

# **Cooperative Agreement with DOE/OIT On Energy Efficiency and Best Practices**

## **Final Report (Submitted 3/18/2009)**

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**Abstract:** This Cooperative Agreement was focused on the development and dissemination of technologies, best-practices, energy-efficiency assessment programs, etc. that could support industry's drive to become more competitive in a rapidly changing and highly competitive global market-place. The Agreement covered a range of collaborative activities between AIChE and DOE/ITP's various Industries of the Future ("IOF") Teams such as:

- 1) Help with technology evaluation and support by providing industry experts to:
  - a) Review solicitation proposals.
  - b) Review technology portfolios as deemed appropriate by DOE/ITP
  - c) Market IOF BestPractices through outreach and technical assistance at the plant-level and via meetings with operations staff.
- 2) Help establish various programs with industry, academia and National Laboratories to develop tools, methodologies and benchmarks that entities served by IOF would find valuable in establishing goals for improving energy consumption in specific processes.
- 3) Support IOF with Technology Vision 2020 programs.

## **A. Chemicals**

### **I. Portfolio Reviews:**

Activities included helping Chemicals IOF with technology evaluation and support by providing industry experts to review the Chemicals IOF (and other IOF's as requested) Technology Portfolio on a regular schedule, as deemed appropriate by DOE/OIT (and those of other IOF's, as requested). AIChE identified the consultants to be used in this activity and arranged for training sessions to provide background knowledge on the portfolio and instruction on review proceedings and the required deliverables from the review process.

Portfolio reviews were held in conjunction with AIChE's Spring Meetings in 2002 and 2004. These review meetings consisted of closed sessions with the project PI's, presentations BY PI's in AIChE sessions and a poster session ("*Technologies for Tomorrow's Chemical Industry*") open to all attendees at the AIChE meeting. Both the open sessions and the poster sessions attracted large audiences and were considered successful in that they provided the opportunity to disseminate information on IOF more broadly. After the reviews with PI's there was a one-day meeting between the review team and DOE to discuss each of the technologies in the Portfolio followed by a consensus final report by the review team with recommendations to DOE.

In addition to formal portfolio reviews the team of consultants was used to review numerous solicitation proposals and SBIR proposals.

A subset of the consultants reviewed an Energy Savings Tool, developed by Energetics, to be used by organizations submitting proposals in response to solicitations. This tool enables users to calculate the amount of energy saved by their proposed projects to DOE/ITP.

## **II. Water Reuse (2002-2003)**

The project objective was to produce an additional chapter to AIChE's updated Water Reuse monograph entitled: "Water Reuse Opportunities by Industry". This new chapter characterized water use within DOE/ITP and the energy issues associated with the water use.

The final work product from this project was reviewed by a team of experts from DOE/ITP and industry.

DOE/ITP has made the work product from this project available to the public on its web site. AIChE published print and electronic versions of the monograph including the new chapter in soft-cover and CD-ROM (ISBN 0-8169-0875-3).

## **III. BestPractices (2001-2008)**

Activities include helping Chemicals IOF with technology evaluation and support by providing industry experts to market Chemicals IOF BestPractices through outreach and technical assistance at the plant level and via meetings with operations staff (and those of other IOF's, as requested).

For this project, AIChE identified experienced candidates with strong operational backgrounds and organized a training meeting to educate the candidates on the Best Practices Portfolio and the expectations of the program. An outline for introducing the BestPractice Toolkit to plant managers was developed and reviewed by DOE/OIT and several trial run presentations undertaken before rolling the program out in the Houston and Beaumont areas.

The consultants were also involved in attended Texas Showcase Steering Committee Meetings, as well as other meetings including the California Energy Solutions Meeting

and the NPRA conference. They helped prepare case studies for presentations at the Texas Technology Showcase and demonstrate the PEP tool – see Energy Efficiency.

Addition work undertaken were (a) working with DOE on a proposed energy certification process to be piloted in Texas, (b) reviewing drafts of technology briefs on Industrial Technologies from the perspective of a plant manager receiving these products (c) participating in various Texas IOF initiatives, and (d) providing input from several plants concerning the proposed Texas plant energy certification proposal.

#### **IV. Energy Efficiency - Utility Benchmarking - (2002-2004):**

The AIChE/CWRT 2001 Summer Meeting included a one-day workshop for industry participants designed to help develop the outline for an energy efficiency project. This activity lead to the development of a project with the following objectives: (a) develop a software tool to map energy consumption by utility segment and benchmark operating practices and (b) provide the user with an estimate of potential savings for each utility segment based on the map and benchmark.

The project group, made up of eight chemical companies, worked with representatives from DOE to define the desired scope and functionality of the tool and developed a template spreadsheet for the desired tool used in preparing a Request for Quote from qualified vendors. Based on the RFQ responses the team selected the winning bidder and worked closely with them in creating and beta testing the final work product. The final product (Plant Energy Profiler –“PEP”) was released in Q4 2004.

#### **V. CPAT (Chemical Process Assessment Tool) – (2005-2008):**

CPAT was developed to enhance DOE’s ability to evaluate proposals for collaborative research projects aimed at developing energy-efficient processes and DOE has solicited and received, provides meaningful and objective projections of the energy-savings potential of the proposed projects. CPAT provides realistic projections for commercial deployment for the new concepts based on the magnitude of the economic incentive to implement the new technology if it were to be successfully developed. Without such an economic justification, new technology cannot be expected to displace conventional technology and save energy.

The CPAT project focused on developing a stand-alone, well documented, tool that DOE could make available to responders to solicitations so that a consistent set of energy saving assessments could be made as part of the evaluation process. CPAT was most completely developed for the chemical industry, and contains information in its database on over seventy of the major products and processes utilized today by the U.S. chemical manufacturing sector. For each of those products and processes, information is provided on the current market size and growth rate, present day raw material and utilities consumption and prices, by-product production and prices, etc. In addition, the capacity of a typical conventional plant is contained in the database together with its estimated

Inside Battery Limits (ISBL) capital cost and its feedstock and process energy consumption. The user is directed to input the same type of information for the new technology, so that an economic comparison may be made and the rate of market penetration (and resulting energy savings) predicted. CPAT has been populated with a limited Forest Products industry database, so that similar developments of economics and energy consumptions can be computed for conventional Forest Products processes and proposed novel technologies, equipment, etc.

The project took place over a number of phases and included a significant amount of internal testing for robustness as well as beta-testing by DOE solicitation awardees for comments on robustness, ease of use and usefulness of results generated. The final version, including extensive documentation, was provided to DOE/ITP in 2008. Since the final tool can be used to evaluate any technology against a base case the tool's name was changed to **Technology Commercialization Assessment Tool (TCAT)**

TCAT was used extensively in the Bandwidth – Exergy/Energy project in evaluating the impact of process improvements in five major chemical processes (see below).

#### **VI. Bandwidth -Energy/Exergy Study (2004-2007)**

The project Objective was to perform exergy analyses for a number of important energy consuming chemical processes using energy and exergy audits and thermodynamic analysis. Exergy analysis is a powerful tool that provides insight into the inefficiencies of processes. Its ability to pinpoint the exact location of losses makes it an invaluable energy performance assessment tool. Such a tool is needed in the Chemical Industry Vision 2020 Technology Partnership program's objective to achieve a 30 percent reduction in material and energy as it evaluates bottlenecks in existing technologies and merits of emerging technologies.

In 2004 DOE/ITP started a program (Bandwidth Study) to evaluate energy and exergy usages and losses in the U.S. chemical Industry. Over 50 processes in commercial practice in the U.S. were studied and the results published in three reports – two intermediate reports, Bandwidth 1 and 2 and a summary report the Final Report of the Bandwidth Study of the Chemical Industry (Final Bandwidth Report) which contains the complete results of two earlier studies.

A sub-project in this area (2004-2005) focused on calculating the impact on the chemical industry of the potential energy savings identified through the above exergy studies. The results of this work were reported to DOE/ITP in 2005.

The Bandwidth program identified five technologies having the highest Total Exergy Losses on an annualized basis (annual volume of chemical production multiplied by Total Exergy Loss per pound). These five technologies (Ethylene, Caustic-Chlorine, Ethylene Oxide, Ammonia and Terephthalic Acid) were singled out for additional study to identify possible process improvements. For each of the selected technologies, concepts for process changes that would likely yield substantial reductions in Total Exergy Losses were developed and evaluated and preliminary designs arrived at. Aspen simulations and Exergy Analyses of these conceptual designs were then run and the resulting information

utilized to estimate capital cost and energy consumptions for each concept. Those ideas which yielded favorable results were then evaluated using DOE/ITP's CPAT(TCAT) software in order to estimate whether the concepts were economical, and if so, the degree to which, and rate at which, the novel concepts could be deployed throughout the US chemical industry. This resulted in total potential U.S. energy savings projections for each technology. A report on this work was submitted to DOE/ITP at the end of 2007.

## **B. Forest Products**

### **I. Portfolio Reviews (2004):**

Forest Products solicitation DE-PS36-03GO9301 review meeting took place in 2004. The review methodology was similar to that described above under Chemicals – Portfolio Reviews.

### **II. Portfolio Management System (2003):**

The American Forest & Paper Association (AF&PA) in partnership with DOE/ITP developed an Agenda 2020 program to identify technology areas needing development to enhance industry competitiveness while minimizing energy intensity and environmental impact. AF&PA's Chief Technology Officer's Committee had the responsibility of implementing Agenda 2020's research activities and monitoring progress of Agenda 2020-related proposals and projects funded in partnership with DOE/ITP.

The project objective was to customize the GenSight Group's R&D Project Portfolio Management process to improve the DOE and AF&PA's CTO Committee's fundamental ability to analyze, select, track and communicate the list of key, high-leverage technology needs and the portfolio of projects required to address these needs and achieve the Agenda 2020 strategic goals.

GenSight finalized customizing their Research and Development Project Portfolio Management (PPM) process and software for the American Forest and Paper Association for Agenda 2020 portfolio management at the end of 2003. The CTO committee reviewed GenSight work and deliverables at a meeting in December and agreed that the project was complete pending submission of a final report. GenSight submitted a final report at the end of 2003 to DOE and CTO committee.

### **III. American Forest & Paper Association Agenda 2020 (2003-2004)**

The project objectives were to (a) develop the criteria by which the key, high-leverage technology needs and project portfolio will be assessed, (b) analyze and perform preliminary prioritization of the high-leverage technology needs developed by the platform teams; and, (c) analyze the current portfolio of projects as needed to achieve the first two objectives. The following main tasks were covered during the course of the program:

- Assembled a team of industry experts to assist in various aspects of the program including Merit Reviews
- Team members reviewed the GenSight Excel collection tool to make sure that it was suitable to use for key project focus areas.
- The team developed an approach and detailed plan to win financial support for the March 2004 Technology Summit.
- Developed a path forward for the implementation of the Gensight methodology as a portfolio management tool for Agenda2020 and DOE.
- Participated in DOE/ITP peer review sessions.
- Prepared session on “New Value Streams from Residuals and Spent Pulping Liquor” for 2004 Technology Summit .
- Reviewed Cap-Econ, the Forest and Paper economic evaluation tool, and provided feedback to BCS. Review included editing prices of materials, checking marketing information and supplying several documents containing industry information and data.
- Participated in DOE-ITP brainstorming session to determine how to best organize future meetings between Agenda 2020 CTO or Executive committee and ITP representatives and to discuss how ITP could play a role in helping to identify sources of funds for the Agenda 2020 program, including funds outside of ITP.
- Developed plans to form a “Forest Biorefinery” consortium.
- Reviewed the outcomes of the two Agenda 2020 Technology Summits and needs and gaps for the eight Agenda 2020Task Groups.
- Worked with Agenda 2020 Task Group leaders to develop compelling cases for future RFPs; this needs analysis was provided to DOE/ITP

#### **IV. Estimate of Energy Consumed by U.S. Pulp and Paper Industry**

DOE requested help in distributing the average energy consumed by the Pulp & Paper Industry into the different types of paper and pulp manufacture technologies currently utilized within the United States so as to evaluate where energy savings could be achieved as a means of focusing their programs in this area.

The project objective was to determine the average energy consumed by the Pulp and Paper Industry by the different types of manufacturing technologies used within the U.S. and was undertaken as described below:

- (a) Develop a model to distribute the total energy consumed by the U.S. Pulp and Paper Industry using existing DOE data which does not distribute the energy consumption within a mill.

(b) Determine the current minimum energy that could be consumed by each process area based on current state of art (SOA) and use this information along with the current average energy use determined in (a) to construct a new model of the US Pulp and Paper industry to show what the energy consumption would be if all mills applied SOA technologies.

(c) A critical evaluation of the various Pulp and Paper industry technologies that can be used to reduce its energy use (e.g. high consistency forming, innovative drying systems, high yield pulping, etc.) and an evaluation of the potential energy savings that would accrue if these technologies were widely deployed.

The final report was submitted in Q3 2006 and DOE comments addressed. DOE requested some additional work to be included in the final version and authorized the expenditure of additional monies to accomplish this.

#### **V. Estimate of Energy Consumed by U.S. Pulp and Paper Industry (2006)**

DOE/ITP has a number of nationwide initiatives to help industrial facilities identify opportunities for saving energy, and thereby cut operating costs.

The project objective was to conduct Energy Savings Assessments (ESA) to reduce energy consumption on paper-machines used by the Pulp and Paper Industry.

Four ESA's were conducted under this program and the results documented and reported to DOE/ITP and the company involved in the ESA.

### **C. Refinery & Petroleum**

#### **I. Reliability and Energy Benefits of Advanced Control and Power Technologies (2003-2004)**

End user feedback suggested that there were serious concerns preventing the application of advanced control and power technologies in petroleum refining facilities. These concerns were so serious that older process control techniques and maintenance prone, hydraulic couplings and steam turbines were still being used to maintain control over the process, rather than expert systems and advanced power conversion techniques. Additional maintenance costs and energy inefficiencies associated with mechanical variable speed devices were accepted as a trade off against the risk of unknown performance by advanced power electronic alternatives.

Thus, current older process control techniques result in energy losses in existing applications and prevent advanced power electronic controllers from being implemented in areas of the refineries where considerable savings from increased energy efficiency and productivity could be achieved. Current older process control techniques reduce the overall reliability of the refinery and do not provide a method to achieve energy optimization over the entire site.

The project objective was to determine the technologies currently being used in refineries and petrochemical plants and their effectiveness in the US outside of California (the CEC funded a parallel study focused on California which was integrated into the US ex California study results).

- a. Identify process optimization currently hindered by control and power technologies
- b. Identify conditions in the process that currently allow energy to be wasted
- c. Identify areas where energy savings could be made in existing applications
- d. Estimate potential energy savings
- e. Identify fixed speed equipment applications that could benefit from alternate technologies
- f. Summarize opportunities for energy savings, increased productivity and increased reliability that could be achieved based on alternative control and power technologies.

Commitments were obtained from a number of major companies to participate in this study. Site Data Requests from all participating CA refineries and petrochemical plants were obtained and analyzed and a report on findings issued to CEC for all CA refineries and petrochemical plants.

A final report covering all participating companies was submitted for DOE/ITP in 2004.

## **D. Glass**

### **I. Improving Glass Industry Energy Efficiency (2005-2007)**

The Glass Manufacturing Industry Council (GMIC) is a non-profit organization that represents a major cross-section of the glass industry, specifically glass producers having glass production facilities in the United States. The GMIC conducts a variety of activities, such as market assessments, information distribution to the general public and glass manufacturers, training sessions, workshops, research evaluation and funding. It acts as a catalyst for financial leveraging of other government agencies, and provides a common voice for the glass industry.

The following work assignments were carried out each year by the Glass Manufacturing Industry Council under this contract:

**Review Glass Industry Research Portfolio:** The GMIC provided input to the DOE regarding current priorities for the development of the U.S. glass industry that relate to the improvement of energy efficiency in that industry, and conducted a joint Glass Project Review in conjunction with the DOE. As a part of the Project Review, the GMIC provided evaluation

support to the DOE, including its recommendations for each project regarding possible improvements, modifications, or discontinuation.

**Facilitate Commercialization Potential Through Partnership Development:** In its capacity as a “coordinating entity” for the U.S. Glass Industry, the GMIC assisted potential project Principal Investigators to identify appropriate partners in order to develop viable and credible proposals. GMIC served as a confidential “sounding board” for industry members seeking direction in pre-award stages. In conjunction with the above, the GMIC provided information to DOE and guidance to GMIC members of potential opportunities for leveraging technical and financial resources of individual companies to achieve common industry goals.

**Identify and Encourage Host Sites for DOE-Sponsored Technology:** The GMIC worked with DOE managers and glass companies as necessary to identify suitable sites for carrying out testing procedures for technologies and equipment being developed under research grants sponsored by the DOE.

**Promote Adoption of DOE supported Technology:** The GMIC publicized and supported the dissemination of Technology Readiness Assessments relating to research projects that were completed and ready to be commercialized. It also organized national training events for Best Practices programs.

**Disseminate Relevant DOE Program Information:** The GMIC utilized its broad industry contacts to disseminate DOE published literature and other media to the U.S. glass industry.

**Collaborate with DOE on Online Stakeholder Engagement Tools:** The GMIC managed and administered DOE-created industry interactive web portals to facilitate a broad dialogue to address a growing number of topics of general interest within an increasingly open industry.

**Conduct Industry Workshops to Develop Pathways for Priority Research:** The GMIC organized technical workshops for the purpose of identifying appropriate direction for future research needs of the glass industry within the Roadmap guidelines. In conjunction with current projects to develop “next generation” melting technologies, the GMIC lead an initiative to identify the appropriate refining technologies required to provide quality glass products from the forming mechanisms utilized by each sector.

