**An Update on the Appalachian Research Initiative for Environmental Science**

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**Abstract:** The Appalachian Research Initiative for Environmental Science (ARIES) began in March 2011, after years of planning. The industry-supported endeavor, which involves researchers at academic institutions across the Appalachian region, has nearly completed two years of study of various issues related to the production of energy and its environmental and social effects. A number of projects have resulted in some interesting results, and many of the studies have been submitted for publication. The “Environmental Considerations in Energy Production” symposium to be held in April 2013 will include some of those results, which will be presented at the meeting and published in a peer-reviewed proceedings volume. This paper highlights some of the research results and discusses the future of the ARIES work.

**Introduction**

ARIES was created to address a number of issues related to energy production in Appalachia, primarily related to coal mining. The elimination of the U.S. Bureau of Mines in 1996 resulted in a great dearth of study into the environmental impacts of energy production, particularly coal mining. Some of the debate conducted at that time indicated a preference that research of this nature should be funded and supported by the industry which benefitted from the work. Without the governmental support, no research in this area was conducted by the government nor supported at academic institutions. A study by the National Research Council of the National Academies of Science (2007) highlighted this lack research on the part of the U.S. government, and recommended that an expenditure of $62 million annually to focus on the environmental aspects of coal mining, with additional funding for operations research and health and safety studies.

By 2009, a number of coal mining operations in Appalachia had faced a crisis based on the lack of peer-reviewed research in the field of coal mining. Permitting and enforcement decisions from state and federal agencies had been made on the basis of a few studies, often conducted in-house by the regulators or by researchers that the industry believed to have an agenda against coal mining. Some of these studies were focused on health impacts that the researchers found to be correlated to coal mining, and those studies, along with some that focused on environmental impacts, were being used as the basis for policy and regulatory development, in addition to permit and operation specific decisions. Consultant studies that were funded by coal operators were rejected for consideration by regulators because of their lack of independence and peer-review.

The advisory committee for the Virginia Center for Coal and Energy Research (VCCER) recommended that the industry take on the responsibility for funding independent research aimed at addressing the problems identified in these permitting and policy controversies and the idea for ARIES was born. Coal mining companies and related support companies and state coal associations were consulted to help develop a framework of ideas and a plan of action for the new initiative. Of key concern were research independence, sufficient financial backing, and the need to address the longer term nature of university research. As a result, an industrial affiliates program, based at VCCER and utilizing the research talents at universities throughout the region was developed and supported by pledges of $15 million over a five-year project life. The ARIES program was to address the environmental impacts of not only coal mining, but of other energy production, including oil and gas, biofuels, electricity generation, and renewable energy. The program was officially launched on March 31, 2011.

While there was a set membership of companies supporting ARIES at the beginning, and specific academic institutions were identified as partners, the goal has been to be an “open door” initiative where other institutions and sponsors would be added as the research progresses. In particular, as the research into coal mining matures, additional industrial members and researchers are being sought to broaden the work into areas of interest to electrical utilities and unconventional gas production.

**ARIES Structure**

For the first two years of the program, the research under ARIES has been organized under six research areas, all focusing on coal mining. In each area, multiple universities and multiple areas of expertise were included to ensure communication between universities and disciplines. A researcher at one of the partner universities was identified as an area lead to assist in management of ARIES, with a particular focus on projects under that area.

While the sponsoring members were consulted for general ideas regarding the research agenda, individual researchers, working with the area leads and ARIES management, developed work plans and budgets. As an industrial affiliates program, neither Virginia Tech or other academic partners collect overhead from ARIES project funds, enabling research to be more efficient. Nearly sixty academic researchers (faculty and research staff) and an almost equal number of students (both undergraduate and graduate) have been engaged in ARIES research. Nearly $6 million has been expended over the first two years of the program.

The first area of work has focused on identifying impacts of coal mining on the streams and biological communities in those streams. Area two has been focused on existing and emerging technologies for treating or remediating impacts on water from coal mining operations. The third area has involved developing prediction techniques so that the strata in the geologic column most likely to create water impacts can be properly managed and isolated where appropriate. Area four looks at materials handling and water management methodology, including fill construction techniques, which will implement the knowledge gained in Area 3 and allow for the protection of water resources.

The researchers in Area 5 have examined the mining and coal processing techniques currently in use, with an eye to developing recommendations for the next generation of eco-friendly mining and processing processes. This work has involved the examination of environmental inputs and outputs for surface mining equipment, methods for determining the impacts of underground coal mining on surface and ground water resources, and opportunities for using coal processing as an integral part of environmental protection, primarily through management of liquid and solid wastes.

Area six has focused on the important questions about the impact of coal mining on human health and community well-being. Included have been investigations of economic and social impacts of mining, studies into potential health effects, and evaluations of actions that a number of stakeholders – industry, government, and communities – need to take to ensure that energy production contributes to sustainable development in the region.

As the work has progressed, a number of planned projects are ending, and a number of others are reaching decision points for future direction. As a result, ARIES management, working with area leads and researchers are examining how to restructure the program of research to ensure the greatest efficiency in answering key questions of concern. Streamlining the ARIES research structure and minimizing the cost of program management are goals of this effort. ARIES in year three and beyond with reflect the changing priorities and more effective organization.

**Research Results**

The work to this point has already yielded important results. ARIES has begun posting Technical Bulletins on its website ([www.energy.vt.edu/ARIES](http://www.energy.vt.edu/ARIES)) and additional means of publicizing the work of ARIES researchers are being considered. After nearly two years, nearly 50 publication or presentations have been prepared or presented. A number of these will be presented at the “Environmental Considerations in Energy Production” symposium to be hosted in Charleston, West Virginia in April 2013 by the Society for Mining, Metallurgy, and Exploration, Inc (SME). Nearly 70 technical presentations are scheduled as a part of that meeting. A peer-reviewed proceedings volume will be published by SME as a result of the symposium.

While there have been advances in all the research projects, some are noteworthy and will be highlighted here. The summaries that follow are far from complete, but give a flavor for the breadth and depth of work being done. Many of these examples will be included in the proceedings of the April 2013 symposium, though many have been or will be published or presented elsewhere.

Research conducted by Dr. Paul Ziemkiewicz and his colleagues at the West Virginia Water Resources Research Institute has demonstrated that a waste product from acid mine drainage treatment (FeOOH) can be used to immobilize selenium that may be associated with coal mining and valley fills. This work has the potential to allow isolation of selenium-bearing rock and for treatment of water containing selenium at a cost much less than techniques currently being used.

An ARIES-related project at Virginia Tech, led by Dr. John Craynon, has investigated the relationship between total dissolved solids, as measured by conductivity, and the health of biological communities in streams. Work by the U.S. Environmental Protection Agency and others suggested that conductivity should be used as a numerical standard for discharges based on its role as a predictor of macroinvertebrate community diversity and well-being in some watersheds. The current work shows very little correlation between conductivity and stream biota in the Dumps Creek watershed in southwestern Virginia, raising questions about the universal implementation of numerical standards for conductivity.

The models for prediction of horizontal displacement from underground mining in steep slope areas have always been lacking in accuracy. ARIES-sponsored work at Virginia Tech, conducted by Dr. Michael Karmis and Dr. Zach Agioutantis, has successfully modified those models and incorporated surface slopes geometry into predictions of horizontal ground movement. The project also included another key aspect to address the size of pillars left underground to protect surface water streams. Standard approaches, based primarily on rules of thumb, have resulted in leaving large pillars in order to eliminate the possibility of stream damage. By examining the propagation of cracks from the underground mine and under the stream bed, and examining strain resulting from mining, the results have demonstrated a new methodology which could reduce the size of pillars by over eighty percent, greatly increasing coal recovery in mines under streams.

In two separate ARIES studies related to community well-being and coal mining, a team at Ohio State, led by Dr. Linda Lobao, and a group at Penn State, led by Dr. R.J. Briggs, determined that coal mining is not associated with poverty in coal mining counties, that coal mining produces increased personal income in those counties with mining, and that in recent years, coal mining counties have performed better with regard to economic metrics than non-mining counties in Appalachia.

While many previous studies on coal mining and health have focused solely on water impacts from mining, an ARIES project at Virginia Tech, supervised by Dr. Emily Sarver and Dr. Leigh Anne Krometis, has focused on the issues related to other stream impairments across central Appalachia. This work shows that bacterial impairment, likely as a result of non-existent or inadequate sewage treatment, has a significant potential to pose threats to human health. Additionally, the work demonstrates a correlation between bacterial impairment and environmental indicators, such as benthic macroinvertebrate community well-being, suggesting a more integrated approach to dealing with stream contamination should be undertaken.

Finally, a study being conducted at the University of Pittsburgh, led by Dr. Jeanine Buchanich, shows that while historically coal mining counties have had higher levels of mortality and morbidity than non-mining counties in Appalachia, the rates are converging and the differences have become statistically insignificant. This work indicates there is no reason to assign causality to coal mining and that other confounding factors that may impact these findings should be thoroughly investigated.

**Conclusions**

The research being conducted under ARIES has resulted in significant findings in the first two years of the program. ARIES has a goal of providing good science that helps resolve questions that have been raised about the impacts of coal mining and other energy production in a thorough, unbiased way. By expanding the current efforts that have been devoted to coal mining issues into research looking at the impacts of unconventional oil and gas production, electricity generation and other aspects of energy production, ARIES can support the economic, environmental and social contributions that can accrue in the Appalachian region. ARIES can achieve this goal through expanded partnerships with companies and organizations committed to good science.

**References**

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