### **U.S.-PAKISTAN CENTERS FOR ADVANCED STUDIES IN ENERGY**

# ENERGIZER

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The Technology Centers gear up to meet energy sector needs in Pakistan











### USPCAS-E TECHNOLOGY CENTERS SET TO LEVERAGE PAKISTAN'S ENORMOUS SOLAR POTENTIAL THROUGH PHOTOVOLTAIC TESTING AND CERTIFICATION SERVICES

#### THE TECHNOLOGY CENTERS AIM TO BE THE DOMINANT PLAYER IN THE SOLAR ENERGY TRAINING MARKET

The U.S.-Pakistan Centers for Advanced Studies in Energy at the National University of Sciences and Technology (NUST) and University of Engineering and Technology Peshawar (UET) have realized significant accomplishments in the past five years including nearly 900 enrolled students, the development of 14 new degree programs, many new courses, ongoing stakeholder engagement, and more than 200 graduates. Financial sustainability is key to maintaining this momentum of the centers at NUST and UET Peshawar. By addressing critical energy sector needs, the centers can position themselves as significant training partners for individuals and businesses throughout Pakistan. Pakistan's solar industry is facing a huge skills gap and requires experienced workers who can ensure customer satisfaction through quality design and installations. According to the "Value Chain Analysis of Solar PV in Pakistan" report by the German Solar Energy Association and GIZ Pakistan, the country has enormous photovoltaic (PV) potential, and it has all the necessary conditions for its development and implementation. However, there is a lack of specific knowledge and expertise relating to PV in the workforce. Currently, there are no accredited facilities that offer solar PV training. Although the Technical Education and Vocational Training Authority (TEVTA) provides training to students, these are solar energyspecific opportunities.

USPCAS-E at NUST and UET Peshawar are partnering with Arizona State University (ASU) to create Technology Centers to address this gap. These centers will train students and energy sector professionals in Pakistan. The goals: provide solar photovoltaic related research, certification testing, consulting and educational services for individuals as well as for private and public sector organizations in Pakistan. In particular, the primary certification services to be provided are performance and qualification testing of PV modules according to IEC 61215 standards, engineering and design evaluation of PV modules and systems, workforce skills and competency training on the design, installation, and operations and maintenance of PV systems. Dr. Govindasamy "Mani" Tamizhmani, director of the Photovoltaic Reliability Laboratory at ASU explains: "Currently more than 90% of solar PV modules in Pakistan are being imported, many of which are substandard quality. My vision for both technology centers is to become nationally recognized and internationally accredited 'centers of excellence' on solar photovoltaic technologies, components and systems."

The Technology Center training programs began in July 2019 and are designed to be immediately applicable, enabling students and professionals to put their new skills to work directly.

Both technology centers are equipped with unique, state-of-the-art tools and equipment to enable offering the services mentioned above. These centers and their equipment can also be leveraged for research and teaching purposes by faculty and students at NUST and UET Peshawar.

#### ADDRESSING MARKET NEEDS

The Technology Center trainings are specifically designed to attract individuals who are looking to start a new solar business or want to gain or upgrade solar powerfocused skills. The target market includes individuals from a variety of positions and backgrounds: inspectors, managers, supervisors, technicians and engineers working in industries, businesses and government agencies. Current students and recent college graduates are also primary target demographics, from new science and engineering graduates to BTECH and DAE students looking to leverage their skills and knowledge in the solar job market.

The competitive advantage of the Technology Centers are the structural relationships with NUST and UET Peshawar, two well-known and respected universities in Pakistan. This relationship aids in name recognition and the marketing of their programs to potential clients throughout Pakistan.

The Technology Centers will provide certified and accredited training in a gender-inclusive learning environment. A hands-on approach will facilitate an applied learning environment fully equipped with the latest equipment and technologies. In the absence of viable alternatives in Pakistan, NUST and UET Peshawar have the unique opportunity to leverage the significant investments, human capacity and equipment in the creation of the technology centers as part of the USPCAS-E program to increase the brand recognition of USPCAS-E in Pakistan through attractive and market required skills, research, product and system services.

### THE TECHNOLOGY CENTERS AT A GLANCE:

OBJECTIVE	Provide solar PV training to individuals in the public and private sector
PRODUCTS/ SERVICES	<ul> <li>Certified Solar PV Training</li> <li>Solar pumping</li> <li>Planning, construction and management of micro hydro</li> <li>Energy efficiency and conservation in buildings and industries</li> <li>Solar business and sales</li> </ul>
POTENTIAL CUSTOMERS	<ul> <li>Master's students</li> <li>Science and engineering graduates</li> <li>BTECH/DAE students</li> <li>Managers, supervisors, technicians</li> <li>Private sector and government employees</li> </ul>
POSITIONING	<ul> <li>Certified and accredited trainings</li> <li>Hands-on approach</li> <li>Highly trained professionals</li> <li>Excellent learning environment</li> <li>Gender-inclusive learning environment open to men and women</li> </ul>

#### TRAIN-THE-TRAINER APPROACH

Arizona State University conducted a five-day train-thetrainer workshop at NUST for faculty and representatives of the solar PV industry. Each trainee learned to deliver training programs that provide vocational proficiency in the application, design, installation and operation of residential and commercial solar PV systems. They also learned how to conduct PV power plant surveys, how to identify potential material, safety and performancerelated issues, and how to conduct analyses on the impact of these issues on long-term energy production for solar PV power plants in Pakistan.

Bülent Bicer, project manager at the Photovoltaic Reliability Laboratory at ASU and the instructor of the workshop explained: "A successful market penetration of renewable energy systems requires an enabling policy framework, high-quality products and a skilled and competent workforce. The focus of this train-thetrainer workshop was to provide internationally accepted best practices and skills in the design, installation and operations of solar PV energy systems in Pakistan. Each trainee was provided with all training materials with the expectation to further disseminate the learned knowledge to professionals, technicians and students through short programs and courses. The five-day training focused on the fundamentals, design, installation and operations of PV energy systems based on international best practices, such as those promoted by the North American Board of Certified Energy Practitioners (NABCEP).

Both NUST and UET Peshawar are committing classroom and lab resources as well as key personnel. USPCAS-E NUST and USPCAS-E UET Peshawar have dedicated space to host training and lectures. The Technology Center personnel will offer short technical training programs. At NUST, the key personnel for the Technology Center are faculty member Dr. Hassan Abdullah Khalid and staff member Mudassir Ayub. At UET Peshawar, the key personnel are Assistant Professor M. Arif Khattak, Technology Center Lead Muhammad Arif, Industrial Liaison Manager Ms. Shaista Afridi, and Lab Engineer Ms. Noor Saif.

These staff members visited ASU for hands-on training at the Photovoltaic Reliability Laboratory at ASU's Polytechnic Campus, a lab headed by Govindasamy "Mani" Tamizhmani. The three-week training at ASU-PRL (ASU Photovoltaic Reliability Lab) focused on providing the technology center staff from NUST and UET Peshawar, with the fundamental knowledge of conducting PV module qualification testing activities required by the IEC 61215 standard.

Noor Saif from UET Peshawar said, "My training focused on laboratory-based testing, both indoor and outdoor. This particular activity experience greatly benefitted me in understanding what actual results can be achieved under real-time testing conditions along with the fact that what external or internal factors could hinder or favor our test results. I learned about all the quality tests that are performed under IEC 161215 and most importantly I had open access to all the latest equipment that are used in the lab and the safety procedures that we shall adopt while doing a test. I got the idea of how we are going to establish our lab in Pakistan and what else we needed in terms of equipment, area, logistics, human resources, and safety measures."

Arif Khattak from UET Peshawar said, "The training provided a model of how to establish and run the technology center at UET Peshawar. ASU provided major help in selection and procurement of the most relevant equipment."

The Technology Centers will also focus on continuous program assessment to provide the highest quality training and services. Continuous improvement efforts will include ongoing monitoring and feedback collection so the centers can determine what's working – and what's not – to adjust the offerings to meet market needs.



### ENSURING THE LONG-TERM SUSTAINABILITY OF THE CENTERS FOR ADVANCED STUDIES IN ENERGY AT NUST AND UET PESHAWAR

The technology centers provide dedicated value-add services to the public and private sector in Pakistan on solar photovoltaic related technologies. The services to the public sector would include training the trainers and technicians for university graduates and technical school graduates; technical assistance to government procurements during tender processes and international product import processes; and independent evaluations of PV power plants maintained and operated by public entities. The services to the private sector would include product certification testing, engineering testing of products and systems, independent EPC (Engineering Procurement and Construction) evaluations, and O&M (Operations and Maintenance) evaluations. These services will be promoted and marketed in line with country-specific climatic conditions and pricing. The generated revenue will enable the centers to become financially self-sufficient after a short period. Interaction with the private industry and public organizations is crucial for the long-term success and sustainability of both centers. For this reason, NUST and UET Peshawar have assigned dedicated individuals for outreach/ marketing activities.

Hassan Abdullah Khalid from NUST explained, "Such a facility will generate revenue by not only providing PV module testing and certifications but also providing additional consultancy and engineering evaluation services to the local industry/PV plants in Pakistan."



USAID has funded the USPCAS-E project for almost five years, and we are indebted to USAID for its support and vision. This quarter is the last quarter of the USAIDfunded project; both NUST and UET Peshawar have developed plans to support and continue the center's operation going forward.

The centers now have about 45 faculty, and more than 1000 MS and Ph.D. students enrolled in energy-related areas from renewables, to thermal and solar energy. By the end of this year, we will have over 400 graduates. The impact of this project goes far beyond our original goals, and the centers will continue to work on research projects that address Pakistan's energy needs.

Projects like this one exist to boost a region or a country's progress in a critical economic area. In the case of USPCAS-E, that area is energy. Energy is often an invisible resource. Its use is ubiquitous, so we often don't see its importance until its gone. With even a brief power outage, activity grinds to a halt. When these disruptions are pervasive, the results can be devastating to economic well-being.

Finding indigenous solutions is the key to sustainable solutions. The USPCAS-E project supported a culture of applied research. Building on this research environment, NUST and UET Peshawar can attract the funding needed for the ongoing support of the centers. The newly formed Technology Centers create a critical mass of high-tech capabilities that can be used by faculty and students for future research endeavors. These Technology Centers also provide a source of income for the centers by offering unique photovoltaic training programs and testing services that address unmet needs in Pakistan.

Finally, the impact of the more than 400 graduates – with more to come – cannot be overstated. These men and women are poised to be catalysts for change in Pakistan's energy sector. Their training, drive, and dedication make them invaluable resources in the creation of a secure energy future for Pakistan.

Thank you to the many faculty, staff, stakeholders, and friends who helped make this project a success. We are indebted to you. We could not have done it without your vision, dedication, and support.

#### DR. SAYFE KIAEI PROJECT DIRECTOR, USPCAS-E



### **ENGAGING STAKEHOLDERS:** 6TH STAKEHOLDERS MEETING AND THINK TANK DIALOGUE

Throughout the USPCAS-E project, Arizona State University kept its stakeholders engaged in driving private sector innovation, recommend policies for economic growth, and contribute solutions to address Pakistan's energy challenges. The stakeholder meetings provided regular opportunities to bring public and private sector experts together to foster dialogue and provide a forum for soliciting feedback and advice.

The 6th Stakeholders Meeting and 3rd Think Tank Dialogue was held in Islamabad, Pakistan, on September 24, 2019. Organized and led by ASU, this consultative meeting was attended by over 90 participants, including officials from the Government of Pakistan, Higher Education Commission (HEC), United States Agency for International Development (USAID), and industry and academic partners. The meeting also provided a forum to share the USPCAS-E program achievements, particularly the applied energy research conducted by faculty and students.

A panel discussion focused on the impact of the USPCAS-E initiative on Pakistan's energy sector and future opportunities.

Panelists included Mr. Shahjahan Mirza (Managing Director Private Power infrastructure Board), Dr. Zain ul Abideen, (Director General HEC), Mr. N.A. Zuberi (COO Three Gorges Dam), Dr. Irfan Mufti, (Dean UET Peshawar), Mr. Ali Qureshi (National Expert, United Nations Industrial Development Organization), and Ms. Misbah Faiz, (USPCAS-E alumni and founder of Khawateen Rozgar Services). The panelist commented on the centers' achievements and emphasized the need for ongoing energy sector involvement in USPCAS-E to keep it relevant to the country's needs through mutually beneficial partnerships.

During the Think Tank Dialogue, a panel discussed the role of Pakistani universities in meeting the country's energy needs, producing a qualified workforce, and conducting industrial R&D. Experts included Dr. Rana Abdul Jabbar (Alternative Energy Development Board), Mr. Hammad Hashmi, CEO GENCO 2, Dr. Naveed Arshad, (Lahore University of Management Sciences Energy Institute), Dr. Fatima Khushnud (IPP Association), and Mr. Asim Ghaffar (Vice President LMKT). They discussed various approaches to bridge the gap between industry and academia, such as project-based internships, industry mentoring, joint research projects, training and capacity building, infrastructure sharing, and joint ventures.

The one-day meeting also featured over 15 research posters that showcasing cutting-edge energy work done by USPCAS-E faculty and their students at both UET Peshawar and NUST. Key stakeholders provided technical feedback on the research projects and noted any commercialization potential.

# NATIONAL ENERGY RESEARCH AGENDA

Significant human and financial investments have been made in Pakistan's energy research infrastructure. There is now an urgent need to align these resources strategically to address national needs. Arizona State University took the lead in working with the energy research institutions of Pakistan to identify current strengths and capacities. The goal is to form a network of researchers that can work together to meet the country's energy research needs. This consultative session was organized by ASU to discuss the direction of future energy research. Researchers from nine centers attended the event (see participant list below).

Dr. Sayfe Kiaei provided a summary of the meeting objectives and explained why there is a need to formulate an energy research agenda for Pakistan. All participants introduced themselves and shared their center's research areas and activities. The group reviewed a draft energy



research agenda prepared by ASU, and Dr. Ghulam Sarwar from the Higher Education Commission shared HEC research funding opportunities under their newly established governance structure. The presentation included details of HEC's Local Challenge Fund, Grand Challenge Fund, Technology Development Fund, National Research Program for Universities, and Technology Transfer Support Fund.

### **NEXT STEPS**

- Centers are encouraged to pursue proposals in their respective domains through HEC's Grand Challenge Fund; the call for proposals will be announced between June and September 2020.
- Develop a new proposal to resolve the procurement issues affecting research work to replace the current Public Procurement Regulatory Authority rules for HEC funding.
- Review the draft energy research agenda prepared by ASU and provide written feedback, especially related to challenges that have not been addressed, such as energy policy.
- Develop a concept note on research ideas and titles for HEC's Grand Challenge Fund.
- Create a single platform that offers a hub of solution providers from industry, academia and government that can meet the energy research needs of Pakistan.
- Create a plan detailing ways to maximize Pakistan's:
  - hydropower potential
  - existing power capacity and promoting efficient usage
  - scientific expertise for policy formulation and implementation.
- Seek investment in agricultural energy technologies and renewables such as bioethanol energy.

### PARTICIPANTS

- Dr. Sayfe Kiaei, Professor, Arizona State University
- Dr. Ghulam Sarwar, Program Coordinator, Higher Education Commission
- Dr. Muhammad Munir Ahmed, Director General, Pakistan Agricultural Research Council
- Dr. Sajid Rashid Ahmed, Principal, College of Earth and Environmental Sciences, Punjab University
- Dr. Irfan Mufti, Dean, University of Engineering & Technology Peshawar
- Dr. Naveed Arshad, Associate Professor, Lahore University of Management Sciences
- Dr. Bashir Ahmad, Director, Pakistan Agricultural Research Council
- Dr. Ehsan Ali, Professor, Punjab Bioenergy Institute, University of Agriculture Faisalabad
- Dr. Khalid Khawaja, Assistant Professor, U.S.-Pakistan Center for Advanced Studies in Energy, National University of Sciences & Technology
- Dr. Tanveer Iqbal, Chairman Chemical Engineering Department, University of Engineering & Technology Lahore
- Dr. Mustafa Anwar, Assistant Professor, U.S.-Pakistan Center for Advanced Studies in Energy, National University of Sciences & Technology
- Dr. Adeel Javed, Assistant Professor, U.S.-Pakistan Center for Advanced Studies in Energy, National University of Sciences & Technology
- Dr. Shahid Imran, Professor, Mechanical Engineering Department, University of Engineering & Technology Lahore
- Dr. Anjum Rasheed, Assistant Professor, Centre for Climate Research and Development, COMSATS University



## THIS ENGINEER PUT RENEWABLE ENERGY KNOWLEDGE TO WORK

Some students earn a degree and work in their profession for a while before creating their own implementation. Not Amir Nangyal. He joined USPCAS-E at UET Peshawar and built his solar energy system after his first semester of study.

"My goal is to provide energy solutions and opportunities, research all industrial problems as much as I can and improve the industrial sector," Amir explains.

Amir is from Yarhussain, a village in the Swabi District, a district in the Mardan Division of Khyber Pakhtunkhwa province in Pakistan.

Growing up, energy crises were a fact of life for Amir. Power outages of up to 18 hours in the heat of summer were commonplace. He knew that he wanted to change the situation for himself and his country. During his first semester, he learned how to design a PV system and then installed one in his home. "I decided to be an engineer and find a solution to this problem. Alhamdulillah, for the last three years, I haven't faced load shedding because I installed a solar system in my house."

Amir explains that Pakistan lacks expertise and access to technology in almost every field. And the energy sector is no exception.

"My wish is to teach everyone about designing their own system and doing power load management."

Amir currently holds two positions. He's a project coordinator for the development of a 50MW solar power project in Dera Ismail Khan, or D.I. Khan, that is sponsored by FAS Energy (a subsidiary of the FawazAlhokair Group). He's also a technical consultant with Baker Tilly Mehmood Idrees Qamar Chartered Accounts for the evaluation and ranking of pre-qualification documents submitted to Pakhtunkhwa Energy Development Organization for the development of hydropower projects conceived by independent power producers, or IPPs.

Before joining USPCAS-E, Amir worked as an assistant manager at Spinning Mill in Gadoon Amazai Industrial Estate, District Swabi, Khyber Pakhtunkhwa. He was looking for ways to improve his skills and education in the field of energy. He knew that he wanted to develop a PV system for his home to get rid of load shedding.

At USPCAS-E, he learned how to do just that. During his exchange visit to ASU in Spring 2016, Amir worked at the Photovoltaic Reliability Lab (PRL) at ASU. His exchange opportunity provided him with critical hands-on experience with a PV system.

"At the end of the training, we were masters of solar panels and PV systems because we performed different tests for claiming warranty of PV panel, factors affecting efficiency, factors affecting materials, defects in PV panels, and causes of failure of the PV system. Because of this knowledge and experience, I got the project coordinator job, and that has boosted my career," Amir explains.

During Amir's training at ASU, he learned how to make weather stations and worked with an MTT (mobile training tool kit), performing different experiments and designing the solar energy system. By installing weather stations, Amir explains, he can get real-time data in that location, and sharing this data can help IPP's in the development of their projects.

"I want to introduce MTTs in every engineering university/ college to facilitate hands-on testing. Every student should be able to design a PV system for their own house to make the saying 'Every house is a powerhouse' true," says Amir.



Amir Nangyal, second from right, visited Intel during his exchange experience in Spring 2016.







### CURIOSITY FUELS THIS ENGINEER'S DRIVE TO REALIZE A RENEWABLE ENERGY FUTURE FOR PAKISTAN

Muhammad Ahsan Amjed is from Rajana, a small town in central Punjab in district Toba Tek Singh. He is currently a Ph.D. student at Ocean University of China (OUC) in Qingdao, China, where he studies energy and environmental engineering. Previously, he worked for the Pakistani oil and gas company Total Engineering Pvt. Ltd., where he worked on renewable energy technologies.

It was a long road to a Ph.D. program, but M. Ahsan says curiosity drove him to pursue engineering.

"My father was a mechanic, and I used to go to his workplace with my elder brother. When I was 12 years old, my brother and I started helping my father at his workshop. At that time, the economic situation of my family wasn't good."

It was hard work, but M. Ahsan was intrigued by the technology he saw in the shop.

"Technical stuff in the workshop always made me curious. I wanted to know more; like how an engine works, how it gets energy from fire, et cetera. My curiosity pushed me to study engineering."

It wasn't easy because M. Ahsan's hometown lacked the educational opportunities that would ensure that he had the high marks needed to gain admission to engineering universities.

"Working with my father at the workshop, studying late at night, dealing with limited financial resources, being from an underprivileged area, and an overall lack of guidance made this journey difficult, but sometimes curiosity works positively to achieve dreams."

M. Ahsan credits his sisters and brothers for supporting him financially and academically to make his dreams possible.

### **DRIVEN TO ADDRESS ENERGY SHORTFALLS**

For the last decade, Pakistan has faced serious energy challenges, and this has impeded economic development. M. Ahsan explains that the situation is more difficult in the countryside — places like his hometown. Energy shortages have disproportionately impacted small businesses and industries, which, he explains, have, in turn, created a sharp surge in unemployment for millions of people.

"When I was about to graduate with my undergraduate degree, this was a hot issue in my country, and it changed my dream into a passion," M. Ahsan explains.

Just after graduation, he learned about a new energy research center with advanced facilities that were being developed by USAID. That caught his attention, and he decided to apply his passion to graduate studies at USPCAS-E at NUST.

Access to a better educational environment and research facilities boosted M. Ahsan's confidence. As an exchange scholar in the United States, he gained a new perspective on international energy policies and development. His research focused on energy security in Pakistan in the hydropower sector. He studies the ways that trans boundary water tensions can impact Pakistan's water, food, and energy sectors in the future.

"My research topic was a little unique from others: I worked on the water, food and energy nexus. The transboundary water division between India and Pakistan is always a hot topic on both sides of the border; it's an issue that could cause a war between two atomic powers if the dispute remains unresolved. Due to growing energy demands, both countries are constructing hydropower stations under limited water flow. My research was to estimate future water flows and power production under different scenarios by using a black box technique of artificial neural networking. My research helped me to understand the sensitivity of that issue better, and that will help in future project designs."





### ENTREPRENEURIAL TRAINING KEY

The entrepreneurial training he received via USPCAS-E was also critical.

"Entrepreneurship training encourages lots of young scholars to start their own businesses in the energy sector. That's what I'm thinking of for the future, too."

M. Ahsan hopes that multidisciplinary knowledge and research on renewable energy will help him to create his own business in Pakistan's energy sector. He knows that the world is moving towards sustainable, clean sources of energy, so his main focus is to target the emerging markets in developing countries like his native Pakistan.

M. Ahsan says it will be an honor to be the first Ph.D. graduate in his hometown.

"Whenever I look back on my life, it seems impossible that I should be here, but my internal curiosity and continuous dissatisfaction with the status quo brought me to this point."

M. Ahsan knows that many young scholars have benefitted from the USPCAS-E program and that these benefits extend beyond each individual to their families and communities, and Pakistan as a whole.

"I would like to say thanks to USAID and USPCAS-E for supporting me at every stage and making this dream possible. It's not just the story of one person; it's the story of one family and one underprivileged small town. Most importantly, it enhanced the mutual relationship of two countries (USA and Pakistan) at a public level and helps Pakistan, from the grassroots level to higher government levels, to mitigate energy challenges."

*M.* Ahsan Amjed was an exchange scholar at ASU as part of the Spring 2017 cohort. He's now pursing a Ph.D. at Ocean University of China in Qingdao, China.

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### FOLLOWING HER HEART TO A SUSTAINABLE ENERGY FUTURE

Even as a toddler, Maham Akhlaq's father had big dreams for her and her older sister.

"It was my father's dream to see my sister become a doctor and for me to become an engineer," she explains.

Akhlaq, who is from Lahore, completed her master's degree in Energy Systems Engineering at USPCAS-E NUST in 2018. Currently, she is a lecturer at Government College University Lahore. She also works as a research associate in a lab in GC University's Physics department. There, she is working on advanced materials and their applications in electronics.

Akhlaq's father passed away when she was only two years old, but his dream became her dream. And her mother's hard work and dedication kept Akhlaq on the path to engineering. Even as a child, she wanted to understand why things happened. She remembers receiving an accidental electric shock as a child, and that immediately, she wanted to understand what had happened and why. "When I was five years old, I suffered from an electric shock while plugging in a television. For an instant, I thought, 'What was this shock, really? Why did this happen only when we plugged it in? Why did I get an electric shock?' That was probably the beginning of my fascination with electronics."

In June 2010, when Akhlaq was still in high school (FSC), there was a 12-hour electrical outage.

"Even in Lahore, one of the most populated cities in Pakistan, we still faced this much load shedding. Around that time, my mother suffered a fracture. Due to the summer heat and load shedding, she was unable to get proper rest, and her recovery was slow."

Akhlaq realized that there were many other people in Pakistan in poor health who were suffering from this massive power outage. She knew that she had to do something about it.

"I thought that as a young person in a developing country, it is my responsibility to address these issues. This energy crisis can only be reduced by relying on clean energy technologies." When she was in the final year of her bachelor's degree program, she studied solid-state electronics as an elective course. It was the course that ignited her interest in solar energy generation and solar panels.

One of my classmates told me about a new energy center at NUST that was working on introducing energyrelated solutions to address the growing energy crisis in Pakistan.

She decided to join USPCAS-E as a graduate research scholar. As part of her studies, she applied to the exchange program that would send her to study and do research in a U.S. university lab for a semester. The opportunity proved to be transformational.

"I was sent to Arizona State University during my research semester. The exchange program contributed immensely to my academic growth as well as personal growth."

Akhlaq was assigned to the Energy Materials Lab under the supervision of Dr. Zachary Holman. The work there involved finding highly innovative, efficient, and costeffective solar energy-related solutions.

"I worked with Dr. Holman and one of his doctoral students on heterojunction silicon-based solar cells, which are considered to be the future of solar cell technology. Everyone from Dr. Holman's research group was always ready to assist me; they never made me feel like we were interns who were there for just a semester."

Apart from academics and research, Akhlaq says that the exchange program was an excellent opportunity to meet people from different cultures who are working together toward a common goal.

"The work ethic and dedication towards their work really amazed me. The research project was based on the synthesis of a novel nanostructure for solar energy applications. I learned to use newly installed equipment for nanostructure synthesis. It took almost 5-6 months with continuous patience and determination to fabricate my required material. For me, my research experience showed me not only the benefits of pursuing a career in academia, but it also taught me how to stay persistent and dedicated to all of my goals."

Her research was based on advanced generation solar cells. These cells are small in structure but provide high efficiency and are low in cost. These low-cost solar cells can be especially beneficial in a country with financial issues.



FIVE YEARS FROM NOW, AKHLAQ SEES HERSELF AS A PH.D. RESEARCHER IN AN ACADEMIC SETTING Working on introducing energy-related Degrees and courses that inspire pakistani Youth to work in renewable energy.

In addition to her love for engineering, Akhlaq loves photography. She especially loves capturing sunrises and sunsets: these remind her how beautiful and amazing nature is. A self-described bookworm, she also gets inspiration from other people through their stories.

"I love reading biographies to get inspiration from other people's lives. I love reading Paulo Coelho, for example."

She explains that the central theme of Coelho's book, The Alchemist, is to pursue your dreams by following what your heart desires.

"This is my inspiration to reach my goals."

# SINGLE-MINDED FOCUS DRIVES THIS ENGINEER TOWARD A RENEWABLE FUTURE

### NOMAN KHAN HAS A SINGLE-MINDED FOCUS WHEN IT COMES TO CLEAN ENERGY: "IT'S SIMPLE: WE NEED CLEAN ENERGY."

He wants all of his friends and colleagues to stay focused, professional, and single-minded about the future of Pakistan. He believes that to make a difference, they must learn and create, invest time and money, make sacrifices, and build everything from scratch.

"We must explore innovative ideas, new research, and new technologies to get out of the vicious circle that an energy crisis creates. We have inherited a broken system, and we must rise up to the task and rid Pakistan of energy crises."

Noman is from Swabi in the Khyber Pakhtunkhwa province. Noman earned his master's degree in materials for energy storage and conversion from USPCAS-E at UET Peshawar. He is currently working as an assistant director in the Pakistan Civil Aviation Authority, which is akin to the Federal Aviation Administration (FAA) in the United States.

He hopes to continue his research but says he is currently preoccupied with his job, so it's hard to focus on academics and research. But he is learning more entrepreneurial skills inspired by Ken Mulligan, the instructor at ASU, who has taught entrepreneurship to the USPCAS-E visiting scholars.

"I see myself as not just a researcher but also someone who puts my research into practice and sells it. Research and development are key to tackling our energy problems. Educating the people, bringing more people to this field, and then creating a critical mass of researchers who can then join forces will also be crucial."

Noman also wants to establish a small think tank of fellows to discuss energy and ideas along with social and economic issues.

"It's also my dream to establish a 'freestyle' school and teach science interestingly and innovatively and encourage creativity, free-thinking, participation, initiative and leadership."

"For Pakistan to make progress, I have a simple formula: we need more billionaires, more Nobel Prizes, more Academy Awards, more Olympic gold medals. I will work to achieve this end in one way or another."



Noman had an engineering mindset from a very young age.

"Engineering was fascinating to me right from the beginning of my school days. My dad purchased a Pentium-II computer during my mid-school years, and I was fascinated with what it was capable of. I would read articles in Microsoft Encarta Encyclopedia, and that was a time when the internet was virtually non-existent in Pakistan. I would spend hours reading articles on science, and that really shaped my future course for the years to come," he recalls.

This put him a class all his own, and he admits, "I gave a hard time to my science teachers because I could read more about my subjects than they could."

But the path was not a smooth one for Noman. His family endured personal tragedies and financial crises. He was able to continue his studies through hard-earned scholarships.

Today he sees that hard work has paid off in the end.

"Engineering has not only changed me and my life for the better, but it has also changed our collective lives in this country. Our standard of living is many times better than it was a decade ago," Noman explains. Noman is still an avid learner, not just in engineering but in other sciences as well, including renewable energy, astronomy and astrophysics.

Noman explains: "It makes me more pragmatic, empowered and non-superstitious. The scientific mindset is a great gift, and one should strive hard to achieve it."

Noman was drawn to study engineering as a result of his personal experiences with energy shortages, shortages that dominated his life. It made it easy for him to choose a course of studies—he knew that he wanted to fix the electricity shortage that loomed over his life and negatively impacted his country and its economic prospects.

He explained, "Pakistan's energy problems had made our lives miserable for a very long time. We were mostly up at nights, frying in the scorching heat of summer, and it was literally a part of every discussion.

And I always hoped that someday I'd be able to do something about it."

Then came along USPCAS-E and rest, as they say, is history. Noman was in the final year of his undergraduate studies at UET Peshawar when USPCAS-E was established. The new center conducted seminars and workshops and encouraged students to look into programs being offered. Noman says he didn't think twice.

"My cohort was the first batch in the energy materials program. And it was the start of a great learning journey that I will always cherish."

Noman participated in the exchange program at ASU in Fall 2016.

"I worked on proton exchange membrane fuel cells during my ASU exchange program. With my colleagues, I developed a new catalyst for proton exchange membrane fuel cells that could lead to better fuel cell performance and lower the cost at the same time. I also published a paper on the same topic."

USPCAS-E was a life-changing experience for Noman. Not only did he learn engineering, but he also gained other things that he believes are perhaps more important. His experience with friends and colleagues in the U.S. significantly changed his thinking process.



"I worked with world-class faculty and also in a setting that was highly professional and innovative too. The cultural experience, international exposure to peoples from all parts of the world, was an absolute blessing. I have a very different (and more accurate) worldview now than I did a few years ago.

"As an exchange scholar, I visited many places that I dreamed of visiting. I learned about the American way of life, including their politics, education, cities, energy systems, and so much more. USPCAS-E is a great idea, and it will shape Pakistan's energy future in the years to come. The young men and women equipped with this knowledge will make a huge difference in my country."

"The most important aspect of my research was the simple realization that to solve our extraordinary energy problems (and associated problems), we will have to come up with extraordinary solutions."

He believes that climate change, in particular, has totally changed how future energy systems should look. He thinks fuel cells show a lot of promise, using hydrogen to electrochemically produce electricity without also producing carbon dioxide is exciting.

"For me, the fuel cell was 'love at first sight' because it is so simple yet a lot more promising than any other energy system, and one day, it will, in one way or another, change the world."

He concedes that we are a long way from that future and that more investment and research are needed to address materials and cost challenges that limit fuel cell development.

### **RESEARCH Q&A:** IMPROVING PAKISTAN'S POWER DISTRIBUTION NETWORK

We talked to Assistant Professor Arsalan Habib Khawaja from USPCAS-E NUST to learn about his recently completed USAID-funded applied research project on fault detection systems for power distribution networks.

#### How did you come up with the idea for this project?

The power distribution network in Pakistan extends for thousands of kilometers, stretching from the power grid to the domestic user side in urban and rural areas. Although upgrades have been done from time to time, the overall infrastructure is old and requires frequent repairs. Mainly, once a line undergoes any fault condition, it requires immediate attention from line repair staff. The faults include damage to support towers, line conductors or faults due to external influence such as extreme weather conditions and short circuit between conductors. Out of all such failures in the existing power distribution network, short-circuit faults are the most typical. I work in the field of electrical power, and the recurring problem was the primary driver behind my research project.

# Now that you have shared this specific issue in Pakistan's energy sector, can you elaborate on your research topic?

The clearance of short circuit faults is the duty of local power electric supply companies that are responsible for their respective urban and rural territories. More or less, all the electric supply companies handle such faults based on the fault duration. For instance, two standard divisions of such faults are 1) those cleared within twenty minutes and 2) those extending for more than twenty minutes.

The time duration also indicates the procedure for fault clearance. Faults cleared within twenty minutes are those faults which are non-permanent and occur as a result of events such as a flying bird or tree branch short-circuiting the conductors of the three-conductor (phase) power line. These faults are cleared automatically by a circuit breaker re-closure procedure by the feeder unit deployed at the grid station. Faults exceeding twenty minutes require manual intervention by line repair staff. It is evident from electric supply companies' recorded data that short circuit non-clearing tripping faults occur frequently and require manual line inspection to trace out short-circuited lines or damaged disc/pin insulators. The fault detection system that I worked on can localize short circuit faults using a minimum of two nodes between faulted and non-faulted states. The system is deployed where fault tracing is needed, whether on the main feeder length or branches. In an event, the span length closest to the fault location is identified by processing magnetic field signals deployed at respective nodes. An increase in the number of nodes improves the resolution with respect to the distance between faulted and un-faulted span length.

Real-world experiments were performed on dedicated 11kV overhead feeders of the I-10 sector in Islamabad Pakistan. The sensing modules were located at a span of 300 meters (with 100 meters between two consecutive poles), and the sensed data was sent to the data center. The designed algorithm was used to localize the faulted span. To observe real-time data on-site, a Pico Oscilloscope was employed to examine the information on a laptop or PC.

An Arduino device with GSM module and ADC (analog to digital converter) was used to capture data from the sensor and send data to the server using GPRS data sim. The setup has the following features:

- Noncontact magnetic field sensor that can be installed up to 10 feet away from distribution lines
- Wireless communication with the server over GPRS
- Own battery backup along with charging solar panel and charging circuit
- Two-way communication device controlled by server and data that can be accessed at any time
- Energy-efficient and customizable system that needs less than 250mA to run
- Waterproof casing to ensure outdoor safety

#### How is this project unique in its application?

I have developed an innovative tripping system for overhead power lines based on noncontact magneticfield measurements. The fault span is located with the magnetic field measured along the transmission line by using highly sensitive, broadband, and a low-cost magneto-resistive magnetic sensor. Further, short circuit faults are located within a few seconds, using a minimum of two nodes between faulted and non-faulted states, thus eliminating efforts for manual inspection by line staff. This project has multiple benefits, including a reduction in power outage times in events of short circuit faults for domestic consumers and preventing the danger of electrification during inspection and retrieval of the punctured pin and disc insulators.



The project is also fully scalable and implementable along the feeder to the consumer end, and it has the potential to be deployed for overhead transmission lines on top of distribution lines.

### You talked about the uniqueness of this research. What are some benefits to industry and the overall economy?

An autonomous and portable device has been developed that can be deployed at various nodes of the power distribution network to localize the fault, reduce manual efforts, and decrease black-out timings. The developed system is sustainable in the following ways:

- The per-node cost is 25,000 PKR. A practical approach can be installing each node on each of the laterals/branches of the feeder to trace the faulty node. The operation and maintenance costs are low, only 5,000 PKR per month for each of these nodes.
- 2. Distribution companies can benefit from the solution by improving their reliability indices, and thus increasing the revenue by cutting down system breakdown time.
- 3. The project has significant potential for various power distribution and supply companies and is adaptable to different terrains and weather conditions.

Assistant Professor Arsalan Habib Khawaja with ASU Professor Bertan Bakkaloglu at the completion of his exchange scholar program.

Looking at the results of field experimentation and discussion with the Islamabad Electric Supply Company (IESCO) official, this project has great potential for being commercialized. IESCO and electricity providers across Pakistan have no reliable method to localize the short circuit fault other than manual scouting of the whole area. As mentioned earlier, the commercialization of this project will ensure the fast recovery of faults on 11 kv distribution lines and prevent damage to help avoid adverse events. More features can be added to the device, such as current monitoring, peak load time calculations, and failure time monitoring. All this can be monitored through a secure remote server.

I want to add here that the marketing of this product will play a crucial role in commercialization. Marketing to other power distribution companies and stakeholders in Pakistan and participating countries depending upon the requirement of power distribution companies is essential.

#### How did Arizona State University support you?

First of all, I'm a U.S. exchange program beneficiary under the USPCAS-E project. Having spent sixteen weeks at ASU, I had the opportunity to work with very experienced and professional researchers in my field. I was able to work at ASU's state-of-the-art labs and also received training on energy policy and entrepreneurship. I learned proposal writing and industry engagement techniques and applied those in the local context. I'm proud to mention that I worked on a joint applied research project with Dr. Bertan Bakkaloglu from ASU that focused on battery health monitoring. It was a rewarding experience for me to work with an IEEE fellow like Dr. Bakkaloglu.

Credit for the remarkable industry collaboration goes to Mr. Ammar Yasser, Corporate Engagement Specialist with Arizona State University. Mr. Yasser helped immensely to get the IESCO officials involved in the fault detection project. He supported us in identifying the right people and accompanied us to several coordination meetings. So overall, ASU helped not just the technical aspects but also with industrial collaboration.



# **BUILDING ENERGY EFFICIENCY BRICK BY BRICK**

Pakistani industry and academia join forces to improve energy efficiency in the brick kiln sector

Pakistan's Higher Education Commission's Technology Development Fund (TDF) Program awarded PKR. 8.681 Million (approximately \$56,000 USD) to principal investigator Muhammad Bilal Sajid for the project "Retrofitting of Brick Kilns to Improve Energy Efficiency and Environmental Impact" as part of its second call for proposals, 2017-2018. This funding is part of each center's goal to raise at least \$1 million over the funded life of the project. Fundraising is key to the long-term financial sustainability of the Centers for Advanced Studies in Energy at NUST and UET Peshawar, and together the centers have raised more than \$2 million to date.

"We will promote energy efficiency technologies on a large scale through a systematic approach," recalls Dr. Muhammad Bilal Sajid, an assistant professor of thermal energy engineering at U.S.-Pakistan Center for Advanced Studies in Energy (USPCAS-E), National University of Sciences and Technology (NUST). Fixed Chimney Bull's Trench Kiln (FCBTK) technology is the most widely used brick firing technology in South Asian countries, including Pakistan. The FCBTK design leads to poor combustion, high fuel consumption and high particulate matter (PM) emissions. It's estimated that approximately 0.5 million tons of untreated PM, sulphur oxides (SOx), and greenhouse gases are emitted from these kilns annually. Sajid's project developed an indigenously retrofitted brick kiln based on a zigzag design that improves combustion while reducing fuel use and particulate matter emissions.

### **GOVERNMENT + INDUSTRY + ACADEMIA**

"The idea of this research project was jointly conceived by NEECA and representatives of All Pakistan Brick Kiln Owners Association," adds Engineer Asad Mahmood, Manager Technical at National Energy Efficiency & Conservation Authority (NEECA). As part of its efforts to promote energy efficiency in the building sector, NEECA realized that establishing model zigzag technology-based brick kilns would raise awareness about its economic and environmental benefits. "Since USPCAS-E aims to address national issues in the field of energy, we joined hands with the academia for this national cause and also to help us in applied research," says Mahmood. In the zigzag technology, bricks are stacked to guide airflow in a zigzag path, while fire moves in a rectangular track through the bricks. The zigzag technology increases the airflow path length resulting in better combustion, a higher heat transfer rate and uniform temperature across the kiln.

### IMPROVED DESIGN FOR A CLEANER ENVIRONMENT

"Our proposed technology is very similar to existing brick kilns in Pakistan, yet it offers superior environmental performance and is economically attractive," notes Dr. Sajid. The design includes:

Installation of Blower Assembly: The zigzag design consists of a blower assembly to force the inflow of more air (and hence oxygen) into the combustion zone of the brick kiln resulting in better fuel combustion. The blower assembly includes (i) a blower/fan, (ii) a variable frequency drive (VFD), (iii) ducting, (iv) a control system, (iv) a power supply (grid-connected, solar panels or a generator).

Change in Brick Stacking Pattern: Airflow is inducted by the blower, and the zigzag brick pattern results in better heat transfer from hot gases to bricks.

Insulation of Brick Kiln: Nearly 35 percent of thermal energy escapes from the conventional brick kiln. Zigzag designbased brick kilns address this issue by building walls, floors and top of the brick kiln with better insulation.

Training of Workforce: Training of the workforce is the critical last step in ensuring that retrofitted brick kilns operate smoothly.

"ASU has always been very dynamic in promoting industrialacademic linkages. The ASU team played a pivotal role in engaging NEECA and the Brick Kiln Owners Association, arranging field visits and meeting with key stakeholders. After several months of effort, a proposal was prepared and submitted to TDF for sponsorship," remarks Dr. Sajid. "The proposal writing and corporate engagement trainings organized by ASU helped me immensely to develop the proposal," he adds.

### **SCALING UP FOR A GREENER PAKISTAN**

In October 2018, the government of Pakistan's Punjab province put a three-month ban on brick kilns in the region as a control measure for smog, a type of air pollution caused by a combination of smoke and fog mostly during winter. That's one of the reasons why Tayyab moved ahead with the idea of utilizing personal funds, while the TDF proposal was still under review process.

"We are always looking into ways to improve efficiency and product quality, and ultimately reduce production costs," remarks Tayyab Ikram, a brick kiln owner. "The improved design saved up to 30 percent in fuel consumption and resulted in nearly 80 percent reduction in particulate matter. The payback period for retrofitting is a maximum of two years," he adds.

"The Brick Kiln Owners Association was very supportive during various phases of this project. Furthermore, the local manufacturing industry is fully capable of fabricating the blower assembly per our requirement. As a next step, we are exploring ways to automate coal feeding," says Tayyab.

Both Sajid and Tayyab envision making this kiln an exemplar for other brick kiln operators in Pakistan. They firmly believe that this improved brick kiln design has enormous potential in Pakistan and will help in transforming the brick kiln sector.



A locally engineered blower assembly reduces fuel consumption and improves quality of bricks.

# USPCAS-E EQUIPS PAKISTANI COMMUNITIES WITH THE LATEST TECHNOLOGY

### APPLIED ENERGY RESEARCH OFFERS EFFICIENCY AND QUALITY IMPROVEMENTS TO DRY FRUIT PROCESSING USING SOLAR-BIOMASS HYBRID TUNNEL DRYERS

Agriculture is often considered the backbone of Pakistan's economy. With technological advancements, farmers are switching from traditional farming techniques to innovative methods that increase production and maximize sales. Farmers in the Swat region of Khyber Pakhtunkhwa are using new techniques to dry fruit. Although fruit dehydration involves more processing time, it has many benefits: shelf life is increased, storage space is reduced, and transportation is easier. These factors also increase the number of available markets and the selling price.

This was the motivation for Dr. Suhail Zaki's idea of bringing solar technology to the fruit drying process in his applied research project, "Development of a Large Capacity Solar-Biomass Hybrid Tunnel Dryer in Swat for Long Term Preservation of Fruit Including Persimmon." Zaki is a professor of renewable energy at U.S.-Pakistan Center for Advanced Studies in Energy at University of Engineering and Technology Peshawar. "If fruit drying is managed efficiently, we can earn good revenue not only in the local industry but also in the form of foreign exchange by exporting these items and thus positively impact Pakistan's farming community," says Zaki.

### SOLAR-BIOMASS HYBRID TUNNEL DRYERS

This applied research project focused on the design, development, testing, and commercialization of solar dryers to process persimmons and other fruits in the Swat Valley. Solar-biomass hybrid tunnel dryers utilize the energy of the sun and wind to dry agricultural products, preparing them for storage and processing. The fruit is spread in even layers on drying racks inside the tunnel. The air below the semi-transparent collector is heated by the sun and spreads throughout the tunnel. The increased temperature decreases the relative humidity of the air, thereby allowing the air to dry the fruits efficiently. Also, the product is completely protected from external environmental impacts such as rain, insects, and animals.

The locally trained craftsmen can build the entire structure and transport to village areas for installation, primarily on rooftops or open fields.



### INDUSTRIAL VISIT TO PAKISTAN'S TARBELA POWER PLANT

Initially built as a water reservoir, the Tarbela project, one of the world's largest earth-filled dam, is now producing over 4,000MW electricity for Pakistanis.

Electrical Systems Engineering master's students from USPCAS-E at UET Peshawar visited the Tarbela Power Plant on July 2, 2019, as part of the industrial visits program. The scholars learned about the construction history of the project and then visited the power station. They visited the control center and got a first-hand look at the turbine and generator functioning at different levels of the powerhouse. "This visit helped me gain further knowledge of hydropower generation particularly in the area of transformer protection and turbine monitoring at powerhouses," shares Ms. Bushra, a second-semester student in the master's program.

"The visit to Tarbela Power Plant was an amazing experience for me. I saw for the first time working of an autotransformer used for the transformation of voltages (either step up or step down) according to load changes in the switchyard. I also saw single windings high-power transformers of 220kv and 500kv. Most interesting for me was seeing the governors installed on generators for the activation of primary reserves," notes another student, Mr. Azmat.

USPCAS-E arranges industrial visits for scholars to discuss ideas for possible research topics, bridge the gap between theory and practice, and help them learn about real-life industry challenges.



### LOOK ONLINE FOR MORE

FIND LINKS TO VIDEOS, PHOTOS AND MORE ON OUR WEBSITE, USPCASE.ASU.EDU

# U.S.-PAKISTAN CENTERS FOR ADVANCED STUDIES IN ENERGY (USPCAS-E)

The U.S.-Pakistan Centers for Advanced Studies in Energy (USPCAS-E) was a five-year program implemented by partners National University of Sciences and Technology (NUST), University of Engineering and Technology (UET) Peshawar and Arizona State University (ASU) from 2014-2019.

The USAID funded portion of the project concludes November 20, 2019.



### QUESTIONS AND MEDIA INQUIRIES:

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