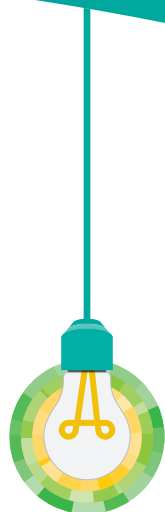
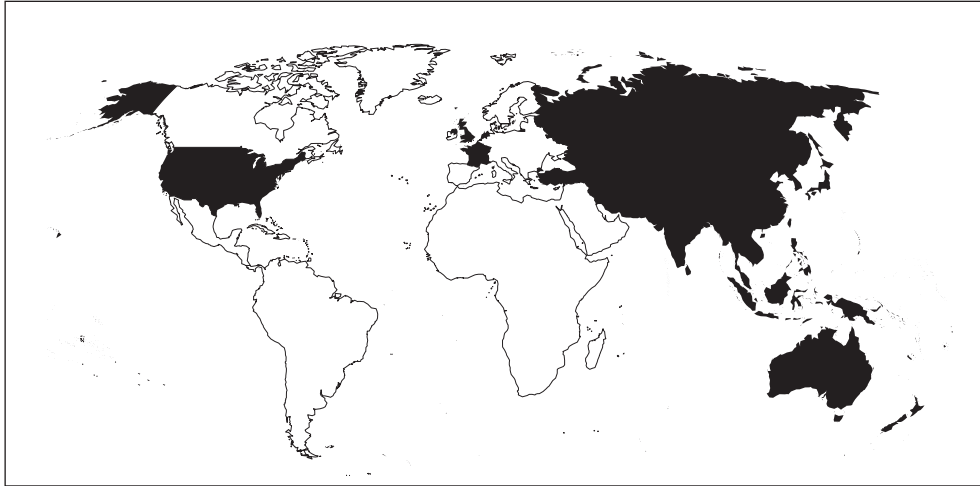


Fostering a **Green, Affordable and Inclusive** Energy Transition in the Impoverished Regions of Pakistan



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Economic and Social Commission
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Fostering a Green, Affordable and Inclusive Energy Transition in the Impoverished Regions of Pakistan

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Contents

Acknowledgements	ii
List of acronyms and abbreviations	v
Executive Summary	vii
Chapter 1: Introduction	1
1.1 Background	1
1.2 Significance of SDG 7 and the just energy transition	3
1.3 Growing focus on off-grid renewable energy to provide energy access	5
1.4 Nexus between energy access and energy poverty	6
1.5 Scope and objectives	8
Chapter 2: Electrifying Pakistan: Unraveling the status quo and challenges persisting in the power sector	9
2.1 Current state of electricity access across Pakistan	9
2.2 Challenges in achieving universal access to electricity in Pakistan	11
2.3 Institutional governance and development projects for rural communities in Pakistan	13
Chapter 3: Decentralized renewable energy systems in Pakistan: A perception survey of energy-deprived regions	15
3.1 Case Study 1: Socioeconomic impacts of micro hydropower plants (MHPPs) in Pakistan	15
3.2 Case Study 2: Opportunities and challenges: The case of solar decentralized systems in Pakistan	20
Chapter 4: Frontiers of change: The way forward for RE developments in impoverished regions of Pakistan	29
4.1 Harnessing the potential of decentralized renewable energy	29
4.2 Mobilizing the finance for upscale of decentralized RE solutions	30
4.3 Policy frameworks and institutional support for decentralized RE	31
4.4 Scaling-up of off-grid systems	33
4.5 Addressing social and gender challenges	33
4.6 Fostering regional cooperation	34
Annex 1: ESMAP energy access multi-tier framework	35
Annex 2: Number of people served through off-grid energy access	36
Annex 3: Nexus of energy access with different indicators of SDG goals	37
Annex 4: Programs for improving energy access in rural residences of Pakistan	38
References	40

List of figures

Figure I.	Challenges for decentralized renewable energy solutions in Pakistan	viii
Figure II.	Challenges pertaining to effective implementation of MHPP models in Pakistan	ix
Figure 1.	Impediments to Pakistan’s growth from the polycrisis	2
Figure 2.	Key indicators of the SDG 7 Road Map for Pakistan under different scenarios	4
Figure 3.	Aspects of an enabling environment for decentralized renewable energy	5
Figure 4.	Transitional Needs for Vicious Cycle of Energy Poverty	7
Figure 5.	Energy poverty across income quartiles	7
Figure 6.	Status quo of electricity consumption and grid access in Pakistan and across other regions	9
Figure 7.	Electricity access across different provinces in Pakistan	10
Figure 8.	Proportion of households between Aggregate Tier 0 and Tier 2, by province	11
Figure 9.	Challenges for on-grid power systems	12
Figure 10.	Key outcomes targeted through surveys	15
Figure 11.	Socioeconomic impacts of MHPPs on communities (survey results)	17
Figure 12.	Projects under the Hydropower and Renewable Energy (HRE) Program of Kreditanstalt für Wiederaufbau (KfW) and Pakistan’s Poverty Alleviation Fund (PPAF)	21
Figure 13.	Electricity source of number of households and their electricity requirements	22
Figure 14.	Community (No. of households) level of satisfaction for different electricity sources	23
Figure 15.	Key challenges hindering the growth of decentralized solar systems in energy deprived regions	23
Figure 16.	Impact of factors (average rating) enabling the push towards decentralized solar systems (10 being most important and 1 being the least important)	24
Figure 17.	Awareness level of survey region around decentralized solar energy systems	25
Figure 18.	Willingness of unelectrified households to adopt off-grid systems against potential financing support	25
Figure 19.	Households’ response toward potential financing support for technology adoption	26
Figure 20.	Off-grid RE challenges due to absence of an institutional and policy framework	32

List of tables

Table 1.	Off-grid challenges for electricity access in Pakistan	12
Table 2.	Challenges in installation, operation and maintenance of MHPPs in Pakistan	19
Table 3.	Average technology cost for off-grid technologies	26

List of acronyms and abbreviations

ADB	Asian Development Bank
AEDB	Alternate Energy Development Board
AJK	Azaad Jammu and Kashmir
AKRSP	Agha Khan Rural Support Programme
COVID-19	coronavirus disease
CSOs	civil society organizations
CPI	consumer price index
CO₂	carbon dioxide
CAGR	compounded annual growth rate
DISCOs	distribution companies
ESCAP	Economic and Social Commission for Asia and the Pacific
ESMAP	Energy Sector Management Assistance Programme
FDI	foreign direct investment
GDP	gross domestic product
GHG	greenhouse gases
GB	Gilgit-Baltistan
GW	gigawatt
HIES	Household Income and Expenditure Survey
IMF	International Monetary Fund
KPK	Khyber Pakhtunkhwa
kW	kilowatt
LCOE	levelized cost of energy
MHPPs	mini/micro hydropower plants
MDBs	multi-lateral development banks
MoCC&EC	Ministry of Climate Change and Environmental Coordination
MoFA	Ministry of Foreign Affairs
MoE	Ministry of Energy

MoPD&SI	Ministry of Planning, Development and Special Initiatives
MW	megawatt
NTDC	National Transmission and Despatch Company
NVTTC	National Vocational and Technical Training Commission
NEPRA	National Electric Power Regulatory Authority
NGOs	non-governmental organizations
PPAF	Pakistan Poverty Alleviation Fund
PEDO	Pakhtunkhwa Energy Development Organization
PBS	Pakistan Bureau of Statistics
PPIB	Private Power and Infrastructure Board
PSA	Pakistan Solar Association
PPAs	power purchase agreements
PPPs	public-private partnerships
RE	renewable energy
SDG	Sustainable Development Goal
SDPI	Sustainable Development Policy Institute
SRSP	Sarhad Rural Support Programme
SAARC	South Asian Association for Regional Cooperation
SBP	State Bank of Pakistan
TEVTA	Technical Education and Vocational Training Authority
WAPDA	Water and Power Development Authority

References to dollars (\$) are to United States dollars unless otherwise stated.

EXECUTIVE SUMMARY

Access to reliable, affordable, and modern energy for all (Sustainable Development Goal 7) is critical for socioeconomic development, addressing climate change, and improving the overall quality of life across the world.

Despite significant progress since 2010, the world is still not on track to achieve the targets prescribed under Sustainable Development Goal 7 (SDG 7). Globally, as of 2021, almost 675 million people still lack access to electricity, driven by some common challenges including mainly poor or non-availability of reliable grid infrastructure, low demand of electricity, economic uncertainties, currency devaluations, inflation, limited fiscal space, supply chain bottlenecks and increasing price of raw materials. Yet, the problem of access to electricity is aggravated in off-grid rural areas where expanding grid infrastructure puts a heavy burden on economies and national governments that lack the capacity and willingness to invest in grid infrastructure. The progress on SDG 7 however has varied across the Asia-Pacific region. The region observed a significant drop in people without access to electricity (157 million people in 2020 as compared to 545 million in 2010), though challenges persist in many countries due to unreliability and unaffordability of available electricity, and the convergence of multiple crises including the COVID-19 pandemic and regional turmoil driven by the invasion of Ukraine.

Pakistan lags in its achievement of SDG 7 targets, with 50 million people still without access to reliable electricity.

This report focuses on the case of Pakistan, where almost 23 per cent of the population (50 million people) do not have access to reliable electricity and 8 per cent of the population do not have access to any form of electricity. The lack of access to electricity has further worsened since the COVID-19 pandemic, as the country faces multiple challenges including an economically-strained power sector, increasing energy costs and adverse impacts of climate change. These crises disproportionately affect low-income and marginalized communities, exacerbating income disparities and impeding access to basic services, like energy, for recovery and development. Thus, as Pakistan plans to recover from its socioeconomic and environmental turmoils, it must look at effective interventions that have the largest impact on the resilience and prosperity of its poorest and most vulnerable communities. Given that the provision of electricity in Pakistan is interlinked with key aspects of poverty reduction and sustainable development, increasing the availability of affordable and reliable electricity stands as a pivotal measure for enhancing the well-being and prospects of people, especially among those residing in underserved and marginalized sectors of society.

Decentralized renewable energy systems will play a key role in addressing the challenges of energy poverty in Pakistan.

Along with improvements in on-grid electricity supply (the expansion of which is both technical and economically a challenge for Pakistan), decentralized off-grid electricity access also plays a critical role. By utilizing local renewable energy (RE) resources, this approach enables the delivery of comparatively cost-effective electrification options to end users residing in remote areas of Pakistan. However, despite a large potential, the progress in upscaling these technologies in Pakistan has remained rather low, not only due to technical, but also related to uncertain or underdeveloped policies, social, financing, or regulatory issues. Given this backdrop, this study aims to analyze the potential for decentralized RE-based models and community solutions, highlight challenges in their implementation and suggests key recommendations that could contribute to national energy transition plans, particularly around electricity access in rural areas.

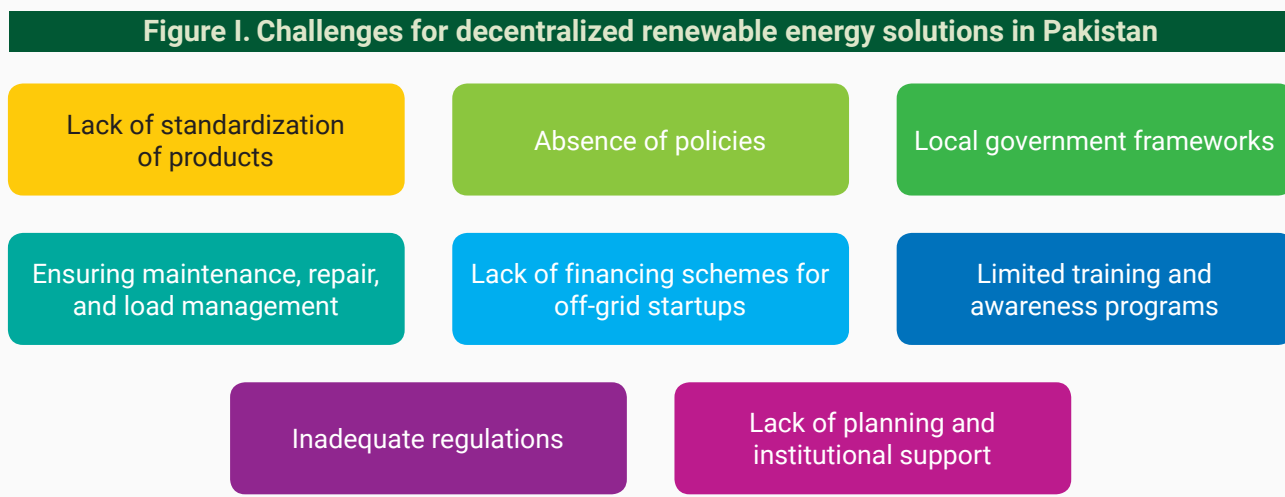
Methodological framework of the study.

The methodological framework uses a mixed-method approach, consisting of both primary and secondary data analysis. Secondary data consists of consultative discussions carried out by the Sustainable Development Policy Institute (SDPI) and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) on "Fostering Green, Affordable and Inclusive Energy Transition in Impoverished Regions

of Pakistan”, along with an extensive desk review around current developments and policy gaps to address the challenges. For primary data analysis, two case studies have been conducted in the energy-deprived regions of Pakistan: i) Socioeconomic Impacts of Micro Hydropower Plants in Pakistan, and ii) Opportunities and Challenges: The Case of Decentralized Solar Systems in Pakistan.

Challenges pertaining to decentralized RE systems in Pakistan.

Based on an extensive desk review of the status of energy access in Pakistan, the existing policy framework for decentralized solutions, and different programs/plans by the development partners, together with the major challenges pertaining to off-grid solutions in Pakistan are indicated in Figure I.



Despite these challenges, efforts have been made by development partners in collaboration with either provincial governments or non-government organizations (NGOs) under different operating models. These include the provision of solar stand-alone systems, community-based off-grid models, public-private partnerships models, and plants installed and operated by a single household. Amongst the various models, community-based initiatives, such as the mini/micro hydropower plants (MHPPs) models initiated by Agha Khan Rural Support Programme (AKRSP), the Sarhad Rural Support Programme (SRSP), and the Solar Micro-Grid model supported by Pakistan Poverty Alleviation Fund (PPAF), emerged as having the highest impact on the socioeconomic uplift of the local population. To address energy security in the Khyber-Pakhtunkhwa (KPK) province, the Pakhtunkhwa Energy Development Organization (PEDO) has also introduced various models based on the similar patterns of AKRSP and SRSP.

Socioeconomic prospects: The case of mini/micro hydropower plants (MHPPs) in Pakistan.

A comprehensive survey was conducted in various regions of northern Pakistan to assess the suitability and impact of MHPPs in providing reliable and affordable energy access. The study involved 101 household surveys to gather input from diverse community members. The results revealed that MHPPs significantly improved electricity accessibility for nearby communities, with 91 per cent of respondents noting better access. Furthermore, these power plants provided free electricity to schools and hospitals, directly benefiting health and education sectors. Health-care facilities obtained new equipment, and schools acquired computers, leading to a 58 per cent increase in education levels, according to respondents. MHPPs also generated employment opportunities, with 69 per cent of respondents reporting an increase in household income. Further, economic development was stimulated by increasing tourists and promoting various businesses.

On the socioenvironmental front, the impact of MHPPs in Pakistan was generally positive, as 96 per cent of respondents noted no relocation of locals during construction. Some respondents highlighted increased water availability for irrigation. Social conflicts were minimal, with 31 per cent of respondents reporting

positive impacts on social relations. Most conflicts related to issues like unequal distribution of electricity and job opportunities were mitigated through adequate compensation in many cases. Overall, the survey demonstrated that MHPPs have a positive and multifaceted impact on electricity access, livelihood opportunities, and socioenvironmental factors in the communities they serve in Pakistan. However, despite depicting a strong case for socioeconomic uplift, MHPPs in Pakistan have also faced various challenges including (but not limited to) those shown in Figure II.

Further, the rapid adoption of MHPPs is steered by community-driven projects that emphasize community ownership and participation. Encouraging community involvement through “sweat equity” ensures inclusivity. However, there is a need for a comprehensive study to identify specific MHPP sites in the northern regions of Pakistan, which are similar to initiatives for other renewable energy sources. Multilateral development banks (MDBs) and provincial governments should lead program activities, including workshops for equipment maintenance and local skilling centres to empower communities. To ensure long-term sustainability, private sector involvement is crucial, requiring policies, innovative funding and operational models to create an enabling environment for MHPPs in Pakistan.

Figure II. Challenges pertaining to effective implementation of MHPP models in Pakistan



Prospects and challenges for solar decentralized solutions in Pakistan.

For the second case study on solar off-grid systems in Pakistan, a survey was conducted in the energy-deprived regions in the province of Sindh, Pakistan, which focused on the effectiveness of decentralized solar systems. A total of 154 households, in 21 different villages, were surveyed. It was found that 13 villages used decentralized energy systems and 8 villages lacked any access to electricity. Out of the surveyed households, only 12 households were using the community grid systems. Most households relied on small solar systems with a single PV plate (50 or 100 Watt) and a 100-ampere battery, obtained either through CSO/NGO initiatives or local markets. A few villages had community-driven solar systems, but none had access to the national grid, resorting to the “kunda systems” for power theft from nearby distribution lines. The communities mainly used electricity for lighting and cooling, with limited economic activities due to

unreliable electricity access, relying on livestock or daily wage labor, with an average monthly income of PKR (Pakistani Rupee) 31,000.

The survey revealed dissatisfaction among most households with their power sources, citing voltage fluctuations and limited access as major challenges. Larger solar systems (over 1 kW) received high satisfaction ratings for providing access to desired electricity services, however, such systems were very limited and mainly owned by the community representative family.

The main factors driving households to transition to off-grid systems were the need for sustainable electricity access, improved access to education and health care, and economic incentives. Environmental benefits were, however, not a primary consideration. Awareness of off-grid solutions varied, with electrified households being more informed, suggesting the need for capacity-building programs in energy-deprived regions. Households without electricity access expressed the need for significant fiscal support to afford off-grid technology, indicating a requirement for free technology provision support schemes. Indeed, when presented with technological improvements, households that already have solar systems were more likely to upgrade to larger systems.

This case study highlights that despite the substantial solar potential in Pakistan, the main challenge lies in the high up-front cost of technology relative to the purchasing power of energy-deprived communities. However, the impact of electricity access on the socioeconomic uplift of the community was clearly evident, particularly its impact on the provision of lighting, water pumping, provision of education, and health services. Due to a lack of awareness and understanding, community engagement is currently low. Pilot projects are thus essential to boost awareness and promote the adoption of off-grid solar solutions, particularly in areas without electricity access. Sustainable adoption of these systems, similar to MHPPs, requires active participation from the private sector, and policy and regulatory frameworks need to be clarified and improved to encourage private sector investment in off-grid initiatives. A comprehensive rural development strategy that integrates improved energy access is essential to drive positive local development and for sustainable poverty alleviation in Pakistan. While the Alternate Energy Development Board (AEDB), in collaboration with World Bank, has conducted a locational study on renewable energy (solar and wind) in Pakistan, similar studies, specifically for mapping rural electrification for Pakistan could be insightful and valuable in terms of policy implementation.

Addressing energy poverty in Pakistan: The case of decentralized RE systems.

This study underscores the paramount importance of energy security in driving social development and alleviating overall poverty in developing countries like Pakistan. While there has been progress in increasing electricity access, the reliability and availability of clean power remain significant challenges impeding development in rural areas. Despite a noticeable shift towards RE in recent policies, the lack of regulatory and policy support for decentralized systems is a critical issue. While community-based organizations and NGOs are making efforts, robust policy and regulatory frameworks are essential for creating an enabling environment for the growth of decentralized RE solutions in the impoverished regions of Pakistan. Thus, in light of the challenges faced in ensuring energy security, this study provides policy recommendations and suggests a roadmap to address these challenges under the umbrella of six thematic areas including: i) harnessing the potential of decentralized RE systems; ii) mobilizing the finance to upscale RE systems; iii) providing policy frameworks and institutional support for RE solutions; iv) scaling-up RE systems; v) addressing the social and gender challenges; and vi) fostering regional collaborations.

Chapter 1: Introduction

1.1 Background

Access to reliable, affordable and clean energy across the world is paramount, as it plays a pivotal role in driving economic growth, social development, environmental conservation, promoting equality and contributing to the overall quality of life. Significant efforts have been made over the past decade to increase electricity access, eventually leading to an increase in global electricity access cover from 84 per cent in 2010 to over 91 per cent in 2021 (with over a billion people gaining access in the period) (IEA, 2023). However, despite this progress, global efforts are not completely aligned with the targets of Sustainable Development Goal 7 (SDG 7), which aims at achieving universal access to affordable, reliable, sustainable and modern energy for all by 2030. As of 2021, almost 675 million people still live without access to electricity (IEA and others, 2023). The critical indicators which have hindered this growth include uncertainty in macroeconomic indicators, increasing inflation, currency fluctuations, mounting debt stress, poor or non-availability of reliable grid infrastructure, low demand of electricity, limited financial supplies, bottlenecks in the supply chain and soaring material prices. The rate of progress to address these challenges has varied intertemporally across countries and regions, with some countries outpacing others (such as Bangladesh and India), while some progressing slowly or even regressing. Nonetheless, substantial progress has been seen in Asia-Pacific countries, which has depicted a positive trend over the past decade. Based on the figures from United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), almost 157 million people in 2020 lacked access to electricity in Asia and the Pacific, which is a decrease from 545 million in 2010

(IRENA, 2022). However, going beyond this number, challenges still persist because i) people with very limited or unreliable access are also quantified under electrified population - ADB indicates that around 350 million people in Asia and the Pacific have limited access to electricity; and ii) the convergence of multiple crises since the COVID-19 pandemic has derailed the Asia-Pacific region from its 2030 goal. Hence, reliable energy solutions and dedicated policy frameworks are required to bring countries back on track to achieving these targets.

This report focuses on the case of Pakistan which is still grappling with its energy access issues as over 50 million people (23 per cent) still do not have access to reliable electricity. This situation has further deteriorated since 2019 as the country has remained in an economically and politically challenged state. At the start of 2023, the energy sector of Pakistan found itself in a financially unsustainable state as well. Driven by the polycrisis resulting from compounded impacts of i) an economically dysfunctional power sector; ii) aftermaths of prolonged impacts of COVID-19-led disruptions; iii) energy supply chain challenges amid regional turmoil, such as the conflict in Ukraine; iv) surmounting inflation; and v) climate change, Pakistan's progress towards economic recovery and the achievement of the Sustainable Development Goals (SDGs) was significantly hampered (Zia, 2023).

The gross domestic product (GDP) growth of Pakistan, in 2022, decreased to 0.29 per cent along with a significant impact on energy and food prices, industrial growth, energy access, and the sector-wide efforts of decarbonizing the economy.

Figure 1. Impediments to Pakistan's growth from the polycrisis

Economic	Fiscal Performance GDP Trade Deficit Inflation
<ul style="list-style-type: none"> • CPI in January 2023 reached 27.6% (up from 13% in 2022). • FDIs decreased to US\$ 684 million during July-January FY2023 (a decrease of 44.2%). • Current expenditure increased by 30% to PKR 6061 billion in July-December FY2023. • Current account deficit of \$3.8 billion (Jan 2023). 	
Energy	Fuel Prices Electricity Cost Energy Access
<ul style="list-style-type: none"> • Between 2022 - 2023, the prices of diesel and petrol increased by 103% and 88% respectively. Gas prices also increased up to 112% for the domestic sector. • Between January 2022 - March 2023, the electricity rates for domestic consumers increased by over 50% (an increase of PKR 8.5/unit). • Over 25 million people in Pakistan are still without access to reliable grid electricity. 	
Environment	Climate-induced disasters Cost of climate change
<ul style="list-style-type: none"> • Between 2000-21, Pakistan witnessed 173 extreme climate disasters with economic losses worth \$3,772 million. Floods in 2022 alone had an economic cost of 2.2% of GDP. • Germanwatch has ranked Pakistan as 8th most vulnerable country to climate change. • While Pakistan has low carbon emissions, it is among top emitters of methane gas. 	
<p>Source: Data from Government of Pakistan, Finance Division, "Monthly Economic Update and Outlook, February 2023", 2023a. Available at https://www.finance.gov.pk/economic/economic_update_February_2023.pdf</p>	

Key impediments to Pakistan's growth in the backdrop of this polycrisis are depicted in Figure 1.

The socioeconomic challenges depicted in Figure 1 have imperiled Pakistan's economic recovery and now energy, food, and environment security are among the key challenges faced by the sector. The impact of this crisis has also been reflected on the external end as the trade deficit has widened. This is coupled with Pakistan's economic vulnerability and efforts to bail out through the International Monetary Fund (IMF) program. As a result, Pakistan has had to reduce its imports and subsidies offered on petroleum products, eventually shifting the burden to end-use consumers. To reduce reliance on imported fuels, particularly for the power sector, Pakistan has also brought the focus back towards coal-based power, which may lock-in inefficient practices and perpetuate the existing risks of capacity payments and higher GHG emissions, eventually derailing the country from its SDG and Paris Agreement targets.

While the aforementioned crises have caused severe disruptions across sectors of economy, the impacts were disproportionately more severe for the low-income and impoverished segments of society. As per the figures by Pakistan's Finance Division, Government of Pakistan, 74 per cent of the people who were affected by disruptions from the

COVID-19 pandemic were engaged in the informal sector (Government of Pakistan, 2020). Another survey report by Pakistan's Bureau of Statistics (PBS) indicated that the largest decrease in monthly income was reported by the Khyber Pakhtunkhwa (KPK) province, followed by Sindh (Pakistan Bureau of Statistics, 2020). The floods of 2022 in Pakistan are an illustrative example, where 58 out of 84 districts that were severely destroyed were home to low-income groups in hard-hit areas (Zia, 2023). The floods of 2022 also had major impacts across rural areas in the provinces in South-Eastern Sindh, KPK, and Balochistan, while also affecting other parts of the country up to Kashmir and some rural areas in Punjab. Apart from the physical impact caused by these shocks, the indirect impacts of these crises across education, health, and livelihoods, were equally severe due to lack of basic services, such as energy, required for a quick recovery.

Pakistan already had a low rates of energy access, with only 77 per cent of the population being provided with a reliable supply of electricity and less than half of the population reliant on clean fuels and technologies for cooking. Against the backdrop of this challenge, a large portion of the population that has access to basic energy services and resources is not able to afford them, thus further derailing the country. While assessing the performance of electricity access and access

to clean cooking through the multi-tier framework, about 7.5 per cent of population in Pakistan lives in tier 0, where 0 signifies no access to electricity and 5 denotes electricity access of up to 23 hours per day. Detailed requirements are also provided in Annex 1.

Consequently, a substantial segment of the population, particularly in rural areas, is still relying

on traditional sources of energy, such as open burning of wood or biomass, to serve their basic energy needs in terms of cooking, which not only affects their health but also increases the national carbon footprint and deforestation (Abre-Rehmat, 2021). Hence, there is a need to strengthen policy frameworks around SDG 7 and energy transition.

1.2 Significance of SDG 7 and the just energy transition

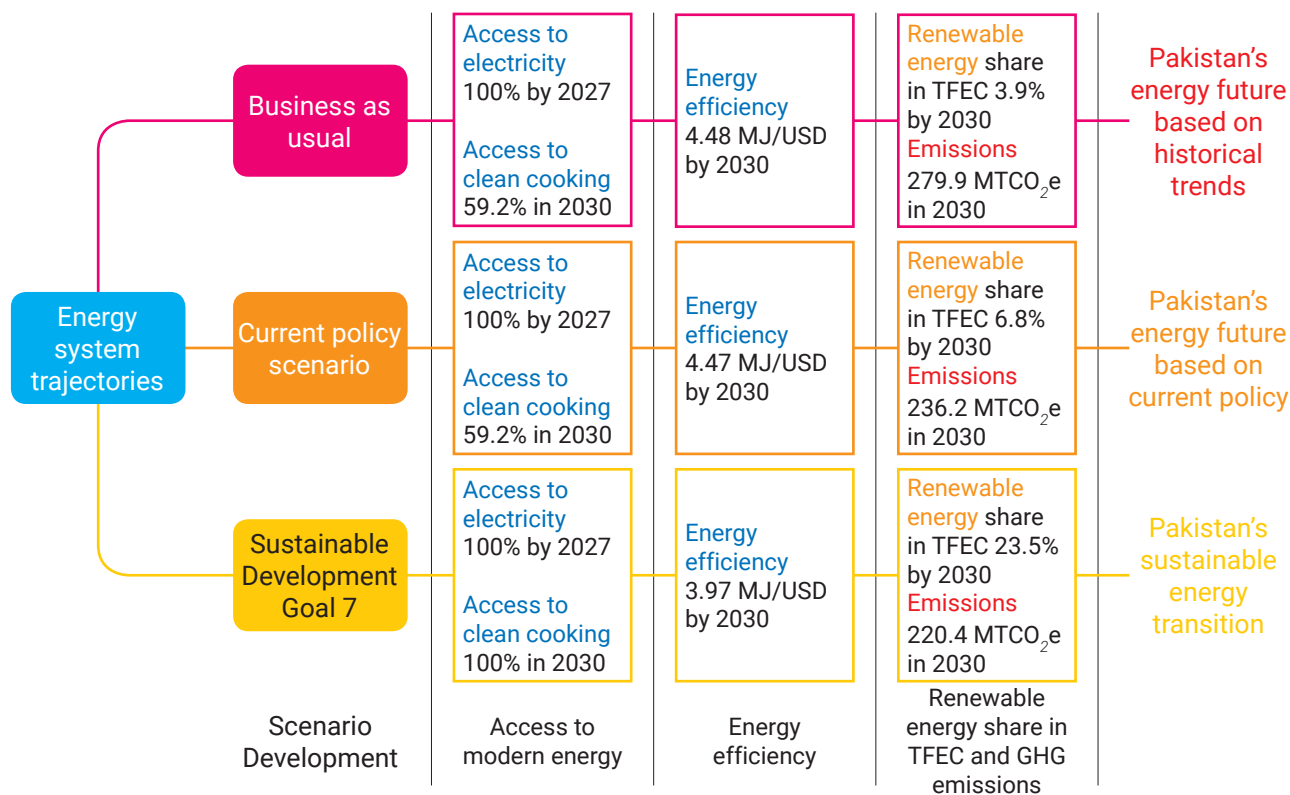
Limited access to clean and affordable energy, particularly in rural areas, is a socioeconomic risk, the impacts of which include lost socioeconomic opportunities and environment degradation, which is driven by the open and inefficient burning of biomass. The low-income populations of Pakistan are more vulnerable to this deficit as they have very limited resources to be used as alternatives. Even in many rural areas with some electricity access (particularly the northern regions of Gilgit-Baltistan), energy poverty persists due to frequent power outages, inadequate supply, and unreliable grid connections. This limits quality of life and affects the functioning of businesses, health-care facilities, and educational institutions. Thus, as Pakistan plans to recover from the challenges highlighted above, it must look at effective interventions that have the largest impact on the resilience and prosperity of the poorest and most vulnerable communities. While Pakistan is amongst countries with low per capita CO₂ emissions [ranked 158th in terms of total (countryeconomy.com, 2022), and 31st in per capita emissions (Worldometer, 2022), it is also ranked as the 8th most vulnerable country to climate change (Eckstein, 2021). Thus, efforts to achieve the national (Vision 2025) as well as international targets (SDGs) will fall short until Pakistan's interest to improve its economy is better aligned with a just energy transition.

The provision of electricity in Pakistan is interlinked with key aspects of poverty reduction and sustainable development. Hence, increasing the availability of affordable and reliable electricity stands as a pivotal measure in enhancing the well-being and livelihood prospects of its people, especially among those residing in underserved and marginalized sectors of society. This can

be addressed through various solutions, such as i) grid expansion and improvements in such areas; ii) provision of stand-alone solar systems; and iii) off-grid renewable energy access. Given that the grid expansion in off-grid areas in Pakistan is both a technical and economic challenge (further explained in Chapter 2), this study focuses on the uptake of decentralized renewable energy systems to address the energy deficit challenge.

Off-grid electrification plays a critical role in extending access of clean energy to communities and improving economic resilience. By utilizing local renewable energy resources, this approach enables the delivery of comparatively cost-effective electrification options to end users residing in remote areas. Moreover, off-grid energy fosters local economic growth, offering several advantages, such as increased household and business financial capacity (through income growth), as well as enhanced employment, business productivity, and women empowerment.

The key defining indicators, contained under Sustainable Development Goal 7 (SDG 7) calling for affordable, reliable, sustainable and modern energy for all by 2030, are clean cooking fuels, renewable energy and energy intensity. In 2022, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) supported the development of the *SDG 7 Road Map for Pakistan* in cooperation with the Private Power and Infrastructure Board (PPIB), Ministry of Energy (Power Division) as the Government focal agency, along with the Sustainable Development Policy Institute (SDPI) as the country partner. A summary of SDG 7 indicator progress for different energy system development scenarios is shown in Figure 2.

Figure 2. Key indicators of the SDG 7 Road Map for Pakistan under different scenarios


Source: Energy Transition Pathways for the 2030 Agenda: SDG 7 Roadmap for Pakistan (United Nations publication, 2022). Available at <https://www.unescap.org/kp/2022/energy-transition-pathways-2030-agenda-sdg-7-roadmap-pakistan>

Note: MJ = MegaJoule; TFEC = Total Final Energy Consumption

Further highlights from the SDG 7 Road Map for Pakistan are also indicated in Box 1.

Box 1. Highlights from SDG 7 Road Map for Pakistan

The Road Map aims to support the Government of Pakistan in enabling the policy measures to achieve the SDG 7 targets by 2030. It has a matrix of technological options and enabling-policy measures for Pakistan as it moves to decarbonize the economy by 2030 and exploit the emission reduction potential in the medium and long run.

For energy access, some of the key aspects highlighted in the document are mentioned below:

- As of 2022, the electrification rate in Pakistan was almost 93.7 per cent. However, only 77 per cent of the population had access to reliable grid electricity.
- The access to clean cooking fuels and technologies is around 49.3 per cent and the remaining population (mainly in rural residences) is still relying on traditional fuels (polluting and inefficient) for their primary heating source.
- Modern RE only accounts for a share of 3.2 per cent in total final energy consumption (TFEC) of Pakistan (excluding the traditional use of biomass in cooking and heating).
- Key strengths for RE: i) abundant resources; ii) potential to drive transition; iii) widely distributed; iv) already established technologies (especially hydro); v) GHG emission reductions; and vi) potential for micro scale power.
- Key weaknesses for RE: i) Poor industrial chain; ii) lack of financing mechanisms; iii) grid instability; iv) seasonal variability; v) limited knowledge and lack of expertise; and vi) policy/regulatory uncertainty.
- Key recommendations for SDG 7 targets:
 - » Penetration of electric cooking and improved cooking stoves.
 - » Sustainable and clean heating, particularly in rural areas.
 - » Increasing household efficiency standards.
 - » Promoting off-grid and community based RE solutions.
 - » Provision of financing facilities to reduce capital cost burden.

1.3 Growing focus on off-grid renewable energy to provide energy access

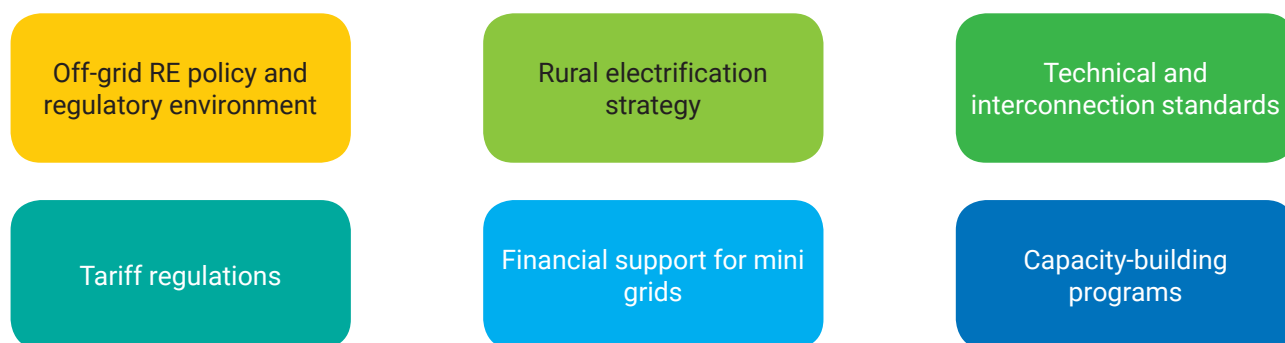
As of 2021, the total number of people connected to solar mini grids have reached 3.54 million (1.155 million at Tier 1 and 2.299 million at Tier 2+). Information on off-grid energy access provided through other off-grid technologies including mini/micro hydropower, solar home systems, and solar lights (varying capacity) is provided in Annex 2. From under 2 GW of total capacity in 2008, off-grid RE increased to 6.5 GW by 2017, and even beyond 8 GW by 2021 (IRENA, 2018). Based on reports from ESMAP, there are at least 19,000 mini grids installed, amounting to a significant investment of \$28 billion, across 134 countries and territories worldwide (ESMAP, 2019). While almost half of this figure is from fossil fuel-based mini grids, it is anticipated that the upcoming mini grids will predominantly rely on renewable energy sources, with hydro and solar power contributing 46 per cent and 40 per cent of the planned capacity, respectively.

To achieve universal access to electricity by the year 2030, the global development and operation of over 210,000 mini grids will be necessary. There has also been a profound increase in the number of mini grids, particularly for rural electrification. A global overview of levelized cost of energy (LCOE) of decentralized energy systems highlights its range from \$0.03/kW to \$1/kW. For 100 per cent RE systems, the average value of LCOE has decreased from \$0.5 in 2016 to \$0.3 in 2021, driven by cost reductions in RE technologies (Weinand, 2023). Further, as per the study of ESMAP, for mini grids

in Asia and Africa, the LCOE ranges from \$0.55/kW to \$0.85/kW. The study also indicates that the LCOE of a solar hybrid mini grid in isolated areas serves productive loads that range from \$0.5/kW to \$0.7/kW. In the case of Pakistan, a number of studies have highlighted the viability of off-grids to be more economical in such areas across Pakistan. These studies find that most of the off-grid areas are located in the northern mountain regions with a dispersed population (especially in Balochistan and hilly areas of GB), where it may not be technically and economically feasible to extend the national grids (Ali, 2021).

However, while renewable energy (RE) decentralized solutions have large potential, their deployment in Pakistan has remained rather slow. The challenges encountered by such systems are typically not only of a technical nature but are frequently related to uncertain or underdeveloped policies, social factors, financing, or regulatory issues. The role the community plays is also important in the design, installation and management of off-grid community energy projects. The more united and aware the community, the greater the likelihood of successful management and operation of off-grid energy projects. The expansion of decentralized and community-based systems requires stable policies, community participation, and favorable economic conditions, which have unfortunately remained a missing element in Pakistan's energy sector planning. Based on successful initiatives within

Figure 3. Aspects of an enabling environment for decentralized renewable energy



Source: Figure designed by authors based on information from South Asian Association for Regional Cooperation (SAARC) Energy Center, "Minigrids and access to electricity in SAARC", Islamabad, 2022. Available at <https://www.saarcenergy.org/wp-content/uploads/2022/04/20220111-Final-Draft-of-SAARC-Mini-Grid-study-report.pdf>

SAARC countries, the policy elements required for scaling up these systems are indicated in Figure 3.

The first key element is the need for a transparent policy and regulatory environment for off-grid systems. Such policies could mainstream off-grid systems in development plans, attract donor investments by offering positive social impacts, such as poverty alleviation, energy security risks, alignment with SDG goals, capitalizing on market growth potential, leveraging advancement in technology, developing community support, benefiting from public incentives and enhancing project resilience. This also calls for a plan for “rural electrification” that clearly demarcates the areas for on-grid and off-grid installation.

The second important element is having an efficient tariff structure and cost recovery mechanism. An off-grid system requires substantial upfront investments, particularly in its infrastructure, equipment and maintenance. Well-designed tariff regulations ensure that sufficient revenue is generated by the system so that it covers the

operational costs, breaks even the investments and maintains long-term financial sustainability. Tariff regulations also assist in several other ways, such as: i) providing transparency on revenue streams to investors; ii) providing revenue stability and recovery; iii) incentivizing energy efficiency; iv) scoping for scalability; v) encouraging cross-subsidization; vi) increasing monitoring and evaluation; and vii) improving awareness and acceptance. Both, the first and second key elements are extremely important as they provide the necessary support to attract much-needed investments and financing for upscaling and extending these mechanisms.

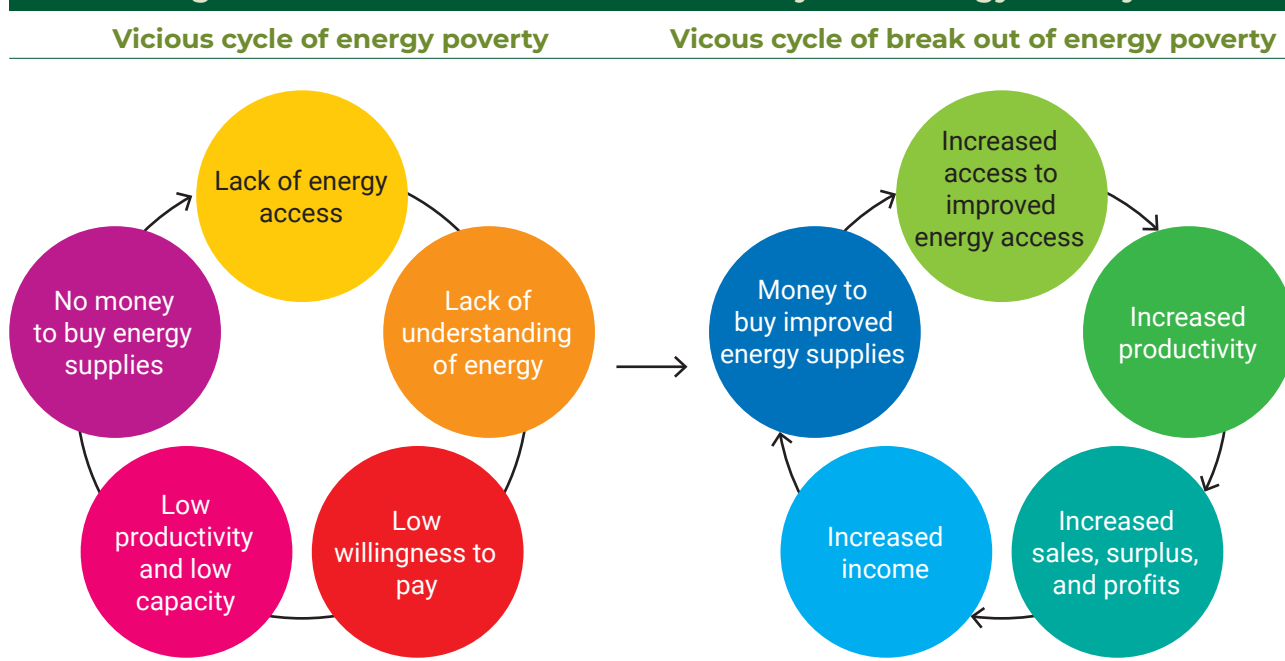
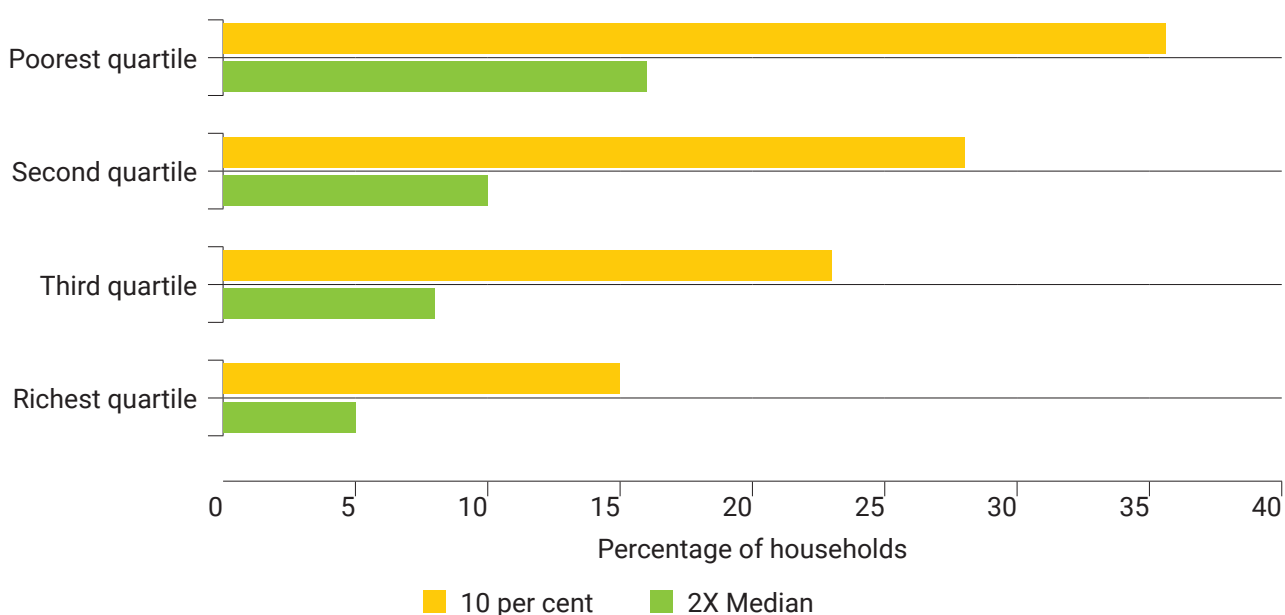
The third element caters to the efficient use of electricity through demand-side management. To ensure efficient use, there is a need to maintain both technical and interconnection standards, and develop specific capacity-building programs to ensure that relevant expertise exists in the local community, and that there are dedicated departments to design, install and operate the mini grids.

1.4 Nexus between energy access and energy poverty

Energy access is central to the socioeconomic development of a region, underpinning livelihoods, education, health, sanitation, water supplies, agriculture, and industry. Lack of financing is one of the major challenges for low-income communities, preventing individuals, businesses and districts from gaining access to those energy services that are needed to improve lives and livelihoods. Thus, efforts to mobilize the finance to support these regions is critical. However, such efforts must not be limited to focusing only on bringing new investments, but must also address how existing available finance (both within public and external donor agencies) is used most efficiently. As per the ESMAP report in 2017, the total spending of Pakistan’s families living in off-grid areas on just lighting products was over \$2.3 billion, including everything from candles to kerosene lamps, to battery-powered torches (World Bank, 2017). This means that impoverished families spend a significant amount of their incomes to meet their energy needs. Moreover, this expenditure is not on fulfilling modern energy needs rather

only for lighting purposes in off-grid, remote areas. Based on a study of selected regions in Ghara Sindh, the SAARC report estimated that an average household is spending around \$25.282017/month just on lighting products (SAARC, 2019). Thus, the country needs to break out of this vicious cycle of energy poverty by developing mechanisms and providing policy support for initiatives that can socially uplift communities and address the goals of SDG 7 (information on the nexus of clean energy with different SDG indicators is provided in Annex 3). Figure 4 represents the transitional needs for energy poverty.

In the context of Pakistan, energy poverty is more closely linked to specific household income than the national economy. A study carried out by Awan and Bilgili (2022), estimates the energy poverty detriments in Pakistan using Household Income and Expenditure Survey (HIES) from 1998-2019 (Awan, 2022). The study indicated that, despite national economic growth, the energy poverty in

Figure 4. Transitional Needs for Vicious Cycle of Energy Poverty**Figure 5. Energy poverty across income quartiles**

Source: Data from Ashar Awan, Faik Bilgili, and Dil Bahadur Rahat, "Energy poverty trends and determinants in Pakistan: Empirical evidence from eight waves of HIES 1998–2019", *Renewable and Sustainable Energy Reviews*, vol. 158 (2022).

energy deficit regions has further increased over the past two decades. The study analyzed data using both "top ten per cent" and "double median" approaches.¹ The results from the study indicated

¹ The 'ten per cent approach' describes that a household which spends more than 10% of its income or total expenditure on fuel/energy is classified as energy poor. According to the 'double median approach', a household is energy poor if its fuel cost is more than double the national median expenditures on fuel.

that the rate of energy poverty is most pronounced in the lowest-income quartile and least prevalent in the highest-income quartile. Utilizing the top ten per cent methodology reveals that 35.6 per cent of households in the poorest bracket experienced energy poverty, in contrast to just 15 per cent in the wealthiest bracket. The percentage of energy-poor households across the income quartile are indicated in Figure 5.

Similarly, employing the double median approach shows that among the least affluent households, 16 per cent are

energy poor, whereas only 5 per cent of the most affluent households face energy poverty.

1.5 Scope and objectives

In the backdrop of the opportunities and challenges highlighted above, it is critical to understand and highlight the scope of RE technologies and how they can foster a sustainable, affordable, and inclusive energy transition in the impoverished regions of Pakistan. Following up on the *SDG 7 Road Map for Pakistan*, this study aims to analyze the energy access situation in Pakistan, and the potential RE-based models and solutions. It also highlights challenges in their implementation and suggests key recommendations that could contribute to national energy transition planning, particularly regarding rural energy access. Key objectives of the report include:

- To understand the current status of electricity access, including access tiers, across Pakistan, and key challenges hindering its growth.
- To take stock of different off-grid RE based models currently being practiced in Pakistan, and what success stories can be further upscaled to ensure access to clean and affordable energy.
- To conduct a survey around the community's perception in response to different off-grid RE solutions and their willingness to install off-grid solar electrification under the presence of different regulatory and financing instruments.
- To examine how energy access interventions may be designed to facilitate productive uses.

Chapter 2: Electrifying Pakistan: Unraveling the status quo and challenges persisting in the power sector

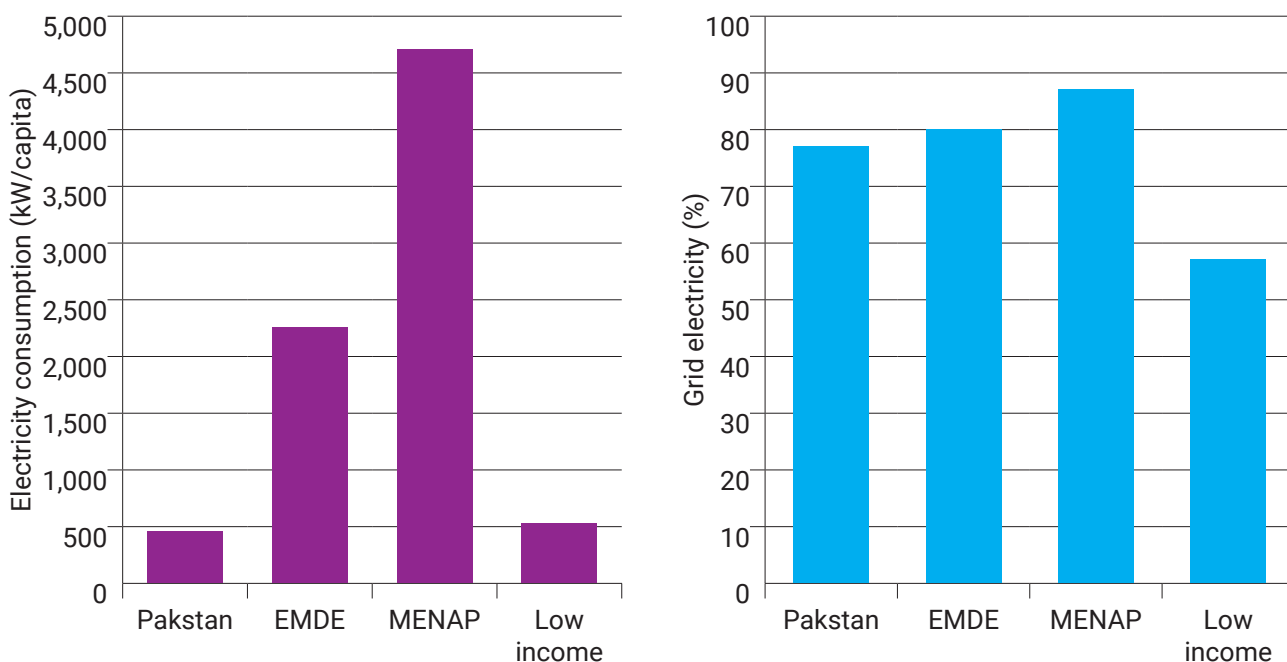
2.1 Current state of electricity access across Pakistan

2.1.1 Overall electricity access

Access to reliable and affordable electricity is one of the key areas which has hindered Pakistan’s socioeconomic development, particularly in the rural areas. The electricity consumption per capita in Pakistan lags behind its peer economies, with per-capita consumption around 452 kWh in

2018 and 438.8 kWh per annum in 2021 (WorldData.info, 2022). This is approximately equal to 10 per cent of the average for other countries in the Middle East and North Africa (MENA), 17.2 per cent in the Asia-Pacific region (IEA, 2020), and 19 per cent of the average for emerging market and developing economies (EMDEs). While the overall electricity access (Tier 1 and up) in Pakistan

Figure 6. Status quo of electricity consumption and grid access in Pakistan and across other regions



Source: Data from Fernanda Brollo, Emine Hanedar and Sebastien Walker, "Pakistan: Spending needs for. Reaching Sustainable Development Goals (SDGs)", International Monetary Fund (IMF) Working Paper No. 2021/108, 29 April 2021. Available at <https://www.imf.org/en/Publications/WP/Issues/2021/04/29/Pakistan-Spending-Needs-for-Reaching-Sustainable-Development-Goals-SDGs-50285>

Note: EMDE = Emerging market and developing economies; MENAP = Middle East, North Africa, Afghanistan and Pakistan; Low-income countries in the report are ones with GDP/capita below \$3000.

is around 96 per cent, the access to grid electricity is only limited to 77 per cent. Around 32,000 villages, accounting to 8.8 million households still do not have access to the national grid (IEA, 2020). A comparative assessment of Pakistan’s access with other countries is shown in Figure 6.

From 2019 to 2020, there was an overall increase of 3 per cent in access to electricity in Pakistan, with 96 per cent of the population having access, as compared to 93 per cent in 2014 - 2015. However, the situation varied across provinces and regions as also depicted in Figure 7. The Sindh province stood out with an increase of nearly 6 per cent in access to electricity. Conversely, all other provinces and regions experienced a decrease in access to electricity between 2014 - 2015 and 2017 - 2018. Notably, in the Khyber Pakhtunkhwa province, access to electricity declined from 96.2 per cent in 2014 - 2015 to 92 per cent in 2018 – 2019 (Cheema, and others, 2021).

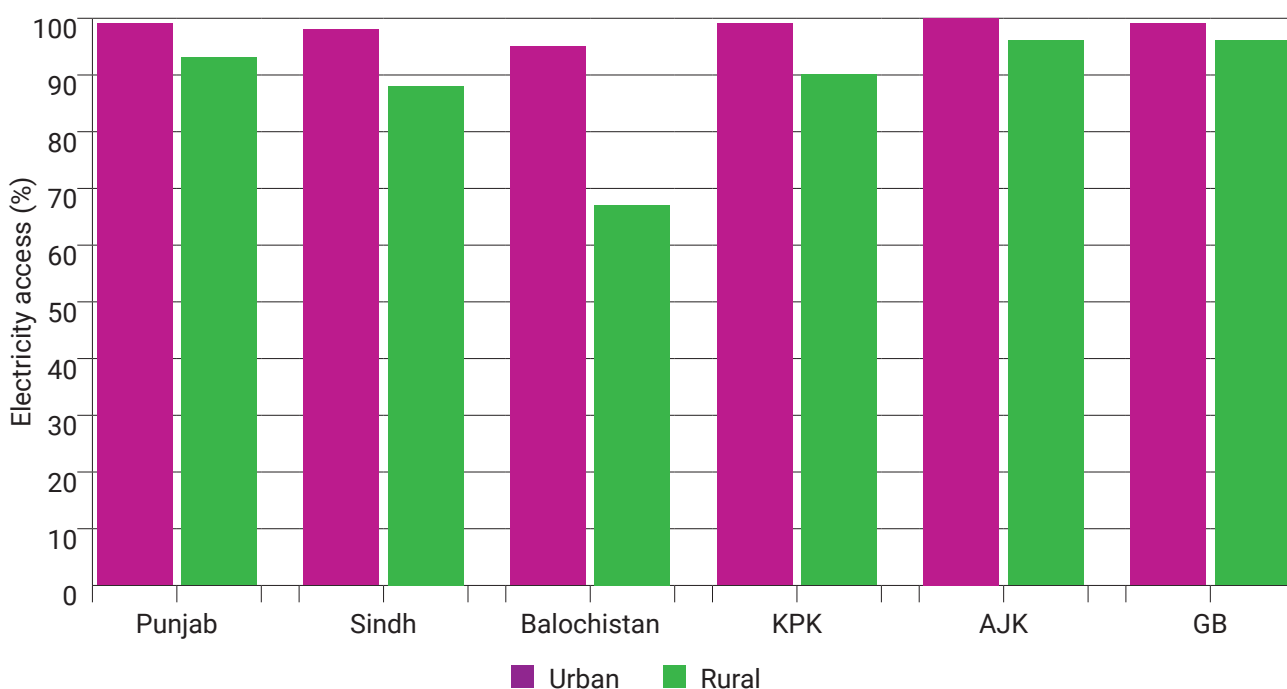
While universal energy access is a key indicator of SDG 7, the eventual goal is to provide means for: i) lighting homes and operating appliances and electronics; ii) running businesses; iii) providing

livelihood opportunities for both small and large-scale businesses; and iv) increasing the provision of basic services, such as education, health, etc. This electricity access is thought of as going beyond national grid connections to using different technology options to provide electricity, such as off-grid or stand-alone systems.

Electricity access across multi-tiers in Pakistan

The Energy Sector Management Assistance Programme (ESMAP) has developed a “Multi-Tier Framework (MTF)” under which the energy access situation can be better analyzed (ESMAP, 2023). This initiative brings about a redefinition in the approach to measuring energy access, moving beyond the conventional binary indicators of simply being “connected or not connected” for electricity access and “solid versus non-solid fuels” for cooking. Instead, it gathers extensive data at the national level and employs it to present an in-depth assessment of the country’s energy situation. This approach acknowledges that electricity access encompasses a spectrum of service levels that households, businesses and institutions require. By utilizing detailed data and information, the initiative aims

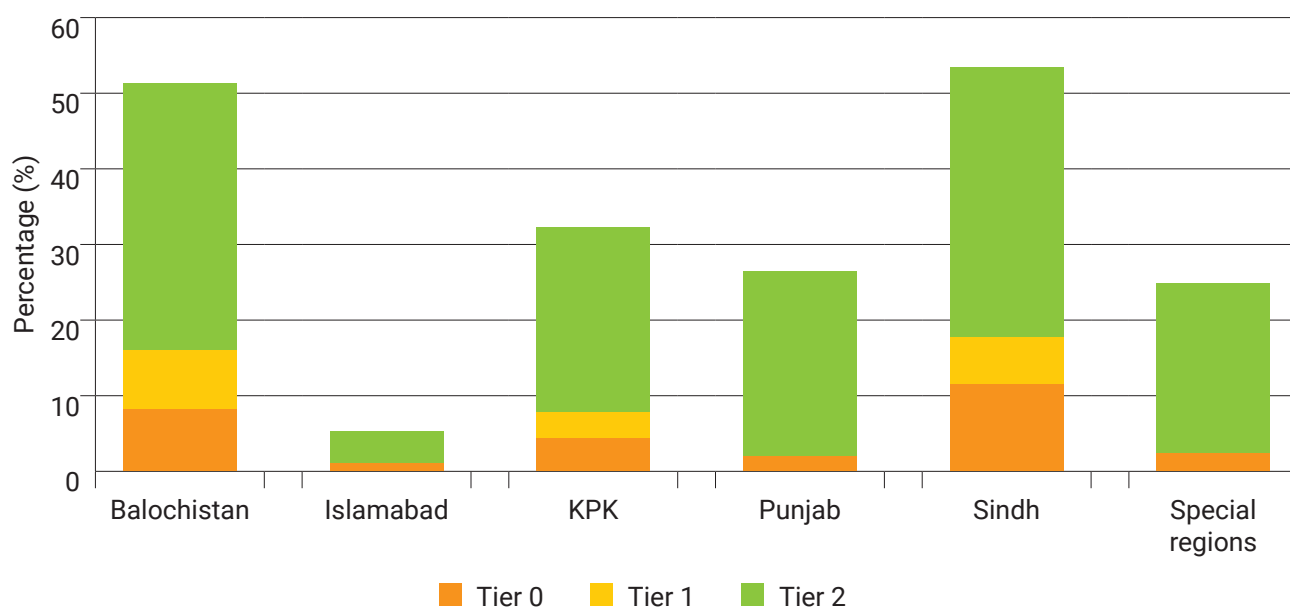
Figure 7. Electricity access across different provinces in Pakistan



Source: Data from A.R. Cheema and others, “Pakistan SDGs Status Report 2021”, Federal SDGs Support Unit. Ministry of Planning, Development and Special Initiatives, Government of Pakistan, Islamabad, 2021. Available at https://www.sdgpakistan.pk/uploads/pub/Pak_SDGs_Status_Report_2021.pdf

Note: KPK = Khyber Pakhtunkhwa; AJK = Ajaad Jammu and Kashmir; GB = Gilgit-Baltistan

Figure 8. Proportion of households between Aggregate Tier 0 and Tier 2, by province



Source: Data from World Bank, "Pakistan Energy Access: Household Panel Survey Data", 19 January 2023. Available at <https://datacatalog.worldbank.org/search/dataset/0040445>

Note: KPK = Khyber Pakhtunkhwa

to enhance the policymaking process and make it more informed.

Detailed data collection for multi-tier access of electricity in Pakistan was conducted by ESMAP in collaboration with the World Bank Group using a survey-based methodology. Based on data collection from the survey, it is indicated that while Pakistan has made considerable progress in electrification,

significant gaps in access remain with 58 per cent of the population falling into Tier 3 or below. These are aggregate tiers of electricity which combine multiple attributes including availability and reliability of electricity, affordability, safety and quality of electricity supply. The electricity access under different tiers for four provinces and special regions of Pakistan is shown in Figure 8.

2.2 Challenges in achieving universal access to electricity in Pakistan

The statistics mentioned in the previous section indicate that access to reliable electricity services in Pakistan is in a comparatively poor state, that widely hinders socioeconomic development. Providing the way forward would require an enabling environment with the right set of policies, institutions, strategic planning, regulations and incentives. Electricity access challenges in Pakistan can broadly be defined into two main categories: i) on-grid electricity access, and ii) off-grid electricity access.

2.2.1 On-grid electricity challenges

As indicated in Figure 9, grid-based electricity access challenges in Pakistan are driven by an economically trapped power sector, where despite a surplus capacity of 12,000 MW, the country is not able to supply grid-based electricity to over 23 per cent of the population. The remaining households also suffer power fluctuations and loadshedding, mainly in the summer season.

For power generation, Pakistan has a total installed capacity of around 41,000 MW of which 65 per cent is based on fossil fuels (Government of Pakistan,

Figure 9. Challenges for on-grid power systems



2023b). Despite having a surplus capacity, the evacuation of power in Pakistan still lags behind the peak demand. Thirty-three per cent of Pakistan’s primary energy is imported with an estimated cost of approximately \$19 billion (Hydrocarbon Development Institute of Pakistan, 2022). In addition to this, Pakistan has high transmission and distribution losses, power theft issues, low recoveries and untargeted subsidy structure. Over time, the circular debt in Pakistan has increased to over PKR 2.5 trillion, which is 3.8 per cent of its GDP and 5.6 per cent of the country’s total debt (Khan, 2022). These figures have been amplified in the backdrop of this multifaceted crisis to create a scenario where Pakistan does not have a fiscal space to invest itself in the power sector without making some major structural reforms.

Another major challenge for on-grid access in Pakistan is the demographic nature of Balochistan (the province with least access to electricity) and other mountainous areas, especially the Hindu Kush Himalaya region. A large area of Pakistan has a dispersed population where grid expansion

is neither technically nor economically feasible. Thus, the country’s distribution companies (DISCOs), already facing substantial financial burdens, further encounter economic challenges in serving these regions. The current grid network, especially the 132 kilovolts (kV) lines, is heavily overloaded and cannot accommodate any additional electricity without undergoing upgrades. Furthermore, in Pakistan, the majority of development plans and their prompt implementation rely on funding from international donor agencies. Nevertheless, the ongoing global economic crisis and security concerns in different areas have led to a reduction in fiscal space, resulting in limited financing for the advancement of clean energy solutions. Additionally, the constitutional status of Gilgit-Baltistan and the disputed regions in Azaad Jammu and Kashmir have further impeded the flow of international finance into these regions.

2.2.2 Off-grid electricity challenges

Table 1 describes some of the major challenges for off-grid systems in Pakistan.

Table 1. Off-grid challenges for electricity access in Pakistan

Problem	Description
Lack of regulations and dedicated policies	While the RE potential in Pakistan has been distributed across the country, there is still no dedicated policy for off-grid energy systems in Pakistan. The energy policy for Gilgit-Baltistan is still under the approval phase, resulting in further delay of projects that are already being halted (two projects with total capacity of 180 MW).
Inefficiency in off-grid systems	In various regions, especially in GB and AJK, mini and microgrids powered by hydropower have been installed. However, their current capacity utilization remains below their potential due to limited understanding, outdated technologies, problem of civil works and inefficient utilization of available water resources. A similar situation exists with home-based solar systems in Balochistan, where the efficiency is notably lower compared to newer and more cost-effective technologies available in the market.

Continued next page

Table 2 Continued

Problem	Description
Limited technical knowledge in off-grid regions	Numerous micro hydropower projects (MHPPs) established by NGOs in GB and AJK are being abandoned because community members lack the necessary technical expertise to manage them effectively after the handover. The lack of timely maintenance, operational challenges, and the absence of repair and service facilities in nearby areas contribute to significant power outages faced by people throughout the year.
Natural hazards/ Disasters/ Geographical conditions	Most of the community energy projects in GB, Chitral and AJK regions also meet failure due to geographical conditions of the region. Being mountainous regions, these regions are more prone to natural disasters, i.e., floods, land sliding, and earthquakes. During the recent floods in 2022 many of the hydro-electric projects were inundated and damaged. In some areas in Gilgit and the AJK region, the floods swept away the entire machinery.
Social and gender challenges	In many impoverished areas across Pakistan, both NGOs and public sector entities have faced significant challenges in installing decentralized plants due to social conflicts and disagreement between community members on land acquisition, location of the plant, and lending of their rooftops. The energy policies are more focused on offering clean and modern energy as substitutes to traditional fuel, but miss out supply of adequate and affordable electricity to home-based microenterprises and post-harvest technologies (e.g., power-operated grain thresher and groundnut stripper) that are labor-intensive for women. Women's enrolment in technical and engineering fields of study is also very low due to socioeconomic and cultural barriers that exist in societies and the defined engagement of women in traditional roles.
Energy security challenges	In rural residences, energy security poses a major challenge for individuals connected to decentralized grids. They encounter significant issues with low voltages, fluctuations and limited local resource availability during seasonal variations. Energy infrastructure in these regions is also very prone to climate-induced disasters. Seven small scale hydropower projects in GB were destroyed during the floods of 2022.
Lack of data and feasibility studies	There have been insufficient feasibility studies conducted for renewable energy projects in such regions, leading to a lack of bankability for investors. As a result, investors experience delays in obtaining crucial information, and the projects are at risk of curtailment due to their inadequate technical or commercial foundation.

2.3 Institutional governance and development projects for rural communities in Pakistan

2.3.1 Policy support for the RE sector across different provinces in Pakistan

Following the 18th Constitutional Amendment in 2010, energy became a provincial matter in Pakistan (Implementation Commission Pakistan, n.d.). All provinces, including special regions have been granted the authority to initiate their own power generation projects, establish transmission and distribution networks, and set tariffs for electricity generated within their respective regions, as long as the energy is not connected to the national grid. Article 157 of the Constitution allows the federal government to construct power plants and lay inter-provincial transmission lines, subject to obtaining consent from the relevant provincial

government before developing any hydropower projects (Info Pakistan, n.d.). The **Power Generation Policy 2015** is the implemented framework used by the federal government to engage with the private sector and foster public-private partnerships (The Gazette of Pakistan, Extra, 2015).

At the national level, the guiding policy for development of renewable energy in Pakistan is the "Alternate and Renewable Energy Policy 2019" which aims increase the share of RE to 20 per cent by 2025 and 30 per cent by 2030. The policy recognizes the high potential of mini/microgrids, off-grids, localized energy systems (LESSs) and business-to-business (B2B) solutions, which offer to combat power scarcity. However, for decentralized solutions, most of the supporting policies and development

plans have been put forward by the provincial departments.

The primary impetus behind the advancement of the power sector in Khyber Pakhtunkhwa (KPK) is the **Khyber Pakhtunkhwa Hydropower Policy 2016**. This policy lays out the procedures and guidelines for executing power projects in KPK through various avenues, including the public sector under independent power producers (IPPs), the private sector, public-private partnerships (PPPs) and captive generation. The responsibility for implementing PPP projects falls under the jurisdiction of the Pakhtunkhwa Energy Development Organization (PEDO) as per the PEDO Act of 2020 (Government of Khyber Pakhtunkhwa, 2020). The Act also explicitly defines the rights pertaining to all hydropower production sites. The development of the renewable energy portfolio in KPK, which includes the merged districts formerly known as Federally Administrative Tribal Areas, is primarily carried out by the Pakhtunkhwa Energy Development Organization (PEDO) through its initiatives, namely the **Khyber Pakhtunkhwa Hydropower and Renewable Energy Development Program**, and the **Environmental and Social Management Framework of 2019**. Within the scope of this program, KPK aims to establish renewable energy and hydropower projects in the Swat River basin. This comprehensive program is undertaken in collaboration with the World Bank and is aligned with both provincial and national policies and regulations to ensure compliance throughout its implementation.

The “AJK Power Development Organization” takes centre stage in AJK when it comes to power projects, with a primary objective of discovering and harnessing the hydropower potential in the region. For involving the private sector, the AJK Private Power Cell offers a convenient one-window service, facilitating the implementation of projects up to 50 MW. This includes providing letters of intent and support, as well as coordinating Power Purchase Agreements (PPAs) and feasibility studies.

In GB, the responsibility for electricity generation, transmission, and electricity sales rests with the Water and Power Department of Gilgit-Baltistan. The department has predominantly focused on hydropower, which accounts for over 90 per cent of the total power generation in the region. However, the absence of an approved energy policy specific to Gilgit-Baltistan has deterred potential investors from showing interest in hydropower projects.

In Balochistan, the power generation policy of 2007 serves as the principal guiding document, applying to projects exceeding 50 MW in size. The Balochistan Power Development Board (BPDB) handles private sector engagement in the province, acting as a facilitator and offering a streamlined process to encourage private investments.

Various programs across Pakistan, aimed at improving energy access in rural residencies across Pakistan, are mentioned in Annex 4.

Chapter 3: Decentralized renewable energy systems in Pakistan: A perception survey of energy-deprived regions

This chapter takes stock of different decentralized renewable energy systems that are operating in Pakistan, and analyzes their impacts on regional socioeconomic development through a perception

survey that was conducted in three different regions of Pakistan, including Karachi, Gilgit-Baltistan (GB), and Khyber Pakhtunkhwa (KPK).

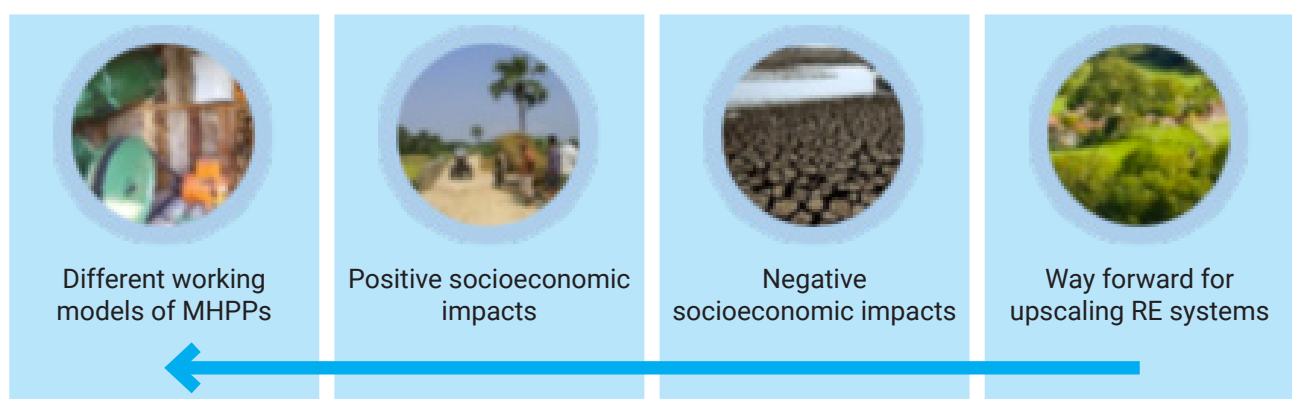
3.1 Case Study 1: Socioeconomic impacts of micro hydropower plants (MHPPs) in Pakistan

In Pakistan, MHPPs are viewed as the most viable decentralized renewable energy solution to supply reliable and cost-effective electricity to the remote and isolated areas of northern Pakistan. While the country has extensively utilized its large hydro potential, constituting 24 per cent of total capacity of Pakistan, there remain numerous untapped MHPP sites in the northern regions that offer great potential for generating clean energy. While large hydropower plants have some negative external effects, such as biodiversity loss and carbon emissions related to material and social displacements, MHPPs are mainly fueled by run-of river water with minimum

impact on these factors, resulting in net-positive externalities.

To scope their suitability for providing reliable and affordable energy access, a survey was conducted across different areas, particularly northern regions of Pakistan. A cross-sectional research methodology was adopted for collecting information through a structured questionnaire with MHPP workers, local communities (households), and subject experts. The aim was to obtain feedback from a wide geographic range and from as many communities as possible surrounding the community-run power

Figure 10. Key outcomes targeted through surveys



plants. To address this, the study carried out 101 household (HH) surveys involving community individuals. Moreover, on-site enumerators made sure to diversify the samples by considering factors such as geography (urban/rural), demography (age/gender) and caste of the respondents. Key outcomes targeted through the surveys are mentioned in Figure 10.

3.1.1 Different working models of MHPPs in Pakistan

The mountainous regions in the north of Khyber Pakhtunkhwa and Gilgit-Baltistan possess significant potential for MHPPs. Interestingly, these areas have limited access to the national grid, resulting in a high proportion of unelectrified and poverty-stricken communities. To address this, most of the MHPPs established in these regions have been funded by multilateral development banks (MDBs) and non-profit organizations. The implementation of most MHPPs in these regions is accomplished through collaborations with organizations, such as the Aga Khan Rural Support Programme (AKRSP), Khyber Pakhtunkhwa Energy Development Organization (PEDO), Pakistan Poverty Alleviation Fund (PPAF), and Sarhad Rural Support Program (SRSP). Some initiatives by these organizations have already been identified in previous sections.

These MHPPs are operating under various modes and are driven by community engagement. In PPAF's mini-grid projects, local community committees oversee the operations and maintenance. The plant operators and technicians are selected from the community and receive payment from the tariff collected from consumers. These operators undergo training in mini-grid operation and management. Nizam Bijli, a subsidiary of Nizam Energy, has introduced a pay-as-you-go model using mobile money in off-grid regions, offering affordable solar home solutions. Customers have the choice of purchasing systems upfront or through 12-month, 18-month, or 36-month payment plans, all of which include health insurance. In rural Sindh, Eco Energy is also providing pay-as-you-go solar solutions, enabling individuals to pay for their energy needs within their means. The monthly payments are usually similar to what villagers typically spend on energy sources including candles, kerosene oil, wood purchase, representing around 14 per cent of their average monthly income.

Some of the distinctive models observed during the survey are:

1. **Community-driven models:** Residents of certain villages independently establish and oversee micro hydropower projects through committees specifically designated to handle connections and invoicing. However, numerous projects operate without being officially recorded, primarily because of the challenges encountered during installation, stemming from the rugged terrain and geography of the region. At the initial stage, many of these plants are installed by NGOs/NPOs, such as AKRSP, which handover the plant to communities after a year of operation. However, in many other cases, the plants are self-funded by the communities who independently develop a cost-sharing model. Up to 1 MW of micro hydropower projects are operational under this category and can serve whole communities. In many of such configurations, the communities were self-responsible for installing the grid lines from hydropower plant to their houses.
2. **Individually-owned systems:** Under this system, a small (less than 100 kW) system is owned by a single individual who either uses it for himself or supplies electricity to the nearby houses, in return for monthly bills or some other bilateral agreements, such as the exchange of different food or grocery items.
3. **Public sector driven plants:** These plants are operated by the skilled labor force of a public sector entity, i.e., PEDO or WAPDA. These plants operate at a capacity of up to 3 MW.
4. **Hybrid model:** The plant is operated by PEDO/WAPDA in conjunction with community members for a limited period to provide training, after which full control is handed over to the community for continued operation and maintenance.

The financing conditions in most of these cases (other than the private sector backed plants) change from region to region. However, the active involvement of the community as well as the relevant entity has been observed to be paramount

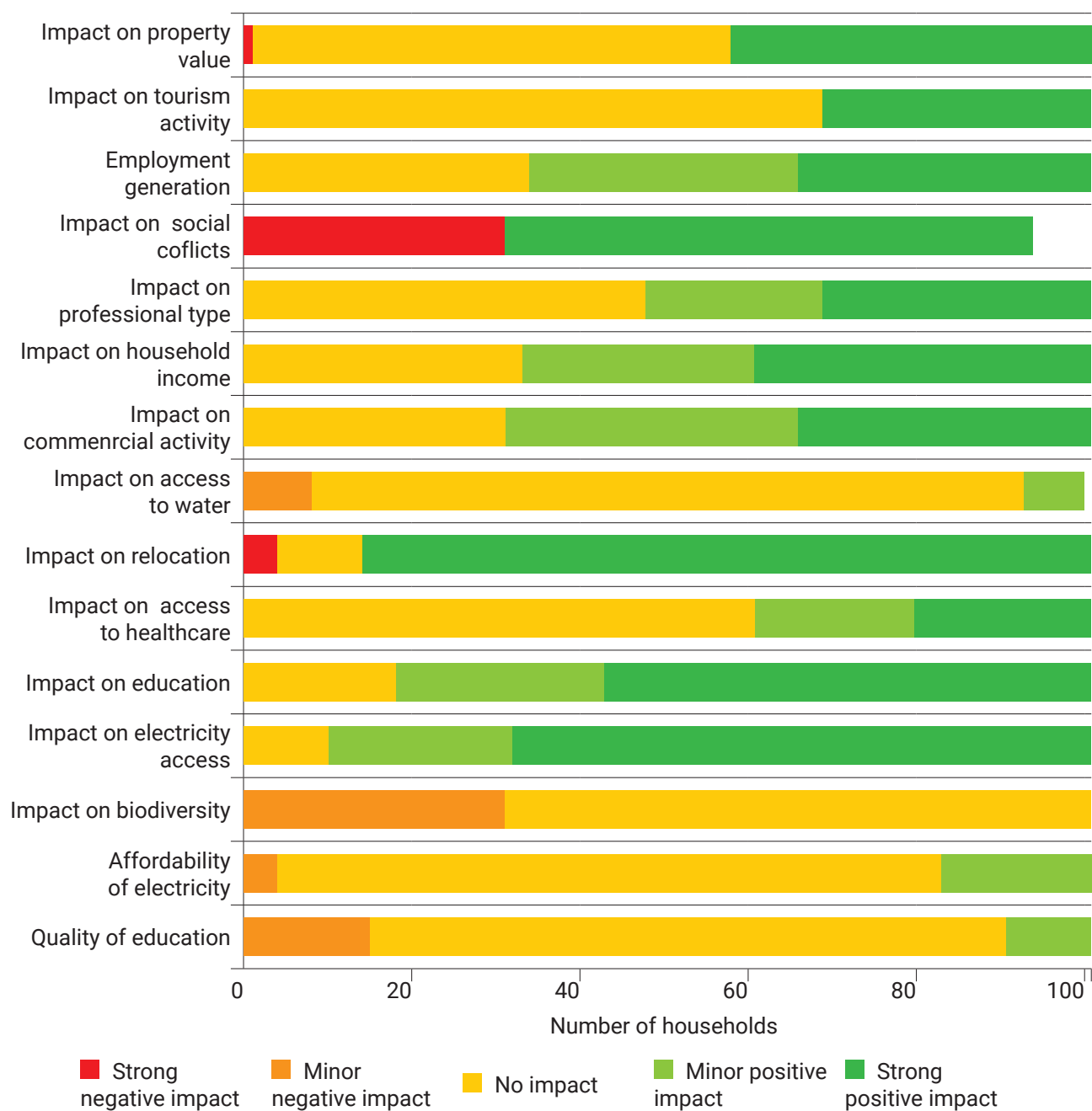
to long-term sustainability. While all of these models were extensively deployed, the extent of their success depends on the level of community engagement and their business models. In the absence of a business framework, the community models were not found to be sustainable. Besides, community awareness of increasing global warming and the positive impacts of clean energy, using especially hydropower electricity, also led to the success of community energy models. This means that

increasing community awareness led to an increased community willingness to tap into RE resource(s) for their domestic electricity requirements.

3.1.2 Survey results

The household survey evaluates the impact of MHPPs across seven key sectors as indicated in Figure 11, describing responses by sample households against each category.

Figure 11. Socioeconomic impacts of MHPPs on communities (survey results)



Education and health impacts of electricity access

MHPPs were found to have a significant influence on electricity access for nearby communities by enabling the utilization of local resources for electricity generation, which was previously hindered by the high expenses of establishing transmission lines. According to 91 per cent of respondents, the installation of MHPPs in their regions resulted in improved access to electricity. The majority of these MHPPs offered free electricity to schools and hospitals, thereby directly benefiting the health and education sectors within the community. Moreover, they had a positive impact on other SDGs, particularly education and health, through provision of electricity access.

MHPPs led to an enhancement in health-care services, as noted by 40 per cent of the respondents. Numerous hospitals were able to acquire new equipment, such as X-ray machines, and Complete Blood Picture (CBC) testing machines amongst others, that was previously unavailable due to electricity shortages. Educational institutes (mainly schools) obtained computers and various other equipment, enabling children to access educational content through television and study after sunset. According to 58 per cent of the respondents, there was a substantial increase in the community's education level, while 25 per cent reported a minor improvement. The remaining did not observe any change in the community education level.

Impact on livelihood opportunities

The development and construction of MHPPs create employment opportunities for many individuals, including local construction services and companies. Community-driven MHPPs also offer direct job prospects for community members to operate the power plants. For a 50 kW system, each power plant employs two people per shift, with three shifts in total. In the case of a 500 kW system, 3-4 community members are employed for each shift. Regarding the impact on professions, 37 per cent of respondents observed a significant positive influence due to the construction activities of these MHPPs, while 25 per cent noticed a minor impact. Additionally, these construction and related employment opportunities contribute to increasing the household income level of community members, as reported by 69 per cent of the respondents.

The establishment of MHPPs also stimulated economic development in the region and in the surveyed areas. A majority of community members found employment as MHPP workers, engaging in various businesses, or as labor, or in the private or public sector. According to 69 per cent of the respondents, the construction of MHPPs led to a notable rise in commercial and industrial activities. The availability of reliable electricity also spurred further developments, including the opening of new flour mills, telecom centers, schools, hospitals, and hotels. Having access to electricity attracted tourists to the region, as hotels and guest houses offered amenities enabled by electricity. Among the respondents, 32 per cent noticed an increase in tourism following the construction of MHPPs, which subsequently resulted in higher land prices. Furthermore, 43 per cent of the respondents reported an increase in property value due to the positive effects of MHPPs on the overall development and attractiveness of the area.

Social impacts of MHPPs

A positive social impact is associated with MHPPs in Pakistan. The negative impact of MHPPs on local communities is generally minimal, as reported by 96 per cent of the respondents who noted no relocation of locals during MHPP construction. A small number of respondents mentioned that around 8-9 households had to relocate due to safety concerns associated with the construction of MHPPs. In some instances, compensation for land use was provided through the provision of free electricity at several sites. As for land use, no negative responses were obtained. Conversely, 7 per cent of respondents highlighted that small run-of-river hydro projects increased water availability for irrigation purposes.

While social conflicts were expected to be present in the development of such models, however, for the case of Pakistan, the survey indicated a very minimal negative impact. According to the survey results, 67 per cent of the respondents reported that there were no social conflicts within the communities due to MHPPs. Moreover, 31 per cent of the respondents reported that it had a positive impact on social relations while 63 per cent reported that it had no impact on social relations, which contrasts with what is often observed with large hydropower projects, where conflicts frequently arise from

land displacement disputes. The small number of social conflicts that were noted arose from issues, such as unequal distribution of electricity and job opportunities associated with MHPPs, as well as disputes related to land ownership. Despite this, it is important to note that most of the respondents stated that they were adequately compensated for their land, which may have contributed to mitigating potential conflicts in those cases.

Challenges pertaining to sustainability of MHPPs

While the communities have harnessed significant benefits from MHPPs, there are still a number of challenges that hinder their upscaling and sustainability once the project is handed over to

the community. Table 2 describes the common challenges faced in installation and operation of these plants.

Based on the survey results and Key Informant Interviews (KIIs) with the plant workers, this case study indicates that MHPPs have a profoundly positive influence on the communities, and various strategies linked to renewable energy investments can be utilized to further enhance their development. Significant benefits have been observed in the form of access to electricity, increased economic activities, job creation, health infrastructure and service improvements, and enhanced access to education. These aspects represent core areas with substantial positive impacts.

Table 2. Challenges in installation, operation and maintenance of MHPPs in Pakistan

Challenge	Description
Logistical issues	A major challenge in the operations of MHPPs in the northern regions of Pakistan is the lack of proper infrastructure and supply chain. This leads to extended waiting times for the experts or maintenance workers (other than the community representatives running the plant) to address the problem. During these delays, communities are left with no power supply. Moreover, the northern regions are susceptible to adverse weather conditions, such as snowfall, glaciers melting, and flooding, which further compounds the difficulties in transporting equipment and workforce to these locations.
High capital cost	The primary challenge that persists is the low paying capacity of communities and the high costs associated with the construction and operation of MHPPs, which also acts as a significant challenge for private sector involvement due to unattractive returns. As a result, these projects mainly rely on NGOs and other CSOs supported by international donors. Moreover, several plants need overhauling and upgrades, but they face financial constraints that prevent them from undertaking the necessary overhauls.
Technical challenges and risks	Along with the points highlighted in the previous discussion on “logistical issues”, there are technical challenges related to the design and construction of the plants. In Mardan and Swat districts, specific problems were observed with the turbines, leading to higher maintenance costs. An additional challenge highlighted by respondents was the electrical safety issues affecting the maintenance and operations of MHPPs. Specifically, there were concerns about the risk of electrocution from electricity lines connecting to the powerhouse.
Human resource challenge	Lack of adequate human resources also poses a significant challenge as many community members lacked the required education and expertise to operate the MHPPs. To address this, community-driven plants adopted a training approach wherein an off-site expert was assigned to guide and train a community member in operating the plants. This training period typically lasted for 1-2 years, after which complete control of the MHPPs was transferred to the local community members.
Quality of electricity supply	The quality of electricity supply from MHPPs was definitely lower when compared to the electricity received from the national grids. More than half of respondents noted that challenges were faced due to voltage fluctuations.
Absence of working business models	Most of the MHPPs are financed by grants or special programs. Due to the lack of community stakes in the financing of the project, community members often take it for granted and expect donors would again support operations and maintenance, which is not true in many cases. Such kinds of community attitude dissuade investments by donor organizations, resulting in the shutdown of the plant.

3.1.3 Key takeaways from the survey

The case study indicates that MHPPs have a significant overall positive influence on the neighbouring communities. There are specific strategies related to renewable energy investments that can be utilized to enhance their development. Key areas that experience substantial positive effects include increased economic activities, job creation, improved access to electricity and better educational opportunities.

Several factors contribute to the rapid adoption of MHPPs in Pakistan, but to ensure that these projects are success stories, establishing a sense of ownership through community-driven plants is key. Encouraging the community to actively participate and contribute through “sweat equity” can ensure inclusivity and localization of the MHPPs.

Secondly, various estimates have been made concerning the potential of hydropower in the northern regions of Pakistan. However, unlike the World Bank’s initiative for solar and wind zones mapping through a variable renewable energy locational study, a comprehensive study to identify

specific sites for MHPPs in specific areas has not been conducted. Undertaking a similar study, combined with a rural electrification map of the region, with a specific focus on community-driven off-grid MHPPs, could significantly expedite their implementation in Pakistan.

Considering the significant number of MHPPs, it becomes crucial to commence program activities led by multilateral development banks and the provincial government. Establishing workshops in the region to enhance local capacity to maintain and repair the equipment should also be a priority. Likewise, the establishment of local skilling centres will empower the community to become self-sustaining in operating MHPPs.

While MHPPs are currently being funded by donors, their long-term sustainability can only be achieved through active participation from the private sector. To achieve this, it is crucial to introduce policies that create an enabling environment for the private sector. Developing and implementing innovative funding and operational models for MHPPs can further enhance private sector involvement in the sector.

3.2 Case Study 2: Opportunities and challenges: The case of solar decentralized systems in Pakistan

3.2.1 Significance of solar mini-grid systems

“Mini grids are described as electric systems, consisting of power generation and distribution network, providing electricity to households, businesses, public institutions, productive and anchor loads (such as telecom towers) in remote settlements or in a town or city. Mini grids can be fully detached from the main grid or connected to it with a provision to isolate themselves from the grid”(SAARC Energy Centre).

Globally, around 19,000 mini grids have been constructed across 134 countries, amounting to an investment of around \$28 billion, and granting access to electricity to approximately 47 million individuals. Specifically, in the South Asia region, there are approximately 9,300 mini grids in operation,

with a substantial number located in Afghanistan, India, and Nepal.

Despite a large potential for solar energy in Pakistan, its share in total power generation of the country is less than 3 per cent. Among the various obstacles to the widespread adoption of renewable energy, a significant roadblock persists in the form of flexibility constraints, including transmission and distribution limitations, isolated grid standing, restricted reserve capacity, and the lack of flexibility in the operation of conventional plants required for the integration of intermittent solar energy. Given this context, decentralized off-grid solar energy that directly provides electricity to consumers has evolved from being a niche concept to becoming widely adopted, acknowledged as a rapid and effective means for embracing renewable energy. Despite facing flexibility challenges in developing nations, this

dynamic scenario presents ample opportunities for its uptake and investing.

3.2.2 Pakistan's efforts to embrace solar photovoltaic (PV) uptake

Pakistan's distributed solar industry gained some pace in the 2010s driven by the power deficits. Over 380 projects (including mini grids, MHPPs, solar pumping systems, hybrid solar-wind systems, and biogas) were implemented by Pakistan's Poverty Alleviation Fund (PPAF). Through support from Kreditanstalt für Wiederaufbau (KfW) (German Development Bank), PPAF has also installed 68 solar mini grids (with approximate capacity of 500 kW) in off-grid locations of KPK. Figure 12 represents the key areas that are covered under the PPAF/KfW program.

Pakistan's Alternate and Renewable Energy Policy 2019 has also put a focus on mini grids, microgrids, localized energy solutions, and B2B for addressing the energy crisis. The Alternate Energy Development Board (AEDB) (merged with PPIB now) is also developing plans for bringing consistency in this area. Private sector companies in the country are permitted to establish power generation plants, but they must obtain prior approval and licenses

from both the regulatory (NEPRA) and the respective DISCO before setting up a distribution system or engaging in electricity sales.

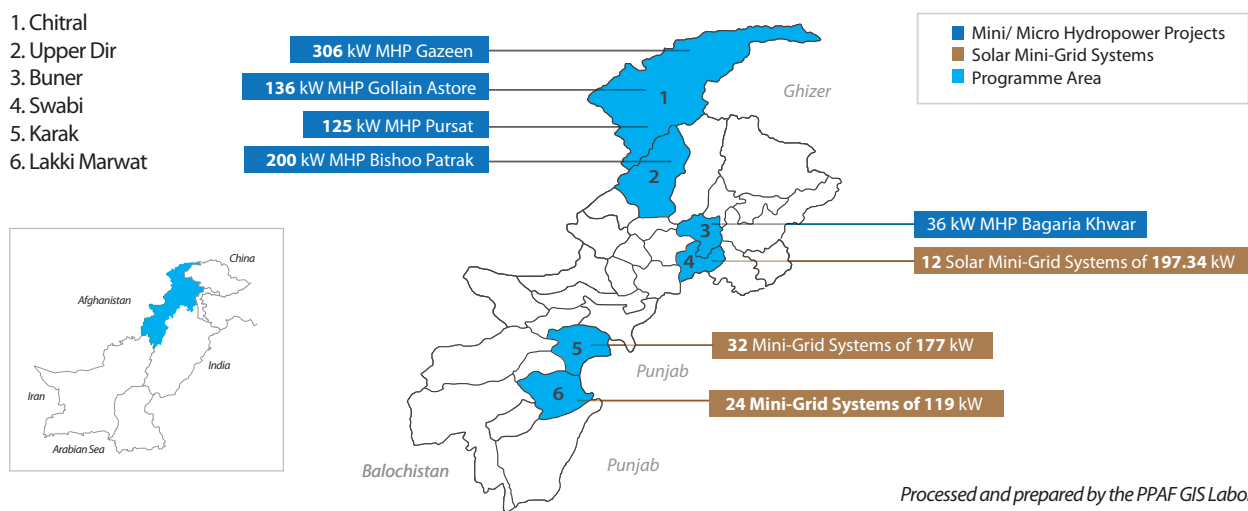
Over the past year, Pakistan has observed an increased focus on solar PV utilization on the policy front, with fast-track solar PV initiative of 10000 MW, solar tube-well policy, and auction of 600 MW solar PV. In the fiscal year (FY) 2022, Pakistan imported around \$1.2 billion worth of solar PV equipment, while China's exports to Pakistan have reached \$870 million, depicting an annual increase of 54 per cent and 37 per cent, respectively. As per the forecasts of Pakistan Solar Association (PSA), Pakistan's demand for solar import in 2023 would be around \$1.8 billion (The Express Tribune, 2023). The solar market of Pakistan is also expected to further grow with an compound annual growth rate (CAGR) of 2.5 per cent between 2025-27.

Nevertheless, against the universe of opportunities and these recent developments, the progress in Pakistan for mini solar grids is still overlooked. In the backdrop of the ongoing polycrisis, the support schemes for solar PV are also halted for the time being. However, the large-scale investment of mini grids as a significant investment requires a crucial prerequisite in the form of an enabling

Figure 12. Projects under the Hydropower and Renewable Energy (HRE) Program of Kreditanstalt für Wiederaufbau (KfW) and Pakistan's Poverty Alleviation Fund (PPAF)

COVERAGE

1. Chitral
2. Upper Dir
3. Buner
4. Swabi
5. Karak
6. Lakki Marwat



Processed and prepared by the PPAF GIS Laboratory

Source: Pakistan Population Alleviation Fund, "Renewable. Energy Programme", 2015. Available at https://www.ppaf.org.pk/doc/HRE_March%202021.pdf

policy and regulatory framework. This emphasizes the importance of creating a favorable financial environment to support decentralized renewable energy, particularly in remote areas without access to electricity. By employing comprehensive electrification planning and implementing robust policies and financial schemes, the integration of mini grids can be significantly advanced.

3.2.3 Survey approach

The survey aimed to identify the major challenges and awareness levels of impoverished regions in the energy deprived regions of Sindh. A total of 154 different households (under 21 different “Goths (villages)”) were surveyed. Thirteen of these regions were using some form of a decentralized energy system while the remaining eight were completely operating without any electricity access. The following key areas were addressed: i) community perspective and major challenges hindering the growth; ii) driving parameters; iii) support measures needed to address the challenges.

3.2.4 Survey results

Figure 13 highlights the key aspects of the population under survey.

Figure 13 indicates:

- The largest proportion of population surveyed was fulfilling its electricity needs through
- stand-alone solar systems. However, these systems differ from the ones commonly witnessed in urban residences. Most of these households had a single plate of solar PV (50 or 100 Watt) running with a 100-ampere battery. Such systems were obtained either through a CSO/NGO initiative or households had to buy them from the local markets (in which they were commonly available).
- For community-driven sources, two villages (“goths” in Sindhi language) were surveyed where around 6-7 households were connected to a common system, though this model is very limited in Pakistan.
- As for grid-based electricity, none of these goths had access to the national grid. The ones using the grid power were accessing it through the “kunda” (power theft) system from the closest distribution lines.
- Given that all these regions were “low-income households”, their electricity requirements were mainly for lighting (at night), phone charging, or cooling purposes (fans during summer seasons). However, along with electricity going to households, communities had also setup a comparatively bigger solar system to run the water pump that can supply water to the households.
- Due to the absence of reliable electricity, these regions do not have access to basic

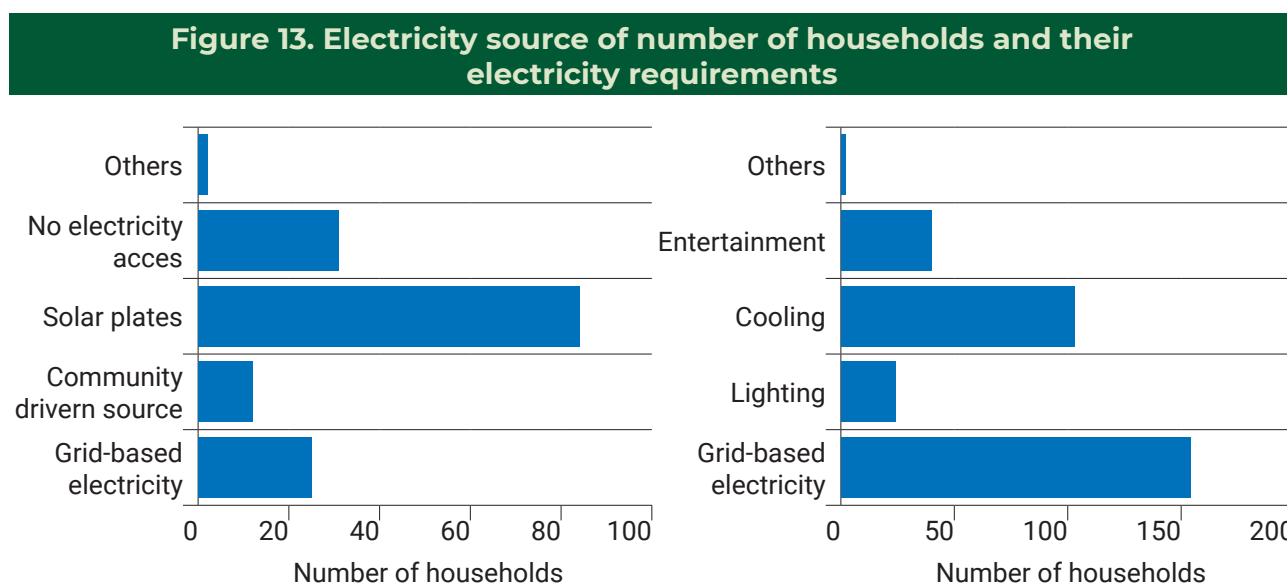
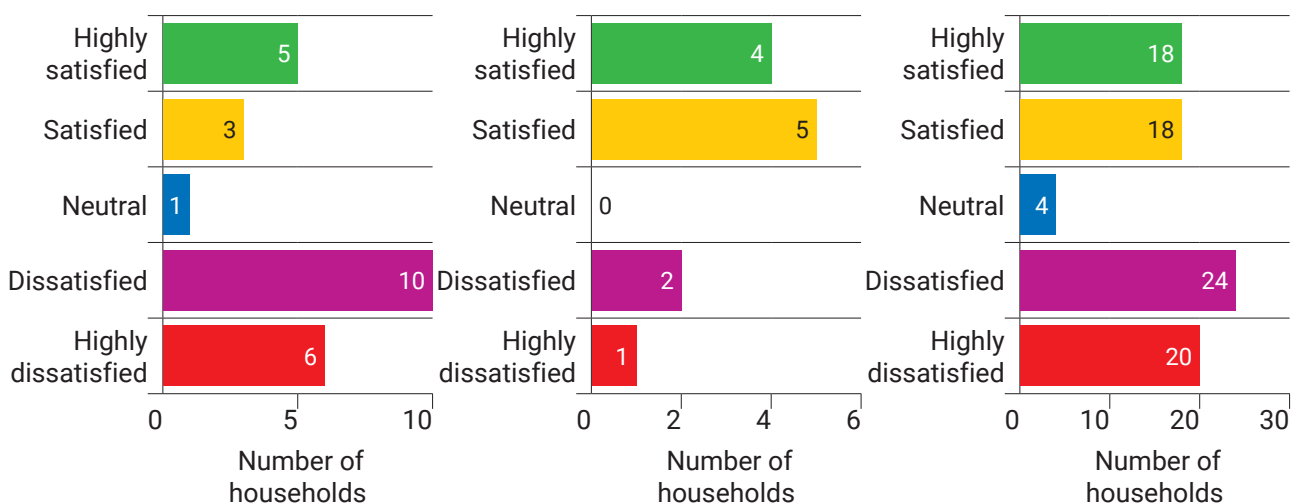


Figure 14. Community (No. of households) level of satisfaction for different electricity sources



necessities, leading to limited economic activities. The livelihoods of most of these communities was either derived from raising livestock or earning daily wages through labor work. The average daily income of these households was PKR 31,000/month (with a minimum value of around PKR 10,000/month and a maximum of PKR 65,000/month).

households noted that even the nearby regions that have access to a grid barely receive 10-12 hours of electricity. Solar stand-alone systems, with a 100 W panel, have to be connected from device to device and are mainly used for lighting and cooling purposes at night. However, the households (although very limited) that were able to install solar systems of over 1 kW were completely satisfied as it was providing them access to all desired electricity services.

Figure 14 indicates that most of the households in the energy-deprived regions (other than ones on community grids) are mostly unsatisfied with their power generation sources. For households with “kunda” systems, voltage fluctuations and limited access were the major challenges. Furthermore, the

Figure 15 highlights the major challenges highlighted by households, identifying the key factors which limited them for buying a solar system or upscaling their existing ones.

Figure 15. Key challenges hindering the growth of decentralized solar systems in energy deprived regions

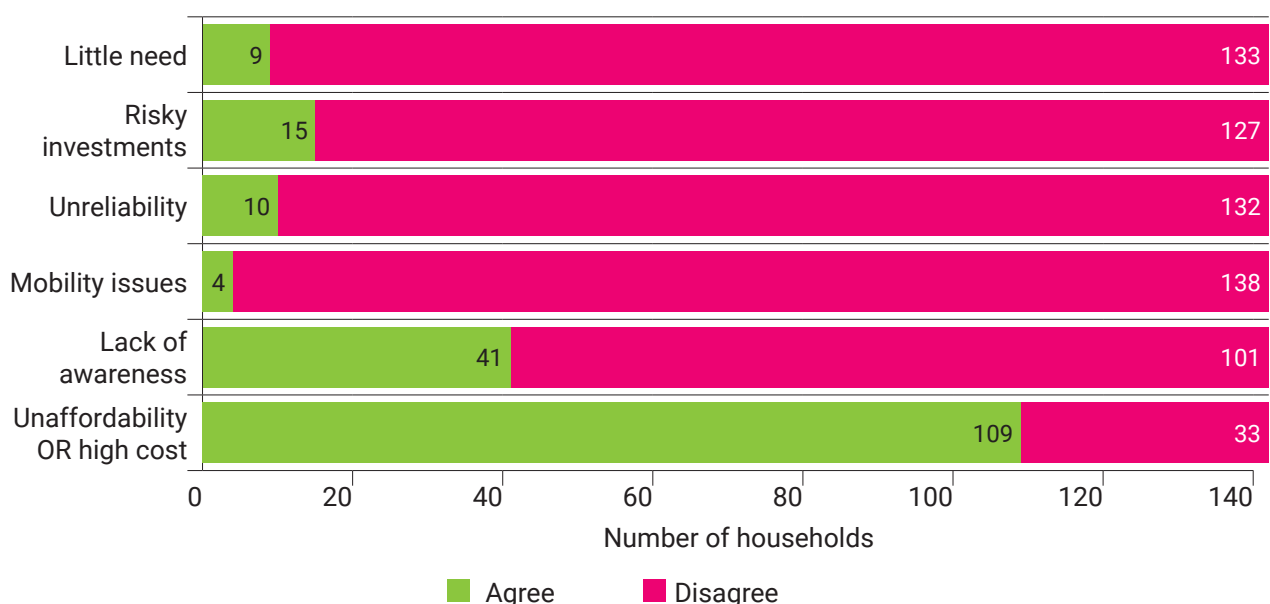
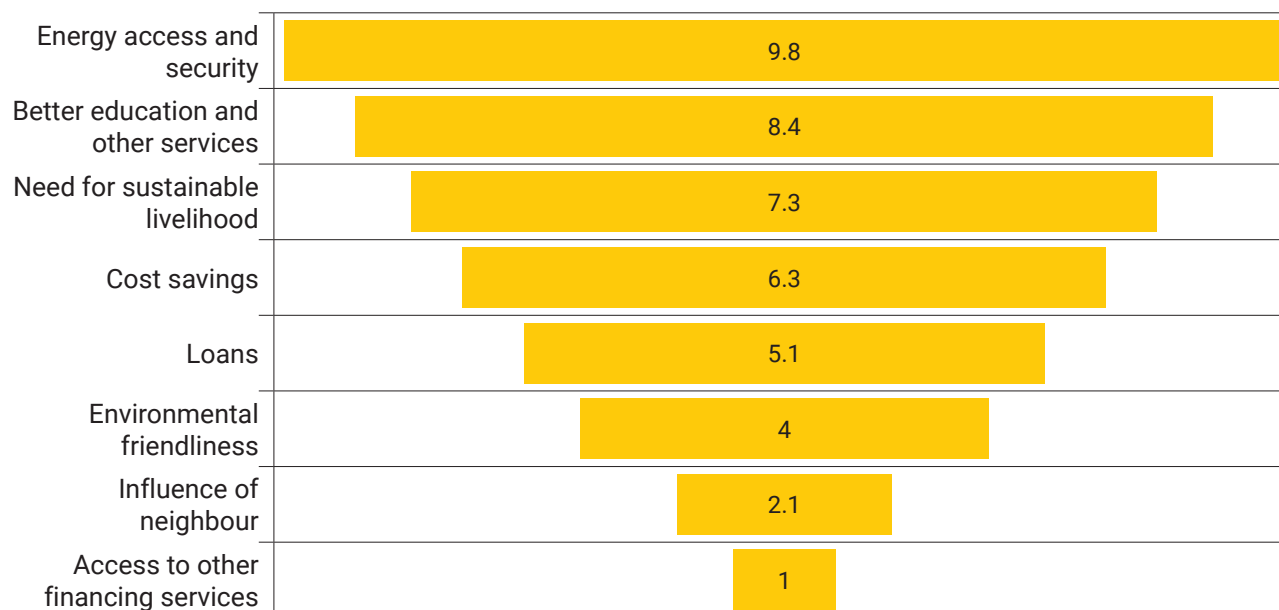


Figure 16. Impact of factors (average rating) enabling the push towards decentralized solar systems (10 being most important and 1 being the least important)



3.2.5 Awareness and willingness to adopt decentralized solar systems

Along with stand-alone solar systems, the households surveyed were also asked about mini and micro off-grid systems to check their awareness level and under what conditions households would transition towards such systems. For households that were connected on a common distributed grid, the average rating of key reasons are identified in Figure 16 (10 being most important and 1 being the least important).

Figure 16 illustrates that the major factor that enabled the communities to transition towards off-grid systems was the need for reliable electricity access, followed by services such as improved education and health services. While the systems were not connected or used for any commercial activity, households indicated that off-grid systems had contributed to improvements in their daily livelihoods.

The environmental impacts of the decentralized energy systems were however limited. Most of the households were using (inefficient combustion) wood or biomass as the primary fuel, leading to environmental hazards particularly through indoor pollution. Resultantly, the unelectrified regions have a higher rate of acute and chronic diseases

in children and adults. The indoor air pollution in Pakistan accounts for 28,000 deaths a year and 40 million cases of acute respiratory illness (Colbeck, 2010). Furthermore, biomass is mainly used for cooking and heating purposes with very limited applications for lighting. Although solar technology does not produce any air pollution or GHGs during its operation,² in the current practice of rural areas, the decentralized systems were not replacing their current wood use, but rather providing a provision for electricity services. Thus, environmental impacts were not perceived to be among the deciding factors of households that adopted such systems. The priority factors for transitioning to decentralized energy systems were the associated economic incentives, and how that influenced their daily livelihoods.

Other households were initially asked about their awareness and understanding of mini/microgrids (knowledge of microgrid existence, purpose and benefits, service offerings, safety and operations, costing mechanisms, and key suppliers that can be reached out for such systems). Figure 17 highlights

² Solar energy technologies require use of materials, such as metals and glass, that are energy intensive to make. The environmental issues related to the production of these materials could be associated with solar energy systems when conducting life-cycle or so-called cradle-to-grave environmental analysis.

Figure 17. Awareness level of survey region around decentralized solar energy systems

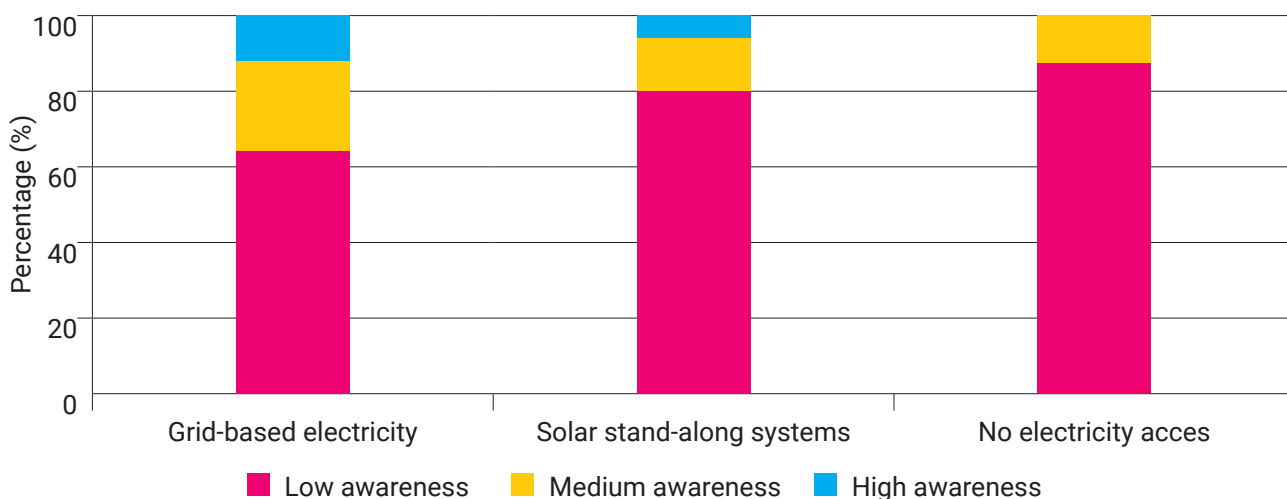
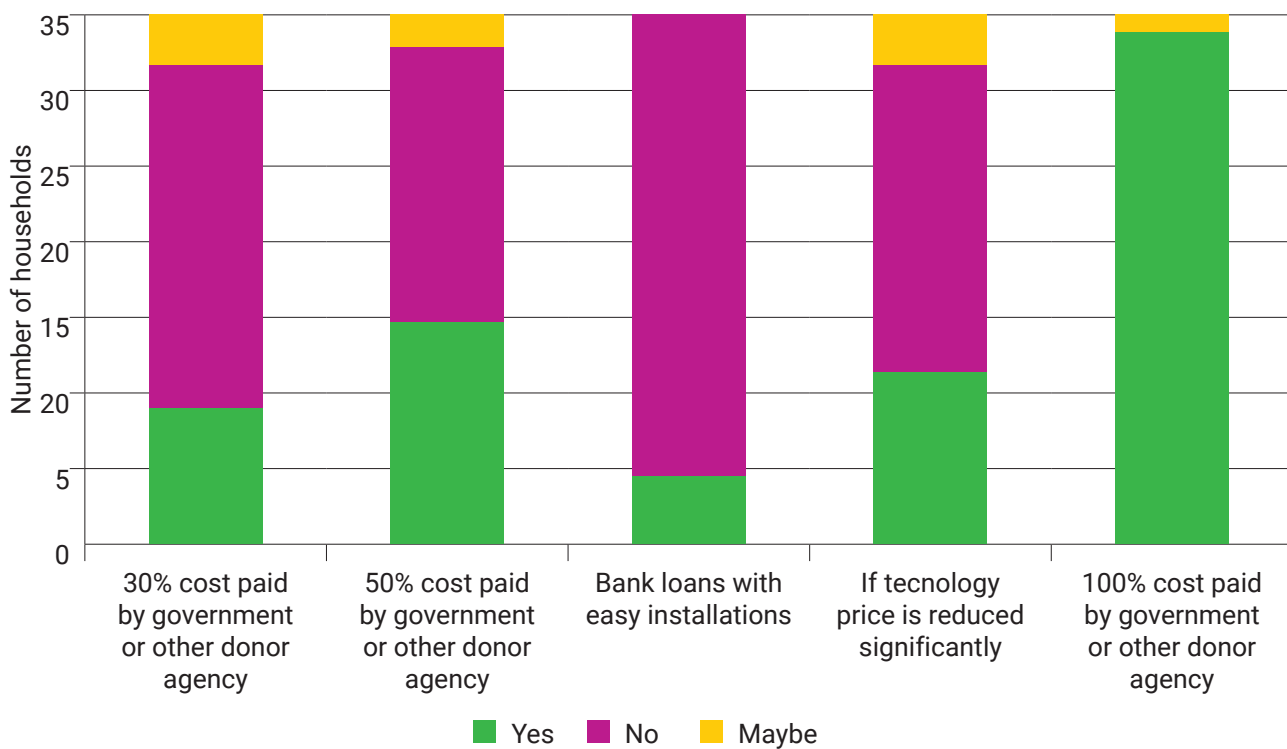


Figure 18. Willingness of unelectrified households to adopt off-grid systems against potential financing support



the awareness of households around mini and microgrid systems.

Figure 17 indicates that households that had access to grid-based electricity were comparatively more aware of the off-grid solutions as well, followed by houses that had solar stand-alone systems. Households that did not have access to electricity had little to no understanding of what solutions off-grid systems can offer, nor how electricity access

can be achieved through those. This provides a strong case for conducting capacity-building programs in these energy-deprived regions.

The households that were aware of these off-grid systems but had not installed them were also requested to respond to conditions under which would install such systems. Figure 18 represents the response of respondents against the options provided to them.

Figure 18 indicates that some very strong fiscal support is required to enable off-grid technology adoption in these regions. The larger share of this population will not be able to afford the technology even if 50 per cent of the cost is reduced. Cost of commonly deployed technologies in these regions is indicated in Table 3.

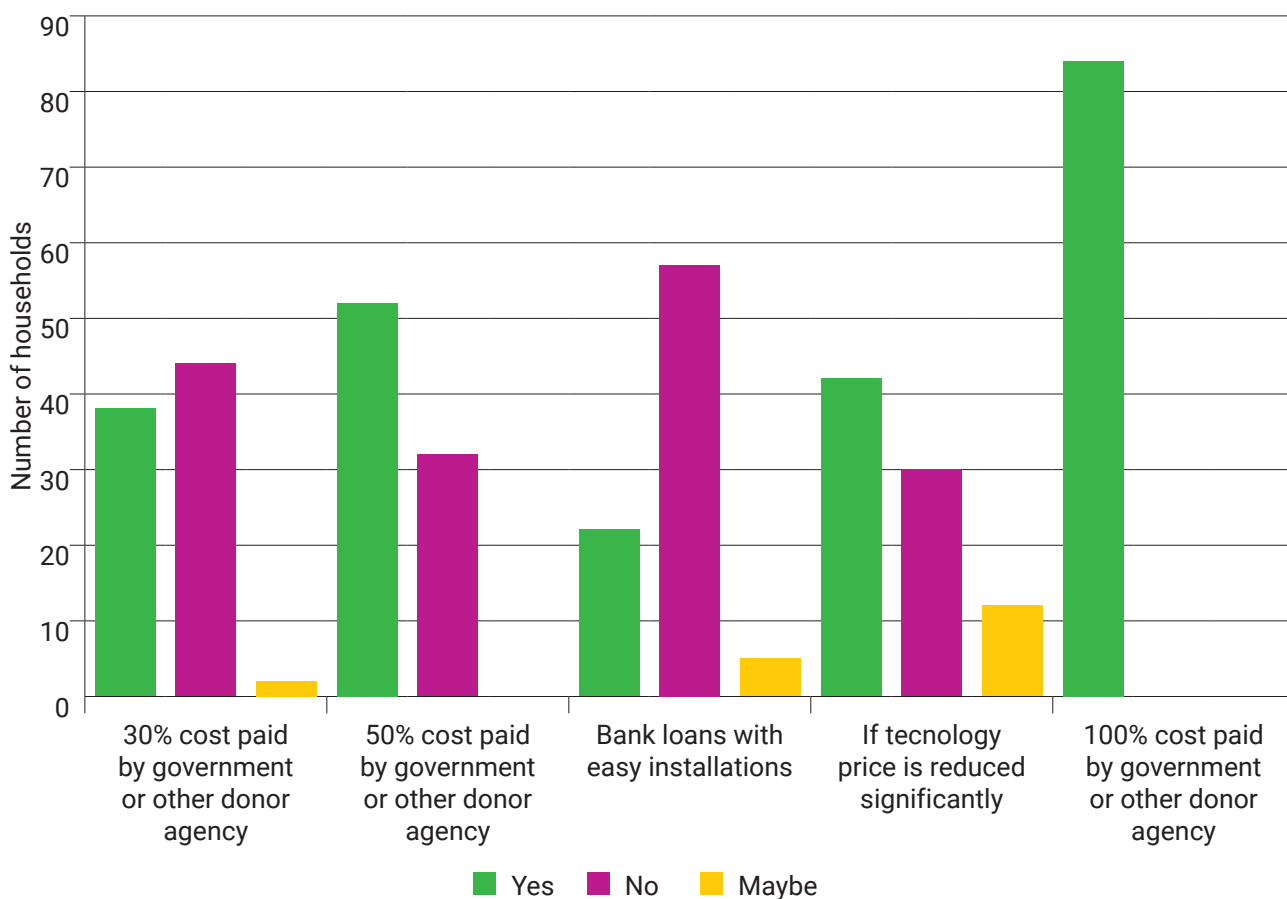
Regarding financial support provided through the bank, these households were of the view that

they would still need to reimburse the bank in the future, which they would not be able to afford. The same response was noted for reduction of technology prices. Hence, the households that do not have access to any sort of electricity need to be uplifted through “free technology provision” support schemes. This can be done either by upscaling previous efforts made by different NGOs/development partners or introducing new funding schemes.

Table 3. Average technology cost for off-grid technologies				
Technology Name	Type	Average Cost	Units	Initial Cost / household (Average)
Solar plates	100 W	8000	2 – 3	16,000 – 24,000
	150 W	15,000	1 – 2	15,000 – 45,000
	500 W (pumps, tube wells)	130,000	1	10,000 – 12,000
Battery	100 AH (ampere hours)	17,000	1-2	17,000 - 34,000
	175 AH (ampere hours)	28,500	1-2	28,500 - 57,000
Off-grid system	12-houses connection (lighting & cooling load) without battery	30,000,000	12	250,00

Source: Cost estimates collected during survey

Figure 19. Households’ response toward potential financing support for technology adoption



As opposed to this, the households that were using solar stand-alone systems were asked to respond to the same question, indicating measures they would need to upsize/improve their systems. Figure 19 indicates that there was more willingness toward adopting technology from those households that already had some electricity access.

3.2.6 Key takeaways from the survey

This case study indicates that apart from solar stand-alone systems, the penetration of decentralized solar systems in Pakistan is very low. On the consumer end, the key challenges pertaining to this are limited awareness, low paying power especially given the recent increase in battery and solar PV prices in Pakistan, and capacity to operate and maintain the larger systems. On the other hand, apart from solar stand-alone systems, most of the developments that happened around decentralized systems were through the support of multilateral or bilateral institutions. While some efforts (solarization schemes) were introduced by the banking sector, the economic crisis of 2023 discontinued their provisions. Further, no regulatory or fiscal support is available that can be used to upscale these efforts. While AEDB was set as a one-window facilitator,

it has focused mainly on setting-up large-scale grid-based plants. Although provincial governments have dedicated energy departments, they have limited fiscal or human capital for improving energy access. This has also limited the involvement of the private sector to invest in off-grid initiatives that have potential to power productive enterprises. Without such comprehensive plans, the provision of energy alone is unlikely to drive positive local development and sustainable poverty alleviation.

Hence, an enabling push is needed from the government. Firstly, establishing a robust institutional framework is paramount. This involves delineating the roles and responsibilities of all stakeholders, particularly government bodies, concerning national electrification. It also encompasses policy formulation, regulatory drafting, oversight, licensing, tariff setting, project planning, and project execution. Secondly, there is a pressing need for an off-grid electrification planning approach, which could be a top-down approach, where the government identifies and prioritizes projects centrally, or a bottom-up approach, where non-governmental entities propose potential projects. Alternatively, a hybrid approach that blends elements of both can be considered.

Box 2. Pilot initiative of mini grids in Thatta (Sindh) - 2016

The Pakistan Poverty Alleviation Fund (PPAF), in collaboration with Indus Earth Trust (IET), initiated a pilot project to install four mini grids in Thatta district of Sindh (namely Hamzo Samo, Bachoo Koli, Jaffar Jokio, Isaque Jokio). Nizam Energy acted as the project vendor and installed the project in April 2017. The post installation results on the community indicated that those villages that previously used kerosene lamps for lighting now had access to uninterrupted electricity all seven days of the week. The resulting socioeconomic impacts were also very clear for men, women, children, and the elderly. The initiative had a clean impact on women who were able to complete their night chores without any fear of not being able to see or being stung by snakes and scorpions. Some villagers were able to start their own enterprises, eventually leading to an increase in their incomes of up to 70 per cent. For long-term financial sustainability, a tariff system was also put in place under which the earnings from this income were to be deposited in a “village bank” once the communities started paying for this power supply. The primary aim of the fund was to cover the expenses related to replacing or upkeeping equipment beyond its warranty period. Ultimately, the most sustainable approach would be for communities to fully fund their own systems. Currently, each household incurs a minimum monthly expenditure of Rs. 1200 on kerosene and candles. By offering a tariff slightly below this amount, the project introduced a leasing option that allows for the gradual repayment of equipment costs over a span of 5-6 years.

Subsequently, crafting a delivery model becomes imperative. This model outlines the degree of private sector involvement and touches upon ownership structures (state-owned, private, community). In cases of hybrid approaches, the delivery model defines conditions such as concession terms and duration. Additionally, it should clarify preferences for licensing rights, such as the grant of exclusive power retail rights and the conditions under which these are conferred.

On the other end, it was also observed that unlike the case of MHPPs, limited community engagement

was observed for this case, driven by the lack of understanding and awareness, and most importantly some successful case studies. Thus, piloting more projects of off-grid solar systems in these areas would create a sense of “understanding” within different Goths, eventually leading to its increased adoption. Along with these projects, increasing the awareness of community around the positive socioeconomic prospects offered by these initiatives is of utmost importance, especially for the population that does not have access to any form of electricity source.

Chapter 4: Frontiers of change: The way forward for RE developments in impoverished regions of Pakistan

Based on an extensive desk review, survey-based case studies and consultative discussions between different stakeholders, this study indicates that the significance of energy security in social development and for addressing poverty alleviation in developing countries, such as Pakistan, cannot be overemphasized. While, Pakistan has observed some progress in increasing electricity access over the past year, the reliability and availability of clean power in rural communities is still a major challenge, hindering their socioeconomic opportunities. There is also a strong relationship between access to clean energy and adaptation to climate change, i.e., having access to clean and affordable energy can develop climate resilience in the communities. Reliable and affordable energy could support in: i) disaster preparedness response through operation of emergency communication systems, charging

stations, and receiving timely announcements; ii) climate smart agriculture that can help farmers in food preservation (mainly refrigeration) during dry months, and use of RE in climate smart farming.

Although Pakistan has observed a well-documented shift towards RE in its recent policies, the regulatory and policy support for decentralized systems is critically missing. There are strong efforts made by community-based organizations, development partners, NGOs, and other civil society organizations. However, a strong policy and regulatory support is required to provide an enabling environment for these decentralized systems to grow. This section proposes policy actions and recommendations to foster energy access through the use of RE solutions in the impoverished regions of Pakistan.

4.1 Harnessing the potential of decentralized renewable energy

The convergence of several factors in Pakistan including i) reliance on imported fossil fuels; ii) high generation cost of the national grid; iii) limited fiscal space; iv) low cost of RE; v) extremely high cost of grid expansion; and vi) prospects of positive community engagements have developed a strong case for off-grid RE. While many regions in the northern areas of Pakistan have adopted different decentralized renewable energy options (such as the case of MHPPs), the total capacity is still being underutilized, owing to outdated technologies, limited understanding, and inefficient use of the available water heads. Driven by these challenges, many MHPPs, across the northern areas of Pakistan, installed by NGOs have been shelved, leading to prolonged power outages throughout the year.

Thus, there is a strong need to come up with support mechanisms for sustainability of such initiatives and scaling them up to their realistic potential.

Secondly, one of the most significant opportunities offered by off-grid RE solutions is their decentralized nature that provides an opportunity to fully utilize the socioeconomic benefits of enhanced energy access. This involves the engagement of local communities across different segments of the value chain. Numerous skills required for installing, operating, and maintaining off-grid systems can be nurtured within the local community, thereby granting access to training and job opportunities, particularly for youth and women. The case studies conducted in this study have also indicated

that actively involving communities throughout project development enhances sustainability and maximizes benefits by fostering local ownership and establishing connections with end users, including income-generating activities. Thus, to develop an inclusive way forward, the debate around off-grid

RE must go beyond electricity generation and also focus on key aspects including: i) need for policies and regulations; ii) capacity-building; iii) institutional framework; and iv) delivery and financing models, cross-sectoral linkages and technologies that can be used.

Policy Recommendations		
<ul style="list-style-type: none"> • Develop a geo-spatial least cost electrification plan by the Ministry of Energy and NEPRA to deploy mini grids, decentralized energy systems and stand-alone solar systems in unelectrified and energy poor areas of Pakistan. • Launch technical assistance programs through public community models where CBOs and community representatives can learn how to effectively use energy from the decentralized systems. • Design and implement capacity-building programs for government departments, financing institutions, and project developers to enhance expertise in the design, installation, and operation and maintenance of mini grids. These programs can receive technical and financial support from multilateral and bilateral institutions. • Formulate, under NEPRAs leadership, specific policies and regulations that encompass permitting and licensing prerequisites, guidelines for connecting with the main grid, tariff establishment, and other relevant aspects concerning mini grids within the country, for projects over 1 MW. The grid arrival rules should incorporate interconnection and compensation mechanisms to mitigate risks associated with connecting to the main grid. To streamline the process of obtaining mini grid licenses and fulfilling regulatory obligations, a unified single-window clearance facility could be set up by PPIB. • Establish clear regulations to develop and enforce technical standards for the instruments utilized in mini grids. Furthermore, notification of technical codes for interconnecting with the national grid should be carried out. • Streamline the governance structure of conflicted/unsettled/remote areas, to address the financing and regulatory needs of energy sector development. The Government of Pakistan should bring clarity on the constitutional status of the northern regions, particularly GB and AJK. 		
Timeframe	Relevant Stakeholders	Key Action Items
Short term	PPAF, ASKRSP, other CSOs and CBOs	Develop special financing models for land affectees.
Short term	Ministry of Energy, provincial governments	Develop business models for “last-mile energy service delivery.
Short term	TEVTA, NEVTA, CSOs, development partners	Launch “Technical Assistance Programs” for building capacity of communities and relevant authorities.
Medium term	NEPRA, NTDC	Develop a “Least cost electrification plan”.
Medium term	NEPRA	Formulate policies and regulations for licensing, connecting with grids, establishing tariffs for the mini grids.
Medium term	PPIB	Establish a unified single window clearance.

4.2 Mobilizing the finance for upscale of decentralized RE solutions

Based on both case studies described in the report, the major challenge hindering access to clean energy is capital investment needs. Given that most of the unelectrified regions have a low-human index, people’s willingness to pay for energy services is far lower as compared to those living in urban areas.

The current progress in these regions has also been reliant on financing from different development partner banks, or other NGOs. However, these efforts still need to be upscaled (especially since 2022 after which financing schemes have stopped) particularly through government support schemes and increased

participation from the private sector. The findings also identified a lack of feasibility studies which discouraged further investments. An insufficient

focus on generating feasibility and technical studies hindered the private sector to conduct financial analysis and additional assessments.

Policy Recommendations

- Create **financial models** that encourage land affectees with reduced bills, tax exemptions, and additional social and environmental co-benefits. This can be led by collaborations between those civil society organizations working to support decentralized energy systems and community-based organizations.
- Create innovative business models for last-mile energy service delivery, especially ones that can lead to business opportunities and income generation through productive use of energy. This can be accomplished through collaborations between Pakistan’s Ministry of Energy and the provincial governments.
- Set up **financing programs or support schemes** that utilize government or donor funding that is available in the country in order to expand the deployment of decentralized RE solutions. Creating dedicated rural electrification funds that combine public and donor finances can facilitate private developers in obtaining financing for these projects.
- Adopt the **Principle of Subsidiarity** by government entities, to delegate tasks efficiently at the consumer level in order to create a favorable environment for the private sector to engage in decentralized energy systems. Comparable barriers and challenges faced by both international and local investors must be tackled by offering a business-friendly atmosphere.
- Develop **feasibility studies and financial models**, under the leadership of provincial governments, that demonstrate the financial viability of such investments within the local context. Such models will attract local and international financing for decentralized clean energy projects. The initiatives taken by PEDO to develop business models for MHPPs in KPK are examples for other provinces to follow.
- Make **provisions for additional concessional financing windows** for the offtake of renewable energy, in addition to reinstating SBP’s RE schemes. **RE could be introduced as a priority area for commercial lending**, thus demanding a higher participation from the commercial banks as well.
- Leverage **larger climate funds such as the Green Climate Fund (GCF)**, under which relevant ministries can join forces to collaboratively address renewable energy (RE), off-grid solutions, battery storage, and other commercial projects. Concessional financing from the GCF can be made available for these initiatives.
- Introduce **profit-based subsidies** for distributed generation, instead of off-take guarantees and capacity payments.

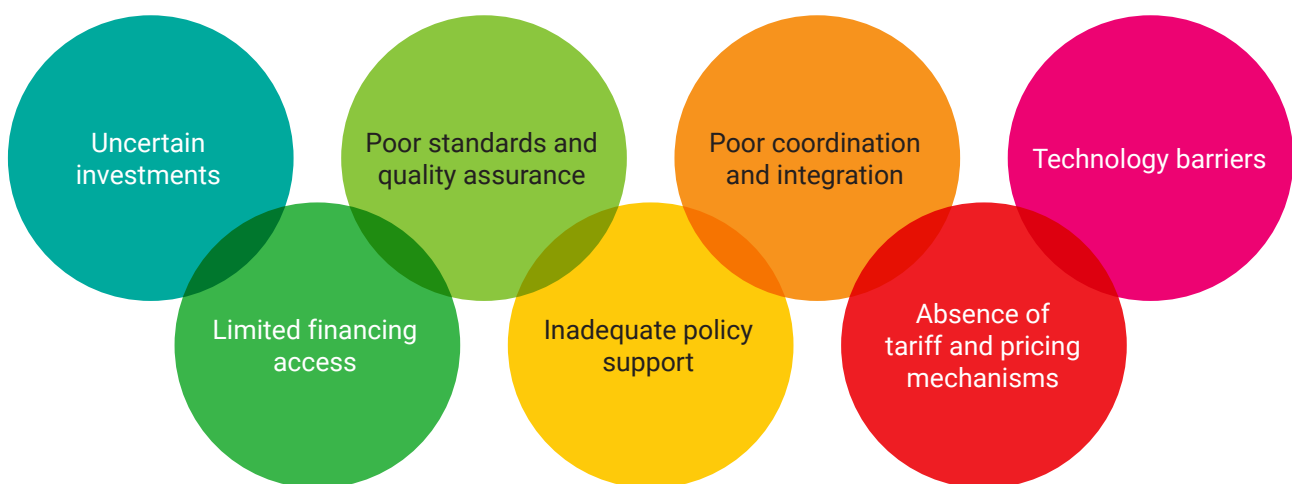
Timeframe	Relevant Stakeholder	Key Action Items
Medium term	Board of Investment, SBP, Ministry of Finance	Set up financing programs or support schemes that utilize government or donor funding available in the country.
Short term	Provincial governments, CSOs	Develop feasibility studies and financial models for off-grid RE.
Short term	SBP, commercial banks	Provision of additional concessional financing windows.
Long term	MoCC&ED, MoFA, MoPD&SI	Leverage larger climate funds such as the Green Climate Fund (GCF) for off-grid RE.

4.3 Policy frameworks and institutional support for decentralized RE

For accelerating the use of off-grid RE solutions in remote areas, placing a necessary institutional framework is crucial. In absence of this support,

widespread adoption can present significant challenges as identified in Figure 20.

Figure 20. Off-grid RE challenges due to absence of an institutional and policy framework



Policy Recommendations

- Develop a **supporting regulatory framework** for decentralized RE in collaboration with the Federal and Provincial Energy Department. This framework should contain streamlined processes, reduce policy barriers, and provide incentives such as tax breaks, subsidies, or other grants.
- Push **“Energy Market Reforms”** that can provide fair pricing and market access to off-grid RE projects. This can also include feed-in-tariff or net metering programs, that can allow off-grid producers to sell access electricity to grid.
- Enable the provision of **“special financing mechanisms”** for RE projects in areas where conventional financing access is limited. This could include venture capital, dedicated funds, or even community-driven financing models that can attract private financing.
- Promote the **adoption of PPPs** to harness the resources and expertise of both sectors. Through private collaboration, the Government can foster off-grid RE and enable their outreach to remote areas.
- Facilitate **technology transfer and research and development collaborations** to promote the use of more efficient technologies. This can be achieved through collaborations between the Government of Pakistan and relevant NGOs and development partners. The academia must also play an important role in developing pilot projects for advanced technologies.
- Engage **local communities in the decision-making process**. Such consultations should be conducted to understand their needs, demands, concerns, and developing an ownership for the local RE projects.
- Set up **monitoring and evaluation mechanisms** to assess the impact and effectiveness for a sustainable off-grid RE market in Pakistan. An evaluation framework will also provide insights into the weaknesses and strengths of implemented policies.

Timeframe	Relevant Stakeholder	Key Action Items
Medium term	Ministry of Energy (Power Division), Provincial Energy Departments	Develop a supporting regulatory framework for off-grid RE.
Medium term	NEPRA, MoE	Foster energy market reforms for providing fair pricing and market access to off-grid RE projects.
Short term	National Energy efficiency and conservation authority, Academic Institutes, PCRET	Enable technology transfer programs for off-grid RE.
Long term	NEPRA, PPIB/AEDB	Develop a monitoring and evaluation framework to assess the impact of policy decisions.

4.4 Scaling-up of off-grid systems

As depicted from the case studies, the current models being used in Pakistan are of small scale that are subject to a number of challenges. This includes: i) production variations (seasonal as well as monthly; ii) water flows (turbidity, sediments, and seasonal variations), sub-optimal designs and equipment; and iii) sub-optimal operation and maintenance, unavailability of spare parts, problems in the civil works, impacts of natural disasters and inadequate revenue collection systems.

While some improvement has been observed, particularly in the northern areas, these challenges

cannot be addressed solely by NGOs and communities, and needs aggregation and scaling-up of the systems. This in turn will bring efficiency in the procurement and ensure social and environmental safeguards of the system. Thus, improving a household’s ability to pay requires an area/village growth approach. The dire need to uplift lives and enable communities is a two-part equation that contains: i) enabling capacity to pay as commerce increases; and ii) ensuring community awareness i.e., understanding the externalities for not paying for clean energy.

Policy Recommendations

- Initiate bulk procurement to address technological challenges. This could enhance quality and reduce production costs. Also, it can enhance bargaining power and improve reliability of supplies.
- Enable better monitoring and reporting for financiers by designing and implementing environmental and social safeguards across a group of utilities by a managing company. This will also centralize responsibility and create harmony among citizens.
- Enable an area/village growth approach to mitigate the risks of distributed generation, and bringing real return to the communities.
- Promote collaborative data-sharing and analytics to facilitate research and the integration of new technologies. This will enhance the dissemination of advanced technologies, standardize designs, and improve the distribution of utilities, which is crucial for progress in the sector.

Timeframe	Relevant Stakeholder	Key Action Items
Short term	Provincial governments, relevant NGOs	Install regulatory measures to expedite bulk procurement of production technologies.
Medium term	Community-based organizations, relevant NGOs.	Establish a robust monitoring and evaluation system for environmental and social safeguards.
Medium term	Investors, relevant operating agencies (CSOs)	Establish a mechanism for data-sharing and analysis.

4.5 Addressing social and gender challenges

In various regions, both NGOs and public sector entities have encountered significant difficulties while attempting to install decentralized plants. These challenges stem from social conflicts and disagreements among community members concerning land acquisition and the plant’s location, as well as resistance to lending rooftops for these projects. Although energy policies in the region prioritize providing clean and modern energy alternatives to traditional fuels, they have

overlooked the provision of sufficient and affordable electricity for home-based microenterprises and labor-intensive post-harvest technologies utilized by women, such as turbines, threshers and groundnut strippers. Additionally, the low enrolment of women in technical and engineering fields can be attributed to socioeconomic and cultural barriers that persist in society, restricting women’s engagement to traditional areas of work.

Policy Recommendations

- Prioritize the **inclusion of women**, who are currently underrepresented, in both the energy sector's workforce and in decision-making processes to unlock the full potential of off-grid RE industry.
- Develop mechanisms to **guarantee the maintenance of gender-disaggregated data, Gender Equality and Social Inclusion (GESI)-sensitive assessments**, as well as monitoring and evaluation processes. These measures aim to enhance the effectiveness of policies in achieving gender and social equality.
- Ensure a **minimum quota for women in the village communities** to increase the participation of women. During project development, participation of women should be made an integral part of the discussions, and its compliance should be ensured by the developing agencies.

Timeframe	Relevant Stakeholder	Key Action Items
Medium term	MoE, parliamentary caucuses/taskforces	Upscale the participation of women in decision-making processes of the energy sector.

4.6 Fostering regional cooperation

South Asia is rich in renewable energy potential, providing ample opportunity for extraction of this potential through mutual collaboration. Despite this, interregional trade in this region is below its regional potential. Significant areas of potential collaboration exist, such as solution-oriented training and research, refining policies in light of regional countries, implementing joint projects, compiling necessary knowledge and best practices, diverting financial

resources to clean energy projects, and collaborating with national and international centers.

Thus, to accelerate off-grid RE developments, regional cooperation in South Asia (particularly the SAARC countries) is critical. To foster this collaboration, this study proposes the following actions:

Policy Recommendations

- For exchange of good practices and learning across the countries, there is a need to develop a "regional mini grid cooperation mechanism" with representation of relevant ministries/departments of the member countries.
- SAARC member countries can join and initiate a specialized course on "Design and operation of mini grids". This course can be offered to the relevant stakeholders (government departments for RE, private sector/NGO representatives, and other key stakeholders of member countries). The course contents could be tailored, where possible, to meet the requirements of relevant countries.
- Develop an online platform (or a facilitation desk) of South Asian countries that connects the mini-grid project developers, investors, service providers and other stakeholders of the region. This platform can support the mini-grid deployment by supporting the investors and securing finance more efficiently.
- Address the political challenges to foster cross-boundary trade agreements to enable the exchange of clean energy technologies between countries.

Timeframe	Relevant Stakeholder	Key Action Items
Short term	SAARC platforms, UN agencies, MDBs/DFIs	Develop a regional mini grid cooperation mechanism.
Short term	Development partners, SAARC platforms	Initiate capacity-building for the regional stakeholders around design and operation of mini grids.
Medium term	UN agencies, MDBs/DFIs	Develop an online platform (or a facilitation desk) of South Asian countries.

Annex 1: ESMAP energy access multi-tier framework

Multi-Tier Framework for Measuring of Electricity Access							
Attributes		Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Peak capacity	Power capacity ratings (W or daily Wh)		Minimum 3 W	Minimum 50 W	Minimum 200 W	Minimum 800 W	Minimum 2 kW
			Minimum 12 Wh	Minimum 200 kWh	Minimum 1.0 kW	Minimum 3.4 kWh	Minimum 8.2 kWh
	Services		Lighting of 1,000 lmhr per day	Electrical lighting, air circulation, television, and phone charging are possible			
Availability (Duration)	Hours per day		Minimum 4 hours	Minimum 4 hours	Minimum 8 hours	Minimum 16 hours	Minimum 23 hours
	Hours per evening		Minimum 2 hours	Minimum 2 hours	Minimum 3 hours	Minimum 4 hours	
Reliability						Maximum 14 disruptions/week	Minimum 4 hours
Quality						Voltage problems do not affect the use of desired appliances	
Affordability					Cost of a standard consumption package of 365 kWh per year < 5% of household income		
Legality						Bill is paid to the utility, prepaid card seller, or authorized representative	
Health and safety						Absence of past accidents and perception of high risk in the future	

Annex 2: Number of people served through off-grid energy access

Source	year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
	Hydropower	Africa	342	343	462	478	617	618	634	634	643
Asia		5254	5537	5844	6136	6268	6308	6372	6401	6449	6449
Central America and Caribbean		53	57	76	78	78	78	79	79	94	94
Middle East		0	0	0	0	0	0	0	0	0	0
Oceania		6	6	7	7	7	7	7	7	7	7
South America		2	2	2	2	2	2	3	3	3	3
Solar lights (<11 W)		Africa	6465	19784	33229	46758	47464	47171	41961	45702	46727
	Asia	9031	19841	30366	40270	42977	68387	98250	121020	99852	78990
	Central America and Caribbean	8	7	9	6	113	324	438	461	315	324
	Middle East	104	226	398	977	2588	5028	4517	5103	4039	4494
	Oceania	58	187	363	836	1317	1317	1324	1223	1277	1067
	South America	2	28	51	69	139	271	351	431	367	480
	Solar Home Systems (11-50W)	Africa	165	571	1055	1825	2477	3120	4725	7291	9278
Asia		11284	14857	17507	19180	18762	17318	15671	13360	9719	7914
Central America and Caribbean		21	21	34	34	51	32	32	49	49	38
Middle East		0	0	0	0	0	0	12	204	204	204
Oceania		0	0	0	0	30	47	143	185	243	486
South America		37	124	145	162	186	159	82	94	85	65
Solar Home Systems (>50W)		Africa	392	439	502	767	1523	2613	3438	4909	6637
	Asia	395	399	403	407	411	510	835	1833	2022	2193
	Central America and Caribbean	0	0	0	1	1	7	33	61	61	62
	Middle East	0	0	0	0	0	0	0	0	0	0
	Oceania	16	22	27	27	27	27	64	102	119	187
	South America	16	16	16	2	72	80	80	80	80	8

Annex 3: Nexus of energy access with different indicators of SDG goals

SDG	SDG Indicator	Prospects of SDG 7
	1.2	Poverty reduction in multiple dimensions
	1.4	Improves effective women participation
	2.4	Sustainable food production systems
	2a	Increase in rural investments
	2.3	Increase agri-productivity and farmer production
	3.9	Reduce deaths and illness from hazardous chemicals
	3.8	Access to health care
	4.1-4.4	Access to education
	5.6	Integrated water resource management
	6.3	Improves water quality
	7.1	Access to energy services
	7.2	Increase in RE penetration
	7a	Promote investment in RE
	7b	Expand clean energy infrastructure
	7.3	Efficient energy use
	8.2	Economic productivity
	8.4	Decoupling economic growth
	9.1	Sustainable and resilient infrastructure
	9.3	Increase access of SMEs to financial services
	11.2	Access to environmentally safe transport systems
	11.3	Integrated and sustainable human settlements
	11.6	Improves air quality
	12.5	Reduce waste generation
	12.2	Efficient use of natural resources
	12.4	Sound management of Environmental waste
	12.6	Sustainable business practices
	12.8	Increase in awareness of sustainable development
	13.1	Strengthen resilience
	14.2	Protect marine and coastal ecosystems from hazardous waste
	15.1	Improves conservation, restoration, and sustainable use of water ecosystems
	17.8	Increase use of clean technology

Annex 4: Programs for improving energy access in rural residences of Pakistan

As indicated in the previous chapters, reliable energy is key to socioeconomic development. While the situation in Pakistan has improved in the 21st century, considerable efforts are required in the rural communities, particularly where there is a lack of access to reliable and affordable energy services. Given this, the provincial government along with other stakeholders, including NGOs and NPOs, has also taken a number of initiatives to improve energy access. Some of these public sector led initiatives include:

- **KPK-Ujaloun ka Safar:** Under this proposed scheme, a total of 1000 MHPPs will be built in two phases. In phase 1, approximately 356 mini and micro hydropower plants are currently being constructed. The combined generation capacity of these plants, excluding those with unapproved Planning Commission Form-I (PC-1) due to non-feasibility, was 32.5 MW, estimated to cost PKR 5.2 billion. As of September 2021, 312 projects have been completed, and 16 are currently under construction. Throughout the implementation of this plan, PEDO has actively collaborated with NGOs, particularly the Agha Khan Rural Support Programme (AKRSP), to ensure its effective execution.
- **KPK-Solarization of schools and health facilities:** PEDO, with the support of the KPK government, has commenced the Schools and Health Facilities Solarization Project. This ambitious initiative aims to solarize 8000 schools and 187 basic health units (BHUs), providing them with a combined capacity of 50 MW. Additionally, there are ongoing efforts to solarize homes, primarily in Chitral and southern districts, as well as 4440 targeted mosques, all of which are currently in the implementation phase.
- **KPK-SRSP MHPP Initiative:** Up to this point, the Sarhad Rural Support Program (SRSP) has successfully installed 353 micro hydropower units in the KPK province, bringing benefits to 927,495 people and generating a total of 29 MW of energy.
- **Balochistan-Solar system for water access:** The Balochistan Energy Department launched a project called "Provision of Solar System for Water Access", which seeks to harness shallow water resources in off-grid regions using solar-powered systems. Additionally, the Public Sector Development Programme (PSDP) includes several off-grid solar initiatives for public sector buildings, streetlights, and home solar systems.
- **AJK-Hydropower development program:** Under this program, AJK has taken active steps towards both hydropower development and solarization. From 2013 to 2017, the AJK power development organization successfully implemented 34 micro hydro stations, collectively generating 1250 MW of power. Additionally, there are currently 122 more micro hydro stations in the pipeline, awaiting implementation.

AJK-Solarization Project: The AJK electricity department embarked on a solarization project with the objective of supplying solar power to 10,000 homes, 400 schools, and 100 health units. Likewise, the water and power department of Gilgit-Baltistan is presently carrying out a seven-year solarization initiative to transition more than 100 buildings and 5 hospitals to solar power.

Pakistan Poverty Alleviation Fund (PPAF) Initiative: In addition to the public sector, the CSOs and the development sector has also led the following efforts. The Pakistan Poverty Alleviation Fund (PPAF) has undertaken a multifaceted approach to address the critical issue of improving energy access in rural Pakistan through the Productive Use of Renewable Energy (PURE). This initiative combines small community grants and microfinance, aiming to reduce the country's heavy reliance on expensive crude oil imports while enhancing rural livelihoods. PPAF's substantial investments in grants and microfinance interventions have unlocked the potential for scaling up off-grid solar electrification in rural areas.

PPAF has pioneered the concept of community-managed renewable energy projects, establishing it as a successful and replicable model. In this approach, communities are actively engaged in initiating, developing, operating, and benefiting from renewable energy projects tailored to their specific needs and available resources. These projects range from solar PV installations in community centres to small wind farms in windy regions and hydropower projects owned by neighboring villages in northern Pakistan, to harness the vast hydroelectric potential of the area.

The impact of PPAF's efforts is impressive, with over 1,000 diverse renewable energy projects (totaling 13 MW) benefitting more than 250,000 people across 38 districts in Pakistan. These projects have received support from various development partners, including the World Bank, KfW (German Development Bank), the International Fund for Agricultural Development (IFAD), and the United States Department of Agriculture (USDA). Notably, these initiatives have not only improved the lives of local communities and businesses but have also stimulated local economies and generated job opportunities for professionals and entrepreneurs. In addition to their socioeconomic benefits, these projects have a significant environmental impact, saving over 9,000 tons of carbon dioxide emissions (CO₂) annually.

References

- Abre-Rehmat, Qurat-ul-Ann, and Faisal Mehmood Mirza (2021). Multidimensional energy poverty in Pakistan: Empirical evidence from household level micro data. *Social Indicators Research*, vol. 155 (January). Available at <https://link.springer.com/article/10.1007/s11205-020-02601-7>
- Ali, Mazhar, and others (2021). Techno-economic assessment and sustainability impact of hybrid energy systems in Gilgit-Baltistan, Pakistan. *Energy Reports*, vol. 7 (November). Available at <https://www.sciencedirect.com/science/article/pii/S2352484721002523>
- Awan, Ashar, Faik Bilgili, and Dil Bahadur Rahat (2022). Energy poverty trends and determinants in Pakistan: Empirical evidence from eight waves of HIES 1998–2019. *Renewable and Sustainable Energy Reviews*, vol. 158.
- Brollo, Fernanda, Emine Hanedar and Sebastien Walker (2021). Pakistan: Spending needs for. Reaching Sustainable Development Goals (SDGs). International Monetary Fund (IMF) Working Paper No. 2021/108. 29 April. Available at <https://www.imf.org/en/Publications/WP/Issues/2021/04/29/Pakistan-Spending-Needs-for-Reaching-Sustainable-Development-Goals-SDGs-50285>
- Cheema, A.R. and others (2021). Pakistan SDGs Status Report 2021. Federal SDGs Support Unit. Ministry of Planning, Development and Special Initiatives, Government of Pakistan. Islamabad. Available at https://www.sdgpakistan.pk/uploads/pub/Pak_SDGs_Status_Report_2021.pdf
- Colbeck, Ian, Zaheer A. Nasir, and Zulfiqar Ali (2010). The state of indoor air quality in Pakistan--a review. *Environmental Science and Pollution Research*, vol. 17, No. 6. (July). Available at <https://pubmed.ncbi.nlm.nih.gov/20162371/>
- countryeconomy.com (2022). Pakistan - CO2 emission. Available at <https://countryeconomy.com/energy-and-environment/co2-emissions/pakistan#:~:text=CO2%20emissions%20in%202021%20were,from%20least%20to%20most%20pollutant>
- Eckstein, David, Vera Künzel, Laura Schäfer (2021). Global Climate Risk Index 2021. Briefing Paper. Germanwatch. Available at <https://www.germanwatch.org/es/19777>
- Energy Sector Management Assistance Program (ESMAP) (2019). Mini grids for half a billion people: Market outlook and handbook for decision makers. Technical Report 014/19. Washington D.C.: World Bank. Available at <https://sdgs.un.org/sites/default/files/2021-05/Mini%20Grids%20For%20Half%20A%20Billion%20People%20-%20Market%20Outlook%20And%20Handbook%20For%20Decision%20Makers.pdf>
- _____ (2023). Multi-Tier Framework for Energy Access (MTF). Available at https://www.esmap.org/mtf_multi-tier_framework_for_energy_access
- Government of Pakistan, Finance Division (2020). Pakistan Economic Survey 2020-2021: Annex IV: Impact of COVID-19 on socioeconomic situation of Pakistan. Available at https://www.finance.gov.pk/survey/chapters_21/Annex%20IV%20Covid.pdf
- _____ (2023a). Monthly Economic Update and Outlook, February 2023. Available at https://www.finance.gov.pk/economic/economic_update_February_2023.pdf
- _____ (2023b). Pakistan Economic Survey 2022-2023. Available at https://www.finance.gov.pk/survey_2023.html
- Hydrocarbon Development Institute of Pakistan (2022). Pakistan Energy Yearbook 2021-2022. Available at <https://www.hdip.com.pk/pakistan-energy-yearbook>
- Implementation Commission Pakistan (n.d.). Final Report of the Implementation Commission Constituted under Article 270 AA of the Constitution of the Islamic Republic of Pakistan. Available at <https://ipc.gov.pk/SiteImage/Misc/files/Year%20Books/Final%20Report%20of%20Implementation%20Commission.pdf>

Info Pakistan (n.d.). Article 157: Electricity. Available at <https://www.infopakistan.pk/constitution-of-pakistan/article/157-Electricity>

International Energy Agency (IEA) (2020). Asia Pacific – Total energy supply, 2020. Available at <https://www.iea.org/regions/asia-pacific>

_____ (2023). Basic energy access lags amid renewable opportunities, new report shows. 6 June. Available at <https://www.iea.org/news/basic-energy-access-lags-amid-renewable-opportunities-new-report-shows>

International Energy Agency (IEA), and others (2023). Tracking SDG7 Report 2023: The Energy Progress Report. Washington D.C.: World Bank. Available at <https://iea.blob.core.windows.net/assets/9b89065a-ccb4-404c-a53e-084982768baf/SDG7-Report2023-FullReport.pdf>

International Renewable Energy Agency (IRENA) (2018). Off-grid renewable energy solutions: Global and regional status and trends. Abu Dhabi. Available at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jul/IRENA_Off-grid_RE_Solutions_2018.pdf

_____ (2022). Asia and Pacific. Available at <https://www.irena.org/How-we-work/Asia-and-Pacific>

Khan, Israr (2022). Circular debt at Rs2.467tr threatens power sector sustainability. *The News International*, 10 June. Available at <https://www.thenews.com.pk/print/964747-circular-debt-at-rs2-467tr-threatens-power-sector-sustainability>

Pakistan Bureau of Statistics (2020). Special survey for evaluating socioeconomic impact of COVID-19 on wellbeing of people. Available at https://www.pbs.gov.pk/sites/default/files/other/covid/Final_Report_for_Covid_Survey_0.pdf

Pakistan Population Alleviation Fund (2015). Renewable. Energy Programme. Available at https://www.ppaf.org.pk/doc/HRE_March%202021.pdf

Pakhtunkhwa Energy Development Organization (2020). The Pakhtunkhwa Energy Development Organization Act, 2020 (Khyber Pakhtunkhwa Act No. XLVI Of 2020). Available at https://kpcode.kp.gov.pk/uploads/THE_PAKHTUNKHWA_ENERGY_DEVELOPMENT_ORGANIZATION_ACT__2020.pdf

South Asian Association for Regional Cooperation (SAARC) Energy Centre (2019). The Nexus between Sustainable Power and Growing Local Economies. SAARC Workshop. Dambulla, Sri Lanka. Available at: https://www.saarcenergy.org/wp-content/uploads/2019/09/Topic-No.-4_Nexus-between-sustainable-Power...pdf

_____ (2022). Minigrids and access to electricity in SAARC. Islamabad. Available at <https://www.saarcenergy.org/wp-content/uploads/2022/04/20220111-Final-Draft-of-SAARC-Mini-Grid-study-report.pdf>

The Express Tribune (2023). Solar grids bring relief to Sindh. 13 April. Available at <https://tribune.com.pk/story/2411592/solar-grids-bring-relief-to-sindh>

The Gazette of Pakistan, Extra (2015). Power Generation Policy 2015. April. Available at <https://nepra.org.pk/Policies/Power%20Policy%202015.pdf>

United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) (2022). *Energy Transition Pathways for the 2030 Agenda: SDG 7 Roadmap for Pakistan*. United Nations publication. Available at <https://www.unescap.org/kp/2022/energy-transition-pathways-2030-agenda-sdg-7-roadmap-pakistan>

Weinand, Jann Michael, and others (2023). Global LCOEs of decentralized off-grid renewable energy systems. *Renewable and Sustainable Energy Reviews*, vol. 183 (September). Available at <https://www.sciencedirect.com/science/article/pii/S1364032123003350>

World Bank (2017). Pakistan off-grid lighting consumer perceptions: Study overview. Working Paper No. 112020. Washington D.C. Available at <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/865301486382674587/pakistan-off-grid-lighting-consumer-perceptions-study-overview>

_____ (2023). Pakistan Energy Access: Household Panel Survey Data. 19 January. Available at <https://datacatalog.worldbank.org/search/dataset/0040445>

WorldData.info (2022). Energy Consumption in Pakistan. Available at <https://www.worlddata.info/asia/pakistan/energy-consumption.php>

Worldometer (2022). CO2 Emissions per Capita. Available at <https://www.worldometers.info/co2-emissions/co2-emissions-per-capita/>

Zia, Ubaid ur Rehman, Nismah Rizwan, and Saleha Qureshi (2023). Addressing Pakistan's energy security issues amid turmoil in the region. Policy Brief No. 89. Sustainable Development Policy Institute (SDPI). March. Available at https://sdpi.org/addressing-pakistans-energy-security-issues-amid-turmoil-in-region/publication_detail

