CIRE and computational science

Lee Riedinger
Director
UTK/ORNL
Center for Interdisciplinary Research and Graduate Education (CIRE)
Professor of Physics

August 19, 2011
Energy Science and Engineering doctorate

- New *interdisciplinary* Energy Science and Engineering PhD
  - Provides breadth while ensuring a “deep dive” in a specific area
  - Specialty areas chosen to resonate with DOE priorities
  - Initial specialties: nuclear energy, bioenergy, energy conservation and storage, renewable energy, distributed energy and grid management, environmental and climate sciences related to energy
  - Entrepreneurial component
  - Approved by the Tennessee Higher Education Commission on January 12, 2011

- Traditional PhD with a concentration in ESE
  - Includes same knowledge breadth and entrepreneurship core as the ESE PhD

- This PhD program is administered and housed in the *Center for Interdisciplinary Research and Graduate Education - CIRE*
ESE curriculum overview

• Core Curriculum (6 credits)
  ESE 511 and ESE 512 - Introduction to Energy Science and Technology -
  taught by Lee Riedinger with contributions from CIRE faculty - Mondays and
  Wednesdays from 12:20 to 2:15 pm - room 306 of Nielsen Physics Building

• Knowledge Breadth Curriculum (6 credits): two courses from following areas
  – Political, social, legal, ethical and security issues related to energy
  – Entrepreneurship, leadership, and management
  – Environmental and climate sciences related to energy

• Knowledge Specialization Curriculum (15 credits)
  Choose five courses from participating department as defined in CIRE
  Graduate Student Handbook
  – Nuclear energy
  – Bioenergy and biofuels
  – Renewable energy
  – Energy conversion and storage
  – Distributed energy and grid management
  – Environmental and climate sciences related to energy

• ESE 599 Seminar (3 credits; 1+1+1): Topical seminars in the focus areas of CIRE
  - time and place to be determined - need talks by CIRE faculty

Many existing courses (500 and 600 level) will be used for specialization in the six major energy tracks

72 hours of graduate credit required for PhD, including at least 36 hours of course work
Knowledge breadth curriculum - 6 credit hours

Ideas so far

• Entrepreneurship
  – MGT 551 - New Venture Planning (Management, College of Business Administration)
  – MGT 552 - Entrepreneurial Strategy Implementation (Management, College of Business Administration)
  – AGNR 530 – Entrepreneurship and Discovery Commercialization - Fred Tompkins (Agriculture and Natural Resources)
  – Mechanical Engineering and Industrial Engineering 457 – Engineering Entrepreneurship - Lee Martin (College of Engineering)
  – Mechanical Engineering and Industrial Engineering 557 – Technology Product Development and Entrepreneurship - Lee Martin (College of Engineering)

• Policy
  – PS 410 - Special Topics – Energy Policy - Bruce Tonn (Political Science)
  – PHY 405 - Science, Technology, and Public Policy - Tom Handler (Physics)

• Climate
  – ENVE 595 - Special Topics - Climate Seminar - John Drake (College of Engineering)
Two UT/ORNL opportunities for graduate students

- **Energy Science and Engineering (ESE) interdisciplinary PhD**
  - Goal is to recruit 20 to 40 new PhD students per year
  - Support by the CIRE program until a research group is chosen from possibilities presented by CIRE faculty
  - 18 students will start in August

- **UT-ORNL Distinguished Graduate Fellowship (DGF)**
  - Research in one or a combination of three areas:
    - Materials science and engineering, including neutron science
    - Computational science and engineering
    - Nuclear science and engineering
  - Goal is to recruit 10 to 12 new PhD students per year
  - 3 students started last fall

- **$28K annual stipend with a few $30K stipends for the top performers**

**Web sites:**
- CIRE: http://cire.utk.edu
- ESE: http://ese.utk.edu
- DGF: http://distinguished.utk.edu
CIRE students

- Fall 2010 - three grad students on Distinguished Graduate Fellowships
- Fall 2011 - 19 new grad students:
  - 3 on Distinguished Graduate Fellowships
  - 16 on Energy Science and Engineering Fellowships
  - 14 have already decided on the research group
  - 3 involved in large-scale computing

<table>
<thead>
<tr>
<th>Name</th>
<th>University</th>
<th>Last Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class of 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Allen, Melissa</td>
<td>Univ. of Tenn - Master’s in Civil and Environ. Engineering</td>
<td>Civil and Environ. Eng</td>
</tr>
<tr>
<td>2 Chin, Charles</td>
<td>Univ. of Tenn. - Master’s in Biomedical Eng.</td>
<td>Biomedical Eng</td>
</tr>
<tr>
<td>3 Culiss, Jerel</td>
<td>Virginia Tech; now at Idaho National Lab</td>
<td>Electrical Eng</td>
</tr>
<tr>
<td>4 Ginder, Ryan</td>
<td>Northwestern University</td>
<td>Materials Science &amp; Eng</td>
</tr>
<tr>
<td>5 Goetz, Callie</td>
<td>Middlebury College</td>
<td>Physics</td>
</tr>
<tr>
<td>6 Hartnett, Chris</td>
<td>Univ. of Tenn. - Master’s in Physics</td>
<td>Physics</td>
</tr>
<tr>
<td>7 Hutchins, Ryan</td>
<td>Brandeis; Master’s from Univ. of Rhode Island</td>
<td>Physics, Math</td>
</tr>
<tr>
<td>8 Jackson, Timothy</td>
<td>Rensselaer Polytechnic Institute</td>
<td>Nuclear Eng</td>
</tr>
<tr>
<td>9 Jones, Steven</td>
<td>Ohio State University</td>
<td>Materials Science &amp; Eng</td>
</tr>
<tr>
<td>10 Kandala, Bhargav</td>
<td>GE Health Care</td>
<td>Mechanical Eng</td>
</tr>
<tr>
<td>11 Li, Meng</td>
<td>China Agricultural University</td>
<td>Biology</td>
</tr>
<tr>
<td>12 McMurray, Jake</td>
<td>Univ. of Mississippi (2001); now Blue Ocean Water Technologies</td>
<td>Chemical Eng</td>
</tr>
<tr>
<td>13 Pezeshki, Alan</td>
<td>California Institute of Technology</td>
<td>Chemical Eng</td>
</tr>
<tr>
<td>14 Ribbons, Relena</td>
<td>University of Massachusetts Amherst</td>
<td>Forest Resources</td>
</tr>
<tr>
<td>15 Sander, Kyle</td>
<td>Oregon State University</td>
<td>Biological and Ecological Eng</td>
</tr>
<tr>
<td>16 Talley, Kemper</td>
<td>Clemson University</td>
<td>Physics</td>
</tr>
<tr>
<td>17 Thompson, Adam</td>
<td>Georgia Tech</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>18 Wood, Stephen</td>
<td>Florida International University</td>
<td>Mechanical Eng</td>
</tr>
<tr>
<td>19 Zhang, Xiwen</td>
<td>Temple University</td>
<td>Biochemistry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>University</th>
<th>Last Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class of 2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Daly, Thomas</td>
<td>University of Tennessee</td>
<td>Nuclear Eng</td>
</tr>
<tr>
<td>2 Ribbeck, Jennifer</td>
<td>LSU</td>
<td>Math</td>
</tr>
<tr>
<td>3 Van Wesep, Robert</td>
<td>University of Michigan</td>
<td>Physical</td>
</tr>
</tbody>
</table>
Overview of CIRE faculty

• First group of 38 faculty appointed by Provost on December 20 - many of the best researchers at UT and ORNL:
  – 18 ORNL
  – 2 UT Institute of Agriculture
  – 18 UTK

• Energy research areas of these 38 faculty:
  1 - Nuclear energy - 5
  2 - Bioenergy and biofuels - 6
  3 - Renewable energy - 3
  4 - Energy conversion and storage - 6
  5 - Distributed energy and grid management - 5
  6 - Environmental and climate sciences related to energy - 4
  7 - Cross cutting - 9 - many are materials people

• More faculty will be added by a Credentials Committee of the faculty

• These CIRE faculty are attacking some of the country’s top energy problems
CIRE faculty work in environmental and climate sciences related to energy

• ORNL has a world-leading scientific computing facility - *Jaguar*

• Jaguar focuses on computationally intensive projects of large scale and high scientific impact

• UT and ORNL have also an NSF petascale computing center - *Kraken*

• The country’s top climate codes run on these computers
Part of the energy solution is nuclear - ORNL and UT are well positioned to support advanced fuel cycle research

- DOE Center for Advanced Simulation of LWR’s (CASL)
- Coupled End-to-End (CETE) demonstration for advanced nuclear fuel cycle S&T
- Fuel examination and reprocessing
- Materials irradiation at HFIR
- Reactor design and engineering
- Nuclear research facility infrastructure (REDC, HFIR)
Best U.S. sites for wind power - Great Plains, Great Lakes, mountain ridges of Rockies and Appalachians

North and South Dakota
Layout considerations for wind parks

• Each turbine must have enough space around the post to rotate in any direction
• Empirical rules about spacing of turbines:
  – Turbines in a line perpendicular to prevailing wind must have spacing 2x rotor radius to avoid collisions
  – Turbines along line of prevailing wind must have spacing of 5x to 10x rotor radius to avoid negative effects of turbulence
• Need a lot of land for a large wind farm
• Precise calculation of wind dynamics needed
• New CIRE student Stephen Wood and mentor Ralf Deiterding of ORNL will attack this problem