Cooperative Agreement
No: AID-391-A-15-00001

ANNUAL REPORT
FISCAL YEAR 2018

U.S.-Pakistan Centers for Advanced Studies in Energy

USAID
FROM THE AMERICAN PEOPLE

ASU

Together, we can strengthen Pakistan's energy future.

Pakistan's economic growth and security require stable and sustainable energy systems that can reliably support businesses and communities nationwide.

Every time rolling blackouts or brownouts shut down an office or load shedding hobbles a manufacturing facility, Pakistan suffers.

Electricity is the life blood of an economy. It delivers the ability to do work.

The USAID-supported U.S.-Pakistan Centers for Advanced Studies in Energy (USPCASE) program is a partnership between Arizona State University (ASU) and Oregon State University (OSU) in the United States and the National University of Sciences and Technology (NUST) and the University of Engineering and Technology (UET) Peshawar in Pakistan.

The universities are working together to strengthen academic programs, support energy research, educate a new generation of skilled engineers, and build enduring connections among government, industry and academia.

That's why USPCASE has made partnerships with government and industry leaders in the energy sector a primary focus.

In a short time, the program has:

- Created state-of-the-art post-graduate education programs in renewable, electrical and thermal energy, as well as energy management.
- Initiated and supported the development of a technology center to support the energy sector with training, certifications and testing facilities.
- Strengthened student understanding of applied research through internships.
- Undertaken nearly 50 joint and applied research projects.
- Organized educational conferences, technical workshops, industry stakeholder meetings and more.

USPCASE Project

Energizing Pakistan

USPCASE Project Progress: Fiscal Year 2018

PROJECT GOALS | **Curriculum** | **Research**

BUILD NEW CENTERS OF ADVANCED STUDIES IN ENERGY

New buildings at the National University of Sciences and Technology (NUST) and the University of Engineering and Technology Peshawar (UET-P) have created a catalyst for change in energy education in Pakistan. These modern facilities feature new labs and libraries and the tools, environment and mindset needed for transformative change.

CREATE A MODERN, RELEVANT CURRICULUM

ASU is supporting NUST and UET-P to develop new masters and Ph.D. degree programs with 12 new programs to date plus more than 100 new courses. These new degree programs translate work in the classroom and lab into the public and private sector in a pragmatic and applied manner with a focus on immediate real-world applications.

FOCUS ON HIGH-IMPACT APPLIED RESEARCH

The centers are focused on energy research that directly relates to ongoing and future energy challenges that affect the lives of ordinary Pakistanis and impede economic growth. These efforts include 36 applied research projects and 12 joint research projects with U.S.-based faculty at ASU and OSU.

12 NEW MASTERS & PH.D. DEGREE PROGRAMS

36 APPLIED RESEARCH PROJECTS

750+ M.S./PH.D. STUDENTS ENROLLED TO DATE

12 JOINT RESEARCH PROJECTS WITH U.S. & PAKISTANI RESEARCHERS

100+ NEW COURSES DEVELOPED

12 TECHNICAL WORKSHOPS WITH VISITING EXPERTS

The USAID-funded U.S.-Pakistan Centers for Advanced Studies in Energy, USPCASE, is a partnership between Arizona State University (ASU) and two leading Pakistani universities: National University of Sciences and Technology (NUST) and University of Engineering and Technology Peshawar (UET-P) along with partner Oregon State University (OSU).

Exchange and Scholarships

FACILITATE LEARNING THROUGH EXCHANGE PROGRAMS

USPCASE supports the academic and research advancement of Pakistani students and faculty by hosting more than 200 exchange students and faculty at ASU and OSU — 30 each semester — to conduct cutting-edge energy research in state-of-the-art labs.

Sustainability

ENSURE LONG-TERM SUSTAINABILITY OF THE CENTERS

USPCASE is working to ensure the sustainability of initiatives at NUST and UET-P through fundraising strategies and the cultivation of six public-private partnerships with the goal of raising $2M in funding, creating 20 new labs and two libraries, and securing 100 internships.

Governance

FACILITATE INDUSTRY COLLABORATION AND STAKEHOLDER ENGAGEMENT

USPCASE is focused on the collaboration needed to develop world-class centers of energy engineering that will serve as Pakistan's go-to think tanks with the technical expertise to close the energy gap. As part of this effort, USPCASE is working to actively engage 120 stakeholders over the life of the project.

137 EXCHANGE VISITORS AS OF FY18

FEMALE **30%**

SEMESTER-LONG RESEARCH EXPERIENCE

CULTURAL AND ACADEMIC EXCURSIONS

OUTREACH OPPORTUNITIES

70+

MEETINGS

TO BUILD ENGAGEMENT WITH THE PUBLIC/PRIVATE ENERGY SECTOR

$1.6 MILLION

RAISED IN EXTERNAL FUNDING

99

INTERNSHIPS

100

STAKEHOLDERS AND FACULTY

ATTENDED MOST RECENT MEETINGS

Focused on the Future

The USPCASE centers are focused on creating long-lasting collaborative partnerships with stakeholders that have the potential to transform the energy sector and realize long-term benefits for Pakistan.

STAKEHOLDER ENGAGEMENT: KEEPING AN EYE ON LONG-TERM SUCCESS

Many research projects have a well-defined beginning and end. But what happens when the end is really just the beginning? The U.S.-Pakistan Centers for Advanced Studies in Energy are working to make sure that the end of their USAID-supported project marks the beginning of a sea change: a broad transformation of energy engineering research and education in Pakistan. Key to project success is sustainability: building new centers at two Pakistani universities that will flourish after the life of the initial project. These centers are envisioned as emerging think tanks that are responsive to energy sector needs — creating innovative solutions to tough energy problems in Pakistan.

USAID is the lead U.S. Government agency working to end extreme global poverty and enable resilient, democratic societies to realize their potential. To create and strengthen a culture of applied research, USAID launched the U.S.-Pakistan Centers for Advanced Studies in Energy (USPCASE). USPCASE is focused on finding ways to increase energy production and availability, with an emphasis on renewable energy and energy production in remote areas, as well as energy storage and transmission, and energy policy.

With significant expertise in power systems, photovoltaics and renewable energy, policy and related energy engineering, ASU was selected to lead the project with Pakistani partner institutions NUST and UET-P along with U.S. partner OSU. Together, they are building a network of stakeholders invested in the ongoing success of the centers.

To engage and inform its stakeholders, USPCASE hosts regular meetings to share project updates and outcomes and to invite input and feedback on curriculum, research projects and more. USPCASE held its fourth National Stakeholders Meeting and Research Expo on April 25, 2018, at the Islamabad Serena Hotel in Pakistan.

Fostering Partnerships and Ensuring Sustainability

Stakeholder engagement is key to the sustainability of the Centers for Advanced Studies in Energy. The centers are developing a critical mass of expertise, creating an educated workforce through the preparation of graduate students, developing technical and policy solutions, and providing technical bandwidth to public and private energy organizations in Pakistan. In order to promote modernization and relevance of the curriculum, strengthen policy decisions and drive innovation, USPCASE is engaging with a wide range of energy sector stakeholders in Pakistan.

Ongoing engagement with stakeholders through one-to-one meetings and industry visits affirm that the centers are developing relevant curricula and research agendas that respond to both public and private sector needs for the long term. Stakeholder engagement with USPCASE increases year over year with participation nearly doubling each year.

"Stakeholder input and feedback are critical to the success of the Centers for Advanced Studies in Energy at NUST and UET," explains Sayfe Kiaei, Motorola Chair and professor at ASU and director of the USPCASE project.

"We are building programs to be responsive to the needs of Pakistan's energy sector. Being nimble and innovative requires multiple perspectives and stakeholder engagement is helping to create the long-term success of these centers."

The stakeholder meetings are an opportunity to learn more about each of the program components — curriculum, research, exchange, governance and sustainability.

The meetings provide the latest information on degree programs and research projects, and provide a forum for input and feedback.

Stakeholder Muhammad Ziauddin, Chief Executive Officer with Élan Partners (Pvt.) Ltd., points to the capacity-building aspects of USPCASE as key to future success. Young people from all walks of life are afforded an opportunity to work in a key sector and stakeholders have the opportunity to provide input to ensure that their experiences in the classroom and lab are informed by real-world challenges in the field.

Stakeholder N. A. Zuberi, Chief Operating Officer, China Three Gorges South Asia Investment Ltd., calls USPCASE "an excellent initiative."

Mr. Zuberi believes that the program is extremely important to Pakistan and appreciates that stakeholder involvement affirms that courses are aligned with the requirements of the energy sector in Pakistan.

Ammar Yasser, Corporate Engagement Specialist for USPCASE, encourages stakeholders to learn more about the project: "There are a number of ways that energy sector stakeholders can engage with USPCASE, from sponsorship of research projects, to working with faculty, to hiring interns and graduates."

Industry representatives may contact Mr. Ammar Yasser, Corporate Engagement Specialist for USPCASE, at ammar.yasser@asu.edu

GOVERNANCE

Sound governance will ensure that the centers are goal-oriented, growth-minded, self-sustaining and able to flourish beyond the life of the funded project.

PROGRESS ON GOVERNANCE

- **100 stakeholders representing all facets of the energy sector attended both stakeholder meetings**
- **Inaugural Think Tank Dialogue held**
- **Supported two conferences**
- **Active engagement in governance forums (National Advisory Committee/Steering Committee)**
- **Active engagement in research and curriculum committees/councils at NUST and UET-P**
- **Two key trainings held to support the efficiency and effectiveness of the centers (proposal development and corporate engagement)**

During this reporting year, USPCASE worked closely with UET-P and NUST on the following governance-related tasks and objectives: committee infrastructure; support of the project management unit; stakeholder engagement; self-assessment; trainings to support grants making and sustainability; UET-P management; and support for international conferences.

ENSURING THAT COMMITTEES ARE FUNCTIONING AND SUSTAINABLE

ASU provided technical insights, advice and recommendations to the National Advisory Committee, the Steering Committee and the Committee on Research Policy on matters pertaining to governance, research, curriculum and sustainability. We worked with partners to structure a realistic and achievable plan of action to institutionalize the centers within their universities for sustainability and supported the creation of energy think tanks for the centers. We also supported partner universities by convening the inaugural Think Tank policy dialogue.

ASU actively contributed in three meetings of the National CAS Advisory Committee and developed joint presentations with NUST and UET-P for the meetings.

In addition to reviewing the Terms of Reference (ToR) for the Steering Committees and providing feedback, ASU participated in all steering committee meetings at NUST and UET-P and followed up on decisions made during these meetings.

We participated in all CRP committee meetings at NUST and UET-P and reviewed projects and other documents to be presented in the meeting and followed-up with NUST and UET-P on action items.

TRAININGS TO BUILD CAPACITY AND SUSTAINABILITY IN CENTER OPERATIONS

Trainings for NUST and UET-P faculty and staff were organized to increase technical expertise critical to the long-term sustainability of the centers: Technical Proposal Writing facilitated by proposal writing expert Mr. Alan Paul, and Corporate Engagement, delivered by industry engagement expert Mr. Lou Farina. Both workshops drew attendees from both partner universities and a large number of stakeholders working in the field of energy.

ASU sustainability efforts such as linking UET-P and NUST with various government and private institutions for collaboration—including with the Higher Education Commission—contribute towards sustainability, effectiveness and efficiency.

ASU is organizing a leadership training for senior and mid-level management at NUST and UET-P to enhance their leadership skills for better management of the centers. ASU is exploring options that include both Pakistani and American trainers. The training is scheduled for the second quarter of fiscal year 2019.

ENERGY POVERTY SESSION

On July 11, 2018, Dr. Clark Miller from ASU conducted a one-day session on Energy Poverty that was attended by 64 participants (including 14 female participants) from NUST, UET-P and civil society organizations involved in energy poverty initiatives. Dr. Miller has done extensive research on the energy-poverty nexus which he shared in the context of Pakistan's energy landscape. He also shared a framework that emphasizes a compound measurement of the quality and quantity of energy provision, and the social value of energy tool, which measures how much value an energy user is able to derive from the use of energy.

PROJECT MANAGEMENT UNIT (PMU)

ASU assisted UET-P management in the implementation of the recommendations of the PMU review.

ASU supported NUST in the PMU review and provided feedback on the report and subsequently supported NUST management in the implementation of recommendations from the PMU review.

Terms of Reference (ToR) for the mid-term performance (institutional) review of PMU were developed in consultation with NUST, UET-P and USAID and ASU provided support to NUST and UET-P in the mid-term review. ASU reviewed the mid-term review report and provided feedback to NUST and UET-P.

At UET-P, in the absence of a project director and other team members, ASU's Deputy Director for USPCASE at UET-P served as co-director and managed the program and administrative matters of the project and the center.

FACILITATING SELF-ASSESSMENT

ASU developed a self-assessment tool for NUST and UET-P at their request. The development of the tool for self-assessment is beyond the scope of the Cooperative Agreement but was deemed critical to promoting long-term sustainability of the centers. Self-assessment activities included a review of the Energy Systems Engineering program at NUST, the USPCASE program at UET-P and the Renewable Energy program at UET-P that included input from a panel of experts from ASU.

Lea Swanson, USAID Punjab Director addressing the audience at the opening ceremony of ICECE 2017. Photo by Arsal Latif/ASU-USPCASE

SUPPORT FOR NATIONAL CONFERENCES

Organizing conferences raises the visibility of the centers and positions them as thought leaders and desirable partners in the energy arena in Pakistan. In the past year, the centers at NUST and UET-P hosted national conferences and participated in an international conference.

International Conference on Energy Conservation and Efficiency 2017

USAID showcased its partnership with Pakistan in the energy sector in the two-day International Conference on Energy Conservation and Efficiency 2017 held in Lahore, Pakistan, November 22-23 of that year.

USAID Provincial Director for Punjab, Ms. Lea Swanson, joined the Vice Chancellor of University of Engineering and Technology-Lahore (UET-Lahore), Dr. Fazal Ahmad Khalid, CEO Lahore Knowledge Park, Dr. Zubair Iqbal Ghouri, and other dignitaries from government, academic and private sectors to kick off the conference. Hosted by UET-Lahore, the conference and accompanying exhibition were co-sponsored by USPCASE.

National Conference on Green Energy Technologies

ASU provided support to USPCASE UET-P in organizing the National Conference on Green Energy Technologies in April 2018 that was attended by representatives of Pakhtunkhwa Energy

Development Organization (PEDO), Peshawar Electric Supply Company, Pakistan Council of Renewable Energy Technologies, AEDB, Planning Commission, Sarhad Rural Support Programme, Khyber Pakhtunkhwa Oil & Gas Company Limited, and Pakistan Science Foundation.

ASU support included identifying speakers, preparing the conference program and informational materials, organizing a poster session, and branding and media coverage.

Planning underway for NUST's National Conference on Energy Trends

As part of the core committee, ASU is providing support to USPCASE NUST in organizing an international conference planned for FY 2019. ASU helped NUST in drafting the program and identifying resource persons and speakers for the sessions.

ADVANCING COLLABORATION WITH THE ENERGY INDUSTRY

THIRD STAKEHOLDERS MEETING: OCTOBER 2017

The third USPCASE National Stakeholders Meeting was attended by over 80 participants including senior officials from the Government of Pakistan, Higher Education Commission (HEC), United States Agency for International Development (USAID), industry and academia. Led by ASU, the primary objectives of the meeting were to share the curriculum changes at NUST and UET, the ongoing research in the field of energy, and to provide a forum to discuss strategies to enhance cooperation and collaboration across industries to address Pakistan's energy needs. Twenty-two poster presentations showcased the applied research being done by faculty and their students. Key stakeholders provided technical feedback on the research projects that will eventually be commercialized.

During the stakeholder feedback session, an energy entrepreneur commented: "There is a disconnect between the private sector and universities—for this reason Pakistan hasn't been able to overcome its energy crisis. I believe that this remarkable partnership between ASU, NUST, and UET-P supported by USAID is a great opportunity to help solve Pakistan's energy concerns and respond to market needs for research."

FOURTH STAKEHOLDERS MEETING AND RESEARCH EXPO: APRIL 2018

The fourth National Stakeholders Meeting brought together over 100 representatives from Pakistan's government and private sector. In conjunction with the stakeholders meeting, USPCASE hosted its first ever Research Expo featuring research projects from ASU, UET-P and NUST as well as research from the Center for Advanced Studies in Water led by the University of Utah. Hundreds of people attended the Expo and it was exciting to see the hard work of USPCASE researchers and students coming to fruition. The centers are poised to cement their status as leading providers of knowledge and high-quality graduates.

MAKING CONNECTIONS

On November 7 2017, a four-way memorandum of understanding (MoU) was signed by Higher Education Commission (HEC) along with ASU, NUST, and UET-P for the U.S.-Pakistan Centers for Advanced Studies in Energy program. This MoU supports development of the energy centers at NUST and UET-P as collective resources for the Government of Pakistan as it addresses the future energy needs and priorities of Pakistan. NUST and UET-P also plan to collaborate with each other—and with other universities in Pakistan and the U.S.—to promote mutual learning, outreach to stakeholders, information exchange and joint degree programs.

ASU supported UET-P in the development of a project proposal (PC-1) requested by FATA Secretariat for solar based microgrids. This project will ensure a sustainable supply of power to the remote communities of FATA.

Research Expo

USPCASE and USPCASW held a joint Research Expo on April 25, 2018 in the Islamabad Serena Hotel. The well-attended event featuring 40 research projects, admissions and program information.


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NUST
Defining futures
U.S.-Pakistan Centers for Advanced Studies in Energy
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RESEARCH
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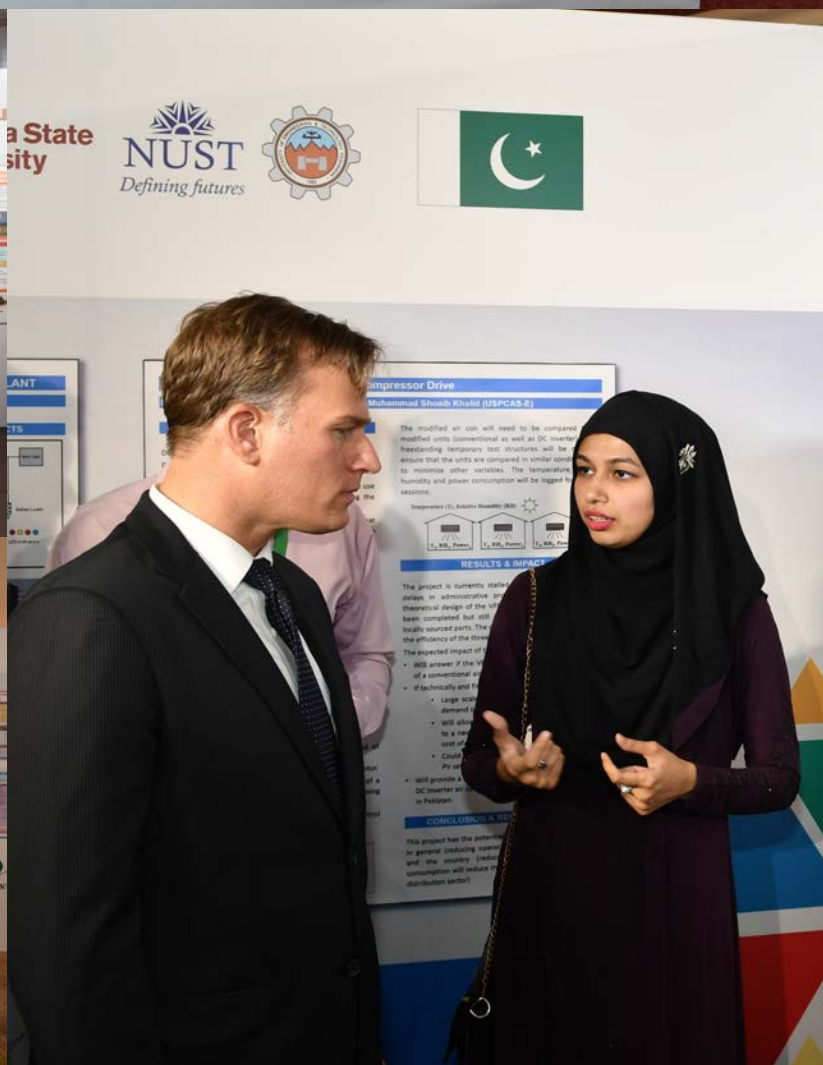

NUST
Defining futures

CURRICULUM

Modernized curriculum and improved teaching strategies and methods will produce highly qualified graduates who meet the workforce needs of the energy industry in Pakistan.

PROGRESS ON CURRICULUM

100+ courses developed to date

750+ MS/PhD students enrolled to date

125 students have graduated to date

14 new labs developed to date

✓ Pedagogy training program begun

✓ Technology Center planning underway

CURRICULUM DEVELOPMENT

In order to develop a curriculum vision for the center, a detailed analysis of existing curriculum streams at NUST and UET-P was conducted, and feedback was solicited from industry and other stakeholders. Similar programs offered elsewhere were also reviewed. The vision was presented to USPCASE management and faculty and further discussions are taking place in the Curriculum Development Working Group and the curriculum sub-committees of NUST and ASU.

NUST envisions offering the Energy Policy stream as an executive evening program for energy sector professionals.

After a detailed review, ASU faculty recommended that UET-P focus on these areas: Electrical Energy Systems Engineering; Thermal Chemical Engineering; Hydropower Energy Systems; and Energy Policy and Management.

Further decisions on introducing the program at UET-P will be based on feedback from ASU faculty and local stakeholders. ASU developed a detailed international assessment of current hydropower programs that highlighted existing best practices.

ELECTRICAL ENGINEERING (POWER) PHD PROGRAM

ASU reviewed the Electrical Energy Engineering (EEE) program at NUST and provided recommendations. NUST's University Curriculum Review Committee approved the Electrical Engineering (Power) PhD program in May 2018. The PhD program will be offered in spring 2019 once approved by Academic Council Meeting (ACM) and a No Objection Certificate is granted by HEC.

ENERGY AND CLIMATE CHANGE COURSE

ASU supported USPCASE in developing an Energy and Climate Change course with the help of international and national climate science experts. These experts included Dr. Hanna Breetz, School of Sustainability/ASU, Dr. Tariq Banuri, member of the Inter-governmental Panel on Climate Change (IPCC) which received the Nobel Peace Prize in 2007, Dr. David Annandale, Mr. Irfan Tariq, Director General, Ministry of Climate Change, and Mr. Saadullah Ayaz of the United Nations Development Program.

ENERGY POLICY PROGRAM

The draft MS program on Energy Policy was submitted to USPCASE NUST for review. The program was jointly developed by Dr. Clark Miller (ASU) and Dr. Kafait Ullah (NUST) based on feedback from the third national stakeholders meeting. Dr. Miller also reviewed various features of MS Energy Management Systems program being offered at UET and proposed recommendations for improvement. NUST plans to offer the new MS program beginning fall 2019.

HYDROPOWER PROGRAM

ASU assisted UET-P in developing the curriculum for an MS program in Hydropower Engineering, in consultation with local stakeholders in the field of hydropower such as PEDO, Centre of Excellence in Water Resources Engineering UET Lahore, AGES Consultant Pakistan, Norwegian University of Science and Technology, and Three Gorges Dam. During the October 2017 stakeholders meeting, the need to establish this type of program was highlighted by many of the stakeholders.

The draft curriculum was also presented in the fourth National Stakeholders Meeting for feedback. Renewable Energy Engineering program

UET's self-assessment report of the MS Renewable Energy Engineering program was shared with ASU for review and feedback. Dr. Harvey Bryan (ASU faculty) developed a feedback summary and sent it to UET-P.

THERMAL SYSTEM ENGINEERING PROGRAM

UET Peshawar shared the draft curriculum of the MS Thermal System Engineering program with ASU faculty for review. ASU faculty T. Agami Reddy, Patrick Phelan and Liping Wang conducted a detailed assessment of proposed courses for the new MS program and provided their feedback and suggestions to UET-P. Dr. Kendra Sharp and Dr. Brian Fronk (OSU) reviewed the thermal lab equipment and software for UET-P.

FIRST CONVOCATION AT NUST CELEBRATES IMPORTANT MILESTONE

USPCASE at NUST held its first convocation ceremony for graduates on April 18, 2018. One hundred and one graduates received master's degrees in energy engineering.

These graduates symbolize the significant changes taking place to transform Pakistan's energy landscape and provide reliable, sustainable power for all Pakistanis.

David Hale, U.S. Ambassador to Pakistan, commended the students for their work and encouraged them to apply their expertise.

"With the skills you've gained here, you are now equipped to tackle Pakistan's most vexing energy challenges," Hale said. "Your achievement and the building we are standing in today is a testament to the 70-year partnership between the United States and Pakistan to build a brighter future for the citizens of both our countries."

POSTGRADUATE STUDY POLICY

A postgraduate study policy was shared with ASU faculty and feedback provided. As per the recommendations, an internship program should be an integral part of MS programs. Facilitating greater participation by female students was highly encouraged in addition to ensuring credit transfer between NUST and UET.

ASU provided an implementation framework for designing and launching online course evaluations. Dr. Harvey Bryan shared a detailed report with UET based on information provided by ASU's University Office of Evaluation and Educational Effectiveness, an ASU entity responsible for administering and managing online evaluations for ASU courses.

TECHNOLOGY CENTER

ASU finalized the Technology Center plan for partner universities. Dr. Govindasamy "Mani" Tamizhmani from ASU coordinated with the ASU Technology Innovation Center to finalize and implement a strategy to procure equipment for the Technology Centers. Dr. Mani planned to visit Pakistan in July 2018 to provide support for the establishment of Technology Centers; however, based on a NUST request, his visit has been postponed to FY2019.

PEDAGOGY ASSESSMENT AND TRAINING

USPCASE kicked off the pedagogy assessment and training initiative in September 2018. Dr. Peter Rillero, a pedagogy consultant engaged by ASU, visited NUST to meet with the management of the school and USPCASE staff. He met with the Principal of the NUST, the heads of departments for Thermal, Electrical and Energy Systems and the Project Director of USPCASE NUST. He briefed them on the objectives of his visit and the approach he plans to use for pedagogical training of USPCASE NUST faculty. He later held an orientation and training session with the faculty. Dr. Rillero also observed three classes for 30 minutes each to observe teaching methodology of the faculty. He conducted a needs assessment and will compile data for an action plan. These efforts will continue throughout FY2019.

Dr. Rillero also had dedicated sessions with all faculty members from UET-P. He observed the classes in Electrical Energy System Engineering and Renewable Energy Engineering, and closely monitored the class delivery methods by UET-P faculty. He also had one-to-one sessions with each faculty member to assess the actual needs of each and met jointly with all faculty members to discuss the agenda of upcoming pedagogy workshop proposed for October 2018. He facilitated a session with students to understand the student-teacher relationship, the understanding level of students and other student-related concerns. The results of a faculty needs assessment questionnaire will also inform the agenda of the planned workshop.

RESEARCH

The centers at both NUST and UET-P are expected to become Pakistan's premier sustainable energy think tanks that will generate cost-effective and sustainable solutions for Pakistan's energy challenges.

PROGRESS ON RESEARCH

12 Joint research projects awarded to date

36 Applied research projects awarded to date

14 New labs developed to date

131 Papers published to date

160 Conference presentations

9 Patents at USPCASE UET-P

APPLIED RESEARCH GRANTS

Applied research grants build the grants-making capacity and capabilities of center faculty while creating an ideal hands-on learning environment for graduate students. The overarching goal is to develop new energy systems, tools, policies and models to improve the generation, distribution and access of energy in Pakistan. Applied and joint research projects are focused on finding indigenous solutions that increase access to reliable and renewable energy across Pakistan. This year, joint research projects with ASU and OSU focused on anti-soiling coating for PV modules, social and hydrological research to improve the impact of distributed energy on sustainable development and alleviate poverty; transformer predictive maintenance, and more.

ASU and OSU supported the approval process by reviewing the proposals and provided mentorship and support during implementation of all applied research projects.

FY2018 APPLIED RESEARCH PROJECTS AT UET-P

TITLE	PRINCIPAL INVESTIGATOR
Data Communicator for Grid Control System (DCGCS)	Dr. Zubair Ahmed Khan UET Lahore
Synthesis of nanofluid to improve the thermal and dielectric breakdown strength of transformer oil	Saim Saher UET Peshawar
Development of a Large Capacity Solar-Biomass Hybrid Tunnel Dryer in Swat for Long Term Preservation of Fruit Including Persimmon	Suhail Zaki Farooqui UET Peshawar
3600 Sun Tracking and Auto Cleaning System for Solar Array	Samia Khtar PCRET Government Research Organization
Design and fabrication of double loop solar water heater coupled with heat storage materials	Dr. Khurshid Ahmad UET Peshawar
Traversing the Path Towards Next Generation Electrical Transportation in Pakistan-Models and Scenarios	Naveed Arshad LUMS
Real Time Monitoring of Distribution Transformers	Dr. Abdul Basit UET Peshawar
Intelligent Controller for Economic Load Dispatch in Microgrids	Dr. Mohammad Naeem Arbab UET Peshawar
Design, Modeling and Assessment of Phase Change Materials (PCM) Based Energy Efficient Prototype Building	Dr. Khan Shazada UET Peshawar
Distributed Energy Management Using Artificial Intelligent Techniques in a Smart Grid	Salman Ahmad UET Peshawar
Reduction of Heat Losses from Cement Kilns by Using a Low Emissivity Paint	Dr. Alam Zaib Khan UET Peshawar

FY2018 APPLIED RESEARCH PROJECTS AT NUST

TITLE	PRINCIPAL INVESTIGATOR
Valorization of biomass residues for methane production through anaerobic digestion technology: Green energy recovery from waste	Dr. Rabia Liaquat, NUST
Solar Power integration of 2-KW into main grid by using Dual-Mode power converter	Dr. Hammad Iqbal Sherazi, NUST
Simulation Modeling, Analysis and Forecasting of Electricity generation and consumption in Pakistan using System Dynamics approach	Dr. Imran Mahmood, NUST Co-PI Dr. Naveed Arshad
Liquid fuel production from Coal/Biomass derived Syngas	Dr. Naseem Iqbal, NUST
Conversion Kit for UPS to a pseudo-hybrid converter with scalable architecture for neighborhood level distribution capability	Dr. Hassan Abbas Khan, LUMS Co-PI Dr. Syed Husain Imran Jaffery, LUMS
Smart Load Enabler for Micro-Grids in Pakistan	Dr. Ammar Hassan, NUST Co-PI Engr. Mansoor Asif
Development of Advanced Metering Infrastructure and Customer Side Systems	Dr. S. Sajjad Haider Zaidi, PNEC Co-PI Dr. B. M Khan, NUST
Development of Self Cleaning and Low Emissivity thin films for glass	Dr. M. Mujahid, NUST Co-PI Dr. Sofia Javed, NUST
Double pervoskite based multiferroic materials for solar cell applications	Dr. M Yaseen, UAF Dr. Syed Rizwan Hussain, UAF
Indigenous Design and Development of a Solar Powered Adsorption Refrigerator (SPAR)	Dr. Taqi Ahmad Cheema, GIKI Co-PI Muhammad Bilal Sajid, GIKI
DC Module to Improve the Efficiency of String Inverter Solar PV System	Dr. Husein Najmi, The Products Factory Co-PI Dr. Ammar Hassan, SEECS
An Advance Rotor for H-Darrieus Type Vertical Axis Wind Turbine (VAWT)	Dr. Adeel Javed, NUST Co-PI Dr. M Bilal Sajid, NUST
Autonomous 11kV Distribution Line Fault Localization System	Dr. Khawaja Arsalan Habib, NUST Co-PI Dr. Hassan Abdullah, NUST
Designing and Fabrication of Semi-Continuous Stirring Tank Reactors to Evaluate and Optimize the Anaerobic Co-Digestion of Poultry Manure	Dr. Muhammad Hassan, NUST
Pseudo-Noise based Impedance Spectroscopy for Battery Health Monitoring	Dr. Khawaja Arsalan Habib, NUST Co-PI, Dr. Hassan Abdullah, NUST

JOINT RESEARCH PROJECTS

Joint research projects pair NUST and UET-P faculty with ASU and OSU faculty. Pakistani faculty gain skills and experience needed to be competitive in future funding opportunities and build their professional networks. As per the cooperative agreement, USPCASE agreed to 10 joint research projects with NUST and UET-P (five with each institution). To date, this target has been exceeded and 12 joint research projects have been awarded. ASU identified four primary areas for research to ensure consistent focus in the proposals submitted for consideration: electric systems, thermal energy, renewable and alternative energy, and policy.

USPCASE worked with NUST and UET-P to develop a call for joint research proposals and then reviewed proposals submitted in collaboration with anonymous peer reviewers. Smaller projects were consolidated into six larger projects.

In late June 2018, the joint research project, Hybrid Energy Testbed for Remote Communities, began their installation at Yarabad (Jalala Canal), near Mardan, Khyber Pakhtunkhwa Province, and about 110 kilometers from Peshawar. This project offers a cost-effective solution to bring renewable energy to small off-the-grid communities. It's just one of the many USPCASE research projects that focuses on creating indigenous energy solutions for the people of Pakistan. It's easy to imagine hundreds of these systems powering small communities throughout Pakistan.

LAB AND LIBRARY DEVELOPMENT

Core to the success of center efforts is the ongoing development of top-notch facilities that support inquiry and research. USPCASE reviews the proposed equipment for NUST and UET's energy labs and provides feedback in an ongoing manner based on the best-in-class equipment standards followed by other universities. USPCASE also reviews and endorses the books, journals and related materials procured by the NUST and UET-P centers for their respective libraries

- ASU assisted NUST in the conceptualization and development of the High Voltage Lab. ASU assistance included identification and review of the equipment and identification of high-voltage testing equipment manufacturers in the United States.
- Dr. Kendra Sharp and Dr. Brian Fronk from OSU reviewed the Thermal Lab equipment and software for UET-P. ASU also provided recommendations on the list of Thermal System Engineering books.
- ASU assisted NUST in conceptualizing and establishing a Power Systems Lab including the development and finalization of equipment list.
- ASU reviewed the lab equipment list for the Renewable Energy Engineering Lab at UET-P and provided feedback.

USPCASE LABS

LABS AT UET-P

- Clean Energy Lab
- Energy Modeling Lab
- Material Characterization Lab
- Material Testing Lab
- Electrical Energy Systems Engineering Lab
- Solar PV Lab

LABS AT NUST

- Energy Storage and Conservation Lab
- Fossil Fuels Research Lab
- Thermal Energy Research Lab
- Biofuel Research Lab
- Advanced Energy Materials and Systems Lab
- Solar Energy Research Lab
- Smart Grids and Electrical Power Systems Lab
- High-Performance Modeling/Simulation Lab

UET PESHAWAR JOINT RESEARCH PROJECTS

PROJECT TITLE	ASU/OSU PI	NUST PI	AWARDED
Anti-Soiling Coating for Quaid-e-Azam Solar Power PV Modules	Dr. Govindasamy Tamish-mani (ASU)	Dr. Saim Saher	Cycle 2
Social and Hydrological Research to Improve Impact of Distributed Energy on Sustainable Development and Poverty Alleviation in Khyber Pakhtunkhwa	Dr. Clark Miller (ASU) Dr. Kendra Sharp (OSU)	Dr. Tanvir Ahmad	Cycle 2
Transformer Predictive Maintenance	Dr. Anamitra Pal (ASU)	Dr. Abdul Basit	Cycle 3

NUST JOINT RESEARCH PROJECTS

PROJECT TITLE	ASU/OSU PI	NUST PI	AWARDED
National Energy Modeling Strategy for Pa-kistan	Dr. Clark Miller (ASU)	Dr. Kafaitullah	Cycle 1
Design and development of condition monitoring testbed based smart solar micro-grid -— community empowerment through access to energy in the rural areas of Pakistan	Dr. Govindasamy Tamishmani (ASU)	Dr. Raza Kazmi	Cycle 1
Development of hybrid micro combined heat and power system for distributed generation in Pakistan	Dr. Brian Fronk (OSU)	Dr. Muhammad Zubair	Cycle 1
Energy Efficiency in Pakistan Building Sector	Dr. Bryan Harvey (ASU)	Dr. Bilal Sajid	Cycle 2
Solar Space Heating Systems Integrated with Thermal Energy Storage	Dr. Arunachala Mada Kannan (ASU) Dr. Brian Fronk (OSU)	Dr Majid Ali	Cycle 2
Battery Cell Impedance Estimation Using PN Sequences	Dr. Bertan Bakkalogolu (ASU)	Dr Khawaja Arsalan	Cycle 3

EXCHANGE

In our global society, an international perspective is key to creating productive relationships and finding global solutions. Programs like USPCASE facilitate meaningful exchange while fostering intercultural dialogue and partnerships.

PROGRESS ON EXCHANGE

42 exchange scholars arrived in the U.S. in FY2018

137 exchange scholars have completed the program as of FY2018

4 technical workshops conducted in Pakistan

3 virtual seminars

517 scholarships awarded to date

EXCHANGE PROGRAM

The goal of the USPCASE exchange program is to bring students and faculty to the U.S. to train them in state-of-the-art labs, provide hands-on research experience, and offer the opportunity to work with top faculty in energy-related engineering disciplines. The exchange experience can be a transformational one as visitors are immersed in high activity labs and surrounded by passionate researchers. Visiting scholars improve their communication skills, including writing, presentation skills and cross-cultural communication. They gain valuable international experience working with people from many different backgrounds and cultures.

Exchange scholars have many opportunities to share Pakistani culture with American students and faculty and act as ambassadors for their home universities.

During the past year, 42 exchange visitors participated in the USPCASE program, 36 students and six faculty.

SUCCESSFUL COMPLETION INCLUDES:

- A minimum of 20 hours a week in their lab with a satisfactory prescribed course of training.
- Attending the 16-week training session in Energy Policy.
- Attending the 16-week training session in Technology Entrepreneurship.
- Cultural excursions like visits to the Grand Canyon, Universal Studios and the Heard Museum for Native American Heritage Month. In these visits, they learned about:
  - Environmental conservation and tourism.
  - Native American tribes land conservation and utilization practices that promote tourism.
  - National Parks as places that promote conservation and appreciation of natural resources while also contributing to the local economy.
- Gaining knowledge and practice of business etiquette, résumé building, interview skills and intercultural communication.
- Submitting the feedback survey.

INCREASING TECHNICAL EXPERTISE IN THE EXCHANGE PROGRAM

ASU increased its efforts in FY2018 to add technical expertise during the U.S. exchange program and will administer monthly reviews of student group interactions and participation in the program. Lab participation is closely monitored to proactively identify issues and address challenges. In addition, dedicated office hours for new cohorts of exchange students will be offered to address questions and provide advising as needed.

SCHOLARSHIPS

Scholarships provide access to top educational experiences for promising students throughout Pakistan. USPCASE is working to provide increased educational access to women and disadvantaged youth.

517 scholarships have been awarded to date.

USPCASE exchange scholars at ASU and OSU as of FY2018

	STUDENTS		FACULTY		TOTAL	
	Male	Female	Male	Female	Male	Female
NUST	45	24	6	2	51	26
UET-P	44	11	5	0	49	11
TOTAL	89	35	11	2	100	37
	124		**13**		**137**	

Technical Workshops in Pakistan

Technical workshops from international expertise to faculty, staff, students and stakeholders in Pakistan.

ENERGY MATERIALS

Zachary Holman [February 2018]

Professor Zachary Holman of ASU led a three-day workshop, on state-of-the-art materials used in photovoltaic modules, including absorbers such as silicon, perovskites, CdTe, and III-V materials; contacts such as high- and low-work-function metal oxides and transparent conductive oxides; and metallization and module packaging materials.

Photovoltaics (PV), long a minor contributor to the global energy mix, has arrived at a market inflection point. In 2016, PV was the dominant source of new electricity generation capacity in the U.S.—beating out gas and coal—and similar crossovers are occurring around the world. Despite this market growth, commercial PV modules still convert only 20 percent of incident solar power into electricity.

The workshop also focused on a different, though complementary topic: preparing publication-quality research manuscripts. Workshop participants practiced generating storyboards, graphical outlines, of a proposed research problem and its hypothesized solution.

As part of the workshop, guest lecturers presented on the state of the PV market globally and in Pakistan, and the Pakistani industry's role in these markets.

The workshop included tours of the Pakistan Council of Renewable Energy Technologies (PCRET) photovoltaics laboratory and NUST characterization facilities, as well as presentations from Asma Shamim and Asad Ali, graduates of previous USPCASE exchange scholar cohorts

STRATEGIC PROPOSAL DEVELOPMENT

Alan Paul [February 2018]

USPCASE organized a Strategic Proposal Writing Training in Islamabad, Pakistan in February 2018. Building on a virtual grants making and proposal writing training conducted in FY2017, this workshop offered a comprehensive three-day in-person training opportunity for faculty, students and Project Management Unit staff. The training was facilitated by Mr. Alan Paul, an international expert in grant making and proposal writing.

Thirty-three faculty members and research associates from NUST and UET-P participated in this training. These workshops are key to strengthening the capacity-building efforts of the centers and ensuring their sustainability into the future.

Research funding can transform an organization and will be essential to the long-term sustainability of the centers. Getting funding means getting noticed by grant-making organizations, and the key to standing out among a sea of funding seekers is an outstanding proposal.

This three-day training workshop offered strategies to identify the right sponsors, the design projects that interest them, and the strategies to convince these sponsors to support your work. Paul demystified the proposal development process, showing participants how to manage relationships with sponsors, university administration and collaborators. Participants had the opportunity to practice techniques for persuasive writing and heard directly from leading Pakistani government sponsors on their funding priorities.

CORPORATE ENGAGEMENT STRATEGIES

Lou Farina [April 2018]

Learning to engage corporate partners and secure funding from industry sources is key to the sustainability of any university research program. Faculty and staff from the U.S.-Pakistan Centers for Advanced Studies in Energy participated in a corporate engagement training workshop facilitated by Mr. Lou Farina.

Farina, a renowned expert on industry engagement, covered important topics including cultural and organizational differences between academia and industry, U.S. university corporate engagement structures, and an overview of the tools for mapping and measuring corporate relationships.

Guest speakers from Lahore University of Management Sciences and Sukkur Institute of Business Administration University introduced the participants to methods and resources being utilized in their respective universities to create and sustain mutually beneficial relationships with local corporations.

REFLECTIONS OF TRAINING PARTICIPANTS

"The training was well organized and Lou has good knowledge and expertise of his area."

– Dr. Zohaib Ur Rehman

"It was a very informative and interactive session. I learned new concepts of corporate engagement."

– Farah Batool

"I had an amazing learning experience at this training because Lou made it very interactive."

– Muniba Sana

HYDROPOWER: TECHNICAL, SOCIAL AND REGULATORY PERSPECTIVES

Kendra Sharp [September 2018]

ASU hosted the workshop "Hydropower: Technical, Social and Regulatory Perspectives," September 24-26, 2018 in Islamabad. The objectives of this session were to discuss technical aspects and social impact of installing hydroelectric projects in Pakistani communities particularly in the northern region, to assess using micro-units of hydropower as part of Pakistan's energy strategy; and to learn government perspectives on incorporating hydropower into the renewable energy mix of the country.

The session was facilitated by Dr. Kendra Sharp, a renowned hydropower expert from OSU. More than 150 engineers from industry and academia participated in the workshop to exchange information and propose solutions focusing on hydropower.

VIRTUAL SEMINARS

Three virtual seminars were delivered via Skype to faculty, students and stakeholders at NUST and UET. Each of these seminars focused on a specific topic and were delivered by ASU and OSU faculty.

SOLAR PHOTOVOLTAICS – TESTING AND CERTIFICATION

Govindasamy Tamizhmani (Dr. Mani)

The solar PV industry has been growing exponentially in the past 10 years. It is more important than ever to independently test and verify the manufacturer claims about power performance at different irradiance and temperature conditions, and to ensure that the PV modules are reliable and durable during the warranty period. Dr. Mani explored the current need for the testing and certification solar photovoltaic (PV) products. The seminar was attended by 192 students and faculty (26 female, 166 male) from both NUST and UET-P.

SOCIAL DRIVERS, DYNAMICS AND OUTCOMES OF ENERGY INNOVATION REMAKE THE WORLD

Clark Miller

Meeting the challenges faced by world's energy systems requires technology innovation, but technology innovation cannot occur with simultaneous social, institutional, market, and policy innovation.

Dr. Clark Miller, Director of the Center for Energy and Society at ASU, led a virtual seminar on the topic of energy innovation for faculty and students from both NUST and UET-P on March 14, 2018. The seminar was attended by 162 students and faculty (11 female, 151 male) from both NUST and UET-P.

Dr. Miller discussed in detail the social, economic and political drivers—as well as the dynamics and outcomes—of energy innovation and identified strategies that can be used to enhance them for delivering positive results.

TECHNICAL ISSUES IN THERMAL POWER GENERATION AND HOW TO SOLVE THEM

Taewoo Lee

Dr. Taewoo Lee from the Ira A. Fulton Schools of Engineering at ASU delivered the seventh virtual seminar "Technical Issues in Thermal Power Generation and How to Solve Them" on September 18, 2018. The seminar was attended by more than 50 students and faculty from NUST, and 48 students and faculty from UET-P.

SUSTAINABILITY

Through technical assistance provided by USPCASE and under the umbrella of the Higher Education Commission (HEC) of Pakistan, the centers at NUST and UET-P are working to become Pakistan's premier sustainable energy think tanks.

PROGRESS ON SUSTAINABILITY

9 local technical seminars by energy sector experts

65+ meetings with energy companies in Pakistan

99 internships secured in different energy sector organizations to date

12 industrial visits

$1.6M of research funding raised to date

First Think Tank dialogue held

ENSURING THE LONG-TERM SUSTAINABILITY OF THE CENTERS

USPCASE is working to ensure the sustainability of the NUST and UET-P centers when the project funding concludes. The goal is to create an environment that will facilitate to long-term success including a strong curriculum, a recruitment pipeline, partnerships and collaborations, marketing mechanisms, research capacity, fund raising, and outreach programs to reach relevant stakeholders across the energy sector in Pakistan.

DESIRED OUTCOMES

- Public and private funds harnessed for investment in centers through payments for research services.
- Centers at NUST and UET-P are able to effectively engage energy sector stakeholders to promote the capabilities of the centers and market the skills and qualifications of graduates.
- Centers are integrated into their respective universities.

Sustainability efforts include meetings with partners and stakeholders; facilitating partnerships and other agreements, including MoU; facilitating think tank dialogues; facilitating local seminars by industry experts; arranging industrial visits for students; and fund-raising activities.

MEETINGS WITH PARTNERS AND STAKEHOLDERS

In the first quarter of FY2018 ASU organized meetings between NUST and UET-P faculty and 29 government/ private organizations to develop linkages and explore opportunities for research collaborations. These

opportunities include partnerships in research, funding, student internships, curriculum revision and seminars.

In the second quarter ASU facilitated approximately 20 meetings with government and private organizations to develop linkages and explore opportunities for collaborations. These opportunities include partnership in research, funding, student internships, curriculum revisions and energy efficiency capacity building. These organizations included: Institute of Policy Studies, German Development Bank (KFW), FATA Secretariat, National Instruments, Center for Excellence, National Incubation Center Peshawar (CEPEC), Pakistan Science Foundation, Pakistan Council of Renewable Energy Technologies (PCRET), Three Georges Dam Limited, U.S. Education Foundation in Pakistan, U.S.- Pakistan Knowledge Corridor Program, Golden Pump Private Limited, Ministry of Climate Change and Pakistan Green Building Council.

ASU organized a meeting of partners with USAID to discuss the sustainability of the two centers post 2019. Different sources of possible support including HEC, Ministry of Energy, Pakistan Science Foundation, China Pakistan Economic Corridor (CPEC), the donor community and the private sector were discussed, and participants developed a road map to ensure the centers' sustainability. As a follow up, ASU facilitated a visit of the Chief Executive Officer of Alternative Energy Development Board (AEDB) from the Ministry of Energy to USPCASE-NUST to apprise AEDB of the facilities and expertise available at the center. They are exploring the option of declaring the center as a Renewable Energy Center. As a result of the visit, AEDB offered the center three or four internships and an MoU is also under consideration.

In the third quarter of FY2018, ASU organized one-to-one meetings with approximately 13 government/ private organizations to develop linkages and explore opportunities for research collaborations. These organizations include Ministry of Energy, Aviation Design Institute, Private Power Infrastructure Board, World Bank Education Office, U.S. Department of Energy, SRSP, FATA Secretariat, HAIER Pakistan, National Bank of Pakistan, Heavy Electrical Complex, Punjab Energy Efficiency and Conservation Agency, United Nations Industrial Development Organization, and Global Change Impact Study Center (GCISC). The potential opportunities include joint implementation/ partnerships of research projects, funding, student internships, curriculum revision and capacity building.

ASU facilitated a discussion on a solarization project by Hecate Inc. of USA with NUST and UET-P. Hecate is interested in installing a 15-20 MW solar farm at both NUST and UET-P. A follow-up meeting will be held to discuss the way forward.

ASU supported UET-P to develop an application for registration of USPCASE as a Professional Engineering Body under PEC Act and CPD Bylaws 2008. The application was submitted, and once approved, USPCASE will be eligible to offer paid training courses to industry.

In the fourth quarter of FY2018, ASU organized one-to-one meetings with approximately 15 government/ private organizations to develop linkages and explore opportunities for research collaborations. These organizations include U.S. Education Foundation in Pakistan, KPOGCL, National Transmission and Dispatch Company, World Wind Energy Association, ADB Lahore chamber of commerce and industry, Siddique Leather Works, Neelum Jehlum Hydro Power Project, Star Hydro, Sustainable Development Policy Institute and Innovation and Partnerships Unit, USAID/Pakistan.

BUILDING RESEARCH AND GRANTS-MAKING CAPACITY

To aid in fund raising capacity-building efforts, USPCASE facilitated a three-day comprehensive proposal writing training in Pakistan. This was a follow up to a virtual seminar offered in FY2017.

In quarter one, three proposals were developed and submitted (one from NUST and two from UET-P) to HEC's Technology Development Fund for $300,000 with ASU support including identification of an research idea/area, getting industrial partner support, proposal development and industrial partner selection.

STUDENT INTERNSHIPS

ASU NUST and UET-P together developed 22 internships for students in various energy sector organizations bringing the total to 99, just shy of the project goal of 100 internships. These include organizations such as National Transmission and Dispatch Company, K-Electric, National Energy Efficiency and Conservation Authority, Pakhtunkhwa Energy Development Organization, HAIER Pakistan, Saarc Energy Center, Mangala Hydal Power Plant, Terbbala Hydal Power Plant, and Nelum Jehlum Power Company.

CREATING NEW RESEARCH OPPORTUNITIES IN ENERGY POLICY

USPCASE UET-P signed a memorandum of understanding (MoU) with National Electric Power Regulatory Authority (NEPRA). (Pictured left: Vice-Chancellor from UET-P and the Chairman from NEPRA sign the MoU document.) This MoU will create new research opportunities in energy policy for UET-P.

PARTNERSHIPS AND OTHER AGREEMENTS

On November 7, 2017, a four-way memorandum of understanding (MoU) was signed by Pakistan's Higher Education Commission (HEC) along with ASU, NUST and UET-P for the USPCASE.

This MoU supports the development of the energy centers at NUST and UET-P as collective resources for the Government of Pakistan as it addresses the future energy needs and priorities of Pakistan. NUST and UET-P also plan to collaborate with each other—and with other universities in Pakistan and the U.S.—to promote mutual learning, outreach to stakeholders, information exchange and joint degree programs.

An MoU was signed on November 23, 2017 between UET-P and Center for Energy Research and Development (CERAD) Lahore for partnering on various areas such as the exchange of information, joint research activities, joint publications, and the exchange of staff, researchers, and members for study and research. Both centers are currently partnering in offering consultancy services to Government of Khyber Pakhtunkhwa on rural electrification projects.

In the second quarter of FY2018, a memorandum of understanding (MoU) was created by USPCASE UET-P and Pakistan Green Building Council (GBC) Lahore on collaborating on the incorporation of Pakistan Green Building Guidelines in the curriculum of centers; partnering in the greening of university campuses; and collaborating on events of mutual interest.

- ASU drafted and arranged an MoU between UET-P and National Electric Regulatory Authority (NEPRA) that was signed on August 15. The MoU focuses on joint energy policy research.
- USPCASE UET-P and PCRET came to an understanding for joint research and the sharing of lab resources and internships. This understanding is expected to result in an agreement in FY 2019.

Planning for the Future: Energy Think Tank Meets to Discuss the Energy Needs of Pakistan

On July 9, 2018, the U.S.-Pakistan Centers for Advanced Studies in Energy organized the first Energy Think Tank meeting in Islamabad, facilitated by Dr. Clark Miller from ASU. A total of 37 faculty and staff from NUST and UET-P along with government representatives, USAID officials, and private industrialists, participated in this think tank dialogue.

Many felt that Pakistan needs to take up the challenge of expanding robust and diverse energy research institutions and capabilities, guide the work of those institutions to meaningfully advise policy, grow the training programs to ensure the availability of highly trained energy policy and engineering professionals, and create the networks and institutional engagement for ensuring that high-quality research effectively informs energy policy choices.

The creation of an energy think tank at USPCASE offers a critical opportunity to establish an effective partnership between universities and policy institutions to oversee the pursuit and achievement of these goals. This meeting provided an opportunity for numerous stakeholders to weigh in on how such a think tank should be designed and operated.

LOCAL SEMINARS AND INDUSTRIAL VISITS

With ASU's support, increased learning opportunities for students and faculty were provided in the form of local seminars and industrial visits. These visits helped students and faculty to understand industry practices, see application of the knowledge they are getting, and identify research areas.

Quarter 1: Five industrial visits were organized at National Power Control Center, Fecto Cement Plant, Heavy Electrical Complex, Ghazi-Barotha Hydel Power Plant and Premier Sugar Mills. Three seminars on "New concepts of emerging electricity markets," "Energy Policy Making in Pakistan" and "the Age of Adaptation" were organized for NUST and UET-P students and faculty.

Quarter 2: ASU supported UET-P in organizing two trainings, Solar System Design (one day), and Green Building Design (two days), along with two industry visits for students to the Senate of Pakistan and High Voltage and Short Circuit Lab. With the support of ASU, increased learning opportunities for students and faculty were provided in the form of local seminars by industry experts and industry visits including: an information session on Fulbright and U.S.-Pakistan Knowledge Corridor scholarships – NUST; Advanced Topics in Thermal Energy Engineering Research – UET-P; Green Buildings and Economy of Pakistan – UET-P; National Instrument Lab View – UET; and Entrepreneurship Eco Cycle – UET-P.

Quarter 3: ASU arranged participation of USPCASE faculty in training on Micro Hydro Testing from GIZ and an International Workshop on "Option for Energy Mix: Issues of Cost and Sustainability."

In collaboration with SAARC Energy Center, ASU organized a local seminar for faculty and students of UET-P on Waste to Energy: Opportunities and Challenges. The seminar covered topics including waste to energy technologies, deployment requirements of waste to energy, deployment strategy for SAARC member states, and lessons learned from the success stories across the world.

ASU facilitated a visit of Renewable Energy Engineering students from UET-P to the Sanjwal Solar Power Plant to show them operations of solar PV power plant.

Quarter 4: ASU facilitated four industrial visits for USPCASE students and faculty: Sahiwal Coal Fired Power for Thermal Energy Engineering faculty and students; Mangla Hydel Power Plant for Energy Systems Engineering faculty and students; Solar Water Heating System at Siddique Leather Works for Renewable Energy Engineering faculty and students; and Neelam Jhelum Hydro Power Project for Energy Management and Sustainability faculty and students.

USPCASE Project News and Highlights

FISCAL YEAR 2018

SOWING THE SEEDS OF A BRIGHT FUTURE:

THE EXCHANGE PROGRAM PROVIDES TRANSFORMATIVE EXPERIENCE

The fourth, fifth and sixth cohorts came to ASU and OSU during the fiscal year 2018. The visiting scholars, graduate students and faculty from NUST and UET-P, have called the exchange program a transformative experience. Not only do they gain hands-on experience in state-of-the-art labs and mentoring from faculty who are experts in their fields, they also gain an understanding and appreciation for other cultures which is critical to success in an increasingly global work environment.

ADVICE FROM OUR EXCHANGE SCHOLARS

"Don't be rigid, always have an positive attitude ... be adaptive according to your situation."

– Usman Hameed

"Do hard work and enhance your skill level in order to make your self viable for any other place."

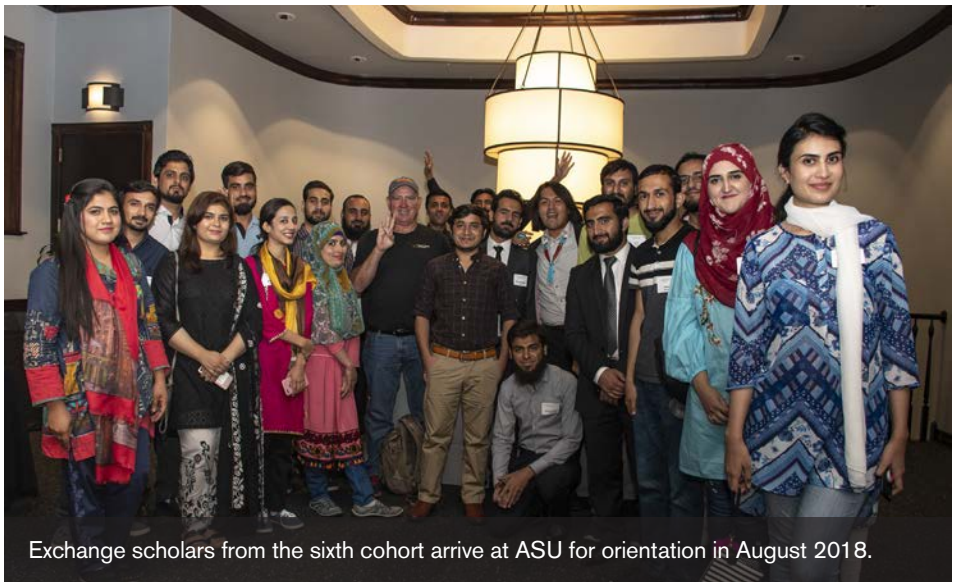
– Ahmed Hassan

"If someone is trying to acclimate to a new place always remember to socialize as much as possible."

– Rehan Anwar

Exchange scholars from the fourth cohort receive completion certificates in their entrepreneurship class at ASU in December 2017.

Exchange scholars from the fifth cohort arrive at ASU for orientation in January 2018.



Exchange scholars from the sixth cohort arrive at ASU for orientation in August 2018.

EXCHANGE STUDENTS CELEBRATE HOMECOMING AT ASU

USPCASE exchange students participated in ASU's annual homecoming event. Homecoming is a signature event that brings together students, parents and alumni to share their Sun Devil pride and celebrate ASU accomplishments.

They staffed a booth with ASU's Office of Knowledge and Development as part of the massive block party that is part of ASU's Homecoming celebration. They had the opportunity to share the mission of the USAID and the value of the USPCASE project to the Pakistani people with the ASU community and the public.

Munazza
Electrical Engineering

"If I had to describe my experience at Arizona State University in one word, I would say, 'Amazing!' The focus of my work here was on energy policy, and I have been able to identify some policy gaps in Pakistan. I'll try my best to work on solutions for the benefit of my country."

Laraib Shaukat
Electrical Engineering

"In Pakistan, the engineering field is mainly dominated by men, and I strongly believe that women should come forward to bring a positive change in our society. The Center for Advanced Studies is an excellent opportunity for women engineers to pursue their dreams in the energy sector."

Kamran Alam
Electrical Engineering

"My research at ASU is in the field of solar technology. Pakistan has immense solar potential, however, it's not being fully utilized. My research focuses on enhancing the efficiency of solar, particularly on a self-cleaning system of solar panels."

The experience was valuable for both the scholars and visitors who were able to learn about USPCASE and the role it has in providing research opportunities in the energy field for our Pakistani exchange students.

Exchange scholar sharing the work USPCASE is doing with the American public during Homecoming. Photo by Erika Gronek/ASU-USPCASE

SCHOLARS VISIT FECTO CEMENT FACTORY

On November 28, USPCASE scholars visited FECTO Cement Factory near Islamabad, Pakistan. The company was a pioneer in setting up a technical collaboration with Japan. It is considered to be the country's first pollution-free cement factory.

Industry visits connect technical knowledge and applied research experiences to real-world applications. The visit was especially valuable for the students of Thermal System Engineering program (TSE) as it was aligned with their course Power Plant Operation. During the visit, the students were able to study various thermal processes and the operation of the heat recovery system and thermal power generation.

IEEE FELLOW BRINGS EXPERTISE TO PAKISTAN

Dr. Bertan Bakkaloglu, a professor at Arizona State University, visited Pakistan in fall 2017 as part of the U.S.-Pakistan Centers for Advanced Studies in Energy (USPCASE) program.

Dr. Bakkaloglu is an international expert in integrated circuit design, and was honored as an IEEE Fellow in 2017 for his contributions to distributed autonomous robotic systems. In his two-day visit to Pakistan, he conducted a seminar titled "Linear and Switch-Mode Power Converter Design from Ground-Up," for the faculty and students from both NUST and UET-P.

The participants also had the opportunity to learn about research work that is being done in Dr. Bakkaloglu's lab at ASU.

ONE STUDENT'S JOURNEY

FROM A PAKISTANI TRIBAL AREA TO A RESEARCH LAB IN ARIZONA

Struggling to support his three children and a desire to get them educated, Muhammad Zain Ul Abideen's father decided to move from FR Kohat—a Pakistan tribal area—to the city of Peshawar where he could earn a better livelihood. This is where Zain became an engineer and continued his passion for research.

"My journey with the U.S.-Pakistan Centers for Advanced Studies in Energy (USPCASE) was an amazing and productive one. I learned about the innovative research being carried out throughout the world in the field of electrical engineering. In 2016, USPCASE provided me a wonderful opportunity to conduct research as an exchange research scholar at Arizona State University in the Photovoltaic Reliability Laboratory (ASU-PRL)."

"During my stint at ASU-PRL, my primary focus of study and research was in the field of solar photovoltaics. Since Pakistan receives ample sunlight, solar power can help us achieve self-sufficiency in energy generation and completely eradicate the energy crisis in Pakistan."

"The practical knowledge that I learned at ASU – where I measured the effect of sand, dust and other airborne particles at various tilt angles of solar photovoltaic modules – was put to good use when I returned to Pakistan. Since Pakistan is planning to commission sizable solar power plants in the near future, this knowledge can help in reducing the output power loss due to airborne dust particles. In 2018, I will be heading to the U.S. once again, this time as a PhD Fulbright Scholar!"

BEST TECH AWARD GOES TO USPCASE

APPLIED PROJECT AT 3RD INVENTION TO INNOVATION SUMMIT

It was USPCASE's opportunity to shine at the 3rd Invention to Innovation Summit, November 29-30 at the UET Peshawar. A project entitled, "An Innovative Demonstration for Low Energy Buildings: Component, energy techniques and ICT Tools" received the Best Technology Award.

The project involved retrofitting a research lab to be a low energy use building. This was done through intelligent energy management of air conditioning and lighting systems as well as using renewable energy generation and recycling.

Solar energy was utilized as the renewable energy source and it was carefully measured via a solar data logger. Walls were insulated and the room use was monitored in an effort to use energy only on an as-need basis. A tool called EstiEnergy Tool was implemented to calculate and estimate energy needs as well.

The summit was organized by the Office of Research Innovation and Commercialization of UET-P in collaboration with the Institute of Research Promotion Lahore.

The endeavor shows USPCASE return on investment and commitment to engaging industry, government and the public in order move Pakistan forward towards energy sustainability.

Dr. Muhammad Noman from USPCASE received the best technology award at the 3rd Invention to Innovation Summit.
Photo courtesy of UET Peshawar

THE POWER OF EXCHANGE: PROXIMITY OPENS POSSIBILITIES

Exchange programs are a critical part of the knowledge transfer that is taking place among the partner institutions that make up the U.S.-Pakistan Centers for Advanced Studies in Energy. More than 200 students and faculty from NUST and UET will visit the United States for a semester-long research and cultural exchange experience during the life of the project.

Imagine being an engineer who couldn't conduct research, a scientist who couldn't perform vital experiments in a lab. That's the reality for some of Pakistan's brightest science and technology scholars, but not for those who come to the U.S. to study at Arizona State University as part of the U.S.-Pakistan Centers for Advanced Studies in Energy.

Through USPCASE, a few dozen Pakistani scholars spend a semester hitting the books in their chosen fields at ASU, learning about U.S. culture and – to the delight of people like thermal engineering student Muhammad Zia Ullah Khan – gaining hands-on experience in a university laboratory. Khan called working in the lab "the main opportunity" he enjoyed as an exchange student. Back home, students often aren't allowed to use university lab equipment.

Khan also called learning the culture very important, and that's a key component to the USPCASE exchange program. Participants do more than expand their technical proficiency. They also acquire perspective and skills that will help them meet some of the pressing electricity shortages that now plague the Pakistani people.

FROM LACK TO LEADERSHIP

"Pakistan has 200 million people in a relatively small country that's super-densely populated and has an insecure supply of electricity," notes Zachary Holman, assistant professor in ASU's School of Electrical, Computer and Energy Engineering.

Although the government has added electricity generation capacity in recent years, population growth has outpaced that capacity, and the nation still endures rolling power outages throughout areas beyond big-city limits.

"When you don't have access to regular electricity, there are a lot of things you can't do," Holman says. Adverse effects to industry, refrigeration and hospital operations are a few of the outcomes he mentions, adding that, "you can't have a productive society," which impacts societal prosperity and stability.

"The students who come through the USPCASE program are supposed to be the next generation of engineers in Pakistan. They need to know a lot more than just how solar cells work." Much of that extra learning comes from studying abroad.

"There are three components to the exchange program," says Andrew Sarracino, international visits coordinator for USPCASE.

"The first is training, the second is professional development, and the third is cross-cultural activity."

In the USPCASE program, that cross-cultural exchange involves Pakistani students studying in the U.S., Pakistani faculty conducting research here, as well, plus there is a series of workshops in which ASU professors go to Pakistan to teach in-country.

Why are such cross-cultural activities important? In part, because they solidify relationships.

"There is much and repeated interaction between the students and the faculty in Pakistan and ASU," Holman says.

"There also are opportunities for research and education collaboration that can take place between ASU and the Pakistani universities funded by USAID," the government agency backing the USPCASE program. "It's hard to start something with someone you don't know."

"HOW DO YOU DRIVE ECONOMIC GROWTH? YOU DRIVE IT THROUGH ENTREPRENEURSHIP AND INNOVATION."

CHANGING MINDS

As Sarracino notes, professional development is a big part of the USPCASE program. To that end, students must take classes in energy policy and entrepreneurship. "They're supposed to be learning things beyond book and lab skills," says Holman. "They're gaining skills that will help them go back to Pakistan and really have impact."

Ken Mulligan teaches classes on entrepreneurship at ASU and is among the instructors imparting such skills.

"One of the challenges in Pakistan is that they are a nation of job seekers, not a nation of job creators," Mulligan says. "How do you drive economic growth? You drive it through entrepreneurship and innovation."

According to Mulligan, changing mindsets is a major challenge for Pakistan. "Engineers are trained as problem solvers. They use the waterfall analytic method for problem solving. It's all formulaic. They look at a problem and they just apply principles and formulas to solve it," he says. But, he adds that entrepreneurship is about value creation, the act of producing "real value for real people. You and I as individual consumers: What things will make our lives better in terms of convenience, comfort and basic economics?"

This is a key question Mulligan brings to his classrooms at ASU and workshops in Pakistan. "It's a hard lesson for engineers," he says. "There are a lot of vagaries and uncertainties attached to advancing an idea from a napkin sketch to a finished product. People who are attracted to engineering tend to like well-defined answers. They like the formula that gives them the same answer every single time. They're curious, they like to investigate, but they don't like uncertainty, and entrepreneurship has a lot of it."

Still, Mulligan is determined to help his students move from problem solvers to solution and job creators. "My mission is to empower the students to have a vision for value creation and understand that their role is to do good from their knowledge base," he says.

"I tell them, 'Why not you? Why shouldn't you be the person who leads the way to a new and better Pakistan?'"

LEARNING TO SPEAK UP

After teaching Pakistani students both abroad and in ASU classrooms, Holman says that one of the biggest benefits exchange offers is "seeing a different way of doing things."

As noted at the beginning of this article, lab work is a new experience for most exchange students. "They always tell me when they leave that the most valuable thing for them was being given the freedom and responsibility to use pieces of equipment on their own," Holman says.

Some of those pieces of equipment are worth more than $1 million. "To the students, this is a complete revelation because even when they have equipment, often students aren't allowed to use it. Sometimes that's about resources, but a lot of it is about a different system and culture."

Hands-on experiences present a different learning mechanism than book and classroom learning. Maria Kanwal, an exchange student from Pakistan's National University of Sciences and Technology (NUST), says her time in the materials science lab enhances her research proficiency. "I have learned quite a few techniques that I had previously been introduced to only theoretically," she says.

In addition, lab work expanded Kanwal's knowledge of materials science. That's Holman's research area, and he explains that it's all about finding new materials to use, putting them together to make solar cells, then "finding out how they perform in real-world conditions. You need to do those things to improve efficiency and reliability."

Kanwal describes the work in the energy materials lab as a place "where novel solar cell technologies are being developed. Exposure to this facility has broadened my horizons about the room for improvement in the current technology," she notes.

UP AND OUT

Lab work isn't the only way Pakistani students are educated and empowered by the exchange program. In the classroom, they're taught to speak up and expected to do so in weekly presentations. Although many students begin this requirement with considerable shyness, Mulligan teaches his students that it's "an opportunity."

EMPOWERED BY EXCHANGE

Exchange scholars do research, learn about energy policy and build their entrepreneurial toolbox during their exchange visits to the U.S. — they also learn a lot about American culture

Here's what he tells them: "If you can get over this fear and learn how to package your ideas in a way that people understand and respond to, you'll create more opportunity for yourself and you'll do more good."

Another learning experience comes from stateside travel. Each semester, Sarracino arranges and chaperones a week-long trek across the Western U.S. in which exchange students visit places like the Hoover Dam, the Grand Canyon and Disneyland. "The purpose of this is for students to realize the potential that they could implement through tourism, land conservation and economic development in their home country," Sarracino says.

"For instance, going to the Grand Canyon, students were able to see how the Hualapai Tribe, a Native American entity, was able to leverage natural resources and turn that into a tourism enterprise."

"I WISH FOR PAKISTAN TO MAKE USE OF THE HUGE SOLAR POTENTIAL THAT IT HAS."

Maria Kanwal

Some of the eye-openers exchange students experience relate more to culture than commercialism.

Sarracino recalls the person who needed shampoo and was stunned to discover Walmart offered up a whole aisle of options. Another couldn't get over how many cars exist in the U.S.

"One day we were driving by a six-story parking garage and I said to the student, 'See that building? That is for parking cars,'" Sarracino recalls. "It blew his mind."

Many students, including Muhammad Khan, report astonishment at the number of well-managed festivals they were able to attend while at ASU. "They're surprised at how the festivals are run in the U.S.," Sarracino notes. "One individual pointed out that waste management gets involved. There are trash cans all around, there are ATMs and food trucks … it's all so organized."

Respect for others is another by-product of the exchange.

"I have found that persons in the U.S.A. are hard working," Khan says. "During the working day, I hardly notice anyone moving around freely. They stick to their work. On the weekend, they enjoy themselves. They value time."

Khan and Kanwal – both from NUST – were selected for the exchange program through a competitive process that brought only 15 of 90 potential travelers to the U.S. Each of these students will leave ASU with renewed commitment to apply their knowledge to help their country.

Kanwal reports this goal: "I wish for Pakistan to make use of the huge solar potential that it has."

Khan has similar service-oriented ambitions.

"The job I'm aiming to pursue in Pakistan is related to research and development," he says. "I could implement my knowledge to help eradicate Pakistan's energy crisis."

BY BETSY LOEFF

ERADICATING POVERTY THROUGH ENERGY INNOVATION

A key idea motivated the Eradicating Poverty through Energy Innovation conference, held February 12-14 at ASU, noted co-organizer Clark Miller, director of ASU's Center for Energy and Society: "Energy innovation can help end poverty in remote and rural communities if projects can deliver high levels of social and economic value for energy users."

Conference sponsors included ASU's QESST Engineering Research Center, USPCASE, ASU International Development, the Partnership for Transborder Communities, LightWorks, the Global Institute of Sustainability, and conference host School for the Future of Innovation in Society.

Participants with diverse expertise from five continents and 11 countries, including USPCASE exchange students, gathered to share research and experiences and deliberate on strategies for creating pathways to full energy access.

OPENING DOORS TO UNDERSTANDING

ASU's annual Open Door outreach event is an opportunity for the public to visit and get a behind the scenes look at university life. It's a chance to talk with faculty and students and learn more about the importance of research and the passion that drives their work.

The USPCASE scholars talked with visitors about their work and shared a little bit of Pakistani culture.

It was a great opportunity to practice public speaking skills while conveying the importance of ongoing renewable energy research.

Visit the USPCASE website to check out the photos on ASU Now and the Fulton Schools of Engineering Full Circle site. And don't miss ASU's highlight video from the event.

ENERGIZING RESEARCH

USPCASE research collaborations take on Pakistan's energy sustainability challenges

A lack of sustainable energy sources in far-flung underdeveloped regions is among the most daunting roadblocks to quality of life still plaguing much of the world.

The challenge is not only technological — requiring advances in engineering and science — but also economic, cultural, educational and governmental. Those causal factors figure into the pursuits of USPCASE.

Through the collaborative efforts of researchers at each of the partner universities, USPCASE is developing multifaceted energy solutions with the potential for global impacts beyond alleviating Pakistan's severe energy deficiencies.

Joint research projects pair NUST and UET-P faculty with ASU and OSU faculty. Pakistani faculty benefit from working with faculty from larger and more mature research environments and gain skills and experience needed to be competitive in future funding opportunities. As part of the five-year project, USPCASE is to undertake 11 joint research projects, six with NUST and five with UET-P.

In addition to joint research projects, USPCASE is facilitating 30 applied research projects in Pakistan, 15 each at NUST and UET Peshawar. NUST is also awarding 10 applied research projects to students with each awardee receiving $5,000 for their project.

The applied research projects are funded for 12 months and are focused on finding immediate energy solutions for communities and promoting scientific research in areas relevant to national needs.

ENERGY DEFICIENCIES HAMPERING PAKISTAN'S PROGRESS

USPCASE focuses on creating models and methodologies that could lead to establishing robust energy development initiatives. By connecting researchers internationally, USPCASE is encouraging the social and political progress necessary for successful long-range planning and support in the energy sector.

"One of our big ambitions is to provide paths to solutions that can be significant contributions to many countries and to many energy industries," says Ahmed Sohail Khan, a mechanical engineer and a USPCASE technical advisor and research scientist.

Pakistan offers what is in effect a universal testbed for possible remedies to many energy development challenges, Khan explains.

The country has about 200 million people living in densely populated areas with an insecure supply of electricity. Many areas endure frequent rolling power outages that can last for 10 hours or more. More than one-quarter of Pakistan's population have no access to electricity at all, living primarily in rural areas far from the country's electric grid.

USPCASE faculty and students are researching ways to provide access to power in rural areas, while also researching renewable sources and energy efficiency.

"There are no policies in Pakistan to require that houses be energy efficient," Khan says, "so many people live in housing that is poorly designed and built, and their homes use enormous amounts of energy, so a lot of it is wasted."

The energy inefficiencies also raise production costs for many industries, making them less competitive in the international marketplace and dragging down the national economy "through billions of dollars' worth of lost productivity," he adds.

Khan says the situation is made more frustrating by mismanagement and a lack of political leadership to take on the hard work to develop and put in place a comprehensive energy policy.

A DIVERSE ARRAY OF ENERGY PROJECTS

Through both the research and education components of USPCASE, groundwork is being laid for developing comprehensive energy policy. Joint research projects span a range of focal points, including power systems, electric power grids, solar energy and related photovoltaic technologies, thermal energy, micro hydro hybrid systems and energy materials. There are also studies on energy policy, economic management and energy security.

"INDUSTRY IS NOW COMING TO US. THEY ARE INTERESTED IN OUR LABORATORIES AND THE ENERGY POSSIBILITIES WE ARE EXPLORING."

AHMED KHAN

COLLABORATIVE ENDEAVORS BENEFIT FACULTY AND STUDENTS

ASU Professor Arunachala Mada Kannan worked with NUST faculty Majid Ali and Muhammad Aamir and OSU faculty member Brian Fronk on a solar power space-heating system involving a solar thermal collector, a thermal energy storage unit and a radiator heat exchanger. Kannan says such collaborative efforts foster interaction that produces benefits through the varied array of expertise that research team members bring to the work.

"We always achieve a synergy that results in something better than what we could accomplish alone," he says.

Equally as valuable, joint research projects lead to other kinds of collaborations, particularly co-authoring papers for publication in research journals and generating ideas for innovative approaches to future research, Kannan adds.

The collaborations are also providing ASU, NUST and UET-P graduate students valuable experience in advanced multidisciplinary research.

It is an especially sought-after opportunity among students at the Pakistani universities who typically are given little hands-on training in research labs in their country.

In most USPCASE research collaborations, students "are developing classical mathematical models and implementing the theory into practice," says Edward William, a technical advisor and research scientist for the program.

Some of the students assisting on USPCASE projects also receive funding to cultivate new ideas and are being provided sources of data and technologies to support their lab work, William says.

PROMOTING KNOWLEDGE SHARING AND CULTURAL EXCHANGE

In addition to joint research project visits, USPCASE has a visiting scholar program at ASU each semester for both Pakistani graduate students and faculty members. They get research training in one of eight labs on ASU's Tempe and Polytechnic campuses that focus on energy policy, energy materials, power systems, power electronics, fuel cells and batteries, photovoltaics reliability and thermal energy.

So far, more than 135 NUST and UET-P graduate students and faculty have completed semester-long exchange programs enabling them to study at ASU and participate in research. ASU and OSU faculty members also visit the Pakistan universities to work on joint research projects.

More than 200 students and faculty are expected to participate in the research and cultural exchanges over the life of USPCASE project. Even more faculty and students benefit from a series of research workshops held in Pakistan that are facilitated by ASU faculty and international experts.

The exchange students also benefit from the USPCASE program's professional development instruction, which includes studies in policy and entrepreneurship to prepare students to be Pakistan's future leaders in energy development efforts.

Working to sustain what USPCASE has started

One of the most important impacts of partnering with a research university of ASU's stature and capabilities are the connections this relationship is helping to build between government, industry and university researchers in Pakistan, says Ahmed Khan.

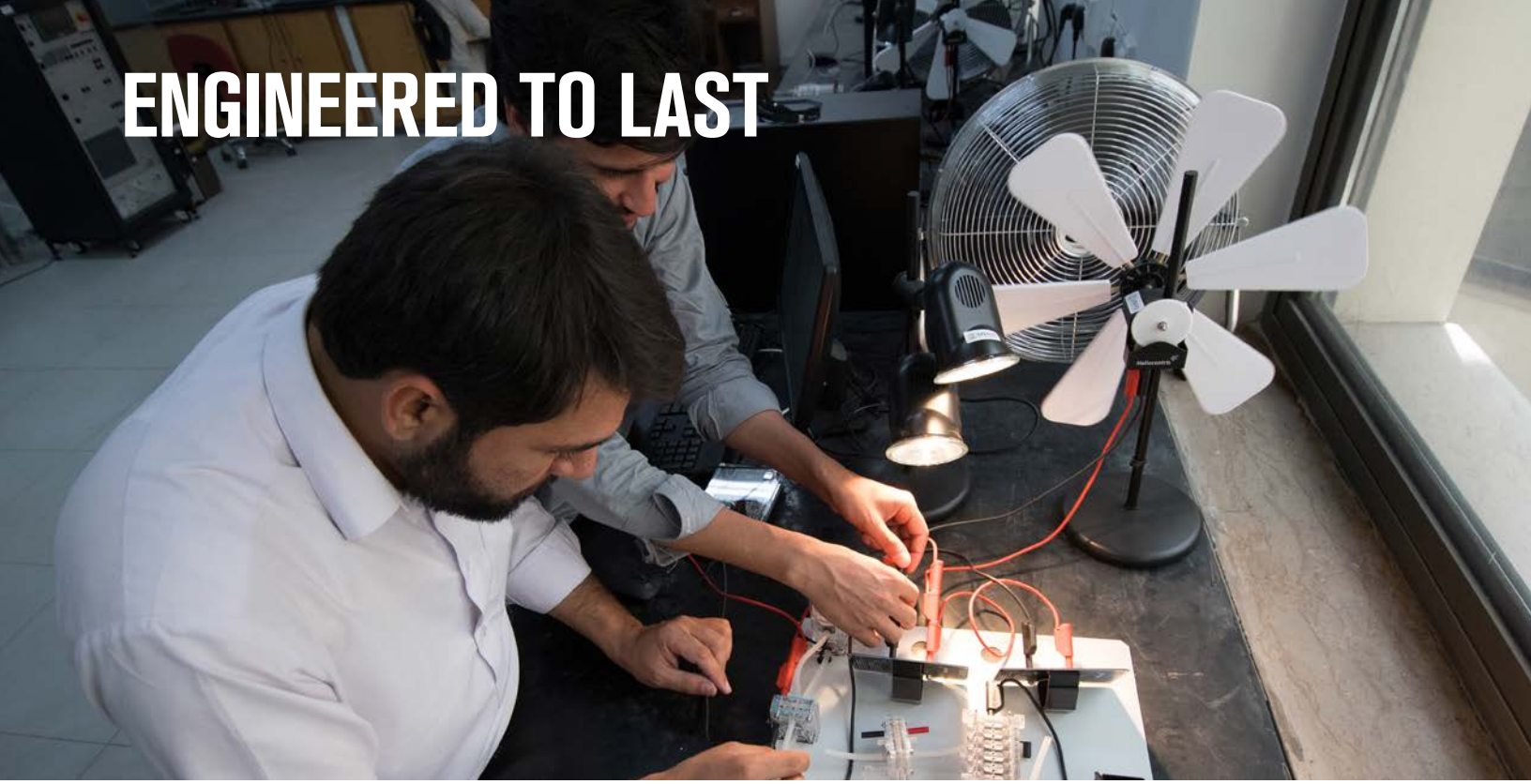
"Industry is now coming to us. They are interested in our laboratories and the energy possibilities we are exploring," he says.

"We are taking some important steps forward on technologies and power systems," says Khan, adding that many of Pakistan's government and industry leaders are recognizing the goals of USPCASE endeavors as critical to the country's social and economic stability.

"It gives us hope of being able to sustain our research projects and of getting the support to stand on our own in the future," Khan says.

BY JOE KULLMAN

ENGINEERED TO LAST



ENGAGING INDUSTRY PARTNERS TO ENSURE LONG-TERM SUCCESS

Engineers design solutions. It's what they do. So, when you're looking at an ongoing problem – the nonstop need for electric power in the modern world – you need a solution that will be as long-term as the problem itself.

That's why the U.S.-Pakistan Centers for Advanced Studies in Energy have made industry engagement a crucial part of their operations. Industry engagement is a key strategy to ensure the sustainability of the centers.

Building a support system

There are several components to the USPCASE industry engagement program, and they're all designed to make the centers more valuable to the Pakistani energy sector. One element involves leveraging the infrastructure of the centers themselves, says Ammar Yasser, USPCASE corporate engagement specialist. The centers have laboratories, expert faculty and graduate students who conduct research in those labs, he explains.

"That infrastructure – facilities and services – we are offering to industry, charging money and creating revenue," he adds.

Revenue is a fundamental goal for the centers. When USAID first put out a call for proposals on the project, it specified that the centers should tap industry support to increase the quality of faculty at the hosting universities – NUST and UET-P. The centers need to create revenue to avoid relying entirely on public or donor financing. USAID hoped the centers would become a model to strengthen higher education that could be replicated in other sectors, universities and, perhaps, nations.

Staffers with the USPCASE initiative have now established solid relationships with industry players. To date, there have been several stakeholder meetings in which executives and engineers from Pakistani energy companies and agencies provide input that guides the curriculum development at UET-P and NUST.

"If the curriculum is aligned with industry need, there will be a good market for our graduates," Yasser notes.

The centers also have established formal partnerships with several organizations, including the oil and gas company KPOGCL, the Pakistani Department of Sciences and Technology, Pakistan Green Building Council, the Center for Energy Research and Development, Sky Electric, Dice and Fauji Fertilizer Company Ltd.

Along with partnerships, the centers have secured contracts. For instance, center experts were hired by the Federally Administered Tribal Areas (FATA) in Pakistan, a region in the northwestern part of the country that was created in 1947 and recently merged with neighboring province Khyber Pakhtunkhwa (KP). There, center scholars created a 10-year energy plan to help FATA secure adequate electric generation resources and strengthen the local economy.

Plus, the centers are in the process of creating facilities from which they can offer industry certifications, equipment testing, training and more.

In addition, the centers foster relationships with organizations that will give students valuable internships to equip graduates with skills desired by industry. Approximately 70 students have secured positions that enabled them to apply lessons to real-world problems.

Going with the flow

The chronic shortage of electric capacity in northwestern Pakistan is a challenge. "KP province has tremendous potential for electricity generation through micro-hydro turbines. However, the control of these turbines is an issue," says Muhammad Saeed, chief executive officer of Switch Mode, a company that has been working with USPCASE UET-P to develop a frequency control mechanism for micro-hydro generators.

Micro-hydro facilities typically produce between 5 and 100 kilowatts of electricity using the natural flow of water in small streams and canals. According to the U.S. Department of Energy, even streams with a depth as shallow as 13 inches could be used for such generation.

The problem, though, is frequency, as explained by Dr. Shoaib Ahmad, who is deputy director of the SAARC Energy Centre. Established under the South Asia Association for Regional Cooperation, this organization fosters energy trade, collaboration, research and knowledge sharing among all eight SAARC nations: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

"Canals run 365 days a year, 24/7, but water is flowing with a speed that is very low … say 1.5 meters per second," Ahmad says.

This means there is no potential energy, such as that stored when water is held behind a damn. There is only kinetic energy, or the energy created by motion.

With potential energy, generator operators can control the frequency of the electricity by increasing or decreasing water flow through a turbine. Since there is no such option in these systems, operators need another solution.

In Pakistan, the grid operates at a frequency of 50 hertz, notes NUST student Afshan Qamar, who worked with Saeed of Switch Mode on electronic load controllers that could stand in for water-flow-based frequency regulation. She explains that the solution she worked on put a resistive load into the micro-hydro generator that operated in parallel with the load from users of the electricity.

"As the user load goes up or down, the load controller senses the frequency on the generator and when that frequency diverts from 50 hertz, the resistive load turns on and off so that the frequency remains balanced," she says.

Other engineers have designed frequency control devices for micro-hydro generators, but they're pricey imports, Qamar adds.

"When you manufacture your own, it can be cheaper. Then more people can deploy micro-hydro," she notes. That's a huge benefit to northern Pakistan, a region that some say could have as much as a 300-megawatt micro-hydro potential.

How much power can individual systems produce? That was the question answered by Ihtesham Ahmad, another NUST student. He worked for the SAARC Energy Centre, where he was tasked with producing a model to estimate the energy potential of any given canal.

"I devised a simple software tool to estimate total annual power generation from canals utilizing any type of micro turbine," he says. This important work was also shared with a government energy development organization.

Another student intern working for SAARC worked on finding ways to reduce the cost of small bio-gas plants used in rural areas. As SAARC's Ahmad explains, a small household bio-gas plant that uses animal manure to generate power for cooking and groundwater irrigation pumps could easily support a family of five or six people. "But in this area, the cost of those plants was around 70,000 to 80,000 rupees," Ahmad says. That's prohibitively expensive for many people who would benefit from such systems, so a USPCASE intern worked on finding ways to cut that cost down below 30,000 rupees.

Working together

Such real-world concerns are one reason SAARC's Ahmad would like to see the USPCASE centers employ more industry participants and practitioners on the teaching staff.

Yasser, who spearheads industry engagement at USPCASE, started building alliances by conducting research to discover who's who in energy in Pakistan. To date, the program has raised more than $1.6 million, and an endowment fund has been established at one of the centers. More than 80 percent of center graduates have gained employment in the industry or gone on to PhD programs, while others have gone on to start their own companies or pursue even more education.

BY BETSY LOEFF

CLEAN LIVING:
Engineering student targets more hydro and hygiene for Pakistan

Qais Ali shown here giving the familiar ASU pitchfork hand sign, was an exchange student with the fifth cohort of USPCASE exchange scholars in spring 2018. Photo by the ASU GIS Photography Studio.

Let's talk trash, real trash.

It's more than an irksome sight at the park or beach. Trash leaches dangerous chemicals into the environment, entangles and wounds wildlife, kills animals that eat it and, studies show, it's hard on mental health. One recent investigation by researchers in the U.K. found that rather than being calmed, de-stressed and restored by tranquil ocean scenery, test subjects reported feeling angry and sad when litter marred the seaside view.

Back in 2013, dismay is what hit Qais Ali as he surveyed Mukshpuri, an idyllic mountain park in northern Pakistan, where he was camping with friends.

"This place is really amazing," he says. "Foreigners also come there for hiking, but when I went there I saw a lot of plastic bags and garbage all around on the top of the mountain near the camping area."

Ali is an electrical engineering master's student at the National University of Sciences and Technology in Islamabad. He was also an exchange student at Arizona State University during the spring 2018 semester as part of the USPCASE program. With his science and business background, Ali realized that the abundance of trash could ruin the appeal of Mukshpuri as a travel destination.

"We will lose our tourism places one by one because no one is taking care of this" refuse, he says.

This awareness turned Ali's simple camping trip into a waste-management venture.

"I told my friends, 'When we go hike, let's collect all these plastic bags and put them in the trash box near the roads.'"

Soon, the enterprising student had formalized his clean-up efforts into an organization he calls Green Pakistan. It coordinates a regular series of trash-collection outings and goes into schools to educate children.

As a participant in the USPCASE exchange program, Ali's state-side studies have briefly halted his cleaning activities, but he's still committed to continuing Green Pakistan.

When Ali returns to his native land after his semester at ASU, he will complete his master's degree in some three or four months. At this point, he is considering pursuing of a doctorate degree and a career in teaching, but before that, he plans to create a management team for his organization to keep it actively cleaning in the District of Swat, a mountainous tourist area and his home when not in school.

"I will expand to other areas, too," he says.

THE DIRTY TRUTH

According to U.S. government researchers, Pakistan generates some 30 million tons of solid waste annually, and that number is increasing by more than 2 percent each year.

"Like other developing countries, Pakistan lacks waste management infrastructure, creating serious environmental problems," notes export.gov, a website produced by the U.S. Department of Commerce.

"Most municipal waste is either burned, dumped or buried on vacant lots, threatening the health and welfare of the general population."

"Proper solid waste management has never been practiced in the country," noted an October 2017 BBC article on Pakistan. "Only half of the rubbish generated is collected by the government, and there is a severe lack of adequate landfill sites."

Of the trash that isn't officially collected, some finds its way into the hands of scavengers. Some goes up in the toxic smoke of trash-burning fires. Some lands in heaps clogging streets, gutters and sewers.

"Because of plastic bags, the sewer system gets blocked and the water stops," Ali explains. "When the water stops, it stays there for months and mosquitoes breed."

The result, he notes, is that mosquito-borne illnesses like dengue fever and malaria now afflict the nation. The number of people affected by these diseases increases year after year, he adds.

"Dengue is really famous now in Pakistan, and people are dying from it because of the dirty water standing in front of houses."

ANTI-JUNK BONDS

Ali's mission to clean up Pakistan has made him an ardent evangelist of cleanliness, and he readily rallies friends and acquaintances to help him. To date, he has brought more than 100 people into clean-up activities. To advertise outings, he reaches this crew with a Facebook feed and a robust email list.

"Most of the volunteers are my friends," Ali says. "They are engineers, doctors, MBAs. Some are doing their bachelors' degrees in physics or chemistry. All of my friends are educated people. When I talk to people around me, they get the message really quickly. They join me, and they also encourage me."

They do more than that. Many also contribute funds: $20 here, $50 there. Ali uses this money to pay workers to clean out sewers, as well as to buy educational materials, contest prizes and videos he uses for school visits. He hopes to make fund-raising a more regular part of the Green Pakistan program.

"It is not the work of one person. I cannot handle it alone," he says. "So, I invite more and more people, and I will make a highly qualified team of volunteers."

A NICE, TIDY HOBBY

Ali will continue his work, but he also hopes to find paid work in his field, and he dreams of bringing more micro-hydro power to his own, energy-starved area.

"There is insufficient electrical energy in Pakistan," he says, which is why he chose electrical engineering.

In Swat, residents suffer as much as 12 hours per day of load shedding, hours during which the local power provider quits sending electricity into customers' premises.

"I want to be able to do research and help my country come out of the energy crisis," he says.

One thing Ali doesn't plan to do is make his work with Green Pakistan his nine-to-five employment. He says he wants to keep it a passion, not a paycheck because he wants to inspire others to join his efforts.

So far, his approach is working.

"Sometimes when we try to collect the trash at tourism places, the people there at the time also start helping us," he says.

"We are the future of Pakistan. We, the young and educated people, can start cleaning by ourselves and not wait for the government to do something," Ali says. "I love to do something special for my people and for my country. That is why I'm doing this."

BY BETSY LOEFF

EMPOWERING OFF-GRID COMMUNITIES

USPCASE APPLIED RESEARCH PROJECTS ARE FOCUSED ON FINDING INDIGENOUS ENERGY SOLUTIONS FOR COMMUNITIES THROUGHOUT PAKISTAN.

Pakistan has plenty of hydro-power resources: more than 300 potential sites could be used to electrify remote villages in the northern part of the country. There's plenty of sunshine, too. As many as 40,000 remote villages could use solar power for electricity generation, according to expert estimates.

Likewise, the nation has plenty of trees and agricultural by-products to fuel biomass generation. It's the fifth largest sugarcane producer worldwide, and sugarcane has the highest energy-to-volume ratio among energy crops, says the International Sugar Organization.

After extracting sugar from the plant's stalk, what's left is bagasse, a ton of which has an energy content similar to one barrel of crude oil.

"More than 16 million tons of bagasse is available annually in Pakistan, and there is a potential to produce up to 1000 MW of electricity from bagasse industry," wrote researchers Muhammad Shoaib Khalid and Abdul Basit in a report to USAID.

Here's the problem with all that potential: Two of the three resources – solar and micro-hydro – have intermittency built in because the sun doesn't always shine, and water doesn't always flow consistently. That's why Khalid and Basit – both professors at UET-P, are primary investigators on an applied research project being conducted by USPCASE.

Working with collaborators at Arizona State University and Oregon State University, the researchers installed and tested a microgrid with multiple generation resources in a remote northern Pakistani village. Called the "Hybrid Energy Testbed for Remote Communities," the project integrates generation from three renewable

resources: solar photovoltaic, micro-hydro and biomass. Researchers from ASU and OSU joined Khalid and Basit in tackling the challenge of integrating three intermittent generation resources into one smoothly operating electric power system that can energize a village without ties to the national grid.

TAKING IT TO THE STREETS

According to a 2018 renewables readiness assessment report from the International Renewable Energy Agency (IRENA), half of Pakistan's rural population still lacks electricity, relying instead on candles, kerosene and wood to fulfill daily energy needs. Some urban residents endure load shedding or rolling blackouts that occur when power providers lack capacity and must de-energize parts of their system. Many others are beyond the national grid. No power lines come their way.

Such power shortages "negatively affect social-, economic- and health-related development goals" of these communities, explains Govindasamy Tamizhmani, a research professor of engineering in the Photovoltaic Reliability Laboratory at ASU's Ira A. Fulton Schools of Engineering.

"This applied research project was focused on designing and prototyping a community-level microgrid that could work with different generation types."

Control and synchronization of that generation were the big challenges the research team faced.

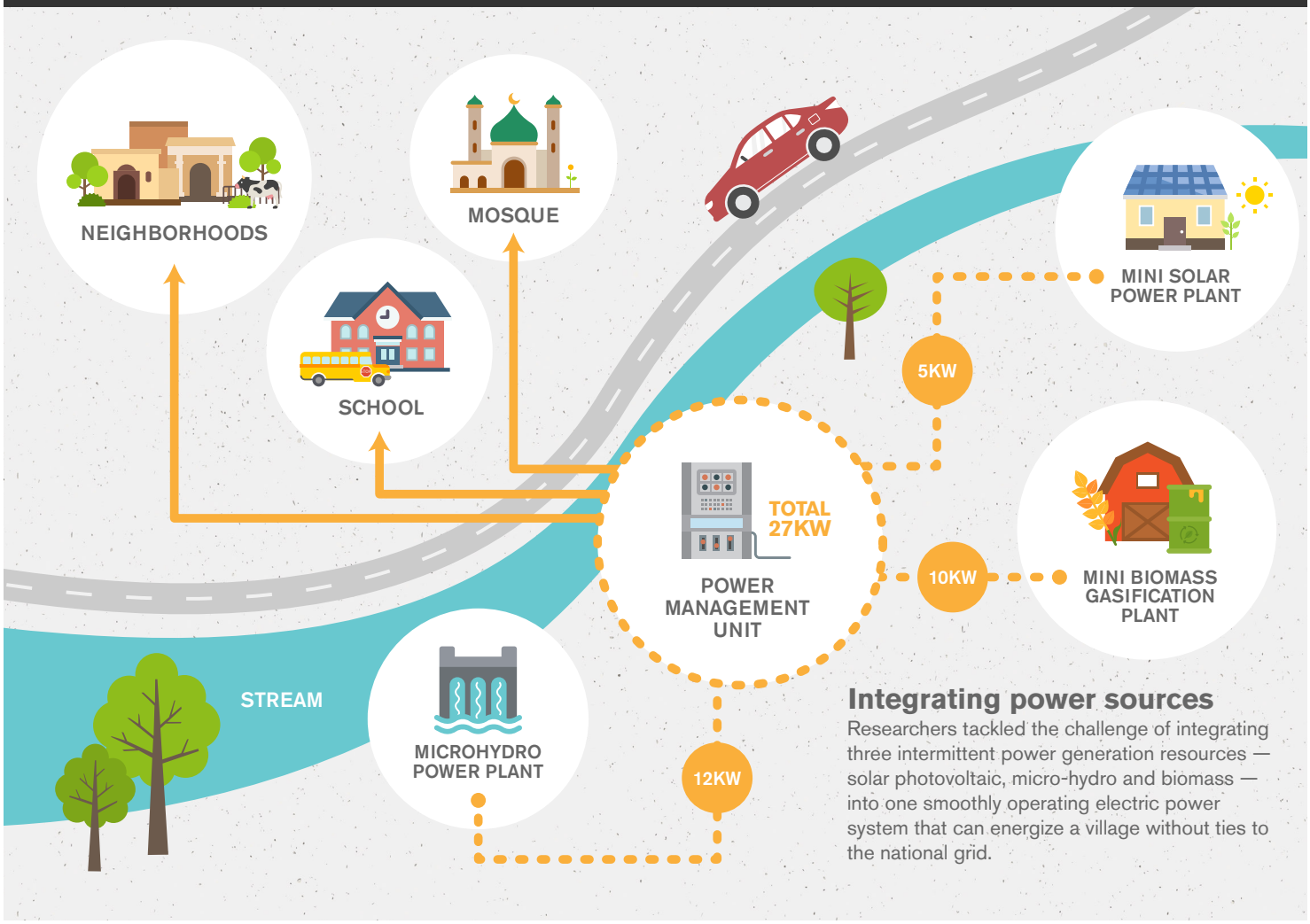
It's far simpler to use one generation resource and, if it's intermittent like solar, add battery energy storage to keep lights on at night. But, storage is cost-prohibitive for most Pakistani villages, Basit says. It also won't work with micro-hydro facilities, which have generation that fluctuates on a seasonal basis.

But, northern Pakistan has several resources to tap, and tying them together is as effective as storage.

When the sun goes down, hydro can pick up the slack, explains Ahmed Sohail Khan, ASU's technical advisor for USPCASE project at UET-P.

"In the winter, there's no water flowing, but you can still have power from the sun. If there's no power from the sun and no power from hydro, you can use biomass gasification-based power. Together, they can supply stable power to fill community needs."

MICROHYBRID JOINT RESEARCH PROJECT



Integrating power sources

Researchers tackled the challenge of integrating three intermittent power generation resources — solar photovoltaic, micro-hydro and biomass — into one smoothly operating electric power system that can energize a village without ties to the national grid.

At the same time, the microgrid had to ensure that the fluctuating energy generation could be regulated in-sync with the changing energy demand — also known as the load side — of the community.

"Multiple types of intermittent power synchronized together and delivering a smooth 50 hertz. It's not an easy task," Khan says.

"We have loads fluctuating from 15 to 27 kilowatts all of the time," Basit explains.

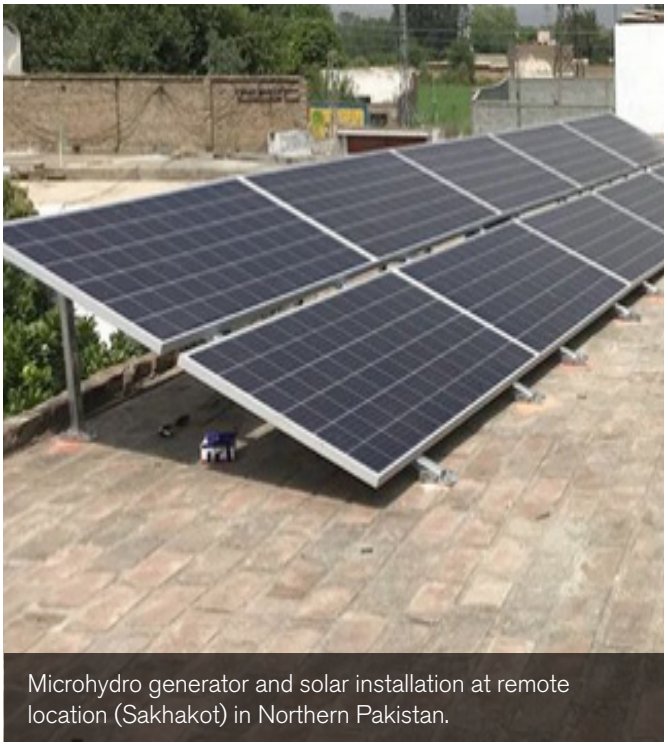
Now the team uses two approaches to balancing electricity supply and demand, an absolute requirement for safe, reliable power flow. First, they developed an electronic load controller associated with the hydro generation. Khan says it has a "a dumping load," activated on surplus energy from the system, that can be turned on and off as needed when the community load fluctuates.

This action keeps system frequency at a steady 50 hertz, which is the standard in Pakistan and the frequency household appliances use.

The dumping or ballast load, however, doesn't go to waste. It heats water for use the following day, Khan explains.

After stabilizing the micro-hydro generation, the team integrates the solar and, ultimately, the biomass generation as well.

A programmable logic controller or PLC – a type of industrial computer – monitors the voltage, frequency and other power-quality parameters of the solar and biomass generation. If both of these generation facilities have matching parameters, the PLC allows power to be integrated.



Microhydro generator and solar installation at remote location (Sakhakot) in Northern Pakistan.

If there are power quality mismatches, it sends signals to correct them. And, when load exceeds generation, algorithms within the PLC determine which load gets priority: industry, school, mosque or households.

COMBINED POWER FROM COMBINED RESEARCH

This testbed was a part of the applied research component of the USPCASE program. Through it, researchers from the National University of Sciences and Technology (NUST) and UET-P team up with U.S.-based colleagues at ASU and OSU to pool time and talents. These collaborations ensure that stateside researchers have in-country expertise to support and guide activity while Pakistani researchers can tap the resources of academic facilities with more mature research environments. That, in turn, fine-tunes skills and helps the Pakistani scholars more effectively vie for research funding.

NORTHERN PAKISTAN HAS SEVERAL RESOURCES TO TAP, AND TYING THEM TOGETHER IS AS EFFECTIVE AS STORAGE.

The applied research arm of these collaborations takes aim at creating solutions that can quickly and affordably address Pakistan's electricity shortfall.

"The overarching goal for this project was to design, prototype and field-test the microgrid concept in a real-world remote community," says Tamizhmani. This was done, he says, "with the expectations that the successful completion of the project will result in a nationwide roll-out of the concept to many other remote communities."

In fact, this project is a ground-breaker in Pakistan.

"It's the only hybrid microgrid in the northern area," says Basit.

SPREADING THE LIGHT

Not only does the microgrid combine multiple renewable energy resources into one stable, reliable power system, it also leveraged local construction to create an affordable, efficient power system.

On the efficiency side, the biomass facility weighs in. It uses a gasification process to transform leaves, wood and crop waste into syngas, a synthetic gas made up mostly of hydrogen and carbon monoxide.

"The syngas directly burns in the generator," says Khan. It's a low-polluting fuel, "a much cleaner process, he adds. "It produces power and, in the winter, it can heat homes in the village."

Even the waste product from the facility is useful. It can be used by local farmers as fertilizer.

On the affordability end of things, this microgrid leverages local production and in-country manufacturing to keep costs down — way down.

GOING LOCAL WITH MICROGRIDS

"Instead of importing commercial biomass gasifiers from abroad, our project team partnered with a local manufacturing company to design and produce the unit in Pakistan," says Tamizhmani. "This approach has not only provided significant savings — we estimate up to 50 percent — but it will also support the local and national economy."

"THE OVERARCHING GOAL FOR THIS PROJECT WAS TO DESIGN, PROTOTYPE AND FIELD-TEST THE MICROGRID CONCEPT IN A REAL-WORLD REMOTE COMMUNITY."

– Prof. Govindasamy Tamizhmani

"For the entire microgrid project including all three components, the team managed to cover the costs within budget, amounting $40,000 in total," says Basit. "This is a testbed, and a testbed costs more. If you want to replicate it, you might be able to reduce costs even more."

Meanwhile, this bargain delivers multiple societal benefits. Because it uses biomass, a microgrid like this diverts agricultural waste from landfills and eliminates problematic slash. It also has the ability to aid in the elimination of energy shortages throughout rural areas, support local industry, add to the economy and, once grid-connected, it may help the national grid manage transmission and distribution system constraints.

What's more, the microgrid concept can help USPCASE facilities in Peshawar stay strong by providing a source of income and funding.

"There is no such solution available in the local market with such level of accuracy, intelligence, and reliability," Khalid and Basit note in their report to USAID.

"This solution has a high level of commercialization potential, and is in high demand for replication in remote areas by the local government."

REAL-WORLD EXPERIENCES IN A REAL-WORLD TESTBED

USPCASE is preparing graduate students to meet the demand for energy engineers in Pakistan, so it's fitting that students were an integral part of the project. They contributed to several aspects of research, including:

- System design and development, with particular attention to integrating the three generation resources for reliable power-system operation
- Cost optimization research to ensure least-cost approaches
- Creation of voltage and frequency control approaches, including the design of the electronic load controller that enables the micro-hydro facility to accommodate fluctuating consumption
- Economic modeling and optimization of the generation resources

"The respective principal investigators from all three universities have heavily involved their students during the planning, design and implementation of this project," Tamizhmani says.

Ahead, the researchers and their student assistants will analyze field data from the pilot microgrid and refine the concept to make it ready for deployment throughout Pakistan.

BY BETSY LOEFF

POWERING UP CONFERENCE PRESENTATIONS

THE PRESENTED RESEARCH CONVEYED THE PRACTICAL IMPLICATIONS AND RESEARCH GAPS IN THE MODELING, SIMULATION AND PHYSICAL DEPLOYMENT OF HYBRID MICROGRID SYSTEMS IN REMOTE AREAS OF PAKISTAN.

Five USPCASE projects presented at 16th Power Systems Conference

Dr. Affaq Qamar, assistant professor at USPCASE UET Peshawar, works in the areas of power systems and power electronics and an exchange scholar at ASU during fall 2018. He presented five papers at the 16th Power Systems Conference organized by Clemson University in collaboration with the IEEE Power and Energy Society and other prominent energy sector organizations.

The conference "Smart Grid Technologies and Innovation" was held in Charleston, South Carolina, from September 4-7, 2018. The conference provided an opportunity for electric power industry experts, electric utilities, government agencies and academic researchers to present and exchange new ideas to elevate the state-of-the-art of power engineering.

The collaborative research titled "Hybrid Energy Test-Bed for Remote Communities — Integration of Solar, Biomass and Microhydro Generator" was conducted by faculty from USPCASE UET Peshawar including Dr. Shoaib Khalid, Dr. Abdul Basit and Dr. Affaq Qamar, with Dr. Govindasamy Tamizhmani from ASU as the research lead. USPCASE master's students from the Electrical Energy System Engineering stream were also actively engaged in the ongoing research as part of their theses and term projects.

The presented research conveyed the practical implications and research gaps in the modeling, simulation and physical deployment of hybrid microgrid systems in remote areas of Pakistan.

The reliance on a microgrid system over a single or few renewable sources results in intermittency problems. Therefore, a hybrid generation approach was used in the proposed microgrid architecture to provide continuous electrical power in a cost-effective manner to off-grid remote areas.

The papers highlighted various approaches for the appropriate modeling of a photovoltaic microhydro and biomass-based interconnected microgrid system in combination with energy storage element schemes and controls to maintain the steady supply of energy to meet load demands.

A novel distributed control scheme was also presented to control the frequency and voltage fluctuations and to prevent damage to attached equipment and residential appliances.

An analysis of the results was shared with attendees, showing the dynamic performance of microhydro and PV after the occurrence of transient disturbances due to a quick change in electric load. The presented work suggested the use of solar PV and microhydro as the primary sources to serve load demand, with biomass and battery providing backup in peak hours.

The research found that the use of a battery bank reduces biomass operation thereby reducing the system's Net Present Cost (NPC) and Levelized Cost of Electricity (LCOE) to make it more economically feasible and reliable.

The fully automatic hybrid microgrid system fulfilling the peak demand of 25KW load is deployed in a village near the district Mardan of Khyber Pakhtunkhwa, Pakistan.

The system is now going through a rigorous testing and validation phase. The research team strongly believes that the outcomes of this research will provide a viable case study that can be replicated in various parts of the country to provide access to electricity in an environmentally friendly and cost-effective way.

THE PRESENTATIONS:

1. Rizwan Kamal, Muhammad Younas, Muhammad Shoaib Khalid, Affaq Qamar, "Cost Optimization of an Off-Grid Hybrid Renewable Energy System with Battery Storage for Rural Electrification in Pakistan"
2. Muhammad Salman, Abdul Basit, Muhammad Shoaib Khalid, Affaq Qamar, "Reduction in Total Harmonic Distortion of Cascaded H-Bridge Multilevel Inverter with Equal Phase Method"
3. Khurram Shahzad, Azmat Rashid Khan, Muhammad Shoaib Khalid, Affaq Qamar, "Voltage and Frequency Control of PV, Micro-hydro and Biomass-Based Islanded Microgrid"
4. Muhammad Younas, Rizwan Kamal, Muhammad Shoaib Khalid, Affaq Qamar, "Economic Planning for Remote Community Microgrid Containing Solar PV, Biomass Gasifier and Microhydro"
5. Azmat Rashid Khan, Khurram Shahzad, Muhammad Shoaib Khalid, Affaq Qamar, "Design Optimization and Reliability Enhancement of Community Based Islanded Microgrid through Frequency Stability"

MINI SOLAR POWER PLANT

MINI BIOMASS GASIFICATION PLANT

MICROHYDRO POWER PLANT

SOLUTIONS-ORIENTED SCHOLARS

Which sector uses the most energy? Chances are, you already know it's the industrial sector, which accounts for about one-third of energy use in the U.S., and power-hungry manufacturing accounts for a little more than half of that fraction.

Chances are, you don't think about agriculture as being a big energy consumer, but Faisal Nawab does. "I belong to a family that depends on agriculture products such as wheat and melons," he says. And, the family farm requires electric pumps to irrigate crops.

"When I was in high school, there were about 18 hours a day of energy cut-offs," Nawab recalls. "Farmers in my village were not able to provide water to their fields, and all the crops got ruined. From that time, I decided to study energy engineering."

Nawab earned a bachelor's degree in electrical engineering, but he didn't sign on with an established utility or seek industry work. He kept thinking about the needs of villages like his hometown, and that's what prompted him to seek out a degree in renewable energy. He found what he was looking for at UET-P where he became a USPCASE scholar.

TAKING THE RENEWABLE PATH

"The only solution to the energy crisis of Pakistan is decentralized, renewable energy, and there is not enough work done in that field," Nawab says. "Without sufficient energy, the economy of Pakistan cannot be stabilized and the country economy will always rely on foreign loans with high interest rates."

Ending this cycle is what motivates Nawab. "It encourages me to enhance the energy security of Pakistan."

Nawab was an exchange scholar at Oregon State University during the fall 2018 semester. There, he conducted research on the waste-to-energy system and the biomass potential of Saccharum munja forests in the Lakki Marwat District in Pakistan's Khyber Pakhtunkhwa Province. A master's candidate, Nawab has also interned for Peshawar Electric Supply Company, where he learned about distributing power throughout a district and protecting the power system from different faults.

What does Nawab plan to do with his Master's degree? Clear a path to bring energy home.

"There are two main problems in the Pakistani power sector. The first is production from expensive fuels, and the other is capacity of the transmission lines," he says. "The only solution to the problem is decentralized renewable power plants."

That's what Nawab hopes to bring to rural Pakistan by building a social organization intent on solving energy sector problems. Five years after picking up his diploma, he wants to be designing and installing small power plants in areas where no power lines currently run.

"I also will try to make different renewable energy technologies usable so they can be operated by less-trained people," he says. "The main focus will be usability of the technology because many people of rural Pakistan are not well educated."

BY BETSY LOEFF

THE POWER OF POLICY: USE ENERGY TO END POVERTY

USPCASE scholars who study energy policy with Arizona State University Professor Clark Miller are likely to learn this fact about The Grand Canyon State: Some 30 percent of the energy used in the state goes to pump, treat, process and deliver water, while more than one-third of that H_2O is consumed to produce energy.

Called the energy-water nexus, that symbiotic relationship plays out worldwide, not just in Arizona. So does the energy-poverty nexus, which reflects the reality that the more economic activity you want to pursue, the more energy you require, and the absence of energy hobbles economic opportunity. The associate director for faculty for ASU's School for the Future of Innovation in Society, and the Director of the Center for Energy and Society, Miller teaches these lessons and more to USPCASE scholars both stateside and abroad.

Miller's research takes a new approach to solving energy poverty.

"Historically, we've defined energy poverty as a lack of access to energy technologies," he says. "This is too narrow. What we really need to do are to find ways to use energy innovation as part of a larger strategy for pursuing sustainable development."

MORE THAN WIRES AND WALL OUTLETS

The World Bank defines energy poverty as, "The state of being deprived of certain energy services or not being able to use them in a healthy, convenient, and efficient manner, resulting in a level of energy consumption that is insufficient to support social and economic development."

Until recently, measuring energy poverty was a binary proposition: Either you had access to electricity at your home or you didn't.

By that measure, nearly a billion people on the planet – about one in seven – do not have access to modern electricity services in their households, Miller says. But, he adds, "Increasingly, people are recognizing that access isn't a sufficient measure. When and how often people have energy matter, too, as does the price and the quality of the power provided."

When Miller mentioned this in a recent workshop he held in Pakistan, one student commented that in his home village, people often had electricity just one day out of four.

There needs to be a multi-tiered framework for measuring energy access, Miler says. "We must break down energy access by different characteristics."

He points to a seven-tier matrix used by the World Bank and United Nations. Among the factors this matrix measures include peak capacity, or how much electricity is available to households; duration, or how many hours per day those electrons flow; and reliability, which refers to outages and load shedding where the utility purposefully trips off power because enough capacity simply doesn't exist. The matrix also considers affordability, safety, power quality and legality of the connection.

A CLOSER LOOK

"The idea of a multi-tier framework is that you break down access into different components and measure it on different tier levels," Miller explains.

So, for instance, on the duration measure, tier one means that you have at least four hours of electricity per day, and one of those hours occurs in the evening. Tier two also has a minimum of four hours of access daily, with two of those being evening hours. Tier three requires eight hours of electricity – three at night – but power quality and reliability are still big problems.

This approach, Miller says, enables power providers to look at access problems throughout a city or a region and pinpoint solutions to bring people up to a higher tier. For instance, if a neighborhood has tier-three power, the power supplier could look for solutions to power quality, reliability and safety issues that still plague those consumers.

This approach offers a more precise and helpful way of measuring access, but it's still a supply-side view, Miller says.

"We also need to look at the demand-side and how well people are able to use energy to advance development. Do people have the kind of electricity services they need to achieve the kind of economic and social goals they want to achieve?" he asks. "How much societal benefit are you providing compared to units of energy consumed?"

Miller urges students to consider the social value of energy and create systems optimized for community gain. "It's not just about technologies and prices. It's about what we're getting at the end of the day in terms of societal benefit," he says.

Therein lies the foundational idea behind his framework for optimizing social benefit per unit of energy produced.

THE GOOD, THE BAD, THE ELECTRONS

According to Miller, energy can create economic opportunity for a community through infrastructure construction, system operation and energy use itself. These activities do more than supply electricity. They provide an economic boost to a community. And, the flip side also is true. Energy can create economic drag.

"Puerto Rico is my go-to example of this," Miller says. "It is a very poor part of the USA. Its average income is half that of Mississippi, the poorest state in the United States.

But its average energy prices are twice those of the rest of the country because they're importing oil to create electricity."

This, Miller continues, resulted in expenditures of some $8 million daily on oil imports – $3 billion a year – and the equivalent of 3 million people each spending about $1,000 per year over the past several years. "They took that money, effectively put it on the table and lit it on fire," he says.

These outlays helped put the Puerto Rican electric utility $9 billion in debt and the whole island $72 billion in debt before Hurricane Maria knocked the power out entirely in September 2017. Lack of funds left the electric system poorly maintained in a hot, humid place where power poles decay quickly. That, Miller says, is one reason Maria was so devastating. It also reflects the fact that, while energy can be generative, helping people create stronger economies and communities, it can also be degradative, pulling resources – like money – out of the community.

To ensure that energy delivers social value, Miller teaches students to keep two principles in mind. First, energy systems should be designed as socio-technical systems. "Sometimes we get caught up in the cool technologies, but we need to think about all the people who need to do what they need to do to make the systems actually deliver value," he says.

Second, the design must focus on creating systems that are indeed socially generative.

Clark Miller meeting with exchange scholars at ASU.

CONSIDERING THE SOCIAL VALUE OF ENERGY

"It's not enough to have two light bulbs and a fan working in every house on the planet," he continues. "The goal is to create a positive feedback loop that keeps the community growing and developing."

These ideas about social value creation were explored in depth at a conference entitled "Eradicating Poverty through Energy Innovation" held at ASU in February 2018.

The conference was co-sponsored by USPCASE and attended by 30 USPCASE exchange students in addition to more than 75 other researchers and community energy advocates from 11 countries and 5 continents. A report written for the conference, Poverty Eradication Through Energy Innovation: A Multi-Layer Design Framework for Social Value Creation, was co-authored by Nafeesa Irshad, a former USPCASE exchange student in Miller's lab who is now a PhD student at ASU.

RAISING THE BAR … AND GROCERY STORE … AND LOCAL MANUFACTURING PLANT

To help students design energy systems with community development and sustainability in mind, Miller teaches a seven-layer framework that considers energy as interconnected to other sectors in the economy. The first concept in that framework is that energy is a social investment.

"It's not about technologies and prices. It's about what we're getting at the end of the day in terms of societal benefits," including as a strategy for poverty eradication, Miller says.

"We like to think in terms of the UN Sustainable Development Goals. How can energy innovation contribute to reducing poverty and inequality, improving food and water security, empowering women and promoting strong institutions, or other facets of sustainable development?"

The second premise of the framework is that social value is not created by energy. It's created by energy services. "What are people able to achieve with that energy? Electrons have no social value whatsoever, but if those electrons can pump water to irrigate a field, then they have value," he explains.

Next, the framework stresses that the delivery of energy services is a product of sociotechnical assemblies. In other words, people have to do work to make those services happen.

In addition, energy systems require energy organization.

Clark Miller meeting with the research team working on improving the social value of energy in KP villages.

"People install microgrids and renewables all over the world, but you come back a year later, and they're not working," Miller says. "They're not working because no one put in place a maintenance crew, a plan for keeping the system running."

Finally, the framework looks at the financial design of energy systems – how the system distributes benefits and costs across different groups – as well as policy that encourages sustainable development goals.

RELATED JOINT RESEARCH PROJECTS

In Pakistan, Miller is involved in three joint research projects with faculty from USPCASE partner universities, NUST and UET Peshawar to provide Pakistan with national energy system modeling strategies and to develop a team to help alleviate poverty in the major Pakistan province of Khyber Pakhtunkhwa by providing access to energy.

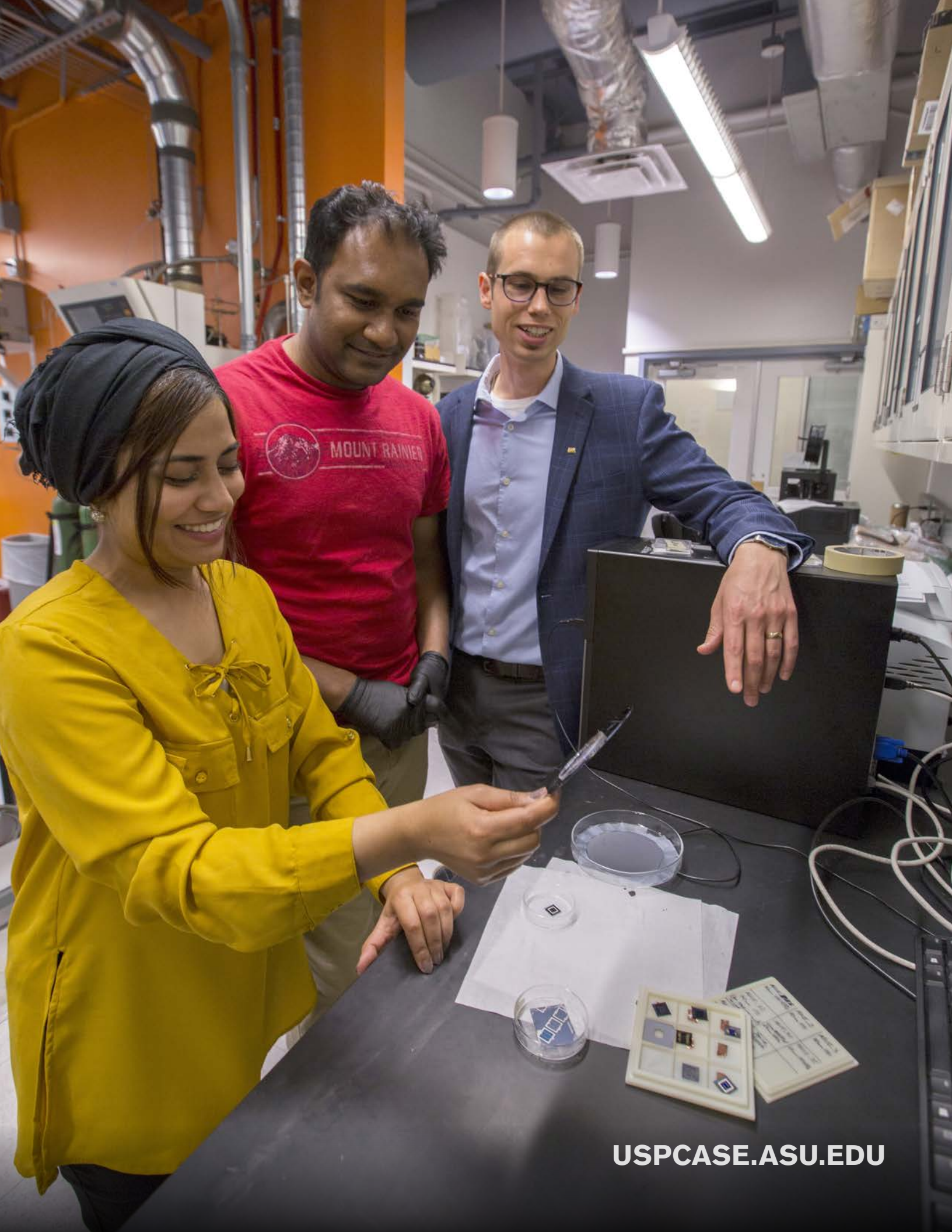
1. "Developing the Strategy for Policy-Oriented Energy Research Modeling" with NUST faculty Kafait Ullah and Kashif Imran.
2. "National Energy Modeling Strategy for Pakistan and KP Province" with UET Peshawar faculty Irfan Mufti.
3. "Social and Hydrological Research to Improve Impact of Distributed Energy on Sustainable Development and Poverty Alleviation in Khyber Pakhtunkhwa" with UET Peshawar faculty Tanvir Ahmad.

The last, in particular, is focused on social value creation and combines hydrological and social research to improve the impact of distributed energy on sustainable development.

That's the kind of win-win approach Miller stresses as he teaches USPCASE engineers about policy to eradicate energy poverty.

"It's time to drop the word 'energy' from the phrase 'ending energy poverty,'" he says. "End poverty. That's what we should be working to achieve."

BY BETSY LOEFF



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