JULY 2021

STRETCHED TO THE BREAKING POINT
RTOs and the Clean Energy Transition

TONY CLARK
SENIOR ADVISOR, WILKINSON BARKER KNAUER LLP

VINCENT DUANE
PRINCIPAL, COPPER MONARCH LLC
(FORMER SVP LAW, COMPLIANCE & EXTERNAL RELATIONS WITH PJM INTERCONNECTION, LLC)

TABLE OF CONTENTS

EXECUTIVE SUMMARY

It has become an article of faith among many in the energy policy world that the Independent System Operator/Regional Transmission Organization model is not just the preferred way to achieve a clean energy grid transition – but the only reasonable way to do so. When confronted with the problems that increasingly bedevil RTOs, these advocates either minimize the threats or suggest a series of modest market tweaks will fix them.

This white paper challenges these orthodoxies. Authored by two experts who have collectively spent decades working with, managing and regulating RTOs, the paper explains why the cracks in the foundations of RTOs are not just cosmetic. It also explores why regulators and the RTOs themselves need to reassess wholesale markets from the ground up as the electricity delivery system transitions to a grid much different from the one of the past.

Given these existential challenges to the RTO model, policy makers should be cautioned against embracing RTOs as the only way to achieve future energy goals, especially in the absence of an identifiable fix to their structural weaknesses.

The white paper acknowledges and accepts the rationale behind the original RTO paradigm, and its historic benefits. It also accepts that the electricity grid will continue to see significant investment in renewable energy – a change fueled by technological advancement, societal demands and public policies. But where it departs from unbridled RTO boosterism is in explaining why many of the underpinnings of the current RTO model are misaligned with public policies that seek to advance grid decarbonization.

Foundational to the challenge facing RTOs is the matter of price formation. Meaningful price signals, as expressed through locational marginal price (LMP), are central to the functioning of RTOs. Prices are the keys to the RTO kingdom. In theory and in practice, prices signal how generation investments should be made, when facilities should retire, and when transmission should be built. They are the primary tool by which grid operators ensure reliability, and they are increasingly important to interconnected distributed resources.

The question becomes: what happens when price is no longer an effective tool for fulfilling the tasks that RTOs were created to complete? If an increasing portion of the grid is characterized by socialized fixed charges and generation that neither sets prices nor responds to price signals, the impact will be profound.

Most renewable advocates argue that RTOs offer the best vehicle to usher in a clean energy transition. They believe RTOs are the only way to build out transmission, ensure customer access to renewables, and achieve deep decarbonization. This paper finds that, in an ironic twist, it may be these very resources that, despite their societal benefits, stretch RTOs past their breaking point. Far from a plea to stop the clean energy transition or the sort of grid that would enable it, the authors argue that regulators and leaders must first candidly confront these tensions. In so doing they should recognize that RTOs – as structured today – may not be the right horse (or at the very least, the only one) to back in the race for clean energy.

INTRODUCTION

Much of the prevailing orthodoxy is that the road to the decarbonized, advanced technology grid of the future goes through a Regional Transmission Organization. If we want to meet carbon targets, expand electrification, and build out the transmission grid then the RTO model offers not just the better, but indeed the only, framework to meet the purpose – or so the argument goes. (1)

What we find perplexing about this singular devotion to the RTO model is how the renewable energy interests shouting loudest for its expansion tend to ignore challenges that are apparent, profound and perhaps even existential to RTOs, at least as we know them today. Equally curious is that many of these challenges are exacerbated by, or even arise directly from, the policy preferences and business models of the renewable interests themselves. And when confronted by these challenges, which might take the form of lethargic interconnection queues offering little cost predictability, or capacity markets that frustrate a state's policy preference to increase renewable resource penetration, the renewable champions for RTOs get angry at the RTOs themselves for not being better or smarter. They're missing the point.

Ask any home improvement aficionado: every tool has its purpose. A hammer is great for driving nails, but drywall screws? You're going to end up with a lot of busted walls and frustration. And so it is with RTOs, struggling to square the circle when it comes to executing on their mission. Inherent in the RTO DNA are principles such as resource neutrality, fuel agnosticism and non-discriminatory economic merit. Selecting a tool built with these attributes to advance the cause of low-carbon emitting resources at the expense of fossil resources seems like an odd choice.

In this white paper, we will look more closely at RTO attributes and how they are likely misaligned with where technologies and public policies are leading the grid. Of critical importance is understanding the role of price and price formation. Central to the RTO model and what distinguishes it from other forms of system operator is its design and use of elaborate market constructs to manage day-to-day system operations and, in some cases, longer term resource adequacy. The engine driving these constructs is price.

It would be nice to think that price is formed simply where supply meets demand; and that the price a buyer pays its seller results from their mutual agreement. The reality for RTOs is that price arises from an immense set of rules that establish an auction and define market clearing algorithms run by complex market settlement software programs to produce a single-clearing price paid to all supply and charged to largely passive demand. In short, the exercise of RTO price formation combines abstract art with impenetrable science. Why is overlaying a centralized market regime to govern a security constrained economic dispatch such a production? The answer lies in recognizing several major constraints endemic to RTO markets, not normally found in well-functioning, organically arising markets. These include: (i) the inability to tolerate shortages, (ii) the non-linear economics and idiosyncratic behavior of supply derived from physical machines with different operating characteristics and performance parameters, (iii) limited participation of active demand and (iv) widespread structural market power concerns.

Okay, so RTO price formation is complex. But these constraints complicating RTO markets are nothing new; they've existed from the outset. How does any of this speak to the question of whether RTOs are good models to lead a clean energy transformation? To answer this question, let's consider the implications on clearing prices resulting from the expanding penetration of renewable resources from three different but interrelated angles: supply (generation and storage), demand and transmission.

1. Letter from former FERC Commissioners to current Commissioners (June 2, 2021), https://documentcloud.adobe.com/link/track?uri=urn%3Aaaid%3Ascds%3AUS%3A5a7f3ba2-5a11-42da-ad75-5c80039e8582#pageNum=1. See also, Renewable Energy Buyers Alliance (REBA), https://rebuyers.org/programs/market-policy-innovations/organized-markets/ ("REBA supports ultimately instituting organized wholesale markets in all regions of the country which are designed and implemented consistent with the principles outlined below, operated by an Independent System Operator/Regional Transmission Organization.").

SUPPLY

Locational clearing prices are the defining feature of the RTOs' energy markets, certain of its ancillary service markets, and in some regions, its centralized capacity markets. To those of us steeped in RTO markets, we take as a given that these markets are single-clearing price auctions and forget that this design is rather unusual, and unlike most other commercial markets, including financial and commodity markets, where price is set once a buyer "lifts" an offer directly from a seller. Indeed, this is how electricity is bought and sold in bilateral market regions around the country. There is no auction, no central counterparty, no passive demand established by forecast and no single-clearing price. But in RTOs the single-clearing price auction is the default. One might go so far as to say, it's the only form of competitive procurement RTOs consider. If something must be bought and sold in a competitive manner in the RTO, (2) then, by golly, let's run an auction.

There is sound reason to back the use of a single-clearing price auction in organized wholesale markets. The reasoning is well established and need not be repeated here. However, it rests on an important assumption; namely, that we can treat electricity as a commodity. (3) A definitional element of a "commodity" is that one unit of the product is fungible to the next. The assumption that one kilowatt hour is fungible to the next has proven workably correct over the years in RTOs. (4)

Of course, electricity (at least in a form useable to power homes and businesses) doesn't simply exist in nature – it is created by machines. Created, in fact, by a variety of different machines, some that harness and directly convert kinetic energy found in nature, some that convert solar radiation through photovoltaic technology, some that burn fuels or split atoms to create thermal energy which in turn creates mechanical energy in an electromagnetic field, and some that create an electric current through an electro-chemical reaction or through electrolysis. And these are still very general classifications, underlying each is a broad range of specific generating technologies, from flywheels to back-up diesel generators; dams to hydrogen fuel cells, nuclear powered pressurized water reactors to windmills, trash burning generators to mine-mouth lignite plants and the list goes on.

The point is, electricity comes into being from a much broader array of methods and technologies than other commodities, such as copper, corn or natural gas. (5) But do these differences matter when assuming commodity market-type fungibility in designing RTO electricity markets?

While the fungibility assumption has been workable to date, it's hardly been perfect. Assuming fungibility while respecting real world characterizations defining different generating plants and generating technologies has required "compensating fixes" unique to RTO markets. These include rules to govern how generators offer and how they are paid, consistent with their physical characteristics such as the unit's minimum run time, start-up times and commitment level (described in PJM as the unit's "parameter limited schedules"). In some cases, marginal resources and the supposedly fungible electricity they generate are not eligible to set the clearing price, giving rise to the "compensating fix" known as uplift costs. (6)

2. By "competitive" we mean to exclude RTO products whose price is set by regulation, such as black start service, reactive power and transmission service.
3. Another dimension to this question is whether, as a matter of public policy or legally (for example, under the Bankruptcy Code), electricity should be treated as a "public service" or a "commodity." These debates fall beyond the scope of this paper.
4. Generators injecting onto and load consuming off the grid is often analogized to the irrigating and withdrawing of water from a pool – a conceptualization which reinforces the notion of electricity as a fungible commodity.
5. RTOs administer their centralized auction markets for the purpose of meeting a delicate physical goal which is to keep the grid secure, in balance and functioning to deliver electricity to ultimate consumers in real time and in all hours of the day and night across all four seasons. The relationship between the price outcome in the RTO market and meeting the physical requirements attendant to delivering electricity to the ultimate customer is much more immediate than the financial derivative or secondary markets in which other commodities are bought and sold.
6. Uplift costs are widespread and result from various "out of market" actions taken by the RTO to maintain reliability, such out-of-merit order dispatch and redispatch with payment of lost opportunity costs. *See generally*, Federal Energy Regulatory Commission, *Staff Analysis of Uplift in RTO/ISO Markets* (August 2014), https://cms.ferc.gov/sites/default/files/2020-05/08-13-14-uplift_2.pdf.

Holding to the fungibility assumption in the case of single-clearing priced capacity markets has proven more strained. (7) If a purpose of a capacity market is to buy iron in the ground, treating one MW of wind capacity as fungible with a MW of natural gas capacity means we're ignoring some pretty different looking, and performing, irons in the ground. (8)

Notwithstanding these challenges, single clearing price locational marginal prices for energy, co-optimized ancillary services and energy derivative products (FTRs) have on balance worked well – to date. (9) An important design predicate that justified the rough fungibility of electrons in the RTO market, which in turn enabled the operation of single-clearing price auctions (albeit with "compensating fixes") was the expectation that generating electrons came with a marginal cost. The "M" in LMP.

The fact is, some resources – and it's those resources whose participation has seen a dramatic increase – have low or no marginal costs as that term is defined by RTO rules, economists, market monitors and regulators. This fact, in our opinion, is the straw that breaks the fungibility camel's back, and poses an existential challenge to the continuing operation of single-clearing priced auction markets for energy and related services in RTOs. We don't believe it will be possible going forward to ignore how the kilowatt hour was generated and simply conduct an auction among all kilowatt hours however derived to set a single-clearing, locational marginal price to pay the various types of generators injecting that electricity. (10)

A difficult fact to accept is that many suppliers in RTO auction markets do not contribute to formation of the energy clearing price. Many are price takers because they are inflexible base load plants, in particular nuclear. Many are price takers because they have next to no marginal operating costs, in particular solar and wind. Finally, many have quite obvious marginal costs, but due to the inflexibility of their operating parameters (say a minimum commitment block) these cost-based offers are ineligible to set the clearing price. Taking this liquidity off the table means that LMP outcomes are not as competitive as many might assume. But more to the point of this paper, it means that in order for LMP to come close to representing the value of the wholesale electricity supplied, a flexible resource with meaningful operating costs must set the single-clearing LMP paid to all suppliers. This need is met in RTO markets by fossil units, typically natural gas simple and combined cycle generation. Stated more directly, in order for a renewable resource to obtain positive revenue from selling its energy in an RTO market, it must rely on a carbon emitting fossil resource to set a positive LMP.

The economics of an investment in renewable generation turn only to a degree on the energy, capacity and ancillary service revenues realized from the RTO market. Other revenue streams, such as renewable energy certificates, production or investment tax credits and bilateral contracts from load serving utilities pursuant to state programs or commercial and industrial customers are important. In fact, their importance is likely to increase as RTO market revenues remain depressed with greater numbers of low marginal cost resources dominating the supply stack in many hours. The choice facing policymakers is limited. As market revenues degrade, either we must embrace more fully these kinds of out-of-market revenue sources or instead accept

7. A recent post from the Sustainable FERC Project indirectly questions the dubious fungibility assumption underlying capacity markets when it analogizes renewable and fossil generation to heirloom and corporate farm tomatoes respectively. Tom Rutigliano, *Fix The MOPR Problem With A Dose of Humility*, Sustainable FERC (Apr. 28, 2021), https://sustainableferc.org/fix-the-mopr-problem-with-a-dose-of-humility/.
8. The "compensating fixes" here include rule frameworks to measure effective load carrying capability or other rules discounting more bluntly the MW value of different technologies. Though empirically driven, that hardly saves them from controversy.
9. We are less convinced when talking capacity markets. *See also*, Jay Morrison, *Wholesale Power: Fungible Commodity or Differentiable Product?* Public Utilities Fortnightly Magazine (Nov. 1, 2018)("It's time for the Commission to finally accept the political, economic, and operational reality that wholesale power is not a fungible commodity.")
10. The question of how to form viable energy prices in RTO markets as zero-marginal cost generation become a more meaningful component of the supply stack has been identified and discussed for years now. *See, e.g.*, Paul L. Joskow, *Challenges for Wholesale Electricity Markets with Intermittent Renewable Generation at Scale: The U.S. Experience*, at 37, (M.I.T. Ctr. for Energy & Envtl. Policy Research, Dec. 18, 2018), https://economics.mit.edu/files/16650. We're not aware whether those pondering solutions to the problem have questioned the fungibility predicate underpinning LMP price formation and whether treating a wind farm (the heirloom tomato described in footnote 7, *supra*) as comparable to a coal plant so upends this assumption as to dash real hope the RTO can heal its markets through relatively simple fixes to the single-clearing price auction rules.

heretofore highly unpopular RTO administrative markets (like capacity markets) or outright regulatory proxies, such as RTO administered reliability must run (RMR) contracts. (11) In either case, wither the single clearing LMP market as a construct to induce and sustain generation, renewable or otherwise.

Put another way, RTOs need to come to terms with the reality that we may be rapidly moving towards a post-marginal price world. And as we will see throughout this paper, that new paradigm will have enormous implications for the viability of the RTO model. So, it's bemusing to observe many in the renewable industry champion RTO markets, given they themselves likely represent the seed that will destroy them, at least in their single-clearing price auction form. As the City of Venice might say to the summer tourist: "we love you, but you're absolutely killing us!" (12)

Prices carry information. To investors they signal when and where to invest. To consumers they signal how much to consume. To suppliers they signal when and how much to supply. As we've discussed, as RTO prices degrade and the quality of information is compromised, interventions become necessary to correct inaccurate information and misdirecting signals. But losing an effective LMP market presents not only an economic efficiency challenge, but also a system operations challenge to the RTO. Price is probably the RTO's most important tool to control the system and maintain balance and security. At one time, those warning against RTO geographic expansion predicted that a single dispatch across a large region would be unmanageable and unreliable. These skeptics were proven wrong because they didn't appreciate that price would do the heavy lifting in unit commitment and ramping that manual operator direction had done previously.

Degrading prices that no longer communicate the right information as far as what the system needs and when it needs it to maintain reliability will require their own kind of corrective intervention. And anyone hopeful for a system where supply is more decentralized with many smaller, distributed resources sitting closer to customers should be a vigorous advocate for getting prices right. The point is simply that in RTOs reliability is highly dependent on price integrity.

But the problem is more profound than embarking on "compensating fixes" or interventions to neutralize the static and restore the price signal. Even if price integrity is restored, what does it matter when an increasing portion of the supply stack doesn't actually respond to price? When you appreciate the RTO administers markets only because it believes its markets deliver reliable operations most efficiently, the conundrum presented in having a supply stack that effectively thumbs its nose at price is evident. Non-dispatchable intermittent resources will inject energy when it's sunny or windy without regard to the RTO's price signal. Zero or even negative prices, something seen occasionally in the market for old televisions and undistinguished brands of upright pianos, but not in markets for other fungible commodities, is a sign something is wrong and unhealthy with the state of RTO electricity markets.

Perhaps breakthroughs in storage technology, or a very different paradigm for participation of demand in the market, might save the RTO's single-clearing price auctions. But for the moment, let's recognize that the RTO market model was predicated on the assumption that generators:

11. A third option might be to "fix" LMP by changing price formation rules. In 2017, PJM launched an effort to question long-held price formation assumptions in light of the changing resource mix. The idea of "Integer Relaxation for Electricity Market Clearing," was floated and sunk promptly upon leaving the dock. Aside from attracting substantial controversy, some based on well-founded concerns such as controlling costs and the exercise of market power, this kind of approach wades further into the "compensating fix" labyrinth described above. A summary of the complex proposal, prepared by the Harvard Energy Policy Group and PJM, can be found here: https://hepg.hks.harvard.edu/files/hepg/files/hepg_chao_jan_2018.pdf?m=1523367435.

12. The RTO model holds an obvious appeal to generation developers of all types. RTO's provide a guaranteed buyer for the output of the developer's plant – no questions asked. Of course, unbridled merchant investment is disciplined by economics that start by assessing how competitive a new plant will be in light of its fixed and anticipated operating costs. This discipline begins to break down when investment is supported by significant revenue streams outside the RTO market, and where the plant has no operating costs to speak of. Under these circumstances, the RTO as a buyer finds itself in a kind of "take or pay" posture – it essentially must absorb all energy output offered by the zero-marginal cost generator, even if it drives LMP to zero or below. It's then left with the job of finding other means to bring in or retain supply resources that provide the RTO the full complement of operational attributes it needs to keep the system reliable.

1. While different, had sufficiently similar operational characteristics that we could regard their electricity as fungible and impose a single clearing price auction-based market design that replicated outcomes found in markets for other fungible commodities;
2. Had real operating costs, in particular fuel costs, that would set a sufficient LMP, when considering all hours in the year, to compensate economic resources for the services they provided to meet demand; and
3. Would respond to LMP signals in a manner consistent with system operator needs and thus enable the market to deliver system reliability.

In considering whether the RTO market model is indeed our best framework to advance the decarbonization agenda, we must ask whether these assumptions continue to hold. We don't think they do. Moreover, we fear these assumptions are so profoundly integral to the RTO market model that either the market must be overhauled or alternate regulatory models given greater consideration.

But before making this policy call, note we have thus far addressed only the present and likely future implications to *supply* resulting from the degradation of price in recent years under the RTO market model.

Let's turn to demand.

DEMAND

Since its inception, delivering reliable electricity has required the operator to accept load, more or less as it comes and goes, and to control a supply stack, that while lumpy, responded to dispatch and ramping instruction. For an RTO, the tool of choice to commit and control generation is price.

In an RTO, for price to do this job, price must be "correct." In practice, "correct" almost always means: does the price create incentives (or disincentives) aligned with desired reliability outcomes? RTOs, their stakeholders and regulators have become accustomed to a never-ending refinement of market rules chasing the goal of incentive compatibility. (13) So it's not surprising to expect RTOs to respond to the novel operational challenges presented by intermittent generation by tinkering further with the rules governing price formation. But this time, the problem is different because it poses a challenge wholly unanticipated by the foundational design of the market: how to control a supply stack that is impervious to the price signal – regardless of how "correct" the price might be?

Short of revolutionary advances to the likes of storage or fuel cell technology - in other words, living with a portfolio increasingly comprised of supply that "is what it is" - then we need to get serious about controlling demand. In fact, a lot of recent literature extolls the promise of demand response as a tool to manage the operational challenge of intermittent renewables and give operators necessary control over the system. But perhaps nothing illustrates how far we have to go in this regard than images this past February of well-lit pandemic-vacated downtown skylines in Austin, Houston and Dallas taken by people gathered around open fires trying to stay warm in suburban backyards.

The RTO model offers promise when it comes to controlling demand because its markets should produce real time price signals that can communicate with smart technologies. When incentivized by smart regulation, this should result in consumers curtailing or deferring consumption to meet reliability objectives. Of course, this sort of direct retail "price responsive demand" has, by and large, never lived up to its promise. Why? In part because of unsupportive regulatory paradigms and an understandable reservation about exposing consumers to volatile time of use prices for an essential service. (14) But also because asking price to change consumptive patterns

13. The ideal would be the complex workings of a Swiss watch telling reliable time for years with just a periodic cleaning of the gears. The reality is closer to a 1960's Italian sports car that might run beautifully, provided it's not in the shop.
14. Indeed, one of the public policy casualties of the February Texas electricity crisis was the business model of those energy retailers (most famously, "Griddy") which pierced the veil between wholesale and retail prices, by exposing consumers directly to wholesale market prices. In the wake of the disaster, the Texas Legislature banned such rate plans from the retail marketplace. See Reese Oxner, *Griddy Energy customers may be off the hook for exorbitant energy bills after company files bankruptcy*, Tex. Trib. (Mar. 16, 2021), https://www.texastribune.org/2021/03/16/griddy-bankruptcy-electricity-bills/.

means changing how and when goods and services are produced and delivered, in short, changing how people live their lives. (15)

It's a tall order. That sort of consumer inconvenience may have been acceptable in the plain old telephone service days, when "Ma Bell" made it worth waiting until nights and weekends to call distant family members. But when it comes to electricity, the thing that makes modern life possible, it is a challenge on an entirely different level. One of us penned a short piece in the early months of the 2020 pandemic observing the flattening peaks in PJM as people woke up at different times, worked from home and as office buildings and the like cut back consumption. (16) These observed changes in usage patterns, and the promise they might continue to a degree after the pandemic subsided, suggested our public health crisis could have lasting impacts "affecting how society lives and works (which) may change load behaviors in a way that decades of price incentives and regulatory programs have largely failed to do." The point is, if it takes a global pandemic to see meaningful changes in how electricity is consumed, what chance does price have to drive the same behavioral change?

But let's put aside the debate as to the degree to which consumers are price elastic and whether price responsive demand can ever serve as a sufficiently powerful tool for the operator to control the system. What is axiomatic is that when that operator is an RTO, any hope to change consumption patterns starts with a viable LMP. In discussing supply, we've already described the problems getting a viable LMP with zero-marginal cost generation.

On the face of things, this problem (degraded energy prices) would seem to work in favor of encouraging load to consume more at the "right" times and less at the "wrong" times. As with many things in the RTO world, the situation is more complex. Even today, in places where the consumer is, indirectly and to a limited extent, exposed to the RTO's real time energy price, the signal is so muted that only the most hopeful stargazers can imagine a world where LMP provides RTOs an operative tool to maintain system balance by moving retail load. First, in most instances, consumers are not exposed to the dynamic (variable) nature of LMP. Second, load is usually settled at a zonal average price and not a nodal LMP. Third, and most important to this discussion, the LMP signal is being overwhelmed by other fixed, non-bypassable charges on the retail bill. And this signal-to-noise ratio is trending in the wrong direction with non-bypassable retail charges multiplying as a consequence of increasing renewable penetration.

Let's explore further the problem of non-bypassable charges. One set of ideas offered to solve the problem, discussed earlier, of how to form LMP without the "M" is to have the RTO create a suite of new product offerings to compensate suppliers more precisely for providing the flexibility, fast start ramping, inertia, stability, etc. necessary to maintain system balance in a high renewable penetration world. Pricing these "reliability services," at least if they are to be co-optimized with those same energy market LMPs still impacted by zero-marginal cost generators, sounds either futile or shockingly expensive in a single clearing price world. But in either case, these new services will add even more complexity to a pricing regime that hardly needs more intricacy.

When considering the conundrum facing RTOs in paying for necessary reliability services, the simpler perspective envisions fossil units "backing up" renewables. This perspective suggests a pricing approach that pays a reservation fee (like RTO compensation for capacity or black start services) or a separate performance fee, not tied to, or co-optimized with, energy market prices (like RTO compensation for reactive services). In either case, by the time these charges reach the retail bill, they almost certainly will appear as fixed, non-bypassable charges.

15. Some changes have minor impacts like shifting fixed interval cycling of certain motors (e.g., pool pumps) or modifying thermostat driven cycling of air conditioners. More meaningful changes involve rescheduling production lines from day to night time, for instance. And some consumption, think street lighting, is just unable to shift regardless of the price signal.
16. *See* Vincent Duane, *Stakeholder Soapbox: 'In These Uncertain Times…'*, RTO Insider (May 18, 2020), https://www.rtoinsider.com/articles/18307-stakeholder-soapbox-in-these-uncertain-times-.

Other fixed, unavoidable charges on the retail bill are transmission and distribution costs. The interconnection of distributed renewable resources at distribution level voltages quite often presents operational issues, like stability concerns, requiring reinforcement of the delivery system. More impactful, is that the locationally constrained nature of wind and solar demands massive reinforcement of the grid or new high-voltage transmission build. We'll get further into the topic of transmission below, but the point to make here is that the distribution and transmission upgrades needed to bring on-line renewables at scale to address current carbon targets will result in dramatic increases to the unavoidable delivery component of the retail customer's bill.

Finally, programs preferred by policymakers to support renewable resources, like solar renewable energy credits or zero-emission energy credits for nuclear, have not been allocated as a tax to the public, but again as a non-bypassable charge to retail electricity consumers. These charges sit alongside the modified pass through to the retail consumer of the RTO's LMP, diluting the signal that LMP might otherwise promise to modify consumption behavior.

We note in passing the likely harm to competitive retail electricity programs that results from expanding the non-contestable components of the retail bill (reliability services, transmission/distribution and support programs for clean resources). (17) But our focus is on the RTO confronting a supply stack that is largely uncontrollable, and whether RTO price signals can be expected to control demand to maintain system balance – even assuming existing regulatory impediments are resolved and customer enthusiasm for uptake increases.

Low wholesale prices (even artificially low negative LMPs) resulting from zero-marginal cost generation *should* provide a basis to build a price responsive demand regime that drives consumption away from low renewable output/high price hours of the day (and night). But as the saying goes, "there is no free lunch." A sober assessment must recognize that in order to affect a customer's decision to consume, this otherwise low-price signal must overcome the noise coming from companion non-bypassable charges that a customer typically incurs without regard to its energy consumption in a given hour. As noted, many of these charges arise in the first place to support or facilitate entry of the clean resource.

All this said, we still believe demand response is appealing in a world of increasing renewable penetration as a tool to maintain balance. Shifting consumption to periods of intense renewable generation and away from periods where fossil resources must be dispatched to balance intermittency has obvious operational benefit. It seems, however, that this will be accomplished by programs that offer a more obvious incentive to customers. (18) Such programs do not depend on, and in fact may be complicated by, RTOs and their wholesale energy pricing regimes. And this should give further pause to those claiming the RTO market model is the best or only way to accelerate a carbon free grid.

TRANSMISSION

We've referenced the widespread call for massive reinforcement and expansion of the transmission grid to accelerate a renewable transformation. The companion call is that we depart from a participant (generation developer) funding of this build out, to a socialized allocation of costs, recognizing the broad set of beneficiaries

17. Similarly, these phenomena will have deleterious effects on the much-touted rollout of distributed energy resources (DERS) and energy storage. For if energy prices throughout the wholesale markets are materially unmeaningful, then it will have an impact on distributed and storage resources as well. This is true both in terms of an investment signal to those who might install them – but also in relation to how the they will interact with the reliability operations of RTOs, all of which depend on getting prices right.
18. *See, e.g.*, Laura Mørch Andersen et al., *Paying consumers to increase their consumption can reduce the cost of integrating wind and solar electricity production into the grid*, VOX EU CEPR(April 26 2019) https://voxeu.org/article/reducing-cost-electricity-supply-paying-customers-increase-consumption.

associated with a carbon free grid. (19)

While this advocacy is persuasive, and we don't argue with the need for extensive transmission network expansion, how comfortably does it sit alongside the proposition that the RTO market model offers the best - or only - path to rapidly decarbonize the grid? Again, there are certain foundational elements of RTO design that seemingly are being swept under the rug.

The starting point is to understand that transmission under the RTO model was not intended to enable generation, at least not in the sense being discussed today. In disaggregating the natural monopoly and exposing generation and (in some cases) retail load to competition, transmission was left apart as a regulated "essential facility." The line drawn between competitive generation and regulated transmission was a bright one. In an RTO model, it was understood that transmission competed with generation in that a reliability criteria violation identified by the RTO's long-range transmission plan might anticipate a network upgrade, unless the market intervened to induce new generation whose entry relieved the constraint thereby cancelling the planned transmission upgrade. The advent of transmission planning for economic and/or public policy purposes pitted generation versus transmissions solutions against each other even more explicitly. (20)

We've talked several times about the "M" in LMP; let's turn to the "L." The genius of locational pricing is that it transparently reflects in energy prices the cost of congestion which can be compared to the cost of a network upgrade which increases transfer capability to relieve that congestion. Locational price separation additionally signals where generation is needed and where it is not. By its very design, locational pricing in concert with the participant funding of generation interconnection works to limit the overbuild or "gold-plating" of the transmission system by (i) pricing congestion transparently and efficiently and (ii) signaling where on the system generation is most valuable. A substantial infrastructure has evolved both in RTOs and in secondary markets to reflect this regime. (21)

Having the RTO centrally plan transmission to identify geographic areas where wind and solar resources can be harvested and then developing socialized transmission infrastructure to deliver low-cost renewable resources to load centers has a pragmatic appeal given the scale of decarbonization being envisioned. But let's not kid ourselves. This approach to planning, developing and paying for transmission upends a lot of the design purpose of LMP and the infrastructure that has developed to execute on this design purpose.

Not to mention, it places one competitor (the zero-emission generator) at a clear advantage compared to other competitors (the dispatchable generators) - the latter having to account for interconnection and network upgrade costs as part of its investment decision. Again, favoring carbon free generation in this respect might be the desired public policy, but aside from straining the non-discriminatory stipulation of RTO markets, it removes the locational advantage for generation proximate to load that would otherwise have been revealed in LMP.

Perhaps the most striking real-world example of the implications of these policies is the Texas CREZ model of transmission development. (22) The policy experiment was certainly effective at getting transmission built and,

19. A good example advocating both points comprehensively is a report commissioned by the American Council on Renewable Energy (ACORE), in coordination with the American Clean Power Association and the Solar Energy Industries Association. Julie Lieberman Concentric Energy Advisors, HOW TRANSMISSION PLANNING & COST ALLOCATION PROCESSES ARE INHIBITING WIND & SOLAR DEVELOPMENT IN SPP, MISO, & PJM (March 2021) https://www.eenews.net/assets/2021/03/29/document_ew_01.pdf. See also Federal Energy Regulatory Commission, Notice of Technical Conference, Docket No. AD21-12-000 (Mar. 2, 2021), https://www.ferc.gov/sites/default/files/2021-03/AD21-12-000.pdf.
20. A good overview of RTO planning, including descriptions of economic or market efficiency planning introduced beginning in 2006, can be found in Joseph H. Eto and Giulia Gallo Regional Transmission Planning: A review of practices following FERC Order Nos. 890 and 1000 Lawrence Berkeley National Laboratory (November 2017) https://certs.lbl.gov/sites/default/files/lbnl-2001079-appendices.pdf
21. It starts with tradeable transmission rights and includes markets to hedge the basis risk between generation and load, banks offering structured risk management products to support asset investment, speculators offering liquidity and centralized trading and clearing environments (such as Nodal Exchange).
22. *See Transmission & CREZ*, Powering Texas, https://poweringtexas.com/wp-content/uploads/2018/12/Transmission-and-CREZ-Fact-Sheet.pdf.

in so doing, dramatically jump-started renewable generation development in Texas. But any suggestion that market forces within the RTO (in this case, ERCOT) were primarily responsible for Texas' renewable development strains credibility. Taking the biggest expense associated with the development of geographically distant intermittent generation resources and uplifting the cost recovery across an RTO footprint is the antithesis of a market. That the resources have no fuel costs and therefore further depress LMPs only compounds the impact.

While not necessarily exclusive to the RTO model, we agree the geographic expanse of some RTOs (not all) can offer compelling scale and portfolio benefits to help manage the variable nature of solar and wind resources. Our goal is not to push back on those seeking to extend this scale by promoting a plan for substantial network expansion and upgrade whose costs are broadly reflected. Rather, it is simply to point out how incompatible that plan is with the logic and intended workings of LMP.

CONCLUSION

There is a widespread orthodoxy among those seeking rapid decarbonization of the grid, consisting of the following tenets:

1. Supporting renewable entry through programs, tax credits, and out-of-market contracts that value renewable's positive environmental externalities, while affording renewables preferred access to the grid;
2. Seeking ways to control demand as the supply stack becomes less controllable; and
3. Building out transmission to optimize renewable generation and manage its variability.

Where we stumble boarding the bus is with the next plank in the platform:

4. Items 1, 2 and 3 are best accomplished – perhaps exclusively – through RTOs.

By offering a single dispatch over a broad geographic area and broad regional planning, we see the appeal of RTOs to those seeking to advance decarbonization. The RTO is also extoled because it offers universal entry into its markets and a captive buyer to all suppliers. Here is where we say, "now wait a minute."

The engine driving RTO markets is the single-clearing locational marginal price. For the reasons discussed here, we harbor reservation about how this model – one which rests on assumptions of fungibility, non-discrimination and resource neutrality - can continue to work both operationally and economically as more wind and solar interconnect, particularly under the terms stated in item 1 above.

Does this mean RTOs can't serve as a vehicle to advance decarbonization? No. But we are inclined to think RTO wholesale electricity markets, which are a defining feature, will have to be re-thought from the ground up. This isn't going to come easily or quickly – particularly considering structural and governance features of the RTO which we intend to explore in a subsequent paper.

In the meantime, it strikes us as a bad, perhaps even dangerous idea, to rule out all other regimes (both existing and potential new or hybrid models) to instead insist on pursuing all efforts to decarbonize the electricity grid through a universally imposed RTO model. In the final analysis, we are intrigued by RTOs and their markets, and we have spent considerable time over the years working to improve them. However, we are simply unwilling to put all our climate eggs into that one basket. Too many industry, technology and public policy trends currently in-motion are working at cross-purposes to several central organizing principles of the RTO itself. An honest assessment of the compatibility of the RTO model to these policy trends should incorporate that consideration, and caution against those seeking to press RTOs as the one and only solution to decarbonizing the power grid.