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Reforming the Interconnection Queue

Accelerating Grid Connections for New Projects

WHITEPAPER

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A Gridlocked Future

Understanding the U.S. Interconnection Crisis

By the end of 2024, nearly 2,300 GW of proposed generation and storage capacity were active in U.S. transmission interconnection queues. The vast majority of this queued capacity remains renewable and zero-carbon resources—such as solar, wind, and battery storage—while proposed natural gas and coal make up a relatively small share.

Over the past decade, the capacity in interconnection queues has increased significantly. Projects that began commercial operation from 2018 to 2023 typically took more than four years from initial request to COD, with a median of about five years for projects built in 2023. Completion rates remain low: among projects seeking interconnection from 2000 to 2018, only about one-fifth of projects (and roughly one seventh of capacity) ultimately reached operation.

This surge in project filings results from several factors. Sharp declines in the costs of solar, wind, and energy storage technologies, combined with generous fiscal incentives under the Inflation Reduction Act of 2022 and strong state-level renewable mandates, motivated developers to submit unprecedented numbers of interconnection requests. Since August 2022 (after IRA), over 1,200 GW of additional capacity have entered interconnection queues; this includes roughly 500 GW of solar and about 540 GW of energy storage additions. The 1,086 GW (solar) and approximately 1,028 GW (storage) figures represent total active capacity as of the end of 2023, not new additions. Hybrid configurations, especially solar-plus-storage, made up a significant portion of this growth.

Regional dynamics continue to reveal geographic and policy-driven imbalances. In California, CAISO's Cluster 15 included 541 requests totaling approximately 347 GW; CAISO has highlighted that its queue now holds more than three times the capacity required to meet the state's 2045 policy targets and has adjusted its Interconnection Process Enhancements accordingly. In PJM, a switch to a first-ready, first-served cluster process and targeted automation has processed around 140 GW of applications since 2023, lowering the transition backlog to about 63 GW by mid-2025. PJM intends to clear the transition inventory in 2025–2026 and has scheduled the first new-cycle application deadline for April 27, 2026.

Adding to this operational challenge is the fragmented process of interconnection itself. Projects must go through separate studies for feasibility, system impact, and facilities. The first-come, first-served model allows speculative filings that often lack site control, financing, or power purchase agreements. As some speculative projects withdraw, other applicants must conduct additional studies, causing further delays. Grid operators face staffing and administrative limits, which increase delays as they handle more applications and perform repeated studies.

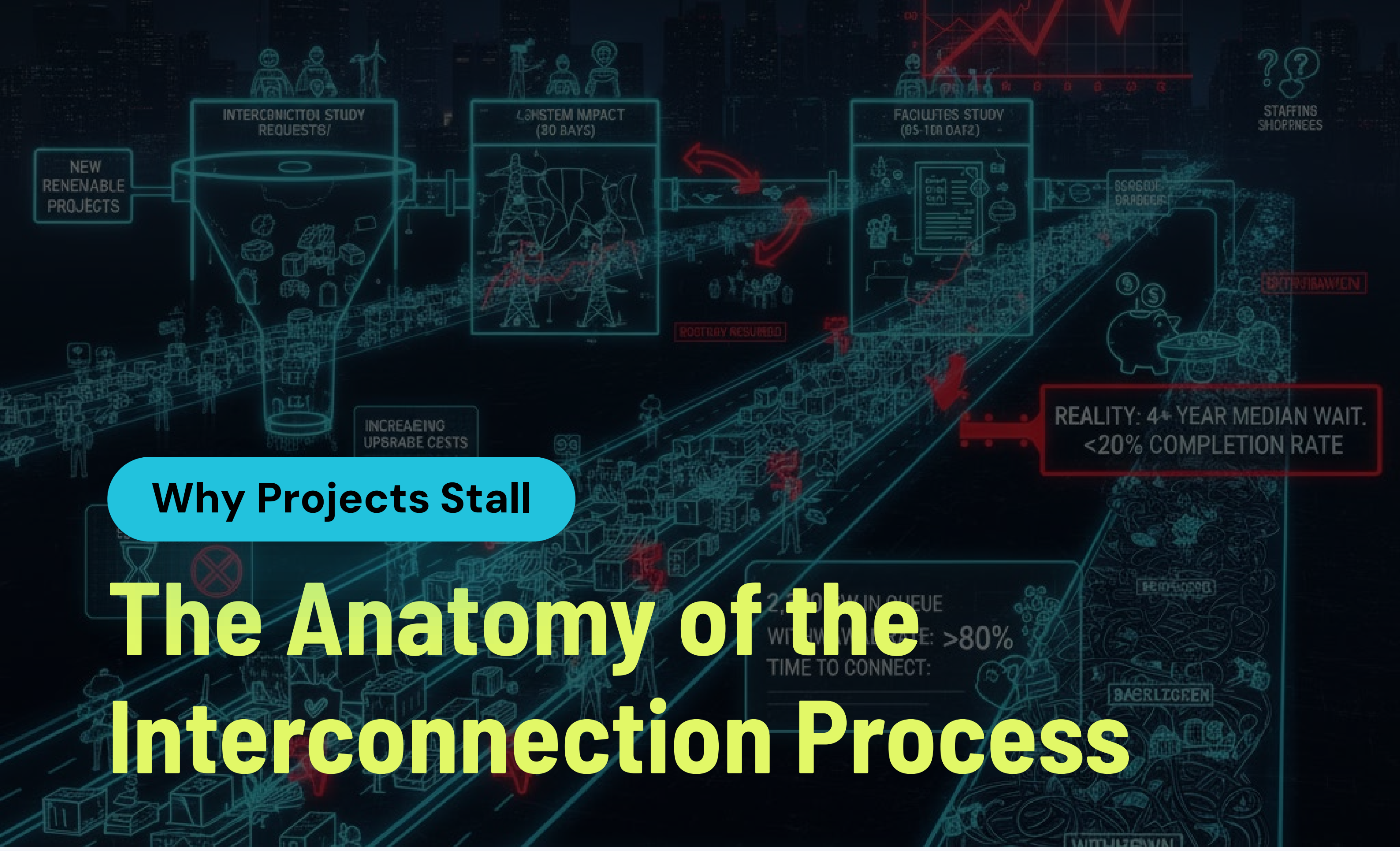
Developers face significant operational and financial uncertainties due to these delays. Projects that are expected to trigger major grid upgrades often incur substantial transmission costs, even if they are eventually withdrawn, creating risks in financial planning. Delays can cause projects to miss deadlines for federal clean energy incentives, which can diminish investor confidence. Some regions report average queue durations exceeding eight years for projects that entered the queue in 2024. In other areas, wait times are between four and six years. These extended project timelines threaten the viability of clean energy deployment.

Delays in project connections pose broader risks to system reliability. As thermal generators retire, slow interconnection timelines can lead to supply shortages and higher capacity prices in specific regions. Simultaneously, electricity demand is rising due to electrification, data-center growth, and industrial load increases.

Thus, the issue goes beyond administrative inefficiency and reaches into structural grid limitations. The gap between expanding renewable goals and outdated transmission systems, combined with fragmented planning and inflexible study procedures, creates a bottleneck that threatens clean energy growth, grid resilience, and investor participation. The urgency is high: clean energy projects are ready, and capital is available, but interconnection and grid infrastructure lag behind. Without comprehensive reforms—both procedural and infrastructural—the U.S. risks delaying essential capacity, undermining decarbonization goals, and weakening market confidence in its energy transition.

Interconnection queues are overwhelmed with renewable projects, facing long delays, high costs, and low completion rates that threaten clean energy deployment.

Outdated transmission systems, fragmented processes, and slow reforms risk grid reliability, investor confidence, and progress toward decarbonization goals.



Why Projects Stall

The Anatomy of the Interconnection Process

The U.S. interconnection process is managed through a complex set of protocols across Independent System Operators (ISOs), Regional Transmission Organizations (RTOs), and non-ISO utilities. No matter the region, project developers must go through a sequence of three engineering studies—Interconnection Feasibility, System Impact, and Facilities—each designed to evaluate and address the effects of new generation on the transmission grid.

The process starts when a developer submits a formal request for interconnection to a transmission provider. After providing technical data and a required deposit, the request is added to the interconnection queue. The transmission provider then begins the Feasibility Study, which usually takes up to 45 calendar days. This initial study models power flow and short-circuit conditions to assess whether connecting the proposed generation could cause thermal overloads, voltage issues, or other operational problems. It also estimates early upgrade requirements and related costs.

If the project passes this stage, the developer may move forward to the System Impact Study by signing a study agreement, showing site control, and submitting a larger deposit. The System Impact Study, expected to be completed in about 90 days, assesses reliability impacts through short-circuit, stability, and power-flow analyses. It identifies specific upgrade needs on both the local and neighboring grids (Affected Systems) and calculates the developer's portion of the upgrade costs. However, any withdrawal or change of a higher-priority project in the queue may cause restudies, disrupting the schedule and requiring the developer to undergo additional analyses.

Once the impact study is approved, the project moves into the Facilities Study phase. By this point, detailed engineering parameters are finalized. The Facilities Study—lasting between 90 and 180 calendar days, depending on precision—defines the scope, schedule, and cost of equipment, substations, and network upgrades necessary for the final grid connection. Developers must then negotiate an interconnection agreement that outlines obligations and costs before constructing the required infrastructure.

This series of studies often proceeds on a first-come, first-served basis. Unfortunately, that queue model permits speculative or low-readiness projects to enter early, leading to significant gridlock when they leave the queue. Additionally, restudy requirements caused by upstream withdrawals add to delays for downstream projects, increasing the administrative burden on grid operators. Understaffing and limited modeling resources further worsen backlogs in many jurisdictions.

Throughout the study process, participants are required to provide increasingly detailed project information and financial assurances. Initial deposits are small; however, later stages demand larger security commitments. Projects may face penalties if they withdraw after showing readiness, a rule meant to discourage speculative applications under reforms like FERC Order 2023. These regulations aim to ensure only viable projects continue. Still, wider adoption of readiness thresholds and penalties varies among ISOs, which slows down the full implementation of reforms.

The procedural complexity reflects financial complexity. Developers often face uncertain and rising costs, especially for transmission upgrades triggered during studies. The allocation of network upgrade costs frequently follows a 'first-developer pays' model, burdening early applicants with major retrofit expenses—costs that cannot be accurately predicted until late in the study. This dynamic discourages project continuation and reduces completion rates.

Such delays and financial uncertainty cause systemic stagnation. Developers whose expected costs surpass budgets or income often choose to withdraw, leading to additional studies and further delays for others. Each withdrawal then adds to operational inefficiencies—requiring more modeling, reassessments, and administrative efforts to reassign study capacity. This cycle of speculative filings, study resets, and delay chains has caused a long-lasting backlog in regions including CAISO, PJM, MISO, ISO NE, ERCOT, SPP, NYISO, and many non-ISO utilities.

The result is a process that is slow, costly, and unpredictable. Projects may wait three to five years on average in the queue before entering service. Many developers choose to abandon projects before they reach commercial operation. Withdrawal rates exceed 80 percent of requested capacity, while completion rates for pre-2018 filings remain under 20 percent. This outcome hinders progress toward clean energy deployment, tightens timelines for federal clean energy incentives, diminishes investor confidence, and risks causing resource adequacy shortages as fossil units retire.

Efforts to modernize this process must tackle several key obstacles: permitting only high-readiness projects into the queue, replacing serial studies with cluster-based assessments, reducing restudy triggers and timeline disruptions, and shifting cost allocation toward regional planning mechanisms. Without reform, the current system traps renewable projects in delays, inflates connection costs, and reduces the grid interconnection's role as a driver of decarbonization.

FERC Order 2023

A Federal Response to a National Bottleneck

On July 28, 2023, the Federal Energy Regulatory Commission issued the landmark Final Rule known as Order No. 2023, titled Improvements to Generator Interconnection Procedures and Agreements. This rule aims to address severe interconnection queue backlogs and structural inefficiencies. It introduces the most significant changes to federal interconnection policy in twenty years. Order 2023 implements a first-come, first-served cluster study framework, improves readiness criteria, sets firm deadlines with penalties to ensure timely processing, and updates the approach to hybrid and storage-rich projects.

A core transformation involves moving from serial processing to clustered study windows. Under the new system, transmission providers must organize interconnection requests into an annual cluster request window—usually 45 calendar days—during which all projects are considered equally queued, and study priority is based on readiness rather than submission date. Projects may enter a cure period to fix deficiencies, but must do so by the end of the window. An additional customer engagement period allows participants to negotiate study costs and opt out without penalty before the cluster study begins. This setup encourages efficient bulk analysis, reduces late-stage restudy disruptions, and cuts down on speculative filings.

To reduce low-readiness applications, Order 2023 strengthens financial and site control requirements. Developers must submit increased deposits at each stage—rising with the project size—and prove definitive site control and a selected transmission interconnection point. Withdrawal penalties are enforced if deviations materially impact the timing or costs for others in the same group. These measures collectively prevent speculative queue entry and encourage only investment-ready projects to move forward.

The rule also replaces the vague reasonable efforts standard previously used for study deadlines with specific timelines and enforceable penalties for transmission providers that miss deadlines. Cluster studies must finish within 150 calendar days after the engagement window, followed by facility studies and negotiations. Affected systems—or neighboring grid operators whose networks are impacted—must coordinate through standardized study agreements and complete their parts within similar timeframes. Failure to comply results in penalties, ensuring transmission providers are held accountable.

Order 2023 introduces technical improvements designed for modern generation profiles. Resources colocated on the same site—such as solar and battery components—can now submit a single interconnection request through one point of interconnection. Developers are allowed to add battery capacity after submission as long as the total capacity does not increase and the queue position remains the same. The rule requires more precise modeling of nonsynchronous technologies, including specific scenarios for storage charging behavior. Studies must also assess alternative transmission technologies—such as advanced conductors, improved power-flow control, voltage source converters, static VAR/STATCOM devices, synchronous condensers, and tower lifting—as part of cluster planning.

Anticipating industry questions and operational hurdles, FERC issued Order 2023-A on March 21, 2024. This rehearing and clarification ruling largely upheld the Final Rule's reforms while providing clarity on several topics. Order 2023-A clarified that the ability to address deficiencies ends at the cluster window close, and minor technical fixes beyond that are limited. The Commission also expanded opt-in rules for standalone build options, allowing multiple projects within a cluster to jointly build network upgrades if they agree. Regarding withdrawal penalties, FERC confirmed limits on penalty severity—penalties may not exceed collected deposits and are only applied when withdrawals significantly impact others.

FERC also reaffirmed that all transmission providers—including early adopters of cluster models—must file compliance materials demonstrating alignment with Order 2023 or justified deviations. Non ISO utilities must show that proposed tariff changes are consistent with or superior to the pro forma rules. In contrast, ISOs and RTOs may propose independent entity variations subject to Commission approval. Entities failing to submit compliant filings by the extended deadline face regulatory risk.

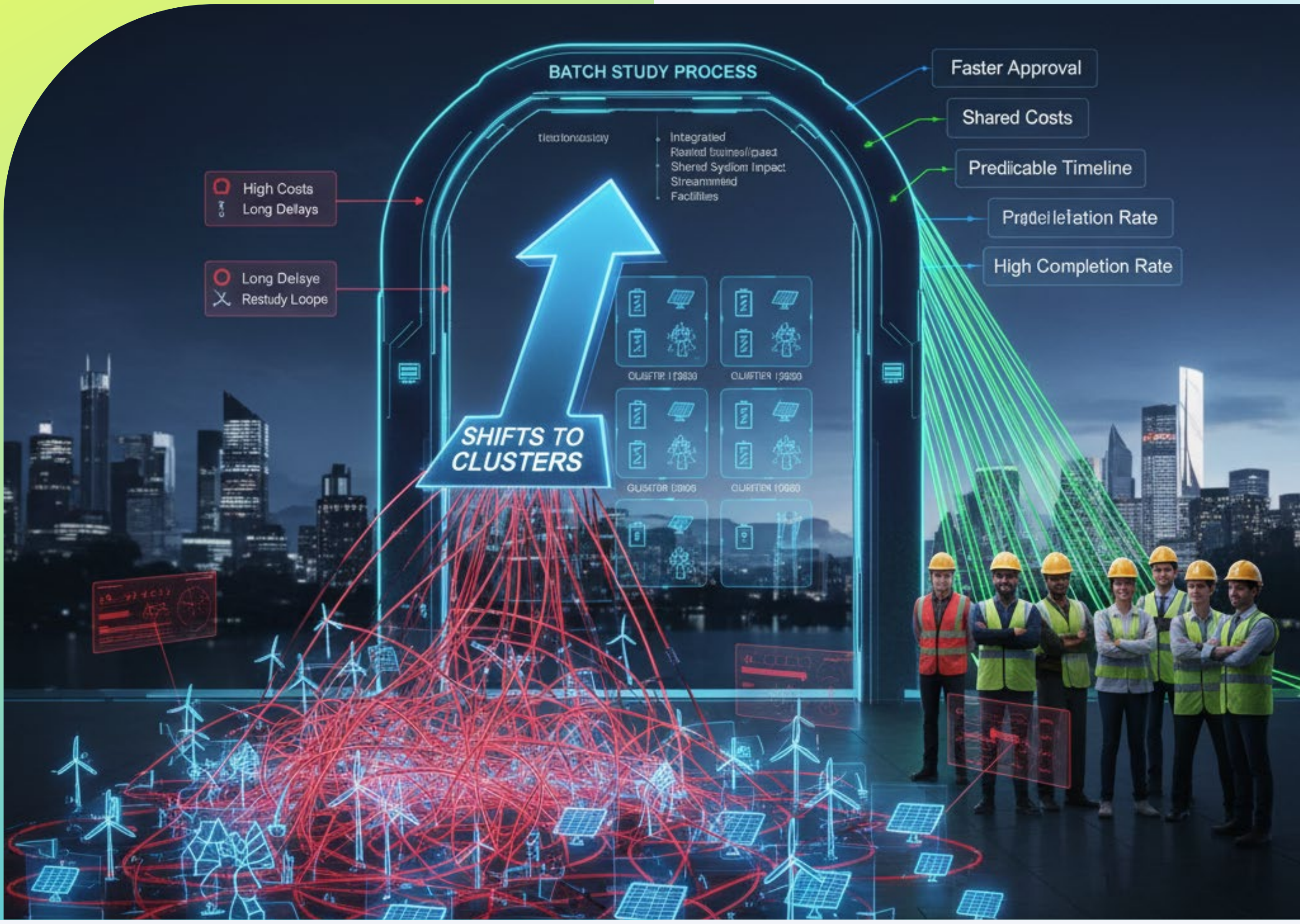
The intended impacts of Order 2023 are broad. Clustering is expected to reduce queue complexity, shorten timelines, and increase cost transparency. Improved readiness measures aim to reduce speculative load. Strict deadlines and coordinated studies across affected systems seek to prevent administrative drift. Technical upgrades accommodate modern generation types, streamlining hybrid and storage-focused applications. Therefore, the rule positions interconnection policy to better support large-scale renewable project deployment.

Initial reactions from market participants and grid operators differ. Proponents emphasize that the first-ready approach, aligned with cluster modeling, will help process thousands of megawatts at once and bring predictability to costly studies. Critics warn that financial barriers could disadvantage smaller developers and that complex hybrid filings may still cause coordination issues. There is concern that ISOs and utilities might interpret compliance timelines or readiness definitions too rigidly, potentially excluding legitimate projects.

Transmission providers are currently progressing through various stages of transition. ISO-NE, PJM, MISO, CAISO, and many non-ISO entities have submitted compliance filings, with some adopting the pro forma terms exactly and others proposing tailored variations. These entities now need to implement the cluster study windows, update their study procedures, modify deposit schedules, and deploy heatmaps or public hosting capacity tools to assist prospective developers. Enforcing deadlines and penalties remains a key point to ensure uniform implementation across the national grid.

Order 2023 also intersects with broader transmission reforms. In May 2024, FERC enacted a complementary rule formalizing 20-year regional transmission planning cycles, five-year updates, right-sizing strategies, and interregional coordination. While distinct from interconnection procedures, these reforms establish a planning framework that supports the goals of timely connection, shared upgrade cost allocation, and proactive transmission expansion.

By establishing clear process frameworks, cost allocation protocols, deadlines, and readiness criteria, Order 2023 aligns interconnection policies with the needs of a rapidly evolving clean energy system. As compliance and implementation continue, the effectiveness of the cluster model and enforcement mechanisms will determine whether renewable project delays can finally be reduced through increased speed, transparency, and better interconnection outcomes.



From Chaos to Clusters

The Shift Toward Batch Study Approaches

The shift from a serial to a cluster-based interconnection study model represents a significant change in the U.S. transmission planning process. Traditionally, transmission providers within Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) processed generator interconnection requests on a first-come, first-served basis. In this process, each project went through a series of feasibility, system impact, and facilities studies. However, as application numbers increased and speculative projects flooded queues, the serial method caused frequent restudies, delays, and high costs.

To address these inefficiencies, grid operators are adopting the use of cluster studies, where interconnection requests submitted within a specific period are grouped and analyzed together. This approach enhances transmission providers' ability to evaluate network impacts comprehensively and reduces duplication of engineering efforts. More importantly, it decreases restudy requirements caused by individual project withdrawals, thereby maintaining study validity and providing greater certainty for developers.

One of the first adopters of the cluster study model was the California Independent System Operator. CAISO processes new interconnection requests annually during designated cluster windows. Each cluster typically comprises hundreds of proposed generation and storage projects, which are analyzed together for potential impacts on grid infrastructure. Moving to this model has helped CAISO reduce restudy frequency and distribute upgrade costs more transparently among multiple interconnecting projects.

MISO has taken similar steps in reforming its process. The operator's interconnection reforms aim to align with FERC Order 2023 by grouping study requests, establishing uniform readiness criteria, and setting enforceable timelines. MISO's reform efforts also focus on increased queue transparency and giving developers early insight into upgrade costs and timelines. This includes leveraging surplus interconnection capacity, where new generation can connect using existing infrastructure, thus avoiding the need for large-scale upgrades.

The advantages of the cluster approach are becoming more apparent. By combining studies and minimizing project-specific re-evaluations, operators can substantially cut down overall processing time. Developers benefit from more predictable and shared cost estimates, and system planners obtain a clearer view of anticipated infrastructure needs. Queue transparency also gets better, as transmission providers can publish consolidated results and timelines.

Technology has further improved the practicality of cluster studies. The use of interconnection management platforms has allowed some ISOs to automate much of the study process. These platforms enable real-time visualization of queue status, automated milestone tracking, and integration of project scoring systems based on readiness or grid impact.

Despite these benefits, implementing cluster models presents some challenges. One issue is the potential exclusion of smaller or less-capitalized developers, who might find it hard to meet higher readiness standards or pay upfront financial security costs. Some ISOs also encounter coordination problems when clusters include projects spanning multiple balancing areas or impacted systems. Maintaining consistency in assumptions, modeling tools, and timelines remains a continuous challenge.

Another concern involves how upgrade costs are divided among projects in a cluster. While clustering decreases the need for restudies, it also adds the challenge of determining cost responsibility for network reinforcements. Operators must create clear and legally defensible methods for cost allocation to ensure fairness and minimize disputes among participants.

FERC Order 2023 has officially required transmission providers to adopt cluster study approaches. According to the rule, each provider must handle interconnection requests during set annual or semi-annual periods, with clear engagement times, standardized deposit schedules, and enforcement tools. The aim is to ensure that only feasible, site-secured, and financially committed projects go through the study process, thus protecting system capacity for serious applicants and lowering administrative burdens.

Across the country, grid operators are at different stages of transitioning to the new model. While some regions already had cluster processes in place and are refining them, others are making major procedural changes to meet federal mandates. The full benefits of clustering—shorter queues, fewer delays, and better cost certainty—will only be achieved through careful implementation, consistent enforcement, and ongoing stakeholder feedback.

As cluster-based study processes advance, they become one of the most promising ways to speed up the connection of renewable and storage projects. Their success relies not just on structural reform but also on clear communication between grid operators and project developers. Ongoing collaboration, technological integration, and thorough evaluation will be crucial to ensure these reforms realize the full potential of the clean energy transition.

Planning Forward

Transmission Expansion
and Cost Allocation Challenges

The ongoing growth of renewable energy sources like solar, wind, and energy storage has revealed a key structural issue: reforming the interconnection queue may speed up project review processes, but without improved transmission infrastructure, many projects still cannot connect to the grid. The commercial viability depends on coordinated transmission expansion, long-term planning, and fair, predictable cost sharing. The capacity of the transmission backbone and interregional connections remains underdeveloped compared to the potential volume of renewable projects waiting in the queue.

FERC Order 1920, issued in May 2024, introduced major reforms to improve long-term transmission planning and cost allocation. The rule mandates 20-year regional planning horizons with updates every five years and creates structured engagement with states on cost sharing. In November 2024, Order 1920-A further strengthened state roles—clarifying scenario-development input, extending the state engagement period when requested, and requiring transparency around any ex-ante cost-allocation methods filed for compliance.

Historically, many upgrade costs have been assigned to the first project that triggers regional transmission reinforcement, placing disproportionate financial burdens on early applicants. This first-developer pays model creates uncertainty and risk for developers, who may not know the estimated upgrade costs until late in the study process. Reform proposals—including those under FERC Order 1920—aim to replace that model with proportional impact allocation or benefit-based mechanisms that distribute costs among multiple beneficiaries of the upgrade. States can voluntarily negotiate during a six-month window to agree on cost-sharing; if no consensus is reached, default formulas are applied.

Innovative portfolio strategies are emerging to facilitate interconnection-related upgrades. In MISO and SPP, the Joint Targeted Interconnection Queue (JTIQ) identified five 345 kV projects with an estimated cost of about $1.6 billion that would enable roughly 28.6 GW of new generation along the MISO-SPP seam. The U.S. Department of Energy awarded $464.5 million to support the portfolio, with remaining costs covered by incumbent utilities and participating projects under approved cost-allocation frameworks.

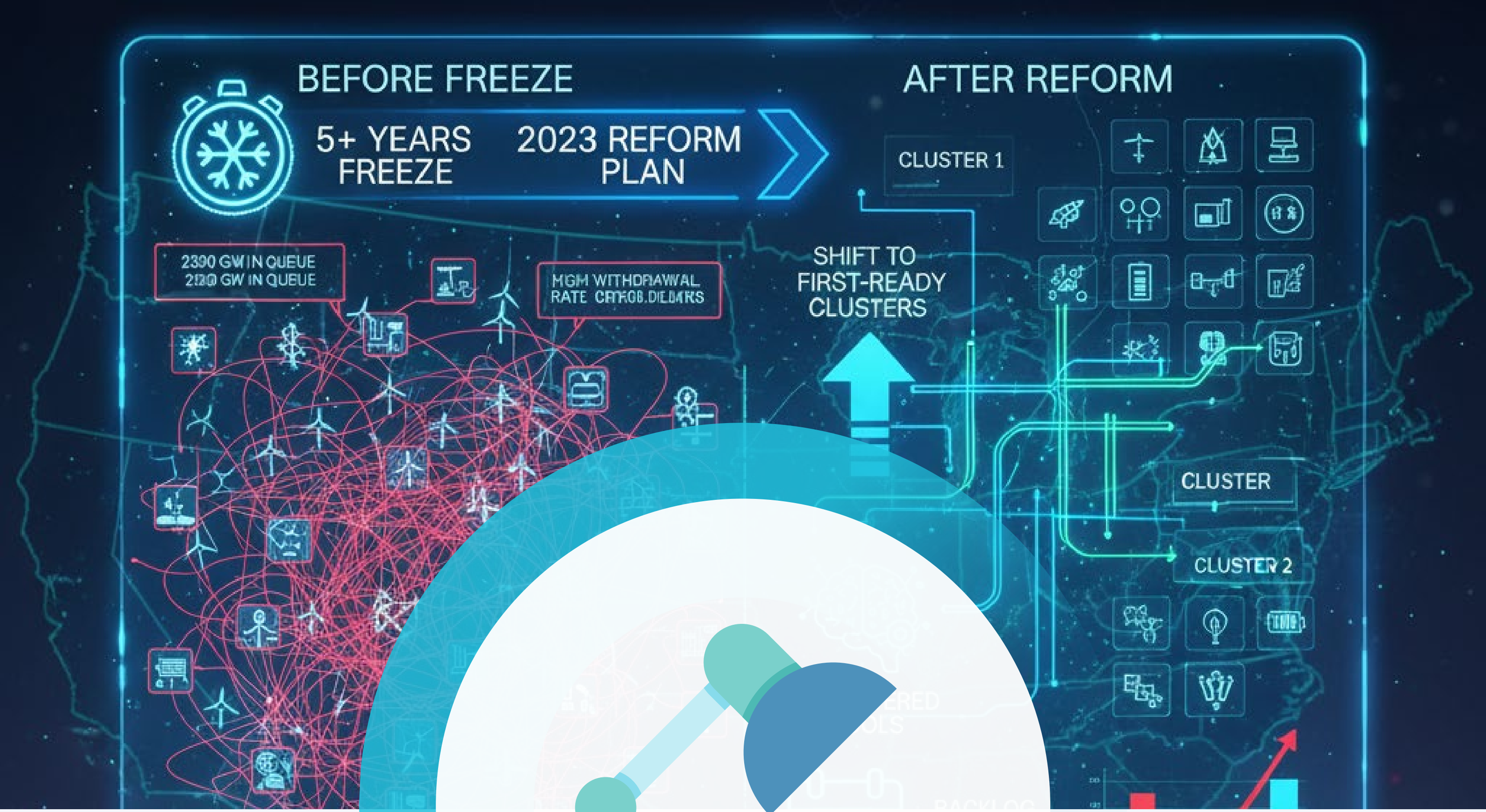
Amid these reforms, key states are struggling with increasing grid demands. For example, Texas needs up to $33 billion in new or upgraded transmission to support growing data center loads, industry electrification, and extensive renewable investments. Traditional cost allocation methods—such as four coincident peak (4CP) approaches—are being reconsidered. Critics say 4CP unfairly burdens industrial loads and shifts costs onto residential customers. Policymakers are exploring alternative methods, like twelve-coincident peak (12CP) models or load-based surcharge adjustments, to distribute infrastructure costs more fairly.

Grid planners and utilities are also under pressure to identify long-term system needs that align with clean energy goals and the retirement of generation assets. Embedded in FERC's reforms is a more proactive planning role for state regulators, offering opportunities to suggest alternative futures or transmission enhancement scenarios. States may request multiple planning scenarios to guide cost allocation discussions, ensuring that investment choices reflect different policy priorities such as emission reduction targets or energy source diversity.

Transmission project financing has entered new territory with programs based on federal laws like the Infrastructure Investment and Jobs Act and the Inflation Reduction Act. DOE-led efforts—the Transmission Facilitation Program, Regional Clean Grid grants, and ARPA-E infrastructure competitions—have helped develop high-voltage transmission lines and grid-improving projects connecting renewable-rich areas to load centers. These funds supplement utility and developer financing, helping reduce costs and speed up interregional upgrades that traditional regulations might otherwise delay.

Successful transmission reform depends on addressing operational, technical, and equity issues simultaneously. Regional planning frameworks should include input from various stakeholders, employ transparent modeling techniques, and clearly define system benefits. Cost allocation must be based on causation—identifying which projects or regions gain from upgrades—while minimizing financial burdens on small utilities and end-user customers. Regulators need to balance state rights with federal oversight to ensure consistent and fair results.

Overall, advancing clean energy deployment depends not only on streamlining the interconnection process but also on expanding and modernizing the grid infrastructure to realize connected capacity. Integration of long-term planning, shared upgrade investments, regional coordination, and equitable cost allocation is essential. Transmission reform—alongside cluster-based interconnection models—is pivotal to turning renewable project delays into streamlined deployment and sustainable system reliability.



Case Studies in Queue Reform

Successes and Lessons from the Field

- **CAISO's Transition**
  to Cluster Study Approach
- **PJM's Interconnection Freeze**
  and 2023 Reform Plan

CASE STUDY # 1

CAISO's Transition to Cluster Study Approach

California's Independent System Operator revamped its interconnection process by adopting annual cluster study windows. Cluster 15 alone received 541 interconnection requests, totaling approximately 347 GW. CAISO combined clustering with deliverability-aware screening, which includes load serving entity point allocations and, when necessary, auction tiebreakers, to ensure queue volumes stay in line with available and planned transmission capacity.

The CAISO framework links project priority to their readiness for execution. Applicants are rated based on factors such as site control proof, signed power purchase agreements, and financial commitments. In areas with limited interconnection capacity, CAISO has introduced sealed-bid auctions. Developers showing high readiness are chosen, while speculative proposals without certainty are excluded. This approach of scoring readiness and using auctions helps improve queue reliability and prioritizes projects that are more likely to be completed.

Under the cluster model, cost allocation shifts from a first-developer-pays approach to a shared upgrade cost pool among all cluster participants. CAISO provides developers with early preliminary cost estimates—including current and maximum cost responsibilities—during the study process, enabling better financial planning. Having earlier insight into potential upgrade costs reduces surprises during facilities studies and encourages developers to pursue build-ready projects.

CAISO has invested in digital queue management tools that visualize study status, track project milestones, and display aggregated queue metrics. These user interfaces promote transparency, reduce administrative overhead, and help developers understand their projects' position in the process. The combination of automation and clarity allows for more frequent feedback loops and faster updates in developer communication.

Outcomes from CAISO's clustering efforts include decreasing restudy frequency, clarifying cost sharing, and accelerating the progress of high-readiness projects toward agreements. The IPE 2023 reforms (set to take effect in late 2024) aim to limit each cluster to zones with existing or planned deliverability, enhancing the usefulness of study results.

Challenges remain: developing fair scoring mechanisms to prevent disadvantaging smaller or minority-owned developers, ensuring cost allocation equity when projects vary significantly in size and location, and managing deliverability allocation within cluster groups that involve limited transmission areas. Nonetheless, CAISO's transition serves as a model for other regions aiming to understand queue volume and reduce delays in connecting renewable generation.

CAISO's experience shows that cluster-based interconnection can boost operational efficiency, enhance cost transparency, and raise project readiness standards. The operator's proactive leadership before federal mandates provided valuable data on implementation challenges and stakeholder impacts. As other ISOs and utilities adopt similar cluster models under FERC Order 2023, CAISO's evolution offers a solid blueprint for streamlining queue management, deploying automation, and prioritizing financial clarity to speed up grid interconnection.

CASE STUDY # 2

PJM's Interconnection Freeze and 2023 Reform Plan

PJM Interconnection, which serves 13 states and the District of Columbia, has historically managed one of the largest interconnection queues in the U.S. Since adopting its first-ready cluster process in 2023, PJM reports processing nearly 140 GW of requests and lowering its backlog to about 63 GW by mid-2025, with outstanding projects scheduled for resolution in 2025–2026.

During the freeze period, PJM developed a reform plan aligned with federal guidance. The new system uses cluster-based processing under a first-come, first-served protocol. Developers must show they have firm site control, financial viability, and contractual commitments before joining the queue. Deposit schedules increase with project capacity, including non-refundable parts to prevent speculative entries. PJM also designed cluster grouping and readiness-based screening to identify realistic, buildable projects.

PJM improved queue transparency by launching updated portals and dashboards. Developers now have better visibility into expected transmission upgrade costs, milestone timing, and application status. PJM's internal analytics projected a significant reduction in the queue if reforms were adopted: simulation studies predicted less backlog, fewer restudies, and quicker study cycles. The forecasts aimed for average interconnection timelines to decrease from over five years to about one to two years by 2026.

PJM's decision to freeze new entries allowed the operator to better manage existing demand while establishing readiness thresholds and deposit structures aimed at reducing speculative filings. As PJM restarted queue entries under the new system, early cluster groups—though small—showed smoother processing, lower withdrawal rates, and more predictable timelines. Project selection increasingly favored developers with proven execution capabilities.

Technologically, PJM initiated a multiyear partnership with Google and Alphabet-backed Tapestry to develop AI-powered tools that prioritize applications, automate study processes, and create a detailed digital model of the grid. These features aim to speed up study cycles and increase transparency as PJM completes its transition work.

Despite progress, PJM faces criticism and challenges. Political and regulatory pressure has increased as high-capacity auction prices and supply shortages surfaced—residents in Pennsylvania and other states called for leadership reform and better interconnection access. Some stakeholders argue that while meeting readiness thresholds improves quality, it may unintentionally exclude smaller developers. Additionally, coordinating affected system studies across PJM's extensive territory adds complexity to cluster implementation.

However, PJM's strategic freeze and reform plan aims to decisively improve interconnection efficiency. With the transition queue expected to be cleared by 2025–2026, PJM has designated April 27, 2026, as the deadline for applications in the first new interconnection cycle under the reformed process.

Smart Tools, Better Data

Technology's Role in Fixing the Queue

As the interconnection queue backlog worsened and project complexity increased, grid operators and policymakers adopted technology-driven solutions to streamline the interconnection process. Advanced hosting capacity maps, dynamic queue dashboards, AI-enhanced modeling tools, and standardized open-data exchanges now serve vital roles in enhancing transparency, reducing Renewable Project Delays, and shortening administrative timelines.

Publicly accessible hosting capacity maps enable developers and utilities to identify locations where new generation—such as solar, wind, or battery storage—can connect without causing major infrastructure upgrades. These maps show capacity limits at the feeder or substation level, helping guide project siting toward areas with available capacity. Reliable hosting capacity analyses help reduce speculative filings and ensure better coordination between development and grid readiness.

Queue dashboards offer real-time insights into the status of interconnection pipelines. Developers can monitor progress through feasibility, system impact, and facilities study phases, view upgrade cost estimates, track cluster cohort assignments, and understand milepost timelines. These dashboards promote transparency for regulators, developers, and grid planners, helping to set clearer expectations about project schedules and resource planning.

Artificial intelligence and machine-learning tools are being used more often to speed up complex engineering tasks. AI-based contingency modeling, fault impact assessments, and cost forecasting help visualize upgrade needs and likely costs early on. In practice, grid operators have teamed up with external providers to automate queue triage and predictive analysis, giving developers valuable insights earlier and cutting down on study delays.

DOE-backed data initiatives, such as the i2X (Interconnection Innovation eXchange), standardize access to queue performance

metrics across regions. Simultaneously, Lawrence Berkeley National Laboratory's 2025 update of the U.S. Interconnection Queue dataset offers a consolidated workbook and visualization through year-end 2024, enabling more accurate benchmarking of volumes, technologies, and timelines.

Grid-enhancing technologies—such as dynamic line ratings, voltage source converters, and optimized conductor systems—offer greater operational flexibility by boosting the capacity of existing transmission assets. Using real-time weather data and thermal modeling, dynamic ratings enable lines to carry more power in favorable conditions. These tools are often used in interconnection studies to delay costly physical upgrades and lower upgrade costs for developers.

Despite the potential of these technologies, challenges still exist. Smaller developers might lack the resources to access or understand advanced tools. AI systems need high-quality historical data, which can vary in completeness across different queue databases. Differences in data protocols across regions make coordination more difficult for cluster studies that involve multiple ISOs or balancing authorities.

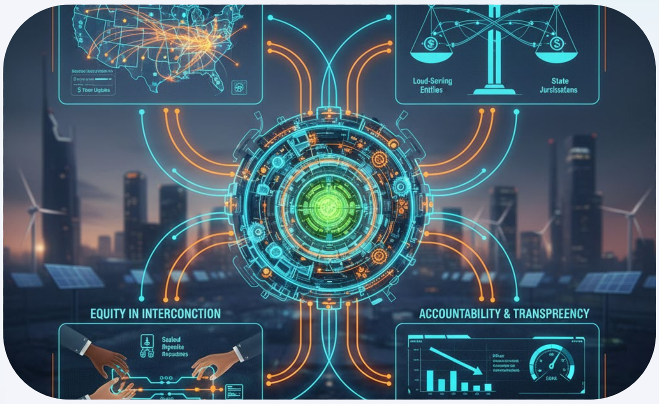
Nevertheless, these tools are making a measurable impact. Hosting capacity maps reduce unnecessary applications, queue dashboards streamline stakeholder communication, AI-enhanced modeling enhances cost transparency, and grid-enhancing technologies defer investment costs. Along with readiness-based clustering, better planning coordination, and clear policy frameworks, these innovations help turn interconnection queues into transparent, predictable pipelines.

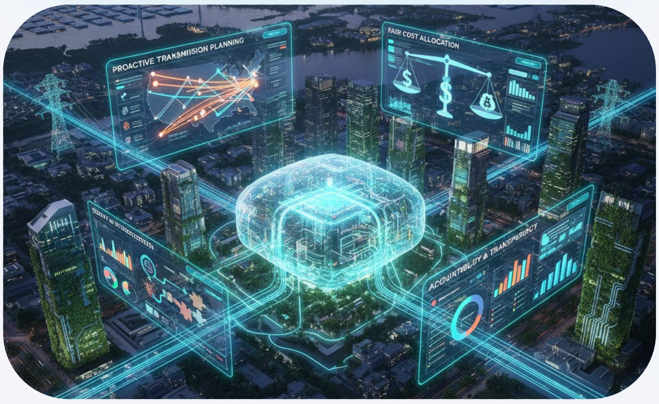
Promoting democratized access to these tools—through open-data platforms, training programs, and publicly accessible dashboards—will ensure that smaller developers, community-scale projects, and underrepresented stakeholders benefit equally. Ongoing investment in interoperable digital infrastructure will reinforce structural reforms and guarantee that the interconnection system can grow alongside clean energy goals.

By integrating advanced tools with regulatory reforms and transmission planning, the sector can shift from slow, opaque interconnection processes to a more efficient, transparent, and equitable system that supports America's clean energy goals.

Aligning the Grid with the Clean Energy Transition

Interconnection reform must be paired with proactive transmission planning, fair cost-sharing, and equity protections to truly support clean energy goals.





Transparency, accountability, and reliability planning are essential to align project timelines with grid capacity and ensure a resilient transition.

Successful interconnection queue reform must be part of a broader, integrated grid strategy that includes procedural improvements, transmission planning, cost sharing, and equity factors—reforming interconnection without coordinated infrastructure growth risks only speeding up study timelines without actually delivering power. To align the grid with clean energy goals, policy, planning, and operational systems need to work together as practical enablers of decarbonization.

Transmission planning needs to become proactive and forward-looking. Planners should forecast grid requirements over 20 years, revising at least every five years. These long-term planning efforts, in collaboration with state regulators, must account for load electrification, generation retirements, and renewable buildout goals. By predicting bottlenecks and pinpointing key corridors among interregional renewable zones, stakeholders can steer investments to where they will deliver the most system value and reliability.

Cost allocation frameworks should reflect shared benefits rather than penalize individual developers. Moving from a first-developer-pays model toward shared or benefit-based allocation decreases financial risk and aligns incentives with collective outcomes. By using production-cost modeling and linking to locational marginal price savings, planners can assign costs proportionally among beneficiaries—load-serving entities, wholesale customers, and state jurisdictions. Transparent, upfront allocation agreements help reduce conflicts and increase certainty for new projects.

Equity in interconnection must be protected. While increasing readiness standards and requiring higher deposits can lower speculative filings, these actions might harm community-scale, minority-owned, or resource-limited developers. Tools like scaled deposit tiers, technical assistance programs, community carve-outs in project scoring, and support for Energy Equity Justice communities help prevent reforms from deepening structural biases in energy access or ownership.

Grid reliability depends on aligning project timelines with transmission capacity. As traditional generators retire, capacity gaps can arise, especially if transmission upgrades fall behind interconnection approvals. Capacity market planning and reliability assessments need to include expected interconnection schedules and potential delays. Proactive procurement and scenario-based planning help ensure smooth transitions without risking service continuity.

Accountability and transparency are also essential. Regulators and operators should monitor key performance indicators such as average queue duration, withdrawal rates, frequency of restudies, and the variance between estimated and actual upgrade costs. Publishing these metrics and benchmarking performance over time enables public oversight and helps identify regions or providers where backlog reduction is not progressing as expected. Stakeholder advisory panels and public comment opportunities during review cycles help ensure the process stays responsive.

Integrating reform, planning, and policy not only activates stranded projects but also aligns clean energy procurement and interconnection timelines. Policy tools like renewable portfolio standards or tax credit eligibility windows should match the queue and infrastructure schedules. Interactive planning dashboards displaying regional resource goals and interconnection readiness help coordinate policymakers, grid operators, and developers.

Ultimately, interconnection reform is a necessary but not sufficient part of grid transformation. It works best when combined with forward-looking transmission planning, fair cost sharing, and inclusive policies. When these elements come together, they create a well-functioning system that is efficient, transparent, inclusive, and capable of supporting current clean energy efforts. This integrated system ensures the grid will not only support proposed projects but also actively promote the scale and speed of decarbonization needed in the near future.

- **Integrated Approach** – Link interconnection reform with transmission planning, fair costs, and equity to meet clean energy goals.
- **Proactive & Fair Planning** – Use long-term forecasts, shared cost models, and equity protections for reliable, inclusive growth.
- **Accountability & Reliability** – Track progress, plan for reliability, and align policies with grid and project timelines.

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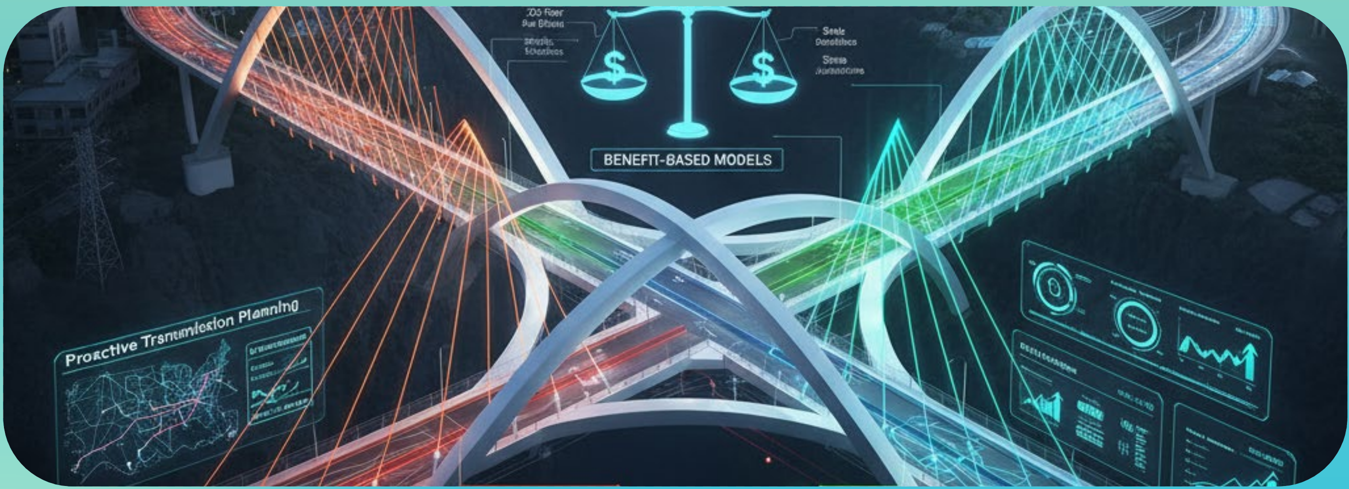

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