June 26, 2019

TO: Members of the Board of Trustees

FROM: John A. Elliott
Interim Provost and Executive Vice President for Academic Affairs

RE: Certificate in Power Grid Modernization

RECOMMENDATION:

That the Board of Trustees approve the Certificate in Power Grid Modernization in the Eversource Energy Center.

BACKGROUND:

The grid modernization initiative aiming to create the grid of the future is one of the largest investments and most consequential projects in the US in terms of infrastructure change and public impact. It envisions a more resilient, secure, sustainable and reliable grid that allows an array of emerging services while remaining affordable to customers. As the nation accelerates into the new paradigm of the utility industry and services, a set of interdisciplinary skills is needed for its engineering workforce. Utility engineers must keep up with the changes, the language and the approaches to more effectively deal with the new challenges of adapting the technologies.

The Certificate in Power Grid Modernization is being proposed to meet the need identified by Eversource Energy to train its personnel as it transitions to the grid of the future. The company has communicated the need to provide training to a cohort of about 15 early career engineers each year on the technical aspects of Grid Modernization. Based on this need, the Center has designed a certificate program that includes increasing human expertise on microgrids, predictive analytics, communication systems and distribution management systems to enable higher level control functions and schemes to manage the increasing levels of Distribution Energy Resources (DER) penetration. The industry’s new challenges of integrating renewables into the grid, predicting future electricity demands, grid smart designs and operations, and physical and cyber security issues will be covered.
# Request for New UConn Certificate Program

## Program information

<table>
<thead>
<tr>
<th>Name of certificate program:</th>
<th>Power Grid Modernization Certificate</th>
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<tbody>
<tr>
<td>Name of initiator unit:</td>
<td>Kylene Perras, Director, Professional Ed</td>
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<tr>
<td></td>
<td><a href="mailto:Kylene.Perras@uconn.edu">Kylene.Perras@uconn.edu</a></td>
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<tr>
<td>Name of sponsoring unit:</td>
<td>Eversource Energy Center</td>
</tr>
<tr>
<td>Name of initiator in sponsoring unit:</td>
<td>Emmanouil Anagnostou</td>
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<td><a href="mailto:Emmanouil.Anagnostou@uconn.edu">Emmanouil.Anagnostou@uconn.edu</a></td>
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<tr>
<td>Name of Associate Departments:</td>
<td>Civil and Environmental Engineering</td>
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<td></td>
<td>Electrical and Computer Engineering</td>
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<tr>
<td>Name of sponsoring School:</td>
<td>School of Engineering</td>
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<tr>
<td>Director of certificate program:</td>
<td>Malaquias Peña Mendez</td>
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<td><a href="mailto:mpena@uconn.edu">mpena@uconn.edu</a></td>
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<tr>
<td>Administrative contact:</td>
<td>Diane Perko</td>
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<tr>
<td></td>
<td><a href="mailto:Diane.L.Perko@uconn.edu">Diane.L.Perko@uconn.edu</a></td>
</tr>
<tr>
<td>Type of certificate:</td>
<td>Graduate, fee-based, hybrid</td>
</tr>
<tr>
<td>CIP Code:</td>
<td>15.0503</td>
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<tr>
<td>Anticipated start date:</td>
<td>Fall 2019</td>
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<tr>
<td>Admission Requirements:</td>
<td>BS degree (engineering or closely related)</td>
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<tr>
<td>Anticipated date of first graduation:</td>
<td>May 2021</td>
</tr>
<tr>
<td>Projected annual enrollments:</td>
<td>20 students per cohort</td>
</tr>
<tr>
<td>Modality:</td>
<td>Online (includes virtual lab/testbed)</td>
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</table>
Background
The Grid Modernization initiative aiming to create the grid of the future is one of the largest investments and most consequential project in the U.S. in terms of infrastructure change and public impact. It envisions a more resilient, secure, sustainable and reliable grid that allows an array of emerging services while remaining affordable to customers. This modernization involves installing the physical framework, optimizing the network, and processing new large flow of monitoring data. An important component of the initiative is the legislative and regulatory actions\(^1\) that each state takes to progress the modernization rate. As the nation accelerates into the new paradigm of the utility industry and services, a set of interdisciplinary skills is needed for its engineering workforce. Utility engineers must keep up with the changes, the language and the approaches to more effectively deal with the new challenges of adapting the technologies.

The Power Grid Modernization Graduate Certificate proposed by the Eversource Energy Center grows from the specific need of Eversource Energy to train its personnel as it transitions to the grid of the future. The company has communicated the need to provide training to a cohort of about 15 early career engineers each year on the technical aspects of Grid Modernization. Based on this need the Center has designed a certificate program that includes increasing human expertise on microgrids, predictive analytics, communication systems and distribution management systems to enable higher level control functions and schemes to manage the increasing levels of Distribution Energy Resources (DER) penetration. The industry’s new challenges of integrating renewables into the grid, predicting future electricity demands, grid smart designs and operations, and physical and cyber security issues will be covered.

With funding from Eversource Energy, the Department of Energy (DOE) and other federal government agencies, the faculty affiliated to the Center are addressing a wide range of research topics that advance the technology in the utility sector. Most of these areas pertain to the Grid Modernization initiative. Some of the areas are: power outages prediction, power outage restoration, vegetation management, solar energy (Photo-Voltaic; PV) forecasting, power grid optimization, distributed energy resources integration, cyber security, and economic assessments. The expectation is that this Certificate will be facilitated by the research that is taking place at the Center. In addition to the research capabilities, the Center is increasingly improving its facilities and infrastructure to support research dealing with the new challenges. For instance, the Center’s recent acquisition of a million-dollar testbed for simulations of the power grid will be an important asset for the

\(^1\) Actions include studies and investigations, planning and market access, utility business model and rate form, grid modernization policies, financial incentives, and deployment of grid technology. For details on where Connecticut stands see https://ncleantech.ncsu.edu/wp-content/uploads/Q12018_gridmod_exec_final.pdf
practice of new concepts; it is expected that students enrolled in the Certificate program will use the testbed to analyze scenarios that could be applicable to their work activity.

**Program Outline**

The program aims to augment the skills and competence of the enrollees in areas of high-priority as perceived by the utility stakeholders. The students will be trained in four main areas offered in the program. All areas will have a teaching and a research component. The first area teaches students the fundamentals and practice of the physical grid as it moves from the traditional one-way flow to two-way flow between home and grid. These aspects and more are covered in the micro-grid course. A second area teaches students how the power grid data are processed for analysis and prediction; accurate prediction is necessary to increase visibility of the grid during natural hazards and for real-time grid operations. These aspects are covered in the predictive analytics course. Utility communication systems and security is an essential part of a smart grid infrastructure. The development of communication capabilities, moving power control systems from “islanding of automation” to totally integrated environments distribution opens new possibilities but also enhances vulnerabilities. These aspects will be covered by the third course on communication systems. The fourth course on distribution management systems will introduce the students on high level control systems, standards and regulations, fault detection, and aggregation of Distributed Energy Resources (DERs) to the system and necessary subjects for management systems.

**Readiness**

The first two courses, microgrids and predictive analytics are already established graduate courses at the Electric and Computer Engineering (ECE) and the Civil and Environmental Engineering, respectively. The last two courses are being developed by an ECE faculty jointly associated with the Eversource Energy Center and have been approved by the C&C committee. The course on microgrids can be delivered as a hybrid (real time broadcasting and recorded) course for remote and local students, whereas the predictive analytics course is fully online. The two new course will be prepared as online courses for convenience and flexibility for working enrollees.

**Program’s Market**

A principal customer of the Certificate is the Eversource Company, which already has offered a plan to reimburse entry-level employees adequately to complete the program in a two-year time frame. The Center is in constant communication with managers at Eversource Energy to get feedback on the training needs of their personnel associated to the grid modernization initiative. Eversource expects to support about 15 entry-level
students per year. The Certificate program proposed is also intended to attract engineers from other utility companies in the region such as United Illuminating and National Grid, which are facing similar grid modernization challenges.

In terms of market competition of this proposed program, there are only a few universities that are taking steps to train engineers in the area of grid modernization such as microgrids or renewables, but none appear to match our proposed interdisciplinary grid modernization study plan and hands-on approach to teaching. Most universities in our region offer courses and programs in Power Grid Engineering to address problems in the classic electric grids. Grid modernization as recognized in our program prepares the student to learn and apply concepts of smart grids, data analytics, utility communication systems, and grid management.

### Strategic teaching

Each course in the Certificate will comply with the university-wide quality standards. The faculty involved in the generation of the courses are top scientist on their respective field and specialty, and some have experience with preparing online curses under the University’s Center for Excellence in Teaching (CETL). Most faculty are full time professors and engaged in projects related to the Grid Modernization and Power Grid Energy. All the courses will adapt to formatting of the University’s Professional Education programs of the School of Engineering.

A strategy to accelerate knowledge transfer to the Certificate’s enrollees in this program will consist on using a common educational framework to link the four courses chosen. For instance, during the first year the course on microgrid (1st semester) and the course on predictive analytics (2nd semester) will both utilize similar software, computer resources and hardware --the aforementioned testbed for simulation of the power grid-- to carry out didactic experiments and student projects. This will reduce the burden of a student to work on different computer languages or platforms to get his or her learning and research done. The second-year courses will also be linked to the knowledge gained during the first year of the program. The communication systems and management courses will provide the student with a clear understanding of and the skills to address issues to manage and optimize modern power grids.

**Describe the educational prerequisites (and professional prerequisites, if appropriate) required of students for admission to this program.**

All students must have completed the prerequisite courses for each course in the Certificate. The prerequisites are included in the course descriptions.
Describe similar programs nationally, regionally, or in CT.
WPI, Iowa State, Drexel, Georgia Tech and Arizona State University, and Michigan Technological University, and Washington State University all have programs and certificates in Power Engineering.

Only Penn State has Power and Grid-Modernization Certificate. This program leans more towards the electric grid modernization without covering other interdisciplinary areas such as management, system optimization and predictive modeling.

Describe the program learning outcomes
Students will have the necessary knowledge at an advanced level in the area of grid modernization to engage in the analysis and design of modern grid systems and services. For example, they will be able to:

- Develop computer programs for the integration of solar PV and microgrids
- Predict PV panel output accounting for panel characteristics and atmospheric conditions
- Apply predictive analytics and stochastic optimization tools to improve load forecasting, grid operations, protection and optimal control.
- Use predictive analytics for emergency response.
- Use appropriate tools and techniques for the planning and design of power systems
- Choose suitable devices for integrating various power sources into a grid, fault detection and system control.
- Enable higher level control functions (e.g. self-healing) and other schemes to manage increasing levels of DER penetration.

Curriculum information
Total number of credits required: 12

Required courses
- **ENVE 5331.** Predictive Analytics for Scientists and Engineers
  - 3 credits
  - Leading Instructor: Prof. Malaquias Peña
- **ECE 5550.** Microgrids
  - 3 credits
  - Leading Instructor: Prof. Peng Zhang
- **ECE 6095.** Advanced Topics in Engineering (Communication Systems for Distribution Grids).
  - 3 credits
  - Leading Instructors: Dr. Yan Li and Prof. Shengli Zhou
- **ECE 6095.** Advanced Topics in Engineering (Distribution Management Systems).
  - 3 credits
Leading Instructors: Dr. Yan Li and Prof. Peng Zhang

Credits earned within the certificate can be applied towards a Master of Engineering (MENG). Please contact the UConn School of Engineering Professional Education Office for additional information about the certificate-to-MENG Plan of Study at soeprofed@uconn.edu

Detailed course information

ENVE 5331. Predictive Analytics (3 credits). This course provides concepts and knowledge for building predictive models. It covers commonly-used machine learning methods and an introduction to deep learning. It presents the end-to-end procedure of the prediction process, which includes data pre-processing, model training and prediction, validation and optimization. The course has a hands-on approach to learning and leverages on open source Python algorithms and software. Methods taught include: regularization and logistic regression, support vector machine, ensemble learning and random forest, and deep learning. The course includes a final project on a topic that the student selects, which addresses a realistic prediction problem.

ECE 5550. Microgrids (3 credits) This course will discuss techniques useful for the grid modernization from a unique angle of microgrid design, analysis and operation. It will cover smart inverters, microgrid architectures, distributed energy resources modeling, microgrid hierarchical control, microgrid stability, fault management, resilient microgrids through programmable network, reliable networked microgrids, and cyber security.

ECE 6095. Advanced Topics in Engineering (Communication Systems for Distribution Grids; 3 credits). Details to be created. As a placeholder, the topics to be taught include: Distribution automation (DA), basics of SCADA, outage management, data model standards (CIM), design of distribution networks, hardware for distribution systems, protection & control, performance measures of distribution systems, communications and DA, DA communication physical layers, wireless communication (VHF, UHF, cellular, satellite LTE, etc.), wire communication (phone line, fiber optics, power line carrier), DA communication protocols (MODBUS, DNP3.0, IEC60870, IEC61850), communication architecture (central DMS communication, polling and report, intelligent node controllers/gateways, interconnections of multiple protocols), characterization of communication systems, coordinating crew location using mobile apps, backup control center.

ECE 6095. Advanced Topics in Engineering (Distribution Management Systems; 3 credits) Details to be created. As a placeholder, the topics to be taught include: Role of DMS in smart distribution, standards and regulations, static and dynamic models, advanced DMS applications (topology processor, Volt/Var control, fault detection, isolation, restoration, state estimation, three-phase power flow, short circuit analysis, optimal feeder reconfiguration, optimal capacitor placement, protection coordination, maintenance &
outage planning), power quality analysis, electric vehicle charging/discharging, active
distribution network under high penetration of DERs, aggregation of DERs for DERMS.

**Program Evaluation**
Conceptual and practical (for final examination).

**Program Administration**
The standard admissions process that the UConn School of Engineering Professional
Education program utilizes. Future programmatic changes would be decided via
collaboration between the Eversource Center, relevant Departments, CETL, and the
Professional Education office.

**Financial Resources**
Future revenue generated may support adjuncts for additional course delivery. To launch
the certificate, funds may be provided working with CETL for instructional design to
develop courses in an online format.

**Other Resource Needs**
A virtual lab (testbed) will be provided through the Eversource Energy Center.

**Other Potentially Affected Units**
At this time, there will be direct collaboration with the Electrical & Computer
Engineering Department and also Civil & Environmental Engineering Department. In
the future, if additional courses are implemented, each relevant Department will be
included for inclusion of additional courses to be offered for this certificate, and cost
share will be determine in advance of the approval of additional coursework.

**Who Can Apply?**
Internal applicants (current UConn students enrolled in another UConn degree or
certificate program) and also external applicants (individuals who are not currently
UConn students).

**Proposed Graduate Catalog Copy**
The Eversource Center offers a 12-credit certificate program to train engineers in the
industry of utility power grid modernization. The certificate program aims to augment
skills and competence of the enrollees in areas of high-priority as perceived by the utility
stakeholders. The students will be trained in four main areas: (1) fundamentals and practice
of the modern power grid, (2) power grid data processing, (3) utility communication systems and security, and (4) distribution management systems.

Required Courses: ENVE 5531, ECE 5550, ECE 6095 (Advanced Topics in Engineering: Communication Systems for Distribution Grids), and ECE 6095 (Advanced Topics in Engineering Distribution Management Systems).

The certificate is offered by the School of Engineering.