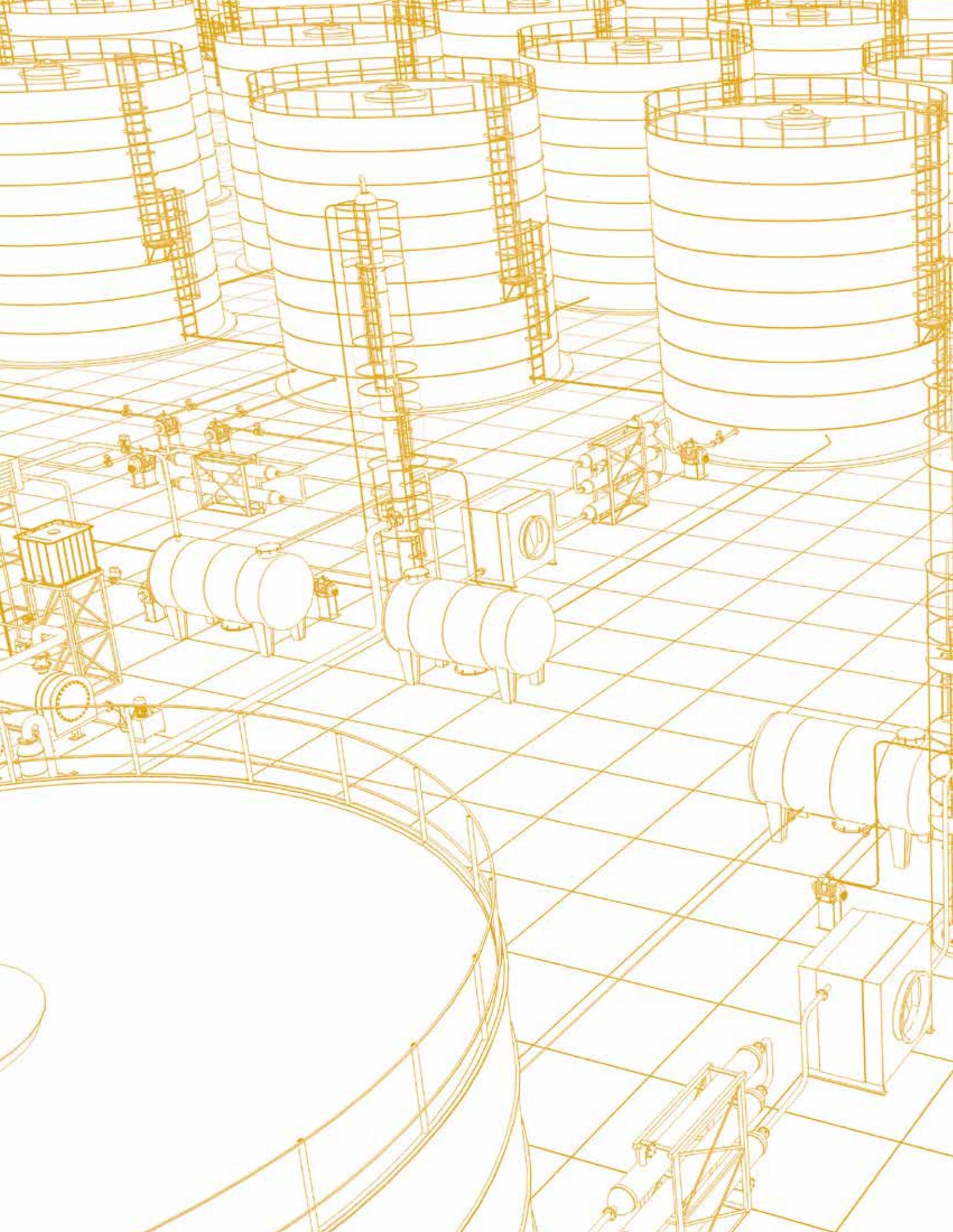




ANNUAL REPORT

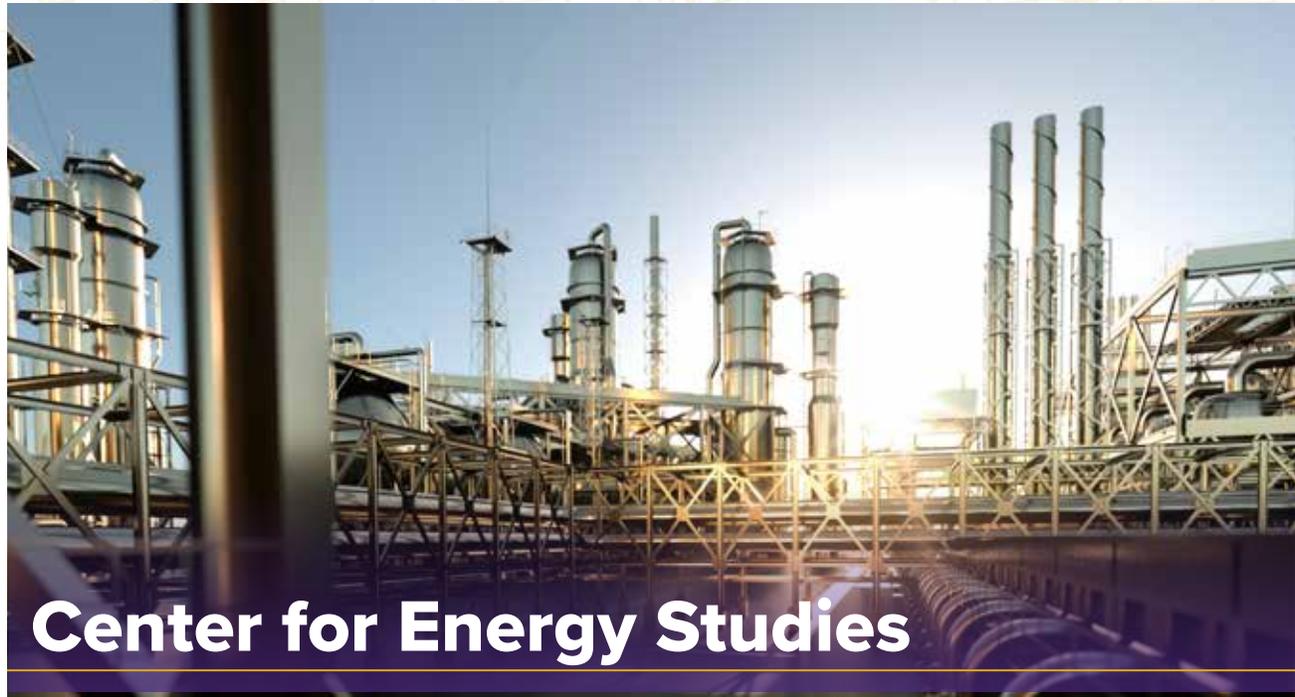
2021



Center for Energy Studies Annual Report 2021

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Center for Energy Studies

David E. Dismukes, Executive Director | lsu.edu/ces

Research Highlights

Center Releases 2022 Gulf Coast Energy Outlook

On November 17, 2021, the LSU Center for Energy Studies released the 2022 edition of the *Gulf Coast Energy Outlook (GCEO)*. As in previous years, this fifth edition of the GCEO provides a comprehensive overview of the Gulf Coast region's energy industry outlook for the upcoming year. David E. Dismukes, executive director and professor, and Greg Upton, associate professor, authored the report.

Last year's *GCEO* addressed COVID-19-related uncertainties and how short-term recovery might evolve. The 2022 *GCEO* addresses several medium-to-longer-term recovery issues, including whether temporary operational adjustments implemented by businesses will persist in a post-pandemic world. The report also considers the impacts of the 2020 and 2021 hurricane seasons.

The Center launched the *Gulf Coast Energy Outlook 2022* with a Zoom webinar, presented by authors Dismukes and Upton. The YouTube video, which includes the presentation, as well as the Q&A session at the end, is available on the CES YouTube channel:

https://www.youtube.com/watch?v=Oxq_lxK55_s



GCEO 2022 findings include

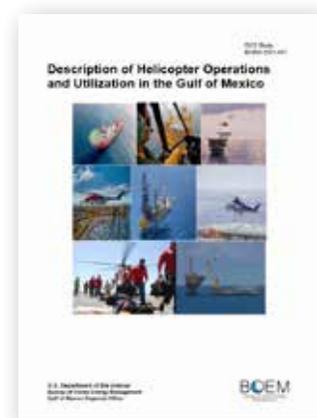
- ▶ U.S. crude oil production is currently below pre-pandemic levels, while natural gas supplies have exceeded pre-pandemic levels. Both oil and gas production are anticipated to increase in the future.
- ▶ Global crude oil demand growth, along with tight supplies and continued OPEC+ discipline, has put upward pressure on oil prices. Oil prices are anticipated to fall in coming years, converging to approximately \$58 per barrel.
- ▶ While decarbonization initiatives may lead to near-term challenges for Gulf Coast industrial expansion, they also create opportunities for continued regional capital investment, as manufacturing industries develop products historically derived from fossil fuels with lower, or net zero, greenhouse gas emissions.
- ▶ Since 2013, U.S. and Gulf Coast power generation-related greenhouse gas emissions are down 20.7 percent and 15.8 percent, respectively, due in part to development of renewable energy and thermal efficiency gains by the region's utilities.
- ▶ The 2022 GCEO identifies \$155 billion in capital development potential through 2029, with liquefied natural gas (LNG) investments making up over 40 percent of this potential. The relative shift in potential capital investments away from chemical industry activities and toward LNG export facilities is expected to continue into the near future.
- ▶ Much like last year, long-run energy demand growth is expected to lead to increased U.S. energy exports, especially to the growing developing world.
- ▶ Texas and Louisiana are anticipated to reach new highs in refining and chemical manufacturing employment over the forecast time horizon, which extends through the end of 2024.



The 2022 GCEO was made possible with sponsorship from Louisiana Mid-Continent Oil & Gas Association, Phillips 66, Entergy, Enverus, Koch, Louisiana Chemical Association, Louisiana Oil & Gas Association, Southwestern Electric Power Company, the Louisiana Department of Natural Resources, TJC Group, Fugro, LLOG, and LLOX.

Faculty Complete BOEM OCS Helicopter Study

CES Associate Professor Gregory B. Upton, Jr., Assistant Professor Cody Nehiba, and Research Associate Sid Narra completed the report “Description of Helicopter Operations and Utilization in the Gulf of Mexico,” an Outer Continental Shelf research project for the Bureau of Ocean Energy Management. The authors estimate the amount of helicopter activity required to support oil and natural gas operations in federal waters in the Gulf of Mexico. Using data from the U.S. Federal Aviation Administration’s novel Next Generation Air Transportation System (NextGen), they track individual helicopters across space and time, matching flight data to offshore activity. The data includes approximately 200,000 helicopter trips that would plausibly support offshore oil and gas operations. The research provides insight into helicopter operations supporting specific offshore activity. Results suggest that, from 2015 to 2019, there were an estimated average 152.5 thousand helicopter trips taken per year to support offshore activity that includes the drilling of exploratory wells, installation of subsea completions, and plugging and abandoning wells.



Nehiba Analyzes Costs, Benefits of Increasing La. Gas Tax

In May 2021, CES Assistant Professor Cody Nehiba authored a white paper that provides a nontechnical guide to the economic benefits and costs of increasing Louisiana's gasoline tax. He considers practical implementation options regarding the tax's equity, revenue usage, and more. Nehiba notes that Louisiana has had the longest-standing gasoline tax in the nation and that there are calls annually to increase the seventh-lowest gasoline tax in the nation to improve road infrastructure, but those calls consistently fail to gain traction. While the state's citizens enjoy the low \$0.20 per gallon tax rate, its benefits are likely offset by the costs of inferior roads, which lead to additional fuel consumption, vehicle damage, congestion, and in some cases, accidents.

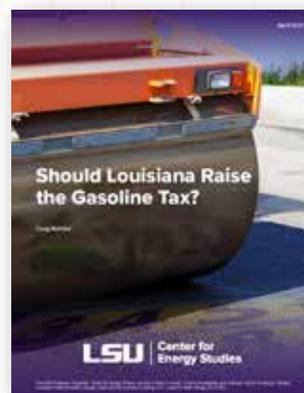
Nehiba notes that gasoline taxes are generally viewed as user fees for roads, funding infrastructure improvements and expansions. Two factors have contributed to the substandard condition of Louisiana's roads: Inflation has reduced the purchasing power of the current per-gallon tax, and more fuel-efficient vehicles mean that our roads experience more vehicle miles driven, with lower gasoline tax revenues per mile collected.

Critics of increased gasoline taxes argue that the tax could be regressive, disproportionately affecting low-income residents; however, Nehiba points to certain policies, such as revenue-recycling schemes, that could offset those tax burdens.

Another issue of concern is that gasoline taxes do not perfectly align with road usage. Nehiba notes that a driver's total tax burden depends on how much fuel they burn, which is not perfectly correlated with the amount they drive and which calls into question the use of gasoline taxes to fund road infrastructure.

One alternative option for funding road infrastructure is a vehicle miles traveled (VMT) tax that charges road users based on how much they actually use roads. VMT taxes have been tested in other states, including Oregon, which has an opt-in VMT tax that allows drivers to replace their gasoline tax charges with a VMT charge. The system allows Oregon to examine the costs and benefits of a VMT tax on a small scale and examine different technology options.

Nehiba notes that Louisiana could benefit from implementing a similar pilot program, potentially getting a "head start" on what might be the future of infrastructure funding.

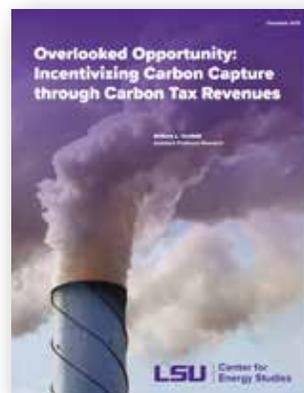


Tarufelli White Paper Details Incentivizing Carbon Capture through Carbon Tax Revenues

A white paper by CES Assistant Professor Brittany Tarufelli reveals an approach that Louisiana can use to decrease the burden of a carbon tax on large industrial CO₂ emitters. Titled "Overlooked Opportunity: Incentivizing Carbon Capture through Carbon Tax Revenues," the paper details how carbon tax revenues can advance Carbon Capture Utilization and Storage (CCUS), a technology that reduces CO₂ emissions.

A carbon tax, which prices CO₂ emissions equal to their environmental damages, is becoming a likely tool for Louisiana and 24 other states as they work to reach net-zero carbon emissions. The white paper reviews the appeal of utilizing carbon tax revenues to fund the research, development, and implementation of CCUS.

Tarufelli notes that policymakers have largely overlooked the possibility of recycling carbon tax revenues to incentivize and reduce the costs of CCUS and points out that this proposition would help emissions-intensive industry and smooth the transition to a lower-carbon economy.



With global energy consumption forecast to grow 50 percent by 2050, and the industrial sector expected to account for roughly half that growth, industry and policymakers are pressed to address the challenges of meeting rising energy demands while reducing CO₂ emissions.

Updated GHG Inventory Key Data Tool for Climate Initiatives Task Force

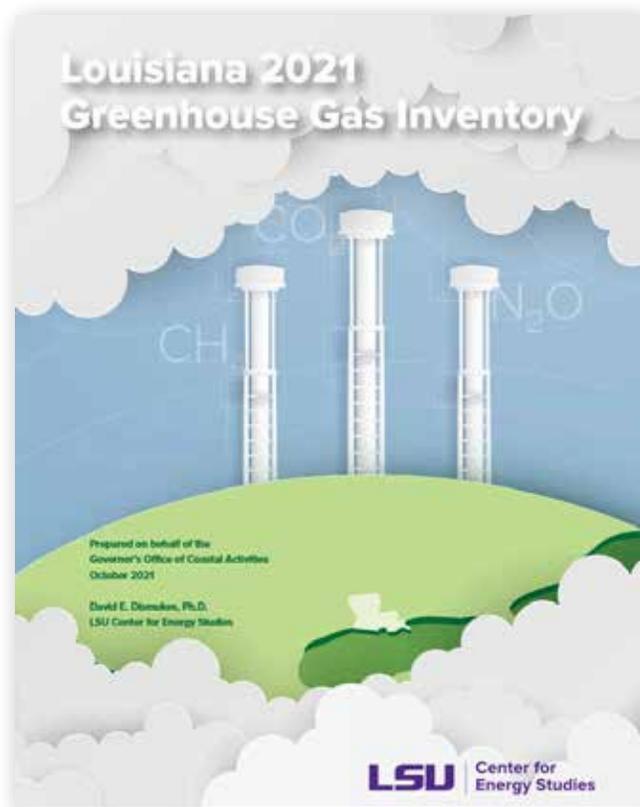
In the *Louisiana 2021 Greenhouse Gas Inventory*, CES Executive Director and Professor David Dismukes provides quantitative estimates of the state's greenhouse gas (GHG) emissions by economic sector. The report, an update of the state GHG inventory conducted by CES in 1997 and 2010, was requested by the Louisiana Governor's Office of Coastal Activities and was produced to serve as a key data tool for the governor's Climate Initiatives Task Force (CTF) as it considered the implications that climate change and greenhouse gas (GHG) emissions have for the Louisiana economy and environment.

For the report, Dismukes uses methodologies and modeling established by the Environmental Protection Agency and follows guidelines set by the Intergovernmental Panel on Climate Change. The "cross-sectional" analysis, or snapshot, in time identifies where each major Louisiana economic sector stands in terms of its GHG emissions. Dismukes describes the inventory estimation process as a "top-down" analysis, as it estimates emissions across broad economic sectors and activities.

Throughout the investigative process, Dismukes worked with the Office of the Governor, various stakeholders, and the CTF Scientific Advisory Group to identify and estimate carbon emission sources and sinks in Louisiana. The report provides estimates of GHG emissions by activity type, economic sector, and GHG pollutant type, and estimates all three across a broad time period, 2000-2018.

Major findings include:

- ▶ Louisiana has a relatively high level of greenhouse gas emissions for its population size and GDP. The state's share of total U.S. GHG emissions has hovered around 4.1 percent to 4.2 percent (1990-2018).
- ▶ U.S. and Louisiana total GHG emissions that arise from the combustion of fossil fuels have been decreasing since 2000.
- ▶ The trend in GHG emissions from the residential and commercial sectors of the Louisiana economy has been relatively consistent since 2000, with the combustion of fossil fuels as the main source.
- ▶ Louisiana's transport-related GHG emission trends have decreased since 2000, likely due to increased vehicle fuel efficiencies, as well as an increase in alternative-fueled vehicles.
- ▶ Louisiana's industrial GHG emissions have steadily increased since 2000, due to the expansion of industrial activity in the state during the past few years.
- ▶ The GHG emission trends from Louisiana's power generation have seen the most improvement of any sector, particularly after 2010.



- ▶ Land use, particularly increasing forest area, can serve as a “sink” for sequestering Louisiana’s carbon emissions. Louisiana’s large forested lands, particularly in the northern part of the state, provide considerable negative emission resources.
- ▶ CO₂ and methane (CH₄) are the two largest pollutants produced by the oil and gas industry. Methane-related emissions have decreased as a result of decreased activity in that sector.
- ▶ Over 92 percent of all Louisiana GHG emissions (as of 2018) are CO₂, with methane accounting for 4.3 percent, and N₂O accounting for 2.13 percent.
- ▶ While U.S. GHG emissions are heavily concentrated in power generation and transportation, Louisiana’s are highly concentrated in industry; therefore, decarbonization of industry must be the predominate focus of attention for Louisiana policy makers in meeting the state’s future GHG emission goals.

Nehiba White Paper Examines Pandemic-related Transportation Trends

The global COVID-19 pandemic shifted, and continues to shift, human behavior in ways that would have been difficult to imagine in 2019. In a white paper, Center for Energy Studies Assistant Professor Cody Nehiba examines the transportation sector to provide valuable insights into the economic and social disruption caused by the pandemic, how we adjusted the way we live and work, and what changes may become permanent. He offers an overview of the dramatic effects of the pandemic on the movement of people and goods, with a focus on Louisiana.



Nehiba finds that as of August 2021, vehicle miles traveled (VMT), which fell almost 40% in April 2020 relative to April 2019, largely recovered. Mileage remained lower than pre-pandemic levels and, though still increasing, might not reach those levels in the near term. While mileage was down from long-run trends, the relatively high level of VMT over the summer of 2021 compared to previous months increased fuel demand and prices. Nehiba reports that the pandemic may have had a long-run effect on fuel consumption, as Americans have begun shifting automobile purchases from light trucks to more fuel efficient automobiles.

Data show that, like vehicle travel, air transportation and tourism numbers were increasing, but remained persistently lower than prior to the pandemic. The rapid increase in air passengers over the summer of 2021 posed challenges for the industry, as flight delays and cancellations propagated throughout the system due in part to employee shortages and work hour restrictions. And finally, freight services appeared to have weathered the pandemic with relatively minor disruption relative to other areas of the transportation sector.

Sponsored Research

Considering a Federal Program to Permanently Plug and Abandon Offshore Oil and Gas Wells. Gregory B. Upton, Jr., Principal Investigator. Columbia University. \$45,000.

Economic Impact Analysis for Koch Industries. David Dismukes, Principal Investigator. Koch Industries. \$37,457.

EMPC Economic Impact Analysis. David Dismukes, Principal Investigator. Exxon Pipeline, \$36,383.

Southeast Regional Carbon Storage Partnership: Offshore Gulf of Mexico. David Dismukes, Principal Investigator. Southern States Energy Board, \$797,678.

Updated Louisiana Greenhouse Gas Inventory and Emissions Analysis for the Governor’s Office on Coastal Activities. David Dismukes, Principal Investigator. Louisiana Office of the Governor, \$65,830.

Publications

Dismukes, David E. "How the Drilling and Permitting moratorium hurts Louisiana's economy and environment." *LOGA Industry Report* (Summer 2021): 28-29.

Dismukes, David E. "Louisiana 2021 Greenhouse Gas Inventory." Prepared on behalf of the Governor's Office of Coastal Activities by the LSU Center for Energy Studies. October 2021.

Dismukes, David E., and Gregory B. Upton. "2022 Gulf Coast Energy Outlook." LSU Center for Energy Studies. LSU White Paper. Fall, 2021.

Dismukes, David E. (with 32 co-authors). "Anticipating and Adapting to the Future Impacts of Climate Change on the Health, Security and Welfare of Low Elevation Coastal Zone (LECZ) Communities in Southeastern USA." *Journal of Marine Science and Engineering* 9(11). November 2021. Article Number 1196.

Iledare, Omowumi O. (with A. Adejola). "Climate Change and the Rising Geopolitics of LNG." Paper presented at the SPE Nigeria Annual International Conference and Exhibition, August 2-4, 2021. Lagos, Nigeria. SPE# 208241-MS.

Iledare, Omowumi O. (with A. Adejola and P. Nnadili). "Data Driven Insights from Nigeria's Natural Gas Data Using PowerBI." Paper presented at the SPE Nigeria Annual International Conference and Exhibition, August 2-4, 2021. Lagos, Nigeria. SPE# 208238-MS.

Iledare, Omowumi O. (with K. Ojukwu, J. Ajiinka, A. Dosunmu, and C. Ibe). "Estimating Fair Market Value of Petroleum Assets in Nigeria: A Risk-based Approach." Paper presented at the SPE Nigeria Annual International Conference and Exhibition, August 2-4, 2021. Lagos, Nigeria. SPE# 207078-MS.

Kaiser, Mark J. "Evaluation of Changes in Expected Ultimate Recovery for U.S. Gulf of Mexico Oil and Gas Fields, 1975-2016." *Natural Resources Research* 30(2): 1229-1252.

Kaiser, Mark J. "A Review of Exploration, Development, and Production Cost Offshore Newfoundland." *Natural Resources Research* 30(2): 1253-1290.

Kaiser, Mark J. "A Review of Onshore and Offshore Pipeline Construction and Decommissioning Cost in the USA – part 1: Specifications, Cost estimation and Onshore Construction." *International Journal of Oil, Gas and Coal Technology* 27(3): 247-285.

Kaiser, Mark J. "A Review of Onshore and Offshore Pipeline Construction and Decommissioning Cost in the USA – Part 2: Offshore and Deepwater Decommissioning Cost Algorithms." *International Journal of Oil, Gas and Coal Technology* 27(4): 363-398.

Kaiser, Mark J. "Tools of the Trade: How to Read a Crude Oil Assay." *Oil, Gas & Energy Quarterly* 69(3): 391-408.

Kaiser, Mark J. "Tools of the Trade: How to Read and Interpret a Crude Oil Assay, Part 2." *Oil, Gas & Energy Quarterly* 70(1): 137-155.

Kaiser, M.J. (with M. Liu). "Cost Factors and Statistical Evaluation of Gas Transmission Pipeline Construction and Compressor-station Cost in the USA, 2014-2019." *International Journal of Oil, Gas and Coal Technology* 26(4): 422-452.

Nehiba, Cody S. "Correcting Heterogeneous Externalities: Evidence from Local Fuel Taxes." *Journal of the Association of Environmental and Resource Economists* (forthcoming).

Nehiba, Cody S. "The Effects of COVID-19 on the Transportation sector in Louisiana: Looking Back and Moving Forward." LSU Center for Energy Studies White Paper. September 2021.

Nehiba, Cody S. "Should Louisiana raise the gasoline tax?" LSU Center for Energy Studies White Paper. April 2021.

Snyder, Brian, David E. Dismukes, and Siddhartha Narra (with V. Gomez). "Use and Limits of Ecosystem Services Valuation in the Gulf of Mexico." New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-006. 90 p.

Taruffelli, Brittany, and David E. Dismukes (with B. Snyder). "The Potential Impact of the U.S. Carbon Capture and Storage Tax expansion on the Economic Feasibility of Industrial Carbon Capture and Storage." *Energy Policy* 149(February).

Upton, Gregory B., Cody S. Nehiba, and Siddhartha Narra. "Description of Helicopter Operations and Utilization in the Gulf of Mexico." New Orleans (LA): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-047. 60 p.

Upton, Gregory B. (with H. Yu). "Labor Demand Shocks and Earnings and Employment Differentials: Evidence from the U.S. Shale Oil & Gas Boom." *Energy Economics* 102(October).

Speaking Engagements

David E. Dismukes

"Natural Gas: Building Gas System Resilience. Overview of the 2021 Polar Vortex and Its Implications for Gas Resiliency." National Association of State Utility Consumer Advocates (NASUCA) virtual mid-year meeting. June 14.

"Opportunities for the Development of a Hydrogen Economy in Louisiana." Louisiana Energy Climate Solutions Workshop, June 18.

"Louisiana 2021 GHG Inventory: Update and Summary of Preliminary Findings." Presentation before the Climate Initiative Task Force. July 29.

"Replacing Natural Gas and Industrial Decarbonization: Utility and Ratemaking Issues." Virtual Joint Annual Meeting: Virginia Committee for Fair Utility Rates, Old Dominion Committee for Fair Utility Rates, and Virginia Industrial Gas Users Group Workshop. September 8.

"State of Energy in Louisiana: A Preview of the 2021 Gulf Coast Energy Outlook." Financial Planning Association of Baton Rouge. November 10.

"Overview of Louisiana's Greenhouse Gas Emissions and Trends." Louisiana Energy Users Group (LEUG) Meeting. November 11.

Gulf Coast Energy Outlook Kickoff Webinar. November 17.

Cody Nehiba

"The Time-of-Day Travel Demand Elasticity Paradox." OSWEET (Online Summer Workshop in Environment, Energy, and Transportation). April 23.

"The Time-of-Day Travel Demand Elasticity Paradox." Association of Environmental and Resource Economists Summer Conference. June 4.

"The Time-of-Day Travel Demand Elasticity Paradox." International Transportation Economics Association Annual Conference. June 24.

"The Time-of-Day Travel Demand Elasticity Paradox." Western Economics Association International Annual Meeting. July 1.

"The Time-of-Day Travel Demand Elasticity Paradox." Southern Economic Association Conference. November 20.

Gregory B. Upton, Jr.

“Electricity Market Restructuring and Retail Rates.” Allied Social Science Association Transportation & Public Utilities Group (coauthor’s presentation). Webinar. January 5.

Baton Rouge 2021 Economic Outlook Virtual Panel Discussion. The Advocate Webinar. Baton Rouge. January 14.

“Electricity Market Restructuring and Retail Rates.” Louisiana State Legislature Joint House Ways & Means/ Senate Revenue & Fiscal Affairs. Baton Rouge. January 26.

“Gulf Coast Energy Outlook.” East Iberville Community Advisory Panel Meeting Webinar. St. Gabriel, LA. January 28.

“What has the U.S. shale oil and gas boom taught us about labor markets?” Podcast. International Association for Energy Economics (IAEE) podcast series. March 25.

“Energy and Economic Update for Louisiana and Gulf Coast Region.” Louisiana Government Finance Officers Association Spring Conference. Baton Rouge. May 7.

“Oil & Gas Induced Economic Fluctuations and Self-Employment.” 5th Annual CEBRA Workshop for Commodities and Macroeconomics, hosted by the Board of Governors of the Federal Reserve System. September 29.

“Gulf Coast Energy Outlook.” Ascension Parish Government. October 14.

Brittany Taruffelli

“Overlooked Opportunity: Incentivizing Carbon Capture through Carbon Tax Revenues.” Alliance for Market Solutions virtual briefing. March 3.

“Toxic Hotspots from Market Design in Regional Climate Policy.” Midwest Economics Association Webinar. March 23.

“Toxic Hotspots from Market Design in Regional Climate Policy.” Association of Environmental and Resource Economists (AERE) Summer Conference. June 2.

“Toxic Hotspots from Market Design in Regional Climate Policy.” International Association for Energy Economics (IAEE). Webinar on Energy, COVID, and Climate Change. June 7-9.

Wei-Hsung Wang

“A Career in Health Physics: Experts in Radiation Protection.” 21st Taiwan Association of Medical Radiation Technologists (TAMRT) Annual Meeting and the 2021 TAMRT International Forum. October 31.

Faculty Highlights

Dismukes Presents Draft GHG Inventory to Climate Initiatives Task Force

On July 29, Center for Energy Studies Executive Director Professor David Dismukes presented a draft of the updated Greenhouse Gas (GHG) Inventory report to a committee of scientists advising Gov. John Bel Edwards' Climate Initiatives Task Force. The report served as a starting point to develop strategies for meeting the governor's emission reduction goals.

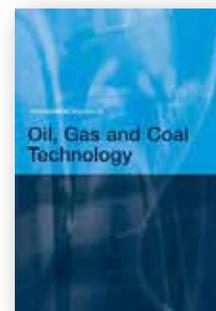
The inventory surveys and provides quantitative estimates of GHG emissions by economic sector using methodologies and modeling established by the Environmental Protection Agency and following guidelines set by the Intergovernmental Panel on Climate Change.



The final version of the 2021 Greenhouse Gas Inventory was released October 28, 2021.

Kaiser Reviews U.S. Pipeline Construction, Decommissioning Cost

In a paper published in the *International Journal of Oil, Gas and Coal Technology*, CES Professor Mark Kaiser examines the cost differences between the construction and decommissioning of offshore and onshore oil and gas pipelines in the U.S. In this first of a two-part review, Kaiser describes the similarities and differences between construction and decommissioning processes and the tradeoffs involved in design that help to explain the cost differences that arise between projects. He provides the basic terminology used in pipeline manufacturing and specifications and outlines the evaluation framework by describing cost estimation procedures, normalization, and data sources.



Upton Provides Dynamic Score Analysis on House Bill

Associate Professor Greg Upton prepared a response to a February 10, 2021, request from Louisiana State Representative Jean-Paul Coussan, chair of the House Committee on Natural Resources and Environment, regarding an independent analysis of the impact of House Bill 57 of the 2021 Regular Session. The response includes a dynamic scoring analysis of the economic impact as a result of the proposed severance tax exemption. The analysis includes taxes, licenses, and fees collected by state government, but not local governments. Analysis is based on the pre-filed version of HB57, filed on March 4, 2021. Both the request letter and response are available online.

Upton Presents Podcast on Labor Markets and the U.S. Shale Oil and Gas Boom

CES Associate Professor Greg Upton prepared a podcast for the International Association for Energy Economics on March 25, 2021. In the podcast, Upton discusses how, over the past decade, the advent of oil and natural gas production from shale geological formations fundamentally changed not only global energy markets but also the communities that reside above these formations. He examines how economists might gain insights from this natural experiment about labor markets and business cycles more broadly. The podcast and transcript are available online at <https://www.lsu.edu/ces/presentations/podcasts/index.php>

Upton Elected to USAEE Council

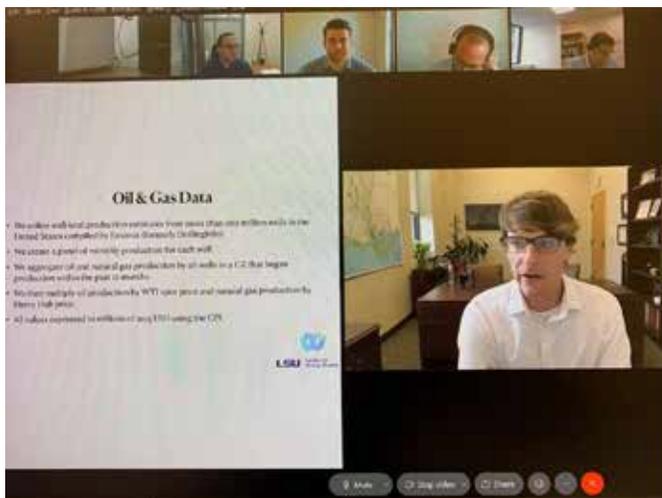
Members of the U.S. Association for Energy Economics (USAEE) have elected CES Associate Professor Gregory B. Upton, Jr., to its 2022 Executive Council. The council, which meets quarterly, guides the strategy and leadership decision making for the organization. USAEE Past President Amy Jaffe nominated Upton for position of council member at large.

The USAEE, the largest affiliate of the International Association for Energy Economics, provides a forum for the exchange of ideas, experience, and issues among professionals interested in energy economics. Neither a lobbying organization nor an advocacy group, the policy-neutral USAEE focuses on advancing the understanding and application of economics across all facets of energy development and use.



Upton's term began January 1, 2022.

Events & Outreach



Associate Professor Greg Upton presents at the **5th Annual Central Bank Research Association Workshop for Commodities and Macroeconomics**, hosted by the Board of Governors of the Federal Reserve System. Upton discussed his paper, coauthored with LSU Professor of Economics Bulent Unel, "Oil & Gas Induced Economic Fluctuations and Self-Employment."

CES Faculty Take Energy Education on the Road, Online

Throughout 2021, the Center's faculty presented research in person and remotely on topics ranging from the Gulf Coast Energy Outlook (for both 2021 and 2022), Louisiana's greenhouse gas emissions and trends, how drivers respond to fuel costs across the hours of the day, electricity market restructuring and retail rates, health physics careers, and more. Several presentations are available upon request.

CES, LMOGA Workshop Addresses La. Energy Climate Solutions

On June 15, the Center for Energy Studies and the Louisiana Mid-Continent Oil and Gas Association hosted the Louisiana Energy Climate Solutions Workshop. The event provided an opportunity for industry and other stakeholders to discuss climate solutions, including carbon capture, utilization and storage, and hydrogen technologies in Louisiana. More than 150 attended the hybrid in-person/virtual event.

The morning sessions addressed investments in methane reduction (Daniel Palmer, OGCI), responsibly-sourced natural gas (Roy Hartstein, Responsible Energy Solutions), current U.S. federal carbon capture and storage policies (Matt Bright, Global CCS Institute), and offshore (Heath Nevels, GHD) and land-based (Melissa Baustian, The Water Institute of the Gulf) CO2 sequestration considerations.

Secretary Tom Harris, Louisiana Department of Natural Resources, and Jason Lanclos, Director, State Energy Office, provided a “Louisiana Update.”

Afternoon sessions focused on Louisiana H2 opportunities (Chris Arges, LSU, Department of Chemical Engineering), technical knowledge gaps involving the midstream (Frank Frey, Principal/Vice President, Engineering Solutions, GHD) and downstream (John Flake, LSU, Dept. of Chemical Engineering) sectors, as well as public education and acceptance of H2 innovations (David Dismukes, LSU Center for Energy Studies).

Follow-up workshops would consider additional new strategies for Louisiana, including the possible leveraging of coastal restoration as a carbon sink for Louisiana (i.e., “blue carbon”).



Coauthors Present Market Restructuring Paper

In July, CES Associate Professor Greg Upton and Assistant Professor Brittany Tarufelli, along with Ken Rose, Associate Teaching Professor at DePaul University and a Senior Fellow with the Institute of Public Utilities (IPC) at Michigan State University, presented their paper, “Electricity Market Restructuring and Retail Rates” for an International Association for Energy Economics webinar. In June, the coauthors also presented their paper via webinar as part of IPC’s Friday Forum series.

The paper examines the effect of restructuring on electricity prices to final consumers. Findings show that “retail rates in restructured states are more responsive to natural gas price changes... and natural gas prices nationally increased in the post-restructuring era.”



Upton (left), Tarufelli, and Agerton (bottom) discuss market restructuring research during an online forum in July.

U.K. Science and Innovation Network Head Talks Clean Energy Opportunities

In July, Associate Professor Greg Upton welcomed the British Consulate-General Houston Head of Science and Innovation Network Lauren George to discuss potential collaboration opportunities between the U.K., LSU, and Gulf Coast industry regarding clean energy goals. George scheduled the visit during a two-week tour of Louisiana.

Upton provided George with informational resources from CES and LSU, including the Gulf Coast Energy Outlook and the Louisiana Economic Outlook, as well as leads on potential Gulf of Mexico wind developments that could transition the state’s historical oil and gas workforce to supporting offshore wind.



Upton meets with British Consulate-General Houston Head of Science and Innovation Network Lauren George.

CES in the News

Throughout 2021, commentary and expert analysis by Center for Energy Studies faculty, as well as references to their published research, appeared in more than 100 local, regional, national, and international news outlets. As has been the case for the past five years, the *Gulf Coast Energy Outlook (GCEO)* was referenced in several news items. Stories that included GCEO findings appeared in *The Advocate*, NOLA.com, *Daily Advertiser*, *Natural Gas Intelligence*, the *Greater Baton Rouge Business Report*, and WWL Radio First News.

Outlets looked to Executive Director and Professor David Dismukes at least once per month in 2021, starting early in the new year with news of President Biden's ban on new federal leases and his administration's climate change initiative. Dismukes was interviewed by the *Greater Baton Rouge Business Report*, *The Advocate*, NOLA.com, and LSU's Tiger TV, and he appeared on a panel addressing renewables on Louisiana Public Broadcasting's Louisiana Public Square. High gasoline prices prompted the Louisiana Radio Network and several other state outlets to speak with Dismukes during the summer, as did the release of the Center's updated Greenhouse Gas Inventory.

Associate Professor Greg Upton was contacted throughout the year by several outlets to discuss developing energy news stories. *The Advocate*, NOLA.com, the Center Square, *Energy Intelligence*, WWNO Public Radio, and a Korean radio program broadcasting from Seoul sought his insights on topics ranging from the U.S. Strategic Petroleum Reserve release, to blue hydrogen, to rising gasoline prices. Upton also made regular appearances throughout the year on WWL Radio's First News with Tommy Tucker to discuss current energy topics, including oil and gas industry impacts from the extended freezing weather in February and the blockage of the Suez Canal, Hurricane Ida recovery, abandoned wells in the Gulf of Mexico, the closing of the Belle Chasse refinery, liquefied natural gas in Louisiana, and the future of renewable energy.

After Hurricane Ida devastated parts of southeast Louisiana in late August, the *Christian Science Monitor*, ABC News, and several local news agencies contacted both Dismukes and Upton regarding energy infrastructure resilience and refinery outages.

In March, Assistant Professor Cody Nehiba's research on Louisiana's gasoline tax, and the possible benefits of funding roadway repair and maintenance with a vehicle miles traveled tax, caught the attention of a civil engineering publication. In August, an interview Nehiba gave on the impact of natural disasters on home ownership appeared on (at least) eight television news affiliates throughout the country. In September, *Forbes* interviewed Nehiba on whether and how telematics devices in vehicles could alleviate certain transportation problems, such as pollution, congestion, and accidents. Nehiba was also quoted in a *Real Estate Weekly* article on energy savings and smart thermostats, and *Business & Industry Magazine* shared news of his white paper on the effects of COVID-19 on the transportation sector.



Throughout 2021, commentary, expert analysis, and references to published research by Center for Energy Studies faculty appeared **in more than 90 local, regional, national, and international news outlets.**

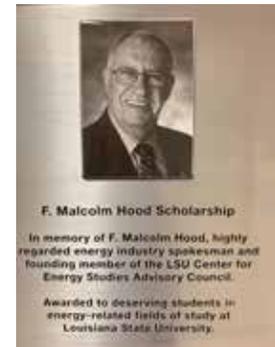
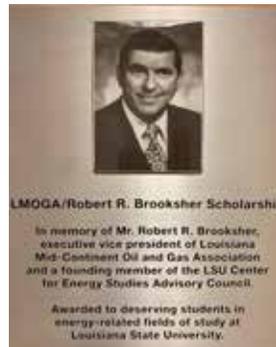
In February, Assistant Professor Brittany Taruffelli's white paper on carbon tax revenues garnered attention from the *10112 Industry Report*. Taruffelli was also interviewed on renewable energy opportunities in several state television and print outlets.

The Center's "In the News" webpage includes a full list of articles and appearances, with links.

lsu.edu/ces/inthenewsarchive.php#a2021

Scholarship Update

CES awarded no scholarships in 2021 as it transitioned to LSU's new online scholarship application and award system, Blackbaud Award Management. Blackbaud enables LSU students to search for and apply to available opportunities funded through the LSU Foundation. Both the LMOGA/Robert R. Brooksher Scholarship and the F. Malcolm Hood Scholarship are available via Blackbaud. Using myLSU credentials, students can apply at www.lsu.edu/scholarships. Awards will resume in 2022.



Personnel

Administration

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

Diana Reynolds, assistant to the executive director

Marybeth Pinsonneault, communications manager

Division of Policy Analysis

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

Mike McDaniel, Ph.D., professional-in-residence (retired)

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

Cody S. Nehiba, Ph.D., assistant professor

Brittany L. Taruffelli, Ph.D., assistant professor

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

Omwumi (Wumi) Iledare, Ph.D., Professor Emeritus, director of the CES 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 director of the Emerald Energy Institute, University of Port Harcourt, Nigeria.

Ric Pincomb, research associate

Stacy Retherford, computer analyst

Mike Surman, IT adviser



Minerals Processing

Minerals Processing Research Division

Ralph Pike, Director | **F. Carl Knopf, Co-Director** | lsu.edu/mpri

One of 31 State Mineral Institutes associated with the U.S. Department of the Interior, the Minerals Processing Research Division (MPRD) of the Center for Energy Studies, established in 1979 by federal legislation, facilitates research and public service programs in process research and technology transfer, sustainable development, energy management, and inherently safer design. MPRD's minerals processing research and public service efforts complement, and benefit from, the energy research performed by the Center for Energy Studies.

Throughout the year 2021, MPRD continued research on industrial energy conservation, with sustained efforts in data reconciliation, heat exchanger network synthesis, and the utilization of captured carbon dioxide to produce value-added chemicals. Collaborative research with the Department of Chemical Engineering focused on catalytic depolymerization and upcycling of mixed plastic wastes for sustainable plastics recycling. Researchers continued to evaluate forecasting methods for effective technology to converting carbon dioxide into products that are economically and environmentally safe.

Current Research

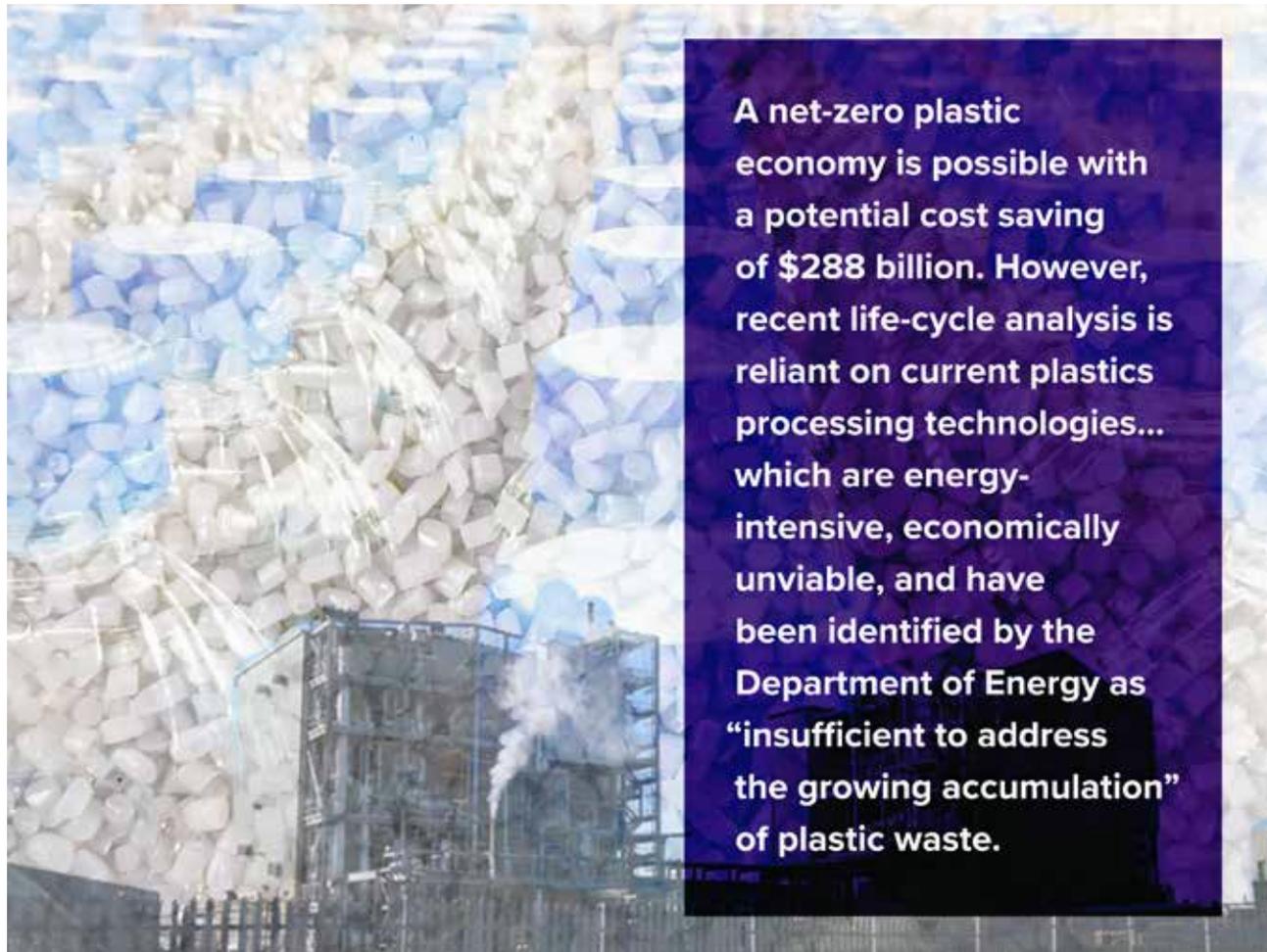
MPRD Develops Training Modules to Evaluate Heat Exchanger Network Operability

The Minerals Processing Research Division has contributed to industrial energy conservation with sustained efforts in data reconciliation, heat exchanger network synthesis, and the utilization of captured carbon dioxide to produce value-added chemicals. The data reconciliation and heat exchanger network synthesis work has focused on reducing heat exchanger capital costs and plantwide utility requirements. This

was generally accomplished using design conditions or a single plant data set that had been reduced by data reconciliation. However, things as simple as heat exchange or catalyst fouling, or as complex as changing feedstocks and changing product demands, all impact the developed energy recovery network. In energy-intensive industries, the energy recovery designs are often complex, which can create operability and control issues as these process changes occur.

By utilizing the collection of large-scale data and subsequent data reconciliation over a range of processing conditions it is possible to evaluate the existing heat exchanger network for operability. As needed, the network can be improved via a combination approach using the dynamics and control features in Aspen Plus and Aspen HYSYS guided by optimization. Optimization suggests potential design changes, but the simulation features in Aspen are used to confirm the robustness of any changes over a wide range of potential processing conditions.

Aspen simulations are the industry standard, which lends credence to this approach. The difficulty here is Aspen dynamics and control are generally not taught at universities, and training engineers is both time consuming and expensive. The Minerals Processing Research Division is developing modules that specifically show how Aspen dynamics and control can be used to confirm operability over varying processing conditions.



MPRD, Chemical Engineering Research Catalytic Role of Induction Heating in Sustainable Plastics Recycling

The development of plastics over the past half century has led to rapid technological advances; however, the long-term negative environmental impacts of these materials compel new depolymerization and upcycling strategies. Since the 1950s, plastic production has increased by ~6 million metric tons (MMt) annually, generating 110 MMt annually (~75 lbs of plastic per person per year), with over 5 MMt of ethylene, styrene, and propylene monomers produced within 25 miles of Louisiana State University. Of the plastics produced, only 7 percent have been recycled to date, with the remaining waste plastics being discarded or incinerated. The production of plastics is expected to increase such that it consumes 20 percent of the global oil supply by 2050. Additionally, plastics production is expected to claim 15 percent of the annual greenhouse gas allotments necessary to limit the 1.5°C global temperature increase.

While current policies and infrastructure investments are geared toward the petrochemical industry, it has been shown that a net-zero plastic economy is possible with a potential cost saving of \$288 billion. However, recent life-cycle analysis is reliant on current plastics processing technologies, specifically pyrolysis to naphtha followed by steam or high-pressure hydrocracking, both of which are energy-intensive, economically unviable, and have been identified by the Department of Energy as “insufficient to address the growing accumulation” of plastic waste.

Recently, researchers with the MPRD and the LSU Cain Department of Chemical Engineering have demonstrated that induction heating methods break down plastics over industrially relevant catalysts, such as certain modified zeolites, thereby generating high concentrations of alkene/alkane hydrocarbons, with narrow product distributions. Induction heating depolymerization offers several benefits over traditional thermal catalysis, in particular, a large interface/bulk temperature gradient and the inhibition of some secondary reactions.

The main findings from this work to date are:

1. The addition of Sn to Pt/zeolite catalysts enhances catalyst activity and greatly affects the selectivity in LDPE depolymerization, leading to more diesel-range hydrocarbon product.
2. The surprisingly high activity of zeolite catalyst Pt/K-SSZ-13.

We have partly explained (2) on the basis of its strong interaction with LDPE polymer chains but need more characterization of this material to fully understand it. As for (1), PtSn in medium-pore zeolites is a well-known dehydrogenation catalyst (while Pt-zeolites are somewhat more selective to cracking), and we suspect that the PtSn catalysts may be dehydrogenating the polymer initially, generating double bonds that then depolymerize through a b-cracking mechanism.

The expected outcome of this project is the production of tunable hybrid plastics, containing both polyolefinic and bio-polymer components, which can be generated from mixed plastic waste streams without costly separation processes or expensive solvents using energy efficient induction heating-driven reactions.

MPRD funds are being used to support chemical engineering graduate student Bernard Whajah on the project. Undergraduate Joseph Heil, who has also worked on the project, receives National Science Foundation funding.

CO₂, CH₄ Projection Research Leads to Evaluation of Forecasting Methods

MPRD faculty are researching methods for projecting amounts and purity of carbon dioxide and methane released from chemical plants and petroleum refineries over decades. These projections will provide information to develop effective technology for converting carbon dioxide into products that are economically and environmentally safe. The research has led the team to evaluate forecasting methods used in the past

regarding the carrying capacity of the earth, depletion of fossil fuels, sustainable development, and global warming. The following is a summary of their findings as of January 2022.

Carrying Capacity of the Earth: A 1968 conference called the Club of Rome was organized by the scientific institution Accademia dei Lincei. The Club of Rome conference's first report, "The Limits to Growth," suggested that economic growth could not continue indefinitely because of resource depletion. The study used the World3 computer model to simulate the consequence of interactions between the earth and human systems. The model was based on the work of Jay Forrester of MIT as described in his book *World Dynamics*. This computer model, the World3 or Meadows model, had 1,000 and subsequent models had 200,000 equations.

This "Limits to Growth" report concluded that, without substantial changes in resource consumption, the most probable result would be a rather sudden and uncontrollable decline in both population and industrial capacity. Although its methods and premises were challenged, subsequent work to validate its forecasts continue to confirm that insufficient changes have been made since 1972 to significantly alter their nature.

Futures Studies, Future Research or Futurology: The endeavors of the Club of Rome are an example of futures studies (or future research or futurology), which attempts to gain a holistic or systemic view based on insights from a range of different disciplines, focusing on social, technological, economic, environmental and political (STEEP) issues. Most strategic planning, which develops goals and objectives with time horizons of one-to-three years, is not considered futures. Plans and strategies with longer time horizons that specifically attempt to anticipate possible future events are definitely part of the field. As a rule, futures studies are generally concerned with changes of transformative impact, rather than those of an incremental or narrow scope.

Corporations and government agencies utilize foresight products to both better understand potential risks and prepare for potential opportunities as an anticipatory approach. Government agencies publish material for internal stakeholders as well as make that material available to broader public. Examples of this include the U.S. Congressional Budget Office long term budget projections, the National Intelligence Center, and the United Kingdom Government Office for Science. Much of this material is used by policy makers to inform policy decisions and government agencies to develop long-term plan. Corporations, particularly those with long product development lifecycles, utilize foresight and future studies in the development of their business strategies.

The Good Judgment Project (GJP) at the University of Pennsylvania was sponsored by the Intelligence Advanced Research Projects Activity (IARPA) and conducted competition among forecasting teams over a period of four years gathering over one million judgements about the future. Very high-skilled super-forecasters were identified, and their abilities analyzed. The results are documented in the book by Tetlock and Gardner, 2015, *Superforecasting: The Art and Science of Prediction*. This project was part of a much larger research effort sponsored by IARPA to support daring research that promises to make American intelligence better at what it does.

Depletion of Fossil Fuel: Marion King Hubbert was an American geologist and geophysicist who worked at the Shell research lab in Houston, Texas. Hubbert assumed that after fossil fuel reserves (oil reserves, coal reserves, and natural gas reserves) are discovered, production at first increases approximately exponentially. As more extraction continues, and more efficient facilities are installed, a peak output is reached, and production begins declining until it approximates an exponential decline. The rate of petroleum production tends to follow a bell-shaped curve.

The Hubbert peak theory is based on the observation that the amount of oil under the ground in any region is finite, and production increases, reaches a maximum, and declines over time. In the U.S., oil production has generally followed the discovery curve after a time lag of 32 to 35 years. Hubbert's upper-bound estimate, which he regarded as optimistic, accurately predicted that U.S. oil production would peak in 1970, although

the actual peak was 17 percent higher than Hubbert's curve. Production declined, as Hubbert had predicted, and stayed within 10 percent of Hubbert's predicted value from 1974 through 1994. With the development of fracking (hydraulic fracturing) in the 2010s, actual production has been significantly greater than the Hubbert curve. The development of new technologies has provided access to large quantities of unconventional resources, and the additional reserves available for production has changed the parameters Hubbert's prediction but not invalidated it.

Although Hubbert's peak theory received the most attention in relation to peak oil production, it has also been applied to other natural resources. Hubbert also predicted that natural gas production would follow a logistic curve similar to that of oil, and it did through 1990 with additional production from fracking causing a production increase rather than decline.

Sustainable Development: Sustainable development, as defined in *Our Common Future*, also known as the Brundtland Report, is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." *Our Common Future* was the culmination of a "900-day" international exercise that catalogued, analyzed, and synthesized written submissions and expert testimony from "senior government representatives, scientists and experts, research institutes, industrialists, representatives of non-governmental organizations, and the general public" from public hearings throughout the world. Key contributions of *Our Common Future* to the concept of sustainable development include the recognition that the many crises facing the planet are interlocking crises that are elements of a single crisis of the whole and of the vital need for the active participation of all sectors of society in consultation and decisions relating to sustainable development.

As the concept of sustainable development developed, it has shifted its focus more towards the economic development, social development, and environmental protection for future generations. The United Nations Sustainable Development Goals (2015-2030) address the global challenges, including poverty, inequality, climate change, environmental degradation, peace, and justice.

Total Cost Assessment: Total Cost Assessment (TCA) is a methodology developed by chemical and petroleum refining industry professionals that was sponsored by the American Institute of Chemical Engineers in 2000 and extended in 2007. TCA is a decision-making tool that monetizes environmental and sustainable costs and sustainable credits to be comparable with raw material costs, manufacturing costs, sales, and taxes. It provides economic information for corporate decisions. The TCA methodology identifies five types of costs including economic, environmental, and societal costs. These costs are described in detail in the *AICHE Total Cost Assessment Manual*. Dow Chemical, Monsanto, GlaxoSmithKline, and Eastman Chemical are industrial companies that have applied TCA methodology. Total Cost Assessment serves as the basis for the triple bottom line evaluation, where the five types of costs are combined into economic, environmental, and sustainable costs and extended to sustainable credits. This methodology served as the basis for selecting the triple bottom-line profit equation for the economic model in this research, Integrating Bioprocesses into Industrial Complexes for Sustainable Development.

All of the results from this research are included in "Integrating Bioprocesses into Industrial Complexes for Sustainable Development" and the 2012 book *Chemicals from Biomass: Integrating Bioprocesses into Chemical Production Complexes for Sustainable Development* by Sengupta and Pike.

Climate Change and Decarbonization: According to the Intergovernmental Panel on Climate Change (IPCC)'s 2019 "Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems," temperatures have risen about twice as fast as the global average. Deserts are expanding, while heat waves and wildfires are said to be becoming more common. Increased warming in the Arctic has contributed to melting

permafrost, glacial retreat, and sea ice loss. Higher temperatures are also causing more intense storms and other weather extremes. Rapid environmental change in mountains, coral reefs, and the Arctic is forcing many species to relocate or become extinct. Climate change threatens people with food and water scarcity, increased flooding, extreme heat, more disease, and economic loss. Human migration and conflict can be a result.

The International Energy Agency report, “Net Zero by 2050: A Roadmap for the Global Energy Sector, 2021,” describes a mainstream trend using future studies. The roadmap describes how the energy sector transformation in the net energy zero (NZE) occurs against the backdrop of large increases in the world’s population and economy. In 2020, there were around 7.8 billion people in the world; this is projected to increase by around 750 million by 2030 and by nearly 2 billion people by 2050 in line with the median variant of the United Nations projections (UNDESA, 2019). Nearly all of the population increase is in emerging market and developing economies: the population of Africa alone increases by more than 1.1 billion between 2020 and 2050. By 2030, the world’s economy is around 45% larger than in 2020, and by 2050 it is more than twice as large. A broad range of energy policies and accompanying measures are introduced across all regions to reduce emissions in the NZE. This includes renewable fuel mandates; efficiency standards; market reforms; research, development, and deployment; and the elimination of inefficient fossil fuel subsidies. Direct emissions reduction regulations are also needed in some cases. In the transport sector, for example, regulations are implemented to reduce sales of internal combustion engine vehicles and increase the use of liquid biofuels and synthetic fuels in aviation and shipping, as well as measures to ensure that low oil prices do not lead to an increase in consumption. CO₂ prices are introduced across all regions in the NZE. They are assumed to be introduced in the immediate future across all advanced economies for the electricity generation, industry, and energy production sectors, and to rise on average to USD 130 per tonne (tCO₂) by 2030 and to USD 250/tCO₂ by 2050. A number of areas in transport and industry in which it is difficult to eliminate emissions entirely – such as aviation and heavy industry – and both sectors have a small level of residual emissions in 2050.

Two books published in 2020 by reputable and knowledgeable authors refute many of the actions described in the above International Energy Agency report. These are: *Apocalypse Never: Why Environmental Alarmism Hurts Us All*, by Michael Shellenberger, and *False Alarm: How Climate Change Panic Costs Us Trillions, Hurts the Poor, and Fails to Fix the Planet*, by Bjorn Lomborg. Shellenberger argues that carbon emissions peaked and have been declining in most developed nations for over a decade. Deaths from extreme weather, even in poor nations, declined 80 percent over the last four decades. The risk of Earth warming to very high temperatures is increasingly unlikely thanks to slowing population growth and abundant natural gas. Lomborg argues that world leaders have committed to wildly expensive but largely ineffective policies that hamper growth and crowd out more pressing investments in human capital, from immunization to education. This book is said to point the way toward making the world a vastly better, if slightly warmer, place for all.

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- Tetlock, P. E. and D. Gardner, *Superforecasting: The Art and Science of Prediction*, Crown, Publishers, ISBN 9780804136693, 2015.
- Sengupta, D. and R. W. Pike, *Chemicals from Biomass: Integrating Bioprocesses into Chemical Production Complexes for Sustainable Development*, CRC Press, Boca Raton, FL, 2012.
- Shellenberger, Michael, *Apocalypse Never: Why Environmental Alarmism Hurts Us All*, Harper; Illustrated edition (June 30, 2020), ISBN-13: 978-0063001695.
- Lomborg, Bjorn *False Alarm: How Climate Change Panic Costs Us Trillions, Hurts the Poor, and Fails to Fix the Planet*, Basic Books; Illustrated edition (July 14, 2020), ISBN-13: 978-1541647466.

On-Line Research, Publications and Programs

Continuous Renewable Energy Generation with Lithium-Ion Battery Storage on the Micro Grid, 180 pages, (2020), ISBN-10: 9798670042307, The book is available both in print and e-book. Kindle Direct Publishing ASIN: B08DSZ2YTH print edition, ASIN: B08P3X7KVM electronic edition for \$39.00.

Essentials of Optimization for Chemical Engineering, 500 pages (2019), now available on Amazon/Kindle, has chapters on analytical methods, LP, SVS, NLP, MILP, MINLP, GO, On-Line (Real-Time) Optimization, GP, DP and CofV. The book is available both in print and e-book, ASIN: 1645700968 print editions, ASIN: B07ZWNFMWC e-book edition for \$29.00.

A companion book, *Essentials of Economic Decision Analysis for Chemical Engineering*, 200 pages (2015) is also available on Amazon Kindle in print (\$8.95) and e-book (\$2.99).

The content of the MPRD web site www.mpri.lsu.edu is continually being updated with new research results including journal articles, conference proceeding, technical reports, theses, dissertations, and computer programs.

Two programs that can give immediate and substantial energy savings for chemical plants and refineries are "pinch technology" and "on-line optimization." Large companies have corporate level groups that routinely apply pinch technology and on-line optimization. Small to medium sized chemical companies in Louisiana do not have the trained personnel needed to apply this technology. Two short courses on these topics are available by request by contacting the Division at www.mpri.lsu.edu.

The MPRD web site also includes professional development, self-study courses for professional engineers' PDH requirements.

Personnel

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

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

Kerry Dooley, Ph.D., research collaborator, BASF Professor of Chemical Engineering

Bernard Whajah, chemical engineering graduate student

Joseph Heil, chemical engineering undergraduate student



Radiation Safety

Wei-Hsung Wang, Director | lsu.edu/radiation-safety

The LSU Radiation Safety Office (RSO), which reports through the Center for Energy Studies to the Office of Research and Economic Development, is a unique, independent, and vital academic unit. The RSO directly supports and also actively engages in research, teaching, and clinical activities involving the use of sources of ionizing and non-ionizing radiation at LSU. Under the direction of the interdepartmental University Radiation Safety Committee (RSC), the RSO is in charge of developing and implementing radiological control policies and procedures, as well as ensuring sound safe practice to not only comply with federal/state regulations and license/registration conditions but also assure adequate protection of people, the environment, and the integrity of the University. The LSU System's broad-scope Radioactive Material License issued by the Louisiana Department of Environmental Quality (LDEQ) allows the University maximum flexibility to accomplish legitimate and realistic education objectives through the effective and efficient operation of a regulatory-mandated radiation protection program carried out by the RSO. Administrative authorization for the radiation protection program from the University is stipulated in the LSU System's Permanent Memorandum No. 30 (PM-30): *Radiation Protection Program*. Enforcement actions for radiation safety violations are authorized under the LSU Policy Statement 99 (PS-99): *Radiation Safety Violations*. In addition, the LSU System's *Safety Procedures for Non-Ionizing Radiation* governs the non-ionizing radiation safety program.

In fiscal year 2020-2021, the RSO reviewed and approved 81 grant proposals involving the use of radioactive materials, radiation producing equipment, or Class 3B and Class 4 laser systems. Funds requested by these proposals were \$57,105,998. Actual funds granted to LSU were \$2,739,684. Twenty-three out of the 81 grant proposals are still under review by the funding agencies. Currently, there are 986 approved radiation workers (including 77 radiation principal investigators) in 166 radiation laboratories with 5,988 annual radiation monitoring devices issued under the LSU's radiation protection program. The program covers the Agricultural Center and its research stations, the Pennington Biomedical Research Center (PBRC), and associated facilities under LSU, such as the Center for Advanced Microstructures and Devices (CAMD), the National Center for Biomedical Research and Training (NCBRT), and the School of Veterinary Medicine

(SVM). The RSO provides training and monitoring for radiation workers and performs routine surveys, inspections, survey meter calibrations (85 meters of different types), leak tests, and radioactive waste management to fully meet regulatory requirements and license/registration specifications. In addition, the RSO evaluates and inspects inventoried Class 3B and Class 4 laser systems for laser intrabeam hazards and provides laser safety training. There are 85 active Class 3B and Class 4 laser systems, 66 approved laser users (including 15 laser principal investigators), and 41 laser laboratories.

Louisiana Department of Environmental Quality Conducts Inspections

There were three compliance and enforcement inspections conducted by the LDEQ's Emergency and Radiological Services Division/Radiation Section in 2021. In March, two inspectors visited the RSO and carried out inspections of the broad-scope radioactive material license, the physical protection of category 1 and category 2 quantities of radioactive material (PPQRM), and the diagnostic radiation producing equipment at LSU. The inspectors reviewed the records of designated Reviewing Officials, individuals granted unescorted access, and policy, program, and procedure requirements under PPQRM regulations [e.g., maintenance/service/repair as well as alarm drill/testing of surveillance equipment, review of security and access authorization programs, refresher training, protection of physical and sensitive information, pre-arranged plan with the local law enforcement agency (LLEA), and an annual meeting with the LLEA], the National Source Tracking System, membership and meeting minutes of the RSC, organization chart of the RSO, preparation, disposal, and shipment of radioactive waste, inventory and leak tests of sealed radioactive sources, frequency of the leak tests, personnel and environmental radiation monitoring, ordering, receiving, and delivering of sources of radiation, review/approval/renewal/deactivation of authorization to use sources of radiation, and radiation survey meters. They also inquired about impacts of the COVID-19 pandemic on the radiological control programs, which had been operated as usual since day one of the campus closure on March 19, 2020, point of contact at the LLEA, annual radiological control and ALARA programs review, administrative limits for occupational radiation exposure, release of liquid radioactive waste, current status of approved radiation principal investigators, radiation workers, personal radiation monitoring devices, and radiation laboratories, deactivation of approved radiation principal investigators, investigation of elevated personal exposure, quality assurance/quality control and operation of radioanalytical equipment, functions and applications of the Health Physics Assistant database management software, authority of LSU's radiological control program and enforcement (i.e., PM-30 and PS-99), appeal process for enforcement actions, and handling of legacy sources. In addition, the inspectors looked over LSU's radioactive



Ji Young Wiley, CAMD radiation safety officer of the RSO, gives annual radiation safety refresher training to CAMD users.

sources of radiation, and radiation survey meters. They also inquired about impacts of the COVID-19 pandemic on the radiological control programs, which had been operated as usual since day one of the campus closure on March 19, 2020, point of contact at the LLEA, annual radiological control and ALARA programs review, administrative limits for occupational radiation exposure, release of liquid radioactive waste, current status of approved radiation principal investigators, radiation workers, personal radiation monitoring devices, and radiation laboratories, deactivation of approved radiation principal investigators, investigation of elevated personal exposure, quality assurance/quality control and operation of radioanalytical equipment, functions and applications of the Health Physics Assistant database management software, authority of LSU's radiological control program and enforcement (i.e., PM-30 and PS-99), appeal process for enforcement actions, and handling of legacy sources. In addition, the inspectors looked over LSU's radioactive

material license, the Radiation Safety Manual, the radiation laboratory close-out procedures, the radioactive waste management process, and the emergency procedures for radiation spills.

The inspectors walked through the radioactive package receiving area, the radioactive material storage area, three radioanalytical laboratories, the radioactive waste storage facilities, and the PPQRM security zones of the RSO. They also conducted an alarm drill at the Nuclear Science Building to observe the response by the LLEA and interview the responding LSU police officers regarding the response plans and training. They visited additional 18 radiation laboratories under LSU's radiation protection program. During the laboratory visits, they checked the inventoried source location, the radiation levels, the function and calibration of in-laboratory



Amin M. Hamideh, manager-operation of the RSO, and Nicholas T. Desselles, radiation safety coordinator of the RSO, conduct a survey to locate radioactive contaminants.

survey meters, the posting and barrier requirements, the storage of radioactive waste, and the *Radiation Safety Manual*. They also reviewed the source inventory and disbursement logs, the annual in-laboratory training records, the in-laboratory radiation surveys, and the functions of the fume hoods. In addition, the lead inspector observed and questioned the approved radiation workers (e.g., faculty members, laboratory manager, clinical technologist, and graduate students) about the research/clinical protocols involving uses of radiation sources, the designated radiation areas, the wearing of personal radiation monitoring devices, the patient workload and release limits, the operation and quality assurance/quality control of radioanalytical and radiotherapeutic equipment, the physical operational parameters and safety features of diagnostic radiation producing equipment, the procedures of ordering, receiving, and storage of radioactive materials, and the 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.

License and Contract Renewals

Radioactive Material License Renewed

The previous system-wide Radioactive Material License expired on May 31, 2021. In close collaboration with LSU Health Sciences Centers New Orleans and Shreveport, the RSO submitted the renewal application packet (295 pages) to LDEQ for review and approval. The Radioactive Material License was successfully renewed and will expire in 2026.

In accordance with the Radioactive Material License renewal, the *Radiation Safety Manual* was also revised. The updated *Radiation Safety Manual* now meets the federal requirements for digital resource and content accessibility and is available online. A hard copy of the revised Radiation Safety Manual has also been distributed to each radiation principal investigator.

Renewal of Radioactive Waste Disposal and Radiation Dosimetry Services

The contract for disposal of low-level radioactive waste materials expired on June 30, 2021. A solicitation packet was prepared by the RSO, and it was submitted to LSU Office of Procurement Services for a bid. After review of the bid results, the radioactive waste disposal contract was awarded to Bionomics, Inc. and a purchase order was issued.

The radiation dosimetry service provided by Landauer ended on June 30, 2021. LSU Office of Procurement Services allowed this term contract to be extended for an additional year. Landauer had been providing consistent quality services and there appeared to be no net or practical benefits in changing the vendor. This contract was approved for renewal for another fiscal year.

Memo of Radiation Safety Practice

With regard to prior regulatory inspections and Radioactive Material License renewal with the LDEQ as well as Liaison Information Report by the Federal Bureau of Investigation, a memo was sent to all authorized radiation principal investigators and other relevant parties to address critical compliance requirements and update the radiological control operation. The purpose of this memo is to review and emphasize certain essential issues concerning the use of sources of radiation under the LSU System's broad-scope Radioactive Material License, the LDEQ's Registration Certificates, the LSU's Radiological Control Program specifications, the applicable federal and state regulations, and the relevant University policies and procedures in order to avoid any violations and public embarrassment to the University. These issues consist of the responsibility and authority of the radiation users and the RSO, enforcement of violations, radiation use applications, training, radionuclide orders and disbursement, radioactive waste handling, transfer, shipment, storage, and accountability of radioactive materials, registration of radiation producing equipment, personal radiation exposure monitoring, requirements for in-laboratory surveys, radiation user fees, essential radiation protection practice, recordkeeping, and moving, transferring, and surplussing of radiation equipment.



RSO technical assistant Hamza Fahd swipes the external surface of a dry radioactive waste box to ensure compliance with regulatory requirements for transportation and disposal.

Professional Contributions and Recognitions

Wang American Board of Health Physics Chair

Dr. Wei-Hsung Wang, RSO director and Center for Energy Studies professor, served as the chair of the American Board of Health Physics (ABHP) for 2021. Wang was installed as a board member of the ABHP in 2019 and served as the vice chair in 2020. The ABHP grants professional certification in the field of health physics. The certification process is accredited by the Council of Engineering and Scientific Specialty Boards.



American Board of Health Physics

The ABHP board included eight members from Mirion Technologies, Inc., the U.S. Environmental Protection Agency, the U.S. Nuclear Regulatory Commission, Worcester Polytechnic Institute, and Y-12 National Security Complex. Wang's term as a board member ends in 2023.

Health physics, usually referred to as the science of radiation protection, is a profession devoted to protecting people and their environment from potential radiation hazards, while maximizing the benefits to mankind from the uses of radiation and radioactive materials. Health Physics is an interdisciplinary science that combines the elements of physics, biology, chemistry, geology, engineering, and statistics to evaluate and enhance practices involving radiation producing machines and radioactive materials with the goal of optimizing system performance with regard to human health and safety, societal-economic impacts, and stewardship of the environment.

Wang appointed to the U.S. Environmental Protection Agency Science Advisory Board

Dr. Wei-Hsung Wang, RSO director and Center for Energy Studies professor, was invited to serve on the U.S. Environmental Protection Agency (EPA) Science Advisory Board (SAB) and the Radiation Advisory Committee by EPA Administrator Michael E. Regan. The SAB is composed of 22 women and 25 men, including 16 people of color, making it the most diverse SAB since its creation.



The SAB is a chartered Federal Advisory Committee, established in 1978, under the authority of the Environmental Research, Development and Demonstration Authorization Act, to provide independent scientific and technical peer review, consultation, advice, and recommendations to the EPA Administrator. Members of the SAB constitute a distinguished body of non-EPA scientists, engineers, and economists who are nationally and internationally recognized experts in their respective fields.

The EPA's request for nominations to the SAB in April 2021 garnered significant public interest and resulted in 352 candidates with a cross-section of scientific disciplines and experience seeking membership on the SAB. Wang was one of 47 selected members, who represented academia, government agencies, non-governmental organizations, and private industry.

Wang Presents at Radiation Safety Conferences

Professor Wei-Hsung Wang coauthored an oral presentation on "Evaluating release criteria for feline patients following radioactive iodine treatment for hyperthyroidism" at the 66th Annual Meeting of the Health Physics Society, in Phoenix in July.

The meeting provided an opportunity for a reunion of current and past LSU Radiation Safety professionals, including (L-R) Wang, LSU radiation safety manager Amin M. Hamideh, University of Missouri deputy radiation safety officer Charles A. Wilson IV (former LSU CAMD radiation safety officer), and Sandia National Laboratory health physicist/radiological engineer Andrew D. Hastings (former LSU CAMD acting radiation safety officer).



Wei-Hsung Wang, Amin M. Hamideh, Charles A. Wilson IV, and Andrew D. Hastings

Wang was also invited to give a prerecorded presentation on “Health physics education and certification in the United States” at the 6th International Symposium on Radiation Education, in Taipei, Taiwan, in June.

Earlier in the year, Wang coauthored two abstracts for the 15th International Congress of the International Radiation Protection Association. He presented on “Assessment of radiation exposure of healthcare workers from patients receiving nuclear medicine procedures,” and “Radioactivity-induced charging: Theory and measurements.”

Scholarly Activities

Grants Submitted

By Wei-Hsung Wang

- ▶ Removal of radionuclides in aqueous environments. Consultant, Louisiana Board of Regents; requested amount: \$210,965 (2022-2025).
- ▶ LSU nuclear multidisciplinary scholarship program. Investigator, U.S. Nuclear Regulatory Commission; requested amount: \$199,998 (2022-2024).

Publications and Presentations

- ▶ Wang W-H. A Career in health physics: Experts in radiation protection (invited pre-recorded video presentation). The 21st Taiwan Association of Medical Radiation Technologists (TAMRT) Annual Meeting and 2021 TAMRT International Forum, October 31, Kaohsiung, Taiwan, 2021.
- ▶ Davila AR, Fletcher JM, Matthews II KL, Wang W-H. Evaluating release criteria for feline patients following radioactive iodine treatment for hyperthyroidism. The 66th Annual Meeting of the Health Physics Society, July 25-29, Phoenix, AZ, 2021.

Journal Manuscripts Reviewed

By Wei-Hsung Wang

- ▶ Paper HPJ-D-21-00113 “Reassessing lead protective garments assessment: Modern approach using ICRP 103”. Reviewed for *Health Phys*, 2021 (David C. Medich, Associate Editor).
- ▶ Paper PNUCENE-D-21-00185 “HEPA filter age evaluation and estimate of nominal lifetime in nuclear facilities”. Reviewed for *Prog Nucl Energy*, 2021 (Malcolm Joyce, Editor).

Personnel News

- ▶ Mr. Li-Yen Chen, an assistant researcher at Taiwan’s Institute of Nuclear Energy Research and a doctoral candidate in health physics at National Tsing Hua University, joined the RSO on August 01, 2021, as a visiting scholar. Mr. Chen is an experienced health physicist in radiation dosimetry. He actively participated in educational and cultural programs at LSU upon his arrival. Dr. Wei-Hsung Wang served as Mr. Chen’s academic advisor and supervised his scholarly research for the period of August 2021 through July 2022.
- ▶ Dr. Ginesse A. Listi, Director of LSU Forensic Anthropology and Computer Enhancement Services Laboratory and a faculty member in the Department of Geography and Anthropology, was recommended unanimously by the RSC to



Dr. Ginesse A. Listi

become a member of the RSC. Dr. Listi is an authorized radiation principal investigator and possesses proficient working knowledge and experience in the areas of radiation producing equipment and radiation safety. Per LSU PM-30, Dr. Listi's appointment was officially confirmed by LSU President William F. Tate IV, with the approval of Dr. Dennis Paul, Chair of the LSU System RSC.



RSO staff: Amin M. Hamideh, Dr. Kenneth L. Matthews II, Melissa H. Esnault, Li-Yen Chen, Nicholas T. Desselles, Ji Young Wiley, and Dr. Wei-Hsung Wang on the steps of the LSU Nuclear Science Building.

Personnel

Administration

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

Amin M. Hamideh, M.S., CLSO, manager-operations & laser safety officer

Nicholas T. Desselles, M.S., radiation safety coordinator & laser safety officer

Ji Young Wiley, M.S., CAMD radiation safety officer

Melissa H. Esnault, business officer

L. Abbigail Granger, D.V.M., LSU SVM liaison

Christy L. White, D.V.M., PBRC liaison

Technical Assistants

Lily Antor

Adam Curet

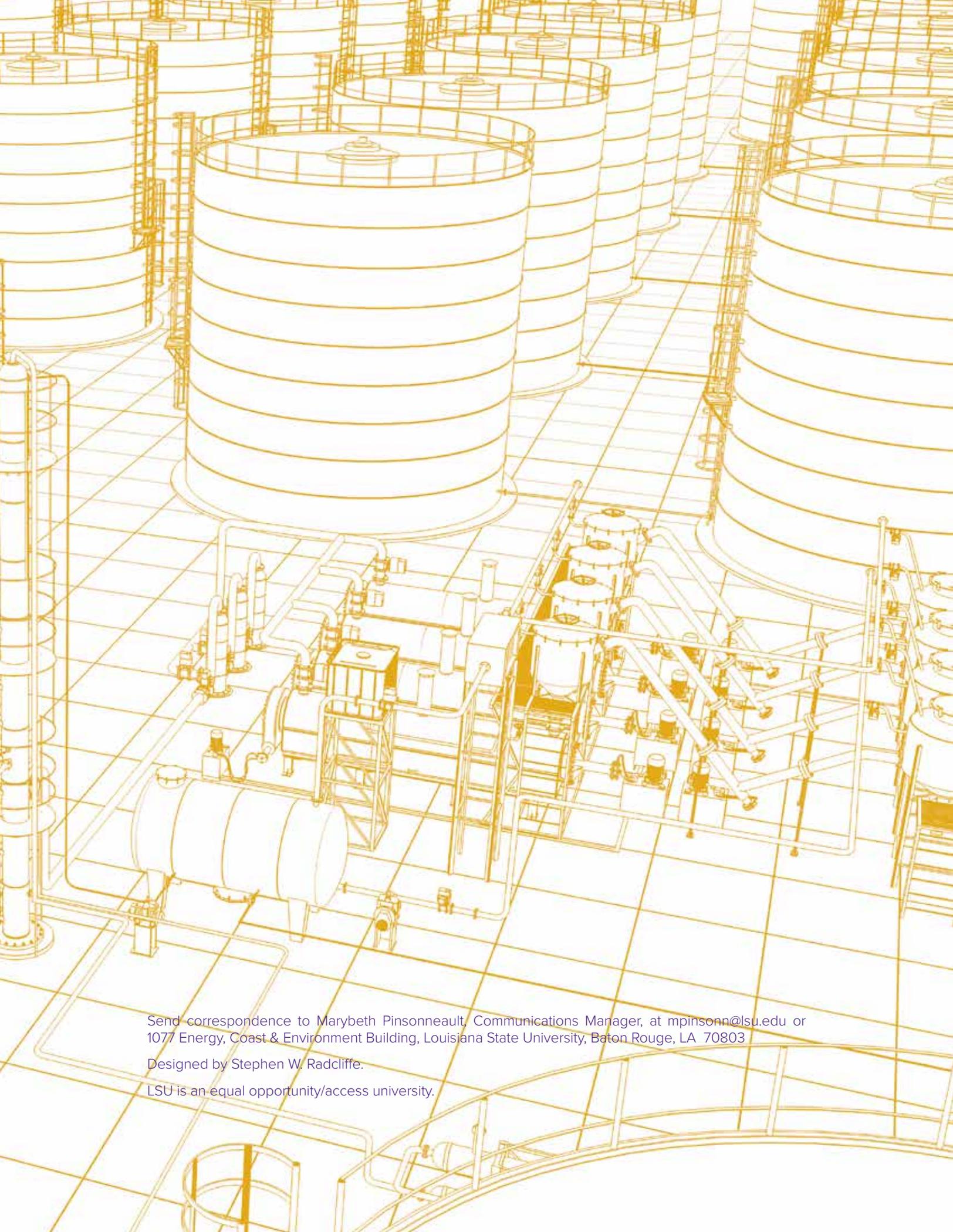
Hamza Fahd

Issac Sanchez

Yangyang Xu

Visiting Scholar

Li-Yen Chen



Send correspondence to Marybeth Pinsonneault, Communications Manager, at mpinsonn@lsu.edu or 1077 Energy, Coast & Environment Building, Louisiana State University, Baton Rouge, LA 70803

Designed by Stephen W. Radcliffe.

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