Discussion of RTO West Ancillary Services and Lessons Learned from California

Scope

This memo highlights and discusses the key decisions to be addressed in establishing a working ancillary services (AS) market in RTO West. The focus of the memo is on the purchase of resources that will enable RTO West to supply AS to the SCs.

The memo first provides some guidance from the lessons learned in establishing an AS market in California. These lessons help to eliminate some of the market design alternatives that exhibited problems in practice. The discussion then focuses on the important decisions that need to be made (either by the Congestion Management Group or the RTO) to specify a fully working market for AS resources in RTO West, illustrated with a simple numerical example.

Ancillary services account for only about 5-10% of the revenue in well functioning electricity markets. It is not the dominant cost issue, but the complexity and varying time scale of the different ancillary services require some additional effort to ensure a workable market mechanism. A skeleton table (Table 4) of pros and cons of different market design facets, in draft "evolutionary" form is provided at the end of this memo to stimulate discussion.

The California Experience

Presently in California, five ancillary services are procured in day-ahead and hour-ahead markets, with voltage support and black start procured through longer-term contracts. Originally, Regulation Up and Down were defined as a single product. RTO West has proposed eight AS products for procurement solely through market mechanisms, with voltage support and black start procured through daily markets and long-term contracts. Furthermore, RTO West is sole provider of Scheduling and Dispatch. The RTO West ancillary service products, listed in Table 1, are defined in the Ancillary Services Work Group Final Draft Ancillary Services Appendix D (dated September 12, 2000 and posted February 5, 2001)

Table 1. Ancillary Services Procurement in California and RTO West

California AS Markets		RTO West (proposed)	
Acquired through daily markets:	Regulation Up Regulation Down Spinning Reserve Non-Spinning Reserve Replacement Reserve	Acquired through daily markets:	Regulation Load Following Up Load Following Down Spinning Reserve Non-Spinning Reserve Replacement Reserve Congestion Redispatch Balancing Energy
Acquired through contracts:	Voltage Support Black Start	Acquired through contracts and daily markets	Voltage Support Black Start
		RTO West is sole provider	Scheduling and Dispatch

California encountered several problems establishing markets for ancillary services. The problems included capacity withholding, exercise of local market power, misrepresenting reserve types, irrational prices, illiquid markets, and others. Most of these problems have been addressed by a serious market redesign effort, which has realized some success, although there are still improvements being implemented.

The lessons learned from California for AS market design have become a field of study unto itself. The fundamental design of RTO West avoids many of the problems experienced in California, as they are inherently mitigated. However, RTO West's procurement auction mechanism is an important concern for which the California experience can provide some guidance. Also, the interactions between energy and AS markets that are evident in the California market may have important implications for RTO West, even though there is no effort to establish an RTO West energy market.

Table 2 below lists the major flaws in the original California market design, the redesign effort to correct these problems, and implications for RTO West. Of major concern for RTO West is the market design for AS procurement. Although it has been proposed that AS resources will be procured via an auction, the design of the auction has not been settled. The following section discusses the alternative designs for AS auctions. The energy-AS market interactions will not present such an issue for RTO West as experienced in California, but it should be recognized that energy prices in neighboring markets do represent an opportunity cost for committing AS resources. The remaining issues of concern presented in Table 2 are already mitigated assuming RTO West's current proposed market structure. Table 4 contains more detailed descriptions of the components of market design.

Table 2: California's Ancillary Service market design problems (not mutually exclusive).

CA Problem	**CA Redesign**	**Implications for RTO West**
		Of Concern To RTO West
Sequential auction of AS services yielded price reversals and high procurement costs.	"Rational Buyer" auction allows substitution of higher-quality services for lower-quality ones if it reduces cost.	Market design for AS procurement is a major concern.
Energy-AS market interactions	Not addressed specifically.	No PX market per se. Energy price is opportunity cost for committing AS resources.
		Not a problem for RTO West
Single market for Regulation	Separated Up/Down Regulation markets.	Already set up with separate regulation and load following up and down markets.
Under-scheduling	Settlement now based on metered rather than scheduled demand. Deviation replacement reserve charge implemented.	Already metered demand.
Loading of committed resources	No-pay for uninstructed deviations. 10-minute pricing.	A monitoring issue, but already employs 10-minute pricing.
Illiquid markets	Deferred at least 10% of day-ahead to hour-ahead. Trading among SC's. Raised limit on imports.	Trading among SC's and self-provision already part of design. RTO West can require participation if illiquid.

Design Alternatives for Ancillary Markets

The core goals of ancillary market design are efficient allocation of resources and competitive pricing. To date the restructured electricity markets have attempted to achieve these goals through procurement of ancillary service resources by auction. Properly designed and operating in a sufficiently liquid market, auctions can obtain efficient and low-cost service that is fair to all participants.

Even a good market design can be defeated by market power, capacity shortage and lack of demand response, which will result in noncompetitive pricing and inefficient allocation of resources.

The main components of the Ancillary Services market design are:

1. the auction type;
2. the bid selection objective or "scoring rule" that determines which bids are selected; and
3. the settlement rules that determine the compensation to providers of Ancillary Services resources.

Pricing of the AS products to buyers is an issue that should be addressed separately. However, in markets in which SC's control both AS resources and loads, pricing could potentially have an impact on bidding strategies and gaming in the AS market.

Auction Type

A sequential auction structure, in which auctions for each service are held separately and in series from highest to lowest quality service, provides low procurement costs and rational prices when analyzed, ***if the potential for optimal bidding strategies of the market participants is ignored***. However, the structure of the sequential AS procurement auction can lead to perverse results, which became dramatically evident in the early versions of the California AS market. The initial CA auction design employed a sequential auction of AS products in descending order response time (which reflects the flexibility of the resource and thus their value to the system operator, in this case the ISO). The sequential auction mechanism resulted in "price reversals", in which lower-value resources commanded higher prices. Providers of Ancillary Service resources gain by withholding capacity from earlier rounds to take advantage of potential scarcity in subsequent rounds, knowing from the start the exact price-inelastic quantities being purchased in each separate auction.

The California ISO has since implemented a simultaneous auction with a "rational buyer" bid selection mechanism, in which higher-value services can be substituted for lower-value services as long as overall procurement costs are reduced. The new process has reduced procurement costs and price reversals. The short-term implementation was constrained by the existing auction software capabilities, and the ISO is continuing to consider other simultaneous auction alternatives.

Because of the problems experienced with sequential auctions in practice, the remaining discussion focuses on a simultaneous auction structure, which can eliminate or at least reduce incentives to game bidding strategies.

Bid Selection Objective Function and Settlement Rule

Scoring and settlement rules are inter-related because together they influence both the optimal bidding strategy of participants, and the final price paid for the needed services. The two fundamental scoring rules aim to

1. minimize procurement costs (product of quantity times price of each reserve type), or
2. minimize the total "bid cost", which is the procurement cost realized if providers are paid their bid (the area under the reserve supply curve)[1].

[1] The "bid cost" is sometimes referred to as "social cost". See for example S. Oren "Design of Ancillary Services Markets", *INFORMS Conference Hawaii* (June 20001, forthcoming).

Four fundamental settlement rules have been proposed.

1. Uniform market clearing price based on usage ("product substitution"). If a regulation bid is used for spinning reserve, it gets the spinning reserve price. This rule naturally arises from a sequential auction.
2. Uniform market clearing price based on bid type ("demand substitution"). Sets the uniform price for each bid type to the highest bid selected of that bid type. If a regulation bid is used for spinning reserve, it still gets the regulation price.
3. Marginal value pricing. Sets the uniform price to the marginal value of the corresponding reserve type, i.e., the marginal value of the highest quality reserve that a bid can provide. This is the highest MCP for the service for which the resource could be used.
4. Pay-as-bid is self-evident. Selected resources are paid their bid. A pay-as-bid system reduces the incentive to misrepresent reserve types, but increases the incentive to overstate costs.

Example

The resource selection and resulting procurement costs for each pair of scoring and settlement rules are best illustrated with a simple example. The following example utilizes a specific set of bids for Regulation and Spinning reserve[2] from two scheduling coordinators. It is assumed that the bidders have no market power so that in a uniform price auction they bid their true cost, and Regulation reserves can be used to meet Spinning demand.

RTO West Demand for Reserves and SC's Bids

	Demand		
RG	500 MW	600 MW at $10/MW	100 MW at $15/MW
SP	500 MW	200 MW at $5/MW	300 MW at $20/MW

The order in which these bids are accepted will be determined by the bid selection method as shown below.

Bids Selected Under a Bid Cost Minimization Objective

500 MW of RG at $10/MW	for	RG demand
200 MW of SP at $5/MW	for	SP demand
100 MW of RG at $10/MW	for	SP demand
100 MW of RG at $15/MW	for	SP demand
100 MW of SP at $20/MW	for	SP demand

This selection method represents a least cost dispatch, and results in a bid cost of $10,500.

Bids Selected with Uniform Pricing and Procurement Cost Minimization

500 MW of RG at $10/MW	for	RG demand
200 MW of SP at $5/MW	for	SP demand
100 MW of RG at $10/MW	for	SP demand
200 MW of SP at $20/MW	for	SP demand

[2] The numerical example is based on a similar discussion in Oren (2001), *op cit*.

When the bids are selected so as to minimize procurement costs under uniform pricing, the bid cost increases from $10,500 to $11,000. Rather than increase the MCP for RG by selecting the bid for 100 MW of RG at $15/MW to substitute for 100 MW of the higher priced SP reserve at $20/MW, the rational buyer will take 200 MW of the higher priced SP reserve and keep the MCP for RG down to $10/MW.

Table 3 tabulates the resulting bid and procurement costs under six combinations of scoring rules and settlement rules.

Table 3: Results for Settlement Rule and Scoring Rule Pairs

		Scoring Rule	
		Minimize Procurement Cost	**Minimize Bid Cost**
Settlement Rule	**Uniform price based on usage**		Bid Cost = $10,500 MCP for RG = $10/MW MCP for SP = $20/MW Procurement Cost = 500MW @ $10/MW + 500MW @ $20/MW = $15,000
	Uniform price based on bid type	Bid Cost = $11,000 MCP for RG = $10/MW MCP for SP = $20/MW Procurement Cost = 600MW @ $10/MW + 400MW @ $20/MW = $14,000	Bid Cost = $10,500 MCP for RG = $15/MW MCP for SP = $20/MW Procurement Cost = 700MW @ $15/MW + 300MW @ $20/MW = $16,500
	Marginal value pricing		Bid Cost = $10,500 MCP for RG = $20/MW MCP for SP = $20/MW Procurement Cost = 1000MW @ $20/MW = $20,000
	Pay as bid	Bid Cost = $10,500 Procurement Cost = $10,500	Bid Cost = $10,500 Procurement Cost = $10,500

The above analysis assumes a fixed set of bids regardless of the market design. However, each combination of scoring rule and settlement rule exhibits its own optimal bidding strategy. The market designs that provide the lowest procurement costs, under the assumptions of absence of market power and bidding of true costs, have also been known to create perverse incentives that induce bidders to misrepresent their reserves and create shortages in the markets for high quality reserves.[3] The important task at hand for RTO West is to specify the specific scoring and settlement rule for the AS resources market.

[3] Oren (2001), *op cit*

Secondary Topics that May be Relevant for Further Discussion

Market Clearing Price

The market clearing (uniform) price can be set as either the highest bid awarded (first-price) or the highest bid NOT awarded (Vickrey or second-price), set by a different participant. These MCP selection rules may also influence the bidding strategies for participants with potential market power.

Two-Part Bids

The auction strategies discussed above assume a simple single-price bid. Optimal strategies for AS providers in a two-part bid (capacity and energy) have been shown to lead to very low capacity (guarantees a reserve payment) with very high energy bids (ensures rarely being dispatched) if bids are ranked by expected cost (and not including the bidder's optimal strategy) and paid the market clearing price for each service. The two-part bid incentive problem can be overcome if the bidders are paid spot price for the reserve, as long as there is adequate ability to arbitrage between markets.

Energy-A/S Market Interactions

Prices and transactions in energy markets can influence the prices and activities in AS markets. The California ISO selects all units in its ancillary services auctions independently of the energy schedules. The energy market closes prior to the AS markets. Two problems have been identified relevant to RTO West. First, you can create the same type of high prices developed by sequential AS auctions with sequential energy and AS auctions. The second issue concerns regulation and spinning reserves, which must be on-line and generating in order to supply the services. The ISO has been required to ignore any minimum energy output of a plant when ranking bids. If generators try to sell as much output as possible from plants already incurring fixed costs associated with spinning, fewer spinning generators with unloaded capacity will be available to sell reserves, driving up prices. No market redesigns to address this issue appears to have been implemented. The RTO market structure does not have an explicit energy market, which reduces the ability of generators to play one market against another, but also makes it very difficult for the price of reserves to equilibrate to the opportunity costs of foregone energy sales. Local market power in higher energy or ancillary services markets can influence the market clearing price in the other market. Therefore, the choice of index to serve as settlement guide for various services should most accurately reflect this opportunity cost.

Conclusion

Although our simple examples show that the pay-as-bid settlement rule has the lowest procurement cost it is also the most sensitive to strategic bidding. In contrast, the uniform pricing based on the marginal value of the corresponding reserve type has the highest procurement cost but is least sensitive to strategic bidding.

We recommend that these alternatives be part of the simulation task, but the detailed specification of the market design be left for the RTO once it is up and running.

Table 4: The Pros and Cons of Design Alternatives in Ancillary Markets

Design Alternatives	Description	Pros	Cons	Discussion
Procurement by Auction	Auctions for separately defined ancillary service products that the system operator procures on behalf of market participants to meet reliability standards	Properly designed, can obtain efficient and low-cost service that is fair to all participants.	Requires sufficiently liquid market to work, which may preclude longer-term forward contracts or other risk management tools. Even a good market design can be defeated by market concentration (i.e., market power) and lack of demand response, which will result in noncompetitive pricing and inefficient allocation of resources in Competitive Electricity Markets. SC's that control both load and generation can make this problematic.	Occurs in California, New England, NYPP, and ERCOT
Auction Structure				
Sequential auction[4]	The auction for products is conducted sequentially from highest to lowest quality. Suppliers are allowed to rebid their uncommitted resources in each round.	In a perfectly competitive market substitution of a high quality reserve for a lower one would occur naturally in a sequential auction (from high to low quality) since bidders would rebid their rejected bids in the subsequent auctions for which their resources are eligible. In principle, assuming bidders bid and rebid their true cost, such a sequential auction would lead to socially efficient procurement. In the absence of market power	May result in price reversal, as experienced in California and New England, where the MCP for a high quality resource (e.g. regulation) is lower than that of a lower quality resource (e.g. spinning reserves). This can occur even with price taking suppliers, as the anticipation of price reversal induces suppliers to understate their capability and wait for a later round in the auction that is expected to fetch a higher MCP.	Initial California structure. The described price reversals have been observed in California and in New England ancillary service markets.

[4] Oren, Shmuel, "Design of Ancillary Service Markets", University of California at Berkeley

Design Alternatives	Description	Pros	Cons	Discussion
		uniform market clearing prices in each auction will indeed induce bidders to bid their true cost.	MCP. Market power exacerbates this situation, as suppliers raise bids in sequential rounds when they perceive thin markets.	
Simultaneous auction with substitution among different reserve types	Generators submit a single bid specifying reserve type, quantity, and price. The system operator can use any of the procured resources to meet demand for any of the reserve products that a resource can provide (this is often referred to as cascading bids). So for instance the System Operator may procure spinning reserves and use them to meet the need for replacement reserves.			
Scoring Rule				
"Rational Buyer" Minimizes total procurement cost	Minimizes total procurement cost and pays to winning bids of each reserve type (as declared by the bidder) a uniform market clearing price set by the highest accepted bid of that type.			California
Minimization of social costs	The bid selection is based on minimizing social cost as reflected by the bids. Market clearing prices for each reserve type are set to the marginal value of that reserve (that equals the highest			New York

Design Alternatives	Description	Pros	Cons	Discussion
	accepted bid for all reserves of equal or lower quality).			
Two-Part Bids[5]	Suppliers offer two-part bids (R, P), one for making capacity available ($R/MW) and another for supplying incremental energy ($P/MWh). Bids are scored based on the system operator's estimate of the expected fraction of the hour (H) in which generation would be needed (R+H×P). The Bids are accepted in increasing order of these scores until the reserve requirements are met.		Reserve units are called in increasing order of their energy bids. There are incentives for suppliers to game the system be selecting the bid (R, P) to maximize expected profit.	
Settlement Rules				
Pay uniform price based on usage	Product substitution. A natural choice in sequential auctions where rejected bids in one auction can rebid or are carried over to the next.		If a rejected bid in an earlier auction is accepted in a later auction (assuming no bid change) then it follows that the clearing price in the second auction will be higher than the first auction. Implying price reversal where lower quality products are priced higher than higher quality products.	A simultaneous auction in which resources are paid based on usage is equivalent to a sequential auction in which rejected bids are carried forward. Although the bid selection is socially efficient, price reversal can still occur so there are still perverse incentives for bidders to understate the quality of their

[5] Chao, Hung-po and Robert Wilson, "Incentive-Compatible Evaluation and Settlement Rules: Multi-Dimensional Auctions for Procurement of Ancillary Services in Power Markets", Stanford (Feb 1999).

Design Alternatives	Description	Pros	Cons	Discussion
				product.
Pay uniform price based on bid type	Demand substitution. A uniform clearing price for each bid type to the price of the highest bid selected of that bid type.			Although the bid selection is socially efficient, price reversal can still occur so there are still perverse incentives for bidders to understate the quality of their product.
Pay uniform price based on marginal value	A uniform clearing price of each bid type to the marginal value of the corresponding reserve type: marginal value of the highest quality reserve that a bid can provide.			In order to avoid the price reversal and guarantee incentive compatibility one would have to set the uniform price of each reserve type to its marginal value.
Pay as bid		Removes incentive to misrepresent reserve type. The least social cost objective and the least procurement cost objective are aligned in a PAB auction. PAB auctions have the advantage of reducing opportunities for collusive behavior.	Increases incentive to overstate costs. In order to insure liquidity in the ISO reserve market and avoid "cherry picking" of cheap resources by influential buyers, it may be necessary, to prohibit self-provision when reserves are procured through a PAB auction.	Adopted in the UK
Incs and Decs	The "DEC game" arises from rules in which the ISO pays for intrazonal congestion relief rather than charging for congestion causation, and socializes the cost of that relief through an uplift.	If the ISO charges for flows on congested intrazonal links then the DEC game disappears, regardless of whether those charges are imposed in forward markets or the real-time market	Participants are incented to create congestion by overscheduling generation and to then be paid again for reducing it. Could be compounded where SC's control generation and load.	California had recurrent problems with the so-called "DEC game", because participants can submit schedules in forward markets that create intrazonal congestion.