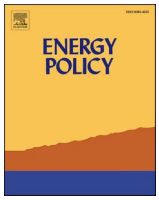
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A holistic framework for the design and implementation of regional transmission cost allocation: Opening a can of worms in the West African Power Pool

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ABSTRACT

Regional transmission cost allocation (RTCA) is widely recognised as a prerequisite for financing and expanding cross-border electricity networks. Although the subject has traditionally been approached from a techno-economic-regulatory perspective, the practical implementation of RTCA reforms is influenced by a broader set of institutional, political, and financial factors that have received limited attention in the literature. This paper develops a holistic framework for designing and implementing RTCA, integrating technical principles with institutional governance, political economy, and financial considerations. The framework is illustrated through an embedded case study of the recent RTCA reform in the West African Power Pool (WAPP), informed by technical modelling, documentary analysis, stakeholder consultations, and the authors' direct participation in the reform process. Applying the framework to the case study shows that successful RTCA reform requires both a sound techno-economic design and the ability to navigate the compromises required to make that design implementable in practice. The recent adoption of the revised RTCA methodology in WAPP provides an opportunity to examine how these compromises were progressively managed through credible institutional arrangements, stakeholder engagement, transitional mechanisms that accommodated political constraints, and financial arrangements supporting both cost recovery and investment. While the institutional context of WAPP is specific to West Africa, the framework developed in this paper provides a structured lens for analysing and guiding RTCA reforms in other regional electricity markets. More broadly, it suggests that successful RTCA should be understood as a multidimensional regulatory process that requires the alignment of techno-economic, institutional, political, and financial arrangements.

1. Introduction

In a multi-national integrated power system, the regional transmission network refers to the part of the transmission network that enables power exchanges to take place among agents in the regional market, encompassing cross-border lines and major transmission corridors even if they are completely internal to the participating countries (ESMAP, 2024). Operating at high voltages (typically above 66 kV), these networks transport large amounts of power efficiently over long distances. Furthermore, they are increasingly recognised as strategic assets that underpin economic integration, energy security, and the decarbonization of power systems (IRENA, 2024; IEA, 2024). Several studies present the substantial benefits that can be achieved through the investment in regional transmission networks, both in developed and developing regions (Chattopadhyay, 2025). In Europe, modelling suggests that increasing cross-border transmission capacity by 64 GW—with an annual investment of about €2 billion after 2025—could reduce generation costs by approximately €5 billion per year by 2030 (ENTSO-E, 2023). Similarly, the Southern African Power Pool's updated master plan estimates that coordinated regional

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transmission planning under its "realistic integration" scenario—accounting for key technical and institutional constraints—would meet projected 2045 demand while cutting investment costs by $111 billion (39%) compared with a benchmark based on uncoordinated, country-by-country expansion plans (SAPP, 2026). In the Middle East and North Africa, the World Bank analysis of the Pan-Arab Electricity Market shows that every $1 billion invested to enhance regional cross-border infrastructure can yield $4.60 billion in system cost savings (World Bank, 2021).

Despite compelling evidence of the economic and operational benefits of regional transmission infrastructure, actual investment remains far below what is required, particularly in sub-Saharan Africa (AEEP, 2022; AfDB, 2024). One central issue in mobilising this investment is the challenge of allocating the costs of regional transmission networks. Regional transmission cost allocation (RTCA) has been repeatedly identified as a decisive factor in determining whether new cross-border infrastructure is ultimately built (Shu and Mays, 2025; CERRE, 2025; Sen, 2024; Pérez Arriaga, 2021; Bushnell, 2019). While it is often framed as a techno-economic-regulatory problem, the reality is that RTCA is also influenced by a broader set of political, institutional, financial, and capacity-building factors. These factors have largely been examined in isolation in adjacent literature, while remaining unexplored in the cost allocation literature, as discussed in Section 2. This paper addresses that gap by developing a holistic framework that explains how techno-economic, institutional, political, and financial dimensions jointly shape RTCA implementation.

This paper develops a holistic framework for the design and implementation of RTCA. The framework conceptualises RTCA as the interaction between the techno-economic-regulatory foundations of this problem and the institutional governance, political economy, and financial dimensions of it, explaining how technically sound RTCA reforms can become practically implementable. It is illustrated through an embedded case study of the recent RTCA reform in the West African Power Pool (WAPP), drawing on technical modelling, documentary analysis, stakeholder consultations, and the authors' direct participation in the reform process. The paper uses the recent experience in WAPP to illustrate how RTCA design and implementation requires navigating a complex set of institutional, political, and financial trade-offs—the "can of worms" that emerges once RTCA moves from theory to practice.

The remainder of the paper is organised as follows. The next section reviews how the topic has been addressed in the literature and identifies the analytical gap this study seeks to fill. Section 3 presents the research design and evidence base underpinning the analysis. Section 4 revisits the techno-economic-regulatory view of RTCA, from the guiding principles to the associated implementation challenges. Building on this, Section 5 develops a holistic view of RTCA, discussing the institutional framework and the practical implementation aspects linked to governance, political economy, and finance. Finally, Section 6 illustrates the framework through the recent RTCA reform in WAPP, before Section 7 concludes with the main findings, limitations, and broader implications.

2. Literature review

The topic of RTCA has primarily been examined from techno-economic and regulatory perspectives, with most studies focusing on the development and evaluation of cost allocation methods. These methods can broadly be grouped according to the underlying principle used to determine who should bear transmission costs. One family of approaches is benefit-based allocation, which assigns costs in proportion to the benefits that each agent receives from a transmission investment, using different theories for quantifying these benefits (Pérez-Arriaga, 1992; Contreras and Wu, 1999, 2000; Roustaei et al., 2014; Meeus and He, 2014; Banez-Chicharro et al., 2017; Avar and Sheikh El-Eslami, 2022; N. et al., 2022). A second family comprises usage-based allocation, which charges agents in proportion to some measure of their utilisation of the network (Happ, 1994; Shirmohammadi et al., 1989; Pérez-Arriaga et al., 1995; Bialek, 1997; Olmos and Pérez-Arriaga, 2007b; Nikoukar et al., 2012). A third category of methods renounces attempting the search for cost causality and adopts simple cost allocation rules, such as allocating the cost according to the line length in each country or pro rata allocation in proportion to countries' peak demand or generation (Ghayeni and Ghazi, 2011; Haro et al., 2025). The techno-economic debate about the merits of these approaches has advanced the conceptual understanding of the implications of the allocation of costs among users and jurisdictions, but it overlooks the practical and institutional dimensions of the implementation of any cost allocation method.

Beyond the RTCA literature, a substantial body of research has shown that the success or failure of power sector reforms depends not only on technical design but also on governance arrangements, institutional capacity, and political economy. Rather than being purely efficiency-driven exercises, regulatory reforms are shaped by broader factors. Gratwick and Eberhard (2008), for example, demonstrate that the failure of the "standard model" of power sector reform in many developing countries led to the emergence of hybrid electricity markets, where institutional realities often outweighed textbook prescriptions. More recently, Ekanem et al. (2025) show that electricity sector reforms are frequently characterised by institutional layering, whereby new regulatory arrangements are gradually introduced while older structures continue to coexist and influence policy outcomes. Likewise, Pavanelli et al. (2023) argue that the evolution of the Nigerian electricity sector cannot be understood solely through formal regulatory reforms but requires consideration of broader institutional dynamics, governance structures, and historical legacies.

The importance of political economy has also been widely recognised in the broader energy transition literature. Ragosa et al. [2024], through a comparative analysis of Britain, Italy, and California, demonstrate that resource adequacy and renewable energy integration are fundamentally shaped by political priorities, governance arrangements, state-market relations, and stakeholder interests rather than by technical considerations alone. Similarly, Zhou et al. (2019) show that the adoption and evolution of renewable energy policies are influenced by mechanisms of policy learning, political competition, normative emulation, and institutional coercion across jurisdictions. These findings collectively suggest that regulatory outcomes emerge from negotiations among actors operating within specific institutional settings, rather than from the intrinsic superiority of particular technical solutions.

Within the transmission literature, similar conclusions have emerged. Stafford and Wilson (2016) analyse the policy-making processes of Regional Transmission Organisations (RTOs) in the United States through the Strategic Action Field framework, illustrating how stakeholder coalitions, institutional arrangements, and organisational incentives shape transmission-related policy decisions. More recently, Chelminski (2025) shows that successful transmission expansion depends on the alignment of organisational capacity, political coalitions, and policy windows, helping explain why some jurisdictions deploy transmission infrastructure more effectively than others. Together, these studies demonstrate that governance, institutional authority, stakeholder engagement, and political bargaining are central determinants of transmission policy implementation. However, they pay comparatively little attention to how these broader governance dynamics interact within the specific topics.

The importance of institutions and political economy becomes even more pronounced in the context of regional electricity markets, where regulatory reforms must be coordinated across multiple sovereign jurisdictions with distinct political priorities, regulatory traditions, and levels of institutional capacity. Studies of cross-border electricity infrastructure increasingly recognise that regional power pools are not merely technical market arrangements but complex systems of regional governance requiring sustained political commitment and institutional coordination. Puka and Szulecki (2014), for instance, conceptualise cross-border electricity infrastructure as a political and institutional

process involving multiple actors with divergent interests, arguing that infrastructure development depends as much on governance and interstate cooperation as on engineering and economics. Similarly, Vanheukelom et al. (2016) show that African regional integration initiatives are fundamentally shaped by political settlements, regional power asymmetries, and the incentives of national governments, suggesting that formal institutional arrangements alone are insufficient to explain integration outcomes.

Recent work focusing specifically on African power pools reinforces these conclusions. Hancock (2024) argues that the institutional evolution of African power pools reflects historical path dependencies, regional political dynamics, and long-term state-building processes, rather than following a uniform model of market integration. Likewise, Elabbas et al. (2023) demonstrate that the evolution of African power pools has been strongly influenced by their specific historical, political, and institutional contexts, emphasising that regional institutions must continuously mitigate non-cooperative behaviour, address members' concerns, and align national incentives to sustain integration. At the regulatory level, Bissiri et al. (2024) and Ojomo (2023) emphasise that effective regional electricity trade in West Africa depends on coherent governance, requiring harmonised regional and national regulatory frameworks alongside institutional arrangements that balance national sovereignty with supranational coordination.

A related stream of literature highlights the importance of credible regulatory and commercial frameworks for mobilising investment in transmission infrastructure, particularly in developing countries. Studies of electricity sector finance emphasise that predictable cost recovery, regulatory stability, and bankable revenue mechanisms are essential for attracting both public and private investment, especially where sovereign risk and institutional uncertainty remain significant (World Bank, 2017; Gridworks, 2022; Rose et al., 2019). Likewise, recent assessments of regional electricity markets argue that financing cross-border infrastructure requires governance arrangements capable of providing long-term confidence to investors and development partners (ESMAP, 2024). Nevertheless, these financial implementation considerations have rarely been examined alongside the technical design, despite their central importance for translating regulatory reforms into investable regional infrastructure.

Despite all these important contributions, the literature remains fragmented. Technical studies on RTCA primarily focus on discussing the techno-economic-regulatory principles of RTCA and the performance of allocation methods, while governance and political economy studies in adjacent literature rarely examine how institutional, political, and financial considerations influence the technical design and shape the development and implementation of power sector reforms. Consequently, there remains no analytical framework that systematically integrates the techno-economic, institutional, political economy, and financial dimensions of any RTCA reform. This paper addresses that gap by developing such a holistic framework and illustrating its application through the recent RTCA reform process in the West African Power Pool.

3. Research design and evidence base

This paper adopts a qualitative research design that combines conceptual framework development with an embedded case study of the recent reform of the RTCA regulation in WAPP. The study develops a holistic analytical framework by synthesising and integrating insights from the technical RTCA literature (discussed in Section 4), the broader literature on electricity sector governance, political economy, and financing in this context, and the practical experience of regional electricity market reform (discussed in Sections 2 and 5). The WAPP reform is used as an illustrative case through which the applicability and explanatory merits of the framework are examined.

The empirical analysis draws on multiple complementary sources of evidence. First, documentary analysis has been undertaken using publicly available regulatory instruments, institutional reports, technical studies, and official regulatory documentation of WAPP (ERERA, 2013, 2015, 2019, 2026a, 2026b; ECOWAS 2007, 2008; WAPP 2021, 2023). Second, the study builds upon the technical modelling and comparative assessment undertaken by the authors during the RTCA revision process in WAPP, including sensitivity analyses evaluating alternative allocation methodologies and design choices (Elabbas et al., 2026), and previously in the European market (Olmos and Pérez-Arriaga, 2007a, 2007b). Third, the analysis incorporates evidence obtained through continuous stakeholder engagement during the reform process in WAPP, including technical workshops, regulatory discussions, consultations with national utilities, regulators, regional institutions, financial partners, and advisory organisations. The combination of these sources enabled the triangulation of technical findings with institutional and practical considerations, reducing reliance on any single source of evidence.

All the authors have participated directly in different stages of the WAPP RTCA revision process, gaining privileged access to technical discussions and implementation considerations that are not fully documented in the public domain. Specifically, the last three authors provided extensive capacity building on the techno-economic principles of RTCA to the leadership of the regional regulator and the system operator of the WAPP, which initiated the RTCA revision process; the first three authors contributed to the technical modelling, methodological assessment, and stakeholder discussions supporting the revision of the RTCA framework; while the fourth author participated in advisory activities related to the institutional, political economy, financial, and implementation dimensions of the reform through the Tony Blair Institute for Global Change, an independent not-for-profit policy institute. This involvement provided valuable insight into the evolution of the reform while also requiring careful attention to analytical neutrality. To mitigate potential bias, the analysis distinguishes, wherever possible, between documented institutional decisions, results supported by technical analyses, and the authors' interpretation of the broader regulatory process.

The purpose of the WAPP case is not to claim universal validity or to evaluate the final performance of the revised RTCA framework, whose operational implementation remains an evolving process. Rather, the case serves as an analytically informative example of how technical, institutional, political, and financial considerations interact and influence the design and implementation of the RTCA reform. While the specific institutional arrangements of WAPP are shaped by the West African context, the holistic framework developed in this paper is intended to provide a structured lens for understanding, analysing and driving similar reform processes in other regional electricity markets.

4. The techno-economic-regulatory foundations of cost allocation

The previous section points to the fact that the RTCA literature has largely evolved around the technical and regulatory design of cost allocation methods. Building on that literature, this section reviews the techno-economic-regulatory foundations that underpin RTCA. It distils the key principles that any sound RTCA methodology should incorporate and discusses the practical implementation challenges that motivate the holistic framework developed in the following section.

4.1. The guiding principles of RTCA

Sound RTCA regulation treats regional transmission infrastructure as a shared asset that enables the efficient development of power trade. Accordingly, transmission costs are recovered through a regulated remuneration, typically as an annuity spread over its lifetime. Since transmission costs arise predominantly from the grid's construction and investment, as operation and maintenance expenses are proportional to the project's size, cost recovery is driven by investment rather than by the amount of electricity transported through the network, which does not cause any cost to the transmission network developer (Rivier et al.,

2013). Once a line is built and becomes part of the network, its investment costs must be recovered, regardless of the amount of electricity flowing through it.

Drawing on decades of theoretical development and practical regulatory experience across different power systems, a broad consensus has emerged around a set of techno-economic-regulatory principles that should guide the design of RTCA methodologies.[1] These principles synthesise insights from microeconomic theory, power systems engineering, and regulatory practice (Olmos and Pérez-Arriaga, 2007a; MIT, 2011; Rivier et al., 2013; Hogan, 2020; ESMAP, 2026). Although different regions may implement these principles through different methodologies, these principles provide the common normative foundation upon which sound RTCA frameworks are designed. These are:

- RTCA should not depend on commercial transactions, since in an efficient system operation, resulting from efficient trading arrangements, electrical flows are determined by the demand and the dispatched generators according to the laws governing the network and regardless of the specific contractual arrangements of these generators and demand;
- RTCA should be based on benefits or, alternatively, actual or estimated future network usage, ensuring that transmission costs are allocated according to economically meaningful measures of cost causation or the services provided by the network;
- RTCA should facilitate the agreement on new projects with net positive benefits, so that cost allocation supports rather than obstructs economically efficient infrastructure expansion;
- RTCA should not interfere with the short-term operation of market agents, preserving efficient operational decisions and avoiding distortions to dispatch or cross-border trade;
- RTCA should be carried out at the country level, leaving each country with the authority to determine how the network costs allocated to it should be charged on its internal network users; and
- RTCA should not introduce unnecessary investment risk, providing stable and predictable revenue recovery mechanisms that support the financing of long-lived transmission infrastructure.

While these principles are recognised within the technical and regulatory literature, they do not by themselves determine whether an RTCA reform can be successfully adopted or implemented. Translating these principles into practice carries with it regulatory challenges that are discussed in the following subsection and subsequently integrated into the holistic analytical framework developed in Section 5.

4.2. Applying the RTCA principles: regulatory implementation challenges

The practical application of the aforementioned principles requires methodological and regulatory decisions, each involving trade-offs between theoretical accuracy, transparency, robustness, and implementability. These choices remain largely within the techno-economic-regulatory domain, yet they already reveal some of the practical tensions that become more pronounced once institutional, political, and financial considerations are introduced.

The first set of implementation challenges concerns the translation of general allocation principles into an operational method:

- ***Quantifying benefits***: Allocating costs in proportion to benefits is often seen as the equitable approach, which is closest to cost causality (assigning network costs to those causing them), yet, in practice, it is highly challenging. The benefits of cross-border projects differ across jurisdictions and are multidimensional, ranging from measurable gains—such as lower production costs—to broader socio-environmental outcomes, like reduced carbon emissions (Fink et al., 2011; ENTSO-E, 2018). Many of these benefits resist precise monetisation and depend on normative assumptions, making it difficult to design an allocation method that is technically robust, politically acceptable, and implementable across states. From a regulatory perspective, the RTCA framework should therefore preserve sufficient flexibility for countries, or systems, to negotiate the mutually acceptable cost allocations whenever the beneficiaries of new investments can be identified with reasonable confidence. If a project delivers positive net benefits—total benefits exceed total costs—then, there exists an allocation of costs that leaves all affected parties better off. One tool often employed in this context is the regulatory test, a formal assessment designed to ensure that the overall benefits of a transmission project exceed its costs. If properly implemented, the cost–benefit analysis conducted as part of the regulatory test to approve the undertaking of new transmission projects can also help identify their beneficiaries, thereby supporting the negotiation process. However, if the negotiation process fails and no consensus is reached, leaving any estimate of the benefits that network users and systems obtain from projects highly contested, then allocation should be performed according to an estimate of the level of the expected usage of these projects by network users and systems. For this, the competent authorities could use a previously defined and agreed-upon method in the RTCA framework.
- ***Measuring network usage***: Several methods attempt to measure network usage, each with its own method-specific assumptions. Some, such as contract path (Happ, 1994) and MW-km (Shirmohammadi et al., 1989), are fundamentally flawed because they are based on commercial transactions (see Elabbas et al. (2026) for more details). Others—like marginal participations, transient flow, or Z-bus-based methods—depend on contentious electrical assumptions that make results difficult to defend (Pérez-Arriaga et al., 1995; Conejo et al., 2002; Nikoukar et al., 2012). Among these methods, the Average Participations (AP) method provides results that are consistent with techno-economic principles, avoids arguable assumptions, and directly uses actual or expected network flows (Bialek, 1997; Vazquez et al., 2002; Olmos and Pérez-Arriaga, 2007a). For these reasons, AP has become an increasingly attractive candidate for transmission cost allocation in many jurisdictions.

Even after selecting an allocation method, several regulatory design decisions remain necessary before an RTCA framework can be implemented. These are related to the following issues, among others:

- ***Selecting a demand and generation split-key***: When cost allocation is based on network usage, it becomes necessary to define a split-key between demand and generation. Since power flows always originate from generation and terminate in demand, both sides make equal physical use of the network, making a 50–50 split a natural and neutral choice. However, a different split-key may be adopted where justified by specific regulatory or system considerations, particularly if this key may condition new investments in generation,[2] provided it remains consistent across the regional framework. Thus, the split-key should be understood not as a purely engineering parameter but as a regulatory design choice.
- ***Defining regional transmission assets and their costs:*** Initially, the RTCA framework must establish a clear definition of what qualifies as regional assets and adopt a standard methodology for their cost valuation. It should also account for other revenue streams generated

[1] For a more detailed discussion of the historical evolution of RTCA thinking and the transition away from transaction-based charging, see Elabbas et al. [2026].

[2] For instance, if the feasibility of several new generation investments and the choice among them are conditioned by the transmission charges allocated to them. In such cases, it might require going back to the allocating the cost between generation and demand according to benefits.

by these assets, such as congestion rents, to avoid over-recovery of costs.

- ***Treatment of existing assets:*** For transmission assets that were built long ago but are now used to facilitate regional trade, allocating their costs to the original beneficiaries, those whose expected benefits motivated the need to build them, is practically impossible. In such cases, network costs should either be allocated based on usage, if a commonly agreed method is defined, or socialised in a manner that does not impact energy trade.

A final implementation challenge concerns the treatment of uncertainty:

- ***Selecting future scenarios***: Allocating the costs of new projects inevitably depends on assumptions about future system conditions, linking RTCA to planning. This process is subject to considerable uncertainty, given the long lifetime of grid assets and the difficulty of forecasting demand growth, renewable penetration, fuel prices, or changes in national energy policies. The challenge is even greater in contexts where regional planning is weak or absent, or where the development of the regional network is heavily dependent on large new generation or demand projects—such as wind farms or hydropower plants—whose commissioning can drastically alter flows. In practice, ex-post settlement mechanisms—such as adjustments based on actual flows or usage—could mitigate some of these uncertainties.

As discussed in the next section, addressing these challenges and managing the implementation of techno-economically sound RTCA reform requires moving beyond the techno-economic-regulatory perspective towards a broader framework encompassing institutional governance, political economy, and financial implementation.

5. A holistic framework for RTCA design and implementation

The practical implementation of RTCA cannot be fully determined by its techno-economic and regulatory logic alone. This section develops a holistic perspective of RTCA by integrating the institutional, political economy, and financial dimensions required to make RTCA workable in practice. The three dimensions are analytically separated for clarity, although in practice they are highly interdependent, as well as with the features of the techno-economic solution adopted. Institutional arrangements determine who has the authority to make decisions and coordinate implementation. Political economy shapes the incentives and willingness of stakeholders to accept these decisions. Financial arrangements determine whether the agreed framework is credible, bankable, and sustainable over time, and whether financing sources become accessible for those transmission projects whose costs are to be allocated. Weaknesses in any one dimension inevitably affect the functioning of the others.

5.1. RTCA institutional dimension

Among the three dimensions, the institutional dimension provides the enabling architecture upon which the political and financial dimensions operate. A functioning RTCA regime depends critically on a well-defined institutional framework that clearly allocates responsibilities across regional and national actors and establishes credible decision-making, implementation, and enforcement mechanisms. Without institutional clarity, neither political agreements nor financing arrangements can be translated into effective regulation, and even technically sound RTCA proposals risk being delayed, abandoned, or implemented inconsistently across jurisdictions. The institutional framework is therefore not merely a matter of regulatory design but also of sequencing, incentives, and operational coordination—determining who proposes the rules, who evaluates and approves them, who implements them domestically, and who enforces compliance. Establishing such a framework requires the presence of a regional political and governmental body with supranational power capable of creating the subsequent regional institutions and giving them their legal mandates and authority. The institutional arrangements through which this authority is exercised differ across regions. For example, in the European Union, executive powers exercised by the European Commission have enabled the delegation of regulatory responsibilities to institutions such as ACER. In contrast, many African regional organisations rely primarily on intergovernmental coordination, whereby regional decisions require implementation by national governments rather than direct supranational enforcement. Other regions, such as the Central American Regional Electricity Market, have adopted intermediate arrangements by creating regional regulatory and operational institutions with delegated executive powers through multilateral agreements. These governance models shape the institutional capacity to adopt, coordinate, and enforce regional RTCA reforms, and therefore constitute an important determinant of their implementation (refer to Vanheukelom et al. (2016) and Elabbas et al. (2023) for more details).

A fundamental step in establishing such a framework is building institutional capacity. The need to design a regional or continental market that is aligned with best international practices must be communicated and must get the buy-in at the highest executive level that matters. Then, an appointed team of experts must examine the best practices successfully adopted in other regional markets and adapt them to the relevant regional context. The RTCA principles discussed above should guide both the selection and implementation of allocation methodologies by system operators and the design of tariff regulation by regulators. Building this technical and regulatory capacity within a coherent institutional framework is therefore a *sine qua non* for adopting sound RTCA regulation.

5.1.1. Institutional actors

In addition to the top-level decision-making institutions mentioned in the preceding section, which are specific to each regional or continental organisation and in principle must be accepted as they are, the institutional actors at the next lower decision-making level can be classified into two categories according to their role in the RTCA process. The first comprises the core institutions that collectively constitute the RTCA governance regime and are directly responsible for designing, implementing, monitoring, and adapting the methodology. The second comprises external actors that do not have formal managerial responsibilities on the RTCA but exert significant influence over its development and implementation. All these actors are involved in the RTCA reform. Drawing on the experience of mature regional electricity markets, particularly the European Internal Electricity Market and the Central American Electricity Market (MER), the core RTCA governance regime typically comprises the following institutional actors:

- ***The regional regulatory authority (RRA)***: Decides the RTCA methodology and approves any modifications to it; oversees its execution and associated payments; resolves arising disputes from its implementation; and implements sanctions and penalties when necessary.
- ***The regional system operator (RSO)***: Serves as the technical body that produces the engineering and economic analyses that underpin allocation methodologies, since it has access to network data and operational realities. It is in charge of executing the approved RTCA methodology, defines the execution procedure, and could propose modifications to it.
- ***National regulatory authorities (NRAs)***: Translate the RTCA rule into binding national regulation and enforce it domestically

(adapting national tariff revenue collection and regulations where necessary).

- ***National system operators (NSOs)***[3]: Ensure day-to-day system operation, including billing and revenue-collection mechanisms required to implement the RTCA arrangements.

The allocation of responsibilities across these actors follows a clear functional logic. Regional institutions are responsible for ensuring consistency and preserving the integrity of the regional market, while national institutions retain authority over domestic implementation. This allocation reflects the principle of subsidiarity: decisions should be taken at the regional level only where regional coordination is essential, while national authorities retain discretion over matters confined to their own jurisdictions. Such a governance structure helps reconcile regional market integration with national regulatory sovereignty. It is worth noting that the institutional structure of both the RRA and RSO can vary across regions (Elabbas et al., 2023). In some cases, they are established as independent regional entities with their own staff, governance, and decision-making powers. In others, they function as coordinated assemblies of the existing NRAs and NSOs (Rose et al., 2019). Regardless of their form, both bodies must ensure the effective representation of national actors, since their legitimacy and operational success depend on the close alignment and participation of the corresponding national regulators and system operators.

External actors include national and regional governmental bodies, which set the overarching policies and mandates of the RTCA regime; investment and financial institutions, which provide capital for transmission projects and to whom a return of capital (from the annuity) is owed (unless the capital is provided as a grant); and technical advisory institutions, which support system operators in the technical analysis. Through their formal and informal relationships with the actors in the RTCA regime, these actors can either facilitate or hinder the effective implementation of the RTCA regulation.

5.1.2. Institutional relationships and coordination

The implementation of RTCA is conditioned by the relationships and coordination between the different actors. These institutional relationships are formally defined by actors' legal mandates, regulatory instruments, and established governance structures. Together, these elements specify the procedural steps for decision-making and the flow of responsibilities across regional and national levels. They determine how the RTCA regulation is developed, approved, implemented, and enforced, as well as how each institutional actor can influence the process. In essence, these formal relationships constitute the operational backbone of the RTCA framework.

At the core of the RTCA regime, the NRAs and NSOs engage directly with the RRA and RSO through continuous consultation on the RTCA rule, ensuring that both the technical and regulatory perspectives are reflected in the design and execution of the methodology. The RSO develops the engineering and economic analyses that underpin the allocation methodology, drawing on operational information provided by the NSOs and consultations with both regional and national regulators. Based on these analyses, the RSO executes the approved methodology and reports the resulting allocations to the RRA. The RRA oversees implementation, manages the compensation payments and resolves any disputes that might arise among the NSOs. The RSO could submit a request for modifications to the RTCA rule to the RRA, which then assesses it and makes a final decision.

Beyond the interactions among regional actors themselves, successful implementation depends on effective coordination between regional and national institutions. Regional regulation should, in principle, play a subsidiary role to national regulation, setting common principles and binding rules only for cross-border issues while leaving domestic tariff design and other matters to local authorities. When allocation is made at the country level, each jurisdiction may recover its cost share domestically through its own mechanisms, without the need to impose a uniform RTCA method. Nevertheless, implementing these regional rules may still require adjustments to national regulations and tariff revenue collection. This is particularly the case when network compensation payments are received or when national regulatory provisions conflict directly with the RTCA regulation.

Despite these clear functional assignments, formal approval processes can become bottlenecks. The typical sequential model, where the regional system operator prepares a proposal, the regional regulator reviews and approves it, and each national regulator subsequently undertakes its own procedures before national implementation, creates two recurring problems. First, procedural fragmentation arises when each NRA applies its own consultation, impact assessment, and legal review, leading to multiple rounds of revision and considerable delays. Second, political reversion can occur when, even after technical approval, NRAs or governments delay ratification due to domestic political pressures or competing priorities. Both issues emerge when there is no regional authority with supranational power to approve directives and regulations at the regional level, thereby limiting the process to the formal approval by the regional regulator (in consultation with the NRAs).

These challenges show that institutional effectiveness depends not only on establishing formal relationships but also on designing governance processes that reduce coordination costs and facilitate collective decision-making. To address these challenges, process innovations are necessary. Simultaneous approval windows can reduce unnecessary procedural delays by ensuring synchronising national decision-making processes. Joint approval committees that bring NRAs and the RRA together can facilitate the resolution of conflicts arising from domestic regulatory constraints before formal adoption (for instance, when national regulation is not aligned with the RTCA regulation). External actors, such as financial organisations, development banks, and technical consultants, can play a pivotal role in facilitating these processes by providing analytical support, facilitating negotiations, and reducing information asymmetries among stakeholders.

Fig. 1 synthesises these institutional relationships into a generic formal chart of governance architecture for RTCA implementation, following the policy analysis framework proposed by Enserink et al., (2022). The figure highlights the separation between regional decision-making (RRA and RSO) and national implementation (NRAs and NSOs), showing how technical analysis, regulatory approval, tariff enforcement, and financial settlement are distributed across different institutional levels. This separation is central to the framework because it determines where coordination problems and procedural delays could occur. The figure also shows why external actors such as development banks and technical advisory institutions can influence RTCA outcomes despite not being part of the formal regulatory regime: they affect the technical evidence available to decision makers and the financial resources for investment.

Note that the formal chart focuses specifically on the institutional relationships that constitute the RTCA regime and therefore does not seek to represent the broader constitutional or political relationships among external actors. In practice, these broader governance arrangements may also play an important enabling role. For example, in some regions the regional political authority may possess executive powers to adopt binding measures directly applicable to national governments, whereas in others implementation relies primarily on intergovernmental coordination and subsequent national action. These higher-level institutional arrangements influence the effectiveness and enforceability of the RTCA framework but lie outside the scope of the formal institutional chart.

Finally, the institutional structure presented here is general and not

[3] Note that the term NSO is used generally in this article, i.e., it can be a system operator without owning the transmission network, or a transmission system operator, or a vertically integrated incumbent utility.

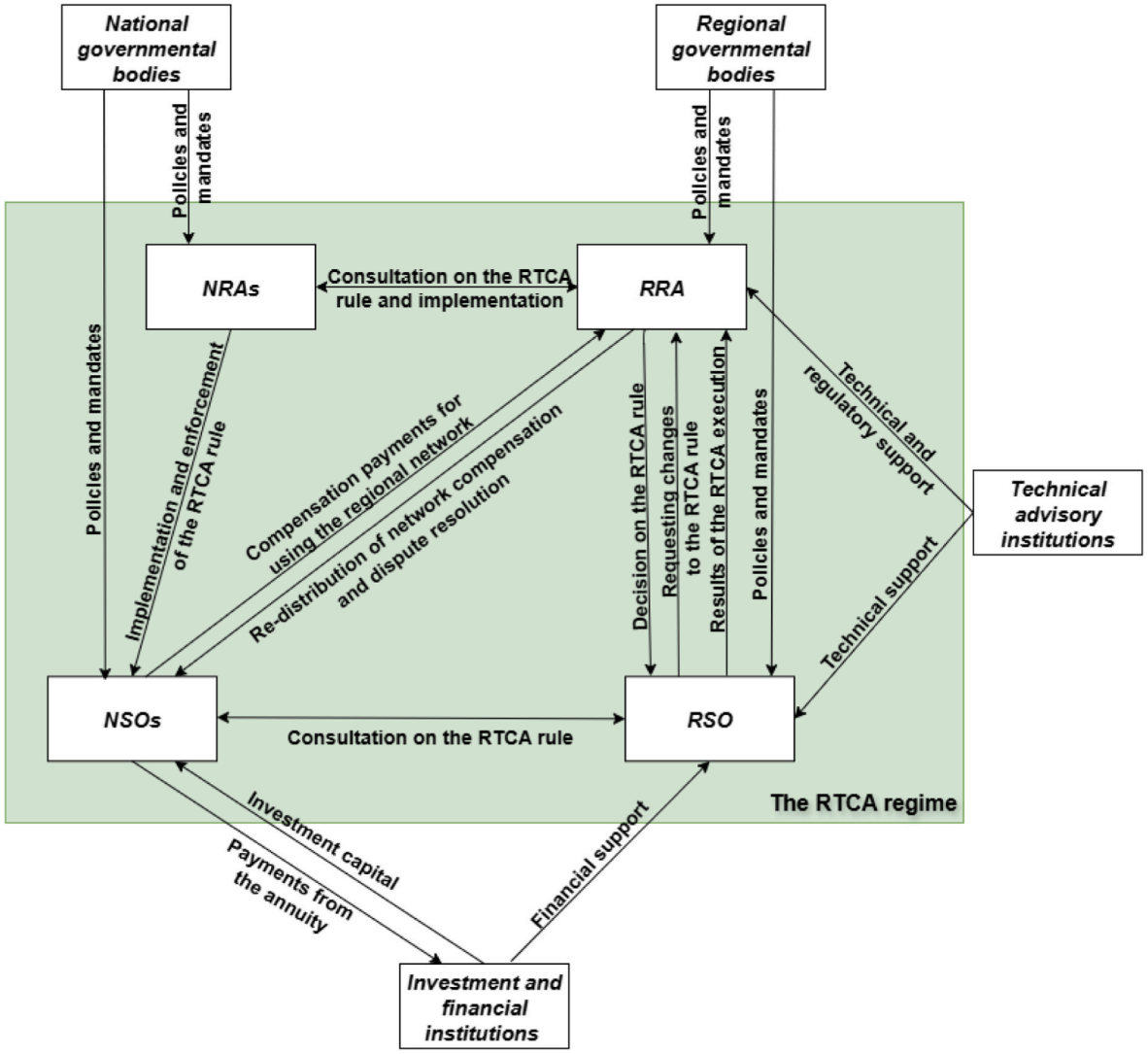


Fig. 1. The formal chart of the RTCA regime and its external actors, based on the framework of Enserink et al., (2022).

unique; it could take different but functionally equivalent forms depending on the specific institutional settings. For instance, in the absence of a national regulator or a national system operator, their functions are typically assumed by the energy ministry or the incumbent utility, respectively, effectively substituting for them in the formal chart. Similarly, the management of network compensation payments could be delegated to an independent entity, which would then assume the corresponding formal relationships with the NSOs, RRA, and RSO. What remains essential is not the precise institutional form, but that these institutions, especially the regional ones, are endowed with sufficient executive power and legal authority to effectively fulfil their functions and mandates. If such institutions are not established or not given sufficient authority for regional decision-making, the regional political and governmental body will retain the final approval and implementation of the RTCA framework.

5.2. RTCA political economy dimension

Even when grounded in correct techno-economic principles and institutional framework, RTCA is a political economy issue at heart. The RTCA regime is influenced by political actors who operate under incentives that often diverge from the collective regional interest (Vanheukelom et al., 2016). From the perspective of the holistic framework proposed in this paper, political economy primarily influences RTCA by shaping the technical and regulatory choices that define the methodology itself. Decisions on cost allocation inevitably have distributional consequences, determining which countries bear higher costs and which benefit from reduced payments. These distributional tensions frequently translate into political resistance, shaping preferences for specific cost-allocation methods or entrenching the status quo. As such, RTCA risks becoming a politically sensitive negotiation rather than a purely technocratic exercise. The challenge lies in reconciling political feasibility with economic efficiency—designing an RTCA framework that is both sound and acceptable to those who must implement and adhere to it.

National governments and utilities approach RTCA negotiations with differing incentives shaped by their trading positions and relative economic and political power. These diverging interests, further influenced by countries' institutional capacity and bargaining strength, have direct implications on:

- ***The choice of allocation method***: Given the significant economic and political implications, disagreement and debate over the most appropriate method are common. In the absence of accepted guiding principles, selecting an RTCA method becomes an endless and unstable process of negotiating acceptable distributional outcomes. Even if some best practices – such as ignoring commercial transactions in cost allocation – are accepted, the absence of a universally

accepted specific cost allocation rule still complicates the debate. As a result, countries frequently advocate for methods that allocate costs in their favour. Net-exporting countries, often endowed with abundant and low-cost generation resources, tend to advocate for cost allocation approaches that minimise their own financial burden and facilitate export opportunities. Conversely, net-importing countries, whose consumers benefit from access to cheaper regional power, often support allocation schemes that spread costs more evenly or assign a larger share to exporters. In addition, countries that host transient flows, so-called wheeling countries, would favour a method that emphasises compensation based on transit flows (e.g., comparing with and without transit conditions).

- ***The choice of the split-key***: Although network usage provides a technical basis for determining how costs should be shared between generation and demand, the selection of the split-key also carries important distributional consequences. Countries that host abundant generation resources may favour a higher percentage of cost to be allocated to demand at the regional level, whereas importing countries favour the opposite. Additionally, within each country, governments must also weigh the interests of generators, consumers, utilities, and system operators. For instance, while importing countries benefit from lower wholesale prices, they might face domestic opposition from producers who lose market share and sell at lower prices, and oppose a higher cost percentage to generation (CERRE, 2025). This issue is more pertinent in countries with an unbundled power system, whereas in countries with vertically integrated utilities, the net trading position of each typically drives their political agenda. These domestic political considerations influence national negotiating positions in regional discussions.
- ***The choice of how forward-looking the RTCA should be***: Any RTCA method necessarily relies on assumptions regarding future network usage, system development, and benefits of network investments. Countries that believe that terms of trade will change, as well as countries that are less experienced in long-term plans, may want to revise the allocated amount more frequently, or they may even require ex-post adjustments based on actual flows, thereby reducing the predictability of financial flows for investors concerning either the overall amounts of these flows, if the remuneration of assets is associated with their level of electrical flow (contrary to sound principles), or the identity of those deemed to be benefiting from or using regional network assets and, therefore, liable for paying for them.
- ***The choice of the financial responsible entity***: Any RTCA framework adopted requires that one or more delegated entities per country are responsible for the payments of the agreed compensations. The effectiveness of the payment mechanism depends on the national arrangements for revenue collection and financial settlement. If the entity responsible for transferring the regional compensation does not have timely access to the corresponding transmission revenues, payment obligations may become difficult to fulfil, particularly in jurisdictions with low tariff collection rates.

In addition to influencing the decision on RTCA technical design variables, political actors could also influence the implementation phase. The literature on electricity sector reform consistently shows that implementation critically depends on existing institutional arrangements, legacy contractual structures, and the incentives facing governments and regulated entities (Gratwick and Eberhard, 2008; Pavanelli et al., 2023; Klug et al., 2022). This is particularly the case when bilateral contracts are the dominant mode of cross-border exchange in the region and when the national tariffs are determined by the government rather than through a cost-reflective regulatory rule. These two characteristics are prominent in the context of developing countries (ESMAP, 2024) and have implications for the establishment of RTCA frameworks. Two implementation challenges are particularly relevant:

- ***The interaction with national tariff regulation***: National tariffs form the backbone of the RTCA framework because they are the mechanism through which the allocated transmission costs are ultimately recovered from end users. Adjusting national tariffs according to the cost faced for using foreign networks—or compensation for hosting flows from neighbouring countries—is difficult to reconcile with politically set tariffs, particularly when they affect sensitive consumer categories or national revenue streams. In practice, regulators in developing contexts often default to transactional or territorial allocation approaches, not because they are economically sound, but because they are simpler to implement and easier to justify politically. Transaction-based charging, despite its technical flaws, has political appeal because it aligns with the narrative of "you pay because you trade", and they only involve the trading parties.
- ***The transition from legacy arrangements***: Moving toward a unified RTCA framework would require abolishing transmission service agreements (TSAs) associated with bilateral contracts. These agreements often contain rigid cost-sharing and payment arrangements that are politicised and difficult to abandon, creating vested interests and friction with any new regional RTCA rule. Successful implementation, therefore, rarely involves replacing existing arrangements overnight. Instead, transitional mechanisms that allow gradual adaptation, preserve contractual certainty, and build confidence among participating countries are often essential for securing political acceptance. From a political economy perspective, transitional arrangements are not merely implementation tools but governance mechanisms that reconcile the long-term objective of regional integration with the short-term distributional concerns of individual stakeholders.

Finally, political dynamics also affect the pace of implementation. Domestic approval processes can stall due to competing national priorities, changes in government, or concerns about short-term political costs. To mitigate these political-economy frictions, advisory and supporting institutions play a crucial mediating role. By providing independent technical analysis and facilitating dialogue, they can depoliticise certain aspects of decision-making and help build trust among stakeholders, especially during the transitional period. In this context, sustained political engagement, transparency, and trust-building are not optional add-ons but essential conditions for making RTCA workable in practice.

5.3. RTCA financial dimension

The financial dimension of RTCA translates institutional arrangements and regulatory rules into concrete transmission investments and flows of payments that sustain regional infrastructure. The effectiveness of the RTCA framework depends on how investments and payments are made, how risks are managed, and how financial obligations are honoured across jurisdictions. These financial aspects are particularly salient in the context of developing countries, where the creditworthiness of utilities is often limited.

5.3.1. Investment and financing arrangements

The literature on infrastructure finance and electricity sector reform consistently shows that regulatory credibility is one of the principal determinants of investment in network infrastructure. Investors evaluate not only the expected revenue generated by transmission assets but also the institutional capacity to honour long-term payment obligations, the stability of regulatory arrangements, and the allocation of financial risks among participating actors. These considerations are particularly relevant in developing countries, where regional transmission projects frequently rely on concessional finance, multilateral development banks, sovereign guarantees, and blended finance mechanisms because domestic capital markets and utility balance sheets are often insufficient to finance large cross-border investments (World Bank, 2017;

Gridworks, 2022; AfDB, 2024; ESMAP, 2024). Consequently, the financial design of RTCA directly influences the bankability of regional transmission projects. From this perspective, RTCA interacts with investment and financing through two principal channels:

- ***Revenue certainty***: Transmission investments recover their costs over several decades through regulated revenues. The predictability of these revenues is fundamental for reducing financing costs. RTCA methods that recover network costs independently of the short-term electricity transactions arranged are generally more consistent with this objective than transaction-based charging mechanisms. Linking revenue recovery to actual energy flows exposes investors to volume risk arising from changes in market conditions, dispatch patterns, renewable generation, or electricity demand, despite these factors having little relation to the original investment decision. By contrast, infrastructure-based approaches–a prescribed steady stream of annuities over a predefined economic life of the assets–separate investment cost recovery from operational variability, thereby providing a more stable financial environment (Rivier et al., 2013; Hogan, 2012).
- ***Risk allocation***: Private capital is mobilised if investors are confident that the regulatory frameworks can adequately mitigate the risks they face and provide stability in revenue streams. Dealing with uncertainty is a standard element of investment decision-making, but in the case of regional transmission infrastructure, it is especially acute given the long lifetimes of assets, the volatility of the outcome of electricity markets, and the political sensitivities of cross-border projects. The importance of these risks increases substantially in developing countries where the revenues derived from electricity tariffs do not cover the cost of supply, utilities may exhibit weak financial performance, and regulatory institutions are still evolving (Klug et al., 2022; World Bank, 2017; Gridworks, 2022). Consequently, financial instruments such as sovereign guarantees, multilateral guarantees, escrow accounts, or other ring-fencing arrangements frequently complement the RTCA methodology itself.

Although RTCA influences investment incentives through revenue certainty and risk allocation, financing arrangements are not always identical across regional transmission projects. Some projects are financed directly by regulated transmission operators, whereas others are developed through special-purpose vehicles (SPVs) or project-finance structures involving multiple governments and international financial institutions. In such cases, the financing agreements determine how capital is mobilised and how lenders are repaid during project development and operation, while the RTCA methodology determines how the long-term costs of the completed asset are ultimately shared among participating countries once it becomes part of the regional transmission system. Financing arrangements and RTCA, therefore, perform complementary rather than identical functions within the regional electricity market.

5.3.2. *Revenue recovery and payment mechanism*

While investment and financing determine whether and how regional transmission assets are constructed, revenue recovery determines whether these assets remain financially sustainable throughout their operational life. RTCA, therefore, extends beyond defining how costs are allocated among participating countries; it also requires mechanisms through which these allocations are translated into actual financial transfers. The credibility of these payment arrangements is particularly important for the implementation of an RTCA reform. A well-functioning payment system must address issues of compliance, default, and macroeconomic instability, all of which are particularly acute in developing regions.

- ***Inter-country payments***: Even where payment mechanisms are formally established, inter-country transfers can remain politically sensitive. This is particularly relevant in regions affected by political instability or tense bilateral relations. Although payments are technically justified as compensation for network usage, they can be perceived through a political lens, especially when there are pre-existing disputes or asymmetries in trade and power relations. In such contexts, governments—or even the public opinion—may resist payments to certain neighbours, associating them with unrelated political or historical conflicts. For this reason, mature regional markets often institutionalise financial settlement through centralised regional arrangements rather than relying exclusively on direct bilateral transfers between countries. Under such arrangements, participating countries meet their financial obligations towards a regional settlement entity, which subsequently distributes revenues according to the RTCA methodology. Besides simplifying administration, this institutional separation reduces the political visibility of bilateral payments and presents the RTCA framework as a neutral, rules-based, regional mechanism for accessing the regional network.
- ***Compliance measures***: Payment defaults—whether by national utilities or governments—can jeopardise not only compensation flows but also the credibility of the entire RTCA framework and increase the perceived risk of future transmission investments. Consequently, the financial credibility of RTCA is intrinsically linked to the institutional credibility of the organisations responsible for its implementation. Comparative experience indicates that regional electricity markets rely on compliance arrangements that combine positive incentives and deterrents—a "carrot-and-stick" approach. Positive incentives may include access to concessional finance, guarantees, or participation in regional funds, while deterrents may involve suspension of certain regional benefits, exclusion from the regional market, or even legal recourse. A precedent can be found in European practice.[4] Implementing these mechanisms ultimately depends on having a functional institutional framework with enforcement authority. Strengthening regional institutional capacity, thus, enhances financial credibility, lowers perceived regulatory risk, and reinforces confidence in the long-term sustainability of the RTCA framework, illustrating the interaction between the financial and institutional dimensions.

As argued above, the holistic perspective developed in this paper conceptualises RTCA not merely as a techno-economic-regulatory problem, but as a multidimensional governance process in which institutional, political economy, and financial considerations jointly shape both regulatory design and implementation, while regulatory design and implementation critically condition the functioning of arrangements related to these three dimensions. Fig. 2 presents a schematic diagram illustrating this framework and the dimensional factors. Rather than operating independently, these dimensions interact throughout the design and implementation process, determining whether a technically sound RTCA methodology can be successfully adopted and sustained. Importantly, the adoption of RTCA rules grounded in sound techno-economic-regulatory principles strengthens the credibility of the overall framework. This facilitates stakeholder negotiations by providing a transparent and defensible basis for allocating costs, while simultaneously increasing confidence that the resulting revenue recovery and payment arrangements will remain stable and financially sustainable over time.

[4] Regulation (EU) 2022/869 establishes the legal framework for Projects of Common Interest in cross-border energy infrastructure. Access to EU funding through the Connecting Europe Facility is contingent on compliance with the criteria and obligations set out in the regulation, including alignment with regional energy infrastructure planning. In cases of persistent non-compliance, the European Commission may initiate infringement proceedings under Article 258 TFEU, which can ultimately lead the Court of Justice of the European Union to impose financial penalties under Article 260 TFEU.

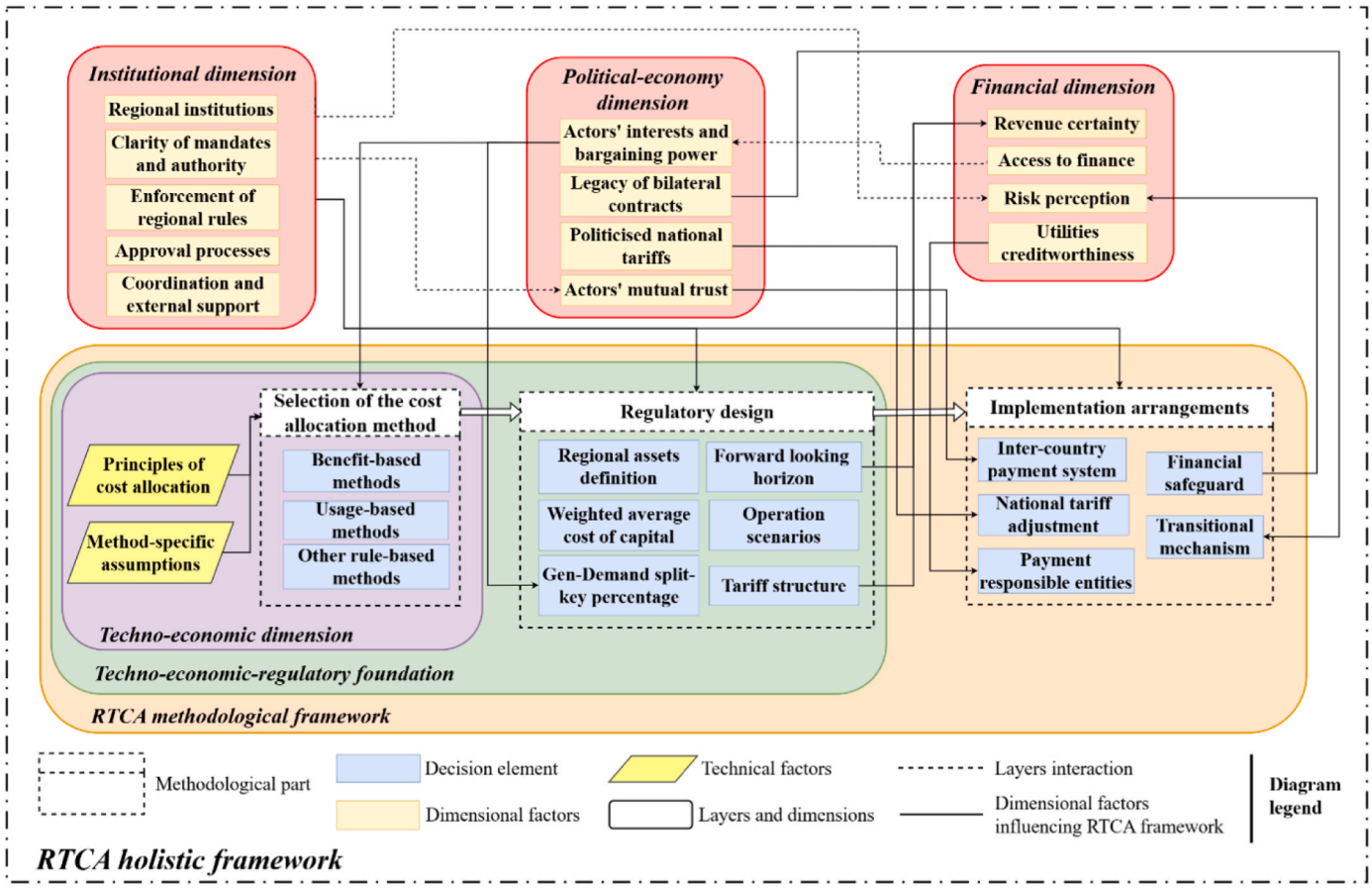


Fig. 2. The RTCA holistic framework, showing the RTCA methodological framework and the different dimensions influencing its design and implementation. To preserve readability, the figure does not explicitly depict all indirect effects, such as the impact of adopting a sound RTCA method on the political negotiation.

The interactions among these dimensions are central to the framework. Institutional arrangements determine whether decision-making authority is sufficiently strong to avoid procedural fragmentation and provide credible enforcement of regional rules. These governance arrangements, in turn, influence the political economy of the RTCA reform by influencing stakeholder incentives, the credibility of negotiations, and the level of trust among participating countries. Political economy considerations affect both the choice of regulatory design and the feasibility of its implementation, particularly where reforms alter the distribution of costs or revenue streams. Financial arrangements complement these dimensions by translating the adopted regulatory design into credible revenue recovery and payment mechanisms. Their effectiveness, however, depends critically on the underlying RTCA rules being sufficiently sound to produce stable, transparent, and economically justified financial flows capable of supporting long-term investment. At the implementation stage, transitional arrangements and payment mechanisms can reduce resistance from stakeholders whose existing revenue streams or contractual arrangements would otherwise be disrupted, thereby facilitating political acceptance of reform. Conversely, successful implementation strengthens institutional credibility and reinforces trust among participating actors, creating favourable conditions for future regional cooperation and subsequent regulatory reforms.

6. The WAPP RTCA reform process

The WAPP was created in 1999 by Decision A/DEC.5/12/99 of the 22nd Summit of the Economic Community of West African States (ECOWAS) Authority of Heads of State and Government and became operational in 2006 (WAPP, 2021). Since then, WAPP has gradually evolved from a network of bilateral exchanges into a coordinated regional system supported by common institutions, regional regulation, and expanding transmission interconnections. This institutional evolution created the conditions under which a comprehensive reform of the RTCA methodological framework became both necessary and feasible.

The reform process has recently culminated in the adoption of a new methodological framework. While the methodological and regulatory framework has now been agreed, its implementation is being undertaken through an agreed transitional period, during which national implementation, operational arrangements, and payment mechanisms are progressively put into effect. Consequently, the WAPP experience is not presented here as a completed implementation success, but rather as an empirical illustration of how RTCA reform can progress from methodological design towards practical implementation within a developing regional electricity market. It is expected that this experience and the lessons learned so far can be useful for similar undertakings in various stages of development in other African regions and the integration project of continental integration promoted by the African Union Commission.

The analysis in this section is organised following the analytical framework developed in the previous section. It first examines how sound techno-economic-regulatory principles led to the adoption of the new regulation and then analyses how the remaining three dimensions influenced the reform process. Throughout the discussion, a distinction is maintained between documented features of the WAPP reform, observations derived from the authors' participation as technical advisers to the RTCA reform process, and the analytical interpretation developed in this paper.

6.1. Techno-economic foundations of the WAPP reform

The evolution of the WAPP regional market progressively altered the requirements placed on its transmission cost allocation framework. Similar to other regions, power trade in the WAPP region initially developed through bilateral agreements associated with dedicated interconnections, beginning with the export of power from the Akosombo hydroelectric dam in Ghana to Togo and Benin (Elabbas, 2024). The development of interconnections was an integral part of these bilateral contracts, which specified the rate of utilisation of interconnections based on the flow of power. Even though bilateral trade remains the dominant mode of trade in the region (WAPP, 2021), WAPP has exerted tremendous efforts over the years to centralise the development of the regional transmission network, reaching the milestone of fully interconnecting all fourteen member countries in July 2023 (WAPP, 2023).

This evolution was reflected in the successive development of regional regulation, which started with the establishment of the ECOWAS Regional Electricity Regulatory Authority (ERERA) by Act A/SA.2/1/08 (ECOWAS, 2008). Among the first regulatory developments was the approval of the RTCA regulation, initiated through a consultancy study conducted by Artelia in 2013 (ERERA, 2013), which culminated in the adoption of Resolution No. 006/ERERA/15, "Adoption of the Tariff Methodology for Regional Transmission Cost and Tariff", by ERERA's Regulatory Council in August 2015 (ERERA, 2015). The resolution describes the regional transmission tariff methodology as "a point-to-point MW-Km load flow-based tariff methodology that is calculated for each and every regional bilateral trade within ECOWAS". At that time, the method reflected the prevailing trading arrangements in WAPP, where few bilateral contracts dominated power trade in the region. The adoption of the method was also inspired by the South African Power Pool, which had adopted it twelve years earlier (UNECA, 2003). Nevertheless, this method remained rooted in a transaction-based conception of transmission cost recovery, making it inconsistent with the sound RTCA principles in Section 4.

Following strong criticisms on the MW-km method (Pérez Arriaga, 2021) and recognition that it is not applicable to competitive trade (e.g., in day-ahead markets using meshed transmission networks), several initiatives were launched to engage stakeholders in taking as a reference the techno-economic-regulatory principles identified above to develop a sound framework and methodology, as shown in Fig. 3. After multiple consultations reflecting on the application of the RTCA principles, WAPP embarked on a comprehensive revision of the tariff methodology, which included a comparative quantitative assessment of the adopted MW-km and AP methods, discussed in Elabbas et al. (2026). The study shows that the MW-km method not only violates the RTCA principles but also systematically over-charges regional bilateral transactions and fails to provide a suitable framework for the development of a competitive regional market, concluding with the recommendation of adopting the AP method.

Following the technical assessment of the method, ERERA, WAPP, and regional stakeholders engaged in an extensive process of defining the methodological framework and its regulatory design, which was influenced by the different dimensions as discussed in the following subsections.

6.2. The RTCA institutional context of WAPP

The institutional conditions that enabled the RTCA reform did not emerge solely from WAPP itself but from the broader regional governance architecture established by ECOWAS. At the political level, the ECOWAS Authority of Heads of State and Government created WAPP as the regional organisation responsible for electricity market integration and subsequently established the ERERA as the regional regulator with responsibility for regional electricity regulation (ECOWAS, 2008; ECOWAS, 2007) Over the past two decades, this governance architecture has progressively evolved through the strengthening of regional institutions, the expansion of regional planning and operational coordination, and the gradual development of common market rules. Previous studies have identified this institutional evolution as one of the distinguishing characteristics of WAPP compared with other African power pools, such as SAPP and EAPP, and as an important factor supporting the development of regional electricity trade (Elabbas, 2024; Elabbas et al., 2023).

Within this governance architecture, the institutional relationships underpinning RTCA closely follow the general framework presented in Section 5. At the political level, ECOWAS, with its supranational institutional framework, provides the legal mandate and strategic direction for regional market integration. ERERA exercises regulatory authority over regional transmission tariffs and cost allocation, while WAPP performs the technical and operational functions required to develop, execute, and periodically update the methodology. At the national level, the implementation responsibilities remain largely with the national regulatory authorities and utilities. Table 1 summarises the principal institutional actors and their respective roles in the WAPP RTCA reform.

One institutional characteristic that proved particularly important during the reform concerns the legal authority delegated to ERERA. Unlike many regional cooperation arrangements, where regional decisions require subsequent approval through separate national regulatory procedures, ERERA possesses statutory and quasi-judicial powers to adopt regulations and decisions that are directly applicable within its legal mandate across the ECOWAS region (ECOWAS, 2007). From the perspective of the analytical framework developed in Section 5, this institutional arrangement substantially reduces one of the principal barriers to regional regulatory reform—procedural fragmentation. Rather than requiring multiple sequential national approval processes before the regional methodology could be adopted, the approval process

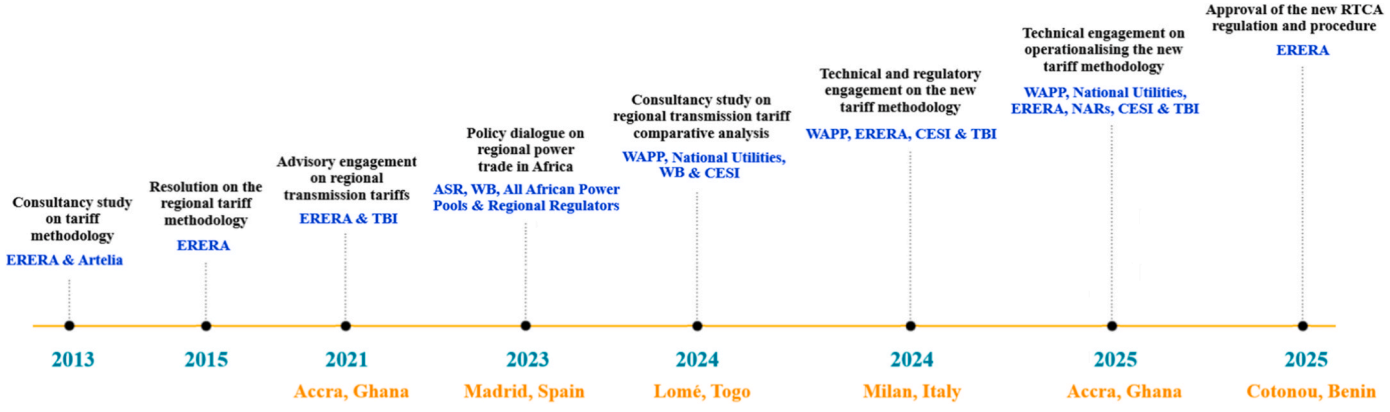


Fig. 3. RTCA engagement initiatives between the WAPP RTCA regime and external actors.

Table 1
Internal and external institutional actors of the WAPP RTCA regime.

N.	Institutional actor	Role
1	ERERA	• Approve the RTCA methodology and any modifications. • Oversee the RTCA execution and associated payments. • Resolve disputes. • Issue penalties and sanctions.
2	WAPP	• Propose modifications to the RTCA methodology. • Execute the RTCA method. • Facilitate investment and execution of regional transmission projects. • Manage payments to special projects.
3	NRAs	• Consult on the adoption of the RTCA methodology. • Implement and enforce the RTCA rule domestically. • Adjust the revenue collection from national tariff according to the regional compensation.
4	National utilities	• Consult modifications to the RTCA methodology. • Negotiate the distribution of costs of new projects. • Pay or receive compensation for network usage.
5	ECOWAS commission	• Establish policies and mandates of ERERA and WAPP. • Adopt regional master plans and facilitate investments. • Facilitate political commitment and decision-making.
6	National governments	• Establish policies and mandates of NRAs and incumbent utilities.
7	CESI, Tony Blair Institute for Global Change (TBI), African School of Regulation	• Provide technical and regulatory support for defining, assessing, and implementing the RTCA methodology. • Facilitate political decision-making.
8	World Bank, African Development Bank, European Investment Bank, USAID, German Development Bank	• Provide financing for regional transmission projects. • Provide financial aid for regional institutions.

is largely confined to the regional institutional structure itself while maintaining continuous consultation with national stakeholders throughout the process.

The documented approval procedure consists primarily of two formal stages. Following the completion of the technical assessment, the WAPP Board approves the proposed methodological revision and submits it to ERERA. ERERA subsequently evaluates the proposal through its Executive Secretariat, specialised technical bodies, and Regulatory Council before adopting the revised regulation (ERERA, 2026a; 2026b). Although institutionally straightforward, this formal process is preceded by an extensive period of technical preparation and stakeholder engagement.

Based on the authors' direct participation in the advisory process supporting the reform, the development of the methodology was characterised by continuous interaction between technical analysis and institutional consultations rather than by a simple sequence of technical proposal followed by regulatory approval. The comparative assessment of alternative RTCA methods was undertaken in close collaboration between WAPP and ERERA, allowing regulatory considerations to be incorporated during the technical analytical stage rather than only after submission of the proposal (Elabbas et al., 2026). Similarly, consultations were conducted with national utilities, national regulatory representatives, and development partners—notably the World Bank, which has traditionally played a central role in financing regional transmission infrastructure within WAPP (WAPP, 2021; Elabbas et al., 2023). These consultations were focused on evaluating how the implementation of the AP method according to the RTCA principles could be adapted to the institutional, operational, and regulatory realities of the WAPP region, while preserving the rationale of the method and producing cost allocation results that essentially comply with the aforementioned principles.

From the perspective of the analytical framework developed in this paper, the WAPP experience illustrates how institutional governance influences the feasibility of regulatory reform. The importance of the institutional dimension does not lie simply in the existence of regional institutions, but in the clear allocation of complementary responsibilities to them across different levels of governance, and the close coordination and inclusion of all the stakeholders in the decision-making process.

6.3. The RTCA political economy dynamics in WAPP

The WAPP reform illustrates how political economy influenced both the technical features of the adopted RTCA methodology and the pathway through which agreement was achieved. But it also illustrates how the high level of soundness of the set of allocation rules proposed facilitated the adherence of the key stakeholders to their adoption. Although the guiding techno-economic principles progressively gained broad acceptance among stakeholders, several design choices remained subject to negotiation because they affected the distribution of costs, existing revenue streams, and the incentives of national actors.

The adoption of the AP method itself generated relatively limited disagreement once stakeholders perceived it as consistent with the agreed techno-economic principles and suitable for future market development. Political negotiation became considerably more pronounced when the discussion moved from the method itself to its design parameters. In particular, the allocation split between generation and demand became one of the most sensitive issues during the consultation process. Sensitivity analyses undertaken during the revision showed that increasing the share allocated to generators shifted a larger proportion of regional transmission costs towards the principal exporting countries, particularly Nigeria, Ghana and Côte d'Ivoire (Elabbas et al., 2026). At the same time, the previously approved method allocated the full cost to demand, meaning that an immediate transition to a theoretically neutral 50–50 split would substantially alter existing revenue streams. According to observations from the stakeholder consultations in which the authors participated, this redistribution proved politically difficult despite broad recognition that exporters also derive substantial benefits from the regional transmission network. This observation is consistent with earlier analyses of WAPP, which show that asymmetries of interests are closely linked to broader regional power dynamics, with dominant exporting countries exercising structural influence over the design of market rules (Elabbas et al., 2023). Several variations of the split key were tested to analyse their distributional consequences. The results of these tests were, then, presented and discussed during successive stakeholder consultations involving WAPP members, regulators and utilities, in which the authors directly participated. Eventually, acknowledging that exporters also benefit from the transmission network and, therefore, need to bear some of its costs, stakeholders agreed on a gradual transition beginning with only 10% of costs being allocated to generation and possibly increasing this share over time (ERERA 2026a). This initial percentage was found to be the highest at which exporters' current revenues are not significantly disrupted and, therefore, the highest that was deemed acceptable.

A second design issue concerned the degree to which the compensation mechanism should rely on forward-looking assumptions. From a techno-economic perspective, RTCA should recover the regulated cost of transmission assets through stable and predictable charges based on expected network usage, thereby avoiding unnecessary uncertainty in regulated revenue recovery. However, stakeholder discussions revealed considerable concern regarding the accuracy of long-term operational

forecasts and the distributional consequences of forecast errors. There was the fear that some countries whose expected imports or exports differed substantially from the actual operation up to that point, could systematically overpay or underpay relative to their actual use of the regional network. According to the observations made in the stakeholder consultation process, these concerns became one of the principal sources of political tension during the design of the implementation arrangements. The compromise eventually adopted was to determine the annual compensation each year using the expected operation scenario for the following year, followed by a reconciliation one year later based on the metered network flows and actual system operation in that year (ERERA, 2026b). Although this approach introduces more frequent adjustments than would be preferred under the guiding techno-economic principles, stakeholders viewed the reconciliation mechanism as necessary to build confidence in the fairness of the allocation during the early stages of implementation, illustrating how political economy considerations can modify the implementation of sound regulatory principles while limiting the impact of these modifications on the soundness and efficiency of the solution adopted.

Beyond influencing the technical design choices, political realities have widely impacted the adoption and implementation pathway of the new RTCA regulation, as reflected in the following aspects:

- ***Regional political tension and instabilities***: The region has experienced periods of political tension, including recent military takeovers in several Sahel countries and their withdrawal from ECOWAS (Wathi, 2025). These developments have, at times, affected even established institutions and their proper functioning; for example, the temporary absence of a fully constituted ERERA Board delayed the adoption of the new RTCA regulation.
- ***Legacy of bilateral trade***: To apply a unified RTCA rule, transmission charges associated with bilateral contracts and their TSAs had to be abandoned. Many of these contracts are politically sensitive because they affect revenue flows to national utilities, mainly net-exporters, and are often rooted in long-standing intergovernmental arrangements. The complete abolition of TSAs was therefore politically unrealistic in the short term. Instead, a transitional period was introduced to allow legacy contractual arrangements to expire progressively while providing time for countries and NSOs to adjust financially before the full application of the new rule.
- ***Politicised national tariffs:*** In several WAPP member states, national tariffs remain politically determined and unreflective of the supply costs of electricity (ERERA, 2019). Unlike the previously approved point-to-point methodology, the new RTCA framework requires the active participation of NRAs and adjusting the transmission revenue collection from tariff within each country according to the results of the RTCA calculation. Although ECOWAS directives require countries to establish independent NRAs, their implementation across member states has been uneven. To mitigate this constraint, ERERA engaged NRAs early in the RTCA revision process and ensured that they were on board with its application. It is expected that, during the transitional period, the practical execution of the compensations resulting from the agreed-upon mechanism relies primarily on the designated national entities—currently the incumbent transmission operators and vertically integrated utilities—to manage these financial obligations.
- ***Coordination on conflicting national regulations***: Differences between national and regional regulations also required close coordination with NRAs. In the case of WAPP, Nigerian regulation obliged generation companies to collect transmission tariffs from consumers and remit them to the NSO. This rule also applied to exported power, which in practice could lead to double charging for importing utilities such as the Communauté Électrique du Bénin (CEB). Addressing this inconsistency required ERERA to engage in bilateral discussions with the Nigerian regulator (NERC), which is expected to be finalised during the transitional period. In any case, it has to be noted that the new RTCA methodology formally terminates any bilateral wheeling payment in any form, and the bilateral discussions between NERC and ERERA have more of a diplomatic motivation than a real risk of double charging.

Finally, the WAPP experience also illustrates how financial and political economy considerations can reinforce one another. During the stakeholder consultation process, representatives of the World Bank explicitly linked the approval of subsequent concessional financing for regional transmission investments to the adoption of the revised RTCA framework. This observation derives from the authors' direct participation in the reform process rather than from published documentation. Nevertheless, it is consistent with the broader literature documenting how multilateral development banks have historically used lending conditionalities to support power-sector reforms and institutional change in developing countries (Foster and Rana, 2019). Analytically, this illustrates one of the interactions identified in the framework developed in Section 5: external financial institutions can influence political incentives by making access to future investment finance conditional upon regulatory reforms that improve the credibility and long-term sustainability of the regional transmission framework.

6.4. The RTCA financial dimension in WAPP

The financial dimension of the WAPP reform extends beyond determining how compensation payments are settled. It also influenced several key design choices of the revised RTCA framework by balancing the objective of predictable cost recovery with the practical realities of financing regional infrastructure in West Africa. Throughout the reform process, financial considerations interacted closely with the techno-economic-regulatory, institutional and political economy dimensions, shaping both the methodological design and the implementation arrangements ultimately adopted.

One of the main financial considerations concerned the bankability of regional transmission investments. A central objective of the reform was to establish a cost recovery mechanism capable of providing stable and predictable revenue streams for transmission assets. Unlike the previously approved MW-km method, whose revenues for transmission owners and, eventually, for financing institutions, depended directly on the commercial transaction flows and, therefore, on the uncertain utilisation of individual transmission lines, the revised framework allocates the annuity of regional transmission assets independently of bilateral trade volumes. This substantially reduces volume risk and aligns revenue recovery with the infrastructure, regulated nature of transmission investment, thereby improving the financial predictability of the regulatory framework. However, uncertainty surrounding future network conditions led stakeholders to complement the forward-looking allocation with an annual ex-post reconciliation mechanism based on actual metered system operation (ERERA, 2026b). Although this introduces periodic adjustments to the allocation results and, therefore, some uncertainty about the identity of the contributors to the recovery of the cost of regional transmission assets and the level of their contributions, adopting this reconciliation mechanism was considered an appropriate compromise between maintaining predictable revenue recovery streams and ensuring confidence in the fairness of the compensations taking place.

Another important financial design decision concerned the choice of the national compensation party. During the consultation process, some stakeholders argued that compensation should be settled directly with network users, expressing concern that designating a single national intermediary would expose the NSO to additional financial risk if domestic tariff revenues proved insufficient. Direct settlement with end-users, however, was considered operationally impractical. The adopted framework, therefore, designates the NSOs as the national compensation parties responsible for collecting and transferring the allocated payments. This arrangement is facilitated by the fact that most

WAPP member states continue to operate vertically integrated utilities, limiting the immediate financial exposure of the NSOs. However, as electricity sector unbundling progresses, this institutional arrangement may require further adaptation to ensure that the financial responsibilities remain aligned with the stakeholders ultimately responsible for revenue recovery. In any case, the new regulation, under article 11.9.3, emphasises that any default in the payment shall be dealt with through sanctions from the regional market (ERERA, 2026a).

The reform also recognised that regional transmission infrastructure may be financed through specific ownership and financing arrangements. While most regional transmission assets are developed under conventional utility ownership, some strategic interconnections—such as the CLSG transmission line—have been developed through SPVs involving dedicated financing structures and international lenders. The revised RTCA framework accommodates these arrangements by maintaining a common method for allocating the costs associated with the use of the regional transmission network, while allowing project-specific contractual agreements to govern the recovery of investment costs where appropriate. Regardless of their ownership structure, operational decisions concerning these assets remain integrated within the regional system operation, thereby preserving both operational efficiency and regulatory consistency across the interconnected network.

Finally, the reform established a financial settlement architecture intended to enhance the credibility of the regional compensation mechanism. Stakeholders agreed that compensation payments would be channelled through the designated national compensation parties and that these payments would be settled via a common regional fund denominated in U.S. dollars, thereby simplifying multilateral settlements and reducing exchange-rate risk.

7. Conclusions

While cost allocation is an interesting techno-economic problem and addressing it has generated a large techno-economic-regulatory literature, approaching it solely from this perspective overlooks the institutional, political economy and financial forces that ultimately shape how RTCA regulations are designed and implemented. This paper developed and applied a holistic analytical framework that integrates these dimensions and examines how they interact throughout the design and implementation of RTCA reforms. The analysis shows that effective RTCA reforms require institutional coherence, political pragmatism, and financial credibility, while also demonstrating that the soundness of the underlying techno-economic principles fundamentally influences the feasibility of the reform itself. Effective regional regulation requires a careful balance between technical soundness and political feasibility, ensuring that cost allocation supports both investment sustainability and long-term confidence in regional transmission development.

The experience of WAPP provides an empirical illustration of this multidimensional reform process. Rather than presenting WAPP as a completed implementation success, the case illustrates how progress from methodological design towards practical implementation depends on the interaction of the dimensions identified in the proposed framework. In particular, it demonstrates how the techno-economic soundness of the cost allocation rules facilitated socio-political consensus around the reform, how regional institutions coordinated decision-making, how political economy considerations shaped methodological choices, and how financial arrangements were designed to support investment in regional transmission infrastructure. Through strong institutional coordination between WAPP and ERERA, underpinned by ECOWAS's commitment to regional integration and the authority it delegated to regional institutions, together with the active engagement of technical and financial partners, the region managed to advance a complex reform in a politically sensitive environment. Transitional mechanisms—such as phased implementation, gradual cost allocation, and targeted financial incentives—proved instrumental in translating technical consensus into an implementable regulatory framework.

This study has several limitations. First, although the revised RTCA methodology has now been formally adopted, its implementation is still in its transitional phase, and some aspects of its practical application will only become observable over time. Second, parts of the WAPP analysis draw on the authors' direct participation in the reform process and interactions with stakeholders, complementing publicly available documentation. While these observations provide insights that are rarely accessible through documentary evidence alone, they inevitably reflect the perspective of an involved participant. Finally, although some of the authors of the paper have participated in similar developments in other parts of the world, the proposed framework has only been empirically illustrated in the context of WAPP, whose comparatively strong regional institutions differ from those of other regional electricity markets. The transferability of the findings should therefore be assessed with due regard to differences in institutional authority, market maturity, and governance arrangements.

Despite these limitations, the analytical framework developed in this paper offers a structured basis for analysing and designing RTCA reforms beyond the WAPP context. For policymakers, it highlights that effective regional transmission regulation requires coordinated progress across the technical, institutional, political, and financial dimensions rather than isolated methodological improvements. For researchers, the framework provides a foundation for comparative analyses across regional electricity markets and for future empirical research examining how different institutional settings, political economy, and financing conditions influence the implementation and long-term performance of RTCA reforms.

CRediT authorship contribution statement

Mohamed A. Eltahir Elabbas: Conceptualization, Formal analysis, Investigation, Visualization, Writing – original draft. **Ignacio J. Pérez-Arriaga:** Conceptualization, Supervision, Writing – review & editing. **Luis Olmos Camacho:** Conceptualization, Supervision, Writing – review & editing. **Federico Pontoni:** Writing – review & editing.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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