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APEx
Association of Power Exchanges

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APEx Objective

To facilitate the development and communication of ideas and practices in the operation of global competitive electricity markets. One of its primary intentions is to provide a platform for the sharing of information between its members.

IN THE SPOTLIGHT

Colombia's Journey Toward a Flexibility Market: Progress, Opportunities, and Challenges

Jaime Alejandro Zapata Uribe
Gerencia Mercado de Energia (XM)

Executive Summary

Colombia is evolving a contract-centric power market to explicitly procure and price flexibility as solar and wind scale and hydro variability intensifies with climate volatility. CREG's modernization agenda -supported by the Ministry of Mines and Energy- seeks to introduce intraday trading, competitive ancillary-services procurement, and clear participation rules for storage, demand response, and aggregators.

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Ahmed Ali Al-Ebrahim
Chief Executive Officer
GCC Interconnection Authority (GCCIA)

Strengthening Regional Electricity Markets Through Interconnection, Resilience, and Innovation

The global electricity sector is undergoing one of the most profound transformations in its history. Rapid growth in renewable energy, increasing electrification of economies, the emergence of advanced storage technologies, digitalization, artificial intelligence applications, and evolving market structures are reshaping how power systems are planned, operated, and traded.

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APEx 2026 CONFERENCE DATES AND REGISTRATION

OCTOBER 21-23, 2026
ATHENS - GREECE

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Senior APEx Member representatives, sponsors, and industry participants from all over the world will come together to share information, network, and plan for the future of electricity markets.

Please register for the conference at
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Ahmed Ali Al-Ebrahim
Chief Executive Officer
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Continued – Director's Column

In the Gulf Cooperation Council (GCC) region, composed of the countries of United Arab Emirates, Bahrain, Saudi Arabia, Oman, Qatar and Kuwait, these developments are occurring alongside ambitious national energy transition programs and long-term economic diversification strategies. The GCC countries continue to make significant investments in renewable energy, grid modernization, and sustainable infrastructure, creating new opportunities for regional cooperation and market integration.

GCC Countries' Renewable Energy and Net-Zero Targets

GCC Country	Renewable Energy Target	Net-Zero Target
United Arab Emirates	**44%** clean energy by **2050** (Energy Strategy 2050)	**2050**
Bahrain	**20%** emissions reduction by 2035 and increasing renewable deployment (national plans continue to evolve)	**2060**
Saudi Arabia	**50%** of electricity generation by **2030**	**2060**
Oman	**30%** renewable electricity by **2030**	**2050**
Qatar	Approximately **18%** renewable electricity by **2030**	Carbon neutrality target under development; significant emissions reduction commitments by **2030**
Kuwait	**30%** renewable electricity by **2030**	Carbon neutrality by **2060** (oil & gas operations) and broader national decarbonization pathway under development

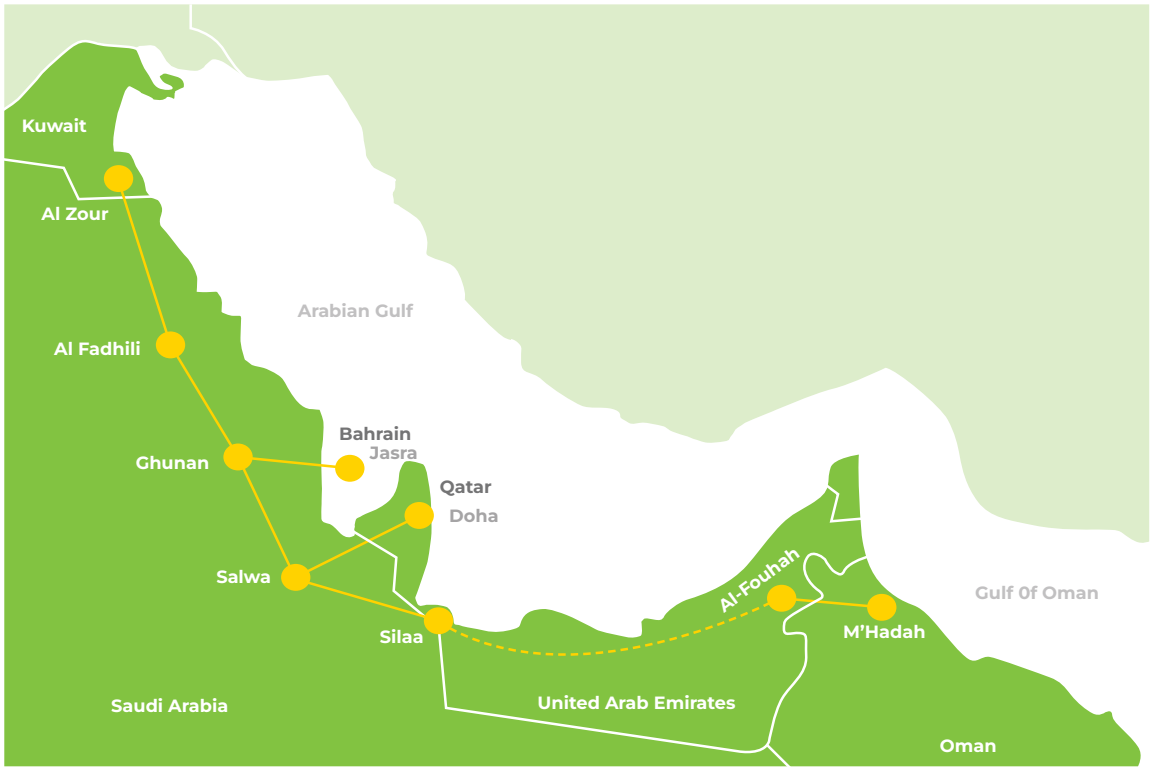
The GCC countries have adopted ambitious renewable energy and decarbonization strategies. Regional electricity interconnections enable greater integration of renewable resources, improve system flexibility, reduce balancing costs, and strengthen energy security across the region.

Ahmed Ali Al-Ebrahim
Chief Executive Officer
GCC Interconnection Authority (GCCIA)

Continued – Director's Column

The convergence of ambitious renewable energy targets across the GCC reinforces the strategic importance of regional electricity interconnections. By enabling the sharing of flexible generation resources, balancing variable renewable output, and facilitating cross-border electricity trade, the GCC Interconnection System provides a critical foundation for achieving national energy transition objectives while maintaining reliability, affordability, and system resilience. This positions the GCC electricity market as an increasingly important enabler of the region's sustainable economic development.

At the heart of this transformation is the GCC Interconnection Authority (GCCIA), whose interconnected transmission network has demonstrated its strategic value for more than fifteen years. The GCC Interconnection Grid continues to enhance reliability and resilience across one of the most important regions for global energy, helping Member States avoid major power disruptions, optimize generation resources, and realize substantial economic benefits through cross-border electricity exchanges.



GCC Electricity Interconnection Network

The GCC Interconnection Network connects the six GCC Member States through a high-voltage transmission system that supports secure electricity exchanges, optimizes the utilization of generation resources, and accelerates the transition toward an integrated regional electricity market.

Ahmed Ali Al-Ebrahim
Chief Executive Officer
GCC Interconnection Authority (GCCIA)

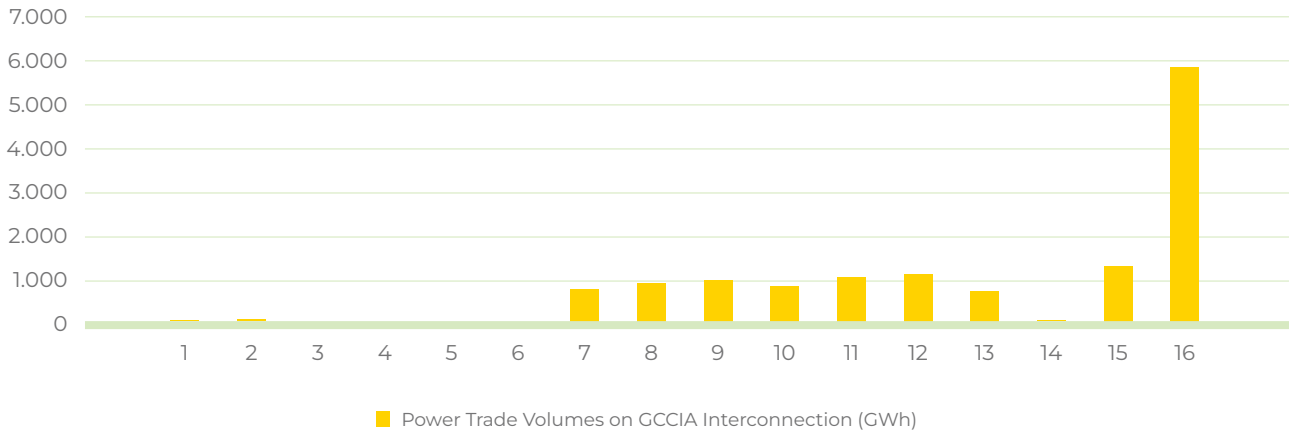
Continued – Director's Column

Today, the role of interconnections extends far beyond emergency support. Modern interconnected grids are becoming essential enablers of competitive electricity markets, renewable energy integration, flexibility services, and regional energy security. As renewable penetration increases, interconnections provide access to wider balancing areas, improve operational flexibility, and facilitate more efficient utilization of generation resources across multiple jurisdictions.

Recognizing these opportunities, GCCIA continues to advance its strategic vision of expanding regional electricity trade and strengthening market integration within the GCC and beyond. The development of new interconnections with neighboring countries, such as Iraq, is creating the foundation for broader regional market participation and enhanced cooperation across the Arab World and Middle East. These initiatives support not only energy security objectives but also the creation of more efficient and sustainable electricity markets capable of delivering long-term value to consumers and economies alike.

Another important priority is ensuring that electricity markets evolve in parallel with technological advancements. The increasing deployment of inverter-based renewable resources, battery energy storage systems, demand-side participation, AI and digital technologies requires new market designs capable of valuing flexibility, resilience, and ancillary services. Market operators, transmission system operators, regulators, and policymakers must work together to establish frameworks that encourage innovation while maintaining system security and reliability.

Power Trade Volumes on GCCIA Interconnection (GWh)



Evolution of Electricity Trading on the GCC Interconnection

Annual electricity trading volumes have increased significantly since the introduction of market-based trading, demonstrating the growing confidence of GCC utilities in utilizing the regional interconnection for economic dispatch and cross-border electricity transactions.

Ahmed Ali Al-Ebrahim
Chief Executive Officer
GCC Interconnection Authority (GCCIA)

Continued – Director's Column

This is where organizations such as APEx play a vital role. The exchange of experiences, lessons learned, and best practices among power exchanges and market institutions worldwide has never been more important. As electricity markets become increasingly interconnected and sophisticated, collaboration among industry leaders enables us to address common challenges more effectively and accelerate the adoption of innovative solutions.

GCCIA highly values its engagement with APEx and its members. The association provides a unique platform for dialogue among market operators, exchanges, regulators, and industry experts who share a common objective: developing efficient, transparent, and resilient electricity markets that support economic growth and the global energy transition.

As we look ahead, I am confident that stronger regional cooperation, continued investment in interconnection infrastructure, and collaborative market development will play a central role in building a more sustainable and secure energy future. Through innovation, resilience, and partnership, we can unlock new opportunities for electricity markets worldwide and deliver lasting benefits for future generations.

Continued – Colombia's Journey Toward a Flexibility Market: Progress, Opportunities, and Challenges

In parallel, XM and partners are advancing pilots and operational studies to validate technical requirements. The near-term imperative is implementation: finalize rules, standardize measurement and telemetry, and align network and digital investments so flexibility products can operate reliably at scale.

• A flexibility market is increasingly essential to integrate renewables and manage hydro-driven variability without compromising reliability.

• Storage, demand response, and aggregators can supply fast-response services, but only with clear products, settlement, and verification.

• Intraday trading and competitive ancillary-services procurement are the most immediate levers to improve efficiency and transparency.

• Transmission, AMI, automation, and cybersecurity are enabling conditions, not optional add-ons.

• Colombia's reforms offer transferable lessons for emerging markets decarbonizing contract-based systems.

As Colombia accelerates its clean energy transition, it is working to make its power system more flexible and resilient. Central to this effort is a dedicated flexibility market that values resources able to respond quickly to imbalances across multiple time scales. The need is rising as a hydro-dominant system integrates more variable solar and wind, advancing sustainability goals while increasing operational requirements for reliability. Colombia's experience mirrors a broader global challenge: aligning policy, regulation, and technology so power systems remain secure, efficient, and affordable as they decarbonize.

This article outlines Colombia's market context, the regulatory and technological steps toward a flexibility market, and the principal opportunities and barriers ahead. It focuses on reforms under consideration, intraday trading, ancillary-services procurement, and participation frameworks for storage and demand-side resources, and closes with transferable takeaways for energy practitioners and policymakers.

What "Flexibility" Means in Power Markets

Operationally, flexibility is the system's ability to stay balanced and secure as conditions change from seconds to days. A flexibility market converts that need into competitively procured products, such as intraday/real-time energy, reserves and regulation, ramping capability, voltage support, congestion relief, and restoration services, with measurement and performance requirements that reward fast, accurate response from hydro, thermal units, storage, flexible demand, and aggregated DER. In contract-heavy systems, explicit flexibility products also reduce out-of-market interventions and create investable revenue streams for new providers.

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Colombia's Power Sector Context: A Hydro-Dependent System at a Crossroads

A legacy of hydropower and market reform: Colombia's modern electricity market emerged from sweeping reforms in the 1990s, transitioning from a vertically integrated monopoly to a competitive wholesale market with multiple generators and retailers. The market relies primarily on bilateral contracts, complemented by a "reliability charge" (the firm energy auction mechanism) to ensure long-term resource adequacy. Hydropower has long dominated the generation mix, supplying roughly 70% of electricity in an average year, supporting comparatively low costs and low carbon intensity.

Growing renewables and new system stressors: Colombia is now diversifying with non-conventional renewable energy sources (NCRES), particularly solar and wind. By late 2025, installed solar and wind capacity reached about 1.8 GW (roughly 9% of ~21.4 GW of effective generation capacity), and government initiatives such as "Plan 6 GW+" target at least 6 GW of additional projects in the near term. While these resources advance decarbonization, their variability increases the need for operational flexibility as demand grows. At the same time, hydro dependence exposes the system to climate risk, especially El Niño-driven droughts that can reduce reservoir levels and strain security of supply.

Gaps in the current market design: Colombia's market remains contract-centric, with a day-ahead energy market but limited instruments to explicitly procure or remunerate flexibility. There is no active intraday market, and most ancillary services are not procured through competitive, transparent auctions. Demand response remains limited, with few incentives for customers to shift or curtail load. Transmission expansion has also lagged demand and new generation in some areas, increasing congestion and operating costs. The modernization agenda is therefore clear: preserve the strengths of hydro-based operations while updating rules, institutions, and infrastructure to integrate variable renewables, distributed resources, storage, and active consumers, creating the conditions for a formal flexibility market.

Institutionally, Colombia pairs centralized operations with market-based transactions. XM operates the National Interconnected System and manages dispatch, settlement, and reliability processes; UPME leads long-term expansion planning; and CREG sets market and network rules. This structure has supported stable operations, but flexibility reform must be coordinated across planning, operations, and regulation, particularly where intraday trading depends on telemetry, forecasting, and congestion modeling as much as on market design.

Progress Toward a Flexibility Market: Regulatory and Technological Developments

In response, Colombia has advanced a package of policies, regulatory reforms, and pilots intended to operationalize flexibility and enable new market participants. Progress spans legal changes to support renewables and distributed resources, proposals to modernize market design, and technology demonstrations (notably energy storage) that expand the system's ability to balance variability.

Continued –
Colombia's Journey Toward a Flexibility Market: Progress, Opportunities, and Challenges

Sequencing is critical: Colombia is moving from targeted pilots to scalable rules that can be applied nationwide. Priorities include standardizing technical requirements (metering, communications, interoperability), defining products and qualification criteria, and operationalizing settlement and compliance so performance is rewarded and underperformance is penalized. Lessons from storage and demand response pilots are informing these requirements before full deployment.

• **Legal reforms enabling renewables and prosumers:** Colombia has enacted foundational legislation to diversify the resource mix and broaden participation. Law 1715 (2014) and Law 2099 (2021) introduced incentives for non-conventional renewables, including tax benefits and clearer integration pathways for solar and wind. Law 2294 (2023) recognized "energy communities" and distributed energy resources, strengthening the legal basis for prosumers and for aggregators to combine customer resources. Together, these measures establish core preconditions for a flexibility market.

• **Modernizing market design and introducing new services:** Since 2018, CREG has pursued a Market Modernization agenda to strengthen flexibility. Draft Resolution 143 (2021) proposed an intraday market and competitive procurement of ancillary services; as of late 2025, it remained pending final adoption. If implemented, the reform would enable sub-daily trading and define market-based products for reserves, frequency regulation, voltage support, and related services, complementing the day-ahead market and reliability charge with clearer price signals for balancing.

• **Regulations for energy storage (BESS):** Colombia has begun integrating battery energy storage systems (BESS), locally referred to as Sistemas de Almacenamiento de Energía en Baterías (SAEB), as a core flexibility resource. CREG Resolution 098 (2019) authorized a grid-scale pilot to relieve transmission congestion. CREG's draft Resolution 103 (2025) would define how storage may be installed, dispatched, and remunerated, allowing independent storage participation in energy and ancillary-services markets and enabling retailers (comercializadores) to own or contract BESS for flexibility across reserves, voltage/frequency support, and congestion management.

• **Demand response and aggregator initiatives:** Demand-side flexibility remains early-stage, but pilots, mainly with large industrial and commercial customers, show that compensated curtailment or load shifting can support reliability and reduce peak costs. Forthcoming reforms are expected to formalize aggregator participation so distributed resources and customer loads can be bundled and offered to the market, supported by clear registration, measurement and verification, and compensation rules. Scaling participation will also require enabling infrastructure, including broader deployment of smart meters and advanced metering infrastructure (AMI).

• **Grid modernization and flexibility pilot projects:** Colombia is investing in the technical enablers of flexibility. Since 2018, XM has led flexibility assessments, often with international partners, informing a 2024–2030 Flexibility Roadmap for grid and market modernization. Early actions include distribution pilots deploying advanced controls and DERMS to coordinate many small assets as aggregated resources or "virtual power plants," alongside the National Registry for Energy Communities. Draft resilience measures prepared in 2025 also include potential grid-forming inverter standards (expected by 2026) to support frequency stability as inverter-based resources expand.

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Key Opportunities in Developing a Flexibility Market

With this policy and implementation agenda underway, Colombia can unlock several high-impact sources of system flexibility. Key opportunities include:

• **Abundant renewable energy potential:** Colombia has substantial untapped solar and wind resources, with major projects advancing in regions such as La Guajira and the Caribbean coast. As variable generation grows, explicit flexibility products can reduce curtailment, mitigate short-term variability, and lower exposure to hydro constraints during droughts, supporting higher renewable penetration while maintaining reliability.

• **Rapid progress in enabling technologies (BESS, DER, smart grids):** Falling costs in storage and digital grid technologies strengthen the business case for flexibility. BESS can deliver fast frequency response, reserves, peak shaving, and congestion relief by shifting energy across time. At the distribution edge, growing DER deployment creates significant flexibility potential if assets can be monitored, aggregated, and controlled, supported by platforms such as DERMS and "virtual power plant" approaches.

• **Untapped demand-side flexibility and new business models:** Colombia's demand side remains an underused reliability asset. Large industrial and commercial customers can provide meaningful curtailment or load shifting during stressed periods, while residential customers and electric vehicle charging can contribute through aggregation. As regulation matures, "flexibility-as-a-service" models may expand, for example, retailers (comercializadores) could manage portfolios of flexible load and storage and transact flexibility products on behalf of customers.

Beyond reliability, flexibility can improve system economics. Transparent pricing can show when constraints are best addressed through network expansion versus local flexibility (storage or demand response) or improved operations, reducing curtailment and reliance on expensive out-of-merit generation during stress periods. Clear revenue streams also reduce investment uncertainty and can accelerate deployment of flexibility resources.

Together, renewable scale-up, technology readiness, demand-side potential, and an active regulatory agenda provide a credible platform for a flexibility market. If implemented effectively, Colombia could become a regional reference for market design that sustains reliability and affordability while enabling a cleaner, more resilient power system.

Continued – Colombia's Journey Toward a Flexibility Market: Progress, Opportunities, and Challenges

Major Challenges and Barriers

Despite strong momentum, Colombia must address several material barriers to implement an effective flexibility market at scale:

• **Regulatory and market design gaps:** Key services and participants still lack fully operational definitions and trading arrangements, limiting participation by aggregators and prosumers. Most ancillary services also lack standardized products, clear procurement processes, and transparent compensation. CREG's modernization package, including intraday trading and ancillary-services auctions, must be finalized and implemented, balancing speed with careful calibration to deliver efficient price signals, fair competition, and reliable outcomes.

• **Infrastructure constraints and investment needs:** Flexibility markets cannot outperform the networks that connect resources to load. In several areas, transmission capacity is tight and expansion has lagged demand growth and generation additions, increasing congestion and constraining dispatch. Distribution systems also require upgrades, sensing, automation, and smart metering, to integrate DER and demand response at scale. Delivering these investments will require coordination across planners, operators, and regulators, alongside timely approval of cost-recovery mechanisms.

• **Operational and technological challenges:** A flexibility market increases operational complexity for XM, potentially requiring faster balancing and dispatch across both large plants and distributed resources. Improved forecasting for variable renewables and responsive demand will be essential, alongside stronger cybersecurity and data governance. Higher shares of inverter-based resources also reduce inertia, increasing reliance on fast controls and updated stability criteria and grid codes, supported by modern tools, training, and contingency planning.

• **Institutional coordination and market readiness:** Implementation requires sustained coordination across CREG (regulation), MME (policy), UPME (planning), XM (operations), and market participants so rules, grid codes, and investment signals reinforce one another. Success also depends on participant readiness: customers must understand and trust new demand response and flexibility programs, and the sector must build skills and processes, potentially using regulatory sandboxes, to test and scale new products safely.

• **Affordability, consumer protection, and market power risks:** More granular pricing can improve efficiency but may raise concerns about bill impacts and fairness if costs are not allocated transparently. Regulators should avoid duplicating existing reliability mechanisms and ensure settlement rules prevent cost shifting. Monitoring frameworks should also evolve to mitigate market power risks in constrained areas or during drought conditions when flexibility supply may be concentrated.

Continued – Colombia's Journey Toward a Flexibility Market: Progress, Opportunities, and Challenges

Implications and Transferable Lessons

Colombia's pathway highlights lessons relevant to other jurisdictions. Flexibility reforms should be built around operational needs rather than technology categories, with products reflecting response speed, duration, location, and verification. Governance matters as much as design: policy (MME), planning (UPME), regulation (CREG), and operations/settlement (XM) must be aligned so grid codes, expansion plans, and market incentives move in the same direction.

Third, implementation should be phased with explicit readiness milestones. Early stages prioritize telemetry and measurement standards, baselines for demand response, and interoperability for aggregated DER; later stages can add more complex services once data quality and operational tooling are proven. Progress should be tracked with a small set of transparent metrics, curtailment reduction, reserve and frequency performance, balancing-cost trends, and fewer out-of-market interventions, so regulators can refine products and procurement volumes over time.

Conclusion: Toward a Flexible and Resilient Energy Future

Colombia's experience reinforces a central lesson of the energy transition: market and regulatory innovation is as critical as technology in delivering cleaner power systems without compromising reliability. By advancing intraday trading, competitive procurement of ancillary services, and updated rules for storage, demand response, and aggregators, Colombia is building the architecture for a more flexible grid suited to rising wind and solar and to climate-driven hydro variability.

The agenda is moving from design to implementation. Finalizing intraday market rules and aggregator frameworks will be decisive in translating policy intent into operational capability. The value proposition is clear: flexibility can integrate a large pipeline of solar and wind projects (often estimated at 14–15 GW) by shifting energy across time and mobilizing fast-response services when conditions change. From strategic battery dispatch and fast frequency response to coordinated demand reductions, well-priced flexibility can reduce reliability risks and avoid unnecessary costs.

For international readers, Colombia offers a practical case study in aligning policy, regulation, and technology to modernize an electricity market. It shows how a system anchored in large hydropower and long-term contracting can evolve toward faster balancing arrangements, demand-side participation, and distributed solutions, lessons relevant for emerging economies pursuing decarbonization alongside reliability and affordability.

Ultimately, flexibility is positioned to become a cornerstone of Colombia's energy future, supporting secure operations as the resource mix becomes cleaner and more variable. Sustained regulatory momentum, accelerated network and digital upgrades, and stronger stakeholder engagement will determine whether Colombia can translate ambition into durable results and regional leadership in resilient market design.

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Katrina.Zarczynski-Magee@pjm.com

Association of Power Exchanges
2750 Monroe Blvd., Audubon, PA 19403 Phone: (610) 666-8925 Website: www.theapex.org
Stu Bresler, APEx Chairman
Email: stu.bresler@pjm.com