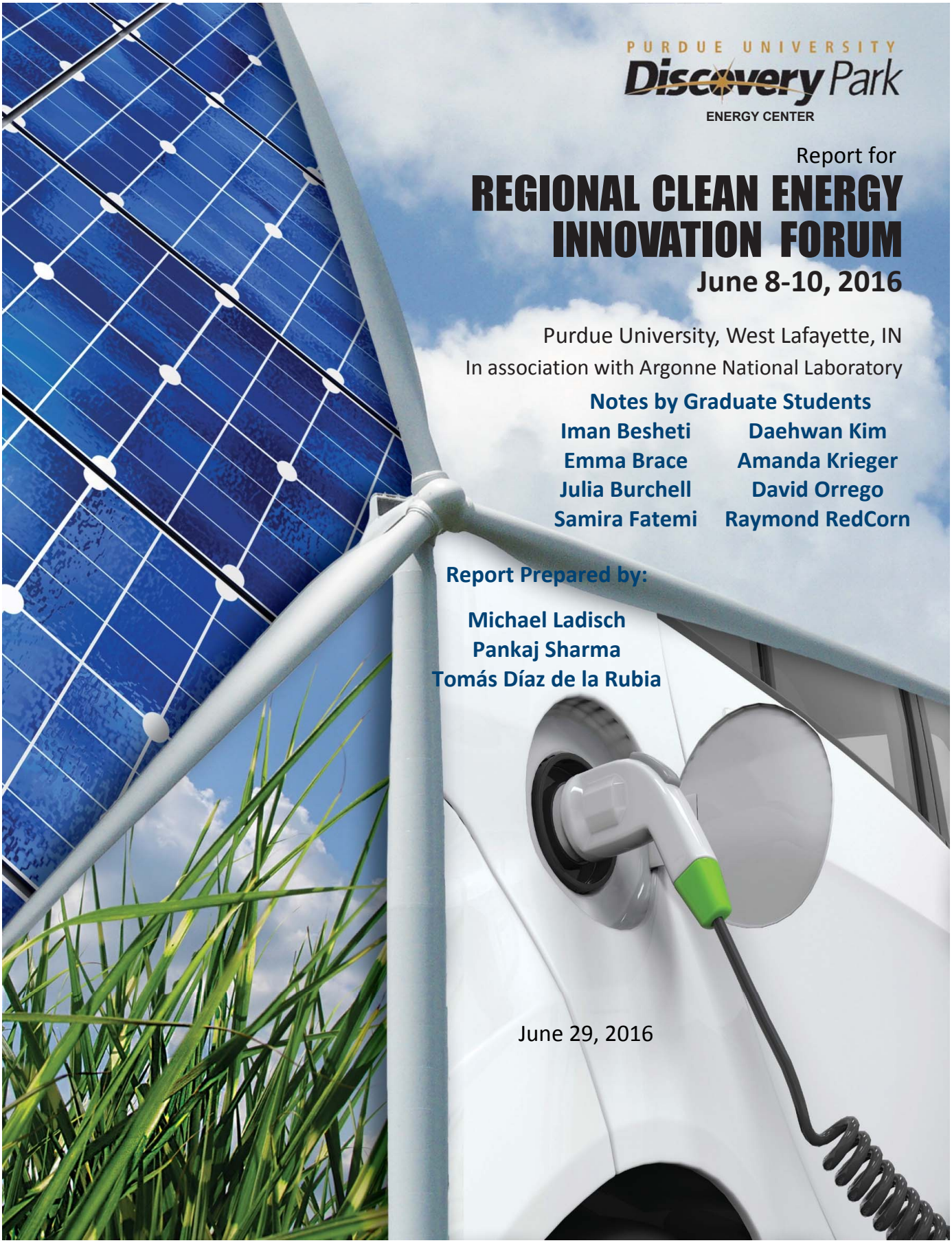
Purdue University

Regional Clean Energy Innovation Forum

West Lafayette, Indiana • June 8-10, 2016



PURDUE UNIVERSITY
Discovery Park
ENERGY CENTER

Report for

REGIONAL CLEAN ENERGY INNOVATION FORUM

June 8-10, 2016

Purdue University, West Lafayette, IN
In association with Argonne National Laboratory

Notes by Graduate Students

Iman Besheti
Emma Brace
Julia Burchell
Samira Fatemi
Daehwan Kim
Amanda Krieger
David Orrego
Raymond RedCorn

Report Prepared by:

Michael Ladisch
Pankaj Sharma
Tomás Díaz de la Rubia

June 29, 2016

Report on

REGIONALCLEANENERGYINNOVATIONFORUM

June 8-10, 2016

Purdue University, West Lafayette, IN

PURDUE UNIVERSITY Discovery Park ENERGY CENTER

In association with Argonne National Laboratory

AGENDA

Wednesday June 8	**Reception and Posters**	**Page**
Thursday, June 9		
8:45-9:30 a.m.	**Welcome (Objective of Forum and Summary of Findings)**	**4**
	Tómas Díaz de la Rubia, Chief Scientist and Executive Director, Discovery Park, Purdue University **Mitchell E. Daniels**, President, Purdue University **Franklin (Lynn) Orr**, Under Secretary for Science and Energy, Department of Energy **Eric Holcomb**, Lieutenant Governor of Indiana **Jim Merritt**, State Senator, Indiana; Chairman of the Senate Utilities Committee	
	Overall Findings of the Panels	**7**
9:30-10:45 a.m.	**Panel #1: Energy Storage** Moderator: **George Crabtree**, Director, Joint Center for Energy Storage, Argonne National Laboratory Panelists: **David Roberts**, President, Battery Innovation Center **Mark Johnson**, Director, Advanced Manufacturing Office, Office of Energy Efficiency and Renewable Energy, Department of Energy **Joaquín Rodríguez-López**, Assistant Professor of Chemistry, University of Illinois at Urbana-Champaign **Thomas Golab**, Vice President and Chief Financial Officer, Navitas Systems	**8**

11:00-12:15 p.m.	**Panel #2: Biomass/Synthetic Biology** Moderator: **Michael Ladisch**, Director, Laboratory of Renewable Resources Engineering; Distinguished Professor of Agricultural and Biological Engineering, Purdue University Panelists: **Kent Peters**, Program Manager for the Bioenergy Research Centers, Biological and Environmental Research, Office of Science, Department of Energy **Jennifer Dunn**, Biofuel Life Cycle Analysis Team Leader and Environmental Analyst, Energy Systems, Argonne National Laboratory **Bruce Dale**, University Distinguished Professor of AgBio Research, Department of Chemical Engineering and Materials Science, Michigan State University **Peter Keeling**, Innovation Director, NSF Engineering Research Center for Biorenewable Chemicals, Iowa State University **Nancy Heimann**, President and CEO, Enginuity Worldwide	**10**
12:30-1:30 p.m.	**Lunch**	
1:45-3:00 p.m.	**Panel #3: Critical Materials/Advanced Manufacturing** Moderator: **Thomas Lograsso**, Director, Division of Materials Science and Engineering Panelists: **Carol Handwerker**, Reinhardt Schuhmann, Jr. Professor of Materials Engineering and Environmental and Ecological Engineering, Purdue University **Chenn Zhou**, Director, Steel Manufacturing Simulation and Visualization Consortium; Professor and Director, Center for Innovation through Visualization and Simulation, Purdue University Calumet **John Barnes**, Vice President, Advanced Manufacturing & Strategy, Alcoa Titanium & Engineered Products	**11**
3:00-3:15 p.m.	**Break**	
3:15-4:30 p.m.	**Panel #4: Wind Energy/Grid Integration** Moderator: **John Bear**, President and Chief Executive Officer, MISO Energy Panelists: **Doug Esamann**, Executive Vice President and President of Duke Energy's Midwest and Florida Regions, Duke Energy **Juan Torres**, Manager, Energy Systems Analysis, Sandia National Laboratory **Lian Shen**, Benjamin Mayhugh Associate Professor of Mechanical Engineering and Associate Director for Research, St. Anthony Falls Laboratory, University of Minnesota **John McDonald**, SmartGrid Business Development Leader, North America; Global SmartGrid Strategy Group, GE Grid Solutions	**14**

6:00 p.m.	**Reception and poster session**	
7:00 p.m.	**Dinner: Remarks** by **Jay Gore**, Vincent P. Reilly Professor in Mechanical Engineering, Purdue University	
Friday, June 10		
7:45-8:30 a.m.	**Breakfast and registration** Discovery Learning Research Center in Discovery Park, 298 Nimitz Dr., West Lafayette	
8:30-9:45 a.m.	**Panel #5: Public-Private Partnerships** Moderator: **Mark Johnson**, Director, Advanced Manufacturing Office, Office of Energy Efficiency and Renewable Energy, Department of Energy Panelists: **Alfred Sattelberger**, Deputy Laboratory Director for Programs, Argonne National Laboratory **Marcey Hoover**, Chief Operating Officer for the Energy and Climate Program, Sandia National Laboratory **Duane Johnson**, Chief Research Officer, AMES Laboratory **Byron Pipes**, John Leighton Bray Distinguished Professor of Engineering, Purdue University **Paul Mitchell**, President and CEO, Energy Systems Network **Justin Hage**, Director for Strategic Planning and Performance Management, Indiana Economic Development Corporation (IEDC)	**15**
9:45-10:45 a.m.	**Breakout sessions: Clean Energy Innovation Midwest Assets** Facilitator: **Ed Morrison**, Director, Agile Strategy Lab, Purdue University	
10:45-11:30 a.m.	**Reports**	
11:30-11:45 a.m.	**Closing remarks** **Tómas Díaz de la Rubia**, Chief Scientist and Executive Director, Discovery Park, Purdue University	

The following is a summary report and notes for the Purdue University Regional Clean Energy and Innovation Forum, held June 8-10, 2016 on the West Lafayette campus.

Objective

The Regional Clean Energy Innovation Forum was held on June 8-10 under the auspices of Discovery Park in association with Argonne National Laboratory. The objective of this forum was to bring together leaders in clean energy innovation from the Midwest region that encompassed the states of Minnesota, Iowa, Wisconsin, Illinois, Indiana, Michigan, Missouri and Ohio. The 195 registrants represented this region's National Laboratories, key university research centers, and industry, as well as faculty and staff from across Purdue University.

Summary

The Midwest has tremendous amounts of natural resources, is rich in manufacturing, and has outstanding national laboratories associated with the U.S. Department of Energy. According to the key note presentation by President Daniels, the solutions to energy problems are important to the work of society, since these solutions relate not only to energy, but also to health, food, and the economic welfare of the region and the nation. Purdue University, together with its partners, carries out pioneering research in technologies both for utilizing or generating energy in new ways as well as in conserving energy. Some examples of new energy ventures close to the West Lafayette campus include a federally funded materials center which will be starting-up in the near future and the world's most advanced jet engine manufacturing facility in Lafayette, IN. In addition, there are significant activities in translation and technology transfer that are occurring at the Purdue Research Foundation's Research Park in West Lafayette, IN.

President Daniels welcomes participants of the Regional Clean Energy Innovation Forum.

Dr. Tómas Díaz de la Rubia summarized the capabilities of Discovery Park in key areas of materials, nanotechnology, bioenergy research, energy storage and wind energy, as well as experience in public/private partnerships. He introduced the Under Secretary for Science and Energy, Dr. Lynn Orr, who addressed the importance of regional clean energy innovation partnerships. These partnerships will play an important role in addressing technology innovation, formation of consortia to advance the region in energy programs, and, building on current DOE programs and business models, would advance clean energy in the Midwest. These partnerships must address climate concerns, air quality, and water quality issues over a sustained period of time in order to ensure environmental and energy security. In the long-term clean energy innovation and private/public partnerships will decide which societies are competitive and which ones are not. This message was conveyed both during the keynote presentations and during separate meetings with the graduate students and faculty who had carried out research supported by DOE.

Concurrent opportunities for major innovations and changes are already occurring, and will define how the United States and other countries will address the goals negotiated at the United Nations Climate Change Conference in Paris on December 12, 2015, for reduction of greenhouse gas emissions. At this meeting, many countries, including the U.S., agreed to double clean energy research and development over the next five years. This research will address the fundamental science of energy generation and utilization as well as mitigation of the effects of CO_2 emissions on climate change.

The DOE's clean energy portfolio will be focused on early stage R&D, with $110 million requested for the FY 2017 budget for Regional Energy Centers. This research initiative includes fostering regional opportunities for energy innovation, and capitalizing on the intellectual capital, as well as the science and engineering enterprises of universities, laboratories, start-ups and other research organizations which have the capability of carrying out technology transfer as part of a team based effort. Since renewable energy availability, local climates and team resources, and available assets of universities and national laboratories vary with region, a regional approach will be an important component of the DOE research portfolio. There are possibly up to 10 multi-stage regions where this approach might be considered, although the extent of the program will depend on budget approvals.

In the case of Indiana there is a synergy between entrepreneurship and discovery, as well as translating new technology developments into the energy industry. Examples cited by Lieutenant Governor Holcomb of Indiana include hundreds of windmills, a solar (photovoltaic) farm at the Indianapolis International airport, and biofuel production facilities currently producing ethanol for fuel use. These synergies and the status of energy technology in Indiana will lead to new jobs, higher wages, and positive economic developments with new technology developments expected to have a regional impact, as well.

In addition to wind and solar power (i.e., photovoltaics), coal and nuclear energy are also important and will make continuing contributions. However, there has been a large decrease in the use of coal over the last ten years. Senator Jim Merritt pointed out that approximately 1/3 of the coal plants will be taken out of service by 2030. While biomass and geothermal energy sources are still struggling, wind has led the way for solar power, and major advances and

improvements in battery storage will have impacts both on solar and wind generated electrical power, as well as meeting some of the needs for corporate and manufacturing facilities where power storage is an important component. Nuclear energy is another option since it provides carbon-free energy. In addition, improvements in production efficiency will also play a role. An example is Subaru which has a major automobile plant in Lafayette, IN, and which has significantly improved its efficiency and serves an example of what can be done. The session ended by Senator Merritt pointing out that "saving energy is bipartisan."

(Left to Right) Suresh Garimella (Purdue), Tomás Díaz de la Rubia (Purdue), Mitch Daniels (Purdue), Pankaj Sharma (Purdue), Jim Merritt (Senator, Indiana), Thomas Golab (Navitas Systems), Lynn Orr (DOE), Eric Holcomb (Lt. Governor, Indiana) welcome participants and speakers in the Regional Clean Energy Innovation Forum at Purdue University.

Overall Findings of the Panels

The key findings of the 5 panels presented a consistent message:

(1) Efficient energy generation and utilization have both a regional and national basis. The time has come to address clean energy that is most appropriate for a given geographical area, and for which solutions and living laboratories to test and prove the solutions, is best done on a regional basis. In our case, the pertinent region is Indiana, Illinois, Michigan, Ohio, Missouri, Wisconsin, Iowa, and Minnesota.

(2) There is a compelling case to be made for a Purdue University led regional energy center whose scientific and engineering basis would address the bioeconomy, wind and solar energy, grid integration, advanced materials, energy storage technology, and public-private partnerships in the Midwest. Purdue has a presence in all of these areas, and together with other partners could act as a lens to focus regional activities on robust and internationally relevant solutions in clean energy; and

(3) Staffing of high technology activities in clean energy will require an appropriately educated and trained workforce. Purdue University, its academic partners, and National Laboratory collaborators are uniquely positioned and actively engaged in addressing this need. A Regional Center for Clean Energy will enable this on-going resource to be ramped up and bring about a renaissance in clean energy research, development, and utilization in the Midwest. The Midwest has potential to become a role model for other Regional Energy Centers.

Under Secretary of Energy Orr discusses energy, environmental security, & mission innovation.

Summaries for Individual Panels

Panel No. 1: Energy Storage

Moderator: George Crabtree (Argonne National Laboratories)
Panelists: David Roberts (Battery Innovation Center), Mark Johnson (Department of Energy), Joaquín Rodríguez-López (Illinois at Urbana-Champaign) Thomas Golab (Navitas Systems)

Energy Storage panelists discuss energy storage technology challenges and opportunities at Purdue University Regional Clean Energy Innovation Forum. (Left to Right): George Crabtree (Argonne National Laboratory), David Roberts (Battery Innovation Center), Mark Johnson (Department of Energy), Joaquín Rodríguez-López (Illinois at Urbana-Champaign), Thomas Golab (Navitas Systems)

Energy storage is critical for expanding the generation of electrical energy and for grid and transportation applications. The development of batteries with higher power density will facilitate more efficient capture of energy from wind and solar by providing ways to store power until it is needed. While energy storage is important, the distribution of energy also faces major challenges including cyber security, since the distribution system is controlled through computer-based algorithms and control systems. A cyber-attack on the electrical grid could have a major consequence on the U.S. economy by causing large power generation plants to be shut down and an electrical power cut off to major manufacturing facilities in urban areas. There are numerous research and implementation opportunities that should be addressed and for which a regional energy center would provide an enabling and catalytic effect.

The production of batteries will need to be less costly and the adaptation of older technologies (such as Kodak's mass manufacture of photographic films) could serve as a model in the manufacture of batteries and other large volume energy storage products. Given the need to

reduce the cost, this approach should enhance utilization of batteries. Renewable electrical energy harvested from the wind and the sun will need to be stored in a cost-effective and robust manner with a number of different configurations.

The need for scientists and engineers who will work in this research area and also in the engineering of cost-effective batteries was also addressed. When batteries are produced on a large scale, many technology problems will likely be encountered and this will benefit from public/private partnerships to address the many aspects of storage technology, ranging from battery technology to optimizing methods for deploying batteries as part of the grid. Advances in storage will require cross-disciplinary research and cooperation, and investment by government and industry. Policy is also needed in order to enable the utilization of the electrical power derived in this manner, and also to apply the technology not only to automotive transport but also to the chemical industry or to on-site manufacturing where a reliable supply of hydrogen, H_2, is also important.

In response to questions, the Panel suggested that there will be multiple technologies that will be needed in order to achieve the goals of energy storage over the next 5-10 years. In addition to technological and regulatory policies, the positioning of the utilities with respect to this technology will be important in terms of financing adaptation of clean and renewable energy by individual consumers (households).

Dr. de la Rubia leading discussion on opportunities for energy innovation in Midwest Region

Panel No. 2: Biomass/Synthetic Biology

Moderator: Michael Ladisch (Purdue University)

Panelists: Bruce Dale (Michigan State University), Jennifer Dunn (Argonne National Laboratory), Nancy Heimann (Enginuity Worldwide), Peter Keeling (Iowa State University), Kent Peters (Department of Energy)

There are a number of products derived from renewable resources, which may either include energy sources (liquid fuels) and perhaps, just as importantly, bioproducts, derived from unutilized biomass materials (after biofuels have been manufactured). The Panel addressed both environmental and supply chain issues, including land use and managing the generation of biomass, which will be needed to provide feedstocks to industrial facilities that utilize lignocellulosic biomass to form both liquid fuels and value-added co-products. The co-products may find use in the manufacture of plastics, coatings, and other chemical products for which an oxygenated (i.e., plant material derived) molecule may have superior properties. As this part of the industry ramps up, beneficial interactions between food, feed, the environment and biofuels should be emphasized, and will likely emerge. Regional factors will impact feedstock selection ranging from agricultural residues (for example, corn stover), woody biomass, and specialty energy crops such as switchgrass and Miscanthus.

Some of the challenges that will face the bioeconomy, but which can be solved if properly addressed, include the transportation of biomass from the point at which it is generated (i.e., the farm) to the point of where it is processed (i.e., fermentation facility). Pricing of the feedstock, as well as the final product, in addition to the pricing of oil against which some of these products will compete, is a key consideration in determining whether or not some of these routes might be practical. Nonetheless, there is significant optimism that this can be done, with current work moving in the direction of using renewable feedstocks for the production of both biofuels and bioproducts.

The production of bioproducts benefits from biology, since biological catalysts (both microorganisms and in some cases enzymes) are able to selectively remove oxygen from sugars derived from biomass. While there is a gap between innovation and use of new technology in the industry, this gap can and must be addressed. A key impediment is the need for massive scale-up of process technologies and manufacturing capabilities for bioproducts derived through biological, biochemical, and chemical catalysis and separations. The correct cost and price points will need to be defined and the quality of products will need to be better than existing products derived from less expensive petroleum. Life cycle analysis will be needed to guide choices for smart designs of production facilities and generation of renewable feedstocks in a sustainable manner. Examples of bioproducts that could be both developed and deployed regionally include aviation biofuels, gasoline extenders for light engines, bio-monomers for biodegradable plastics, and specialty chemicals derived from both the lignin and cellulosic components of biomass feedstocks. Translation of technologies from laboratory to commercial production must be a focus, with the existing regional infrastructure providing pre-existing capital infrastructure from which to expand the biorenewables portfolio in a meaningful way.

Overall, the areas that require both fundamental research and translation efforts are in sustainable biofuels and bioproducts, feedstock production and fundamentals of biomass deconstruction.

Bioproducts have an important role to play since their price points place them at a higher selling value than the fuel itself and thereby would have a positive economic effect. Some of the considerations in selecting which bioproducts might provide a good fit with biorefineries that are currently under development include obtaining a product that could serve as a building block for other chemicals; may be manufactured by a process that has an improved GHG profile over products with equivalent functionality but derived from petroleum; and has a unique characteristic and sufficiently large market to attract companies to manufacture it.

The cost sensitivity of these processes is due to the cost of the feedstock (e.g., corn stover) where prices (between $40 and $80/ton) of biomass must be considered. A sustainable supply of biomass feedstock must be available. However, low oil prices make it difficult to keep biofuels competitive. A focus on the technology and links between producing fuels and chemicals will be important for the economics of biorefineries and for planning purposes so that these biorefineries can carry out either thermal or bioprocessing types of reactions. Regardless of the approach, sustainability will be the key in managing the interaction of crops with growth conditions so that these provide consistent feedstocks suitable for deconstruction and separation for eventual production of fuels, biopolymers, and biochemicals from lignocellulosic biomass. Energy policy changes may also be needed.

Panel 3: Critical Materials/Advanced Manufacturing

Moderator: Thomas Lograsso (Ames Laboratory)

Panelists: John Barnes (Alcoa Titanium & Engineered Products), Carol Handwerker (Purdue University), Chenn Zhou (Purdue University Northwest)

Panel 3 addressed the need for a stable supply of clean energy, and the diversification of expanded production. Appropriate materials for fabrication of equipment and systems that generate electricity using wind, electrical power and other means is an important factor. This Panel gave an industrial viewpoint and observations regarding how renewable energy and clean technologies could be conveyed in ways that are appealing to people. For example, at Alcoa, one of the approaches used for rolling out new products is to manufacture these products in a way that they are appealing to the consumer. The supply chain of both technology and materials can be controlled in a predictable manner. It is important for utilization of new materials to communicate the message of what the material will do and the price point at which it will be successful. Innovation, integration, and industrialization of new discoveries and developments have many challenges which must be recognized and overcome.

The development of new materials, and manufacturing of these materials in new ways, will impact clean energy through improving efficiency (and therefore generating less CO_2), as well as by providing materials that can be used in aviation, transportation systems, and for energy generation and storage. One example given was the computer simulation of the internal parts of a blast furnace, where modeling and prediction of heat distribution patterns at very high temperatures lead to improvements in blast furnace operations and reduced the amount of energy required.

Nanotechnology has the potential to provide materials with superior properties, but scalability is a challenge. Transfer of technology from the laboratory to large-scale manufacturing faces a gap

that requires a flexible team that is critical of their work and can identify gaps needed to overcome manufacturing issues. The technology readiness level (abbreviated TRL) captures some of the inherent challenges with transition from TRL3 (small scale) to TRL6 or 7 (pre-commercial and pilot plant) scale requiring a significant effort and careful planning in order to achieve final goals. Within this context, the production of titanium powder by Alcoa underscored many of the challenges. Titanium powder, which is difficult to handle, is manufactured to specifications on a very large scale. Success required not only innovation but also integration of the different unit operations that occur in the manufacture of the powder. This project succeeded due to an understanding of how large-scale production could be industrialized.

Some examples of critical materials and advanced manufacturing for wind energy included windmills, where permanent magnets enabled more efficient operation, lead-free solder, which addressed a safety issue but also changed properties of circuit boards, which had previously used lead in their soldering method.

Erin Lucas and Pankaj Sharma discuss commercialization opportunities in the Midwest region.

Titanium metal parts presented different challenges. Ingot to install (ship ingots to Airbus and to Boeing for manufacture of aircraft components) was the original model which is undergoing major changes due to 3D printing. 3D printing enables parts to be manufactured using powders. However, systems integration of 3D printing capabilities with other manufacturing is also required and presents both an opportunity and a challenge. The problem in this case is that machines do not integrate well, but once this is overcome, the use of 3D "ink" results in "infinite" possibilities with the adoption limited by the vision and imagination used to implement the technology. Given the numerous possibilities presented by the new materials, John Barnes (from Alcoa) pointed out that there is "no saturation point in education." More is better from the point of view of developing, translating, and implementing new technologies.

The fundamental problem that defines gaps in translation revolves around the key questions of:

1. Is it economic?
2. Is there a market for the product?
3. Can the materials use cycle be closed?

In order to bridge what is known as the "valley of death," an increased level of accountability with respect to high level goals is needed so that the development pathway can be carried forward in an efficient and productive manner, and the product development cycle avoids "the valley of death."

In the case of magnets, the rare earths first needed for the magnets is very challenging particularly with respect to recycle. In this case, the magnets need to be kept intact and collection becomes a huge issue if these materials are to be recycled.

Professor Carol Handwerker proposes challenges and solutions for developing critical materials to Thomas Lograsso (AMES Laboratories). James Chavez (Sandia National Laboratory) is in background.

While there are various ways that the Critical Materials Institute can achieve its goals, the International/National Electronics Manufacturing Institute carries out projects only with in-kind resources. The adaptation of new materials for clean energy is related to supply chain, and suppliers (for example, Alcoa) must keep up with the technology as it develops given its huge impact on manufacturing of advanced materials which go into different types of products for conserving energy, utilizing energy more efficiently, or generating energy.

Panel No. 4: Wind Energy/Grid Integration

Moderator: John Bear (MISO Energy)

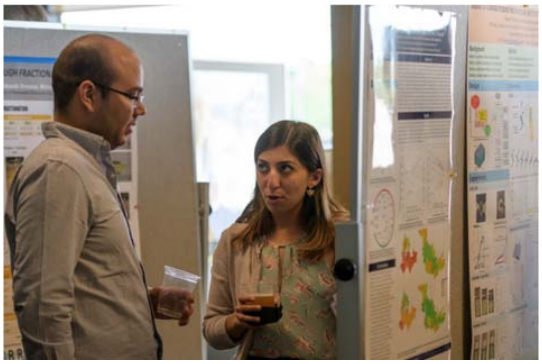
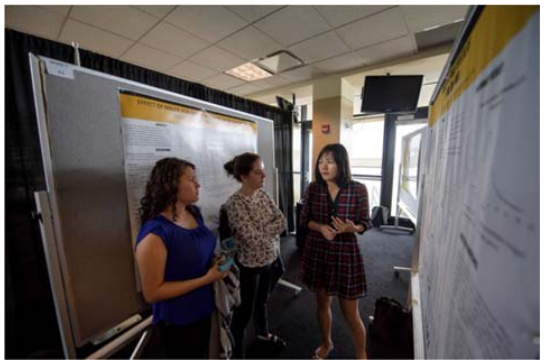
Panelists: Doug Esamann (Duke Energy), John McDonald (GE Grid Solutions), Lian Shen (University of Minnesota), Juan Torres (Sandia National Laboratory)

A key area for efficient use of electrical energy is the grid. One of the concepts currently being examined is a self-healing grid that will implement, divert, or redirect electrical power in response to extreme events. This requires establishment of foundational standards, which involve technology, industry standards and policy. In 2009, NIST, under the America Recoveries Act (ARA), coordinated development of the smart grid and examined many of the issues involved.

The key to a smart grid and utilization of renewable power is management of demand since solar and wind power will not replace baseload power because of the variability in the renewable, electrical power generation. Consequently, baseload and large electrical generation facilities are still needed. Many of these are currently coal-based, although there is a move to shutter some of the older coal facilities and replace with natural gas.

Juan Torres of Sandia Laboratories pointed out that Hawaii provides a case study in that it has small diesel generators that provide power, with their grid being built upon electromechanical generation capabilities. In the case of Europe, wind and solar are "super highly meshed," and provide a living laboratory and interesting case studies for the U.S. and the management of the U.S. grid. A smart grid looks at both demand and supply, not just the demand side, and consequently requires significant optimization. There is much more work to be done on the demand side of electrical power usage.

A smart grid will need to be optimized on a regional basis; hence, the Regional Clean Energy and Innovation Center could play a role, and could facilitate coordination on a larger national basis. Some questions to be addressed relative to cyber security include the close link of physical operations and computer control, and achieving a stable grid. There needs to be clear understanding of the risks that are involved. One of the panelists suggested that a cybersecurity course be required of all students (only a few graduate students at the meeting had actually taken a cybersecurity course at this time). Since digital control and cybersecurity will be critical for stable operation of a grid and many other types of power generation, this should be a high priority. One other comment offered that integrating wind power with hydropower would be difficult because the hydropower may not be well-controlled, particularly during periods of drought or other special events.

Graduate students and researchers present and discuss posters on their research on biocatalysts.

During dinner, Jay Gore reflects on the many excellent ideas and approaches for regional clean energy innovation, discussed during the forum.

Panel No. 5: Public/Private Partnerships

Moderator: Mark Johnson (Department of Energy)

Panelists: Justin Hage (Indiana Economic Development Corporation), Marcey Hoover (Sandia National Laboratory), Duane Johnson (AMES Laboratory), Paul Mitchell (Energy Systems Network), Byron Pipes (Purdue University), Alfred Sattelberger (Argonne National Laboratory)

A Panel on public/private partnerships was headed by Mark Johnson (Director, Advanced Manufacturing Office at DOE) who is familiar with various forms of partnerships. These included CRADAs (ventures between faculty and/or national laboratories and small businesses), the Small Business Voucher Program, and related small business programs. One of the challenges indicated was identifying who a small business should work with in order to form a partnership and effectively develop new technology. Research laboratories could provide facilities to external partners, thereby reducing the need to replicate the same facilities in the private sector and improve the accessibility and efficiency with which new technology is developed. One of the issues discussed included the foundational problem of companies spinning off businesses (examples are General Electric, IBM, and others), in which the businesses are run separately. This was presented as causing a negative impact on research. In

this case, the research, which was previously carried out in a contiguous organization, was fragmented.

In the area of clean energy, there is currently global agreement to increase carbon efficiency and do it as technology becomes available. Public and private partnerships are needed throughout the country, with regional emphasis on regional issues and solutions that apply on a national basis. In order to achieve this, tax credits and other incentives could be put in place. In addition, an energy systems network is another approach, and an example is given between the partnership of utilities and automotive transportation currently being developed through shared-ride vehicles. In Indianapolis, the use of electrical vehicles on a shared-ride basis is being tested to make more efficient use of the vehicles and encourage adaptation of electrical vehicles. Byron Pipes described the new Institute for Advanced Manufacturing which is one of the NNMI laboratories, as a win/win situation.

It is imperative to speed up the timeline from discovery to development, and work with industry partners to define gaps and challenges before the translation process starts, if at all possible. Examples would be the environmental remediation associated with cell phones and laptops, where design might make it easier to recycle components. Marcey Hoover described DOE's Sandia National Laboratories, which have a budget of approximately $3B, and which address energy and climate, safety and security, nuclear energy, and bioenergy challenges. Unlike the defense and intelligence work also being done at Sandia, the laboratory wishes to share and partner in the energy areas.

The challenges in carrying out the work under the auspices of a public/private partnership appear to be communication, and at times, differences in culture (i.e., timelines and expectations). Alfred Sattelberger described Argonne National Lab, a $750M DOE laboratory in the Chicago area, with 15 research divisions and 5 national user facilities. Argonne is also home to the Joint Center for Energy Storage Research, an energy innovation hub that includes 4 other national labs, 5 companies and 5 universities. Al mentioned a new DOE-funded program called Chain Reaction Innovations that allows entrepreneurs, on a competitive basis, to apply for access to the Argonne ecosystem and use of its experimental and computational facilities. The bottom line of this Panel was given by Mark Johnson, who stated that "the public wants science with an outcome." Other key take-aways are that economics are regional (therefore, benefiting from a regional center). At the same time, appropriate partnerships create prosperity with technology. The building of technology, for which there are no competent workers, however, is not constructive, and therefore, an educational component will be very important.

Public/private partnerships benefit from tax incentives to support small businesses through technical assistance, and an example was given for Sandia Laboratories. In this case, 2500 small businesses from around the State are supported through funding of $48 M resulting in creation of 5,000 New Mexican jobs. This requires, however, that PI's will work with businesses, and entails a significant management effort. In Chicago, the investment community is involved through Argonne Laboratories and businesses in the area, which address clean energy, the battery program, and also work through the University of Chicago, to make connections between academics and private companies, as well as the National Lab.

Other programs that are available for partnerships include traineeship programs managed by the Advanced Manufacturing Office at DOE, and building "boxes," i.e., integrated systems for prototypes of electrical systems. Successful public/private partnerships require people trained to work in the various parts of translating technology and starting up new businesses. A number of key points were made during the discussion by the Panel, of what might be needed for educating students to pursue projects within this context. These included:

1. Understanding policy and business;
2. Learning how to do economic analyses (GE was given as an example);
3. Understanding how to solve an energy problem, as compared to simply discovering science. These require completely different mind-sets;
4. Facilitating continuous discussions between scientists, researchers, and engineers as a project develops;
5. Identifying timelines and then achieving them;
6. Learning how to build milestones into timelines, and then handling difficult go/no go decisions;
7. Understanding how to start small, working with proposals that require cost-share, and learning how to create value propositions.

All of these elements go into public/private partnerships, and could be done on a regional basis with the Regional Clean Energy Center providing the infrastructure and people to begin the formation of these partnerships and also provide the technical, scientific, developmental, and educational components required for success.

Participant List

REGIONAL CLEAN ENERGY INNOVATION FORUM

June 8-10, 2016
Purdue University, West Lafayette, Indiana

PURDUE UNIVERSITY Discovery Park ENERGY CENTER

PARTICIPANTS

Lena Abu-Ali
Intern
Eisenmann

Ryan Adams
Graduate Student
Purdue University

Tom Adams
Research Engineer
NSWC Crane

Shubham Agrawal
Graduate Student
Purdue University

Taylor Allred
Graduate Research Assistant
Purdue University

Emani Alston
Student
USNA

Joe Andler
Graduate Research Assistant
Purdue University

Soroush Aramideh
Research Assistant
Purdue University

William Arnett
Graduate Research Assistant
Purdue University

Praneet Singh Arshi
Graduate Research Assistant
Purdue University

John Barnes
Vice President, Advanced Manufacturing & Strategy
Aloca Titanium & Engineered Products

Kate Bartter
Director
Office of Energy and Environment
The Ohio State University

John Bear
President and Chief Executive Officer
MISO Energy

Iman Beheshti Tabar
Graduate Research Assistant
Purdue University

Jason Bice
Research Assistant
Materials Engineering
Purdue University

Mary Blanchard
Associate Director
Wisconsin Energy Institute

Eric Bowler
Senior Engineer
Whirlpool Corporation

Emma Brace
Graduate Research Assistant
Laboratory of Renewable Resources Engineering
Purdue University

Julia Burchell
Graduate Student
Purdue University

Peter Burns
Director, ND Energy
University of Notre Dame

Stephen Caskey
Research Assistant
Purdue University

Clint Chapple
Distinguished Professor
Purdue University

James Chavez
Vice President
Sandia National Laboratories

Hoon Choi
Graduate Researcher
Purdue University

Chul Hun Choi
Ph.D. Student
Purdue University

Emily Coleman
Research Assistant
Laboratory of Renewable Resources Engineering
Purdue University

Liang Cong
Research Assistant
Purdue University

George Crabtree
Director, Joint Center for Energy Storage Research
Argonne National Laboratory

Melba Crawford
Associate Dean, Research
College of Engineering
Purdue University

Bruce Dale
University Distinguished Professor of AgBio Rsearch
Dept of Chemical Engineering & Materials Science
Michigan State University

Emily Damian
Project Engineer
Citizens Energy Group

Mitch Daniels
President
Purdue University

Bandal Suryakant Dattatraya
MD Solar Electronics
India

Gregory Deason
Senior Vice President and Director of Innovation
Purdue Research Foundation

Eugene Deloatch
Dean, Clarence M. Mitchell, Jr. School of Engineering
Morgan State University

Nicole Delozier
Intern
Indiana Office of Energy Development

Swapnil Dattatray Deshmukh
Graduate Research Assistant
Purdue University

Tomás Díaz de la Rubia
Chief Scientist and Executive Director
Discovery Park
Purdue University

Whitney Dolan
Graduate Student
Department of Biochemistry
Purdue University

Jennifer Dunn
Principal Environmental Analyst
Argonne National Laboratory

Sara Duque
Visiting Scholar
Purdue University

Arthur Dysart
Graduate Student
Purdue University

Anter El-Azab
Professor, Materials Engineering
Purdue University

Kevin Ellett
Research Scientist
Indiana Geological Survey

Ryan Ellis
Graduate Research Assistant
Purdue University

Abby Engelberth
Assistant Professor
Agricultural & Biological Engineering
Purdue University

Doug Esamann
EVP & President, Midwest and Florida Regions
Duke Energy

Samira Fatemi
Graduate Student
Purdue University

Scott Forbey
Battery Manufacturing Research Engineer
Battery Innovation Center

Brian Furrer
Chief Executive Officer
Bio Town Ag

Aalok Gaitonde
Graduate Research Assistant
Purdue University

Yash Ganatra
Graduate Research Assistant
Purdue University

Suresh Garimella
Exec VP for Research/Partnerships
Purdue University

Emre Gencer
Graduate Research Assistant
Purdue University

Ehsan Ghafari
PhD Student
Purdue University

Seyedali Ghahari
Research Assistant
Purdue University

Albert Gilewicz
Director - Energy and Utilities
Purdue University

Thomas Golab
Vice President and Chief Financial Officer
Navitas Systems

Douglas Gotham
Director, State Utility Forecasting Group
Purdue University

Jay Gore
Vincent P Reilly Professor in Mechanical Engineering
Purdue University

Vikrant Goyal
PhD Student
Purdue University

Brian Graeser
Graduate Research Assistant
Purdue University

Julie Griffith
Vice President for Public Affairs
Purdue University

Justin Hage
Director, Strategic Planning
Indiana Economic Development Corporation

Ashley Hammac
Research Soil Scientist
USDA-ARS

Carol Handwerker
Reinhardt Schuhmann Jr. Professor of Materials Engineering, and Environmental and Ecological Engineering
Purdue University

William Hart
Manager
Sandia National Laboratories

David Harvey
Graduate Student
Purdue University

Joshua Hawke
R&D Engineer
NSWC Crane

Nancy Heimann
President and CEO
Enginuity Worldwide

Neal Hengge
Graduate Student
Purdue University

Addie Henley
Cadet
West Point

Barron Hewetson
PhD Candidate
Agricultural & Biological Engineering
Purdue University

Eric Holocomb
Lt. Governor
Indiana

Marcey Hoover
Chief Operating Officer for the Energy and Climate Program
Sandia National Laboratories

Xianyi Hu
Research Assistant
Purdue University

Carl Huetteman
Project Manager
Energy Center
Purdue University

Neera Jain
Assistant Professor
Mechanical Engineering
Purdue University

Nelson James
Research Assistant
Purdue University

Hongyue Jin
PhD Candidate
Purdue University

Duane Johnson
Chief Research Officer
Ames Laboratory

Mark Johnson
Director, Advanced Manufacturing Office
U.S. Department of Energy

Cindy Karina
Student Researcher
Purdue University

Peter Keeling
Innovation Director
NSF Engineering Research Center for Biorenewable Chemicals
Iowa State University

Daehwan Kim
PhD Student
Purdue University

Katie Kitamura
Graduate Student
Purdue University

Kurt Koehler
Founder/President
AlGalCo

Robert Kramer
Professor, Physics
Director, Energy Efficiency and Reliability Center
Purdue University, Calumet

Amanda Kreger
Graduate Student
Purdue University

Thomas Kreke
Laboratory of Renewable Resources Engineering
Purdue University

Michael Ladisch
Distinguished Professor Agri & Biological Engineering
Director, Laboratory of Renewable Resources Engineering
Purdue University

Li LI
Associate Professor
Southwest University

Xiaojun Lin
Associate Professor, ECE
Purdue University

Siyu Liu
PhD Student, IE
Purdue University

He Liu
Visiting Scholar, Agi & Bio Engineering
Purdue University

Haotian Liu
Research Assistant
Herrick Labs
Purdue University

Xingya Liu
Laboratory of Renewable Resources Engineering
Purdue University

Thomas Lograsso
Director, Division of Materials Sciences and Engineering
Ames Laboratory

Mustafa Lokhandwala
Student
Purdue University

Shengqi Lu
Research Assistant
Purdue University

Luna Lu
Associate Professor
Purdue University

Erin Lucas
Director of Special Programs
Energy and Commerce Committee

Robert Lucht
Professor, Mechanical Engineering
Purdue University

Mark Lundstrom
Professor, Electrical and Computer Engineering
Purdue University

Mark Maassel
President
Indiana Energy Association

Xiangying Mao
Research Assistant
Purdue University

Amy Marconnet
Assistant Professor, Mechanical Engineering
Purdue University

Chad Martin
Agricultural and Biological Engineering
Renewable Energy Extension Specialist
Purdue University

Andrew Martin
Energy Intern
Purdue University Physical Facilities

Scott McClary
Graduate Research Assistant
Purdue University

John McDonald
SmartGrid Business Dev Leader, North America
Global SmartGrid Strategy Group
General Electric

Susan McNay
Vice President, Government & Public Relations
Enginuity Worldwide

Abigail Mechtenberg
Assistant Teaching Professor
University of Notre Dame

Jim Merritt
State Senator, Indiana
Chairman of the Senate Utilities Committee

Caleb Miskin
Postdoctoral Researcher
Purdue University

Paul Mitchell
President & CEO
Energy Systems Network

Ahmad Shah Mohammadi
PhD Student
Purdue University

Ed Morrison
Regional Economic Development Advisor
Center for Regional Development
Purdue University

Nathan Mosier
Professor, Agricultural and Biological Engineering
Purdue University

Austin Nash
Graduate Research Assistant
Purdue University

Trung Nguyen
Postdoctoral Researcher
Purdue University

Martin Okos
Professor, Agricultural and Biological Engineering
Purdue University

Tolu Omotoso
Special Projects Coordinator
Energy Center
Purdue University

Franklin (Lynn) Orr
Under Secretary
Department of Energy

David Orrego
Graduate Student
Purdue University

Guillermo Paniagua
Associate Professor, Mechanical Engineering
Purdue University

Hodge Patel
State Director for Senator Joe Donnelly
Government Relations

Kent Peters
Program Manager
Department of Energy

Mark Petri
Director
Iowa Energy Center

Byron Pipes
John Leighton Bray Distinguished Professor of Engineering
Purdue University

Kimberly Rasar
Associate Deputy Under Secretary for Science and Energy
Department of Energy

Raymond RedCorn
PhD Student
Laboratory of Renewable Resources Engineering
Purdue University

Yazmin Rendon Munoz
Visiting Scholar
Purdue University

Taufik Ridha
Graduate Research Assistant
Chemical Engineering
Purdue University

David Roberts
President
Battery Innovation Center

Joaquín Rodríguez López
Assistant Professor, Chemistry
University of Illinois at Urbana-Champaign

Tim Rushenberg
Vice President
Indiana Energy Association

Enas Sakr
PhD Research Assistant
Electrical and Computer Engineering
Purdue University

Al Sattelberger
Deputy Laboratory Director for Programs
Argonne National Laboratory

Peter Schubert
Director
Richard G. Lugar Center for Renewable Energy
IUPUI

Dan Schuster
Senior Energy and Strategy Risk Engineer
Purdue University

Pankaj Sharma
Managing Director
Purdue University

Lian Shen
Benjamin Mayhugh Associate Professor of Mechanical Engineering, Associate Director for Research, St. Anthony Falls Laboratory
University of Minnesota

Ginger Sigmon
Managing Director, ND Energy
University of Notre Dame

Clara Smith
YDS International Consulting, LLC

Nicholas Soepriatna
Post-doctoral Researcher
Purdue University

Sabrinna Soldavini
Research Assistant
Purdue University

John Stenger
Operations Director
Sycamore Gas Company

Paul Sturm
Director of Strategic Development
Discovery Park
Purdue University

Vijay Suri
Vice President
Eisenmann

Bandal Angad Suryakant
Engineer, Solar Electronics
India

Bandal Karan Suryakant
Manufacturing Engineer
Cummins

John Sutherland
Professor, Fehsenfeld Family Head of Environment And Ecological Engineering
Purdue University

Don Takehara
Assistant Director for Research
University of Illinois at Urbana-Champaign

Jialiang Tang
Graduate Student
Purdue University

Brandon Terry
Postdoctoral Research Associate
Purdue University

Juan Torres
Manager, Energy Systems Analysis
Sandia National Laboratories

Tristan Vance
Director
Indiana Office of Energy Development

Thomas Vanparais
CEO
Indiana Electric Cooperatives

Alex Vásquez-Castillo
Student
Purdue University

Richard Voyles
Professor and Associate Dean for Research
Purdue Polytechnic Institute
Purdue University

Yoselyn Walsh
Student
Purdue University

HaiYan Wang
Jiaxing University

Nien-Hwa Linda Wang
Maxine Spencer Nicholas Professor
Chemical Engineering
Purdue University

Peng Wang
Graduate Student
Purdue University

Shiyan Wang
Graduate Student
Purdue University

George Weeden Jr.
Graduate Research Assistant
Purdue University

Charles Wineland
Editor/Writer
Purdue University

Cliff Wojtalewicz
Managing Director
Burton D. Morgan Center of Entrepreneurship
Purdue University

Eduardo Ximenes
Bioprocess Research Scientist
Purdue University

Leslie Yoo
Energy Efficiency and Renewable Program Director
Office of Energy Development

Hao Zhang
PhD Student
Purdue University

Leyu Zhang
Research Assistant
Laboratory of Renewable Resources Engineering
Purdue University

Tianhua Zhang
Visiting Scholar
Environmental and Ecological Engineering
Purdue University

Ximing Zhang
Postdoc
Purdue University

Fu Zhao
Associate Professor, Mechanical Engineering
Purdue University

Zibo Zhao
Ph.D. Student
Purdue University

Chenn Qian Zhou
Director, Steel Manufacturing Simulation and Visualization Consortium; Professor and Director, Center for Innovation through Visualization and Simulation
Purdue University Calumet

George Zhou
Assistant Professor
Environmental and Ecological Engineering
Purdue University

Danshi Zhu
Visiting Scholar
Department of Food Sciences
Purdue University