Roadmap for Rapid Solarization of

Pakistan's Textile Clusters

(Faisalabad & Multan)

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List of Abbreviations

ADS	Alternate Development Services
APTMA	All Pakistan Textile Mills Association
ARE Policy	Alternative & Renewable Energy Policy
CBAM	Carbon Border Adjustment Mechanism
CPPA	Central Power Procurement Agency
CPP	Captive Power Plant
CPPA-G	Central Power Purchasing Agency-Guarantee Limited
CTBCM	Competitive Trading Bilateral Contract Market
DG	Distributed Generation
DISCO	Distribution Company
ESG	Environmental, Social and Governance
EU	European Union
FY	Financial Year
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GM	Gross Metering
IPP	Independent Power Producer
IRR	Internal Rate of Return
ISMO	Independent System and Market Operator
KPI	Key performance Indicator
kWh	Kilowatt hours
LCOE	Levelized Cost of Electricity
MRV	Monitoring, Reporting & Verification
MW	Megawatt
NEPRA	National Electric Power Regulatory Authority
NM	Net Metering
NPV	Net Present Value
NTDC	National Transmission and Dispatch Company Limited
O&M	Operation and Maintenance
PBP	Payback Period
PPA	Power Purchase Agreement
PPIB	Private Power and Infrastructure Board
RE	Renewable Energy
ROI	Return on Investment
S1, S2	Scenario 1, Scenario 2 (proposed scoping scenarios in this study)
SBP	State Bank of Pakistan
SMEDA	Small and Medium Enterprises Development Authority
TEA	Techno-Economic Analysis
TR	Trading Rate
UoSC	Use of System Charge
VPP	Virtual Powerplants
WAPDA	Water and Power Development Authority
WR	Wheeling Rate

1. Background and Purpose

A compact, implementable roadmap explaining off‑grid and on‑grid options, wheeling economics (current issues and suggested tariffs), and competitive trading bilateral contract market (CTBCM) scenarios; with clear actions, timelines, and responsibility assignments for stakeholders (textiles, NEPRA, ISMO and the like).

This roadmap includes the core findings of the conducted study into a practical, prioritized plan for accelerating renewable adoption in Pakistan's major textile clusters (Faisalabad and Multan). It is clearly pragmatic:

(1) Enable and promote the rapid private deployment of distributed solar (small and medium enterprises (SME)-focused),
(2) Enable larger centralized projects which minimize system LCOE and maximize avoided CO_2 and;
(3) Implement CTBCM with transitional safeguards (phased, differentiated wheeling and measuring, reporting and verification (MRV) integration for CBAM compliance).

2. Problem Statement

Textile production in Faisalabad and Multan is energy‑intensive and reliability‑constrained. Mills deploy mixed-source resilience (diesel, gas, grid, and rising solar). Rapid solarization addresses competitiveness (lower unit costs), reliability (less outage impact), and export risk (CBAM compliance), but success depends on wheeling economics, metering/settlement clarity, and viable competitive trading bi-lateral contract markets (CTBCM) design. Without actionable transitional policy the market will bifurcate: large-centralized projects may continue enjoying the benefits, while SMEs remain financially excluded.

3. Current Energy Profile of Selected Clusters and Scenarios considered for technoeconomic modeling and Environmental Analysis

Figure 1 shows the existing energy profile from sample textile mills considered in solarization under CTBCM context, and **Table *1*** shows the scenario matrix design for solar adoption under various grid mechanisms (net metering (NM), gross metering (GM) and CTBCM).

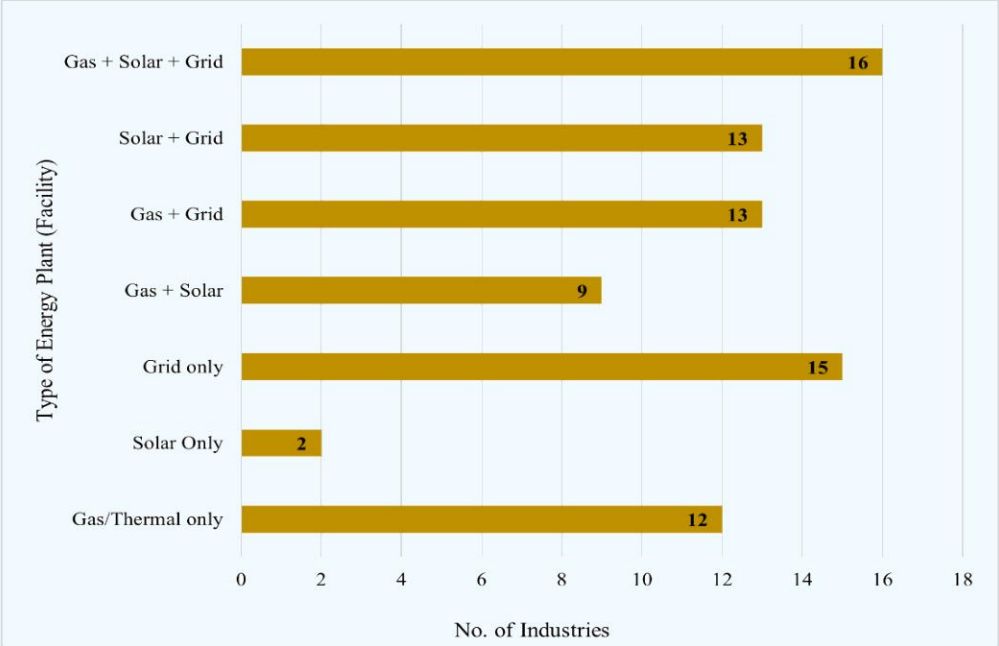

Figure 1: Comparative energy profile of Sample Textile industries

Table 1: Scenarios and Cases Analyzed in Study

Scenario A: High Renewable Fraction (87% Solar)

- **Configuration:**
  - On-site solar meets 87% of load (3,733 MW capacity)
  - Minimal grid (or external energy) dependency (13%)
- **Open-Trading Interpretation:** *Unit Sales-Based Model*
- **Economic Profile:**
  - High CAPEX ($2.43B)
  - Low operational cost
  - Curtailment risk during peak solar hours

Scenario B: Low Renewable Fraction (75% Solar)

- **Configuration:**
  - On-site solar meets 75% of load (2,175 MW capacity)
  - Moderate grid (or external energy) dependency (25%)
- **Open-trading Interpretation:** *Unit Purchases-Based Model*
- **Economic Profile:**
  - Lower CAPEX ($1.43B)
  - Higher grid cost exposure
  - Reduced curtailment

Case	Metering Mechanism	CTBCM Threshold	Scenario Applicability
1	N/A (Business-as-Usual with NM for PV)	N/A	Baseline
2	Net Metering	N/A	A/B
3	Gross Metering	N/A	A/B
4	Net Metering <1MW + CTBCM >1MW	1 MW	B (Mid-size mills)
5	Gross Metering <1MW + CTBCM >1MW	1 MW	B (Mid-size mills)

6	Net Metering <500kW + CTBCM >500kW	500 Kw	A (Large mills)
7	Gross Met. <500kW + CTBCM >500kW	500 kW	A (Large mills)
8	Full CTBCM Implementation	0 kW	A/B

4. Off-grid (On-site/captive) scenario: Practical summary and critical points

Conceptualization: On-site rooftop/ground-mount PV, often paired with storage and existing captive generation (diesel/gas); dominant for SMEs and mid-sized mills.

Advantages: Low transaction complexity, quick payback (lower renewable fraction, but low initial costs (S2 (Scenario-B) style, described above), resilience to outages, simpler MRV for site emissions.

Limitations: Higher system-level LCOE (compared to very large, centralized builds), limited ability to sell surplus except under favorable wheeling rules, constrained by rooftop/land area for scale.

Critical policy observations:

- Off-grid/captive systems are the fastest route to scale but are fragile to high wheeling charges: when wheeling rates (WR) > PKR 12–15/kWh many mid-size projects become uneconomic (see **Figure *3***).
- Net metering caps (current 1 MW; proposal to raise to 5 MW) materially change project economics for industrial consumers; expand cap is essential.
- Implement phased implementation of CTBCM with reduced caps and co-run both net metering and CTBCM to preserve SMEs as well as large textile industries.

Recommended actions (0–18 months):

1. Prioritize concessional SME finance windows (SBP/DFIs) for on-site PV + storage.
2. Temporarily exempt off-grid exports from non-network legacy charges during CTBCM pilot period.
3. Raise net/gross metering cap to 5 MW for textile parks (NEPRA/Power Division), or implement on-time CTBCM with reduced caps (500 kW) preserving both SMEs and large mills.
4. Issue model O&M and MRV templates for on-site assets to fast-track CBAM reporting.

5. On-grid (offsite/centralized) scenario: Practical summary and critical points

Conceptualization: Larger ground-mount or aggregated cluster solar farms selling into CTBCM or under long-term PPAs (S1 style).

Advantages: Lowest system LCOE, highest absolute NPV, superior carbon avoidance per $ invested; attractive for exportable CBAM revenue capture.

Limitations: Higher CAPEX and longer paybacks; require grid reinforcement and credible market governance to enable trading and settlement.

Critical policy observations:

- S1 benefits strongly from higher trading rates (TR): raising TR materially increases NPV and shortens payback (see **Figure *4***).
- Grid reinforcements and storage are preconditions for large S1 projects to avoid curtailment and provide system services.

Recommended actions (0–36 months):

1. Identify and allocate strategic transmission pockets (an 800 MW target has been suggested) and designate priority CTBCM corridors for cluster projects.
2. Offer "Preferred Access" time-tiered dispatch priority to projects that co-install storage/DR.
3. Offer revenue-stabilizing instruments (First-Mover Guarantee fund) to early S1 participants to de-risk initial exposure.

Key quantitative anchors: **Figure *2*** shows levelized cost metrics for solarization under various proposed scenarios and show that CTBCM implementation would eventually lead towards de-centralization of power transmission and improve levelized (per unit) energy costs for key textile industrial hubs. In the follow-through, it is shown that CTBCM trading-rate (TR) sensitivities (illustrative TR ≈ PKR 20–30/kWh), a critical wheeling threshold where many distributed projects break (PKR ≈ Rs 12–15/kWh), and a policy objective to target interim wheeling in the range **PKR 5–8/kWh** during the transition phase to preserve distributed project economics.

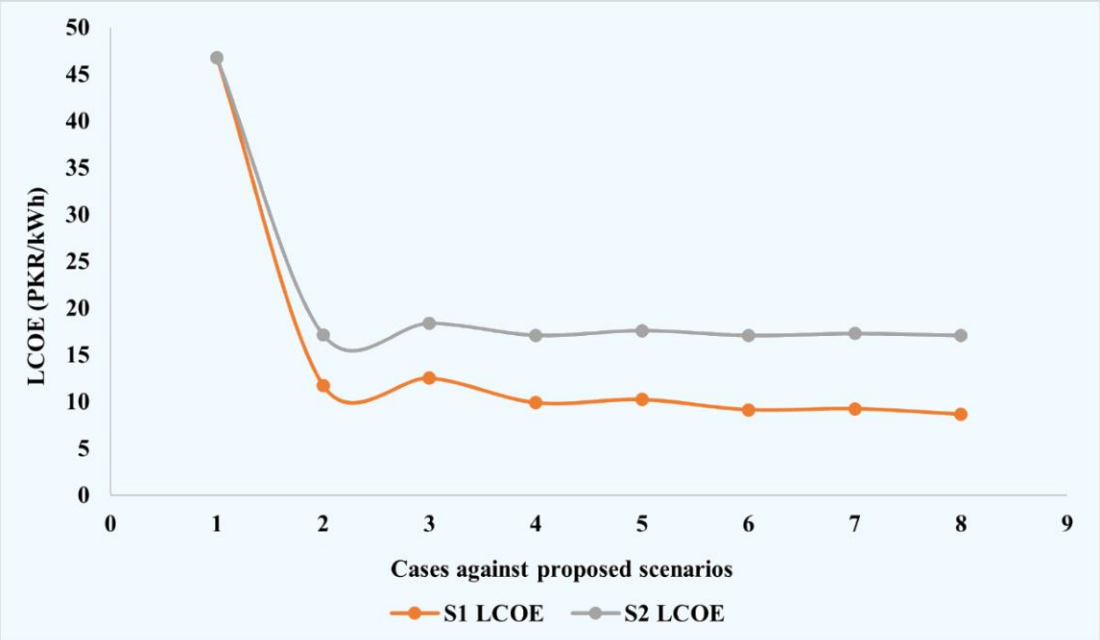

Figure 2: LCOE obtained against various cases across proposed scenarios

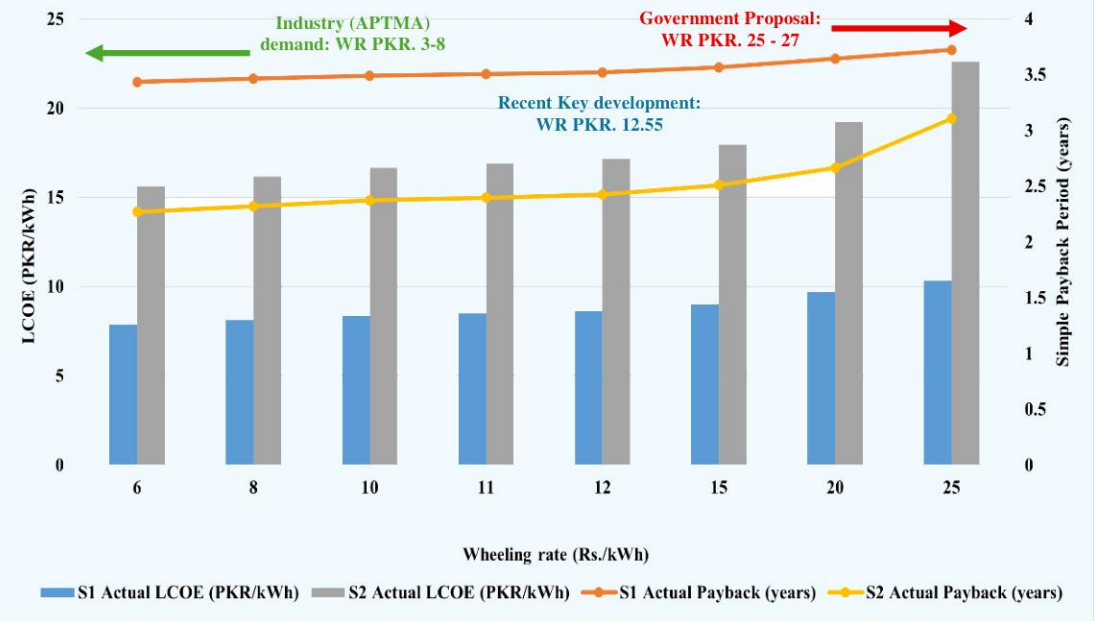

Figure 3: Impact of Wheeling charges on LCOE and Payback period (Case 8)

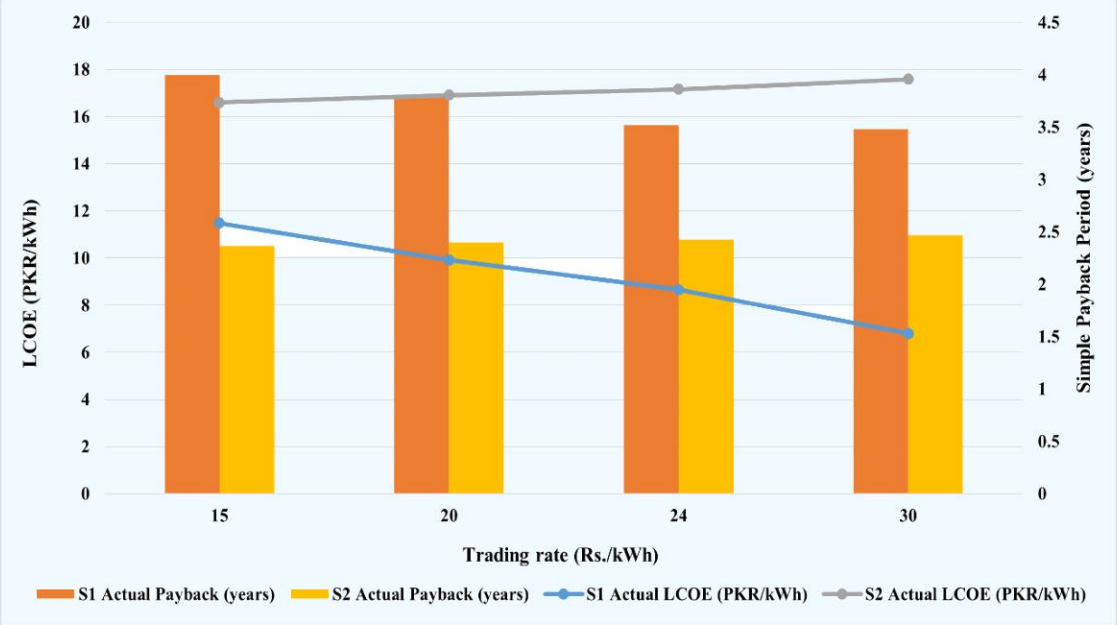

Figure 4: Impact of Trading rate on LCOE and Payback period (Case 8)

6. GIS Mapping and CTBCM Ready Pockets

The specific mapping results for some of the selected sites are shown in **Table *2***:

Table 2: Solar GIS Mapping Results

Mill Name	Installed PV (MW)	Mapped PV Area (ha)	Avg. GHI (kWh/m²·yr)
Faisalabad			
Crescent Bahuman Ltd.	8.00	1.75	1930
Crescent Textile Mills	3.50	0.8	1960
…	….	….	…..
Lucky Textile Industries Ltd.	12.00	2.8	1935
Nishat Mills Ltd.	14.20	3.4	1950
Sapphire Textile Mills Ltd.	16.00	3.8	1960
Sitara Chemical	1.00	0.2	1945
Tayyab Textile Mills Ltd.	20.00	4.5	1950
Totals & Averages	**125.79**	**28.75**	**1947**

Multan			
Fazal Cloth Mills Multan	11.53	2.6	1960
Mahmood Textile Mills Ltd.	15.00	3.4	1955
MG Industries Multan	2.00	0.4	1950
Reliance Weaving Mills	7.30	1.7	1945
Roomi Fabrics Ltd.	14	3.35	1950
Totals & Averages	**49.83**	11.45	**1952**

Zones within 2 km of the primary grid facility and having solar capacity >1 MW were classified as **"CTBCM-ready pockets"**, where bilateral trading under the CTBCM regime can be initiated with minimal infrastructural upgrades.

7. CTBCM design and CTBCM‑scenario matrix

CTBCM objective: Create a market where bilateral contracts and trading enable efficient allocation of renewable generation across industrial clusters while preserving investor protection.

Practical CTBCM thresholds (recommended):

- **Lower CTBCM entry threshold:** 500 kW for pilot clusters; scale to 1 MW+ as systems stabilize.
- **Suggested initial trading rate (TR):** Establish a market reference band (e.g., **PKR 20–24/kWh**) for early pilots with transparent auction or bilateral negotiation paths.
- **Policy design features:**

- **Phased implementation:** Pilot (0–12 months), Transition (12–36 months), Scale (36–60 months).
- **MRV & settlements:** Standardized meter, data interfaces, and settlement modulation for commercial clarity.
- **Risk mitigation:** Short‑term PPAs or floor‑price guarantees from a First‑Mover fund for the initial 12–24 months.

CTBCM scenario matrix:

- Case A: Full CTBCM (0 kW threshold): fastest market benefits, but higher governance risk.
- Case B: Hybrid threshold (500 kW / 1 MW): pilot inclusive of SMEs and larger projects; recommended for Faisalabad/Multan.
- Case C: CTBCM for large only (>3 MW): protects grid but excludes many SMEs.

8. Wheeling charges: Critique and suggested schedule

Current problem (Critical): Wheeling is often bundled with non‑ network legacy charges (debt servicing, cross subsidies) that inflate per‑ kWh costs and unpredictably erode project returns. This creates the "Wheeling Paradox": high, undifferentiated wheeling kills distributed projects; too low wheeling threatens utility finances.

Quantitative sensitivities:

When WR rises from PKR 6 → 25/kWh, S2 IRR and payback collapse; S1 loses more absolute dollars but is relatively resilient (see **Figure 3**).

Suggested transitional wheeling schedule (phased & differentiated):

- **Phase 0 (Pilot, 0–12 months):** WR = PKR 5–8/kWh for intra‑ cluster transactions inside identified CTBCM-ready pockets; exempt from non‑ network legacy charges for MRV‑ verified projects.
- **Phase 1 (Transition, 12–36 months):** WR gradually steps up to **PKR 9–12/kWh** for intra‑ cluster; inter‑ cluster distances get distance‑ differential (e.g., +PKR 2–4/km zone).
- **Phase 2 (Stabilize, 36–60 months):** Gradual convergence to cost‑ reflective wheeling (target band **PKR 12–15/kWh**) with explicit, transparent allocation of non‑ network costs to fiscal instruments (not per‑ kWh shock).

Operational rules: - Differentiate wheeling by:

(a) distance (intra‑ cluster vs inter‑ cluster),
(b) time of day (ToU discounts for off‑ peak), and
(c) cluster size (preferential tiers for SMEs).

Use revenue from later phases to create a Green Market Stabilization Fund (see **Section 8**) to compensate utilities for stranded costs rather than penalizing generators.

9. CBAM & MRV integration: Practical steps for export compliance

Why essential: CBAM monetizes avoided emissions, but only where MRV is credible. Textile exporters who can substantiate Scope‑2 reductions will gain market access and export value.

Practical MRV steps (0–24 months):

1. Issue standardized MRV templates for mills (energy, fuel, emissions factors) and require third‑party verification for CBAM claim eligibility.
2. Link MRV certification to eligibility for First‑Mover guarantees, preferential wheeling tiers, and access to targeted green finance.
3. Pilot a CBAM‑linked registry that tracks emissions avoided and routes provisional carbon receipts into the Green Market Stabilization Fund. **Table *3*** shows emissions avoided under S1/S2.

Table 3: Emissions Reduction by Renewable Adoption in selective textile hubs

Scenario 1 — 87% Renewable Fraction (3,750 MW Solar in-rush)				
Case	Total CO_2 emissions (kg/yr)	Total CO_2 emissions: Lifetime (kg)	Emissions avoided (kg/yr)	Emissions avoided: Lifetime (kg)
Base case (Case 1, business-as-usual)	2,157,012,369	53,925,309,225	—	—
Renewable cases (Cases 2–8 consolidated)	394,502,053	9,862,551,325	1,762,510,316	44,062,757,900
Scenario 2 — 75% Renewable Fraction (2,175 MW Solar in-rush)				
Case	Total CO_2 emissions (kg/yr)	Total CO_2 emissions: Lifetime (kg)	Emissions avoided (kg/yr)	Emissions avoided: Lifetime (kg)
Base case (Case 1, business-as-usual)	2,157,012,369	53,925,309,225	—	—
Renewable cases (Cases 2–8 consolidated)	538,538,001	13,463,450,025	1,618,474,368	40,461,859,200

In the next phase, as an adoption guideline for CBAM compliance, a fixed carbon credit is taken (i.e. $15/ton), and incorporated in all the scenarios and results are analyzed. Introducing a CBAM-

based carbon credit produces a consistent positive uplift in project economics for practically every renewable case relative to the no-CBAM baseline. In the analysis of base and proposed cases, the CBAM adjustment lowers adjusted LCOE, raises IRR and ROI, increases absolute NPV, and shortens payback in nearly all renewables cases (cases 2–8), while leaving the pure base case metrics (case 1) unchanged (**Figure 5**).

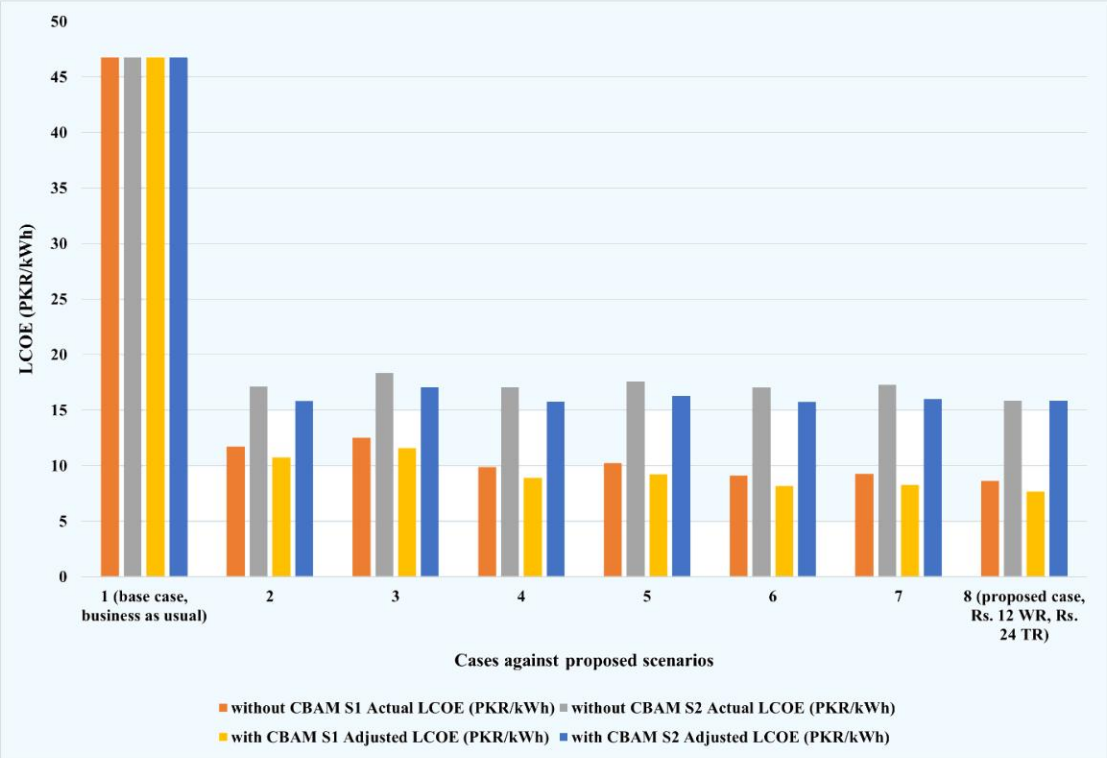

Figure 5: LCOE results obtained across various cases after CBAM incorporation

10.Implementation roadmap, responsibilities, and timeline

Time bands: Immediate (0–12 months), Short (12–24 months), Medium (24–36 months), Long (36–60 months).

Table *4* shows the implementation roadmap for decarbonization in textile clusters through solarization under CTBCM regime.

Table 4: Implementation roadmap for Solarization of Textile clusters under CTBCM regime

Time band	Actions	Responsibilities
Immediate (0–12 months)	➢ Lower CTBCM pilot entry to 500 kW; authorize MRV pilot and exemption from non-network charges for MRV-verified projects. ➢ Expand net/gross metering cap to 5 MW for textile parks. ➢ Launch concessional green loan facility for textile SMEs (SBP, DFIs). (State Bank, commercial banks). ➢ Publish model PPA/MRV/wheeling templates and one-window commercial onboarding portal.	(Power Division, NEPRA, ISMO) – first action; (NEPRA) – second action; (State Bank, commercial banks) – third action; (Power Division, ISMO) – fourth action.
Short (12–24 months)	➢ Operationalize phased wheeling schedule (Phase 1) for CTBCM pilot zones. ➢ Start 3 – 5 MRV-verified cluster pilots in Faisalabad/Multan with guaranteed temporary UoSC relief. ➢ Allocate prioritized transmission pockets and announce priority grid reinforcements.	(NEPRA, DISCOs) – phased wheeling; (Industry consortium + Power Division) – cluster pilots; (NTDC, CPPA) – transmission/grid reinforcements.
Medium (24–36 months)	➢ Scale CTBCM beyond pilot pockets with standardized settlement windows. ➢ Launch Green Market Stabilization Fund seeded by a small fraction of carbon/CBAM revenue and public contributions.	—
Long (36–60 months)	➢ Transition to cost-reflective wheeling (Phase 2) while ensuring compensation mechanisms for utilities. ➢ Scale S1 centralized projects coordinated with storage and system services.	—

11.Finance, incentives and risk allocation

Key measures:

- Concessional finance (SBP) for SMEs; longer tenors and partial credit guarantees.

- Tax breaks and duty exemptions for PV and battery imports until local manufacturing ramps (FBR).
- First‑Mover Guarantee Fund and PPA floor‑price instruments to de‑risk initial CTBCM participants.
- Use CBAM/carbon receipts to subsidize transition costs (Green Market Stabilization Fund).

Risk allocation: Clearly allocate market‑price risk to sellers who opt for merchant exposure; protect SMEs with short‑term fixed PPAs or hybrid structures where part of the output is sold under stable rates.

12. Monitoring, evaluation & success metrics (KPIs)

Suggested KPIs: Installed PV capacity in clusters (MW); target: +300–500 MW in 3 years for Faisalabad/Multan combined.

- SME project finance disbursed (PKR million / year).
- Number of MRV‑verified mills (count) and CO_2 avoided (tCO_2/yr).
- Average wheeling charge (PKR/kWh) and % of WR revenue placed in stabilization fund.
- CTBCM trade volumes (MWh) and number of bilateral contracts executed.

Evaluation cadence: Quarterly for pilots; semi‑annual for system scale‑up decisions.

13. Critical caveats and governance warnings

- **Do not rush a full national WR hike**: Abrupt increases above PKR 12–15/kWh will kill distributed projects (S2) and exclude SMEs.
- **Avoid filling WR with legacy non‑network costs**: Allocate stranded/legacy costs to fiscal transfers or the stabilization fund to avoid per‑kWh shocks.
- **MRV integrity is essential**: Weak MRV will lead to contested CBAM receipts and loss of political credibility.
- **Stakeholder engagement**: Power Division and industry associations (APTMA, PRGMEA) must be part of steering group alongside NEPRA; policymakers cannot design CTBCM in isolation.

14.Closing note

This roadmap extends the report's technical depth into a clear, actionable plan, which balances rapid SME solarization with strategic centralized investment and a carefully phased CTBCM design, ready for stakeholder review and immediate pilot execution.

Prepared for: Power Division / NEPRA / APTMA / SBP / ISMO; (Faisalabad & Multan textile cluster brief.

Annex A: Detailed Action and Responsibility Guideline

Table A.*1* shows detailed action plan extracted from key technoeconomic analyses for solarization study under CTBCM regime in Faisalabad and Multan clusters.

Table A.1: Final Action plan along with concerned stakeholders

Action	Lead	Supporting	Timeline	Milestones
Lower CTBCM pilot threshold to 500 kW; authorize MRV pilot exemptions	Power Division / NEPRA	ISMO, APTMA	0–6 months	Official directive issued; 3 pilot agreements signed
Launch concessional SME green loan window	State Bank of Pakistan (SBP)	Commercial banks, DFIs	0–12 months	First 100 SME loans disbursed
Publish model PPA / MRV / wheeling templates & one-window portal	ISMO / Power Division	NTDC, CPPA	0–6 months	Portal live; templates adopted by DISCOs
Operationalize phased wheeling schedule (Phase 1)	NEPRA / DISCOs	Power Division	12–24 months	Phase 1 tariff schedule published; intra-cluster pilots operating
Seed Green Market Stabilization Fund with CBAM fraction	Power Division / Finance Ministry	SBP, ISMO	12–36 months	Fund established with governance charter
Designate strategic transmission pockets & start reinforcements	NTDC / CPPA	Provincial energy offices	12–36 months	Tender issued for 800 MW reinforcement works
Scale CTBCM beyond pilot pockets	ISMO	NEPRA, Power Division	24–60 months	Full market operations; standard settlements in place

Annex B: Pilot Checklist (For CTBCM cluster pilots)

1. Select 3 – 5 mills (tiered by size) across Faisalabad & Multan.
2. Confirm rooftop/land PV sizing and baseline load profiles (hourly).
3. **Metering:** Install time‑resolved bidirectional meters; test data export to settlement system.
4. **Finance:** Confirm concessional loan approval letters for participating SMEs.
5. **MRV:** Appoint third‑party verifier and register pilot project.
6. **Contracts:** Sign simplified PPA/wheeling agreements using model templates.
7. **Reporting:** Publish monthly results (MWh traded, wheeling revenues, CO_2 avoided).