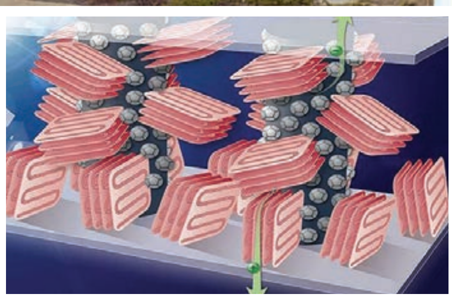
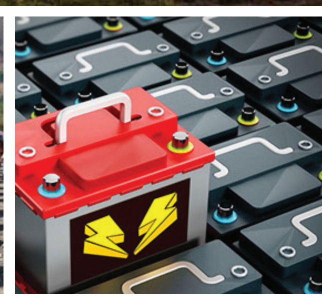
ADVANCED ENERGY RESEARCH AND TECHNOLOGY CENTER™
RESEARCH PROJECTS

INNOVATION AND EXPLORATION
2022



ADVANCED ENERGY™
Research and Technology Center
AT STONY BROOK UNIVERSITY

www.aertc.org

NEW YORK STATE OF OPPORTUNITY. | Division of Science, Technology & Innovation

ADVANCED ENERGY RESEARCH AND TECHNOLOGY CENTER™

INNOVATION AND EXPLORATION

Emerging technologies and cutting-edge research. Microgrids and smart buildings. Offshore wind and geothermal power. Modern utility grids and alternative fuel vehicles. Today, entrepreneurs, researchers, and engineers are developing bold new advances in energy that will change the industry, and the world, forever. After decades of research and development in renewables, batteries, and other new technologies, the drive toward the development and adoption of cleaner, more sustainable energy is rapidly accelerating – not a moment too soon.

The recent devastation wreaked by Mother Nature across the United States has had a tremendous impact on human lives, the economy, and the environment. From the destruction caused by flooding in Texas to Hurricanes Irma and Maria ravaging Florida and Puerto Rico, these disasters exposed the sweeping changes the energy industry must make to ad-dress aging energy infrastructures. The need to rebuild – not just using existing technology, but with state-of-the-art advancements – was never more critical than now.

The Advanced Energy Research and Technology Center™ (AERTC), a NYS Center of Excellence located at Stony Brook University (SBU), partnering with a number of institutions including Brookhaven National Laboratory (BNL), City University of New York, SUNY Farmingdale, NYU-Tandon School of Engineering, and the New York Institute of Technology (among others), represents a unique opportunity to take a national lead in the development of clean technology, alternative and renewable energy technologies, as well as smart grid and energy conservation. Investigators at SBU and BNL have embarked on cutting edge research across a broad spectrum of these new opportunities with the theme of "reliable, affordable, and environmentally sound energy for America's future." This publication describes currently funded research programs and projects on a wide variety of advanced energy topics that will impact America's future, all focused on developing new technologies and driving innovation to ensure the future of energy is always on the cutting edge of industry and research.

As diverse as these efforts are, an overarching theme is the application of nanoscience and nanotechnology to overcome critical barriers. New properties being discovered in familiar materials present many scientific questions, but they also offer the promise of new, more efficient and cost-effective solutions, which are explored at the AERTC within the state-of-the-art Thermomechanical and Imaging Nanoscale Characterization (ThINC) user facility. Advanced Energy Research and Technology Center™ projects involve new generations of students, imbuing them with the knowledge, skills, and awareness of the broader societal implications and economics of energy research and supplies the growing national demand for energy-centric science and engineering graduates. Stony Brook University is consistently listed among the top universities in the world and has among its faculty recipients of both the National Medal of Science and the National Medal of Innovation and Technology and leads the 64-campus SUNY system in earning competitively-awarded federal research funds. BNL has a history of outstanding scientific achievement that spans more than six decades and led to seven Nobel Prizes. Its leadership role is achieved by positioning the BNL's user facilities: the National Synchrotron Light Source II (NSLS-II), Relativistic Heavy Ion Collider (RHIC) and the Center for Functional Nanomaterials (CFN) – in continued leadership positions working in teams with universities and industries. Both Stony Brook University and Brookhaven National Laboratory have long been the SUNY leader in technology transfer, whether measured by licensing fees, invention disclosures, issued patents, or executed licenses. The campuses have a "cradle to Fortune 500" suite of economic development programs, from R&D collaboration to the nurturing of new enterprises with its incubator programs and facilities. The projects described here are a modest representation of the depth and breadth of our commitment to the research disciplines that bear on energy research. Much more needs to be done and our faculty colleagues and industry partners are rising to these challenges. We invite you to join us!

Robert B. Catell

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ABOUT THE AERTC

The AERTC engages with energy-based institutes, laboratories, and programs throughout the country. Our LEED platinum facility at the Stony Brook Research and Development Park supports major research and training centers: Advanced Energy Training Institute (AETI), Center for Integrated Electrical Energy Storage (CIEES), Center for Mesoscale Transport Properties (m2m), Institute for Gas Innovation and Technology (GIT), New York Energy Policy Institute (NYEPI), New York State Center for Clean Water Technology (CCWT), NYSERDA's Clean Energy Business Incubation Program (CEBIP), National Offshore Wind Research and Development Consortium, and Thermomechanical & Imaging Nanoscale Characterization (ThINC). Each of these centers harnesses an expert team of researchers, educators and investigators dedicated to pursuing advanced energy solutions. As the founding organization of the New York State Smart Grid Consortium (NYSSGC), we also work closely with the NYSSGC in bringing together business and government leaders, policy makers and researchers in developing innovative programs to deploy smart-grid technology.

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As of 1/1/19

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ADVANCED ENERGY™ TRAINING INSTITUTE AT STONY BROOK UNIVERSITY

ADVANCED ENERGY TRAINING INSTITUTE

Ms. Patricia Malone

Stony Brook University, Center for Corporate Education (CCE), brings its expertise in professional and industry certification to the Advanced Energy Training Institute (AETI) which includes new and innovative programs in energy and sustainability, ranging from sustainable project and business management skills to green building, energy efficiency, power and smart power. Working with core partners, such as the U.S. Green Building Council (USGBC, USGBC-LI, and the Advanced Energy Center partners including NYSERDA, PSEG, NYPA, National Grid, IBM and others, the Advanced Energy Training Institute is identifying new credentialing venues, linking and clustering certification programs, conducting focus groups and engaging statewide agencies and partners to create a platform for honest credential brokering in sustainability and smart energy.

PROGRAM SAMPLING:

LEED Training

Leadership in Energy and Environmental Design (LEED) Breen Building Rating system, developed by the US Green Building Council (USGBC) provides a suite of standards for environmentally sustainable construction. LEED certification is the nationally accepted benchmark for the design, construction and operation of high performance buildings.

LEED Accreditation (GA & AP)

LEED Green Associate (GA) Exam Preparation course prepares participants for the rigors of the LEED GA Exam. LEED GA is the first step in becoming a LEED Accredited Professional (AP). LEED AP Exam Preparation course is also offered.

Leadership

The STEM fields are central to tackling the world's most complex problems, from global challenges, to economic efficiency, to reducing air pollution – the possibilities are endless. CCE Leadership programs teach building high performance teams, organizational culture, the human dynamics of leading and how to manage conflict. Courses include: Leadership Certificate; Women in STEM Leadership Program.

Project Management and Business Analysis

Project Management and Business Analysis program enrich skills that promote project efficiency, tighter cost and time management, enhanced communication of objectives and better use of human resources. Business Analysis

Quality and Continuous Improvement/ Lean/Six Sigma

For businesses looking to create a competitive advantage, CCE provides a blueprint to lean transformation and the attainment of operational excellence. By applying these continuous improvement principles, businesses can achieve greater efficiency and profitability. Companies learn how to improve their operations with a systematic focus on customer needs, quality improvement, and waste elimination, while empowering your employees and fostering faster throughput. Courses include: Introduction to Continuous Improvement, Certified Lean Professional, Certified Six Sigma Green Belt and Black Belt; ISO; Internal Auditing.

Management/Professional Development

The role of an effective manager/ supervisor is to get each employee working to her or her maximum potential. CCE course help develop the skills of top managers. Courses include: Supervisory Skills/Managerial Effectiveness, Customer First Culture, Cybersecurity, Team Building.

CORE INSTITUTION

Stony Brook University

Smart Grid Workshops

The smart grid promises to increase the efficiency of today's electric system and save billions of kilowatt-hours each year. The Smart Grid applies information technology, tools and techniques so the grid runs more efficiently. The current electric grid is inefficient for meeting today's demands. When customers know how much energy they use, usage will reduce. Today's demands on energy created the need for alternative solutions to our electric system which is over a century old. Upgrades are necessary to traditional power plants – Smart Grid will increase energy efficiency in a smart, lower-carbon way!

- Security Issues in the Smart Grid
- Educate and Incentivize Consumers to Save Energy
- Smart Grid Modeling
- Wireless Networking for Smart Grid
- Smart Grid Optimization – How The Grid Becomes Smart
- Visualization of Smart Meter Data
- Business Opportunities in Smart Grid Security
- Wireless Networking for the Smart Grid

FUNDING

Stony Brook University

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IIBA

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U.S. Green Building Council Chapter LONG ISLAND

CENTER FOR INTEGRATED ELECTRIC ENERGY SYSTEMS

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Dr. James Misewich
CIEES Team Leader

Dr. Benjamin S. Hsiao
Executive Director

Center for Integrated Electric Energy Systems (CIEES) is NY Center for Advanced Technology (CAT). CIEES is supporting industry-academia projects with NY companies, addressing technologies ranging from synthetic fuels to additive manufacturing and energy storage. All of these activities shared one common goal: realizing our vision of Long Island as the 'Valley' of renewable energy and smart grid. During disruptions caused by COVID-19, CIEES clients quickly adapted to the new reality and continued to operate, generating 57 new jobs, and retaining 48 jobs over 2019-2021. $17,689,773 of economic impact was recognized by CIEES industry partners between July 1, 2019 and June 30, 2021.

In addition, during the reporting period of July 1, 2020 and December 31, 2021, CIEES research programs generated 13 new technology disclosures, which were filed with the University Intellectual Property Partners office; and seven new patent applications were filed by the University during the reporting period on CIEES research program technologies. During the reporting period from July 1, 2020 and December 31, 2021, 13 new federal and non-profit grants totaling approximately $2,028,171 were received by CIEES faculty in support of CIEES research projects. Several companies, such as StorEn Technologies and ThermoLift accomplished significant business expansion. After CIEES team successfully completed testing the StorEn vanadium flow battery, the company was able to raise $1,069,000 in private funding, which allowed to start development of a large-scale battery for wind farms. This development is especially welcome on Eastern Long Island, which is experiencing unprecedented penetration of wind power from off-shore wind farms in the Block island area. On May 18 2020, ThermoLift Inc. received $426,500 for the demonstration of an advanced natural gas-driven heat pump and air conditioner in Canada.

The Center continued expanding its technical capabilities in microgrid and energy storage. Specifically, the center secured two U.S. NAVY projects, "Robust and Intelligent Integration of Micro-Grids to Improve Isolated Site Resilience" and "Management system for microgrid-tied kV-class supercapacitor units". The projects are focused on development of energy storage and energy management products for microgrids by utilizing the latest advances in broad-band communication technologies. The projects involves NY companies, such as Unique Technical Services, Shirley, NY (battery and grid management), BrenTronics, Commack, NY (Li-ion grid-tied storage) and Iouxus, Oneonta, NY (supercapacitive energy storage). The NAVY project will also employ five SBU PhD students who will receive hands-on training in microgrid development and operation. The CIEES team is in the process of installing the microgrid platform at CIEES lab in the Advanced Energy Center.

The Center continued supporting the New York State Climate Leadership and Community Protection Act (CLCPA), which envisions a transformation of the State's electricity grid to 70% renewable generation by 2030, zero-emission electricity by 2040, and an 85% economy-wide reduction in greenhouse gas emissions from 1990 levels by 2050. The Center location on Long Island is strategic in utilizing 9 GW of off-shore wind power for NY State economy. To this end the Center team won an award from the off-shore wind power installer, Oersted Corp. "Energy Storage Solutions for Transmission Planning and Grid Stability

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with Massive Offshore Wind Farms" The project will build a hi-fidelity dynamic model and simulator of the Zone K and I with off-shore wind and storage, and comprehensively evaluate the benefit of storage control in improving the onshore grid stability.

As part of the workforce development mission, CIEES continued to work with The Department of Electrical & Computer Engineering at Stony Brook University (SBU) on its outreach program during the academic year 2020-2021 as well as during the summer of 2021. This effort is committed to serve students in high needs schools and from underrepresented groups and to meet the requirements of the Next Generation Science Standards (NGSS)/New York State Science Learning Standards (NYSSLS).

CIEES offered a virtual summer camp 'Online Robotics Camp' for over 70 middle school students that had an unprecedented success in attendance in August 2020. We are planning to continue with virtual offerings for both students and teachers for the Fall 2020 and beyond, as in-person activities will not be allowed on campus or field trips from schools. They consisted of 4-6-hour hands-on, interactive building and design tasks. The table below describes examples of activities (the most demanded by schools) during the past academic year.

During the summer, we ran a camp in four sections of five (one-hour and a half) sessions each for a total of 120 students and offered additional office hours to accommodate for discussions. For some students, two additional sessions were offered. All camp activities had a hands-on component and we shipped the materials to the students in advance. Moreover, some of the activities were COVID-related (e.g. 3D-design and printing of a mask holder) to emphasize the important role of engineering in resolving current societal challenges

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CHEM CUBED
BAH Holdings, LLC

m2m
Center for Mesoscale Transport Properties
AT STONY BROOK UNIVERSITY

CENTER FOR MESOSCALE TRANSPORT PROPERTIES: MOLECULAR TO MESOSCALE OVER TIME

Dr. Esther Takeuchi

Dr. Amy Marschilok

CORE INSTITUTIONS

Stony Brook University

Brookhaven National Laboratory

The Advanced Energy Research and Technology Center is home to the Center for Mesoscale Transport Properties, an Energy Frontier Research Center (EFRC) funded by the U.S. Department of Energy (DOE). The Director of the Center is renowned energy storage researcher, Professor Esther Takeuchi, with accomplished scientist Dr. Amy Marschilok acting as Center Operations Officer. In addition to Stony Brook University, the Center has five University participants and two national laboratory participants. The Center for Mesoscale Transport Properties is funded by a four-year $12 million grant.

The Scientific Mission of the Center is to build the scientific knowledge to enable creation of scalable electrochemical energy storage systems with high energy, power, and long life, through identification and purposeful probing of localized resistance of materials and interfaces under dynamic conditions from the molecular to the mesoscale.

The research proposed under this renewal award leverages the insights gained over the prior four-year period to enable simultaneous high power, high energy, scalable electrical energy storage systems.

This will be achieved through a focused and integrated effort with access to state-of-the art theoretical and experimental tools to study the transport of relevant species (ions, electrons, and mass), redox reaction kinetics, and chemical transformation of the associated complex interfaces in working electrochemical cells.

FUNDING

Department of Energy (DOE)

New York State Energy Research and Development Authority (NYSERDA)

Empire State Development's Division of Science, Technology and Innovation (NYSTAR)

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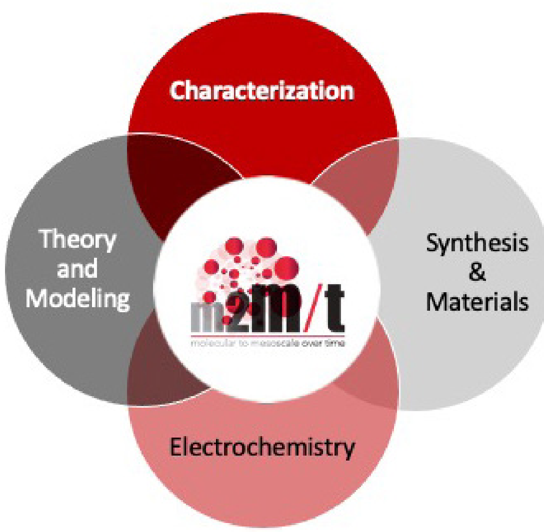

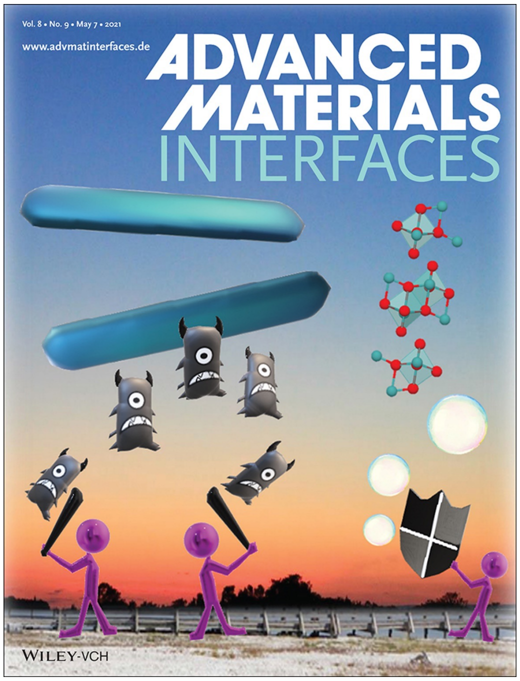

This research demonstrated a high cycle life low cost battery using environmentally friendly materials.

Wang, Lei; Yan, Shan; Quilty, Calvin D.; Kuang, Jason; Dunkin, Mikaela R.; Ehrlich, Steven N.; Ma, Lu; Takeuchi, Kenneth J.; Takeuchi, Esther S.; Marschilok, Amy C.: *Achieving Stable Molybdenum Oxide Cathodes for Aqueous Zinc-Ion Batteries in Water-in-Salt Electrolyte,* Adv. Mater. Interfaces, 2021, 8, 2002080. [DOI: 10.1002/admi.202002080]

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Institute of Gas Innovation and Technology AT STONY BROOK UNIVERSITY

INSTITUTE OF GAS INNOVATION AD TECHNOLOGY (I-GIT)

Dr. Devinder Mahajan

CORE INSTITUTION

Stony Brook University

An Integrated Gas Energy Institute

A collaboration between Stony Brook University's Advanced Energy Research and Technology Center (AERTC) and National Grid, I-GIT is a consortium composed of academic and industry leaders working together to find clean and affordable solutions to meet the nation's growing energy demands and challenges.

I-GIT is administered within AERTC, where it is housed with offices and state-of-the-art laboratories. Its expert team of researchers, educators and investigators are working closely with the clean-tech community to bring together business and government leaders, policymakers and researchers in developing innovative programs to deploy advanced energy technologies.

THERE ARE FIVE PILLARS THAT DEFINE I-GIT

1. A transition to low-carbon technologies

I-GIT will focus on hybrid fuel technologies through the introduction of various renewable sources, such as gas, hydrogen, fuel cell, geothermal and thermal heat.

2. Gas technology gap analysis

Preparing and maintaining a gap analysis will provide I-GIT opportunities to support environmental, societal and economic development goals.

3. Workforce training

To meet future needs, I-GIT will use AERTC's corporate training program and develop graduate certificate programs with member input.

4. Becoming an international consortium

I-GIT will build upon AERTC's existing relationships with other countries, including China,Japan, Korea and the United Kingdom, to increase membership and establish a global advanced technologies exchange mechanism.

5. Leveraging industry funding

To help expand its funding base, I-GIT will work with state and federal agencies.

For more information about I-GIT, visit stonybrook.edu/gas-innovation

ECOPARTNERSHIPS

US – CHINA STRATEGIC AND ECONOMIC DIALOG

A US DEPARTMENT OF STATE INITIATIVE

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New York Energy Policy Institute
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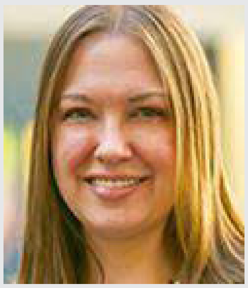

Dr. Elizabeth Hewitt

The New York Energy Policy Institute (NYEPI) is an interdisciplinary research center housed in the Department of Technology and Society in Stony Brook University's College of Engineering and Applied Sciences (CEAS).

NYEPI retains a core focus on energy, but has begun to align its approach to address the new challenges and opportunities associated with cutting-edge opportunities that are emerging out of big data, artificial intelligence research, and ethics. Specifically, NYEPI supports the current strategic alignment of its home department of Technology and Society, an interdisciplinary department that merges technical and quantitative skills with social science and policy expertise to support the core mission of the department: Smart engineering education. Under that umbrella, NYEPI builds on the department's alignment with smart development, smart communities, and smart ethics, all of which have clear connections to energy:

- **Smart Development:** The grand challenge of development stems from the fact that modern civilization arose using energy resources, largely fossil fuels, with increasingly obvious negative environmental consequences. Going forward smart development will be needed to help the rest of the world develop without locking in undesirable consequences.
- **Smart Communities:** Sustainable urban systems (SUS) research to advance smart communities is driven by the interdependencies of resources, people, and infrastructure in cities. The confluence of smart buildings, smart grid, and smart transportation frame the importance of big data and the internet of things to the future of human habitation; central to this is the provision of energy to urban centers.
- **Smart Ethics**: Technological development is ripe with unintended consequences, energy being no exception. As we allow our systems to operate with increasing autonomy and diminished human intervention important ethical considerations are raised. Issues ranging from energy poverty to the establishment of the roles and limits of robotics and artificial intelligence in society only scratch the surface of the ethical and moral dilemmas that lie ahead. Additionally, meaningful policy tools are needed to address these ethical considerations.

NYEPI's executive director is Dr. Elizabeth Hewitt, one of the core faculty members in the Department of Technology and Society. Dr. Hewitt is trained as an urban planner and social scientist, and her work explores energy and resilience in buildings and cities. NYEPI's president and founder is Dr. Gerald Stokes, the former chair of SUNY Korea's Department of Technology & Society. NYEPI also benefits from the expertise and partnership of other faculty members and researchers.

NYEPI began in 2010 as a consortium of New York universities and Brookhaven National Laboratory. Initial funding for the institute came from NYSERDA. Under that support, the staff provided analysis of policy options, maintained a database of energy experts and conducted workshops.

In the coming year, NYEPI will work to align more strategically with externally-funded faculty projects in the Department of Technology and Society and will drive smart engineering education research around the core challenges of energy.

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The New York State Center for Clean Water Technology

THE NEW YORK STATE CENTER FOR CLEAN WATER TECHNOLOGY

Dr. Christopher Gobler

CORE INSTITUTION

Stony Brook University

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- New York State Environmental Protection Fund as administered by the Department of Environmental Conservation
- New York State Department of Health
- National Science Foundation
- US Department of Energy
- US Department of Defense

The New York State Center for Clean Water Technology (CCWT) was borne out of a local problem-contamination of ground and surface waters with nitrogen and other contaminants.

THE PROBLEM

Suffolk County is home to more than 1.5 million people and 74% of homes are unsewered. The wastewater from individual homes is discharged to antiquated cesspools and septic tanks that deliver nitrogen and other contaminants to groundwater.

Discharge of these contaminants into ground-water has two major impacts:

1. Nitrogen-rich groundwater is having a cascading negative effect within marine ecosystems where it is contributing to the loss of salt marshes and seagrass, as well as the expansion of harmful algal blooms that degrade water quality and threaten fisheries and human health. In a region where tourism, recreational boating and commercial fishing represent billion-dollar industries that are dependent on water quality and fisheries, excessive nitrogen loading represents a serious environmental and economic threat to Suffolk County.
2. Contamination of the sole source aquifer in Long Island creates additional challenges in providing clean drinking water to communities, since there are no reasonably available alternative drinking water sources. Septic tank leakage in addition to legacy contamination that resulted from industrial practices, continue to degrade the quality of groundwater resulting in an increased exposure to toxic contaminants by Long Island residents.

While there now exists technologies that remove more nitrogen and other emerging contaminants from waste streams than standard cesspools and septic tanks, these technologies are not without their shortcomings. They are expensive, have large infrastructure footprints and limited effectiveness, presenting challenges for widespread adoption.

Beyond nitrogen from wastewater, Long Island groundwater and drinking water has been contaminated by industrial and household pollutants such as 1,4-dioxane and perfluoronated compounds. CCWT is also investigating processes that may be most effective in removing these compounds from drinking water supplies.

A WIDESPREAD CHALLENGE

The challenge of water quality degradation caused by nutrient loading and other contaminants is a scenario that is widespread across the nation and beyond. Twenty-five percent of homes in the United States have cesspools and septic tanks (US Census Bureau), infrastructure that is not designed to remove nutrients and other emerging contaminants. Further, in many instances the homeowners and water utilities are often unprepared to remove complex contaminants from drinking water supplies. In short, the contamination of water has become a major issue throughout the United States and across the globe.

THE SOLUTIONS

New technologies are needed to optimize nutrient and emerging contaminant removal from household wastewater and drinking water that is affordable, reliable, effective, and suitable for widespread deployment. Further, the solutions that are developed for Long Island will be marketable to other regions, states and nations because of the global nature of this problem.

THE CENTER

The Center for Clean Water Technology represents a collaborative, multidisciplinary initiative marshaling the best science and engineering to develop innovative solutions to our water quality problems. Funded by New York State through its Environmental Protection Fund and the Environmental Facilities Corporation, the Center is a nexus for both innovation and entrepreneurship, recognizing that significant economic opportunity lies in developing solutions to this critical environmental problem.

CLEAN ENERGY BUSINESS INCUBATOR PROGRAM

Heidi E. Anderson

CORE INSTITUTION

Stony Brook University

Executive Director

Heidi E. Anderson

Clean Energy Business Incubator Program

AT STONY BROOK UNIVERSITY

The Clean Energy Business Incubator Program (CEBIP) provides assistance and resources for developers of renewable and clean energy technologies. By mentoring entrepreneurs CEBIP helps them establish successful enterprises to bring their technologies to market. Bringing an innovation to market can be a difficult process requiring technical and business guidance, successful acquisition of funding, and continuing to retain a competitive advantage.

CEBIP's aim is the creation of high-paying cleantech jobs and industry within New York State that addresses current and future clean energy needs. CEBIP seeks to address many key needs of an early-stage, energy-based technology business, which is especially critical in today's rapidly-changing marketplace. We have assembled an unsurpassed team of partners and access to unparalleled resources to maximize prospects of startups and new business ventures.

New York State is progressing rapidly toward the goal of 100% carbon-free electricity by 2040. While NYS has one of the lowest per capita costs of electricity across US states, it ranks 8th in total energy consumption. [2021 US EIA] As a global leader in positive climate change and social justice, NYS requires energy solutions that lower cost, improve access, reduce climate impacts, and enter the worldwide stream of commerce to bring financial rewards by way of good jobs and tax revenues.

Enormous investments in basic research at Long Island's research institutes will continue to yield early stage technologies that need feasibility testing, decisions on how and when to enter the commercial development pathway, and securing financing. CEBIP has assembled an unsurpassed team of partners to maximize prospects of start-ups.

CEBIP has brought some of Long Island's leading industry experts together to provide guidance and direction to our companies. The CEBIP Advisory Board is comprised of business leaders and clean energy experts that have real-world experience and can offer invaluable advice. The CEBIP Management Team, with extensive industry knowledge and access to a wealth of resources, is an excellent source point for the clean energy entrepreneur. No equity is taken, but strong engagement, accountability and progress are required. In addition, CEBIP can tap into the invaluable knowledge and experience of faculty and staff both at Stony Brook University and Brookhaven National Laboratory. We also have the capability of accessing the NYSERDA funded Entrepreneurs in Residence and Scale for ClimateTech programs that provide dedicated resources to tackle specific needs..

CEBIP has access to the vast professional services and technological resources that Long Island has to offer. Long Island and Stony Brook University resources popular with our companies include:

- Center in Integrated Electric Energy Systems (CIEES) to accelerate the program of renewable energy.
- The Strategic Partnership for Industrial Resurgence (SPIR) utilizes the extensive engineering resources of the SUNY system to help local industry compete more effectively.
- Center for Biotechnology offers leading experts in biorenewable energy.
- Small Business Development Center at Stony Brook University assists entrepreneurs including preparation of MWBE certification and SBIR grants.

- Manufacturing and Technology Resource Consortium (MTRC) at Stony Brook University, the Empire State Development's Regional Manufacturing Extension Partnership (MEP) center for the Long Island region.
- Long Island Angel Network (LIAN) and Long Island Capital Alliance (LICA provide opportunities to pitch and network to CEBIP companies that have passed the rigor of the CEBIP.
- The Advanced Energy Research and Technology Center (AERTC) is the leader in advanced energy technology research within New York State.

CEBIP is fully committed to helping clean energy technology companies bridge the gap between invention and market using the expertise, business acumen and technological resources of our management team, Advisory Board and extensive partners. We will continuously work towards the development of a successful clean energy economy on Long Island, with the ultimate goal of creating new jobs and having a strong climate and economic impact in New York.

CEBIP operates directly under the direction of the Long Island High Technology Incubator (LIHTI). LIHTI is a non-profit organization dedicated to helping new technologically-innovative companies to grow by providing them with a variety of support resources and services. CEBIP is financially supported by the New York State Energy Research and Development Agency (NYSERDA). NYSERDA strives to facilitate change through the widespread development and use of innovative technologies to improve the State's energy, economic and environmental wellbeing.

CONTACT

Executive Director

Heidi E. Anderson
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www.cebip.org

PARTNERS

ADVANCED ENERGY™ Research and Technology Center AT STONY BROOK UNIVERSITY

Brookhaven National Laboratory

NEW YORK STATE | NYSERDA

Stony Brook University

CIEES CENTER FOR INTEGRATED ELECTRIC ENERGY SYSTEMS AT STONY BROOK UNIVERSITY

Center for Corporate Education AT STONY BROOK UNIVERSITY

LIHTI Long Island High-Technology Incubator

Strategic Partnership for Industrial Resurgence AT STONY BROOK UNIVERSITY

AMERICA'S SBDC NEW YORK

Manufacturing and Technology Resource Consortium (MTRC) AT STONY BROOK UNIVERSITY

ScaleFor ClimateTech

EPRI ELECTRIC POWER RESEARCH INSTITUTE

FUZEHUB

NORDIC INNOVATION HOUSE NEW YORK

National Offshore Wind Research and Development Consortium

NATIONAL OFFSHORE WIND RESEARCH AND DEVELOPMENT CONSORTIUM

Robert B. Catell
Chairman

FUNDING

NYSERDA

United States Department of Energy

The National Offshore Wind Research and Development Consortium is a nationally focused, independent, not-for-profit organization funded by the United States Department of Energy (DOE), the New York State Energy Research and Development Authority (NYSERDA), and led by key offshore wind industry stakeholders and research institutions. Based at Stony Brook's Advanced Energy Research and Technology Center (AERTC), the Consortium is dedicated to managing industry-focused research and development of offshore wind to maximize economic benefits for the US.

REDUCE COST AND RISK OF OFFSHORE WIND

The goal of the Consortium is to prioritize, support, and promote research and development (R&D) activities that reduce cost and risk of offshore wind development projects throughout the US while supporting US-based manufacturing and the offshore wind supply chain.

Specific technical objectives are aligned with the 2016 National Offshore Wind Strategy published by the DOE and include:

- Advancing offshore wind plant technology
- Developing innovative methods for wind power resource and site characterization
- Developing advanced technology solutions for installation, operation and maintenance, and supply chain

ADDRESS BARRIERS TO IMPLEMENTATION

The Consortium will support initiatives that address specific barriers to implementing offshore wind in the US. Key elements of the Consortium's approach include:

- Leadership by an independent board of directors made up of public and private sponsors as well as representatives from U.S. national labs and utilities
- Establishment of diverse advisory groups made up of research partners, investors, manufacturers, and other key industry stakeholders
- Development of a prioritized, national research strategy for incorporating stakeholder input
- Research project awards through competitive solicitations
- Regular engagement with stakeholders and advisory groups

TECHNICAL SOLUTIONS TO REDUCE COST

The Consortium will prioritize research directly applicable to the technical barriers faced by offshore wind developers, original equipment manufacturers (OEMs), and the supply chain. The goals are to identify and encourage the pursuit of technical solutions that reduce US offshore wind levelized cost of electricity (LCOE)* and increase opportunities for the U.S. manufacturing and supply chain establishment. By demonstrating value to end users, the Consortium will chart a path to financial self-sufficiency and continue its work well beyond the initial four-year award period.

MAJOR PARTICIPANTS

United States Department of Energy (DOE) – the federal agency charged with ensuring the security and prosperity of the US by addressing energy, environmental, and nuclear challenges through transformative science and technology solutions.

New York State Energy Research and Development Authority (NYSERDA) – a public benefit corporation that advances innovative energy solutions with extensive experience commercializing new technologies and spurring private investment.

ADVANCED ENERGY RESEARCH TECHNOLOGY CENTER

(AERTC) at Stony Brook University – a partnership of academic institutions, research institutions, energy providers and industrial corporations focused on efficiency, conservation, renewable energy and nanotechnology applications for new and novel sources of energy.

The Carbon Trust – a world leader in offshore wind R&D and administrators of the Offshore Wind Accelerator, a self-sustaining European consortium to commercialize research investment.

Renewables Consulting Group (RCG) – a leading off-shore wind consultancy in the US with more than a decade of experience and a deep understanding of the US offshore wind market and supply chain.

CONTACT

Chairman

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Principal Investigator

Richard Bourgeois, PE
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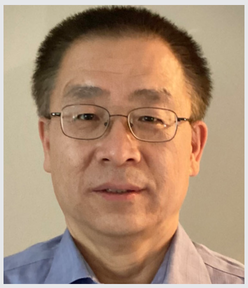
PARTNERS

ThINC
THERMOMECHANICAL & IMAGING NANOSCALE CHARACTERIZATION
AT STONY BROOK UNIVERSITY

THERMOMECHANICAL AND IMAGING NANOSCALE CHARACTERIZATION



Guowei Tian, PhD

Yunming Hu

CORE INSTITUTION

Stony Brook University

Chief Scientist, AERTC

Dr. Miriam Rafailovich

The Thermomechanical and Imaging Nanoscale Characterization (ThINC) is a core facility of the Advanced Energy Research and Technology Center™ (AERTC) serving the engineering, chemistry, physical and life science communities. It is dedicated to establishing partnerships between Stony Brook University and industrial laboratories for enabling cutting-edge research in nanoscience.

The facility houses wet and dry laboratories, sample preparation suites, and state of the art microscopy and metrology instrumentation, with experienced scientists, who are available to teach and guide users in their use and finding the best approach to understanding their needs in nanotechnology. If needed, the scientists will then guide the users in drafting proposals for using additional instrumentation available at the BNL-CFN. Our facility opens doors to regional industry and students, providing them with educational resources allowing them to explore, innovate, and go further into the world of nanotechnology.

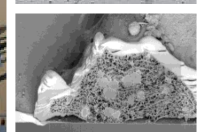
ELECTRON MICROSCOPY

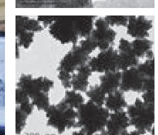
Focused Ion Beam-Scanning Electron Microscope (FIB-SEM, Zeiss Xbeam 340)

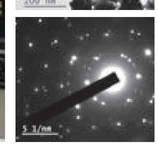
- FE-SEM combines the 3D imaging and analytical performance of the GEMINI column with the ability of FIB for material processing and sample preparation on a nanoscopic scale
- Variable Pressure mode available
- Multiple detectors available: Inlens Duo (SE and BSE mode), SE2, VPSE, EDS and EBSD
- Capella FIB column with Ga-Liquid metal ion source
- Capable of cryo FIB-SEM

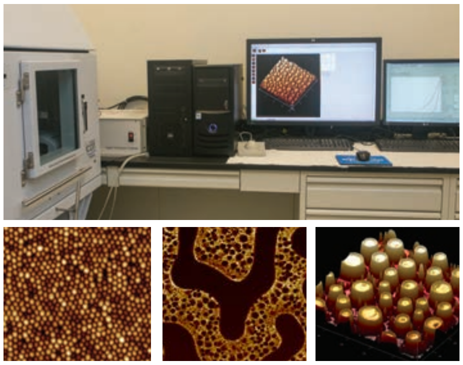
Transmission Electron Microscope (TEM, JEOL JEM 1400)

- Precentered single-crystal LaB6 filament, achieve high resolution of 0.38nm
- Accelerating voltages: 40~120kV at the step of 20kV
- Suitable for materials science, polymer and biological applications
- Features available: Cryotomography, STEM, EDS for elemental identification





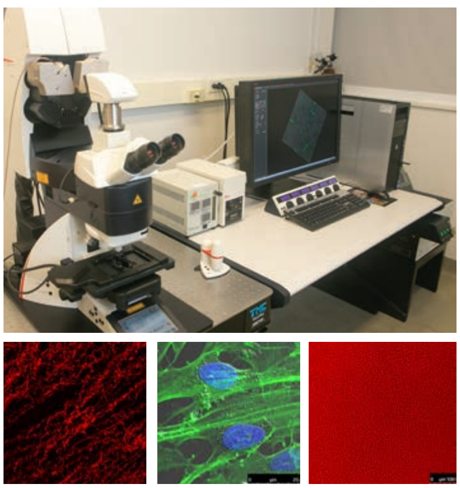




SCANNING PROBE MICROSCOPY

Atomic Force Microscope (AFM, Bruker Dimension ICON)

- Nanomechanics/nanoindentation
- Nanoelectrical characterization
- Imaging in air/fluid
- Heating and cooling stages
- Multi-modes available, including: Contact,Tapping and ScanAsyst modes



LIGHT MICROSCOPY

Upright Confocal Microscope (Leica TCS SP8 X)

- Upright geometry suitable for materials science applications with opaque samples or substrates
- Immersion lenses permit imaging of submerged samples
- GaAsP hybrid detection system (HyD)
- White light laser 470~670nm, and UV laser 405nm
- Tokai Hit stage incubator providing 37˚C and 5% CO2 (live cell imaging)

Fluorescent Microscope (AMG EVOS FL)

- Light Cubes: DAPI (Ex 360/ Em 447 nm) GFP (Ex 470/ Em 525 nm)

White (non-transparent samples)

- Equipped with 4~40x LWD objectives and 100x coverslip-corrected oil objective
- Equipped with Bioptechs stage temperature controller providing 37˚C for live cell observation

THERMOMECHANICAL CHARACTERIZATION

Dynamic Mechanical Analysis (DMA, TA Q800)

- Temp. range: -145~600˚C

Differential Scanning Calorimetry (DSC, TA Q2000)

- Temp. range: -90~550˚C

Thermal Gravimetric Analysis (TGA, TA Q50)

- Temp. range: ambient +5~1000˚C

Thermal Conductivity Meter (DTC300)

- Temp. range: -20~300˚C
- Thermal conductivity range: 0.1~40W/mK

SAMPLE PREPARATION

Ultramicrotome & Cryo-ultramicrotome (Leica EM UC7/ FC7)

Freeze plunger (FEI Vitrobot)

High Vacuum ACoater/ Freeze Fracture Unit (Leica EM ACE 600)

Cryo Transfer SEM sample Holder (Leica VCT 100)

Cryo Transfer TEM Specimen Holder (Gatan Gat-626)

Turbo Freeze Drier (EMS 775)

- Comprehensive sample preparation station for microscopy characterization including EM, LM and SPM
- Conventional biological sample preparation for EM characterization
- Rapid plunge freezing for Cryo-fixation and Cryo EM characterization
- Applicable samples including polymer, gels, emulsions and biological samples

CONTACT

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Chung-chueh.Chang@stonybrook.edu

MODELING AND SIMULATION

CLEAN POWER TRANSITION

PI: Gang He, SBU

"Electrifying energy use and decarbonizing electricity" is a key strategy for global energy transition. China's power sector presents the best case to study clean power transition as it is now the world single largest coal consumer and as a result is the biggest CO2 emitter. The clean transition of world's largest power sector will have a significant impact on how China, and to a large extent, the world – uses energy and addresses climate change. This project explores the roadmaps to achieve high penetration of renewable energy and low carbon power supply in China where coal dominates current supply mix. This project develops and expands SWITCH-China (a loose acronym for Solar, Wind, Hydro, and Conventional generation and Transmission Investment) model to analyze least-cost generation, storage, and transmission capacity expansion for China under various policy and cost scenarios, especially with high penetration of renewables. SWITCH uses an unprecedented combination of spatial and temporal resolution with extensive data mining to design realistic power systems and plan capacity expansion to meet policy goals and carbon emission reduction targets at minimal cost. This project also develops an integrative modeling tool to study the energy-X nexus issues to study the trade-offs between the interactive energy-X nexus. The project explores the energy landscape change from political, economic and institutional perspectives beyond technology. (SBU, University of California at Berkeley)

Publications:

G. He, D. M. Kammen. *Where, when and how much wind is available? A provincial-scale wind resource assessment for China.* Energy Policy. 74:116-122 (2014).

G. He, A. Avrin, JH. Nelson, J. Johnson, A. Mileva, J. Tian, D.M. Kammen. *SWITCH-China: A System Approach to Decarbonizing China's Power System.* Environmental Science and Technology. 50(11):5467–5473 (2016).

G. He, D. M. Kammen. *Where, When and How Much Solar is Available? A Provincial-Scale Solar Resource Assessment for China.* Renewable Energy. 85:74-82 (2016).

G. He, H. Zhang, Y. Xu, X. Lu, Editors. Special Issue. *Environmental Challenges and Potential Solutions of China's Power Sector.* Resources, Conservation and Recycling. Volume 121, Pages 1-164 (2017).

J. Hu, L. Huang, M. Chen, G. He, H. Zhang. *Impacts of Power Generation on Air Quality in China – Part II: Future Scenarios.* Resources, Conservation and Recycling. 121:115–127 (2017).

OPTICAL PATTERN RECOGNITION USING MULTIPLE PHASE-SHIFTED JOINT TRANSFORM CORRELATION WITH LOG-POLAR TRANSFORMATION

PI: M. N. Islam, Farmingdale State College

Optical joint transform correlation (JTC) technique utilizes optical lens and can recognize a pattern of interest efficiently, where the processing can be done at the speed of light. To enhance the correlation performance, a multiple phase-shifted reference based JTC (MRJTC) technique is developed, which produces a single correlation peak for each potential target in a given input scene. To further improve the discrimination between a target and a non-target object, a fringe-adjusted filter is incorporated in the proposed system. Finally, a log-polar transform algorithm is developed for the MRJTC technique to make the pattern recognition invariant to scale and rotation variations. At the correlation plane, the peak-to-side lobe ratio is measured and compared to a threshold to detect and track a pattern of interest in an unknown input scene. The proposed system is simulated with various input scenes where a successful and efficient pattern recognition performance is observed. (U.S. Army)

Publication:

M.N. Islam, *Proceedings of International Conference on Optics,* Photonics and Lasers, Barcelona, Spain, May (2018).

MODELING AND SIMULATION

MODELING AND MITIGATION OF HIGH FREQUENCY CABLING OF WBG MOTOR DRIVES

PI: Fang Luo, SBU

Long cable WBG motor drives face long standing issues of reflected wave overvoltages due mismatch of cable and load impedance. This overvoltages can lead to insulation failures, partial discharge as well as converter overcurrent. Moreover, both conducted and radiated EMI concerns worsen with longer cable length. This project mainly deals with modelling of cable and dV/dt filters to analyze and mitigate the issues related to reflected wave and EMI noise. The idea is to modular frequency sweep-based cable modeling for different configurations of cable length, cable type and motor loads. The work aims at modeling of reflected wave phenomenon with 92% accuracy over various configuration of WBG Motor drives.

Publication:

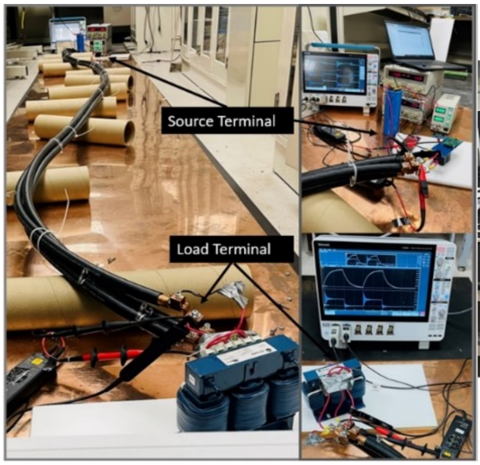
K. Choksi, Y. Wu, M. Hassan and F. Luo, " Inspecting Impact of Cabling Infrastructure on Reflected wave and EMI for More Electric Aircraft (MEA) motor drives," 2022 IEEE/AIAA Transportation Electrification Conference and Electric Aircraft Technologies Symposium (ITEC+EATS)

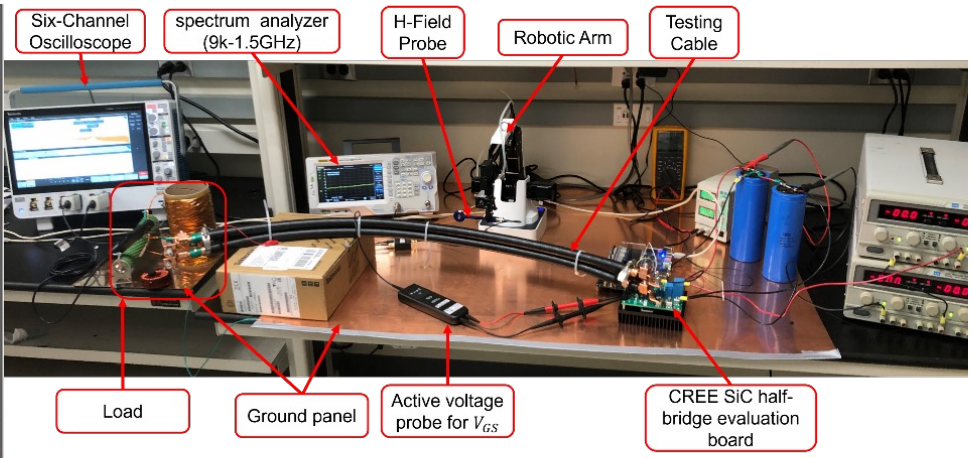
K. Choksi, Y. Wu, M. Hassan and F. Luo, " Evaluation of Factors Impacting Reflected Wave Phenomenon in WBG Based Motor Drives," 2022 IEEE International Power Electronics Conference (IPEC), Himeji Japan 2022.

Y. Wu, K. Choksi, M. Hassan and F. Luo, " An Extendable and Accurate High-Frequency Modeling of Three-phase Cable for Prediction of Reflected Wave Phenomenon," 2022 IEEE Applied Power Electronics Conference and Exposition (APEC), 2022.

B. Narayanasamy, A. S. Sathyanarayanan, F. Luo and C. Chen, "Reflected Wave Phenomenon in SiC Motor Drives: Consequences, Boundaries, and Mitigation," in IEEE Transactions on Power Electronics, vol. 35, no. 10, pp. 10629-10642, Oct. 2020, doi: 10.1109/TPEL.2020.2975217.

B. Narayanasamy, A. S. Sathyanarayanan, A. Deshpande and F. Luo, "Impact of cable and motor loads on wide bandgap device switching and reflected wave phenomenon in motor drives," 2017 IEEE Applied Power Electronics Conference and Exposition (APEC), 2017, pp. 931-937, doi: 10.1109/APEC.2017.7930808





MODELING AND SIMULATION

INTEGRATED PRODUCTION LINE AND HVAC SYSTEM

PI: Qing Chang, SBU

We have created an integrated thermal and production system model to optimize energy and monetary savings in a manufacturing plant. Utilizing simulation methods, we have combined the two largest energy consumers in a manufacturing facility; the production line and the HVAC system. By joining these two systems, we created an overall control scheme to coordinate shut offs of certain machines without any throughput loss on the production line. These timed shut offs are called opportunity windows. The opportunity windows for the production line are synced with the peak periods of energy demand for the HVAC system to optimize the energy cost savings. (GM)

Publications:

M. Brundage, Q. Chang, D. Chen, and V. Yu. *Energy Savings Opportunities of an Integrated Facility and Production Line.* Proceedings of ASME 2013 Manufacturing Science and Engineering Conference (2013).

M. Brundage, Q. Chang, Y. Li, G. Xiao, and J. Arinez. *Energy Efficiency Management of an Integrated Serial Production Line and HVAC System.* 9th IEEE International Conference of Automation Science and Engineering (2013).

RESEARCHER PROFILE

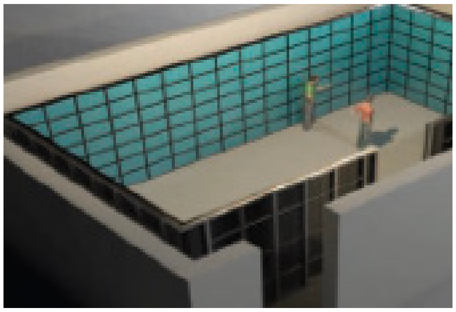
Arie E. Kaufman

Distinguished Professor of Computer Science and Radiology, former Chair of Computer Science (1999-2017)

Energy Projects:
Smart grid Visual modeling

Awards and Honors:

- Fellow, National Academy of Inventors (NAI) (2017-)
- Fellow, IEEE (1998-)
- Fellow, ACM (2009-)
- Member, European Academy of Science (2002-)
- Chief Scientist, Center of Excellence in Wireless and Information Technology (CEWIT) (2007-)
- IEEE Visualization Career Award (2005)
- Entrepreneur Award, State of New York (2002)
- Innovative Research Award, State of New York (2005)
- Long Island Technology Hall of Fame Inductee (2013)
- Editor-in-Chief, IEEE Transactions on Visualization and Computer Graphics (TVCG) (1995-98)



VISUAL INTERFACE TO AID ENERGY AWARE LAYOUT AND USE OF SMART SPACES, BUILDINGS, OFFICES AND INDUSTRY FACILITIES

PIs: Arie Kaufman and Klaus Mueller, SBU

We will devise an approximate but fairly accurate simulation framework to model heat, cooling, lighting and the like and show these profiles as a heat map on walls and floors of smart spaces. These maps could then be used for energy-aware room layouts, utilization and possibly also solar panel placement. We will further model the light and heat exposure from exterior sources such as the sun to augment the map. (IBM, NY)

MODELING AND SIMULATION

SYNCHRONIZED LOW-ENERGY ELECTRONICALLY-CHOPPED PASSIVE-INFRARED (PIR) SENSOR FOR OCCUPANCY DETECTION (SLEEPIR)

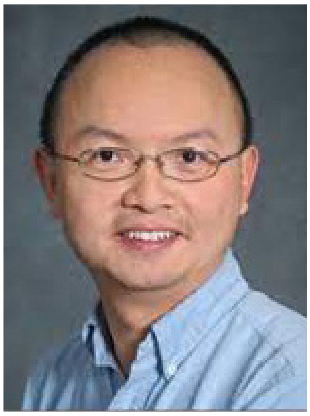
PI: J. Longtin, SBU and Y Wang, Texas A&M

Residential buildings represent a large fraction of U.S. annual energy use for heating and cooling. In spite of their energy usage, most residential buildings implicitly assume that the occupants are home at all times, and provide heating or cooling accordingly.

This project will develop an advanced, low-cost occupancy sensor for residential homes by building upon commercially available pyroelectric infrared (PIR) sensor technology to detect human presence. When residents are determined to not be home by the system, the heat or cooling temperatures are adjusted for energy savings until the occupants return. The SLEEPIR innovation relies on the use of a solid-state, liquid crystal display (LCD)-based "optical chopper," which temporarily interrupts the flow of heat to the sensor and allows the device to detect both stationary and moving individuals. Unlike mechanical choppers, the solidstate LCD has no moving parts and is silent, thus improving reliability and reducing electrical power consumption. The technology is built around low-cost, commercially available PIR sensors, which are inexpensive, widely available, proven to be reliable, and use very little power. The sensor system will use Bluetooth 5 protocol, allowing each sensor to communicate to its nearest neighbor to feedback to the main controller, which will over-ride the house thermostat if occupants are determined not to be home. Privacy concerns are minimized, as the PIR sensor is a single light sensor, rather than a camera or microphone-based solution. A machine-learning algorithm will be used to establish daily patterns for the occupants to increase the predictive capability of the system, while also reducing false negatives, i.e., the system assuming that house is vacant when residents are actually present. Challenges for the project include finding the optimal material(s) for the LCD optical chopper, enabling differentiation between pets and people, ensuring that occupants continue to be detected during quiescent times in the home, e.g., sleeping or watching TV, and minimizing power use.

The system will be powered by a small solar cell with a supercapacitor. For locations in dimly lit rooms, a long-life button battery will be used to keep the battery change interval infrequency (several years). System feedback to the residents will be provided in terms of smart phone apps and in-house display units to indicate the energy saved with the device, thus reinforcing the positive aspects of the system while minimizing the tendency to override the system. (ARPA-E SENSOR Program)

RESEARCHER PROFILE



Gang He
Assistant Professor, Department of Technology and Society
Stony Brook University

Energy Projects:

• Clean power transition • Energy system modeling • Energy-X nexus

Awards and Honors:

- Institute for New Economic Thinking Young Scholar 2013
- Aspen Environment Forum Scholar 2011
- Cynthia Helms Fellow, World Resources Institute, 2008
- Asia 21 Young Leaders, Asia Society, 2007

ENERGY GENERATORS AND CONVERTERS

FREE COOLING OF DATA CENTERS

PIs: Tom Butcher, SBU and BNL, Jon Longtin, William Worek, SBU

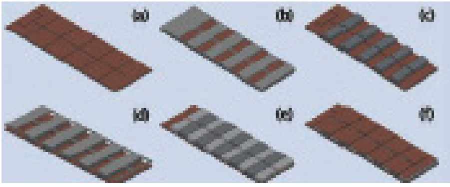
Modern data centers can contain hundreds or thousands of computer servers that produce considerable heat. These machines, however, can often be comfortably run with ambient room temperatures upwards of 90 to 100°F or more. At the same time, considerable electrical energy is consumed by maintaining the room at traditional temperatures of 68 to 72°F. This project is directed at implementing an evaporative cooler for data center cooling. By using evaporative cooling rather than traditional expansion cooling, HVAC energy loads can be reduced substantially while still providing an adequate ambient environment for the computers within the data center. The project involves installing a modern, high-efficiency evaporative cooler on a data center in southern California, and then monitoring energy use compared to the traditional HVAC equipment currently installed. This project is led by Brookhaven National Laboratory, with Stony Brook University as a partner. (DOD ESTCP)

INNOVATIVE APPROACH FOR LOW-COST HIGH-VOLUME THERMOELECTRIC DEVICE MANUFACTURE

PIs: Jon Longtin, and David Hwang, SBU

Vehicle transportation is responsible for 65% of the annual oil consumption in New York State, yet less than 30% of the fuel energy is converted into mechanical power in a vehicle, with the balance lost as waste heat. Significant progress has been made in the past ten years to recover vehicle waste for electricity production by using solid state thermoelectric (TE) devices, with 5-10% fuel savings reported. Despite the promise of thermoelectric materials, however, the high-volume manufacturing of TE devices represents a severe bottleneck for widespread adoption of such devices for commercial applications on vehicles and in industrial settings. In this project, we are developing concepts for an innovative manufacturing solution to overcome these technical bottlenecks and to develop marketable, cost-effective TE generators (TEGs) by directly fabricating the functional TE layers onto exhaust pipes in a rapid, economical, and industrially scalable manner.

The approach is based on recent progress developed by our team at SBU to develop TEGs fabricated directly onto exhaust and waste-heat components. The technology is based on thermal spray and laser micro-machining for non-equilibrium material synthesis of bulk materials (filled skutterudites and magnesium silicides), thermal spray direct write of thick films and laser micromachining for feature patterning to fabricate TEGs directly onto waste heat components. In contrast to traditional state-of-art TEG technologies based on prefabricated modules, our manufacturing process will eliminate epoxy binding and mechanical clamping and thus can significantly increase the



durability of the TEG, while reducing manufacturing cost and energy use. Such direct-integrated TEGs can also reduce the time of material synthesis and device processing from weeks to hours or less through its inherently scalable manufacturing process. Our developments can also be extended to other applications, such as electricity power plants (fossil and nuclear), diesel locomotive engines and ship engines. The project includes a series of inter-related manufacturing tasks that will be explored over a 12-month period. (NYSERDA)

ENERGY GENERATORS AND CONVERTERS

CREATING SELF-CLEANING AIR PURIFYING SURFACES FOR URBAN AND ENERGY APPLICATIONS

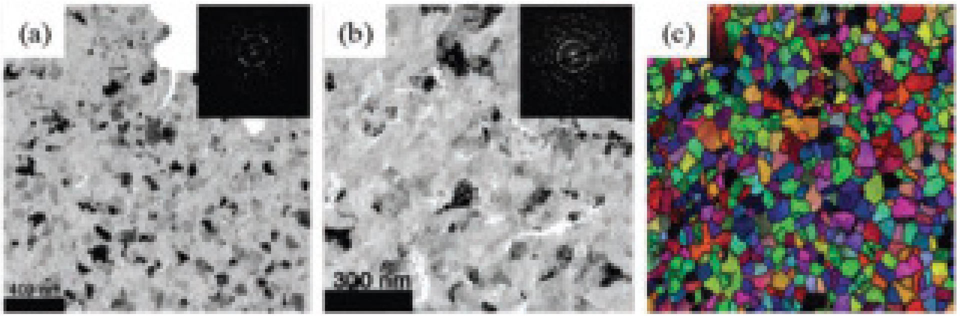
PI: Alexander Orlov, SBU

Creating nanostructured surfaces, which can remain self-cleaning and air purifying, is now becoming a reality. In this project, which involves industrial collaboration with the NY based company, we work on testing performance of catalytic coatings, which can potentially transform urban environment by making it cleaner, more energy efficient. It can also improve public health by removing numerous air pollutants. In addition, it can also create self-cleaning solar cells, which has the potentially to substantially improve their efficiencies. The coatings have already been applied on numerous buildings both in Europe and the US. (DOT)

ENHANCING THE DAMAGE TOLERANCE OF PLASMA-FACING MATERIALS FOR FUSION REACTORS

PI: Jason R. Trelewicz, SBU

Plasma-facing components (PFCs) for reactor scale fusion devices require materials to operate under far-from equilibrium conditions of extreme temperature, radiation, and stress. While tungsten has emerged as a promising candidate due to its high melting temperature, exceptional strength at elevated temperatures, and good sputtering resistance, the realization of tungsten as a next-generation PFC material requires revolutionary advances in alloy design to limit irradiation-induced damage at high temperatures. One approach for enhancing radiation tolerance involves the refining of grain size to the nanometer regime. The resulting nanocrystalline structure is composed of a high density of grain boundaries, which limit the accumulation of irradiation damage by defect absorption at these boundaries; however, nanocrystalline grains are notoriously unstable at elevated temperatures, and their growth would eliminate the high density of available defect sink sites and corresponding damage tolerance. The objectives of this research are to elucidate the mechanisms of nanostructure stability in tungsten alloys with evolving grain boundary structures, assess their implications for defect absorption, and engineer the solute distribution and grain size at the nanoscale to produce stable alloy states. Activities combine atomistic simulations with in situ irradiation exposure and nanomechanical testing of novel tungsten alloys to understand the mechanisms responsible for their stability, radiation tolerance, and deformation physics at the nanoscale. From this research, a new understanding of radiation effects in tungsten alloy nanostructures will be developed to markedly enhance their potential as advanced PFC materials and provide opportunities for their exploration in future reactor platforms. (BNL, NSF)



Nanocrystalline tungsten with a grain size of 75 nm in (a) its as-synthesized state and (b) irradiated using tungsten ions to a total dose of 10 displacements per atom. Defects can be observed within the grains as well as accumulating at the grain boundaries. Grain orientation maps such as shown in (c) for nanocrystalline tungsten are employed to study the effect of irradiation on grain orientation and structural stability.

ENVIRONMENTAL SUSTAINABILITY

OFF-GRID RENEWABLE POWER PRODUCTION USING WOOD WASTE ON LONG ISLAND

PIs: Devinder Mahajan, Benjamin Hsiao and Tae Jin Kim, SBU

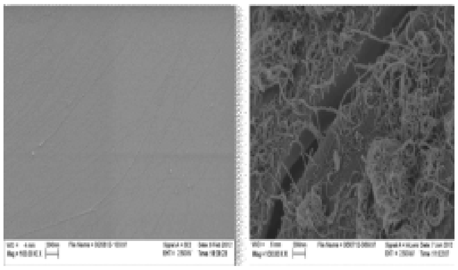
According to the local utility PSEG Long Island, tree trimmings produce an estimated 364 cubic yards of wood daily, enough to produce 60MW of green power. This wood is currently being processed into mulch, transported off Long Island or otherwise disposed in a potentially unsustainable manner. The utility records also reflect that the last major windstorm to hit Long Island (Superstorm Sandy) produced approximately 40,000 cubic yards of wood debris (420,000 MW power equivalents) and left sections of Long Island without power for up to two weeks.

Those lucky enough to own a generator used diesel fuel to power them, which resulted in air emissions that polluted the region. The debris from Sandy was enough to power about 40,000 homes for an entire year, and the use of wood to produce energy could have resulted in reductions of 512,000 tonnes CO2eq. We thus consider wood waste on Long Island a low-hanging fruit for sustainable green power conversion. This vision compelled us to form a public-private-partnership that is led by Stony Brook University (SBU) in partnership with an industry consortium. Notables among the industry group are: PSEG LI, the local power distribution utility; Asplundh, a tree service contractor; Long Island Energy Infrastructure Development (LIEID). The heart of the proposal is a commercial mobile power pallet, dubbed PP20, available from All Power Labs (APL), a California company. We have initiated a study to explore the feasibility of this project on Long Island. (CIEES)

DEVELOPING A NEW GENERATION OF SUSTAINABLE POLYMER NANOCOMPOSITES FOR ENERGY AND CONSUMER APPLICATIONS WHILE ADDRESSING CONSUMER SAFETY ISSUES

PI: Alexander Orlov, SBU

Producing a new generation of polymer nanocomposite materials can revolutionize transportation and energy issues by delivering superior performance (mechanical, thermal and others) while reducing weight and environmental impact. However, there is also a concern from the consumer point of view about safety of nanomaterials. This research program addresses both aspects in a holistic way. Firstly, we develop new approaches in incorporating more sustainable nanomaterials into polymers to achieve an outstanding performance in various industrial applications. Secondly, we develop novel methods in studying stability and toxicity of encapsulated nanomaterials leading to better design strategies for nanocomposites. (NSF)



Publication:

J. Ging, R. Tejerina-Anton, G. Ramakrishnan, M. Nielsen, K. Murphy, J. Gorham, T. Nguyen, A. Orlov. *Development of a Conceptual Framework for Evaluation of Nanomaterials Release From Nanocomposites: Environmental and Toxicological Implications*, Science of Total Environment, 473-474, 9-19, (2014).)

OFF-GRID POWER PRODUCTION IN KENYA USING LOCAL WASTE MATERIALS

PIs: Devinder Mahajan, SBU; Professor Kin Kinyua, JKUAT; J. Hasty APL; L. Martin and A. Leakey, Turkana Basin Institute (TBI)

The northwest Kenya is home to Turkana Basin Institute that operates on off-grid power. We are focused to operate an off-grid 20 kW gasifier that could provide power for the institute. As the first step to demonstrate that the gasifier could use local waste as feedstocks – doum nuts, a waste from palm trees and prosopis, an invasive species spread throughout Kenya. APL delivered the 20 kW gasifier at Jomo Kenyatta University of Agriculture and Technology (JKUAT). The unit will be commissioned at JKUAT by APL shortly. The next step is to test various feedstocks. We are now considering a partnership with the UN Institute of Environmental and Sustainable Development (IESD), Shanghai, China who would also provide funding to expand the scope of the project at JKUAT.

ENVIRONMENTAL SUSTAINABILITY

RESEARCH EXPERIENCE FOR UNDERGRADUATES (REU) SITE IN ‘NANOTECHNOLOGY FOR ENERGY, HEALTH AND THE ENVIRONMENT

PI: Gary Halada, SBU

To truly understand interaction between the environment (outdoors, under extreme industrial conditions, or within the human body) and natural and human-made materials, it is essential to understand reactions at the nanoscale. It is at this level, from single molecules to ultrathin films on surfaces, that structural and chemical transformations first occur which affect critical environmental processes, such as corrosion of advanced printed alloys, association of hazardous waste with soil or buildings, and attachment and growth of cells. Likewise, by exploring the electron transfer processes which occur at the surface of catalytic nanoparticles and the nature of the association of organic molecules with the surface of nanoparticles we can design new, safe and inexpensive processes for forming nanomaterials for energy and biomedical applications. To accomplish these goals, we build interdisciplinary partnerships within the University, with other colleges and research groups, with industry and with Brookhaven National Laboratory. Our REU site, which began in 2011, has so far supported over 80 undergraduates from over 40 colleges, including many community colleges and colleges with large underrepresented populations. Inclusion and accomplishment are benchmarks of the program – more than 50% of our participants have been female, and more than 25% of our participants have been from underrepresented minority groups. These students have gone on to graduate study at prestigious institutions, high tech jobs in a number of industries, or become medical professionals and business leaders. By creating these undergraduate opportunities, we hope to help build a research community and workforce to apply nanoscale technologies in energy and other critical areas.

www.stonybrook.edu/nanotech (NSF)

ECOPARTNERSHIPS–LANDFILL GAS USAGE STRATEGIES

PIs: Devinder Mahajan, David Tonjes and Tae Jin Kim, SBU

The SBU-Tongji project is one of the 18 projects under the U.S.-China EcoPartnership program as part of the Strategic and Economic Dialog (S&ED). The partnership is implemented by the U.S. Department of State and National Development Reform Commission, China. The project focus is to find ways to monitor, harvest and monetize methane from landfills, wastewater treatment plants and other sources. The project is also looking at ways to convert captured methane into transportation fuels: dimethyl ether (DME), a diesel substitute and gasoline. Recently, Tongji has developed a modified model to calculate fugitive methane while SBU is focused on pathways to transportation fuels. One technology to remove H2S is being targeted for scale-up.

ENVIRONMENTAL SUSTAINABILITY

WASTE MANAGEMENT AND INNOVATION

PI: David J. Tonjes, SBU

We provide technical and scientific advisement and data management to the Town of Brookhaven (LI, NY) waste management program for it to progress in a more sustainable direction. We work on technology assessments, understanding underlying waste processes, and assessing impacts from potential future, currently operating, and legacy facilities. The Town of Brookhaven Department of Recycling and Sustainable Materials Management has funded these efforts since 2009 through a series of annual grants.

The work has included: sorting wastes and analyzing collection data to infer changes that occurred due to the adoption of single stream recycling; analyzing the impact of degradable plastics on solid waste management systems; collecting ground-water data and geological information to parameterize a site-specific groundwater transport model and determine interannual differences in the state of the aquifer system; describing impacts on groundwater systems due to large-scale compost sites; defining food waste processes and management potentials; investigating the mechanisms and rates that lead to the generation of solid waste, and the changes in solid waste composition that have occurred and continue to occur, and how those changes may affect alternative waste management facilities; modeling the processes that control the generation of a renewable fuel source, landfill gas; and working to create a pilot implementation of a catalytic sulfur removal system for landfill gas recovery systems. (Brookhaven)

Publications:

K.L. Thyberg, D.J .Tonjes. *The Environmental Impacts of Alternative Food Waste Treatment Technologies in the US.* Journal of Cleaner Production

158:101-108. DOI 10.1016/j. jclepro.201704.169 (2017).

O. Aphale, D.J.Tonjes. *Multi-model Validation Assessment of Groundwater Flow Simulation Models Using Area Metric Approach.* Groundwater 55(2):219-226. DOI 10.1111/gwat.12470 (2017).

L. Clark, D.J. Tonjes, D. Mahajan. *Improving Custom Landfill Gas Modeling at a Multi-Phase Landfill.* Poster. Canadian Waste-to-Resource Conference, Niagara Falls, Ontario, Canada, NY. October 24 (2017).

RESEARCHER PROFILE

Alexander Orlov

Associate Professor, Materials Science and Chemical Engineering Department, Consortium for Inter-Disciplinary Environmental Research. Affiliate Professor, Chemistry Department, Institute for Advanced Computational Science, Advanced Energy Center, Department of Technology and Society.

Energy Projects:

- Sustainable Hydrogen Production
- Clean Fuel Production
- Sustainable Polymer Nanocomposites
- Ceramic Membranes

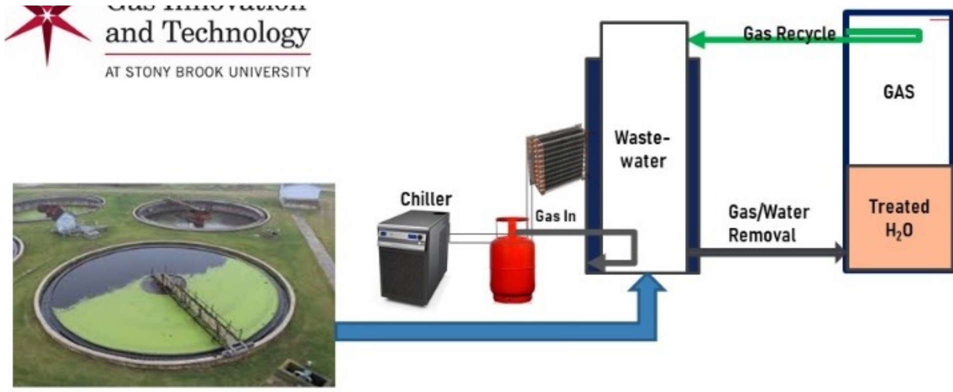
Awards and Honors:

- American Institute of Chemical Engineers Sustainable Engineering Forum Education Award, 2018
- American Chemical Society Award for Incorporating Sustainability into Chemistry Education, 2017
- Chancellor's Award of Excellence in Scholarship and Creative Activities from State University of New York, 2016
- EU (the European Council of Academies) – US (National Academy of Engineering) Frontiers of Engineering, 2016
- Sigma Xi Distinguished Lectureship, 2015
- US National Academy of Engineering Frontiers of Engineering Education, 2015
- US National Academy of Science Kavli Fellow, 2014

ENVIRONMENTAL SUSTAINABILITY

A NON-CHEMICAL GREEN PROCESS TO TREAT WASTEWATER

PIs: Devinder Mahajan, SBU; Jade Killean and Wiam Homir, (I-GIT); Julia Hasty, All Power Labs



Wastewater management is a major issue facing engineers as freshwater crisis expands globally. In the United States, despite investments in the Publicly Owned Treatment Works (POTWs) dictated by the Clean Water Act (CWA), the point source discharges continue to be a significant contributor to the degradation of surface water quality. Wastewater treatment is energy intensive and accounts for 2% of total U.S. electricity (2). In 2000, energy-related emissions resulting from POTW operations led to total emissions of 15.5 million metric tonnes (MMT) CO2-equivalents (CO2-eq.). Coupled with the CO2 emissions of 14.8 (MMT), the CO2-eq. associated with CH4 releases from organic sludge degradation in wastewater treatment systems amounted to about 0.3% of total U.S. GHG emissions. In 2012, U.S. clean water needs for building new and updating existing wastewater treatment plants alone were $102 billion.

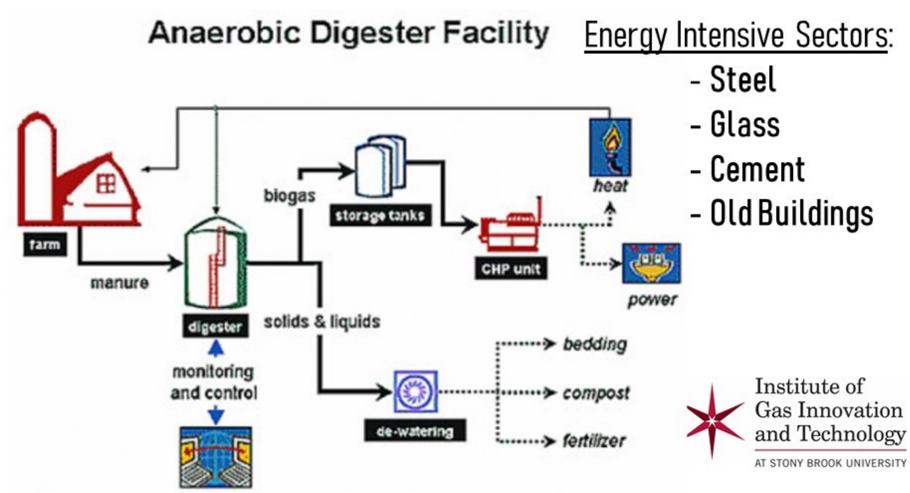
Typical commercial technology is multi-step: 1) separation of non-food components, 2) disinfection treatments are chlorination and ultraviolet (UV) and both have comparable energy consumption, 3) chemical additions of ferric salts and lime enhance coagulation and sedimentation processes for improved solids removal as well as removal of toxic pollutants.

These steps can be complemented with CH4 recovery, a step that includes the aeration process, which facilitates microbial degradation of organic matter, and can account for 25% to 60% of the energy use in wastewater treatment plants. Additionally, pumping systems typically add 10-15% of energy cost at wastewater treatment plants. We have developed a non-chemical approach to separate water and dissolved organics/inorganics from wastewater streams. The disruptive technology involves physical phase change of a commonly used non-reacting gas to "hydrate", the gas is recycled. We recently completed construction of a batch unit and tested for water separation with brewery wastewater. We envision testing wastewater streams from: 1) breweries, 2) landfill leachate, 3) wastewater treatment plants. The process will be applicable to multiple segments of the industry including wastewater from hydraulic fracturing of oil & gas. (PowerBridgeNY, NSF- I-Corp, ITAS)

ENVIRONMENTAL SUSTAINABILITY

MARKET ANIMATION OF SUSTAINABLE EXPANSION OF ANAEROBIC DIGESTERS BASED METHANE IN NEW YORK STATE

PIs: Devinder Mahajan and Vatsal Bhatt (SBU), Kevin Neumaier (Sustainable Dairy Technologies), Matt Tomich and Phil Vos, (Energy Vision)



The Renewable Natural Gas (RNG) potential in New York State's manure and food wastes exceeds 34.2 trillion BTUs, or over 35% of the natural gas consumed by NY electric utilities in 2017. Today, a tiny fraction of RNG is captured from manure from 28 anaerobic digesters operating on NYS dairy farms for on-site electricity production. From climate perspective, dairy-manure and food waste-derived RNG is net-carbon-negative when considering "lifecycle" GHG emissions. By one estimate, carbon-negative RNG from a fraction of these sources could offset all GHG emissions from natural gas burned by electric utilities in NYS. The Institute of Gas Innovation and Technology (I-GIT) led team proposed to bring key stakeholders together and identified barriers and solutions to large-scale RNG production and off-take in NYS. This involves: 1) engaging dairies (and generators of organic waste), to seek operational data on digesters, both existing and proposed, 2) establishment of an advisory board whose members are drawn from State agencies and 3) engaging utilities to understand off-take agreements. I-GIT would analyze the data, share with the Advisory board through meetings/conference calls to propose deployable solutions. This Market Animation approach would set the stage to capitalize on the potential of RNG in NYS. Data sharing arrangements with other progressive states, such as California, would help NYS realize the potential to greatly expand NY's digester capacity.

The I-GIT team will help NYSERDA coordinate funding activities awarded under PON 3739 worth $16 million. (NYSERDA, National Grid)

Publication:

3rd Annual Scientific Summit on Dairy Methane Management Research Virtual 2020, December 13-14, 2021. Co-Organizers: I-GIT/Cdfa/UC Davis/CSE/Denmark Trade Council.

NEW YORK STATE SOLID WASTE CHARACTERIZATION

PIs: David J. Tonjes and Elizabeth Hewitt, SBU, Co-PI: Gang He, SBU

Multi-task investigation supporting recycling in New York State. The major task is the characterize the New York State solid waste stream by sorting wastes and recyclables at facilities across the State and determine how such sampling results can describe the generation of wastes in New York.

RENEWABLE ENERGY

VIRTUAL WIND SIMULATOR WITH ADVANCED CONTROL AND AEROELASTIC MODEL FOR OPTIMIZING LAND-BASED AND OFFSHORE WIND FARMS

PIs: Fotis Sotiropoulos, Xiaolei Yang, SBU

Wind energy, yielding reduced carbon emissions, improved air quality and reduced water consumption by offsetting the use of fossil energy, has become a key player in the global energy markets. Wind turbines are often grouped into wind farms. In wind farms, wind turbines interact with each other through turbine wakes. The power loss due to turbine wakes is around 20% but can be as high as 80% for some scenarios. The wakes from upwind turbines also increase the dynamic loads of downwind turbines, and thus increase the maintenance cost. Therefore, understanding the mechanism of turbine wakes is critical for reducing the cost and increasing the competitiveness of wind energy. The objective of this project is to develop an advanced high-fidelity computational fluid dynamics tool with turbine control and aeroelastic models for simulating turbine wakes in utility-scale large wind farms under site-specific wind and terrain conditions. The computer code, referred to as the Virtual Wind Simulator (VFS-Wind), can simulate complex atmospheric turbulence over real-life terrestrial, coastal and ocean environments using cutting edge models for parameterizing the wind turbines that can account for the flow structures generated both by the blades and the turbine nacelle. The code can also simulate broad-band ocean waves and 6-degree-of-freedom motion of floating platforms for offshore turbines. VFS-Wind is used extensively by industry to tackle and solve real-life problems at utility scale. Recent applications include the simulation of the Horns-Rev wind farm in Denmark, the Pleasant Valley wind farm in Minnesota owned by XCEL Energy, and the Vantage wind farm in the Washington state owned by Invenergy. VFS-Wind is the first code to be validated at utility scale by comparing actual wind farm operational data with numerical simulations .

Publications:

X. Yang, M. Pakula, F. Sotiropoulos. *Large-Eddy Simulation of a Utility-Scale Wind Farm in Complex Terrain.* Applied energy, 229, 767-777 (2018).

D. Foti, X. Yang, F. Campagnolo, D. Maniaci, F. Sotiropoulos. *Wake Meandering of a Model Wind Turbine Operating in Two Different Regimes.* Physical Review Fluids, 3(5), 054607 (2018).

D. Foti, X. Yang, X., F. Sotiropoulos. *Similarity of Wake Meandering For Different Wind Turbine Designs For Different Scales.* Journal of Fluid Mechanics, 842, 5-25 (2018).

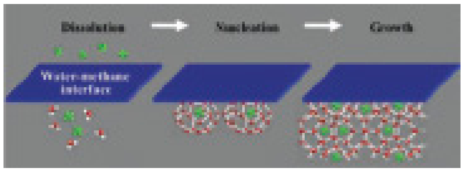
X. Yang, F. Sotiropoulos. *A New Class of Actuator Surface Models for Wind Turbines*. Wind Energy, 21(5), 285-302 (2018).

PHOTOCATALYSIS FOR SOLAR FUEL GENERATION

PIs: Peter Khalifah and Mike White, SBU and BNL

We are at the center of a thrust to develop materials that can harness the sun's energy for the efficient production of hydrogen fuel via solar water splitting ($2 H_2O$ + light - $2H_2 + O_2$). The pressing challenge is to use visible light efficiently (>50% of terrestrial solar energy) to drive this photoelectrolysis reaction. Random material searches have resulted in the discovery of a handful of promising materials, which can utilize visible light to split water, but with very low overall efficiencies. Higher efficiencies can only be achieved with better materials and a better understanding of light-driven water splitting mechanisms. A joint SBU-BNL team has been assembled to tackle these challenges comprehensively.

Prof. Khalifah will coordinate the effort to synthesize perfect surfaces (crystals and thin films) of complex oxide-based materials, while Prof. White will coordinate studies of the molecular reactions that occur at these surfaces. The synthesis efforts will integrate Stony Brook's J. Parise (Geosciences), A. Oganov (Geosciences) and M. Dawber (Physics) together with BNL researchers J. Rodriguez (Chemistry), I. Bozovic (CMPMS), G. Gu (CMPMS), and W. Han (CFN). Characterization efforts at SBU will include A. Orlov (MSE), M. Fernandez-Serra (Physics), P. Stephens (Physics) and Lars Ehm (Geosciences/NSLS) while those at BNL revolve around the efforts of E. Fujita

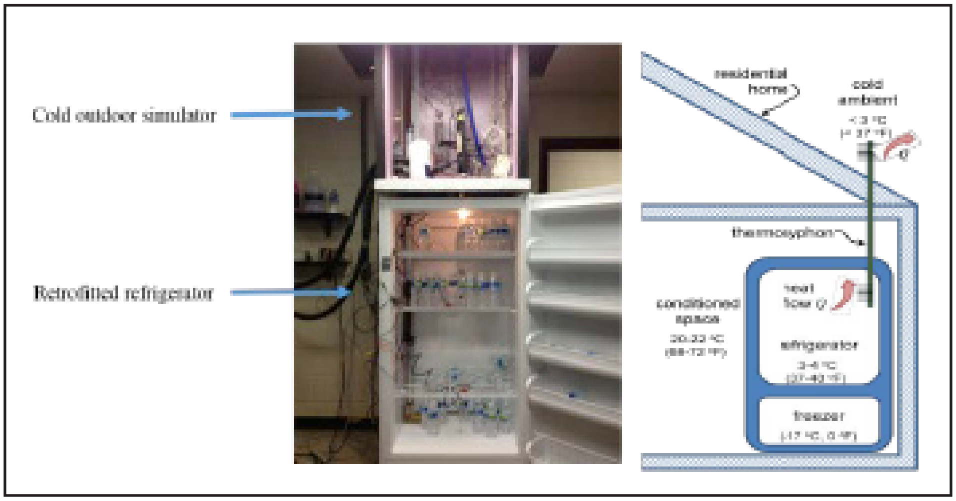


(Chemistry), S. Lymar (Chemistry), J. Muckerman (Chemistry), M. Newton (Chemistry), and M. Hybertsen (CFN). With these high quality samples and these detailed characterization efforts, it will be possible to achieve a more fundamental understanding of the relationship between the optical and transport properties of the bulk material and the effectiveness of water splitting reactions at its surface. (BNL)

RENEWABLE ENERGY

HIGH EFFICIENT REFRIGERATOR USING COOL OUTSIDE TEMPERATURES

PI: Jon Longtin, SBU



U.S. households consume >150 billion (B) kWh of electricity per year for residential refrigerators. In many parts of the US, however, the outside temperature falls below the 37-40°F refrigerated-space temperature for several months out of the year, particularly in the northern half of the country. A natural choice is to use the low outside temperatures for cooling to reduce electricity usage for residential refrigerators. This project uses thermosyphons to provide a low-resistance heat transfer path from the refrigerated space to the cold outside. A thermosyphon is simple in construct and design, consisting of a hollow tube that has been evacuated and filled with a working fluid. The tube is oriented vertically and heat is added at the bottom of the device in the evaporator, vaporizing the working fluid and causing it to rise to the top of the device. Heat is removed in the condenser at the top of the device, causing the vapor to condense onto the pipe wall. The liquid flows back down the sides to the evaporator by gravity. The thermosyphon has several key features that make it ideally suited for improving residential and commercial refrigeration applications:

- Minimal temperature difference: since the device uses the latent heat of phase change, significant heat flows can occur with a very small temperature difference (3-4°F) across the device, making it behave much like a thermal superconductor.
- Heat transfer in one direction only: the thermosyphon is the thermal equivalent of an electrical diode or fluid check valve. Heat only flows when the bottom region of the device is hotter than the top, due to the fact that there is no working fluid under normal conditions in the top of the device. Thus, when the outside temperature is warmer than the refrigerator space, the device simply stops working; heat will not flow back into the refrigerated space. No other control is needed.

A testbed is now being developed to test a residential refrigerator unit with a simulated cold-climate ambient. (DOE MaxTech, BNL Seed Grant, USB)

CATALYSIS FOR THE GENERATION OF FUELS

PIs: Mike White, SBU and BNL and Jose Rodriguez, BNL

We have been working on aspects of fuel generation for the hydrogen economy. A key step in the production of hydrogen involves the use of steam to convert carbon monoxide obtained from natural gas or biomass into hydrogen and carbon dioxide by a catalytic process known as the water-gas-shift (WGS) reaction. The WGS process is energy intensive and Rodriguez and White are investigating novel materials that have high catalytic activity at reaction temperatures lower than that possible with today's best commercial catalysts. The new catalysts are composed of small metallic nanoparticles (Au or Cu) supported on a reducible metal oxide (CeO2, TiO2) with each component playing a unique but synergistic role in the WGS process. Work performed at BNL has shown that the active phase of these materials corresponds to metallic Au or Cu and not the metal oxides as previously proposed. The use of ceria (CeO2) was also shown to yield the most active WGS catalysts, which is partly due to the ease in which oxygen atoms can be removed from the surface of the catalyst. Continuing studies are focused on understanding more about the influence of particle size and reaction conditions on catalyst activity, the unusual activity of Au nanoparticles and the development of an atomic scale mechanism for the WGS reaction process. (BNL)

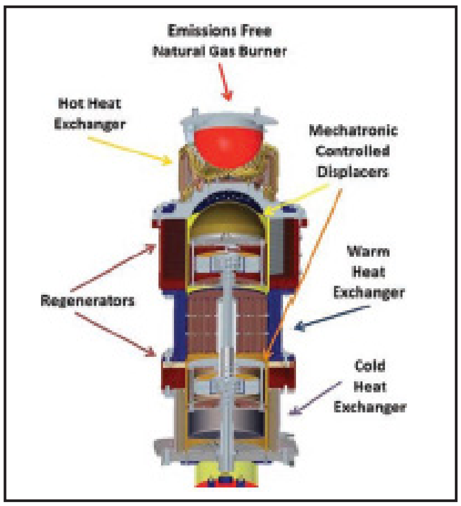
RENEWABLE ENERGY

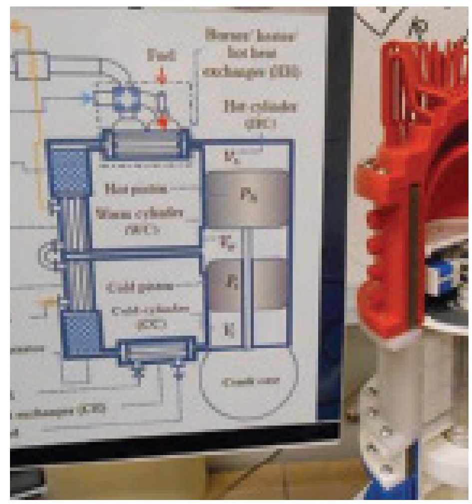
ANALYSIS AND DESIGN OF HEAT EXCHANGERS FOR A VUILLEUMIER NATURAL-GAS DRIVEN HEAT PUMP

PI: Jon Longtin, SBU

Heat pumps represent an attractive means for residential heating. By moving heat from outside to inside the house, rather than producing heat directly by burning a fuel, heat pumps can result in significant energy costs. This project focuses on the design and analysis of heat-driven heat pump based on the Vuilleumier thermodynamic cycle. The device is driven by natural gas, oil or propane for residential home heating. The device can deliver 160% or more of the fuel consumed as heat to the home, in contrast to even the most efficient traditional heating systems that have a maximum value of 95%.

This project focuses on the design of the heat exchangers for a next-generation Vuilleumier heat pump, as well as modeling the overall thermal and mechanical device operation. (DOE/NYSERDA/ThermoLift)





DEVELOPMENT OF A COST EFFECTIVE METHOD FOR WIND TURBINE MAINTENANCE

PIs: Nikhil Gupta and Yi Yang, NYU

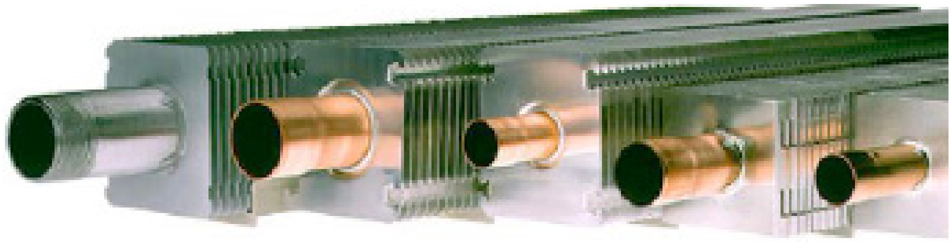
The cost of repair and maintenance of wind-turbine blades, including time down and replacement, can cost upwards of $300,000. LazarOn, a cost effective means of performing wind-turbine blade diagnostics, requires neither hazardous man-hours or turbine downtime. The innovative, patented system employs a loop of thin fiber-optic cable deployed to each turbine blade. The cable is also connected to a fixed-wave laser, and extensometer and photodetector combination to measure the vibration signature of a rotating or vibrating blade. Because a shift in those signatures could indicate a crack in progress, the system lets owners spot problems in real time, during normal operation, obviating the dangerous and expensive process of shutting down the turbine for inspection by eye. LazarOn, already with two patents, won $150,000 for further development in New York's PowerBridge competition. (NSF)

The LazarOn sensing element, 0.25-mm diameter fiber optic cable in a 6-mm loop, is easily mounted near a blade in the turbine hub or inside the root so it need not disrupt airflow as would other proposed blade sensors.

RENEWABLE ENERGY

FORCED FLOW CONVECTIVE BASEBOARD FOR HIGH EFFICIENCY ENERGY DELIVERY

PIs: Tom Butcher, SBU and BNL, Jon Longtin, SBU



This research project explores the feasibility of integrating a forced-air supply for common baseboard radiators to dramatically improve their performance when supplied with low-temperature water. This offers the potential to improve the annual efficiency of condensing boilers, solar thermal systems and hydronic heat pumps. While some concepts for fan-assisted radiators have been identified, they are expensive and noisy. This concept will allow market introduction of a low-cost product by program partner Slant/Fin Corp., the largest residential baseboard manufacturer in the US. The design envisioned involves a small air flow that injects air upward into the bottom section of a baseboard, inducing a larger flow of room air through the baseboard fins. The concept can be compared with some chilled beam designs and is also used in the popular Dyson bladeless fans that recently came onto the market. The primary focus is on a new product, but the application to retrofit to existing baseboard will also be explored. The intended use is for heating but exploratory studies tests are planned to evaluate the technology for cooling applications as well. Minimum fan power requirements will be identified and the potential for self-powering with heat from the hydronic loop will be explored in this research project. Project partners include Brookhaven National Laboratory (program lead) and Slant/Fin, Inc. (NYSERDA)

RESEARCHER PROFILE

Jon P. Longtin

Dean of Engineering, Department of Mechanical Engineering and Visiting Scientist, Brookhaven National Laboratory

Energy Projects:

High-Performance Cold-Climate Heat Pumps • Advanced Power Plant Cooling • Laser-based Free-Space Optics for High-Speed Data • High-Efficiency Fuel Cells • Novel Sensing, Diagnostics, and Data Analysis

Awards and Honors:

- Licensed Professional Engineer in New York State (2012)
- Brookhaven Inventors Award for U.S. Patents (2010; 2011)
- D 100 Award for technology developed at Stony Brook (2007)
- Licensed Innovation Award for technology licensed by a company (2005)
- Excellence in Teaching Award, Stony Brook University (1998, 2017)
- NSF Presidential Early Career Award for Scientists and Engineers (PECASE) (1997)
- 11 issued and pending patents, three licensed

PATHWAYS TO GREENING POWER AND TRANSPORTATION SECTORS

PI: Devinder Mahajan, SBU

I-GIT has teamed up with the Center for Sustainable Energy (CSE)-San Diego to focus on Renewable Natural Gas (RNG) production. Two demonstration projects are being developed:

1) use of wood waste for off-grid power production (20kW -150kW) and
2) storing surplus electricity from renewable sources such as solar and off-shore wind as hydrogen by electrolysis.

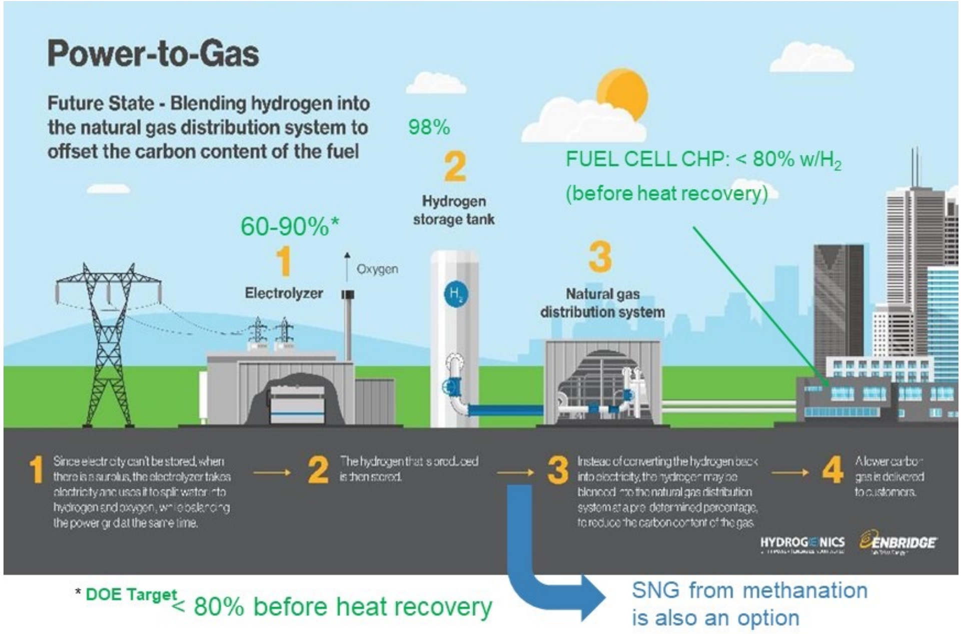
The team is reviewing various options to site these projects on Long Island. (CSE-CIEES)

RENEWABLE ENERGY

INSTITUTE OF GAS INNOVATION AND TECHNOLOGY (I-GIT)

PIs: Devinder Mahajan, Christopher Cavanaugh, National Grid

A new independent initiative to design and advocate policies that enable or support the development of technologies to expand the value of societal investments in natural gas related infrastructure including, transmission, distribution, data, local renewable production and end-use applications for space conditioning, process, electric generation, vehicular transportation and greenhouse gas mitigation. Founded in 2018, I-GIT is a partnership between Advanced Energy Research and Technology Center (AERTC) and National Grid. Several other entities joined thereafter. The first charge of I-GIT is to assess pathways that would lead to zero or net-zero power production in New York State by 2050. Specifically, I-GIT is investigating renewable methane and hydrogen, the latter produced from renewable off-shore wind. Multiple projects are underway under I-GIT umbrella in collaboration with CEWIT. (National Grid, CSE-San Diego, Danskammer Energy, AERTC, CIEES, SPIR)



Publication:

Devinder Mahajan, Christopher Cavanagh, Arie Kaufman, Rong Zhao, Shawn Jones, Gozde Ustuner, Jeff Hung. 2020 NY-BEST Energy Storage Technology and Innovation Conference. Mode: Virtual. New York BEST. Session: Topic: New Developments in Non-Battery Energy Storage Technology. Session: "Super long duration storage: Hydrogen and Power-to-gas. December 8-9, 2020.

OFF-GRID WOOD WASTE TO ENERGY (WTE) DEMONSTRATION: LONG ISLAND RESILIENT CHP

PIs: Devinder Mahajan and Jake Lindberg, SBU; Julia Hasty, All Power Labs

Long Island's geographic location puts the region at risk of losing power during intense storms due to flooding, downed power lines and debris strewn all across the island. Local utility PSEG Long Island's records reflect that the last major windstorm (Superstorm Sandy) to hit Long Island produced approximately 40,000 cubic yards of wood debris and left sections of Long Island without power for up to two weeks. This amount of wood has 420,000 MW-equivalent if converted into power so wood waste-to-energy is the basis of a proposed demonstration project on Long Island. This is a joint project with All-Power Labs (APL), and Peconic Recycling, Inc.

At the heart of the project is an innovative commercial mobile power pallet, dubbed "PP30", a 30kW gasifier provided by APL and fueled by waste wood on Long Island. The APL system (PP30™) is a modular unit that could be deployed routinely to avoid landfilling of debris and to provide emergency power. Under the proposed project, one APL 30 kW power pallet will be initially staged at a designated site. Though the PP30 unit has documented success gasifying wood chips in California, the consortium seeks to gather performance, emissions, reliability and affordability data using a feedstock mix produced from operations on Long Island. The

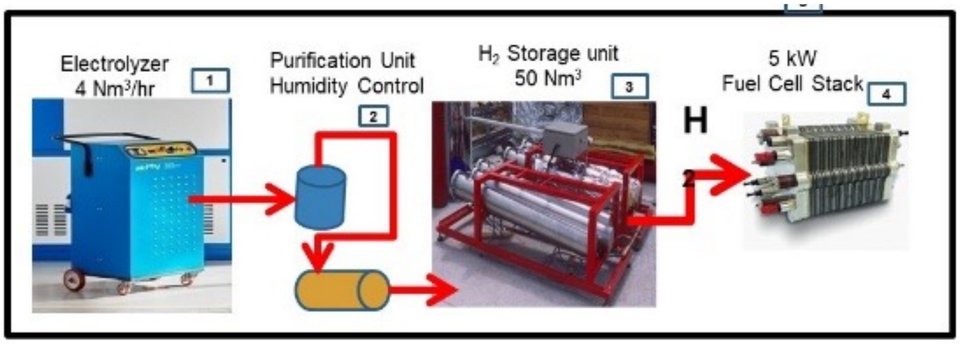
business model envisions revenues from the sale of power, and to produce a potentially usable solid by-product, biochar. A mobile data collection system to monitor a series of units will be managed by CEWIT. (Peconic Recycling, Inc. and APL)

RENEWABLE ENERGY

POWER TO GAS (P2G) DEMONSTRATION ON LONG ISLAND

PIs: Devinder Mahajan, Jake Lindberg, Thomas Butcher, Satya Sharma, Rong Zhao (SBU), CSE-San Diego

This is a joint project between multiple industry, I-GIT, and CEWIT. As the share of renewables increase, the intermittency of these energy sources must be stabilized in electricity networks to realize their full potential. The power-to-gas (P2G) option offers a pathway to store renewable power from solar, wind or hydro to be converted into renewable hydrogen to directly power fuel cells for electricity or to be further reacted with captured CO2 to form renewable natural gas (RNG) that could be either burned directly or injected into pipelines. The potential of P2G to store energy that surpasses battery storage by at least two orders of magnitude, could be realized. The big data management will be provided by CEWIT.



1. Electrolyzer: Novel Membranes/Heat Management
2. Purification Unit: Optimized water vapor removal
3. Hydrogen Storage-

3a. Absorption/Desorption kinetics in mixed metal hydrides

4. Fuel Cell- Membranes /Catalyst/Heat Management
5. P2G Unit integration- HEAT Management

The P2G concept is relatively new and regional data is crucial to expand its application in New York State. In Europe, there are 70 operating P2G plants but in the U.S, there are a few test units. This project will demonstrate the integration of a suite of technologies (water electrolyzer, CO2 extraction system, hydrogen storage system, and a fuel cell) to serve as a test bed for advanced P2G applications. The project also includes identifying optimal combinations to establish baselines for each source of renewable energy (solar, wind, hydro) and educating the public, including international audiences, about the tools and techniques available with the P2G test bed located on Long Island. Batteries are well established as a device for energy storage applications. The well-to-wheel efficiency of batteries is rather impressive at 73% whereas for the Power-To-Gas (P2G) storage option, the well-to-tank efficiency is 52% but when combined with the tank-to-wheel efficiency, the overall efficiency reduced drastically to 22%. The Institute of Gas Innovation and Technology (I-GIT) is at the forefront to realize the P2G potential. The P2G concept is a serious contender as a "Large Scale" energy storage option. To advance the P2G concept to commercial stage, several key R&D areas that remain to be addressed are: 1) Reduced hydrogen production cost, 2) Safe and high-density transport of hydrogen, both as liquid hydrogen and in existing re-purposed natural gas pipelines while maintaining integrity of pipeline materials, 3) Transient hydrogen storage for uninterrupted feed availability, 4) Customized end-use. (I-GIT, National Grid, Danskammer Energy, Con Edison, CIEES)

Publication:

Transatlantic Power-to-Gas {TAP2G) Workshop, Aberdeen, Scotland [October 3-4, 2019]

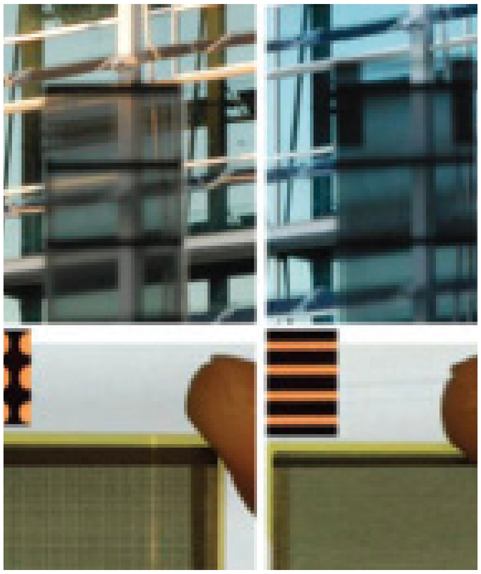
Co-organizers: EMEC, I-GIT and Scottish Hydrogen and Fuel Association

PHOTOVOLTAIC AND FUEL CELLS

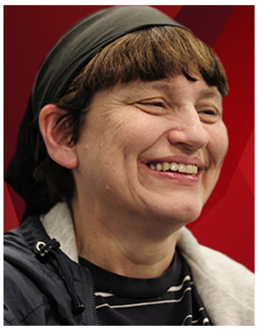
DEVELOPMENT OF LASER SCRIBING TECHNOLOGY FOR HIGH EFFICIENCY BUILDING INTEGRATED THIN-FILM SOLAR MODULES

PI: David J. Hwang, SBU

Research goal of this project is to provide a viable inter-cell connection solution based on precise and cost-effective nanosecond laser scribing technology, and also develop highly efficient building integrated photovoltaic solar cell (BIPV) manufacturing technology based on CIGS thin film materials. Key tasks include optimization of nanosecond laser scribing parameters in conjunction with tuning of thin film material systems, and process optimization towards superior module aperture areal efficiency and PV efficiency approaching performance of costly state-of-the-art process. (Korea Institute of Science and Technology)



RESEARCHER PROFILE



Miriam Rafailovich

Distinguished Professor, Undergraduate Program Co-Director (CME), Department of Materials Science and Engineering, AERTC Chief Scientist

Energy Projects:

- Bioenergy and Biofuels
- Photovoltaic and Fuel Cells
- Combustion • Nanotoxicology
- Environmental Sustainability

Awards and Honors:

- Lady Davis Fellowship
- Long Island Technology Hall of Fame Inductee
- SUNY Chancellors Award for Research in Science, Engineering, and Medicine (2007)
- Fellow, American Physical Society
- Siemens Foundation Recognition Award as Outstanding Mentor for the Westinghouse, Competition in Math, Science, and Technology

NANOPARTICLE ENHANCEMENT OF POLYMER ELECTROLYTE MEMBRANE FUEL CELL POWER OUTPUT

PI: Miriam Rafailovich, SBU

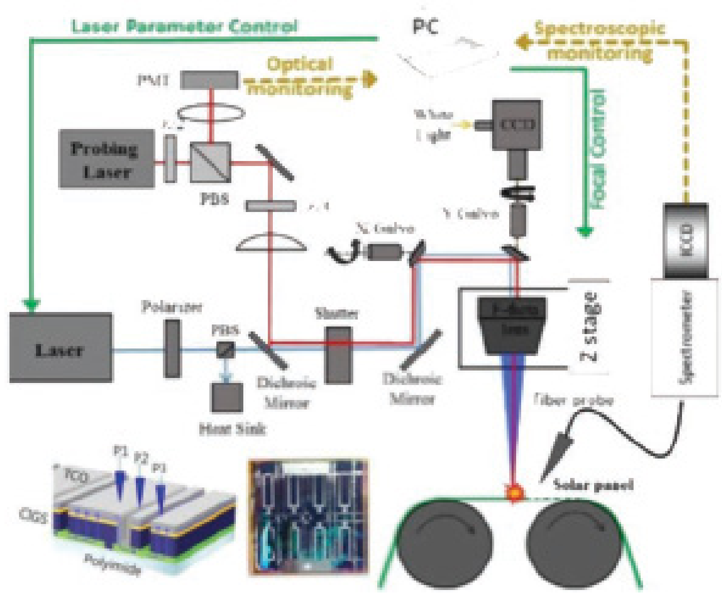
PEM fuel cell technology is one of the most promising future alternative energy sources because it has relatively low-operating temperature, high-power density, quick response and pollution-free operation. However, its relatively low power output compared to that of its price has prevented it from many practical applications. Nanoparticles have been widely known to possess catalytic capabilities. Some predicted that gold nanoparticles that are platelet shaped and have direct contact to the substrate to be the "perfect catalysts, if they could actually be produced. We found that under the optimal flow rate of 0.1 SCFH, the addition of nanoparticles resulted in a more than 500% increase in the power output of the fuel cell. One major limitation of the current PEM technology is the reduction of power as the current is increased past a maximal value. Nanoparticle enhanced PEM membranes do not seem to have that limitation and no current maximum has yet been determined. Hence, the actual power enhancement at high current loads could actually be far greater than the quoted value. Further research is in progress to determine this limit and the specific catalytic reaction which is responsible for this increase. This advancement represents a major step in the production of PEM cells for commercial high power applications. (NSF-MRSEC)

PHOTOVOLTAIC AND FUEL CELLS

DEVELOPMENT OF MONOLITHIC INTEGRATION TECHNOLOGIES FOR FLEXIBLE CIGS SOLAR MODULES USING ALL-LASER SCRIBING

PI: David J. Hwang, SBU

Practical challenge in utilizing renewable solar energy is reducing the cost per watt and simultaneously improving conversion efficiency to compete with current fossil fuel technology. Flexible CIGS thin film solar cells have shown remarkable cell efficiency, and deformable characteristic of flexible substrates enables cost-effective roll-to-roll production path. Portable or building integrated power sources are example of useful applications. Main objective of this project is to develop monolithic CIGS thin film solar cell fabrication technology on flexible substrate by thin film process optimization and precision laser processing. Techniques for all-laser CIGS thin film solar cell module interconnect technique specifically compatible with roll-to-roll process are under development. (Korea Institute of Energy Technology Evaluation and Planning)



DEVELOPING SELF-CLEANING GLASS FOR SOLAR PANELS

PI: Alexander Orlov, SBU

The solar photovoltaics (PV) industry is experiencing a significant global growth. According to the European Photovoltaic Industry Association, the global PV capacity rose from 39.7 GW at the end of 2010 to more than 68 GW at the end of 2011. Capturing this growth in the US in general and in the NY State in particular can bring tremendous opportunities for energy independence, job creations and economic competitiveness. Increasing electricity output from the solar panels, even by few percents, can translate into billions of dollars in savings.

Developing self-cleaning solar panels can have a transformative impact on PV industry. Solar panel surface contamination (soiling) results in significant decrease in output and or/increase in maintenance costs. Some studies shown a decrease in solar cells output by 4-10 % on average in the first year of operation due to soiling. For example, the US based Solar Electric Power Association (SEPA) found that photovoltaic electricity output can decline by about 10% during the first year of operation due to accumulation of dirt, dust and other residues.

The project our group is currently working on can help to increase the PV output via two transformative solutions fitted within the supply chain:

1) coating solar panel glass before solar panel assembly to introduce self-cleaning properties;
2) treating the existing solar panels already installed in NYS to make them self-cleaning.

This novel approach can be tremendously beneficial in increasing energy efficiency of the existing and future PVs installations. (SBU, Powerbridge, NYSERDA)

PHOTOVOLTAIC AND FUEL CELLS

ENGINEERING ENVIRONMENTALLY RESPONSIBLE FLAME RETARDANT MATERIALS FOR ENERGY DELIVERY

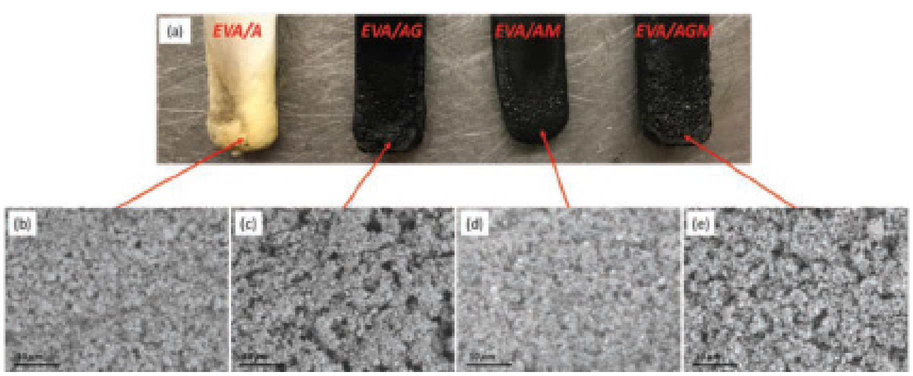
PI: Miriam Rafailovich, SBU

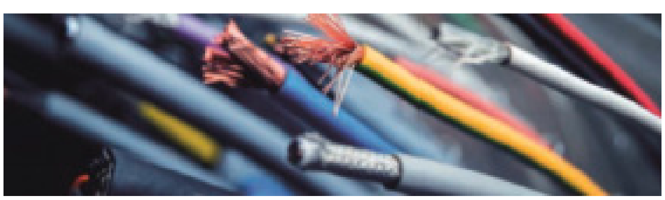
Ethylene-vinyl acetate (EVA) is an elastomeric copolymer known for its excellent tactile properties in the adhesive industry [1] Its high ductility also make it an at-tractive component of polymer blends where it can provide a very large range of thermos-mechanical properties with broad applications in areas as disparate as footwear and electronics. In particular, EVA blends have been promoted as an environmentally friendly alternative to polyvinyl chloride (PVC) in cable sheathing. PVC has been traditionally used for producing the insulation and sheathing of cables due to its resistance to corrosion, flame retardancy, and ductility. However, processing PVC involves the release of a toxic by-product, dioxin, a highly dangerous and carcinogenic chemical. Another potential hazard of using PVC is the plasticizers leaking. Adding plasticizers can further enhance the ductility of PVC to fulfill the requirements of cable sheathing, but these chemicals are suspected carcinogens and easily leak out from the PVC matrix, where they can enter the environment, pollute water systems, and cause significant harm to animals and humans. We have successfully engineered a flame retardant ethylene-vinyl acetate (EVA) composite which has similar mechanical properties to polyvinyl chloride (PVC) and therefore may prove to be an alternative material for cable sheathing, which is as effective, without the adverse effects on the environment. Four composites were studied, EVA with aluminum hydroxide (ATH), EVA with ATH and molybdenum disulfide (MoS2), EVA with ATH and graphene nanoplatelets (GNPs), and EVA with all three components. Tensile testing showed nearly identical results for the EVA/ATH and EVA/ATH/MoS2 compounds, while the EVA/ATH/GNPs compound had higher mechanical properties. The compound containing all three components showed further enhanced mechanical properties, indicating that a synergy was established. This was further confirmed using Scanning Electron Microscopy (SEM) where GNPs were seen to increase the dispersion of the MoS2 and ATH components within the polymer matrix. Cone calorimetry test clearly showed a large decrease in heat release rate when GNPs were added, which was further enhanced by adding GNPs and MoS2 together. Application of the UL-94 test confirmed that the new nanocomposite could achieve the UL-94 V0 rating, indicating that it met stringent flame retardant criteria. (SBU)

Reference:

Capitalizing on the molybdenum disulfide graphene synergy to produce mechanical enhanced flame retardant ethylene-vinyl acetate composites with low aluminum hydroxide loading, Yichen Guo,Yuan Xue , Xianghao Zuo, Linxi Zhang, Zhenhua Yang, Yuchen Zhou, Clement Marmorat, Shan He and Miriam Rafailovich, Polymer Degradation and Stability 144 (2017) 155e166.

Support from NY State Center for Advanced Technology and ICL Industrial Products. We would also like to acknowledge the Advanced Energy Center for access to the ThINC facility.





Optical image of burnt UL-94 samples: (a) From left to right: EVA/A, EVA/AG, EVA/AM and EVA/AGM. SEM images taken on the burnt surface (indicated by red arrows): (b) EVA, (c) EVA/AG, (d) EVA/AM, and (e) EVA/AGM.

Optical image of burnt UL-94 samples: (a) From left to right: EVA/A, EVA/AG, EVA/AM and EVA/AGM. SEM images taken on the burnt surface (indicated by red arrows): (b) EVA, (c) EVA/AG, (d) EVA/AM, and (e) EVA/AGM.

TOP: PVC wire cables bottom: Optical image of burnt UL-94 samples: (a) From left to right: EVA/A, EVA/AG, EVA/AM and EVA/AGM. SEM images taken on the burnt surface (indicated by red arrows): (b) EVA, (c) EVA/AG, (d) EVA/AM, and (e) EVA/AGM.

PHOTOVOLTAIC AND FUEL CELLS

THIN FILM SOLAR CELLS WITH TUNABLE TRANSPARENCY

PIs: T. A. Venkatesh, SBU and Mircea Cotlet, BNL

Solar technologies are currently based on conventional solar cells made out of inorganic materials like silicon which are generally opaque. Organic semiconducting materials, including conjugated polymers, have been investigated as potential replacement materials for solar cells. Conjugated polymer-based organic photovoltaic solar cells have several at-tractive features such as being made of inexpensive materials by cost-effective processing methods like printing techniques, dip or spin casting, requiring low amounts of active material (around 100 nm thick layer) and being light weight and mechanically flexible. However, even at thicknesses of around 100 nm, these continuous thin films also tend to be quite opaque, restricting their application for integrated photovoltaics such as power-generating windows. In order to obtain transparent solar cells, recent efforts have focused on reducing the thickness of the active layer to less than 100 nm, which improves the transparency but drastically reduces the conversion efficiency of the solar cells. Hence, the overall objective of our research effort is to develop conjugated polymer based thin films with a novel microporous structure as active

materials for solar cells with tunable transparency and good photovoltaic properties. (DOE)

COMBUSTION

DEVELOPING AND INVESTIGATING THE CHEMICAL AND MECHANICAL ASPECT OF CU/ZEOLITE CATALYSTS FOR SELECTIVE CATALYTIC REDUCTION OF NOX BY NH3 (NH3-SCR)

PI: Tae Jin Kim, SBU

Stringent environmental regulations of the greenhouse gases, such as NOx, emissions have driven extensive research in new and advanced functional materials. Recently, US Environmental Protection Agency (EPA) and Department of Transportation's National Highway Traffic Safety Administration (NHTSA) passed new regulations on fuel economy and emission standards. The enforced standards are 20mg/mile for NOx emission. NOx (NO and NO2) are exhausts from automobiles (especially diesel cars, 95% NO and 5% NO2) and stationary sources, such as power plants, during combustion of fossil fuels. Due to high activation energy barrier (364 kJ/mol) conversion of NO into non-toxic gases such as nitrogen and water, is very difficult even if the reaction is thermodynamically favorable (ΔG = -86 kJ/mol). Thus, to decrease the activeration energy, advanced heterogeneous catalysts design and different NO decomposition reaction pathways (selective catalytic reduction (SCR) and lean NOx trap (LNT)) should be developed. Zeolite supported catalysts (e.g., Fe- or Cu-ZSM5, SSZ-13, BEA, Y) and mesoporous materials (SBA15) are currently being used and have been extensively investigated for diesel car applications.

Our group has designed and constructed an apparatus to conduct a preliminary study of the SCR of NOx with standard zeolites (MFI, FAU, MOR and CHA) and supported zeolite catalysts. Based on the pore size, dimensionality, number of membered ring and oxidation state of surface species (Cu or Fe), we hypothesized significant differences in the conversion of NO and products selectivity during the SCR reactions. In addition to the zeolite structures, because water concentrations are critically affected on the catalyst deactivation, we also considered water vapor in an apparatus. Figure 1 (above) shows a schematic and installed system of the NOx treatment SCR reaction. To measure the converted gas products, FTIR spectrometer, which combined with a spectroscopic gas cell, has been used. Our research team has tested standard zeolite catalysts using the FTIR spectroscopic techniques and obtained very low (<10% NO conversion) catalytic activity, which was similar to previous reports. Using the Cu-SSZ-13, however, the maximum NO and NH3 conversion shows of 91% and 90% respectively at 300°C. (Figure 2) This result suggested that our group successfully designed and constructed a setup that could be used for the investigation of the SCR of NO with NH3 and will continue to be used for further studies. Future studies to continue this work include further development of catalysts with several synthesis methods and analysis of intermediate species via the Operando study under a wider reaction temperature ranges. (SBU)

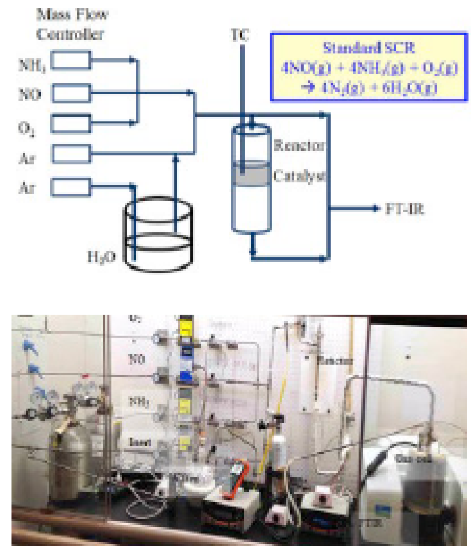


Figure 1. Schematic diagram of NH3/SCR system

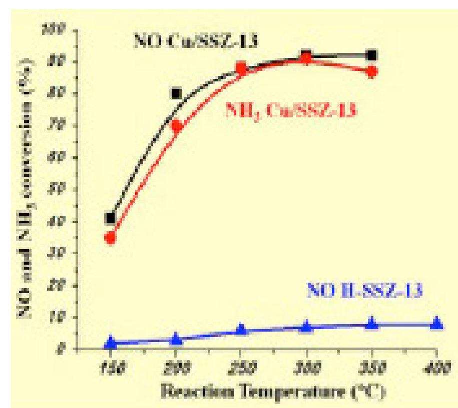


Figure 2. NO conversion versus temperature for Cu-SSZ-13 (square, black) and H-SSZ-13 (triangle, blue) catalysts. NH3 conversion versus temperature for Cu-SSZ-13 (circle, red) is also shown.

COMBUSTION

DESIGN OF NANOSTRUCTURED TUNGSTEN ALLOYS FOR THE FUTURE OF FUSION ENERGY

PI: Jason R. Trelewicz, SBU

Tungsten has emerged as a promising candidate material for the high heat flux divertor region of future fusion reactors due to its high melting point, good thermal conductivity, creep resistance, high temperature strength, sputtering resistance, and chemical compatibility with tritium. However, the potential for transient events in ITER and an eye toward DEMO raises concerns about tungsten's recrystallization temperature, oxidation resistance, long-term radiation tolerance, and mechanical performance. The technical aim of this research is to address these limitations in tandem by precisely tailoring the volume fraction, chemistry, and structural state of grain boundaries in nanostructured tungsten alloys. (DOE)

Publications

W.S. Cunningham, J.M. Gentile, O. El-Atwani, O, C.N. Taylor, M. Efe, S.A. Maloy, J.R. Trelewicz. *Softening due to Grain Boundary Cavity Formation and its Competition with Hardening in Helium Implanted Nanocrystalline Tungsten*. Scientific Reports, 8, 2897 (2018).

O.K. Donaldson, K. Hattar, T. Kaub, G.B. Thompson, J.R. Trelewicz. *Solute Stabilization of Nanocrystalline Tungsten Against Abnormal Grain Growth*. Early Career Scholars in Materials Science: Invited Feature Article, Journal of Materials Research, 33, 1 (2018).

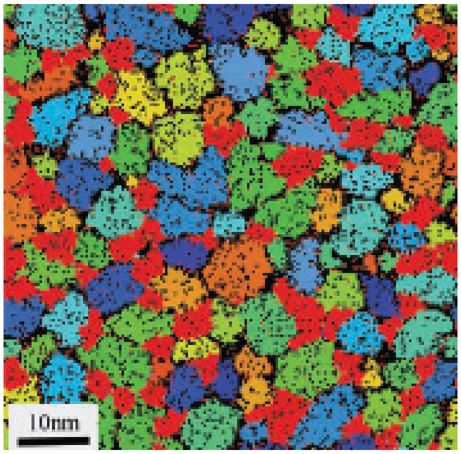


Figure 1: Representative grain model of a nanostructured W-Ti-Cr alloy where Ti (black) and Cr (red) are designed into the tungsten microstructure (other colors represent W grains) to stabilize the grain boundary network against grain growth and recrystallization while simultaneously enhancing mechanical performance.

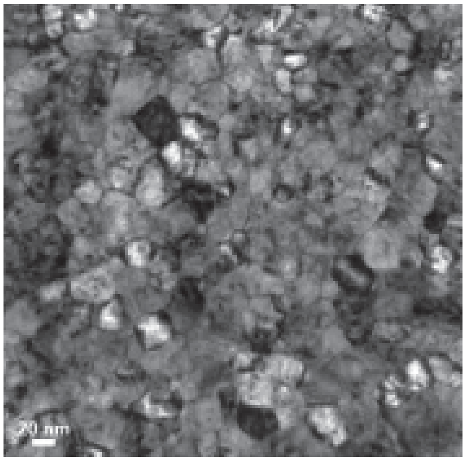


Figure 2: Electron micrograph of a nanstructured W-Ti alloy irradiated with high-energy gold ions to explore the radiation tolerance of this novel material, which was produced based on the insights gained through the model shown in Figure 1.

RESEARCHER PROFILE

Jason R. Trelewicz

Assistant Professor, Department of Materials Science and Engineering;
Affiliate Professor, Institute for Advanced Computational Science;
Director, IACS High Performance Computing Consortium, Stony Brook University

Energy Projects:

- Materials for Fusion Reactors Accident
- Tolerant Cladding for Fission Reactors
- Harsh Environment Sensors

Awards and Honors:

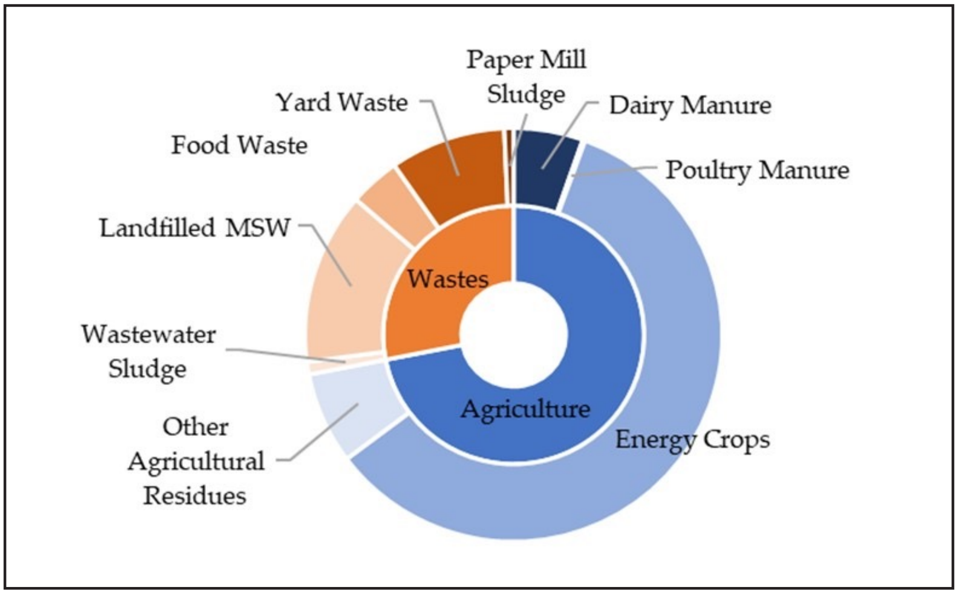
- National Science Foundation CAREER Award, 2016
- Symposium Chair, International Symposium on Plasticity, 2016
- TMS Young Leader Professional Development Award, 2015
- Emerging Leaders Alliance Capstone Program, 2014
- Defense Manufacturing Conference Top Speaker Award, 2010

COMBUSTION

ESTIMATION OF RENEWABLE NATURAL GAS IN NEW YORK STATE AND ITS CATALYTIC PRODUCTION FROM RENEWABLE HYDROGEN AND CARBON DIOXIDE

PIs: Devinder Mahajan and Stephanie Taboada, SBU

Public attention to climate change challenges our locked-in fossil fuel-dependent energy sector. Natural gas is replacing other fossil fuels in our energy mix. One means of improving the Greenhouse gas (GHG) impact of fossil natural gas is to replace it with renewable natural gas (RNG), which has no climate change impact when combusted. However, the potential for improvement should be quantified before committing to the change. This study quantifies the potential production of biogas (i.e., the precursor to RNG) and RNG from agricultural and waste sources. Only about 10% of the state's available resources are used to generate biogas, of which a small fraction is processed to RNG on the only two operational RNG facilities in the state. RNG production is supported by several New York State and federal policies, but its value can be increased 10-fold by applying to California's incentive policy. A second renewable substitute for fossil natural gas is "green" hydrogen. Injecting RNG and "green" hydrogen gas into the pipeline system can reduce up to 20% of the state's carbon emissions resulting from fossil natural gas usage, which is a significant GHG reduction. Subsequent to this study, we are also evaluating nano-sized particles of Co and Ni, supported on gamma-alumina or ceria to catalytic conversion of carbon dioxide to renewable methane by hydrogenation. (I-GIT and NYSERDA Science Training & Research to Inform Decisions (STRIDE) Student Fellowship)



Publication: Devinder Mahajan, Stephanie Taboada, Lori Clark, and Kyoung Ro. Estimation of renewable natural gas potential in New York State. PRESENTATION FORMAT: On-Demand Oral. DIVISION/COMMITTEE: Environmental Chemistry. 2020 Fall ACS Meeting. San Francisco, CA. PAPER ID: 3434346.

THE "LUMBURNATOR": A NEXT GENERATION WOOD STOVE

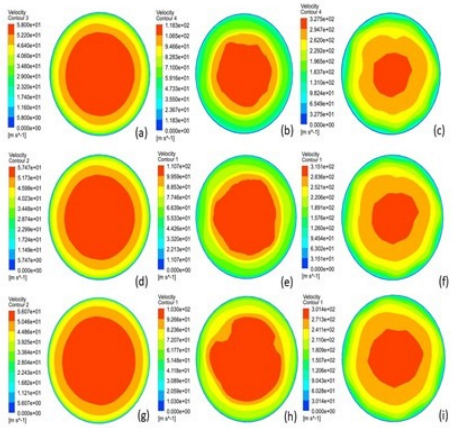
PIs: Devinder Mahajan, John Longtin, Vladimir Zaitsev, SBU and Thomas Butcher, BNL

Biomass combustion is a major source of airborne particulate matter (PM) in the northeastern region of the United States. Hence, the reduction of PM emitted by biomass fired home heating appliances, especially wood stoves, has been identified as a priority in New York State. A desirable wood stove must operate near the stoichiometric air ratio. A novel combustion chamber is being developed with a geometric configuration (firebox dividers) and an air flow system (AFS) and a propane fired afterburner system (PFAS) for evaluation to design a better wood stove. (NYSERDA).

COMPUTATIONAL FLUID DYNAMIC MODELING OF METHANE-HYDROGEN MIXTURE TRANSPORTATION IN PIPELINES

PIs: Devinder Mahajan, T. Venkatesh and Kun Tan, SBU

Replacing fossil fuels and natural gas with alternative fuels like hydrogen have been suggested and thoroughly examined for years. However, because of the vast property difference between hydrogen fuel and traditional energy sources, hydrogen conversion in large scale requires huge investments. Instead of jumping directly from the current energy system to a pure hydrogen energy society, several intermediate steps must be considered for practical reasons. Blending hydrogen to methane is one of the most important intermediate steps. Running hydrogen blended methane in existing natural gas pipelines can reduce carbon emissions. Methane-hydrogen gas has been served as an alternative fuel in many existing applications that commonly use fossil fuels. End-use applications like engines and burners can switch from petrol to methane-hydrogen mixture with a few modifications. Computational fluid dynamic (CFD) modeling is a numerical method for solving fluid flow related differential equations with assistance of iterative computer capability. In this research, a 3D steady-state CFD model has been built to study energy efficiency of methane-hydrogen fuel transportation in a straight horizontal pipe flow using the same setup described in Cadorin et al. (2010). Additional models built on top of the reference model were constructed for testing variables such as 1) hydrogen concentration, 2) pipe surface roughness of common pipe materials, and 3) pipe diameter. (I-GIT, NSF and NYSERDA)



Publication:
Kun Tan, Devinder Mahajan, T. A. Venkatesh. Computational Fluid Dynamic Modeling of Methane-Hydrogen Mixture Transportation in Pipelines: Estimating Energy Costs. MRS Advances, Submitted 2022.

PIPELINE INTEGRITY ASSESSMENT USING ARTIFICIAL INTELLIGENCE

PIs: Devinder Mahajan, Sakshi Sharma and Yue Zhao, SBU

Based on VJT's previous work with organizations such as BP, Total, Con Edison, PSE&G, National Grid, EPRI and the like, VJT has witnessed the impacts of corrosion on existing pipeline infrastructure and the catastrophic failures that can occur. In-situ monitoring, pigging, replacement of steel pipes with composites, etc. are some of the methods that organizations are using to combat and deal with the corrosion issues and VJT has played a role by providing Non-Destructive Testing (NDT) services, primarily in the form of radiography, to observe and detect corrosion. Detecting and observing corrosion is the current best practice, however, VJT is interested in developing and using AI and ML tools along with sensors, NDT data, and metallurgical data, to generate a predictive model that can enable companies to be proactive about corrosion mitigation strategies. Proactive response toward corrosion will ensure continued efficiency of infrastructure and enable companies to plan outages, repairs, and extend the life of infrastructure as well as reduce the risk of catastrophic failure saving money, lives, and the environment. This predictive model will be a combination

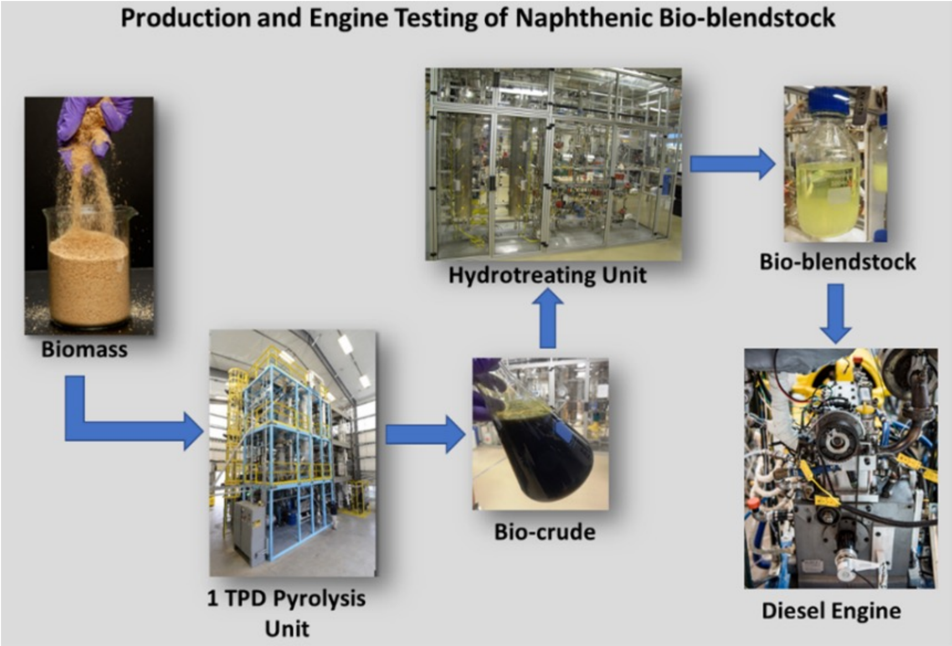
of AI/ML algorithms along with a Big Data approach that's comprised of data based on NDT and other relevant data on the pipelines and the pipes themselves. (I-GIT and VJ Technologies)

COMBUSTION

NAPHTHENIC BIOFUEL-DIESEL BLEND FOR OPTIMIZING MIXING CONTROLLED COMPRESSION IGNITION COMBUSTION

PI: Dimitris Assanis, SBU, Co-PIs: Ofei Mante and David Dayton, RTI International

The objective of the proposed project is to investigate and demonstrate the use of a naphthenic distillate as a multicomponent liquid bio-blendstock for use in medium-duty (MD) and heavy-duty (HD) mixing controlled compression ignition (MCCI) engines. The hypothesis is that the addition of the biomass-derived naphthenic distillate will reduce the concentration of normal paraffin (contribute to poor cold-weather performance) and aromatics (increases propensity for soot formation) and thus improve the quality of the finished blended fuel. Naphthenes are intermediate hydrocarbons between normal paraffins and aromatics, therefore the biofuel can be used to adjust the properties of the blended fuel. Fuel chemistry studies using surrogate fuel mixtures of major cycloalkanes in the bio-blendstock will be used to document the effects of fuel molecular structure on key diesel fuel properties and the engine combustion and emissions formation processes. The surrogate fuel studies will also be used to guide the production of the bio-blendstock. The naphthenic bio-blendstock will be produced via catalytic fast pyrolysis (CFP) and hydroprocessing. The bio-blendstock produced will undergo full fuel composition analysis, including the fuel tests required to meet the ASTM-D975 specifications. Through composition analysis, the project team will assess the impact of the bio-blendstock on key properties of the finished fuel, such as energy density, sooting propensity, cetane number, and cold weather behavior (pour point and cloud point). Fuel blends of different concentrations of bio-blendstock surrogate fuels will be prepared for experimental testing in a single-cylinder research diesel engine equipped with state-of-the-art fuel injection equipment, instrumentation, and data acquisitions systems. (US Department of Energy – EERE, Bioenergy Technologies Office)



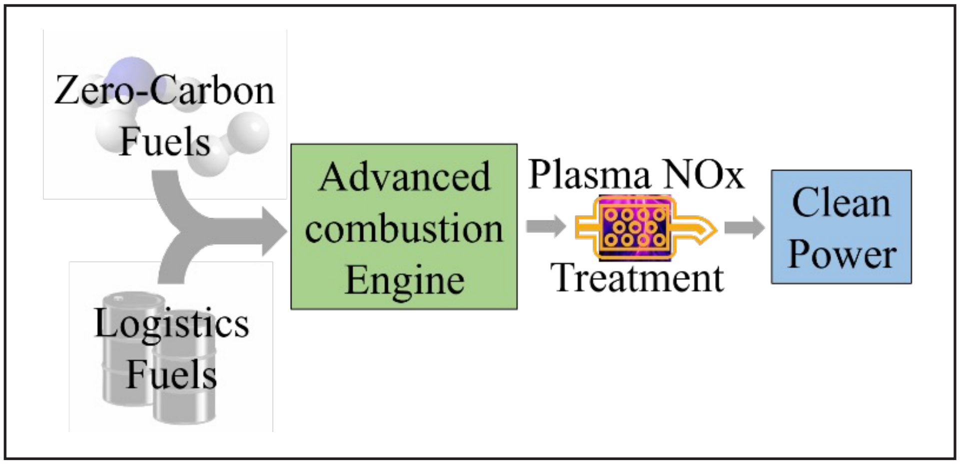
Publication:

Rodrigo Ristow Hadlich, Zhongnan Ran, Ruinan Yang, Dimitris Assanis, Stony Brook University; Ofei Mante, David Dayton, RTI International, "Experimental Investigation and Comparison of a Decalin / Butylcyclohexane Based Naphthenic Bio-Blendstock Surrogate Fuel in a Compression Ignition Engine", SAE Technical Paper 2022-01-0513, 2022, Accepted – In Press. Zhongnan Ran, Rodrigo Ristow Hadlich, Ruinan Yang, David Dayton, Ofei Mante, and Dimitris Assanis, "Experimental Investigation of Naphthenic Biofuel Surrogate Combustion in a Compression Ignition Engine", Fuel 312,122868, 2022, doi:10.1016/j.fuel.2021.1228680.

COMBUSTION

ADVANCED DUAL FUEL COMBUSTION OF ZERO-CARBON AND TRADITIONAL LOGISTICS FUELS

PPI: Dimitris Assanis, SBU
Co-PIs: Noah Van Dam, J. Hunter Mack and Juan Pablo Trelles, University of Massachusetts – Lowell



Experimental and computational investigations will be carried out to guide the understanding, development and demonstration of an advanced combustion mode using zero-carbon fuels (e.g. hydrogen (H2) and ammonia (NH3)). Fundamental experiments in a constant volume combustion chamber (CVCC) at UML will be used to characterize the combustion and reactivity behavior of NH3/H2 blends relevant for advanced combustion. Experimental work will then transition to single-cylinder research engine experiments at SBU to demonstrate the advanced combustion mode on an internal combustion engine platform. In parallel, computational fluid dynamics (CFD) experiments will be conducted, tying both experiments together, using the fundamental CVCC data to validate chemical kinetic and combustion models that will then be used in engine simulations to help guide the engine experiments and operation. Mid- to high fractions of NH3/H2, displacing 40% up to 100% of traditional hydrocarbon logistics fuels (e.g., F-76, JP-5) on an energy basis, will be targeted to achieve significant logistics fuel savings while maintaining high-quality combustion with low emissions. Additional experimental and modeling work will be done on a plasma catalytic reactor for NOx after treatment. The plasma catalytic reactor systems will be developed using real exhaust gas composition information from engine experiments and simulations, for production-like data. (Office of Naval Research)

COMBUSTION

STTR PHASE 1: HYBRID ELECTRIC X-ENGINE FOR VTOL PROPULSION SYSTEM

PPI: Dimitris Assanis, SBU
Co-PIs: Noah Van Dam, J. Hunter Mack and Juan Pablo Trelles, University of Massachusetts – Lowell

This feasibility study computationally modeled a LiquidPiston Inc. prototype engine to investigate the performance of an actively fueled pre-chamber combustion system in a novel rotary engine, operating on conventional light diesel fuel under compression ignition (CI) mode conditions. The closed-cycle computational model of a non-Wankel rotary engine was thoroughly investigated to achieve optimal efficiencies, in a multitude of loading conditions relevant to automotive and aeronautical applications. Computational fluid dynamics (CFD) modeling was conducted in CONVERGE CFD, targeting the operation of a single pre-chamber and downstream main chamber engine system, roughly from 100 crank angle degrees (CAD) before top dead center (bTDC) to 100 CAD after top dead center (aTDC). In the developed framework, optimization studies involved main decision variables, including the engine's compression ratio (CR), the injector's position within the pre-chamber, the injector's nozzle hole count and nozzle hole diameters. Traditional and split-injection strategies for the introduction of diesel fuel into the pre-chamber were evaluated by varying spray-related parameters including total injected mass, injection pressure, start of injection(s), and injection duration(s). The main metrics used to evaluate the engine's operation include (1) pre-chamber, main chamber, and overall combustion efficiencies and (2) closed-cycle average load performance determined by a relative indicated mean effective pressure metric. Additionally, the injected fuel phase state (liquid vs vaporized) and wall film thickness, if present, were used as performance metrics to determine fuel-air mixing success. Pre-chamber and main chamber maximum pressures were kept below 150 bar and injection pressures were limited at 1000 bar. As a result of this study, the best-performing cases demonstrated an overall combustion efficiency (ηc) that surpassed 90%, in both mid-load and high-load operating conditions. (LiquidPiston, Inc. and United States Air Force)

Publication:

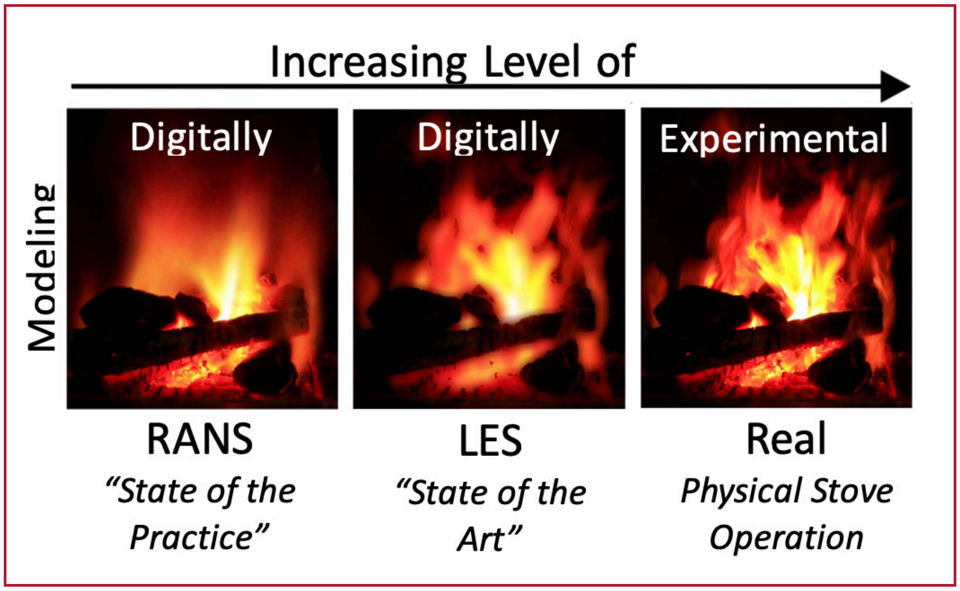
Ioannis Nikiforakis, Gaurav Guleria, Mahmoud Koraiem, Dimitris Assanis, Stony Brook Univ; Curtis Collie, Tiago Costa, Piyush Kute, Alec Shkolnik, LiquidPiston Inc, "Understanding Pre-Chamber Combustion Performance in a Closed-Cycle Model of a Novel Rotary Engine", SAE Technical Paper 2022-01-0396, 2022, Accepted – In Press.

COMBUSTION

LARGE EDDY SIMULATIONS FOR SUPERIOR, COMPUTATIONALLY OPTIMIZED OXIDATION USING BIOMASS (LESS CO2 USING BIOMASS)

PIs: Dimitris Assanis, SBU and Rebecca Trojanowski, BNL
Co-PIs: Jon Longtin, SBU and Tom Butcher, BNL

Residential wood heating currently contributes 275% more particulate matter with a diameter of 2.5 microns and smaller (PM2.5) than all industrial, commercial, and institutional heating emissions combined, 550% more PM2.5 than the electricity generation sector, and 35% more PM2.5 than the transportation sector. To date, there has been relatively little adoption of numerical simulation in the assessment, design, and development processes for biomass fired heaters, leaving much of the R&D to be a slow, laborious, and iterative process to reduce emissions and increase the efficiencies of such devices.



Guided from the gas turbine and internal combustion engine sectors that use advanced modeling to optimize performance and emissions, SBU and BNL will partner to lay the foundation to start developing an improved high-fidelity, coupled, multi-zone approach for modeling biomass combustion. Coupling detailed dynamic boundary conditions, detailed chemical kinetic mechanisms, robust combustion models, and Large Eddy Simulations (LES) turbulence modeling, can provide a much more accurate analysis of biomass combustion, with detailed spatially resolved flow field and species data. Predicted emissions such as NOx, CO and PM from detailed chemistry mechanism simulations will allow engineers and manufacturers to assess the impact of a variety of conditions. Hence, biomass heaters can be improved as part of an iterative design process before realizing the device in hardware.

The use of solid biomass has been slated as part of the renewable energy portfolio. Therefore, it is imperative we work to identify and address gaps in the fundamental research associated with its consumption. Development of a successful modeling framework will support the innovation of biomass heaters by utilizing Computer Aided Engineering to guide the optimization of wood heater designs, thus shifting the paradigm in the development time required to reduce emissions and increase efficiency.

Publications: Mahmoud Koraïem and Dimitris Assanis, "Wood Stove Combustion Modeling and Simulation: Technical Review and Recommendation," International Communications in Heat and Mass Transfer, 2021, Volume 127:105423, doi:10.1016/j.icheatmasstransfer.2021.10542

BIOENERGY AND BIOFUELS

DESIGN OF MICROCHEMICAL SYSTEMS FOR DISCOVERY OF METHANE SCIENCE

PI: Ryan L. Hartman, NYU

Methane, a key component of our domestic natural gas resource, is used for energy and the sustainable production of chemicals. Methane gas can form crystalline sI hydrates with liquid water at elevated pressures and sub-cooled temperatures. This project investigated methane sI hydrate crystal growth kinetics by designing a microfluidic device capable of controlling nucleation via thermoelectric temperature cycling. This work was supported primarily by the MRSEC Program of the National Science Foundation under Award Number DMR-1420073. Methylations of aromatics are also useful steps in the preparations of fine chemicals and pharmaceuticals. The second project focuses on energy efficient catalytic routes to methane C-H activation, which involves the design of microchemical systems for the study of a new family of homogeneous catalyst. This work was supported by the National Science Foundation under Award Number CBET-1551116. (NSF)

Publications:

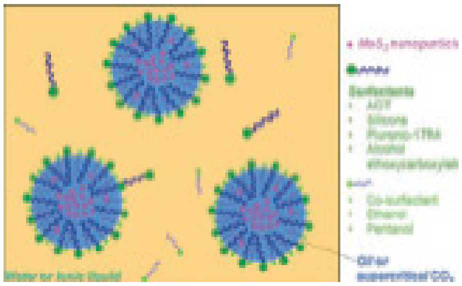
W. Chen, B. Pinho, R.L. Hartman. *Flash Crystallization Kinetics Of Methane (Si) Hydrate In A Thermoelectrically-Cooled Microreactor,* Lab Chip, 17, 3051-3060 (2017).

B. Pinho, Y. Liu, B. Rizkin, R.L. Hartman. *Confined Methane-Water Interfacial Layers and Thickness Measurements Using In Situ Raman Spectroscopy.* Lab Chip, 17, 3883-3890 (2017).

DEVELOPMENT OF A FLEX BIO-PLANT: MICROEMULSION-BASED PRODUCTION OF BIO-METHANOL AND BIO-BUTANOL FROM BIOMASS-DERIVED SYNTHESIS GAS

PIs: Devinder Mahajan, SBU, Scott Turn, U Hawaii, and Ponisseril Somasundaran, Columbia University

The slurry-phase MoS2 catalyzed process to produce mixed alcohols shows that the system operates as a 4-phase system (catalyst/solvent/aqueous/gas) limiting mass transfer to produce mixed alcohols in low yields. The ongoing work envisions a microemulsion system in which the dispersed oil phase in water medium functions as a reservoir of nanocontainers for the MoS2 catalyzed reactions. The CO2 in syngas, present in supercritical state under operating temperature and pressure, itself acts as the dispersed oil phase and is solubilized in a water medium using non-ionic surfactants. This would substantially enhance alcohol production rates through higher catalyst/gaseous reactant contact in the oil phase and excellent heat management through the dispersion medium. Also, selective partitioning of heavier products in to the oil phase helps in reducing the downstream fractionation load of mixed alcohols. The proposed partnership brings together expertise of two NSF centers: the Center for Advanced Studies in Novel Surfactants (ASNS) is formulating MoS2 containing microemulsions that can be stable under operating temperatures and pressures and CBERD is conducting tests to evaluate the prepared



microemulsions for mixed alcohols. A successful system would achieve the CO conversion per pass from < 20% to > 50% making this pathway a potential commercial process. (NSF-CBERD, US ARMY)

ASSESSMENT OF REFORMING THE ENERGY VISION (REV) PROJECTS

PIs: Devinder Mahajan, Eugene Feinberg, Jon Longtin (SBU); Thomas Butcher (BNL)

The Reforming the Energy Vision (REV) is an ambitious New York State initiative that is focused on reducing atmospheric CO2 while providing a multitude of low-carbon technology options to customers. I-GIT is tasked with reviewing the effectiveness of such programs that are being managed by National Grid in New York. A formal report will be submitted under this contract. (National Grid, CIEES)

Publication:

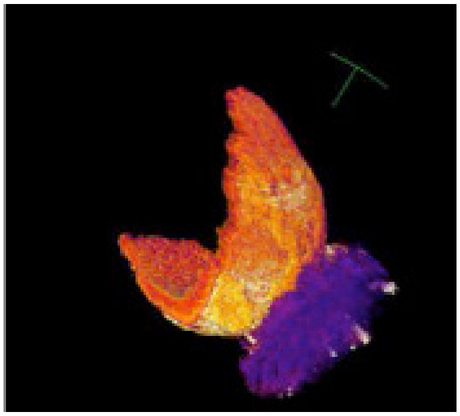
D. Mahajan, C. Xiaoli, D. Tonjes. *Energy Harvesting and Utilization Potential of Fugitive Methane with Climate Change Consequence.* Prog. Ener. & Comb. Sci., 56 33-70 (2016).

BIOENERGY AND BIOFUELS

TURNING WASTE INTO FUELS, SOIL ADDITIVES AND IMPROVED CONSTRUCTION MATERIALS

PI: Alexander Orlov, SBU

This project is focused on several innovative approaches on utilizing waste biomass to produce biofuels while using the byproducts of the process as soil improvement additive. We have utilized a synchrotron radiation source to understand the mechanisms of biomass pyrolysis by conducting X-ray tomography studies. We have also collaborated with USDA to understand how this technology can be used to improve soil quality, decrease pesticide runoff and reduce water requirements for crop irrigation. In addition to biomass utilization, we are exploring the innovative concept of using waste concrete to achieve removal of air pollutants from power station. This breakthrough technology employs a recently discovered chemistry of waste concrete, where we demonstrated how to achieve a complete removal of NOx and SOx, which are priority air pollutants originating from power stations held responsible for health problems of millions of people worldwide. (DOT)



DEVELOPMENT OF NANOCATALYSTS FOR FUELS FROM CO2-ENRICHED SYNGAS USING A SI²-MICROREACTOR

PIs: Devinder Mahajan, SBU and Debasish Kulia, NC A&T

The objectives of our CREST Partnership is to: 1) conduct fundamental research on conversion technology using CO2-enriched syngas as feedstock for efficient and economic production of liquid transportation fuels, in collaboration with the Advanced Energy Research and Development Center (AERTC) at Stony Brook University (SBU).

Our goal is to: 1) develop new materials for catalytic conversion of H2/CO/CO2 mixture into fuels using Si-microchannel microreactors (SiMM). This work complements our ongoing research on conversion of syngas to biofuel using novel nanocatalysts encapsulated in high surface area mesoporous supports, 2) provide education and training for under-represented undergraduate and graduate students, 3) serve as a pipeline for K-12, community college, undergraduate, and graduate students into bioenergy related STEM disciplines and careers. (NSF)

Publication:

C. Okoli, K.A. Kuttiyiel, J. Cole, J. McCutchen, H. Tawfik, R. Advic, D. Mahajan. *Sonochemical Synthesis of Metal Alloy Nanoparticles in Different Solvents for Use as Electrocatalysts.* Ultrason. Sonochem., submitted (2017).

INSTITUTE OF GAS INNOVATION AND TECHNOLOGY (I-GIT)

PI: Devinder Mahajan, SBU

Biogas, primarily a mixture of CH4, CO2, N2, H2S, is a renewable source of methane (CH4). Methane sources (landfills, waste-water facilities) naturally produce hydrogen sulfide (H2S) contaminated "biogas" that pose nuisance to public. Once H2S is removed, methane can be harvested for power and fuel use. NanoSulf™ is a self-renewing catalytic process that improves over commercial H2S removal methods by requiring less frequent media changes and is a drop-in replacement, thus reducing capital and operational costs. The process is modular that moderates overall process cost by 30%. The proposed study focused on market assessment and potential of the technology for scale-up at the Town of Brookhaven landfill site. (National Grid, AERTC).

Publication:

D. Mahajan, C. Xiaoli, D. Tonjes. *Energy Harvesting and Utilization Potential of Fugitive Methane with Climate Change Consequence.* Prog. Ener. & Comb. Sci., 56 33-70 (2016).

BIOENERGY AND BIOFUELS

BIOGAS MANAGEMENT FOR POWER AND TRANSPORTATION FUELS PRODUCTION

PIs: Devinder Mahajan, SBU; Chai Xiaoli, Tongji University

In July 2013, the NSF funded Center for Bio-energy Research and Development (CBERD) at SBU signed an agreement with Tongji University, China to jointly develop technologies to economically convert biogas from landfills and other sources to transportation fuels. The Partnership will design effective systems for generation and management of biogas from solid waste facilities. The project will use a suite of technologies tested by CBERD at the Town of Brookhaven landfill; including upcoming gas-to-liquid conversion technologies to produce fungible liquid fuels. The follow-up tests will be conducted at the Shanghai Laogang landfill in Shanghai – one of the largest landfills in China. The project will be monitored by the joint EcoPartnership secretariat and the project progress will be reported annually during an event during the high-profile US-China Strategic and Economic Dialog (S&ED) hosted by the U.S. Department of State (Ministry of Science and Technology (MoST), China).

Publication:

D. Mahajan. *Preface to Special Topic: Low-Carbon Pathways Toward Decarbonizing Economy in Asia Pacific*
9, 021301; doi: 10.1063/1.4978466 (2017).

RESEARCHER PROFILE

Devinder Mahajan

Professor, Chemical & Molecular Engineering, Stony Brook University & Director, Institute of Gas Innovation and Technology

Energy Projects:

- Low-Carbon Energy Technologies
- Distributed Fuel and Power Production

Awards and Honors:

- Member Inductee, National Academy of Inventors, Washington DC (2018)
- High-End Foreign Expert, Energy & Environment, SAFEA, Beijing, China (2015-17)
- Jefferson Science Fellow, Department of State, Washington DC (2011-17)
- Marie Curie Researcher of Biomass Volarization, Joint European Commission (2013-17)
- Certificate of Recognition, Bureau of Energy Resources, US Department of State (2012)
- Fulbright Specialist Scholar, Asian Institute of Technology, Thailand (2010)
- Outstanding Mentor Award, United States Department of Energy (2007; 2009)
- Fellow, Agency of Industrial Science and Technology (AIST), Tsukuba Science City, Japan (1997)

BIOENERGY AND BIOFUELS

CATALYTIC ACTIVITY OF CU/CHA ON THE NH3-SCR REACTION

PI: Tae Jin Kim, SBU

NOx is the common term for mononitrogen oxides (NO and NO_2), which are exhausted from automobiles and stationary sources during combustion (fossil fuels in vehicles' engines or coal in electric power plants). Recently, Cu based zeolite especially Chabazite, CHA (Cu-CHA) has been selected for selective catalytic reduction (SCR) applications because it showed exceptional hydrothermal stability in addition to the higher NO reduction activity. In this research, Cu/CHA catalysts with various Cu loadings (0.5wt%~6.0wt%) were synthesized via incipient wetness impregnation and were applied to the SCR of NO with NH_3 and NO oxidation reaction. XRD and N_2 adsorption/desorption data showed that CHA structure is maintained with the incorporation of Cu (Figure 1), while specific surface areas decreased with increasing Cu loading. At intermediate Cu loading, 4 wt%, the highest NH3-SCR activity was observed with ~98% N2 selectivity from 150°C to 300°C. (Figure 2) Small amounts of water, 2%, slightly increased NO conversion in addition to the remarkable N_2O and NO_2 reduction at high temperature. Water effects are attributed to the improved Cu ion reducibility and mobility. NO oxidation results provided no relation between NO_2 formation and SCR activity. Physicochemical properties, NO conversion, N_2 selectivity, and activation energy data showed that impregnated samples' molecular structure and catalytic activity are comparable to the conventional ion-exchanged (IE) samples' ones. (SBU, BNL)

Publication:

N. Akter, X. Chen, J.B. Parise, J.A. Boscoboinik, T. Kim. *Effects of Copper Loading on the NH3-SCR and NO Oxidation Over Cu Impregnated CHA Framework Zeolite by the Incipient Wetness Method.* Korean J. Chem. Eng., 35(1), 89-98 (2018).

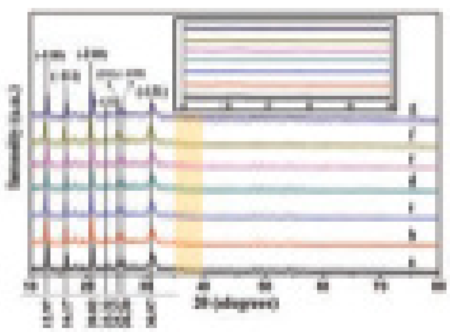


Figure 1.
XRD patterns of a) CHA, b) 0.5% Cu/CHA, c) 1% Cu/CHA, d) 2% Cu/CHA, e) 4% Cu/CHA, f) 5% Cu/CHA, and g) 6% Cu/CHA samples. Inset: XRD patterns between 35° and 40°.

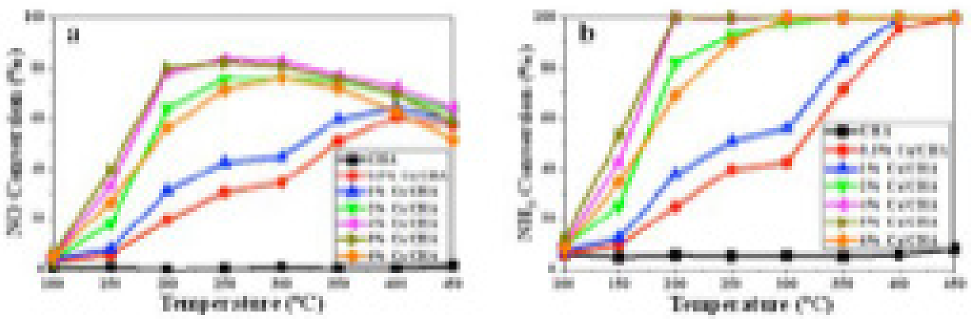


Figure 2.
a) NO Conversion as a function of temperature over Cu-CHA, b) NH3 Conversion as a function of temperature over Cu-CHA during NH3 SCR on Cu-CHA. Reaction conditions: 50 ml/min (500 ppm) NO, 50 ml/min (500 ppm) NH3, 10% O_2 balanced with Ar, total rate 200ml/min. ~40 mg sample is used.

TECHNICAL AND EVALUATION ANALYSIS OF ADVANCED STRATEGIES FOR THE ENERGY VOLARIZATION OF BIOMASS

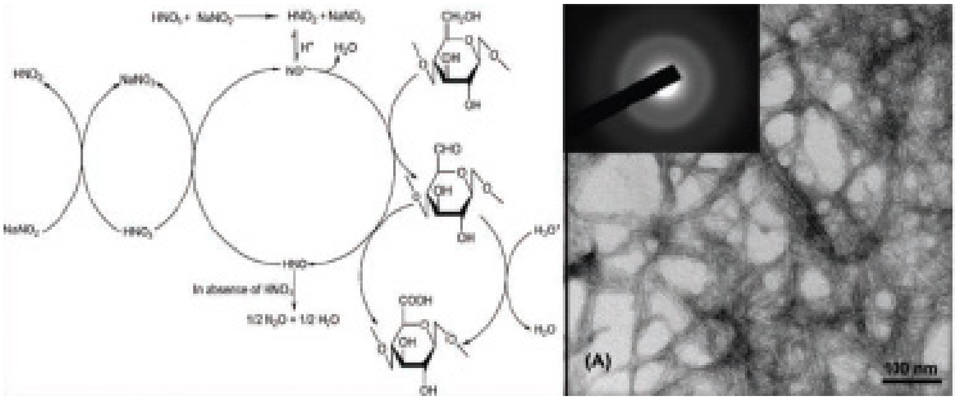
PI: Devinder Mahajan, SBU

A nine-country (Spain, UK, France, Greece, Chile, China, Japan, Canada and USA) consortium, led by the Universidad Politécnica de Madrid (UPM), Spain, has been awarded four-year funding of €302,000 by the European Commission (EC) under the Marie Curie International Research Staff Exchange Scheme (Marie Curie IRSES). NSF is providing funding to the U.S. PI to interface with the EC consortium on a developing joint program in biomass conversion into fuels and chemicals. The key deliverables are personnel exchange and joint proposal development. (NSF)

BIOENERGY AND BIOFUELS

A SIMPLE APPROACH TO PREPARE CARBOXYCELLULOSE NANOFIBERS FROM UNTREATED BIOMASS

PI: Benjamin S. Hsiao, SBU



Carboxycelluloses are important derivatives of natural cellulose polymers, and they have been widely used in many biomedical applications, such as hemostatic materials and surgical sutures. Recently, the developments of different methods to produce carboxycelluloses in nanoscale, such as nanofibers or nanospheres, have further expanded their usage in existing and emerging applications, such as water purification, nanocomposites, nanopaper, drug delivery, ultra-porous lightweight foams and aerogels, gas barrier films, biomaterials, stability enhancers for carbon nanotube dispersions, etc. Many other forms of nanocelluloses without carboxyl groups, such as cellulose nanocrystals, microfibrillated cellulose, bacterial nanocellulose and cellulose nanofibers, have also been extensively studied in the literature.

The major features of carboxycellulose nanofibers, which can be referred to as functional nanocelluloses, are two: (i) the nanoscale format is resulted from the existence of building blocks – cellulose microfibrils, – in the cell walls of biomass, rather than by regeneration of dissolved cellulose polymer chains requiring energy-intensive processes; (ii) the modification, such as by TEMPO oxidation, carboxymethylation, phosphorylation, acetylation, and silylation, on the nanocellulose surface introduces negative charges, which not only facilitate nanofiber dispersion in suspensions, but also provide functional sites for utilization (e.g. adsorption) and further chemical reaction. In addition, nanocelluloses can be extracted from any biomass, including underutilized sources, such as grasses, weeds, shrubs and agricultural waste.

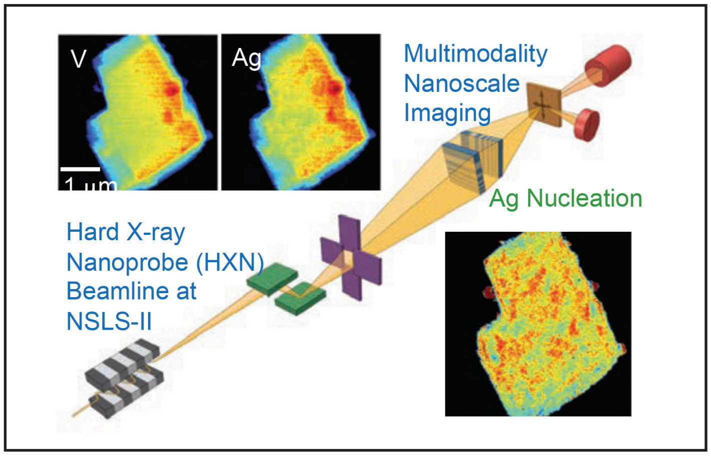
Thus, the development of environmentally friendly and low energy means to extract carboxycellulose nanofibers, from low valued biomass, has untapped potential to replace synthetic polymers in many applications, especially water purification. This is because carboxycellulose nanofibers can offer very large surface area and functional groups, ideally suited as filtration membranes or/and adsorption media for water treatments.

A simple approach was developed to prepare carboxycellulose nanofibers directly from untreated biomass using nitric acid or nitric acid-sodium nitrite mixtures. Experiments indicated that this approach greatly reduced the need for multichemicals, and offered significant benefits in lowering the consumption of water and electric energy, when compared with conventional multiple-step processes at bench scale (e.g. TEMPO oxidation). Additionally, the effluent produced by this approach could be efficaciously neutralized using base to produce nitrogen-rich salts as fertilizers. TEM measurements of resulting nanofibers from different biomasses, possessed dimensions in the range of 190-370 and 4-5 nm, having PDI=0.29-0.38. These nanofibers exhibited lower crystallinity than untreated jute fibers as determined by TEM diffraction, WAXD and 13C CPMAS NMR (e.g. WAXD crystallinity index was ~35% for nanofibers vs. 62% for jute). Nanofibers with low crystallinity were found to be effective for removal of heavy metal ions for drinking water purification. (NSF)

BATTERY AND STORAGE RESEARCH

MULTIMODALITY X-RAY IMAGING AT NANOMETERS

PIs: Yong Chu, BNL, Esther S. Takeuchi, SBU and BNL, Amy C. Marschilok and Kenneth J. Takeuchi, SBU



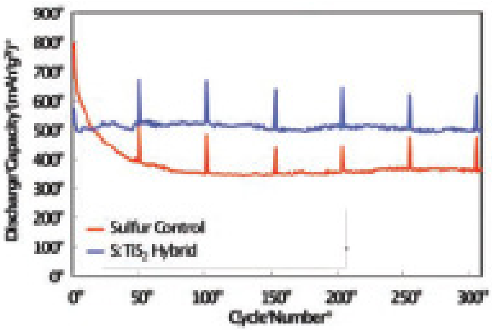
Powerful x-ray imaging capabilities, currently being developed at the Hard X-ray Nanoprobe (HXN) at the National Synchrotron Light Source II (NSLS-II), are opening new scientific opportunities for investigating complex nanostructures with unprecendented sensitivity and resolution. These multimodality imaging capabilities allow simultaneous visualization of interfacial morphology, elemental distribution, and disturbance of crystalline lattice. They are ideally suited for examining how complex interfaces of battery materials are transforming during electrochemical reactions. In close collaboration with the HXN team, Takeuchi Group is aiming at gaining a mechanistic understanding of electrode transformation due to Li+ insertion and redox of Ag+ cation in systems such as silver vanadium phosphorous oxides (SVPO) and silver hollandite. The figure below illustrates how the HXN fluoresce x-ray imaging capability was to visualize Ag phase separation from a single crystalline SVPO matrix with a spatial resolution of 15 nm. With commissioning of additional imaging modalities, it will be possible to image disturbance of crystalline lattice due to Li+ and reduction of Ag+ cations, providing comprehensive structural details. (BNL)

MULTIFUNCTIONAL CATHODE ADDITIVES FOR LI-S BATTERY TECHNOLOGY

PIs: Hong Gan, BNL, Esther S. Takeuchi, SBU and BNL, Amy C. Marschilok and Kenneth J. Takeuchi

The state of he art Li-ion batteries are approaching their limit in energy density and power capability as determined by the lithium metal oxide cathode and the graphite anode based chemical systems. Although adequate for most mobile electronic devices, the calls for battery technologies with higher energy density and lower cost is urgent for other application especially in the area of transportation, such as electric vehicle. Li-S battery technology is considered t be one of the most promising future technology that could result in double or triple the energy density over today's best Li-ion batteries, while still achieve the lower cost target due to the abundant of the sulfur element on the earth crust. The major challenges that prevent today's Li-S battery technology for commercialization are the reduced chemical stability, lower power capability and low cycle life, which strongly associated with the complicated reaction mechanism and the dissolution of the reaction intermediates.

Our team is focusing on the development of the next generation sulfur battery technology by introducing capacity contributing conductive cathode additives to the sulfur cathode. Mechanistic investigation of the system at the components and cell level enables us to better understand the chemical and electrochemical behavior of each material as well as the strong interaction between multiple cell components (see publication). Improved cell cycling performances and power capability are achieved by proper selection of the cathode additive. Sulfur and TiS2 hybrid cathode showed improved cycle life under 1C rate discharge (C/5 at every



51st cycle; see Figure) over more than 300 cycles. The Learning from these studies paves the pathway for additional Li-S battery system improvement and optimization. (DOE)

Publication:

K. Sun, S. Dong, Q. Zhang, D. Bock, A. Marschilok, K. Takeuchi, E. Takeuchi, H. Gan, Interaction of CuS and Sulfur in Li-S battery System. J. Electrochem, Soc., 162 (14) A1-A6, (2015).

BATTERY AND STORAGE RESEARCH

HIGH CAPACITY ANODE INVESTIGATION

PIs: Esther S. Takeuchi, SBU and BNL, Amy C. Marschilok and Kenneth J. Takeuchi, SBU

Increasing battery energy density remains an important challenge to enable widespread adoption of electric vehicles. However, increasing energy density requires new materials. Implementation of new materials demands new fundamental understanding of the material and its electrochemistry prior to implementation. The Advanced Power Sources Laboratory provides comprehensive capabilities in power source research, characterization, evaluation, and testing. State-of-the-art equipment and software are available to perform a wide variety of research activities for almost any primary or rechargeable technology. Multidisciplinary in nature, the research involves aspects of inorganic chemistry, electroanalytical chemistry, materials science and engineering, and physics. Three state-of-the-art facilities, located at the Advanced Research and Technology Energy Center and the Chemistry building at Stony Brook and in the Interdisciplinary Science Building at Brookhaven National Laboratory, were custom-designed for the group's research. The proximity of Stony Brook University to Brookhaven National Laboratory facilitates access to the advanced characterization capabilities located there.

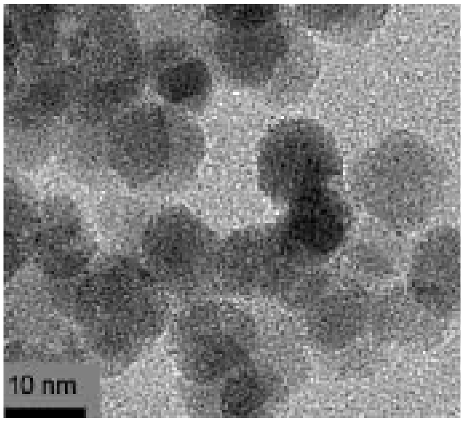
Mercedes-Benz Research Development North America (MBRDNA) is supporting to the Stony Brook University Advanced Power Sources Laboratory to enable basic research advancing alternative high capacity anode materials for lithium ion type batteries. Mercedes-Benz is consolidating all activities in connection with electric mobility under the new product brand EQ, and the Concept EQ gives a clear outlook onto a completely new generation of vehicles. Mercedes-Benz Cars plans to launch more than ten electric vehicles by 2025: in all segments from smart to large SUVs.(Mercedes-Benz Research and Development, North America through the Stony Brook University Foundation)

NEW MATERIALS FOR STATIONARY GRID-SCALE ENERGY STORAGE

PIs: Esther S. Takeuchi, SBU and BNL, Amy C. Marschilok and Kenneth J. Takeuchi, SBU

The vast majority of recent battery research investment has focused on the important problem of electrical energy storage for transportation applications. The successes of these investments and electric vehicle development will shift substantial transportation energy demand from oil-supplied to grid-supplied, and will consequently put even further stress on the already over-stressed electrical grid. This vision requires the development of new battery chemistries and materials for stationary electrical energy storage applications with enhanced cycling, deep discharge capabilities, safety and low cost. This represents a major research challenge and opportunity.

The key to battery-based stationary electrical energy solutions will be in new chemistries and new materials with enhanced properties for the stationary application including high energy density, deep cycling, long cycle life, safety and low cost. Specifically, our group will focus on synthesis, characterization and electrochemistry of low cost environmentally friendly anode materials. The elements to be used are naturally abundant, with lower cost and less environmental impact than many electrode materials in common use today. The overall objective of this work is development of novel anode materials for low cost large scale secondary batteries. Collaboration with Brookhaven National Laboratory will be leveraged to enable utilization of advanced synchrotron and electron tools to characterize the novel electrical energy storage materials. (NYSERDA)



BATTERY AND STORAGE RESEARCH

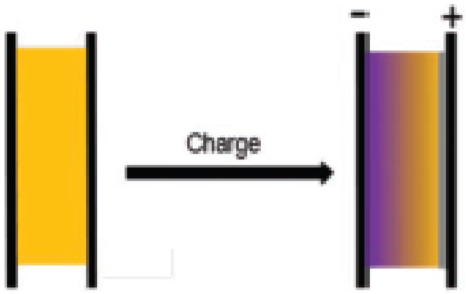
WORKLOAD-AWARE STORAGE ARCHITECTURES FOR OPTIMAL PERFORMANCE AND ENERGY EFFICIENCY

PIs: Erez Zadok and Arie Kaufman, SBU

The most significant performance and energy bottlenecks in a computer are often caused by the storage system because the gap between storage device and CPU speeds is greater than in any other part of the machine. Big data and new storage media only make things worse because today's systems are still optimized for legacy workloads and hard disks. The teams at Stony Brook University, Harvard University and Harvey Mudd College have shown that large systems are poorly optimized, resulting in waste that increases computing costs, slows scientific progress and jeopardizes the nation's energy independence. First, the team is examining modern workloads running on a variety of platforms, including individual computers, large compute farms and a next-generation infrastructure, such as Stony Brook's Reality Deck, a massive gigapixel visualization facility. These workloads produce combined performance and energy traces that are being released to the community. Second, the team is applying techniques such as statistical feature extraction, Hidden Markov Modeling, data-mining and conditional likelihood maximization to analyze these data sets and traces. The Reality Deck is used to visualize the resulting multi-dimensional performance/energy data sets. The team's analyses reveal fundamental phenomena and principles that inform future designs. Third, the findings from the first two efforts are being combined to develop new storage architectures that best balance performance and energy under different workloads when used with modern devices, such as solid-state drives (SSDs), phase-change memories, etc. The designs leverage the team's work on storage-optimized algorithms, multi-tier storage and new optimized data structures. (NSF)

DUAL FUNCTION SOLID STATE BATTERY WITH SELF-FORMING SELF-HEALING ELECTROLYTE AND SEPARATOR

PIs: Esther S. Takeuchi, SBU and BNL, Amy C. Marschilok and Kenneth J. Takeuchi, SBU

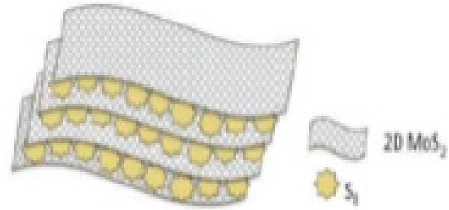


Lithium based battery systems are attractive due to their high energy densities, however, safety issues resulting from the organic electrolyte and dendritic lithium formation are major concerns. Solid state electrolytes provide an opportunity to replace the conventional liquid flammable electrolyte. Self-forming batteries can be envisioned where the anode and cathode are formed upon charge from a single solid electrolyte. The Li/I2 couple is an attractive target due to its high energy density and opportunity to self-heal. Notably, the primary Li/I2 battery has been a successful technology as the power source for implantable cardiac pacemakers.

The objective of this project is to demonstrate a solid state rechargeable battery based on lithium metal (Li) and iodine (I2) cathode with a self-healing electrolyte and separator. The resulting rechargeable self-assembled metal/iodine solid state battery will provide high energy density. This study will contribute to the future development of high energy density solid state self-forming, self-healing, solid-state, safe and reliable rechargeable batteries. (DOE-EERE)

SULFUR LOADED MS_2 BARRIER FOR CONTROL OF POLYSULFIDE SHUTTLING IN LITHIUM SULFUR BATTERIES

PIs: Esther S. Takeuchi, SBU and BNL, Amy C. Marschilok and Kenneth J. Takeuchi, SBU



The goal of this project is to demonstrate a novel sulfur rich two-dimensional (2-D) nanosheet MS_2 (M= Mo, Ti) composite lithium-sulfur battery system with high capacity (high sulfur loading) and capacity retention (decreased polysulfide dissolution). This will be achieved by a novel electrode construction based on 2-D MS_2/S8 which will overcome limitations of sulfur's low electronic conductivity and parasitic reactions that result from polysulfide dissolution during charge/discharge process that shorten the cycle life and reduce capacity. The high theoretical energy density of the Li/S couple provides an opportunity to reach Department of Energy goals of high energy density and long cycle life for vehicle technology, resulting in electric vehicles with a long range and long life battery system.

The proposed Li/S battery concept utilizes 2-D-nanosheet transition metal dichalcogenides (MS2, M = Mo, Ti), to capitalize on the positive transition metal center, to facilitate the trapping of negatively charged polysulfide chains before entering bulk solution to reduce polysulfide shuttling. Sulfur will be embedded between the MS2 nanosheets to create a 2-D-MS2/S8 composite cathode, which will enable high sulfur loading in cathode and enhanced material homogeneity by the inclusion of 2-D nanosheets. (DOE-EERE)

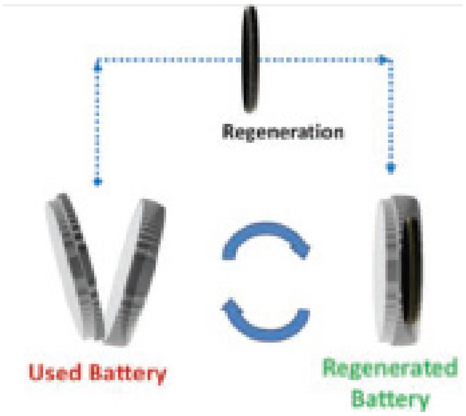
BATTERY AND STORAGE RESEARCH

REGENERABLE BATTERY PROJECT

PIs: Esther S. Takeuchi, SBU and BNL, Amy C. Marschilok and Kenneth J. Takeuchi, SBU

Currently, effective recycling of advanced batteries is limited. Only lead acid batteries are effectively recycled. This results in large numbers of batteries moving to land fill. With increasing battery size, this becomes a significant issue. Globally, over 500 million electric vehicles are predicted to be sold by the year 2040, with US sales predicted to exceed 100 million. To achieve high quality power and effective integrate renewable energy generation into the electric grid, large scale batteries will be required. If all large scale batteries used for these purposes are destined for land fills, the result could exceed hundreds of millions of metric tons of battery waste per year.

This program will reimagine battery design, manufacture, and use life cycles to improve energy and reduce environmental impact. Novel concepts to extend the life of battery components and the possibility of reusing battery components will be explored and demonstrated. (Stony Brook Foundation.)



STOREN VANADIUM FLOW BATTERY

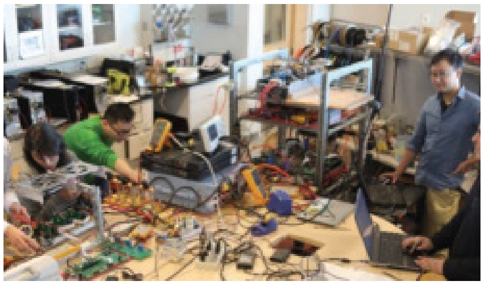
PI: Vyacheslav Solovyov, SBU

The vanadium flow battery (VFB) is a rechargeable flow battery that employs vanadium ions in different oxidation states to store chemical potential energy. The battery exploits the ability of vanadium to exist in solution in four different oxidation states and uses this property to make a battery that has just one electroactive element. The main advantages of the vanadium redox battery are that it can offer almost unlimited energy capacity simply by using larger electrolyte storage tanks, it can be left completely discharged for long periods with no adverse effects. The aqueous and inherently safe and non-flammable. All these feature are very appealing for local energy storage. CIEES has installed the StorEn flow battery at our facility in Stony Brook, NY. The test plan includes evaluation of round-trip efficiency, total capacity, the maximum power etc. CIEES will work with Green Technology Accelerator Center at Rochester Institute of Technology to quantify environmental impact of implementing the battery technology at state level. (CIEES)

SYSTEM (ESS) AND RENEWABLE ENERGY SOURCES

PI: Vyacheslav Solovyov, SBU

CIEES, in collaboration with Unique Technical Services (UTS), won a NYSERDA grant for evaluation of molten salt (ZEBRA) batteries. NYSERDA will grant 11 batteries ($250K value) to evaluate applicability of the technology for seasonal energy storage in the Eastern Long Island corridor. The unique situation in Eastern Long Island is that the electricity demand is at a maximum in the summer due to a surge in the vacationer population. The CIEES-UTS team will install the battery pack and evaluate its performance as a seasonal storage solution for Eastern Long Island. (UTS)



BATTERY AND STORAGE RESEARCH

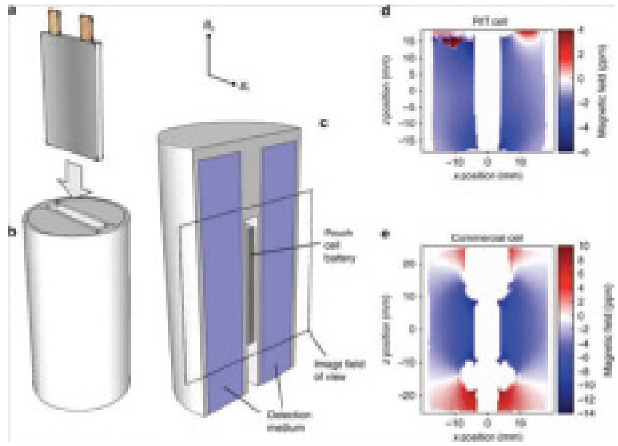
CHEMISTS DEVELOP MRI-LIKE TECHNIQUE TO DETECT WHAT AILS BATTERIES

PI: Alexej Jerschow, NYU

It is surprisingly difficult to determine how long a battery will last, and what may be wrong with it. A series of high-profile failures and recalls have acutely highlighted this problem. Now, a team of NYU researchers have developed a technique that can nondestructively analyze cells either during manufacturing, or during use or testing, and determine certain defects and the state of charge. The method is fast, and provides an unprecedented look into cells. The underlying methodology is based on magnetic resonance imaging, and is used to measure the tiny changes in magnetic fields surrounding a cell when it changes charge state or becomes defective. The researchers anticipate that this technique could become a core tool in battery assessment and development and accelerate the introduction of higher capacity devices while insuring safety and reliability. (NSF, NYU Technology and Acceleration & Commercialization Program)

Publication:

A. J. Ilott, M. Mohammadi, C. M. Schauerman, M. J. Ganter, A. Jerschow, Nat Comm 9:1776, http://dx.doi.org/10.1038/s41467-018-04192-x. (2018).



Magnetic field map measurements for the fully charged cells. a-c Sample placement, and image orientation; d,e field maps measured for the cells. Field maps are referenced here to the empty holder, giving an absolute field map or the Li-ion cell.

RESEARCHER PROFILE

Amy C. Marschilok

Research Professor, Department of Chemistry; Research Associate Professor, Department of Materials Science and Engineering; Center Operations Officer, m2m/t Energy Frontier Research Center

Research Interests:

- Inorganic chemistry
- Interfacial electrochemistry
- Batteries, capacitors, liquid and solid electrolytes

Awards and Honors:

- 2011 Woman of Distinction Award Education Category Recipient, Girl Scouts of Western NY
- 2007 Western New York YWCA Leadership Award Professional Service Category Recipient
- 2006 Greatbatch Visionary of the Year Award-Corporate Offices/ Technology Center
- 2004 Mattern-Tyler Excellence in Teaching for Outstanding Teaching Assistant

MULTIFUNCTIONAL CATHODE ADDITIVES FOR LI-S BATTERY TECHNOLOGY

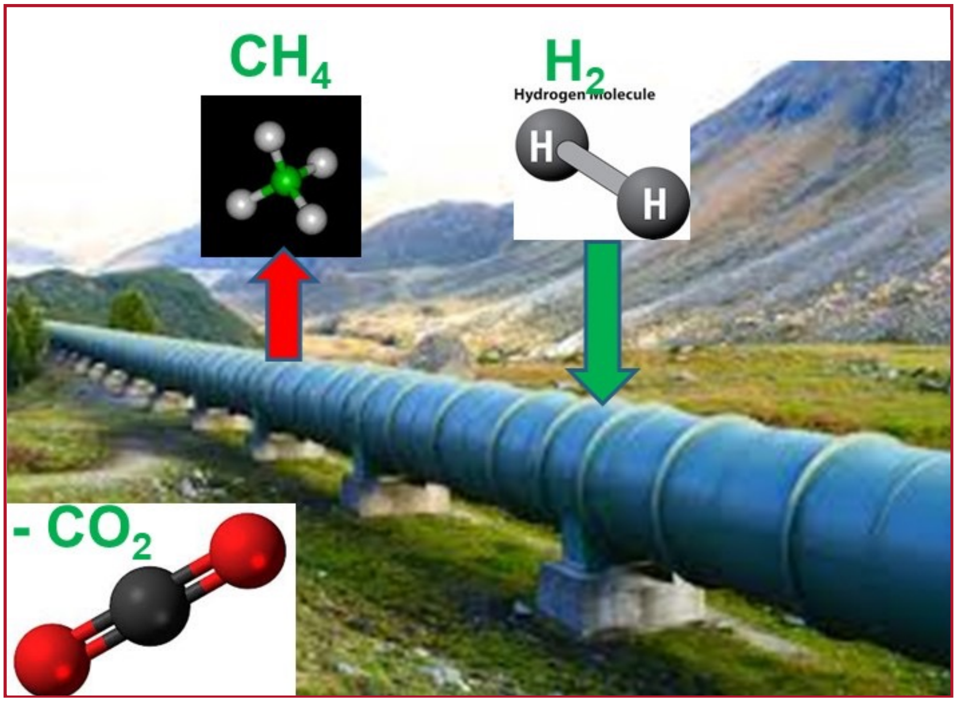
PIs: Hong Gan, BNL and Esther Takeuchi, SBU

Li-S battery technology will be developed as a low-cost, high energy density alternative to current state of the art Li-ion battery technology. The Multifunctional Cathode Additives (MFCA) concept will address important challenges currently faced by the Li-S system by (1) improving cathode electronic conductivity, (2) providing excess lithium source, (3) reducing polysulfide dissolution in electrolyte. Successful development of Li-S battery incorporating the MFCA approach will enable low-cost, high energy density battery technology relevant for PEV application. (DOE)

BATTERY AND STORAGE RESEARCH

LARGE SCALE HYDROGEN STORAGE AND DISTRIBUTION IN NEW YORK STATE

PIs: Devinder Mahajan, T. Venkatesh, C. Clayton, T. Butcher, Sayantani Sikder, Jake Lindberg, Leela Sotsky, Satya Sharma and Rong Zhao, Zhachary Lerman, SBU



This project will determine the current ability of each component of the utility gas distribution system to transmit hydrogen or natural gas/hydrogen blends and identify the requirements for increased use of hydrogen to deliver green power to New York State customers. The five proposed tasks are structured to assess gas network requirements as a function of blended percentage of hydrogen in natural gas, including requirements for pipe and joining materials, metering and system controls and storage to establish engineering risk assessment and associated protocol; build a test unit to simulate pipeline system and collect data to visualize structural changes (embrittlement, fatigue) to pipeline components using advanced spectroscopic techniques; validation of the relationship between Wobbe Number and blend percentage for geologic natural gas blended with hydrogen using high resolution gas chromatographs. The project is a collaboration between the Institute of Gas Innovation and Technology (I-GIT) at Stony Brook University and National Grid and builds on the results reported in literature from Europe and projects funded by the United States Department of Energy. Together with known data, we calculate that upon achieving total decarbonization of natural gas, New York State can achieve 24.89 million metric tons of CO_2 or a 15.0% decrease in New York's total CO_2 emissions. (NYSERDA/National Grid)

Publication:

Stephanie Taboada, Devinder Mahajan, Christopher A. Cavanagh, McKenzie Schwartz. *Hydrogen injection in natural gas pipelines for decarbonization of power sector in New York State.* Symposium: Fuel Processing for Hydrogen Production, Transforming the Future through Chemical Engineering. AIChE Annual Meeting 2019. Hyatt Regency, Orlando FL, United States. November 10-15, 2019. AIChE Abstract ID# 579106

EARTH ABUNDANT MATERIALS: AN OPPORTUNITY FOR THE NEXT GENERATION OF BATTERIES

PI: Esther Takeuchi, Co-PIs: Kenneth Takeuchi and Amy Marschilok, SBU

This work probes new battery systems using naturally abundant, low-cost materials with minimal environmental impact. The batteries will be based on earth abundant materials having higher natural abundance than lithium. Cathode investigations will focus on metal oxides based on low cost and low toxicity transition metals.

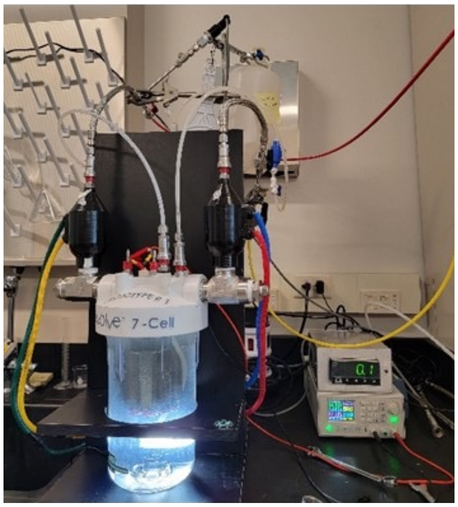
(Sandia National Laboratory,

Department of Energy)

BATTERY AND STORAGE RESEARCH

EVALUATION OF EVOLVE HYDROGEN TECHNOLOGY

PIs: Devinder Mahajan, Jake Lindberg and Gozde Ustuner, SBU



Gilman Industries LLC has developed a novel hydrogen producing water electrolyzer technology that is potentially superior to those presently in the commercial market. The technology is are far enough along for further testing that is being done at the I-GIT laboratories to independently test in both single cell and 7-cell Evolve™ units. We are conducting a series of tests that are needed for a feasibility study for Gilman Industries, and to validate the technology. This engagement between Gilman Industries and I-GIT is designed to help evaluate Gilman Industries to develop Evolve™ electrolyzer technology for customers. We recently completed a series of runs to establish hydrogen production from Deionized (DI), tap and simulated seawater samples. (Gilman Industries and CIEES)

FLUORINATED ELECTROLYTES ENABLING HIGH ENERGY DENSITY BATTERIES

PI: Amy Marschilok, SBU
Co-PIs: Esther Takeuchi and Kenneth Takeuchi, SBU

Fluorinated electrolytes are under study as a novel approach for constructing a mechanically stable solid electrolyte interphase (SEI) enabling high reversibility. The designed electrolytes will have practical chemical and physical properties enabling their use to extend the cycle life of high energy density batteries. (Department of Energy – Energy Efficiency & Renewable Energy)

FLUORINATED ELECTROLYTES FOR OPERATION OF LI-ION BATTERIES UNDER EXTREME CONDITIONS

PI: Esther Takeuchi, SBU, Co-PIs: Amy Marschilok, Kenneth Takeuchi and Carlos Colosqui, SBU; David Bock, BNL; Yue Qi, Brown University

The project will establish a new class of fluorinated esters. The objectives are to develop new electrolytes for Li-ion batteries that will enable improved performance under conditions of high operating voltage, wide temperature range, and fast (4C) charge. Systematic study of electrolyte constituents and their relative concentrations is being used to correlate the electrolyte formulation to improved battery function under the extreme conditions listed above. (Department of Energy)

ELECTRODES BASED ON TWO DIMENSIONAL (2D) MORPHOLOGY FOR HIGH CAPACITY BATTERIES

PIs: Kenneth Takeuchi, SBU and Lei Wang, BNL, Co-PIs: Esther Takeuchi and Amy Marschilok, SBU

This project focuses on the preparation, characterization, and electrochemical testing of 2D active material and their incorporation into electrodes. The project encompasses synthesis and characterization of the materials, incorporation of the into composite electrodes, and electrochemical testing to assess function relative to electrodes prepared with bulk particles. Higher rate and stability are achievable from this class of materials. (Brookhaven National Laboratory, Department of Energy)

CENTER FOR RESEARCH IN EXTREME BATTERIES: ADVANCING TRANSFORMATIONAL ARMY BATTERIES

PI: Amy Marschilok, SBU
Co-PIs: Esther Takeuchi and Kenneth Takeuchi, SBU

The objective of this work is to study batteries from a safety perspective. Calorimetric methods such as isothermal microcalorimetry (IMC) will be used in conjunction with electrochemistry, physical and chemical characterization to relate dissipated heat to specific reactions taking place inside the battery. The thermal data provides insight into lifetime as well as battery safety. (University of Maryland, Army Research Laboratory)

BATTERY AND STORAGE RESEARCH

UNDERSTANDING BATTERIES USED FOR ELECTRIC VEHICLES

PI: Esther Takeuchi, SBU
Co-PIs: Kenneth Takeuchi and Amy Marschilok, SBU

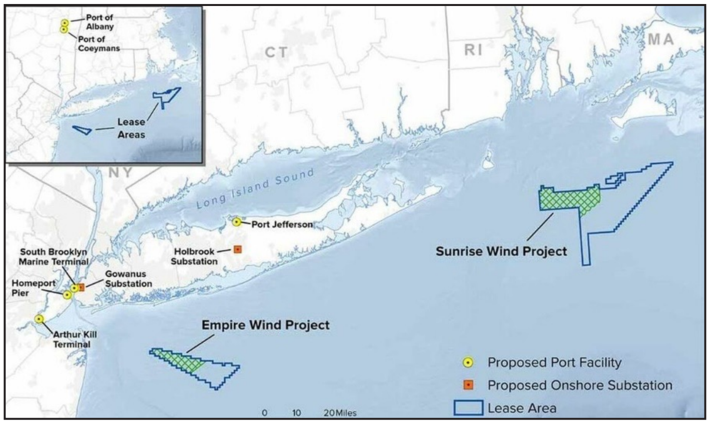
In this program, we utilize advanced characterization tools at Stony Brook University and Brookhaven National Laboratory to investigate the mechanisms occurring in batteries suitable for electric vehicles. Particular emphasis is placed on using operando and in situ techniques that provide definitive correlation between changes in non-destructive measurable properties and electrochemical behavior. The use of operando and in-situ methodology allows the collection of data at multiple cycle numbers on the same cell.

Layered lithium metal oxides (LiMO2) are important cathode materials for lithium ion batteries. The early Li Ion batteries used Lithium cobalt oxide active materials. More recently, metal oxides with ternary metals (M = Nickel, Cobalt, and Manganese) have evolved as the leading cathode materials for next generation Li-ion batteries in the marketplace. The properties of LiNixMnyCozO2 (NMC) cathode materials can be tuned by adjusting the ratio between the three metals. The presence of Ni contributes to higher cathode discharge capacity and high running voltage, the presence of Co enhances the material rate capability and stabilizes the layered structure of the cathode for long cycle life, and the presence of Mn supports the material electrochemical stability and thermal stability for improved safety. With a push to satisfy the higher energy density requirements necessitated by electric vehicles, nickel rich NMC materials, are being considered and adopted by battery manufacturers and users. However, while NMC cathode materials with high Ni content have increased capacities, however, they also exhibit decreased cycling stability. The research underway is exploring the chemistry and electrochemistry of high nickel NMC type cathode materials. A variety of characterization tools are being used to probe this material of high interest to the marketplace. (Mercedes Benz Research and Development, North America)

ENERGY STORAGE SOLUTIONS FOR TRANSMISSION PLANNING AND GRID STABILITY WITH MASSIVE OFFSHORE WIND FARMS

PIs: Yue Zhao, Vyacheslav Solovyov and Benjamin Hsiao, SBU

This project addresses two of the most important challenges in offshore wind energy (OSW) integration into NYISO Zone K and J – onshore transmission upgrade and grid stability – by developing comprehensive energy storage solutions. Existing studies on transmission upgrade in the NYISO territory have been primitive as wind energy forecast errors and system contingencies are ignored, whereas real-world power system operations in the presence of forecast errors and contingencies will encounter much more complex scenarios and potentially require a significantly higher need for transmission upgrade. We investigate optimal energy storage placement, sizing, and operation strategies under realistic power system operations with massive OSW, and evaluate the value of storage in reducing the need for transmission upgrade and OSW curtailment. We also utilize the fast control of energy storage, inverters and OSW wind turbines for stabilizing the voltage and frequency of the onshore grid in the presence of wind fluctuations and system contingencies. (AERTC, Sunrise Wind)



BATTERY AND STORAGE RESEARCH

EMI FILTER MINIMIZATION USING ACTIVE-FILTERING AND INTEGRATION APPROACHES

PI: D. Fang Luo, SBU

Compact adapters draw a lot of attentions from the market. An EMI filter plays a significant role in these converters to control the EM interferences, yet they occupy as much as ⅓ of the total system weight and volume, as shown in Fig.1. High switching frequency is usually deployed to reduce the size and weight of the passives. However, higher switching frequency, higher di/dt, and higher dV/dt also bring much higher EMI noises, and it might result in much bigger bulky EMI filter design. The volume exhibited by the EMI filter shows a bottleneck for further improving the adapter's power density. This research project focuses on aggressively reducing the bulk passive EMI filter size by means of active EMI filtering, noise self-containment, and passive filter integration. The research will target on the filter design and minimization, and will not include filter reduction by changing modulation method, adopting soft-switching, or changing the converter topology. By implementing zero phase filtering techniques, 37 dB more attenuation around 150 kHz than conventional AEF as well as 70 x more passive component value reduction than conventional AEF is achieved.

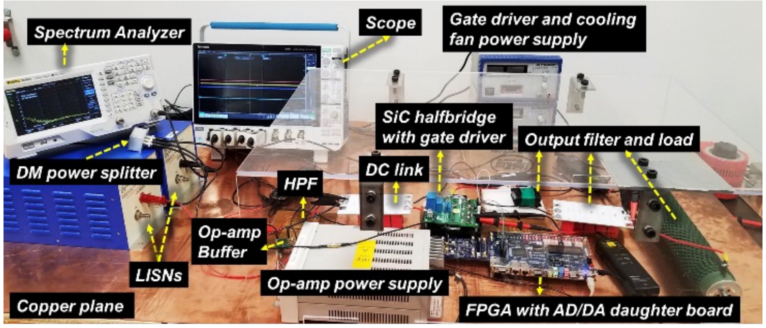
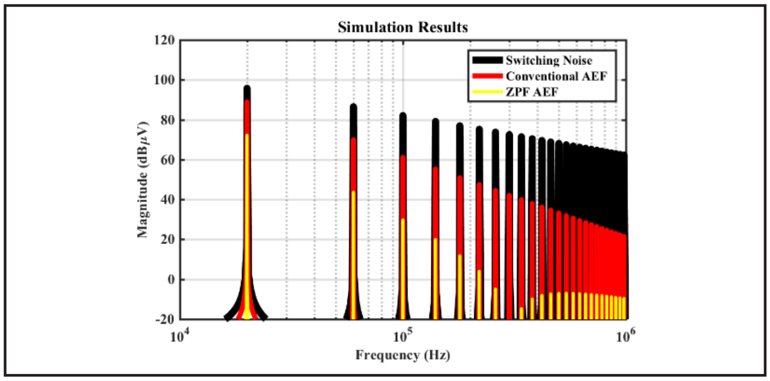


Fig.1. EMI Test Setup



RESEARCHER PROFILE

Esther Takeuchi

William and Jane Knapp Endowed Chair in Energy and the Environment; Distinguished Professor of Chemistry in the College of Arts and Sciences and in Materials Science and Chemical Engineering in the College of Engineering and Applied Sciences; Director, m2M/t Energy Frontier Research Center; and Chief Scientist of the Energy Sciences Directorate at Brookhaven National Laboratory

Awards and Honors:

- Fellow, American Association for the Advancement of Science (AAAS), 2018
- European Inventor Award in the "non-EPO countries" category, presented by the European Patent Office (EPO), 2018
- Charter Member, National Academy of Innovation (2013)
- E.V. Murphree Award, American Chemical Society (2013)
- National Inventors Hall of Fame (2011)
- Recipient of National Medal of Technology and Innovation (2009)
- Astellas USA Foundation Award (2008)
- SUNY Distinguished Professor (2009)
- 140 issued US Patents
- Emerging Leaders Alliance Capstone Program, 2014
- Defense Manufacturing Conference Top Speaker Award, 2010

Energy Projects:

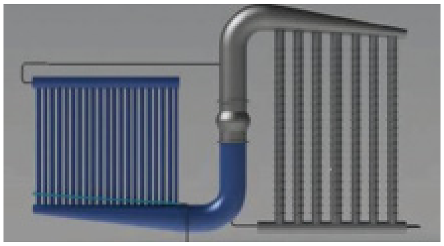
- Energy storage
- Portable power sources
- Micro-power sources

SMART POWER MANAGEMENT

CONDENSING FLUE GAS FOR SUB-AMBIENT EVAPORATIVE COOLING AND COOL STORAGE

PI: Jon Longtin, SBU

Power plants that do not require a large body of water for cooling, and/or that consume little to no water for operation would significantly enhance U.S. electricity production potential. Evaporating water is an extremely effective cooling mechanism, but the water is lost during the evaporation process. The power plant itself, however, produces significant quantities of water vapor through the natural combustion process. The objective of this project is to condense water vapor from the combustion byproducts (flue gas) by using a high-performance thermosyphon to move heat from the flue gas o the ambient with no additional refrigeration system required. A thermosyphon uses the latent heat of vaporization – rather than a temperature gradient – for heat transfer. As such, the thermal resistance for heat transfer can be substantially reduced. The condensate will be stored and used for subsequent evaporative cooling using commercially available technologies. The project presents several innovations in terms of active fluid management and co-current flows in the thermosyphon, polymer-based components in the flue gas to minimize corrosion effects, and a simulation-driven, highly optimized design. The technology is suited for coal, natural gas, or combined-cycle plants. This technology meets the ARPA-E Program



Objectives of dissipating no net water to the atmosphere, no loss of efficiency or the power plant, and being implemented with less than a 5% increase in the levelized cost of electricity. The project addresses the ARPA-E Mission Area of ensuring that the United States maintains a technological lead in developing and deploying advanced energy technologies. (ARPA-E)

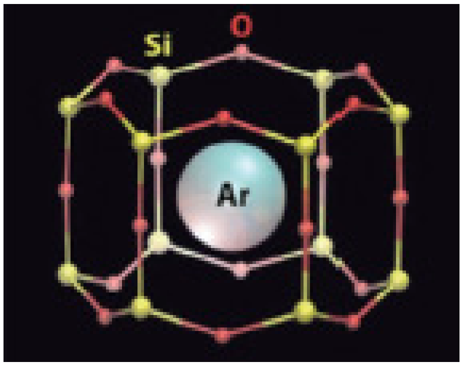
FUNDAMENTAL RESEARCH OF 2D ZEOLITE

PI: Tae Jin Kim, SBU

Argon and other noble gases have previously been trapped in three-dimensional (3D) porous materials, but immobilizing them on surfaces had only been achieved by either cooling the gases to very low temperatures to condense them, or by accelerating gas ions to implant them directly into materials. Recently, the SBU and BNL research team has synthesized a two-dimensional (2D) structure and successfully trapped argon atoms inside the nanosized pore structure at room temperature. This achievement, reported in a paper published in Nature Communications, will enable scientists to use traditional surface-science tools – such as x-ray photoelectron and infrared reflection absorption spectroscopy – to perform detailed studies of single gas atoms in confinement. The knowledge gained from such research could inform the design, selection, and improvement of adsorbent materials and membranes for capturing gases such as radioactive krypton and xenon generated by nuclear power plants. This research is carried out in part at Center for Functional Nanomaterials and the CSX-2 beamline of the National Synchrotron Light Source II, Brookhaven National Laboratory, which is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. DE-SC0012704. This research used resources of the National Energy Research Scientific Computing Center, a DOE Office of Science User Facility supported by the Office of Science of the U.S. Department of Energy and was supported by Brookhaven's Laboratory Directed Research and Development program and the National Scientific and Technical Research Council (CONICET) of Argentina. (DOE)

Publication:

J.Q. Zhong, M. Wang, N. Akter, J.D.

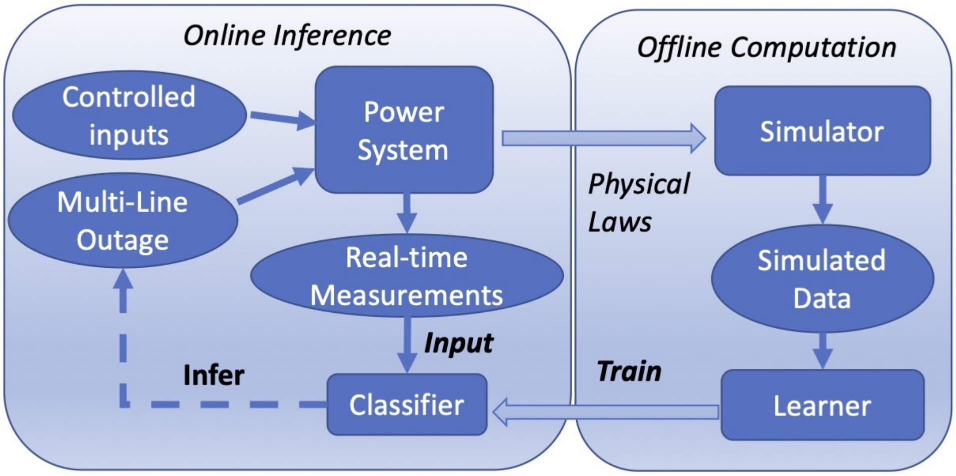


Kestell, A.M. Boscoboinik, T. Kim, D.J. Stacchiola, D. Lu, J.A. Boscoboinik, Immobilization of single argon atoms in nanocages of two-dimensional zeolite model systems. Nat. Commun. (2017).

SMART POWER MANAGEMENT

LEARNING FOR FASTER COMPUTATIONS TO ENHANCE THE EFFICIENCY AND SECURITY OF POWER SYSTEM OPERATIONS

PI: Yue Zhao, SBU



The electric grid is a complex critical infrastructure system that underpins all economic and social activities in the US. It is thus of utmost importance to maintain its efficient, reliable and secure operation at all times. The system, however, is undergoing an unprecedented period of transformation with rapid growths in renewable energy and electric vehicles, as well as increasing concerns of cyber security. Consequently, not only there is a higher requirement for efficient and secure operation of the grid, but also achieving it becomes much more challenging. The issue is especially acute from a computational perspective, as problems of much greater complexity need to be solved more frequently. As such, conventional approaches for solving secure power system operation problems face major challenges in maintaining their efficacy in the rapidly evolving power grids. To overcome these challenges, this project develops novel machine-learning-based methods to greatly accelerate solving key and large-scale secure power system operation problems. Notably, the developed methods integrate data-driven methods with the physical models of power systems. The developed algorithms will lead to greatly enhanced efficiency, reliability and security of power systems in the presence of high penetration of renewable energy and without the need of building more transmission lines or procuring much higher reserve capacity, resulting in tremendous economic savings for consumers. The project will also contribute to the much-demanded educational needs in the industry by training the next generation workforce to master interdisciplinary expertise of machine learning and power systems.

This project develops new machine learning algorithms, both leveraging and integrated with existing computational tools, to greatly improve the computational efficiency of solving challenging power system operation problems. We accomplish this by designing algorithms that use data to replace some of the existing heuristics based on human experience. We use a bottom-up approach by carefully formulating the problems to determine the best interface between the physical system and machine learning. This allows us to design algorithms that are aware of the physics of the problems and complement existing tools in the field. Specifically, we i) solve for optimal generator dispatch levels by introducing a data-driven component to the existing algorithms; ii) perform fast identification and quantification of problematic contingencies using reinforcement learning; and iii) find the most secure and efficient generation unit commitment schedule. These algorithms can be directly integrated into current solvers and have the potential of providing orders of magnitude speedup over existing methods. As such, this project offers a) new machine learning paradigms and algorithms, b) innovative ways of integrating machine learning methods with physical model-based optimization algorithms, and c) transformative tools that solve key power system operation problems in a holistic framework with much faster speeds. (NSF)

Publications:

J. Li, M. Yue, Y. Zhao, and G. Lin, Machine-learning-based online transient analysis via iterative computation of generator dynamics, Proc. IEEE SmartGridComm, 2020.

SMART POWER MANAGEMENT

INTEGRATION METHODS FOR HIGH-DENSITY INTEGRATED ELECTRIC DRIVES

PI: Fang Luo

Considering the importance of the precise current measurement in power electronics for the purpose of control and protection, and the developments in the area of packaging, coming up with current measurement methods with features such as small size, high accuracy, lightweight, low cost, and easy integration, research on current sensors is significantly essential. According to the performed studies and simulations, GMR current sensors are the most compatible solutions with the power module designed by the University of Arkansas for this project. Because of the small size of the power module and placement of the devices close to each other, external magnetic fields, which are not intended to be measured, and variation in the temperature inside the power module can lead to errors in the current measurement. Therefore, decreasing the sensitivity of the sensors to the external magnetic fields, and temperature fluctuation is the main challenge of using GMR sensors. For this reason, the proposed study is working on potential solutions to improve the performance of the current measurement system. One of the tested methods for alleviating this problem is using two GMR sensors and two stages of instrumentation amplifiers in the signal conditioning circuitry, as shown in Fig. 1, where S^1 and S_2 are GMR current sensors, IA1-IA3 are instrumentation amplifiers and H_1 and H_2 are showing the direction of magnetic field, generated by the current passing through the current trace, being sensed by each sensor. Two GMR Sensors (TGS) solution is in the process of on-board tests, and the next step toward the fully packaged power module is to implement the TGS method into the power module.

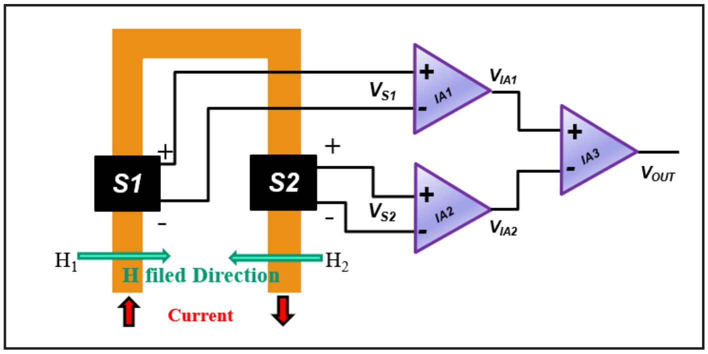


Fig. 1. TGS method

Fig. 2 is showing the preliminary test results for TGS method. Matching results of Vout-test captured from practical test and the Vout-math achieved from math function applied between V_{IA1} and V_{IA2}, noted on Fig. 1, validated the TGS method.

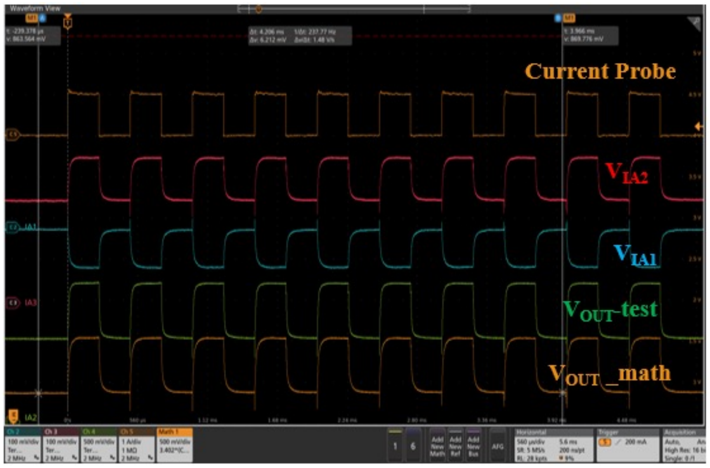
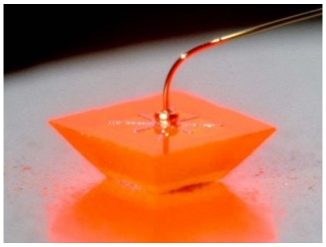


Fig. 2. Test results

STUDY OF ALLnGaP MATERIALS FOR SOLID STATE LED APPLICATIONS

PIs: Michael Dudley and Balaji Raghothamachar, SBU

AlInGaP grown lattice matched on GaAs substrate using OMVPE has been applied in LEDs since late 1980s. Though high brightness can be achieved, the reliability might be sacrificed, which are usually caused by the presence of defects. The goal of this project is to design more efficient amber and red LEDs by characterizing and mitigating defects associated with high efficiency epitaxy designs. In this project, nondestructive characterization technique synchrotron X-ray topography is applied to study the distribution of the defects across the AlInGaP/GaAs wafers, and the relationship between the defect distribution and reliability is analyzed. Other characterization techniques like TEM, SEM, AFM and XRD are also applied together with synchrotron X-ray topography to build the relationship between the growth conditions and the formation mechanism of the defects. (Lumileds)



Publications:

H. Peng, T. Ailihumaer, Y. Liu, B. Raghothamachar, M. Dudley, Journal of Crystal Growth 533, 125458, https://www.sciencedirect.com/science/article/pii/S0022024819306736

H. Peng, T. Ailihumaer, B. Raghothamachar, M. Dudley, Journal of Electronic Materials, 1-9, https://link.springer.com/article/10.1007/ s11664-020-07981-7

SMART POWER MANAGEMENT

BROADBAND ELECTRO-MAGNETIC MODELING AND TESTING FOR RELIABLE POWER-ELECTRONIC-BASED ENERGY CONVERSION SYSTEM FOR ELECTRIC AIRCRAFTS

PI: Fang Luo, SBU

Electrification in the aviation industry is one of the most important ways to reduce fuel energy consumption and pollution of the environment. Along with moving toward this goal, improving the reliability of the whole power system is crucial. One of the main factors threatening the performance of systems and decreasing their lifetime is the Partial Discharge (PD) phenomenon, which can be defined as partially bridging between two conductors. PD can damage the insulation materials and eventually lead to the failure of the systems. Therefore, the proposed study is working on the factors related to motor drives like voltage level, voltage rise time, duty cycle, and frequency affecting the PD events in all parts of the system such as motor drive, cables, and motor windings. Since the system designed for any aircraft should tolerate the environmental condition in high altitudes, low temperatures and pressures, variation of the PD events intensity and pattern with a wide range of the temperature and pressure level is another topic of study during this project. In the final stage of the project, in collaboration with the University of Illinois at Urbana-Champaign and the University of Arkansas, using a joint test between the motor drive and motor placed in a chamber for simulating the low temperature and low air pressure of high altitudes, a multivariable possibility function will be extracted to directly relate the effect of each factor and chance of presence of PD to provide solid guidelines for designing a reliable power electronic-based energy conversion system for electric aircrafts.

Publications:

- Sama Salehi Vala, K. Choksi, A. B Mirza, Fang Luo, "Exploring Interactions Between Reflected Wave and Partial Discharge in WBG Motor Drives" 2022 IEEE Energy Conversion Congress and Exposition (ECCE), 2022 *(UNDER REVIEW)*.
- Sama Salehi Vala, A. B. Mirza, Fang Luo,"A Review on Partial Discharge Phenomenon in Rotating Machines operated using WBG Motor Drives"2022 ITEC

TRANSMISSION LINE EFFECT OF MOTOR

PI: Fang Luo, SBU

In motor drive systems comprising of switching converters, cable and motor terminals face overvoltage due to the reflected wave phenomenon caused by mismatch of the impedance between converter and load. The sensitivity of voltage stress across system insulations due to this overvoltage need to be clarified in respect of cable length, type of load, parasitics of cable/ load and switching dv/dt. Maximum overvoltage while having the least impedance (main antiresonance of the system) causes the worst voltage stress. Also, it should be noted that for a motor load (modeled by a network of resistances, inductances and capacitances in LTspice simulation), the terminal overvoltage would not distributed equally across the motor winding turns. Then, due to the secondary resonances between inter-turn elements, the worst voltage stress could even be more than expected. The overvoltages' data gathered from the test for different configurations of the motor drive system, could be authentic input for partial discharge test (winding insulation lifetime studies) in regards of load side overvoltages' magnitude, risetime and dv/dt.

SMART POWER MANAGEMENT

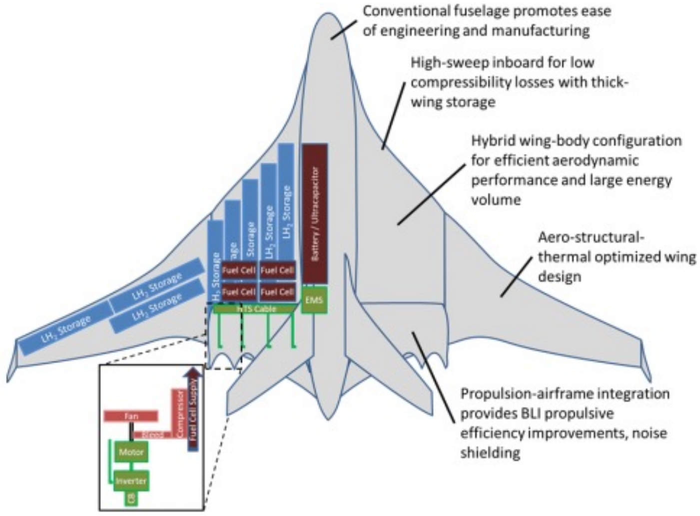
DEVELOPMENT OF POWER ELECTRONICS CONVERTER FOR EXTREME LOW TEMPERATURES

PI: Dr. Phillip Ansell (UIUC), Co-Pi: Dr. Kiruba Haran (UIUC), SBU PI: Dr. Fang Luo (SBU)

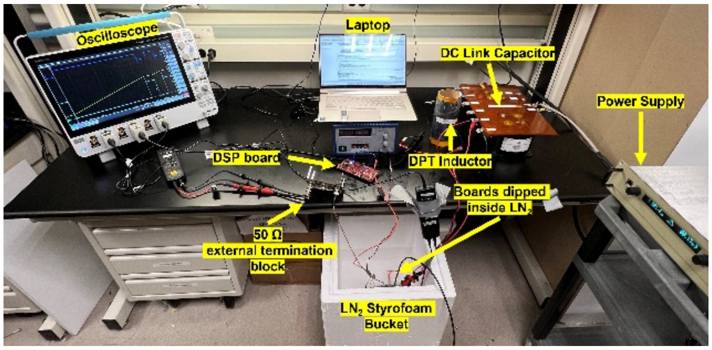
The aeronautics industry has been challenged on many fronts to increase efficiency, reduce emissions, and decrease dependency on carbon-based fuels. The global aviation industry produced 781 million tons of CO2 in 2015, a number that is expected to substantially increase. The NASA ARMD Strategic Implementation Plan has indicated ambitious goals for the next three generations of commercial aviation to ensure sustainability of the industry, including a 50% reduction in carbon emissions produced from aviation by 2050, relative to 2005 levels. The motivation for more efficient, alternative energy in aviation is also supported by the need to reduce operating costs and ensure profitability of commercial aviation.

The ongoing ULI study is spearheading the development of a Cryogenic Hydrogen-Energy Electric Transport Aircraft (CHEETA) design concept. An artist rendering of this vehicle concept is shown above. The research activities of this ULI program will lead to ground-level technological development and conceptual design of a fully electric commercial aircraft architecture that utilizes liquid hydrogen (LH2) energy storage with fuel cell energy conversion and an electrically driven distributed propulsion system. This vehicle concept will utilize an on-board cryogenic system to store and maintain LH2, which is used not only as a lightweight energy storage strategy, but also as a cryo-coolant to enable highly efficient superconducting electric systems.

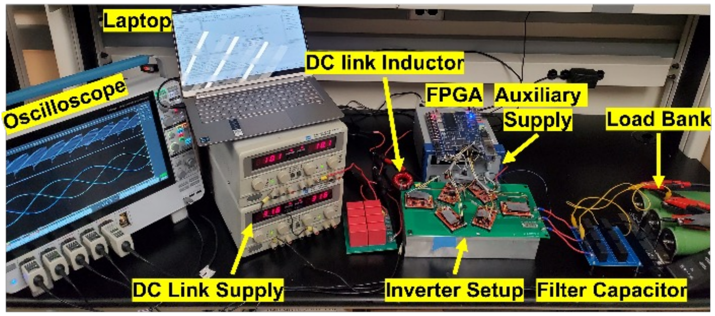
The team at SBU is contributing in terms of developing a cryogenic converter that can operate a superconducting machine. Since the superconducting motor has extremely low winding inductance and is sensitive to high frequency AC harmonics fed from the motor drive, therefore a current source inverter (CSI) was found most suitable and was developed at SBU. To have as successful development of cryogenic converter, the team characterized numerous commercially off the shelf (CPTS) components including capacitors, inductors, gate drivers, and switching devices. Based upon successful operation of individual components at 77 K, the team has successfully developed a three-phase converter with cryo compatible components.



Conceptual sketch of CHEETA configuration



Component characterization at LN2



Converter test setup at room temperature

SMART POWER MANAGEMENT

DEVELOPMENT OF POWER ELECTRONICS BUILDING BLOCK (PEBB) USING DOUBLE SIDED COOLED SIC POWER MODULE WITH 3D PRINTED HIGHLY INTEGRABLE COLD-PLATE

PI: D. Fang Luo, SBU

The power electronic building block (PEBB) is a concept of building a unified power processing unit from smaller numbers of standardized unit, which have high degree of intelligence and control autonomy. The PEBB concept includes power processor blocks (single phases or multiple phases), gate drives and sensor blocks, analog-to-digital converter blocks for sensor signals, switching or gate drive control blocks, and blocks for communication with higher level controllers. Each PEBB includes built-in self-protection against voltage surges, overvoltage and undervoltage, fault currents, ground currents, internal faults, overloads, and overtemperature. This project aims to develop a PEBB with highest power density.

The designed module is 2.5D integrated package, that enables double sided cooling. The module layout follows P-cell, N-cell optimization philosophy. Two DBC's are etched and utilized in a way, which forms a vertical loop between commutating device. This vertical loop helps to mutually cancel magnetic flux, which leads to the reduction of stray inductance. This cancellation is enhanced by the intermediate multilayer PCB interposer. The primary task of these PCB interposer is to constitute connection between separate nodes and hold the die. Fuzz button, that was successfully demonstrated as an interconnect in RF world, is leveraged in this design. Fuzz buttons are stranded thin wires that forms a spring/sponge like cylindrical shape. It reduces the skin effect and shows efficacy to hold its low impedance value till GHz range. Fuzz buttons are placed directly on the top surface of the bare die, that does not require any attachment layer. Fuzz buttons are held in place using previously mentioned PCB interposer, and pressed firmly using custom made copper pillar. This reduces the interfacial stress in the MOSFET and increases their reliability and lifetime. This module is designed with Wolfspeed 1200V, 13 mΩ SiC Mosfet die (CPM3-1200-0013A) and 1200V, 50A Schottky diode die (CPW5-1200-Z050B).

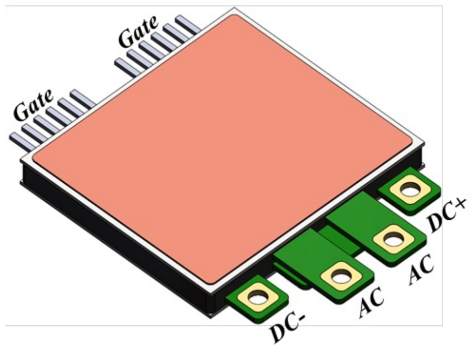


Fig.1. Module overview

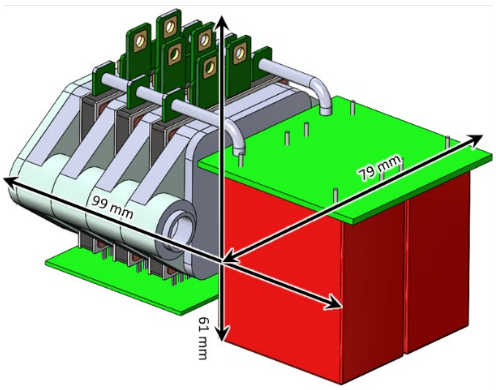


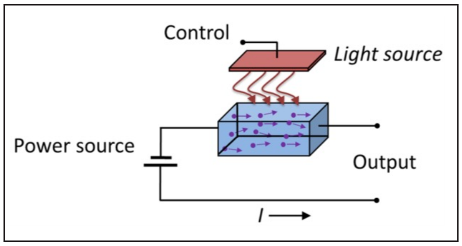
Fig.2. System configuration

INVESTIGATION OF DEFECT GENERATION AND PROPAGATION IN ELECTRICALLY AND PHOTONICALLY STRESSED SILICON CARBIDE

PIs: Michael Dudley and Balaji Raghothamachar, SBU

Optical Transconductance Varistor (OTV) relies on the photoconductive property of semi-insulating silicon carbide, which is normally insulating but when illuminated, charge carriers are pumped to the conduction band and the material becomes conductive in proportion to the light intensity. However, very little is scientifically known about defect creation and propagation in highly stressed photonic driven high voltage devices.

In this project, both ex-situ and in-situ experiments (white beam and monochromatic beam synchrotron X-ray topography) are carried out to study the behavior of the defects when high electric field and intense light are applied. (ARPA-E, Opcondys)



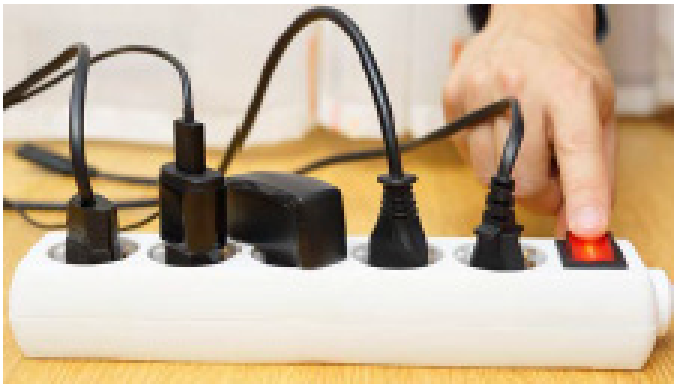
Publications:

H. Peng, Y. Liu, Z. Chen, Q. Cheng, S. Hu, B. Raghothamachar, M Dudley, K. Sampayan, S. Sampayan, Journal of Crystal Growth 579, 126459 (2022) https://doi.org/10.1016/j.jcrysgro.2021.126459.

SMART GRID AND MICROGRID

ANALYTICS FRAMEWORK FOR UNDERSTANDING HOUSEHOLD ENERGY CONSUMPTION

PI: Klaus Mueller, SBU



The introduction and gradual popularity of energy consumption monitoring devices, commonly known as smart-meters, has provided us with an opportunity of capturing and understanding household energy. Our interface provides various visualizations in which users can interactively explore their energy use profile. They can select and compare different time segments of their profiles and show them in context of local weather (obtained from a weather service), social activities (obtained from a calendar) and the use of their household devices (obtained from the user via a visual user interface). Our visual interface aggregates all this information into a modern multi-faceted information visualization framework that can be interactively manipulated to allow users to learn where, when and how energy was consumed. Once the sources of adverse energy consumption have been identified, use s can employ the historical data to play out different use behaviors and see the effect on energy use, as well as the size of the energy bill. They can also use the software to predict future or replay past energy consumptions with changed habits, devices and their settings. The insight gained can then lead to positive energy-use behavioral changes by the consumer, which is of benefit of everyone involved. (NSF)

RESEARCHER PROFILE

Eugene A. Feinberg

Distinguished Professor, Department of Applied Mathematics and Statistics

Awards and Honors:

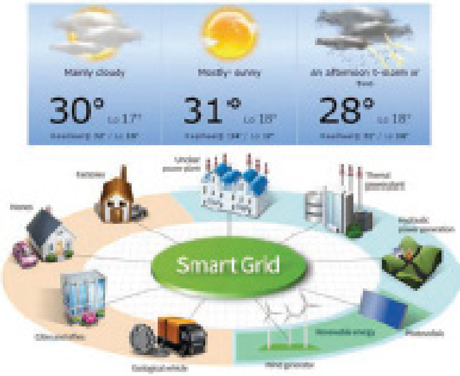
- Fellow of INFORMS (2011)
- SUNY Distinguished Professor (2012)
- IEEE Charles Hirsh Award (2012) for developing and implementing on Long Island, electric load forecasting methods and smart grid technologies
- Honorary Doctor, Institute of Applied System Analysis, National Technical University of Ukraine (2011)
- SBU Director of DOE Smart Grid Regional Demonstration Project: Long Island, Smart Energy Corridor (2010-2015)

Energy Projects:

- Smart Grid Electric Load Modeling and Forecasting
- Modeling and Optimization of Electric Power Transmission and Distribution

SECURE, RELIABLE AND INTEGRATED SMART GRID SOLUTIONS UNDER VARIABLE WEATHER CONDITIONS

PIs: Eugene Feinberg, SBU, Alexander Domijan, UB, and Ilya Grinberg, Buffalo State College



The project focuses on the integrated analysis and improvements of smart grid reliability with dynamic reconfiguration under variable weather conditions. This project develops and implements algorithms and software solutions for distribution network reconfiguration under variable weather conditions and demonstrates the developed solutions in the lab at the physical level. (Research Foundation of SUNY, 4E Network of Excellence Program)

SMART GRID AND MICROGRID

SMART GRID NATIONAL ENERGY CONTROL CENTER

PIs: Arie Kaufman and Klaus Mueller, SBU

We will develop new visualization and interaction paradigms, using the Reality-Deck, for the SCADA system of the future. The RealityDeck is an immersive Giga-pixel display wrapping around a room of size 40' x 30' x 11' high, containing 416 LCD display screens driven by an 70 graphics processing unit (GPU) cluster that rivals the performance of modern supercomputers. The RealityDeck will fully immerse visitors in 1.5 billion pixels of information, approaching the visual acuity of the human eye. It will allow national energy grid analysts to manage the smart grid's large, multi-variate data, maintain a comprehensive view of the nation's complex energy infrastructure, quickly react to emerging prices or problems and take preventive measures before they arise. (NSF, NGC).

CONTROLLING NON-SYNCHRONOUS MICROGRIDS FOR LOAD BALANCING OF RADIAL DISTRIBUTION SYSTEMS

PIs: Tianqi Hong and Francisco de León, NYU

This project proposes a novel control strategy such that downstream non-synchronous microgrids can perform load balancing functions. The proposed method can eliminate (or reduce) the unbalance of currents at the substation transformer of radial distribution systems. The load balancing ability of microgrids has been studied for two different scenarios: using communications between the microgrid and the substation; and, using only local measurements at the microgrid. The limitations posed by the availability of measurements and system topology requirements for the success of the process are discussed. Two numerical examples are provided to validate the proposed control scheme with time domain and time-sequence power-flow simulations. (NYU)

Publication:

T. Hong, F. de León, Controlling Non-Synchronous Mi-crogrids for Load Balancing of Radial Distribution Systems, IEEE Transactions on Smart Grid, Vol. 8, No. 6, November pp.2608-2616 (2017).

SMART LOAD MANAGEMENT OF DISTRIBUTION-CLASS TOROIDAL TRANSFORMERS USING A DYNAMIC THERMAL MODEL

PIs: Haowei Lu, Akim Borbuev, Saeed Jazebi, Tianqi Hong and Francisco de León, NYU

Thermal behavior is a prime factor in the accurate performance assessment of power transformers as well as in the prediction of their life expectancy. This project develops a computer modeling tool based on an electro-thermal equivalent circuit of transformers that is able to predict the hot spot temperature and average surface temperatures for all internal layers of distribution-class toroidal transformers. Temperature is the limiting factor that prevents running transformers for hours or days in overload conditions. The modeling tool presented is capable to identify the safe maximum overload current and duration that a transformer can handle without introducing damage or loss of life. The model is helpful to predict the short-term (few hours) and long-term (few days) overload capabilities of transformers. The electro-thermal model can also be used as a tool to optimize the design and evaluate the performance of transformers. The model is built using circuit components (lumped R and C) obtained from the thermal-electrical analogy. The model is validated with numerous Finite Element Method (FEM) simulations and laboratory tests with transformers of various power ratings. (NYU)

Publication:

H. Lu, A. Borbuev, S. Jazebi, T. Hong, F. de León, Smart Load Management of Distribution-Class Toroidal Transformers using a Dynamic Thermal Model, IET Generation, Transmission & Distribution, vol. 12, no. 1, January, pp. 142-149 (2018).

SMART GRID AND MICROGRID

AN INTERACTIVE USER INTERFACE FOR THE SMART GRID

PI: Arie Kaufman and Klaus Mueller, SBU

In the traditional system, customers just purchase the energy from suppliers and consume it. However, smart grid is two-way communication channel between suppliers and consumers. The roles of consumers are to reduce their total consumption and shift their usage to off-peak time. However, it is difficult to encourage consumers to change their behavior with simple visualization. In this project, we have developed an interactive system to help customers gain better understating of their energy consumption. In our system, since customers hardly understand their energy consumption of their own electric devices, customers could configure their own virtual house with electric devices to estimate their current energy consumption. Customers could choose what kind of devices they have by dragging and dropping an electric device into their virtual house. Customers can easily select a specific model of each d vice. Our system also provides a tool to analyze their energy consumption pattern in order to control their energy usage efficient. Given their total energy consumption from their smart meters, it shows their daily, weekly and monthly energy usage patterns. In addition, it enables customers to predict their energy consumption once they replace their current electric devices with new ones. (DOE)

CENTRALIZED UNBALANCED DISPATCH OF SMART DISTRIBUTION DC MICROGRID SYSTEMS

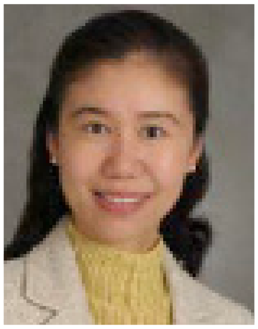
PIs: Tianqi Hong and Francisco de León, NYU

This project is about three proposed operation strategies such that a set of dc microgrids in distribution systems can co-operate pursuing particular objectives: loss reduction, full unbalance compensation, and partial unbalance compensation. Loss reduction is a regular strategy for distribution utilities operating their systems efficiently by optimal dispatch of three-phase in/out powers of dc microgrids. Full and partial unbalance compensation strategies can solve single- or two-phase overloading problems of substation transformers temporarily and slow down their aging process. To validate the performance of the proposed operation strategies, several steady-state studies are performed in the IEEE 123-bus test system. According to the simulation results, the operation losses can be reduced by up to 34% with 15.2% DG penetration. The maximum single-phase loading of the substation transformer can be reduced by up to 30%. (NYU)

Publication:

T. Hong, F. de León, Centralized Unbalanced Dispatch of Smart Distribution dc Microgrid Systems, accepted for publication in the IEEE Transactions on Smart Grid

RESEARCHER PROFILE



Qing Zhang, Assistant Professor Department of Mechanical Engineering

Energy Projects:

- Battery Manufacturing System Efficiency Improvement
- Manufacturing System Energy Management
- Integrated Micro-grid and Production System

Awards and Honors:

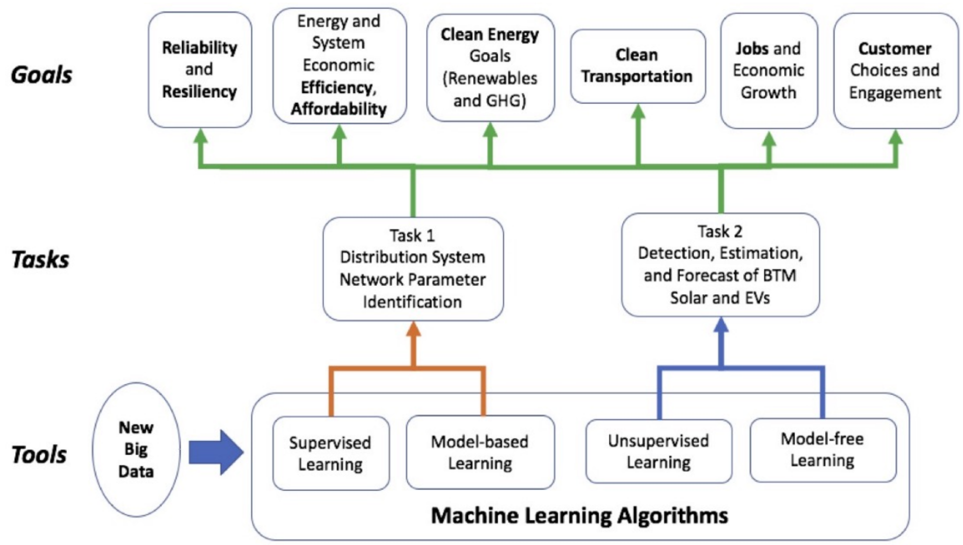
- National Science Foundation Fellowship CAREER Award (2014)
- General Motors Boss Kettering Awards (2008, 2006, 2005)
- General Motors R&D Center, The Charles L. McCuen Special Achievement Awards (2008, 2006 and 2005)

SMART GRID AND MICROGRID

LEARNING DISTRIBUTION GRIDS (LEAD): MACHINE LEARNING ALGORITHMS FOR HI-FIDELITY MODELING, MONITORING, AND FORECASTING OF DISTRIBUTION SYSTEMS AND DISTRIBUTED ENERGY RESOURCE

PI: Yue Zhao, SBU

The power distribution systems in the New York State are experiencing transformative changes in recent years, in particular the rapid growth of renewable energies, electric vehicles (EVs), and flexible demands. Yet the way the utilities operate the distribution systems has remained largely unchanged. As such, the status quo of New York's power distribution systems is that the knowledge the utilities have on their systems are far from comprehensive or accurate. With significantly higher penetration of renewables, EVs, and other distributed energy resources (DERs) in the coming decade, it is crucial for the utilities to obtain a "hi-fidelity picture" of the distribution systems.



The project employs a suite of machine learning algorithms to improve the modeling, monitoring, and forecasting for power distribution systems and DERs. The project is enabled by the rapid penetration of advanced sensors in power distribution systems in New York. A suite of supervised and unsupervised machine learning algorithms provide a) hi-fidelity modeling and network parameter identification/estimation for power distribution systems, and b) accurate detection, estimation and forecast of behind-the-meter solar and EVs. The project is conducted utilizing real-world advanced metering infrastructure (AMI) and supervisory control and data acquisition (SCADA) data from National Grid, and AMI and Solar PV data from New York Power Authority (NYPA). (NYSERDA)

Publications:

K. Pu and Y. Zhao, Behind-the-Meter Disaggregation of Residential Electric Vehicle Charging Load, Proc. IEEE CDC, 2022

RESEARCHER PROFILE

Erez Zadok, Professor and Graduate Academic Adviser, Computer Science Department, College of Engineering and Applied Science, Stony Brook University

Energy Projects:

- Computer System Auto-Tuning • Trace Analytics
- Smart Grid Security • Data Deduplication

Awards and Honors:

- Dell-EMC Faculty awards, 2014-2018
- NetApp Faculty awards in 2009 & 2011
- LISTnet's "Top 20 techies of Long Island award, 2009
- Chancellor's Award for Excellence in Teaching, State University of New York (SUNY), 2007-2008
- IBM Faculty Awards: 2006 and 2008
- NSF CAREER award, 2002

SMART GRID AND MICROGRID

ROBUST AND INTELLIGENT INTEGRATION OF MICRO-GRIDS TO IMPROVE ISOLATED SITE RESILIENCE

PI: B. Hsiao, Yacov Shamash, Fang Luo (SBU)

This project targets the research gaps in advanced energy management in isolated micro-grids with multiple energy-storage devices and loads and proposes a systematic study in the "seamless integration" control for such a microgrid system, including model-based energy dispatching control strategy through wireless communication, and high efficiency multi-port power converter for the intelligent integration of multiple energy storage devices. Through the demonstration of this project, the team is expected to establish a research/validation platform in university labs for future advanced energy conversion/routing research while collaborating with other ONR (Office of Naval Research) research team. This modular power conversion architecture along with the proposed control/integration concept can significantly advance the reliability and resiliency of naval power system while also reduce its cost.

Microgrid setup at Lab106(AERTC)

EDUCATION AND OUTREACH

THE ADDITIVE MANUFACTURING MATERIALS, PROTOTYPING AND APPLICATIONS CENTER (AMMPAC)

The Additive Manufacturing Materials, Prototyping and Applications Center (AMMPAC) leverages leading expertise and state-of-the-art analytical and manufacturing equipment at Stony Brook University (SBU) and at the Composites Prototyping Center (CPC) to support education, training, adoption and optimization of additive manufacturing technologies. This is accomplished via a collaborative model for access to:

a. Prototyping facilities at SBU and CPC, including fused deposition thermoplastic polymer and composite printing, UV photopolymerization and Digital Light Processing (DLP) printing;

b. Advanced functional materials research and development facilities, including polymer nanocomposite blending and extrusion equipment, systems for spark plasma sintering and ball milling, wet chemistry and electrochemical synthesis;

c. State-of-the-art testing and characterization at SBU (including surface X-ray and chemical (vibrational) microspectroscopies, X-ray fluorescence, scanning electron microscopy, mechanical impact, tensile strength and adhesion testing, and facilities for accelerated degradation tests), at CPC (mechanical testing and digital scanning), and via university collaborations with nearby Brookhaven National Laboratory (providing synchrotron-based X-ray imaging and spectroscopy as well as nanoscale imaging, X-ray diffraction and tomography); and

d. Advanced digital design assistance (at SBU, including collaboration with the new Digital Design Laboratory in the Dental School and computational mechanics and multiscale design expertise in the Department of Mechanical Engineering).

Other local partners are being engaged to broaden the impact of AMMPAC activities, including the New York State Advanced Energy Center (which houses an industrial partner focused on design of materials for additive manufacturing as well as other potential end-users), the facilities under development for the engineering-driven medicine initiative for the College of Engineering and Applied Sciences at Stony Brook (which will include a research focus in organ printing), the out-reach programs of the Institute for Research and Technology Transfer at Farmingdale State University, Suffolk County Community College's Manufacturing Technology facility, and new collaborative activities between AMMPAC and the New York Institute of Technology and Columbia University. Additional collaborations will help to grow the center into new markets and opportunities, regionally as well as nationally. AMMPAC also has representation in the SUNY Networks of Excellence and NYSERDA additive manufacturing initiatives, promoting further growth and outreach.

stonybrook.edu/commcms/ampac/

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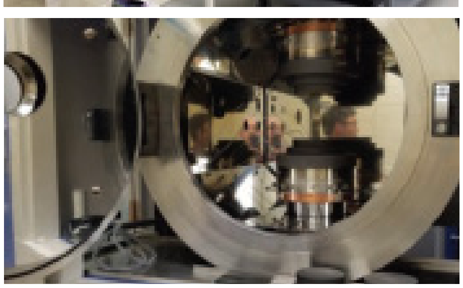
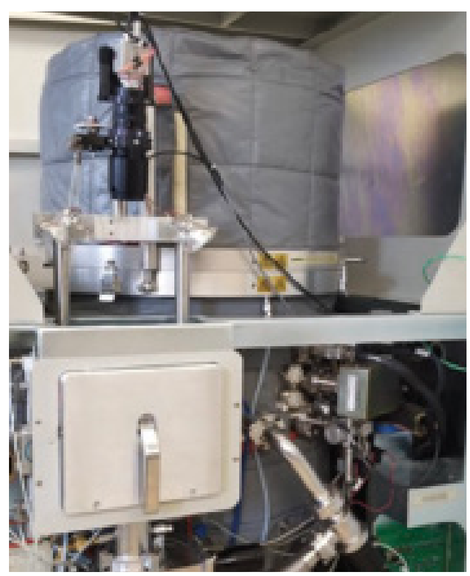
ADVANCED ENERGY™ Research and Technology Center AT STONY BROOK UNIVERSITY

Stony Brook University

Farmingdale State College State University of New York

Suffolk County Community College





EDUCATION AND OUTREACH

THE ADVANCED ENERGY CONFERENCE SERIES: A HISTORY OF GROWTH AND SUCCESS

The Long Island Alternative Energy Consortium is a cooperative effort by seven public and private colleges and universities (Stony Brook University, Farmingdale State College, SUNY Old Westbury, SUNY Maritime, New York Institute of Technology, Suffolk County Community College and Nassau Community College), working with public entities (including Brookhaven National Laboratory) and private companies, to ensure that students get the education and training they need to work in the emerging and rapidly evolving industries of renewable and alternative energies, including photovoltaics, advanced materials for energy storage, and offshore wind energy.

This collaboration is the beginning of a broad interdisciplinary focus on energy and related issues for a variety of career paths. The ultimate goal is to boost the Long Island economy and contribute infrastructure jobs in the energy sector. Academic Program Development – faculty at these colleges will work closely with each other and with industry and government representatives to enhance existing or develop new, academic programs for students interested in working in businesses that design, industrialize, distribute or assess alternative energy for the benefit of Long Island, New York State and the nation as a whole. For example, a new minor in energy science, technology and policy (ESTeP) – enriched with content from multiple campuses – was developed with NSF support to provide students with the skills to analyze energy policy decisions, follow the dynamics of various energy markets and understand how to use and manage emergent energy technologies. Students from underrepresented populations and nontraditional students, such as veterans or those seeking new careers, are among the demographics the minor targets.

Lectures and Conferences – in order to facilitate the discovery and understanding of key issues in the field, members of the Consortium sponsor lectures and conferences relating to sustainable and alternate energy, bringing in experts to interact with students, faculty, government agencies and private companies. The institutions also work with many organizations such as the Department of Labor, the Workforce Development Institute, and BOCES to host job fairs where Long Island businesses can find well-prepared students to work in Long Island's emerging energy sector through job fairs.

Internships – companies, government agencies, colleges and universities (via their placement offices and faculty/internship referrals) will collaborate to enable students to acquire meaningful, job-related work experiences on Long Island, earn academic credit and develop skills, insight and experience that will guide their future careers.

Collaborative Research – the Consortium will link Long Island's world class college and university resources in basic and applied research to business and government communities in order to bring innovative solutions to their impending energy problems.

liaec.aertc.org

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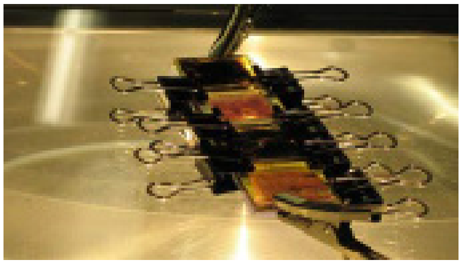
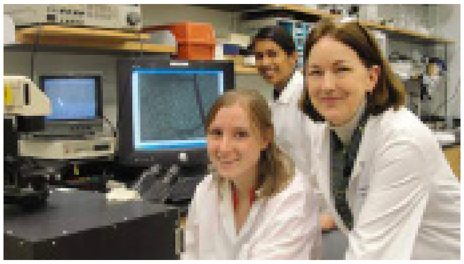


Undergraduate class project on nanocrystalline dye solar cells at SBU.



Research experiences for undergraduates.

ADVANCED ENERGY Research and Technology Center AT STONY BROOK UNIVERSITY

Stony Brook University

Farmingdale State College State University of New York

NCC NASSAU COMMUNITY COLLEGE

Suffolk COUNTY COMMUNITY COLLEGE

NYIT New York Institute of Technology

Brookhaven National Laboratory

EDUCATION AND OUTREACH

THE ADVANCED ENERGY CONFERENCE SERIES: A HISTORY OF GROWTH AND SUCCESS

Individuals Attending

	2007	2008	2009	2010	2011	2012*	2013	2014	2016	2018
Attendees	270	960	1080	1441	443	1640	1662	684	1624	1230

Individuals Presenting

	2007	2008	2009	2010	2011	2012*	2013	2014	2016	2018
Presenters	21	136	192	232	123	342	369	129	298	213

Corporate/Organizational Participation

	2007	2008	2009	2010	2011	2012*	2013	2014	2016	2018
Participants	100	375	466	533	214	237	254	403	696	488

*Advanced Energy 2012 canceled due to Hurricane Sandy (estimated)

Academic Participation

	2007	2008	2009	2010	2011	2012*	2013	2014	2016	2018
Colleges/ Universities	6	17	31	37	25	31	72	29	45	35
Posters	8	36	48	59	37	60	96	30	85	46

2007

2009

2008


2009


2009

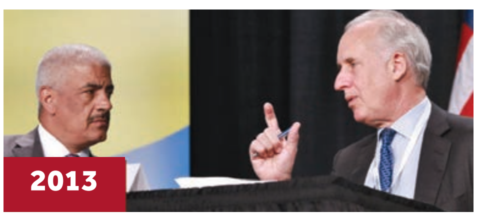

2010

EDUCATION AND OUTREACH

2010


2010

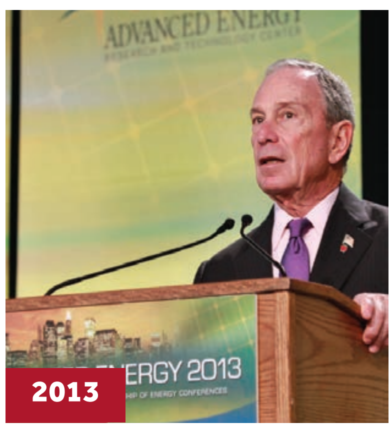

2011


2013

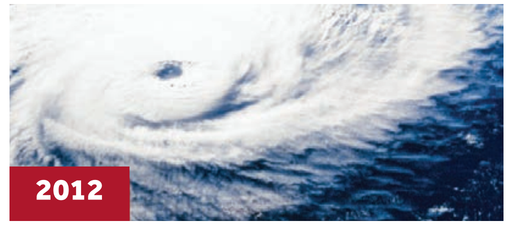

2013


2010

2011



2013


2012


2014

2016

2018


2014


2018

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Vice President for Economic Development Stony Brook University

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