Proposed EE 2701

Sustainable Electricity Supply: Renewables and Conservation

Motivation:

1. Climate change/global warming is the gravest threat facing humanity. Electricity is essential for a modern society and nearly fifty percent (as much as 2/3rd if the transportation is electrified) of the energy is consumed in this form. Nearly 70 of electricity is generated using fossil fuels that create the greenhouse gases responsible for climate change.

   The mission of this course is make students go beyond the awareness of climate change; rather, it is to make them an advocate/champion and doers to utilize renewables for generation and the latest technology for conservation. The course is designed so that students will learn the fundamentals of electricity (its generation, transmission, and distribution), sources of electricity (conventional and renewable), costs, constraints, and environmental impacts - all within the context of social values and public policy.

2. This course will be designed to be offered in the second semester of the sophomore year with the prerequisite of only EE2001, i.e., without the knowledge of the phasor analysis that will be taught as a part of this course. This is done in order to allow this course to be taught at 2-year community colleges such that credits transfer to UMN. This is one of the ways to boost the number of transfer students and it also aligns with the objective of our ONR grant: "Increasing Electric Power and Energy Engineering Pipeline Nationwide."

Catalog Description: (3.0 cr; Prereq - EE2001; or EE 3005 for MechE students; spring, every year) General overview of energy usage, role of electricity in it and the contribution to global warming/ climate change. With this backdrop, understanding of the present electric power systems with conventional generation and transmission, and the possibility of introducing renewable sources such as solar (PVs) and wind. Future electric transportation systems consisting of electric and hybrid vehicles. Conservation using LEDs and their use in green houses for growing vegetables. In the context of applications described above, understand the fundamentals of electric power systems, power electronics and electric machines/drives concepts to apply them to these various applications.

Contact Hours: 3 hours of lecture per week.

Text: *None – course material will be uploaded to the course website during the semester*.

References: Links to latest research and findings, material on www.cusp.umn.edu; Textbooks by N. Mohan – www.wiley.com/college/mohan

Prerequisites by Topics:

Physics - motion of interacting objects, the forces that they exert on each other and the quantities that are conserved in those interactions, electrical and magnetic interactions. ECE **-** An understanding of nodal and mesh analysis of simple resistive circuits. An understanding of first and second-order transients in RL, RC, and RLC circuits. An understanding of the fundamentals of diodes, BJTs and FETs.

Course Outline and Learning Outcomes:

1. (1 week)
   Sustainability – what does it mean what is its significance in the generation and distribution of electricity and understanding of our present energy overview: Energy Consumption in various forms, Global Warming and Climate Change, Impact of Fracking, Role of Electricity - 1 week

2. (1 week)
   An understanding of Traditional sources of electricity generation: coal, natural gas, hydro, nuclear, Renewable Sources of Generating Electricity – Availability of Resources and an Introduction: Wind and Solar. Environmental impact of conventional sources of electricity generation, how these compare to renewable sources, impact on consumers (e.g.: wind versus natural gas)

3. (1 week)
   An understanding of Present State of Electricity Supply, Present Power Systems Infrastructure – Generation to usage. Opportunity for conservation by increasing conversion efficiencies

4. (1 week)
   An understanding of Delivering Electricity to Consumers over Transmission Lines, Fundamentals of ac in contrast to dc, Phasor Analysis to make it simpler: Power, Reactive Power, PF, Efficiency, Single-phase and three-phase circuits, Transforming voltages (efficiency/waste/loss in each system, comparisons between the two, and therefore connection to environmental/economic impacts)

5. (2 weeks)
   An understanding of Generating Electricity using Photovoltaics (PVs): Physics, i-v Characteristics and Maximum Power Point of PV Cells, Interconnecting to a single-phase utility grid by a power-electronics converter, Interconnecting it to a three-phase utility grid by a power-electronics converter. Costs and constraints related to solar energy: economics, infrastructure, environmental, current limitations, future potential and expectations, public policy given its variable nature, social values

6. (3 weeks)
   An understanding of Harnessing Energy from the Wind: Physics, Maximum Power Point at various wind speeds, Various electrical structures, Various type of generators and their operating principles. Costs and constraints related to wind energy: economics, infrastructure, environmental, limitations (shadow effect, migration patterns, etc., global perspectives, public policy due to variable nature, social values)

7. (1 week)
   An understanding of Other Sources of Generation using Natural Gas, Fuel Cells: Physics and Interconnection, Micro-Turbines for Micro-grids. Costs, advantages/disadvantages, environmental impacts

8. (1 week)
   An understanding of Electrifying Transportation, Electric and Hybrid-Electric Vehicles, High Speed Trains. Sources of power (multiple fuel sources), environmental comparison of conventional vs. hybrid vehicles/transportation

9. (1 week)
   An understanding of Electrical Storage: Batteries and Flywheels and possible environmental impacts and limitations (w.r.t. levels of consumption)

10. (1 week)
    An understanding of Electricity Conservation Potential in Pumps and Compressors, Heating, Ventilating and Air Conditioning, Induction Cooking, LED Lighting

11. (1 week)
    An understanding of Emerging Applications such as Growing Vegetables in Greenhouses using grow lights and Other Possible Applications such as Electricity-saving Apps

All through the course, critical thinking and decision making on socio/economic impact of energy/electricity.

Relationship to ABET Student Outcomes:

In accordance with ABET accreditation criteria, all engineering programs must demonstrate that their students achieve certain outcomes. This list of outcomes may be found on the ABET.org website. Of the outcomes listed in the ABET criteria (enumerated as (a) through (k)), this course teaches skills which help the student achieve the following outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering

(e) an ability to identify, formulate, and solve engineering problems

(i) a recognition of the need for, and an ability to engage in life-long learning

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.