

THE PENNSYLVANIA STATE UNIVERSITY

John and Willie Leone Family Department of Energy and Mineral Engineering (EME)

Strategic Plan 2014-15 through 2018-19

**Prepared by the EME Faculty
Led by the EME Strategic Planning Committee**

Luis F. Ayala H., Chair

Seth Blumsack

Vera J. Cole

William A. Groves

Mark S. Klima

Antonio Nieto

Randy Vander Wal

Finalized and Submitted by
Turgay Ertekin, Department Head
John and Willie Leone Family Department of
Energy and Mineral Engineering (EME)
The Pennsylvania State University

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MISSION STATEMENT

We are an interdisciplinary, diverse department dedicated to the safe, efficient, and environmentally responsible recovery, processing and utilization of earth resources.

VISION STATEMENT

The EME Department will be a global focal point for natural resources extraction, processing, utilization, and environmental aspects of energy and minerals use while integrating with business, finance and policy with cutting edge research, world-class education and close industrial interaction. We will continue to position ourselves as a unique think-tank for whole-systems energy strategies that include fossil fuels, renewable energy, emissions management and sequestration, as well as energy efficiency, health and safety, commodities trends, and international implications of climate change shifts in policy, risk, and financial stability for energy systems. We will reinforce, extend, and diversify our strengths in transdisciplinary innovation and collaboration and become recognized for addressing critical, scientifically important problems in Energy and Earth Resources and Technologies.

STRATEGIC GOALS AND METRICS

Goal 1: Advance a sustainable teaching portfolio that provides a top-rated education for students who will recognize us as their first choice to become leaders in our academic fields

EME seeks to become the destination department for students who are interested in majors pertaining to the energy and mineral industries while attaining sustainable teaching loads for all faculty. Efforts to enhance undergraduate education will focus on improving the educational experience of EME students while maintaining ABET accreditation of the engineering programs. We will also focus on enhancing educational experiences in energy business and making those experiences available to students in all our majors. Graduate education enhancements will focus on providing students with the opportunity to develop deeper research skills and improved professional skills through the revamping of the curriculum and graduate experience of tomorrow's leaders in the energy and mineral sectors.

Strategic Initiatives Related to Undergraduate Education

The overarching goal of our undergraduate education strategy will remain balancing and stabilizing the student population in each academic program within the department. This will require keeping the number of students in each program at a sustainable level commensurate to available resources and the implementation of policies of student

recruiting and retention that encourages students in overpopulated programs to consider the significant opportunities offered by our underpopulated programs such as Mining Engineering. Specific strategies for the enhancement of the undergraduate experience in EME include:

- Consolidate curriculum offerings by emphasizing scientific and engineering tools that are common to all our programs and are essential for developing life-long learning skills and habits.
- Bring teaching loads to sustainable levels within the next strategic cycle. This would require a combination of new faculty hires, curriculum consolidation, and obtaining an increased number of graduate assistantships.
- Incorporate engaged scholarship activities into the curriculum to enhance the student's professional development skills. For example, the Department will continue to foster its strong connections with industry and alumni through the use of invited speakers in courses and seminars, the application of industry-relevant design problems in course assignments including more emphasis on sustainable energy and mineral production, the expansion of undergraduate research opportunities, and the promotion of international educational experiences. Any content additions will be offset by removing other course material. The goal is to provide an exceptional undergraduate student experience.
- Increase opportunities for interaction across majors, for example, through design projects, interdisciplinary classes, and promotion of minors or double majors in the department (and possibly across departments within the College).
- Explore new course delivery techniques while adding additional course sections to provide more flexible scheduling options for EME students, within the constraints of faculty availability. This may include the creation of hybrid courses using both in-person and online course delivery methods to improve both the course content and subsequent course and program assessment.
- Pursue opportunities for upgrading instructional laboratories to allow additional or larger course sections to be offered. This includes, for example, taking full advantage of the Hosler Building renovation (Goal 6) and seeking additional laboratory sponsorships.
- Hire fixed-term faculty over the short term to maintain the quality of education during peak enrollment periods with a long-term goal of hiring tenure-line faculty to ensure that program excellence is maintained.
- Limit general education courses only to the level required to satisfy our expected contribution to the general education mission our College while restructuring them in line with the new general education requirements being developed by the

University. With more resources, the Department stands ready to expand its offerings. This may be achieved under the new University budget model being currently discussed, when more budgetary allocations are made to the Department as a function of the student credit hours generated.

- Implement fund raising activities for undergraduate and graduate scholarships. Establish alumni funds and approach alumni annually to donate for scholarships in the department. EME will also launch directed **alumni events** that focus on specific topics to maintain alumni interaction and encourage alumni donations.

Strategic Initiatives Related to Graduate Education

Our significant challenges with undergraduate enrollment have placed undue stress on our graduate education mission. Within the next strategic cycle, EME will strive to enhance our graduate education offerings and increase the faculty pool in charge of graduate advising and teaching our graduate-level courses (currently less than half of our EME graduate faculty) by rebalancing our undergraduate portfolio using the strategies outlined previously. Specific strategies for the enhancement of the graduate experience in EME include:

- Reviewing, updating, and reassessing our current EME graduate program offering, rationale, student and faculty satisfaction with the program, desired outcomes, policies and protocols.
- Realign the EME graduate course curriculum along with EME's research goals (see Goal 2, below). Engage EME faculty across all our disciplines in the revamping of our M.S. and Ph.D. curricula and offerings. EME faculty at large will define the graduate strategy that would best embrace our interdisciplinary nature, increase overall operational efficiency as a Department, and showcase each of the graduate specializations in demand by students with interest in our academic graduate offerings, and promote stakeholders satisfaction with our graduate offerings.
- Further align our graduate offerings with student and prospective employer's needs. Gather data on job placement and satisfaction/relevance of graduate experience from EME graduates and employers and actively modernize our offerings in response to it.
- Further align our graduate offerings towards the development of professional skills by providing graduate students with the basic skills necessary to be a successful graduate student and provide individualized guidance for each graduate student's research and education. Refocus the existing graduate colloquium towards enhancing graduate student research abilities and revise the EME Ph.D. curriculum to develop deeper research skills (quantitative, writing, oral presentation).

- Become more competitive in graduate funding and increase the prestige of our Ph.D. program by actively recruiting a diverse population of Ph.D. students that are eligible for competitive fellowships (e.g., NSF Graduate Fellowship; EPA STAR Fellowship; Link Energy Fellowship), and setting expectations that graduate students eligible for scholarships and fellowships need to be aggressively pursuing these opportunities. Specific recruiting initiatives would involve reaching out to undergraduates in relevant student societies, particularly those that are not active in EME (e.g., IEEE Penn State Chapter; National Society for Black Engineers; American Meteorological Society student chapters).
- Institute a periodic external review process for the EME graduate program.

Metrics:

Undergraduate Education:

- Enhance our leadership in each of our academic fields and pursue number one rankings across all our academic disciplines
- Attain average teaching loads of three courses per year for all tenured and tenure-track EME faculty by 2019
- Attain student-faculty ratios ranging from a minimum of 15:1 to a maximum of 40:1 across all EME academic programs by 2019. Current student- faculty ratios (AY2013/14) are approximately 95:1 for Energy Business and Finance (EBF), 25:1 for Energy Engineering (ENENG), 25:1 for Environmental Systems Engineering (ENVSE), 10:1 for Mining Engineering (MNGE), and 90:1 for Petroleum and Natural Gas Engineering (PNGE) if one only includes students enrolled in University Park and faculty in the EME roster at the time of this writing.
- Maintain enrollment controls that guarantee proper student-faculty ratios are maintained on a long term basis
- Increased number of teaching assistantships assigned to EME to improve the quality of undergraduate education
- Direct alumni events conducted for every academic program by 2019
- Increased number of undergraduate scholarships
- Maintain ABET accreditation of all departmental engineering programs
- Improved student satisfaction of EME programs from exit surveys
- Improved job satisfaction of EME graduates from alumni surveys

Graduate Education:

- Revised and improved graduate program proposal(s) successfully approved by Graduate Council and fully implemented by 2017.
- Increased EME faculty participation in the EME graduate program; i.e., overall increase in number of EME faculty mentoring graduate students and teaching or developing at least one graduate class at least once every other year;
- At least five on-campus events per year aimed at increasing the visibility of EME's graduate offerings among Penn State students outside of EME. These might include

seminars or information sessions held in conjunction with relevant student societies or groups on campus; or information disseminated at professional conferences

- 10% of our students will have applied for a competitive external fellowship
- First external review process for the graduate program conducted by 2019
- Increased number of graduate assistantships available to EME from private funds and additional general budget allocation
- Improved graduate student satisfaction metrics and exit surveys
- Improved job satisfaction of EME graduates from alumni surveys

Goal 2: Become a National and Global Model for the Successful Execution of High-Impact Multi-Disciplinary Research in Energy and Earth Resources and Technologies

EME seeks to become recognized nationally and internationally for a commitment to addressing socially critical and scientifically important problems within and at the intersections of the knowledge domains that make up EME's portfolio of expertise. Because of EME's expertise, we are uniquely poised to make strategic contributions in the areas of natural gas science and engineering; renewable energy utilization; mineral resource extraction; and analysis of large-scale systems. We would like to become a nationally and internationally recognized hub of scientists with the highest caliber of creativity and productivity in generating high-impact scientific contributions in our specialization areas. EME already has an excellent record of working with the Institutes at Penn State to advance research. The department has a long history of deep involvement with the EMS Energy Institute that we intend to continue. EME has also competed successfully for a number of the energy co-hires with PSIEE. Over the next five years, EME will strengthen its most important research partnerships with other units at Penn State and will build new partnerships with research Institutes whose strategic initiatives align with those in EME.

Strategic Initiatives Related to Research

EME is uniquely positioned to become a national model for integration of multiple research disciplines under one academic roof. We are far ahead of our peer departments in terms of the interdisciplinary research that we are able to accomplish, but we could do more. EME will encourage all tenure-line and research faculty to devote at least some time to interdisciplinary research pursuits (e.g. joint advising of Ph.D. students, proposal-writing, etc). If every faculty member in EME allocated 10% or more of their research time towards interdisciplinary work, it would set EME apart in an increasingly crowded energy analysis marketplace without sacrificing excellence in core disciplines. Additional strategic initiatives for the enhancement of the research mission of EME include:

- Build one of the nation's premier research infrastructures for **natural gas science and engineering**, and become a national model for the successful integration of business and policy issues with science and engineering research, through our deep involvement with the **Institute for Natural Gas Research (INGaR)**. EME is currently positioned to expand its faculty ranks in the petroleum/natural gas

engineering area through support from INGaR, and we will work with the incoming INGaR director to add a public policy component to INGaR's mission and portfolio of activities. EME views the maintenance of a strong partnership with Geosciences as crucial to building this premier level of recognized research expertise in natural gas science and engineering, particularly as it is relevant to the development of the Marcellus, Utica and other unconventional shale plays in our own backyard.

- Establish a rapid-response task force whose mission will be to collect and synthesize information regarding faculty research activities related to **water and energy**; and to make recommendations to the department head and faculty regarding how EME should position itself to respond to University water initiatives. Many EME faculty are involved in research across the water-energy nexus, but these efforts need to be coordinated in a way that will position EME to respond to the University's emerging water initiative. In particular, EME seeks to become more involved with water-related initiatives through the **Energy and Environmental Systems Institute (EESI)**. Unlike other EMS departments, EME currently has no salary-line faculty associate in EESI. We will seek to add at least one EESI associate from EME with some water-related expertise or research activities. EME will also seek to partner more actively with the faculty in other EMS departments, particularly Geosciences, working on research issues related to water and energy utilization.
- Expand participation in the **NETL Regional University Alliance (RUA)**, to the extent that the RUA will exist into the future and will continue to support scientific research in the area of fossil fuel utilization, carbon sequestration, and smart grid technologies. The RUA has been the largest single source of resource support for EME faculty in each of the past two academic years. EME has had roughly 20% of its faculty participate in RUA projects; we seek to increase that number to more than one-third.
- Act to develop a stronger relationship with the **Institute for Cyber-Sciences** through competing for relevant co-hire positions; seeking supporting funding for Centers and other research activities; and lending relevant expertise towards University-wide energy modeling initiatives such as the smart micro-grid at the Philadelphia Navy Yard. EME has a number of faculty that utilize or develop tools and techniques for computationally-aided research. Examples include the modeling of large-scale complex natural or engineered systems (power grids; pipelines; subsurface reservoirs; molecular modeling); non-linear optimization; and big-data analytics for electricity demand. In addition, EME faculty have served on the University Task Force for Cyber-Sciences and the recommendations of the task force are now being implemented through strategic spending, faculty co-hires in areas including energy.
- Take a leading role in the creation and operations of a policy-focused research center, and in particular will develop a recognized body of work related to natural gas policy. Policy-oriented research continues to be a strategic priority for the EMS College.

- Take advantage of the on-campus research opportunities offered through the **Sustainability Institute** and become a campus leader in leveraging campus infrastructure for use as a living laboratory (see Goal 6). The first and foremost priority in this vein is to make the renovated Hosler building the single most advanced and energy-efficient academic building on Penn State's campus, and to influence the design of the building with data harvesting and research in mind.
- Strengthen our historic partnerships and build stronger linkages with other EMS units, including the **EMS Energy Institute**, in the areas of sustainable aspects of energy resource development, oil & gas resources with emphasis on unconventional reservoir environments, and its core strengths in coal and fossil fuel research; and the **Department of Geosciences (GEOG)**, in the areas of water, earth resource science and engineering, risk analysis, and through our shared partnership in INGaR. We view our interdisciplinary partnership with the Geosciences department as a crucial part of our strategic plan; studies in petroleum and natural gas engineering are greatly enhanced by studies in petroleum and natural gas geology.

Metrics:

- Increased number of faculty involved in at least one interdisciplinary research activity within EME and/or with our strategic partners
- Increase sponsored research activity to at least and beyond levels observed in the 2011/2012 academic year (see Fig. 3 in Appendix)
- Increased amount of externally-funded interdisciplinary research initiatives
- Increased number of publications and research grants across our department disciplines.
- Increased number of joint publications with international collaborators
- Increased overall research output
- Increased number of awards and recognitions received by EME faculty members
- Increased number of memberships of EME faculty in high-impact national and international advisory boards and committees.

Goal 3: Excel in recruiting and maintaining a department of diverse people, ideas, and backgrounds.

EME seeks to expand its commitment to providing a department with a diverse student body, faculty, and staff that is supportive and values contributions from all of its members. The EME Department aspires to build an academic environment and diverse culture with broad perspectives that promote the highest forms of collegiality and collaboration among the faculty, students and staff and to become distinctive for its commitment to academic excellence through diversity.

Strategic Initiatives Related to Diversity

- Identify diversity strengths and challenges in the Department

- Develop policies and goals consistent with the College’s Diversity plan on recruitment and retention to ensure a diverse student body, faculty and staff
- Identify best practices for diversity recruiting and retention
- Continue to participate in programs that bring underrepresented students to campus, for example, SEEMS and STEM programs
- Pursue all avenues of undergraduate scholarships and graduate fellowships at the University level available for diversity recruitment
- Work with the College to increase the number of underrepresented groups in the faculty, staff, and student populations.

Metrics:

- Increased number of students from underrepresented groups entering the Department (recruitment)
- Increased number of students from underrepresented groups graduating from the Department (retention)
- Increased number of faculty and staff members from underrepresented groups in the Department

Goal 4: Embed sustainability as a fundamental value in our teaching, research, service and operations.

The Penn State Sustainability Strategic Plan defines sustainability as “the simultaneous pursuit of human health and happiness, environmental quality, and economic well-being for current and future generations.” In a world where the economic necessity of affordable energy, water, and mineral resources conflicts with environmental concerns rising from their exploitation and utilization, EME is uniquely positioned *to lead* and advance on issues of sustainability related to the extraction, conversion and utilization of energy and mineral resources. The equation has changed. Where we once sought to meet energy needs as inexpensively as possible, we must now do it as *sustainably* as possible for the well-being of current and future generations. By taking the steps necessary to embody sustainability in our teaching, research, and service, EME will remain a world leader in solving energy and mineral problems for the benefit of humanity.

Strategic Initiatives Related to Sustainability

- In our EME teaching and research, frame all subject matter in the context of earth’s planetary boundaries and the global impact of human activity on earth system processes. This perspective is both a responsible and necessary educational component for our disciplines.

- Seek and develop opportunities for cross-disciplinary inquiry into sustainability challenges related to geo-resource extraction, conversion and utilization and to energy management, economics and policy. These opportunities will address the social, economic and environmental aspects of sustainability; encourage intellectual risk taking, innovation and independent thinking; and, be available to undergraduate and graduate students in all EME majors. Possibilities include, but are not limited to, interdisciplinary courses in renewable energy that examine environmental, economic, social and engineering perspectives and a new Rock Ethics Institute faculty position in EME focused on the distributive effects of resource extraction (currently proposed).
- Integrate sustainable design principles in engineering programs where feasible, consistent with ABET General Criterion 3. Student Outcomes (c), “an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.”
- Embrace, in our teaching and research, the vision, compromise and understanding that energy resource development, recovery (including geo-resource extraction) and utilization are activities that require awareness of the transitional use of local ecosystem services such as land, air, and water, which will be fully reclaimed and treasured for future generations in a strategic and economic manner
- Continue to grow and enrich sustainability-focused programs currently offered in EME. These are the undergraduate (online) Energy and Sustainability Policy BA program and the interdisciplinary graduate program, Renewable Energy and Sustainability Systems MPS, with two options (“Solar Energy” and “Sustainability Management and Policy”) that are managed by EME faculty.
- Initiate program to assess sustainability literacy within EME department. Work with others, including University's Sustainability Institute, to develop appropriate assessment tool. Use assessment outcomes to recognize gaps and opportunities in EME program curricula.
- Reflect the sustainability values of the new Hosler building environment in EME operations and student learning experiences. This includes zero-waste operations, intentional energy awareness and management, encouragement of sustainable values in occupant behavior and choices, and engaged learning that uses the building's systems, design and performance as living laboratory, outlined in Goal 6.

Metrics:

- Increased number of EME faculty and students recognized as innovators and thought leaders on issues related to sustainability in energy and mineral engineering
- Increased research output (undergraduate, graduate and faculty) in areas related to sustainable resource management, economics and policy.

- Assess, monitor and improve the sustainability literacy of EME students.

Goal 5: Promote Global Reach

EME seeks to nurture an environment that inspires creativity and enables pursuit of opportunities that engage all of the stakeholders: faculty, staff, students, University at large, alumni, employers, industry, accrediting bodies, and government; in order to best contribute to developing the breadth and depth of the scientific understanding of complex global issues related to the energy and mineral industries. To achieve this goal, EME also seeks to expand its global efforts in teaching, research and service.

Strategic Initiatives Related to Global Reach

- Further build on our strategic alliance with the **John A. Dutton e-Education Institute**. Through the John A. Dutton e-Education Institute, the EME Department currently offers 25 online courses, available both to World Campus and residential students. Requirements for the Energy and Business Finance minor can be fulfilled entirely with courses offered online. The Energy and Sustainability Bachelor of Arts program is offered fully (and only) online to World Campus students. Most of the students in this program live out of state, with many in other countries. In 2012, this program was recognized by the Sloan-C Consortium as Outstanding Online Program of the year. In this strategic cycle, we will further strengthen our alliance with the following specific goals:
 - To aggressively pursue online education opportunities that contribute both to existing undergraduate programs and to engage external stakeholders through short courses and professional and executive education;
 - To create additional online sections for our 200-300 level bottleneck courses across our EME undergraduate curricula consistent with Goal 1 above;
 - To extend the Department's Web-based educational offerings to a targeted global market;
 - To integrate teaching faculty who participate in teaching online courses into the department in order to promote collegiality, community, and sharing;
 - To appoint an EME faculty member as our "EME Director of Online Programs" to champion and oversee this strategic alliance.
- Nurture and celebrate collegiality and sense of community. Nurture the view among both faculty (fixed-term and standing) and graduate students that being part of a world-class research institution is a serious social responsibility.

- Identify and establish collaborations in natural gas extraction, mining and mineral processing research across engineering and policy areas with partners in India, South America and Africa.
- Engage industry and alumni to actively support the creation of sponsored research centers within EME and their activities.
- Reward and support the undertaking of service assignments by EME faculty (standing and fixed-term) aligned to our engaged scholarship and global reach strategic goal;
- Use social media to engage and involve students, faculty, alumni, and industry.

Metrics:

- Appointment of an EME faculty member as “EME Director of Online Programs”
- Increase in revenue-producing online initiatives
- Increase in satisfaction amongst teaching faculty in our online programs
- Increase in industry and alumni engagement.

Goal 6: Embrace and engage in the Hosler building renovation project to achieve state-of-the-science learning and research facilities tailored specifically to the interests of the Department’s students, faculty, alumni, and industry partners.

Strategic Initiatives Related to Hosler Living Laboratory Renovation

For a whole building retrofit on the capital plan, the Hosler Building renovation will follow all OPP design standards for new construction: LEED-NC (LEED® for New Construction & Major Renovations) following the PSU Application Guide, with 30% improvement over ASHRAE 90 (Energy Standard for Buildings), and compliant with ASHRAE 189 (Standard for the Design of High Performance, Green Buildings). EME stands ready to participate as contributing building stakeholders, with faculty, staff and student representation, to provide input into the renovation process. As an energy department, EME stakeholders will work with the hired design firm to guide the design concept, following the common desire to establish a transformative living laboratory.

A deep retrofit of the Hosler building will serve as a compelling platform for a new energy systems living laboratory in the West Campus, to engage both faculty and students while maintaining a sustainable approach to energy use, repurposed materials, local energy production, indoor environmental quality, and informative user feedback. The Hosler Building renovation will benefit from the learning process of the Steidle Building renovation, providing a smooth transition from a high-energy demand structure with limited space for a large department, into a living laboratory framework for research and education: with low energy demand, local energy production, high indoor environmental

quality (IEQ; air and water), and high utility space allocation for laboratories and workspaces. The next generation Hosler Building will better utilize passive solar gains to the south, and the high thermal mass of the brick envelope, while exposing the occupants to more daylight and common spaces. Laboratories will be suitably allocated for large classroom educational purposes as well as for leading research capabilities.

As our working environment is growing increasingly transdisciplinary in nature, suites of laboratories will be developed, supporting research clusters around modern energy systems, mineral systems, health, safety, and sustainability. Space must also be flexible to allow persistent advocacy for an equitable and cohesive distribution of space, commensurate with student enrollment, and including new space for laboratories. With the transition to big data analysis, common space will be formed for large-scale data visualization, for video and audio conferencing with national and international research colleagues, while also providing new avenues for online course development characteristic of the progressive approach to online education in the College of EMS and the Department of EME. Reorganization of space will follow a core mission to students to provide access to the Hosler living laboratory, additionally forming a collegial, collaborative environment for faculty and staff, while attracting future support from donors to grow and enrich the site.

Specific EME objectives for the Hosler renovation project include the following:

- A design that allows for the building itself to serve as a living laboratory for sustainable energy and energy efficiency research, with appropriate data and control systems included to allow for the study of energy use, patterns, and to facilitate the exploration of sustainability concepts
- Use of state-of-the-art systems with regard to monitoring and providing visual feedback for energy demand and indoor environmental quality (IEQ)
- Use of renewable / alternate energy technologies including photovoltaic systems and energy storage as on-site generation and living laboratory space
- Active learning laboratories of adequate capacity to support program enrollments
- Incorporation of a visualization center with state-of-the-art hardware and software
- Video conferencing and distance learning capabilities
- Work with the EMS Development office to garner alumni and industry support for enhancing the Hosler renovation (e.g. naming opportunities for classrooms, laboratories)

Metrics:

- Formation of Hosler renovation project stakeholder team in EME.
- Seamless transition into new spaces.
- Increased teaching, communications, and research laboratory space.

- Identification of sponsors for targeted renovation initiatives.
- Successfully exceeding LEED (Leadership in Energy and Environmental Design) and ASHRAE target certification levels for PSU, with active building management and energy feedback visualization systems