

Needs For and Alternatives To

APPENDIX 5.2

**MISO Market Products, Operation and Locational
Marginal Pricing**

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MISO Market Products, Operation and Locational Marginal Pricing

MISO Market Electricity Products

Midwest Independent Transmission System Operator, Inc. (MISO¹) operates a wholesale market for electricity products. It is a wholesale market because the products are bought and sold in bulk, and when bundled together they can be resold to retail load. The participants in the MISO market are not generally the end-use or retail customers of electricity. There are three types of physical power products that are traded in the market: energy, generation capacity and ancillary services and there are specific market rules pertaining to each product.

Energy is the primary product in the MISO power market and the units of trade are MWh (megawatt-hours). A 100 MW (megawatt) generator operating for one hour produces 100 MWh of electricity. MISO sets the market clearing price, schedules the operation and dispatches the generator, sells the power on behalf of the owner of generator, purchases the power on behalf of the load serving entity and settles the account with both parties at the market clearing price.

MISO also operates a capacity market where generators can sell surplus capacity and load serving entities can purchase any shortfalls in capacity they have. Capacity is defined as the maximum output of an electrical generator and is measured in MW.

Load serving entities are required to have sufficient capacity resources available to meet their expected peak demand plus a prescribed planning reserve margin to allow for generation outages and load forecast uncertainty. These capacity resources are actual, physical generation units that are available to operate at the time of peak electricity demand. Although a load serving entity may acquire capacity through a contract, ultimately that capacity is backed by “iron in the ground”.

¹ As of April 1, 2013 MISO is now known as the Midcontinent Independent System Operator.

Pricing for new capacity is related to the fixed annual costs of the generator. At present a combustion turbine is likely the lowest capital cost option (although not the lowest operating cost) for new additional capacity. The annual fixed costs of such a combustion turbine represent the upper end of the market value of new generation capacity. Given the long lead times to permit and construct new capacity resources, load serving entities are not necessarily able to perfectly match their capacity resources to their requirements. MISO's capacity market allows those market participants who have surplus capacity to sell to the load serving entities that need to top up their capacity needs in the short term.

The third MISO market is for ancillary services. These services are necessary to maintain moment by moment control and maintain the reliable operation of the interconnected transmission system. The MISO ancillary services market is for two types of products, regulating reserves and contingency reserves. Regulating or frequency response reserves are intended to help balance the minute to minute load variation on a power system. A slight excess of generation over load will cause the system frequency to speed up very slightly. In response generators providing regulating reserves would be adjusted down to restore the target 60 Hz frequency used in North American power system. The quantity of generating units assigned to provide regulating reserves is relatively small, approximately 1% of the load.

Contingency reserves are spare generation that is ready to be called into operation should a currently operating generator stop generating unexpectedly. A portion of contingency reserves must be ready to pick up load immediately and a portion of the reserves must be available to pick up load within 15 minutes. MISO carries a total of 2,000 MW of contingency reserves at all times. All generators within the market footprint, and external asynchronous resources, which include power supplied through Manitoba Hydro's High Voltage Direct Current (HVDC) system, can offer energy or ancillary services into the MISO market. While ancillary services are an important part of operating a reliable power system, they are a relatively minor part of the overall electricity cost representing less than 2% of the value of the energy market.

MISO Market Operations

MISO operates two energy markets for energy and ancillary services, and facilitates a market for generation capacity. The two MISO operated energy and ancillary product markets are the Day-Ahead Energy and Ancillary Services Market (DA) and the Real-Time Energy and Ancillary Services (RT) Market. MISO facilitates the market for generation capacity, also known as the MISO Resource Adequacy Market, through its resource adequacy requirements for load, the tracking of bilateral capacity transactions, and through the MISO Voluntary Capacity Auction (VCA) for generation capacity.

Manitoba Hydro has two options for buying and selling capacity and energy into the U.S. market. It can engage in bilateral sales transaction for energy and capacity with other MISO market participants. Or as an external market participant it can participate in the MISO Day-Ahead and Real-Time energy markets and can sell surplus generation capacity into the MISO Voluntary Capacity Auction (VCA).

The Day-Ahead Energy and Ancillary Services Market is designed to set up a financially binding operating plan for the next day based on demand and supply offers from available generation. In the day-ahead market, MISO determines the market clearing price for energy and ancillary services for each hour of the upcoming day using the security constrained economic dispatch process outlined in section C of this Appendix. During the actual operating day, the real time market operates; again using the security constrained economic dispatch process, using actual system conditions and updated generation supply to calculate real time energy and ancillary service product prices.

The real-time market is designed to serve as the true-up mechanism between quantities of energy cleared in the day-ahead market and actual real-time system conditions. A market participant which exactly forecasts its demand and generation output for the Day Ahead market will settle its transactions based on the day ahead price for each hour. To the extent there are inevitable deviations from the day ahead quantities due to load variation from forecast or

unscheduled generation outages, the deviations from the day ahead plan will be settled at the real time price. RT prices are more volatile than DA prices due these variations from forecast, but over the long run the prices in the DA and RT markets are not significantly different.

The MISO energy and ancillary service markets are an efficient and transparent mechanism for Manitoba Hydro to sell surplus energy or provide for imports. Given the price volatility of these spot markets market participants may choose to fix prices under forward bilateral contracts. The MISO market design allows for bilateral contracts between buyers and sellers, enabling them to freely negotiate and agree to in advance, the terms and prices for energy. Parties to a bilateral contract must notify MISO of the energy quantity and duration of the contract, and then a settlement for the energy occurs directly between the two bilateral contract parties, rather than with the MISO market.

The MISO Resource Adequacy Market, also referred to as the MISO capacity market, is primarily a bilateral market based on the MISO's resource adequacy requirements. For the upcoming planning year, each load serving entity must forecast its peak load to MISO. They are then obligated to have sufficient generation capacity to meet this peak load plus a planning reserve margin as determined by MISO. Generators can sell the maximum output of their plant (capacity) to the load serving entities under bilateral contracts – which are tracked by MISO to ensure sufficient capacity is purchased. To the extent the load serving entity needs additional capacity MISO operates a VCA for the sale and purchase of capacity for the upcoming planning year. However, as most capacity is sold under long-term supply contracts, on a percentage basis relatively little volume actually clears in the VCA.

Energy Price Formulation in the MISO Energy Market – Locational Marginal Price

MISO utilizes a complex computer system called security constrained economic dispatch to calculate market prices each hour in the Day Ahead and Real Time energy markets. Security constrained means that the dispatch of generation must observe system limits such as

transmission line capacities and ancillary service requirements when selecting which units to operate.

MISO accepts offers to generate power from each generator available within the market footprint, and from adjacent external market participants including Manitoba Hydro. As of July 2012 there were about 6000 generators within the MISO market footprint, with a total generation capacity of over 131,000 MW eligible to offer power into the MISO energy markets. MISO collects the offers to generate, and selects from them from lowest to highest price until it has sufficient offers to meet the load for that period. In the Day Ahead market the dispatch period is one hour. In the Real Time market the period is five minutes. The selected generators are dispatched or instructed to operate. MISO calculates the market clearing price for the energy market for each period as the value of the last offered accepted to meet the current load, as illustrated in Figure 1.

Figure 1. ILLUSTRATIVE MARKET SUPPLY CURVE

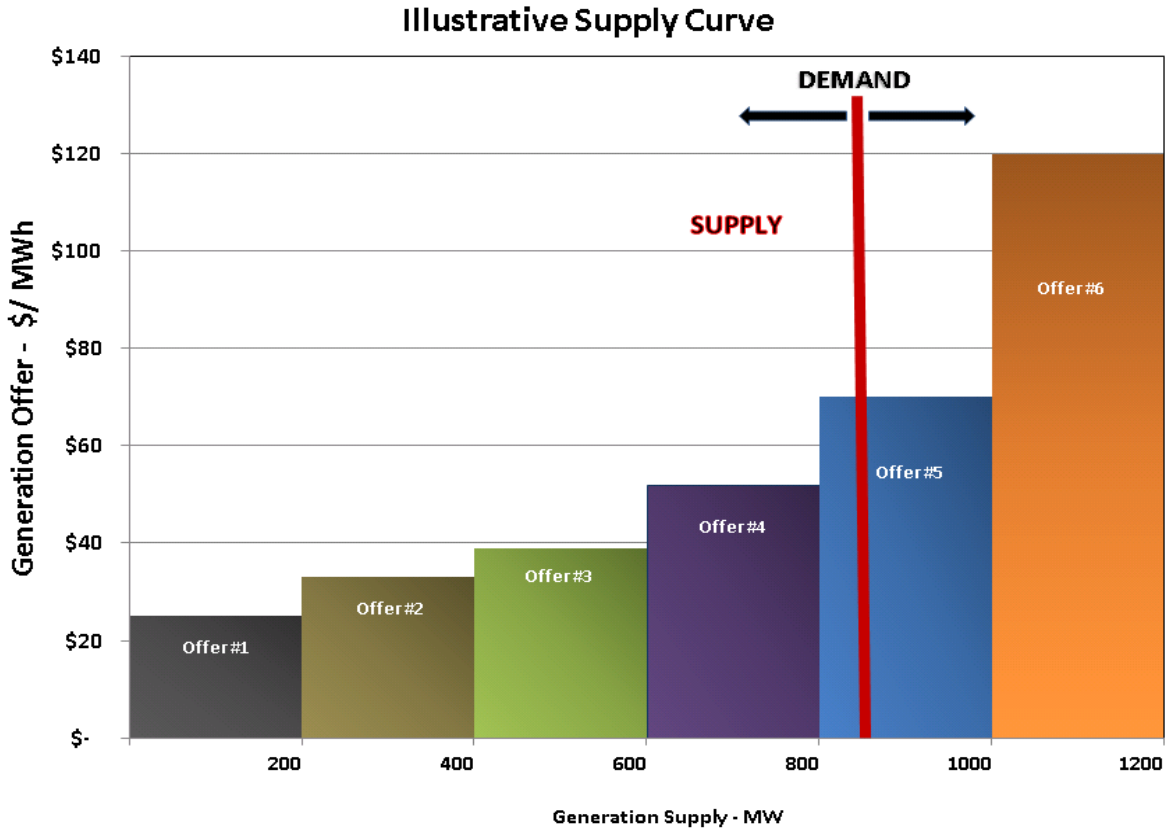


Figure 1 shows six illustrative offers from generators who each have a capacity of 200 MW. The offers are sorted by price, from lowest to highest and the market operator selects or dispatches sufficient offers each hour to meet the current demand or load. In this example, the market clears at \$70/MWh, the value of the highest offer selected. Offers #1 through #5 are all necessary to meet the demand of about 850 MW, and each would be paid the market clearing price established by Offer #5. Offer #5 is referred to as the marginal or price setting generator, and would be partially dispatched in this example to the extent the load is greater than 800 MW. Note that the demand can and will vary in a power system from hour to hour. In this example, should the demand drop by 200 MW, Offer #5 would no longer be required to meet the load and Offer #4 would be the marginal generator, and the market price for energy would drop to \$50/MWh.

Actual MISO market price calculations involve offers from thousands of generators and are considerably more complex. Thermal generators can have lengthy startup and shut down times, and these must be considered in the dispatch. There are transmission lines losses to be accounted for. Security constraints including transmission line loading limits must also be observed. When there is insufficient transmission to deliver all of the lowest cost power to the load, the transmission line is said to be congested. The market operator will then dispatch an alternate and more expensive generator located such that it will not cause the transmission line to overload. The costs of line losses and of redispatching for transmission congestion cause the price of electricity at different locations on the power system to be different. This type of pricing is known as locational marginal pricing (LMP) and it can serve to devalue remote generation unless sufficient transmission is available to deliver the generation to load.