Proposed Data Science and Engineering PhD Program

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THE UNIVERSITY OF TENNESSEE KNOXVILLE

Bredesen Center
for Interdisciplinary Research and Graduate Education

OAK RIDGE National Laboratory

PhD program started in 2011 - Energy Science and Engineering - UTK and ORNL

- **Interdisciplinary PhD in *Energy Science and Engineering* (ESE)**
  - **Specialty areas: nuclear energy, bioenergy, energy conservation and storage, renewable energy, distributed energy and grid management, environmental and climate sciences related to energy, transportation science**
  - **Entrepreneurial and policy components**
- **PhD program is administered in the UT/ORNL *Bredesen Center for Interdisciplinary Research and Graduate Education***
- **Task force formed in August 2015 by Chancellor Cheek and ORNL Director Mason to study need for an interdisciplinary PhD in *Data Science and Engineering* (DSE) - chaired by Lee Riedinger (UTK) and Jeff Nichols (ORNL)**

Task force members - data science and engineering

	Member	Institution	Position	Unit
1	Jeff Nichols	ORNL	Associate Laboratory Director	Computing and Computational Sciences
2	Shaun Gleason	ORNL	Division Director	Computational Sciences and Engineering
3	Arjun Shankar	ORNL	Team Leader	Computational Sciences and Engineering
4	Budhu Bhaduri	ORNL	Group Leader	Computational Sciences and Engineering
5	Gina Tourassi	ORNL	Director	Biomedical Sciences and Engineering Center
6	Thomas Proffen	ORNL	Division Director	Neutron Data Analysis and Visualization
7	Jack Fellows	ORNL	Director	Climate Change Science Institute
8	Lonnie Love	ORNL	Group Leader	Energy and Transportation Science
9	Mike Leuze	ORNL	R&D Staff Member	Computer Science and Mathematics
10	Peter Tortorelli	ORNL	Deputy Director	Materials Science and Technology
11	Stacy Prowell	ORNL	Team Leader	Computational Sciences and Engineering
12	Lee Riedinger	UTK	Director	Bredesen Center
13	Russ Zaretzki	UTK	Professor	Business Analytics and Statistics
14	Mark Dean	UTK	Professor	Electrical Engineering and Computer Science
15	Chris Cox	UTK	Head	Environmental and Civil Engineering
16	John Kobza	UTK	Head	Industrial and Information Engineering
17	David Keffer	UTK	Professor	Materials Science and Engineering
18	Colleen Jonsson	UTK	Director	NIMBIOS
19	Ralph Lydic	UTK	Professor	Psychology
20	Vasileios Maroulas	UTK	Professor	Mathematics
21	Brent Mallinckrodt	UTK	Associate Dean	College of Arts and Sciences
22	Suzie Allard	UTK	Associate Dean	College of Information and Communications
23	Carolyn Hodges	UTK	Dean	Graduate School
24	Bob Davis	UTHSC	Professor	Governor's Chair with ORNL
25	Joseph Kizza	UTC	Head	Computer Science and Engineering

Wide enthusiasm for an interdisciplinary PhD program in *data science and engineering,* building on model of the existing *energy science and engineering PhD*

Proposed PhD in Data Science and Engineering

- National focus and need
- State need
- Expanding area of academic research
- Essential for improved discovery and productivity in many sectors of industry productivity, laboratory R&D, and academic research programs
- Proposed areas of research:

Applied computing

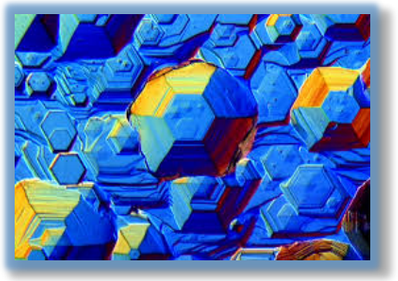
Data analytics

Statistics and machine learning

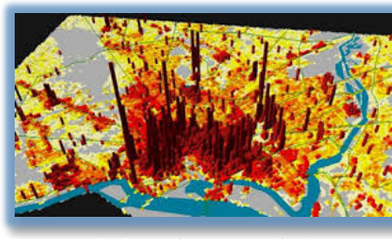
Domain science


Health & Biological Science


Environmental/Climate Science


Materials Science


Transportation Science


Urban Systems Science

National Security


Advanced Manufacturing

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Data Science and Engineering curriculum overview

- **Core Curriculum - 21 credit hours:**
  - **Understand and apply modern statistics and data analysis**
  - **Understand computing and coding skills in serial and parallel modes**
  - **Understand information storage and retrieval**
  - **Develop comprehensive foundation in statistics, data mining, machine learning along with the ability to read current literature and implement software tools**
  - **Have an understanding of other modeling and simulation approaches from applied mathematics**
- **Knowledge Breadth Curriculum - six credit hours relating to policy and/or entrepreneurship**
- **Knowledge Specialization Curriculum - deep dive into area of specialization in a *domain area***
- **DSE 599 Seminar: topical seminars in the focus areas of the DSE PhD**

72 hours of graduate credit required for PhD, including at least 36 hours of course work for a student with a BS degree, 24 with a Master's

Bredesen Center current and past PhD students in ESE doctoral program

- Graduate students - total count is now 137, including 25 new ones in August
  - First class started in August of 2011
  - Also 5 part-time grad students from ORNL
  - Students who have left the program - 19
- PhD completed - 11 in ESE, 4 in departments with ESE concentrations
- National fellowship awards - 11:
  - NSF Graduate Research Fellowship - Kemper Talley (2011), Mallory Ladd (2014), Jayde Aufrecht (2016)
  - NDSEG Fellowship - Ryan Ginder (2013), Patrick Shower (2014)
  - Hydro Foundation Fellowship - Mark Christian (2013)
  - Nuclear Nonproliferation and International Safeguards Fellowship - Blake Palles (2015) and Anagha Iyengar (2016)
  - Nuclear Forensics Graduate Fellowship from Department of Homeland Security - Marie Kirkegaard (2015)
  - Fulbright Fellowship - Kassie Ernst (2016)
  - Nuclear Energy University Program Fellowship from DOE - Brianne Heisinger (2016)

Matching the best students with the best faculty

126 Energy Science and Engineering faculty - all are based in departments or divisions - we have no faculty lines of our own:

- **76 based at ORNL**
- **47 based at UTK, including 8 Governor's Chairs**
- **3 based at UTIA**

ORNL-based faculty become joint faculty with our program.

Expectations of faculty are to engage with the center, sometimes work on a committee, be available for a seminar or general student interaction, and mentor and support a grad student if desired by both parties.

Areas of research of our ESE graduate students:

- **Transportation Sciences - 5**
- **Nuclear Energy - 29**
- **Energy Conversion and Storage - 14**
- **Environmental and Climate Sciences - 14**
- **Bioenergy and Biofuels - 26**
- **Cross-Cutting Energy Sciences - 7**
- **Energy Materials - 17**
- **Renewable Energy - 9**
- **Distributed Energy and Grid Management - 6**
- **Computational energy systems - 10**
- **Energy Geography - 2**

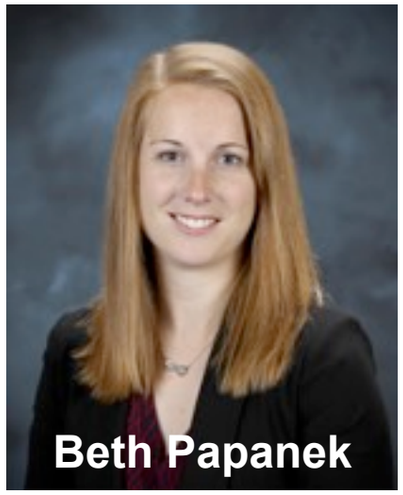
‘Diplomacy Lab’ course on the nuclear fuel cycle - policy aspect of ESE doctoral program

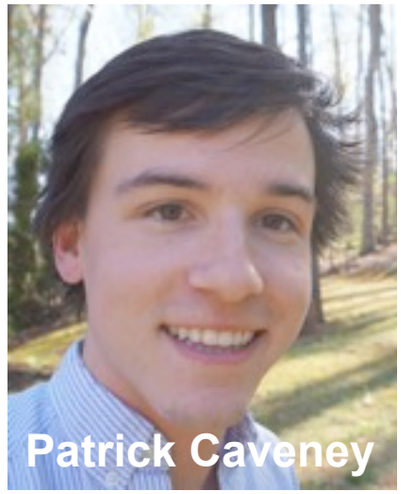
- Course this semester in conjunction with U.S. State Department and Baker Center
- State Department chose our course about the nuclear fuel cycle and associated issues of international diplomacy and economics
- ESE 597, section 2: Special Topics Course - “The Costs and Benefits of a Closed Nuclear Fuel Cycle” - 3 graduate credit hours
- Course is led by Andy Worrall, Fuel Cycle Technology R&D Leader, Reactor and Nuclear Systems Division, ORNL
- Andy is giving few lectures about nuclear fuel cycle and students are working on research on technical, political, and economic issues of this topic
  - The research includes assessment of the true costs and benefits associated with reprocessing and adoption of a closed nuclear fuel cycle – in terms of broad economic (long-term energy independence), political (mitigating risks to the overall nuclear sector), technological, and non-proliferation goals

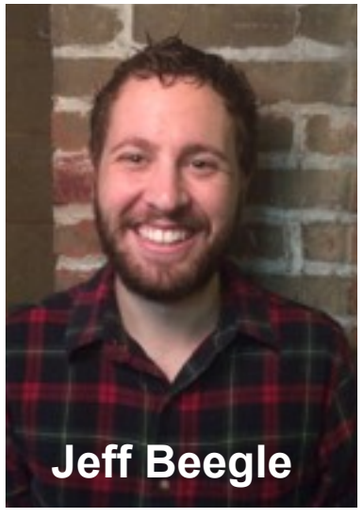
BIG DATA IN PUBLIC DIPLOMACY - Spring 2017 Diplomacy Lab Course - develop a focused, prescriptive approach regarding whether and how *big data* can be used in providing actionable guidance for public diplomacy

Success from entrepreneurship track in ESE program - formation of small companies by our grad students

- *Nano Elements Source*
  - Evolved from entrepreneurship class last year - ORNL technology for nano-fermentation of quantum dots
  - License deal signed between small company from Chattanooga and ORNL for a laboratory technology - a bioreactor to make nano dots
  - Beth Papanek (finished after 4 years) and Patrick Caveney (3rd year)
- *Grow Bioplastics LLC*
  - Produce home-grown high-performance plastic and rubber materials based on lignin
  - Tony Bova (3rd year grad student) and Jeff Beegle (2nd year)
- *SimPath LLC*
  - Combine DNA synthesis and assembly methods to construct multiple variations of a DNA pathway quicker and cheaper than normal
  - Rob Moseley (3rd year grad student) and Ben Mohr (2nd year)

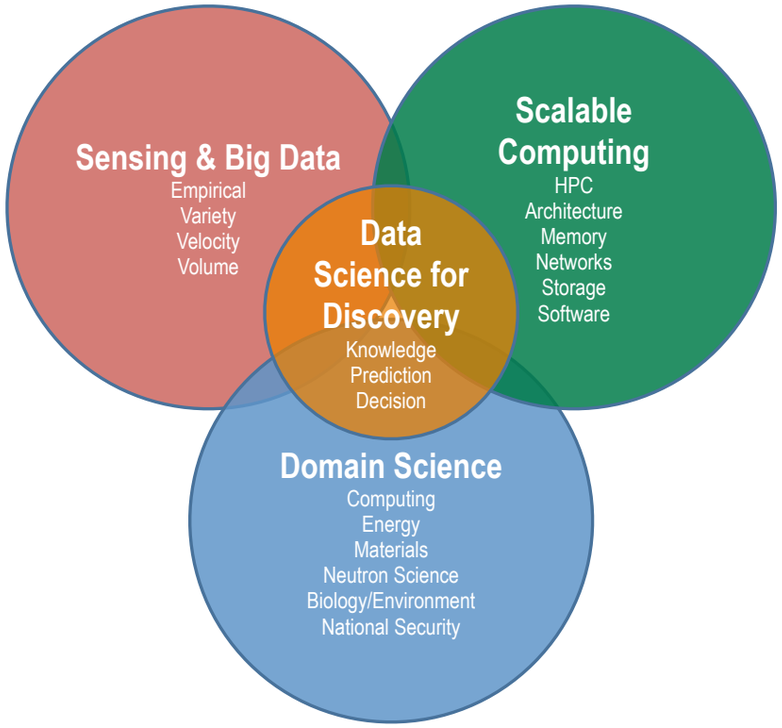






Proposed Data Science and Engineering doctorate

- Plan for a student body size initially around half of Energy Science and Engineering degree program; grow to 20 to 25 new grad students per year
- Operate in parallel to ESE degree
- Leverage supercomputer at ORNL and *big data* expertise there
- Doctoral degrees through UTK with involvement of faculty and students at UT Health Science Center (Memphis) and UT Chattanooga
- Russell Zaretzki, Haslam College of Business, will be DSE director within Bredesen Center
- Should have big impact on Tennessee



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Plan for DSE doctorate start

- October 2016 - DSE curriculum approved by Graduate Council
- November 2016 - submit DSE PhD proposal to Graduate School, then UT system, Board of Trustees, and Tennessee Higher Education Commission
- December 2016 - learn that governor has put $6M into his budget proposal
- January 2017 - accept grad school applications for ESE and DSE programs
- February 2017 - interview prospective grad students for both ESE and DSE
- March 2017 - make fellowship offers for ESE and for DSE, if it looks like the legislature will approve the DSE one-time money
- August 2017 - enroll first batch of DSE students - 10 to 15 in first class

Governor Bredesen visit - April 2016 - ESE512 class

Financial model for Bredesen Center

- We have no base funding from the university or state
- Annual operating expense of around $1.7M/year - few staff, operating, interviewing, first 1.5 year stipends ($30K/year) plus tuition for 25 new PhD students
- Require cost sharing when a grad student joins a group at UT or ORNL
- Receive overhead recovery on contracts from ORNL for partial or full support of a grad student - this year $540K of income
- 2010 - State of Tennessee provided $6.2M of one-time money for Energy Science and Engineering PhD program - this covered the differential for five years
- After five years, UTK returns to us the differential from the pool of tuition funds paid for the 137 doctoral students - 80% this year
- Data Science and Engineering PhD program - same model - hope to get $6M of one-time state funds for next fiscal year - this would provide the differential for five or six years