

A History of Energy at the University of Massachusetts Lowell – 2023

By Christopher Niezrecki, Ph.D.

UMass Lowell has had a long and distinguished reputation of being a leader in energy education and research that has spanned over 60 years.

It Started with Nuclear Engineering

Nuclear Science and Engineering began at Lowell Technological Institute (LTI) by the Physics Department in 1958 when the Commonwealth of Massachusetts, with the advocacy of then Board of Trustee Chair Samuel Pinanski, identified LTI as the location for the construction of a Nuclear Research Center. This was in response to President Eisenhower's "Atoms for Peace Initiative" and the commercial operation of the Yankee Atomic Electric Company's nuclear reactor in Rowe, Massachusetts. In addition to radiation laboratories, the center included a 5.5 MV Van de Graaff accelerator, a 1 MW open pool-type nuclear research reactor, and a Cobalt-60 radiation facility. Academic and research programs were created in radiation health physics, radiochemistry, nuclear physics, medical physics and nuclear engineering. A B.S. degree in Nuclear Engineering was established in 1975 and the first class graduated in 1977. The Department of Nuclear Engineering was created in the college of Engineering at the University of Lowell. The stalwarts of the program that include (but not limited to) James Phelps, Jose Martin, Gilbert Brown, and John White. In 1980 University of Lowell became, and remains to this day, the only public university in the entire northeast to have a BS degree in nuclear engineering accredited by the Accreditation Board for Engineering and Technology (ABET). Graduate degrees with concentrations in solar, sustainability and nuclear engineering are offered under the umbrella of Energy Engineering, an interdepartmental, multi-disciplinary program administered within Mechanical Engineering, Chemical Engineering and Physics Departments.

In 1983 the Nuclear Engineering Department at one point was merged into Mechanical Engineering, creating the department called "Mechanical and Energy Engineering" offering ABET accredited Nuclear BS, Mechanical BS, and graduate degrees including Energy Engineering. Some years later, the Nuclear Engineering program was combined with the Chemical Engineering Department that included a Nuclear Science and Engineering program. The nuclear engineering and radiological science education and infrastructure was moved into Chemical Engineering (early 90's) and survived from the 1980's through the 2000's. The BS program was discontinued in 1995, and the Nuclear Engineering Option was offered in Chemical Engineering as an outlet for students interested in studying Nuclear Engineering at the university. The last BS degree in Nuclear Engineering was awarded in 1999, and the first Chemical Engineering-Nuclear Option degree was awarded in 1998 with accreditation provided that same year. The Energy Engineering Program spanned both Mechanical and Chemical Engineering Departments with Dr. Jose Martin's focus on solar energy, while the other faculty offered the nuclear engineering program. The department name was simplified to Chemical Engineering and Dr. Gilbert Brown served as the coordinator of the Nuclear Engineering Option until his retirement in 2017, when the position was then filled by Dr. Sukesh Aghara.

Nuclear Engineering Today

The research and ABET accredited programs in nuclear engineering and science have been resurgent in the past decade with applications in clean energy, energy security, imaging, space, and medical applications. The programs have recruited a vibrant mix of faculty with expertise in nuclear engineering, radiological health sciences and medical physics. Faculty conduct research in nuclear non-proliferation and safeguards, nuclear fuel cycles, energy materials, radiochemistry, radiochemical separation, advance reactors (small modular reactors and micro-reactors), multimodal radiation sensors, and medical therapeutics.

The research is funded through the National Nuclear Security Administration, National Science Foundation, Nuclear Regulatory Commission, Department of Energy, national laboratories and industry. In addition to their education and research portfolios the program faculty are involved in globally recognized nuclear engineering training programs and workshops. For example, the Intercontinental Nuclear Institute (INI), a training program for young international nuclear professionals, is funded through the International Atomic Energy Agency (IAEA) and has been run at Lowell and the Czech Republic for the past 8 years. Lowell has also been a host to the US Nuclear Industry Council's Advance Reactor Summit and workshops on Applicability of the IAEA Safety Standards to Small Modular Reactors, among others.

The Growth of Solar Engineering

Professor Jose Martin was a true inspirational leader for broadening the scope of the nascent Nuclear Engineering Department to include not only nuclear fission, but also nuclear fusion solar energy, and more generally energy engineering. The first formal course in Solar Engineering was offered by the late Dr. William Filippone of the then Nuclear Engineering Department in the Fall of 1977, shortly after the so-called "Energy Crisis". Because of student and faculty interest, new graduate courses were added such as Solar Energy Conversion, Fundamentals of Solar Thermal Technologies, Solar Design and the Energy Engineering Workshop. A graduate program leading to a M.S. degree in Energy Engineering with a Solar Concentration was approved around 1981. At that time, this was only one of three graduate programs in solar energy in the USA.

Originally, it was intended for senior undergraduate students and later on it was also offered to graduate students in other engineering and science disciplines. Because of student and faculty interest, new graduate courses were added such as Solar Energy Conversion, Fundamentals of Solar Thermal Technologies, Solar Design and the Energy Engineering Workshop. A graduate program leading to a M.S. degree in Energy Engineering with a Solar Concentration was approved around 1981. In 1983, as a consequence of Dr. Filippone's retirement from Univ. of Lowell, Dr. John Duffy was hired to teach solar engineering courses.

The burgeoning Solar Engineering Program received a grant from the Department of Energy to assist in the evaluation of the International Energy Agency Solar Plant in Almeria, Spain, and other grants from other agencies to work on holographic solar spectral splitting. Later on, in collaboration with the Physics Department, it was authorized to offer a program leading to a Ph.D. in Physics with a Solar Concentration. Other activities involving students included solar car races. In addition to Dr. Duffy and Dr. Martin, other key contributors to solar efforts at the University were Dr. William Berg and Dr. Ziyad Salameh, of the Electrical Engineering Department whose work focused on the evaluation of battery energy storage systems.

Members of the faculty established collaborative efforts with nongovernment organizations, innovative technology firms and state agencies. A notable example was the collaboration with Enersol, a nonprofit organization whose goal was to bring solar electricity to the rural poor. Enersol's efforts started in the Dominican Republic, with the assistance of Enersol's president, Mr. Richard Hansen. Several graduate students were encouraged and supported to spend some time in that country learning about the challenges and opportunities involved with decentralized rural electrification. What they learned made it possible for the graduates to have an impact on hundreds of thousands of poor people in South Asia and Latin America.

In the early 80's, substantial funding from the Commonwealth of Massachusetts permitted the establishment of the Center for Sustainable Energy in 1987. The Center did extensive work on photovoltaic assisted lighting in malls and other facilities around the state, as well as batteries for energy storage, water pumping, and solar drying of grains, the health and social costs of energy generation and the impact of government policies on sustainable development. The late Prof. Aram Karakashian and Dr. Bill Berg (UMass Lowell Ph.D., Physics - Energy Engineering Option) with involvement of Prof. Duffy had a

funding from the state of Massachusetts to test and explore utilization of commercially available silicon photovoltaics (PV).

In 1996, Drs. Sukant Tripathy and Jayant Kumar obtained funding to explore the feasibility of organic PV devices from EPRI. In the mid-1990's with the ONR and the U.S. Army (Natick Labs) funding a polymeric semiconductor PV device was fabricated at UMass Lowell. There was a lot of interest from the US Army in development of lightweight, portable PV for field deployment. In the year 2000, the US Army funded a \$2M project to develop lightweight OPV (organic PV) on flexible substrates. Unfortunately, Prof. Tripathy passed away in December 2000, but the grant continued till the stipulated time. The research continued with funding from ONR (\$280k) to further develop materials for development of OPV.

In 2001 the company Konarka Technologies Inc. was spun out from patents filed by Dr. Kumar's group, with Venture funding to manufacture OPV's using a roll to roll process. Konarka Technologies was headquartered in Lowell with approximately 60 employees spread between U.S., Germany and Austria. Konarka technologies raised funds from venture groups, NIST, DARPA as well as large corporations totaling more than 100 million US dollars. A DOE funded EFRC with UMass Amherst as the lead and UML (Dr. Kumar) and Konarka as subcontractors was funded from 2008-2013 for a total of ~\$13 million dollars. UML subcontract was ~\$800k. Unfortunately, Konarka lost its venture funding in 2012 and shut down in 2013, a time when most U.S. PV companies went out of business due to competition from China. The intellectual property generated by Konarka has led to a number OPV companies in Europe and the U.S. (e.g., Ambient Photonics).

Dozens of graduate students participated in the Energy Engineering solar program, and some of the earliest doctoral dissertations dealt with the thermodynamic limits to energy conversion, solar rural electrification, the optics of solar cells, while master degree theses were written on solar drying, holographic splitting for energy conversion, ray tracing, solar electrolyzers and fuel cells, phase change thermal storage systems, the impact of surface treatment on solar absorptivity and thermal emission, energy efficiency and battery performance. During the 90's until 2012, the Energy Engineering Program (Solar option) was led by Dr. Duffy who focused on research related to passive solar systems monitoring, electrolyzers and fuel cells, stochastic methods for optimal solar system designs, and service-learning. Dr. Robert Parkin served as the Solar Energy Engineering program coordinator until 2015, followed by Dr. Walter Thomas (until 2021), and Dr. Juan Pablo Trelles (present). The Solar Energy Option within the Energy Engineering Program became the Renewable Energy Option in 2016 to better reflect the breadth of courses available to the students.

Addressing Global Energy Equity

Dr. Duffy was heavily involved in service-learning and organized numerous solar energy projects in Peru and on the Tohono O'odham Indian reservation in Arizona. Since 1997, he has spearheaded the Village Empowerment project with the communities surrounding the city of Huarney, in the Andes mountains of Peru. The project has included the installation of 100 solar systems in 61 mountain villages, powering vaccine refrigerators, transceiver radios, and lights in medical posts, as well as water pumping and water purification in remote areas. Twenty-nine two-week trips to Peru were made with over 150 students, faculty, and volunteers. Additionally, he led student projects up to 2019 that helped the residents of Tohono O'odham Nation in Arizona have access to running water and solar-generated electricity.

In January 2003, Professor Robert Giles started travelling biannually to Haiti. Studying the culture and community dynamics, he started mentoring teams of science and engineering students working on the challenges of food, energy and water in impoverished international communities. With this experience, Giles leased a two-story building in the city of Les Cayes and established the Haiti Development Studies Center (HDSC) June 2013. Supporting several young Haitian adults serving as research interns taking UML online courses, Professor Giles visited Les Cayes two to four times annually with faculty-led student

engineering teams focused on energy equity and water security projects while teaching these concepts at one of the local schools. Dr. Christopher Niezrecki also visited the HDSC and helped with solar installations in 2014 and 2015. In 2015 he collaborated with Soluz Inc. and Richard Hansen to help install a ~5kW solar PV system in a school in Honduras and another in the Dominican Republic in 2016.

The HDSC program enabled American students to sharpen their research skills and to raise their awareness about factors that hinder progress in impoverished countries. The program also helped Haitian students get the education they needed to move their country forward. The facility was shut down in June 2020 due to the growing gang violence in Haiti. Subsequently, Giles created an academic partnership with the University Science of Education program in the Southern Department of Haiti (UPSAC) and, with the assistance of UML's advanced undergraduate students, began teaching a Science of Energy course with laboratory curriculum involving the fundamentals of electronics, data acquisition, and computer programming skills with applications in solar PV. During the Fall of 2022, Dr. Giles initiated a plan to replicate his international research program in Winneba, Ghana in collaboration with the University of Education Winneba in Ghana.

Wind Energy Transforms the Center

The first involvement of UMass Lowell faculty with utility-scale wind energy occurred in the summer of 2008, when Dr. Christopher Niezrecki attended the Sandia National Laboratories Wind Turbine Blade Workshop. The outcomes of this meeting led to the formation of the Wind Turbine Research Group by Niezrecki in 2009 that included Drs. Peter Avitabile, James Sherwood, Julie Chen and a handful of other faculty. The primary research at that time focused on wind turbine blade testing, structural dynamics, non-destructive evaluation, monitoring, and composites manufacturing. The group obtained funding from the Department of Energy to research the effects of defects within wind turbine blades in collaboration with NREL and TPI Composites Inc. In 2010, after receiving a UMass President's Office Science and Technology Initiatives Fund grant, the name was changed to the Center for Wind Energy and was founded directed by Niezrecki and supported by Patrick Drane. That same year, Drs. Niezrecki and Sherwood visited NSF to discuss the formation of a new wind energy Industry-University Cooperative Research Center (I-UCRC) with program managers. UML hosted its first Wind Energy Research Workshop in September of 2011 with support from NSF. In 2012, Niezrecki led the effort to form the Industry-University Cooperative Research Center for Wind Energy Science Technology and Research (WindSTAR) with a successful planning grant from NSF in collaboration with the University of Texas at Dallas (UTD), Iowa State University, and Texas A&M University. This was followed in 2014 by a successful award for UML and UTD in 2014 that officially started the nation's only NSF Center devoted to wind energy - WindSTAR.

UML hosted another Wind energy Research Workshop in 2016 and in the years that followed, funding to support the Center came in from numerous sponsors such as the Massachusetts Clean Energy Center, Department of Energy, National Renewable Energy Labs, NSF, ONR, NYSERDA, and numerous companies. Through the Center of Wind Energy, multiple other workshops and conferences were hosted at UMass Lowell including: Energy Innovation Forum (October, 2017); The Role of Energy Storage in Our Carbon-Free Future (November, 2019); The Future of Hydrogen for the Commonwealth of Massachusetts (November, 2021); and two others that focused on block chain technology and energy efficiency for the emerging cannabis industry in Massachusetts. Dr. David Willis led educational and outreach efforts with the Kid-Wind Project starting in 2015.

In July 2019 the Fraunhofer Institute in Boston closed its doors and several of the research scientists including Drs. Cordula Schmid and Jan Kosny joined the Center. Most of the solar, thermal, and energy diagnostic equipment came to UMass Lowell and significantly augmented UMass Lowell's energy capabilities. Also that year, the entire fourth floor of Perry Hall was renovated, opened, and was designated as energy research space, allowing for multiple faculty from the Center to consolidate separate laboratories

and work collaboratively. In 2020, Dr. Niezrecki established a collaboration with Stony-Brook University to conduct research on energy resiliency for the Navy and has since received \$10M+ in research funds from ONR that has supported dozens of faculty throughout the Center. Other notable strategic partnerships that were established in the 2010's include strategic collaborations with the Partnership for Offshore Wind Energy (POWER-US) and Greentown Labs (the nation's largest clean-tech incubator located in Somerville, MA). In 2020, Central Maine Power (a subsidiary of Avangrid Inc.) established a \$5M partnership with UML to financially support the Center's research for 10 years.

As the Center for Wind Energy grew, its research expanded significantly as new funding came in and new faculty joined. Other areas of energy research the Center began to support included solar, energy storage, fuels, hydrogen, and even nuclear. In December 2021, the Center for Wind Energy was renamed to the Center for Renewable Energy and subsequently in August 2022, the name was finally changed to what it is today, the **Center for Energy Innovation**.

Student and Faculty Success

Many early graduates from the program achieved distinguished careers in the solar energy field. Dr. Harish Hande, co-founder of SELCO India, has received several international awards, including the Ramon Magsaysay Award in 2011 for his efforts to bring solar electricity to the poor, and Dr. Manuel Blanco is the Chairperson of Solar Paces, the International Energy Agency branch in charge of developing solar thermal technologies. Dr. Carolina Barreto was until very recently Power Africa Off-grid Project Senior Technical Advisor for USAID. The Electrochemical Society (www.electrochem.org) established a new award in Sustainable Energy Technology, and named it after Walter van Schalkwijk (class of 75) who was the first to design a manufacturable lithium-ion battery. John B. Lavelle (class of 83) served as the CEO of General Electric Renewable Energy's offshore wind business. Two current faculty members at UML obtained graduate degrees from the Energy Engineering program (Dr. Juan Trelles and Dr. Walter Thomas).

The faculty within the Center have achieved phenomenal success in large part because of the robust ecosystem that was fertilized over a dozen years and high-level of collaboration the Center members have. The following faculty who have been part of the Center have received the prestigious NSF Faculty Early Career Development Program (CAREER) award while working in the Center: (Drs. Juan Pablo Trelles, Hsi-Wu Wong, Yuzhang Lin, Maria Carreon, and Marianna Maiaru). In addition, Drs. Trelles and Fanglin Che also received the prestigious Department of Energy Early Career Research Program award. Other notable faculty such as John Hunter Mack, Murat Inalpolat, Marianna Maiaru, Hsi-Wu Wong, and Margaret Sobkowicz Kline, have received million dollar grants to support their energy related research on next-generation fuels, wind turbine blade monitoring and manufacturing, plastic recycling, and bioconversion of polyester wastes to high-value chemical products, respectively.

The Center Today

The Center for Energy Innovation (www.uml.edu/energy) today consists 70+ faculty members who have developed a model for addressing energy challenges through research collaborations with industry as well as state and federal government. Companies can work side-by-side with our renowned faculty and talented students to develop tomorrow's clean energy solutions. Our center includes 12 primary research thrust areas pertaining to the energy industry, with research looking to a future of sustainable energy sources and systems. Current research thrust areas include:

- Wind Energy
- Solar Energy
- Nuclear Energy
- Power Transmission & Transportation
- Energy Storage & Fuel Cells
- Cybersecurity

- Alternative Fuels & Hydrogen
- Bioenergy & Energy from Waste
- CO2 Capture, Sequestration & Utilization
- Buildings & Energy Efficiency
- Energy Policy & Economics
- Energy Equity

From clean energy generation, resilient energy storage and distribution infrastructure, and the responsible management of the byproducts of energy, to the role energy plays in society at large as we work toward an equitable green economy, our faculty and students are committed to collaboration, creative problem-solving, and urgency as we tackle one of the world's greatest challenges.

The Center for Energy Innovation is now part of the Rist Institute for Sustainability and Energy (started in 2019; www.uml.edu/sustainability/) and works collaboratively with two other UML entities (1) the Climate Change Initiative and (2) the Office of Sustainability. The goal is to create blueprints for human-scale sustainability in communities throughout our region and across the world.

For more information, contact:

Christopher Niezrecki, Ph.D.
Distinguished University Professor, Mechanical Engineering
Director, WindSTAR I-UCRC and Center for Energy Innovation
Co-Director, Rist Institute for Sustainability and Energy
Co-Director, Structural Dynamics & Acoustic Systems Laboratory
University of Massachusetts Lowell

E-mail: Christopher_Niezrecki@uml.edu
Phone: 978-934-2963 (W)
www.uml.edu/energy



CENTER FOR ENERGY INNOVATION