



IMPACT

2019 - 2020 ANNUAL REPORT

Faculty affiliate's research examines the energy consumption of alternative transportation

PAGE 8

ARPA-E awards CMU researchers ~\$4M to develop AI and machine learning tools

PAGE 12

University Energy Institute Leadership Summit gathers 100+ national directors for collaboration

PAGE 16

DIRECTORS' LETTER



Jay F. Whitacre
Director, Wilton E. Scott
Institute for Energy
Innovation
Trustee Professor in
Energy, Materials
Science & Engineering
and Engineering &
Public Policy



Anna J. Siefken
Executive Director,
Wilton E. Scott Institute
for Energy Innovation
Adjunct Faculty
Member, Heinz College
of Information Systems
and Public Policy

2020 has presented society with unprecedented challenges, and Carnegie Mellon University has experienced a range of impacts. The campus was closed, students and colleagues moved to remote work over a handful of days, and we had to find new ways to continue our impactful research and partnerships. As many of you know, our Institute had to cancel CMU Energy Week 2020, our marquee event each year, just weeks before its start date. We regrouped to launch a webinar series called, "Energy, Resilience, and COVID-19 - Pivoting in 2020," which explored critical issues such as infrastructure planning, transportation energy, economic development, and how robotics can improve energy resilience in times of crisis. We hosted experts on virtual panels for cleantech startups, job seekers, energy corporations, and solar investors. We continue to connect with our partners and friends remotely, and look forward to a time when in-person gatherings are practical and safe.

Now more than ever, our network of energy leaders, researchers, and global partners is essential to accelerating the transition to a sustainable, low-carbon future. With this in mind, we are so glad that we co-hosted the 2019 University Energy Institute Leadership Summit (p 16) last fall, which brought together 67 energy institutes from 32 states to strengthen university connections and define opportunities between these critical thought centers. And the network continues to expand.

The Institute continued to support groundbreaking energy research and technologies. Notably, our Faculty Affiliate Sean Qian and Energy Fellow Constantine Samaras (PhD, Engineering 2008) led a collaborative team, funded by the U.S. Department of Energy, that will examine the energy consumption of delivery drones and robots (p 8). We deepened our ties with national labs like NETL and NREL (p 26). Carnegie Mellon students developed innovative solutions in the lab, at case competitions, and presented their cutting-edge research globally (p 22). We are proud to support the efforts of these "future energy leaders."

In this IMPACT report, you will read about how our alumni are moving forward in groundbreaking ways, and learn more about us. We hope to work with you in the coming year in charting a path forward for the energy sector. Feel free to reach out.

Best Regards,

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DOE Funding to Advance Vehicle Technology Innovation

Fuel cell research projects at CMU were awarded \$3.7M.

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2019 University Energy Institute Leadership Summit

100+ leaders from 67 energy institutes convened to discuss collaboration and network opportunities.

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Energy Storage Capstone Project

Tepper MBA students work with renewable energy developer Oriden, a Mitsubishi Power spinoff with CMU ties.

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From DOE Cleantech UP Competitors to Standout Startups

CMU spinouts Gecko Robotics, Fifth Season, and Hyliion: Making an impact nationally.

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A Bright Partnership

CMU and NextEra Energy Resources collaborate on Pennsylvania solar research, technology development, and education.

PAGE 35

Interview with Scott Institute Advisory Board Member Katie McGinty

Former Pennsylvania Cabinet member lends expertise as newest member of Board of Advisors.

HIGHLIGHTS TIMELINE

JUNE 2019

Kate Whitefoot selected to participate in the National Academy of Engineering's invite-only 2019 U.S. Frontiers of Engineering Symposium as one of the nation's **brillest young engineers**

The Carnegie Mellon Racing student team's fully electric car that they designed and manufactured wins the 2019 international **Formula SAE North championship**

SEPTEMBER 2019

Greg Lowry and Zachary Ulissi selected to lead the **Energy-Water Desalination Hub** through the College of Engineering and the National Alliance for Water Innovation

Scott Institute co-hosts **2019 University Energy Institute Leadership Summit** with the Colorado School of Mines Payne Institute for Public Policy

Engineering and Public Policy Ph.D. student Elizabeth Reed named a **Siebel Scholar** and identified as a **Siebel Energy Science Fellow**

JANUARY 2020

Scott Institute Seed Grants for Energy Research program receives 28 proposal submissions with approximately **\$1.5 million** in requested funding from CMU faculty

APRIL 2020

U.S. Department of Energy selects Anna J. Siefken as a Clean Energy Education and Empowerment (C3E) Ambassador

Soumya Kar and **Destenie Nock** selected as Energy Fellows, along with **Larry Pileggi** as a Senior Energy Fellow, joining **Zachary Ulissi** and **B. Reeja Jayan**, who were named in late 2019

AUGUST 2019

The Sherman and Joyce Bowie Scott Hall receives **two awards**: the **2019 International Architecture Award** and the **2019 American Architecture Award** from the Chicago Athenaeum Museum of Architecture and Design and the European Centre for Architecture Art Design and Urban Studies

NOVEMBER 2019

The **Advanced Research Projects Agency-Energy (ARPA-E)** awards \$1.1 million to two CMU teams led by Energy Fellows Zachary Ulissi and Venkat Viswanathan for the development of artificial intelligence and machine learning tools

Research from Neil Donahue, Greg Lowry, and Krzysztof Matyjaszewski named some of the **world's most highly cited** in the sciences, according to Clarivate Analytics

MARCH 2020

Scott Institute and **NREL** collaborate on DOE's American-Made Solar Prize Round 2 Set! Demo Day

Faculty Affiliate Ryan Sullivan wins **Carnegie Science Award** for innovative research on how aerosol particles affect clouds involved in regulating climate

JUNE 2020

Energy Fellow Venkat Viswanathan named **MIT Innovator Under 35** for breakthrough battery research that decreases EV costs

We address the world's most important energy-related challenges by enabling **collaborative research, strategic partnerships, policy outreach, entrepreneurship, and education.**

We support transformative work that strives to optimize energy resources and reduce the environmental impacts associated with energy production and use with social equity. We also seek to encourage the development of breakthrough technologies that will accelerate the transition to a **sustainable, low-carbon energy future.**

RESEARCH FOCUS AREAS

1. Technology

2. Efficiency

3. Computation

1. Future Energy Technologies

- High-Performance Renewables
- Transportation Energy, EVs, Infrastructure, and Electrification
- Storage, Batteries, Fuel Cells, and Internet of Things (IoT)
- Decarbonization, Carbon Capture, Sequestration, and Utilization

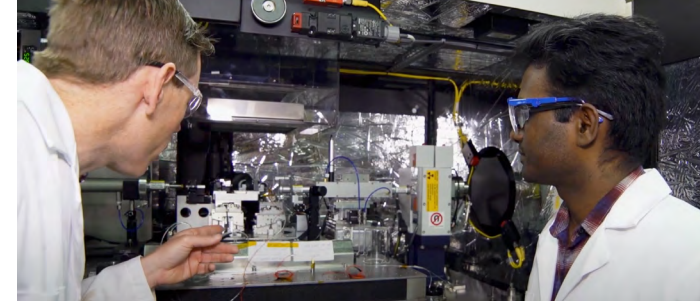
2. Resource Efficiency, Policy and Analysis

- Efficiency of Traditional Fuels and Resource Recovery
- Environmental Monitoring, Sensing, and Treatment
- Energy Policy, Economics, and Community
- Enhanced Water Resources

3. High-Tech Energy and Computational Solutions

- Grid Modernization, Energy Planning, System Reliability, and Resiliency
- Building Performance, Urban Planning, Design, and Analytics
- Machine Learning, AI, Autonomous Vehicles, and Robotics for Energy Systems
- High-Performance Computing and Data Centers

RESEARCH HIGHLIGHTS

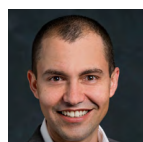


Mechanical Engineering Professor Shawn Litster and his research group (pictured above) work on hydrogen fuel cell technology and batteries for transportation energy use.



Shawn Litster, Mechanical Engineering (MechE) professor,

is involved in two projects on fuel cells for heavy duty vehicles. The projects, totaling \$3.7 million in DOE funding, focus on innovative research of technologies for trucks, off-road vehicles and the fuels that power them. Litster is leading one of the two projects, supported by a \$2 million award, that will support new research on polymers for fuel cell electrodes. Partners for this project include Chemical Engineering Assistant Professor **Zachary Ulissi***, and companies Ballard Power and Chemours.

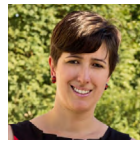


In "Considering the Nuclear Option: Hidden Benefits and Internalized Social Costs of Nuclear Power in the U.S. Since 1970" published in *Resource and Energy Economics*, Heinz College Professors **Edson**



Severnini and **Akshaya Jha** with Ph.D. student **David Adler** found that the substitution between nuclear and coal is not one-to-one, and that nuclear power plant openings result in a roughly 200 GWh reduction in coal-fired generation per month on average, conditional on demand. Their analysis indicates that policymakers should

consider the benefit of nuclear power generation as a low-carbon source of electricity.



The journal *Nature Sustainability* highlighted research by Engineering and Public Policy (EPP) Professors



Paulina Jaramillo* (Engineering 2004, 2007) and **Daniel Armanios** with several co-authors. The article

suggests that women may not be benefiting from electricity access as much as men once considerations were made based on their use of appliances within the household.

Civil and Environmental Engineering (CEE) Associate Professor **Mario Bergés** is



leading a CMU team in a NASA-funded project exploring the application of artificial intelligence to analyze equipment data with the goal of understanding electricity use in smart habitats. If we intend to explore the moon or Mars, astronauts need smart habitats that will support life and remain operational when they are vacant. If the team determines how power is consumed, they could learn the status of all the electric-powered systems in the habitat.



Philip Leduc, MechE professor, estimates an annual energy loss of 16.33% due to low transmittance covering

of solar panels in a 2020 article entitled "Modeling the Transmittance of Anisotropic Diffuse Radiation

Towards Estimating Energy Losses in Solar Panel Coverings" published in the journal *Applied Energy*.

School of Architecture Adjunct Professor **Stephen Quick's**



research for the City of Pittsburgh, featured by *Mobility Lab*, looked at how levels of light pollution are impacted by the adoption of LED streetlights in urban areas, and measured the ways in which the lights can be adjusted for additional benefits like weather and circadian rhythm.



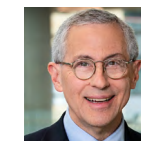
Research by Scott Institute Director Emeritus **Jared L. Cohon**, Affiliate **Allen**



Robinson and EPP and Tepper School of Business Professor **Nicholas Muller***, analyzed the cumulative effects of the shale gas boom in the Appalachian basin from 2004 to 2016 on air quality, climate change, and employment.

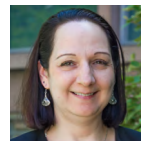


Their findings conclude air quality and employment effects follow the boom-and-bust cycle, while climate impacts persist for generations beyond the period of natural gas activity.



Professor **Jay Apt** and collaborators demonstrated that increased failure probabilities previously

shown to affect PJM Interconnection's conventional generator fleet at extreme temperatures pose significant reliability risks not considered in standard resource adequacy modeling. Their findings are published in a new paper entitled "Resource Adequacy Implications of Temperature-Dependent Electric Generator Availability."



In "Using Rainfall Measures to Evaluate Hydrologic Performance of Green Infrastructure Systems under Climate Change," **Constantine Samaras*** (Engineering 2008), **Jeanne Van Briesen*** and CEE Ph.D. student **Lauren Cook** found that using annual rainfall measurements to track the performance of green stormwater infrastructure systems provides insights into their future success, without the use of hydrologic simulation or on-site sensors, which may not always be feasible.

* Energy Fellow

CMU EPP and Materials Science and Engineering PhD student Katrina Ramirez-Meyers and Trustee Professor in Energy Jay Whitacre work on a used hybrid bus battery pack utilized in an Energy Science, Technology and Policy Project Course.

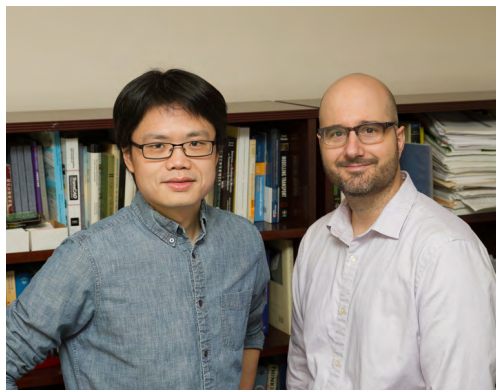


Alternative Transportation

The Impact of Alternative Transportation on Energy Consumption and Emissions

The role of new modes of transportation and mobility has been an important topic for researchers for many years — and the effort is growing with key faculty at CMU.

Since 2019, Scott Institute Energy Fellow **Constantine Samaras** (Engineering 2008) has led “Drones, Delivery Robots, Driverless Cars, and Intelligent Curbs for Increasing Energy Productivity of First/Last Mile Goods Movement,” a research project focused on the energy usage of delivery drones and robots. The project is one of two being funded by a \$2.5 million grant from the U.S. Department of Energy (DOE).



Scott Institute Faculty Affiliate Sean Qian and Energy Fellow Constantine Samaras are collaborating on the DOE-funded project, “Drones, Delivery Robots, Driverless Cars, and Intelligent Curbs for Increasing Energy Productivity of First/Last Mile Goods Movement.”

These projects fall into the DOE’s Technology Integration category where this type of work brings together key stakeholders to provide data on the impact of mobility services and solutions.

Now entering the project’s second year of research, Samaras’ collaborator **Sean Qian**, associate professor in the Civil and Environmental Engineering Department and Heinz College, is creating a traffic model of Allegheny County to assess the energy and mobility implications of converting to these robotic delivery methods. Through real-world testing and validation, the data, analysis and insights from this work will fill critical information gaps to inform research needs as well as short- and long-term transportation that maximizes energy efficiency and affordability.



“In looking at the actual costs v. potential savings of implementing new technology, there are certain trade-offs to consider,” said Qian. “When there’s a good balance of pros and cons, we can evaluate — at the county level — the mobility, energy consumption as well as emission benefits and impacts of having deliveries made by new technology vehicles.”

Qian led another DOE-funded project in 2020 with similar goals. The work entitled “Holistic and Energy-Efficient Rural County Mobility Platform (RAMP),” examines the extent to which most rural communities across the nation lack accessible and affordable ways to travel within their area and to/from their urban centers.

For example, Qian examines the key issues with the current shuttle services being offered in places like Greene County in southwestern Pennsylvania and seeks to address limitations on the system. Focusing on four critical types of trips (commuting, community and religious services, food, and health care), his team is developing an algorithm that will determine how to handle real-time transportation and delivery requests.

Greene County will serve as a test bed for RAMP, an innovative rural county mobility platform driven by Qian’s algorithm. RAMP will be a hybrid service consisting of two complementary components: a volunteer-based ridesharing system and a structured shuttle service, both designed and optimized using available data.

“We want to demonstrate the effectiveness of these new mobility services and demonstrate the replicability of this platform in other rural counties across the U.S.,” said Qian.

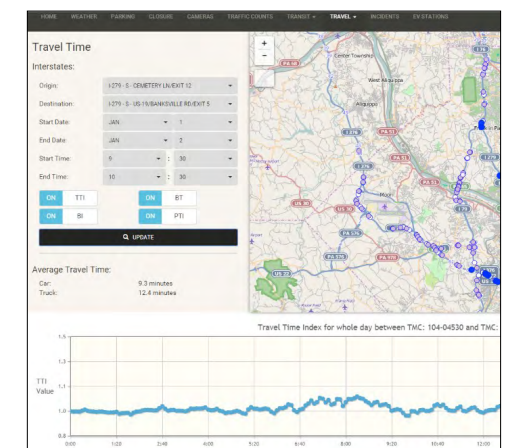
Feedback from county residents will shape the “human-centered design” process, while an online platform and phone-based system will support trip reservations, volunteer-request matching, and information dissemination.

Qian’s research addresses ways to handle such requests that are further away from dense traffic areas, leveraging existing volunteer programs. He has partnered with local startup 412 Food Rescue, led by Heinz College alumna **Leah Lizarondo**, to address mobility service for passengers, and possibly for groceries and medication too. Qian will investigate if existing platforms can extend

into rural areas and transport food and passengers for their last mile.

Using calibrated modeling methods, Qian’s objective is to show that balanced choices can lower the cost of running shuttle services, save time for riders, and decrease traffic congestion — which, in turn, can lead to decreases in energy consumption and emissions.

“It is critical not only for us to understand mobility of transportation, but also to consider energy implications,” said Qian. “We are combining machine learning technology, system modeling, simulation, and energy metrics to really understand how we can do a better job in saving energy from the transportation sector and improving mobility for rural residents.” ■



Scott Institute Faculty Affiliate Sean Qian is creating a traffic model of Allegheny County, which requires analyzing travel time in Pittsburgh, Pennsylvania.

SEED GRANTS

Scott Institute Seed Grant Funding to Advance Eight CMU Energy Projects

Carnegie Mellon University research projects that explore perspectives on energy policy, batteries and storage, and smart grid implementation are among the projects selected by the Scott Institute for Energy Innovation's 2020 Seed Grants for Energy Research.

The annual funding program, now in its eighth round, supports the development of new energy research in areas such as sourcing, production, efficiency, and environmental impacts. The program also provides resources for vital equipment repairs. The awards allow Carnegie Mellon professors to jump-start their cutting-edge work and provide an infusion of critically important resources to increase readiness for substantial external consideration and funding.

"This year, Scott Institute faculty affiliates from across the university submitted 28 proposals equaling approximately \$1.5 million in funding for their innovative research," said Scott Institute Co-Director **Andrew Gellman**. "This is a highly competitive selection process."

The Institute awarded almost half a million dollars to eight faculty-led projects. Specifically, the Institute paired \$330,000 with almost \$200,000 in additional funding from the EQT Foundation.

THE 2020 SEED FUNDING WINNERS



Paulina Jaramillo* (Engineering and Public Policy), along with NC State University's Joseph DeCarolis, will bring energy modeling into the 21st century by applying policy-

focused academic modeling, maximizing transparency, building a networked community, and working toward the common goal of examining U.S. energy futures to inform future energy and climate policy efforts.



B. Reeja Jayan* and **Shawn Litster** (Mechanical Engineering) will use nano-computed tomography and a synchrotron small-angle X-ray scattering technique to investigate the effect of polymer coatings on the mechanical fatigue of battery electrodes. This fatigue in lithium-ion batteries is one of the main reasons for their capacity fading, resulting from the volume expansion and shrinkage of electrode particles during cycling.

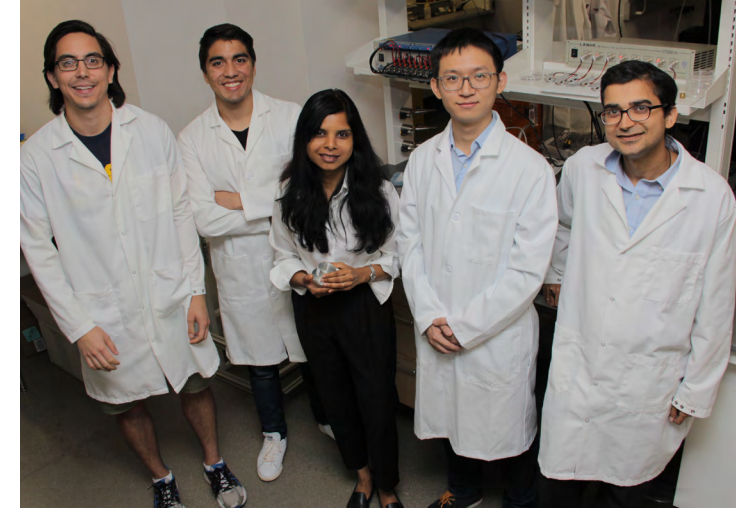
Maryam Saeedi in collaboration with **Ali Shourideh** (Tepper) will utilize a novel data set on the daily volume of U.S. natural gas transported in the interstate pipelines to develop a mathematical model that will estimate how monopoly regulations and mergers affect decisions on the location of pipelines and storage units. The researchers will use the estimated model to revise guidelines for merger analysis and price regulations in this market.



Vyas Sekar and **Swarun Kumar** (Electrical and Computer Engineering) are developing algorithmic and systems foundations for enabling general, accurate, and energy-efficient analytics for low-power wireless sensors. Despite many advances in sensing, computing and wireless technologies, simultaneously achieving energy-

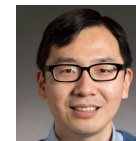
"This seed support has directly led to \$16.5 million in external funding from various agencies, corporations, and nonprofits. This is a solid return on our investment towards development of transformative energy technologies."

— SCOTT INSTITUTE EXECUTIVE DIRECTOR ANNA J. SIEFKEN



With support from a Scott Institute Seed Grant, Energy Fellow B. Reeja Jayan's lab will investigate the effect of polymer coatings on the mechanical fatigue of battery electrodes.

efficiency, fidelity and generality has remained an elusive goal.



Sheng Shen (Mechanical Engineering) and **Xu Zhang** (Electrical and Computer Engineering) will work on next-generation methane detection to fulfill a broad range of needs in the oil and gas industry, such as protection and security, persistent monitoring, leakage recognition and tracking, and early warning. Their team will design and fabricate miniaturized infrared transducers for methane sensing by integrating on-chip light sources and detectors, in order to significantly reduce the response time and cost of current photonic sensing devices.

Kate Whitefoot (Mechanical Engineering and Engineering and Public Policy) will field a survey experiment with consumers looking to purchase a vehicle in order to understand how fuel efficiency and emissions ratings information influences their choice. The preliminary results will allow Whitefoot's team to establish a full-scale research project in collaboration with automakers and the Environmental Protection Agency to inform the redesign of this information.



Osman Yağan (Electrical and Computer Engineering and CyLab) with **Carlee Joe-Wong** (Electrical and Computer Engineering) are seeking to

advance the state-of-the-art in modeling, controlling, and optimizing the robustness of the smart grid by exploring two novel research directions. First, they will consider the optimal allocation of support-dependency links to maximize the robustness. They will also examine the situation where nodes can be "healed" during a cascading failure and will develop control strategies that slow down the spread of failures, prevent failures to reach to a certain part of the network and stop the cascade of failures, and recover the network's normal operation.



Mohammad Islam (Materials Science and Engineering) will utilize funding to have laboratory equipment, like absorption and fluorescence spectrometers, repaired. Thirteen faculty members use the equipment to characterize optical properties of novel nanoparticles that are used for electrochemical applications.

"Since launching the program in 2013, we have awarded more than \$2.8 million in funding to 65 research teams at Carnegie Mellon," said Scott Institute Executive Director **Anna J. Siefken**. "This seed support has directly led to Scott Institute faculty affiliates receiving \$16.5 million in external funding from various agencies, corporations, and nonprofits. We consider this a solid return on our investment towards development of transformative energy technologies."

* Energy Fellow

FEATURED AWARDS & HONORS



The DOE's Advanced Research Projects Agency-Energy (ARPA-E) awarded CMU researchers over

\$1.1 million for the development of artificial intelligence and machine learning tools. Chemical Engineering (ChemE) Assistant Professor **Zachary Ulissi*** will lead a project on reinforcement learning and machine learning potentials for catalyst metastability; and Mechanical Engineering (MechE) Associate Professor **Venkat Viswanathan's*** team will use the funding to speed up the process of materials innovation for electrochemical devices, batteries for next-generation electric vehicles, and new routes to making chemicals and fuels.



Anthony Rollett, Materials Science and Engineering professor, was also awarded a \$2.4 million ARPA-E grant

for advances in materials research, additive manufacturing, and heat exchanger design. The project is one of 18 being supported for the creation of critical heat exchangers for thermal energy use in electricity, nuclear reactors, and transportation, among others. In addition, Chemistry Professor **Newell Washburn** received a more than \$500,000 grant from ARPA-E to develop a machine learning algorithm that could help design more durable and energy-efficient concrete.



Erica Cochran Hameen (Fine Arts 2014), Scott Institute faculty affiliate and architecture professor, was awarded the Presidential Leadership Award by the National Organization of Minority Architects at their 47th National Conference. Hameen, co-director of CMU's Center for Building Performance and Diagnostics, was recognized for her collaborative work with architects and for her efforts to advance social justice through architectural pursuits.



Venkat Viswanathan* was recognized as an Innovator Under 35 by *MIT Technology Review*. His research explores next-generation batteries for

electric vehicles and aviation, computational material design, and data-driven material discovery. He has made major strides in developing anodes made out of pure lithium, promising a new class of batteries that pack more energy and deliver more power for a given amount of weight. These new batteries could enable cheaper electric vehicles and low-emission aircrafts.

Vivian Loftness* University Professor, was honored with the 2019 Legacy Award by Pittsburgh's USGBC chapter, the Green Building Alliance,



for her contributions and dedication to environmental and climatic design. She was also named to the national boards of the American Institute of Architects and the International Living Futures Institute.



Scott Institute Faculty Affiliates **Swarun Kumar** and **Kate Whitefoot** along with Computer Science's **Rashmi Vinayak** each received a



five-year \$650,000 Faculty Early Career Development (CAREER) Award, the National Science Foundation's (NSF) most prestigious award for young faculty members. The award will be used to support their research on topics



ranging from the resource and energy efficiency of large-scale data centers to low-power, wide-area networks and transportation energy.

Carnegie Mellon's College of Engineering was selected to



be part of the DOE's Energy-Water Desalination Hub as a founding member of the National Alliance for Water Innovation. Scott Institute Director **Jay Whitacre** with Professors **Greg Lowry**, **Zachary Ulissi***, and **Venkat Viswanathan*** will participate in the initiative, which will include researching more cost-effective ways to achieve a circular water economy from new water sources.



Jonathan Malen, MechE professor, and Feng Xiong from the University of Pittsburgh won a \$500,000 NSF award to develop a

thermoelectric semiconductor using tungsten disulfide that converts waste heat into energy. Their research uses a novel doping approach that enhances the electrical conductivity of a material while lowering its thermal conductivity. This research work has future applications in devices like high-performance transistors.

ChemE Professor **Ignacio Grossmann** received several prestigious awards including



the Founders Award for Outstanding Contributions to the Field of Chemical Engineering from the American Institute of Chemical

Engineers, the highest award given by the organization, and the Albert Nelson Marquis Lifetime Achievement Award. He was named a Marquis Who's Who Top Educator for his dedication and lasting contributions to chemical engineering and society.



The DOE awarded MechE Professor **Rahul Panat** and Computer Science Professor **Vipul Goyal** \$400,000 to work on strengthening grid security using blockchain technology. Current energy grids face the risk of attack by malicious hackers, which, according to their research, could be minimized by placing the control system on a distributed network such as a blockchain. Panat and Goyal are working to create a simulated Supervisor Control and Data Acquisition (SCADA) system and integrate onto an eight-anode blockchain.

Anna J. Siefken, executive director of the Scott Institute for Energy Innovation, was selected as a U.S. Clean Energy Education and Empowerment



(C3E) Ambassador by the DOE. She joins a cohort of distinguished senior leaders who serve as role models and advocates for women in clean energy. They represent the U.S. C3E program at public forums and work to strengthen the recruitment, retention, and advancement of highly qualified women in the energy field.

* Energy Fellow

ENGAGEMENT

CMU Faculty, Staff, and Students Engage Global Audiences to Inform Energy Discourse

Himanshu Deshpande, an Energy Science, Technology and Policy master's student, presented his research on "Assessing the Economics of Commercial/Residential Storage Using an Intertemporal Decision Framework" at the 37th United States Association for Energy Economics/International Association for Energy Economics North American Conference (USAEE/IAEE) in Denver, Colorado, in Nov. 2019. Deshpande worked on this research independently as a semester project and then as a summer intern with Scott Institute Director and Trustee Professor in Energy **Jay Whitacre**, and with MIT Energy Initiative Postdoctoral Associate **Guannan He** (Engineering 2019).



Panayiotis Moutis, Scott Institute systems scientist, presented his team's work on "Resistive-Aware Linear Approximations for Solving the Optimal Power Flow Problem for Distribution Networks" at the 2019 Sustainable Power & Energy Conference in China, and in turn, won the Excellent Paper award at the event.

CMU startups **Grid Fruit** and **Teratonix**, along with Mechanical Engineering Professor **Jack Beuth** and the Institute's **Reed McManigle** and **Anna J. Siefken**, participated in the 2019 ARPA-E Energy Innovation Summit in Denver, Colorado, from July 8-10. The goal of the conference is to move transformational energy technologies out of the laboratory and into the market. The Scott Institute sponsored the annual conference and technology showcase.



James Manning (pictured above left), Civil and Environmental Engineering (CEE) Ph.D. student, received the John Gray Scholarship, which included a \$2,000 award, at the International District Energy Association (IDEA) 2019 Conference. Manning's research interests are in the utilization and optimization of the relationship between water infrastructure and microgrid power systems for rural and peri-urban communities in the developing world. He is advised by Energy Fellow **Paulina Jaramillo** (Engineering 2004, 2007) and Scott Institute Faculty Affiliate **Kelvin Gregory**.

Design Professor **Dan Lockton** co-hosted *Imagaries of Climate Pathways* as part of the Plurality University Network's *Many Tomorrows Festival 2019*. At the event, students presented their projects that answered the questions, "How do we imagine climate change? What futures do we understand, or can we envision, for our own communities or others?" The students investigated these topics by applying design research methods.

Dana Cupkova, assistant professor in the School of Architecture and co-founder and design principal of EPIPHYTE Lab, lectured at Pennsylvania State University in April 2019. Cupkova spoke about the relationship between design space and ecology; her research explores how this relationship can be enhanced through computational methods, thermodynamic processes, and experimentation.

OCTOBER 9, 2019

Distinguished Lecture: We Need a Green Real Deal — The Imperative of Deep Decarbonization

Melanie Kenderdine

Principal, Energy Futures Initiative (EFI)

Kenderdine discussed EFI's work on innovation policy, the California decarbonization techno-economic assessment (in which she was a lead author) and a "Green Real Deal" — in development as of Oct. 2019.

OCTOBER 22, 2019

Distinguished Lecture: The Grid Energy Storage Strategy

Sue Babinec

Program Lead of Grid Storage, Argonne National Laboratory (ANL)

Babinec spoke on the evolution of ANL's broad grid storage strategy based on lessons learned from experiences with industrial commodity giants, an energy storage startup and a DOE funding agency with a mission to change the way things are done by high-risk/high-reward projects.

NOVEMBER 20, 2019

Technology, Sustainability, and Business Forum, in partnership with CMU's Tepper School of Business

Mark Mesler (Tepper 2001)

Vice President of Finance and Investor Relations, Bloom Energy

Linda Rega

Manager of Financial Services Energy, Siemens
The conference brought together leaders from across the private sector, multiple levels of government, and academia to discuss topics related to the broad theme of sustainability.

DECEMBER 3, 2019

CMU Energy + Cleantech Startup Advisory Showcase

To continue boosting the regional ecosystem as a Wells Fargo Innovation Incubator (IN²) Channel Partner, the Institute convened 8 startups to pitch their companies and ideas to a panel of



23 entrepreneurial advisors, investors, accelerators, and industry energy experts.

DECEMBER 11, 2019

Pittsburgh Energy Dialogues

This one-day event, held in partnership with Boston Consulting Group, Schlumberger, and Davies Public Affairs, convened energy representatives from industry, government, and academia to engage in an open, comprehensive, and constructive dialogue about the role of natural gas in pathways to decarbonization, consumer behavior, and global energy transition.

FEBRUARY 5, 2020

Technical Talk: Solid-State Batteries

Jeff Sakamoto

Professor, University of Michigan

Recent material breakthroughs in Li metal solid-state electrolytes could enable a new class of non-combustible solid-state batteries delivering twice the energy density (1,200 Wh/L) compared to Li-ion.

FEBRUARY 25, 2020

Distinguished Lecture: E-mobility and the Evolving Electric Grid

Steven Malnight

President, Duquesne Light Company

Malnight discussed his company's work on electrifying the region, transportation, and the evolving needs of the electric grid to support e-mobility and other distributed resource deployment.

Watch events online at cmu.edu/energy

Webinar Series: Energy, Resilience and COVID-19 — Pivoting in 2020

In this series, launched in April 2020, we highlight insights from research, industry and innovation related to how COVID-19 is impacting the way we do business, and what it means to the energy systems we rely upon. Topics explored include Robotics and Energy, Energy Resilience, and Technology.

Bloom Energy Vice President of Finance and Investor Relations Mark Mesler (Tepper 2001) delivers a Scott Institute Distinguished Lecture entitled "The Future of Energy is Distributed, Sustainable, and Personalized."



University Energy Institute Summit Draws Over 100 National Leaders to Pittsburgh

The Scott Institute for Energy Innovation created and co-hosted the 2019 University Energy Institute Leadership Summit Sept. 25 and 26, 2019, in collaboration with the Colorado School of Mines' Payne Institute for Public Policy.

The summit drew 101 leaders representing 67 academic energy institutes and centers from 32 states across the U.S. to the Wyndham Grand Hotel in downtown Pittsburgh, Pennsylvania. The event participants, who hailed from as far as Hawaii and Alaska, explored the possibility of creating a network of national energy institutes. They discussed how an organization would advance efforts in energy research, education, decarbonization strategies, innovation, public policy and advocacy, and could more easily facilitate communication between national energy leaders.

"As we look toward the future of energy and the environment, it is crucial to leverage our collective strengths on important energy issues. The potential for impact with this group is enormous," said **Jay Whitacre**, director of the Scott Institute for Energy Innovation and College of Engineering Trustee Professor in Energy.

National and local government officials as well as Carnegie Mellon leadership and alumni welcomed attendees. Officials who provided remarks included **Chanette Armstrong**, principal deputy director of the Department of Energy's Advanced

Research Projects Agency-Energy (ARPA-E) and a 1981 alumna of CMU's College of Engineering; Allegheny County Executive Rich Fitzgerald, a 1981 alumnus of CMU's College of Engineering; and CMU Provost and Chief Academic Officer **James H. Garrett, Jr.** (Engineering 1982, 1983, 1986).

"As a community of educators and innovators, this group gathered here has a pivotal role in preparing our world for future energy and conservation needs," said Garrett.

The workshop, supported by ARPA-E and the Alfred P. Sloan Foundation, included fireside chats, roundtables, networking receptions and keynote presentations. Topics included "Energy in the Higher Education Curriculum" by **Elizabeth J. Wilson** (Engineering 2004), director of the Arthur L. Irving Institute for Energy and Society at Dartmouth College, and "21st Energy Justice" delivered by energy investor and climate advocate Michael Dorsey.

"The summit marks a crucial first step in helping avert the unfolding climate crisis by laying the foundational infrastructure to harness the tremendous intellectual capital from the heads of our nation's leading energy institutes," said Dorsey. "These leaders hold the keys to drive a robust and informed transformation of national and global energy technology, policies and regulations toward more renewable and sustainable ends for America and beyond."

Energy Institute Directors Jay Whitacre, Morgan Bazilian, and Martha Broad discuss "The Importance of Collaboration in the University Energy Space" on a panel moderated by energy investor and climate advocate Michael Dorsey.



During the conference, U.S. Department of Energy National Energy Technology Laboratory (NETL) Director Brian J. Anderson participated in a fireside chat with CMU President Emeritus, University Professor and Scott Institute Director Emeritus **Jared L. Cohon** on NETL's use of technology in finding ways to improve the country's energy usage for the future. In addition, ARPA-E Associate Director for Technology-to-Market James Zahler delivered a keynote on creating new energy frontiers in the U.S. innovation ecosystem. Distinguished participants included Sloan Foundation Program Director Evan Michelson.

Morgan Bazilian, director of the Payne Institute for Public Policy, led a roundtable discussion on how to create strong, long-lasting partnerships between energy institutes in terms of geographical scope, shared assets and funding.

"The global energy landscape is changing dramatically," said Bazilian. "With the levels of uncertainty inherent in the system, as well as the enormous impacts energy has on development, security, the environment, economy and people's daily lives, it is a great time to tap into the combined wealth of knowledge and expertise in our university energy institutes."

"The more than 100 participants were vocal in their support of collaboration and future networking, noting that anything is possible once people get to know one another," said Scott Institute Executive Director **Anna J. Siefken**. ■

Learn more at cmu.edu/energy/events/2019/summit.html



The Scott Institute's Executive Director Anna J. Siefken and Director Jay Whitacre stand with CMU Provost and Chief Academic Officer James H. Garrett, Jr., at the 2019 University Energy Institute Leadership Summit.

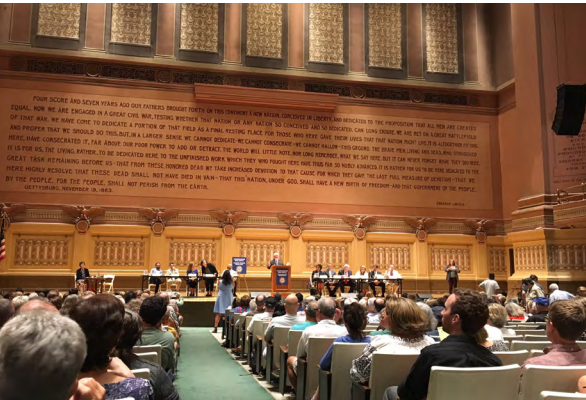


Attendees ask questions during a presentation at the 2019 University Energy Institute Leadership Summit.



Scott Institute Executive Director Anna J. Siefken poses with keynote speaker and energy investor Michael Dorsey, Colorado School of Mines Payne Institute for Public Policy Director Morgan Bazilian, and MIT Energy Initiative Executive Director Martha Broad.

POLICY OUTREACH



Jay Whitacre, director of the Scott Institute and Trustee Professor in Energy, spoke on a panel titled “Moving to a Greener Economy.” The discussion was part of a Town Hall in Pittsburgh, on Aug. 14, 2019. Hosted by Congressman Mike Doyle (PA-18), who serves on the House Energy and Commerce Committee and the bipartisan Climate Change Caucus, the event focused on climate change and exploring pathways to net carbon zero by 2050. A second panel explored state and local action on climate change.



The School of Architecture’s **Vivian Loftness*** and Civil and Environmental Engineering Professor **Chris Hendrickson** were appointed to the National Academies Committee entitled “Accelerating Decarbonization in the United States: Technology, Policy and Societal Dimensions.” The two-year endeavor focuses on the technologies and policies needed today for full decarbonization by 2050.

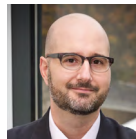


Paulina Jaramillo* (Engineering 2004, 2007), Engineering and Public Policy (EPP) professor, helped develop an open-model approach to support energy and climate

policy. In contrast to other models that explore a limited range of possibilities or use closed models, Jaramillo’s approach will be an open-source computer model of the energy system that can help test the effects of proposed policies and inform decisions. The model examines U.S. deep decarbonization options, making drastic cuts in greenhouse gas emissions, in order to mitigate the worst effects of climate change.

Constantine Samaras*

(Engineering 2008) co-authored an opinion editorial for *The New York Times* on climate policy, specifically the suggested “12-year” deadline to avoid a climate catastrophe. In the article, he considers whether this deadline is legitimate and what we must do in order to meet it.



Nicholas Muller*, Tepper School of Business and EPP professor, delivered four talks on his research to governmental agencies including the Federal Reserve Bank of San Francisco and the U.S. Environmental Protection Agency. He spoke to his studies entitled “On the Relationship Between Environmental and Macroeconomic Policy and Long-Run Environmental Accounting in the United States Economy.” These were published as working papers with the National Bureau of Economic Research.

Civil and Environmental Engineering Professor

Destenie Nock* published a paper in the journal *Applied Energy* entitled “Changing the Policy Paradigm: A Benefit Maximization Approach to Electricity Planning in Developing Countries.” Nock and collaborators have developed a methodology



for finding the optimal expansion of a power system under the objective of maximizing social benefit, as it relates to distributional equality for electricity access, subject to a budget constraint. They found that a high preference for equality leads to lower overall electricity consumption levels, but improved electrification rates due to greater investment in transmission infrastructure.



The Scott Institute jointly released a CMU policy guide on *21st Century Trends in US Mobility* with our colleagues at the Mobility21 Center and Traffic21 Institute. **Rick Grahn**, **Stan Caldwell**, and Scott Institute Faculty

Affiliate **Chris Hendrickson** recommend policies based on their analysis of travel behavior and underlying trends that might be affected by emerging technologies. The authors provide a variety of policy recommendations regarding transportation to decrease energy consumption.



Joseph Hezir (Engineering 1972, Heinz 1974), Scott Institute Board of Advisors member, presented on climate change and the need for clean energy innovation at the American Association for the Advancement of Science’s

Beyond Electricity — Climate Change and the 75% Problem Symposium. Hezir, who is also principal of the Energy Futures Initiative, urged the scientific community to increase the pace of environmental technology innovation in order to fulfill the goals set in the Paris Agreement.



Terry Collins, professor of Chemistry, participated on a panel focused on *Circular Economy Opportunities & Gaps* at the *2019 Conference on Nano-Micromaterials for Circular Economy and Sustainability* in Singapore. Joined by experts in academia and industry, Collins spoke on sustainability and the potential of solar energy. Collins also presented a talk titled, “The New Field of Sustainable Ultradilute Oxidation Catalysis (SUDOC),” which outlines methods for integrating health, environmental and fairness performance metrics with technical and cost performance ones with a goal toward transformative sustainable water purification.

* Energy Fellow

Renewable Energy Education

Startup Oriden Collaborates with Scott Institute, Tepper School of Business to Explore Energy Storage

One of Pittsburgh's newest renewable energy companies is a startup called Oriden. Its name is a play on the English word "origin" and the Japanese word "denki," which means electricity.

Oriden, a Mitsubishi Power spinoff company, launched at the Scott Institute's conference, CMU Energy Week 2019. A meeting one year earlier at CMU Energy Week 2018 sealed the future for this renewable spinoff in the Pittsburgh region. At the same event, Mitsubishi Power launched the Carnegie Mellon Power Sector Carbon Index.

"It's beneficial to have a third-party partner like Carnegie Mellon's Scott Institute that is well-respected and unbiased," said **Paul Browning** (Engineering 1990), president and chief executive officer of Mitsubishi Power and chief regional officer of Mitsubishi Power Europe, Africa, Middle East and Americas. "When we were thinking of launching a renewable

energy development company, we wanted to make sure our forecasts and the fact that 'the world needs this' are not biased. Partnering with the university gives us a lot of confidence in that way."

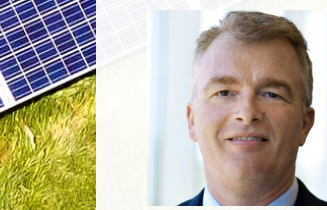
The startup remains a strong partner with the Scott Institute and Carnegie Mellon.

In the spring of 2019, Oriden partnered on a semester-long capstone class project offered through the Tepper School of Business. Nine MBA students were tasked with developing a business model for utility-scale storage projects in the PJM electricity market. The students were advised by Tepper Energy Business Track Faculty Coordinators **Jay Apt**, a Scott Institute faculty affiliate, and **Chris Telmer**, associate professor of Financial Economics.

"We try to view the capstones as consulting projects in which we deliver value for the companies," said Telmer. "In return, students get real-world experience working closely with a business on a specific need or challenge."

Giovanna Chabot, a Tepper School of Business student who graduated in May 2020, participated in the capstone class project.

"Working on a project so novel was fascinating. It was really unique to be able to assess a problem that other developers are



"It's beneficial to have a third-party partner like Carnegie Mellon's Scott Institute that is well-respected and unbiased."

— PAUL BROWNING (ENGINEERING 1990)

working on at the same time," said Chabot, who interned at the company as a finance associate in summer 2019. "The student teams held interviews with multiple groups, including industry experts in the field, at electric utilities, and in the renewable energy development and policy spaces. Most said they were hopeful about how storage — like what Oriden envisions — will fit within the PJM landscape."

At the culmination of the class, the students presented their results to Oriden's executives at their headquarters in Pittsburgh, and wrote a white paper, which is published online.

Chabot was able to skillfully leverage this class experience during her interview with National Grid, an energy company in the Boston area. She now works there full-time.

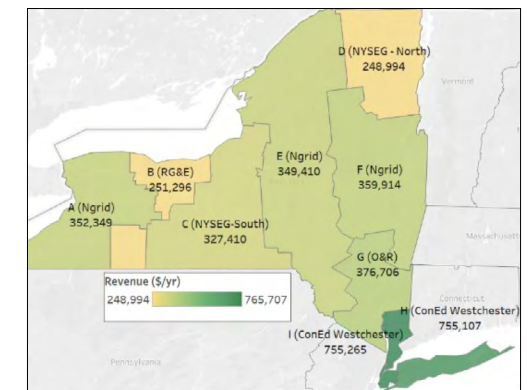
Browning notes the partnership with Carnegie Mellon has provided key opportunities for Oriden to recruit top CMU student talent.

"We've hired Carnegie Mellon students as interns and full-time employees," he said. "Our relationship with CMU has been a good way to get our name out on campus and get students interested in what we're doing and being part of our company." ■

Read the students' white paper at bit.ly/tepper-project



Tepper School of Business MBA students present their final deliverables to Oriden at the company's office in Pittsburgh.



This figure from the students' white paper illustrates the total possible annual revenue per region for a 2MW/8MWh battery system across New York Independent System Operator zones.

STUDENT NEWS



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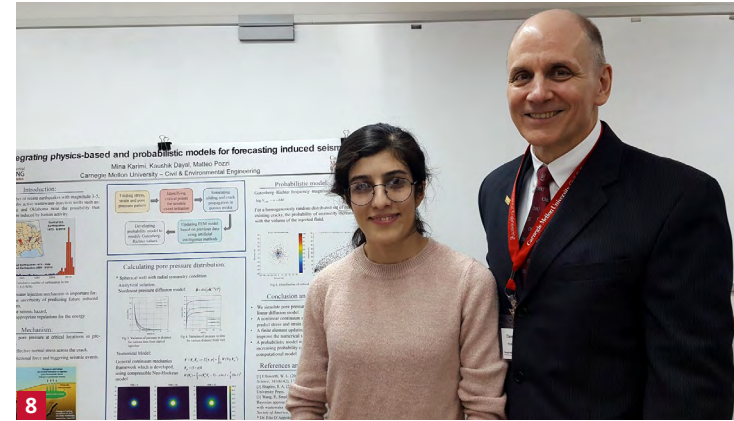
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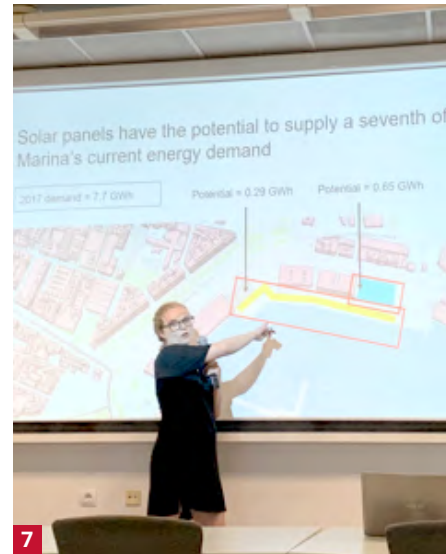
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The Scott Institute funded 22 students with travel support so that they could participate in case competitions and present their cutting-edge ideas at international workshops and conferences.

1 **Matt Griffin** and **Kristina Nikiforov** in the Tepper School of Business, with **Ansh Nasta** in the **Energy Science, Technology and Policy (EST&P) program**, were selected as finalists to compete in the Net Impact Future of Energy Mobility Challenge. The team, advised by Scott Institute Systems Scientist **Panayiotis Moutis**, went on to pitch their idea on electric vehicle charging stations for deployment during emergencies to Shell in March 2020.

2 **Siena Duplan, Meghna Jani, JinJing Luo, Yushi Yao, and Jianfu Zhang** from Heinz College's **Master of Information Systems Management Program** offered 14 energy-saving recommendations to Hershey's Twizzlers making process for their capstone project. These recommendations included both immediate and long-term ideas to reduce energy consumption and have broader applications for how general manufacturing processes

can take practical steps to address environmental and social demand.

3 **Kwaku Jyamfi**, a **Civil and Environmental Engineering (CEE)** master's student, won Best Student Research Poster at Duke Energy Week 2020 and a cash prize of \$3,000. His novel methodology uses waste chains to generate electricity in underdeveloped regions. Jyamfi is advised by CEE Department Head and Hamerschlag University Professor **David Dzombak**.

4 **Flore Marion**, **School of Architecture** Ph.D. candidate, co-authored the first annual Pittsburgh Municipal Building Benchmarking Report with the Sustainability and Resilience Division of the Department of City Planning. The report titled "The Impact of Benchmarking and Transparency Ordinances on Stakeholder Interactions and Building Energy Efficiency" evaluates the effectiveness of benchmarking legislation in Pittsburgh and other major

U.S. cities. Marion's dissertation is being used to help eliminate water and energy waste in Pittsburgh.

5 In February 2020, Heinz College **Public Policy and Management** students **Clare Callahan, Smriti Sharma** with EST&P students **Vinita Srinivasan** and **Parth Thakar** placed third in Columbia University's Energy Case Competition. The competition involved two phases: Devise a blueprint for installing and operating a 350 MW offshore wind farm in New York, and plan for a 1 GW energy portfolio. By leveraging their interdisciplinary backgrounds, the team developed a sea-float technology for gas turbines to meet 40% of the 1 GW demand.

6 **Turner Cotterman**, **Engineering and Public Policy** Ph.D. student, was awarded the Ken Pearson Scholarship for his research at the 22nd Annual Conference on Global Economic Analysis in Poland. Cotterman presented his paper, "Why Rapid and Deep Decarbonization Isn't Simple: Linking Bottom-up Socio-technical Decision-making Insights with Top-down

Macroeconomic Analyses." This work proposes a framework for analyzing the impacts of decarbonization while accounting for different behavioral, political, and social dynamics.

7 **Elizabeth Yoder**, an EST&P student, collaborated with 11 international students at the Interdisciplinary Sustainable Architecture LAB Workshop in Spain. They created a sustainable architecture plan and a design for a carbon-free electricity system for two structures, La Base and Tinglado, including a microgrid.

8 On June 20, 2019, **Mina Karimi**, CEE Ph.D. student, presented her work on "Integrating Physics-based and Probabilistic Models for Forecasting Induced Seismicity" at the Engineering Mechanics Institute Conference in the famous Beckman Auditorium at Caltech in California. Karimi is advised by Scott Institute Faculty Affiliates **Kaushik Dayal** and **Matteo Pozzi**.

ENERGIZING THE INDUSTRY

How Three CMU Startups are Revolutionizing Green Technology

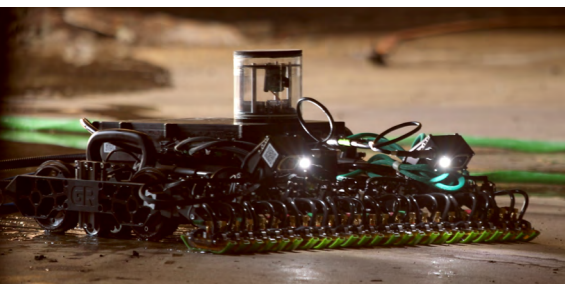
Launched in 2015, the U.S. Department of Energy's Cleantech University Prize (Cleantech UP) was designed to inspire and equip the next generation of clean energy entrepreneurs and innovators by providing competitive funding for business development, commercialization training, and other educational opportunities.



CMU was one of eight institutions selected to host regional annual Cleantech UP Collegiate

Competitions. Organized by the Scott Institute from 2016-2018, the Allegheny Cleantech University Prize Collegiate Competition established team development and training to aid students in developing the skills to move clean energy technologies from the discovery phase to marketplace. Winners of the regional competitions were eligible to compete in the national competition for the opportunity to win \$100,000.

Since then, participants have formed hundreds of ventures, creating many jobs, and raising millions in follow-on funding. Among them, three startups — Gecko Robotics, Fifth Season, and Hyliion — stand out.



GECKO ROBOTICS

In late 2019, Gecko Robotics received \$40 million from notable investors like Drive Capital, Founders Fund, and Mark Cuban. The startup had previously raised \$9 million.

Gecko's robots use magnetic adhesion to climb up walls and tanks to perform safety and infrastructure inspections in industries like oil & gas, power, and pulp & paper. Last year, the startup expanded its operations team into Houston, Texas, to focus on the oil and gas industry.

Currently working across 35 states, the company continues to build upon their 100 employees and over \$20 million in annual revenue.

In recognition of its success, Gecko Robotics was also selected by the Pittsburgh Technology Council as a Tech 50 Finalist, while its co-founder and COO **Troy Demmer**, a former CMU Tepper School of Business student, was selected for *Forbes'* 30 under 30 List in Energy.

FIFTH SEASON

Fifth Season, formerly called RoBotany, has had similar success in their endeavor to increase the efficiency of vertical farming via robotics and artificial intelligence. Most recently, the company, which won the 2017 Cleantech UP Competition, built a 60,000-square-foot solar-powered farm in Braddock, Pennsylvania. The farm will allow them to produce and market over 500,000 pounds of produce in its first full year of operation.

As of late 2019, Fifth Season had raised \$35 million in funding from Drive Capital



and private investors for their solution that utilizes 97% less land and up to 95% less water than traditional farming and increases labor efficiency by over 50%.

In the same year, co-founder **Austin Webb** (Tepper 2014) spoke with local media outlets *NEXTpittsburgh* and *Pittsburgh City Paper* about the startup's effort to expand the company into even more areas of Pittsburgh. A partnership with National Hockey League Hall of Famer Mario Lemieux, announced in June 2020, will allow the company to accelerate expansion plans.

As of Sept. 2020, Fifth Season collaborates with grocery retailers Giant Eagle and Whole Foods, as well as local restaurants to provide fresh produce year-round. They've also donated more than 100 pounds of fresh produce to members of the Pittsburgh community.

Fifth Season's success has been featured in national publications, such as *Forbes*, *The New York Times*, and *Fast Company*, which honored the company as one of its "World Changing Ideas." Webb won a 2020 Smart Business Dealmaker of the Year award and was featured in *Pittsburgh Business Times'* 2017 inaugural 30 under 30 listing.

HYLIION

Hyliion, which won the U.S. Department of Energy Clean Tech Prize at the 2015 Rice Business Plan Competition, is a leading provider of electrified powertrain solutions for Class 8 vehicles, helping to eliminate carbon intensity and reduce greenhouse gas emissions in the commercial transportation industry. Hyliion moved its headquarters from Pennsylvania to Cedar Park, Texas, just north of Austin, in 2018.

Under CMU alumnus and Hyliion founder **Thomas Healy's** (Engineering 2014) leadership, the company has raised \$52 million in capital to date and acquired Gentherm's battery division to fuel its ongoing innovation in hybrid electric technology.

Hyliion was selected for the 2018 Jim Winsor Memorial Technical Achievement Award. The startup's innovation has also gained recognition from organizations such as MassChallenge, Ethical Corporation, and *Heavy Duty Trucking* magazine. In 2017, Healy was recognized among *Forbes'* prestigious 30 Under 30.

The company has garnered several strategic industry partnerships, most notably Dana Inc., a global leader in drivetrain and e-propulsion systems. Hyliion also closed a deal with leading transportation services provider Penske Truck Leasing to deploy three of Hyliion's hybrid Class 8 vehicles.

In June 2020, Hyliion went public after merging with Tortoise Acquisition Corp., a publicly traded special purpose acquisition company with a strategic focus on the energy sector and decarbonizing commercial transportation in North America.

Healy previously served as a founding board member of the Allegheny Cleantech UP Competition to help other entrepreneurs develop and find success similar to that of Hyliion. ■



Photo Credit: Hyliion

Read more about CMU's energy startups at cmu.edu/energy/research-innovation/energy-innovations/startups.html

INNOVATION NEWS



B. Erik Ydstie, Chemical Engineering professor, was selected by the DOE and National Renewable Energy Laboratory as one of 10 American-Made Solar Prize Round 2 Set! finalists. After receiving \$50,000 in the first phase of the competition called "Ready!" Ydstie and his team won \$100,000 in cash prizes and \$75,000 in support vouchers for their innovation "Continuous Silicon Wafer Production" in the second phase, which is called "Go!" As a designated Power Connector in the \$3 million solar energy innovation competition, the Scott Institute supported Ydstie with mentoring and guidance.



A team of researchers placed in the top 10 in all divisions of the ARPA-E Grid Optimization Competition for their lightweight optimization algorithm that optimizes power generation settings across large power networks while adhering to physical grid constraints. The team includes Electrical and Computer Engineering Professors **Javad Mohammadi** (Engineering 2016) and **Soumya Kar*** (Engineering 2010), and CU Boulder Professors **Kyri Baker** (Engineering 2014) and Mohammadhafez Bazrafshan.



In 2019, **RoadBotics**, a startup based out of CMU's Robotics Institute and co-founded by **Christoph Mertz**, closed a \$7.5 million Series A funding round. The company uses smartphone and artificial intelligence technology to monitor and assess the condition of concrete and asphalt surfaces. These assessments are used to help governments and engineering firms make well-informed pavement management decisions.



CMU spinout **Conservation Labs** raised \$1.7 million in seed funding for its smart water monitor, H2know, in late 2019. The product uses machine learning technology to help consumers understand water flow, prevent water damage and provide actionable water insights and conservation recommendations. Founder and CEO **Mark Kovscek** (Mellon College of Science 1992) has worked since 2018 to bring this technology to market.

In Sept. 2019, CMU spinoff **Teratonix**, founded by former CMU Professor **Yi Luo**, competed in the Cleantech Open Global Forum in Los Angeles and was one of four regional winners. Representing the Cleantech Open Northeast cohort, the startup received a cash prize of \$10,000 for its maintenance-free power source to replace batteries and convert radio waves into electricity.

* Energy Fellow

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FACULTY AFFILIATES ACROSS 28 CMU CENTERS AND DEPARTMENTS

14

ENERGY FELLOWS FROM VARIOUS DISCIPLINES



CMU CLEANTECH STARTUPS RAISED \$218M SINCE 2012*

213 GRADUATES OF ENERGY SCIENCE, TECHNOLOGY AND POLICY MASTER'S DEGREE PROGRAM SINCE 2011

ATTENDEES AT 25 EVENTS

1.5K+ \$16.5 MILLION



NSF FACULTY EARLY CAREER AWARD RECIPIENTS IN 2019-2020

65 SEED GRANT PROJECTS SUPPORTED SINCE 2013

AWARDED \$2.8 MILLION RESULTING IN

\$16.5 MILLION IN EXTERNAL FUNDING

* As of August 2020



Industry & Academia: Working Together on the Future of Pennsylvania Solar

Chanelle Mayer, NextEra Energy Resources senior project manager of Renewable Business Development, speaks on the CMU Energy Week 2019 panel, "Finding Grid-Scale Solar: Identifying and Implementing Best Practices for Pennsylvania."

Some states, like California and North Carolina, have capitalized on solar generation — receiving at least 5-10% of electricity from one of the country's fastest-growing electricity sources. While solar energy is increasing in Pennsylvania, it provides less than 1% of the state's electricity.

In 2018, the Scott Institute, in collaboration with the PA Department of Environmental Protection, commercial developers and utilities, set out to find the best ways for the state to realize its potential for solar energy development.

Through this project, "Pennsylvania's Solar Future Plan," the Institute established a partnership with NextEra Energy Resources, **the nation's leader in wind and solar power generation** and electricity production from clean and renewable sources.

CMU Heinz College students were tasked with identifying financially and environmentally feasible sites for the deployment of grid-scale solar in the Pittsburgh metro area. They found 675 sites with a total potential capacity equivalent of 11 GW of electricity.

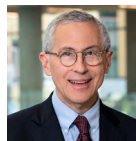
Scott Institute Executive Director **Anna J. Siefken**, who advised the students, co-presented these findings with NextEra Energy Resources Senior Project Manager of Renewable Business Development Chanelle Mayer at the Sustainable Energy Fund's annual conference, Energypath.

A number of key collaborations with NextEra Energy Resources have since developed.

Mayer continued the conversation at the Scott Institute's CMU Energy Week 2019 during a panel on siting grid-scale solar. Meanwhile, NextEra Energy Resources' Senior Vice President of Development Michael O'Sullivan (now retired) delivered an intriguing keynote on the current landscape of **utility-scale wind and solar power**, with a look ahead at **storage**.

"By 2030, customers could begin to use solar and battery systems to dramatically reduce their consumption of energy from the grid, even without the ability to sell excess solar with net energy metering," said O'Sullivan during his talk at CMU Energy Week, which NextEra Energy Resources sponsored.

Scott Institute Faculty Affiliate and Carnegie Mellon Electricity Industry Center Co-Director **Jay Apt** says, "One of the best talks I heard at CMU Energy Week was by Michael O'Sullivan." Apt utilized the recording of O'Sullivan's talk in his classroom of Engineering and Public Policy and Tepper School of Business students.



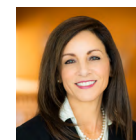
"Events like CMU Energy Week are a key component to helping us develop, and to helping people understand the need for more renewable development across the state," said NextEra Energy Resources Project Manager Garrett Childers. "People

have a source they can go to, that they know and trust, like CMU, that can give them the information they're looking for. Efforts like that are an essential part of our partnership and in bringing more renewable energy to the state."

O'Sullivan (pictured at right) returned to campus in late 2019 to meet with over 60 sustainability and energy experts and at a special evening VIP reception. Afterward, he presented on "**Energy in Transition** in North America and Pennsylvania."

NextEra Energy Resources is also collaborating with faculty on research aiming to increase the energy capacity of solar cells so that they can maintain their size but have the ability to absorb more energy.

"We're always looking at new ways of being able to site projects; to not have panels take up as much space or need as much ground in smaller parcels," said NextEra Energy Resources Project Manager Garrett Childers. "The big driver for us is to find a way to get these panels and our footprint smaller without having to impact the actual energy capacity of a project."



The Scott Institute is looking forward to continuing its partnership with NextEra Energy Resources by hosting Marlene Santos, president of Gulf Power Company (a NextEra Energy-owned company). Santos is also the proud parent of a 2013 Computer Science graduate

and is one of 14 participants chosen by the university president to serve on his advisory board for the CMU Experience — providing recommendations for improving the student experience. ■

Learn more about becoming a partner at cmu.edu/energy/get-involved/partner



From left to right, NextEra Energy Resources' Chanelle Mayer, Garrett Childers, and Robert Michalczak pose for a photo at the Scott Institute's VIP Reception and Keynote by Michael O'Sullivan.

ALUMNI NEWS



"The most important thing I've learned since graduating from CMU is that distributed supply with home solar and intermittent generation of solar and wind on transmission level have created a need for grid intelligence and energy balancing hardware and software solutions."

— LEIGH ZANONE (DIETRICH, TEPPER 2004), 8MINUTE SOLAR ENERGY SENIOR DIRECTOR OF OPERATIONS AND ASSET MANAGER



Leah Lizarondo (Heinz 2003), chief executive officer of 412 Food Rescue, received the 2020 Vital Voices Global Leadership Award for her innovative use of technology to engage Americans in the fight to end hunger, eliminate food waste and combat climate change. 97% of food waste ends up in landfills, generating a large portion of U.S. methane emissions. 412 Food Rescue has recovered over 10 million pounds of food, in turn, preventing greenhouse gases derived from it decomposing in landfills.



Oak Ridge National Laboratory selected **Jesse Thornburg** (Engineering 2016) into its "Innovation Crossroads" program, the Southeast's only entrepreneurial research and development program based at a DOE national lab. Thornburg and his Grid Fruit startup team are developing a new operating framework to monitor and control commercial refrigeration systems installed at food retailers.



Scott Institute Board of Advisor **Kathryn Jackson** (Engineering 1990) was appointed to the board of directors for DQE Holdings LLC, Duquesne Light Holdings, Inc., and Duquesne Light Company. She is the director of Energy & Technology Consulting for KeySource and was previously the chief technology officer for three international corporations where she directed investment platforms.



Sakshi Mishra (Engineering 2015), a researcher at NREL, was invited to speak at the DOE's 2019 Association of Energy Engineers World Energy Conference and Expo on the Better Buildings, Plants Program Panel. She presented a talk titled *REopt Energy Integration and Optimization*, a decision support model that combines technology and economics to optimize energy systems for buildings, campuses, communities and microgrids.



Maynard Holliday (Engineering 1984) recently joined RAND Corporation as a senior engineer after having served as the senior technical advisor to the Office of Undersecretary of Defense for Acquisition Technology and Logistics at the Pentagon. His career has bridged policy, research and private industry with various positions focused on nuclear energy and robotics.

FACULTY IN THE MEDIA



Senior Energy Fellow and Alumni Chair Professor of Environmental Engineering and Science **Ed Rubin** discussed using renewable resources to offset fossil fuels in the **LOS ANGELES TIMES**.

Paulina Jaramillo* (Engineering 2004, 2007), professor of Engineering and Public Policy, spoke with **THE NEW YORK TIMES** about



central vs. distributed grid systems when Pacific Gas & Electric used rolling blackouts. In 2019, California's largest utility used blackouts to protect dry forests from live power lines that could spark or overheat and set wildfires.

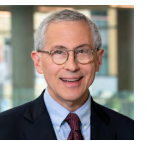


Constantine Samaras* (Engineering 2008), associate professor of Civil and Environmental Engineering and Engineering and Public Policy, was quoted in a **NATIONAL GEOGRAPHIC** article in May 2020 focused on the intense decrease in carbon emissions from the pandemic lockdowns and how it didn't impact climate change. In response, Samaras said technological, behavioral and structural change is the best way to reduce emissions.

Jeremy Michalek, professor of Mechanical Engineering and Engineering and Public Policy, was interviewed by **WIRED** about the federal tax credit phaseout for Tesla's electric vehicles (EV). The EV policy expert commented on how it could affect state "zero emissions vehicle" targets.



In **THE CONVERSATION US**, Carnegie Mellon Electricity Industry Center Director **Jay Apt** discussed the history of electricity in relation to the 2017 film, *The Current War: Director's Cut*.



Lee Branstetter, professor of Economics and Public Policy, contributed to a **WIRED** article on China increasing its number of coal plants.

Branstetter, who has joint appointments in the Heinz College and Dietrich College, says the answer can be found in energy regulations crafted during the Chinese coal boom of the 1980s. The Chinese government adopted several energy policies to encourage the construction of coal plants. As a result, many plants were rapidly built.

Stefani Danes, adjunct professor in the School of Architecture, spoke with **NEXTPITTSBURGH** about Pittsburgh's first ecovillage located at Chatham University's Eden Hall campus. Danes is helping guide the project.



BUSINESS INSIDER turned to **Raj Rajkumar**, George Westinghouse Professor of Electrical and Computer Engineering, for his thoughts on Tesla's groundbreaking Autopilot feature and how it compared to competing technologies as of June 2020.



* Energy Fellow

ENERGY FELLOWS

The Scott Institute Energy Fellows Program incentivizes, promotes and rewards Carnegie Mellon University's most dedicated tenure track energy faculty. Each fellow receives funding, resources and membership in the Scott Institute Fellow Council. We are grateful for their contributions to the energy field.

SENIOR FELLOWS

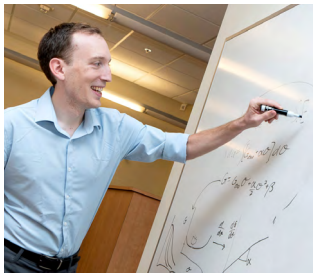
Karen Clay
Professor of Economics and Public Policy, Heinz College
Tepper School of Business (Courtesy),
Department of Engineering and Public Policy (Courtesy)

Vivian Loftness
University Professor, School of Architecture

Larry Pileggi
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Ed Rubin
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Director, Integrated Environmental Control Modeling Group

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Director, Center for Water Quality in Urban Environmental Systems



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Stefan Bernhard
Professor of Chemistry
Director, Bernhard Research Group

Paulina Jaramillo
Arthur Hamerschlag Career Development Professor of Engineering and Public Policy
Co-Director, Green Design Institute (Engineering 2004, 2007)

B. Reeja Jayan
Associate Professor of Mechanical Engineering, Chemical Engineering (Courtesy), Electrical and Computer Engineering (Courtesy) and Materials Science and Engineering (Courtesy)
Principal Investigator, JLAB

Soumya Kar
Associate Professor of Electrical and Computer Engineering (Engineering 2010)

Nicholas Muller
Lester and Judith Lave Associate Professor of Economics, Engineering and Public Policy in the Department of Engineering and Public Policy and Tepper School of Business
Co-Director, Green Design Institute

Destenie Nock
Assistant Professor of Civil and Environmental Engineering and Engineering and Public Policy

Constantine Samaras
Associate Professor of Civil and Environmental Engineering and Engineering and Public Policy (Courtesy)
Director, Center for Engineering and Resilience for Climate Adaptation
Co-Director, Carnegie Mellon Power Sector Carbon Index (Engineering 2008)

Zachary Ulissi
Assistant Professor of Chemical Engineering
Director, Ulissi Group

Venkat Viswanathan
Associate Professor of Mechanical Engineering, Physics (Courtesy), Materials Science and Engineering (Courtesy) and Chemical Engineering (Courtesy)

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The Scott Institute's internal faculty advisory committee offers general strategic advice and guidance to the Institute. Committee members serve terms of one to three years and are chosen to provide disciplinary diversity and representation of faculty members across the university. The Institute is grateful to the following members:

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Mellon College of Science, Chemistry

Christopher Bettinger
College of Engineering, Materials Science and Engineering, Biomedical Engineering

Karen Clay
Heinz College of Information Systems and Public Policy
Tepper School of Business
College of Engineering, Engineering and Public Policy

Erica Cochran Hameen
College of Fine Arts, School of Architecture (Fine Arts 2014)

Baruch Fischhoff
College of Engineering, Engineering and Public Policy, Institute for Politics and Strategy

Shawn Litster
College of Engineering, Mechanical Engineering, Materials Science and Engineering

Nikolaos Sahinidis
College of Engineering, Chemical Engineering (Engineering 1990)

Nicola Secomandi
Tepper School of Business, Operations Management

Jeanne VanBriesen
College of Engineering, Civil and Environmental Engineering, Engineering and Public Policy

Venkat Viswanathan
College of Engineering, Mechanical Engineering, Materials Science and Engineering, Chemical Engineering



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The Scott Institute Board of Advisors offers general strategic advice, connections and guidance. The Institute is thankful for the following members' continued support.

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BOARD MEMBER

Scott Institute Board of Advisor Katie McGinty on the Necessity of Energy Research



A recognized innovator in clean energy, the environment, and life sciences, and a champion of advanced technology development, **Kathleen "Katie" McGinty** has served on the Scott Institute Board of Advisors since the Institute's launch in 2012 — taking a brief hiatus in 2015 during her campaign for the United States Senate. She has worked in the public and private sectors for over 25 years and led the Pennsylvania Department of Environmental Protection in the execution of Governor Rendell's green initiative. Currently, McGinty serves as the vice president of Global Government Relations at Johnson Controls — a company that improves the efficiency and sustainability of buildings via new technologies.

McGinty values the tangible impact of Johnson Controls, as the company's work in energy efficiency and new digital capabilities reduce energy and mortality rates across the globe. Their innovations in green technology are crucial in shifting to a more sustainable future, which McGinty admits may be tough. However, she believes the Scott Institute plays an invaluable role in pushing that new and dynamic reality forward.

"The Scott Institute gives public utility commissions, state governments and corporations the courage to take on an antiquated system, and finally drive a reinvention towards sustainability because of the caliber and credibility of a voice like the Institute proving it's possible, and in fact, it's urgent," she said.

Her involvement in the Institute stemmed from her connection with Director Emeritus **Jared L. Cohon**, whom she praises for not only his earlier leadership of the Institute, but also for his depth of expertise in areas like water resources. She also admires the cutting-edge work at Carnegie Mellon in energy policy by leaders such as **Jay Apt**, Energy Fellow **Vivian Loftness**, Professor Emeritus **Volker Harkopf**, and Director Emeritus **M. Granger Morgan**.

"The kind of research that Scott Institute conducts, the Seed Grants and now the incredible leadership in having initiated the cross-university collaborative around energy research (more on the University Energy Institute Leadership Summit on page 16) is just extraordinary in terms of the breadth and scope of the work being done at CMU," she said.

McGinty serves on the boards of the American Council on Renewable Energy, Energy Futures Initiative, and the Franklin Square Energy Partners. She said she considers it a privilege to also be a part of the Scott Institute Board.

"Energy is literally the lifeblood of our economy, and really our society," said McGinty. "Energy can either be that which seals for us a grim fate if we continue on the current trajectory, or energy can inspire unprecedented innovation, collaboration and dynamism when you have the throw-weight of Scott Institute caliber research behind it." ■

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Sherman and Joyce Bowie Scott

The legacy of Wilton E. Scott, oil and gas geologist and energy industry leader, lives on through the Wilton E. Scott Institute for Energy Innovation. His son Sherman (Engineering 1966) and wife Joyce Bowie Scott (Fine Arts 1965) — *pictured at left* — established the Institute in 2012, providing support along with the Richard King Mellon Foundation to house it in the Sherman and Joyce Bowie Scott Hall.



Carnegie Mellon University

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