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Prepayment as a Liquidity and Revenue-Adequacy Reform in Ghana's Electricity Market

A Prepaid-by-Default Framework with Creditworthy Industrial Postpaid Exceptions

Dr. Elikplim Kwabla Apetorgbor[1]

[1]An Independent Researcher

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Abstract

Ghana's electricity market faces a structural cash conversion problem: electricity is procured and delivered continuously, yet a material share of customer revenue is billed late, collected incompletely or allowed to accumulate as receivables. This timing and collection mismatch weakens the Electricity Company of Ghana's (ECG) capacity to remit sector revenue through the Cash Waterfall Mechanism, increases reliance on fiscal transfers, contributes to arrears accumulation and transmits distribution sector weakness to generators, fuel suppliers and lenders. This paper evaluates the economic, financial, regulatory and operational case for making smart prepaid service the default settlement class, while retaining postpaid service for demonstrably creditworthy industrial and strategic customers under a tightly governed exception regime. The analysis draws on audited financial statements, official energy statistics, regulatory instruments, Ghana's Energy Sector Recovery Programme, international evidence on prepayment and utility reform, and a transparent scenario model. ECG's 2024 accounts report revenue of GHS 19.03 billion, trade and other receivables of GHS 15.14 billion, trade and other payables of GHS 54.50 billion, cash of GHS 0.59 billion and a net loss of GHS 8.26 billion. Under low, base and high conversion scenarios, the model estimates recurring annual cash recovery gains of approximately GHS 1.41 billion to GHS 2.17 billion, together with a separate, non-additive working capital acceleration of GHS 1.02 billion to GHS 1.33 billion. The central policy proposition is therefore "prepaid by default, postpaid by qualified exception." Ghana's telecommunications market demonstrates the commercial scalability of this model: prepaid mobile voice subscriptions accounted for 98.92 percent of the market in 2024 and 98.81 percent in the third quarter of 2025, while postpaid accounts remained a small exception (National Communications Authority, 2026a, 2026b). Although the sectors differ technically, the underlying commercial rule, fund first, consume within an authorised balance, reconcile digitally and reserve credit for qualified accounts, can be adapted to electricity distribution and retailing. The framework assigns distinct responsibilities to the Public Utilities Regulatory Commission, the Ministry of Energy and Green Transition, ECG, the Energy Commission, the Ministry of Finance, payment service providers and consumer protection institutions. It also specifies industrial postpaid eligibility criteria, smart meter and data architecture, social safeguards, procurement controls, key performance indicators and a phased 48-month implementation plan. The paper concludes that default prepayment is an essential revenue assurance reform that can materially strengthen liquidity and payment discipline, but cannot by itself correct tariff inadequacy, technical losses, foreign exchange exposure, inefficient procurement or legacy debt. Its value lies in converting retail electricity from unsecured involuntary credit into a digitally governed, transparent and financeable settlement system.

Keywords: *Prepaid Metering, Electricity Distribution, Utility Finance, Liquidity, Revenue Adequacy, Smart Meters, Ghana, Industrial Credit, Regulation, Energy Poverty, Telecommunications Analogy, Pay-Before-Use.*

JEL Classifications: *L94; Q41; Q48; G32; H54; O13*

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I. INTRODUCTION

Financial distress in electricity markets rarely begins with a single unpaid invoice. It develops through a chain of mismatches involving the timing of energy purchases, the timing and accuracy of retail billing, the probability of collection, the cost of enforcement and the allocation of foreign exchange and fuel price risks. In Ghana, this chain is concentrated in the distribution segment because ECG is the principal retail cash collection interface for the interconnected power system. When retail collections are delayed or incomplete, the deficiency is transmitted upstream through reduced remittances to generators and fuel suppliers, larger government support requirements, arrears accumulation and higher perceived credit risk. The result is not merely an accounting problem; it is a sector-wide working capital and bankability problem.

The scale of the challenge is visible in official data. ECG's audited 2024 financial statements report revenue of GHS 19.03 billion, government grants of GHS 17.03 billion, trade and other receivables of GHS 15.14 billion, trade and other payables of GHS 54.50 billion, cash of only GHS 0.59 billion and a net loss of GHS 8.26 billion (ECG, 2025a). The receivables balance is equivalent to roughly 290 days of the year's revenue, although this ratio should not be interpreted as a pure day's sales outstanding measure because the balance includes legacy and potentially impaired exposures. The current ratio is approximately 0.28 and the cash ratio about 0.01. These indicators show a utility with a large revenue base but extremely weak immediate liquidity and creditor coverage.

The physical-commercial interface compounds the financial problem. The Energy Commission reports that ECG purchased 16,617 GWh and sold 12,122 GWh in 2024, implying combined distribution losses of 27.1 percent (Energy Commission, 2025a). At the national level, residential customers represented about 85.7 percent of customer accounts but only 41.4 percent of electricity consumption, while industry accounted for about 42.3 percent of consumption from a very small number of customers relative to the household base. This asymmetry has direct implications for metering strategy. A mass prepaid programme must be designed for millions of relatively low-volume customers, while a much smaller set of large-load customers requires sophisticated credit, telemetry and settlement arrangements rather than a one-size-fits-all rule.

Ghana has already adopted important components of the necessary reform. The Energy Sector Recovery Programme recognises metering, revenue management and conversion of non-strategic public institutions to prepaid service as priority measures (Ministry of Finance, 2023). The World Bank-supported Energy Sector Recovery Program for Results and associated investment operations emphasise smart prepayment meters, a head-end system, a meter data management platform and commercial-management systems (World Bank, 2024a; 2025a). Ghana's National Energy Compact targets a large-scale smart-meter rollout and a pathway toward cost recovery (Government of Ghana and World Bank, 2026). Yet the policy architecture remains incomplete because prepaid metering is still treated primarily as a technology deployment rather than as a comprehensive settlement-class reform.

This paper advances a stronger proposition: electricity prepayment should become the default retail settlement class in ECG's service territory, while postpaid supply should be retained only as a regulated credit exception for customers that can demonstrate adequate creditworthiness, system importance and payment security. The reform should apply to residential customers, ordinary commercial customers, non-strategic ministries, departments and agencies (MDAs), metropolitan, municipal and district assemblies, and any industrial customer that does not meet a defined credit threshold. Credible industrial and strategic customers may remain postpaid because their load profiles, billing complexity, power quality needs and commercial significance can justify monthly settlement. However, such service should be supported by audited financial information, interval metering, direct debit, security deposits or bank instruments, enforceable credit limits and automatic migration following default.

The strongest domestic commercial analogy is Ghana's telecommunications industry. Mobile operators have built and financed nationwide retail networks by requiring the overwhelming majority of users to purchase airtime and data before consumption, while reserving postpaid arrangements for a small group of qualified customers. National Communications Authority data show that 38.71 million mobile voice subscriptions, or 98.92 percent of the market, were prepaid in 2024, compared with 0.42 million postpaid subscriptions. By the third quarter of 2025, prepaid subscriptions remained dominant at 41.68 million, or 98.81 percent, against approximately 0.50 million postpaid accounts (National Communications Authority, 2026a, 2026b). The experience of a capital-intensive network business that processes millions of low-value, real-time transactions provides a strong basis for adapting pay-before-use settlement to electricity distribution and retailing. Electricity requires stronger continuity, affordability and consumer protection safeguards because it is an essential monopoly service, but that difference does not justify extending unsecured postpaid credit to the entire mass market.

The argument is intentionally more disciplined than the claim that prepaid meters can "solve" ECG. Prepayment directly addresses collection probability, billing lag, arrears growth, field disconnection costs and customer-level revenue visibility. It does not eliminate technical losses, close a gap between tariffs and revenue requirements, neutralise exchange rate losses, renegotiate take-or-pay obligations or improve generation dispatch. It

is therefore a necessary liquidity and revenue assurance reform, not a substitute for the wider financial recovery programme. This distinction is central to the credibility of the proposal and to realistic expectations of its fiscal impact.

The paper contributes to the literature and policy debate in five ways. First, it links prepayment to working capital economics and sector payment waterfalls rather than treating it only as a household demand management technology. Second, it develops a differentiated customer class model that reconciles mass prepayment with industrial credit needs. Third, it provides an illustrative scenario model anchored in ECG's audited revenue base and official collection benchmarks. Fourth, it translates the concept into a complete implementation architecture, including regulation, digital systems, procurement, consumer protection, cybersecurity, industrial credit scoring and performance measurement. Fifth, it uses Ghana's telecommunications market as a domestic, market-tested analogue for a prepaid-by-default and postpaid-by-qualified-exception retail strategy.

The remainder of the paper is organised as follows. Section 2 diagnoses Ghana's liquidity and revenue-adequacy problem. Section 3 reviews the relevant empirical and institutional literature. Section 4 explains the analytical method. Sections 5 and 6 present the economic case for prepaid default and the rationale for postpaid industrial exceptions. Sections 7-12 develop the regulatory, financial, operational, social and technology architecture. Section 13 discusses the limits and wider implications, and Section 14 concludes with sequenced policy recommendations.

II. GHANA'S ELECTRICITY-SECTOR LIQUIDITY PROBLEM

➢ *The Retail Cash-Conversion Bottleneck*

An electricity distributor is financially viable only when it converts delivered kilowatt-hours into cash quickly enough to cover bulk energy invoices, network operations, taxes, debt service and capital expenditure. The classic cash conversion cycle is more severe in electricity than in many industries because the "inventory" is consumed immediately, cannot be repossessed after delivery and is costly to disconnect or pursue through litigation. Under postpaid service, the utility extends unsecured, involuntary credit between consumption and payment. The credit period includes the consumption month, meter reading and validation, bill production, the contractual payment window, collection delay and any enforcement period. A nominal 30-day bill can therefore become 45 to 75 days of financing exposure even before arrears are counted.

Where the distributor has weak customer data, inaccessible meters, estimated billing, politically sensitive disconnections or fragmented payment channels, the effective credit period becomes longer and the probability of full recovery declines. The utility then finances customers through supplier arrears, government support or reduced maintenance. Prepayment reverses the timing: cash is collected before energy is delivered, so the distributor no longer carries ordinary consumption receivables for converted customers. The economic benefit is therefore the sum of reduced bad debt, accelerated cash receipts, lower billing and enforcement costs, improved meter data and better demand visibility, less the capital and operating costs of the prepayment platform.

This cash-conversion perspective is particularly important in Ghana because the Cash Waterfall Mechanism allocates available ECG collections among sector beneficiaries. The CWM can improve transparency in distributing cash, but it cannot allocate cash that has not been collected. Improving the upstream allocation formula without strengthening retail cash conversion leaves the underlying constraint unchanged. Conversely, improving customer collections enlarges the distributable pool and reduces the distance between approved sector revenue requirements and actual cash settlement.

➢ *Financial and Operating Evidence*

Table 1 Selected Ghana Electricity-Sector Financial and Operating Diagnostics

Indicator	Latest Value Used	Interpretation for Policy Design
ECG revenue, 2024	GHS 19.03 billion	Large cash base; small collection improvements have material value.
ECG trade and other receivables, 2024	GHS 15.14 billion	High balance-sheet exposure to delayed and legacy cash conversion.
ECG trade and other payables, 2024	GHS 54.50 billion	Severe upstream creditor pressure and sector arrears transmission.
ECG cash, 2024	GHS 0.59 billion	Minimal immediate liquidity relative to payables and monthly obligations.
ECG net loss, 2024	GHS 8.26 billion	Liquidity reform must be accompanied by cost, tariff and FX reforms.
ECG distribution losses, 2024	27.1%	Prepayment must be integrated with technical and non-technical loss reduction.
National customers, 2024	6.17 million	Mass deployment requires industrial-scale logistics and digital support.

Residential share of accounts	85.7%	Default prepayment should focus on high-volume account classes.
Industrial share of consumption	42.3%	Large customers require bespoke credit and telemetry treatment.
2025 business-as-usual sector shortfall	About GHS 35 billion	Prepayment can materially reduce the gap, but cannot eliminate it on its own.

Sources: ECG (2025a); Energy Commission (2025a); Ministry of Finance (2025a). Values are rounded. The 2025 shortfall is a government projection and is not directly comparable with ECG's audited accounting loss.

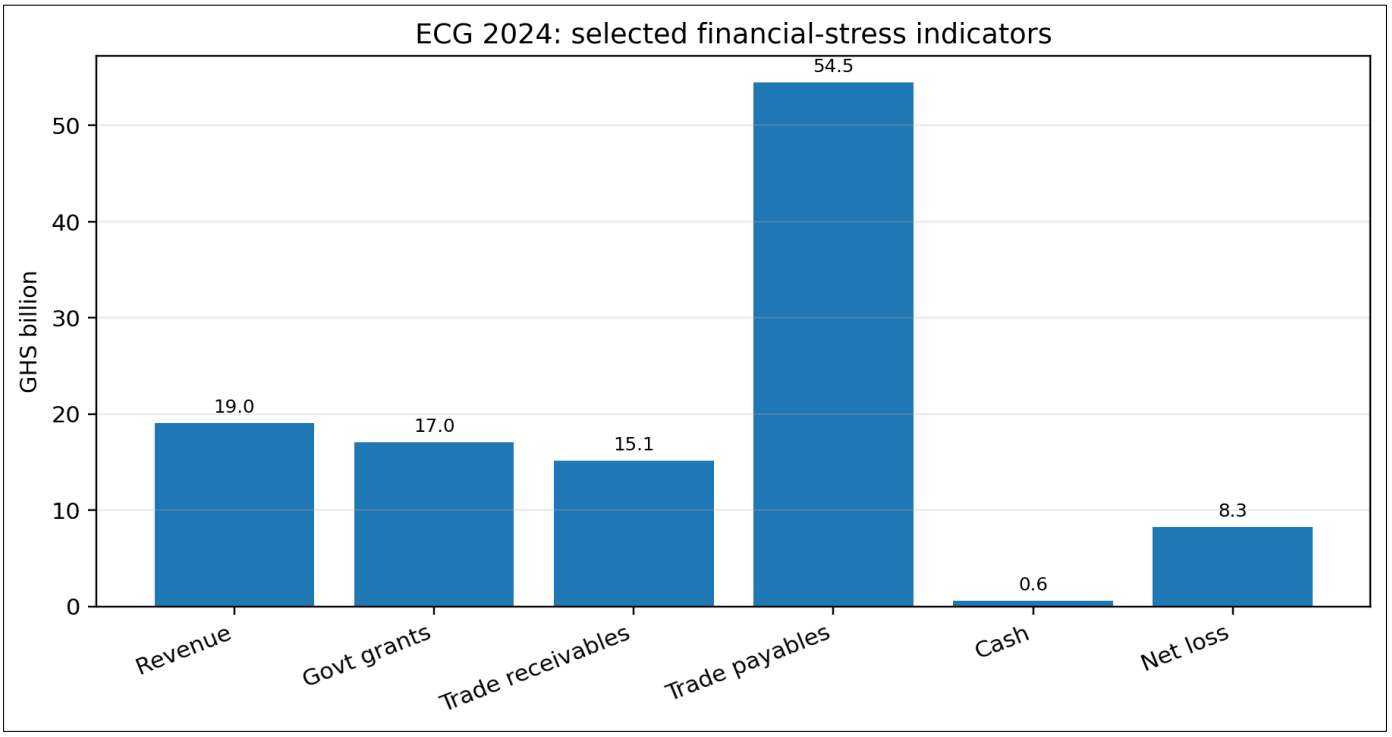

Fig 1 ECG 2024 Selected Financial-Stress Indicators.
Source: Author, Based on ECG (2025a).

The figures reveal why collection reform should be assessed through both income-statement and balance-sheet channels. Revenue may be recognised when electricity is billed, but sector obligations are paid with cash. A utility can therefore report substantial revenue and still be unable to settle generators. The combination of large receivables, much larger payables and very low cash indicates a structural maturity mismatch: ECG is effectively financing customers while being financed by suppliers and the state. Prepayment reduces the creation of new customer credit and protects the cash value of future tariff adjustments.

The 27.1 percent distribution loss rate also clarifies the boundary of the reform. A smart prepaid meter can reduce some commercial losses by eliminating unbilled consumption, exposing tampering, improving meter reading accuracy and enabling remote control. It will not repair overloaded conductors, undersized transformers or poor network topology. The investment programme must therefore combine meter deployment with feeder metering, transformer-level energy accounting, geographic information system (GIS) mapping and targeted network reinforcement. Otherwise, a distributor may improve collections from billed energy while still losing a large share of energy before it reaches billable points.

The customer distribution provides a practical sequencing logic. Residential and ordinary commercial accounts are numerous, geographically dispersed and relatively expensive to bill and collect manually; they are the natural default-prepayment population. Industrial customers are few but financially consequential. Their treatment should be determined by risk, not by political influence or tariff label. A large industrial customer that is consistently late and unsecured should not remain postpaid merely because it is classified as industrial. Equally, a bankable export manufacturer with automated payment, a clean record and adequate security should not be forced into a retail-style vending arrangement that disrupts continuous production.

➢ *Fiscal and Macro-Financial Transmission*

The distribution liquidity problem has fiscal consequences because the state ultimately absorbs part of the gap through explicit transfers, energy-sector levies, guarantees, restructuring arrangements or arrears clearance. The 2025 Budget reported substantial energy-sector support in 2024 and projected a large business-as-usual shortfall for 2025 (Ministry of Finance, 2025a).

These transfers compete with health, education and infrastructure expenditure. They also create a contingent-liability channel: when distribution cash is insufficient, government credibility is used to sustain fuel supply and generation availability.

The macro-financial effect is amplified by foreign exchange exposure. A significant portion of generation, fuel and debt-service obligations are denominated in or indexed to foreign currency, whereas retail revenue is collected in cedis. Delayed collection therefore creates both a timing loss and an exchange-rate risk. Cash collected several months after consumption may have lower foreign-currency purchasing power. Prepayment cannot eliminate the currency mismatch, but it shortens exposure duration and improves the regulator's ability to distinguish genuine tariff inadequacy from collection inefficiency.

Liquidity also affects the cost of capital. Generators and fuel suppliers' price in delayed payment risk, curtail maintenance, seek guarantees or restrict further investment. Distribution reform can therefore create an indirect financing benefit by improving confidence in the sector payment chain. The reform should be presented to lenders and investors as part of a comprehensive revenue security package that includes tariff indexation discipline, transparent CWM remittances, loss reduction targets, audited settlement data and limits on politically directed credit.

III. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

- *Empirical Evidence on Prepayment*

The empirical literature identifies four main channels through which prepayment affects utility and customer outcomes: payment timing, collection probability, consumption behaviour and transaction costs. Jack and Smith (2020), using randomised rollout timing in South Africa, find that prepaid metering reduced electricity use and generated net utility revenue gains because reduced recovery costs outweighed lower sales. Qiu, Xing and Wang (2017) similarly report that prepaid plans can reduce residential electricity consumption through salience and budgeting effects. These studies support the proposition that prepayment changes behaviour, but they also warn that revenue effects depend on the balance between higher collection and lower volume.

Ghana-specific evidence is increasingly relevant. Otchere-Appiah et al. (2021) examine smart prepayment and non-technical losses, emphasising the importance of technology and system integration. Azila-Gbettor, Atatsi and Deynu (2015) report changes in energy-related behaviour among prepaid households. Adanu, Akpalu and Kuada (2025) find that the consumption effect of switching from postpaid to prepaid meters may weaken over time and document associated welfare implications. The policy implication is that the business case should not rely primarily on permanent demand reduction. The stronger case rests on improved collection, cash timing, billing integrity and data quality.

Qualitative studies expose distributional and service risks. O'Sullivan, Viggers and Howden-Chapman (2014) show how prepayment increases feedback and budget control but can also intensify the burden on households facing payment difficulty. Baptista (2015) demonstrates that prepayment reshapes everyday urban practices and does not automatically guarantee equitable access. Bloomer and Boateng (2024) examine the relationship between prepayment, energy poverty and alternative energy use in Ghana. Kambule et al. (2019a) document drivers of prepaid-meter rejection in Soweto, while Kambule et al. (2019b) show heterogeneous consumption patterns across income groups. These findings make consumer protection an economic design requirement, not a peripheral social-policy add-on.

The international experience also shows that technology alone is insufficient. Tewari and Shah (2003) describe the South African prepayment experiment and emphasise institutional learning, customer acceptance and policy design. Advanced metering infrastructure can improve outage management, loss detection and billing, but its benefits depend on data governance, communications reliability, system interoperability and utility capability (Alonso et al., 2023; World Bank, 2020a). Poorly procured meters can create stranded assets, proprietary lock-in and mass vending failures. A credible reform therefore requires a complete operating model.

Table 2 Selected Evidence and its Relevance to Ghana

Study or Source	Core Evidence	Design Implication
Jack and Smith (2020)	Prepayment reduced use and produced net utility revenue gains through lower recovery costs.	Model collection and enforcement savings, not only sales volume.
Adanu et al. (2025)	Ghanaian consumption response may attenuate; welfare effects matter.	Do not overstate permanent conservation; embed protection.
Otchere-Appiah et al. (2021)	Smart prepayment can support reduction of non-technical losses.	Integrate meters with analytics and field enforcement.
Bloomer and Boateng (2024)	Prepayment can interact with energy poverty and alternative fuels.	Track self-disconnection and protect vulnerable customers.
Kambule et al. (2019a)	Rejection is influenced by trust, perceived fairness and implementation experience.	Use transparent engagement, grievance redress and independent audit.
Tewari and Shah (2003)	Large-scale rollout requires institutional learning and policy coherence.	Pilot, evaluate and scale with interoperable standards.

Alonso et al. (2023)	AMI regulation should define data, interoperability, cost recovery and service rights.	PURC must regulate the system, not just approve hardware.

➢ *Utility-Finance and Regulatory Literature*

The broader utility reform literature shows that financial viability depends on the joint performance of tariffs, collections, losses and operating efficiency. Trimble et al. (2016) describe quasi-fiscal deficits and hidden costs in Sub-Saharan African electricity systems. Kojima and Trimble (2016) demonstrate that affordability and utility viability must be addressed together through targeted subsidies and efficient service delivery. Foster and Rana (2020) caution that neither formal restructuring nor private participation substitutes for credible regulation, commercial discipline and political commitment. Cubbin and Stern (2006) link regulatory governance to sector performance, underscoring the importance of predictable rules and institutional capability.

Prepayment fits this literature as a commercial-governance reform. It hardens the budget constraint at the customer interface, reduces discretionary arrears and creates granular data. However, a hard customer budget constraint is sustainable only if the tariff is legitimate, service quality is credible and vulnerable households can access targeted support. Otherwise, prepayment may shift the visibility of sector insolvency from utility arrears to household self-disconnection without resolving underlying affordability.

The reform also has a corporate-finance interpretation. Postpaid electricity creates accounts receivable, working-capital financing needs and bad-debt risk. Prepayment generates negative working capital for the converted segment because customer cash proceeds energy delivery. Negative working capital is valuable where suppliers require timely settlement and borrowing is expensive. Yet the meter programme itself is capital intensive. The net present value must therefore account for meter acquisition, communications, systems integration, financing cost, replacement, vending fees, cybersecurity, customer support and disposal, not merely the avoided bad debt.

➢ *Telecommunications as a Market-Tested Prepaid Analogue*

The telecommunications sector provides a useful cross-industry benchmark because mobile operators also manage capital-intensive networks, large customer populations, continuous service availability, complex tariffs, high transaction volumes and substantial revenue-assurance risks. Their mass-market model is nevertheless built principally on prepayment. Customers register an account, fund it through distributed channels, consume voice or data against an available balance and receive real-time or near-real-time usage information. Postpaid service is offered selectively where credit quality, customer value and contractual safeguards justify it.

Ghana's own market demonstrates the durability of this arrangement. The National Communications Authority reports that prepaid mobile voice subscriptions represented 98.92 percent of the market in 2024 and 98.81 percent in the third quarter of 2025 (National Communications Authority, 2026a, 2026b). This is not a temporary pilot or a niche payment channel; it is the dominant commercial architecture of a national network industry. The evidence weakens the argument that mass-market customers must necessarily consume a network service first and pay later. In practical terms, the telecommunications industry has already normalised the proposition that access can be broad, transactions can be small and frequent, and payment can precede consumption.

The transferable element is the sales and settlement logic rather than the underlying engineering. Electricity retailers can adopt the same core architecture: verified customer identity, a funded account, ubiquitous vending channels, real-time balance management, transparent tariff application, automated reconciliation, fraud and tamper analytics, and immediate customer notification. This arrangement converts the ordinary retail transaction from unsecured credit into authorised consumption against available funds. It also reduces the need for mass credit assessment, debt collection, physical disconnection and repeated provisioning for doubtful accounts.

The analogy has limits that must be incorporated into policy design. Electricity is an essential service delivered through a local monopoly, is difficult to substitute in the short term and supports health, safety and productive activity. A failed electricity credit purchase can therefore have more serious consequences than an exhausted airtime balance. The appropriate lesson is not to copy telecommunications practices mechanically, but to combine their proven pay-before-use commercial discipline with electricity-specific protections: lifeline support, friendly hours, emergency credit, medical needs protocols, service quality reciprocity, transparent disconnection rules and qualified postpaid treatment for credible industrial and strategic users. Subject to these safeguards, the telecommunications experience provides strong practical evidence that prepaid-by-default can work at national scale in electricity distribution and retailing.

➢ *Conceptual Framework*

The paper integrates five conceptual lenses. First, transaction-cost economics explains why prepayment can reduce meter-reading, bill delivery, debt collection and disconnection costs. Second, working-capital theory explains the value of accelerating cash and preventing receivables. Third, credit-risk theory supports differentiated postpaid eligibility based on probability of default, exposure at default and loss given default. Fourth,

regulatory economics explains why tariff adequacy, service obligations and consumer rights must be jointly determined. Fifth, behavioural economics explains how salience, real-time feedback and liquidity constraints affect consumption and acceptance.

These lenses produce the core rule: prepaid service should be the standard settlement arrangement where the cost of extending and enforcing credit exceeds the operational cost of prepayment. Postpaid service should be permitted where the customer's credit quality, transaction value and operational requirements make secured monthly settlement more efficient. The boundary is therefore not "household versus industry" in an absolute sense; it is "unsecured mass-market credit versus qualified and secured credit."

IV. DATA AND METHOD

➢ *Research Design and Sources*

This study uses a policy and financial case study design. It combines: (i) ECG's audited financial statements; (ii) Energy Commission statistics on electricity purchases, sales, losses, consumption and customer classes; (iii) government budget and Energy Sector Recovery Programme documents; (iv) PURC and Energy Commission regulations and technical codes; (v) World Bank and International Monetary Fund programme documents; and (vi) peer-reviewed literature on prepayment, smart metering, utility finance and energy poverty. The approach is appropriate because the policy question concerns institutional design and cash flow mechanics rather than a single causal treatment effect.

All financial values are reported in nominal Ghana cedis unless stated otherwise. The scenario model uses ECG's 2024 revenue of GHS 19.034 billion as the reference revenue base. The baseline collection efficiency of 85.6 percent is drawn from the World Bank's sector programme documentation for 2022 and is used as a transparent benchmark rather than being presented as ECG's audited 2024 collection rate. This distinction matters because collection efficiency definitions can differ according to whether legacy collections, government offsets, adjustments or current billing are included.

The analysis does not assume that all reported receivables are recoverable or caused by ordinary postpaid billing. The receivables figure is used as a balance sheet indicator of cash conversion stress. The scenario results are illustrative and should be replaced during implementation by a regulator-verified customer-level baseline covering billings, receipts, arrears ageing, write-offs, vending, consumption, disconnections and customer class migration.

➢ *Financial Model*

The recurring annual cash recovery effect is estimated as: Annual cash uplift = R × s × (CE1 - CE0), where R is annual ECG revenue, s is the share of revenue converted to prepaid treatment, CE0 is baseline collection efficiency and CE1 is post-reform collection efficiency for the treated revenue base. This measure captures additional cash recovered from current period revenue. It does not include changes in consumption or tariffs, meter costs or loss reduction benefits.

The working capital acceleration is estimated as: Cash timing benefit = R × s × DSO reduction / 365, where DSO reduction is the decrease in effective collection days. This is a one-off release or acceleration of cash associated with the transition; it should not be added mechanically to the recurring annual uplift when presenting a steady-state income effect. Its economic value is the financing cost avoided and the liquidity made available during the transition.

Three scenarios are used. The low scenario converts 65 percent of revenue to prepaid treatment and raises treated-segment collection to 97 percent. The base scenario converts 75 percent and raises collection to 98 percent. The high scenario converts 85 percent and raises collection to 99 percent. Each assumes a conservative 30-day timing improvement. The model deliberately excludes speculative benefits from demand reduction, theft detection and operating-cost savings; these should be estimated separately during pilots.

➢ *Limitations*

The study is not an econometric impact evaluation and does not establish that the entire calculated cash uplift would be caused by meter conversion. Collection performance may also respond to tariffs, income, enforcement, outages, data cleaning and political directives. Customer migration can reduce consumption, which may lower billed revenue while improving margins and system efficiency. Meter failure, bypass and vending outages can offset expected gains. These uncertainties justify phased deployment with control groups or matched feeder comparisons.

Further, a prepaid system changes the location of risk. The utility bears less credit risk, but customers bear greater short-term liquidity risk and may self-disconnect. This distributional effect is not captured in ECG's cash model. The policy must therefore be evaluated using both financial KPIs and welfare indicators, including frequency and duration of self-disconnection, minimum-service access, complaint resolution and use of polluting substitutes.

V. WHY PREPAID-BY-DEFAULT IS ECONOMICALLY NECESSARY

➢ *Preventing New Arrears Rather than Managing Old Arrears*

Legacy arrears restructuring is necessary but does not prevent new arrears. A utility can securitise, discount or refinance old debt and still return to distress if current consumption continues to be supplied on unsecured credit. The first purpose of prepaid conversion is therefore to stop the creation of avoidable new receivables. This is

analogous to closing a leak before financing the accumulated water damage.

For residential and small commercial customers, the credit decision is rarely explicit. The utility does not conduct affordability or credit assessment before extending postpaid consumption, and the cost of enforcing small debts can exceed the debt itself. Universal postpaid service consequently embeds a subsidy from prompt payers, suppliers and taxpayers to customers who delay or evade payment. Prepaid default makes the settlement rule transparent and neutral: consumption occurs within a funded balance, while targeted social support is delivered explicitly rather than through arrears tolerance.

- *Accelerating Sector Cash and Strengthening the CWM*

Prepayment changes the sequence of the retail transaction. Instead of "consume, measure, bill, pursue and collect," the sequence becomes "fund, authorise, consume and reconcile." The difference is economically significant because generators and fuel suppliers generally cannot defer their own obligations indefinitely. Faster cash conversion improves ECG's ability to meet CWM allocations and reduces the need for ad hoc prioritisation among sector creditors.

The value extends beyond collection percentages. Daily vending produces a more continuous cash profile than monthly billing, reducing intra-month liquidity volatility. With appropriate treasury management, ECG can forecast daily cash, ring-fence funds for statutory and sector obligations, and detect regional anomalies quickly. Real-time data also enables PURC to compare approved revenue requirements with actual cash receipts and to distinguish under-collection from under-pricing.

ECG should therefore treat prepaid conversion as a sales-strategy and revenue-architecture reform, not merely as a meter-replacement exercise. The relevant telecom lesson is that the customer account, payment channel, usage authorisation, tariff engine, transaction ledger, fraud controls and service platform must operate as one commercial system. Once cash is received before consumption, the distributor no longer needs to finance ordinary household and small-business receivables. Daily vending can be swept, reconciled and allocated through the sector payment architecture, while postpaid exposure remains visible, capped and secured.

- *Reducing Billing and Enforcement Costs*

Manual postpaid systems require meter readers, route planning, bill printing or messaging, complaint handling, debt collection, disconnection, reconnection and litigation. Estimated bills create further disputes and undermine trust. Smart prepayment can automate much of this cycle. Remote configuration, token or account-based vending, tamper alerts and interval data can reduce field visits and target enforcement resources. The savings are especially relevant across millions of low-value accounts.

These benefits are not automatic. A meter that communicates poorly or is not integrated with the customer and revenue systems can reproduce the same problems in digital form. The operating model must define data ownership, exception handling, reconciliation, token reversals, meter replacement, failed transaction resolution and service-level agreements. A "meter installation" KPI without a "successfully communicating and financially reconciled meter" KPI is inadequate.

- *Protecting Tariff Adjustments and Improving Regulatory Accountability*

Cost-reflective tariffs do not improve liquidity if bills are not collected. Conversely, high collection cannot compensate for a structurally inadequate tariff. Prepayment allows these two problems to be distinguished more clearly. When nearly all eligible customers pre-fund consumption, the regulator can observe whether cash shortfalls arise from tariff design, losses, outages or operational inefficiency rather than ordinary debt accumulation. This improves regulatory accountability and public debate.

Prepayment also protects the time value of tariff revenue. In an environment of inflation and currency depreciation, delayed payment erodes the ability of cedi revenue to meet foreign currency indexed obligations. Daily or weekly funding shortens this exposure. The reform should therefore be integrated with PURC's multi-year tariff and quarterly adjustment mechanisms, not implemented as a stand-alone commercial project.

- *Improving Data for Loss Reduction and Investment Planning*

A smart prepaid rollout can create a granular digital map of customers, meters, transformers, feeders and payment behaviour. When boundary, feeder, transformer and customer meters are time-synchronised, ECG can calculate energy balances and locate losses. Consumption profiles support transformer sizing, demand forecasting, outage analysis, demand response and targeted capital expenditure. These system benefits may exceed the direct billing benefit over the asset life.

The data opportunity also creates governance risk. Customer consumption data can reveal occupancy, business activity and appliance patterns. Ghana's Data Protection Act and Cybersecurity Act therefore require privacy-by-design, role-based access, encryption, retention limits, breach response and independent testing. Commercial analytics must never become uncontrolled surveillance or an unregulated data market.

VI. WHY CREDIBLE INDUSTRIAL CUSTOMERS SHOULD RETAIN A POSTPAID OPTION

- *Economic Rationale*

Industrial electricity supply differs from mass retail service. Large customers may operate continuous processes, multiple meters, dedicated substations, time-of-

use tariffs, demand charges, reactive power penalties, embedded generation and complex power quality arrangements. A simple token balance may create avoidable operational risk if communications or vending systems fail. Monthly postpaid settlement can be efficient where consumption is accurately metered, the customer is creditworthy and payment security is enforceable.

Industrial production also has wider economic value through employment, exports, tax revenue and supply chains. An unintended disconnection caused by a temporary vending or banking failure can destroy work in process and impose costs far above the electricity invoice. The case for a postpaid option is therefore not preferential treatment; it is risk-efficient settlement for customers whose credit and operational profile justify it.

However, industrial classification alone is not evidence of creditworthiness. Some large customers accumulate politically difficult arrears that expose the sector to greater losses than thousands of households. Postpaid status must therefore be earned, priced and monitored as a credit facility. The regulator should prohibit indefinite unsecured exposure, require standard security terms and publish aggregate exposure under the exception regime.

- *Proposed Eligibility Test*

Table 3 Proposed Treatment by Customer Segment

Customer Segment	Default Settlement	Permitted Exception or Safeguard
Residential	Smart prepaid	Lifeline credit, emergency credit, protected hours and targeted subsidy for eligible vulnerable households.
Ordinary commercial	Smart prepaid	Short, system-controlled emergency credit for verified payment-system failure only.
Non-strategic MDAs/MMDAs	Treasury-funded prepaid	Central wallet or budget-controlled account; no uncontrolled arrears.
Hospitals, water, security and other critical services	Prefunded smart account	Ring-fenced Treasury allocation, emergency reserve and no abrupt disconnection that threatens life or safety.
Small and medium industry	Smart prepaid by default	Postpaid only after meeting the credit score and security requirements.
Large creditworthy industry / special load tariff (SLT)	Postpaid eligible	AMI, direct debit, security, credit limit, 30-day settlement and automatic sanctions.
Defaulting or high-risk industry	Smart prepaid or load-limited	Migration triggered by payment breach or deteriorating credit score.

A postpaid industrial licence should be granted only when the customer meets minimum thresholds across six dimensions: payment history; financial capacity; security; metering and telemetry; operational significance; and legal enforceability. A scorecard is proposed in Appendix A. Minimum non-negotiable conditions should include a communicating interval meter, a clean 24-month payment record or an approved cure plan, direct debit, a security deposit or bank instrument, a contractual credit limit, and consent to automatic migration or load limitation after specified default.

Security should be proportionate to exposure. A standard requirement could cover 1.5 to 2.0 times the average monthly bill, adjusted for volatility, sector risk and concentration. Export-oriented firms with strong off-takers may provide letters of credit, standby instruments or escrow. Public enterprises should not receive weaker treatment solely because they are state owned; their payment mechanism should be backed by a budget appropriation, Treasury deduction or dedicated escrow.

Postpaid exceptions should be reviewed at least annually and whenever risk signals change. Triggers may include two late payments in twelve months, covenant breach, an adverse audit opinion, material tax or statutory arrears, meter communication failure, unauthorised load expansion or uncertainty about the validity of security. The exception register should be subject to PURC audit to prevent political or administrative discretion from recreating unsecured credit.

- *Tariff and Credit Pricing*

Postpaid credit has a financing cost. PURC should determine whether that cost is recovered through a credit-service charge, security requirement or differentiated payment terms. The objective is not to penalise industry but to avoid making prepaid customers subsidise the working capital of postpaid customers. A credible customer that provides strong security and automated payment may face little or no additional charge; an unsecured exception should face a higher cost or be disallowed.

Industrial tariff design should remain separate from credit design. Demand charges, time-of-use prices and power-factor incentives should reflect system costs. The postpaid privilege should address settlement timing and security, not create hidden tariff discounts. Bills should be based on validated interval data and issued promptly, with a maximum 30-day settlement period unless PURC expressly approves a shorter or structured arrangement.

VII. REGULATORY AND INSTITUTIONAL ARCHITECTURE

- *PURC: Rule-Maker, Consumer Protector and Performance Regulator*

PURC should issue a Prepaid Default and Postpaid Exception Code under its statutory mandate and existing consumer service framework. The code should define eligible customer classes, transition dates, meter cost treatment, service quality standards, friendly hours and emergency credit rules, critical service protections, industrial credit criteria, disconnection protocols, complaint timelines, data reporting and audit rights. It should be subject to consultation and accompanied by a regulatory impact assessment.

PURC should regulate outcomes rather than installations. Core metrics should include collection efficiency, cash collected against current billings, arrears ageing, meter communication rate, vending availability, first-time installation success, billing exceptions, tamper resolution, complaint closure, self-disconnection incidence and service restoration. Capital expenditure should be admitted into the tariff only for meters and systems that pass acceptance tests and remain available at agreed performance levels.

The Commission should also protect customers from double charging. Meter capital and financing costs must be transparently treated in the tariff, and customers should not pay both an upfront meter charge and full regulated cost recovery unless explicitly justified. Vending fees should be capped or absorbed as a utility operating cost. Token reversals, failed transactions and delayed credits should have automatic compensation rules.

- *Ministry of Energy and Green Transition: Policy Coordination and Delivery Assurance*

The Ministry should establish the reform as a national electricity settlement policy and coordinate ECG, PURC, the Energy Commission, the Ministry of Finance, the Cyber Security Authority, the Data Protection Commission, the Northern Electricity Distribution Company (NEDCo) and public institutions. It should lead the cross-government implementation compact, resolve institutional bottlenecks and ensure that procurement and financing choices remain consistent with sector recovery objectives.

The Ministry should not replace the regulator or micromanage meter procurement. Its role is to set policy direction, secure Cabinet approval where required, coordinate public sector conversion, mobilise concessional and commercial financing, and publish implementation progress. Independent technical and fiduciary assurance should report to a steering committee with published minutes and decision logs.

- *ECG: Commercial Transformation and Execution*

ECG must treat the programme as a commercial-transformation project, not a procurement campaign. It should begin with a verified customer census, meter and transformer mapping, data cleansing, feeder energy balances, revenue-segment analysis and a baseline of current collections and arrears. Installation teams must be integrated with customer service, finance, IT, revenue protection and network operations.

ECG should create a central programme management office with authority over architecture, vendors, field delivery, change management and benefits realisation. Each installed meter should be linked to a customer identity, premise, GIS location, transformer, tariff, payment account and communications status. Financial reconciliation from the payment gateway to the customer wallet and general ledger should occur daily. Unreconciled balances should be treated as priority operational incidents.

The utility should also redesign its workforce model. Meter readers and disconnection teams should be retrained for installation quality, data assurance, revenue analytics, customer support, feeder audits and anti-tamper operations. Labour transition is essential to capture operating savings without creating organisational resistance or service gaps.

- *Energy Commission, Ministry of Finance and Other Institutions*

The Energy Commission should certify technical compliance with the National Electricity Distribution Code, the National Electricity Distribution Metering Code and applicable IEC standards. It should maintain a framework for approved equipment and accredited testing laboratories while avoiding vendor-specific standards. Interoperability and lifecycle support should be mandatory.

The Ministry of Finance should lead public-sector settlement reform. Non-strategic MDAs should move to budget-controlled prepaid accounts. Critical services should use prefunded consolidated wallets with emergency reserves and clear responsibility for replenishment. Treasury should settle verified legacy public-sector arrears through an agreed process rather than embedding them indefinitely in new prepaid balances.

Banks, mobile money operators and fintech firms should provide redundant payment channels, real-time settlement and escrow where appropriate. The Cyber Security Authority and Data Protection Commission should participate in architecture reviews, incident response planning and compliance audits. Consumer associations, industry bodies and civil society should be represented in consultation and monitoring.

Table 4 Institutional Responsibility Matrix

Institution	Primary responsibility	Accountability instrument
PURC	Settlement-class code, tariff treatment, consumer safeguards, KPI regulation, postpaid-exception audit.	Licence conditions, tariff decisions, compliance orders and public dashboards.
Ministry of Energy and Green Transition	Policy direction, cross-government coordination, financing and implementation oversight.	Cabinet-approved policy, steering committee and quarterly delivery report.
ECG	Customer data, procurement execution, installation, systems integration, vending, revenue assurance and service.	Programme benefits register, audited data and service-level agreements.
Energy Commission	Technical codes, equipment certification, interoperability and installation standards.	Type approval, testing and technical audit.
Ministry of Finance	Public-sector funding mechanism, legacy arrears treatment and fiscal-risk oversight.	Treasury circular, budget controls, escrow and published settlement report.
CSA and DPC	Cybersecurity and privacy governance.	Security assessment, incident reporting and privacy-impact assessment.
Banks and fintech providers	Payment access, settlement, redundancy and reconciliation.	Regulated service agreements, uptime and settlement standards.
Consumers and industry bodies	Consultation, feedback, compliance and independent scrutiny.	Consultative forum and grievance-review mechanism.

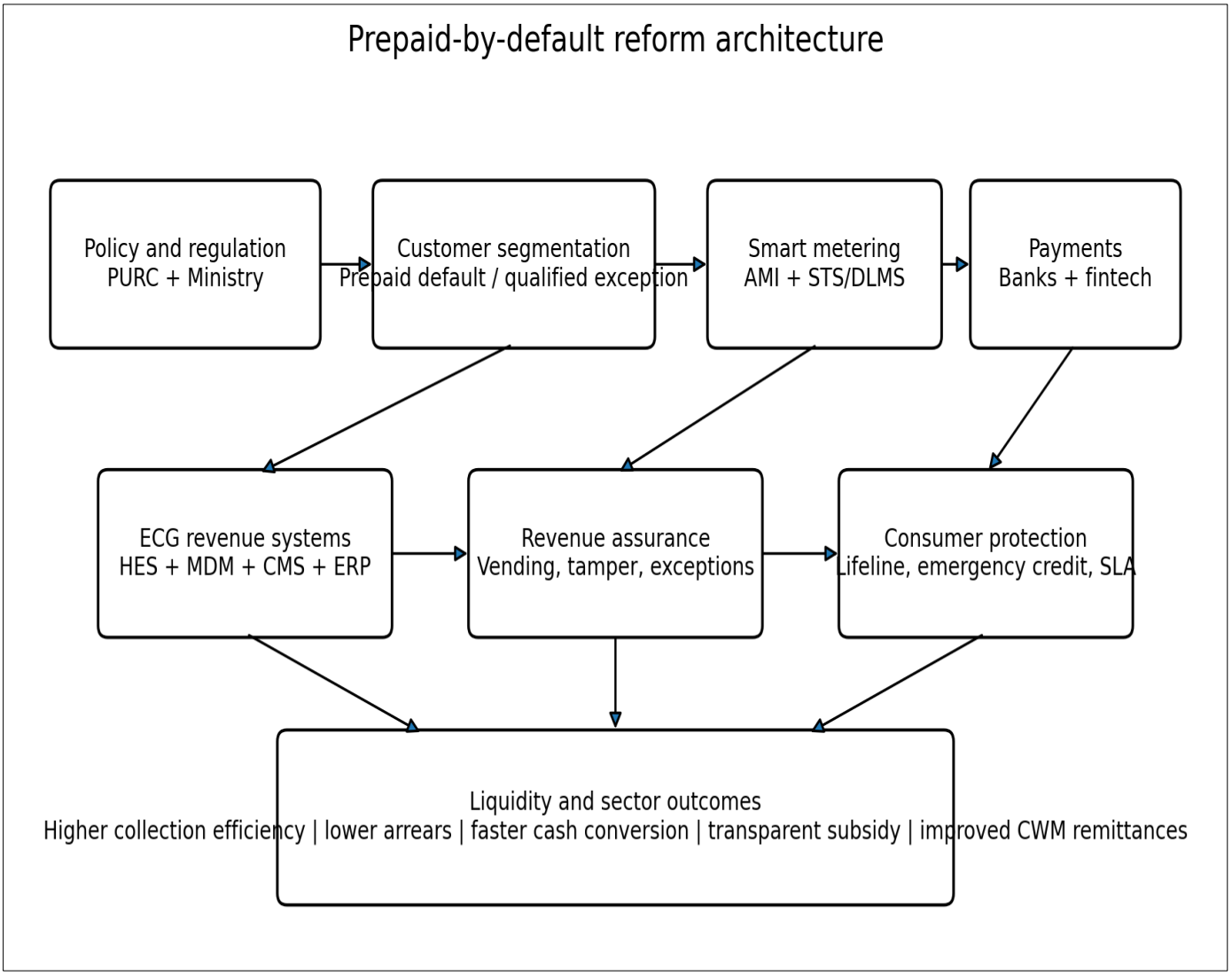

Fig 2 Prepaid-by-Default Reform Architecture.
Source: Author.

VIII. FINANCIAL SCENARIO ANALYSIS

➢ *Assumptions and Results*

Table 5 Illustrative Financial Scenarios Using ECG's 2024 Revenue Base

Parameter	Low	Base	High
ECG revenue base	GHS 19.034 billion	GHS 19.034 billion	GHS 19.034 billion
Baseline collection efficiency	85.6%	85.6%	85.6%
Share of revenue under prepaid treatment	65%	75%	85%
Treated-segment collection efficiency	97%	98%	99%
Assumed collection-day improvement	30 days	30 days	30 days
Recurring annual cash-recovery uplift	GHS 1.410 billion	GHS 1.770 billion	GHS 2.168 billion
One-off working-capital acceleration	GHS 1.017 billion	GHS 1.173 billion	GHS 1.330 billion
Recurring uplift as a share of the GHS 35 billion shortfall	4.0%	5.1%	6.2%

The scenario results show that relatively modest improvements in collection efficiency can produce material cash gains because ECG's revenue base is large. The recurring uplift ranges from about GHS 1.41 billion to GHS 2.17 billion. The working capital acceleration ranges from about GHS 1.02 billion to GHS 1.33 billion. These measures capture different effects: the first is recurring cash that would otherwise remain uncollected in the model, while the second is a one-off timing effect during the transition. They should not be combined as though both were recurring annual gains. The economic value of the timing effect depends on financing costs and the speed of rollout.

Even the high scenario represents only about 6.2 percent of the government's projected GHS 35 billion business-as-usual sector shortfall for 2025. This is an important result. It confirms that prepayment is financially meaningful, but does not support the stronger claim that metering alone can rescue the entire sector. Tariff adequacy, foreign exchange losses, procurement costs, generation contracts, fuel supply, technical losses and legacy obligations remain decisive.

The model is conservative because it excludes operating cost savings, non-technical loss reduction and avoided bad debt write-offs. It may also be optimistic if customer consumption declines materially, meter bypass continues, vending systems fail or collection efficiency for converted customers remains below the assumed levels. A regulator-verified pilot should therefore decompose the realised value into five accounts: cash timing benefit, bad debt reduction, operating cost savings, loss reduction and consumption effects.

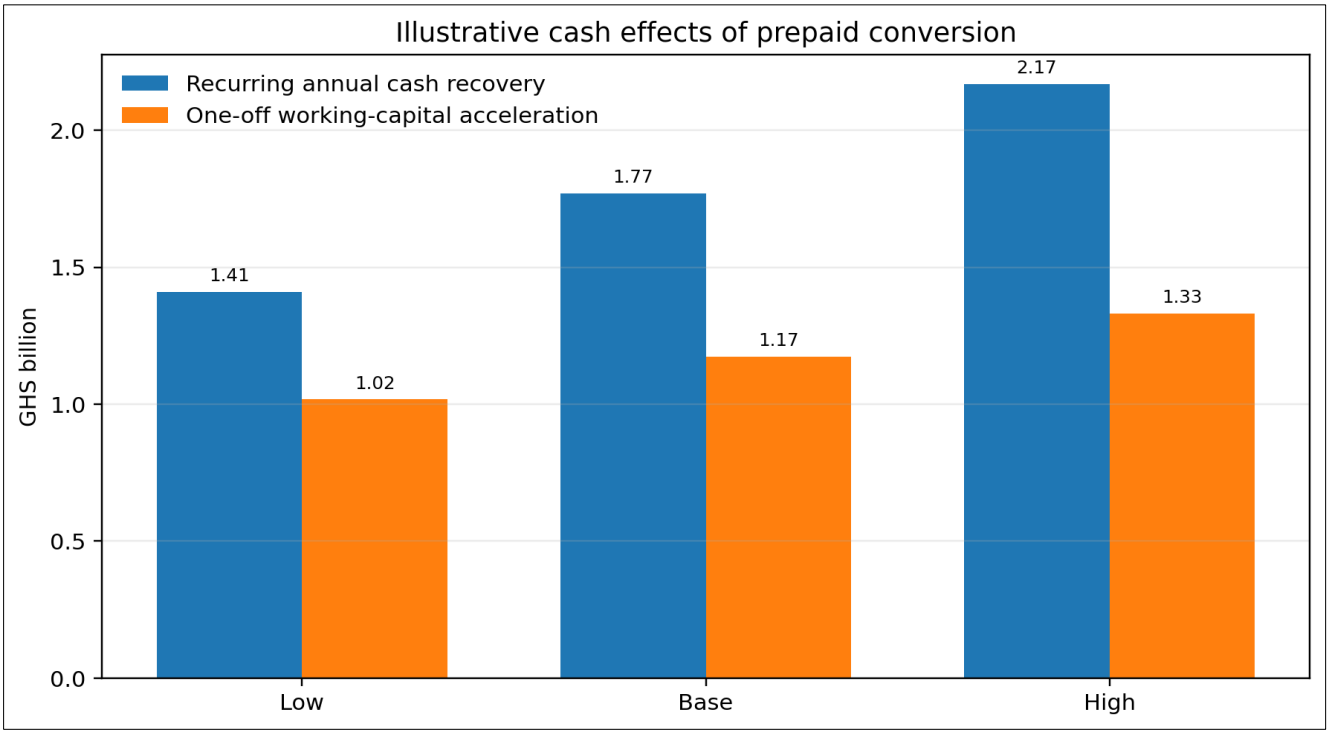

Fig 3 Illustrative Cash Effects of Prepaid Conversion.
Source: Author's Scenario Model.

➢ *Business-Case Requirements*

The investment decision should be based on lifecycle net present value. Costs include meters and communications equipment, head-end and data systems, installation, customer acquisition, financing, payment fees, maintenance, replacement, cybersecurity, customer support, training and electronic waste disposal. Benefits include additional collections, earlier cash, reduced meter reading and debt collection costs, avoided estimated billing, reduced non-technical losses, improved outage management and better capital planning.

Procurement evaluation should use total cost of ownership rather than the lowest unit price. A meter that is inexpensive but proprietary, difficult to communicate with or expensive to maintain can destroy value. Bids should disclose ten-year costs for communications, software licences, spares and replacement; local support capability; source code or escrow arrangements where appropriate; interoperability test results; cybersecurity certification; and exit provisions. Payment to vendors should be tied to operational availability and verified benefits, not merely to delivery to a warehouse.

Financing options include concessional loans, utility bonds supported by ring-fenced collections, vendor finance, results-based financing and carefully designed meter-service contracts. Any private-finance model must protect public data ownership, avoid excessive foreign-currency exposure and preserve the regulator's ability to change tariffs or vendors. A foreign-currency meter loan repaid from cedi tariffs can recreate the currency problem the reform is intended to mitigate.

IX. IMPLEMENTATION ARCHITECTURE AND ROADMAP

➢ *Design Principles*

Table 6 Core Design Principles

Principle	Operational Meaning
Prepaid by default	All eligible customers migrate unless they qualify for a regulated exception.
Postpaid by qualified exception	Postpaid service is a secured and reviewable credit facility.
No meter without data integration	Installation is complete only when customer, GIS, network, payment and ledger records reconcile.
Interoperability by design	Meters and systems comply with open standards and can operate across approved vendors.
Protection before enforcement	Vulnerable and critical-service safeguards are operational before mass migration.
Benefits-based procurement	Vendor payment and regulatory asset admission depend on verified availability and outcomes.
No new public-sector arrears	Public institutions use prepaid or Treasury-prefunded controlled accounts.
Transparent exception register	Industrial and strategic postpaid exposure is audited and reported in aggregate.
Measure welfare as well as cash	Self-disconnection, affordability and complaint indicators sit beside collection KPIs.

➢ *Digital and Operational Stack*

The minimum architecture comprises smart meters; secure local and wide-area communications; a head-end system; a meter data management system; a customer information and commercial management system; a payment gateway; enterprise resource planning and general ledger systems; GIS; an outage management system; supervisory control and data acquisition (SCADA) or distribution management interfaces; and analytics. Each layer should have defined interfaces, data dictionaries, ownership and service levels.

For token-based prepayment, compliance with the Standard Transfer Specification and relevant IEC 62055 standards is essential. For advanced metering, DLMS/COSEM under the IEC 62056 series supports interoperable data exchange. The architecture should permit account-based prepayment, remote tariff updates, load limiting and time-of-use functions while maintaining offline contingency channels for areas with weak communications.

Daily financial reconciliation is non-negotiable. Every payment should be traceable from the customer channel through the payment aggregator, bank settlement, customer wallet, meter credit and ECG ledger. Suspense accounts, failed purchases and reversals should have ageing limits and automated alerts. Independent assurance should sample end-to-end transactions and confirm that revenue is neither trapped with intermediaries nor lost between systems.

➢ *Phased 48-Month Roadmap*

Table 7 Proposed Implementation Roadmap

Phase	Period	Priority actions	Gate to proceed
0. Mobilisation	Months 0-6	Policy and code; customer baseline; architecture; procurement strategy; privacy and social assessments; pilots designed.	PURC code issued; verified baseline; architecture and safeguards approved.
1. High-value control	Months 6-18	Convert non-strategic MDAs; high-loss feeders; large commercial and defaulting industrial customers; deploy core systems.	Collection and system-availability targets met in independent evaluation.
2. Mass migration	Months 18-30	Scale residential and ordinary commercial conversion; expand payment channels; retrain staff; targeted network works.	At least 95% communications and vending availability, with compliance against complaint service standards.
3. Completion and segmentation	Months 30-42	Complete remaining eligible customers; formalise industrial exception register; optimise analytics and revenue assurance.	Audited exception exposure and feeder-level energy balances operational.
4. Optimisation	Months 42-48	Benefits audit; tariff true-up; vendor-performance settlement; replacement and e-waste plan; policy refinement.	Independent benefits-realisation report and sustainable operating budget.

Phase 0 should include pilots that are statistically and operationally useful. Sites should represent urban, peri-urban and rural areas; different communications conditions; high- and low-loss feeders; public institutions; and industrial customers. The evaluation should compare treated and comparable untreated feeders on collections, consumption, losses, complaints, outages and self-disconnection. A pilot that tests only whether meters can be installed does not test the policy.

Phase 1 should prioritise customers and locations with the highest cash and control value. Non-strategic public institutions are important because government should not require private households to prepay while allowing public accounts to accumulate uncontrolled arrears. High-loss feeders offer learning on tamper and data integration. Defaulting large customers should be converted early because concentration makes their arrears financially material.

Mass migration should proceed only after payment channel redundancy, customer support and spare meter capacity are proven. Deployment rates should be matched to the ability to resolve faults. A programme that installs 20,000 meters per week but can repair only 1,000 failed installations creates reputational and revenue risk. The critical capacity measure is the number of stable, operational meters, not gross installations.

➢ *Customer and Stakeholder Management*

Public communication should explain the commercial logic, customer rights, tariff neutrality, how to buy credit, how existing debt will be treated and how to complain. Customers should receive clear installation notice and a practical demonstration. Communication should be available in relevant Ghanaian languages and accessible formats. Community leaders, consumer groups, assembly representatives, trade associations and industrial bodies should be engaged before field deployment.

Legacy debt treatment must be explicit. Old postpaid arrears should not be silently loaded onto prepaid meters in a way that consumes all new purchases. PURC should approve a debt recovery protocol with protected minimum energy. Options include deducting a fixed percentage from each purchase, negotiating a settlement, writing off verified irrecoverable balances or clearing public sector arrears separately. Customers must receive statements showing principal, adjustments and deductions.

A national grievance mechanism should integrate call centres, Unstructured Supplementary Service Data (USSD), mobile applications, district offices and escalation to PURC. Priority incidents include inability to purchase credit, incorrect meter mapping, unsafe installation, unexplained deductions, critical service risk, suspected fraud and privacy breaches. Service standards should provide automatic compensation where ECG or a payment provider causes prolonged loss of access.

X. CONSUMER PROTECTION, AFFORDABILITY AND A JUST SETTLEMENT TRANSITION

➢ *The Self-Disconnection Risk*

Under postpaid service, non-payment becomes visible as utility arrears and eventual disconnection. Under prepaid service, payment difficulty may instead appear as self-disconnection: the household simply remains without electricity. This improves the utility's balance sheet but can conceal welfare loss. A responsible regulator must therefore monitor access outcomes rather than assume that a zero arrears balance indicates successful service.

Key indicators should include the number of customers with zero consumption for defined periods, frequency and duration of low-balance events, repeated emergency-credit use, minimum monthly purchases and reported use of charcoal, kerosene or small generators. Data should be anonymised for policy analysis.

Households that repeatedly self-disconnect should be assessed for targeted support, not automatically treated as theft or non-compliance.

➢ *Targeted Protection Instruments*

A just prepayment regime should include a lifeline block or social tariff, automatic credit for eligible households, friendly hours during nights and specified holidays, limited emergency credit, a medical needs register and protections against unsafe disconnection. Subsidies should be explicit, budgeted and based on assessed need where feasible. Smart meter data can improve targeting, but eligibility decisions should not rely solely on consumption because low consumption may reflect poverty rather than efficiency.

Critical public services require a distinct safeguard. Hospitals, water systems, security installations and essential street lighting should have prefunded accounts with a Treasury-backed emergency reserve. The objective is to eliminate uncontrolled postpaid arrears without creating a public-safety risk. Disconnection should occur only under an approved escalation protocol, with senior notification and continuity arrangements.

Payment access must be broad. Customers should be able to purchase credit through mobile money, banks, authorised agents, USSD and offline contingency mechanisms. Cash-dependent and digitally excluded customers should not pay a poverty premium through agent fees or transport. PURC should monitor geographical access, channel uptime and transaction charges.

➢ *Service Quality and Reciprocity*

Prepayment strengthens the customer's payment obligation; it should be matched by stronger utility service obligations. Customers who pay before consumption should receive reliable vending, accurate metering, prompt fault repair and transparent compensation for outages or meter errors. Regulatory legitimacy depends on this reciprocity.

PURC should consider automated service credits for prolonged vending platform outages and verified meter faults. Where supply quality is poor, the customer should not bear the entire transaction risk. Publishing feeder-level service and metering performance will also reduce the perception that prepayment is merely a revenue collection instrument.

XI. TECHNOLOGY, CYBERSECURITY, INTEROPERABILITY AND PROCUREMENT

➢ *Interoperability and Avoidance of Vendor Lock-In*

Ghana should adopt a vendor-neutral reference architecture. Meter procurement should require compliance with IEC payment meter standards, STS where token systems are used, and DLMS/COSEM for meter data exchange. Type approval should include functional, environmental, tamper resistance, communications and cybersecurity tests. ECG should retain ownership of customer and meter data and the right to export them in usable formats.

Contracts should require documented interfaces, data dictionaries, migration tools and transition support. Proprietary encryption keys, vending databases and meter management functions should not remain under exclusive vendor control. Key management should be governed by ECG under independently audited procedures. Software escrow or equivalent continuity protection should be considered for critical proprietary components.

A multi-vendor strategy can reduce concentration risk but may increase integration complexity. The appropriate balance is a common platform and standards with approved meter families, not uncontrolled device diversity. Procurement lots should be large enough for scale but small enough to preserve competition and performance comparison.

➢ *Cybersecurity and Privacy*

Smart meters expand the attack surface of the electricity system. Threats include unauthorised remote disconnection, fraudulent credit, manipulation of consumption data, denial of service, compromised vendor credentials and privacy breaches. Security must be designed across devices, communications, applications, identities, operations and suppliers. NISTIR 7628 and ISO/IEC 27001 provide useful governance foundations when adapted to Ghanaian law and operational context.

Minimum controls should include secure boot and signed firmware, encryption in transit and at rest, hardware key protection, multi-factor authentication for privileged access, network segmentation, least privilege, immutable logs, vulnerability management, penetration testing, security operations monitoring, incident-response exercises and recovery procedures. Remote-disconnection commands should require enhanced authorisation and audit trails.

Privacy controls should minimise data collection, define lawful purposes, limit retention and govern sharing with payment providers, contractors and researchers. Customers should be informed about data use. High-resolution interval data should not be disclosed for unrelated commercial purposes without legal basis and appropriate consent.

➢ *Procurement and Anti-Corruption Controls*

Meter programmes combine high capital cost, complex technical specifications and millions of distributed assets, making them vulnerable to overpricing, counterfeit equipment, ghost installations and change order abuse. Procurement governance should include independent cost benchmarking, beneficial ownership disclosure, conflict of interest declarations, factory and field acceptance testing, serial number tracking, geotagged installation evidence and public contract summaries.

Payment milestones should be linked to delivery, successful installation, sustained communication, accurate financial reconciliation and warranty performance. A retention amount should remain until performance is verified. Independent engineers and auditors should have access to systems and samples. Failed or replaced meters should be tracked to prevent re-entry into inventory.

Local content requirements should focus on sustainable capability: installation, testing, software integration, customer support, data analytics, repair and eventual assembly where commercially viable. Local participation should not be used to waive technical standards or conceal politically connected intermediaries. Technology transfer should be measurable through training, certification and local service capacity.

XII. RISK ANALYSIS AND MITIGATION

Table 8 Principal Reform Risks and Mitigants

Risk	Transmission mechanism	Mitigation
Consumer rejection	Distrust, debt deductions, installation disruption and perceived unfairness delay rollout.	Consultation, transparent debt rules, demonstrations, independent grievance process and service reciprocity.
Self-disconnection and energy poverty	Cash-constrained households lose access despite formal connection.	Lifeline subsidy, emergency credit, friendly hours, linkage to the Livelihood Empowerment Against Poverty programme and welfare monitoring.
Vending or communications failure	Customers cannot obtain or load credit; revenue and trust decline.	Multi-channel redundancy, offline mode, uptime SLA, disaster recovery and automatic compensation.
Meter bypass and tamper	Customers evade payment and expected loss reduction fails.	Tamper-resistant devices, analytics, feeder balances, inspections and proportionate enforcement.
Vendor lock-in	High lifecycle costs, weak competition and stranded systems.	Open standards, interface ownership, exit rights, interoperability tests and modular procurement.
Cyberattack	Fraudulent credit, data theft or remote service disruption.	Secure architecture, security operations centre monitoring, testing, key governance and incident response.
Poor customer data	Meters map to wrong accounts or tariffs; reconciliation fails.	Census, GIS verification, identity controls and field quality assurance.
Public-sector underfunding	Critical institutions exhaust prepaid balances.	Treasury prefunding, emergency reserves, consumption budgets and escalation protocols.
Industrial production disruption	Credit or system failure interrupts continuous processes.	Qualified postpaid option, redundant communications, direct debit and controlled load-limiting.
Overstated business case	Expected savings fail to materialise and tariff burden rises.	Pilot evaluation, conservative modelling, benefits audit and performance-linked vendor payment.
Foreign-exchange financing risk	Meter debt service rises faster than cedi revenue.	Local-currency or hedged finance, concessional terms and transparent tariff treatment.
Institutional fragmentation	PURC, Ministry, ECG and MoF decisions conflict.	A single implementation compact, clear responsibility matrix, decision log and independent programme assurance.

The most consequential strategic risk is that policymakers overpromise. If the reform is presented as a complete solution to ECG's financial condition, failure to resolve tariff, loss and cost problems will be blamed on prepaid meters and may destroy public confidence. Public communication should be precise: the reform secures and accelerates retail revenue; it does not create revenue that the tariff does not provide or eliminate costs embedded elsewhere in the value chain.

A second risk is implementation asymmetry. It would be inequitable and politically unsustainable to convert households rapidly while allowing public institutions and influential large customers to remain unsecured. The sequence should visibly apply discipline across classes, beginning with high-value government and defaulting accounts alongside customer-protection pilots.

A third risk is fragmentation between technology and finance. Meter teams may report installation success while the finance system cannot reconcile receipts, or the regulator may allow capital recovery without verifying benefits. Governance should require a single benefits-realisation ledger linking each investment tranche to operational and financial outcomes.

XIII. DISCUSSION: WHAT THE REFORM CAN AND CANNOT ACHIEVE

- *A Necessary Anchor, not a Silver Bullet*

The evidence supports default prepayment as a necessary anchor of ECG's commercial recovery. It directly addresses a core inconsistency: a financially distressed utility should not continue to provide routine unsecured credit to millions of customers when secure, regulated alternatives exist. Preventing new arrears,

accelerating cash and improving data are foundational to any credible recovery plan.

Nevertheless, sector revenue adequacy depends on tariffs, sales volume, collection and cost. In simplified form, cash adequacy equals billed energy multiplied by the effective tariff and collection rate, less the cash cost of supply and operations. Prepayment increases the collection term and may reduce losses and operating costs. It does not automatically correct an inadequate tariff or reduce inefficient power purchase costs. A comprehensive reform package must therefore address all elements simultaneously.

The scenario analysis also highlights scale. Recurring gains of GHS 1.4 billion to GHS 2.2 billion are large enough to improve CWM payments, maintenance and lender confidence, but small relative to a projected system shortfall of GHS 35 billion. The policy should be judged by whether it delivers its defined cash and control benefits, not by whether it closes unrelated structural gaps.

The telecommunications comparison also changes the burden of proof in the policy debate. Ghana is not being asked to accept an unfamiliar sales principle. It already purchases a widely used network service predominantly on a prepaid basis through agents, banks, mobile money, USSD and digital applications. The practical question is therefore not whether pay-before-use can function in a large network industry, but whether ECG, PURC and the Ministry can adapt that proven commercial logic to electricity with adequate interoperability, consumer safeguards and industrial credit governance. Properly implemented, the model can be adapted successfully to power distribution and retailing.

- *Implications for Tariff Policy and Social Protection*

With broad prepayment, PURC would gain more reliable data on realised demand, energy sales and cash collection. Tariff reviews could distinguish the revenue requirement from collection failure more clearly. This may improve willingness to adopt cost recovery tariffs because customers and government can see whether approved revenue is actually collected and applied. Transparency in CWM remittances should be published alongside tariff decisions.

At the same time, prepayment makes affordability constraints immediate. The appropriate response is not to preserve universal postpaid arrears but to make social policy explicit. A targeted lifeline financed transparently is more equitable than implicit credit that benefits both poor and non-poor defaulters. Smart-meter data, combined with social-registry information and privacy controls, can support better targeting and evaluation.

- *Implications for Investment and Sector Bankability*

Investors assess not only tariff levels but also the credibility of cash conversion and remittance. A prepaid-dominant distribution system with audited settlement data can support receivables-backed or collection-backed financing more credibly than a system dominated by uncertain postpaid debts. It can also improve the valuation of distribution concessions or performance-based private participation by reducing information asymmetry.

However, ring-fencing must be designed carefully. Over-securing collections for a meter financier could subordinate generators or essential network expenditure. Financing agreements should be consistent with the CWM, approved by the relevant authorities and disclose waterfall priorities. The purpose is to strengthen the sector payment chain, not create a new senior claimant that captures the improvement.

- *Political Economy and Institutional Credibility*

Prepayment removes discretion from routine credit and therefore affects beneficiaries of the existing system. Resistance may come from customers accustomed to delayed payment, employees whose roles change, vendors seeking proprietary control and institutions that prefer opaque arrears. Successful reform requires political sponsorship, but also rules that constrain political exemptions. The postpaid-exception process must be objective and auditable.

Institutional credibility will be strengthened if government leads by example. Public institutions should receive budgeted energy allocations and operate within controlled accounts. Where the state requires continuity for strategic services, it should fund that continuity explicitly. This approach respects both public-service obligations and sector financial discipline.

XIV. CONCLUSION AND POLICY RECOMMENDATIONS

Ghana's electricity liquidity crisis is partly a settlement design problem. ECG buys and distributes electricity continuously but still extends broad postpaid credit in an environment of high losses, weak cash coverage, large receivables and substantial upstream payables. Converting eligible customers to smart prepaid service would prevent new arrears, accelerate cash, reduce collection costs, improve data and strengthen the cash available for sector remittances. The reform is therefore necessary for financial recovery. Ghana's telecommunications experience reinforces this conclusion: a prepaid-dominant, digitally reconciled sales model can operate at national scale, support broad access and coexist with a limited postpaid segment. The same commercial principle can be adapted to electricity distribution and retailing, provided it reflects the sector's essential service obligations and includes credible social and industrial safeguards.

The appropriate policy is not universal prepaid service without exception. It is prepaid by default and postpaid by qualified exception. Residential, ordinary commercial, non-strategic public-sector and non-creditworthy industrial customers should migrate to prepaid or prefunded smart accounts. Credible industrial

and strategic customers should retain postpaid service where their credit quality, security, metering and operational significance justify it. The exception must be governed as a credit facility with transparent criteria, a credit limit, direct debit, security and automatic consequences for default.

The reform must be delivered as an integrated commercial, regulatory and digital programme. PURC should issue the settlement-class code, protect consumers and regulate outcomes. The Ministry of Energy and Green Transition should coordinate policy and financing. ECG should execute customer-data reform, systems integration, deployment and revenue assurance. The Energy Commission should enforce technical standards. The Ministry of Finance should prevent new public-sector arrears through prefunding and controlled budgets. Cyber, privacy, payment and social-protection institutions must be embedded from the outset.

The illustrative financial model suggests recurring annual cash recovery gains of about GHS 1.41 billion to GHS 2.17 billion and a separate one-off working capital acceleration of about GHS 1.02 billion to GHS 1.33 billion. These gains are material but insufficient to close Ghana's entire electricity sector shortfall. Prepayment must therefore proceed alongside loss reduction, cost-reflective and socially balanced tariffs, foreign exchange risk management, contract and procurement reform, dispatch efficiency, CWM transparency and legacy debt resolution.

The decisive test is whether the reform improves cash and service outcomes, not how many meters are purchased. A successful programme will produce communicating meters, reconciled payments, fewer arrears, lower losses, stronger remittances, reliable vending, protection for vulnerable customers and transparent postpaid exposure. With those disciplines, prepayment can become more than a billing technology: it can serve as the retail financial architecture for a more solvent, accountable and investable Ghanaian electricity market.

➢ *Priority Actions*

- Within six months, PURC should consult on and issue a Prepaid Default and Postpaid Exception Code with consumer, industrial-credit and public-service safeguards.
- The Ministry of Energy and Green Transition should establish a cross-government implementation compact and publish a 48-month delivery plan with independent assurance.
- ECG should complete a verified customer, meter, transformer and feeder baseline before mass procurement and publish the baseline methodology.
- The Ministry of Finance should convert non-strategic public institutions to budget-controlled prepaid accounts and create prefunded arrangements for critical services.
- All postpaid industrial accounts should undergo credit risk assessment, be adequately secured and be renewed annually; non-qualifying accounts should migrate to prepaid service or controlled load limiting.
- Procurement should remain vendor neutral, follow open standards, assess lifecycle cost and link payments to sustained communications, reconciliation and benefits realisation.
- PURC should publish quarterly dashboards covering collection, arrears, meter availability, vending, losses, complaints, self-disconnection and postpaid exception exposure.
- A social protection package should be operational before mass migration, including lifeline support, friendly hours, emergency credit and a medical needs protocol.
- PURC, the Ministry of Energy and Green Transition and ECG should establish a telecommunications and electricity commercial architecture working group to translate proven prepaid account management, vending, digital settlement, fraud control and customer service practices into electricity sector standards.
- The programme should be evaluated through controlled or matched pilots, with results disclosed before each scale-up gate.
- Prepayment benefits should be integrated with the wider Energy Sector Recovery Programme rather than used to defer tariff, loss, cost and contract reforms.

➢ *Highlights*

- Ghana should adopt prepaid metering as the default settlement class for residential, ordinary commercial, non-strategic public-sector and non-creditworthy industrial customers.
- Postpaid service should become a regulated credit privilege, not a general entitlement, and should be limited to objectively qualified industrial and strategic customers with enforceable security.
- Using ECG's 2024 revenue base, illustrative conversion scenarios indicate recurring annual cash recovery gains of about GHS 1.41 billion to GHS 2.17 billion, separate from a one-off working capital acceleration of about GHS 1.02 billion to GHS 1.33 billion.
- Prepayment is necessary but not sufficient: it must be integrated with loss reduction, cost-reflective tariffs, foreign exchange risk management, CWM discipline, interoperable smart meter architecture and targeted social protection.
- A 48-month implementation programme is proposed, with explicit consumer safeguards, industrial credit scoring, cybersecurity controls, transparent procurement and outcome-based regulatory monitoring.
- Ghana's telecommunications market provides a domestic proof of concept: mass-market mobile service is overwhelmingly prepaid, while postpaid service is retained as a narrow customer-class exception.

APPENDIX A. INDUSTRIAL POSTPAID ELIGIBILITY SCORECARD

Table A1 Illustrative 100-Point Postpaid Eligibility Score

Dimension	Weight	Illustrative Criteria
Payment history	25	On-time payment ratio; no unresolved arrears; no repeated disputes used to delay payment.
Financial capacity	20	Audited accounts; liquidity and leverage; profitability or reliable sponsor support.
Security package	20	Cash deposit, bank guarantee, standby letter of credit, escrow or equivalent enforceable support.
Metering and telemetry	15	Communicating interval meter, validated data, remote monitoring and no material tamper history.
Operational/economic significance	10	Continuous process, employment, exports, public-interest function and cost of abrupt interruption.
Legal and governance quality	10	Valid entity, authorised signatories, enforceable contract, beneficial ownership and compliance record.

- *Recommended Threshold:*

At least 75 points, with no score below 50 percent in payment history, security, or metering and telemetry. PURC may approve sector-specific variations, but the non-negotiable minimum should remain enforceable payment security and a communicating revenue meter.

- *Automatic Suspension Triggers:*

Two late payments within twelve months; payment more than fifteen days overdue; invalid or expired security; a material meter communication failure that is not remedied; unauthorised load expansion; an insolvency event; or misrepresentation. Suspension should result in migration to prepaid service, enhanced security requirements or a controlled load limit.

APPENDIX B. PROPOSED REGULATORY PERFORMANCE DASHBOARD

Table B1 Minimum Quarterly KPI Set

Area	KPI	Illustrative Regulatory Direction
Deployment	Meters installed and commissioned	Report gross installations and net stable operational meters.
Availability	Vending and payment platform availability	At least 95%, with class and location breakdown.
Payments	Vending/payment platform availability	At least 99.5%, excluding approved maintenance.
Cash	Current-period collection efficiency	Progressive target by customer class and feeder.
Working capital	Effective collection days	Measure separately for postpaid and converted accounts.
Losses	Feeder and transformer energy balance	Publish high-loss feeder action and verified improvement.
Customer service	Complaint resolution within SLA	Report by complaint type and provider.
Protection	Self-disconnection and emergency-credit use	Monitor effects on vulnerable customers and trigger a support review where necessary.
Industrial credit	Postpaid exposure and arrears	Aggregate exposure, security coverage and exceptions.
Cyber	Material incidents and recovery time	Report under national incident protocol.
Finance	Benefits realised versus business case	Independent annual verification and tariff true-up.

APPENDIX C. FINANCIAL MODEL NOTES

Let R = GHS 19.034 billion; CE0 = 0.856; s = treated revenue share; CE1 = post-reform treated segment collection efficiency; and d = reduction in effective collection days. Recurring uplift is $R \times s \times (CE1 - CE0)$. Cash timing acceleration is $R \times s \times d / 365$.

Low scenario: $19.034 \times 0.65 \times (0.97 - 0.856)$ = approximately GHS 1.410 billion. Base scenario: $19.034 \times 0.75 \times (0.98 - 0.856)$ = approximately GHS 1.770 billion. High scenario: $19.034 \times 0.85 \times (0.99 - 0.856)$ = approximately GHS 2.168 billion.

The investment case should extend the model to include consumption elasticity, non-technical loss reduction, bad debt write-offs, operating cost savings, meter and system capital expenditure, communications costs, financing terms, tax, replacement and terminal value. It should also include scenario probabilities and sensitivity to exchange rates.

➢ *Declarations*

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- *Conflict of Interest:*
  The author declares no conflict of interest related to the analysis presented in this manuscript.

- *Data Availability:*
  The analysis uses publicly available audited financial statements, official statistics, legislation, regulatory documents and published research. The illustrative scenario model is fully described in the paper.

- *Author Contribution:*
  Conceptualization, policy analysis, financial modelling, drafting and revision: Dr. Elikplim Kwabla Apetorgbor.

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