Annual Report - 2013

Award ID: 0966298
Institution: University of Texas Austin
Title: IGERT: Sustainable Grid Integration of Distributed and Renewable Resources

Principal Investigator(s)

Name: Thomas F. Edgar
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Name: Ross Baldick
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Co-Principal Investigator(s) or Trainee/Associate Advisor(s)

Name: David Adelman
Project Years Active: 2010-2011, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: David T. Allen
Project Years Active: 2010-2011, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: K S. Barber
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Co-PI and Trainee/Associate Advisor

Name: John C. Butler
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Dongmei Chen
Project Years Active: 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Ulrich Dangel
Project Years Active: 2010-2011, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Alexandre K. daSilva
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: James S. Dyer
Project Years Active: 2010-2011, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Thomas F. Edgar
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Co-PI and Trainee/Associate Advisor

Name: Matthew L. Fajkus
Project Years Active: 2010-2011, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: W M. Grady
Project Years Active: 2010-2011, 2011-2012
Role in Project: Trainee/Associate Advisor

Name: Robert E. Hebner
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Christine Julien
Project Years Active: 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Kara Kockelman
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Alexis Kwasinski
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Co-PI and Trainee/Associate Advisor

Name: Arumugam Manthiram
Project Years Active: 2010-2011, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Jeremy P. Meyers
Project Years Active: 2010-2011, 2011-2012
Role in Project: Trainee/Associate Advisor

Name: C B. Mullins
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Atila Novoselac
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Rodney S. Ruoff
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Surya Santoso
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Keith Stevenson

Project Years Active: 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Michael Walton
Project Years Active: 2011-2012, 2012-2013
Role in Project: Trainee/Associate Advisor

Name: Michael Webber
Project Years Active: 2010-2011, 2011-2012, 2012-2013
Role in Project: Co-PI and Trainee/Associate Advisor

Trainees

Name: Rosaria M. Berliner
Total number of months funded: 13
Project Years Active:
2011-2012 Project Year - Trainee supported for 9 months
2012-2013 Project Year - Trainee supported for 4 months

Name: Kristen Cetin
Total number of months funded: 9
Project Years Active:
2012-2013 Project Year - Trainee supported for 9 months

Name: Matthew Charlton
Total number of months funded: 24
Project Years Active:
2010-2011 Project Year - Trainee supported for 9 months
2011-2012 Project Year - Trainee supported for 12 months
2012-2013 Project Year - Trainee supported for 3 months

Name: Robert V. Crawford
Total number of months funded: 21
Project Years Active:
2011-2012 Project Year - Trainee supported for 9 months
2012-2013 Project Year - Trainee supported for 12 months

Name: Greg Dahlberg
Total number of months funded: 21
Project Years Active:
2010-2011 Project Year - Trainee supported for 9 months
2011-2012 Project Year - Trainee supported for 12 months

Name: Hunter B. Estes
Total number of months funded: 24
Project Years Active:
2010-2011 Project Year - Trainee supported for 9 months
2011-2012 Project Year - Trainee supported for 12 months
2012-2013 Project Year - Trainee supported for 3 months

Name: Arturo Gutierrez

Total number of months funded: 21
Project Years Active:
2011-2012 Project Year - Trainee supported for 9 months
2012-2013 Project Year - Trainee supported for 12 months

Name: Alexander J. Headley
Total number of months funded: 9
Project Years Active:
2012-2013 Project Year - Trainee supported for 9 months

Name: Erin Keys
Total number of months funded: 9
Project Years Active:
2012-2013 Project Year - Trainee supported for 9 months

Name: Kate McArdle
Total number of months funded: 9
Project Years Active:
2012-2013 Project Year - Trainee supported for 9 months

Name: Abigail Ondeck
Total number of months funded: 5
Project Years Active:
2012-2013 Project Year - Trainee supported for 5 months

Name: Akshay Sriprasad
Total number of months funded: 24
Project Years Active:
2010-2011 Project Year - Trainee supported for 9 months
2011-2012 Project Year - Trainee supported for 12 months
2012-2013 Project Year - Trainee supported for 3 months

Name: Kristina Tajchman
Total number of months funded: 9
Project Years Active:
2012-2013 Project Year - Trainee supported for 9 months

Name: David P. Tuttle
Total number of months funded: 24
Project Years Active:
2010-2011 Project Year - Trainee supported for 9 months
2011-2012 Project Year - Trainee supported for 12 months
2012-2013 Project Year - Trainee supported for 3 months

Name: Sean M. Wood
Total number of months funded: 21
Project Years Active:
2011-2012 Project Year - Trainee supported for 9 months
2012-2013 Project Year - Trainee supported for 12 months

Associates

Name: Stephen F. Bourne
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Name: Tong D. Chen
Project Years Active: 2012-2013

Name: Wesley J. Cole
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Name: Robert L. Fares
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Name: Harsha Kumar Maddur Chandrashekar
Project Years Active: 2011-2012, 2012-2013

Name: Krystian X. Perez
Project Years Active: 2012-2013

Name: Kody M. Powell
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Name: Joshua D. Rhodes
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Name: Amir Toliyat
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Name: Charles R. Upshaw
Project Years Active: 2010-2011, 2011-2012, 2012-2013

Accomplishments and Contributions of the IGERT

Interdisciplinary Research Achievements

First Achievement: Robert Crawford's research focus is around the thermal management of buildings and nutrient feeding of microorganism. He has completed a four part study developing an evaporation based, passive pumping system and analyzed factors that may limit operations. In the first part, the aforementioned system is designed and constructed with special attention paid to the effect of microchannel feeding dimensions on evaporation rates and pumping height. The second part probes the heat removal capability of the system when subjected to constant, uniform heat fluxes. In the third part, the effect of fouling and degradation of the evaporation surface is explored. The last part focuses around applying the system to a building to determine the feasibility of lessening air conditioning loads.

Second Achievement: Arturo Guttierrez researches the use of polyanion materials as cathodes in lithium ion batteries. They are considered safer than traditional oxide cathodes because of the strong binding within the polyoxyanion structure. The pyrophosphate Li2MP2O7 (M = Mn, Fe, and Co) cathode has the potential for two lithium ions to be extracted per M which leads high theoretical capacities of ~ 220 mAh/g. In addition, the high redox potential of the pyrophosphate materials ensures high energy and power densities. No literature report has shown the extraction/insertion of more than one lithium ion per M from the Li2MP2O7 pyrophosphates. Utilizing Microwave Assisted Hydrothermal and Solvothermal synthesis in order to produce materials with smaller particle sizes may allow more than one lithium ion to be extracted from the structure and result in safer and more efficient batteries.

Third Achievement: Sean Wood investigates synthesizing new materials replacing graphite in anodes of lithium ion batteries. The use of other Group IV elements (silicon, germanium, tin, and lead) have much higher capacities that are structurally buffered from the inside against the huge expansion by substances like titania or alumina. There are two main scientific challenges resulting from the same fundamental problem: a massive 200-300% volumetric expansion during lithiation that results in a) rapid consumption of the battery's lithium reserves by continual solid electrolyte interphase (SEI) formation and b) cycle life degradation by particle pulverization and electrical isolation. A directed engineering approach is used to create a protective layer on the outside of the particles with a built-in void space into which the particles can expand and contract without continually forming more SEI.

Education Achievements

First Achievement: Collaboration among IGERT students continues to evolve. During years one and two, the weekly meetings provided networking opportunities between students. In comparison, more dynamic collaboration has been observed in year three. Trainees, affiliates, and alumni have actively created learning experiences enhancing the entire team's understanding of the grid's functioning as it relates to their individual research projects. Several students initiated activities for the entire group: Erin Keys coordinated the trip to the Bluebonnet Electric Cooperative; Hunter Estes headed up a learning tour to the Bureau of Economic Geology; and Wesley Cole organized a Journal Publication Workshop. The aforementioned examples exemplify the IGERT program as an all-inclusive assemblage regardless of a student's identification as a trainee, affiliate, or alumni. IGERT affiliates and alumni share their research and publication experiences with IGERT trainees, providing a full-circle mentoring experience.

Second Achievement: Sustainable Grid IGERT Trainee, Arturo Gutierrez, participated in a customized research experience in Munich, Germany. This was the second year of the study abroad experience, representing an ongoing relationship between UT Austin and the Technical University of Munich (TUM) while abroad. Arturo attended three conferences, International Symposium on Ceramic Materials and Components for Energy and Environmental Applications (Dresden), Advanced Automotive Batteries Conference (AAB), and ACHEMA Conference (Frankfort). Dr. Gasteiger, in the Department of Chemistry at TUM invited Arturo to present a seminar to chemistry students showcasing

his Ph.D. research on the use of polyanion materials as cathodes in lithium ion batteries. While attending the AAB Conference, Arturo presented a 2-hour poster session to an international audience. A full report can be found here: http://research.engr.utexas.edu/igertsustainablegrids/index.php/experience/study-abroad

Third Achievement: The 2012 External Advisory Committee recommended developing additional coursework for IGERT students. The following short courses have been developed: Dr. Baldick's "Introduction to Electric Power and Locational, Marginal Pricing"; Dr. Webber's "Water, Technology and Policy", "Clean.Smart.Energy", "The Future of Energy", and "Energy, Technology, and Policy"; Dr. Kwasinski's "Power-Net Development". Additionally, newly developed semester-long energy courses include: Dr. Adelman's "Energy Development and Policy" that is made of interdisciplinary student teams from law, business, public affairs, and engineering; Dr. Kwasinski's "Advanced Topics of Power Electronics" and "Distribution of Generation Technologies"; Dr. Edgar's "Modern Control Theory with Application to Energy Systems"; Dr. Barber's "Home Animation Course". Lastly, a Graduate Portfolio Program in Energy Studies is currently under development and is designed to have an interdisciplinary approach to energy issues.

Trainee Achievements

First Achievement: Arturo Gutierrez gave two presentations in Germany (already sited in previous section) and a third as an invited speaker, (2012 November) Ionic Substitution and Segregation in Spinel Cathodes used for Lithium-ion Batteries presented at Texas Materials Institute, Austin, TX.

Second Achievement: Kristina Tajchman, a first year IGERT Trainee, has two papers accepted for publication, (2013, June), Electric Grid Modernization: Measuring Progress and Monitoring the Under-recognized Areas of the Electricity Infrastructure Required to Realize the Smart Grid Concept, 22nd International Conference on Electricity Distribution hosted by CIRED, Stockholm, Sweden; and, (2013, June), Transmission and Distribution Modernization: An Analysis of the Under-recognized Areas of the Electricity Infrastructure, Electric Grid, annual CESB Conference in Prague, Czech Republic.

Third Achievement: A meeting with UTeachEngineering (http://www.uteachengineering.org/) staff and IGERT members in January 2013 resulted in a plan for IGERT students to develop a one-week mini-module adding to the high school course developed by UTeachEngineering, Engineer Your World. The IGERT students submitted ideas for the modules and determined that concepts around storage/transference of electricity could be combined with teaching the students how the grid works; filling an energy gap in the current curricula for the Engineer Your World course. All IGERT students agreed to work on the project during three 90 minute work sessions scheduled outside of the regular IGERT weekly meetings.

International Opportunities: Achievements

Research/Educational Achievement 1: The partnership with TUM continues to evolve and in 2012 reflected an opportunity for Arturo Gutierrez, an IGERT Trainee, to actively participate and contribute in several international conferences. Arturo was able to apply his experience and new knowledge to his research as well as sharing with the UT IGERT group.

Outreach Activities

Title: Explore UT
Media Outlet/Organization: University of Texas at Austin
Activity Date: 03/02/2013
Description: "Solar Energy" was part of the annual 6-hour UT open house. In partnership with the Pecan Street Project, IGERT trainees and affiliates introduced approximately 1500 visitors to solar, wind, and water power using energy toys.

Title: NanoDays
Media Outlet/Organization: Austin Children's Museum
Activity Date: 03/24/2013
Description: Sean Wood, along with museum volunteers, facilitated a dozen NISENet activities for hundreds of visitors.

Title: Science Club (1)
Media Outlet/Organization: Texas School for the Deaf
Activity Date: 11/27/2012
Description: Wesley Cole, Arturo Gutierrez, Kristina Tajchman, Harsha Kumar facilitated sustainable energy activities with deaf and hard of hearing high school students at the Texas School for the Deaf.

Title: Science Club (2)
Media Outlet/Organization: Texas School for the Deaf
Activity Date: 12/11/2012
Description: Robert Fares and Krystian Perez facilitated engineering activities with deaf and hard of hearing high school students at the Texas School for the Deaf.

Title: Science Club (3)
Media Outlet/Organization: Texas School for the Deaf
Activity Date: 01/24/2013
Description: Erin Keys facilitated sustainable energy activities with deaf and hard of hearing high school students at the Texas School for the Deaf.

Title: Science Fair Judges
Media Outlet/Organization: Texas School for the Deaf
Activity Date: 05/17/2013
Description: Steve Bourne, Arturo Gutierrez, Wesley Cole, Krystian Perez, and Hunter Estes provide feedback and judge science fair projects for local science fair competition. Winners will advance to regional competition.

Title: Science Sunday (1)
Media Outlet/Organization: Austin Children's Museum
Activity Date: 10/14/2012
Description: "Measuring Our World" is a four-activity cluster that teaches children about length, volume, mass, time, and the tools we use to measure these characteristics. Sean Wood participated.

Title: Science Sunday (2)
Media Outlet/Organization: Austin Children's Museum
Activity Date: 12/09/2012
Description: "Happy Polydays" is a cluster of five activities that teach about polymers. Kate McArdle, Kristen Cetin, Hunter Estes and Krystian Perez helped facilitate the activities.

Title: Science Sunday (3)
Media Outlet/Organization: Austin Children's Museum
Activity Date: 01/13/2013
Description: "Sticking Together" is a four-activity cluster that teaches children about adhesion and magnetism. Steve Bourne participated.

Title: Science Sunday (4)
Media Outlet/Organization: Austin Children's Museum
Activity Date: 02/03/2013
Description: "Measuring Our World" is a four-activity cluster that teaches children about length, volume, mass, time, and the tools we use to measure these characteristics. Abigail Ondeck, Kate McArdle, Steve Bourne participated.

Publications, Presentations, and Patents

Journal Articles in Refereed Publications

Cole, W., Rhodes, J.D., Powell, K., Edgar, T. (2013). Turbine Inlet Cooling with Thermal Energy Storage, International Journal of Energy Research, DOI: 10.1002/er.3014.

Journal Articles in Non-Refereed Publications

Cole, W. J., Powell, K. M., & Edgar, T. F. (2012). Optimization and advanced control of thermal energy storage systems. Reviews in Chemical Engineering, 28(2-3), 81?99. doi:10.1515/revce-2011-0018.

Rhodes, J.D., Stephens, B., Webber, M.E. (2012). Energy audit analysis of residential air-conditioning systems in Austin, Texas. ASHRAE Transaction, 118 (1) (2012) 143?150. Retrieved March 13, 2013, ASHRAE_ChicagoProgram_Final_HiRes_r.pdf.

Conference Publications

Toliyat A., Kwasinski, A.,and Uriarte, F.M. (2012, November). Effects of high penetration levels of residential photovoltaic generation: Observations from field data. Accepted to International Conference on Renewable Energy Research and Applications (ICRERA), Nagasaki, Japan. DOI: 10.1109/ICRERA.2012.6477269, p 1-6.

Conference Presentations

Bourne, S. and Novoselac, A. (2012, August 2) The Effects of Emissivity and Insulation Levels on Radiant Barrier Performance. Technical Session at the 2nd International Conference on Building Energy and Environment (COBEE 2012), Boulder, CO.

Fares, R. L., Meyers, J., & Webber, M. E. (2012, November 14). Economic Operational Planning of Grid-connected Battery Energy Storage. ASME International Mechanical Engineering Congress and Exposition, Houston, TX.

*Gutierrez, A. & Manthiram, A. (2012, June). Doping, Fluorination, and Segregation in 4 V Spinel Cathodes used in Li-ion Batteries. Invited Talk given at the Technische Universität München, Munich, Germany.

*Gutierrez, A. & Manthiram, A. (2012, June). Understanding the Effects of Cationic and Anionic Substitutions to the Spinel Cathodes of Lithium-ion Batteries. Poster session at the Advanced Automotive Batteries Europe 2012 Conference, Munich, Germany.

*Gutierrez, A. & Manthiram, A. (2012, November). Ionic Substitution and Segregation in Spinel Cathodes used for Lithium-ion Batteries. Invited Talk given at the Texas Materials Institute, Austin, TX.

Rhodes, J.D., Nagasawa, K., Upshaw, C.R., and Webber, M.E. (2012, July). The role of small distributed natural gas fuel cell technologies in the smart grid, Accepted to ASME 2012 6th International Conference on Energy Sustainability, San Diego, CA.

Nagasawa, K., Upshaw, C., Rhodes J.D., and Webber, M.E. (2012, July). Data management for a large-scale smart grid demonstration project in Austin, Texas. Accepted to ASME 2012 6th International Conference on Energy Sustainability, July 23-26, 2012, San Diego, CA.

*Tuttle, D. (2012, July). BEV Range Sufficiency, PHEV Electrification of Miles, TCO,

& Increasing PEV Adoption Rate. Presented at EPRI Plug-In 2012 Conference, San Antonio, Tx.

Upshaw, C R. (2013, January). Development of Individualized Home Models for Energy and Water Analyses: Introduction and Future Work. Presented at Webber Energy Group Symposium, Austin TX.

Partnerships/Collaborations

Academic Partner 1

Active Status

Yes

Partner Name

Technical University of Munich (TU Munchen)

Type of partner

Ph.D.-granting institution

Foreign-based institution

Funding arrangement for this partner

No funding/direct financial interaction is involved in this partnership.

Activities for this partner/institution

Facilities: IGERT trainees use a partner organization's facilities for project activities.

Personnel Exchange: IGERT Trainees and/or partner organization personnel use each other's facilities or work at each other's sites on an ad hoc or as-needed basis.

Activities for this partner/institution

Arturo Gutierrez IGERT Trainee spent eight weeks in summer 2012 at TU Munchen. See complete report on the summer abroad at http://researech.engr.utexas.edu/igertsustainablegirds/images/stories/Munich

Academic Partner 2

Active Status

Yes

Partner Name

UTeachEngineering

Type of partner

Non-Ph.D.-granting institution

Funding arrangement for this partner

No funding/direct financial interaction is involved in this partnership.

Activities for this partner/institution

Collaborative Research/Teaching: Partner organization's personnel work with IGERT project staff on collaborative research/teaching.

Activities for this partner/institution

IGERT trainees, affiliates, and alumni (in progress) design mini module(s) for use in the Teach Engineering curriculum used in local high schools' engineering classes. UTeachEngineering prepares undergraduates, degree-holders, and in-service educators to teach innovative and exciting curricula that will allow their students to discover what engineering is, what engineers do, and the role that engineering plays in shaping their world. (http://www.uteachengineering.org/)

Other Partner 1

Active Status

Yes

Partner Name

Pecan Street Project

Funding arrangement for this partner

Partner provides funding to the IGERT project for research, curriculum, or other project activities, but not directly for trainees.

Other :Non profit provides IGERT Affiliate students with graduate research support (stipends/salary)

Activities for this partner/institution

Personnel Exchange: IGERT Trainees and/or partner organization personnel use each other's facilities or work at each other's sites on an ad hoc or as-needed basis.

Activities for this partner/institution

Pecan Street, Inc. completed construction of the Pike Powers Commercialization Lab that is part of Pecan Street Inc., a public-private initiative to make Central Texas an energy technology hub. The lab located in the heart of Austin, at the Mueller Housing Development, will promote research, commercialization and education tied to smart energy grids, advanced information technology, clean energy and health care applications. IGERT trainees, affiliates, and alumni have access to data for home energy usage at the Mueller Housing Development. This data is used to contribute to the body of research on sustainable energy and the grid. Students actively accessing/working with data include Erin Keys, Hunter Estes, Robert Fares, Josh Rhodes, Akshay Sriprasad, Dave Tuttle and Charles Upshaw.

Other Partner 2

Active Status

Yes

Partner Name

City of Austin/Austin Energy

Funding arrangement for this partner

No funding/direct financial interaction is involved in this partnership.

Activities for this partner/institution

Facilities: IGERT trainees use a partner organization's facilities for project activities.

Activities for this partner/institution

IGERT trainees and affiliates received access to data for home energy usage at the Mueller Development. These data have been used in preparing manuscripts by Robert Fares, Charles Upshaw, and Joshua Rhodes.

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