The Consortium for Clean Coal Utilization
Letter from the Director

Our society faces the challenge of providing clean energy to a world that, due to growing populations and standards of living, has a rapidly increasing demand for electricity. Universities play a pivotal role in this endeavor; not only do we educate our youth—the future decision-makers—but we also generate ideas for next-generation technologies and conduct the research that brings these ideas to fruition.

Washington University in St. Louis is in a unique position to contribute to global energy solutions. We have an exceptionally talented faculty and student body, and we also have a chancellor who is particularly well versed in and passionate about the field of energy. Chancellor Mark S. Wrighton invests his time and university resources to ensure we have a global impact on energy that comes from wisdom. The university achieves unparalleled global impact via the McDonnell Academy Global Energy and Environment Partnership (MAGEEP), an international network of 28 partner universities working together to address global concerns, with a specific emphasis on energy.

Our university has a strong presence in a wide range of energy projects, including renewable energy sources, but the world’s electricity largely comes from coal—50% in the United States, 75% in India, and 80% in China. The rapid, unabated increase in electricity consumption that is occurring in developing countries forewarns that coal use will increase, despite risks to the climate. Coal has its environmental challenges, but is a secure, affordable, and reliable source of energy.

With this backdrop, in 2008 we created the Consortium for Clean Coal Utilization, a partnership with industry dedicated to ensuring that coal can be utilized with minimal impact on the environment.

We at Washington University are proud to be working toward a sustainable future by addressing the scientific challenges and opportunities of clean coal utilization.

Richard Axelbaum, The Stifel and Quinette Jens Professor, Department of Energy, Environmental & Chemical Engineering; Director, Consortium for Clean Coal Utilization

Steven Chu, left, United States Secretary of Energy and Nobel Laureate, presented the keynote speech at the 2nd International Symposium on Energy and Environment in Hong Kong where the formation of the Consortium for Clean Coal Utilization was announced. He is pictured with Mark S. Wrighton, center, chancellor of Washington University in St. Louis, and John F. McDonnell, vice chair, Board of Trustees, Washington University in St. Louis. (December 2008)
A Vision for the Future

Reducing the Carbon Footprint on a Global Level. The Consortium for Clean Coal Utilization is a center for advanced coal research, including studies of carbon capture, utilization, and storage. The Consortium operates under the umbrella of the International Center for Advanced Renewable Energy and Sustainability (I-CARES), which Washington University established in June 2007 to encourage and coordinate university-wide and external collaborative research on energy, environment, and sustainability (icares.wustl.edu).

The Consortium’s mission is to be a resource to industry for the advancement of technologies that foster clean utilization of coal by creating an international partnership between universities, industries, foundations, and government organizations. Our goals are:

- to advance technologies for clean utilization of coal
- to develop solutions to mitigate carbon dioxide emissions
- to improve public understanding of the role of coal as a source of energy
- to train a motivated, talented workforce that is capable of addressing the future challenges of utilizing coal

The establishment of the Consortium was made possible through generous commitments from the lead sponsors: Arch Coal, Peabody Energy, and Ameren. Funding is used to support research facilities, education and outreach activities, and collaborative research projects.

“From a university perspective, this is an exciting way to take coal—one of the nation’s most abundant energy resources—and put it to work for the public good. The university will also work to build public understanding of the energy options for the future. The Consortium for Clean Coal Utilization will place St. Louis at the center for clean coal research.”

—Mark S. Wrighton, chancellor

Cover Image: iStock

Professor Himadri Pakrasi and undergraduate Cynthia Koehler inspect lab-scale photobioreactors for algae production under controlled conditions.
Advanced Coal & Energy Research Facility (ACERF)

State-of-the-Art Facility. The development and scale-up of fledgling technologies conceived of in laboratories will be critical to meet future worldwide demands for clean and reliable energy. That is why the Consortium recently completed a state-of-the-art facility for testing early-stage technologies at a pilot scale (1 MW thermal). The Advanced Coal & Energy Research Facility (ACERF) is a unique combustion test lab where research scientists and students may perform studies in the areas of:

- Carbon dioxide capture
- Process efficiency improvement
- Air pollution control
- Biomass combustion and co-firing
- Oxy-coal combustion
- Novel burner design

In addition to the combustion testing equipment, ACERF is also home to a series of research photobioreactors (shown top right) for the production of algae and other aquatic organisms. Algae, through natural photosynthesis, capture and consume carbon dioxide contained within the combustion exhaust gas.

Testing Services. ACERF is accessible to industry, faculty, and students within the United States and abroad. The facility has knowledgeable researchers and a skilled technical support staff available to assist users. Contact cccu@wustl.edu for more information.
Training Top Students. To accomplish the major changes that are needed in how we produce and use energy, a large and talented workforce must be trained. We attract the best and brightest students from around the world to the field of engineering and applied science—with a focus on energy technologies—thus educating tomorrow’s global energy leaders.

The Consortium provides for the development of course materials, invited lectures by leading experts, short courses, and outreach programs to promote awareness of the role of coal in today’s energy mix, emphasizing how coal may be utilized in a more environmentally friendly way.

A Wide Range of Research Capabilities:

- Computational modeling of combustion systems
- Drop tube furnace for single particle combustion studies
- Lab-scale (30kW) oxyfuel combustion furnace
- Fuel characterization
- Mercury analysis
- Fine particle characterization
- Fly ash-based materials testing
- Synthesis of nanomaterials for CO2 utilization
- NMR spectroscopy and imaging for CO2 sequestration and utilization
- Computational modeling of CO2 injection for geo-sequestration
- Microreactors for supercritical CO2 sequestration experiments
- Molecular dynamics modeling of advanced catalysts for CO2 utilization

Graduate student Yi Yang, left, works with Professor Young-Shin Jun to understand the fate of carbon dioxide after it has been sequestered underground.

Area high school students visit ACERF and discuss our energy future.
Research Highlights

**Groundbreaking Research.** The Consortium funds research projects in many areas, including:

**Geological CO₂ Sequestration**

Studies are conducted to understand the fate of carbon dioxide stored underground in geological formations, such as depleted oil reservoirs, unmineable coal seams, and saline reservoirs. New NMR imaging tools are being developed that will provide real-time visualization of the CO₂ injection process, and injection strategies are being optimized using genetic algorithms and computational modeling.

**CO₂ Utilization**

As an alternative to underground storage, technologies are being developed to convert CO₂ into useful products. One approach is to utilize CO₂, sunlight, and photocatalysts to produce valuable hydrocarbon fuels or chemicals. Another is to catalyze the reaction of CO₂ and methane using unique nanomaterials. CO₂ is also being injected into large bioreactors where it is consumed naturally by algae, which can then be converted into valuable products.

**Carbon Capture**

By burning coal using oxygen instead of air, CO₂ of high purity can be directly produced and pollutants more efficiently captured, resulting in near zero emissions. Methods of increasing the efficiency of oxy-coal combustion are being evaluated.

**Biomass Cofiring**

Burning coal with wood or agricultural residues reduces CO₂ emissions and helps to meet renewable energy targets. Approaches to fuel processing and cofiring are being developed to maximize efficiency and minimize emissions.

**Coal Byproducts**

As an alternative to large storage facilities, new uses for coal ash are being developed to create valuable materials. The fate of heavy metals in coal ash is studied to determine possible environmental impacts.
International Research

International Partners. The Consortium for Clean Coal Utilization recognizes climate change as a global concern. The strength of the international research community is needed to address this challenge.

The Consortium supports international research to foster the environmentally responsible use of coal for three main purposes: power generation, materials/chemicals synthesis, and fuel production. The research program encompasses a wide range of issues surrounding coal utilization, including technology R&D, policy, and assessment of impacts on air and water quality, climate, and health effects. Faculty members at Washington University lead the research projects and collaborate with researchers from partner universities around the world.

Partner Universities of the McDonnell Academy and International Affiliates*

*Stuttgart and Prague are International Affiliates; all others are Partner Universities

The McDonnell Academy Global Energy & Environment Partnership (MAGEEP) is a network of 28 leading partner universities across the globe that collectively identify and tackle global energy and environmental challenges.

MAGEEP@wustl.edu
Consortium Members

Role of Consortium Members

- Play an active role in identifying the research direction of the Consortium and in the selection of research projects
- Are kept informed of the latest advances in coal technology
- Participate in the development of new coal technologies
- Attend annual meetings, workshops, and short courses

Lead Sponsors

- Peabody Energy
- Arch Coal
- Ameren

Research Affiliate

- Photon Systems Instruments

If your organization would like to join the Consortium for Clean Coal Utilization or you seek additional information, contact the Consortium director:

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or visit cccu.wustl.edu