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MSA Report

A Review of Regulating Reserves Performance in Alberta

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Market Surveillance Administrator

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

A number of market participants have expressed concern that they believe at times, System Controllers 'lean' on regulating reserve rather than dispatching up the merit order. As evidence of this activity, participants have observed that small blocks of power have set the system marginal price (SMP) for extended periods of time, and have done so when demand is ramping up. The allegation of improper use of regulating reserve and the supporting rationale has caught the MSA's attention, and has led us to undertake a review of regulating reserve performance.

The study employs a data set from January 2003 through May 2004. As some of the required analyses are made using data on a 10-minute time step, many of the variables have more than 70,000 observations.

The statistical relationships found between SMP and regulating energy are generally weakly positive. Regulating energy levels and changes provide little explanatory value to the levels and changes in SMP, except to say that when SMP is high, regulating reserve utilization tends to be high and vice versa. This is consistent with the notion that SMP will be high when the system is tight energy, and when we would therefore expect regulating energy utilization to increase.

The analysis does not show that individual System Controllers are a significant influence in overall price determination. The data shows that there is a range of regulating utilization across controllers. However, given the discretionary nature of the function, we do not conclude that this range is inappropriate.

Analysis of when small blocks of energy set SMP for extended periods of time shows that these events overwhelmingly occur when the system is least dynamic. A detailed example of a small size block setting SMP for an extended period is presented and discussed. Insights gained from this example led to further work that confirmed a significant lagged response of Area Control Error (ACE) to large increases in SMP. High absolute values of ACE lead to CPS2 violations that are one of the System Controller's measures of reliability. However, the evidence suggests that the strategies of the System Controllers in minimizing CPS2 violations coupled with the lack of dispatch fidelity on the load and generation side are leading to what we believe is a stable sub-optimal outcome. At times when the next dispatch up the merit order produces a significant increase in SMP, System Controllers can anticipate a large swing in ACE and a possible CPS2 violation. With a mandate to manage system reliability, it is only rational that System Controllers will resist these circumstances. What to market participants might appear to be some evidence of price management on the part of System Controllers is, in fact, reliability management in the face of overwhelming non-dispatched response by some load and supply under certain conditions. There is a key interrelationship between dispatch fidelity (what is asked for equals what is provided and needed) and price fidelity (sufficient dispatch through the merit order to provide an efficient price signal) that needs to be properly articulated and addressed.

We do not believe that culpability for the sub-optimal outcome can or should be assigned to one particular party. We believe that both System Controller and generation and load participants are acting rationally in the face of the current market rules and the strategies of the other players.

The MSA's hope is that by publishing this study and demonstrating the interconnectivity of the concepts it will lead to a more 'confidence rich' environment and collaborative approach to the current review of the market.

The trends and statistical analysis performed in this study do not, in our opinion, provide supporting evidence that the System Controllers are engaged in systematic misuse of regulating reserves to 'manage' market prices. The body of evidence shows that the variability in the utilization of regulating energy across hours is consistent with the overall system dynamics, which include load ramps, generation offer profiles, interchange activity and AS contract timing. The results show that the System Controllers are most active in dispatching through the merit order when the system is in its most dynamic hours.

From this work we draw four recommendations:

Recommendation 1: The AESO, Alberta Department of Energy and participants (generation and load) consider the relationship between dispatch fidelity and price fidelity as they examine modifications to market design. Price and dispatch fidelity will not likely improve without changes to the market structure.

Recommendation 2: The AESO should consider reviewing its participant training around the System Controller's use of regulating reserves, and provide more education into overall reliability standards and criteria. Such training should be aimed at articulating the most critical issues that the System Controllers are facing with the outcome being collaborative efforts to deal with them. As well, the AESO should consider publishing, on an on-going basis, analytical work regarding the use of regulating reserves for the market's review.

Recommendation 3: The AESO should consider appropriate disclosure of operating and reliability data used as inputs into the System Controller's dispatch decisions such as regulating range and utilization as well as reliability data, such as Area Control Error (ACE) and CPS2 performance. We do not believe that it would be necessary to publish such data on a real time basis, as this may lead to potential gaming (such as lowering unit output when the system is high in the range to force a dispatch and increase SMP). Increasing transparency through the disclosure of operating and reliability data is fundamental to improving confidence in the System Control function and overall market operation.

Recommendation 4: The AESO should provide to System Controllers on-going training with respect to the operational guidelines to be applied in the dispatch of the system, with a view to promoting consistency in dispatching and increasing the market's confidence in the dispatch process.

1 INTRODUCTION AND SUMMARY

A number of market participants have expressed concern that they believe at times, the System Controllers 'lean' on regulating reserves rather than dispatching up the merit order. As evidence of this activity, participants have observed that small blocks of power have set the system marginal price (SMP) for extended periods of time, and have done so when demand is ramping up. During ramp hours, it is natural to expect the System Controllers to work up the merit order, with higher priced energy being dispatched. The allegation of improper use of regulating reserves and the supporting rationale has piqued the interest of the MSA, and has led us to undertake this review of regulating reserves performance.

The research to be presented does not attempt to determine what prices *ought* to have been at any given moment. Rather, it examines the relationships between load, generation, interchange activity, area control error, SMP, and regulating reserves in order to understand whether the outcomes are reasonable and theoretically consistent given prevailing system dynamics.

This study is organized into the following sections. Section 2 provides an overview of regulating reserves, including the criteria governing the levels and performance of regulating reserves and the measure of operational performance (NERC's Control Performance Standards). It outlines what, in our view, are the principle factors impacting the utilization of regulating reserves including load and generation patterns, interchange activity, ancillary service contract timing and dispatch activity.

Section 3 reviews some statistical relationships between regulating energy and its utilization and prices, on both an hourly and a 10-minute basis. This section presents the underlying relationships between levels and changes in regulating energy utilization and levels and changes in prices.

Section 4 examines regulating reserves performance by individual controller in order to address industry concerns that controller 'style' impacts system dispatch.

Section 5 examines the phenomenon of small blocks setting SMP for extended periods of time in terms of both the frequency and timing of such events. It goes on to provide what we believe to be a plausible explanation of these events, using both anecdotal and statistical evidence.

Section 6 provides conclusions from the research and recommendations going forward.

2 REGULATING RESERVES OVERVIEW

2.1 BACKGROUND

System Reliability is often viewed by the public as simply an issue of "keeping the lights on". In reality, reliability is a multi-dimensional phenomenon, with many indicators that are monitored for good performance. In particular, the Alberta control area (or Alberta Integrated Electrical System [AIES] as it is more formally known) is synchronously connected to the Western Electric Coordinating Council (WECC). Through this membership many benefits and obligations accrue. The subject of this study is the use of regulating reserves in the AIES. Alberta's reliability obligations, including the use of regulating reserves, are outlined in the Reliability Management System Agreement (RMS) between WECC and the Alberta Electric System Operator (AESO)[1].

Generators that provide regulating reserve service are controlled by an automatic generation control (AGC) system that adjusts generator output levels within an established regulating range to compensate for the moment-to-moment changes in load and generation, as well as follow the trend in energy imbalances. This compensation provides a balance between generation and load within the Alberta control area while maintaining the interchange schedule on the interconnection with British Columbia and the scheduled frequency of 60Hz. AGC performance is monitored through the use of the North American Electricity Reliability Council (NERC) Control Performance Standards 1 and 2 (CPS1 & 2) via Alberta's membership in the WECC.

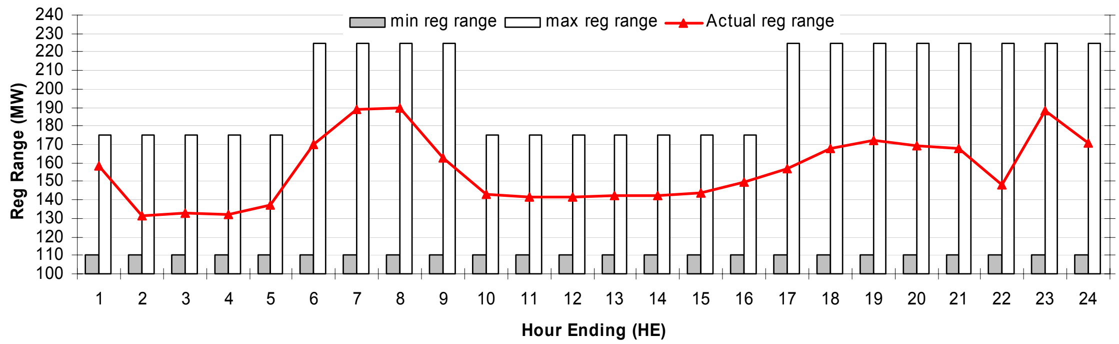
The policies for the System Controller in dispatching generators to provide regulating reserve range (regulating capacity) in the Alberta control area are outlined in the AESO's *Operating Policies and Procedures (OPP) 401: Reserve Management*[2]. The actual amount of energy produced from the regulating range is determined by the imbalance between load and generation and frequency maintenance requirements in the Alberta control area. The AGC master controller calculates the amount of regulating energy required from units providing regulating range to keep the interchange and frequency on schedule. Amongst other things, system frequency, the generation-load imbalance and response characteristics of generators providing regulating service will be inputs into this calculation.

As a member of WECC, the AESO is required to carry sufficient operating reserves. The criteria for determining minimum operating reserves, contingency reserves plus regulating reserves are established by WECC. The procurement guidelines are shown in **Figure 1**, as well as the actual average amount of range (capacity) that was procured by hour ending (HE) from January 2003 to May 2004. The maximum range that can be procured under normal circumstances[3] is 175MW or 225MW, depending on the hour, while the minimum range is 110MW for all hours. As the figure shows, on average the

[1] www.aeso.ca/files/2001-10-03-RMS_Agreement_W_Amendments.pdf
[2] The AESO's Operating Policies and Procedures can be found at: www.aeso.ca/downloads/OPP_Link_May19_04.pdf
[3] The AESO can procure and dispatch more than the 175/225MW maximums if system conditions warrant it.

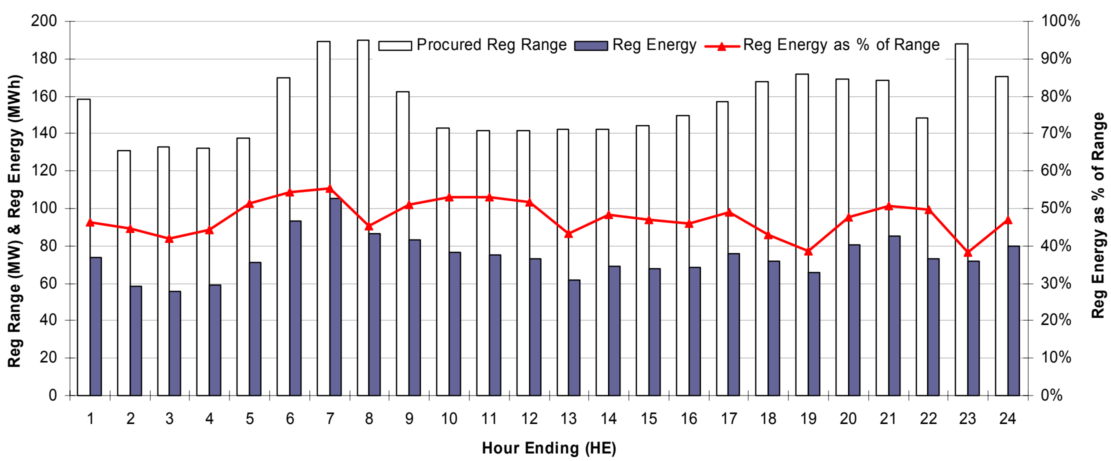
AESO procures about 78% of the maximum range (156MW compared to an average maximum range of 200MW).

Figure 1 Maximum and Minimum Range and Actual Procured Regulating Range (MW), January 2003 - May 2004



The amount of energy produced from the regulating range varies by hour (**Figure 2**). The hour with the least regulating energy is HE03, with an average of 56MWh of energy coming from an average range of 133MW. The hour that experiences the highest energy contribution from the regulating range is HE07, with an average 105MWh of energy coming from an average range of 189MW.

Figure 2 Procured Regulating Range (MW), Regulating Energy (MWh) and Regulating Energy as a Percentage of Range (%), January 2003 - May 2004



As can be seen in **Figure 2**, regulating energy in MWh varies significantly across the hours of the day. However, as a percentage of procured range, the hourly profile is much flatter and averages 47.6%.

There are several reasons why there is a wide variance in both procured range and regulating energy production across hours. The principle determining factors are system load ramping and system generation ramping, while changes in the tie-line schedule and the turn-over of regulating contracts from on-peak to off-peak and vice versa also contribute to the higher regulating range and regulating energy production in certain hours. These factors will be discussed in detail starting in section 2.3.

2.2 OPERATIONAL PERFORMANCE

NERC's Control Performance Standards (CPS) are measures of how well a system is balancing load and generation. Of particular importance for real-time operations and system balancing is CPS2. It is a performance indicator designed to bound ten-minute average Area Control Error (ACE)[4]. It provides an oversight function to limit excessive unscheduled power flows that result from large ACEs. CPS2 is monitored by the system operators on a real time basis. Therefore avoiding CPS2 violations is a key real-time driver for dispatch decisions. CPS2 violations occur if:

$$AVG_{10-\text{minute}}(ACE_i) \geq L_{10}$$

where:

$AVE_{10\text{-minute}}(ACE_i)$ = average 10-minute ACE

$L_{10} = |51.16|$ MW[5]

Therefore to avoid CPS2 violations, the controllers must keep the average value of ACE below or equal to |51.16| MW for each 10-minute interval in every hour. Typically, System Controllers will dispatch the system with the objective of keeping ACE as close to zero as reasonably possible.

Complying with CPS2 is not voluntary. It is a key responsibility for the Alberta control area and a prerequisite for membership within WECC. As such, it is a critical driver for real time dispatch decisions. If a control area does not comply with CPS2, it is deemed by WECC not to be providing its required regulation service. Financial penalties are levied

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[4] ACE = $(NI_a - NI_s) - 10\beta(f_a - f_s)$, where NI_a = actual net interchange; NI_s = scheduled net interchange; f_a = actual system frequency; f_s = scheduled system frequency (60hz); β = frequency bias (92MW/0.1hz in Alberta); 10 = constant factor to convert frequency bias to MW/hz. ACE is therefore how far a control system is off its scheduled interchange (how much it is inadvertently importing or exporting) while limiting the control area's contribution to frequency deviations in the whole interconnect.

[5] $L_{10} = 1.65 \in_{10} \sqrt{(-10B_i)(-10B_s)}$

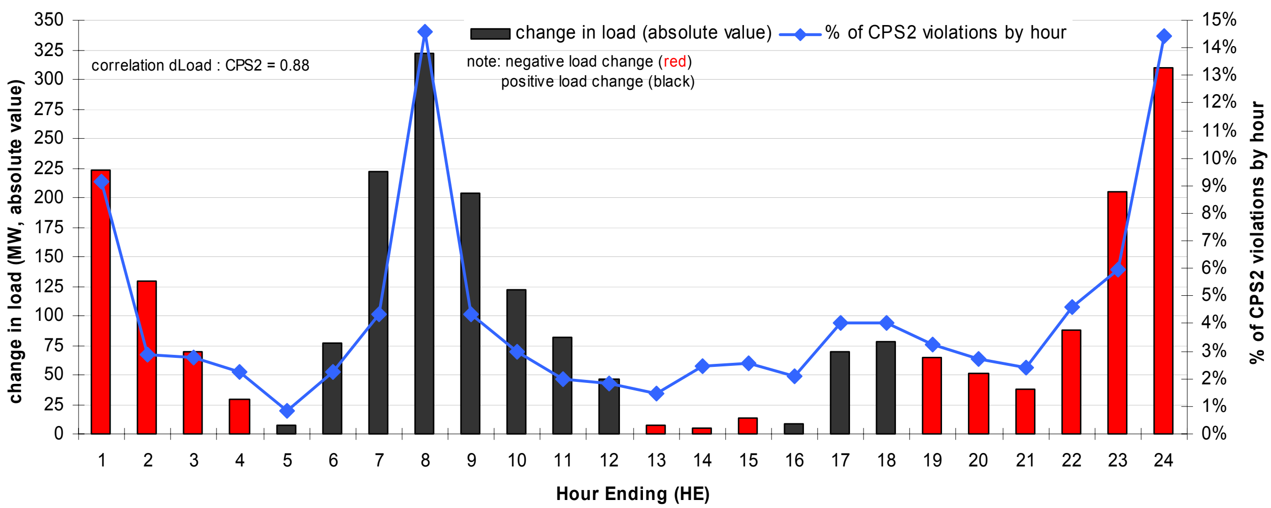
$\in_{10}$ is a constant derived from the targeted frequency bound. The bound, $\in_{10}$ is the same for every control area within an Interconnection, 1.65 is a constant used to convert the frequency target to 90% probability. It is the number of standard deviations from the mean of a statistical normal distribution (Gausian distribution) that will result in a probability of noncompliance of 10%. B_i is the frequency bias of the control area. B_s is the sum of the frequency bias settings of the control areas in the respective Interconnection.

against the control area if it does not maintain 90% compliance with CPS2[6]. A control area failing to comply is required to take immediate corrective action and achieve compliance within three months. WECC will require a control area to purchase more regulation range if compliance is not achieved.

2.3 CPS2, LOAD CHANGES AND REGULATING RESERVES

Figure 3 reports the average hour-over-hour change in load and the percentage of CPS2 violations that occurred by hour between January 2003 and May 2004. The number of CPS2 violations per hour is an excellent indicator of which hours System Controllers are most challenged in balancing load and generation. As the figure shows, over 50% of CPS2 violations have occurred during two 3-hour intervals: HE07 – HE09 and HE23 – HE01, despite the fact that these hours are allocated the largest regulating range. These two time intervals contain the fastest load ramp rates and the largest changes in generation offer schedules. They are also the intervals where on-peak and off-peak regulating contracts turn over and the intervals where, on average, the tie-line switches from a net export position to a net import position or vice versa. The correlation between the absolute hourly change in load and percentage of CPS2 violations by hour is 0.88.

Figure 3 Hour-Over-Hour Change in Load (MW, absolute value) and Percentage of CPS2 Violations by Hour Ending, January 2003 - May 2004



High system ramps (both generation and load) present issues for balancing load and generation if generator dispatch responses and ramp rates differ from the load ramp rate. Any ramp rate mismatch requires increased balancing effort from units dispatched for regulating reserve.

The correlation between the number of CPS2 violations and the absolute volatility (standard deviation) of regulating energy is 0.71. During the hours that are most difficult to keep the system in balance, the variability of regulating energy is highest. In short, the

[6] The CPS2 compliance level is calculated using the following formula:

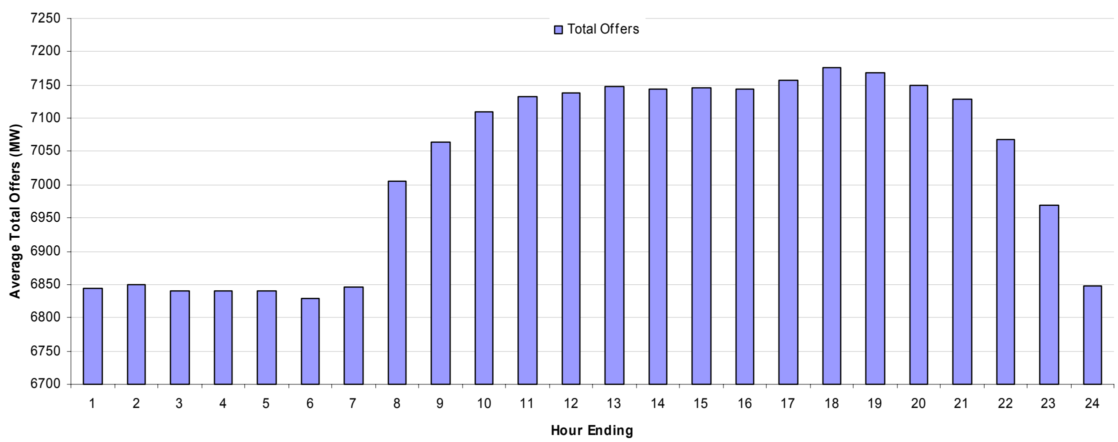
$$CPS2 = \left[1 - \frac{\text{Violations}_{\text{month}}}{(\text{Total Periods}_{\text{month}} - \text{Unavailable Periods}_{\text{month}})}\right] * 100$$

system is ramping through the regulating range the most in the hours that have the most CPS2 violations, as the controllers strive to maintain ACE within the required bounds. These are also the hours with the largest changes in load.

2.4 ENERGY MARKET OFFER VOLUMES

Figure 4 presents average generation offers by hour ending for January 2003 to May 2004. The figure shows significant step functions in the offered energy schedule between HE07 and HE08 and again, although less dramatic, between HE23 and HE24. The average amount of offered energy jumps from 6845MW to 7005MW between HE07 and HE08, a change of almost 160MW. Between HE23 and HE24, the average amount of offered energy falls by 120MW.

Figure 4 Average Total Offers by Hour Ending, January 2003 - May 2004



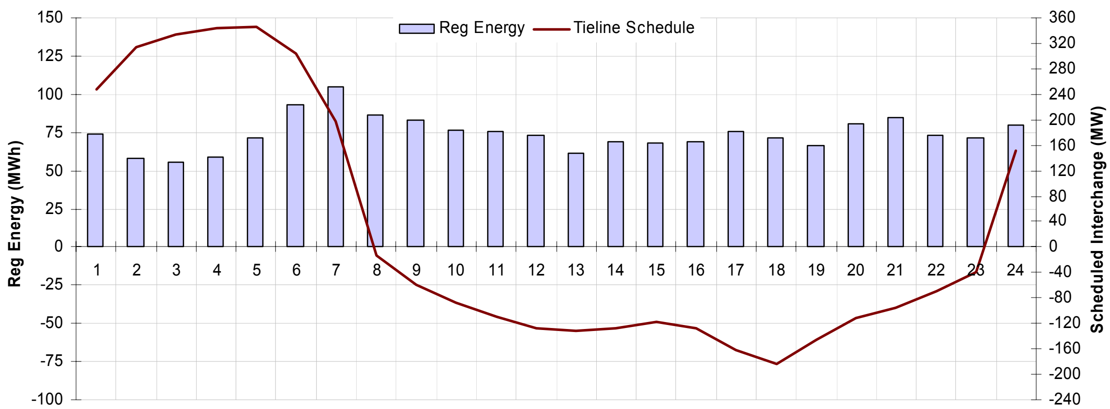
Although, in the macro sense, load ramps and changes in the generation offer schedule may appear offsetting, in the second-by-second system balance, they are important determinants of regulating energy. This is because regulating range utilization (the amount of energy being produced from a given range) is impacted by the divergent ramp rates of components of the system. Not only is the ramp rate of a marginal unit important, but any unit ramp that leads to a variation in total output, such as ramping by a zero offered unit following a restatement, will lead to an increased balancing effort from the regulating range. Any reshuffling of the merit order or any variation in load will lead to increased reliance on the regulating range if they are not exactly and instantaneously off-setting.

2.5 INTERCHANGE ACTIVITY

Figure 5 reports regulating energy and scheduled BC interchange flows. Between HE07 and HE08, on average the system swings from a net export position which averages 197MW to a net import position of 12MW. Although this 210MW swing acts to partially offset an average internal load growth of 320MW, the turnover of schedules requires considerable balancing and re-dispatching of the merit order. The tie-line ramp occurs from 10 minutes prior to the end of the hour to 10 minutes past the top of the hour. Internal generation will be re-dispatched during the tie-line ramp, which will generally have ramp rates that do not match the tie-line ramp rate. The mismatch in tie-line and generation ramp rates coupled with the heavy load ramp will require increased dependence on the regulating range to balance the system.

This dynamic is repeated between HE23 and HE24. During this interval the tie-line schedule with BC swings, on average, from 40MW of net imports to 150MW of net exports. Again, the change does help to partially offset the internal load decline which averages 310MW between HE23 and HE24. The tie-line swing and associated ramp will require considerable re-dispatching of the merit order and a heavier reliance on regulating service to maintain ACE within the required bounds.

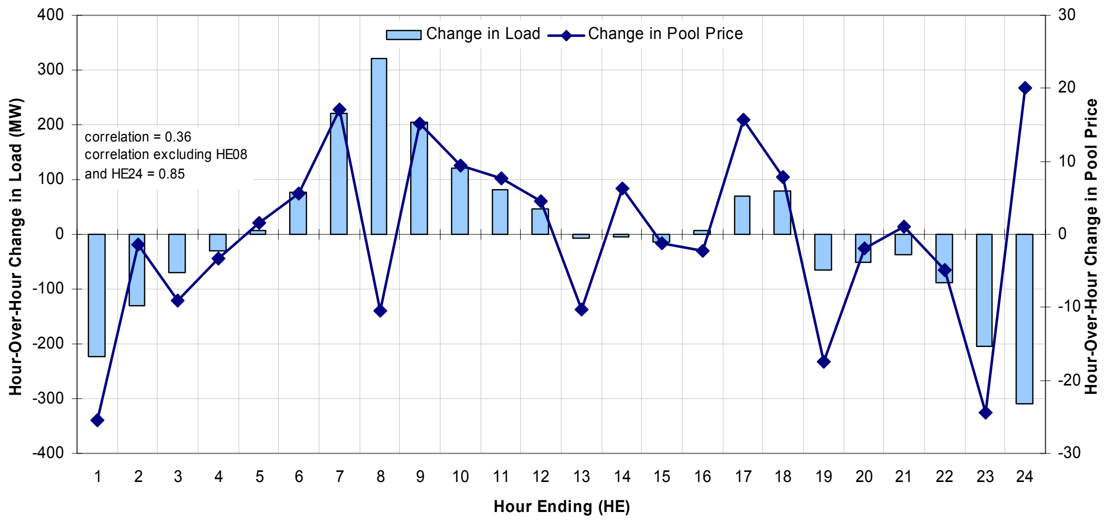
Figure 5 Scheduled BC Interchange (MW) and Regulating Energy (MWh), January 2003 - May 2004



The impact of the tie-line switch-over and step changes in the offer schedule also influence the relationship between internal load and Pool price. **Figure 6** illustrates the relationship between the hour-over-hour change in load and corresponding change in price. In general, changes in load and changes in price are highly positively correlated, with the exception of HE08 and HE24. The correlation between the change in Pool price and the change in load by hour ending is 0.36 when HE08 and HE24 are included in the calculation. However, removing these two hours increases the correlation by almost 50 points, to 0.86.

On average, from HE07 to HE08, price falls by $9.29/MWh despite the fact that internal load increases by 320MW. The reverse occurs in HE24, where the average hour-over-hour change in load is -310MW, yet the average corresponding change in Pool price is $19.31/MWh. These outcomes are the result of the swing in the tie-line schedule along with the change in the average amount of offered energy over the two time intervals.

Figure 6 Hour-Over-Hour Change in Load (MW) and Change in Pool Price ($/MWh), January 2003 - May 2004



2.6 ANCILLARY SERVICE CONTRACT TIMING

On top of the balancing required to handle the heavy system ramps and tie-line schedule changes from HE07 – HE09 and HE23 – HE01, the on-peak / off-peak regulating contracts also turn over at the end of HE07 and HE23. Generally, coal units provide the bulk of off-peak regulating service, while the hydro units provide a significant portion on-peak, with gas units providing the balance. In the morning, prior to the end of HE07, coal units will begin repositioning themselves, moving out of providing regulating range, where they are not generating at full output. As the coal units begin repositioning, the hydro units are also ramping into position to provide on-peak regulating service. This changeover can create significant generation ramping in the system and leads to a heavier reliance on balancing energy from the regulating range at the end of HE07 and beginning of HE08. Moreover, if the ramps are not well coordinated, timing issues can leave the system short of regulating range if the coal units have repositioned themselves into the energy market prior to the hydro units being in position in the regulating market[7]. If this occurs, the system can have difficulties maintaining its ACE within the bounds set out by CPS2, creating more violations at the end of HE07 or beginning of HE08.

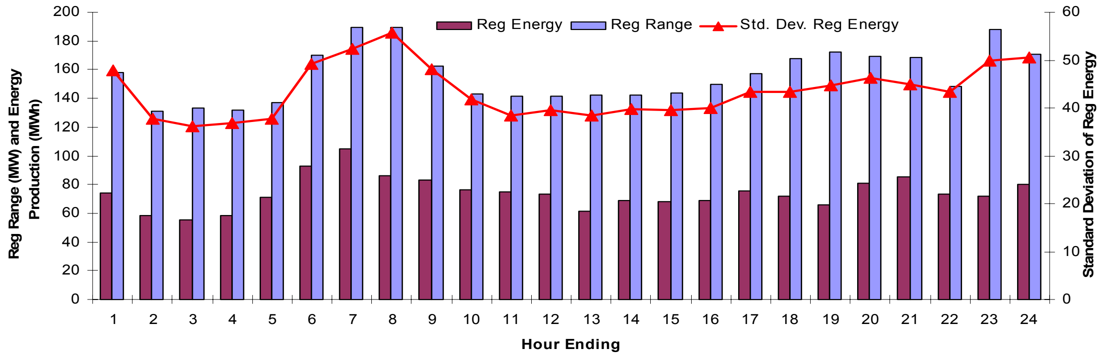
2.7 REGULATING ENERGY VOLATILITY

As a consequence of the heavy system load ramps, offer schedule changes, interchange swings and AS contract turnover, the absolute volatility of regulating energy production from the regulating range, measured by its standard deviation, peaks during HE08 in the morning and HE24 in the evening (**Figure 7**). The high standard deviations in the hours surrounding and including HE08 and HE24 indicates that the system ramps up and down through the regulating range more during these hours due to the increase in difficulty

[7] This is particularly acute with regulation down range. As the coal units ramp into the energy market the hydro units also ramp up to the bottom of their regulation range. Therefore, there is an injection of energy into the system (from both coal and hydro units), but the system is at the bottom of the regulating range. This can lead to a high positive ACE for the system and increased CPS2 violations.

balancing the variety of ramp rates arising from both changing internal load as well as changes to internal and external generation.

Figure 7 Regulating Range (MW), Energy Production (MWh) and Standard Deviation of Energy Production (MWh) by Hour Ending, January 2003 - May 2004

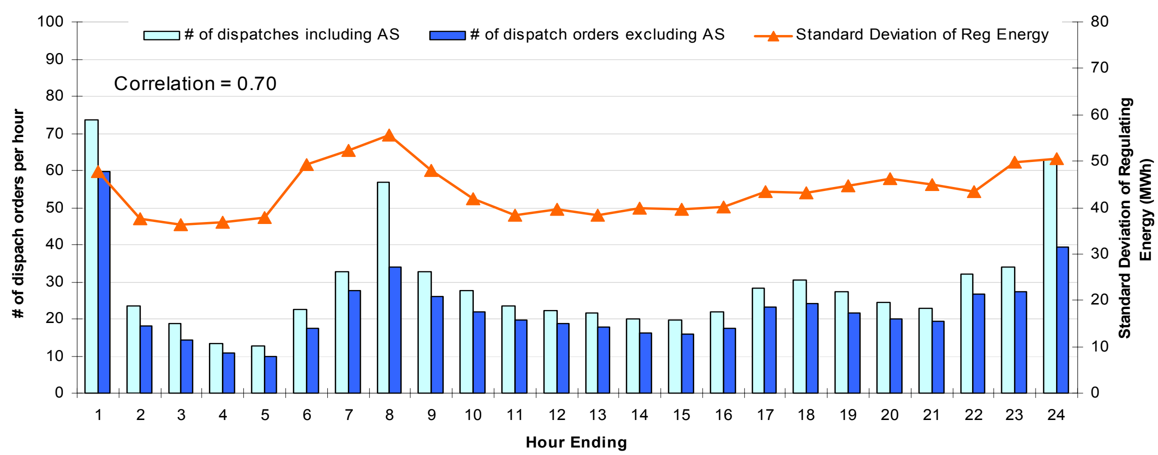


2.8 HOURLY DISPATCH ACTIVITY

Figure 8 reports the average number of dispatches per hour. Overall, the highest amount of dispatch activity occurs during HE01, when the day-ahead offer schedule comes into effect. Dispatch activity falls off overnight, as generally larger coal blocks set SMP and system dynamics (load, generation, interchange and reserves changes) are most stable. Dispatches increase monotonically from HE05, peaking at HE08. This coincides with the increase in system dynamics. This pattern is repeated from HE21 through HE01, as increased system dynamics necessitate increased dispatching.

Higher system dynamics and dispatch are associated with high volatility of regulating energy within the regulating range due to increased system ramping of load, generation and the tie-line. The correlation between the number of dispatches and the standard deviation of regulating range is 0.70.

Figure 8 Average Number of Dispatches per Hour Ending and Standard Deviation of Regulating Energy, January 2003 - May 2004



3 REGULATING RESERVES AND MARKET PRICES

3.1 REGULATING ENERGY AND SMP

By definition, energy produced from the regulating range will impact price volatility as it inadvertently acts as a price capacitor. Regulating energy acts as an unavoidable substitute to energy dispatched through the merit order because energy dispatches are unable to respond to moment-to-moment imbalances between load and generation. Energy dispatches tend to be a blunt instrument when a precise instrument is required. Self dispatching behavior from both generation and load, as well as a built in 10% tolerance for over-generation and the ability to reject a dispatch means that there often exists large differences between what is dispatched and what responses actually occur. Therefore the use of regulating reserves is an unavoidable overhead cost to the Alberta control area (as is regulating reserves in all other control areas). Costs include the direct costs of procuring regulating range, as well as the indirect cost arising from the impact on the fidelity[8] of the price signal generated through the merit order.

Dispatches up or down will not be perfectly synchronous with changes in the supply/demand balance for a number of reasons including:

- Generator ramp rates do not match load ramp rates, leading to the requirement for up and down balancing volumes
- Time lags between supply/demand changes, dispatch instructions, and generator or load responses
- Non-compliance to dispatch instructions
- Independent generator and load actions that counteract or over-amplify dispatch instructions, including zero offer price chasing behavior or un-offered price sensitive load reactions
- Interchange ramp rates that are not synchronous with domestic load and generation ramp rates
- Lumpiness of merit order offers may not align with expected load changes, leading to over or under dispatching with regulating range balancing the difference
- Lagged generation or load responses to the hourly settlement price rather than to the minute-by-minute SMP
- Uncertainty in near-term load and generation changes leads to over or under dispatching through the merit order

Any of these will introduce 'noise' into the price signal being generated through the merit order and will impact price fidelity. Clearly in a market design based on SMP set minute

[8] Price fidelity refers to a clear price signal arising from the supply/demand balance and is executed via the merit order

by minute through orderly dispatch, there is a link between dispatch fidelity[9] and price fidelity.

Overall, the hourly relationship between the Pool price and regulating energy as a percentage of procured range is given in **Figure 9**. The correlation between the average hourly Pool price and energy as a percentage of procured range is almost non-existent, at 0.014. This is not surprising given that regulating energy is a relatively small input into the overall system balance when compared to load, generation and interchange activity.

Figure 9 Hourly Pool Price and Regulating Energy as a Percentage of Procured Range, January 2003 - May 2004

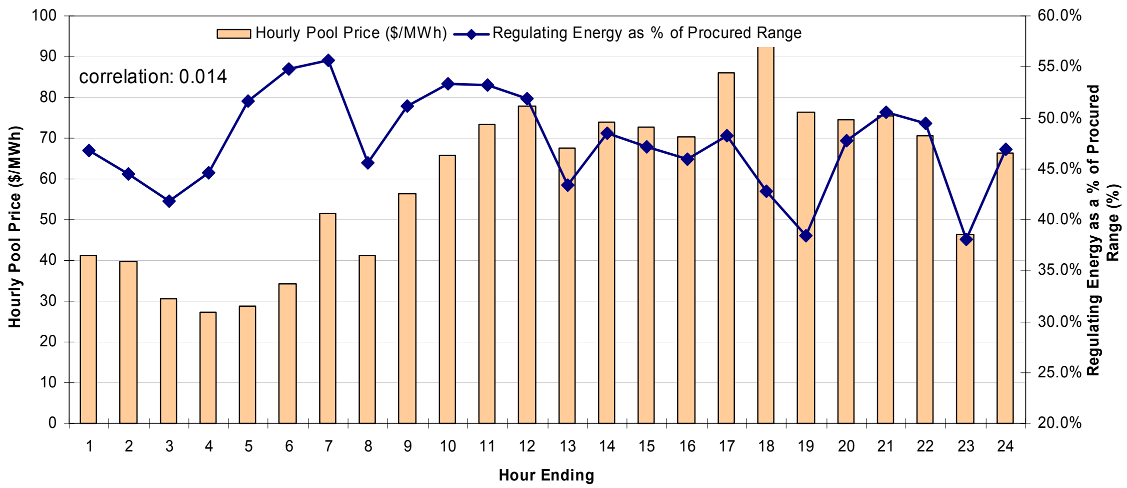
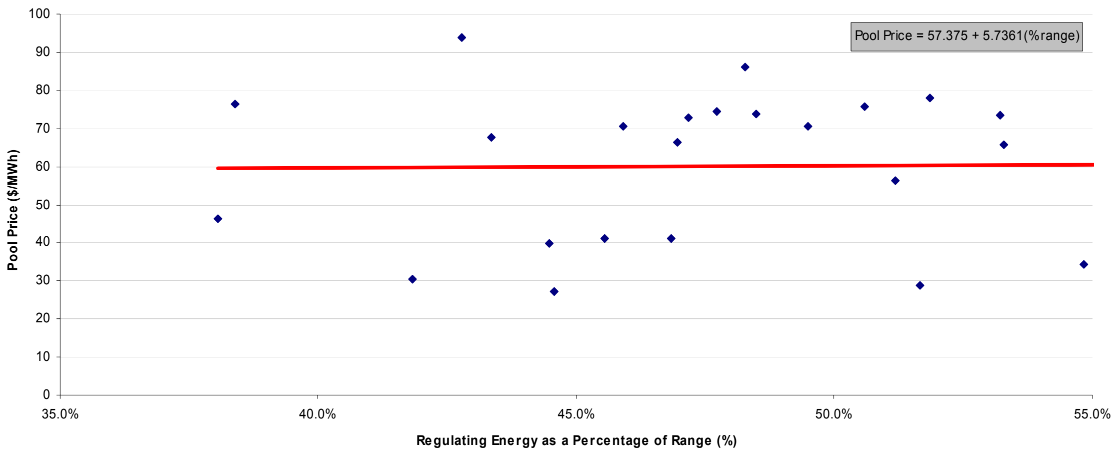


Figure 10 presents an alternative way of looking at the data of figure 9 by plotting average hourly Pool price against average hourly regulating energy as a percentage of range. The trend line shows a weakly positive relationship between hourly price and regulating energy utilization. However, the t-statistic is 0.07, indicating that the relationship between Pool price and regulating reserve as a percentage of range is statistically insignificant (the slope of the trend line is not statistically different than zero).

9 Dispatch fidelity refers to the notion that what is requested through dispatch equals what is provided by generators and load and also equals what is required for system balance

Figure 10 Hourly Pool Price versus Regulating Energy as a Percentage of Range, January 2003 - May 2004



There is some concern that analyzing this relationship on an average hourly basis may mask important intra-hour dynamics. Therefore SMP and regulating energy as a percentage of procured range have also been analyzed on a 10-minute basis (which corresponds with the intervals for calculating CPS2).

Figure 11 plots SMP 10-minute averages against regulating energy as a percentage of procured range 10-minute averages using data from January 2003 through May 2004. The data contains over 74,000 observations. On a 10-minute basis, the correlation between these variables remains weak at 0.06. The regression statistics are reported in **Table 1.** The results indicate a statistically significant positive relationship between SMP and regulating energy as a percentage of procured range. A 10% increase in regulating energy is associated with a $1.80/MWh increase in SMP. Care must be taken when interpreting these results however. The data is non-normally distributed, with the bulk of the observations falling in the solid black mass between $0/MWh and $150/MWh. The data appears stratified around $225/MWh and around $500/MWh, which is the result of fairly stable step-functions in the merit order. Additionally, the SMP data is positively serially correlated over time. Serial correlation will lead to an overly optimistic R-squared statistic (even though it is only 0.004) and more importantly, will lead to an estimate of the error variance that is smaller than the true error variance, leading to an over-estimate of the t-statistic.

Data issues aside, both the hourly data and 10-minute data show a range of results that vary from insignificant (basically no relationship between SMP and regulating energy) to a weakly significant positive relationship between SMP and regulating energy.

Figure 11 SMP ($/MWh) versus Regulating Energy as a Percent of Procured Range (%), 10-Minute Intervals, January 2003 - May 2004

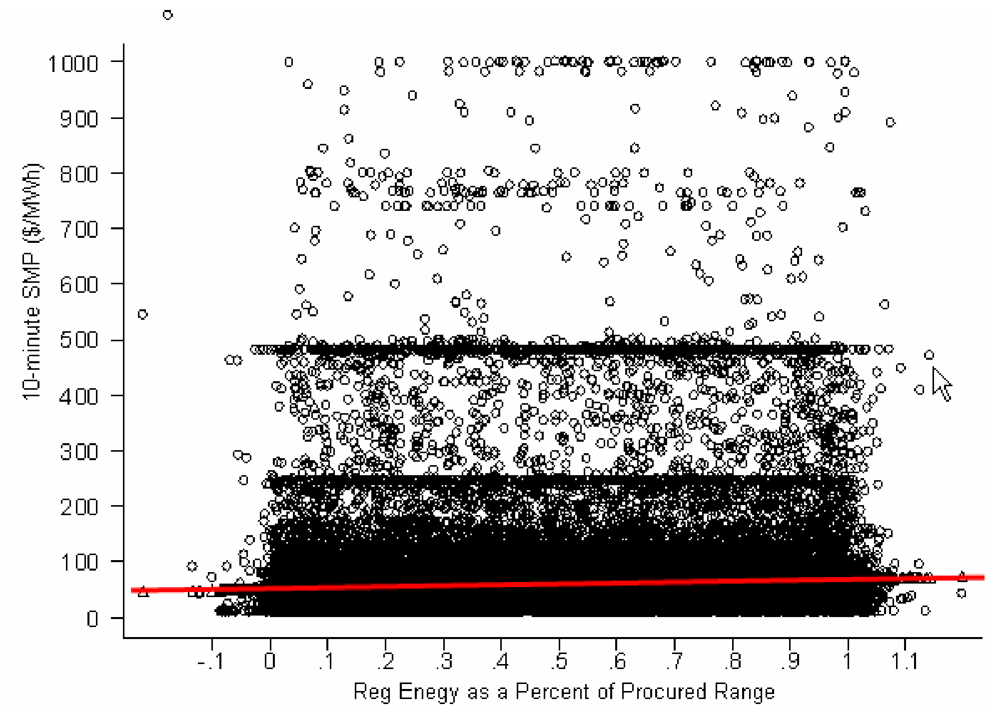


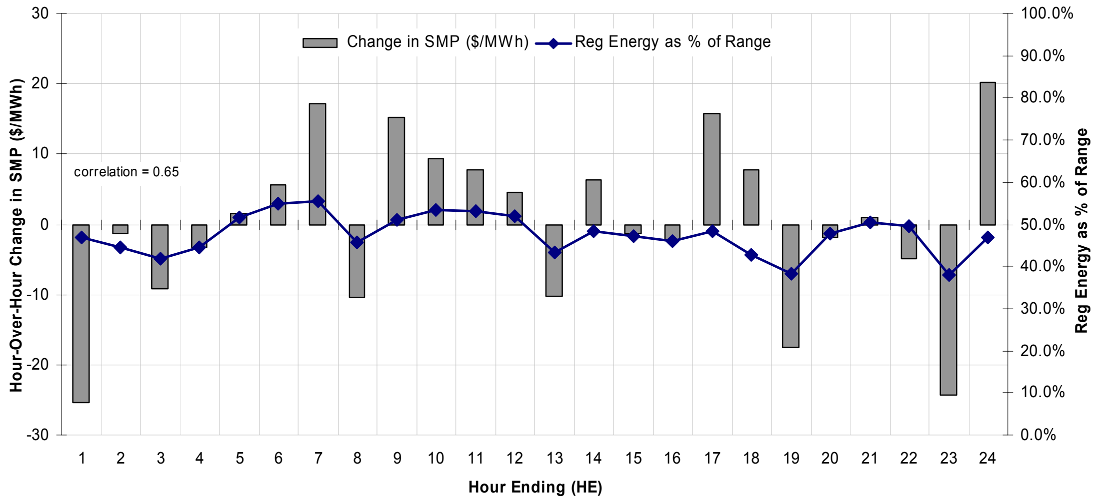
Table 1 Regression Results: 10-Minute SMP versus Regulating Energy as a Percentage of Procured Range, January 2003 - May 2004

SMP (10 minute)	coefficient	t -stat
reg eng as % of range	18.6	17.5
Constant	50.3	86.2
Number of obs	74440	
F(1, 74438)	306.72	
R-squared	0.0041	

3.2 CHANGE IN SMP AND REGULATING ENERGY

The change in SMP is more highly correlated with regulating energy as a percentage of range than is the level of SMP. **Figure 12** presents the hour-over-hour average change in Pool price against regulating energy as a percentage of procured range. The correlation between these variables is 0.65. The figure shows that large positive hour-over-hour changes in price tend to be associated with higher utilization of regulating energy and vice versa. This follows logically from the fact that large positive changes in SMP occur in hours where system load has the fastest upward ramp. As mentioned previously, hours with the fastest ramps require the most balancing energy from the regulating range and also have the highest number of CPS2 violations.

Figure 12 Hour-Over-Hour Change in SMP ($/MWh) and Regulating Energy as a Percentage of Procured Range (%) by Hour Ending (HE), January 2003 - May 2004



To capture any intra-hour dynamics, the data has been analyzed on a 10-minute basis. **Figure 13** plots the change in SMP from one 10-minute period (interval t-1) to the next (interval t) against regulating energy as a percentage of procured range during interval t. On a 10-minute basis, the correlation between the variables is 0.195. The trend line shows a positive and statistically significant relationship between the change in SMP and regulating energy utilization. The R-squared statistic is 0.038 (**Table 2**), indicating that regulating energy as a percentage of range, on its own, provides little explanatory value with respect to the variation in SMP.

Figure 13 Ten Minute Change in SMP versus Regulating Energy as a Percentage of Procured Range, January 2003 - May 2004

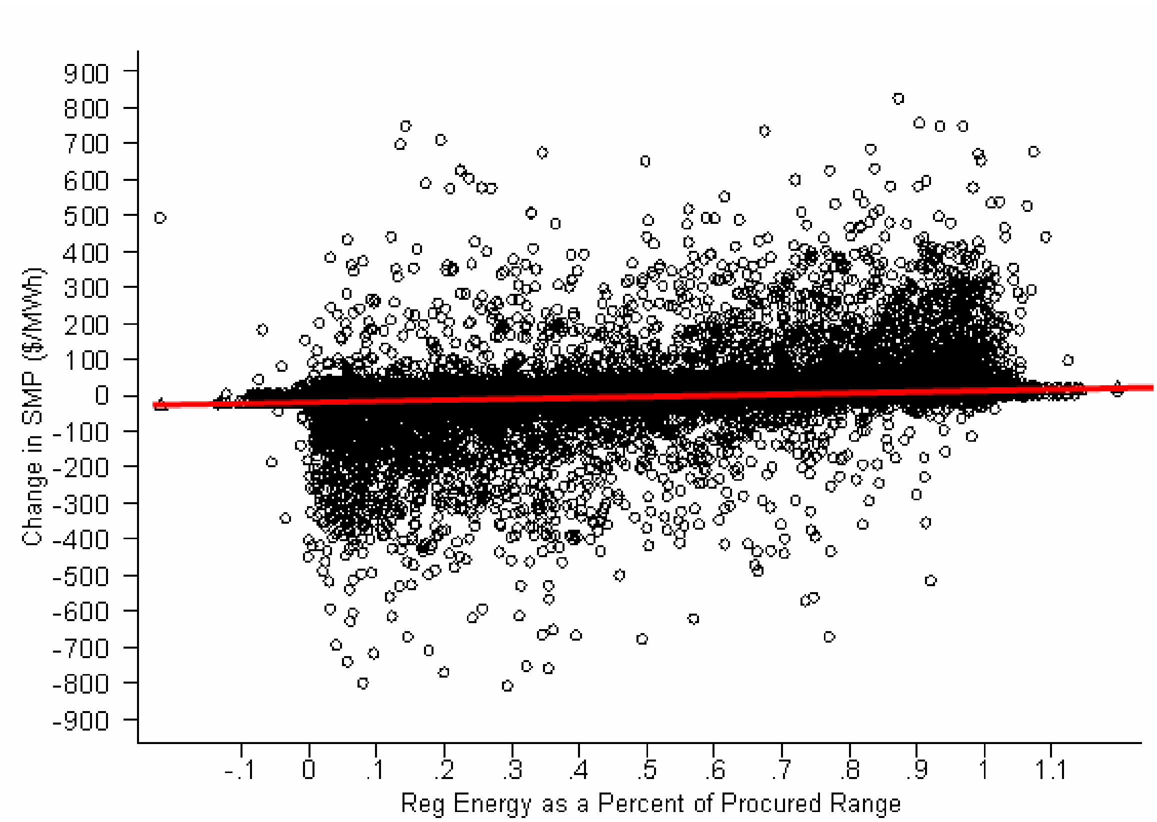


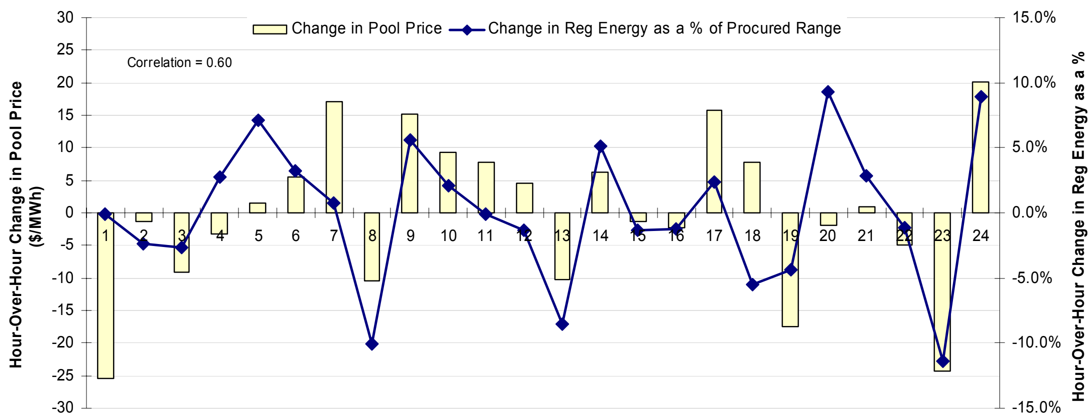
Table 2 Regression Results Ten-Minute Change in SMP versus Regulating Energy as a Percentage of Procured Range, January 2003 - May 2004

Change in SMP	Coefficient	t-statisitic
Reg Enegy as % of Range	33.03	54.12
constant	-15.69	-46.84
Number of obs	74439	
F(1, 74437)	2929.12	
R-squared	0.038	

3.3 CHANGE IN PRICE AND CHANGE IN REGULATING ENERGY

Figure 14 presents the average hour-over-hour change in price versus the hour-over-hour change in regulating energy as a percentage of procured range. As with the previous analysis, the data shows a positive correlation (0.60). Positive hour-over-hour changes in price are associated with positive hour-over-hour changes in regulating energy utilization and vice versa.

Figure 14 Change in Pool Price and Change in Regulating Energy as a Percentage of Procured Range, January 2003 - May 2004



On a 10 minute basis the correlation is lower at 0.14 (**Figure 15**). The regression results show a positive, statistically significant relationship between the change in SMP and change in regulating energy utilization. As with the previous series, the data is noisy, with a low R-squared statistic (**Table 3**). Overall, this suggests that the change in regulating energy utilization provides little explanatory value to the variation in SMP.

Figure 15 10-Minute Change in SMP versus Change in Regulating Energy as a Percentage of Range, January 2003 - May 2004

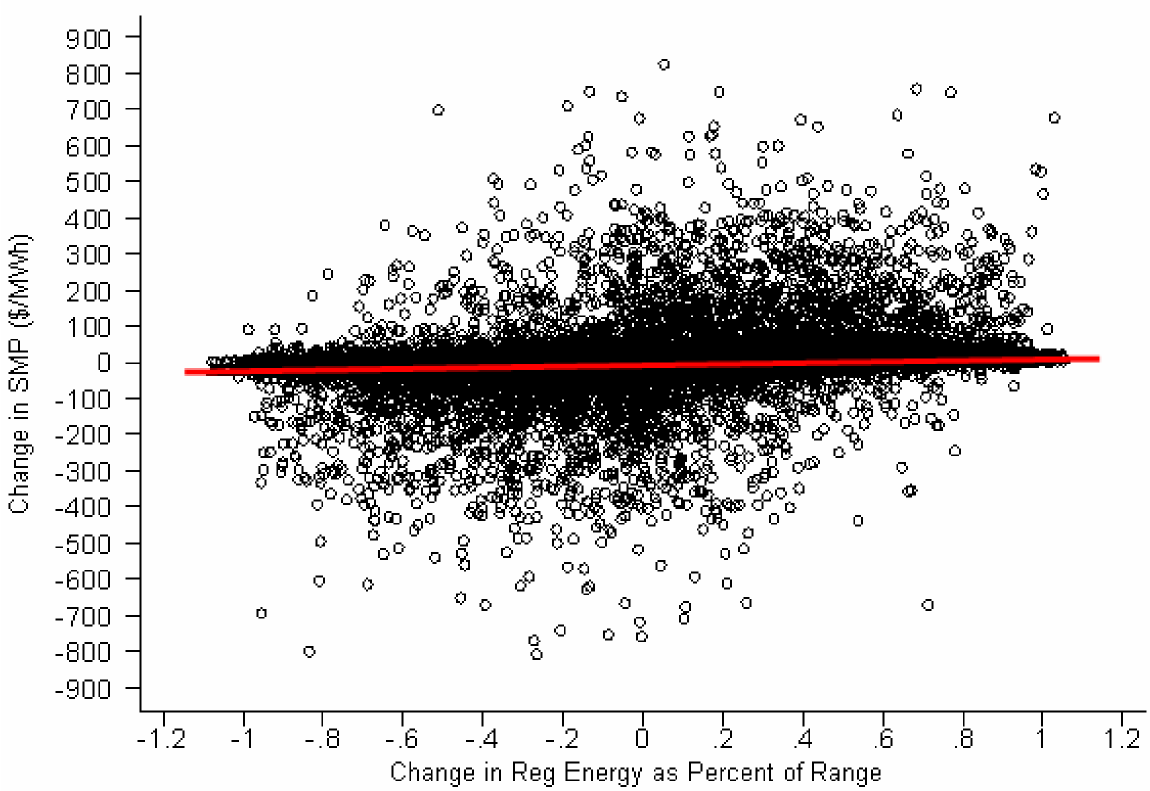


Table 3 Regression Results: 10-Minute Change in SMP versus 10-Minute Change in Regulating Energy

Change in SMP	Coefficient	t-statistic
Change in reg eng as % of range	17.00	38.35
Constant	0.00	0
Number of obs	74441	
F(1, 74439)	1471.02	
R-squared	0.02	

3.4 SUMMARY OF STATISTICAL REVIEW

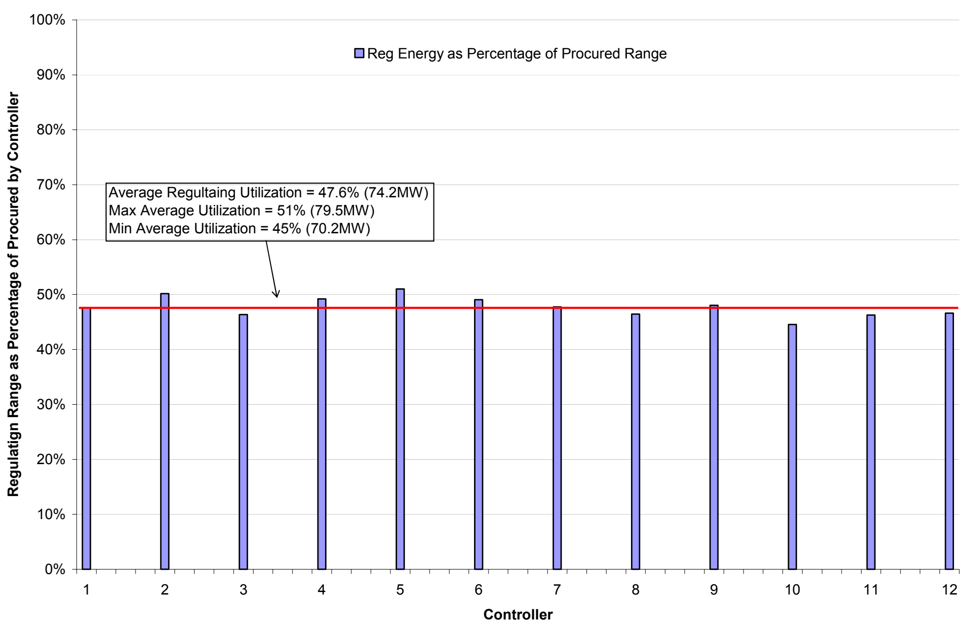
Overall, the statistical evidence provided suggests that both levels and changes in regulating energy utilization are weak predictors of the level and change in SMP. This result is not unexpected given that the analysis is focused on one, relatively small component of a highly dynamic system. It should be noted that it is encouraging to find that none of the relationships examined produced an inverse or negative relationship between SMP and regulating energy. This would have been of concern as it would have suggested that on a systematic basis, high changes or levels of regulating energy are associated with falling or lower prices. This is not the case. Higher levels and positive changes in SMP, which are consistent with the system being short of energy, are associated with positive changes and high levels of regulating energy-- consistent outcomes when the system is tight energy. Considering that in the best circumstances regulating energy naturally works as a price capacitor, these results do not provide evidence that the System Control systematically over-employs regulating energy in order to dampen prices.

4 REGULATING RESERVES BY CONTROLLER

Participants have expressed concern that there exists discernable differences among the various controllers with respect to the utilization of regulating energy and that these differences include the alleged 'leaning' on regulating reserves to damped upward price movements.

Figure 16 presents regulating energy utilization by controller[10]. Overall, the mean utilization was 47.6%. The highest utilization was 51%, which translates to approximately 5.3MW more energy than the average. The minimum utilization was 45%, or about 4MW less, on average than the mean for all controllers.

Figure 16 Regulating Energy as a Percentage of Range by Controller, January 2003 - May 2004



There are a number of reasons that controller averages differ. Most important is the distribution of hours that are worked. Some controllers work more HE07's, which require more regulating energy utilization because of system dynamics, while some controllers work more shifts during flat load hours.

We fully expect that there will be a distribution of averages among the controllers given the discretionary nature of dispatching. Previous experience and training, attitudes towards risk and the vagaries of human reactions will all cause different utilization rates.

That being said, for the energy market it is important that this impact be minimized. Clearly it would not be optimal if the function generating the distribution of SMPs is highly dependent on specifically who is dispatching the system. Regression analysis performed did not show controllers being a statistically significant determinant of SMP in

[10] Only controllers that had a sufficient number of observations throughout the dataset were included.

any specification tested, while load and generation levels, interchange activity and hour ending were all significant predictors of SMP.

We are cognizant that controller style will remain an important issue for participants and clearly do not want it to be impacting price fidelity. To that end, we have recommended to the AESO that they provide on-going training of the operational guidelines to be applied to the dispatch of the system, with a view to minimizing, where possible, differences among controllers. This is not to say we believe under the current regime, there is an undue influence on price, rather it is to promote a 'best practices' approach that recognizes the legitimate participant concerns that controller style may influence dispatch decisions and hence energy market prices.

5 SMALL BLOCKS, SMP AND REGULATING ENERGY

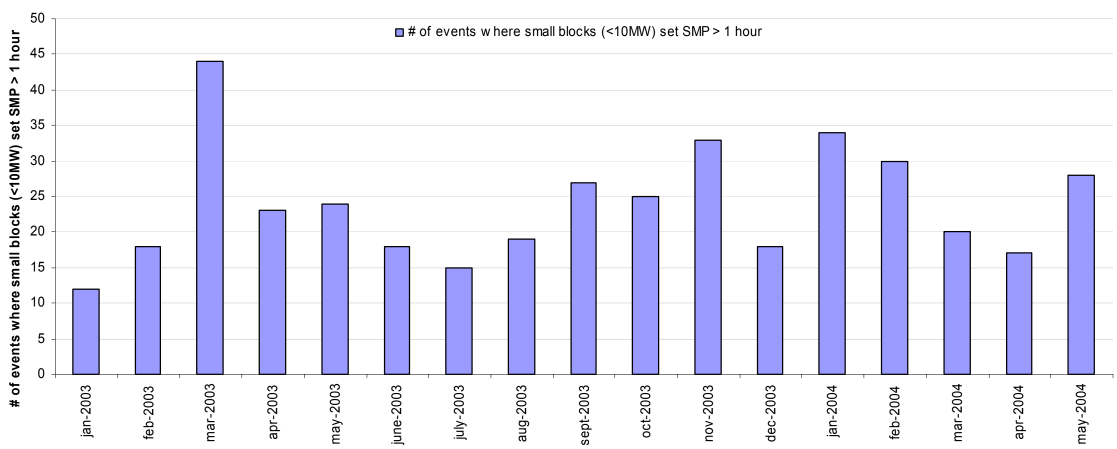
5.1 SMALL BLOCKS: FREQUENCY AND TIMING

Small blocks setting SMP for extended periods of time, especially when system load is ramping, has been cited as evidence that System Controllers lean on regulating reserves to dampen prices. As such, it is important to understand how often small blocks set SMP and when this particular dynamic occurs.

Overall, from January 2003 to May 2004, blocks of 10MW or less set SMP 14% of the time. These small blocks of energy set SMP for more than 1 hour on 406 occasions[11], or approximately 5% of the time. This suggests that small blocks setting SMP for extended periods of time is far from rare, and can be expected to occur about 5 times a week on average.

Figure 17 presents the distribution of small blocks setting SMP more than 1 hour by month. The fewest number of these events occurred in January 2003 (12 occurrences), followed by July 2003 (15 occurrences) and April 2004 (17 occurrences). The largest number of events occurred in March 2003 (44 occurrences), followed by January 2004 (34 occurrences) and November 2003 (33 occurrences). The correlation between average Pool price and small blocks setting SMP for more than 1 hour was measured and found to be weak at 0.05. There is no pattern to suggest that these events started at a certain time or have become more prevalent over time. Rather, they appear as part of the overall system dynamics, and are likely influenced by a myriad of factors including load and generation dynamics as well as bidding and dispatch behavior.

Figure 17 Number of Incidents Where Small Blocks (<10MW) Set SMP for More than 1 Hour



[11] The definition of small blocks being 10MW or less and an extended period of time being 1 hour or more are somewhat arbitrary. These definitions are being employed to simply provide some context to the frequency of such events.

There are numerous reasons why small blocks can set SMP for an extended period of time. They include:

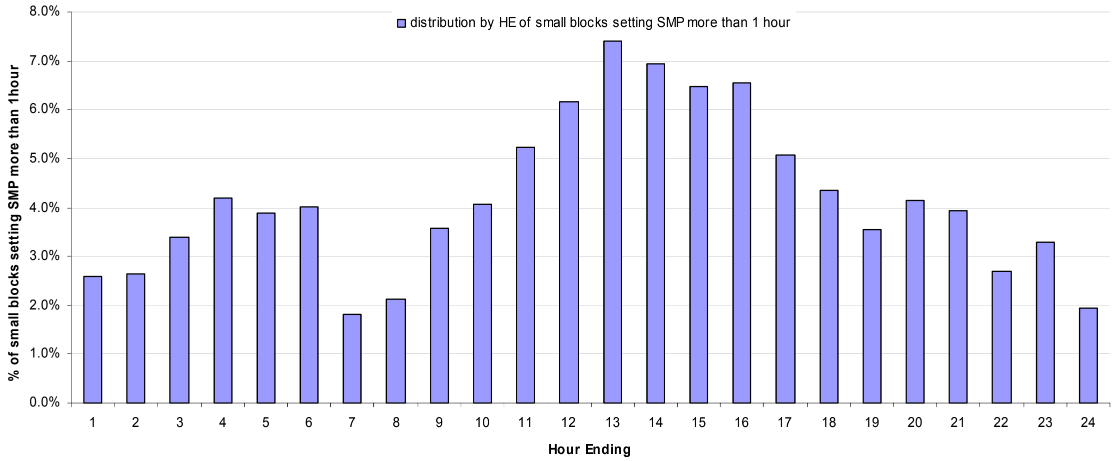
- Day ahead offers being shaped to follow expected load trends. If shaping offers are from $0/MWh or low priced blocks, generation can increase with load, while SMP remains unchanged. For example, Hydro units will shape day-ahead offers to follow load.
- Energy restatements, especially from those units that zero offer with the intent of price/load chasing or from units adjusting output levels to meet on-site load or steam requirements (in the case of co-generation facilities). Generation can follow load with SMP remaining unchanged. This type of load following is typical of gas-fired generators in the province.
- Changes in generation without accompanying restatements (changing generation levels without submitting energy restatements). For example, generators will use the 10% over-generation allowance, which across the system can add up to a significant amount of generation. Again, generation can trend with load with SMP not changing.
- Ramping of the tie-line as hourly schedules turn over. Changes in the level of imports or exports can offset load growth or reductions, thus keeping SMP unchanged.
- Partial dispatches – blocks can be partially dispatched. As load increases, these blocks can be fully dispatched. Generation will increase, but there will be no change in SMP, and no dispatch visible to the market at large.
- Change in wind or water conditions can lead to coincidental load following from the wind-turbine facilities or run-of-river hydro facilities, neither of which is truly dispatchable.
- Regulating energy absorbing load changes leading to a static price.

Essentially, all of the system dynamics that drive the need for regulating energy in the first place can, on occasion, balance out allowing a small block of energy to set SMP for an extended period of time.

Figure 18 presents the distribution of small blocks setting SMP for more than 1 hour by hour ending. These types of events are far more likely to occur during hours where the change in load is the smallest and overall system dynamics are most stable. Only 4% of these events have occurred during the critical morning ramp hours, HE07 and HE08. HE23 and HE24 accounted for just over 5% of the occurrences. Overall, the correlation between the absolute change in load and small blocks setting SMP is -0.75.

Given these outcomes, it does not appear that small blocks setting SMP for extended periods is occurring overly frequently during ramp hours.

Figure 18 Hourly Distribution of Incidents of Small Blocks (<10MW) Setting SMP for More than 1 Hour



In a dynamic system it is somewhat surprising that small blocks set SMP with such frequency. The following example, along with some supporting statistical evidence provides, in our view, a plausible explanation for these events.

5.2 EXAMPLE: SMALL BLOCK SETTING SMP FOR AN EXTENDED PERIOD OF TIME: APRIL 2004

The following example occurred in April 2004. A 4MW block set the SMP at \$42.58/MWh for 275 consecutive minutes (4 hours, 35minutes) between 08:25 and 13:00. Prior to that event, the SMP had been stable at \$41.08/MWh for 55 minutes, set by a 25MW block.

Figure 19 illustrates the SMP from 8:00 to 14:00. The figure shows both the flat SMP from 08:25 to 13:00, and the effect on SMP had the System Controller dispatched up +10MW (pink square), +20MW (blue triangle) and +40 MW (green square), over various points during the static price event. Over the course of the event, a small dispatch up would have caused a sharp increase in SMP. From 08:00 to 10:00 and from 11:00 until 13:00, a 10MW dispatch up would have more than doubled SMP to \$105/MWh. A 20MW dispatch would have almost quadrupled SMP to \$220/MWh. A 40MW dispatch up would have increased the SMP by a factor of 6 to \$280/MWh. From 10:00 to 11:00 a 10MW dispatch up would have caused the SMP to increase to \$220/MWh and a 20MW to 40MW dispatch would have increased SMP to \$240/MWh.

Figure 19 SMP and Price Sensitivity to Dispatch Up

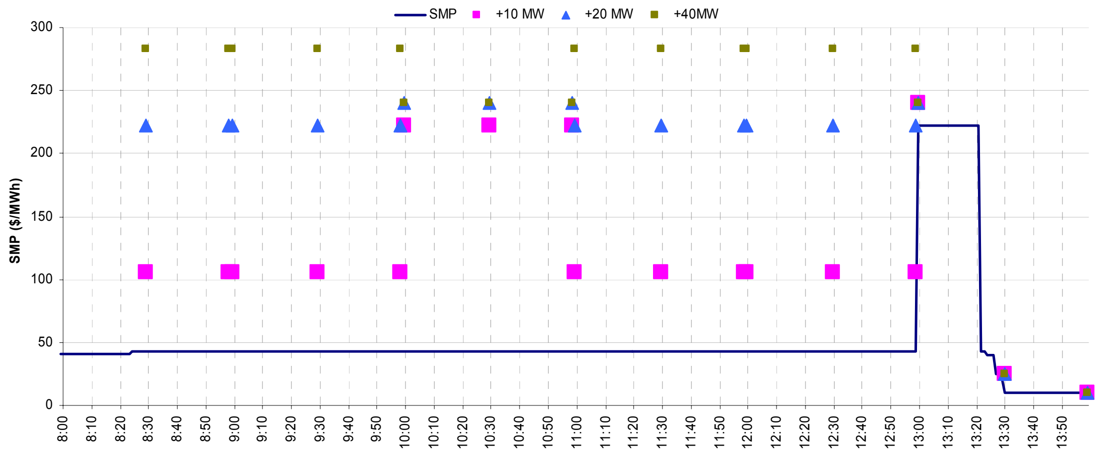


Figure 20 illustrates the merit order taken at 08:30 and shows where the SMP was set relative to the overall merit order. The price setting block is shown by the pink square. As is evident, a small dispatch up would have caused a significant increase in the price because the SMP was set at the bottom of a vertical step function in the merit order.

Figure 20 Merit Order (08:30)

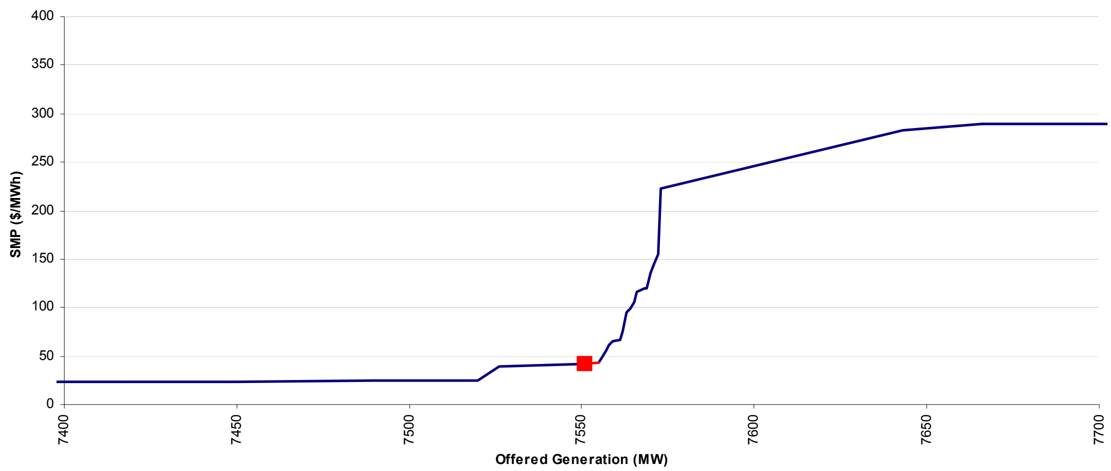
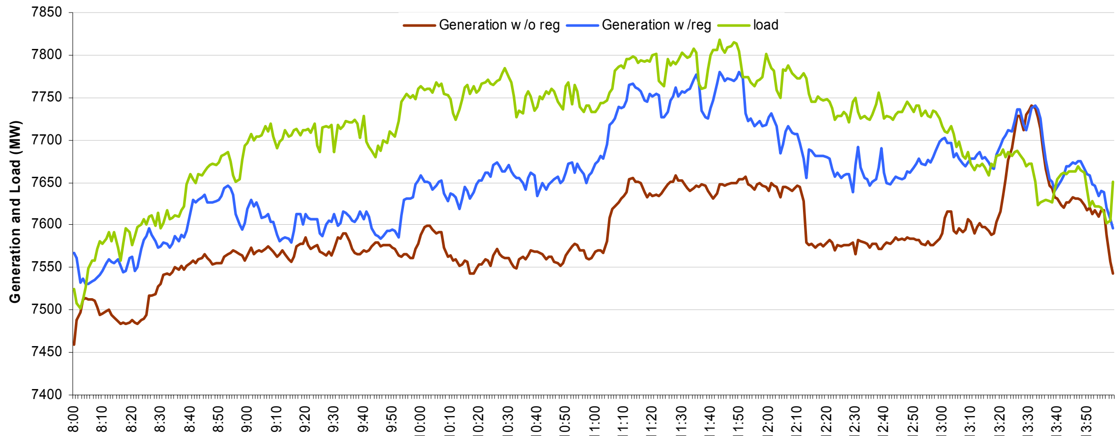


Figure 21 reports internal AIES load, along with total generation including and excluding regulating energy. In **Figure 21**, the vertical distance between the internal load (green line) and internal generation with regulating reserves (blue line) is equal to scheduled tie-line flows plus inadvertent energy (unscheduled flows). The vertical distance between the blue line and the brown line (internal generation excluding regulating reserves) is the level of regulating energy.

Figure 21 AIES Internal Load and Generation (With and Without Regulating Reserves)



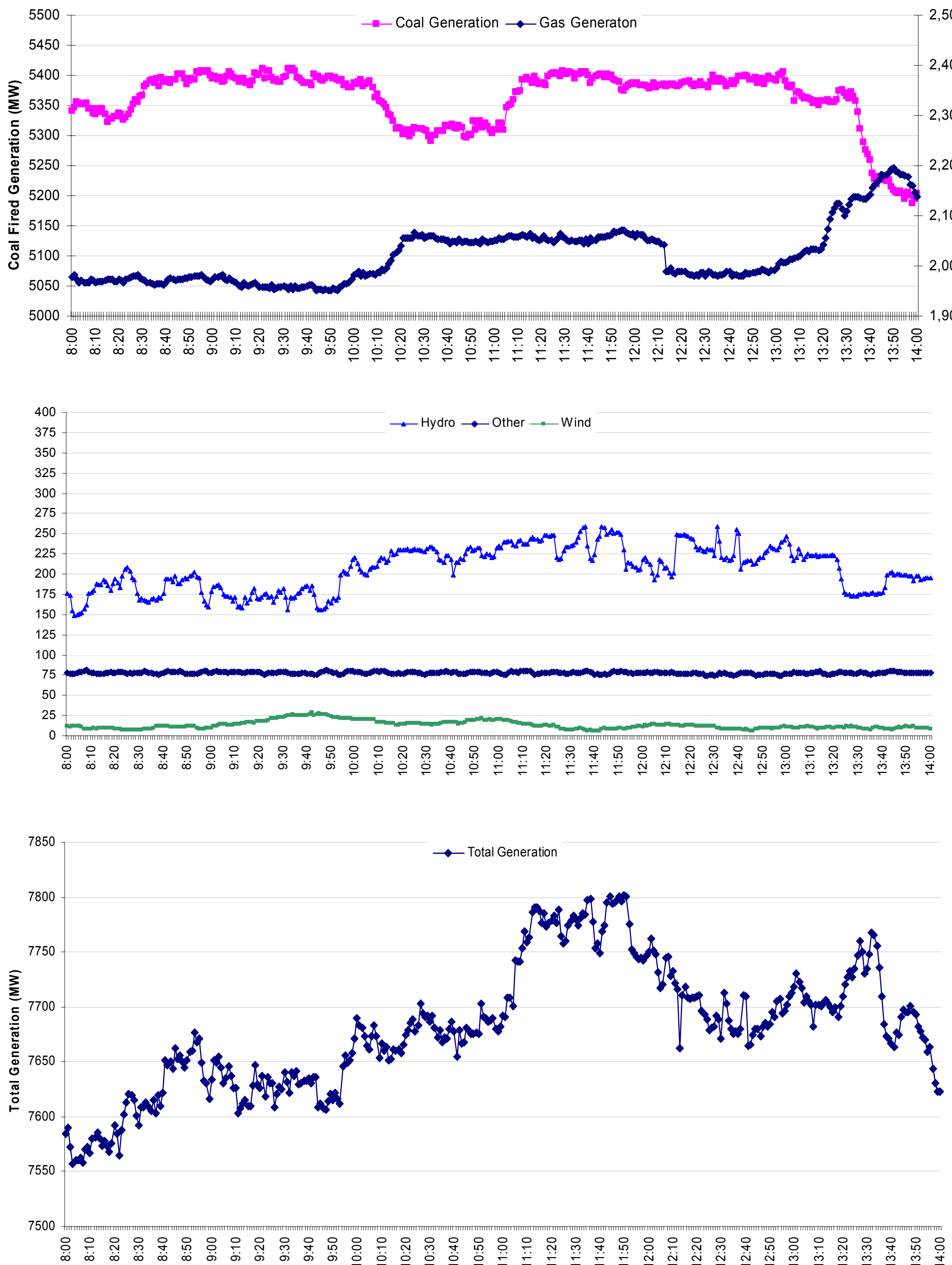
The trend in load is increasing from 7600MW at 08:25 to a peak of 7820MW by 11:43 and back down to 7732MW by 13:00. Load trends follow consumption patterns of all consumers in the province. As well as trending, load swings up and down on a moment-to-moment basis as residential, commercial and industrial loads alter their consumption. It is not uncommon in Alberta for a single large industrial participant to swing load by up to 50MW in any given moment (about 1/3 of the typical regulating range).

Alberta also carries price sensitive loads that will react to price swings (100MW – 250MW). Typically these loads do not offer into the merit order. This can create additional issues in managing ACE as large industrial loads may come off due to price spikes, although the System Controller has no firm idea of when or how much load may react to an increase or decrease in the SMP.

5.2.1 GENERATION TRENDS

Total generation (**Figure 22**), including generation from the regulating range increased from 7590MW to 7800MW from 08:25 to 11:50, and then trended down to 7700MW by 13:00. The trend in generation was influenced by a number of factors, including derates at coal-fired units and then their return to full output, energy restatements at gas-fired units, which increased output, and load following hydro production arising from the day-ahead offer profile and variability in wind generation, along with the output reaction from the regulating range.

Figure 22 Coal, Gas, Hydro, Wind/Other and Total Generation Profiles



Coal-fired generation ramped from a low of 5330MW at 8:25 to slightly less than 5400 by 8:35. The increase was due to a unit ramping up from 315MW to 385MW. Coal-fired generation remained steady around the 5400MW mark until 10:00, when 3 coal-fired units were derated by 30MW-40MW per unit. No energy restatements were submitted in response to the derates because the derate volumes were within the allowance provided in ISO Rule 3.5.4[12]. At 11:00 the units returned to their pre-derate generation levels.

In response to the loss of about 100MW of coal-fired generation, a gas unit was restated from 9MW to 65MW from 10:00 to 12:10. The effect of the restatement can be seen in the increase in overall gas-fired generation between 10:00 and 12:00. Note that the coal-fired unit derates only lasted between 10:00 to 11:00. This extra 56MW of generation absorbed much of the peak in load between 11:00 and 12:00.

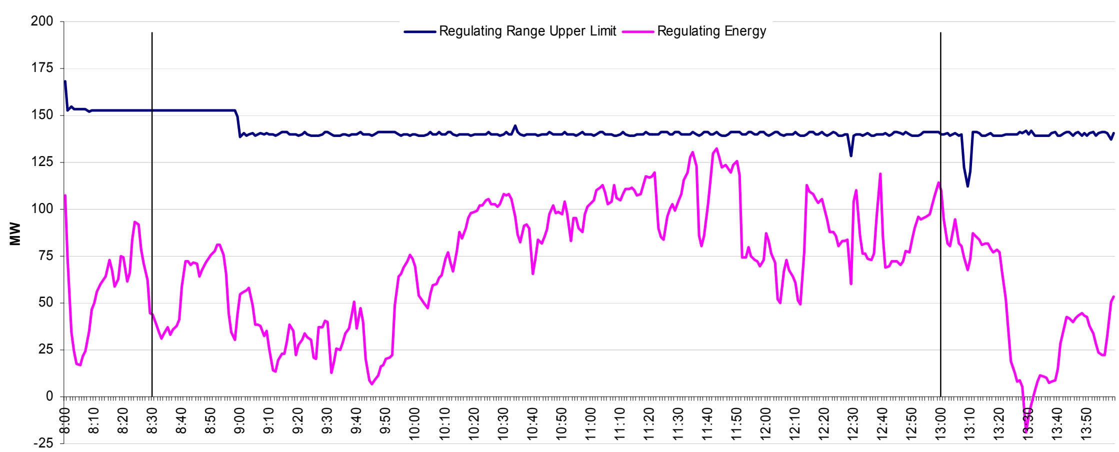
Hydro generation also trended up with load – partly because they were providing regulating range-and partly due to the load following profile in its day-ahead offers.

Wind generation added about 20MW of variability to the overall generation profile. Wind output varied from about 8MW at 8:30, and trended up to almost 30MW by 9:30. Wind production trended down thereafter, hovering around the 10MW mark from 11:20 onwards.

The regulating range and regulating energy production are shown in **Figure 23.** From 08:25 until 10:15, regulating energy was generally hovering in the lower half of the range, averaging 46MW, despite the fact internal load increased by 160MW. Part of this load increase was served by 75MW of imports that came in from 9:00 to 11:00 (**Figure 24**). Part of it was served by load profiled day-ahead offers, while the balance was provided by regulating reserves.

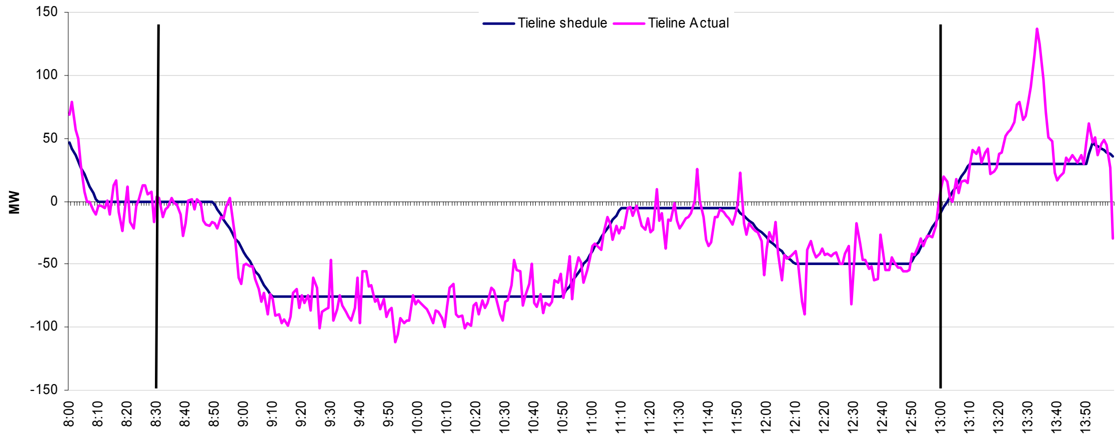
From 10:20 through the dispatch up at 13:00, energy produced from the regulating range trended up to an average of 95MW. The dispatch up at 13:00 appears to have occurred in response to a shift in the interchange schedule from 50MW of imports to 30MW of exports (which is equivalent to load ramping 80MW over 20 minutes from 12:50 to 13:10).

Figure 23 Regulating Range and Actual Regulation Energy Produced



[12] ISO Rule 3.5.4 states that restatements are compulsory if the MW capacity of the asset is reasonably expected to change by the lesser of 10% of the offered capacity or 50MW (although there is no penalty for under-generation).

Figure 24 Scheduled and Actual Interchange Flows



Although we can second guess the System Controllers with the luxury of hindsight, throughout the 08:25 to 13:00 static price event, the system was well within the mandatory CPS2 limits, with ACE averaging 6MW throughout the period, and the largest 10 minute interval coming in at |15.3| MW. It was not until the dispatch up at 13:00, which caused the SMP to increase from $42.58/MWh to $222.49/MWh, that the control area encountered a CPS2 reliability issue. Between 13:30 and 13:39, ACE was 50.1MW, which was within 0.06MW of a CPS2 violation (**Figure 25**).

Figure 25 Area Control Error (MW)

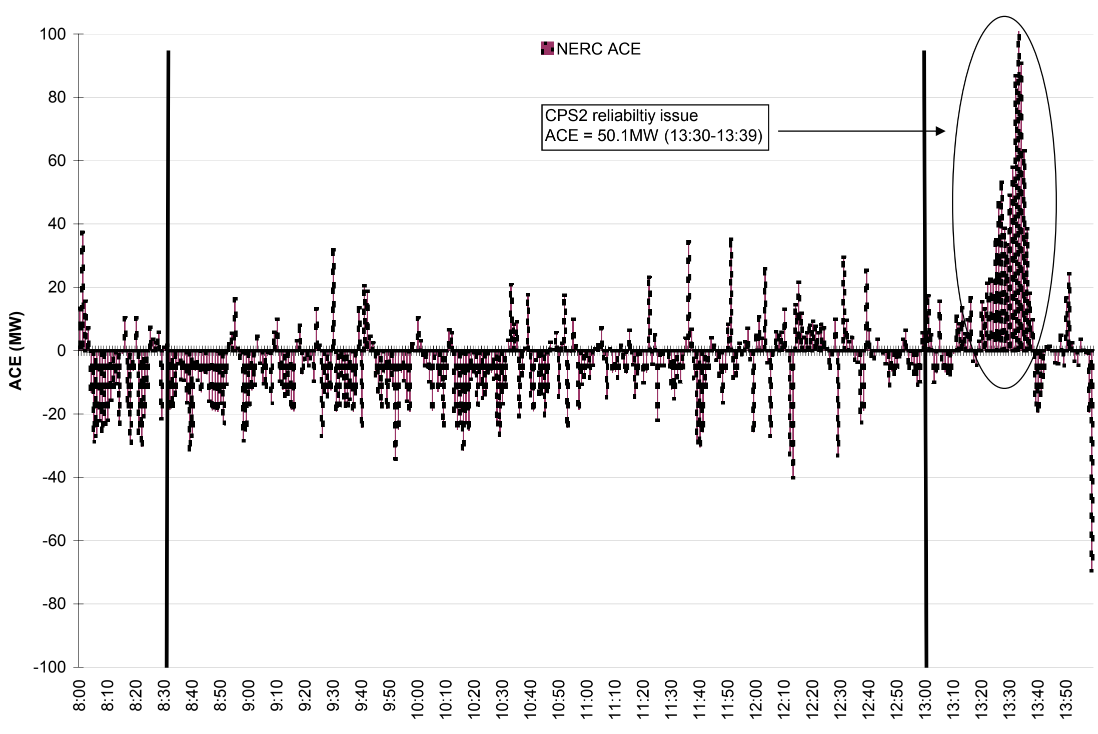
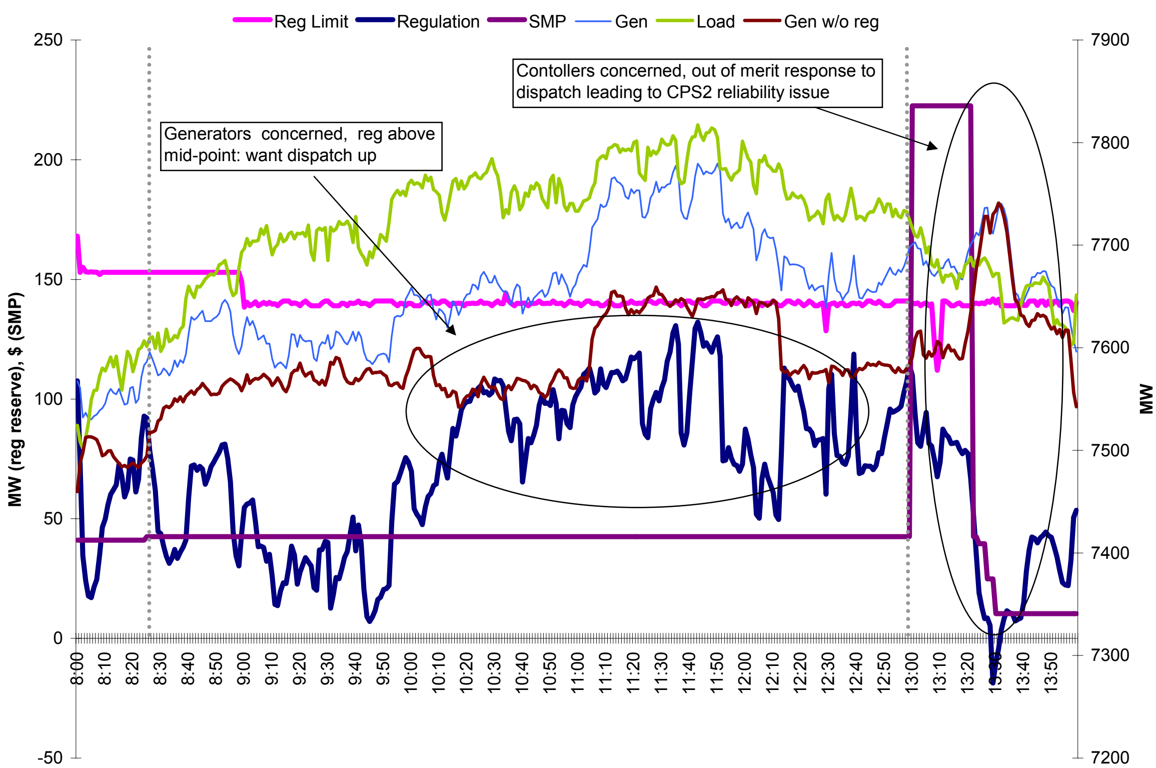


Figure 26 gives an overall picture of the static price event. It shows that internal generation supplemented by tie-line flows and regulating energy, trended with load throughout the 08:25 to 13:00 period. Regulating energy moved into the upper half of the range after 10:00, and averaged above the midpoint as imports declined during HE12. Regulating energy edged back down during HE13, as imports increased and load started trending down. As the interchange scheduled switched from 50MW of imports to 30MW of export at 13:00, the System Controller dispatched up the merit order.

Figure 26 Regulating Range, Regulation Energy, Load and Generation



The dispatch up at 13:00, which moved the price from \$42.58/MWh to \$222.49/MWh created a situation where a number of generators engaged in price chasing behavior. This was exacerbated as price sensitive load backed down, creating significant over-generation in the system and a CPS2 reliability issue as ACE exceeded 50MW from 13:30 to 13:39.

5.2.2 SYSTEM OVER-REACTION TO SMP

At 13:00, the System Controller dispatched up, calling on 49MW of generation. **Table 4** shows the dynamic response that occurred after the price moved to \$222.49/MWh. During HE14, over 250MW of energy responded to a price signal created by a 49MW dispatch up[13]. The influx of energy caused the System Controller to dispatch down at 13:22 to $42.58/MWh, and then to $10.32/MWh by 13:30. The SMP remained at $10.32/MWh for the remainder of the hour. The settlement price for the hour (HE14) was $91.38/MWh.

Table 4 Dynamic Price Response from Generators

Unit Type	Output @ 13:00	Output after increase in SMP	Time of Maximum Output	Change in Output	Restatement/Comment
gas	20	28	13:38	8	no restatement
gas	0	43	13:19	43	restatement of 35MW @ 13:13
gas	138	147	13:20	9	restatement from 135MW to 150MW for 1 minute @ 13:25
gas	94	118	13:51	24	no restatement
gas	123	144	13:31	21	no restatement
gas	9	63	13:35	54	restatement @ 13:15
gas	325	358	13:12	33	dispatched
gas	0	21	13:27	21	no restatement
gas	82	100	13:30	18	no restatement
gas	11	34	13:53	23	no restatement
Total				**254**	

Some units continued to come on even as other units were following their dispatch down instructions. The maximum net generation change (excluding regulating generation) for the hour was 150MW between 13:00 and 13:31. During this period, generation excluding regulating reserves increased from 7590MW to 7741MW.

Price sensitive load responded as well (**Table 5**). Although it is difficult to identify what portion of the load change was price sensitive and what was part of the non-price sensitive trend, overall load fell by 150MW between 12:59 and 13:59, and then jumped by 100MW after the settlement period ended. From this we estimate approximately 100MW of price sensitive load reacted to the increase in SMP.

Table 5 Estimated Load Response to SMP

Time	12:59	13:59	14:05
Load	7738	7591	7700
Change in load		-147	109

Because the SMP is settled on an hourly basis, price chasing generators and price sensitive load are somewhat indifferent to whether they generate/drop load before, during or after the price jump, as long as the response occurs within the settlement hour. If the first 22 minutes of the hour are $222/MWh, then the minimum price for the hour (if the SMP falls to $0/MWh for the remaining 38 minutes) will be $81.40/MWh. In general, the mismatch between the SMP, which is set every minute, and the settlement price which is

[13] Note that some of the out-of-merit responses do not appear compliant with ISO Rule 3.5.4 regarding compulsory restatements.

an hourly average can lead to system *hysteresis* where generation and load reactions over-shoot dispatch orders and are lagged (within the hour) to a price event.

Figure 26 highlights two crucial interconnected dynamics, and what we believe is a key short-term issue in the market. The first dynamic is that regulating range drifted above its midpoint from around 10:30 to 12:00. This is a central concern for generators, many of whom want to see increased dispatches when this occurs, and cite this as a lack of *price fidelity*[14] or System Controllers 'leaning' on reserves to dampen price (presumably by this reasoning, the System Controller should have dispatched down when regulating energy was below the midpoint as well). The second dynamic shows the over-reaction from generators and load, in the order of 250MW[15] of reaction occurring from a request for 50MW of energy. This lack of *dispatch fidelity*[16] is a serious concern for the System Controller, as it leads to CPS2 reliability issues. These dynamics are clearly interconnected. System Controllers may be reluctant to dispatch up if ACE is on schedule, even though they may be in the upper half of their regulating range, because, through repeated experience they expect an over-reaction to their dispatch instructions which can lead to CPS2 violations. Generators, frustrated that dispatches are not occurring when they believe they should, engage in price chasing behavior when dispatches do occur. This leads to CPS2 violations, unacceptable levels of inadvertent energy and causes an operating burden on adjacent control areas. ***These dynamics are self-reinforcing and form a repeated, sub-optimal outcome for both generators and System Control***.

5.3 STATISTICAL EVIDENCE OF LAGGED OVER-REACTIONS TO LARGE CHANGES IN SMP

These dynamics are not isolated to the example presented. **Figure 27** presents the change in ACE from one 10-minute interval to the next (interval t-1 to interval t) plotted against the change in SMP (interval t-1 to interval t). Around the moment of a change in SMP (within interval t), there is no statistical relationship between the change in SMP and the change in ACE.

[14] Again, price fidelity refers to a clear price signal arising from the supply/demand balance via the merit order

[15] To clarify, there was a gross generation reaction of 250MW of generation and estimated 100MW of load, leading to a gross reaction of 350MW. However, some generators were dispatched down during the hour in response to the over-generation situation, and followed their dispatch instructions (they accounted for approximately 100MW). Therefore the net over reaction was in the order of 250MW.

[16] Dispatch fidelity refers to the notion that what is requested through dispatch equals what is provided by generators and load.

Figure 27 Change in ACE (10-Minute intervals) versus Change in SMP (10-Minute intervals), January 2003 - May 2004

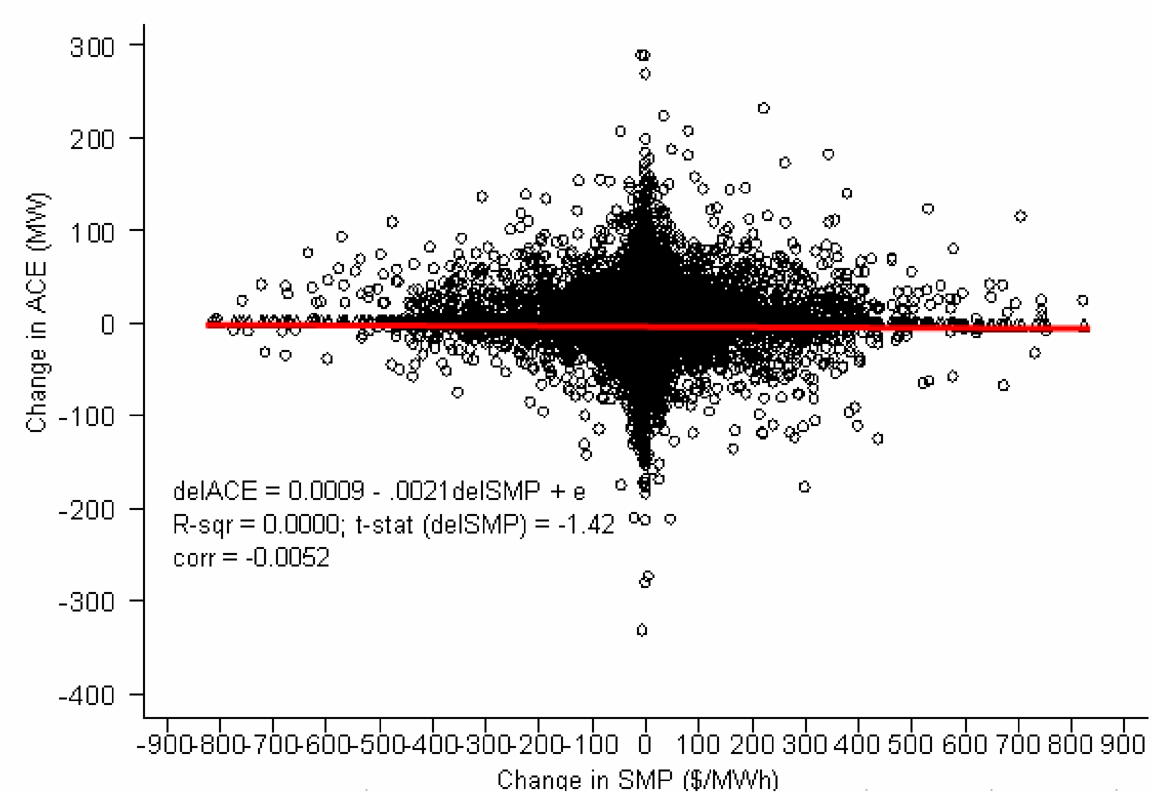
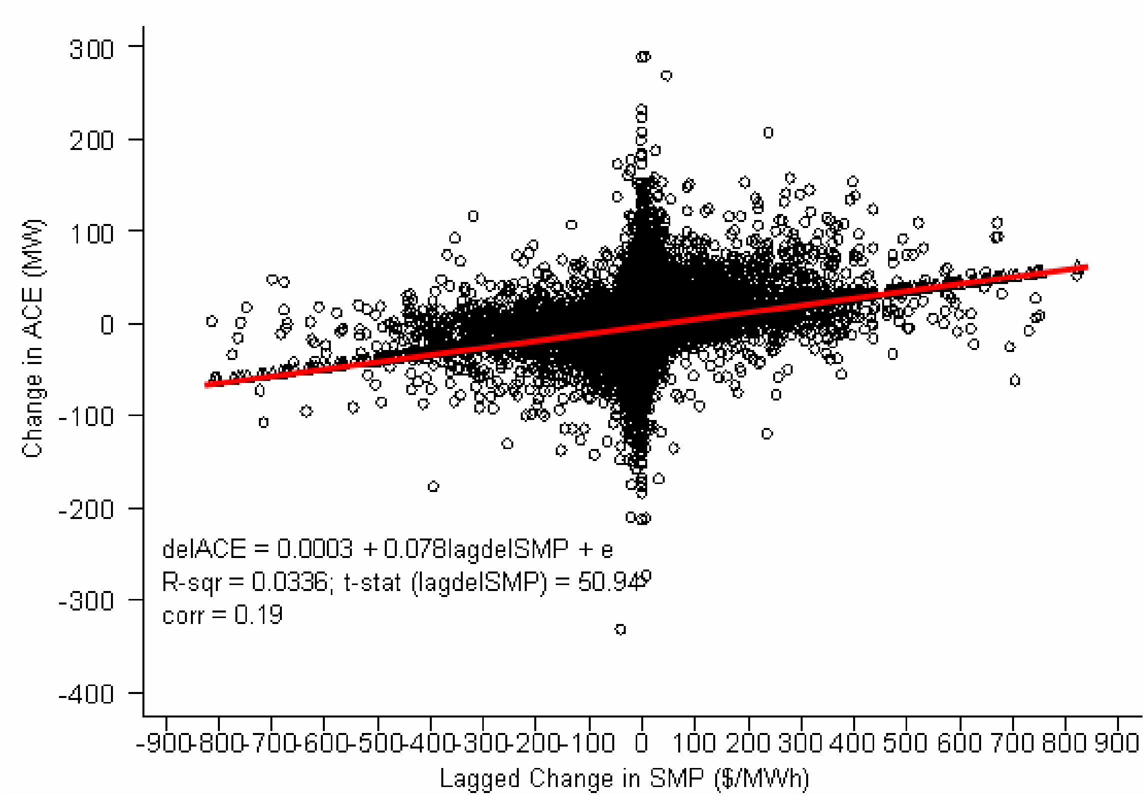


Figure 28 shows this relationship as we expand the time horizon. The figure presents the change in ACE (interval t-1 to interval t) against the lagged change in SMP (interval t-2 to interval t-1). The data shows that large positive changes in SMP between intervals t-2 and t-1 (20 to10 minutes prior), are associated with large positive changes in ACE in the current 10-minute time interval (t). This suggests systematic lagged responses to dispatch orders, which tend to over-compensate for dispatch instructions and lead to swings in ACE. We refer to this dynamic as *system hysteresis*, or a lagged and over reactive response to dispatch instructions by generation and load.

Figure 28 10-Minute Change in ACE versus the Lagged Change in SMP, January 2003 - May 2004

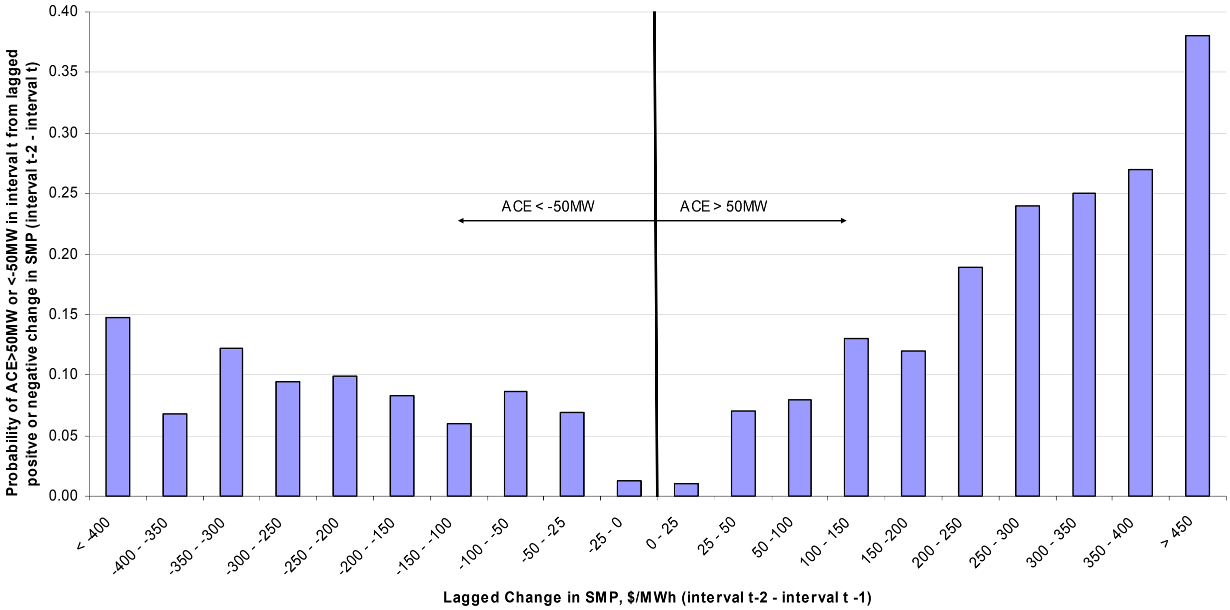


Another way of articulating this issue is presented in **Figure 29**. On the horizontal-axis are changes in SMP that occurred between interval t-2 and interval t-1. On the vertical axis is the probability ACE will increase by more than 50MW (in the case of a positive price change) or decrease by more than -50MW (in the case of a negative price change) in the current time interval. Note that we are not measuring CPS2 violations per se, rather we are measuring the probability that there will be a large change in ACE arising from a change in SMP that occurred 10 to 20 minutes earlier.

When the SMP increases (right side of the figure), the probability of a lagged over-reaction from load and generation (as measured by a change in ACE >50MW) increases substantially. For a small change in SMP, the probability of ACE changing substantially 10-20 minutes later is very low (around 1%). For a large positive change in SMP (>450MW for instance), the probability of ending up in an over-generation situation, where ACE has jumped by more than 50MW is much higher (38%).

Notice also that the distribution of probabilities is not symmetrical. The left-hand side of the graph presents the probability that a negative change in SMP will cause ACE to change by more than -50MW. This is measuring the (lagged) impact of generation coming-off, or price sensitive load coming on in response to a fall in SMP (causing under-generation). The probability distribution is much flatter, suggesting that load and generation are more reactive to upward price signals than to downward price signals.

Figure 29 Probability Distribution of a Change in ACE (>|50|MW) Arising from a Lagged Change in SMP ($/MWh), January 2003 - May 2004



What is being described here is a basic short-term issue that the System Controller faces. An extremely steep merit order (which is characteristic of the mid-merit in most hours) means that System Controllers will often be in a situation where requesting a small amount of energy will require a large upward change in SMP. The probability distribution illustrates that when they initiate large upward changes in SMP, they will expose themselves to potential CPS2 violations because of large changes in ACE. Under these operating conditions, it is only rational for the System Controller to be wary of dispatching up steep sections of the merit order for small amounts of energy (the potential costs outweigh the benefit). This wariness is interpreted by market participants as a 'price bias', when it is in fact a rational response to potential reliability concerns (System Controllers have a reliability bias).

This analysis does not intend to diminish the 'price bias' concerns of participants. We believe their concern about price bias is a rational interpretation of the information they see in the marketplace. However, this may be a result of a failure to adequately communicate the true nature of the short-term problem facing the System Controllers, rather than purposeful 'price management'.

5.4 DISPATCH FIDELITY AND PRICE FIDELITY

The ostensibly stable and sub-optimal outcome that has been reached appears to be the consequence of a repeated game where the pursuit of dominant strategies by each player is inadvertently leaving all players dissatisfied with the outcome. Dominant strategy can be defined as the maximizing strategy of one player, given the maximizing strategies of all the other players. For the System Controller, the dominant strategy is the strategy that minimizes CPS2 violations. It should be kept in mind that this is not a voluntary strategy, but an obligation as a member of WECC. The System Controller's dominant strategy is to be as conservative as possible in dispatching to high SMPs given the expectation of over-reaction by non-offered price sensitive load and price chasing generation. The dominant strategy of a subset of generators (mostly peaking generation) and basically all price sensitive load is to stay out of the merit order and chase price (or price-avoid in the case of load), given the conservative dispatch strategy of the System Controller. These strategies are outcomes of each other, as players adjust over time and 'learn' the game. Both strategies are within the rules of the game, and more importantly, are the most rational (dominant) for each player. Equally important is that no side will benefit from changing its strategy if it expects the other side will not. Therefore, it is not expected that the strategy of either side will change unless there is a change to the structure or rules of the game.

We believe that this sub-optimal outcome has also created a 'confidence lean' environment which has detrimentally impacted the current dialogue around market design and short-term adequacy. Generators' perceive that System Controller is managing price, which is impacting their bottom line. This has become a serious point of discontent.

System Controllers view out-of-merit activity by generators and loads as an activity that undermines their ability to dispatch the system and live up to their reliability obligations as members of WECC. This is also a point of serious discontent.

Both sides appear entrenched in their perspectives, leading to reduced communications and cooperation with respect to understanding the true market and operational issues and collaboratively designing solutions.

6 CONCLUSIONS AND RECOMMENDATIONS

The trends and statistical analysis performed in this work do not, in our opinion, provide supporting evidence that the System Controllers are engaged in systematic misuse of regulating reserves to alter competitive prices. The body of evidence shows that the variability in the utilization of regulating energy across hours is consistent with the overall system dynamics, which include load ramps, generation offer profiles, interchange activity and AS contract timing. The results show that the System Controllers are most active in dispatching through the merit order when the system is in its most dynamic hours.

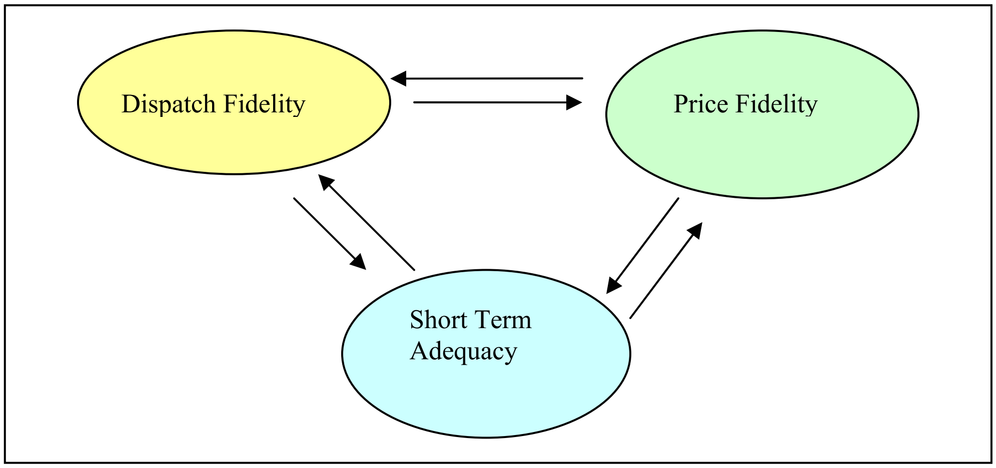
The statistical relationships between SMP and regulating energy are positive, and on a 10-minute basis, are weak. Regulating energy levels and changes provide little explanatory value to the levels and changes in SMP, except to say that when SMP is high, regulating reserve utilization tends to be high and vice versa. This is consistent with the notion that SMP will be high when the system is tight energy, and when we would therefore expect regulating energy utilization to increase.

Finally, the analysis does not show that individual System Controllers are a significant influence in overall price determination. The data shows that there is a range of regulating utilization across controllers. However, given the discretionary nature of the function, we do not conclude that this range is inappropriate.

In terms of small blocks setting SMP for extended period of time, the data shows that these events overwhelmingly occur when the system is least dynamic. However the evidence suggests that the strategies of the System Controllers in minimizing CPS2 violations coupled with the lack of dispatch fidelity on the load and generation side are leading to what we believe is a stable sub-optimal outcome. There is a key interrelationship between dispatch fidelity (what is asked for equals what is provided and needed) and price fidelity (sufficient dispatch through the merit order to provide an efficient price signal) that needs to be properly articulated and addressed.

It is from the example and corroborating statistical evidence presented in section 5 that we draw the relationship between price fidelity, dispatch fidelity and short-term adequacy. **Figure 30** provides a representation of the interconnectivity of the overall relationship between these components of the market. We believe that all three concepts are self-reinforcing – if there are issues with dispatch fidelity, there will be issues with price fidelity and short term adequacy. If there are issues with price fidelity, there will be issues with dispatch fidelity and short-term adequacy. No one component can work efficiently on its own.

Figure 30 Dispatch Fidelity, Price Fidelity and Short Term Adequacy



From the research, we do not believe that culpability for the sub-optimal outcome can or should be assigned to one particular party. We believe that both System Controller and generation and load participants are acting rationally in the face of the current market rules and the strategies of the other players.

The MSA's hope is that by publishing this study and demonstrating the interconnectivity of the concepts it will lead to a more 'confidence rich' environment and collaborative approach to the current review of the market.

6.1 RECOMMENDATIONS

It is natural for participants to be concerned about the use of regulating reserves and its impact on price. For this reason it is critical that the AESO responds to participants' concerns and provide explanations and analysis that promote transparency with respect to regulating reserves. To date, we do not believe that communications and analysis provided by the AESO to the market at large have been successful in alleviating participant unease. At times, participants have expressed frustration that the AESO's responses to inquires into the utilization of regulating reserves have not satisfied their concerns, which has fuelled participant apprehension rather than providing reassurance. Moreover, it does not appear that in the AESO's one-on-one consultations they have adequately depicted (albeit to a generally critical audience) the nature and consequences of the dispatch issues they are facing. The apparent communication break-down has allowed the regulating reserve issue to expand from being 'occasional' observations of small blocks setting SMP into a wider spread perception that the System Controller is managing Pool price.

Recommendation 1: The AESO, Alberta Department of Energy and participants (generation and load) consider the relationship between dispatch fidelity and price fidelity as they examine modifications to market design. Price and dispatch fidelity will not likely improve without changes to the market structure.

Recommendation 2: The AESO should consider reviewing its participant training around the use of regulating reserves, and provide more education into overall reliability standards and criterion. Such training should be aimed at articulating the most critical issues that the System Control is facing with the outcome being collaborative efforts to deal with them. As well, the AESO should consider publishing, on an on-going basis, analytical work regarding the use of regulating reserves for the market's review.

Recommendation 3: The AESO should consider appropriate disclosure of operating and reliability data used as inputs into controller dispatch decisions such as regulating range and utilization as well as reliability data, such as Area Control Error (ACE) and CPS2 performance. We do not believe that it would be necessary to publish such data on a real time basis, as this may lead to potential gaming (such as lowering unit output when the system is high in the range to force a dispatch and increase SMP). However, there is likely an alternative method for publishing such data that would benefit participants while at the same time not impairing the System Control's ability to manage the supply-demand balance or open the system to potential gaming. A simple delay in publishing the data should suffice. Increasing transparency through the disclosure of operating and reliability data is fundamental to improving confidence in the System Control function and overall market operation.

Recommendation 4: The AESO should provide to System Controllers on-going training with respect to the operational guidelines to be applied in the dispatch of the system, with a view to promoting consistency in dispatching and increasing the market's confidence in the System Control Center.