



Punishing Participation: Behavioral Repercussions of Pakistan's Net Billing Reform for Its Decentralized Green Transition

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ABSTRACT

Pakistan's citizen-led solar expansion, importing 17 GW of panels in 2024, was driven by high retail tariffs and a net metering regime that compensated exported electricity at near-retail rates. In March 2025, regulators moved to replace net metering with net billing, reducing the export buyback rate from roughly Rs 27/kWh to Rs 10–13/kWh, citing cross-subsidies from solar adopters to non-solar consumers. This paper analyzes the reform not as a neutral tariff adjustment but as a behavioral intervention, applying insights from loss aversion, the endowment effect, psychological reactance, mental accounting, and institutional trust. It predicts that consumers will perceive the sharp rate reduction as a confiscated entitlement, triggering battery-led partial grid defection, slower new adoption, intensified self-consumption at system cost, and erosion of regulatory credibility. While the cross-subsidy concern is legitimate, a blunt net billing regime penalizes solar adoption itself rather than its unequal access. The paper proposes an equity-sensitive alternative: a graduated five-year export-rate phase-out, income-tiered buyback rates, grid-connected storage incentives, community solar, and a transparent value-of-solar tariff. This package corrects distributional inequities, preserves investor confidence, and sustains Pakistan's decentralized clean-energy trajectory without a behavioral backlash.

Keywords: Behavioral Economics, Green Energy Transition, Cross-Subsidy, Climate Policy, Regulatory Trust

JEL Codes: D91; Q48; Q54.

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1. INTRODUCTION

Pakistan's energy transition has not begun in planning documents alone; it has emerged from rooftops, factory sheds, farms, shops, and households responding to a severe affordability crisis (Ahmad et al., 2016; Mehmood et al., 2022). During 2024, Pakistan added approximately 17 GW of solar photovoltaic (PV) capacity, the vast majority of which was installed outside the formal net-metering framework and therefore remains unreflected in grid-connected statistics, yet this volume is substantial enough to significantly shift the trajectory of the power sector (Bhandari et al., 2024). REN21 (2025) notes that Pakistan has imported nearly 45 GW of solar panels during the last four to five years, with 17 GW worth of solar panels being installed in 2024 alone, which suggests that a significant portion of the solar panel installation is taking place outside the confines of net-metering. Rehman et al. (2026) similarly term this a decentralized trend with the households, commercial users, and industries looking for a source of cheaper and more reliable power in the face of chronic power shortage and higher tariffs.

It is essential to distinguish this off-grid and unregistered solar expansion from the officially documented net-metered capacity tracked by the national grid. There are currently about 283,000 net-metering customers in Pakistan, whose total officially registered distributed solar capacity stands at 4,124 MW, up sharply from just 321 MW in 2021, according to official data presented in the Economic Coordination Committee (Government of Pakistan, 2025). A follow-up IEEFA briefing also finds that net-metered solar PV connections grew from 226,440 in October 2023 to 283,000 in December 2023, and the amount of solar PV installed at the end of the year was 4,124 MW (Tahir et al., 2023). The share of solar in Pakistan's electricity mix jumped significantly, with more than 14% of the country's electricity generated from solar power in 2025, compared to 4% in 2021 (Siegrist, 2021; Ember, 2025; Reuters, 2025). This was a change in ownership by citizens, and not a state-led change, but a consumer-led change in response to tariffs that rose by 155% over three years (Shah, 2025).

However, there has been a regulatory backlash because of this transition. In March 2025, Pakistan's Economic Coordination Committee passed amendments to the solar net-metering buyback rate (Khalid & Zorays, 2025), which was around Rs 27/kWh and was reduced to Rs 10/kWh, due to the need to shift costs from solar adapters to non-solar grid consumers. The new settlement mechanism is to distinguish between electricity exported and imported: imported electricity will be charged at the appropriate retail tariff (peak/off-peak) plus taxes and surcharges, and exported electricity will be bought at the reduced rate. Ali et al. (2020) document that high electricity prices are one of the main drivers of Pakistani households' decision to invest in solar PV; thus, the overall economic environment plays a significant role in influencing consumer choices about energy, with electricity import prices ranging from Rs 35-55/kWh. Empirical evidence of 683 households in Pakistan also shows that the perceived cost and risk negatively impact intentions to adopt solar PV systems (Tanveer et al., 2021), which indicates that increasing the gap between export compensation and import costs under net billing will hinder solar PV adoption.

This research examines the central policy puzzle: why would a regulator penalize the very behavior that reduces grid strain, lowers emissions, cuts imported-fuel dependence, and improves household energy resilience? The answer lies in the tension between system-level financial recovery and consumer-level rationality. Net billing could help utility revenues in the

short term, but it has an impact on behavioral incentives that led to the solar boom in Pakistan. Reduced export compensation may incentivize adopters to switch to battery storage, shift their load, over-size their self-consumption, under-report, or partially defect the grid. These predicted responses are by no means speculative, but rather are based on well-established principles of behavioural economics: loss aversion (Leoneti & Gomes, 2025; Kahneman & Tversky, 2013; Kahneman & Tversky, 1979), the endowment effect (R. Thaler, 1980), and psychological reactance (Brehm, 2012) which explain why actors resist perceived losses of existing entitlements more strongly than they pursue equivalent gains. The proposed shift, therefore, risks converting cooperative prosumers into defensive self-suppliers. This paper argues that Pakistan's net-billing reform should not be assessed only as a tariff correction, but as a behavioral intervention with consequences for adoption, equity, grid demand, and the long-term legitimacy of the energy transition.

This study employs a conceptual policy evaluation methodology, using a qualitative behavioral framing approach. The analysis integrates behavioral economics constructs-loss aversion, the endowment effect, mental accounting, psychological reactance, and institutional trust-with regulatory policy analysis to evaluate Pakistan's transition from net metering to net billing. The framework is applied to publicly available tariff data, official net metering statistics from the Economic Coordination Committee, solar import figures from REN21 and IEEFA, and comparative policy evidence from jurisdictions including California (NEM 3.0). This methodological approach is suited to policy problems where behavioral responses may diverge from predictions of neoclassical cost-benefit models and where primary empirical data is not yet available due to the early stage of the regulatory transition.

2. BACKGROUND

2.1 The Net Billing Transition in Pakistan: Policy Rationale, Consumer Behavior, and Regulatory Implications

The net metering policy in Pakistan (2015-2025) allowed the rooftop solar energy consumers to sell their surplus power to the grid and utilize the exported units against the imported ones, which means that the exported units will be valued at almost the retail tariff. This helped in making solar power cost-competitive since the consumers were able to save almost Rs 26–27/kWh, leading to shorter pay-back periods of around 2-5 years. Another international example indicates that retail-rate net metering has a significant positive effect on the private economics of distributed PV systems since exported electricity is valued at or near the same rate as electricity consumed at the meter is avoided (Darghouth et al., 2011; Yamamoto, 2012; Eid et al., 2014; Borenstein, 2017).

The new net billing regime will alter this: imports and exports will be subject to their own billing transactions. The consumers would pay the full retail tariff with taxes and surcharges for the electricity they consume from the grid, and the solar electricity that is exported would be paid at a lower avoided cost or fuel-cost-linked rate of about Rs 10-13/kWh. This makes the value of the surplus exports less desirable and thus discourages consumers from oversizing their systems for export. Indeed, the literature suggests that, when regulators aim to tailor distributed solar tariffs to avoid system costs instead of retail tariffs, they may opt for net billing or value-based export tariffs, as reported (Picciariello et al., 2015; Hirth, 2013; Eid et al., 2014; Gautier et al., 2018; Kubli, 2018; Schittekatte et al., 2018).

The most solid research on the government's argument is that retail-rate net metering can lead to cost-shifting when retail customers who install solar power do not actually reduce their net electricity consumption but continue to use the electricity grid for back-up power, imports, and exports. Many tariff components, such as network costs, capacity costs, and policy charges, are based on volume generated. Therefore, if the prosumers reduce their grid consumption, they reduce their contribution to fixed tariff costs, which will fall on non-solar consumers (Picciariello et al., 2015; Eid et al., 2014; Schittekatte et al., 2018). This leads to distributional issues as the rooftop solar adopters typically have good access to capital and a suitable rooftop, whereas the non-adopters may be those subjected to higher tariffs or higher cost burdens (Kubli, 2018; Borenstein, 2017). High DSV can also be correlated with utility revenue erosion, further considerations for tariff redesign, fixed charges, and even demand charges, and/or avoided-cost-based export compensation, depending on the literature source (Darghouth et al., 2011; Castaneda et al., 2017; Gautier et al., 2018).

The shift is also in response to concerns about revenue from utilities. A changing mix of electricity demand by very high-paying customers as they install rooftop solar and end up using less electricity through the distribution grid could result in losses in sales, with distribution companies still having long-term network obligations and capacity payments, and other long-term cost commitments. This results in a problem of revenue recovery if utilities have to rely on volumetric tariffs to recover fixed costs (Satchwell et al., 2015; Schittekatte et al., 2018). In these systems, savings on electricity from solar PV power can put economic pressures on non-solar electricity customers, as they absorb the unrecovered costs of solar PV power, raising equity issues (Simshauser, 2016; Cai et al., 2013). This dynamic aligns with the 'utility death spiral' hypothesis, discussed further in Section 3.3 (Castaneda et al., 2017; Laws et al., 2017).

The proposed transition from full retail rate net metering to net billing or avoided cost compensation or value of solar tariff deployed in Pakistan is in line with an international trend of transitioning away from full retail rate net metering (Fikru, 2022). A notable example is California's NEM 3.0, which decreased the export compensation and increased its alignment with avoided grid costs, resulting in a less attractive standalone rooftop solar offering and incentivizing battery storage and self-consumption (SAAD, 2025; Mahbub et al., 2026). International studies indicate that distributed solar (DS) offers benefits like avoided generation, loss reduction, and environmental benefits, which are not necessarily equivalent to the full retail tariff, so export compensation needs to take into account the balance between solar adoption, cost recovery of the grid, and fair treatment of non-solar consumers (DSouza et al., 2021; Pena-Bello et al., 2023; Hirth, 2013; Borenstein, 2017; Kubli, 2018).

3. THEORETICAL FRAMEWORK – BEHAVIORAL ECONOMICS LENSES

This study uses behavioral economics as an analytical framework to predict how Pakistani rooftop-solar consumers may respond to the proposed shift from net metering to net billing. Consumers do not only react to changes in prices in the traditional economic analysis, but they also react to perceived losses, fairness, ownership, trust, and institutional credibility in behavioral economics. Thus, the planned decrease in export compensation should not only be interpreted as a tariff change, but also as a behavioral shock that could relieve investment choices, dependence on the grid, and trust in energy regulation on the consumer side.

3.1 Loss Aversion

According to loss aversion, people are more affected by a loss than by an equivalent gain. Prospect theory, as proposed by Kahneman and Tversky, indicates that humans assess outcomes in comparison to a reference point where losses below a reference point result in stronger responses than gains of the same size (D. Kahneman, 1979; Kahneman & Tversky, 2013; Gurevich et al., 2009). In Pakistan's scenario, it is the old export rate for the net metering that acts as a benchmark for the consumer. As detailed in Section 2.1, the export compensation dropped from Rs 26–27/kWh to approximately Rs 10–13/kWh, a perceived direct loss of Rs 14–17 per exported unit. This reference-point shift—where the former incentive of Rs 27/kWh becomes an entrenched entitlement—triggers defensive behaviors: consumers actively minimize grid exports and maximize self-consumption, even investing in battery storage not for economic returns but to avoid the psychological pain of "losing" Rs 14–17 on every exported unit. This is important because the policy may be a loss to some consumers, and those consumers might respond more strongly than consumers who have not yet received the higher rate. This perceived loss may trigger political resistance, accelerated battery adoption, reduced future grid investment, or a deliberate move toward minimizing grid interaction.

3.2 Endowment Effect

The endowment effect is a theory that describes why people value benefits that they already have more than those that are the same but that they do not own. Classic experiments by Kahneman, Knetsch, and Thaler found that the value of something rises when it is part of someone's life, so they would ask for more money to part with an entitlement than they would pay to get it in the first place (Knetsch, 1989; Kahneman & Thaler, 1990). This idea can have a direct impact on the current consumers of net metering in Pakistan. Consumers who have invested in solar systems in the context of retail rate or near retail rate compensation schemes might then think that the old export rate is now part of their entitlement, and not simply a temporary measure in the regulation. The reform can lead to the emergence of two groups of prosumers: those who are protected as early adopters and those who are not protected, as new adopters will receive less export compensation. While this dual construction might lessen the initial blowback from current users, it can also foster perceptions of unfairness among new users and diminish the trust in investment in long-term solar energy.

3.3 Psychological Reactance

Psychological reactance is a response to what is felt to be a restriction of freedom of choice, resulting in a counteractive drive to re-establish the freedom by reacting with resistance or avoidance. According to Brehm's theory of psychological reactance, the restriction or removal of valued behavioral options triggers a negative reaction of the individual (Brehm, 1966; Steindl et al., 2015). Net billing means that solar adopters could perceive a limitation in using the grid as an economic balancing mechanism. The reform does not promote tidy entry into the grid but could spur consumers to take steps to lessen their reliance on the distribution companies. That may involve installing batteries, having systems oversized for self-sufficiency, moving some loads to the day when solar energy is created, or even completely off-grid defection. This is typical of the broader 'utility death spiral' literature, which foresees that as tariffs go up and consumer confidence falls, this will drive further self-generation, lower utility sales, and put more pressure on remaining consumers (Castaneda et al., 2017; Laws et al., 2017).

3.4 Mental Accounting

Mental accounting is the process of assigning money into different mental accounts—accounts in which money is not treated as completely fungible with money in other accounts. Thaler also suggests that the effect of framing and categorizing on evaluations of gains and losses, payments, and savings is different (R. H. Thaler, 1999; R. Thaler, 1980). Under net metering, consumers operated within a single mental account where one exported unit "banked" one import credit—a seamless, psychologically frictionless exchange. Net billing fractures this into two painful, separate accounts: a high-cost import account and a low-reward export account. This mental partitioning is a powerful behavioral driver pushing consumers toward load shifting and grid independence, even when the pure financial calculus does not justify it. Consequently, import payments are perceived as a high-cost, painful account while export receipts register as a low-value, disappointing account. This separation can raise the impetus to use solar electricity at the site as opposed to exporting it. The behavioral outcome is intensified self-consumption: daytime appliance use, battery charging, and deliberate load shifting away from grid dependence.

3.5 Trust as a Behavioral Variable

Trust is a key behavioral variable in energy policy; consumers take long-term investment decisions in a situation of regulatory uncertainty. Studies on public acceptance of energy technologies demonstrate that institutional trust has an impact on the public's perception of the policies with respect to legitimacy, fairness, and credibility (Huijts et al., 2012; Steindl et al., 2015). However, in the case of Pakistan, if the end-user thinks that NEPRA or the government is playing with the definition after the household has invested in solar, then the reform will affect the trust of the end-user in the regulator. This is particularly crucial as rooftop solar energy is an asset with long lives, and consumer investment decisions are driven by their expectations of tariff stability. This can lead to less willingness to engage in future grid-dependent programs such as battery aggregation, demand response, electric vehicle charging, or distributed energy markets if the regulator is thought to be looking out for the distribution companies or the independent power producers, instead of the consumer. Therefore, the impact of the trust may be wider and longer-lasting than the impact of the tariff.

4. PREDICTED BEHAVIORAL CONSEQUENCES

4.1 Accelerated Grid Defection

The first predicted consequence is accelerated grid defection or partial grid defection. A decrease in the export rate could be seen as a loss by consumers and as a limitation on being able to benefit from an investment in solar energy, which could trigger a reduction in dependence on the grid. This can be done by installing batteries, expanding the daytime self-consumption, or adopting back-up systems to prevent importing costly electricity. The utility death spiral literature backs up this concern in that, as consumers cut back on their purchases from utilities, utilities may pass on the fixed costs to a smaller base of customers, squeezing tariffs for customers that remain on the grid (Laws et al., 2017; Castaneda et al., 2017; Schittekatte et al., 2018). This risk can be more potent in Pakistan as high tariffs, supply insecurity, and low levels of trust in the electricity industry already provide an incentive to be self-sufficient.

4.2 Collapse or Slowdown in New Solar Adoption

The second predicted consequence is a sharp slowdown in new rooftop solar adoption. A decreased export rate has a direct negative impact on the financial return from the surplus generation. It can further increase the payback period from the once appealing two to five years to much longer. Behavioral economics argues that a change in policy that makes things worse at a well-established reference point is particularly salient for consumers (D. Kahneman, 1979). Net billing, then, may not be viewed as a net-neutral new policy by potential adopters of electric vehicles, but rather as an even worse deal than the previous net metering policy. This could be especially the case for middle-income families, who have greater sensitivity to payback periods, financing costs, and policy uncertainty. Academic research on the economics of solar energy also demonstrates that rooftop PV tariff design, compensation mechanisms, and the projected electricity savings are critical factors in driving rooftop PV adoption (Darghouth et al., 2011; Satchwell et al., 2015).

4.3 Self-Consumption Behavior That May Reduce Grid Benefits

The third impact is a change from an export-oriented solar behavior to a self-consumption-oriented behavior. Net billing offers relatively low payments to consumers for exports, and they continue paying the retail tariff for imports. This encourages the consumption of solar power onsite, instead of sending it to the grid. This is rational for households but may lead to a loss of some grid benefits with distributed solar, such as peak demand reduction, line loss reduction, or local distribution network support, if solar power were exported. Research on tariff designs reveals that, as export compensation decreases, consumers tend to shift loads and store energy to maximize private bill savings, as opposed to maximizing system value (Yamamoto, 2012; Hirth, 2013; Eid et al., 2014). However, unless time of use export rates and/or storage incentives are carefully designed, net billing could lead to system-suboptimal but individually rational behavior.

4.4 Erosion of Institutional Trust

The fourth impact is on loss of trust in institutions. Regulators that are perceived as "fair, transparent, and consistent" are more likely to have consumers follow policy changes. The transition may lead to distrust towards NEPRA and power-sector governance if it is experienced as a sharp cut from an anticipated benefit. This can have implications beyond rooftop solar that can last for years. When people lose trust, it can lead to lower adoption of future technology upgrades such as smart metering, demand-response programs, TOU pricing, electric-vehicle integration, and distributed storage programs. In addition to economics, public acceptance of energy policies is also shaped by the sense of fairness, institutional trust, and procedural legitimacy of the research used to support the policy (Huijts et al., 2012; Siegrist, 2021). Therefore, the behavioral cost of the reform may exceed the immediate financial savings expected by policymakers.

4.5 Comparative Evidence – California's NEM 3.0 as a Natural Experiment

As noted in Section 2.1, California's NEM 3.0 moved from full retail-rate net metering to an avoided-cost valuation approach, making exported electricity less valuable and incentivizing self-consumption and battery storage. The California case is relevant as a plausibility argument: while there are significant differences in levels of income, financing conditions, grid reliability, and institutional trust between California and Pakistan, the assumption is that, when export compensation falls, consumers will not simply accept lower returns but will also change the

way the system is designed and the way they will use it. Crucially, unlike California, Pakistani consumers face an additional non-financial behavioral driver: chronic load-shedding and supply insecurity. Solar adopters have already invested in rooftop PV as a hedge against unreliable grid supply, and the shift to lower export compensation amplifies the psychological premium of energy autonomy. This makes Pakistani consumers uniquely reactive to tariff reductions, as grid defection represents not merely a financial calculation but an escape from the persistent unreliability of centralized supply. Academic literature backs this mechanism by indicating that distributed solar economics are heavily reliant on compensation policy, electricity tariff structure, and the import and export price relationship.

The behavioral effects could be even worse for Pakistan than in California. One is that household incomes are lower, so battery storage is less affordable to many consumers, and could make solar power out of reach for middle-class households. Second, as with the costs or prices of storage, the non-financial value of batteries can make it more attractive to at least partially defect even when storage is costly. Third, increased regulatory distrust could make the reform less likely to be embraced as a recalibration of the policy rather than just a technical tariff change, thereby increasing the resistance to the reform. So, while NEM 3.0 is not necessarily a direct signal of what will happen in Pakistan, it is a good comparative warning shot: When export compensation is reduced, standalone rooftop solar energy adoption gets slower, interest in storage rises, and notions of fairness, cost recovery, and consumer trust get stirred.

5. DISCUSSION – UNPACKING THE CROSS-SUBSIDY ARGUMENT

The cross-subsidy argument behind Pakistan's proposed shift from net metering to net billing should not be dismissed, because it addresses a genuine distributional problem within the electricity system. Rooftop solar adopters, who "save" on the grid by using electricity from their rooftop PV panels, may also see a reduction in the fixed costs, capacity fees, and other fees that are "hidden" in the volumetric tariff. These unrecovered costs can then be passed on to non-solar customers, many of whom are lower-income households unable to install solar panels or have access to upfront capital or concessional financing. Such a concern is supported by international evidence that if the net metering is poorly designed, it can lead to cost distortions from prosumers to other consumers and to a decrease in the cost recovery of the utilities (Eid et al., 2014; Picciariello et al., 2015; Schittekatte et al., 2018). In Pakistan, official data show that around 80% of net metering users are concentrated in urban and affluent areas, and only 0.83% of grid customers receive disproportionate benefits. The equity concern becomes especially important (ARZACHEL, 2024). However, the weakness of the proposed policy response is that it treats solar adoption itself as the problem, rather than addressing unequal access to solar finance. A blanket reduction in export compensation may reduce cross-subsidies. However, it may also slow clean-energy adoption, discourage middle-income households, and protect the existing centralized power structure without expanding access for poorer consumers. The more appropriate policy response would be distributive reform: income-tiered buyback rates, targeted solar financing, community solar models, and green microfinance for households unable to afford upfront investment. Pakistan-specific research supports this direction. Khan et al. (2024) suggest that, along with the net-metering reform, tax relief,

subsidies, and green financing mechanisms should also be implemented to ensure the continuation of renewable-energy integration even in times of economic pressure. Likewise, there is field-experimental evidence from the pay-as-you-go solar market in Pakistan. Similarly, Bonan et al. (2023) demonstrate that behavioral and payment-design interventions also have the potential to influence consumer payment behaviors and can be used to design policies that affect participation, rather than just disincentivizing it. So, the real policy question is not whether net metering results in a cross-subsidy, but whether net billing is the most equitable. This would be a more equitable transition and would alleviate tariff distortions and increase solar access for LMI customers without imposing a technology penalty.

6. POLICY RECOMMENDATIONS

Pakistan should take a step-by-step approach to move from net metering to significantly lower net billing. Adopting rooftop solar power should also be incentivized in a more balanced way that would avoid the distributional distortions and impact on distribution company revenue. The goal of the policy should not be to dissuade distributed solar diffusion, but to redesign solar compensation.

First, NEPRA ought to implement a stepped five-year reduction in retail rate export compensation, instead of a step down to the avoided cost level. A gradual roll-out would mitigate perceived policy losses, provide investor confidence, and enable households, installers, and lenders to set expectations. This is significant, as social sciences research indicates that abrupt changes are more resistant than incremental changes, and research on solar adoption indicates that the tariff stability and expected savings from rooftop PV are key determinants for investment in PV systems (Kahneman & Tversky, 2013; Darghouth et al., 2011; Borenstein, 2017).

The government should offer grid-connected storage incentives. Net billing, which drastically cuts export value, could cause consumers to install batteries and take a step back from the grid. It should therefore not be possible to get subsidies for batteries unless they are connected to the grid and provide the services needed, including evening peak reduction and backup capacity. This would reduce the risk that storage could become a means to grid defection and increase the likelihood that it would become a means to stability on the grid (Laws et al., 2017; Kerby & Tarekegne, 2024).

Pakistan must consider implementing buyback rates, based on income or consumption, rather than a rate on exports. Compensation for exports might be reduced for high consumption/prosumers and high-income prosumers, and protected rates for limited system sizes for small and middle-income prosumers. This cuts to the chase of the cross-subsidy issue, but is not a punishment for households who are installing solar primarily for bill savings. The literature reveals that it is not so much the uptake of solar energy but the differential access to finance and the costs of the fixed grid that are shifted to non-solar users that represent the core problem (Eid et al., 2014; Picciariello et al., 2015; Kubli, 2018).

Community Solar and Virtual Net Metering should be implemented to ensure that solar benefits are extended to people who do not have appropriate roofs, apartment dwellers, and renters in Pakistan. This would address the equity concern that people who can afford rooftop solar and have a suitable roof are the ones who have taken advantage of the benefits. Community solar provides an opportunity to expand participation through subscribing to a

shared solar project, as well as offering bill credit (Nock & Baker, 2019; Mormann, 2019; Patel, 2022).

NEPRA should formulate a transparent Value of Solar Tariff (VOST) rather than defaulting to average avoided fuel cost alone. A properly specified VOST would quantify and compensate exports based on measurable, regulator-verified system benefits. Specifically, NEPRA should mandate the calculation of: (i) avoided peak fuel generation costs, reflecting the displacement of expensive furnace oil or imported gas during daytime hours; (ii) line-loss mitigation value, accounting for reduced transmission and distribution losses when solar generation is consumed near the point of production; (iii) avoided system capacity value, capturing deferred investment in peaking plants and grid infrastructure; (iv) voltage support benefits at the distribution level; and (v) environmental externality value, monetizing carbon abatement at the margin. This parameterized approach is more analytically defensible than both full retail-rate net metering and crude avoided-fuel-cost compensation (Hirth, 2013; Brown & Sappington, 2017; Fikru, 2022).

Overall, the best reform package would include a five-year phase-down of export rates, a protected export rate for small adopters, a grid-connected battery incentive, access to community solar, and a clear value of solar tariff. It would address the government's legitimate concern of cross subsidies and minimize the likelihood of consumer backlash, slower uptake of solar power, battery-powered grid defection, and loss of confidence in NEPRA. Therefore, Pakistan must rethink net metering and consider it as an equity-sensitive solar policy instead of implementing a cruder net billing regime.

7. CONCLUSION

The proposed change in Pakistan from net metering to net billing is well motivated based on a real issue of cross-subsidy. However, the solutions could generate new behavioural and institutional challenges. This renders the equity question very legitimate indeed but the proposed solution for reducing the export compensation from about Rs 27/kWh to almost Rs 10-13/kWh could be a recipe for new behavioural and institutional issues. This paper posits that loss aversion, psychological reactance, and institutional trust suggest consumers are not likely to view the reform as a charge-neutral tariff adjustment. Rather, many will see it as the loss of an entitlement they have acquired, resulting in resistance, slow adoption, self-consumption, battery-led defection from the grid, and loss of trust in NEPRA.

The main conclusion is that the issue in Pakistan's policy is not the adoption of solar *per se*, but differential access to solar finance and differential distribution of net metering benefits. A blunt net billing regime would have negative impacts on cross-subsidies, but would also have negative impacts on consumer confidence and would deter middle-income consumers from adopting, and may also contribute to a partial take-off of the grid. However, International experience, including that of California (NEM 3.0), indicates that lower export compensation can bring about a change in the behavior of consumers: attachment rates of storage and self-consumption batteries have risen from 10% to around 60%, which may be more pronounced given low incomes in Pakistan.

The distributed solar support system should be revamped, rather than discarded, in Pakistan. A more balanced reform would include a five-year step phase-down, grid-connected

storage incentives, income-tiered buyback rates, community solar for renters and non-rooftop households, and a transparent Value of Solar Tariff (VOST) with regulator-defined parameters for avoided fuel costs, line-loss mitigation, capacity deferral, voltage support, and environmental benefits. This would take care of the valid concern of cross-subsidy while keeping the momentum of rooftop solar energy going, safeguarding small consumers, and keeping the regulator afloat. In the end, Pakistan must make a policy decision: a simple net billing approach, which might lead to backlash and defection from the grid, or an equity-oriented approach that allows wider access and takes care of long-term clean-energy transition aspirations. The latter course of action is not only more in line with behavioral evidence and distributive justice, but it is also imperative to continue the energy transition in Pakistan, which has already resulted in more than 17 GW of imported solar and distributed generation, making an indelible footprint in the energy future of the country.

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