Research and Education in the Generation using Renewables, Storage, Smart Delivery and Efficient End-Use of Electricity

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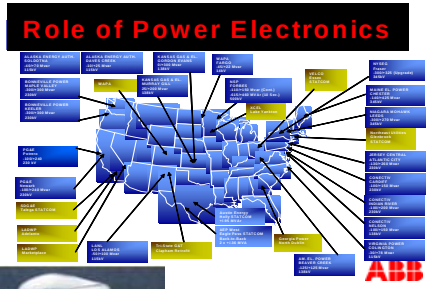
Wind

Solar

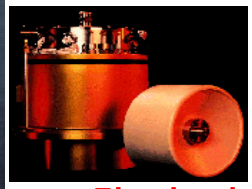
Role of Power Electronics



Hybrid

Fuel Cells

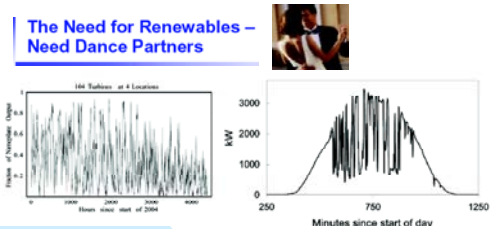
CFL



Flywheels for Storage

Science Week 2009
University of Minnesota
September 29, 2009

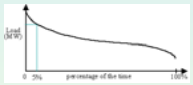
The Need for Renewables – Need Dance Partners

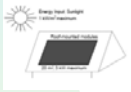


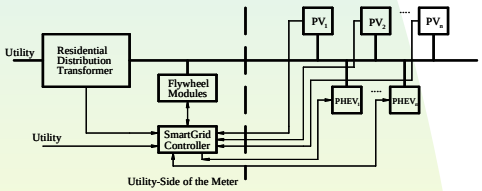
Wind Solar

NaS Battery Storage (Xcel Energy)

Project Cost: 5 M$
(U of M as a co-PI)

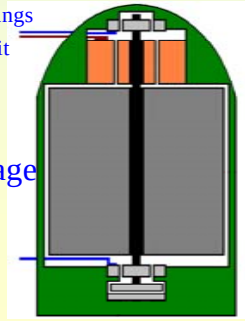






Radial & Axial Bearings
Motor/Generator Unit

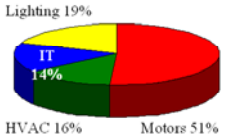
Flywheel Storage



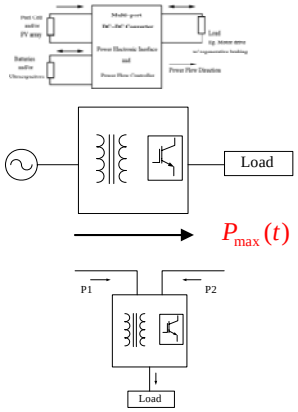
Chargers for Plug-in (Hybrid) Electric Vehicles

Chargers for EV1 fleet & S10 based on Minnesota Rectifier-UMN Patent

End-Use Efficiency Enhancement (<20% to >60%)



Multi-port Converter

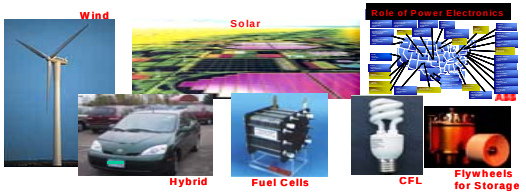


Research in Power Electronic Systems

Dept of ECE
University of Minnesota

Emphasis on:

- Renewables/Storage
- Smart Delivery
- Efficient End-Use

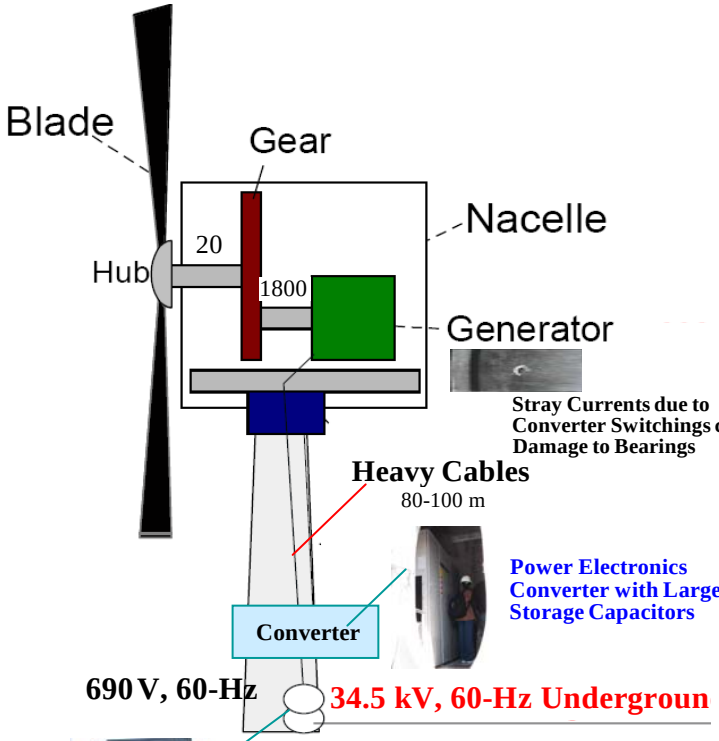


Research Group:
2 Post-docs
11 PhD Students

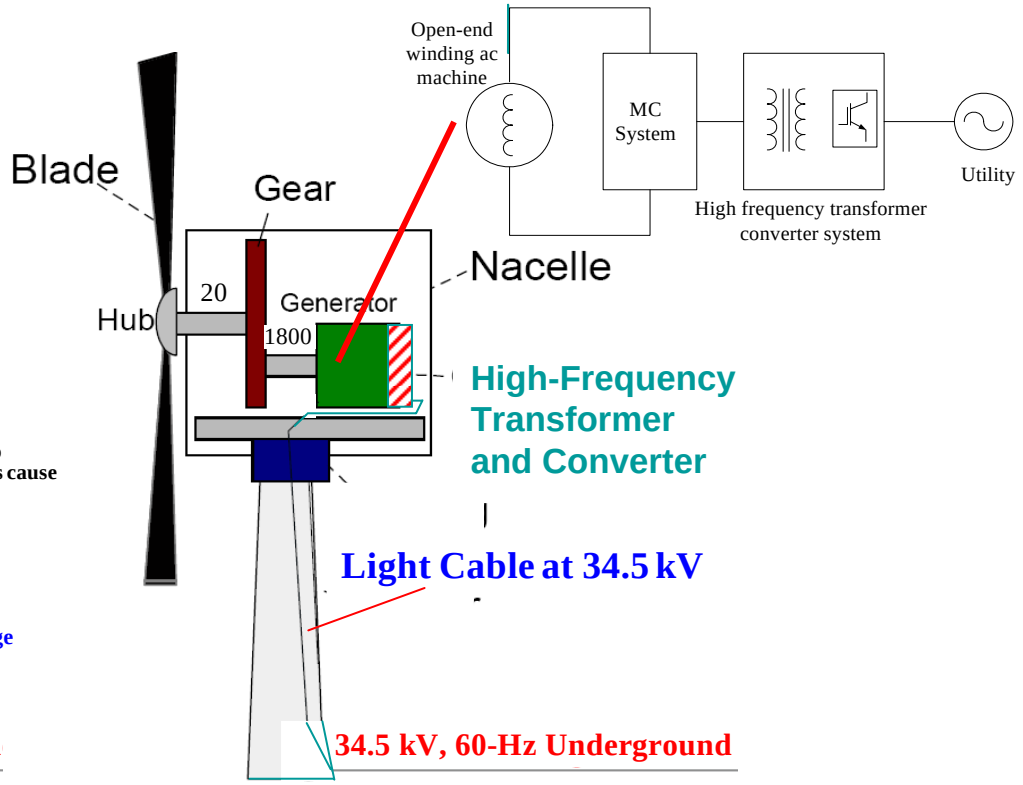
Research Sponsors:

- U.S. Navy (ONR)
- NSF
- Xcel Energy
- UMCEE
- Collaboration with NTNU

Present Generation System

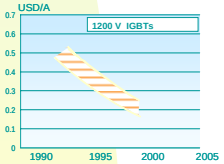


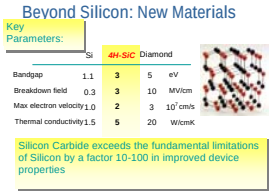
Proposed Generation System



Heavy Transformer

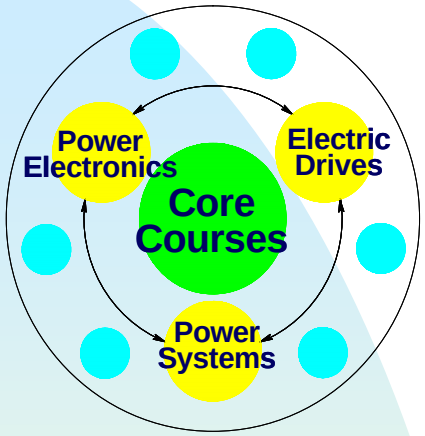
60 *Hz*





U.S. Patent Application filed by the University of Minnesota (pending)
UMN & ONR Grant on Open-Ended Machine Research: $577,262
ONR Grant on Power Electronics based High Frequency Transformer: $395,578

Integrated Undergraduate Curriculum



≡ Complementary Courses:
Embedded Controllers,
Programming Languages
Communication, Control, etc

Next Step:

Online Course Modules

- Certificates for Practicing Engineers
- Use in Courses at other Universities (ABET: 432)
- Graduate Courses and Certificates

ONR-NSF-EPRI Grant for Curricular Reform

(1.26 M$, 2006-2011)

CI-EESE Members:

- Midwest ISO
- New York ISO
- ISO - New England
- Air Force Research Lab
- Hamilton Sundstrand
- Ulteig Engineers
- UMCEE Members

Benefits to CI-EESE Members:

- Free online courses to all employees
- Continuing Education Credits
- Attend Yearly Workshop

Yearly Fee: $10,000/year

Contact: Prof. Ned Mohan
mohan@umn.edu

www.ece.umn.edu/groups/power

Center for Innovation in Electric Energy Systems Education (CI-EESE)

Goal

Develop a Workforce with a Forward-Looking Education, emphasizing

- Renewables/Storage
- Smart Delivery
- Efficient End-Use

Increasing Enrollments:

- Power Systems– 90
- Power Electronics– 118
- Electric Drives- 124

(Yr 2008-2009)

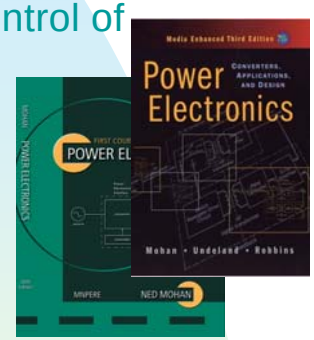
Enduring Curriculum:

- 97 University courses are now using our Hardware Labs.
- 73 Faculty have agreed to Champion this nationwide.

Power Electronics

Features:

- Switching Power-Pole as the Building-Block
- Includes dc-dc Converters and dc-ac Inverters
- Feedback control of Converters



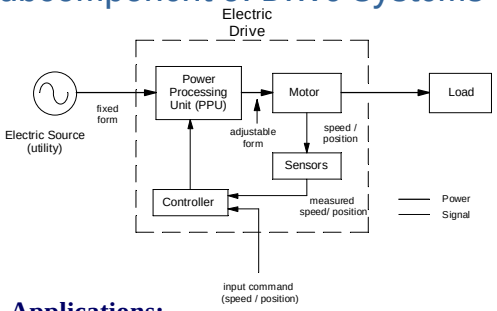
Textbook
- Slides
- Solutions manual

Hardware Lab

- **Course Learning Objectives**
- **Online Homework Problems**

Electric Drives

Teaching Machines as a subcomponent of Drive Systems



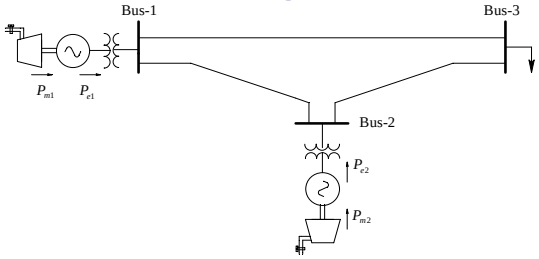
Applications:
- Harnessing of Wind Energy
- Electric and Hybrid-Electric Vehicles

Textbook
- Slides
- Solutions manual

DSP-Controlled Lab

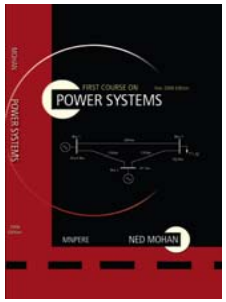
- **Course Learning Objectives**
- **Online Homework Problems**

Power Systems



Includes Topics such as
- Renewables/Storage
- HVDC, FACTS
- Voltage Stability

Textbook
- Slides
- Solutions manual



Software-based Lab:

- MATLAB/Simulink, PowerWorld, EMTDC
- Complete Lab on CD
- 18 Short Video Clips

- **Course Learning Objectives**
- **Online Homework Problems**

HiRel Systems
Duluth, Minnesota
Phone: 218-727-3115

Lab Manuals can be downloaded from:
www.ece.umn.edu/groups/power