Results and Achievements

RESEARCH AND DEVELOPMENT

The Center aims to encourage scholarship, generate new information, contribute to the body of literature and advance state-of-the-art, particularly in the fields of fuels, materials, and environmental sciences and engineering. The products of these endeavors are manifest in the form of publications in refereed journals, patents and other intellectual properties, and in presentations and participation in conferences and symposia. Related outcomes are the involvement of our staff in scientific societies and academies and in our interactions with other researchers here and abroad.

Publications, Copyright, Patents and Other Intellectual Property

The CAER research staff published 30 articles during FY 97-98 and the same number for the following fiscal year in refereed scientific journals. A further 73 and 89 documents were published during those same fiscal years respectively as articles in non-refereed journals, topical reports, and in conferences and workshop proceedings. A complete listing of refereed publications for the last two fiscal years appears in the Appendices of this report.

The CAER’s bimonthly newsletter Energeia is now in its 10th year of publication with a readership of about 5500, including 600 international subscribers. Energeia features articles on issues and technical advancements relevant to the energy field. The publication is available in hard copy form or on the CAER web site (found at http://www.caer.uky.edu).

The process of developing, and commercializing intellectual property involves several steps, moving from an invention disclosure, to the establishment of proprietary rights through patents, copyrights or trade secrets, to developing agreements with industry for the use or practice of the know-how or technology. Because of the applied nature of the Center’s research and its historic ties to the coal and petrochemical industries, the CAER has been productive in terms of patent applications. A listing of these patents can be found in the Appendices.

Workshops, Symposia and Seminars

The CAER sponsors several meetings that are held in Lexington and help to highlight UK research interests. In October, 1999 the Waste Management Group held the third International Ash Utilization Symposia, with an attendance of 297 people from 23 countries. Organizers of the symposium included the CAER, the journal FUEL, and the US Department of Energy’s Federal Energy Technology Center. FUEL has published a special issue of selected papers delivered at the meeting for each of the past symposia and will, again, for the 1999 symposium.

Workshops on Adsorbent Carbon have been held by the CAER in alternate years starting in 1991, helped consider-
ably by industrial sponsorship. The fifth workshop was held in July, 1999, and was attended by 63 people representing mostly academic and industrial concerns. The meetings have intentionally been kept small, in order to create an informal atmosphere. Relately, the CAER will host the 25th Biennial Carbon Conference of the American Carbon Society, “Carbon 2001.” This large conference is predicted to have upwards of 500 attendees.

For ten years, the Center has sponsored a Fuel Science Seminar Series which brings noted scientists from industry, government and academia to UK each year. The seminar series serves to provide a forum for the exchange of research ideas, and as an instructional tool for UK graduate and undergraduate students. In 1994, the CAER started its Distinguished Lecture Series. Past lecturers have included Sir Harold Kroto, a co-recipient along with Rick Smalley of the 1996 Nobel prize in chemistry for their discovery of C_{60}. This lecture was followed by Dr. Edward Teller in 1996, who spoke on the history of the atomic bomb to a capacity crowd at the UK Singletary Center. The 1999 speaker was Dr. Alan Hoffman of the University of Washington, who is internationally recognized for his work on responsive polymers and their application to medicine.

As a professional education highlight, Darrell Taulbee coordinated a short course at the CAER entitled “Coal Quality and Combustion” on November 16th, 1998. The course was taught by Rod Hatt of Commercial Testing and Engineering Co.

Professional Affiliations and Interactions

The Center continued its Faculty Associates program which aims to strengthen ties with UK academic departments. CAER Faculty Associates during the period included:

- Peter Eklund (Physics and Astronomy);
- Don Hancher (Civil Engineering);
- Eric Grulke (Chemical and Materials Engineering);
- Pinar Menguc (Mechanical Engineering);
- Kozo Saito (Mechanical Engineering);
- Robert Haddon (Chemistry/Physics and Astronomy)

We have continued to support and foster international collaborations that currently involve links with organizations in several European countries, Israel, Australia, The People’s Republic of China, South Africa, Japan, and Turkey. During the last two fiscal years the laboratory also hosted the following visiting scientists:

- Adrian Hutton, School of Geosciences, University of Wollongong, NSW, Australia;
- Henry Foner, Geological Survey of Israel, Jerusalem, Israel;
- Kazuhito Saito, Idemitsu Kosan Co., Ltd, Chiba, Japan.

A continuing effort to pursue collaborations is also illustrated by the large number of companies and institutions that sent visitors to the laboratory: 55 in FY 97-98 and 74 in FY 98-99. These affiliations are listed in the Appendices.

Many of the Center’s staff are actively involved in the scientific societies and academies, and in helping to plan and arrange national and international conferences. Among the offices that are held and the distinctions that have been made:

- Frank Derbyshire, recipient of the 1997 Henry Storch Award, Fuel Chemistry Division, American Chemical Society;
member of the Advisory Board, American Carbon Society; Editor of the Americas, journal FUEL; 1999 Peter Given Lecturer at The Pennsylvania State University; Advisory Board, Pittsburgh Coal Conference.

- Burt Davis, Secretary, Petroleum Chemistry Division, American Chemical Society; Historian, North American Catalysis Society; Newsbrief Editor, Applied Catalysis.


- John Stencel, Director, KY-DoE Experimental Program to Stimulate Competitive Research (EPScoR).

**TEACHING AND INSTRUCTION**

Universities are increasingly viewed as engines for economic growth via technology development and the education of a skilled labor force. One of the principal elements of the University’s mission is teaching and instruction. The Center assists in this important responsibility by providing scholarships and other forms of financial assistance to students, and through co-op, student exchange and study-abroad opportunities. Our staff contributes to curriculum and teaching, serves on student advising committees and acts as mentors for students at the precollege, undergraduate, graduate and postgraduate levels. Our lab has served as a proving ground and source of experiential education for hundreds of young people who are now practitioners in industry, government, and academia.

**Scholarships and Student Financial Assistance**

Approximately $490,000 was spent in FY 98/99 in scholarships and other forms of financial assistance for undergraduate, graduate and postdoctoral students at UK. A direct annual grant of about $55,000 is made to the Kentucky Mining Engineering Scholarship Program for undergraduate mining engineering students from Kentucky. Thirty nine students, most of whom were from coal-producing counties, received scholarships last year. The most recent scholarship recipients reside in the following counties: Crittenden, Fayette, Floyd, Henderson, Johnson, Knott, Letcher, Martin, Muhlenburg, Perry, Pike, and Pulaski.

Last year eight graduate students (six in 97/98) were provided with Research Assistantships and eight post doctoral scholars were employed by the Center (seven in the previous year). Eighteen undergraduate students worked directly with our staff as co-op’s at the lab, up from twelve in FY 97-98. CONSOL Energy sponsored research work at the CAER for two undergraduates the past two summers.

**Curriculum and Advising**

For nearly 10 years, most fall semesters have seen the Center offering through the College of Engineering a fuel science course, CME 599, Topics in Chemical Engineering. The course is team-taught by CAER staff and focuses on the structure, chemistry, processing, and utilization of fossil fuels. It is intended to provide a general overview of the subject for senior undergraduate and graduate students.
Staff members also hold positions with academic departments: Jim Hower, Adjunct Professor in geological sciences; B.K. Parekh, Adjunct Associate Professor in mining engineering. Others are involved in directing the research of graduate students, and serve on thesis and dissertation advising committees at UK and at other universities. The latter included (all at UK unless otherwise noted):

- Frank Derbyshire: Chengliang Jiang, Mining Engineering; Rodney Andrews, Chemical and Materials Engineering; Yuguo Wang, Chemistry; T. Li, Mechanical Engineering.
- Burt Davis: Marina Sorokina, Agronomy; Annette Brenner, Chemical Engineering; Chaoxian Cai, Todd Fields, Yuguo Wang, Chemistry; Michelle A. Parent, Department of Chemistry, University of Waterloo, Canada;
- Jim Hower: Penny Alano, Geological Sciences; Ted Wilson, Steve Brooks, Mining Engineering; Wenlong Gan, Geoscience, University of Wollongong (Australia)
- B.K. Parekh: Chengliang Jiang, X. Jiang, and Ted Wilson, Mining Engineering; and R.S. Devarakonda, Chemical and Materials Engineering.

Two CAER staff members continued work toward advanced degrees through the university’s Employee Education Assistance Program. Of these, one (Scott Lambert) completed the requirements for a baccalaureate degree in computer science.

Student Exchange and Study Abroad

The greatest percentage of students supported by the Center came from the University of Kentucky. However, the CAER also sponsors a number of student exchanges and summer practicums for students from other universities and research institutions in the United States and abroad. These exchanges may involve pursuing a course of study or research co-op experiences in the lab. Eleven exchange students or post-graduate scholars completed practicums or studies during the reporting period - students from Davidson College, Transylvania University, Morehead State University, the University of Alicante (Spain), the Royal Institute of Technology (Sweden), the Chinese Academy of Sciences and the University of Burgundy (France).

The latter exchange program between UK and the University of Burgundy, extends a longterm collaboration between the two universities' schools of agriculture to now include the schools of engineering. Three students from Burgundy's School of Engineering in Dijon worked at the lab for four months to complete work toward a baccalaureate degree in materials science and engineering.

Programs for Pre-college Youth

Educational outreach is further extended to middle schools and high schools. Many studies have shown that educational mentoring programs can motivate and stimulate the interest of pre-college students in science in a way that the classroom cannot. In this regard, the CAER has developed a summer internship for high school students from Kentucky. The program has been offered each summer since 1993 and was further augmented in 1998 by a human-resource development grant awarded from the KY-DOE EPSCoR program (M. McAlister). The two-week program hosts up to eight students. Each student is assigned a mentor and performs a variety of tasks in the laboratory or in the field (coal mines, power plants, etc.). At the end of the program, students were required to make a short presentation describing their experience before an audience that included teachers, students, mentors and other staff. A healthy percentage of the students have gone on to choose a college major in engineering or the physical sciences at UK or elsewhere. Perhaps of greater importance, each student gained from the experience and took away good memories, a feeling of accomplishment and new friend-
ships. Last year’s students hailed from: Breathitt, Christian, Cumberland, Floyd, Franklin, Hardon, Knott, and Muehlenburg counties.

Another K-12 effort that the CAER participates in is the Fayette County Public Schools’ Experience Based Career Education (EBCE) program. The program places high school seniors in local businesses, government offices, universities and other work settings, and provides the student an opportunity to survey various careers and vocations. Students are assigned a mentor and shadow that individual for a period of one-month. Five students from Bryan Station and Dunbar high schools spent time at the Center over the past two years to gain some appreciation of the different scientific and engineering professions.

SERVICE AND TECHNOLOGY TRANSFER

The previous pages of this report have described the CAER’s contributions to research and scholarship and the training and educational needs of students. Among our most important aims is to assure that the benefits of investigations, research and study are made available to the public and brought into the widest possible use. This is accomplished by pursuing an aggressive strategy of intellectual property development and technology transfer, through the provision of consulting and analytical services, and through effective communication and information services.

Technology Licensing

We described earlier the process of bringing an invention through the invention disclosure and patenting process. Beyond this, finding a potential licensee and demonstrating the efficacy of a particular innovation necessarily requires fairly wide ranging technical discussions between the inventor(s), intellectual property managers, and the product development groups of client-industries. Quite often, samples and materials are exchanged for testing, prototyping and cost engineering. Even after licensing, the industry will often require close collaboration in the early stages of technology development and scale-up. The Center’s staff is presently engaged in technical discussions, covered under mutual confidential disclosure agreements, with as many as 50 companies.

The potential rewards for navigating this process can be significant, both monetarily as well as from the satisfaction of seeing one’s laboratory research implemented on a commercial basis. Such was the case with a recent license agreement signed between the University of Kentucky and New Horizons, LLC, one of a handful of companies in the United States involved in the recovery and marketing of coal fines. Due to the difficulties associated with handling these materials, hundreds of millions of tons of coal fines have been discarded over the years. However, recently enacted Federal tax incentives have spurred efforts to find a way to render these materials suitable as a fuel stock for coal-fired electric power generation. The bulk of these efforts have concentrated on the development of improved binders and briquetting technologies to address the problems encountered with shipping, crushing and combusting coal fines. The CAER has been a leader in binder and briquetting technologies for many years, but only recently was it able to licensed a proprietary binder system developed by Darrell Taulbee. That resulted in a non-exclusive license to New Horizons, LLC.
Consulting and Analytical Services - The Industrial Support Program

An initiative was launched in 1997 to extend CAER’s analytical services to include problem-solving, collaborative research and testing for industry. The basic idea was to provide a single point of contact (Darrell Taulbee) for the referral of requests for technical assistance from industry. Since that time, 200 projects for approximately 90 clients have been taken to completion with income in excess of $600k. In addition to establishing approximately 80 new contacts, the initiative has led to an expanded pool of industrial partners for joint proposals and teaming arrangements. Last year, a sample of the Center’s clients included: ABC Coke, Delta Resins and Refractories, United Catalysts Inc., Wiley Engineering Services, NexGen Resources, Marathon-Ashland Petroleum Co., R.W. Beck, Procter and Gamble Company, Trans-Ash Canada, AK Steel, East Kentucky Power Cooperative, the Tennessee Valley Authority, American Electric Power Corporation, Pace Carbon Fuels LLC, Lexmark International, Inc., and Ticora Geosciences, Inc.

Communication

The world is increasingly a smaller place. Global communication and transportation have lead to the free movement of goods, services, people, data, and technical know-how. Our economic competitiveness depends on the ability to compete in a global work place, and productively use information technologies, including computers, e-mail and the Internet.

The Internet has become a medium of widespread and compelling interest and presents unprecedented opportunities for communication. With this in mind, the CAER set up its first WEB site in 1995, and since that time have added and maintained six additional WEB sites.

- The Center for Applied Energy Research, www.caer.uky.edu;
- The International Ash Symposium, www.flyash.org;
- Catalysis Research and Testing Center, crtc.caer.uky.edu; and
- KY-DOE Experimental Program to Stimulate Competitive Research (EPSCoR), www.epscor.org;
- Materials Research, Science and Engineering Center (MRSEC), www.mrsec.uky.edu;
The web sites were established to expose the Center to a much larger audience than had been traditionally reached and to expand access by the general public, the university, granting agencies, industry and others who might be interested in the Center’s research. The increased visibility has yielded contacts from industry, has promoted the sales of IEA coal research reports, and resulted in requests for reciprocal links to and from the web sites.

**Publication Sales and Mine Map Information System**

The Center has been an authorized US agent for the International Energy Agency (IEA) Coal Research publications since 1990. IEA Coal Research is a collaborative project established in 1975 involving member countries of the International Energy Agency (IEA). Its purpose is to provide information about, and analysis of, coal technology, supply and use. This service is administered by CAER library manager, Theresa Wiley. The following table shows the sales of publications in FY 97-99. The highest demand was for reports on the subject of coal supply and markets.

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<th>TYPE OF ORGANIZATION</th>
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<tr>
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<td>FY97-98</td>
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<tr>
<td>Industry</td>
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<td>Government</td>
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<td>Academia</td>
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Staff members continue to support the Mine Map Information Center, along with the Kentucky Department of Mines and Minerals. The Mine Map Information Center, managed by John Hiett, is the Commonwealth’s premier facility for Kentucky coal and clay mine information. All available data and maps, which includes 102,000+ records, regarding these mines are available with information beginning in 1884 to the present. The heart of the project is the Mine Map Information System (MMIS). This database resides on the CAER’s VAX (since 1984) and provides the indexing, retrieval and reporting required for the mine maps and data. Data may be accessed in a universal manner and distributed in any format.

Last year more than 1100 services (walk-in, appointment, phone, fax, e-mail/web accessed) were performed for individuals from all over the nation and for 150 state and federal agency contacts; and about 600 people came to the facility to use in-house services. A major undertaking this year was the office moving to new facility in Frankfort, Kentucky. A new office was constructed and over 10 tons of equipment, materials and maps were moved to the new location.