ANNUAL REPORT

2016

LSU
CENTER FOR ENERGY STUDIES

ANNUAL REPORT 2016

CONTENTS

Center for Energy Studies

DAVID DISMUKES
EXECUTIVE DIRECTOR
www.ces.lsu.edu

This past year represents another productive year for CES and all of its constituent divisions. Of particular note is that all of our CES units have managed to secure a number of externally-funded projects that, collectively, rival our prior 2006-2008 research funding peaks. CES researchers in our Policy Analysis Division, in Louisiana Geological Survey, Radiation Safety, and in Minerals Processing, are all tackling a variety of problems ranging from the integration of solar energy into electric power systems, to the changing nature and role of infrastructure development to our regional economy, to understanding clean energy and carbon sequestration techniques, and in developing new educational programs for our next generation of nuclear scientists.

These projects are not just integrated across our internal CES divisions but also engage researchers and faculty across the campus.

This past year, our Policy Analysis Division, in conjunction with the Economics & Policy Research Group in the E. J. Ourso College of Business, started work on the inaugural *Gulf Coast Energy Outlook*, a publication that will be designed to serve as a companion to the long-running and successful *Louisiana Economic Outlook* (*LEO*) published by Professors Loren Scott and Jim Richardson. The *Gulf Coast Energy Outlook*, however, will "drill down" on a number of energy industry-specific topics and analyses and will provide an outlook to 2020 for many Louisiana energy sectors that include oil and natural gas production, petrochemicals, liquefied natural gas and energy exports, refining, and electric power. The report, sponsored by Regions Bank, will be rolled out in early spring 2017.

LGS has also continued with its award-wining research and is slated to provide an extensive level of geological assistance in the recent $1.3 million grant research award issued by the U.S. Department of Energy to CES' own Policy Analysis Division. LGS and the Policy Analysis Division will examine the opportunities for carbon capture, utilization and storage (CCUS) in the industrial corridor between Baton Rouge and New Orleans. Other study participants include faculty from the departments of Geology (College of Sciences), Environmental Sciences (College of the Coast and Environment), and Petroleum Engineering (College of Engineering).

In addition, LGS provided extensive analyses and assistance during the tragic South Louisiana floods that devastated a large number of communities surrounding LSU. Doug Carlson's work in this area categorized and assessed the monumental displacement of business and property damage that arose from the flooding event and underscores the critical importance of the Survey in examining issues arising from catastrophic events.

CES' Division of Minerals Processing, like LGS and the Division of Policy Analysis, is also involved in carbon capture issues and their implications for Louisiana's petrochemical industries. This work consists primarily of continued development of web-based energy education and learning modules that explain key carbon mitigation technologies to engineering students at more than 10 major universities. The Minerals Processing Division also supports the Energy Sustainability Remote Laboratory that collects and synthesizes energy efficiency best practices across a range of minerals processing industries.

Lastly, our Division of Radiation Safety continues to provide important expert guidance and direction across campus on nuclear and radioactive material handling issues to support LSU's varied teaching, research and clinical services mission. Over the past year, the Radiation Safety Division has helped shepherd the development, and ultimately the award, of an interdisciplinary grant from the Nuclear Regulatory Commission (NRC) designed to buoy LSU's nuclear instructional capabilities. The grant will be coordinated between the Division of Radiation Safety, the College of Science (Physics) and the College of the Coast and Environment (Environmental Sciences).

In addition, our own internal nuclear tour de force, Dr. Wei-Hsung Wang, completed his own Tour du France this past year as part of an official delegation promoting and developing exchanges between the U.S. and France on nuclear development issues. Watch out for "Livenuclear" wristbands and energy drinks from Wei-Hsung in 2017!

Overall, this has been a great year for CES, and we appreciate the continued support we get from all of our various stakeholders. We are looking forward to expanding upon these accomplishments next year and hope to see you at one of our many events, including our Energy Summit, in 2017.

Research

DOE Awards CES-led Research Team $1.3 Million for Clean Energy Research

The Center is leading a DOE-funded project examining the technical and economic feasibility of developing a commercial-scale carbon capture and storage (CCS) project in Louisiana's industrial corridor between Baton Rouge and New Orleans. CCS is a technology used by industry to capture CO_2 emissions produced from the use of fossil fuels in industrial processes, preventing the carbon dioxide from entering the atmosphere. The $1.3 million research grant was awarded to an interdisciplinary team of scholars, led by CES Professor and Executive Director David E. Dismukes, to investigate this important environmental and economic development opportunity for Louisiana and the Gulf Coast.

The research team includes:

- Brian Snyder (co-principal investigator), assistant professor, LSU Department of Environmental Sciences;
- Keith Hall, associate professor and director, Mineral Law Institute, LSU Law School;
- Juan Lorenzo, associate professor, LSU Department of Geology & Geophysics;
- Chacko John, state geologist and director, Louisiana Geological Survey;
- Brian Harder, research associate, Louisiana Geological Survey;
- Mehdi Zeidouni, assistant professor, Craft & Hawkins Department of Petroleum Engineering;
- Richard G. Hughes, professional-in-residence, Craft & Hawkins Department of Petroleum Engineering.

Dismukes notes that this a unique opportunity for LSU that underscores its strengths in working with a wide range of stakeholder groups to solve applied energy and environmental challenges for our state. The project will include active private sector participation in order to identify large-scale industrial candidate emission sources, such as natural gas processing or petrochemical plants, and then transporting those industrial emissions to either permanent underground storage facilities, or using them in higher-valued energy applications such as enhanced oil recovery (EOR).

The goals of the project are to "define a business case model" in which industrial carbon emissions can be safely and profitably stored, Dismukes said. There is also a large public awareness and acceptance component to the project. From a technical perspective, LSU will be conducting a number of high-level, supercomputer-based technical evaluations of the sub-basin and its geological potential to safely store large levels of carbon in a single location as well as exploring a myriad number of technical issues associated with the effective monitoring and verification of these permanent CO_2 storage sites.

The award is part of the DOE National Energy Technology Laboratory's (NETL) Carbon Storage Assurance Enterprise, or CarbonSAFE, program, which seeks to develop an integrated CCS storage complex constructed and permitted for operation in the 2025 timeframe in several phases.

carbon capture and storage

preventing carbon dioxide
from entering the atmosphere

SWEPCO Partners with CES, Electrical & Computer Engineering on Solar Project

The Southwestern Electric Power Company (SWEPCO) is partnering with CES Assistant Professor Greg Upton and Amin Kargarian Marvasti and Shahab Mehraeen, both faculty members in LSU's Division of Electrical and Computer Engineering, on a project to determine how residential rooftop solar power could be incorporated into the electric grid. The project will also investigate whether the incorporation of battery storage could enhance the scalability of solar in an economical way to account for a relatively large share of the state's electricity production. SWEPCO provides electricity to 225,000 customers in 13 parishes in Northwest Louisiana.

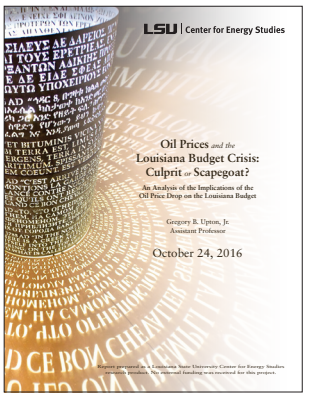
The project, titled "Integrating Storage into Rooftop Solar: An Economics and Engineering Approach," received $117,051 of funding through the Louisiana Board of Regents as part of its Industrial Ties Research Subprogram (ITRS).

Current Projects

CES's recent and ongoing projects spanning 2016 total more than $2.7 million.

During 2016, CES researchers began or continued work on more than one dozen funded projects, including

- an empirical analysis of the Outer-Continental Shelf pipeline network in the Gulf of Mexico for the Bureau of Ocean Energy Management's Coastal Marine Institute;
- the DOE-funded feasibility project for commercial-scale carbon capture & storage along Louisiana's industrial corridor;
- a multidisciplinary feasibility study for the Board of Regents on integrating storage into rooftop solar;
- and a combined heat and power (CHP) project for the La. Department of Natural Resources that investigates opportunities for improving resiliency, emissions compliance requirements and efficiency.



Publications

White Paper Addresses Oil Prices, Louisiana Budget Crisis

Assistant Professor Greg Upton prepared a white paper titled, "Oil Prices and the Louisiana Budget Crisis: Culprit or Scapegoat?: An Analysis of the Implications of the Oil Price Drop on the Louisiana Budget." In the paper, Upton examines how the oil and gas industry has contributed to both the state's finances and economy from a historical perspective. He discusses the 2016 drop in oil prices and considers how it might impact the state's budget. He also provides a broad view of Louisiana's revenues and assesses likely causes of recent budgetary problems. He suggests that, in light of the events of the past decade, Louisiana has a unique opportunity to make changes to its tax code in a manner that is consistent with long-term goals and good tax policy.

Research prepared for the white paper was incorporated into several presentations by Upton, including "Oil and Gas Prices and Louisiana's Fiscal Outlook," delivered at the National Federation of Municipal Analysts (NFMA) annual conference in Chicago; "The Evolution of the Louisiana Tax Structure," with Jim Richardson, professor, LSU Public Administration Institute, given to the Task Force on Structural Change at the Louisiana State Capitol; and "Oil Prices and the Louisiana Budget Crisis: Culprit or Scapegoat?" at the Central Louisiana Chamber of Commerce in Alexandria.

Media coverage associated with the white paper included interviews with Alexandria's *The Town Talk* and KALB TV.

CES 2016 Publications

In 2016, CES faculty research appeared in publications ranging from the offshore-focused *Oil & Gas Journal* and *Marine Policy* to the public-health-oriented *Health Physics*. Topics included

— the vulnerabilities of working coasts in supporting critical energy infrastructure;

— service vessel activity in the U.S. Gulf of Mexico;

— using geographic information systems to determine site suitability for a low-level radioactive waste storage facility;

— and major issues in recent utility merger proceedings, including assessing merger standards of review, understanding ratepayer benefits, and managing potential financial risks.

CES 2016 Publications

Dismukes, D.E. and S. Narra. Identifying the vulnerabilities of working coasts supporting critical energy infrastructure. Water 8(1).

Dismukes, D.E. (with M.W. Deupree). The challenges of the regulatory review of diversification mergers. *The Electricity Journal* 29(4):8-14.

Goddard, D.A. (with R. Sandrea). New reservoir-quality index forecasts field well-productivity worldwide. *Oil & Gas Journal* 114(12):55-60.

Kaiser, M.J. Economic Analysis of a Zero-Mass Withdrawal Geothermal Energy System. *Journal of Sustainable Energy Engineering* 3(3): 191-220.

---. A review of deepwater pipeline construction in the U.S. Gulf of Mexico–Contracts, cost, and installation methods. *Journal of Marine Sciences and Application* 15(3): 288-306.

---. Service vessel activity in the U.S. Gulf of Mexico in support of the oil and gas industry using AIS data, 2009-2010. *Marine Policy* 63:61-80.

Pulsipher, A.G. (with C.A. Wilson, K. Matthews, and W.H. Wang). Using geographic information systems to determine site suitability for a low-level radioactive waste storage facility. *Health Physics* 110(2):S17-S25, Supplement 1.

Upton, G.B. The effects of merit-based scholarships on educational outcomes. *Journal of Labor Research* 37(2):235-261.

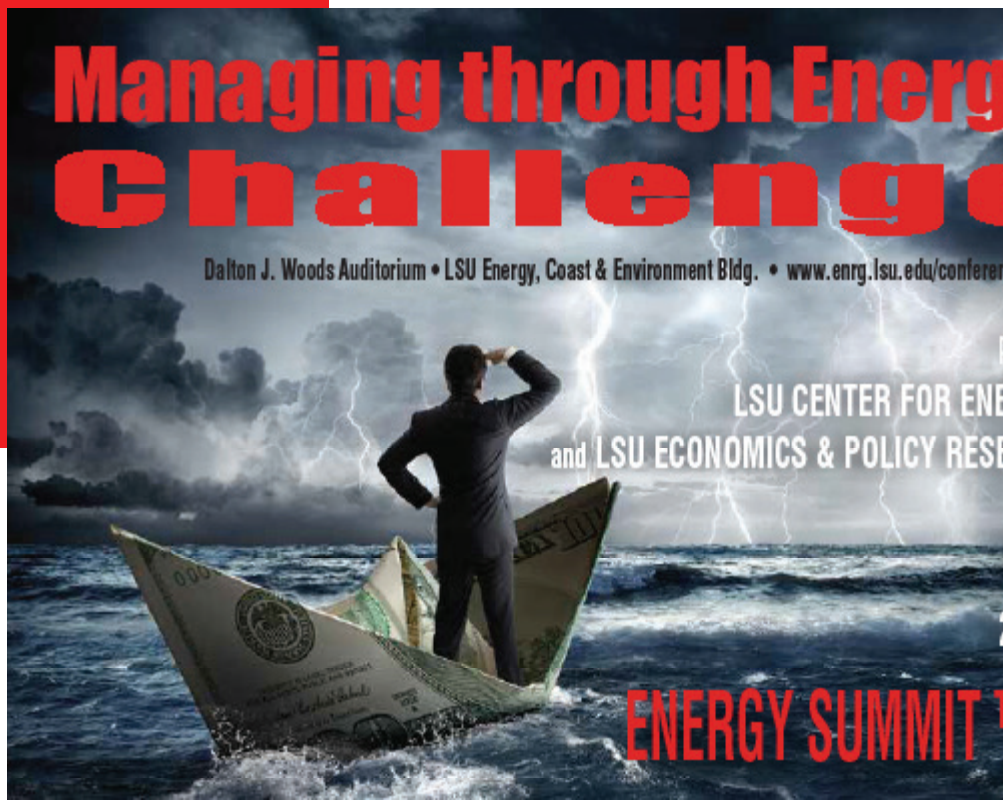
---. Oil prices and the Louisiana budget crisis: Culprit or scapegoat? An analysis of the implications of the oil price drop on the Louisiana budget. LSU CES Whitepaper.

---. Was the Stelly Plan really revenue neutral? *Baton Rouge Business Report* 34(22):45.

Vachon, M.C. A comparison of the economic and labor market impacts of resource extraction. *USAEE Dialogue* 24(1).

To view or download CES publications, visit www.lsu.edu/ces/publications

Outreach & Education



Martha Moore, senior director, economics and policy analysis, American Chemistry Council, addresses the Energy Summit audience on the topic of "Petrochemical Industry Challenges and Opportunities." Moore said that the U.S. petrochemical industry was in the midst of a multiyear renaissance as a result of low-cost shale gas. Since 2010, 277 new petrochemical plants or expansion projects valued at $168 billion had been announced, but workforce issues, including a lack of skilled workers, could slow the progress.

Kinder Morgan Vice President, Public Affairs, Allen Fore discusses the industry's infrastructure outlook at Energy Summit™ 2016. Kinder Morgan is the largest midstream and the third largest energy company (based on enterprise value) in North America, with more than 84,000 miles of pipelines and 180 terminals.

In his presentation, "Climate Risk and the Fossil Fuel Industry," Jim Krane, Wallace S. Wilson Fellow in Energy Studies at Rice University's Baker Institute for Public Policy, identified four main risks affecting the industry: government policies, decline in demand, investor avoidance and competition between fossil and non-carbon sources of energy.

Energy Summit™ 2016

On October 26, CES hosted Energy Summit™ 2016: "Managing through Energy Challenges." A diverse group of more than 100 attendees representing industry, government agencies, academia and the media participated in the day-long event.

Energy Summit™ presentations are available to view or download at www.lsu.edu/ces/conferences

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Lopa Parikh, senior director of Federal Regulatory Affairs at the Edison Electric Institute, listens to a question after her presentation on challenges to baseload generation, in which she stressed that industry's goal is to "strike a balance among reliability, sustainability, and affordability."

Participating in the roundtable discussion on energy and economic implications for Louisiana were (l-r) Eric Smith, associate director, Tulane Energy Institute; Loren Scott, CEO Loren Scott & Associates and LSU Professor Emeritus; and Dek Terrell, professor and executive director, LSU Economics & Policy Research Group. David Dismukes served as moderator for the panel.

For conference sponsorship information, contact mpinsonn@lsu.edu.

On March 15, the Center, along with BP and the Grow Louisiana Coalition, presented "Energy Outlook: The Global Energy Industry and Its Impact," with Mark Finley, chief U.S. economist with BP. Finley discussed predicted future energy demand through 2035, including the estimation that world GDP would more than double, but that unprecedented gains in energy efficiency would mean that the energy required to fuel the higher level of activity would grow by only about one-third over the outlook period. He reported that fossil fuels were forecast to remain the dominant form of energy powering the global expansion, providing around 60 percent of the additional energy and accounting for almost 80 percent of total energy supplies in 2035. Gas would be the fastest growing fossil fuel supported by strong supply growth, particularly of U.S. shale gas and liquefied natural gas (LNG), and by environmental policies; and the oil market would gradually rebalance, with the current low level of prices boosting demand and dampening supply.

Chevron Provides $10K Conference Sponsorship

Chevron has generously donated $10,000 in support of the Center's annual fall conference, Energy Summit™. Sponsorships such as these support conference planning, promotion and operations, including catering and parking, which are not entirely covered by attendance fees.

The Center expresses its sincerest gratitude for the ongoing support by Chevron.

Faculty Presentations

Spreading the wealth of energy expertise: 11 presentations, 10 cities, 4 states, 2 continents

Center for Energy Studies faculty are in high demand as presenters at conferences and meetings and as contributors on expert panels. In 2016, our researchers presented their work and engaged in discussions at several meetings throughout the state, as well as in Washington, D.C., Chicago, Tulsa and Tampa, and in Bergen, Norway, for the annual meeting of the International Association for Energy Economics.

View or download CES presentations at www.lsu.edu/ces/presentations

Dismukes Speaks on Utility Regulation, Natural Gas Policy

CES Executive Director David Dismukes spoke in June at the annual meeting of the National Conference of Regulatory Attorneys, or NCRA, in Tampa, and in August at the Fundamentals of Natural Gas Policy Academy in Bismarck, N.D.

For the NCRA meeting, Dismukes presented "The Future of Policy and Regulation," which summarizes traditional regulation theory and practice and describes the role of social investments in regulation and their impacts. The NCRA provides educational opportunities tailored to government regulatory attorneys, with a focus on state regulatory issues. The conference covers regulatory topics related to electricity, gas, water, telecommunications, federal regulations, and ethics.

At the Natural Gas Policy Academy, Dismukes taught "Natural Gas 101," an overview of the natural gas industry, to legislators and executive agency staff. Presented by the Council of State Governments, the three-day program covered smart modernization and emerging issues in natural gas and included a visit to a site in the Bakken shale play.

Upton Presents at La. Alternative Fuels Conference & Expo

Assistant Professor Greg Upton presented at the Louisiana Alternative Fuels Conference & Expo held in Lafayette on April 14. His presentation, "Alternative Fuel Vehicles and Utility Rate Design: The Devil's in the Details," describes different utility rate design structures and potential implications for customers. Upton also provides various examples of how the economics of alternative fuel vehicles can be significantly impacted by the rate structures including fixed and variable charges, time of use charges, and block rates.

The focus of this year's conference was to inform public and private fleet managers, safety officials, alternative fuel stakeholders, and government agency officials about the implications of fuel price fluctuations, stabilizing fuel costs in the future, and advances in alternative fuel technologies.

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Upton Guest Speaker for DIS-TRAN Event

On August 18, Assistant Professor Greg Upton presented "Funding Renewable Energy and the Future of the Power Grid" at DIS-TRAN Packaged Substations' Conference & Expo in Pineville, La. Upton explained the role of subsidies in the growth of renewable energy investments and the importance of utility rate design in aligning incentives for distribution, transmission, and generation. DIS-TRAN Packaged Substations, based in Pineville, designs and supplies high voltage, open-air substations and switchyards.

Member of French Parliament, Consul General Visit CES

On March 16, the Louisiana Department of Natural Resources and the Center hosted a delegation from the French Consulate General's office in New Orleans to discuss unconventional oil and gas resources and hydraulic fracturing. DNR's Communications Director Patrick Courreges and Mineral Resources Petroleum Lands Director Emile Fontenot, with CES Executive Director David Dismukes, answered questions regarding policy, technology and economics related to the state's unconventional oil and gas industry.

Seated l-r: Eric Szij, head of staff, French Parliamentary Office for Scientific & Technological Assessment, Congressman Christian Bataille. Standing l-r: Luc Boyer, Counselor for Energy, French Trade Council, Gregor Trumel, French Consul General, Brent Campbell, DNR director for the Engineering Regulatory Division, Emile Fontenot, Mineral Resources Petroleum Lands director, and Patrick Courreges, DNR communications director.

Center Hosts WEN Student Reception

The Center hosted a Women's Energy Network student networking reception on the evening of April 6. The gathering allowed more than 50 undergraduate and graduate students, male and female, to gain helpful insight and ask questions regarding potential careers in energy. CES Assistant Professor Mallory Vachon (fourth from right) coordinated the event.

WEN South Louisiana chapter members, along with LSU Student chapter members, attending the event included (l-r): Kristi Obafunwa, A'Dair Flynt (student), Margaret Patton, Rosemary Farr (student), Janine Boyd (student), Mallory Vachon, Linda Cummings, Andrea Tettleton, Abby Boyd.

CES in the News 2016

The Center for Energy Studies' energy experts are sought after by media to provide expert commentary on current and pressing energy issues. Throughout 2016, faculty responded to more than 20 requests for interviews from *The Advocate*, *The Greater Baton Rouge Business Report*, Bloomberg media, Louisiana Public Radio and more.

In January, *The Advocate* asked David Dismukes to comment on Cheniere's LNG project in Cameron, La. He explained that the long-term success of the export terminals would depend on whether energy companies could secure long-term contracts to market the fuel at a fixed price.

In March, *The Advocate* came calling again, this time for commentary on the low oil and gas rig count. Dismukes noted that the market was banking on the continuing decreases to start having production impacts but that they were relatively low and slow coming. He said that while the rig counts were important, the production numbers were equally significant.

In its June 7 issue, the *Business Report* featured an op-ed by Greg Upton, CES assistant professor, titled, "Was the Stelly Plan really revenue neutral." In it, Upton describes the "structural shift" in Louisiana's tax revenue that began with passage of the Stelly Plan in 2002 and argues that any discussion about taxation must address tax revenues in comparison to the amount of economic activity in the state.

In an October *Advocate* article on Organization of Petroleum Exporting Countries' (OPEC's) promise to cut oil production, Dismukes commented that, although Saudi Arabia had agreed to assist OPEC in reducing production by between 200,000 to 700,000 barrels a day from the near-record levels being

pumped out by its members, the agreement did not include OPEC members Iran, Nigeria and Libya and that the cartel had not allocated the production cuts. "If Saudi Arabia is prepared to step into the breach and make this entire production cut (on its own), then that's fine," Dismukes said. "But I'm really having my doubts about whether they're prepared to hold that up, given the position they're in right now."

After the presidential election in November, the *Business Report* asked Dismukes how the Trump presidency might affect the industry. Although Trump had expressed broad support for a robust energy industry, he had not revealed energy agenda specifics. Dismukes said he expected some policies to change under Trump and others to remain the same. He said that prices were determined by the global market, and the price trajectory would not change simply because of the election; however, he did predict that there would be "a screeching halt" on regulations, particularly at the EPA.

Scholarships

Brooksher, Hood, GCPA Scholarships Awarded

In the spring of 2016, the Center for Energy Studies Scholarship Committee awarded the following scholarships for the 2016-17 academic year:

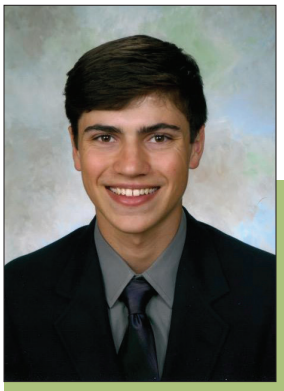
LMOGA/Brooksher Scholarship was awarded to **Joseph LeJeune**, a senior majoring in mechanical engineering. LeJeune is from Baton Rouge. The LMOGA/Brooksher Scholarship, named for the late Robert R. Brooksher, Jr., an executive vice president of Louisiana Mid-Continent Oil and Gas Association and founding member of the LSU Center for Energy Studies' Advisory Council, supports the educational goals of LSU students interested in energy-related fields, with a particular emphasis on energy policy related to the oil and gas industry. The annual scholarship is awarded in the amount of $1,000.

F. Malcolm Hood Scholarship was awarded to **Danté Hebert**. The Carencro native is a sophomore majoring in mechanical engineering. Created to honor the late F. Malcolm Hood, a highly regarded energy industry spokesman who served as an advisor when the Center was created and was a member of its Advisory Council, the scholarship supports the educational goals of LSU students interested in energy-related fields, with a particular emphasis on energy policy. The scholarship is awarded in the amount of $1,000.

David Olver Memorial Scholarship went to **Tyler Parker**, a junior majoring in electrical engineering, from Baton Rouge. Provided by the Gulf Coast Power Association emPOWERing Foundation, the David Olver Memorial Scholarship is intended for LSU students interested in future careers in the electric power industry. The award amount for 2016-17 was $5,000.

GCPA emPOWERing Women Scholarship was earned by **Cassidy Hebert**, a junior majoring in electrical engineering, from Lake Arthur, La. Also provided by the Gulf Coast Power Association emPOWERing Foundation, the emPOWERing Women Scholarship is intended for female LSU students interested in future careers in the electric power industry. The annual award amount is $2,500.

The Center congratulates these outstanding students and thanks our scholarship donors for their support of these students as they prepare for careers in the energy industry.



LeJeune

D. Hebert

Parker

C. Hebert

Personnel Update

Vachon

Vachon Receives Upjohn Institute Early Career Research Award

Center for Energy Studies Assistant Professor Mallory Vachon has been granted a W.E. Upjohn Institute for Employment Research 2016 Early Career Research Award for her project, "The Temporary Migration Response to Industry-Specific Shocks: Evidence from the U.S. Shale Boom." The award provides resources for junior faculty to pursue research related to labor markets and public workforce policy. Vachon's research interests include energy, labor, and public economics, with a focus on the local economic impacts of natural resource extraction.

Vachon, who joined the Center for Energy Studies faculty in the fall of 2015, received her Ph.D., M.A., and B.A. in economics at Syracuse University. She is a member of the American Economic Association, the International Association for Energy Economics, the Southern Economic Association, and the Society of Labor Economists.

Pulsipher Reappointed to NPC

Allan Pulsipher, associate director and Marathon Professor of Energy Policy, was appointed to a fifth two-year term on the National Petroleum Council. The council is an advisory body to the Secretary of Energy whose members represent all sectors of the oil and gas industries.

Under President Obama the NPC was expanded to include representatives of academic and public interest groups. It advises the secretary and conducts studies of interest to the industry, the public and the secretary.

ELSEVIER

Upton Invited to Participate in Elsevier Energy Forum

Assistant Professor Greg Upton has been asked to participate in the recently formed Elsevier Energy Forum, which comprises a group of selected early career researchers, spanning all areas of energy, and Elsevier's Energy publishing team. The Forum will meet regularly and the Early Career Researcher members will drive the agenda, to ensure the group addresses the most pertinent issues affecting energy researchers today. Of the 17 members, representing 12 nations, Upton is one of only four from the U.S.

Vachon Named to WEN, Pink Petro Boards, Presents at SEA Meeting

Women's Energy Network™

PinkPetro™

In December 2016, Assistant Professor Mallory Vachon was named to the Pink Petro Advisory Board. Pink Petro is a Houston-based company and social media organization created for women professionals in the energy industry.

Vachon was also asked to serve as communications director on the Executive Board for the South Louisiana Chapter of the Women's Energy Network (WEN). WEN's aim is to educate and develop professionals of various disciplines (lawyers, engineers, accountants, etc.) who work in energy industries, with a particular emphasis on encouraging women to enter the energy industry and embark on long-term energy-related careers. In November, Vachon was a panelist for the "State of the Industry" discussion at the WEN South Louisiana chapter's annual dinner in New Orleans.

Also in November, Vachon presented "The Temporary Migration Response to Industry-Specific Shocks: Evidence from the U.S. Shale Boom" at the Southern Economic Association's annual meeting in Washington, D.C.

Beijing Visiting Scholar at CES

In March of 2016, Yuhua Zheng, associate professor, School of Business Administration, China University of Petroleum, Beijing, began working as a visiting scholar at the Center for Energy Studies. Zheng's research involves economic assessments of several offshore oil and gas fields in the South China Sea and in Gulf of Mexico. After a successful year of research, she returned home March 18, 2017.

Zheng

Personnel

Administration

David E. Dismukes, Ph.D., executive director, director of the Policy Analysis Division, and professor

Allan G. Pulsipher, Ph.D., associate executive director and Marathon Oil Company Professor of Energy Policy in the Center for Energy Studies

Diana Reynolds, assistant to the executive director

Marybeth Pinsonneault, communications manager

Division of Policy Analysis

Gregory B. Upton, Jr., Ph.D., assistant professor

Mallory Vachon, Ph.D., assistant professor

Mike McDaniel , Ph.D., professional-in-residence (retired) and an adjunct professor of environmental sciences in the School of the Coast and Environment

Don Goddard, Ph.D., associate professor (retired)

Division of Research & Development

Mark J. Kaiser, Ph.D., director of the Research & Development Division and professor

Siddhartha Narra, Ph.D., research associate

Division of Energy Information & Data

Omowumi (Wumi) Iledare, Ph.,D., (retired) director of the Energy Information and Data Division, professor of petroleum economics and policy research, adjunct professor of petroleum economics at the Craft & Hawkins Department of Petroleum Engineering at LSU and the University of Ibadan.

Ric Pincomb, research associate

Stacy Retherford, computer analyst

Mike Surman, computer analyst

Minerals Processing Research Division

RALPH PIKE, DIRECTOR
F. CARL KNOPF, CO-DIRECTOR
www.mpri.lsu.edu

The Minerals Processing Research Division (MPRD) of the Center for Energy Studies was established in 1979 by Federal legislation as one of 31 State Mineral Institutes associated with the U.S. Department of Interior. The mission includes facilitating research and public service programs in process research and technology transfer, sustainable development, energy management, and inherently safer design. This minerals processing research and public service complements and benefits from the energy research and geological research performed by other groups in the Center for Energy Studies and the Louisiana Geological Survey.

The Division is renewing its work on carbon capture and sequestration from power plants. Research is also continuing in development of web-based energy education and learning modules. **These modules are currently being used to promote key energy technologies to engineering students (sophomore to senior year) at 10+ universities.**

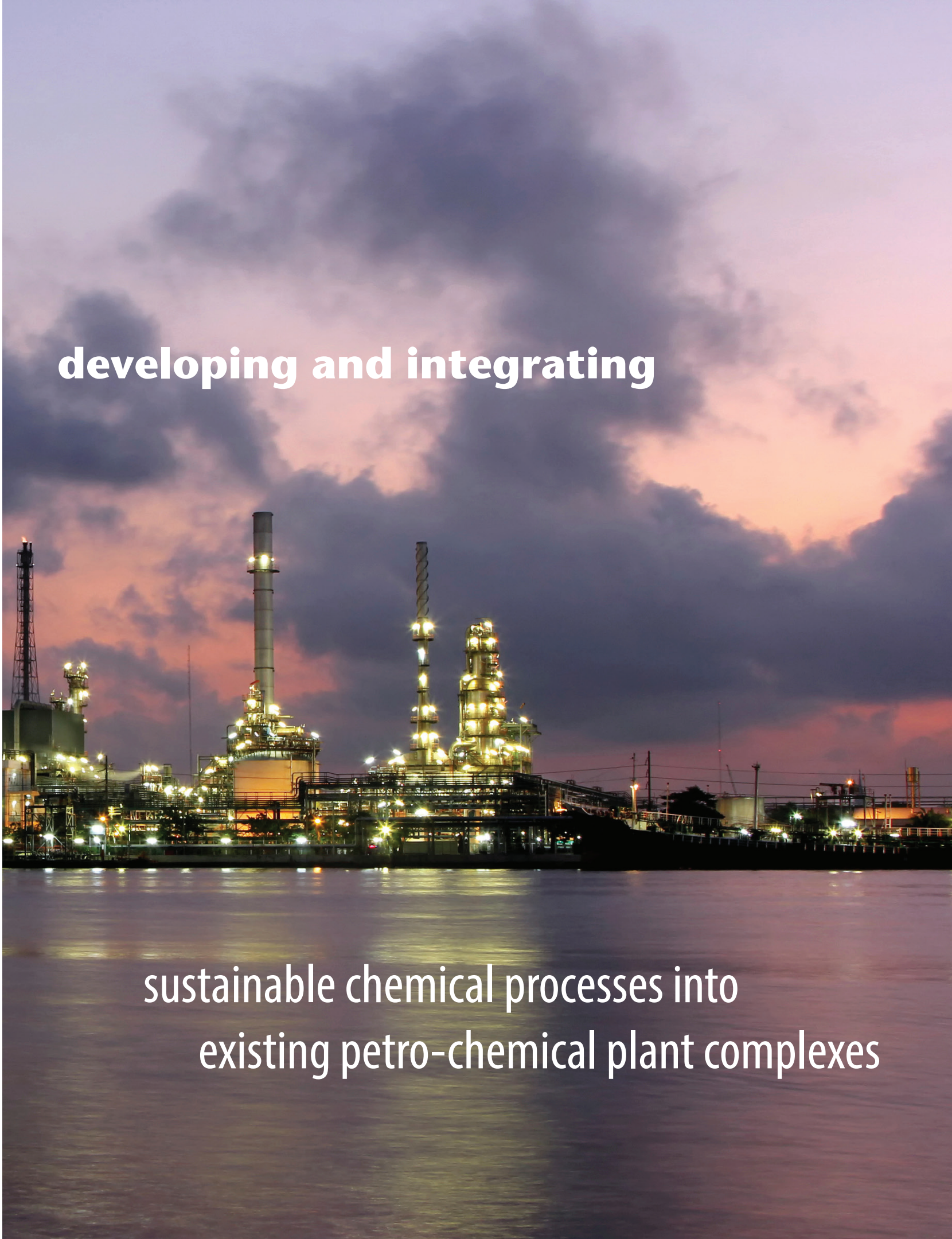
Finally, research is continuing to evaluate the resilience of the infrastructure of the Chemical Processing Industry (CPI) to determine the capability of the complex to absorb and recover from adverse events and of the impact of these events on the supply chain of critical chemicals.

Carbon Dioxide Capture for Sequestration

Design and economic analysis for carbon capture from the flue gas of existing pulverized coal-fired power plant operations have been investigated. This included the case that produced steam for regeneration of the sorbent used for carbon capture. This project was in support of TDA Research, Inc.'s DOE contract for the design and fabrication of a pilot scale reactor for testing on coal stack gas that uses a carbon capture adsorbent. A flowsheet simulation was used to evaluate fixed, fluidized and moving bed reactor designs based on a minimum cost of carbon dioxide mitigated for existing pulverized coal-fired power plants, such as American Electric Power's Conesville Unit No. 5. Conesville, Ohio. (See "TDA Final Report MPRI-TDAR-2," available on the Division's web site www.mpri.lsu.edu and DOE Report "DOE/NETL-401/110907.")

Key technical challenges to all carbon dioxide sequestration processes for capturing carbon dioxide from coal-fired power plants include: large flue gas volume, relatively low CO_2 concentration, flue gas contaminants and high parasitic power demand for sorbent recovery. All carbon capture processes require sorbent regeneration, and these sorbent processes utilize steam extracted from the power plant for regeneration. This steam extraction will adversely affect power plant performance as less steam for electricity generation will be available. Costing of sequestration processes requires accurate accounting for all sequestration costs (capital, labor, etc.) as well as accounting for the power lost from the power plant.

As background, power plants are designed and optimized for full-load operation, which is termed the "design case" or "base-case." All operations that are not full-load operation are termed "off-design" operation. Capture of CO_2 with sorbent steam regeneration causes the


developing and integrating
sustainable chemical processes into
existing petro-chemical plant complexes

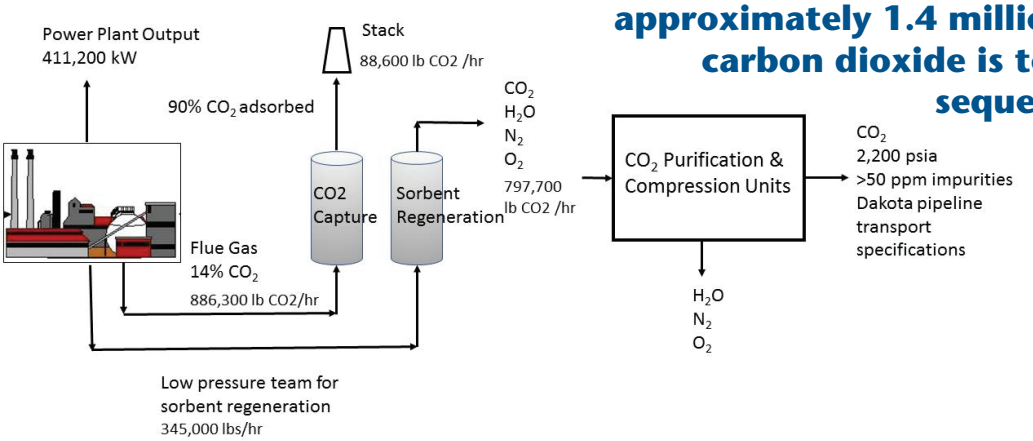
power plant to operate in an off-design operation. Here off-design calculations included steam extraction as needed for regeneration of the sorbent. Evaluating the impact of adding CO_2 capture to the Conesville #5 Power Plant base case power plant, a solid adsorbent was used capturing 90 percent of the base-case generated CO_2. Regeneration of the regeneration system required 345,000 lbs/hr of low pressure steam. This steam flow rate was ~ 11 percent of the total high pressure (HP) steam generated in the boiler. Also, the power plant would deliver 22,494 kW less electricity due to steam regeneration for the regeneration process that is six percent of full-load operation.

A significant additional cost was electricity for the sequestration process, estimated at 22,494 kW. The result was an increased utility cost of 33.6 percent based on current (no sequestration) operations for Conesville No. 5 electricity cost of 6.4 ¢/kW-hr. The result of parasite electricity + capital costs for regeneration equipment resulted in an increased utility cost of 33.6 percent based on current (no sequestration) operations for Conesville No. 5 electricity cost of 6.4 ¢/kW-hr. Detailed calculations can be found in the TDA Final Report.

The Aspen HYSYS flowsheet simulator was used to design the process for the adsorber, regenerator and downstream processing to produce pipeline quality carbon dioxide at 2,200 psia and impurities at less than 50 ppm that is required for pipeline transportation. With HYSYS, the process equipment, operating conditions and energy (power, cooing water, etc.) requirements were determined. The economic analysis used Aspen Icarus In-Plant Cost Estimator to determine capital and operating costs, other manufacturing costs and economic returns.

As shown in the diagram below, the process uses an adsorber to remove 90 percent of the carbon dioxide from the flue gas from a coal-fired power plant. The carbon dioxide is separated from the adsorbent by regenerating the adsorbent with steam. This stream from the regenerator is sent to two serial steps of compression, heat exchange and two-phase separation to increase the pressure to 132 psia. Then, a silica gel packed bed removed the remaining water. Additional compression and cooling was used to remove the nitrogen. The purified carbon dioxide was sent to a pump to increase the pressure to 2,200 psia, which is required for sequestration.

Recently DOE announced that a post combustion CO2 capture system was in commercial operation on the W.A. Parish coal-fired power plant in Thompsons, Texas, southwest of Houston. Designed to capture approximately 90 percent of the carbon dioxidefrom a slipstream of flue gas, approximately 1.4 million metric tons of carbon dioxide is to be sequestered annually.



Process Flow Diagram for Capturing Carbon Dioxide from a Coal-Fired Power Plant

The purity of the CO_2 put into the pipeline for transport is to be greater than 99 per cent. The captured CO_2 is to be transported via a new 132 km / 82-mile-long, 12-inch diameter underground pipeline to the West Ranch oil field and is injected into the 98-A, 41-A, Glasscock and Greta sand units of the Frio Formation, approximately 1,640–2,066 meters / 5,000–6,300 feet below ground surface for enhanced oil recovery (EOR).

Energy Sustainability Remote Laboratory

The Center continues to host the Energy Sustainability Remote Laboratory (ESRL) www.esrl.lsu.edu. ESRL allows partner universities to implement authentic experiences by providing data from actual operating energy or energy-intensive manufacturing systems – a natural gas-based cogeneration unit, a nuclear power plant, a coal-fired plant, a photovoltaic solar facility, and bench-scale units for biomass processing to chemicals, and biomass gasification, as well as pre-tested background materials and suggested inquiry-based assignments. Currently ESRL is used by engineering programs at LSU, Auburn, University of Alabama, University of South Alabama, UNLV, FSU, and several other schools.

Research on Resilient Critical Infrastructure for the Chemical Industry

Resilience is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. Research is underway with the objective to improve the resilience of the infrastructure of the Chemical Processing Industry (CPI). The project uses the simulation of a chemical production complex based on multiple plants in the lower Mississippi river corridor to evaluate the capability of the complex to absorb and recover from adverse events and of the impact of these events on the supply chain of critical chemicals. Realistic evaluations are being performed with the assistance of the MPRD Industrial Advisory committee and the ExxonMobil Operations Integrity Management. The methodology developed at the National Infrastructure Simulation and Analysis Center of Sandia National Laboratories with an agent-based chemical supply chain model are being included in the evaluations, and collaboration with this group is being developed.

Technical Sessions at National Meetings

The following three technical sessions and poster session at the American Institute of Chemical Engineers' 2016 Annual Meeting in San Francisco, November 13-18, 2016, were chaired by Ralph Pike and Debalina Sengupta. Each technical session had eight presentations from industry engineers and university researchers on numerous aspects of developing innovative processes to produce fuels and chemicals from renewable resources, with an average of 50 attendees in each of the three sessions: "Sustainable Fuels from Renewable Resources," "Sustainable Chemicals: Advances in Innovative Processes," and "Fundamentals of Environmental Transport Phenomena."

Three technical sessions—on "Sustainable Chemicals: Advances in Innovative Processes," "Sustainable Fuels from Renewable Resources," and "Advances in Environmental Fundamentals"—are being organized for inclusion in the AIChE Annual Meeting, Minneapolis, to be held on Oct. 29 – Nov. 3, 2017.

Professional Development Courses, Publications, Programs Available On-Line

Professional development courses are on the Division's web site, www.mpri.lsu.edu. The interactive heat exchanger synthesis program THEN is being rewritten and enhanced with an Excel interface and graphical display. This course and computer program are part of the web site materials that are continually being revised and extended with new research journal articles, conference proceedings, technical reports, theses, dissertations and professional development self-study courses for professional engineers' PDH requirements.

Personnel

Ralph W. Pike, director,
Horton Professor of Chemical Engineering

F. Carl Knopf, associate director,
Anding Professor of Chemical Engineering

Undergraduate and graduate students provide assistance.

Louisiana Geological Survey

CHACKO J. JOHN
DIRECTOR & STATE GEOLOGIST
www.lsu.edu/lgs

The Louisiana Geological Survey (LGS) originated in 1869 and was later officially established by the Louisiana legislature in 1934 (Act 131). LGS is currently a research unit affiliated with Louisiana State University having been legislatively transferred in 1997 from the Louisiana Department of Natural Resources.

The mission and goals of LGS are to preform geological investigations that benefit the state of Louisiana by:

- Encouraging the economic development of the natural energy, mineral, coastal, water, and environmental resources of the state through appropriate research projects;
- Providing unbiased geological information on natural and environmental hazards and other issues as and when called upon to do so by state, federal, or other agencies and private companies and citizens;
- Ensuring the effective transfer of geologic information through research publications, presentations at professional conferences and other meetings, production of geologic maps, etc.

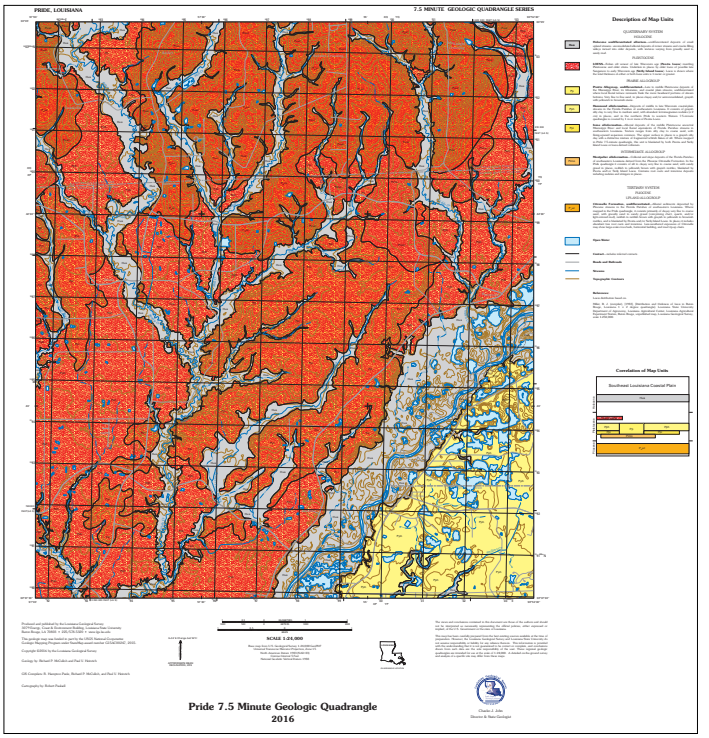
Geologic Mapping

Surface-geologic mapping projects conducted by the LGS during the past 20 years comprise 1:100,000-scale compilations of 30 × 60 minute geologic quadrangles and 1:24,000-scale field-mapped 7.5-minute geologic quadrangles. The vast majority of these mapping efforts were funded under the STATEMAP component of the National Cooperative Geologic Mapping Program (NCGMP), begun in 1993 and administered by the U.S. Geological Survey (USGS).

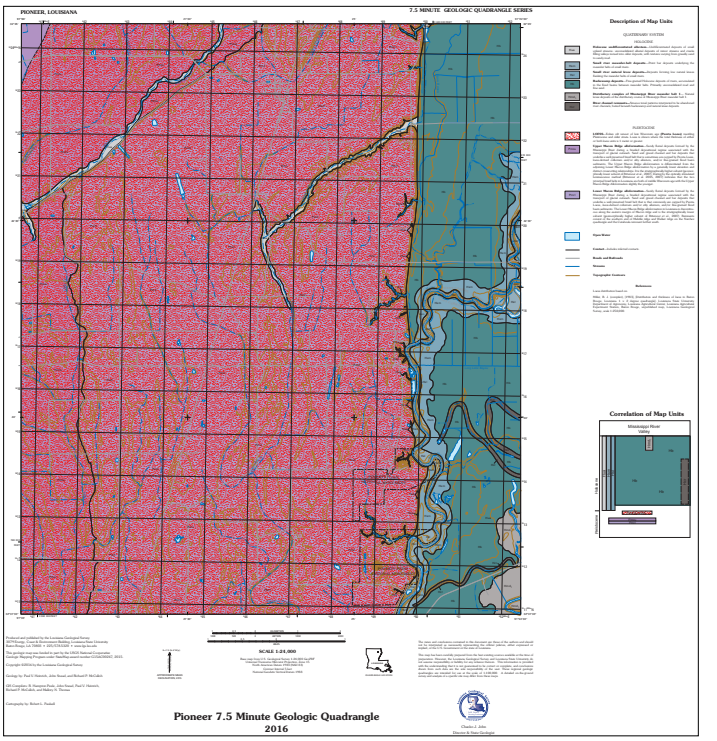
The principal goal of this program of geologic mapping for LGS initially was to prepare statewide surface geology coverage at 1:100,000 scale in 30 × 60 minute quadrangle format. This scale was emphasized because it is at the large end of the range of intermediate scales, and preserves abundant detail from source mapping done at larger scales (principally 1:62,500 and 1:24,000) while yet covering relatively large areas. By the close of FY 2013, LGS had completed 30 × 60 minute geologic quadrangle coverage of the entire state (30 sheets total) with a mix of published lithographs and draft open-file compilations.

Since the late 1990s, LGS also prepared 7.5-minute geologic quadrangles at 1:24,000 scale totaling 53 sheets. Forty-three were prepared with STATEMAP support, and the other ten were prepared for the U.S. Army Corps of Engineers within the Fort Polk region, southcentral Louisiana.

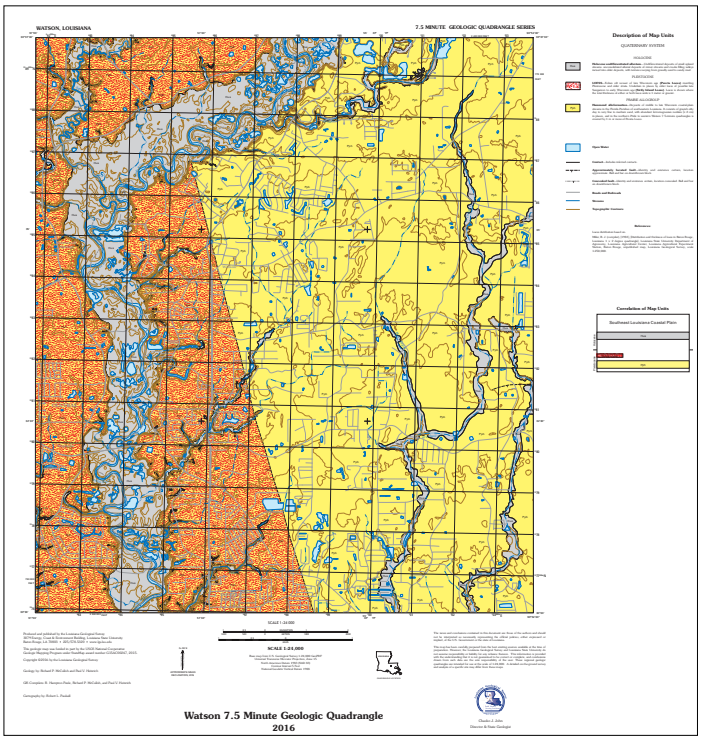
State map 2015-2016 deliverables completed and submitted included geological maps and pamphlets covering four 7.5 minute quadrangles in two study areas (Poverty Point area in northeastern Louisiana and the Amite River Valley north-northeast of Denham Springs).



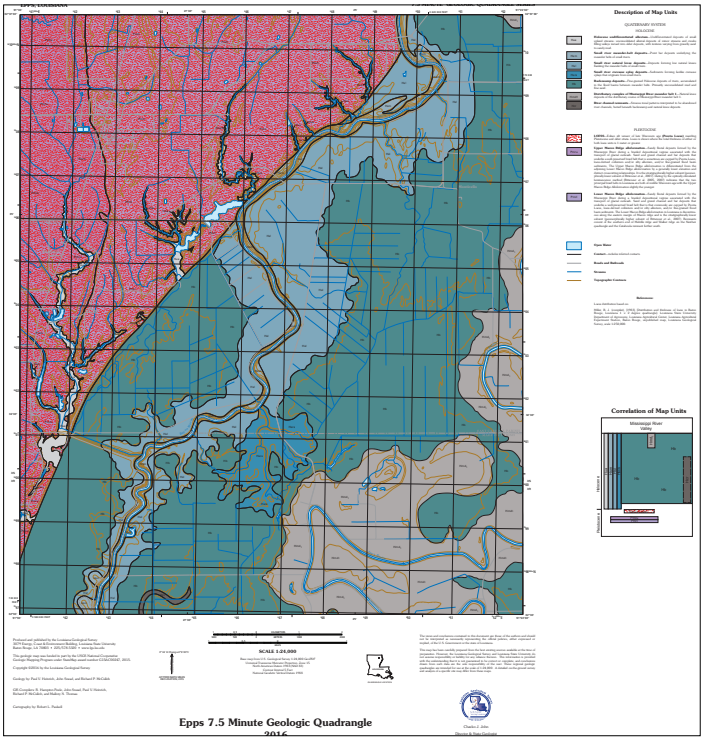
Pride 7.5 Minute Geologic Quadrangle
2016



Pioneer 7.5 Minute Geologic Quadrangle
2016



Watson 7.5 Minute Geologic Quadrangle
2016



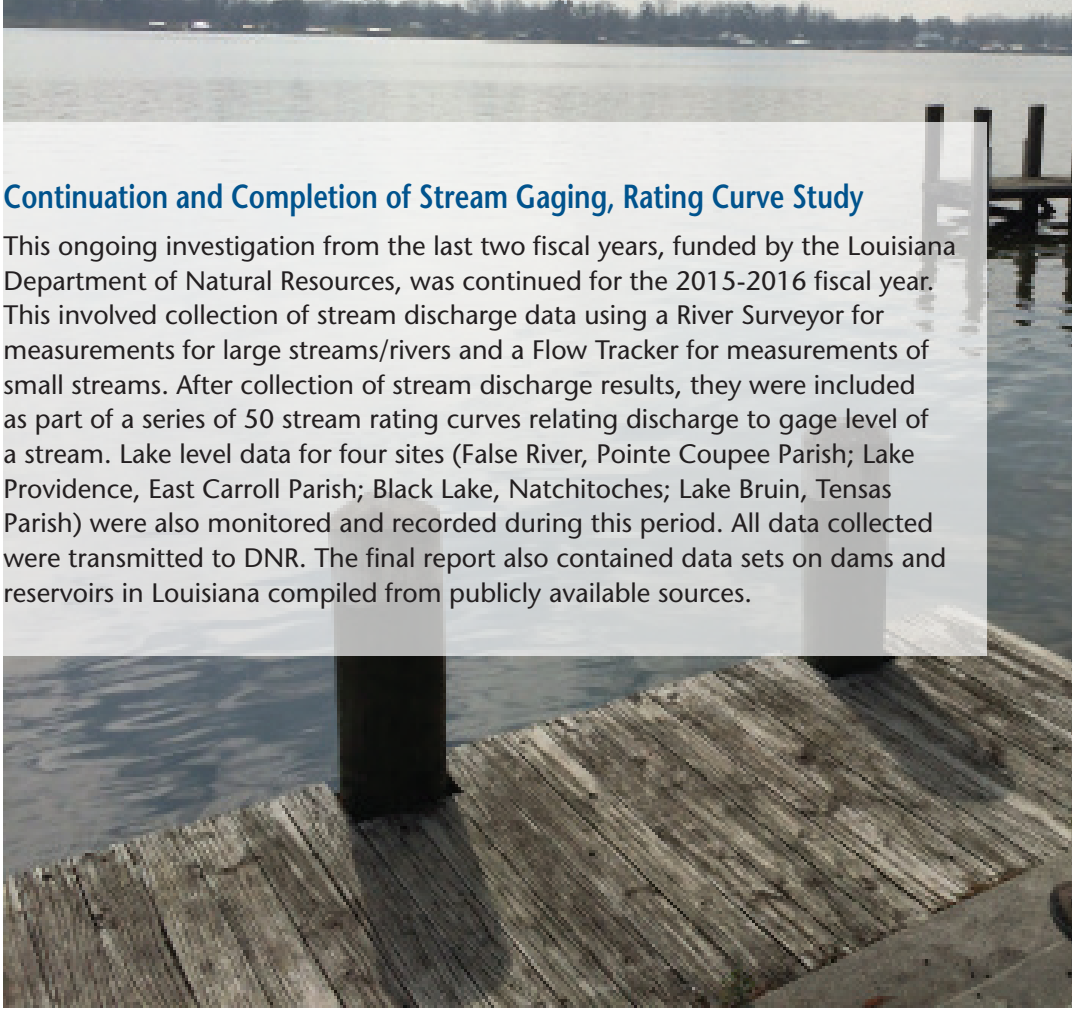
Epps 7.5 Minute Geologic Quadrangle
2016

Projects in 2016

GIS Development of the Buried Holocene-Pleistocene Surface in the Louisiana Coastal Plain

This project was funded by the Water Institute of the Gulf on behalf of the Coastal Protection and Restoration Authority (CPRA) of Louisiana to investigate and develop a three-dimensional GIS dataset of the buried Holocene-Pleistocene regional unconformity known as the "Base of the Holocene" for coastal Louisiana. This research was undertaken because of a lack of a single comprehensive map of the Holocene-Pleistocene surface that covers the entire coastal plain and adjacent continental shelf. Instead, the available data consisted of maps created by various authors at different times in different study areas using different criteria. As a result, many gaps existed in the coverage of these maps as well as conflicts in their interpretations.

The technical work conducted for this project consisted of (1) an investigation and compilation of existing published and unpublished boring data; (2) an analysis of collected data points; (3) the development of the GIS dataset of the Holocene-Pleistocene surface within the study area; (4) an assessment of the accuracy of the source data and (5) the preparation of deliverable GIS data sets, digital maps and a final report with an interpretation of the data. It is intended that this Holocene-Pleistocene surface model of this study area will offer improvement in understanding geologic variables in engineering design of coastal restoration projects, reduce uncertainties in assessing future geo-environmental conditions, support coastal project planning and decision making and improve data and assumptions used in predictive subsidence modeling.

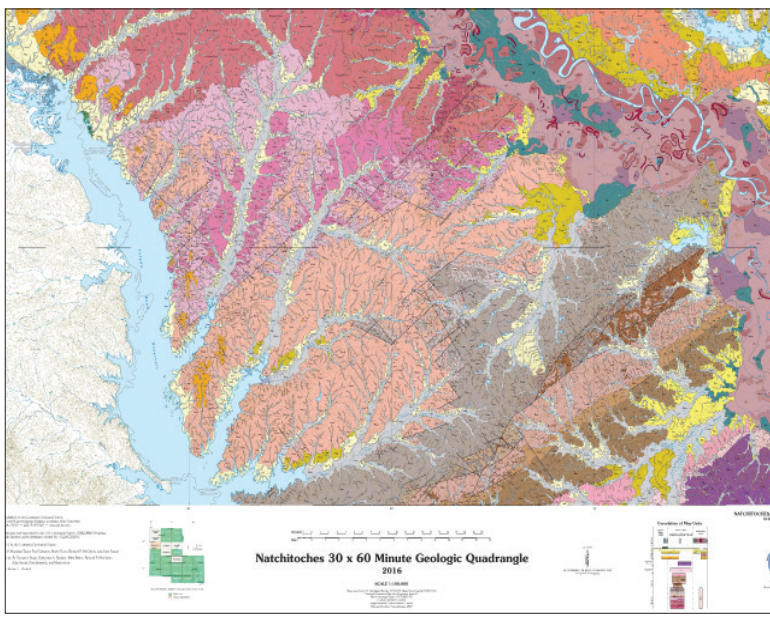


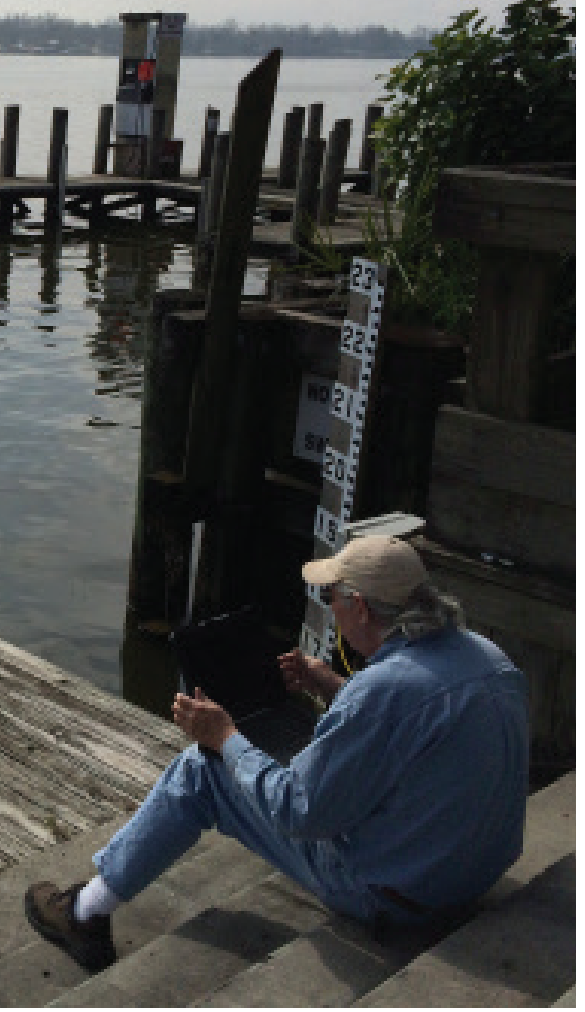
Continuation and Completion of Stream Gaging, Rating Curve Study

This ongoing investigation from the last two fiscal years, funded by the Louisiana Department of Natural Resources, was continued for the 2015-2016 fiscal year. This involved collection of stream discharge data using a River Surveyor for measurements for large streams/rivers and a Flow Tracker for measurements of small streams. After collection of stream discharge results, they were included as part of a series of 50 stream rating curves relating discharge to gage level of a stream. Lake level data for four sites (False River, Pointe Coupee Parish; Lake Providence, East Carroll Parish; Black Lake, Natchitoches; Lake Bruin, Tensas Parish) were also monitored and recorded during this period. All data collected were transmitted to DNR. The final report also contained data sets on dams and reservoirs in Louisiana compiled from publicly available sources.

Preservation Potential of Prehistoric Cultural and Sand Resources

This study, started last fiscal year and funded by the Bureau of Ocean Energy Management (BOEM), was to investigate how the paleolandscape of the late glacial continental shelf responded to the erosive effects of the late Pleistocene-Holocene transgression. During this period of sea-level rise, wave and tidal movement preferentially eroded the coastal plain interfluves and often spared the valley fills and paleo-valleys that progressively accumulated. As part of this report, these erosive effects of the late Pleistocene-Holocene transgression on preservation of paleo-landscapes and associated features were evaluated using data provided by BOEM. In addition, a final GIS compilation of all these data sets were finalized along with other data collected and evaluated as part of the final report submitted to BOEM.





Baseline Determination of Groundwater Quality in South Central St. Tammany Parish

This parish-funded project involved sending letters to owners of private water wells requesting permission to sample the wells which ultimately resulted in the sampling of 97 domestic water wells and three public supply water wells to determine baseline values for 42 different analytes, including aluminum, arsenic, barium, benzene, boron, bromide, butane, cadmium, calcium, chloride, chromium, cobalt, copper, diesel range organics (DRO), electrical conductivity, ethane, ethylbenzene, fluoride, gasoline range organics (GRO), iron, lead, magnesium, manganese, methane, nickel, nitrate, nitrite, oil range organics (ORO), pentane, phosphate, phosphorous, potassium, propane, silicon, sodium, strontium, sulfate, toluene, total dissolved solids, vanadium, xylene(s) and zinc. Sampling was completed between December 2015 and June 2016 and analytical analysis of samples was completed by August of 2016, after which a final report was submitted to the parish.

Evaluation of Water Permit Requests

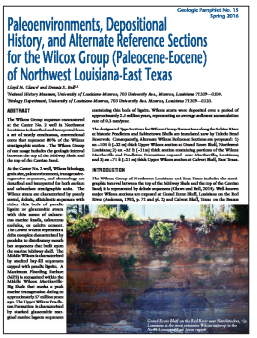
This three-year project funded by DNR, now in its second year, requires LGS to provide DNR with unbiased recommendations for water permit requests. Such applications are mostly for withdrawal of water from running surface water resources submitted to the DNR secretary pursuant to Act 955 of 2010. Applications are generally received by DNR from other state agencies, parish governments, etc., and are evaluated mainly to determine environmental consequences resulting from the action proposed in the concerned application.

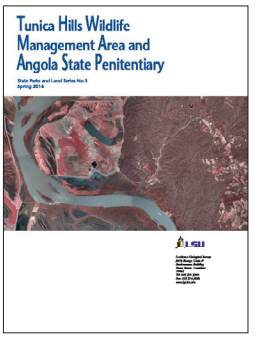
Energy Projects

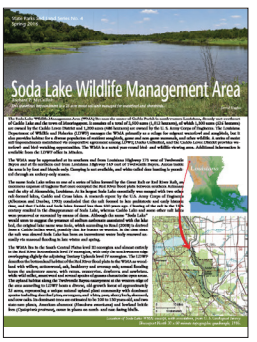
Update and Revision of the 2015 Oil & Gas Map: LGS is currently working on updating the 2015 oil and gas map, expected to be available in digital format by the end of the fiscal year 2016-2017.

Parish Atlas Series: Work on the *Parish Atlas Series*, which started last fiscal year, is on hold at present mainly due to the lack of sufficient staff.

Integrated CCS in the Louisiana Chemical Corridor: LGS researchers participate in the DOE $3.1 million award to the Center for Energy Studies-led research team for the project titled "Integrated CCS in the Louisiana Chemical Corridor," described in the Center for Energy Studies sections of this annual report.







LGS Publications 2016

This year's publications include:

- "Paleoenvironments, Depositional History, and Alternate Reference Sections for the Wilcox Group (Paleocene-Eocene) of Northwest Louisiana-East Texas," by L.N. Glawe and D.E. Bell, 2016
- "Tunica Hills Wildlife Management Area and Angola State Penitentiary," by Richard P. McCulloh
- "Soda Lake Wildlife Management Area," by Richard P. McCulloh
- "Columnar Section of Differentiated Wilcox Group Strata Exposed in Northwest Louisiana," by Richard P. McCulloh, 2016
- "Geologic Mapping Of Natchitoches At 1:100,000 Scale," by Paul Heinrich, Marty Horn, Richard McCulloh, and John Snead.

Near Millerville Road, Baton Rouge, August 2016. (Credit: unknown)

LGS Researcher Studies August 2016 Rain, Flood Events

During the months following August's historic rainfall and flooding events in the Baton Rouge area, Douglas Carlson, assistant professor-research (who was a victim of the flood), researched and authored a paper titled, "Is the Great Rainfall and Flood of August 2016 a 100-Year, 500-Year or 5,000-Year Event?" In it, Carlson reports rainfall and flood data, economic impacts, and property damage.

The flood inundated tens of thousands of homes and 1,000 businesses between August 12 and August 14.

30,000 people were rescued.

The number of people housed in shelters reached 11,000 at one point.

More than 100,000 residents and 5,000 businesses were damaged.

Approximately 30 percent of the homes in Baton Rouge and in eight surrounding parishes were impacted by the flood.

The floods disrupted work for more than 250,000 workers in the Baton Rouge area.

Carlson reports that damage to housing units was approximately equally distributed between East Baton Rouge Parish and Livingston Parish, accounting for approximately 73 percent of all housing units impacted, with lesser amounts in other southern Louisiana parishes. Only 22 percent of homes in Livingston that were impacted by the flood were covered by flood insurance.

More than 1,000 square miles were flooded. The portion of various communities inundated by the August flood in East Baton Rouge Parish varied but was large for all four communities: 81.7 percent of Central, 47.2 percent of Zachary, 45.3 percent of Baker and 27.4 percent of Baton Rouge.

Carlson concludes that the event was a 1,000-year-or-more flood in areas of Livingston and East Baton Rouge Parish north of I-12, but approximately a 100-year flood south of the Interstate. For areas near Lake Maurepas and north of the Louisiana-Mississippi state line, the August flood is a-few-decade event.

Carslon maintains that further development will increase the likelihood of major floods similar to the August 2016 event, citing the increasing rate of major flooding along the Amite River at Denham Springs, which has experienced 15 of the largest 30 floods between 1921 and 1979, and 15 of the largest 30 floods between 1980 to 2016, including the two largest floods in the last 36 years.

The paper is available in the LGS *NewsInsight Online* newsletter at http://lsu.edu/lgs

An example of a flooded business in Denham Springs, Louisiana (heavy.com, 2016).

Note the Quick Stop market included gas pumps which as can be seen from this view are totally under water from the flooding Amite River.

7:35 a.m.

11:04 a.m.

A member of the volunteer "Cajun Navy" transports stranded residents.

LGS Outreach Activities

Earth Science Week

Sponsored Nationwide by the American Geoscience Institute (AGI) and at the request of LGS, Louisiana Governor John Bell Edwards issued a proclamation declaring October 9-15 as Earth Science Week 2016. The week's celebration placed emphasis on energy, paleontology, water quality, conservation and climate change. As in previous years, LGS received 50 educational kits from AGI that were distributed to K-12 school earth science teachers with the assistance of the Louisiana Department of Natural Resources Office of the Public Information Director.

Geologic Mapping Day

In collaboration with the Baton Rouge Geological Society (BRGS) LGS sponsored a Geologic Mapping Day at the East Baton Rouge Parish Bluebonnet Library, where LGS researchers John Snead, Rick McCulloh and Paul Heinrich presented different aspects of geologic map production. The event was open to the public and was very well attended by BRGS members as well as the public. A wall display of quadrangle geologic maps was also done for this event.

Tenth Annual Groundwater Symposium

The Louisiana Geological Survey and the Louisiana Water Research Institute (LSU) organized and hosted the "Groundwater, Surface Water and Water Resources" Symposium on March 24-25, 2016. It was a very well attended symposium (100+) and many LGS staff members were involved in various aspects of the program. Attendees also received educational credits towards the registration requirements of the Louisiana Board of Professional Geoscientists (LBOPG).

Personnel

Administrative Personnel

Chacko J. John, Ph.D., director and state geologist, professor-research

Patrick O'Neill, LGS Publications Sales and Resource Center

Basin Research Energy Section

John Johnston, research associate (retired-part-time)

Brian Harder, research associate

Reed Bourgeois, computer analyst

Geological Mapping & Minerals Mapping Section

Richard McCulloh, research associate

Paul Heinrich, research associate

Water & Environmental Section

Marty Horn, assistant professor-research

Douglas Carlson, assistant professor-research

Riley Milner, research associate

Cartographic Section

John Snead, cartographic manager (retired-part-time)

Lisa Pond, research associate

Robert Paulsell, research associate

R. Hampton Peele, research associate

Staff

Melissa Esnault, administrative coordinator

Jeanne Johnson, accounting technician

Radiation Safety Office

WEI-HSUNG WANG, DIRECTOR
www.radsafety.lsu.edu

LSU delivers quality education and nationally competitive research that contribute to the economic development of the state and the nation. The Radiation Safety Office (RSO), an independent radiological control unit under the direction of the Radiation Safety Committee (RSC), provides regulatory-mandated guidance and support of academic activities in teaching, research, and clinical services involving the use of sources of ionizing and non-ionizing radiation at LSU. The RSO is responsible for developing and implementing radiation compliance policies and procedures as well as ensuring safe practice to not only comply with federal and state regulations and licensing/registration conditions but also assure adequate protection of people, the environment, and the integrity of the University.

The University's radiation protection program is sanctioned in the LSU System's Permanent Memorandum-30 (PM-30): Radiation Protection Program and LSU Policy Statement-99 (PS-99): Radiation Safety Violations, while the LSU System's Safety Procedures for Non-Ionizing Radiation governs the non-ionizing radiation safety program. The RSO directly supports LSU's research programs and thus reports to the Office of Research and Economic Development, with administrative supervision and assistance through the Center for Energy Studies.

In fiscal year 2015-2016, the RSO reviewed and approved 44 grant proposals involving the use of radioactive materials or radiation producing equipment. Funds requested by these proposals were $68,264,864.10. Actual funds granted to LSU were $27,832,702.49. Eight out of the 44 grant proposals are still under review by the funding agencies.

Currently, there are 954 approved radiation workers (including 95 radiation principal investigators) in 183 radiation laboratories with 6,952 annual radiation monitoring devices issued under LSU's radiation protection program including the Agricultural Center, the Pennington Biomedical Research Center, and associated facilities under LSU, such as the Center for Advanced Microstructures and Devices, the National Center for Biomedical Research and Training, and School of Veterinary Medicine. The RSO provides training and monitoring for radiation workers and performs surveys, inspections, survey meter calibrations, leak tests, and radioactive waste management to fully comply with regulatory requirements and licensing/registration conditions. The RSO also evaluates and inspects inventoried Class 3B and Class 4 laser systems for laser intra beam hazards and provides user training. There are 86 active Class 3B and Class 4 laser systems, 107 approved laser users (including 17 laser principal investigators), and 32 laser laboratories.

Construction of a New Radiation Therapy Vault at the School of Veterinary Medicine

A new linear accelerator (LINAC) vault building has been constructed for LSU School of Veterinary Medicine. This building is located on the west side of the existing LINAC vault building. Due to the concern of potential radiation exposure from the operation of the existing LINAC to the construction workers (i.e., non-radiation workers), safety procedures have been developed and implemented. In addition, no elevated radiation exposure was identified based on the measurements of the passive environmental radiation monitoring devices around the edge of the roof. The construction is expected to be completed in March 2017.

Mandatory Security Enhancement through Global Threat Reduction Initiative Support

To provide reasonable assurance of the security of risk-significant radioactive materials in quantities of concern by protecting them from theft or diversion, the U.S. Nuclear Regulatory Commission (NRC) established 10 CFR Part 37-*Physical Protection of Category 1 and Category 2 Quantities of Radioactive Material* on March 19, 2013. Agreement States had three years to issue and implement compatible requirements. Consequently, LDEQ incorporated these federal mandates into Louisiana Administrative Code Title 33, Part XV, in November 2015.

The RSO worked with the Global Threat Reduction Initiative (GTRI) program and secured extramural funds to implement an upgrade of the security control measures. The GTRI program, now the Office of Global Material Security, under the National Nuclear Security Administration of the U.S. Department of Energy, provides security enhancements that are beyond the current U.S. NRC standards. This program fully funds all acceptable recommendations for material and labor (including a three-year warranty of the installation) to radiological facilities for national security efforts. The GTRI Technical Program, Project Management & Planning team was invited to LSU to conduct a site assessment in March 2015. A proposed security enhancement plan was presented and subsequently a Statement of Work and a Sustainability Letter from the GTRI program were prepared for review. In March 2016, the agreement between the GTRI program and LSU was executed. A Professional Services Contract was issued and then recorded in July 2016. The pre-assessment and installation of the security system began in September 2016. This project was expected to be completed by the end of 2016.

RSO technical assistant Gregory Martini conducts a routine survey of an approved radiation laboratory.

RSO technical assistant Blaine Irle (left) and radiation specialist Amin M. Hamideh inspect the content in a dry solid radioactive waste container for proper disposal.

Inspection by the Louisiana Department of Environmental Quality

Radioactive material license and analytical radiation producing equipment inspections were conducted by an inspector from the Louisiana Department of Environmental Quality's (LDEQ's) Radiation Surveillance & Enforcement Section. The inspector examined the policies, procedures, and implementation for Increased Controls and Unescorted Access. He reviewed the records of the National Source Tracking System, escorted access to security zones, a list of Trustworthiness and Reliability Officers, radioactive waste disposal and shipment, inventory and leak tests of sealed radioactive sources, meeting minutes of the Radiation Safety Committee, and training for individuals granted unescorted access. He also inquired about the annual ALARA program review, the administrative limits for occupational radiation exposure, internal violations to LSU's radiological control program, quality assurance/quality control and operation of radio-analytical equipment, the authority of the radiological control program and enforcement, the classification and management for radioactive waste, the consent form for background check, and the alarm drills. In addition, he looked over the procedures for leak tests of sealed radioactive sources, radioactive waste handling, and operation/quality control of radiation counting equipment.

The inspector walked through the radioanalytical laboratories and the radioactive waste storage facilities of the RSO. In addition, he visited 13 radiation laboratories under LSU's radiological control program. During the laboratory visits, he checked the radiation levels, function and calibration of survey meters, posting and barrier requirements, and the Radiation Safety Manual. He also reviewed the inventory and the disbursement logs, the in-laboratory training records, and the in-house radiation laboratory surveys. Furthermore, he questioned the approved radiation workers (e.g., principal investigator, clinical laboratory scientist, technician, and graduate student) about the research protocols involving uses of radiation sources, designated radiation areas, operation and quality assurance/quality control of radioanalytical equipment, physical parameters and safety features of analytical radiation producing equipment, wearing of personal radiation monitoring devices, procedures of ordering and delivering radioactive materials, and practice for radioactive waste labeling/storage/disposal. After the walk-through, an exit interview was held and no areas of concern were listed on the LDEQ's Field Interview Form.

Professional Contributions and Recognitions

Robinson Earns Certified Laser Safety Officer

Jabari Robinson, manager-operations at the RSO, completed all requirements for certification as a Certified Laser Safety Officer (CLSO). Administered by the Board of Laser Safety (BLS), this certification is awarded to individuals who meet educational standards, satisfy professional laser safety experience requirements, and have passed a written examination. This written examination covers nine areas of practice: lasers and optics fundamentals, laser /optical radiation biological effects, non-beam hazards associated with lasers, laser control measures, regulations and standards, hazard evaluation and classification, maximum permissible exposures, laser safety program administration, and laser measurements.

BLS certification is one of the highest credentials a laser safety professional can achieve. It recognizes the individual who has achieved a credible level of knowledge and expertise as well as possesses a higher level of commitment to evaluate laser associated hazards and implement appropriate control measures. This certification demonstrates to the public, colleagues, and employers one's qualifications to manage advanced laser safety issues.

Dr. Ginesse A. Listi (right), director of LSU Forensic Anthropology and Computer Enhancement Services (FACES) Laboratory, assists RSO operations manager Jabari Robinson in conducting an inspection on a diagnostic radiation producing machine which is used to identify humanskeletal remains for forensic cases.

Wang Serves on Certified Laser Safety Officer Review Board

Wei-Hsung Wang, director of the RSO and professor of the Center for Energy Studies, participated on the BLS CLSO Review Board, with the primary objective to revise the BLS CLSO examination to be in compliance with the updated ANSI Z136.1-2014, *American National Standard for Safe Use of Lasers.*

Wang Chair of American Board of Health Physics

Wei-Hsung Wang became Chair of the Part II Panel of Examiners of the American Board of Health Physics (ABHP). As Chair, Wang was responsible for the administration and coordination of question preparation, review, and grading.

Health Physics is the application of diverse scientific principles to the protection of people and environment from the hazards of radiation. Established in 1958, the ABHP is the certification body for the practice of professional health physics and is responsible for determining the qualifications of a Certified Health Physicist. The ABHP certification process is accredited by the Council of Engineering and Scientific Specialty Boards.

Wang Takes Nuclear Tour de France

Wei-Hsung Wang attended the 2016 Technical Tour of the French Nuclear Facilities. The objectives of this tour are (1) to promote and develop exchanges about the status and knowledge of nuclear development and achievements in France and in the U.S. in different technical fields and (2) to continuously enhance the relationship between France and the U.S. in the field of nuclear education and training. This biennial event was organized by the French Section of the American Nuclear Society and the French Nuclear Energy Society and sponsored by ANDRA, AREVA, Electricity of France, and the French Atomic Energy Commission.

Wang and eleven other U.S. university professors of nuclear energy from the Georgia Institute of Technology, Purdue University, Virginia Commonwealth University, University of California Irvine, University of Florida, University of Idaho, University of Tennessee, and University of Wisconsin Madison were selected to participate in this tour. They visited Cadarache Technological Research and Development Center for Energy, the MELOX facility for MOX fuel fabrication, Atalante facility for fuel cycle studies,a large LWR components fabrication plant, a deep underground radioactive waste research laboratory, a fuel reprocessing plant, and the EPR construction site.

Wilson Receives Elda E. Anderson Award

Charles A. Wilson, IV, radiation safety officer of the Center for Advanced Microstructures and Devices (CAMD), received the 2016 Health Physics Society (HPS) Elda E. Anderson Award. This prestigious award is presented each year to an outstanding young member of the HPS for excellence in research or development, discovery or invention, devotion to health physics, and/or other significant contributions to the profession of health physics.

Since 1962, award recipients have excelled in their health physics careers and held significant leadership positions in academia, government agencies, industry, and national and international professional societies.

Wei-Hsung Wang

Scholarly Activities

Grants Awarded

- LSU Faculty Development Program in Health Physics. Newhauser WD, Wilson VL, Matthews II KL, Dismukes DE, Armbrust KL, Wang W-H, US Nuclear Regulatory Commission, Contract # NRC-HQ-84-16-G-0007.
- LSUHSC-NO Radiological Physics for Residents. Matthews II KL, Dey J, Wang W-H, Jia G, LSU-Health Science Center, Contract # 45065-1.

Grant Pending

- Nuclear science and engineering nonproliferation research consortium. Newhauser WD, Wang W-H, Matthews II KL, US Department of Energy.

Publications

- Wilson IV CA, DiGregorio T, Wang W-H. Radiation in pop culture. *Health Phys* 111:S26, 2016.
- Wilson IV CA, Hamideh AM, Wang W-H. Visualizing high order daughters' activities using Wolfram Mathematica. *Health Phys* 111:S85, 2016.
- Steele A, Waggenspack WN, Wilson IV CA, Ikuma L. Baton Rouge Community College/Louisiana State University: A partnership for STEM student success. Paper presented at the ASEE Annual Conference & Exposition, New Orleans, Louisiana. doi: 10.18260/p.26366, 2016.

- Wilson IV CA, Steele A, Waggenspack WN, Gegenheimer JB. Curiosities regarding exam review sessions at LSU's College of Engineering. Paper presented at the ASEE Annual Conference & Exposition, New Orleans, Louisiana. doi: 10.18260/p.26619, 2016.
- Wilson IV CA, Waggenspack WN, Steele A, Gegenheimer JB. The unsubstantiated cutoff: Deeper analysis of supplemental instruction sessions on engineering courses. Paper presented at the ASEE Annual Conference & Exposition, New Orleans, Louisiana. doi: 10.18260/p.27025, 2016.
- Steward JE, Wilson VL, Wang W-H. Evaluation of safety culture at a major public university. J *Chem Health Safety* 23:4-12; 2016.
- Wilson IV CA, Matthews II KL, Pulsipher AG, Wang W-H. Using geographic information systems to determine site suitability for a low-level radioactive waste storage facility. *Health Phys* 110 (Suppl1):S17-S25; 2016.

Grant proposal and journal manuscripts reviewed (by Wei-Hsung Wang)

- Paper NST-2016-0407 "Combining Monte Carlo simulations and dosimetry measurements for process control in the Tunisian cobalt 60 irradiator at the end of source life." Reviewed for Nucl Sci Tech, 2016 (Dongmei Xu, Associate Editor).
- Paper HPJ-D-16-00169 "A useful device for the reduction in interventionalist hand dose." Reviewed for *Health Phys*, 2016 (Kelly Classic, Associate Editor).
- Proposal "The prevalence of methodologies used to counteract insider threat security risks associated with the use of radioactive materials in research and clinical settings." Reviewed for National Institute for Occupational Safety and Health SWCOEH Pilot Projects Research Training Program, 2016 (David I. Douphrate, Director).
- Paper HPJ-D-16-00017 "Radon in the workplace, the Occupational Safety and Health Administration Ionizing Radiation standard." Reviewed for *Health Phys*, 2016 (J. Matthew Barnett, Associate Editor).

CAMD radiation safety officer Charles A. Wilson IV verifies shielding on a Klystron at the LSU J. Bennett Johnston Sr. Center for Advanced Microstructures and Devices.

Staff News

Charles A. Wilson, IV, assumed the position of radiation safety officer at CAMD on April 15, 2016. Wilson received both his master's degree in medical & health physics and bachelor's degree in physics from LSU. As a doctoral candidate in environmental sciences at LSU, Wilson's research investigates the radiological implications of naturally occurring radioactive material. This project includes mathematical coding for visualization and analysis of high-order decay equations with no assumptions of equilibrium, as well as improvement of the methodology for sample collection, preparation, counting, and analysis. These novel approaches optimize the analysis of serial decay chains to all realistic scenarios that historically required improper assumptions and where decayed progenies have not or cannot achieve equilibrium or when equilibrium has been disturbed. In his previous research, Wilson utilized Geographic Information System software to optimize site selection of nuclear facilities. Incorporating graphical and statistical data from multiple sources can more effectively address nuclear concerns. He has authored/co-authored several peer reviewed publications, conference proceedings, and abstracts.

He possesses an abundance of essential operational knowledge of environmental and accelerator health physics as well as effective communication and interpersonal skills. In his current position, Wilson administers a comprehensive radiological control program at CAMD to ensure compliance with university policies as well as state and federal regulations governing the possession, use, registration, transfer, and disposal of sources of radiation.

Personnel

Wei-Hsung Wang, Ph.D., CHP, CSP, CLSO, director

Jabari Robinson, M.S., operations manager & laser safety officer

Amin M. Hamideh, radiation specialist & laser safety officer

Richard E. Teague, RRPT, senior technologist

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