Web-Enabled Master’s Degree in Power Engineering and Power Electronics (MPPE)

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NSF-Supported PEEC Workshop
Arlington, VA July 26-27, 2014
Acknowledgements

Nearly ~7M$ in support by:

- NSF
- ONR
- DOE
- NASA
- UMCEE

Team Effort:
- Bruce Wollenberg
- Bill Robbins
- Paul Imbertson
- Sairaj Dhople (new colleague)
- Approximately 40 collaborators

Advisor:
- Dr. Nari Hingorani
U.S. Seen as Biggest Oil Producer After Overtaking Saudi Arabia

Crisis in Graduate Education

• We are simply not teaching the courses that we ought to be!

• Many courses are at the verge of disappearing due to lack of
  - faculty to teach them, and
  - Critical number of students to them.
Mission

First-rate Graduate Education in “Power” to Students in Large Numbers

• To uphold Critical National Infrastructure
  - Power we use at home
  - Economic Security
  - National Defense
  - Sustainability
Application Areas

Electricity Generation, Transmission and End-Use:
  • Reliable, Robust, Smarter Grid
  • Renewables/storage
  • Increased Energy Efficiency – Climate Change

Transportation
  • Trains
  • Planes
  • Hybrids/EVs

Defense
  • Navy
  • Air Force
  • Army

Industrial Competitiveness
  • Automation/Robotics/Advanced Manufacturing
Graduate Courses on Power System: (22 credits)
1. Power Systems + Lab (3 + 1 Credits)
2. Advanced Power Systems I+ Lab (3 + 1 Credits)
3. Advanced Power Systems II (3 Credits)
4. Power Generation Operation and Control + Lab (3 + 1 Credits)
5. Power System Protection and Relaying + Lab (3 + 1 Credits)
6. Electricity Markets (3 Credits)

Graduate Courses on Power Electronics: (13 credits)
7. Power Electronics + Lab (3 + 1 Credits)
8. Advanced Power Electronics I + Lab (3 + 1 Credits)
9. Advanced Power Electronics II (3 Credits)
10. Wind Energy Essential (2 Credits)

Graduate Courses on Electric Machines/Drives: (10 credits)
11. Electric Machines/Drives (3 Credits)
12. Vector Control Electric Machines/Drives + Lab (3 + 1 Credits)
13. Electric Machine Design (3 Credits)
Graduate Courses on Power Systems: (22 credits)

1. Power Systems + Lab (3 + 1 Credits)
   - Ned Mohan
2. Advanced Power Systems I+ Lab (3 + 1 Credits)
   - Collaborative
3. Advanced Power Systems II (3 Credits)
   - Collaborative
4. Power Generation Operation and Control + Lab (3 + 1 Credits)
   - Bruce Wollenberg
5. Power System Protection and Relaying + Lab (3 + 1 Credits)
   - Pratap Mysore
6. Electricity Markets (3 Credits)
   - Ross Baldick
Modules for the Collaborative Courses in Power Systems

1. Transmission Lines and Cables: AC versus DC – Ram Adapa (EPRI)
2. Switching Transients and Lightning Protection, Insulation Coordination – MOV Surge Arresters – Dharshana Muthumuni (HVDC Research Centre)
3. Transient Stability; Blackouts – Tom Overbye (University of Illinois)
4. Voltage Stability – Udaya Annakkage (University of Manitoba)
5. PMUs in Power Systems – Virgilio Centeno (VPI)
7. Power Quality, Flicker, sags and swells – Surya Santoso (UT Austin, TX)
8. Power System Dynamics, small-signal stability, PSS – Udaya Annakkage (U of Manitoba)
9. Reliability – Chanan Singh (TAMU)
10. Demand Response; Load Management – Clark Gellings (EPRI)
11. Smart Grid; Synchrophasors; EMS Control Centers – Jay Giri (Alstom)
12. Communication and Cyber Systems Infrastructure for Electric Power Utilities – Mark Adamiak (GE) -requested
13. Weather and Variable Generation – Implications for Power System Operations - Mark Ahlstrom (WindLogics)
Power Generation Operation and Control Labs

- Example: Unit Commitment
  - Students run full 168 hour UC with various generator data sets
  - Students can alter load profile
- Unit Commitment in Matlab uses Lagrange Relaxation algorithm
- All input via Excel Spreadsheets
- Full Lab manual
- Other labs cover all chapter topics in text

168 hour load profile used with UC Lab
Uniqueness of our Courses

• Integrated Curriculum
  – Power Systems, Power Electronics, and Electric Machines/Drives
  – **45** course-credits; more will be developed
  – Backed up by textbooks

• Labs
  – Software-based (normally, graduate courses don’t have Labs but *why not?*)

• Quality
  – First-rate content developed by experts (4 NAE members, over 10 IEEE Fellows) from academia and industry
Textbooks underlying these courses:

- Translated into 8 Languages
- Plans for Edited Books for all other courses
Moodle-based Online Numerical Questions

Example:

In a Boost dc-dc converter, \( L = \{l\} \) \( \mu \text{H} \). It is operating in dc steady state under the following conditions: \( V_{\text{in}} = \{v\} \text{V} \), \( D = \{d\} \), and \( f_s = \{f\} \) 0 kHz. Assume ideal components. In this Boost converter, the output load is changing. Calculate the critical value of the output load \( P_0 \) in \textit{watts} below which the converter will enter the discontinuous conduction mode of operation.

Answer: \(((\{v\}^2\{v\}\{d\}*(\text{pow}(10,3)))/(20\{l\}\{f\}))\)
CUSP™

**Consortium of Universities for Sustainable Power**

- Content is totally free to download
- **182** U.S. Universities have become members

[www.cusp.umn.edu](http://www.cusp.umn.edu)
Allows Flipped-Classroom Pedagogy

**Pre-class:** watch a 15-minute module and answer online concept quiz (5%)

**During-class:** discuss and solve real-world, design-oriented problems (15%)

**Post-class:** homework problems on individual basis (15%)

NSF Award DUE-0942168: Collaborative Research: An Innovative Instructional Strategy for Widespread Dissemination of Electric Energy Systems Curriculum as a Model in STEM Education
Active Learning Classrooms at UMN
Moving Forward:

Based on this Content –

Option 1: Web-based Instructor-taught courses towards a master’s

Option 2: MOOC - like courses

- Converting these courses to degree-granting courses
Option 1:

Web-Based Instructor-Taught Courses in Real-Time:

Mimicking on-campus courses -

• Instructor and TA connect with students three-times per week in a virtual classroom (Synchronously and recorded for later viewing)

• Online and Hand-Graded Quizzes, HW, Exams, etc.

• Proctored Exams
**Annual Schedule (tentative) of Course Offerings (total: 45 credits):**

<table>
<thead>
<tr>
<th>Courses</th>
<th>Fall 15 (13 credits)</th>
<th>Spring 16 (15 credits)</th>
<th>Summer 16 (17 credits)</th>
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<tbody>
<tr>
<td><strong>Power Systems (PS) Track</strong></td>
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<td>Power Systems +Lab</td>
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<tr>
<td>Wind Energy Essentials</td>
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<tr>
<td><strong>Electric Machines and Drives (ED) Track</strong></td>
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<tr>
<td>Electric Machine Design</td>
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Additional Courses to be developed:


2. High Power Electronics in Power Systems (3 credits)

3. High Voltage Insulation, Surge Arresters, Insulation Coordination (3 credits)

4. Finite Element Analysis for Designing Transformers and Electric Machines (3 credits)

5. Control for Power and Power Electronics Engineers
Option 2:

Global Education Online (GEO)™

• Self-Paced
• Modular – mix and match
• Each Course will have the following:
  ✓ Video Clips
  ✓ Textbook
  ✓ Quizzes, HW, Exams, etc
  ✓ Forum for Discussion
  ✓ E-Learning Communities
• Very Low Cost – affordable in India, Africa, Latin America, Middle-East and so on.
Converting GEO™ Courses towards a master’s degree:

• Those who pass a GEO™ course with “High Distinction” will be invited to take a Proctored Exam of the “real-time” version, for it to be counted towards the master’s degree.
Golden Opportunity:
- Complete Curriculum
- First-rate Course Content
- Delivered by Practitioners
- Zero Residency
- Enormous unmet need globally!
NSF-Sponsored Workshop on Electric Energy Curriculum Reform
(Minneapolis, MN Oct 4-5, 2014)
- 2 nights of lodging covered on a first-come basis

Website:
www.cusp.umn.edu

**NSF Grant:** Workshops on Reforming Graduate/Undergraduate Curriculum in Electric Energy Systems with Emphasis on Sustainability. Award Number: ECCS-1137653.
Saturday, Oct 4\textsuperscript{th}

8:00-10:30am

**Importance of Reform in Electric Energy Education**

- Dr. Steven Crouch, Engineering Dean, University of Minnesota
- Dr. Peter Cho, Program Officer, Office of Naval Research (ONR)
- Dr. Pramod Khargonekar, Head of Engineering Directorate, NSF
- Mr. David Macmillan, UMN Regent and Senior VP of Minn. Power
- Dr. Jeff Matthews, Global Engineering Director at Cummins
- Mr. James Soeder, Senior Technical Fellow for Power at NASA
- Dr. Patrick Chapman, CTO of SolarBridge Technologies

*NYT: Up to 34\% of Installed Solar Panels Defective*
11:00-12:00 Power-Related CUSP™ Curriculum -
   Ned Mohan, University of Minnesota

12:00-1:30pm **Luncheon Speaker:**
   Dr. Ananth Iyer, Faculty Director of PudueNExT to deliver online courses aimed at a global audience

1:30-5:00pm **ONR-funded Graduate Curriculum Development**
   – *Power Systems*
   – *Power Electronics*
   – *Electric Machines and Drives*

5:00-6:00pm **DOE-funded Laboratory Development**
Sunday Morning:

WBG Revolution in Power Electronics

140 M$ Initiative!

North Carolina Is Home to America’s Newest High-Tech Manufacturing Hub

Mr. Joseph Weimer, Air Force Research Lab, Wright Patterson Air Force Base
Dr. Anant Agarwal, DOE-EERE
Mr. Eric Persson, International Rectifier

POSTER SESSION!!!!
Thank you!
Any Suggestions?