compared with corn. Research and investment capital are now being directed at overcoming these barriers.

For example, one ethanol producer has announced the expansion beginning in 2007 of an existing corn ethanol plant in Iowa so it can use corn stover to produce ethanol. Also, much has been learned about producing, harvesting, storing and processing switchgrass in electric power generation. In addition, the President's Advanced Energy Initiative includes increased funding for research aimed at improving the technology for cellulosic ethanol production. DOE has a goal of reducing the cost of cellulosic ethanol to $1.07 per gallon by 2012, which would likely put it at or below the cost of producing ethanol from corn, opening up an enormous opportunity for producing cellulosic ethanol.

Activities of USDA

USDA has a variety of programs to support renewable energy. Many programs are conducted cooperatively with DOE, EPA, other agencies, university researchers and private business. Without going into detail, the following list illustrates the range of activities:

- **Research programs.** The Agricultural Research Service conducts research on issues such as: ethanol from starch crops other than corn; co-products from grain-based ethanol production; biodiesel production processes and product quality; cellulosic ethanol, including cellulosic feedstock design, which aims to develop an understanding of plant cell wall molecular biology and to develop high yielding biomass feedstock suitable to as many ecoregions in the U.S. as possible; cellulosic feedstock production, which focuses on production management techniques, including ways to help provide biorefineries with year-round supplies; cellulosic feedstock logistics, which addresses the need for sustainable and efficient harvesting, handling, storage and delivery of biomass; and cellulosic feedstock conversion. The Cooperative State Research, Education and Extension Service supports renewable energy through formula funding and competitive grants under the National Research Initiative, the Small Business Innovation Research Program, and the Sustainable Agricultural Research and Education Program. The Forest Service conducts research on sustainable feedstock systems with a goal of reducing costs of wood production, transportation, and conversion to ethanol and other biobased products.

- **Rural development programs.** USDA's Rural Development offers a range of renewable programs that may be used for renewable energy production, including loans to rural electric cooperative borrowers for producing and distributing renewable energy; grants for planning and working capital, such as for ethanol and biodiesel plants; grants and loans for renewable energy production and energy conservation under section 9006 of the 2002 Farm Bill, the Renewable Energy Systems and Energy Efficiency Improvements Program; loan guarantees for renewable energy ; and competitive research and demonstration grants under the section 9008 of the 2002 Farm Bill, the Biomass Research and Development Act Initiative.
- **Conservation programs.** The Natural Resources Conservation Service helps producers farm sustainably through technical assistance and through financial assistance under the

Environmental Quality Incentives Program and the Conservation Security Program (CSP). CSP provides financial assistance for specific energy production and conservation activities.

- **Biofuel production direct financial assistance.** The Farm Service Agency operated the Bioenergy Program under section 9010 of the 2002 Farm Bill until authority expired in 2006. The program, directly subsidized biofuel production at $150 million in Fiscal Year 2006.
- **Biodiesel and bioproduct marketing support.** The Office of Energy Policy and New Uses in the Office of the Chief Economist administers section 9004 in the 2002 Farm Bill, which is the national Biodiesel Education Program and section 9002, "Biopreferred," the Federal Biobased Product Preferred Procurement Program.
- **USDA renewable energy use.** USDA's Departmental Administration administers legislation and Executive Order 13149 directed at reducing USDA use of fossil fuels and increasing use of alternative fuels, including biofuels.

Conclusion

In conclusion, the strong and growing U.S. economy has an undeniable need for energy. Meeting this demand in a cost-effective way that promotes domestic economic growth and energy security offers biofuels a tremendous economic opportunity. Increasing the market share of biofuels to the point that energy security is markedly enhanced will be a long-term and complex effort. Such an expansion can occur only with achievements on multiple fronts—higher crop yields, more acres planted to energy crops, alternative feedstocks, higher value co-products, more efficient conversion and distribution systems for both feedstocks and biofuels. Market-based policies and intelligent joint public-private efforts are keys to success. Targeted government grants for feasibility and development work and research expenditures to overcome cost barriers are positive approaches that help overcome expansion barriers and still rely on market signals to allocate resources efficiently. The 2007 Farm Bill provides another opportunity to address the implications of expanding renewable energy for U.S. agriculture and rural areas.

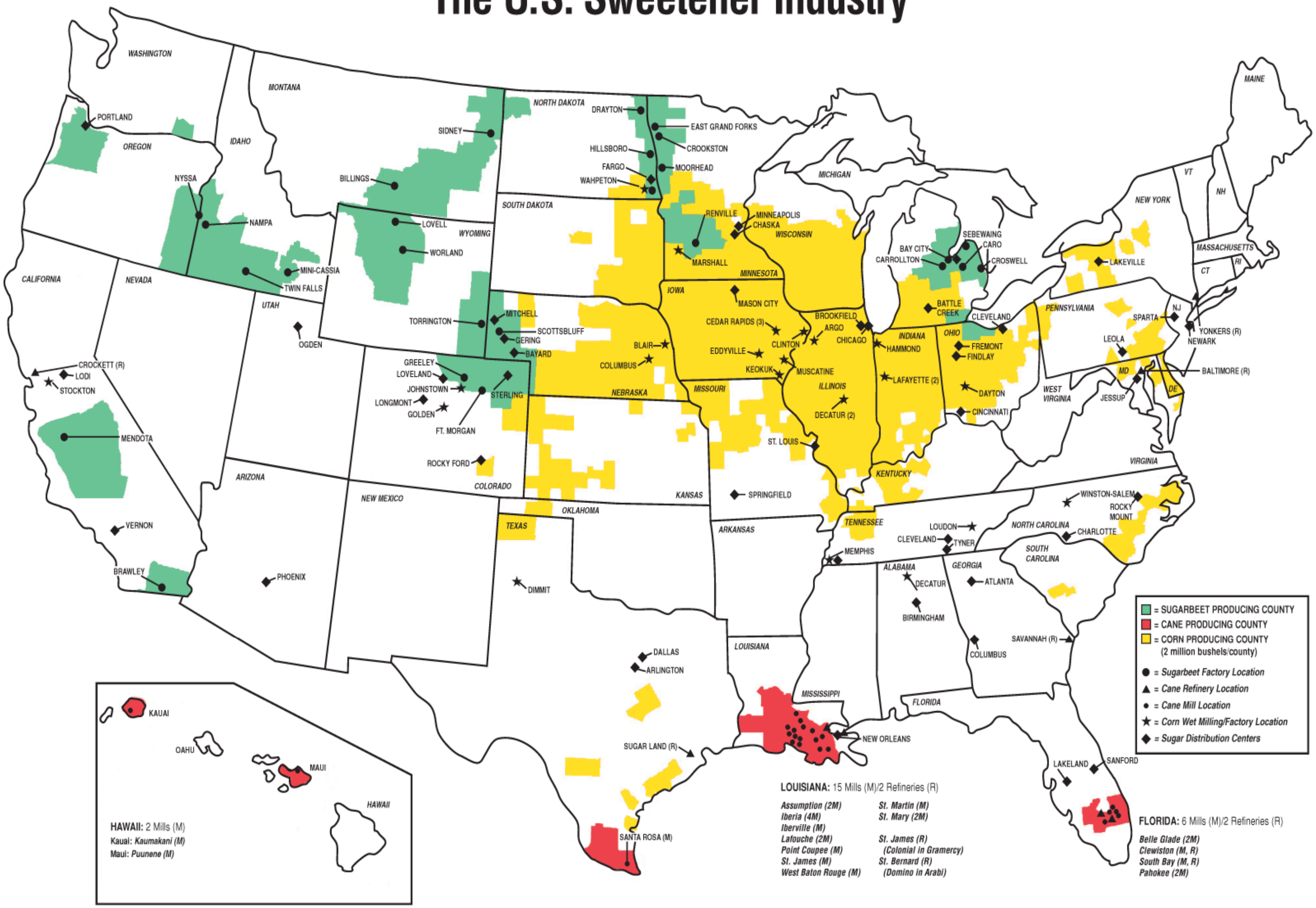
That completes my comments and thank you, Mr. Chairman.

Attachment G

Sugar Production
in the United States

and its biomass possibilities and
impossibilities

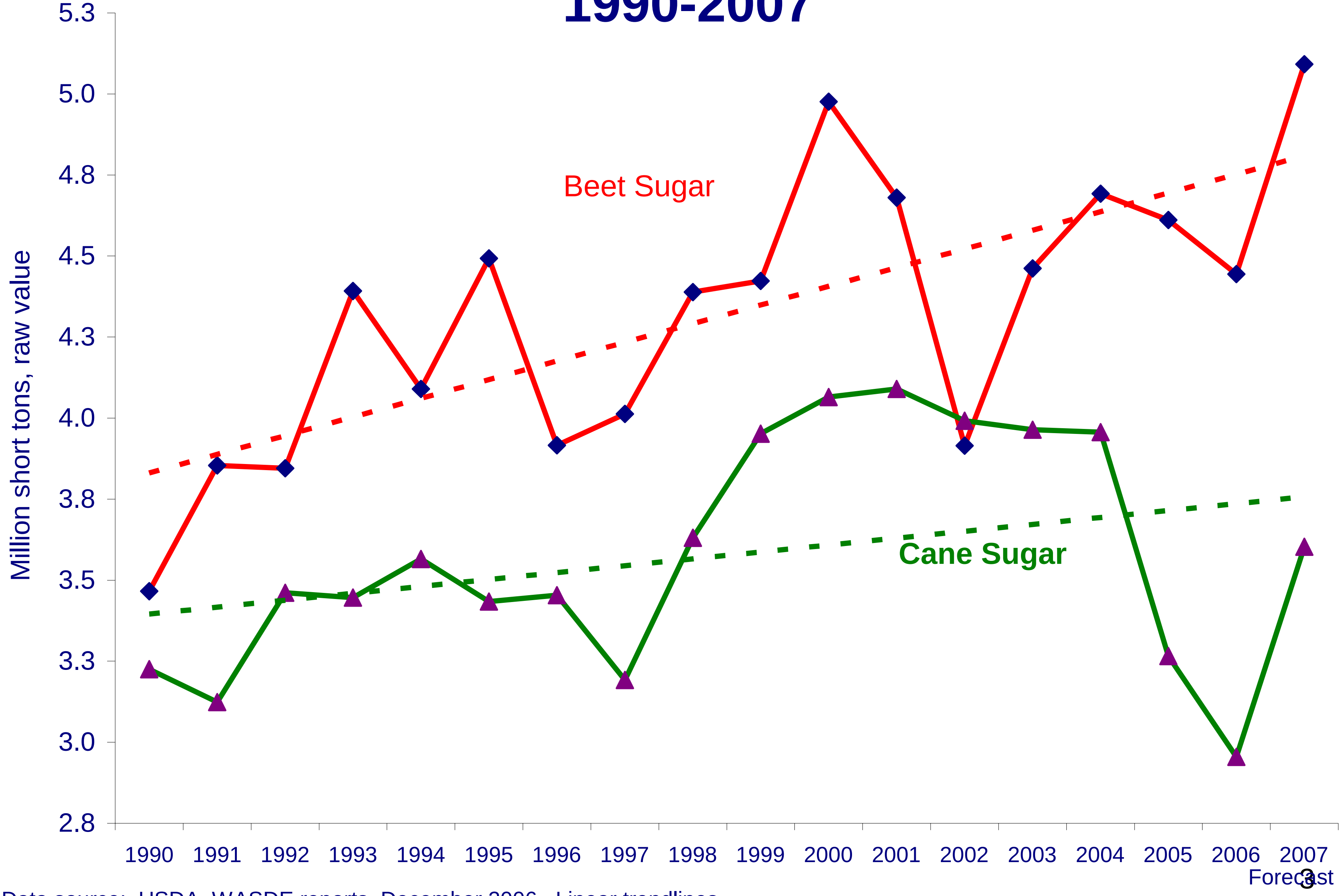
The U.S. Sweetener Industry



American Sugar Alliance, 2111 Wilson Blvd., Suite 600, Arlington, VA 22201
Phone: 703-351-5055 Fax: 703-351-6698 www.sugaralliance.org

2004

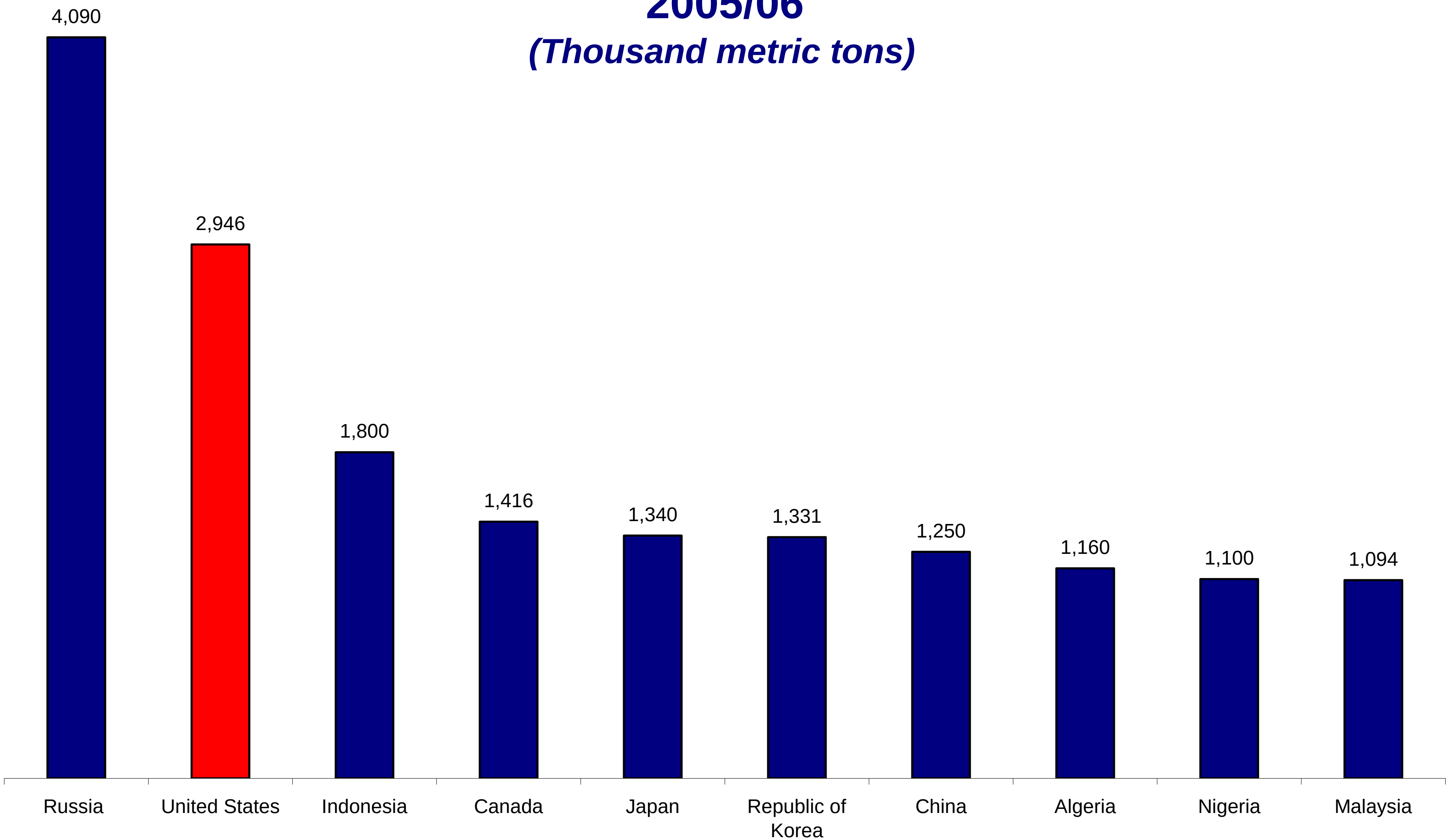
U.S. Beet and Cane Sugar Production, 1990-2007



Data source: USDA, WASDE reports, December 2006. Linear trendlines.

United States: World's Second Largest Net Importer 2005/06

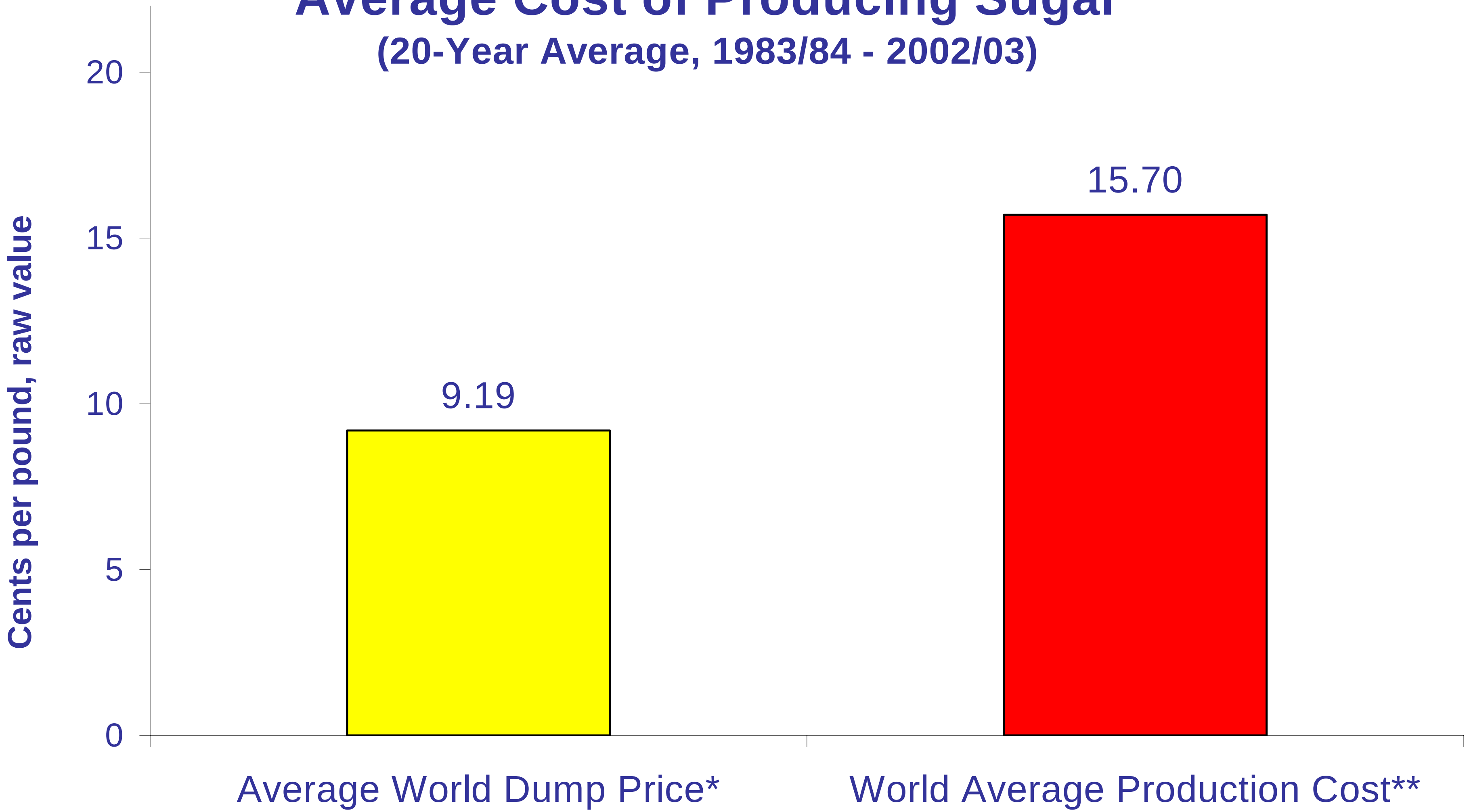
(Thousand metric tons)



Source: Foreign data--USDA/FAS, May 2006; U.S. data--USDA World Agricultural Supply and Demand Estimates (WASDE), October 2006.

World Sugar Dump Market Price: Barely More Than Half the World Average Cost of Producing Sugar

(20-Year Average, 1983/84 - 2002/03)



*New York contract #11, f.o.b. Caribbean ports. Source: USDA.
**Beet and cane sugar weighted average, raw value. Source: "The LMC Worldwide Survey of Sugar and HFCS Production Costs: The 2003 Report," LMC International, Ltd., Oxford, England, December 2003.

USDA Sucrose Ethanol Study

Feedstock Costs

	$/gallon
Corn (dry mill)	0.53
Corn (wet mill)	0.40
Sugarcane	1.48
Sugar beets	1.58
Molasses	0.91
Raw sugar	3.12
Refined sugar	3.61

Advantages of Sugar Cane

- Tonnage of biomass per acre (15 or more dry tons per acre compared to switchgrass at 2 to 6.75 dry tons per acre) [1]
- Pre-existing delivery system to mills (if sugar and ethanol facilities are co-located)
- Geographically located in many areas where corn ethanol is not being produced in large quantities
- Located close to current oil refineries

1. Source: “25 X 25: Agricultural and Economic Impacts” November 2006

Disadvantages

- Bagasse currently used for firing plants would not be available in a 100 percent cellulosic ethanol production facility
- Sugarcane used to produce sugar would compete with sugarcane for ethanol and could become dependent on the price of ethanol and oil
- Extra electricity sold into the grid from cane mills may not be available
- By-Products if using current Brazilian model -- Vinasse

Green electricity

- Florida Crystals Corporation (FCC) produces enough electricity for 43,000 homes per day in Florida
- The total electricity production of FCC and U.S. Sugar Corporation displaces over one million barrels of oil per year that would otherwise be needed for power
- HC&S in Hawaii is currently providing power to the grid on the Island of Maui
- The Rio Grande Valley Sugar Producers plan to sell power in 2008

President's Farm Bill Proposal

- Initiate a new, temporary program to provide $100 million in direct support to producers of cellulosic ethanol

- Create a Cellulosic Bioenergy Program that would provide $25 million annually to share the cost of biomass feedstocks used by cellulosic ethanol producers

Brazilian Ethanol Program

- The Ethanol Program has also been a mechanism of transfer of subsidized public funds (a total of ≈ US $10 billions) to a few important industrialists
- With “high” oil prices ≈ US $40/barrel possible economic incentive for Ethanol program expansion
- With “low” international oil prices (below ≈ US $30/barrel) -- Ethanol Program growth <u>will</u> depend upon its contribution to curb the increase of the ***greenhouse effect*** – Is this realistic?
- Is the proposed U.S. program realistic? (U.S. and Brazil together only produce 9 billion gal total and U.S. consumption of gas and diesel was 200 billion in 2006)

Source: “The Brazilian Ethanol Program Biofuels for Transport” Prof. Emilio Lèbre La Rovere, Federal University of Rio de Janeiro, Brazil, 4 June 2004

Audubon Sugar Institute (ASI)

- In Louisiana, ASI is conducting a sugarcane-to-ethanol research project using bagasse
- Research shows that one dry ton of sugarcane bagasse can generate 80 gallons of ethanol while corn is closer to 100 gallons
- Peter Rein, director of the Institute says, “The challenge is the economics. We can do it in the lab. The technology is there, but the economics aren’t there yet to be commercially viable.”

Source: “Ethanol from Sugar” James Jacobs, Ag Economist, USDA Rural Development

Attachment H

POLICY GAP ANALYSIS: FINDINGS & POLICY RECOMMENDATIONS FOR THE BIOMASS SECTOR

PREPARED FOR: THE BIOMASS R&D
TECHNICAL ADVISORY COMMITTEE'S
POLICY SUBCOMMITTEE

PREPARED BY:
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February 17, 2007

Introduction

The Biomass Research and Development Initiative (BRDI) is the multi-agency effort to coordinate and accelerate all Federal biobased products and bioenergy research and development in the United States. BRDI is guided by the Biomass Research and Development Act of 2000, passed in June of 2000 (Title III of the Agricultural Risk Protection Act of 2000, P.L. 106-224), and revised by section 937 of the Energy Policy Act of 2005. The Act established the Biomass Research and Development Technical Advisory Committee - a group of 30 individuals from industry, academia, state government – to advise the Secretaries of Energy and Agriculture on the direction of biomass research and development..

The purpose of this paper is to analyze existing policies impacting bioenergy and biobased products and to evaluate their effectiveness. It also is to identify policy gaps which exist, to develop recommendations which will improve biomass-related policies, and to influence biomass policy discussion and decision making, in particular the upcoming discussions regarding the 2007 Farm Bill.

To complete this analysis, the Biomass R&D Technical Advisory Committee surveyed existing policies related to biomass technologies. This included a literature search as well as discussions with experts in the field. Policies were analyzed based on their effectiveness in furthering biofuels, biopower, or biobased products. They also were analyzed in terms of their perceived effectiveness in meeting the Committee's Vision goals.

The status of the role of biofuels, biopower, and biobased products was assessed and major barriers to further market penetration were identified. The effectiveness of relevant policies at affecting market penetration was then evaluated. This analysis is summarized in each of the Biofuels, Biopower, and Biobased Products policies matrices included in this document. From this analysis, Committee members then developed recommendations for improving existing policies. If there were no existing policies promoting the development of biomass technologies in key areas, new policies were recommended.

The paper is organized into three major sections: biofuels, biopower, and bioproducts. Each section lists findings related to a specific policy or key area of biomass technology. Each finding is followed by a policy recommendation. In cases where there is no existing policy, recommendations regarding new policy options are provided. Appendices A-C provide additional information used to develop this analysis. Appendix A contains tables highlighting key bioproducts. Appendix B provides a list of all biomass-related policies, and Appendix C is a proposal submitted by the Committee for the U.S. government to consider which outlines a comprehensive program to promote the increased production of biobased products and bioenergy research and development in the United States.

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I. BIOFUELS

Findings and Recommendations

1 The Federal Renewable Fuels Standard (RFS)

Finding: The RFS in EPAct 2005 mandates 7.5 billion gallons per year of renewable fuels production by 2012. Current renewable fuels production is on track to meet this near term goal. Ethanol from corn is in line to meet goals over the next few years (based on an estimate: one billion gallons per year of sustained growth) although growth of ethanol from corn sugar beyond 15 billion gallons per year targets faces several significant barriers, including agricultural inputs (cost of fuel, fertilizer), scarcity of land (urbanization and lack of arable land), competition with other uses, and lack of feedstocks other than corn (e.g., sugar cane, sugar beet, other crop starches, and cellulosic materials such as switchgrass). Moreover, tax incentives with short term sunset clauses do not provide the investment community the level of comfort needed to make long-term investment.

1.1 *Recommendation: Establish Broader-based RFS*
The Federal Government should establish an even broader-based RFS for the transportation sector, targeting a higher percentage of consumption of biofuels. Moreover, incentives should have longer time horizons to attract the long-term capital investments needed for the development of the production and distribution network required to achieve biofuels goals. Additional funding for future incentives should be targeted at cellulosic biofuels (biochemically or thermochemically produced).

2 Volumetric Ethanol Excise Tax Credit (VEETC)

Finding: In 2004, ethanol and biodiesel constituted approximately 1.5 percent and 0.9 percent of the gasoline and diesel markets, respectively. Ethanol has received sustained federal support through VEETC a $0.51 per gallon tax credit for blenders who blend ethanol with gasoline. Only recently have Federal programs begun to support other biofuel options, such as biodiesel, through the Biodiesel VEETC which provides $0.50 per gallon for biodiesel ($1.00 for agri-biodiesel and renewable biodiesel). VEETC has been one of the most successful biofuels policies to date and can help the market share of biofuels to grow. The current market demand for increased oxygenates is adequate to drive growth of ethanol by one billion gallons per year through 2012 which should reach the RFS of 7.5 billions gallons by 2012.[i] Put in perspective, demand for oxygenates in 2004 was only 1.2 percent of the total 2.1 billion gasoline-equivalent gallons (GGE) of transportation fuels (includes gasoline and diesel).

2.1 *Recommendation: Diversification of Feedstocks*
Diversification of the feedstocks for biofuels will strengthen continued growth of biofuels. Funding for competitive R&D should be expanded by at least an order of magnitude over 2006 levels to be more aligned with the President's Twenty in Ten goal. [ii] *Credits for*

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[i] Personal communication from Jeff Cooper, NCGA, in April, 2006. Numbers were still being vetted in final report.
[ii] The President's Twenty In Ten Goal: Increasing The Supply Of Renewable And Alternative Fuels By Setting A Mandatory Fuels Standard To Require 35 Billion Gallons Of Renewable And Alternative Fuels In 2017 – Nearly Five

alternative biofuels should be implemented. Funding should be structured to reduce the cost and lower the barriers to commercialization of cellulosically derived biofuels as well as grain derived biofuels. Cellulosic production methods and technology may deserve disproportionate funding to support a more competitive market price for cellulosically derived biofuel. Grain derived biofuel production technology that reduce production costs should also be pursued. Biofuels should not be separated into different commodities based upon the feedstock they came from.

3 Federal Fleet Requirements (FFR)

Finding: FFR is a mandate which can be met through the use of alternative vehicles and/or fuels.

3.1 *Recommendation: Mandates and Incentives*
FFR is a gateway policy for more widespread use and creates a base market for renewable fuels. Continued development of mandates and incentives, not preferences, must be instituted as federal (and local) policies.

4 The Clean Air Act (CAA)

Finding: CAA requires reformulated gasoline (RFG) be used in non-attainment areas to reduce harmful emissions of ozone. As the phase out of MTBE as a fuel oxygenate nears completion, ethanol has become the primary oxygenate additive increasing ethanol consumption and production.

4.1 *Recommendation: Environmental Programs and Regulations*
Continued application of environmental programs and regulations such Clean Cities, the CAA*, and Regional Environmental Greenhouse Gas agreements will encourage the increased use of biomass for fuels, power, and products.*

5 Multi-agency Panel

Finding: We find that multi-agency panels are an effective tool to analyze and implement policy initiatives which have broad-based implications. We recommend the federal government develop a multi-agency panel to analyze the following potential policy initiatives:

5.1 *Recommendation: Cellulosic Biofuels*
Major new initiatives are needed in support of cellulosic biofuels commercialization efforts (as distinct from R&D). The committee recommends that the federal government analyze the idea of a "Government Biofuels Authority" (see Appendix C), as one such approach.

5.2 *Recommendation: Private Investors*
Potential private investors in biofuels require a stable and predictable policy environment for making long-term capital investment decisions. The government should help create

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Times The 2012 Target Now In Law. Reforming And Modernizing Corporate Average Fuel Economy (CAFE) Standards For Cars And Extending The Current Light Truck Rule.

this policy environment. The committee recommends that the federal government analyze several approaches for potential implementation, including

5.2.1 Recommendation: A National Carbon Emissions Policy
(See recommendation in Cross Cutting Section).

5.2.2 Recommendation: Setting a Floor Price on Oil
The world market price falling below a prescribed level would trigger government revenues that could be used to help provide incentives for production of biofuels.

Biofuels Policy Matrix

Goals	Status	Gaps	Barriers	Policies	Policy effectiveness[3]
Biofuels Consumption 2010: 8.0 Billion GGE 2015: 13 Billion GGE 2020: 23 Billion GGE 2030: 50 Billion GGE	**Biofuels Consumption** 2004: 2.1 billion GGE renewable fuels consumed in transportation sector. 2005: Ethanol production was 4.3 B gal with 1.7 B gal in planned capacity; 2005: Biodiesel production was 70-75 million gal with 278 million gal in planned new capacity.	Production, distribution, transportation, and storage infrastructure for biofuels is inadequate to meet Vision goals.	Motor gasoline production and distribution infrastructure is mature. Biofuels are not currently allowed access to pipelines even in low level blends, Pipeline infrastructure is not currently available to biofuels.	Production - Clean Fuel Tax Deduction - Ethanol and Biodiesel Tax Credit (VEETC) - Small Ethanol Producer Credit - Small Agri-Biodiesel Producer Credit	 P E P P
				Consumption - The Clean Air Act and Federal RFG Areas - Federal Fleet Requirements - Federal Renewable Fuels Standards - State & Alternative Fuel Provider Rule	 E E N/A
				Distribution/Infrastructure - Alternative Fuel Infrastructure Tax Crédit - Federal CCC Bioenergy Program[4]	 N/A E
	Ethanol Cost Ethanol from corn: $1.10/gal Ethanol from cellulose: $2.25/gal	Significant technical gaps to achieving ethanol from cellulose@ $1.07/gal by 2012.	Petroleum prices historically have been relatively low resulting in a lack of investment in alternative fuels.		
	Feedstock Availability (5/2/06) Corn:$2.11/bushel Soy:$5.39/bushel	Corn production only sufficient to meet 2015 volume target (13-15 B GGE) without impacting food supply.[5]	Perception of food vs. fuel and its impact on food prices.		
	Consumer Acceptance	Consumers are not familiar with biofuels due to low levels of availability.	Consumers must accept biofuels' performance and characteristics. Lack of public knowledge of biofuels.	- Alternative Motor Vehicle Credit - Hybrid Motor Vehicle Credit	E N/A
	Market Prices (4/06)[6] Ethanol & Gasoline Component Spot Market: Ethanol:$2.72/gal; Gasoline:$2.37/gal Biodiesel & Diesel Component Rack Market: Biodiesel:$3.15/gal; Diesel:$2.28/gal		Motor gasoline market and infrastructure is mature: renewables are not. Prior to recent surge in oil prices, gasoline and diesel prices were about 15-25% below biofuels.		

[3] E = effective; P = partially effective; I = ineffective; C = counterproductive
[4] 2006 Farm Bill is being discussed during the summer of 2006 and may include extension of the Commodity Credit Corporation vehicle. This would extend and effective policy for capital investments in biofuels production and sales.
[5] Personal communication from Jeff Cooper, NCGA, in April, 2006. Numbers are still being vetted in final report.
[6] *Fuel Ethanol and Biodiesel Report*. May 1, 2006. OPIS.

II. BIOPRODUCTS: Findings and Recommendations

1 Biobased Products

Finding: Biobased products have the potential to reduce U.S. dependence on chemical products derived from petroleum and natural gas. Many of these chemical products are of strategic importance. The Committee has set a goal of 55,300 million pounds of petroleum-based chemical products displaced by biobased products by 2030. In its current form, despite the hard efforts of the administrators of the program, the USDA BioPreferred Program has had minimal impact towards federal procurement of biobased products. The definition of bioproducts is currently very narrow. Outside of this program, there are no federal policies to promote procurement of biobased products and no incentive programs to promote production or use.

1.1 *Recommendation: Definition of Biobased Products*
Broaden the definition of bioproducts and strengthen the federal mandate for purchasing of bioproducts. This could be tailored after the Federal Fleet requirement incentive for biofuels.

1.2 *Recommendation: Production Incentives*
Provide incentives for the production and use of bioproducts analogous to those in place for biofuels.

1.3 *Recommendation: Construction Incentives*
Provide incentives for the construction of bioproducts infrastructure by reauthorizing and expanding the CCC Bioenergy Program to include biobased products.

1.4 *Recommendation: Certification*
Certification of biobased products methodology and requirements should be modified, to include basic minimum performance criteria.

1.5 *Recommendation: Multi-agency Panel*
The federal government should develop a multi-agency panel to analyze the environmental benefits of biobased products.

1.6 *Recommendation: Review State Incentive Programs*
The Federal government should review state incentive programs for biobased products and determine whether they can be applied to federal programs.

Bioproducts					
Goals	**Status**	**Gaps**	**Barriers**	**Policies**	**Policy effectiveness**[7]
Consumption & Production 2010: 24 B lbs 2015: 26 B lbs 2020: 36 B lbs 2030: 55 B lbs	**Consumption & Production** 2005: 17.6 B lbs biobased products produced. DOE analysis has identified high opportunity products (sub-tables 1-3a&b).	The cost of sugars from cellulosic feedstocks is currently higher than the cost of sugars from corn grain (starch). Reducing the cost of processing to convert sugar streams or lignin streams to products. Lack of technologies to utilize proteins as polymer building blocks.	Cost of incumbent products - petroleum based chemicals and materials are already widely used by the industry and have been relatively inexpensive. Conversion of fabricators and end users to new materials requires extensive certification and testing, re-education and may require added capital cost for new machinery, and material storage.	Federal Biobased Products Preferred Purchasing Program (FB4P) Creates federal purchasing preferences for specific biobased products. (Numbers in () represent percentage of product which must be biobased) • Mobile equipment, hydraulic fluids (44%) • Roof coatings (20%) • Water tank coatings (59%) • Diesel fuel additives (90%) • Penetrating lubricants (68%) • Bedding, bed linens, and towels (12%)	I
	Markets Markets for emerging biobased products remain small with little to no purchasing incentive. Limited early adoption is occurring in some markets such as polylactic acid polymers (corn based), polyurethanes made from soybean oil, and others.	Markets for most biomass extractives, for hemicellulose-derived xylose (beyond as a feedstock for production of xylitol), and for lignocellulosic process residues are largely non-existent.	Test method for industry certification and regulatory compliance designed for petrochemicals are often inappropriate for biobased products leading to increased liability and regulatory burdens.		
	R&D DOE analysis has identified high opportunity products (sub-tables 1-3a&b).	Mixed sugars and other intermediates (and new products) that will be produced in a lignocellulose-based biorefinery are still relatively expensive.			

[7] E = effective; P = partially effective; I = ineffective; C = counterproductive

III. BIOPOWER: Findings and Recommendations

1 Renewable Energy Tariffs

Finding: Electricity Feed Laws and Advanced Renewable Tariffs (ARTs), widely used in Europe, have been successful policy mechanisms for stimulating the rapid development of renewable energy. There are currently eight countries in Europe, and four states in the U.S. which have considered or have introduced programs patterned after Renewable Energy Tariffs.

Advanced Renewable Tariffs: Notable Details
Biomass Tariff: $0.11/kWh, plus $0.0352/kWh for generation on peak
Inflation Adjustment: 20% excluding Solar PV
Term of Contracts: 20 years
Project Size Limit: 10 MW (10,000 kW)
Contracts are Open to All
Simplified Interconnection
No Cap or Limit on the Program
Existing Systems Included
Program Review Every Two Years

2 Renewable Portfolio Standards (RPS)

Finding: RPS and Green Power Purchasing Programs (GP3), implemented at the state level in the U.S., have created markets for renewable energy enabling them to compete with less expensive modes of power production.

2.1 *Recommendation: Biopower Capacity*
Target the development of new biopower capacity so biopower can provide a significant share of renewable electric power as part of a Renewable Portfolio Standard (RPS). Specifically, this recommendation could be supported by Feed Laws providing a clear and consistent purchase price for renewable energy by utilities.

3 Regional Agreements and Cap-and-Trade

Finding: Regional agreements and partnerships have begun cap-and-trade programs and emissions trading systems. These programs (once they enter into force) will mandate companies to lower greenhouse gas emissions in the electric power sector, creating incentives for renewable power such as biopower production.

3.1 *Recommendation: Regional Agreements and Cap-and-Trade*
Continued development of regional agreements for greenhouse gas emissions abatement need to occur. There is already an existing commodities and exchange market for carbon credits. As federal legislation catches up with state and local legislation, power companies will be required to reduce greenhouse gasses and other air pollutants.

Regional Agreements: Reduction in Air Emissions and Greenhouse Gas
Regional Greenhouse Gas Initiative (RGGI)
The Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP)
Western Governor's Association (WGA)
Powering the Plains
West Coast Governors' Initiative
Southwest Climate Change Initiative

4 R&D for Biopower Generation and The Production Tax Credit (PTC)

Finding: There is a clear gap in R&D for biopower generation. The cost (per MWh) must decrease. PTC provides $0.019 per kilowatt-hour (kWh) payment, payable over ten years, to private investors as well as to investor-owned electric utilities for electricity produced from renewable energy sources including closed-loop biomass facilities. Closed loop biomass refers to any crop specifically grown to produce energy. Currently, power projects using "open-loop" biomass receive the PTC at only one half the rate for wind, solar, and geothermal energy projects. The federal distinction between "open loop" and "closed loop" biomass has hampered development of widely available biomass resources, the use of which could contribute significantly to energy production. In addition, the PTC has a sunset (2008) clause which creates a disincentive for capital investments in biopower.

4.1 *Recommendation: Include "sustainable open loop" Biomass and Extend the sunset provisions*
The PTC should include "sustainable open loop" biomass in its definition of renewable energy production. This will create the amounts of feedstocks needed to impact energy production in the United States. In addition, biomass tax credits under the PTC should be equal with those of wind and solar.

5 Education Gap

Finding: There is a gap in education of both the public on the advantages of biopower (or the disadvantages of fossil fuel power) as well as the workforce to utilize biomass feedstocks as sources of power generation.

5.1 *Recommendation: Education*
Develop and implement policies to promote education of the workforce and educate the public.

6 Increase Renewable Electricity Generation

Finding: Increased production will encourage the development of domestic manufacturing capacity of the technologies used in renewable electricity generation. Citing and other community concerns must also be addressed.

6.1 *Recommendation: Renewable Electricity Generation*
America must rapidly increase centralized and decentralized renewable electricity generation, taking advantage of biomass, geothermal, hydropower, landfill gas, biogas from animal operations and other organic waste, solar, and wind, as well as thermal uses.

7 Transmission and Distribution

7.1 *Recommendation: Renewable Electricity Delivery*
To deliver safe, reliable, and affordable renewable electricity to customers, all renewable electricity producers must be allowed fair and nondiscriminatory access to the grid. Both transmission and distribution systems and non-wire approaches must be available to get the electricity from the producer to the market. As with generation, public concerns about increased transmission capacity must be addressed.

8 Building Renewable Electricity Markets

8.1 *Recommendation: Wholesale Markets for Renewable Electricity*
To meet the 25x25 goal, both retail and wholesale markets must be built for renewable electricity. The economic, system, environmental, and social benefits should be incorporated into the overall value of renewable electricity.

Biopower					
Goals	**Status**	**Gaps**	**Barriers**	**Policies**	**Policy effectiveness**[8]
Consumption & Production 2010: 3.1 Quads 2015: 3.2 Quads 2020: 3.4 Quads 2030: 3.8 Quads	**Consumption & Production** - 2004: 2.13 Quads (4% share) of renewable power produced by electric utilities and industrial sector. - Renewable Portfolio Standards exist in 22 states and promote biopower along with other renewables. - $7.25/MMBtus in 2005 (corresponding to 6.86 cents per kWh of electricity)	Reduce syngas cost to $5.25 per million Btus (corresponding to 6.18 cents per kWh of electricity) in FY 2011.	Coal is inexpensive and plentiful in the U.S.	Production Tax Credit (PTC) Feed Laws Regional Air Quality Agreements RPSs at state levels Advanced Renewable Tariffs (ARTs) (Europe)	I E N/A E
	Infrastructure	The relatively large scale and capital costs of thermochemical process facilities, including the cost and payback of systems.	Electrical infrastructure is more conducive to large centralized power production facilities, not distributed power generation which is most characteristic of biomass.	Commodity Credit Corporation (CCC) aids producers through loans, purchases, payments, and other operations, and makes available materials and facilities required in the production and marketing of agricultural commodities. DOE released a biorefinery solicitation to design, construct, build and operate an integrated biorefinery employing lignocellulosic feedstocks for the production of combinations of: (i) liquid transportation fuels; (ii) biobased chemicals; (iii) substitutes for petroleum-based feedstocks and products; and (iv) energy in the form of electricity or useful heat.	E
	R&D	Knowledge of how to effectively integrate thermochemical and biochemical (sugars) process technology in biorefinery configurations.			
		Thermochemical conversion of biomass to power needs new clean-up technologies and better, more efficient turbines.			
	Education	Widespread availability of personnel with knowledge of operation and maintenance of thermochemical systems.			

[8] E = effective; P = partially effective; I = ineffective; C = counterproductive

IV. Cross-Cutting

Findings

1 Tax Credits

Finding: Tax credits and tax exemptions are used to promote the use of renewable fuels with the goal of displacing petroleum use in the transportation sector. There are four Federal tax subsidies for the production and use of alcohol transportation fuels: (1) a 5.4 cents-per-gallon excise tax exemption, (2) a 54 cents-per-gallon blender's tax credit, (3) a 10-cents-per-gallon small ethanol production tax credit, and (4) the alterative fuels production tax.

2 Uncertain Regulatory Climate

Finding: The biomass power sector has suffered from an uncertain regulatory climate and lack of a long-term pricing structure. Many facilities have experienced an extended period of a combination of electricity price uncertainty, fuel availability and pricing uncertainties, and in some cases, operational issues that have resulted in economic hardship. Power pricing for most facilities after mid-2006 has yet to be determined.

3 Infrastructure

Finding: There is a need for new policies to modify or create new infrastructure to help reduce transportation costs of biomass. What separates solid biomass from other renewable energy options is the need to collect, transport, and store feedstock. Biomass, with its low energy density compared to fossil fuels, is relatively expensive to transport, limiting most projects (not based on dedicated energy crops) to collection radii of roughly 50 miles. The recent rise in diesel fuel prices (for truck transport of biomass) has had a noticeable impact of biomass power plant viability.

4 Fragmented Bioenergy Industry

Finding: The bioenergy industry is fragmented and composed of biomass providers (i.e., farmers, foresters, agricultural processors, and urban operators), biomass procurers (i.e., companies that collect, process, and transport biomass residues to end users), and biomass users (i.e., power plant operators, landscape companies, and liquid fuel manufacturers). As a result, each segment of the industry has competing interests and faces differing regulations making it difficult for the industry to address common issues or speak in a uniform manner on regulatory issues.

Recommendations

1 Establish stable funding

Recommendation: Establish stable funding for bioenergy programs based on the premise that many of the benefits represent public goods which accrue to all Americans.

2 Leverage Federal (R&D)

Recommendation: Leverage federal research and development (R&D) efforts and improve coordination to realize greater investment in biomass. In specific, target the development of varieties with improved characteristics suitable for biobased products.

3 Conduct Demonstration and Pilot Projects

Recommendation: In conjunction with state collaborations, fund a select number of demonstration and pilot projects designed to prove the commercial readiness of biofuels production technologies that use lignocellulosic feedstocks. Where possible, use existing state or federal facilities.

4 Require Federal Purchasing

Recommendation: Federal agencies should purchase biofuels, bio–based products, and biopower, including combined heat and power where possible, with specific targets for 2010 and 2020. Local governments and public institutions should be encouraged to follow the federal agencies' lead.

5 Biomass Stakeholders

Recommendation: Encourage biomass stakeholders to develop an integrated and coordinated plan to create a favorable regulatory environment for bioenergy development, while maintaining the required oversight of the existing utility, transportation fuel, and waste management industries.

6 Revise Statutory Definitions

Recommendation: The federal government should review and revise statutory definitions which may be preventing the development of environmentally acceptable waste management alternatives known as conversion technologies and seek amendments to existing law to provide diversion credits to local jurisdictions for solid waste processed by eligible conversion technologies meeting environmental standards.

7 Increase Access to Biomass Resources

Recommendation: U.S. Department of Agriculture (USDA), The Food and Drug Administration (FDA), and the U.S. Forest Service (USFS) should develop a plan to determine how to gain better access to biomass resources and continue basic and applied research identifying the highest value use for forest fuel and harvest residues. They should coordinate activities with the Bureau of Land Management (BLM) to ensure criteria for watershed protection, water quality, and fire prevention will be met.

8 Develop carbon cap-and-trade Program

8.1 Recommendation: Bioproducts Should Displace Hydrocarbon Incumbent
The U.S. should establish a carbon cap-and-trade program for bio-products displacing hydrocarbon incumbent, as part of a framework of incentives to promote adoption of bio-products.

8.2 Recommendation: Incentivize Adoption of Biobased Power
The United States should establish carbon cap-and-trade programs to incentivize adoption of bio-based power. R&D is needed to assure the U.S. has a positive LCA / energy balance for the carbon trading.

9 Allow Heavier Loads on the Highway System

Recommendation: To encourage the use of current technology and evaluate the use of future technology that would allow heavier loads on the highway system while respecting the needs for safety standards and infrastructure.

10 Demonstrate the Commercial Readiness of Bioproducts

Recommendation: In conjunction with state collaborations, fund a select number of demonstration and pilot projects designed to prove the commercial readiness of bioproducts production technologies that use renewable feedstocks. Where possible, use existing state or federal facilities.

11 Analyze National Carbon Emissions Policies

11.1 Recommendation: Low-carbon Transportation Fuels Standard (LCFS),
The committee recommends that the federal government analyze national carbon emissions policy options and their potential impact on biomass energy. One option is to analyze a national low-carbon transportation fuels standard (LCFS), along the lines of the one proposed recently for California by Governor Schwarzenegger. Such a mandate may be similar in its impact for bringing renewable biofuels into the market as RPS mandates have been for increasing market share of renewable electricity. A CO_2 cap-and-trade system is another approach that should be analyzed and which would likely have different implications from a LCFS for biofuels development.

12 Establish a Carbon Policy for Biopower and Bioproducts

Recommendation: Similar biofuel carbon policy options should be analyzed for bioproducts and for biopower.

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Appendix A: Bioproducts Targeted for Market Impact

Table 1: Vision Biobased Products, Production USA

	Million Pounds	
	2002	2004-2005
Organic Acids	576	987
lactic acid[1]	*114*	*600*
citric acid	*462*	*387*
Ethanol for Industrial Use	1757	1971
Starch[2]	3000	6684
Sorbitol[3]	515	697
Glycerol/Glycerine[4]	410	432
Alkyd resins[5]	550	682
Soy-based Products[6]	654	934
Specialty Oils/Aroma Chemicals[7] *	9	8.9
Spearmint		*1.7*
Peppermint		*7.1*
Forest Chemicals*	2826	2740
Crude Sulfate Turpentine[8]		*1202*
Tall Oil[9]		*1094*
Pine Rosin[10]		*444.6*
Cellulose Polymers	2500	2500
Cellulose fibers	*360*	*** NA*
Cellulose derivatives[11]	*2140*	*696*
TOTAL	**12,797**	**17,635**
% Market share	**5%**	**8%**

Table 1: Biomass R&D Technical Advisory Committee’s Vision, DOE & USDA, 2006.

Table 2: Top Value Added Chemicals From Biomass
1,4 succinic, fumaric and malic acids
2,5 furan dicarboxylic acid
3 hydroxy propionic acid
Aspartic acid
Glucaric acid
Glutamic acid
Itaconic acid
Levulinic acid
3-hydroxybutyrolactone
Glycerol
Sorbitol
Xylitol/arabinitol

Table 3a: Low Molecular Weight Lignin Products and Classes Identified in "Top Ten Lignin" Study	
Compound or Class	Product Examples
Simple Aromatics	Biphenyls, styrene, benzene, toluene, xylenes
Quinones	Anthraquinone
Hydroxylated aromatics	Phenol, catechol, propylphenol, eugenol, syringols, aryl ethers, resols/novolaks, alkylated methyl aryl ethers
Aromatic aldehydes	Syringaldehyde, vanillin
Aromatic acids and diacids	terephthalic Acid, vanillic acid
ß-ketoadipic acid, aliphatic acids	New polyesters
Aromatic and aliphatic polyols	Cycohexane diol
Alkanes	cyclohexane

Table 3b: High Molecular Weight Lignin Products and Classes Identified in "Top Ten Lignin" Study
Carbon fiber; Polymer fillers; Polyelectrolytes ; Thermoset resins; copolymers with furfural; wood; adhesives; wood preservatives

Table 2: Top Value Added Chemicals from Biomass, Volume I. PNNL, NREL, August 2004
Table 3a: Top Value Added Chemicals from Biomass, Volume II. PNNL, NREL, July 2005
Table 3b: Top Value Added Chemicals from Biomass, Volume II. PNNL, NREL, July 2005

Appendix B - Biomass Policy Descriptions

Policy Title	Topic Area	Potential Applicants	Originating Legislation	Type	Incentive Amount	Effective Date	Description	Assessment of Effectiveness
Clean Fuel Tax Deduction	Purchase of New clean fuel vehicles, cost of retrofitted clean fuel vehicles, costs of storing and dispensing of alternative fuels	Businesses, personal tax payers, fuel dispensers	EPAct 1992, Working Families Tax Relief Act of 2005, EPAct 2005 § 1348	Tax Deduction	Varies by vehicle type – see below	Ends December 31, 2005	Purchase of New clean fuel vehicles, cost of retrofitted clean fuel vehicles, costs of storing and dispensing of alternative fuels. Maximum allowable deductions are: Buses with seating capacity of 20+ adults: $50,000; Truck or van with GVWR of 26,000+ lb: $50,000; Truck or van with GVWR of 10,000-26,000 lb: $5,000; All other vehicles (excluding off-road): $2,000. The tax deduction will phase out at the end of 2005.	
Alternative Motor Vehicle Credit	Purchase of New dedicated alternative fuel vehicles: light-, medium-, & heavy-duty vehicles; fuel cell; hybrid; dedicated natural gas, propane, & hydrogen; light-duty lean burn diesel vehicles	Consumers; vehicle sellers if purchasers is a non-tax-paying entity	EPAct 2005 § 1341	Tax Credit	50% of incremental cost of vehicle, plus 30% of incremental cost of vehicles with near-zero emissions	January 1, 2006 – December 31, 2010	Purchase of New dedicated alternative fuel vehicles.The tax credit equals 50% of the incremental cost of the vehicle, plus an additional 30% of the incremental cost for vehicles with near-zero emissions (SULEV or Bin 2 for vehicles <14,001 lb GVWR). The following are incremental cost limits for dedicated AFVs: $5,000: 8,500 GVWR or lighter; $10,000: 8,501 - 14,000 GVWR; $25,000: 14,001 - 26,000 GVWR; $40,000: 26,001 GVWR and heavier. The credit expires December 31, 2010.	
Hybrid Motor Vehicle Credit	Purchase of Hybrid vehicles	Consumers	EPAct 1992, EPAct 2005 § 1341	Tax Deduction through December 2006, Tax Credit	Varies by year vehicle purchased	December 2006 – December 31, 2010	Clean Fuel Vehicle Property Tax Deduction through 2006: Purchase Year/Maximum Deduction Per Vehicle - 1992-2003/$2,000; 2004/$1,500; 2005/$1,000; 2006/$500. This tax credit expires December 31, 2010.	
Federal Fleet Requirements	Alternative fuel use in federal fleets	Federal entities with vehicle fleets	EPAct 1992, EPAct 2005, Executive Order 13149 (Greening the Government through Federal Fleet and Transportation Efficiency) EPAct 2005 §	Legislated Requirement	75% of light-duty vehicles in federal fleets must be AFVs & all federal fleets must use alternative fuels in AFVs – or – must receive a waiver from the Secretary of Energy if fuels are not available – or – must choose a petroleum reduction path – and – reduce petroleum use by 20%	No set beginning or end dates	75% of light-duty vehicles in federal fleets must be AFVs & all federal fleets must use alternative fuels in AFVs – or – must receive a waiver from the Secretary of Energy if fuels are not available – or – must choose a petroleum reduction path – and – reduce petroleum use by 20%. No set beginning or end dates.	
State & Alternative Fuel Provider Rule	Alternative fuel use in state fleets; cost of installation of clean-fuel vehicle refueling equipment (includes E85, natural gas, compressed natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, biodiesel [B20 or higher])	State entities with vehicle fleets; fueling station owners/fuel providers	EPAct 1992, EPAct 2005 § 703	Legislated Requirement, Tax Credit	75% of new light-duty state fleet vehicles must be AFVs; 90% of light-duty alternative fuel providers fleet vehicles must be AFVs – or – must choose a petroleum reduction path – and – fueling stations are eligible for a 30% credit for the cost of installing clean-fuel vehicle refueling equipment	Present – December 31, 2010	75% of new light-duty state fleet vehicles must be AFVs; 90% of light-duty alternative fuel providers fleet vehicles must be AFVs – or – must choose a petroleum reduction path – and – fueling stations are eligible for a 30% credit for the cost of installing clean-fuel vehicle refueling equipment. Present – December 31, 2010	
Ethanol and Biodiesel Tax Credit (VEETC)	Blending, retailing, and producing alcohol, ethanol, and biodiesel fuels	Blenders, retailers, producers	American Jobs Creation Act of 2004, EPAct 2005 § 1344	Tax Credit	Varies by fuel and blend	Ethanol: January 2005 – 2010; Biodiesel: January 2005 – December 2008	$0.51/gallon for ethanol. Expires in 2010 but will most likely be renewed. The credit is given to the blender because corn-to-ethanol is already profitable. The intent is to get more ethanol blended into fuels. Note production costs (excluding capital costs) for ethanol are approximately $1.10/gal and for convential gasoline $1.58/gal in 2005. Sunset for Ethanol: January 2005 – 2010; Biodiesel: January 2005 – December 2008	
Small Ethanol Producer Credit	Ethanol production	Small ethanol producers (less than 60 million gallons/year)	EPAct 2005 § 1347	Tax Credit	$0.10/gallon up to 15 million gallons annually; capped at $1.5 million per year per producer	2005	Ethanol production: $0.10/gallon up to 15 million gallons annually; capped at $1.5 million per year per producer	This tax credit is too small to effect any substantiative volume and isn't included in EIA NEMS model.
Small Agri-Biodiesel Producer Credit	Small agri-biodiesel producers (less than 60 million gallons/year)	EPAct 2005 § 1345	Tax Credit	$0.10/gallon up to 15 million	N/A	2005	Biodiesel production: $0.10/gallon up to 15 million gallons. No sunset date.	N/A
Alternative Fuel Infrastructure Tax Credit	Cost of Alternative Refueling Property: natural gas, propane, hydrogen, E85, biodiesel mixtures above B20	Refueling station owners (business and residential); equipment sellers if refueling business owner is a non-tax-paying entity	EPAct 1992, Working Families Tax Relief Act of 2004, EPAct 2005 § 1342	Tax Credit	30% of the cost of alternative refueling property, up to $30,000 for business, $1000 for residential	Equipment put into service after December 31, 2005, to expire on December 31, 2009	30% of the cost of alternative refueling property, up to $30,000 for business, $1000 for residential. Sunset date: January 1, 2006 – December 31, 2010	
Federal Renewable Fuels Standard	Increasing the production of biofuels		EPAct § 1501	Regulation	N/A	2005	Requires 7.5 million gallons of ethanol produced by 2012.	This requirement based on current productiona nd planned capacity of the ethanol industry, will be met by 2012.
The Clean Air Act and Federal RFG Required Areas	Fuels/Emissions	Cities failing to meet Clean Air Act Standards enforced by EPA	Clean Air Act 1990 § 211	Regulation	N/A	1990	This is a State/Federal issue. EPA designates regions of low air quality and eneacts regulations to meet those requirements. The regions then can meet those regulations however they like. Related to this issue - when ethanol is an additive it increases the octane rating and volitility of the fuel; creating high VOC volumes which lower air quality standards.	

Appendix B - Biomass Policy Descriptions

Policy Title	Topic Area	Potential Applicants	Originating Legislation	Type	Incentive Amount	Effective Date	Description	Assessment of Effectiveness
Renewable Electricity Production Tax Credit (PTC)	Electricity generated from renewable sources (landfill gas, wind, hydroelectric, geothermal, municipal solid waste, refined coal, Indian coal, small hydroelectric, closed- and open-loop biomass, solar energy, small irrigation power)	Commercial and industrial entities	The Working Families Tax Relief Act of 2004, American Jobs Creation Act of 2004, EPAct 2005 § 1301	Corporate Tax Credit	Varies	EPACT 2005 extended credit through 2008	The REPC provides a tax credit of 1.5 cents/kWh, adjusted annually for inflation, for wind, closed-loop biomass and geothermal. The adjusted credit amount for projects in 2005 is 1.9 cents/kWh. Electricity from open-loop biomass, small irrigation hydroelectric, landfill gas, municipal solid waste resources, and hydropower receive half that rate -- currently 0.9 cents/kWh. Sunset 10 yrs	With respect to biomass, this policy is ineffective. The definition of closed loop and open loop disqualifies important biomass feedstocks for energy production.
Renewable Energy Production Incentive (REPI)	Payments for electricity produced and sold by renewable energy generation facilities (solar, wind, geothermal, biomass [except MSW], landfill gas, livestock methane, and ocean)	Tribal Government, Municipal Utility, Rural Electric Cooperative, State/local governments that sell project's electricity, Not-For-Profit Electrical Cooperatives, Public Utility, Commonwealths	EPAct 1992, EPAct 2005	Financial Incentive Payment	1.5 cents/kWh (indexed for inflation)	1992 – FY 2026	The Renewable Energy Production Incentive (REPI) provides financial incentive payments for electricity produced and sold by new qualifying renewable energy generation facilities. Qualifying facilities are eligible for annual incentive payments of 1.5 cents per kilowatt-hour (1993 dollars and indexed for inflation) for the first ten year period of their operation, subject to the availability of annual appropriations in each Federal fiscal year of operation. Sunset 2026	
Feed Laws or Advanced Renewable Tariffs (ARTs)	Biopower prices	Biopower producers	European Union	Financial Incentive Payment			ARTs are rates paid for electricity per kilowatt-hour generated. Below is a summary of ARTs most important elements. * Wind Energy Tariff: $0.11/kWh * Biomass Tariff: $0.11/kWh, plus $0.0352/kWh for generation on peak * Small Hydro Tariff: $0.11/kWh, plus $0.0352/kWh for generation on peak * Solar Photovoltaics Tariff: $0.42/kWh * Inflation Adjustment: 20% excluding Solar PV * Term of Contracts: 20 years * Project Size Limit: 10 MW (10,000 kW) * Contracts are Open to All * Simplified Interconnection * No Cap or Limit on the Program * Existing Systems from January 1, 2000 Included * Contracts Available Fall 2006 * Program Review Every Two Years	ARTs are not yet implemented to the full extent in the U.S.
Regional Greenhouse Gas Initiative (RGGI), The Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP), Western Governor's Association (WGA), Powering the Plains, West Coast Governors' Initiative, Southwest Climate Change Initiative	Carbon dioxide reduction, Cap and trade	All	Various regional agreements	Regulation	N/A	Various	Implementation of a multi-state cap-and-trade program with a market-based emissions trading system. The proposed program will require electric power generators in participating states to reduce carbon dioxide emissions.	Various cap-and-trade programs are being discussed in congress as well as industry initiatives to curb carbon emissions.
Renewable Energy Systems and Energy Efficiency Improvements Program	Energy efficiency		Federal Grant Program					
Tribal Energy Program Grant			Federal Grant Program					

Appendix B - Biomass Policy Descriptions

Policy Title	Topic Area	Potential Applicants	Originating Legislation	Type	Incentive Amount	Effective Date	Description	Assessment of Effectiveness
BioPrefered Program, formerly the Federal Biobased Products Preferred Purchasing Program (FB4P)	Purchasing biobased products	Federal Government Procurement Offices	2002 Farm Bill § 9002	Purchasing	N/A	January, 2006	USDA recently designated 6 items under the FB4P program: • Roof Coatings 20% • Water Tank Coatings - 59% • Diesel Fuel additives - 90% • Penetrating lubricants - 68% • Bedding, bed linens, and towels - 12% • Mobile equipment, hydraulic fluids - 44%	
Federal Commodity Credit Corporation (CCC) Bioenergy Program			2002 Farm Bill § 9002	Tax Credit		2002	To be eligible, ethanol producers must produce and sell ethanol commercially and have authority from the Bureau of Alcohol, Tobacco, Firearms, and Explosives to produce ethanol for fuel or sell denatured ethanol rendered unfit for beverage use. Payments are based on the increase in bioenergy production compared to the previous year's production.	The program is structured to encourage participation by smaller producers. Producers with less than 65 million gallons of annual production capacity are reimbursed on a ratio of one feedstock unit for every 2.5 feedstocks used, while larger facilities are reimbursed on a ratio of one to 3.5. Additionally, a payment limitation restricts the amount of funds any single producer may obtain annually under the program to 5% of the total funds available. The CCC Bioenergy Program has encouraged the increased production of bioenergy and the construction of new production capacity, which has helped the ethanol industry double in size since the creation of the program in 2001. Profitability is difficult in the first year of production for any company, and the margins in the first few years of production for new ethanol and biodiesel facilities are exceedingly tight. The CCC Bioenergy Program provides valuable financial assistance to ensure the success of these new companies.

U.S. GOVERNMENT BIOFUELS AUTHORITY

This memorandum is presented by Hamilton Clark & Co., an investment banking firm that works primarily with energy technology companies. The memorandum outlines the rationale for establishing a U.S. government sponsored "Authority", modeled after the Tennessee Valley Authority, which would develop a large and economically viable cellulosic ethanol industry in the United States by 2015. The Authority would make its technology available to private sector companies and could eventually be privatized. A suggested privatization model is Sasol, Ltd. a publicly traded coal-to-liquids company formed by South Africa in 1950 and privatized in 1979.

The Problem:

1. The U.S. Has a Transportation Fuels Crisis

Most of the American public agrees that U.S. dependence on imported oil has reached untenable levels. In 2005 about 65% of crude oil and petroleum products were supplied by imports, out of which 17% came from the Persian Gulf region. In order to augment our use of petroleum-based fuels, President Bush has proposed a bold strategy to produce biofuels in the U.S.

2. The U.S. Is Not On Track to Meet Our Biofuels Targets – Need for Cellulosic Ethanol

In order to realize a "more balanced and diverse energy portfolio that includes domestic biomass resources" the Biomass R&D Technical Advisory Committee of the DOE and the USDA established it's *Vision for Bioenergy and Biobased Products in the United States.* The Committee established aggressive goals for biofuels, defining market share targets and consumption for 2010, 2020, and 2030, as shown below:

Technical Advisory Committee's Vision Goals for Biofuels

	2000	2004	2010	2015	2020	2030
Market Share (%)	0.7	1.2	4.0	6.0	10.0	20.0
Consumption (billion gasoline equivalent gallons per year	1.1	2.1	8.0	12.9	22.7	51.0
Consumption (million gasoline equivalent barrels per day	0.072	0.14	0.521	0.841	1.480	3.327

Corn ethanol production has the U.S. on track to meet 2010 goals. However, most experts agree that in order to reach 2015 - 2030 targets the U.S. must also develop a large and viable cellulosic ethanol industry to complement corn ethanol. This memorandum suggests that a U.S. government sponsored biofuels Authority focus its efforts only on cellulosic ethanol production.

3. It is Unlikely That the Private Sector Will Develop a Large Cellulosic Ethanol Industry

Based on our discussions with companies, investors and banks, we believe that it is unlikely that financing will be available to build cellulosic plants according to the proposed targets, due to:

- **Price Risk**. Cellulosic ethanol profitability requires that crude oil prices continue to remain above about $60 per barrel. Future price reductions orchestrated by OPEC could make cellulosic ethanol projects uneconomic, similar to what occurred during the energy crisis in the 1970s when government efforts were thwarted by falling crude prices.

- **Technology Risk**. The complexity of *feedstock supply* and *conversion technologies* confuse financiers:

    - Cellulosic ethanol is different than corn ethanol:

        - corn feedstock is generally available to all biorefineries, it is grown to uniform standards, is traded on commodity exchanges and can be contracted for long periods of time by cooperatives or developers

        - conversion technology is relatively simple, available from a number of technology suppliers, and biorefineries are built by a large number of engineering and construction firms willing to accept 100% plant completion liability. Construction is proven at scale of 100+ million gallons per year without technology risk

        - corn ethanol plants are relatively easy to finance, equity and debt guidelines are understood and a number of companies have completed their initial public offerings allowing access to the public equity market

    - Cellulosic ethanol has none of these attributes:

        - cellulosic feedstock is not readily available, competing feedstock suppliers (agriculture residues, woody crops, wood waste, energy crops (switchgrass) and municipal solid waste) confuse financiers as to their proposed qualities and availability. Large biorefineries will require very large acreage devoted to dedicated energy crop feedstock, which has not been thoroughly vetted in the farm community

        - competing conversion technologies confuse financiers because bioprocessing technology experts argue over their proprietary approach to pre-treatment, hydrolysis and fermentation technology; while thermo-chemical experts argue over their proprietary approach to pyrolysis or Fischer-Tropsch syngas technology. There are no engineering and construction firms offering completion guarantees on plant construction

        - because no commercial cellulosic ethanol plant has ever been built, financiers are not willing to accept the technology risk of choosing the wrong feedstock or the wrong conversion technology. Without completion guarantees there will be no debt financing available for cellulosic plants. Equity financing is not available given long project development cycles

The Solution: Develop the Industry, and then Privatize it

1. U.S. Government Biofuels Authority, Like the Tennessee Valley Authority, $4 billion per Year Over Ten Years

Our firm's assessment is that, given current conditions, the best way to develop a cellulosic ethanol industry in the U.S. by 2015, is to establish a U.S. government Authority, like the Tennessee Valley Authority (TVA), that would build, own and operate the first fleet of cellulosic ethanol plants in the U.S. By building the first fleet of commercial-scale plants, price risk and technology risk could be mitigated, allowing the industry to develop in the private sector from 2015 to 2030 on its own merits.

We believe that:

- the goal of this undertaking should be in the range of 500,000 barrels per day (8 billion gallons per year) of cellulosic ethanol production. This could be accomplished by building about 20 biorefineries in various growing regions, each sized at about 25,000 barrels per day (400 million gallons per year). Our research suggests that at targeted yields of 10 tons per acre and 100 gallons per ton, each biorefinery would require about 400,000 acres, and the entire undertaking would require about 8 million growing acres

- biorefineries would use different homogeneous feedstocks (switchgrass, ag residues, woody crops) or heterogeneous feedstocks (combination of energy crops, woody crops, ag residues, wood waste, MSW), grown in various regions of the U.S., in order to determine the best yield per acre for a particular feedstock and a particular region

- biorefineries would utilize different technology solutions both in bioprocessing and thermochemical conversion platforms, in order to determine the best yield per ton for a particular feedstock in a particular region

- at HamiltonClark's estimated capital cost of about $75,000 per daily barrel produced, (like the TVA), we estimate that this strategy would require a U.S. Treasury guarantee of the Authority's bonds equal to approximately $4 billion per year over 10 years

- assuming successful deployment, after 10 years the Authority would be self financing (like the TVA), or it could be privatized

We believe that such a strategy would be successful, and the result would be that:

- a large and viable cellulosic ethanol industry would be developed over the next 10 years and then move on to the private sector

- price risk for the next 10 years could be mitigated by direct government ownership

- technology risk could be reduced or eliminated by figuring out which technology works best at scale with which feedstock in which region of the U.S.

- our nation's biofuels targets could be achieved

- the U.S. Treasury guarantee of the Authority's bonds would eventually be eliminated

2. Tennessee Valley Authority Model

There is a very close comparison between the economic crisis during the Depression and our country's need for cheap electricity during World War II which necessitated development of the TVA; and our current energy crisis with respect to transportation fuels, and our war on terrorism. A short history of the TVA and its goals and objectives (courtesy of the TVA website) is illustrative of these issues and how the TVA model could be adopted to develop a viable cellulosic biofuels industry in the U.S. over the next 10 years:

Background

- President Franklin Roosevelt needed innovative solutions if the New Deal was to lift the nation out of the depths of the Depression. TVA was one of his most innovative ideas. Roosevelt envisioned TVA as a totally different kind of agency. He asked Congress to create "a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise." On May 18, 1933, Congress passed the TVA Act.

- Right from the start, TVA established a unique problem-solving approach to fulfilling its mission-integrated resource management. Each issue TVA faced - whether it was power production, navigation, flood control, malaria prevention, reforestation, or erosion control - was studied in its broadest context. TVA weighed each issue in relation to the others. From this beginning, TVA has held fast to its strategy of integrated solutions, even as the issues changed over the years.

1930s

- TVA developed fertilizers, taught farmers how to improve crop yields, and helped replant forests, control forest fires, and improve habitat for wildlife and fish. The most dramatic change in Valley life came from the electricity generated by TVA dams. Electric lights and modern appliances made life easier and farms more productive. Electricity also drew industries into the region, providing desperately needed jobs.

1940s

- During World War II, the United States needed aluminum to build bombs and airplanes, and aluminum plants required electricity. To provide power for such critical war industries, TVA engaged in one of the largest hydropower construction programs ever undertaken in the United States. Early in 1942, when the effort reached its peak, 12 hydroelectric projects and a steam plant were under construction at the same time, and design and construction employment reached a total of 28,000.

1950s and beyond

- These were years of unprecedented economic growth in the Tennessee Valley. Farms and forests were in better shape than they had been in generations. Electric rates were among the nation's lowest and stayed low as TVA brought larger, more efficient generating units into service. Expecting the Valley's electric power needs to continue to grow, TVA began building nuclear plants as a new source of economical power.

- Today, TVA is the nation's largest public power company, with 33,000 megawatts of generating capacity. Through 158 locally owned distributors, TVA provides power to nearly 8.5 million residents of the Tennessee Valley.

TVA's Financing Relationship with the U.S. Treasury

Originally, in the 1930s, TVA issued bonds that were fully guaranteed by the U.S. Treasury. This allowed TVA to immediately launch its mandate with the knowledge that its financing was secure. The U.S. Treasury also had a number of checks and balances which were built into the legislation.

In 1959 this was changed such that TVA currently receives no appropriations from the federal government, is not authorized to issue stock and its bonds are not guaranteed by the U.S. Treasury. Therefore, it must meet its capital requirements through internally generated funds and power program financings. TVA securities may only be issued to provide capital for TVA's power program, including the refunding of existing debt. TVA bonds are backed solely by the net power proceeds of the TVA power system and are neither obligations of nor guaranteed by the U.S. government. The bonds carry a AAA rating.

Financial Summary of the TVA

2005 Financial Results ($ in millions)

Operating revenues	$ 7,794
Operating income	$ 1,291
Net income	$ 85
Total assets	$34,566
Total liabilities (inc. debt)	$32,174
Capital	$ 2,392
Cash provided from operations	$ 1,346

3. Future Privatization, Like Sasol, Ltd.,

Our firm's assessment is that once the cellulosic biofuels Authority is operating at scale, its technology could be licensed to other private companies, and the business could eventually be privatized. A good example of this strategy was how the South Africa government developed Sasol, Ltd., to take advantage of that country's huge coal deposits and lack of any meaningful crude oil production. South Africa has a population of 44 million and consumes about 550,000 barrels per day.

Background

- In 1950 the government of South Africa set up Sasol, Ltd. (South Africa Synthetic Oil Limited), and authorized funding for its first project, a coal-to-liquids facility called Sasolburg in the South African countryside.

- When oil prices increased in the 1970s the South African government decided to lend Sasol $6 billion to build two new facilities at Secunda, SA, each being about 10 times as large as Sasolburg. Sasol had commercialized its coal-to-liquids technology during the 1970s, so in 1979 the government decided to privatize the company, listing it on the Johannesburg Stock Exchange. The stock also trades on the NYSE and the government currently owns a 24% interest, the rest is owned by the public.

- Sasol currently produces 160,000 barrels per day of synthetic crude oil which is further refined into gasoline and diesel fuel. This is about 30% of the country's liquid fuels requirement. Each of their 80,000 barrel per day refineries cost about $6 billion to build ($75,000 per daily barrel produced) at current prices. The learning curve on this technology has driven the breakeven price down to about $30 to $35 per barrel and has allowed Sasol to license its technology to other companies and other countries.

- Sasol currently has about 16,000 employees, the market capitalization of the company is US$22 billion, and it has US$ 2.7 billion of long term debt, about US$ 500 million of cash and an enterprise value of US$24.8 billion. The South African government does not guaranty its debt. For the year ended June 2005 revenues were US$ 9.1 billion, net income was US$ 2.0 billion, EBITDA was $3.4 billion and operating cash flow was US$ 2.5 billion.

- With an enterprise value of US$24.8 billion and 160,000 barrels per day of production, the company is worth about US$155,000 per daily barrel of production.

4. Conclusion

In a joint effort, the DOE and USDA, under the direction of the Biomass Research and Development Technical Advisory Committee, should immediately prepare a plan for their respective Secretaries, to establish a United States Biofuels Authority, modeled after President Roosevelt's TVA, that would build, own and operate up to 500,000 barrels per day of cellulosic ethanol production in various regions of the U.S. by 2015.

Financing of the Authority should be modeled after the early years of the TVA, namely with a full guarantee of the U.S. Treasury, but with checks and balances as to the issuance of bonds by the Authority.

We estimate that a targeted 500,000 barrel per day undertaking would cost about $75,000 per daily barrel produced, or about $40 billion ($4 billion over about 10 years). Assuming that crude prices do not fall and that the technology works at scale, we estimate that, like the TVA, the Authority would eventually be able to repay its government guaranteed bonds, and be self financing.

When the technology has been proven and the cost reduced, the Authority's technology could be transferred to the private sector through privatization and technology transfer. Based on today's enterprise value of Sasol Ltd., and assuming that the Authority was producing at 500,000 barrels per day, the Authority would have an enterprise value in the public markets today of about $77 billion. This suggests that, assuming the business plan is successful, U.S. taxpayers would be obligated to guarantee up to about $40 billion of debt, and in 10 or 15 years might be able to sell the Authority to private investors for a valuation that might be in the range of about $77 billion.

Attachment I

U.S. Department of Energy
Energy Efficiency and Renewable Energy

The Biomass Program

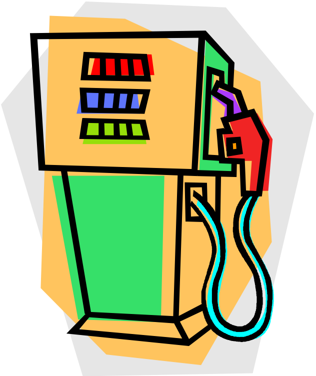
Office of the Biomass Program

Energy Efficiency and Renewable Energy

March 2, 2006

- Where are we heading?
- Why this direction?
- How will we get there?
- What has been accomplished?
- Funding

EERE Biofuels Initiative



What can be done and When?

- 3.4 Billion from corn now will Increase to 12.5 Billion by 2017
- 30% of our current gasoline use met with biofuels by 2030

The Market Exist

- Nationwide E-10 market
- 12.5 BGY by 2017 from corn
- 5 BGY by 2017 from cellulose
- 1 BGY Green/BioDiesel

National Benefit

The Biofuels Initiative, together with the fuels use reduction from the Vehicles and Hydrogen programs within EERE, 20 in 10 (20% reduction in 10 years)

Infrastructure

- PAD II – E-85 strategy
- Everywhere else E-10 strategy
- Public/Private partnership to broaden fuel delivery infrastructure.

Environment Benefits

- 18% to 72% less GHG
- 32% to 81% less carbon dioxide (CO2)
- Up to 58% less methane (CH4)

Strong Support

- Bipartisan Support
- New proposed Legislation for greater RFS
- Incentives at State and Federal level
- States allowing blending at ethanol producers
- Strong Industry Support and Interest

Existing Fuels Market

Current Transportation Fuels Demand

- **2004 gasoline consumption: 139.6 B gal per year**
- **2004 On-Highway Diesel consumption: 37.1 B gal per year**

Current Barriers to Market Growth

- **Biodiesel is trade name**
- **Labeling is an issue across states and U.S.**
- **No reference standard**
- **Limited QA field methods**
- **Limited QA on feedstocks**
- **Fuel issues are NOT transparent to the consumer**

How Do We Get There?

- 2006 SOTU speech make cellulosic ethanol competitive with “other” forms
- 2007 SOTU speech 20 in 10
- 2006 Initiative 30% by 2030
- Implement new strategy
  - Use 932 awards to achieve cost goals
  - Use 10% solicitation to accelerate private investment and expand feedstocks
  - Focus only on 2017 goals

Whole Crop Integrated Biorefinery

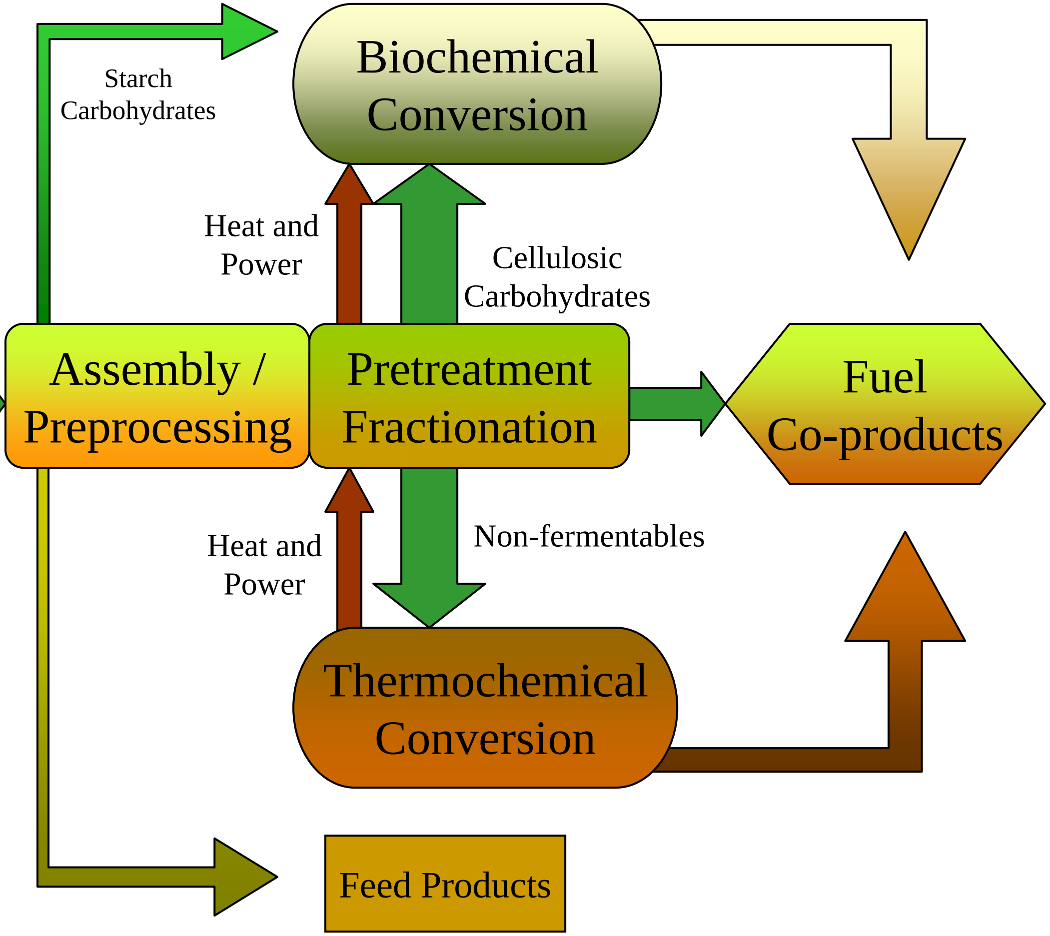
Federal Roles

Feedstocks: USDA/DOE

Conversion: DOE/NSF

Infrastructure: EPA/DOT & DOE

Commercialization: USDA/DOE



Communication: NSF/USDA/DOE

Deployment: DOE/USDA

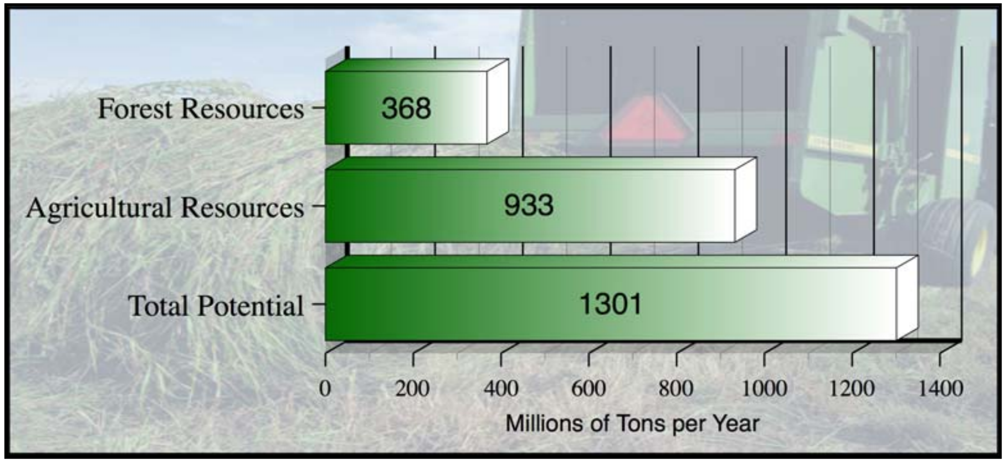
Permitting: EPA/DOE

QA: NIST/DOE/DOT/EPA

Conversion of Available Feedstocks

Current Portfolio

- Ag Residues
- Wood Waste
- MSW
- Dedicated Crops



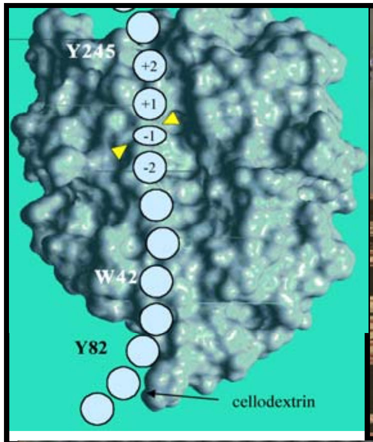
- "Billion Ton" study biomass availability
- Agricultural lands
  - soybean residue, manure, switchgrass, poplar/willow energy crops, etc.
- Forest lands
  - Forest thinnings, fuelwoods, logging residues, wood processing and paper mill residues

National Biofuels Action Plan

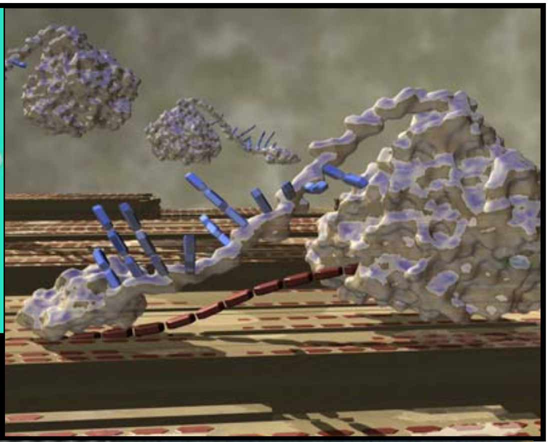
Inter- and Intra-agency Coordination Plan.

- comprehensive across agencies
- lead/follow format
- covers 4 areas
    - feedstocks
    - conversion
    - infrastructure or deployment
    - international
- no budget
- managed by R&D Board
- Schedule
    - draft complete by March 16
    - Submit to NAC by Sept 30
    - Finalize Jan 08

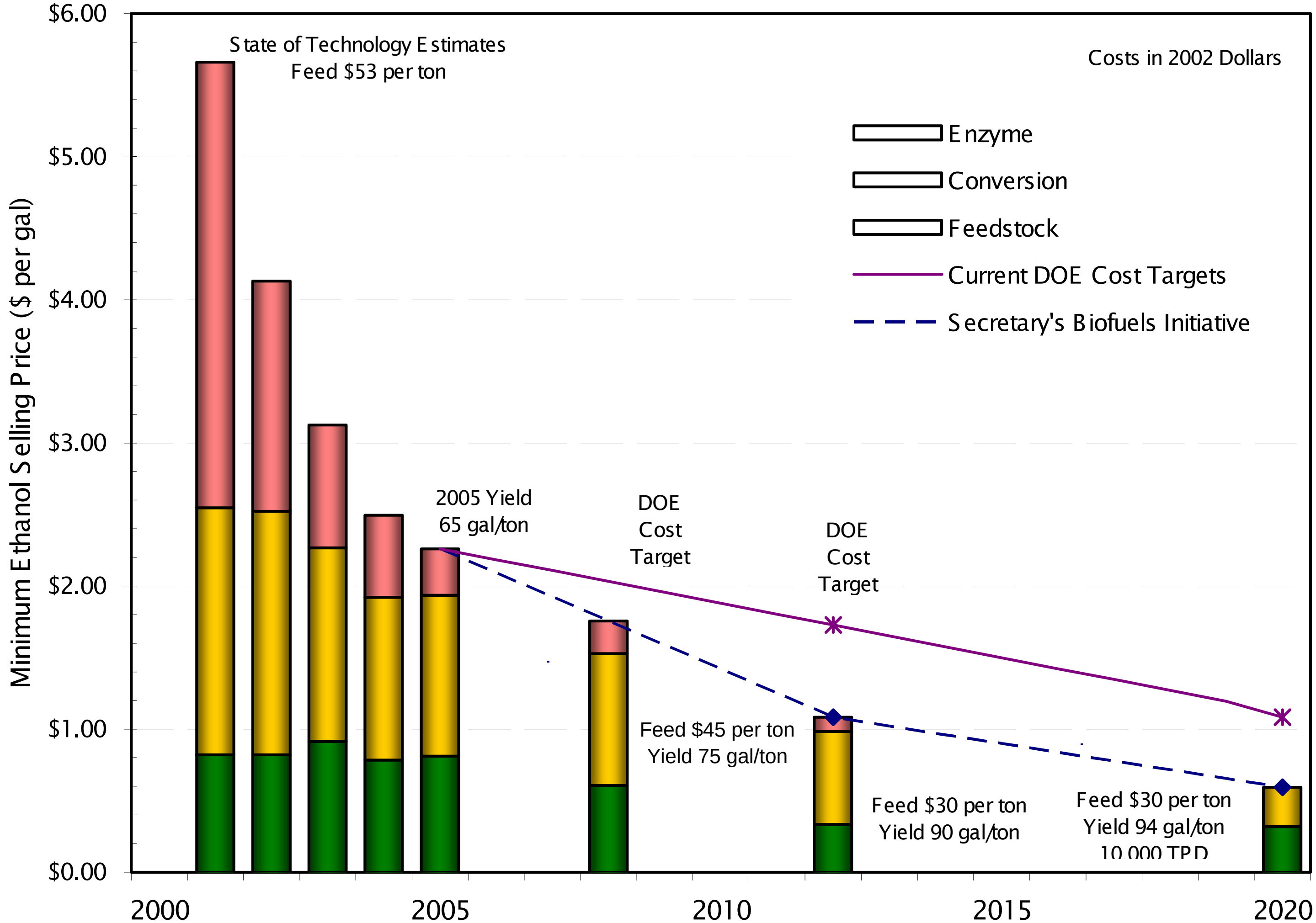
E1 from *A. cellulotiticus*



CBH1 from *T. reesei*



Cost Target Acceleration



Biofuels Summary & Conclusions

- ✓ Federal activities will focus on 2017 objective
- ✓ Cost of cellulosic ethanol is not as critical
- ✓ Data for investment confidence is essential component.
- ✓ Vehicle technologies must deliver on efficiency improvements
- ✓ Science & Technology will create bridge to other opportunities beyond today's ethanol & biodiesel

Attachment J

Biomass R&D Technical Advisory Committee Meeting

Orlando, FL

February 14, 2007

SFRP Mission

– **“To foster collaborative relationships that provide new and revised research knowledge to enable the southeast to remain competitive in the global forestry market while enhancing the forest landscape and assuring that this natural resource will be sustained indefinitely.”**

SFRP Vision

- **The South’s forests will be healthy working forests that provide societal benefits, ecosystem services, and products, both traditional and new.**

SFRP Objectives

- **Provide a structure to respond to and address regional, landscape scale, forest resources issues**
- **Assemble best available team of scientists and TT specialists to address topical issues irrespective of political and organizational boundaries and structures**
- **Expand fiscal support for southern forest resources research and technology transfer (grants and contracts)**

SFRP Operation

- **501 (c)(3) with Elected Officers**
- **Director**
- **Board & Executive Committee**
- **Development Committee**
- **Science Committee**

SFRP's Current Research / TT Priorities

- **Carbon Management**
- **Water Quality and Yield**
- **Southern Forest Resources Economics --- Includes Tourism**
- **Biomass / Biofuels**
- **Biodiversity**

Carbon Activities

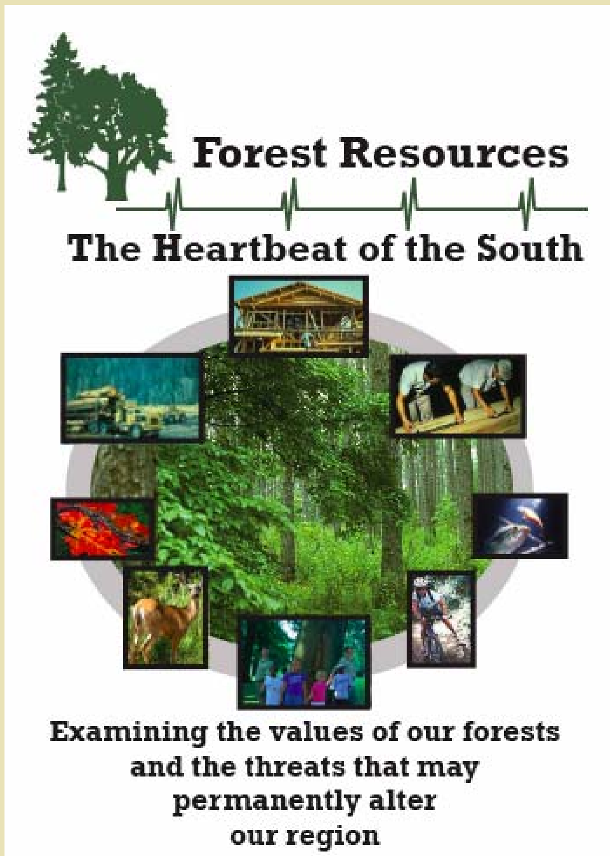
Carbon Conference:

Critical Processes and Properties Regulating Carbon Cycling in Southern Forests

May 31 – June 2, 2006

Asheville, NC

Economic Development Overtures



- Southern Governor's Association
- Southern Growth Policies Board
- Southern Economic Development Council
- Southern Center for Rural Development

Biodiversity

- **USDA Biodiversity (Weedy Invasive Species) --- <u>A FINALIST --- 2006</u>**
  - **<u>Potential award $500,000</u>**

Biomass: Issues and Opportunities Facing the South

- The South provides 60% of the US timber supply
- Many rural communities are:
  - Richly endowed with forest resources
  - Heavily dependent on forestry
  - Socially and economically disadvantaged
- Recent setbacks in pulpwood markets
- Urgent need to diversify utilization of forest resources
- Potentially large resource of underutilized biomass
  - Small diameter, dense stands
  - Stands posing high fire risk
  - Harvest residues
  - Manufacturing residues
- Bioenergy and biobased products are:
  - Timely and viable option

The Big Change: The Forest Biorefinery

- Consists of three parts:
  1. **Sustainable Forest Productivity**
  2. **Extracting Value Prior to Pulping**
  3. **New Value Streams from Residuals and Spent Pulping Liquors**
- **T**raditional tree growing, liberation of fibers, and recovery boilers become old technology
- Replaced by the extracting of fiber, fuel, chemicals, and power streams valued by society and the marketplace
- Evolves chemical pulp mills into forest biorefineries– preserving infrastructure, jobs, and supply chains

Cullinan

The Big Change: The Forest Biorefinery (continued)

- **Provides outlets for millions of tons of currently unusable forest biomass**
- **Helps reduce fuel loading and improves forest health and conditions**
- **Reduces dependency on foreign oil**
- **Sustainable supply of feedstocks for the production of energy and materials**

SFRP: Forest Biomass Training Grant

- $1 million grant
- 4 phases
  - – Encyclopedia: review and synthesize literature – publish synthesized material in Forest Encyclopedia Network
  - – Training Material (fact sheets, power points, etc. and web based learning center)
  - – Conduct Train-the-Trainer Programs
  - – Support and fund “end user training”

The Process

- Forest Encyclopedia Content Development
  - Literature Review and Synthesis, Content Development (Synthesized material), Peer Review, Final Edit, Publish, Update
- Product Development
  - Content Development (Fact Sheets, Power Points), Peer Review, Final Edit, Publish, Update
- Delivery
- Evaluation

The Principals

- Phase 1: TX A&M Univ.; Univ. GA; U.S. Forest Service – So. Station; So. Regional Extension Forester
- Phase 2: TX A&M; UGA, UT, SREF
- Phase 3: TX A&M; UGA, UT, SREF, USFS
- Phase 4: So. Universities; So. State Foresters; SREF; USFS; State Forestry Assoc.; Logger Assoc.; NRCS; RDA; etc.

The Audiences

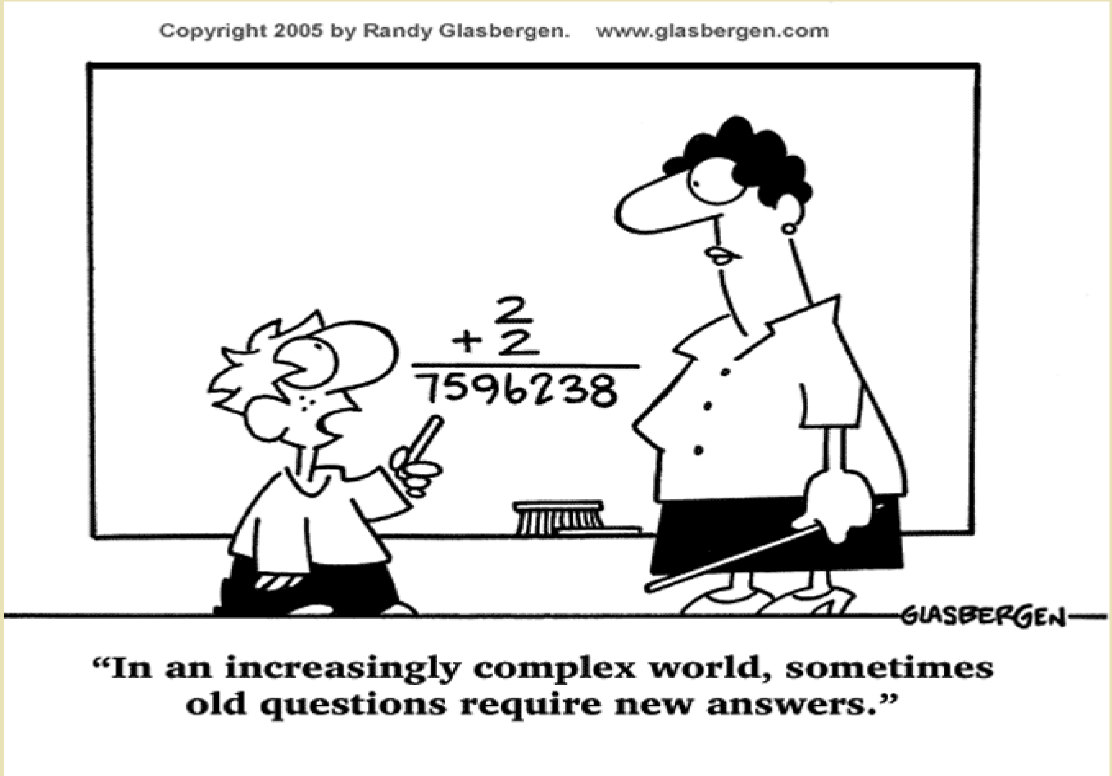
- Materials targeted to:
  - State forestry, wildlife and fishery persons; consulting and industry foresters and biologists, timber harvesters, etc.
  - Community & economic development professionals
  - Energy, Transportation, Petroleum Persons, and
  - Forest landowners.
- Materials delivered through: Educators – conventional processes and distance learning:
  - University Extension, State and Federal Agencies, NGO Community, etc.

The Biomass Forest Encyclopedia Network (FEN): Product Development and Delivery

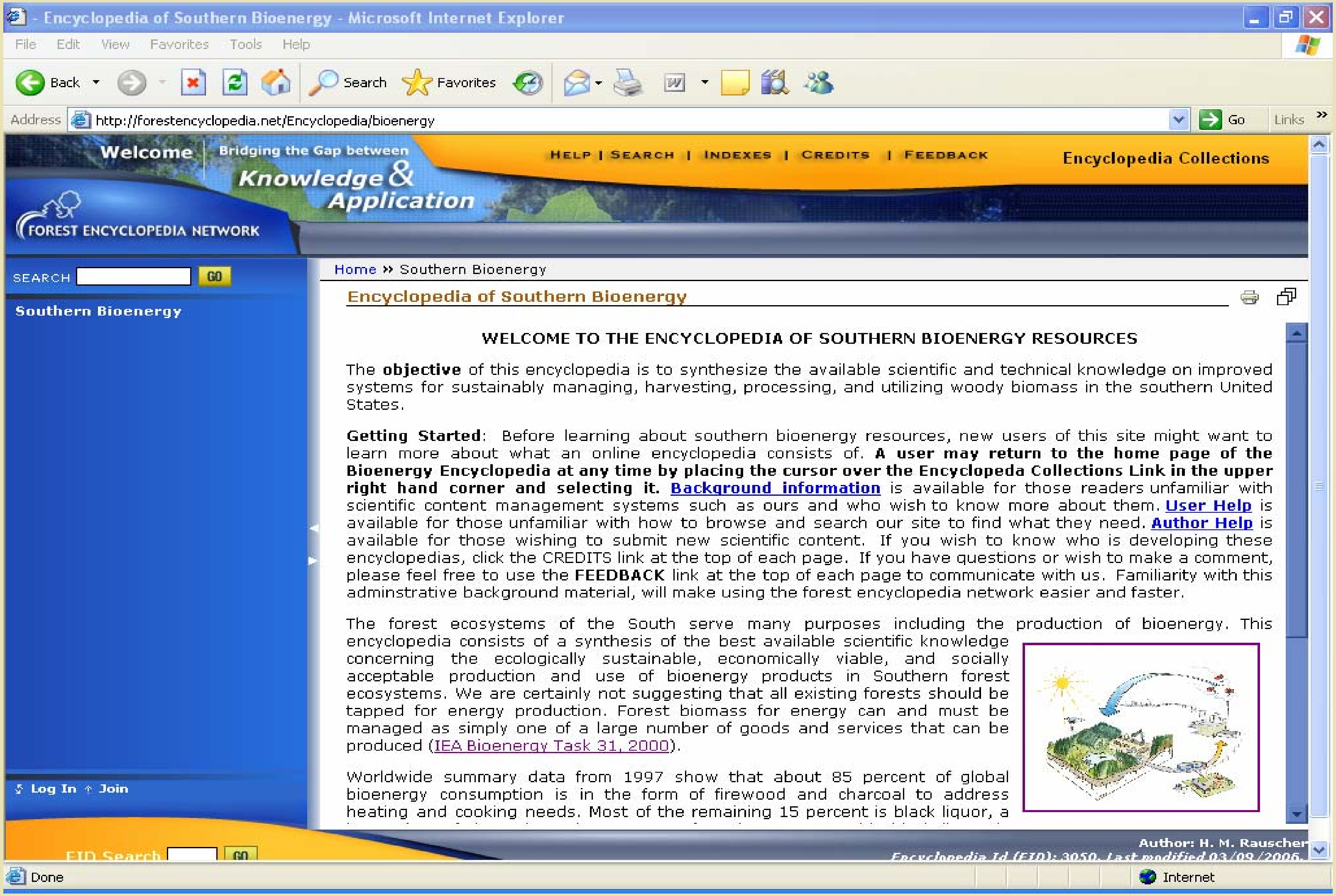
Real Time Scientific Knowledge for Forest Practitioners

Southern Regional Extension Forestry

A new approach to an old problem:

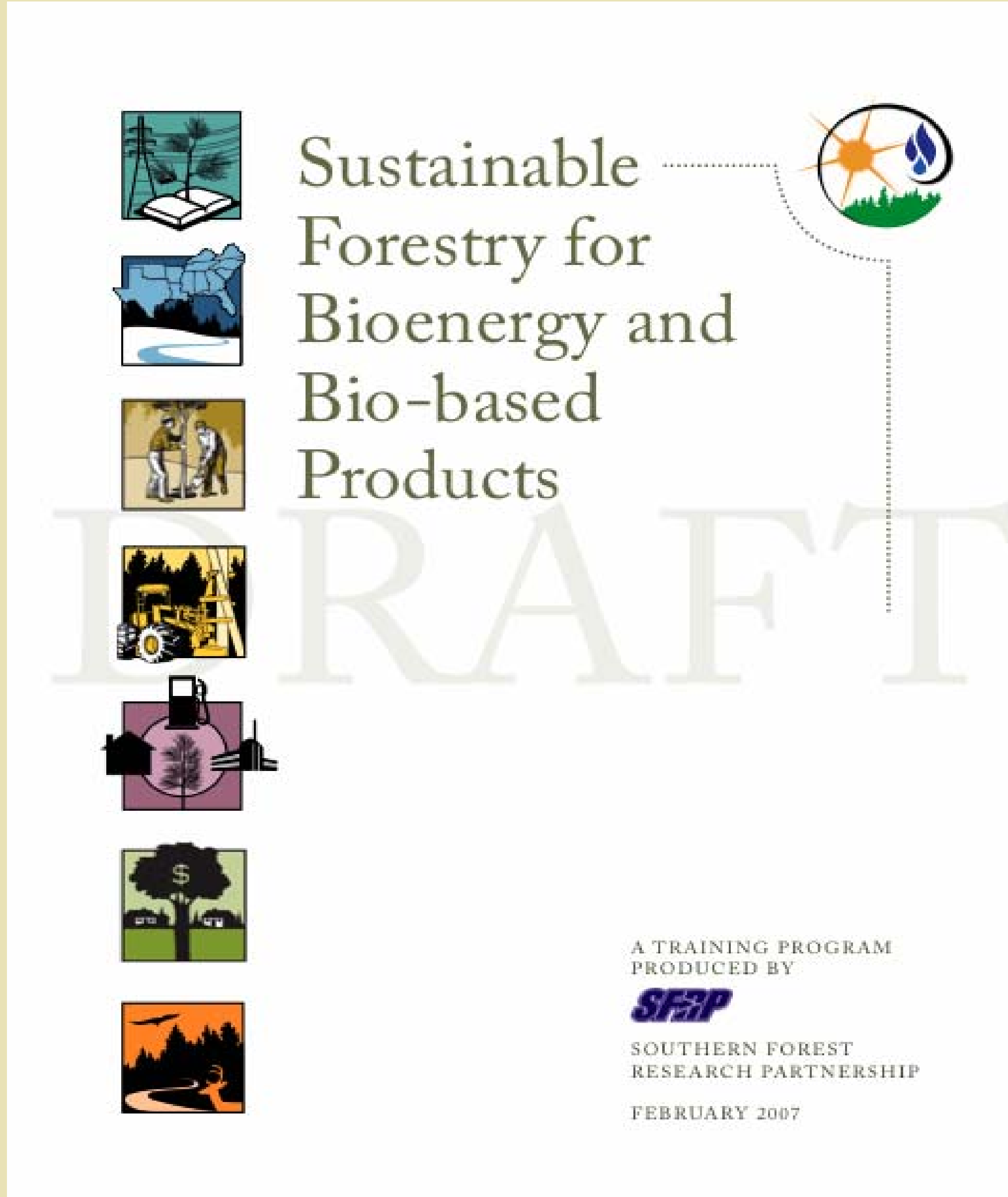


Forest Encyclopedia



Forest Encyclopedia Materials

- 229 Pages of Material
- 280 Images
- 416 Citations



Sustainable Forestry for Bioenergy and Bio-based Products

A TRAINING PROGRAM PRODUCED BY

SFRP

SOUTHERN FOREST RESEARCH PARTNERSHIP

FEBRUARY 2007

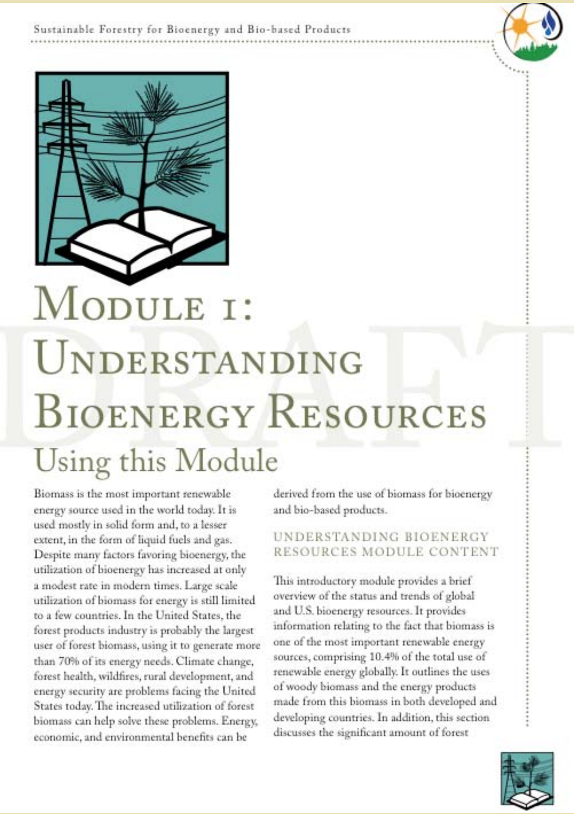
Southern Forest Research Partnership, Inc.

Biomass Curriculum – Training Notebook

- Table of Contents
- History of the Project
- Module Topics
- Using the Encyclopedia of Southern Bioenergy
- Introduction to the National Web Based Learning Center for Forest Owners

Module 1 Fact Sheets

- What is Biomass?
- Global Utilization of Biomass
- Benefits of Biomass Utilization



Sustainable Forestry for Bioenergy and Bio-based Products

MODULE 1: UNDERSTANDING BIOENERGY RESOURCES

DRAFT

Using this Module

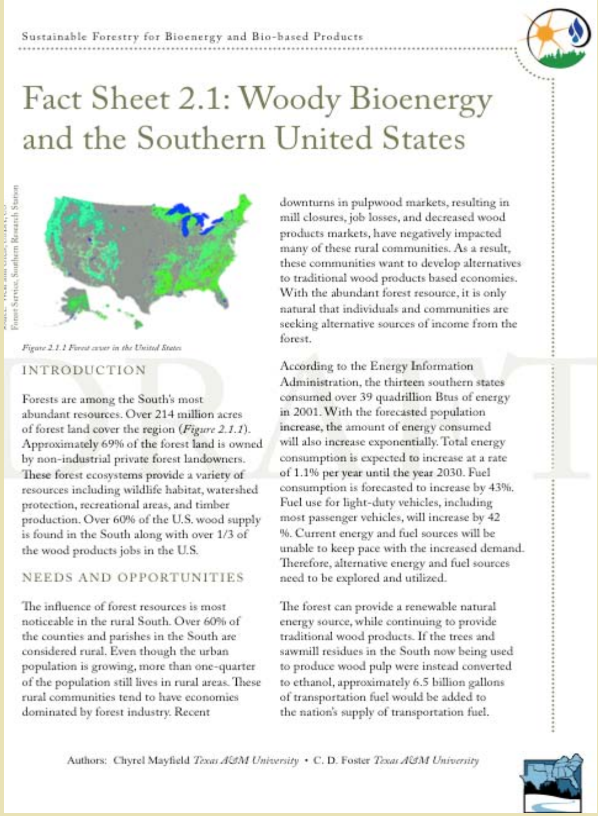
Biomass is the most important renewable energy source used in the world today. It is used mostly in solid form and, to a lesser extent, in the form of liquid fuels and gas. Despite many factors favoring bioenergy, the utilization of bioenergy has increased at only a modest rate in modern times. Large scale utilization of biomass for energy is still limited to a few countries. In the United States, the forest products industry is probably the largest user of forest biomass, using it to generate more than 70% of its energy needs. Climate change, forest health, wildfires, rural development, and energy security are problems facing the United States today. The increased utilization of forest biomass can help solve these problems. Energy, economic, and environmental benefits can be derived from the use of biomass for bioenergy and bio-based products.

UNDERSTANDING BIOENERGY RESOURCES MODULE CONTENT

This introductory module provides a brief overview of the status and trends of global and U.S. bioenergy resources. It provides information relating to the fact that biomass is one of the most important renewable energy sources, comprising 10.4% of the total use of renewable energy globally. It outlines the uses of woody biomass and the energy products made from this biomass in both developed and developing countries. In addition, this section discusses the significant amount of forest

Module 2 Fact Sheets

- Woody Biomass and the Southern United States
- Availability of Woody Biomass in the South
- Sungrant Fact Sheets



Sustainable Forestry for Bioenergy and Bio-based Products

Fact Sheet 2.1: Woody Bioenergy and the Southern United States

Figure 2.1.1 Forest cover in the United States

INTRODUCTION

Forests are among the South's most abundant resources. Over 214 million acres of forest land cover the region (*Figure 2.1.1*). Approximately 69% of the forest land is owned by non-industrial private forest landowners. These forest ecosystems provide a variety of resources including wildlife habitat, watershed protection, recreational areas, and timber production. Over 60% of the U.S. wood supply is found in the South along with over 1/3 of the wood products jobs in the U.S.

NEEDS AND OPPORTUNITIES

The influence of forest resources is most noticeable in the rural South. Over 60% of the counties and parishes in the South are considered rural. Even though the urban population is growing, more than one-quarter of the population still lives in rural areas. These rural communities tend to have economies dominated by forest industry. Recent downturns in pulpwood markets, resulting in mill closures, job losses, and decreased wood products markets, have negatively impacted many of these rural communities. As a result, these communities want to develop alternatives to traditional wood products based economies. With the abundant forest resource, it is only natural that individuals and communities are seeking alternative sources of income from the forest.

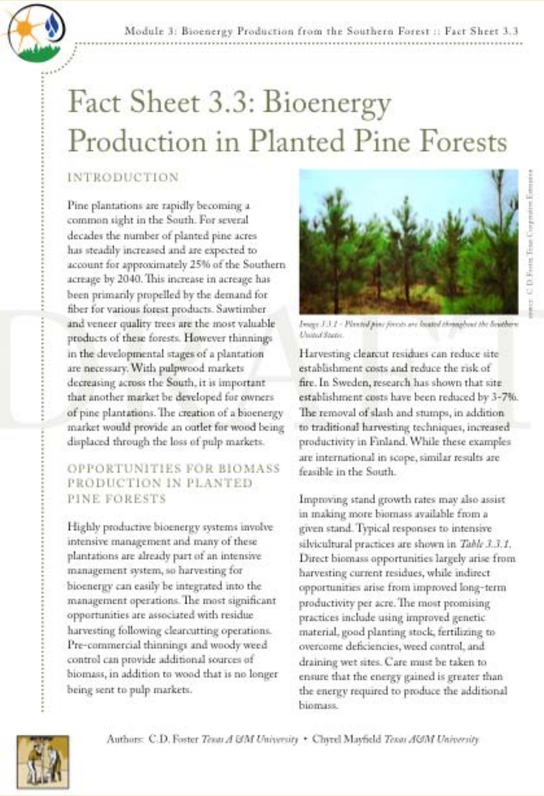
According to the Energy Information Administration, the thirteen southern states consumed over 39 quadrillion Btus of energy in 2001. With the forecasted population increase, the amount of energy consumed will also increase exponentially. Total energy consumption is expected to increase at a rate of 1.1% per year until the year 2030. Fuel consumption is forecasted to increase by 43%. Fuel use for light-duty vehicles, including most passenger vehicles, will increase by 42 %. Current energy and fuel sources will be unable to keep pace with the increased demand. Therefore, alternative energy and fuel sources need to be explored and utilized.

The forest can provide a renewable natural energy source, while continuing to provide traditional wood products. If the trees and sawmill residues in the South now being used to produce wood pulp were instead converted to ethanol, approximately 6.5 billion gallons of transportation fuel would be added to the nation's supply of transportation fuel.

Authors: Chyrel Mayfield *Texas A&M University* • C. D. Foster *Texas A&M University*

Module 3 Fact Sheets

- Forest Mgmt. for Bioenergy Products
- Bioenergy Production Among Common Southern Forest Types
- Bioenergy Production in Planted Pine Forests



Module 3: Bioenergy Production from the Southern Forest :: Fact Sheet 3.3

Fact Sheet 3.3: Bioenergy Production in Planted Pine Forests

INTRODUCTION

Pine plantations are rapidly becoming a common sight in the South. For several decades the number of planted pine acres has steadily increased and are expected to account for approximately 25% of the Southern acreage by 2040. This increase in acreage has been primarily propelled by the demand for fiber for various forest products. Sawtimber and veneer quality trees are the most valuable products of these forests. However thinnings in the developmental stages of a plantation are necessary. With pulpwood markets decreasing across the South, it is important that another market be developed for owners of pine plantations. The creation of a bioenergy market would provide an outlet for wood being displaced through the loss of pulp markets.

OPPORTUNITIES FOR BIOMASS PRODUCTION IN PLANTED PINE FORESTS

Highly productive bioenergy systems involve intensive management and many of these plantations are already part of an intensive management system, so harvesting for bioenergy can easily be integrated into the management operations. The most significant opportunities are associated with residue harvesting following clearcutting operations. Pre-commercial thinnings and woody weed control can provide additional sources of biomass, in addition to wood that is no longer being sent to pulp markets.

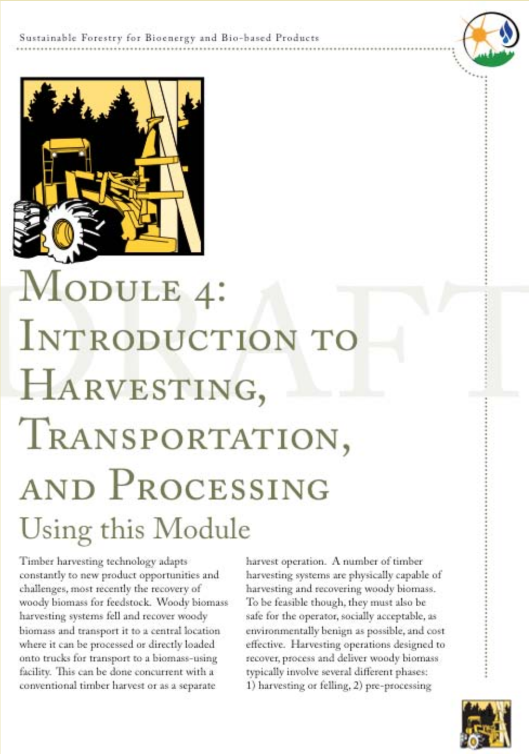
Harvesting clearcut residues can reduce site establishment costs and reduce the risk of fire. In Sweden, research has shown that site establishment costs have been reduced by 3-7%. The removal of slash and stumps, in addition to traditional harvesting techniques, increased productivity in Finland. While these examples are international in scope, similar results are feasible in the South.

Improving stand growth rates may also assist in making more biomass available from a given stand. Typical responses to intensive silvicultural practices are shown in *Table 3.3.1*. Direct biomass opportunities largely arise from harvesting current residues, while indirect opportunities arise from improved long-term productivity per acre. The most promising practices include using improved genetic material, good planting stock, fertilizing to overcome deficiencies, weed control, and draining wet sites. Care must be taken to ensure that the energy gained is greater than the energy required to produce the additional biomass.

Authors: C.D. Foster *Texas A&M University* • Chyrel Mayfield *Texas A&M University*

Module 4 Fact Sheets

- Conventional Harvesting Systems
- Small-Scale Harvesting Systems
- Pre-Processing and Drying
- Transportation and Delivery
- Storage
- Cost Factors



Sustainable Forestry for Bioenergy and Bio-based Products

DRAFT

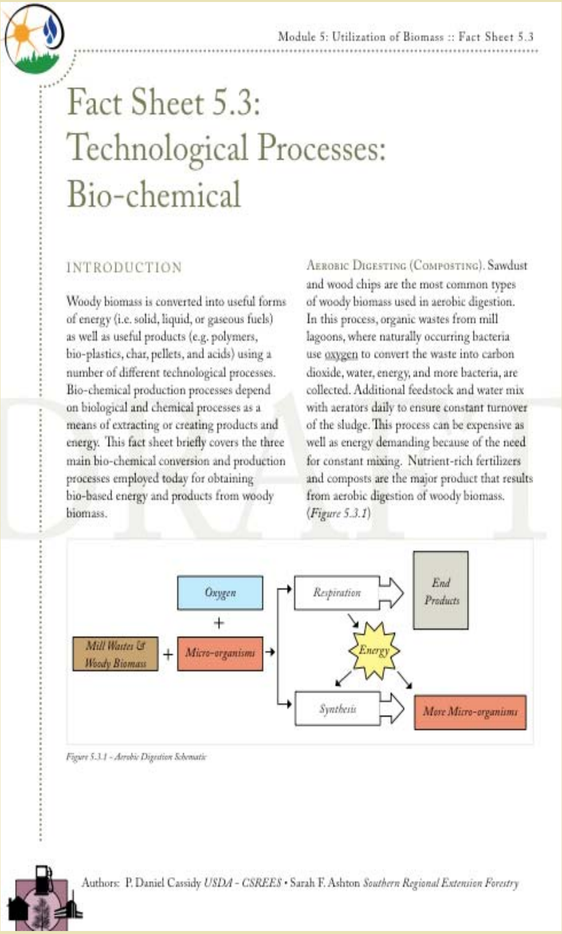
Module 4: Introduction to Harvesting, Transportation, and Processing

Using this Module

Timber harvesting technology adapts constantly to new product opportunities and challenges, most recently the recovery of woody biomass for feedstock. Woody biomass harvesting systems fell and recover woody biomass and transport it to a central location where it can be processed or directly loaded onto trucks for transport to a biomass-using facility. This can be done concurrent with a conventional timber harvest or as a separate harvest operation. A number of timber harvesting systems are physically capable of harvesting and recovering woody biomass. To be feasible though, they must also be safe for the operator, socially acceptable, as environmentally benign as possible, and cost effective. Harvesting operations designed to recover, process and deliver woody biomass typically involve several different phases: 1) harvesting or felling, 2) pre-processing

Module 5 Fact Sheets

- Wood Processing Residues
- Wood Properties
- Technology Process: Bio-chemical
- Technology Process: Thermochemical
- Bioenergy
- Ethanol
- Biodiesel
- Energy Basics
- Chemical Products
- Bio-based Products
- Ash Content


Module 5: Utilization of Biomass :: Fact Sheet 5.3

Fact Sheet 5.3: Technological Processes: Bio-chemical

INTRODUCTION

Woody biomass is converted into useful forms of energy (i.e. solid, liquid, or gaseous fuels) as well as useful products (e.g. polymers, bio-plastics, char, pellets, and acids) using a number of different technological processes. Bio-chemical production processes depend on biological and chemical processes as a means of extracting or creating products and energy. This fact sheet briefly covers the three main bio-chemical conversion and production processes employed today for obtaining bio-based energy and products from woody biomass.

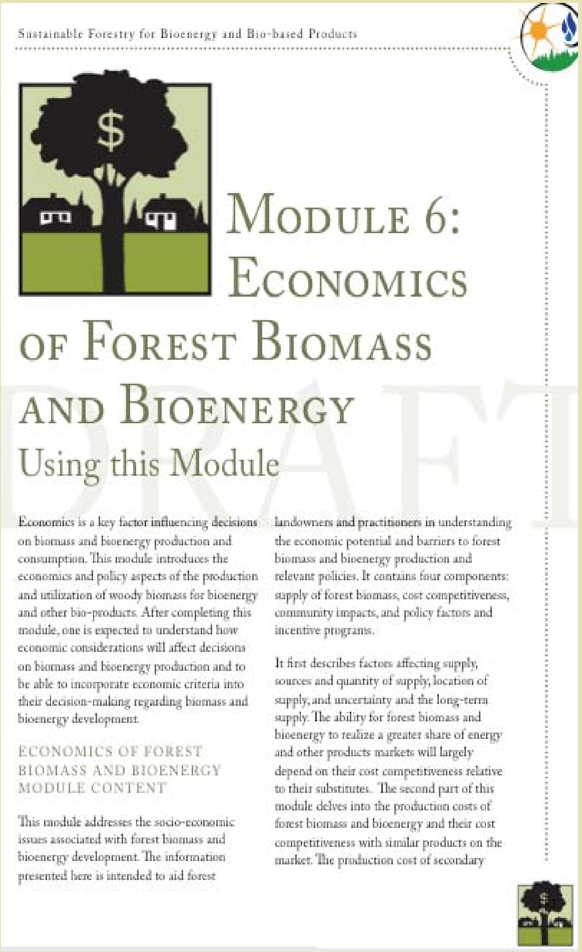
Aerobic Digesting (Composting). Sawdust and wood chips are the most common types of woody biomass used in aerobic digestion. In this process, organic wastes from mill lagoons, where naturally occurring bacteria use oxygen to convert the waste into carbon dioxide, water, energy, and more bacteria, are collected. Additional feedstock and water mix with aerators daily to ensure constant turnover of the sludge. This process can be expensive as well as energy demanding because of the need for constant mixing. Nutrient-rich fertilizers and composts are the major product that results from aerobic digestion of woody biomass. (*Figure 5.3.1*)

Figure 5.3.1 - Aerobic Digestion Schematic

Authors: P. Daniel Cassidy *USDA - CSREES* • Sarah F. Ashton *Southern Regional Extension Forestry*

Module 6 Fact Sheets

- Woody Biomass Supply: Location and Availability Factors
- The Economics of Forest Biomass Production and Use
- Forest Bioenergy Production and Rural Economic Development
- Bioenergy Policy Incentives



Sustainable Forestry for Bioenergy and Bio-based Products

MODULE 6: ECONOMICS OF FOREST BIOMASS AND BIOENERGY

Using this Module

Economics is a key factor influencing decisions on biomass and bioenergy production and consumption. This module introduces the economics and policy aspects of the production and utilization of woody biomass for bioenergy and other bio-products. After completing this module, one is expected to understand how economic considerations will affect decisions on biomass and bioenergy production and to be able to incorporate economic criteria into their decision-making regarding biomass and bioenergy development.

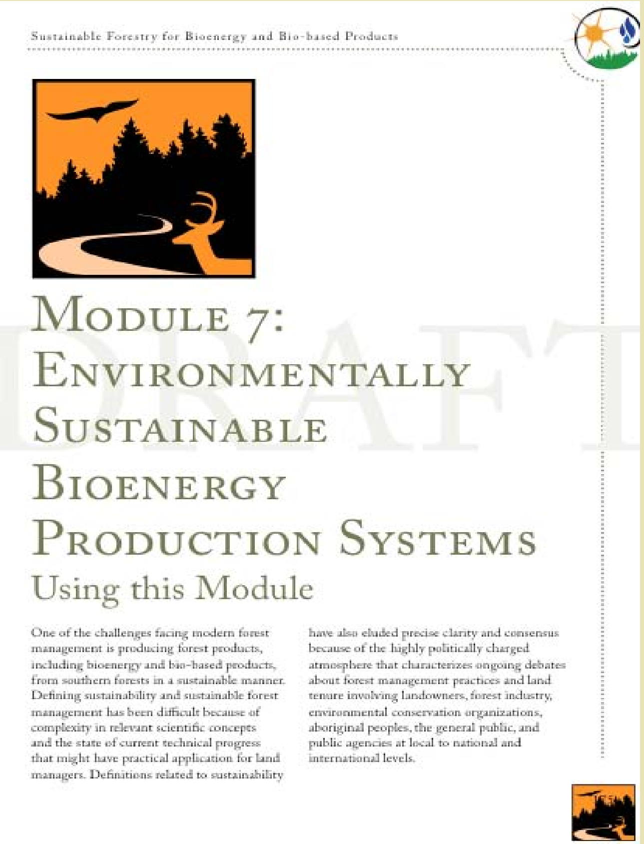
ECONOMICS OF FOREST BIOMASS AND BIOENERGY MODULE CONTENT

This module addresses the socio-economic issues associated with forest biomass and bioenergy development. The information presented here is intended to aid forest landowners and practitioners in understanding the economic potential and barriers to forest biomass and bioenergy production and relevant policies. It contains four components: supply of forest biomass, cost competitiveness, community impacts, and policy factors and incentive programs.

It first describes factors affecting supply, sources and quantity of supply, location of supply, and uncertainty and the long-term supply. The ability for forest biomass and bioenergy to realize a greater share of energy and other products markets will largely depend on their cost competitiveness relative to their substitutes. The second part of this module delves into the production costs of forest biomass and bioenergy and their cost competitiveness with similar products on the market. The production cost of secondary

Module 7 Fact Sheets

- Adaptive Forest Management
- Forest Bioenergy Certification
- Conserving Soils
- Water Conservation
- Biodiversity
- Environmental Sustainability



Sustainable Forestry for Bioenergy and Bio-based Products

DRAFT

MODULE 7: ENVIRONMENTALLY SUSTAINABLE BIOENERGY PRODUCTION SYSTEMS

Using this Module

One of the challenges facing modern forest management is producing forest products, including bioenergy and bio-based products, from southern forests in a sustainable manner. Defining sustainability and sustainable forest management has been difficult because of complexity in relevant scientific concepts and the state of current technical progress that might have practical application for land managers. Definitions related to sustainability have also eluded precise clarity and consensus because of the highly politically charged atmosphere that characterizes ongoing debates about forest management practices and land tenure involving landowners, forest industry, environmental conservation organizations, aboriginal peoples, the general public, and public agencies at local to national and international levels.

PowerPoint Presentations

- Complement the Encyclopedia and Fact Sheets
- One PowerPoint per Module
- Each slide has lecture notes
- Available on CD and online

Module 4:
Introduction to Harvesting, Transportation, and Processing

Southern Forest Research Partnership, Inc.

Recovering Woody Biomass

- Logging residue represents great potential
- 41 million dry tons of logging residue
- Needs to be augmented by other wood sources

Recovering Woody Biomass with Timber Harvesting Technology

- Similar technology
- Similar processes
  - Felling and recovery
  - Pre-processing and drying
  - Transportation and delivery
  - Storage

Web-Based Learning Modules

http://www.forestandrange.org/Biomass/Index.asp

UTN Web Based Learning Center.

icon Harvesting Biomass for Bioenergy Production

Home
Credits
1.Forms of Woody Biomass
- Unconsolidated Woody Biomass
- Comminuted Biomass Materials
- Composite Residue Logs
2.Conventional Biomass Harvesting Systems
3.Small-scale Biomass Harvesting Systems
4.Processing and Drying
5.Transport and Delivery
6.Storage
7.Costs
Additional Materials
References

Glossary | Modules | Ext. Agent Resources | SFRP Home | Credits

forestandrange > SFBB > Modules > Harvesting > Unit 1 > **Lesson 1**

Unconsolidated Woody Biomass

Unconsolidated Woody Biomass
Source: Ben Jackson

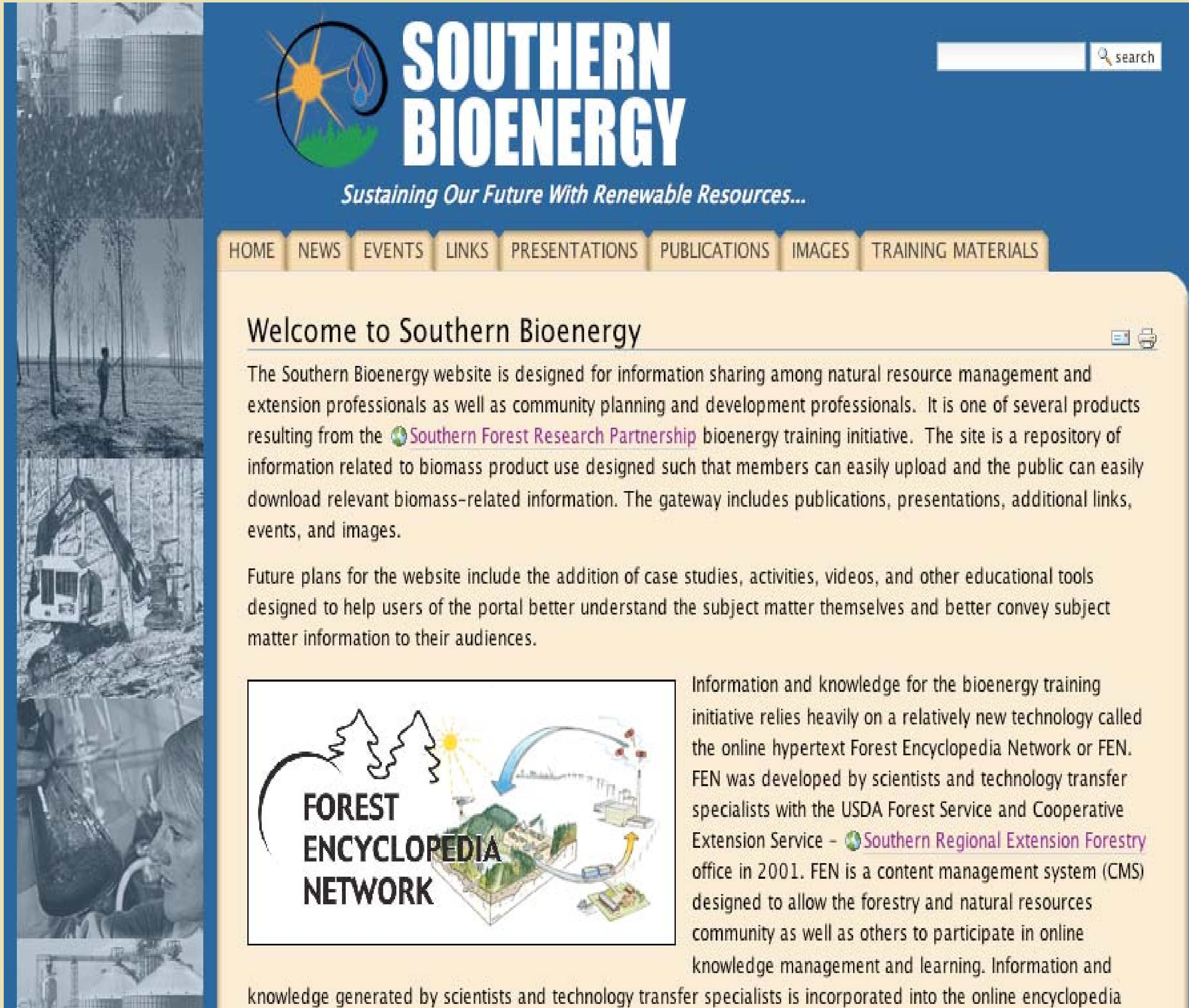
Unconsolidated slash is woody biomass in its raw form after it has been removed from the bole of the tree. Historically, this material was considered unmerchantable. In most southern harvesting operations, unconsolidated slash is left in place on the logging site or concentrated at the landing. While not commonly practiced, this slash can be transported to a biomass-using facility by conventional logging trucks, log trailers, or specialized containers on trailers. Because unconsolidated material is bulky with lots of air space, efforts have been made to compress this material to allow for more biomass to be transferred per load. In most cases, however, compression has not proven operationally feasible.

Transporting forest biomass from the woods to a utilization site is often difficult. As this figure shows, the method by which the biomass is prepared for transport makes a large difference in how much can go into one truckload. The volumes of material at right all have the same weight. When utilizing biomass, careful consideration must be taken for transport issues.

Volume differences of the same weight material by different product types
Source: USDA Forest Service Forest Product Laboratory

Southern Bioenergy Web Portal

http://southernbioenergy.net



HOME | NEWS | EVENTS | LINKS | PRESENTATIONS | PUBLICATIONS | IMAGES | TRAINING MATERIALS

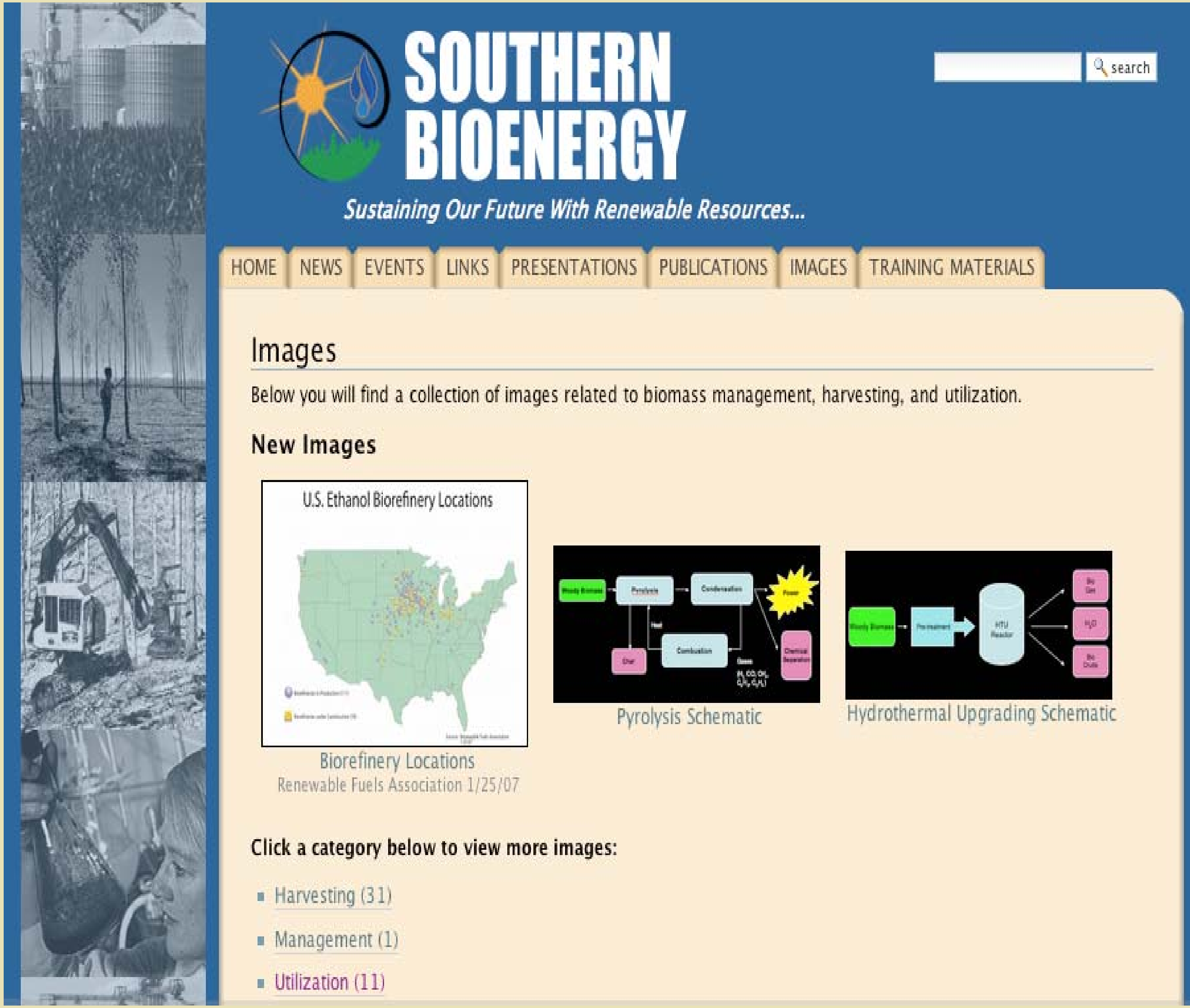
Welcome to Southern Bioenergy

The Southern Bioenergy website is designed for information sharing among natural resource management and extension professionals as well as community planning and development professionals. It is one of several products resulting from the Southern Forest Research Partnership bioenergy training initiative. The site is a repository of information related to biomass product use designed such that members can easily upload and the public can easily download relevant biomass-related information. The gateway includes publications, presentations, additional links, events, and images.

Future plans for the website include the addition of case studies, activities, videos, and other educational tools designed to help users of the portal better understand the subject matter themselves and better convey subject matter information to their audiences.

Information and knowledge for the bioenergy training initiative relies heavily on a relatively new technology called the online hypertext Forest Encyclopedia Network or FEN. FEN was developed by scientists and technology transfer specialists with the USDA Forest Service and Cooperative Extension Service – Southern Regional Extension Forestry office in 2001. FEN is a content management system (CMS) designed to allow the forestry and natural resources community as well as others to participate in online knowledge management and learning. Information and knowledge generated by scientists and technology transfer specialists is incorporated into the online encyclopedia

Southern Regional Extension Forestry


SOUTHERN BIOENERGY
Sustaining Our Future With Renewable Resources...
search
HOME
NEWS
EVENTS
LINKS
PRESENTATIONS
PUBLICATIONS
IMAGES
TRAINING MATERIALS
Images
Below you will find a collection of images related to biomass management, harvesting, and utilization.
New Images
U.S. Ethanol Biorefinery Locations
Biorefinery Locations
Renewable Fuels Association 1/25/07
Pyrolysis Schematic
Hydrothermal Upgrading Schematic
Click a category below to view more images:
Harvesting (31)
Management (1)
Utilization (11)

Forest Biomass Training Program Testing

- **Encyclopedia Site: http://www.forestencyclopedia.net**
  - **February 1 – 2, 2006 College Station, TX**
- **Train-the-Trainer Pilot Program – Atlanta, GA, February 2007**
- **Train-the-Trainer Final: Summer 2007**
- **End User Training, Fall 2007and beyond**

Conclusions

- There is a substantial biofuels opportunity in the Southern U.S.
- The U.S. is the world’s largest and most demanding marketplace
- The forest industry is uniquely positioned (resources and infrastructure) to provide improved and sustainable products and energy opportunities for the benefit of the Nation and Society

Follow-Up Actions

- Add Additional Modules
  - Policy and Legislation
- Sustain the Bioenergy Encyclopedia
  - USDA has an investment in this information technology --- need to sustain the investment
- Follow-up Conferences/Workshops/Seminars
  - “Understanding Relationships Between Biomass/Biofuels Production and Biodiversity”

Follow-up Actions (cont.)

- Forestry Biomass Language in Forest, Energy and Research Titles of the forthcoming Farm Bill
- Funding for Title II of the Healthy Forest Restoration Act

Comments and Questions

Attachment K

Bacterial Biocatalysts for Fermentation of Biomass Sugars to Ethanol

K.T. Shanmugam and Lonnie O. Ingram

Dept. of Microbiology and Cell Science
University of Florida
Gainesville, Florida

Public Meeting of the Biomass Research and Development Technical Advisory Committee
Feb. 14, 2007

President Bush
State of the Union Address
Jan 23, 2007

“To reach this goal, we must increase the supply of alternative fuels, by setting a mandatory fuels standard to require *35 billion gallons of renewable and alternative fuels in 2017* -- and that is nearly five times the current target.”

“We must continue investing in *new methods of producing ethanol using everything from wood chips to grasses, to agricultural wastes*.”

VISION

FOR BIOENERGY AND BIOBASED PRODUCTS IN THE UNITED STATES

Bioeconomy for a Sustainable Future

2006

Biomass Research and Development Technical Advisory committee

BR&Di

Biomass Research and Development Initiative

Vision for Bioenergy and Biobased Products in the United States **Biofuels Goals**						
	2000	**2004**	**2010**	**2015**	**2020**	**2030**
Consumption of Biofuels (Billions Gasoline Gallon Equivalent)	**1.1**	**2.1**	**8.0**	**13**	**23**	**51**

Areas of Focus for R & D

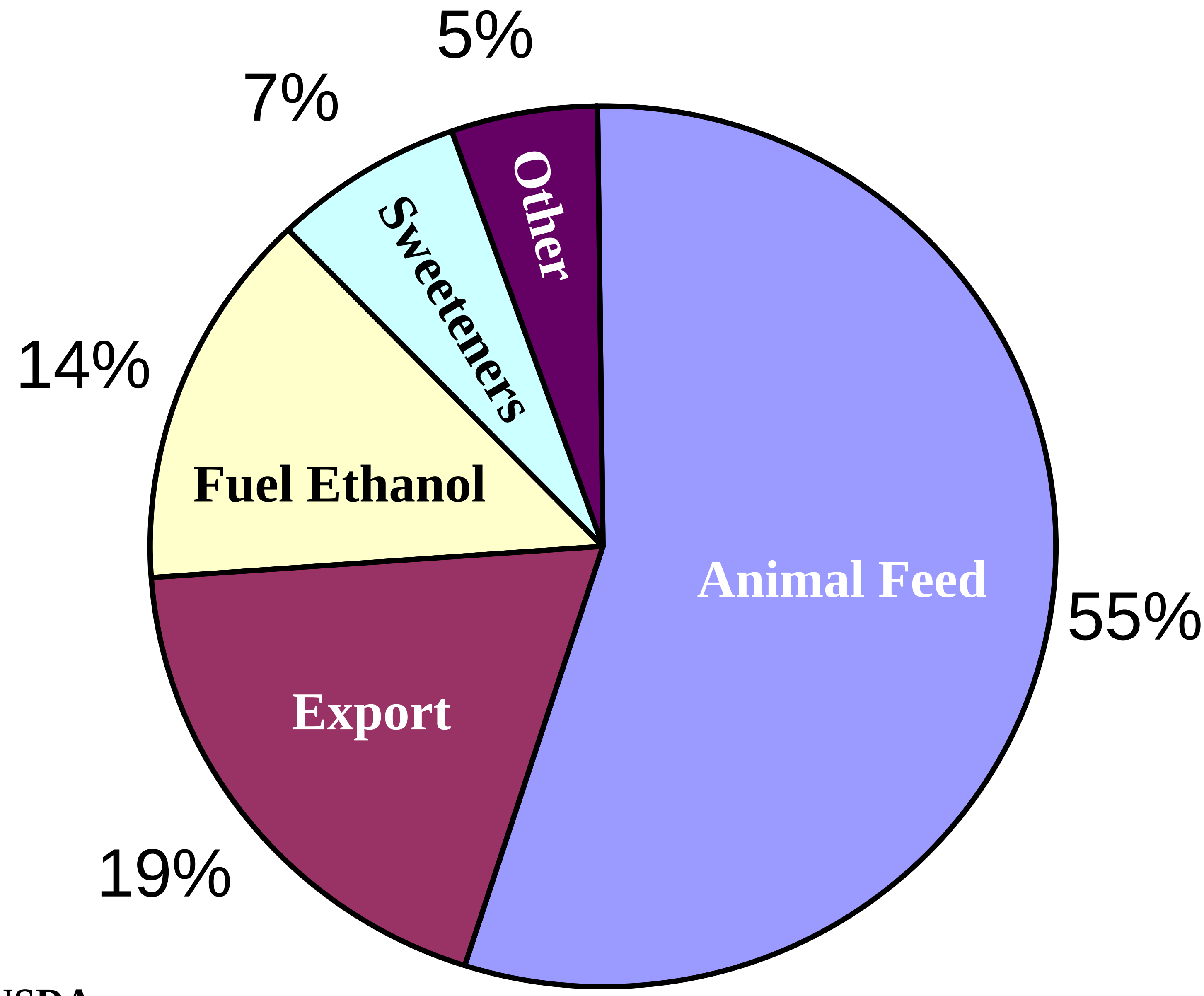
- **Reducing the cost of fermentation**
- **Enabling greater conversion of lignocellulosic biomass**

US Fuel Ethanol Production

Biorefineries (112)	**5.5 B Gallons / Yr**
Under Construction (77 + 7)	**6.2 B Gallons / Yr**
Anticipated Total	**11.7 B Gallons / Yr**

Source: Renewable Fuels Association - Jan. 29, 2007

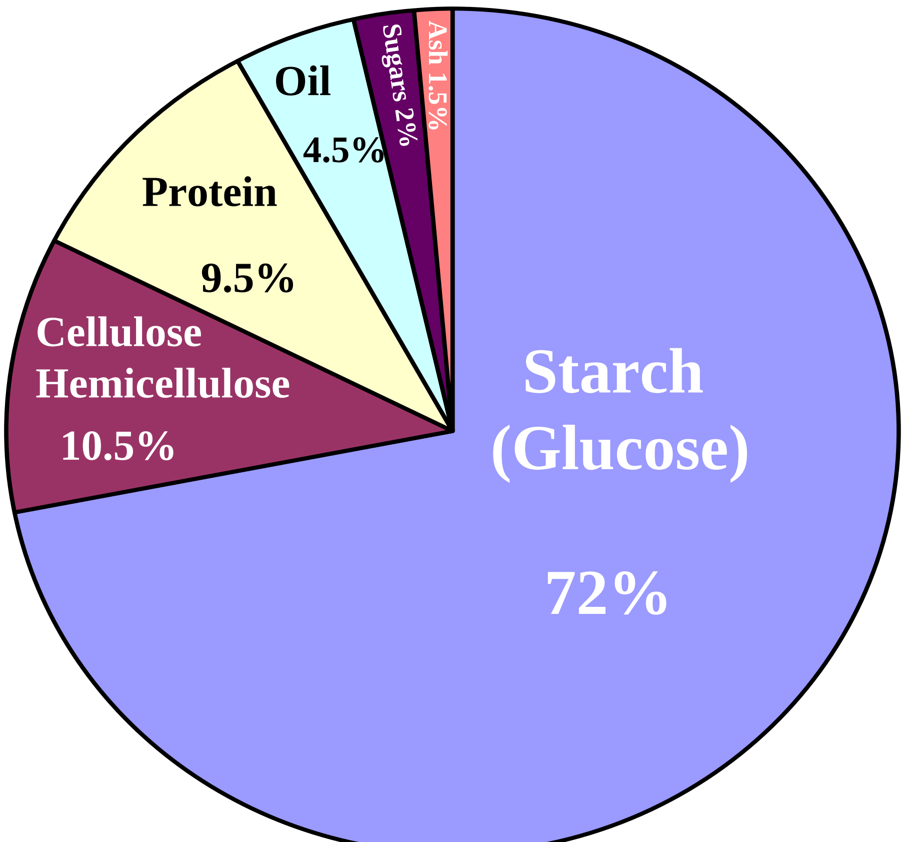
USES OF CORN – 2005/2006



Source: USDA

Corn to Ethanol

Corn Kernel → Corn Meal → (Enzymes) Glucose → Fermentation (Yeast) → Purification → Ethanol



US Corn Production (2004)

US Total	11.8 Billion Bushels
Iowa	2.24 BB
Illinois	2.09 BB
Nebraska	1.32 BB
Minnesota	1.12 BB
Indiana	0.93 BB
Florida	2.88 MB

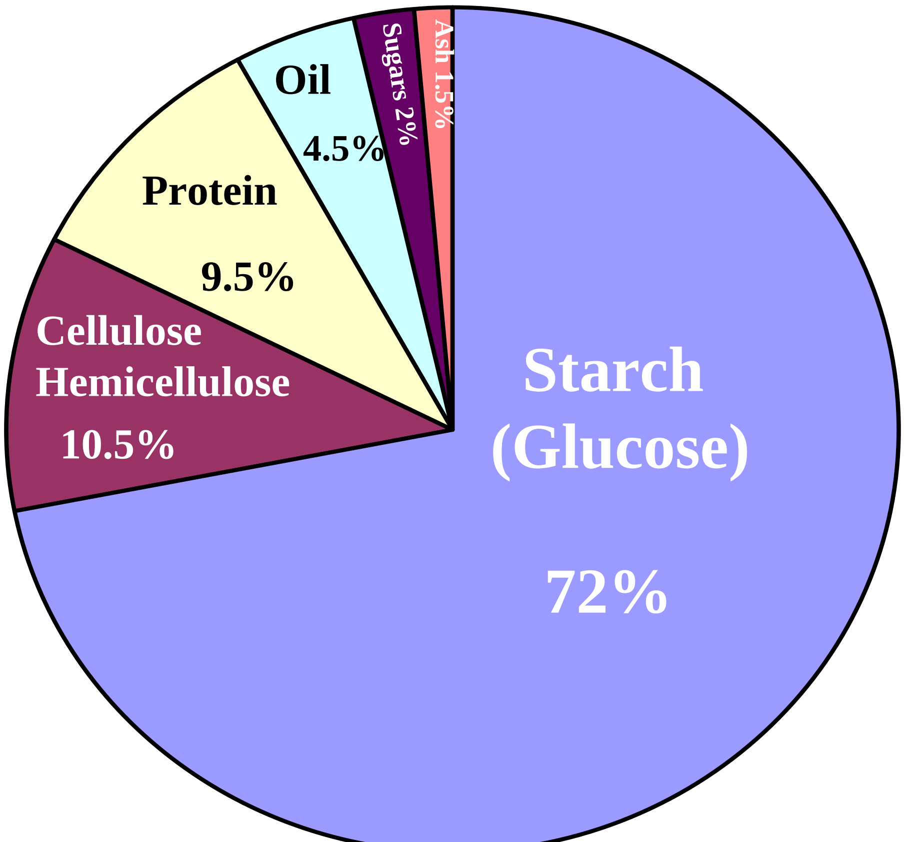
Source: USDA-ARS

Other Sources of Sugars

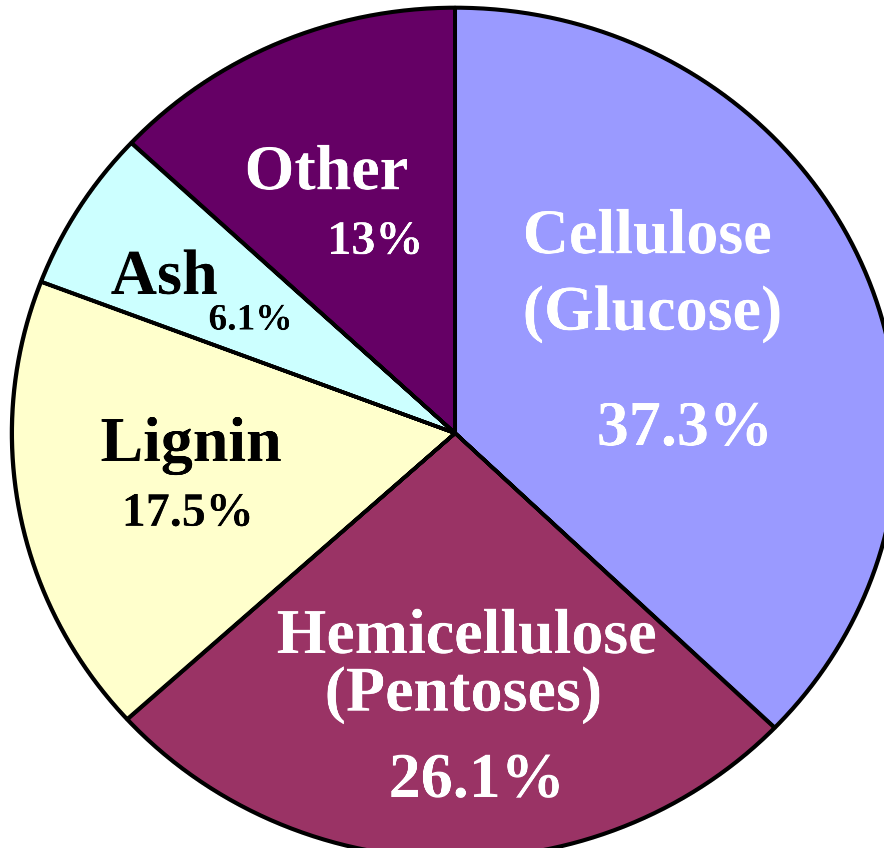
- **Crop Residues**
- **Energy Crops**
- **Forest Products**

Other Sources of Sugars

Corn Kernel



Corn Stover



Source: NREL

Sugar cane Bagasse – Biomass Residues

(South of Lake Okeechobee, Florida)

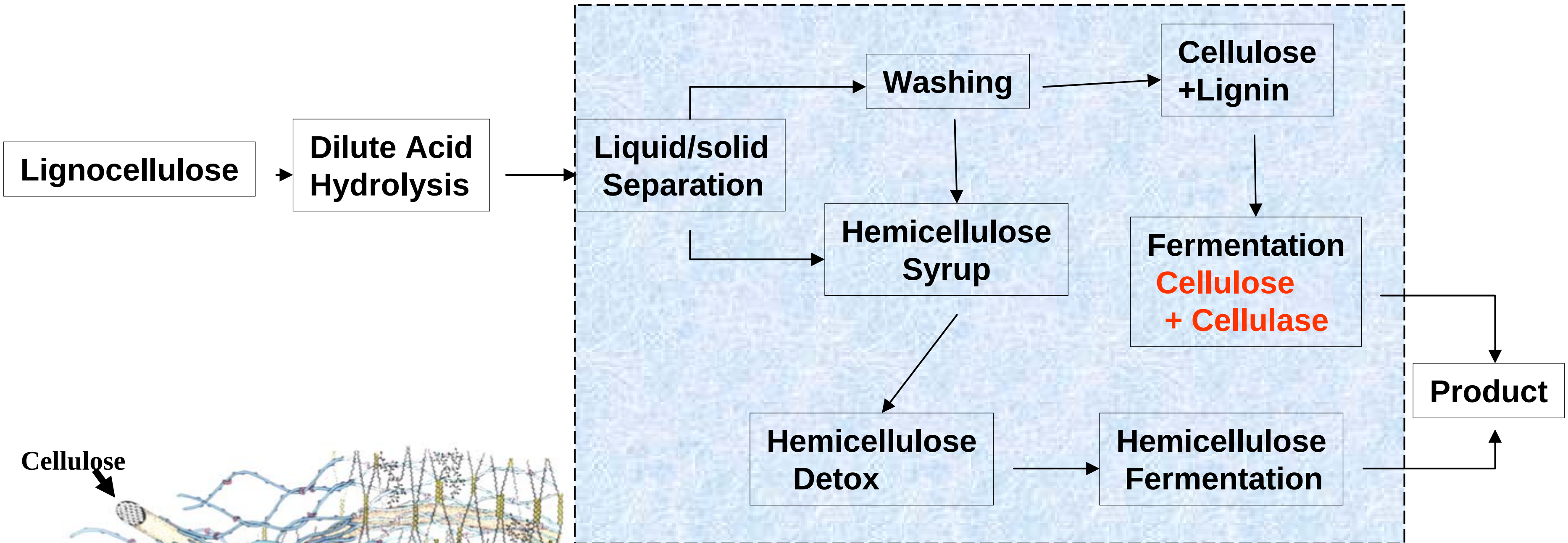
Energy Crop

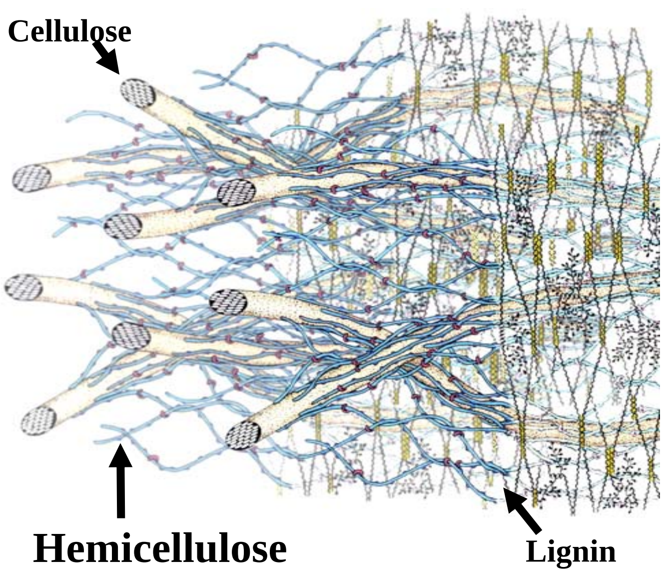
Switch grass bales (1200 lb) from 5 year old field – Northeast South Dakota
Source: DOE Biofuels Joint Roadmap, June 2006

Hard Woods and Soft Woods

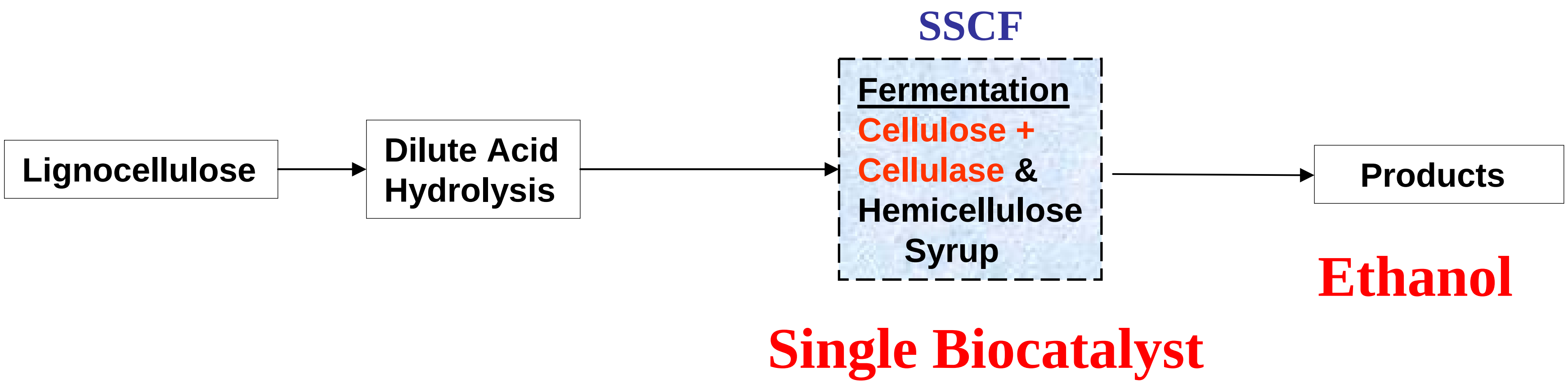
A rich tapestry of hardwood and softwood trees.
The old mill pond at the Aldridge Sawmill site, East Texas terrain.
Photo courtesy of USDA Forest Service

Conversion of Biomass to Fuel Ethanol & Chemicals

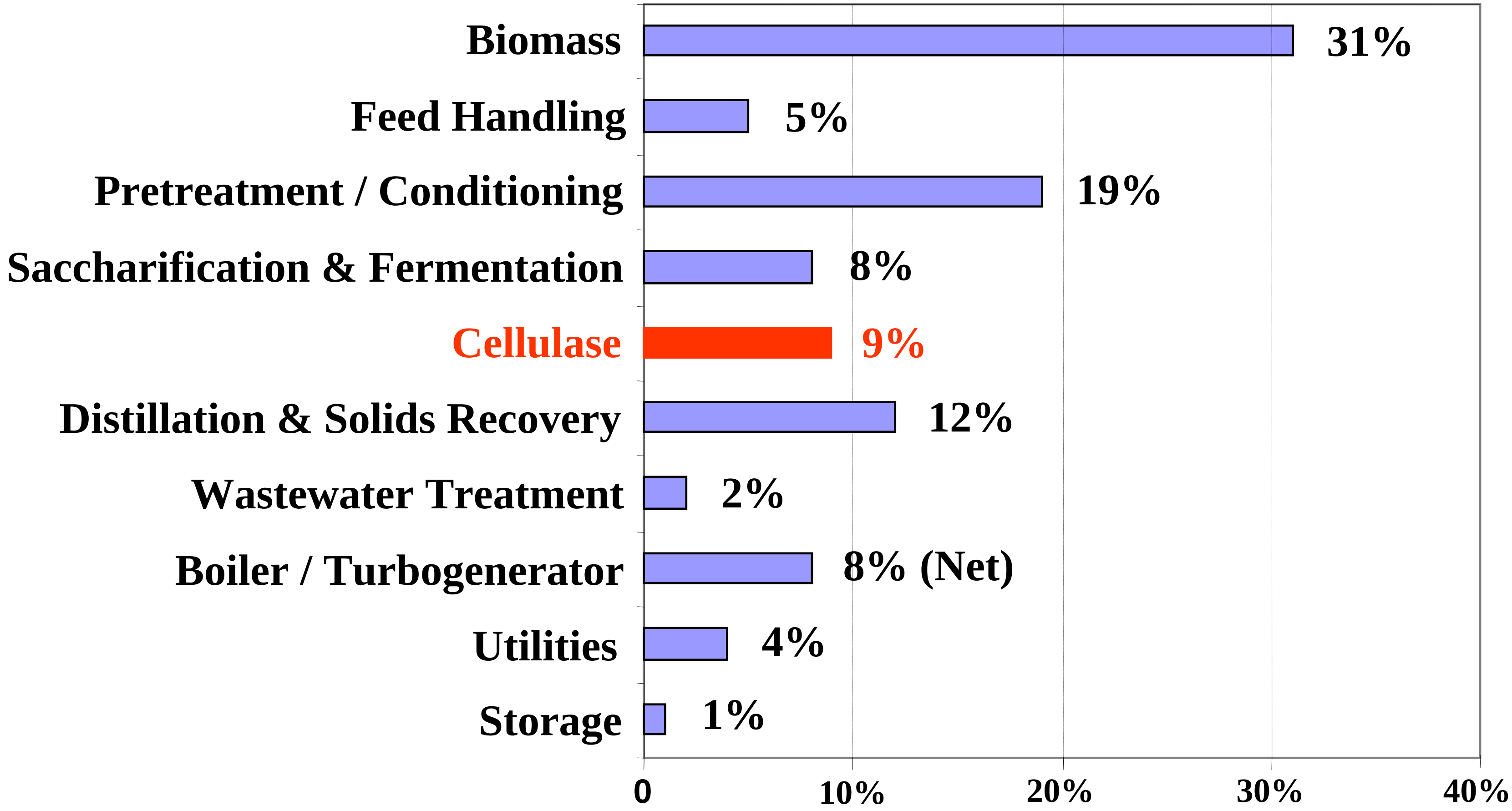




Process Simplification with Advanced Biocatalysts

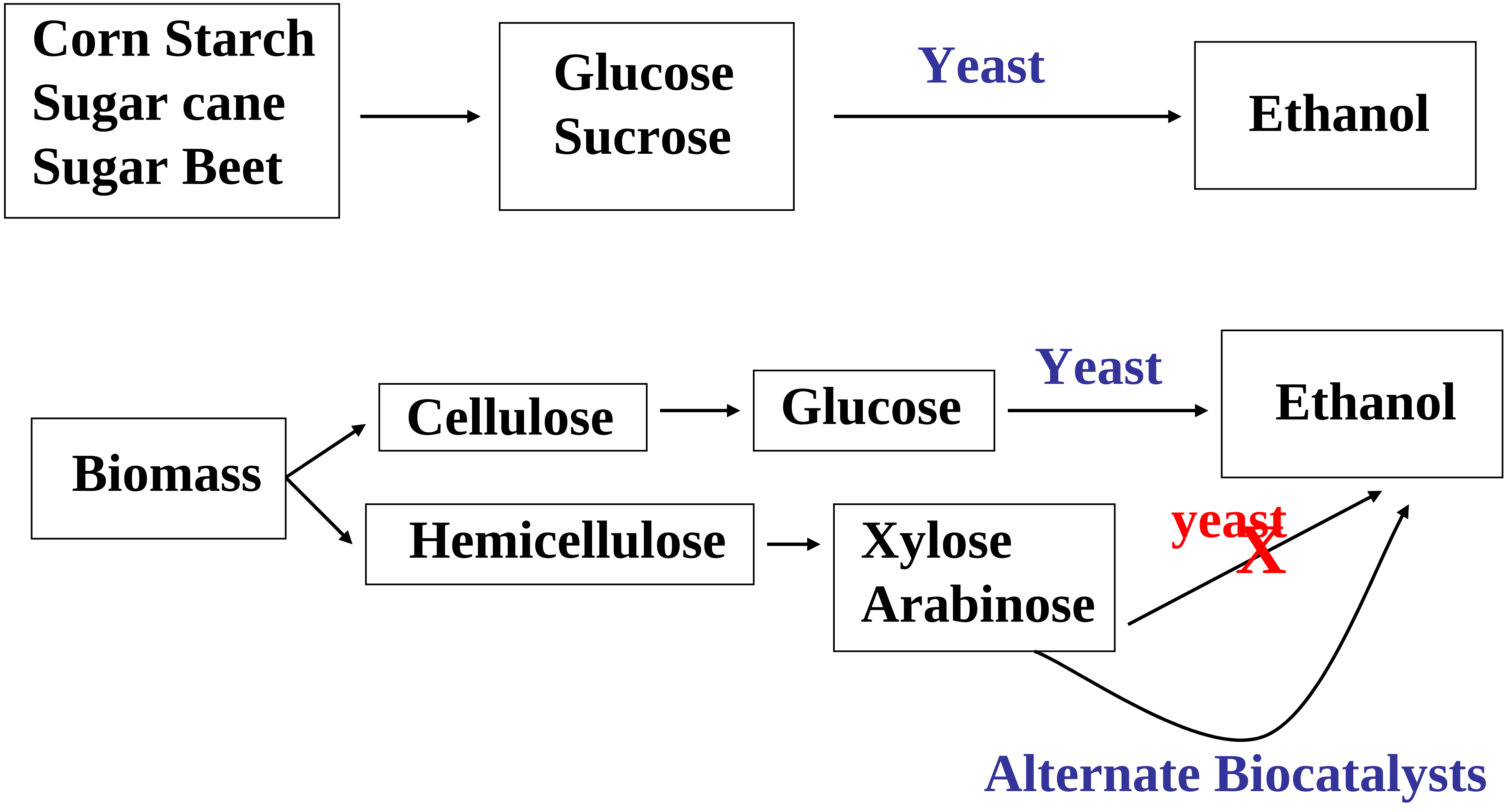


Cost Contribution from Each Process Area
(% of Ethanol Selling Price)



Source: NREL/TP-510-32438; June 2002

Yeast Fermentation Characteristics



Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda

A Research Roadmap Resulting from the Biomass to Biofuels Workshop Sponsored by the U.S. Department of Energy

December 7–9, 2005, Rockville, Maryland

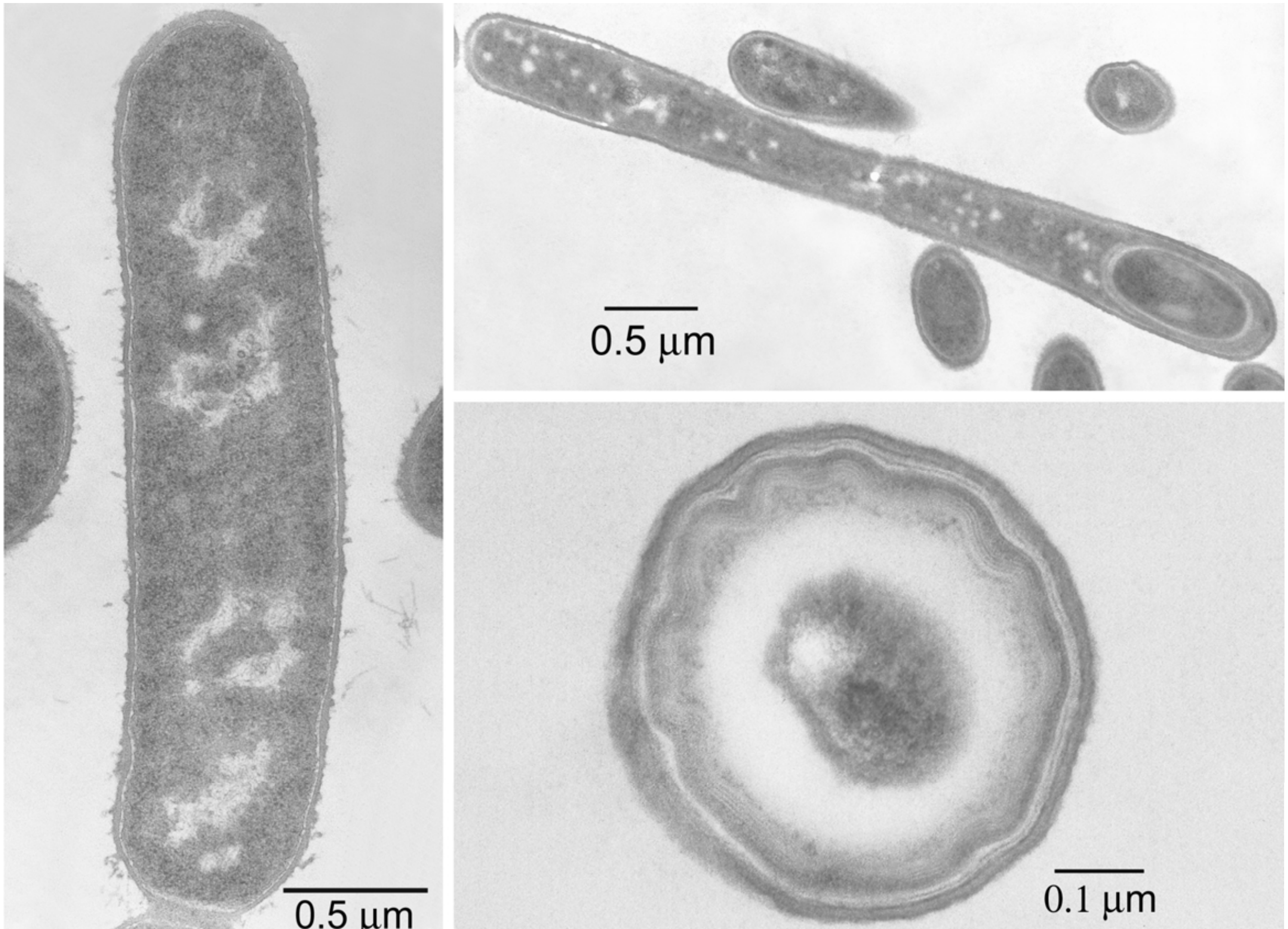
DOE/SC-0095, Publication Date: June 2006
Office of Science, Office of Biological and Environmental Research, Genomics:GTL Program
Office of Energy Efficiency and Renewable Energy, Office of the Biomass Program

From DOE Research Roadmap, 2006

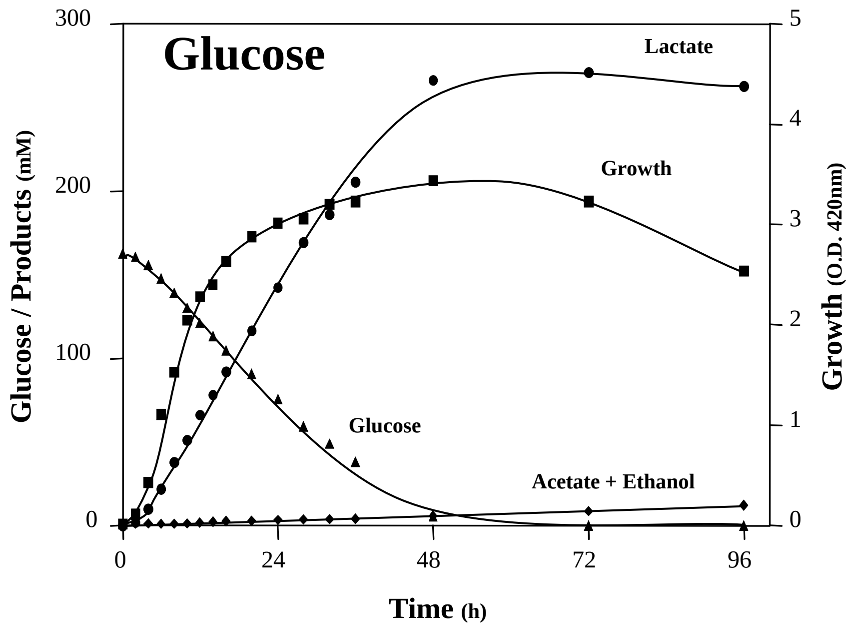
Technical Milestones
Within 5 years

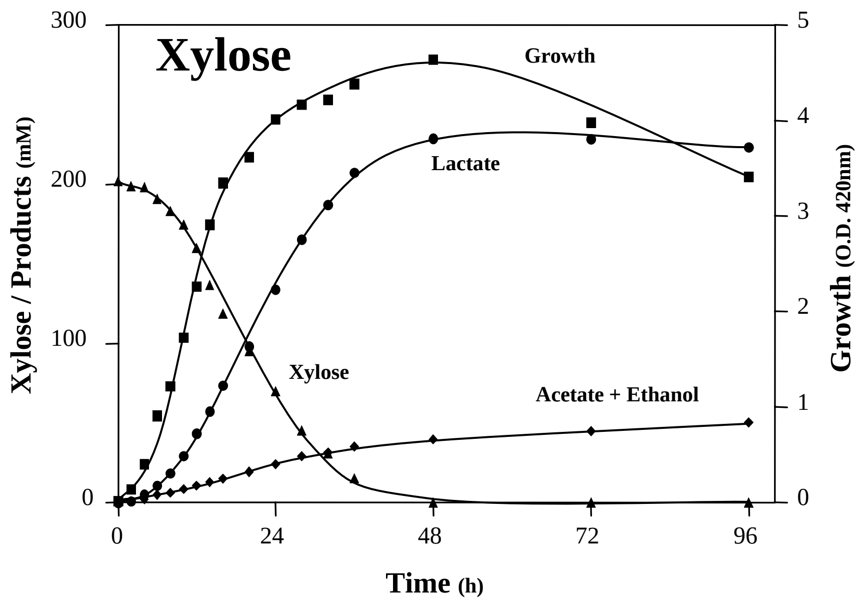
Candidate microbes such as *thermophilic ethanologens* compatible with desired cellulase enzyme optima. This allows process simplification to single-vessel fermentation with *efficient use of all biomass-derived sugars*

Bacillus coagulans, a potential Second Generation Biocatalyst



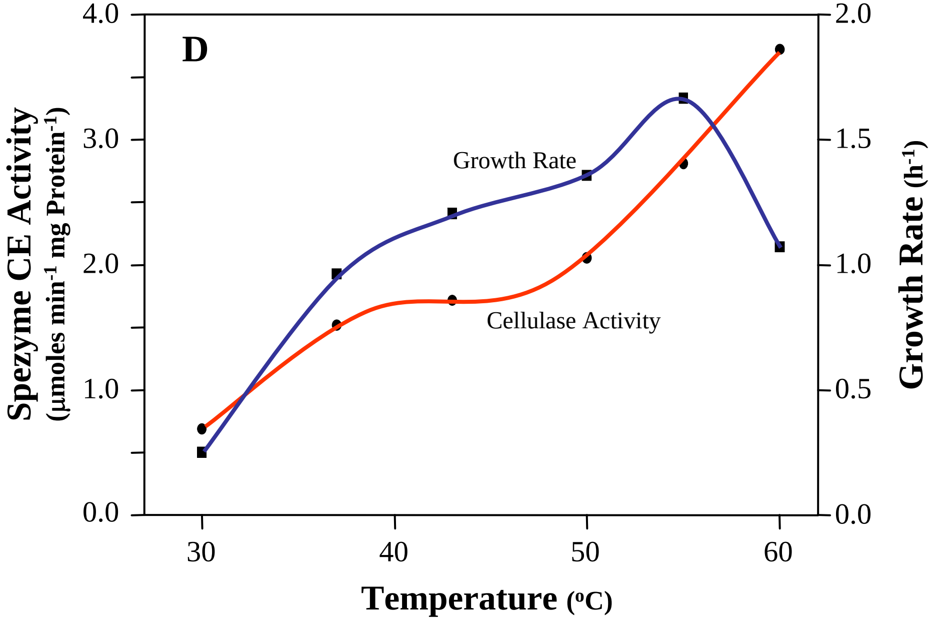
B. coagulans Ferments glucose and Xylose



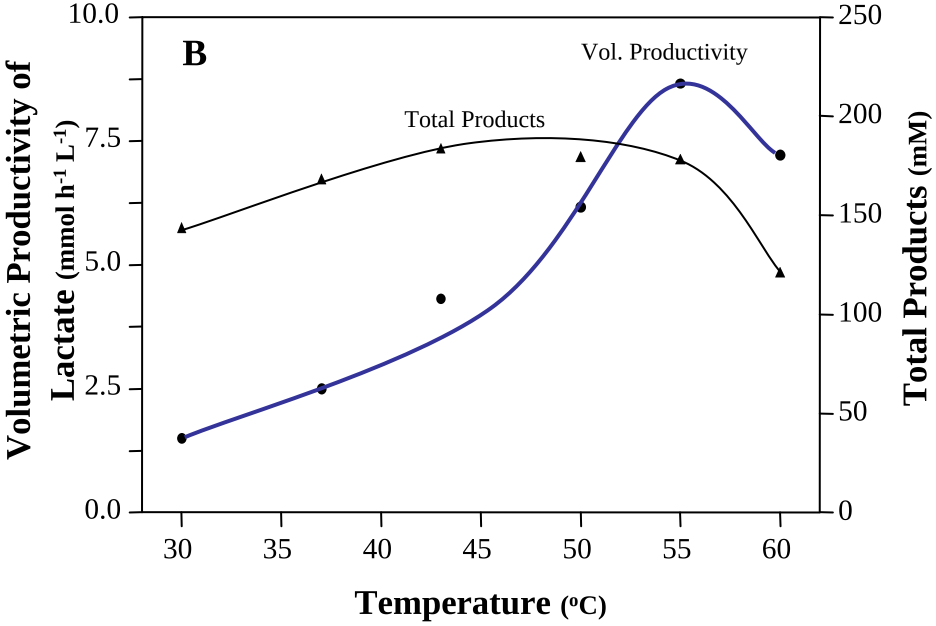


Growth and Fermentation of *B. coagulans* matches that of Fungal Cellulase Activity

Effect of Temperature

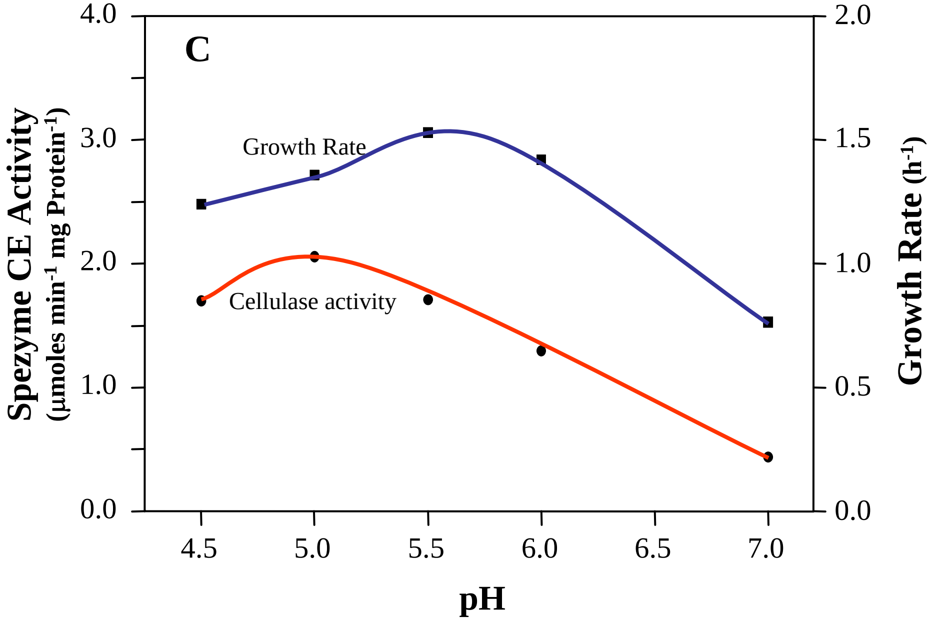


SSF of Crystalline Cellulose

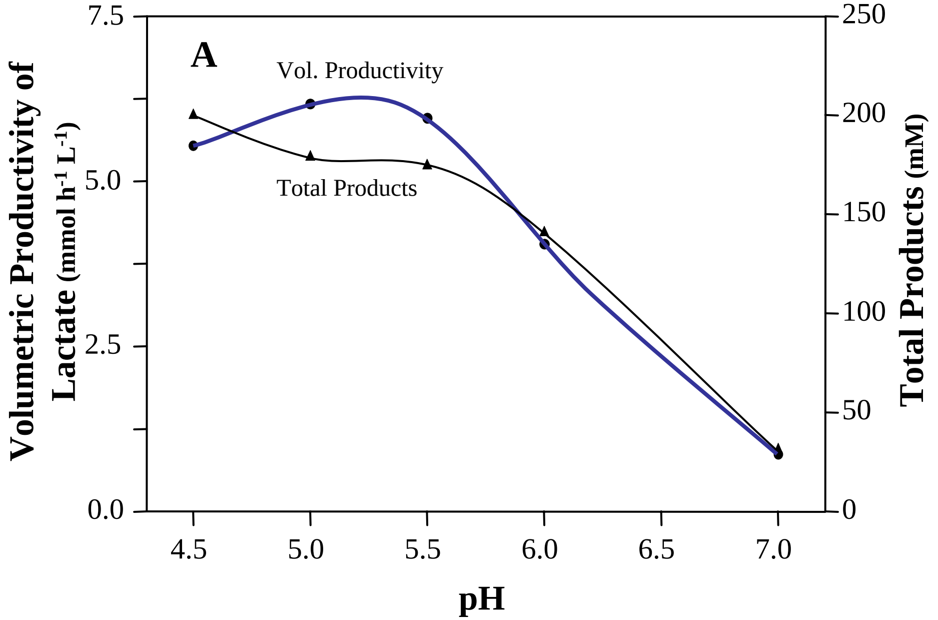


Growth and Fermentation of *B. coagulans* matches that of Fungal Cellulase Activity

Effect of pH



SSF of Crystalline Cellulose

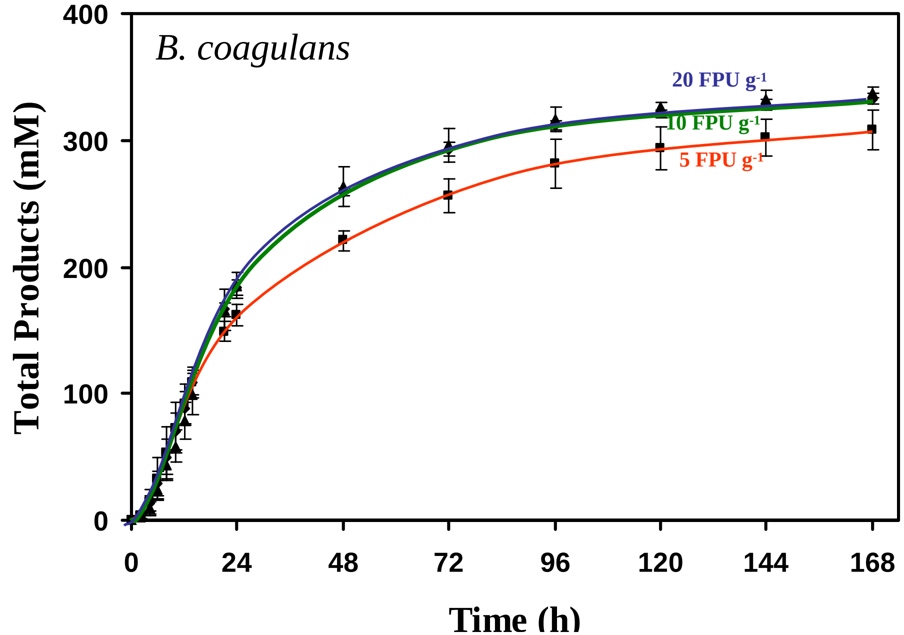


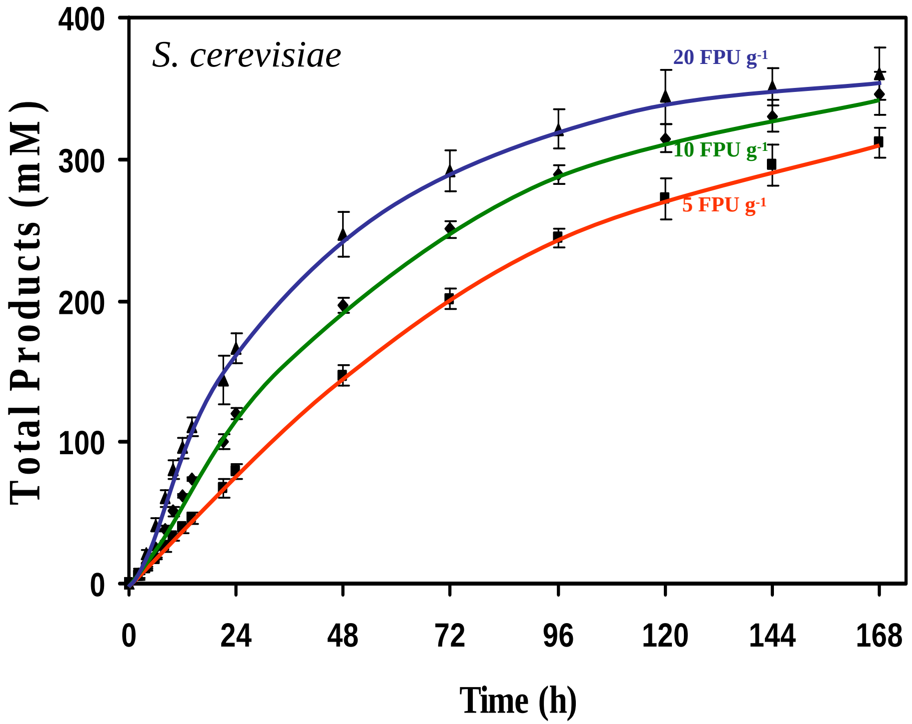
From DOE Research Roadmap, 2006

Technical Milestones
Within 15 years

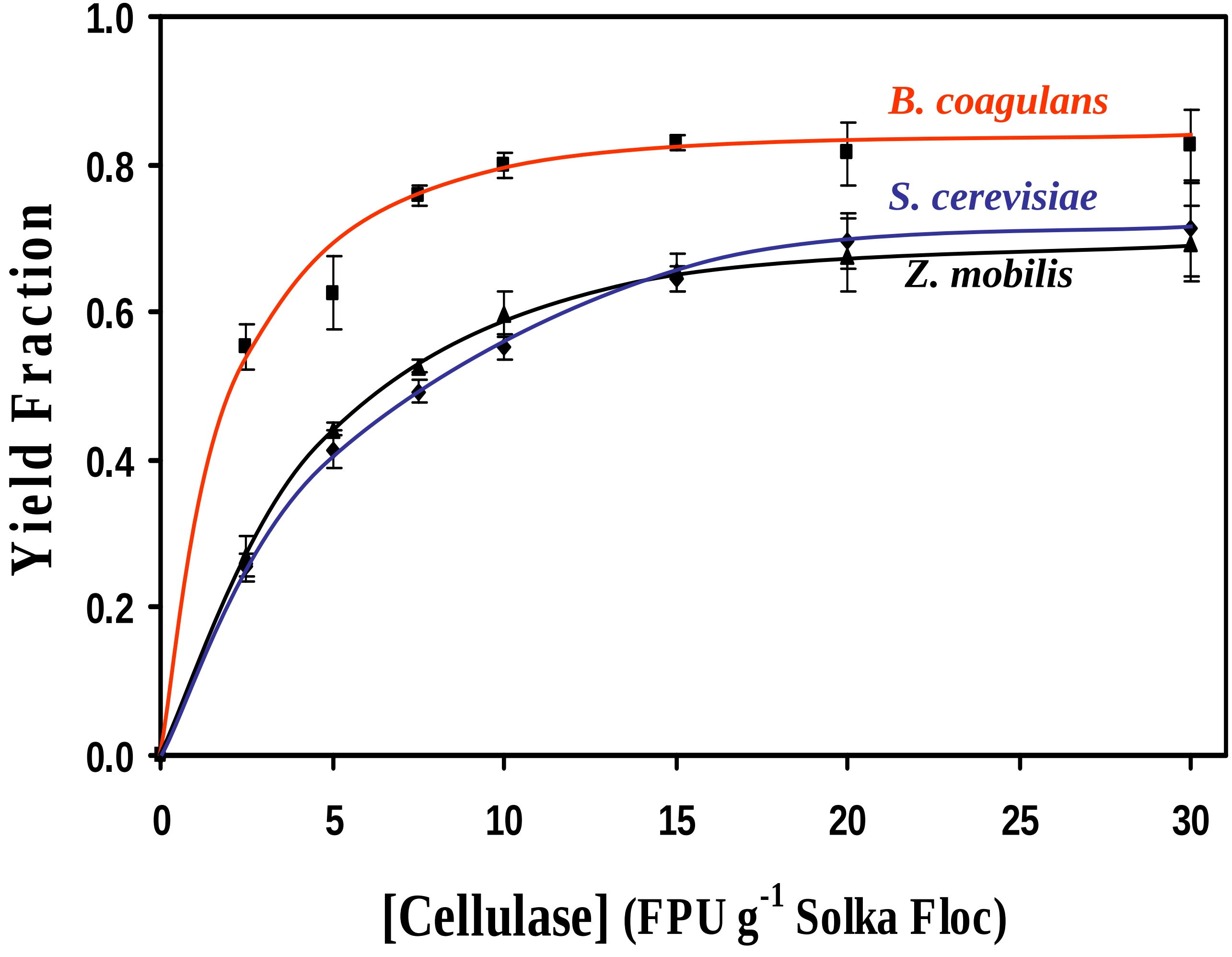
Thermophillic microbes demonstrated at scale to enable simultaneous saccharification and fermentation.

SSF of Cellulose



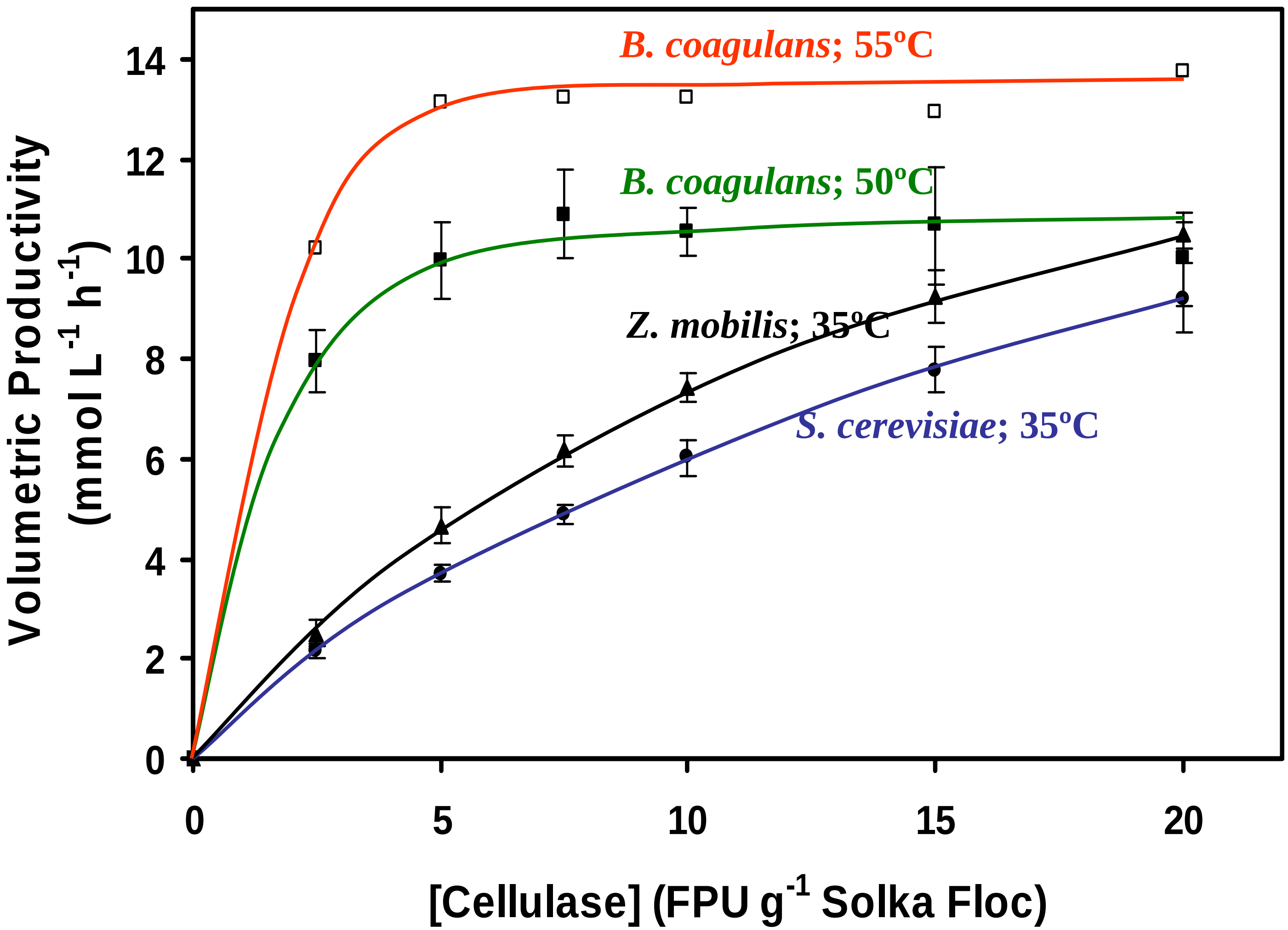


B. coagulans produces more product in shorter time

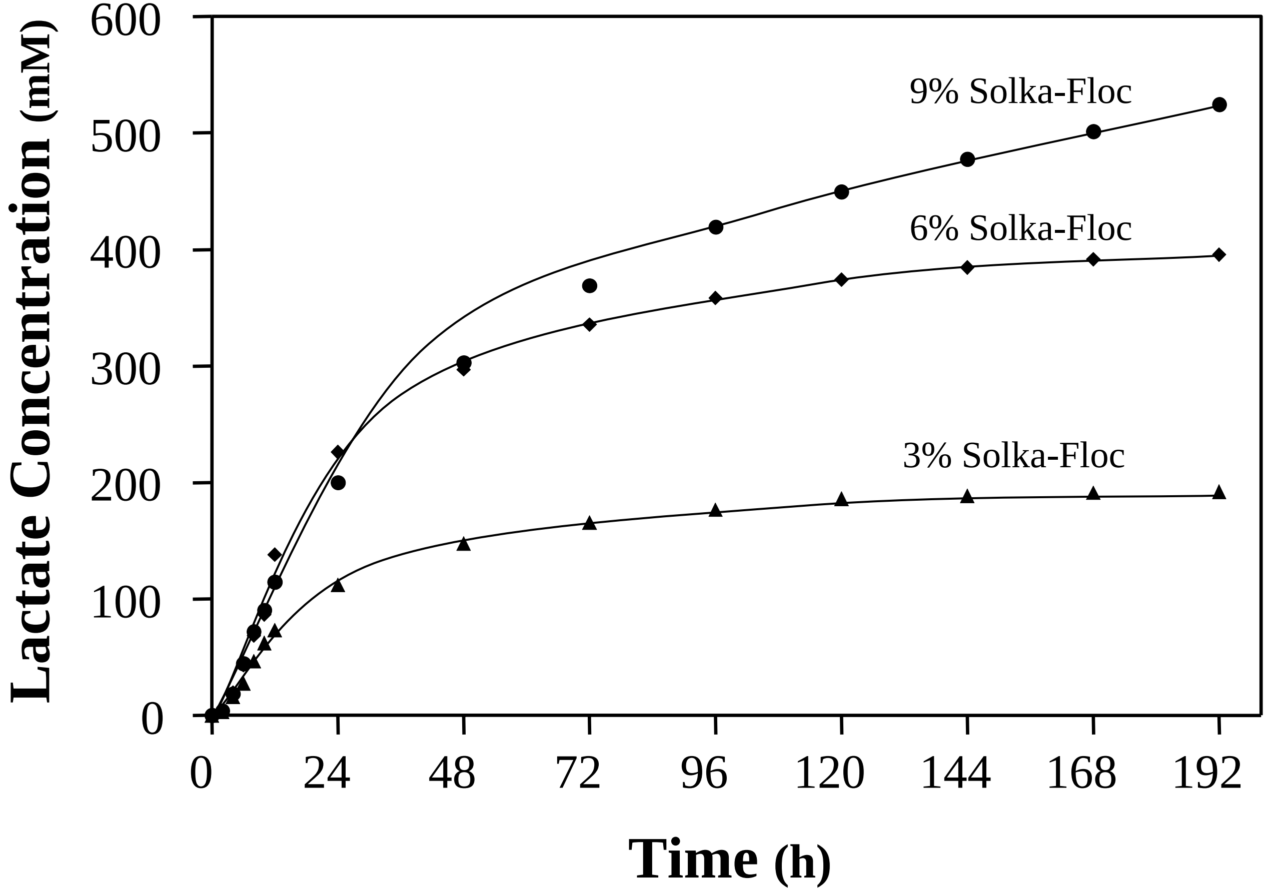


Fermentation time: 48 h

SSF with *B. coagulans* requires less enzyme than yeast



SSF of Cellulose with cellulase and *B. coagulans*



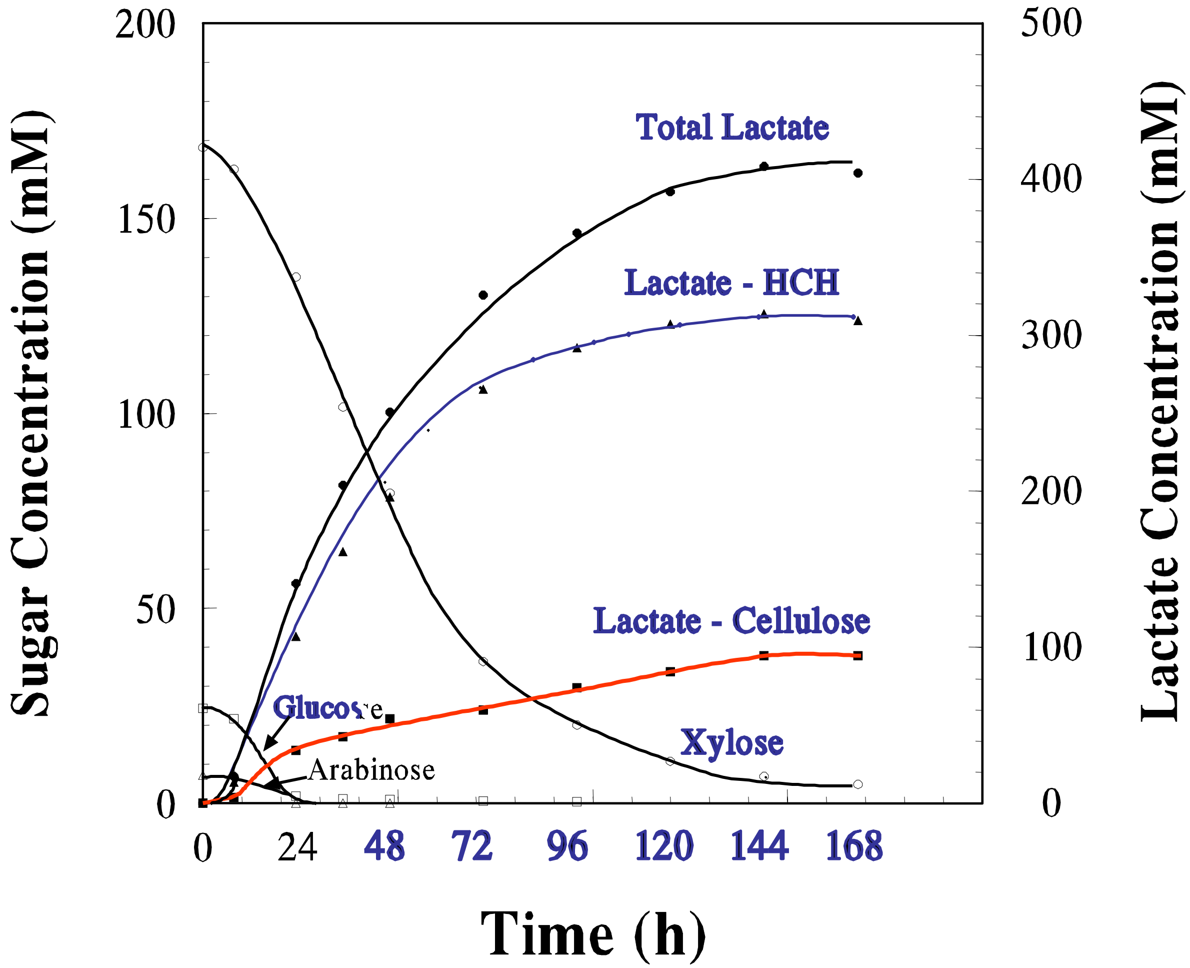
Genencor Spezyme CE, 10 FPU/ g cellulose

From DOE Research Roadmap, 2006

Technical Milestones
Within 15 years

Simultaneous saccharification and cofermentation (SSCF), in which hydrolysis is integrated with fermentation of both hexose and pentose sugars but with cellulase produced in a separate step. For example, development of thermophilic ethanol- producing organisms for use in SSCF could allow the consolidated process to run at higher temperatures, thus realizing significant savings by reducing cellulase requirements.

SSCF of Sugarcane Bagasse HCH with Cellulose by *B. coagulans*

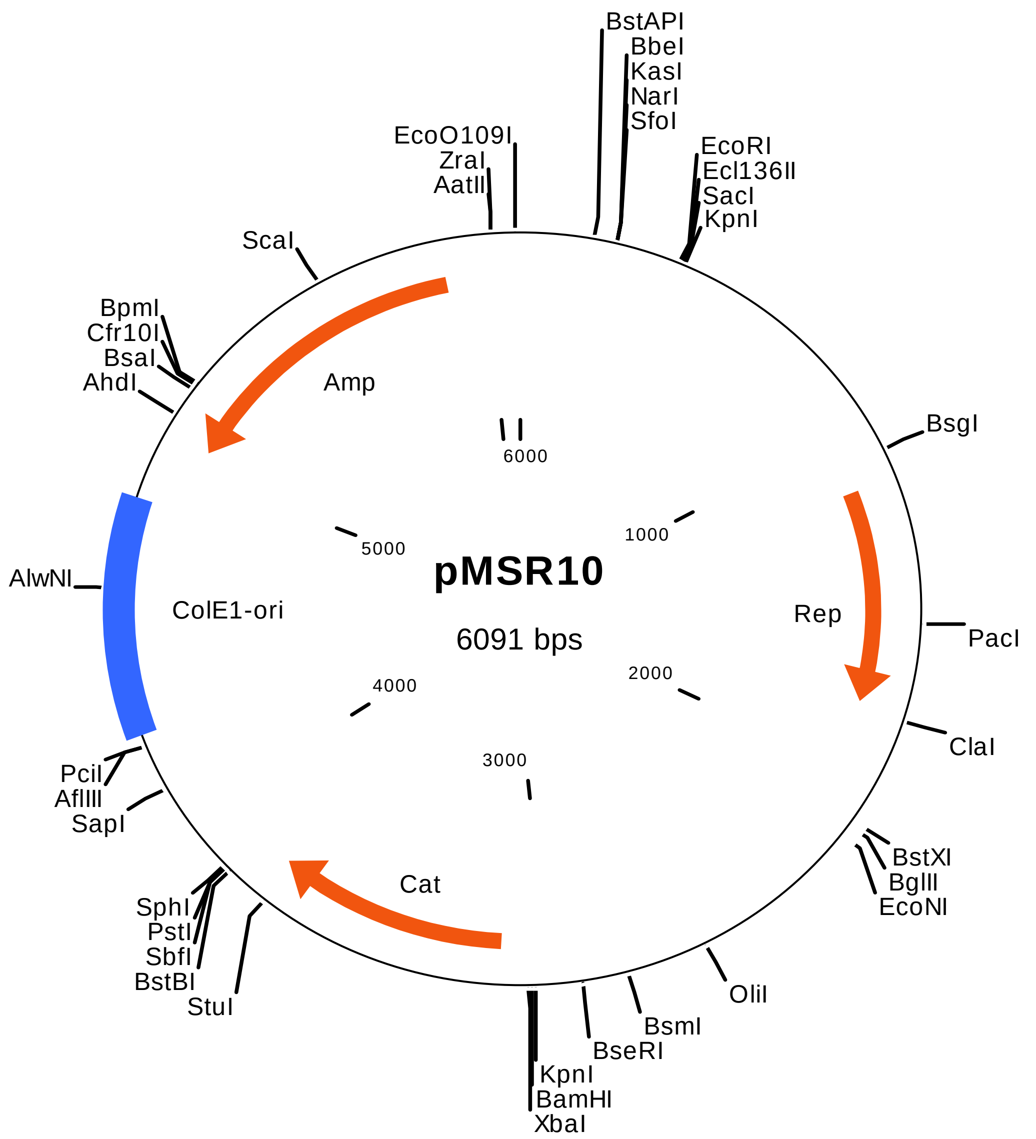


Metabolic Engineering of *B. coagulans* for Ethanol Production

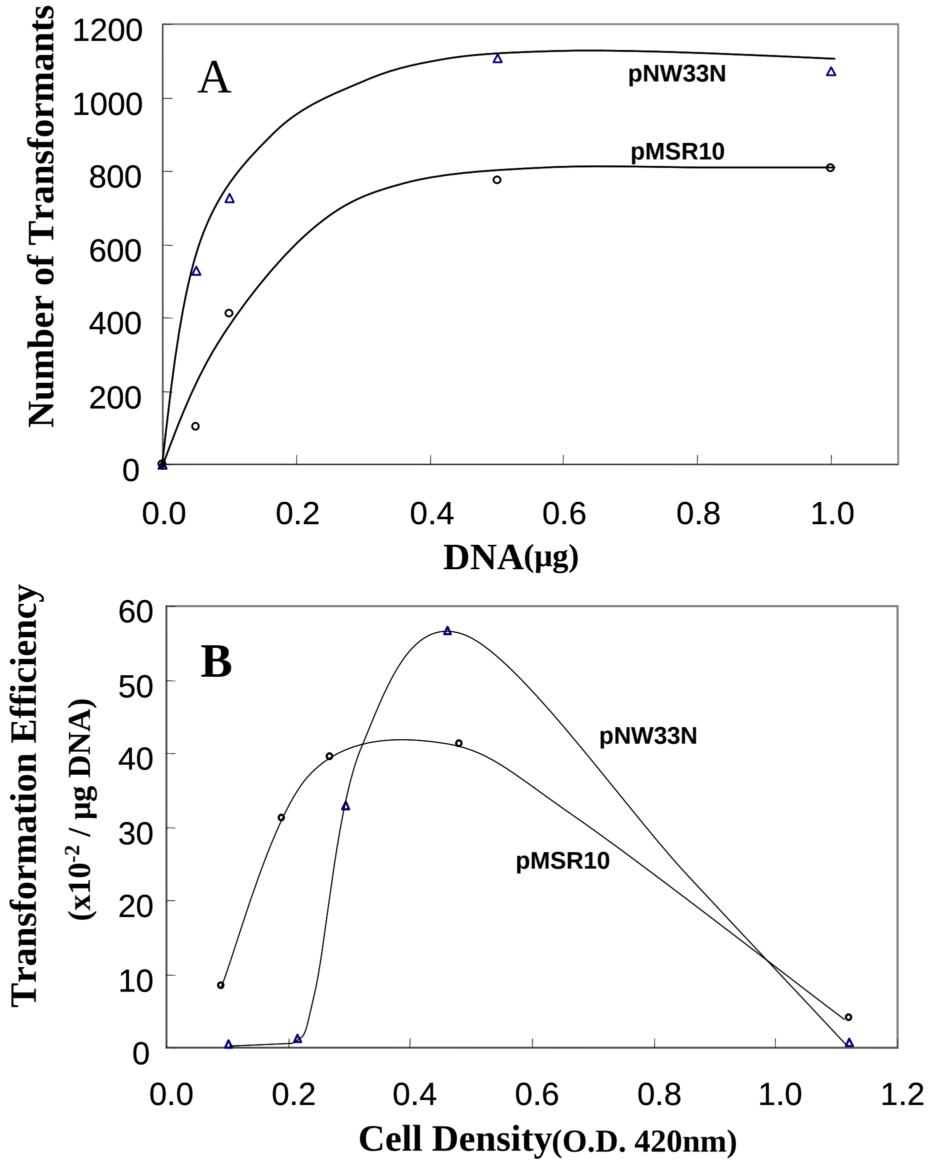
Current Research

1. Vector Plasmids
2. DNA Transfer
3. Source of Pyruvate decarboxylase
4. Source of Alcohol Dehydrogenase
5. Alternate Pathways for Ethanol Production

Thermophilic *B.coagulans* / *E. coli* Shuttle Vector

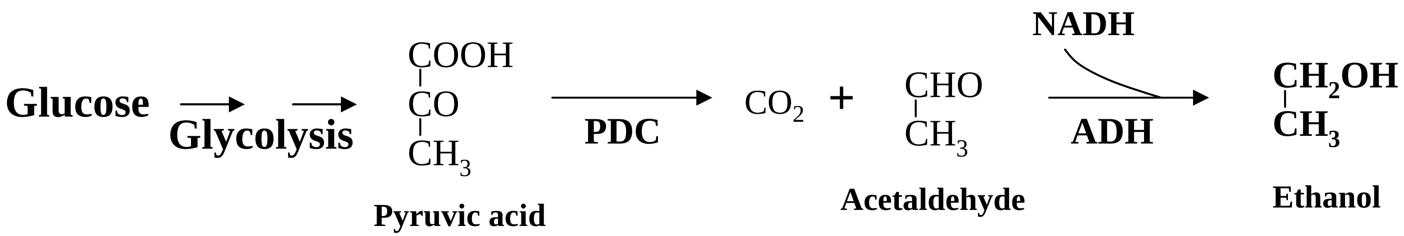


DNA Transfer into *B. coagulans*

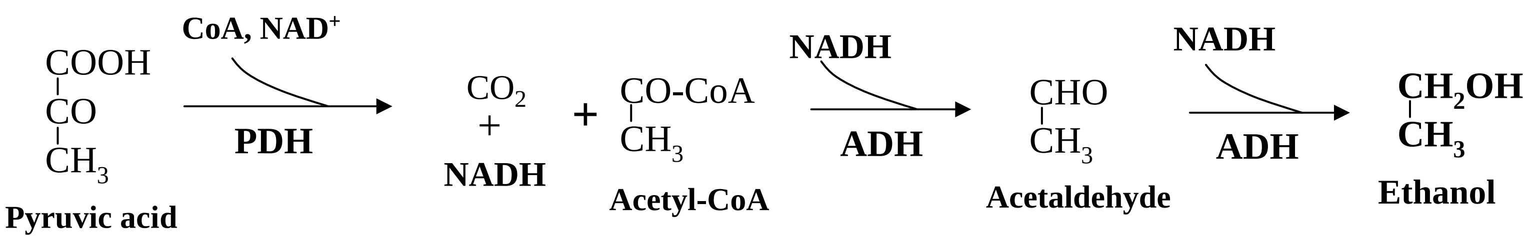


Pathways for Ethanol Production

Ethanologenic Organisms (yeast, *Zymomonas mobilis*, ethanologenic *E. coli*)



A Novel Pathway for Ethanol Production Developed in *E. coli*



Sources of Pyruvate Decarboxylase Gene

- ***Zymomonas mobilis***
- ***Acetobacter pasteurianus***
- ***Zymobacter palmae***
- ***Sarcina ventriculi***
- **Yeast**

pdc **genes from these organisms are available for metabolic engineering of *B. coagulans***

Genome Sequence of *B. coagulans*

Incomplete Draft Sequence (DOE-JGI)

~ 2.9 x 10^6 bp
2,675 Putative ORFs
G+C % - 46.2

~600 ORFs unique to the organism
~100 ORFs shared with Lactobacillus
~2000 ORFs shared with *Bacillus subtilis*

Seven ORFs encoding Alcohol Dehydrogenase like Enzymes

Bacillus coagulans, a Second Generation Biocatalyst for Biomass to Ethanol Fermentation

- **Growth and Fermentation temperature matches that of fungal cellulases**
- **Requires less fungal cellulases for SSF of cellulose compared to yeast**
- **All the sugars in biomass are rapidly fermented**
- **Effective SSCF of hemicellulose hydrolysate (overlimed) and cellulose**
- **Gene transfer system has been established**
- **Genome sequence is available for metabolic engineering**

Research Support

US Department of Energy

State of Florida / University of Florida
Agricultural Experiment Station