# SPECIAL REPORT FOR SC C5
# ELECTRICITY MARKETS AND REGULATION

**CHAIR: Yannick Phulpin**

**SECRETARY: Anthony Giacomoni**

**SPECIAL REPORTERS**

**Ivan Pavić (PS1), Vladislav Berezovsky (PS2), Anant Venkateswaran (PS3)**

## A few words about session papers

Session papers are focused on specific subjects – referred to as 'preferential subjects' – selected in advance by the 16 Study Committees of CIGRE and available in the Call for Papers .

Session papers are selected through a two-phase review process – abstracts and full Papers.

Have a look at the Technical Programme, which has a list of papers selected for the session, and so has an overview of subjects that will be discussed.

## And specificity of CIGRE sessions

At CIGRE sessions authors are given the opportunity to present their paper during half-day specific meetings – the poster sessions.

Four days are also dedicated to 'Group Discussion Meetings' organised by Study Committees. Four meetings run simultaneously each day from Tuesday to Friday, managed by the Study Committee Chairs. The purpose of these meetings is the discussion of the session papers on the basis of "special reports" that incorporate the gist of the session papers and raise a number of questions for discussion.

The special reports are available to all on free access – at the end of May - on the CIGRE website, on the Session page. This report is for SC C5.

For fruitful discussions delegates are strongly encouraged to read the papers before the session and prepare contributions for the discussions.

The set of session papers is made available for downloading to all duly registered delegates before the session through their private account on the registration portal. Papers are also readable on the session smartphone application on site in Paris.

Follow our session latest news and general programme - by regularly visiting our website!

## INTRODUCTION

**Study Committee C5:** ***Electricity Markets and Regulation*** covers the analysis of the impacts on the planning and operation of electric power systems of different market approaches and solutions. This includes new structures, institutions, actors and stakeholders as well as the role of competition and regulation in improving the end-to-end efficiency of the electric power system.

For the 2026 Session, a total of 87 papers were selected based on the three Preferential Subjects (PS):

PS1: MARKET DESIGNS AND NON-MARKET APPROACHES TO SUPPORT THE ENERGY TRANSITION

- Ensuring resource adequacy and supporting investment decisions.
- Cost allocation for the energy transition: who owns and who pays.
- Tradeoffs between markets and regulatory approaches.

PS2: DEVELOPING RELIABLE PRICE SIGNALS AND REGULATIONS ACROSS THE VALUE CHAIN

- Tools and approaches for markets to withstand adverse events and shocks.
- Consistent end-to-end price signals to integrate emerging technologies, distributed energy resources and energy communities.

PS3: APPLYING PRACTICAL EXPERIENCES TO EMERGING ISSUES

- Integrating various electricity markets with emission reduction approaches and long-term contracts.
- Market designs and products to deal with increasing short-term uncertainty.
- Data analytics in electricity markets, market surveillance and transparency.

## PARIS POSTER SESSION

Authors of Study Committee C5 session papers are required to present their papers during the **SC C5 Poster Session scheduled on Tuesday, 25th August 2026 from 8:30 – 12:30** in Halle Ternes on level 1. This is the opportunity for authors and delegates to discuss papers in detail ahead of the Group Discussion Meeting (GDM) on 26th August 2026 in Room 352AB.

Template and instructions on poster preparation are available on the CIGRE 2026 Session website. Posters will be displayed on digital screens. **Poster presentations must be uploaded on the ConfTool platform beginning on 18th May 2026 and by 29th June 2026 at the latest** for review by the poster session convener. Poster conveners may ask for a final version. The final version, incorporating any requested changes, must be uploaded by **14th August 2026**. It should be noted that authors will **not** have the possibility to upload their own file on the day of the Poster Session. If the author(s) cannot attend the Poster Session, he/she or the relevant National Committee is requested to send a substitute.

## PARTICIPATING IN THE 2026 PARIS SESSION GROUP DISCUSSION MEETING

You are invited to participate in discussing this Special Report at the Study Committee C5 Group Discussion Meeting (GDM) on **Wednesday, 26th August 2026 starting at 08:45 in Room 352AB** at the Palais de Congress de Paris.

The special reporters have compiled 14 questions. These questions are not specifically aimed at the papers' authors, but are synthesised from common issues and trends identified across the papers. This provides the opportunity for a broader response and participation in the discussion session.

We encourage you to share your views or experiences in response to the specific questions in this report. During the GDM, each prepared contribution will be allocated a time slot of three to four minutes for presentation.

**Procedure for Contributions**

1. Contributors should upload contributions on the registration portal – "Contributions to Group Discussion Meetings" section - using your existing account and own credentials before **7th August 2026**, for a prior screening and a good organization of the Group Discussion Meeting.
2. Access to contribution uploading is given only to duly registered delegates.
    - As a consequence, registration to the CIGRE Session should be finalized before uploading contribution(s) online.
    - Register now for the Session registrations.
    - Contributions uploading will be open at the beginning of June 2026.
3. Special Reporters will review the prepared contributions (PowerPoint presentation with a max of three slides and a written Word file with a max of 1000 words per contribution). A guide for contributors as well as templates and sample pages will be available on the Paris Session webpage.
   Important notice: No commercial names are to be included in presentation or the written summary (even TSO/DSO names).
4. Any recommendations or changes to the contributions will be provided to the contributors by the Special Reporters directly on the Registration platform between the 7th of August and the 14th of August 2026. Contributors are encouraged to visit their account on the registrations portal to see the results of this review.
5. All contributors with accepted/finalised contributions will be contacted by the Special Reporters between the 7th of August and the 14th of August 2026, to finalize the presentation and receive instructions regarding the session.
6. Important note:
    - All contributions must be uploaded prior to the conference in Paris.
    - Last minute changes to the contributions will not be granted.
7. During the GDM, the Study Committee Chair may call for spontaneous contributions, which will only be verbal with no slides. All attendees are eligible to make such a contribution. Attendees who provide a spontaneous contribution are then required to deliver a written contribution, which will be included in the Session Proceedings. This text is required to be forwarded within a maximum delay of two

weeks after the Study Committee GDM Session (i.e. by **9th September 2026**) to the SC C5 Secretary Anthony Giacomoni (agiacomoni82@gmail.com).

8. It is expected that the questions relevant to the Preferential Subjects will attract many prepared contributions. The number of contributions for each Preferential Subject (PS1, PS2 and PS3) may need to be limited. The selection will be based on relevance, quality and time of submission of the contribution.

9. Please note that accepted contributors will be required to attend a short pre-session meeting with the Special Reporters, SC Chair and SC Secretary on **Tuesday, 25th August 2026** to finalise presentation arrangements. The contributors' meeting will take place from 8:30 through 10:00 in the Palais des Congrès in Hall Ternes (level 1), in parallel with the SC C5 poster session. The purpose of this short meeting is to review the final details of the contribution and to receive the latest instructions (such as the schedule).

## PREFERENTIAL SUBJECT 1

## MARKET DESIGNS AND NON-MARKET APPROACHES TO SUPPORT THE ENERGY TRANSITION

**Special Reporter: Ivan Pavić**

The papers presented under Preferential Subject PS1, "Market Designs and Non-Market Approaches to Support the Energy Transition," highlight how the energy transition is driving a profound transformation of electricity systems, requiring new approaches to market design, regulation, and infrastructure development. The rapid growth of variable renewable energy sources (RES), electrification, and distributed energy resources is increasing system complexity, introducing greater uncertainty, and challenging traditional energy-only market frameworks ([10909], [11295], [12559], [11929]). In response, both market-based mechanisms and targeted non-market interventions are evolving to ensure system reliability, efficient operation, and adequate investment signals ([10972], [11119], [12638]).

Across the contributions in this session, a consistent theme is the need to better align economic signals with physical system realities. This includes improved approaches for capacity remuneration, transmission cost allocation, market coupling, congestion management, as well as enhanced pricing structures reflecting temporal and locational system conditions ([10581], [10751], [12236], [12467], [12557]). At the same time, ensuring investment predictability and financial viability emerges as a critical priority, addressed through long-term contracts, auction mechanisms, and innovative financing solutions ([11286], [10972], [10594], [11294]). Nowadays, grid capacity often becomes a bottleneck for further RES integration, particularly in renewable-rich regions that are geographically distant from load centers ([10581], [12236]). This requires either significant transmission expansion or new concepts such as flexibility-based congestion management, local flexibility markets, and innovative grid funding schemes ([10973], [11297], [11973]). Particular challenges arise in unlocking flexibility at the distribution level, where topics such as voltage regulation incentives, time-of-use grid tariffs and local flexibility markets are increasingly explored ([11423], [11738], [11297]).

Flexibility plays a central role in this transition, with increasing recognition of the value of storage, demand response, and distributed energy resources. Markets are progressively adapting to incentivize these capabilities, while non-market measures—such as regulatory frameworks, planning processes, and infrastructure policies—remain essential to overcome structural barriers and enable coordinated system evolution ([10984], [11293], [11298], [11215]). Yet, regulatory uncertainty and the slow evolution of frameworks often remain key bottlenecks for the deployment of new technologies and business models. This is particularly evident for energy storage, where incomplete or evolving regulatory treatment and limited revenue stacking opportunities have slowed large-scale integration in many jurisdictions ([11293], [11298]). Other topics such as new supply concepts from self-supply options, energy communities ([11977], [12295]) and transmission equipment degradation due to pollution ([11299]) are also affected by slow regulation progress.

**QUESTIONS FOR PS1**

Q1.01: How can we increase the pace of regulatory processes, so they keep up to date with state-of-the-art technologies and market needs in power systems?

Q1.02: How effective are the regulations and rules for battery storage implementation in your jurisdiction, i.e. are there any regulatory bottlenecks for faster storage deployment?

Q1.03: What are the mechanisms used in your region to solve the issue of geographical distance between renewable-energy-rich areas and energy-intensive centres?

Q1.04: Are spot markets sufficient to foster investment into new dispatchable generation technologies in your country? If not, what are the mechanisms created to circumvent this issue?

Q1.05: Which concepts are incorporated in your jurisdiction to unlock flexibility for distribution grid purposes, i.e. to solve distribution grid challenges?

## PREFERENTIAL SUBJECT 2

## DEVELOPING RELIABLE PRICE SIGNALS AND REGULATIONS ACROSS THE VALUE CHAIN

**Special Reporter: Vladislav Berezovsky**

The papers presented under Preferential Subject PS2, "Developing Reliable Price Signals and Regulations Across the Value Chain," emphasise the challenges faced by electricity markets due to climate-related shocks, operational uncertainty, decentralisation and the rapid integration of flexible and distributed energy resources. A strong focus on preserving reliable operational and economic signals under stressed system conditions emerges across the contributions, including in the context of droughts, scarcity events, financial stress and transmission constraints ([12086], [12089], [12138], [12149], [12151], [12156], [12192], [12271] and [12293]). Collectively, the papers show that electricity markets are evolving beyond traditional centralised paradigms towards systems requiring adaptive regulation, probabilistic operational tools and dynamic coordination between market participants, regulators, transmission system operators (TSOs), distribution system operators (DSOs) and distributed energy resources. There is a recurring focus on the interaction between operational reliability measures and market-based price formation. Scarcity pricing, reliability mechanisms, maintenance scheduling incentives and emergency interventions directly affect dispatch efficiency, congestion management, operational security and investment signals ([10495], [10587], [11212], [11529], [12086], [12149] and [12192]).

Several papers focus on integrating flexible resources and decentralised participation into electricity markets through coherent, end-to-end pricing signals. Demand response, storage systems, vehicle-to-grid technology, energy aggregators, energy communities, peer-to-peer transactions and transactive energy are identified as key enablers of future low-carbon electricity systems in several papers ([10494], [10593], [11208], [11209], [11212], [11292], [11296], [11523], [11524], [12105], [12116], [12223] and [12296]). These contributions demonstrate that distributed flexibility can improve operational efficiency, reduce peak demand, enhance renewable energy integration and support local resilience. However, they also emphasise that current regulatory and market frameworks remain fragmented across wholesale, balancing, distribution and retail levels. Consequently, multiple papers emphasise the importance of new coordination models involving aggregators, DSOs, local flexibility markets, and transactive energy platforms that can enable decentralised optimisation while maintaining operational reliability and transparent economic incentives ([10494], [11208], [11296], [12116], [12223] and [12296]). Additional contributions address the growing role of retail tariff structures, temporal granularity and prosumer-oriented pricing mechanisms in shaping distributed flexibility and consumer behaviour. This includes time-of-use tariffs, block tariffs and hourly matching approaches ([11744], [11931] and [11211]).

Another recurring theme throughout the session is the increasing importance of advanced analytical, monitoring and operational tools that can support electricity markets in the face of growing uncertainty and system complexity. Several papers use Monte Carlo simulations, resilience maturity models, the Residual Supply Index for market monitoring, bi-level optimisation frameworks, forecasting algorithms and financial contagion modelling to enhance operational coordination, risk assessment, market surveillance and regulatory decision-making ([10495], [11523], [11524], [12138], [12151], [12156] and [12293]). These contributions demonstrate that traditional deterministic approaches are becoming insufficient for systems characterised by higher levels of renewable energy penetration, decentralised

participation and stronger interactions between technical and financial system behaviour. Together, the papers show that maintaining reliable price signals across the electricity value chain will increasingly depend on adaptive regulation, stronger coordination mechanisms, advanced operational analytics and market designs that can integrate distributed and flexible resources while preserving system reliability and economic efficiency.

**QUESTIONS FOR PS2**

Q2.01: How can electricity markets provide reliable price signals during periods of scarcity, climate shocks and system stress, while maintaining efficient long-term market incentives?

Q2.02: Which regulatory and market mechanisms are most effective for integrating Distributed Energy Resources while preserving coherent price signals across the wholesale, network and retail levels?

Q2.03: How can regulatory frameworks and price signals encourage operational flexibility, reliability and efficient behaviour from market participants without excessive regulatory interventions?

Q2.04: How can advanced monitoring, probabilistic modelling and risk assessment support adaptive regulation and operational decision-making in increasingly complex electricity systems?

## PREFERENTIAL SUBJECT 3

## APPLYING PRACTICAL EXPERIENCES TO EMERGING ISSUES

**Special Reporter: Anant Venkateswaran**

The papers presented under Preferential Subject PS3, "Applying Practical Experiences to Emerging Issues," highlight how electricity markets across regions including India, Latin America, Europe, Africa, China, the GCC, and Russia are evolving to address decarbonization, renewable integration, flexibility needs, operational uncertainty, and digital transformation. They describe practical applications of carbon-aware dispatch, SCED/SCUC frameworks, ancillary services reforms, real-time and balancing markets, cross-border market integration, battery energy storage systems (BESS), virtual power plants (VPPs), demand response, shorter settlement intervals, market liquidity improvements, machine learning, data analytics, market surveillance, and enhanced transparency frameworks. These applications demonstrate the global transition toward more flexible, data-driven, reliable, and sustainable electricity market ecosystems capable of supporting the energy transition.

A common theme across these papers is the transition from conventional centrally managed power systems toward more dynamic, data-driven, and flexibility-oriented market structures capable of supporting high penetrations of renewable and distributed energy resources. Integrating electricity markets with emission reduction objectives and long-term transition mechanisms, the evolution of market design to manage increasing short-term operational paradigms, leveraging data as the most valuable asset through analytics and visualization (digitalization), and cross-border market integration were the key areas addressed in these papers.

Overall, the papers collectively demonstrated that electricity markets are undergoing a profound transformation driven by decarbonization, digitalization, and decentralization. The practical experiences shared across the diverse regions provides valuable lessons on how market operators, regulators, and system planners are adapting operational tools, market structures, and policy frameworks to ensure reliability, transparency, flexibility, and sustainability in increasingly complex power systems.

### QUESTIONS FOR PS3

Q3.01: How can electricity markets balance decarbonization goals with affordability and reliability?

Q3.02: What market design changes are most effective in managing renewable variability and short-term operational uncertainty?

Q3.03: How can flexibility resources be better integrated into ancillary service and balancing markets?

Q3.04 What lessons from regional market integration initiatives can improve cross-border flexibility and reserve sharing?

Q3.05 How can advanced analytics, AI, and market surveillance tools improve transparency, liquidity, and operational decision-making?

## PAPER SUMMARIES

### PS1: MARKET DESIGNS AND NON-MARKET APPROACHES TO SUPPORT THE ENERGY TRANSITION (27 papers)

**10581 - Bridging Renewable Ambitions with Grid Economics: India's Transmission Cost Allocation Model:**
The article analyses India's evolving inter-state transmission cost allocation framework under large-scale renewable integration. It examines the Point of Connection methodology, capacity-based General Network Access, and socialised treatment of HVDC corridors. The study argues that peak-driven transmission planning makes energy-based pricing inefficient, and shows that pooled, capacity-anchored cost recovery improves tariff stability, investment bankability, and consistency with system-level renewable evacuation needs.

**10594 – Monetization Through Securitization of Cash Flows as an Innovative Financing Mechanism for Infrastructure Projects in India:**
This article presents a case study of monetizing operational transmission assets through securitization of future cash flows. Using an SPV and trust-and-retention structure, a major transmission utility raised about INR 150 billion at competitive rates while retaining asset ownership and control. The study shows that securitization lowers financing costs, improves capital recycling, and provides a scalable, replicable financing model for transmission and other regulated infrastructure sectors supporting the energy transition.

**10751 – Assessing Capacity Accreditation Choice on Resource Mix Outcomes:**
This paper analyses how different capacity accreditation methodologies influence resource mix and system adequacy in power systems with high renewable and storage penetration. By iterating between a capacity expansion model and a resource adequacy model, it compares ELCC, EFC, MRI, and CPCF approaches for wind resources. The results show large variability across methods and highlight that EUE-based metrics and original (not "brought-to-criterion") system states provide more stable signals for long-term planning, while locational capacity values are critical to ensure adequacy-efficient investments.

**10909 – Simulating the Energy Transition: A Market-Oriented Approach with the ATLAS Model:**
This paper introduces ATLAS, an agent-based electricity market simulation model developed by RTE to analyze short-term market dynamics under the energy transition. ATLAS explicitly represents forecast uncertainty, sequential market clearing from day-ahead to balancing, complex and linked orders, and physical operating constraints of assets. Applied to European 2030 and 2050 scenarios, the model shows rising balancing needs, increased use of cross-border capacity, and growing counter-activations, highlighting how balancing markets may increasingly function as near-real-time economic dispatch tools in high-renewable systems.

**10972 – Ensuring Investment Predictability for Decarbonized Power Sources – Long-Term Decarbonized Power Source Auction:**
This paper examines Japan's Long-term Decarbonized Power Source Auction, introduced to secure long-term investment predictability for power generation compatible with carbon neutrality by 2050. The scheme provides multi-year capacity payments focused on fixed-cost recovery for new and retrofitted decarbonized assets, complementing short-term power markets. The paper reviews early auction outcomes, identifies challenges such as limited participation by long-lead-time technologies, and compares the Japanese framework with overseas mechanisms to propose future refinements balancing supply security, cost efficiency, and decarbonization.

**10973 – An Integrated Market and Non-Market Approaches for Promoting Green Transformation and Digital Transformation in Japan:**
This article proposes a combined market-based and non-market strategy to address grid congestion and supply–demand mismatches arising from rapid renewable deployment and data-center growth in

Japan. Market measures include distributed energy trading with locational marginal pricing to incentivize efficient DER use and investment. Non-market approaches guide infrastructure siting through grid-capacity visualization, data-center location policies, and demand-side control. Together, these measures aim to co-optimize electricity and digital infrastructure, supporting simultaneous green and digital transformation.

**10984 – Market and Regulatory Unbundling in South Africa: Lessons from Telecommunications for the Electricity Sector's Energy Transition:**
This paper compares South Africa's experience with sectoral unbundling in telecommunications and electricity to draw lessons for the ongoing power sector reform. It shows how Local Loop Unbundling in telecoms largely failed due to regulatory uncertainty, incumbent resistance, and weak investment incentives, leading to infrastructure stagnation. By contrast, the Electricity Regulation Amendment Act of 2024 adopts a hybrid structural model with an independent Transmission System Operator and dedicated mechanisms such as Independent Transmission Projects to attract private investment in grid expansion. The paper concludes that transparent cost recovery, strong institutions, and programmatic infrastructure development are critical for successful electricity market reform.

**11119 – Comparative Analysis of the Parameters Needed to Define the Security of Supply Indicator and its Application in Capacity Mechanisms in Europe:**
This paper reviews how European countries estimate Value of Lost Load, Cost of New Entry, and Reliability Standards, highlighting significant methodological differences despite ACER harmonisation efforts. It shows that financial assumptions such as WACC and hurdle-rate premiums strongly influence CoNE, while VoLL varies widely due to different consumer surveys and valuation methods. By using probabilistic Monte Carlo simulations, the study confirms that when coherent assumptions are used and the new entrant is modelled as a peaking plant, the Reliability Standard closely aligns with the reliability level that minimises total system cost, even in high-renewables scenarios. The results support the economic rationale underpinning European capacity mechanisms.

**11215 – Designing EAC Markets for the Energy Transition: Navigating Between Voluntary Incentives and Regulatory Signals:**
This paper analyzes the evolving role of Energy Attribute Certificates (EACs) in supporting the energy transition, examining both voluntary and regulated markets worldwide, including Russia. It reviews recent reforms to voluntary standards such as the GHG Protocol, RE100, and SBTi, highlighting growing emphasis on additionality, geographic and temporal matching, and market integrity. The study finds that overly granular requirements like hourly matching may increase complexity without delivering proportional emissions benefits in systems with abundant dispatchable low-carbon generation. A Russian market case study shows that real decarbonization effects depend more on market design and new capacity deployment than on certificate granularity alone. The authors conclude that effective EAC markets should prioritize additionality and investment signals while balancing voluntary incentives with regulatory frameworks.

**11286 – Energy Hubs in Brazil: A Proposal for Feasibility Assessment using Real Options Analysis:**
This paper proposes a methodology for assessing the economic feasibility of large-scale Energy Hubs in Brazil using Real Options Analysis (ROA). Energy Hubs combine renewable generation with storage, hydrogen production, and energy-intensive loads such as data centers, enabling integrated multi-energy optimization under uncertainty. A detailed case study for Northeast Brazil (Suape) shows that, while a conventional discounted cash-flow analysis yields a strongly negative expected NPV, incorporating managerial flexibility through options to delay, expand, and abandon the project transforms it into a positive-value investment. The results highlight that ROA is essential for valuing complex capital-intensive energy infrastructures and for supporting strategic investment decisions in highly uncertain decarbonization pathways.

**11293 – Energy Storage and Market Evolution: Regulatory, Operational and Economic Dimensions for the Brazilian Power Sector:**
This paper examines the integration of energy storage systems (ESS) into Brazil's electricity sector

from regulatory, operational, and economic perspectives, benchmarking Brazil against international experiences in Australia and the United Kingdom. It highlights the paradox of abundant renewable generation combined with rising curtailments and operational stress due to insufficient flexibility mechanisms. Brazilian case studies demonstrate the technical value of ESS but also reveal regulatory fragmentation, limited remuneration frameworks, and constraints on revenue stacking. The authors argue that ESS must be treated as service providers rather than residual assets, integrated into planning models, capacity mechanisms, and ancillary-service markets. The paper concludes that ongoing reforms—such as public consultations, forthcoming capacity auctions, and recognition of storage operators—are critical but must be accelerated to unlock large-scale deployment and support a resilient, cost-effective energy transition in Brazil.

**11294 – Enhancing Predictive Models for Bid Discounts in Brazilian Transmission Auctions: Integrating Technical Variables, Temporal Dynamics, and Strategic Bidder Information:**
This paper develops predictive models for bid discounts and awarded Annual Allowed Revenue (AAR) in Brazilian electricity transmission auctions conducted under a revenue-cap regulatory regime. Using a comprehensive dataset covering all auctions from 1999 to 2024, the study combines econometric methods and machine-learning techniques to assess how technical, financial, macroeconomic, temporal, and strategic variables shape auction outcomes. Results show that bid discounts are inherently difficult to predict due to strategic behavior and structural changes in the auction environment, whereas winning AAR values are far more predictable because they are strongly anchored to regulated revenue ceilings and cost drivers. The findings highlight the asymmetric predictability of auction outcomes and underscore the central role of institutional design and regulatory parameters in shaping bidding behavior and investment incentives.

**11295 – Market Effects of Wind and Solar Growth in Brazil: Price and Regulation Signals, Curtailment, and the Role of Hydropower Flexibility:**
This paper analyzes the market and regulatory impacts of the rapid expansion of wind and solar generation in Brazil, focusing on price signals, curtailment, and commercialization risks. Using hourly operational and market data from 2021 to 2025, the authors quantify modulation, seasonalization, submarket, and curtailment risks for hydropower, wind, and solar generation under flat bilateral contracts. Results show a significant deterioration in the economic performance of wind and solar assets relative to their granted firm energy, driven by increasing curtailment, price cannibalization, and transmission bottlenecks—particularly in the Northeast submarket. The study highlights the strategic importance of hydropower flexibility in high-VRE systems and argues for market and regulatory reforms that explicitly value flexibility, capacity, and system services alongside energy.

**11297 – Distributed Energy Resources and Brazil's Transition to a Fully Liberalized Electricity Market:**
This paper examines how Distributed Energy Resources (DERs) can be integrated into Brazil's electricity market as the country advances toward full retail liberalization. It argues that aggregation models, granular temporal and locational price signals, and modern settlement arrangements are essential to align market incentives with the operational needs of distribution networks. Drawing on international experiences from Australia, the United States, and Europe, the study highlights the importance of digitalization, open data governance, and real-time measurement to enable active consumer participation and new roles for aggregators and prosumers. It identifies regulatory, technical, and market challenges—such as tariff reform, interoperability standards, and fair allocation of network costs—and proposes strategic directions to ensure that market liberalization enhances flexibility, efficiency, and system reliability in Brazil.

**11298 – The Regulatory Role of Battery Energy Storage in Brazil: Gaps and Opportunities:**
This paper analyzes the regulatory role of Battery Energy Storage Systems (BESS) in Brazil following the establishment of the legal framework under Law No. 15,269/2025. It reviews the multiple system services provided by BESS—such as flexibility, ancillary services, peak capacity, arbitrage, and integration with renewables—and discusses how storage was recognized as essential infrastructure. While highlighting significant advances, including tax incentives, planning integration, and the launch of a dedicated capacity auction for batteries, the study identifies remaining regulatory gaps related to

remuneration, revenue stacking, network access charges, auction design, and business models. The paper concludes that a stable, predictable regulatory environment is crucial to unlock investment, balance market and regulatory approaches, and accelerate the deployment of storage as a core pillar of Brazil's energy transition.

**11299 – Regulatory Enhancements for Operational Sustainability of Transmission Systems in Severely Polluted Environments:**
This paper addresses the technical and regulatory challenges faced by electricity transmission systems operating in severely polluted environments, such as coastal and industrial regions. Using empirical evidence from the ARGO transmission concession and other Brazilian case studies, it shows that environmental pollution accelerates insulator degradation, leading to frequent outages, reduced availability, and unanticipated operational costs that are not adequately recognized under current regulatory frameworks. The authors propose regulatory enhancements organized around four pillars: recognition of preventive equipment replacement, mandatory quantitative pollution studies in auction design, revision of asset service-life assumptions, and regulatory recognition of recurring pollution-related operational expenditures. These measures aim to better align regulation with operational reality, improve transmission reliability, and support efficient electricity markets—an increasingly critical requirement for integrating variable renewable energy sources during the energy transition.

**11423 – Proposed Tariff Component for Compensating Voltage-Regulating Reactive Power in the Swedish Transmission System:**
This paper presents a new tariff component proposed by the Swedish transmission system operator (Svenska kraftnät) to economically incentivize grid users to provide voltage regulation through reactive power exchange. As inverter-based resources increasingly connect at the distribution level, existing connection agreements limit their ability to support transmission-level voltage control. The proposed scheme classifies reactive power exchange as voltage-regulating or non-regulating using high-resolution measurements and regression analysis, and determines compensation via UQ-diagrams based on voltage levels and reactive power direction. The tariff is technology-neutral, optional, and designed to reward grid users whose behavior reduces the need for costly investments in devices such as STATCOMs or synchronous condensers. The paper demonstrates how the mechanism can enhance system stability, improve utilization of existing assets, and align economic incentives with operational needs in a high-renewables power system.

**11738 – Impact of Economic Incentives on Flexibility for Small Companies in Sweden:**
This study assesses how grid tariffs, spot prices, and ancillary service markets affect demand-side flexibility for small commercial consumers in Sweden. Using measured data, it shows that grid-tariff-driven optimization yields the largest savings, while ancillary services and local flexibility markets offer complementary but uncertain revenue streams.

**11929 – Long-Term Load Forecasting for Jordan's Electricity System:**
This study forecasts Jordan's electricity demand and peak load for 2026–2050 using statistical methods and neural networks. ANN models outperform traditional techniques in accuracy. Scenario-based results support long-term planning, infrastructure investment, and sustainable electricity market regulation under demographic and economic uncertainty.

**11973 – Low-CAPEX Incentive-Based Demand Response in Conventional Networks:**
This paper proposes a low-cost, incentive-based demand response scheme suited to distribution systems without smart meters. Using distribution-transformer-level verification and a non-bypassable charge, the design reduces free-riding and ensures financial sustainability. A case study in Argentina illustrates the approach.

**11977 – Regulatory and Economic Conditions for Self-Consumption in Bosnia and Herzegovina:**
This study assesses self-consumption (prosumer) development under Bosnia and Herzegovina's new RES law. Low electricity prices limit PV profitability, requiring subsidies for households. Net

metering/billing thresholds are high relative to demand, and widespread adoption could significantly reduce DSO revenues, highlighting the need for tariff reform and capacity-based network charges.

**12236 – Grid Investments in the European Flow-Based Day-Ahead Market:**
This paper analyses how targeted grid reinforcements in the Core European flow-based day-ahead market affect network constraints and price spreads. Using realistic capacity-calculation and market-coupling simulations, it shows that investments focused on active constraints significantly reduce congestion, shadow prices, and extreme price volatility, particularly in Hungary and neighboring bidding zones.

**12295 – Colombia's Regulatory Framework for Distributed Renewables in Energy Communities:**
This paper evaluates Colombia's regulations for integrating distributed renewables and Energy Communities. Using a genetic-algorithm approach and hosting-capacity analysis, it identifies regulatory gaps and proposes coordinated connection and incentive-based rules to improve network performance, enable higher renewable penetration, and support a robust, community-driven energy transition.

**12467 – Cost Sharing for Internationally Coordinated Congestion Management:**
This study proposes a pollution-based cost-sharing method for congestion management in internationally coordinated power systems. Using security-constrained OPF simulations, it demonstrates that causality-based allocation better reflects responsibility for congestion than location- or volume-based methods, supporting fairer and more efficient cross-border grid operation.

**12557 – Greenlink Interconnector and the Irish Single Electricity Market:**
This study evaluates the early impacts of the 500 MW Greenlink HVDC interconnector between Ireland and Great Britain. It shows improved price convergence, increased imports, reduced dispatch-down of renewables in Northern Ireland, and enhanced market integration, highlighting interconnection as a key driver of flexibility, lower prices, and energy security.

**12559 – Evolution of the Generation Portfolio in Ireland and Northern Ireland:**
This historical analysis reviews a century of power system development in Ireland and Northern Ireland, focusing on the last decade's transition from fossil fuels to renewables. It shows how capacity markets, renewable support schemes, system services, and interconnection enabled coal, peat, and oil exit while maintaining reliability in a high-renewables system.

**12638 – Market-Based Procurement of Ancillary Services in Serbia:**
This paper describes Serbia's transition from non-market to auction-based procurement of balancing capacity. Market-based auctions improved transparency, competition, and efficiency, enabled aggregator participation, and prepared Serbia for future integration with European balancing platforms such as MARI, TERRE, and PICASSO.

## PS2: DEVELOPING RELIABLE PRICE SIGNALS AND REGULATIONS ACROSS THE VALUE CHAIN (29 papers)

**10494 - Incentivising Flexibility from Transmission-Connected Loads to Increase Network Utilisation and Capacity:**
The article examines how flexibility from large transmission-connected loads can improve transmission network utilisation and defer costly reinforcements. It explores congestion curtailment and rapid runback services, customer and regulatory constraints, and market interactions. Based on extensive stakeholder engagement, it proposes an incentive framework to unlock latent network capacity while balancing fairness, certainty, and operational complexity.

**10495 - Incorporating a Market-Based Rate of Change of Frequency Control Ancillary Service in Nodal Electricity Markets:**

This paper proposes integrating a market-based Rate of Change of Frequency control service into nodal electricity markets. Through a security-constrained economic dispatch framework, it demonstrates how pricing inertia enables efficient trade-offs between energy, contingency reserves, and frequency security. Simulation results show lower system costs and improved flexibility compared with administratively fixed inertia requirements.

**10587 - Regulatory Mechanism for Handling Imbalances for Renewable Energy (RE) Sources in India:**
The article reviews the evolution of India's imbalance pricing framework for wind and solar generation under the Deviation Settlement Mechanism. It explains regulatory changes introduced to address high renewable penetration, including tighter deviation bands, modified deviation formulas, and partial frequency linkage. The study shows how improved forecasting, aggregation, storage deployment, and thermal flexibility are essential to integrate renewables while maintaining grid reliability.

**10593 – Aggregator Framework for Renewable Energy Generators in India:**
This paper explains the operational, metering, scheduling, and settlement framework for Renewable Energy aggregators in India under the ISTS regime. It details how aggregation of schedules and actual injections reduces variability, improves forecast accuracy, and lowers deviation settlement charges. Practical case studies demonstrate significant commercial gains from portfolio-level netting of deviations, while also showing how aggregators simplify coordination with load dispatch centres and strengthen grid discipline.

**11208 – Energy Storage Systems as a Flexible Market Tool for the Russian Power and Capacity Market:**
This paper analyses how Energy Storage Systems can serve as flexible, multi-purpose tools in Russia's electricity and capacity markets amid growing renewable penetration and regional supply challenges. Based on international experience, it classifies storage technologies and identifies their potential roles in energy arbitrage, capacity provision, ancillary services, and demand response. The study finds that under current Russian market conditions, the most profitable near-term application of storage is reducing capacity payments rather than energy arbitrage, due to limited price volatility. It concludes that full integration of storage requires dedicated technical standards and regulatory frameworks covering participation across wholesale markets, capacity mechanisms, and real-time system operation.

**11209 – Demand Response in UPS of Russia: Results and Prospects:**
This paper reviews the development of demand response (DR) as a flexible and low-capital tool within Russia's electricity and capacity markets. It describes the evolution from early price-based demand reduction to a pilot aggregated demand management scheme and, since 2024, a permanent market-based DR mechanism integrated into the day-ahead market. The authors show that DR has reduced peak demand, mitigated price spikes, and delivered net economic benefits to consumers, while enhancing system reliability. Future prospects include expansion into real-time balancing, closer integration with energy storage, and increased participation of data centers and other digital-intensive consumers.

**11211 – Hourly Alignment Tools for Certification of Electricity Origin in Russia:**
This article examines the Russian electricity origin certification system launched in 2024 and explores the feasibility of introducing hourly matching between clean electricity generation and consumption. It reviews demand trends for generation attributes, compares Russia's system with emerging international standards for granular (hourly) certificates, and assesses technical, regulatory, and market implications. The analysis shows that while Russia's data infrastructure can support hourly accounting, widespread implementation may reduce the effective use of solar and wind attributes and increase complexity for market participants. The authors conclude that hourly tools should be introduced cautiously and incrementally to avoid undermining the current growth of the clean electricity attribute market.

**11212 – Realizing the Value of Vehicle-to-Grid for Industrial Consumers: Investment Viability and Market Design Considerations:**
This paper evaluates the techno-economic viability of Vehicle-to-Grid (V2G) schemes for large industrial consumers in Russia's liberalized electricity market, where electricity and capacity are priced separately and nodal pricing applies. Using a discounted cash-flow model across multiple regions and scenarios, the study shows that V2G can be financially viable over a ten-year horizon, primarily driven by savings on capacity payments through peak shaving and by peak–off-peak price spreads. Results indicate that regions with higher capacity price components benefit the most, and that V2G provides robust demand-side flexibility aligned with market price signals. While grounded in the Russian context, the findings are relevant to other liberalized markets with capacity mechanisms and locational pricing.

**11287 – Planning for Reliability with Variable Renewables: Brazil's Diagnostic and Pathways for ELCC Implementation:**
This paper argues that Effective Load Carrying Capability (ELCC) should become the core reliability metric in Brazilian power-system planning as variable renewable energy penetration rises. It shows that Brazil's current energy-based planning framework fails to capture time-coincident reliability risks, system strength constraints, and diminishing marginal capacity value of wind and solar. Using simplified ELCC simulations applied to the national expansion plan, the authors demonstrate that rapid renewable capacity growth translates into much smaller firm capacity contributions, increasing the need for complementary resources and ancillary services. The paper proposes a harmonized framework in which ELCC addresses energy adequacy while probabilistic Short-Circuit Ratio metrics capture electrical robustness, aligning market incentives, planning, and reliability outcomes.

**11292 – Utility-Scale Battery Integration in Brazil: Feasibility Analysis for Different Applications and Regulatory Enablers:**
This paper assesses the economic viability of utility-scale Battery Energy Storage Systems (BESS) in Brazil under the evolving regulatory framework. Using project-level cash-flow modeling, it compares required revenues with potential income from energy arbitrage, capacity provision, and ancillary services. Results show that, under current market conditions, energy arbitrage and ancillary services provide limited revenue due to low intraday price volatility and immature remuneration schemes. Capacity provision—particularly via the planned BESS-specific capacity auction from 2026—emerges as the dominant and most viable revenue stream. Although recent regulatory advances, including formal legal recognition of storage and tax incentives, significantly improve prospects, the study concludes that full economic viability ultimately depends on allowing effective revenue stacking and strengthening price and ancillary-service signals.

**11296 – Brazil's Experience with Availability-Based Demand Response Procurement under the Regulatory Sandbox Framework: Lessons Learned and Proposals for Future Regulatory Enhancements:**
This paper presents Brazil's experience with procuring availability-based Demand Response (DR) through a regulatory sandbox framework coordinated by the National Power System Operator (ONS). It describes the design, implementation, and outcomes of the first two competitive procurement mechanisms carried out in 2024 and 2025 to contract demand reduction availability for peak load management. Results demonstrate growing market participation, cost reductions relative to price caps, and effective delivery of contracted demand reductions, particularly from industrial consumers and aggregators. The paper identifies lessons learned regarding auction design, timelines, baseline definition, and data automation, and proposes regulatory enhancements to support the potential integration of availability-based DR into Brazil's permanent Structural DR Program as a reliable source of system flexibility during the energy transition.

**11523 – Impacts of Cooperative and Competitive Participation Modes of Battery Energy Storage Systems on Electricity Markets:**
This paper investigates how different market participation modes of Battery Energy Storage Systems (BESS)—cooperative alliances versus independent competitive operation—affect electricity market clearing prices and social welfare. Using a bi-level optimization framework, the authors model BESS

as price-makers interacting with the market operator, comparing cooperative behavior (modeled as an MPEC) with competitive behavior (modeled as an EPEC). Case studies show that both modes reduce peak-valley price spreads by shifting energy temporally, but cooperative BESS alliances exert greater market power, achieve higher revenues, and more effectively smooth prices. However, this coordinated arbitrage leads to increased total system costs and partial loss of social welfare compared to competitive operation. The study highlights a key regulatory trade-off: while cooperation maximizes BESS revenues, appropriate price signals and rules are needed to prevent excessive market power and ensure that storage deployment improves overall market efficiency.

**11524 – Study on China's Market Participation Model for Aggregated Distributed Photovoltaic Resources Based on Multi-Agent Credit Assessment:**
This paper analyzes market participation pathways for aggregated distributed photovoltaic (DPV) resources in China and proposes a novel virtual power plant (VPP)-based aggregation framework to address forecasting uncertainty, deviation risk, and fair revenue allocation. The model employs a bi-level Stackelberg structure in which the aggregator optimizes portfolio bidding while individual DPV agents retain autonomy. Each DPV agent uses LSTM forecasting to predict output, while a dynamic credit assessment mechanism weights bids and allocates revenues based on historical accuracy and compliance. Simulation results using real provincial data show significant reductions in day-ahead bidding errors and increases in total revenues compared with conventional aggregation methods. The credit mechanism suppresses opportunistic behavior and improves incentive compatibility, offering policy-relevant insights for scaling distributed PV market integration under China's transition toward full market-based renewable participation.

**11527 – Extreme Load Interval Estimation Under Demand Response Uncertainty:**
This paper proposes a bilevel user-equilibrium model to estimate maximum and minimum system loads under demand-response uncertainty. By capturing closed-loop price–load interactions and aggregating diverse flexible loads via a virtual battery model, it efficiently identifies extreme load intervals and the most influential load types, outperforming Monte-Carlo approaches.

**11529 – Analysis of Lost Opportunity Costs for Hydropower Under LMP:**
This study analyzes why locational marginal pricing (LMP) creates lost opportunity costs for hydropower in hydro-dominant markets. It shows that upstream–downstream coupling constraints break dispatch-following incentives, leading to inefficiencies. The paper provides a theoretical basis for adapting pricing mechanisms to better integrate hydropower in modern electricity markets.

**11744 – Block Tariffs and Prosumer Billing in Bosnia and Herzegovina:**
This paper presents the implementation of block tariff billing and prosumer settlement at Elektroprivreda BiH. It details algorithms for consumption blocks, high/low tariffs, and net metering or net billing for prosumers. Results show how differentiated tariffs affect revenues, consumption patterns, and incentives for energy efficiency.

**11931 – Evaluating Time-of-Use Electricity Tariffs in Jordan:**
This paper evaluates Jordan's ToU tariffs using smart-meter data and MV feeder analysis. Results show improved tariff fairness and reduced cross-subsidization, but limited overall load shifting. Highly flexible industrial users respond strongly, sometimes increasing off-peak network stress, underscoring the need for network-aware tariff design and complementary demand-response measures.

**12086 – Chile's 2021 Electricity Scarcity Amid Energy Transition:**
This paper analyzes Chile's 2021 scarcity event, where electricity shortages emerged despite large installed capacity. Drought, fuel constraints, coal retirements, and renewable intermittency created supply stress. Temporary regulatory measures mitigated risk but revealed the need for forward adequacy planning, probabilistic monitoring, and capacity mechanisms aligned with flexibility and reliability.

**12089 – Governance and Institutional Design After Chile's 2025 Blackout:**
This paper examines governance failures revealed by Chile's nationwide blackout in February 2025. Beyond technical causes, it identifies deficiencies in oversight, accountability, and contingency planning within the institutional framework. The authors propose regulatory reforms to strengthen transparency, enforcement, and resilience in a rapidly decarbonizing electricity system.

**12105 – Voluntary Demand Response in Colombia: Operational Insights and Market Impact:**
This study analyzes Colombia's voluntary demand response (DDV) mechanism using real operational data. While participation has expanded, gaps between contracted and verified disconnections persist. The paper highlights regulatory improvements, data-driven verification methods, and incentive alignment as key to strengthening demand-side flexibility and supporting system reliability.

**12116 – Demand as an Active Agent: Colombia–UK Comparison:**
This comparative study analyzes how Colombia and the United Kingdom integrate demand as an active market participant. It highlights the UK's mature regulatory framework, advanced smart metering, and large-scale demand flexibility programs, contrasting Colombia's emerging regulation and pilots, and proposes lessons to accelerate active demand deployment in Colombia.

**12138 – Adapting TRMM to Evaluate Energy Market Resilience (Colombia):**
This paper adapts the Transmission Resilience Maturity Model (TRMM) to assess the resilience maturity of Colombia's wholesale electricity market facing high-impact, low-probability events. The adapted framework identifies gaps in risk management, situational awareness, and recovery practices, providing regulators and operators with a structured tool to strengthen market resilience.

**12149 – Regulatory Evolution of the Reliability Charge in Colombia under Climate Stress:**
This paper analyzes how Colombia's Reliability Charge and scarcity-price mechanisms evolved after the 2015–2016 and 2023–2024 El Niño events. It assesses regulatory adjustments, differentiated scarcity prices, and incentive reforms, highlighting lessons learned and proposing improvements to strengthen system reliability amid climate change and energy transition challenges.

**12151 – Offer Dynamics and Market Power Using the Residual Supply Index (Colombia):**
This paper applies the Residual Supply Index (RSI) to analyze bidding behavior and market power in Colombia's electricity market. Comparing historical and current regulatory methodologies, it shows how RSI identifies pivotal suppliers, reveals strategic price behavior, and supports regulatory monitoring to strengthen competition and transparency.

**12156 – Monitoring Systemic Risk in Colombia's Wholesale Power Market (El Niño 2023–2024):**
This paper develops a methodology to monitor financial and systemic risk in Colombia's wholesale electricity market during the 2023–2024 El Niño event. By combining spot exposure, contracting positions, and financial indicators, it identifies vulnerable retailers, simulates contagion effects, and provides early-warning signals to support timely regulatory intervention.

**12192 – Energy Resilience Alternative: Supply Shortage Management in Colombia:**
This case study examines the activation of Colombia's Supply Shortage Risk Statute (ESRD) in 2024 during severe drought conditions. It evaluates impacts on reservoir management, dispatch, prices, and reliability, and highlights the need to diversify the energy mix and integrate international best practices to strengthen resilience against climate variability.

**12223 – Optimal Renewable Energy Sharing by Active Customers:**
This paper proposes an optimization method for allocating photovoltaic energy shares within energy communities. Using high-resolution consumption data, the model maximizes real-time self-consumption and minimizes grid injections, improving economic efficiency, fairness, and system resilience, while supporting EU energy-sharing policies introduced after the 2021–2022 energy crisis.

**12271 – Securing Energy Supply in Interconnected Regional Markets (Andean vs Europe):**
This paper compares how Colombia and the European Union managed electricity supply crises between 2022 and 2024. It highlights Colombia's temporary export restrictions during El Niño and

Europe's reliance on market integration and REPowerEU measures, showing that regional market coupling and adaptive regulation are key to energy security under scarcity.

**12293 – Regulatory Incentives for Optimizing Transmission Asset Maintenance:**
This study proposes an incentive-based regulatory framework to reschedule transmission maintenance away from peak-demand hours. Using Monte Carlo simulations, it shows that penalty-reward schemes can reduce operational risk, improve reliability, and align agent behavior with system efficiency without prescriptive mandates.

## PS3: APPLYING PRACTICAL EXPERIENCES TO EMERGING ISSUES (31 papers)

**10173 - Operationalizing the Eastern Africa Power Pool Market: A Holistic Framework for Regional Electricity Integration (2021–2025):**
This paper provides a practitioner-led account of transforming the Eastern Africa Power Pool from fragmented bilateral trading to an integrated regional electricity market. It presents a three-pillar framework combining phased zonal market design, extensive shadow trading, and robust legal foundations. The experience demonstrates how inclusive governance and iterative implementation can align national interests and support the African Single Electricity Market vision.

**10178 - Enhancing Spinning Reserve Scheduling Through Ramp Rate Dependent Modeling and Limited Participation: A Scalable Market Design Framework for Grid Reliability:**
The article addresses reliability challenges in New York's power system arising from overestimated ramping capability of duct-fired combined-cycle gas turbines. It proposes a reserve scheduling framework using multiple ramp rates and limited participation in duct-firing zones. Simulation results show improved operational feasibility, capture of otherwise stranded reserves, and enhanced reliability with minimal cost impact.

**10422 - Optimizing Intra-State Generation Dispatch for Economic Efficiency: A Case Study at State Level in India:**
This paper evaluates a transition from conventional Merit Order Dispatch to Security Constrained Economic Dispatch for intrastate operations in Maharashtra, India. Using one year of data, it shows that SCED delivers consistent cost savings, better management of renewable variability, and stronger system security. The study highlights additional benefits from marginal price signals and coordinated integration of hydro resources.

**10423 - Ancillary Services Market in India: Emerging Opportunities and Optimal Despatch for Battery Energy Storage Systems:**
This paper analyses the Indian Tertiary Reserve Ancillary Services market, highlighting persistent unmet reserve requirements caused by insufficient market participation. It assesses the techno-economic feasibility of Battery Energy Storage Systems to bridge this gap. Using real market data and an optimization framework, the study shows that BESS can enhance grid reliability while achieving commercially attractive revenues.

**10580 - Implementation and Operation of Security Constrained Unit Commitment in Indian Power System:**
This paper reviews the first year of operational experience with Security Constrained Unit Commitment in India, implemented to ensure adequate spinning reserves under high renewable variability. It explains the day-ahead and real-time SCUC algorithms, data architecture, and coordination with SCED and ancillary services. Results show improved reserve adequacy during evening peaks, while highlighting emerging challenges related to down-reserve scarcity and congestion management.

**10582 - Role of Real-Time Market in Facilitating Renewable Energy Integration and Optimization in India:**
This paper evaluates India's Real-Time Market as a key mechanism for managing renewable

variability and real-time imbalances. Through empirical case studies, it shows how 15-minute auctions enable DISCOMs and renewable-rich states to correct forecast errors, optimise procurement costs, and reduce deviation exposure. The results demonstrate that RTM enhances operational flexibility, improves price signals, and supports secure large-scale integration of variable renewable energy.

**10585 - Proactive Role of Regulatory Institutions in Developing and Implementing the Regulatory Framework:**
This paper documents Maharashtra's transition from the Final Balancing Settlement Mechanism to a modern Deviation Settlement Mechanism aligned with national standards. It highlights the regulator's proactive role through a dedicated working group, phased implementation, and intensive stakeholder engagement. The reform improved grid discipline, transparency, renewable integration, and frequency control, demonstrating that active regulatory oversight is critical for successful power market reforms.

**10590 - Impact Assessment of Pollutant-Specific Minimization Strategies in Security and Emission Constrained Economic Dispatch (SECED) in India:**
This paper evaluates Security and Emission Constrained Economic Dispatch as a tool to reduce $CO_2$ and local pollutants in India's power system. Through national-scale simulations, it shows that limited emission reductions can be achieved at modest cost through redispatch, while deeper cuts sharply increase costs. The results support centrally coordinated emission-aware dispatch as a practical complement to India's forthcoming carbon market.

**11210 – Reducing the Risks Associated with Rising Electricity Prices as Russia Moves Towards Carbon Neutrality by Combining Energy and Forestry Projects:**
This paper analyses how Russia can pursue carbon neutrality while avoiding sharp increases in electricity prices. It compares market and non-market decarbonization mechanisms, including renewables, CCUS, carbon pricing, and forestry climate projects, using indicators such as LCOE and cost per ton of $CO_2$ reduced. The study finds that purely technological pathways tend to be capital-intensive and inflationary, whereas forestry-based carbon offset projects offer lower-cost emission reductions. Among several hybrid scenarios, a "phased transformation" combining moderate RES growth, partial retention of thermal generation, and forest climate projects is identified as the most balanced option, limiting electricity price growth while meeting climate goals.

**11213 – Balancing Cost and Emissions in the Russian Electricity Market through Carbon-Aware Dispatch Scenarios:**
This paper investigates alternative ways of integrating carbon regulation into electricity markets using the Russian day-ahead market as a case study. It demonstrates that embedding $CO_2$ costs directly into generators' marginal bids raises wholesale prices and creates windfall profits for low-carbon generators, imposing a high burden on consumers. As an alternative, the authors propose a nodal allocation approach in which carbon costs are assigned to consumers based on their electricity consumption and node-specific carbon intensity calculated via power-flow tracing. Modeling results with a carbon price of 1,000 RUB/t$CO_2$ show that this targeted allocation can reduce total consumer payments by about 43% while maintaining decarbonization incentives and avoiding price distortions.

**11288 – Market Pricing Analysis for Wind Energy with BESS: A Stochastic Evaluation of PPA Strategies and Storage Integration:**
This paper extends a stochastic financial model for hybrid wind–solar projects by incorporating Battery Energy Storage Systems (BESS) as a tool for energy arbitrage. Using Monte Carlo simulation and risk–return analysis, it evaluates how storage affects profitability, volatility, and optimal portfolio composition under long-term PPAs. Results show that, under an arbitrage-only representation, BESS tends to reduce median returns due to higher capital costs, while modestly smoothing revenue volatility. Storage shifts the risk–return frontier and favors wind-heavier portfolios but delivers limited value unless complemented by additional revenue streams such as ancillary services. The study concludes that the economic attractiveness of BESS in Brazil critically depends on cost reductions and the development of explicit remuneration mechanisms beyond energy arbitrage.

**11291 – Spot Price Formation in the Brazilian Wholesale Electricity Market: Challenges and Perspectives:**
This paper analyzes the limitations of Brazil's current cost-based spot price formation (PLD) in a power system increasingly dominated by variable renewable energy. The authors show that centralized optimization models struggle to reflect real-time scarcity, flexibility needs, and locational constraints, weakening economic signals and socializing system costs. Drawing on international experience, the paper proposes a transition toward a hybrid pricing paradigm that preserves centralized dispatch while introducing bid-based elements, combined with a two-settlement system. Supporting mechanisms such as a virtual reservoir for hydropower coordination, security bids to protect supply adequacy, and market-monitoring tools are discussed and tested in a case study, demonstrating improved price signals, better incentive alignment, and reduced reliance on distortionary sectoral charges.

**11608 – Electricity Market Participation of New-Type Flexible Resources in Guangdong (China):**
This paper presents Guangdong's electricity market practices for integrating heterogeneous flexibility resources, including pumped hydro, battery storage, and virtual power plants. It describes bidding rules, clearing-model adaptations, and early experience with a ramping ancillary service, showing how market design can better exploit flexibility in high-renewable power systems.

**11687 – Market Integration in the Gulf Region through Ancillary Services Sharing:**
This paper evaluates cross-border ancillary services integration in the GCC power system to manage renewable variability. It shows that imbalance netting and reserve sharing can significantly reduce balancing costs and improve reliability with limited regulatory changes, offering a practical roadmap for regional cooperation in high-renewable power systems.

**11689 – Reforming Unscheduled Deviations in the GCC Power Grid:**
This paper analyzes the reform of the GCC Unscheduled Deviation mechanism, proposing a shift from 60-minute to 15-minute net deviation calculation. Results from 2024–2025 show improved imbalance detection, fairer cost allocation, and better incentives under high renewable variability, especially with optimized thresholds and expanded emergency declarations.

**12064 – Thailand's REC Issuer Platform and Green Energy Market Trends:**
This paper presents Thailand's digital REC Issuer Platform developed by EGAT to support the rapid growth of the voluntary REC market. Platform digitalization reduced processing time by ~60%, manpower costs by ~50%, and eliminated data errors through interoperability with the I-REC Evident registry, enabling scalable, transparent green energy market development.

**12087 – Chilean Experience with BESS in Energy and Ancillary Services Markets:**
This paper examines the integration of battery energy storage systems (BESS) into Chile's cost-based electricity and ancillary services markets. Using real operational data, it shows how BESS enhance flexibility, reduce curtailment and thermal dispatch, and lower system costs, while highlighting regulatory needs for opportunity-cost recognition and fair remuneration.

**12088 – Electrical Integration Opportunities for CIGRE RIAC Countries:**
This study analyzes electrical integration across Ibero-American (RIAC) countries as a key enabler of the energy transition. It identifies regulatory, technical, and planning barriers, highlights renewable complementarities, and proposes HVDC-based interconnections, harmonized regulations, and coordinated governance to improve resilience, efficiency, and regional electricity market development.

**12106 – Market Liquidity as a Condition for Energy Transition in Colombia:**
This paper examines market liquidity as a structural prerequisite for Colombia's energy transition. It analyzes liquidity indicators, barriers, and regulatory reforms, showing how standardized contracts, derivatives, transparency tools, and broader participation improve price signals, risk management, and investment conditions in a renewable-rich electricity system.

**12139 – Linear Optimization of Demand Response with Endogenous Marginal Pricing (Colombia):**

This paper proposes a linear optimization model for demand response where the system marginal price is determined endogenously within the dispatch problem. By eliminating iterative price calculations, the approach improves efficiency, price accuracy, and social welfare, providing clearer economic signals for integrating demand as an active market resource.

**12144 – Strengthening Unit Commitment Models: Colombian Case Study:**
This paper proposes a methodological framework to enhance Colombia's unit commitment and redispatch models. Through structural reformulation, numerical scaling, solver tuning, and automated testing, the approach significantly improves computational efficiency, numerical stability, and robustness while preserving optimal dispatch results, supporting transparent and reliable market operations.

**12148 – Transforming Decision-Making through Data Quality (Colombia):**
This paper shows how the Colombian ISO/market operator XM improved decision-making by institutionalizing a data-quality process. Using data governance, PDCA cycles, metrics, and continuous monitoring, XM increased master-data quality by over 7%, reduced operational risk, and strengthened regulatory compliance in a data-intensive energy market.

**12150 – Deviations Mechanism as an Incentive Tool in Colombia's Energy Transition:**
This study analyzes Colombia's deviations (imbalance) mechanism under rising renewable penetration. It shows that traditional penalty-based schemes are ill-suited to variable generation and argues for evolving the mechanism toward near-real-time, cost-reflective settlements that align forecasting incentives, operational efficiency, and renewable integration goals.

**12204 – Machine Learning for Data Validation in Peru's Electricity Market Settlements:**
This study presents a customer-specific, unsupervised machine learning approach to validate energy consumption data in Peru's settlement process. Using clustering and data-quality rules, it efficiently detects atypical, null, and repeated profiles, improving situational awareness and robustness of the active-energy settlement process managed by COES.

**12355 – Electricity Market Island in European Interconnection (CBAM Impact):**
This paper analyzes how the EU Carbon Border Adjustment Mechanism (CBAM) risks isolating Southeast European electricity markets. It shows that without full market coupling and recognition of green attributes, CBAM increases uncertainty, reduces cross-border trading, discourages renewable investment, and may fragment the European power market into isolated "electricity islands."

**12360 – New Perspectives on Energy Market Design (User-Centric Model):**
This paper proposes a user-centric redesign of the Colombian electricity market where consumers become active prosumers. It identifies seven pillars—demand response, distributed resources, peer-to-peer trading, digitalization, AI, smart grids, and adaptive regulation—to enhance system flexibility, resilience, and sustainability while supporting large-scale renewable integration.

**12488– Bidding Optimization for Battery Energy Storage Systems:**
This paper examines stochastic optimization strategies for battery energy storage bidding across energy, imbalance, and ancillary service markets. It shows how uncertainty, ancillary events, and state-of-charge deviations affect feasibility and profits, demonstrating that robust, multi-market optimization and corrective actions are essential for reliable and profitable BESS participation.

**12534 – Price Regulation Service for Active Regulatory Intervention:**
This paper proposes a Price Regulation Service enabling proactive regulatory intervention in balancing energy markets. By allowing selected providers to adjust bids before market clearing, regulators can mitigate market power abuse, stabilize prices, and improve efficiency. The approach uses sensitivity analysis within dynamic dispatch to protect consumers in high-renewable systems.

**12565 – The 70% Rule in the South-East Europe Capacity Calculation Region:**
This paper details the implementation of the EU 70% cross-zonal capacity rule in the SEE region. Using coordinated NTC, remedial action optimisation, and redispatch, TSOs increased

market-available capacity while preserving grid security, improving price convergence and market integration across BG-GR and RO-BG borders.

**12593 – Energy Multimarket Short-Term Trading (Senergy-Nets, Slovenia):**
This paper presents practical experience from a multimarket flexibility pilot in Ljubljana, where district-heating CHP assets were traded across intraday, balancing (aFRR), and DSO flexibility markets. It highlights the role of aggregation platforms, operational constraints of heat-led assets, and regulatory mismatches that limit full exploitation of multimarket flexibility.

**12612 – Reducing Balancing Reserves Using Ensemble Forecasts (Japan):**
This paper presents a method using ensemble weather forecasts to size balancing reserves for FIT renewables in Japan. By assigning forecast reliability ranks, TSOs reduced replacement reserve requirements by around 30%, lowering procurement costs while maintaining system reliability in high-renewable conditions.