

4 Ancillary Service Markets

4.1 Summary of Performance in 2007

Overall, average Ancillary Service (A/S) prices decreased by 35 percent in 2007 compared to prevailing prices in 2006. The total procurement cost also decreased by 35 percent while the total procurement volumes of the four A/S products stayed almost at the same level as in 2006. The decrease in the aggregate A/S price resulted from price decreases in all four types of A/S markets to various extents.

The A/S markets also experienced a significant decline in hours of bid insufficiency in 2007 compared to the previous year. With the exception of Non-Spinning Reserve in the summer, bid deficiency occurred in less than one percent of the operating hours in each month for all four services. The relatively higher frequency of bid insufficiency for Non-Spinning Reserve in July and August can be attributed to tight supply conditions and high opportunity costs of providing energy during periods of high loads.

4.2 Ancillary Services Market Background

The CAISO procures Regulation Reserve, Spinning Reserve and Non-Spinning Reserve in the Day Ahead and Hour Ahead Markets such that the total procurement volumes plus self-provision volumes meet or exceed the Western Electricity Coordinating Council's (WECC) Minimum Operating Reliability Criteria (MORC) and North American Electricity Reliability Council (NERC) Control Performance Standards (CPS). The CAISO procures A/S at the lowest overall cost while maintaining the reliability of the system and the competitiveness of the markets. The combination of a single-price auction pricing mechanism across the control area and the Rational Buyer algorithm, which allows for economic substitution of less expensive bids in place of more expensive bids across services, facilitates a least-cost procurement approach to meeting reliability requirements.

The definitions for the actively procured Ancillary Services are:

- 1) Regulation Reserves: Reserved capacity provided by generating resources that are running and synchronized with the CAISO controlled grid, so that the operating levels can be increased (incremented) or decreased (decremented) instantly through Automatic Generation Control (AGC) to allow continuous balance between generating resources and demand. The CAISO operates two distinct capacity markets for this service, upward and downward Regulation Reserve.
- 2) Spinning Reserves: Reserved capacity provided by generating resources that are running (i.e., "spinning") with additional capacity that is capable of ramping over a specified range within 10 minutes and running for at least two hours. The CAISO needs Spinning Reserve to maintain system frequency stability during emergency operating conditions and unanticipated variations in load.

- 3) Non-Spinning Reserves: Generally, reserved capacity provided by generating resources that are available but not running. These generating resources must be capable of being synchronized to the grid and ramping to a specified level within 10 minutes, and then be able to run for at least two hours. Curtailable demand can also supply Non-Spinning Reserve provided that it is telemetered and capable of receiving dispatch instructions and performing accordingly within 10 minutes. The CAISO needs Non-Spinning Reserve to maintain system frequency stability during emergency conditions.
- 4) Requirement: The CAISO maintain minimum amounts of Regulation, Spinning, and Non-Spinning Reserves to meet WECC and NERC control performance criteria. The quantity of Regulation Reserve capacity needed for each Settlement Period of the Day Ahead Market and the Hour Ahead Market shall be determined as a percentage of the aggregate scheduled demand for that Settlement Period. The quantity of Spinning Reserve and Non-Spinning Reserve is calculated as (a) 5 percent of the Demand (except the Demand covered by firm purchases from outside the CAISO Control Area) to be met by Generation from hydroelectric resources plus 7 percent of the Demand (except the Demand covered by firm purchases from outside the CAISO Control Area) to be met by Generation from other resources, or (b) the single largest Contingency, if this is greater or (c) by reference to such more stringent criteria as the CAISO may determine from time to time.

CAISO market participants can self-provide any or all of these A/S products, bid them into the CAISO markets, or purchase them from the CAISO. The CAISO procures two other ancillary services on a long-term basis: voltage support and black start. Reliability Must Run (RMR) contracts serve as the primary procurement vehicle for these services. Through the remainder of this chapter, the term “ancillary services” (A/S) will be used only to refer to the three reserved-capacity products defined above.

Scheduling Coordinators (SCs) simultaneously submit bids to supply any or all three products to the CAISO in conjunction with their preferred day-ahead and hour-ahead schedules. Submitted A/S bids must be associated with specific resources (system generating units, import interchange location, load, or curtailable export) and must contain a capacity component and an energy component. The CAISO selects resources to provide A/S capacity based only on their capacity bid prices and deliverability. Thereafter, the CAISO uses the energy bid prices to dispatch units to provide real-time energy.

4.3 Prices and Volumes of Ancillary Services

Overall, A/S prices decreased 35 percent from a weighted average price of \$11.12/MW in 2006 to \$7.41/MW in 2007. Decreases in average price of each of the four Ancillary Services contributed to the overall price decrease. The prices of Regulation Down, Regulation Up, Spinning Reserve, and Non-Spinning Reserve dropped 42 percent, 12 percent, 47 percent, and 35 percent respectively compared to 2006. Despite the significant price decreases for all four A/S services in 2007, prices in 2007 for all four services were within the normal range of historical prices, as indicated in Table 4.1.

The lower prices observed in 2007 may be partially attributed to lower hydroelectric generation in 2007. As shown in Chapter 2, average hydroelectric generation in 2007 was 2,000 MW -

3,000 MW or roughly 50 percent below the 2006 levels. The extremely high hydroelectric production observed in the spring of 2006 resulted in lower offers into the A/S markets by hydro resources as they were producing at or near maximum capacity with little or no unloaded capacity for upward services and high opportunity cost for backing down production for Regulation Down. The high hydroelectric production that year also displaced gas-fired resources that may have otherwise been online and offered into the A/S markets. Both of these factors resulted in higher, and more volatile, A/S prices in 2006. Spring of 2007 had much lower hydroelectric production and as a consequence was not subject to these two seasonal issues. In addition to the hydroelectric production, loads during the summer of 2007 were relatively mild in comparison to 2006, resulting in less pressure on spot wholesale electricity prices which also helped moderate prices in the A/S markets.

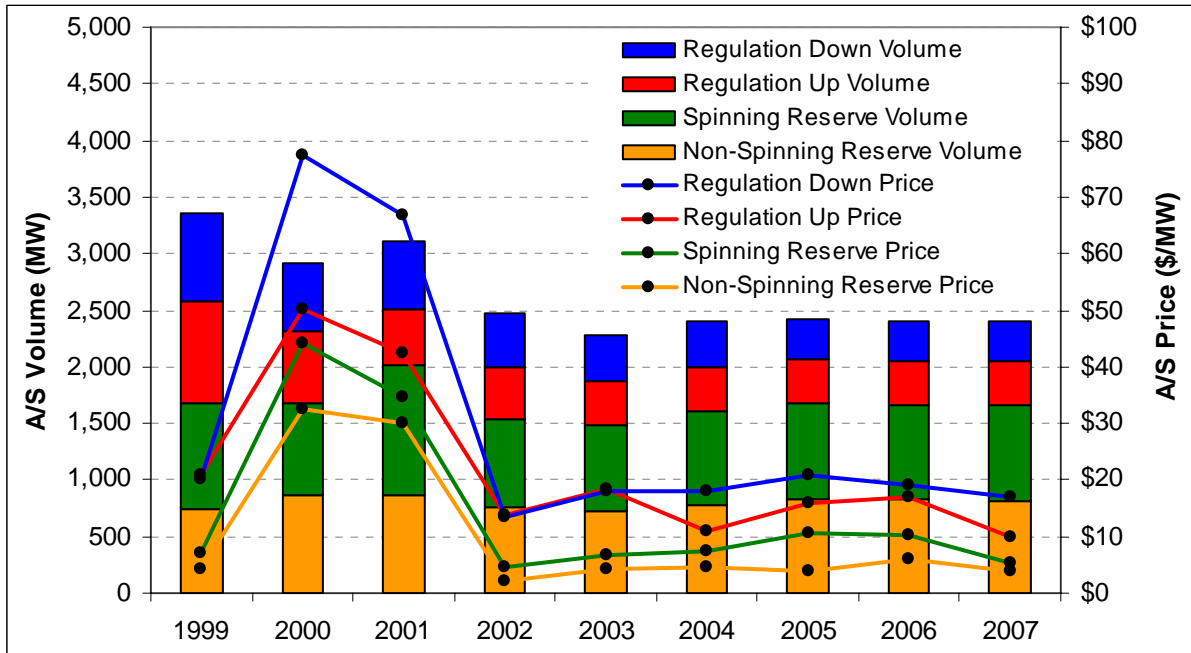
Procurement volumes, in total, were essentially unchanged from 2006. The average volumes of all four types of procurements remained at the same level as last year. Table 4.1 compares prices and volumes from previous operating years.

Table 4.1 Annual Hourly Average A/S Prices and Volumes

	Year	Regulation Down	Regulation Up	Spinning Reserve	Non-Spinning Reserve	Average A/S Price
Price (\$/MW)	1999	\$20.84	\$20.22	\$7.07	\$4.35	\$11.97
	2000	\$50.15	\$77.28	\$44.07	\$32.46	\$41.03
	2001	\$42.33	\$66.72	\$34.69	\$30.03	\$36.42
	2002	\$13.76	\$13.41	\$4.66	\$2.15	\$7.08
	2003	\$18.43	\$18.08	\$6.62	\$4.20	\$9.81
	2004	\$10.95	\$17.95	\$7.25	\$4.43	\$8.63
	2005	\$16.05	\$20.94	\$10.45	\$3.98	\$10.72
	2006	\$17.01	\$18.94	\$10.11	\$5.96	\$11.12
	2007	\$9.97	\$16.81	\$5.42	\$3.98	\$7.41
	Year	Regulation Down	Regulation Up	Spinning Reserve	Non-Spinning Reserve	Total Volume
Volume (MW)	1999	769	903	942	735	3,349
	2000	594	633	818	861	2,907
	2001	614	492	1,148	862	3,117
	2002	469	460	775	763	2,466
	2003	416	381	767	722	2,286
	2004	408	395	817	782	2,403
	2005	363	386	841	839	2,428
	2006	354	389	831	831	2,405
	2007	361	379	849	815	2,403

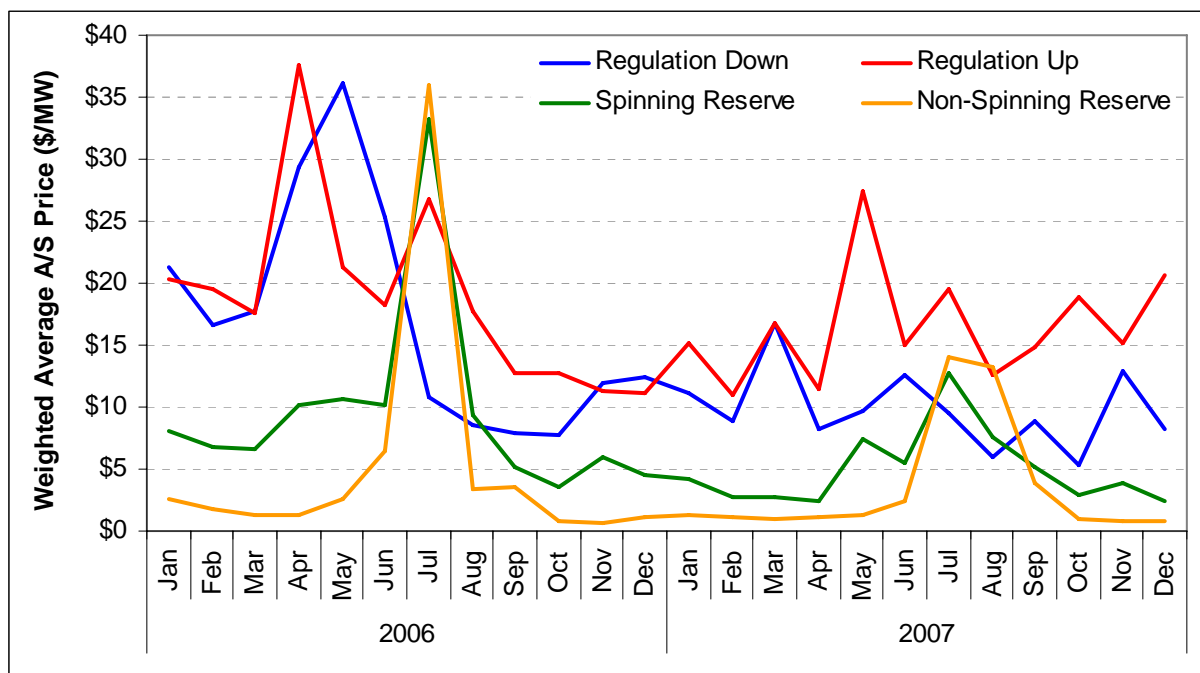
Figure 4.1 depicts the historical pattern of prices and volumes since 1999 and indicates that A/S prices and volumes have been relatively stable over the past six years (2002-2007) as compared to the period from 1999 to 2001.

Figure 4.1 Annual Average A/S Prices and Volumes



Monthly day-ahead reserve prices do tend to vary with seasonal load levels as seen in Figure 4.2. However, the volatility in monthly average A/S prices is lower in 2007 compared to 2006, as spring hydro-electric production and summer heat waves were milder in 2007 than the previous operating year. As a result of cost-minimizing economic substitution of less expensive bids for higher quality services in place of more expensive bids for lower quality services, prices of upward A/S reserves generally display a decreasing pattern in the order of Regulation, Spinning Reserve, and Non-Spinning Reserve. Notwithstanding, price reversion may still happen due to the step-wise characteristics of A/S bid patterns. As shown in Figure 4.2, the average price of Non-Spinning Reserve was higher than that of Spinning Reserve in July and August of 2007.

Figure 4.2 Monthly Weighted Average A/S Prices



Hourly average day-ahead prices are shown in Figure 4.3 and Figure 4.4 along with seven-day moving averages showing short-term price trends across the year. Compared to 2006, prices of Regulation Reserves in 2007 were lower due to lower spring hydro-electric runoff but displayed a higher volatility across the year. However, the impact of the spring hydro-electric runoff can still be seen in the pricing trends for Regulation Down Reserve. The price pattern for Operating Reserves clearly reflects the summer peak load conditions during the two heat waves in July and August.

Figure 4.3 Day Ahead Regulation Reserve Market Clearing Prices (A/S MCPs) with Seven Day Moving Averages

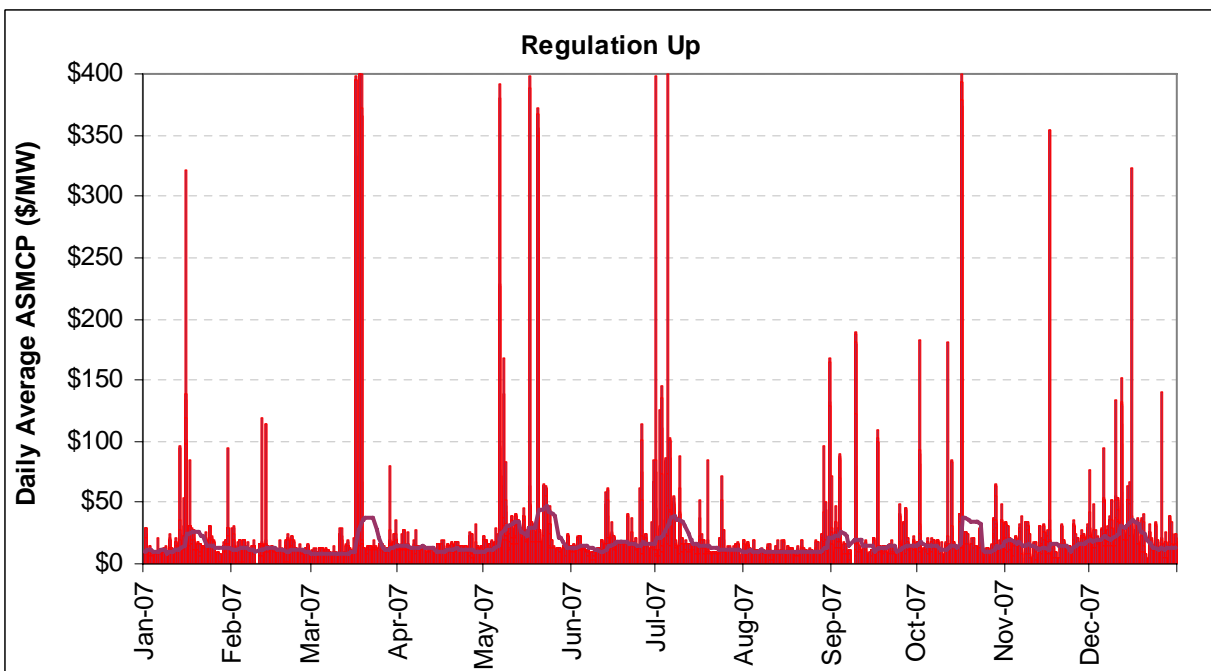
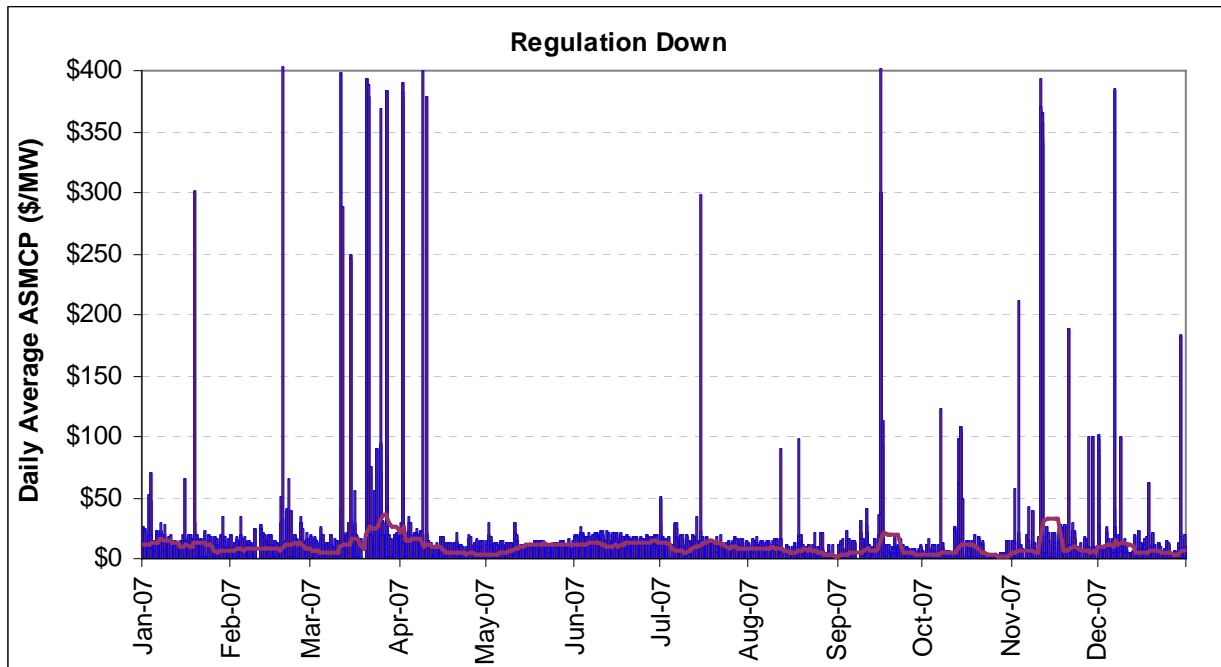


Figure 4.4 Day Ahead Operating Reserve Market Clearing Prices (A/S MCPs) with Seven Day Moving Averages

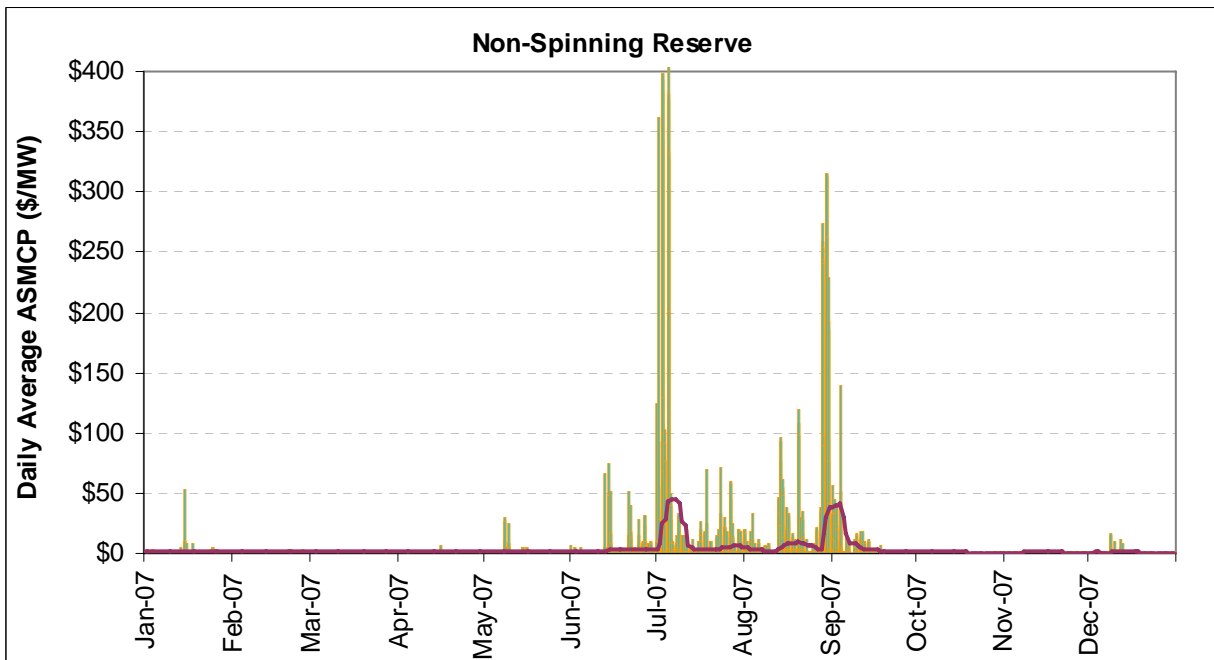
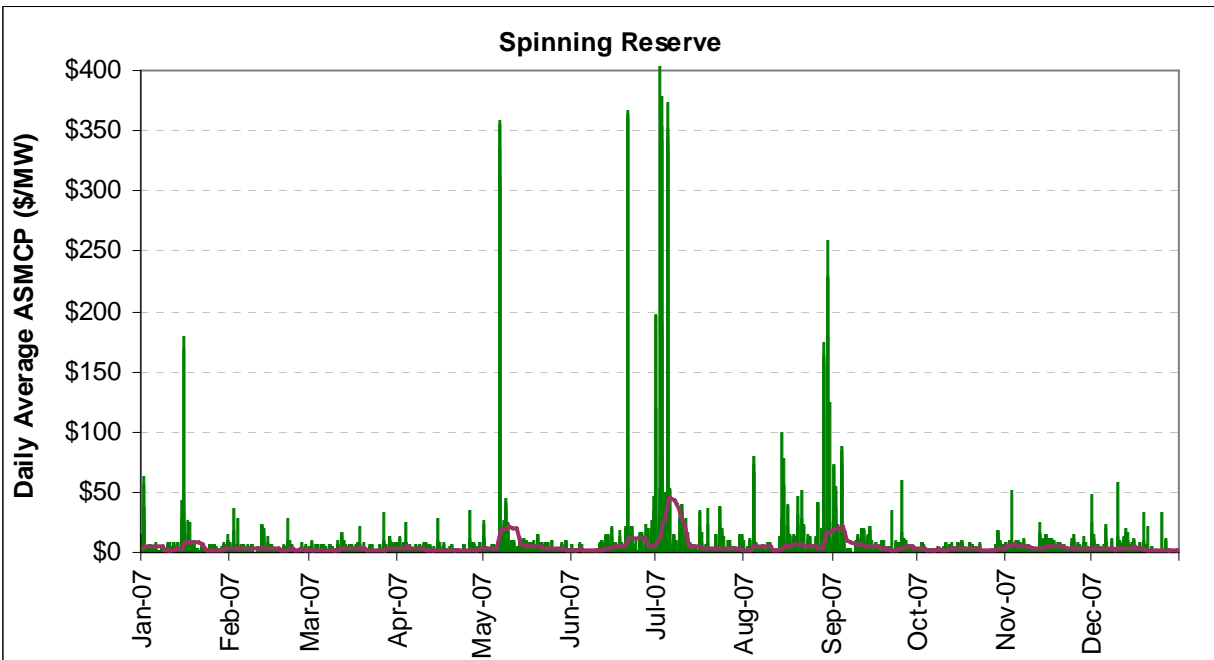


Figure 4.5 shows the variation of A/S prices across different operating hours. Prices of Upward Regulation and Operating Reserves generally follow the load pattern, with higher prices in peak load hours. However, Regulation Down Reserve prices observe an opposite trend with high prices in the early morning hours when the load is low. These high prices for Downward Regulation Reserve are especially prominent during the spring morning hours, as fewer resources are operating in a range where they can back generation down and hydro-electric resources are reluctant to reduce output due to the spill conditions that accompany spring runoff period, as illustrated in Figure 4.6. Figure 4.6 also shows the seasonal variation of Non-Spinning Reserve prices. As more resources are online and operating at high output levels in the summer peak hours, the supply of Non-Spinning Reserve is limited, resulting in higher prices. Higher energy prices in the summer peak hours also contributed to the price spikes of Operating Reserves by driving up the opportunity cost of reserving generation capacity.

Figure 4.5 Day Ahead Hourly Average A/S Prices (2007)

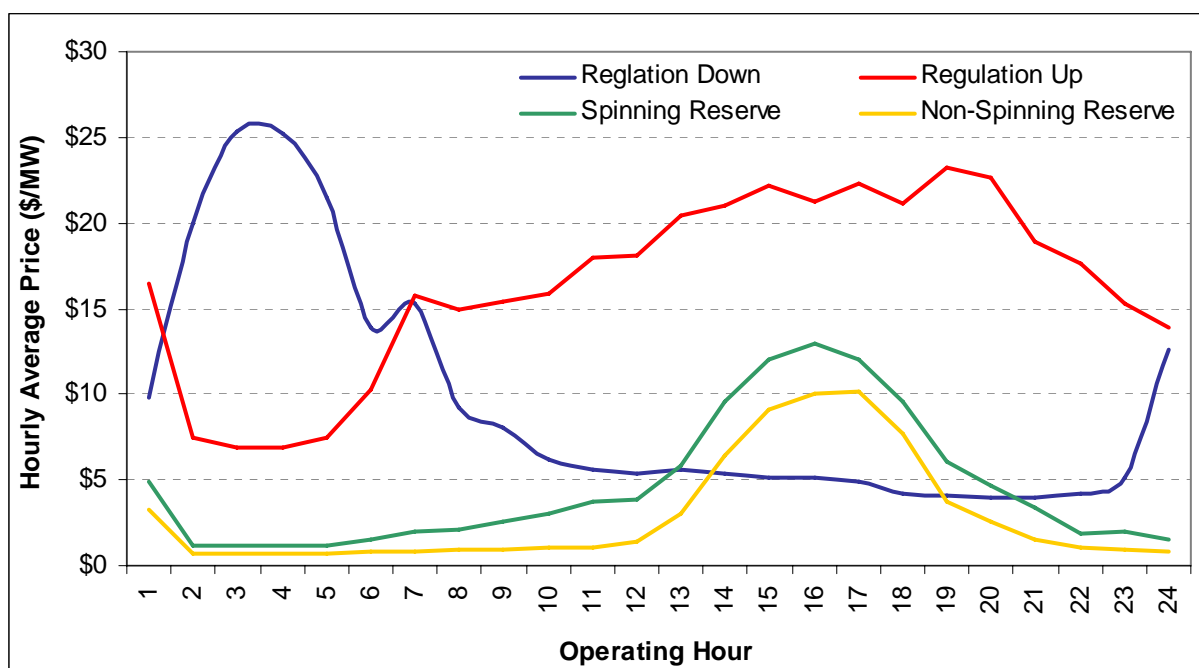
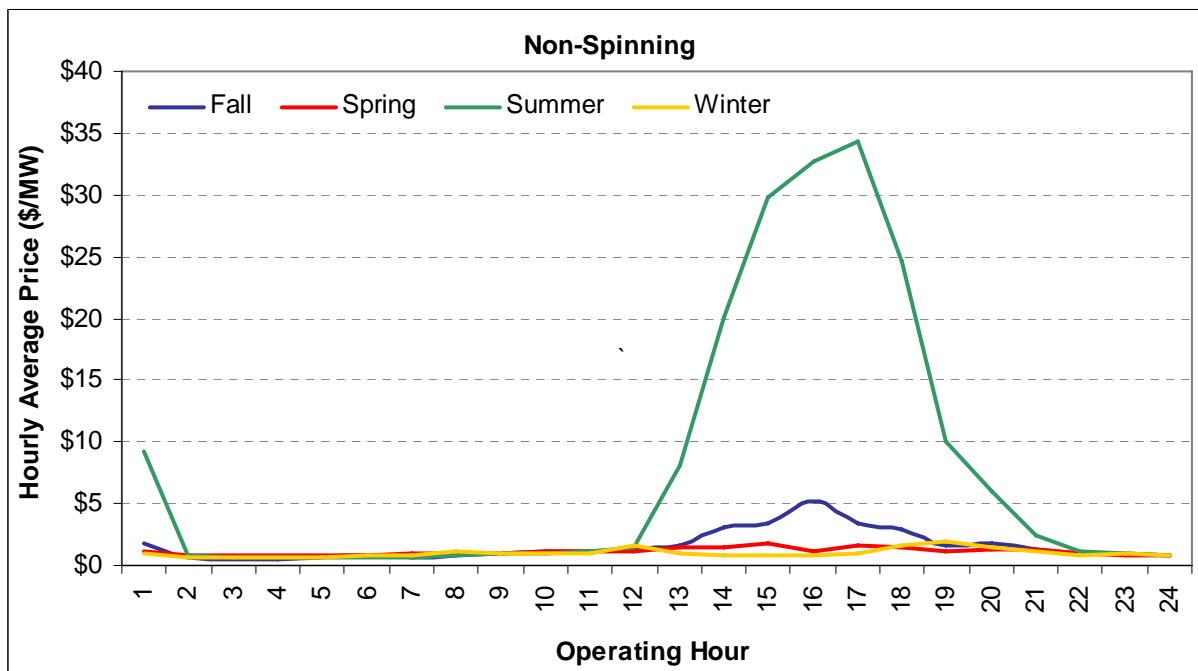
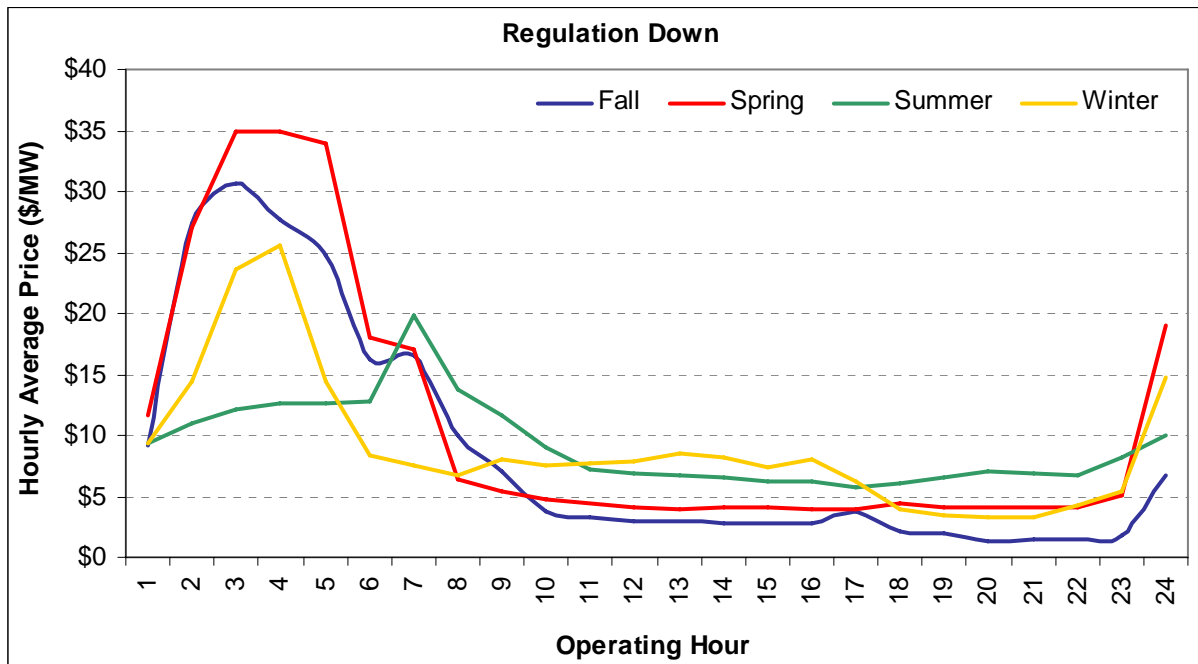


Figure 4.6 **Hourly Average A/S Prices by Season (2007)**



The price duration curves for the A/S Day Ahead Markets, shown in Figure 4.7 and Figure 4.8, reflect generally expected price behavior with the higher quality products exhibiting the highest sustained prices. Overall, Operating Reserve prices were at price levels above \$25 in fewer than 2 percent of the operating hours in 2007, down from about 5 percent in the preceding year. At the same time the percentage hours with Regulation Reserve prices over \$25 decreased from about 20 percent in 2006 to fewer than 10 percent in 2007.

Figure 4.7 Price Duration Curves for 2007 Regulation Reserve Markets

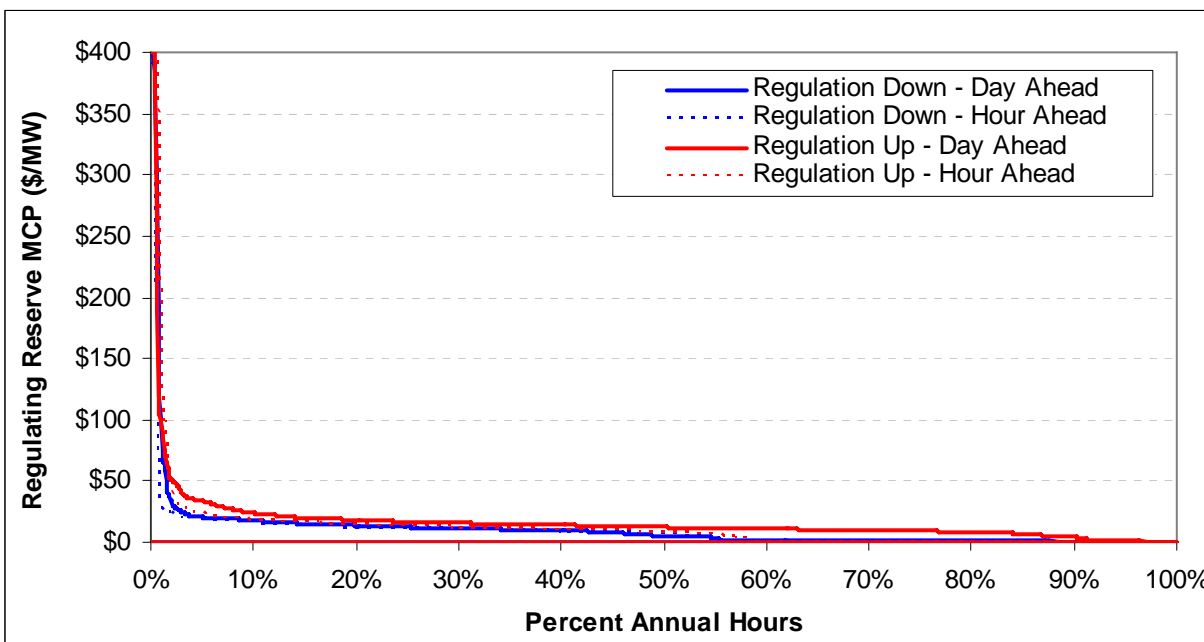
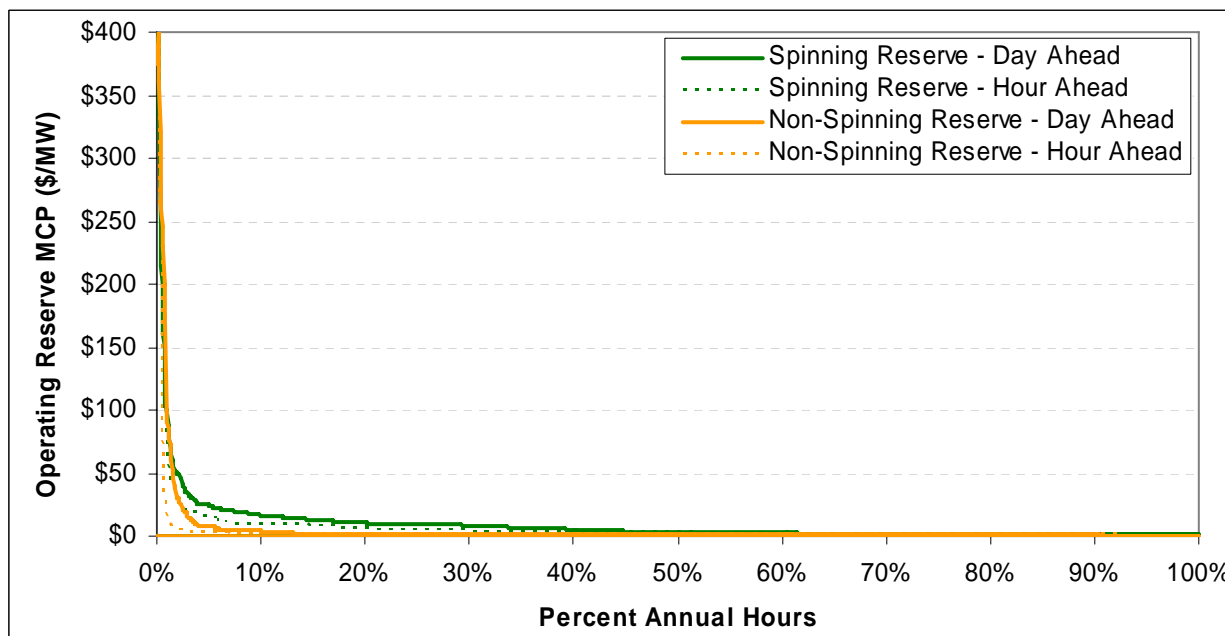


Figure 4.8 Price Duration Curves for 2007 Operating Reserve Markets

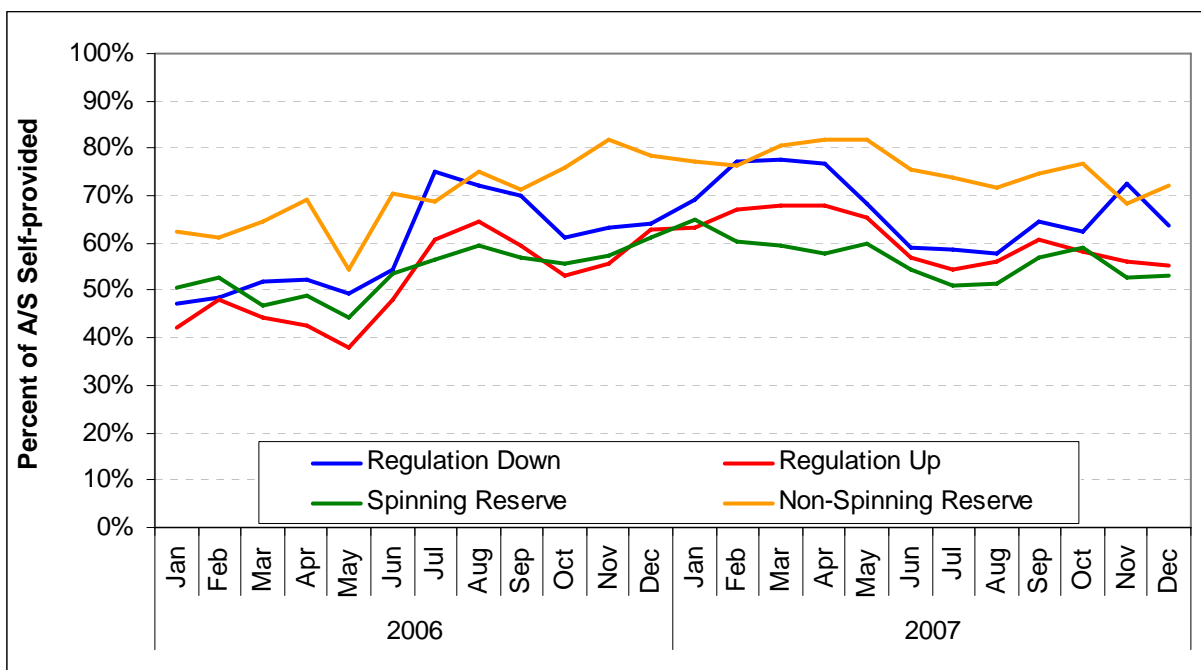


4.4 Ancillary Services Supply

4.4.1 Self-Provision of Ancillary Services

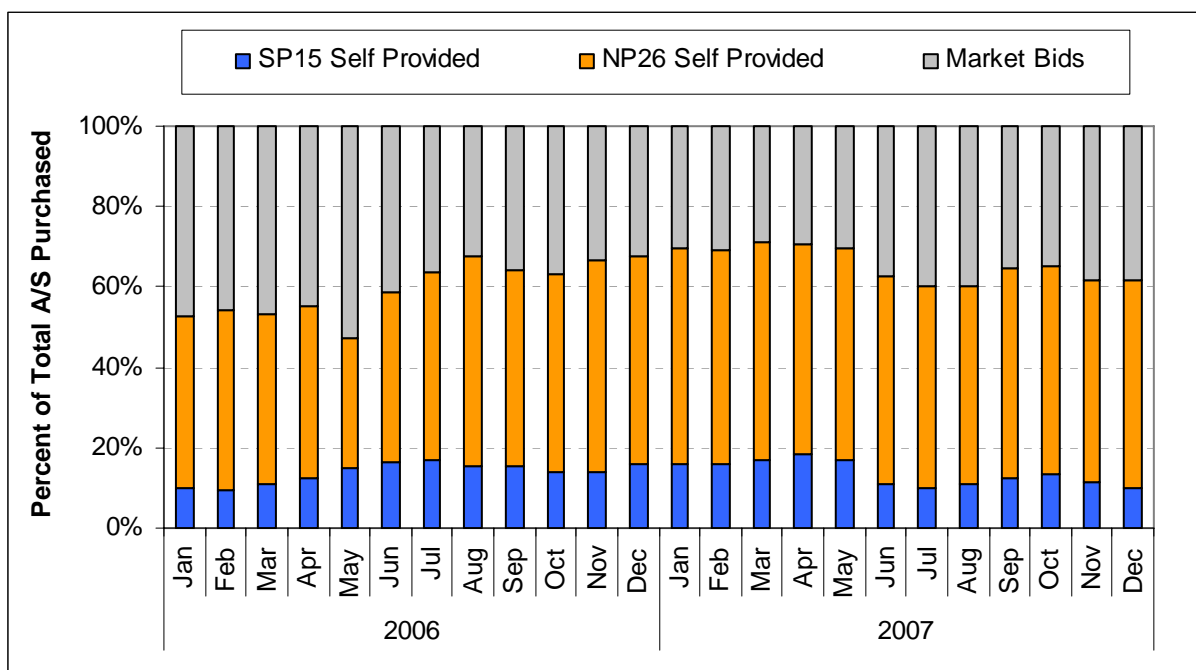
Self-provided ancillary services remained a significant share of the total supply in 2007, ranging between 50 and 80 percent for most services in most months. Self-provision on all four ancillary services, as a percent of purchases, increased in 2007, particularly for the first half of the year (Figure 4.9). This increase is likely attributable to lower levels of hydro-electric generation in the spring of 2007. Because hydro-electric resources were producing near their limit and had limited Downward Regulation capacity, higher levels of non-hydro-electric generation increased the availability of Regulation Down Reserve capacity in 2007. Summer months exhibited a relatively lower percentage of self-provision due to the fact that more generation controlled by LSEs with A/S obligations is being used to serve that LSE’s load in the summer months.

Figure 4.9 Hourly Average Self-Provision of A/S



It is also interesting to view self-provision by zone. Figure 4.10 shows the breakout of total A/S procured by source (market bid, self-provided in NP26, and self-provided in SP15). During 2006 and 2007, the CAISO purchased A/S on a system-wide basis and did not practice zonal procurement. Consistent with this practice, the percentages shown in this figure are with respect to total system-wide A/S procurement. Note that hourly average self-provision in NP26 ranged from 49 percent to 54 percent during 2007 while the corresponding figure in SP15 was much lower, between 10 percent and 19 percent throughout 2007. Although the 2007 self-provision percentages in SP15 remained at similar levels as 2006, the corresponding figures in NP26, especially for the first half of 2007, generally increased. Typically, due to the distribution of load between the North and South, the calculated A/S requirement in SP15 is higher than that of NP26. Although not shown in this chapter, on average, roughly 70 percent of A/S is procured in NP26 with the remainder in SP15. However, as shown in Figure 4.8, combined procurement from resources in SP15 (procurement from market bids and self-provided A/S) is usually significantly lower than the calculated zonal A/S requirement. This disparity between the North and South is facilitated by transmission capability on Path 15 and Path 26, along which energy from A/S can be transferred from north-to-south to provide reliability support in the event of a contingency.

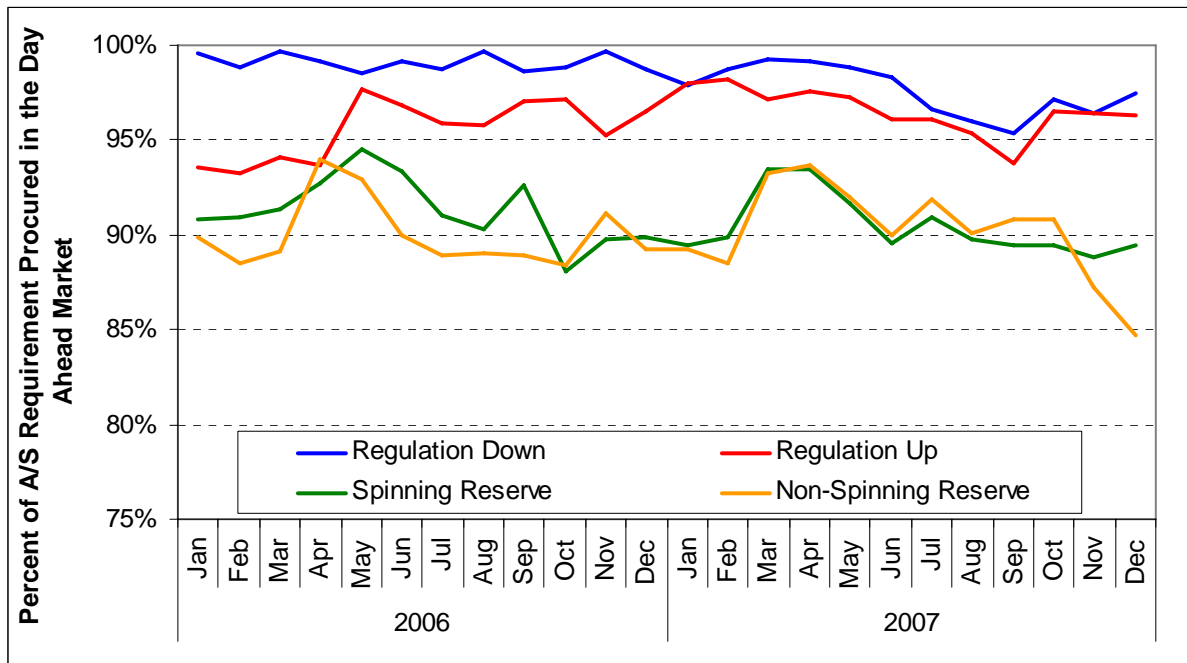
Figure 4.10 Hourly Average Self-Provision of A/S as a Percent of Total Procurement, by Zone, for All Services Combined



4.4.2 Day-ahead vs. Hour-ahead Procurement

With the exception of Non-Spinning Reserve, the percent of A/S requirement procured in the Day Ahead Market remained relatively stable at above 90 percent. The proportion of Non-Spinning Reserve procured in the day-ahead was between 85 percent and 95 percent for most of the year (Figure 4.11).

Figure 4.11 Hourly Average Day-Ahead Procurement, 2006 - 2007



4.4.3 Bid Sufficiency

Bid insufficiency occurs when there is not enough available capacity bid into the markets to meet the procurement requirements. In addition to potentially creating reliability issues, bid insufficiency in the A/S markets can result in market power concerns as essentially any supplier to the A/S market in bid deficient hours is pivotal. Additionally, market power concerns can arise if bid sufficiency exists but only marginally so. In these cases, certain suppliers may also be pivotal in the sense that the A/S requirements could not be met absent their supply. The CAISO employs several measures of bid sufficiency. Volumes of capacity shortages convey information about the magnitude of the deficiency events and the count of operating hours where bid-in capacity falls short of requirements represent commonly used metrics that provide insight into the frequency and severity of shortage events. Table 4.2 provides these two metrics for the past two operating years.

Table 4.2 Bid Insufficiency (2006 – 2007)

	Number of Hours With Shortage				
	Regulation Up	Regulation Down	Spinning Reserve	Non-Spinning Reserve	All Services
2006	159	110	145	113	527
2007	20	11	35	36	102
Percent Δ	-87%	-90%	-76%	-68%	-81%

	Average Percent of Requirement Short				
	Regulation Up	Regulation Down	Spinning Reserve	Non-Spinning Reserve	All Services
2006	21%	16%	8%	15%	13%
2007	15%	7%	6%	8%	8%

The frequency of bid insufficiency and average percent of requirement short declined significantly in 2007 compared to 2006 for all four types of reserves. The following figures (Figure 4.12 through Figure 4.15) show the frequency of hourly bid deficiencies and the average amount of deficiency (expressed as a percentage of the total requirement) by month and by service, for the past two years.

Unlike the clear pattern of bid insufficiency of Regulation Reserves during the spring months of 2006, there was no such concentration in the spring of 2007 as the bid insufficiency hours for Regulation Reserves decreased to a trivial amount. This decline in frequency of bid insufficiency for Regulating Reserves is directly attributed to the lower hydroelectric production in 2007 and the resulting impact that had on availability of Regulating Reserve from both hydro and online gas-fired resources. In comparison, hydro flows and hydro generation were significantly lower in 2007 than the preceding year, which made the provision of Regulation Reserves less restrictive and, therefore, decreased the hours of bid insufficiency for Regulation Reserves especially in the spring.

The number of hours with bid insufficiency for Operating Reserves also decreased significantly in 2007, by roughly 70 percent. The summer of 2007 was relatively mild with contrast to that of the previous year when CAISO load records were repetitively set and refreshed. Because the procurement requirements of Operating Reserves depend on load levels, a relatively mild summer in 2007 would essentially lower the demand for Operating Reserves. Moreover, relatively lower summer load levels in 2007 resulted in higher supply margins, some of which was available for providing Operating Reserves.

Figure 4.12 Frequency of Bid Insufficiency in the Hour Ahead Market and Average Capacity Short – Regulation Down

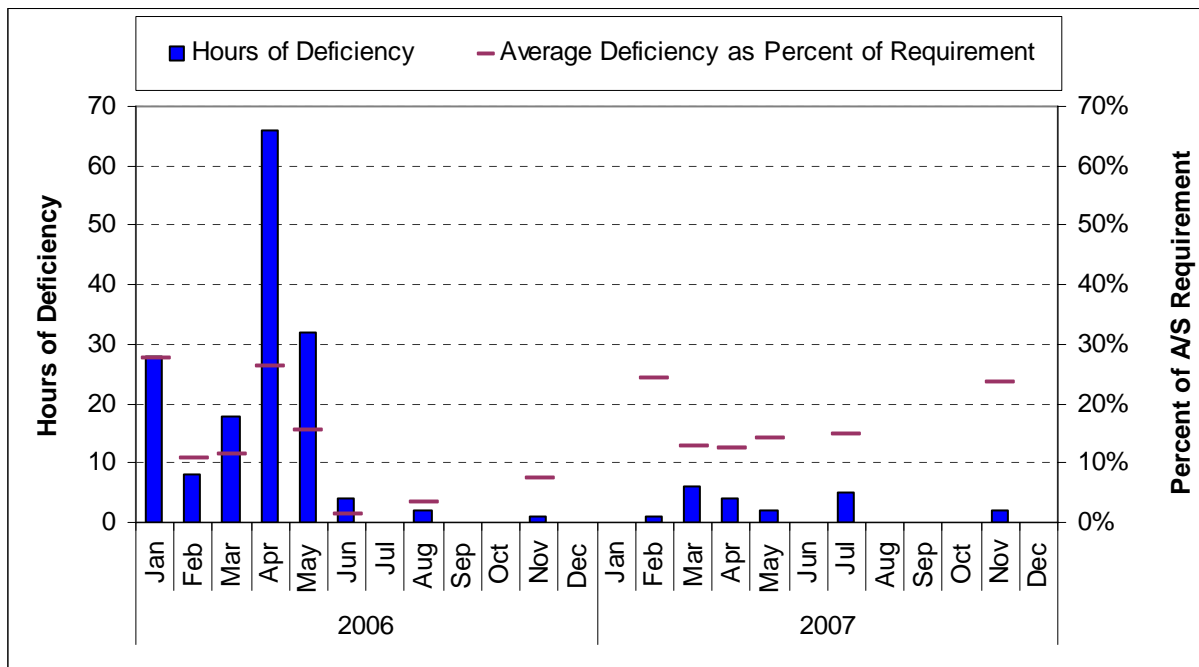


Figure 4.13 Frequency of Bid Insufficiency in the Hour Ahead Market and Average Capacity Short – Regulation Up

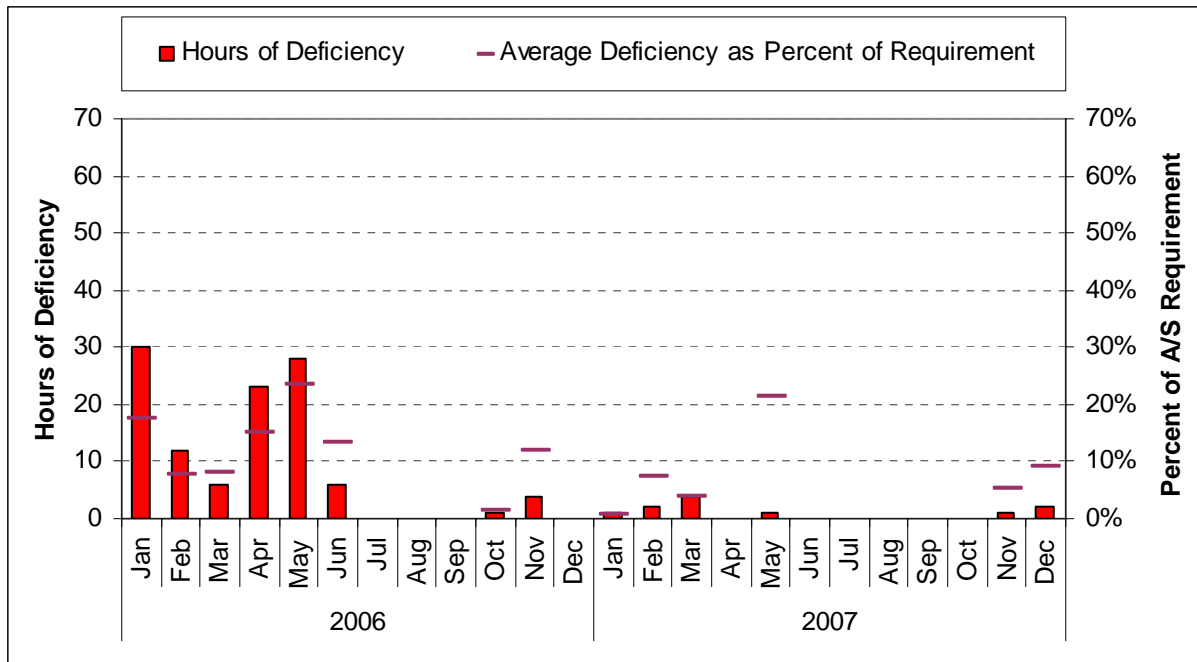


Figure 4.14 Frequency of Bid Insufficiency in the Hour Ahead Market and Average Capacity Short – Spinning Reserve

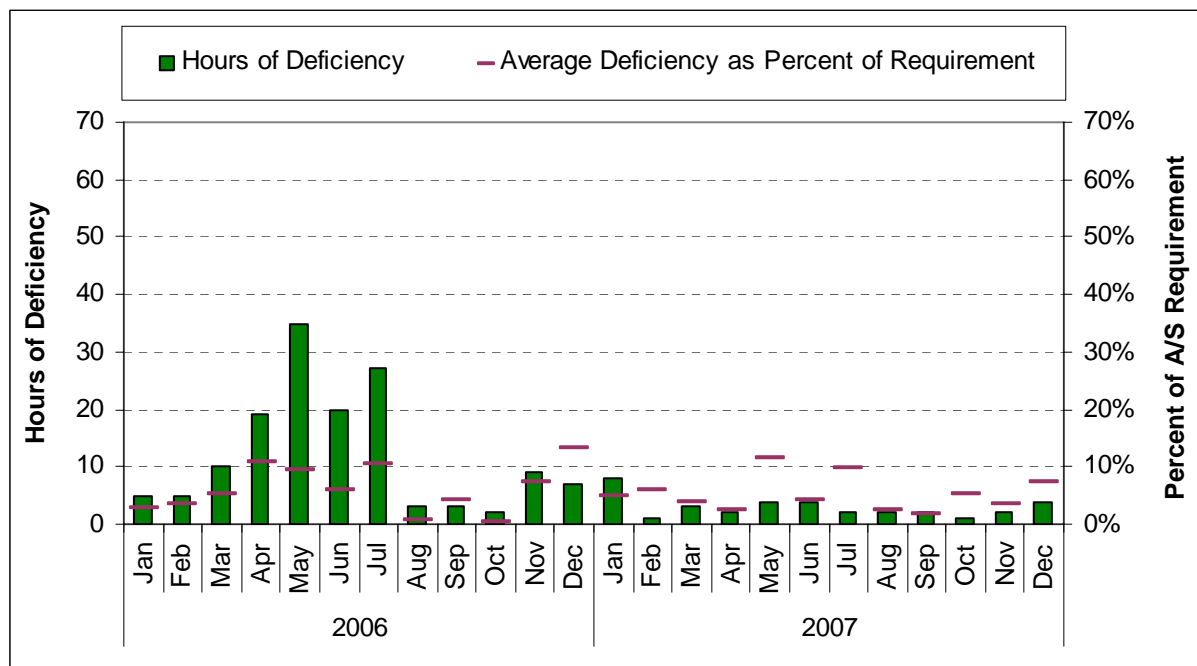
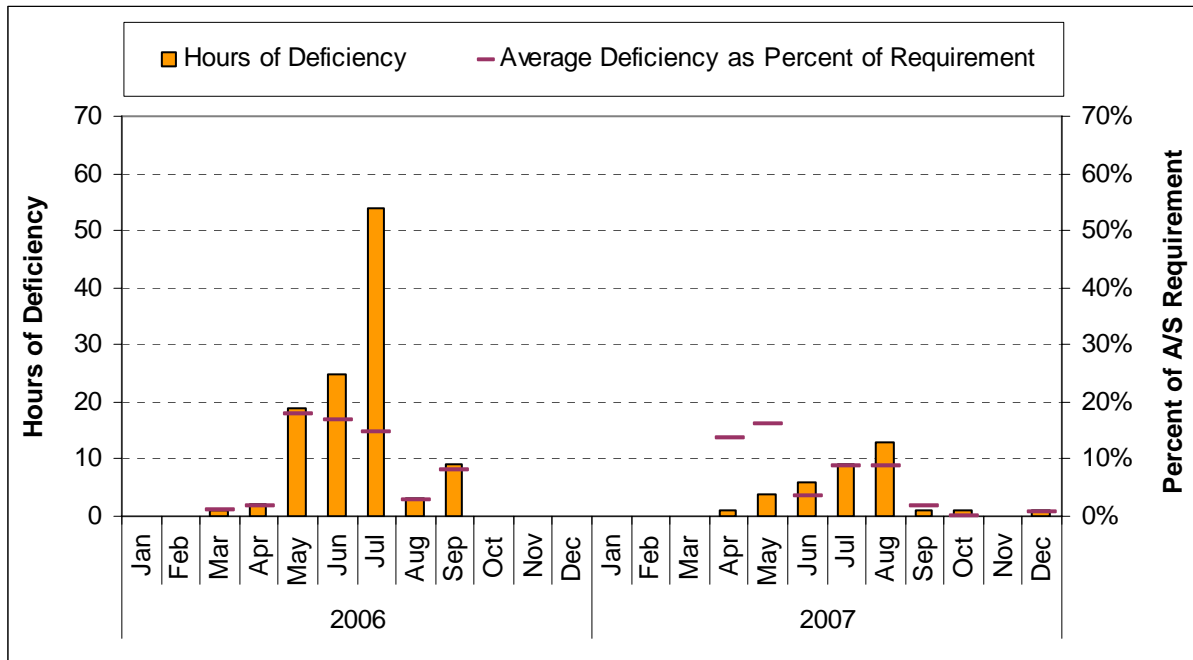


Figure 4.15 Frequency of Bid Insufficiency in the Hour Ahead Market and Average Capacity Short – Non-Spinning Reserve



4.5 Costs

The total cost of A/S capacity per unit of MWh load decreased in 2007 compared to 2006. The A/S procurement cost to load in 2007 averaged \$0.63/MWh, which is 35 percent lower than the \$0.95/MWh average the year before. Figure 4.16 provides the monthly details on these costs. With the exception of July, all monthly total cost of A/S capacity per unit of MWh load remained under \$1.00/MWh in 2007.

Figure 4.16 Monthly Cost of A/S per MWh of Load

