Meeting Summary:
Biomass Research & Development Technical Advisory Committee

September 10-11, 2007

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I. Purpose

On September 10 – 11, 2007, the Biomass Research and Development Technical Advisory Committee (Committee) held a quarterly meeting, the third of the 2007 calendar year. The purpose of the meeting was to discuss its recommendations to the Secretaries of Energy and Agriculture, its Roadmap for Bioenergy and Biobased Products in the United States, and participated in a tour of the General Motors Milford Proving Ground and a Ride & Drive of FFVS, Hybrids and FCEVs. The Committee also heard updates from the Departments of Energy and Agriculture as well as presentations from universities, Argonne National Laboratory and a venture capital firm. The two-day meeting was held at the Westin Detroit Metropolitan Airport Hotel and at the GM Renaissance Center in Detroit, MI.

Background: The Committee was established by the Biomass R&D Act of 2000 (Biomass Act) and revised in the Energy Policy Act of 2005. The Biomass R&D Board was established under the same act to work with the Committee to advise on interagency biomass R&D activities. The Committee is charged to: advise the Secretary of Energy and the Secretary of Agriculture on the direction of biomass research; facilitate consultations and partnerships; and evaluate and perform strategic planning.

A list of attendees is provided in Attachment A. The agenda is provided in Attachment B. A summary of approval and changes to the recommendations is in Attachment C. Meeting presentations are provided in Attachment D.

II. U.S. Department of Energy: Overview

The U.S. Department of Energy (DOE)'s Designated Federal Officer for the Biomass R&D Technical Advisory Committee, Valri Lightner, gave an update on the Biomass Program's activities since the May meeting, including the Biomass R&D Board, the peer review process and the solicitations. These activities are highlighted below.

A. Biomass R&D Board Update

The Biomass R&D Board is developing an "action plan" to be completed by early 2008 that will focus on near term interagency collaboration. The Board will seek input and comment on the Plan from the Committee. One of the priorities of the Biomass R&D Board is to become more engaged with the Committee. In previous years, the Board has meet with the Committee annually, however now the Board is interested in meeting with the Committee more than annually. The Board will participate in November's meeting where they will listen to the recommendations which will be put into the planning process.

B. Program Peer Review

The DOE Office of the Biomass Program is going through its peer review process. The peer review is a required independent review of the Program's R&D portfolio and overall strategy. Independent technical experts are brought in as reviewers so as to bring no bias or conflict of interest. The Platforms that are being reviewed are thermochemical, biochemical, biorefineries, biodiesel, feedstocks and infrastructure. Individual platform peer review reports will be available for the November Committee meeting at http://obpreview07.govtools.us/. The Program is also developing a Multi-Year Program Plan (MYPP) to guide platform research over the next ten years. The Biomass Program would like the Committee to review and provide comments on the MYPP.

C. Recent Solicitations

Each year DOE and the U.S. Department of Agriculture (USDA) issue a joint R&D solicitation per guidance in the Biomass R&D Act of 2000. The topics for the DOE-USDA Joint Solicitation are: feedstocks, conversion, analysis, and products. These topics have been dictated by the Energy Policy Act of 2005 (EPAct 2005) update to the Biomass R&D Act. The solicitation is now closed and pre-proposals have been reviewed. Once the selections have been announced they can be discussed with the Committee.

D. Transition Modeling Efforts

Zia Haq of the U.S. Department of Energy Office of the Biomass Program discussed the biomass scenario model, which is a dynamic systems model in STELLA software that analyzes the behavior of complex feedback systems over time. The model is designed to track the deployment of ethanol given the development of new technologies and the reaction of the investment community to those technologies in light of the competing oil market, vehicle demand for biofuels and various government policies over time.

The model focuses mainly on agricultural residues and energy crops. DOE would like to work more closely with the USDA Forest Service to get better data as well as better representation of how markets for forest resources behave in the future. The model is focused on ethanol; however DOE is looking at expanding to biodiesel. The objective of the model is to evaluate how the ethanol industry could grow under different technology, policy, and market scenarios. The model assumes E10 and E85 markets with FFVs. Part of the investment decision is based on comparing the price of oil and ethanol.

The Scenario Model is not currently configured to conduct probabilistic analysis. All EERE programs are trying to incorporate probabilistic growth scenarios. Incorporation of probabilistically based risk assessments are of interest to the biomass program and some work is being done in this area with Independent Project Analysis (IPA).

DOE's ability to reduce uncertainty will help advance cellulosic ethanol. DOE staff used their best judgment to determine how investors would behave with the loan guarantee program or risk reduction program. DOE staff ran the model to determine the impact of a significant subsidy ($2/gallon on the first 500 million gallons of cellulosic ethanol). DOE would like to run additional model scenarios and the Communications Subcommittee members would like to volunteer to develop other scenarios to be run. A conference call for discussion is planned.

There has been a lot of interest in the model from policy makers and DOE is working on a paper that outlines the basic workings of the model as a first step and is hoping to gain more interest. This is just the beginning of the effort. There was one major review of the model with 14 people including feedstock producers, General Motors and others. Other smaller reviews with key stakeholders have been held. Significant changes to the model have been made based on these reviews. However, it is still a work in progress. The Department of Energy is looking at a variety of ways to improve the model. A description of the model is available at http://www.30x30workshop.biomass.govtools.us/default.aspx?menu=model and questions can be referred to Zia Haq at zia.haq@ee.doe.gov. Regarding hydrogen, the Hydrogen Program at DOE has their own model and assumptions.

E. Agency Response to the Committee's Annual Recommendations (2002-2006)

Valri Lightner gave a brief overview of agency response to the Committee's annual recommendations, which focused on the following: joint solicitation implementation and merit review process, technical direction of projects funded under the joint solicitation, progress of projects funded under the Initiative and relation to the Committee Roadmap, R&D portfolio and the direction of future RFPs. She stated that Agencies' response to the Committee's annual recommendations was not timely, however, they were able to get the Secretaries' Annual Report to Congress approved in less than a year.

Valri Lightner pointed out that the agencies will continue to provide technical updates to the Committee and the Committee should inform the agencies of which updates they would like to receive. She said that Departments of Energy and Agriculture have been struggling with analysis of the awards from the joint solicitation and how to show their benefit. Coordination between agencies can be improved, and Valri expressed her hope that the Biomass R&D Board can help resolve this. There will probably be new definitions of biomass and cellulosic in the new Farm Bill and Energy legislation, but definitions being used today are what is in the EPAct 2005. Valri said that if the Committee would like to hear more about hydrogen activities, a representative from that program can present at a future meeting.

III. Comments from Congressman Knollenberg

Congressman Joe Knollenberg (R-MI) expressed gratitude to the Committee and General Motors for meeting in Detroit. He stated that biomass has environmental and economic benefits as well as with national security. He expressed his support of increased fuel efficiency in automobiles and that the automobile industry supports biofuels. He would like to see increased efficiency and reduced emissions instead. He expressed his support for the programs outlined in the meeting agenda.

IV. U.S. Department of Agriculture: Overview

A. 2007 Joint Solicitation Projects and Results of 9008

Bill Hagy of USDA gave an update on the status of the 2007 DOE-USDA Joint Solicitation selection process. Of the 688 pre-applications received, 141 were selected to submit full applications. Letters will go out to those pre-applicants and they will be given until the end of October to submit a full application. The term recalcitrance was clarified during his presentation and projects involving recalcitrance were categorized in the conversion area (biochemical and thermochemical). DOE has put their $4 million of the joint solicitation into recalcitrance.

Findings from the Section 9008 study conclude the process and terms of solicitation are consistent with legislation and that USDA infrastructure in place for administering the award is consistent with general accepted practices for competitive solicitation.

USDA commissioned NREL to review the status of Section 9008 research projects. Helena Chum from the National Renewable Energy Laboratory (NREL) has submitted a draft report, which will be shared with the Committee as soon as it is final. Recommendations from NREL are that there needs to be reporting on these projects for several years after they are awarded. This year as part of a grant agreement, USDA will initiate a reporting process after funds are provided to a grantee. The report concludes that USDA needs to develop a better framework for data collection and analysis. USDA is currently working on developing a database to show results.

B. Energy Council (USDA)

The purpose of the Energy Council is to coordinate internal USDA collaboration and leverage resources for renewable energy/energy efficiency development needs. The Chief Economist and the Under Secretary for Rural Development are co-chairs of the Council.

Bill Hagy informed the Committee that the both the House and the Senate recognize the importance of having the Energy Council in place. An international committee has been added as a fourth committee to the Energy Council. The four committees are: research and development, commercialization, marketing/outreach, and international.

C. USDA Energy Matrix

Bill Hagy showed to the Committee the USDA Energy Matrix. It is a work-in-progress, but currently the public can navigate it as a Department resource. The goal of the Matrix is to link to all Federal programs involved in biomass-related research. The Matrix could become an entry point in the Federal government to those who have interest in energy and renewable energy.

D. Farm Bill – New Subsidies

Bill Hagy stated that a House version of the Farm Bill was passed in July and the Senate provided a draft bill. The latest version has been delayed which was originally to be signed in October.

For the cellulosic loan guarantee program, the Administration proposed to have all guarantee programs under one platform, however the House did not agree with this proposal. The Senate refers to it as cellulosic and the House refers to it as biofuels and biochemical. In the past version of the Farm Bill the House allowed for loan guarantees of up to 90 percent (90 percent exposure to government for any loss).

V. Creating the Biofuels Future: Designing "Win-Win" Solutions

Bruce Dale's (Michigan State University) presentation is included in Attachment D of the meeting summary. Discussion captured during the question and answer portion of the presentation is summarized below.

Dale emphasized that successful development of a cellulose-based biofuels industry is possible. He encourages integrated research and stated that there is a tendency to compartmentalize. He believes that researchers should do a better job of conducting research on an integrated system.

With the tools available and by knowing where to focus attention, achievement of a cost where feedstock represents 70 percent and processing less than 30 percent is possible.

Most of the agricultural land in the U.S. is used to grow animal feed. Replacing animal feed protein in the context of a biorefinery could make both animal feed and large amounts of biofuel.

The regional processing centers would most likely work with multiple feedstocks, whichever grows in the specific area and what is available at different times of year.

The increase in ammonia utilization in the process of pretreatment has not been calculated.

Farmers in Michigan are currently using cover crops. Dairy farmers use them because they are the first feed that animals get in the Spring. One of the projects Michigan State will be pursuing is looking at enzyme production in cover crops.

It takes ten times as much water to produce ethanol as it does petroleum. Regional biomass processing could be a way of recycling water. There may be a problem using cover crops in regions where there is not a lot of water. In Illinois one cannot get crop insurance if a cover crop is put in.

VI. A Financial Perspective on Bioenergy

Bill Lese's (Braemar Ventures) presentation is included in Attachment D of the meeting summary. Discussion captured during the question and answer portion of the presentation is summarized below.

Ethanol production costs should be kept down and the main cost will probably be in feedstock. A cellulosic producer credit would have value for venture capital firms. There is a need for a loan guarantee program in order to have financing from a commercial venue. In order to get to the estimated $0.62 a gallon, venture capitalists have to go through a risk scenario they cannot overcome without government support. Outside help is needed in order to get biofuels off the ground.

VII. Technical Advisory Committee: Subcommittee Updates

A. Analysis Subcommittee

The Analysis Subcommittee has been asked to review USDA and DOE foundational documents. The majority of documents are from USDA. Harry Baumes at USDA is the Analysis Subcommittee's point of contact for these documents.

For DOE the Analysis Subcommittee is currently reviewing the Reynolds Report. DOE is asking the Subcommittee to review the report while it is still underway so that the study can be modified if needed before the final report is issued. The Analysis Subcommittee would rather be engaged in review before the reports are final rather than after.

B. Policy Subcommittee

The Policy Subcommittee was not tasked with anything since the last meeting. They have been waiting on guidance on this from the Committee. There was nothing to task the Policy Subcommittee with at the September meeting, but they will probably look at the Farm Bill in the future. The Policy Subcommittee did give input on what should be in the Farm Bill. Once it is complete they will review.

The Policy Subcommittee can have a conference call with Zia Haq of DOE to prioritize a list of policy options for DOE to use in their scenario analysis.

C. Communications Subcommittee

The Communications Subcommittee expressed that it is trying to determine its role. Writing rebuttals to negative publicity to renewable fuels seems to be a legitimate role for the Communications Subcommittee.

Information should be collected (both positive and negative) and stored and organized so that members of the Communications Subcommittee can respond. A list of recurring negative issues should be made along with rebuttals and documents to which the press should refer. Issues that were brought up include feed vs. fuel and water. This could possibly be posted on the Committee's internal website.

When e-mails are sent regarding this, they should be flagged so that Committee members know that they include action items.

VIII. Discussion on Updated Committee Roadmap

Comments made with regards to the updated Committee Roadmap were:

- The Roadmap reads very well. There could be enhancement of byproducts of the processes. The topic is not addressed as strongly as it could be.
- There were some grammatical issues to address in the Roadmap that should be edited.
- John McKenna's memo entitled "U.S. Government Biofuels Authority" needs to be mentioned in the Roadmap.
- There are four new images in the Roadmap. The table was removed as discussed during the May meeting. Perhaps more images should be added so that document is more approachable.

It was mentioned that it is important to approve the Roadmap before the current political environment changes.

There was unanimous approval of the Roadmap (Henson Moore abstained from voting) with accepted changes.

IX. General Motors Milford Proving Ground Site Visit

Upon the completion of the first day's meeting, the Committee visited the General Motors Milford Proving Ground for a tour of the emissions laboratory, series of presentations and a ride and drive of biofuel vehicles and hybrids,.

X. Wood-to-Wheels

Dr. David Reed from Michigan Tech University presented on the woody biomass research initiative at Michigan Tech University. His presentation is included in Attachment D of the meeting summary. Discussion captured during the question and answer portion of the presentation is summarized below.

Michigan Tech has close ties with the industry and GM has been supportive of the University. Engines today are optimized to run on gasoline. Engine design for ethanol would look very different.

Carbon sequestration as described in the presentation refers to carbon in the above ground portion of woody biomass. The big issue is above ground carbon and low ground carbon (what is released from the soil). Woody biomass at a commercial plant would use gasification more than biochemical conversion.

Companies are working actively with processing plants to guarantee prices on securing feedstocks for the long term. There is a great advantage to large landowners that are willing to make long-term arrangements.

Michigan Tech is doing analytical work on the cost of collection and densification, one of the big economic factors impacting price.

XI. Life Cycle Analysis for Biofuels with the GREET Model

Michael Wang from Argonne National Laboratory (ANL) discussed the well-to-wheels lifecycle analysis with the GREET model (greenhouse gases, regulated emissions, and energy use in transportation). His presentation is included in Attachment D of the meeting summary. Discussion captured during the question and answer portion of the presentation is below.

Michael Wang pointed out that more studies conclude a positive energy balance for ethanol production.

Regarding the argument that ethanol production in Brazil is destructive to rainforest lands, Wang said that sugarcane plantations in Brazil are in the south and south central region of the country, not in the Amazon. One way to conserve the rainforest is to put a value on rainforest lands.

Carbon in ethanol is the carbon from the air the plant takes in, so it is re-emitted to the air. Lifecycle stages consume fossil energies that emit greenhouse gases.

Michael Wang informed the Committee that ANL does not have any plans to examine algae as a feedstock. ANL's sponsor DOE decides its top priorities. DOE determines what pathways need to be examined, but is also open-minded as there are always new and emerging pathways.

Wang said there is a paper that has been done analyzing sugarcane; however it needs to go through DOE review before it becomes final. Wang also said that he generated a three-pager in 2005 with a point-by-point analysis in relative flaws in models and Wang's rebuttal to criticism of his work. Michael Wang said he would be happy to share that with the Committee and update it.

The 76 percent reduction in greenhouse gases as shown in Wang's presentation includes the impact of open field burning and lack of environmental controls for Bazilian sugar cane ethanol. Open burning is a major source of carbon emissions for sugar cane ethanol.

Michael Wang stated that the assumptions used in models are the issue, not the models. He said he would not criticize researchers based on the model they used as long as they use valid assumptions. The model is just a tool to put the assumptions together. Wang recognizes that basis of the data used to analyze corn versus switchgrass are completely different. There is much more experimental data for analyzing corn than there is for switchgrass, which has not been grown on a large scale.

A draft report of GREET's analysis of renewable diesel is to be given to DOE in October. It is going through review at DOE and Argonne and will be made public after the review is complete.

XII. Discussion on Recommendations to the Secretaries

Valri Lightner suggested that the Biomass R&D Board could assist in developing responses to the Recommendations to the Secretaries. During the discussion, the Committee agreed to open recommendation B7 of the Annual Recommendations for Fiscal Year 2007 up to include consultation with the Strategic Materials Board and other such organizations or Agencies Recommendation B7 had previously requested a response from the Departments of Defense and State (not currently represented on the Biomass R&D Board), however, it may be difficult and time consuming to get the concurrences of the Secretaries of State and Defense on the Report to Congress.

Henson Moore stated that the Recommendations could be forwarded to the Strategic Materials Board (if it still exists) for response from the Departments of State and Defense in addition to Energy and Agriculture, which are represented on the Strategic Materials Board (or similar organization).

It was brought up that the Committee is not under any duty to recommend anything to the Departments of State and Defense, but rather to the Departments of Energy and Agriculture. Given this, the Committee should move on to the Board with strong emphasis for them to take action at the appropriate level with the appropriate agencies.

The November meeting with the Board will be an opportunity to ask questions.

A Summary of approval and changes to be made to the Committee Recommendations can be found in Attachment C.

XIII. Topics of November Meeting Agenda

Topics discussed to be addressed at the November meeting include:

- Approve program of work for 2008 (definite agenda item)
- Committee members should divide up Recommendations and briefly explain (for a minute or 2) each during the meeting with the Biomass R&D Board. It should not be a reread, but an explanation. These people should be identified prior to the meeting with the Board. Valri Lightner mentioned that we are trying to meet for 2 hours with the Board, but it may be only one hour. The sub-bullets with the short list (incorporated in one of the formal recommendations) should be included.
- The Biomass R&D Board can describe the Biofuels Action Plan to the Committee.
- Feedstock group in the Board is looking at items such as the Billion Ton Study.
- ARS under USDA met prior to the September Committee meeting to talk about their current activities related to biofuels. The output from this meeting should be ready for the November Committee meeting and could be a possible presentation.
- Lou Honory has good case study to present on biobased lubricants. The research is sponsored by the USDA and DOE (Lou would like to have 20 minutes to present).
- Office of Science could present on the awarding of the Bioenergy Research Center contracts and what research will be conducted in each of the centers. Valri Lightner to organize with the Office of Science.

Suggested dates for 2008:

- February 5-6
- May 20-21
- September 9-10
- December 2-3

Possible locations for 2008 meetings:

- Visit cellulosic plants that are being built around the country (nothing for 2008, but for future years)
- Tour an ethanol plant in Iowa – possibly for May meeting. Rodney Williamson with Lou Honory to help.

XIV. Public Comment

Wilfred Vermerris, University of Florida, suggested the creation of a website where people can ask the Committee questions. He also mentioned that there is interest in orange peels as a different feedstock.

David O'Toole, Booz Allen Hamilton, mentioned research in feedstock availability as huge component to trying to achieve the goals of bioproducts and bioenergy. He said that getting the feedstock is the key.

Attachment A: Attendees

Committee Members Present

Thomas Ewing (co-chair)
Henson Moore (co-chair)
Bob Dineen
Douglas Hawkins
Charles Kinoshita
Eric Larson
Jim Martin
Edwin White
Thomas Binder
David Anton
Lou Honary
Mark Maher
John McKenna
Mitchell Peele
Jeffrey Serfass
Robert Sharp
Rodney Williamson
Ralph Cavalieri
Robert Ames
Mary McBride
Timothy Maker
William Berg

Committee Members Not Present

James Barber
Arthur "Butch" Blazer
John Hickman
Scott Mason
Larry Pearce
E. Alan Kennett
J. Read Smith
Scott Faber

Federal Employees Present

Bill Hagy
Zia Haq

Other Attendees

Congressman Joe Knollenberg (R-MI)
Michael Wag, Argonne National Laboratory
Wilfred Vermierris, University of Florida
Bill Lese, Braemer Energy Ventures
Barry Morton, National Association of Wheat Growers
Bruce Dale, Michigan State University

Total Attendees- 39

Designated Federal Officer – Valri Lightner

Attachment B: Agenda

<u>Day 1: Westin Detroit Metropolitan Airport September 10, 2007</u>

11:00 am – 11:50 am	Welcome/Update: OBP/DOE **–** *Valri Lightner, Biomass Program, DOE* o Update on Board activities o Peer Review o Transition Modeling Efforts – *Zia Haq, Biomass Program, DOE* o Agency Responses to the Committee's 2002-06 Annual Recommendations
11:50 – 12:05 pm	*Working Lunch (to be provided)*
12:05 – 1:00 pm	Welcome/Update: USDA – *Bill Hagy, Rural Development, USDA* o Update on 2007 Joint Solicitation Projects/Peer Review o Update Energy Counsel (USDA) o Update on Energy Matrix o Results of 9008 o Update on Farm Bill – New subsidies
1:00 – 1:45 pm	Presentation: Michigan State University – *Dr. Bruce Dale, Dept. of Chemical Engineering & Materials Science, Michigan State University*
1:45 – 2:30 pm	Presentation: Financial Perspective on Bioenergy – *Bill Lese, Braemar Ventures*
2:30 – 3:00 pm	Discussion: Subcommittees – Discuss new charges and activities – *Subcommittee Chairs*
3:00 – 3:45 pm	Discussion: Updated Committee Roadmap – *Roadmap Subcommittee Chair*
3:45 pm	*Public Comment/Adjourn*

General Motors Milford Proving Ground Site Visit

4:00 pm	Shuttle leaves the Westin for GM Milford Proving Ground
4:45 pm	Shuttle arrives at MPG
5:00 pm	Tour of Bldg 31 Emissions Laboratory – *Kevin Cullen, GM Technical Fellow - Emissions*
5:40 pm	Transport to Bldg 105
5:50 pm	Begin working dinner
6:05 pm	Welcome – *Beth Lowery, GM Vice President, Global Public Policy*
6:10 pm	Vehicle Emission Interaction with Low and High Concentration Ethanol Blend Fuels – *Kevin Cullen, GM Technical Fellow – Emissions*
6:30 pm	History and Factors Influencing Automotive Fuel Ethanol in the U.S. – *Coleman Jones, GM Biofuel Implementation Manager*
6:50 pm	E85 FFV / Ethanol Experience in Europe - Saab BioPower – *Kjell Bergstrom, GM Powertrain Europe – Director, Advanced Engineering*
7:10 pm	E22 / E100 FFV Experience in Brazil - GM FlexPower – *Henrique Pereira, GM Powertrain Brazil – Manager, Engine Systems and Controls*
7:30 pm	GM Ethanol Infrastructure, Partnering, and Marketing Initiatives – *Mary Beth Stanek, Director, Energy, Environment and Safety Policy*
7:50 pm	GM Advanced Propulsion Strategy – *Tom Stephens, Group Vice President, GM Powertrain*
8:00 pm	Ride & Drive FFVS, Hybrids, FCEV, Casual Q&A with SMEs
9:00 pm	Shuttle departs for Renaissance Center – Guests depart for (Marriott Hotel)

Day 2: GM Renaissance Center, Rooms 8 & 9 September 11, 2007

7:30 – 8:00 am	*Breakfast*
8:00 – 9:00 am	Presentation: Wood-to-Wheels, Michigan Tech University – *Dr. David D. Reed, Vice President for Research, Michigan Tech University*
9:00 – 9:45 am	Presentation: Life Cycle Analysis for Biofuels – *Michael Wang, Argonne National Laboratory*
9:45 – 10:30 am	Discussion: Approve FY 2007 Recommendations to the Secretaries
10:30 – 10:45 am	*Break*
10:45 – 11:30 am	Discussion (continued): Recommendations to the Secretaries
11:30 – 12:30 pm	*Lunch (to be provided)*
12:30 – 1:30 pm	Discussion (continued): Recommendations to the Secretaries
1:30 – 1:45 pm	*Break*
1:45 – 2:15 pm	Discussion: 2007/2008 Committee Work Plan
2:15 – 2:30 pm	Public Comment
2:30 pm	*Closing Comments/Adjourn*

Attachment C: Summary of Approval and Changes to Recommendations

Summary of changes to be made to the Committee Recommendations:

- Rework Jim Martin's recommendation where it says Secretary of Agriculture and Energy in consultation with

  Motion passed to include Jim Martin's recommendations.

- Include a background paragraph explaining why each recommendation was made. Possibly use this format for future recommendations. There should be one to two volunteers to write each paragraph ready for review and final comment by the November meeting. Jim Martin's structure is a good format for each recommendation.

- The issue of prioritization was brought up. The list has not been prioritized.

  Recommendation A passed

  Recommendation B removed (regarding transparency of reviewers)

  Remove point 1 under Recommendation C

  Point 3 under Recommendation C passed

  Recommendation 2 under 3 moved to the bottom of Recommendations

- The Biomass R&D Board has discussed tax incentives. Treasury was asked to take the lead. The renewable fuel standard will have more impact than any kind of incentive and the Board should look more at renewable fuel standards.

  Motion passed to rewrite number 4 under Recommendation C. Tom Binder to take responsibility.

  Number 5 under Recommendation C to be combined with number 8. James Martin to take responsibility. Eric Larson added that it is an RD&D issue and the recommendation should be rewritten in terms of crop selection. Bill Hagy recommended looking at the House and Senate Farm Bill when rewriting.

  - Number 6 under Recommendation C: Co-product utilization would help.

  - Number 7 under Recommendation C: Open up discussion of what was sent to the Board under the last section or call it to the attention of the Board or Secretaries and refer to it. This should be the final Recommendation.

The revised Recommendations are to be distributed to all members of the Committee for final approval.

Additional Recommendations to be drafted:

- Eric Larson to draft sentences on activity in coal and carbon capture and the need for support for R&D or carbon capture in storage of biomass.
- Mark Maher to add a recommendation on the evaluation of sufficient support for life cycle analysis of biofuels feedstreams of the national laboratories and to take appropriate action to increase support. It was suggested that USDA and others could be added to the national labs in this recommendation.

Motion carried to adopt the Recommendations discussed at this meeting which will be circulated electronically.

Recommendations should be completed by the end of September and in October they should be circulated for approval prior to the November meeting.

Attachment D: Meeting Presentations

DOE Office of Biomass Update

Valri Lightner

September 10 – 11, 2007
Biomass R&D Technical Advisory Committee Meeting

Board Activities

- "New" Board has been meeting monthly since May.
  - Monthly meetings are the third Friday of the month.
- Focus of meeting discussions has been on breaking down the implementation barriers to the President's 20 in 10, primarily: feedstocks, infrastructure, distribution (via intermediate blends), finance and policy.
- Informal interagency teams have been established in these areas.
- The Board has committed to developing a draft action plan by the end of the year that will focus on near term interagency collaboration.
  - Booz Allen Hamilton is under contract to assist with action planning.

Peer Review

- Peer review is conducted using area expert peers that do not have a conflict (real or perceived) of interest with the Biomass program.
- Peer review process includes review of all projects during a platform review along with the overall strategy of the platform and an overall program review to review crosscutting activities and overall program strategy.
- Peer review committees are established to review platforms with experts from the platform area. A chairman is selected that also participates as a member of the overall program review committee.
- The overall Program Review includes:
  - overall program strategy
  - crosscutting activities – analysis, communication
  - each platform and their strategy
  - the outcome of the platform review from the each review committee chair
- A written peer review report will be publicly available.

Peer Review

- The following platform reviews have been conducted:
  - Thermochemical – July 10-12, Golden, CO
  - Biochemical – August 7-9, Denver, CO
  - Biorefineries – August 13-15, Golden, CO
  - Biodiesel and Other – August 15, 16, Golden, CO
  - Feedstocks – August 21-23, Washington, DC
- October 2, 3 will be a review of the Infrastructure Plans in Washington, DC
- Overall Program Review is planned for November 15, 16 in Baltimore, MD
- Details/registration at: http://obpreview07.govtools.us/

Solicitations

- Open Solicitations
  - Biochemical Conversion for up to $33.8 million over 4 years – closes October 30
- Closed Solicitations
  - Thermochemical Conversion for up to $7.75 million over 3 years
  - 10% Scale Biorefinery Demonstration for up to $200 million over 5 years
  - DOE/USDA Joint Solicitation for up to $18 million
- Announcements
  - On June 7, DOE-USDA announced $8.3 million over 3 years for biomass genomics development
    - For full press release see www.energy.gov/news/5115.htm
  - On June 26, DOE announced $375 million over 5 years for 3 Bioenergy Centers
    - Oak Ridge National Laboratory
    - University of Wisconsin
    - Lawrence Berkeley National Laboratory
    - For full press release see www.energy.gov/news/5172.htm
- Upcoming Solicitations
  - Pyrolysis
  - DOE-USDA Joint Solicitation

USDA Rural Development

Committed to the future of rural communities.

Biomass *R&D* Technical Advisory Committee Meeting

Detroit, Michigan

September 10, 2007

William F. Hagy III

Deputy Administrator, Business Programs

USDA Rural Development

USDA Rural Development

Committed to the future of rural communities.

Biomass Initiative Update

- *Update on FY 2007 Solicitation*
- *Update Section 9008 Portfolio Analysis*
- *Secretary's Energy Council*
- *Demonstration of Energy Matrix*
- *Status of Farm Bill*

Section 9008 - 2007 Solicitation Status

- Notice published June 11th, 2007
  - **30 day pre-application window**
  - **45 day full-application window**
- ~$18 million available ($14 USDA, $4 DOE)
- Pre-Application Merit Review - Completed
  - **Washington, DC, August 6th to 10th, 2007**

Section 9008 - 2007 Solicitation Status (con't)

- Selection Officer Approval and Debrief Letters sent (for pre-apps)
  - **Completed by mid-September, 2007**
- Approximate submission deadline for full-applications
  - **Last week October, 2007**
- Full-Application Merit Review
  - **First week December, 2007**
  - **Golden, CO**
- FY 2007 Awards made
  - **Last week of December, 2007**

Funding Distribution – Section 9008

- **Feedstock Production – 20%**
- **Overcoming Recalcitrance – 45%**
- **Product Diversification – 30%**
- **Analysis for Strategic Guidance – 5%**

Scoring Criteria – Section 9008

- Criterion 1: **Technical Relevance and Merit**
  - **40 %**
- Criterion 2: **Technical Approach/Workplan**
  - **25%**
- Criterion 3: **Fossil Energy Displacement, Energy Efficiency, Rural Economic Development, and Environmental Benefits**
  - **20%**
- Criterion 4: **Technical Management and Facility Capabilities**
  - **15%**

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Peer Review Process – Section 9008

- Consensus Panel Review
  - Scientific and Technical Peers
- Non-Agency Personnel
- Pre and Full Applications

Pre-Application Peer Review Panel Composition – Section 9008

- 28 (72%) – Academia
- 6 (15%) – National Laboratory
- 5 (13%) – Others (Private Industry and Non-profits)
- 0 (0%) – Federal Agency Personnel

Total – 39 Reviewers

Pre-Application History – Section 9008

FY	~Number of Pre-Apps Submitted	~ Funds Requested
2003	400	$ 370,000,000
2004	450	$ 108,000,000
2005	670	$ 450,000,000
2006	311	$ 250,000,000
2007	688	$ 600,000,000

2007 Pre-Applications Recieved – Section 9008

Topic Area	Number of Pre-Applications Submitted	Percentage of Total
Feedstock	212	31%
Recalcitrance	169	25%
Products	237	34%
Analysis	70	10%
	688	***100%***

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Approximate Breakdown for Full-Application Invitations

- **Based on recommendation by Merit Review Panel**
  - **Selection Officer approval still required**
- **Total 688 Submitted**
  - **141 (20 %) of total recommended for invitation by Merit Panel**
    - **35 – Feedstock ~ $29 million**
    - **39 – Recalcitrance ~ $32 million**
    - **49 – Products ~ $28 million**
    - **18 – Strategic Guidance ~ $9 million**

Section 9008 Study

- **Purpose: Evaluate FY 02 thru FY 05 Section 9008 Awards and recommend a set of performing measures for current and future benefits of program**
- **Conducted by Helena Chun, NREL**
- **Findings:**

  - Process and terms of solicitation consistent with legislation

  - USDA infrastructure in place for administering award is consistent with general accepted practices for competitive solicitation
- **Concludes that multiple peer review process is consistent with best practices in RD management**

Section 9008 Study (con't)

- **Recommendations:**
  - **Track outputs and outcomes overtime**
  - **Develop a better framework for data collection and analysis**

USDA'S Energy Council

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

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

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Update on Farm Bill

- **House Version Passed**
- **Senate Version October**
- **Significant Programs/Initiatives**
  - **Cellulosic Loan Guarantee Program**
  - **Rebates/Subsides**
  - **Other Initiatives**

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QUESTIONS

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CREATING THE BIOFUELS FUTURE: DESIGNING "WIN-WIN" SOLUTIONS

Bruce E. Dale
Dept. of Chemical Engineering & Materials Science
Michigan State University
www.everythingbiomass.org

Biomass R&D Technical Advisory Committee
Detroit, MI
September 10, 2007

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Linked Sustainability Challenges of the Coming Decades

- Diversify transportation fuels & end strategic role of petroleum in the world
- Provide food for growing & wealthier population (which will consume more meat)
- Control greenhouse gases & limit other human emissions (for example, nitrogen & phosphorus discharge to ground & surface waters)
- Provide economic opportunities for rural people
- *These challenges & opportunities* ***intersect*** *at biofuels, particularly cellulosic biofuels*
- *Abundant opportunities for creative design, "win-win" and system level thinking*

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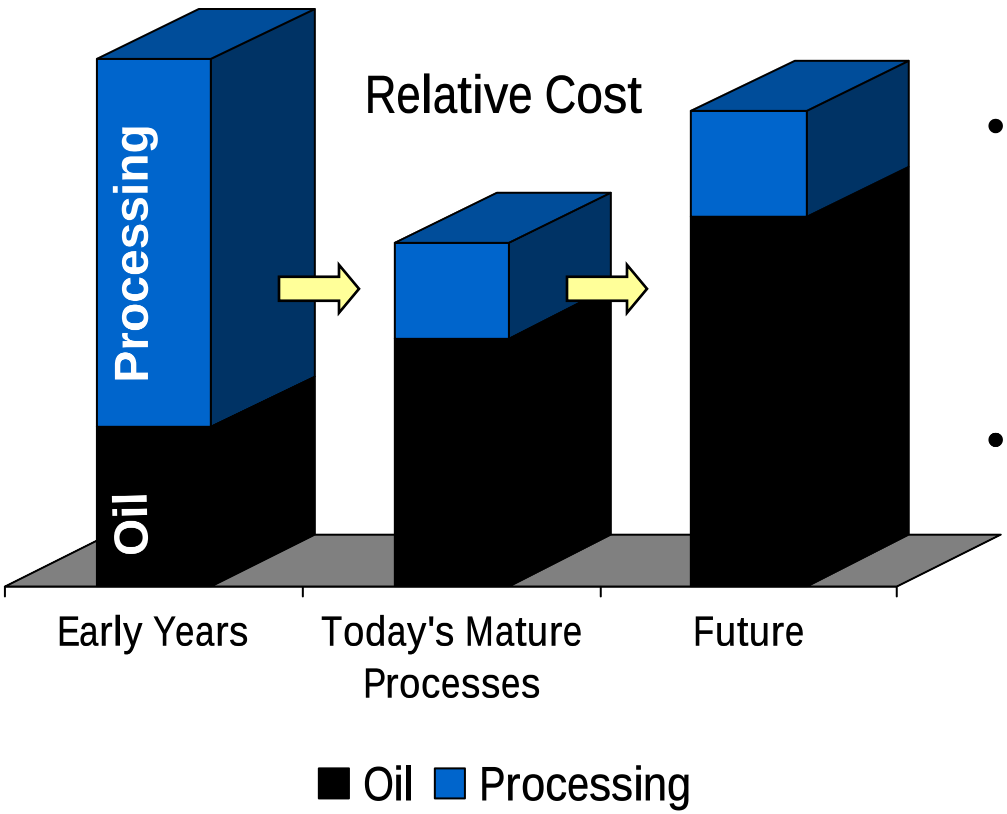
Impact of Processing Improvements: Oil's Past & Future



- Historically, petrochemical processing costs exceeded feedstock costs
- Petroleum processing efficiencies have increased and costs have decreased <u>dramatically</u> but reaching point of diminishing returns
- Petroleum raw materials have long-term issues
  - Costs will continue to increase as supplies tighten
  - High price variability
  - Impacts national security
  - Climate security concerns
  - Not renewable
- **Not a pretty picture for our petroleum dependent society**

From J. Stoppert, 2005

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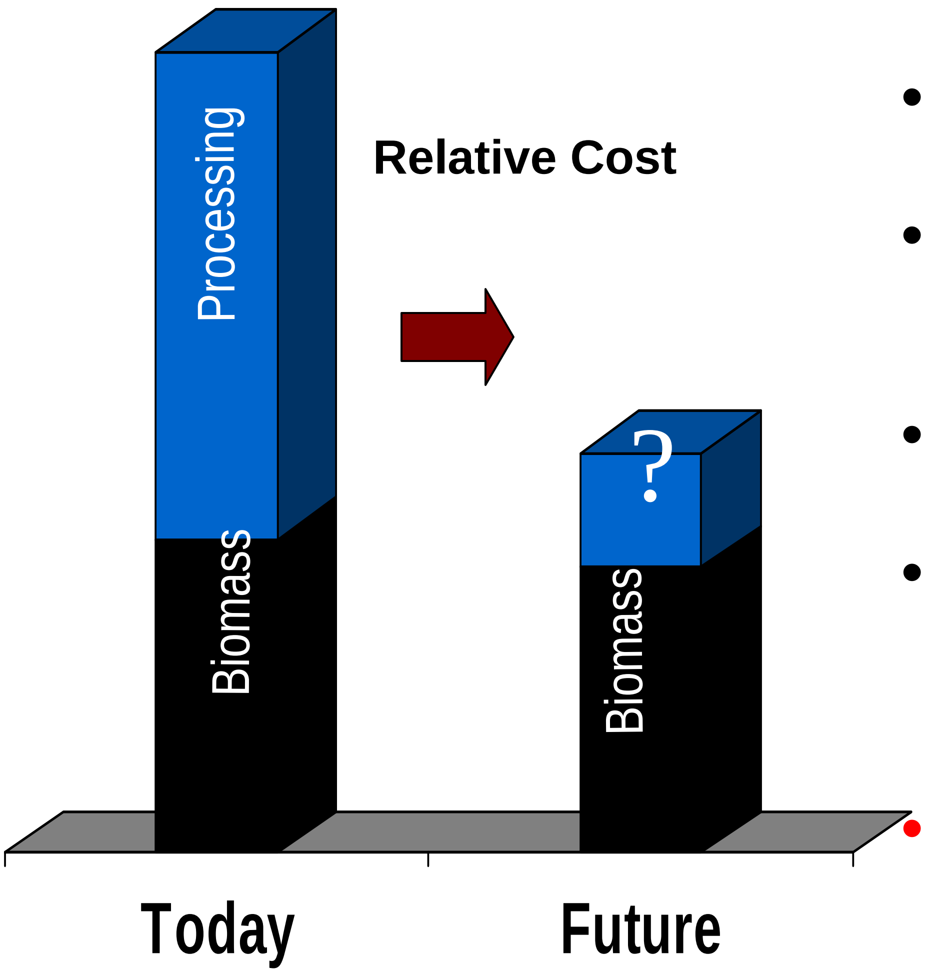
Impact of Processing Improvements: The Future of Cellulosic Biomass Conversion

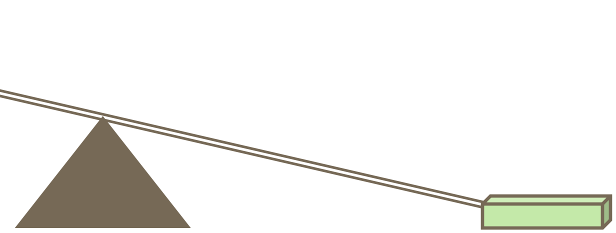


Adapted from J. Stoppert, 2005

- Processing is dominant cost of cellulosic biofuels today
- Cellulosic biomass costs should be stable or decrease
- Processing costs dominated by pretreatment, enzymes & fermentation
- Biomass processing costs must (& will) decrease
- Two ways to do this:
  1. "Learning by doing" in large scale plants
  2. Applied (cost focused) research
- Much more attractive future
  - Domestically produced fuels
  - Environmental improvements
  - Rural/regional economic development

Biofuels: Changing Balance Between Processing and Feedstock

Today



Feedstock

Processing

- Pretreatment
- Enzymes
- Fermentation

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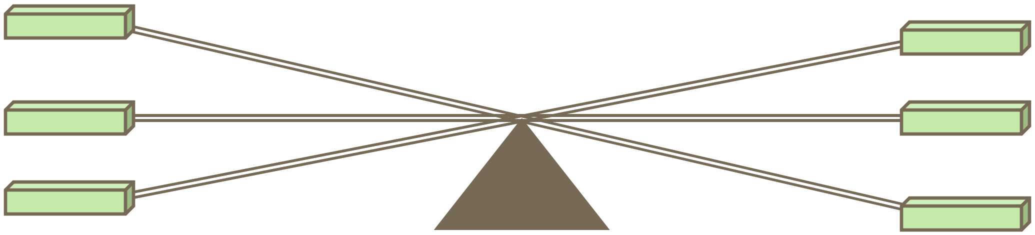
Biofuels: Changing Balance Between Processing and Feedstock

Near Future

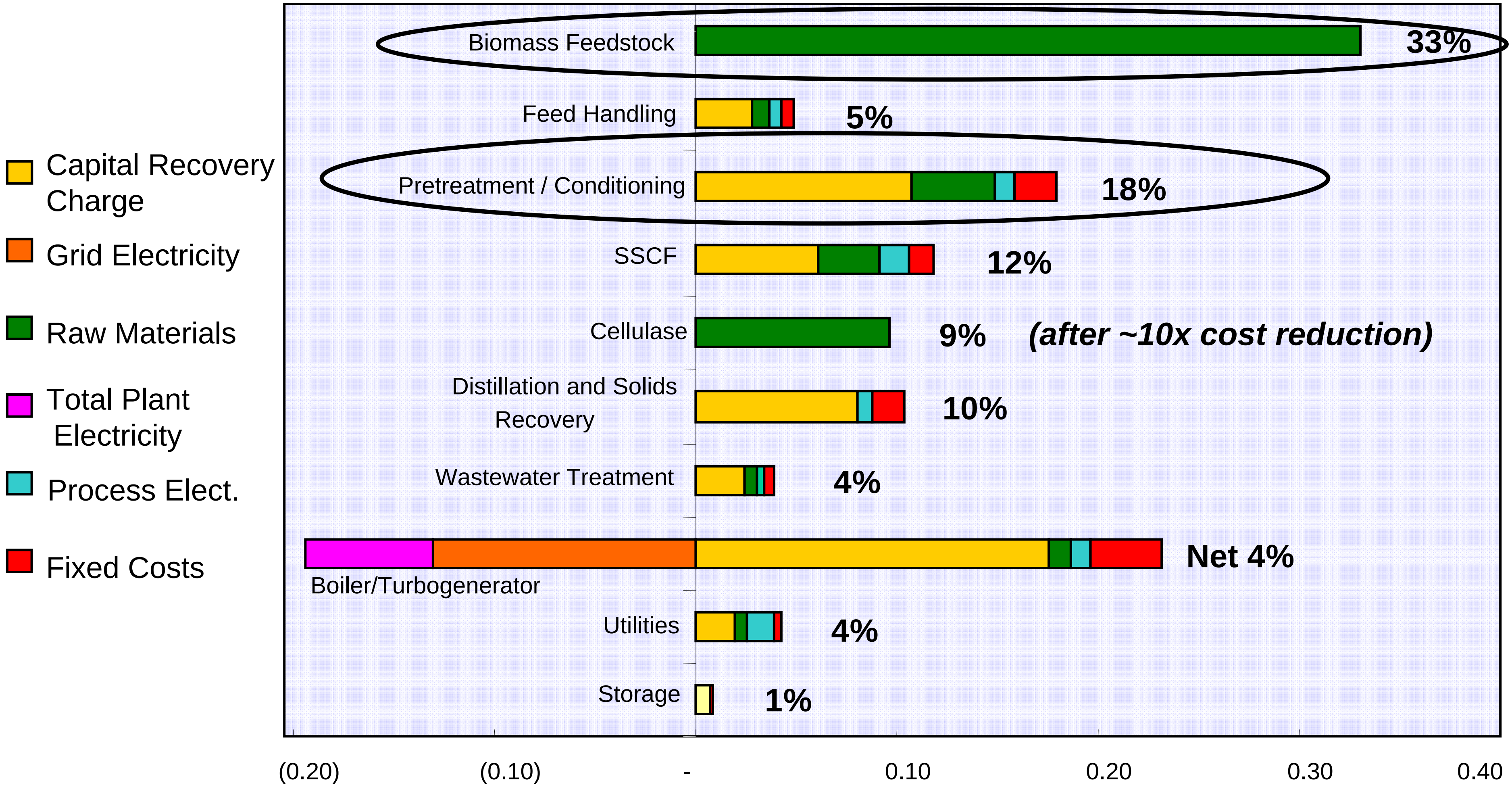


Feedstock

- Biomass yield & properties
- Harvest/transport logistics
- Sustainability, eg. greenhouse gas certification
- Rural economic development
- Co-products (chemicals, materials
- …Many more!

Processing

Key Processing Cost Elements



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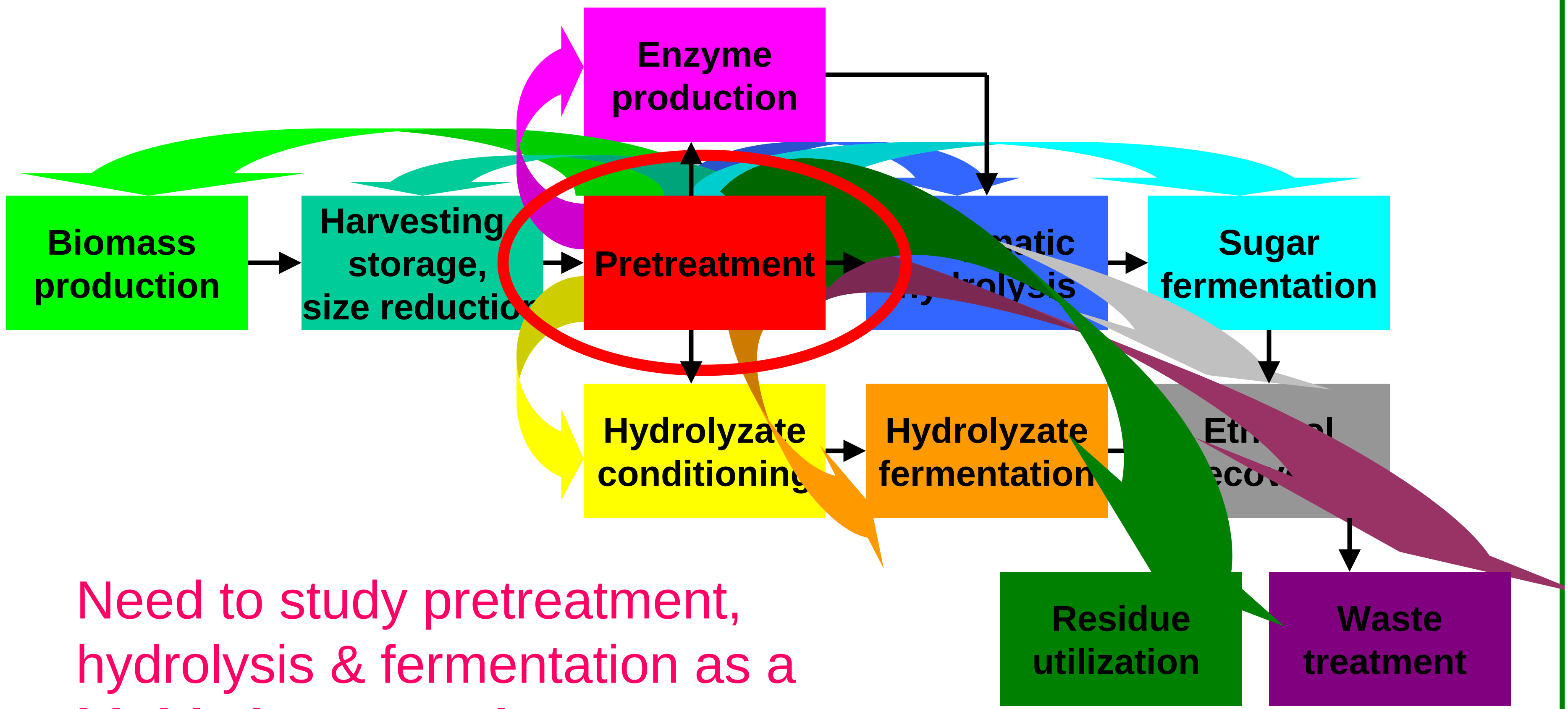
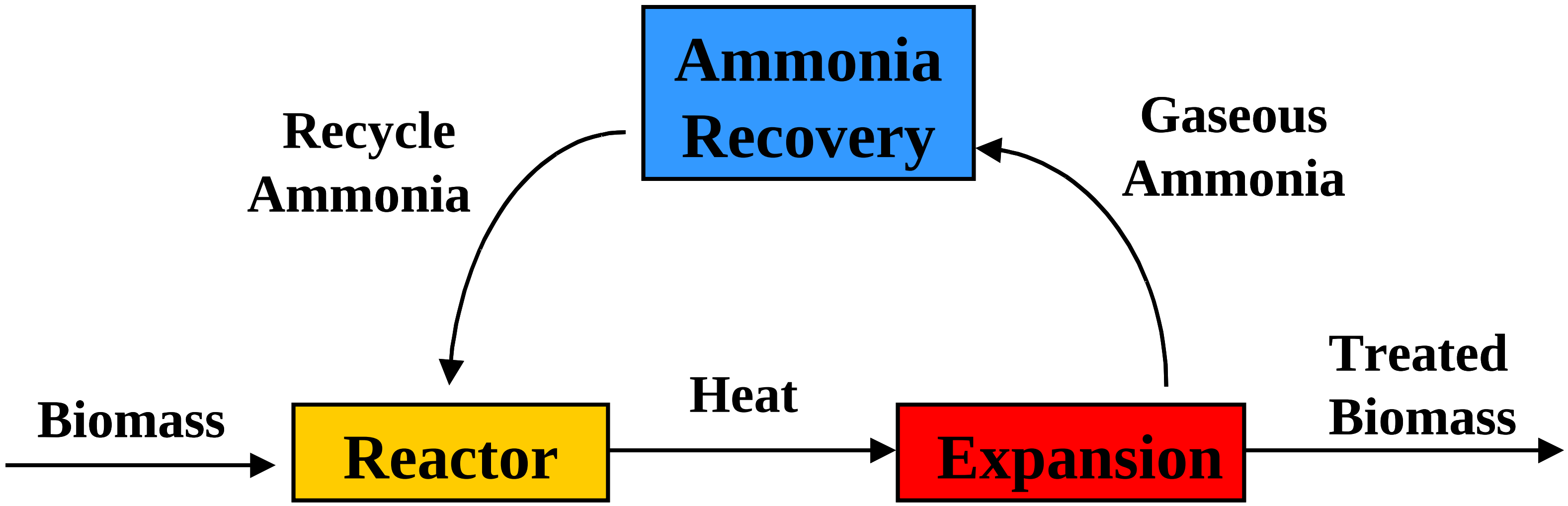
Central Role and Pervasive Impact of Pretreatment for Biological Processing



Need to study pretreatment, hydrolysis & fermentation as a **highly integrated system**

How does AFEX work?



- Biomass heated (~100 C) with concentrated ammonia
- Rapid pressure release ends treatment
- 99% of ammonia is recovered & reused, remainder serves as N source downstream for fermentation
- AFEX covered by multiple U. S. and international patents
- Fermentation inhibitors NOT produced

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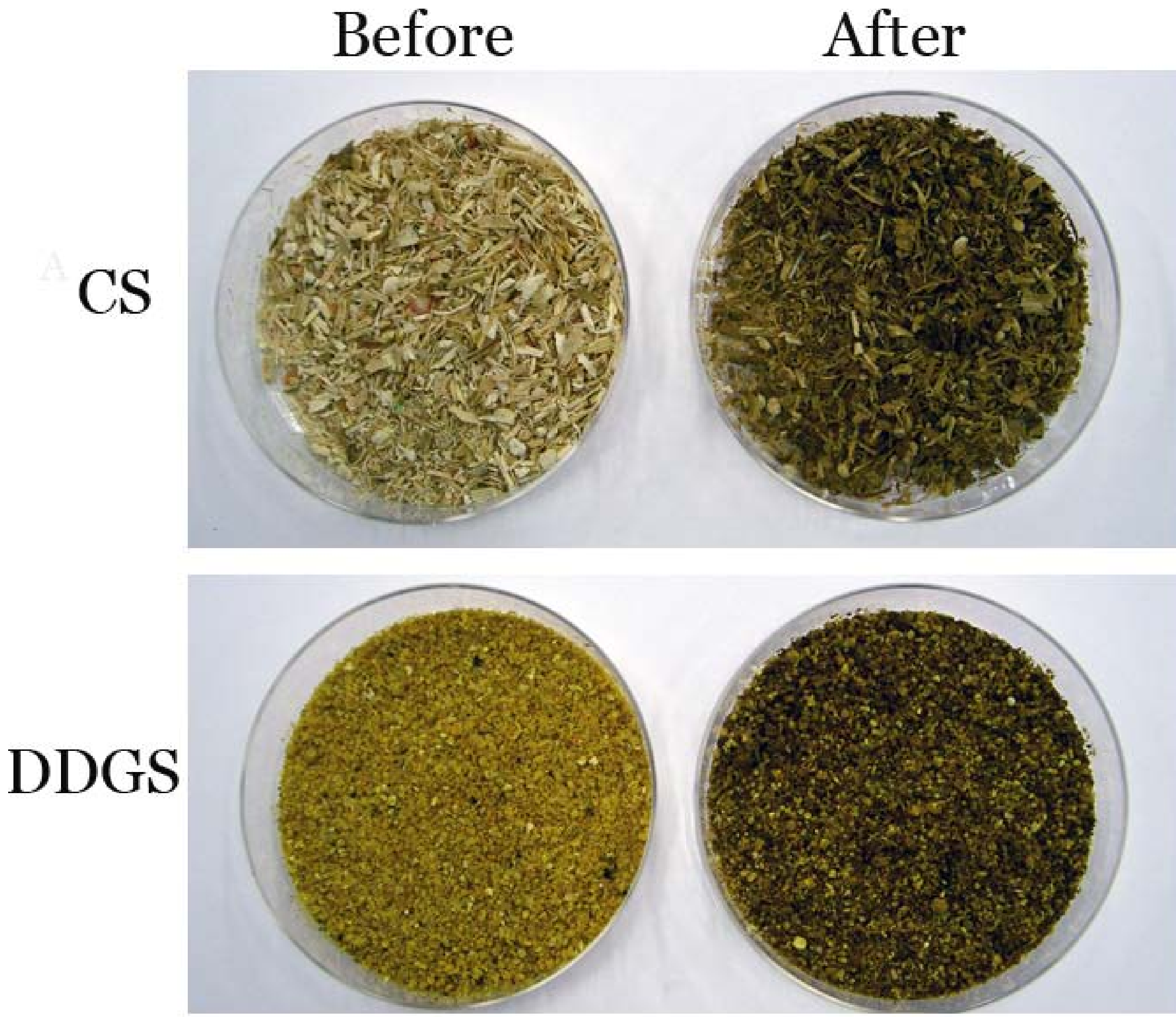
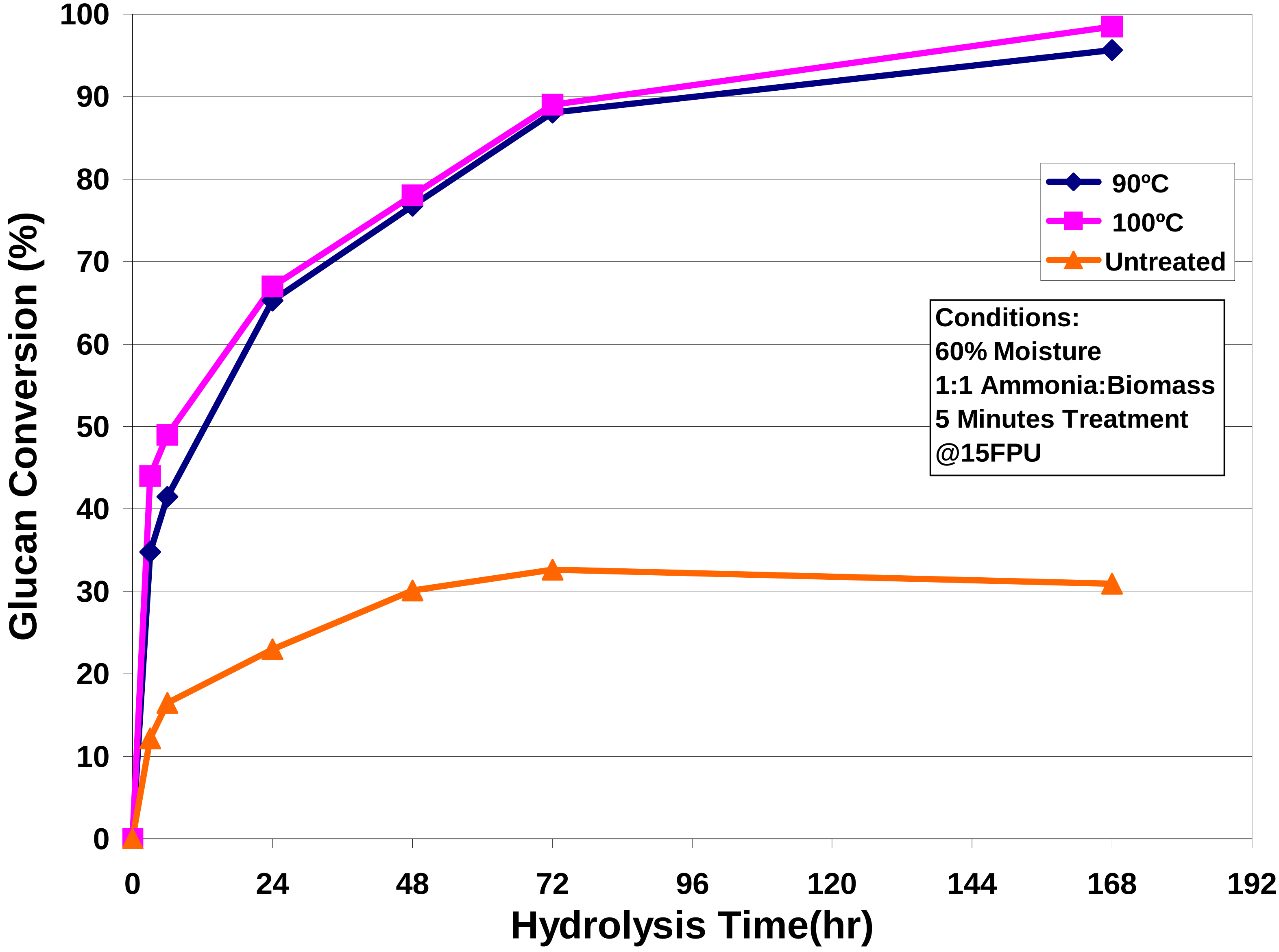
Before and After AFEX



Kinetics of Glucan Hydrolysis



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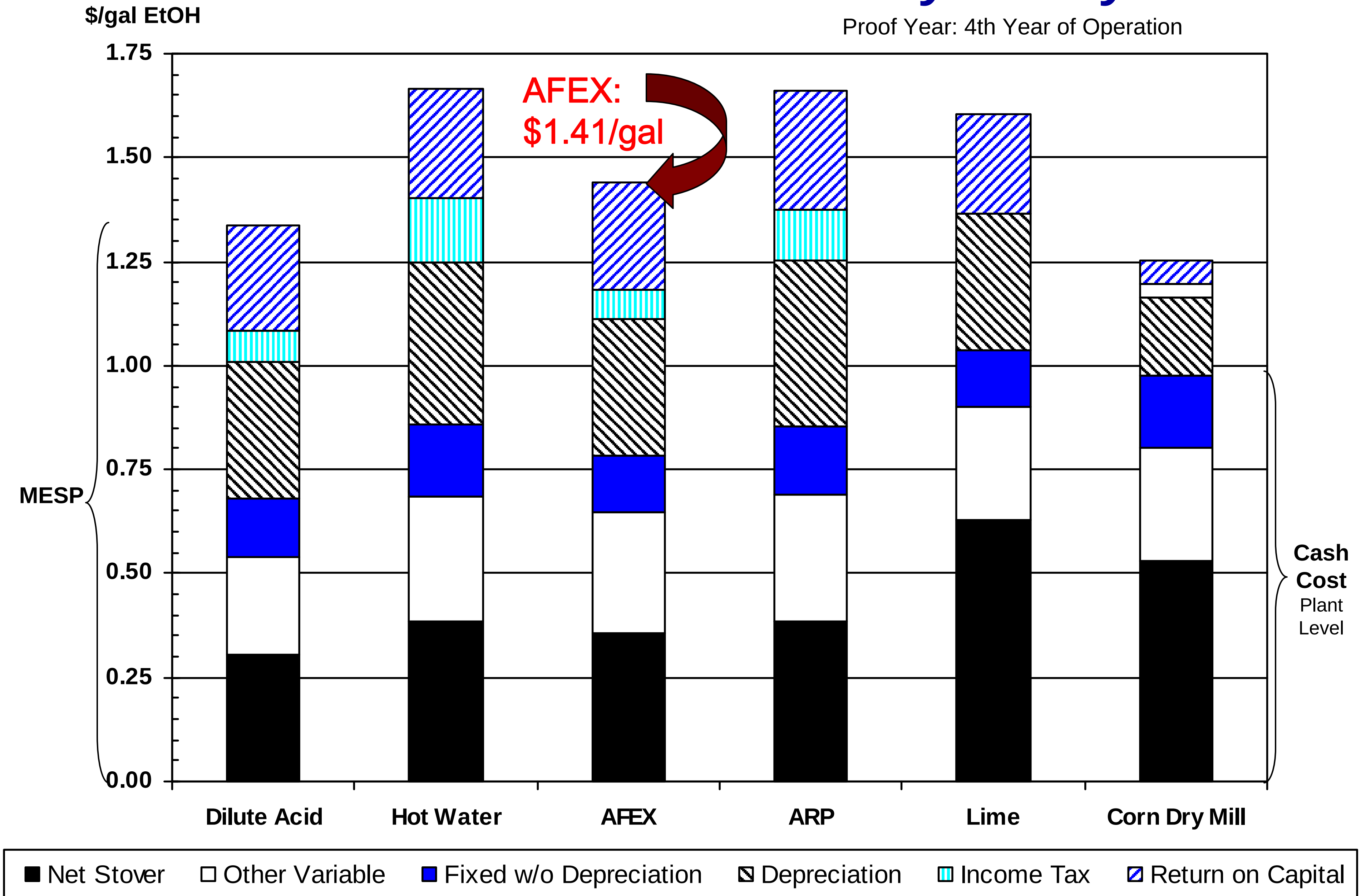
Pretreatment Economic Analysis by NREL



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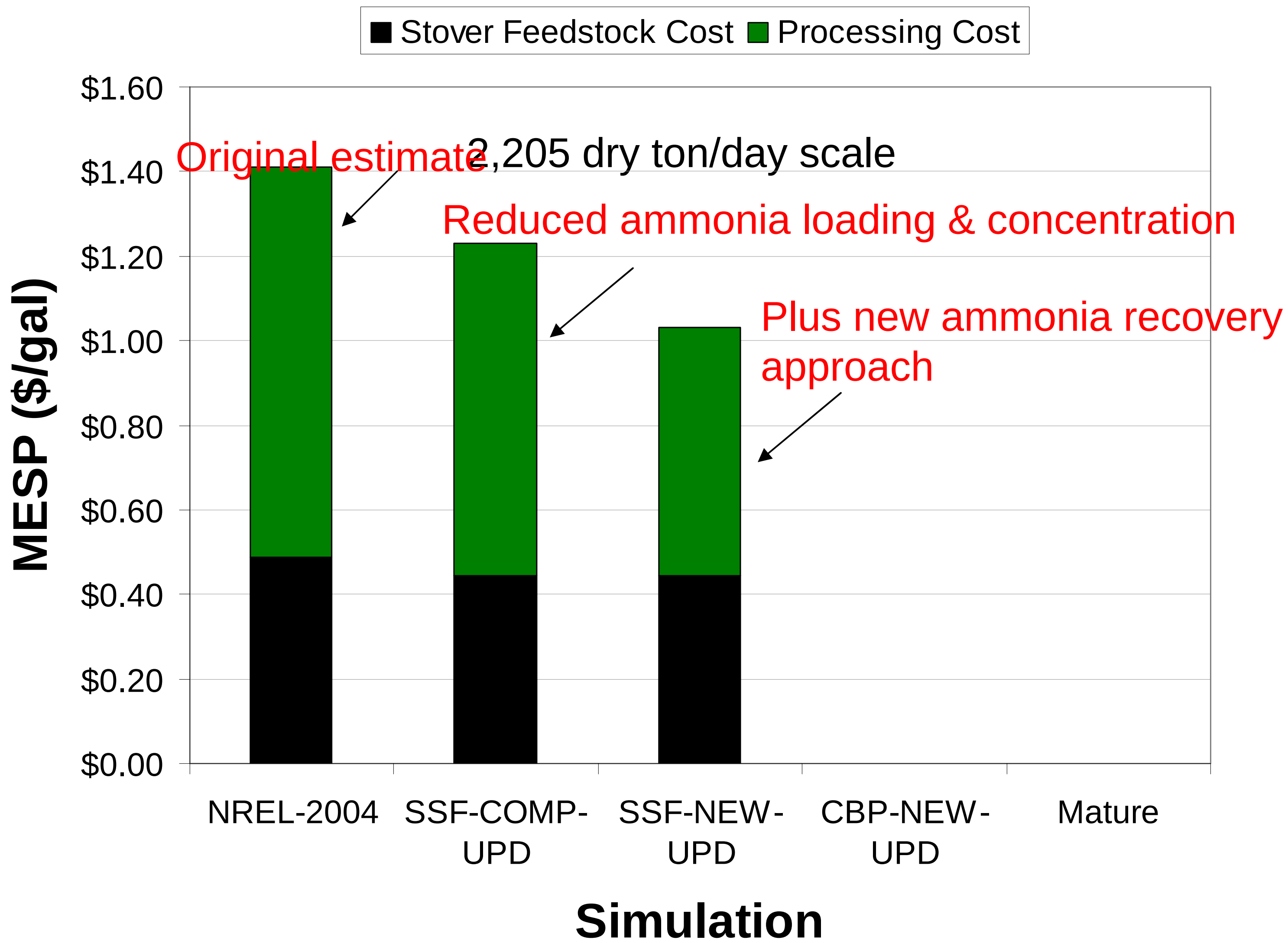
Results of AFEX Economic Analysis*

- Reduce ammonia loadings
- Reduce required ammonia recycle concentrations (manage system water)
- Reduce capital cost of AFEX
- **Analysis performed by Dr. Tim Eggeman of NREL*

Improvements in AFEX Give Improved Ethanol Production Costs



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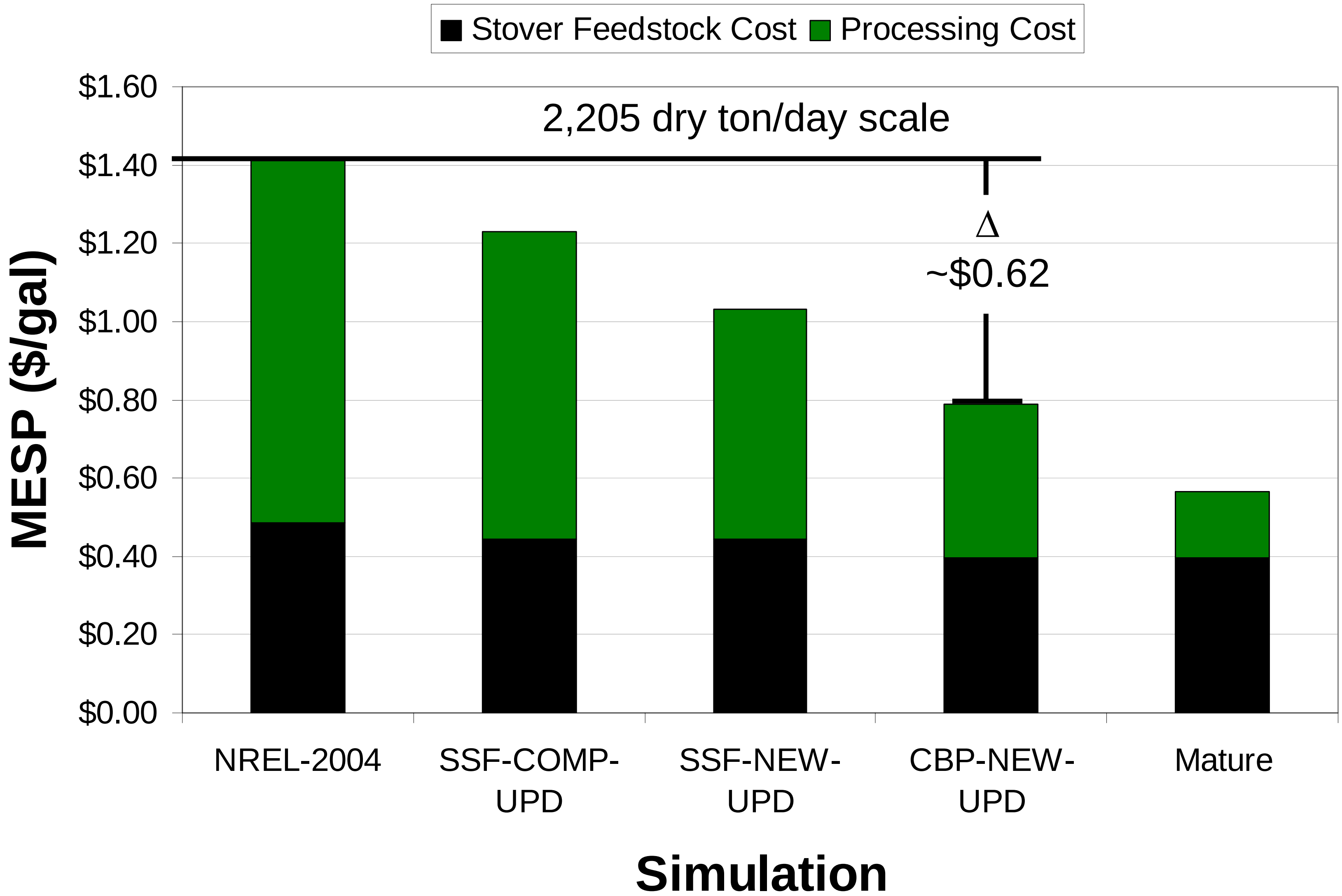
End Result of Process Improvement will be Very Low Cost Cellulosic Ethanol



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We Have Come a Long Way: But There is Much Left to Do

- Processing Cost Reduction
  - Large scale plants (~$400 million)
  - Strong public & private research investment (~$1 billion)
- Feedstock-related issues should become increasingly important
  - Cost & availability
  - Harvesting, logistics, transport
  - Sustainability, eg. greenhouse gas certification
  - Rural economic developmennt
  - Resolving "food vs. fuel" issues

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Anticipating the Biofuels Future

- Premise: *the cellulosic biofuels industry will grow rapidly in coming years.*
- Some resulting questions:
  - How will society/interest groups, etc. react?
  - How will related environmental issues (carbon sequestration, water, soil quality, landscape values, biodiversity, etc.) be addressed?
  - What will the implications be for food/feed/fiber markets?
  - Can we coproduce fuels (& foods/feeds)
  - How can farmers & local communities benefit?
  - How will the research enterprise respond?

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What Happens Because of Inexpensive Ethanol?

- Petroleum dominance declines
  - *Reduce petroleum's influence on prosperity & politics*
  - *Less chance for international conflict*
  - *Greater economic growth opportunities for poor nations*
- Environmental improvements possible
  - *Reduced greenhouse gases*
  - *Reduced nitrogen & phosphorus-related pollution*
  - *Improved soil fertility*
- Rural economic development possible
  - *Local cellulosic biomass processing*
  - *Greater wealth accumulation in rural areas*
  - *Less migration to cities to find economic opportunity*
- Less expensive food (animal feed) possible
  - *Improved animal feeds: protein & calories*
  - *Less expensive, more abundant human food*

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Will People Go Hungry Because of Biofuels?

- Three major U.S. crops *alone* (corn, soy, wheat) produce 1300 trillion kcal & 51 trillion grams protein/yr
- Could meet U.S. human demand for protein & calories with 25 million acres of corn (~5% of our cropland)
- *Most U. S. agricultural production (inc. exports) is fed to animals-- i.e., we are meeting <u>their</u> protein/calorie needs from our land resources. Their needs are:*
  - 1040 trillion kcal/yr (5 times human demand)
  - 56.6 trillion gm protein/yr (10 times human demand)
- Thus we can address perceived “food vs. fuel” conflict by providing <u>animal feeds</u> more efficiently, on less land
- Dairy & beef cattle consume more than 70% of all calories and protein fed to livestock
- As nations grow richer, they want more protein, especially more meat….

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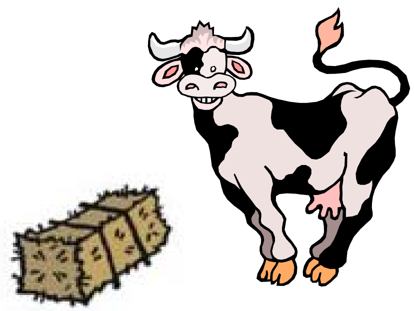
Ruminant Animals & Biorefineries:

Improve Cellulose Conversion for Biorefinery = Improve Cellulose Digestibility for Cows

Mobile Cellulose Biorefinery
(a.k.a. Cow)

Stationary Cellulose Biorefinery



=

Ruminant Bioreactor:

Biomass Input ~ 26 Lb/Day*

Capacity ~ 40 Gal Fermentor

SSCF Bioreactor:

Biomass Input ~ 5,000 Dry Ton/Day
= 10 M Dry Lb/Day
Capacity ~ 45 M Gal Fermentor

Cow is 3x more efficient than industrial bioreactor

*Rasby, Rick. "Estimating Daily Forage Intake of Cows". University of Nebraska-Lincoln Institute of Agriculture and Natural Resources, http://beef.unl.edu/stories/200608210.shtml, 10/02/06.

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U.S. Livestock Consumption of Calories & Protein

ANIMAL CLASS	HERD SIZE (THOUSANDS)	TOTAL PROTEIN (MILLION KG/YR)	TOTAL ENERGY (TRILLION CAL/YR)
Dairy	**15,350**	**10,400**	**184.8**
Beef	**72,645**	**25,100**	**525.3**
Hogs	60,234	6,900	136.2
Sheep	10,006	461	10.6
Egg production	446,900	2,470	4.3
Broilers produced	8,542,000	9,540	150.3
Turkeys produced	269,500	1,760	28.6
Total consumed by U.S. livestock		**56,630**	**1,040.00**
Human requirements		**5,114**	**205**

Grasses: Sustainable Sources of Protein & Calories for Cattle Feeding?

Thinking Ahead: Farmers & Biofuels

"More than a century of bitter experience has taught farmers that when they simply sell a raw crop, they fall ever further behind."

David Morris "The American Prospect" April 2006

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Capturing Local Benefits from Biofuels

- Some issues for farmers/local interests
  - If farmers merely supply biomass, they will not benefit much from the biofuels revolution
  - Investment required for cellulosic ethanol biorefinery is huge ~ $250 million and up—difficult for farmers to participate
- Some issues for biofuel firms/larger society
  - Supply chain issues are enormous—need 5,000 ton/day from ~1,000 farmers: chemicals/fuels industries have zero experience with such large agricultural systems
  - Cellulosic biomass is bulky, difficult to transport
  - Need to resolve "food vs. fuel" problem: actually "animal feed and fuel opportunity"
- Is there a common solution?
  - Regional Biomass Processing Center– concept worthy of study
  - Pretreat biomass for biorefinery & ruminant (cattle) feeding
  - Much lower capital requirements—accessible to rural interests
  - Develop additional products over time—animal feed protein, enzymes, nutraceuticals, biobased composites, etc

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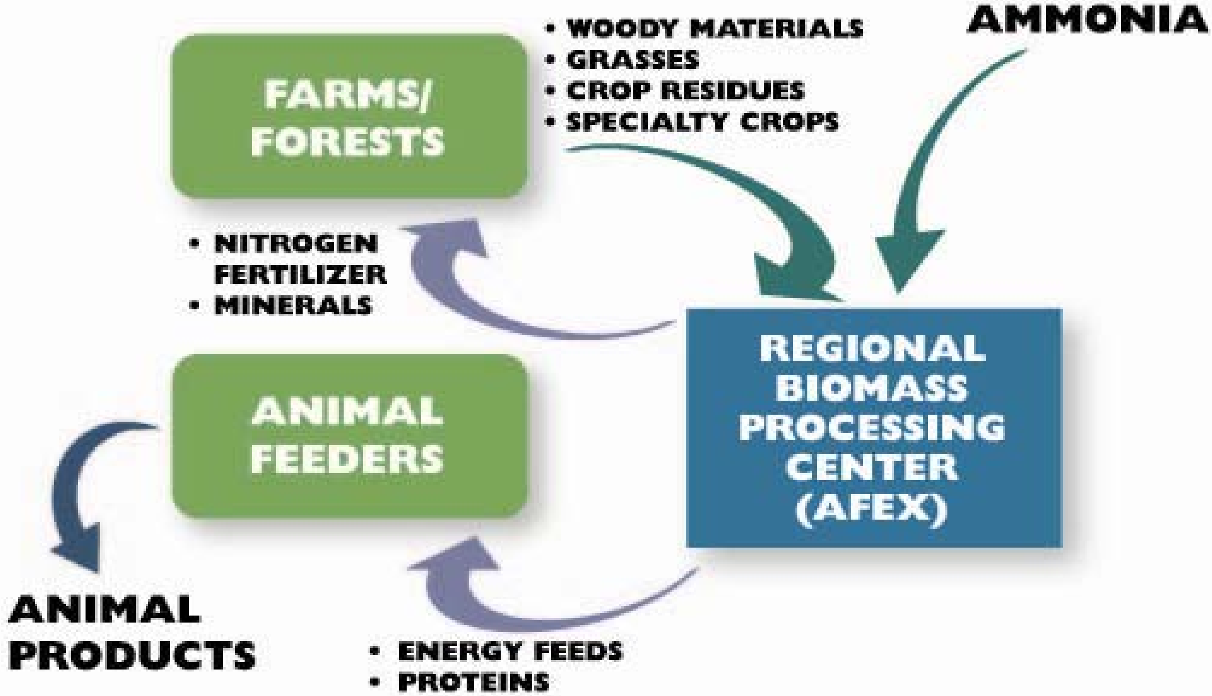
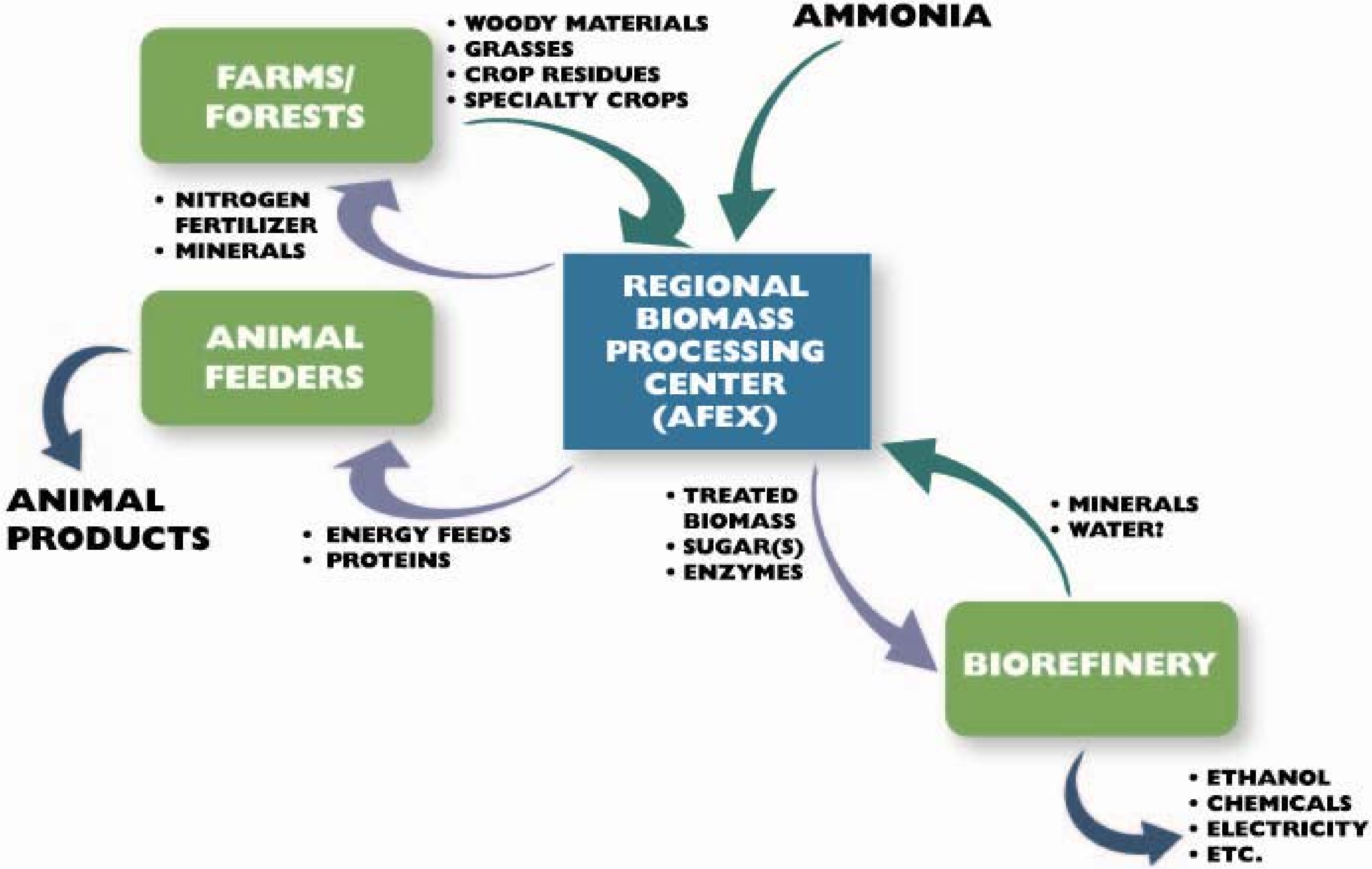
REGIONAL BIOMASS PROCESSING: SUPPLY CHAINS



REGIONAL BIOMASS PROCESSING: SUPPLY CHAINS



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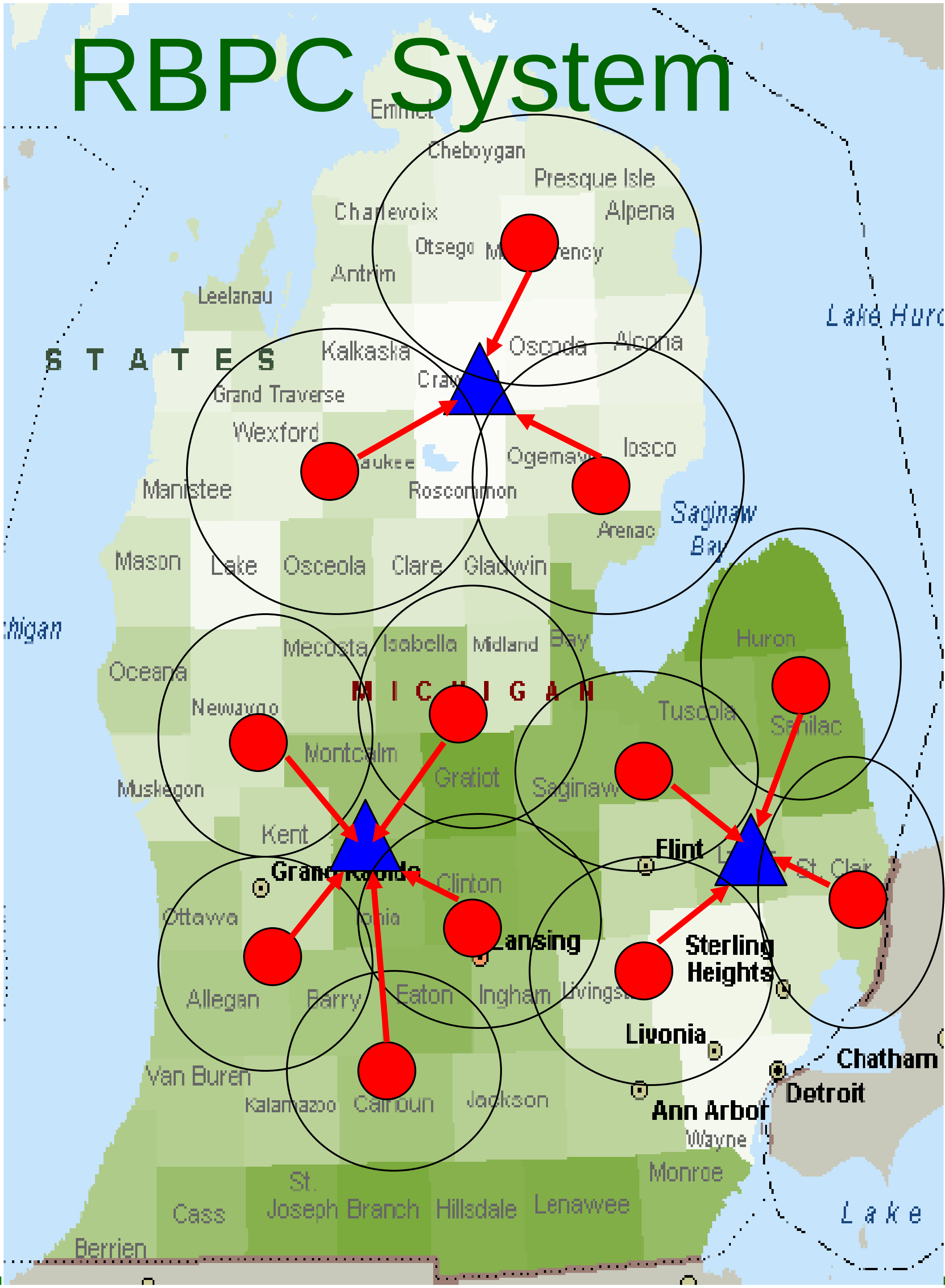
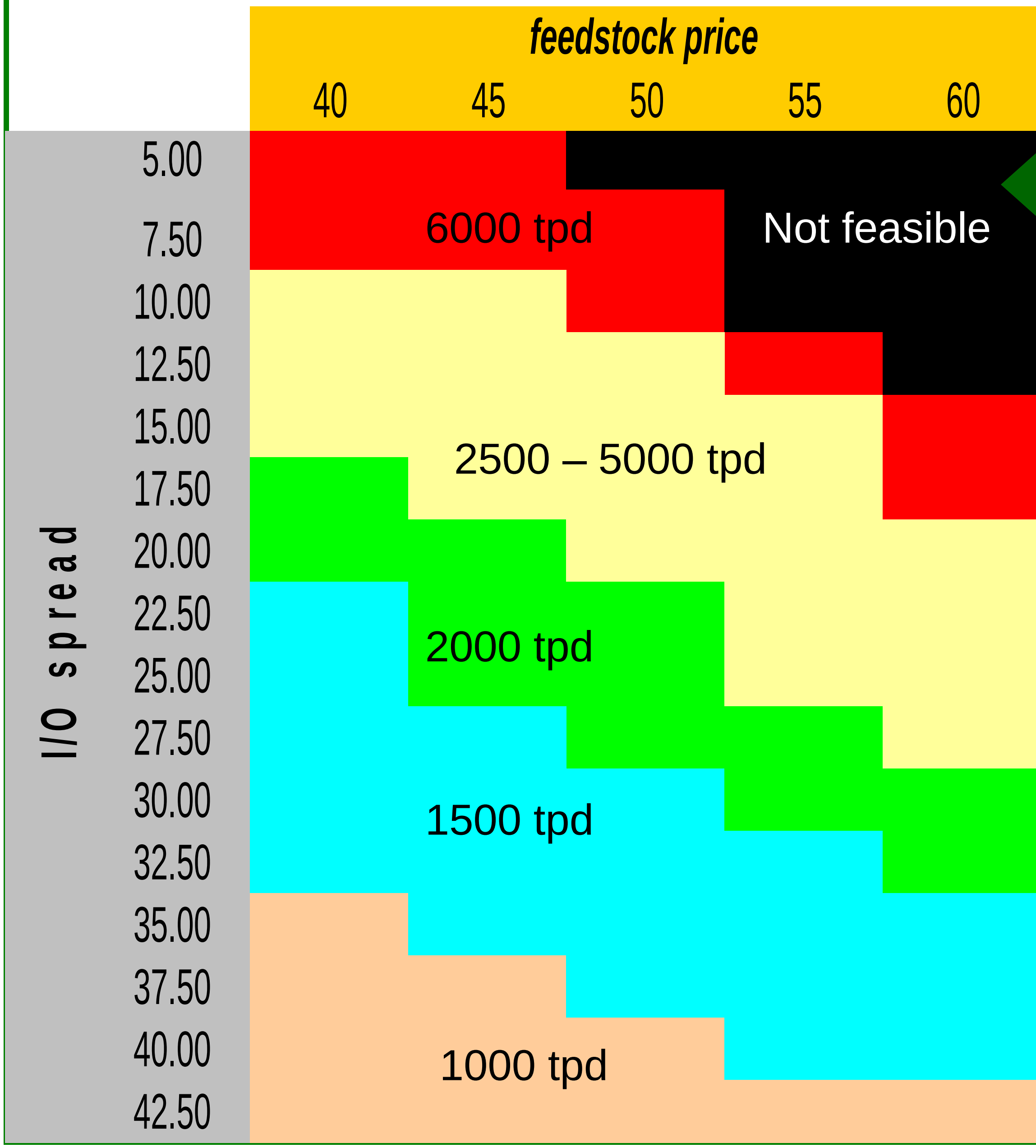
RBPC System

- ➢Decentralized, spatially optimal pretreatment centers
- ➢Multiple RBPCs supply single, larger biorefinery
- ➢Greater geographic coverage
- ➢Synergistic local relationship
- ➢Fewer contracts to manage
- ➢Uniform, already pretreated biomass for biorefinery

Sustainable rural economies + Sustainable biofuels



Economically Feasible Set



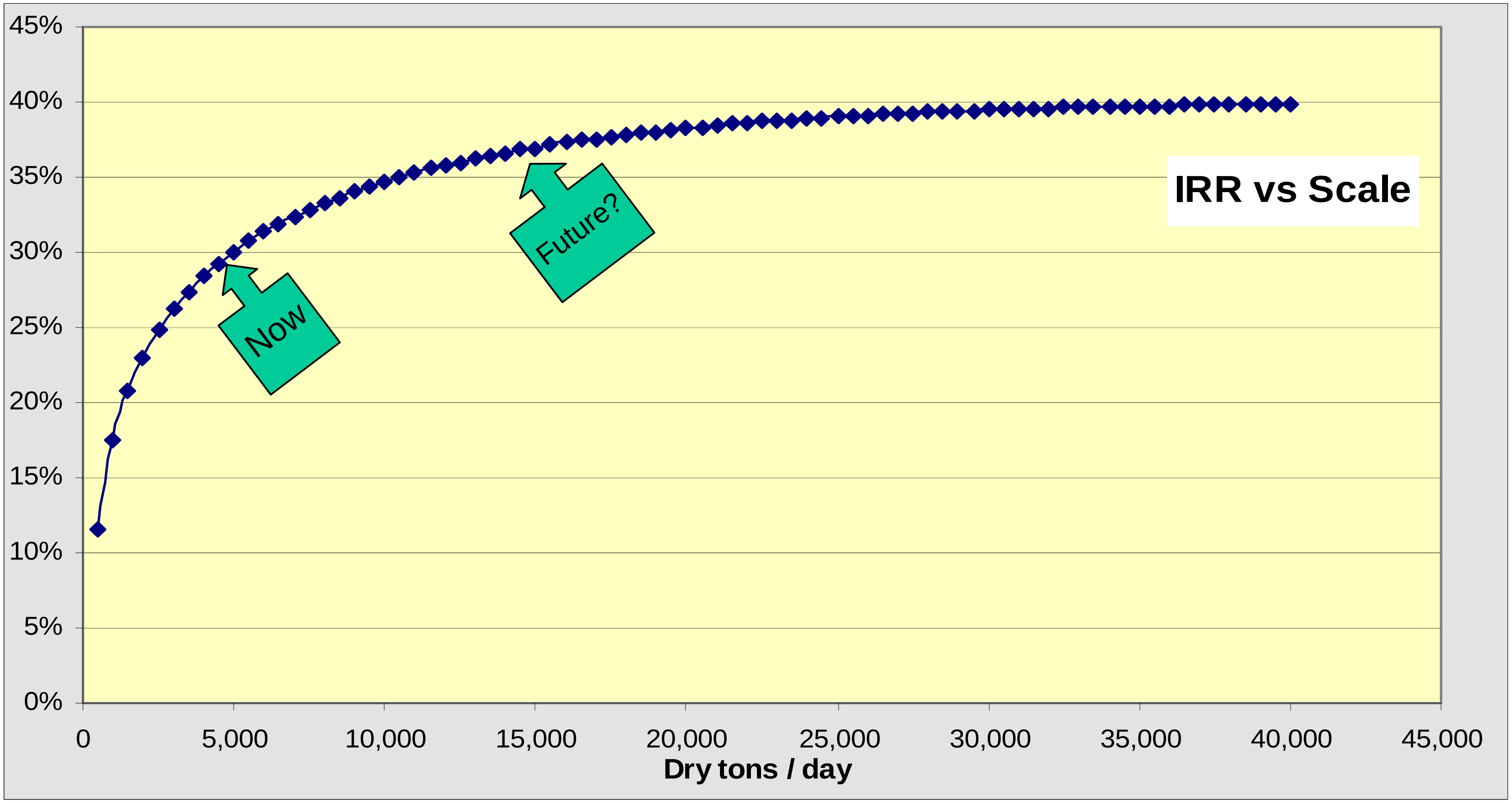
Minimum **scale plant that works (>12% ROI) under price combination**

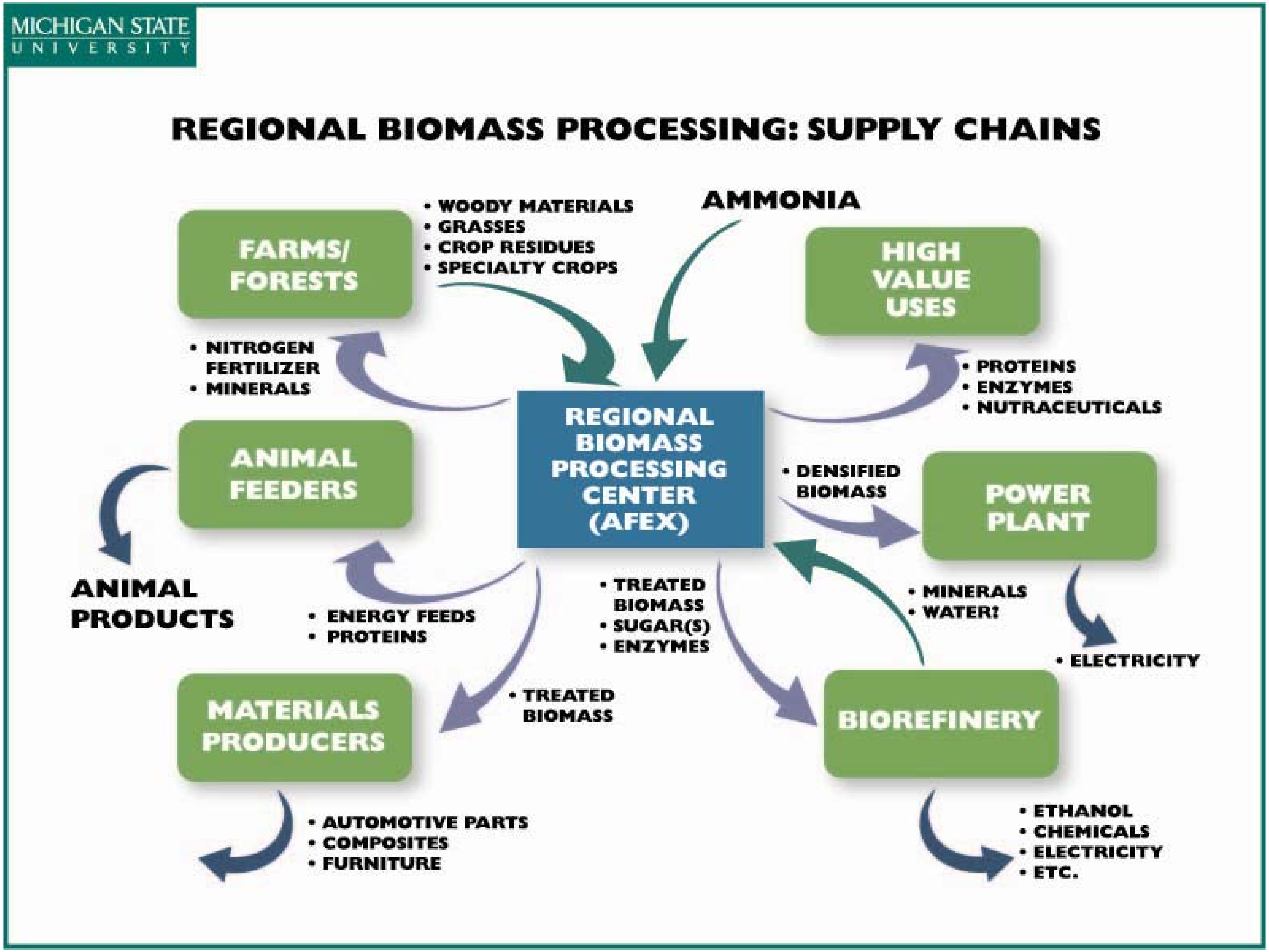
- I/O spread = BIG driver
- As I/O spread grows; smaller facilities work
- @ LCB < $50, ***can*** achieve > 12% ROI;
- I/O Spread NOT sole determinant - LCB price plays a major role.
  - under $25, all feasible
  - over $65, only 7000 tpd +, with BR price > $82.50 feasible
  - Others?

Impact to Biorefinery

- Lower capital costs
- Lower operating costs
- Add: more available LCB

- Larger, & /or more, facilities
- More economies of scale
- Move up return curve

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REGIONAL BIOMASS PROCESSING: SUPPLY CHAINS
FARMS/ FORESTS
• WOODY MATERIALS
• GRASSES
• CROP RESIDUES
• SPECIALTY CROPS
AMMONIA
HIGH VALUE USES
• NITROGEN FERTILIZER
• MINERALS
• PROTEINS
• ENZYMES
• NUTRACEUTICALS
ANIMAL FEEDERS
REGIONAL BIOMASS PROCESSING CENTER (AFEX)
• DENSIFIED BIOMASS
POWER PLANT
ANIMAL PRODUCTS
• ENERGY FEEDS
• PROTEINS
• TREATED BIOMASS
• SUGAR(S)
• ENZYMES
• MINERALS
• WATER?
• ELECTRICITY
• TREATED BIOMASS
MATERIALS PRODUCERS
BIOREFINERY
• AUTOMOTIVE PARTS
• COMPOSITES
• FURNITURE
• ETHANOL
• CHEMICALS
• ELECTRICITY
• ETC.

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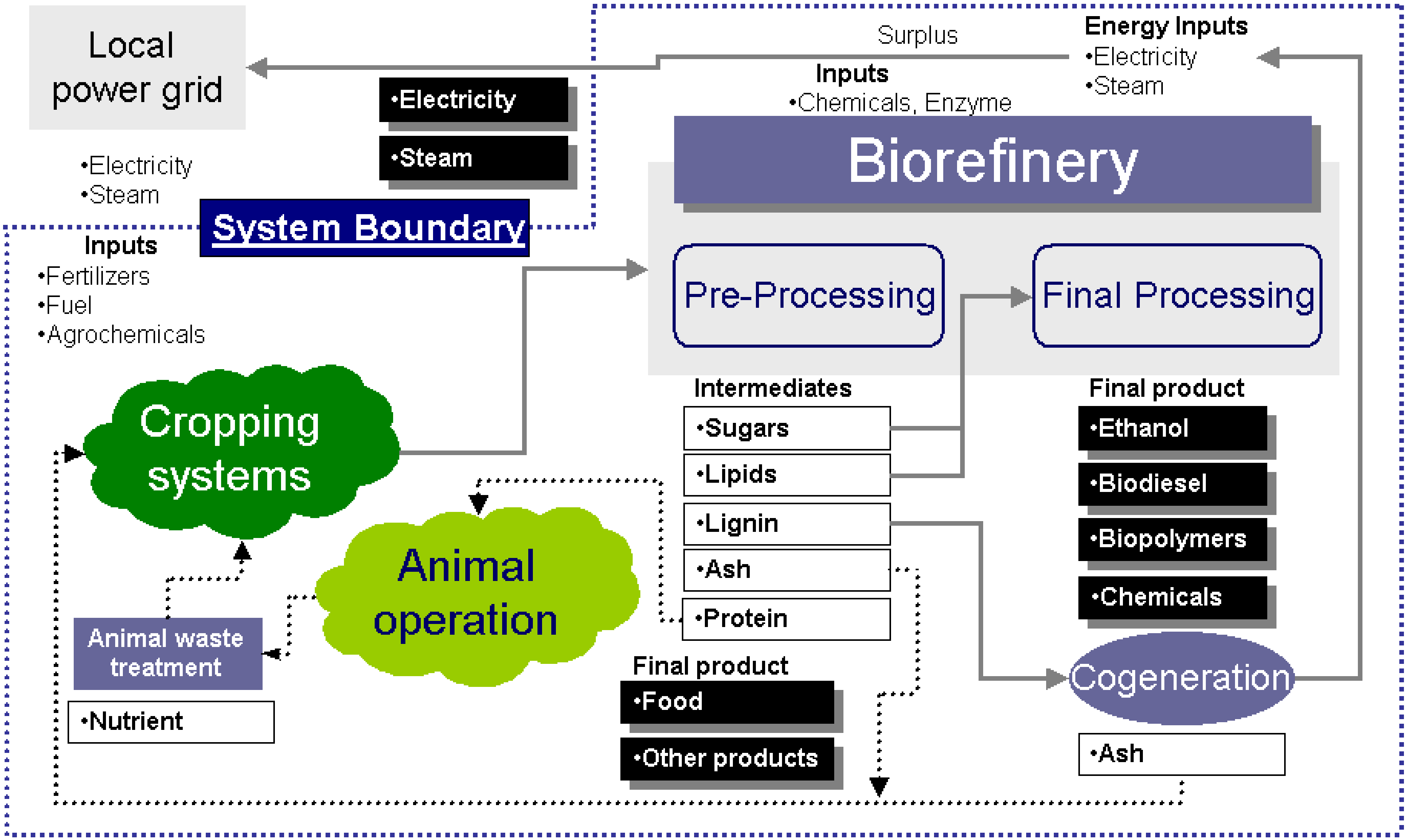
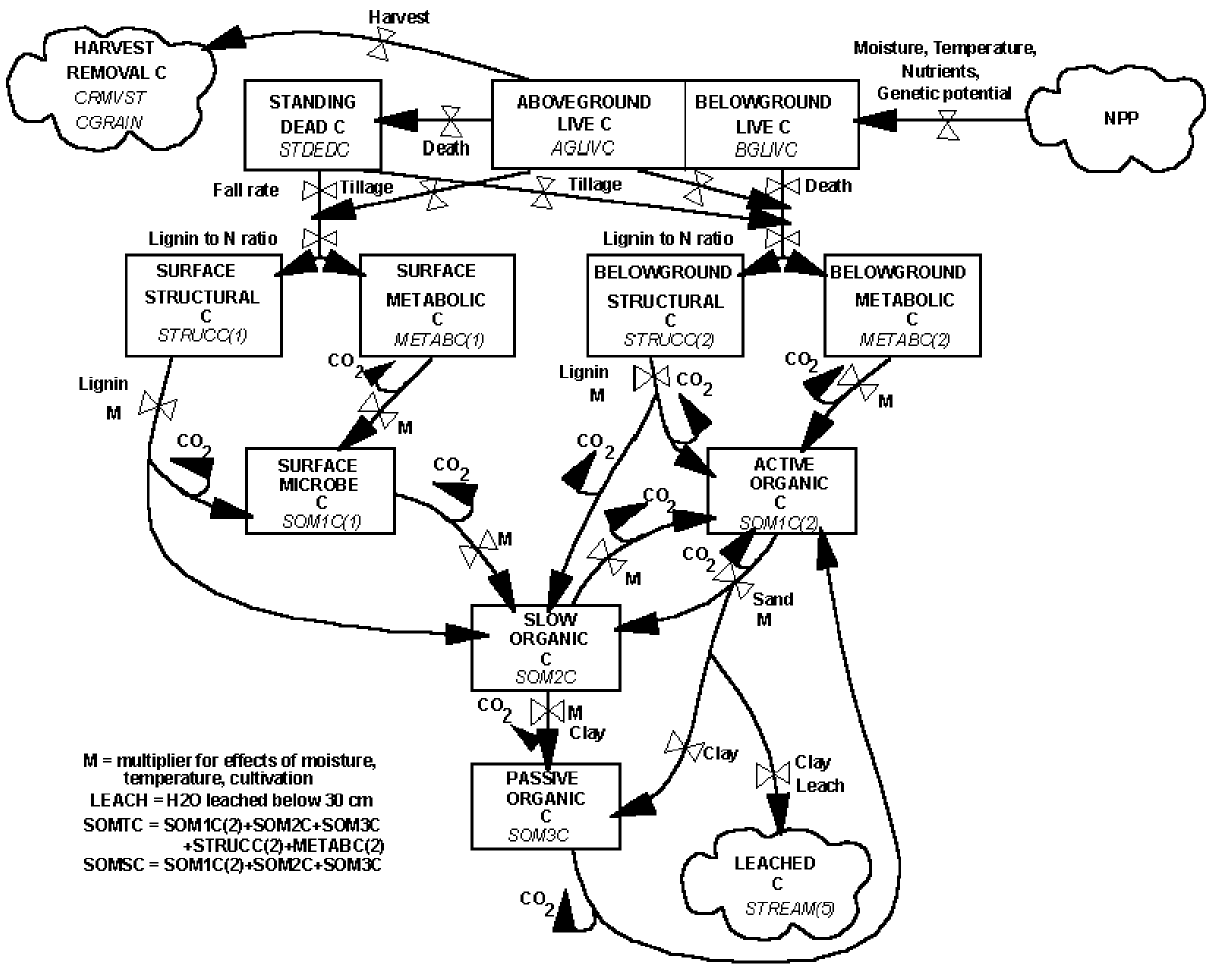
What Happens Because of Inexpensive Ethanol?

- Petroleum dominance declines
  - *Reduce petroleum's influence on prosperity & politics*
  - *Less chance for international conflict*
  - *Greater economic growth opportunities for poor nations*
- Environmental improvements <u>possible</u>
  - *Reduced greenhouse gases*
  - *Reduced nitrogen & phosphorus-related pollution*
  - *Improved soil fertility*
- Rural economic development <u>possible</u>
  - *Local cellulosic biomass processing*
  - *Greater wealth accumulation in rural areas*
  - *Less migration to cities to find economic opportunity*
- Less expensive food (animal feed) <u>possible</u>
  - *Improved animal feeds: protein & calories*
  - *Less expensive, more abundant human food*

ALL BIOMASS IS LOCAL



Soil Organic Carbon Dynamics in CENTURY



Improving the Sustainability of Biofuels: Corn Stover Removal & Cover Crops

- We want to harvest corn residue (stover) to make cellulosic ethanol & improve farmer profits
- However, corn stover removal will tend to reduce soil organic matter (soil fertility) & increase soil erosion
- This is not the right direction…
- *Can we find a way to remove stover sustainably?*
- Use winter cover crop
  - Plant cover crop (cool season grass: wheat, rye, oats) after corn harvest
  - Cover crop grows rapidly in spring, takes up excess soil nitrogen & phosphorus
  - Kill or plow under cover crop before planting next corn crop
  - *Or* harvest cover crop as biofuel feedstock- we are now studying this option

Grasses: Improve Soil Quality & Reduce Nitrogen & Phosphorus Losses

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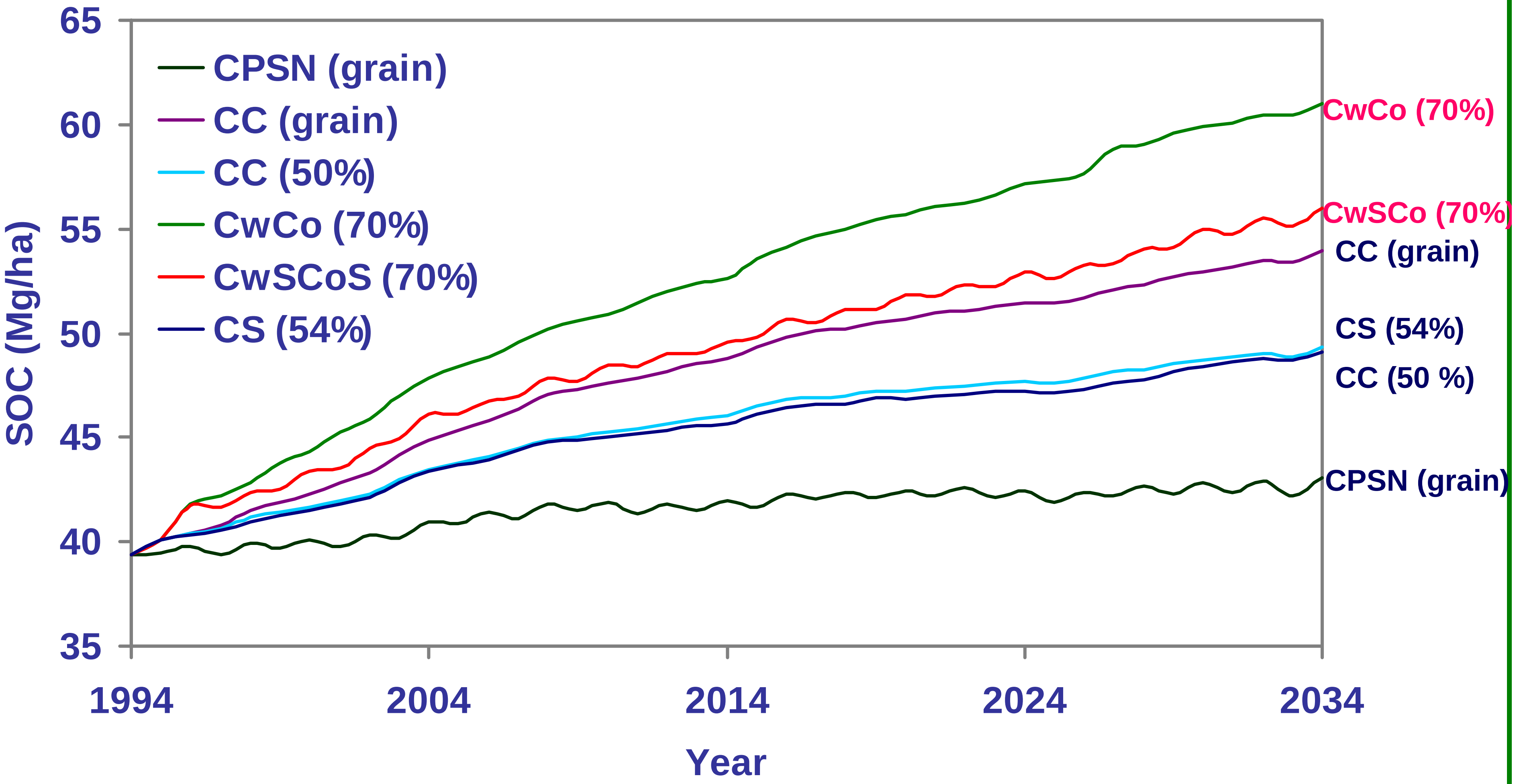
Bare Corn Field- Holt, Michigan
May 5, 2005

Improving the Sustainability of Biofuels: Corn Stover Removal & Cover Crops

- Basic cropping system
  - Corn (plow till) – soybean (no-till): CPSN (grain)
- Effect of winter cover crop under no-till corn continuous cultivation
  - 0 % of corn stover removed: CC (grain) (No cover crop)
  - Average 56 % corn stover removal: CC (56%) (No cover crop)
  - Wheat and oats as winter cover crops with 70 % corn stover removal : CwCo (70%)
- Effect of winter cover crop under no-till corn-soybean rotation
  - Wheat and oats as winter cover crops after corn cultivation with 70 % corn stover removal: CwSCo (70%)
  - Average 54 % of corn stover removed: CS (54%) (No winter cover crop)

Cover Crop Increases Soil Fertility While Still Removing Lots of Stover



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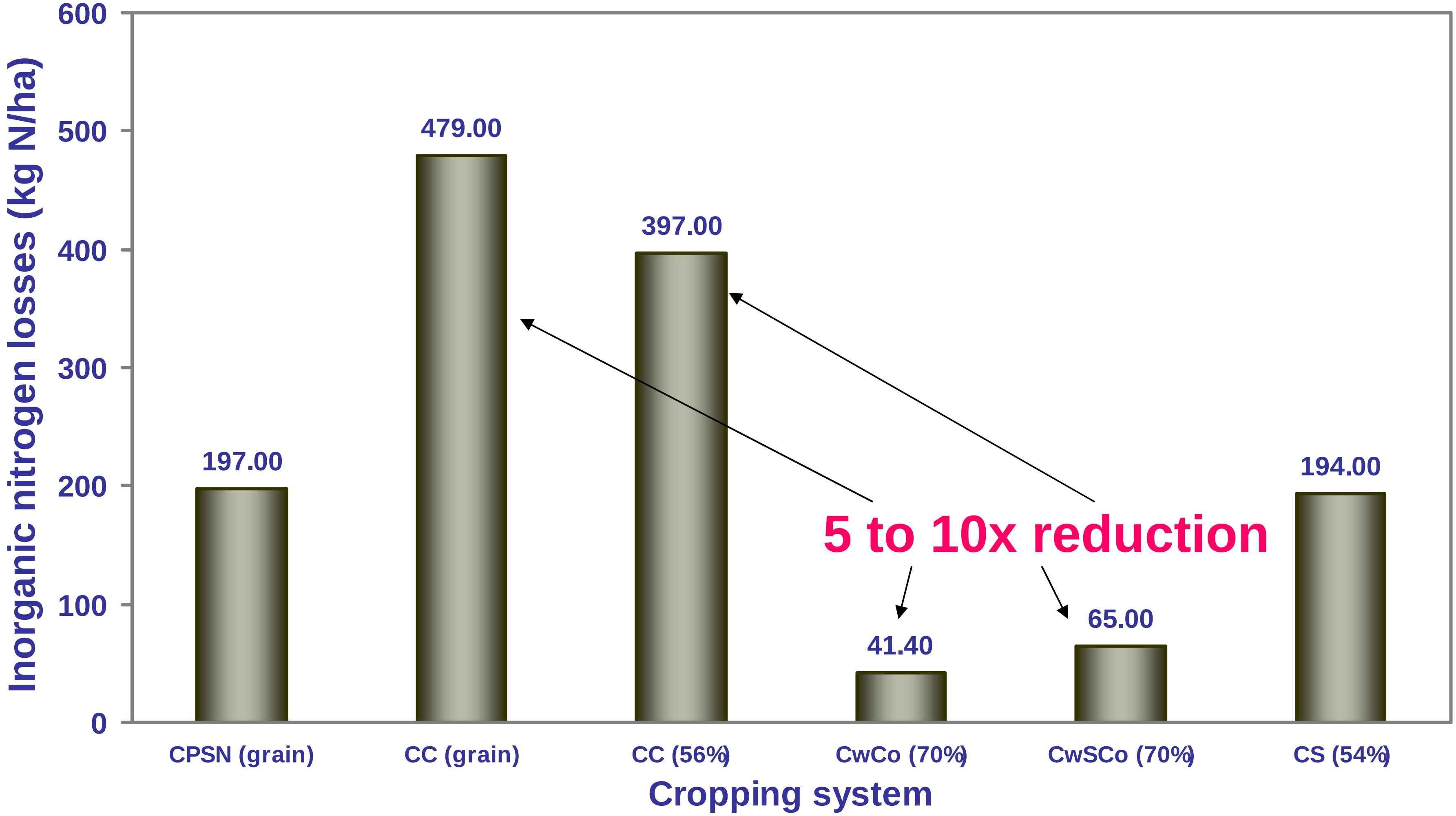
Cover Crops Reduce Nitrogen Losses Tenfold*



*40 year time scale, Washington County, Illinois

What Happens Because of Inexpensive Ethanol?

- Petroleum dominance declines
  - *Reduce petroleum's influence on prosperity & politics*
  - *Less chance for international conflict*
  - *Greater economic growth opportunities for poor nations*
- Environmental improvements possible – if we make it so
- Rural economic development possible – if we make it so
- Less expensive food possible – if we make it so
- ***The future is ours to create***

Questions ??

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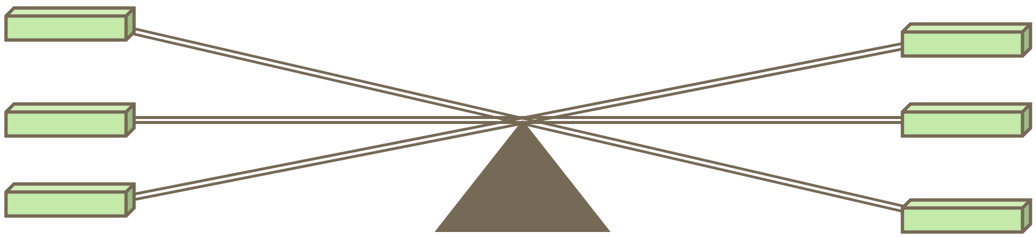
My Assumptions/Points of Departure

- Inexpensive crop raw materials will catalyze the growth of new and existing biocommodity industries
- Life sciences will be critical to the development of biocommodity industries:
  - Modify properties of plant raw materials
  - Improve processing technology
  - Permit novel products
  - Enhance environmental performance of system
- *We have a unique opportunity to design these industries for better environmental performance*
- One important tool: life cycle analysis (LCA)

Biofuels: Changing Balance Between Processing and Feedstock

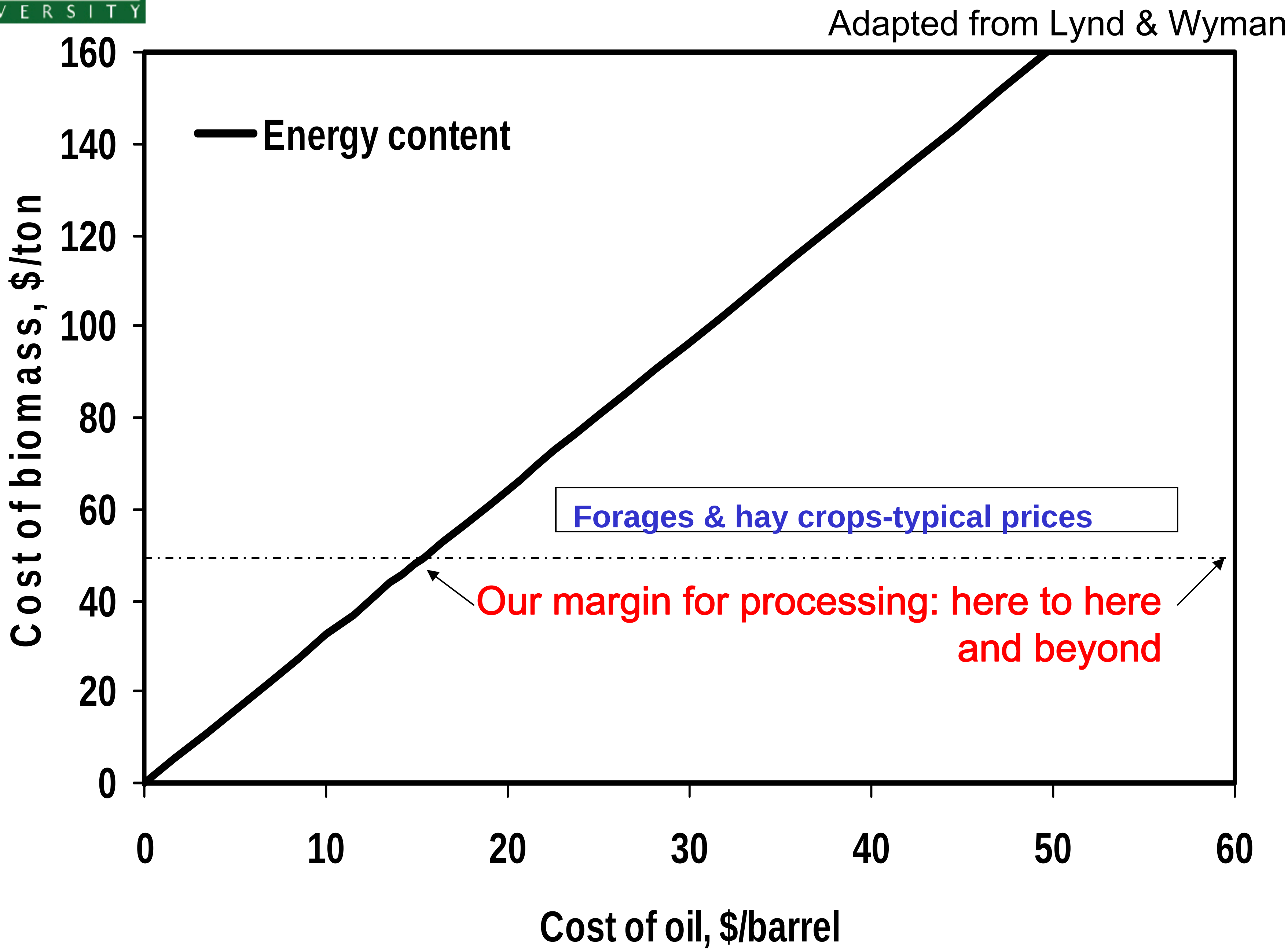
Near Future



Feedstock

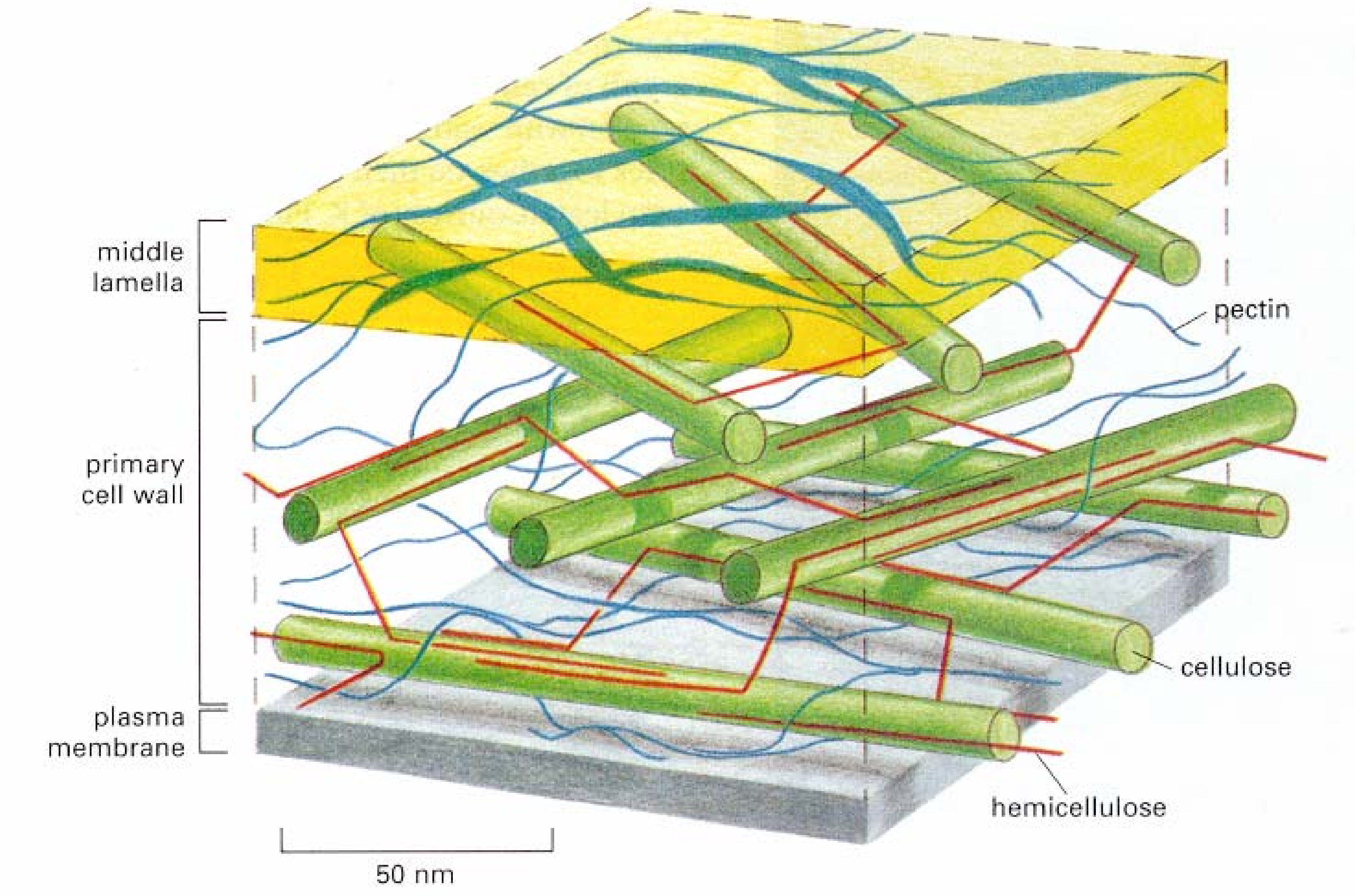
- Biomass yield & properties
- Harvest/transport logistics
- Sustainability
- Rural economic development
- Co-products
- ...Many more!

Processing



Plant material is much, much cheaper than oil on both energy & mass basis

Why Is Pretreatment Necessary?



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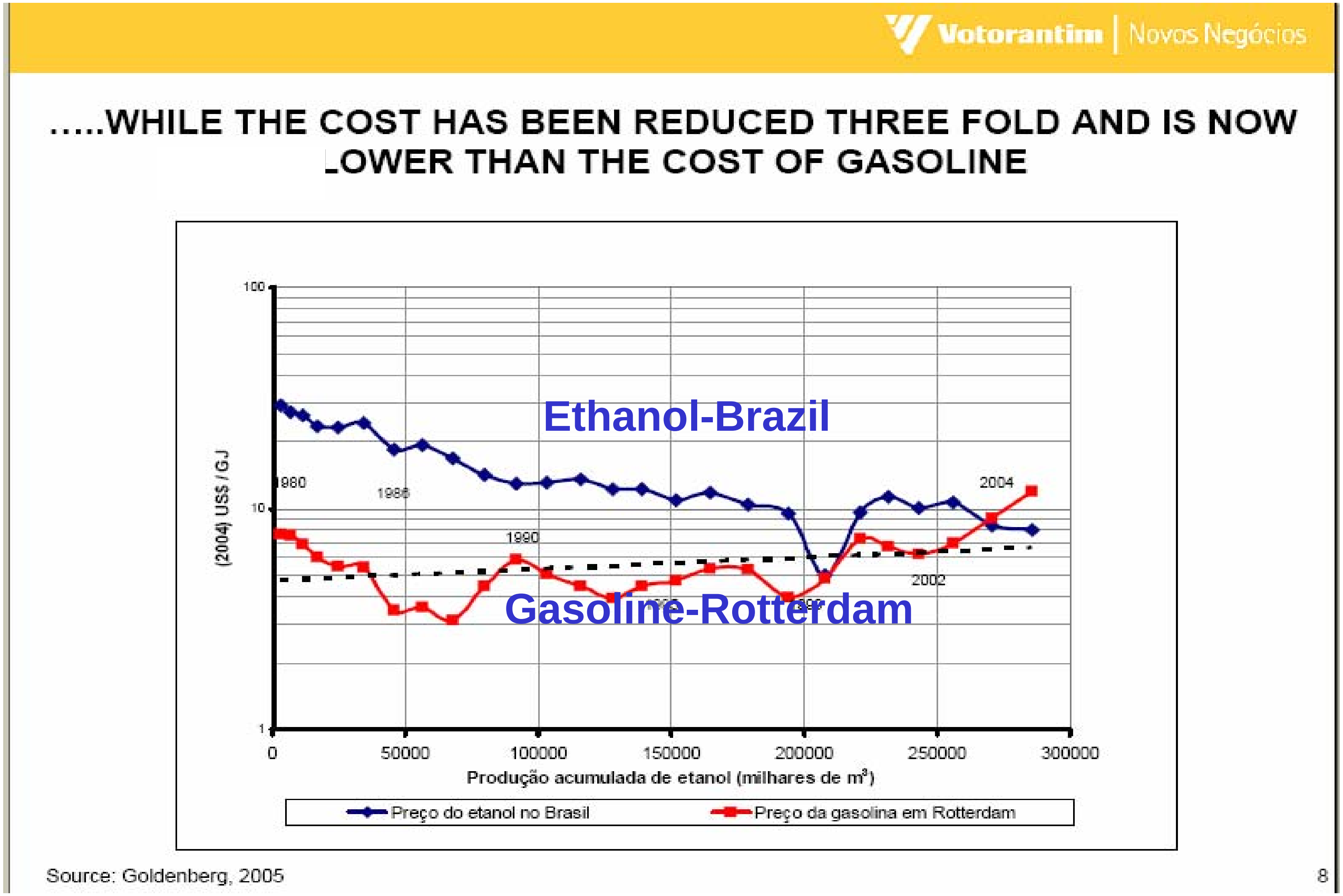
Brazil Has Been Reducing Sugar Ethanol Costs for 30 Years
Cellulosic Ethanol Costs Have Declined and Will Decrease More!



Source: Goldenberg, 2005

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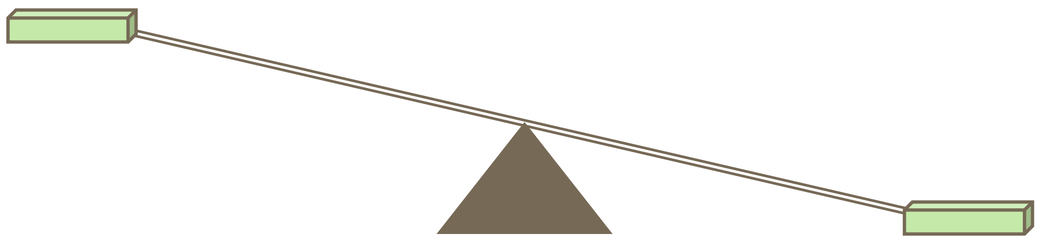
Water Loadings and Stover Solids Made Soluble by Pretreatments

Pretreatment	Water:Solids Ratio	% Solids Solubilized
Dilute acid	>5	36
Flowthrough	>10	29.3
Controlled pH	6.2	37.7
AFEX	0.6	12.0
ARP	>5	40.0
Lime	10.0	23.0

Biofuels: Changing Balance Between Processing and Feedstock

Today



Feedstock

Processing

- Pretreatment
- Enzymes
- Fermentation

BRAEMAR
ENERGY VENTURES

A Financial Perspective on Bioenergy

Biomass Research Development Initiative

September 10, 2007

Braemar Summary

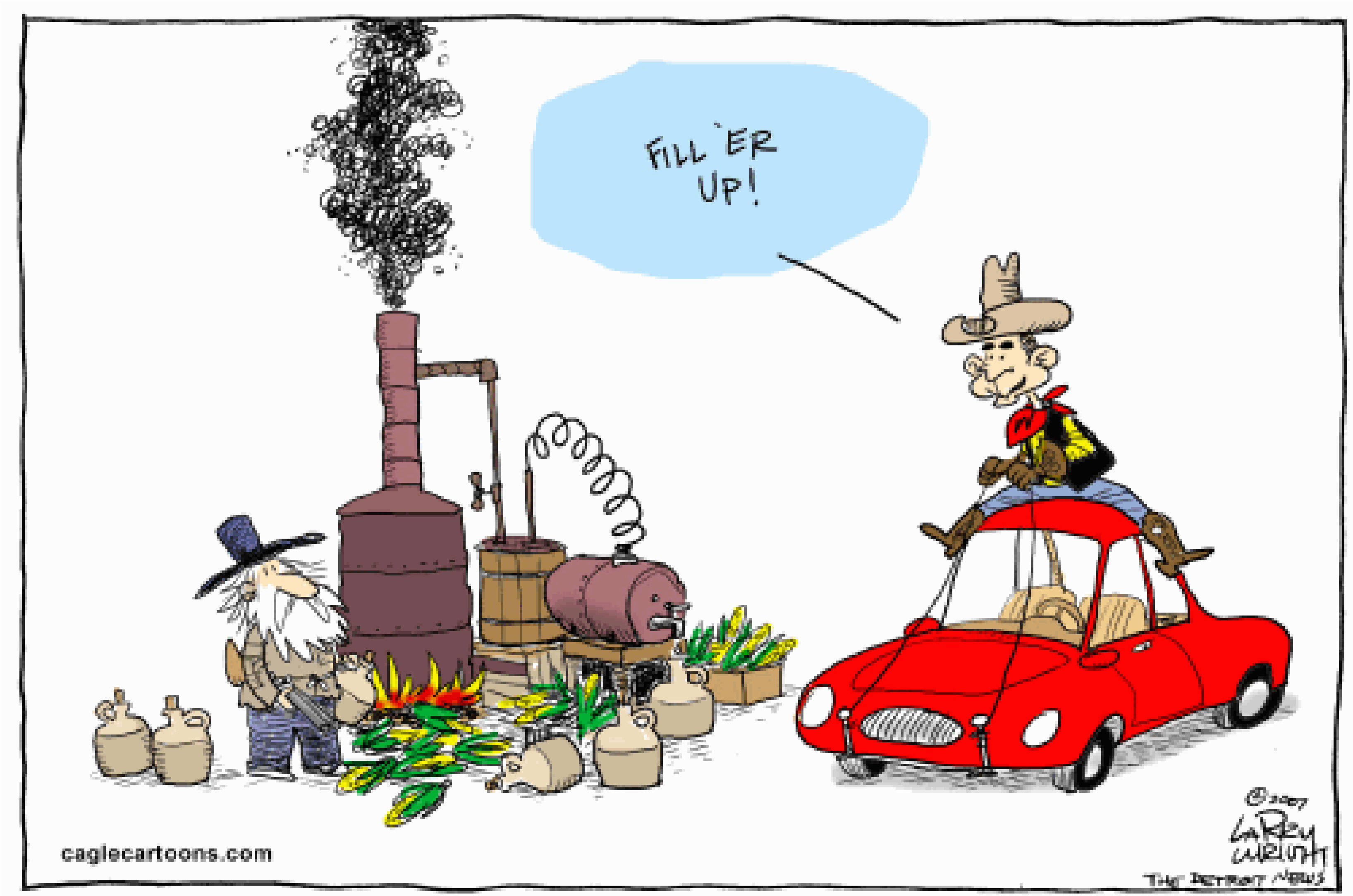
The Firm

- Braemar Energy Ventures is a venture capital firm devoted to financing companies developing new technologies for conventional and alternative energy markets.
- Braemar has one of the strongest teams in this specialized sector with over 100 years of collective energy experience, and extensive technical and operating skills.
- Braemar's first fund has a current book value of 3.0x investments and a gross unaudited IRR of 85.5%.
- Principals' prior energy and environmental investments returned $226 million on investment of $106 million through 10 IPO's and 11 trade sales.

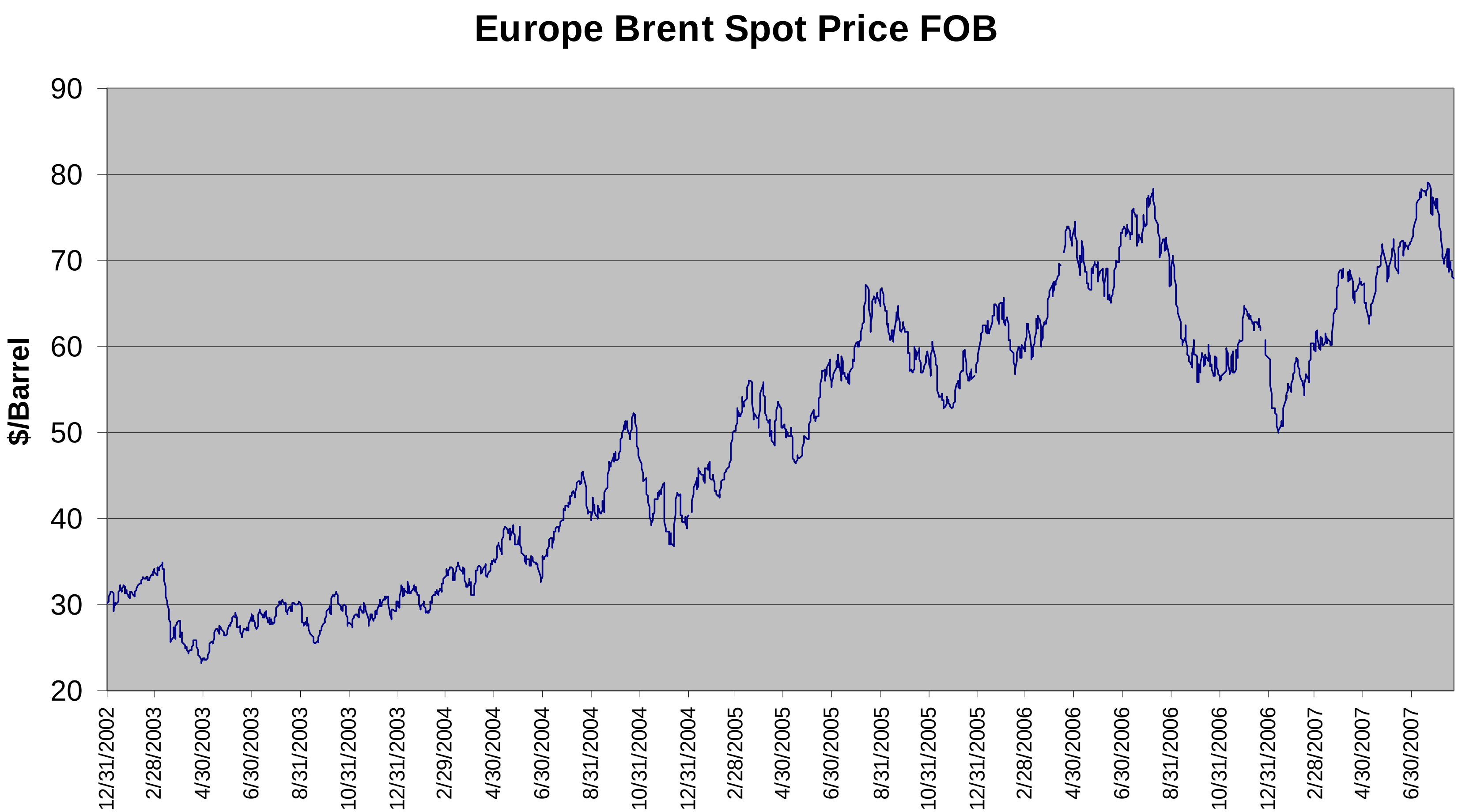
The Opportunity

- The multi-trillion dollar global market for energy is historically underserved from a technology perspective.
- Demand for new energy technologies is being driven by rising energy consumption, increasing environmental and security concerns, and strained infrastructure.

Makin' Alcohol Ain't Like It Used To Be…



Pressure on Oil Prices

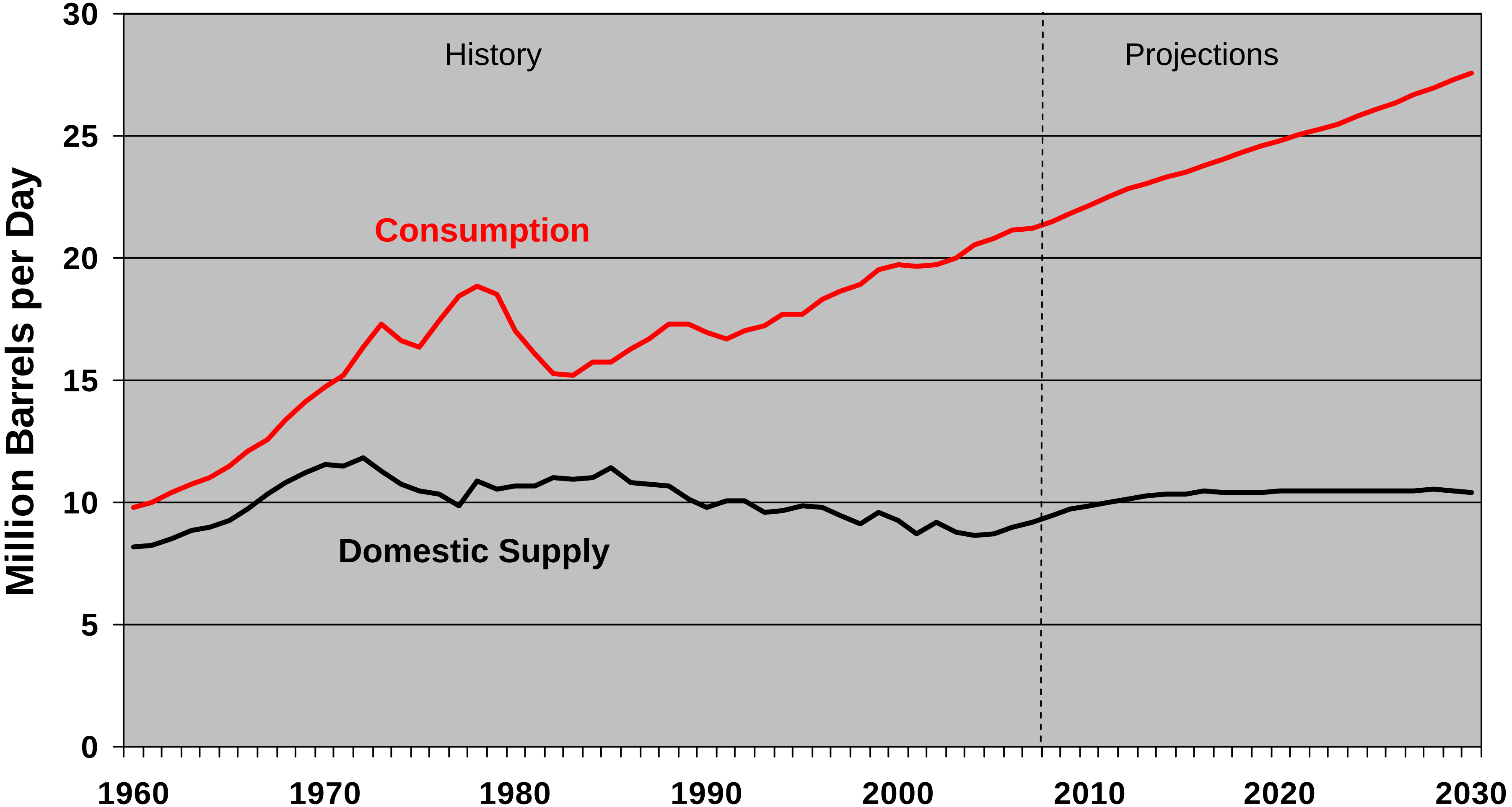


BRAEMAR ENERGY VENTURES

Source: EIA

Increasing Demand for Oil imports in US

Domestic Oil Consumption & Supply



Source: EIA Annual Energy Outlook 2006

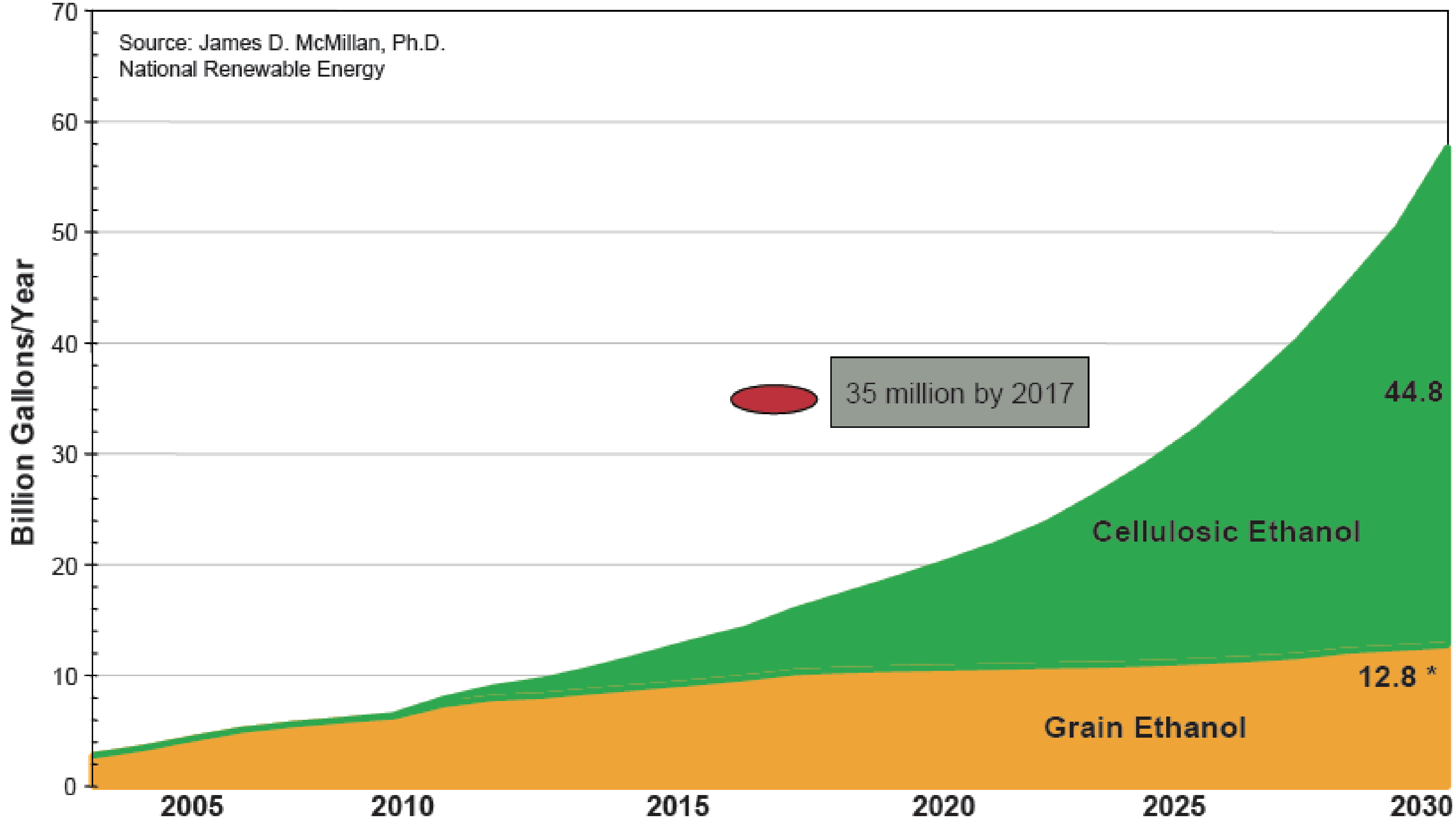
Why Cellulosic Ethanol?

- US DOE Developing 30 x 30 Road map to replace 30% of transportation fuels by 2030
- 1.3 billions tons of cheap abundant feedstocks in the US alone
- Fewer transportation bottlenecks (not limited to the breadbasket)
- No disruption to food production
- Reduced green-house gases
- Government Support and loan guarantees
- Expected to eventually become lower cost than grain ethanol

Market Opportunity—US Ethanol Demand

Reaching 60 Billion Gallons of Biofuels by 2030

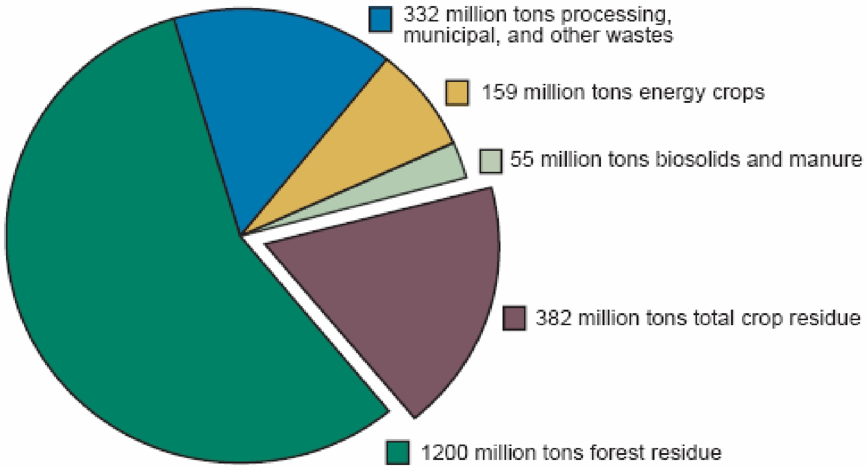
A Scenario for Growth of Ethanol to Supply 30% of 2004 U.S. Gasoline Demand by 2030



* Note: This number could be higher. The National Corn Growers Association predicts that as much as 15 -18 billion gal/yr could be produced from grain. Major changes to land use, exports, etc could also have substantial impacts. Regardless, significant cellulosic ethanol will be required to meet the 2030 goal and future national needs.

Source: NREL

No Shortage of Feedstocks for Cellulosic Ethanol



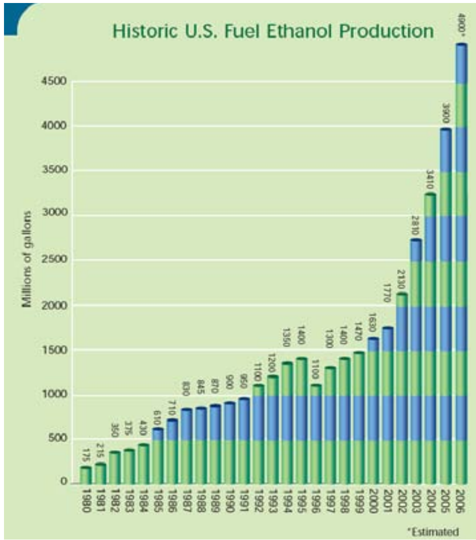
Arthur D. Little. 2001. "Aggressive Growth in the Use of Bioderived Energy and Products in the United States by 2010." Reference 71038. Final Report.

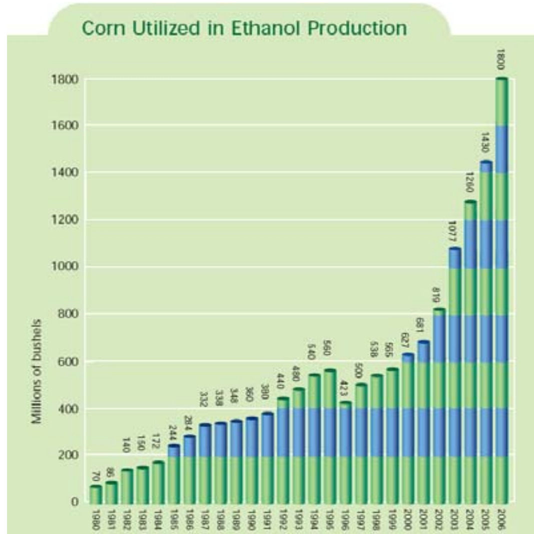
Source: DOE

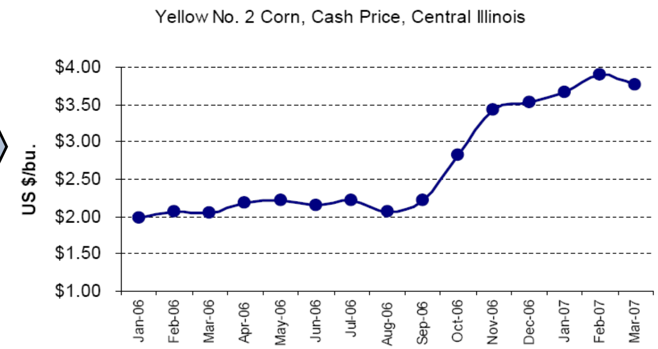
Locate Near Feedstock and Customer Fewer Transportation bottle necks

Source: Oak Ridge National Laboratories

Avoids Use of Corn to Prevent Disruption to Food Production







The Result…

USA TODAY

75,000 protest tortilla prices in Mexico

Updated 2/1/2007 9:43 AM ET

MEXICO CITY (AP) — Some 75,000 unionists, farmers and leftists marched to protest price increases in basic foodstuffs like tortillas, a direct challenge to the new president's market-oriented economic policies blamed by some for widening the gulf between rich and poor.

CNNMoney.com

Mexican government renews tortilla price cap

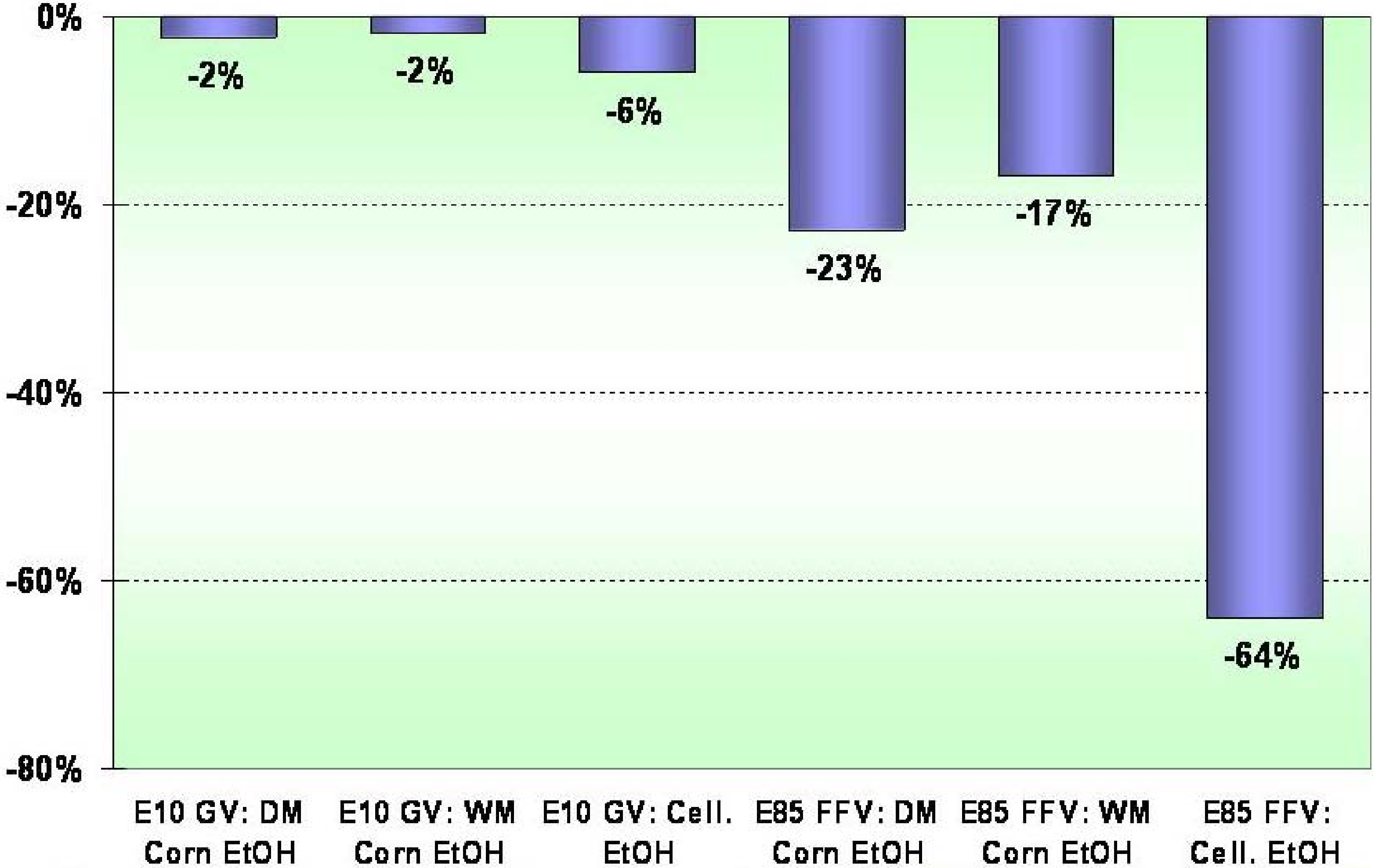
Price of the staple crop, pushed up by ethanol producers, threatens to spark inflation, angering consumers.

April 25 2007: 4:32 PM EDT

MEXICO CITY (Reuters) -- Mexico's government renewed a deal with retailers and producers Wednesday to cap prices of the food staple tortilla to control inflation and placate angry consumers.

Prices for corn, the main ingredient in tortillas, surged in December and January to their highest in a decade because of increased demand for the grain from U.S. ethanol fuel producers

Ethanol Blends, Especially E85 Made from Cellulosic Ethanol, Can Significantly Reduce GHG Emissions



Reductions in Per-Mile GHG Emissions by Ethanol Blend to Displace Gasoline

Source: Argonne National Labs

President's New Biofuels Initiative

- Reduce U.S. gasoline consumption 20% by 2017
  - -Require 35 billion gallons of renewable and alternative fuels by 2017 to displace 15% of projected annual transportation use
- President's 2008 Budget will
  - -Include nearly $2.7B for the Advanced Energy Initiative, an increase of 26% above the 2007 request
  - -Provide $179M for the President's Biofuels Initiative, an increase of $29M (19%) compared to the 2007 budget
- President's Farm Bill proposal will include more than $1.6B of additional new funding over ten years for energy innovation, including bioenergy research and $2B in loans for cellulosic ethanol plants

Source: NREL

DOE Selects Five Ethanol Conversion Projects for $23M in Federal Funding

- “These projects will play a critical role in furthering our knowledge of how we can produce cellulosic ethanol cost-effectively,” Assistant Secretary Karsner said.
- Commercialization of fermentative organisms is crucial to the success of integrated biorefineries.
- Fermentative organisms speed refining by converting lignocellulosic biomass material to ethanol.
- Winners
  - -Cargill Incorporated to receive up to $4.4 million
  - -Verenium Corporation to receive up to $5.3 million
  - -E.I. Dupont de Nemours & Company to receive up to $3.7 million
  - -Mascoma Corporation to receive up to $4.9 million
  - -Purdue University to receive up to $5.0 million

Source: DOE

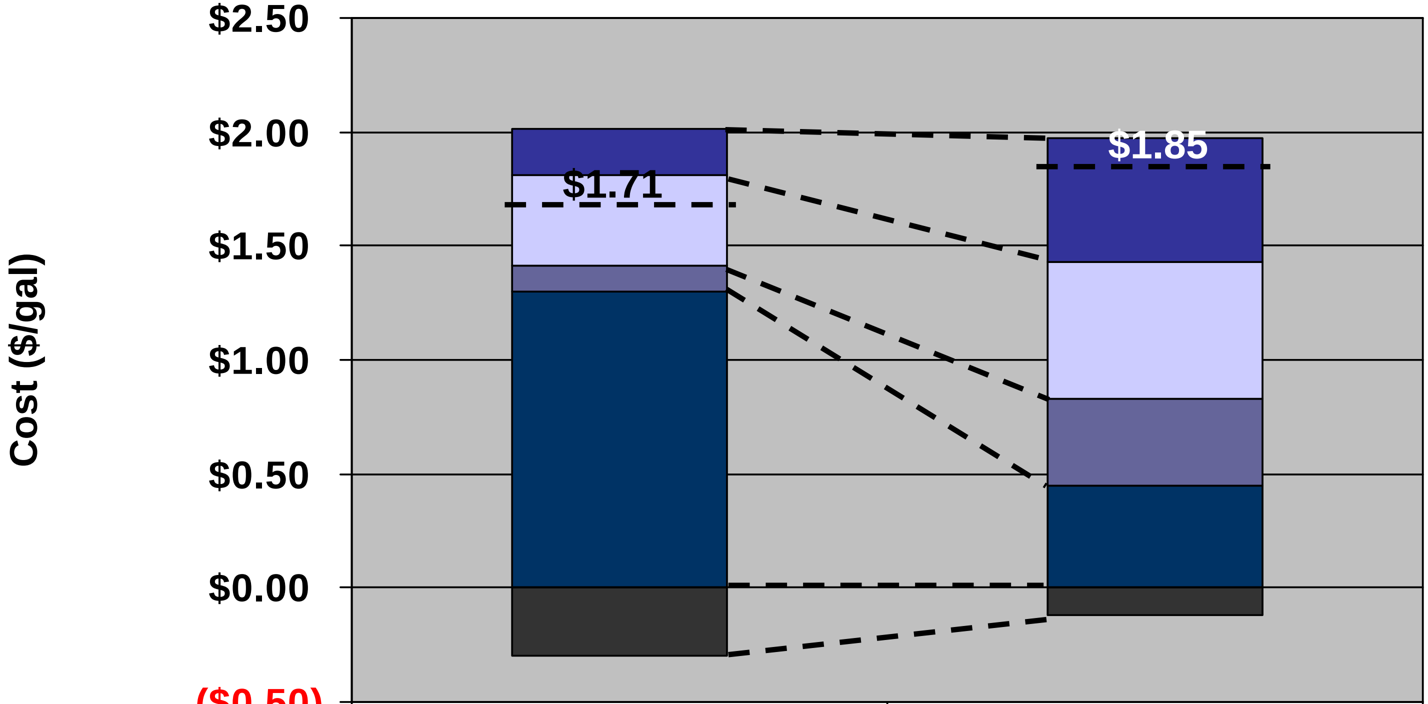
DOE Loan Guarantee Program

- The DOE Loan Guarantee Program authorized by EPAct of 2005 for alternative energy projects has been Funded
  - **Review of pre-applications has begun**
  - **Congress gave DOE authority to issue guarantees for up to $4 billion in loans**
- DOE hopes to announce selected pre-applicants before the end of the fiscal year (30 September 2007).
- On August 3, DOE hired David Frantz to direct the loan guarantee office
- For FY 2008 (beginning October 1 2007), the President is seeking authority to issue guarantees for up to **$9 billion** in loans
- Pre-application submittals are heavily weighted toward biomass
- DOE is under pressure to advance the Loan Program

Source: DOE

Cellulosic Plant Economics

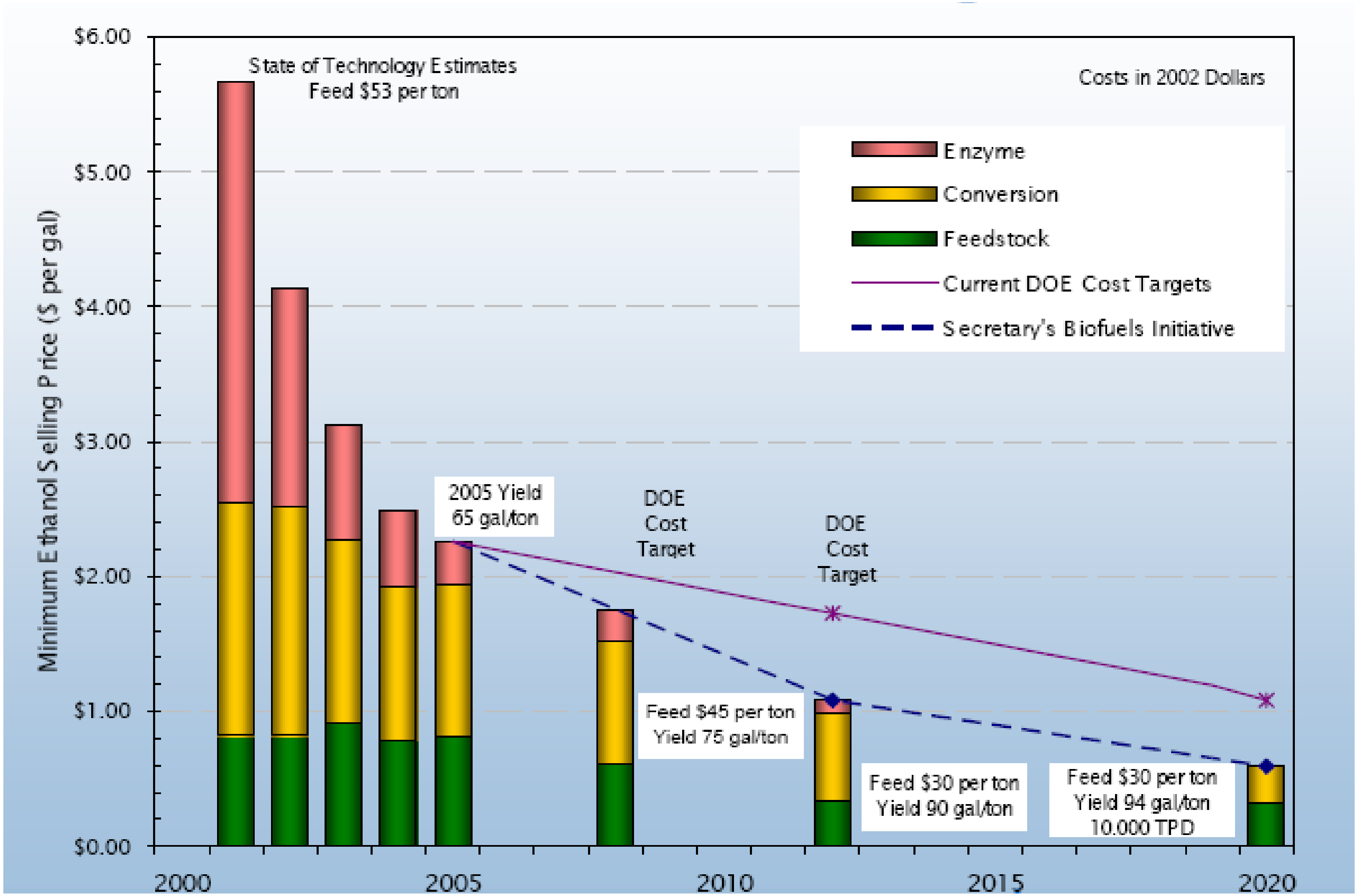
Corn Ethanol v Cellulosic Ethanol (25Mg/y)



	Starch	Cellulose
Depreciation of Capital	$0.20	$0.54
Variable Operating Costs	$0.40	$0.60
Fixed costs	$0.11	$0.38
Feedstock	$1.30	$0.45
Co-products	($0.30)	($0.12)

Notes: Based on data from USDA study comparing a traditional dry mill to a facility processing corn stover. Costs adjusted for inflation, commodity prices (corn at $4/bushel) and recent industry price quotes. Capex depreciated over 10 years. Does not account for any government subsidies.
Source: USDA, January 2005.

Cellulosic Ethanol Production Costs



BRAEMAR ENERGY VENTURES Source: NREL

Case Study: Enerkem Technologies

- Canadian gasification and catalysis group, spin-off of the University of Sherbrooke, Quebec. Based in Sherbrooke and Montreal. Staff of 26 full-time
- has a 125,000 gallon pilot plant which can produce syngas and alcohols from a variety of biomass wastes and will be producing ethanol by year end
- is about to build a 2 million gallon alcohol commercial demo plant to be operational in 2008
- is in discussions with partners to build three 10 million gallon commercial plants producing ethanol from municipal solid waste and wheat straw and being approached by others regularly
- has a highly evolved and thorough R&D plan committed to the development of downstream, high value added fuels and chemicals

Source: Enerkem Technologies

Case Study: What are the main barriers to commercialization for new tech biofuel producers?

There are essentially 4 major barriers which Governments can address:

1. Funding first commercial projects
2. Red tape
3. Permitting blue-print
4. Feedstock security

Source: Enerkem Technologies

Barrier 1: Funding first commercial projects

- First commercial 10 million gallon project costs expected to be in the $40 to $60 million range
- Significant venture capital funds now available in the market for biofuels but are typically directed at funding a company's development and organization, not projects. Realistically, as an average, approx. $10 to $20 US million from VC funds can be allocated to a first commercial scale project
- Company may be able contribute a further $10 US million in-kind (essentially engineering labor in project)
- $20 to $30 million i.e. approx 50% of total capital is still needed
- Technology not bankable at that point i.e. banks will not fund given technology has minimal profitability track record
- Government has to step-in for approx. 50% of the total investment

Source: Enerkem Technologies

Barrier 1: Funding first commercial projects

- Government investment ideally in the form of grants not to put pressure on the project's financials given likelihood of extended commissioning and marginal profitability of first projects
- Project could reimburse the funds without interest once it has started being profitable. Example of such Gvt funding program in Canada: SDTC $500 Million Next Generation Renewable Fuels Fund (www.sdtc.ca/en/news/media_releases/media_23032007.htm)
- Alternatively, loan guarantees could be considered by Gvt but this is suboptimal since it has a tendency of having the Gvt think as a banker and questions a technology's "bankability" (role of Gvt should be to unlock it not to question its "bankability")

Source: Enerkem Technologies

Barrier 1: Funding first commercial projects

- Farmer MAC or the Federal Home Loan Bank System charters could be expanded to allow these government sponsored enterprises (GSEs) to purchase renewable energy loans for a premium from lenders
- Congress could authorize the establishment of the "Renewable Energy Government Loan Corporation" that has a mission of purchasing renewable energy loans from lenders- loans could be pooled and securitized

Source: Crain Consulting

Barrier 2: Red tape of Government programs

- Application and Reporting requirements of most Gvt programs make it challenging for small companies to apply and follow-up
- In many cases only large corporations with sufficient administrative staff can deal with the red tape involved in certain Government funding programs
- Most technologies are developed by smaller, quicker and more creative entrepreneurial groups; not by large corporations. Therefore by making their programs so difficult for small companies Government is possibly “defeating its purpose” i.e. actually blocking the development of high quality technologies that the nation could be benefit from
- Efforts have to be made by Government to simplify its application and reporting requirements while making sure only the best candidates get selected (A big candidate doesn’t necessarily mean the best)

Source: Enerkem Technologies

Barrier 3: No permitting blue-print

- Most technologies have minimal permitting precedents
- Therefore permitting authorities require more information than usually before granting a construction permit. This slows down process and puts more cash pressure on technology groups as they have to continue funding their business and projects while permit demands are being processed
- It is the opposite that should actually occur: premiere projects of national priority should be considered as pilots from a permitting standpoint
- “Pilot Permits” should be quickly granted with close involvement/monitoring from planning authorities to gather data and build the case/blueprint for following commercial projects

Source: Enerkem Technologies

Barrier 4: Feedstock security

- Often difficult to convince biomass resource groups or waste managers to supply first commercial projects
- Government may be able to help by, in example:
  - "Incentivizing" resources (biomass, waste, crops etc) going to first industrial scale ups ($ per ton incentive)
  - Adjusting policy to prioritize the conversion of opportunity feedstocks into fuels vs. other uses. Perhaps eventually government could set a quota obligating a certain % of a specific resource to supply fuel to projects (e.g. setting penalties to pulp & paper groups for not converting 10% of their feedstock into ethanol)

Source: Enerkem Technologies

Cellulosic Ethanol Production Value Chain

Feedstock	Biomass Processing			Ethanol Recovery	Transportation/ Distribution/ Utilization
	Pretreatment/ Hydrolysis	Fermentation	Thermochemical		

Resource Development
- Ceres
- Syngenta
- Agrivida
- EdenSpace
- Dupont
- Monsanto
- Tate & Lyle
- Florida Crystals
- Chevron/ Weyerhauser
- Kruger

Biomass Handling and Collection
- John Deere
- Waste Management

Enzymatic
- Iogen
- Mascoma
- C5-C6
- Dyadic
- Novozymes
- Sigma Adlrich
- Actelios
- **Verenium**

Non-Enzymatic
- Bluefire
- Altra
- Sunopta
- Abengoa

Glucose
- Earthanol
- Citrus Ethanol

Pentose
- **Verenium**

Co-products
- Ambrozea

Gasification
- Lurgi
- **Enerkem**
- Thermo Chem Recovery Intl.
- Xethanol
- Woodland Biofuels
- Clear Fuels

Pyrolysis
- Dynamotive
- Ensyn

Catalysis
- Range Fuels
- Gas Technologies
- Coskata
- BRI

Ethanol Recovery:
- Transionics
- Ceramem
- Compact Membrane Systems
- Vaperma

Transportation/ Distribution/ Utilization:
- ADM
- Pure Energy Corp.
- Cillion
- Hawkeye
- Verasun
- Greenfield Ethanol
- Propel Biofuels
- Petrobras

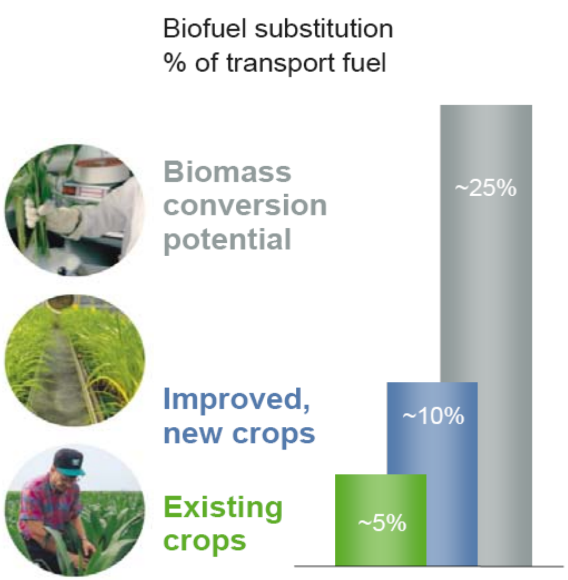
Resource Development

Parts of the Equation	Relevant Traits	Impact
Acres	▪ Stress tolerance (e.g. drought, heat, cold, salt)	▪ Growth on marginal acreage helps enable critical mass
Tons per acre	▪ Increased yield (e.g. photosynthetic efficiency)	▪ Lower production and transport costs and increased carbon sequestration
Dollars per acre	▪ Nutrient requirements (e.g. nitrogen utilization)	▪ Lower fertilizer costs and less N2O emissions
Gallons per ton	▪ Composition & structure (e.g. C5/C6, cell wall structure)	▪ Increase theoretical yield of ethanol per ton of biomass
Capital cost of refinery & variable cost per gallon	▪ Composition, structure & enzyme production (e.g. cellulases)	▪ Eliminate need for acid hydrolysis, reduce need for enzymes and bring actual yield closer to theoretical
Co-products	▪ Metabolic engineering & sequestration	▪ Enhance overall economics

Source: Ceres Company Presentations

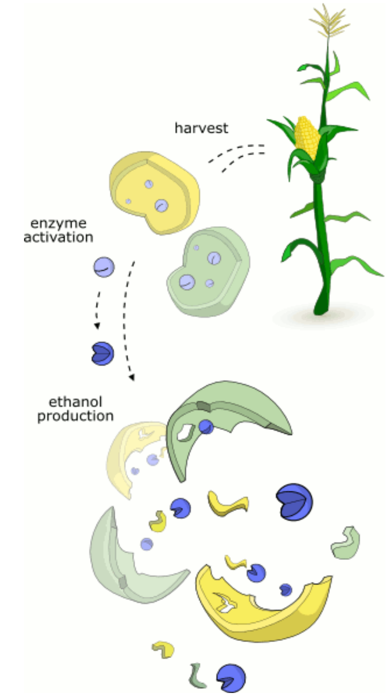
Some Examples of Energy Crop Developments

Syngenta –Designing GM corn which will to help convert itself into ethanol, by co-producing enzymes within kernels and well as research in plant-expressed enzymes in cellulose biomass-waste



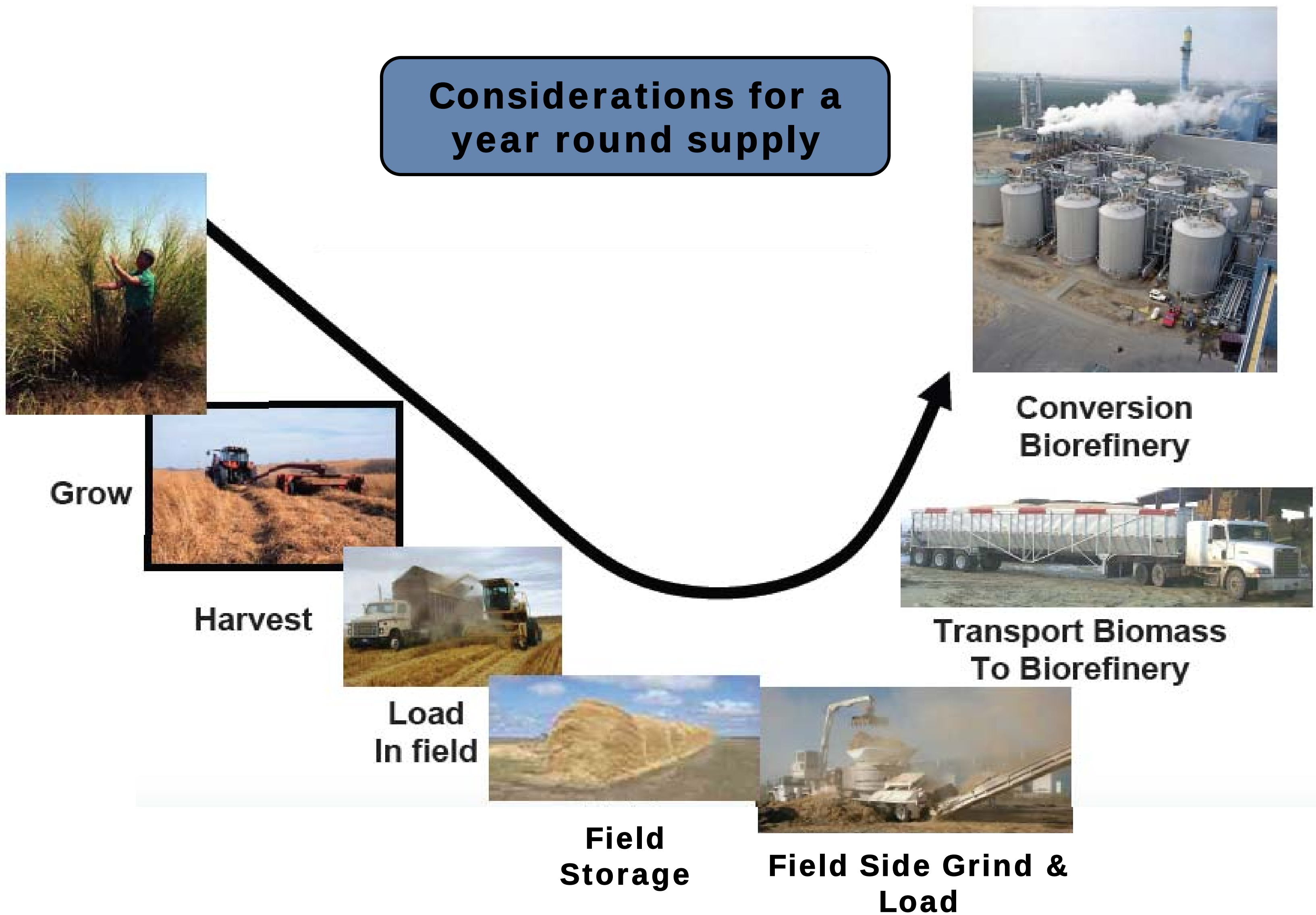
Ceres – Developing energy crops such as switchgrass, miscanthus, energycane and poplar for the production of biofuels utilizing breeding and genomics technologies to boost yields and increase usable acreage while minimizing energy inputs

Agrivida – Working on improved liquefaction and saccharification characteristics for entire corn plant to be converted into ethanol, including the unused stover



Source: Company Websites

Biomass handling



Sources: ORNL, UT Battelle.

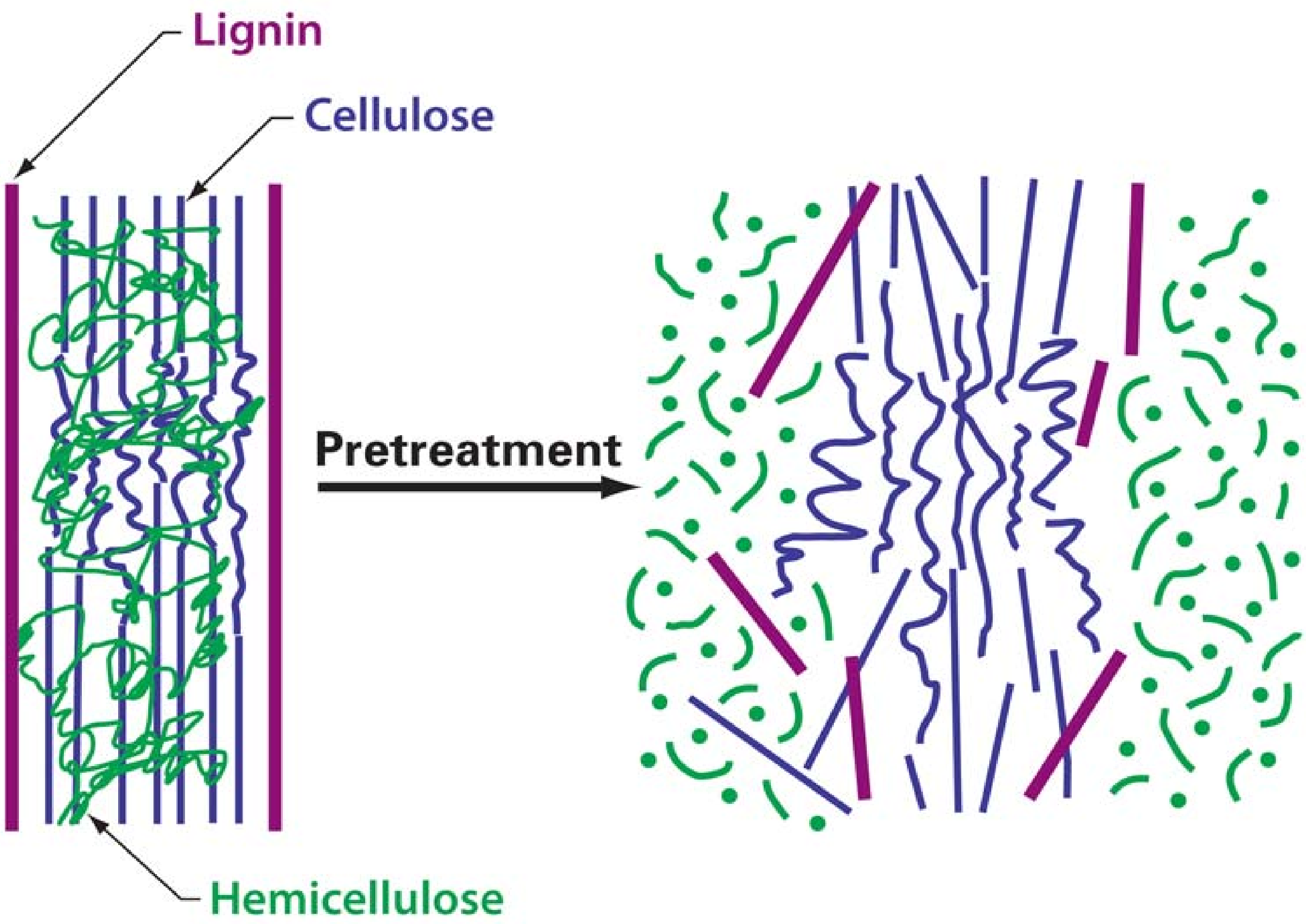
Novel methods of harvesting

New methods under development for collecting corn *and* stover simultaneously

John Deere Combine with stover attachment

Modified Claas head

Pretreatment

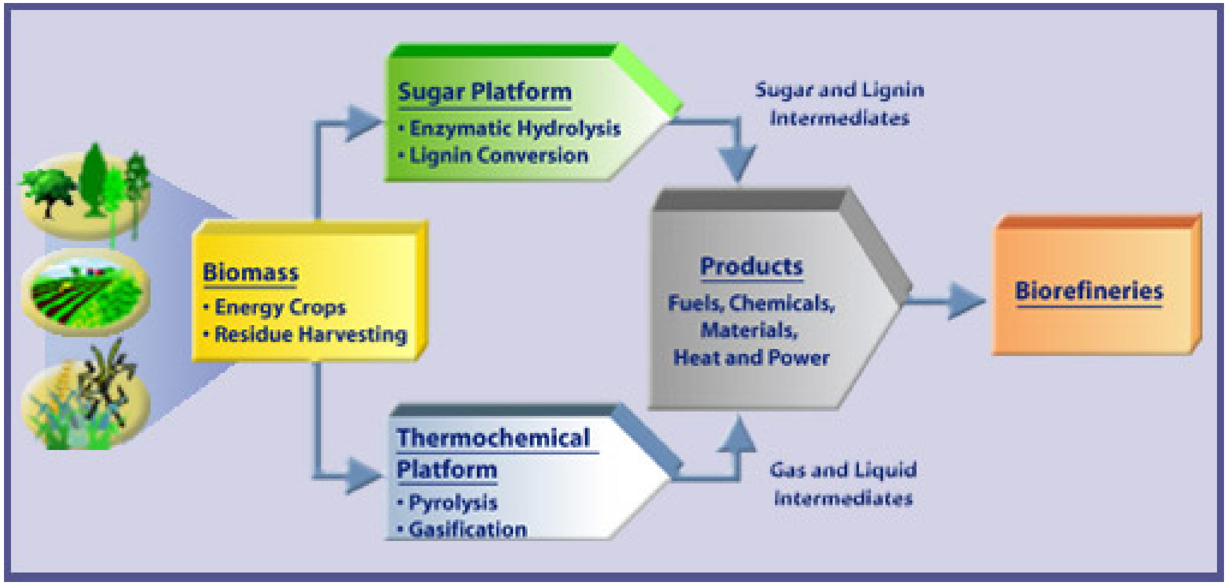


Pretreatment methods

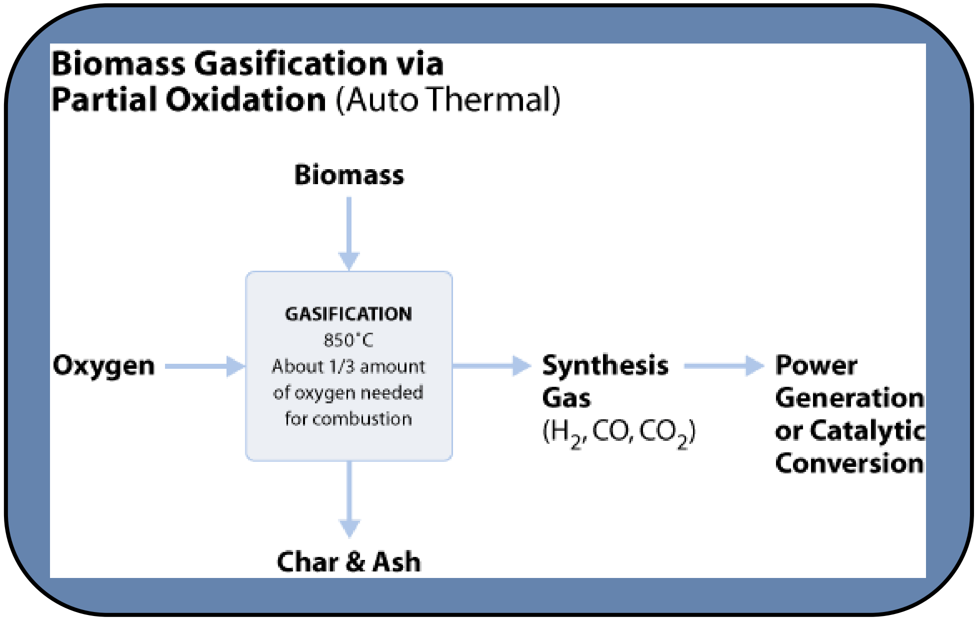
Approach	Technologies	Pros	Cons
Physical	Freeze/Thaw Cycles Radiation Mechanical Sheering Pyrolysis	• No chemical or water inputs • No toxic residuals	• High energy input • Limited effectiveness • Expensive
Biological	Microbial/Fungal Enzymatic	• Good cellulose and lignin degradation	•Not very efficient •Requires long treatment times
Bio-chemical	**Non Catalyzed** Steam Explosion Hot Water (batch) Hot Water (percolation) Hot Water pH Neutral	• Hydrolyze significant fraction of hemicellulose • Prevents lignin re-precipitation • Relatively well understood	• High energy input • Often requires additional processing or the addition of a catalyst for maximum yield
	Acid Catalyzed Nitric Acid Sulfer Dioxide Sulfuric Acid Sulfuric Acid (hot wash process)	• Hydrolyze significant fraction of hemicellulose • Can reduce cost	• Some undesirable glucose degradation • Byproducts can inhibit fermentation
	Base Catalyzed AFEX/FIBEX Ammonia Lime	• More effective at solubilizing a greater fraction of lignin • Can reduce cellulase requirement	• Leaves much of the hemicellulose in an insoluble polymetric form
	Solvent-Based Organosolv (Clean Fractionation)	• Hydrolyze significant fraction of hemicellulose • Can provide more valuable byproducts	• Significantly more expensive • High energy input
	Chemical-Based Peroxide Wet Oxidation	• Extremely simple • Low energy input • By products do not inhibit fermentation	• Not very efficient when used alone • Requires highly consistent feedstock • Leave a large portion of cellulose in solid fraction

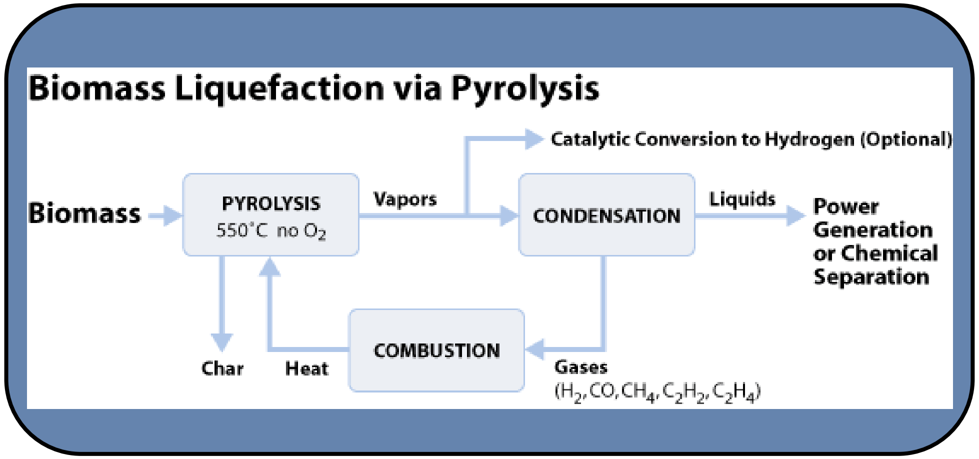
There are multiple pathways for biomass conversion

- Fermentation (the sugar platform) is only one method for converting biomass to ethanol
- Various thermo-chemical methods are also viable pathways for the creation of a variety of biofuels



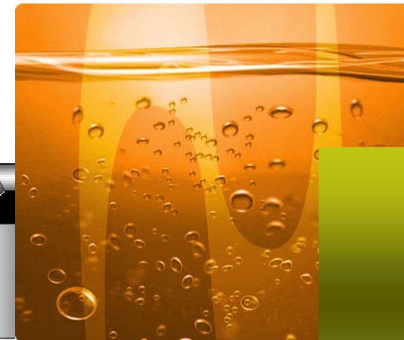
Thermo-chemical approaches to biomass treatment



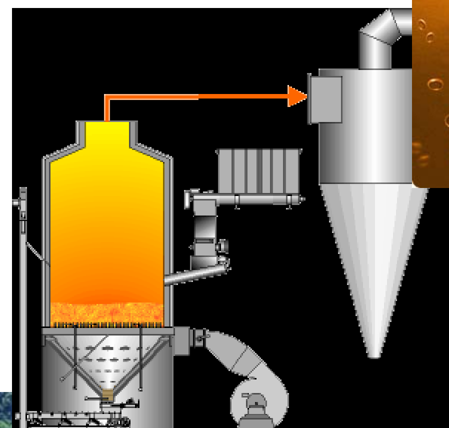


Technology Progression

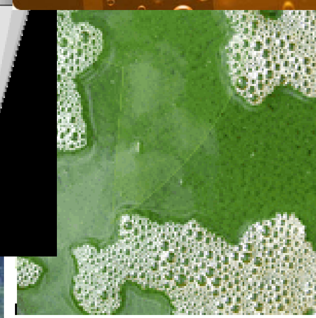
Synthetic Biorefinery



Gasification

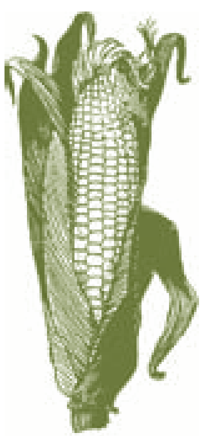


Direct Synthesis?



Algae

Corn



Cellulosic Bioethanol

Where in the Supply Chain Should a VC Invest?

- Resource Development (Feed stocks)
- Biomass Handling
- Pretreatment
- Biochemical Treatments –Sugar Production
- Gasification Treatments/Catalytic Conversion
- Ethanol Recovery
- Integrated Plant Systems
- Energy Reduction Technologies
- Transportation and Storage Technologies
- All the above

Answer

- **Resource Development Technologies / Feed stocks**
  - Technology to improve yields and increase processing efficiency will significantly reduce costs
- **Pretreatment**
  - Low cost enzymes and/or little or no enzymes
- **Integrated Biochemical Plant Systems for Homogenous Waste Streams**
  - Full value is recognized from systems that can produce high volumes of low cost sugar and convert sugars into ethanol at the highest possible concentrations
- **Integrated Gasification Systems for Homogenous and Non Homogenous Waste Streams**
  - Full value is recognized from producing large volumes of low cost syngas and catalytically converting syngas into ethanol or other biofuels.
- **Ethanol Recovery**
  - Alternatives to distillation
  - Improved Catalysts
- **Energy Reduction / Water Reduction Technologies**

To What Extent should VCs be Investing in Capital Intensive Projects?

- Pilot Plant
- Demo Plant
- Commercial Plants
- All of the Above

Answer

- VCs should be prepared to invest in pilot, demo and part of small commercial plants with some government funding support, then use proven technology to develop projects with third party financing and/or launch an IPO.
- Licensing is an alternative, but revenue generation is much more limited.

Strong Partners needed for VC Backed Companies to be Competitive and Scale

- Strategic Partners
  - -Project Developers/EPC contractors
  - -Industrial Companies with low cost Feedstocks
  - -Industrial Biotech Companies
  - -Energy companies

Financial Partners

Large Private Equity Funds

Hedge Funds

Key Lessons learned Investing in Cellulosic Ethanol

- Commercializing Cellulosic Ethanol technology has many technical challenges, takes longer and costs more than one would expect.
- If your technology is new, make sure you grill your proposed contractor to make sure you really understand the contractor's capabilities and risk tolerance for new technology
- A great technology is important, but a strong management team is still the key
- A bull market has advantages, but also have disadvantages, i.e. shortage of contactors, suppliers and engineers.
- Government support and loan guaranties are important
- Make sure you have an experienced rock-solid investor syndicate
- Make sure you understand the entire supply chain

Potential Exit Strategy

- IPO
  -Verasun, Aventine

- Merger with a Public Company
  -Celunol/Diversa > Verenium

- Strategic Buyer
  -ADM, Cargill, Broin, Pacific Ethanol
  -Shell, BP, Chevron

- Financial Buyer
  -Energy focused private equity groups

Comparable Company analysis for Cellulosic Ethanol Companies

COMPARABLE COMPANY ANALYSIS

COMPANY	STOCK PRICE 9/5/2007	52 WEEK HIGH	52 WEEK LOW	MARKET CAP	TEV	LTM Rev.	LTM EBITDA	NTM Rev.	TEV/ LTM Rev.	TEV/LTM EBITDA	TEV/ NTM Rev.	LTM EPS*	NTM EPS*	LTM PE	NTM PE
Cellulosic															
Abengoa Bioenergy Corporation	5.59	5.66	2.75	91.68	105.81	164.51	13.19	NA	0.64x	8.02x	NA	0.30	NA	18.90	NA
Colusa Biomass Energy Corp.	0.18	0.18	0.02	7.09	7.08	-	-	NA	-	-	NA	(0.01)	NA	(13.24)	NA
Xethanol Corporation	0.97	4.50	0.90	28.61	10.97	10.93	(8.24)	NA	1.00x	-1.33x	NA	(0.84)	NA	(1.16)	NA
Bluefire Ethanol Fuels, Inc.	4.61	7.90	1.30	102.22	102.80	-	-	NA	-	-	NA	-	NA	-	NA
Verenium Corporation	5.50	6.98	4.10	356.81	364.41	51.53	(14.75)	NA	7.07x	-24.71x	NA	(1.59)	NA	(3.47)	NA
Biotech															
Dyadic International, Inc.	5.30	7.10	3.65	158.68	130.18	15.38	(8.61)	20.04	8.46x	-15.12x	6.50x	(0.45)	(0.40)	(11.89)	(13.25)
Genencor International, Inc.	19.27	19.30	13.48	1,158.51	1,223.50	410.42	70.03	NA	2.98x	17.47x	NA	0.31	NA	62.39	NA
Novozymes A/S	662.00	705.00	402.50	40,915.24	42,479.24	6,662.00	1,732.00	NA	6.38x	24.53x	NA	13.22	NA	50.07	NA
Syngenta AG	227.30	248.30	175.90	22,145.65	23,882.41	7,919.00	1,512.00	8,895.92	3.02x	15.80x	2.68x	6.67	11.53	34.10	19.71
Ethanol															
Archer-Daniels-Midland Co.	33.05	42.35	30.20	21,753.17	26,375.17	37,416.08	3,022.09	45,161.55	0.70x	8.73x	0.58x	2.32	2.68	14.23	12.34
Holdings, Inc	14.50	28.83	13.10	607.58	531.70	1,451.74	110.37	1,813.65	0.37x	4.82x	0.29x	1.23	0.63	11.84	23.12
Pacific Ethanol, Inc.	11.84	19.80	11.24	481.28	635.47	181.87	(0.51)	466.11	3.49x	-1252.55x	1.36x	(2.73)	0.30	(4.33)	39.15
Verasun Energy, Corp.	13.11	26.90	12.11	1,049.07	1,291.42	509.25	173.03	1,253.43	2.54x	7.46x	1.03x	0.83	0.78	15.82	16.70

* LTM Diluted EPS Before Extraordinary Items

Valuation in this area requires a multi-disciplinary approach

Source: CapitalIQ

Recommendations for Cellulosic Industry Development and Growth

- Implement a stronger RFS Standard that helps meet the DOE 30x30 Road map or supports the President's initiative to reduce gasoline consumption by 20% in 2017
- Develop strong and flexible loan guarantee programs
- Create a Production Tax Credit for cellulosic ethanol producer
- Address Crop Risk Insurance issue regarding moving from more traditional crops to energy crops
- Develop a national carbon reduction strategy either in the form of a cap and trade system or implement a carbon tax that will help provide more incentive for cellulosic ethanol developers

Summary

- Cellulosic ethanol has the potential to replace a significant portion of US gasoline consumption but several technical, logistical and project finance challenges must be solved
- Cellulosic ethanol development has powerful market drivers: High volatile oil prices, Renewable Fuel Standards, environmental concerns, subsidies, energy security and growing numbers of financial and strategic investors
- VCs investing in companies that commercialize cellulosic ethanol production must be very patient investors and prepared to leverage government support and strategic relationships

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BIOMASS RESEARCH & DEVELOPMENT INITIATIVE

Analysis Subcommittee Review of USDA/DOE "Foundational" Documents

Ralph Cavalieri
Ed White
Doug Hawkins
John Hickman
Charles Kinoshita
Eric Larson
John McKenna

Procedure

- Quality of Assumptions
- Quality of Data
- Appropriateness of Analysis Methods
- Are Conclusions Supported by the Analysis
- Quality of Peer Review

1. [ARS] Crop and soil productivity response to corn residue removal: A literature review, by *Wilhelm, et al.*

Reviewers: John Hickman (Lead); Eric Larson, Ed White

Summary: Very well done review. This article qualifies as a foundational document into providing important background information as to the maximum permissible corn stover removal rates that ensure sustained soil productivity.

2. [ARS] A matter of balance: Conservation and renewable energy, by *Johnson, et al.*

Reviewers: John Hickman (Lead); Charles Kinoshita

Summary: Overall, this article does not qualify as a foundational document or analysis. Rather it is more of an editorial, based on limited data, that we need to be more cautious in guidelines to remove crop residue until better data is available. The paper also proposes an alternative approach to determine crop residue removal guidelines. The concepts proposed by the authors deserve serious consideration and debate in developing residue removal guidelines, but must be supported by more science based research. Recommendations, at a minimum, must recognize that crop residue conversion to biofuels provide tangible environmental benefits, albeit how to balance such benefits aside soil sustainability will be difficult.

3. [ARS] Enhanced Biotransformation of Furfural and Hydroxymethaylfurfural by Newly Developed Ethanologenic Yeast Strains, by Liu *et al.*

Reviewers: Ralph Cavalieri (Lead); Ed White

Summary: Reports research dealing with development of strains of ethanol-producing yeasts that were more tolerant of inhibitory fermentation products, furfural and hydroxymethylfurfural (HMF). The adpated strains were able to convert 100% of HMF into FDM, a less inhibotry metabolite, while retaining ethanol productivity. The methods used are appropriate and the conclusions are supported by the data collected. The article is published in a blind peer-reviewed journal, so it meets the scientific standards of peer-reviewed scholarship.

4. [ARS] Bacteria engineered for fuel ethanol production: Current status, by Dien, *et al.*

Reviewers: Charles Kinoshita (Lead); Ed White

Summary: The document is a review paper, not an analysis, therefore there were no key assumptions or appropriate analysis methods used. The review paper is very thorough within its narrow focus area and the data quality is extensive. The conclusions are reported very succinctly. The publication presumably was peer reviewed by a confidential panel of experts.

5. [OCE] The 2001 net energy balance of corn ethanol, by Shapouri and McAloon

Reviewers: John Hickman (Lead); Eric Larson; Ed White

Summary: Key assumptions were appropriate. The authors should report more details as to the procedures to allocate energy to ethanol and co-products and compare their results to that utilized in other studies. Some of the data quality was poor. The authors also do very little to conclude that methodology to determine energy use and allocate total energy between ethanol and co-products is indeed an improvement over previous studies. This appears to be an internal document without peer review. The author's have other more detailed reports which would appear to be better classified as a "foundational" document as compared to this report.

6. [OCE] Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus

Reviewers: Eric Larson (Lead), Ed White, Doug Hawkins

Summary: Assumptions behind the analysis are described clearly and, in most cases, they are well justified. The detailed methodology is well described conceptually. Two sensitivity studies were carried out, which provides helpful insights. However, it would have been appropriate to include at least one additional sensitivity study focusing on alternative methods for allocating by-product credits. Very detailed input data are provided. The conclusions are generally well-supported by the analysis. It is unclear what independent review was undertaken of this document.

7. [FS] Engineering yeasts for xylose metabolism, by Jeffries

Reviewers: Ralph Cavalieri (Lead), Ed White

Summary: This is a review article published in a peer-reviewed journal. As such it does not lend itself to our normal assessment. It is a relatively thorough review of the state of published knowledge as of the date of its writing, sometime in 2005. It is especially useful in its conclusion that careful adherence to anaerobic conditions during adaptive evolution of yeast strains is necessary for success and that *P. stipitis* along with new strains derived from nature are important areas of continuing research and development. While an important document, it is unclear why this is considered to be a "foundational document" to the USDA as it plans its biomass program.

8. [OBP] Bob Reynolds' Ethanol Infrastructure Report

Reviewers: Doug Hawkins (Lead), Ralph Cavalieri, John McKenna

Summary: Overall, the report provides one scenario for large scale ethanol production and does a very good job of analyzing the infrastructure that might be required to distribute and store this much fuel. There are aspects of the report which feel "incomplete" – such as the analysis of potential ethanol production from dedicated cellulosic energy crops. The assumptions that there will be demand for fuel ethanol in the years and at the levels of production contemplated in this study are reasonable assumptions to make. Although , they reference their own earlier work for some assumptions. It would be more appropriate to reference an independent prediction – say from DOE or DOT on this matter.

8. [OBP] Bob Reynolds' Ethanol Infrastructure Report (con't)

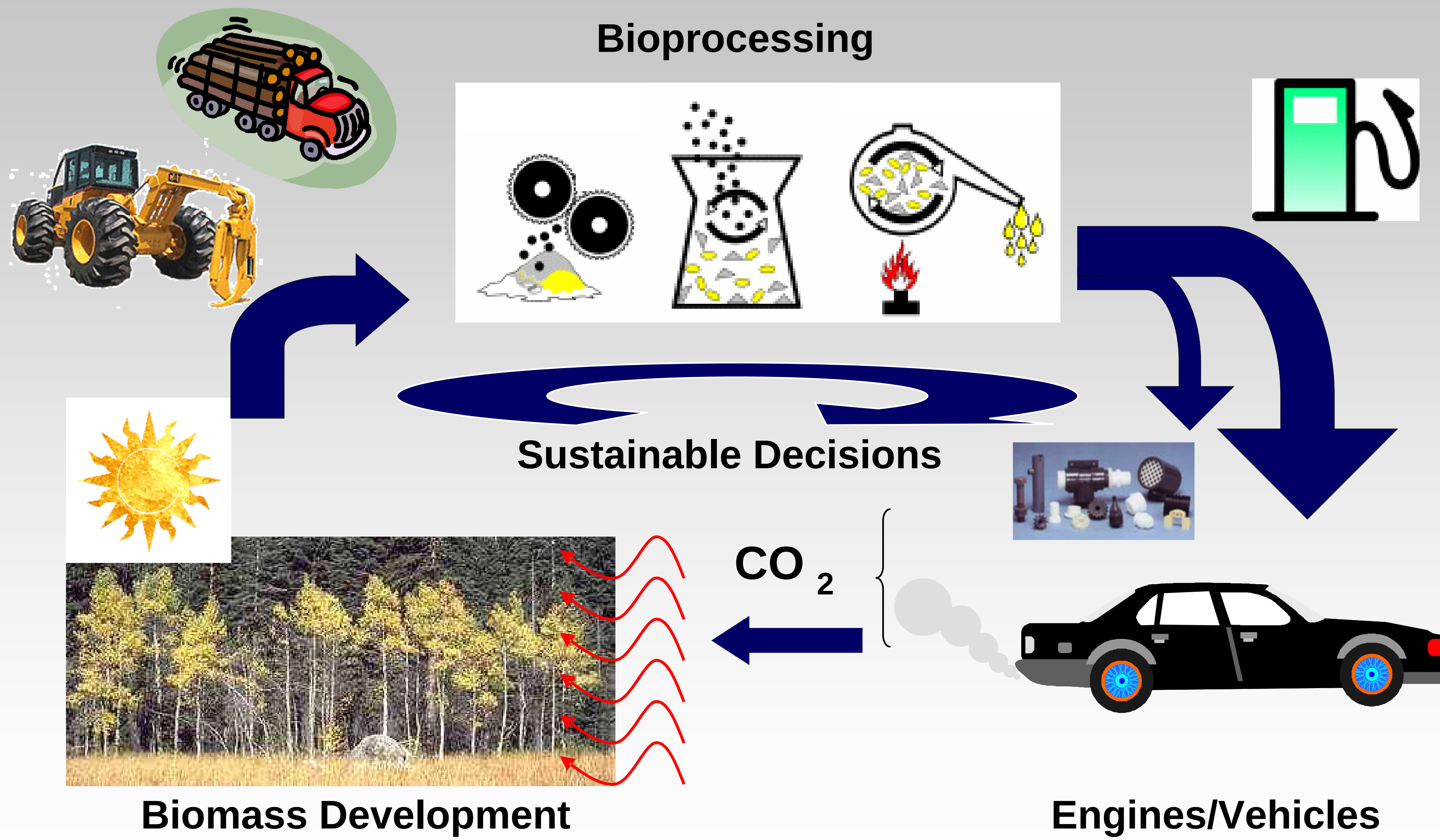
Summary (con't): One of the curious methods employed in this work is the estimation of costs required for ethanol infrastructure followed by the subtraction of costs that would have been required for gasoline infrastructure projects (based on increased gasoline demand). The approach can best be described as "how much ethanol can come from corn if nothing else matters" coupled with "if one produced 40 BGY of ethanol from corn, what would it cost to move, store, blend and distribute it". One of the curious methods employed in this work is the estimation of costs required for ethanol infrastructure followed by the subtraction of costs that would have been required for gasoline infrastructure projects (based on increased gasoline demand). In the production area, the data quality is "OK". Reasonable ethanol production values are used and referenced, potential increases in productivity are similar to those used in other reports. There are areas where data is lacking – cost to build a cellulosic ethanol plant, for example. There is also a need to have a better idea of where long-term steel prices will go – given the large impact of steel cost on the overall cost of plants and infrastructure.

Michigan Tech's Wood to Wheels Initiative

David D. Reed, Ph.D.
Vice President for Research

MichiganTech

Wood-to-Wheels (W2W)



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W2W Mission

- To create and disseminate knowledge/ technologies related to W2W
  - Woody Biomass Development/Recovery
  - Biochemical/Thermochemical Processing
  - Engine/Vehicle Systems
  - Sustainable Decisions

- To facilitate the creation and promote the growth of businesses engaged in the W2W value chain

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What is W2W?

- **Research initiatives:**
  - Address the entire W2W value chain: Forest resources → Harvesting/logistics → Biochemical Processing → Biofueled vehicles
  - Engaging researchers from across entire Michigan Tech campus: Forestry, Engineering, Sciences, Business

- **Educational programs:**
  - New multi-disciplinary approach to graduate education
  - Broader issues: professional development, leadership, entrepreneurship, sustainability concepts
  - Impact on undergraduate curricula and courses

- **Technologies that support commercial-scale production**

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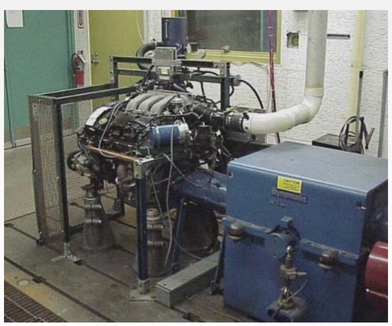
Woody Biomass Development

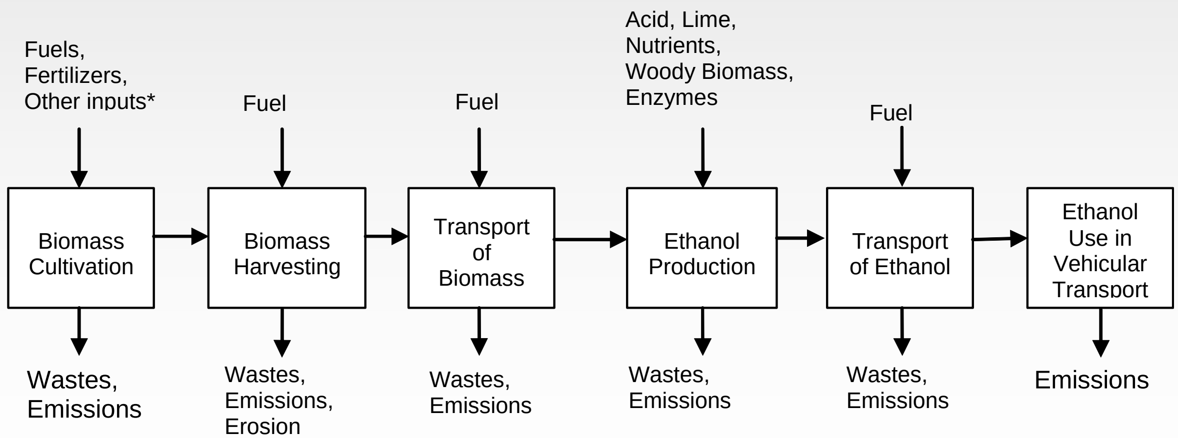
Bio-Processing

Wood-to-Wheels

Vehicle/Engine Systems



Sustainable Decisions



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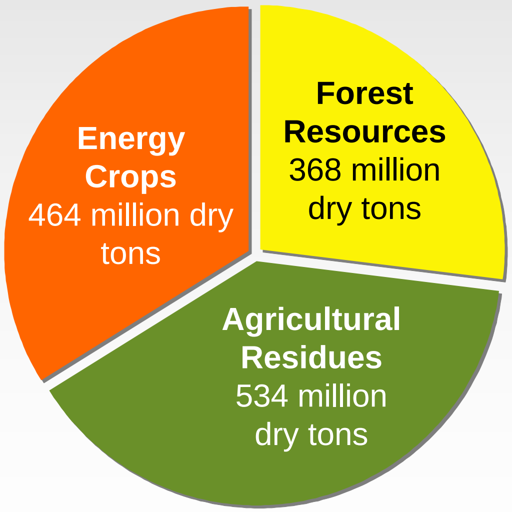
Biomass Development: Inventory – How much gasoline could biofuels replace?

The "Billion Ton Vision"

Enough biomass is available in the US to replace 30% of current gasoline consumption



The "1.8 Million Ton Vision"

If on average the 315,000 UP residents use 482 gal/yr, this corresponds to:

- **151.7 mil gal gasoline**
- **182.7 mil gal E85**
- **155.3 mil gal ethanol**
- **1.8 mil dry tons of lignocellulosic biomass**

Can we recover this much biomass?

Prof. Robert Froese
School of Forest Resources and Environmental Science

MichiganTech

Just forest residues can replace 75% of U.P. gasoline consumption with E85

Biomass Feedstock Supply in the Michigan Upper Peninsula, in dry tons per year and $2005

Biomass Feedstock		Potential Supply	Currently Available and Unutilized	Available at $25/ton Farmgate Price
Forestry	Sawmill and pulp mill residues	1,493,601	Negl.	343,528
	Logging residues	503,243	503,243	65,422
	Thinning residues	853,800	853,800	110,994
Forestry Total		2,850,644	1,357,043	519,944
Urban Wood Waste		41,962	41,962	5,455
Dedicated Energy Crops		606,219	Negl.	6,062
Grand Total		3,498,825	1,399,005	531,461

Sources: USDA, DOE, Walsh (2006, unpublished) and MTU Forest Resources and Environmental Science

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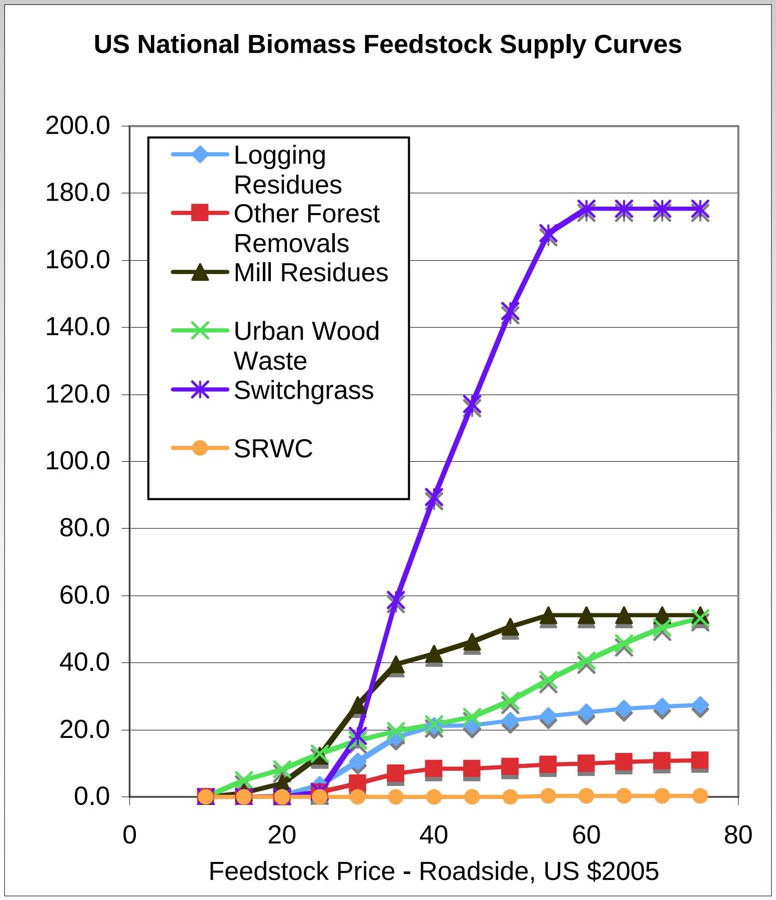
A successful biofuel industry depends on a reliable and sustainable feedstock supply



"The lack of credible data on price, location, quality and quantity of biomass creates uncertainty for investors and developers of emerging biorefinery technologies." (Office of the Biomass Program, U.S. Dept. of Energy 2005)

"Feedstock cost and potential supply are very sensitive to tradeoffs among competing land uses and competing resource values, such as wildlife habitat." (De La Torre Ugarte et al. 2006)

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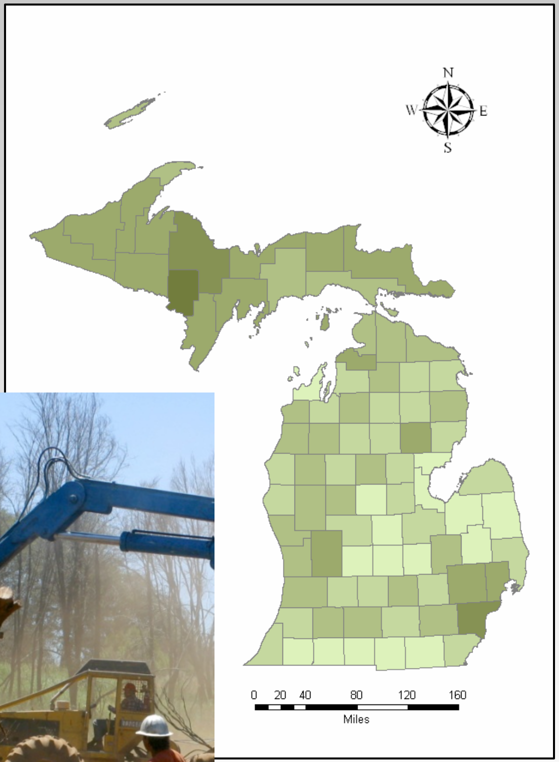
Initiatives relating to Woody Biomass:



- **Geographic Information System (GIS) Analysis and Modeling**
  - **Land use/cover maps**
  - **Spatial inventory of available woody biomass**
  - **Optimization and validation of forestry models for biomass and carbon**
- **Biotechnology**
  - **Faster growing trees**
  - **Optimized woody components for cellulose based enzyme consumption**

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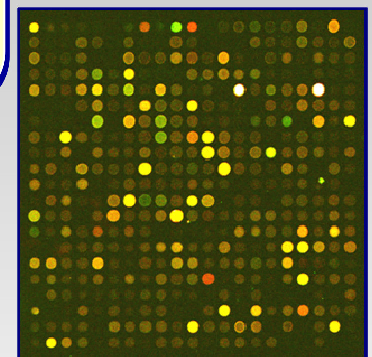
Forest Functional Genomics & Biotechnology

Our expertise:

Micropropagation
Gene transformation
Molecular biochemistry
Whole-genome microarray and metabolite profiling

Research areas:

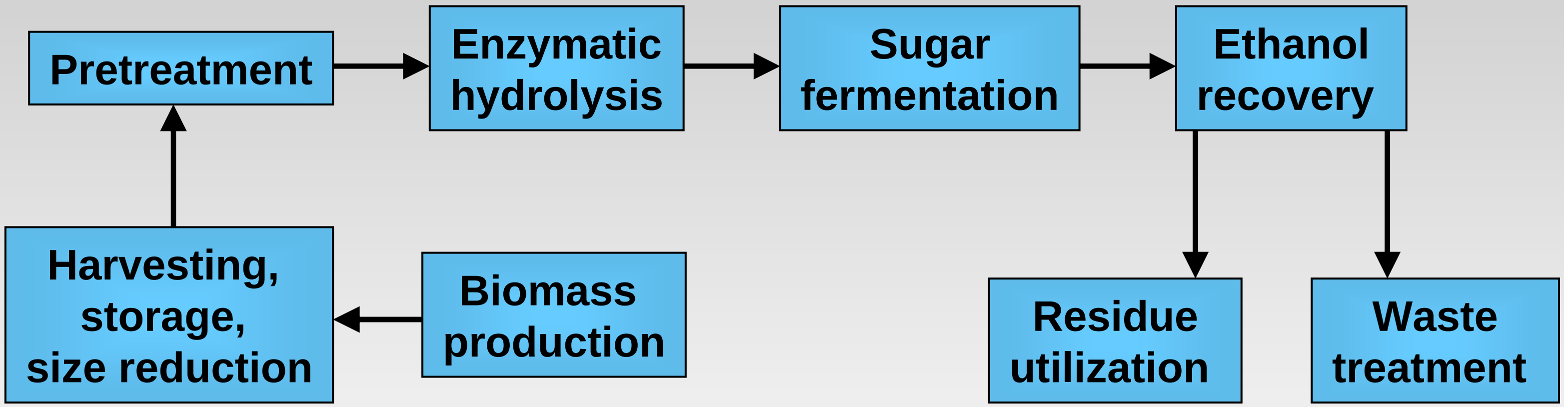
Wood formation
Defense & fitness
Natural variations
Carbon sequestration



Microarray Gene Expression Analysis

Metabolite Profiling
&
Chemical Fingerprinting

Cellulosic Biomass Conversion to Ethanol



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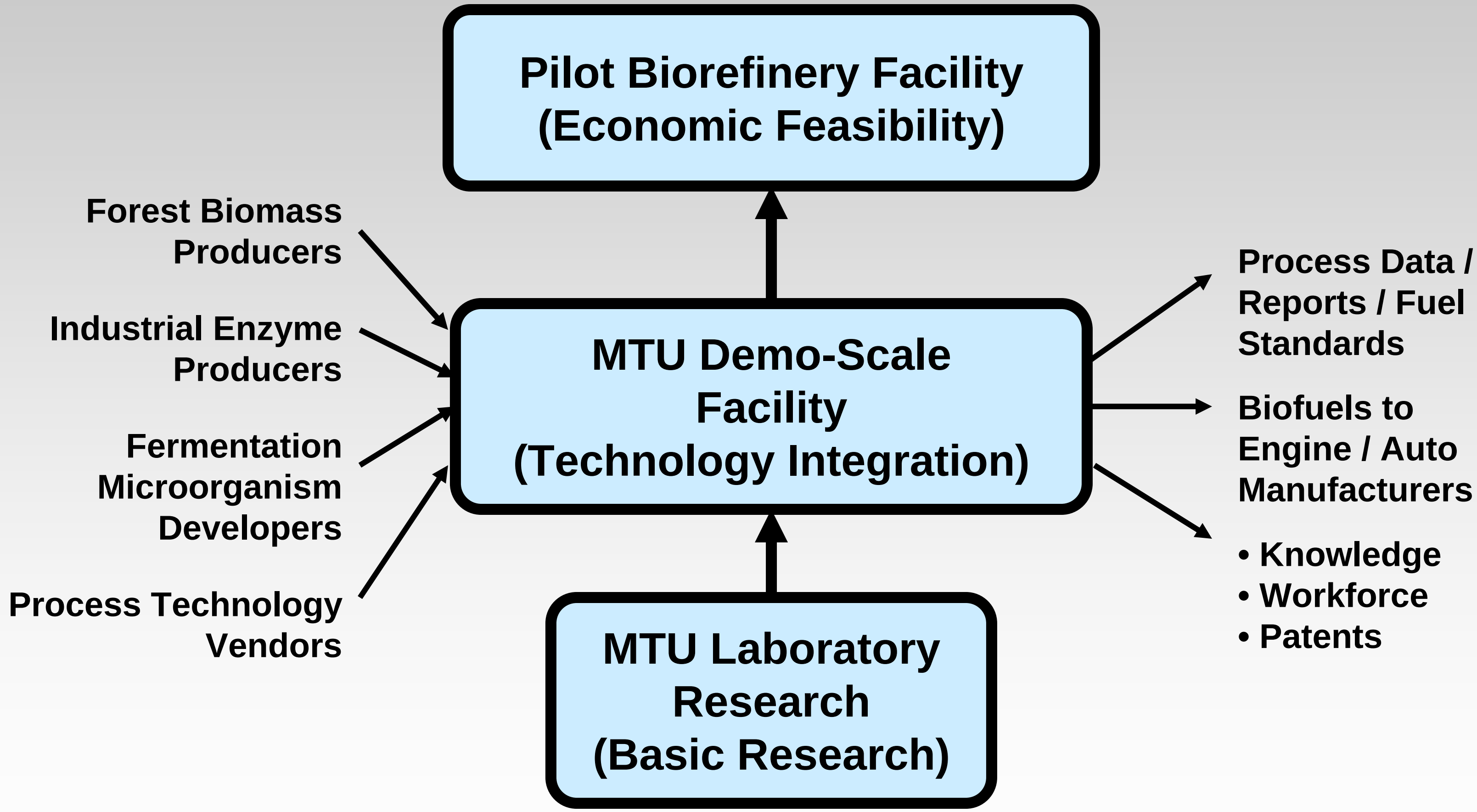
Goals of Bioprocessing Research

- **Increase efficiency and yields:**
  - Increase ethanol yields from 70-100 gal / dry ton
  - Decrease processing time from 7 days to 2 days
  - Flexible processes to handle biomass mixtures
  - Optimize use of process energy, water, & nutrients
  - Reduce production costs for ethanol
- **Technological Innovations:**
  - Establish pretreatment conditions to maximize sugar yields
  - Engineer more active and selective enzymes
  - Discover / develop better microbial strains

Size Scales for Bioprocessing Facilities



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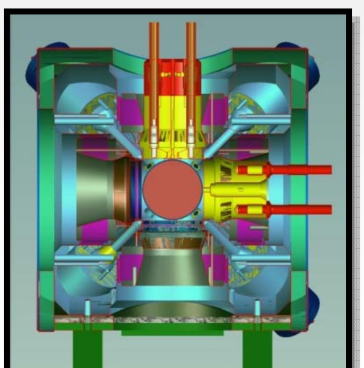
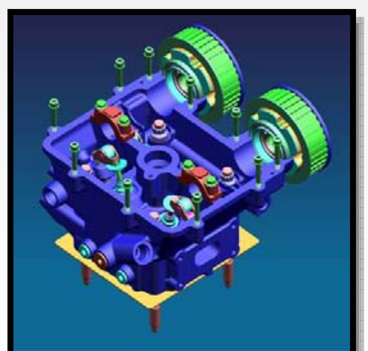
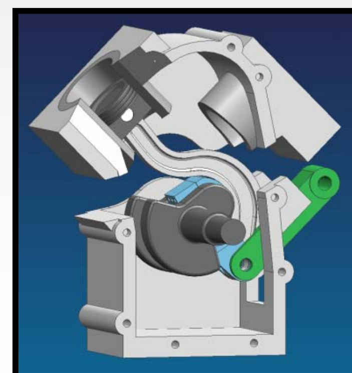
Engine/Vehicle Initiatives

Prof. Jeff Naber
Dept. of Mechanical Engineering







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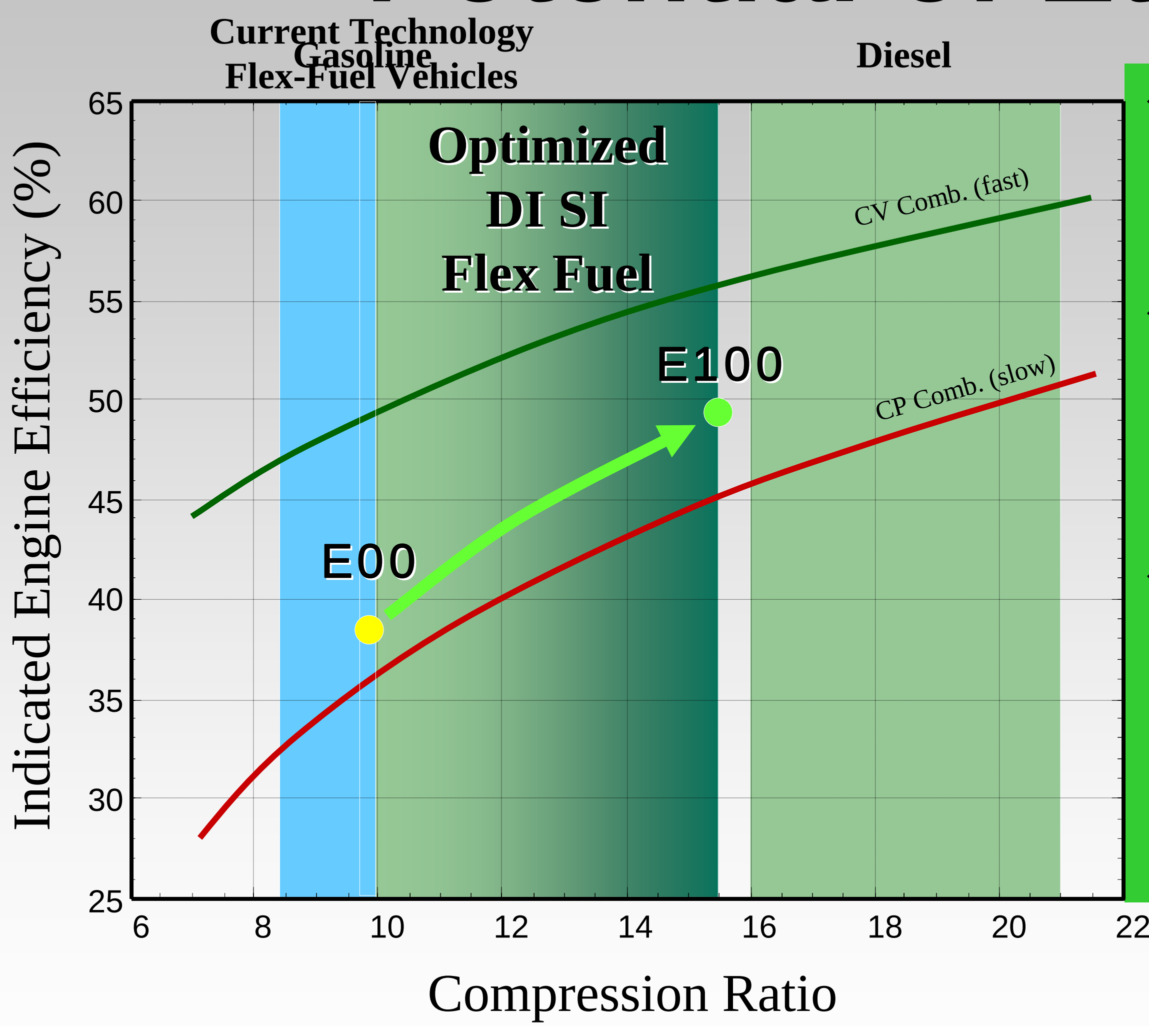
Ethanol as a Fuel

Property[1]	Gasoline	Ethanol	Impact of Ethanol
Chemical Formula	C4 – C12	C_2H_5OH	Oxygenated fuel
Composition, Weight % (C, H, O)	(86, 14, 0)	(52, 13, 35)	Slightly lower combustion temp.
Lower Heating Value (Btu/gal)	115,000	76,000	Reduced MPG
Octane Number (R+M)/2	86-90	100	Reduced knock, Improved efficiency
Reid Vapor Pressure (psi)	8-15	2.3	Reduced start-ability
Latent Heat of Vaporization (Btu/gal)	150	396	Increased charge cooling, Reduced start-ability
Volume % fuel in Stoich Mixture	2	6.5	Requires increase fuel vaporization & mixing
Stoich air/fuel (weight)	14.7	9	Requires increased fuel vaporization & mixing
Laminar Flame Speed (cm/s)[2]	27	42	Increased thermal efficiency, Increased EGR tolerance

- **Ethanol: better SI engine fuel than gasoline from combustion standpoint**
- **Significant challenges in fuel preparation for E100**
- **E85 helps but doesn't eliminate the problem.**
- **→ Engine & fuel system should change for ethanol.**

Potential of Ethanol



- **EPA has demonstrated a 20% improvement with E85, high CR and EGR**
- **MIT estimates 30% improvement with DI SI Gasoline/Ethanol, turbocharging & downsizing**
- **E85/E100 optimized SI engines should be nearly as efficient as diesels**
  - **Lower engine cost**
  - **Lower toxic emissions**

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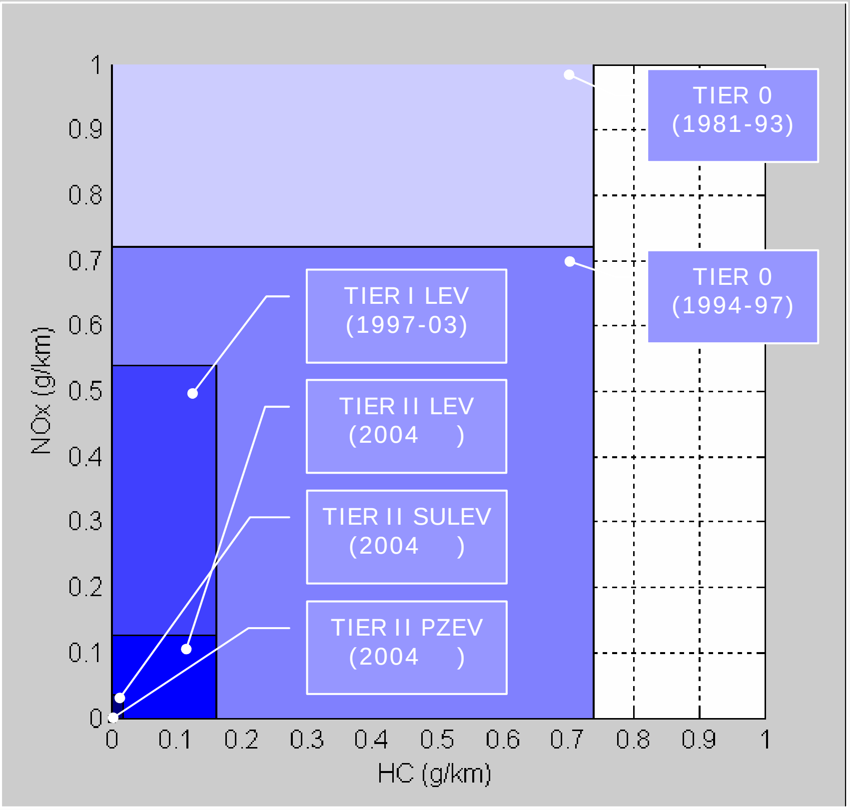
Technology Solution for Flex-Fuel Hybrids is Required

- Current flex-fuel vehicles do not meet PZEV standards because of crank-start HC emissions.
- Hybrid applications amplify the problem because of increased start-stop cycles.
- Legislation requires hybrids to meet the PZEV standard.
- Technical solution required for PZEV Flex-Fuel Hybrid
  - Company that develops robust cost effective solution will have market advantage

US Emissions Standards*



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Commercialization Status of Cellulosic Ethanol

- 15-20 Pilot Plants Worldwide, Mostly Small Batch Operations
- 2 Demonstration Plants Opened (Ottawa & Japan) with 2-3 Others to Open Later in 2007
- 15-20 Commercial Plants Being Built Worldwide
- Large Range of Feedstocks Proposed - Mostly Agricultural & Forestry Residues

Prof. Barry Solomon
Department of Social Sciences

MichiganTech

State Interest: Regional Economic Effects

- Largest Cost Items: Capital & Feedstocks
- Capital Cost for Cellulosic Plants Higher than for Grain Ethanol
- Employment Needs Modest, Except During Construction Phase
- Very Few Studies Have Estimated Regional Economic Effects (Most Studies National)
- High Risk & Uncertainty with Cellulosic Ethanol Plants Owing to Lack of Commercial Experience

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Results for one Scenario

- Assumes: 52 MGY & 20 Yr. Operations
- Jobs: 1,647 / yr. During Construction Phase
- Jobs: 526 / yr. During O & M Phase
  - Mostly in Manufacturing, Services, Transportation, Trade
- Increased Real Disposable Income: Avg. $32 Million / yr
- Economic Output: $148 Million / yr
- Gross Regional Product: $65.9 Million / yr

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Regional Economic Effect Conclusions:

- **Effects of Commercial Cellulosic Ethanol Plants Increase with Scale of Production**
  - **Range studied (.26 – 52 million gallons EtOH/yr)**
- **While MI is Behind MN & WI in Grain Ethanol it Can Catch up via Cellulosic Ethanol Industry**
  - **Will not happen without strategic initiatives of State Government**

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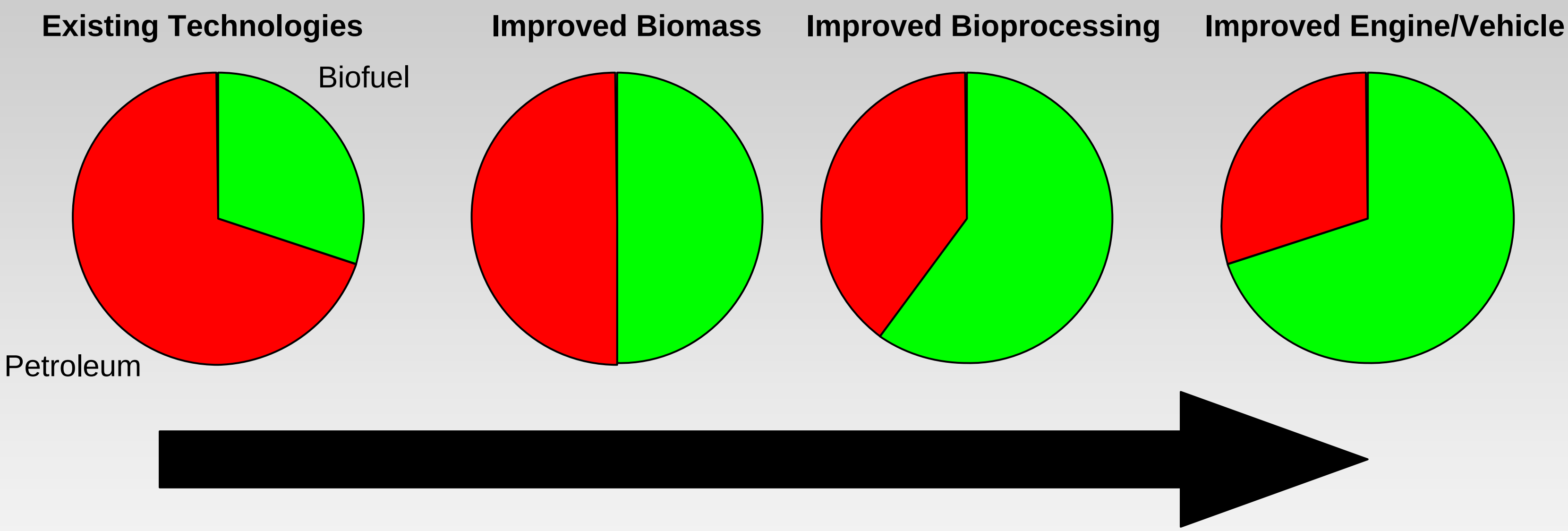
W2W Summary: Outcomes

- Contribute to technical workforce with highly-skilled graduates -- balance perspective on research, life-cycle, and business issues.
- Trees and forests with increased productivity, carbon sequestration, and solar energy efficiency.
- Integrated bioprocesses, improved microorganisms and enzymes for the production of bio-based fuels.
- Vehicle systems that are optimized for bio-based fuels.

Displacement of Petroleum via Wood-to-Wheels



The life-cycle and multi-disciplinary nature of W2W will allow us to realize a tremendous reduction in petroleum usage.

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Argonne
NATIONAL
LABORATORY
... for a brighter future

Updated Well-to-Wheels Results of Fuel Ethanol With The GREET Model

Michael Wang

Center for Transportation Research

Argonne National Laboratory

Presentation to the Biomass R&D Technical Advisory Committee

Detroit, MI, Sept. 11, 2007

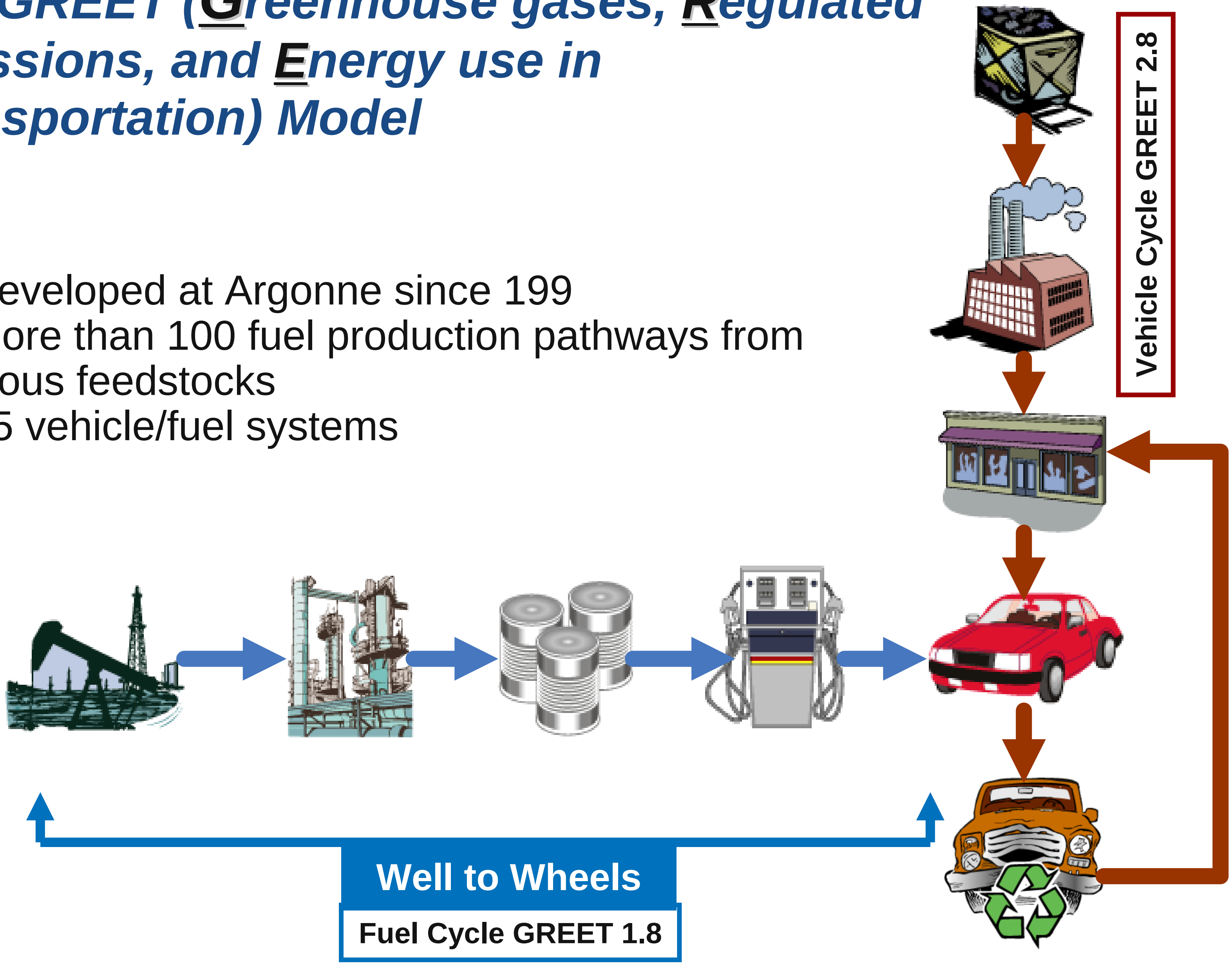
U.S. Department of Energy

UChicago Argonne LLC

A U.S. Department of Energy laboratory managed by UChicago Argonne, LLC

The GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) Model

- Developed at Argonne since 199
- More than 100 fuel production pathways from various feedstocks
- 75 vehicle/fuel systems



Energy and Emission Outputs with GREET

- **Emissions of greenhouse gases**
  - CO_2, CH_4, and N_2O (and other optional GHGs)
- **Emissions of six criteria pollutants**
  - VOC, CO, NO_x, SO_x, PM_{10}, and $PM_{2.5}$
  - Total and urban separately
- **Energy use by type**
  - All energy sources (fossil and non-fossil)
  - Fossil fuels (petroleum, natural gas, and coal combined)
  - Petroleum
  - Coal
  - Natural gas

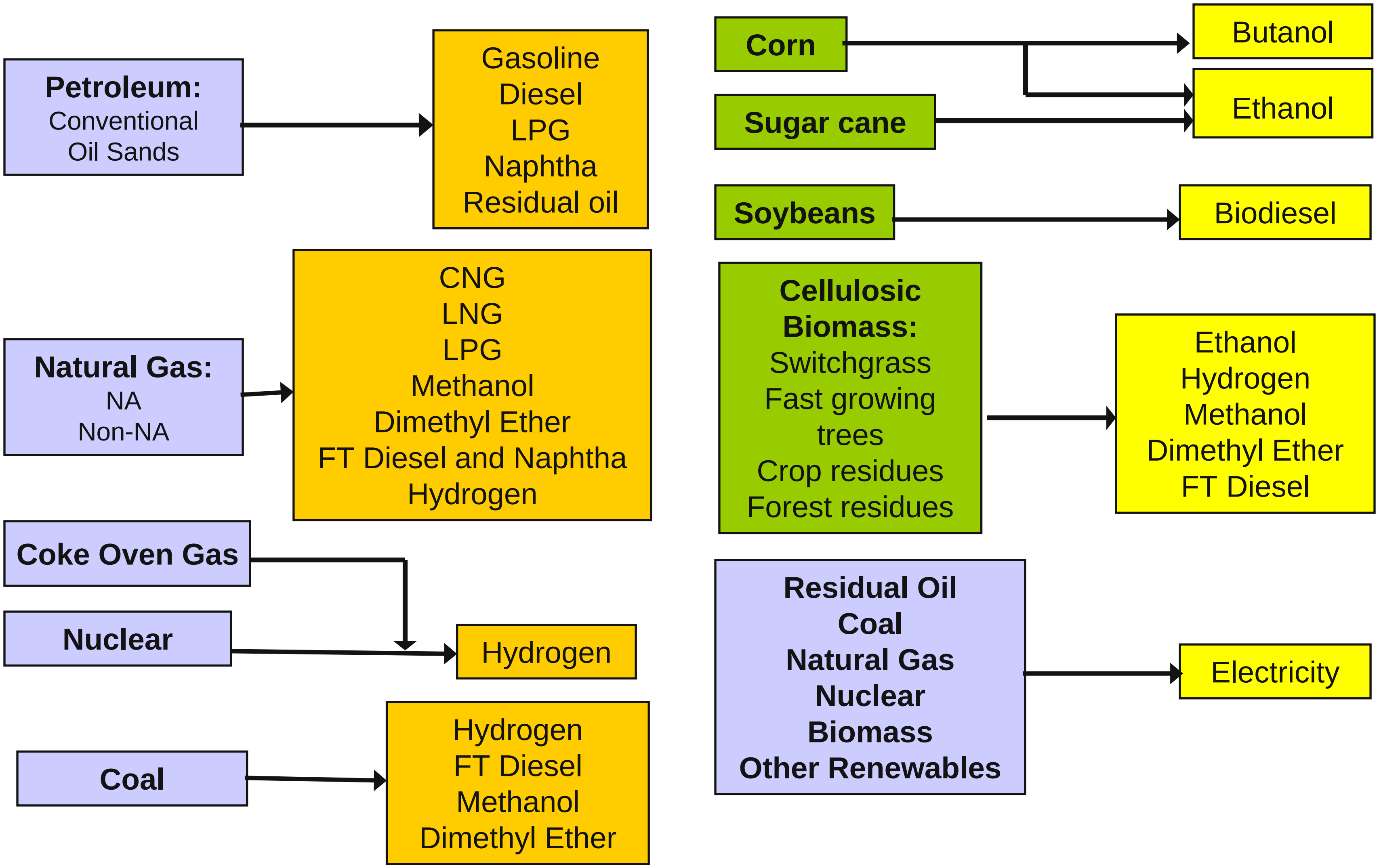
GREET is in public domain

Available at ***www.transportation.anl.gov/software/GREET/index.html***

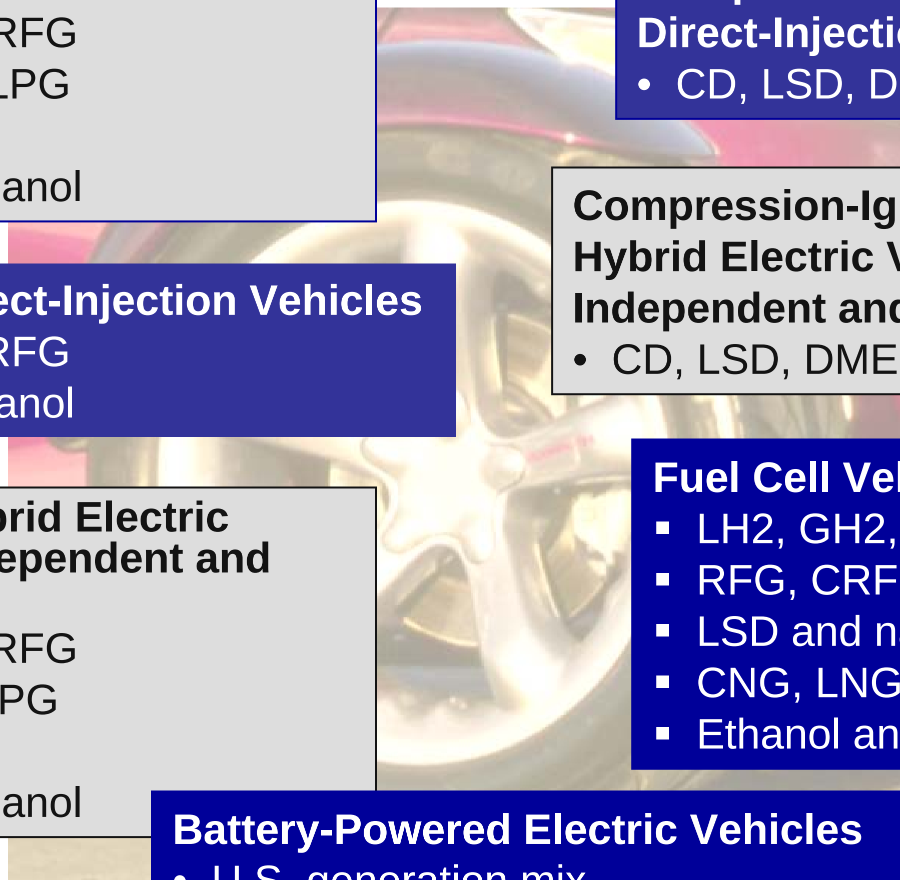
At present, there are more than 3,500 registered GREET users worldwide

The most recent GREET version was released in August 2007

Fuel Production Pathways from Various Energy Feedstocks (Well-to-Pump) in GREET



Fuel Combustion in Vehicle/Fuel Systems (Pump-to-Wheels)



Spark-Ignition Vehicles
- CG, RFG, and CRFG
- CNG, LNG, and LPG
- LH2 and GH2
- Methanol and ethanol

Spark-Ignition Direct-Injection Vehicles
- CG, RFG, and CRFG
- Methanol and ethanol

Spark-Ignition Hybrid Electric Vehicles: Grid-Independent and Connected
- CG, RFG, and CRFG
- CNG, LNG and LPG
- LH2 and GH2
- Methanol and ethanol

Compression-Ignition Direct-Injection Vehicles
- CD, LSD, DME, FTD, ED, and BD

Compression-Ignition Direct-Injection Hybrid Electric Vehicles: Grid-Independent and Connected
- CD, LSD, DME, FTD, ED, and BD

Fuel Cell Vehicles
- LH2, GH2,,
- RFG, CRFG,
- LSD and naphtha
- CNG, LNG, LPG,
- Ethanol and methanol

Battery-Powered Electric Vehicles
- U.S. generation mix
- California generation mix
- Northeast U.S. generation mix
- User-selected generation mix

Major Assumptions Affect Life-Cycle Analysis

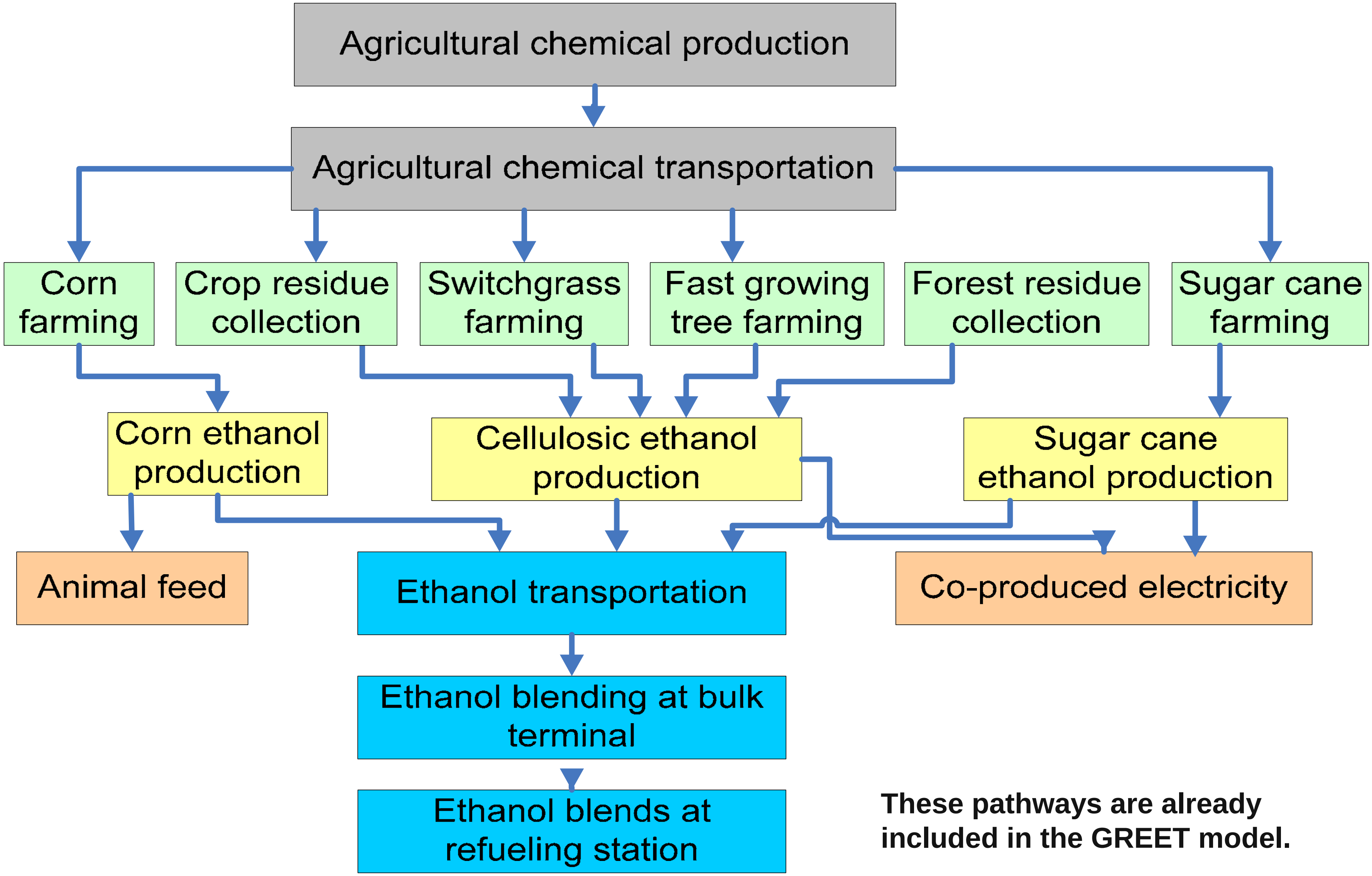
- WTP
  - Energy efficiencies of fuel production activities
  - GHG emissions of fuel production activities
  - Emission factors of fuel combustion technologies
- PTW
  - Fuel economy of vehicle technologies
  - Tailpipe emissions of vehicle technologies
- Approach to modeling uncertainties in GREET
  - GREET is designed to conduct stochastic simulations
  - Distribution functions are developed for key assumptions in GREET

Feedstocks for Biofuel Production Are Diversified and Vary Across Regions

- Sugar Crops
  - Sugar cane
  - Sugar beet
- Oil Seed Crops
  - Soybean
  - Rapeseed
  - Palm
- **Others**
  - Waste cooking oil
  - Animal fat
- Grain Starch
  - Corn
  - Wheat
  - Barley
  - Sorghum
- Cellulosic Biomass
  - Corn stover, rice straw, wheat straw
  - Forest wood residue
  - Municipal solid waste
  - Energy crops
  - Black liquor
  - Fast growing trees

The feedstocks that are underlined are already included in the GREET model.

GREET Ethanol Life-Cycle Analysis Includes Activities from Fertilizer to Ethanol at Refueling Stations

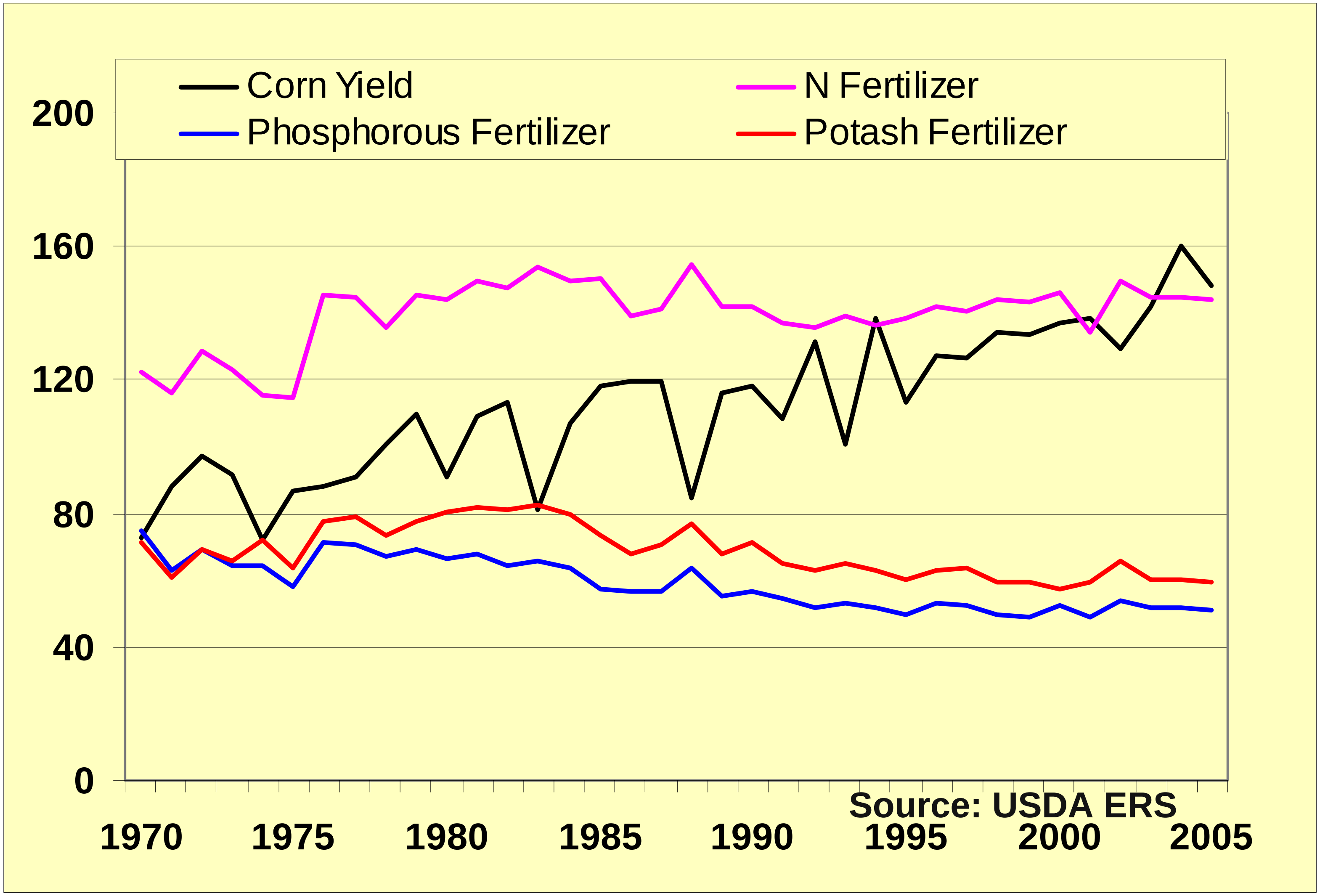


These pathways are already included in the GREET model.

Key Issues for Bio-Ethanol Life-Cycle Analysis

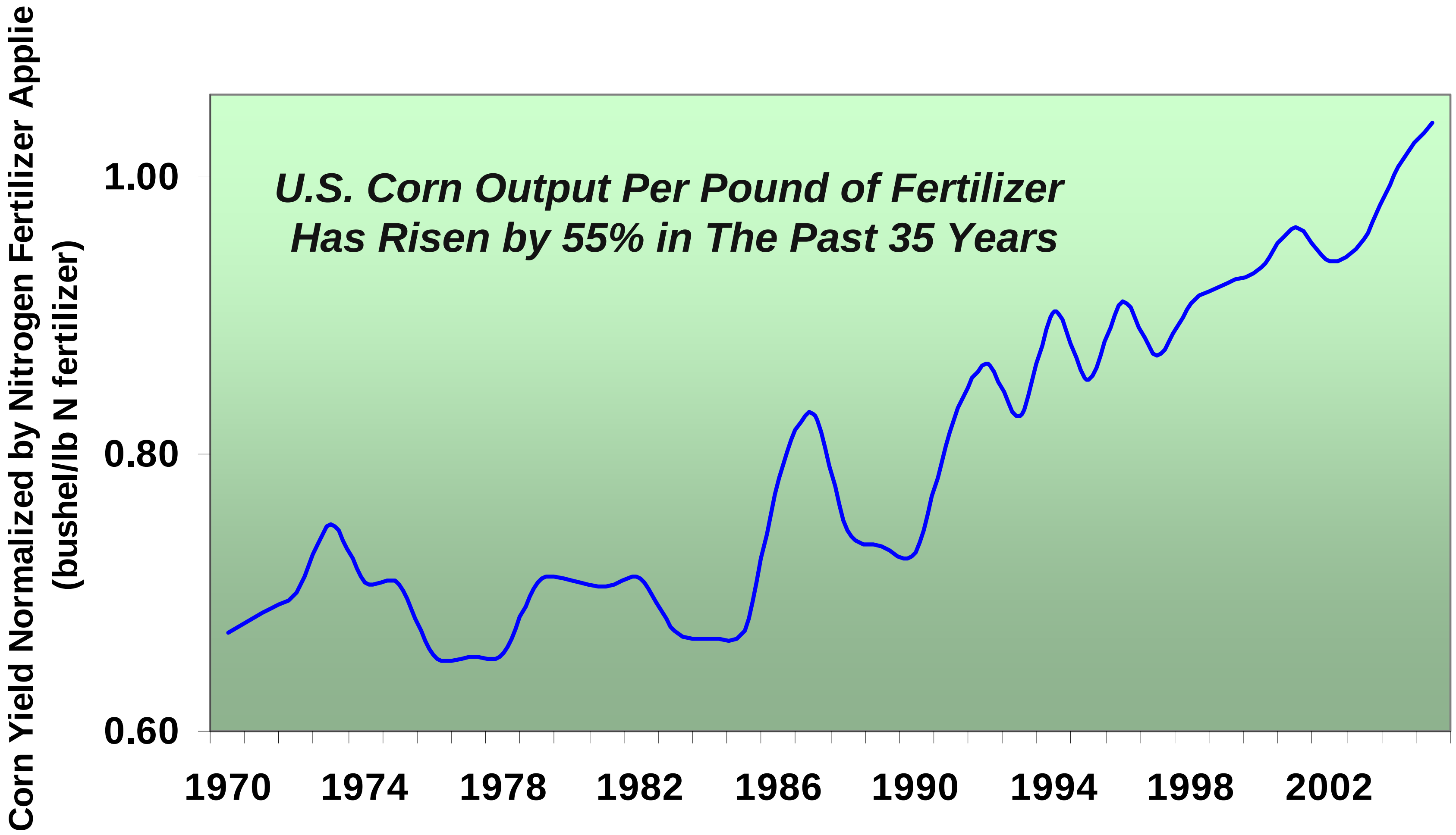
- Nitrogen fertilizer production
  - Nitrogen fertilizer is produced primarily from natural gas. About 40% of total US ammonia demand is met by imports (2005)
- Use of fertilizer and chemicals in farms
  - N2O emissions from N-fertilizer application
  - Lime application: CO2 emissions
- Farming is a key activity for cellulosic biofuel life cycle
- Open field burning in sugar cane plantations causes significant emissions (80% of can is harvested by burning in Brazil)
- Energy use in corn ethanol plants
  - The amount of process fuels for steam production
  - The type of process fuels
- Co-products
  - Animal feeds for corn ethanol
  - Electricity for cellulosic and sugar cane ethanol
- Potential land use change and resulted CO2 emissions

U.S. Fertilizer Use for Corn Farming Has Stabilized or Declined, While Corn Yield Continues to Increase



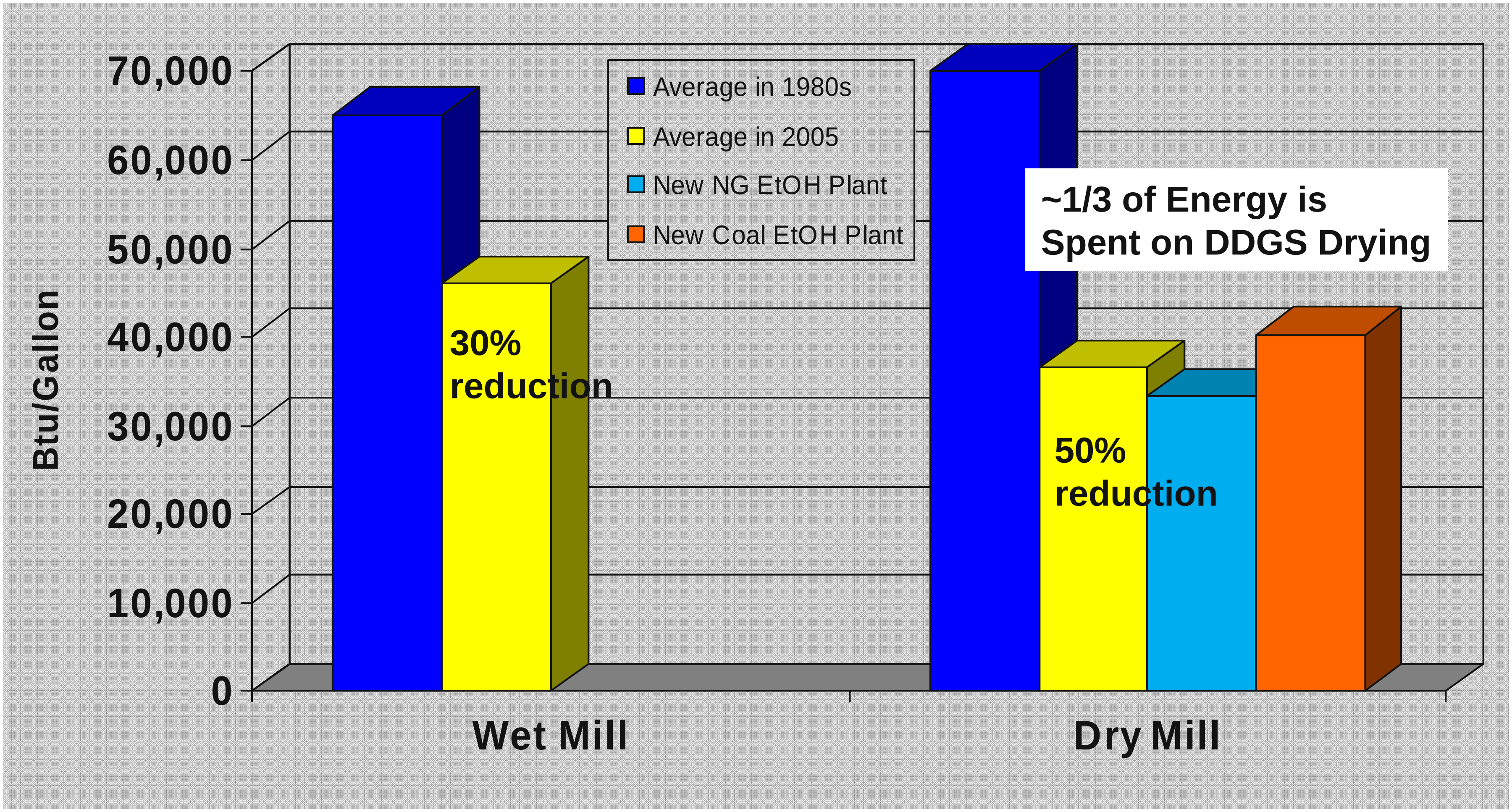
Corn yield is in bushels/acre; Fertilizer use is in lbs/acre.

Accurate Ethanol Energy Analysis Must Account for Increased Productivity in Farming Over Time



Based on harvested acreage. Source: USDA ERS

Improved Technology and Plant Design Has Reduced Energy Use and Operating Costs in Corn Ethanol Plants



Data for new ethanol plants is from Mueller and Cuttica (2006)

Accounting for Animal Feed Is a Critical Factor in Corn Ethanol's Lifecycle Analysis

Allocation Method	Wet milling	Dry milling
Weight	52%	51%
Energy content	43%	39%
Process energy	36%	41%
Market value	30%	24%
Displacement	~16%	~20%

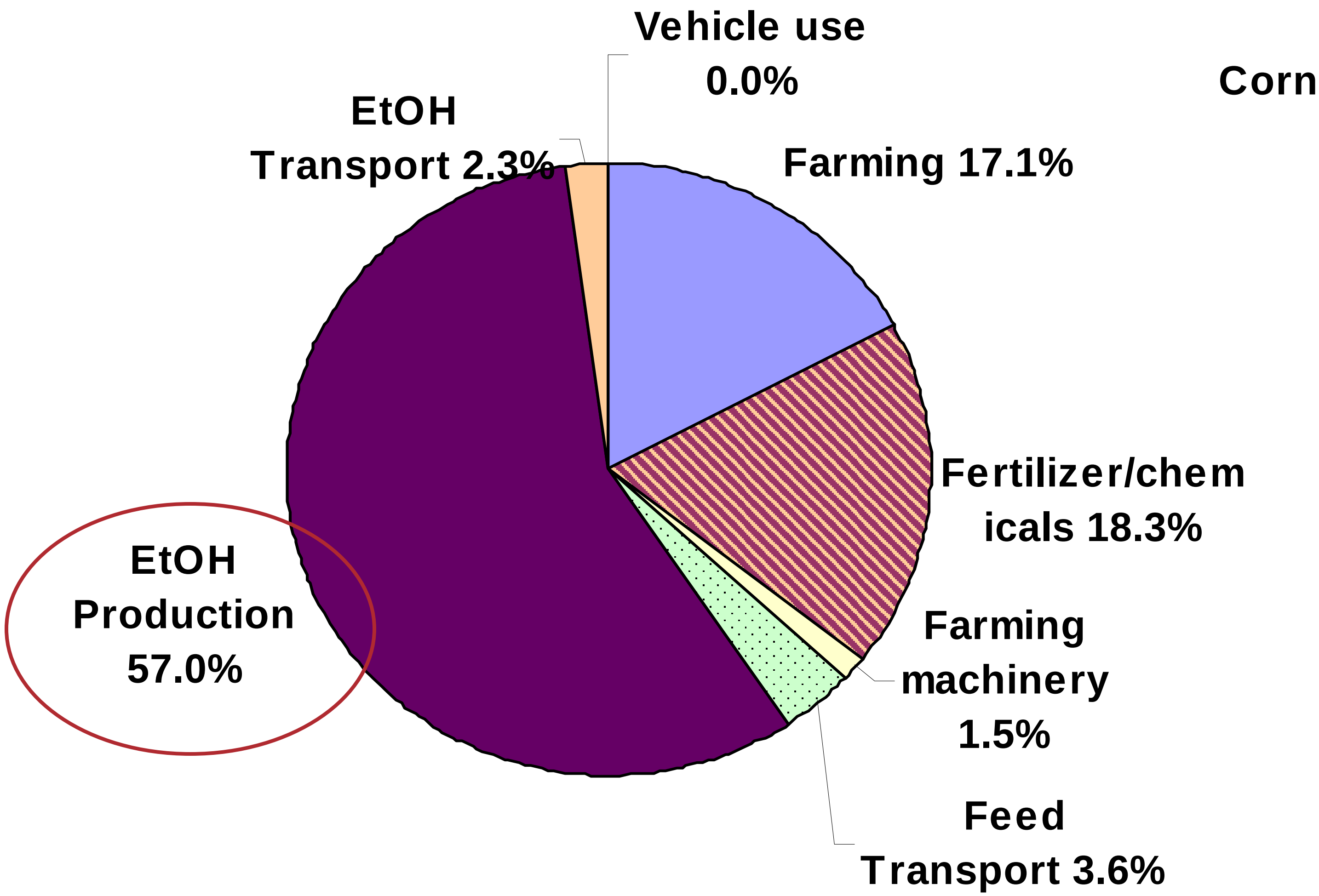
Argonne uses the displacement method, the most conservative approach.

Energy Embedded in Farming Equipment Is Not a Significant Contributor to Ethanol's Life-Cycle Energy Use

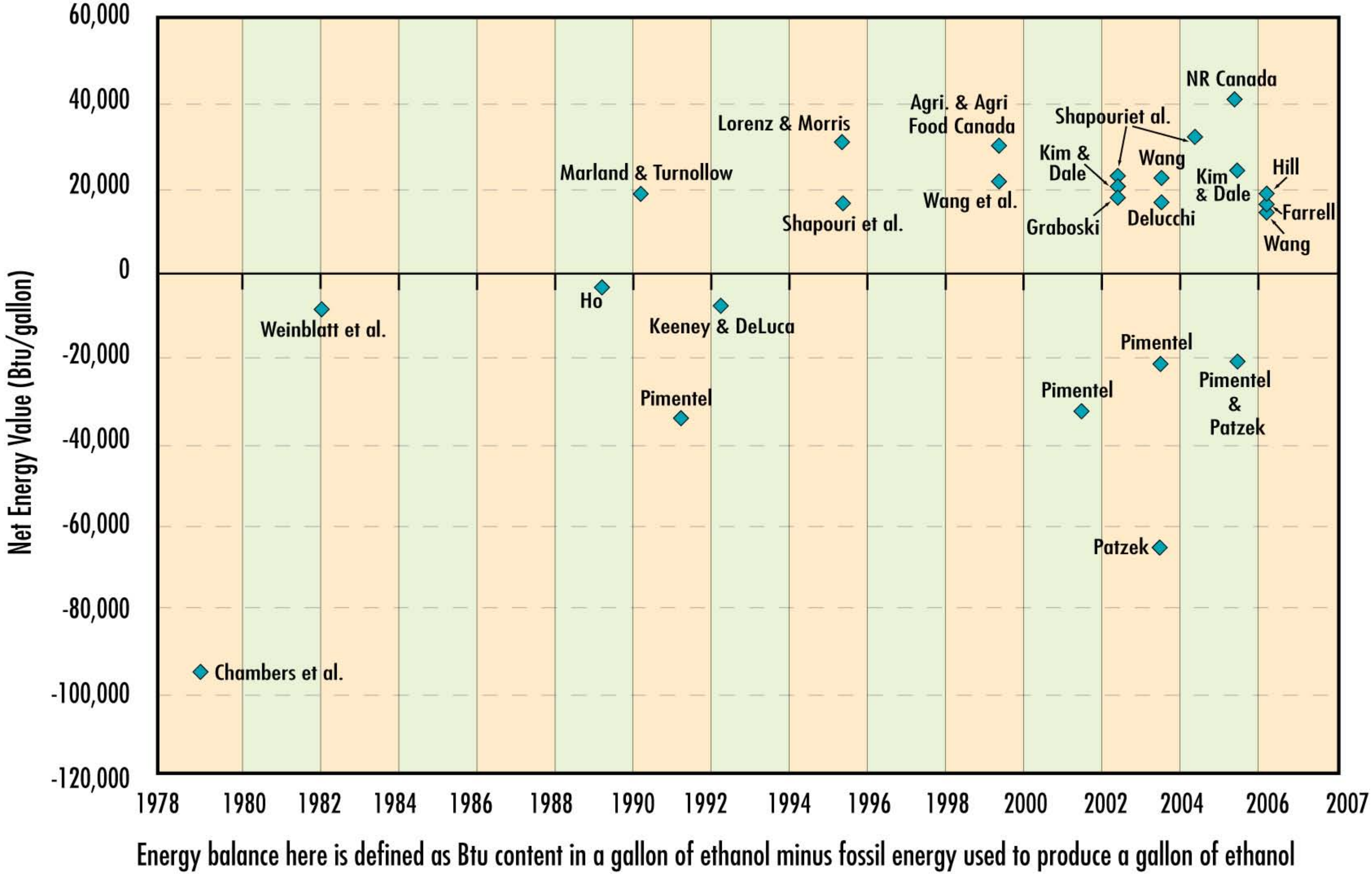
- Size of farm (550 acres assumed in this study)
- Life time of equipment
- Energy for producing equipment materials (the majority of equipment materials is steel and rubber)
- Argonne has found that farming equipment may contribute to <2% of energy and ~1% GHG emissions for corn ethanol

Equipment	Weight (tons)	Lifetime (yr)
Large tractor	10	15
Small tractor	5.7	15
Field cultivator	2.6	10
Chisel plow/ripper	4.0	10
Planter	3.7	10
Combine	13.7	15
Corn combine head	4.0	10
Gravity box (4)	7.3	15
Auger	0.9	10
Grain bin (3)	10.5	15
Irrigation	5.3	12
Sprayer	0.6	10

Life-Cycle Fossil Energy Use: Corn Grain Ethanol



Most Recent Studies Show Positive Net Energy Balance for Corn Ethanol

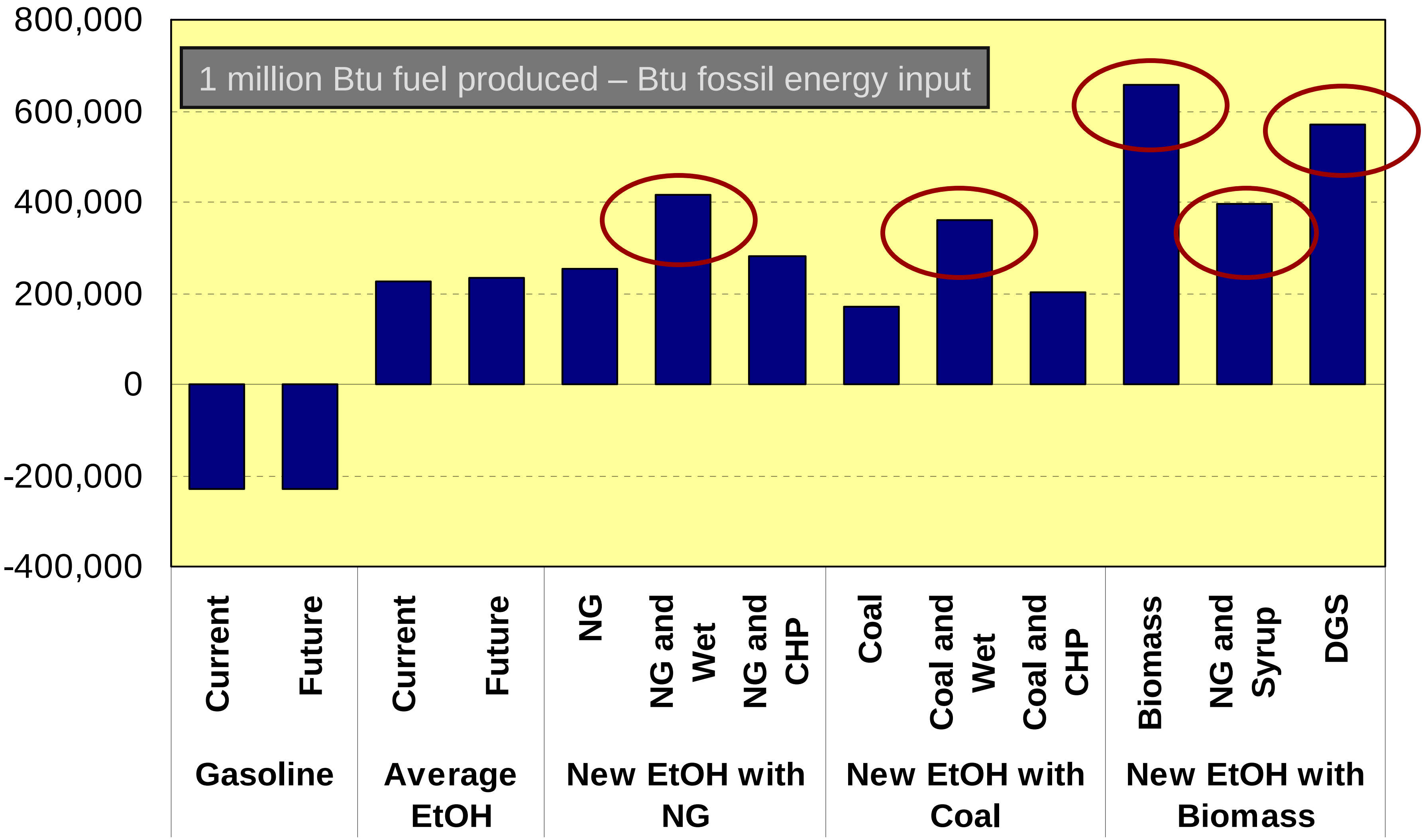


Energy balance here is defined as Btu content a gallon of ethanol minus fossil energy used to produce a gallon of ethanol

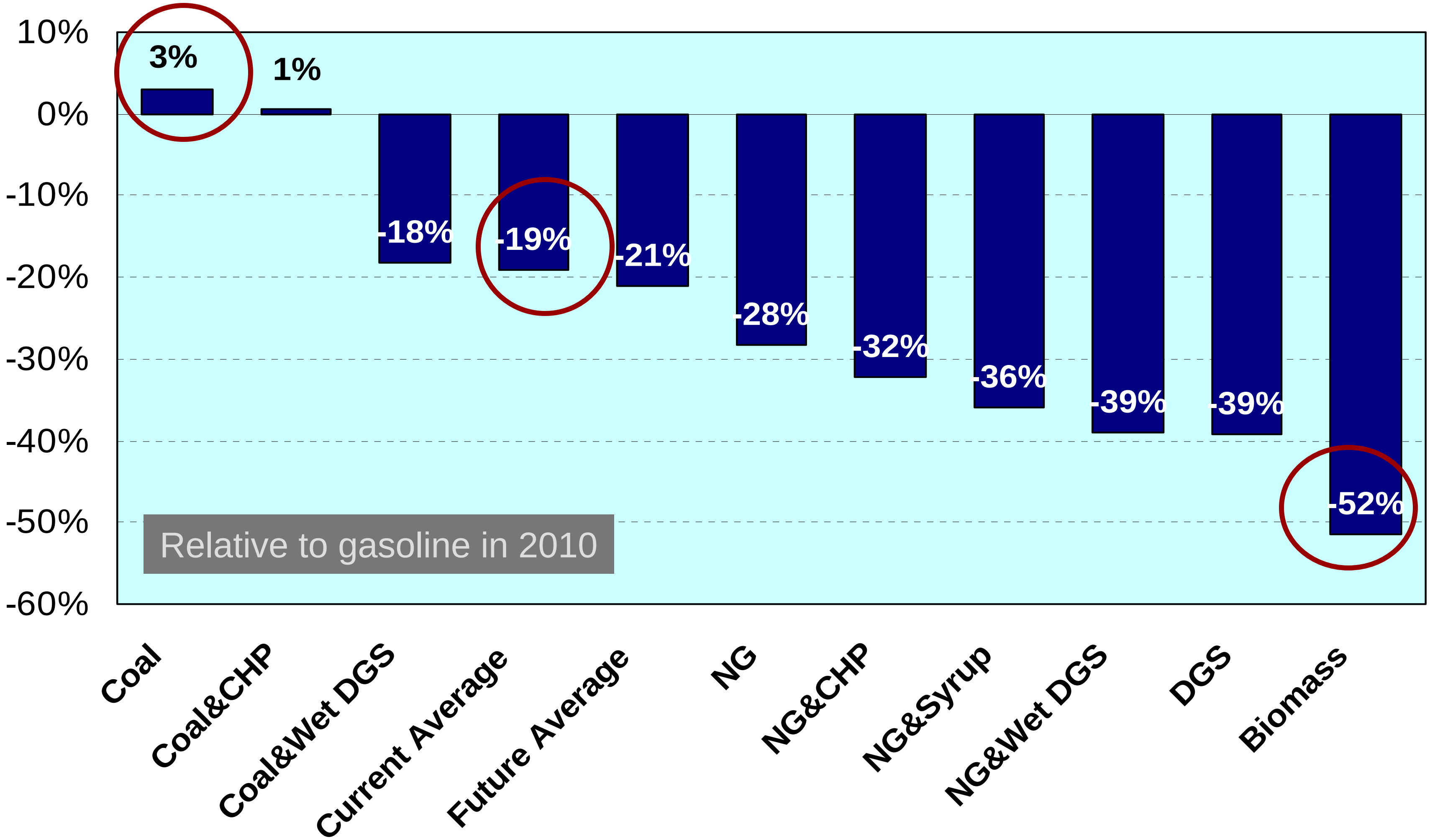
Argonne Recently Examined Life-Cycle Impacts of Process Fuels in Different Types of Corn Ethanol Plants

	NG	Coal	Biomass	DGS
Base Design	√	√	√	√
CHP	√	√		
Syrup	√			
Wet DGS (No drying)	√	√		

Use of Renewable Process Fuels Improves Net Energy Balance Significantly for Corn Ethanol



Large Avoidance of GHG Emissions by Corn Ethanol With Use of Renewable Process Fuels

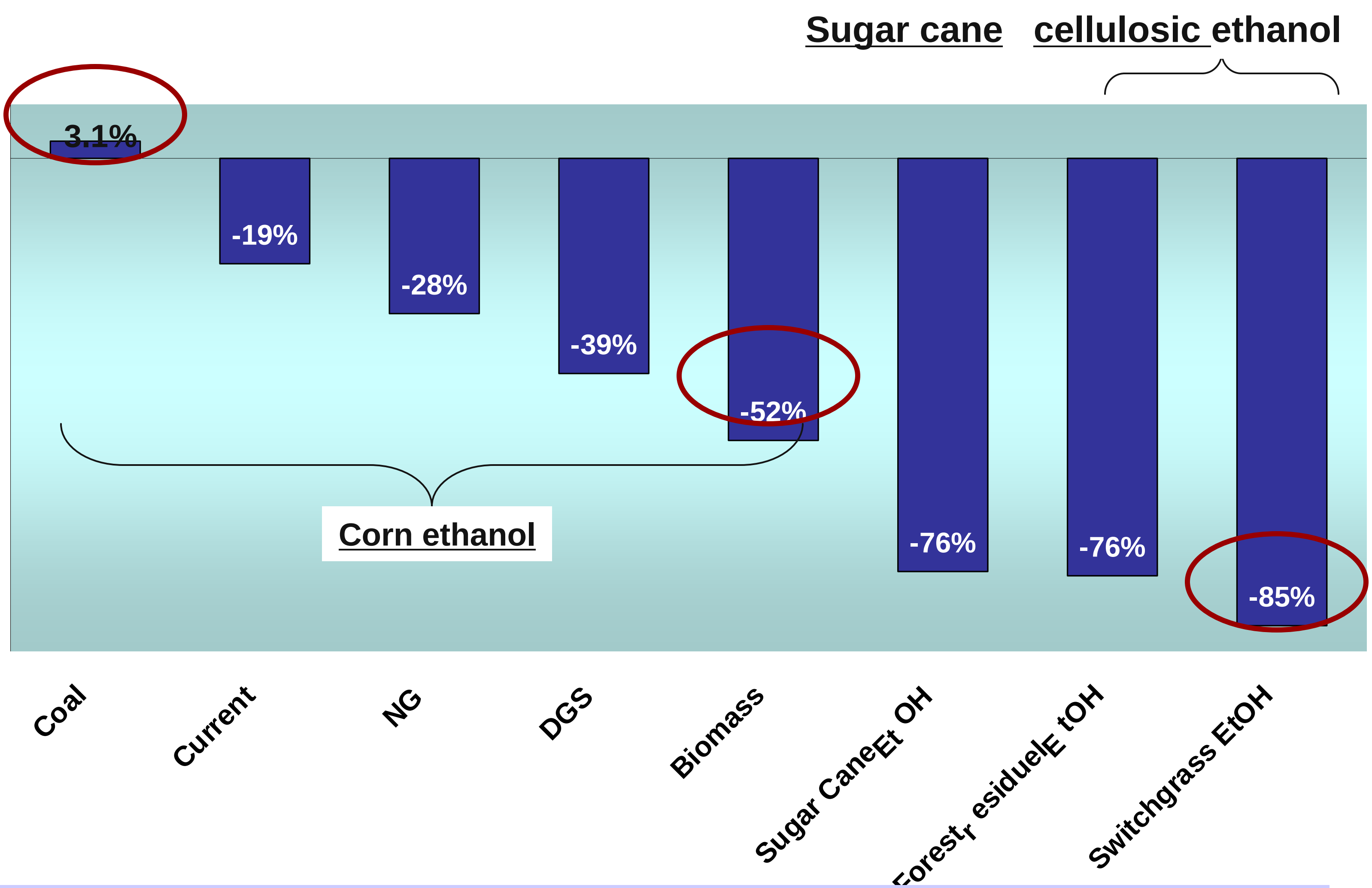


Sugarcane Farming and Ethanol Production Concentrate in the South and South Central Brazil

Reflections of Brazilian Ethanol Program

- Key players have become integral parts of the Brazilian ethanol program
  - Sugar cane growers and sugar mill operators are often the same people
  - Oil companies (e.g., PetroBras) have developed transportation and refueling infrastructure
  - Auto companies have changed the production of dedicated ethanol vehicles to flex fuel vehicles
- The flexibility of the Brazilian ethanol program
  - Sugar cane mill operators are flexible between sugar and ethanol production
  - Flex fuel vehicle owners are flexible of using gasoline and ethanol
- Environmental concerns
  - Open burning for manual harvesting creates air pollution problems
  - Manual harvesting is being displaced with mechanical harvesting
  - Ethanol plants, and stationary sources in general, lack stringent NOx emission regulations

From Corn to Sugar Cane to Cellulosic Biomass, GHG Emissions Avoidance Are Increased



GHG Emission Reductions by Ethanol Relative to Gasoline (per Energy Unit Basis)

Butanol Can Be Produced from Starch/Cellulosic Feedstocks As a Potential Transportation Fuels

- Butanol poses the following advantages
  - Butanol has a low heating value of 99,840 Btu/gal
    - *86% that of gasoline*
    - *30% higher than ethanol*
  - Low co-solvency with water, low risk for corrosion in fuel storage and transport facilities
  - Butanol might be used as a fuel blend with gasoline
- Limitations of butanol include
  - No commercial scale renewable butanol production facilities
  - Lack of vehicle/engine performance data with butanol
  - Large amount of acetone co-produced from ABE process

A Large Amount of Acetone Is Produced from the ABE Process for Butanol Production

Product Yields of the ABE Process and Ethanol Plants

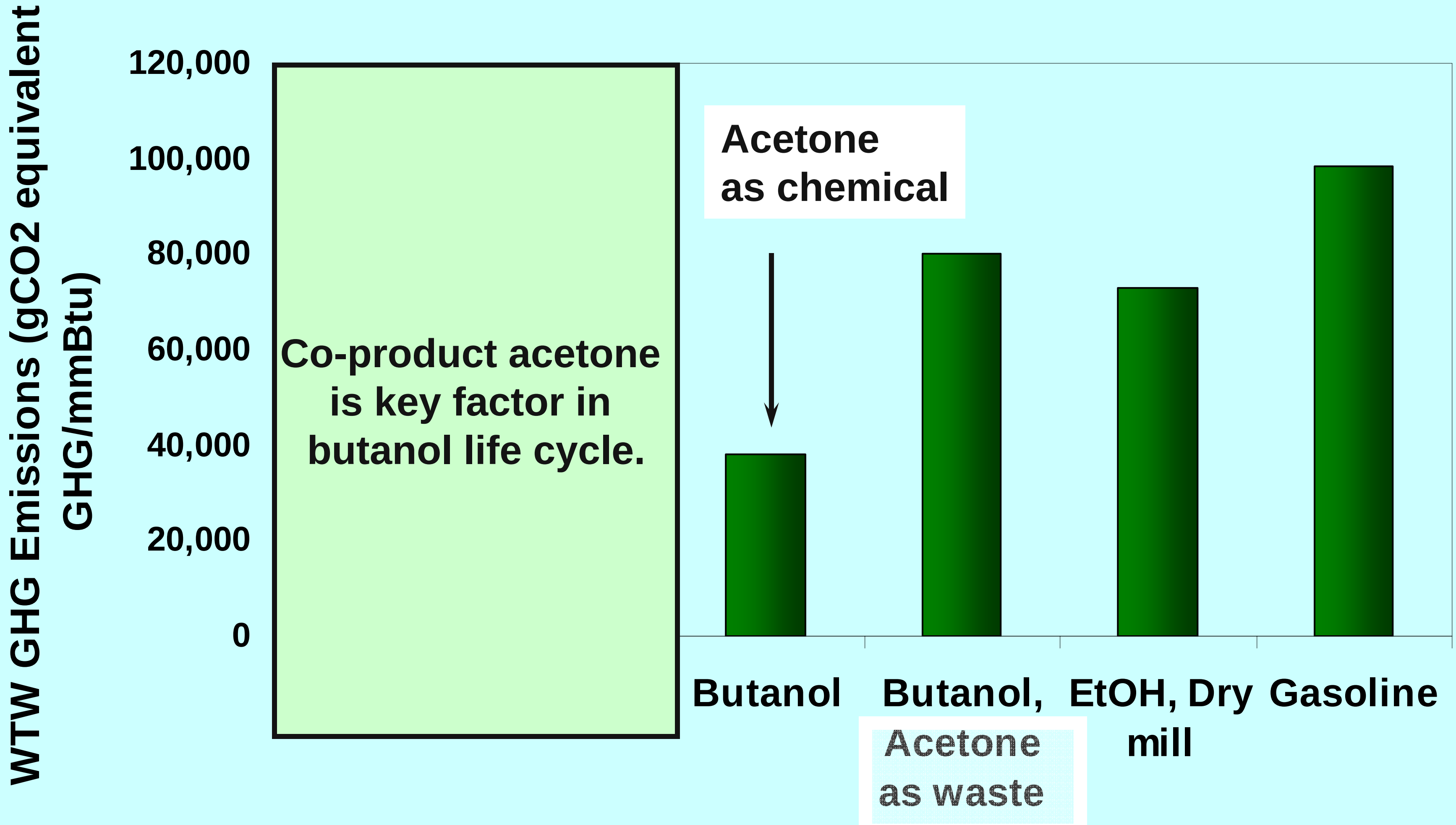
	Corn Butanol Plant				Corn EtOH Dry Mills
	Acetone	Butanol	Ethanol	Total	Ethanol
Btu/bu. Corn	69,525	149,267	2,828	221,620	198,458
Gal/bu. Corn	0.87	1.50	0.04	2.41	2.60

These are based on 15% moisture content of corn and un-denatured fuel.

Product Shares of the ABE Process

	Acetone	Butanol	Ethanol
Energy basis	31.4%	67.4%	1.3%
Volume basis	36.1%	62.2%	1.7%
Mass basis	35.4%	63.1%	1.5%

GHG Effects of Corn-Based Butanol Depend on How to Treat By-Product Acetone



Fuel Cycle: On-Going and Planned Activities for Petroleum and BioFuel Production Pathways

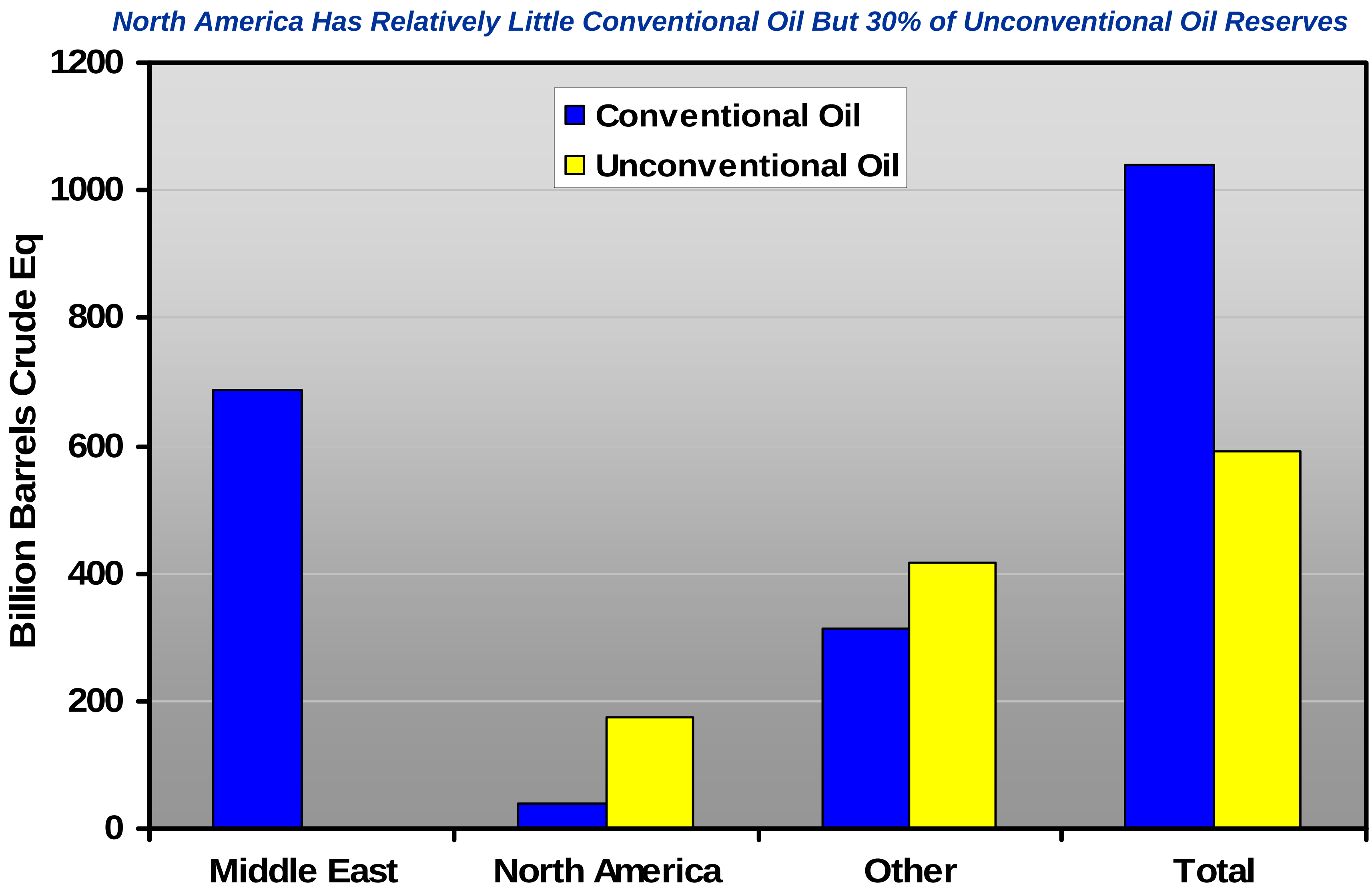
Petroleum Fuels

- Current GREET activities
  - Updating petroleum refining efficiencies with EIA survey data
- New options of interest
  - Venezuelan heavy and sour crude
  - US oil shale?
- Water requirement for petroleum fuel production

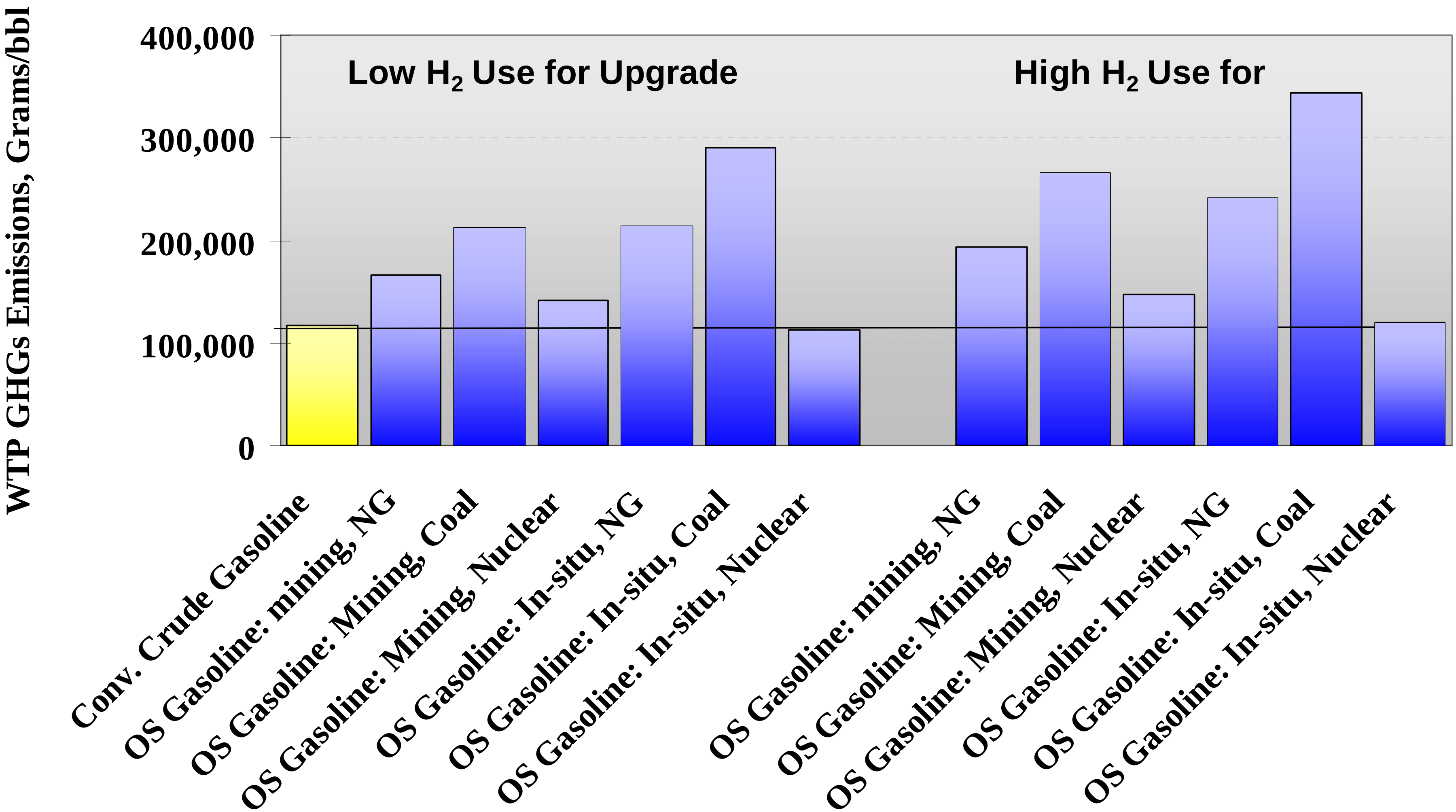
Bio-fuels

- GREET biofuel pathway additions in the near future
  - Renewable diesel from soybeans via hydrogenation
  - Ethanol from sugar beets
- Water requirement for biofuel production
- Other biofuel pathways of interest
  - Biodiesel and renewable diesel from
    - *Rapeseeds*
    - *Animal fats*
    - *Palm oil*

ANL Analyzed Energy and GHG Emissions of Oil Sands Recovery and Upgrade



WTP GHG Results Show That Oil Sands Operations Are Carbon-Intensive



Potential Land Use Change by Large-Scale Biofuel Production Is Being Debated

- U.S. annual corn ethanol production from 6 to 15 billion gallons in ten years by 2015
  - Besides increases in per-acre corn yield, where will additional amount of corn for ethanol production be from?
  - In 2007, U.S. corn farming acres have increased by 12 million through switch from soybean to corn farming (additional 1.5 billion bushels of corn for additional 4 billion gallons of corn ethanol)
  - U.S. has been exporting 20% of its total annual corn production; reduction in U.S. corn export will impact global corn/grain market
- Brazil has 12.4 million acres of sugar cane plantations. It can increase sugar cane plantations to 25 million acres in the near future
  - While sugar cane farming is in South Central Brazil, what is the current farming practice and vegetation for the additional sugar cane acres?
  - Will the increase in sugar cane farming acres push farming of corn, soybean, and cattle to the Amazon rainforest region?
- Palm oil production in Malaysia has caused conversion of some tropical forest and pit soil into palm tree farming; what is the environmental and GHG consequences?
- No quantitative simulations of land use change at the national and global level have been done yet, and results may not be available anytime soon