

CIEES ANNUAL REPORT 2019



CIEES
CENTER FOR INTEGRATED
ELECTRIC ENERGY SYSTEMS

AT STONY BROOK UNIVERSITY

DIRECTOR'S MESSAGE



Dear Colleagues,

This has been another productive year for the Center. In 2019, the **Center for Integrated Electric Energy Systems (CIEES)** continued to advance its goal of promoting job creation and workforce development on Long Island and the downstate NY area. We are reaching out to a wider sector of energy-related food-energy-water system (FEWS) businesses and more actively engaging young Stony Brook University (SBU) faculty. Over the reporting period our industrial clients created 18 new NY jobs, retained one job, and generated \$1.664 M in economic impact, all directly related to the CAT's assistance.

In the past year, we installed a second large energy storage system at our facility in the Advanced Energy Center (the first one is the molten salt battery bank). This system, developed and marketed by StorEn Technology, is a vanadium redox flow battery, engineered to fit inside a small enclosure. The system setup involved the safe transfer of approximately 1 ton of electrolyte, and the setup of a power and battery management system. The CIEES team of engineers and students finished the task on time and on budget, and delivered a unique and compact vanadium sulfate flow battery for testing and evaluation. The CIEES team installed the necessary infrastructure, supervised all steps of the system setup, including the transfer of the vanadium sulfate electrolyte. The system has been successfully tested after undergoing multiple charge-discharge cycles.

CIEES continued to expand into areas where SBU faculty members possess world-class expertise, such as narrow-band semiconductors, water purification, and thermodynamic modeling. CIEES has also successfully expanded its scope to advance new technologies to improve the innovative nexus of FEWS. Strengths of SBU faculty including energy efficient water filtration, water quality and marine biology are being leveraged in projects with AquaVectors and SWF technologies. Water quality and its effect on aquaculture are considerable concerns on Long Island, where water pollution by nitrogen runoffs and other products degrade the quality of coastal waters. For example, the Hsiao group, in SBU's Department of Chemistry, has been developing energy efficient water filtration solutions that use renewable materials.

We also assisted traditionally defense-oriented businesses on Long Island with diversification and the re-design of their products for the civilian markets. This activity is directed towards making these Long Island businesses more competitive and resilient to federal funding cycles. One of our clients, Bren-Tronics, is such an example. Bren-Tronics derives over 90% of its revenue from defense contracts. Some of their products, such as their medium-scale Li-ion battery with an integrated inverter, would be highly suitable for residential energy storage in areas with high peak demand. CIEES's team assisted Bren-Tronics in developing a marketing and regulatory strategy for the civilian version of its 5 kW/h integrated storage unit.

Workforce development played a prominent role in last year's activities. Our industrial projects employed 14 graduate and undergraduate students and two post-doctoral fellows. The students obtained invaluable hands-on experience in water purification technologies, power electronics and battery management, narrow band semiconductors and other high-tech areas. We also continued strengthening our collaboration with Brookhaven National Laboratory (BNL). On April 25, 2019 CIEES co-hosted the Industrial Additive Manufacturing Workshop on Metals and Ceramics on the BNL campus, (www.bnl.gov/iam2019/index.php.) The event attracted over 20 local business leaders, who learned about analytical and synthesis capabilities at the BNL and SBU campuses. Our other outreach activities included participation (e.g. CIEES booth presentations) in the Light and Sound Conference in Rochester, NY, and the annual CEWIT conference in Stony Brook, NY.

In 2019 the Center cost-shared a program, "Next Generation Engineering Laboratories". The program was funded as an educational grant by National Grid. This activity aimed to serve students from high needs school districts and underrepresented groups and to meet the requirements of the "Next Generation Science" identified by Stony Brook University. Moving forward, CIEES is teaming up with the College of Engineering and Applied Sciences (CEAS) at Stony Brook University to launch a new program designed to support student startups in engineering with a focus on Energy technologies. The program will support student teams in STEM fields who are interested in converting their senior projects into startup prototypes and launching entrepreneurial activities. To this end, CIEES will be working with the Vertically Integrated Projects teams from the undergraduate student body in CEAS.

Finally, CIEES has successfully completed the service transition of industrial clients who were previously served by Sensor CAT. This transition was accomplished with the hiring of a new business manager, Mr. Lawrence Weber, who was previously employed by Sensor CAT.

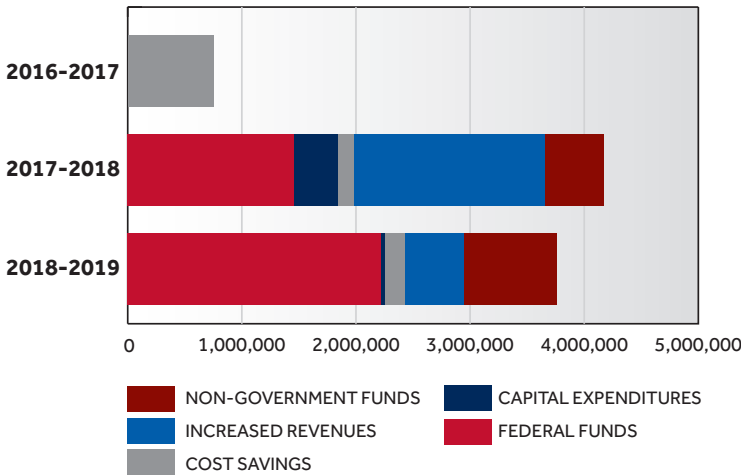
Professor Benjamin Hsiao
CIEES Director

The **Center for Integrated Electric Energy Systems (CIEES)** is a part of the New York State network of Centers for Advanced Technology and is located at the Advanced Energy Research and Technology Center (AERTC).

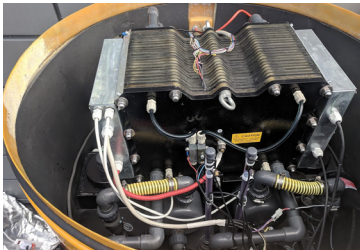
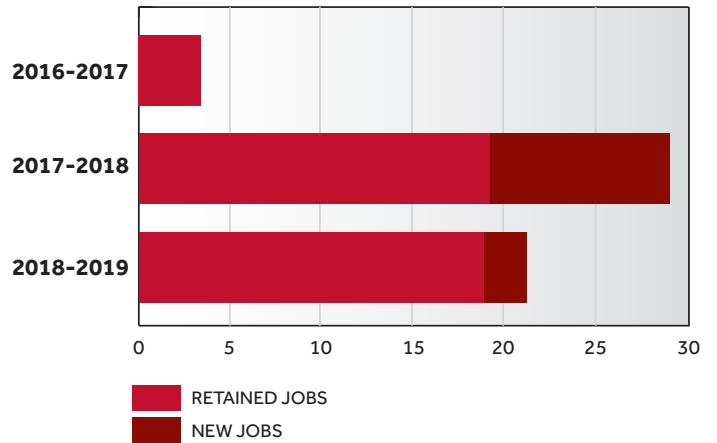
The CIEES goal is to make New York a global leader in renewable energy technologies, and the integration of renewable sources into the electric grid. CIEES supports collaborations with university experts and Brookhaven National Laboratories in the following thrust domains: electric grid technology, energy storage technology, and integrating storage in the grid.

2019 AT A GLANCE

ECONOMIC IMPACT



JOB CREATION



JANUARY 2019

CIEES team finished testing the Vanadium flow battery as a part of long-term reliability study, sponsored by StorEn Technology.



FEBRUARY 2019

Dr. Anurag Purwar, Research Associate Professor of Mechanical Engineering in the College of Engineering and Applied Sciences (CEAS) at Stony Brook University and principal investigator of several CIEES projects, has received a \$225,000 grant from the National Science Foundation (NSF) to conduct research and development of SnappyXO, a robotics platform.



MARCH 2019

The CIEES team presented the Center's capabilities at The New York Battery and Energy Storage Technology (NY-BEST™) Consortium meeting. CIEES is working with BEST to position New York State as a global leader in energy storage technology, including applications in transportation, grid storage, and power electronics.



Innovate Long Island saluted its 2019 Innovators of the Year at the Crest Hollow Country Club in Woodbury. CIEES client, StorEn, which is advancing the clean-gen science of revolutionary vanadium-flow batteries, received a prestigious Innovators of the Year award.



APRIL 2019

Manufacturing and Technology Resource Consortium (MTRC) has opened a User Facility to support the needs of manufacturing companies, such as CIEES clients, in reducing the costs of prototype development. The equipment in the facility is available to the client companies of MTRC and other qualified manufacturers of NY State.



On April 25, 2019 CIEES co-hosted the Industrial Additive Manufacturing Workshop on Metals and Ceramics on the BNL campus, www.bnl.gov/iam2019/index.php. The event attracted over 20 local business leaders, who learned about analytical and synthesis capabilities at the BNL and SBU campuses.

2019 AT A GLANCE

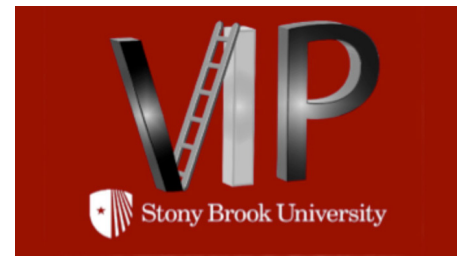


MAY 2019

Center for Mesoscale Transport Properties (m2M/t) Director, SUNY Distinguished Professor and CIEES thrust leader, Esther Takeuchi, received an honorary degree from Notre Dame University and was invited to give the main address at the Notre Dame University Graduate School Commencement ceremony.



Dr. Benjamin S. Hsiao, was elected a member of University of Connecticut, Academy of Distinguished Engineers. The Academy, which has inducted 236 total members since its inception in 2003, honors School of Engineering alumni and Connecticut engineers whose careers have been characterized by their sustained and exemplary contributions to the engineering profession through research, practice, education, policy or service.



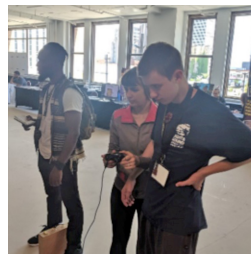
OCTOBER 2019

CIEES started collaboration with the Vertically Integrated Projects Program (VIP) under a new "VIP to student startup assistance program". The purpose of the new program is to promote creation of student startups in STEM areas, such as electrical, chemical and mechanical engineering. The long-term nature of the projects provides students with the opportunity to grow as a team member, make substantial contributions, and rise through the ranks of team leadership.



JUNE 2019

A memorandum of understanding was signed initiating a partnership between Stony Brook University and the Center for Sustainable Energy (CSE) that will support, foster and accelerate cutting-edge research being conducted in Stony Brook's Research & Development Park. The team, supported by CIEES, will also work to secure additional funding for projects and assess the regional and global commercial potential of clean energy strategies that contribute to the U.S. transition to a low-carbon economy.



JULY 2019

CIEES team presents at Light & Sound Interactive Conference, Rochester, NY. The booth featured information about CIEES services and clients.



NOVEMBER 2019

Prof. Esther Takeuchi received the 2019 Sigma Xi Walston Chubb Award for Innovation, an annual award established in 2006. Prof. Takeuchi is recognized internationally for her work on the development of batteries that power hundreds of thousands of life-saving cardiac defibrillators implanted in patients each year.



AUGUST 2019

CIEES team presents at 1st Annual Scientific Summit on Dairy Methane Management Research in Davis, CA. The workshop discussed the latest advances in methane emission from animal farms. CIEES PI, Prof. Devinder Mahajan, is leading a NY State effort on using animal-generated methane to generate energy.



SEPTEMBER 2019

CIEES launches Next Generation Engineering Laboratories (NGELs) program for mid-high schools, jointly with SBU's CEAS. During 2019, about 30 schools brought a total of 800 students in grades 6-12 to Stony Brook to participate in Design and Build/Create Labs. The majority of these students (73%) attended high need schools on Long Island and in New York City.



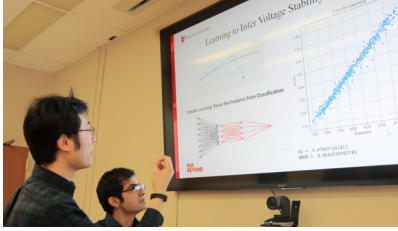
DECEMBER 2019

CIEES signs an agreement with Tesla Science Center at Wardenclyffe in Shoreham, NY on joint funding of the "Tesla day competition" for high-school students. The Center is Nikola Tesla's last remaining laboratory, which is being transformed into a global science center that embraces his bold spirit of invention, provides innovative learning experiences, fosters the advancement of new technologies, and preserves his legacy in the Tesla Museum.

FEATURED FACULTY PROFILES

SMART ENERGY SYSTEMS LAB

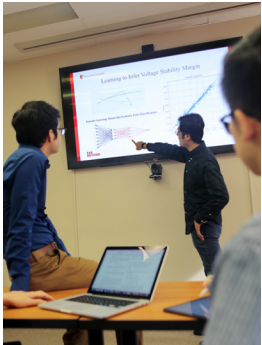
OUR MISSION



We aim to provide key technologies that enable our energy sector to achieve long term sustainability, reliability and affordability goals. Our lab develops

a) real-time computation tools for comprehensive monitoring and reliable operation of power systems, and b) efficient market and pricing mechanisms for massive grid integration of renewable energies and other distributed energy resources (DERs), e.g., electric vehicles (EVs). As such, we provide new capabilities for the Independent System Operators (ISO) and electric utilities to achieve a) orders of magnitude of enhancement of grid reliability and security against system contingencies, and b) decentralized and incentive compatible operation of clean and flexible energy resources at very large scales.

OUR CAPABILITIES



Our lab has developed a suite of novel machine-learning-based tools for key power system applications, including a) real-time system component outage and fault detection and identification, b) online voltage stability analysis, c) online transient stability analysis, and d) network congestion and electricity market equilibrium prediction.

Our lab has developed real-time control algorithms for ensuring power system stability under sudden loss of generation and resilience against cascading failures.

Our lab has also developed practical market and pricing mechanisms that enable, with provable performance guarantees, efficient and massive integration of renewable energies, demand response, and other DERs into both power transmission and distribution systems.

RECENT PROJECTS

“Grid Ready Energy Analytics Training with Data”, Department of Energy.
“Data-Driven Distribution Grid Stability Analysis and Design with High Renewable Penetration”, SBU-BNL SEED Grant.

SOLID-STATE AND OPTO-ELECTRONICS LABORATORY

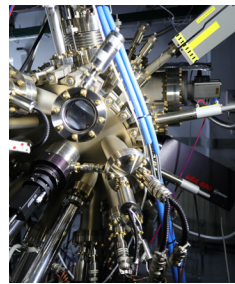
OUR MISSION



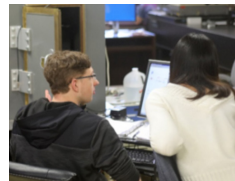
Solid-State and Opto-Electronics Laboratory specializes in growth, fabrication and advanced characterization of optoelectronic devices including semiconductor lasers. We specialize in narrow-band semiconductors, such as LED's, lasers and receivers. The devices are most efficient in an important mid-IR, 3-4 micron spectral region, where hydrocarbons have strong absorption lines. The LED's and receivers are thus ideally suited for hydrocarbon detection in air, for example for

natural gas leak detection, identification of hazardous substances and many others. Our laser technology demonstrated exceptionally powerful mid-IR lasers for military and space applications.

OUR CAPABILITIES



The laboratory equipment park includes everything necessary to complete the production process of an optoelectronic device – from design to packaging. Powerful computer simulation packages such as BeamProp, COMSOL and PADRE are used for device structure design. The designed structures are grown by Molecular Beam Epitaxy (MBE) in VEECO Gen 930 reactor including materials of III and V groups. Immediately after growth, epitaxial materials are characterized with high-resolution X-ray diffractometry and photoluminescence and carrier lifetime measurements with time resolution from 200 femtoseconds to microseconds providing rapid feedback for optimization of growth. Powerful optical Namarsky microscopes with magnification of 1500 times and Veeco Dimension atomic



force microscope are used to monitor surface morphology of the grown wafers. The wafers are further processed in a Class 100 clean room. The typical procedures include oxygen plasma cleaning, e-beam metal and optical quality dielectric deposition, plasma etching, substrate lapping polishing and cleaving. Unpackaged devices are tested with probe stations operating from liquid helium to room temperatures and above. The good devices are mounted with chip bonding machine and electrically connected to the mount's terminals using ball and wedge wire bonding machines.

RECENT PROJECTS



The SBU mid-IR laser technology has been successfully deployed at Mars Curiosity mission. The LED-receiver pairs are currently being used in development of compact, low power methane sensors. In this development, a partner company utilizes the SBU LED technology to design and manufacture a low-cost sealed multi-gas sensor with a 10 year lifetime. The sensor is utilizing the mid-infrared range where multiple common gases (CO₂, water vapor, methane, formaldehyde etc.) have very strong absorption signatures.

PARTNER PROFILES

BREN-TRONICS, INC.

Project: Redesign of military-grade 5 K Wh integrated Li-ion energy storage for behind the meter applications

Bren-Tronics, is a NY- based (Commack) small business that has been operating continually since 1973. For over 30 years, Bren-Tronics has been the Department of Defense's go to partner for their power and energy needs. Over 95% of BT shipments support the warfighter. CIEES and Bren-Tronics developed a joint proposal and won a NYSTAR military vendor assistance award. The program provides assistance in establishing civilian applications for military products. In this project, Bren-Tronics and CIEES re-designed an existing 5 kWh, 48 V battery, currently offered to DoD customers under the brand name Brenergy 480. The CIEES team identified markets and regulations needed to promote the battery storage system for civilian applications.



FLOWER TURBINES LLC



Project: Mechanical Design Optimization and Simulation of a Vertical Axis Wind Turbine – V

CIEES has just launched a project with Flower Turbines to develop a prototype of a small vertical axis wind turbine.

The company is looking to perform detailed design and engineering of the turbine and to do modeling and simulation using CAD/CFD software. CIEES will recruit an engineering student to interact with manufacturers with the goal of making the design easy and cost effective to manufacture.

THE CENTER FOR SUSTAINABLE ENERGY

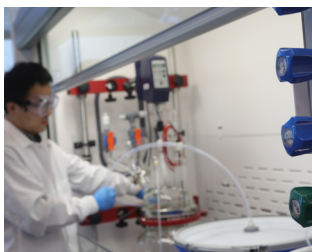
Project: Feasibility Study on Power to Gas (P2G) to Power and Transportation Fuels Systems

The Center for Sustainable Energy (CSE) with headquarters in San Diego has recently established a branch office in the Center of Excellence for Wireless and Information Technology (CEWIT) in the Stony Brook R&D Park. CSE and I-GIT (The Institute of Gas Innovation and Technology) have established a partnership to work on sustainable energy projects. Under this contract, CSE and I-GIT have identified a specific project namely, Power2Gas (P2G) for development. The P2G concept is relatively new and regional data are crucial to expand its application in New York State. During the reporting period, CIEES-I-GIT delivered a preliminary design of the P2G, which included an electrolyzer combined with a compressed storage system (high pressure tanks). The team is discussing several possible demonstration sites for the 5 kW unit on Eastern Long Island.

SWF TECHNOLOGIES

Project: Scale up of the nitro-oxidation method for fabrication of carboxycellulose nanofibers for water purification

The main goal of this project is to evaluate the scale up process of extracting cellulose nanofibers (CNF) from local and underutilized biomass (e.g. agriculture waste) as a sustainable resource and to use these nanofibers for effective adsorption of toxic contaminants (organics and heavy metals) from contaminated water. Instead of discarding biomass wastes into the environment, they will be chemically converted into low-cost materials to be used for water purification, or adsorbents to remove water pollutants (e.g. heavy metals, dyes, organic toxicants and ammonium ions).



GREEN POWER LLC

Project: Green Power Tower Wind Flow Simulation and Design for Improving Energy Efficiency

Green Power Tower (GPT) Energy is a New York, NY based company which has created a new and efficient vertical axis wind turbine. The turbine incorporates a patented rigid omni-directional structure, which can be of varying sizes and is modular. For this project, CIEES is working with the Mechanical Engineering Department to perform Fluid Dynamics simulation and to improve design of the turbine.

PARTNER PROFILES

STOREN TECHNOLOGIES LLC

Project: Evaluation of StorEn Vanadium Flow Battery Technology



StorEn Technologies
Energy you can depend on

Vanadium sulfate flow batteries have long been known as a scalable and inexpensive energy storage solution. However, a typical flow battery installation is comprised of multiple tanks and pumps which need to be plumbed on-site. StorEn developed a complexly sealed flow battery that can be dropped on a customer site and operated immediately. StorEn needed third-party validation

of the technology and a test site where the battery solution could be presented to potential customers and invertors. It is critical to demonstrate that the flow battery has a distinct advantage over more entrenched technologies, such as Li-ion. The CIEES team coordinated safe delivery of 1 ton of Vanadium Sulfate electrolyte, filling of the flow battery container, and the installation of the high-current wiring. The battery is undergoing tests

BAH HOLDINGS LLC

Project: Evaluation of NDIR Gas Sensors



BAH Holdings is a startup company developing optical sensing solutions for the petrochemical industry. The company is interested in developing a new generation

of gas sensors using mid-IR lasers and LEDs that are being researched in SBU's Electrical Engineering department. CIEES established a project that utilizes the laser testing facilities at our laser lab. The SBU student working on this project evaluated 2nd harmonic lasers and demonstrated detection of both ethane and methane gases. The results are significant, since detection of methane allows the utility to discern a natural gas leak from other sources of methane, such as sewer gas.

UNIQUE TECHNICAL SERVICES (UTS)

Project: Evaluation of an integrated energy system with molten salt battery energy storage



CIEES, in collaboration with Unique Technical Services (UTS), won a NYSEDA grant for the evaluation of molten salt (ZEBRA) batteries. NYSEDA granted 11 batteries to evaluate applicability of the technology for seasonal energy storage in the Eastern Long Island corridor. The battery packs were installed at the AERTC facility and are currently undergoing evaluation. UTS paired the batteries with their proprietary battery management system which allows running the battery pack more efficiently.

AQUA VECTORS

Project: Nitrogen Removal Process Evaluation from Wastewater Treatment



Aqua Vectors Inc develops electrolytic detoxification technology that removes nitrates, phosphates, arsenates, organisms, and pharmaceuticals from water and wastewater. Currently Aqua Vectors technology is targeting nitrates, a common ground-water contaminant in rural areas and

fairly reliable indicator of the presence of other contaminants, such as bacteria and pesticides. This development is especially relevant for Long Island, where nitrate levels in aquifers and surface waters have increased at an accelerating rate since 1985. During the project a team of scientists in SBU's Department of Chemistry will evaluate efficiency of electrolytic detoxification in removing nitrates from wastewater.

ISLAND PYROCHEMICAL INDUSTRIES (IPI)

Center for Intergrated Electric Energy Systems

Project: Production of Ethyl Cellulose for Energy Applications



This project is focused on synthesis of ethyl cellulose,

as well as its characterization and applications as energy materials. The main objective of this project to optimize the reaction conditions to control the desired quality of ethyl cellulose. To this goal, a team of scientists from SBU's Department of Chemistry set up a high-pressure research reactor. The setup is now producing pilot quantities of ethyl cellulose from renewable and widely accessible natural cellulose. Currently the CIEES-IPI team is working on scaling up the process to pilot production level.

PARTNER PROFILES

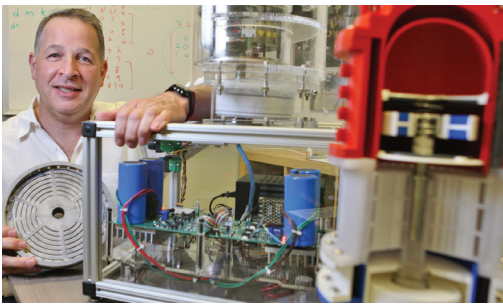
THERMOLIFT

Project: **Thermolift Natural Gas Fired Heat Pump for Building Heating and Cooling**



ThermoLift, based in Stony Brook, NY is developing a cold-climate, natural gas air-conditioner and heat pump technology that combines heating, air-conditioning, and water heating into a single appliance. It can provide a 30-50% reduction in

building HVAC costs as well as associated reductions in greenhouse gas emissions. On this project, the CIEES team is working on product development and optimization, which includes designing the whole HVAC system accompanying ThermoLift's heat pump and optimizing it to achieve proposed energy savings.



Project: **Thermodynamic and Kinematic Modeling of ThermoLift Vuilleumier Natural-Gas Heat Pump**

ThermoLift is also developing a natural gas air-conditioner

and heat pump technology that combines heating, air-conditioning, and water heating into a single appliance. This project will leverage the expertise of Dr. Longtin in thermodynamic modeling of complex heat engines. Specifically, Dr. Longtin's team is optimizing the heat exchanger and the absorber, which can potentially increase the heat pump efficiency by 15%.

OMNITEK PARTNERS

Project: **Harvesting from CNC Machines**



Omnitek Partners is an innovative small business focused on the development of advanced technology and products. Since 2000, Omnitek Partners has been devoted to solving problems for clients within the military, medical, and commercial marketplaces. The CIEES team is working on the development of energy harvesting micromachines that would find applications in sensors, autonomous robots, and surveillance systems. The work is focused on mathematical modeling of the harvester and optimization of the design.

ECO2HEAT



The main goal of this project is assisting the small company Eco2Heat in obtaining UL certification of their far infrared heating wall panels. The project is in its completion stages. Several panel types have been examined by the UL branch in Melville, NY, minor changes have been made by the company according to the results of the preliminary examination, and the modified panels will undergo the final testing at the UL facility. Theoretical analysis of the panels showed significant (up to 30%) reduction of CO₂ emissions if the panels are used in a smart home environment.

NATIONAL GRID

Project: **Off-Grid Power Production from Renewable Gas Source**



The CIEES team is evaluating the market and technology for distributed energy generation using gas on Long Island. The goal is to estimate the impact of renewable

gas on Power Production on Long Island. Distributed natural gas generation is considered a viable option for relieving grid strain in congested load pockets, such as the South and North Forks of Long Island. The natural gas generators, working in tandem with renewable energy sources, offer an economic alternative to chemical energy storage in some load pockets. The CIEES team, led by Dr. Devinder Mahajan, Director of Institute of Gas Innovation and Technology (I-GIT), identifies hybrid gas sources based on off-grid technologies for distributed power production.

CHEMCUBED

Project: **Evaluation of additive manufactured composites for energy applications**



ChemCubed is a fast-growing company in the advanced composites field.

This project is focused on developing new metal ink formulations for printing flexible electronic circuits. The improved ink has a significant cost advantage over competing products. Currently, the company is actively marketing printed electronic tags and RFID's for security, logistics and retail applications.

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ENERGY GENERATION AND ENERGY POLICY



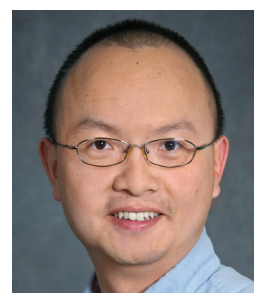
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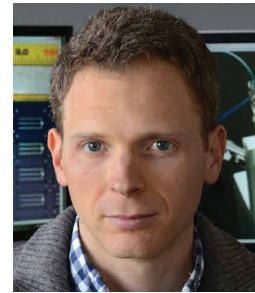
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INFORMATION TECHNOLOGY AND BIG DATA



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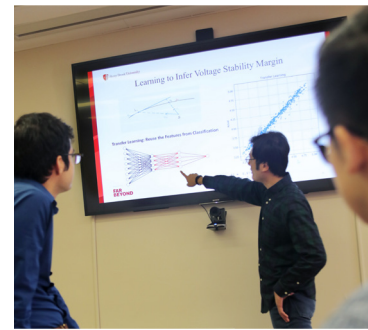
The CIEES goal is to make New York a global leader in technologies that will accelerate the progress of renewable energy as one of the mainstream resources displacing fossil fuel-based electric power worldwide by facilitating the integration of renewable sources into the electric grid.

CIEES will promote industry growth in New York by supporting industry collaborations with university experts in the following domains:

**CHEMISTRY AND MATERIALS
ENERGY GENERATION AND ENERGY POLICY
SEMICONDUCTORS AND ELECTRONICS
INFORMATION TECHNOLOGIES AND BIG DATA**

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