

Energy Engineering Undergraduate Degree Program: Lessons Learned from Program Development and Launch

Dr. Greg Kremer, Ohio University

Robe Professor and Chair of Mechanical Engineering, Ohio University Program Director: Energy Engineering Director: "Designing to Make A Difference" ME / EnE senior capstone design experience.

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Introduction:

The National Academies have identified energy issues as among the most significant facing humankind in this century, and at least three of the fourteen NAE Grand Challenges for Engineering are directly related to energy and the environment. Increased worldwide demand for energy and decreasing supplies of easily accessible fossil fuels have created geopolitical and economic concerns. Increased understanding of environmental effects of power generation and challenges with large-scale implementation of renewable power options have made it clear that powering the world is a challenging problem with no easy solution.

The engineering community is responding to these challenges in many ways. Energy engineering has developed as a profession with its own association (<http://www.aeecenter.org/>) with over 16,000 members and its own journal (<http://www.ij-ee.org/>). They predict significant job opportunities for graduates in the Energy Engineering profession due to energy economics and the age of the current work force in the field. Surveys of members of the Association of Energy Engineers show relatively large numbers nearing retirement, an anticipated growth in employment opportunities, and overall strong career opportunities (<http://www.aeecenter.org/files/reports/2015EnergyManagementJobs.pdf>).

At the university level, many graduates of chemical, electrical, mechanical, and other undergraduate engineering disciplines specialize in energy through technical electives and research projects. There are also specialized degree programs, although they are somewhat limited at the undergraduate level. Penn State's Energy Engineering program (<http://www.eme.psu.edu/eneng>) was one of the first, and is ABET accredited. Other notable undergraduate Energy Engineering programs include those at Berkeley Engineering (<http://engineering.berkeley.edu/academics/undergraduate-guide/academic-departments-programs/engineering-science/energy-engineering>), IUPUI (<http://www.engr.iupui.edu/departments/me/undergrad/bseen/index.p>), and Ohio University (<https://www.ohio.edu/engineering/mechanical/academics/undergraduate/energy-engineering.cfm>). There is also an ABET accredited "Mechanical and Energy" program at the University of North Texas (www.engineering.unt.edu/mechanicalandenergy/). Additional options at the undergraduate level include MIT's interdisciplinary energy studies minor (<http://energy.mit.edu/minor/>) and Duke's new minor in Energy Engineering (<http://energy.pratt.duke.edu/minor-requirements>). In the energy technology area there are additional options, including Thomas Edison State University's BS in Energy Systems Technology (<http://www.tesu.edu/ast/bsast/Energy-Systems-Technology.cfm>), and Oregon Institute of Technology's BS in Renewable Energy Engineering (<http://www.oit.edu/wilsonville/academics/degrees/renewable-energy-engineering>). The options for graduate-level education related to energy systems are significant and diverse, including professional masters programs in Energy Systems Engineering at Lehigh

(<http://www.lehigh.edu/~inesei/degree/index.html>), Michigan (<http://isd.engin.umich.edu/degree-programs/energy-systems-engineering/index.htm>, available online) and Northeastern (<http://www.coe.neu.edu/degrees/ms-es>, available online).

Ohio University's main campus is in Appalachian Ohio, a region heavily impacted by resource extraction. In the summer of 2011, questions around the advantages and challenges related to the expansion of horizontal hydraulic fracturing led the Russ College of Engineering and Technology at Ohio University to devote an entire multi-day Dean's retreat (with the Chairs, Directors, and College Board of Visitors) to the discussion of how we as a college should respond. One major aspect of the discussion centered on the relative merits of a program focused on a specific energy challenge (such as horizontal hydraulic fracking and the extraction of fossil fuels) versus a program that develops a broad understanding of the technical, economic, and policy aspects of energy options. Some board members have been in industry and government long enough to have seen many specific issues and programs come and go, so they recommended we develop an undergraduate Energy Engineering program in a way that would be sustainable and remain relevant. They also believed that there would be an increasing demand for graduates, and that if done properly it would complement existing degrees (chemical, electrical, and mechanical), have a net positive effect on enrollment, and enhance the national reputation of the college. We also reviewed anecdotal evidence regarding student interest, which showed that a significant and growing number of potential students ask about or express interest in programs and courses related to energy. Our existing energy-related technical electives have also shown good enrollment. We left the Dean's retreat with a charge to develop an undergraduate engineering program to prepare students to evaluate energy options on a system level, balancing technical considerations, policy, regulations, life cycle cost, and environmental impacts.

Program Development and Approval:

Based on some initial research, we created the following working definition of an Energy Engineer for the purposes of starting our program development:

Energy engineers simulate, analyze, design, build, monitor, and maintain engineering solutions to problems involved with energy conversion (generation), distribution, storage, and utilization. Their education is multi-disciplinary, including fundamentals of Chemical, Mechanical and Electrical Engineering, as well as systems engineering, energy economics (over the full life cycle) and energy policy. They are employed by utilities, governments, industries, and research centers.

By August of 2011 we had assembled a "founding advisory board" for the program. It was crafted to provide viewpoints from a broad range of energy sectors including power generation, oil and gas, nuclear, renewables, controls, energy performance contract service providers, and equipment suppliers. Letters of support were provided by a large utility and a research institution. In an early phone conference we helped the advisory board understand ABET, the

basics of program development, and their role in the process. Our open-ended discussion time was guided by the following questions:

1. What was your 'employment objective' for your first job in the energy field?
2. What skills/abilities were most important to you in your first job in the energy field?
3. What do you look for when hiring for entry-level jobs in the energy field?
4. What characteristics are evaluated in performance reviews for entry-level engineers in the energy field?
5. What range of advanced education and training opportunities are important for graduates of an energy engineering undergraduate program?
6. What trends are occurring in research, government regulations or incentives, industry, etc. that should impact program requirements for student graduating in 5 to 10 years?

Part of the open discussion focused on the current strengths in energy research in our university, especially in clean coal and electrochemical conversion technologies, and how they compare with those of other colleges. As we discussed educational programs, some of the overall themes and guidance that emerged from the discussion included:

- Balance between engineering (fundamental) and technology (applied)
- Balance between general (broad understandings) and specialized (industry specific skills)
- Develop students' ability to choose appropriate options for energy generation/conversion, distribution, storage and utilization.
- Include classical and alternative energy conversion technologies, centralized and distributed energy resources, impacts on water, air and climate, and the broad short and long term economic implications.
- Building modeling
- Dynamic nature of incentives + regulations
- Political engagement

To prepare for the next meeting, the board was given the task of thinking about program objectives. In a day-long on-campus meeting in October 2011, we compiled board member input relative to mission, goals, objectives, and major characteristics of an Energy Engineering Program, and developed a set of draft program educational objectives. After some additional discussion of the draft objectives among program faculty and back-and-forth with the board, the Program Educational Objectives were set as follows: (note the sub-bullets represent additional guidance from the board members)

The Energy Engineering program focuses on producing graduates who possess:

1. The necessary skills to be a valued individual and team contributor in a professional environment.
 - a. To prepare students to meet this objective, the program should develop students with adaptability, client focus, integrity, ability to lead and motivate others, conflict management, ability to give and receive constructive criticism, and effective communication.
2. The characteristics for diverse career options in the multidisciplinary energy field.
 - a. ... the program should develop students with entrepreneurial mindset and relevant experience, who will be good citizens of their community and profession, and able to gain industry certifications (CEM, etc.).

3. The necessary analytical and technical skills to identify complex problems as well as devise and implement their solutions.
 - a. ... the program should develop students who take initiative, have a knowledge of standards and codes, have a working knowledge of equipment (Pumps, Motors, Compressors, Turbines, Generators) and energy efficiency, can perform safety & risk analyses and life-cycle assessments, have project management and time management skills, and understand the basics of engineering economics and material and energy balances.
4. An understanding of the impact of underlying systems and environmental/societal policies on the global energy infrastructure.
 - a. ... the program should develop students with a capacity for systems-level thinking, ability to assess scale and scope of a project, be familiar with environmental policy and global competition for resources.

Though the program is administratively housed in the Mechanical Engineering Department, the program faculty consist of members from chemical engineering, electrical engineering, mechanical engineering, industrial and systems engineering, civil engineering, and environmental sciences and policy. Program faculty worked the remainder of 2011 and into 2012 to develop a curriculum that integrated technical fundamentals and some advanced topics from existing courses, economic analysis from existing Engineering Economy and Economics of Energy courses, a revived Engineering and Public Policy course, a new Applied Systems Engineering course, and a few Energy Engineering specific courses on Fuel and Energy Conversions. A flowchart of the current curriculum is included as an Appendix to this paper. It is important to note that the program is substantially different from any other engineering program in the college. The overlap is about 60% with the closest program (Mechanical Engineering). It would take a minimum of three additional semester terms to complete a second degree (for example, over 50 semester credits would be required for a mechanical engineering student to also earn an Energy Engineering degree). The first year curriculum follows the 'common schedule' for first year engineering programs, with the only differences being the discipline specific freshman design course and colloquium. The second year is also substantially similar to mechanical engineering, with only 7.5 hours that are not common between the programs. The major differences are in the junior and senior years. This gives students ample time to learn about the different degree options and in consultation with their advisors make informed decisions about which program to pursue.

In order to gain approval for the new academic program, we needed to get approval at the university level and the state level. The approval required us to show a need for the program and show that it could be financially sustainable. Some key points of our argument are summarized below:

Reasons for starting the new program:

1. Opportunity to be a leader in this emerging academic area.
 - i. There are no four-year energy engineering programs in our state or region, giving us a notable distinction over our primary academic competitors.

2. Having one of the first EnE programs will strengthen our national reputation as a Center of Excellence for Energy.
3. It is a low risk way to potentially attract more out of state students due to the relative uniqueness of the program. The program has the potential for medium to long term positive enrollment impact (to combat the in-state demographic factors predicted to decrease enrollment).
4. Strong support from EnE advisory board.
5. The program was developed based on program objectives and suggested program characteristics provided by the EnE advisory board, meeting one of the requirements for accreditation.
6. It should help college recruiting efforts, even for other programs, since it is unique enough that it could get students to take a look at our university. Some who look will decide they want a traditional program with the option to take energy-related electives, rather than try the new EnE program. Engineering Ambassadors have reported that they are receiving a lot of questions from potential students about programs that prepare them to work in the energy field.

Potential issues with starting the new program:

1. It may draw students from other programs, rather than 'new' students for the college
 - Because the EnE program is a multidisciplinary program that primarily makes use of existing courses taught by a range of programs in the college, this is not really a resource issue but an issue of how students are counted. If we consider it a college program (that is administered by a department for practical reasons) the 'credit' for the student enrollment could be divided between participating programs. The hours for the courses accrue as always to the program of the instructor of record.
 - There should be no negative impact on the college or the participating programs if it is managed properly. Although it is hard to predict beforehand, surveys can be used during program implementation to identify how many students enrollment decisions were influenced by the availability of the EnE program.
2. Will the students be able to get jobs?
 - EnE board members think so.
 - To assist our first graduates, we could make extra effort to arrange internships for all students to help establish a job market for EnE graduates.
3. Will new resources and faculty be needed?
 - No new faculty are needed during program startup - the small number of EnE specific courses mean few committed teaching resources are needed.
 - Some resources are needed for one or two new lab activities that would be in addition to those currently available in ME or ChBE, but these new lab activities are also of interest to other programs.

Though the academic approval process does take time, the program was approved in 2014 and was able to begin accepting students during the 2014-15 academic year. Unfortunately,

the approval came so late that there was no opportunity to promote the program to potential incoming students or do any recruiting for 2014-15. We did get a few students to transfer into the program that first year, and three of them will make up our first graduating class in Spring 2016-17.

Evaluation and Discussion

Although we have been working on this program for about six years, it has only been about three years since the program officially launched. Based on our experiences in program development and implementation, we are able to provide some 'lessons learned' for any other programs considering how to respond to the challenge of preparing graduates to work productively on our future energy challenges.

Enrollment

We have intentionally tried to have a slow rollout of the program since new courses needed to be developed without many extra resources, we wanted to make sure students were choosing the major for the right reasons, and since the other programs in the Mechanical Engineering Department are experiencing record enrollment levels. The program director meets with each potential transfer student to discuss the risks and opportunities associated with joining a new academic program that is not one of the traditional disciplines that job advertisements recognize. The results of these meetings are that about ½ of potential students choose to remain in a traditional engineering program (usually mechanical or chemical) and pursue an emphasis in energy, while the other ½ decide that Energy Engineering is the better option for them. We have only had one energy engineering student choose to transfer out (to mechanical engineering), so we would recommend that others adopt a similar approach to help potential students make educated decisions about joining the program. An area for improvement is in communication materials that more clearly display the differences in entry-level job and graduate school opportunities available in the energy field to the graduates of energy, chemical, mechanical, and other engineering disciplines.

We were also very intentional in designing the program to avoid any chance of students who are unable to meet the grade requirement in one of the core chemical or mechanical engineering courses (for example a C or better in Material and Energy Balances) to seek to transfer into the energy engineering program. It is an academically rigorous program, with only a small difference in the number of required engineering courses compared to other programs (to allow for a few more economics courses). Since there is the potential for confusion in the energy field about the distinction between technology positions (like solar panel installers) and engineering positions (like certified energy managers), we recommend that energy engineering programs maintain a high level of academic rigor to preserve the distinction of the engineering degree.

The current enrollment in the program is 25 students, of which 12% are female. Based on our experience so far and other anecdotal evidence from talking to current and prospective students, it appears likely that the gender diversity in this program will be somewhere between the lower percentages for mechanical engineering (our averages are normally under 10%) and the higher percentages for chemical engineering. There are about 5 - 10 additional students who have requested or are in the process of transferring into the program. Ten students were admitted for 2016-17, the first class that had access to recruiting materials throughout their college decision process. Our goal is to build to the level of 20 new students admitted to the program each year, and a total enrollment of about 75 students. To meet these goals, in addition to some factors that just take time (name recognition for the program once a number of graduates are employed, more awareness among HR departments of hiring companies so they include energy engineering majors as eligible for relevant jobs, and securing ABET accreditation), an area for improvement is in recruiting materials - the materials available for this new program are improving, but are still more of an 'add-on' than representative of a program with its own clear identity. We believe we need to better tell the story of energy engineering in order for students and employers to take full advantage of the opportunity.

When proposing this program, we predicted that although it has the potential to attract students who would otherwise enroll in traditional degree programs (ChBE, EE, and ME), the EnE Program would have little impact on existing program enrollments due to the nature of student major selection. We thought that the majority of current and future undergraduate engineering students would continue to be attracted to traditional engineering programs since they provide students with employment options in a wide array of industrial sectors, including the energy sector. Our predictions have proven correct - the concerns from some programs that their enrollment might be negatively impacted, brought up because we are following a responsibility centered budgeting model, has not materialized or become an issue. That is due in part to the small total number of students currently in the energy engineering program, as well as the continued increase in enrollment in the chemical and mechanical engineering programs. An area for improvement is to more closely track the number of students entering the program as freshmen who come from out-of-state or who report that the energy engineering program was a differentiating factor in their choice of a university. The amount of data we currently have is too small to report any findings.

Curriculum

One of the supporting factors for offering the energy engineering program was our prediction that it would require only a small amount of additional resources to develop and execute. Our experience has shown that this prediction was mostly accurate. The new fuels conversion course (essentially a combination of select parts of multiple chemical engineering courses) and energy conversions lab (a combination of some existing ME and ChemE lab activities, along with some new activities) had to be developed by our faculty, but they were able to make use of some existing resources and materials. Further, they were

created in a way that allows them to be offered as technical electives for our mechanical engineering students, and they form the core of a collection of courses that in the future may form an Energy Systems interdisciplinary minor. This minor would likely appeal mostly to mechanical engineering students who could obtain it with a total of 10 additional credits if they choose their electives properly, but may also appeal to some electrical and civil engineering students who seek additional expertise and certification in energy systems. Other courses in the minor would be Energy Engineering and Management, Economics of Energy, Engineering and Technology Public Policy, and Applied Systems Engineering.

The other courses that could not be used as-is from existing courses were the colloquium series and design courses. In developing and implementing an energy engineering colloquium (or speaker) series, we found representatives from the energy field to be very eager to share their stories and experiences with our students, and were pleased by their strong level of excitement about the new program. Speakers internal to the university (from the sustainability office and the director of utilities) joined speakers from local utilities to lead plant tours and help students get a much better understanding of what some energy engineering jobs look like. Our colloquium enrollments have been in the area of 12 - 15 students, so we have arranged for a mixture of independent activities (energy engineers only) and joint activities (energy and mechanical engineering students). This has seemed to work well to maintain the distinctive identity of the energy engineers, while making more effective use of resources in the combined activities.

The senior level courses are being offered for the first time this year, and since only five senior energy engineering students were eligible for capstone design projects this year, we used overlap scheduling and included those five in the same room with the 65 students in the ME capstone course. The capstone project for the energy engineering students was proposed by the university's building energy systems manager – review and update the building energy models for four new campus buildings built with LEED certification in mind, identify discrepancies between actual building performance and model predictions, and develop engineering proposals for projects which provide a return on investment in less than 3 years and that would enable the buildings to meet or exceed the energy use goals. In contrast, the 13 mechanical engineering design teams are working on new product initiation projects, which include a significant amount of manufacturing and detail design. The basic process of design thinking, project management, and the development of professional skills is consistent for both energy and mechanical engineers, but there is a clear difference in project emphasis (building modeling versus prototype design) and in the use of specific design methods. These differences can be seen as a problem or an opportunity - we have a tradition of encouraging ME students to learn from the other team's projects and not just their own, and having the added diversity of the energy engineering project is beneficial for broadening those learning opportunities. An area for improvement is a better differentiation in the area of design methods and other specific tools so that design for environment and other tools that apply more to energy engineers can be emphasized more clearly for those students while design for manufacturability and assembly and other tools are emphasized for

mechanical engineers. There also needs to be additional efforts to help the energy engineering students see how the range of design tools and methods really do apply to their education even if they do not directly apply to their capstone project. Another area of future work is to gather data on the positive and negative effects of having the students from both programs together for the capstone so that if the number of energy engineering students significantly increases, we can make an informed decision on whether to have independent capstone design courses or maintain the integrated capstone design experience. We have a similar situation for our freshman design course – it also uses overlap scheduling to include the energy engineers without requiring extra resources. In that course, there is a small design project common to all teams which involves transferring energy into motion. There is no real advantage from a learning perspective to continuing to have the energy engineering and mechanical engineering students together for this class, but as long as the class size doesn't get too large the tradeoff is between the need for fewer instructional resources versus the restriction that the common project needs to be carefully selected each year to apply to both groups of engineering students.

As we continue to receive guidance from our advisory board about the desired characteristics of our graduates, we have broadened our previous technical electives to include both technical and professional electives, and have begun promoting integrated interdisciplinary minors like Project Management and Strategic Leadership to our students. See the flowcharts in the Appendix that show how these certificates can be earned with only two or three additional courses, by properly selecting elective courses. We believe the additional skills and certification gained will add great value for our graduates, and plan to track graduates with these additional skills to see if they progress quicker or are hired into better opportunities than graduates without them. An area of future work is to review the curriculum with the advisory board and determine if it is possible to make add these in as 'select from' options in the program that all graduates would earn with their degree. The challenge is in minimizing or avoiding any increase in the number of hours required for graduation.

Program Accreditation

We are on track to seek accreditation for this program in the 2018 review cycle. This will be an accreditation of a new program from a college that already has accredited programs. We will make use of the option to gather two years of course materials representing the first group of graduates (2016-17) and the second group of graduates (2017-18), and requesting the accreditation, if approved, be retroactive to those first graduates. This approach allows all classes in the program to have been offered at least twice, and provides more opportunities for demonstrating the cycle of assessment and continuous improvement.

Our Advisory Board has been updated and expanded from the founding advisory board to one that can help guide us in program improvement and job opportunities for our graduates. The backgrounds of the current advisory board encompass ME ChE, EE, ISE, physical

chemistry, and law. Based on recent changes in ABET's expectations regarding educational objectives and further guidance on how they should be written, our expanded advisory board met on 11/16/2016 to help craft an updated set of program educational objectives, shown below. Our student advisory board also reviewed and gave input.

1. Within a few years of graduation, alumni will have attained one or more of the following:
 - Employment and advancement in public or private sectors of the multidisciplinary energy field, or in another technical or professional field.
 - Admission and progress toward or completion of a graduate degree program in engineering, business, law, or in another technical or professional field.

Signs of advancement and further development in these areas could include:

1. Attaining assignments of increasing responsibility
2. Developing a professional network
3. Moving from being an individual contributor to leading projects
4. Advancing toward professional licensure or Certified Energy Manager (CEM) Certification
5. Positively impacting society and the environment through innovative research results, or new products or services brought to market
6. Further development of the characteristics of a productive professional, including:
 - Taking initiative and being a self-starter
 - Proactively identifying opportunities rather than reacting to problems, including opportunities to positively impact the triple bottom line (financial, environmental, social) for customers by employing new technologies or innovative approaches
 - Effectively interacting with clients to help them understand what they need, including helping them move between big picture requirements and SMART (Specific, Measurable, Assignable, Realistic, Time-bound) plans
 - Effectively engaging and communicating across disciplinary and functional roles, including with co-workers from multiple levels and locations in the organization, and with customers and clients
 - Applying a cross-disciplinary, innovative, energy-efficiency oriented approach to solving complex problems
2. Alumni will uphold and advance the values of our university and the engineering profession and use their skills and influence to contribute to the greater good
 - Alumni will uphold and advance the core values of: Community, Character, Civility, Citizenship, Commitment, and the university's commitment to sustainability.
 - Alumni will behave with integrity in ways consistent with the [Association of Energy Engineers Code of Ethics](#), the [NSPE Code of Ethics](#), and their company's values and beliefs, and will engage with other professionals through relevant professional societies and/or company 'communities of practice'.

Signs of upholding and advancing these values and contributing to the greater good could include:

- Being engaged in the world and thinking beyond themselves, further developing a broad and systems-level perspective on issues that affect society (especially those involving the impact of technology on the environment and society), engaging in civil public discourse about those issues, and working to respectfully resolve different points of view
- Embracing commonly-held company core values, including: Acting with integrity and an ethic of stewardship, interacting with candor and humor, and being authentic, accountable, collaborative, courageous, humble, inclusive, innovative, insightful, passionate, professional, and respectful
- Participating in government and/or using their technical expertise to influence public policy
- Contributing to the development of solutions to society's current energy needs through advancements in production, processing and utilization of renewable or non-renewable energy
- Taking on the role of gatekeeper for society, addressing new ethical challenges related to energy options and the smart grid (such as cybersecurity), and promoting and advancing appropriate environmental measures

The relationships with board members and others from industry who have participated in the colloquium series have helped us strengthen existing and establish new relationships with energy-related companies. During our Spring 2017 Advisory Board Meeting, we compiled board member responses to the question: "What do you expect in a graduate, what do you look for when hiring entry level engineers, and where do you look for the evidence (GPA, interviews, co-op, etc.)?"

1. Good communication skills, oral and written - evaluated at the interview.
2. Examples of leadership - provided in the resume and interview
3. Examples of teamwork - provided in the interview
4. Evidence of a well-rounded curriculum in the coursework that they have taken - the reputation of the school is also taken into consideration
5. Minimum GPA of about 3 though sometimes slightly lower is accepted and in actuality something closer to 3.5 is more normal at top companies
6. Examples of work experience, and other meaningful activities with some type of real world connection are important differentiators
7. Responses to behavioral interviewing questions that examine things like change management, time priorities, managing through conflict, diversity, humility (can they ask a dumb question) etc.
8. Positive attitude, passion and enthusiasm - assessed at the interview
9. Critical thinking and problem solving, or the ability to think their way through a problem and defend an answer when there is no right answer - assessed at the interview. this is seen as more important than technical knowledge because it's easier to train employees in that than in the fundamental problem solving and thinking skills

10. Examples of innovation and creativity - assessed at the interview
11. Core values and ability to be trusted (how they handle confidential material) - assessed on co-op or in the interview
12. Grit and tenacity - is this someone we want on our team when things go wrong. Assessed at interview.

Other important comments differentiating Energy Engineers include:

- Energy engineers need entrepreneurial mindsets - they need to succeed without micro-management and be able to take projects from womb to tomb.
- Integrating Certified Energy Manager (CEM) certification within the program would be value added - and would help our students get jobs. In some ways, the CEM exam topics identify the skills that employers would expect Energy Engineering graduates to have at higher levels than graduates of other engineering programs.
- Support for Project Management Professional (PMP) certification would also be useful.
- Life extensions are a big thing in the energy industry now as well as management and integration of distributed resources
- Management in a virtual world and the ability to work remotely are skills needed for the future, but they also still need to be ready and willing to meet face to face especially with hourly employees

An area for improvement for our program is to seek more input from, or engagement with, Energy Engineering professional societies.

Employment opportunities

We do not have enough experience to make any conclusions about job placements and demand for graduates, but our students are getting co-op placements and permanent job offers from a range of companies. Also, the indications from the companies we are in contact with show a strong interest in graduates of the energy engineering program. In the on-campus career fair in February 2017, companies inviting Energy Engineers to apply included AES Corporation/Dayton Power & Light, Babcock and Wilcox, Bi-Con Engineering, Evoqua Water Technologies, Fluor-BWXT Portsmouth LLC, Honda North America, JPMorgan Chase & Co., Marathon Petroleum Company, Nationwide, and the US Navy. An area for improvement is to continue working with our career services office to achieve better awareness of the new program among companies that recruit at our university. There were at least three additional companies at the career fair who likely hire people to fill a role that an energy engineer would be qualified to do. It is possible that those companies did not invite energy engineering applicants because they had no openings in those areas, but it is more likely that they did not know enough about the energy engineering degree to realize those students would be a good fit.

We have also noticed that the impact of internships or work experiences on our students' career paths and interests may be even more influential than in other programs. In future

work, if this trend persists we will try to determine if the reason is that other career options may not be as well-known as for traditional programs, or if there is some other reason that we can address.

Conclusions and Next Steps

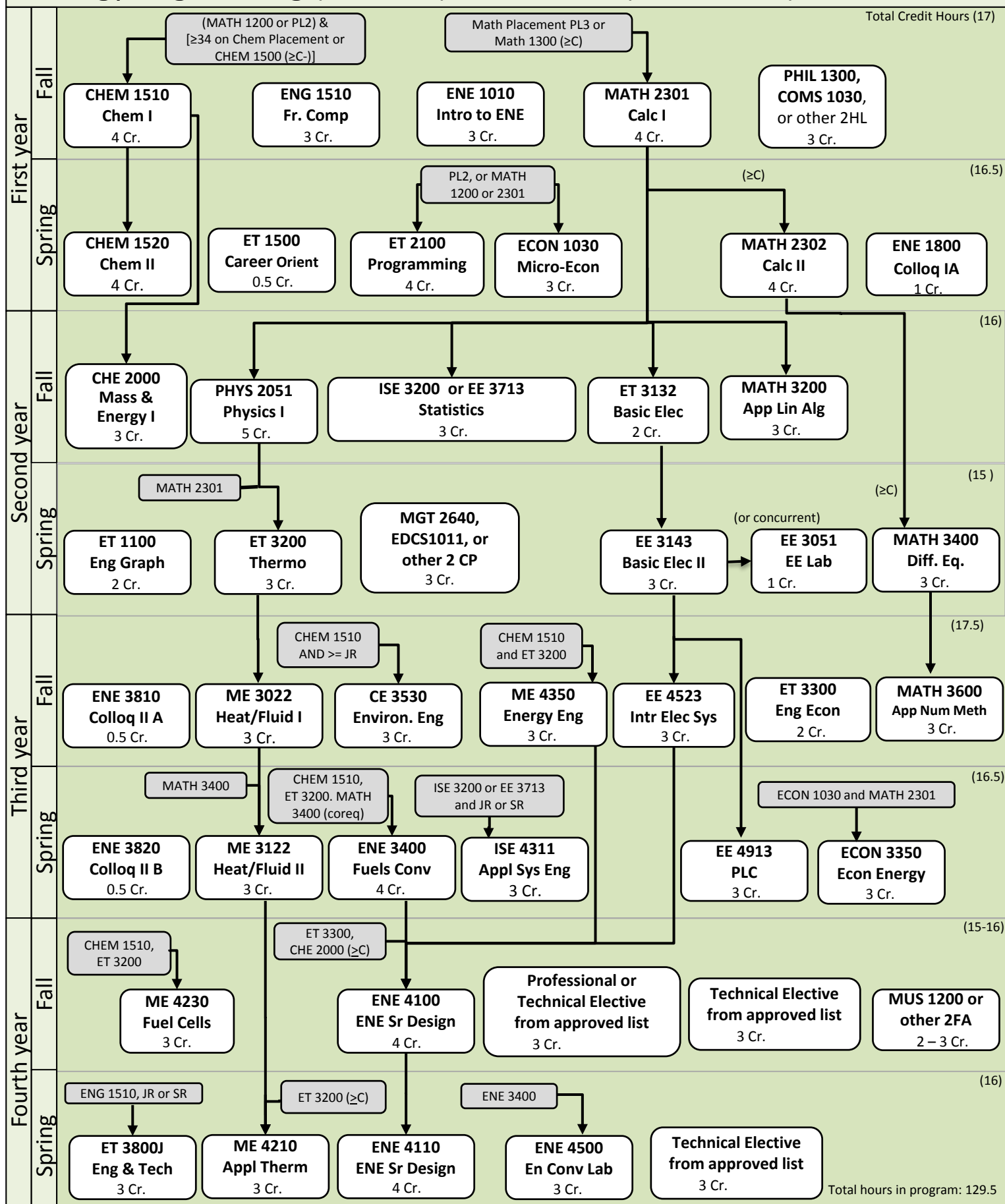
Although enrollment numbers are still modest, we believe we are on target to have an energy engineering program that is sustainable and effective in preparing graduates who have a different fundamental skill set and perspective than graduates of traditional engineering programs. We do not make any claims that undergraduate degree programs like ours are better than graduate degree programs or the other options like minors, but we do believe it was the best decision for our situation. We also believe our program fills an important need and complements other offerings to create a strong network of opportunities to prepare graduates to be innovative and successful in the energy field. We encourage other colleges who are considering educational program responses to our global energy challenges to identify their own strengths and develop other program offerings that complement those already available.

Appendix

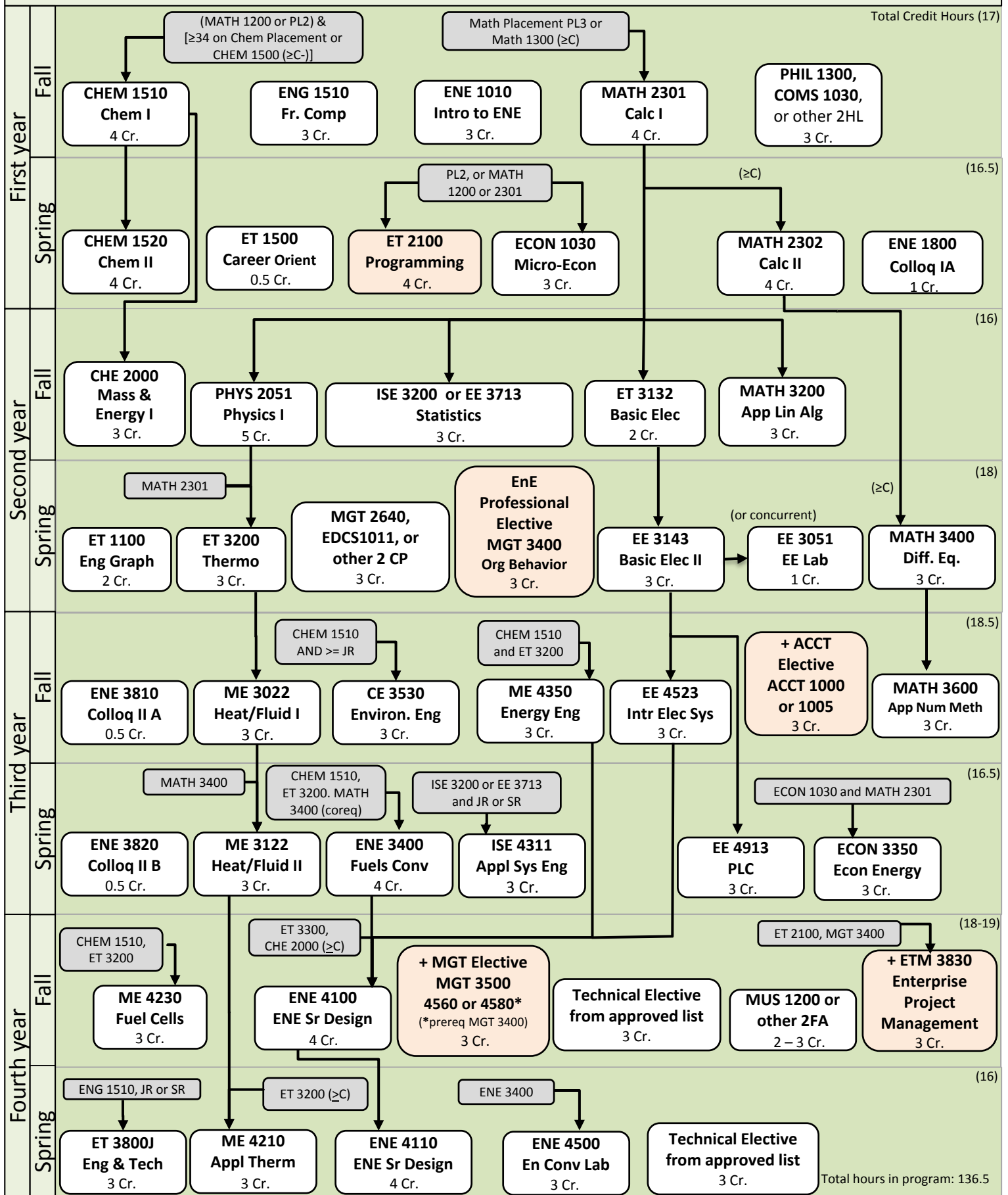
The following pages contain flowcharts showing the courses and prerequisite structure for:

- Energy Engineering undergraduate program
- Energy Engineering + Project Management Certificate (our university's term for an interdisciplinary minor in Project Management)
- Energy Engineering + Strategic Leadership Certificate

Energy Engineering (BS 7274) Curriculum (2017-2018)



Energy Engineering (BS 7274) + Project Management Cert. (2017-2018)



Energy Engineering (BS 7274) + Strategic Leadership Cert. (2017-2018)

