# Proposed
# UBECA Program Plan and Budget
# FY 1998

# Mission
# Market Leadership for Effective Commercialization

- To serve as the primary voice of power producers with interests in biomass power generation
- To encourage the development and commercialization of sustainable biomass fuel resources and economically competitive biomass energy conversion technologies

# Goals

- Develop cost-shared industry-led projects to
  - demonstrate advanced energy concepts
  - diversify U.S. fuel base
  - decrease greenhouse gas emissions
  - revitalize the rural economy

- Strengthen communication and increase membership
  - Government Relations
  - Outreach and Education
  - Market/Technology Analyses
  - Commercialization Strategies

# Member Needs

- Keeping Well-Informed
  - Swiftly changing industry - analyze uncertainties
  - Legislative developments
  - Regulatory changes and incentives
  - Technology Cost & Performance, R&D Issues
  - Strong coordinated activities

- Obtaining Competitive Edge
  - Identify near-term, creative niche markets
  - Reduce deployment risk
  - Identify cost-effective integrated systems
  - Identify business partners and appropriate financial arrangements

# The Challenge of Commercialization - Meeting Market and Developer Needs

Conditions to Satisfy:

- Evidence of sustained interest in biomass technology and confidence that the technology will be competitive with alternative technologies;
- Market research showing significant revenue/sales potential;
- Identification of situations where biomass technology may be applied immediately;
- Early buyer involvement, providing design inputs which result in cost and performance standards;
- Identification of uncertainties and manageable risks;
- Understanding and acceptance of cost/benefit profiles;
- Market incentives leading to investment, promotion, and success; and
- Government participation in cost-shared development and demonstration programs, ~~and translation of public interest into legislation and regulations.~~

# Developments in Legislation and Regulation

- Federal
  - Administration Budget and OMB Passback
  - House Authorizations Bill
  - House and Senate Appropriations Bill
  - Conference Committee Report
  - Restructuring Bills
  - FERC Rulemakings
  - EPA Regulations

- State
  - Electricity Restructuring
    - -- Legislation
    - -- PUC Orders

# Strategic Approach

- Focus on members' and other stakeholders' needs through a program of industrial outreach;
- Nurture partnerships with key stakeholders;
- Build on past project successes and experience;
- Analyze complex information and present it clearly, accessibly, and persuasively; provide timely and effective dissemination of results;
- Use technical and market analyses as the guiding tool in creating commercialization strategies; and
- Leverage budgeted resources through joint participation in activities with other organizations in the bioenergy community.

# Meeting the Needs

**ACTIVITY AREAS:**

- Government Relations
  - Congress
  - DOE
  - USDA
  - U.S. Forest Service
  - White House OSTP
- Outreach and Education
  - Utilities (IOUs and Munis)
  - IPPs
  - "Green" Power Marketers
  - Industries (cogenerators)
- Market/Technology Analyses
- Commercialization Strategies

# Task Plan

## TASK 1. GOVERNMENT RELATIONS

OBJECTIVES:

- Monitor Congressional activities and provide timely information to UBECA members on legislation affecting the DOE Biomass Power Programs so that appropriate actions can be taken;

- Plan an active role in promoting policies, incentives, and regulations that encourage integrated biomass power development in the United States and abroad.

ACTIVITIES

1.1 Disseminate Legislative Updates and Alerts

1.2 Prepare White Papers

1.3 Exchange Communications

# Task Plan

## TASK 2. OUTREACH AND EDUCATION

OBJECTIVES:

- Foster partnerships among stakeholders in both the public and private sectors;
- Ensure cooperation of energy and related programs at the federal, regional, state, and local levels; and
- Provide a forum for DOE program managers to interface with their private sector constituents.

ACTIVITIES

2.1 Increase UBECA Visibility

2.2 Create Annual Achievement Awards

2.3 Expand Communication Mechanisms (UBECA Journal)

2.4 Expand Information Assets (World Wide Web site)

2.5 Conduct Workshops/Seminars

# Task Plan

## TASK 3. TECHNICAL/MARKET ANALYSES

OBJECTIVES:

- Assess opportunities for new bioenergy conversion technologies in both domestic and foreign markets;
- Assist UBECA members to identify barriers that may restrict the entry of those technologies; and
- Assess alternative strategies to help overcome those barriers.

ACTIVITIES

3.1 Collect and Disseminate Market Data

3.2 Conduct Technology Assessments

3.3 Evaluate Changing Power Market

# Task Plan

## TASK 4. COMMERCIALIZATION STRATEGIES

OBJECTIVES:

- Develop guidelines and a framework of workable strategies for commercialization of bioenergy conversion technologies; and
- Raise the awareness of the financial community about opportunities that exist for investment.

ACTIVITIES

4.1 Case Studies

4.2 Commercialization Workshop

# Task Plan

## TASK 5. MANAGEMENT AND ADMINISTRATION

OBJECTIVES:

Support corporate business matters, membership records, financial administration and duties, and other activities of the UBECA Board of Directors and officers.

ACTIVITIES

5.1 Board of Directors Administration

5.2 Membership Administration

5.3 Management Policy Papers

5.4 Contract Administration and Reporting

5.5 Financial Administration

5.6 FY 1999 Program Plan and Budget

# Task Plan

| Task | Deliverables |
|---|---|
| 1. Government Relations | Legislative Updates and Alerts<br>White Papers<br>Briefing Materials |
| 2. Outreach and Education | *UBECA Journal*<br>Annual Meeting<br>Annual Achievement Awards<br>Press Releases<br>Trade Press Articles<br>World Wide Web Site<br>Executive Seminars/Workshops<br>Technical Seminar<br>Brown Bag Seminars |
| 3. Technical/Market Analyses | Market Data Compilation<br>Technology Assessments<br>Utility Restructuring Analysis |
| 4. Commercialization Strategies | Case Studies<br>Commercialization Workshop |
| 5. Management and Administration | Board Administration<br>Membership/Financial Administration<br>Management Policy Papers<br>Contract Administration/Reports<br>FY 1999 Program Plan & Budget |

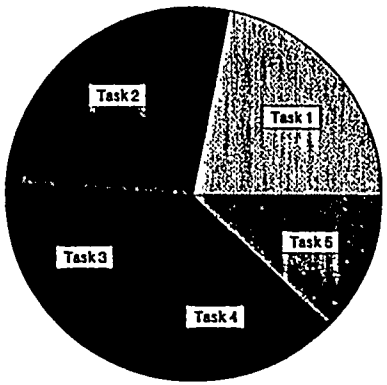
# Revenue Target
# FY 1998

| | REVENUE TARGET |
|---|---|
| Member Dues | $50,000 |
| Meeting Sponsorship | $10,000 |
| Meeting Fees | $5,000 |
| U.S. Department of Energy | $285,000 |
| **TOTAL** | $350,000 |

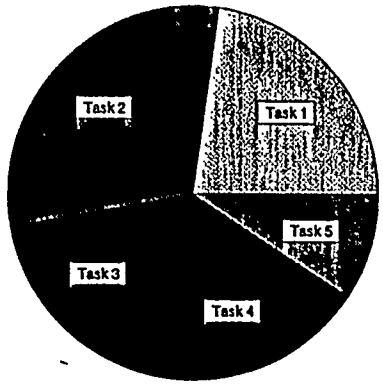
# Budget Summary
# FY 1998

| | Total $K | % | DOE $K | % |
|---|---|---|---|---|
| Task 1. Government Relations | 77 | 22 | 65 | 23 |
| Task 2. Outreach and Education | 96 | 27 | 85 | 30 |
| Task 3. Technical/Market Analyses | 66 | 19 | 50 | 17 |
| Task 4. Commercialization Strategies | 69 | 20 | 60 | 21 |
| Task 5. Management and Administration | 42 | 12 | 25 | 9 |
| | 350 | 100 | 285 | 100 |

TOTAL




DOE



# Budget Issues

- Intensify membership recruitment
  - Review member dues rates and structure
  - Enhance value of products and services
- Solicit funding from other federal and state agencies
- Increase cost-share with other associations
- Leverage in-kind member services
- Availability of cost-shared DOE funds

# Conclusions

- UBECA is building the base constituency for the DOE Biomass Power Program
- UBECA provides unique forum for information exchange and technology transfer
- Federal dollars are leveraged effectively
- Together, the public and private sector can accelerate the commercialization of biomass energy and reap the national benefits.

**United BioEnergy Commercialization Association**

# Partnering to Compete: Biomass and the Bottom Line

Ronald Belval, P.E., Chairman
Joseph Badin, Executive Director
Jonathan Kirschner, Project Coordinator

U.S. DOE Biopower Program
Semi-Annual Review
July 15, 1998

## Global Situation

- Global energy requirements continue to grow rapidly driven by:
  - Economic and population growth
  - Pressures to improve quality of life
- Governments recognize that the *availability* of *affordable, reliable commercial* energy supplies is vital to all sectors of society

## Global Situation (continued)

- Growing concerns about potential global climate change and greenhouse gases
- Biomass energy can have a significant strategic value to the U.S. and to all growing economies

## Strategic Value of Biomass Energy

- Vital resource for achieving a sustainable economy
- Very large and wide-spread resource base
- Can be integrated into the established infrastructure
- Potential to be a reliable and affordable resource
- Reduce landfill wastes

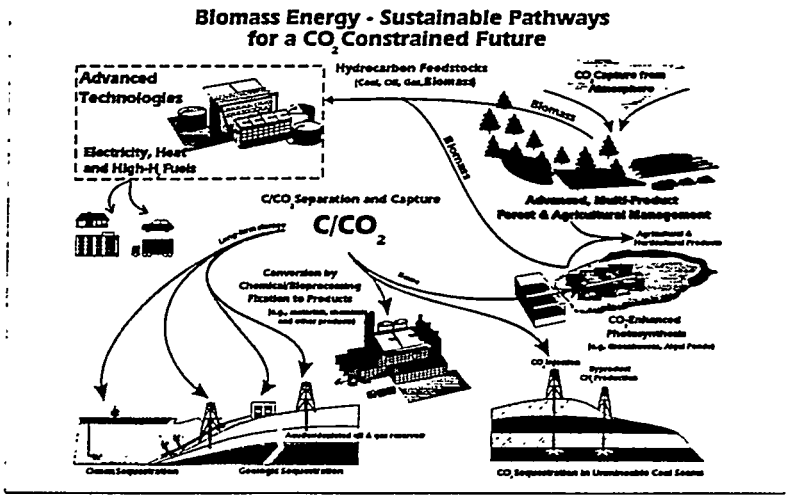
## Strategic Value of Biomass Energy (continued)

- Carbon dioxide neutral
- Reduce dependence on imported fuels
- Local economic benefits/jobs
- May fulfill requirements of a Renewable Portfolio Standard
- May produce tradeable emissions credits

## Strategic Value of Biomass Energy (continued)

- Can utilize wide-ranging, new and improved energy conversion technologies for baseload and peaking generation
- Can provide flexible, convenient, and diverse forms of energy to meet various end-use needs

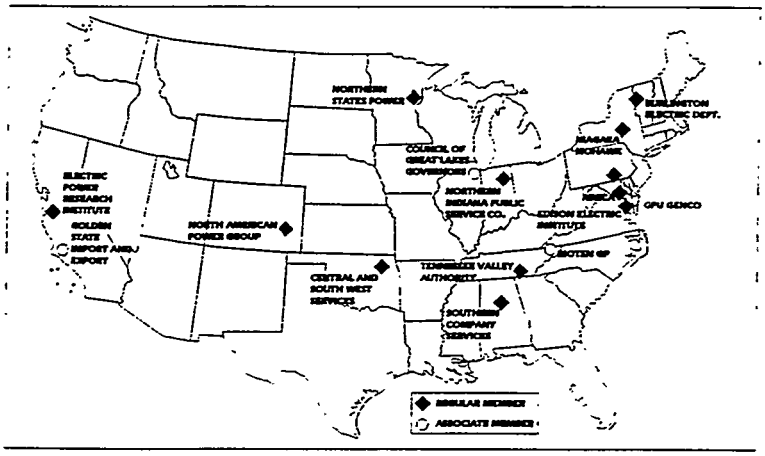
# Our Vision




- How can we get there?
- How UBECA helps

# Who We Are...

**United BioEnergy Commercialization Association**




# How Can We Get There?

- Have a clear vision
- Identify technology and market pathways
- Establish competitive targets
- Encourage demonstrations and replications to showcase successes
- Build the biomass community
- Find champions and sponsors
- Provide input to public policy

## How Can We Get There?
### (continued)

- Create market-based incentives
- Form partnerships
  - Company and Company
  - Industry and Industry
  - Industry and Government
- Ensure effective communication and outreach

## How UBECA Helps

- Provides a forum to promote bioenergy
- Facilitates communication, innovation, technology transfer, and accelerates commercialization
- Provides strategic briefings to interested groups
- Expands outreach to encompass agricultural, forestry, coal, industrial, and environmental stakeholders

## How UBECA Helps (continued)

- Monitors restructuring activities
- Identifies market opportunities today and charts the roadmap to the future
- Represents technology developers, end-users and operators: the source of technical cost and performance requirements
- Identifies critical R&D needs and targets

## How UBECA Helps (continued)

- Partners with communities (education and economic development)
  - Rural
    - forest residues
    - energy crops
    - poultry and animal wastes
  - Urban
    - reduce landfills
    - potential waste and demolition wood resources

## How UBECA Helps (continued)

- Provides case studies and success stories
- Assists with market assessment
- Proposes market incentives
- Endorses policy actions
- Educates and communicates

## How Can I Participate?

Contact

Joe Badin, Executive Director or

Jonathan Kirschner, Project Coordinator

301-621-3002

301-621-3003

FAX 301-621-3725

e-mail: enesupf@ix.netcom.com

# AGENDA

## UBECA Meeting

Held at Edison Electric Institute

July 29-30, 1997

- Minutes of the June 10, 1997 UBECA Board of Directors Meeting (Approval)
- FY 1998 UBECA Program Plan & Budget (Approval)
- DOE Application for Funding of Management Support Services (Approval)
- Management Support Agreement between UBECA & Energetics (Approval)
- Termination Agreement between TTC & UBECA (Approval)
- Committee to Plan Joint UBECA/NBIA Annual Meeting (Assign)
- Workshop Topics (Discussion)
- Membership (Discussion)
- Other Business

# UNITED BIOENERGY COMMERCIALIZATION ASSOCIATION
# MINUTES OF THE BOARD OF DIRECTORS MEETING[1]

*July 29-30, 1997*
*Edison Electric Institute*
*Washington, DC*

## TUESDAY, JULY 29, 1997

*Attendance*

**Board Members**

Ron Belval, Chairman - Burlington Electric Dept.
Chuck Linderman - Edison Electric Institute
Ed Neuhauser - Niagara Mohawk
John Holt - National Rural Electric Cooperative Association
Doug Boylan - Southern Company
Dan Mahoney (Counsel) - Soble International

**Energetics Personnel**

Harvey Weisenfeld
Joe Badin
Jonathan Kirschner

**Department of Energy Personnel**

Ray Costello
Lynne Gillette
Jake Kaminsky

### Approval of Meeting Minutes of April 8 and June 10

Both sets of minutes were approved.

### FY 1998 UBECA Program Plan and Budget

Joe Badin presented Energetics' corporate qualifications and described four task areas outlined in the *FY 1998 Program Plan and Budget* prepared by Energetics:

- Government Relations
- Industry Outreach and Education

[1] These minutes cover only those deliberations that Energetics personnel were present for.

- Marketing and Technology Analysis
- Commercialization Strategies

The major points of the discussion were:

• UBECA is prohibited from lobbying, but timely legislative alerts to the Board and the membership would be useful in keeping them informed of pending Congressional action.

• *UBECA Journal* was not reaching as many people in the utility industry as perhaps publishing articles in the leading trade journals would. It might be more cost effective to contribute articles to *Electricity Journal, Public Utilities Fortnightly, and Rural Electrification* magazines.

• Brown-bag seminars are a great tool for reaching the membership and for encouraging action and ideas. It was suggested that a brown-bag seminar be held at EEI and one possibly at the Washington office of the Northeastern Regional Biomass Program (Rick Handley is main contact). One topic that was proposed for a brown-bag seminar was *Barriers to Biomass Co-firing*, possibly with the participation of EPA and ASTM. Coal ash is presently considered a non-hazardous substance that can be sold for flowable fill, however no ASTM standard currently exists for co-fired ash, and this is an obstacle to the broader acceptance of biomass/coal co-firing. Efforts must be made to reach beyond UBECA an to inform people who are outside the association of the brown-bag lunches.

• The President's Million Solar Roofs program will increase competition from the photovoltaic sector. Also, micro gas turbines have demonstrated that they can produce electricity for $300/KW. As of yet, no life cycle costing analyses had been performed for biomass. The possibility of leveraging the efforts taking place at NREL and Lawrence Berkeley Lab, was mentioned.

• It was suggested that an ad hoc Commercialization Committee be formed from the membership.

Ray Costello, DOE Program Manager, told the Board that he was very supportive of UBECA and wanted maximum benefit for everyone, however, he said, only $100K would be available from DOE's Biomass Energy Program for UBECA in FY 1998. This was considerably less than the level of support originally anticipated by the association (about $285K), and the Board met that afternoon, in closed session, to re-examine UBECA's activities in the face of the reduced level of funding and to discuss completion of arrangements with TTC, including signing a letter closing out TTC support of UBECA.

**WEDNESDAY, JULY 30, 1997**

*Attendance*

**Board Members**

Ron Belval, Chairman - Burlington Electric Institute
Chuck Linderman - Edison Electric Institute
Ed Neuhauser - Niagara Mohawk
John Holt - National Rural Electric Cooperative Association
Doug Boylan - Southern Companies

**Energetics Personnel**

Joe Badin
Jonathan Kirschner

Discussions focused on ways to adapt the UBECA *FY 1998 Program Plan and Budget* to a lower level of DOE funding. It was agreed that while all of the tasks were important, a specific list of deliverables would help identify the most crucial aspects of each. Ed Neuhauser said that legislative tracking was extremely important for his utility, as well as being notified of any Requests for Proposals (RFP) that DOE might issue that could be of interest to UBECA members. It was decided that the organization would publish two brochures initially. The first would be of a general nature, intended to help recruit potential members. The second would be a brief, but informative piece designed to show how biomass was currently being used to reduce emissions of greenhouse gases. This brochure would be distributed by Chuck Linderman at the Kyoto Global Climate Change Summit in December. The target date for shipping materials to Japan was November 20.

Other suggestions for disseminating information to members included legislative alerts and quarterly updates of important meetings, programs, and government solicitations. A monthly update was also suggested if there is sufficient activity to warrant it. The following ideas for UBECA activities were discussed:

- UBECA should move away from developing white papers to assembling information that is already available.
- Membership and/or revenue targets should be set (i.e., increase revenues from utility memberships to $80K or increase membership by 30% over the next twelve months).
- Set publication targets, such as publishing 3 major articles in 4 journals during the coming year.
- Communication with the National Laboratories that are doing biomass work must be improved. UBECA should be involved in the annual DOE Contractors' Review Meeting.

- Centers of Excellence, such as the McNeil Power Generating Station in Vermont could be the subject of concept papers.

- One activity that was mentioned was an evaluation of the changing power market, and the possibility of publishing 2 case studies, one on the fuels side and one on the technology side, was discussed.

- It was decided that fees for legal services performed by Soble International be paid out of members' dues, and not out of the Department of Energy grant.

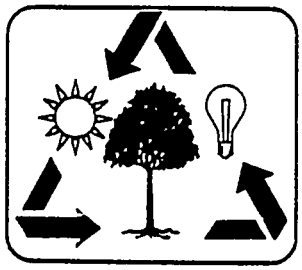
- The joint UBECA/NBIA meeting was also discussed.

It was decided that Energetics would redraft the *FY '98 Program Plan and Budget* based upon an assumed budget of $300K ($100K from membership, $200K from DOE)[2] and resubmit it to the Board.

[2] The level of DOE funding ultimately awarded for FY'98 was only $100K. The final version of the *FY'98 Program Plan and Budget* reflects a level of activity that corresponds to this reduced award.

# *United BioEnergy Commercialization Association*

## *Board of Directors*



## *MEETING AGENDA*

***November 19, 1997***
***10:00 am - 3:00 pm***
***at***
***Energetics, Inc.***
***501 School Street, SW, Washington, DC***
***Suite 500***
***L'Enfant Plaza Metro (Dept. of Transportation Exit)***

| TIME | TOPIC | FACILITATOR |
|---|---|---|
| 10:00 - 10:05 | Welcome and Introduction | R. Belval |
| 10:05 - 10:10 | Agenda<br>• Acceptance<br>• Additional Items | |
| 10:10 - 10:15 | Review of Minutes (July 29-30, 1997) | J. Kirschner |
| 10:15 - 11:45 | Treasurer's Report | C. Linderman |
| | Ratification of Management Services Contract and Settlement of Prior Account | |
| | Membership Update | J. Badin |
| | FY 98 UBECA Program Plan and Budget | R. Belval |
| | Joint UBECA/NBIA Workshop | |
| | Review of DOE Funding Agreement | |
| 11:45 - 12:00 | Status of EPRI Biomass Power Program | E. Hughes |
| 12:00 - 1:00 | Luncheon/Discussions | |
| 1:00 - 1:20 | Status of the DOE Biomass Power Program and Plans for FY 1998 | L. Gillette |
| 1:20 - 2:30 | Statement Supporting Biomass Energy Conversion Technologies (Discussion of Proposed Press Release) | R. Belval |
| 2:30 - 3:00 | Wrap-up<br>• Other Business<br>• Action Items<br>• Next Meeting Plans | |
| 3:00 | Adjourn | |

# UNITED BIOENERGY COMMERCIALIZATION ASSOCIATION
# BOARD OF DIRECTORS MEETING

*Energetics, Inc.*
*501 School Street, SW, Washington, DC*
*Wednesday, November 19, 1997*

# MEETING SUMMARY

## *Attendance*

### UBECA Board Members

Ron Belval, Chairman - Burlington Electric Dept.
Chuck Huling - Georgia Power Company
John Holt - National Rural Electric Cooperative Association
Chuck Linderman - Edison Electric Institute
Ed Neuhauser - Niagara Mohawk

### Other UBECA Members

Evan Hughes - Electric Power Research Institute

### Energetics Personnel

Joe Badin - Executive Director, UBECA
Jonathan Kirschner - Project Coordinator, UBECA
Harvey Weisenfeld - Corporate Advisor, UBECA
Jan Brinch - Senior Associate, Energetics
Rich Scheer - Assistant Vice-President, Energetics

### Department of Energy Personnel

Lynne Gillette - Program Manager, DOE Biomass Power Program

The Board met in a closed-door Executive Session from 9:30 a.m. until 10:45 a.m. to discuss the closeout arrangements with Technology Transition Corporation (TTC).

### Approval of Agenda

The agenda was approved without modification.

## Approval of Meeting Minutes of July 29-30, 1997

The draft meeting minutes were accepted with some modifications which appear in the final version.

## Treasurer's Report

Chuck Linderman, UBECA Treasurer, reported that he had signed a check to pay Energetics' invoice of $7,100 thereby leaving an ending balance in the UBECA account of approximately $39,200.

## Ratification of Management Services Contract and Settlement of Prior Account

The Board ratified the management services contract with Energetics, but noted that Technology Transition Corporation had an outstanding invoice (August 1997) for $67.5K. It was decided that members of the Board should meet with Bob Mauro of TTC to discuss the outstanding invoice and to arrive at an agreement for closing out TTC support of UBECA.

## Membership Update

Joe Badin announced the recruitment of two new members, Central and South West Services and Golden State Import and Export. Joe also announced that he had met with Dave Beecy of the Office of Fossil Energy, U.S. Department of Energy. Dave was interested in biomass' potential to reduce coal consumption by as much as 35%. Joe said that he would meet again with Dave and discuss additional support for UBECA's activities from the DOE Office of Fossil Energy and from the Federal Energy Technology Center (FETC). It was suggested that Chuck Linderman and John Holt accompany Joe Badin and Harvey Weisenfeld to meet Dave Beecy and George Rudins (Deputy Assistant Secretary, Office of Coal Technology).

## FY 98 UBECA Program Plan and Budget

The main message being conveyed by the *FY 98 UBECA Program Plan and Budget* is that UBECA is an industry-driven organization whose focus is on technology transfer. Harvey Weisenfeld said that both DOE's Office of Energy Efficiency and Renewable Energy (EE) and its Office of Fossil Energy (FE) were exploring incentives to get these technologies into the marketplace. These incentives included capital buy downs, production credits and a government-sponsored insurance pool to defray much of the risk associated with such projects.

Joe Badin announced that he would be representing UBECA on the Board of Directors of the Bioenergy Research Association (BERA) and that he would be coordinating with Don Klass (BERA Chairman) to hold brown-bag lunches during the coming year. There was some discussion about utility restructuring and broadening the scope of materials that could be considered as biomass fuels, specifically the use of farm waste products that could be gasified and combusted in a microturbine. Joe Badin mentioned that Sandia National Laboratory would be issuing a Request for Proposals (RFP) for just such a demonstration project. It was expected that the RFP would be released within a few weeks.

## Joint UBECA/NBIA Workshop

The upcoming UBECA/NBIA Workshop was discussed and it was decided that UBECA would host a joint biomass stakeholders' meeting entitled "Obstacles to Commercialization" the day before the main meeting. A summary of the proposed speakers was also delivered.

## Review of DOE Funding Agreement

Joe Badin stated that the application had been submitted to the DOE Field Office in Golden, Colorado where it was still being reviewed.

## Status of EPRI Biomass Power Program

Evan Hughes said that EPRI's Biomass Power Program was not a single program but resided in various parts of EPRI (Coal Combustion Performance, NOx, Fossil Boilers, Renewables). Evan explained that the EPRI membership was giving biomass low priority. The best thing that UBECA could do to help would be to bring both traditional utilities and new power generating companies to not only accept biomass as a fuel source, but to see biomass as the renewable of choice for companies who have coal-firing assets and experience.

EPRI had conducted six co-firing tests in utility boilers during the previous year: GPU/Penelec (wood fuel, wall-fired boiler); TVA-Allen (wood in a cyclone boiler); TVA-Colbert (wood, wall-fired boiler); New York State Electric and Gas (NYSEG) (wood, tangential boiler); Madison G&E (switchgrass, wall-fired); and Northern Indiana (wood waste, cyclone boiler). A test firing of short rotation willow growth at NYSEG (a member of the Salix Consortium) ran into handling problems caused by the fibrous willow wood and had to be postponed. The willow was successfully co-fired later, as a smaller fraction of the heat input to the boiler. Evan summarized by saying that co-firing had been proven to be technically feasible but that the price differential with coal was not great enough to make it attractive to utilities, at least not while the focus is on competition, cost cutting, and meeting NOx standards, while spending capital budgets only on items having a 3-year (or less) payback.

## Status of the DOE Biomass Power Program and Plans for FY 1998

Lynne Gillette, DOE Program Manager, gave a presentation on the Department of Energy's Biomass Power Program. Lynne described 5 major continuing projects:

- Hawaii Gasification Project whose goal is to demonstrate direct integrated biomass gasification/turbine technology with hot-gas clean up.

- Vermont Gasification Project whose goal is to demonstrate indirect biomass gasification technology for power production.

- Minnesota Agri-Power Project whose goal is to demonstrate a fully integrated biomass system utilizing alfalfa stems to produce 75 MW of power.

- New York Salix Project whose goal is to scale up willow trees as an energy crop for co-firing by the year 2000.

- Iowa Switchgrass Project whose goal is to demonstrate closed-loop systems using switchgrass to fire a 35 MW facility.

Lynne also described two new initiatives, including a small modular systems Request for Proposals (RFP) that would soon be issued by Sandia National Laboratory and a co-firing initiative that was still under development.

The issue of whether or not to broaden the definition of biomass was raised again. Lynne Gillette said that DOE was more interested in developing energy crops such as willow and switchgrass. It was not really interested in Municipal Solid Waste. Ed Neuhauser discussed the difficulties inherent in removing organic matter from soil (issues of soil fertility and erosion needed to be addressed). Ed also explained that Timber Stand Improvement (TSI), involving the thinning out of forests, could create a vast new biomass resource, although no utility would be willing to invest money in TSI on land which it may not own when the trees mature. The Board decided that broadening the definition of biomass fuels should not be pursued at this time, but should be left as a topic for further discussion.

The remainder of the meeting was spent drafting the industry statement to be issued prior to the Kyoto Conference on Global Climate Change. The statement was approved by the Board and issued on November 24th.

**Other Business**

Rick Peterson (Northern States Power), who was unable to attend the meeting, telephoned to announce that Northern States Power Co. (NSP) had selected District Energy St. Paul, Inc. and Lindroc Energy of Encinitas, California, to each supply 25 megawatts of biomass power to the NSP system beginning in summer 2002. These two projects represent Phase II of NSP's legislative commitment for a total of 125 MW of biomass generation to be in place by the end of 2002. Rick also said the NSP was in the final stages of negotiating a fuel supply contract with MnVAP, the Minnesota Valley Alfalfa Producers.

**Next Meeting**

It was decided that the next meeting of the UBECA Board would be held in the spring of 1998.

*- meeting adjourned at approximately 3:00 p.m. -*

# *United BioEnergy Commercialization Association*

## *Board of Directors*

## *MEETING AGENDA*

***June 24, 1998***
***9:00 am - 3:00 pm***
***at***
***Energetics, Inc.***
***501 School Street, SW, Washington, DC***
***Suite 500***
***L'Enfant Plaza Metro (Dept. of Transportation Exit)***

| TIME | TOPIC | FACILITATOR |
|---|---|---|
| 9:00 - 10:00 | Executive Session (Board Members Only) | R. Belval |
| 10:00 - 10:05 | Welcome and Introduction | R. Belval |
| 10:05 - 10:10 | Agenda<br>• Acceptance<br>• Additional Items | |
| 10:10 - 10:20 | Review of Minutes (November 19, 1997) | |
| 10:20 - 10:35 | Treasurer's Report | C. Linderman |
| 10:35 - 10:55 | Settlement of Prior Account and Other Outstanding Invoices | |
| 10:55 - 11:25 | Membership Update and Report on EPRI Biomass Interest Group Meeting (May 28-29) | J. Badin |
| 11:25 - 11:40 | Status of Restructuring / Renewable Portfolio Standards | J. Bergman |
| 11:40 - 12:00 | PTI Overview and Potential Biomass Interest in Urban and Rural Communities | Ama Frimpong, PTI |
| 12:00 - 1:00 | Luncheon/Discussions | |
| 1:00 - 1:20 | Allowance Trading Agreement Between NIMO and Suncor | E. Neuhauser |
| 1:20 - 1:40 | Update on DOE/FETC Activities | P. Goldberg, FETC |
| 1:40 - 2:00 | Update on DOE Biomass Power Program | L. Gillette |
| 2:00 - 3:00 | Wrap-up<br>• Other Business<br>• Action Items<br>• Next Meeting Plans | R. Belval |
| 3:00 | Adjourn | |

# UNITED BIOENERGY COMMERCIALIZATION ASSOCIATION
# BOARD OF DIRECTORS MEETING

*Energetics, Inc.*
*501 School Street, SW, Washington, DC*
*Wednesday, June 24, 1998*

# MEETING SUMMARY

## *Attendance*

### UBECA Board Members

Ron Belval, Chairman - Burlington Electric Dept.
Doug Boylan - Southern Company
John Holt - National Rural Electric Cooperative Association
Chuck Linderman - Edison Electric Institute
Ed Neuhauser - Niagara Mohawk
Steve Soble - Soble International
Simon Langer - Soble International

### Other UBECA Members

Joe Battista - GPU Genco
Phil Badger - TVA (afternoon session only)

### Energetics Personnel

Joe Badin - Executive Director, UBECA
Jonathan Kirschner - Project Coordinator, UBECA
Elaine Weber - Contracts Administrator

### Invited Speakers

Lynne Gillette - Program Manager, DOE Biomass Power Program
Phil Goldberg - Advanced Crosscutting Technologies, Federal Energy Technology Center
Ama Frimpong - Public Technologies, Inc.
Jennifer Bergman - Energetics, Inc.

### Others

Joel Morrison - Energy and Fuels Research Center, Penn State University

The UBECA Board of Directors met in a closed-door Executive Session from 9:00 a.m. until 10:30 a.m. to discuss the closeout arrangements with Technology Transition Corporation (TTC). Present at the Executive Session were the Board members, legal counsel, and Energetics personnel. Elaine Weber reported that it was her belief that UBECA, under TTC, had over billed the Department of Energy (DOE) by $1452 in 1997 (as an adjustment to its 1996 billing) and it was her best estimate that the association, under TTC, had also over billed the membership by $15,545 for the same period. She also reported that TTC still had not turned over all of the UBECA records to Energetics, and it was decided, on the advice of counsel, that no settlement should be made with TTC until this had been achieved. In exchange for all the records, UBECA would make a final separation payment to TTC based upon an estimate of what is owed less the amounts over billed . Both parties would then sign a settlement statement releasing them from all outstanding claims against each other. It was also decided that UBECA would make an initial payment of $1280 to Soble International out of the membership budget to cover an invoice which TTC had failed to pay. The UBECA Board resolved to make every effort to settle all other outstanding payables to Soble International in a timely manner.

Upon conclusion of the Executive Session, the non-board members and speakers who were present were invited into the meeting. Joel Morrison from Penn State University's Energy and Fuels Research Center was in Washington to attend the DOE-sponsored co-firing workshop and was considering membership of his organization in UBECA. Similarly, Joe Battista of GPU Genco and Phil Badger of TVA (both UBECA members) stayed in Washington an extra day to attend the board meeting. Joel Morrison said that Penn State was experimenting with burning hog fat as #6 fuel oil. Joe Battista described his company's experiments with blends of coal and sawdust at the Shawville Power Station and with separate injection of sawdust at their Seward Power Station. GPU's experiments had shown that heavily composted sawdust burned too slowly. Joe said that a $2 million test burn of utility waste wood (penta poles, creosote poles, cross arms and pallets) was scheduled for this coming winter. While tipping fees were not very high, the charge for hauling away such waste wood could vary anywhere from $80 - $200 a ton. Joe Badin requested a schedule of the upcoming test burns so that UBECA members could be kept up to date.

Phil Goldberg of FETC introduced himself saying that his principal area of research was developing coal-fired power systems and that he was expecting FETC to develop a working relationship with UBECA in order to further develop co-firing.

**Approval of Agenda**

The agenda was approved without modification, although the order of presentations was altered slightly to accommodate the presenters' schedules.

**Approval of Meeting Summary of November 19, 1997**

The November meeting summary was accepted.

## Treasurer's Report

Chuck Linderman, UBECA Treasurer, reported that the UBECA checking account balance as of June 22 was $14,675.65 and that the association was awaiting payment of $19,300.91 from DOE Golden Field Office for Energetics' services. Outstanding liabilities for the association were reported to be $95,543.26. This amount was contingent upon the final settlement with TTC, and could be expected to be reduced considerably.

## Membership Update and Report on EPRI Biomass Interest Group Meeting (May 28-29)

Joe Badin gave an update on recruitment activities. In his report, Joe stated that UBECA would like to extend membership to the National Laboratories and to grass roots organizations. By expanding membership beyond the utility industry, the association could seek foundation grants for solving waste disposal and energy problems. Joe had also held meetings with several people at the World Bank, including Masaki Takahashi who had been working on a bagasse gasification plant in Brazil, and who was also interested in coal gasification (John Holt mentioned that the NRECA was funding a 3 MW plant that would use Brazil nut hulls as fuel).

Joe also reported on a meeting that was held with Dr. Steve Schuck of the Australian Biomass Energy Taskforce who had visited the U.S. last winter on a fact-finding tour. A meeting was also held with Ama Frimpong of PTI. This initial meeting was very fruitful and members of PTI are interested in working with UBECA. This could lead to additional funding for the association through foundation grants (see "PTI Overview" below). Joe was also continuing his contacts with Gary Baum of the Institute of Paper Science and Technology Association (IPSTA) and a member of the Board of the Biomass Energy Research Association (BERA), and Del Raymond of Weyerhauser Corporation. UBECA had also initiated contact with the White House Office of Science and Technology Policy to discuss an interagency biomass initiative.[1]

Joe distributed the agenda and a handout from the EPRI Biomass Interest Group (BIG) meeting held in May. Since Evan Hughes was not present, Joe highlighted the major issues that were discussed at the BIG meeting, including pooling resources to do collaborative research, development, and demonstration projects on biomass energy.

## Status of Restructuring / Renewable Portfolio Standards

Jennifer Bergman of Energetics presented an overview of the status of utility restructuring and renewable portfolio standards in the United States. The key messages of her presentation were:

- Restructuring was attracting new players into the electricity industry, but the future for new market players is uncertain;

[1]A meeting was subsequently held July 7th with Sam Baldwin, Principal Scientist on the National Science and Technology Council and Study Executive Director for the President's Committee of Advisors on Science and Technology (PCAST) Energy Research and Development Panel. The panel published its *Report to the President on Federal Energy Research and Development for the Challenges of the Twenty-First Century* in November 1997.

- Congress and the Administration were considering federal restructuring legislation (19 bills had already been introduced) but no action could be expected this session;

- There was a great deal of diversity among state restructuring activities but some common themes exist (retail choice by date certain, rate reductions, stranded cost issues limiting progress, mechanisms to address public purpose programs are in place).

- Thus far, six states have enacted renewable portfolio standards (AZ, CT, ME, MA, NE, VT).

Chuck Linderman pointed out that the gas industry was adamantly opposed to federal restructuring legislation and that many of the key Congressional committee chairmen came from gas-producing states.

Ed Neuhauser said that New York State was using a systems benefits charge to support three areas of activity within the state: assistance to low income families, energy efficiency and renewable energy programs, and environmental protection. The State of California had also opted for a systems benefits charge instead of a renewable portfolio standard.

**PTI Overview and Potential Biomass Interest in Urban and Rural Communities**

Ama Frimpong gave an overview of Public Technologies Inc. (PTI) and explained that its main mission was to facilitate the transfer of technology to American cities in order to help them solve pressing problems, such as the year 2000 computer bug. PTI is divided into five Task Forces:

- Energy
- Environmental Protection
- Transportation
- Information Technology
- Public Safety

PTI is funded mainly through monies appropriated by Congress to the Urban Consortium, but also earned money through the sale of its publications. PTI was interested in biomass as an alternative fuel for municipal electricity generation and was looking forward to working with UBECA to heighten awareness among city managers.

**Allowance Trading Agreement Between Niagara Mohawk (NIMO) and Suncor Energy**

Ed Neuhauser described the greenhouse gas emissions reduction trade worked out between his utility (Niagara Mohawk) and the Canadian oil and gas company, Suncor Energy. This arrangement, which was announced on March 5th, is one of the first which attaches an actual value to carbon dioxide and could be worth as much as $6 million over 10 years. According to the agreement, Suncor will make an initial purchase of 100,000 metric tons of greenhouse gas emission reductions from Niagara Mohawk with an option to buy up to an additional 10 million tons of reductions over ten years. The agreement means that Suncor will use the reductions below 1990 levels achieved by NIMO to achieve its own voluntary emission reduction targets

while providing Niagara Mohawk with additional funding for research and renewable energy projects. The agreement has won praise from both the American and Canadian governments as a demonstration of a market-based approach to reducing greenhouse gas emissions.

**Update on DOE Biomass Power Program**

Lynne Gillette, DOE Biopower Program Manager, provided an update of activities taking place under the DOE Biomass Power Program. There are currently four major projects continuing:

- Hawaii Gasification Project (in close-out phase)
- Vermont Gasification Project
- Minnesota Agri-Power Project (which was held up for a year until the details of a twelve-year power purchasing agreement could be worked out)
- New York Salix Project

Other projects include the Iowa Switchgrass Project, the goal of which is to demonstrate a closed-loop biomass system using switchgrass to fire a 35 MW facility. Additional work is being carried out in support of thermochemical conversion research and biomass feedstock development.

The board discussed the possibility of inviting Ken Campbell of the Minnesota Valley Alfalfa Producers (MNVAP) to the next meeting to offer advice on drawing up a model power purchasing agreement. It is hoped that having a model contract would facilitate future biomass power projects, and might help speed up progress on the Iowa Switchgrass Project.

Lynne announced the ten winners of the Small Modular Power Systems feasibility study contracts. The list included UBECA members Bioten GP and Niagara Mohawk. A solicitation for Phase II of the project is anticipated for October 1999. She also described the DOE Co-Firing Initiative which is jointly sponsored with EPRI and FETC. This initiative includes ongoing demonstration projects and some new projects to be launched in 1999, as well as information development and dissemination for power generation decision makers. Among the projects mentioned was a co-firing brochure to be developed cooperatively by UBECA and NREL.

**Update on DOE/FETC Activities**

Phil Goldberg, from the Advanced Cross-Cutting Technologies division of FETC (Pittsburgh), gave the board an overview of FETC coal/biomass co-firing results. Phil explained that while biomass was really the domain of DOE's Office of Energy Efficiency and Renewable Energy, FETC was interested in co-firing as a means of reducing fossil-based emissions of CO2, SO2, and NOx, and also to promote fuel diversity and reduce waste. The coal industry was FETC's primary customer and they were now looking at biomass as a response to the gas industry. However, he said, while anyone could burn biomass in a specially-designed plant, the real challenge was to use existing capital.

Biomass-related projects were appearing in many FETC product line portfolios and additional activities were being considered. Many FETC projects are biomass specific, have a biomass

element, or are relevant technical development activities. Specifically, Phil mentioned the following:

- Co-firing R&D
- Co-firing demonstrations
- Integrated Gasification Combined Cycle (IGCC)
- Gas to liquids
- Advanced turbine systems
- Fuel cell demonstrations
- Fluidized bed combustion (FBC) co-firing
- FETC in-house R&D and analyses

As part of its DOE mission, FETC promotes energy security and sustainable development by improving environmental and economic performance of power systems. Long-time FETC stakeholders include organizations that design, build, operate, regulate, and supply fuels or equipment to the power industry. According to Phil, FETC's coal-fired power systems technologies are the key to accelerated near-term use of biomass fuels in co-firing applications and optimized future use of biomass. Ed Neuhauser raised the issue of ASTM standards C9 and 618 pertaining to co-fired coal ash, and Phil responded that FETC was not doing any work on commingled ash. Ed said that it was critical that the commingled ash issue be settled or the entire New York Salix project could grind to a halt.

**Wrap-up**

The meeting resulted in the following list of action items for the UBECA management team:

- Draft a letter to TTC requesting that all remaining UBECA records be sent immediately to Energetics;
- Begin the process of updating the UBECA web site;
- Begin work on a membership directory;
- Produce a paper and poster for the BioEnergy '98 conference scheduled for October 4-8;
- Work with NREL on the co-firing brochure;
- Contact the National Bioenergy Industries Association (NBIA) about holding a joint meeting in the fall.[2]

*- meeting adjourned at approximately 3:00 p.m. -*

[2]It was subsequently learned that due to committee report language in the 1999 Energy and Water Appropriations Bill restricting DOE funding of trade associations, it is doubtful that funds will be available for a joint meeting this year.

# - UBECA -

# Biomass Energy Near-Term Opportunities

*Prepared by*

**UBECA**
**United BioEnergy Commercialization Association**
**Columbia, Maryland**

*Prepared under contract to the*

**U.S. Department of Energy**
**Biomass Power Program**

**September 1998**

# BIOMASS ENERGY - NEAR-TERM OPPORTUNITIES

## TABLE OF CONTENTS

# PART I: PULP & PAPER INDUSTRY

## ENERGY USE BREAKDOWN FOR THE PULP AND PAPER INDUSTRY

## Energy Use Breakdown for the Pulp and Paper Industry

The paper and allied products industry (SIC 26) manufactures pulp, paper and paperboard from virgin and recycled fiber. The tens of thousands of products produced by the industry include newsprint, printing and writing papers, tissue, heavy-grade kraft paper, cardboard, corrugated, and construction-grade paper-board. The industry can be divided into two principal sectors. The energy intensive mill sector processes raw materials into paper and paperboard, and includes the SIC codes 261 (Pulp Mills), 262 (Paper Mills), and 263 (Paperboard Mills). The converting sector further processes the sheets of paper and paperboard into other finished products such as envelopes and boxes, and includes SIC codes 264 (Coating and Glazing), 265 (Paperboard Boxes and Containers), and 266 (Building Paper and Board). The mill sector accounts for about 95% of energy use in the pulp and paper industry, and is the focus of this analysis.

Over the last twenty years or so, many of the smaller, older mills have been closed down and replaced with larger integrated mills. The integrated mills produce both pulp and paper and/or paperboard. The trend is distinctly toward larger size (over 2000 tons/day) plants with the capability to consistently process high-quality products at higher speeds. The larger plants are better able to take advantage of energy-efficient cogeneration and process improvement technologies through economies of scale.

As shown in Table 1, the pulp and paper industry consumed over 2.5 quads of energy in 1995. The industry is the third-largest industrial energy consumer in the U.S., behind only petroleum refining and chemicals. Table 1 also shows that a large portion (about 57%) of the industry's energy demands were met by self-generated and residue fuels, such as hogged wood, bark, and spent pulping liquor. The use of self-generated and residue fuels by the industry has increased by 72% since 1972. The industry has also significantly increased its cogeneration capacity, and generates more than 40% of the total on-site electricity produced by the U.S. manufacturing sector. Despite the industry's impressive record for cogeneration and utilizing waste materials for energy, the industry still ranks third in energy purchases and ranks first in fuel oil consumption (though the industry has decreased its use of fuel oil by

**Table 1. Historical Fuel and Energy Use in the U.S. Pulp and Paper Industry**
**(trillion Btu unless otherwise indicated)**

| | 1972 | 1992 | 1994 | 1995 |
|---|---|---|---|---|
| **Total Purchased Fossil Fuel and Energy** | **1,246** | **1,126** | **1,116** | **1,105** |
| Purchased Electricity | 94 | 168 | 167 | 158 |
| Purchased Steam | 23 | 26 | 42 | 45 |
| Coal | 225 | 341 | 325 | 329 |
| Fuel Oil | 469 | 167 | 164 | 150 |
| Natural Gas | 444 | 446 | 438 | 452 |
| Other | 4 | 17 | 9 | 10 |
| Energy Sold | (-13) | (-39) | (-31) | (-39) |
| **Total Self-Generated and Residue Fuels** | **847** | **1,494** | **1,451** | **1,459** |
| Hogged Fuel (50% moisture) | 42 | 243 | 188 | 208 |
| Bark (50% moisture) | 94 | 152 | 172 | 158 |
| Spent Liquor Solids | 698 | 1,068 | 1,058 | 1,078 |
| Self-Generated Hydroelectric Power | 9 | 15 | 6 | 4 |
| Other | 3 | 16 | 27 | 10 |
| **Total Energy[1]** | **2,093** | **2,620** | **2,567** | **2,564** |
| **Total Production (000 short tons)** | 65,036 | 84,558 | 98,582 | 100,141 |

[1] Numbers may not add to totals due to rounding.
Source: American Forest & Paper Association, Washington, D.C.

almost 68% since 1972). In 1994, the industry spent about $6.2 billion on purchased energy, or nearly 4.3% of the value of its shipments.[1]

## Energy Consumption Trends

As shown in Table 1, total energy consumption in the U.S. pulp and paper industry has grown by about 0.5 quads since 1972 (an increase of 22%) while production in terms of tons of product produced has grown by over 74%. The industry has significantly improved its energy efficiency, reducing the total energy use per ton of product produced from 32 million Btu/ton in 1972 to 25.6 million Btu/ton in 1995.[2] These improvements in energy efficiency have been achieved through increased use of cogeneration, improved "housekeeping," waste reduction, waste heat recovery, and chemical and wood residue recovery; by using advanced production and process control technology; and by closing older, less efficient mills. The industry has significantly cut its use of fuel oil since 1972, largely replacing it with self-generated and residue fuels. As shown in Figure 1 (attached), the majority of the industry's energy demands today are met by spent pulping liquor, followed by natural gas and coal.

Projections for energy consumption to the year 2010 and 2020 are based on the Energy Information Administration's (EIA) most recent annual forecast, the *Annual Energy Outlook 1997 (AEO/97)*.[3] *AEO/97* presents forecasts of energy supply, demand, and prices through 2015 for the pulp and paper industry. The analysis presented here extends the AEO's forecast to the year 2020 by using a linear regression of the data. AEO's projections are based on the results of the EIA's National Energy Modeling System (NEMS). The NEMS Industrial Demand Module forecasts energy consumption and energy intensity subject to the forecasted delivered prices of energy, technology mix, and macroeconomic variables representing employment and value of output in each industry. *AEO/97* presents a forecast for three different economic growth scenarios: reference (business-as-usual) case, low economic growth and high economic growth. For each of these three cases, NEMS uses different fundamental assumptions concerning factors that affect the domestic economy and world oil markets, as explained in the sidebar.

**Key Assumptions for Annual Energy Outlook 1997**

Economic Growth

In the reference case presented by *AEO/97*, productivity in the pulp and paper industry grows at an average annual rate of 1.8% from 1995 through 2015, and the labor force grows by 1.0% per year. Taken together, these factors help yield a growth in real gross domestic product (GDP) of 1.9% per year (when measured in 1992 chain-weighted dollars). The high-economic growth case assumes that national growth rates in productivity, the labor force, and GDP are assumed to be 0.7, 0.7, and 1.4%, respectively.

Global Oil Markets

In the reference case, the mean global oil price increases by 1.0% annually to reach $21 per barrel (in real 1995 dollars) by 2015. The range between the assumed oil prices in the low- and high-economic growth cases reflects uncertainty in the world markets. In the low-economic growth scenario, oil reaches $14 by 2015, whereas it reaches nearly $28 per barrel under the high-economic growth scenario. In all cases, the activities of the Organization of Petroleum Exporting Countries (OPEC) is responsible for a significant level of uncertainty.

[1] U.S. Department of Commerce, Bureau of the Census, *1994 Annual Survey of Manufacturers*, M94(AS)-1 (Washington, D.C., 1996).

[2] American Forest & Paper Association, Washington, D.C.

[3] Energy Information Administration, *Annual Energy Outlook 1997*, DOE/EIA-0383(07) (Washington, DC, December 1996).

Table 2. Projected Energy Consumption in the U.S. Pulp and Paper Industry (trillion Btu)

| | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|
| **Reference Case** | 2571.3 | 2679.8 | 2805.3 | 2867.1 | 2895.0 | 3013.9 |
| Fossil Fuels | 1050.8 | 1043.6 | 1040.2 | 1019.0 | 988.3 | 983.5 |
| Purchased Electricity | 259.5 | 279.1 | 291.2 | 295.2 | 296.0 | 310.9 |
| Renewables | 1261.0 | 1357.1 | 1473.9 | 1552.9 | 1610.7 | 1720.1 |
| **High Economic Growth** | 2571.3 | 2731.0 | 2915.0 | 3044.3 | 3145.8 | 3307.8 |
| Fossil Fuels | 1050.8 | 1058.7 | 1073.0 | 1078.8 | 1058.1 | 1070.3 |
| Purchased Electricity | 259.5 | 285.7 | 303.9 | 314.2 | 322.6 | 343.6 |
| Renewables | 1261.0 | 1386.6 | 1538.1 | 1659.3 | 1765.1 | 1890.2 |
| **Low Economic Growth** | 2571.3 | 2630.3 | 2696.8 | 2688.2 | 2640.8 | 2704.6 |
| Fossil Fuels | 1050.8 | 1028.7 | 1007.2 | 966.1 | 916.3 | 894.4 |
| Purchased Electricity | 259.5 | 272.9 | 279.5 | 276.4 | 269.8 | 278.8 |
| Renewables | 1261.0 | 1328.7 | 1410.2 | 1445.7 | 1454.7 | 1531.8 |

Source: U.S. Department of Energy, Energy Information Administration, Supplementary Tables for the Annual Energy Outlook 1997, December 1996, and unpublished data received January 1997.

Table 2 shows projected energy consumption for the pulp and paper industry through 2020 for the three economic scenarios. In the reference, or "business-as-usual" case (which is charted in Figure 2, attached), total energy consumption is projected to grow at an average rate of 0.6% per year, increasing overall consumption from over 2.5 quads in 1995 to just over 3 quads in 2020. This growth rate is well below the industry's average annual growth of about 1% per year for the period 1972 through 1995.

In all three scenarios it is anticipated that consumption of fossil fuels will continue to decline, and that consumption of purchased electricity and self generated fuels and residues (labeled as "renewables" by the EIA) will continue to increase.

## Energy Intensity Trends

According to recent data from the American Forest & Paper Association (AF&PA), the pulp and paper industry has reduced its total energy intensity by about 22% since 1972. Table 3 shows industry energy intensity for the years 1972, 1994 and 1995. Fossil fuel consumption per ton of product produced has decreased even more -- by over 40%. The consumption of self-generated and residue fuels per ton of product produced has increased slightly -- from 13 million Btu/ton in 1972 to 14.6 million Btu/ton in 1995.

The AEO forecasts energy intensity for each of the major energy-intensive industries, including pulp and paper. A key assumption used in the NEMS Industrial Demand Module is the Unit Energy Consumption (UEC) estimate, which measures the amount of energy required to produce one unit of the industry's output. Table 4 shows the shows the UECs developed by the EIA for the pulp and paper industry. EIA calculates UECs for three different technology levels: *existing* (the UEC of average installed capacity in 1991); *new*

Table 3. Historical Energy Intensity in the U.S. Pulp and Paper Industry (million Btu/ton production)

| Energy Consumed | 1972 | 1994 | 1995 |
|---|---|---|---|
| Total Energy | 32.1 | 26.0 | 25.6 |
| Fossil Fuels | 19.1 | 11.3 | 11.0 |
| Self Generated Residues | 13.0 | 14.7 | 14.6 |

Source: American Finest Paper Association, Washington, D.C.

*1991* (the UEC of the average new plant built from the ground up on 1991); and *new 2015* (the UEC of the average new plant built in 2015). Based on the UECs, an equipment retirement rate of 2.3%, anticipated industry growth rates, and other assumptions, the NEMS projects energy intensity levels for the pulp and paper industry. Table 4 shows the UECs for the major process steps involved in pulp and paper mill production: wood preparation, pulping, bleaching and papermaking.

Table 5 shows the projected energy intensity for the pulp and paper industry in each of the three economic scenarios, as projected by the *AEO/97*. Here energy intensity is presented as the amount of energy consumed per constant dollar of output. Again, the *AEO/97* projects values to the year 2015; we extended the analysis to 2020 by conducting a linear regression of the data. In the reference case, energy intensity is projected to decline at an average rate of 1.2% per year, from 21,270 Btu per dollar of output in 1995 to 15,520 Btu per dollar of output in 2020. The consumption of fossil fuels per unit of output shows the sharpest decline of the different fuel types, going down from 8,690 Btu per dollar of output to 4,870 per dollar of output, a decrease of almost 44%.

**Table 4. Unit Energy Consumption (UEC) for the Pulp and Paper Industry**
**($10^6$ Btu/ton process step product)**

| Process Step | Existing UEC | New 1991 UEC | New 2015 UEC |
|---|---|---|---|
| Wood Preparation | 0.3 | 0.2 | 0.2 |
| Pulping | | | |
| Kraft Pulping | 15.7 | 11.5 | 9.4 |
| Waste Paper Pulping | 2.8 | 2.6 | 2.5 |
| Semichemical Pulping | 7.4 | 5.4 | 5.2 |
| Mechanical Pulping | 5.7 | 4.8 | 4.7 |
| Bleaching | 6.7 | 5.0 | 4.6 |
| Papermaking | 9.5 | 7.1 | 5.3 |
| TOTAL UEC | 25.8 | 19.4 | 15.9 |

Source: Energy Information Administration, unpublished data received January 1997.

The overall education in energy intensity for the reference case of 1.2% closely matches the historical level of 1.3%, calculated using data provided in Table 3. As shown in Table 5, the difference in energy intensity between the high-economic growth and low-economic growth cases are not very significant. This reflects the expectation that the implementation of process efficiency improvements in the U.S. pulp and paper industry will occur regardless of small upturns or downturns in the domestic economy and world oil markets.

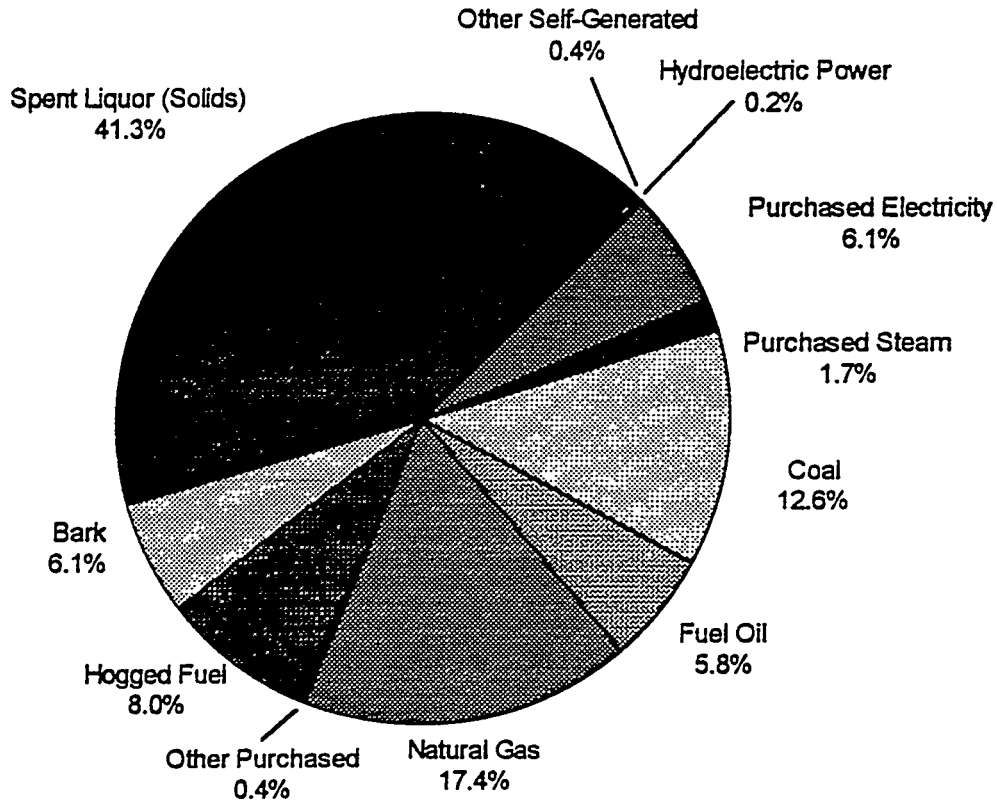
Table 5. Projected Energy Intensity in the U.S. Pulp and Paper Industry($10^3$ Btu/$87 output)

| | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|
| **Reference Case** | 21.27 | 19.84 | 18.56 | 17.62 | 16.87 | 15.52 |
| Fossil Fuels | 8.69 | 7.72 | 6.88 | 6.27 | 5.75 | 4.87 |
| Purchased Electricity | 2.15 | 2.07 | 1.93 | 1.81 | 1.73 | 1.61 |
| Renewables | 10.43 | 10.05 | 9.75 | 9.54 | 9.39 | 9.05 |
| **High Economic Growth** | 21.27 | 19.74 | 18.42 | 17.47 | 16.73 | 15.32 |
| Fossil Fuels | 8.69 | 7.66 | 6.78 | 6.15 | 5.62 | 4.69 |
| Purchased Electricity | 2.15 | 2.06 | 1.92 | 1.80 | 1.72 | 1.59 |
| Renewables | 10.43 | 10.02 | 9.72 | 9.52 | 9.39 | 9.04 |
| **Low Economic Growth** | 21.27 | 19.94 | 18.70 | 17.79 | 17.05 | 15.77 |
| Fossil Fuels | 8.69 | 7.80 | 6.98 | 6.39 | 5.92 | 5.07 |
| Purchased Electricity | 2.15 | 2.07 | 1.94 | 1.83 | 1.74 | 1.63 |
| Renewables | 10.43 | 10.07 | 9.78 | 9.57 | 9.39 | 9.08 |

Source: U.S. Department of Energy, Energy Information Administration, Supplementary Tables for the Annual Energy Outlook 1997, December 1996, and unpublished data received January 1997.

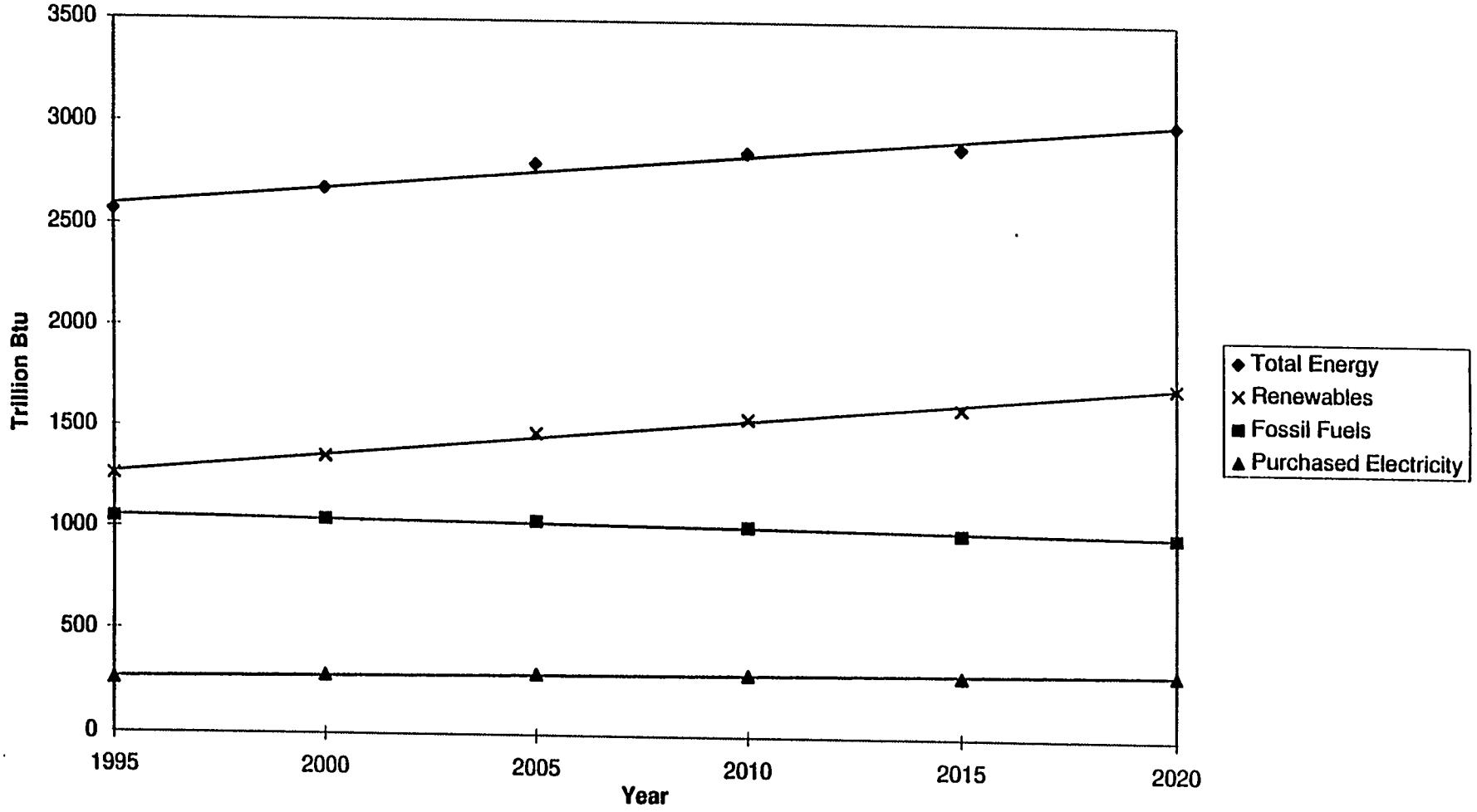
## Figure 1. U.S. Pulp and Paper Industry Energy Sources 1995

**Total Energy Use**
**2.56 Quads**




Source: American Forest & Paper Association, 1996.

**Figure 2. Projected Energy Consumption in the U.S. Pulp and Paper Industry**
**Reference Case**




Source: U.S. Department of Energy, Energy Information Administration, Supplementary Tables for the Annual Energy Outlook 1997, December 1996.

# AMERICAN FOREST, WOOD, AND PAPER

# AMERICAN FOREST, WOOD AND PAPER INDUSTRY
# GASIFICATION COMBINED CYCLE INITIATIVE

## *Executive Summary:*

Three joint Forest Products Industry-Department of Energy (DOE) projects have so far been endorsed by both the Chief Technology Officers Working Group and the CEO Climate Change Options Advisory Group of the American Forest & Paper Association as appropriate to demonstrate biomass and black liquor gasification. If proven, these technologies offer great potential for improved capital effectiveness, energy efficiency, environmental performance, global competitiveness and safety in the forest, wood and paper industry. These advantages will be gained from:

- the ability to increase electrical power production capability by up to 300%;
- providing the potential to positively impact green house gas emissions by over 30 million metric tons of carbon per year;
- making available these technology options early enough for the majority of U.S. industry to utilize them in normal capital replacement decisions; and
- providing U.S. facilities with significantly more effective and efficient power houses compared to currently growing segments of the global industry, such as southeast Asia.

The three projects are:

- Champion's Courtland, Alabama mill to demonstrate a full-scale pressurized, oxygen-based Kraft black liquor gasification system,
- Georgia Pacific's Big Island, Virginia mill to demonstrate semi-chem caustic/ carbonate liquor gasification, and
- Weyerhaeuser's New Bern, North Carolina mill to demonstrate gasification of residual biomass.

Each of the three projects utilizes a different gasification technology in a different application. Choosing one technology over another to demonstrate on a sequential basis would result in significant delay of getting the technology to the marketplace for use by all segments of the industry. The combination of these three projects ensures that the broadest range of the pulp and paper industry will benefit from the proposed demonstrations. Each of the applications may be used separately, or may be combined for the highest level of benefits. Demonstrating them in different mill configurations ensures that, if proven, the technology will find broad market acceptance in a wide range of facilities in the industry—be it for replacement of current technology or for incremental new capacity.

Because of the age of the industry's powerhouses, these technologies need to be demonstrated in parallel if they are to be available in time for broad application across the industry. Due to the diversity of the industry's needs, no one technology can provide a full solution. Though the three technologies differ, there are fundamental issues of chemistry and physics that are common across each project. This can reinforce the robustness of the projects, reduce the risk of failure, and—in the event of a project delay or diminished success—provide an adaptable alternative.

The Agenda 2020 Energy Performance research area task group has included gasification combined cycle in their most recent request for proposals, since there may be other opportunities as well. The intent is to seek out the full range of sites and technologies where biomass and black liquor gasification can be demonstrated for broad application within the industry, thus increasing the likelihood that pulp and paper manufacturers will have the best technology options from which to choose.

In the following document, the history of how the industry arrived at this point is reviewed, the importance of the technology to the industry and the nation is discussed, a brief description of the technologies involved is provided, the necessity for government funding is established, a management oversight plan is suggested and a path forward is proposed.

## *Table of Contents*

### *The History*

Gasification of various carbonaceous feedstocks has been practiced successfully for over forty years for the production of synthesis gas for chemicals.

In the mid 1970's, the pulp and paper industry around the world began to realize that the industry's energy conversion equipment of that time was inefficient, capital intensive, and had safety and environmental issues. The Gunnar Sundblad Conference in Stockholm, Sweden addressed this issue in May 1976. At that conference, four new technology options for Kraft recovery were proposed. Twenty-two years later, the industry is ready for first commercial demonstrations. Through the Agenda 2020 process, three specific demonstration projects have been identified.

The Tomlinson recovery boiler has been the dominant technology for recovery of chemicals and energy from the spent pulping liquor (black liquor) of the Kraft pulping process since the 1930s. There have been many attempts to develop alternatives, but none have achieved commercial success. While many improvements have been made in the Tomlinson furnace since its introduction, **it still has relatively low thermal efficiency and a low power-to-steam output ratio**. In addition, it is high in capital and maintenance costs, and the potential for a smelt water explosion remains. There are more than 200 Tomlinson boilers in the U.S., and about 80% of them were built or rebuilt before 1980. Therefore, most recovery boilers will need major modifications or replacement within the next 20 years.

In semi-chem operations, as in the Kraft process, it is important to the economics of the process to recover the sodium chemicals used in pulping. The majority of semi-chem plants use a Copeland fluid bed boiler in which there is no recovery of the energy value of the lignin. Three mills use Tomlinson recovery boilers to recover the cooking chemicals, but all use supplemental fuel to sustain combustion.

As recently as 1970, hog fuel or wood room waste was considered to have little value and was regarded as more of a nuisance than a fuel. Many mills preferred to landfill it rather than reduce boiler capacity by displacing then cheap oil. Higher fossil fuel prices focused more attention on the value of hog fuel; and today, it is commonly burned in a boiler designed specifically for such wastes or in a combination boiler burning fossil fuels as well. Hog fuel or combination boilers have drawbacks similar to recovery boilers in that **the power-to-steam output ratio is low and they have fairly high capital and maintenance costs**. Today, it is frequently uneconomic to transport and burn forest residuals for their energy value. However, they represent a significant potential fuel source if they could be utilized more efficiently.

In spite of their poor characteristics, the industry can be proud of the progress it has made in using these fuels to supply its steam and electric power needs. In 1972, these fuels supplied about 36% of its steam and power needs; but through conservation efforts and improvements in combustion and power generation efficiencies, about 54% of these needs for the pulp, paper and packaging sector are currently supplied with these same materials.

Never without new challenges, the industry has continued to upgrade the equipment used for pulping, papermaking, and forest products to increase production, achieve greater efficiency in fiber use and improve the quality of its products. Industry customers have become far more demanding about quality, particularly as the technologies using its products have become much more advanced. High-speed printing presses, copiers, facsimile machines and the like are less tolerant of small quality changes and variations in paper, forcing specifications once thought unrealistic. At the same time, environmental regulations have become more stringent, and the

industry has had to add significant environmental control processes and equipment to its mills. The Cluster Rules have added new requirements, and greenhouse gas initiatives may well do the same.

What have these issues to do with energy? The changes that have been made to the industry's processes and equipment have resulted and continue to result in a shift in the amount of steam and power needed per pound of product to less steam but far more electric power. A modern paper machine has an electric power load per ton that is 1.5–2 times that of an older machine.

The industry is meeting some of its needs by increasing the amount of power generation in the mill, but the additional power generally is purchased from a local utility supplier. The electric utility industry is changing even more rapidly than the forest products industry. During the next several years, the entire electric utility industry could be deregulated. The industry's supplier of electric power in the future may be the local utility, a utility a thousand miles away, or even a broker buying and selling kilowatt hours the same way stocks are traded today. For some mills, this may mean lower cost electric power; for some, deregulation could mean a trade-off between reliability and cost. In any event, electric utility deregulation means changes for the forest products industry that could place a premium on its ability to self-generate electrical energy from non-fossil fuels.

Most of the pulp, paper and forest products produced in North America are consumed in North America; and, until recent years, international exports and imports of these products was not a significant factor in the economic profit of producers. That picture has also changed rapidly. The industry is facing ever-increasing international competitive pressures in both the export and import markets. High tariffs and government subsidies in Europe, Asia and South America threaten its ability to compete and to remain a viable industry in the future. To remain viable, operating costs need to be reduced; and energy—in most cases, the third highest cost after raw materials and labor—has to be one of the primary targets for cost reduction.

In summary, the Agenda 2020 technology visioning process has recommended the early demonstration of gasification combined cycle technologies and is currently supporting significant fundamental research to enhance their success. A wide membership of the industry has expressed serious interest and support for these demonstrations. Significant learnings have been and are being derived from prior pilot facilities—including demonstrations of the MTCI PulseEnhanced™ Steam Reforming process at Inland Container and Weyerhaeuser, the Kvaerner Chemrec black liquor process at Frövifors, Sweden, and the Battelle/FERCO Low Inlet Velocity process at Burlington, Vermont.

Currently, Champion, Georgia Pacific and Weyerhaeuser have proposed to work together with the DOE and the AF&PA to obtain government cost share for three **technology demonstration** projects. Funding is expected to come from the three companies as well as the DOE. In addition, a request for proposals has been issued which seeks additional opportunities for effective demonstration of these or other technology options. The U.S. Department of Energy has been briefed and has expressed considerable support and willingness to participate. To facilitate the timely success of these first units, an alliance of the industry is also a possibility.

The President's Commission on Science and Technology has recommended these technologies for their potential to make a significant contribution to the country's obligations under global climate. Those present at the American Forest & Paper Association Agenda 2020 Chief Technology Officers Working Group Meeting on March 3 & 4, 1998 unanimously agreed to pursue a gasification initiative and an early technology implementation; and on May 19, the CEO

Global Climate Change OAG informed the AF&PA Board of their unanimous support of the planned path forward.

### *The Technologies*

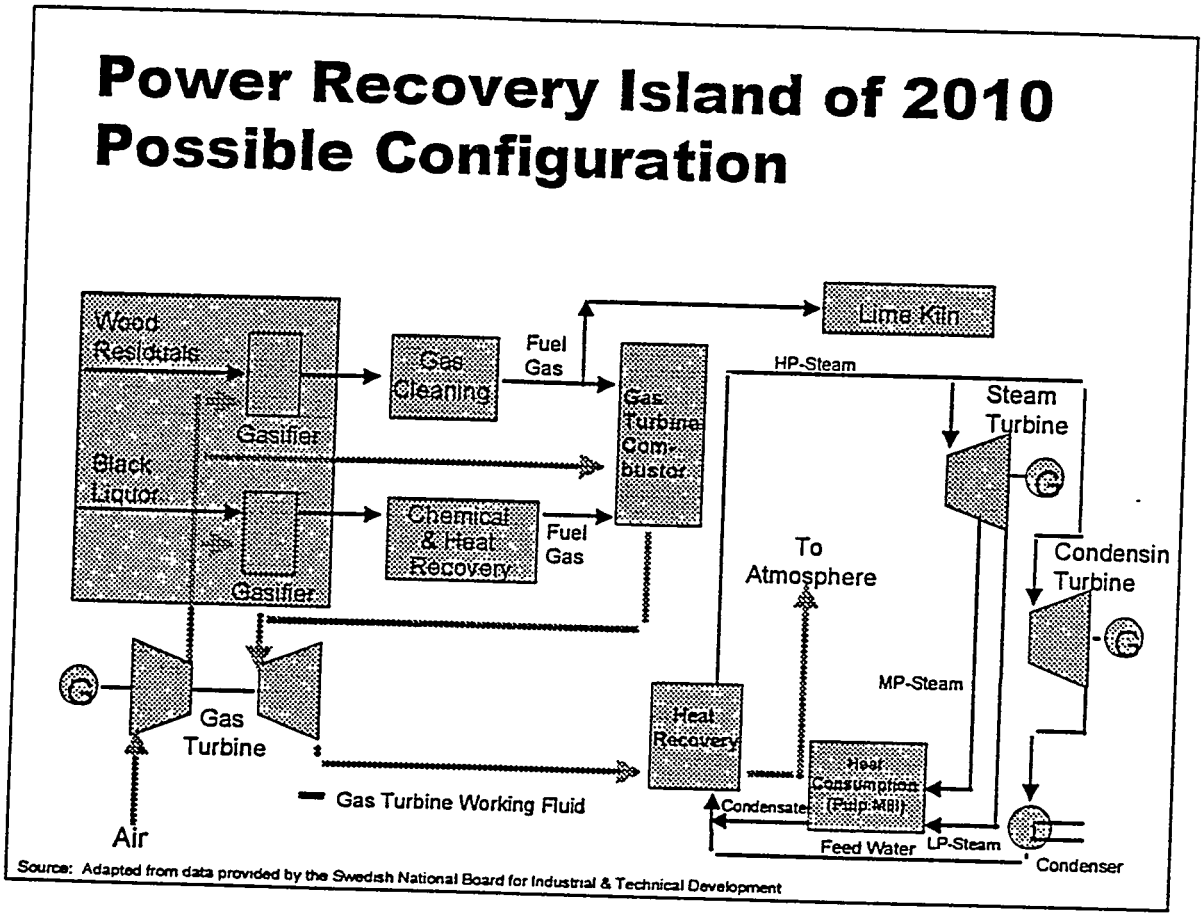
> ***Gasification:*** The conversion of low cost solids or liquids into clean burning gases for replacement of expensive fossil fuels.
>
> ***Combined Cycle:*** The use of a gaseous fuel in a gas turbine followed by the production of steam, which is subsequently used in a steam turbine such that both turbines produce electric power.

Kraft black liquor and semi-chem caustic-carbonate liquors are mixtures of organic components dissolved from the wood, inorganic cooking chemicals and water. Even when concentrated in multiple effect evaporators, they contain large percentages of water and are low quality fuels. Gasification allows separation and recovery of the inorganic cooking chemicals while producing from the organics in the liquor a combustible gas product that, when cleaned, is a very viable medium Btu fuel. As applied to biomass, gasification allows one to take a fuel that is roughly half water by weight and produce from it a higher quality fuel. These fuel gases can be used as direct replacements for fossil fuels.

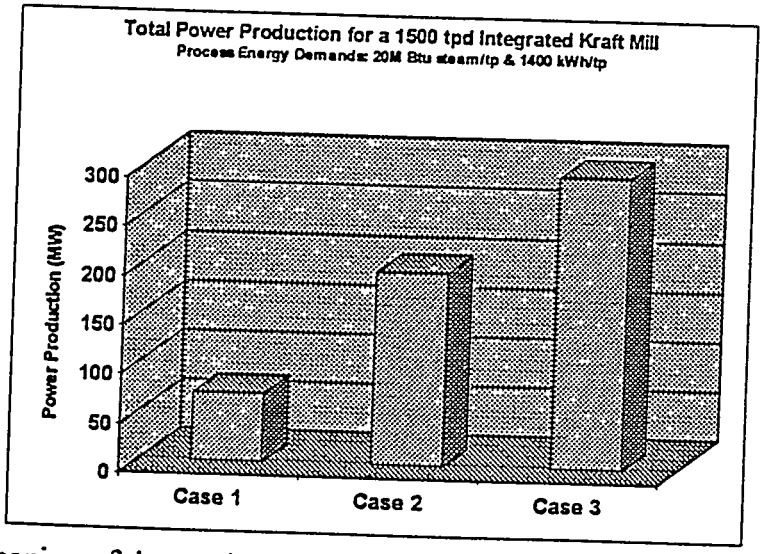
A key impetus to commercialize biomass and black liquor technologies is the ability to fire the product gases in a gas turbine and to use the gas turbine exhaust, which is at about 1000°F, to raise steam that can be passed through a steam turbine to generate additional electric power. In recent years, the industry has become a significant user of gas turbines as it has increased the amount of power generated on mill sites. Where this has occurred, it provides the basis for partial or complete replacement of natural gas with syngas from black liquor and biomass as natural gas prices increase. In spite of these trends, there is still a substantial and growing amount of power purchased from utilities. Gasification combined cycle has the potential for greatly increasing the amount of electric power generated per unit of fuel.

For example, if one takes the black liquor and hog fuel generated in a 1,500 ton-per-day integrated Kraft mill, it is possible to generate about 70 MW of power using the current technology of a Tomlinson recovery boiler, a combination boiler, and a steam turbine generator. Replacing the Tomlinson recovery boiler with an integrated gasification combined cycle (IGCC) black liquor system increases the potential power generation to nearly 200 MW The same black liquor and hog fuel supplied to a combination of black liquor and biomass gasification in IGCC configuration can generate nearly 300 MW of power (approximately a 300% and 400% increase, respectively). The efficiency gain depends on the specific configuration examined; but typically, the overall cycle efficiency of an IGCC plant can be up to 10% higher than a conventional cycle.

The **shared vision of the industry** is reflected in the figure at the top of page 7 where a hypothetical powerhouse configuration is shown utilizing both black liquor and biomass gasification. Having these developing technologies available by 2010 or before will allow the majority of the industry to have these significantly improved options as they make necessary powerhouse replacement decisions.




The impact these technologies can have (reference Eric Larson, Princeton) is shown in the figure below.



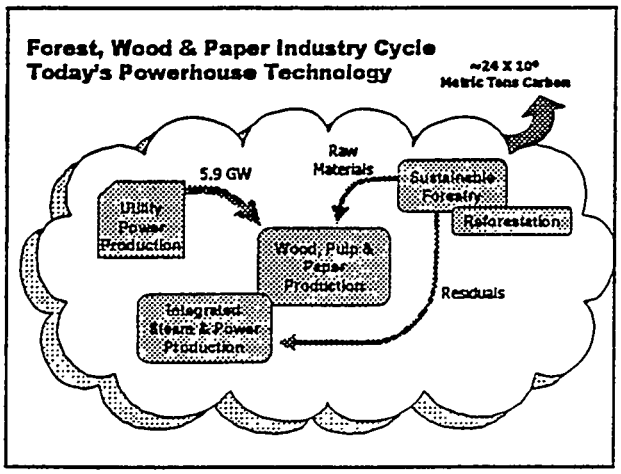

*Case 1: Tomlinson boiler +biomass power boiler, back-pressure steam turbine (BPST)*

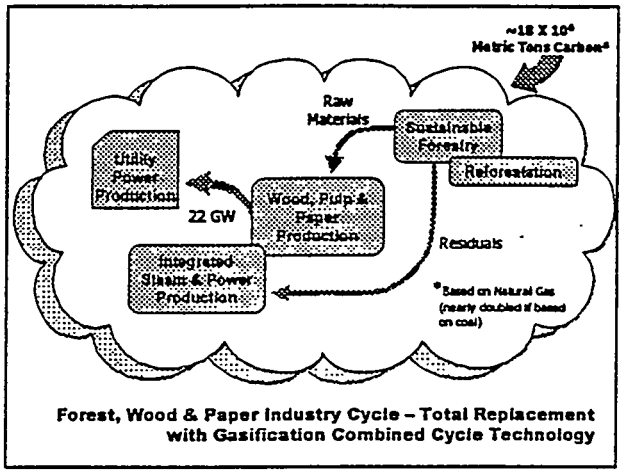
*Case 2: Black liquor gasifier + biomass power boiler in combined cycle with BPST*

*Case 3: Black liquor gasifier + biomass gasifier in combined cycle with BPST*

All gasification combined cycle technologies (IGCC) include cleaning of the product gases from the gasification step prior to their final combustion. Therefore, it is possible to better control the quality of the gas and to remove some of the precursors of adverse environmental emissions. The overall result is lower environmental emissions than current technology.

The recent greenhouse gas protocol agreed to by the U.S. in Kyoto, Japan calls for sharp reductions in emissions of greenhouse gases. The U.S. forest products industry is, on the one hand, provides large sequestration of carbon both through long-term storage in its products and by planting and growing trees. On the other hand, it is an emitter of carbon dioxide through its manufacturing processes. As a large user of energy, regulatory initiatives that are developed to meet the goals of the Kyoto agreement are likely to have a huge impact on the economic viability of the forest products industry.




If proven to be economically and commercially viable, biomass and black liquor gasification combined cycle technologies offer tremendous opportunities for this industry to make a positive contribution to the reduction of greenhouse gas emissions. Initial estimates indicate that, if fully implemented, these technologies have the potential to reduce carbon emission by 30 to 60 million metric tons per year, depending on whether the fossil fuel displaced is natural gas or coal. Significantly less than 10% of the industry's boilers would have to transition to the new technology to achieve a 7% reduction goal for the industry. These impacts are graphically represented below.

Furthermore, these technologies are believed to have **crosscutting applications** for other energy intensive industries, such as chemicals, petrochemicals, utilities and refining. By demonstrating these technologies in the forest products sector where there is a high likelihood of success, the Department of Energy—along with key gasification technology suppliers—could help facilitate the transfer of the technology to other potential applications. This would expand the potential for improved energy efficiency and environmental performance in other sectors.

As stated above, the industry has recognized the advantages for itself and for the Nation of biomass and black liquor gasification technologies since the late 70's. Since this time, it has worked with the DOE and others to bring these technologies to commercial reality. Safety, energy efficiency, capital effectiveness and global competitiveness have been consistent drivers for the advancement of these technologies.

If proven successful, some of the specific benefits of IGCC include:

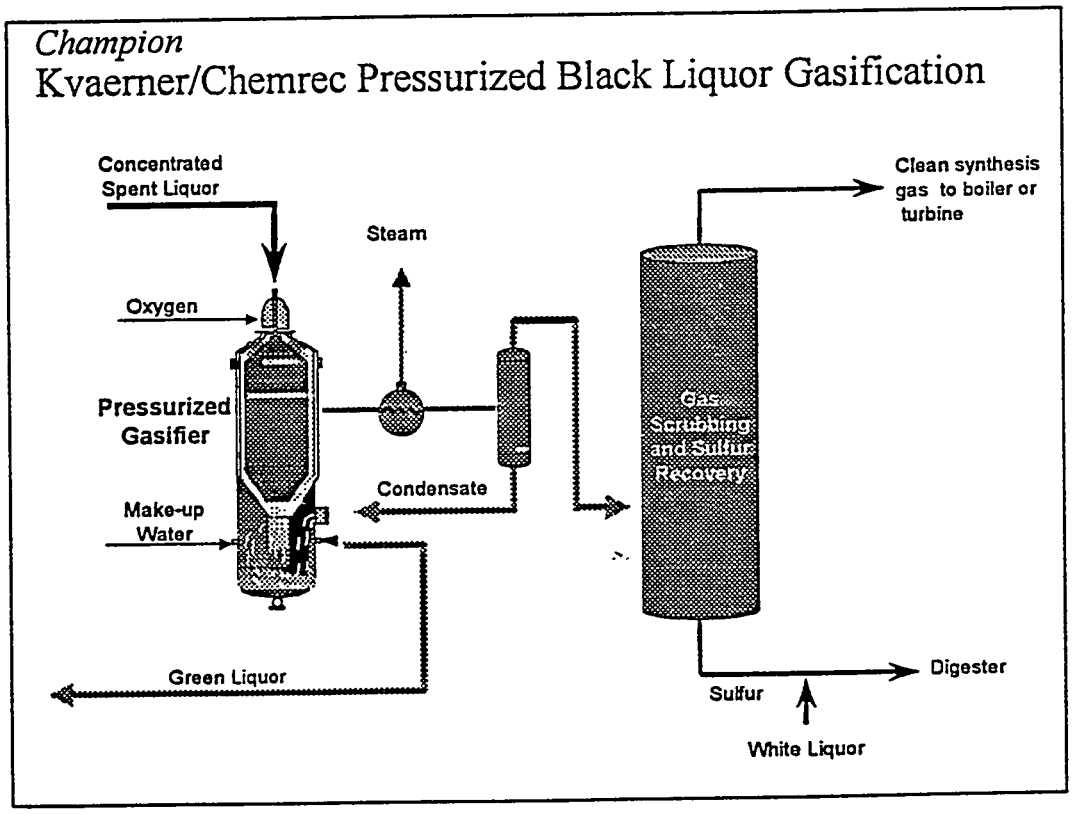
- Higher energy efficiency—up to 10%
- Higher reduction efficiency for Kraft cooking chemicals—typically 5% improvement
- Higher electrical power generation—in excess of twice the kWh/ton
- Lower environmental emissions
- Improved safety and capital effectiveness

These benefits, however, are to some degree offset by risks—particularly to the first users of the technologies. These risks include:

- Capability of the suppliers
- Ability to keep units on line in the early years
- Maintenance costs
- Impact on production
- Possibility of failure to achieve design performance

The aging of industry powerhouses and the current national emphasis on global climate change create a window of opportunity for rapid demonstration. The Industry supports developing the structure and the federal funding for pursuing the timely demonstration of these technologies, and the Administration's initiative on reducing carbon emissions may provide the extra support needed to "lift" these technologies over the economic and feasibility barriers to show that they are attractive, reliable and robust. In addition, the industry speaking with one voice instead of fragmented will greatly enhance its ability to achieve the benefits these technologies offer in a manner that is consistent with national goals.

**Kværner Chemrec™ Pressurized Black Liquor Gasification System**




Development of the Kværner Chemrec™ System began in the early 1980s. The original parent company of this technology, SKF Steel, began the development of plasma-based gasifiers for black liquor, but excessive carryover of alkali materials and high electrical power consumption caused them to abandon this approach. They built a lower temperature pilot plant in 1987 that established that black liquor gasification was feasible without plasma energy support. Kværner purchased the technology in 1990 and continued development in both low-pressure air-blown

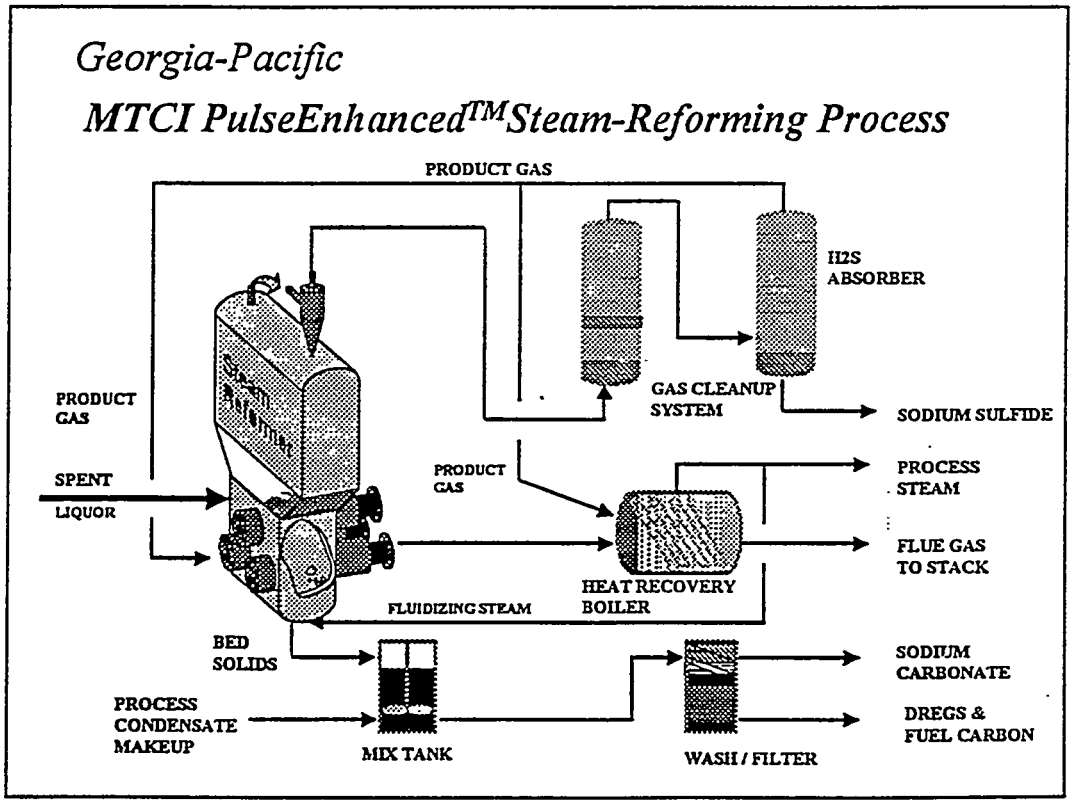
pilot and commercial facilities and a high-pressure oxygen-blown pilot facility, leading to the proposed entrained flow configuration for this demonstration.

Concentrated black liquor, preferably at 65% solids or higher, is injected into the upper portion of the gasifier together with atomizing steam and oxygen. The gasifier operates at about 1700–1800°F and around 400 psi. The high pressure and a very short residence time result in a very compact unit. The organics in the liquor are partially oxidized to form a combustible gas while the inorganics melt and flow down the gasifier as entrained droplets or a thin layer on the walls. The small amount of smelt in the gasifier and the absence of large quantities of water ensure that a smelt water explosion is precluded.

The product gases from the gasifier contain combustible gases as well as hydrogen sulfide and steam. They are cooled in a heat exchanger to generate process steam and are scrubbed of hydrogen sulfide in a conventional absorber/ stripper system—technology long in use in the petrochemical industry. The concentrated hydrogen sulfide stream from the stripper is treated in a conventional Claus plant to form elemental sulfur for use in preparation of polysulphide cooking liquors. The cleaned product gases can be burned in a boiler or gas turbine.

A similar demonstration of the Kværner Chemrec™ gasifier at an unbleached linerboard mill in Sweden is under discussion. Should that demonstration go forward, the information available to the U.S. industry is likely to be limited and delayed. Further, there will be virtually no information available on the very important aspect of integration of black liquor gasification into the kraft process.

**MTCI/StoneChem PulseEnhanced™ Steam Reforming Process**



The StoneChem gasification process employs indirect heating of a steam fluidized, bubbling bed of sodium carbonate solids. Black liquor is sprayed directly into the bed, where the liquor droplets uniformly coat the bed solids, resulting in high rates of heating, pyrolysis and steam reforming. Bed temperatures are maintained at approximately 1100°F, thereby avoiding liquid smelt formation and the associated smelt-water explosion hazards. Neither combustion (burning) of the black liquor nor alkali smelt formation occurs in the steam reforming process. Steam reacts endothermically with the black liquor char to produce a medium-Btu syngas rich in hydrogen. This product gas passes through a cyclone to remove particulate matter followed by a heat recovery unit. It is then further cooled and scrubbed to recover additional chemicals and produce a clean burning fuel. Chemical recovery is accomplished by continuously purging the dry (sodium carbonate and potassium carbonate) solids from the reformer bed and dissolving them in a mix tank.

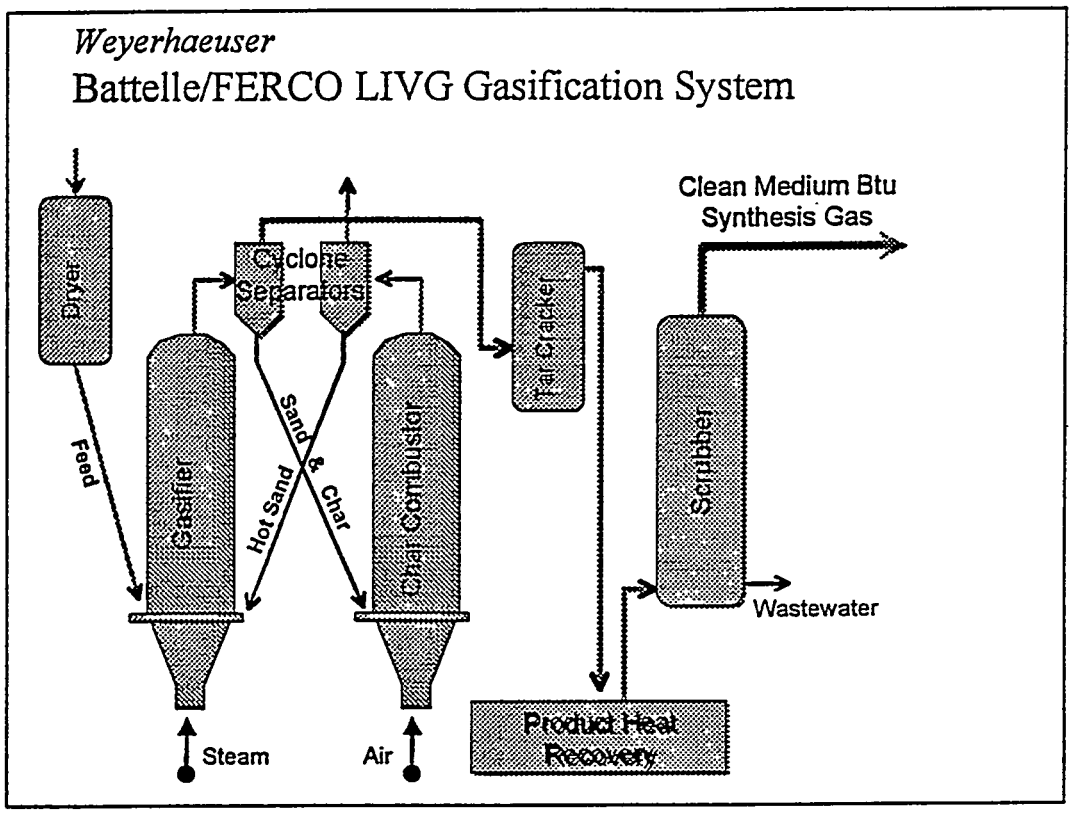
Heat required for the endothermic steam reforming reactions is supplied by heat exchangers immersed in the fluidized bed. The heat exchangers consist of bundles of pulsed heater resonance tubes that supply the necessary heat by burning a portion of the product gas, thus making the PulseEnhanced™ Steam Reformer self-sufficient with regard to fuel. The excess product gas and the hot combustion gases leaving the pulsed heaters are sent to a waste heat boiler to generate process steam and preheat combustion air for the pulsed heaters.

Georgia Pacific believes that there are three extensions of this technology. First, it is a new process for high-yield chemical pulping where historically there have been only three dominant processes—namely, NSSC, Billerude and the soda process. Each of these processes have serious limitations which have prevented expansion of high-yield chemical pulping. Inclusion of a gasifier in the soda process makes this process reliable and energy efficient, thereby giving the industry a process choice that will likely increase the use of the high-yield pulping process.

Second, the PulseEnhanced™ Steam Reformer process is expected to be compatible with the inclusion of wood waste, especially sawdust. While it is beyond the scope of the proposal, Georgia Pacific intends to investigate this possibility and change the mill power island in accordance with the resulting economics.

Third, as demonstrated on a small pilot scale by Weyerhaeuser, the PulseEnhanced™ Steam Reformer process is also applicable to kraft black liquor. The current view is that the initial application is most probable in conjunction with a recovery boiler as supplemental capacity or as replacement for one boiler in a multi-boiler mill. Although the Big Island unit is designed for a soda process, there is a small sulfur reduction capability. If, as expected, the Big Island unit as constructed is found to be capable of processing kraft black liquor, Georgia Pacific will seek an environmental permit for a demonstration of this capability. This trial could be conducted on "imported" black liquor and could be of several days duration. It would investigate the compatibility of refractory material and the lower and narrower range of temperatures identified in the earlier trials at Weyerhaeuser, New Bern. The capability of the PulseEnhanced™ Steam Reformer unit to process commercial quantities of kraft black liquor would in this way be demonstrated. While beyond the scope of the currently proposed project, it is a question that Georgia Pacific wants to answer before its next recovery boiler rebuild or purchase.

**Battelle/FERCO Low Inlet Velocity Gasification System**




The Battelle/FERCO biomass gasification system (initially developed by Battelle) has been the subject of several evaluations by Weyerhaeuser over more than a decade. It seems particularly suited to a pulp mill environment since it operates at close to atmospheric conditions, produces a medium Btu gas, is tolerant of changes in feed quality, requires less attention to fuel drying and holds the promise of requiring significantly less capital. The medium Btu gas (450–500 Btu/scf) produced from wood residuals is accomplished without an oxygen plant. A gas having a heating value in this range can normally be readily utilized by existing oil or gas-fired equipment without de-rating and with little retrofit equipment.

Wood is fed, with size reduction and partial drying, into a gasifier where it is contacted with hot sand and a conveying stream of steam. The wood reacts, producing a medium Btu product gas and char which, along with the sand, is separated from the product gas by cyclones. The solids discharge of the cyclone directs the sand and char mixture into a combustor where the char reacts with air to reheat the sand, which then returns to the gasification vessel. The product gas continues on to heat recovery and water scrubbing to remove condensable organic material. The flue gas from the combustor at 1,900°F provides a valuable heat source for generation of steam or other process heating applications.

The inherent high reactivity of wood and other biomass feedstocks makes it possible to utilize extremely compact equipment for generation of the medium Btu product gas. Specific throughputs of over 2,000 lbs/hr-ft$^2$ of reactor area have been achieved in the research unit and are expected to be even greater in the development unit currently in start-up at Burlington, Vermont. These throughputs are more than an order of magnitude higher than conventional fluid

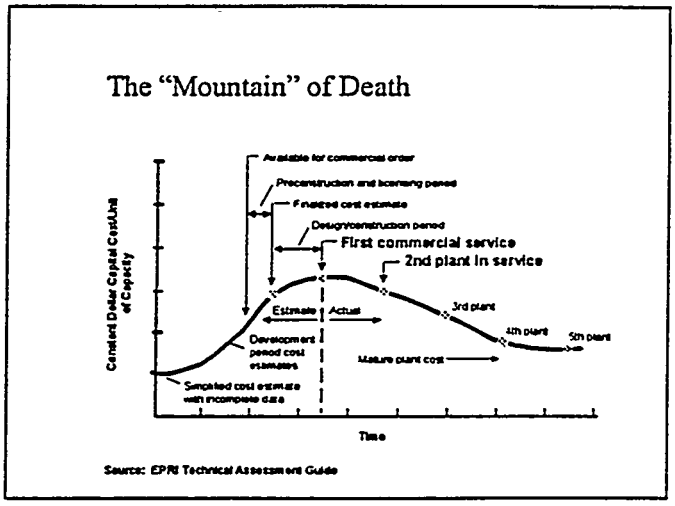
bed gasification reactors. This should translate to lower capital cost than systems requiring larger equipment. In addition, the two-zone system allows the heating value of the cool, cleaned product gas to remain constant—independent of the moisture level of the feed.

Although the Burlington demonstration is an essential step in the evolution of this technology, as was the Weyerhaeuser pilot facility in the evolution of the PulseEnhanced™ Steam Reformer technology, it leaves many questions unanswered. The risks that will be addressed at New Bern include integration of a fuel dryer, use of the syngas in a lime kiln application, significant improvement in design resulting from a chemical process plant, as opposed to a boiler, design philosophy, long-term operability and maintenance costs, and process control philosophies in a pulp mill integrated environment. In addition, the New Bern proposed facility represents a significant scale up to a size typical of the needs of pulp mills.

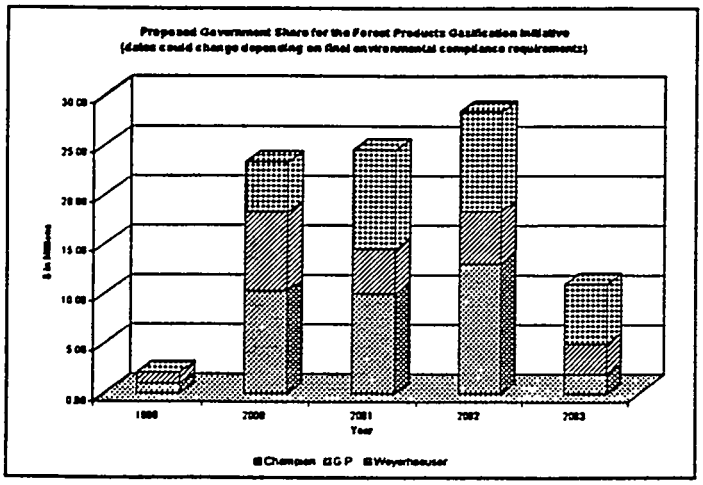
### *The Necessity for Government Funding*

The government is asking industry to meet stringent environmental and energy efficiency standards through numerous regulations, including potential new treaty obligations on greenhouse gases. These cannot be met in a cost efficient way without significant new advances in technology, such as those provided by the gasification processes. The U.S. government recognizes this.

The gasification technologies discussed here have been in development for several years, but the risk and costs associated with full-scale demonstration have prevented them from becoming commercialized. Industry estimates indicate that the first project for each technology approach will cost 30–40% more in capital than subsequent projects and will also have increased initial start-up and demonstration costs.




The figure on the right from the Electric Power Research Institute Technical Assessment Guide represents the experience of the utility industry, which is typical of process industries like forest products. This figure clearly shows that the first commercial units are significantly higher in capital than later units.




Host facilities and key suppliers are now in place and willing to share the cost and risk associated with proving these new technologies with the Department of Energy through the framework of Agenda 2020. The DOE-funded demonstrations are intended to bring the technologies to the marketplace—it is unlikely that they would otherwise make it because of the cost and risk involved. As shown here, the three projects being recommended to the DOE have a five-year cost of ~$200,000,000. The

industry is proposing approximately a 50–50 cost share between DOE and the private sector participants.

In addition to financial support, the demonstration of these new technologies will need support from the Environmental Protection Agency (EPA). Due to the timing of the proposed MACT II rules, the projects will each need assurance from EPA that the mills will have the flexibility needed to complete the demonstrations without being in violation of EPA regulations.

The anticipated compliance deadline of the MACT II rules could be as early as 2001, yet the proposed demonstrations are not anticipated to be completed until 2002 to 2004. If the demonstrations fail, which is unlikely, the mills will need at least 18–24 months to restore the old technology and retrofit it to be in compliance with MACT II. Since the proposed new technologies provide numerous environmental benefits, it is anticipated that EPA will be willing to work with the host facilities to allow the demonstrations to proceed with the needed regulatory flexibility.

### *Management Oversight Plan*

The demonstrations of these technologies will offer numerous benefits to the industry as a whole. Jointly funded DOE demonstrations require that the ultimate results be shared with the public. Through the American Forest & Paper Association's Chief Technology Officers group, agreed-upon progress reports will be shared with the AF&PA membership. This will allow participation by member companies in the demonstration of the technology.

Additionally, the final report will be extremely detailed, as required by law, and will be made available to AF&PA members as well as the public. If these technologies can be proven to be commercially viable, then subsequent installations will have a major advantage of installing technology that bypasses the deficiencies of the initial demonstration without the risk and added cost associated with being first.

The management oversight recommendations which follow incorporate DOE requirements, but have been supplemented by using principles learned in **highly successful** joint activities including BLRBAC (Black Liquor Recovery Boiler Advisory Committee). Those principles are:

1) Written goals
2) Generation of accurate data
3) Mutually agreeable goals
4) Scheduled meetings to share data
5) Joint problem solving
6) Routine reports to members
7) Routine reports to the industry

Each of the three gasifier project proposals will incorporate the major input from the Agenda 2020 process. This will lead to **mutually agreeable goals**. The resulting proposals will specify technical and commercial goals with deliverables and milestones. This will provide **written goals**.

It will be the primary responsibility of each company to achieve their milestones and goals, and the DOE will have primary oversight responsibility. Reports will be generated on the required schedule with the required format and content. This is one phase of **generation of accurate data**.

However, the three gasification projects have an unusual **supporting** relationship and will be of significant interest to the pulp and paper industry. Each of the three projects will distribute periodic progress reports directly to the Agenda 2020 CTO Working Group. This is another phase **of reports to the committee and to the industry**.

Each project has the opportunity and is encouraged to request key industry technical experts to participate in problem-solving activities. This arrangement will allow for an unprecedented opportunity for **joint problem solving,** and should maximize the transfer of technology.

Finally, each project will designate a realistic number of "open house" days where **industry representatives can see** the units in sustained operation.

All of the foregoing activities will ensure that alternatives and techniques learned on one project will be available to the other projects. For example, a risk analysis of the Big Island project showed a potential high risk for maintenance to the pulse chambers of the gasifier. This has led to a request to design two separate combustion chambers instead of a single chamber. This design may permit isolation of a single chamber so maintenance can be performed on the "idle" chamber. This design alternative, whether used or not, will be available to the other projects. Other opportunities for sharing of information include materials of construction, refractory technology, gas cleaning technology, liquor filtering, fuel feed mechanisms, predictive maintenance, and control strategies. This high degree of technical cooperation is expected to significantly increase the probability of success.

Each project will distribute its final report to the DOE and to the Agenda 2020 CTO Working Group. This is one of the last steps in **reports to the industry**. Finally, each project will submit a peer reviewed technical or management article to the Technical Association of the Pulp and Paper Industry (TAPPI) or the Paper Industry Management Association (PIMA) for publication and presentation at a conference. This "committed" distribution and publication will result in an unprecedented **sharing of technology**.

### *The Path Forward*

A significant effort will be required to develop and execute these projects over the next 4–5 years. Some of the most significant early activities are listed below:

- **July 10, 1998**, communicate opportunities around this issue to interested AF&PA members
- **July 14–31, 1998**, make recommendation of gasification projects to DOE
- **September–October, 1998**, begin negotiation of contracts with DOE
- **July – October, 1998**, discussions with EPA regarding assurances for regulatory flexibility for demonstrations
- **November, 1998**, complete DOE contract negotiations
- **December, 1998**, begin first phase of Champion and Georgia Pacific projects
- **December, 1999**, begin first phase of Weyerhaeuser project
- **Continued outreach** to industry and other potentially interested parties including suppliers, universities and national labs
- **Lobby as an industry group** for needed federal funds
- **Develop and execute** demonstration projects

*Attachment I*

**Kværner Chemrec Technology Demonstration**

Pressurized Oxygen-Blown Black Liquor Gasification
and Integrated Combined-Cycle Cogeneration

Targeted Agenda 2020 Energy Performance Area: Commercialization of combined-cycle gasification technologies for both black liquor and biomass


## Abstract

Champion International Corporation, together with Air Products and Kværner Chemrec™, plans to demonstrate pressurized oxygen-blown black liquor gasification and combined-cycle co-generation at Champion's Courtland, Alabama paper mill. Phase 1 is the detailed engineering of a 1.2 million pounds/day black liquor solids gasification plant including gasifier, heat recovery, gas cleaning, and sulfur management. Phase 2 is the construction of the facility, and Phase 3 is the start up and initial operation. The combustible product gas would be fired initially in a bubbling fluidized bed boiler; and, when the quality of the gas is assured, it would be fired in a gas turbine as partial replacement for the current natural gas fuel.

Black liquor gasification offers the potential for up to ten percent higher energy efficiency over conventional technology, higher reduction efficiency of Kraft pulping chemicals, up to twice the electrical power generation per pound of black liquor, lower environmental emissions and positive greenhouse gas effects, improved safety, and improved capital effectiveness. The Kvaerner Chemrec™ System is the most advanced black liquor gasification technology, and offers the highest potential for successful commercialization. The Courtland facility offers the possibility of demonstrating the firing of the product gas in an existing gas turbine. This is a unique opportunity to bring this high-potential technology to the pulp and paper industry.

The demonstration program, including design, construction and operation, would span approximately five years. This proposal discusses the first-year detailed engineering phase of the program in some detail with Phases 2 and 3 in more general terms. The Phase 1 effort would provide more detail on these latter phases.



Proposer

Champion International Corp.
One Champion Plaza
Stamford, CT 06921
Attn. Edward G. Kelleher

Sub-proposer

Air Products and Chemicals, Inc.
7201 Hamilton Blvd.
Allentown, PA 18195
Attn. David R. Ruprecht

Sub-proposer

Kvaerner Chemrec AB
Floragatan 10 B
S-114 31 Stockholm, Sweden
Attn. Lars L. Stigsson

## Background

The Kraft process accounts for more than half of the pulp produced in the United States and 80% of paper contains Kraft pulp. Forecasts do not indicate any change in this for the foreseeable future. Recovery of the cooking chemicals is key to the economics of the Kraft process, and the Tomlinson recovery boiler has been the dominant technology for this since the 1930s. There have been many attempts to develop an alternative to the Tomlinson boiler, but none have been commercially successful. While many improvements have been made in the Tomlinson boiler since its introduction, it still has relatively low thermal efficiency and a low power-to-steam output ratio. It is high in capital and maintenance cost, and there is the potential for a smelt water explosion. There are more than 200 Tomlinson boilers in the U.S. and about 80% of them were built or rebuilt before 1980. Therefore, most recovery boilers will need major modifications or replacement within the next 20 years.

Gasification of various kinds of carbonaceous feedstock has been practiced successfully for over forty years for the production of synthesis gas for chemicals. Gasification of black liquor has been studied for many years, most intensely starting in the early 1980s. In 1990, Kvaerner purchased the parent gasification technology of today's concept and continued its development. An atmospheric pressure air-blown demonstration gasifier was installed at the AssiDoman Frovifors mill in Sweden in 1991; and, in 1997, a commercial atmospheric pressure air-blown gasifier was started up at the Weyerhaeuser New Bern mill in North Carolina. In addition, Kvaerner Chemrec built a pressurized pilot gasifier at a Swedish mill in 1994. Learnings from these operations have been incorporated into the conceptual design for the proposed demonstration.

Integrated gasification combined cycle (IGCC) technology is the marrying of carbonaceous fuel gasification, firing of the product gas in a gas turbine, followed by the production of steam and subsequent generation of additional electrical power in a steam turbine generator. Several large-scale IGCC plants, based mainly on coal gasification, are operating at the present time. The development of IGCC technology based on black liquor presents many challenges compared to other feedstock, but would have significant benefits for the pulp and paper industry if proven successful.

The proposed project has not received any prior government funding.

## Objectives

The objective of Phase 1 of this project is to do a detailed design and cost estimate of the gasification plant, heat recovery, gas cleaning and sulfur management facilities, and the integration of the demonstration plant with the existing Courtland mill—including provisions for liquor supply, initial product gas combustion, product gas combustion in a gas turbine, green liquor ties, white liquor ties, and utility ties. The estimate would include all costs to complete the demonstration.

The objectives of the overall project include:

- Demonstration of large-scale pressurized oxygen-blown black liquor gasification
- Demonstration of product gas clean up and sulfur management
- Demonstration of combustion of the product gas in a gas turbine (igcc)
- Demonstration of sulfur recovery from the product gas of black liquor gasification

- Production of polysulfide-containing white liquor from the recovered sulfur
- Investigation of the yield effects of using polysulfide-containing white liquor in the kraft pulping process
- Comprehensive process analysis of the integration of black liquor gasification into the kraft process

### Pre-Project Requirements

In order to proceed with the latter phases of the project, the EPA must include an 'innovative technology' provision in the MACT II regulations or grant a site-specific waiver so that Champion will be assured sufficient time to implement conventional modifications to Courtland's No. 1 recovery boiler should the subject demonstration not be successful. It is also necessary that the State of Alabama approves the project and grants the necessary permits.

### General Project Approach

The work under Phase 1 will entail detailed engineering, cost estimating, and process analysis of the demonstration plant integrated into the existing Courtland Kraft mill. The project cost estimating will be in sufficient detail to provide a ±10% estimate of the full demonstration. Champion will focus on the process integration with its existing facility. Air Products will engineer the demonstration plant in cooperation with Kvaerner Chemrec and suppliers for the various plant components. Kvaerner Chemrec will focus on the design of the gasifier and integration of the facility's sulfur management system with the Kraft pulp system. It is expected that, due to internal manpower availability, subcontract support will be engaged for some elements of the detailed design. At the end Phase 1, there should be sufficient detailed information for all parties to determine their interest in proceeding with the latter phases.

The latter phases of the project include procurement of the equipment, construction of the demonstration plant, commissioning, and operation. Since the existing No. 1 recovery boiler has about twice the capacity of the proposed gasification plant, it would remain in operation, but at a reduced rate when the demonstration plant is operating. Initially, it is planned to burn the product gases in an existing fluidized bubbling bed boiler to which a scrubber is being retrofitted. When it has been demonstrated that the product gases are consistently of the quality required for gas turbines, it is planned to fire the product gases in the existing Frame 6 gas turbine, replacing up to fifty percent of the natural gas fuel on a Btu basis. This demonstration should provide all of the information necessary to make a decision on the commercial viability of the process and all of the data necessary to substantiate the benefits expected from the technology.

### Benefits to the Industry

The benefits to the industry of the successful demonstration of this technology are many and include:

- Higher overall energy efficiency—up to 10% higher—resulting in less demand for fossil fuels
- Higher green liquor reduction efficiency—5% improvement expected as typical
- Higher electrical power generation—up to twice the kWh/ton as conventional cycle
- Lower environmental emissions—including nox and $CO_2$ emissions

- Improved safety—eliminates the potential for a smelt-water explosion present with a Tomlinson boiler
- Higher kraft pulp yields from polysulfide-containing white liquor usage

Once the technology is demonstrated, the industry can apply it at any Kraft facility as a way to get incremental capacity and/or as a replacement for recovery boilers when they reach the end of their useful life.

The U. S. pulp and paper industry is facing ever increasing international competitive pressures. High tariffs and government subsidies in Europe, South America and Asia threaten its future competitiveness. Successful demonstration of this technology would be a major contributor to helping keep the U. S. Kraft industry viable and competitive in addition to all of the other benefits of the technology.

**Schedule**

| | Start | Completion |
|---|---|---|
| **Phase 1 - Engineering** | | |
| Engineering | 4Q98 | 1Q00 |
| permitting | 4Q98 | 4Q99 |
| process optimization | 4Q98 | 1Q99 |
| definitive estimate | 2Q99 | 1Q00 |
| **Phase 2 - Construction** | | |
| Construction | 2Q00 | 4Q01 |
| bid package awards | 2Q00 | 2Q00 |
| gasifier package | 2Q00 | 4Q01 |
| $O_2$ supply | 2Q00 | 4Q01 |
| sulfur management | 4Q00 | 4Q01 |
| mill interfaces | 1Q01 | 4Q01 |
| pulping line modifications | 3Q01 | 4Q01 |
| **Phase 3 - Demonstration** | | |
| Demonstration | 1Q02 | 2Q03 |
| start up | 1Q02 | 2Q02 |
| baseline operation | 2Q02 | 1Q03 |
| gas turbine integration | 1Q03 | 2Q03 |
| commercial operation | 2Q03 | |

**Budget and Funding**

All spending is in millions ($1,000,000) of dollars.

| | Proposers | DOE | Project Total |
|---|---|---|---|
| **Phase 1 - Engineering** | | | |
| fiscal 99 | 1.00 | 1.00 | 2.00 |
| fiscal 00 | 0.25 | 0.25 | 2.50 |

| | | | |
|---|---|---|---|
| **Phase 2 - Construction** | | | |
| fiscal 00 | 10.00 | 10.00 | 22.50 |
| fiscal 01 | 10.00 | 10.00 | 42.50 |
| **Phase 3 - Demonstration** | | | |
| fiscal 02 | 11.75 | 11.75 | 66.00 |
| fiscal 03 | 0.75 | 0.75 | 67.50 |

| **Phase 1** | |
|---|---|
| Air Products and Chemicals labor | 1.145 |
| Kvaerner Chemrec labor | 0.430 |
| Champion International labor | 0.550 |
| Travel | 0.075 |
| Outside contracts | 0.300 |
| Total | 2.500 |

**Key Personnel**

**Champion**

Edward G. Kelleher, Director, Energy Management; Eng.Sc.D. in chemical engineering; 18 years pulp and paper experience including powerhouse simulation, energy optimization and power generation. Principal Investigator on DOE project DOE/CS/40341-T4-6, Feasibility of Black Liquor Gasification in Combined Cycle Co-generation

Ronald McCarty, Director, Utilities; BS in electrical engineering; 38 years pulp and paper experience including project design, power systems operations, plant engineering, maintenance.

Lars Danielsson, Director, Pulping; BS in chemical engineering; 33 years pulp and paper experience including pulping research, mill operations, process design, advanced pulping technologies.

Fred Magee, Mill Engineer (Courtland); BS in civil engineering; 22 years pulp and paper experience in project engineering.

David Myers, Manager, Chemical Recovery and Utilities (Courtland); BS in chemical engineering; 22 years pulp and paper experience in process engineering, power and recovery operations, power and steam distribution.

Gary Martin, Fiber Supply Manager (Courtland); BS in pulp and paper technology; 19 years pulp and paper experience including pulping, bleaching, and lime kiln/causticizing operations, process engineering.

**Air Products**

David R. Ruprecht, Sr. Development Manager; degrees in metallurgical engineering and business; 27 years experience in the development and commercialization of industrial gas and power applications.

John J. Lewnard, Engineering Associate; Ph.D. in chemical engineering; 12 years experience in development of advanced energy systems including fluidized bed boilers, gas turbines and gasification technologies.

Robert N. Miller, Sr. Contract Development Manager; Ph.D. in geochemistry; 20 years experience in research and managing government contracts.

**Kvaerner Chemrec**

Lars L. Stigsson, Vice President, Studies and Configurations; BS degree in chemical engineering; 20 years experience pulp and paper research and the development of technologies related to black liquor gasification.

Niklas Berglin, Lead Process Engineer; Licentiate - Heat and Power Technology; several years experience in pulp mill energy analysis and black liquor gasification integration.

**Proposers' Contract Specialist**

Robert N. Miller
Air Products and Chemicals, Inc.
7201 Hamilton Blvd.
Allentown, PA 18195

**Bibliography**

Larson, E.D., and Raymond, D.R., "Commercializing Black Liquor and Biomass Gasifier/Gas Turbine Technology", TAPPI Journal, December 1997, 50-57.

Stigsson, L., "Chemrec$^{TM}$ Black Liquor Gasification", TAPPI International Recovery Conference, Tampa, FL, June 1998.

Industra Inc., Engineers and Consultants, Black Liquor Recovery Alternate Study DE-FC02-93CH-10563, Golden, 1996.

Berglin, N., Consonni, S., Larson, E.D., "Black Liquor Gasifier/Gas Turbine Co-generation", Turbo-Expo '97, Orlando FL, 1997.

*Attachment II*

**MTCI/StoneChem Technology Demonstration**

Steam Reforming Black Liquor Gasification at Georgia-Pacific's Mill in Big Island, Virginia


## Abstract

Georgia-Pacific Corporation, together with StoneChem, Inc., proposes to demonstrate PulseEnhanced™ Steam Reforming black liquor chemical recovery at Georgia-Pacific's mill in Big Island, Virginia. The technology was developed and patented by Manufacturing and Technology Conversion, International (MTCI) and is currently licensed to StoneChem, Inc. for use in North America. Pilot studies of steam reforming have been carried out on a 25 ton per day reformer at Inland Container's Ontario, California mill and on a 50 ton per day unit at Weyerhaeuser's New Bern, North Carolina mill.

This full-scale demonstration project will include engineering, construction, startup, and operation of a 400,000 pounds per day black liquor solids steam reformer plant including reformer reactor, gas cleanup system, heat recovery, and chemical recovery. The project will replace existing smelters and provide the entire chemical recovery capacity for the Big Island mill. Excess product gas will be burned in a heat recovery unit to produce 600 psig process steam to replace a portion of the steam currently generated by higher cost natural gas. This represents an energy recovery opportunity currently not available to Big Island or other non-sulfur semi-chemical mills.

The Big Island Mill converted to non-sulfur caustic-carbonate pulping in 1972, and has extensive experience in processing the high viscosity and difficult burning sodium based black liquor. Pilot tests on Big Island black liquor at MTCI's facility in Baltimore, Maryland have shown the capability of the steam reforming process and confirmed the potential energy and environmental benefits. The Big Island mill represents a unique opportunity to demonstrate the capabilities and applicability of the Steam Reformer Gasification Technology for chemical recovery in the Pulp and Paper Industry. The extremely low sulfur chemistry of this facility provides a lower risk opportunity for demonstration of the technology, while the size of the mill provides the opportunity for this process to provide complete chemical recovery.

The demonstration program, which includes design, construction, and operation, will cover a four-year period. This proposal describes the project approach, schedule, benefits, and objectives.



Proposed by:

Georgia-Pacific
PO Box 105605
Atlanta, Georgia 30348-5605
Attention: Benjamin A. Thorp

Sub-proposer:

StoneChem, Inc.
6001 Chemical Rd.
Baltimore, Maryland 21226
Attention: Lee Rockvam

**Background**

The recovery process is an essential component of a pulp and paper mill operation from both an economic and an environmental aspect. Chemicals used in the pulping process are recovered and spent liquor organic solids are converted to energy (typically process steam). The Tomlinson recovery boiler has been the predominant technology; however, fluidized bed combustors have also been used successfully in some segments of the industry. Both technologies have inherent deficiencies including low thermal efficiencies, high capital and maintenance costs, and various operational problems. The Tomlinson unit has the additional potential for smelt-water explosions.

Gasification of black liquor represents a new and better approach for the chemical recovery process and eliminates many of the deficiencies of the Tomlinson and fluid bed combustion technologies. Gasification benefits include increased efficiency in energy conversion and chemical recovery, elimination of the smelt-water explosion hazard, reduced maintenance costs, and significantly lower environmental emissions including particulate, TRS, NOx, VOC, and greenhouse gases. The benefits are particularly attractive to semi-chemical non-sulfur processes that require higher cost auxiliary fuel to sustain combustion of the black liquor.

The steam reforming technology is ideally suited to the conversion of a variety of variable moisture content organic feedstocks, such as black liquor. Carbon conversion efficiency to gas can be high, typically 95%. The MTCI Steam Reformer technology is unlike the other gasification processes currently available. The process employs indirect PulseEnhanced™ heating of a steam fluidized bed of sodium carbonate solids. This process produces an endothermic reaction converting black liquor organics to a gas in the absence of air or oxygen at temperatures below those required for smelt formation. This approach avoids the shortcomings of exothermic reactions found in other gasification processes that utilize higher temperatures and produce smelt. MTCI has carried out studies of spent liquor reforming in a 0.5 ton per day black liquor solids pilot unit since 1990. Successful pilot trials have been conducted steam reforming Big Island black liquor for 108 continuous hours at this facility. Tests on the product gas from the pilot trials have confirmed the potential energy and environmental benefits. A 25 ton per day black liquor solids reformer was operated on mill sludge and imported black liquor at Inland Container Corporation's Ontario, California, mill in March 1992. A nominal 50 ton per day black liquor solids pilot demonstration plant began operation at Weyerhaeuser's New Bern, North Carolina, Kraft mill in the spring of 1994. A 500 hour continuous test was successfully completed at New Bern in August 1995. Although neither is in current operation, the results from both units identified improvements that will be incorporated into the design of the proposed demonstration unit.

A project team was formed to analyze the alternatives for the Georgia-Pacific mill in Big Island to meet the requirements of the EPA Cluster Rule MACT I regulations and MACT II proposed regulations. After analyzing various options, two project alternatives were determined to be economically viable and capable of meeting the requirements of the project. A conventional (Tomlinson) recovery boiler option could meet the project objectives with proven technology and demonstrated safety, environmental and energy performance. A steam reformer, while not a proven technology for this application, offers to meet the project requirements with better safety, environmental and energy performance than a conventional recovery boiler.

## Objectives

The project will install a steam reformer and associated equipment to process all of the black liquor (400,000 pounds of black liquor solids per day) from the pulping process at the Georgia-Pacific mill in Big Island, Virginia. The steam reformer and associated equipment will operate with environmental emissions at or below the limits set by the environmental permit. The equipment installed will maximize the recovery of energy and chemicals while producing a sodium carbonate solution suitable for use in the pulping process.

## Pre-Project Requirements

In order to proceed with the project, the EPA must include an 'innovative technology' provision in the MACT II regulations. An alternative would be for EPA to provide Georgia-Pacific official documentation that if the steam reformer technology fails to meet the project requirements, additional time will be allowed to implement a conventional recovery boiler option.

The Virginia Department of Environmental Quality must grant a revised air permit for Big Island prior to beginning any construction. The steam reformer supplier must guarantee that the permit requirements can be met under all conditions and at all times. The preliminary engineering and detailed cost estimate must confirm the economics obtained from the budget estimates. The project must also obtain the necessary funding and corporate approvals for this technology.

## General Project Approach

The work will consist of preliminary engineering required to completely define the scope of the project and secure the necessary funding. Preliminary engineering will be followed by detailed engineering to specify and procure all of the equipment required, finalize the process design, design all foundations, steel, piping, electrical, instrumentation and process controls and finalize the construction sequence and schedule. Prior to the completion of the detailed engineering, a firm will be contracted to provide the construction services for any equipment not purchased on a 'turn-key' basis. The construction contractor will provide the supervision, labor and construction equipment to install the equipment, piping, electrical, instrumentation and controls required by the project. As the construction activities are completed, commissioning teams comprised of personnel from Georgia-Pacific, the equipment manufacturers, the engineering company and the construction contractor will commission and start up the equipment. Training for Big Island mill supervision, operations and maintenance will be conducted by Georgia-Pacific staff personnel and representatives from the equipment manufacturers.

The project will be started up and placed in service with the existing Smelter equipment kept on standby. The existing equipment will be utilized during periods when the steam reformer or associated equipment must be modified or adjusted. After the steam reformer is operating reliably, it will be tested to demonstrate environmental compliance as well as contractual compliance. The existing Smelter equipment will be removed from service after successful steam reformer testing.

## Benefits to Industry

Successful completion of this project will demonstrate this technology to be capable of providing the **full** chemical recovery capacity for a mill. The project will demonstrate the reliability and operational flexibility of the technology and all of the associated equipment. Once the

technology is demonstrated, the industry can apply this at other facilities to obtain better energy conversion, improved safety and environmental performance.

The predicted total thermal efficiency of the steam reformer technology is over 70% compared to approximately 65% for conventional recovery boilers. The improvement in thermal efficiency will provide over 120 MBtu per day of additional process steam. This is equivalent to 4,600 pounds of high-pressure steam per hour at Big Island. The predicted environmental benefits to the industry of the steam reformer technology compared to conventional recovery boiler technology are listed below:

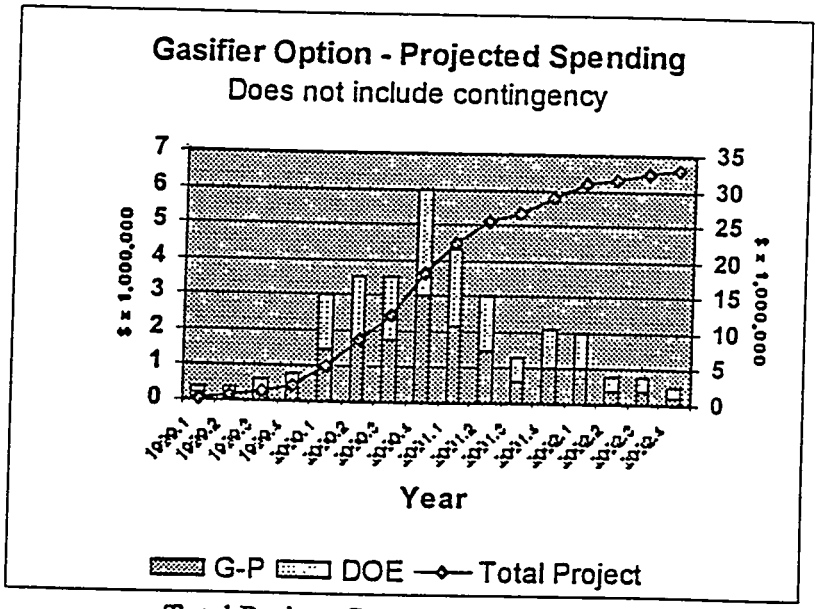
| Emissions | Reformer | Recovery Boiler |
|---|---|---|
| TRS (ppmv) | 1 | 1-2 |
| NOx (ppmv) | 25 | 150 |
| CO (ppmv) | 25 | 250 |
| HCl (ppmv) | ND | 5 |
| Particulate (gr/dscf) | 0.01 | 0.02 |
| VOC's (ppmv) | 5 | 80 |

**Preliminary Schedule**

| Activity | Start | Complete |
|---|---|---|
| MACT II regulations published | | 1999.2 |
| Environmental modeling | 1998.3 | 1999.2 |
| Environmental permit | 1999.2 | 1999.4 |
| Preliminary engineering | 1999.1 | 1999.2 |
| Final engineering | 1999.3 | 2000.1 |
| Purchase major equipment | 1999.4 | 2000.1 |
| Construction | 2000.2 | 2001.2 |
| Start up and modifications | 2001.3 | 2002.1 |
| Performance & compliance tests | 2002.1 | 2002.3 |
| Industry Demonstration | 2002.1 | 2002.4 |

**Preliminary Spending Schedule**
All spending in $ x 1,000,000

| | G-P | DOE | Project Total |
|---|---|---|---|
| 1999.1 | 0.20 | 0.20 | 0.40 |
| 1999.2 | 0.20 | 0.20 | 0.80 |
| 1999.3 | 0.30 | 0.30 | 1.40 |
| 1999.4 | 0.40 | 0.40 | 2.20 |
| 2000.1 | 1.50 | 1.50 | 5.20 |
| 2000.2 | 1.75 | 1.75 | 8.70 |
| 2000.3 | 1.75 | 1.75 | 12.20 |
| 2000.4 | 3.00 | 3.00 | 18.20 |
| 2001.1 | 2.15 | 2.15 | 22.50 |
| 2001.2 | 1.50 | 1.50 | 25.50 |
| 2001.3 | 0.65 | 0.65 | 26.80 |
| 2001.4 | 1.05 | 1.05 | 28.90 |
| 2002.1 | 1.00 | 1.00 | 30.90 |
| 2002.2 | 0.40 | 0.40 | 31.70 |
| 2002.3 | 0.40 | 0.40 | 32.50 |
| 2002.4 | 0.25 | 0.25 | 33.00 |




Total Project Cost: $33,000,000

**Qualifications Of Key Personnel**

Georgia-Pacific Corporation

Gerald Laughlin - Project Manager: Over 30 years pulp & paper project management experience, 20 years with Georgia-Pacific on projects ranging in size from $10 million to over $150 million.

J. Pat Moore - Environmental Responsibility: B. S., M.S. Environmental Science; 13 years experience in environmental engineering and compliance in the forest products industry.

Mike Ohl - Process Responsibility: B.S. Applied Science Paper Technology; 27 years pulp & paper experience. Experience includes research & development, process engineering and process control engineering.

Keith Flynt - Operations Responsibility: BSME; 13 years experience in power and recovery operations at the Big Island mill.

Ralph Sisk - Project Engineering Responsibility: BSCET; 19 years experience. 7 years at the Big Island Mill in engineering and operations.

Philip Campbell - Staff Consulting Engineer – Pulp: B.S. Math; 31 years pulp & paper experience. Experience includes operations, mill engineering, environmental engineering, project engineering, and mill management.

Robert DeCarrera - Staff Consulting Engineer – Power & Recovery: BSCE; 23 years pulp & paper experience. Experience includes operations, construction, project management and design and staff engineering.

**StoneChem, Inc.**

Momtaz N. Monsour - President StoneChem Inc.: PhD. Engineering Sciences; M.S. Aeronautics; B.Ae.E. Aeronautics; Director and Co-Founder of MTCI, Inventor of steam-reforming and pulsed combustion technology, Previous leadership responsibilities include Director Fuel Cell Div. of Department of Energy.

Lee Rockvam - Vice President- Pulp & Paper Applications StoneChem Inc.: B.S. Chemical Engineering; Master Studies Industrial Management; 19 years Paper Industry experience including positions as Technical Director, Pulp Mill Manager, Paper Mill Manager, and Manager of Business Planning.

William Steedman - Principal Engineer- ThermoChem Inc.: B.S. Chemical Engineering. Currently responsible for design of steam reforming technology. Experience includes Group Leader for development of fluidized bed boilers; Process design engineering at Battelle Laboratories.

**Proposer's Contracting Specialist**

Benjamin A. Thorp
Director, Pulp & Paper Engineering

Mailing Address:
Georgia-Pacific Corporation
PO Box 105605
Atlanta, Georgia 30348-5605
GA030-18

Shipping Address:
Georgia-Pacific Corporation
133 Peachtree Street, N.E.
Atlanta, Georgia 30303
GA030-18

Phone: 404-652-4618
FAX: 404-584-1466
E-mail: bathorp@gapac.com

**Bibliography**

MTCI, "Pulse Enhanced™ Steam Reforming and Recovery of Kraft Spent Liquor", Report to Department of Energy of Results of the Weyerhaeuser, New Bern Demonstration, Revised September 1997

Brown, C.A., and Hunter, W.D., "Operating Experience at North America's First Commercial Black Liquor Gasification Plant", TAPPI International Recovery Conference, Tampa, FL, June 1998

Stigsson, L., "Chemrec™ Black Liquor Gasification", TAPPI International Recovery Conference, Tampa, FL, June 1998

*Attachment III*

**Battelle/FERCO Technology Demonstration**

Low Inlet Velocity Gasification of Biomass, Weyerhaeuser New Bern Mill, North Carolina

For many years, Weyerhaeuser has evaluated and encouraged the development of biomass gasification combined cycle technology in general and, in particular, the technology developed by Battelle Memorial Institute and currently licensed to Future Energy Resources Company (FERCO). This technology is being piloted at the 200 BDT/day size at the McNeil Power Station in Burlington, Vermont. As part of a DOE feasibility study, Weyerhaeuser is participating on the Burlington Project Team with the objective of helping that demonstration to be successful as well as providing efficient technology transfer for the first large-scale demonstration facility being evaluated for construction at Weyerhaeuser's mill in New Bern, North Carolina.

The New Bern market pulp mill represents a unique opportunity for this demonstration in that its incremental thermal energy is supplied by #6 and #2 oil. The mill has had a long history of interest and activity in the gasification area, and currently operates the world's largest atmospheric black liquor gasification system, designed to process 0.73 M lb/d BLS. The knowledge and experience that has been achieved from the mill's activities with gasification—coupled with its dependence on oil as an incremental fuel and its high power costs—provides a unique opportunity for the effective demonstration of the Battelle/FERCO technology.

Proposed by: Weyerhaeuser Company
CC II-103
PO Box 2999
Tacoma WA 98477-2999
Attention: Delmar R. Raymond

## Background

Biomass gasification combined cycle technology has continued to be a high industry energy priority for several years. Sharing the industry's interest in this technology, Weyerhaeuser has been actively following and encouraging its development. The Company believes that this technology is ready for a first large-scale demonstration and has offered to provide a host site. Following the completion of a feasibility study, partially funded by the DOE through the National Renewable Energy Laboratory, a proposal for the initial steps toward engineering and construction of the first large-scale demonstration plant based on the FERCO/Battelle technology was submitted through the Agenda 2020 Energy Task Group and was subsequently funded. Weyerhaeuser believes that the New Bern mill is a unique location for the demonstration project and has researched this possibility in detail. The project there is anticipated to cost ~$60,000,000 with the funds being committed in the 2000–2003 time frame. Approximately $30,000,000 will be required from the federal government or other sources to make this project viable and successful.

## Objectives

The project will install a FERCO/BCL Low Inlet Velocity Gasification system and associated equipment to process ~700 BDT/day of wood residuals and pulp mill sludges. The medium Btu syngas from the system will replace oil currently being burned in the mill's lime kiln and power boilers. The specific objectives achieved for the industry will include a thorough understanding of:

- capital and operating costs and opportunities for capital cost reductions in future units;
- the impact of utilizing medium Btu gas in lime kilns and power boilers previously fired with oil; and
- operating and control strategies to optimize the capital effectiveness of the equipment.

All of the learnings surrounding the above objectives will be reported to industry participants through the Agenda 2020 mechanism in a timely fashion.

## General Project Approach

Preliminary engineering for the New Bern installation is being done under Weyerhaeuser's current project with the Department of Energy. The additional engineering required to secure the necessary funding will be done as part of this project. This will be followed by detailed engineering to specify and procure all of the required equipment; finalize the process design; design all foundations, steel, piping, electrical, instrumentation and process controls; and finalize the construction sequence and schedule. Prior to the completion of the detailed engineering, a firm will be contracted to provide the construction services for any equipment not purchased on a "turn-key" basis. The construction contractor will provide the supervision, labor and construction equipment to install the equipment, piping, electrical, instrumentation and controls required by the project. As the construction activities are completed, commissioning teams comprised of personnel from Weyerhaeuser, the equipment manufacturers, the engineering company and the construction contractor will commission and start up the equipment. Training for New Bern mill supervision, operations and maintenance will be conducted by Weyerhaeuser staff personnel and representatives from the equipment manufacturers.

Once the system is operating satisfactorily, a minimum demonstration period of one year will be undertaken. During this time, interested industry representatives will be invited to observe the plant's operation at times acceptable to local operating management.

**Benefits to the Industry**

Although the pulp and paper industry is currently No. 1 in the industrial generation of electricity, there is a clear movement toward more and more dependence on purchased electrical power. This undeniable trend is the result of a combination of changes in the industry's manufacturing processes. To remain competitive and satisfy stricter environmental requirements, mills are undergoing modernization and process optimization with a resulting decrease in built-in capacity for cogeneration of electricity. Added environmental control equipment, primarily scrubbers and precipitators, create greater electrical demand. Alternatives to chlorine bleaching sequences, involving on-site oxygen/ozone generation, and an industry trend towards more thermo mechanical pulp also contribute to increased demand. Recycling is having electric power consequences, since using recycled fiber adds to electrical demand (except in TMP fiber replacement). Another consequence of recycling is that it leaves no appreciable amount of residue, as wood does, that can be used as fuel.

Conversion efficiency can be increased through innovations in drying biomass before conversion to useful energy, but will be attained primarily through advances in conversion technology. The Dutch-oven boiler of the 1950's operated at less than 15% overall thermal conversion efficiency to electricity with a condensing turbine. It is expected that the advanced biomass gasification combined cycle (BGCC) technologies now emerging will produce three times as much electrical energy from the same amount of biomass, operating at close to 45% efficiency. If these technologies can be shown to be cost competitive, they will become the technologies of choice over the next 10–15 years. Biomass and black liquor will not be delivered to furnace cavities, but rather to gasifiers. The gases exiting the gasifier will be cleaned and used to fuel gas turbine combustors and lime kilns. Steam will be produced in heat recovery steam generators downstream of the gas turbines. This steam will be used for further power generation and for process steam. The result will be a significant technology shift for many of the industry's manufacturing facilities, from high-steam/moderate-electricity operation to lower-steam/higher-electricity operating designs. BGCC systems will be an important part of that technology shift.

In order to achieve this technology shift, three things must happen. The new technology must be shown to be available for less capital than current technology. The new technology must be shown to be more environmentally compatible and to be able to produce significantly more electricity for the same thermal load. This project will demonstrate the validity and magnitude of these attributes.

**Preliminary Schedule**

Complete an engineering estimate suitable for capital allocation* ..... June, 1999

Develop the business case that justifies the economic sustainability of the demonstration project* ..... June, 1999

Quantify federal funding possibilities ..... October, 1999

Secure the necessary funding and contractual obligations ..... January, 2000

Complete engineering for construction ..... May, 2000

**Preliminary Schedule (continued)**

Complete construction ..... November, 2001

Complete shakedown and testing ..... November, 2002

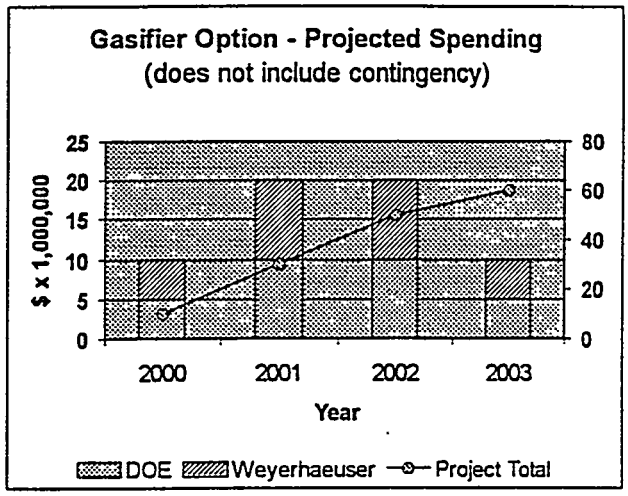
Carry out industry demonstration ..... November, 2003

**funded under current DOE project*

**Preliminary Spending Schedule**

| Year | Weyerhaeuser $ x 1,000,000 | DOE $ x 1,000,000 | Project Total $ x 1,000,000 |
|---|---|---|---|
| 2000 | 5 | 5 | 10 |
| 2001 | 10 | 10 | 30 |
| 2002 | 10 | 10 | 50 |
| 2003 | 5 | 5 | 60 |

Total Project Cost: $60,000,000




**Qualifications of Key Personnel**

Delmar R. Raymond – Program Director
PhD ChE; over 25 years management experience in the pulp & paper industry

James F. Lincoln – Project Manager
BSME and MBA; over 20 years pulp & paper experience, including process engineering and project management

Craig A. Brown – Process responsibility
MSME; over 17 years experience in the pulp & paper industry, including managing gasification demonstration project

William Koos – Project engineering responsibility
BSME; 11 years experience at Weyerhaeuser's New Bern mill with responsibility for all major maintenance and capital projects; 13 years prior engineering experience

Others to be determined.

**Proposer's Contracting Specialist**

Judith A. Kieffer

Mailing Address:
Weyerhaeuser Company
CC II 103
PO Box 2999
Tacoma WA 98477-2999

Shipping Address:
Weyerhaeuser Company
Campus Center II
501 South 336th
Federal Way WA 98003

Phone: 253-924-6200
Fax: 253-924-6812
e-mail: kieffej@wdni.com

**Relevant Publications**

Report on New Bern Biomass to Energy Project, Phase 1 Feasibility Study
Weyerhaeuser Company, Stone & Webster Engineering, Amoco, and CP&L
June, 1995

Advanced Biomass to Energy Conversion Technologies for the Pulp & Paper Industry
D. R. Raymond and J. A. Kieffer
2nd Biomass Conference of the Americas; Portland, Oregon; August, 1995

Alternative Energy Sources and Technologies for the Pulp & Paper Industry
D. R. Raymond; Applied Biochemistry and Biotechnology; Vol. 57/58, 1996

Report on the Workshop on Commercializing Black Liquor & Biomass Gasification for Gas Turbine Applications in the Pulp & Paper Industry
D. R. Raymond and E. D. Larson; Princeton, New Jersey; January, 1997

Commercializing Black Liquor and Biomass Gasifier/Gas Turbine Technology
E. D. Larson and D. R. Raymond; TAPPI Journal; December, 1997

# SECTOR EMISSIONS AND MITIGATION OPTIONS

## PULP AND PAPER

### Contribution to U.S. Greenhouse Gas Emissions

Carbon emissions from combustion of fuels in the forest products industry has been calculated based on energy consumption data collected for the Manufacturing Energy Consumption Survey (MECS). These are shown in the table below. Direct emissions are based on end-use only. Primary emissions include energy losses from the generation and transmission of electricity, based on the fuel mix for the national grid. Forest products includes pulp and paper mills, as well as the manufacture of lumber products.

**Combustion-Related Carbon Emission Trends for the U.S. Forest Products Industry (million metric tons of carbon equivalents)**

| | 1985 | 1988 | 1991 | 1994 |
|---|---|---|---|---|
| Direct Carbon Emissions | 55.57 | 60.76 | 64.79 | 69.15 |
| Primary Carbon Emissions | 65.77 | 71.91 | 76.72 | 82.40 |

### Background on the Pulp and Paper Industry

The U.S. has the world's largest installed pulp, paper, and paperboard production capacity, some 86 million air-dry metric tons (ADMT) per year in 1993, or about 30 percent of global capacity. Manufactured products from the paper and allied products industry (SIC 26) include newsprint, printing and writing paper, tissue, paper plates, card stock, corrugated cardboard, cartons, and construction-grade paperboard. The industry can be divided into two principal sectors. The energy-intensive mill sector processes raw materials into paper and paperboard, and includes the SIC codes 261 (Pulp Mills), 262 (Paper Mills), and 263 (Paperboard Mills). The converting sector further processes the sheets of paper and paperboard into other finished products, and includes SIC codes 264 (Coating and Glazing), 265 (Paperboard Boxes and Containers), 266 (Building Paper and Paperboard), and 267 (Miscellaneous Converted Paper Products, e.g., bags, envelopes, sanitary products, etc.).

In 1994, the industry as a whole employed 621,400 workers and shipped products valued at almost $144 billion (about 4% of all U.S. manufacturing shipments in 1994). Total value added by manufacture was estimated to be over $63 billion. The value of shipments from the mill sector alone was $58 billion and the value added was $26 billion. Average hourly earnings for the industry's 479,000 production workers was $14.33, about 15% above the 1994 national industry average. The value of exports and imports in 1993 was

$9.6 billion and $10.6 billion, respectively. Major imports were newsprint, printing and writing paper, and bleached kraft pulp. Major exports included paperboard, waste paper, and bleached kraft pulp. In addition to traditional competitors in the world such as Canada and Scandinavian countries, the U.S. industry is facing increasing competition from low cost producers such as Chile, Indonesia, Brazil and South Africa.

The U.S. is home to close to 550 pulp and paper mills located in 42 states. The majority of this capacity is in the South (54%), with the other forested U.S. census regions about evenly dividing the remaining capacity (Northeast 13.5%; North Central 18.4%; Mountain and Pacific 14%). Over the last twenty years or so, many of the smaller, older mills have been closed down and replaced with larger integrated mills. The integrated mills produce both pulp and paper and/or paperboard. The trend is toward larger size (over 2000 tons/day) plants with the capability to consistently process high-quality products at higher speeds.

***Energy and Materials Consumption***

The paper and allied products industry is the third-largest industrial energy consumer in the U.S., behind only petroleum refining and chemicals. It accounts for 12.4 percent of total manufacturing energy use, or about 3 percent of national energy use. The mill sector of the industry accounts for the majority of energy use -- about 95% of all energy used in the paper and allied products industry (and thus is the focus of most energy-related data collection efforts for the industry). In 1995, the industry consumed over 2.5 quads of energy. A large portion of this energy demand (about 57%) was self-generated from residue fuels such as spent pulping liquor solids, hogged fuel, and bark, as well as a small amount of hydroelectric power. Since the early 1970s, the industry has increased its use of self-generated and residue fuels by over 70%. The industry has also significantly increased its cogeneration capacity and generates more than 40% of the total on-site electricity produced by the manufacturing sector. Energy-efficiency has also greatly improved: the total energy use per ton of product produced has dropped 22% since 1972 -- from 32 million Btu/ton in 1972 to 25.6 million Btu/ton in 1995. Fossil fuel and other purchased energy consumption per ton of product has decreased even more -- by over 40% since 1972.

***Environmental Issues***

Many environmental issues and concerns affect the industry. Sustainable forestry management is needed to provide an assured source of high-quality virgin fiber while meeting environmental objectives to protect soil, water and air quality, wildlife and fish habitat, and species biodiversity. The industry is also committed to aggressive paper recovery and recycle/reuse goals. In addition, the industry produces a variety of solid,

liquid and air emissions that are subject to federal and state regulatory control. According to recent reports, the industry generated about 220,000 tons of hazardous waste in 1989 and about 1.5 million tons of air pollutant emissions in 1991. The industry spends about $3 billion per year on pollution abatement and environmental improvements, representing over 20% of total capital expenditures.

## Factors Shaping Industry Response

### *Competitive and Structural Factors*

*Capital intensive:* New capital expenditures in the last decade have averaged 10.4 percent of revenues (AFPA, 1994), making paper and allied products the most capital intensive of the manufacturing industries. On average, the industry has invested over $120,000 of plant and equipment for every industry employee, more than twice the average of other manufacturing industries in the U.S. The high capital costs restrain the ability of the industry to install new technologies -- especially technologies that will not significantly contribute to lowering production costs.

*Energy intensive*: The energy intensity of the paper and allied products industry was 21 MJ (20,000 Btu) per dollar value of shipments in 1991, ranking it as the second most energy intensive industry group in the manufacturing sector. Despite the industry's impressive record for cogeneration and utilizing waste materials for energy, the industry still ranks third in energy purchases and ranks first in fuel oil consumption. In 1994, the industry spent about $6.2 billion on purchased energy, or nearly 4.3% of the value of its shipments. Rising fossil fuel costs would create additional incentives to increase reliance on self-generated energy and further increase the energy efficiency of pulp and paper production processes.

*Environmental concerns*: Manifested in changing market demands and more stringent environmental regulations, environmental concerns are among the most important drivers of technological change in the pulp and paper industry.

### *Technology Options*

There are major opportunities for improving the efficiency of process energy use in the pulp and paper industry. A number of new energy-saving process technologies such as digesters and paper or pulp dryers, are under development or recently commercialized, and process heat integration analysis has been applied in several mills. Most process-specific changes that bring energy efficiency improvements also bring productivity and other improvements. Reducing process energy needs per ton of product will lead directly

to reductions in $CO_2$ emissions. At the same time, it may also facilitate quantum improvements in cogeneration technologies for on-site heat and power generation. Advanced biomass-based cogeneration systems, which would provide major improvements in efficiency over existing systems, are currently undergoing rapid development. Black liquor/biomass gasification systems currently being studied are potentially 30% more efficient at producing electricity than existing recovery boilers. Such systems are likely to be commercially ready by around the turn of the century.

# INDUSTRIAL COGENERATION AND DISTRIBUTED GENERATION PROGRAM FOR CARBON EMISSION REDUCTION

# CCAP II

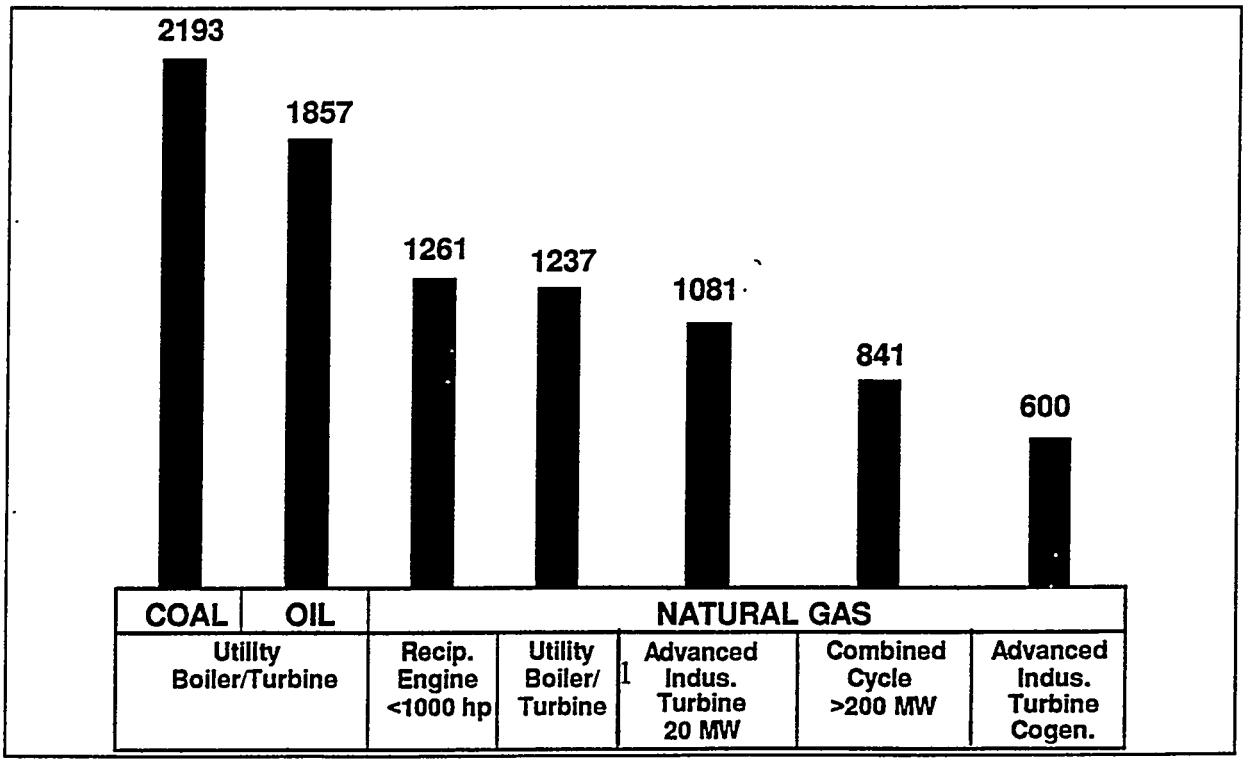
# Industrial Cogeneration and Distributed Generation Program for Carbon Emission Reduction

## 1.0 Background

The production of electricity is a major source of carbon emissions. Electricity generation currently accounts for 36 percent of total carbon emissions, according to EIA. Coal, which accounts for about one-half of electricity generation, produces 80 percent of the (electricity related) carbon emissions. Carbon emissions from power generation is very likely to increase as coal continues to account for about one-third of new capacity. EIA projects that close to 300 GW of new capacity will be required will be needed by 2015 to meet rising demand and compensate for the retirement of 38 GW of nuclear capacity. This added capacity, if met by the current mix of technologies, will result in a 34 percent increase in carbon emissions from 1995 levels.

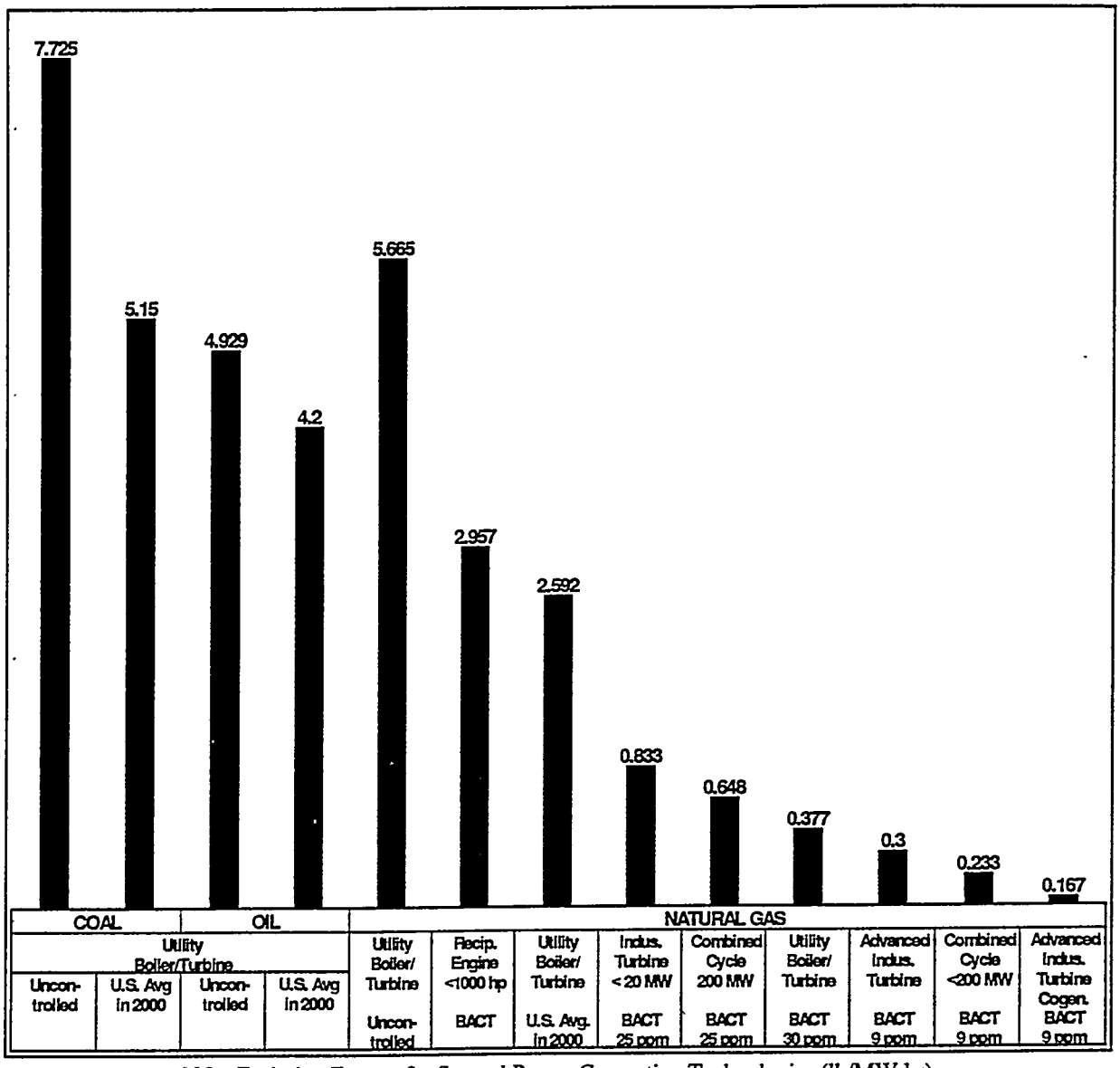
The United States currently accounts for approximately 40 percent of the new capacity additions in the world and thus has a significant impact on global carbon emissions. While the U.S. share of new additions will decrease as other countries continue to electrify, U.S. manufacturers provide over 60 percent of the equipment worldwide and are play a leading role in the development of power generation technology.

Emissions will increase as demand increases unless cleaner technologies are brought to market




$CO_2$ Emission Factors for Several Power Generation Technologies (lb/$MW_e$hr)

readiness through U.S. manufacturers. Advanced cogeneration technologies can provide a near term reduction in carbon emissions and nitrous oxides while renewable technologies become established in the market. For example, the natural gas-fired Advanced Turbine System (ATS) produces 60 percent less carbon emissions and 95 percent less $NO_x$ than coal-fired central power




$NO_x$ Emission Factors for Several Power Generation Technologies (lb/MW$_e$hr)

station technology on an output basis (lbs/kWh). Gas turbines are more efficient than steam boiler electricity generation, primarily found in the industrial and commercial sectors

Industrial scale cogeneration, around 20 MW, is becoming increasingly important as the technology's cost drops, the electric industry restructures and distributed generation increases.

The manufacturing sector will want to adopt these technologies to lower costs and provide flexibility in the power markets as well as lower their emission profile. Support for the advanced cogeneration program will encourage both the manufacturing and the power generation industry to implement these clean technologies while providing a bridge to the next generation of renewable energy options.

Cogeneration, which is the sequential production of electricity and heat from a single fuel source, is a extremely effective means of reducing carbon emissions. Efficiencies of close to 60 percent can be obtained in combined cycle systems, where electricity is generated both from the turbine and steam raised from the turbine exhaust heat. In combined heat and power cycles, where the exhaust heat is used in the manufacturing process or for space conditioning, thermal efficiencies can approach 85 percent. With cogeneration, lower carbon emissions are obtained through the replacement of coal-fired central power plant and the elimination of local boilers.

Cogeneration and industrial on-site power generation will be important elements in the restructuring of the electric utility industry. Industrial power plants (around 20 MW) are being installed to support local "load pockets," which would normally require expensive upgrades to the transmission systems. There is a movement away from centralized generation to "distributed" generation which is located closer to the load. Because of the uncertainty in the electricity market and the nation-wide overcapacity in generation, there is a reluctance to invest in large (1000 MW) plants. Industrial, commercial and institutional users will find utilities less willing or able to deter their investments in on-site generation.

In order to reduce carbon emissions in the generation of electricity while providing a bridge to renewable technologies as they continue their progress into the marketplace, five near-term technologies should be supported. These include:

- Advanced Turbine Systems Program: ATS is the highest efficiency distributed power system available in the 2000-2005 time frame. The program should be accelerated to meet market entry in 2000 to coincide with increasing distributed generation capacity. The program has projected 50 GW of ATS capacity by 2010, which would translate to a Carbon emissions reduction of 153 million tons annually, or 4 percent of total U.S. emissions.

- Natural Gas Reciprocating Engine Development Program: Reciprocating engines, also known as diesel engines, are widely used to provide on-site generation (typically between 100 and 3,000 kW) in baseload, peak shaving and emergency backup applications. The engines are also used in machine drive applications, to drive, for example, pumps and compressors Some 3500 engines are sold annually. Natural gas engines are derived from diesel oil models. There is a significant amount of technology in the laboratory phase that needs to be developed and integrated into the natural gas engines to improve emission performance and efficiency. The successful adaptation of these technologies will increase the market share of natural gas engines in the reciprocating market to over 50 percent, thereby reducing $CO_2$ emissions by 4-million tons and $NO_x$ emissions by 6000 tons annually.

- Black Liquor Gasification Combined Cycle: Black liquor contains the lignin (the carbohydrate "glue" holding wood fibers together) that is removed in the reduction of wood to fiber in the pulping process. It is currently burned in recovery boilers, which produce steam for process use and electricity generation along with $CO_2$, $NO_x$ and other air toxins. The gasification of the black liquor will increase the efficiency of its recovery and thereby lower emissions. Over the next 5 to 10 years, more than one-half the recovery boilers will be replaced. The next window of opportunity will occur in 40 years, at the start of the next life cycle of the boilers. The cogeneration potential in the forest products industry is estimated to be 8300 MW.

- Fuel Cell-Gas Turbine Combined Cycle: The combination of the fuel cell with a gas turbine has the potential of achieving electric generation efficiencies approaching 75 percent. The fuel, either natural gas of a coal or biomass-derived gas, would first be fed to a fuel cell. The hot exhaust gas from the fuel cell would be combined with any reformed fuel and expanded in the gas turbine. Carbon emissions would be extremely low, and the system would displace electric generation plant with higher carbon emissions. This program incorporates the technologies of the Advanced Turbine Systems program and the Fuel Cell programs.

- Micro turbines: Micro turbines can be simple, inexpensive to operate and maintain as well as they have the potential to run on multi-fuels such as diesel, natural gas, propane, landfill gas and biogas. Small generating equipment, in the 40 to 200 kW range, will play an important role in distributed generation. These "micro-generators" can be placed at the point of demand and avoid the need for substations, transformers and overhead wires. Micro turbines have low emissions with the use of a catalytic burner. NOx levels are below 3 ppm.

# INDUSTRY STATISTICS

## Table A1. Total Primary Consumption of Energy for All Purposes

| Industry/SIC Code | Total (trillion Btu) | Net Electricity[a] (million kWh) | Residual Fuel Oil (1000 bbls) | Distillate Fuel Oil[b] (1000 bbls) | Natural Gas[c] (billion cu. ft.) | LPG (1000 bbls) | Coal (1000 short tons) | Coke and Breeze (1000 short tons) | Other[d] (trillion Btu) |
|---|---|---|---|---|---|---|---|---|---|
| Food and Kindred Products/20 | 956 | 49,536 | 4,317 | 2,968 | NA | 1,433 | 6,913 | NA | NA |
| Textile Mill Products/22 | 274 | 29,532 | 1,966 | 1,064 | 105 | 629 | 1,362 | 0 | 13 |
| Paper and Allied Products/26 | 2,506 | 58,896 | 24,883 | 1,593 | NA | 1,379 | 13,252 | NA | NA |
| Chemicals and Allied Products/28 | 5,051 | 129,093 | NA | 2,410 | 2,162 | NA | NA | 423 | 526 |
| Petroleum and Coal Products/29 | 5,967 | 30,782 | 10,411 | 3,683 | 813 | NA | NA | NA | 4,864 |
| (Petroleum Refining/2911)[e] | (5,762) | (29,152) | (10,292) | (1,525) | (769) | (15,889) | (134) | 0 | (4,733) |
| Stone, Clay, and Glass Products/32 | 880 | 30,814 | 1,377 | 3,431 | 370 | NA | 13,132 | NA | NA |
| (Hydraulic Cement/3241) | (312) | (9,455) | (138) | (638) | (38) | (12) | (8,736) | (232) | (36) |
| Primary Metals Industry/33 | 2,467 | 146,276 | NA | 1,868 | 688 | NA | 32,243 | 11,228 | 72 |
| (Blast Furnaces, Steel/3312) | (1,673) | (38,183) | (NA) | (NA) | (408) | (74) | (30,904) | (9,802) | (16) |

[a] "Net Electricity" is obtained by summing purchases, transfers in, and generation from noncombustible renewable resources, minus quantities sold and transferred out. It does not include electricity inputs from onsite cogeneration or generation from combustible fuels because that energy has already been included as generating fuel (for example, coal).

[b] "Distillate Fuel Oil" includes Nos. 1, 2, and 4 fuel oils and Nos. 1, 2, and 4 diesel fuels.

[c] "Natural Gas includes natural gas obtained from utilities, transmission pipelines, and any other supplier(s) such as brokers and producers.

[d] "Other" includes net steam (the sum of purchases, generation from renewables, and net transfers), and other energy that was used to produce heat and power or as feedstock/raw material inputs.

[e] For the petroleum refining industry only, the feedstocks and raw material inputs for the production of nonenergy products (i.e., asphalt, waxes, lubricants, and solvents) and feedstock consumption at adjoining petrochemical plants are included in the "Other" column, regardless of type of energy. The remaining columns for the petroleum refining industry include only energy that was consumed for the production of heat and power. The "Other" column also includes net steam and other energy used in the production of heat and power. Those inputs and feedstocks that were converted to other energy products (e.g., crude oil converted to distillate and residual fuel oils) are excluded.

Source: MECS 1991

## Table A2. Components of Total Electricity Demand (Estimates in Million Kilowatthours)

| Industry/SIC Code | Purchases | Transfers In[a] | Total Onsite Generation[b] | Sales and/or Transfers Offsite | Net Demand for Electricity |
|---|---|---|---|---|---|
| Food and Kindred Products/20 | NA | NA | 5,743 | 988 | 55,273 |
| Textile Mill Products/22 | NA | NA | NA | NA | 29,866 |
| Paper and Allied Products/26 | 63,744 | 1,308 | 53,831 | 9,012 | 109,871 |
| Chemicals and Allied Products/28 | 131,858 | 7,201 | 41,428 | 9,967 | 170,520 |
| Petroleum Refining/2911 | NA | NA | 12,993 | 2,410 | 42,145 |
| Hydraulic Cement/3241 | 9,490 | 0 | NA | NA | 9,888 |
| Blast Furnaces, Steel/3312 | NA | NA | 6,235 | 1,297 | 44,417 |

[a] Transfers In" are the quantities purchased by a central purchasing agent or other establishment of the same company.
[b] "Onsite Generation" includes cogeneration, generation by renewable energy sources, and conventional generation by combustible fuels.
Source: MECS 1991

## Table A3. Total Consumption of Offsite-Produced Energy for Heat, Power, and Electricity Generation

| Industry/SIC Code | Total (trillion Btu) | Net Electricity[a] (million kWh) | Residual Fuel Oil (1000 bbls) | Distillate Fuel Oil[b] (1000 bbls) | Natural Gas[c] (billion cu. ft.) | LPG (1000 bbls) | Coal (1000 short tons) | Coke and Breeze (1000 short tons) | Other[d] (trillion Btu) |
|---|---|---|---|---|---|---|---|---|---|
| Food and Kindred Products/20 | 922 | 50,518 | 4,317 | 2,966 | 497 | 1,429 | 6,913 | NA | NA |
| Textile Mill Products/22 | 272 | 29,522 | 1,966 | 1,064 | 105 | 629 | 1,362 | 0 | 12 |
| Paper and Allied Products/26 | 1,540 | 65,052 | 24,883 | 1,566 | 532 | NA | 13,063 | NA | 307 |
| Chemicals and Allied Products/28 | 2,674 | 139,059 | 7,247 | 1,999 | 1,616 | 1,119 | 11,153 | 132 | 221 |
| Petroleum Refining/2911 | 1,065 | 31,562 | 36,915 | 826 | 762 | 6,235 | 134 | 0 | 3 |
| Hydraulic Cement/3241 | 312 | 9,490 | 138 | 616 | 38 | 12 | 8,736 | 232 | 35 |
| Blast Furnaces, Steel/3312 | 842 | 39,480 | 4,986 | 901 | 387 | 74 | 1,075 | 9,553 | 10 |

[a] "Electricity" consists of quantities of electricity that were purchased or transferred in.

[b] "Distillate Fuel Oil" includes Nos. 1, 2, and 4 fuel oils and Nos. 1, 2, and 4 diesel fuels.

[c] "Natural Gas includes natural gas obtained from utilities, transmission pipelines, and any other supplier(s) such as brokers and producers.

[d] "Other" includes all other energy that was purchased or transferred in and not shown elsewhere.

Source: MECS 1991

## Table A4. Capability to Switch from Electricity to Alternative Energy Sources (Estimates in Million Kilowatthours)

| Industry/SIC Code | | | | Alternative Types of Energy[a] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Receipts[b] | Switchables | Not Switchable | Natural Gas | Distillate Fuel Oil | Residual Fuel Oil | Coal | LPG | Coal Coke and Breeze | Other[c] |
| Food and Kindred Products/20 | 50,518 | 1,305 | 45,174 | 325 | 378 | 193 | 244 | 15 | 183 | NA |
| Textile Mill Products/22 | 29,522 | 266 | 28,232 | 0 | NA | 0 | NA | 0 | 0 | 0 |
| Paper and Allied Products/26 | 65,052 | 3,181 | 59,815 | 1,406 | 576 | 649 | 859 | 128 | 47 | 230 |
| Chemicals and Allied Products/28 | 139,059 | 2,377 | 130,168 | 1,414 | 532 | 156 | 322 | 0 | 225 | 259 |
| Petroleum Refining/2911 | 31,562 | 1,360 | 29,664 | 1,122 | 376 | 574 | NA | 0 | 556 | 233 |
| Hydraulic Cement/3241 | 9,490 | 109 | 9,288 | NA | 10 | NA | NA | NA | NA | 0 |
| Blast Furnaces, Steel/3312 | 39,480 | 1,716 | 36,545 | 1,708 | NA | 1,640 | NA | NA | NA | NA |

[a] "Alternative Types of Energy" consist of those energy sources that could have been substituted for electricity receipts during 1991. The quantities are expressed in millions of Kilowatthours, and therefore represent the quantity of electricity that could have been displaced by the given alternative type of energy.

[b] "Total Receipts" represents those quantities of electricity generated off the manufacturing establishment site and available at the site for consumption.

[c] "Other" includes all other types of energy not already identified that could have been consumed in place of electricity.

Source: MECS 1991

## Table A5. Quantity of Electricity Sold to Utility and NonUtility Purchasers (Estimates in Million Kilowatthours)

| Industry/SIC Code | Total Sold | Utility Purchaser[a] | Nonutility Purchaser[b] |
|---|---|---|---|
| Food and Kindred Products/20 | 988 | 940 | 48 |
| Textile Mill Products/22 | NA | NA | NA |
| Paper and Allied Products/26 | 9,012 | 8,254 | 759 |
| Chemicals and Allied Products/28 | 9,967 | 7,269 | 2,698 |
| Petroleum Refining/2911 | 2,410 | 1,029 | 1,381 |
| Hydraulic Cement/3241 | NA | NA | NA |
| Blast Furnaces, Steel/3312 | 1,297 | 490 | 807 |

[a] "Utility" is a company that produces and/or delivers electricity and/or natural gas, and is legally obligated to provide service to the public within its franchise area.

[b] "Nonutility Purchaser" includes independent power producers, small power producers, and cogenerators not located at the establishment site.

Source: MECS 1991

## Table A6. Components of Onsite Electricity Generation (Estimates in Million Kilowatthours)

| Industry/SIC Code | Total | Cogeneration | Renewables | Other[a] |
|---|---|---|---|---|
| Food and Kindred Products/20 | 5,743 | 5,579 | 6 | 157 |
| Textile Mill Products/22 | NA | NA | NA | NA |
| Paper and Allied Products/26 | 53,831 | 45,447 | 2,856 | 5,528 |
| Chemicals and Allied Products/28 | 41,428 | 38,348 | NA | 3,079 |
| Petroleum Refining/2911 | 12,993 | NA | 0 | NA |
| Hydraulic Cement/3241 | NA | NA | 0 | 0 |
| Blast Furnaces, Steel/3312 | 6,235 | 4,560 | 0 | 1,674 |

[a] "Other" is that electricity obtained from a generator fueled by combustible energy sources such as diesel or other fuel oils.

Source: MECS 1991

## Exhibit A7. Forecast Cogeneration Additions by industry (MW Installed): 1996-2015

| Industry | SIC | 1996-1997 | 1998-1999 | 2000-2001 | 2002-2003 | 2004-2005 | 2006-2010 | 2011-2015 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Food | SIC 20 | 1,442 | 1,456 | 1,500 | 1,567 | 1,625 | 4,185 | 4,287 | 16,062 |
| Textiles | SIC 22 | 292 | 297 | 308 | 324 | 338 | 875 | 900 | 3,334 |
| Pulp & Paper | SIC 26 | 1,841 | 1,853 | 1,903 | 1,979 | 2,051 | 5,345 | 5,586 | 20,558 |
| Chemicals | SIC 28 | 2,633 | 2,774 | 2,985 | 3,249 | 3,516 | 9,809 | 11,068 | 36,034 |
| Petroleum Refining | SIC 29 | 729 | 739 | 763 | 801 | 837 | 2,181 | 2,259 | 8,309 |
| Stone, Clay, & Glass | SIC 32 | 153 | 165 | 182 | 203 | 224 | 644 | 760 | 2,331 |
| Primary Metals | SIC 33 | 513 | 524 | 545 | 576 | 603 | 1,569 | 1,622 | 5,952 |
| **TOTAL** | | **7,603** | **7,808** | **8,186** | **8,699** | **9,194** | **24,608** | **26,482** | **92,580** |

Source: RCG/Hagler, Bailly, Inc., February 1992

# PART II: INTERNATIONAL OPPORTUNITIES

## BIOMASS GASIFICATION OPPORTUNITIES IN THE SUGAR PROCESSING INDUSTRY

### India

India represents the largest sugar market in the world, with over 450 sugar mills currently operating. The subcontinent benefits from the two or more monsoon seasons which yield longer caning seasons and therefore a greater supply of bagasse for cogeneration projects. A majority (it is difficult to accurately determine, but some experts suggest 80-90%) of sugar mills already have some form of power self-generation already installed. Furthermore, there is evidence suggesting that most sugar industrialists are beginning to install larger cogeneration facilities and indeed a few are already selling electric power to the regional State Electricity Boards (SEBs). The power market in India has undergone a dramatic deregulation since 1993 and a framework is developing for long-term, commercial-contractual sales and agreements. As of this writing, major foreign investors are near financial closing of up to US$ 4 billion worth of projects in the traditional fossil fuel energy sector.

These trends bode well for the biomass energy sector. If one assumes that the average sugar facility is 2,500 tons of cane crushed per day (tcd), which yields approximately 12 MW of power under conservative assumptions, the market potential can be estimated at 450 x 12 = 5,400 MW or $5.4 billion.

Initiators of this proposal have been in contact with sugar industrialists in India, and there is reason to believe that over 100 MW of capacity will be installed in 1995 alone. Moreover, the initiators of this discussion paper have received some initial interest from a North American consortium which is developing two 50 MW projects in the Indian state of Uttar Pradesh. The same have also held early discussions with an established U.S. power developer which is pursuing a 25 MW project in the southern state of Tamil Nadu (TN).

### Brazil & the Phillippines

While no specific data on the biomass fuels markets is presented here, both countries have large and well-developed sugar processing industries, as well as other agricultural industries with potential biomass-fuel by-products. One obstacle to commercial development of Brazil, however, remains in the form of artificially low tariff rates for utility-generated electricity sold to industrial consumers. Further restructuring of the Brazilian energy sector will be necessary before small-scale power generation is commercially viable as envisioned by the Fund.

In the Phillippines, however, sugar production, tobacco, and paper mills, among others, present strong potential in an environment more conductive to private-power production for industrial use. Several studies of renewable energy potential have been completed and non-

government organizations activity in promotion of biomass fuels is high. There is a promising potential for commercially-viable biomass cogeneration in the Phillippines.

## Central America

Central America as a region represents another significant market potential. Costa Rica, in particular, has over 20 sugar mills, two of which are already equipped with 30 MW cogeneration capacity. Guatemala and El Salvador have a similar number of mills and in 1994 a bagasse-fired cogeneration project in Guatemala received co-financing from the IFC. Therefore, overall market potential in Central America is roughly estimated at 50 mills x 20 MW = 1,000 MW or US$ 1 billion. The existing bagasse projects and continued demand for electric power in the region suggest that this market will continue to expand through the rest of the decade.

## Mexico

Mexico has 64 sugar mills, and while the sugar industry has been depressed in Mexico since its privatization in 1992-1993, there are indicators which point to a brighter future. Since privatization, the industry has downsized its workforce and stabilized production. In the medium term, the sugar market will face an overall increase in demand, including from the export sector beginning in 1995. Therefore, the initiators of this proposal believe that the Mexican market may reach approximately 50 mills, assuming some mills will be shutdown given a more competitive environment. Again, this yields an overall investment potential estimated at US$ 1 billion.

# INTERNATIONAL BIOMASS ENERGY STATISTICS

## Table 1: Biomass Fuel Consumption and Production 1985-1990

| Region | Biomass Fuel Production and Consumption (Quadrillion Btu) |
|---|---|
| North America | 3.63 |
| Europe | 0.99 |
| Nordic Countries | 0.24 |
| EEC | 0.23 |
| Central Europe | 0.03 |
| Southern Europe | 0.33 |
| Eastern Europe | 0.16 |
| Africa | 2.1 |
| Asia | 4.4 |
| Latin America | 1.5 |
| Oceana | 0.1 |

Source: D.A. Tillman, *The Combustion of Solid Fuels and Wastes* (New York, NY: Academic Press, 1991), p. 66.

## Table 2: Biomass Energy Resources and Market Potential in Asia and the Pacific and Africa

| Country | Biomass (Megawatts) | |
|---|---|---|
| | Market Potential | Resource Assessment |
| **ASIA AND THE PACIFIC** | | |
| China | --- | a |
| India | 3,800 | 17,000 |
| Indonesia | 1,800 | 10,000 |
| Pakistan | 300 | --- |
| Phillippines | 9 | b |
| Russia | --- | c |
| **Subtotal** | **5,909** | **27,000** |
| **AFRICA** | | |
| South Africa | --- | --- |

a = 260 million tons oil equivalent.
b = 105 million terawatts-electric annual yield.
c = 60 million tons oil equivalent.

Note: Letters indicate availability of only partial totals or totals in different units. Dashes indicate data not available.

Source: U.S. Export Council for Renewable Energy, *Global Impact Analysis Report*, submitted to the U.S. Department of Energy, Golden Field Office (August 1996).

## Table 3: Biomass Energy Resources and Market Potential in Asia in the Americas

| Country | Biomass (Megawatts) | |
|---|---|---|
| | Market Potential | Resource Assessment |
| **CENTRAL AMERICA** | | |
| Costa Rica | a | b |
| El Salvador | --- | --- |
| Guatemala | --- | 500 |
| Honduras | c | d |
| Nicaragua | --- | --- |
| Panama | --- | --- |
| **Subtotal** | --- | --- |
| **NORTH AMERICA** | | |
| Mexico | --- | 1,000 |
| **CARIBBEAN** | | |
| Barbados | --- | 12 |
| Dominica | --- | --- |
| Dominican Republic | --- | 15-45 |
| Haiti | --- | --- |
| Jamaica | --- | --- |
| **Subtotal** | --- | 27-57 |
| **SOUTH AMERICA** | | |
| Argentina | --- | e |
| Bolivia | --- | --- |
| Brazil | 3,200<br>8,800 | --- |
| Chile | --- | f |
| Peru | --- | --- |
| **Subtotal** | **3,200-8,800** | --- |

a = 17 to 500 million kilowatthours per year from sugarcane.
b = 400 to 500 million kilowatt hours per year from sugarcane.
c = 54 million kilowatthours per year from sawmill.
d = 30 million kilowatthours per year from sawmill.
e = 50 megawatts at Copahue field, otherwise unknown.
f = Large but inaccessible.

Note: Letters indicate availability of only partial totals or totals in different units. Dashes indicate data not available.

Source: U.S. Export Council for Renewable Energy, *Global Impact Analysis Report*, submitted to the U.S. Department of Energy, Golden Field Office (August 1996).