Liquid Biofuels Task 39

IEA Bioenergy

Newsletter

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FROM THE TASK LEADER

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WELCOME TO IRELAND

Participants to the meeting in November, discussed more fully in the Policy section, welcomed Bernard Rice of Ireland's Agriculture and Food Development Authority to the Task. Ireland joined the Task at the ExCo meeting in Finland in November 2002. Rice presented an overview of the situation in Ireland. Ireland will require about 80,000 tonnes of biofuels to meet its goal of 2% substitution by 2005. At present, gasoline and diesel usage is about equal, so the biofuel could be biodiesel, ethanol, or a combination of both. At present, there is no remission of road excise taxes to support biofuels. The resources available on an annual basis to produce biofuels include:

- 8,000 tonnes reclaimed vegetable oil
- 10,000 tonnes tallow
- 20,000 ha of rape on set-aside lands
- 10,000 ha sugar beets
- 20,000 tonnes molasses
- Undetermined quantities of grass

Bioenergy developments in Ireland include the use of tallow in boilers, particularly in the rendering industry and the use of limited amounts of unprocessed rapeseed oil in modified engines. A 6 MW CHP facility using tallow is proposed, and approximately 7000 tonnes of reclaimed vegetable oil banned from feed uses is available and may be used in boilers or for biodiesel.

Ireland is interested in ethanol from sugar beets, but the process has marginal economics and depends on full remission of excise taxes. Lignocellulosic feedstocks including wood wastes and grasses may also become available. Ireland recognizes that lignocellulosic ethanol is not currently economically competitive with grain ethanol but would like to follow technical developments on this topic.

PLANNING FOR THE NEXT TASK PERIOD, 2004-2006

At ExCo50, the Executive Committee asked existing Operating Agents and Task Leaders if they had interest in continuing their Tasks in the next 3-year period. All present OA's and TL's agreed they were. Participants were also asked dif they would like to submit competitive bids. In all except one case (the Forestry Task), there was no expression of interest in competition. Specifics of the new

Tasks were not discussed by the ExCo, and there were no mandates given to the Tasks regarding content of the new proposals. However, the ExCo will have to make preliminary decisions at the next meeting in late April, 2003. To meet that goal, preliminary plans must be assembled by approximately March 15, 2003.

It is therefore up to Task 39 to develop a proposed Work Plan for 2004-2006 based on the needs of countries that wish to participate. This includes both the present countries in Task 39 plus other countries that may wish to join in the future.

Participants agreed that main benefit from the Tasks is information exchange, and that the IEA is an effective way to interact "over the oceans." The participants agreed that a new Task should address several considerations:

- Examine a broad range of biofuels, including ethanol and biodiesel, but placing increasing emphasis on others like MeOH, DME, FT-liquids, and similar
- Track policy developments
- Provide information on ongoing implementation efforts
- Tie in with the Clean Fuels/Clear Data project
- Provide information on how to use biofuels to improve CO_2 performance
- Provide knowledge of early developments
- Include an examination of the role of biobased products in adding economic value to biofuels
- Examine opportunities for biohydrogen
- Track new technical achievements, including but not limited to ligno-ethanol.

To obtain a better sense of the priorities of these and other topics, a survey of interests will be designed and send to all participants. The survey will also be sent to the ExCo members of other countries that are not presently members of Task 39. The responses of that survey will be summarized by the Task Leader and distributed for comment. Based on those comments, the Task Leader will draft an outline for consideration at the Spring 2003 ExCo meeting.

WORLD EVENTS/INFORMATION

Ethanol Industry Sets All-Time Monthly Production Record - over 166,000 Barrels Per Day of Ethanol Produced in November
http://www.ethanolrfa.org/pr021218.html

Harris Group Inc. Gets Biomass Ethanol Process Work With NREL
http://www.ethanolmarketplace.com/120902_news.asp

Flexible fuel vehicles make E-85 viable option
http://www.zwire.com/site/news.cfm?newsid=6764059&BRD=1896&PAG=461&dept_id=130713&rfi=6

Bush Admin. Continues Investments for Ethanol, Bioenergy Projects
http://www.contactomagazine.com/bioenergy1023.htm

Ethanol becomes golden child
http://www.lincolncourier.com/news/02/11/08/e.asp

Proposed rule threatens biodiesel's future
http://www.ifbf.org/publication/spokesman/story.asp?number=20113&type=News

USDA value-added grants analysis released
http://www.agriculture.com/default.sph/AgNews.class?FNC=goDetail__ANewsindex_html___48872___1

Ottawa's new Kyoto plan gives industries guarantee
http://www.globeandmail.com/servlet/ArticleNews/PEstory/TGAM/20021121/UKYOTN/national/national/national_temp/3/3/28/

China Pushes Use of Ethanol as Fuel
http://english.peopledaily.com.cn/200211/18/eng20021118_106974.shtml

Chevron Awarded Patents on Low-Emission Gasolines Containing **...**
http://www.prnewswire.com/cgi-bin/stories.pl?ACCT=104&STORY=/www/story/11-19-2002/0001844609&EDATE=PR Newswire (press release)

U.S. EPA quantifies emission effects of biodiesel
http://www.dieselnet.com/news/0211epa.html

IEA Bioenergy Strategic Plan 2003-2006
http://www.ieabioenergy.com/media.php?read=21

World First In Development Of Ecoethanol: Huge potential for Canadian economy & Kyoto
http://www.iogen.ca/

Biodiesel Train on Track in India
http://www.solaraccess.com/news/story?storyid=3451

Biorefinery Project Awards
http://www.ott.doe.gov/biofuels/whats_new_archive.html

Report: Global Biotech Acres Climbed 12% in 2002
http://www.agweb.com/news_show_news_article.asp?file=AgNewsArticle_20031151443_5512&articleid=94471&newscat=GN

Backers: Ethanol helps US as war looms
http://www.bbiethanol.com/news/view.cgi?article=689

Brazil's new agriculture minister backs ethanol program
http://www.bbiethanol.com/news/view.cgi?article=655

Canada and India to Boost Ethanol Use
http://www.bbiethanol.com/news/view.cgi?article=641

Province competing for ethanol production
http://www.bbiethanol.com/news/view.cgi?article=619

Higher Corn Yields are Making Ethanol More Energy Efficient
http://www.whybiotech.com/index.asp?id=2213

Biodiesel Emissions Reduce Cancer Risk Compared to Diesel
http://www.biodiesel.org/resources/pressreleases/gen/090602_cancer_risk.pdf

Americans Support Biodiesel Incentives for Use in School Buses
http://www.biodiesel.org/resources/pressreleases/fle/120602_SchoolbusStudy.pdf

POLICY/REGULATORY ISSUES SUBTASK

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VIENNA, AUSTRIA NOVEMBER 19-20, 2002

Representatives of the IEA Bioenergy Task 39 on Liquid Biofuels met in Vienna, Austria, on November 19-20, 2002. The purpose of this meeting was to review current projects, plan for a new "Consultant Project", and begin planning for activities in the period 2004-2006.

Five of the ten participants including Austria, Ireland, Netherlands, United Kingdom, and United States were represented at the meeting. There were also 3 observers from Austria.

Josef Spitzer presented an introduction to Austria's interests in IEA Bioenergy. Austria participates in eight of the eleven active Tasks and leads the Task on Greenhouse Gas Emissions. Austria has ongoing interests in the area of biofuels and has related interests in the area of biohydrogen, feedstock availability as it relates to biofuels, the influence of byproducts, including CO_2, and others.

Kurt Pollak presented an overview of the biofuels interests of his company, OMV Aktiengesellschaft, the Austria petroleum company. Austria currently uses about 4.6 million tones of petroleum diesel annually, and only about 1.6 million tonnes of gasoline. The diesel is used primarily in large trucks, although many passenger cars and small trucks also use this fuel. Historically, gasoline use was greater than diesel use until 1993. Since then, the use of diesel has continued to grow, and the trend is expected to continue for the foreseeable future. Therefore biodiesel has a greater opportunity for helping Austria meet its CO_2 reduction goals than ethanol. The situation in Austria is similar to much of Europe with an emphasis on diesel, although the percentage diesel used in Austria is higher than average. This contrasts significantly with North America where gasoline is still the most common fuel.

Gerfried Jungmeier of Joanneum Research provided an overview of Austrian research on life-cycle analysis of biomass systems. At present, he is completing a study of bioenergy systems for the Austrian Ministry of Agriculture. The study included over 140 different biofuels scenarios and provides detailed calculations to evaluate the relative merit of various fuels. Jungmeier provided a copy of his viewgraphs to meeting participants.

Heinz Prankel of BLT Weiselburg provided an overview of the status of the European biodiesel standard. After several years of hard work, the standard is nearing acceptance. Separate standards are provided for biodiesel used in vehicles and biodiesel used in space heating. The standards are expected to be put in place following a vote on December 10. The standard for biodiesel is more thorough and restrictive than the previous national standards. It is also more restrictive than the ASTM standard used in North America. A primary difference between the EU and North American standard is the specification for iodine number. Prankl also provided an overview of current European Bioenergy networks. Additional information can be obtained at the web site http://www.eubionet.vtt.fi.

REVIEW OF ONGOING PROJECTS

Country Reports

A template for country reports was sent to participants a few months ago. Information has been received from Canada, Finland, Netherlands, and United Kingdom. The other countries will be reminded to complete their information as rapidly as possible.

Case Studies

A template for the case studies has been agreed upon and will be distributed soon. It was agreed the report should be completed as early in 2003 as possible.

Ethanol and Biodiesel Standards

As reported by Prankl, the European standard for biodiesel is nearly complete, and that for North America (ASTM) is also in place. There is therefore little need for additional action on biodiesel.

There is increasing activity in Europe on standards for ethanol and ethanol blends. It is anticipated that a project will start in late 2002 to study which standards should be developed. In the previous Task 27, some work was done to assemble existing standards for ethanol, but that work was not published in the final report. It was decided that the present Task will make that information available to all current participants and will continue to track standardization efforts for ethanol. Sweden and the EU will be contacted to document any recent developments in those areas while Shell will be contacted to determine the industrial interest.

Roadmaps and Strategies

Compilation of the various Roadmap and Strategy Documents from the various participants is still considered to be valuable. All participants were requested to provide a list of relevant documents and electronic copies.

A new document from USA describing the goal established by an industry-based board that advises Department of Energy was distributed. The document sets aggressive goals for biopower, biofuels, and biobased products for 2003.

New Biodiesel Projects

As part of the Biodiesel subtask, two projects to collect updated information on biodiesel topics have been developed. The first project will provide an update of the worldwide biofuels situation, and the second will provide a "best case" summary of biodiesel experiences. Task funds allocated to the biodiesel subtask will be used for the work. Werner Körbitz discussed the projects with the group and provided a summary of the effort he will provide. The participants unanimously approved the two projects as proposed by Manfred Wörgetter.

Assisting with "Agreed Calculations"

The Task initially agreed to cooperate on a project to look at the basic assumptions for calculating life-cycle analyses. The project was proposed by NOVEM to the European Commission. IEA Bioenergy agreed to participate on the basis of an "in-kind" contribution where we provide data to the project but provide no direct financial assistance.

After initial evaluation, the Commission asked that the original proposal be combined with two others to form a larger project lead by NOVEM. The new project was entitled "Clean Fuels, Clear Data" to reflect its overview scope at looking at bioenergy in a broad way and developing appropriate LCA analysis tools. The scope of the new project includes analysis of biomass availability, performance of biofuels, and strategies for larger-scale production of biofuels in Europe. The new project was evaluated, funded and start in December 2002. A initial meeting is scheduled for early 2003.

IEA Bioenergy will assist the project by providing primarily data and information from North America. It was noted that Task 39 will end in 2003 and that the Clean Fuels project will continue past that date. The group agreed to consider the interaction in future plans if the current biofuels Task is extended.

IEA Biohydrogen Alternative Fuels Project

Shortly before the ExCo50 meeting, IEA Headquarters contacted IEA Bioenergy to determine if there was interest in being part of a joint project on hydrogen. The project would be operated by the IEA Advanced Motor Fuels Agreement (AMFA) group but would involve participation by several different Agreements. IEA Bioenergy expressed potential interest in the project and recommended that Task 39 be involved. An organizational meeting for the project was initially scheduled for late November 2002, but that meeting has now been postponed until early 2003.

After discussion, the Task 39 participants agreed there is significant interest in biohydrogen and that we should support interactions with others in this area. Further, the group agreed that this may be an effective way to open a broader exchange of ideas and information with the AMFA group, a high priority. It was unanimously agreed to proceed with discussions about this project to determine what can be accomplished. While it was recognized that the larger joint hydrogen project may have a different time frame than Task 39, there may also be opportunities for future collaboration if the current Biofuels Task is extended. The group strongly supports continuing discussions with the other Agreements on this topic. In addition, strong interest was expressed in using this project to establish a better working relationship with the IEA AMFA Agreement.

Windsor Workshop

IEA Headquarters is partially organizing the Windsor Conference, it has encouraged the various IEA Agreements In discussions at ExCo50, IEA Bioenergy agreed that that it would be useful to have some presence at the Windsor Conference.

While this is a high-quality conference, it was decided that the scope was largely outside the interests of participants, and that the Task would not hold a major meeting in connection with that conference .

Don Stevens agreed to provide an overview of the Task 39 work on biofuels and agreed to help organize a meeting session on development biofuels technologies. Participants were urged to provide suggestions about people in their countries who might be interested in giving a paper at this meeting.

OTHER PROJECTS

The group discussed other projects that were discussed earlier in the Task period. The earlier discussions suggested these topics were of interest, but that they would not be considered in detail until 2002.

New fuels

Most participants are interested in the "next generation" biofuels such as methanol, DME, MTHF, and others. Participants discussed various new projects they were aware of such as the study to use the Värnamo gasifier to produce DME. It was decided that providing a good overview of the State of the Art for new biofuels would be a good consultant project.

Biomass Feedstock Availability

At earlier meetings, the group had expressed interest in trying to understand the limitations and opportunities for biofuels based on feedstock availability. The Forestry Task indicated it could potentially help in such a study, but both groups agreed that such an undertaking was complex and costly. As a result, no specific work was started in this area.

At the same time, there has been increasing interest in exploring the feedstock availability in Eastern Europe. Several Eastern European countries are scheduled to join the EU, and the biomass resources of those countries could have a major impact on the availability of biofuels in the whole of Europe as well as worldwide implications. Participants agreed that information of this type would be very useful, particularly if the impact of those resources on biofuels implementation could be estimated. Following discussion, the group decided that such a study would best be conducted as part of the proposed consultant project.

CONSULTANT PROJECTS

A general discussion of the planned "Consultant Project was held. The use of consultants to provide more detailed studies of specific topic areas worked well within the prior Task 27, and has been planned since the inception of Task 39. Four project areas were identified and discussed in detail.

- Impacts on Liquid Biofuels from Feedstocks in Eastern Europe
- Implementation Experience with Existing Biofuels
- Summary of State of the Art for New Biofuels
- Biohydrogen as a biofuel
- Procedures, Schedule, and Management for the Consultant Projects

BIODIESEL SUBTASK

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COMMENTARY ON SOME NEWS

Werner KOERBITZ
Austrian Biofuels Institute
http://www.biodiesel.at

CALIFORNIAN POWER COMPANY INVESTING IN BIODIESEL

Source: Biodiesel - Courier / 07 January 2003

Southern States Power Company, Inc. (Riverside, California), a member of the National Biodiesel Board, announced that it has completed negotiations and has made an initial investment in LSTI Environmental Energies, which was formed to produce an innovative mobile, modular Biodiesel technology that is planned to produce up to 3 million gallons (approx. 10.000 ton) of EPA-registered and branded "OxEG Biodiesel" annually in each production location. The first units produced are scheduled to be utilized by the Inland Empire BioEnergy, the partnership SSPC recently formed with a Californian grease recovery and recycling business.

Harrison A. McCoy, president and CEO of SSPC, commented, "With the completion of these negotiations, SSPC has paved the way for the rapid deployment and installation of low cost Biodiesel production units, which will allow our portfolio investment companies to generate cash flow more quickly and significantly increase the on-road market share for OxEG Biodiesel."

Site development for the installation of the first units is underway, and the initiation of Biodiesel production is anticipated to begin in a matter of months. The unique nature of the technology will allow the Inland Empire BioEnergy to produce ASTM quality fuel utilizing a readily available, lower cost feedstock."

COMMENTARY
Ongoing growth for Biodiesel by increasing investment this time by a power generation company - very interesting diversification! And obviously another Biodiesel unit in the USA, which is committed to high quality as assured by the new and improved ASTM-standard D-6751-02. California is following the successful example of the Austrian farmers' cooperative SEEG, which is producing Biodiesel of high EN 14214 qual-

ity from professionally collected recycling oils since 1995.

GERMANY AS WORLD-WIDE LEADER IN BIODIESEL PRODUCTION: OVERALL PRODUCTION REACHING OVER 850.000 TON HIGH QUALITY BIODIESEL PER YEAR.

Source: Biodiesel - Courier / 30 August 2002

Having started in 1996 with a production of approx. 80.000 ton/yr of Biodiesel at the oilmill Connemann in Leer, Germany has accelerated the expansion of production capacity dramatically in the last 2 years and will reach a total of 883.000 ton by March 2003.

This is shown in the most recent update of the AGQM, a quality assurance council, in which 14 German producers, 1 French and 1 Austrian producer are represented. Biodiesel is marketed since the very beginning as pure 100% fuel and is sold today according to the quality standard DIN E 51.606. Biodiesel is distributed through over 1.500 pumps all over Germany as a well recognised and branded product.

Based on the warranties as provided by Volkswagen, Audi, BMW, MAN, Mercedes, Seat and Skoda, a Biodiesel market potential exists for more than 2.5 million cars. There are no blends on the market. Having faced severe quality problems in the past, 16 Biodiesel production plants formed a quality assurance council as an interest group in order to market only Biodiesel of controlled quality thus creating and reaffirming customer confidence. The high-quality Biodiesel pumps can be easily identified by a special quality seal, which is also promoted throughout the country. For more details (in German language) see http://www.agqm-biodiesel.de/

COMMENTARY:
A good example that strict quality management pays off, so the problems as created by a few "moonshine-producers" are disappearing.

CANADA PLANS LEGISLATION TO BOOST BIODIESEL USAGE: FIGHTING GLOBAL WARMING AT HOME AND IN THE CARS.

Source: Biodiesel - Courier / 31 October 2002

Never mind corporate responsibility, or government responsibility; let's talk about personal responsibility. That's the gist of Canada's new plan for fighting global warming. The proposal entails convincing every last Canuck to reduce her or his own contribution to greenhouse gas emissions by 1metric ton annually (or about 20 percent). Translation: cooler showers, lower thermostat settings, less private automobile use, and other lifestyle changes for Canadians. If successful, the effort would yield a total annual emissions reduction of 31 million metric tons. The government says the plan is sensible because a significant amount of Canada's greenhouse gases stem from fossil fuels burned to heat homes and power cars. It plans to offer financial incentives for energy-efficiency upgrades in private homes, increased use of public transit and the use of cleaner fuels such as Biodiesel.

COMMENTARY:
Good idea to reduce global warming! But savings of just 1 metric ton annually is not very challenging. Take an average of 20,000 km driven annually and a consumption of approx. 7 litre Biodiesel /100 km and you get 4.2t reduction in greenhouse gas emissions. Tax the risks --- support the benefits !

ETHANOL SUBTASK

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"CURRENT STATE OF FUEL ETHANOL COMMERCIALIZATION"
DECEMBER 11-12, 2002
YORK, UK

I would like to thank our gracious hosts (Tony Sidwell, Gary Punter, Adele Long) at British Sugar for all their help organizing this productive meeting and providing the participants with a tour of and transportation both to and from the York Sugar Factory.

Nine of the ten Task 39 participating countries, the exception being Austria, were represented at this meeting. This meeting was a combination of a technical and policy related review of the state of fuel ethanol commercialization. The format was slightly different to previous meetings with the emphasis on discussion between the participants rather than the traditional symposia format of presentation and question sessions.

The meeting was divided into eight sessions (Overall Process Concepts, Pretreatment, Fractionation & Co-product Development, Hydrolysis, Fermentation, Equipment and Scale-up Requirements, Commercialization, and Policy/Regulatory Issues,) that generally represent the major stages of ethanol production from biomass and on average there were two to three presenters per session. These notes reflect a summary of the key points from the speakers on the central theme of the meeting.

OVERALL PROCESS CONCEPTS SESSION

BIO-FUELS: THE FUELS OF THE FUTURE

Birgitte K. Ahring & Lars Rohold
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The challenge for the bioethanol industry is to produce their product from waste biomass such as wheat straw or corn stover. The aim is to make bioethanol an energy commodity produced without subsidy and traded in the world market. The major technical problem to realizing that goal is "opening up" the waste biomass structure to make the sugar content available for ethanol production at a production cost competitive with fossil fuels.

The Technical University of Denmark and the Risø National Laboratory have developed a conceptual process "Danish Bioethanol Concept" to combine biogas and bioethanol production with recycling of manure as the process water. This conceptual process is considered leading edge technology, ready for exploitation and is currently being implemented. Production cost currently is 0.20-0.25 Euro/litre ethanol with petroleum production cost at 0.15 Euro/litre (+ externalities) and MTBE production cost at 0.45 Euro/litre. Therefore ethanol appears to be reaching competitive levels and there is still potential breakthroughs in pretreatment of biomass, enzyme and yeast/ thermophilic bacteria technology to further cut that production cost. There is also the potential for bioethanol usage in fuel cell vehicles.

The Danish Bioethanol Concept has been described in considerable detail in previous issues of the newsletter. Wheat straw is subjected to a wet oxidation pretreatment (195ºC, 12 bar O_2, Na_2CO_3), the pretreated mixture is then sent to SSF fermentation (40ºC) to convert the hexose sugars and a thermophilic fermentation (70ºC) to convert the pentose sugars. Ethanol is produced and the remaining water mixture along with dry manure is sent to an anaerobic treatment (55ºC) that produces biogas (methane). The solids from the anaerobic treatment are then recycled back and combined with the wheat straw in the wet oxidation pretreatment.

Metabolic engineering has included the development of plasmids for improving the hyperthermophilic bacteria and producing enhanced ethanol-producing strains through deletion of genes involved in the formation of unwanted bi-products and introduction and up-regulation of genes involved in ethanol production or substrate metabolism.

There are four main groups partnering this concept at the Center for Biofuels: DTU (BioCentrum, KT, IPL); Risø National Laboratory; KVL and Industrier.

Subsidies for fuel ethanol have generally been the proposed solution to market introduction, but technical advances have been successful at bringing the ethanol production cost into the range of gasoline offering support for rural economies, environmental benefits, energy supply security and the potential to substitute up to 30% of the world petroleum requirement.

SOFTWOOD PROCESS DEVELOPMENT UNIT

David J. Gregg, Olga Mirochnik & Doug Kilburn
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Our research group has focused on the production of ethanol from softwoods over the last 10 years as this is the most abundant feedstock in our part of Canada. In the past, as a result of initially working on agricultural residues and hardwoods, we developed a process that involved an SO_2 catalyzed steam explosion front-end and an SHF back-end. Following the 10 year period of process research and optimization we concluded that there are a significant number of challenges facing this process that include:

- Substantial hemicellulose sugar loss (20-30% of original sugar) at compromise pretreatment conditions (maximum sugar recovery but not maximum for either hemicellulose or cellulose)
- High lignin removal cost (40-45% of total production cost)
- Low lignin value (substantial condensation)
- Fermentation limited to glucose and mannose sugars
- Dilute fermentation streams

The most important of these challenges are the high lignin cost and low value for the extracted lignin. We have concluded that unless, we can develop a very cheap method for removing this lignin (the most successful attempt was to develop a hot alkaline peroxide (HAP) fractionation scheme that was technically competent though not economic), and/or develop ways to enhance the value of that lignin the steam pretreatment process, as currently defined, is nearing its limit for effectively providing value to each of the three main lignocellulosic components.

As a consequence we have begun to look at two organosolv processes. An acetic acid process while possessing a number of highly advantageous properties still requires a substantial amount of research for full utilization of all sugars and scale-up. Early results from the ethanol organosolv process appear encouraging, lignin extraction while not as effective as HAP is still effective, lignin characteristics so far good, hydrolysis results very good, fermentation so far is good and better than acetic acid.

An optimum economic product mix for softwood processes will likely be biased towards the sugars for steam pretreatment and a mixture of cellulosic sugar and lignin based for the organosolv processes.

PRETREATMENT SESSION

PRETREATMENT OF LIGNOCELLULOSICS

John N. Saddler, David J. Gregg, Xiao Zhang
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The choice of pretreatment for a lignocellulose-to-ethanol process is highly dependent on the nature of the substrates (agricultural residue, hardwood, softwood), and the co-product development strategy.

Steam pretreatment shows promise for agricultural residues and works well for hardwood feedstocks but has not been successful on softwoods without costly and severe lignin removal techniques.

Organic solvent (organosolv) pretreatments dissolve lignin fragments and minimize condensation reactions, thus tending to produce a more valuable lignin. These pretreatments also hydrolyze the hemicellulose, decrease the cellulose DP, and have the potential to swell cellulose microstructure to enhance enzyme accessibility.

Co-product potential value differs between the steam pretreatment and organosolv processes. Extractives evaporate with the steam in steam pretreatment while they can be readily collected in the spent liquor of an organosolv process. All of the lignin from the steam pretreatment is only suitable for burning while in the organosolv processes the low molecular weight portion has potential as an antioxidant and the remainder as adhesives or lubricants.

SELECTED RECENT RESEARCH RESULTS ON PRETREATMENT OF CELLULOSICS BY HEMICELLULOSE HYDROLYSIS

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Traditional models that simulate hemicellulose degradation during dilute acid pretreatment have suggested a depolymerization pattern of polymers becoming monomers and then degradation products. However, pretreatment experimental data does not tend to fit models of this pattern. Adapting these types of models, by adding a term to account for the changing accessibility of the bonds with conversion, we have been able to significantly improve the fit of the predictions to the experimental data. Detailed evaluation of these exercises suggest that sugars depolymerize and ultimately disappear through reactions that do not pass through the monomer stage, i.e., going directly from oligomers to degradation products. This has significant implications for determining pretreatment product yields.

Comparison of batch and flow-through reactors indicated that both temperature and flow rate enhanced removal of xylan with water. This is contrary to first order kinetic models in which changes in rate have no effect. Lignin removal trials using water and two concentrations of sulfuric acid (0.05 wt% & 0.1 wt%) suggested higher levels of lignin removal with greater flow up to a limit (>10 ml/min). Batch systems showed a good correlation between digestibility and xylan removal and a poor correlation between digestibility and lignin removal. Flowthrough reactors showed a good correlation between digestibility and both xylan and lignin removal. Charlie suggested that it is more likely the case that both xylan and lignin affect cellulose digestibility as shown by the flowthrough system and also that the nature of the lignin changes (we remove it, it goes into solution, change it into something else, it reprecipitates and is less in the way of the lignin). Plots of xylan removal versus lignin removal indicate that there is a poor correlation between the two in batch conditions and good correlation at high flow rates. This is confirmed by the lignin removal being only 10-12% solubilized in batch whereas in continuous conditions there is up to 75% removal of lignin.

FRACTIONATION & CO-PRODUCT DEVELOPMENT SESSION

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Biomass is a complex of high molecular weight polymers, frequently, chemically linked, (cellulose, hemicellulose, lignin), mixed with low molecular weight materials (fatty acids, resin acids, phytosterols, etc.) and minerals (metal ions, anions, silica, etc.). To be effective a biomass fractionation or biorefining process, which is the separation of these complex mixture of chemicals into a number of useful fractions, must take into account all of these.

Biorefining has the same objectives as commercial oil refining or corn wet milling and often entails a combination of chemical bond cleavage and physical separation. Similar to those industries biorefining has advantages such as including maximum utilization of the resource to minimize raw material cost of each product, maximization of revenues from a single plant (smaller plant sizes, lower capital cost, lower raw material cost), minimization of waste product generation and waste treatment costs, and provision for multiple revenue streams that protect plant profitability.

General principles of biorefining technologies include:

> Protect the value of the different components of the raw material even though market size is inversely proportional to price;
>
> Polymers are more valuable than the monomer although it is sometimes necessary to depolymerize in order to separate and purify;
>
> Multi-state processing is more efficient then single stage although being more capital intensive.

Currently defined biomass fractionation processes can be roughly divided into conventional chemical pulping processes and organosolv based processes. The chemical pulping processes (Kraft, sulfite, and soda) destroy the chemical value of coproducts because of the need to recovery and recycle the costly inorganic cooking chemicals. Sometimes chemicals such as lignosulfonates, Kraft lignin, soda lignin, tall oil, yeast and ethanol are recovered.

Organosolv-based processes (e.g. Organocell, Clean Fractionation, Alcell/Lignol) while still requiring high recovery and recycling efficiencies of the cooking chemicals are much more likely to retain the chemical value of the co-products.

Ken described the current status of a number of organosolv biorefining processes: (Organocell (methanol based) - technology shelved; Clean Fractionation (aqueous alcohol and ketone mixture) – halted development with Eastman Kodak and now redirected to annual fibers; Alcell (aqueous ethanol) – pulping demonstration scale plant closed, technology sold to Lignol Innovations Corp.

The Alcell process has been modified by Lignol to become a delignification process combined with cellulose conversion to ethanol i.e., bioconversion instead of pulping. The feedstock will be wood residues and agricultural wastes such as straw. Products/co-products are expected to be ethanol (process produces its own solvent), organosolv lignin, xylose, acetic acid, furfural and extractives. Combined revenue from the multiple co-products provides a high level of profitability and this in turn allows for relatively small-scale (100 tpd) plants to be matched to single sawmill residue output. This process solves a current environmental disposal problem, produces chemicals and fuels from waste renewable resources, with essentially no waste stream remaining to treat. Lignol is now in the later stages of development with a commercial plant projected for early 2005.

In conclusion, biorefining can make cellulose-to-ethanol technology financially attractive now through increased revenues, multiple revenue sources, smaller scale plants, lower cost raw material and being environmentally benign.

HYDROLYSIS SESSION

ENZYMATIC HYDROLYSIS OF LIGNOCELLULOSIC MATERIALS: STATUS AND PERSPECTIVES

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Liisa framed her talk around a list of bottlenecks or challenges for understanding and enhancing enzymatic hydrolysis of lignocellulosic materials. The list included specific activity of the cellulases, stability of the enzymes, end product inhibition, the role of cellulose binding domain (CBD), composition of the cellulase mixtures for optimum hydrolysis of different raw materials, role of other enzymes (hemicellulases, ligninase systems), productivity, recycling of enzymes and hydrolysis technologies.

Cellulases, particularly those from *Trichoderma reesei*, have been characterized and categorized with regard to their amino acid composition, 3D structure, molecular mass, isoelectric point, structural organization (catalytic domain, linker region, binding domain) and functionality (endo or exo gluconase). Methods have included structural studies using x-ray crystallography (catalytic domains), NMR (CBD's), molecular modelling; protein engineering of the catalytic domain used to determine the catalytic mechanism (carboxylic acids and ring distortion), involvement of tryptophans in the substrate binding, role of the active site loops, pH optimum, pH stability (thermostability); protein engineering of the linker peptide using linker deletions; protein engineering of the cellulose-binding domain (CBD) with determining the role of three aromatic amino acids on the flat surface, pH behaviour, and fusion proteins. Most of our current knowledge seems to allow us make enzymes worse rather than enhance them.

Hemicellulases and ligninases have not been studied in as much detail as the cellulases. Studies using these enzymes along with cellulases during enzymatic hydrolysis have corroborated much of the pretreatment studies that indicated the hindrance of both hemicellulose and lignin in conversion of the cellulose.

The most likely area of major knowledge and hydrolysis enhancement is in adjusting the cellulase mixtures to suit a particular raw material. Other less positive enhancements may be seen in determining the role of the hemicellulase/ligninase systems, enhancing enzyme productivity levels, and development of hydrolysis technologies. The least likely areas of enhancement would seem to be altering the specific activity of the cellulases, enhancing the enzyme stability, reducing the end product inhibition, determining the role of CBD's and recycling of enzymes.

QUESTIONS & COMMENTS ON ENZYMATIC HYDROLYSIS

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Tony used a series of questions and comments to generate discussion. From an enzymatic hydrolysis process development standpoint maybe the most important concept to remember is that only the enzymes diffuse and the substrates are insoluble. The water content for hydrolysis will determine the nature of the mixture (semi-solid, slurry, suspension), reactor type (stirred agitated reactors) and agitation mechanism and expense. Reaction temperature must be decided and determines the needs for heating, enzyme efficiency and whether we use the enzymes that are available now or use thermophilic enzymes.

Enzyme efficiency is often misunderstood and cellulase hydrolysis is often thought to be a relatively slow process. Cellulase enzymes given the half-life of cellulose (several million years) are actually very efficient. Even though the cellulase enzymes appear inefficient in reality you are looking rate enhancements of many orders of magnitude. These enzymes are very efficient at hydrolyzing glycosidic bonds. Probably the most rate-limiting factor is the insoluble substrate (with crystalline and amorphous regions) and the need to sequester/bind a single molecule of substrate into the active site. Binding modules of cellulase enzymes may also be a rate-limiting factor in that there are instances in which the binding is irreversible (no longer free to diffuse) on the substrate and limits the remaining hydrolyzable surface area. End-product inhibition may also result from the released soluble products diffusing into the active site and compete with the substrate. Beta-glucosidases become important in reducing the end-product inhibition and are in many cases more active on soluble oligosaccharides as than on disaccharides.

The choice of enzymes is also uncertain. There are bacterial enzymes (family 9) that are as efficient as fungal enzymes but are produced in lesser quantity than fungal enzymes. We don't know how many different enzymes are required for an effective process. If these systems must be tailored to suit different substrates then we must consider why the enzyme synergy is so poor (2-3 normally) compared to starch enzymes. Do we use enzymes characterized to date, isolate new enzymes (new sources) or improve/evolve known enzymes knowing that they still need to sequester a single molecule into its active site? Pretreatment of the substrate remains an important element in the equation.

Operationally there are a number of fundamental questions that remain unanswered. Given current hydrolysis characterization do we have the quantities of enzyme required and will we have the capacity to produce them on a continual basis at the required scale? Will enzyme recycle fill any role in reducing enzyme production and what role do the binding modules and enzyme dilution have on this capability? How stable are the enzymes under industrial conditions i.e., is there potential for proteolysis from contaminating organisms? Should we produce microbes instead of enzymes i.e., production of enzymes *in situ*?

FERMENTATION SESSION

PENTOSE FERMENTATION RESEARCH

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Fermentation research is advancing on many fronts with arabinose fermentation by yeasts having been achieved and likely to be commercially implemented in the next few years (3-5). There are at least two routes that will be used although which one is better and what genetic background it will go into is not really known as there are a multitude of possibilities. However, there remains a glimmer of hope in solving the arabinose fermentation issue. Xylose fermentation is advancing in both *S. cerevisiae* and native xylose fermenting yeasts, and thermophilic yeasts (45ºC) being developed for SSF including xylose fermentation.

Although the bulk of Tom's talk was on engineering *Saccharomyces* yeasts he feels that modification of native xylose fermenting yeasts may be a better way to go. For example his work on *Pichia stipitis* suggests that there may still be some room for improvement on the poor yields by backing off on the concentration and there will not be any xylitol production.

We have learned a great deal about xylose fermentation in *Saccharomyces* although we are probably still quite a ways from commercial yeast. Laboratory strains have a polyploidy background without very many selectable markers. Most strains only have one selectable drug marker and not all of the strains take a drug marker very well. This means that for multiple engineering steps in an industrial yeast background we only have a single shot at selection. Consequently other methods must be developed for example currently large cassette expression technology is used to go in with multiple genes in one shot. These techniques are working well and seem to be providing some of the necessary tools for pushing laboratory strains into the industrial setting.

Tom then gave a detailed discussion on recent research work on xylulokinase overexpression to force xylose metabolism away from xylitol production into the PPP (pentose phosphate pathway) and eventually the ethanol fermentative pathways. Detailed genetic work compared gene expression on two different substrates (xylose and glucose) and under two growth conditions (low and high aeration) and found the following: the genes for energy production were affected most; genes for fermentation were unchanged; many genes for glycolysis were unchanged; genes for PPP were induced under aerobic conditions; genes for the TCA cycle and respiration were induced on xylose. In conclusion *Saccharomyces* does not repress respiration on xylose i.e., xylose is not recognized as a fermentable carbon source, so we must learn how to down-regulate respiration in order to use this organism for xylose fermentation. Apparently Tom's group has discovered how to do this and is continuing to work at incorporating glucose and xylose fermentation into these yeasts.

THE PERFECT FERMENTATION MICROORGANISM FOR BIOETHANOL PRODUCTION – HOW?

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To date industry has achieved very high gravity fermentations using starch based raw material with 30-38% dry matter in the SSF process a 99% sugar utilisation is accomplished within 48 hrs and the ethanol yields are in the range of 85-95% of the theoretical yield.

What needs to be addressed currently, to achieve equally efficient ethanol production in lignocellulosic raw materials, is an improvement in the pentose transport system and modulation of the redox metabolism. The latter system is difficult to manipulate as redox equivalents are involved in a large number of cellular reactions. We also need to improve our understanding of regulation, quantification of fluxes, levels in and transfer of redox equivalents between different compartments.

There is a general interest in utilising *Saccharomyces cerevisiae* for both hexose and pentose fermentation. Systems biology and metabolic engineering will be very important tools to achieve an efficient pentose fermenting yeast Important targets will not only include efficient xylose and arabinose fermentation, but also reduced production of glycerol, xylitol and other potential by-products, and alleviation of glucose repression. However, we also need to look into conditions prevailing in real substrates – lignocellulosic hydrolysates, transfer strain constructions from the laboratory to industrial strains.

Essential traits of an efficient fermentation organism for ethanol production from lignocellulosic material are: broad substrate utilization, high ethanol yields and productivity, minimal by-product formation, high ethanol tolerance, increased tolerance to inhibitors, tolerance to process hardiness/stress resistance. Desirable traits include simultaneous sugar utilization, hemicellulose and cellulose hydrolysis, GRAS2 status, recyclable, minimal nutrient supplementation, and tolerance to low pH and high temperature.

In nature there are currently no available fermentation microorganism that fulfills alls these demands. The compromises will depend on the process configuration and locations of bioethanol production. We do not presently have molecular knowledge of all the required properties. Experience from whole process experiments and pilot scale is important to identify industrial scale problems.

To design a good fermentation microorganism will likely require combinations of classical strain improvements and metabolic engineering. The development of measures that could describe the fermentation performance in relation to the harshness of the hydrolysate will enable a better comparison of results achieved in different laboratories.

EQUIPMENT AND SCALE-UP REQUIREMENTS SESSION

PLAN FOR UK PLC

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British Sugar has been working on a plan to present to the British government for the production of bioethanol. This will initially come from sugar beets (2004), later a partial lignocellulosic addition (2007) and a complete lignocellulosic plant by 2012. They also estimate that by 2015 there will be ethanol fuel cells appearing and by 2030-2050 renewable hydrogen. Up until recent changes in the British Government stance it was felt realistic to project an ethanol market of 5% (1.2 million tonnes) by 2010 based on the required duty exemption at the time. However, just recently the Chancellor has suggested a higher exemption.

On November 27th, 2002 the following Chancellors pre budget statement was made "In April 2002, the Government invited bids for fuel duty reductions or exemptions to support research and development into a range of alternative fuels. All the qualifying bids covered bioethanol. In light of the new environmental data and new research, the Government intends to introduce a new duty rate for bioethanol set at 20 pence per litre below the prevailing ULSP duty rate…. While the new duty rate will apply to bioethanol produced from any feedstock, the Government is particularly keen to support the development of bioethanol from ligno-cellulosic feedstocks, such as straw and forestry residues, as this looks likely to offer particular environmental advantages. Production of ligno-cellulosic bioethanol is at a comparatively early stage of development, and the Government will therefore consider how best to give it further support."

We are now working out the way to implement the addition of a biorefinery concept into our current sugar production facilities. State of the art bioethanol plants are available now if you are interested in converting starch to ethanol. Lignocellulosic additions to a modern bioethanol plant will consist of new crops and waste biomass handling facilities, conversion of hemicellulose to sugars, conversion of cellulose to sugars, lignin conversion to CHP and power, with the ethanol eventually going into fuel cells.

British Sugar is currently concluding feasibility studies for Plant 1. They are proposing to work with lignocellulosic technology providers to feed into the design and planning for current plants and also putting together a UK consortium to convince the UK Government and to be able to deliver.

There was then considerable discussion with regard to the types of incentives/support the British Government should provide to initiate and sustain a competitive bioethanol industry in the UK.

SCALE-UP OF ENZYMATIC BIOMASS ETHANOL PROCESSES

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A typical enzymatic bioethanol process consists of: inputs such as feedstock (e.g. agricultural residue), enzyme and yeast or bacteria; sub-process units such as pretreatment, hydrolysis, fermentation, distillation, solid/liquid separation and outputs like ethanol, wastewater, heat or steam, acid or alkali lignin residue.

The key unit operations have certain scale-up issues associated with them. Pretreatment has the goal of achieving uniform heat and mass transfer to biomass for short residence times (minutes). Design considerations include batch versus continuous reactors, feeding low bulk density agricultural residues into a pressurized continuous reactor, handling high concentrations of suspended solid slurries, material of construction and custom design reactors may be necessary to meet process requirements (e.g., feedstock specific).

Enzymatic hydrolysis and fermentation have an overall design goal of achieving uniform adequate mixing and temperature. Design considerations include batch versus continuous reactors (cost versus operability), uniform mixing of slurries in large fermentors and minimal back mixing in continuous process. High mechanical energy input could lead to: high capital and operating costs for the mixing; excessive heat input thus requiring higher cooling requirements; and potential high shear with subsequent enzyme denaturing. Cooling of high-solid slurries can lead to fouling and blockage of heat exchangers.

The solid liquid separation sub-process is expected to achieve high solid content of lignin residue for combustion or further processing. Design considerations include centrifugation versus filtration and specific feedstock properties.

Every process development has scale-up considerations with the expectation to achieve process/cost performance targets and equipment reliability. Suggestions for meeting this expectation based on experience include the use of commercially proven equipment or similar design and work with equipment manufacturers in designing new equipment if necessary to achieve process requirements.

Abengoa expects to develop processes that can be scaled up to commercial operations and minimize risks in scaling up those processes by developing engineering design data. A suggested path to successful process development include scaling down to pilot and to bench scale equipment if feasible, integrating process testing at pilot plant level is essential, use commercial equipment for pilot plant process development, develop a clear understanding of the fundamental process requirements, it is desirable to also develop predictive process kinetic models for engineering design.

EQUIPMENT AND SCALE-UP REQUIREMENTS: PILOTPLANT IN SWEDEN

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Jan started the presentation with a description of the various reasons for the pilot plant, development efforts across Sweden supporting introduction of fuel ethanol, and the current state of EU legislation that limits the level of ethanol in petrol (one year decision for full tax reduction on 19th December, long term decision next year based on EU directive, two years left in ethanol program).

The pilot plant is a research and development unit to verify and optimise the techniques that have been developed in the laboratory or PDU at Lund, and also to gather basic data for scale up to production plants (100-250 times larger). The facility will use a two-step dilute acid and enzymatic hydrolysis process with a 2 tonne of dry substance/500 l ethanol per day capacity. Recirculation of process streams in the complete plant is planned. This facility represents an investment of 15 million USD.

The process will include the following subunits screening, dilute acid (H_2SO_4/SO_2) prehydrolysis, washing, dilute acid (H_2SO_4/SO_2) hydrolysis, enzymatic hydrolysis (SSF), washing/filtration, fermentation, distillation, evaporation and condensate treatment. The pretreatment is based on a two stage countercurrent reactor developed at NREL.

Financing for the pilot plant started in March 2002, building commenced in September 2002 and testing is anticipated to start in November, 2003. Development of a complete process is expected by 2005 and a full-scale production plant in operation by 2007-2008.

Current estimated production costs (US$/litre ethanol) for ethanol from cellulose with dilute acid hydrolysis are 0.18 for raw material, 0.13 for energy, 0.03 for chemicals, -0.12 for by-product credit, 0.05 operating costs, 0.14 capital costs for a total of 0.41.

COMMERCIALIZATION SESSION

COMMERCIALIZATION

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Commercialization of any process must include a money making business plan, some sort of competitive advantage and a market for its products. Current business plans require an estimate of the price and market size of the product in twenty years.

A money making business plan for biomass conversion to ethanol needs an ethanol market at an acceptable price and a competitive advantage to overcome the costs of being "first to market" or just to compete. Key inputs to this business plan include market size and price, R&D cost estimate, feedstock cost, capital costs, product versus operating cost inflation. Positive scenarios are possible and a couple of examples were described. One example would have a greater than $1.50 US/gallon ethanol at $35 US/ton feedstock (40 cents per liter) with a capital cost in the range of the NREL current estimates of $200 million US for a 50 million gallon per year facility and the product inflation rate would be assumed to equal the operating cost inflation. Another example would be a greater than $1.25 US/gallon ethanol at a lower feedstock cost i.e., $15 US/ton feedstock (33 cents per liter) with the other properties being similar to the above case.

Ethanol is a bulk market so price is unlikely to be a competitive advantage unless driven by technology or coproducts. Other examples of competitive advantage could be a captive market such as Shell distributing to itself or technology advantages in areas like biocatalysts, hydrolysis processes, and gasification/catalysis. However, the latter technology areas are crowded fields and highly competitive and at this point in time difficult to assess whether competitive advantage based on technology really exist.

The ethanol market varies worldwide and is driven by very different factors. Policies and tax incentives help in some areas (US and Brazil) while GHG emission targets help in others (EU). Predictions for when world supply of petroleum and demand become unbalanced vary significantly. There continues to be a lot of debate on this issue with very different predictions coming from the various modeling groups (geological supply, financial, etc.). There are also other alternative fuels that could supply the market including natural gas and coal based products. In large part the cost still remains the ultimate market driver.

On the positive side of the equation there is tremendous industrial interest in the production of ethanol and other coproducts from biomass. There are a number of proponents of process technology (DuPont, Iogen/Shell, High Plains/Abengoa, BC International, Arkenol, Masada Resources) and the more recent players seem to have the capability to both introduce and adequately finance the technology (not dependent on engineering guarantees as they can internally finance). Cellulase enzyme production companies (Genencor, Novozymes, Iogen) already exist and pilot plants (Iogen, BC International, Arkenol, Masada Resources) have been and continue to be built to test and scale the technologies.

There remain a significant number of technical, financial and political bottlenecks in developing or expanding a fuel ethanol industry and market. I have just touched on some of the economic bottlenecks although there will be many more described by other speakers at this conference. To overcome these there must be a large enough reward and an opportunity to create/get into the market with some sort of competitive advantage.

Biorefineries are a great concept although they still need significant additional R&D and market development funding. Sustainable processes for feedstock production are of great concern as there is currently no consensus on the best practices for agricultural residue collection. Financially viable business plans for biorefineries will require adequate R&D and business development funding as well as organization access to capital markets which in the past have held up technology introduction.

ABENGOA ETHANOL COMMERCIALIZATION

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ABENGOA has four major business divisions (engineering and industry construction, systems and networks, environmental services, bioenergy). In total ABENGOA has 200 companies operating in 40 countries with over 10,000 employees. Sales and EBITDA in 2001 was 1.38 billion and 166.4 million Euros respectively. Thirty six percent of those sales were generated outside Spain. The company started in the 1940's with the engineering division and represented about 50% of the total sales in 2001. Bioenergy is the latest addition to the company and represented approximately 8% of the total sales in 2001. The corporate philosophy is to use innovation drive as a springboard for sustained growth.

Abengoa Bioenergy has a small R&D group with most of the bench-scale R&D being done by collaboration with partners and subcontractors. We are currently the 4th largest ethanol producer in the US with significant growth planned, the market leader in Spain, carrying out preliminary conversations with the rest of Europe and exploring ways to enter local markets in Latin America. There is currently 226 million L of ethanol production in Spain (composed of ethanol direct blending and ETBE) with an extra 325 million L in various stages of promotion/start-up. In the USA there is 325 million L of ethanol production operational and an expected 150 million L to be added within the next 2 years. The combined total production is 1.036 billion L (274 million US gallons).

The EU biofuel challenge is based on two main drivers, environment and climate change as well as security of supply. The EU is committed to reduce CO_2 emissions, although the emissions from transport are growing. Approximately 98% of the transport market is dependent on petroleum. Minor drivers include the generation of new rural jobs and agriculture support through demand for grain and sugar beets.

Ethanol market drivers for Abengoa in the EU include the strong leading position in an emerging industry and although the current framework limits the development to pilot projects there is a great opportunity for significant growth in the near future.

In the USA there are estimates that the MTBE phase-out could represent a ten-fold increase in the demand for ethanol over 2000 figures. Estimated demand based on the Renewable Fuel Standard is more modest at a doubling of demand but still significant.

ABENGOA has a growth strategy based on geographic expansion (U.S., Europe and Latin America), plant capacity expansion, increased client base (new markets: E-diesel, E-85) and distribution capacity, and utilization of lower cost biomass (agricultural residues) with a large supply for sustainable growth.

Technology development efforts at ABENGOA have been categorized into three tiers. The first tier represents improvement of the current grain ethanol processes through better conversion yield, lower energy consumption and higher value for co-products. Tier two is associated with the development of commercially viable biomass-to-ethanol technologies. The final tier is working with the biorefinery concept for maximum product value.

We are involved with three activities for development of new markets for ethanol, E-diesel, E-85 promotion through use of flexible fuel vehicles in the EU, and development of ethanol fuel cells.

POLICY/REGULATORY ISSUES SESSION

CLIMATE NEUTRAL GASEOUS AND LIQUID FUELS (GAVE):STIMULATING MARKET INTRODUCTION IN THE NETHERLANDS

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Jörg discussed policy and marketing issues associated with the Dutch (GAVE) program that has been described in more detail in past newsletters as well as at the GAVE website (http://gave.novem.org). The program is based on stimulating the market introduction of climate neutral gaseous and liquid fuels in the Netherlands. Climate neutral fuels are defined as energy carriers that reduce CO_2 emissions by 80% (the goal for post Kyoto in 2010) compared to fossil alternatives through the whole production chain. The Netherlands has a Kyoto commitment of 6% reduction in CO_2 emissions over the 1990 level, this represents a 38 MT reduction. This commitment will be met through various policy measures including introduction of sustainable energy forms with the goal of reaching a 10% sustainable level of production by 2020. As mentioned above the goal for the post Kyoto period is an 80% reduction in CO_2 from the 1990 levels through comparative advantages of existing Dutch industries.

The GAVE process started in 1998 and has already gone through an inventory phase that determined the attractive fuel chains within the existing infrastructure to substitute for gasoline, diesel and natural gas. Part of the analysis included the ease of introduction into the existing infrastructure as well as making sure that all stakeholders had a part in determining and supporting the outcome. Another criteria for successful fuel introduction was having at least one sufficiently large partner to realize market introduction. For the period 2001 to 2008 the successful candidate fuel chains will go through a demonstration process that includes 3 phases: alliance formation (2001-2002), blueprint development (2002-2004) and demonstration (2003-2008). In the alliance phase the parties receive a subsidy (up to 50% of the cost to a maximum of 100,000 Euros) to get together and work out a plan to develop their fuel chain option. Within the blueprint phase the parties get together and develop a blueprint that contains enough detailed engineering information for a demonstration of the fuel chain. The blueprint phase is supported from 25-35% of the cost up to a maximum of 500,000 Euros. The final stage is the demonstration phase with support of 30% up to a maximum of 2.5 million Euros. A number of the fuel chains (FischerTropsch trigeneration (heat, electricity and biofuel) and diesel, hydro-thermal upgrading (HTU oil), biohydrogen for transport and micro-CHP, synthetic natural gas and bio-methanol for hydrogen) were then discussed with regard to their progress through the alliance and blueprint phases.

Novem provides support to the GAVE process through finding partners, having networking meetings, acting as a brokerage between stakeholders, and supplying information on new state of the art studies, EU policy development on biofuels, and international opportunities.

The current hot or fire points for the Netherlands include linking short and long term projects through experience with conventional biofuels and new generation fuels, niche to niche jumping by using the existing infrastructure and experience in bioenergy field, GAVE intensive care with close monitoring of the GAVE and GAVE-relevant projects, and the EU-financed VIEWLS project.

The Clear Data and European Scenarios from Clean Transportation Fuels from biomass (NNE5-2001-00619, acronym VIEWLS) which is an EU project (with 19 partners including IEA Bioenergy Task 39) for policy advice on uniformity of environmental performance, opportunities for new EU countries and introduction cost of 2% and 5.75%.

Current drivers and issues associated with clean transportation fuels in the Netherlands include domestic production limitations of biomass both now and in the future, energy input versus output ratios, climate neutral (CO_2) ratings, cellulosic ethanol and EU directives.

Task 39 provides state of the art and current international development information on biofuels. This information includes technology, policy, financial perspectives, various strategies for biofuels and market introduction, and also performance data on biofuels.

FUEL ETHANOL IN CANADA: POLICY & REGULATORY STATUS

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Current Canadian production of ethanol consists of five plants with a total capacity of 185 million litres/year. The net production amount of ethanol is 225 million litres/year in blended gasoline (5-10%) with some Western Canadian production being exported and U.S. production being imported into Central Canada.

Ethanol fuel consumption is approximately 3 billion litres total of E10 equivalent gasoline. This is sold in 6 of the 10 provinces and 1 of the 3 territories. E85 gasoline is dispensed from 2 federal government stations to a fleet of 60 flexible fuel vehicles in Ottawa and one commercial station.

The current ethanol fuel market is based on a fuel tax exemption for the ethanol portion of the ethanol/gasoline blends. There is a 0.06 Euro/litre federal excise tax exemption and the Provinces also offer varying levels of tax exemption.

The Canadian government also has R&D support for development of new production technology such as cellulosic biomass, the previously mentioned federal fleet of ethanol vehicles and a National Biomass Ethanol Program to encourage financing of new plants.

Future incentives for fuel ethanol development are tied to Federal GHG reduction and agricultural diversification strategies. An example of this is the recently released “Climate Change Draft Plan: Achieving Our Commitments Together” which includes the option to increase to 35% by 2010 the portion of gasoline in Canada to contain either 10% ethanol or a standard which focuses on the GHG content of the ethanol portion.

USDA BIOFUELS ISSUES AND ACTIVITIES

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Bioenergy is important to the USA for energy security, environmental and rural economic reasons. The major barrier to bioenergy is cost competitiveness with gasoline while minor barriers include supply, emissions, energy efficiency and quality. For biofuels to become competitive technology is important although policy is essential and in reality policy probably represents 90% of the barrier while technology represents only 10%. For maximum benefit what is required is technology to support good policy.

Don then went through the various executive orders (EO 13134 – Developing and Promoting Biobased Products and Bioenergy), legislation (Biomass R&D Act of 2000, Farm Security and Rural Investment Act of 2002) and other policy (USDA & DOE coordination, formation of the Biomass R&D Board and Technical Advisory Committee) that he believes signify a significant departure from the past and tremendous opportunity for biofuel research and development.

The Biomass R&D Technical Advisory Committee has developed a list of top strategies for Plant Science and Feedstock Production as well as for Fuels Development. The former area includes lifecycle costs of feedstocks, plant biochemistry and enzymes, logistics of handling multiple feedstocks, chemical and chemical/biological processes, life cycle economics of biological vs. competition and optimizing agronomic practices. Fuels development strategies include research and public education on biotechnology, genetically modified organisms, genetically modified crops, genomics, thermochemical conversion, multiple sugar stream handling strategies, enzymatic pretreatment, solving conversion of lignocellulosic materials, biological conversion and production of hydrogen from biomass.

Another example of a change in policy is the Energy Title of the Farm Bill. This is an historic first for farm legislation and recognizes a major shift in policy that includes federal procurement of biobased products. This creates tremendous opportunity for rural America and for agriculture with new opportunities in sustainable energy production and biomass based products development. The bioenergy program with continue as will biomass research and development but there will be new initiatives such as biorefinery grants, biodiesel fuel education programs, energy audit and renewable energy development, hydrogen and fuel cell technology development and further opportunities for cooperative research and extension.

Progress has also come in the coordination and promotion of the various USDA programs associated with biofuels and bioproducts. The Biobased Products and Bioenergy Coordination Council (BBCC) (http://www.ars.usda.gov/bbcc/) has been formed to fill this role for the multitude of research, development and commercialization programs of the USDA. The USDA has five main mission areas: Research, Education, and Economics; Natural Resources and Environment; Farm and Foreign Agricultural Service; Rural Development; and Marketing and Regulatory Programs. Biofuels and bioproducts include many of these mission areas for example the Agricultural Research Service (ARS) has a research program that covers biodiesel, ethanol, energy alternatives for rural practices and energy crops. Within this program a wide variety of topics are addressed such as designing and breeding herbaceous plants, sustainable production of energy crops, feedstock collection methods, conversion of biomaterials to fuels, value-added coproduct development, pretreatment on the farm and in rural communities and on-farm systems to supply energy needs. Over the last year there is evidence of very effective coordination and promotion efforts both within the USDA and with other groups/organizations. I hope this continues so that we can produce a vibrant rural America.

FUTURE WORKSHOPS/SYMPOSIA

IEA Bioenergy - Task 39 – All Subtasks
25-26 March 2003
Brussels, Belgium
Contact person: *mailto:Don.Stevens@pnl.gov*

BioCat2003
March 4-5, 2003
Barcelona, Spain
http://www.catalystgrp.com
Register: *mailto:cnf@catalystgrp.com*

III International Slovak Biomass Forum
February 3-4, 2003
Bratislava, Slovakia
http://www.ecb.sk/en/ecb_activities_events_isbf2003.html

Georgia Biofuels Symposium
Feb 18-19, 2003
Georgia, Atlanta, USA
http://www.gactr.uga.edu/conferences/2003/Feb/18/biofuels.phtml

Global Alternative Fuel Forum for Automotive Applications
February 18-20, 2003
Munich, Germany
http://www.theenergyexchange.co.uk/conferencecalendar.htm

Automotive Fuels 2003
April 14-15, 2003
Amsterdam, The Netherlands
http://www.nen.nl/cgi-bin/index.pl?http://www.nen.nl/nl/act/agen/20030414_fuels/

25th Symposium on Biotechnology for Fuels and Chemicals
May 4-7, 2003
Breckenridge, Colorado
http://www.nrel.gov/biotech_symposium/

20th Anniversary Windsor Workshop: Towards Sustainable Transportation
June 2-5, 2003
Toronto, Canada
http://www.windsorworkshop.ca/2003html/general.html

Hart World Fuels Conference
March 25-27, 2003 – San Antonio, Texas, USA
May 19-20, 2003 – Brussels, Belgium
June 8-11, 2003 – Rio de Janeiro, Brazil
August 24-26, 2003 – Singapore, Thailand
September 21-23, 2003 – Washington DC, USA
http://www.cwacts.com/hart/

Bioenergy 2003 International Nordic Bioenergy Conference and Exhibition
September 2-5, 2003
Jyvaskyla, Finland
http://www.finbioenergy.fi/index.asp

The Eighth Grove Fuel Cell Symposium
September 24-26, 2003
London, UK
http://www.grovefuelcell.com/organisers.htm

4th European Motor Biofuels Forum

November 24-26, 2003
Berlin, Germany
http://www.europoint-bv.com/events/biofuels2003/index.htm

BIODIESEL

Biodiesel Research and Brainstorming Workshop
January 29-30, 2003
New Orleans, Louisiana, USA
http://www.bbiethanol.com/nbb/

Biodiesel Production Technology
February 12-14, 2003
Nevada, Iowa
http://www.biodiesel.org/misc/workshop/workshopbrochure.pdf

Stability of Biodiesel Workshop
June, 2003 TBC
Graz, Austria
http://www.biodiesel.at

ETHANOL

EPACs 13th Annual Ethanol Conference
June 11-13, 2003
Big Sky, Montana, USA
http://peakstoprairies.org/greening/index.htm

BBI International's Fuel Ethanol Workshop and Trade Show
June 16-19,2003
South Dakota, USA
http://www.bbiethanol.com

World Summit on Ethanol for Transportation
November 2003
Quebec City, Quebec, Canada
http://www.bbiethanol.com/wset/index.html

POLICY/REGULATORY ISSUES

US DOE Ethanol Workshop Series: Ethanol Workshop
February 3, 2003
Frankfort, Kentucky, USA
http://www.bbiethanol.com/doe/conference.cgi?doeid=42

Harvesting Clean Energy
February 10-11, 2003
Boise, Idaho, USA
http://www.bbiethanol.com/calendar/

8th International RFA National Ethanol Conference
February 17-19, 2003: Policy and Marketing
Scottsdale, Arizona, USA
http://www.ethanolrfa.org/nec.shtml

IEA Bioenergy – Task 39
Policy/Implementation Subtask
Late Sept.
Location, TBD

CONTACT INFORMATION

Please find information below for both the IEA Bioenergy contacts and IEA Bioenergy Task 39 contacts. Additional information is available at http://www.iea.org and http://www.ieabioenergy.com.

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Ethanol Subtask Leader	Jack Saddler mailto:saddler@interchange.ubc.ca
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IEA MEMBERSHIP

Country/Org.	IEA	Bioener-	Task 39
Australia	✓ Bio-	✓	
Austria	✓	✓	✓
Belgium	✓ ✓Bio-	✓	
Brazil		✓	
Canada	✓	✓	✓
Croatia		✓	
Czech Rep.	✓		
Denmark	✓	✓	✓
European Comm.	✓	✓	✓
Finland	✓	✓	✓
France	✓ Bio-	✓	
Germany	✓		
Greece	✓		
Hungary	✓		
Ireland	✓	✓	✓
Italy	✓	✓	
Japan	✓ Bio-	✓	
Korea	✓		
Luxembourg	✓		
Netherlands	✓	✓	✓
New Zealand	✓ Bio-	✓	
Norway	✓ Bio-	✓	
Portugal	✓		
Spain	✓		
Sweden	✓	✓	✓
Switzerland	✓	✓	
Turkey	✓		
UK	✓	✓	✓
USA	✓	✓	✓
Total	27	20	10