University of Colorado **Boulder**

2018 Program Review

Department of Electrical, Computer and Energy Engineering

Academic Review and Planning Advisory Committee Report

Approved

04/23/2019

Provost and Executive Vice Chancellor for Academic Affairs. | Date

Contents

Process Overview

The review of the Department of Electrical, Computer and Energy Engineering (ECEE) was completed in accordance with the 2018 review guidelines. The Academic Review and Planning Advisory Committee (ARPAC) conducts and writes the final reviews of all Boulder campus academic units. ECEE completed a self-study in December 2017. An internal review committee of two CU Boulder faculty members from outside of the unit checked the study and issued findings in February 2018. The internal reviewers generally found the report fair and accurate and noted several issues for subsequent exploration by the external reviewers and ARPAC. The external review committee, consisting of two experts within the discipline from outside of the University of Colorado Boulder, visited the unit over April 23-24, 2018, reviewed relevant documents, and met with faculty, students, staff, and university administrators. Internal and external reviewer comments and recommendations are cited at appropriate points throughout the report. This public document reflects the assessment of and recommendations for ECEE as approved by ARPAC.

Academic Review and Planning Advisory Committee (ARPAC)

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Unit Overview

The Office of Data Analytics (ODA) annually compiles standardized quantitative descriptions of campus academic units and makes these available online at https://www.colorado.edu/oda/institutional-research/institutional-level-data/information-department/academic-review-and-planning.
This report cites data posted in October 2017, reflecting the state of the Department of Electrical, Computer, and Energy Engineering (ECEE) as of the academic year (AY) 2016-2017.

ECEE includes world-class researchers in several areas of electrical and computer engineering. National laboratory programs including those at the National Renewable Energy Laboratory (NREL), the National Institute of Standards and Technology (NIST), the National Oceanic and Atmospheric Administration (NOAA), and the National Center for Atmospheric Research (NCAR) integrate their research with the department. ECEE has nurtured strong corporate partnerships including with Lockheed Martin and Ball Aerospace that have resulted in commercialized products. Faculty have also created their own start-ups. The external reviewers identified power electronics and high frequency electronics as having significant visibility, along with the groups in remote sensing, control systems, and signal processing and communications.

The department offers the BS degree in electrical engineering and in electrical and computer engineering (with an option in biomedical engineering) as well as undergraduate minors in computer engineering, electrical engineering, energy engineering, electrical renewable energy systems, and signals and systems. The department affords undergraduates the opportunity to pursue concurrent degree programs in a number of disciplines within the field. At the graduate level, ECEE offers

a number of MS degrees including a BS/MS and a professional MS, as well as a PhD in electrical engineering;.

Personnel and Governance

The Department of Electrical, Computer and Energy Engineering self-study identifies 36 tenure and tenure-track (TTT) faculty members (the Office of Data Analytics has 39), consisting of one distinguished professor, 16 professors, eight associate professors, and 11 assistant professors. The department employs two senior instructors and 15 lecturers/djuncts. In addition, three research professors, one associate research professor, one assistant research professor, and 15 postdoctoral fellows work in ECEE. ODA counts 34 non-TTT research faculty as ECEE affiliates. It is not clear how to reconcile the enumeration differences between the self-study and the ODA report. The 12 full-time staff members include two graduate advisors; two undergraduate advisors; a lab coordinator; a grant accountant; an HR/payroll specialist; a curriculum coordinator; an IT director; a procurement specialist; an assistant to the chair; an education, assessment, and innovation program manager; and an office and finance manager. At the time of their review, the external reviewers described three staff positions as vacant.

The department bylaws conform to campus norms with regards to executive structure, voting rights, standing committees, and evaluation procedures. They do not include guidelines on expectations of faculty for annual merit review or promotion and tenure. Both the internal and external reviewers raised the issue of clarifying these expectations (see Analysis). While the College of Engineering and Applied Science (CEAS) has standards in place, University of Colorado Board of Regents policy requires each unit to have its own guidelines.

Research and Scholarship

The ECEE self-study enumerates six broad research areas within the department: power electronics; radio frequency, electromagnetics, and remote sensing; optics, nano-structures, and bio-electronics; computer engineering; dynamics and controls; and information theory, communication, and signal processing. While these distinctions are historically understood in the field, the self-study reports that, “The boundaries between these sub-disciplines are often blurred, since indeed the fundamental advances occur at the interface of several sub-disciplines.”

The National Academy of Engineering, the Optical Society of America, and the Institute of Electrical and Electronics Engineers (IEEE), among other important societies, count ECEE faculty members as inductees. Honors bestowed on ECEE faculty members include several National Science Foundation Career awards and a number of IEEE awards. In addition, awards have recognized numerous ECEE faculty member publications. As previously noted, ECEE faculty members pursue collaborations across the University of Colorado Boulder and with government institutes including NIST, NREL, NOAA, NASA, and NCAR.

An ODA ranking of grants awarded demonstrates that ECEE has a good record, including a 12% increase in grant funding over the last five years. Funding sources include the National Science Foundation, the Department of Energy , the Advanced Research Projects Agency–Energy, the Office of Naval Research, the Defense Advanced Research Projects Agency, etc. Future grant funding looks less certain, especially for NSF funding.

The external reviewers, representing two large public university programs, note that the department’s moderate size might limit

its ability to grow in prestige within the discipline. Nevertheless, they praise ECEE as a center of "several distinguished research areas of excellence." In particular, they laud the power electronics, high frequency electronics, and embedded systems groups for their visibility. An accounting by Academic Analytics counts the department's per capita total publications as falling low in the second quartile of ranked AAU public programs.

Among the strategic challenges that inform an accounting of ECEE funding and space (see Analysis), a noteworthy 50% decline in the count of computer engineering faculty members stands out. The decline appears out of step with strategic developments: technological progress continues to place computer engineering at the forefront of research needs. Despite the remarkable trajectory of this sub-discipline within ECEE, the external reviewers note that the faculty associated with this work have effectively leveraged their strengths by nurturing ties with the Department of Computer Science.

Undergraduate Education

With 419 majors, ECEE ranks seventh in enrollment among eight engineering units. This is in contrast to its TTT faculty member count, which is the largest in this same cohort. Degrees awarded have increased 7% over five years, while the number of majors shows a 17% increase over the same period. The ECEE self-study report describes the undergraduate population over time as "static" while the demand for ECEE undergraduate degree holders has constantly grown. Interestingly, ECEE student number stagnation parallels a nationwide trend.

Even with the department's relatively large cohort of TTT faculty, ECEE lecturers teach an increasing proportion of undergraduate student credit hours (SCH). ODA reports a 42% increase in lecturer-taught SCH over the five-year period 2012-

17. Over the same period, SCH taught by ECEE graduate students declined by 75% and SCH taught by TTT faculty members declined by 9%. Overall, TTT faculty members teach 49% of SCH, including a significant number of hours in individual instruction.

The ECEE self-study describes an ongoing effort to improve the undergraduate program through a “multi-tier continuous improvement process” described as “Plan-Do-Check” (PDC). With a comprehensive look at core courses, degree tracks, and the whole program, ECEE hopes to arrive at an improved and streamlined undergraduate curriculum that will reinvigorate the program. To date, the department has renovated its core freshman courses, reformulated the senior Capstone Design Lab course to better prepare students for industry jobs, added a senior-level entrepreneurship course, and implemented programmatic changes to better engage both students and faculty. In spite of stagnant enrollment numbers, the self-study makes no mention of systematic student recruitment efforts.

The internal reviewers’ survey of ECEE undergraduate students returned a mixed picture of student views. While the results might not be representative of the student population (only 183 of the 419 majors replied), the satisfaction range of those who answered fell between 50-70% range depending on the issue. In particular, the quality of undergraduate advising stood out among the results as a problem. A number of respondents mentioned that they had had multiple advisers over a short period. The success of efforts to revamp advising college-wide to ensure that students are more consistently served remains unknown. Other findings from the ECEE IRC student survey showed that only 70% of students expressed satisfaction with course availability in the major, and only 63% were satisfied with the availability of electives. Students in particular

registered their dissatisfaction with the availability of required computer science courses; ECEE majors noted that they often could not enroll before computer science majors took the available spots. Moreover, CEAS requires all engineering students to take these classes.

The surveyed students reported teaching quality as a consistent concern. Their comments reveal that a favorite instructor left the program and multiple respondents named at least one TTT professor as a poor teacher. In addition, students noted that the department inadequately coordinates course content, saying that the same material is taught across multiple courses. The student survey participants also expressed concern that some courses taught in earlier years covered more material and that this scope reduction left them feeling ill prepared to successfully finish their studies.

The surveyed students also named poor communication around research opportunities as a concern and noted that the faculty did not impress them as encouraging research work in their labs. While the students also registered positive reports about ECEE teaching and research, the number and consistency of their negative responses is cause for concern, especially in light of the department's self-analysis in regard to undergraduate education.

The ECEE self-study includes a plea for institutional-level undergraduate outcomes tracking.

Graduate Education

With 350 graduate students (230 MS/ME, 120 PhD), the ECEE graduate program counts as the largest in CEAS. The 2015 launch of a professional MS in embedded systems engineering has significantly augmented the count of ECEE MS students. The introduction of professional MS programs in power

electronics (2016) and photonics (2017) show similar promise. ECEE is actively involved in including some of the material for these programs in massive open online courses (MOOCs) that are under development. Industry demand for graduates of both the professional and traditional master's degree programs has inspired a curricular redesign. Today, available research funding extends beyond PhD students to include MS students pursuing support for research that leads to a thesis and publication. The option for combined BS/MS degrees also attracts undergraduates to the MS degrees. The unit self-study indicates that professional MS enrollments count for approximately half of all graduate student enrollments. In light of the professional MS program's success, ECEE has undertaken a re-evaluation of the role of the "traditional" master's program.

ODA statistics show that ECEE employs 103 research assistants (RAs) and 23 teaching assistants/graduate part-time instructors (TA/GPTIs). The unit self-study also mentions that some top students have combined RA/TA packages. Student comments mention that Boulder's high living costs do not align well with the size of RA or TA packages. The ECEE self-study surmises that continued PhD program growth will hinge on the unit helping students to identify new funding opportunities (including to develop coursework to prepare students to qualify for competitive external funds).

Nationally, electrical engineering PhD programs have experienced stable to slightly declining enrollments. The ECEE self-study reports a decrease in the department's PhD enrollments from 153 to 117 between 2011 and 2017. Over that time, the contingent of ECEE postdoctoral fellows grew, from three to 19. This timeframe also saw an increase in professional MS students and a decrease in traditional MS student

enrollments. In contrast to the ECEE self-study's evaluation for undergraduate education, the graduate education chapter includes a detailed description of the department's recruitment process (specifically aimed at PhD students), which has clearly been thoroughly considered, and which reflects concern over dropping PhD enrollments.

As it has done for its undergraduates, the unit has added programmatic support to the PhD program to help students to prepare for life after degree, either in industry or academia.

Space and Physical Infrastructure

The Department of Electrical, Computer and Energy Engineering recently completed a well-received and inexpensive ($22,000) renovation of its largest lecture room. A $1 million renovation of its undergraduate electronics lab included additional space to accommodate student growth. Three other teaching labs are in need of renovation, for which ECEE is fundraising and working with CEAS and campus advancement teams. Among other upgrades, the labs need ventilation hoods added, but the poor state of the Engineering Center's heating, ventilation, and air conditioning system does not permit this upgrade. Nor do current Engineering Center space allocations permit the unit to gain needed additional offices, creating challenges for incoming graduate students and staff members. Moreover, there are no restrooms in the ECEE area of the center. To help alleviate these shortcomings, the college plans to move part of the department to the East Campus.

Inclusive Excellence

Although ECEE has not submitted a required inclusive excellence narrative, the unit self-study proposes changes designed to increase faculty and student diversity. To quote the self-study, "the department has been aggressively addressing the issue of inclusive excellence using many strategies: hiring

women faculty, who themselves become role models for our female students; increasing the enrollment and the retention (with better advising) of female and underrepresented undergraduate and graduate students." They have had some success with these projects, increasing the numbers of women and underrepresented minorities in both faculty and student cohorts above engineering department national averages. Campus statistics show a faculty contingent comprosed of 14% individuals who identify as women, 9% who identify as international, and 20% who identify as being from an underrepresented minority population. These numbers place ECEE high among CU Boulder engineering units and moderately high campus wide. The undergraduate student demographics show strong positive growth in women, international, and underrepresented minority student numbers, although these percentages are in the middle of the pack for the current review cycle. The trends are similarly positive for the graduate student cohort.

Climate

While the ECEE self-study report states that ECEE faculty value civility, mutual respect, and collegiality, climate-related incidents within the department have required the chair's intervention. In addition, staff members have indicated that faculty members do not always treat them respectfully. The unit self-study acknowledges these issues, suggesting that ECEE has them under control. However, the external reviewers report,

> several communities within the ECEE department feel marginalized. This discontent is a brewing storm that must be addressed as soon as possible. The marginalized groups include female undergraduate students (which we found influences the experience of all undergraduate students), teaching-focused faculty not on the tenure track, and newly hired tenure track faculty. While the ERC believes most of this problem emanates from a few senior, tenured faculty members,

> the negative impact of their unchecked behavior is a drag on morale department-wide. Furthermore, this environment may have contributed to the departure of some faculty in recent years and is currently creating irreparable harm to the department's reputation among undergraduate students.

A survey of ECEE faculty, staff, and graduate student appointees conducted by ARPAC staff in September 2017 revealed concerning and significant issues regarding climate. Twelve of 26 faculty respondents indicate that faculty intimidate other faculty; 10 feel that there is not a positive sense of community, nine feel undervalued, and seven feel excluded. Staff responses indicated that some faculty were disrespectful; they further showed that women and people of color were singled out for disrespectful treatment. A separate survey of undergraduates, conducted by the internal reviewers indicated that some faculty were openly sexist. And, based on their meeting with students, the external reviewers shared that "multiple female undergraduate students and their male colleagues emphasized the blatantly derogatory and insulting words from some faculty in the department. The students were noticeably stressed by the situation and even more by the non-action of the department and college."

Budget

CEAS provides ECEE a budget that covers roughly $4.5 million in faculty salaries, $545,000 in staff salaries, and $120,000 in operating expenses per year. Indirect cost recovery monies from department-generated grants provide approximately $460,000 per year for new faculty startup packages, departmental matching for large proposals, and large equipment matching funds. While the department balances its budget, large startup packages put a strain on its operations. The Engineering Excellence Fund has helped the department pay for remodels of teaching labs. ECEE has also engaged

CEAS and campus advancement personnel for larger-scale fundraising. According to the ECEE self-study, the department does not receive funds to support incoming graduate students. This has impacted recruiting negatively. The department wishes to fund 15 RAs or TAs per year to retain the best applicants. ECEE has requested that revenues from its professional master's programs go toward addressing various department needs, most especially related to graduate student funding and space renovation/expansion.

Past Reviews

The Academic Review and Planning Advisory Committee (ARPAC) last reviewed the Department of Electrical, Computer and Energy Engineering (ECEE) in 2011. At the time, ARPAC asked ECEE to develop a strategic plan, to identify faculty hiring priorities, to strategize how to fund an increased number of graduate students, to identify and prioritize staffing needs, to work to increase diversity, to streamline the undergraduate curriculum, to reconfigure its space, and to clarify faculty evaluation criteria. The 2018 ECEE self-study updated ARPAC on progress in these areas but still offered no strategic plan. Since 2011, ECEE has hired nine assistant professors and one associate professor with some attention to specific areas of expertise. Graduate student funding has increased as a result of increased research funding (from $9 million to $12 million). In addition, ECEE proposes increasing the number of TA offers to deal with future needs based on a desired increase in undergraduate numbers. The department has almost reached its targeted number of graduate students, and as previously mentioned, enrolls the largest graduate student population in the college. Staff numbers have increased. Faculty hires have increased gender diversity (now at 18% women), and the student body has become more diverse, too. Efforts to streamline and revise the curriculum are ongoing. The department has addressed some space issues, but shortfalls continue to present challenges. Faculty evaluation criteria remain insufficiently clarified, as pointed out by the 2018 internal review committee.

Campus Context

The Department of Electrical, Computer and Energy Engineering serves as a nexus for collaborations both within CEAE and campus-wide. The ECEE senior capstone project, for one, is designed to allow students to work broadly across disciplines. Such work involves research undertaken with personnel in Aerospace Engineering, Physics, Chemistry, Biochemistry, Molecular, Cellular and Developmental Biology, Applied Mathematics, Mechanical Engineering, Chemical and Biological Engineering, Integrated Physiology, and Neuroscience. Cross-disciplinary collaborations also involve researchers at the Anschutz campus medical school, and with NIST and NREL. Four ECEE-housed centers also work to promote the department's outreach within CU Boulder and beyond: Colorado Power Electronics Center (CoPEC); the NOAA-CU Center for Environmental Technology (CET); the NSF STC on Real-Time Functional Image (STROBE); and the NSF MRSEC Soft Materials Research Center.

Disciplinary Context

Despite its moderate size, ECEE retains a strong national profile, particularly in the areas of power electronics and high frequency (RF) electronics. The professional master's degree offerings, including online degrees, have likewise helped to raise ECEE's profile. The external reviewers note that the computer engineering group is small and young but nationally well known; the unit self-study expresses concern that that, as a result, it has been difficult to retain faculty in this area.

The department's numerous undertakings with national labs also speak to the importance of ECEE research ties and their national visibility. In addition, ECEE faculty work regularly with colleagues at major US research programs, demonstrating the department's place in a strong collaborative network.

Data gathered by Academic Analytics show that the department ranks within the top fifty percent nationally of AAU public electrical engineering programs for collaborations, grants, and publications.

Analysis

The Department of Electrical, Computer and Energy Engineering boasts a distinguished faculty contingent, a large and growing graduate program, a strong campus presence, and a nationally respected research profile, including demonstrated success in attaining research funding. However, a negative department climate threatens these strengths. The unit must find ways to establish and maintain a supportive and safe environment for faculty, staff, and students. Only a welcoming and inclusive climate will make it possible for the unit to significantly build on recent diversity gains. ECEE also faces a number of other pressing challenges, including a shortage of space to accommodate projected enrollment growth and outdated laboratory, teaching, and office spaces, as well as challenges in retaining faculty in critical program areas, especially computer engineering. ARPAC believes that a better focused department with a common future vision will successfully address these pressing issues. In order to facilitate that development, ARPAC recommends (as it did in 2011) that ECEE create a strategic plan.

Climate

The unit self-study acknowledges climate concerns, but the extent of the problem appears larger when considered in the light of internal review student questionnaires and the findings of the external reviewers. Undergraduate students and staff in particular report a lack of civility and blatant sexism from professors as well as from some students. In addition, ECEE undergraduates report a lack of mechanisms to register concerns and a lack of department responsiveness. ECEE has recently created a climate committee staffed by faculty, staff, and student representatives to suggest solutions. ARPAC agrees that this is a start, but believes that an effective remedy will require a action taken above the department level. That step might involve the creation of a written conduct code and a structure to report and sanction violations. The available

evidence points to a small number of senior faculty members as a root cause of a big problem. The external reviewers write,

> The department, the College, and the University need to immediately address the behavior of a seemingly few faculty that discredits, discourages, and disparages under-represented students and faculty. In particular, multiple female undergraduate students and their male colleagues emphasized the blatantly derogatory and insulting words from some faculty in the department. The students were noticeably stressed by the situation and even more by the non-action of the department and college. This situation was also echoed to the ERC during our short meeting with the departmental staff. While many in ECEE are aware of the problem, there is no reporting structure or accountability for addressing this issue. Several undergraduates voiced their disdain and said that they would discourage future students from studying in ECEE until the situation improves. While the ERC is still not clear on all details, the departure of a highly effective, non-tenure-track teaching faculty member who has been heavily engaged with students, particularly early in their studies, may be partly due to a lack of respect from the few problematic faculty and is seen by the students as a significant step backwards for student/faculty interactions. We note that we met with the students for about 45 minutes and were astonished at the clarity of their remarks and the stress caused by this situation. We caution that, if we left with this negative impression after a relatively brief visit to campus, future employers and supporters of the department will certainly hear of this soon, if they have not already. This is unfortunate, that the actions of a few are taking away from the incredible work of the majority of the faculty and staff. In discussing this situation with other university representatives from outside of ECEE, there were indications that these problems extend, at least to some extent, beyond ECEE. As this sort of situation could easily blow up at any time and cause irreparable damage to the campus's reputation, actions should be implemented at the College level to drive a potentially significant culture change.

ARPAC understands that the CEAS dean's office has begun working with ECEE on climate concerns. Nevertheless, ARPAC remains deeply concerned about the ECEE climate. The unit's future success will depend on its ability to successfully create a culture that supports and encourages a diverse student, staff, and faculty population.

Strategic Planning

The 2011 ARPAC review recommended that the Department of Electrical, Computer and Energy Engineering undertake a robust strategic planning process. The unit's 2018 self-study reports some progress related to planning and inserts the adverb "strategically." However, much of the reported progress appears piecemeal and has not established a clear overall department plan. A more substantive strategic planning process might discuss ECEE's circumstances in relation to its aspirational peers. A consideration of appropriate metrics (publications, collaborations, grant funding, conference presentations, etc.) might help to focus comparisons. The department has positive news to report, including the evolution of curricula across all degrees, and progress with increasing faculty and student diversity. Discussing these advances as part of a concerted planning effort involving broad unit member participation could do much to advance ECEE, and could also have a positive effect on climate. Admirably, the chair has organized retreats and regular meetings, but, again, it seems that these have not led to a unifying strategic vision or goal.

ECEE needs to enunciate a clear mission setting forth both pedagogical and research goals. ARPAC agrees with the external reviewers that a strategic plan needs to emphasize building on the program's strongest parts rather than trying to do everything. As a moderately sized electrical engineering unit, ECEE will have a stronger profile by emphasizing and supporting its best programs. A carefully considered strategic

plan, encompassing a broader vision as well as specific action items will better equip the department to deal with the issues addressed in this report's subsequent sections. Finally, ECEE should align its strategic planning work with the recently completed college strategic plan.

Undergraduate Education

The unit self-study identifies stagnant undergraduate enrollments as a concern, and ECEE has implemented a curricular review to ease student navigation of the major. While the unit has made a good start by tackling curricular issues and implementing solutions, reversing stalled undergraduate enrollments will depend on additional adjustments such as improvements in outreach and recruitment (currently not addressed in the self-study), as well as helpful changes in department climate, course availability, teaching quality, and advising. The students' answers to the internal reviewers' survey made their pressing concerns about deficiencies in these areas clear. Word of mouth is powerful, and when ECEE students announce that they wouldn't recommend ECEE at the University of Colorado Boulder as a major to a high school student (as the external reviewers report), that message needs to resonate loudly and clearly with department faculty members.

As part of a strategic planning process, the department needs to enunciate a clear undergraduate-program pedagogical mission. In addition, the department needs to stabilize student advising, as high advisor turnover has reduced students' ability to receive consistent and high-quality advice. ARPAC hopes that the new CEAS advising organization might alleviate some of the concerns that ECEE students called out.

ECEE tenured and tenure-track faculty, instructors, lecturers, adjuncts, and TAs (whose numbers are expected to increase) all

need to work together to better align their undergraduate course offerings. In addition, teaching mentorship needs greater reach and consistency: the department should expand teaching guidance beyond mentoring available to TTT faculty members for success in the tenure process. Notably, the department's growing dependence on lecturers appears to have exacerbated the problem of maintaining curriculum consistency.

As class sizes increase, the unit will require larger spaces to accommodate introductory courses. Cooperation with other units will be necessary to ensure that there are spaces available in required courses that are not offered by ECEE itself. The department should take care to evaluate incoming undergraduate students' knowledge of basic topics to ensure that they place correctly in introductory class. This should also have the advantage of keeping students appropriately challenged and of reducing enrollments in some currently over-subscribed required courses.

In their exit interview, the external reviewers noted that the department appeared to lack a student-centered outreach program. The department should make such a program the focus of strategic planning, and should consider assigning it to one of the currently vacant staff lines. The external reviewers' report concludes with this paragraph, which ARPAC urges ECEE to act upon:

> The ERC found it interesting that the Outreach Initiatives section of the ECEE Self-Study only described departmental interactions with its Industrial Advisory Board. Many peer departments would have also described their interactions with the community, especially with pre-collegiate students. Although this sort of activity may not be part of the culture at CU Boulder, it can help to establish a steady pipeline of high

quality students. The state of Colorado has a strong collection of technology companies, many of whom may already be involved in K-12 outreach. Collaborating with some of those companies in this area could also provide a mechanism for further developing department/industry ties.

ARPAC joins the external reviewers in endorsing the establishment of an ECEE undergraduate student advisory board with membership drawn from current students. As the external reviewers note, such a board could help to build a population of student ambassadors whose interests might align nicely with the department's outreach and recruitment needs.

ARPAC also concurs with the unit self-study in its plea for detailed post-graduation student outcomes reporting. Such information should also help the department support its outreach and recruitment efforts.

Graduate Education

ECEE's professional master's tracks have succeeded in bringing student numbers and revenues up. They have also taken some energy and attention away from the traditional MS and BS/MS tracks, as well as from the PhD. A strategic planning process should carefully consider such a dynamic and ask questions about the graduate programs' focus. ECEE has already undertaken strong initiatives for graduate curricular improvement, including encouraging, indeed requiring, cross-disciplinary and entrepreneurial work. These promising efforts should continue, and consideration should be given to making sure that the department's human and monetary resources align with a well-understood graduate program mission.

The department will need to secure more generous PhD funding packages to grow the program and compete with peer programs for the strongest applicants. A more focused

department mission, one that emphasizes existing areas of excellence and national prominence, should also aid PhD student recruitment. ARPAC supports ECEE's plans to increase the number of TAs as an answer to shortfalls both with undergraduate teaching needs and with graduate student funding packages. As that plan moves forward, it is ARPAC's hope that the unit will decrease its reliance on lecturers to deliver undergraduate courses. The unit expresses the wish that professional master's revenues be returned to the department. However, it is ARPAC's understanding that professional master's revenues are in fact supporting the professional master's programs.

Faculty Retention

The external reviewers link the department's difficulties retaining junior faculty with climate issues. The internal reviewers did not explicitly make this connection but cited a lack of clearly articulated promotion and tenure evaluation criteria. In response to the 2011 ARPAC review, the unit's self-study acknowledges that work to clarify the criteria or make them more flexible has not occurred. The external reviewers suggest that ECEE faculty workload guidelines do not accurately account for individual faculty members' strengths. For one, they do not account for differences in research activity versus teaching loads. The external reviewers suggest a classification system such as "highly research active or low research active" correlated with lower or higher teaching contributions. This is based on their observation that the department appears to assign more research-active junior faculty members to teach larger sections while some less research-active senior faculty members get out of heavy teaching loads. ARPAC believes that the department must address this discrepancy and urges ECEE to ensure that senior faculty continue to teach the larger undergraduate courses. The department should make sure that appropriate weight is given

to department and college service as well as teaching and research in both its annual merit and tenure and promotion processes.

The department also needs to integrate instructors more fully into the department's curricular development and governance. As a critical part of the ECEE teaching faculty, instructors have important contributions to make to these discussions. The department would be wise to consider what the instructors have to say about undergraduate pedagogy. The department also needs to better support instructor teaching by implementing a broader mentoring structure.

The unit should follow up on the 2011 ARPAC recommendation that "Faculty should be given a clear explanation by the dean and department chair of whether and how the 'quality' of publication is taken into consideration in evaluations of their professional activities, (e.g., what metric(s) is/are used to assess quality?). Faculty also should be instructed about how an assessment of the quality of publications relates to the assessment of the quantity of publications."

Postdoctoral Fellows

The department must do more to support its postdoctoral fellows. The fellows, who ECEE employs to teach and conduct research, require clearer expectations and guidance for their work. A mentoring structure might help to give the fellows a better chance in succeeding in subsequent commercial and/or academic environments. Such a structure would also help ECEE-affiliated principal investigators in describing to the NSF and other grant-giving organizations how they plan to support postdoctoral fellows on grant monies.

Space and Infrastructure

The external reviewers describe ECEE's current space situation as "dire." The evidence supports their assessment. The unit

faces challenges around aging teaching labs, including poor air-handling capacity from a lack of lab ventilation hoods, insufficient office space to support current and projected needs, inadequate access to adequate classrooms, and the absence of contiguous restroom facilities. While ECEE has tried to make the best of a difficult situation, including by renovating existing facilities, this band-aid approach has little long-term chance at sufficiently addressing the shortfall. The college and the campus must work together to address ECEE's needs and those of other units operating in an aging facility with a limited footprint. ARPAC understands that the path to a sustainable solution will likely involve inconvenient temporary displacements but believes that ultimately ECEE should arrive in a contiguous space. ECEE has initiated major fundraising activities in support of space improvements with college and campus advancement teams. It is ARPAC's belief that this effort will be more successful if it is in the service of a strategic plan that describes a long-term department vision.

Staff

The lack of an adequate personnel contingent continues to frustrate ECEE. As of a spring 2018 count, the department had three vacancies among 12 staff positions. ECEE would like to have 15 positions in total. In particular, staffing for academic advising challenges the department. High advisor turnover has resulted in a less than ideal undergraduate experiences. In addition to targeting climate concerns, ARPAC again places hope in the department's engaging in a strategic planning process. The process should present ECEE with an opportunity to better grasp its current and projected staffing needs. The department plan should arrive at clear and effective responsibility assignments and an optimal personnel number (whether the 15 currently envisioned or some other total). The plan should consider the external reviewers' recommendation that staff lines include positions dedicated to protecting and

maintaining current and projected equipment investments and renovated teaching lab space.

Inclusive Excellence

The Department of Electrical, Computer and Energy Engineering understands the challenges that it and other engineering departments face when working to increase women and minority representation across faculty, undergraduate students, and graduate students. While current numbers represent a notable improvement over the last review cycle, a count of 19% women representation on the faculty should be seen only as a first step. Disturbingly, the climate survey administered as part of this review indicates that the growing gender and ethnic diversity of the department is not welcomed by all, with evidence that a few senior faculty in particular create a hostile environment for some. To help with the work of creating a welcoming and nurturing community, ECEE should engage all available campus resources (including the Office of Diversity, Equity and Community Engagement, the Office of Institutional Equity and Compliance, etc.). Absent significant climate improvements, gains in women and minority representation might end. ECEE should also take advantage of national organizations like IEEE to research climate improvement strategies. The department could also look to work underway at peer institutions, such as the Women in Science and Engineering (WISE) initiative at the University of Arizona. Other University of Colorado Boulder engineering departments, too, provide opportunities for learning (including Chemical and Biological Engineering and Computer Science, that both have a larger percentage of women at all levels). ECEE has made a good start, and ARPAC looks forward to a continuation and expansion of efforts to create an inclusive atmosphere welcoming a diverse population. ARPAC urges ECEE to complete and submit its required inclusive excellence narrative as part of this process.

Recommendations

The members of the Academic Review and Planning Advisory Committee address the following recommendations to the Department of Electrical, Computer and Energy Engineering (ECEE) and to the offices of responsible administrators:

To the Unit:

1. Work with the ECEE climate committee, the College of Engineering and Applied Science, and campus administrators to communicate policies concerning uncivil and disrespectful behavior; these policies must include a written conduct code as well as a reporting structure for faculty, staff, and students. Include existing campus structures including the campus Professional Rights and Duties of Faculty Members policy. In addition, ECEE needs to be prepared to report and act on violations, including applying sanctions as called for by campus policies. Report to the dean and to ARPAC on the creation and implementation of the written conduct code. Reach out to the Office of Institutional Equity and Compliance and director of faculty relations to institute training for faculty and staff. All members of the department need to model appropriate behaviors, particularly in how faculty interact with staff members and with students.

2. Institute a strategic planning process. Strategic planning should address:

    a. A unifying department pedagogical and research mission, with a focus on ECEE's current strengths and long-term aspirations. Regarding undergraduate teaching, "pedagogical" includes classroom teaching, curricular reform, academic advising, as well as research opportunities with faculty.
    b. Specific plans for future faculty hiring with attention both to programmatic needs and diversifying the faculty,

c. Optimal utilization of staff as well as optimal staff assignments (including for outreach and advising work)
d. A detailed consideration of current and future space needs including for labs, offices, and teaching facilities.
e. A review of the balance between traditional and professional master's degree programs.

3. Build on good first steps to recruit more women faculty as well as more faculty from other underrepresented populations. Ensure that the unit climate and mentoring structures optimize opportunities to retain these faculty members.

4. Establish mentoring policies for postdoctoral fellows that prepare them for work within and outside of academia.

5. Establish and implement guidelines (in cooperation with the college) for tenure and promotion and merit evaluation that conform to regent law and policy and incorporate standards for quality of research, not just quantity. University rules require that each unit have clear written criteria for annual merit, reappointment, tenure and promotion.

6. Ensure that teaching loads for tenured and tenure-track faculty equitably distribute teaching of larger classes between junior and senior faculty.

7. Include instructors as appropriate in faculty governance and curricular development. The unit should review its bylaws to make sure that they comply with university and campus rules: in particular, all departments should have explicit bylaws regarding instructors, senior instructors, and teaching professors, in keeping with the Academic Affairs Response to the Task Force on Instructors.

8. Continue and expand efforts to recruit a more diverse and inclusive population of undergraduate and graduate students. Ensure that the unit climate is conducive to attracting and retaining women students and students from other underrepresented populations.

9. Complete and submit an inclusive excellence narrative.

10. Create an outreach program to high school and transfer students designed to increase the size of the undergraduate class. Involve faculty members and current ECEE students in the process and seek guidance from the college and from the Office of Diversity, Equity and Community Engagement's Precollegiate Development Program.

11. Consider introducing tests to help unburden over-subscribed introductory courses and to avoid mismatches between class materials and and students' prior academic preparation so that students can be placed appropriately.

12. Actively communicate research opportunities to undergraduate students. Incentivize professors to include undergraduate students in their research plans, taking advantage of campus resources like the Undergraduate Research Opportunities Program (UROP).

13. Work with the college to improve and increase the number of graduate student packages, building on unit success in creatively combining TA and GRA awards. An increase in undergraduate numbers and a shift of teaching from short-term lecturers could aid in justifying increases in TA/GPTI numbers.

14. Following on the completion of a strategic plan, work with college and campus administrators on short-term and long-

term space shortfall solutions. The solutions should improve undergraduate teaching and lab spaces, research labs, offices, as well as amenities including bathrooms. Make a case for securing long term contiguous space.

15. Work with college and campus advancement personnel on a fund-raising plan. Leverage the to-be-completed strategic plan to help with fund-raising targeted at urgent needs including for new and renovated space as well as graduate-student fellowships.

16. Advocate with the college to gain an optimal staffing complement. Advisors and lab technicians are two areas in need of particular attention in terms of stability and workload.

To the Office of the Dean:

17. Support ECEE in improving the climate for faculty, staff, and students. Ensure that ECEE creates a written conduct code and reporting structure to deal with climate issues. Ensure that policies on uncivil behavior are appropriately communicated and enforced.

18. Work with the department to ensure that ECEE complies with regent policy in creating annual merit, reappointment, promotion, and tenure guidelines.

19. Work with the department to ensure that ECEE's bylaws and governance structure conform to university and campus policy regarding instructors, senior instructors, and teaching professors.

20. Work with ECEE to improve and increase the number of graduate student packages; consider an increase in TA/GPTI positions as part of this plan.

21. Work with ECEE and the senior vice provost for academic resource management to address short- and long-term space issues, including teaching spaces, labs, and offices, as well as necessary amenities, like bathrooms.

22. Work with ECEE and the Office of Advancement to put together a fund-raising plan predicated on clearly defined goals enunciated in the strategic plan requested in this review process.

23. Work with ECEE on staffing and on creating an undergraduate advising staffing plan that works both for the unit and the college.

To the Office of the Provost:

24. Instruct the senior vice provost for academic resource management to work with the College of Engineering and Applied Science on short- and long-term space solutions for ECEE.

Required Follow-Up

The Department of Electrical, Computer and Energy Engineering chair shall report annually on the first of April for a period of three years following the year of the receipt of this report (i.e., April 1st of 2020, 2021, and 2022) to the dean of the College of Engineering and Applied Science and to the provost on the implementation of these recommendations. Likewise, the dean shall report annually on the first of May to the provost on the implementation of recommendations addressed to the college. The provost, as part of the review reforms, has agreed to respond annually to all outstanding matters under their purview arising from this review year. All official responses will be posted online.