



Swappable Battery based Electric 3-Wheelers for Inclusive Clean Mobility

USAID-Supported Pilot Project Deployment for Low-Income Transport Workers in Pakistan

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Thematic Track 3: Forging Inclusion in Developing Energy Systems Strategy and Planning

Session Topic: 3.3 Inclusive Innovation and Technology Deployment

Background

- Pakistan is confronted with challenges, including:
 - Soaring Energy Imports
 - Electricity Abundance
 - Poor Air Quality
 - Ambitious Nationally Determined Contributions (NDCs)
- The Government of Pakistan (GoP) approved the Electric Vehicle Policy (EVP) in 2020 to address these issues
- Since 2020, less than a few dozen electric three-wheelers have made to roads
- This is primarily due to the following reasons:
 - High Cost of Electric Three Wheelers
 - Long charging time (5-7 hours)
 - Range Anxiety
 - Provincial Approval Delays
 - ...



3-Wheelers – Low(est) Hanging Fruit in EV Adoption

Untapped Business Opportunity

100% Commercial

**2 Million Fuel-based
Three-Wheelers on Roads
in Pakistan**



**11%
YoY Growth**



- **Almost 53% of the 3W operations are on 'rented' vehicles**
- **75% Ridership is Female**

Pilot Project

- In late 2023, the Pilot Project started its operations.
- The project successfully deployed 20 electric three-wheelers within Multan city, comprising 12 passenger and 8 loader electric three vehicles.
- Two battery swapping stations were set up to ensure swap availability in different parts of the city

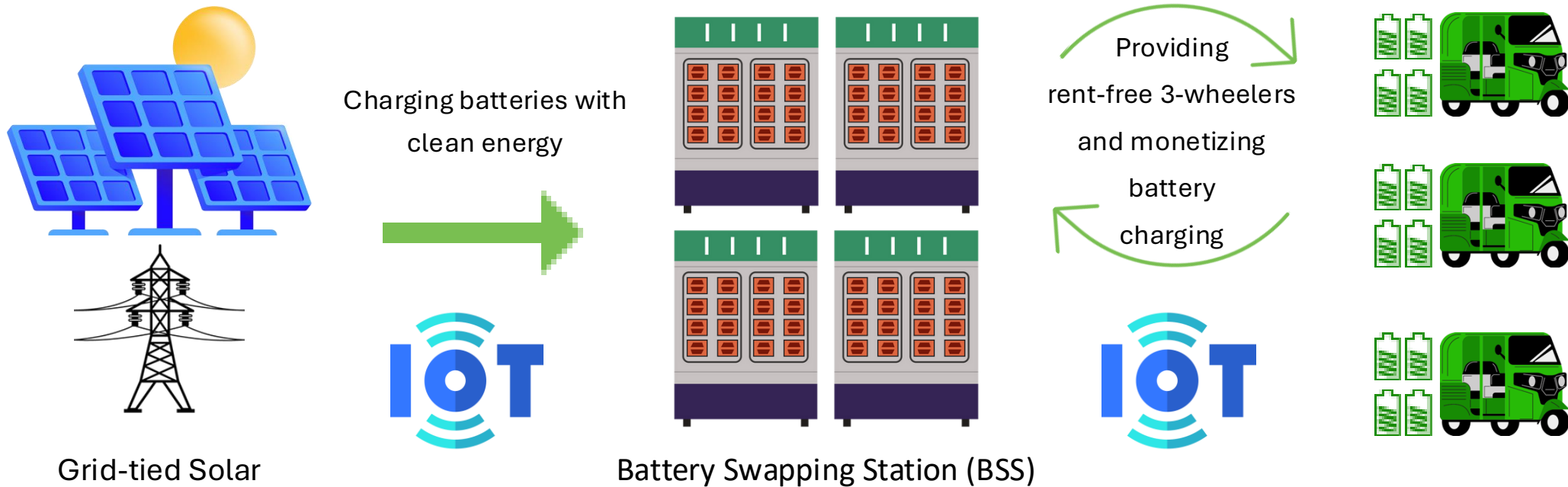


Swappable Battery-based Three-Wheeler

- Four Li-Ion Batteries of 1.44kW each
- Motor: 4KW
- Load Capacity: 400kg
- Mileage per Swap: 100km
- Motor Control Unit (MCU)



Our Pilot – Mobility as a Service (MaaS) using Swappable Batteries



Battery Swapping Station (Site-1: Grid Powered)

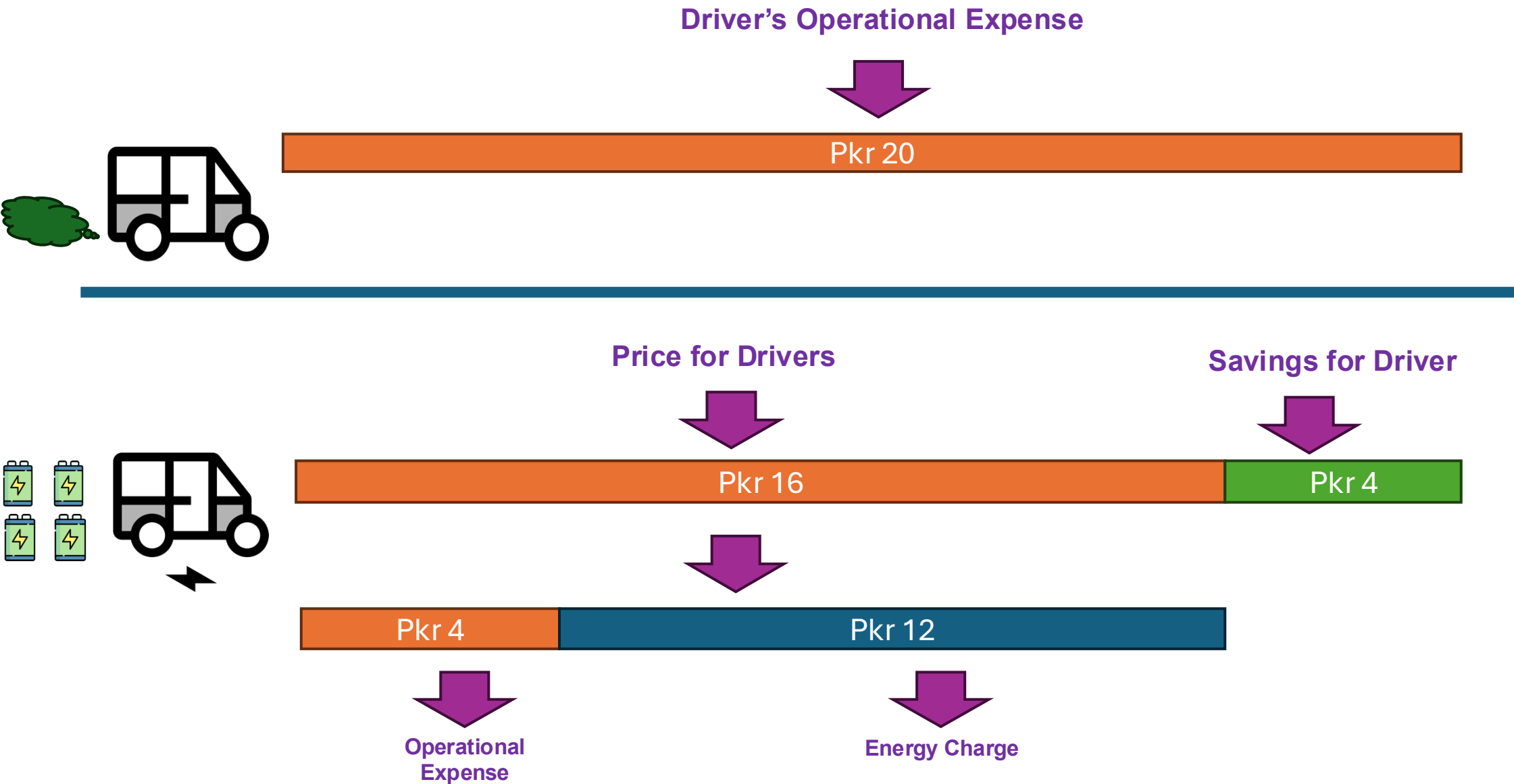


Battery Swapping Station (Site-2: Solar Powered)





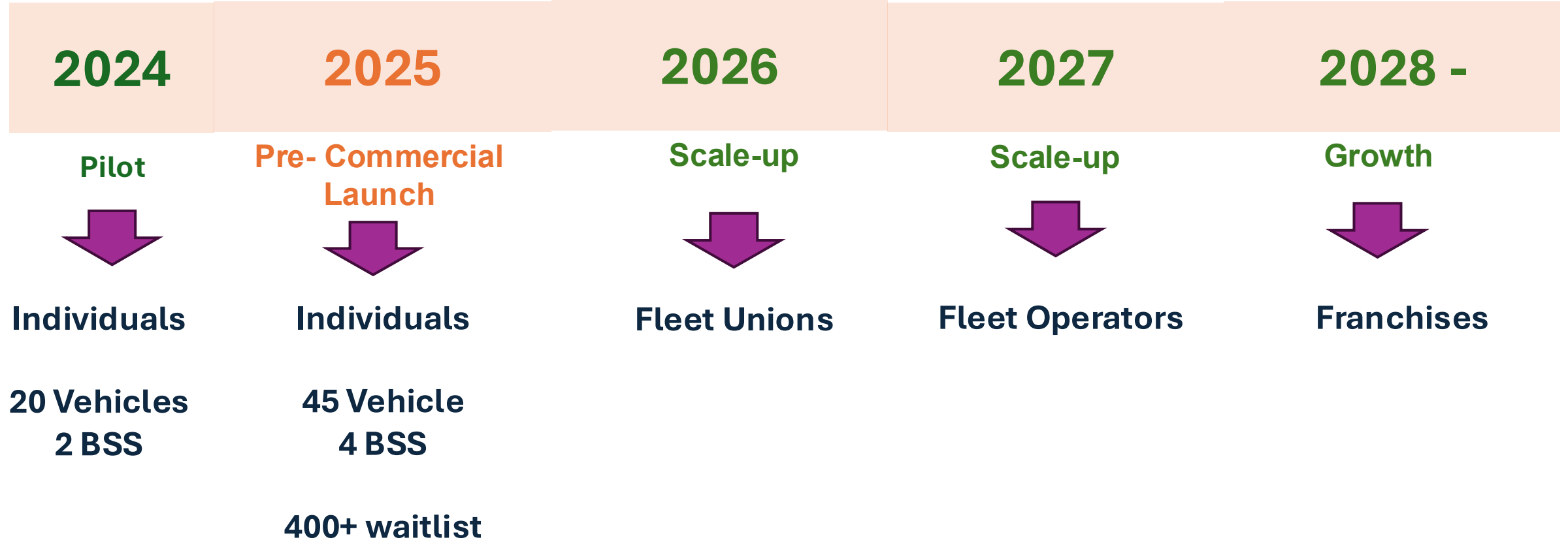
Unit Economics (per km) – Electric 3Ws and Fossil Fuel 3Ws – Pilot Project



Key Performance Indicators (First 9 months)

Sr. No.	Indicator	Project Target	Baseline	Project Average	Total Achieved
1	Carbon emissions reduced because of electric three-wheelers	Up to 70% reduction	100 gCO2/km	64.925 gCO2/km	8668.759 kg CO2 saved
2	Energy consumption efficiency improved a result of electric three-wheelers per kilometer (km)	Up to 80% better efficiency	0.43 KWh/km	0.09 kWh/km	53557 KWh saved
3	Average fuelling/battery swapping time reduced	10 minutes	-	4.3 minutes	4.3 minutes
4	Average distance covered by an electric three-wheeler on a single battery swap	65km	45km	45.81km	45.81km
5	Achieve a driver satisfaction rate among the participating drivers.	60%	20%	87.5%	87.5%
6	Passengers' preference for electric over ICE based 3-wheelers.	80%	50%	94%	94%
7	Achieve a driver adoption/retention rate among the participating drivers.	80%	60%	97.5%	97.5%
8	Number of Technical faults with drive train reported per month	15-20	35-40	4	29

Traction



Pakistan – Battery Swapping Network



Partner Ministries	Ministry of Industries & Production; Ministry of Energy (Power Division) National Energy Efficiency and Conservation Authority; Ministry of Climate Change and Environmental Coordination
Implementation Organisations	Lahore University of Management Sciences
Project Partners	To be determined
Funding Volume Provided	To be determined
Project Duration	15 months for Detailed Preparation Phase
Status	Active
Phase	Detailed Preparation Phase
Call	Call for Projects 2023

Background: The government of Pakistan has implemented new regulations aimed at facilitating the registration of Electric Three-Wheelers (E3Ws) and expediting the issuance of manufacturing licenses for Electric Vehicle (EV) manufacturers. Despite these efforts, the adoption of EVs in the Three-Wheeler (3W) segment, which comprises approximately 2 million vehicles, remains minimal due to various underlying factors.

Approach to Transformational Change: The project aims to increase the visibility of battery swapping value chain for mobility purposes by deploying a network of swapping stations and electric-three-wheelers across Pakistan.

The project will result in an increase in the visibility of the battery swapping value chain for transportation purposes, catalyse widespread EV adoption by addressing fundamental barriers associated with typical electric vehicles having fixed batteries, develop national capacities in e-mobility, reduce vehicular airborne pollution, and attract investments in manufacturing and franchising. Additionally, challenges such as limited residential parking and frequent power outages are addressed through battery swapping, which integrates solar photovoltaic (PV) technology with Battery Swap Stations to provide renewable and alternative power sources, reduce energy charging costs, and lower greenhouse gas emissions.

The financial cooperation (FC) component supported by grant-based financing, will establish a network of BSSs in Punjab province to alleviate range anxiety and provide vehicles at zero upfront cost to early adopters, mitigating perceived risks associated with new technology adoption. It will introduce a commercially viable model with attractive returns to attract private sector investment for expanding the BSS network and increasing vehicle uptake.

The technical cooperation (TC) component of the project will provide assistance to the private sector to accelerate the development of the domestic EV industry. On the policy and regulatory front, measures will enhance public sector capacity in various areas including EV policy and regulation, standards and road safety, electricity supply planning and tariff design, gender diversity and social inclusion, environmental protection, and battery and solar PV recycling.

Mitigation potential: It is estimated that the project could directly reduce 250.000 tCO₂e during its implementation timeline and more than 1.200.000 tCO₂e over lifetime of the supported technologies.

IMAGE: © MORTENROCHSSARE

2023 Call for Projects
500 Projects Submitted
6 Selected for Funding



Competitive Funding for Decarbonization Projects in

- Transport
- Industry
- Renewable Energy

Renewable Transformation Challenge



Renewable Transformation Challenge 2025: Meet the top 10!

03. July 2025

ISES and Elsevier are excited to introduce the top 10 entries of the Renewable Transformation Challenge 2025 to you!

These top 10 entries were selected out of 150+ applications we received for the challenge this year and they represent exciting renewable energy projects from all around the world and were carefully selected by our expert jury of international solar experts over the past week.

<https://www.ises.org/news/renewable-transformation-challenge-2025-meet-top-10>

AGRISOL: Rural Agriculture Powered by Solar Energy - Indonesia

AGRISOL is a decentralized renewable energy solution for rural agriculture, built to replace fossil-fuel-powered tools with affordable solar alternatives. It introduces a two-part system: A solar-charged battery swap station located in farming areas. Solar-powered agriculture tools AgriSol-Pump, a portable solar water pump operated by the batteries from the station. For many farmers in Indonesia, the cost of petrol-based agriculture tools such as irrigation pumps is so high that letting crops fail is sometimes the only choice. AGRISOL-pump enables farmers to significantly reduce their production costs while eliminating the need for petrol and reducing carbon emissions. By collaborating with vocational schools for production and maintenance, AGRISOL also builds local skills and service capacity, laying the groundwork for both sustainability and local empowerment.



Comprehensive PV Implementation – Lebanon

This project has resulted in the installation of 130 KW for water pumping in 2 sites, nine 1.6 KW system for a recreational site, 23 KW for a school, and 7.6 KW for an organization's branch. A total of 350 KW of PV were installed and 150,000 individuals are benefiting from the installed systems which are generating more than 250 MWh annually. These have resulted in annual savings exceeding \$50,000. All systems are on/off grid systems capable of independent operation and energy storage in batteries, while having the ability to feed back into the grid in case the mains electricity becomes available, and PV production exceeds the immediate needs. Local individual funding of all the implemented projects insures overall project sustainability and expandability.



Hybrid Solar Dryers for Resilient Food Systems – Mexico

The project develops and implements a hybrid renewable energy system for food drying in rural Zacatecas, Mexico. It integrates direct and indirect solar thermal technologies, PV/T panels, and a PV solar-powered heat pump, with optional LPG and biomass backup to ensure year-round



resilience. The primary objective is to reduce post-harvest losses and fossil energy dependency by deploying a replicable, low-emission, community-based drying solution powered primarily by solar renewable energy. The project enhances food preservation, strengthens rural livelihoods, and contributes to climate resilience and sustainability in vulnerable agroecosystems.

Scaling Up Energy Access in Malawi with minigrids – Ireland

The goal of the Scaling Up Energy Access in Malawi (SEAM) project is to provide accessible green energy to households and rural communities in Dedza District, Malawi. As part SHA Malawi's efforts since 2008 to develop and implement market-based green energy solutions for cooking, lighting, and productive uses of energy, the SEAM project promotes the use of interconnected solar minigrids: off-grid electricity generation and storage installations that provide access to reliable, renewable, clean energy for rural communities. The UN set Sustainable Development Goal (SDG) 7 to tackle the issue of 760 million people living without access to electricity; 75% of whom live in sub-Saharan Africa. Malawi is particularly burdened, with only 14% of the population having access to national grid electricity. Rural access to electricity is even lower, sitting at a mere 1%, despite 88% of the country's population living in rural areas. Expansion of the National Grid is forecasted to be more than 20 years away for a significant proportion of Malawi's rural population. This ongoing lack of access to electricity severely affects quality of life and stalls economic development meaning alternative energy solutions are needed now.



SunstorePowerpan at the Khoisan solar shelter - United Kingdom

The SunstorePowerpan is a hybrid solar/bio-char combined cooking and electricity generating appliance, designed to be the world's most cost effective and carbon negative feeding station for institutions and off-grid communities. It uses a modular, inverted PMMA Fresnel lens array to concentrate up to 1KW of solar flux on to a flat plate aluminum heat pipe absorber. This energy is delivered by latent transfer, into an insulated 30 litre cooking pan. Six solar cycles per day are possible in good solar



BIOGREENFINERY - Spain

BIOGREENFINERY is a pilot renewable-fuel facility at ITC in the island of Gran Canaria integrating a hybrid off-grid microgrid (solar, wind, battery, biodiesel backup) with PEM and alkaline electrolysis, nitrogen generation, and a Haber-Bosch reactor to produce green hydrogen and ammonia. It fuels a hydrogen-fuel-cell bus and two cars, demonstrating zero-carbon transport in an isolated region. Backed by around 6 M€ from EU REACTEU and aligned with the Canary Islands' 2040 decarbonisation target and EU Green Deal, the project validates the technical feasibility and economics of e-fuel production in remote areas. As a 'e/bio fuels platform,' it enables continuous operation, data collection, and a blueprint for scaling renewable fuels in hard-to-abate sectors.



GreenBox – Congo

GreenBox is a 100% solar-powered cold storage solution designed to eliminate food spoilage and post-harvest losses in developing countries, where up to 50% of horticultural produce is wasted before reaching consumers. Installed in farming groups, aggregation centers, and markets, GreenBox cold rooms enable smallholder farmers, retailers, and wholesalers to store perishable foods 24/7, extending shelf life from 2 to 21 days. The project's primary objective is to ensure food security, increase farmer income, and reduce poverty by providing affordable, sustainable cold storage at critical points in the food chain. By preserving food quality and preventing spoilage, GreenBox helps deliver safe, nutritious food to local communities while advancing climate resilience and economic empowerment. The primary objective of GreenBox™ is to empower farming communities by reducing food spoilage.



Kokota and Njau Islet Solar Electrification Project - Tanzania

The Kokota and Njau Islet Solar Electrification Project is a flagship renewable energy initiative spearheaded by Photons Energy Limited, aimed at delivering sustainable and reliable electricity to two remote off-grid communities located on Kokota and Njau Islets in the Pemba region of Zanzibar, Tanzania. These islets are home to vibrant fishing communities who, for decades, lacked access to electricity and depended on costly and environmentally harmful energy sources such as diesel generators, kerosene lamps, and disposable batteries. The lack of reliable energy limited access to clean water, education, healthcare, and economic opportunities. The primary objective is to provide universal access to clean, affordable, and sustainable electricity to the residents of Kokota and Njau through the deployment of solar-powered mini-grid systems. This is in line with SDG 7 on clean energy for all.



Solar-powered Battery Swapping for Urban Mobility – Pakistan

This project demonstrates the deployment and evaluation of Pakistan's first decentralized, solar-powered battery swapping infrastructure for electric three-wheelers (e3Ws). The project is implemented in Multan, a secondary city with high vehicular pollution and limited mass transit, using a mobility model powered by renewable energy, 20 swappable battery-based e3Ws and 2 Battery Swapping Stations (BSSs) were launched. One BSS was powered by a 20 kW solar PV hybrid system. The objective was to analyze the technical, economic, and social viability of powering last-mile urban mobility using renewable energy. The project reduced vehicular CO emissions by up to 70%, improved energy efficiency by 80% over oil-based 3Ws, and achieved 92% driver retention and 97% passenger preference. The project is a replicable model for climate vulnerable urban centres and leads towards sustainable mobility.



Turning Waste to Clean Cooking Energy – Tanzania

Bantu Technologies is transforming biomass waste into clean, affordable cooking energy through biomass briquettes and stoves. Based in Zanzibar, our project tackles deforestation, waste pollution, and energy poverty by replacing charcoal with briquettes made from bagasse and other organic waste. Our primary objective is to accelerate the transition to renewable energy for cooking in underserved communities while promoting circular economy principles. With over 20% monthly user growth and positive



About the **LUMS Energy Institute (LEI)**

A leading national think tank advancing Pakistan's transition to clean, secure, and inclusive energy systems.

WHO WE ARE

- LEI conducts data-driven research and shapes policy to accelerate Pakistan's clean-energy transition.
- Interdisciplinary teams across engineering, public policy, economics, and environmental science deliver low-carbon, evidence-based solutions and a national platform for knowledge exchange.

TECHNICAL FOCUS AREAS

- **Power Sector**
- **E-Mobility**
- **Energy Access**
- **Energy Informatics**
- **Climate & Sustainability**
- **Oil & Gas**
- **Sustainable Infrastructure**

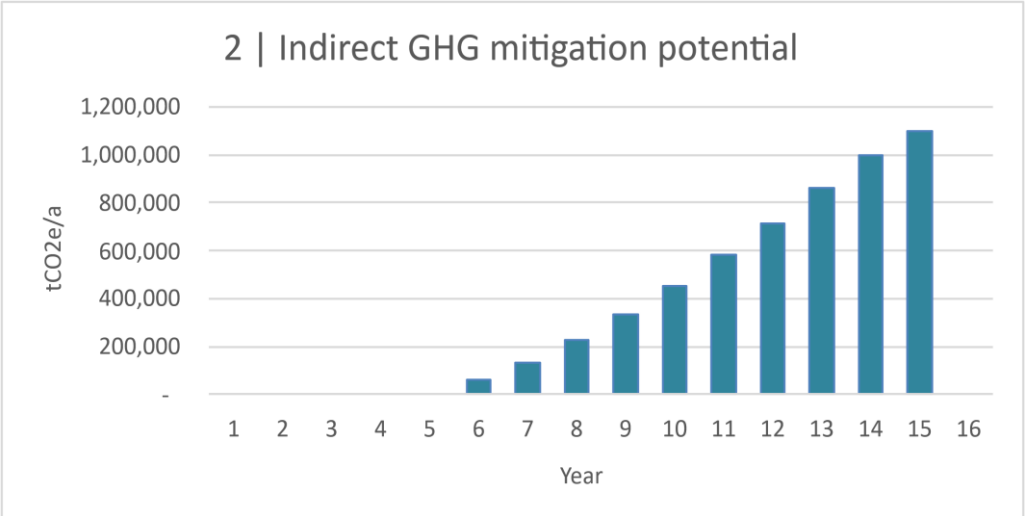
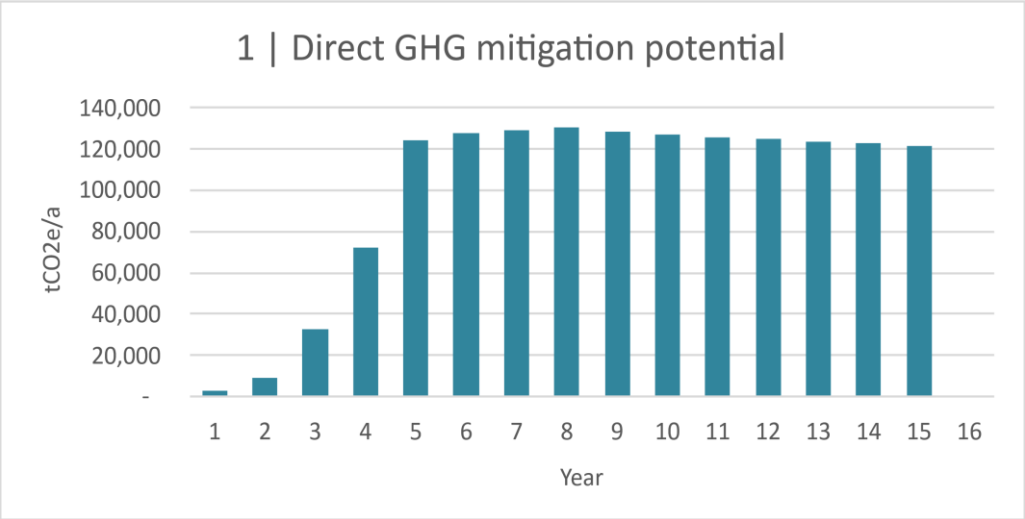
For further information, please visit lei.lums.edu.pk

Thank You

Appendix

Mitigation Potential

	Direct mitigation potential		Indirect mitigation potential	
	Project Implementation	10 years after project end	Project Implementation	10 years after project end
	tCO ₂ e/a	tCO ₂ e/a	tCO ₂ e/a	tCO ₂ e/a
Year 1	2,796		0	
Year 2	9,170		0	
Year 3	32,846		0	
Year 4	72,337		0	
Year 5	124,202		0	
Year 6		127,673		60,229
Year 7		128,935		132,687
Year 8		130,792		227,324
Year 9		128,532		332,031
Year 10		127,058		453,049
Year 11		126,057		581,454
Year 12		124,960		715,084
Year 13		123,977		861,490
Year 14		123,116		997,717
Year 15		121,864		1,097,272
Year 16		0		0
Average	48,270	126,296	0	545,834
Total	241,351	1,262,964	0	5,458,337
Grand total	1,504,315		5,458,337	
Over technology lifetime:				
Average	100,288	tCO ₂ e/a	545,834	tCO ₂ e/a
Total	1,504,315	tCO ₂ e	5,458,337	tCO ₂ e



Geographic scope of the project

Project Locations (Punjab Province)



- **Lahore (Provincial Capital)**
 - Population: 11.7 million
- **Faisalabad**
 - Population: 3.89 million
- **Multan**
 - Population: 1.8 million

Three-Dimensional Solution

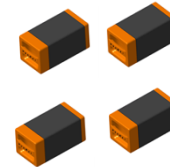
→ **Technology Platform**



→ **Battery Swapping Services through Swapping Station Network**



→ **Renting-out Three Wheelers (MaaS)**



Challenges

- Land Acquisition for Solar Site
- Electricity connection delays
- Locally unavailability of spare parts (MCU & Cradles)
- After-Sale services delays by MEPCO (Transformer fault)
- Dead mileages due to limited BSS availability (Drivers Anxiety)
- Battery behavior in summer
- Inadequate space for solar system at urban sites
- ...

Major Learnings

- Site Selection
- Electric Utility
- Electricity Prices
- Driver Related
- Standards and Regulations
- Spare Parts and Maintenance Facilities
- ...

SDG Addressed



About Myself – ***Dr Huzaifa Rauf***

- B.S in Electrical Engineering (FAST-NUCES, 2016)
- M.S in Electrical Engineering (LUMS, 2018)
- Ph.D. in Electrical Engineering (LUMS/University of Maryland, 2023)

Current Roles

- Assistant Professor in the Department of Electrical Engineering at **FAST-NUCES**
- Project Consultant and Manager in USAID **e-Mobility R&D Center** at **LUMS Energy Institute**

Research Focus

- Li-ion battery modeling, energy storage, EVs
- AI & Machine Learning in energy systems
- Battery reliability and sustainable infrastructure

Professional Impact

- Leading sustainable EV projects in Pakistan
- Collaborating with industry and government for EV advancements