POTOMAC ECONOMICS

Simulation of Real-Time Co-Optimization of Energy and Ancillary Services for Operating Year 2017

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Independent Market Monitor
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1. Introduction

Potomac Economics, the Independent Market Monitor ("IMM") for the wholesale market in the Electric Reliability Council of Texas, Inc. ("ERCOT") region, provides this report in response to the discussion at the open meeting of the Public Utility Commission of Texas ("Commission") on October 26, 2017, directing ERCOT and the IMM to assess the expected benefits of the potential implementation of Real-Time Co-optimization ("RTC") of energy and Ancillary Services ("AS") in the ERCOT wholesale electricity market. In this study, the IMM used the actual offers and commitment status of resources in ERCOT (along with other information not considered Protected Information under the ERCOT Protocols) for operating year 2017 to simulate the effect RTC would have had on dispatch, prices, costs, and system conditions under the assumption that market participant behavior remained unchanged.

Key findings from the simulation include:

- A significant reduction in production costs (as measured by offer curves) to serve load ($11.6M);
- A significant improvement in system reliability due to reduced overloading of network constraints and reduced use of Regulation Up Service ($4.3M);
- A significant reduction in system congestion costs ($257M);
- A significant reduction in AS costs ($155M): and
- A significant reduction in energy costs ($1.6B or approximately $4/MWh).

2. Simulation Method and Assumptions

The IMM simulated RTC for operating year 2017 using open source tools (python, CVXOPT, and MIPCL-PY) and a combination of published and publishable (i.e., information not considered Protected Information under the ERCOT Protocols) data including, but not limited to, 60-Day Security Constrained Economic Dispatch ("SCED") Disclosure Reports, binding constraints, and shift factors to model changes in market results if RTC had been used to allocate reserve capacity. The simulation program code, data, and use instructions are published at http://www.ercot.com/mktinfo/rtm/immtool.

The IMM used the following assumptions and methods in its simulation:

- Offers remained constant (SCED step 2 offers as published in the 60-Day report);
- Commitment remained consistent (the simulation used the status of each resource as published in the 60-Day report);
- If a resource had provided a particular AS in the trailing twelve months, it was considered qualified to provide that service in real time with an assumed offer of $0/MWh;
- AS provided by load and offline resources were held constant and not co-optimized;
- Regulation Down Service awards were held constant and not co-optimized;
- Each interval was simulated individually, with no dependence upon the results of previous interval simulations;
- If a resource was awarded Responsive Reserve Service (RRS), any Non-Frequency Responsive Capacity (NFRC) was subtracted from its high limit;
    - NFRC was determined as either the telemetered NFRC (if the resource was originally carrying RRS), or the highest value of High Sustainable Limit (HSL) – RRS – Regulation Up – High Ancillary Service Limit (HASL) recorded in the trailing twelve months);
- Only the 35,040 intervals that were previously published in the 60-Day reports were simulated and the results were extrapolated to the intervals that were not published;
- AS awards followed the requirements as outlined in *Ancillary Service Market Transactions in the Day-Ahead and Real-Time Adjustment Period* Business Practice Manual;
- Production costs, congestion, reliability, and energy prices were compared to simulations of the current real-time market (SCED) to reduce effects of possible data errors; and
- The results of the simulation using open source tools were compared to the results of a simulation run by ERCOT using similar assumptions performed using proprietary software (SAS). Of the 35,040 intervals simulated, 34,946 produced results that were

virtually indistinguishable[1] in both simulations; only those intervals are included in the results presented in the next section.

3. Simulation Results

3.1. Production Cost Savings

The main feature of RTC of energy and AS is the resulting movement of reserves away from low cost resources that can efficiently produce energy and towards higher cost resources. The amount of savings that energy producers would realize by having their reserves and energy co-optimized is an important metric in deciding whether RTC is worth the implementation costs. Although there is no granular public information regarding the production costs of each resource in ERCOT, all of the offers for 2017 have been published in the 60-Day reports. Assuming that resource offers are competitive and therefore reflective of its marginal costs, a resource's production cost is determined by its start-up offer, its minimum run offer, and the area under its offer curve (more precisely, the value of its offer curve integrated from the low limit to the dispatch level.) Because commitment decisions in this simulation remained unchanged from actual commitment decisions in operating year 2017, the start-up costs and the minimum runs costs are not affected by RTC and can be ignored. With the ability to move reserve capacity away from less costly resources and towards more expensive resources, however, the IMM estimates that the production costs for 2017 would have dropped by $11.6M with RTC.

Because the simulation assumed that commitment remained constant, this estimate of production costs savings is likely lower than what would be expected. Prices would be lowered by RTC leading to resources being less likely to commit, thus forgoing start-up costs and minimum run costs and further increasing the production cost savings. The IMM has made no attempt to quantify this effect.

[1] "Virtually indistinguishable" intervals met the following three criteria: 1). SCED objective functions within $1000, 2) RTC objective functions within $1000, and 3) SCED system lambdas within $10.

3.2. Reliability Improvements

Two features of RTC of energy and AS that can improve reliability are:

1. The movement of reserves away from – and energy production to – locations that need more energy to reduce overloading of constraints; and
2. A more efficient use of ramping capability and non-frequency responsive capacity to reduce the reliance on Regulation Up Service during scarcity.

3.2.1. Network Overloading Reductions

Current market design will move energy production to prevent network constraints from exceeding their limit as long as the cost of doing so remains below a dollar amount that varies by voltage level (the shadow price cap). A monetary metric for the reliability improvement of reducing or eliminating constraint overloading is the amount of overload reduction multiplied by the shadow price cap for that constraint.

3.2.2. Reduced Reliance on Regulation Up Service

By more efficiently assigning RRS, and thus more efficiently deploying NFRC, as well as by more efficiently using the ramp capacity available in the system, RTC reduces the amount of Regulation Up Service used to serve energy via the Power Balance Penalty Factor mechanism.

3.2.3. Total Reliability Effect

The total effect on reliability for 2017 seen with RTC was an improvement of $4.3M.

3.3. Congestion Cost Reduction

The geographical movement of energy and reserves discussed above in Section 3.2.1 would also have reduced real-time congestion in a similar way to how it reduced network constraint overloading. The geographical movement of reserves and energy in the 2017 simulation of RTC reduced congestion costs, as measured by the shadow price of the constraint multiplied by the flow on the constraint, by $257M, a 26% reduction.

3.4. Ancillary Services (AS) Cost Reduction

Allowing AS to be provided from all of the available reserves in the system, rather than just those offered in the day-ahead market, significantly increased the supply of reserves and produced a significant reduction in the price of AS. Also, without the risk components inherent in offering products in the day-ahead market, the offer prices for reserves were $0/MWh.

To measure the reduction in AS costs, the IMM compared the day-ahead prices of Non Spin Reserve Service, Responsive Reserve Service, and Regulation Up Service and multiplied them by the quantities originally provided by online generation resources. The IMM then compared that amount to the prices generated by the RTC simulation multiplied by the same quantities. The increased supply and lowered offer prices in the simulation lowered the amount of money spent on AS by $155M.

Because the simulation assumed that commitment remained constant, this estimate of AS cost reduction is likely higher than expected outcomes. RTC is expected to lower prices leading to resources being less likely to commit, thus reducing the amount of reserve capacity online and offered into the market, ultimately reducing the amount of the price decrease. The IMM has made no attempt to quantify this effect.

3.5. Energy Cost Reduction

Energy prices were significantly reduced in the RTC simulation for the following reasons: 1) energy production was shifted away from higher cost units and toward lower cost units, 2) energy production was shifted geographically to relieve congestion, and 3) energy and reserves were shifted to improve use of units' NFRC and ramping capability. As a result, in a year with relatively few occurrences of scarcity pricing, scarcity pricing levels were eliminated and energy prices were reduced. The amount of price reduction, as measured by the average price paid by load (system lambda) multiplied by the total generation for each interval, was $1.6B, or approximately $4/MWh.

Because the simulation assumed that commitment remained constant, this estimate of energy price reduction is likely higher than would be expected. Prices would be lowered by RTC leading to resources being less likely to commit, thus reducing the amount of reserve capacity online and offered into the market, ultimately reducing the amount of the price decrease. The IMM has made no attempt to quantify this effect.

4. Conclusion and Recommendation

Substantial benefits can be achieved by implementing RTC of energy and AS. First, jointly optimizing all products in each interval allows AS responsibilities to be continually adjusted in response to changing market conditions. This is seen in the simulation for operating year 2017 in the substantial reduction in production costs, reliability improvements, and congestion, even under a set of conservation simulation assumptions. Second, RTC improves the accuracy of shortage pricing. Even in 2017, a year with high installed reserves, the simulation found that there were many intervals where the average load price was at a level which would imply scarcity. With RTC, however, the number of those intervals decreased significantly. In an energy only market that depends on scarcity pricing signals to provide incentive for proper levels of investment, it is important the scarcity pricing reflects actual scarcity rather than the inefficient assignment of reserve capacity.

The IMM has consistently and continually recommended implementation of RTC since the implementation of the nodal market.[2] ERCOT has estimated a total cost of $40M and a project duration of 4 to 5 years to implement RTC if the Commission decides to move forward with the implementation of RTC and after applicable Protocol changes have been approved by the ERCOT Board of Directors.[3] This simulation of RTC for operating year 2017, and in particular the projected production costs savings of $10M-$12M annually, provides quantitative evidence of the benefits and improved market efficiencies of RTC that more than justify the implementation costs. Therefore, we recommend the Commission and ERCOT move forward with implementation of RTC as expeditiously as possible.

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2 *See Proceeding to Consider Protocols to Implement a Nodal Market in the Electric Reliability Council of Texas Pursuant to SUBST R. §25.50.1*, Docket No. 31540, Direct Testimony of David B. Patton, Staff Ex. 1 at 23-28 (Nov. 10, 2005).

3 *Electric Reliability Council of Texas, Inc.'s Progress Report Regarding Real-Time Co-optimization*, Project No. 41837, at 5-9.