

NSF TUES Grant: A Collaborative, Multi-Campus Program to Enhance STEM Learning in Energy Science, Technology and Policy

Dr. Gary P. Halada, Stony Brook University

Dr. Halada, Associate Professor in Materials Science and Engineering at Stony Brook University, directs an interdisciplinary undergraduate degree program in Engineering Science. He designs educational materials focused on nanotechnology, advanced manufacturing, and how engineers learn from engineering disasters and how failure and risk analysis can be used to teach about ethics and societal implications of emerging technologies. Halada also coordinates the Long Island Alternative Energy Consortium, a collaborative effort among seven campuses to develop multi-disciplinary, multi-institution undergraduate and experiential education programs in renewable and alternative energies. In recognition of his academic activities, he received the 2012 SUNY Chancellor's Award for Excellence in Teaching.

Dr. Nada Marie Anid, New York Institute of Technology

Nada Marie Anid, Ph.D., is the first female dean of NYIT's School of Engineering and Computing Sciences (SoECS). In this role, she oversees 80 engineering and computing sciences faculty members and approximately 3,500 graduate and undergraduate students at campuses located in Manhattan and Old Westbury, N.Y., the Middle East, and China. Her expertise is in Industry-academic partnerships; Entrepreneurship and Innovation; Emerging Technologies; Sustainability; Global Engineering Education; STEM K-12 Outreach.

Dr. Anid embraces NYIT's forward-thinking and applications-oriented mission and is working on several strategic partnerships between the School of Engineering and the public and private sector, including the creation of the School's first Entrepreneurship and Technology Innovation Center (ETIC) and its three labs in the critical areas of IT & Cyber Security, Bio-engineering and Health, and Energy and Green Technologies. She is a board member of several organizations including the Greater Long Island Clean Cities Coalition (GLICC), LISTnet, the Institute for Sustainability (IFS) of the American Institute for Chemical Engineers (AIChE), the Riverdale Conservancy, and the Environment and Public Health Network of Chinese Students and Scholars (ENCSS). Dr. Anid is a Program Evaluator for the Engineering Accreditation Commission of the Accreditation Board of Engineering and Technology (ABET), and holds leadership positions in AIChE, the New York Academy of Sciences, the American Society for Engineering Education (ASEE), the US Deans Engineering Council and its Public Policy Committee, among others. She earned her Ph.D. in environmental engineering from the University of Michigan (Ann Arbor), and bachelor's and master's degrees in chemical engineering from the Royal Institute of Technology (KTH-Stockholm). Prior to joining NYIT, she was chair and graduate program director of the Chemical Engineering Department at Manhattan College.

Marta A Panero, New York Institute of Technology

Dr Panero is Director for Strategic Partnerships for the School of Engineering and Computing Sciences at New York Institute of Technology.

Dr. Nicole Simon, Nassau Community College

Nicole A. Simon is an Associate Professor of General Science Studies at Nassau Community College. Her primary research interests are in cognitive processes in learning, cognitive load theory, and evidence-based instructional design principles. Her specific contributions include comprehensive experimental studies of the role of prior knowledge base in learning; cognitive load in virtual and simulated laboratory experiments for science education; and critical thinking skills utilized in those roles. She focuses specifically at the use of virtual environments to deliver scientific inquiry curricula and science assessments to students in the classroom and at professional development to help teachers integrate scientific inquiry into their curricula. Her expertise in educational technology and online learning allows her to create virtual learning environments for her students that may be used as both assessment tools and for student retention of learned information. Dr. Simon has authored several research papers on critical thinking, cognitive load

theory, and high-order learning within e-learning for science education. Dr. Simon received her B.A. in Biology from the University of Delaware, her M.S. in Science Education from Hofstra University, and her Ph.D. in Educational Technology Management from Northcentral University.

Prof. Yeong Ryu, State University of New York, Farmingdale

YEONG S. RYU graduated from Columbia University with a Ph.D. and Master of Philosophy in Mechanical Engineering in 1994. He has served as an associate professor of Mechanical Engineering Technology at Farmingdale State College (SUNY) since 2006. In addition, he has conducted various research projects at Xerox Corporation (1994-1995), Hyundai Motor Corporation (1995-1997), and New Jersey Institute of Technology (2001-2003). He has been teaching and conducting research in a broad range of areas of system identification and control of nonlinear mechatronic systems and vibrations in structures requiring precision pointing to eliminate the detrimental effects of such diverse disturbance sources. He has authored or co-authored more than 70 publications. His work currently focuses on the development and implementation of modeling and control of renewable energy systems, characterization of nanomaterials, photovoltaics, and nanoscale integrated systems. He is a member of the American Society of Mechanical Engineers (ASME), American Society for Engineering Education (ASEE) and the Materials Research Society (MRS).

Barbara Hillery, SUNY Old Westbury

A Collaborative, Multi-Campus Program to Enhance STEM Learning In Energy Science, Technology and Policy (ESTeP)

Abstract:

We report on the results of a NSF Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (TUES) grant to support the interaction of six public campuses and one private university (five four-year institutions and two community colleges) to develop curricula and programs in energy science, technology and policy. The programs developed under this project leveraged resources at all the campuses to provide students with coursework that improves their knowledge of basic scientific concepts related to energy production, distribution and use, and introduces them to basic engineering fundamentals in sustainable energy.

The multi-disciplinary program trains the students in a systems-based approach to energy technology, and enhanced understanding of how to analyze energy policy decisions (including the impact of technical, economic and regulatory factors). Several online and hybrid courses have been developed as part of this project to enhance accessibility and allow for cross-registration between campuses. Overall, courses developed or selected for the program introduce students to emergent energy technologies (including the smart grid and infrastructure systems of the future), probabilistic risk assessment, and the dynamics of various energy markets, including identifying changing energy needs on a local to a global scale.

Data from surveys, combined with evidence from student portfolios and feedback from stakeholders, are presented to show how students in the program gain in their understanding of key concepts and how associated experiential activities, including internships, research experiences and exposure to real-world case studies. The ensuing energy education enhances students' preparation to meet the challenges of creating and using emerging technological solutions to current and future energy needs.

I. Introduction:

Need for the program

There are almost 3 million jobs in the oil and gas industry the U.S (with 7 million related jobs in manufacturing, transportation and support to utilities and energy production)¹, as well as an additional 3 million jobs related to the sustainable energy sector², and this number is expected to increase dramatically over the next five years with expanded use of biofuels and shale gas exploration leading the U.S. to energy independence. Moreover, career opportunities will be driven by clean energy technologies such as solar energy, wind energy, alternative fuel vehicles, micro-grid systems and new energy storage technologies, as well as the Smart Grid.

Historically, energy curricula outside of traditional electrical power engineering have not been a significant element of undergraduate education with most programs available today at the graduate or the professional certification level. The National Energy Policy Conservation Act of 1978 mandated state energy offices and state regulated utilities to offer “energy audits” providing a market-push for new skill sets, albeit different from the skills taught by the engineering educational establishment³. This particular development has circumscribed both the number of students interested in the subject matter and professionals in this field as well as the set of skills being taught, all of which represents a challenge to energy education today, in particular given new developments and technologies that are re-shaping the energy industry.

Preparing students to master the many facets of an industry that is constantly changing requires more than a prescribed set of skills. For students to analyze energy policy decisions, follow the dynamics of various energy markets, or understand how to use and manage emergent energy technologies, the smart grid and future infrastructure systems, they will need an interdisciplinary education supported by a diverse set of perspectives, including practical experiences and multidisciplinary approaches. Ultimately, to respond to the skilled workforce development needs of industry as well as the need to develop a generation of graduates who understand the sustainable, system-based approach to energy research and development, we require a successful energy education paradigm focused on industry, academia, research and policy-making, while at the same time, leverage the resources of a consortium of colleges, from community colleges to four year research-intensive universities

The unique minor program and related coursework, developed collaboratively through this NSF sponsored program, provides appropriate guidance within the format of a well-structured academic curriculum and also emphasizes the participation of students in suitable internship and research courses. Hence the program not only fulfills workforce and education needs for energy curricula, but it also enhances STEM learning for all students.

Participants

The participants in the project are all members of the Long island Alternative Energy Consortium (LIAEC), 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.

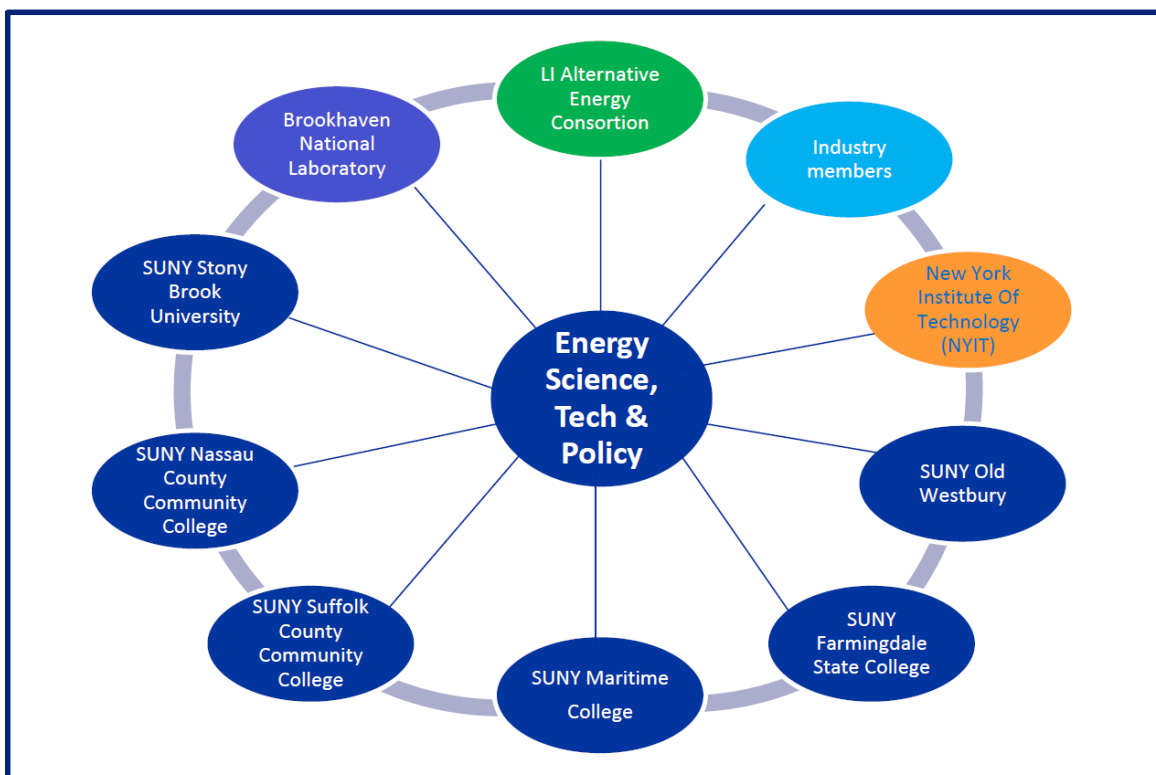


Figure 1. Participants in the Energy Science, Technology and Policy Program (ESTeP) includes six State University of New York (SUNY) schools, as well as NYIT (private university), and additional members such as Brookhaven National Lab (via SUNY Stony Brook), the Long Island Alternative Energy Consortium, and representatives from industry.

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. This particular project is consistent with the LIAEC goals of:

- Developing a multi-campus, multi-disciplinary undergraduate energy education curriculum, including cross-registration and development of on-line and hybrid instruction to leverage the diverse capabilities and strengths of the outstanding partner institutions. This includes leveraging the more than 40 energy-related undergraduate academic programs (majors and minors) and hundreds of relevant courses at the participating campuses.
- Sponsoring lectures and conferences to facilitate the discovery and understanding of key issues in energy education and research.

- Supporting workforce development in energy and green jobs, including collaborations between companies, government agencies, colleges and universities to develop meaningful, job-related internship experiences.
- Creating a network to foster communication and research in advanced energy technology to bring innovative solutions to impending energy needs.

Here we report on results from the NSF-sponsored project, which supported collaborative curricula development on several of the four-year college campuses (Stony Brook University, New York Institute of Technology (NYIT), Farmingdale State College, and SUNY Old Westbury) as well as the two community colleges (Suffolk and Nassau). While all campuses participated to some extent, we will focus in this paper on activities at Stony Brook University, NYIT and the community college campuses.

Stony Brook University, part of the State University of New York (SUNY) system, has over 25,000 students including over 16,000 undergraduates, enrolled in 65 major programs (as well as over 75 minor programs). It is a Research I level university with over 200 million dollars of annual research expenditures, and co-manages nearby Brookhaven National Laboratory for the U.S. Department.

New York Institute of Technology (NYIT), a global private university with more than 12,000 students at two campuses in New York, including one in Old Westbury (Long Island) and New York City, as well as in Abu Dhabi (UAE), Nanjing (China) and Vancouver (Canada). Since 1955, NYIT has pursued its mission to provide career-oriented professional education, give all qualified students access to opportunity and support applications-oriented research that benefits the larger world.

Together, Nassau and Suffolk County Community Colleges on Long Island enroll almost 50,000 undergraduate students from a diverse background (over 31% of the student body from minority populations underrepresented in STEM disciplines).

Goals:

Short term goals of the program included:

- Implementation of a minor course of study in energy education – the Energy, Science, Technology and Policy (ESTeP) minor;
- Creation of a partnership with stakeholders (including local communities and industrial partnerships for program development, recruitment of mentors, and establishment of internships);
- Establishment of additional distance learning opportunities through the participating campuses and the SUNY Learning Network;
- Enhanced recruitment, and learning in energy-related skills and experience;
- faculty professional development in energy education;
- Increased interest and participation in a ‘green’ energy workforce and research.

While the above goals have been achieved over the course of three years, long term goals include eventual establishment of a full degree program in alternative energy technology

and policy with joint admission; integration with a large internship program facilitated through an online database and advisor; and expansion of the program through the distance learning model and broad-based recruitment activities to other regions; expanded workforce development and participation in ‘green’ energy research.

II. Approach and Implementation:

The partners have worked diligently to achieve the stated goals at the various campuses as well as to coordinate on the common multidisciplinary offerings to enhance educational offerings in energy science, technology and policy. Together the partners have completed the following:

- Design and approval of the energy minor at New York Institute of Technology (NYIT) and Stony Brook University (SBU-SUNY) http://www.nyit.edu/about_nyit/news/multi-campus_undergraduate_energy_minor_to_enhance_stem_learning_nsf_award/
- Design and teaching of new on-line course at NYIT as well as at Nassau County Community College (NCCC)
- Promotion and advertisement of courses, including two Information Sessions for the Energy Minor at NYIT, and a session with presentations by the Career Advisement office and the Chair of the Energy program.
http://www.nyit.edu/engineering/energy_management/minor_in_energy_science
- Events such as the NYIT annual energy conference every June, where all the participating universities were invited. This regular conference has been broadly advertised, including by the LI Alternative Energy Consortium and a full-page ad in Newsday.
- Development and deployment of a website to assist in dissemination of information on the energy minor, internships, and related activities of the consortium
<http://liaec.aertc.org/education.htm>
- Co-development and use of templates for electronic portfolios, used by students in the minor program to document evidence of learning, collect reflections, and assess student progress, both in the minor and in internships related to minor program requirements.
- Several consortium meetings held to assess progress, discuss obstacles, and collect information on cross-registration and course development.

Energy Education Model

Several learning objectives were established for the minor in energy science, technology and policy (ESTeP). The goal is that when students complete the minor, they should be able to:

1. Understand basic scientific concepts related to energy production, distribution and use, including: the natural resources, nature of fossil fuels, combustion, nuclear reactions, and electricity.

2. Understand basic engineering concepts related to energy production, distribution and use including: power plants, distribution and transmission, batteries and storage, and energy materials.
3. Understand the multidisciplinary nature of developing and maintaining energy sources, including generation, storage, transmission and use of energy.
4. Understand the concept of sustainability as it applies to energy and society.
5. Be able to apply a systems-based approach to energy from a technological and policy perspective.
6. Understand how to analyze energy policy decisions (including the impact of technical, economic and regulatory factors).
7. Understand key issues affecting the use and management of emerging energy technologies (including solar, wind and geothermal sources), the smart grid and future infrastructure systems.
8. Have the ability to follow the dynamics of various energy markets, including understanding the changing energy needs on a local to global scale.
9. Be able to apply the concepts of ethical decision making to the development and use of energy sources.
10. Have the necessary workplace or research skills necessary to successfully participate in industrial, policy-making and research positions in energy- related fields.

These outcomes are appropriate and valuable for students from many backgrounds, including majors in physical and life sciences; management, policy and business; architecture, design, engineering and technology fields. Students who enroll in the minor will benefit from partnerships between academic institutions, private industry, college and government laboratories, and legislative offices.

How we are trying to pursue this model

While the overall intent of the project has been to develop a fully integrated cross-campus curriculum to leverage strengths at each participating college, the implementation process has had to rely first on establishment of the minor program at each four year campus as well as introductory coursework at the community colleges to aid in recruiting students who wish to transfer to four year programs. Alternatively, the community college students are able to use the courses available at their campuses to fulfill two-year degree requirements (if that is their ultimate intent).

Both SUNY Old Westbury and Farmingdale State College have incorporated energy-related activities and simulations (one of which was developed by a faculty member at Stony Brook

University) into their existing coursework. At this time, limited information is available on the impact of these activities and modules on learning outcomes on those campuses, though data is currently being collected. Courses developed through the Renewable Energy and Sustainability Center at Farmingdale have been recommended to students at the other partner campuses, and several Stony Brook students have been able to take advantage of these courses.

So far, both Stony Brook University and NYIT have approved multidisciplinary minors in energy topics. These are outlined below. In addition, the NSF-TUES program support has resulted in the development of introductory courses in energy at both Suffolk and Nassau County Community Colleges. These courses include:

GSS 122 – Science of Energy at Nassau Community College (NCC): This introductory course covers the scientific principles and technological innovations related to Energy resources. The study of mechanics, electricity, magnetism, and thermodynamics pertinent to energy are explained. Students develop an appreciation of energy use in the contemporary world by examining alternate energy systems such as solar, wind, photovoltaic, hydro, biomass, the ocean, and renewable alternative energy sources and Green environmental sustainability processes. An on-line section of the course has also been developed which has allowed greater access to students from collaborating institutions. This course has proved especially valuable for enhancing diversity in the program, as the student cohort in the introductory online course was over 40% female and 50% students with African-American or Hispanic backgrounds.

NCC also offers other courses in energy-related physics and ecology, as well as electrical circuitry, which have been recommended to students interested in the energy programs at the four-year colleges.

CHE 295 – Introduction to Research Methods at Suffolk Community College (SCC): An online course developed and taught in the summer which focuses on interdisciplinary teamwork to investigate and apply scientific techniques towards current problems in energy, health, the environment and network with practicing research scientists.

Energy Minor at Stony Brook University:

The interdisciplinary minor approved in 2015 at Stony Brook University is entitled “Energy Science, Technology and Policy”. The Minor in Energy Science, Technology and Policy provides students with coursework intended to enhance their understanding of basic scientific concepts related to energy production, distribution and use, introduce them to basic engineering concepts in sustainable energy and a systems-based approach to energy technology, and enhance understanding of how to analyze energy policy decisions (including the impact of technical, economic and regulatory factors). Courses introduce students to emergent energy technologies (including the smart grid and future infrastructure systems), probabilistic risk assessment, and the dynamics of various energy markets, including understanding changing energy needs on a local to global scale. The Minor requires use of an electronic portfolio to demonstrate attainment of learning objectives through course-based activities.

Admission to the minor: requires a minimum grade point average of 3.0 in the three introductory courses. Courses must be planned with in consultation with the Minor program advisor or director. Any course substitution must be approved in advance by the director of the Minor.

Curriculum:

1. Introductory courses (required – each 3 cr.)

CME 201: Sustainable Energy

GEO 105: Energy Resources for the 21st Century

ESG 201: Learning from Engineering Disaster (online beginning in 2016)

2. Technical electives (choose 3 – vary 3 to 4 cr. each):

Science/Technology focused:

ESE 350: Electrical Power Systems

ESE 319: Electromagnetics and Transmission Line Theory

ESE 352: Electromechanical Energy Converters

EEO 323: Electromagnetics (**non-SBU students only**)

EEO 470: Renewable Distributed Generation and Storage (**non-SBU students only**)

EEO 482: Power Systems Engineering I (**non-SBU students only**)

EEO 425: Electric Machinery and Energy Conversion (**non-SBU students only**)

MEC 301: Thermodynamics

MEC 305: Heat and Mass Transfer

ESG 302: Thermodynamics of Materials (Note: cannot take both ESG 302 and MEC 301 for minor requirements)

Policy focused:

ESM 486: Innovation and Entrepreneurship in Engineering

EDP 301: The Built Environment I

EH1 343 - H: Sustainable Natural Resources

MAR 336: Marine Pollution

3. ESM 488: Cooperative Industrial Practice (required – at least 3 cr.)

The ESM 488 internship must be energy-related; students may also substitute independent research course (499) if appropriate (and is approved by director of the minor). While ESM 488 is not formally an “online” course, all reporting is done through Digitation electronic portfolios, and communication with the faculty coordinator at Stony Brook may be conducted primarily via email. This has allowed for the expanded use of this course for enhancing the quality and reporting of experiential learning.

The minor at Stony Brook does allow for substitution of appropriate introductory coursework and technical electives taken at other campuses (including online coursework) to count towards the minor requirements. In this way, students at Stony Brook can take advantages of strengths and

resources at partner campuses in designing their academic program. Of course, any energy relevant coursework taken by a student at the community colleges can also transfer directly to credit towards the minor if the student transfers to Stony Brook University to complete a four-year degree.

As the minor was only recently registered in official publications (student catalogs and online) at Stony Brook, only a small number of students have registered for the program (nine to date). However, the number of students expressing an interest in the three introductory courses is large (at least twenty five have expressed a strong interest), so we expect a growing cohort. Both students officially registered for the minor and those expressing interest who are successfully completing the introductory courses have been included in the survey responses cited below.

Energy Minor at the New York Institute of Technology:

As a member of the Multidisciplinary, Multi-campus Undergraduate Minor to Enhance STEM Learning in Energy Science, Technology and Policy, NYIT offers a Minor in Energy Science, Technology, and Policy. This program enables undergraduate students in all majors to develop "green skills" in their chosen field. Many employers are seeking to reduce their "carbon footprint" and promote clean, more efficient technologies, which are less harmful to the environment. Further information about NYIT's offering is available at:

http://www.nyit.edu/engineering/energy_management/minor_in_energy_science

Key resources include the Energy and Green Technologies Laboratory at NYIT, which is one of three labs in the Entrepreneurship and Technology Innovation Center (ETIC). Projects at NYIT include solar carports, plug-in hybrid vehicles (PHEV), and the Long Island Carbon Footprint Project. Demonstration projects are underway at partner institutions such as Stony Brook University and Farmingdale State College which focus on smart grid technology, building automation, solar energy, small scale wind power, geothermal heat pumps, green data centers, and alternative fuel vehicles.

The Minor in Energy Science, Technology, and Policy at NYIT requires 15 credit units including 12 credits of required courses and 3 credits of electives, such as:

1. Required Courses (12 cr.)

- IENG 122 Energy Science and Technology 3 cr.
- ETCS 105 Career Discovery 2cr.
- IENG 285 Energy Technology Project 3 cr.
- ETCS 365 Externship for the Technical Professions 1 cr.
- IENG 590 Energy Policy, Economics, and Technology 3 cr.

2. Elective Courses (3 cr.)

Choose one of the following

- BIOL 107 Environmental Sciences 3 cr.
- PHYS 156 Environmental and Energy Issues 3 cr.
- ICSS 309 Technology and Global Issues 3 cr.
- IENG 510 Energy Management 3 cr.

After the School of Engineering and Computing Sciences at NYIT secured approval to offer the energy minor, it also established the ability for other (SUNY) schools within the consortium to participate. The first cohort of students enrolled in the minor at NYIT, included seven students enrolled in the minor, (28% students from Hispanic background, 28% female students). The minor has attracted students majoring in Architecture, Architecture Technology, and Mechanical Engineering.

During the second year, eighteen students registered in the ESTeP minor. In addition, ten students took the course “Career Discovery” ETCS-105-F01 offered at NYIT, which included 10% female and 50% of minority status students. During the fall of 2016, the number of students registered in the energy minor has risen to twenty one, and it is expected that additional students will enroll in the spring semester.

III. Outcomes

The partnership with other universities represents an invaluable resource for academic collaboration across campuses. Through the project, faculty and staff have been able to collaborate on the development of multi-institutional educational programs, in particular in the field of energy education at the undergraduate level.

All partners have been involved in the development of the minor through approval of additional courses for the ESTeP program at each of the participating campuses.

NYIT, which was the first institution to offer the minor, has redoubled its efforts to enroll students in the program. For that purpose, NYIT has been holding regular Information Sessions about the new Minor in Energy Science, Technology and Policy.

The ESTeP minor has attracted students from Engineering as well as Architecture and Architecture Technology, which confirms that the program is relevant and of interest to students from different disciplines. NYIT provides access to all students enrolled in the minor to the new Entrepreneurship and Technology Innovation Center (ETIC) in particular its new Energy and Green Technologies laboratory.

Faculty involved in the program benefited from the opportunity to use educational instruction technologies, in the development and delivery of online courses. These faculty are also involved in a committee that is considering a common electronic portfolio for all students, which will enhance student learning and assessment of learning gains. Instructors associated with the courses in the minor have benefited from the feedback and input from faculty in other schools involved in the consortium.

Some of the partners (NYIT, SBU) have been involved in the conversation about the best methods for cross-registration and curriculum development, and, as the single private institution on this partnership, NYIT has also been active in working on reviewing the methodologies for private/public collaborations at the institutional level to promote common programs (i.e., the Energy Minor).

Moreover, the partners have been engaged with external stakeholders to ensure that the curriculum offerings are industry-relevant and contribute to workforce development in the region.

Issues in development of multi-institution collaborative curricula

The partners have encountered some delays as a result of SUNY and NYIT institutional concerns, in particular how the registration process and requirements are coordinated amongst the institutions involved, which range from community colleges to four year, research-intensive institutions, public and private institutions. In part, these delays have reflected institutional concerns about use of external coursework in the completion of minor requirements. This is a result of understandable concerns: How can a course be pre-approved for completion of requirements, which is not under the control of home institution faculty? How can quality be assured under these circumstances? What is the best process for ongoing review and approval of courses, akin to a transfer process? While we have finally found answers to these questions, for the most part, the project is moving forward, in spite of some delays. Overall, we have a clear path forward, and progress is bound to accelerate over the next few months.

It is important to note that the questions encountered and the difficulties in building a true multi-institution approach to curricula design and implementation reflect the challenges noted by a number of studies. For example, Johnson and Thomas (1997) also noted difficulties in cross-institution collaboration stemming from negative faculty views on ensuring quality in required courses outside their home institution.⁴ Stein and Short (2001) noted that “colleges and universities are steeped in traditions that support both local autonomy and faculty control over the curriculum.”⁵ This leads to a concern by some faculty, faced with the prospect of building a multi-institution program that this might result in a “loss of individual and institutional decision-making authority.” Indeed, institutions rightfully pride themselves on the uniqueness of their programs and the considerable effort and creativity invested in their curricula development efforts.

Many suggestions have been made in practices to address these concerns. Imel (1995) cited the need to recognize and leverage the particular strengths of participating institutions.⁶ This is certainly something which our consortium has done in pursuing this project. In addition, Short and Stein (1998) cited four methods for building successful collaborative curriculum development efforts among six Missouri higher education institutions: “(a) creating a culture of collaboration, (b) addressing institutional requirements, (c) establishing and meeting high standards, and (d) meeting the needs of educators across organizational types”⁷. These authors, in their 2001 paper, also specifically cited the key role of open, honest and thorough communication amongst all parties in establishing the synergy necessary to create successful collaborative curricula and overcoming roadblocks resulting from policy, bureaucracy, or even institutional bias. Likewise, the “Big 12 Engineering Consortium” (which involved 11 universities) required a high level of communication to ensure that a healthy, and useful, curriculum would be developed and implemented: “Communication is critical to the success and the sustainability of the program alliance, and ensuring the right people at each school are engaged was a major activity during the first year that will continue into the future.”⁸ Hence the

backdrop of ongoing interactions and cross-institutional communications provided by the LIAEC framework has proven to be essential in our efforts.

Dissemination of results to communities of interest

The project and the resulting minor (and activities developed as part of the minor, including the development of online courses) have been disseminated by the establishment of a website as well as through presentations at various conferences, including NYIT's Energy conference every June. The main activities for the program include:

Website development: <http://liaec.aertc.org/education.htm> with links and description of multi-campus energy minor, as well as resources for internships and development of experiential learning opportunities. Also included are links to events and contact people at participating campuses.

Publications and presentations: Partners published and/or presented on the program, describing its main components, and/or referencing it at:

- Gary P. Halada and Nancy McCoy Wozniak, “Enhancing Assessment of Experiential Learning in Engineering Education through Electronic Portfolios”, Proceedings of 2014 Zone 1 Conference of the American Society for Engineering Education (ASEE Zone 1), paper 60, 978-1-4799-5233-5/14, accessible at: <http://asee-ne.org/proceedings/2014/Professional%20Papers/108.pdf> (2014); it includes acknowledgment of federal support for the program.
- Wozniak, Nancy, Ellen Murphy, Eric Howd, Catherine Roche, and Keith Landa. ["ePortfolio Use In SUNY - The Time is Now."](#) *CIT 2013 - Transformation in Higher Education: Sharing Ideas and Showing Results*. Utica, NY 2013 (presentation at the New York State Conference on Instruction and Technology (CIT) in which electronic portfolio templates and examples developed for the energy minor were shown)
- Stacie Nunes, Jennifer Waldo, Spencer Mass (SUNY New Paltz) and Gary Halada (Stony Brook University); “Research with Undergraduates: Faculty Who Did It, Why and How”, SUNY STEM Conference; Broadening Participation in STEM, October 10-11, 2013, Albany, NY. (panel discussion at the SUNY STEM education conference)
- Simon, Nicole, “ESTeP Portfolio Student Handbook” (Nassau County Community College) -- a guide to help learners through the process of what an e-portfolio is used for and how to begin. The guide includes a step-by-step process of each screen and what the features are for those screens. The guide also includes screen-shots to aid users.
- Ziqian (Cecilia) Dong, Ph.D., Asst. Prof., School of Engineering & Computing Sciences (SoECS), NYIT 2. Pai Zhu, Sr. Student, SoECS, NYIT 3. Michael Bobker, Building Performance Lab, CUNY 4. Marco Ascazubi, Student, BPL, CUNY (2015). *POSTER: Simplified Characterization of Building Thermal Response Rates*. 6th International Building Physics Conference (IBPC), June 14-17, 2015. Torino, Italy.

- Anid, N.; M. Panero (NYIT); C. Zheng; J. Liu (2015). EcoPartnership on water quality management and conservation in the U.S. and China. *Journal of Renewable and Sustainable Energy*. 7 (041513), <http://scitation.aip>. DOI: doi: 10.1063/1.4929535
- Nada Marie Anid, Ph.D., Dean, School of Engineering and Computing Sciences, NYIT (2015). *Energy and Sustainability Inspire Next Generation*. Article by Dr. Nada Anid published in the spring 2015 The Corridor Journal of Strategic Alliances, Special Issue on Sustainable Energy and the Environment.
- Robert N. Amundsen, Ph.D., CEM, LEED AP BD+C (2015). *Global Crossroads for Energy Professionals*. Article published on The Corridor Journal of Strategic Alliances, spring 2015 special issue on Sustainable Energy and the Environment.

Student Posters and Presentations:

Several NYIT students participated in a design competition at the Cradle of Aviation Museum, for which five students conducted research and then presented results as posters at NYIT's Annual Energy Conference on June 10, 2015. All student posters acknowledged federal support for the program. They included posters by:

James M. Collins, Jr.: (2015). *Biogas Energy Facility for the Cradle of Aviation Museum*. Student Poster presented at NYIT's 2015 NYIT Energy Conference at the session to highlight School of Engineering and Computing Sciences Minor in Energy Science, Technology and Policy Program.

James A. Furey, NYIT student (2015). *Hybrid Solar and Wind System for the Cradle of Aviation Museum*. Student Poster presented at NYIT's 2015 NYIT Energy Conference at the session to highlight School of Engineering and Computing Sciences Minor in Energy Science, Technology and Policy Program.

Guillermo Fuentes, NYIT student (2015). *Small-Scale Wind Energy Facility for the Cradle of Aviation Museum*. Student Poster presented at NYIT's 2015 NYIT Energy Conference at the session to highlight School of Engineering and Computing Sciences Minor in Energy Science, Technology and Policy Program.

Ivan Hernandez-Rico, NYIT student (2015). *Small-Scale Wind Energy Facility for the Cradle of Aviation Museum*. Student Poster presented at NYIT's 2015 NYIT Energy Conference at the session to highlight School of Engineering and Computing Sciences Minor in Energy Science, Technology and Policy Program.

David Fabre, NYIT student (2015). *Solar Carport Parking Field for the Cradle of Aviation Museum*. Student Poster presented at NYIT's 2015 NYIT Energy Conference at the session to highlight School of Engineering and Computing Sciences Minor in Energy Science, Technology and Policy Program.

IV. Evaluation

Overall, student surveys (see Appendix A) and analysis of interviews with participating faculty and administrators have indicated progress in the program, despite some of the difficulties noted above. The project appears to be making progress in ways that will ensure benefits beyond the conclusion of the grant.

- Long Island Alternative Energy Consortium (LIAEC). The project continues to strengthen the consortium and makes it likely that the cooperative activities and shared ideas will continue to build on a strong foundation.
- Transfer Connections. The number of students starting college at two-year institutions continues to grow. SUNY is working toward a system of “seamless” transfers and the grant has helped continue this process by encouraging students to consider majors early in their studies and accumulate credits that will apply when they transfer.
- The Energy Minor. The project still anticipates that, in the spirit of the minor, the strengths of the different institutions, courses, and student research will complement one another. STEM students have a number of requirements but the minor is attracting attention and should continue to grow.
- Online Courses. The energy online courses participate in an important educational movement. The exchange of ideas and practices about these courses strengthens the consortium and helps students adapt to new kinds of learning.
- Education and Practice. STEM students in general and engineering students in particular sometimes complain that their classroom learning is based more on tradition than current practice and future needs. The courses related to the energy project are providing practical experiences, demonstrating that education can be directed toward current issues and needs.

This project has provided extremely valuable experience on the development of multi-institution educational programs, in particular in the field of undergraduate energy education. Methodologies (and roadblocks) to cross-registration and curriculum development have been explored, as well as methodologies for private/public institution partnerships in academic program development. Identification of key learning needs and objectives, with input from stakeholders (including industry and policy making bodies), has allowed participating academic institutions to develop a curriculum with real-world applicability and relevance to work-force development in the energy sector.

A wide range of stakeholders are being taken into account in the design of the energy curriculum. These include industry and policy making bodies. Hence it is critical that students in the program be capable of communicating key issues in energy technology and policy with those both inside and outside academia. It is also likely that many of those who complete the minor will have majors or career goals outside of engineering or research – for example, in business, teaching, and public sector jobs. Therefore, it is likely that this project will have a broad impact on society (especially in future developments in energy policy and commercial enterprises). With a focus on policy, as well as science and engineering, this minor will be

broadly applicable to undergraduates from many disciplines. In light of this, it is also very important that we continue our efforts to recruit students from underrepresented groups.

Our experience in multi-institution program development will be valuable for those who seek to create academic programs in other fields. Furthermore, our development of a multi-disciplinary program in energy education responds well to the general need for enhancing student preparation in areas of emerging technology, which do not simply map to current curriculum offerings at any single institution. This is the same difficulty experience in designing curricula for environmental fields, nanotechnology, bioengineering, and other areas for which traditional educational backgrounds may prove inadequate to meet societal needs (now and in the future). By exploring how a program responsive to such needs may be developed (including experiential and applied learning), the results of this program will benefit academia in general.

V. Conclusion

Our team believes that multi-institution program development is a valuable experience cutting across majors (education, management, architecture, medicine). The designing of cross cutting curricula ensures that our programs prepare students for advanced studies and challenging positions in business, government, and industry and are "industry ready" by the time they graduate.

The development of a multi-disciplinary program in energy education responds well to the general need for enhancing student preparation in areas of emerging technologies, which do not simply map to current curriculum offerings at any single institution. By exploring how a program responds to such needs may be developed (including experiential and applied learning), the results of this program are scalable and will benefit academia in general.

Appendix A

The following material was based on surveys and interviews conducted by the external evaluator for the program, Dr. Leo Gafney.

Student Response: Surveys In both semesters of the 2014-15 academic year, pre/post surveys were administered to consider changes in students' familiarity with certain ideas related to energy and also to capture their comments about sustainability and any impact on their thinking about careers. The following summarizes the data for the fall semester. Online courses also require considerable work from the instructor; perhaps more than traditional courses.

Fall 2014 the pre/post surveys for the 2014 fall semester were completed essentially by students from only two of the participating institutions, Stony Brook and Suffolk County CC. Stony Brook had very few respondents for the post survey.

Table 1. Number of Respondents by Institution		
Institution	Pretest	Posttest
Suffolk Co. Community College	8	9
New York Institute of Technology	3	2
Exchange student from Brazil	1	
Stony Brook	39	5
Total	50	16

Students reported a wide range of majors although they were primarily in the sciences: Engineering: 30; Biology/Biochemistry 6; Business 2; Health Sciences 2; Economics 2; Physics 2; One each: Computer Science, Astronomy, Psychology, Journalism, English, Math, Arts and Sciences

In view of the small numbers and differences in numbers from pre to post surveys, the data have marginal statistical value, but they do provide further data regarding trends. As can be seen in the table, there were again dramatic increases in reported knowledge. Data for the first two categories of responses (a great deal; a fair amount), and averages for all categories are shown in the table.

Table 2. In general how much knowledge do you have about each of the following? A great deal; a fair amount; some; very little; none. (Pre: N = 51; Post: N = 11)				
Answer Options	A great deal or a fair amount		Rating Average (5-pt scale)	
	Pre	Post	Pre	Post
Sustainability	28%	88%	3.08	4.19
Alternative energy	35%	81%	3.2	4.25
The global concern regarding energy policy	22%	75%	3.08	4.06
The global concern regarding energy use	37%	81%	3.27	4.25
The benefits of alternative energy	61%	82%	3.65	4.31

How to manage energy use	35%	75%	3.16	4.19
Policies on alternative energy management	18%	62%	2.64	3.63
Systems approach to energy use and policy	12%	81%	2.31	3.81
Energy policy and design on a global scale	14%	81%	2.45	3.94
Global need for various energy markets	24%	81%	2.84	4.13
AVERAGE	29%	79%	2.97	4.08

Regarding reasons for enrolling the in the course, students listed: an interest in energy, particularly sustainable energy, alternative sources of energy, and the environment

Responding to an item about sustainability, students in both the pre and post surveys, expressed the positive and negative meanings. The following are from the pre-survey:

I've seen the graphs showing our rising energy consumption; I'm very aware of the impact humanity is having on the environment and that we have become our own worst enemy. The media and people in general are downplaying the effects of wasteful energy consumption and constant pollution.

If technology is not made to be sustainable, we have a greater chance for failure in the future. Something is sustainable if it is efficient and reliable for the future.

I feel that I have a strong understanding of sustainability. Sustainability to my understanding is a balance of economy, society, and the environment where if there is an equilibrium amongst those factors this would promote an positive optimal lifestyle/living. I understand sustainability is using natural resources in a way to leave a good amount of them for the next generations.

I know near to nothing about the thermodynamic/science portion, but I understand the economic and international relations portion.

Spring 2015 Students, in greater numbers, completed the energy surveys before and after the spring 2015 semester. Results were similar to those for the previous semester. Significant gains were seen in students reporting on their general knowledge and familiarity with energy-related ideas.

Table 3. Number of Respondents by Institution		
Institution	Pretest	Posttest
Stony Brook	56	18
Suffolk County CC	12	11
Nassau CC	19	10
New York Institute of Technology	19	12
Old Westbury	0	3
Total	106	54

As is evident in the table below, there were again dramatic increases in reported knowledge. Trends with regard to items were similar to those found in the fall 2014 survey results. Data for the first two categories of responses (a great deal; a fair amount), and averages for all categories are shown in the table.

Table 4. In general how much knowledge do you have about each of the following? A great deal; a fair amount; some; very little; none. (Pre: N = 107; Post: N = 54)

Answer Options	A great deal or a fair amount		Rating Average (5-pt scale)	
	Pre	Post	Pre	Post
Sustainability	25%	69%	2.86	4.06
Alternative energy	42%	80%	3.25	4.26
The global concern regarding energy policy	32%	60%	3.12	3.83
The global concern regarding energy use	45%	65%	3.36	4.00
The benefits of alternative energy	62%	79%	3.60	4.25
How to manage energy use	38%	68%	3.18	4.02
Policies on alternative energy management	16%	49%	2.58	3.53
Systems approach to energy use and policy	15%	57%	2.48	3.72
Energy policy and design on a global scale	12%	53%	2.47	3.68
Global need for various energy markets	29%	71%	2.89	3.98
AVERAGE	32%	65%	2.98	3.93

Regarding reasons for enrolling in the course, student responses in both the pre and post survey were almost equally divided between those who said it was a requirement and those who expressed interest in energy. In response to the post-course survey some students gave longer responses, noting their interest in particular aspects of energy and in online courses:

I've always been interesting in alternative energy, seeing solar panels and listening to stories about alternative fuels as a child made me wonder why we weren't moving faster into this new, mysterious infrastructure in this country. I didn't really investigate alternative energy and sustainability further until I heard that this class was being offered.

I was previously uninformed about how we could actually implement alternative energy. I also wanted to figure out what energy source is ideal to invest time and money into in order to get the best outcome.

Responding to an item about sustainability, in the pre-survey about three-quarters of the students were not able to articulate a clear understanding,

It is keeping the Earth environmentally sound and better able to support life.

It is planning for the future.

Of those who were more articulate and somewhat more accurate, some gave brief answers, and some were more expansive. Some went beyond the customary definition with interesting ideas.

Being able to use energy sources without depleting all resources.

I understand sustainability as a way to provide our generation with enough energy to keep the current lifestyle without compromising future generations.

Sustainable energy is the form of energy obtained from non-exhaustible resources, such that this form of energy serves the needs of the present without compromising the ability of future generations to meet their needs.

My understanding of sustainability is somewhat limited to two ideals, one being the sustainability of a certain power source in the face of environmental conditions and the second being the sustainability of our own species with the knowledge and technology which we have at our disposal today.

In response to the same item on the post survey, students were somewhat more precise in their statements than for the pre survey. But as in the pre survey, they often went beyond energy in their responses and this was understandable since the question asked about “sustainability” not “sustainable energy.” Students also tended to answer from the perspective of their majors or particular interests.

I understand that energy and power, in general, is very hard to contain and sustain. And probably one of the biggest challenges we'll face.

With regard to engineering a produced good or technology that does not deplete the environment from which it was taken of natural resources, nor put any by-products into the environment that are harmful to living organisms. An equation that balance what is taken, created, and produced.

I have learned that everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist benefiting both. Successful sustainability will help the social, economic and other requirements of present and future generations.

Sustainability is the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance

Energy and Career Aspirations In response to a survey item asking, “What career aspirations do you have related to energy,” about 20% of those responding (N = 98) to the pre survey expressed an interest related to the environment, business and energy. Responses to the post survey for this item were similar.

I do hope to work in the environmental engineering field. Hopefully in either maintaining established alternative energy sources, creating new ones or making them more available to everyday people.

One of my career goals is to become a restoration ecologist who works on repairing environmental damage and restoring fragile ecosystems.

I am majoring in business and Energy is a huge topic today around the globe so having a better understanding of it would really help me in my desired field

Energy Policy The last item on the survey asked, “What areas of energy policy do you think are most in need of change?” In responding to the post survey, students were expansive in their statements about a variety of energy issues related to public and private life.

I have learned a lot from this class and things are certainly changing very slowly. I have been able to narrow my line of questioning with regard to energy policy. For instance, how do we wean ourselves off fossil fuels without creating an economic problem? How do we change incorrect popular public belief about sustainable energy? How do we make

sustainable energy technologies more efficient and more profitable for the economy? We have begun with providing incentives to companies who switch to green technologies or sustainable practices.

There needs to be a more concerted effort to manage existing technologies and develop more effective means to filter out toxins and make what we have now less damaging while also learning to integrate new sources effectively without interference by corporations.

We need to focus more on smaller markets rather than changing everything at once. For instance I would focus on cars. They use a tremendous amount of oil, if we find an alternative source it will financially improve and environmentally will benefit the environment.

Suffolk County Community College: Since Suffolk County Community College had an almost equal number of pre/post respondents and as a community college, we wanted to look at the rated responses. The Suffolk responses are generally lower than the general average for the pre-survey and higher for the post-survey. These are of course self-reported so we cannot infer too much. But assuming fundamental honesty it is gratifying to see such large gains.

Table 5. In general how much knowledge do you have about each of the following? A great deal; a fair amount; some; very little; none. (Pre: N = 12; Post: N = 11)

Answer Options	A great deal or a fair amount		Rating Average (5-pt scale)	
	Pre	Post	Pre	Post
Sustainability	17%	82%	2.83	4.45
Alternative energy	50%	91%	3.42	4.55
The global concern regarding energy policy	25%	82%	3.17	4.27
The global concern regarding energy use	42%	91%	3.33	4.55
The benefits of alternative energy	58%	91%	3.67	4.64
How to manage energy use	33%	73%	2.92	4.18
Policies on alternative energy management	8%	45%	2.25	3.55
Systems approach to energy use and policy	9%	64%	2.09	3.73
Energy policy and design on a global scale	9%	54%	2.09	3.64
Global need for various energy markets	8%	82%	2.83	4.00
AVERAGE	26%	76%	2.86	4.16
All Respondents AVERAGE	32%	65%	2.98	3.93

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