Draft White Paper on Over-supply and Shortage of Downward Ramping Supply in Off Peak Hours

Department of Market Monitoring

January 14, 2011

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1 Introduction

The ISO periodically experiences over-supply conditions in the real time market, most predominantly in hours 1 through 10. During these periods, the ISO must sell electricity to minimize the imbalance between injections (imports plus generation) and withdraws (exports plus load). In some periods, there is scarce or even insufficient decremental energy bids the real time market to accommodate the imbalance requirement. This often results in negative prices indicating that the over-supply conditions are severe enough that participants are being paid to reduce the amount of electricity put onto the ISO grid. In addition to creating operational challenges, this also results in low negative prices.

Integration of additional capacity from intermittent resources to meet the 20 percent and 33 percent renewable targets will increase further the need for dispatchable ramping capacity in the real time market. This study characterizes the frequency and extent of over-supply in the real time market and analyzes the potential for additional dispatchable ramping capacity to relieve this condition. The study focuses on periods of over-supply where the supply of downward ramping capacity was scarce and resulted in negative prices during 2010.

Our analysis suggests the following conditions are contributing to, or resulting from, over-supply conditions:

- The frequency of over-supply conditions in the 5 minute real time (RTD) market are concentrated in night time and early morning hours ending one through ten.
- Over-supply conditions are not generally foreseen during the Hour Ahead Scheduling Process (HASP), in which the final amount of hourly imports and exports are determined. This is reflected by the fact that prices in the HASP are significantly higher (and usually positive) compared to the negative prices occurring in RTD during these hours.
- On average, only about 200MW of additional downward capacity was needed to accommodate over-supply conditions. During 75 percent of these hours, the amount of additional decremental capacity needed to avoid over-supply was 300 MW or less. However, we can expect that value to increase as more intermittent renewable resources come on-line to meet the 20% and 33% RPS.
- The duration of over-supply conditions tend to last less than ten minutes (i.e. one or two five minute intervals) and are not concentrated in the first or last few intervals of an hour. This indicates that while the over-supply conditions are resolved rather quickly, inter-hour ramping is not a primary factor in creating this over-supply.
- The real time market is extremely inflexible in the early morning hours due to a high volume of self scheduling from both internal resources and the inter-ties which contributes to over-supply conditions.
- Almost 90 percent of imports are self scheduled; almost half of which are imports from day ahead schedules not re-bid in HASP. However, during hours of over-supply in the 5-minute real time market, there was a significant supply of imports/exports bids that could have been used to decrease net imports at non-negative prices significantly higher than the negative prices occurring in RTD due to over-supply.

- If the HASP market optimization was better aligned with RTD, potentially fewer imports and more exports would clear so that the real time market had more flexibility to accommodate over-supply conditions.

As noted above, a relatively small amount of additional downward ramping capacity would currently be required to relieve the problem of over-supply. Based on our analysis, there appears to be sufficient downward ramping capacity online during these hours that could be made available through offering economic bids instead of self scheduling. This additional downward capacity may come from a variety of sources:

- Multi-stage generation optimization (MSG), which was implemented in December, has the potential to reduce the degree to which combined cycle resources self-schedule to manage configuration changes once more resources opt for MSG designation. This could reduce amount of self-scheduled energy during these hours by up to 200 MW.

- Hydroelectric resources also self schedule a considerable amount during the off-peak hours. While there are flow restrictions and economic energy use plans that limit the extent of the flexibility of these resources, a few hundred MW of additional downward ramping capacity, from the 4,500MW of hydro energy that is self scheduled would mitigate a large portion of the downward ramp scarcity and resulting negative prices.

- Scheduling and dispatchability of wind generation within the ISO is another potential source of relief for the over-supply conditions. There is, on average, between 750 MW and 1,000 MW of wind generation scheduled during these hours. Half of this amount is not scheduled in the day-ahead market but does get scheduled in the real time market. This exacerbates the over-supply conditions in the real time (5-minute) market as the additional scheduled wind generation must be offset by further reducing the output of other generators. Aligning the day ahead wind schedules more closely with the hour ahead and final real time output would reduce the extent to which wind generation contributes to the over-supply conditions faced in real time. Being able to dispatch these resources in real time to respond to over-supply conditions would provide additional benefit.

Given the historical magnitude of deficiency in downward ramp, the additional flexibility from combined cycle units, additional offers from hydroelectric units, and more accurately scheduling wind resources could be enough to eliminate a majority of instances of this issue.

Real time over-supply conditions could also be reduced by better leveraging intertie resources in the HASP. Our analysis shows that divergence in the pricing between HASP and RTD could result in up to 200 MW of undispatched export bids that would clear at prices closer to the RTD price. Similarly, there are up to 500 MW of cleared import bids that would not clear if the HASP and RTD prices converged. Improvements made to the HASP market to better foresee over-supply conditions will help price convergence and help relieve over-supply conditions by reducing the amount of net imports cleared. A secondary item related to intertie schedules is that there is on average 5,500 MW of self scheduled imports. These schedules are protected in the market through a penalty bid price. As such, they are not subject to economic adjustment and are only adjusted when the market has exhausted all economic bids. This would only become important after the ISO achieved better recognition of ramping constraints in HASP.

Convergence bidding is scheduled to be implemented February 1, 2011 and has the potential to contribute to a short term solution. Virtual bids will attempt to profit from the price differences

between the IFM and RTD markets. Over-supply conditions are concentrated in the early morning hours, hours 1 through 10, reducing real time prices. Virtual bidders can profit from selling in the IFM and buying back in real time. Virtual supply sold in the IFM will displace physical generation; the RUC process will later commit enough physical generation to meet forecasted demand, however only the minimum load from those commitments will be scheduled as energy. The net effect could be reduced overall energy schedules in the off peak hours going into real time. Furthermore, the reduced physical generation procured in the day ahead have the potential to reduce self scheduling in real time by reducing the energy basis from the day ahead market that is not re-bid in real-time and therefore becomes self scheduled by default.

The market impacts of a shortage of ramping energy can be significant; however there appear to be alternatives for alleviating the shortage even in the short run. Under the current design, market impacts resulting from the over-supply conditions are limited to the real time 5-minute market. In the long run, as more renewable resources come online, the market will need additional flexibility to address the changes in imbalance due to intermittent generation. The ISO and stakeholders have been engaged in discussions regarding new products to address this need. Regardless of any new products that are developed, there appears to be a significant amount of additional flexibility that can be derived from existing resources through lower self-scheduling.

2 Low Off-Peak Prices From Over-supply

The ISO experiences over-supply conditions in the real time market, most predominantly in hours 1 through 10. During these periods, the ISO must sell electricity to minimize the imbalance between injections (imports plus generation) and withdraws (exports plus load). In some periods supply is greater than demand and there is scarce or even insufficient energy bid into the real time market in the downward direction to accommodate the imbalance requirement. This often results in negative prices indicating that the over-supply conditions are severe enough that participants are being paid to reduce the amount of electricity put onto the ISO grid.

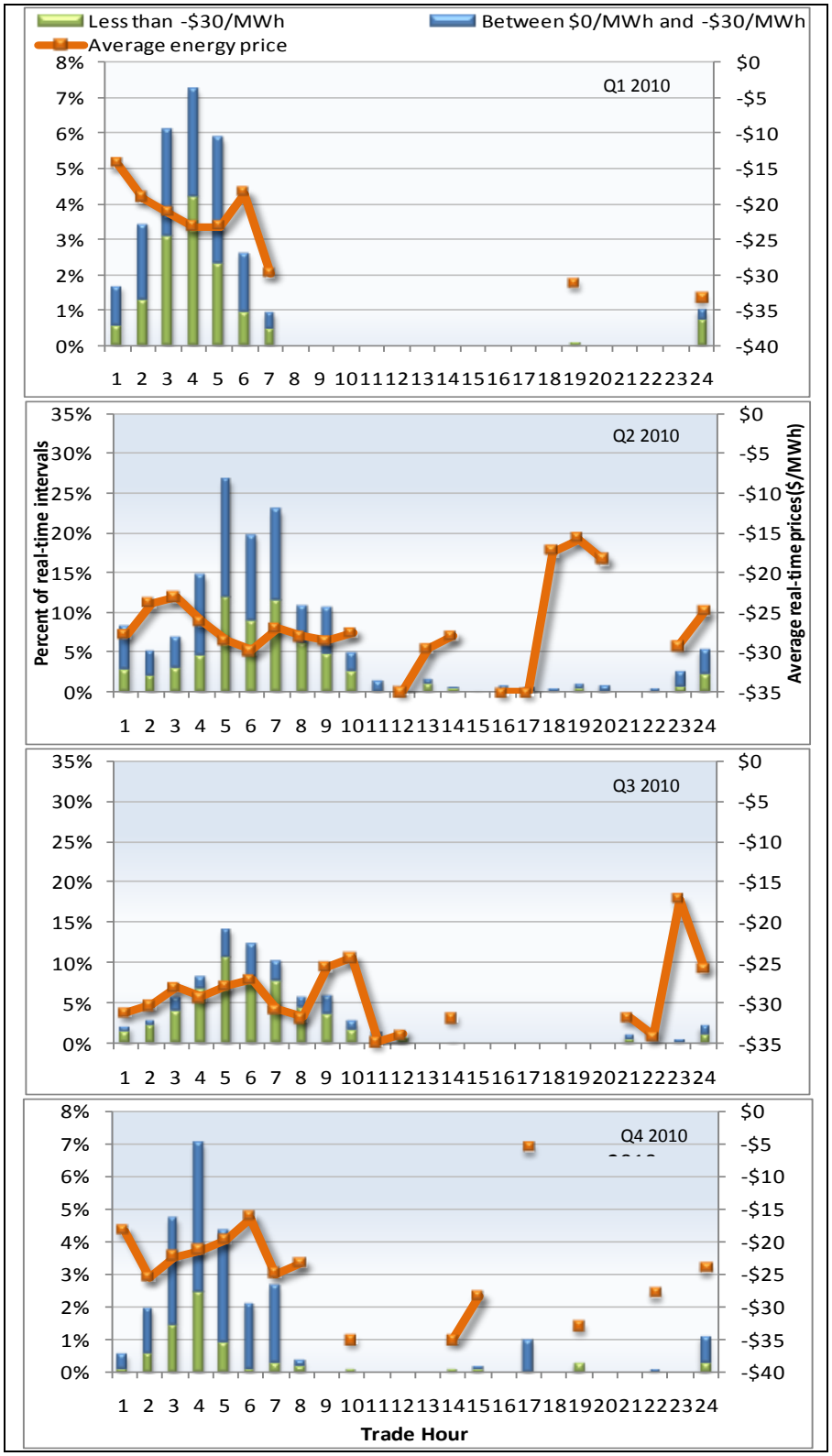
System energy prices between -$30/MWh (the current bid floor) and $0/MWh indicate the real time market had to dispatch negatively priced bids to meet load.[1] A price below the bid floor is indicative of intervals during which there was not enough dispatchable downward capacity to meet the imbalance requirement during over-supply. In this circumstance the market had to either cut self-scheduled power, violate the power balance constraint, and/or lean on downward regulation to counter over-supply conditions.[2] When ACE becomes positive, indicating over-supply conditions, the automated generation control (AGC) will send out downward dispatches every four seconds to units with regulation down until ACE recovers to zero. Throughout this section, the term “over-supply” will be used to indicate a 5-minute interval in the real time market during which the system energy price was zero or negative.

[1] A negative bid price indicates that a supplier is willing to take electricity from the ISO if they are paid to do so. For example, an internal generating resource that bids -$10/MWh is willing to reduce their output if they are paid $10/MWh to do so. For import bids, the supplier is willing to reduce the import quantity if paid $10/MWh to do so.

[2] The power balance constraint is a constraint in the market optimization that requires that supply is equal to demand. In cases of over-supply where the power balance constraint is violated, the market software is not able to reduce supply sufficiently to equal demand. When the power balance constraint is violated, a penalty price becomes effective in setting LMPs.

Figure 2.1 below shows the percentage of real time intervals during which the system energy component was less than or equal to $0/MWh, indicating an over-supply condition. The percentages are further segmented into intervals with system energy price between $0 to -$30 and prices less than -$30. In all quarters, the majority of prices at or below $0/MWh occurred in the early morning hours, more specifically hours one to ten. The first quarter of 2010 had the lowest frequency of real time intervals less than or equal to $0/MWh with a maximum of 7.5 percent during hour 4. The second quarter had a maximum frequency of 34 percent in hour 5, and the third quarter fourteen percent in hour 5. The increase in intervals during the second quarter is due in large part to the seasonal increase in low priced electricity hydro units both in California and northwest that result from the spring snow melt. Approximately seven percent of intervals in hours one through ten of Q3 had energy prices less than or equal to $0/MWh. The majority of Q3 negative prices were below -$30/MWh indicating a violation of the power balance constraint, thus more negative prices on average. The last quarter had fewer instances of over-supply conditions, on average 3 percent of real time intervals, which were concentrated in hours one through seven.

Figure 2.1 Frequency of real time intervals with system energy price less than or equal to $0/MWh and corresponding average prices

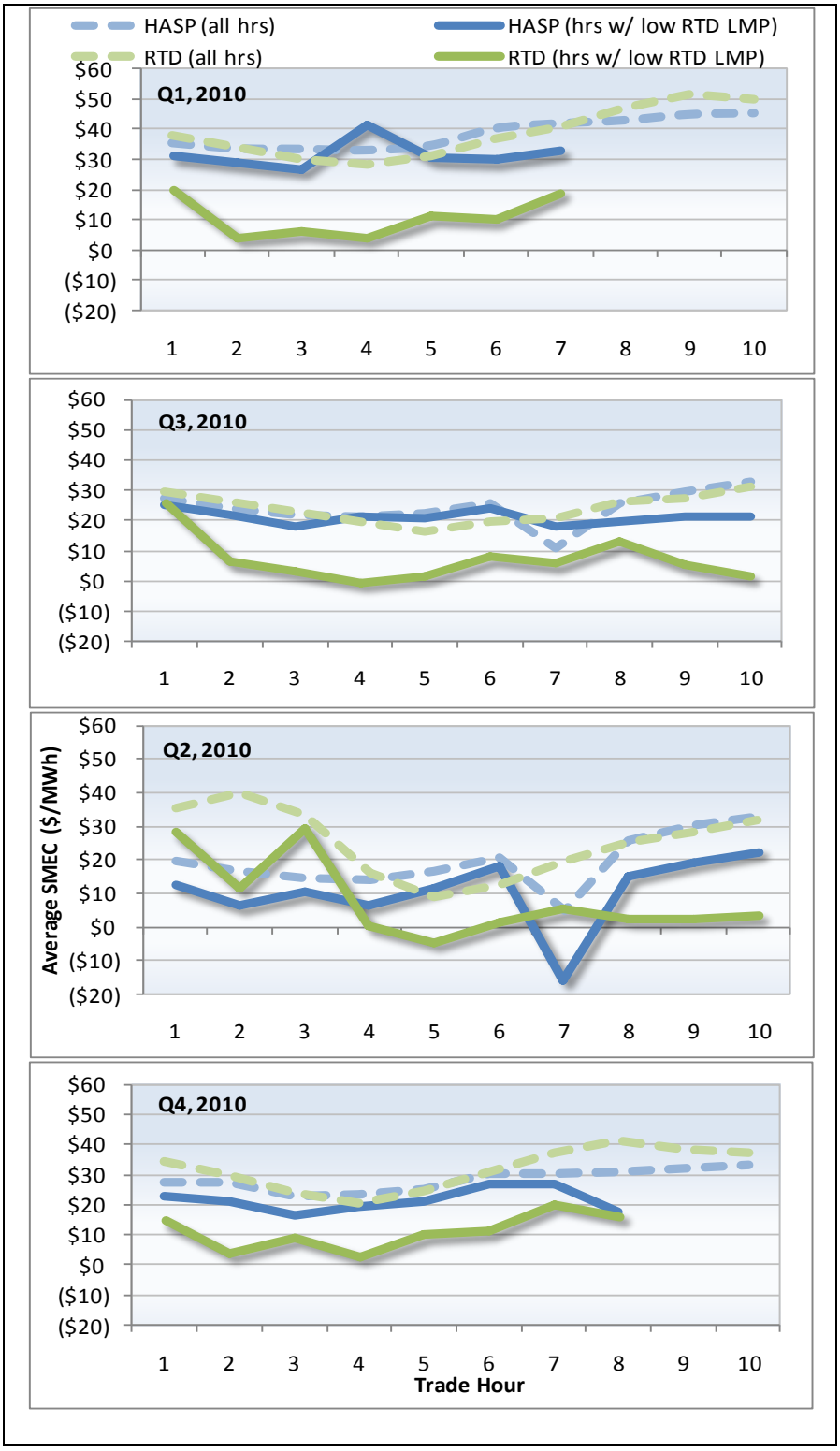


The impacts of over-supply in the 5-minute real time market can create significant price divergence between the hour ahead intertie market and the 5-minute dispatch market, despite the similar supply and demand conditions faced by each. Figure 2.2 compares the average hourly system energy price of the HASP and RTD markets for all hours as well as only hours where there was over-supply in the 5-minute market. The average prices in Figure 2.2 highlight two main points.

- First, over-supply and a shortage of downward ramping energy to address it have a significant downward impact on the 5-minute RTD price. Electricity is relatively inexpensive during these low-demand hours across all hours, however during hours where downward ramping energy is scarce the price is significantly lower.
- Second, while HASP and RTD prices are consistent when measured across all hours, they diverge significantly during hours of over-supply, indicating the scarcity of downward ramping electricity is not recognized by the HASP market.

Positive HASP prices will 1) clear import bids at or below the HASP price as they are willing to sell energy to the ISO for at least the bid price, and 2) only clear export bids above the HASP price because they are willing to buy energy at or below the bid price. The higher the HASP price, the more imports and the fewer exports are cleared, with a net effect of more imports (supply). Because the HASP price is significantly higher (and positive), there is opportunity to clear additional export and fewer import intertie bids that will help resolve the over-supply situation in HASP before the RTD is forced to manage it. This is quantified in Figure 4.3 and discussed in Section 4. Another consequence of the divergence between HASP and RTD is the imbalance charge that results from the ISO buying imports it may not need at a positive price in the HASP and then paying generators to reduce output in the RTD market to compensate for that over-supply. The resulting difference in cost is charged to schedule coordinators with uninstructed energy and to load.

Figure 2.2 Hourly average system energy cost for HASP and RTD[3]



[3] Average prices are calculated across hours where the RTD market exhibited over-supply as indicated by any RTD interval where the system energy price was less than or equal to $0/MWh.

3 Amount of Deficiency in Downward Ramping Capability

To provide an indication of the magnitude of the over-supply conditions are in terms of deficiency in downward ramping capacity, Figure 3.1 shows the average, 75thpercentile, and 90th percentile of ramping shortage by hour for each quarter of 2010 as well as the percentage of real time intervals included in the sample. The median magnitude of ramping shortage ranges between approximately 100MW and 250MW, suggesting that the half intervals with ramping deficiency and low prices could be avoided with minimal amount of additional downward ramp available to the market. On average across all four quarters, the market would only need an additional 300MW of downward ramping capacity to reduce the amount of over-supply conditions by 75 percent and 645MW to accommodate 90 percent.

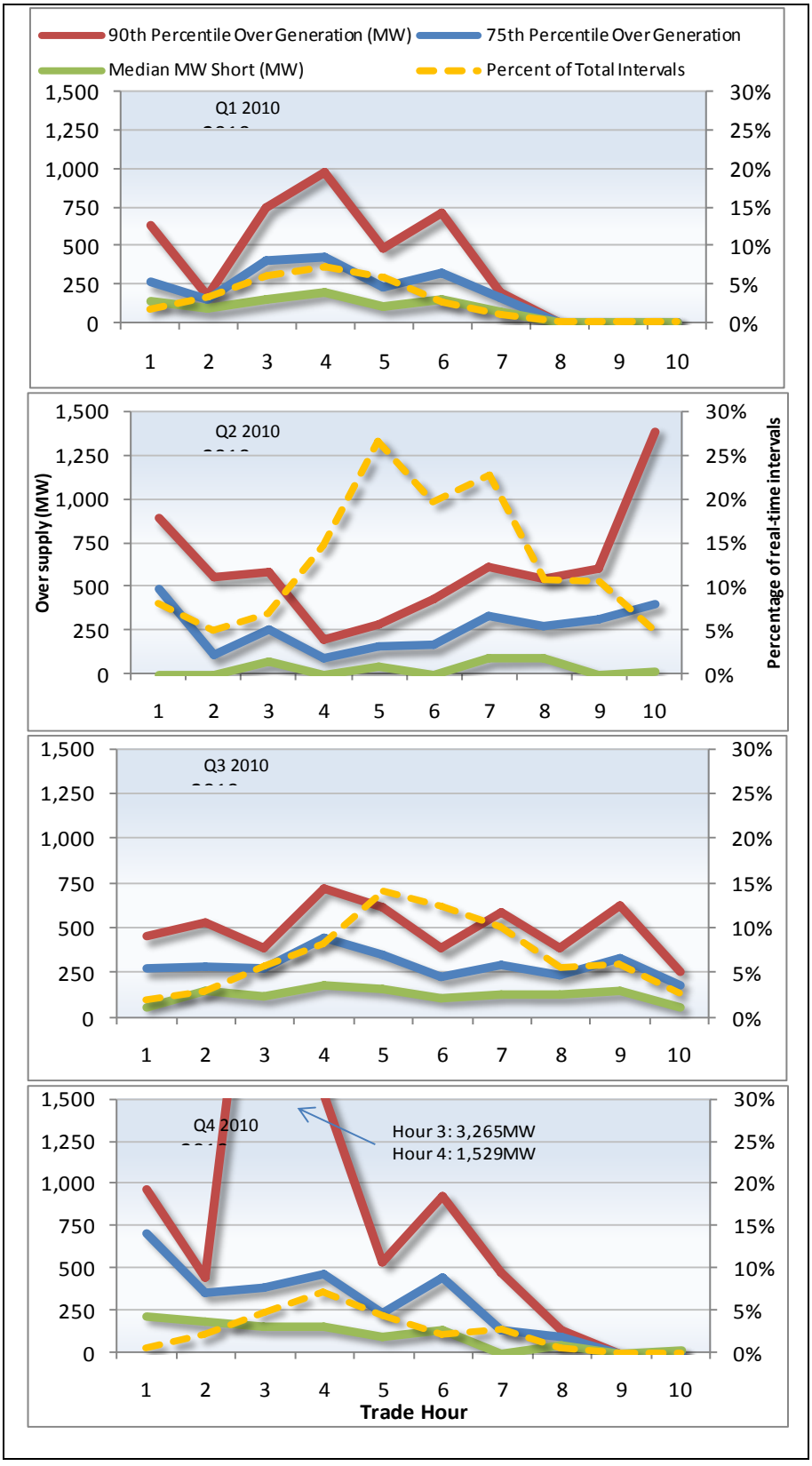
- In Q1, the percentage of intervals with negative prices was relatively low compared to the other two quarters, at the highest 7.5 percent, and the excess MW averaged around 250MW. In this quarter, there were no intervals in hours 8 through 10 with negative prices.

- Q2 and Q3 had an increase in the frequency of intervals, topping out at about 16%. Even though the frequency increased, the average excess MWs during the last two quarters still remained around 250MW.

- Q4 had few over-supply conditions, similar to that of Q1. Hour 9 had no instances of over-supply and only one interval in hour 10. The median remained well below 250MW in almost all hours and the 75th percentile less than 500MW with the exception of hour 1. The 90th percentile for hours 3 and 4 were 3,265MW and 1,529MW respectively. This is due to few intervals during those hours with energy prices $0/MWh or less but some extreme outliers pulling the 90th percentile up. Again, despite some 3 outliers, on average across all quarters the 90th percentile was 645MW.

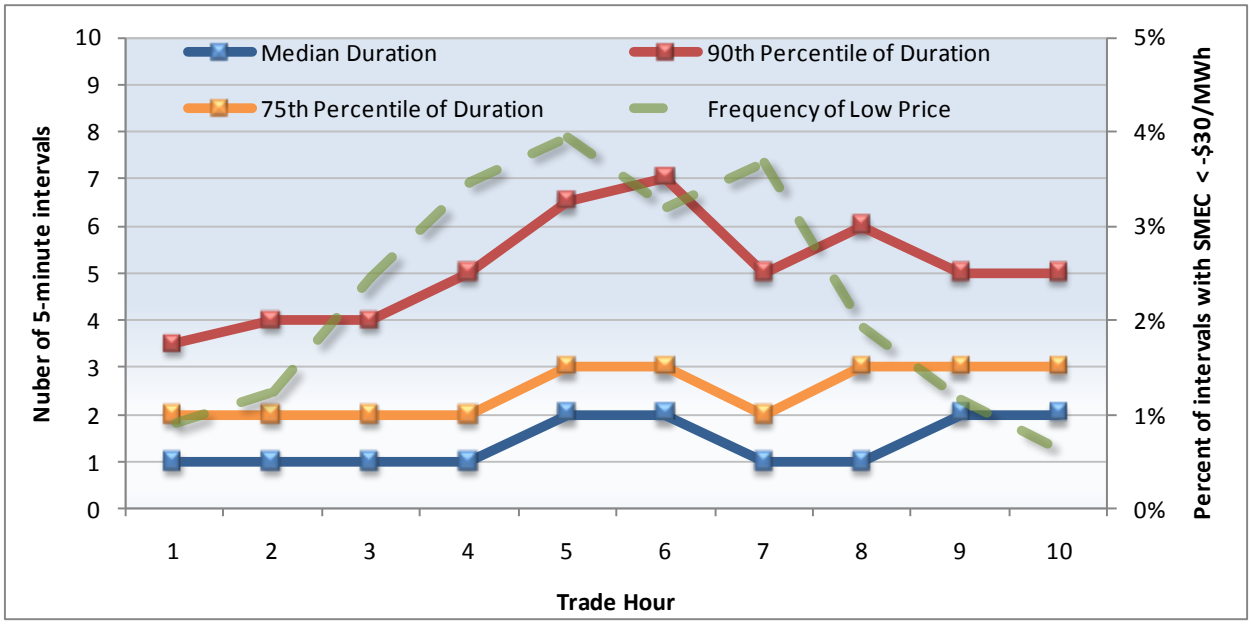
In summation, if there were 300MW of additional downward dispatchable capacity, the frequency of over-supply conditions would be reduced by approximately 75 percent. That doesn't necessarily mean there will be 75 percent fewer negative prices; a unit bidding in negative prices may be dispatched to eliminate the over-supply condition and set a negative price. It does, however, mean that the frequency of power balance constraint violations and more extreme negative prices would decrease by 75 percent.

Figure 3.1 Magnitude of over-supply conditions by hour



Another indication of the extent of the shortage in downward ramping capacity is the duration of sustained system energy prices below -$30/MWh, which is shown for all quarters in 2010 in Figure 3.2. The median duration of these low prices is between two and three 5-minute intervals, or ten to fifteen minutes, indicating the shortage of downward ramping energy is relatively short-lived. During most hours, 90 percent of the price spikes below -$30/MWh are five intervals long or less. This, along with the degree of deficiency shown in Figure 3.1, indicate that the solution to this issue requires only a small to moderate amount of relief in the form of lower scheduling or additional downward ramping capacity to be exercised for short periods of time.

Figure 3.2 Duration of system energy cost less than -$30/MWh – Q1 through Q4, 2010

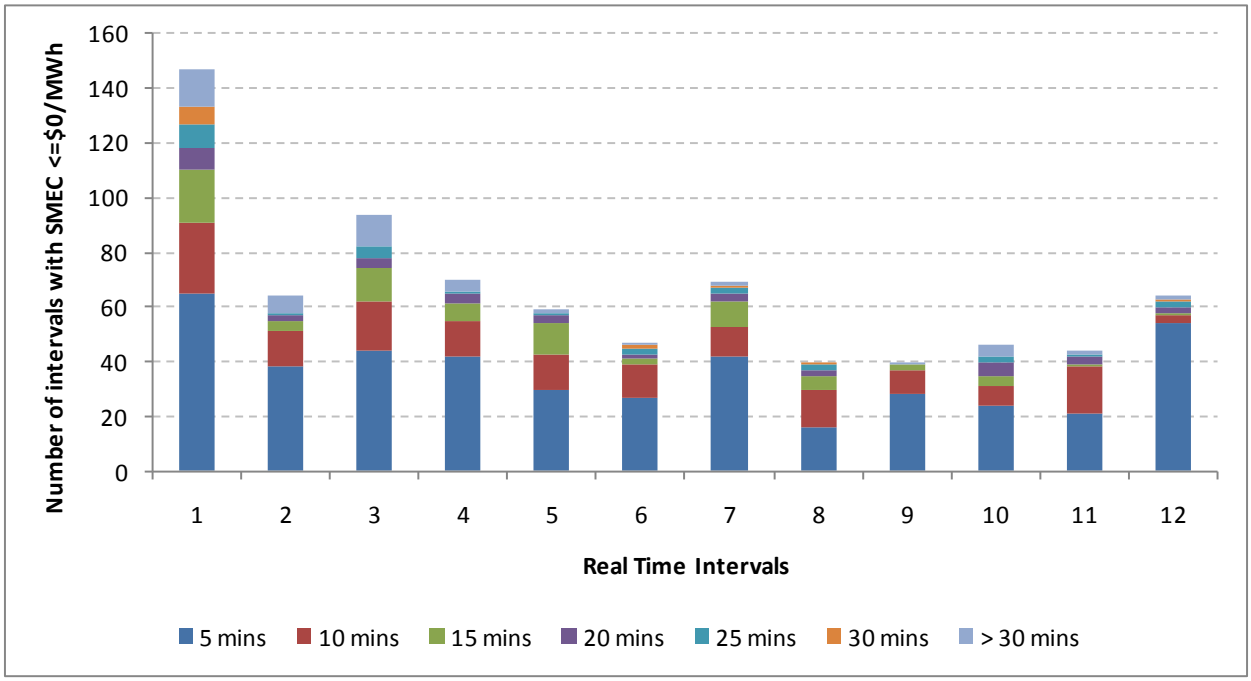


Inter hour ramping is modeled differently between the HASP and RTD market runs. The HASP market assumes an immediate drop off or pick up of generation between interval 4 in one hour and interval 1 in the proceeding hour. In the five minute RTD market, generation is modeled as ramping down over twenty minutes. The ramp starts ten minutes before the end of one hour and finishes 10 minutes after the start of the subsequent hour. When generation is dropping off from one hour to the next, the real time market will have more generation in the first one or two intervals of the next hour compared to the first HASP interval. The difference in modeling may result in over-supply conditions in the first one or two five minute intervals of the real time market.

Figure 3.3 shows the number of intervals with system energy prices $0/MWh or less by interval and duration. If an over-supply condition lasts for 15 minutes, or three 5 minute real time intervals, the first interval in which the condition began is counted as a 15 minute over-supply condition. There is not a significant trend of when over-supply conditions begin, indicating that while the difference in modeled ramping may contribute, it is not a key factor in over-supply conditions. We would assume that if

modeled ramping were the key factor, the majority of over-supply conditions would start and end in the first two 5 minute real time intervals.[4]

Figure 3.3 Duration of system energy cost less than -$30/MWh by interval – Q1 through Q4, 2010



4 Factors contributing to over-supply and low off-peak prices

Several factors contribute to over-supply conditions. One major cause of over-supply is when most or all of the internal generating units that are online are operating at their minimum operating point. This may be the unit's minimum load, or a higher value on their output curve as determined by downward ramping capabilities, forbidden regions, minimum operational levels related to ancillary service provision, or self scheduled output levels. These factors all limit the amount of available downward capacity from the fleet of units that are online. As seen in Figure 2.1, over-supply occurs more frequently during the morning hours.

Renewable resources are another contributing factor in over-supply. Renewable resources are not required to schedule in the day-ahead market, thus the real time market picks up the forecasted generation in the hour-ahead scheduling process (HASP). The additional generation forecasted in the real time market is submitted as self schedules, adding to the inflexibility of the real time market at a time when it cannot de-commit other resources and has limited ability to move down. Had these resources scheduled in the day-ahead market, it would have displaced other physical resources, thus not

[4] The analysis was also done counting each interval during which the over-supply condition existed. For example, a 15 minute over supply condition starting in interval 2 and ending in interval 4 would be counted as a 15 minute duration in all three intervals. This method of counting led to a flatter trend that what is shown below, further emphasizing that inter-hour ramp modeling is not the main factor.

adding to the inflexibility in real time. Furthermore, the actual generation in the real time market can vary significantly from the hour-ahead forecasted generation by a few hundred MW, most notably in the late and early morning hours when over-supply conditions are more likely. As more renewable resources come online over the next few years, over-supply conditions will most likely increase if current scheduling practices remain unchanged.

During Q3 of 2010, the majority of over-supply conditions occurred in the early morning hours, more specifically during hours one to ten, in the real time 5 minute market. Of those intervals, the majority of downward capacity from internal resources is due to self scheduling and minimum operating points. The market prefers to violate the power balance constraint, i.e. allow generation to be greater than load, than cut self schedules because self schedules are protected with extremely negative penalty prices. Therefore when most of the downward capacity online is self scheduled, the dispatchable downward capacity is limited resulting in over-supply conditions; the real time market run cannot de-commit units therefore the minimum operating points cannot be decreased in the 5 minute market runs.

Capacity from the ties is also mainly self scheduled imports in the real time market, approximately 45% of which is self scheduled in the day-ahead market and not re-bid in HASP. Furthermore, the HASP market does not foresee over-supply conditions and thus clears positively priced import bids which adds to the amount of non-dispatchable generation in the real time market and contributes to price divergence between the two real time markets.

Overall, the market does not have sufficient dispatchable downward capacity due to the amount of self scheduled internal generation and imports to avoid over-supply conditions in the early morning hours. In addition, the frequency and magnitude of over-supply is likely to increase as more renewable resources come online due to the inherent unpredictability and timing of generation of those resources, most notably wind.

There are two main contributing factors to the magnitude and frequency of over-supply conditions, inflexible schedules from both internal resources and inter-ties and limited downward ramping capability. Schedules are considered inflexible when they are protected in the market by an extreme negative penalty price, such as self schedules. As previously noted, and shown in Figure 4.1 shows the total downward capacity from internal resources over 60 percent is due to self schedules and 30 percent due to minimum operating limits. Thus only 5 percent, or on average 300 MW, is economically bid in from internal resources providing the market with some flexibility. Reducing the amount of self scheduled capacity from internal resources would help alleviate over-supply conditions.

Interties also contribute to the inflexibility of the real time market during these intervals. Imports add to the amount of generation on the system and limit the amount of downward ramp. The 5 minute real time market sees cleared imports, which are cleared in HASP, as protected self schedules. Furthermore, if imports were bid in economically in the HASP rather than self scheduled, the HASP market may clear fewer imports.

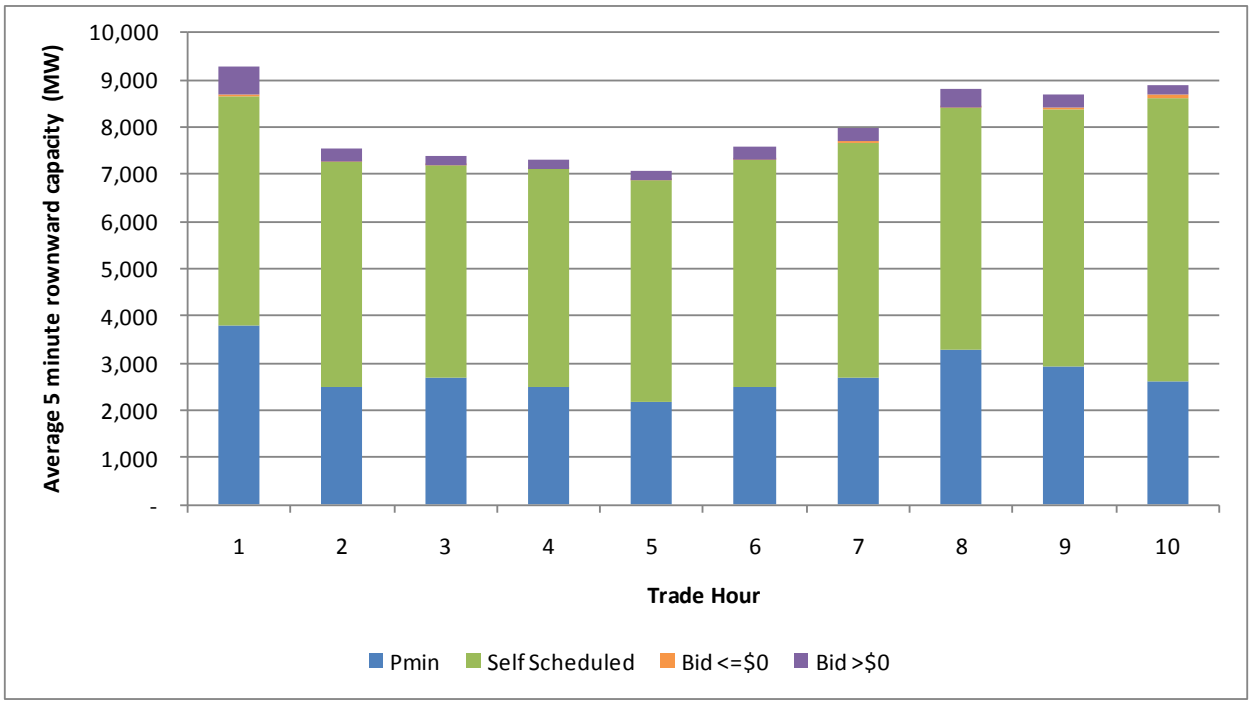
Some of the main contributors to over-supply is significant amount of online capacity due to minimum operating points (pmin) as well as self scheduled capacity above pmin. For a better indication of the driving factors during hours of over-supply, we categorize the dispatchable downward capacity by hour by:

- Pmin: online capacity between 0MW and the units operating minimum point taking into account any pmin re-rates, and/or if the unit was on regulation.

- Self Scheduled: Capacity self scheduled above the unit's real time minimum operating point.
- Bid In <=$0: Capacity bid in between -$30/MWh and $0/MWh
- Bid In > $0: Capacity bid in greater than $0/MWh

Figure 4.1 shows the average ramp constrained 5 minute dispatchable downward capacity categorized for internal resources during intervals of over-supply in Q3 2010[5]. For all hours shown, with the exception of hour 1, on average at least 95% of the capacity was either due to minimum operating points or self scheduled; 88% in hour 1. Less than 0.2% of capacity is bid in between -$30 and $0. Currently, the downward capacity market is not liquid in that very few scheduling coordinators bid in capacity at or near the bid floor. However, there is sufficient capacity online above Pmin to dispatch downward during over-supply conditions for even the extreme outliers of the 90th percentile previously mentioned. The challenge is the capacity online is mostly self scheduled.

Figure 4.1 Internal downward capacity in over-supply conditions – Q3, 2010[6] [7]



Capacity at minimum operating levels shown in Figure 4.1 cannot not be decreased in the real time market because it is a physical operating limit and the RTD market does not de-commit units[8]. Downward capacity bid in greater than $0/MWh will not alleviate the issue as that capacity wouldn't be dispatched in an over-supply condition. Self scheduled capacity is the only capacity that would have the ability to become more flexible if it were to be bid in at a negative price rather than self scheduled. To

[5] Results for Q1 and Q2 are comparable to Q3

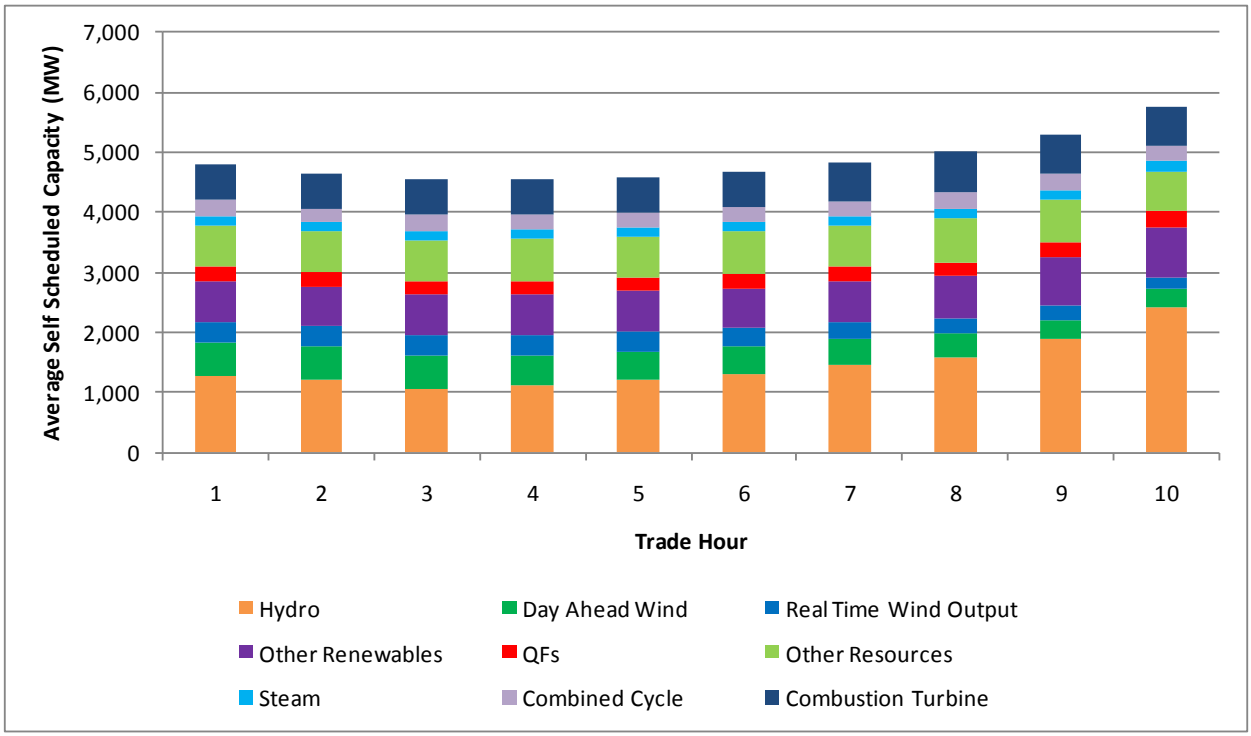
[6] Dispatchable downward capacity is determined by taking each unit's desired operating point from the previous interval and determining how far down its bid curve, relevant for the current interval, that unit could be dispatched provided its bid in ramp rate, forbidden regions, derates, and current pmin and pmax values.

[7] Quarter 3, 2010 is shown here as a representative quarter. Results of all four quarters can be found in Appendix A.

[8] With convergence bidding, virtual supply may decrease unit commitment and therefore over-supply conditions.

gain perspective on what types of factors may be influencing the high rate of self scheduling, the self scheduled capacity show in Figure 4.1 is broken down by technology type in Figure 4.2 below. Figure 4.2 shows the average self schedule capacity in Q3, constrained by ramping capabilities, during hours in which one of the twelve RTD intervals had a zero or negative system energy cost.

Figure 4.2 Self scheduled capacity during over-supply conditions by technology type – Q3, 2010[9] [10]



Overall, there isn't one technology type that represents the majority of self scheduled capacity. The consistently largest type of technology self scheduling capacity during periods of over-supply is hydro. By Q3 the seasonal effect of spring runoff has essentially diminished. Hydro is followed by wind, steam, and gas units.

- Renewable resources, including hydro, wind, qualifying facilities, and other renewable resources, account for over half of the self scheduled generation during these hours.
- Hydro is the most prevalent renewable self scheduling but does have a seasonal trend correlated with snow melt. Typically during the spring and early summer months there is more hydro self scheduled than during other months of the year.
- DA Wind (500MW) and RT Wind (300MW) –Wind resources are not required to schedule in the day-ahead market therefore the day-ahead wind schedules can be significantly less than the real time output. RT wind represents the amount of wind in the real time market incremental to the day-ahead market. Since there is no fuel cost for wind resources, they tend to self schedule in

[9] Quarter 3, 2010 is shown here as a representative quarter. Results of all four quarters can be found in Appendix A.

[10] The technology types used to disaggregate the data are based on masterfile definitions and may not accurately categorize all resources.

the day-ahead and real time markets. Furthermore, PIRP wind resources are required to self schedule 100% of the forecast in the real time market. Currently, wind resources are not dispatchable on a 5 minute basis and generate whenever they can given the weather conditions.

- QFs[11] (250MW) – Qualifying facilities are not dispatchable on a 5 minute basis so they self schedule.
- Other renewable (700MW) – These renewable resources may have a variety of reasons they are self scheduled including, but not limited to, contracts, not being 5 minute dispatchable, or other environmental credits.
- CCYC (200MW) – Combined cycles are typically self scheduled to get the unit into a specific configuration because the current market optimization does not account for certain physical characteristics of combined cycle plants. Self scheduling from CCYC units should decrease with MSG implementation in November 2010.
- Combustion Turbines (800) - Some combustion turbines may have operational characteristics reflected in the market data not being accounted for in the current market, which may decrease with MSG. However, the operational characteristics may not be aligned with the physical ability of the units which would provide additional flexibility. It has also been recognized that several resources categorized as combustion turbines are QFs, thus affords the ability to justify self scheduling.
- Steam (150MW) – Some steam units cannot be cycled off overnight due to minimum down times and therefore self schedule to minimize cycling and enable them to be available for peak hours.
- Other[12] (750MW) –As with combustion turbines, several of these resources have been identified as QFs thus justifies the self scheduling behavior. The ISO should be able to elicit more flexibility from these types of resources.

On average, the system has approximately 2,000MW ramp constrained 5 minute downward dispatchable capacity that is currently self scheduling and should be able to provide economic bids. Given the highest 90th percentile value was just below 1,500MW, the current online capacity would be able to meet system conditions provided they were bid in economically rather than self scheduled.

In addition to self scheduling of internal resources, the ISO is a net importer. Therefore imports can have a large impact on real time prices. Imports limit the amount of downward flexibility in the real time 5 minute market because they are procured in HASP and protected with extreme negative penalty prices in the 5 minute market. Figure 4.3 below shows the average downward dispatchable capacity imported on ties during hours in which one RTD interval had a zero or negative system energy cost. The capacity is broken down into day ahead self schedules, day ahead economically bid generation not re-bid into the HASP market, additional self schedules in the HASP market, additional economically bid generation into the HASP market, self scheduled exports, and economically bid exports.

Almost 90% of imports are self scheduled in the HASP market, or approximately 4,000MW, which includes day ahead economic, day ahead self scheduled, and HASP self scheduled. Almost 2,000MW are day ahead schedules economically bid but not re-bid in the HASP market. The amount of exports shown

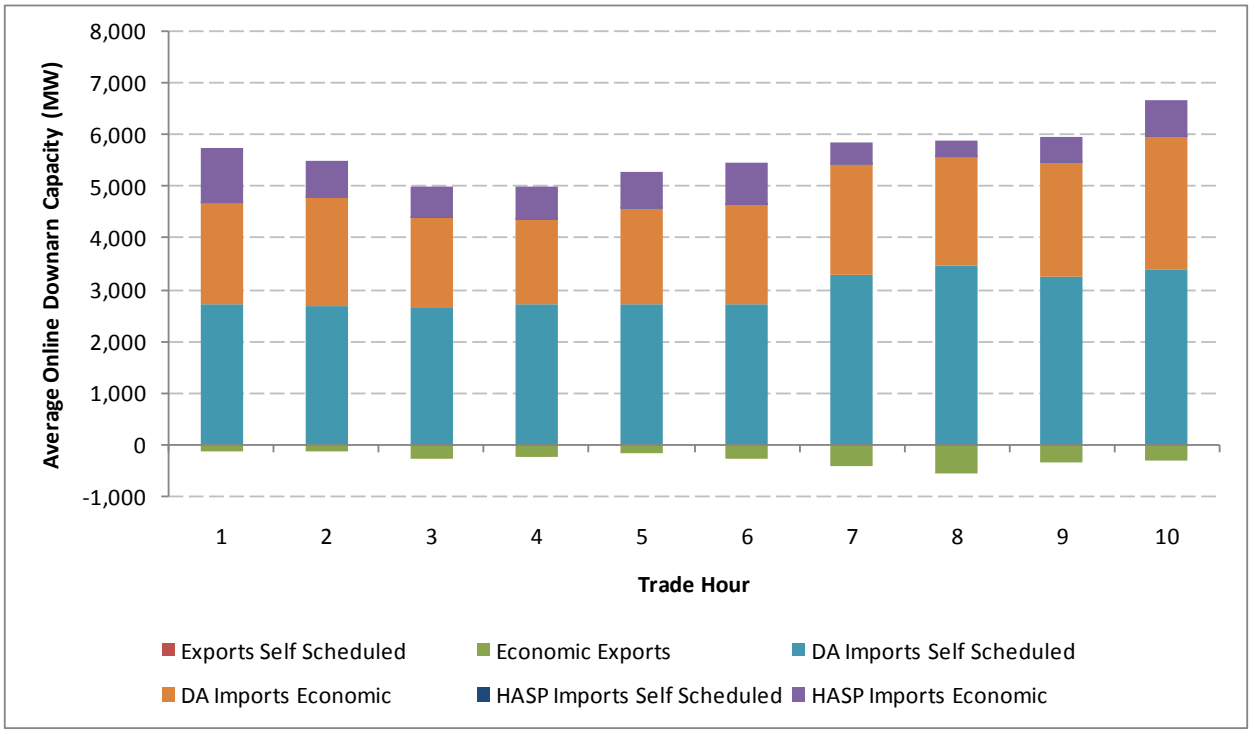
[11] QFs, or qualified facilities, include technology types such as co-generation and wind. Approximately 1,900MW of the ISOs total QF capacity is from wind resources.

[12] Other renewable resources include biomass, biogas, solar, biodiesel, and geothermal. Resources included in “other” have been identified mostly as QFs that were not categorized as QFs when registered with the ISO.

represents the additional exports bid into the market that were not cleared due to the corresponding bid prices being less than the market clearing price.

The real time market could gain additional flexibility from interties if either imports reduced the amount of self scheduling and bid imports economically and/or more exports were bid in at slightly higher prices. However, even if more capacity was bid in economically, given the discrepancy between HASP and RTD prices during these hours shown in Figure 2.2, the market may not clear fewer imports or more exports. As previously noted, the HASP market does not foresee the over-supply conditions in RTD. If the HASP market were better able to forecast over-supply in the real time market, prices should slightly decrease and fewer imports and/or more exports will clear the market. As a result, the real time market prices should converge and the magnitude and frequency of over-supply conditions in the RTD market decrease.

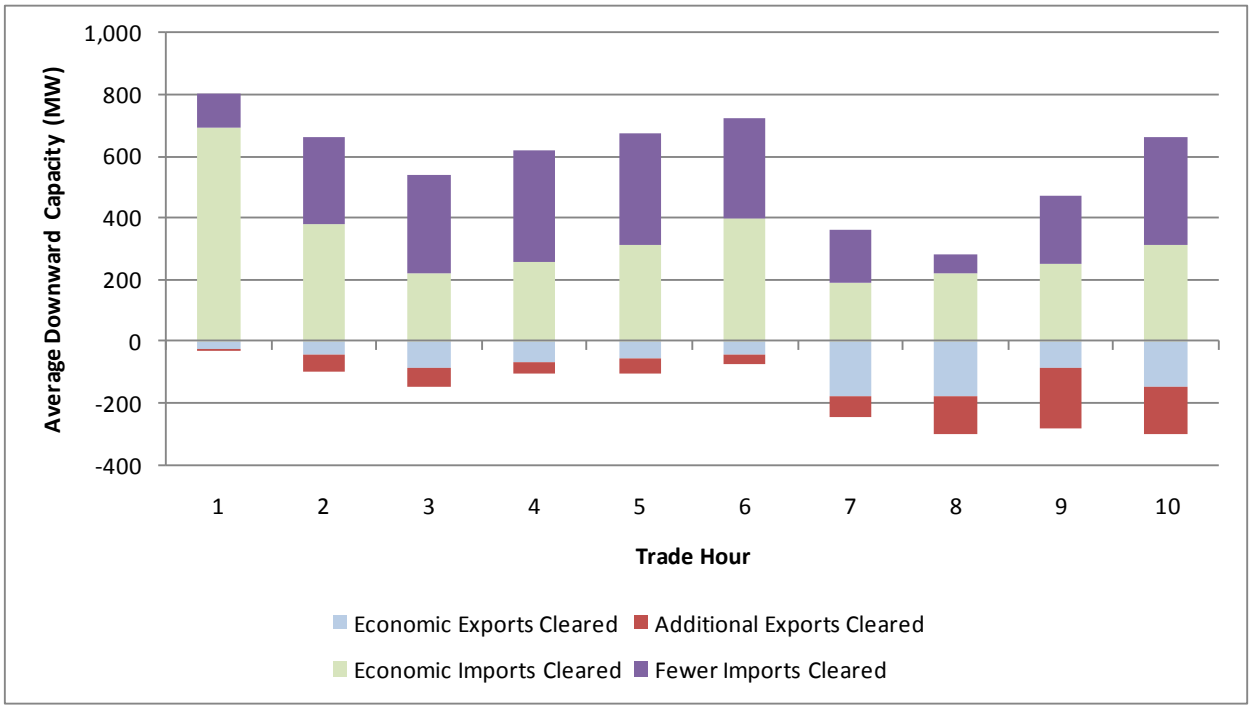
Figure 4.3 Downward capacity across ties in over-supply conditions by bid category – Q3, 2010[13]



The portion of the capacity shown in Figure 4.3 that would decrease supply in real time if HASP and RTD prices were to converge is shown in Figure 4.4. If the HASP and RTD market were to converge during these hours, there would be fewer imports cleared and more exports cleared in HASP. The convergence price was determined by taking the midpoint between the average hourly HASP price and the average hourly real time price. Imports would decrease by the amount of capacity bid in between the convergence price and the HASP price, which on average is approximately 250 MW. Exports would increase by the amount of capacity bid in between the convergence price and the HASP price, which is on average 75 MW. In total, the real time market would have on average an additional 325 MW of flexibility to handle over-supply conditions.

[13] Quarter 3, 2010 is shown here as a representative quarter. Results of all four quarters can be found in Appendix A.

Figure 4.4 Additional flexibility across ties with RTD and HASP convergence – Q3 2010



The frequency and magnitude of over-supply is contributing to significant price divergence between the HASP and RTD market prices. The real-time market does not have access to enough downward 5 minute dispatchable energy to decrease generation to meet load. Furthermore, as more renewable resources become integrated to the grid, over-supply conditions will most likely become more prevalent. On average, the real time market only needs an additional 200MW to address most over-supply conditions, and only an additional 300MW to address 75% of over-supply conditions. In the short run, the current scheduling practices by both internal resources and from the interties can be adjusted to easily meet 75% or close to 90% of over-supply conditions. With the implementation of MSG and slight adjustments to bidding practices by some scheduling coordinators, the extent of negative prices in the real time market can be significantly reduced. In the long run, improvements to the HASP market in addition to changes in scheduling practices previously mentioned will be necessary as more and more renewable resources integrate onto the grid.

5 Summary

We have empirically reviewed several factors that are primary contributors to over-supply conditions in the off-peak hours for the purpose of understanding the issue as well as highlighting potential areas for additional analysis that will be useful in determining which market design options may be more fruitful in mitigating over supply. The ISO has proposed to stakeholders several alternatives targeted at altering scheduling rules, providing financial incentives, and altering the way in which PIRP resources participate in the ISO. This study highlights that there is the potential to nearly fully mitigate the over-supply issue in the short run through directly addressing self scheduling and better alignment between the HASP and RTD markets.

This analysis has shown that a deficiency in downward ramping capacity has been persistent through 2010 and has resulted in significant price impacts in the real time 5-minute market. Further, the amount of downward ramping deficiency that the ISO observes during periods of over-supply is small (between 250 MW and 500 MW) and relatively short lived (ten to fifteen minutes on average). This is a tractable issue and indicates there may be existing solutions that can relieve the issue in the short term. In fact, an additional 300 MW of downward ramping capability would reduce the frequency of extreme negative prices by 75 percent.

Based on our analysis, there appears to be sufficient downward ramping capacity online during these hours that could be made available through offering economic bids instead of self scheduling. Multi-stage generation optimization (MSG) has the potential to reduce the degree to which combined cycle resources self-schedule to manage configuration changes. Hydroelectric resources also self schedule a considerable amount during the off-peak hours and, despite flow restrictions and economic energy use plans, may be able to offer some additional downward ramping capacity. Given the historical magnitude of deficiency in downward ramp, the additional flexibility from combined cycle units and additional offers from hydroelectric units could be enough to eliminate a majority of instances of this issue. We have also highlighted that while meaningful participation by wind generation in the real-time 5-minute market may not be feasible in the immediate term, changes in the scheduling practices of these resources could help relieve over-supply conditions in real time and could be addressed in the short term.

The real time over-supply conditions could also be reduced by better leveraging intertie resources in the HASP. Our analysis shows that divergence in the pricing between HASP and RTD result in up to 200 MW of undispatched export bids that would clear at prices closer to the RTD price. Similarly, there are up to 500 MW of cleared import bids that would not clear if the HASP and RTD prices converged. Improvements made to the HASP market to better foresee over-supply conditions will help price convergence and help relieve over-supply conditions by reducing the amount of net imports cleared. Also, there is on average over 5,000 MW of imports that are self scheduled. While much of this may be self scheduled do to existing contract terms, there is likely some room for economic adjustment.