MATRIX OF LONG-TERM MARKET DESIGN FEATURES AND BREAK-OUT TOPICS AND QUESTIONS

Prepared for WRI/RFF Workshop

Market Designs for the Clean Energy Transition: Advancing Long-Term Approaches

December 16-17

The four papers that Corneli, Gimon, Pierpont and Tierney have prepared for this workshop present a range of approaches to creating organized long-term electricity markets that could help to bring about the investments in clean electricity resources necessary to achieve our climate goals and also ensure an affordable and reliable electricity supply. To facilitate a comparison of the various features of these approaches, WRI and RFF developed this matrix of design features to help the reader compare how the four authors address key issues related to the transactions envisioned, the market host/operator and participants, resource adequacy, attainment of clean energy goals, etc.

The matrix begins with a summary description of each design, followed by six topics areas (A through F) appearing on the right of this page. These six topic areas also form the basis of the break-out groups in the workshop. Each topic area compares relevant market design features across the four papers, and ends with a series of Potential Questions to be discussed in the break-outs.

In the "Other Issues" topic area that follows, we present features that are relevant and important but are beyond the scope of our six break-out groups.

The matrix does not include many details that would ultimately be involved in designing such long-term markets or centralized procurements, some of which are discussed in the fifth paper prepared for the workshop: *Experience with Competitive Procurements and Centralized Resource Planning to Advance Clean Electricity*. Such details include: prequalification requirements for bidders, pro forma contract terms for bidders, performance standards/penalties, detailed market governance rules, etc. The four papers do cover <u>some</u> additional features needed for any detailed market design and these appear in the matrix Appendix.

<u>CONTENTS OF MATRIX</u>

SUMMARY DESCRIPTION				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
	Every 3 years, precise renewable integrating system expansion models (PRISM) evaluate bids for new clean energy resources and select the set of resource types, locations and quantities that, when added to the existing system, meet the models' key constraints (constant system balancing, declining carbon budget, etc.)at least cost. Selected projects receive long-term contractual revenue hedges based on their levelized cost of energy, less their received energy and ancillary service market revenues.	The Organized Long-term Market (OLTM) calls for periodic, centrally optimized (by WIS:DOM-like system model) selection of bids from resources to deliver hourly schedules of MWh over multi-year periods. Schedule specification may range from as-produced/ take-or-pay to firm hourly shapes for physical or financial delivery to Day-Ahead/Real-Time (DA/RT) market. The objective function for the optimizer is least-cost for the collective demand. Winning bids are offered contracts paying as-bid prices for scheduled delivery of energy. Voluntary buyers then subscribe to shares of energy deliveries promised by winning bidders. Fully subscribed projects' contracts are finalized, and upon commercial operation project, begins delivering energy to DA/RT market, with buyers paying as-bid prices to project outside of DA/RT market as a financial derivative (e.g., a swap) of DA/RT prices. Contracts are envisioned to be highly tradable and to support liquid secondary financial and physical (e.g., providers of storage and flex load) markets to lay off or take on changing positions and to more efficiently match actual production and consumption to scheduled deliveries.	A market mechanism for long-term contracts with a specified production profile. Winning resources are awarded financial, long-term contracts with the market or with individual Load Serving Entities (LSEs) on the basis of their as-bid cost of power per MWh, for a bidder-determined fixed hourly and seasonal profile of power production for the contract term. Under the contracts, the seller is paid its fixed as-bid price for all contracted forward energy production, and the seller pays the buyer all real-time energy prices, as determined by the short-term security constrained economic dispatch (SCED) market, for all the contract's contracted production profile. In other words, the long-term contract is a financial contract for differences applied to a specific hourly and seasonal production profile. The long-term market's two alternative clearing mechanisms are intended to select resources with the highest system value relative to project costs.	The market design has three elements: (1) competitive, co-optimized wholesale energy and ancillary service markets to ensure efficient dispatch; (2) a resource-adequacy (RA) approach for ensuring capacity of the right types and in the right places; and (3) retail pricing to enable loads to see and decide whether to respond to dynamic prices and provide flexible resources. The Regional Transmission Organization (RTO) would determine various types of RA needs in future periods, and conduct annual long-term resource procurements to solicit proposals for RA based in part on input from states on necessary attributes of resources (e.g., zero-emitting) not otherwise recognized in the RTO's RA requirements. The latter include: Local RA (to ensure adequate resources in zones with delivery constraints), Flexible RA (to assure real time balancing services), and System RA (to otherwise meet peak load and reserves). LSEs can meet their RA obligation through RTO procurement, or ownership or bilateral contracts.

A. PRODUCT-PRICE-SELECTION-RISK - **Product definition, pricing & payment, interaction with day-ahead/real-time markets. Winner selection methods and key VRE risk implications.**				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Long-Term Market Host (Operator)	Potential options include RTO, regional voluntary association of power companies (similar to the Western Energy Imbalance Market known as the EIM), multi-state board.	The procuring organization and the market operator can be separate entities. They could be private third-parties, a power-authority or state/multi-state run. The OLTM is regulated by the Commodity Futures Trading Commission (CFTC), so preferably is not run by a Regional Transmission Organization/ Independent System Operator (RTO/ISO). The legal counter-party situation is similar to a day-ahead market though.	Pierpont gives several options for the organization that operates this market. He suggests either a grid operator or a government agency, in which case the procurement would be run to achieve policy goals. Lastly, he suggests that the market could be run by a third-party exchange.	The RTO would be the central procurement entity for Local RA and Flexible RA, with amounts allocated to relevant LSEs. LSEs would have the option to own or bilaterally contract for System RA, or to participate in RTO procurements for System RA.
What Product Is Procured and How Are Its Prices Expressed in Bids?	A financial swap of the variable revenue each project receives in the short-term market for a fixed payment stream of its expected levelized cost per MWh (which is what bid is based on). Resource specific performance standards in the contract adjust fixed payments to incentivize efficient operation and following dispatch instructions.	Specified amounts of energy delivered in specific intervals. The OLTM is designed with specific profiles to offer, e.g., variable, or shaped and firm. The market design can iterate and evolve what profiles get sold through user feedback. However, the number of products needs to be small to promote greater liquidity in secondary markets.	The product procured is a financial contract that pays the seller a fixed price per MWh for a specific hourly and seasonal production profile for each year covered by the contract, coupled with the obligation on the seller to pay load the real-time (SCED) price for all the scheduled energy, regardless of whether it is actually delivered. Bids are in \$/MWh.	Local RA and Flexible RA are centrally procured by the RTO. System RA may be owned or bilaterally contracted for by LSEs, or procured through the RTO. Offers are in \$/MW and are intended to reflect the revenue the offerer needs over the long-term, net of expected energy and ancillary service revenues.
Sellers	Seller participation is voluntary. Project developers who seek a long-term revenue hedge with a credit-worthy counterparty. Existing resources facing revenue inadequacy can also bid for long-term, going-forward cost based hedging contracts. PRISM models populated with other resources based on publicly available data. Two distinct self-supply options are provided for LSEs that wish to develop	Seller participation is voluntary. Selected resources are paid as-bid with various performance and credit assurance structures. Buyers (LSEs or other wholesale energy traders) buy shares of the output in standardized output shapes, they must also provide credit assurance. This does not obviate other bi-lateral arrangements, if they are more attractive.	Sellers would participate voluntarily. It is not specified if the market would be restricted to new resources or allow for both new and existing resources. The market mechanism is intended to support procurement and efficient financing of new resources. As a financial, rather than physical contract, there is significant flexibility in how bidders participate (e.g. this market product could be used to hedge portfolios of projects).	New and existing resources may voluntarily submit offers to the RTO to supply Local, Flexible or System RA (to the extent that they qualify to provide each type). New and existing resources may also be supplied to LSEs via ownership or bilateral agreements. System RA resources owned or already committed-to by the LSE may qualify to satisfy self-supplied System RA, and/or submitted into the RTO's procurement.

	their own clean energy resources rather than buy a pro-rata share of whatever the LT market selects.			
Buyers and settlement	LSEs. Agreeing to accept settlement obligations (including optional self-supply provisions) is mandatory for all LSEs that participate in the configuration market. Participation in the market itself may be voluntary (like EIM), encouraged (like RTO membership) or both mandatory and encouraged (like Open Access Transmission Tariffs). The difference between each project's as-bid fixed costs and spot market revenues are settled on load, subject to penalties (deductions in fixed cost payments) in contract for specific failures to perform. Aggregate net payments to projects are pro-rated to LSEs by an appropriate metric of demand.	LSE participation is voluntary. The long-term contracts between LSEs and sellers are financial swaps of as-bid prices for spot market prices, based on the scheduled quantities and times, and are not contracts for physical delivery. Contracts are intended to be traded in secondary markets to transfer contracted financial obligations relative to spot market prices to entities best able to manage (profit from) any mismatch. Each LSE thus bilaterally settles any financial differences in either the secondary market or the short-term market.	LSEs. Participation could be voluntary, but ideally states would mandate long-term procurement or hedging, which this market product could satisfy. Load pays each seller for its scheduled MWh at its bid price; each seller pays load for its scheduled MWh to at the spot market price. Project retains revenue from any physical deliveries to the spot market in excess of scheduled amounts. Aggregate net costs of fixed price contracts are pro-rated to LSE's by share of total load.	LSEs. All RTO RA obligations are mandatory for LSEs (pay for or self-supply as applicable). Each offerer is incented (or required, in the case of resource supply with market power) to offer its costs less expected energy and ancillary service revenues; total cost of accepted offers are allocated to LSEs on a pro-rata basis based on metrics and needs for each RA product.
Self supply provisions	Has two self-supply options: (a) "Buy-all, sell-all." The LSE bids its clean energy resources into LT market, and continues to pay for their full share of the market's total winning portfolio, netting its LT market revenues against its allocated LT market costs; and (b) "Virtually optimized." The LSE submits its proposed portfolio to market operator, who uses PRISM clearing models to analyze its incremental impact on system costs. LSE can then choose to: (i) to develop the portfolio and avoid settlements completely, but pay an adjustment fee covering any increased system costs it causes, or (ii) bid the portfolio into the	LSE could "custom order" a specific set of resources (e.g., located locally) from the market operator, who would then charge it the incremental change in system cost, if any, due to that portfolio (its "shadow price") instead of the default cleared portfolio. LSE can always find supply elsewhere.	Buyers would not be required to cover all of their load through this mechanism, and could choose to self-supply or purchase from the spot market to meet their needs.	LSEs may own or bilaterally contract for resources. If these resources are eligible for Local RA or Flexible RA, they must offer the resources into the market (and be credited for their pro-rata obligations during settlement). They may offer other resources into the System RA solicitation.

	market under the “buy-all, sell-all” approach.			
Discussion of Interaction With Day-Ahead and Real-Time Energy Markets	Only resources that participate in the short-term (SCED) spot market would be eligible to participate in the RTO-specific version of the LT market. Participation in the SCED markets would be subject to each SCED market’s rules. SCED revenues would form the basis of the floating leg of the fixed-for-floating revenue assurance swap.	Interacts like any hedge or derivative based on DA and RT prices. Physical or financial hedge both possible.	This long-term market would work in tandem with existing DA and RT energy markets. Suppliers would be dispatched by the DA and RT markets and would receive compensation for energy delivered in the DA/RT markets. However, the long-term contract would function as a contract for differences: the supplier would receive a fixed price payment, while returning the real-time energy value of their contracted production profile back to the buyer. Resources would still have an incentive to maximize their value in the DA and RT markets, but would be mitigating their exposure to price risk for their contracted production profile.	The resource adequacy construct would work in conjunction/parallel with existing day-ahead and real-time energy markets that would take into account any state-directed carbon prices for emitting resources. Resources procured to meet the RA obligation (by RTO or by LSEs) would be required to offer into day-ahead and real-time energy markets.
Allocation of VRE Curtailment & Availability Risk	Designed to shield developers of variably intermittent and time-limited resources from reduced revenues due to both curtailment and unavailability of prime mover, since these costs are minimized and internalized by the winner selection criteria..	Variable depending on implementation details.	Curtailment risk (beyond what is captured in the value of a given production shape) primarily falls on load (since Locational Marginal Prices, LMPs, are likely to be low at times of VRE curtailment) and generator availability primarily on the project (since LMPs are likely to be high at times of prolonged unavailability of wind and sunshine). However, expected value of a production shape should account for expected curtailment risk.	Depends on any performance incentives included in RA products and pricing.
Winner Selection Criteria	Winning resources are those that are included in the PRISM optimization of resources that meet the PRISM’s constant system balancing and its declining carbon	There are multiple possible means of connecting sellers and buyers in an OLTM. They span a spectrum. On one end, the optimizer/portfolio	Two proposed systems. The first is based on the difference between fixed price bid costs and the projected value of the bid production profile	RTO would evaluate and select winners based on least-cost/best fit optimization of the portfolio as a whole.

	constraint at least cost. This means bid price matters, but is not dispositive, since another more expensive resource may result in lower overall cost due to its ability to better support balancing and carbon emission reductions than other resources with lower levelized costs.	assembler creates portfolios in one stage, decides on a price for the output that covers the selected bids and then has a period of time (like a quarter) to market the portfolio and find buyers. The optimizer must decide how big a portfolio to put together, then selects the least-cost group of bids. On the other end, buyers could commit to a demand curve (i.e. provide a level of interest at different price points) and the portfolio optimizer then assembles possible configurations that meet demand. Once a portfolio is selected and buyers are found for the output, the collective output from the portfolio is divided in contracted shares that the buyers buy and then can trade.	(evaluated using transparent forward price forecast and methodology agreed upon by the market operator, market participants and stakeholders). The second approach is based on LSE bids of willingness to pay and demand profiles by hour and seasons, with a simple optimization to select the resources that maximize the value to buyers, net of cost, for supply up to their demand in each time block. These approaches differ in how resources are valued and market clearing methodology. In both cases, the market seeks to select those resources with the highest net value to the system.	
Method of Evaluation	Same as the selection criteria.	The portfolio assembly process can be quite complex. Its goal is a least-cost portfolio within constraints set by buyers (output shapes, geographic footprint, emissions). Some differentiation in buyers needs can be accommodated through shadow pricing; for example a buyer insisting on a minimum fraction of local content might pay an extra unbundled premium on top of their payments for a standard contract share.Regulatory oversight like in any commodities market. Since this is a derivative market, standard considerations apply. For example, from an LSE's point of view, a ten-year contract should cost what they might expect to pay in the spot markets, on average, over the next ten years.	Two systems are proposed. The first is to evaluate bids based on the net value of each bid, which is determined by the value per MWh minus the cost per MWh (which is the fixed bid price). Bids would then be ranked from highest to lowest in net value and those with the highest net values would clear. The second proposed method is for buyers (LSEs) to submit willingness-to-pay bids for a certain demand profile (e.g. by hour and seasons). The clearing mechanism would clear the resources that maximize the aggregate value to buyers net of fixed contract costs.	Same as the selection criteria.

Basis for Payments to Winning Bids	Pay-as-bid.	Pay-as-bid	Pay-as-bid	Pay-as-bid. RA procurements are not auctions and do not produce a single clearing price. Selected offers are paid through contracts for $/MW as proposed given the outcome of the least-cost optimization (or as administratively determined in the event market power is exercised and mitigated).

A. POTENTIAL QUESTIONS

1. What are the top 2 pros (and top 2 cons) to each of the following proposed approaches

i. Requiring bidders to offer firm hourly energy schedules for the term of their contracts.

ii. Using sophisticated system and weather modeling to identify the most suitable projects.

2. What difficulties do you envision in selecting winning projects based on

i. Pierpont's proposed difference between projects' levelized cost bids and the expected market price (or LSE value) in each scheduled hour of firm delivery over the next 10 years?

ii. Corneli and Tierney's proposal for winner selection based on a sophisticated "least-cost, best-fit" analysis of the entire supply portfolio and its reliability and, in Corneli's case, ability to meet specific carbon budgets?

iii. Gimon's mix of "least-cost, best-fit" analysis and a secondary matching of proposed schedules with load preferences?

3. Which of the approaches identified in question 2 creates the best incentives for projects to bid at their actual cost and to perform most efficiently?

B. LONG-TERM (LT) MARKET SELLERS - Existing unit participation, encouraging retirements, self-supply, and promoting innovation.				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Treatment of Existing Units *Will proposed market design effectuate timely and efficient retirement of resources that would otherwise impede decarbonization and how?*	Existing resources and key characteristics are represented in market clearing / winner selection PRISM tools based on public information, and thus do not need to bid to support efficient resource selection. Continual additions of clean energy resources needed to meet the PRISM tools' balancing and carbon constraints will result in an ongoing trend to oversupply, and thus reduce prices in, the short-term spot energy markets. These expected price reductions will replace current expectations that equilibrium pricing conditions are "just around the corner"and thereby drive retirements of less efficient resources.. Existing resources that face inadequate short-term market revenues to keep operating are allowed to place "retirement bids" in the LT market. This allows the LT market to offer contracts based on going-forward cost to any such existing plants (e.g., nuclear, post-contract VREs, efficient gas) that contribute cost-effectively to meeting the balancing and carbon constraints.	Existing units can participate in resource portfolios. If project owners wish to retire resources, they could phase their bids out and phase in bids from new resources over time, either severally or as part of a portfolio bid.	Not explicitly addressed, but no restrictions on participation from existing resources.	Existing resources may participate in the procurements. Local or Flexible RA resources must participate in RTO procurement if they seek to have RA contracts. Those that are not selected as part of the winning portfolio can pursue bilateral agreements with LSEs, continue to operate solely in the short-term market, or choose to retire.

Features to Promote Innovation	A "carve out" of a modest share of total LT market procurement is set aside for promising innovative technologies to bid for, competing against each other but not against existing resources.	Innovation is supported by better market access through inclusion in a portfolio. For example, value stacking is easier to accomplish. Customers can also apply constraints or carve-outs that facilitate innovation to portfolio construction. In that case divergent customer expectations can be accommodated via shadow-pricing.	The market design itself will not promote innovation, although it would be open to a wide range of innovative technologies to compete. Rather, deployment of innovative technologies is assumed to be driven by clean energy and technology commercialization support policies.	RTO procurement could include a set-aside amount for state-specified innovative resources.

B. POTENTIAL QUESTIONS

1. *Retiring only the "right" resources.* Gimon, Pierpont and Corneli all propose long-term market features to support and preserve the efficiency of spot-market prices, assuming timely retirements of existing units when spot market prices fall below sustainable levels. Since these prices could, in the absence of a suitable carbon price or proxy, also drive existing clean energy resources to retire, Corneli proposes "retirement bids" as an exception to the rule that only new resources bid into his proposed long-term market. Other proposals contemplate both existing and new resources bidding into the long-term market.

(a) What are the pros and cons of offering long-term contracts at going-forward cost to existing resources that would otherwise retire, based on their ability to contribute to continued reliability during rapid decarbonization? ("Decarb Reliability Must-Runs or RMRs")

(b) What are the best alternatives to this approach for solving the problem of how to retain existing clean energy resources during an extended period of rapid deployment of large amounts of renewable energy resources, storage, and flex load resources (other than hoping sufficiently high carbon prices will be implemented broadly soon enough to avoid the problem)?

2. *Innovation.* Corneli, Gimon and Tierney contemplate some sort of limited "carve-out" for innovative technologies in the long-term market. This is intended to shield them from some degree of competitive pressure while they achieve scale, learning-by-doing, and operational viability. Pierpont's proposal looks to the presumed companion carbon policy as the driver of innovation.

(a) Many argue that large scale procurement programs in the US and Europe were central drivers of the dramatic reductions in wind and solar costs. Assuming there is a public interest in promoting similar rapid reductions in the costs of other technologies critical to rapid and reliable decarbonization (e.g., Sepulveda et al.'s "clean flexible base" and "clean cycler" technologies) is it appropriate to have such a procurement-based demonstration and scale-up feature incorporated in wholesale electricity markets?

(b) If not, what would be better alternatives for helping such technologies cross the "Valley of Death" associated with the inability to finance early-stage projects as they transition from the lab bench to full commercial scale?

C. RESOURCE ADEQUACY - How the market design ensures or contributes to resource adequacy, especially as approaches to resource adequacy evolve with increasing shares of variable, non-dispatchable resources.				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Resource adequacy	Anticipates that the PRISM process could be adapted to better estimate RA needs, and the contribution of each resource to them, than Unforced Capacity (UCAP) and Effective Load Carrying Capacity (ELCC). The PRISM optimization process could procure various amounts of an efficient mix of resources as needed to achieve a specific RA performance target (e.g., 1 load-shedding event in *x* years). A relatively low "*x*" would allow the SCED market to achieve material levels of scarcity pricing, helping to incent efficient decentralized development of at least some types of flexibility resources. In this case, the PRISM market would provide high levels of revenue assurance in the absence of sufficient bilateral credit, along with an efficient mix of more capital intensive clean energy resources.	The OLTM does not have the goal of providing resource adequacy, but it is intended to facilitate the ability of scarcity prices in the spot energy market to succeed in providing resource adequacy. .	This long-term market is not intended to address resource adequacy directly. Rather, Pierpont assumes that the short-term energy markets value resource adequacy through scarcity pricing. Since short-term market prices are the basis of settlement and valuation of long-term contracts, the resource adequacy value of various resources should be reflected in resource selection.	Resource adequacy needs would be determined by RTOs in their 10-year plans. Annually, the RTO would establish or LSEs' forward year-by-year obligations for each RA product. The RTO would conduct annual procurements of Local, Flexible and System RA. All Local and Flexible RA would be centrally procured, with costs allocated to LSEs on a pro-rata basis. LSEs may own or bilaterally contract for those types of resource, but to get credit for them, they must offer them into the RTO central procurement. LSEs must either self-supply any remaining System RA or participate in the RTO's procurement of System RA (in which case they pay for their pro-rata allocation of costs). RTO procurement will ensure that any needs not met through self-supply are met through procurement.

C. POTENTIAL QUESTIONS

1. With high levels of VRE and time-limited resources, the grid will shift from an environment in which most resources are "firm" and can make equivalent contributions to balancing load at all times, including times of system stress, to one in which different resources will only be able to contribute to balancing load when their underlying energy resource is itself available. This means shifting from an environment where, in terms of reliability, "a MW is always a MW", to one in which each MW has a different resource adequacy value at different times and locations. This value itself is dynamic, since it will likely decrease as more of the same type of resources are deployed. These changes will shift the focus of resource adequacy from having the right *amount of MW* to avoid more than y load-shedding events per x years, to having the right *mix of resource types* to avoid more than y events / x years.

- What are the implications for long-term planning, procurement and markets of the loss of the universal ability to use MW of capacity (or UCAP, or ELCC) as a stable, fungible quantity across time, locations and resource types for the contribution of various resource types to always meeting the electric system's core balancing requirement?

2. Tierney's planning and procurement approach differs from Corneli's co-optimized procurement in the long-term market approach primarily in how the modeling and optimization might be done, and in whether it is co-optimized with resource bid evaluation and selection, or is done ex-ante and independently from bid characteristics and resource selection.

- What differences in effectiveness do you think are likely between Tierney's RTO planning and Corneli's market co-optimized approaches, in light of their underlying similarities?

3. Gimon intends for his long-term voluntary market, which uses an algorithmic winner selection process similar to Corneli's, to make it easier for LSEs to meet regulatory requirements such as resource adequacy. Various authors (e.g., Wolak, 2020) have proposed imposing a requirement on LSEs to have long-term contracts for enough energy delivery in all hours to meet their peak load requirement.

- How do you think using Gimon's organized market as a source for such mandatory "all-required-energy" contracts would work to ensure resource adequacy in combination with scarcity pricing?

D. CLIMATE - Meeting climate goals: interaction with state/fed climate, clean energy, and/or renewable energy policies.				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Discussion of Interaction with Federal and State Policies on Carbon and Renewables (existing and potential)	Existing or future carbon prices would affect resource costs and revenues in the short-term SCED markets; as such, their impacts would flow through the swaps of each resource participating in and cleared by the long-term market. The LT market would tend towards achieving its carbon budget over time even without a carbon price, but a uniform carbon price could make it more efficient and effective. Clean electricity credits or other state or federal proxies for a carbon price would be accepted, i.e., their impacts on project revenues and costs would flow through both the SCED market and the LT market bidding process and be reflected in the LT market's financial swaps.	Buyers with preferences for clean energy would be likely to use the long-term market to achieve a lower cost clean energy supply. The long-term market could also help derisk investments driven by a price on carbon.	The long-term market is intended to work in tandem with clean energy policies at the state or federal level. If states or federal policy seek to incentivize or disincentivize particular types of resources, those policy interventions could change the relative competitiveness of resources in the market. This long-term market mechanism could also be used as a procurement structure to meet clean energy targets through long-term procurement, by restricting participation just to those resources that qualify.	The RTO's FERC-approved would contain provisions requiring the RTO's resource solicitation process to recognize state clean energy goals and requirements. For example, if the state requires LSEs to take on obligations for zero-carbon resources (or technology-specific requirements), then such requirements would factor into the RA product attributes specified in the RTO planning process and RA solicitations.

D. POTENTIAL QUESTIONS

1. Existing state climate and clean energy policies include Renewable Portfolio Standards (RPSs), cap-and-trade programs (RGGI, California), and Zero Emission Credit programs. Many states are setting more aggressive goals and policies for zero-carbon or renewable generation. Federal policies that might be enacted in the future include carbon taxes, cap-and-trade, or a Clean Energy Standard (CES). Many companies and cities are committing to increased purchases of renewable and/or zero-carbon electricity, and many power companies are setting goals to eliminate or dramatically reduce GHG emissions by 2050. It is uncertain how these public and private policy drivers of clean energy investment will evolve in the years ahead, so effectiveness under multiple policy scenarios - including scenarios without strong federal climate policy -- are an important market design feature

(a) RPSs require LSEs to use electricity from renewable energy, or purchase Renewable Energy Credits, in an amount equal to a specified percentage of their retail sales volume. Some RPSs require, or may require, most or all energy to be from renewable resources in the years ahead. How would each of these market designs facilitate or impede the functioning of an RPS requiring most (e.g., in excess of 90%) or all energy to come from renewable sources? Would there be any conflicts?

(b) CES proposals require an LSE to use electricity from clean energy, or purchase Clean Energy Credits, in an amount equivalent to a specified percentage of its retail sales volume. How would any of these four market designs either facilitate or impede implementation of a CES requiring most or all energy to come from clean (i.e., zero GHG emission) sources? Would there be any conflicts?

(c) How would any of these four market designs facilitate or impede implementation of a carbon tax or a cap-and-trade program?

2. Modeling of least-cost paths to a net-zero emission economy in 2050 typically shows rapid growth in overall electricity generation, and demonstrates the need for least-cost mixes of solar, wind, and other zero-carbon resources, along with storage and demand response to keep overall costs as low as possible.

(a) Compared with current market designs, which of these four designs is likely to lead to lower (or higher) costs of financing for clean energy developers? Why or why not?

(b) Compared with current market designs, which of these four designs is likely to lead to lower cost mixes of all zero-carbon resources? Why or why not?

E. TRANSITIONS - **Interaction with existing fed/state electricity laws and regulations; how the transition to new design could occur.**				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Discussion of Interaction with Existing Federal and State Electricity Laws and Regulations, and How the Transition to the New Design Could Occur	Asserts that LT market could initially be implemented through a section 205 filing under current authorities, settlements could be carried out under the same authorities and basic structures as transmission and capacity market cost settlements are today, and states could voluntarily treat market outcomes as prima-facie evidence of need, reasonableness, etc. in any state regulatory proceedings. State incentives for clean energy projects would be welcome, and would be accepted as offsetting revenues in evaluating and pricing of long-term revenue assurance swaps.	OLTMs would mostly be under jurisdiction of CFTC, although some kind of Memorandum of Understanding (MOU) probably required with FERC (as is the case today with various markets). State electricity laws manifested via customer preferences. For example, if buyers must purchase 70% clean, they will specify that to the OLTM, or improve their mix through other purchases. If there is enough commonality among buyer wishes, that will drive the type of product the OLTM produces. Some amount of transparency mandated for the portfolio assembler would be needed. For example, it would report on expected emissions (actual emissions also be tracked). Commercial transparency can be achieved by revealing bids after some suitable time intervals, must reveal selected winning contracts. States could sponsor OLTMs through creation of power authorities, share of start-up costs or balance sheet/credit support. State policies would be drivers for customer demands.	Not addressed	Changes to wholesale market rules would be proposed by each RTO for approval by FERC. These rules would address such things as: the role of the RTO in identifying quantities for each RA product that would be procured in the long-term competitive solicitations; the ability of states to designate other attributes of resources (e.g., clean energy requirements) that LSEs must supply within the state; provisions for states to allow or require LSEs to procure their RA obligation directly rather through RTO markets; the relationship of the RTO planning process to the procurement process.

E. POTENTIAL QUESTIONS

Some of these proposals focus on a new end-state and offer a few suggestions for how to transition from the current market designs to the one described by the proposal. Others (Tierney's and Corneli's) offer more detailed discussion of how the proposal relates to existing laws and regulations governing the electricity sector in different jurisdictions, and how they might be incrementally implemented without major revisions to statutes and RTO tariffs.

1. For the proposed market design that you find most compelling, what are the biggest challenges in transitioning from current market designs to the one embodied in the proposal? What new features or changes in the proposal would best help facilitate its successful deployment?

2. Outside of any of these proposals, are there other policy or law changes at the federal level that you think are achievable and would substantially help wholesale markets support the deployment of the clean energy resources needed for rapid decarbonization?

3. What next steps would you recommend to advance evolution in market design that will support rapid, least-cost decarbonization?

F. MODELING - Model features and capabilities relied on by these markets designs.				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Model Features and Capabilities Relied on by These Market Designs	Procurement auction winners will be identified by PRISM models (e.g., enhanced versions of GenX, RESOLVE, WIS:DOM, RIO, etc.) with highly granular, regional data on wind and solar availability by location and hour, with an hourly (or finer) system balancing constraint and a declining science-based GHG emission constraint, elected by participants or as imposed by policy. The model's objective function is to minimize costs, subject to these constraints. The bid evaluation and winner selection will use as-bid costs and operating characteristics of resources instead of engineering assumptions, to identify the lowest cost portfolio of incremental energy resources needed for the system to meet these constraints every 3 years, given a wide range of possible wind and solar irradiance patterns. The same models and data sets will be used for scenario analysis to identify least-cost solutions that could be enabled by transmission and other infrastructure investments (e.g., distributed energy resources management system, "DERMS"), and to evaluate the best candidates for such infrastructure through regional transmission and distribution system planning proceedings. Such scenario analysis can also be used to evaluate the system cost impacts of the one option for LSE self-supply. These same models may, potentially, also be used to identify and select portfolios capable of achieving any given RA target (in terms of the expected frequency of	Candidate portfolios will be identified in the long-term market by WIS:DOM-like models. LSEs could then contract for shares of these candidate portfolios. The models may also be asked to identify preferred resources by various LSEs, and through a scenario-type analysis, identify the incremental costs the LSE would have to pay for its desired resource mix.	A robust, transparent modeling approach would be used, with robust stakeholder engagement and transparency, in the market-operated winner selection alternative. In this approach, the models would be used to project hourly market prices and to select the resources whose as-bid hourly schedule prices have the greatest amount of surplus relative to the as-bid schedule prices. Presumably, similar models could be used by LSEs as they make the comparable projections to determine their willingness to pay in Pierpont's decentralized, LSE-driven approach to winner selection.	A robust, transparent modeling approach would be used, along with a stakeholder process, to determine the "least cost / best fit" result used in the 10 year forward resource planning process carried out by each RTO. Comparable models would also be used to develop the RA products and to specify the capabilities they will require for resources to be eligible to participate, and which may form the basis of their compensation.

	involuntary load shedding events), thus adding robust RA capabilities to the long-term market and allowing it to "dial in" any degree of scarcity pricing potential desired in the short-term market.			

F. POTENTIAL QUESTIONS

1. The winner selection approach suggested by Corneli and Gimon would require relatively high levels of accuracy and specificity in its results. "Accuracy" means the resources it selects would need to perform in the real world, in terms of balancing, operating costs and carbon emissions, very much like they do in the modeling environment. Inaccurate models could select inefficient resources instead of efficient ones. "Specificity" means the selected resources would have to outperform portfolios with other configurations. ,Otherwise, the results of the market would appear arbitrary and unfair. The model results could lack specificity even if they are accurate. For example, if there are many winning combinations that would perform the same, at the same costs, then there is no good reason from choosing one winning portfolio out of the many comparable alternatives.

(a) Given what you know about such models, are they capable today of producing such accurate and specific results today?

(b) If not, is there a clear line-of-sight, in terms of model enhancements, to achieve the amount of accuracy and specificity needed for them to be used to clear a market? Does that fact that LP / MIP models are used today in competitive IRP processes support or contradict your conclusions?

2. Given the interdependency of costs and system performance on the overall type and mix of clean energy resources deployed that we see in most PRISM policy analyses, how do you think the 10 - year forward resource planning proposed by Tierney could best deal with uncertainty about future cost, availability and performance characteristics of key clean energy balancing resources within the 10 year period? Corneli, Gimon and Pierpont all favor a much shorter and more frequent optimization period, so that early commitments to resources to be deployed in a decade or more can be avoided. Could this iterative, current period optimization and updating approach be used in long -term planning as well as long-term markets?

3. Both Pierpont and Gimon propose resources procured in current periods be evaluated based on their offers of financially firm hourly schedules of energy production over long contract terms, e.g., 10 years. From a modeling perspective, is it possible to form expectations of

(a) specific levels of energy production at solar or wind facilities and

(b) LMP prices in each hour of the next ten years?

What kind of information can models and data provide about long-term energy production in specific future hours that, in your view, will be most helpful to selecting an efficient mix of resources to support low-cost and reliable decarbonization of the power sector?

OTHER ISSUES – Transmission, market power, load growth / load shape impacts of electrification				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Transmission expansion	PRISM scenario analysis, outside of the long-term market, identifies potential cost reducing transmission, which is then included in a regional transmission expansion plan. When the new transmission is approved, bids from resources it will enable are elicited in subsequent LT market rounds.	For a sufficiently large portfolio, cost sharing among participating resources for transmission expansion becomes viable. OLTMs could also be synchronized with Competitive Renewable Energy Zones (CREZ) zone type efforts. OLTMs also provide more visibility into long-term market conditions than bi-lateral arrangements, which can feed better into long-term planning processes.	Not explicitly addressed, as the proposed market mechanism is for long-term energy contracting.	Transmission expansion and/or non-wires alternatives will be included in the RTO resource plan and procured where a transmission offer is selected as part of the least-cost procurement (and where it is not otherwise included in an LSE's plan).
Market Power Concerns and Strategies to Address	A detailed analysis of market power potential in the LT market is included, with specific mitigation measures proposed for bids from existing resources, which appear to be the primary potential problem	There are possible market control or manipulation concerns with the portfolio assembler/optimizer, which can be alleviated by regulated or non-profit structure and solid governance, or by allowing competing portfolio assemblers.	Market power in the long-term market mechanism is not explicitly addressed.	The RTO would evaluate the competitiveness of each solicitation. If there is market power (e.g., in the case of Local RA proposals), the RTO would set "contract amounts based on administratively determined $/MW costs where such market power exists"
Features to accommodate load growth, changes in load shape, and other impacts of electrification of end uses.	The incremental, forward-looking market rounds on a 3 year interval should capture any electrification-related effects on demand and load shape, and ensure deployment of adequate and complementary resources to continue to balance supply with consumption in all dispatch intervals, including those with high load and with low VRE availability.	Long-term market purchase interest will reflect buyer expectations for load growth. Over purchases can be compensated by secondary sales. .	LSEs participating as buyers in the market would likely factor electrification into the demand they wish to procure in the market, their willingness to pay, and their demand profile.	As part of the 10-year plans, each LSE provides projections about gross and net loads given expected additions to load through electrification of transport, industry, and buildings. The market design relies, indirectly, on states' actions to enable flexible demand through retail pricing and/or metering and other communications technologies. That demand would participate in the real-time and day-ahead energy markets.

APPENDIX – Miscellaneous Features				
	Corneli	**Gimon**	**Pierpont**	**Tierney**
Eligible Technology Categories (e.g., grid-connected generation, storage, demand response (DR) and flexible load, behind the meter generation and storage)) or services (e.g., variable energy, flexible balancing control services, transmission services)	Grid-connected resources, including storage, and any distributed energy resources (DERs), including flexible load, that actively participate in the short-term spot markets.	Any resource that can participate in real-time markets. Potentially other resources could also (e.g. transmission, separate flexible off-take). Flexible resources will have contractual parameters for behavior and, provided those parameters are met, can sell additional flexibility, in shorter term markets.	Technologies are not specified, but the long-term market is intended to enable the deployment of zero-carbon resources that are prioritized through complementary clean energy policy. If this mechanism was used as the procurement mechanism to meet a clean energy policy goal, this market mechanism could be restricted to only carbon-free resources.	RTO market rules would define resource attributes needed for reliability, e.g., the three RA types above. Resources could be central-station, behind the meter, wires projects, etc., to the extent a technology or resource qualifies. Rules would also recognize state preferences for other resource attributes (e.g., zero-carbon emitting) beyond Local, Flexible and System RA needs. RTO sets procurement targets based on these resource attributes (in addition to technical requirements for each RA product type) .
Quantity and Frequency of Procurements	Every three years. Resources with a longer lead time in development can "bid-through" several procurement periods.	Procurement quarterly or yearly. Contracts with the portfolio for 7-10 years. Post-contract production can be re-bid in subsequent procurement periods. Such sales allow buyers to access older vintage resources closer to maturity.	Pierpont suggests running the long-term market annually, though it is flexible. It should be run as frequently as possible while minimizing administrative costs. The quantity procured is determined by load-serving entities and state regulators. It is not intended to cover all demand.	Long-term resource procurements would be conducted annually. The quantity of any type of resource would be determined by the RTO in the 10-year plan. Longer lead time resources that a state seeks to see developed (e.g., transmission capacity addition for offshore wind) would have the opportunity to supply needs in later years with reconfiguration procurements in nearer time periods.

Lead Time to Contract Start (Delivery)	Resource-specific and as specified in hedging contract's performance requirements.	Lead-time for portfolio delivery is 0-2 years. Individual resources within the portfolio can have longer lead-times as negotiated with the market operator.	Not specified	Supply offers would specify delivery period(s) in their offers.
Length of Contracts Awarded	Resource-specific and as specified in hedging contract's performance requirements. But long enough to result in low cost-debt financing.	Contracts awarded to resources are 7-10 years (some exceptions). LSE likely would only contract for 10-15% of their ongoing needs in any given year. The market-operator /optimizer might have other constraints, for example in a particular region for an OLTM meant to support the formation of a CREZ.	Would be determined by the market operator and stakeholders, but likely at least 10 years.	Not specified