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Simplified Bidding for WEPEX

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Executive Summary

This paper suggests several simplifications to the bidding scheme proposed as part of California's industry restructuring by the CPUC and WEPEX.

The WEPEX proposal is silent or incomplete on many critical details of bid specification and evaluation. Complicated and difficult to implement, it requires too much information from bidders on the one hand while failing to take into account all available information on the other. Bids for storage, hydro and other energy limited generation are not evaluated properly. The ex-post price of energy does not accurately reflect unit commitment costs and operating constraints. Finally, the WEPEX proposal needs stronger incentives to prevent gaming of bids.

Under the proposed, simplified bidding scheme, participants in the PX need only bid a quantity of energy generation or load for each hour at posted PX prices for each hour. The energy bid requires no cost information. The PX adjusts only the posted market price for each hour in response to net supply and demand for the hour. The PX needs no merit-order dispatch, optimization, or administratively adjusted prices.

This simple bidding process allows for continuous, independent 168-hour markets for energy, transmission and ancillary services. Buyers and sellers will have a full week of posted prices on which to base their unit commitment, maintenance and other scheduling decisions and submit bids consistent with these scheduling decisions. It will be very easy for generators to evaluate the costs and revenues of alternative schedules. Buyers will also be able to plan ahead based on the posted prices. Bids will be easier to communicate. The PX and ISO will have a week to balance their respective schedules for energy, transmission and ancillary services for each hour.

This proposal also simplifies the ISO's transmission bidding process for the ISO and all scheduling coordinators including bilateral contractors and the PX. The ISO will post transmission prices that reflect inter-zonal congestion. Scheduling coordinators will use these transmission prices to prepare balanced transmission and energy schedules that will reflect transmission congestion. The ISO will manage transmission congestion by

ISO -
PX -
WEPEX -

adjusting the transmission prices in response to transmission availability and demand and current schedules. This approach can transition to more detailed zonal pricing if warranted by increased congestion.

Accepted bids are entered as binding schedules for the parties in order to improve reliability, facilitate dispatch, and discourage gaming. During the week ahead of an hour, participants can revise schedules as conditions change by submitting additional bids that buy back already-confirmed schedules and by paying or receiving increases or decreases in price. By timing their bids, buyers and sellers will be able to hedge price risks and will self-allocate risk more appropriately.

The PX and ISO evaluation tasks are much simpler and less subject to administrative rules, arbitration and litigation. The PX can focus on efficient bidding and communication and the ISO can focus more on reliable real-time operation and much less on economics.

The existing PX bidding process, because of its detailed rules for bid format and cost allocation, will doom itself; every allocation rule is another harbor for entities to arbitrage, raising PX prices higher. Because the proposed bid process is simpler, easily understood and more transparent, it is easier to audit and more resistant to gaming. Participation in the PX's energy market and the ISO's transmission and ancillary services markets is easier and fairer; enhanced energy market competition and lower prices result.

The simplifications proposed in this paper require minimal changes to other aspects of the WEPEX proposal. The use of zones for congestion pricing, the allocation of losses to generators, and the real-time operating procedures in the WEPEX proposal need not be significantly modified to adopt our simplified bidding scheme.

The reductions in software development, cost, time, complexity and risk that result from these simplifications improve the likelihood that the PX and ISO can be implemented by the CPUC's January 1, 1998 deadline. Most importantly, consumers will pay lower prices because a larger number of more competitive bidders with better information will make better economic decisions.

Simplified Bidding for WEPEX

Table of Contents

Simplified Bidding for WEPEX

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1. Summary

1.1. *Introduction*

This paper suggests several simplifications to the bidding scheme proposed as part of California's industry restructuring. It builds on the work of the "WEPEX" consultative process, the April 29, 1996 joint application of Pacific Gas & Electric, San Diego Gas & Electric and Southern California Edison to the Federal Energy Regulatory Commission. Other sources include meeting summaries and reports on the WEPEX and CPUC web sites, and several important papers.[3] The ideas in this paper do not require changes in most aspects of the WEPEX proposal, but they should help WEPEX more readily achieve its objectives.

The WEPEX proposal is silent or incomplete on many critical details of bid specification and evaluation. Complicated and difficult to implement, it requires too much

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[3] Cazalet, E., "Decomposition of Complex Decision Problems with Applications to Electrical Power System Planning", Ph.D. thesis, Stanford University, May, 1970. This early, theoretical paper shows how electric power system operation and planning can be broken up into simpler decision problems using prices.

Chao, H., and S. Peck, "A Market Mechanism for Electric Power Transmission," forthcoming, Journal of Regulatory Economics. This recent paper provides a theoretical foundation (consistent with much of this paper) for transmission pricing, losses and economic equilibrium of electric power markets with complex networks.

Harvey, S., W. Hogan and S. Pope, "Transmission Capacity Reservations and Transmission Congestion Contracts", Harvard University, June 6, 1996 (revised August 7, 1996). This innovative paper lays a solid foundation for transmission pricing and rights in complicated networks that can be implemented in a more simplified and decentralized way using the methods in this paper.

Wu, F., and P. Varaiya, "Coordinated Multilateral Trades for Electric Power Networks: Theory and Implementation", University of California, Berkeley, June 7, 1995. This important paper takes a somewhat different approach to decentralized operation of a restructured electric power market.

information from bidders on the one hand while failing to take into account all available information on the other. Bids for storage, hydro and other energy limited generation are not evaluated properly. The ex-post price of energy does not accurately reflect unit commitment costs and operating constraints. Finally, the WEPEX proposal needs stronger incentives to prevent gaming of bids.

The simplifications and process changes set forth in this proposal improve upon the WEPEX proposal in a number of ways. Bid preparation for sellers will be simpler and less restrictive. Buyers will also be able to plan ahead based on posted prices. The PX and ISO evaluation tasks are simpler and less subject to administrative rules, arbitration and litigation. The PX can focus on efficient bidding and communications and the ISO can focus more on reliable real-time operation and less on economics. Because the bid process is simpler, easily understood and more transparent, it is easier to audit and more resistant to gaming. Participation in the PX is easier and fairer; enhanced energy market competition and liquidity result.

Many details of our proposal are not provided in this paper for the sake of brevity or because they would duplicate details in the WEPEX proposal. Some details remain to be developed after consultation with experts who have detailed technical knowledge of scheduling and dispatch protocols and commodity market operation.

The authors of this paper are both independent consultants. We were not paid by any party to prepare this paper. We ask that readers help us to improve this proposal and correct the remaining technical errors. Contact us at the phone numbers and e-mail addresses on the first page of this proposal.

1.2. *Simplified Bidding*

The essence of this proposal is a simplified bidding scheme for electric energy, transmission, and ancillary services. In the current WEPEX proposal, those buyers and sellers of energy who choose to participate in the PX must submit multi-part energy cost functions to the PX.[4] The PX and ISO then use complex, merit-order, unit commitment, scheduling and dispatch procedures in conjunction with power flow optimization software to schedule generation and loads, and to determine the prices for energy, transmission and ancillary services. The required methods and software do not exist, may not be workable, are not easily audited, and must be designed and developed at great expense by WEPEX. The information requirements are burdensome and the process is highly centralized. Simplifying and redesigning the process by decentralizing much of the decision making and information in the scheduling process will make the competitive generation market

[4] This proposal retains the basic institutional structures for an Independent System Operator "ISO" and a Power Exchange "PX" proposed by WEPEX and the California Public Utilities Commission "CPUC".

more transparent, easier to understand, and easier to audit. It will achieve the CPUC's policy objectives without the risks, time and expense of developing complex optimization software.

Under the proposed, simplified bidding scheme, participants in the PX that buy and sell electric energy need only bid (schedule) a quantity of energy (generation or load) for each hour at posted PX prices for each hour. Cost information need not be provided to the PX by the participants. The PX adjusts only the posted market price for an hour in response to net supply and demand for that hour. By adjusting the market price of energy in response to net supply and demand, the PX bid evaluation process is greatly simplified.[5] No complex ex-post calculation of prices is needed as in the WEPEX proposal because all transactions are consummated at posted prices.

Accepted bids are entered as binding schedules for the parties in order to improve reliability, facilitate dispatch, and discourage gaming. During the week ahead of the hour, participants can revise schedules as conditions change by submitting additional bids that buy back already-confirmed schedules, and paying or receiving increases or decreases in price. By timing their bids, buyers and sellers will be able to hedge price risks and will self-allocate risk more appropriately.

In this simplified bidding proposal, the PX continues to be a scheduling coordinator as defined in the WEPEX proposal. Other scheduling coordinators will submit their generation and load schedules directly to the ISO and may or may not carry out an internal bidding process like the PX. Other scheduling coordinators may also schedule transactions into the PX's market at the PX's posted prices. All generation, load, transmission and ancillary service schedules finally accepted by the ISO must be balanced and operationally feasible.

This simplification of the bidding process allows the development of continuous, weekly 168-hour markets not only for energy, but also for the allocation of congested inter-zonal transmission interfaces and for ancillary services, as described below. Buyers and sellers have the benefit of a full week of posted hourly prices on which to base their unit commitment, maintenance and other scheduling decisions. Compared to the WEPEX proposal, it will be far easier for buyers and sellers to evaluate the costs and revenues of alternative bids and to plan ahead. The bid decision will be easier to communicate. Buyers and sellers will have more control over their decisions and confidential business data will remain private. Transactions can be audited very easily. Prices will be fairer, more stable, and difficult to game. The PX and ISO will have an entire week to balance the schedules for each hour. Their evaluation tasks will be much simpler and less subject

[5] The price adjustment process will operate much like a typical commodity market in a commodities exchange. The process is further described in Section 2 of this proposal.

to administrative rules, arbitration, and litigation. Most important of all, the resultant improvements in operating efficiency will lead to lower prices for consumers.

The proposal also simplifies the transmission bidding process. As with energy, schedulers simply bid a quantity of transmission capacity for each hour between the zones established by the ISO, at ISO-posted inter-zonal transmission prices for each hour. The ISO will manage inter-zonal congestion by adjusting the inter-zonal transmission prices in response to transmission supply and demand.

Transmission usage must be scheduled with the ISO by all scheduling coordinators, and the ISO will only accept transmission schedules that it determines are feasible with respect to the capability of the transmission system and all other transmission schedules. The ISO's posted prices for the use of congested inter-zonal interfaces will provide scheduling coordinators with proper incentives to bid feasible transmission schedules. Any unfeasible bids will be rejected by the ISO. Subsequent changes in transmission prices will be used to provide incentives to submit feasible bids or to cause others to reschedule and release committed transmission.

The initial transmission prices quoted by the ISO for each zone pair (or alternatively, for each inter-zonal interface) will reflect congestion and the underlying physical and reliability constraints on the transmission system,[6] but they may not necessarily be the same as the difference between PX energy prices between zones. However, scheduling coordinators will have an incentive to adjust their transmission and energy schedules so as to maximize their profits and minimize their costs, thereby causing the ISO and PX to adjust transmission and energy prices over the course of the week-long bidding process, until the inter-zonal transmission prices converge upon the inter-zonal energy price differentials. The transmission price adjustment process is further described in Section 3 of this proposal

As in the WEPEX proposal, the ISO will determine the ancillary requirements. Ancillary services will include at least:

- Spinning reserves
- Non-spinning reserves (quick start)
- Replacement reserves (60 minute start)
- Regulation (4 second AGC)
- Balancing energy (for forecast error, transmission losses and scheduling coordinators' purposeful or accidental imbalances)
- Reactive (VAR) support

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[6] The ISO may use conventional power flow software (more complex, optimal power flow software that simultaneously dispatches generation and transmission is unnecessary) to check for feasibility of all transmission schedules.

- Black start capability.

Bidding of ancillary services is further described in Section 4 of this proposal.

The ISO will directly control the operation of resources which have been selected to provide ancillary services in the ISO's real-time dispatch, and it will have the authority to control all resources in the event of a system emergency. Absent an emergency, scheduled generation will simply operate to meet its schedule.

Schedule deviations in the real-time market will be priced at the difference between the scheduled price and the actual real-time price. To discourage participants from gaming bids and avoiding their share of reliability-related costs, excessively large schedule deviations by scheduling coordinators could be allocated proportionately larger charges if such deviations are not caused by the ISO's real-time dispatch. A discussion of real-time dispatch is found in Section 5 of this proposal.

1.3. *Benefits of the Proposal*

The end results are bidding and evaluation processes that move closer to the CPUC's goals for

- Reliable and efficient system operation,
- Non-discriminatory access by all market participants, and
- A transparent, visible spot market for electricity.

The simplifications in our proposal should also significantly reduce the development time, costs, and risks for both the ISO and the PX. This proposal solves many of the remaining technical problems in the WEPEX proposal without requiring as much expensive, risky, time consuming software development effort that is unavoidable under the existing WEPEX proposal. Thus, on-time implementation of the PX and ISO by the CPUC's January 1, 1998, deadline is much more likely. Our simplifications should also increase the attractiveness of the PX market to all types of participants including independent power producers, load aggregators, municipal utilities and extra-regional buyers and sellers.

1.4. *Review of the Proposal*

Our proposal is a set of subtle changes to the PX and ISO bidding processes. We propose to modify the bidding processes as follows:

- Bidding and pricing of energy, transmission and ancillary services is simplified so that, in each of these markets, quantity bids at posted market prices are sufficient.
- The PX matches purchases from the PX and sales into the PX acting as a classical market clearing exchange.[7]
- Rolling week-ahead, 168-hour markets replace the day-ahead and hour-ahead markets.
- Neither the PX nor ISO performs a merit-order or optimal power flow schedule of generation, load and transmission (achieving the same objectives more efficiently through the proposed bidding processes).
- The buyers and sellers retain complete control over their purchase, sales and scheduling decisions and their confidential economic data.

2. Simplified Energy Bidding

2.1. *Simplified Energy Bids and Prices*

The primary motivation for this proposal is the simplification of the energy bids and the bidding process for buyers, sellers, the PX, other scheduling coordinators and the ISO. The simplifications and improvements to the bid process for the PX are discussed in this section.

In this proposal, energy buyers and sellers that wish to transact with the PX will bid hourly energy quantities to the PX. Start-up costs, no-load costs, and incremental cost curves or incremental and decremental costs will not be required for scheduling energy. At the time buyers and sellers submit their bids, they will have access to PX posted prices for the next hour and the rest of the week which will enable them to consider all costs in their bid.

The PX will simultaneously conduct energy markets for each of the next 168 hours (one week). Trading in the PX market for each hour will continue until the market for that hour closes, at the time when it is necessary for the ISO to take over control to prepare for and conduct the real-time dispatch. When trading in an hour is closed, trading

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[7] The separate spot markets for energy, transmission and each ancillary service could be within the ISO, in a single organization separate from the ISO, or in several organizations, each separate from the ISO. To conform with the current WEPEX proposal, in this proposal we locate the energy market within the PX, separate ancillary services spot markets in both the ISO and PX, and the transmission market within the ISO. Other scheduling coordinators may also conduct energy and ancillary services spot markets or may schedule into or out of the PX markets. Ideally, all of the markets - even those for transmission and ancillary services - would be operated separately from the ISO, so that the ISO can concentrate on its primary function of assuring system reliability without being sidetracked by economics.

in an additional hour at the end of the week will open so that the 168 hour, one-week market is maintained.

A quantity bid without start-up, no-load and incremental costs is possible because buyers and sellers have knowledge of future hourly prices for the week. Knowledge of future prices enables buyers and sellers to consider all of their costs, revenues and constraints in submitting bids, instead of having the PX responsible for using complex cost curves and arbitrary protocols to make the same kinds of decisions with less information. When buyers have posted prices for each hour, the quantity bid for each hour is essentially all that the PX needs to know about the bid.

There is, of course, an important connection between the energy bids and transmission congestion. The price of transmission congestion determines where generators can sell to maximize their profits and where buyers can purchase to minimize their costs. The bidding process must be designed to work simply when congestion is not significant and to be responsive when congestion is important.

As described in Section 3, the ISO will post 168 hourly transmission prices to coincide with the energy prices posted by the ISO for each hour. The posting of inter-zonal transmission prices is based on the WEPEX zonal model, which defines zones (sets of locations) within which intra-zonal congestion will be ignored for the purposes of transmission bidding. As described in Section 2.3, using the transmission prices posted by the ISO, sellers can submit generation bids in a zone to serve load in another zone, and buyers can submit load bids in a zone to use generation in another zone. Buyers and sellers in California and other locations in the WSCC can trade in the same way.

Another important scheduling issue is must-run generation. Must-run generation is generation that is required to operate for a variety of transmission system-related or local reliability reasons. In this proposal, the ISO determines the amount of must-run generation that is required at each location or zone. If there are several sellers in a zone, then the ISO (as well as each scheduling coordinator, including the PX) can establish markets to meet local must-run generation requirements. If there is only one seller or a few sellers in a zone, then that seller will operate local generation in the zone to meet the ISO's must-run generation requirement under a performance-based contract or other regulated price mechanism. In either case, must-run generation is scheduled into the portfolio of its scheduling coordinator and the schedules are passed through to the ISO.

Must-take generation is generation which by contract or agreement must be scheduled. In this proposal must-take generation will be scheduled with the PX or other scheduling coordinator as required by the contract or agreement. Such schedules will be passed directly to the ISO.

Simplified Bidding for WEPEX

In the event that combined must-take and must-run generation requirements exceed load, the bidding process described below will drive the posted price to very low levels, or perhaps even negative. In the unlikely event that buyers cannot be found at these low price levels, the extraordinary measures described in the WEPEX proposal may be needed.

2.2. *PX Matches Supply and Demand using Prices*

In this proposal the PX will match PX buyers and PX sellers of energy in each of the 168 hours of its then-current market by adjusting its posted price of energy in each of the 168 hours in response to supply and demand for energy in each of those hours. Energy prices will be posted for each of the zones defined by the ISO.

Buyers may submit binding bids for energy to serve hourly loads at the current posted price for the zones defined by the ISO for each hour. Sellers may submit binding bids for energy from generation at the current posted price for the zones defined by the ISO for each hour.

2.3. *Using Transmission to Match Energy Bids*

In submitting their bids, buyers and sellers in a given zone may also submit bids in other zones[8]. Bids in other zones are joint quantity bids to purchase transmission from the transmission market (unless they already own transmission rights) and buy or sell energy.

Transmission rights owners may also submit bids to purchase energy in one zone and sell it in another. Arbitrageurs may purchase transmission rights to accomplish the same trade[9]. Computerized program traders will quickly identify such opportunities and cause the market to be highly efficient and competitive.

Inter-zonal trades will cause the ISO to adjust the congestion price of transmission to the point and the PX to adjust the zonal energy prices until the energy price differences between zones equal the zone-to-zone transmission price. The bidding for transmission and adjustment of transmission is discussed in Section 3.

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[8] Technically, the PX could purchase transmission to match energy buyers and sellers. However, this would put the PX in a position of profiting on a transaction, beyond the normal PX transaction cost. Allowing the PX to profit on transactions in this way would not be in keeping with the goal of the PX as an independent market clearing exchange.

[9] Should transmission or energy for a joint inter-zonal bid be unavailable at the posted prices, the PX will reject the entire joint bid.

Simplified Bidding for WEPEX

Using posted transmission and energy prices, the PX will conduct one vast spot market for generation throughout California. This will accomplish one of the CPUC's main restructuring objectives by providing "a transparent, visible spot market for generation". In the absence of congestion, the prices throughout the state will be identical. When there is inter-zonal congestion, the ISO's transmission prices will provide the signals necessary to avoid congestion, and will result in the segmentation of the single state-wide spot price into a number of zonal spot prices. In Section 3, the ISO's transmission price adjustment process and the interplay of the ISO, PX, and other scheduling coordinators is discussed.

2.4. *The PX Price Adjustment Process*

The PX price adjustment process will operate much like price adjustments in other commodity markets. The purpose of the PX is to provide an open and efficient process in which buyers and sellers at all locations can compete fairly. In this section we outline some principles that might guide the PX in carrying out the price adjustment process. However, these are principles only. As in other commodity markets, the PX will have to continuously review and refine its procedures to assure an efficient, fair market.

For each new hour added to the 168 posted hours, the PX will set the opening prices based on current and previous prices in similar hours on similar days of the week. Simple adjustments to the opening price for the price effects of forecasted changes in load, and unit and transmission availability based on experience from similar hours in prior periods, may be useful.

The price adjustment rule for the PX is simple and is based on whether there is a bid surplus or deficit at the current posted price. The PX will decrease price in response to a bid net surplus and increase price in response to a bid net deficit. The bid surplus in a zone in any hour is defined as:

net bid surplus = generation bid surplus + import bid surplus
- load bid surplus - export bid surplus

Each bid surplus is the MW of rejected bids at the current posted price.

The size of the price increase or decrease and the frequency with which prices will be adjusted will be set by experience. Frequent, large changes in price will make the market very responsive, but possibly unstable. Infrequent, small changes in price will make the market less responsive. The factors that affect the size and frequency of price adjustments will depend on the number, size, and behavior of the market participants.

It may be useful to always quote posted energy and transmission prices to the quarter point (¼ of mill or $/mWh) or some other value. Price changes would then be limited to quarter point changes. Real-time prices need not follow the same conventions.

Simplified Bidding for WEPEX

Since the market for each hour is open for one week, there is plenty of time for the market to converge, as well as to deal with unforeseen special problems. An important feature of this market that sets it apart from many other commodity markets is that the PX and buyers and sellers will quickly build tremendous experience, because one market is closed and a new market is opened each hour.

Two types of market convergence are of interest. The first type of convergence is to assure that total of all scheduled loads less generation plus exports less imports balance in each zone. This should be guaranteed since the PX and ISO will only accept bids that closely balance and are feasible in the transmission system. If supply and/or transmission is available, it will always be possible for a load to find a supplier at some price.

The second type of convergence is in prices. Do the differences in zonal energy prices approximate the transmission price between the zones? If such a price convergence error is very large, then buyers and sellers will close the gap quickly. Sudden changes in system conditions shortly before the close of the PX market could leave an imbalance between zone price differences and transmission prices, but this is less important than the quantity balance, and there may be opportunities for further changes before and during real-time dispatch. The design of the bidding process also guarantees that each generator is paid the posted price at the time of its bid and each buyer pays the posted price at the time of its bid, and that receipts and disbursements balance for the PX.

The experience of other commodity exchanges in managing price adjustments should also provide guidance, even though the need for coordination with the transmission market may pose some unique issues. The basic problems of price adjustment in this market have many similarities to the problems of price adjustment in other commodity and securities markets. The knowledge base that exists in those other markets will provide insights, management tools and software that can be applied directly to the PX energy market.

The trading and auditing protocols used in other commodity markets can be employed to facilitate market liquidity and to make it more difficult for any single party or group to control the market. Periodic technical studies can improve the adjustment speed and stability of this market.

The trading and settlement software developed for use in other commodity markets, including software that matches buyers and sellers anonymously, without the need for a market maker, can be adapted to meet the requirements of this market. There will be no need for the development of complex unit commitment, dispatch, and transmission system optimization models.

Simplified Bidding for WEPEX

The PX will typically receive quantity bids in response to the PX's posted price. If the PX receives a substantial surplus or deficit of bids, then the PX will reject all bids and adjust the price. Buyers and sellers would then submit new bids at the revised price. When the surplus or deficit is within acceptable limits as determined by the PX, it will accept all bids at the posted price. Any small surplus or deficit can be held on account by the PX and offered for sale or purchase at the next opportunity. Much and perhaps all of this bid and settlement process can be automated eventually. It need not all be automated by the January 1, 1998 target date.

During the week-long period leading up to each hour, loads and generation and transmission availability are likely to change. The price adjustment process will have to be sufficiently sensitive so that prices will be responsive to these new conditions.

As an additional option that can be implemented to increase the flexibility of the bidding process, buyers and sellers could also submit an "at the market" bid that would be held open until the PX could find a buyer at the current or new posted price. Buyers and sellers who want to signal the markets could also be permitted to submit a "good until canceled" quantity bid at a specific price. The PX would hold the offer open until a buyer is found, the bid is withdrawn, or the market closes for the hour.

2.5. *Other Market Rules*

PX buyers and PX sellers will be matched anonymously at the PX's market price. The PX will enforce and guarantee performance of PX buyers and PX sellers on their contracts at the contract price. Should a buyer or seller over- or under-estimate its needs or capability prior to close of the market for the hour, it must sell or buy additional energy to/from the PX at current prices. Consistent with FERC policies, PX buyers and sellers who fail to meet their schedules in real-time dispatch could also be assessed a substantial monetary charge above the costs of replacement energy for significant imbalances. Such a charge could help to prevent gaming, in which buyers or sellers might abandon their commitments to pursue better alternatives.

Buyers and sellers will be able to manage their risk by buying or selling portions of their energy for a given hour at different times in the week ahead of the close of the market for the hour. For example, large buyers may choose to spread their purchases for an hour over several bids submitted at different times in the week ahead in order to avoid moving the energy price for that hour. Other rules may be required to limit the market power of large buyers and sellers.

A nominal transaction charge will be assessed by the PX on both the buyer and seller for each trade, to cover the PX's costs of operation. The transaction charge will be a very small percentage of the dollar amount of the trade and will be assessed on both the

buyer and seller. If transmission is used, the transmission transaction charge could be added to the transmission price.

Offers to buy or sell are binding, but they may be withdrawn at any time prior to execution by the PX. Once an order has been executed, the seller and buyer are committed to the quantity bid at the posted price. Accepted bids are entered as binding schedules for the parties in order to improve reliability, facilitate dispatch, and discourage gaming.

During the week ahead of an hour, participants can revise schedules as conditions change by submitting additional bids that buy back already confirmed schedules, and by paying or receiving increases or decreases in price. By timing their bids, buyers and sellers will be able to hedge price risks and will self-allocate risk more appropriately. Schedule changes will be charged the normal transaction charges for the purchase and sale. The transaction charge, in addition to covering PX costs, will also discourage unnecessary churning.

Buyers and sellers may submit bids simultaneously to the PX for a whole set of hours in a single transaction at the posted price for each hour, with the condition that if the bid cannot be accepted by the PX in any one hour, then the conditional bids for all hours will be rejected. This may assist some generators in making unit commitment decisions.

The PX will post the PX's current market price and current sales and purchase totals on a continuous basis on its online information system. Bids will be received on the PX online information system and by other means.

The PX and other scheduling coordinators will continuously submit updated schedules to the ISO. In other words, schedule changes will be communicated electronically to the ISO for approval as they occur, rather than submitting periodic updates. In this way, the ISO and market participants will always have access to current information regarding the state of the system and its resources.

2.6. *Other Benefits of Simplified Energy Bidding*

The PX will not need to carry out a merit-order or economic scheduling of generation and loads. All of the objectives of economic scheduling of generation and loads will be better accomplished by the market mechanisms proposed here.

Compared to a day-ahead market, a weekly market will facilitate simpler and more-economic unit commitment, storage utilization, hydro operations and load management. For example, when sellers have forward price information for a week or

more, the unit commitment decision is much easier to analyze. Buyers have more time to plan changes in their production schedules and maintenance activities. Further discussion of the informational and scheduling benefits of this simplified bidding proposal to buyers and sellers is found in Section 6.

The arbitrary distinction between a day-ahead and an hour-ahead market in the WEPEX proposal is unnecessary. A weekly, 168-hour market is practical in this proposal because of the simplifications to the form of the energy bids and the simplification of the PX's decision making. If it is of value, the weekly market can be extended to weeks, months or longer.

Simplified bidding and pricing of energy will also facilitate the development of secondary months-ahead or years-ahead markets. Secondary markets could also serve the week-ahead market and possibly the day- and hour-ahead markets. However, because transmission is so important, the spot market needs to be coordinated with the ISO's management of transmission and ancillary services. Secondary markets without the transmission data provided by the ISO will not be as effective.

The week-ahead market for each hour in this proposal is not strictly a futures market because actual delivery of all of the schedules is anticipated. The physical and financial markets for energy in this proposal are closely connected. This strong tie to the physical market is necessary because scheduling decisions must be coordinated closely to meet transmission system physics and constraints.

3. Simplified Transmission Bidding

3.1. *Managing Transmission Congestion*

This proposal uses transmission pricing to simplify congestion management. Transmission prices posted by the ISO can be defined to provide all of the information that scheduling coordinators need in order to submit transmission bids to the ISO that are likely to be accommodated within the capability of the transmission network. The ISO will adjust the transmission prices using a process similar to the process the PX will use for adjusting energy prices, as described in Section 2 of this proposal. In some cases the ISO will reject transmission bids and adjust transmission prices until the transmission bids submitted to the ISO conform with the capability of the transmission system and the already-accepted transmission schedules.

Under the WEPEX proposal, the ISO reschedules generation and loads in order to meet transmission constraints, thereby duplicating much of what is done or could be done by the scheduling coordinators. Scheduling coordinators are given little initial guidance on

how to prepare schedules that will avoid congestion. The scheduling coordinators, including the PX, also must submit generation and load quantity data and a considerable amount of economic data to the ISO. All of this data is used by the ISO to adjust schedules for transmission congestion and to compute transmission prices on the basis of zonal energy price differences which must be determined simultaneously with the transmission prices. The ISO's process for managing congestion and calculating transmission prices depends on unproved optimal power flow (OPF) methods or administrative adjustments that are time-consuming and difficult to deploy and use. Scheduling coordinators do not know final transmission prices or their actual schedules until some time after the bids are accepted.

The management of congestion seems complex because of the physics of electric transmission systems; energy flows on parallel transmission paths according to physical laws and not according to schedules. Although this proposal provides a method of managing congestion using prices that works equally well for complex networks with many parallel paths and simple networks where parallel paths are not as important, it is presented in the context of the WEPEX zonal model. The proposal is easily extended to more complex network representations when necessary.

In this proposal a transmission schedule for an hour is defined between a specified pairs of zones. There may be several physical paths between the two zones and there may be no direct transmission line between the two zones. The actual path by which energy flows between two zones is not determined by the schedule or economics; it is determined by the physics of the electric transmission network.

Congestion is typically monitored on the physical paths: transmission prices for each constraint on the physical paths is adjusted to manage congestion. The prices on physical paths are then translated into transmission prices for zone-to-zone pairs. These zone-to-zone transmission prices are the most convenient way for schedulers to incorporate transmission prices into their scheduling decisions.

In this proposal, the inter-zonal energy price difference is not automatically set equal to the inter-zonal transmission price. This distinction may not seem important because in this proposal the transmission price between two zones will approach the difference in energy prices between the zones as trading continues. However, separating the ISO's transmission price from the PX's energy price differences is important because it provides buyers, sellers and traders with the necessary price signals to efficiently schedule energy trades that result in feasible transmission schedules.

3.2. *Zonal Transmission Pricing*

In California, transmission congestion is currently not a significant factor, except on a few major transmission interfaces. When congestion is not significant, transmission prices will be small in comparison to energy prices, and buyers, sellers, schedulers and the ISO can operate with little concern for transmission.

However, in some hours, on some major transmission interfaces, transmission congestion will be critical. Thus the bidding process must be designed to work simply when congestion is not significant and to be responsive when congestion is important. In this proposal we use transmission prices to coordinate decentralized scheduling of energy and transmission. In order to achieve the many benefits of decentralized scheduling, transmission prices must have sufficient locational detail to reflect actual congestion.

Recognizing that most of the substantive effects of transmission congestion occur on a few major interfaces, the WEPEX proposal uses a simplified model based on transmission zones to characterize portions of the transmission system between which past experience indicates congestion is most likely to occur. New zones are created after operating experience has shown that significant congestion, exceeding specified thresholds, has occurred.[10]

3.3. *Reliability Criteria Determine Network Constraints*

WSCC, NERC, ISO, and transmission owner-specific reliability criteria and load flow studies would determine the transmission system's capabilities and the transmission constraints that must be enforced. Such constraints include transmission nomograms that limit the aggregate flows on groups of transmission links, and limits on individual lines (where such limits may be based on thermal capabilities or more-restrictive system voltage stability, dynamic stability or transient stability requirements).

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[10] This proposal makes use of the zonal model established by WEPEX. However, this proposal would also be consistent with a model in which the ISO could dynamically define zones. In such a model, the ISO's posting of transmission prices for an hour would define sets of locations within which congestion between locations can be ignored. The ISO's criteria for dynamically adding zones or locations to its transmission price posting would be simple: zones would be added when congestion somewhere in the network is significant and an intra-zonal transmission price is needed to eliminate this congestion. The ISO could add or remove zones from the posting at any time. Typically, in peak hours, there would be more zones in the posting than in off-peak hours. Transmission and generation outages could also cause the definition of zones to vary.

3.4. *Power Flow Reference Case*

A reference power flow case will be used by the ISO in each hour to monitor transmission congestion. The reference power flow case for each hour will reflect the best estimate by the ISO of the final schedules for generation and transmission. The ISO will only need to change the reference case when there are significant changes in market conditions. A reference power flow case based on the ISO's estimate of the final transmission schedule avoids the problems that would occur if the ISO based its estimates of congestion only on the transmission schedules currently submitted to and accepted by the ISO.

Network sensitivity factors calculated from this reference case will be used by the ISO to determine transmission prices as described below.

3.5. *ISO Sets Transmission Network Sensitivity Factors*

Using standard power flow computer software (not more complex, optimal power flow software[11]), network sensitivity factors are easily computed by the ISO. For pricing transmission between any zone-pair, we need the vector of network sensitivity factors that reveals the MW changes in flows on the physical, inter-zonal paths in a network for a 1 MW increase in schedules between that zone-pair. There will be one vector of sensitivity factors for each zone-pair.

These vectors of network sensitivity factors will be used by the ISO to translate prices on physical paths to prices for zone-pairs. For example, in a three zone network, the network sensitivity vector for energy scheduled between zone 1 and zone 2 might be

Zone 1 to 2 network sensitivity vector :

- a 1 MW *increase* in generation in zone 1 and a 1 MW *decrease* in zone 2 generation causes
- a 0.7 MW increase in flow on path 1 to 2,
- a 0.3 MW increase in flow on path 1 to 3, and
- a 0.3 MW increase in flow on path 3 to 2 (ignoring losses).

Also assume that the current prices on the constraints on the physical paths between the zones are

- 2.0 mills for path 1 to 2,
- 0.0 mills for path 1 to 3, and

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[11] Optimal power flow software would attempt to simultaneously schedule generation, loads and transmission to minimize costs. In this proposal, our bidding process is designed to solve for the most economic schedules using more decentralized, market-oriented approach. For this proposal we need only a physical model of the transmission system which is provided by simpler, standard power flow models.

- 6.0 mills for path 3 to 2.

The transmission price between zone 1 and zone 2 is computed using the network sensitivity vector elements and the path prices as follows:

$.7 \times 2.0 + 0.3 \times 0.0 + 0.3 \times 6.0 = 3.2$ mills

In this example, the price on the zone 1 to 2, physical path is priced at 2.0 mills compared to the zone 1 to 2 schedule path which is priced at 3.2 mills; this is because only 70% of the energy flows on the direct physical path from zone 1 to zone 2 at a price of 2.0 mills. The remaining 30% of the energy flows on the schedule path from 1 to 3 to 2 at a price of 0.0 + 6.0 mills.

One network sensitivity vector is needed for each zone-pair of interest. Each vector will have the same number of elements as the number of zones defined by the ISO. Many elements of each vector may be small or zero and can be ignored. Other approximations of the sensitivity vectors may be possible. The need for accuracy in the sensitivity factors is low because they will be used primarily for transmission pricing, and the transmission price will be only a fraction of the energy price.

The calculation of sensitivity factors can be performed using the reference power flow case for the hour, and the reference case need only be updated when the underlying conditions change significantly. Pre-computed sensitivity factors may often be sufficient; however, the computations are not costly or time consuming.

When parallel flows are not present, the physical and schedule paths will be the same and the network sensitivity factors will not be needed.

3.6. *ISO Allocates Responsibilities for Transmission Losses*

The simplified bidding proposal presented in this paper is compatible with the WEPEX loss responsibility methodology. Many different approaches can be used with this proposal to allocate responsibilities for transmission losses [12]. To minimize changes in the WEPEX proposal, the current WEPEX proposal for assigning loss responsibility is assumed here.

Two effects need to be considered in assigning losses:

- The *incremental* energy required at each location in the network to compensate for losses from an additional 1 MW increment of generation or consumption at that location.

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[12] The theoretical ideal would be to include the marginal costs of losses in the transmission price. The ISO would purchase the average loss energy from the scheduling coordinators at the lowest possible cost. The difference between marginal and average losses would be credited to the transmission system.

- The *total* energy required system-wide to compensate for the total losses associated with all energy transfers on the system.

In the WEPEX proposal, responsibilities for system losses are allocated to generators in such a way that the sum of all of the generators' loss allocations is equal to the total energy required for system transmission losses. In the WEPEX proposal, an incremental loss factor is first calculated for each generator location. This can be calculated from the reference power flow case for the hour.

The total amount of system-wide transmission losses can also be calculated from the reference power flow case for the hour.

Transmission loss responsibilities are then allocated to each generator by applying a *scaled incremental loss factor* to each generator, where the scaling factor is such that the sum, over all generators, of the generator's output multiplied by the generator's scaled incremental loss factor is equal to the total system-wide transmission loss energy.

3.7. ***Transmission Rights***

In the existing WEPEX proposal, participants will be able to schedule their use of the transmission grid on the basis of either physical transmission rights or financial rights. When financial rights are used, transmission congestion contracts (TCCs) will entitle the rights-holder to the transmission congestion payments associated with transmission prices between zones. TCCs would permit buyers and sellers to manage the volatility in transmission congestion prices (to which they would not have been subject, under a physical transmission rights model). When physical rights are used, depending on how the physical rights are defined (i.e., on a path basis vs. an inter-zonal basis) it may be necessary to purchase physical rights on more than one path to complete a zone-to-zone transmission schedule.

Under this simplified proposal, either of these same mechanisms can be used for scheduling transmission uses and for managing transmission congestion price risk. The ISO will establish hourly markets as necessary for the sale of either physical or financial transmission rights, to facilitate economically efficient energy transactions between zones.

The ISO will also be responsible for facilitating markets for firm inter-zonal transmission capacity rights. Firm transmission rights will give the rights-holder the firm right to transmit energy on inter-zonal interfaces (or between zones, depending on the specific definition of the rights). If the firm transmission capacity rights are viewed as financial rights, such rights would give the owner title to hourly inter-zonal transmission congestion revenues.

Simplified Bidding for WEPEX

The ISO will post prices for transmission capacity reservations either (i) on all inter-zonal transmission paths or (ii) between all pairs of zones, or both. The ISO will accept only those bids for transmission capacity that are simultaneously feasible with respect to all other transmission schedules and all transmission constraints. If demand for transmission capacity exceeds supply, then the ISO will increase transmission capacity prices until supply and demand balance.

The price adjustment process for transmission capacity will be carried out using procedures similar to those used in the ISO's hourly transmission market. Once long-term inter-zonal transmission rights have been released into the marketplace, it is expected that the owners could resell such rights in the ISO's hourly transmission market. For longer periods, an ISO facilitated secondary marketplace could be operated for trading such rights through the ISO's electronic bulletin board system.

3.10. *ISO Accepts only Feasible Transmission Schedules*

Transmission service must be scheduled with the ISO by all scheduling coordinators, and the ISO will only accept transmission schedules that it determines are simultaneously feasible with respect to the capability of the transmission system and all other transmission schedules. Transmission schedule feasibility is easily checked using either the power flow model or the reference power flow case and the network sensitivity factors. Rejections of schedules should not happen frequently because the scheduling coordinators prepare schedules using transmission prices which reflect congestion.

By accepting only feasible transmission schedules, the ISO will not need to reschedule any generation to resolve inter-zonal congestion as in the WEPEX proposal. The ISO will consider any rejected bids in the total supply and demand for transmission when setting new transmission prices.

The scheduling coordinators' submittals must include schedules which are consistent with the appropriate inter-zonal rights, which can be acquired in advance (through a long-term capacity rights auction) and/or through the ISO's 168 hour bidding process for such inter-zonal rights (in which the ISO sells such rights by proposing prices which clear the market, similar to the energy bidding process).

If demand for transmission exceeds the supply, the ISO's price adjustment process will increase the price of the affected transmission. Owners of transmission rights may resell their inter-zonal transmission rights and reschedule energy production if they can increase their profits. Buyers of transmission may find other ways to sell generation or satisfy load in order to reduce their costs. Thus, the posted prices will provide scheduling coordinators with proper incentives to bid feasible transmission schedules.

3.11. *ISO Transmission Price Adjustment Process*

This section outlines some principles that might guide the ISO in carrying out the price adjustment process. Explicit rules need not be provided at this time because the ISO will have to have the flexibility to continuously review and refine its procedures to assure an efficient, fair market.

The task of making a market in transmission should be kept completely separate from the ISO's other responsibilities of determining the reliable capability of the transmission system and operating the transmission system securely. The market making function could even be carried out by a separate transmission exchange entity "TX"; however, under this proposal the transmission exchange will be housed in the ISO to conform with the CPUC's and WEPEX's organizational plans.

For each new hour added to the 168 posted hours, the ISO will set the opening transmission prices based on current and previous prices in similar hours on similar days of the week. The reference power flow case will be useful in making adjustments to the opening price for the price effects of forecasted changes in load, and unit and transmission availability.

The ISO will continuously post the net transmission schedules for all zone-pairs. The ISO will use its standard power flow model, or the network sensitivity factors and the reference power flow case, to compute any changes to the loading on active inter-zonal transmission physical constraints. Surpluses or deficits of transmission capability relative to these constraints will also be computed.

The transmission price adjustment rule for the ISO will be to decrease the price on the inter-zonal physical transmission constraints in response to a surplus of transmission capability and increase price in response to a deficit.

The size of the price increase or decrease and the frequency with which prices will be adjusted will be set by experience. Frequent, large changes in price will make the market very responsive, but possibly unstable. Infrequent, small changes in price will make the market less responsive. The factors that affect the size and frequency of price adjustments will depend on the number, size, and behavior of the market participants.

Other bidding principles and procedures, described in the discussion of the PX energy market, can be applied directly to the ISO transmission market.

3.12. Interplay Between *PX Energy and ISO Transmission Auction Protocols*

The following outline of protocols shows the interaction and information flows between the ISO and PX for hourly energy and transmission. The same interactions and information flows would occur between the ISO and any other scheduling coordinators (although this proposal does not presume what type of energy scheduling process the other scheduling coordinators might choose to implement). This description is only an outline to give the readers a sense of the process. More detailed protocols will be needed for implementation.

1. The ISO posts current transmission prices for the next 168 hours for each inter-zonal interface that the ISO deems necessary in order to manage congestion.
2. The PX posts current energy prices for the next 168 hours for each of the WEPEX zones.
3. The generators and load schedulers continuously[13] submit quantity bids for any hour to the PX. The PX also will also accept joint bids with transmission to match energy bids in different zones using inter-zonal transmission at ISO transmission prices (see Section 2.3).
4. The PX continuously attempts to match buyer and seller bids in each zone for each hour at the posted price. If a bid to the PX is accepted, it becomes a binding schedule. If the bidder modifies a previous binding schedule, it will pay (or receive) any difference in price from the original schedule plus (or minus) a small transaction fee.
5. The PX purchases transmission in the ISO market for any bidder requiring transmission rights necessary in Step 4. If the rights can be purchased at the posted transmission price[14], the transmission schedule and the associated energy schedules that have been submitted by the PX to the ISO are binding on all parties. If transmission rights cannot be acquired at the posted price, all new joint transmission and energy bids are rejected.
6. The ISO continuously tracks the transmission schedule and rejected transmission bids at current posted transmission prices. Using the reference power flow case and the network sensitivity factors, the ISO determines the loading on constrained interfaces. The ISO will increase the price on any overloaded interfaces , and decrease the price on other interfaces. The constraint price changes will be

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[13] There is no particular reason to accept bids or adjust the energy or transmission prices on any set interval. Most commodity and stock exchanges change prices as often as necessary to respond to supply and demand. In some cases they have limits on the size of bids and changes in price during a day, for example.

[14] Transmission prices will be negative in the counter direction to a positive transmission price. Essentially a transmission schedule with a negative price is a sale of transmission rights.

translated into changes in the zone-to-zone transmission prices using the network sensitivity factors.

7. The PX continuously monitors the bid net surplus[15] in each zone where the
   net bid surplus = generation bid surplus + import bid surplus
   - load bid surplus - export bid surplus
   If the net bid surplus > 0 in an hour in a zone then the PX decreases the posted energy price for the zone; if < 0 then the PX increases the posted energy price for the zone.
8. The ISO accepts dispatch control of each hour at 30-to-60 minutes before the hour (or at whatever time is specified by the protocols), and the PX then closes its bidding for that hour. The final schedules are then dispatched by the ISO.
9. At the close of each hour, a new hour is added at the end of the week to replace the hour turned over for dispatch. The PX and ISO then make initial estimates of all prices for the new hour, and the ISO uses a reference power flow case for the hour to calculate network loss and sensitivity vectors.
10. The process operates continuously, returning to Step 1.

4. Simplified Ancillary Service Bidding

4.1. *ISO Sets Ancillary Service Requirements*

The ISO will determine requirements for ancillary services based on WSCC, NERC and local operating guidelines. The ISO will dispatch ancillary services as necessary after close of the hourly market. Ancillary services may include[16]:

- Spinning reserves
- Non-spinning reserves (quick start)
- Replacement reserves (60 minute start)
- Regulation (4 second AGC)
- Balancing energy (for forecast error, transmission losses and scheduling coordinators purposeful or accidental imbalances)
- Reactive (VAR) support
- Black start capability

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[15] A bid surplus is defined as the total MW of bids of a given type offered but not accepted at the current posted price.

[16] Most of these ancillary services protect against unplanned loss of generation or increases in load. It may also be necessary to define turndown ancillary services to protect against unplanned decreases in load or increases in generation.

The ISO will directly control the operation of ancillary services in the real-time dispatch.

Under the WEPEX proposal, ancillary services are paid both a readiness and an energy price. The readiness charges must be arbitrarily added to the energy prices, or the readiness charges must be allocated to the transmission system use charges in one way or another. The allocation method will tend to bias the real-time price lower or higher.

Under this proposal, ancillary services providers will be paid (or pay) only the real-time energy price for any energy delivered (or consumed). A bid or dispatch curve provided by the bidder will specify the ISO's dispatch of the service as a function of the real-time energy price[17]. This bid or dispatch curve will include the seller's recovery of any readiness charges. The real-time dispatch of ancillary services is discussed in the next section.

Bidding for ancillary services required by the ISO could be managed as a set of distinct markets (one for each ancillary service) by an ancillary service exchange "AX". Alternatively, the ISO could assume the role of the AX, keeping this function distinct within the ISO. In this proposal, to conform with the current WEPEX proposal, we will assume that the ISO conducts an ancillary services auction. In addition, the PX may conduct ancillary service markets for acquisition of a portfolio of ancillary services from generators that bid into the PX. For simplicity, we assume that the other scheduling coordinators will self-provide ancillary services or purchase their requirements from the ISO, although they may also submit bids to provide ancillary services to the ISO. For simplicity, we also assume that the PX and ISO will use the same protocols for their ancillary services bidding processes. Only the ISO bidding process is described below.

4.2. *ISO Matches Ancillary Service Buyers and Sellers*

The ISO will maintain separate markets for each ancillary service for 168 hours in accordance with the ancillary service quantity requirements set by the ISO. The ISO will post prices for each service for each hour. When necessary, the ISO will maintain separate ancillary service markets by zone.

The ISO will match buyers and sellers of ancillary services. Buyers and sellers of ancillary services will submit binding quantity bids. The quantity bid will be the capacity (maximum hourly energy) that can be produced by the service if fully dispatched by the

[17] A bid curve specifies a bid price as a function of the energy dispatched. A dispatch curve specifies the energy to be dispatched as a function of the real-time price. Either curve is the reciprocal of the other. In some circumstances it is easier to think in terms of the dispatch curve which commits the owner of the resource to dispatch at various levels as a function of price. To keep things simple, we will require that the dispatch curve be non-decreasing as a function of price. The simplest possible dispatch curve is a single price at which the owner would be willing to operate the ancillary service resource at any level.

ISO. If the supply of an ancillary service exceeds the ISO-defined requirement, the ISO will adjust its price downward. If the requirement exceeds supply, the ISO will adjust the price upward. Price adjustments will continue until supplies and requirements for each ancillary service are balanced. The ISO will use price adjustment procedures that are very similar to the procedures that have been discussed for the PX's energy auction.

The ISO will accept ancillary service bids for the amount of capacity that could be fully dispatched at the posted price of the ancillary service. The dispatch curve (reciprocal of the bid curve) provided by the seller of the service will indicate the full dispatch price. Bids will be binding once accepted and a FERC approved charge may be assessed in case of non-performance. Bidders will have an incentive to bid services with dispatch curves that will dispatch at the lowest acceptable price because such services will be more likely to be dispatched and return a profit margin when the real-time price is higher than the bid price.

4.3. *Ancillary Service Bids and Prices*

Sellers of ancillary services will provide technical information such as ramp rates and start-up times as in the WEPEX proposal. The ISO's criteria will determine which ancillary services a seller is eligible to provide. For example, a combustion turbine with a start-up time less than the quick-start time standard for non-spinning reserves could be bid into this market. The unused portion of the generating capability of a unit that is scheduled to operate for the hour could be bid into the spinning reserve market.

Under this simplified bidding proposal, sellers of ancillary services submit quantity bids for each ancillary service category, just as they do for energy and transmission. The posted price of ancillary services will be the highest price that ancillary service providers will require for the ISO to dispatch the service at its full capability. The actual price paid will be the real time energy price.

Sellers of ancillary services will likely submit their quantity bids to the ancillary service market with the highest price for which they are authorized by the ISO criteria to provide. Buyers of ancillary services will submit binding offers to purchase their required or pro-rated amounts of each ancillary service. Given hourly prices of ancillary services and energy, it will be a straightforward problem for ancillary service sellers to determine the most profitable combination of energy and ancillary services products to bid.

5. Real-Time Operation

The ISO will have direct control over the real-time dispatch of generation and loads scheduled to provide ancillary services, and control over all resources and loads in

the event of a system emergency. Scheduled generation will simply operate to meet its schedule[18]. Ancillary services, including regulation, will be dispatched by the ISO, as is proposed in the WEPEX proposal.

Schedule deviations in the real-time market will be priced at the difference between the scheduled price and the actual real-time price. To discourage participants from gaming bids and avoiding their share of reliability-related costs, excessively large schedule deviations by scheduling coordinators could be allocated proportionately larger charges if such deviations are not caused by the ISO's real-time dispatch.

We assume that the real-time dispatch will dispatch the ancillary services using methods similar to those used in the WEPEX proposal.

6. Buyer and Seller Information And Scheduling

In the current WEPEX proposal, the buyers and sellers must provide the PX with complex, multi-part bids and pricing curves they may prefer to keep in confidence. The PX then uses a "black-box" optimization to determine the "least cost" schedule of generation and loads and to compute marginal cost prices. The PX coordinates its schedule with the ISO using difficult optimal power flow methods to determine transmission congestion prices and losses. The PX uses this information to modify the generator schedules and the marginal cost prices using ad hoc procedures. All of this must be accomplished in just a few hours from the time bids are submitted to the time the next day's schedule is published. It must be done again just before the start of each hour.

It is clear from the WEPEX documents that the participants see many unsolved problems with how bids should be developed, how generators should be committed and dispatched, how the marginal cost prices should be calculated, and whether the optimal power flow methods will work. The WEPEX proposal itself is largely silent on these issues. Using ad-hoc adjustments and an administrative formula to calculate the price that all generators receive (and all buyers pay), as the WEPEX proposal suggests, will make the process susceptible to gaming, second-guessing and time-consuming litigation.

Under the existing WEPEX proposal, buyers and sellers will surrender substantial control over their scheduling, operating and profit decisions to the PX and ISO. Without forward prices, the operators of hydro, storage and other limited energy resources, and

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[18] The bidding and scheduling methods defined in this proposal can also be applied to real-time operation when communications and metering technology permit. Also, as such technology permits, the time between close of scheduling by the scheduling coordinators and the operation of real-time dispatch can be reduced, thus reducing the requirements for some kinds of ancillary services. Finally, the use of real-time prices to influence price-sensitive loads and generation can slowly be implemented.

regional utilities not in the PX will be unable to submit bids that make best use of their facilities. Buyers that are able to take advantage of hourly price information will not have sufficient time to plan. In some instances under the WEPEX proposal, sellers and buyers may have to submit a number of conditional bids in order to achieve their profit and operating objectives. Sellers that can offer a combination of energy and ancillary services will have to submit different pairs of quantities and prices for each hour.

Sellers and buyers who are reluctant to turn over their business decisions and confidential data will avoid using the PX process unless it is mandatory. Without sufficient participation, the PX will be unable to provide transparent, liquid spot markets in energy and ancillary services. All of these factors are likely to result in higher prices.

In our simplified proposal, the PX posts hourly energy and ancillary services prices for a full week of 168 hours. Sellers bid the quantities of energy and ancillary services that will minimize inefficiencies and will provide them with the greatest profit at the current posted market prices for each hour at their locations. Buyers will be able to determine what adjustments to make in their hourly consumption of energy in order to minimize their costs while considering a wide range of other factors such as production requirements and labor costs which often must be coordinated over many hours and days, or longer. All transactions will take place at agreed-upon prices between willing buyers and sellers. The PX will have a full week to balance supply and demand in each hour.

The price of energy for a given hour will evolve until the market for that hour is closed. As all of the market participants gain experience over time, we expect that most of the price changes will be the result of changes in expectations about loads due to weather and unplanned outages of generation and transmission.

Under this proposal, sellers with thermal generation will be able consider a number of important variables in their bid, including unit commitment costs, variable heat rates, minimum loads, ramp rates, co-generation steam revenues, geothermal steam contracts, fuel contract minimums and maximums, environmental restrictions and taxes, ancillary services revenues and any other factors important to their revenues, costs and operating constraints. With hourly prices for the full week ahead, sellers will find it easier to calculate bid quantities that maximize the difference between their revenues and costs while taking into account all of the information that is available to them.

Pumped storage, hydro system and geothermal operators, extra-regional sellers and others will be able to use the posted pool prices to maximize their profits by taking into account changing factors that a PX- or ISO-centralized schedule of their units (as in the WEPEX proposal) would ignore. Pumped storage operators will be able to determine the optimal combination of energy purchases during off-peak hours, and energy and ancillary services sales during on-peak hours. It will also be easier for pumped storage

operators to determine how much energy they should buy over the weekend and how much energy to hold in storage until later in the week. Hydro system operators will be able to balance flow and storage constraints and the interactions among hydro plants on the same river system to arrive at the most profitable use of those facilities.

Under this proposal, buyers and sellers will be able to use spreadsheets or computer programs to prepare their bids in a simple, straightforward way. Sellers that can provide both energy and ancillary services will be able to find the quantities of each that will both minimize inefficiencies and maximize their profits. Prices will be less susceptible to gaming so all participants will have confidence that they are paying or receiving a fair price. Access to markets with forward hourly prices for energy and ancillary services for the week will greatly simplify and improve all participants' decision making. Moreover, they will not have to prepare price bids that require complex marginal cost calculations as required by the proposed WEPEX bidding format. Under either proposal, the same basic technical information is required of generators and end-users for reliability and technical analysis.