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Assessing Impact of Grants on Clean Energy Research and Innovation: Case study of Center for Advanced Studies

Uzair Ahmed Khan[1], Dr. Najib Ullah Khan Marwat[2]
[1]MS Research Scholar, US Pak Center for Advanced Studies in Energy, University of Engineering and Technology, Peshawar
[2]Assistant Professor, US Pak Center for Advanced Studies in Energy, University of Engineering and Technology, Peshawar
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***Abstract*—** In today's global world, education is not only major driver of socio-economic development but also highly linked international arena. Therefore, both developed world and international aid agencies are interested in educational development in developing economies. The story of Pakistan educational sector is no more different. Since its inception, Pakistan remain host to international aid agencies both as in-country projects and traveling reforms. US Pak partnerships in the area of higher education with thematic focus on green energy has a long history. It is important to assess the impact to evaluate the effectiveness of donor grants in indigenous energy crises solution. This research is aimed at assessing USPCASE Project at UET Peshawar against its strategic objectives and impact. Data about project has been collected using primary and secondary data collection methods. Primary data collected from all stakeholders including Students, faculty, administration, management, university leadership, ASU staff and faculty, government organization and industry through online surveys, individual and group interviews. Data collected has been analyzed through rigorous quantitative and qualitative techniques. Statistical techniques of perceptions on key research objectives have been carried followed by content analysis for finding lines of evidences. Various statistical test like (Pi test, Chi Test) have been conducted to find significance of analysis and data. USPCAS-E has not only excelled in education but also on the forefront of research activities for government and non-government Organization. Provide revised curricula as well as financial management, governance, teaching, and other reforms necessary to make university education and research more relevant to the needs of industry and government. It has been explored that the USAID support to energy center has been properly utilized and has significantly impacted the energy sector in general and energy higher education in particular. The results also inform that keeping the center at same level of performance will be a challenging task and thus proper sustainability measures may be taken by university leadership.

***Keywords*—** Sustainability, Impact Assessment, Greener Cooperation, SDGs, Policy.

I. Introduction

Human society in 21st century is facing many challenges including poverty, health, education, migrations, energy and environment etc. These challenges are highlighted in UN Sustainable Development Goals. Sustainable energy for all is one the most important goal that impact many other areas including health, education and environment. Sustainable energy for all has following main objectives [1]:

1. By 2030, ensure universal access to affordable, reliable, and modern energy services
2. Increase substantially the share of renewable energy in the global energy mix by 2030
3. double the global rate of improvement in energy efficiency by 2030
4. By 2030, enhance international cooperation to facilitate access to clean energy research and technologies, including renewable energy, energy efficiency, and advanced and cleaner fossil fuel technologies, and promote investment in energy infrastructure and clean energy technologies
5. By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, particularly LDCs and SIDS.

Innovation is critical for transition towards low carbon economy. These includes innovations in all domains including technology, policy, finances and social systems around energy. These innovations are fostered by research center, best minds and finances. Strategically, incremental innovation in existing technologies along with radical innovation for new energy technologies are progressing with different pace globally. Though many breakthroughs were possible in past few years, yet many more challenges still need solutions. Reports by IEA indicates that public spending on Energy Research and Development has doubled from 2000 to 2012 but since then it is more stable. Energy research were allocated around 80% of total public research spending which sums around USD 30 billion

globally [8] as indicated I Figure 1.2 below. Whereas the corporate energy research spending is showing continuous growth with sums of USD 90 billion in 2019 globally.

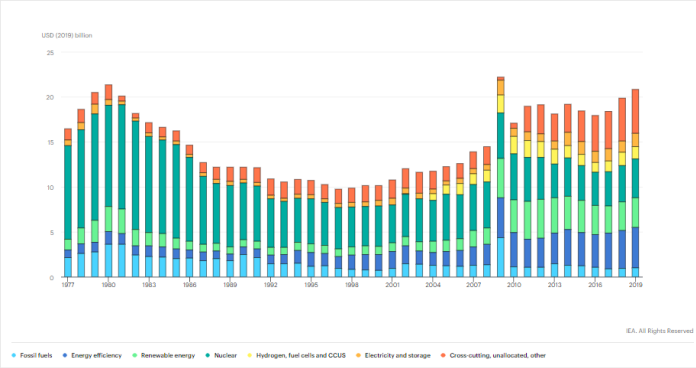

Figure 1.1 IEA public energy technology R&D and demonstration spending by technology, 1977-2019

II. LITERATURE REVIEW

In today's global world, education is not only major driver of socio-economic development but also highly linked international arena. Therefore, both developed world and international aid agencies are interested in educational development in developing economies. The story of Pakistan educational sector is no more different. Since its inception, Pakistan remain host to international aid agencies both as in-country projects and traveling reforms. The aid received by Pakistan has witnessed fluctuation over the years with its domestic social, political and economic situation (Institute of Social and Policy Sciences, 2012). This can be observed in historic aid review by United States as indicated in Fig. No 2.1. The country received first international aid with the Colombo Plan (1950), a project for socio-economic uplift of south Asian region.

It was based on the partnership concept of self-help and mutual help in the development process and focused on human resource development and South–South cooperation.

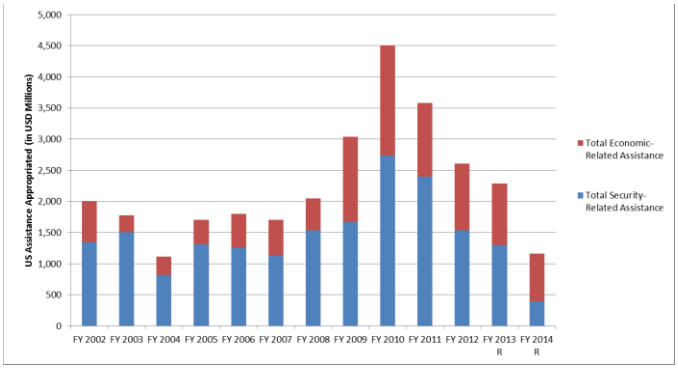

Fig 2.1 US aid to Pakistan 2002-2014 [Center for Global Development, 2014]

Under the Colombo Plan, due resources were allocated to adult literacy and diploma programs for technical skill. The adult literacy rate of about 16% remains same for a decade showing either mismanagement or restrained resources (Khawaja, n.d.). This is why international donor agencies have fluxed financial resources under Aid to Pakistan Consortium in higher education and professional education sector followed by management training programs.

The government has made important state policy of providing universal elementary education in 1956 and 1962 Constitutions. Thus required funds will be provided by government. With constrained financial resources, government opted for lending for education. Consequently, a surge from IFIs can be observed in mid-70's. World Bank education credit program for rural area, establishment of Institute for Business Administration, Jinnah Postgraduate Medical Center, the Indus Basin Project, Faisalabad Agricultural Institute and many more were established in following decades with international aid.

In conference of world education forum held in Dekar 2000, educational goals for developing countries were highlighted with strong determination that international community will fund the initiatives. Malik (2007, p. 3) states that this "aid was tied to policy initiatives to encourage the fiscal arrangements required to ensure governments spent enough and in the right place to meet international education targets." The United Nations' (UN) Millennium Development Goals (MDGs) further have stressed on universal education by defining targets, objectives and timelines. Currently, International community from around 30 nations states and other organizations are making the pool for educational aid with significant contributions from few of them for the cause for example, during 2009–11, The World Bank was the largest donor, providing USD 739.89 million for education, followed by the US (USD 291.36 million), the Netherlands (USD 88.40 million), and the UK (USD 87.4 million). It makes 97% of educational donations to developing and under0-developed economies.

In Pakistan's case, the decline in adult literacy from an already appallingly low 16.4 percent in 1951 to 16.3 percent within a decade reflected the government's inability to meet the challenge due either to the paucity of funds allocated or their mismanagement (Khawaja, n.d.). During the 1960s, as part of the International Development Association (IDA) credit under the Aid-to-Pakistan Consortium, the US extended support for setting up professional and higher education institutions and for improving local management expertise.1 With the government having committed to providing universal elementary education as a basic principle of state policy in the 1956 and 1962 constitutions, the financing of education had become avowedly a state responsibility (Bengali, 1999, p. 6). Increased IDA support, mostly from the IFIs, can be linked to the shift in thinking and lending for education in the mid-1970s. The first World Bank education credit (1972) addressed basic education, specifically targeting rural areas and girls' schooling. The World Education Forum held in Dakar in 2000 not only set international goals for education in developing countries, but also obtained commitments from the international community to ensure that lack of resources should not prevent countries from achieving the Education for All (EFA) goals. Malik (2007, p. 3)

states that this "aid was tied to policy initiatives to encourage the fiscal arrangements required to ensure governments spent enough and in the right place to meet international education targets." The United Nations' (UN) Millennium Development Goals (MDGs) go a step further by providing clearer targets and timeframes. At present, international aid for education comprises a pool of over 30 bilateral and multilateral donors, although the bulk of this aid comes from a few donors. During 2009–11, nine donors—including Australia, Canada, the EU, Germany, the Netherlands, the UK, the UN, the US, and the World Bank—provided 97 percent of all aid. The World Bank was the largest donor, providing USD 739.89 million for education, followed by the US (USD 291.36 million), the Netherlands (USD 88.40 million), and the UK (USD 87.4 million)The template is used to format your paper and style the text. All margins, column widths, line spaces, and text fonts are prescribed; please do not alter them. You may note peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

III. METHODOLOGY

This research is aimed at assessing USPCASE Project at UET Peshawar against its strategic objectives and impact. The major areas explored will include:

- Effectiveness of US-Pakistani Universities partnership
- Overall project management
- Overall project outcomes
- Sustainability of results
- Governance

In order to explore the main objectives, following detailed methodology will be applied.

3.1 Data Collection

Data about project will be collected using primary and secondary data collection methods. Primary data will be collected from all stakeholders including Students, faculty, administration, management, university leadership, ASU staff and faculty, government organization and industry through online surveys, individual and group interviews. Meanwhile secondary data will be gathered from various project reports and review documents of USPCASE. Three types of data will be collected:

I. Quantitative data through online surveys from USPCASE students and faculty

II. Qualitative data through group interviews with various stakeholders

III. Quantitative and qualitative data from USPCASE documents, project reports, quarterly and annual reports

3.2. Survey and Group Interviews

Survey questionnaire cover following main points:

- Exchange experience
- Partnership
- Research skills
- Lab Utilization
- New Curriculum
- Learning
- Entrepreneurship
- Sustainability
- Jobs opportunities

Detailed questionnaire is delineated as annexure I. Group interviews were semi structured as delineated in annexure II. A sample size of survey and group interviews are tabled as Table 3.1.

Table 3-1 Sampling Pattern of individual and group interviews conducted

Type	Students	Alumni	Faculty	Industry	Others
Individual Survey	121	13	17	5	3
Group Interview	3 (Each with 4 participants)	3 (Each with 4 participants)	NIL	NIL	NIL
Key Informants Interviews			5	12	2 USAID officials 6 UETP Leadership 2 HEC officials
Total Responses	210				

3.2 Data Analysis

Data collected will be analyzed through rigorous quantitative and qualitative techniques. Statistical techniques of perceptions on key research objectives will be carried followed by content analysis for finding lines of evidences. Various statistical test like (Pi test, Chi Test) will be conducted to find significance of analysis and data.

IV. RESULTS AND DISCUSSION

4.1 Effectiveness of Exchange Programs

Overall, 231 students from CAS/UETP, all of whom were enrolled in the M.S. program, participated in the online survey. One hundred and ten students did not apply for the exchange program, and 121 applied. Of the respondents, 20 percent believed that the selection process for the exchange program was not transparent, 25 percent did not know much about the

selection process, 52 percent found the selection process transparent, and 3 percent did not answer.

Of 121 applicants to the exchange program, 61 (50 percent) were selected and 60 (50 percent) were not. Of the 61 selected students, 15 did not participate in the exchange program. Of those participating, 22 percent did not agree that CAS prepared them well before the start of the exchange program; however, 96 percent believed that ASU adequately supported them in adjusting to the new environment during the exchange program. The percentage of students who confirmed the support of their U.S. partner university was higher at UETP than at the other two CASs (86 percent at NUST and 75 percent at MUET).

Among UETP student respondents, 85 percent found the exchange program helpful in improving their applied research skills, and 15 percent did not. The survey also found that 80 percent of students found the exchange program helpful in improving their applied research output. Of the 46 students who responded to the question on improvement in proposal writing skills, 36 (78 percent) found the exchange program helpful in improving their proposal writing skills, and 22 percent did not as indicated in Figure 4.1.

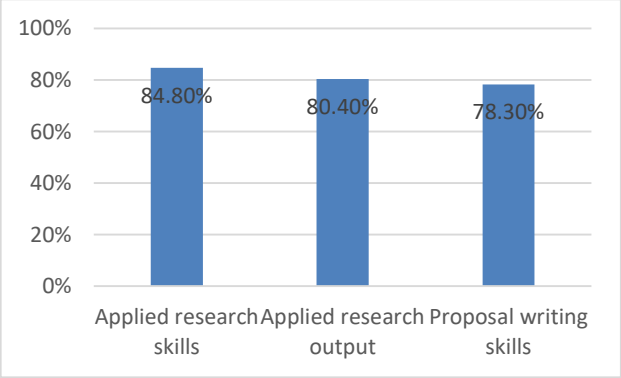

Figure 4.1: Improved Student Applied Research Skills, Applied Research Output, and Proposal Writing Skills at CAS/UETP

4.2 Qualitative Analysis of Exchange Program impacts and outcomes

The evaluation team conducted three group interviews with current UETP students. The data showed that the exchange program was helpful for students in improving their skills in applied research, utilizing the equipment in the labs, problem solving skills, and communication. One of the students said, *"My research skills were polished. Before going to Arizona, I didn't have any experience. I used to read research papers but was totally blank in understanding them because I was not exposed to technology at all. I didn't have experience with machines, characterization techniques, and how the research is done in real time."* Students also found the exchange program helpful in improving their problem-solving ability along with their research skills. One student shared his views as follows: *"For students, improvement has been seen in my opinion. Their technical and critical thinking skills and their command over the subject in which they have performed their research at ASU."*

The qualitative data also reflect that the exchange program helped students in writing more research papers and developing more research ideas. Students also found that professors at ASU helped them in changing their perspective about education, technology, research, and engineering.

Students also experienced the use of labs for their research work at ASU and considered this to be helpful. ASU staff showed the exchange students all the relevant labs at ASU, and the students had a chance to work in the labs of their interest. One of the students had an interest in working in the policy research lab, and during the exchange program he had the opportunity to work in ASU's policy research lab. Most of the UETP students also worked on their research related to their theses as they did not have labs set up at UETP at that time and they wanted to utilize this opportunity effectively. A few of the students studying materials for energy storage and conversion also did research work in the materials and characterizations labs at ASU.

Qualitative data also show that some of the students lacked confidence and effective presentation skills. Data from interviews with students and faculty show that students from UETP improved both their confidence levels and their presentation skills. UETP faculty also noticed a change in the students who went on the exchange program, especially female students. Faculty believed their students were more confident and comfortable interacting with fellow students and also with the teachers after the exchange.

Students highlighted a few challenges they faced regarding the exchange program. One challenge was the timing of the interviews. Students felt that having interviews for the exchange program while they were preparing for exams was too hectic. A few students also raised concerns over the selection process. One said, "*My name was on [the] notice board; however, they said you were not selected. When I questioned [this], they said we had received email from ASU. Then I asked them to show me the mail, and they said this is confidential.*"

Another challenge raised by UETP students concerned research proposals. One student said, *"UETP students in [the] exchange program do not have [a] research proposal ready when they go on [the] exchange program. A core reason is sending of first- and second-semester students on the exchange program, whereas NUST selects its exchange scholars from the third semester and they have the capacity to develop research proposals by the time they get to enroll in the third semester.*

4.3 Assessment of exchange program for faculty

Overall, 14 faculty members from UETP participated in the online survey, and of these, only 4 applied for the exchange program. Among the four applicants, only one faculty member was not selected for the exchange program, and the remaining three selected faculty members participated in the exchange program. Two of these three faculty members said that the exchange program helped in improving their applied research skills and research outputs. They also felt that the exchange program improved their teaching and proposal writing skills.

In-depth interviews were conducted with five faculty members. Faculty members who were on the exchange program at ASU at the time of the evaluation were interviewed on Skype. Interview data show that most of the faculty members who did not apply for the exchange program held a Ph.D. from a

European university and felt that a program lasting only a few weeks would not make much difference to their professional development. One of the respondents shared his perspective of the exchange program by saying, "*My master's is from Sweden … from [one of the] top 50 universities in engineering. My Ph.D. is from Denmark, and with five and [a] half years of exposure in European universities, my research skills are well developed; therefore, [a] six-week program did not make any difference*."

Some faculty members thought it was better for them to stay in Pakistan and work with their students rather than participating in the exchange program. They felt that being away from their students for four months was a challenge and that the students needed their time. They could work virtually with the ASU team rather than going on the exchange program. Others did not opt for the exchange program due to personal and family issues.

All the faculty members participating in the exchange program felt that the program improved their teaching skills and applied research output; in addition, they initiated joint research projects. Some of the faculty members who did not apply for the exchange program had a different perspective, and they believed that the exchange program was not well planned or well structured.

The low ratio of exchange program applicants among the faculty at UETP indicated that the faculty did not see value in the program. They also were not provided with a clear and detailed plan for the duration of the exchange program. The exchange program for faculty is open-ended and does not require deliverables to be submitted over the course of the program or include a follow-up program with exchange faculty. The ASU local team in Pakistan also did not notice differences in exchange faculty after they returned from ASU; however, they found the program very useful for students at UETP.

4.2 Joint Research, Applied Research, and Public-Private Partnerships

Fourteen faculty members responded to an online survey regarding joint research, applied research, and public-private partnerships. The majority of faculty (64 percent) were involved in applied research at CAS/UETP (**Error! Reference source not found.**). Nine faculty members responded to the question on the relevance of applied research to energy sector organizations' needs; 78 percent strongly agreed that their research is relevant to the needs of energy sector organizations. Overall, 93 percent agreed that applied research topics are aligned with the explicit needs of the energy sector, and only 7 percent disagreed. UETP faculty agreed that energy sector organizations are participating in and supporting applied research being conducted at UETP. Satisfaction (i.e., satisfied or extremely satisfied) with the selection process for applied research projects was reported by 86 percent of faculty, and the same percentage was satisfied with grants for applied research projects. However, 7 percent were extremely dissatisfied, and another 7 percent were dissatisfied. Of the UETP faculty respondents, 14 percent were not satisfied with the technical support provided by ASU regarding applied research projects, and another 14 percent were extremely dissatisfied; however, 71 percent were either satisfied or extremely satisfied with the ASU support. Concerning autonomy for using research grants, 14 percent of faculty were either dissatisfied or extremely dissatisfied, 64 percent were satisfied, and 21 percent were extremely satisfied. Nearly all the responding faculty (92 percent) agreed that the labs contributed to improving applied research at UETP; 9 percent of faculty did not agree.

During interviews, faculty discussed three joint research projects that UETP initiated with ASU. These projects are mostly in the initial phase of procurement, and no results have been reported to date. The projects include:

During interviews, faculty discussed three joint research projects that UETP initiated with ASU. These projects are mostly in the initial phase of procurement, and no results have been reported to date. The projects include:

1. Integration of biomass PV and micro-hydro;
2. Energy generation from biomass; and
3. Energy policy.

The faculty believes that these joint research projects will be helpful for the energy sector of Pakistan. The UETP faculty and ASU interviews indicated that both universities engaged in a consultative process with the sector organizations to prioritize the joint research projects and that the universities then discussed and finalized the joint research projects. An ASU respondent further shared that the target of five joint research projects has been achieved with two additional projects recently awarded. Three cycles of joint research project funding have been completed. A faculty member from UETP explained the review and evaluation process for joint research projects by saying, "*There are two levels for reviews, one is midterm and one is that final level of review. There are technical advisors from ASU, and in both these evaluations, we have the technical advisor from UETP as [a] member of the committee. [The] committee monitors the progress of joint research projects.*"

Since ASU works with both UETP and NUST, the three universities have encountered major challenges in working together, mostly in terms of administration and competition between UETP and NUST regarding joint research projects. A respondent from ASU shared his view that "*NUST and UETP had [a] rivalry as ...* [a] *big brother, big sister rivalry, maybe, but it was resolved in the later cycles.*" Faculty also raised issues with the distribution of funding between ASU and UETP (**Error! Reference source not found.**). The faculty point of view was that most of the fieldwork is done in Pakistan, and fieldwork requires funding; however, a major part of the funding goes to ASU, and this has been a challenge for UETP faculty. One faculty respondent said:

- *"The research grant that we get is $30,000, while $40,000 goes to ASU. The problem with some of the projects is that everything is done here like data collection [and] fieldwork, so [a] major chunk of the money goes to these operational expenses. I suggested [they] do something—at least they should provide some support in surveys or provide us some software, which could cover our cost. The distribution of money is not rational, and I think more … should be given to [the] Pakistani partner as we collect data, [do]*

fieldwork, and provide them, and they just do analysis."

Faculty members also shared that they should be equally involved in decision-making. As one said, *"We should be equal in terms of decision and monetary terms. I raised this point many times."*

ASU professors and researchers have not been able to visit Pakistan for joint research projects, and UETP faculty has to communicate distantly; both UETP faculty and ASU respondents highlighted that this has been a challenge. An ASU respondent said, "*I think the distance is obviously one of the issues, but that is always the case, even with joint projects in the U.S., we have projects with, no matter how many Skype calls we have, face to face makes a significant difference.*" UETP also highlighted that the review process from the ASU side takes considerable time and gave the example of current joint projects: "*The process with ASU is too lengthy, for example the project, which I am going to do today, the process to get it, started from October. It's like almost seven months.*

The UETP CAS administration was asked about the challenges in joint research projects. An administrator explained:

- *"[What] we were expecting is not there. It's not physically there on the ground. I cannot see any American person coming here and working and using or deploying these technologies. This is the first thing, and [the] second thing is I cannot see the impact. If there is a project going on, nobody knows what is the scale and what might be the bigger impact. Realistically, I do not see any major impact so far. I was very keen that if [the] U.S. university can help us in technology transfer because they have the labs, they have robust mechanisms, and we were very keen if they give us some of the product. Our experts can re-fabricate those here and then [they] can be brought into the market. That was my expectation, but unfortunately we are not up to the level or up to that mark yet."*

To identify applied research projects, CAS/UETP has an open call for project proposals, which are selected based on their relevance to meet the needs of the energy sector in Pakistan. There are many applied research projects in the implementation phase, but no project has yet reached the product development and commercialization stage. When the PMU leadership was asked about significant contributions made by CAS to applied research, a respondent replied:

- *"I will say, 'No.' I can tell you the four components of applied research, one is [research and development], the second one is proof of concept, the third one is pre-commercialization, and [the] last one is commercialization. Even in [the] U.S., when I am talking about Silicon Valley, it takes almost nine years. We actually started back in 2015, and we started from … scratch, so … [the] time … is very short, and making some new materials and [bringing them] to the market is something which realistically no one expects. The second thing is that we do not have [a] supporting ecosystem in Pakistan."*

There was evidence of some interesting applied research projects related to integrated energy modeling and power factor improvement. In interviews conducted with energy sector organizations, there was clear excitement and interest in working closely with UETP. Interviews conducted with Pakhtunkhwa Energy Development Organization (PEDO), Peshawar Electric Supply Company (PESCO), and Khyber Pakhtunkhwa Oil and Gas Company Limited (KPOGCL) showed that sector organizations are looking forward to working with CAS faculty and students on applied research projects. PESCO highlighted challenges in power theft and line losses and also the need for a system to identify when transformers need maintenance before they break down. PESCO wanted to work closely on applied research projects related to power distribution and net-metering as well. There has not yet been any project initiated with PEDO or PESCO. The significant results of applied research are not yet apparent. Moreover, relationships with the sector organizations have developed quite recently and are limited to only a few meetings and discussions at the junior level. The higher management of PEDO and PESCO has not yet become involved, and no formal MOU is in place. A sector organization respondent said, *"There is no applied research, the only focus is on copy and paste, no field exposure. If they are given field exposure, they can give good results."*

Students also responded regarding the relevance of applied research to the needs of the energy sector. One replied, "*We feel there is no linkage between academia and industry.*" They also felt that the unavailability of labs, limited applied research funding, and slow process of proposal acceptance have been major challenges for applied research. The students' perspective was that the research activities undertaken at UETP are primarily for academic purposes and that these activities have little to do with research that can solve the country's energy issues. The students felt they were involved in research that may have academic merit but does not offer anything to the energy sector of Pakistan.

Energy sector organizations were consulted in the technical review of applied research projects, and a representative of the sector organizations sits on the review committee. CAS/UETP leadership and sector organizations were also satisfied with the process in place for conducting applied research that will meet the needs of the energy sector. ASU highlighted that there are set rules and policies and a template for applied research projects, which are shared with the UETP faculty and other stakeholders. ASU provided its review, feedback, and support in the absence of technical advisors.

CAS alumni were also interviewed and shared their views regarding public-private partnerships. A representative said, "*Honestly, on paper they have [public-private partnerships]; in reality a lot is to be done. There are MOUs they have signed but no follow-up—there was no result.*" Recent MOUs have been signed with Haier and the National Transmission and Dispatch Company. There were also discussions and meetings with the Pakistan Air Force and Heavy Industries Taxila to build partnerships with the center to address their energy and materials research. The recently established industry liaison office has

also been actively trying to engage organizations from the government and private sector. There have been efforts and meetings to establish working relationships with PEDO and PESCO, but these partnerships are at a very early stage of discussions. Sector organizations need the clarity and confidence provided by the center's showing that it can provide solutions to their problems and that it has the capacity to deliver. The outreach and linkages between sector organizations need to be enhanced to build the center's reputation for excellence in the energy sector. KPOGCL has a strong working relationship with CAS/UETP and provides considerable support to the center. The CEO of KPOGCL is on the curriculum review committees and also teaches as a visiting faculty member in the energy management and sustainability degree program. However, UETP relies mostly on KPOGCL, and there is a need to expand the scope of partnerships and also involve other sector organizations in applied research and curriculum review committees.

3.2.1. Lab Utilization

Overall, 79 percent of UETP faculty (n=14) participating in the survey said that labs were operational, and 21 percent said labs were not fully operational at UETP. Of UETP faculty, 82 percent believed the lab facilities were easily accessible, and 18 percent believed they were accessible. Lab usage by faculty was reported as follows: 18 percent rarely used lab facilities, 72 percent used labs frequently, and 9 percent used them very frequently. Over four-fifths (82 percent) of faculty used labs for teaching, and the same percentage used them for their research work. More than one-fourth (27 percent) of faculty believed that the labs were not adequate to meet their teaching needs. More than one-third (36 percent) of faculty believed the labs significantly improved the quality of applied research, 55 percent believed they somewhat improved the quality, and 9 percent believed that there was no improvement in applied research quality because of the labs.

Among the UETP students surveyed, 73 percent said the labs were operational. In terms of accessibility, 17 percent of students believed labs were not easily accessible, 1 percent said they were not accessible at all, 38 percent believed labs were easily accessible, and 44 percent said labs were accessible. In terms of lab usage, 13 percent of students said they never used labs, 31 percent rarely used them, 45 percent used them frequently, and 11 percent used them very frequently. Regarding whether the labs improved the quality of applied research, 39 percent of students believed they improved the quality of applied research, 40 percent said they improved it somewhat, and 9 percent believed the labs made no improvement to the quality of applied research. Eleven percent of students were dissatisfied with the lab equipment, and 1 percent were extremely dissatisfied and believed that the lab equipment was not adequate to conduct applied research.

Qualitative data regarding the labs and their utilization was collected through interviews with students, faculty, sector organizations, HEC, and USAID. In response to questions regarding labs, students said that the labs were operational and that they were provided with training to use the lab equipment. Some of the students provided a different perspective, saying that they were not given training to use the lab equipment, but that the engineers working in the labs helped them a great deal. Students also highlighted that they could access the labs on weekdays but could not work on weekends, as lab engineers were not available on weekends. One student commenting on the adequacy of labs for applied research reported:

- *"Labs are not here for applied research and … faculty isn't professional. I raised [this] specifically with [the] head of department regarding the labs. … I have told them the faculty should not be like the way it is right now. The labs must be inaugurated. The equipment is lying here for the last one year and it isn't yet opened for students. They say they have problems from HEC. I have been to [the] materials research lab [and] we had [an] XRD machine; it took 16 days coming from Germany to here. I don't know where are those written things, like a lab should be opened for students in two years. They don't have enough knowledge and experience to run these things."*

Another student responded and said, *"That's a very good facility; however, faculty don't have [the] knowledge to run these facilities and how they work, and if they go out of order how to fix them. They have hired contractors from China and Germany."* All the students agreed that their research work was affected by the delays in operationalizing the labs and that they did not get a chance to work on the equipment in the labs. Another student shared an example of a student whose research work was affected:

- *"One of my friends … graduated from GIKI [Ghulam Ishaq Khan Institute of Engineering Sciences and Technology]; he then … enrolled here in CAS. He started his research back in January 2017; now it's May 2018 and he still has to perform two tests of XRD and Scanning Electron Microscope. He is asking … the faculty to use the lab for these tests, as materials lab installation is complete. He has been told that you have not maintained [a] specific account for the usage of [the] lab. He has been asked to submit the application to use the labs. He chooses his research topics based on the lab and equipment availability. He waited till August 2017 for [the] labs to [be] functional …. [then he was] sent to NUST and GIKI to use their labs."*

Faculty believed that 70 percent of labs were operational and that students were using the labs with the supervision of lab engineers. One faculty member said:

- *"Labs have just been established in [the] last three or four months. The equipment is interlinked, and labs are being utilized 70 percent; however, there are some issues of costing because if our students were performing the tests free, then our systems would be degrading. For students to use labs, there is budget allocated for them, which is 1 lac, so out of this money he can utilize the labs, but we cannot give a free hand to the students to use equipment because if you give free hands others will not get their turn. For thermal system engineering, we don't have [many] facilities because this was started last year, and I tried my best because I joined the center in April, and the target was*

to establish labs by [the] end of [the] first semester, but due to funding issues, approval from USAID [was] delayed, and this is [the] end of the second semester, and we have yet to establish one of the labs. We don't have any thermal energy lab, so no utilization."

ASU respondents also shared their perspective regarding labs and their utilization. ASU found the labs to be the most critical and challenging component. The ASU team believed that students were properly utilizing the labs as well as some of the equipment, which was solely for training purposes. A week-long training program is provided to the students on the use of specific equipment. One ASU respondent reported, *"Most of the equipment [is] accessible to students; however, there is some sophisticated equipment which I don't think could be left to students, like [the] electron microscopes and others. This equipment needs well-trained operators. I think that is one of the ways to better utilize the equipment."* An ASU respondent also commented on lab utilization by sector organizations:

- *"The services of labs are being availed by the energy sector, including NEECA [the National Energy Efficiency and Conservation Authority]. We also have [an] energy auditing kit, and we are approached by the industry for energy auditing services. When we arranged [an] industry visit, the industry wanted their employee to be trained on the lab equipment that we have in the center. We are trying to facilitate the industry to use the lab equipment. The focus on weekend use, evening hours opening, etc., is already a part of the process. We're trying to use infrastructure better."*

Sector organizations were also asked if they have used the labs. A respondent from PESCO said:

- *"We have not used it yet; however, we visited it last month. We have already submitted it to [the] chief, and after the chief's visit something will happen. We are also having time-to-time training of our management in [the] power sector, electronics, and electrical power lab. We will keep it for visits. Whatever is taught in our staff colleges is an old technology, and it is all shifting on [to the] new one now. We want to bring our staff here for training.*

The KPOGCL respondent said:

- *"I am an electrical engineer, and I have seen the equipment lying dormant with UETP in the past, and some of the equipment used by oil and gas still lying dormant in the campus. We had a number of meetings with the professors. We proposed a number of ways to utilize them, and we have given the rates—this is their rate and you charge this rate, and this is so automatic that you don't need to do hard work. Fortunately, things are very easy for oil and gas. … We have taken rates from HDIP [Hydrocarbon Development Institute of Pakistan], OGDCL [Oil and Gas Development Company Limited], and other departments; however, there is a kind of mental block at the university to market it."*

The respondent from PESCO said:

- *"Yes, I know about their labs, and I have visited all of them including [their] technical lab, metallurgy lab, policy lab, and computer lab. We can get a lot of help. [The] power lab will be very helpful, and they are working on smart grids because it is a basic need for the future, and we can work with them. The lab that I've visited is well equipped; one smart grid is being established in PESCO headquarters, and hopefully we will be able to get help from them regarding the smart grids."*

One lab engineer, supported by research associates, works at each lab. The evaluation team collected qualitative data from the lab engineers. One engineer reported:

- *"The trainings are offered on a daily basis from 8:30 to 10:30 a.m. Only two lab engineers were there for five labs, and only three labs were reported to be in students' use: solar PV, material characterization, and material synthesis. All these are fully functioning and regularly in use. Students spend eight hours a week in [these] three labs. Moreover, students of UETP are also facilitated and they are charged for using labs. Charges that applied to students are deducted from the grants of projects they were involved in. Students are not permitted to use the lab equipment independently without mandatory trainings. I don't think that there are any challenges. Students are allowed to use lab equipment even after office hours, however, only when the lab engineers supervise them."*

Most of the labs are operational at UETP, except the thermal energy lab, and some other labs are missing equipment. Materials synthesis and materials characterization labs were set up at CAS/UETP to meet the research needs of the materials for energy storage and conversion degree program, which was later terminated, and the center started a new program on renewable energy. These labs were recently merged into the renewable energy lab. No detailed needs assessment was performed before initiating the Materials for Energy Storage and Conversion (MESC) program and setting up the materials synthesis and characterization labs. Students enrolled in the MESC program chose their research projects based on the hope that these labs would be available. However, the labs were installed late, and students had to go to other universities to work on their research projects; some of the students were told by faculty to opt for only simulation-based projects due to the unavailability of research labs. This situation has affected the research of the MESC program's students.

CONCULSION

Human society in 21st century is facing many challenges including poverty, health, education, migrations, energy and environment etc. These challenges are highlighted in UN Sustainable Development Goals. Sustainable energy for all is one the most important goal that impact many other areas including health, education and environment. In today's global world, education is not only major driver of socio-economic development but also highly linked international arena.

Therefore, both developed world and international aid agencies are interested in educational development in developing economies. In research and development, Universities are capable to make significant contributions. They can put together diverse set of expertise from different disciplines to spur new innovative ideas, thoughts and un-biased perspectives on the subject. They provide new knowledge, new understandings, technologies and trained human resources able to deal with complex energy problems of twenty first century. That's why huge investment as presented are poured to universities for energy innovation. Aligned with targets fixed by UN SDG No 7, developed nations and international development sector organizations have invested in energy educations and research in less developed countries. Overall, 231 students from CAS/UETP, all of whom were enrolled in the M.S. program, participated in the online survey. One hundred and ten students did not apply for the exchange program, and 121 applied. Of the respondents, 20 percent believed that the selection process for the exchange program was not transparent, 25 percent did not know much about the selection process, 52 percent found the selection process transparent, and 3 percent did not answer.

Of 121 applicants to the exchange program, 61 (50 percent) were selected and 60 (50 percent) were not. Of the 61 selected students, 15 did not participate in the exchange program. Of those participating, 22 percent did not agree that CAS prepared them well before the start of the exchange program; however, 96 percent believed that ASU adequately supported them in adjusting to the new environment during the exchange program. The percentage of students who confirmed the support of their U.S. partner university was higher at UETP than at the other two CASs (86 percent at NUST and 75 percent at MUET). It has been explored that the USAID support to energy center has been properly utilized and has significantly impacted the energy sector in general and energy higher education in particular. The results also inform that keeping the center at same level of performance will be a challenging task and thus proper sustainability measures may be taken by university leadership.

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Mr. Uzair Ahmed Khan is MSc research scholar at MS in Energy Management and Sustainability at US Pak Center for Adcanced Studies in Energy, UET Peshawar. His reaearch focus on global development, energy and environment.

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