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Partnering Universities:



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



## ANNUAL REPORT

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

# Energizing Pakistan.

**Imagine losing power for up to 16 hours a day. Your connection to the world through the internet is severed. Your appliances cease to function. The air conditioning keeping your home comfortable cuts off. This is a reality faced by thousands of Pakistanis each day as rolling blackouts sweep through the nation regularly. Not only does this present socioeconomic hurdles for the people of Pakistan, it restricts economic growth and reduces foreign investment.**

The USAID funded U.S.–Pakistan Centers for Advanced Studies in Energy (PCASE) program is a partnership between Arizona State University (ASU) and Oregon State University (OSU) and two leading Pakistani universities: the National University of Sciences and Technology (NUST) and the University of Engineering and Technology (UET) in Peshawar.

Through sound governance, modernized curriculum in energy, exchange programs, and new teaching strategies and methods, PCASE centers will produce skilled graduates as well as the applied research needed to advance the energy sector in Pakistan.

PCASE is focused on facilitating applied research relevant to Pakistan's energy needs and serving as a bridge between academia and government/industry while also undertaking

sustainable policy formulation.

Through this partnership, ASU is leveraging its expertise in higher education, university design, applied research and energy to help Pakistan release its enormous potential for economic growth through its universities. These efforts will set a new standard for supporting the success of both Pakistani women and disadvantaged youth in the engineering profession.

With technical assistance provided by ASU and under the umbrella of the Higher Education Commission (HEC) of Pakistan, the centers at both NUST and UET are expected to become Pakistan's premier sustainable energy think tanks, generating cost-effective, industry-relevant and sustainable solutions to address Pakistan's energy challenges.

*The views expressed in this document do not necessarily reflect the views of the U.S. Agency for International Development (USAID) or the United States Government.*





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# Executive Summary

*PCASE centers are focused on creating an energy curriculum and research programs that will benefit Pakistan well into the future.*



The PCASE project has five components: governance, curriculum, exchange and scholarships, research and the long-term sustainability of the centers. This is a summary of the accomplishments in fiscal year 2017.

For the **governance component**, PCASE worked to assure center governance structures were in place to approve new curriculum and award research projects, activities that will contribute to preparing these centers to be state-of-the-art schools of advanced study in energy in Pakistan. PCASE also contributed to creating and strengthening coordination and collaboration mechanisms for Centers for Advanced Studies (CAS) partner universities with ASU, the Higher Education Commission of Pakistan (HEC) and stakeholders and faculty at ASU and Oregon

## 2016-2017 HIGHLIGHTS AND ACCOMPLISHMENTS

- 2 new state-of-the-art buildings
- 5 new degrees developed by the centers
- 200 master's and PhD students enrolled at NUST and UET
- 20+ research projects at NUST and UET in energy systems technologies
- 6 joint research projects with faculty from ASU, OSU, NUST and UET
- 50+ new courses developed
- 50+ industry/NGO/governmental interactions
- 4 workshops in green building, gender equity, photovoltaic systems and entrepreneurship
- 4 technical virtual seminars led by faculty; 8 seminars by industry experts
- Over \$1.5M in new research funding
- 25 interns working in industry, government and utility companies

State along with others to develop a strategy and roadmap for the centers at NUST and UET.

The major advancements of the project were in the **curriculum component**. ASU and OSU working together with NUST and UET, designed and developed many courses to build a new curriculum in energy, and new degrees in energy. These master's and PhD degree programs align with those of the best schools in the world and are tailored to address industry and government needs related to the energy sector in Pakistan. The centers are engaging stakeholders throughout the design and development of both courses and degrees to ensure the relevance to energy sector needs.

For the **research component**, NUST and UET worked on 10 applied research projects at NUST and nine at UET with support and mentorship from ASU faculty. These research projects have already resulted in 56 publications, participation at 52 conferences (37 NUST and 15 UET), and two patents awarded and three filed.

ASU also awarded six joint research projects, with ASU and OSU faculty working in collaboration with partner university faculty to address the energy distribution and policy needs and issues in Pakistan including solar energy, hybrid energy (grid+renewables), energy policy and green buildings. These are detailed on page 14.

Two new buildings were constructed at NUST and UET to further the research and curriculum goals of the centers. The new four-story, 60,000 square-foot building at NUST includes five classrooms, eight high-tech energy laboratories, a seminar hall, conference rooms, a library, multiple office spaces and elevator access. The new facility at UET is 54,000 square feet with five lecture halls, seven state-of-the-art energy labs, plus a conference room, student cafe, female common room, faculty lounge, office space and two elevators. See page 37 for details.

For the **exchange and scholarships component**, ASU and OSU trained over 50 master's and PhD students and faculty. Students took an entrepreneurship class to learn about the startup process and how to pitch and refine their ideas. Students also attended a policy class on the modeling of energy, decision making, developing ideas for regulations and implementation.

Students and faculty at NUST and UET along with industry guests benefited from four workshops with visiting scholars from ASU and OSU on green buildings, gender equity, photovoltaic systems and entrepreneurship.

ASU faculty delivered four technical virtual seminars covering different fields of engineering study. See pages 17 to 21 for more details.

Through the **sustainability component**, PCASE created many linkages with more than 50 industries, NGOs, government entities and international institutions to develop new research projects. There were many forums created to bring stakeholders together and demonstrate the many advancements and results obtained through the centers, and showcase the quality of the students and research, as well as the qualifications of graduates.

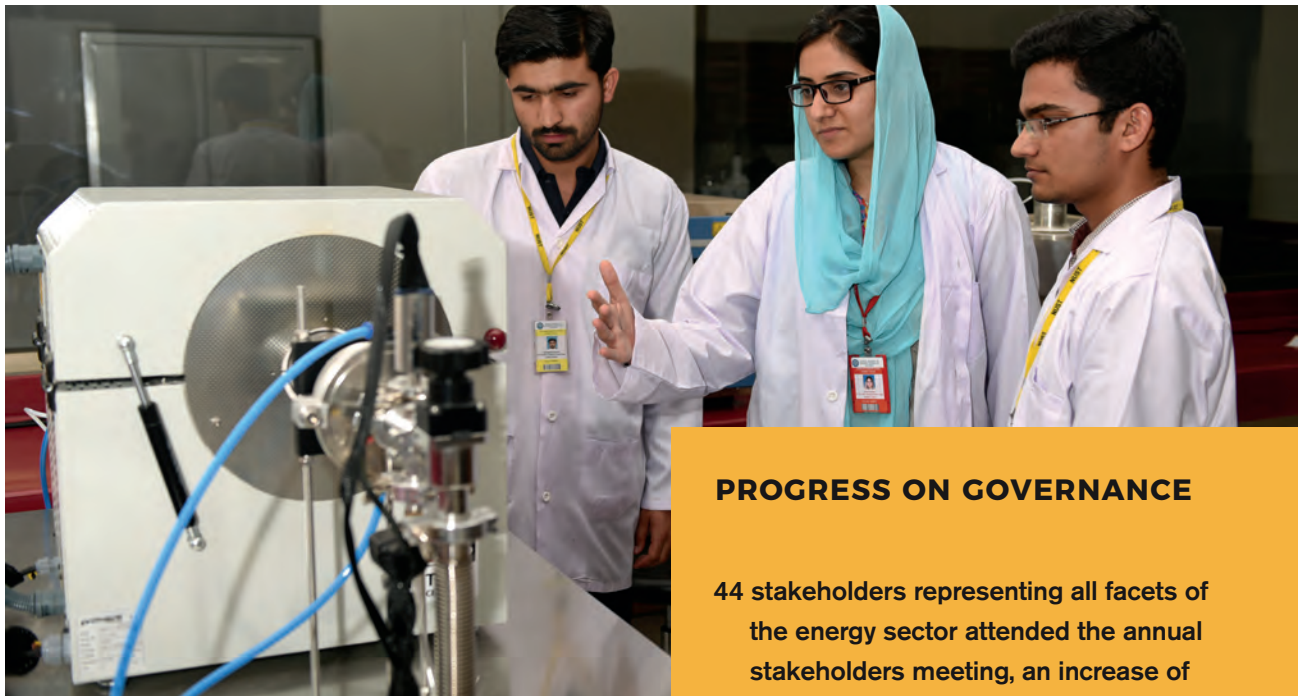
## ACRONYMS

ASU	Arizona State University
CAS	Centers for Advanced Studies
CPEC	China Pakistan Economic Corridor
HEC	Higher Education Commission of Pakistan
KP	Khyber Pakhtunkhwa
LoP	Life of project
MoU	Memorandum of Understanding
NPCE	National Policy Council on Energy
NUST	National University of Sciences and Technology
OSU	Oregon State University
PICO	Pakistani Information and Cultural Organization
PMU	Project management unit
PV	Photovoltaic
SWOT	Strengths, weaknesses, opportunities and threats
TORs	Terms of reference
UETP	University of Engineering and Technology (Peshawar)
USPCASE or PCASE	U.S.-Pakistan Centers for Advanced Studies in Energy



# Governance

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



During this reporting year, PCASE worked closely with UET and NUST on the following governance-related tasks and objectives: project management unit review, stakeholder engagement, self-assessment and trainings, UET management and the development of international conferences.

## **PROJECT MANAGEMENT UNIT REVIEW**

ASU actively engaged with NUST and UET with establishing their respective Project Management Units (PMU). ASU's Deputy Director at UET served as interim co-director for PCASE at UET and coordinated the hiring of key PMU staff.

## **PROGRESS ON GOVERNANCE**

44 stakeholders representing all facets of the energy sector attended the annual stakeholders meeting, an increase of more than 144% over fiscal year 2016

PCASE organized two conferences with over 200 attendees at each

Active engagement in National Center for Advanced Studies Committee

Active engagement in research and curriculum councils

## SELF-ASSESSMENT AND TRAININGS

PCASE developed a program for self-assessment of curriculum, research, facilities, teaching and project management for NUST and UET.

The templates were developed after an extensive review of the existing self-assessment mechanisms at several institutions including NUST. In order to avoid duplication of effort or the creation of parallel systems, PCASE undertook a thorough review of quality assurance practices at NUST. The review included conferring with NUST's Quality Assurance Directorate and ensuring that any new template complemented the existing system at NUST.

## STAKEHOLDERS MEETING

In December 2016, PCASE organized the second National Stakeholders Meeting on Energy. The purpose of the meeting was to align the curriculum and applied research at NUST and UET centers with the requirements of the energy sector and to discuss strategies and initiatives for long-term sustainability of the centers.

This meeting was attended by 44 stakeholders from federal and provincial institutions (including Ministry of Water and Power, NTDC, Energy Departments), the energy industry (including Three Gorges Dams, Attock Gen, Star Hydro), bilateral and multilateral donors (including KfW, GIZ, and The World Bank), academia (including UET Lahore) and civil society organizations (including PPAF and SRSP).

## UET MANAGEMENT

Because a number of UET's center staff left the project during this reporting period, ASU's team based in Peshawar increased the level of support to UET to help keep the project on track.

ASU support included assisting in the local hiring for most of the project management unit (PMU) staff and revising the human resources manual; facilitating capacity-building exercises for PMU staff; securing USAID approvals for staff; assisting in completion of annual performance evaluations for employees; and revising and clarifying job roles and responsibilities.

PCASE staff worked with vice chancellor and the dean to develop center governance and on the day-to-day operations of the center. This included the hiring of eight new faculty, increasing the number of faculty from 12 to 20 in 2017. PCASE also assisted in the hiring of three new research associates and two lab engineers.



## PROCESS FOR JOINT RESEARCH AWARDS

PCASE developed a process for awarding joint research project awards between ASU/OSU faculty and UET/NUST faculty. Central to this process is the support of ASU's faculty to NUST and UET faculty in conducting quality research. It also promotes faculty-to-faculty interaction which will continue beyond life of the project. Proposal writing is an additional support being provided by ASU. See Figure 1 below.

Six joint research awards were funded. See page 14 for more details and a list of funded projects.

## 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, PCASE working with UET and NUST hosted two national conferences.

### National conference on Green Energy Technologies

PCASE supported the UET center in organizing the National Conference on Green Energy Technologies in May 2017. More than 200 people attended the conference.

PCASE reviewed the current developments, opportunities and challenges in renewable energy technologies and power engineering, with specific reference to the national needs.

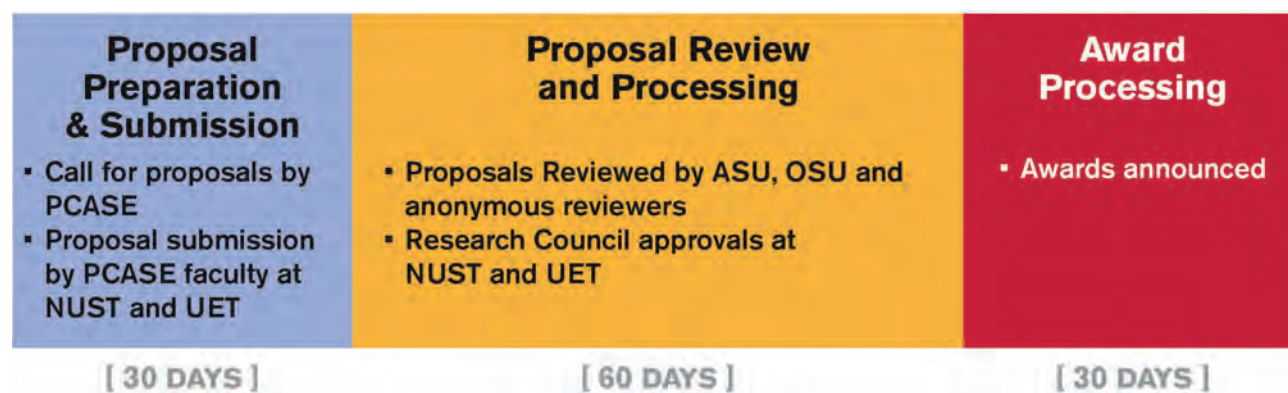
The conference was a great step towards connecting academics, energy and government officials, policy makers and entrepreneurs. PCASE also assisted in organizing the conference by forming and charging administrative and technical



committees who then executed the conference plan.

Presentations included two keynotes, Energy resources and role of alternative renewable energy technologies in development of KPK and Energy Crisis and Remedial Measures in Pakistan. Additional presentations included Bioenergy potential and utilization in Pakistan; Harnessing of wind power - Recent Developments; The Current Energy Crisis and Environmental Issues: A Potential Solution; Synthetic fuels: FUN-Materials for Chemical Energy Conversion; Integration of Power and the Evolving Grid –Challenges and Research Directions; Transformers Health Monitoring using Non-Intrusive Fault Diagnosis Methods; and Power Systems Efficiency Improvement through Power Factor.

**Figure 1: Process for joint research projects awards**







### **International conference on Sustainable Energy Technologies**

An International conference on Sustainable Energy Technologies was held in Islamabad in September 2017. PCASE assisted by inviting local speakers, selecting posters for display, and arranging conference logistics. More than 350 people attended the conference.

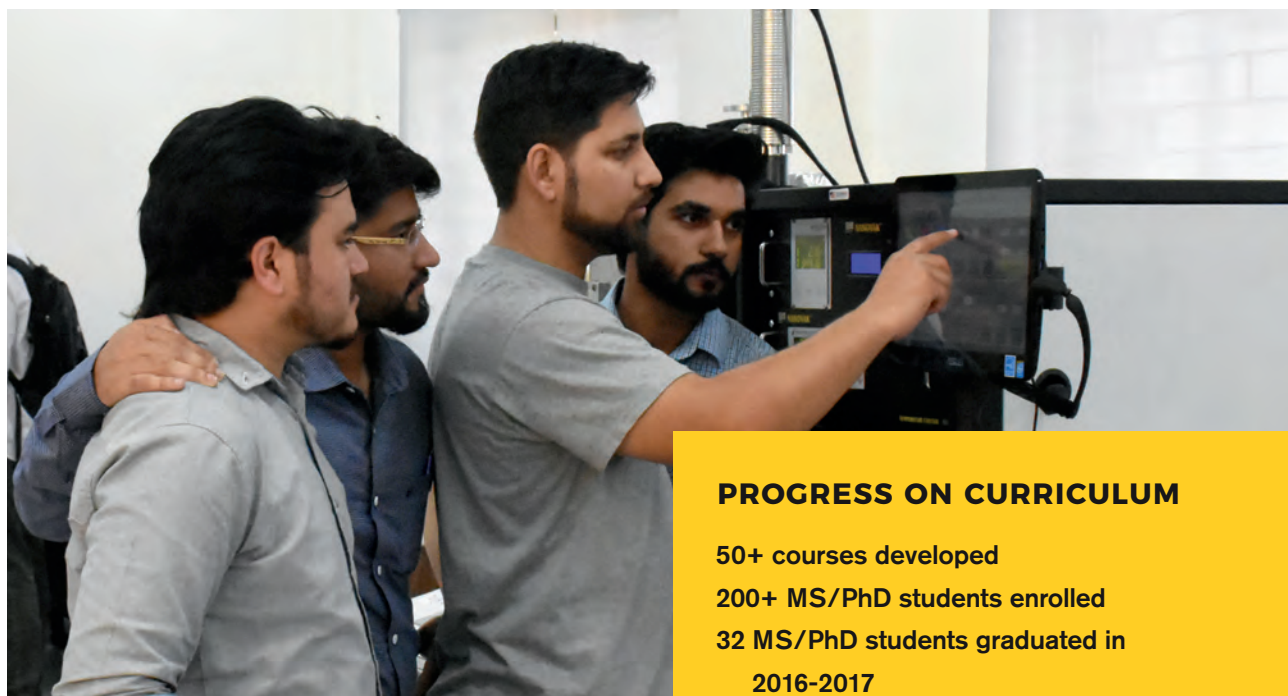
This international conference focused on various thematic areas of energy especially electrical energy system engineering, renewable energy engineering, thermal energy engineering and energy management and sustainability. The conference was helpful in bringing stakeholders together to share best practices.

The conference featured six sessions and 14 papers. Presentations included: Solar Energy – Opportunities and Challenges in Pakistan; Overview of Pakistan Power Sector and Key Challenges; Technical Session on Energy Policy and Power Engineering; Integrated Energy Planning for Pakistan; Grid Integration of Renewable Energy in Pakistan; 50 MW of Solar Energy – Lessons From ASU's 60 Year History with Solar Energy; Indigenous R&D of Micro-Hydro Power Plants (MHPPS) to Improve the Pace of Off-Grid Electrification; and The Need for Industrial Energy Audits in Pakistan.

The ultimate objectives of this conference were to develop and strengthen the links among academia, industry, entrepreneurs and policy makers engaged in the energy sector; to exchange the latest information, ideas and developments related to the research and innovation in energy sector; to provide students and young researchers an opportunity to interact with relevant academics and professionals; and enhance public awareness regarding energy crisis and its sustainable solution in Pakistan.

# 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

50+ courses developed

200+ MS/PhD students enrolled

32 MS/PhD students graduated in  
2016-2017

10+ new labs developed

## CURRICULUM DEVELOPMENT

PCASE working with NUST and UET re-imagined the energy curriculum, creating more than 50 new courses and five new master's and PhD programs.

At NUST, PCASE assisted in the development of curriculum of Energy Systems Engineering and Thermal Energy Engineering. PCASE also reviewed the working paper of the PhD program in Thermal Energy Engineering in the context of international best practices.

At UET, PCASE assisted in the review of curriculum for Renewable Energy Engineering, Thermal System Engineering, Energy Management and Sustainability, and Electrical Energy System Engineering. PCASE

also reviewed the curriculum of the proposed PhD program in Renewable Energy Engineering and Electrical Energy System Engineering, using international best practices to guide decision making.

PCASE compiled and delivered a document on a course evaluation process to support partner universities in developing a robust course evaluation process at their respective schools.

See Table 1 for a center-by-center breakdown of new courses and degrees.

## NEW LABS

During FY17, PCASE worked together with NUST and UET to develop new labs for the following degree programs:

- MS Electrical Engineering (Power)
- MS Thermal System Engineering
- PhD Electrical Energy System Engineering
- PhD Renewable Energy Systems

**Table 1: Energy engineering degree programs and new courses**

developed/offered in FY17, revised by ASU, which are or will be offered at the NUST and UET Centers.

NUST		UET	
34 NEW COURSES DEVELOPED (45 TOTAL)	1 NEW DEGREE PROGRAM APPROVED*	20 NEW COURSES DEVELOPED	4 NEW DEGREE PROGRAMS*
MS Energy Systems Engineering		MS Electrical Energy System Engineering	
MS Thermal Energy Engineering		MS Thermal System Engineering *	
MS Electrical Engineering (Power)		MS Renewable Energy Engineering	
PhD Energy Systems Engineering		Master of Energy Mgmt & Sustainability *	
PhD Thermal Energy Engineering *		PhD Electrical Energy System Engineering *	
		PhD Renewable Energy Systems *	



# Research

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



## 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 goal ASE is to develop new energy systems, tools, policy and models to improve the generation, distribution and access of energy in Pakistan. The main goal of the applied and joint research projects is to increase access to reliable and renewable energy across Pakistan. This year, joint research projects with ASU and OSU focused on development of national energy modeling strategy for Pakistan; development of hybrid and renewable energy generation for rural areas; design and

## RESEARCH HIGHLIGHTS

**20 applied research projects at NUST and UET**

**6 new joint research projects with ASU and OSU, 3 with NUST and 3 with UET**

**56 papers published**

**51 conference presentations**

development of a microgrid energy system; solar powered refrigeration; materials for renewable energy; and application of wireless sensor networks for electricity metering and monitoring.

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

**Table 2: List of applied research projects awarded in FY 2017**

CENTER	PROJECT TITLE	FACULTY
NUST	Development of Advanced Metering Infrastructure and Customer Side Systems	Dr. S. Sajjad Haider Zaidi
NUST	Development of Self Cleaning and Low Emissivity Thin Films for Glass	Dr. M. Mujahid
NUST	Indigenous Design and Development of a Solar Powered Adsorption Refrigerator (SPAR)	Taqi Ahmed Cheema
NUST	Double Pervoskite Based Multiferroic Materials for Solar Cell Applications	Dr. M. Yaseen
UET	Variable Frequency Air Conditioner Compressor Drive	Musharraf Ahmed Hanif
UET	Fuel and Electricity Theft Detection and Reporting Using Wireless Sensor Networks	Gul Muhammad Khan

## JOINT RESEARCH PROJECTS

Joint research projects pair NUST and UET 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 per the cooperative agreement, PCASE is to undertake 10 joint research projects with NUST and UET (five with each institution). To ensure consistent focus in the proposals submitted for consideration, ASU identified four primary areas for PCASE work on research: electric system, thermal energy, renewable and alternative energy, and policy.

PCASE worked with NUST and UET 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.

See Figure 1 on page 8 for an overview of the process.

**Table 3: List of joint research projects awarded in FY17**

PROJECT TITLE	ASU/OSU FACULTY PI	PAKISTANI FACULTY PI	PARTNERS
National Energy Modeling Strategy for Pakistan	Dr. Clark Miller	Dr. Kafait Ullah/ Dr. Kashif Imran	NUST, ASU
Design and Development of Condition Monitoring Testbed Based Smart Solar Microgrid – Community Empowerment Through Access to Energy in the Rural Areas of Pakistan	Dr. Govindasamy Tamizhmani	Dr. Syed Raza Kazmi/ Dr. Hassan Abdullah Khalid	NUST, ASU
Development of Hybrid Micro Combined Heat and Power System for Distributed Generation in Pakistan	Dr. Brian Fronk	Dr. Muhammad Zubair/ Dr. Muhammad Bilal Sajid	NUST, OSU
Development of Khyber Pakhtunkhwa Province Integrated Energy Model. Modeling of Khyber Pakhtunkhwa Energy Supplies, Demand, Gaps, Futuristic Projections and Energy Policy Vision 2035	Dr. Clark Miller	Mr. M. Ifran Mufti	UET, ASU
Renewable Based Power for Remote Communities Through Biomass Gasifier	Dr. Brian Fronk	Qari M. Khalid Waheed	UET, OSU
Design and Installation of Islanding Rural Microgrid Containing Alternative Energy Sources	Dr. Govindasamy Tamizhmani	Muhammad Shoaib Khalid	UET, ASU





## LAB AND LIBRARY DEVELOPMENT

Core to the success of center efforts is the development of facilities that support inquiry and research. The centers at NUST and UET both required upgraded and expanded facilities to put them on a level playing field with their international peers. PCASE reviewed the proposed list of equipment for NUST and UET's energy labs and provided feedback based on the best-in-class equipment standards followed by other universities.

PCASE reviewed the lab plans and lab equipment proposed by UET for the **Thermal System Lab**, including analytical instruments for determining thermal conductivity, thermal diffusivity, specific heat, and coefficient of thermal expansion.

For the **Renewable Energy Lab**, PCASE proposed additional equipment, RE-based consumables and additional accessories for current equipment, in particular, equipment for third-generation solar cells.

For the **Electrical Power System Lab and Simulation Lab**, new software was proposed that is critical for students working in the areas of power systems and controls.

PCASE also reviewed and endorsed the books NUST and UET proposed for their respective libraries. ASU faculty also endorsed and provided their detailed feedback on the proposed list of books, journals, and energy-themed magazines for the UET library.

# Exchanges and Scholarships

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



*Exchange students on an Arizona Public Service Electric Company (APS) visit in the U.S.*

## EXCHANGE PROGRAM

The goal of the PCASE 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. Visiting students 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.

## HIGHLIGHTS

**111 students and faculty attended ASU and OSU for a research experience in FY17**

**Gender diversity: 82 male and 29 female participants**

**4 technical workshops conducted by U.S. faculty in Pakistan**

**4 virtual technical seminars delivered by U.S. faculty**

**Visiting scholars participated in numerous cultural excursions in Arizona, Oregon and throughout the region**

Many cultural opportunities give students and faculty the opportunity to share Pakistani culture with American students and faculty and act as ambassadors for their home universities.

During the past year, 50 exchange visitors participating in the PCASE program, 47 students and three faculty.

**Table 5: List of PCASE exchange scholars at ASU to date.**

	STUDENTS		FACULTY		TOTAL	
	Male	Female	Male	Female	Male	Female
<b>NUST</b>	35	17	4	1	39	18
<b>UET</b>	40	11	3	0	43	11
<b>TOTAL</b>	75	28	7	1	82	29
	103		8		111	



### TECHNICAL WORKSHOPS IN PAKISTAN

There were a total of four technical workshops held in Islamabad, Pakistan during the past year. During this time, four faculty from ASU travelled to Pakistan to deliver technical workshops to participants from NUST and UET as well as stakeholders.

#### Quarter 1 Workshop: Green Buildings

*Workshop organizer: Dr. Harvey Bryan, ASU*

The U.S. green building industry has developed a suite of green building practices. To date, these practices have been primarily voluntary, however, several recent regulatory standards have been developed and were discussed.

The discussion of voluntary practices included the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) System, The Green Building Initiative's (GBI) Green Globes, International Living Future Institute's Living Building Challenge and the EPA's Energy Star.

The regulatory discussion included the ASHRAE



189.1 Standard, International Green Construction Code, and California's CalGreen Code. Workshop participants gained a good understanding of these practices and how they could be adapted to Pakistan.

#### Quarter 2 Workshop: Gender Equity

*Workshop organizer: Dr. Chad Haines, ASU*

This workshop offered specific action plans for universities, engineering departments and individual faculty to implement. The workshop focused on creating linkages with local secondary schools to encourage young women to pursue engineering degrees and careers; building networks of women engineers for support; and developing gender supportive environments. The underlying theme of the workshop was that for transformation to take place, individuals must take action rather than expect administrations to create policies. Faculty members must actively recruit women students, foster inclusive environments, and organize and advocate for meaningful structural and cultural changes.





*Ken Mulligan, standing, provided a hands-on entrepreneurship workshop for students and faculty in Pakistan.*

### **Quarter 3 Workshop: PV Reliability and Technical Centers**

*Workshop organizer: Dr. Govindasamy Tamizhmani, ASU*

Solar photovoltaics is one of the fastest growing energy technologies in Pakistan. This four-day workshop focused on three key areas of solar photovoltaics (PV): manufacturing of solar cells and panels; performance evaluation of solar panels; and reliability evaluation and standards of solar panels. The fourth day was devoted to a discussion with PCASE faculty on establishing solar PV reliability laboratories in Pakistan.

Industry experts in Pakistan were invited to give guest lectures. This workshop was attended by a significant number of female participants.

### **Quarter 4 Workshop: Technology Entrepreneurship**

*Workshop organizer: Professor Kenneth Mulligan, ASU*

The number one risk of failure for a tech startup is neglecting to put the customer's willingness to pay for a product at the core of product design.

This workshop focused on developing a scalable and sustainable business model that mitigates this risk and other risks associated with creating new products or services. Using a hands-on approach, students were expected to develop their innovation into a validated business model.





*ASU and OSU faculty delivered four virtual seminars, providing additional expertise to project partners in Pakistan.*

## VIRTUAL SEMINARS

Four virtual seminars were delivered via Skype to participants at NUST and UET. Each of these 90-minute seminars focused on a specific topic and were delivered by ASU and OSU faculty.

### **Quarter 1 Virtual Seminar: Multidisciplinary research work: the FREEDM project**

*Presented by Dr. George Karady, ASU*

PCASE organized the first of a series of virtual seminars for approximately 150 NUST and UET Peshawar energy engineering students and faculty. Delivered by ASU Professor George Karady, the seminar focused on the multidisciplinary research center FREEDM, an NSF Engineering Research Center for Future Renewable Electric Energy Delivery and Management. FREEDM is a joint research project with ASU, North Carolina State University, Florida Agriculture and Mechanical University, and the Missouri University of Science and Technology.

During the seminar, Dr. Karady spoke about the ways that the FREEDM system aims to modernize the power grid system by using a solid-state transformer, described as a 'magical device' that will revolutionize the conventional transformer.

The seminar concluded with an interactive question and answer session. Dr. Karady answered questions about power grids and offered advice to attendees on their current research projects.

### **Quarter 2 Virtual Seminar: Hydrogen Economy**

*Presented by Dr. A.M. Kannan, ASU*

Delivered by ASU Professor A.M. Kannan, this seminar focused on the importance and relevance of switching towards a hydrogen economy, its performance as an automotive fuel alternative and the challenges faced with this transition. The workshop also explored the benefits and disadvantages of fossil fuels and highlighted the available opportunities in sustainable energy devices that are exemplified by solar power and hydrogen fuel cells.





*PCASE Virtual seminars were well attended by students at both NUST and UET.*

### **Quarter 3 Virtual Seminar: Introduction to High Temperature Solar Thermal Power Generation**

*Presented by Dr. Brian Fronk, OSU*

This seminar was dedicated to introducing concentrated solar thermal power production technology to its audience, with a focus on central receiver systems. Recent developments in concentrated solar thermal power plants in the U.S. and barriers to deployment were discussed. Particular attention was given to recent work at Oregon State University that involved developing high-temperature, supercritical carbon dioxide solar thermal systems. Approximately 119 students and faculty participated in this seminar.

The seminar was especially well-received by NUST faculty and students because of its relevance to the Thermal Energy Engineering program offered by PCASE NUST.

### **Quarter 4 Virtual Seminar: Where Will Solar Go Next?**

*Presented by Dr. Zachary Holman, ASU*

Professor Holman discussed the present state of solar cell and module technology, key market drivers that are propelling science and engineering innovation, and areas of solar cell research in which academic institutions can lead and provide unique value.

Professor Holman began with a short overview of solar research at ASU and within his research group, including current funded projects, capabilities and facilities. The goal of this overview was to facilitate new collaborations between ASU and NUST/UET faculty. A NUST faculty member contacted Prof. Holman after the seminar and they agreed to start an informal collaborative project—which may seed a future full proposal—through a NUST CASE-N scholar who will be coming to ASU in spring 2018.





### ANNUAL SCHOLARSHIP REVIEW

At the end of the this fiscal year, an annual review of both NUST and UET's scholarship programs was completed. The following areas were reviewed with both NUST and UET scholarship coordinators: scholarship criteria; the selection process; the number of female and disadvantaged candidates; and scholarship recipient matriculation.

The primary outcome of this review was an understanding of the need to refocus initiatives regarding the recruitment of female and disadvantaged candidates. A second recommendation was to pair scholarship awards to a service project that will highlight PCASE's commitment to giving back to Pakistan. The review was passed on to the PCASE deputy directors at NUST and UET for review and feedback.

**NUST 131** scholarships  
**UET 98** scholarships

Once compiled, the final review will be passed on to the NUST and UET administrations for consideration.

# Sustainability

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



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

## **BUILDING RESEARCH AND GRANTS-MAKING CAPACITY**

In order to become self-sustaining and to meet research funding goals, the centers need to increase their capacity to compete for grant funding. Exchange activities include proposal writing training and mentoring.

## **PROGRESS ON SUSTAINABILITY**

Supported 8 local technical seminars by energy sector experts

Facilitated industry participation in 5 center events

Increased participation at annual stakeholders meeting

More than 50 meetings with energy companies in Pakistan

22 internships secured in different energy sector organizations

Think tank formation initiated

Technology Center conceptualized

\$1.5M of research funding

In addition, PCASE offered a virtual proposal writing training in Pakistan. This effort will continue with a future in-person training in Pakistan.

## **STRENGTHENING STAKEHOLDER RELATIONSHIPS**

PCASE facilitated visits to many stakeholders creating opportunities for collaboration. These efforts resulted in 50 meetings with energy sector organizations, to explore the possibility of developing partnerships. Six partnerships have been established; these include Center for Energy Research and Development; KP Oil and Gas Company Limited; Department of Science and Technology; Sky Electric; and Fauji Fertilizer Company Limited

The second stakeholder meeting was hosted December 2016 and more than 40 people attended this event. The main takeaway from this event was the need to better align curriculum and research to industry needs focusing on policy and equipping students with innovative tools to be more marketable.

PCASE promoted industry participation at events with the following results:

- 9 participants at the National Conference on Green Energy Technologies
- 25 participants at the International Conference on Sustainable Energy Technologies
- 10 participants in the Green Building Workshop
- 14 participants in the PV Reliability Workshop
- 4 participants in the Gender Workshop

PCASE helped to facilitate linkages with energy sector, through visits of center students to seven industries and through the facilitation of student internships.

ASU NUST and UET together developed 22 internships for students in various energy sector organizations. 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.

## **PLANNING FOR THE FUTURE**

PCASE also supported both partner universities in drafting realistic and achievable sustainability plans. One of the key goals for each center is to assume the role of a think tank in Pakistan. PCASE is providing support in defining what this means for the centers and how to get there. In the past year, PCASE assisted in drafting the concept note.

### **Technology Center**

As part of sustainability plans, both centers intend to develop technology centers to offer consultancy, testing and training services. ASU is supporting NUST and UET to develop technology centers. Technology centers will offer the following services: PV testing; battery testing; energy auditing; and short courses and trainings.

### **Communications**

Communication and outreach activities provide building blocks for the future by creating communications and marketing collateral including publications, newsletters, photo libraries, videos and video footage. Ongoing communication activities will increase the knowledge of how these assets can be leveraged to recruit students, compete for research funding and grants, and to establish the centers as go-to partners for the energy sector in Pakistan.



# Cultural Exchange

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*Cultural exchange is a primary component of the exchange scholar experience. Scholars have the opportunity to participate in a wide range of local and regional experiences and learn about life in the United States while sharing Pakistani culture with the people they meet.*



*Above: Scholars tour the capital of the Navajo Nation in Window Rock, Arizona.*

*“I met so many people.”*

*“It was good experience with lots of memories.”*

*“People so friendly.”*

*“Everyone wanted to learn our dancing from Pakistan.”*

*“I learned about American culture and American foods.”*

These are just some of the many comments from scholars after participating in a cultural exchange activity. Through scholar exchanges like the one through the U.S. - Pakistan Centers for Advanced Studies in Energy, students not only learn technical and research skills, they also gain a global perspective interacting with people of all backgrounds and cultures in the United States. Scholars also participate in major campus events like Homecoming and Open Door at ASU and ad hoc events like the viewing of the eclipse. Read more in the highlights section of this report beginning on page 26.



## **CULTURAL EXCHANGE OPPORTUNITIES SPRING 2017**

Bonneville Dam Tour in Oregon  
Hoover Dam in Nevada  
Grand Canyon Excursion  
Heard Museum of American Indian Culture  
and Art Visit in Phoenix  
Lantern Festival in Casa Grande, AZ  
Pakistan Independence Day Celebration in  
Scottsdale, Arizona  
Navajo Nation Tour in Window Rock, AZ  
National Football League game and Major  
League Baseball game  
Arizona Renaissance Festival  
California Science Center and Universal  
Studios



*Top: Scholars on the skywalk above the Grand Canyon.*

*Middle left: Scholars met with the public and shared the work of PCASE during ASU's annual Open Door event that brings 10,000 community visitors to campus to learn about university research and more.*

*Lower left: Scholars had a great view of the solar eclipse on August 21, 2017.*



# Highlights from the past year

## ASU/PCASE Energizes Entrepreneurial Aspirations for Pakistani Scholars

The second cohort of Pakistani engineering scholars completed their entrepreneurship course of study at ASU in spring 2017. In addition to entrepreneurship, the students studied engineering and policy in an effort to enact change and improve their country's energy prospects.

ASU entrepreneurship professor Kenneth Mulligan said, "The intention of the program is to improve availability of clean reliable power in Pakistan. Strategic innovation and entrepreneurship provides a pathway for widespread implementation of their innovative technical solutions."

"Pakistan is subject to rolling blackouts that impede stability, progress and business. The problems faced in Pakistan are not easy problems, which is why coming up with solutions that reside 'outside the box' are so critical," says Mulligan, who has taught and mentored the cohorts. "They get to use causative thinking, systems analysis and technical feasibility to solve complex technical problems in energy generation and distribution. However, this problem-solving approach and skill set is insufficient in the development of innovative and disruptive products and technologies."

Mulligan believes that all of the scholar's final projects have market potential. All 27 of the visiting scholars, from the second cohort took Mulligan's class. One project of particular interest was presented by Nafeesa Irshad. Irshad's project involved developing a solar-powered drinking water purification system which addresses both Pakistan's need for renewable energy and clean water.



*Kenneth Mulligan, professor for the U.S.-Pakistan Centers for Advanced Studies in Energy, presents Pakistani exchange scholars their certificates of completion for the entrepreneurship portion of the program. Photographer: Erika Gronek ASU/PCASE*

"In Pakistan, unsafe drinking water is the main cause of children's deaths and other health issues," said Irshad.

"This system would provide safe water to the people through its high temperature and UV C action," said Irshad. UV C, a type of ultraviolet light, kills microbes and cleans the water. "It would be [a] more energy-efficient system as compared to existing reverse osmosis technologies."

Noaman Khan, another enterprising student in the class has the idea to pursue low-cost catalysts for proton exchange membrane (PEM) fuel cells. He wants to find new materials that can possibly replace platinum as a catalyst because the material is so cost-prohibitive.



A more affordable, durable and reliable catalyst would reduce the cost of fuel cells, therefore opening up a market opportunity, according to Khan. Future applications could include the large-scale commercialization of the technology for automotive and other fuel cell applications.

Khan says of the program that it, “is not about publishing research papers but [about] solving Pakistan’s energy problem. It requires science and entrepreneurship to go side-by-side. I didn’t realize it before this course. We should make discoveries that can create value.”

According to Mulligan, “Entrepreneurship gets them to think about implementation and commercial feasibility. It’s a way to connect their engineering skill set with an entrepreneurial mindset. Who has the problem? What is their true pain point? What solution solves both the technical feasibility and commercial feasibility? The benefits are enormous. It equips them to think in terms of real impact on their communities back in Pakistan.”

**“Strategic innovation and entrepreneurship provide a pathway for widespread implementation of their innovative technical solutions.”**

“My task is to instruct them in Lean Methodology — the core of tech entrepreneurship — and to inspire and mentor their abilities to solve problems through tech entrepreneurship and commercialization,” adds Mulligan.

The scholars now see themselves as problem solvers and value creators and hope to take their plans back home and turn those ideas into entrepreneurial ventures in Pakistan.

## Bottom-Up Bioenergy Strategy to Generate Social Impact and Mitigate Poverty

Dr. Rabia Liaquat from NUST spent six weeks at ASU working with the School for the Future of Innovation in Society (SFIS) to identify a strategic approach to improving the policy framework involved in using biomass resources as a means for bioenergy production.

Liaquat credits the Swette Center for Environmental Biotechnology within the Biodesign Institute at ASU for providing state-of-the-art equipment and expertise to carry this waste-to-energy research forward.

She is excited to bring her new knowledge home as it could help to address Pakistan’s energy needs.

She would like to encourage more women to come forward to play a constructive role in Pakistan’s energy transition. Liaquat also credits PCASE’s entrepreneurship course for helping women aspire to be entrepreneurs and move Pakistan toward economic sustainability.

Liaquat says that, “Pakistan still needs capacity building, technology transfer, industry linkages and national-international training for successful operation and [to] move towards sustainable bioenergy resources.”

She believes that the launch of waste-to-bioenergy projects with the help of PCASE helps to fulfill a national need.



*Dr. Rabia Liaquat  
Photographer: Erika Gronek,  
ASU/PCASE*

## PCASE Scholars Become Energy Policy Trainees

ASU's School for the Future of Innovation in Society (SFIS) Associate Director Dr. Clark Miller is PCASE's energy policy lead, having developed and organized a training workshop in energy policy and leadership for all of the students in the project.

Two of the participating master's students, Bilal Malik and Nafeesa Irshad along with their professor, Dr. Rabia Liaquat, were hosted by SFIS as energy policy trainees with PhD student Carlo Altamirano as their program liaison. All three said they are excited to be at ASU, praising in particular the culturally diverse student community as being supportive and welcoming.

Dr. Liaquat sees the virtue in interdisciplinary cooperation among faculty, between universities, and especially between academia and policymakers. The students have gravitated towards a communal learning environment that they have found at the university.

"It's so interactive!" said Irshad, while Malik appreciated faculty who are "always ready to talk with us." They all hope to be leaders in the transition to a renewable energy future in Pakistan. Liaquat and Irshad, with Malik's support, intend to encourage and empower other women to enter the energy field.



Left to right: Carlo Altamirano, Nafeesa Irshad, Dr. Clark Miller, Dr. Rabia Liaquat and Hafiz Muhammad Bilal Ahmed Maki.  
Photograph: ASU/SFIS

## PCASE Scholars Prep for Workforce, Leverage ASU Experience

In October 2016, 27 exchange scholars were trained at ASU in job-seeking skills like résumé writing and interview preparation.

One of the more unique points during the presentation discussed was whether to use a résumé versus a curriculum vitae.

Context, job type and country all factored into how students might apply for employment in the future. With an ever-changing global job market, students needed to weigh the pros and cons of both approaches.

Best practices for updating résumés, keeping a clean digital footprint, breaking stereotypes about engineers and how to prepare for an interview, were all covered.





## Fall 2016 Cohort Reflects on Impact of PCASE



"The best, so far, experience in my 24 years [of] life." — Asad Ali, ASU

"My experience in [the] U.S. and what I have learned is beyond words and it's going to shape my whole life in a new direction."  
— Hafiz Muhammad Bilal Ahmed Maki Malik, ASU

"Within a four month of period, I can see the benefit from this training in my career and educational endeavors." — Anam Qadir, OSU

"I have learned a lot on power electronics and its simulation tools — now I feel very confident to validate my research results using PLECS and PSIM." — Usman Rahat, ASU

"Travelling is a great teacher. I learned and came across so many new things that I was utterly unfamiliar with." — Muhammad Umer, OSU

"I feel blessed to have been exposed to [the] land of opportunities." — Dr. Rabia Liaquat, ASU

"I was able to witness firsthand the extraordinary academic vision and research culture at ASU and got to learn from some of the most remarkable people I've ever met, who were all very good at what they were doing." — Syeda Qudsia, ASU







## Third PCASE cohort arrives in U.S.

The third cohort of PCASE scholars from Pakistan arrived in January 2017. They are starting on their professional development workshops and in the coming weeks they will be participating in Dr. Clark Miller's policy workshop, Kenneth Mulligan's entrepreneurship class, and conducting research at various labs.

The third cohort included 28 scholars at ASU and 6 at OSU, 21 men and 13 women. This cohort included the largest number of female participants in the program to date. The promotion of gender equality for engineers is a key aspect of PCASE.

The cohort will return to Pakistan to complete their studies at the National University of Science and Technology (NUST) and the University of Engineering and Technology (UET) in May 2017.

## PCASE participates in Pakistan's largest renewable energy exhibition

### Solar Pakistan: 6th International Renewable Energy Exhibition and Conference

PCASE participated in the 6th Annual Renewable Energy Exhibition and Conference that took place in Lahore, Pakistan in March 2017. The exhibition is one of Pakistan's largest energy events, bringing together the energy industry, decision makers and stakeholders to discuss solutions to control the ever-increasing energy deficit in Pakistan.

PCASE staff, students and faculty from the National University of Sciences and Technology (NUST) and the University of Engineering and Technology (UET) Peshawar briefed visitors about various initiatives that PCASE is undertaking to help Pakistani universities focus on applied research relevant to Pakistan's energy needs, help produce skilled graduates in the energy field and serve as a bridge between the government, industry and academia.

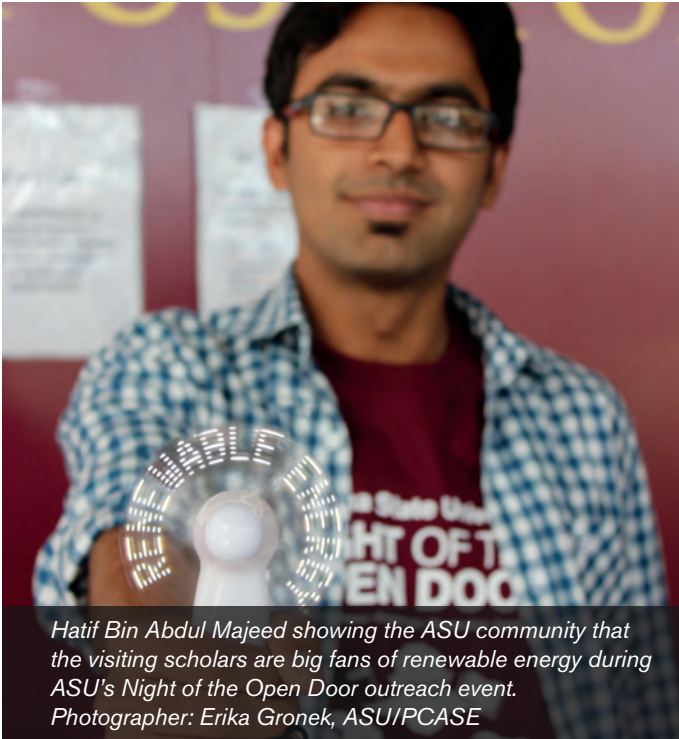
While visiting the PCASE booth at the exhibition, Chaudhry Sher Ali Khan, Pakistan's Provincial Minister for Energy, Mines and Mineral Development expressed his appreciation for the work that PCASE is doing to advance energy and energy research.



Chaudhry Sher Ali Khan, Pakistan's Provincial Minister for Energy visiting the PCASE booth.  
Photographer: Hassan Zulfiqar / PCASE

# Students envision an energy-independent Pakistan

## Profiles and perspectives from Night of the Open Door



*Hatif Bin Abdul Majeed showing the ASU community that the visiting scholars are big fans of renewable energy during ASU's Night of the Open Door outreach event.  
Photographer: Erika Gronek, ASU/PCASE*

**Improving the energy grid in Pakistan was, without exception, the priority for a cohort of Pakistani graduate scholars studying engineering at Arizona State University in spring 2017.**

As participants in the U.S. - Pakistan Centers for Advanced Studies In Energy (PCASE) program, the students recently demonstrated renewable energy concepts during Arizona State University's Night of the Open Door – an event during which Phoenix-area residents visit the ASU campuses, meet faculty and students, and explore research projects.

Toy solar car races at the PCASE exhibit attracted many young visitors and their parents, giving the engineering students an opportunity to explain the importance of developing renewable sources of power. They also handed out LED light-up fans that, when they spin, spelled out, "Renewable Energy: I'm a big fan."

### Meet Anam Zahara, Southern Punjab

A NUST graduate with a B.E. in telecommunications engineering, Anam Zahara from Southern Punjab is now working on a masters degree in energy policy with a focus on electrical engineering through the program.

"We have many rolling blackouts in my area of the country," she explains. Her vision is to integrate her telecommunications and electrical engineering education so she can "be a part of the process that improves Pakistan's energy infrastructure."

Education is a priority in Zahara's family – both parents are teachers, two sisters are medical doctors and another has a master's degree in agriculture.

"One thing I've learned here is that time is money," she says with a smile. "It's important to be punctual for class."

**“I believe small start-up companies will contribute significantly to solving my country's energy problems.”**

**Usman Salahuddin, Karachi**

### Meet Usman Salahuddin, Karachi

For Usman Salahuddin from Karachi, the decision to pursue an advanced degree in energy systems was born of frustration. With a B.S. in chemical engineering from NUST, Salahuddin found himself literally powerless almost daily at his job in the fertilizer industry.

"There was not enough gas to feed the furnace, so we'd have to shut down the factory," he explains. "It taught me that we cannot rely on fossil fuels. We must develop renewable, technologies that can be safely implemented for industry."

His attraction to the PCASE program was heightened by the opportunity to focus on entrepreneurship. "This program not only makes us researchers, it also emphasizes becoming entrepreneurs," Salahuddin says.





*Farah Akram greeting members of the ASU community who were curious about the USAID project.  
Photographer: Erika Gronek, ASU/PCASE*

### Meet Farah Akram, Karachi

Farah Akram, who has a power electronics degree from NUST, did not let her poor sense of direction and fear of animals thwart her aspirations to pursue a master's degree in electrical power engineering.

"The ASU Campus is so big that I got completely lost on my first day," she says, explaining that her campus at NUST was small in comparison "But everyone was so helpful, and eventually I found my way," noting with a laugh that she's been able to avoid stray cats and dogs.

The majority of Akram's family is in business and she, who describes herself as "extremely organized," is the only engineer. "Our family is passionate about education," she says. "Engineering made the most sense for me."

### CULTURAL EXCHANGE EXCURSIONS

Unanimously, the students declared the Arizona Renaissance Festival their favorite cultural experience to date. They donned crowns along with other festival-goers and enjoyed the jousting knights, circus performers, musicians and the marketplace.

Actually, marketplaces of all sorts are of interest to the students. "We love shopping," declares Zahara, who says she's particularly enjoyed Arizona Mills and Tempe Marketplace – both accessible via public transportation.

But more important than shopping and festivals are the opportunities to collaborate with other students.

"I feel so welcome – faculty has been extremely supportive," says Akram. "This has been an unimaginable new experience."

"The cultural exchange has helped me learn how to socialize with people who are different," says Barki. "One day on a trip via the Light Rail, a group of elderly ladies got on – so we stood up and gave them our seats. Everyone clapped. It was definitely a notable moment."

Salahuddin notes that the learning exchange extends well beyond American customs and culture. "We are not just meeting American students – there are students from five different countries working on one of my lab projects," he says. "Exposure to these new, wide-ranging perspectives will be incorporated into the problem-solving processes we use when we return home."



*(Above and below) PCASE scholars visiting the Arizona Renaissance Festival. Photo credit: Erika Gronek ASU/PCASE*





## Postcards from the Ledge:

### Hoover Dam excursion for Pakistani scholars bridges knowledge, culture

27 Pakistani engineering scholars PCASE at Arizona State University engaged in an educational adventure over spring break 2017. Spring break offered a respite from their classes and lab work, and brought the chance to see one of the greatest achievements in hydroelectric power first hand.

The scholars kicked off their journey by first visiting one of nature's greatest engineering wonders, the Grand Canyon, followed by a wonder of humanity's electrical and civil engineering ingenuity at Hoover Dam.

"The sheer brilliance that the engineers displayed in an era when such a megastructure was a rarity, is a sight to behold. It solved the water distribution problems for seven different states and shaped the landscape of California into what it is today," said Haider Saif Agha from National University of Sciences and Technology (NUST), Islamabad.

Learning about a pinnacle of clean energy was key for these scholars because many of them are studying photovoltaic, wind and hydroelectric energy options. The PCASE project has set out to explore renewable energy as a means for resolving the energy crisis happening in Pakistan today — leaving the country with blackouts that last 6-16 hours a day.

"The main purpose of building Hoover Dam was (for) flood control, irrigation and power production. I was fascinated to see how the states of California, Nevada, Arizona, Utah, New Mexico, Colorado and Wyoming resolved the water conflict for mutual benefit," said Asfand Yar Ali, of University of Engineering and Technology, Lahore. "I see in the comparison with Pakistan's Kalabagh Dam ... which helps Pakistan with flood control, which has been a big issue since 2010. We are facing minor and major floods every year in monsoon. Similarly, the dam will help Pakistan rejuvenate its agriculture and overcome energy crisis."

"Big dams in Pakistan are normally earth and rock fill dams, so there is a need to build concrete arc dams like Hoover Dam in Pakistan that are more impressive, efficient and modern," said Muhammad Ahsan Amjed, NUST.

"The construction of the dam really reminds me of one of the most primordial characteristics of human beings, that is, we are tool builders in this universe. We build tools to harness the potential of nature to expand our horizons, to reach the 'adjacent possible' and Hoover Dam is surely a way to prove it in a tangible form. I learned that we can also solve all of our country's energy problems by just mixing innovation and engineering in the right proportions," said Usman Salahuddin, NUST.

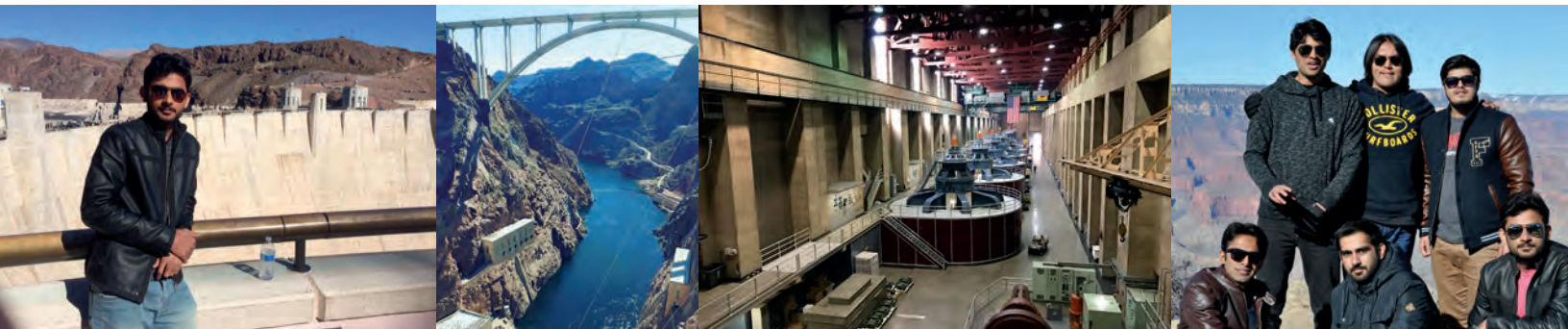
The scholars also visited the California Science Center during their break. "My favorite part was the free earthquake simulator," said Atoofa Zainab, NUST. "I learned about the how certain buildings are made in case of an earthquake. The lesson that I learned is that Pakistan is in dire need of these types of services and technologies because it will ultimately help the younger generation."

### Inspiring the Heart and the Sharing of Cultures

"I have honestly no words to define my experience I had on spring break. It was both fun and a learning experience," said Farah Akram of NUST. "The places we visited showed us the new face of the world. The views of the Grand Canyon, innovative construction of Hoover Dam, fun and virtual reality based rides of Universal Studios, well-demonstrated learning in California Science Center and playful time in Santa Monica let us live the most beautiful time of our lives."

"Something that really impacted my heart was the celebration of diversity in America. America celebrates its diversity, be it in L.A., Tempe, Las Vegas or any other city. I was impacted by views on tolerance, freedom of speech, action," said Haider Saif Agha, NUST.

"If you really want to understand the culture and people of any particular area, you will have to travel across that region in order to better understand their traditions, their peculiarities, cultural idiosyncrasies, (and the) subtle differences in their way of living. Such excursions help us renew our perspective about our research, our lives and our goals," said Muhammad Ahsan Amjed, NUST.



## PCASE scholars inspired by Wozniak visit

Steve Wozniak, visited the ASU campus in February 2017 and told several hundred students to create products they “desperately want” and that “motivation is more important than knowledge.”

The Apple co-founder and personal computer pioneer came to ASU as a nod to National Entrepreneur Week and gave an impromptu talk to about 400 students in a courtyard outside an engineering building on the Tempe campus.

PCASE scholar, Saddam Ali Khan was lucky enough to meet him. Inspired by Wozniak's talk Khan reflected that, “the fastest way to summit the mountains of your dreams is to follow in the footprints of those already at the peak.”

Haider Saif Agha said, “Hearing him (Wozniak) made me realize that passion and dedication pay off at the end. He talked about his hard work and his products like (they were) his babies that he nurtured and gave to the world.”



Saddam Ali Khan meets computer industry icon and Apple co-founder Steve Wozniak. Photo credit: ASU/PCASE

Haider realized, “that passion is what drives you to success. It doesn't matter which country you're from, how many resources you have or how badly the odds are stacked against you. Passion is king.”

The scholars of PCASE have passion for their work and their studies. Wozniak's visit was certainly a highlight in their academic journey.

## News from Oregon

Visiting scholars at Oregon State University successfully completed a Toastmaster Speechcraft program hosted by OSU's School of Mechanical, Industrial and Manufacturing Engineering Toastmaster Chapter.

As part of the program, each scholar worked with the group to develop public speaking skills and presented four speeches to develop different aspects of public speaking. They celebrated the completion of the program with pizza and a bowling party with OSU graduate students and faculty at the Student Union.

When they return to Pakistan, the group hopes to continue to engage with Toastmasters through a chapter in Islamabad.



OSU scholars hosted a party with faculty, staff and students to celebrate Pakistan Resolution Day. The scholars presented a speech on the history of the day, provided information about Pakistani geography and culture, and provided a green and white Pakistani flag cake to share with the group. Photo credit: OSU/PCASE

## Class Notes: Where are our scholars now?

**Asad Ali**, from Zachary Holman's Lab at ASU, published “Improved light management in planar silicon and perovskite solar cells using PDMS scattering layer” in a journal called Solar Energy Materials and Solar Cells.

**Mahmood Jamil**, a scholar from NUST is now a lecturer and may be going to New Zealand for his PhD.

**Abdul Kashif Janjua** collaborated on the paper “Customer Benefit Optimization for Residential PV with Energy Storage System” which will be presented at the IEEE Power Engineering Society's (PES) general meeting in Chicago.

**Akif Zia Khan**, one of our first visiting faculty members, is now in Hong Kong working on his PhD.





*The third cohort of exchange students prepares to depart the U.S.*

## PCASE Scholars visit the Sanjwal Power Plant

Scholars at the University of Engineering and Technology (UET) Peshawar had the opportunity to visit the Sanjwal PV power plant. This plant produces 5 megawatts of electricity for nearby industries during weekdays. The plant sells power to the national grid in Pakistan after hours and during weekends. The visit educated scholars about power generation and transmission from photovoltaics.

The scholars were given an in-depth look at control room operations inside a PV power plant. They got to see first hand the bus bars as well as the plant's inverters.

The visit was especially valuable for the students from the electrical energy system engineering track. Industry visits are a vital part of the PCASE program and relate directly to the scholars' coursework.

*Sanjwal Power Plant*





## Cultural excursions foster international kinship

### Students and faculty exchange culture and create lasting impressions

Cultural excursions are part of the valuable knowledge exchange between Pakistan and the U.S. Here's a snapshot of some of their adventures:

**The Grand Canyon:** Scholars visited one of the seven wonders of the natural world and learned about the geography and history of the area as well as how forces of nature have transformed the Arizona landscape. They also learned about surrounding Native American tribes and were able to share their own culture with tourists.

**Native American Pow-Wow:** Scholars witnessed an authentic Native American Pow-Wow, experiencing a myriad of cultures from more than 150 tribes from all over the United States.

**The Heard Museum:** Scholars had the chance to visit one of the best exhibits of traditional and contemporary Native American art in the United States. They learned about Native American history, culture and traditions. The trip gave them the opportunity to reflect on Pakistani culture in comparison and contrast to Native American cultures.

**Arizona Diamondbacks Game:** Play ball! Scholars attended a professional American baseball game and had a bit of fun comparing baseball with cricket. They got into the spirit and cheered for the Diamondbacks along with other fans.



OSU students surveying a map of the Grand Canyon. Photo credit: PCASE

## Seminar Heats Up Oregon

In spring 2017, Oregon State University organized a seminar on the "Recent Advances in High-Temperature Solar Thermal Power Generation."

This seminar was dedicated to introducing concepts in concentrated solar thermal power production technology while focusing on central receiver systems.

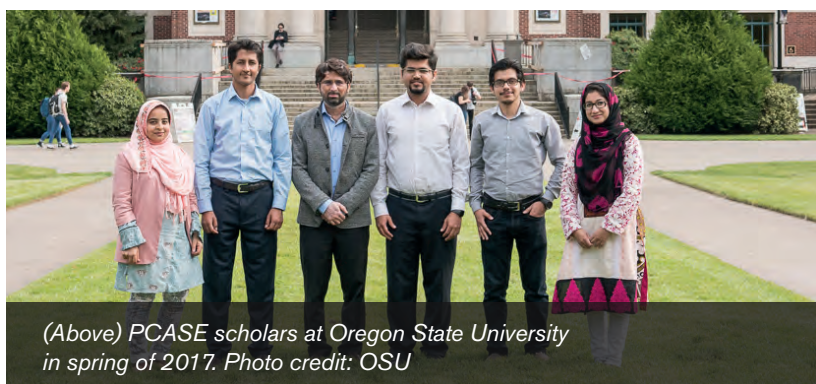
Recent developments in concentrated solar thermal power plants in the U.S., and the continuing barriers to deployment, were also discussed at the seminar.

Particular attention at OSU was honed on developing high temperature, supercritical carbon dioxide solar thermal systems.

Supercritical carbon dioxide ( $s\text{CO}_2$ ) is an attractive working fluid in power and refrigeration cycles due to its favorable thermophysical properties, high volumetric heat capacity and low global warming potential.

For power cycle applications,  $s\text{CO}_2$  can yield higher efficiency and smaller components than conventional steam Rankine cycles.

The seminar concluded with a discussion of the practical challenges of utilizing  $s\text{CO}_2$  for solar thermal applications and how microchannel devices can mitigate some of these challenges.



(Above) PCASE scholars at Oregon State University in spring of 2017. Photo credit: OSU

# The Big Move

## NUST inaugurates new energy research center

Pakistan's Federal Minister for Water and Power, Khawaja Muhammad Asif and John Groarke, from the United States Agency for International Development (USAID) and Mission Director in Pakistan, inaugurated a state-of-the-art research center for energy at National University of Sciences and Technology (NUST) in May 2017. Lieutenant General Naweed Zaman, HI (M), (retired), Rector of NUST, was also in attendance.

The research center was constructed with support from the U.S. Federal Government. The new four-story, 60,000-square-foot building includes five classrooms, eight high-tech energy laboratories, a seminar hall, conference rooms, a library, multiple office spaces and elevator access.

Speaking at the event, Federal Minister, Khawaja Muhammad Asif, expressed his appreciation for the assistance provided by the American government and people, saying that, “the provision of better-equipped research facilities with assistance from the U.S. Federal Government is a testimony to our continued efforts and commitment to improving the quality of education in Pakistan and addressing the energy issues facing it.”

Highlighting the United States' long-term commitment to strengthen Pakistan's education sector and help find practical solutions for the country's energy challenges, Mission Director Groarke said, “These new buildings will house academic programs that will help shape the future of Pakistan and set new standards for the success for both women and disadvantaged youth, especially in the energy engineering profession.”

Expressing his views at the launch, Lieutenant General Zaman, said that the role of USAID in the promotion of education is admirable, adding, the center would help produce 250 skilled graduates by 2019 which would boost the energy sector in Pakistan. He hoped that the state-of-the-art facilities of this center would add value to the existing academic and applied research culture at NUST.

Another similar center has been constructed at the University of Engineering and Technology (UET), in Peshawar, Pakistan.

This initiative is part of USAID's larger \$127 million investment to harness applied research in order to find innovative solutions for Pakistan's energy, water, agriculture, and food security challenges.



*John Groarke, Mission Director USAID/Pakistan and Khawaja Muhammad Asif, Minister of Water and Power, Pakistan inaugurated the new research center at the National University of Sciences and Technology (NUST).*



**“These new buildings will house academic programs that will help shape the future of Pakistan.”**

**John Groarke, USAID Mission Director**



## Scholar collaborates on solar research that benefits Arizona and Pakistan

PCASE scholar Abdul Kashif Janjua, part of the second cohort to visit ASU has collaborated on a research paper presented at the IEEE Power Engineering Society's (PES) general meeting in Chicago, July 2017. The society provides the world's largest forum for sharing the latest in technological developments in the electric power industry, for developing standards that guide the development and construction of equipment and systems, and for educating members of the industry and the general public.

Janjua collaborated on a paper entitled, "Customer Benefit Optimization for Residential PV with Energy Storage System" under the tutelage of Dr. George Karady from Arizona State University.

The paper shows that solar energy can benefit residential customers in Arizona. Photovoltaic energy storage could be optimized to maximize profit as well as minimize utility bills for customers. The analysis in the paper used data and patterns involving variables like load, temperature, anticipated temperature and battery discharge rates to achieve optimal results.

Janjua said, "The climate of Arizona and [the] summers in Pakistan are quite similar so PV systems are feasible in both areas. The same research can be used to optimize the size of a PV system and the charging strategies [with] the only difference being the tariffs which can be programmed into the developed algorithm with little effort"

The mentorship and collaboration process from his time at ASU has been an invaluable asset to his education. Of Karady he states that, "he was [the]

most supportive, helpful and encouraging professor."

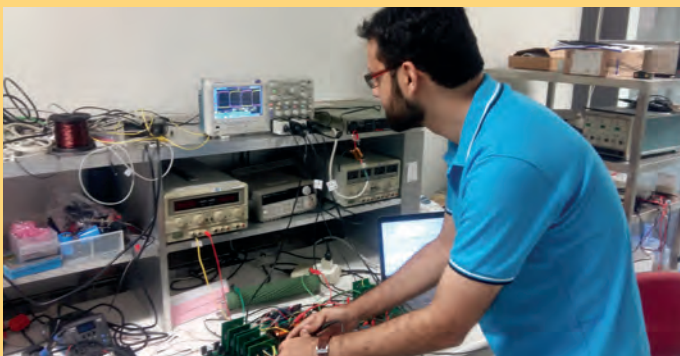
Currently, Janjua he is pursuing his master's degree at NUST in energy systems engineering. His research focuses on smart micro and nanoscale grid architecture and economic dispatch problems.

He plans to pursue a doctorate and then potentially apply his research in the commercial sector. In the meantime, he is in the process of publishing another research paper along similar lines in Pakistan.



*Abdul Kashif Janjua, right, is seen here receiving his certificate of completion in entrepreneurship at ASU's Generator Lab. Photo credit: Nathan Dascasin ASU/PCASE*

## NUST faculty member now lecturing in Hong Kong



Akif Zia Khan, affiliated with PCASE NUST as a faculty member, worked with Dr. George Karady on the curriculum for the Electrical Energy Engineering master's track as well as lab equipment for the Smart Grids lab.

Khan has been chosen as a recipient of a PhD research studentship from the University Grants Council of Hong Kong Polytechnic University.

After completion of his PhD he plans to return to PCASE and resume his responsibilities to strengthen of the center.









**[USPCASE.ASU.EDU](http://USPCASE.ASU.EDU)**

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

Arizona State University  
ASU Skysong  
+1 480-884-1600

1475 N. Scottsdale Rd.  
2nd floor, Suite 200  
Scottsdale, AZ 85257