**University of Pittsburgh, Swanson School of Engineering**

**Electrical & Computer Engineering Department**

**Summer 2018 Term**

**Course: Clean Energy Power Grid Engineering: Scandinavia**

**ENGR-1281 / ENGR-2281**

**Description:** This is an overview course designed to introduce students to electric power transmission and distribution grid technologies dedicated to reliably, efficiently, economically, and safely managing electric power across utility networks in the U.S. and internationally. The course will cover the application of various grid technologies from power generation through power consumption including transmission networks, grid automation, power electronics systems, communications and control, protection, grid operations, grid connectivity, renewable energy resource integration, cyber security, micorgrids, DC technologies, and other emerging areas, as well as a brief introduction to power utility markets, business processes, and policy/regulation.

Students will gain an understanding of the how the broad spectrum of power grid technologies are applied in the electrical energy industry, with an emphasis on transmission and distribution systems at the electric utility level related to clean energy integration. An understanding will be gained of the history of the electric power industry in the U.S. and abroad, as well as today’s challenges and opportunities related to clean energy development and necessary power grid infrastructure investment.

The course will offer a review of new clean energy grid related projects in the U.S. and specifically in the Pittsburgh region. Students will then travel to Scandinavia (Denmark and Sweden) to visit other universities, technology suppliers, and site installations of key technology applications, in order to compare and contrast a part of Europe’s efforts in clean energy development and the application of power grid technologies to accomplish certain goals, with that of the U.S. and our region.

**Instructor:** Dr. Gregory Reed

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**Prerequisites:** This course is open to engineering and other students with a basic knowledge and background in math and sciences (up through calculus and introductory physics); and a general understanding of energy networks / electric power systems, technologies, and resources.

**Objectives:** By the end of the course the students will:

1. Have a basic understanding of the fundamental principles of electric power grid infrastructure, technologies, operations, and the integration challenges of clean energy resources at all levels;
2. Be able to use these principles to understand the planning, design, analysis, and implementation of future energy and electric power networks with a focus on clean energy development needs;
3. Develop an appreciation of the engineering and social complexities associated with the needs to develop more reliable, resilient, secure, economic, and sustainable energy resources and delivery infrastructure – including the role of microrgrids, DC technologies, energy storage, power conversion, and other evolving paradigms;

4. Gain experience in assessing the differences between meeting these challenges on regional, national, and international scales.

Contact Hours: The course will be composed of 45 contact hours, delivered as follows:

* 29 hours will be comprised of the international field component of the course (conducted during the time in Denmark and Sweden).
* 16 hours will be comprised of classroom instruction and regional field components, which will be conducted during the months of March and April (two sessions of 4 hours each for a total of 8 hours) and on May 1st and 2nd (two sessions of 4 hours each prior to departing for Scandinavia).
* See details under the Lectures section of this syllabus

**References:** References, papers, and other course materials to be provided by the instructor

**Text:** Empires of Light, Jill Jonnes; Text provided at first pre-departure lecture

**Lectures:** Dates Topics

#1 Fri – Mar 23 **Benedum XX, 5 p.m. – 8 p.m.**

Introductions, Course Overview, Trip and Scandinavia Cultural Review

Introduction to Power T&D Grid Technologies and Energy Resources

Electric Power System Basics, and Overview of the Power Industry

Electric Power Transmission and Distribution System Design and Analysis

Modernization of the Existing Electric Power T&D Infrastructure

Power System Operation, Protection, and Control

#2 Sat – Apr 14 **EIC 9 a.m. – 2 p.m.; Pitt District Thermal Plant**

Renewable Energy Development and Grid Integration

Smart Grid Technologies - Control, Automation, Communication, Security

District energy overview, technologies and approaches

Power Electronics Technologies - FACTS and HVDC Systems

Emerging Microgrid Concepts and Developments

Electric Power Industry Practices, Policies, and Markets

TOUR – Carillo/Bellefield district thermal plants

#3 Mon – Apr 30 **Duquesne Light and Pitt Ohio Tour 9 a.m. – 2 p.m. (meet on campus 8:15 a.m. travel & lunch provided);**

TOUR – Duquesne Light Company overview, operations, & training facility

TOUR – Pitt Ohio Express DC microgrid facility

**Travel:** Dates Location/Site/Topics

Tues – May 1 Depart for Stockholm, Sweden

Wed – May 2 Arrive in Stockholm. Take a guided city walking tour. Welcome dinner

Thur – May 3 Visit KTH Royal Institute of Technology (Pitt Faculty will arrange the visit)

Fri – May 4 Visit to Vattenfall (Evenemangsgatan 13 SE-169 79 Solna, Sweden) – Pitt will try to arrange (we might need help if we can’t make it happen) the visit but we will need to provide transportation to and from.

Weekend Enjoy attractions and museums around Stockholm.

Mon – May 7 Depart Stockholm for Vasteras. Visit ABB, FACTS/HVDC lecture.

Transfer to hotel in Ludvika and check into accommodations for the night, group dinner

Tue – May 8 9:00am-1:00pm - Visit ABB in Ludvika, depart and return to Stockholm (Stay in Stockholm overnight)

Wed – May 9 Depart Sweden for Copenhagen, arrive in Copenhagen, if possible quick tour and dinner.

Thur – May 10 Visit to the Avedore Power Station, Danish Oil and Natural Gas (DONG Energy).

Fri – May 11 9 a.m. – 1 p.m. Visit to Jaerispris Thermal Solar and District Energy facility; 1:00pm-5:00pm. Visit Denmark Technical University (DTU), lunch provided

Weekend: Enjoy attractions and museums around Copenhagen using your 48 hour Copehagen Card which includes entry to Rundetaam, Rosenborg Castle, National Aquarium Denmark, Designmuseum Denmark, Tivoli Gardens, and much more!

Mon – May 14 11:00am-5:00pm Visit Middelgrunden Wind Turbine Cooperative for a lecture followed by a boat trip to a wind turbine, lunch provided, Copenhagen Evening – departure dinner

Tue – May 15 Return to Pittsburgh, PA

**Assignments and Methods Evaluation:**

Homework and other special assignments will be project-based. A final course project, which will be team-based (two students per team) will also be assigned.

In addition to attending and participating actively in all classes, which involves engaging in discussions, responding to questions, and sharing observations and documentation from field trip work, students are required to complete the following:

1. Expectation essay, which should include the goals the student has for the course and what each hopes to achieve/learn/advance in terms of knowledge from technical, societal, academic, and practical application perspectives. This should be 1 or 2 pages in length, **due to Monday, April 30.**
2. Journal, documenting each site visit, including pre-departure site visits at Duquesne Light, Pitt Ohio, and Pitt District Thermal Facility. This can include written information, observational drawings, and photographs relevant to class topics. Each entry should be a minimum of 2 to 3 pages in length. Journals will be collected at the end of the term for grading purposes, **due Thursday, May 31.**
3. Reflective essay, which should include an overview of the course experience from all perspectives and a reflection on the experiences in comparison to the original expectations. This should be 2 or 3 pages in length, **due Thursday, May 31.**
4. Final project/report of a special investigation/topic. Students will choose a topic of special interest to investigate throughout the course, including materials and experiences covered in both the classroom and field components. Undergraduate students will work in teams of two students per team; and graduate students will work individually. All students/student teams will discuss their proposed ideas throughout the development of the course, and submit a proposal for review by the professor upon return from the international trip component to Scandinavia. In addition to the classroom and field components, students should conduct library and internet research pertaining to the topic, collect data from the field trips relevant to the topic, and analyze the ideas involved based on the principles being learned throughout the course. The final report will be due on Friday June 30, 2017. It should be approximately 20-25 pages in length (including text, images, references, etc). Typed, single space, Arial font 11, 12-15 pages of writing, **due Friday, June 29.**

**Grading Policy:**

Item % of Final Grade

Class Participation 10%

Expectation Essay 10 %

Course/Program Journal 30%

Reflective Essay 15%

Other Misc. Assignments 10%

Final Term Project 35 %

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100%