RENEWABLES FIRST

# The Many Dividends of Solar Rush in Pakistan


Whitepaper
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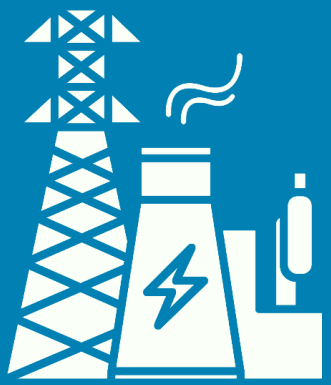
## Disclaimer

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 errors, feel free to reach out to us at: info@renewablesfirst.org

# Key Highlights

| | |
|---|---|
| **Solar inflows continue** | Pakistan has emerged as the world's second-largest importer of Chinese solar panels in FY25, with imports totaling 17.9 GW. Cumulative imports as of September 2025 have surpassed 50 GW. |
| **Solar generation expands** | A 32 GW solar PV deployment has the potential to generate over 42 TWh of electricity, equivalent to 38% of grid electricity sales. |
| **Thermal utilization declines** | Rising solar adoption has reduced the demand for conventional power from the grid. Between FY22 and FY24, the utilization rate of imported coal plants fell from 78% to 11%, while for local coal and RLNG power plants, it dropped from 81% to 70% and 51% to 31%, respectively. |
| **Economic value rises** | Over the past nine years, citizen-led investments, primarily driven by household savings and private capital, have mobilized between USD 17 – 19 B across Pakistan's solar value chain. In FY25 alone, these investments have mobilized an estimated USD 5 – 6 B in capital. |
| **Employment opportunities grow** | The distributed solar industry has created an estimated 300,000 direct and 200,000 indirect jobs between FY17 and FY25, with the majority concentrated in EPC services and construction activities. |
| **Emissions reduction accelerates** | Solar PV has potentially avoided 35 million $MtCO_2$-eq emissions in FY25. Sustaining an annual deployment rate of 3 GW could enable the avoidance of 50 million $MtCO_2$-eq emissions per year by FY30. |



# Evolving power sector trends

## Total imports as of September 2025

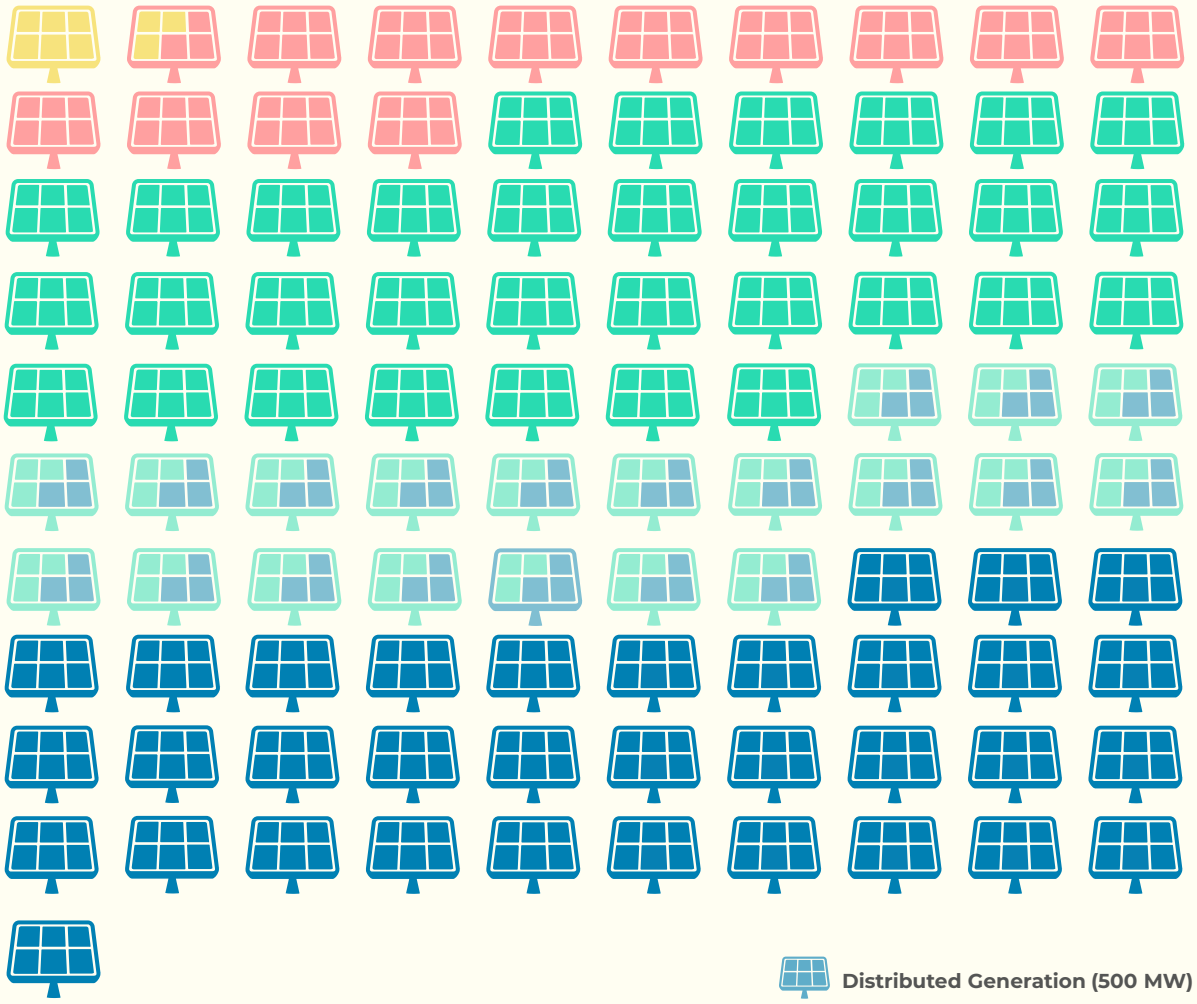
# 50,592 MW

**780 MW** installed at utility scale

**6,100 MW** installed as net metering solutions

**~16,500 – 26,400 MW** deployed behind-the-meter, in grid-deprived areas, or in captive power plants[1]

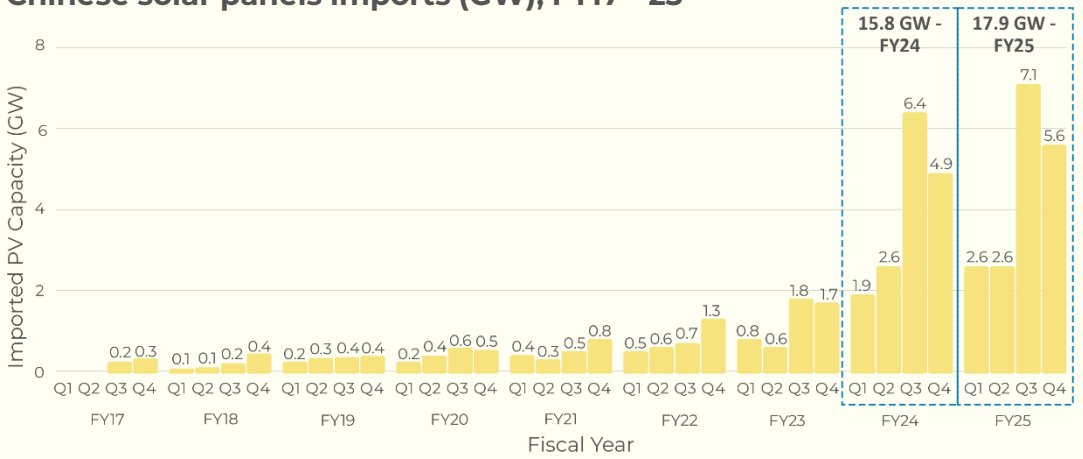
**~17,300 – 27,200 MW** stockpiled, undeployed



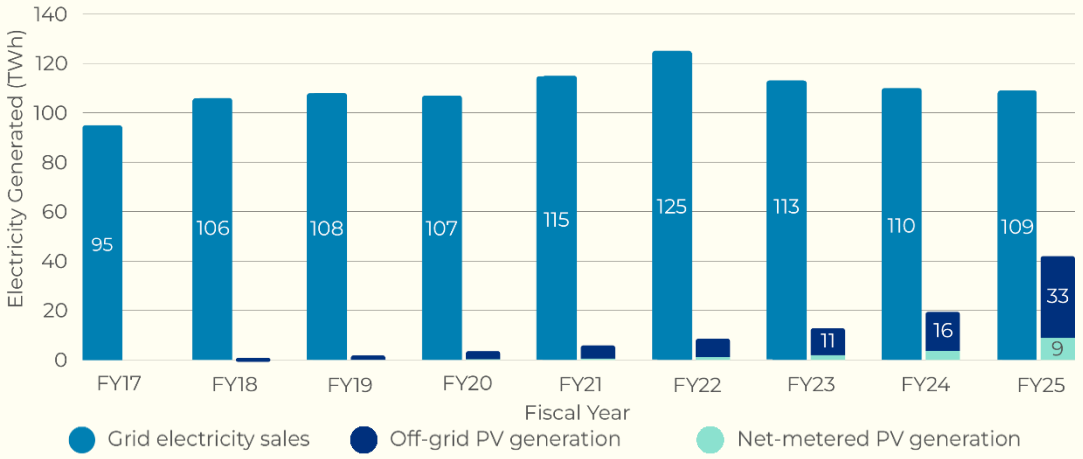

[1] Based on Transition Zero and PRIED analysis. For detailed assumptions and methodology, refer to Annex-I

# Pakistan's solar momentum continues to accelerate in FY25, with deployed solar now generating an estimated 42 TWh of electricity

## Chinese solar panels imports (GW), FY17 - 25




## Solar generation vs. grid sales, FY17 - FY25

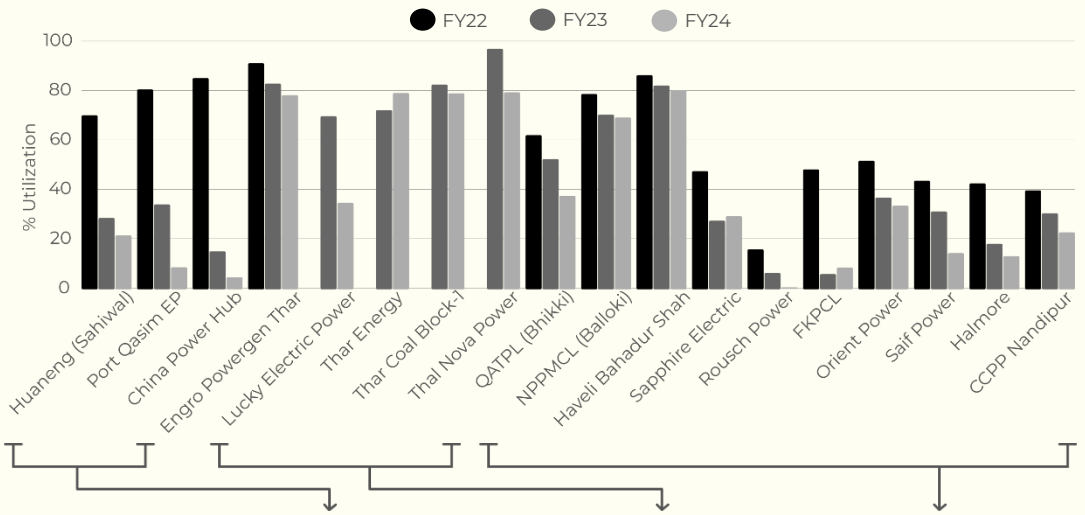



- Pakistan's citizen-led solar momentum has continued its acceleration, with FY25 panel imports reaching 17.9 GW. This positions the country as the 2nd largest global importer of Chinese solar panels in a single year. Cumulative panel imports have exceeded 50 GW through September 2025, reflecting the continued demand for cheap and distributed electricity.
- The proliferation of distributed solar PV is shifting Pakistan's power generation landscape. Deployment of 32 GW of solar panels, imported by September 2025, has the potential to generate 42 TWh of electricity annually, a volume equivalent to 38% of the current electricity sales from the national grid.[1]
- The surge in distributed generation, high electricity tariffs, and increasing energy conservation practices at the consumer end are contributing to a continuous decline in conventional electricity sales. Grid sales have dropped by 9.4% in FY23, 2.6% in FY24, and 1% in FY25.
- The decline is particularly noticeable in the agricultural and industrial sectors, driven primarily by off-grid solar deployment in agriculture and by a mix of off-grid adoption and other demand-side factors in industry, resulting in an overall 11% YoY reduction in grid electricity sales across these two sectors during FY24.

[1] For detailed assumptions and methodology, refer to Annex-I
Data Source: NEPRA State of Industry Report, Ember, RF Insights

# Affordable, distributed solar PV reduces reliance on thermal power plants and lowers their utilization

**% Utilization of thermal plants, FY22 - FY24**




| Fiscal Year | Imported Coal | Local Coal | RLNG |
|---|---|---|---|
| **FY22** | 78.44% | 91.02% | 51.46% |
| **FY24** | 11.35% | 69.93% | 30.70% |

**Average utilization rate of thermal power plants**

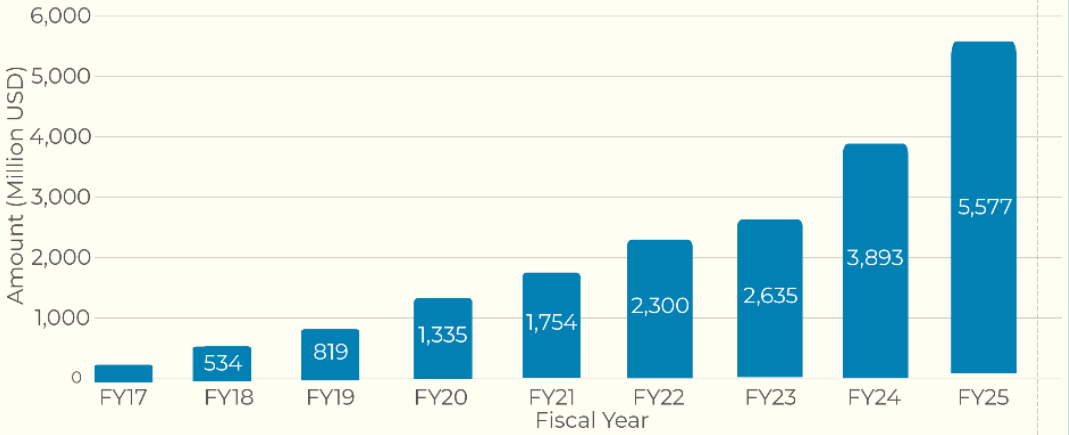
- The steepest reduction in utilization rates has occurred in imported coal and RLNG-fired plants, with % utilization rate falling to as low as 4% for the China Power Hub plant. Owing to their high generation costs and reliance on imported fuels, these plants sit at the lower end of the economic merit order and are increasingly excluded from dispatch amid weakening grid demand.
- The transition has reduced the import burden of fossil fuels. Coal imports dropped from 18 million Mt. in FY22 to 6 million Mt. in FY24, while 21 RLNG cargoes for FY26–27 were cancelled amid the decreased demand for power generation.[1].

[1] Learn more in Renewables First (2025), "Pakistan Energy Market Review"
Data Source: NEPRA Performance Evaluation Report, PACRA Coal Mining and Trading Report 2025, RF Insights

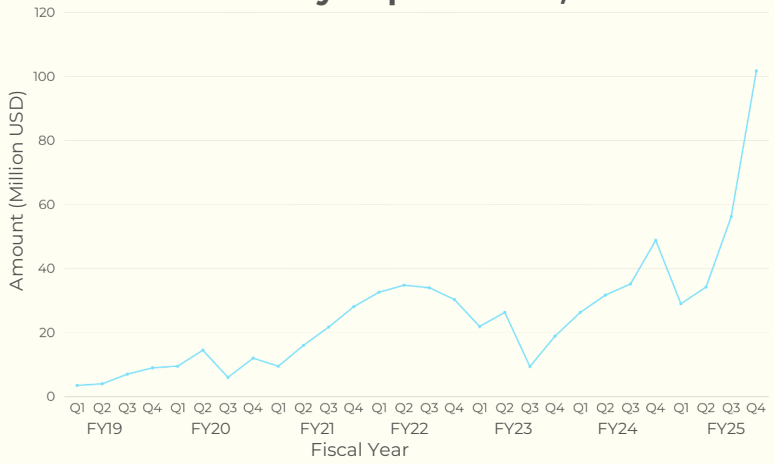
# Economic gains

# Citizen-led solar deployment mobilizes an estimated 17–19 B in capital, driving domestic value creation, with storage now following suit

## Domestic capital mobilized on solar installations, FY17 - FY25




## Lithium-ion battery import trend, FY19 - FY25

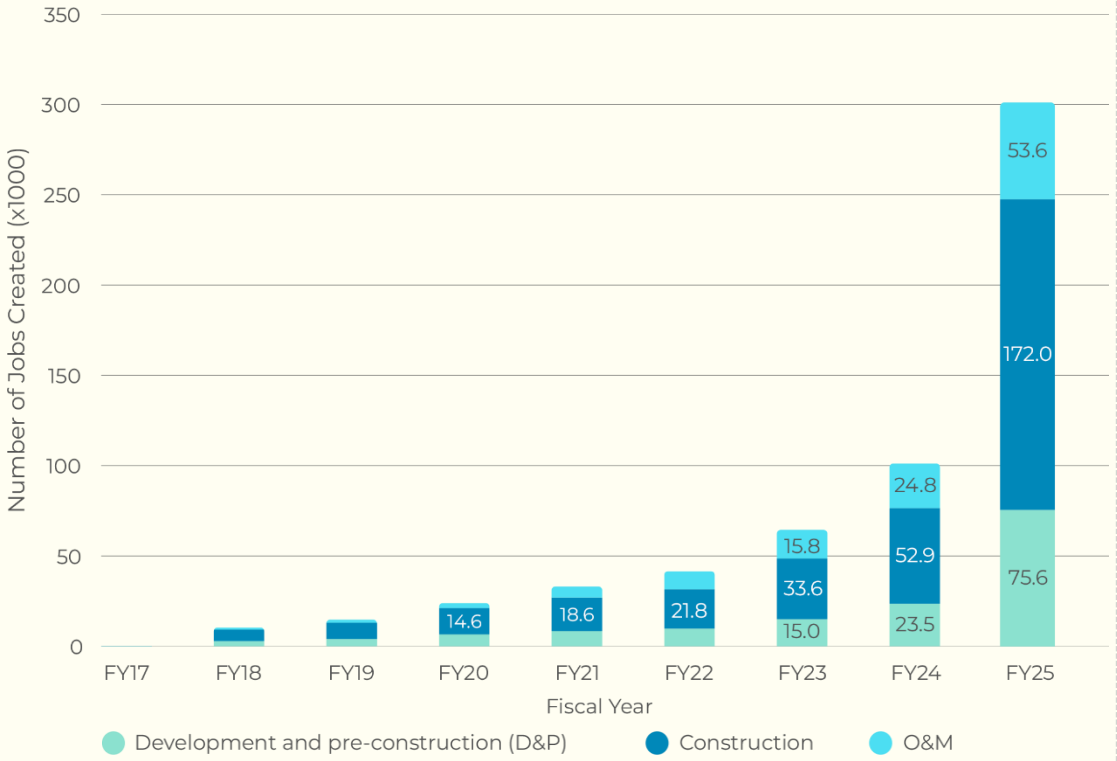



- Citizen-led investments, financed through private capital and household savings, have been the primary driver of solar adoption in Pakistan. Between FY17 and FY25, these investments, covering the deployment and import of solar PV systems and related equipment, are estimated to have mobilized around USD 17–19 billion (B).[1] In FY25 alone, approximately USD 5–6 B was invested, underscoring the scale of distributed solar as a source of local economic value.
- Capital expenditure across the sector remains heavily hardware-driven. Solar panels account for the largest share, with cumulative imports of 50.5 GW valued at roughly USD 7.7 B, followed by inverters, mounting structures, and other electrical components.
- In parallel, energy storage adoption is accelerating. Since FY19, lithium-ion battery imports from China have reached over USD 700 million, including USD 101.7 million in the last quarter of FY25 alone. This rapid growth positions energy storage as the next phase of Pakistan's distributed energy evolution, with critical implications for grid flexibility, reliability, and domestic industrial development.

[1] For detailed methodology, refer to Annex-II.
Data Source: Ember Li-ion Battery Exports, RF Insights, Industry & Market Consultations

# Distributed solar generates over 500,000 jobs across Pakistan, supporting local livelihood and economy

## Direct jobs created by solar PV, FY17 - FY25




- The rapid expansion of distributed solar in Pakistan has generated substantial employment across the energy value chain. Between FY17 and FY25, the sector is estimated to have created around 300,000 direct and 200,000 indirect jobs.[1]
- Direct employment is primarily concentrated in business development, construction, and operations and maintenance (O&M), while indirect jobs are distributed across supporting industries such as logistics, retail, and services.
- Energy solution providers, engineering, procurement, and construction (EPC) firms, and service contractors account for the majority of direct employment, particularly during the labor-intensive construction phase.

**Direct Jobs 300,000**

+

**Indirect Jobs 200,000**

→

**Total Jobs 500,000**

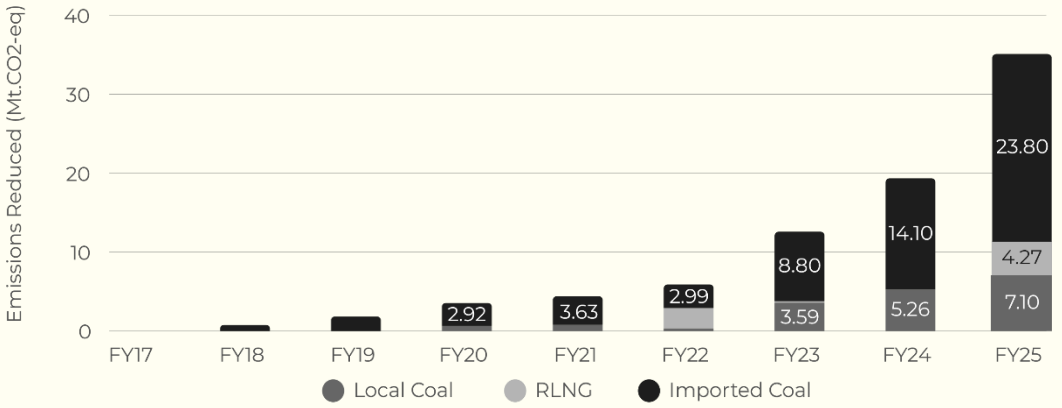
[1] For detailed methodology, refer to Annex-III

Data Source: World Bank Renewable Energy Jobs and Sector Skills Mapping for Pakistan 2022, RF Insights, Industry & Market Consultations

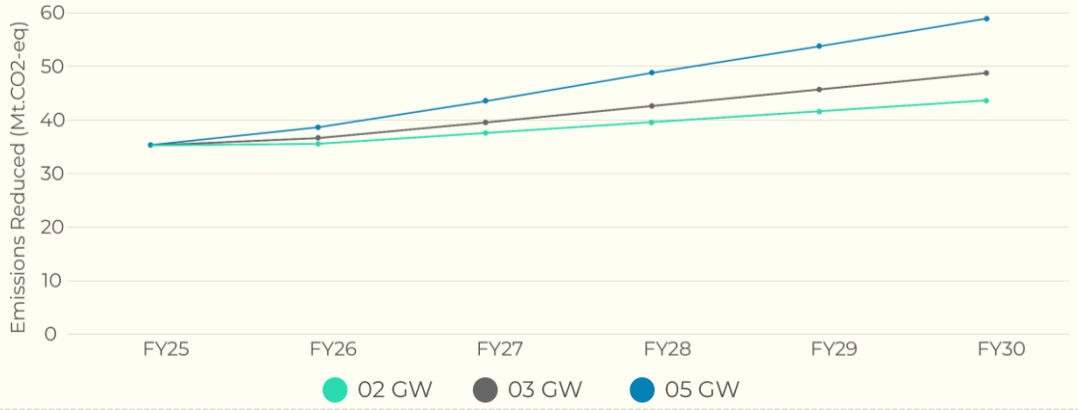
# Emissions reduced

# Solar PV deployment delivers clean electricity by avoiding 35 million Mt. $CO_2$-eq emissions from the energy sector

## Annual emissions reduced by displacing thermal power plants, FY17 - FY25




## Emissions reduction trend for annual deployment scenarios, FY25 - FY30




- As distributed solar PV continues to displace grid-based generation and supply electricity to remote and underserved areas, it is progressively decarbonizing Pakistan's power sector. In FY25, it has avoided an estimated 35 million $MtCO_2$-eq in emissions through clean electricity generation.[1]
- Between FY17 and FY25, Cumulative avoided emissions are estimated at 83.6 million Mt. $CO_2$-eq, underscoring the technology's growing contribution to Pakistan's Net Zero ambitions.
- Maintaining the deployment momentum presents a clear pathway toward deeper emission cuts across the energy sector. Under a scenario of 03 GW additional distributed solar deployment each year from FY26 to FY30, annual avoided emissions could reach 50 million Mt. $CO_2$-eq by FY30.

[1] For detailed methodology, refer to Annex-IV

Data Source: RF Insights, NEPRA State of Industry Report, IPCC (2006) Guidelines, CREA $CO_2$ Emissions from Pakistan's Energy Sector 2021

# Appendix

# Annex-I: Assumptions & Limitations

The analysis focuses on Pakistan's distributed solar sector, where much of the off-grid deployment, related economic activity, and job creation occur within the informal economy. Estimates presented in this report are derived from market intelligence and industry consultations and are reported using the following analytical assumptions.

| Fiscal Year | Description |
|---|---|
| Solar PV deployment and deployment lag | The estimated solar PV deployment is between 22.57 – 32.49 GW.[1] However, for simplicity of analysis, imported solar panel deployment is assumed to have a one-year deployment lag. Panels imported in fiscal year 'n' are considered deployed in fiscal year 'n+1'. Based on expert estimates, all panels imported up to September 2024 are assumed to have been fully deployed. |
| Solar Utilization Rate | A uniform capacity utilization rate of 16.7%, consistent with the reported capacity factor of IGCEP 2025, is applied across all geographic regions and throughout the analysis period. |
| Curtailment Factor | For all off-grid systems, a 10% reduction in effective generation is assumed to account for curtailment, in line with expert estimates. |
| Emission Factor | Avoided emissions were calculated using fuel-specific emission factors of 992 g/kWh for coal and 495 g/kWh for gas/RLNG, derived from NEPRA-reported primary fuel consumption and corresponding emission coefficients based on IPCC (2006) guidelines. |
| Plant % Utilization | Calculated as "Gross generation / (Dependable capacity * Available hours)" |

[1] Data Source: Transition Zero & PRIED Analysis "Shedding Light on Pakistan's Distributed Solar Revolution"

# Annex-II: Analysis methodology for economic activity

Economic activity from solar PV deployment was assessed through a two-track approach, combining market-based cost analysis with component-level capital flow estimation.

- In the cost-based estimation technique, deployment cost (per watt, kilowatt, and megawatt) for each year was derived through a market survey conducted across EPCs working in the residential, commercial, and industrial solar PV sector. The average deployment cost is applied to annual deployment volumes to estimate yearly capital mobilization, which is the upper bound of capital mobilized.

- The component-level estimation captured investment flows across key components, like modules, inverters, structures, cabling, and logistics, using inputs from 50+ EPCs, distributors, and market experts. Reported capital shares were aggregated and scaled to the total deployed capacity, providing the lower bound of capital mobilized.

Results from both approaches were cross-validated with sector experts to produce final estimates, reflecting the average annual economic activity generated across Pakistan's distributed solar value chain.

# Annex-III: Analysis methodology for new jobs created through solar PV

Estimates of new job creation from solar PV deployment were derived using employment factors (EFs) from the World Bank's "Renewable Energy Jobs and Sector Skills Mapping for Pakistan". Job estimates were calculated annually based on installed capacity, covering three key phases: Development & Pre-construction (D&P), Construction, and Operations & Maintenance (O&M).

- D&P Jobs = MW Installed × D&P EF
- Construction Jobs = MW Installed × Construction EF
- O&M Jobs = Cumulative Installed Capacity × O&M EF
- Total Direct Jobs (annual) = D&P Jobs + Construction Jobs + O&M Jobs
- Indirect Jobs = Direct Jobs × Indirect Job Factor (0.7)

To account for improvements in workforce productivity and efficiency over time, 2020 EF values were used as a baseline, with an annual decline factor of 4.9% applied in subsequent years. Final job estimates were cross-validated through expert consultations with industry practitioners and sector specialists.

# Annex - IV: Analysis methodology for avoided emissions

Avoided emissions were estimated using a counterfactual generation approach, assuming that electricity supplied by distributed solar PV would otherwise have been generated by underutilized thermal power plants. These plants were categorized according to their economic merit order, and their missed generation volumes were used to determine avoided emissions.

- Solar Generation = Installed Solar Capacity × Capacity Factor
- Counterfactual Generation = Solar Generation (displaced thermal output)
- Avoided Emissions (per fuel/plant) = Counterfactual Generation x Fuel-specific Emission Factor
- Total Emissions Avoided = Σ (Emissions Avoided across all thermal assets)

For future projections, counterfactual generation from distributed solar PV was allocated across fuel types (coal, gas/RLNG) based on the average fuel share in Pakistan's thermal generation mix over FY19–FY24. Corresponding average emission factors for each fuel category were then used to calculate expected annual avoided emissions.

# Annex - V: Abbreviations

| | | | |
|---|---|---|---|
| **EPC** | Engineering, procurement, construction | **PV** | Photovoltaic |
| **FY** | Fiscal year | **RLNG** | Re-gasified liquefied natural gas |
| **GW** | Gigawatt | **TWh** | Terawatt-hour |
| **Mt** | Metric ton | **USD** | United States dollar |
| **$MtCO_2$-eq** | Metric tonnes of $CO_2$ equivalent | **YoY** | Year-on-year |
| **O&M** | Operations and maintenance | | |

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