RENEWABLES FIRST

Customer Owned Renewable Electrification (CORE) Finance Mapping

Bridging information asymmetry to accelerate clean energy finance

About CORE

Customer-owned renewable electrification (CORE) describes energy systems characterized by localized participation, where the 'customer' (defined as the off-taker or host entity) holds the primary interest in the energy generated, whether through direct investment, cooperative shares, or public-private partnerships.

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Acknowledgement:

We are grateful to Huma Naveed, HeraldX, Data Darbar and Shezad Abdullah for their valuable feedback and assistance in formulating this study.

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Disclaimer:

All the information and analysis provided in this document are accurate and to the best of our knowledge and understanding, in case you identify any error, please email: info@renewablesfirst.org

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Executive Summary

Formal debt has financed just 3.4% of the USD 14 Billion (B) deployed in distributed solar. Industrial and agriculture customers took up most of it; residential, the most finance-deprived segment is barely featured.

Affordability to energy security	A 6-7 kW solar system with a battery costs about USD 3,500, a full year's income for the average Pakistani household. Few can write that cheque, and fewer than one in five have.
Solar pays for itself	Solar generates monthly savings that beat the hurdle rate of nearly every available financing option. The loan, in effect, pays itself off, funded by the very bill reductions the system was installed to deliver.
Behind-the-meter (BTM) solar leads the energy shift	Energy and price shocks pushed Pakistan's inflation to a record 38% in May 2023, the highest in nearly five decades. With electricity costs squeezing households and industry alike, solar became the cheapest way out.
More than 7 million (M) solarized households	Only 18% of Pakistani households are solarized, with most paying out of pocket. The opportunity for financial institutions is point-of-purchase access bundled with asset-aligned, longer-tenor loans. Underwriting the asset is key, not just the borrower.
Solar is powering irrigation	Agri-solar now powers 1 million tubewells, financed by a mix of equity, subsidies, MFIs and agri-focused products of commercial banks. The unit economics are the cleanest for this segment leading to a 60% displacement of diesel, and the old fuel bill alone covers principal and markup.
C&I remains critically underserved	Commercial & Industrial solar is split in two. Top-tier clients stay banked due to large ticket sizes, EPC-led and bankable cash flows. Everything below runs on cash and retailer credit, with bank and MFI penetration near zero.

Solar is now Pakistan's most effective hedge against energy price shocks and geopolitical risks

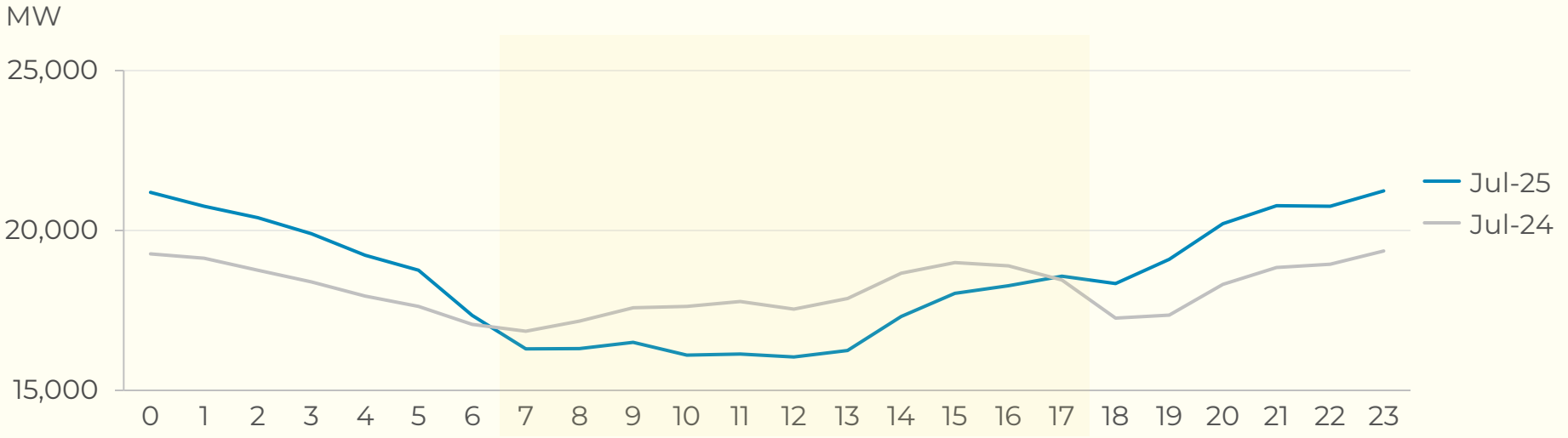
Pakistan's Solar Rush

A rapid expansion of distributed solar generation has reshaped daytime demand, creating a structural surplus of low-cost electricity during midday hours. This energy transition is pushing new RLNG and coal plants toward stranded-asset status.

Burning our way out of the Peak

However, the evening peak has become increasingly dependent on expensive and constrained thermal fuels, particularly RLNG, whose prices have risen sharply amid recent geopolitical disruptions and volatility in global energy markets.

Hourly electricity demand profile - July 2025 vs 2024



Data source: The independent system and market operator (ISMO)

From affordability to energy security, a new paradigm in Pakistan’s clean energy debate

“BTN” Behind the Numbers	Fewer than one in five Pakistani households have gone solar, yet the ripples are already reshaping the country's energy landscape. The transition, so far, belongs to the well-off, those who can write a cheque for panels and inverters without flinching.
The affordability gap	The average Pakistani household earns roughly USD 3,500 a year. A 6-7 kW system with a battery costs about the same. Going solar means handing over a full year's income, a cheque most families cannot write.

Average annual household income, 2024–25, at 1 USD = 280 PKR.

Quintile	*Urban (USD per year)*	*Rural (USD per year)*	*Total (USD per year)*
1st	1,817	1,796	1,794
2nd	2,394	2,341	2,363
3rd	2,780	2,824	2,817
4th	3,472	3,394	3,445
5th	6,297	5,550	5,971
Total	**4,147**	**3,092**	**3,522**

Data source: Household Integrated Economic Survey (HIES), PBS

Answer to the affordability question is three syllables long, “Financing”

If most consumers lack the cashflow to cover principal and interest, how can they possibly afford a solar loan? The answer lies in the asset itself: solar generates monthly savings that beat the hurdle rate of nearly every available financing option. The loan, in effect, pays itself off, funded by the very bill reductions the system was installed to deliver.

Results of Residential Use Case Simulations by IEEFA

System Size	*Battery Size*	*LCOE (USD per kWh)*	*Payback Period*
10 kW	0	0.049	1.5
10 kW	5 kWh	0.052	2.7
10 kW	10 kWh	0.064	3.3

A residential consumer with a 10kW sanctioned load has an annual energy demand of 19.5 MWh, split 72:28 between off-peak and peak hours.

The primary use case is energy arbitrage, charging the battery from solar PV during the day and discharging during peak tariff hours to cut grid reliance and bills.

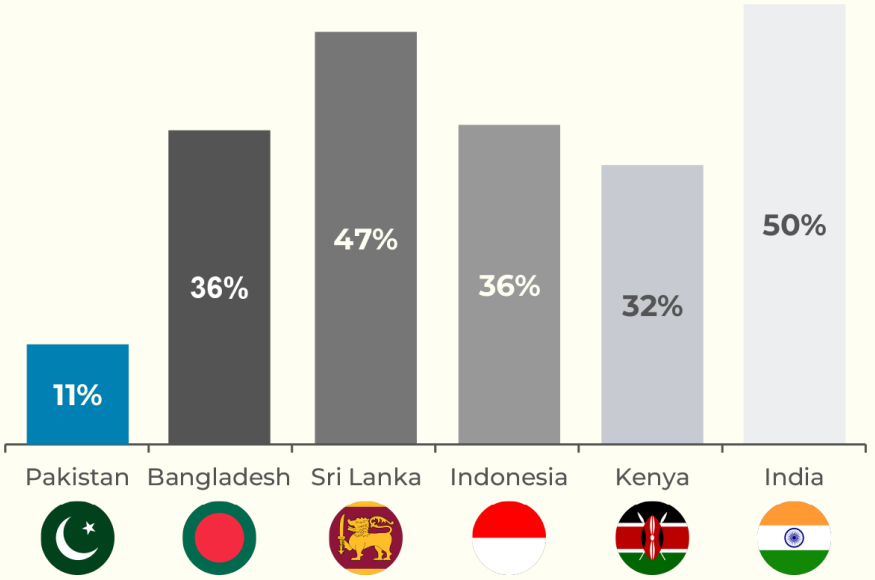
Simulations at 5 kWh battery increments show a typical 10kW solar plus BESS setup delivers a LCOE of PKR 14.5 - 18 per kWh (USD 0.052 – 0.064 per kWh), undercutting both peak and off-peak grid tariffs. Even a 5 kWh battery produces meaningful savings against the peak tariff of PKR 46.85 (USD 0.17) per unit.

Data source: Battery storage and the future of Pakistan's electricity grid, IEEFA

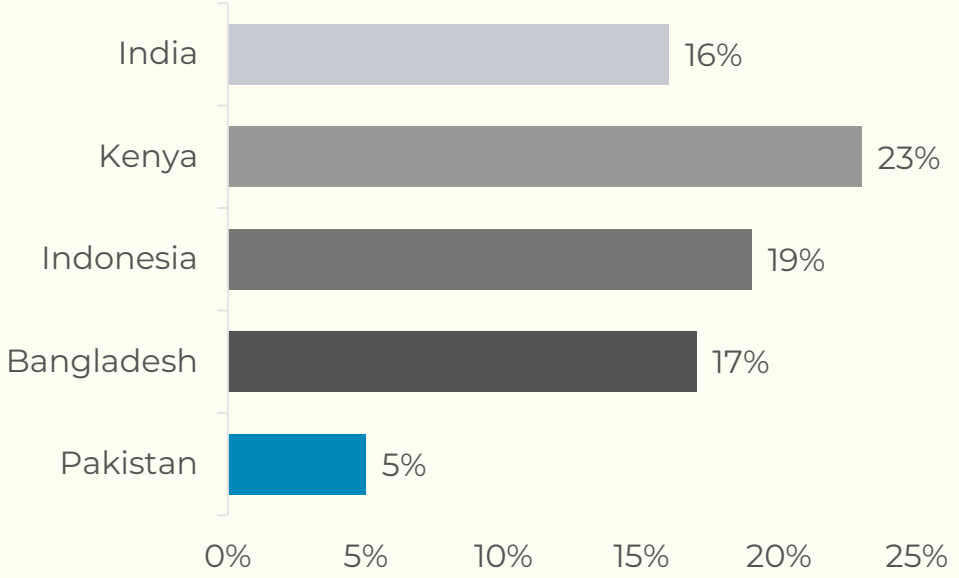
But structural constraints continue to stand in the way of clean energy financing

Pakistan's solar rush arrived precisely when consumer financing was at its most broken. The economic volatility of 2022–24, capped by a policy rate pinned at 22%, made financing any consumer product feel like a pipe dream. What little liquidity the system had was being redirected to plug the fiscal hole, not to seed a new asset class. Layer on the structural constraints of solar asset-class lending, and the negligible financing numbers begin to explain themselves. We unpack these challenges in detail in our ***Market Diagnostic Study for Solar Financing 2025.***

Lending to private sector as % GDP - 2024



SME loans as a % of total advances 2024



Data source: PwC Banking Publication 2025, Market Diagnostic Study for Solar Financing 2025

Bridging the knowledge gap for effective intervention

Without systematic data on **financing sources**, **distribution channels**, **market segments** served, and **emerging informal mechanisms**, efforts to democratize solar access lack the evidence base needed for effective intervention, and the transition risks locking into the country's most economically advantaged segments.

As part of its research to establish the Clean Energy Finance Innovation Lab (CEFIL), Renewables First launched the Market Diagnostic Study on Solar Financing in December 2025 to examine the products, perceptions, and policies holding back distributed solar financing and to inform a path forward.

Building on that work, we conceived CORE Finance Mapping as a necessary precursor to CEFIL. Before scaling financing products and policy, foundational questions need answers: where is the money flowing, across which sectors, system sizes, and regions, and who is being reached versus left out? Without this baseline, data gaps will continue to limit targeted policy design and financial innovation.

01

Foundation

Market research

Diagnostic studies and CORE Finance Mapping to understand products, policies and financial flows across sectors, system sizes, and regions.

Diagnostic | Data | Evidence

02

Alignment

Stakeholder engagement

Convene regulators, policy makers, financers and developers to align around shared evidence, surface constraints and co-frame the intervention.

Policy | Regulators | Industry

03

Partnership

Capital partners

Bring in catalytic and commercial capital DFIs, climate funds, banks, and NBFCs – to blend risk tolerance with scale structure bankable vehicles.

Catalytic | Commercial | Evidence

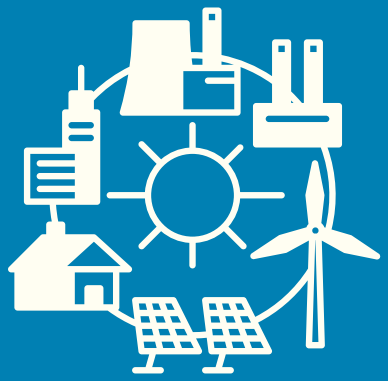
04

Deployment

Instrument design

Design and launch financial instruments – guarantees, concessional lines, receivables facilities - piloted, iterated, and scaled with partners.

Design | Pilot | Scale



Mapping Distributed Solar Assets

A Practical Framework based on Primary and Secondary sources

Mapping distributed solar finance to design equitable interventions

A triangulated, bottom-up methodology combining field data, market consultations, and national statistics to estimate deployment and financing flows across segments.

Tier 1 – Primary Field Work

Geospatial mapping Sindh. Punjab, KPK n = 3 provinces	**Retailer survey** n = 393 Point-of-sale data	**EPC consultations** n = 7 major EPCs	**Financial institutions** n = 13 banks/MFBs & PMIC, WB, gov.
System sizes by segment type	*Financing options, behind-meter ratios*	*Oversizing rate, segment pricing*	*Financing quantum, agri. insights*

Tier 2 — National datasets

NEPRA reports & hearings Official Figures	**PBS HIES** Household Integrated Economic Survey	**Population Census 2023** Extrapolated till 2025	**Agricultural Census 2024**
Net-metering, connections, electrification rate	*Solar penetration, rural-urban split*	*Total household denominator*	*Tubewell quantum and fuel mix*

Tier 3 — Published Market Estimates

PRIED C&I Capacity Data	**TransitionZero** Market Size Estimates	**GoP sources** Policy & Sector Data

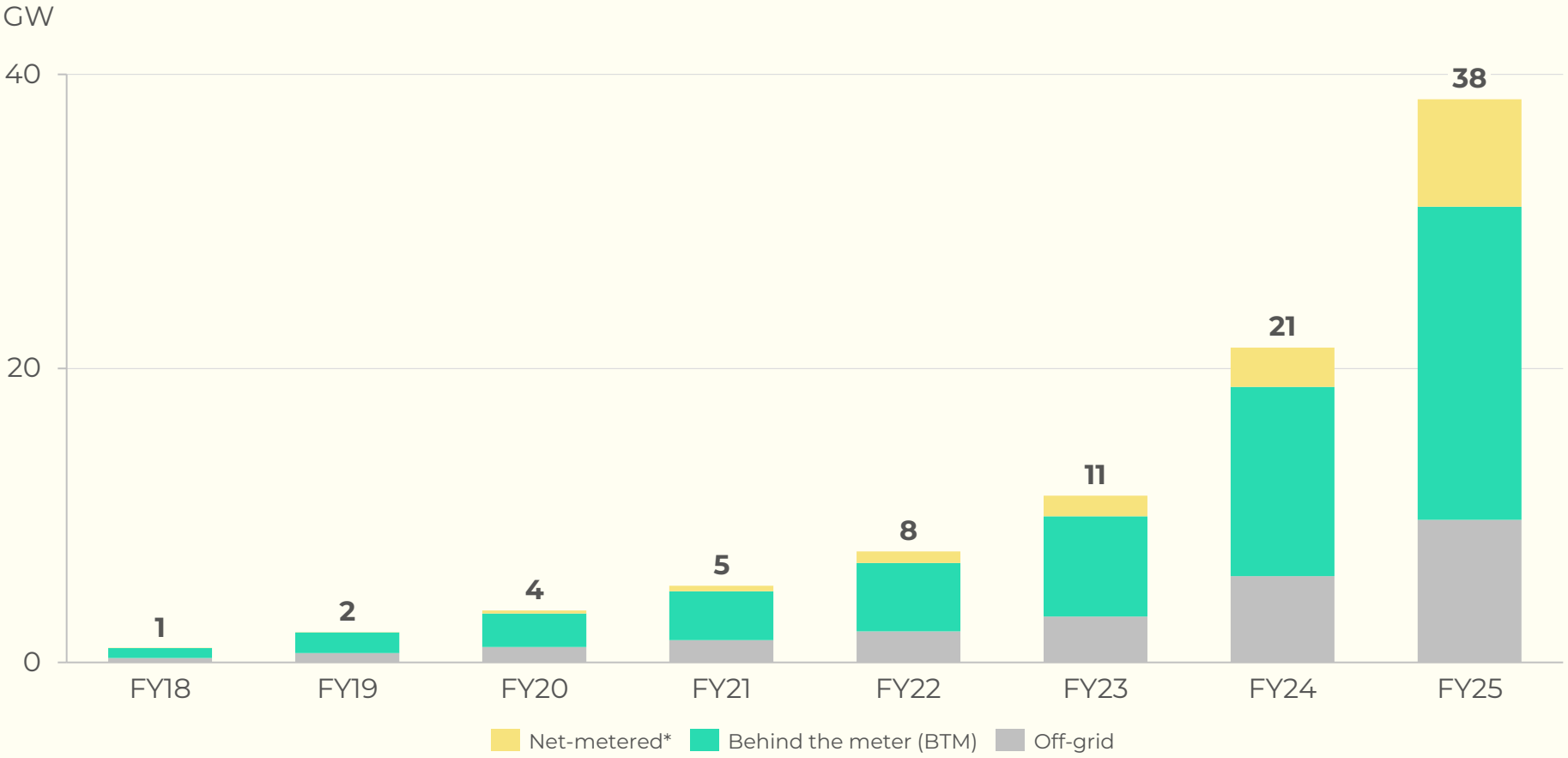
Combined with EPC-derived insights and reconciled C&I numbers

Cross Validation for consistency: Every final estimate verified against ≥ 2 independent sources across system sizes, pricing, volumes, and financing

Squeezed by record inflation, Pakistanis went solar

Energy and price shocks pushed Pakistan's inflation to a record 38% in May 2023, the highest in nearly five decades. With electricity costs squeezing households and industry alike, solar became the cheapest way out.

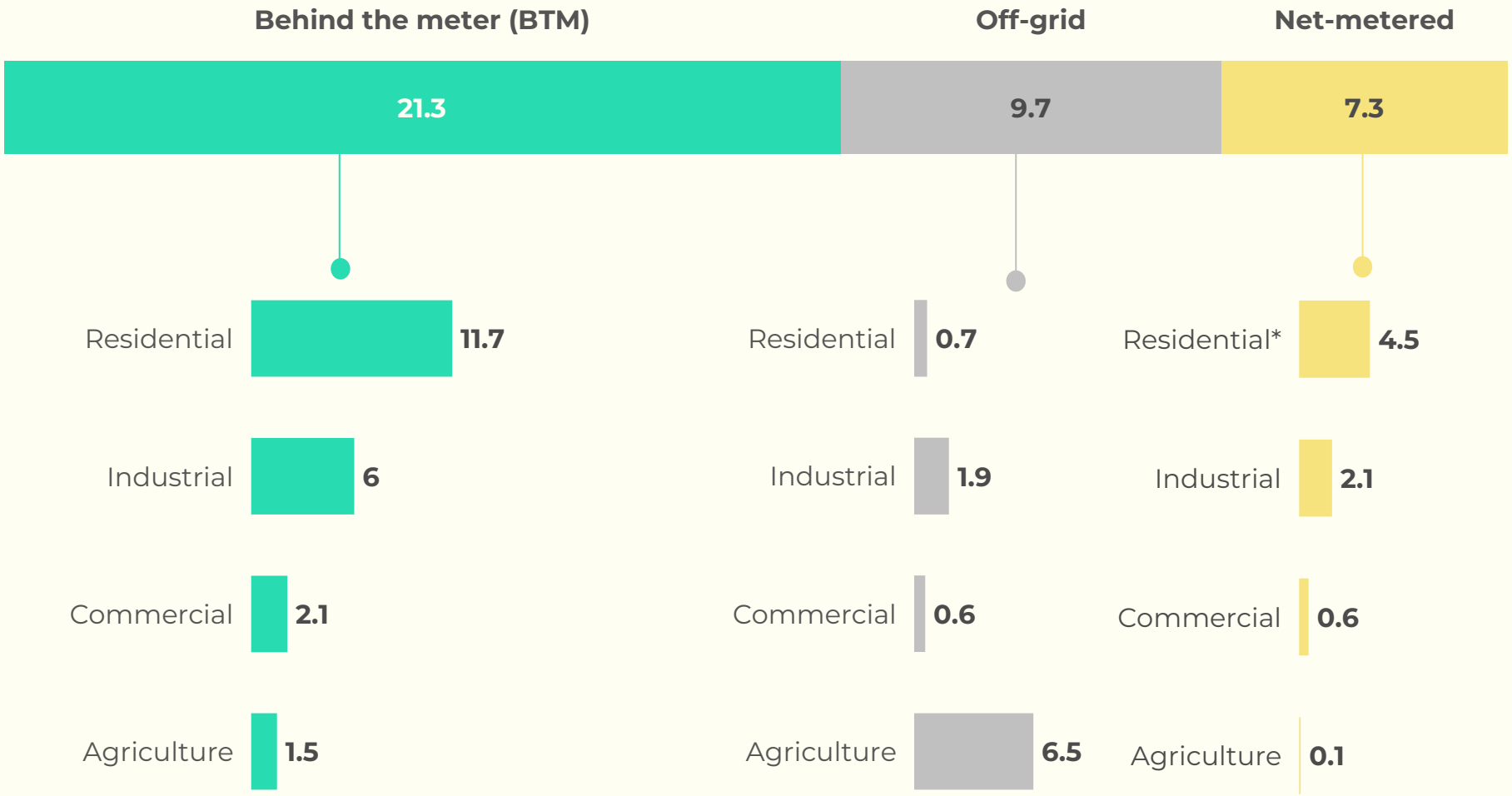
Estimated segment-wise solar deployed, FY18 - FY25



* 20% oversizing of residential net metered capacity
Data source: Renewables First analysis

BTM solar leads Pakistan's energy shift, driving the majority of 38 GW

Estimated sector-wise solar deployed, FY25



*7.3 GW includes 20% oversizing of residential net metered capacity
Data source: Renewables First analysis

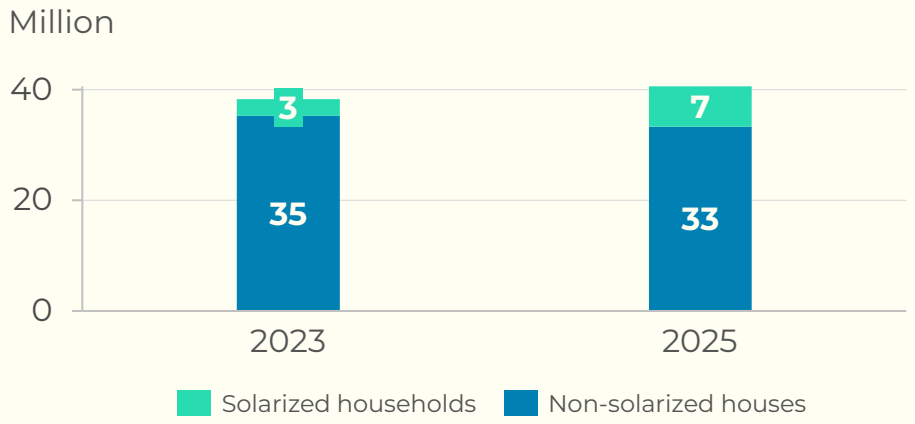
Residential Segment

Residential Solar Capacity 2025: Methodology

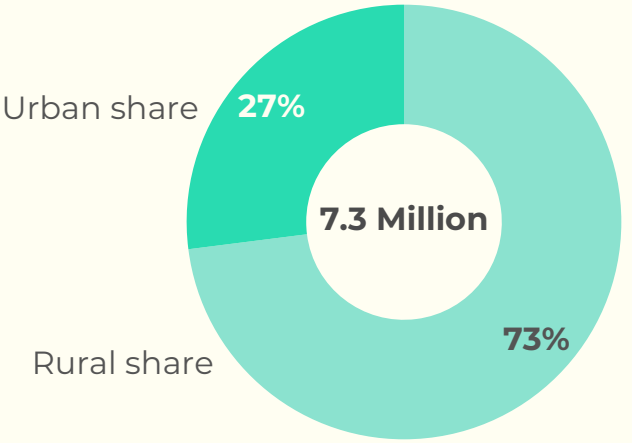
Data collection	PBS HIES 2024-25 & Census 2023	NEPRA Reports & Hearings	Geospatial Mapping, Retailer Surveys & EPC Consultations
Method	Estimate total households 2025	Estimate split: Grid, Grid + Solar, Off-grid	Oversizing in net-metering installations
Adjust	Assign system sizes		
Output	Grid, Grid + Solar, Off-grid capacity estimates	Final residential capacity	

Residential solar adoption up 147% since 2023 - now reaching 7.3 million households

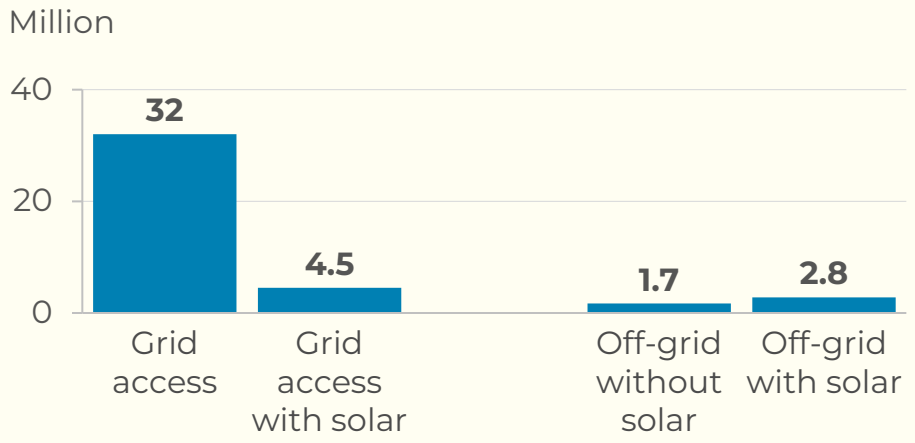
Total houses solarized and non-solarized, 2023 vs 2025



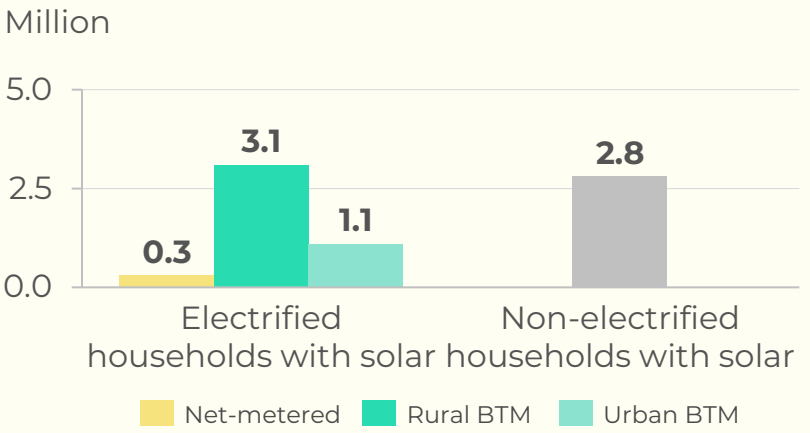
Solarized households 2025, rural vs urban split



Grid and off-grid households with solar integration, 2025



Electrified and non-electrified households, 2025



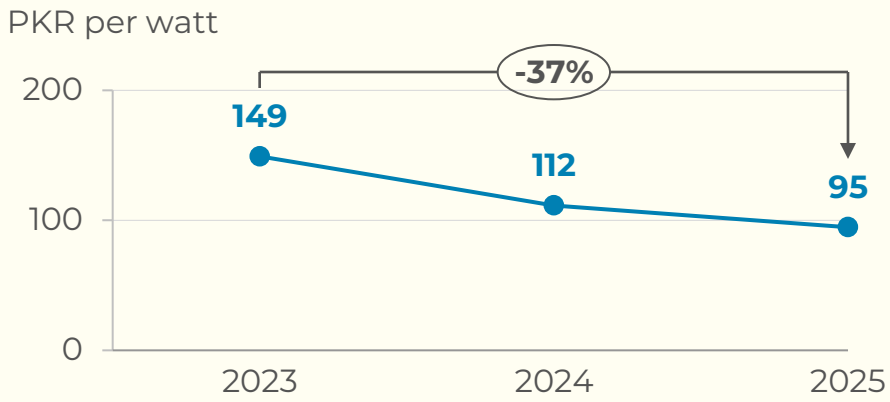
Data source: Renewables First analysis

Solar costs drop 37%, yet affordability still determines system size across settlement tiers

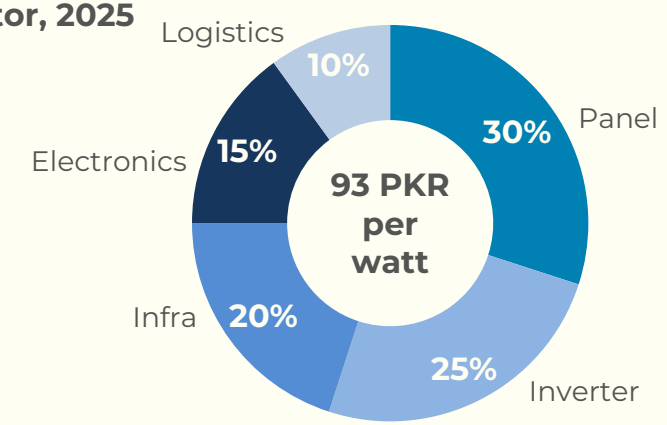
Segment-wise system size and cost for residential sector, 2025

	Common ranges	Average system size	Cost (PKR Million)
Urban	5-10 kW & 10-20 kW	10.5 kW	1.2
Peri-urban	3-5 kW & 5-10 kW	5 kW	0.7
Rural	1-3 kW	2 kW	0.3
Off-grid	0.1-0.5 kW	0.3 kW	0.04

Price trend for solar system in residential sector, 2023 - 2025



Cost breakdown of solar system in residential sector, 2025



Data source: Renewables First analysis

BTM solar dominates but is financed outside the banking system

16.9 GW

Residential sector

Total deployment cost (USD M)	**6,525**
Solar financing value (USD M)	**40.4**
Financing penetration	**0.6%**

Survey results – Popular Financing methods in Residential sector

Financing method*	Respondents (%)
Full cash payment upfront	88.9
Bank loan	0.4
Microfinance Loan	0.4
Installments (Retailer)	7
Other	0.4
Multiple	2.9

Banks lost residential solar on distribution, they'll lose solar + storage on product design

BTM customers find bank processes intimidating and assume formal credit is expensive then pay 2-3 times that rate to BNPL and retailer credit without realizing it.

The barrier is perception and access, not economics. Retailer credit & BNPL have absorbed the demand banks could have captured, not because they compete on rate, but because they show up where the customer is.

The next wave compounds the gap. Grid instability, net-metering policy shifts and falling battery prices are pulling demand from solar-only toward bundled solar + storage.

Today's products are short-tenor consumer credit grafted onto a 10-year asset; a mismatch that suppresses ticket sizes and pushes away customers.

The whitespace are players solving both: streamlined access at the point of purchase, bundled into asset-aligned, longer-tenor financing that underwrites the asset, not just the borrower.

*Data source: Renewables First analysis

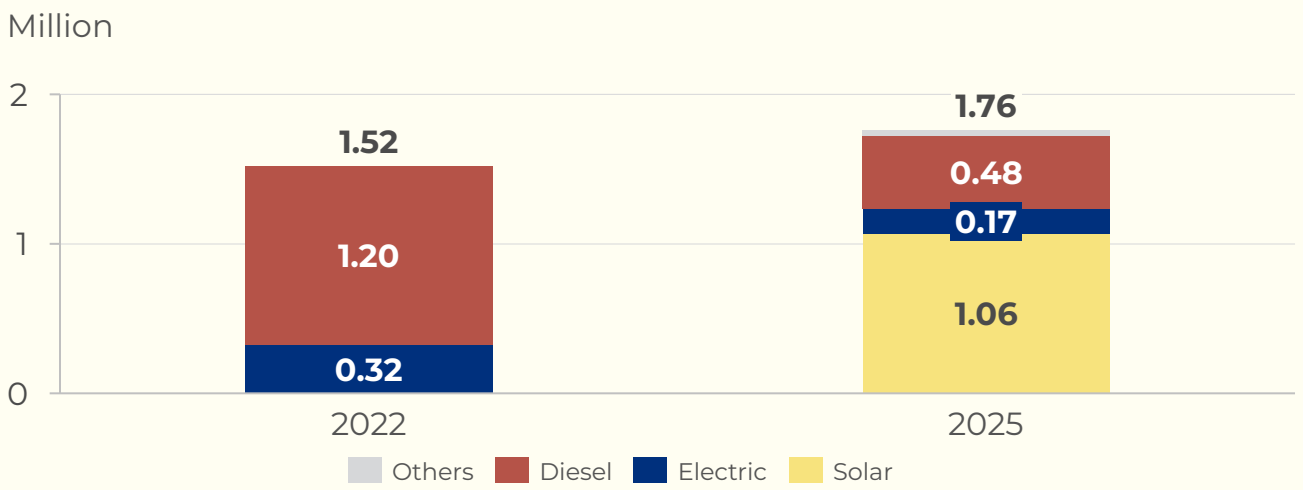
Agriculture segment

Agricultural Solar Capacity 2025: Methodology

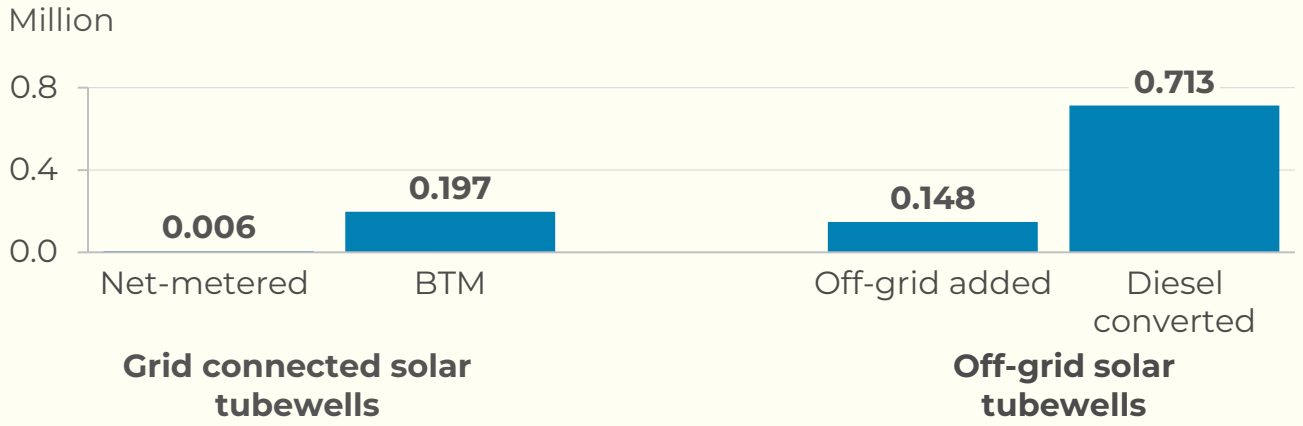
Data collection	PBS Agricultural Census 2024-25 & older datasets	NEPRA Reports & Hearings	Geospatial Mapping, Retailer Surveys & EPC Consultations
Method	Total tubewells & new additions 2025	Estimate split: Net-Metered, BTM, Off-grid	Grid consumption change: solarized electric tubewells
Adjust	Assign system sizes		
Output	Grid, Grid + Solar, Off-grid capacity estimates	Final agricultural capacity	

Solar overtakes diesel as the dominant power source for tubewells

Tubewell mix in agriculture sector, 2022 vs 2025



Grid and off-grid tubewells deployed in agriculture sector, 2025



While total tubewells increased by ~16% between 2022 and 2025, the real shift is in how irrigation is powered.

Over just two years, the energy mix has transformed dramatically: **solar has surged from near-zero to 61% of all tubewells, while diesel has sharply declined from 79% to 28% and electric from 21% to 10%.** This reflects a structural transition, not incremental growth, as farmers rapidly move away from costly diesel and unreliable grid supply.

The scale and speed of this shift suggest that previous census data likely underreported converted tubewells, as solarization has occurred faster than formal systems can capture.

This is further reinforced by the fact that 54% of electric tubewells and 60% of diesel tubewells have already been solarized, indicating widespread retrofitting rather than only new installations.

Solar is now redefining irrigation access - enabling lower operating costs, greater reliability, and independence from fuel and grid constraints in a water-stressed agricultural system.

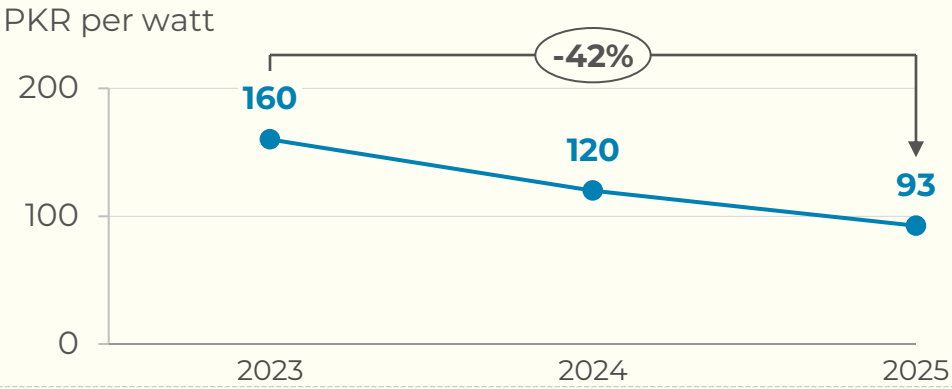
Data source: Renewables First analysis

Solar system costs down 42% while diesel prices surge - driving the shift to solar irrigation

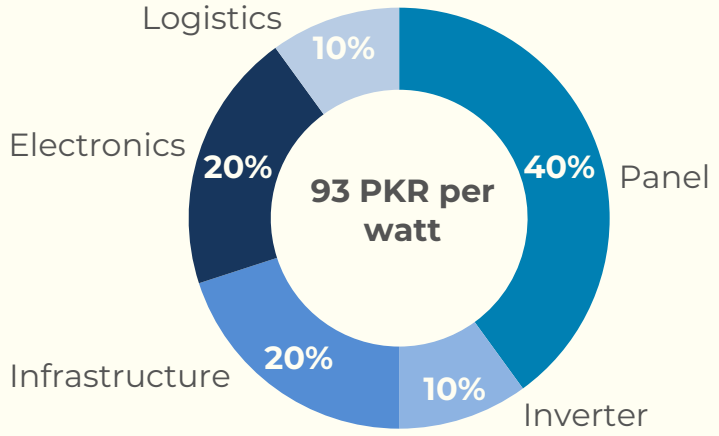
Segment-wise system size and cost in agriculture, 2025

	Size (kWh)	Cost (PKR Million)
Common solar system sizes in agricultural sector	5	0.6
	7.5	0.9
	10	1.2
	15	1.9

Price trend for solar system in agriculture, 2023 - 2025



Cost breakdown of solar system in agriculture, 2025



Data source: Renewables First analysis

Agri solar financing: access-led, off-grid, and subsidy-anchored

Agriculture sector

Total deployment cost (USD M)	**3,224**
Solar financing value (USD M)	**101.4**
Financing penetration	**3.1%**

Agri Solar financing as percentage of total Agri financing from FY 22 - 25

< 0.5%

Cost of irrigation through diesel tubewell as a % of total farming input cost

15% - 20%

Agri solar is 22% of total solar lending and around 1 million tubewells have already been solarized. MFIs like NRSP have absorbed the volume at 30 - 35% markup rates.

Bank products exist at lower pricing and longer tenors with some success, HBL's agri solar financing being a notable example but the banking sector's stringent requirements systematically exclude the smallholder, tenant, and undocumented segments.

The unit economics are the cleanest in the thesis. 60% of solar tubewells displace diesel, prior diesel spend funds the solar instalment, with the spread covering principal and markup.

Stable irrigation cashflows align with how banks already underwrite tractor leasing; solar tubewells, despite the same asset-backed logic, sit outside that infrastructure. The wedge is sharpened by those unit economics.

A single platform solving distribution (point-of-purchase via installers and dealers), structuring (asset-aligned 7-10-year tenors, crop-cycle repayment, storage bundled where reliability matters) and underwriting (cash-flow signal from prior diesel spend). Underwrite the asset and the cash flow it replaces, not just the borrower or the title deed.

Data source: Renewables First analysis

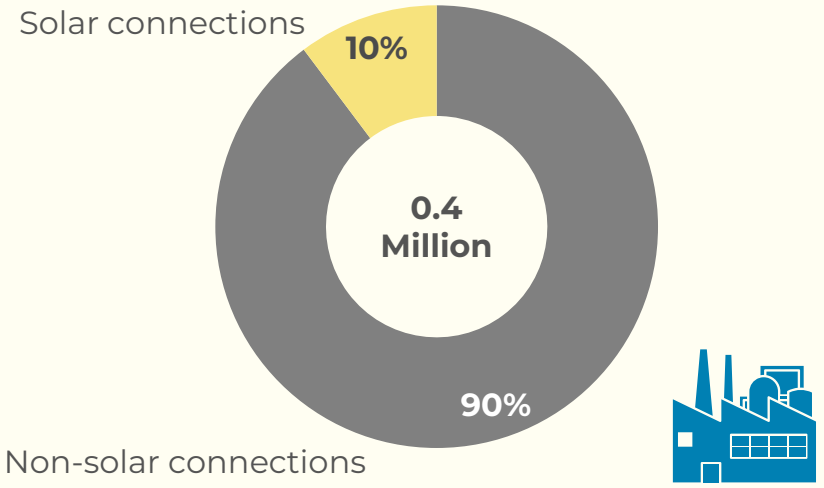
Commercial & industrial segment

Commercial and Industrial (C&I) Solar Capacity 2025: Methodology

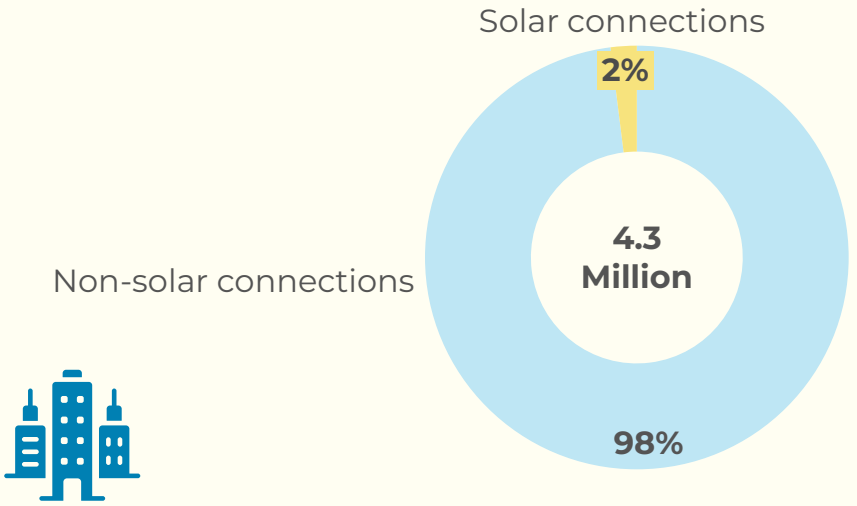
Data collection	NEPRA Reports & Hearings	Geospatial Mapping, Retailer Surveys & EPC Consultations	
Method	EPC macro estimates on sectoral capacities	Estimate split: net-metered, BTM, off-grid	Assign system sizes to estimate penetration
Adjust	Grid consumption change as minimum solar capacity	Off-grid capacity cross-checked with PRIED	Final estimates cross-checked with experts
Output	Net-metered, behind-the-meter, off-grid capacity estimates	Sectoral penetration estimates	

Large installed base, limited penetration, most commercial & industrial users remain untapped

Solar penetration in industrial grid connections, 2025



Solar penetration in commercial grid connections, 2025



Out of an estimated **10 GW industrial capacity** :

- **1.9 GW** operates off-grid
- **2.1 GW** is net-metered
- **6.0 GW** remains residual BTM capacity

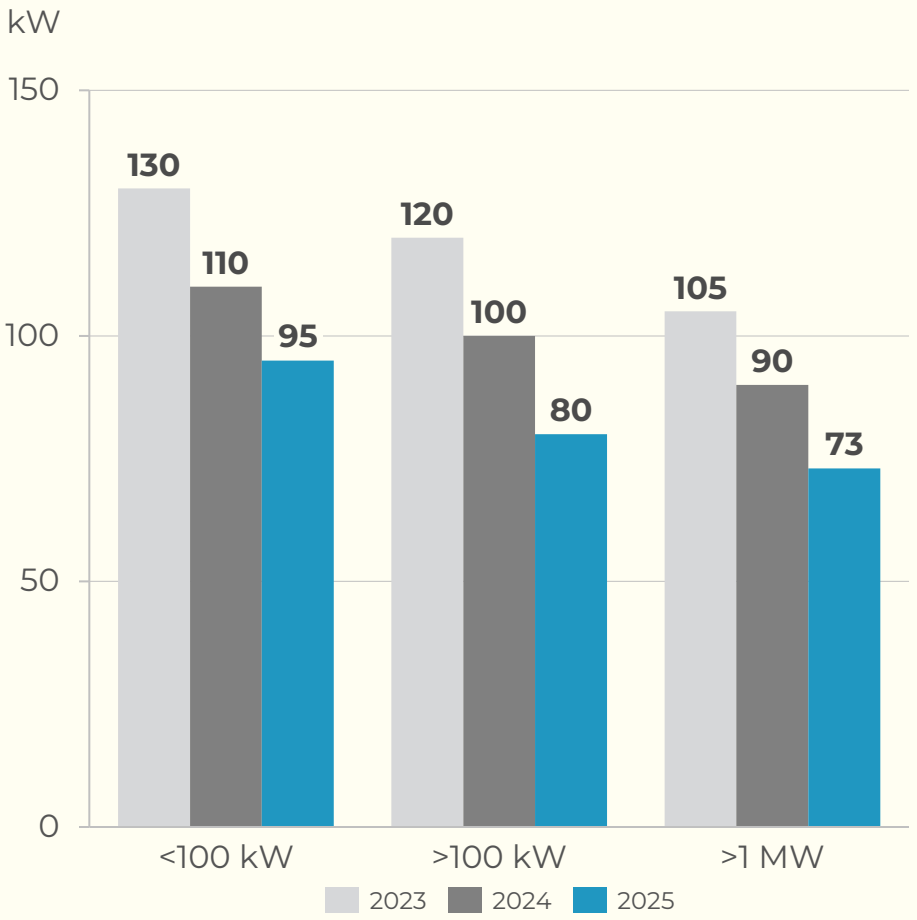
Out of an estimated **3.3 GW commercial capacity**

- **0.6 GW** operates off-grid
- **0.6 GW** is net-metered (NEPRA estimates)
- **2.1 GW** remains residual BTM capacity

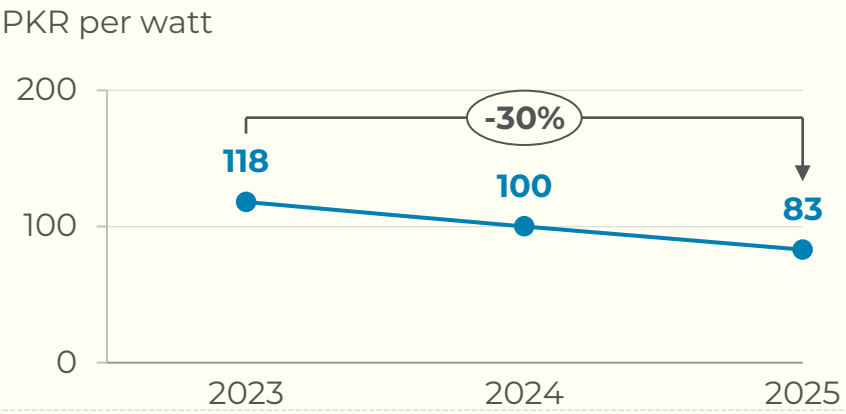
Data source: Renewables First analysis

Cost declines persist, but smaller C&I systems remain structurally more expensive

Decline in cost of solar system size in C&I, 2023 - 2025



Average price trend for solar system in C&I, 2023 - 2025



Segment-wise system size and cost in C&I, 2025

	Common Range	Average Size	Cost (PKR M)
Smaller C&I	20-50 kW	35	3.9
Medium C&I	150-500 kW	312.5	31.3
Large C&I	>1 MW	1	89.2

Data source: Renewables First analysis

C&I solar is a two-speed market - bank-financed at the top, informal at the bottom

Industrial sector

10.0 GW

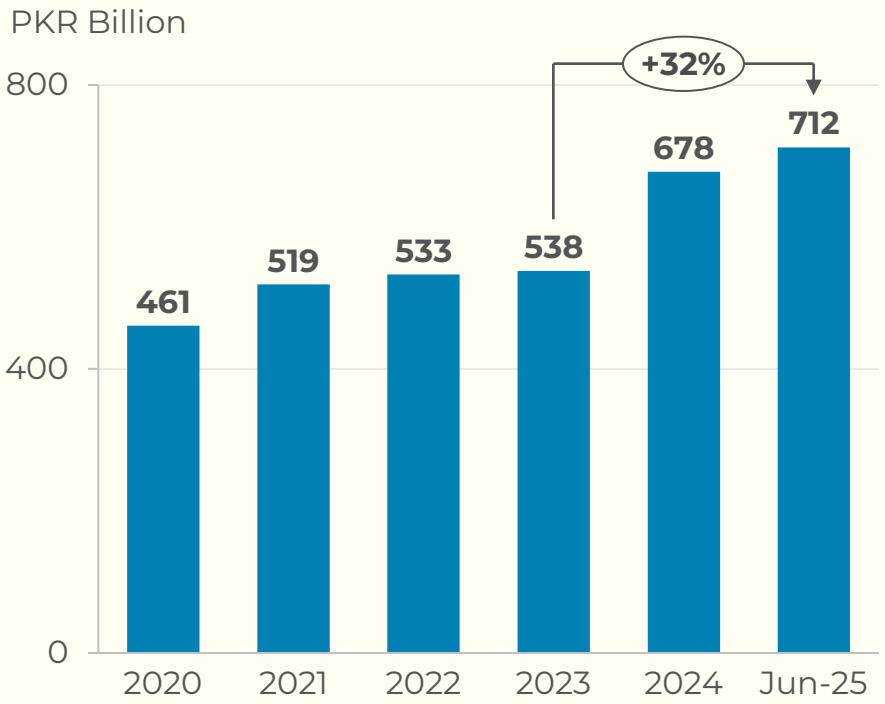
Total deployment cost (USD M)	2,984
Solar financing value (USD M)	277.8
Financing penetration	9.3%

Commercial sector

3.3 GW

Total deployment cost (USD M)	995
Solar financing value (USD M)	48.0
Financing penetration	4.8%

Outstanding SME loan portfolio, 2020- Jun25



C&I solar is bifurcated by financing access. Top-tier industrial and commercial clients remain banked, large ticket sizes, EPC-intermediated transactions, bankable cash flows.

Everything below has fallen out of formal finance. SMEs and small commercial users are running on cash and retailer credit, with bank and MFI penetration close to zero.

The mechanism is regime change, not market failure.

While the SBP green-financing scheme ran, banks reached down-market to capture subsidized exposure and C&I deployment surged. Once it withdrew, lending retreated to top-tier only and the SME segment was left with no formal option. Financing, not unit economics, is now the binding constraint on C&I growth. Net-metering data masks the real picture.

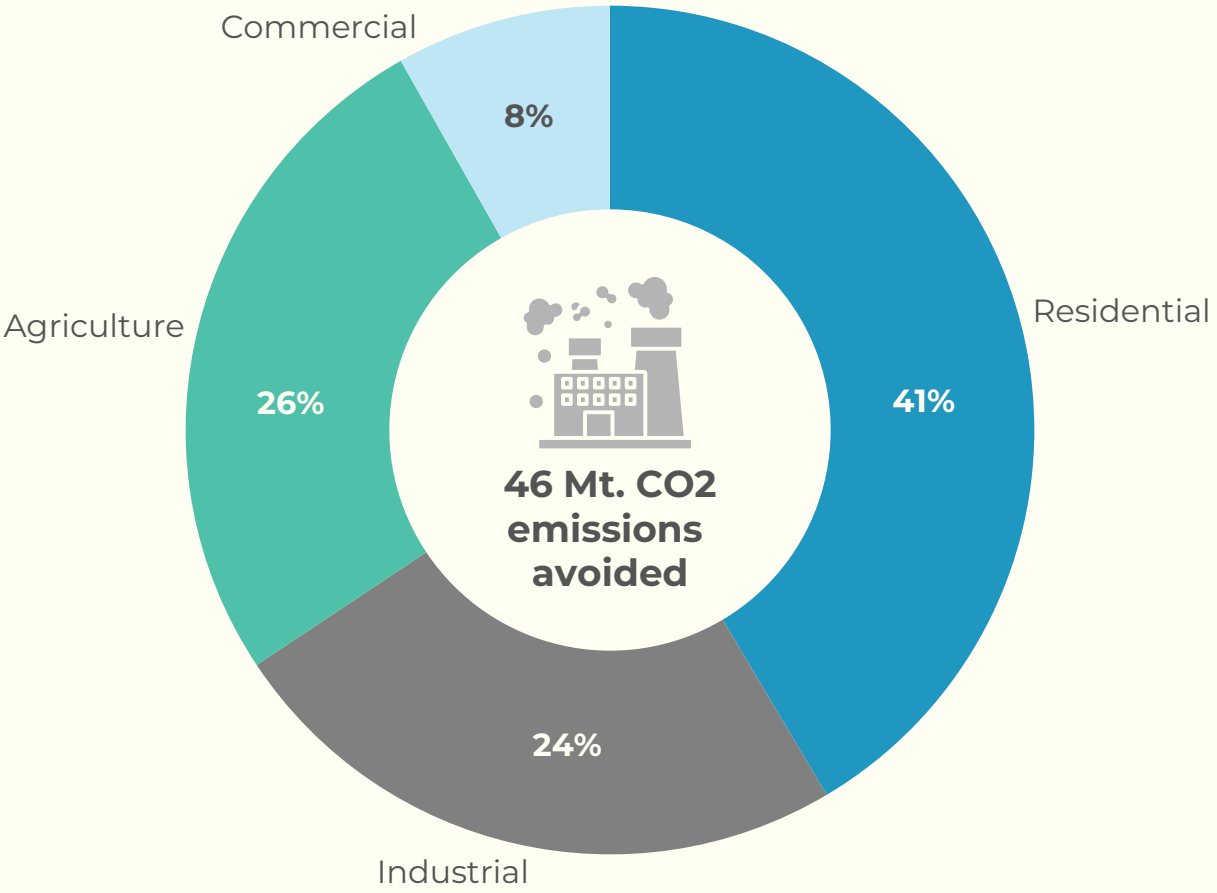
Large industrial systems exceed the 1 MW net metering cap, so they're BTM-only and invisible in registries. SME systems are fragmented and informal, often off-grid or VFD use cases that never touch the grid. Whatever NM data shows for C&I, the real deployed base is materially larger and skewed toward the segment formal finance won't reach.

Data source: Renewables First analysis, PwC Banking Publication 2025

Emissions

Total emissions avoided reach 46 Mt CO_2 in 2025, with off-grid solar driving ~30% of the impact

Sector-wise annual reduction in emissions after solar deployment, FY25



Emissions reductions from solar deployment in Pakistan are significant but uneven across segments and do not directly mirror installed capacity.

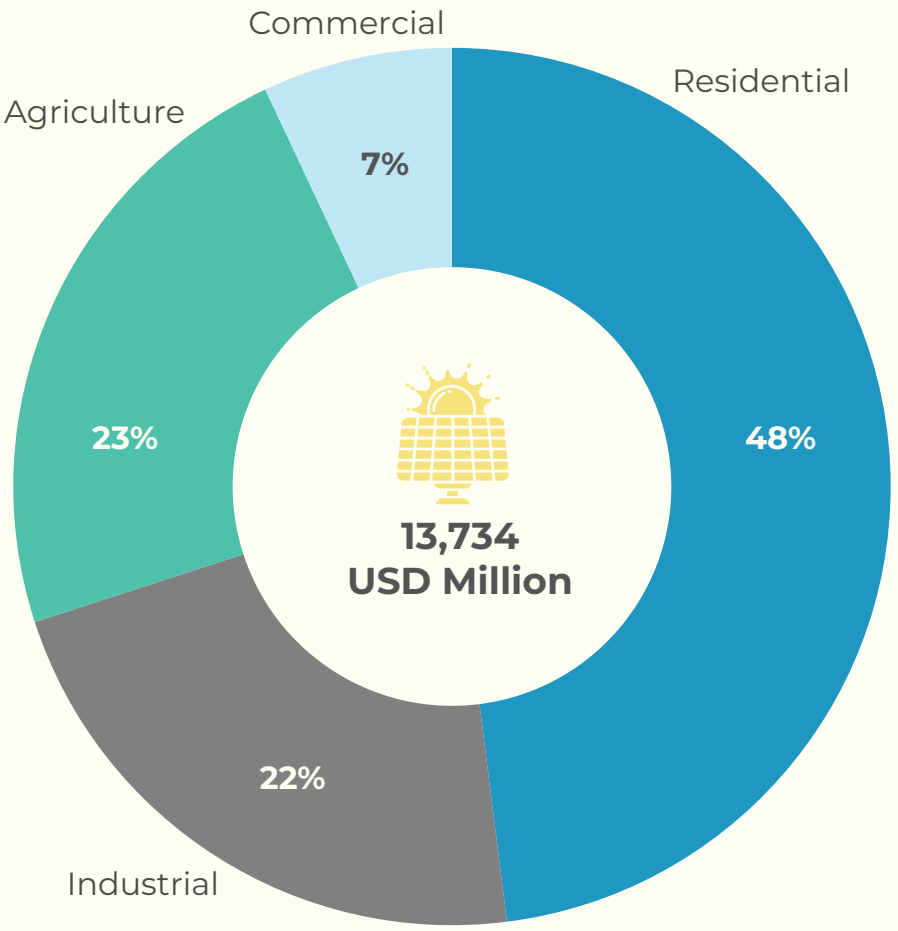
- in 2025, total emissions avoided reached approximately 46 Mt CO_2-eq. Residential segment contributed the largest share (41%), driven by its scale and predominantly grid-connected installations.
- A distinct pattern emerges in agriculture, where emissions reductions are predominantly driven by off-grid solar. Unlike other segments, this impact is not linked to grid decarbonization but to direct fuel switching, particularly the replacement of diesel-powered tubewells. This highlights the disproportionate climate benefit of off-grid solar in agriculture, where even moderate capacity can yield large emissions savings.
- Overall, the split between grid-based (73%) and off-grid (27%) emissions avoided reflects two parallel transition pathways. Pakistan's solar transition is not solely grid-driven but also heavily dependent on decentralized, off-grid adoption.

Data source: Renewables First analysis

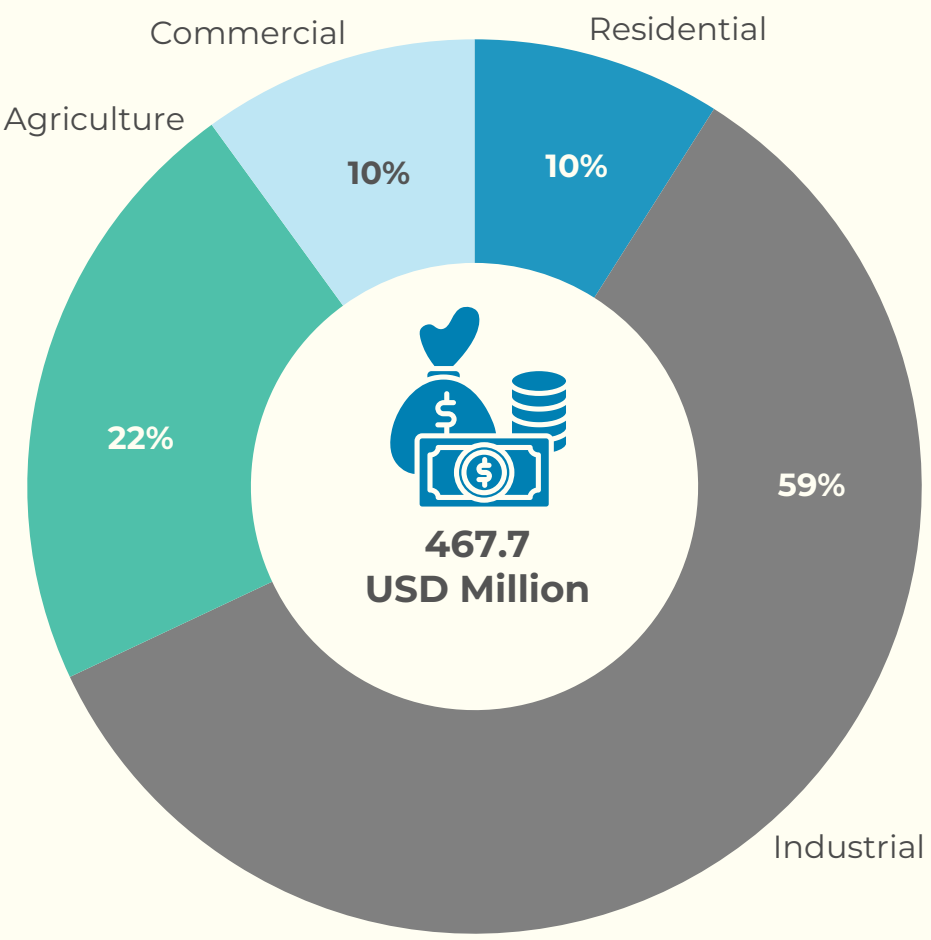
Deployment & financing

Formal financing has penetrated just 3.4% of a USD ~14 Billion solar market

Cost of solar deployment sector-wise, FY25



Financing share sector-wise, FY25

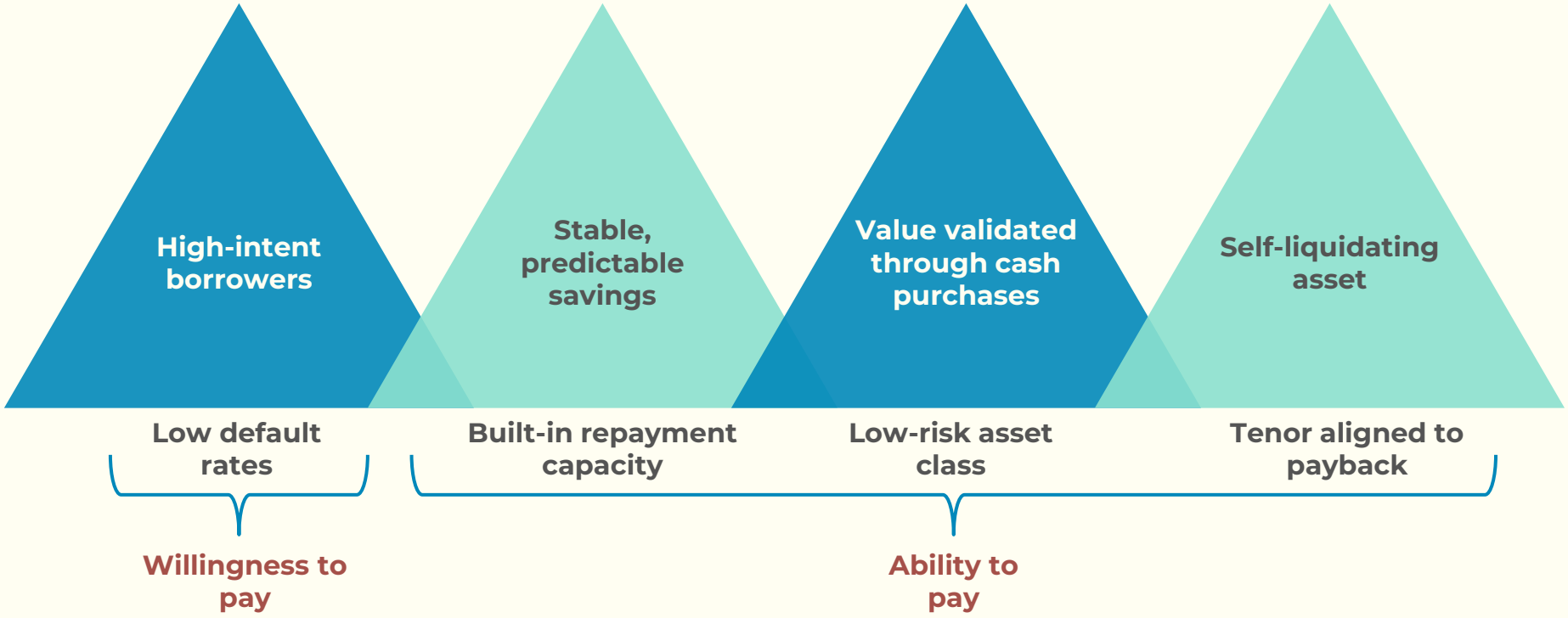


Data source: Renewables First analysis

For conventional lenders, solar loans are a low-risk entry point into cashflow-based lending without traditional collateral

Mismatch with conventional lending	Distributed solar sits awkwardly within conventional credit models. Loan sizes are small, transaction costs per borrower are high, and underwriting remains collateral-centric even when repayment capacity is visible through energy savings and payment behaviour.
Differentiated Products based on Borrowers	Solar demand spans a wide credit spectrum, from low-visibility rural and informal households to fully banked commercial and industrial users. A single product cannot serve all of them; financing models must be matched to system size, documentation quality, ownership structure, and repayment visibility.

Solar Loans Warrant a Different Risk Lens



Renewables First (RF) is a think and do tank for energy and environment. Our work addresses critical energy and natural resource issues with the aim to make energy and climate transitions fair and inclusive.

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