April 22, 2021

TO: Karl Scholz, Provost
    William Karpus, Dean, Graduate School

FROM: David A. Noyce, Executive Associate Dean

RE: Review of the Power Conversion and Control Capstone Certificate

At its April 21, 2021 meeting, the College of Engineering Academic Planning Council (APC) unanimously recommended for approval the attached review and self-study of the Power Conversion and Control Capstone Certificate in the College of Engineering.

The review committee found the program is meeting the prescribed student learning objectives and enrollment of students from historically underrepresented groups has steadily grown over the past three years. The program provides excellent preparation for those students interested in enrolling in the Master of Science in Electrical Engineering, Power Engineering named option program.

The review committee did note that growth in the program is stagnant and suggests that the program include additional courses in grid applications to expand the pool of those that may be interested in the program.

On behalf of the College of Engineering, I accept the APC’s recommendation to approve this program review.

Attachments: Review Committee Report
               Department Self-Study

cc: Jocelyn Milner, APIR
    Karen Mittelstadt, APIR
    Parmesh Ramanathan, Associate Dean, Graduate School
    Jenna Alsteen, Graduate School
    Chris Brace, Assistant Dean for Graduate Affairs, College of Engineering
    Andrea Strzelec, Program Director
    Ed Borbely, Associate Dean, InterPro/Engineering Professional Development
    Sara Hagen, Academic Planner, College of Engineering
    Dan Ludois, Program Review Committee Chair
A. A summary of the activities of the review committee and materials reviewed

The committee members reviewed the self-study document to formulate questions and follow up discussion topics with key people in the program. Three separate interviews were conducted: 1. Program Faculty, 2. Program Administrators, and 3. Students.

1. Program faculty members Giri Venkataramanan and Bulent Sarlioglu met with the entire review committee for an hour-long discussion on the program. Tom Jahns shared comments with the Chair separately due to schedule conflicts, but his comments aligned with those made by Giri and Bulent. The faculty confirmed the history of the program, its technical rigor and its strong affiliation with UW research group Wisconsin Electric Machines & Power Electronics Consortium (WEMPEC). Since WEMPEC is a large industrial consortium, it serves as a recruitment tool for the capstone program. When the committee inquired about apparently high drop rate, the faculty said that was a multi-variable problem. They anecdotally shared that the program students are all professionals with full time employment in industry, some of which have been out of school for several years, and the program can be especially challenging given the time commitment and requisite “dusting off” of dormant skills. Overall the faculty were clearly proud of the program and confirmed the contents of the self-study.

2. Program administrator Daryl Harrison was interviewed by the committee and provided excellent additional information/clarification on the program. First, she clarified the enrollment statistics, revealing their true meaning. Since 2015, 130 students have signed up for the capstone, with 113 enrolling in courses. Of these 113, 78 have completed the capstone. Of the 78 that have completed the capstone, 52 have gone on to the MS program. Daryl has kept meticulous notes on the students participating in the program and tracked reasons for dropping out or taking a pause in the program. (some students will take a gap between courses) The primary reasons are due to the life circumstances of the students and the rigor of the program (meeting minimum GPA requirement). Sample student feedback Daryl received for students dropping or pausing includes:

“…too much calculus...” “...too much responsibility at work...” “...military deployment…”

The committee and others we interviewed agree that these reasons reflect the life stage of the students participating in an online professional program, rather the program itself.

Other information provided by Daryl were detailed enrollment statistics/demographics. This took the form of a slide deck with additional data on program diversity and enrollment statistics beyond those in the self-study. The committee learned that while enrollment on an annual basis is relatively flat/consistent, participation of underrepresented groups is
increasing. Below is a plot of the demographics for the MS Online program for which the Capstone Program is a feeder. Daryl said that she has been using the Society of Women Engineers (SWE) and the Society of Black Engineers Conferences as recruiting venues for the Power Capstone and the MS Online programs. A female student interviewed confirmed that she came across the program via recruitment efforts at SWE. This suggests that current outreach initiatives are effective and should be continued/expanded.

3. **Program Students** The committee reached out a current program course, ECE 412, to seek students to gather feedback from. We set up a meeting room during office hours to allow students from the program to speak with us if they chose to. One student participated, and we asked her to paint a picture of her program experience and what her motivations were for participating in the program.

The student graduated in mechanical engineering from Grand Valley University MI in 2016, and is now a practicing engineer in Kalamazoo MI. Currently, her career focuses on next generation batteries (cell technology) as a design engineer and sees herself continuing with her current employer (although not necessarily forever). Her work in batteries is mostly on cordless power tools and she has had little background in ECE (thus her interest in gaining more). She appreciates the PC capstone starting from scratch, i.e. building the material from the ground up. The student initially found program via google, attended a SWE conference in 2019 and met UW recruiter (likely Daryl). She compared the UW program with Michigan State University and wanted a “new” school outside of Michigan. Thus far she really enjoys the PC capstone and plans to continue with the online MS here at UW. To complete the capstone, she needed a prerequisite (ECE 355) and is in her third of four courses (and will take the last one over summer). She is currently in 412 and likes
the class because of classmate (peer) interaction but sees challenges for students from other countries. Prior to the UW PC capstone she took only one online undergraduate summer course at MSU before (which was very modular based and non-interactive). She interacts with a study group of 2 – 4 other students in class that she is on a first name basis with. Her prior two classes (355 and 411) had mandatory class participation (with optional class opportunities), and equal TA-prof-student interaction. ECE 355 had more Piazza and less student-to-student interaction. Her current course, ECE 412, is a flipped classroom whereas 355 and 411 were more traditional recorded lecture classes. She endorsed the recommended class order and thought it was very helpful; having taken 411 after 412 would have increased the gap between 355 and 411, not that 412 material would have required 411 material.

B. An evaluation of the strengths and weaknesses of the program,

Strengths: The program is strong and healthy for reasons enumerated in the self-study. These primarily include a roadmap towards the MS program, filtering out weaker candidates for the MS program, establishing a link between UW research and students, a high quality and societally relevant curriculum, growing diversity of the student body, etc. Information provided beyond the self-study by interviewing program faculty (Venkataramanan, Sarlioglu, Jahns) and administrators (Daryl Harrison) supported the claims of the self-study, i.e. it appeared accurate. Student feedback also supported the self-study and was very positive overall. See the self-summary for further strength details.

Weaknesses: The primary weakness of the program that the committee identified is relatively static enrollment. Mechanisms to grow program enrollment should be considered.

C. Advice to the program, dean, and/or provost for improving the program,

Expand the definition of diversity in the self-study document. It seems primarily focused on women rather than broader underrepresented groups in engineering. However, the data provided by Daryl Harrison clearly shows broader diversity data is being tracked, just not indicated in the self-study.

Expand the program to include one or two more courses related to power conversion and let students select 3 of 4, for example. This could bolster enrollment by casting a broader net within power conversion industries.

D. Recommendations for future directions

The primary recommendation for the program is the expansion of term “power conversion” to be broader within the context of electrical engineering. For example, the Power Conversion Capstone is narrowly focused on machines (ECE 411), power electronics (ECE 412) and Controls (ME 446). Historically the committee understands why this was done, these are the core areas for electric drive systems that pertain to culturally relevant topics, e.g. electric vehicles, industrial automation, etc. The program can expand to include electric grid related topics (ECE 427). This would expand power conversion capstone to include Grid topics such as power systems, solar, wind, etc. that are
also affiliated with power electronics and control. A student participating in the capstone could then select 3 of 4 four courses, tailoring their power conversion focus to their educational or professional development needs. The broader scope would attract a broader group of professionals/companies, effectively growing the program, with minimal effort. This idea was discussed with program faculty and administrators and they agreed with it.

E. Specifications for any necessary follow-up action

No specific actions are necessary beyond the considerations outlined above.
Self-Study for Capstone Certificate in Power Conversion and Control

Date submitted: 11 January 2021

Primary Contacts: Dr. Andrea Strzelec, Program Director (strzelec@wisc.edu) or Ed Borbely, Associate Dean of Engineering Professional Development (borbely@wisc.edu)

Department: College of Engineering Office of Professional Development

School/College: College of Engineering

1. Program Description and Context

The Power Conversion and Control Capstone Certificate (PCC) addresses the learning goals of practicing engineers by providing further study with senior, highly respected faculty in the UW–Madison College of Engineering. It provides engineers with an opportunity to gain specialized expertise, including technical knowledge of power electronics, drives, and controls. The certificate also provides a “stepping stone” for students wishing to apply for admission to the university's online Master of Science: Electrical Engineering named option in Power Engineering.

The curriculum was developed in response to needs identified by more than 80 corporate sponsors of the renowned Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). The Capstone was developed to offer a credential for professional electrical engineers looking to focus their knowledge on power electronics but not ready to undertake a full Master’s.

The format of the Power Conversion and Controls Capstone Certificate is completely online to accommodate working professionals. The 9-credit capstone certificate was designed for completion in three consecutive terms of 3 credits (one course) per term. Fundamental coursework in electrical engineering is a prerequisite, as is coursework in electromechanical energy conversion. (ECE 355 Electromechanical Energy Conversion is available online for admitted students).

The Learning Outcomes for the program are:

1. Analyze how torque and speed are controlled in the major classes of electric machines
2. Evaluate how power electronics are used to perform electrical power conversion from one form into another.
Further details, including current tuition and costs, are provided on the program's website.

2. Demonstration of Need and Recruitment/Outreach Include populations targeted, data to demonstrate need, and efforts to recruit/inform students

Need for the program: The Power Conversion and Control Capstone Certificate was developed based on an identified need from the ECE: Power MS program. The first 3-4 courses of the Master’s program were packaged into this graduate capstone, which became a pre-requisite for admission to the ECE: Power MS program. Students must complete the capstone with a minimum GPA of 3.3 to be eligible for admission to the Master’s program. This ensures that students will be successful in the MS program, which is a rigorous set of electrical engineering courses. From Fall 2015 to Summer 2020, 144 students were admitted to PCC, and 56 (43%) went on to the Power MS. The PCC program allows them to collect a certification even if they determine that the Master’s program is not right for them, or if they don’t make the Master’s GPA cutoff. This is an important factor for the US News and World Report ranking of the Master’s program as well – as it keeps students who wouldn’t be competitive in the program from enrolling, and maintains our completion statistics.

Targeted population: The program is targeted to highly skilled electrical engineers working in the field of power electronics. WEMPEC member companies are particular targets for this program, as are participants in the Power Electronics short courses taught in EPD.

Recruiting Efforts: Although hampered in 2020 by the COVID-19 pandemic, recruiting efforts for this program are quite vigorous. EPD presents the PCC as part of our portfolio in a variety of graduate fairs (UW, Oak Ridge National Laboratory, etc.), conference expositions (IEEE, ASME, SAE - Society of Automotive Engineers, SWE - Society of Women Engineers), to the WEMPEC member companies at the annual consortium meeting, and in all of the relevant EPD short courses in automotive engineering and power electronics. Recruiting efforts are further supported by Department of Continuing Studies staff with webinars, email campaigns, and inquiry responses.

3. Program Administration and Resources Include a description of academic administration and a description and evaluation of the fiscal model (if appropriate)

Academic Administration: The program is administered by a collaboration between ECE faculty and an EPD Program Director (PD, Dr. Andrea Strzelec assumed responsibility of this program in May 2020) with the invaluable help of Student Services Specialist (SS) Ms. Daryl Harrison. The PD and SS handle student inquiries, recruiting, and manage admissions. Admissions decisions are made by the ECE faculty assigned by ECE to the PCC/Power MS Admission committee. The courses are taught by ECE faculty, lecturers and EPD lecturers.
Fiscal Model: EPD and ECE have just established a new fiscal model for this program, which went into effect in Fall of 2020. In this new model, the program revenue is split 10-45-45% between the COE, ECE and EPD. ECE has taken on the responsibility of all of the instructional costs (faculty, TA, grader), which was previously the responsibility of EPD.

4. Advising and Student Services

Advising: Advising for the capstone is standardized based on the capstone curriculum offering schedule. Whether students need to take 3 or 4 courses is determined by the admissions committee as part of the admissions process. Therefore, advising is done by Student Services and is programmatically limited to making sure that the students know which of the courses are being offered in a particular semester, providing help with registration enrollment, and guiding students appropriately to the Power MS application.

Student Services: EPD has a team of three Student Services Specialists, who are each assigned to lead specific programs, but can assist students in any program in an as-needed basis. In particular, Ms. Daryl Harrison has been the Student Services Specialist since the inception of the program. She has an exceptional reputation with the students in the program, and represents the continuity of the program (PDs, faculty have changed) as the students transition into the Power MS Program. Daryl provides guidance on “all things related to being a student at UW-Madison” – which includes helping students register, helping them navigate the Bursar’s office, and providing them information on available training available such as the Online Student Learning Orientation.

5. Faculty/Staff Participants

Include a list of participating faculty, instructional staff, administrative staff with their role and department affiliation noted

Faculty: Prof. Tom Jahns, ECE
         Prof. Giri Venkataramanan, ECE
         Prof. Mike Zinn, ME
         Prof. Bulent Sariglu, ECE

Instructional Staff: Rich Schiferl, EPD

Administrative Staff: Dr. Andrea Strzelec, EPD
                      Ms. Daryl Harrison, EPD
                      Additional EPD Student Services Team Members available for support: Stephanie Scholze, Justin Bush
                      EPD Learning Design Team: Stacey Binder, Amanda Renz
6. **Student Enrollment** *Include total number of students enrolled/declared in the program compared to program enrollment goals; address low enrollment policy (if applicable)*

The PCC is both a stand-alone program and a feeder to the Power MS program. Data is presented for both total enrollments, and the number of students that continued on to the Master’s program, after successful completion of the capstone.

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<thead>
<tr>
<th>Term</th>
<th>PCC Student Admissions</th>
<th>Continued on to MS</th>
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<tr>
<td>Fall 2015</td>
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<td><strong>Total</strong></td>
<td><strong>144</strong></td>
<td><strong>56/131 = 42%</strong></td>
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The program is currently meeting enrollment goals, but we are looking to expand enrollment further.

7. **Curriculum** *Include evidence that required courses have enrollment capacity to certificate progress and completion*

The PCC curriculum consists of 3-4 courses, depending on the student’s preparation. All students take:

- ECE 411 Introduction to Electric Drive Systems*
- ECE 412 Power Electronic Circuits
- ME 446 Automatic Controls

*The admissions committee recommends ECE 355 Electromechanical Energy Conversion for students without a strong background in the subject, as a pre-requisite to ECE 411.
8. **Assessment** Include the assessment plan and a summary of annually conducted assessment activities, with an analysis of the extent to which the program is meeting the learning goals. This assessment evidence should form the basis for any proposals for curricular changes.

The annual assessment is completed by the EPD PD and the ECE faculty advisers. Once the assessment is completed, a summary of the recommendations is assembled by the PD and shared with the faculty director, who shares them with the appropriate faculty and oversees the implementation.

Due to the COVID-19 pandemic, an alternative assessment plan was filed for 2020. Therefore, we have included the 2019 assessment plan as part of this document.

9. **Program Completion** Include comments on number of certificates awarded annually relative to program goals; for capstone certificates include placement of “graduates.”

From Fall 2015 to Spring 2019, 130 students were admitted to, and 78 (60%) completed the capstone and were awarded the certificate. Over 5 years, 78 certificates have been awarded, an average of 16 per year over the course of the program’s life. Of those 78 certificate earners, 56 continued on to the Master’s program – a graduate placement rate of 72% into the Power MS.

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10. Overall Analysis of Self-Study and State of the Program Include recommendation and proposals for academic or administrative improvements

Overall, the state of the Power Conversion and Control Capstone is strong. The program is running well and primed for additional growth. This desire for growth was at the heart of the new relationship – both for program administration and the financial model, between EPD and ECE.

It is anticipated that the new relationship model between EPD and ECE will only strengthen the capstone, as more faculty will be involved in the program and there will be more opportunities for interaction between the on-campus and off-campus students. The diversity of faculty and students in the combined classes will improve the experience for both sets of students.