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CRITICAL PERSPECTIVES OPEN ACCESS

Synergizing Public Incentives and Private Capital: A Hybrid RAB-RBF Framework for Low-Carbon Energy Infrastructure Access in Low- and Middle-Income Countries

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ABSTRACT

Regulated asset base (RAB) and results-based financing (RBF) are key emerging infrastructure finance models, offering stable returns (RAB) and outcome-based incentives (RBF). This perspective proposes a hybrid RAB-RBF model to bridge the “viability gap” in developing regions and catalyze low-carbon energy infrastructure access where cost-reflective tariffs are unaffordable. The integration uses RBF to “write down” the initial capital cost of low-carbon energy assets. The remaining net asset value is then placed under a light-handed RAB framework. This combined approach aims to attract private capital (via RAB stability) while ensuring climate-friendly access (via RBF incentives). We argue this hybrid creates a sustainable pathway for private investment by aligning investor and societal incentives. This article outlines the theoretical basis and provides a mathematical model for tariff setting. It details necessary regulatory innovations and illustrates the financial mechanics through a hypothetical case study. Finally, it emphasizes the critical need for robust regulation and reliable funding to ensure access.

1 | Introduction

Financing is a key constraint on improving access to low-carbon energy infrastructure in low- and middle-income countries (LMICs) [1]. The sector faces a fundamental structural dichotomy. On one hand, commercial financing requires market-rate returns, often exceeding 15% in emerging markets [2]. These returns translate into high tariffs that many rural populations cannot afford. On the other hand, grant financing offers affordability for the end-user but is inherently limited by the finite budgets of donor agencies [3]. Recent geopolitical developments, including the rise of nationalist political movements in the West and shifts in U.S. policy under the Trump administration, highlight the risks of relying on grants alone to expand energy access in LMICs. The mini-grid sector illustrates this “missing middle” problem clearly. Solar-hybrid mini-grids are technically well-suited for rural electrification, yet they remain

capital-intensive infrastructure assets. As a result, new financing approaches are needed to mobilize private capital while maintaining affordable service delivery. Two such approaches are the regulated asset base (RAB) model [4] and results-based financing (RBF) [5].

In a RAB regime, a regulator authorizes a utility or concessionaire to set tariffs that cover its operational costs and ensure a fixed, predetermined return on invested capital. This structure offers predictable and stable returns, which are essential for attracting private investors [6]. In contrast, RBF links public or donor funds to the achievement of specific, independently verified outputs or outcomes, such as new connections or a clean energy delivered. Funds are disbursed only after results are validated, which encourages efficient and performance-driven service delivery [7]. By integrating the upfront capital support and performance incentive of RBF with the long-term

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revenue stability of the RAB model, the capital structure can be improved. Donors help de-risk early investment and market entry, while regulators provide a stable operational framework and greater investor certainty.

This article addresses this issue by conducting a conceptual study. It first reviews these two models. We then propose how they can be combined to finance low-carbon energy projects. We present a simple regulatory revenue equation to illustrate the hybrid, and discuss its advantages (e.g., risk-sharing, incentives) and challenges (e.g., complexity, funding certainty). Finally, a hypothetical case study, based on current trends in sub-Saharan Africa, illustrates how the hybrid RAB-RBF might work in practice.

The rest of this article is organized as follows: Section 2 provides a brief review of the RAB and RBF models, while Section 3 provides the proposed hybrid model, including its advantages and challenges. Section 4 provides a hypothetical case study to further illustrate the hybrid model. Finally, Section 5 concludes this article.

2 | Theoretical Framework: Two Models

2.1 | The Regulated Asset Base (RAB) Model

The RAB model [4] is a regulated-cost framework widely used in infrastructure (electricity, water, etc.) in developed countries. The basic idea is that a utility's allowed revenue is set to cover its prudent costs and offer a return on the value of its invested assets (the "asset base"). The revenue build-up at date t (R_t) in the RAB model is given by:

$$R_t = (WACC \times RAB_{t-1}) + D_t + OPEX_t + Incentives, \quad (1)$$

where $t-1$ is the opening value, weighted average cost of the capital ($WACC$) is the allowed real return on the capital, depreciation (D) spreads the capital cost over time, $OPEX$ is operating expenses, and $Incentives$ are any performance bonuses or penalties. The asset base evolves as:

$$RAB_t = RAB_{t-1} + I_t - D_t, \quad (2)$$

where I_t being new investment in year t and RAB_{t-1} is the initial or opening asset base. Under this "building block" approach, the regulator sets tariffs to allow the utility to earn a stable and predictable return on the RAB. By design, the RAB model reduces long-term investment risk, as investors are assured recovery of prudent costs and a fixed return rather than exposure to market volatility. Key features of RAB models include:

- **Stable Returns for Investors:** Projects are financed at a lower cost because investors recover capital plus an agreed return. For example, UK projects like Sizewell C and Thames Tideway Tunnel allow partial cost recovery during the construction phase. This approach lowers the cost of capital by avoiding interest roll-up.
- **Value for Consumers:** Consumers pay regulated charges tied to asset value and efficiency. In theory, this balances "value for money" with investor returns.

- **Regulatory Oversight:** A trusted regulator sets price controls and enforces standards to ensure projects meet service and climate goals. Investors will participate only if they have confidence that regulators will honor agreed tariffs.
- **Performance Incentives (optional):** Modern RAB designs often include adjustment mechanisms, such as bonus or penalty factors, for service quality, reliability, or efficiency. This shows that pay-for-performance features can be effectively embedded within existing RAB frameworks.

While common in high-income markets, RAB-like regulation is also used in developing regions. For example, African mini-grid tariff regulations often calculate a "regulated asset base" of equipment (PV panels, batteries, lines) to set cost-recovery tariffs [8].

2.2 | Results-Based Financing (RBF)

Under the RBF pay-for-performance model [5], donor or governments pay providers only after they deliver verified results. In the energy sector, these results often include new household connections, clean energy generation, or carbon reductions. Mathematically, the payment is expressed as $P_t = \lambda Y_t$, where Y_t represents the verified output in period t , and λ is the per-unit incentive. Because the provider must cover all up-front costs and only recovers funds upon successful delivery, they bear the primary financial and performance risks. Key features of RBF include:

- **Outcome-Linked Payments:** Funds disbursed after achieving targets. This aligns finance with results rather than inputs.
- **Flexibility for Providers:** Implementers choose how to achieve results. They get an incentive to find the most cost-effective method to meet targets.
- **Risk Transfer:** The implementer assumes performance risk as they must finance costs until results are proven. This transfers risk from the funder, which is often a government or donor, to the service provider.
- **Independent Verification:** An external verifier confirms that outputs meet the agreed criteria before payment is made.

RBF is a popular tool for low-carbon energy projects across Africa and Asia, covering off-grid solar, cookstoves, and mini-grids. For example, a World Bank program in Nigeria offers developers a fixed US\$350 subsidy for every new connection [9]. While proponents argue that RBF effectively attracts private firms to underserved markets by focusing on performance, the model has several drawbacks. Specifically, implementers must secure significant up-front capital because they incur project costs long before receiving results-based payments. They also face counterparty risk, as they need high confidence that the funder will actually pay after verification. Furthermore, the required verification and administration processes increase overall transaction costs. Consequently, RBF is often blended with grants or technical assistance to mitigate these risks and make projects more viable for private participants.

3 | The Hybrid Mechanism: Integrating RAB and RBF

RAB and RBF address different problems: RAB secures investment with cost-recovery rules, while RBF drives performance outcomes. We propose a hybrid model that combines cost-based tariffs with performance incentives. Conceptually, a regulated energy utility could earn revenue under a RAB license, supplemented by an RBF-style bonus for achieving climate-focused results. For instance, suppose a utility's allowed revenue in year t is specified as:

$$R_t = (WACC \times RAB_{t-1}) + D_t + OPEX_t + \lambda Y_t, \quad (3)$$

where the RBF term λY_t is added to the conventional RAB model in Equation (1). The RBF term is defined by the units of outcome—such as new connections, renewable energy delivered, or carbon avoided—multiplied by the payment rate per unit, λ . This rate is set by policy to determine the total incentive payment.

In the hybrid model, revenue consists of a fixed component—the regulated return on the RAB—with a results-based component. Importantly, the RBF bonus is paid from a public fund or surcharge rather than through consumer tariffs, which prevents overcharging the end-user. The RAB component ensures that essential investments, such as grids and generation assets, are financed with a fair profit, while the RBF component rewards “social value” outcomes that standard tariffs typically fail to cover.

Many existing RAB regimes already incorporate performance incentives for factors like reliability and quality. The novelty here is to target incentives specifically at climate or energy access metrics. For example, the RBF payment rate (λ) could be set so that rural solar mini-grids earn additional revenue for each new connection or MWh of renewable energy delivered. This combined framework aligns stakeholders' interests by providing investors with the security of guaranteed cost recovery. Simultaneously, it offers performance-based rewards for meeting specific energy access or carbon reduction targets.

3.1 | Advantages of the Hybrid Model

- **Mobilizing Capital with Guarantees:** By providing a regulated return, the RAB component can significantly reduce financing costs. RAB models allow for early cost recovery, even during the construction phase, which reduces the overall interest burden. This mechanism improves project bankability and helps attract private investment into underserved areas. At the same time, RBF payments leverage donor or public funds to supplement project revenue only when results are delivered.
- **Incentivising Results:** The RBF leg explicitly rewards outcomes that a pure RAB might neglect. While a distribution utility might be indifferent to its customer mix if all pay their bills equally, RBF provides a specific incentive to reach low-income or remote households. This can address market failures in clean energy deployment.
- **Risk Sharing and Flexibility:** The hybrid model shares risk among parties. The investor's risk of not recovering costs is mitigated by the tariff guarantee, while the public

risk of paying for non-delivery is mitigated by tying payments to verified results. Implementers have the flexibility to choose how they achieve targets, as the RBF design encourages innovation. Simultaneously, they maintain a stable revenue floor through the guaranteed returns of the RAB framework.

- **Aligning with Policy Goals:** Regulators can use this model to embed climate and social objectives into the price control. For instance, in the hybrid RAB-RBF framework, regulators can target renewable generation, energy efficiency, or rural access. This ensures that infrastructure build-out also meets decarbonization goals. In effect, RBF acts like a subsidy for green outcomes within the RAB policy.
- **Leverage Co-Finance:** The RBF portion can attract donor funds or development bank support. Major agencies, such as the African Development Bank and the World Bank, are already funding energy access through performance-based programs. By blending these with regulated asset financing, governments can stretch scarce subsidy dollars further while still mobilizing private equity.

3.2 | Challenges of the Hybrid Model

- **Regulatory Complexity:** Implementing a hybrid scheme requires sophisticated regulation. The regulator must design the RBF metrics and rates carefully to reflect the value of outcomes, and ensure independent verification. This adds administrative burden beyond a standard RAB.
- **Regulator and Governance Risk:** A credible RAB framework depends on a stable and independent regulator that can commit to tariff-setting rules over long investment horizons. In many low-income countries, regulators face political pressure to suppress tariffs, delay price reviews, or retrospectively alter allowed returns [10]. Such interventions weaken investor confidence and can undermine the core value of the RAB model, namely, predictable cost recovery. Governance risks, including regulatory capture or unclear allocation of responsibilities between ministries and regulators, further complicate implementation. Without credible commitment mechanisms, private investors may discount the regulatory promise embedded in the RAB.
- **Institutional Capacity Constraints:** The hybrid model places substantial demands on institutional capacity. Reliable asset valuation, tariff setting, performance monitoring, and outcome verification all require technical expertise, data systems, and transparent processes [11]. In contexts where regulatory agencies are understaffed or lack experience with performance-based mechanisms, weaknesses in monitoring and verification may erode the credibility of both the RAB asset base and the RBF payments. This can lead to disputes, delays, or opportunistic behavior by regulated entities.
- **Funding and Counterparty Risk:** The effectiveness of the RBF component hinges on the availability of predictable and reliable funding, typically from government budgets, donor agencies, or climate finance facilities. In practice, these funding sources may be exposed to fiscal stress,

political reprioritisation, or exchange-rate volatility. Delays or shortfalls in RBF disbursements can create liquidity pressures for project developers, even when agreed performance targets are met. If public or donor funders are perceived as unreliable counterparties, the RBF element may fail to sufficiently de-risk projects, undermining the hybrid model's intended benefits.

- **Incentive Calibration and Behavioral Distortions:** Setting appropriate RBF payment levels is challenging. If incentives are too low, they may not meaningfully influence provider behavior or justify the additional administrative complexity. If incentives are too high, they risk over-subsidization, rent-seeking, or strategic focus on easily achievable targets at the expense of service quality or long-term system sustainability. Regular review and transparent adjustment of incentive parameters are therefore essential to maintain alignment with policy objectives.
- **Affordability and Political Economy Considerations:** While the RAB component ensures cost recovery, it also implies tariffs that may be politically sensitive in low-income or rural contexts. Even modest tariff increases can face resistance from consumers or policymakers [12]. The RBF component can help offset affordability constraints by subsidizing socially desirable outcomes, but only as long as such support is sustained. Premature withdrawal of subsidies risks service deterioration or stranded assets, highlighting the importance of long-term policy commitment.

The hybrid approach can, in principle, combine the strengths of both models, but its success depends critically on regulatory credibility, institutional capacity, and assured funding. These challenges underscore the need for careful design, phased implementation, and governance arrangements tailored to country-specific conditions, rather than a one-size-fits-all application. For example, regulators in countries like Uganda or Kenya would need to integrate the hybrid into their tariff methodologies. Some African mini-grid regulations already use similar concepts [8], but success requires ensuring reliable funding flows for results-based payments.

4 | Hypothetical Case Study: Rural Electrification by RAB-RBF

To illustrate the hybrid model, consider a hypothetical program in a Sub-Saharan country. The government aims to expand electrification with renewable microgrids in rural areas. It establishes a regulated mini-grid utility under a RAB regime. The RAB is set to include all approved grid assets, with an allowed return ($WACC = 12\%$) and a depreciation schedule. The utility earns cost-plus revenues from customers.

RBF Component: Simultaneously, a donor-backed RBF fund is set up. For each new household connected and verified to receive electricity from the mini-grid, the utility receives a bonus of $\lambda = \$40$ per connection. If the target is 50,000 households, the maximum RBF pay-out would be \$2 million (on top of tariffs).

Outcome: In year t , let the utility's RAB be \$50 million. Its allowed revenue (without RBF) would be $0.12 \times 50M + D_t + OPEX_t$.

If it connects 10,000 new homes that year, it earns an extra $10,000 \times \$40 = \$400,000$ from the RBF fund. This boosts its total revenue, making the investment more attractive to finance. The bonus also offsets some costs of reaching remote customers. These customers may consume little electricity, but are important for access goals.

Analysis: The utility's incentives are aligned because it can recover core costs through the regulated tariff. Simultaneously, the utility gains a direct financial benefit from the RBF component for each new connection achieved. Investors see a stable base return on the \$50 M asset, plus performance upside. If the utility fails to meet the 10,000-connection target, it simply forgoes the bonus for the unachieved results. It does not face any additional penalty beyond the loss of that potential revenue.

This case is inspired by real programs: For example, Rwanda's Energy Sector Result-Based Financing (RBF II) Project¹ aims to connect 200,000 households on-grid and 50,000 off-grid. In our hybrid model, such connections would be funded partly by tariff revenues in line with RAB and partly by RBF subsidies. By linking RBF payments to "low-carbon" outcomes, such as the mini-grids use solar or hydro, the program also advances climate goals.

Lesson: The hybrid RAB-RBF aligns financing with development targets. It ensures utilities can invest in expanding service through stable returns on assets, while having "skin in the game" to achieve broad access via payment for connections. In our example, regulators would carefully set the RAB parameters and λ so that the program reaches the desired scale without requiring excessive subsidy.

5 | Conclusion

The RAB-RBF hybrid offers a powerful, yet complex, framework for scaling low-carbon energy infrastructure in the Global South. The RAB element lowers investment risk and attracts private finance by assuring cost recovery and a fixed return. Simultaneously, the RBF element directly incentivises providers to achieve specific social and environmental targets, such as new connections or renewable energy delivery. This hybrid is conceptually captured by a regulatory revenue formula that supplements the usual cost-recovery structure with a per-result bonus. The advantages are clear. It mobilizes private capital, enhances focus on tangible outcomes, and facilitates climate-access synergies. Early analysis suggests that carefully calibrated, performance-based bonuses can make high up-front costs viable without compromising universal service obligations. However, significant real-world challenges remain, necessitating regulatory competence, assured long-term funding streams, and strong stakeholder buy-in. Ultimately, the RAB-RBF hybrid offers a conceptual blueprint for investment that is both stable and outcome-driven. It strategically reallocates subsidies into result-linked incentives, allowing policymakers to achieve more "with less" by leveraging private finance. For policymakers and international financiers committed to 2050 energy goals, further exploration of this model through detailed feasibility studies and pilot schemes is essential. These initiatives will help open new pathways toward achieving universal, low-carbon electrification.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the author used ChatGPT to improve grammar, enhance readability, and re-fine the language of the manuscript. After using ChatGPT, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Endnotes

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