The Forward Energy Market as a long-term reliability solution for PJM

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Summary

PJM's Reliability Pricing Model (RPM) has come under increasing strain. Rapid load growth, slow supply response, and rising capacity prices have created immediate reliability and affordability concerns. PJM launched its Powering Reliability Through Market Design (PRTMD) initiative to respond to these challenges. We believe that the process must address not only the immediate problems facing the RPM, but also the underlying market design problem that makes those problems difficult to resolve. This is a strengthened version of PJM's Path C.

The central challenge is a credibility trap. Scarcity produces high-capacity prices, as the market is designed to do. But when those prices translate quickly into consumer affordability shocks, they create pressure for political and regulatory intervention. Investors then reasonably expect future intervention when scarcity again produces high prices. Scarcity revenues become less credible, investment falls relative to what is needed, and scarcity persists. The market signal may correctly indicate the need for investment while simultaneously becoming less capable of inducing it.

The Forward Energy Market (FEM) provides a structural way out of this trap. Rather than suppressing scarcity prices, the FEM insulates consumers from short-term price shocks through forward energy and energy options. It shifts regulatory attention from intervening in prices after scarcity occurs toward overseeing prudent long-term contracting before the fact. At the same time, forward contracts allow generators to convert uncertain future scarcity revenues into more predictable contractual revenues that can support investment. The resulting sequence reverses the credibility trap: hedging makes scarcity prices politically sustainable, contracting makes scarcity revenues financially credible, credible revenues support investment, and investment eliminates persistent scarcity.

Achieving this outcome requires addressing two foundational features of the RPM:

- Reliability should be built around transactions of actual need—granular energy and energy options—rather than administrative approximation such as capacity.
- The reliability mechanism should provide timely, continuous signals of future need and immediate opportunities to respond, instead of a single large procurement event that provides delayed and incomplete feedback.

The FEM addresses both weaknesses. It shifts the reliability mechanism from administrative capacity to continuous trading of granular forward energy and energy options up to four years ahead. A progressively increasing LSE hedging requirement causes expected future needs to enter the market as they become known, while flow trading and trade-to-target technology make continuous trading of highly granular products feasible. The FEM builds on PJM's Path C—starting with Path C's transition to energy products and adding mandated hedging, granularity, and timeliness as primary design criteria. The result is a reliability mechanism with a tighter feedback loop between supply and demand and a more credible connection between scarcity, revenues, investment, and eventual equilibrium.

1. Introduction

PJM faces an increasingly difficult resource-adequacy challenge. Demand is growing rapidly, driven in significant part by data centers and broader electrification, while dispatchable generation is retiring and new resources face long development and interconnection timelines. The consequences are already visible: insufficient entry, sharply higher capacity prices, consumer affordability concerns, and increasing difficulty accommodating new large loads.

PJM's Powering Reliability Through Market Design (PRTMD) initiative (PJM Interconnection 2026) appropriately asks whether the Reliability Pricing Model remains capable of delivering durable resource adequacy under these conditions. PJM presented three paths: continue with capacity markets but introduce long-term capacity products (A - stabilized markets), allocate reliability differentially across types of customer classes (B - differential reliability), or pursue a deliberate transition to an energy centric market (C). In this paper we propose strengthening Path C while recovering valuable elements of other paths, such as the mandatory hedging from Path A. The next steps require looking beyond individual RPM parameters. The immediate symptoms are important, but they reflect a deeper problem with the feedback mechanism through which scarcity is supposed to induce investment.

Capacity prices increased by more than 800 percent for the 2025/26 delivery year. In one sense, this is exactly what a capacity market is intended to do: resource inadequacy should produce high prices, and high prices should signal the value of new supply. What follows in a healthy market is simple: supply enters the market, bringing prices down from their extremes to the level required to support competitive entry.

The PJM market is struggling because price shocks cause pain for consumers faster than supply can react. Much of PJM load is insufficiently insulated from capacity price shocks. High prices therefore become consumer affordability shocks. Those shocks create political and regulatory pressure for price caps, backstop procurement, and changes to market rules. In the RPM, all of this happens before supply can enter and bring prices back down to reasonable levels.

The consequences are severe. Regulatory intervention effectively sets revenues at non-market levels. Investors observe repeated intervention and discount future revenues. The capacity market signal says that resources are inadequate, but investors question the credibility of the future revenues that would support a response. Investment is insufficient and scarcity persists.

PJM calls this dynamic the credibility trap. Section 1.1 describes the trap in detail. Section 1.2 explains how the Forward Energy Market (FEM) breaks it: dampen the impact of price shocks on consumers while improving the feedback loop for supply. With these improvements, the market can transform a larger share of uncertain scarcity revenues into contractual revenues that can support investment and maintain the shared reliability compact.

On the demand side, the FEM mandates hedging. Long-term forwards and options separate scarcity prices from the prices consumers actually pay. This spreads out the impact of price

shocks and shifts regulatory incentives toward prudent contracting rather than ex-post price suppression.

Escaping the credibility trap, however, also requires improving the underlying market feedback mechanism. Even a credible price signal is of limited value if it arrives late or does not tell suppliers what the system actually needs. The RPM relies on an administrative capacity product and a small number of discrete procurement events. Physical supply and demand must first be translated into capacity through rules governing accreditation, deliverability, ELCC, and other parameters, while future needs are revealed primarily through periodic auctions. These features make signals less precise and slower to incorporate new information.

This distinction becomes increasingly important as the grid changes. A relatively slow feedback mechanism was more tolerable when demand changed gradually, and generation technologies were comparatively homogeneous. It is much less suitable when large new loads can emerge quickly and supply consists of technologies with sharply different production profiles, flexibility, and availability.

The long-term objective of the PRTMD should therefore be to restore the connection between scarcity, credible market signals, investment, and reliability. Doing so requires both making scarcity revenues credible and tightening the feedback loop through which future needs are revealed and met. Sections 1.3 and 1.4 explain why the RPM struggles with this second task and how the FEM addresses both problems within a single energy-centric reliability mechanism.

1.1 The current challenge: the credibility trap

The central diagnosis of PJM's Powering Reliability Through Market Design is not that its capacity market is mispricing reliability, but that the market has fallen into a trap: the very signal meant to summon investment ends up destroying its own credibility. PJM is careful to note that the capacity market is working as designed—clearing high to signal that reliability is scarce, just as it once cleared low to signal surplus. The failure is that a price signal only does its job if it is durable enough to trigger the investment it calls for. The trap is best understood as a chain, each link driving next until it closes back on itself.

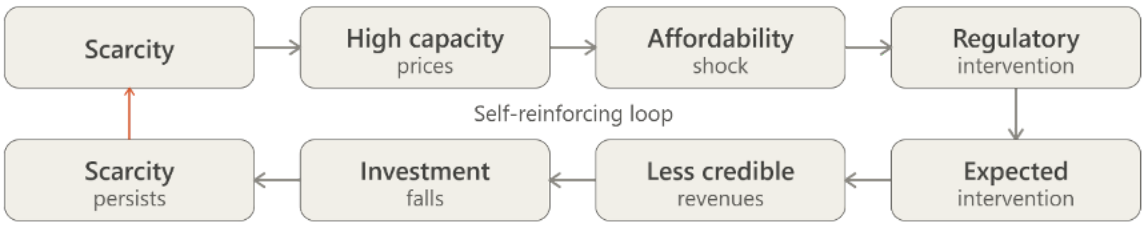

Figure 1: The Credibility trap.

1. **Scarcity**. PJM has entered a period of structural scarcity. Demand is growing at its fastest rate in decades, driven by data centers and broader electrification, while

dispatchable generation retires and new construction faces doubled timelines and sharply higher costs. Supply cannot catch up in the near term.

2. **High prices**. Scarcity drives high capacity prices. These high prices are the market's rational response to the shortfall, and they are economically correct, not a malfunction. The capacity market is producing the high prices it was meant to create in times of scarcity.

3. **Affordability shock**. High prices drive a consumer affordability shock. The RPM was designed on the assumption that most load would be insulated from spot volatility through long-term forward contracts. In practice, a large share of PJM load—particularly default service in restructured states—is procured on short horizons, a rational choice during the long surplus era that leaves customers directly exposed once the market turns scarce. This combination of high prices and lack of hedging has created an affordability crisis.

4. **Political/regulatory intervention**. The affordability shock drives political and regulatory intervention. A sudden, visible jump in consumer bills generates intense pressure to act through price caps, emergency backstop procurements, or other administrative overrides. Each of these signals that the revenue generators should count on may not fully materialize.

5. **Investors expect future intervention**. Intervention teaches investors to expect future intervention. Generation is financed over fifteen- to twenty-year horizons, so what a developer needs is not a high price in a single auction but confidence that the revenue will persist long enough to recover a multi-billion-dollar investment. Having watched a decade of consequential rule changes, MOPR imposed and reversed, ELCC methodology revised, caps modified under pressure, and now fresh intervention, investors reasonably conclude that more is coming.

6. **Scarcity revenues become less credible**. Expected intervention makes scarcity revenues less credible. Once investors anticipate that high prices will be capped or overridden, they discount those prices when deciding whether to build. The signal still says "scarcity"; investors simply no longer trust that the revenue behind it will survive. At the same time, LSEs are discouraged from signing the long-term contracts that might restore that credibility, uncertain whether today's high prices will persist or be muted before the contracts pay off.

7. **Investment falls**. Less credible revenue means investment falls relative to what is needed. With revenue durability in doubt, capital waits on the sidelines or moves to markets with clearer revenue visibility.

8. **Scarcity persists**. Falling investment means scarcity persists—closing the loop. Too little enters, the shortfall endures, and enduring scarcity regenerates the high prices that started the sequence.

What makes this a trap rather than a tuning error is that no single parameter is at fault. As long as unhedged load, demand growing faster than plants can be built, and a credible threat of price-suppressing intervention coexist, the market cannot perform its investment function—no minor adjustment can solve the loop. Escaping the credibility trap requires a structural change to how reliability revenue is contracted. That is the task the forward energy market takes up.

1.2 The FEM solves the credibility trap

The forward energy market solves the credibility trap by breaking the chain at each successive link. Rather than suppressing scarcity prices, the FEM allows those prices to perform their economic function while insulating consumers from the resulting short-term shocks and converting scarcity revenues into durable, contractually committed revenues. The resulting sequence directly reverses the credibility trap:

Figure 2: The FEM solves the credibility trap.

1. **The FEM breaks the affordability shock**. The first step is to separate scarcity prices from the prices consumers actually pay. Under the FEM, LSEs progressively hedge expected demand with forward energy and uncertain tail demand with energy options. Forward contracts lock in the price of expected energy before delivery. Options protect load against extreme prices by giving the buyer the right to obtain energy at a predetermined strike price when spot prices rise. As a result, scarcity can still produce the high prices needed to signal the value of additional supply without transmitting those price spikes directly to consumers. Consumers still ultimately bear the cost of maintaining reliability, but that cost is contracted in advance rather than arriving as a sudden affordability shock.

2. **The FEM changes the incentives for political and regulatory intervention**. Once consumers are insulated from short-term price spikes, the political problem changes. Under the current system, scarcity becomes visible through sudden bill increases, creating immediate pressure to suppress the price through caps, backstop procurement, or changes to market rules. Under the FEM, the relevant regulatory decisions occur primarily before scarcity materializes: how much LSEs must hedge, how quickly they must build their positions, what products they may use, and how prudent procurement should be overseen. Political and regulatory attention therefore shifts from intervening in scarcity prices after the fact to managing long-term contracting before the fact. Scarcity

prices can remain credible because protecting consumers no longer requires suppressing the prices intended to induce investment.

3. **Long-term contracts make scarcity revenues predictable**. This change makes generator revenues substantially more durable. A generator considering entry no longer needs to rely primarily on the expectation that high capacity or spot prices will survive political intervention for many years. Instead, it can sell forward energy and options years before delivery and convert expected future scarcity revenues into contractual revenues. The distinction is critical for investment. A high market price today is only a signal; a long-term contract transforms that signal into a revenue stream against which a project can be financed. The FEM therefore replaces much of the risk identified in the credibility trap with contractual certainty.

4. **Greater revenue certainty increases investment**. More predictable revenues reduce the risk associated with developing new generation and make projects easier to finance. When the forward market reveals scarcity, prices for forward energy and options rise. Those higher prices create an opportunity for prospective suppliers to enter, contract with buyers, and secure the revenues needed to support construction. Importantly, the opportunity remains available continuously rather than disappearing once a single auction has cleared. The market therefore gives investors both the signal that additional supply is valuable and the means to lock in the revenues associated with responding to that signal. Investment increases because the revenues supporting that investment are more credible.

5. **Investment eliminates the scarcity.** The final step closes the loop in the opposite direction. Under the credibility trap, intervention weakens revenues, weak revenues suppress investment, and inadequate investment causes scarcity to persist. Under the FEM, hedging protects consumers, protection reduces the incentive to suppress scarcity prices, credible prices are converted into long-term contracts, and those contracts support investment. New supply then enters until the scarcity that generated the elevated forward and option prices is competed away. The FEM therefore restores the feedback mechanism that the credibility trap had broken: scarcity produces a credible signal, the signal produces investment, and investment eliminates persistent scarcity.

The core distinction is that the FEM does not attempt to escape the credibility trap by preventing prices from becoming high when the system is scarce. High scarcity prices are economically useful. The FEM instead makes those prices politically sustainable for consumers and financially credible for investors. That restores the connection between scarcity, investment, and eventual market equilibrium.

1.3 Administrative products and delayed signals undermine the RPM

Sections 1.1 and 1.2 describe the credibility problem: scarcity prices cannot induce sufficient investment when consumers face abrupt price shocks, and investors expect the resulting

political and regulatory intervention. But hedging on the demand side is only one requirement of an effective reliability mechanism. The signal must also tell the supply side what is needed and when it is needed, and do so early enough for supply to respond.

Electricity markets are fundamentally feedback mechanisms. Changes in expected supply and demand should produce price signals, and those signals should give market participants incentives to adjust investment, production, consumption, or other behavior. For this process to converge efficiently, signals must be precise, timely, and trustworthy.

The RPM struggles on all three dimensions. Its central product—capacity—is an administrative approximation of the underlying physical need for energy. Heterogeneous generation technologies and demand profiles must be translated into a single quantity through rules governing NRIS, deliverability, ELCC, and other parameters. These rules necessarily influence which resources can participate and how much capacity they are deemed to provide. Changes in those rules can materially alter market outcomes without any corresponding change in the grid's physical capabilities.

The result is an imprecise signal. A high capacity price can indicate that PJM expects the system to be short, but it provides limited information about exactly what supply is valuable—at what hours, locations, and states of the system. A solar resource, a battery, a baseload generator, and a peaker provide fundamentally different energy profiles, yet the reliability mechanism ultimately translates each into the same one-dimensional product. The administrative translation inevitably loses information.

The signal is also delayed. The RPM relies primarily on a large, discrete procurement event based on PJM’s forecast of future need. Information that becomes available before or after that event does not immediately produce a corresponding market signal and opportunity to respond. Once the auction has procured the required capacity, a supplier that subsequently identifies a way to alleviate a shortage may have no direct opportunity to earn the capacity revenues associated with doing so.

These problems reinforce the credibility trap. Traditional generators must decide whether a high capacity price represents a durable investment opportunity while also assessing whether future capacity rules and prices will remain intact. Renewable resources face changing ELCC and deliverability determinations that can materially alter their capacity value. Meanwhile, the one-and-done nature of the auction delays the market’s ability to incorporate new information about rapidly changing demand and supply.

These shortcomings were less consequential when demand changed slowly and generation was comparatively homogeneous. Under those conditions, a noisy or delayed feedback mechanism could still converge over time. With today’s rapid load growth and increasingly heterogeneous supply, convergence over many years is insufficient.

Long-term reliability therefore requires more than making RPM scarcity revenues politically credible. PJM must also tighten the underlying feedback loop: market participants should be able to express actual future energy needs as soon as those needs become known, prices

should reveal the specific nature of any expected scarcity, and suppliers should have an immediate opportunity to respond. The FEM is designed to provide that mechanism.

1.4 Addressing feedback dynamics with the forward energy market

The Forward Energy Market addresses both problems identified above. It helps escape the credibility trap by replacing consumer exposure to short-term scarcity shocks with long-term hedging, and it repairs the underlying feedback mechanism by replacing an administrative capacity product and discrete procurement events with continuous forward trading of physical energy needs. It embraces the spirit of PJM's Path C and reinforces the goal with key features required to improve the market feedback loop.

Today's day-ahead and real-time markets work because the products being traded correspond closely to the physical system. Energy is differentiated by time and location, allowing market prices to reveal where and when electricity is valuable. These markets provide the information PJM needs to schedule and dispatch resources efficiently.

PJM does not currently have an analogous centralized market for medium- and long-term planning. Instead, the RPM translates future physical needs into capacity and procures that administrative product through discrete auctions. The FEM extends the basic logic of the energy market forward in time: rather than translating expected future supply and demand into capacity, participants trade forward energy and energy options corresponding directly to what they expect to produce or consume.

The FEM proposed by Cramton et al. (Cramton et al. 2024) combines three core elements:

- **Granular forward energy and energy options** allow supply and demand to transact their actual anticipated needs.
- **Progressive hedging requirements beginning four years ahead** require LSEs to reveal their expectations of future demand and turn forward contracting into a reliability mechanism.
- **Flow trading and trade-to-target technology** make it practical to trade a large number of granular products continuously without requiring participants to manage thousands of individual transactions.

The distinction from capacity is fundamental. A solar plant expecting to generate 25 MW at 1 p.m. and 20 MW at 3 p.m. can sell those quantities in the relevant forward products. A data center expecting to consume 10 MW continuously can build a forward position corresponding to that load profile. Dispatchable generation capable of producing during uncertain peak conditions can sell energy options, while LSEs can purchase those options to cover the uncertain tail of their demand. The market therefore preserves information that is lost when all of these resources and needs are translated into a single capacity quantity.

The FEM becomes a resource-adequacy mechanism through the hedging mandate. LSEs are required to progressively cover their eventual realized load, with minimum hedging requirements increasing over the four years preceding delivery. Because an LSE must begin building its position as soon as future demand becomes reasonably foreseeable, new information enters the market continuously rather than waiting for the next capacity auction. Market prices then aggregate participants' evolving beliefs about future supply and demand.

This creates a much tighter feedback loop. If expected demand rises three years ahead, forward prices can respond three years ahead. If a new large load becomes likely eighteen months before delivery, its purchases can immediately affect prices. If expected supply falls two months ahead, the market can signal the shortfall then. In each case, suppliers retain an opportunity to respond and benefit from addressing the newly revealed need.

The same structure that improves signaling also addresses the credibility trap. Forward energy protects consumers by fixing the price of expected consumption in advance, while energy options protect against extreme prices associated with uncertain or tail demand. Scarcity prices can therefore remain visible without producing the same immediate affordability shock. At the same time, suppliers can convert expected future scarcity revenues into forward prices and option premiums, creating more durable contractual revenues to support investment.

The FEM thus combines the forward-planning objective of a resource-adequacy mechanism with the informational advantages of an energy-centric market. Reliability is no longer based primarily on PJM translating physical supply and demand into an administrative capacity product. Instead, market participants continuously transact the energy and optionality they expect ultimately to need or provide. In the way that PJM's Path C is not about changing to an energy-only market, neither is the FEM.

This is the central structural change proposed in this paper. The FEM makes scarcity prices more sustainable, scarcity revenues more credible, future needs more transparent, and the market response more immediate. In doing so, it restores the feedback mechanism required for scarcity to induce investment and for investment ultimately to eliminate scarcity.

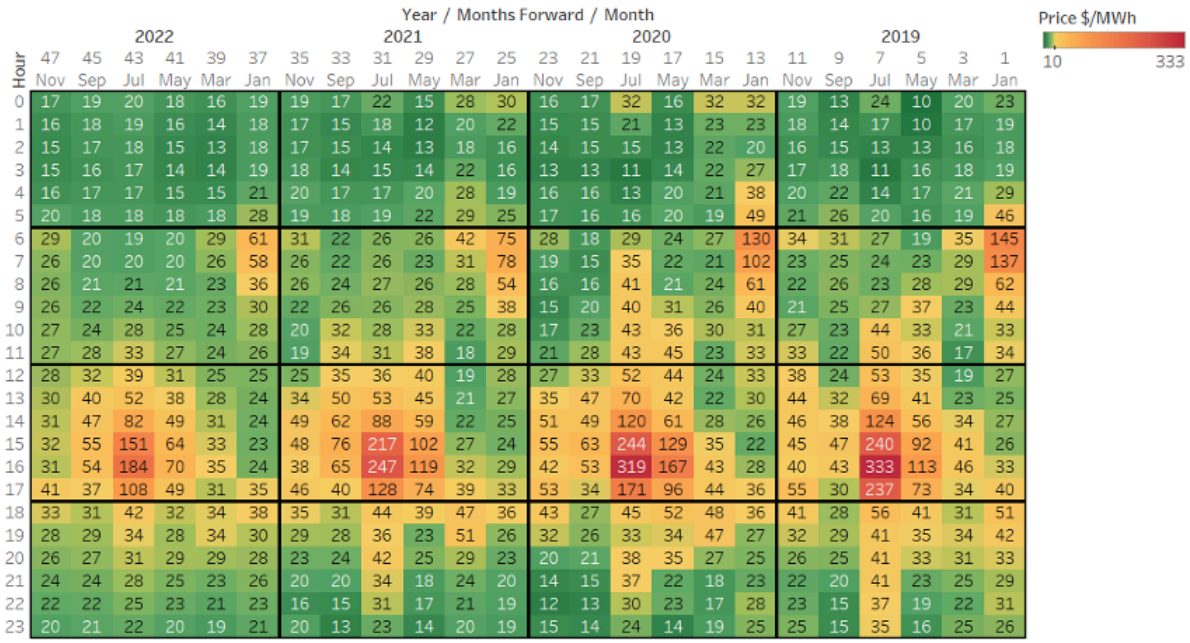

Figure 3: The FEM has separate products for every hour of every day looking ahead four years, each with its own price signal.

1.3 Recommendations for the PTRMD

Forward Market Design believes that foundational reform will be a key result of PJM's PTRMD. Specifically to PJM's questions:

Q1: The path(s) (either as described in the PJM paper or alternative paths) that your organization believes PJM should pursue and why?

We believe that developing an energy-centric model—broadly PJM's path C—is the necessary path to long-term reliability. We believe PJM should pursue the FEM and energy-centric models as a long-term solution alongside any short-term adjustments in the PRTMD initiative.

Q3: Any specific areas of the market design that your organization believes should be included in the scope of the upcoming stakeholder process, including why focusing on those areas will help stabilize PJM's wholesale markets and support more durable resource adequacy in the region?

We see foundational market design issues in terms of the reliance on administrative products and the weak market signals. We believe these are a key piece of long-term reform.

Q4,5,6: Areas that should remain out of scope in these stakeholder discussions and why it is appropriate to narrow the scope of work accordingly? The process that your organization would recommend be used to structure the stakeholder engagement? Any thoughts you have on issue prioritization and timing considerations for addressing these issues?

PJM will need both short-term and long-term solutions. We suggest parallel tracks. Short-term solutions that tweak the current market design are critical to navigating the present, but they will not deliver long-term reliability. Long-term solutions that address foundational issues take time to develop, so they cannot be delayed. Parallel tracks will ensure that each gets its due without sequencing, delay, or conflict.

Q7: Any education or analysis that you would request from PJM to support the upcoming stakeholder engagement?

We request that PJM engage deeply in the exploration of the FEM and energy-centric mechanisms broadly.

2. Critical market design issues

The challenges ahead of PJM are the result of weaknesses in the RPM that have grown in relevance in recent years. Some issues are foundational—solving them will cover for many smaller problems, while neglecting them will perpetuate PJM's long-term reliability challenges. We see two foundational issues that we believe PJM must address through the PRTMD:

The primary foundation of PJM's next reliability mechanism should be transactions of actual need—energy—instead of distorted administrative approximations like capacity. Capacity products are administrative, in the sense that they are artificial creations of PJM. They are governed by constructs and formulas like NRIS, deliverability, and ELCC. They attempt to distill energy needs into a single-dimension, distorting and obfuscating true supply and demand as they do. While the impact of these distortions was tolerable when generation was comparatively homogenous and demand grew slowly, they became debilitating as the market evolved. Across ISOs, capacity auctions have suffered poor price formation and exercises of market power. It has proven impossible to address these issues effectively (Patterson and Reiter 2016).

PJM's next reliability mechanism must deliver continuous signals of need with immediate incentives to address shortfalls. The RPM procures capacity through a one-and-done event. There is no meaningful subsequent test of resource adequacy and, similarly, no second chance if supply were to step in to fill a shortfall. Incentives are indirect—a shortfall now suggests supply can profit by stepping in to address a future shortfall instead of establishing direct incentives to deliver what is needed now. The response of supply to such delayed and indirect signals is predictably delayed and muted.

The first issue is the heart of PJM's Path C—transitioning to an energy-centric market. It also reinforces Path C with the requirement that transacting the actual need requires granularity. The second issue is closely related—an energy-centric market will also struggle if other hurdles prevent supply from meeting demand. We believe that it is critical for PJM to address both of these issues.

2.1 Replacing capacity with derivatives of physical products

PJM's next-generation reliability mechanism should be grounded in the physical products that generation and load will trade. This is the heart of PJM's Path C, and it entails both a shift in the type of products and their granularity.

Capacity was conceived as a way to address the missing money problem and guarantee that sufficient generating capability would be available to cover peak load.

As the primary driver of reliability, capacity's shortcoming is that it is an administrative product disconnected from physical needs. Whether a generator is eligible to sell capacity and how much it is permitted to sell is governed by rules and formulas like NRIS, deliverability, and ELCC. Not only are these rules and formulas artificial, but they are influenced heavily by the stakeholder process.

Nowhere are the shortcomings clearer than in PJM's recent capacity market results. When capacity prices spiked for the 2025/26 delivery year, PJM members responded and pushed PJM to reduce the price cap. In parallel, members observed that conservative ELCC ratings were a factor behind price spikes. Subsequent capacity auctions have cleared at the new cap.

PJM's recent capacity prices are effectively negotiated outcomes. Far from revealing an underlying market truth, the capacity auctions effectively regurgitated the result of a negotiation among stakeholders. Even worse, unlike a fully-negotiated outcome, the capacity market offers no guarantees of future resource adequacy. Customers pay for capacity with little indication that it will lead to reliability.

The solution is to implement a reliability mechanism centered around the actual physical need, granular energy, instead of capacity. When the products in the spot market are directly transacted forward, there is minimal opportunity to distort what is being consumed.

Reliability comes from transacting energy ahead. Derivatives of energy, including forward energy and energy options, allow supply and demand to buy and sell energy ahead, transacting based on actual needs instead of an administrative capacity construct.

To understand the difference, it helps to unpack what happens today and compare to products that work.

2.1.1 Unpacking the failure of the RPM capacity product

A deep dive on the RPM illustrates why the capacity market signal is so weak. For this discussion, the main elements of the capacity market are as follows:

- PJM works with stakeholders to define the single-dimensional capacity product and eligibility requirements, including the NRIS/ERIS distinction, deliverability criteria, and ELCC ratings that will be used to translate from true supply and demand into the capacity product.

- The capabilities of each generator are translated into a capacity rating.
- PJM models future demand and translates need into a capacity requirement and a purchasing strategy (demand curve).
- PJM clears the capacity market.

There are several reasons to distrust this outcome. For one, capacity forces a multi-dimensional supply profile into a single number, potentially missing hours of need or understating supply. For another, it explicitly omits ERIS resources that might potentially provide energy in times of shortage. For a third, ELCC and other formulas are very sensitive and can over- or under-estimate actual generating capability for any individual resource, distorting incentives. We see this distrust now, with many voices criticizing the current formulas.

Beyond distrust, supply has many reasons not to act on a shortage signal. High prices in the capacity market do not tell us that any particular technology would be profitable in the energy market—the capacity market does not tell us what the market needs. Moreover, history says that high capacity prices will be capped by administrative action, suggesting that even if current prices were profitable, future prices may not be.

In short, the RPM neither signals what the market needs nor provides credible evidence that the market will pay in the long run. Coupled with low price caps in the spot market that limit generator revenues, it is unsurprising that supply has failed to respond sufficiently.

2.1.2 Products that support reliability

Planning future electricity delivery requires differentiating energy in three dimensions: time, location, and optionality. When the reliability mechanism is based on procuring needed quantities in this space, administrative translation is not necessary—supply and demand are both captured precisely and honestly, sending a credible and accurate signal to the market about anticipated need.

Energy is the physical product. Location and time are the differentiating factors of energy transacted in the spot market. These two primary dimensions describe what supply can deliver and what demand needs:

1. *Time*. Intra-day variation in load and generating capabilities mean that each hour of the day is different, ergo each hour of the day should be a separate product. A solar plant should be able to sell different quantities at different times of day, and a battery should be able to buy forward energy for one hour and sell for a later one.
2. *Location*. Transmission constraints mean that energy at one location in the grid is not equivalent to energy at another location. Forward energy should be differentiated by location to enable demand to express where they need energy and for supply to express where they expect energy will be able to deliver.

There is always uncertainty about future demand—at any specific time or place, an LSE only knows a distribution of the load it must serve. Managing the tail is tricky because energy must be consumed when it is generated—buying forward energy to cover extreme load is problematic because demand will be forced to sell energy it cannot use. This illustrates the third key dimension, whether the energy is certain to be needed/delivered:

3. *Optionality*. Can the generation technology choose not to produce if the energy is not needed or will the buyer be forced to take delivery? If the energy can be produced on-demand, it is appropriate for covering tail load; if not, it should be primarily limited to base load.

The first two dimensions can be enabled through granular forward energy for every hour of every day and location. The third dimension, optionality, can be captured by offering different types of derivatives, forward energy and energy options.

Demand has the information to build a distribution by time, location, and certainty of need. Supply has the information to know how much they expect to be able to deliver to each location. When reliability is grounded in these terms, the market feedback mechanism can do what it is supposed to do.

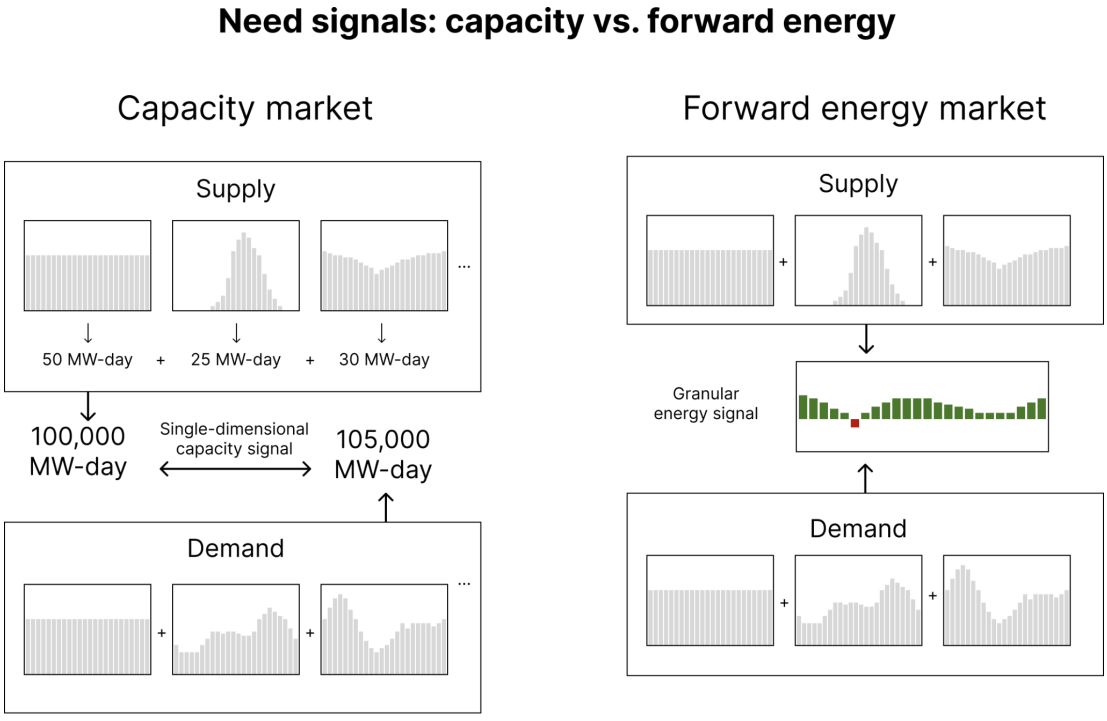

Figure 4: The RPM reduces supply and demand to a single dimension. True supply and demand is distorted and information is lost, limiting the value of the market signal. The FEM trades in granular products that precisely illuminate market needs.

2.13 Note: Capacity vs. options

Capacity and energy options can both support resource adequacy, but they do so through different contracts. That distinction matters for the credibility trap because the problem is not simply insufficient revenue; it is how scarcity costs reach consumers and how scarcity revenues reach generators.

A capacity contract pays a generator for being available, while energy is settled separately in the spot market. Capacity therefore provides generators with an additional revenue stream, but it does not hedge consumers against scarcity prices. If the spot price rises sharply, unhedged load remains exposed.

An energy option changes these mechanics. The buyer pays an option premium in advance. In return, when the spot price exceeds the strike price K, the seller has already committed the contracted quantity of energy at an effective price of K. The buyer is therefore insulated from scarcity prices above K, while the seller exchanges the uncertain upside from those scarcity prices for a known option premium. Options thus tie the reliability obligation directly to energy delivery while protecting load from extreme spot prices.

Options break the affordability shock

Suppose the spot price rises to $5,000/MWh. Under capacity, the capacity payment does not offset the consumer's $5,000/MWh energy exposure. Under an option struck at $1,000/MWh, the generator has already sold the contracted portion of its energy at an effective price of $1,000/MWh. The buyer is therefore insulated from the $5,000/MWh scarcity price on that quantity and remains exposed only to the strike price. The scarcity price therefore remains visible and economically meaningful, but it no longer produces the same immediate affordability shock. In the FEM, forward energy covers expected demand while options hedge uncertain or tail demand. Consumers still pay the cost of reliability, but increasingly through predetermined forward prices and option premiums rather than unexpected scarcity prices.

Options change the incentive for intervention

This insulation changes the regulatory problem. Under a capacity construct with poorly hedged load, high scarcity prices quickly become a consumer-affordability problem, creating pressure to cap prices or modify market rules. Under the FEM, the principal consumer-protection decisions move earlier in time: how much LSEs should hedge, how far ahead, and with what mix of forwards and options. Regulatory incentives therefore shift from suppressing scarcity prices after the fact toward ensuring prudent long-term contracting before the fact. Scarcity prices can remain credible because protecting consumers no longer requires undoing the price signal.

Options make revenues more predictable

Options also change the form of generator revenue. Without hedging, scarcity revenue depends on scarcity occurring and on high prices being allowed to persist. With an option, the expected value of that upside is reflected in an upfront contractual premium. The generator gives up some uncertain future scarcity rents in exchange for more predictable revenue. Forward energy works

similarly: generators can contract future production while LSEs progressively build hedge portfolios over the years preceding delivery.

	Capacity	**Forward energy + options**
Consumer scarcity exposure	Largely remains	Hedged above option strike
Generator revenue	Capacity payment + uncertain energy revenues	Forward revenues + option premiums
Regulatory focus	Prices and market parameters	Long-term hedging and contracting
Revenue predictability	Lower	Higher

Table 1 Capacity vs Options

The key point is that options do not eliminate scarcity rents; they change their form. They insulate demand from price shocks, shift regulatory attention from suppressing prices to managing hedges, and convert a larger share of uncertain scarcity revenues into predictable long-term contractual revenues. Those are the mechanics through which the FEM addresses the credibility trap.

2.2 Providing timely signals

PJM's next-generation reliability mechanism should also improve the timeliness of market signals. Timeliness entails two properties: signals of need should come as soon as the need is known, and signals should come before opportunities to meet need. This is a close complement to PJM's Path C that is a prerequisite for an energy-centric market to deliver reliability.

First, signals should be sent as soon as market participants anticipate a need. In today's market, lead times for both demand and supply can vary greatly. An extreme weather event might be anticipated days in advance; a data center addition might be anticipated months in advance; a thermal plant might plan to run hot for a few days; inoperable wind turbines might be fixed with a few months notice, to name some examples.

Second, signals should come ahead of opportunities to meet the need. A signal of need is of little use if there is no subsequent ability to meet it.

The current RPM struggles in both of these, but both are possible with modern market technology.

2.2.1 What happens today

The RPM neither offers prompt signals of need nor opportunities to meet revealed needs. What happens is quite simple: *A one-and-done capacity auction is run 3 years ahead to buy 100% of needed capacity based on a PJM model of expected need. Annual top-up events are held if PJM's model projects the need for more capacity*. Notice:

- New demand anticipated > 3 years ahead of need is not signalled until the capacity auction. New demand anticipated < 3 years ahead is minimally signaled in annual top-up events. Shocks anticipated < 1 year ahead are never signaled.
- Once a signal is sent, it is too late to respond because capacity has already been procured.
- Signals are only as good as the data PJM gets from utilities. A developer might anticipate a data center months or years in advance, but PJM only learns about it when enough paperwork has been filed that the utility reports it up to PJM.

The RPM effectively relies on indirect signaling and incentives—high prices in 2025/2026 point to an opportunity for supply to profit from capacity payments in 2026/27 and beyond rather than incentivizing additional capacity for the 2025/26 year.

Such indirect incentives undermine the market feedback loop. Consider a generator with a mechanism to increase peak supply for the 2025/26 year, given 2 years of warning. Once capacity cleared, the signal was there but the incentive was not—the generator would have ample time to increase peak supply but would not receive any capacity payments for doing so. Capacity payments would only go to the incumbents in the market prior to the auction. Examples like this abound. Indirect incentives directly prolong and undermine convergence of the market mechanism.

In the RPM, any reactions are lumpy—nobody moves until the signal is so strong that everyone moves—and delayed—most do not move until substantially after a signal is sent.

2.2.2 What should happen

PJM's next-generation reliability mechanism should signal needs as soon as they can be known and give an opportunity to address them:

- Changes in supply and demand should be signaled as soon as they are known, whether 4 years ahead, 1.5 years ahead, or 2 months ahead.
- After new demand is signaled, there should be an opportunity for sellers to benefit by meeting it. Demand can be met in many ways, and proper signaling will let the market do it in the most efficient way possible—new resources can enter, incumbent generation can adjust planned output, or even responsive demand can dial back.

- Signals should incorporate participants' expectations. Developers are the ones making the investment and decisions. While they face uncertainty, they have the best and freshest information, and they should be incentivized to signal their anticipated needs to the market.

When market signals like these are available, they make long-term reliability possible. They are readily achievable with modern market technology.

3. The forward energy market

The forward energy market (FEM) proposed by Cramton et al. (2024) and referenced in (PJM Interconnection 2026, 66) directly solves for the challenges faced by the RPM.

Forward markets are where participants make planning and investment decisions. A well-designed forward energy market addresses the key issues undermining the RPM and guarantees sufficient resources to prevent shortages. Today, we have an unruly stakeholder debate over complex rules and administrative parameters. By contrast, a forward energy market solves the problems of price formation, price discovery, and market power by letting market participants gradually trade forward energy and options and observe price information. Portfolios and positions can be updated to achieve targets.

In the FEM, Load-serving entities buy forward energy to cover expected load and options to cover tail (unexpected) demand. Meanwhile, generators sell forward energy for base load and options to monetize dispatchable capacity. To coordinate trade, LSEs must hold a position in energy or energy options that is an increasing share of their ultimate realized load. The share increases from 0% four years ahead to 100% day-ahead. Flow trading allows gradual, granular trade, eliminating two sources of market failure: incomplete markets and market power.

The system operator manages default risk through collateral and soft accreditation—accepting capital as collateral from financial players but encouraging generators to tie forward energy and energy options directly to physical grid resources. In this way, the FEM gains the flexibility of financial products with the reliability guarantees of accredited physical generation.

The FEM employs the latest market design technology to deliver near-continuous signals of market beliefs. Flow trading with trade-to-target bidding enables the market to clear tens of thousands of granular products hourly without impacting liquidity.

3.1 Components of the forward energy market

The FEM is a package of market design technologies designed to address the critical design issues facing PJM today. It includes five components:

1. *Granular products*. Forward energy and options are defined at a high granularity to precisely match the trade in the spot market.

2. *Participant resource adequacy mandate.* LSEs and large generators are required to build hedged positions, with minimums increasing linearly over four years. This assigns responsibility for assessing need to the participants who have the best private information and the most control. The linear ramp produces a continuous signal of beliefs as LSEs build or reveal their portfolios. Mandated hedging also helps eliminate liquidity risk.

3. *Hedging penalties.* LSEs are penalized when their realized load exceeds their hedged quantity and when their hedging fell behind the prescribed ramp. With both forward energy and energy options available, penalties should be the exception, even in shortage conditions.

4. *Financial products with collateral or soft accreditation*. Managing default risk is critical for the grid operator. Sellers must put up collateral or tie sales to physical grid resources; buyers must put up collateral or demonstrate a history of customer revenues.

5. *Flow trading market technology.* The FEM clears hourly using new flow trading and trade-to-target bidding technology. These technologies make participation straightforward and mitigate liquidity risk.

Each component plays an important role in addressing the fundamental issues behind the market

3.1.1 Granular products

The FEM defines separate forwards and options by load zone for every hour of every day up to 4 years ahead, enabling both supply and demand to accurately express what they will transact. There is no need to translate generation capabilities or needs into an artificial reliability framework.

- **Forward energy (by load zone, hour, day).** Forward energy is offered as separate products by load zone, hour, and day to match the natural granularity of transactions in the spot market. Forward energy is a derivative of day-ahead energy (day-ahead energy is already a derivative of real-time energy).

- **Energy options (by load zone, hour, day).** Energy options are a derivative of real-time energy and identical in granularity to forward energy. Options come with a fixed $1000/MWh (or similar) strike price. Options give demand the ability to reserve supply to cover tail load at a fixed price. As such, the strike price lies above the marginal cost of generation for peaker resources but substantially below top spot market prices.

Other products such as forward reserves and renewable energy certificates may be transacted in the FEM as desired.

Granular products are critical to avoiding the issues of a capacity product. Products may be bundled for ease of trade (e.g. weekdays/weekends) when transacted far ahead of delivery.

3.1.2 Resource adequacy mandate

The FEM mandates that LSEs build hedged portfolios according to a linear ramp over four years. This turns the forward market into a reliability construct, improves system estimates of future needs, and helps address liquidity issues.

LSEs are required to cover their load with forwards or options, with the minimum hedging requirement ramping up linearly over 4 years. Enforcement is based on realized load instead of models.

Mandated hedging based on realized load requires LSEs to take responsibility for projecting future load and share their beliefs with the market. LSEs have better information about their future load than PJM. For example, a data center developer will have the best information about what energy it will need and when. When LSEs buy to meet the hedging mandate, they reveal this information to the market, allowing it to develop a more accurate forecast of future needs.

Large generators with market power are analogously required to sell their energy. The same 4-year ramp applies so that generators cannot undermine the forward market by withholding energy.

This mandate also ensures that all products are being actively traded in the market. In traditional futures markets, liquidity is sparse for all but the most common products and virtually nonexistent far ahead of delivery. Mandating trade according to a linear ramp ensures that participants are actively engaged in trading all products in the market, thereby eliminating liquidity concerns.

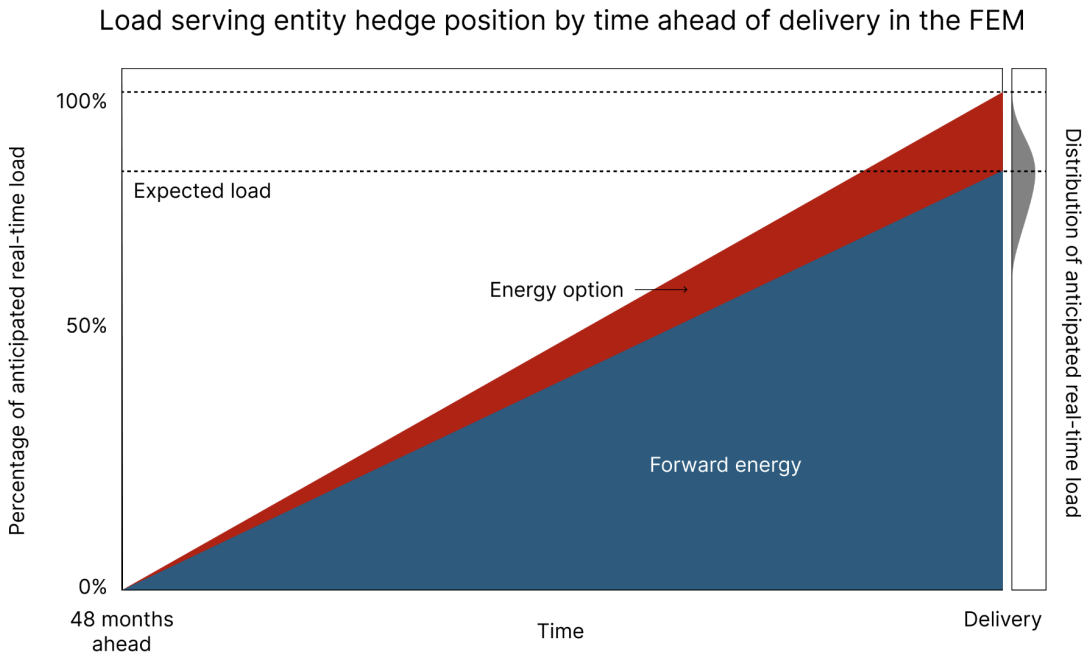

Figure 5: Load serving entities steadily buy the energy and options they need over 4 years, until they are fully hedged at delivery.

3.1.3 Hedging penalties

Participants are penalized when they fall short of the resource adequacy mandate. Resource adequacy is a public good, and new load that comes to the market on short notice increases the cost of resource adequacy for all. Penalties can be thought of as a Pigouvian tax that captures this externality. Proper aggregation ensures that any caps on penalties minimally distort the market.

LSE penalties are based on realized load. The energy an LSE purchases in the spot market is compared against the total quantity hedged (forward energy plus energy options); if energy purchased in the spot market is greater, penalties are assessed. Similarly, if the total hedged position at any point in the prior 4 years fell below the mandated linear ramp, penalties are also assessed.

Under normal conditions, LSEs will be far from paying penalties. LSEs will buy forward energy to cover expected load and options to cover for extreme events. Realized load will be on-par with the quantity of forward energy purchased, with the options in the hedge portfolio providing a substantial buffer before any penalties would be triggered.

Penalties may increase in severity as delivery nears. Stiff penalties at delivery ensure that LSEs are properly incentivized to cover their tail, while milder penalties ahead of delivery provide grace for uncertainty about future load.

The penalties for falling behind the hedging ramp are important to capture the externality that a "surprise" load creates on the market. Consider a data center that starts buying energy 6 months ahead of coming online. This will be a shock. The data center will have missed 3.5 years of hedging in the FEM; the penalties for this should be commensurate with the cost of accommodating the load on short notice. If the data center was new to the market, it is important that the externality be covered, though it may be rolled into a *new load fee* instead of being framed as a penalty.

Many details will be important when implementing penalties. They will require calibration. Caps may be considered, particularly at the monthly aggregate level. This can ensure that penalties capture an LSE's effective level of preparedness for shortage events while ensuring that they do not reach objectionable levels.

3.1.4 Financial products with soft accreditation as collateral

Collateral requirements are designed to deliver the flexibility of a financial product with the guarantees of a physical one. Soft accreditation means that buyers and sellers can point to their energy market participation instead of putting up capital—buyers point to their customer base and sellers point to their physical grid resources. Capital requirements are based on the imbalance—the difference between verifiable physical positions and FEM positions.

The FEM is built on financial products. Forwards and options are cleared financially based on the spot market prices, allowing the FEM to be attached to the spot market with minimal changes. As with similar financial products, buyers and sellers must put forward collateral to cover the risk of default.

Financial products are critical because they allow the market to be more open. Safely transacting physical products would require central validation of both the buyer and seller in some fashion. Limiting the forward market to physical products would thus require accreditation and modeling similar to capacity markets today, inevitably artificially limiting trade. Financial products that only require capital as collateral enable broad participation, including, for example, financial players, new supply that is still being built, ERIS resources that are not seeking accreditation, and renewables that anticipate generating more than administrative models predict.

However, as a reliability tool, the forward energy market must be (directly or indirectly) matching real supply to real demand. Notably, capital as collateral is useless if there isn't physical energy to buy in the spot market. Even as financial products are traded in the FEM and many are backed by capital as collateral, the FEM must ensure that real supply and real demand are being balanced.

Soft accreditation allows for a smooth blending of financial and physical to drive this matching. Soft accreditation says that sellers can limit collateral requirements based on the quantity of verified physical grid resources, and buyers limit collateral based on the quantity of verified customer revenues. Buyers and sellers are exempted from collateral requirements on those quantities—beyond the exemption, capital requirements increase smoothly with the imbalance between a buyer or seller's validated physical position and their position in the forward market. This gives us the best of both worlds. On one hand, anyone can buy or sell, provided they are willing to put up capital, ensuring that artificial administrative constraints are not blocking legitimate generation from selling in the market. On the other hand, the desire to reduce collateral costs creates a strong incentive for supply and demand to tie back to physical grid resources when they can. Market forces naturally drive forward energy to be backed by real generation.

Soft accreditation can be implemented using existing accreditation constructs. As a conservative starting point, NRIS, deliverability, and ELCC ratings can be used to define the verified physical resources on the supply side. New generation, ERIS resources, and renewable resources might then choose to put up collateral to sell above their existing limits. Alternatively, nameplate capacity might be used for ERIS and renewables—generation will naturally limit itself to what it expects to be able to deliver.

The net result is a reliability mechanism that is simultaneously open to all resources and robust in matching real supply to real demand.

3.1.5 Flow trading market technology

Flow trading (Budish et al. 2023) with trade-to-target bids is the core market technology that makes it feasible to have hourly clearing of highly granular products four years ahead without suffering liquidity issues or making it impractical to participate.

Flow trading in the FEM includes the following key features, described in detail in (Cramton et al. 2024):

- **Hourly clearing.** Hourly clearing is the basis for a near-continuous signal of market beliefs. The market clears all products hourly with a uniform price for each product. The bidding window ends on the hour, with results posted one minute later. Once results are posted, bids can be updated until the next clearing event. The optimization is a convex program that can be solved quickly and guarantees a unique price for each product.

- **Flow trading primitives.** Flow trading makes it easy to participate when the market clears frequently and natural to gradually build a position. Flow trading solicits bids that spread the quantity to be traded over time—"I want to bid 0.1 MWh at a price of $32/MWh in each clearing event over the next month" or more simply "I want to bid at a rate of 2.4 MWh per day at a price of $32/MWh over the next month." The system automatically maps the flows to quantities in individual clearing events. This is similar to the concept of time-weighted average pricing in traditional finance tools; flow trading

builds it into the core of the market. Sophisticated participants can set pricing and use supply curves.

- **Portfolios and trade-to-target high-level bidding.** The default bidding language makes it natural to trade tens of thousands of products simultaneously. In trade-to-target bidding, a participant can submit “I want to hold portfolio X of forward energy and energy options; I want to buy the portfolio at a rate of Y units per day until I have accumulated the full portfolio” or more simply “I want to hold portfolio X of forward energy and energy options at delivery; given my current holdings, set the rate so I achieve it precisely.” More sophisticated bidding tools would allow participants to consider risk preferences and price.

Flow trading with trade-to-target bids mirrors the broader design of the FEM. Basic trade-to-target precisely corresponds to the mandated linear ramp—an LSE uploads the results of its modeling as its targets, and trade-to-target will do the rest.

The mechanism also addresses two primary causes of liquidity issues: clearing too often and having too many products. Traditional market mechanisms solicit separate bids for each clearing event. Managing bids creates overhead for participants and, when the market clears too frequently, leads to volatility and liquidity issues in individual events. In flow trading, participants only need to interact when they want to change the *rate* of trade. Traditional markets also struggle with liquidity when there are too many products, since participants are unable to devote sufficient attention to each product. With portfolio bidding, tens of thousands of products can be managed through a single portfolio.

3.2 Key benefits of the forward energy market

The forward energy market delivers key benefits that address the foundational issues challenging the RPM.

- **Market forecasts are more accurate than current models.** Instead of today’s one-sided market, where PJM buys capacity based on an administrative model, the FEM is a two-sided market that aggregates the beliefs of individual LSEs. Since LSEs have better information about their future demand, the market signal is a more accurate indicator of future needs.

- **Energy+options replaces administrative capacity as the driver of reliability.** Reliability is primarily achieved through the trade of financial products that correspond directly with physical capabilities of supply and needs of demand. This directly addresses the first foundational issue with the RPM.

- **Soft accreditation enables generation to sell what it believes it will actually be able to deliver without jeopardizing reliability.** Accreditation in the RPM guarantees that supply can deliver but conservatively limits participation. On the other hand, eliminating

accreditation in the RPM would allow participation by new resources, ERIS, resources, and others, but it creates reliability risk if sellers fail to deliver. Building accreditation into collateral as a way reduce capital requirements, alongside penalties for failure to deliver, gives the best of both worlds—new generation can start selling energy as soon as it is confident enough to put up collateral, and renewables can sell beyond any ELCC-like limits if they are confident they will be able to deliver. Market forces will drive us to the situation we want: most sellers will be generators that point to their grid resources as collateral, while a minority will be pure financial players that always use capital.

- **The FEM produces a continuously-updated signal of future supply and demand.** Instead of having a single RPM event or a small number of discrete events, flow trading clears flows hourly. A mandated linear ramp means that the market is always active and the FEM produces a continuously-updated signal for every hour of every day up to four years ahead.

- **Supply can enter at any time and benefit.** With hourly clearing in the flow trading market, participants can observe a shortage signal one hour and jump in the next to meet the need. Ongoing trading events means that participants can always benefit by reacting to price signals. For example, two years ahead, roughly half of forward energy is (nominally) yet to be transacted. A supplier who can come in to make that cheaper will be able to sell forward energy in the FEM over the next two years and benefit.

- **Demand buys as soon as it believes it will need energy.** Demand faces penalties if it doesn't build its hedge position according to the mandated linear ramp. New demand, such as data centers, accrue penalties every day it waits to start buying energy. This incentivizes new demand to start buying energy as soon as it privately expects to need it, sending a signal to the market.

- **Mandates and trading technology solve traditional liquidity challenges.** Traditional futures markets struggle to provide liquidity for the most common products more than 6 months or a year ahead, let alone highly granular products. Mandated hedging and flow trading technology make it easy to transact tens of thousands of products over years ahead of delivery, guaranteeing liquidity and valid market signals.

3.3 Addressing missing money

If the penalty is optimally set, the FEM has no missing money—prices in the FEM are at precisely the minimum levels required to achieve the desired level of reliability and supplementary payments are eliminated. Additional motivation for investment may be important if hedging is incomplete, and PJM has multiple levers at its disposal should it need to do so. These levers include appropriate price caps, the operating reserve demand curve (ORDC), the hedging penalty, and a transitional capacity product.

Missing money refers to the general phenomenon in electricity markets where the total revenues available to generation are insufficient to support new entry even though it is

economically beneficial. This deficiency has two causes: (1) spot market prices are capped during near-shortage, and (2) the market fails during shortage.

Standard economic principles say that prices should rise to the value of lost load (VoLL) when in shortage. Estimates vary, but the true VoLL in the US is regularly estimated to be above $10,000/MWh and possibly as high as $35,000/MWh (ERCOT 2024). Were prices to rise to the VoLL, prices would incentivize new generation to enter any time the value it created for consumers exceeded costs. However, when spot market prices fall below the VoLL, incentives are weakened.

In the FEM, If demand is fully hedged, we do not need to worry about missing money. By definition, the market is clearing a sufficient quantity of forward energy and energy options to support PJM's mandated level of reliability. A capacity product is not required.

For a given level of reliability, the outcome in the FEM is superior to the outcome in the capacity model. Demand in the FEM will be paying precisely the minimum price required to buy the quantity of forward energy and forward options required to achieve the target level of reliability; to the extent that entry is required, it will be the minimum price required to support said entry, otherwise it will be lower. Compare this to a capacity market that clears at an administrative cap, where generator revenues are the combination of energy and capacity payments. Generator revenues will, with certainty, undershoot or overshoot the minimum price found by the FEM. If revenues undershoot, then demand pays for capacity without reaping the desired level of reliability; if revenues overshoot, demand overpays.

In practice, PJM may need additional levers to motivate investment because demand is not fully hedged. The first-best solution is to set appropriate price caps and use the ORDC to strengthen generator revenues in the spot market. This has proven successful in other markets like ERCOT. Adjusting hedging penalties can also be used to improve the completeness of hedging. Finally, a capacity market may be used to fill the gap, particularly as a transitional tool.

3.4 PJM reliability standards

PJM will want to maintain reliability standards, and the FEM offers multiple avenues to do so. PJM adopts its preferred reliability metrics, then achieves the desired level of reliability through the following levers:

- **Penalty level.** PJM can increase grid reliability by raising the penalties on failing to hedge. Larger penalties will force LSEs to hedge for progressively more extreme tail events. Increasing the penalty level is appropriate when PJM believes that LSEs individually possess the necessary information about future demand.
- **Centralized procurement.** PJM can choose to centrally procure additional options to cover for tail events. Central procurement gives PJM more control and reduces

overprocurement when the tail events in question are not strongly correlated among LSEs.

- **Adjustment of the price cap or ORDC.** Increasing the price cap or ORDC will motivate investment the same way it does today.

3.5 Implementing the FEM

The FEM represents a substantial shift in operation for PJM. It will require a well-orchestrated transition that ramps up activity in the FEM.

First, market participants will need to learn a new market mechanism. While the activities are related to existing hedging practices, the precise details will be new. Likewise, while flow trading and trade-to-target are intuitive, they are also new. Organizations will need time to learn the mechanism and structure themselves around the new activities.

Second, the transition must enable proper construction of load forecasts and market expectations. It will be important to ramp up the FEM in a way that allows participants to develop and refine their forecasts for the purpose before they become the centerpiece of grid reliability. It will also be important to give participants an opportunity to experience the market and build expectations about future trade.

Third, existing mechanisms will need to be tuned. While the FEM coexists with other processes today, many will perform better with tuning. This will be an incremental process.

Finally, throughout the transition, the FEM and capacity market must coexist for continuity. As a change that fundamentally alters generator revenue streams, the FEM transition presents the ultimate potential credibility trap. PJM will want to orchestrate the transition so that supply perceives revenues as stable rather than uncertain.

4. Recommendations and requests for the PJM process

Forward Market Design offers a handful of suggestions and requests as the PRTMD process proceeds.

1. **[Q4,5,6] Establish parallel short-term and long-term tracks.** We suggest PJM establish parallel tracks to develop short-term and long-term solutions. Both are important to the future of the grid. Short-term solutions will be needed to mitigate present issues with load growth and supply. These include the kinds of market design adjustments mentioned in the call—forward auction timing, seasonal capacity markets, ELCC enhancements, and Demand Response improvements. Unfortunately, these will not deliver long-term reliability. Long-term solutions will be needed to ensure that the PJM market is healthy into the future.

Natural gravity will focus the conversation on stopgap measures and quick fixes while leaving long-term reliability at risk. Explicit parallel tracks will make sure that each gets due consideration without delay.

2. **[Q3] Focus on robust and responsive price signals for long-term reliability.** PJM has a mission to deliver reliable electricity at least cost. Stopgap measures, curtailed large loads, and small adjustments to the RPM will not achieve this. PJM should devote sufficient attention to market designs that provide robust and responsive price signals, addressing the underlying market design issues that are challenging the RPM today. If PJM adopts parallel tracks, this should be a foundation of the long-term track.

3. **Give due consideration to challenging market design issues.** Natural gravity will focus on easy and familiar solutions. The problems PJM faces are challenging and will require time to solve.

4. **[Q7] Support study and simulations.** The FEM is a framework with many details to be considered. To make progress with the FEM, we would request PJM's active engagement in the review of ideas, details, and key dimensions. We would also request support obtaining the data needed to simulate the FEM and demonstrate its effectiveness in PJM.

5. Beyond the PRTMD—price-first interconnection

The interconnection process is a PRTMD-adjacent issue that Forward Market Design recommends PJM consider carefully. PJM recently dramatically improved its interconnection process, but interconnection is closely tied to reliability, and there is more that PJM can do.

It is impossible to design good markets without considering the friction for new entrants. In this case, interconnection is a primary source of friction and one that is directly under PJM's control. Interconnection adds friction in two ways:

- The interconnection process directly adds to the time required to bring new resources to the grid. PJM's new process is optimistically planned to take roughly two years from submission to contract; in practice, similar processes at other ISOs leave developers waiting three to five years. On top of the time required to build new resources and network upgrades, such multi-year waits make it difficult for supply to respond to rapidly-changing demand.

- An uncertain and costly interconnection process puts risk on developers, limiting interest and creating uncertainty about what resources will actually make it through to contracting. This uncertainty makes it difficult to assess future grid reliability.

In light of the tight coupling between interconnection and reliability, we recommend that PJM keep interconnection reform as part of the conversation.

5.1 Price-first interconnection

One specific innovation that we believe PJM should keep in mind is an approach we call price-first. Price-first replaces an iterative, reactive process with a posted-price mechanism to greatly improve interconnection. In our price-first approach:

- PJM sets bus-level interconnection prices ($/kW) that represent the fair medium-term cost of grid upgrades. In effect, PJM posts prices for NRIS.
- Developers submit to the interconnection process with full cost certainty and commitment; project withdrawals are nearly nonexistent, cluster restudy is eliminated, and projects can go from application to contract in 6-12 months.
- The interconnection process is faster and more certain—developers can respond to market needs more quickly, and projects in the queue will be built with much higher certainty.

SPP's latest comprehensive planning process (CPP) employs posted prices for interconnection (GRID-C), projecting an average wait time of 7 months (Southwest Power Pool 2025). While SPP's approach cannot be directly applied to PJM due to its reliance on a specific comprehensive plan, our price-first approach is specifically designed to be applied by ISOs like PJM.

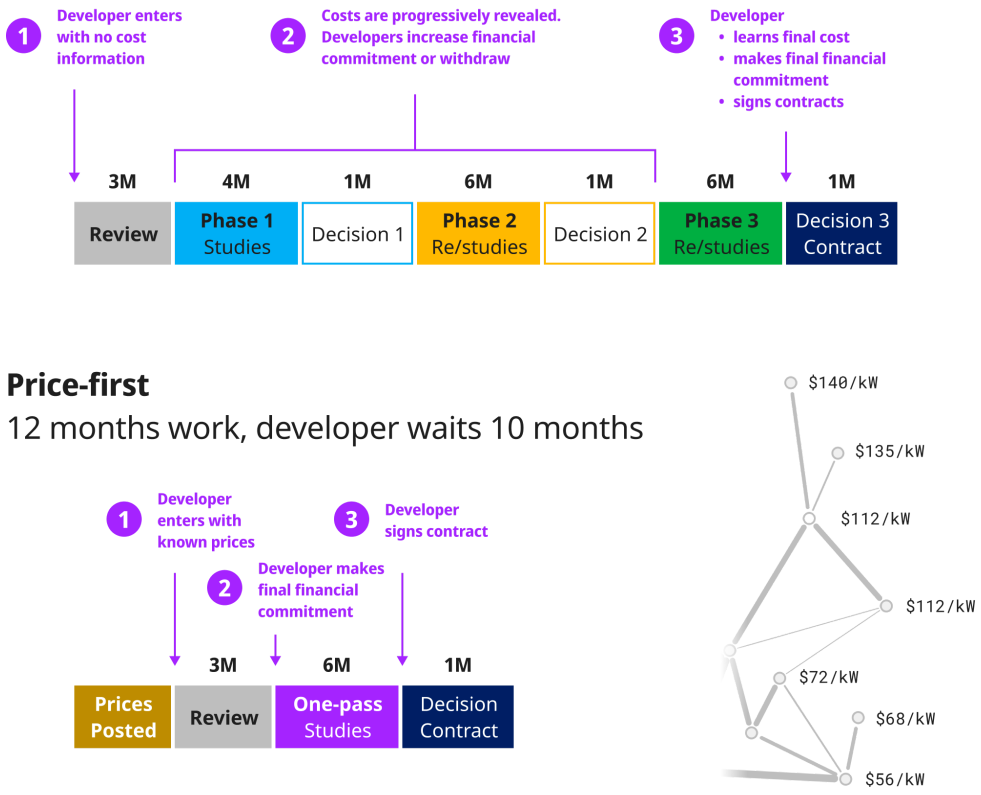

Figure 6: Price-first interconnection sets a price ($/kW) for interconnection rights on each bus. This posted price represents the fair medium-term cost of grid upgrades required to support interconnection at that point in the grid. Compared to PJM's current multi-phase cycles, it is substantially faster and more predictable.

6. Conclusion

Forward prices with the same granularity and flexibility as today's spot market are imperative in a better market design. Well-formed forward electricity prices should drive investment decisions. Thanks to advances in trading technology, this is now possible. System operators can conduct a forward market years ahead with ample liquidity, empowering market participants to manage their needs and minimize risks. Transparent forward prices with the time and location granularity of the spot market will promote efficient investment. The FEM will do this.

Noisy, laggy, distorted, uninformative signals dramatically impede feedback mechanisms. They become all the more problematic as the domain becomes more complex and underlying facts vary faster. PJM and other grid operators have experienced this first-hand in their capacity markets. Performance was acceptable when generation technology was simpler and demand

changed slowly. Today's grid is a mix of highly heterogeneous generation technologies and requires (comparatively) fast responses by supply to meet the needs of the grid, such as data center demand. Going forward, RPM is not up to the task.

PJM's next reliability mechanism must tighten the feedback loop, eliminating all possible sources of obfuscation, noise, and delay. This is the only way to deliver long-term reliability in today's rapidly evolving markets. PJM has pointed to this with Path C—we propose that the solution is a combination of Path C's energy-centric products, granularity, and timeliness improvements. We offer the Forward Energy Market as a long-term solution, and we encourage PJM and stakeholders to consider it thoroughly through the PRTMD process.

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