

# **Annual Report**

**(July 1, 2013 – June 30, 2014)**



**Richard G. Lugar Center for Renewable Energy (LCRE),**  
Purdue School of Engineering and Technology,  
Indiana University-Purdue University Indianapolis

**June 30, 2014**

***The mission of the Richard G. Lugar Center for Renewable Energy is to:***

*Address the societal needs for clean, affordable and renewable energy sources, improve the nation's energy security, and help mitigate the negative impacts of climate change.*

*Promote research excellence in the area of renewable energy through collaborative efforts among faculty in the disciplines of engineering, chemistry, physics, biology, environmental affairs, and public policy.*

*Promote renewable energy applications through teaching, learning, civic engagement, and synergistic partnerships with industry, government labs and local communities.*

## **Introduction**

The Richard G. Lugar Center for Renewable Energy (LCRE) is located on the campus of Indiana University Purdue University-Indianapolis (IUPUI), and is administratively housed in the Purdue School of Engineering and Technology, IUPUI. *The LCRE consists of 44 Research Members spanning multiple disciplines, 25 Advisory Board Members, and 12 Entrepreneurs-in-Residence, plus about 60 students, interns and post-doctoral researchers.*

The LCRE is an interdisciplinary research center, and strives to meet the societal and public needs and challenges in these key energy and environmental areas. The Center helps create a collaborative environment for solving these challenges. The following report summarizes these activities and represents the hard work and commitment of our Research Members, Advisory Board, staff, and entire LCRE family.

## **Focus Areas – Renewable Energy**

- Batteries
  - Li-metal
  - Anode/cathode/electrolyte chemistry
  - Seawater flow battery
- Fuel Cells
  - Non-Pt catalyst for PEM
  - Hydrogen storage
  - Hydrogen generation
  - SOFC for APU and home energy
- Combustion Engines
  - Advanced gas turbines
  - Internal combustion engines
  - Power and propulsion systems
- MSW Energy from Waste
  - Heat, oils for refining, electricity
  - Advanced gasification
  - Gas-to-liquids biofuels
- Policy & Economics
  - Urban, State, Federal
  - Energy forecasting and land use
  - Environment & Human health
- Commercial/Institutional & Buildings
  - Sustainable institutions
  - Energy and resource recovery
- Traditional Renewables
  - Solar power (including Space Solar)
  - Wind power (including hydraulic)
- Installation & Maintenance
  - Training
  - Automation
  - Diagnostics
- Manufacturing Science
  - Photovoltaic semiconductors
  - Nanotechnology
  - Fuel Cells
  - High temperature ceramics and coatings
- Efficiency
  - Industrial assessment
  - Curriculum development
  - Sustainable Technologies Certificate
- Entrepreneurism
  - Economic pro forma & business plans
  - Incubators and mentoring
  - Raising capital
- Sustainability & Lifecycle Analysis
  - Electric vehicles
  - Energy storage
  - Urban environment
- Switchgear, Diagnostics & Cybersecurity
  - Single transistor inverter
  - Synchronous distributed generation (patented)
  - Microgrids

The LCRE is an anchor tenant of the new Science and Engineering Lab Building (SELB), opened on November 17, 2013. Facilities include two state-of-the-art chemistry labs of 945 square feet each, a conference room with seating for 8, and two dedicated offices, all on the second floor. The 2-letter code for the SELB is “EL”, and the building is located in the northwest corner of Blackford and W. New York Streets.

Our Advisory Board, and the entire energy community of Indiana, mourned the passing of Mr. Bill Wylam this year. Known as “Battery Bill”, Mr. Wylam was instrumental in many important advances in battery technology and applications over many years. Other Board members who have moved on: Bill Marsan, Katherine Winter, and George Caraghiaur.

Two of our Research Members have accepted postings elsewhere, and will drop from our ranks. Dr. D. Thomas “Tom” Iseley is returning to Louisiana Tech University where he will be a professor of Civil Engineering and serve as the director of the Trenchless Technology Center. Tom was our leader in the waste-to-energy sector of the LCRE. We will certainly miss his enthusiasm and charisma. Dr. Rebecca Barthelmie will now be with the Sibley School of Mechanical and Aerospace Engineering at Cornell University. Rebecca’s world-class work in wind energy earned her the Distinguished Faculty Research Lecturer at IU Bloomington in 2014, complete with a private banquet (which your Director was honored to attend). She has expressed interest that we can continue to work together.

The LCRE website has been refreshed and is steadily being updated and improved. Please visit often at [www.lugarenergycenter.org](http://www.lugarenergycenter.org) There is a Give Now button for your convenience in making tax exempt donations to advance the goals and mission of the Center.

## **Summary of Research and Educational Activities**

The LCRE is continuing to make progress and achieve results in its core research fields and to establish itself as a leader, especially with regards to alkaline anion exchange membrane (AAEM) fuel cells, lithium ion batteries, and electric vehicle research and education. Additionally, the capabilities of the LCRE are being expanded in these and new areas as evidenced by the departmental hiring of several new faculty members in the fields of electrical and mechanical engineering, and the induction of several new Research Members.

Below is a summary of the latest updates with regard to existing and new research and educational programs at the LCRE:

### ***Recent Publications***

1. Carley, S., Lawrence, S. 2014. Energy-based Economic Development: How clean energy can drive development and stimulate economic growth. *Springer*.
2. Carley, S., Hyman, M. 2014. The American Recovery and Reinvestment Act: Lessons from Energy Program Implementation Efforts. Accepted at *State and Local Government Review*.
3. Baldwin, E., Brass, J., Carley, S., MacLean, L. 2014. Issues of scale in distributed generation electrification for rural development. Accepted at *WIRES: Energy and Environment*.
4. Warren, D., Carley, S., Krause, R., Rupp, J., Graham, J. 2014. Predictors of attitudes toward carbon capture and storage using data on world views and CCS-specific attitudes. *Science and Public Policy*.
5. Wendling, Z. A., Attari, S. Z., Carley, S., Krause, R. M., Warren, D., Rupp, J., Graham, J. D. 2013. On the importance of strengthening moderate beliefs in climate science to foster support for immediate action. *Sustainability* 5(12): 5153-5170.
6. Carley, S., "Global expansion of renewable energy generation: An evaluation of policy instruments." Paper presented at the 35<sup>th</sup> Annual Research Conference, Association for Public Policy Analysis and Management, Washington, D.C., November, 2013.
7. Carley, S., "Social learning and policy diffusion: adoption, reinvention, and amendment of the renewable portfolio standard." Paper presented at the Energy systems in Transition Conference, Karlsruhe, Germany, October, 2013.
8. Carley, S., "Global expansion of renewable energy generation: An evaluation of policy instruments." Paper presented at the 32<sup>nd</sup> U.S. Association of Energy Economists/International Association for Energy Economists Conference, Anchorage, AK, July, 2013.
9. Carley, S., "Global expansion of renewable energy generation: An evaluation of policy instruments." Paper presented at the annual Transatlantic Policy Consortium, The Hague, Netherlands. May 2013.
10. Kauffman, Nathan, Jerome Dumortier, Dermot J. Hayes, Robert C. Brown, and David A. Laird. (2014). "Producing energy while sequestering carbon? The relationship between biochar and agricultural productivity." *Biomass & Bioenergy* 63: 167-176.

11. Dumortier, Jerome. (2013). “The effects of uncertainty under a cap-and-trade policy on afforestation in the United States.” *Environmental Research Letters* 8(4): 044020.
12. Elobeid, Amani, Miguel Carriquiry, Jerome Dumortier, Francisco Rosas, Kranti Mulik, Jacinto F. Fabiosa, Dermot J. Hayes, and Bruce A. Babcock. (2013). “Biofuel expansion, fertilizer use and GHG emissions: Unintended consequences of mitigation policies.” Special Issue “Economics of Bioenergy” in *Economics Research International*, Article ID 708604, (<http://dx.doi.org/10.1155/2013/708604>).
13. Amardeep Singh, Afshin Izadian, Sohel Anwar, “Adaptive Nonlinear Model-Based Fault Diagnosis of Li-ion Batteries,” *IEEE Transactions on Industrial Electronics*, 2014.
14. Afshin Izadian, “[Self-Tuning Fault Diagnosis of MEMS](#),” Early Access, *IFAC, Journal of Mechatronics*, vol. 23, issue 8, Dec. 2013, pp. 1094–1099
15. Afshin Izadian, Nathaniel Girrens, Pardis Khayyer “[Renewable Energy Policies, A Brief Review of the Latest U.S. and E.U. Policies](#),” *IEEE Industrial Electronics Magazine*, vol. 7, issue 3, September 2013.
16. Afshin Izadian, “[Controllable Lenses for Photovoltaic Energy Generation Enhancement](#),” *IEEE Transactions on Electron Devices, Journal of Photovoltaic*, vol. 3, no. 3, pp. 1113-1117, July 2013.
17. Afshin Izadian, Gretchen Edelson, Steve Johnson, “Gate Driver of DC-DC Boost Converters using National Instruments LabVIEW and NImyDAQ,” *IEEE Electro-Information Technology Conference*, Milwaukee, WI, June 2014.
18. Dan Shen, Afshin Izadian, “A Hybrid Wind-Solar-Storage Energy Generation System Configuration and Control,” *IEEE, ECCE Conference* 2014.
19. Amardeep Sidhu, Afshin Izadian, Sohel Anwar, “Nonlinear Model Based Fault Detection of Lithium Ion Battery Using Multiple Model Adaptive Estimation,” *19th IFAC World Congress*, South Africa, 2014.
20. Shweta Hegde, Afshin Izadian, “[Control of Single Switch Inverters](#),” *IEEE PECTI*, 2014.
21. Masoud Vaezi, Majid Deldar, Afshin Izadian, “[A Model Linearization Technique for Hydraulic Wind Power Systems](#),” *IEEE PECTI*, 2014.
22. Shweta Hegde, Afshin Izadian, “[A New SEPIC Inverter: Small Signal Modeling](#),” In proceedings of *IEEE Industrial Electronics Conference, IECON 2013*, Vienna, Austria.
23. Arash Edalatnoor, Afshin Izadian, Masoud Vaezi, “[Indirect Adaptive Control of Droplet Dispensing in Digital Microfluidic Systems](#),” In proceedings of *IEEE Industrial Electronics Conference, IECON 2013*, Vienna, Austria.
24. Masoud Vaezi, Afshin Izadian, “[Multiple-Model Adaptive Estimation of a Hydraulic Wind Power System](#),” In proceedings of *IEEE Industrial Electronics Conference, IECON 2013*, Vienna, Austria.
25. Amardeep Sidhu, Afshin Izadian, Sohel Anwar, “[Model Predictive Control of MEMS LCR](#),” In proceedings of *IEEE Industrial Electronics Conference, IECON 2013*, Vienna, Austria.
26. Amardeep Sidhu, Afshin Izadian, Sohel Anwar, “[Fault Diagnosis of Li-ion Batteries using Multiple Model Adaptive Estimation](#),” In proceedings of *IEEE Industrial Electronics Conference, IECON 2013*, Vienna, Austria.
27. Majid Deldar, Afshin Izadian, Sohel Anwar, “[Modeling of a Hydraulic Wind Power Energy Transfer System Utilizing a Proportional Valve](#),” *IEEE Energy Conversion Congress and Exposition, ECCE 2013*, Colorado, September 2013.

28. C. Lim, B. Yan, L. Yin, and L. Zhu, "Geometric characteristics of 3D reconstructed anode electrodes of lithium ion batteries", *Energies*, 7, 2558-2572; doi:10.3390/en7042558, 2014.
29. Huan Hu, Vikhram V. Swaminathan, Mahmoud Reza Zamani Farahani, Glennys Mensing, Junghoon Yeom, Mark A. Shannon, Likun Zhu, "Hierarchical and Re-entrant Micro/Nano-structures for Superhydrophobic Surfaces with Extremely Low Hysteresis", 246th ACS National Meeting & Exposition, Indianapolis, 2013.
30. Mahmoud Reza Zamani Farahani, Arash Edalatnoor, Nate Kroodsmas, Dennis D. Meng, Likun Zhu, "Integrated Micro PEM Fuel Cell with Self-regulated Hydrogen Generation from Ammonia Borane", 246th ACS National Meeting & Exposition, Indianapolis, 2013.
31. Vikhram V. Swaminathan, Spandana Gannavaram, Shihui Li, Huan Hu, Junghoon Yeom, Yong Wang, and Likun Zhu, "Microfluidic Platform with Hierarchical Micro/Nanostructures and SELEX Nucleic Acid Aptamer Coating for Isolation of Circulating Tumor Cells", *IEEE nanotechnology 2013*, Beijing, China.
32. Umut Tugsal and Sohel Anwar, "Fuzzy Pattern Classification Based Detection of Faulty Electronic Fuel Control (EFC) Valves Used in Diesel Engines", *Machines*, Vol 2, 2014, pp. 99-119.
33. S. Anwar and W. Niu, "Analytical Redundancy Based Predictive Fault Detection of a Steer-By-Wire System Using Nonlinear Observer", *Asian Journal of Control*, Vol 16, No. 2, 2014.
34. Sina Hamzehlouia, Afshin Izadian, and Sohel Anwar, "Modeling and Control of a Hybrid-Hydraulic Electric Vehicle", *Advances in Automobile Engineering*, Vol 2, No. 1, 2013. doi: 10.4172/2167-7670.1000102.
35. Q. R. Farooqi, B. Snyder, and S. Anwar, "Real Time Monitoring of Diesel Engine Injector Waveforms for Accurate Fuel Metering and Control", *Journal of Control Science and Engineering*, Vol 2013 (2013), Article ID 973141, 9 pages <http://dx.doi.org/10.1155/2013/973141>.
36. Ragibul Huq and Sohel Anwar, "An Electrical Capacitance Based Measurement Method for Soot Load Estimation in a Diesel Particulate Filter", *IFAC World Congress*, Cape Town South Africa, August 24-29, 2014.
37. Vinay K S Muddappa and S. Anwar, "Fault Diagnosis Of Li-Ion Battery Using Electrochemical Model Based Observer And Fuzzy Logic", *ASME IMECE 2014*, Montreal, Canada.
38. B. Pattel, H. Borhan, and S. Anwar, "An Evaluation of the Moving Horizon Estimation Algorithm for Online Estimation of Battery State of Charge and State of Health", *ASME IMECE 2014*, Montreal, Canada.
39. Sohel Anwar, Changfu Zou, and Chris Manzie, "Distributed Thermal-Electrochemical Modeling of a Lithium-Ion Battery to Study the Effect of High Charging Rates", *IFAC World Congress*, Cape Town South Africa, August 24-29, 2014.
40. Amardeep Singh, Afshin Izadian, Sohel Anwar, "Nonlinear Model Based Fault Detection of Lithium Ion Battery Using Multiple Model Adaptive Estimation", *IFAC World Congress*, Cape Town South Africa, August 24-29, 2014.
41. Changfu Zou, Chris Manzie, and Sohel Anwar, "Control-Oriented Modeling of A Lithium-Ion Battery for Fast Charging", *IFAC World Congress*, Cape Town South Africa, August 24-29, 2014.

42. R. Huq and S. Anwar, "Soot load sensing in a Diesel Particulate Filter via electrical capacitance tomography", ASME International Mechanical Engineering Congress and Exposition, San Diego, CA, Nov 15-21, 2013.
43. Amardeep Singh, Afshin Izadian, and Sohel Anwar, "Fault Diagnosis of Li-Ion Batteries Using Multiple-Model Adaptive Estimation", IECON, Vienna, Austria, November, 2013.
44. Bandi, P., J. Schmiedeler, and A. Tovar. Design of Crashworthy Structures With Controlled Energy Absorption in the HCA Framework. ASME Journal of Mechanical Design, Vol. 135, Issue 9, Pages 091002.1-091002.11, 2013.
45. Lee, S., and A. Tovar. Topology Optimization of Piezoelectric Energy Harvesting Skin using Hybrid Cellular Automata. ASME Journal of Mechanical Design, Vol. 135, Issue 3, Pages: 031001.1-031001.12, 2013.
46. Lee, S., C. DiBernardo, and A. Tovar. "Outrigger system design of tall building using topology optimization," Proceedings of the 8th China-Japan-Korea Joint Symposium on Optimization of Structural and Mechanical Systems. Gyeongju, Korea, May 25-29, 2014.
47. Khadke, K.R., W. An, and A. Tovar. "Variable fidelity and reliability based optimization for ceramic composite material design". In Proceedings of the ASME 2013 International Design Engineering Technical Conferences (IDETC 2013). Portland, Oregon, August 4-7, 2013.
48. Liu, K., and A. Tovar. "Multiscale topology optimization of structures and cellular materials using direct and inverse homogenization," Proceedings of the ASME 2013 International Design Engineering Technical Conferences (IDETC 2013). Portland, Oregon, August 4-7, 2013.
49. Emami, A. and A. Tovar. "Biomimetic design of lightweight structures for energy absorption: learning from antlers and horns," In Proceedings of the Engineering Mechanics Institute Conference (EMI 2013), Evanston, Illinois, USA, August 4-7, 2013.
50. H. Yu, Xi Chen, Z. Wang, D. Deep, E. Lima, Y. Zhao, and S. D. Teague, Mass-conserved volumetric lattice Boltzmann method for complex flows with or without willfully moving boundaries, Phys. Rev. E, 89 (2014) 063304
51. X. Chen, H. Yu, J. Yogesh, Y. Zheng, Y. Xu, and F. Wu, The influence of different driving patterns on parity time-reversal symmetry, Acta. Phys. Sin., 63(6) (2014) 060206
52. H. Yu, R. Chen, H. Wang, Z. Yuan, Y. Zhao, Y. An, Y. Xu, and L. Zhu, GPU accelerated lattice Boltzmann simulation for rotational turbulence, Computer & Mathematics with Applications, 67(2) (2014) 437-451
53. N. Chen and H. Yu, Mechanism of axis switching in low aspect-ratio rectangular jets, Computer & Mathematics with Applications, 67(2) (2014) 437-444.
54. H. Yu, R. Chen, and L. Zhu, "GPU-accelerated Lattice Boltzmann method for direct numerical simulation of decaying isotropic turbulence with and without rotation ", (2014), in "Proceedings of 26th International Conference on Parallel Computational Fluid Dynamics Parallel CFD2014", Trondheim, Norway, May 2014. (T. Kvamsdal , Editor).
55. P. Schubert, A. Urbanek, "Hydrogen Recharge Dynamics and Vessel Design for Porous Silicon Storage Media," Proceedings, TechConnect World 2014, National Harbor, MD, 15-18 June 2014.
56. P. Schubert, D. Witte, "Analysis of a Gasification Plus Oxidation (GPOX) MSW Volume Reduction System," Int'l Thermal Treatment Technologies, San Antonio, TX 20-23 Oct. 2013.



57. D. Witte, M. Kaushal, R. Jaithaliya, A. Mathur, "Scalable Hydrogen Production from Biomass," World Hydrogen Technologies Conf., Shanghai, 25-28 Sept. 2013.
58. P. Schubert, J. Babcock, "Advances in Synthesis of Porous Silicon for Hydrogen Storage," World Hydrogen Technologies Conf., Shanghai, 25-28 Sept. 2013.
59. P. Schubert, A. Wilks, "Hydrogen and Hydrogen Storage Media from Rice Hulls," World Hydrogen Technologies Conf., Shanghai, 25-28 Sept. 2013.
60. L. Huang, J. Zhou\*\*, A. Hsu, R. Chen\*, "Catalytic partial oxidation of n-butanol for hydrogen production over LDH-derived Ni-based catalysts", International Journal of Hydrogen Energy, 38, (2013) 14550–14558.
61. L. Ma, H. He, A. Hsu and R. Chen, "PdRu/C catalysts for ethanol oxidation in anion-exchange membrane direct ethanol fuel cells", J. Power Sources, 241 (2013) 696-702.
62. J. Guo, J. Zhou, D. Chu and R. Chen, "Tuning the Electrochemical Interface of Ag/C Electrodes in Alkaline Media with Metallophthalocyanine Molecules", J. Phys. Chem. C, 117 (2013) 4006-4017.
63. R. Chen, J. Guo and A. Hsu, "Non-Pt Cathode Electrocatalysts for Anion-Exchange-Membrane Fuel Cells" for Book "Electrocatalysis in Fuel Cells", Chapter 15, p. 437-481 (03/31/2013) ISBN 978-1-4471-4910-1.

### ***Patents Granted***

1. Schubert, P., "Solid-State Hydrogen Storage Media and Catalytic Hydrogen Recharging Thereof," US 8,518,856, 27 August 2013.
2. Schubert, P., "System, Methods and Materials for Storing and Retrieving Hydrogen," US 8,673,811, 18 March 2014.
3. Schubert, P., "System and Method for Controlling Biochar in Biomass Reactors," US 8,691,115, 8 April 2014.

### ***Conferences attended, Invited Talks, Collaborations featuring LCRE***

1. Sanya Carley, Martin School of Public Policy and Administration, University of Kentucky (April 2014).
2. Sanya Carley, ARPA-E (November 2013).
3. Sanya Carley, Centre for Energy Economics and Policy, ETH Zurich (October 2013).
4. Sanya Carley, Council Member, U.S. Association of Energy Economists.
5. Sanya Carley, Panel Co-Chair and Conference Reviewer, Energy and Environment track, Association for Public Policy Analysis and Management.
6. Afshin Izadian, "Power Electronics and Renewable Energy Systems Research," LCRE Spring Forum, 6 May 2014.
7. Afshin Izadian, Panelist on Research Commercialization Workshop, "Making it Work: How to Commercialize Your Innovation," Monday, March 31, 2014, IUPUI.
8. Afshin Izadian, "Patents and Companies for University Faculties," LCRE Annual Retreat, Jan 24, 2014.
9. Jing Zhang, Organizer, Advanced Coating Symposium, Changwon National University, April 2014.

10. Likun Zhu, invited lecture: “Computed tomography image-based study for understanding the impact of electrode microstructure on lithium ion battery performance”, Beijing University, China, 2 August, 2013.
11. Andres Tovar, “Optimal design and additive manufacturing (3D printing) of ultra lightweight structures,” Raytheon, Indiana, Jun 4, 2014.
12. Peter Schubert, Panelist, Congressional Leadership Day, IN District 6 (Luke Messer), on “Energy for Indiana”, 5 April 2014, Ball State University, Muncie, IN.
13. Peter Schubert, Panelist, “Promoting Sustainable Development in the Oceans,” Blue Tech Summit, San Diego, CA, 7-8 Nov. 2013.
14. Peter Schubert, Panelist, “Innovation Ecosystems for Energy Solutions,” Council of Energy Research and Environmental Leaders, Argonne National Lab, Illinois, Nov 2013.
15. Peter Schubert, “Waste-to-Energy: Two New Technologies for Indiana,” Indiana Conf. on Energy Management, Indianapolis, IN 14 Aug 2013.
16. Peter Schubert, Panelist, “Renewable Energy in Indiana”, WTIU, Bloomington, IN, 2013.
17. Peter Schubert, speaker, National Governor’s Association meeting, Indianapolis, 19 May 2014.
18. Rongrong Chen, “Electrocatalysis of Oxygen Reduction Reaction and Ethanol Oxidation Reaction on Multi-functional Catalysts in Alkaline Media”, Electrochemical Conference of Energy and Environment, E3, Shanghai, China, March 13-16, 2014.
19. Rongrong Chen, “Polymeric Electrolytes and Catalysts for Anion-Exchange-Membrane Fuel Cells”, The 8th Pacific Rim International Congress on Advanced Materials and Processing (PRICM-8), Waikoloa, Hawaii, August 4-9, 2013.

### ***Research Grants and Milestones***

1. E. Dos Santos, National Science Foundation I-Corps grant, “Neat Grid-Tie Inverter” \$50,000. *Note that Entrepreneur-in-Residence Lee Saberson has joined Dr. Dos Santos’ team, and was a key factor in the selection of this highly-competitive grant program.*
2. J. Dumortier, Soy Transportation Coalition (2013), “Alternative, Sustainable Approach to Fuel Tax”, PI, \$51,065.
3. A. Izadian, “Hydraulic Wind Turbine Health Monitoring,” Role :PI, Vibration Institute Inaugural Award Grant, \$1000. May-Aug. 2014.
4. A. Izadian, “Hydraulic Wind Turbine Health Monitoring,” Role :PI, Vibration Institute Inaugural Award Grant, \$1000. May-Aug. 2014.
5. A. Izadian, “Mobile X-Ray Truck Reactive Power Control,” AMPATH, Indiana University, Role: PI, \$2500.
6. A. Izadian, Indiana University International Travel Grant (competitive, 15 page application), \$800. November 2013.
7. A. Izadian, “Single Switch Inverter Design and Implementation,” Single Switch Systems Inc., \$12,000. Role: PI. Oct 2013- April 2014.
8. A. Izadian, “Design and Implementation of Power Electronic Circuits using myDAQ,” National Instruments, \$56,000 (2 payments of \$28,000). Role: PI. Oct-2013-Dec 2014.
9. A. Izadian, “Power Electronics Education Laboratory,” National Instruments, \$5,100, Role: PI.

10. A. Izadian, "Infinite-Level Voltage Inverters," Office of Vice Chancellor for Research, \$25,000, Role: PI.
11. A. Izadian, "Minimized Switch Continuous Level Power Inverters," Vice Chancellor for Research JUMP START, \$10,000. *Only 3 awarded university-wide.*
12. A. Izadian, "Towards a Statewide FIRST Robotic Training Camp," \$23,000, IUPUI Solution Center, Venture Fund, Role: PI, September 2012-December 2013.
13. J. Zhang, NASA "Summer of Innovation" Mini-Award, providing renewable energy education to K-12 students in Indianapolis, 2014.
14. L. Zhu, National Science Foundation, August 2013-July 2016, \$291,002, "Computed tomography image-based study for understanding the impact of electrode microstructure on lithium ion battery performance".
15. S. Anwar, "Development of a Robotic Massaging Device (RMD)", Funding Opportunities for Research Commercialization and Economic Success (FORCES), IUPUI Office of the Vice Chancellor for Research, \$25,000, 06/01/2014 – 05/31/2015, Co-Principal Investigator.
16. S. Anwar, Electrical Capacitance Based Soot Load Sensor for Diesel Particulate Filter, Funding Opportunities for Research Commercialization and Economic Success (FORCES), IUPUI Office of the Vice Chancellor for Research, \$25,000, 01/2014 – 06/2014, Principal Investigator.
17. A. Tovar, IUPUI Curriculum Development Grant RFP, RISE to the IUPUI Challenge: "Development of a Research course on Design of Mechanical Systems", PI, \$2,500, Aug 2013 - Dec 2014.
18. A. Tovar, Honda R&D Americas, Vehicle Research CAE, "Nonlinear Crashworthiness Design Tool Development Using Hybrid Cellular Automata", PI, 100%, \$79,000.00, April 2012 - Oct 2014.
19. A. Tovar, IUPUI Purdue School of E&T: Engineering Excellence Research Fund, "Design Optimization of Lightweight Crashworthy Structures for Uncertain Collision Scenarios", Advisor, \$2,500, Oct 2013 - Apr 2014.
20. A. Tovar, BISHOP Steering Technology Inc., "Manufacturing, Development of Advanced Direct-generated G-code CNC program based on NURBS geometry", Co-PI, \$4,000, Jun - Sep 2013.
21. A. Tovar, Purdue Research Foundation, PRF, International Travel Grant, \$1,000, Dates: May 2014 - Aug 2014.
22. P. Schubert, Fulbright Specialist, two-week assignment to University of Malta, US Dept. of State, \$11,000, March 2014.
23. R. Chen, NSF, "The Development of Multi-Functional Catalysts to Replace Pt for Fuel Oxidation Reactions in Low Temperature Fuel Cells Toward Environmentally Friendly Energy Production" \$400,000 (03/2014-03/2016).

### ***Literature Reviewing Service (selected)***

- Intl J. Hydrogen Energy (R. Chen)
- J. Power Sources (R. Chen)
- J. Electrochem. Soc. (R. Chen)
- J. Physical Chem. (R. Chen)

- Assoc. Public Policy Anal. and Mgmt. Conf (Carley)
- National Energy Lab academic affiliate (Carley)
- IEEE Trans. Power Electronics (Dos Santos)
- IEEE Trans. Industry Applications (Dos Santos)
- IEEE Trans. Industrial Electronics (Dos Santos)
- IET Power Electronics (Dos Santos)
- Intl Trans. Electrical Energy Sys. (Dos Santos)
- European Trans. On Electrical Power (Dos Santos)
- J. Power Electronics Brazilian Soc. (Dos Santos)
- Publication Chair, NWRCS 2014: Rapidly Transitioning Wireless Spectrum Using Research to Deployable Innovations, May 2014 (Izadian)
- Publication Chair, IEEE Electro-Information Conf., 2014 (Izadian)
- Publication Co-Chair, IEEE Electro-Information Conf, 2013 (Izadian)
- IEEE Transactions on Industrial Electronics (Izadian)
- IEEE Industrial Electronic Magazine (Izadian)
- IEEE Transactions on Control System Technology (Izadian)
- IEEE Transactions on Power Electronics (Izadian)
- IEEE Transactions on Energy Conversion (Izadian)
- ELSEVIER, Journal of Solar Energy (Izadian)
- IEEE Transactions on Intelligent Transportation (Izadian)
- IEEE Transactions on Neural Networks (Izadian)
- IEEE Transactions on Electron Devices, Journal of Photovoltaic (Izadian)
- NSF Civil, Mechanical and Manufacturing Innovation (Zhang)
- EPA Science to Achieve Results (Zhang)
- NSF Panel Reviewer May 2014 (Zhu)
- Proposal Reviewer, U.S. Army Corps of Engineers Engineering Research and Development Center (Zhu)
- Reviewer for J. Electrochemical Society (Zhu)
- Int'l. J. of Hydrogen Energy (Zhu)
- Computational Materials Science (Zhu)
- IEEE Transactions on Vehicular Technology, Assoc. Editor (Anwar)
- SAE Transactions – J. Passenger Vehicles, Assoc. Editor (Anwar)
- ISRN Automotive Engineering, Assoc. Editor (Anwar)
- Advances in Automobile Engineering, Assoc. Editor (Anwar)
- Engineering Structures - Reviwer (Tovar)
- J. of Mechanical Design - Reviewer (Tovar)
- J. of Materials Engineering and Performance - Reviewer (Tovar)
- J. of Structural Engineering - Reviewer (Tovar)
- Int'l J. of Solids and Structures - Reviewer (Tovar)
- Structural and Multidisciplinary Optimization - Reviewer (Tovar)
- Applied Stochastic Models in Business and Industry – Reviewer (Tovar)
- 2014 Air Force Summer Faculty Fellowship Program – Reviewer (Tovar)
- NSF Reviewer CMMI (Tovar)
- Fulbright Commission – Colombia-USA (Tovar)

- Editorial Board Member, J. of Surfaces and Interfaces of Materials (Tovar)
- Scientific Committee Member, Journal Intekhnia, Saint Thomas Aquinas University (Tovar)
- NSF Graduate Research Fellowship Program, Panelist for Mechanical Engineering II, 2014 (Yu)

### ***Enterprise Development***

1. A. Izadian, co-founder Single Switch Systems, Inc., 2014.
2. A. Izadian, co-founder Kalium Biomedical, LLC, 2013.
3. M. Razi Nalim, Aerodyn Combustion, LLC, 2013.
4. P. Schubert, pitch to investors – 2<sup>nd</sup> Annual TransTech Business Development Conference, University of W. Virginia, Morgantown, WV, “Bio-hydrogen for thermal power plants,” Nov 2013.

## **Outreach**

The 2014 Spring Forum topic was “Microgrid Interconnects and Energy Storage”, and drew 78 participants to the Campus Center. Keynote speakers included Mr. David Stippler, the Indiana Utility Consumer Counselor, and Mr. Ken Geisler, VP of Strategy, Smart Grid Division, Siemens. Additional invited speakers represented dynamic local companies such as EnerDel, Go Electric, Indy Power Systems and Mechanical Electrical Systems. Academic presentations came from IUPUI, Purdue, and Argonne National Lab. Panel moderators from Indianapolis Power and Light Company and NIPSCO guided exciting discussions of this emerging and challenging field. Tours to 2 microgrid labs and the solar installation on the Business/SPEA building at IUPUI were offered. Follow-on responses were highly favorable. Sponsorship for this event was received from Mr. Robert McFarling (private citizen), Faegre Baker Daniels, and Blinkless Power Equipment, LLC. Thanks to their generous support we are pleased to report that the event was break-even financially.

- *Note that speaker presentations are available on our website, here:*  
<http://www.lugarenergycenter.org/index.php/events/>

The LCRE Annual Retreat, held in January 2014 brought together for the first time the Research Members, the Advisory Board, and the Entrepreneur-in-Residence team. Attendance was low due to very bad weather, however, several strong connections were made. Invited talks by Drs. Jian Xie and Afshin Izadian were provided for the benefit of all members, titled respectively: “Funding Success, and SELB Lab Plans”, and “Working with IURTC and ORA to Commercialize Technology”. Copies of their presentation materials are available on request, as is an overview of the EIR team with brief biographical sketches identifying areas of capability.

### **Other recent outreach activities include the following:**

- **IUPUI Energy Club**- Research Member Dr. Jerome Dumortier is the Faculty Advisor. A field trip was taken to Duke Energy’s Edwardsport gasification plant in September 2013 including the Energy Club, LCRE Research Members, and participants from Rose-Hulman Ventures. A second field trip together with the Entrepreneur-in-residence team was taken to visit Duke’s Wabash River Station outside of Terre Haute. A third field trip brought a large group to the Perry K steam plant, operated by Citizens Energy, in downtown Indianapolis.
- **Students for the Exploration and Development of Space (SEDS @ IUPUI)** is a student group formed in August 2012 as part of SEDS-USA. The faculty advisor is Dr. Peter J. Schubert. A student team is studying the performance of solar panels as a function of altitude in an urban environment. They have plans to set experiments on the rooftops of various downtown skyscrapers in Indianapolis, and publish their findings in a national technical conference.

## **New Personnel at LCRE**

The LCRE continues to rely upon its highly qualified staff and Research Members to advance its mission and benefit the university, city, state, and world. Below is a list of new personnel at the LCRE and some additional background about each:

### **Staff**

#### **Aneena E. Urbanek, Visiting Research Associate**

Mrs. Urbanek served a 4 month part-time paid assignment with the LCRE to bring greater focus to corporate donations and to manage the 2014 Spring Forum. She is a graduate of Purdue University with a BS in Mechanical Engineering, and had worked for 10 years as a Senior Associate and Project Engineer at Eli Lilly and Company. This was Aneena's second such assignment, and she now cycles back into the Entrepreneur-in-Residence program, working to bring funds into LCRE for research in hydrogen storage materials.

### **Research Member**

#### **Yongzhu Fu, Ph.D., Assistant Professor, Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI**

Dr. Fu has degrees in Materials Science and Engineering (UT-Austin), Chemical Engineering (Dalian Inst. of Chemical Physics), and Polymer Materials (Tsinghua University). He has held research positions within a number of laboratories and national laboratories focused on advanced materials for electrochemical energy conversion and energy storage. At the Lugar Center's Spring Forum he outlined record-breaking results in the cycle lifetime of lithium-sulfur batteries. He is a member of the Electrochemical Society and the American Chemical Society. Dr. Fu recently co-authored (with Dr. Schubert) a poster presentation on the seawater flow battery, an exciting patent pending innovation owned by IURTC – the technology transfer arm of the Indiana University system. Dr. Fu has 1 US patent, with 2 additional patents pending. He is the newest member of the ME department at IUPUI.

### **Advisory Board Members**

#### **Kelly Huntington, President and CEO, Indianapolis Power & Light Company**

Ms. Huntington is responsible for business strategy for the electric utility which serves the IUPUI campus and the Indianapolis area. She has lead approximately \$1.2 billion in capital expenditures for modernization of base-load generation fleet, construction of new CCGT and conversion of two existing units from coal to natural gas. She has held this post since June 2013.

#### **Thomas G. "Tom" Utterback, Principal Systems Engineer, Raytheon Technical Services Company, Indianapolis**

Mr. Utterback has 20 years of experience in avionics integration with broad and sensitive roles related to military aircraft. Tom is also a licensed commercial airline captain and flight instructor. He has a passion for renewable energy and sustainable development, and was introduced to the Lugar Center at an Alumni function for IUPUI's Purdue School of Engineering and Technology.

### **Dustin “Dusty” Wilson, Director of Energy Systems, SAIC**

Mr. Wilson is a long-time advocate of the LCRE, received his MBA from IUPUI, and has served as panelist and moderator at our Spring Forums. Since 2012 Dusty has been heavily involved in waste-to-energy research with LCRE, working on the MSW processing system known as “Old Blue”. In June of 2014, LCRE graduate student Drew Witte successfully defended his Masters thesis on optimal control of this gasification-plus-oxidation (GPOX) thermochemical conversion system. We are deeply grateful for Dusty's leadership in providing outdoor lab capabilities, manpower, and other resources to conduct this research.

### **Rob Hochstetler, VP of Power Production, Hoosier Energy**

Mr. Hochstetler is an integral member of an executive leadership team delivering energy to 18 member distribution cooperatives in Indiana and Illinois, through a 1,500 mile network. Rob implemented board policy on renewable generation that increased it from 0 to 7% over 7 years. He is a licensed Professional Engineer in Indiana and New York, and has been involved in energy for 24 years. Rob is transitioning to a new role in a new company, as will be described further in the 2015 Annual Report.

## **Student Projects**

*Stalk Stoker Monetization* by students Peter Froehlich, Linda Klain, Dustin Teuscher, and Daniel Wang, all MBA students from the Kelley School of Business in the D.I.V.E. program (Discovery, Innovation and Ventures Enterprise) run by LCRE Research Member Dr. Todd Saxton. This project was mentored by Mr. John Craun, our Entrepreneur-in-Residence assigned to the IURTC spin-up company Biomass Unit Ops, LLC. The purpose was to identify the first 20 paying customers for the patented biomass conversion technology known as Indirectly-Heated Pyrolytic Gasification (I-HPG). They identified organic farms and craft breweries as early adopter markets. On the latter, Dustin Teuscher has followed up the team's broader study with a specific case study of the rapidly-growing Sun King Brewery in Indianapolis. His work will lead to a cost-of-ownership model, and we intend to co-author a paper with Sun King's Chief Engineer, and present it at the Craft Brewer's Association annual convention in 2015.

*Wave Energy* was a senior capstone design project for Mechanical Engineering undergraduate students, sponsored by Ms. Joline Ohmart. She approached the LCRE for help and advice with a new concept for harvesting renewable energy from wave motion. This led to a successful study and presentation by the student team.



*Rooftop Garden* by students Dan Godfrey, Katie Griswold, Turki Alotaibi, Eric Nicholas, Ryan Patterson, and Matt Storey. This unique project involved mentorship from both Butler University and IUPUI. It was conceived by Dr. Tim Carter, Director of the Center for Urban Ecology at Butler, MacKenzie Beverage, Butler's first Sustainability Coordinator, Colleen McCormick, IUPUI's first Director of the Office of Sustainability, and Peter Schubert, Director of the LCRE. The team designed a modular, low-cost and light weight rooftop vegetable garden greenhouse, complete with water and energy management, CO<sub>2</sub> recovery, and sufficient strength to withstand sub-tornado winds. Dr. Carter recently announced that funding is now available, and they will build one!

*Boiler MACT* by students Daniel Reyzman and Thomas Watkins. This project was conceived by and mentored by Mr. Pete Grills of Bingham Greenebaum Doll, LLP (Indianapolis), Mr. Jessie Kharbanda, Executive Director of the Hoosier Environmental Council, and Peter Schubert, Director of LCRE. The work was funded jointly by the IUPUI Solution Center, the Hoosier Environmental Council, and the LCRE. The purpose was to study the impact of US EPA laws on coal- and oil-fired boilers at small- and medium-sized enterprises and smaller municipalities in Indiana, and to explore opportunities for renewable energy technologies to be deployed more widely. The final report is 62 pages long, and provides guidance to those seeking to employ renewable energy and includes a list of power generation sites around the State, highlighting those operations which have already moved to renewable energy solutions. A copy of the report is available upon request.

*Biochar* by student Akash Bansal, Chemical Engineering Senior, India Institute of Technology – Bombay. Mr. Bansal joins us for a 10 week internship. His goal is to produce and sell biochar as a demonstration of the commercial value of university research. The Stalk Stoker, inaugurated last year in the Outdoor Biomass Laboratory (1000 Waterway, Indianapolis) has been updated and readied for biochar production by student Drew Witte, and EIR Joe Paganessi who has been brought on as a Visiting Research Associate for his experience in biomass gasification.

*Hydrogen ICE* by student Derich Cutshaw of Motorsports Engineering, IUPUI. A genset generously donated by Mr. Rich Perkoski of Port Vue Plumbing (McKeesport, PA) is being retrofitted to run on hydrogen-rich gas. This can be used for electric power generation from the Stalk Stoker, or for recharging an electric vehicle using the hydrogen generation technology being developed by AlGalCo (Indianapolis).

*E-10* by student Andrew Burrows, Mechanical Engineering IUPUI. Andrew is updating the Solectria-modified Chevy S-10 all-electric vehicle so it can be used for local errands and publicity events on behalf of the LCRE. It is also a research platform for work with AlGalCo to demonstrate range extension with their renewable hydrogen technology.

*R.E. Visualization* by student A. Michael Robertson, an Art Exploratory student an Mechanical Engineering Technology student at IUPUI. Michael has designed a concept car to run on hydrogen stored using patented LCRE technology. During summer 2014 he will be developing visualizations of renewable energy technology, including dioramas to convey the interconnectedness of all the elements of Research Member technologies.

## **Outlook for AY 2014-2015**

In June 2013, President Obama issued his Climate Action Plan, and has been advancing it aggressively ever since. His leadership has helped move the public perception of the impact of human activity on our planet's ecosphere such that recent polls are showing rapid change. A June 2014 Yale-Gallup poll shows that 71% of Americans were "personally convinced that global warming is happening". Yet, far fewer consider the threat sufficiently imminent to take action.

Business development activities related to renewable energy technologies have been severely challenged. The advent of horizontal drilling with hydraulic fracturing has produced sufficient natural gas (mostly methane) that prices have dropped significantly. This has driven a strong movement from coal to natgas in power generation. This also raises economic obstacles to development of alternate and renewable energy technologies. Investor pitches in the cleantech space routinely indicate that relatively few such investments are being made in the venture capital market, at least here in the US.

Federal funding for renewable energy is both reduced and more competitive than in years prior. Significant reductions in the price of photovoltaics (solar cells) and continuing reductions in the price of wind-generated electricity have made these renewables more cost competitive than ever before. While research continues in both areas, they are largely commercial now, with less government investment in making incremental advances.

Energy efficiency is an area where LCRE members are having an impact. The DOE-funded Industrial Energy Center, run by Research Member Dr. Jie Chen has been training students and providing gratis energy audits to regional businesses. More information on their progress can be found at the website: <http://www.iupui.edu/~meengr/iac/>. The conversion of energy and storage of energy are also hot topics, as evidenced by the attendees at this year's Spring Forum.

These factors, projected into the next academic year, suggest that the LCRE can make the greatest impact by supporting and enhancing commercial deployment of renewable energy technologies. Towards this end, there is early concept development just starting on the potential of a business incubator in this space. Collaborations are becoming increasingly important to win major governmental grants. In this space, the LCRE director has been promoting technologies at events such as the National Governor's Association meeting, the Electric Drive Train Association, the TechConnect World 2014 event, the Blue Tech Summit, as well as exploratory discussions with national labs. During her tenure as VRA, Mrs. Aneena Urbanek developed promotional materials for all RMs who responded, and these are now included in a professional brochure highlighting key LCRE technologies.

As you can see from the extensive list of publications, professional service, and innovations in this report, our Research Members are relentlessly pursuing advancement of LCRE goals in myriad ways. A record number of multiple RM co-authorships is evident. It may be expected that energy costs will rise in the future, and the urgency for renewable energy will only increase. Our Center is working to help right now, and preparing for a more sustainable future. In the 2014-2015 academic year, this work is expected to continue, expand, and grow.

## **Appendix A**

### **Executive Committee**

1. Alan Jones, Ph.D., Assistant Professor of Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI
2. Rongrong Chen, Ph.D., Research Associate Professor of Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI
3. Steve Rovnyak, Ph.D. Associate Professor of Electrical and Computer Engineering, Purdue School of Engineering and Technology, IUPUI
4. Mark Goebel, Ph.D., Professor of Biochemistry and Molecular Biology, Indiana University School of Medicine
5. Eric Dannenmaier, Professor of Law and Dean's Fellow, Director, Environmental and Natural Resources Law Program, Indiana University Robert H. McKinney School of Law
6. M. Razi Nalim, P.E., Ph.D., Professor of Mechanical Engineering, Associate Dean for Research & Graduate Programs, Department of Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI

## Appendix B

### **Advisory Board**

The LCRE AB meets quarterly on campus to review progress and provide strategic advice.

1. Dr. Seth W. Snyder, Argonne National Laboratory, and President of the Council for Chemical Research.
2. Robert Galyen, Chief Technology Officer, Amperex Technology Limited.
3. John Kirkwood, JD, Partner, Krieg DeVault.
4. Keni Washington, Managing Director, Earth Solar Technologies Corporation.
5. Doug Wasitis, Director of Federal Relations, Indiana University.
6. Kelly Huntington, President and CEO, Indianapolis Power and Light (new this year!)
7. Lane Ralph, Private citizen, formerly State Director for Sen. Lugar.
8. John Waters, President, Waters and Associates Consulting.
9. Kären Haley, Executive Director, Indianapolis Cultural Trail, Inc.
10. Carey Lykins, President and CEO, Citizens Energy Group.
11. Dr. Wayne Eckerle, Vice President, Corporate Research and Technology, Cummins, Inc.
12. Cathy Tripodi, Senior Vice President, Council on Competitiveness.
13. Cary Aubrey, Manager, Bio-energy Development, Indiana State Department of Agriculture.
14. Steve Kozey, General Counsel, Midwest ISO.
15. Todd Colpron, VP of Business Development, IndyPowerSystems.
16. Dr. Maureen McCann, Director, Purdue Energy Center, Purdue University.
17. Doug Esamann, President, Duke Energy Indiana.
18. Craig Herndon, Director of Critical Technology Innovation, NSWC Crane.
19. Laurie Tuttle, VP Hybrid Program, Allison Transmission.
20. William D. "Bill" Crawford, Senior Business Development Executive, American Solar Integrators, LLC .
21. Dan M. Martin, Senior Scholar, Woodrow Wilson International Center .
22. Terry Hall, Partner, Faegre Baker Daniels.
23. Jim Wheeler, Thomas P. Miller and Assoc.
24. Tom Utterback, Principal Systems Engineer, Raytheon (new this year!)
25. Dustin "Dusty" Wilson, Director of Energy Systems, SAIC (new this year!)
26. Rob Hochstetler, VP of Power Production, Hoosier Energy (new this year!)

## Appendix C

### **Research Members**

1. Dr. Jie Chen, Mechanical Engineering, Purdue School of Engineering and Technology at IUPUI
2. Dr. Hazim El Mounayri, Mechanical Engineering, Purdue School of Engineering and Technology at IUPUI
3. Dr. M. Razi Nalim, Mechanical Engineering, Purdue School of Engineering and Technology at IUPUI
4. Dr. Yaobin Chen, Electrical and Computer Engineering, Purdue School of Engineering and Technology at IUPUI
5. Dr. Sohel Anwar, Mechanical Engineering, Purdue School of Engineering and Technology at IUPUI
6. Dr. David Goodman, Electrical and Computer Engineering Technology, Purdue School of Engineering and Technology at IUPUI
7. Dr. Stephen Hundley, Computer, Information, and Leadership Technology, Purdue School of Engineering and Technology at IUPUI
8. Dr. Youngsik Kim, Mechanical Engineering, Purdue School of Engineering and Technology at IUPUI
9. Dr. Afshin Izadian, Electrical and Computer Engineering, Purdue School of Engineering and Technology at IUPUI
10. Dr. Lingxi Li, Electrical and Computer Engineering, Purdue School of Engineering and Technology at IUPUI
11. Dr. Rongrong Chen, Mechanical Engineering, Purdue School of Engineering and Tech at IUPUI
12. Dr. Maher Rizkalla, Electrical and Computer Engineering, Purdue School of Engineering and Tech at IUPUI
13. Dr. Steven Rovnyak, Electrical and Computer Engineering, Purdue School of Engineering and Technology at IUPUI
14. Dr. Alan Jones, Mechanical Engineering, Purdue School of Engineering and Tech at IUPUI
15. Dr. Tamer Wasfy, Mechanical Engineering, Purdue School of Engineering and Technology at IUPUI
16. Dr. Dong Xie, Biomedical Engineering, Purdue School of Engineering and Technology, IUPUI
17. Dr. Jian Xie, Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI
18. Dr. Likun Zhu, Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI
19. Dr. Mark Goebel, Biochemistry and Molecular Biology, IU School of Medicine at IUPUI
20. Dr. Gabriel Filippelli, Professor of Earth Sciences, Director Center For Urban Health, Earth Sciences Department, Purdue School of Science at IUPUI
21. Dr. Asok Sen, Mathematical Sciences, Purdue School of Science at IUPUI
22. Dr. Xianzhong Wang, Biology, Purdue School of Science at IUPUI

23. Dr. Ken Richards, Public and Environmental Affairs/Law, IU School of Public & Environmental Affairs/IU Maurer School of Law
24. Dr. Eric Dannenmaier, Director, Environmental and Natural Resources Law Program, IU School of Law
25. Dr. Tom Iseley, Construction Engineering Management, Purdue School of Engineering and Technology, IUPUI
26. Dr. Pierre Atlas, Political Science, Marian University
27. Dr. Carol Rogers, Indiana Business Research Center, Kelley School of Business, IUPUI
28. Patricia Fox, Organizational Leadership and Supervision, Purdue School of Engineering and Technology at IUPUI
29. Dr. Jan Cowan Architectural Technology Program, Purdue School of Engineering and Technology at IUPUI
30. Dr. Jerome Dumortier, Public and Environmental Affairs, IU School of Public and Environmental Affairs
31. Dr. Peter J. Schubert, Electrical and Computer Engineering, Purdue School of Engineering and Technology at IUPUI
32. Dr. Jing Zhang, Mechanical Engineering, Purdue School of Engineering and Technology at IUPUI
33. Dr. Stephen K. Randall, Department of Biology, School of Science, IUPUI
34. Dr. Rebecca Barthelmie, Professor of Atmospheric Science and Sustainability, Department of Geological Sciences, Indiana University-Bloomington
35. Dr. Sara Pryor, Provost Professor of Atmospheric Science, Department of Geological Sciences, Indiana University-Bloomington
36. Andres Tovar, Ph.D., Assistant Professor, Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI
37. Sanya Carley, Ph.D., Assistant Professor, School of Public and Environmental Affairs (SPEA), Indiana University
38. Euzeli C. Dos Santos, Jr., Ph.D., Assistant Professor, Electrical and Computer Engineering, Purdue School of Engineering and Technology, IUPUI
39. Huidan “Whitney” Yu, Ph.D., Assistant Professor, Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI
40. Dr. Elaine Cooney, Professor of Electrical and Computer Technology, Department Head, Technology, IUPUI.
41. Dr. E. Jane Luzar, Professor of Economics, Professor of Public and Environmental Affairs, Dean, IUPUI Honors College.
42. Dr. Paul E. Sokol, Professor of Experimental Physics, Department of Physics, IU-Bloomington.
43. Dr. Ali Razban, Senior Lecturer, Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI.
44. Dr. Yongzhu Fu, Assistant Professor, Dept. of Mechanical Engineering, Purdue School of Engineering and Technology, IUPUI.

## Appendix D

### **Entrepreneurs-in-Residence**

The EIR program was initiated in December 2011 in cooperation with Dr. Joe Trebley of the Indiana University Research and Technology Corporation (IURTC) – the technology transfer organization for the IU system. Dr. Trebley heads the Startup Support and Promotion initiative to help faculty create businesses based on their intellectual property. The most crucial role for the EIRs is to serve as PI for federal Small Business Innovation Research (SBIR) grants made by spIn-Up companies which can then subcontract to university faculty. This allows faculty members to retain 100% appointments while benefiting from the entrepreneurial experience of the EIR and avoiding the federal requirement that the PI be 51% or more associated with the small company. Three SBIR proposals have been submitted to the NSF, DOE, and USDA in AY 2013-2014. In addition to SBIRs, EIRs help develop business plans, often in concert with students from the Kelley School of Business, and they bring networking opportunities to LCRE. The following individuals provide pro bono work on behalf of the university with the hope and expectation that, upon receiving funding, they can begin to draw a salary commensurate with their level of interest and availability, while creating commercially-viable going concerns based on research from LCRE Research Members:

1. Mr. John Craun
2. Dr. Randall Gatz
3. Dr. Shashikala K
4. Dr. James Logson
5. Mr. Joe Paganessi
6. Mr. Edward F. Plocharczyk
7. Dr. Seth Potter
8. Mr. Peter Price
9. Dr. Bob Rosenstein
10. Mr. Lee Saberson
11. Mr. Morris Stillabower
12. Mrs. Aneena Urbanek

## **Appendix E**

### **Director's Afterward**

A great many people contribute to this organization. We are privileged to be administratively housed within the School of Engineering and Technology at IUPUI and to have the support of Dean David Russomanno and his staff. Administrators and facility services people from all across the Indianapolis campus have worked hard in creating an environment conducive to research and learning. Thanks to all of you who help make this important work possible.