APPENDIX C - ENERGY MARKET

Frequency Distribution of LMP

Figure C-1, Figure C-2, Figure C-3, Figure C-4, Figure C-5, Figure C-6 and Figure C-7 provide frequency distributions of real-time locational marginal price (LMP), by hour, for 1998, 1999, 2000, 2001, 2002, 2003 and 2004.[1] The figures show the number of hours (frequency), the cumulative number of hours (cumulative frequency), the percent of hours (percent) and the cumulative percent of hours (cumulative percent) that LMP was within a given, $10-price interval, or for the cumulative columns, within the interval plus all the lower price intervals.[2]

The first six figures show that during the period 1998 to 2003, locational marginal price (LMP) was most frequently in the $10-per-MWh to $20-per-MWh interval. In 2004, however, LMP occurred in the $30-per-MWh to $40-per-MWh interval most frequently at 22.0 percent of the time and in the $20-per-MWh to $30-per-MWh interval nearly as frequently at 21.6 percent of the time. In 2004, LMP was less than $60 per MWh for 81 percent of the hours and less than $100 per MWh for 99 percent of the hours. LMP was $150 per MWh or greater for five hours (0.06 percent of the hours) in 2004.

Frequency Distribution of Load

Figure C-8, Figure C-9, Figure C-10, Figure C-11, Figure C-12, Figure C-13 and Figure C-14 provide the frequency distributions of PJM load by hour, for the calendar years 1998 through 2004. The figures show the number of hours (frequency), the cumulative number of hours (cumulative frequency), the percent of hours (percent) and the cumulative percent of hours (cumulative percent) that the load was within a given, 5,000 MW load interval, or for the cumulative columns, within the interval plus all the lower load intervals. The integration of the Allegheny Power Company (AP) Control Zone in 2002 and of the Commonwealth Edison Company (ComEd), the American Electric Power Company (AEP) and The Dayton Power & Light Company (DAY) Control Zones in 2004 means that annual comparisons of load frequency including those years are significantly affected by PJM's geographic growth.[3]

For the years 1998 and 1999, the most frequently occurring load interval was 25,000 MW to 30,000 MW at 35 and 34 percent of the hours, respectively. For the years 2000 and 2001, the most frequently occurring load interval was 30,000 MW to 35,000 MW at 34 and 35 percent of the hours, respectively. For the year 2002, the most frequently occurring load interval was 30,000 MW to 35,000 MW at 26 percent of the hours, with the load interval 35,000 MW to 40,000 MW nearly as frequent at 25 percent of the hours. In 2003, the most frequently occurring load interval was 35,000 to 40,000 MW at 31 percent of the hours, while load was less than 35,000 MW for 36 percent of the hours.

The frequency distribution of load in 2004 reflects the integration of the ComEd, AEP and DAY Control Zones. The most frequently occurring load interval was 35,000 MW to 40,000 MW at 16 percent of the hours. The next most frequently occurring interval was 40,000 MW to 45,000 MW at 15 percent of the hours. Load was less than 60,000 MW for 75 percent of the time, less than 70,000 MW for 93 percent of the time and less than 90,000 MW for all but nine hours.

1 LMP was instituted in PJM in April 1998. Before then, there had been a single system price, the market-clearing price (MCP).
2 Only positive LMP intervals are included in these figures.
3 Zones, control zones and control areas are geographic areas that customarily bear the name of a large utility service provider operating within their boundaries. The names apply to the geographic area, not to any single company. The geographic areas did not change with the formalization of the control zone and control area concepts during the Phase 3 integrations. For simplicity, zones are referred to as Control Zones for all three phases. The only exception is ComEd which is called the ComEd Control Area for Phase 2 only.

As the AEP and DAY Control Zone integrations did not occur until October 1, 2004, the summer peak reflected only the ComEd Control Area integration. That peak demand for the summer of 2004, including ComEd, was 77,887 MW and occurred on August 3, 2004.

Figure C-1 - Frequency distribution by hours of PJM LMP: Calendar year 1998

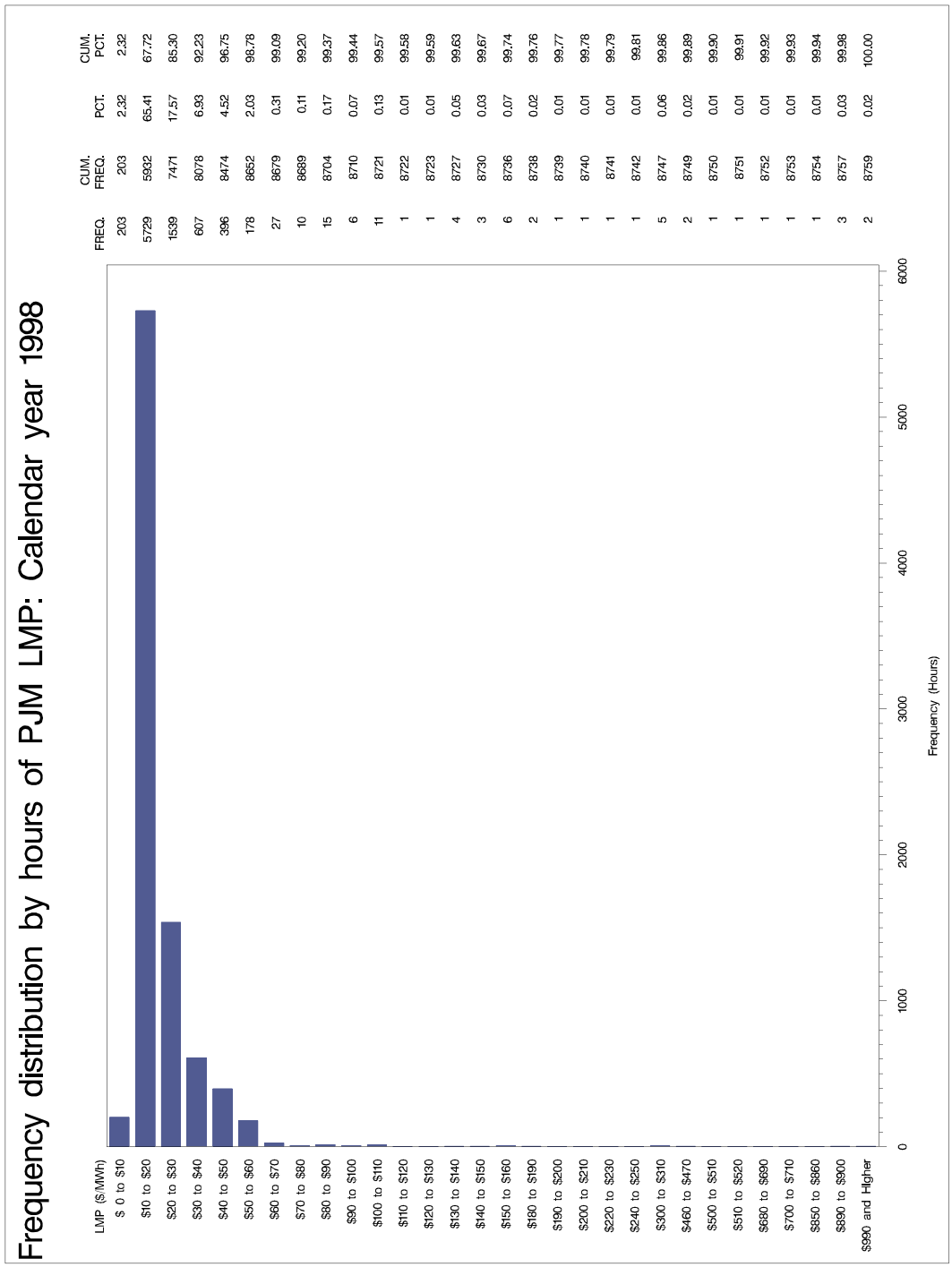


Figure C-2 - Frequency distribution by hours of PJM LMP: Calendar year 1999

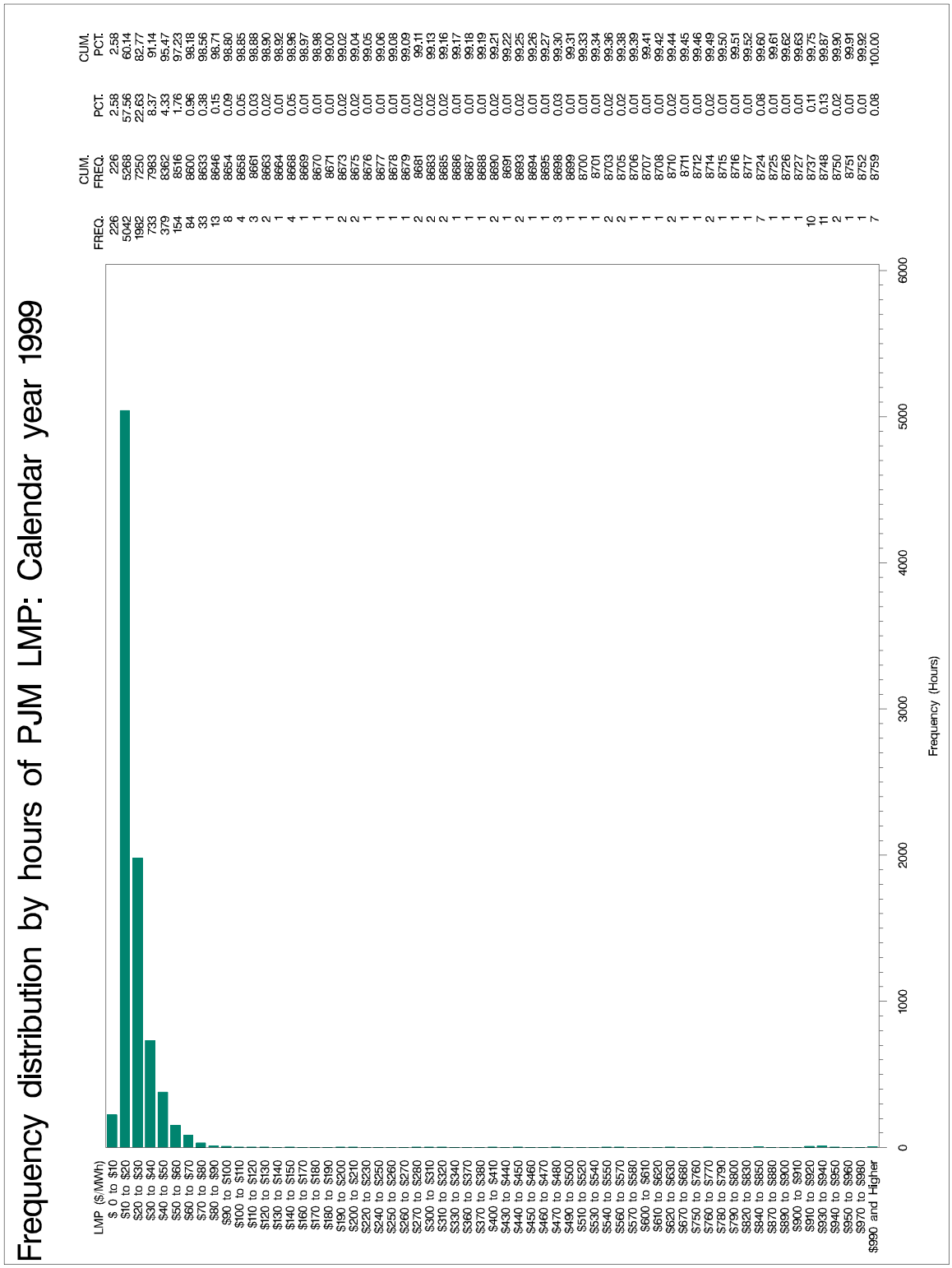


Figure C-3 - Frequency distribution by hours of PJM LMP: Calendar year 2000

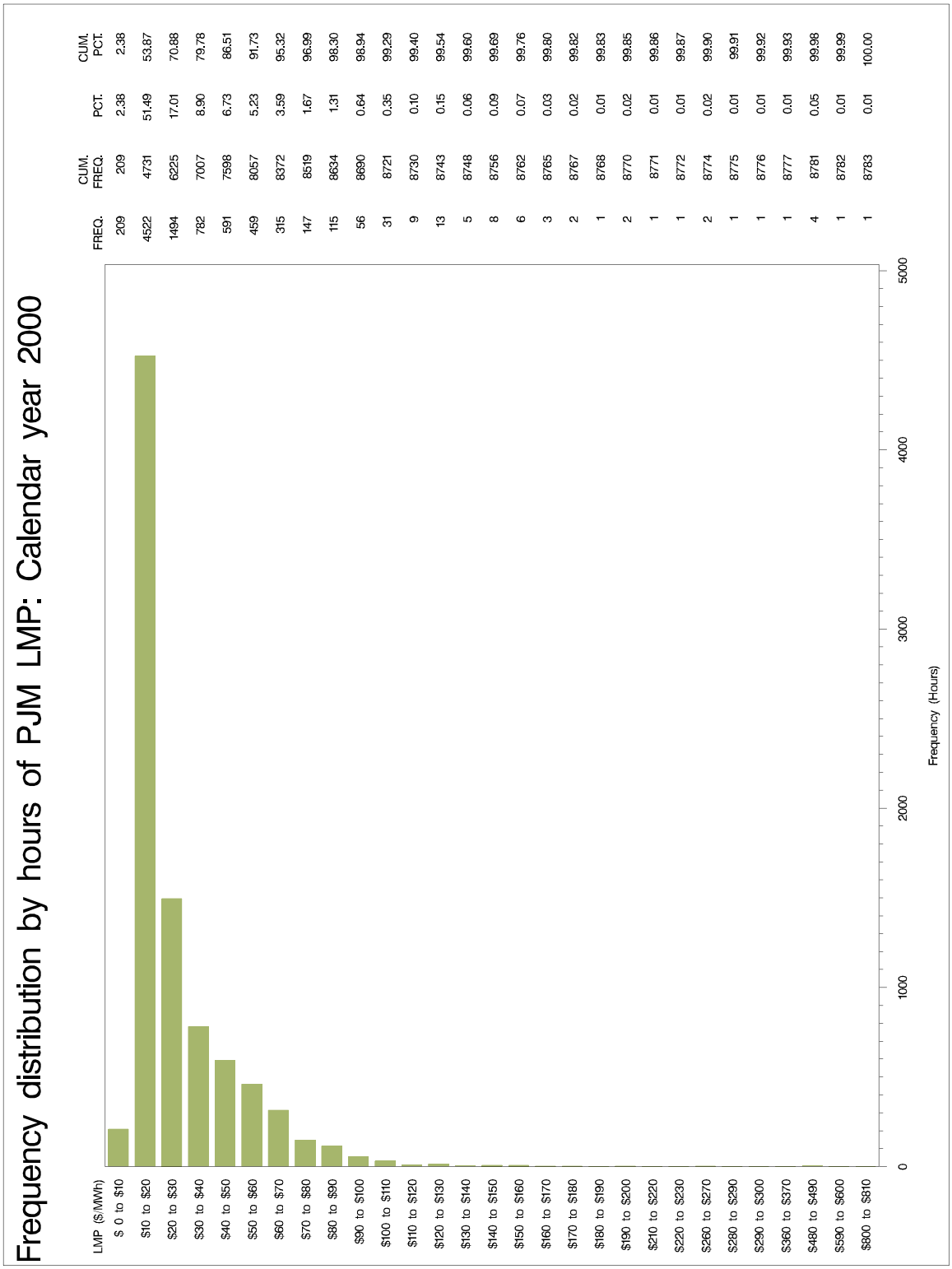


Figure C-4 - Frequency distribution by hours of PJM LMP: Calendar year 2001

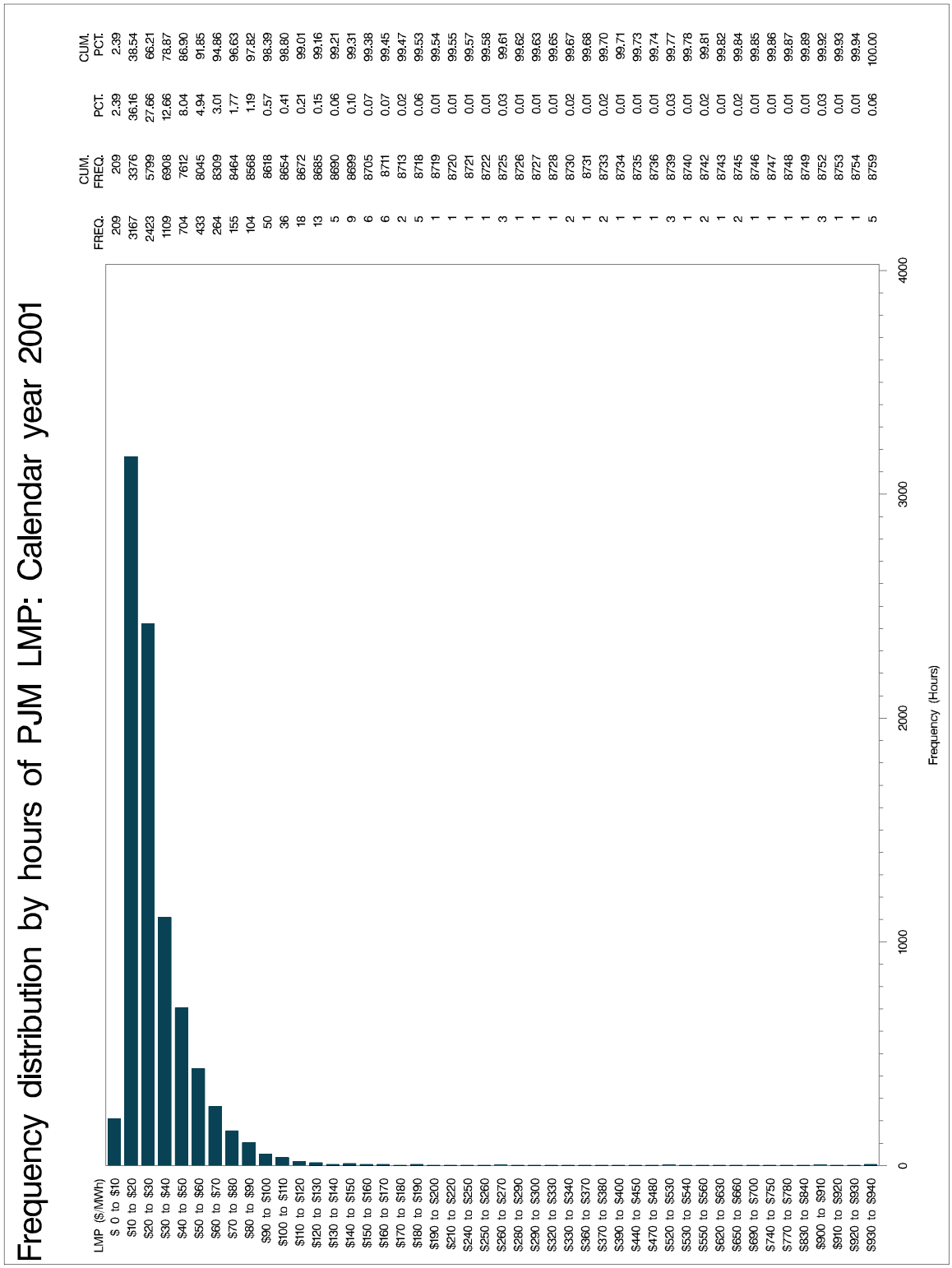


Figure C-5 - Frequency distribution by hours of PJM LMP: Calendar year 2002

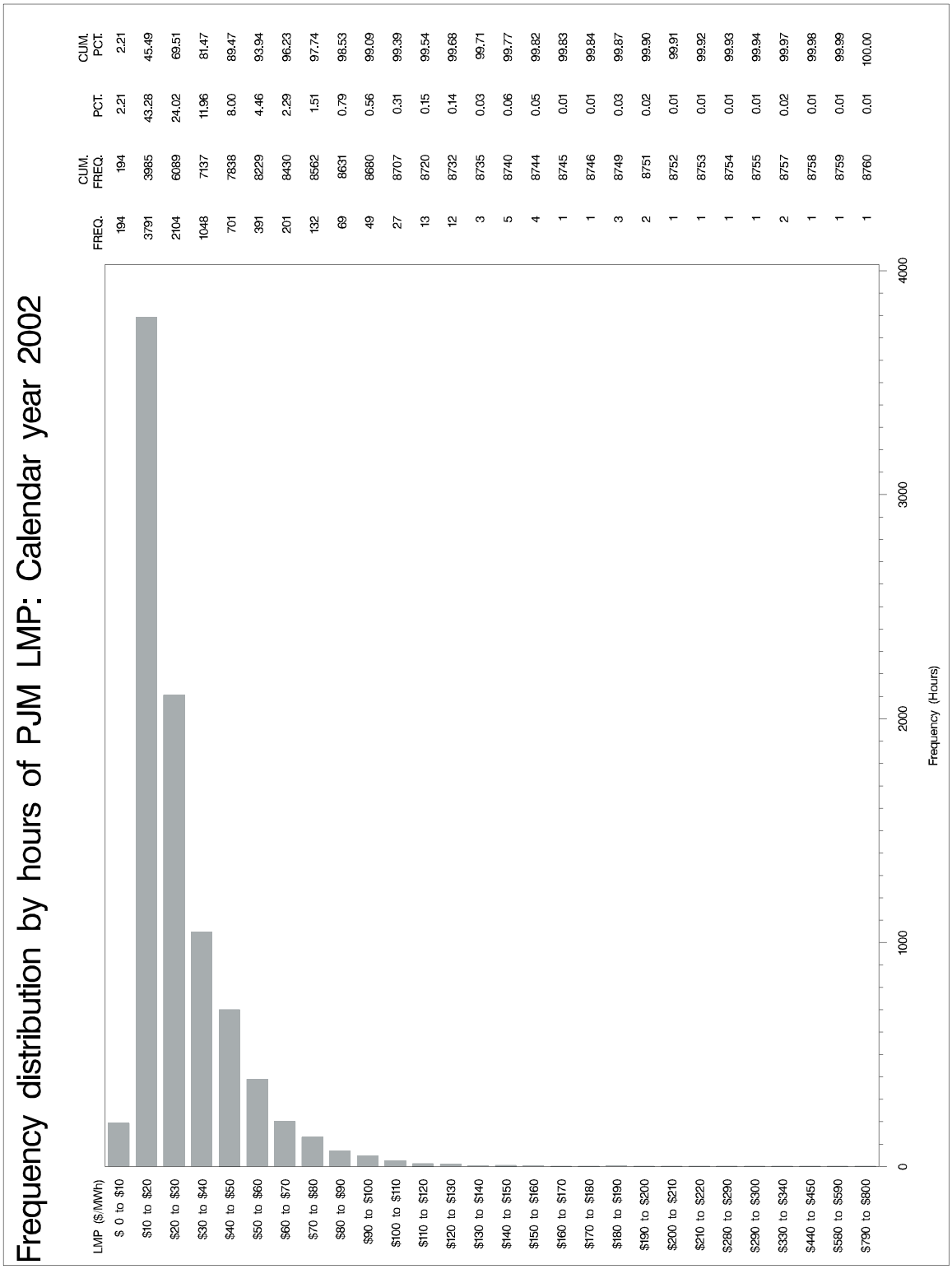


Figure C-6 - Frequency distribution by hours of PJM LMP: Calendar year 2003

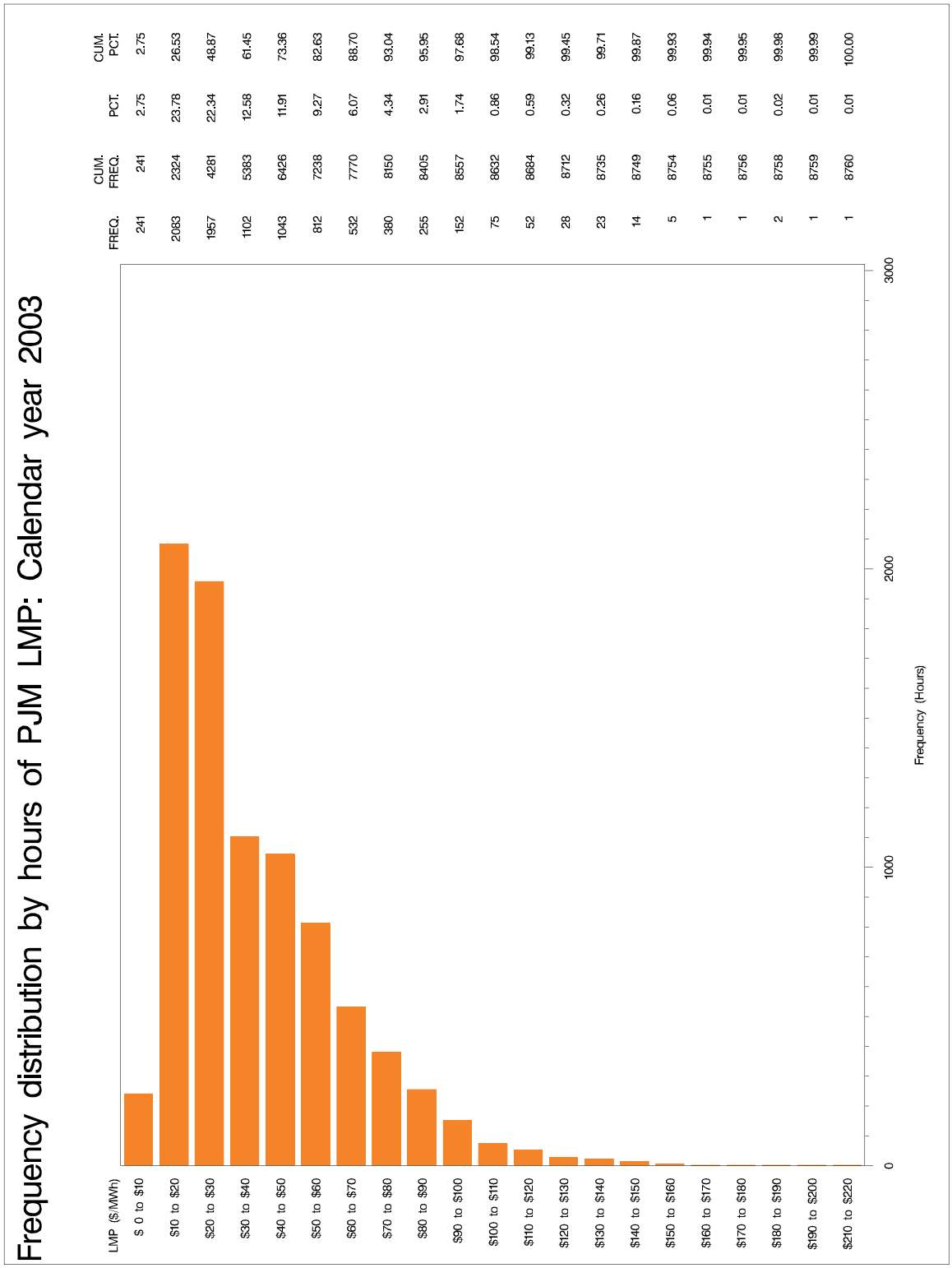


Figure C-7 - Frequency distribution by hours of PJM LMP: Calendar year 2004

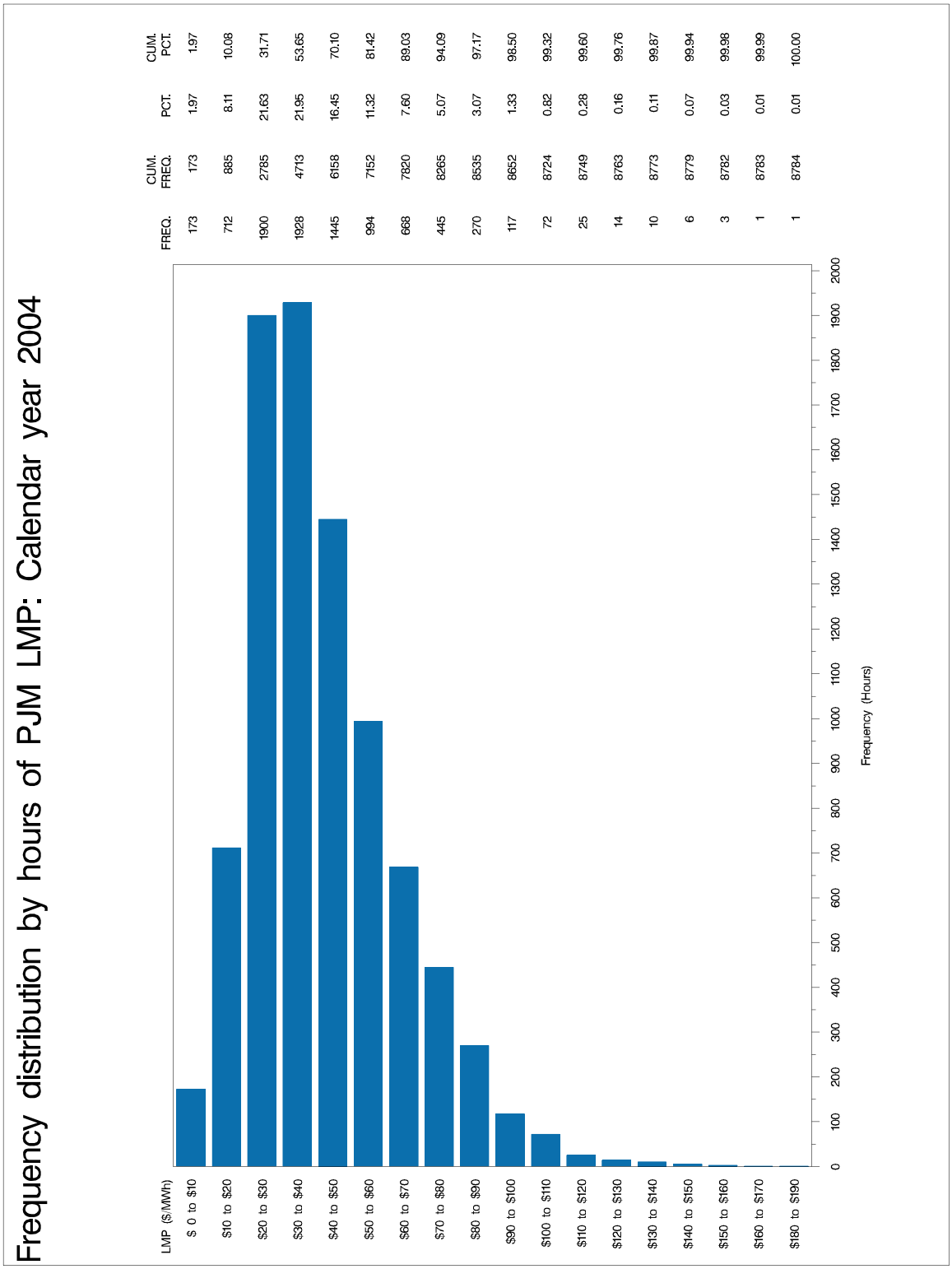


Figure C-8 - Frequency distribution of hourly PJM load: Calendar year 1998

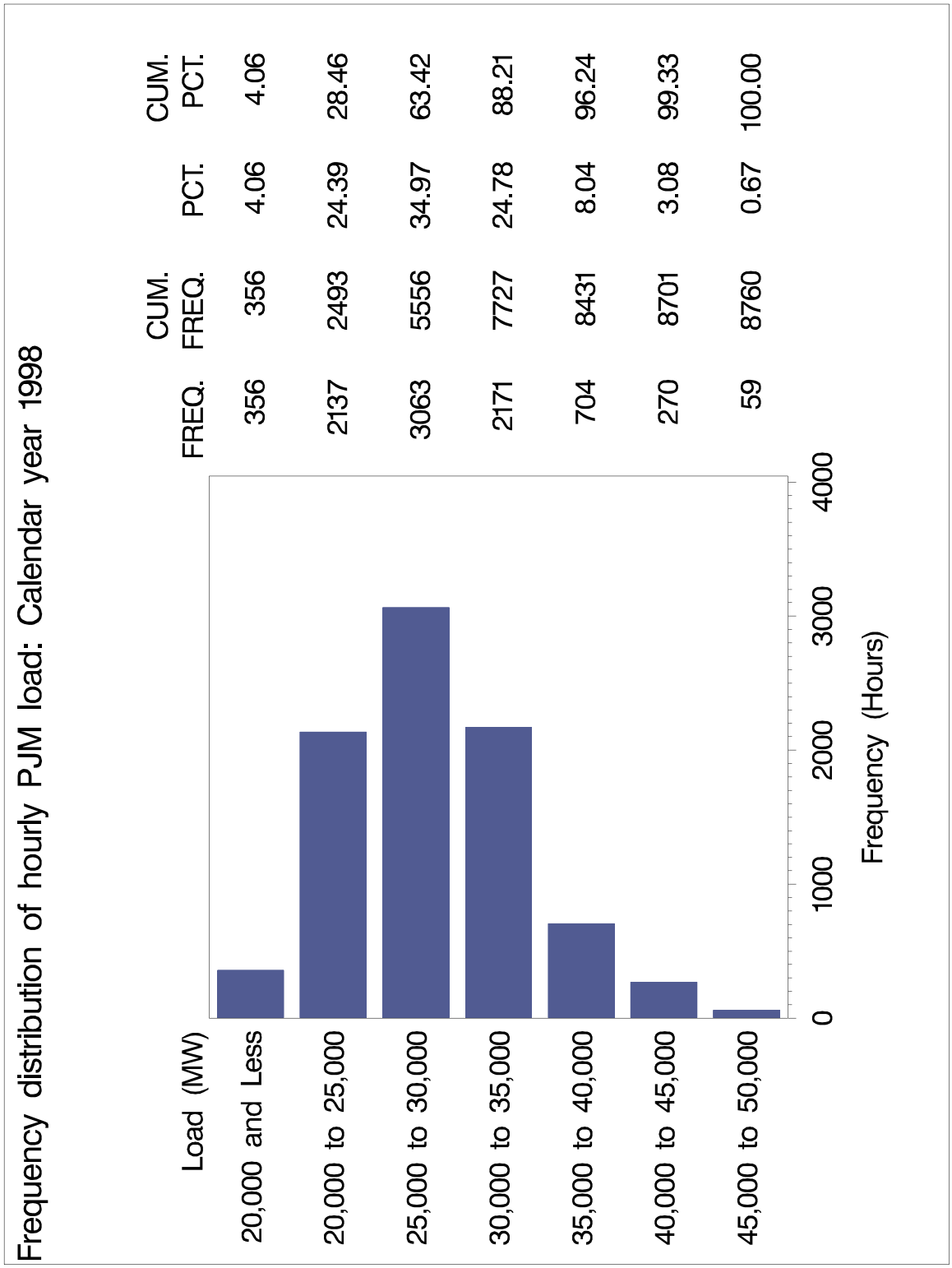


Figure C-9 - Frequency distribution of hourly PJM load: Calendar year 1999

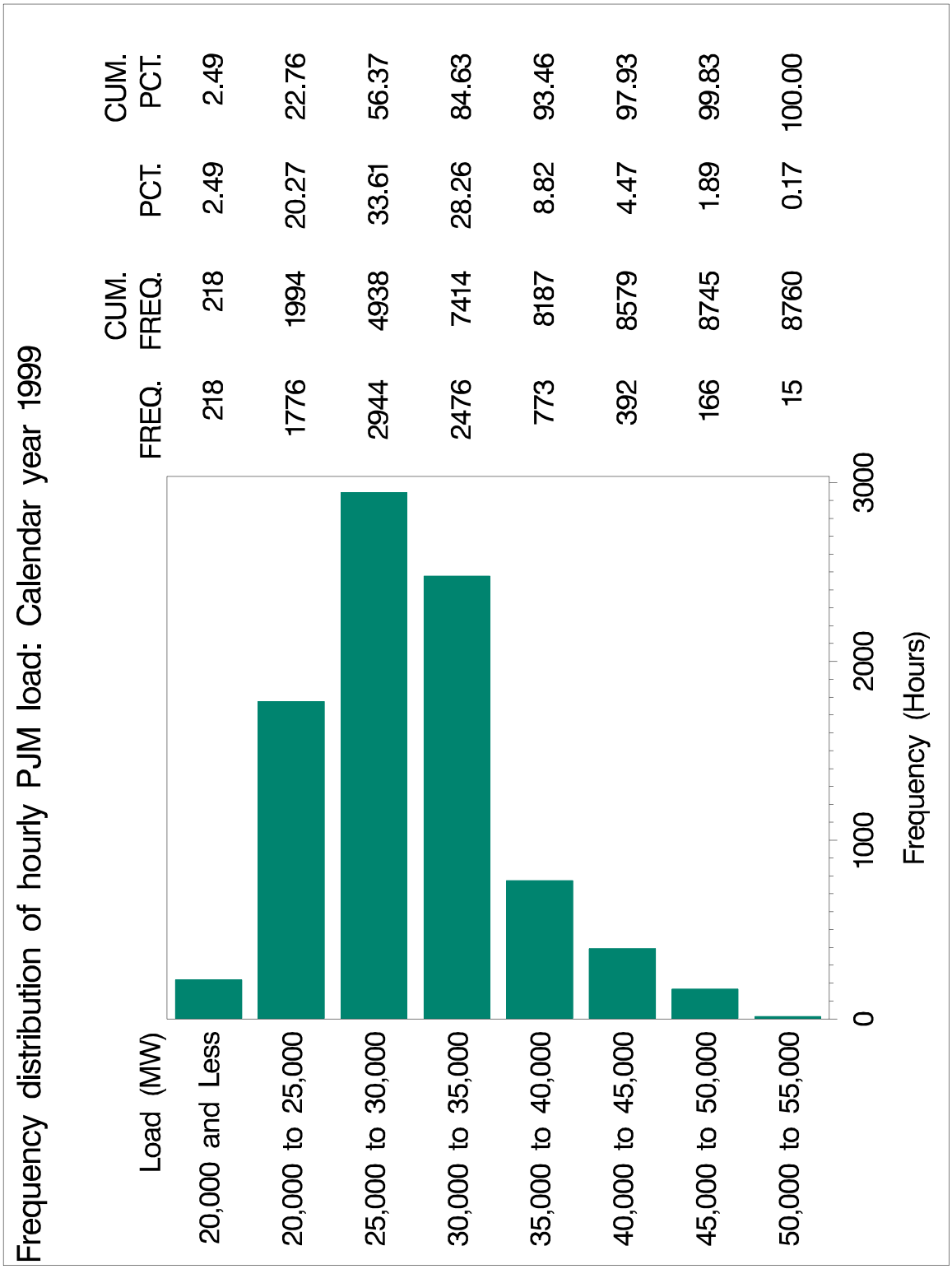


Figure C-10 - Frequency distribution of hourly PJM load: Calendar year 2000

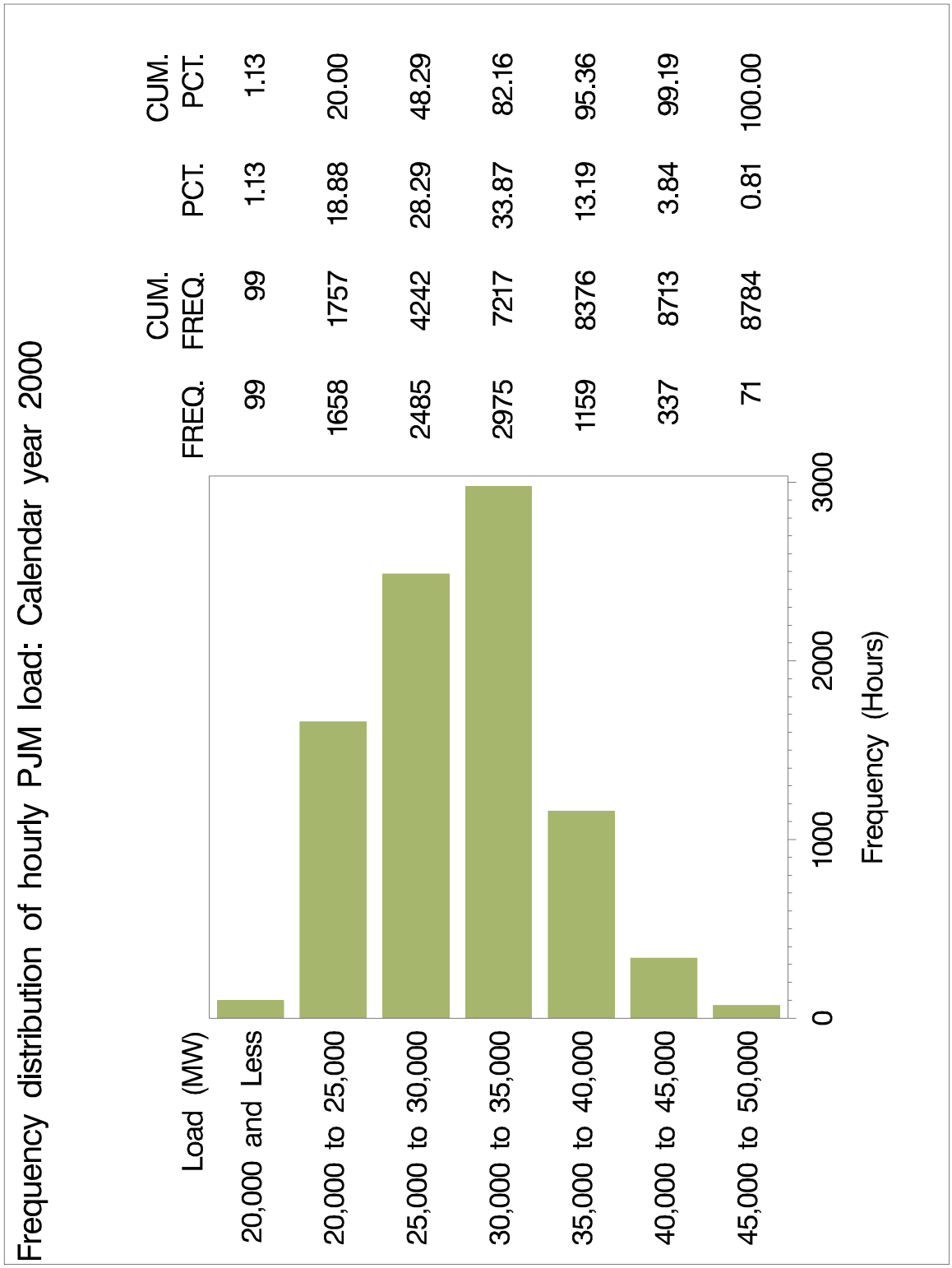


Figure C-11 - Frequency distribution of hourly PJM load: Calendar year 2001

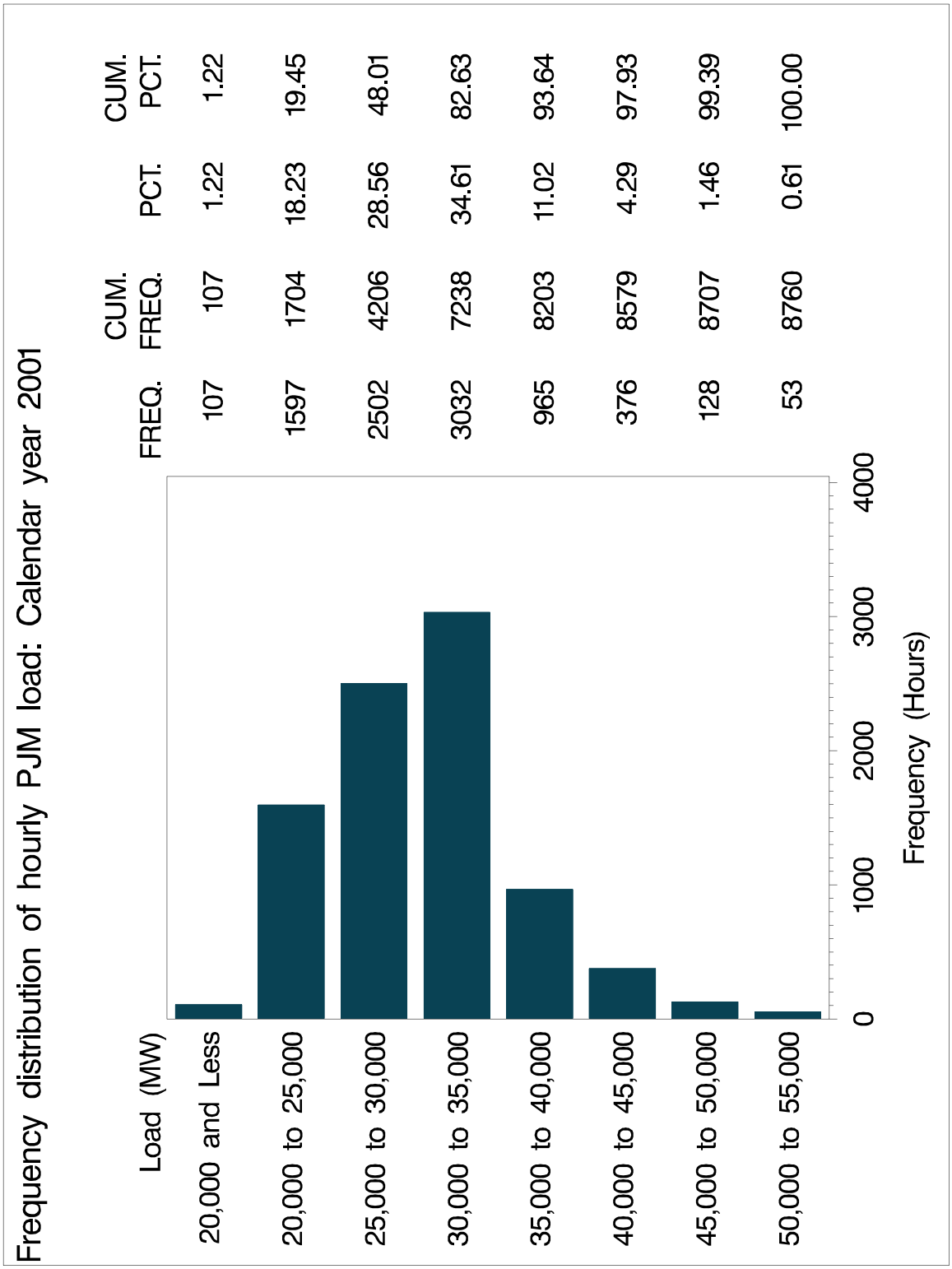


Figure C-12 - Frequency distribution of hourly PJM load: Calendar year 2002

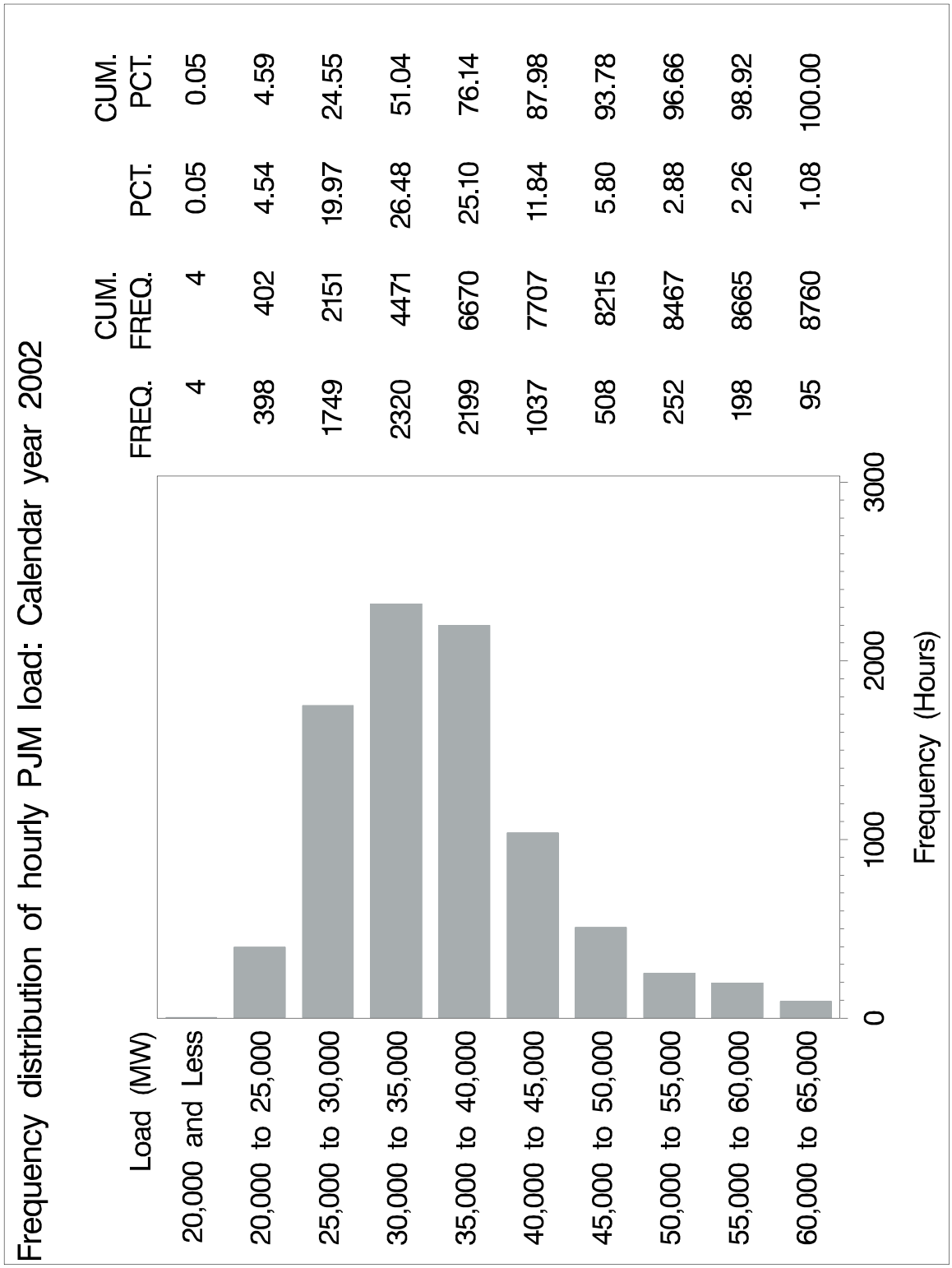


Figure C-13 - Frequency distribution of hourly PJM load: Calendar year 2003

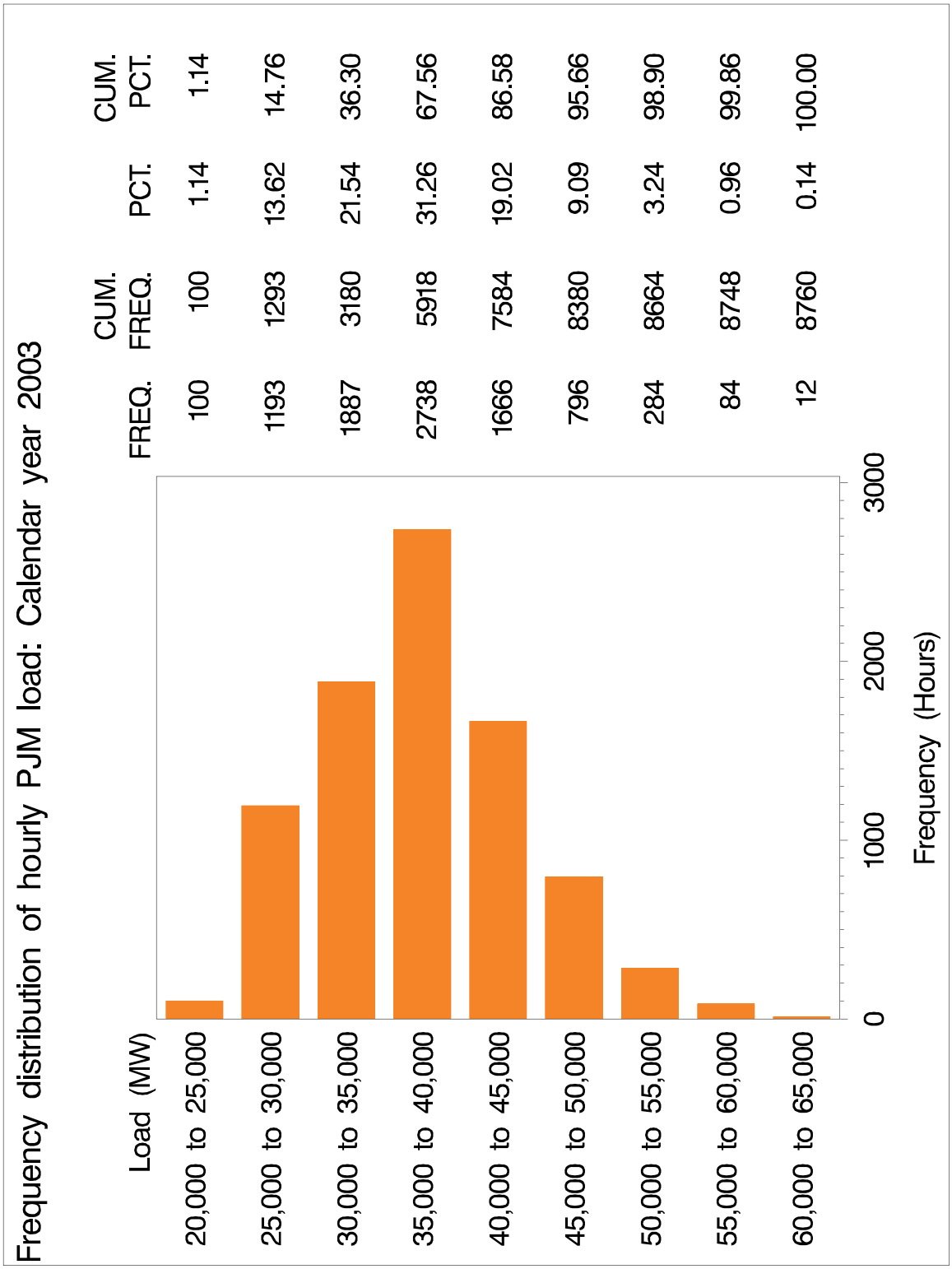
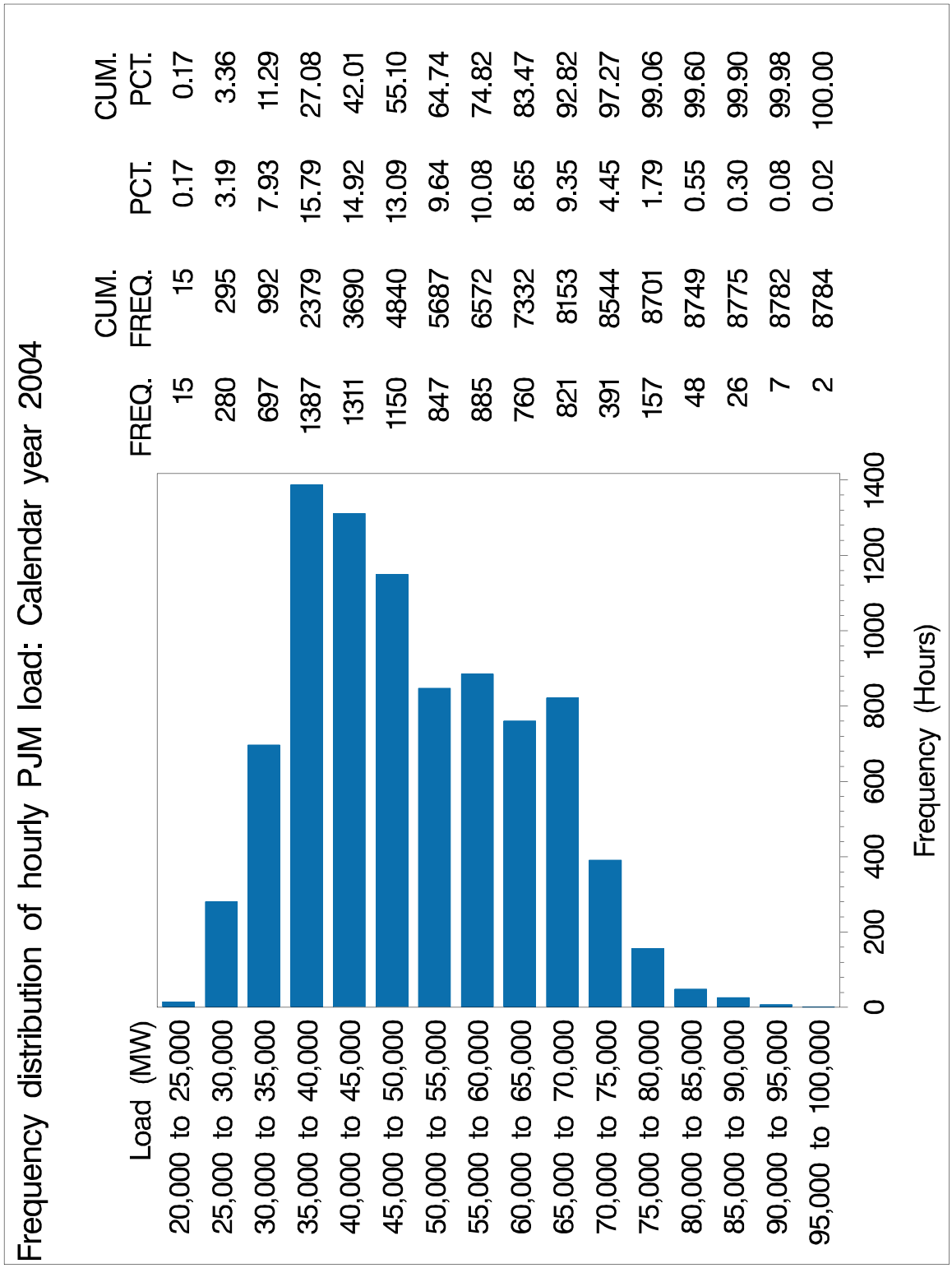


Figure C-14 - Frequency distribution of hourly PJM load: Calendar year 2004



Off-Peak and On-Peak Load

Table C-1 presents summary load statistics for 1998 to 2004 for the off-peak and on-peak hours, while Table C-2 shows the percent change in load on a year-to-year basis. The on-peak period is defined for each weekday (Monday through Friday) as the hour ending 0800 to the hour ending 2300 Eastern Prevailing Time (EPT), excluding North American Electric Reliability Council (NERC) holidays. Table C-1 shows that in 2004 on-peak load was about 30 percent higher than off-peak load. This same spread is evident for all of the previous six years except for 2003 when it was 20 percent higher. The median peak load during the previous six years had ranged from 20 percent to 30 percent higher than the median off-peak load. With the addition of the ComEd, AEP and DAY Control Zones, average load during on-peak hours in 2004 was 34.2 percent higher than in 2003. Off-peak load in 2004 was 32.9 percent higher than in 2003. (See Table C-2.)

Table C-1 - Off-peak and on-peak load (MW): Calendar years 1998 to 2004

	Average Hourly Load			Median Hourly Load			Standard Deviation of Hourly Load		
	Off Peak	On Peak	On Peak/ Off Peak	Off Peak	On Peak	On Peak/ Off Peak	Off Peak	On Peak	On Peak/ Off Peak
1998	25,268	32,344	1.3	24,728	31,081	1.3	4,091	4,388	1.1
1999	26,453	33,269	1.3	25,780	31,950	1.2	4,947	4,824	1.0
2000	26,917	33,797	1.3	26,313	32,757	1.2	4,466	4,181	0.9
2001	26,804	34,303	1.3	26,433	33,076	1.3	4,225	4,851	1.1
2002	31,817	40,362	1.3	30,654	38,378	1.3	6,060	7,419	1.2
2003	33,595	41,755	1.2	32,971	40,802	1.2	5,546	5,424	1.0
2004	44,631	56,020	1.3	43,028	56,578	1.3	10,845	12,595	1.2

Table C-2 - Multiyear change in load: Calendar years 1998 to 2004

	Average Hourly Load		Median Hourly Load		Standard Deviation of Hourly Load	
	Off Peak	On Peak	Off Peak	On Peak	Off Peak	On Peak
1998	N/A	N/A	N/A	N/A	N/A	N/A
1999	4.7%	2.9%	4.3%	2.8%	20.9%	9.9%
2000	1.8%	1.6%	2.1%	2.5%	-9.7%	-13.3%
2001	-0.4%	1.5%	0.5%	1.0%	-5.4%	16.0%
2002	18.7%	17.7%	16.0%	16.0%	43.4%	52.9%
2003	5.6%	3.5%	7.6%	6.3%	-8.5%	-26.9%
2004	32.9%	34.2%	30.5%	38.7%	95.5%	132.2%

Off-Peak and On-Peak, Load-Weighted LMP: 2003 and 2004

Table C-3 shows load-weighted, average LMP for 2003 and 2004 during off-peak and on-peak periods. In 2003, the on-peak, load-weighted LMP was 60 percent greater than the off-peak LMP, while in 2004, it was 50 percent greater. On-peak, load-weighted, average LMP in 2004 was 5.1 percent higher than in 2003. Off-peak, load-weighted LMP in 2004 was 11.1 percent higher than in 2003. Similarly, both on-peak and off-peak median LMPs were higher in 2004 than in 2003, by 5.0 percent and 35.1 percent, respectively. Dispersion in load-weighted LMP, as indicated by standard deviation, was 18.2 percent lower in 2004 than in 2003 during on-peak hours, while the standard deviation was 17.9 percent lower in 2004 than in 2003 during off-peak hours.

Table C-3 - Off-peak and on-peak, load-weighted LMP (Dollars per MWh): Calendar years 2003 to 2004

	2003			2004			Change 2003 to 2004	
	Off Peak	On Peak	On Peak/ Off Peak	Off Peak	On Peak	On Peak/ Off Peak	Off Peak	On Peak
Average LMP	$31.75	$49.97	1.6	$35.28	$52.53	1.5	11.1%	5.1%
Median LMP	$22.52	$46.08	2.0	$30.42	$48.39	1.6	35.1%	5.0%
Standard Deviation	$23.53	$23.88	1.0	$19.31	$19.53	1.0	-17.9%	-18.2%

Fuel-Cost Adjustment

Fuel costs for 2003 and 2004 were taken from various published sources. Natural gas prices are the average of the daily cash price for Transco, Z6, non-New York and Texas Eastern, M-3 and adjusted for transportation. Oil prices are the daily price for No. 2 from the New York Harbor Spot Barge and adjusted for transportation to burner tip. Coal prices are calculated based on unit-specific cost-based offers.

The PJM load-weighted, fuel-cost-adjusted LMP has been developed using a year-over-year calculation. A price index is calculated for each month as a chain-weighted index, where the weights are the number of MWh generated by each marginal unit and the associated price of the marginal fuel type.

The percent of the marginal unit fuel mix is calculated on a monthly basis for each year. Each marginal unit is identified and the amount of system load that is influenced by each marginal unit is calculated to determine a load-weighted, monthly average for each marginal fuel. These marginal unit fuel shares are used to calculate monthly Laspeyres, Paasche and Fisher Indices.[4]

The PJM load-weighted, fuel-cost-adjusted LMP is calculated by dividing the appropriate monthly Fisher Index into the appropriate annual hourly PJM load-weighted LMP. For example, to calculate the 2004 fuel-cost-adjusted LMP, one would divide each hour of the 2004 PJM load-weighted LMP by the appropriate 2004 monthly Fisher index and then calculate the mean, median and the standard deviation.

4 J. F. Kenney and E. S. Keeping, Mathematics of Statistics, Pt. 1, 3rd ed. Princeton, NJ: Van Nostrand, 1962. pp. 65-67.

LMP during Constrained Hours: 2003 and 2004

Table C-4 presents summary statistics for load-weighted, average LMP during constrained hours in 2003 and 2004. During constrained hours, the load-weighted, average LMP was 1.0 percent higher in 2004 than it had been for constrained hours in 2003. During constrained hours, the median, load-weighted LMP was 1.3 percent higher in 2004 than in 2003, and the dispersion of LMP, as shown by the standard deviation, was 17.7 percent lower in 2004 than in 2003.

Table C-4 - Load-weighted, average LMP during constrained hours (Dollars per MWh): Calendar years 2003 to 2004

	2003	2004	Change
Average LMP	$45.41	$45.88	1.0%
Median LMP	$41.29	$41.83	1.3%
Standard Deviation	$25.11	$20.68	-17.7%

Table C-5 provides a comparison of load-weighted, average LMP during constrained and unconstrained hours for the two years. In 2004, load-weighted, average LMP during constrained hours was 12.7 percent higher than load-weighted, average LMP during unconstrained hours. The comparable number for 2003 was 30.9 percent.

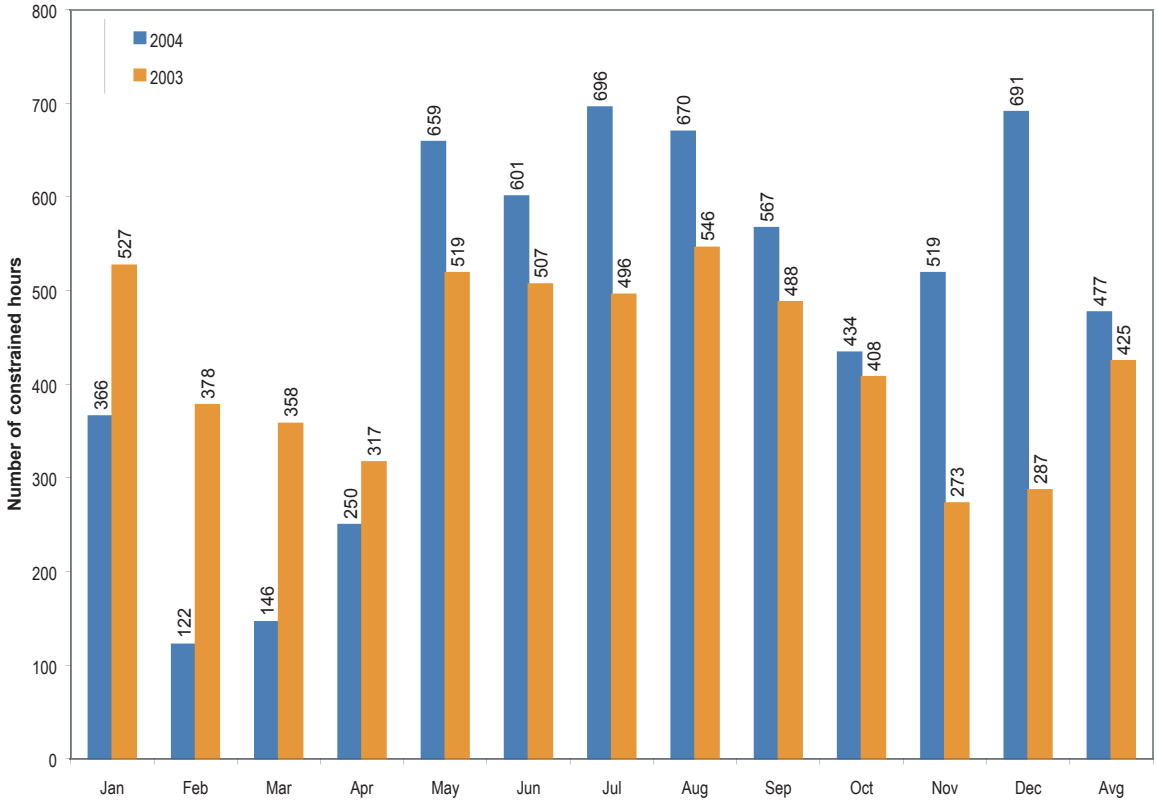
Table C-5 - Load-weighted, average LMP during constrained and unconstrained hours (Dollars per MWh): Calendar years 2003 to 2004

	2003			2004		
	Unconstrained Hours	Constrained Hours	Difference	Unconstrained Hours	Constrained Hours	Difference
Average LMP	$34.69	$45.41	30.9%	$40.72	$45.88	12.7%
Median LMP	$25.00	$41.29	65.2%	$36.55	$41.83	14.5%
Standard Deviation	$24.45	$25.11	2.7%	$22.12	$20.68	-6.5%

Figure C-15 shows the number of real-time constrained hours during each month in 2003 and 2004 and the average number of constrained hours per month for each year.[5] There were 5,104 constrained hours in 2003 and 5,721 in 2004, an increase of approximately 12.1 percent. Figure C-15 also shows that the average number of constrained hours per month was slightly higher in 2004 than in 2003, with 477 per month in 2004 versus 425 per month in 2003.

5 The constrained-hour data presented here use the convention that an hour is considered congested when the difference in LMP between at least two buses is greater than $0.00 and congestion occurs for 20 minutes or more within an hour. In prior years, this Appendix to The State of the Market Report defined a congested hour as one in which the difference in LMP between at least two buses in that hour was greater than $1.00.

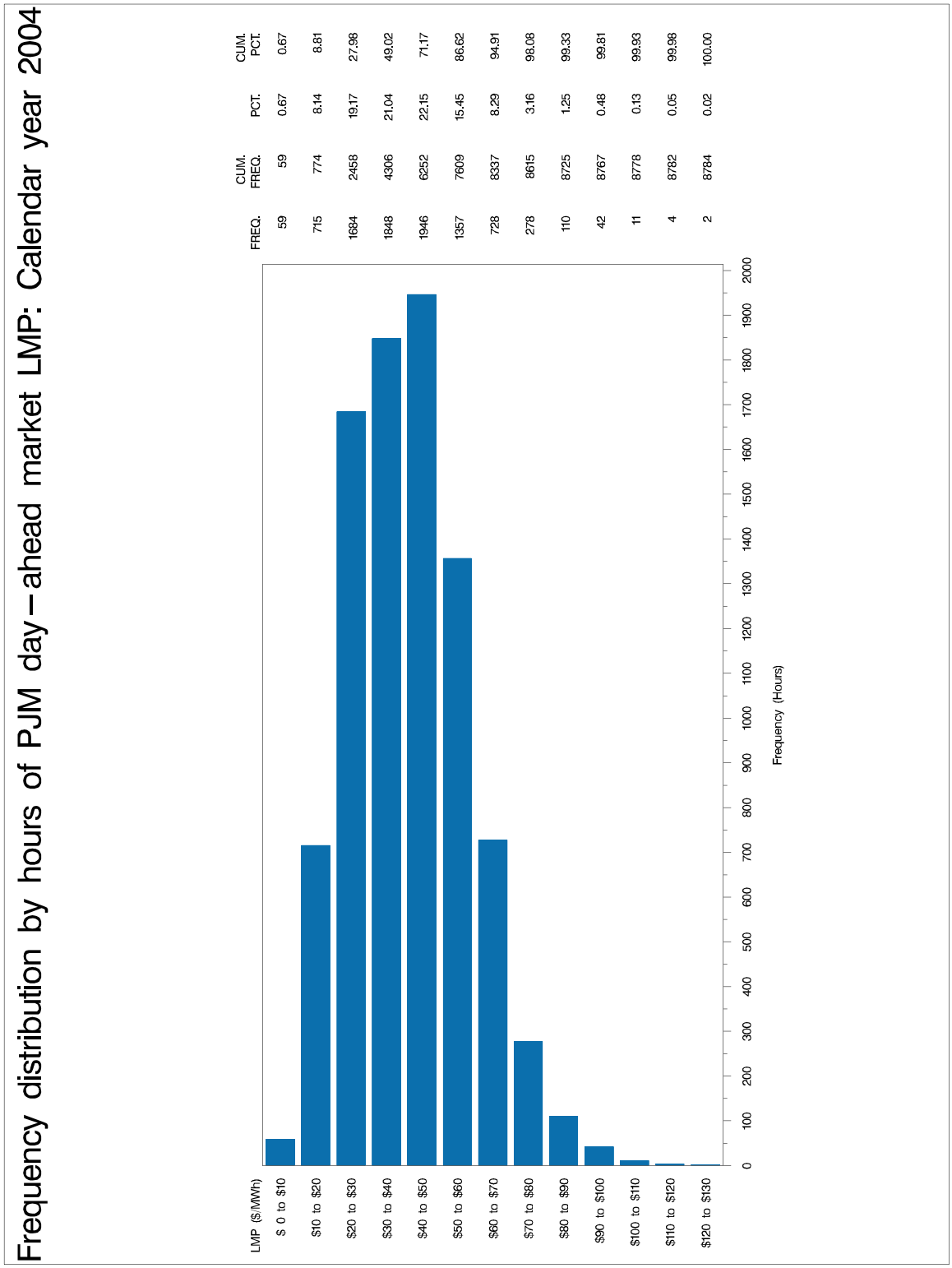
Figure C-15 - PJM real-time constrained hours: Calendar years 2003 to 2004



Day-Ahead and Real-Time Prices

Real-time prices are slightly higher than day-ahead prices on average and real-time prices show greater dispersion. This pattern of average, systemwide LMP price distribution for 2004 can be seen in Figure C-7 and Figure C-16. Together they show the frequency distribution by hours for the two markets. In PJM's Real-Time Energy Market, both the $20-per-MWh to $30-per-MWh interval and the $30-per-MWh to $40-per-MWh interval occurred with almost equal frequency, approximately 22 percent of the hours. (See Figure C-7.) The most frequently occurring price interval in the PJM Day-Ahead Energy Market was the $40-per-MWh to $50-per-MWh interval with 22 percent of the hours. (See Figure C-16.) The $30-per-MWh to $40-per-MWh interval was the next most frequently occurring with 21 percent of the hours. The $20-per-MWh to $30-per-MWh interval occurred during 19 percent of the hours. In the Real-Time Energy Market, prices were less than $30 per MWh for 32 percent of the hours, while prices were less than $30 per MWh in the Day-Ahead Energy Market for 28 percent of the hours. Cumulatively, prices were less than $40 per MWh for 54 percent of the hours in the Real-Time Energy Market and 49 percent of the hours in the Day-Ahead Energy Market; less than $50 per MWh for 70 percent of the hours in the Real-Time Energy Market and 71 percent of the hours in the Day-Ahead Energy Market; less than $60 per MWh for 81 percent of the hours in the Real-Time Energy Market and 87 percent of the hours in the Day-Ahead Energy Market. In the Real-Time Energy Market, prices were above $120 per MWh for 35 hours (0.40 percent of the hours), reaching a high for the year of $180.12 per MWh on December 20 during the hour ending 0900 EPT. In the Day-Ahead Energy Market, prices were above $120 per MWh for two hours (0.02 percent of the hours) and reached a high for the year of $129.35 per MWh on January 15, 2004, during the hour ending 1800 EPT.

Figure C-16 - Frequency distribution by hours of day-ahead energy market LMP: Calendar year 2004



Off-Peak and On-Peak LMP

Table C-6 shows average LMP during off-peak and on-peak periods for the Day-Ahead and Real-Time Energy Markets during calendar year 2004. Day-ahead and real-time, on-peak average LMPs were 58 and 52 percent higher, respectively, than the corresponding off-peak average LMP. The real-time, on-peak average LMP was 0.6 percent higher than the day-ahead, on-peak average LMP. Median LMPs during on-peak hours were 67 percent and 63 percent higher in the Day-Ahead and Real-Time Energy Markets, respectively, than median LMPs during off-peak hours. In contrast to average prices but consistent with historical experience, the real-time, on-peak median LMP was 4.3 percent lower than the day-ahead, on-peak median LMP. Since the mean was above the median in these markets, both showed a positive skewness. The mean was, however, proportionately higher than the median in the Real-Time Energy Market as compared to the Day-Ahead Energy Market during both on-peak and off-peak periods (9 percent and 17 percent compared to 3 percent and 9 percent, respectively). The differences reflect larger positive skewness in the Real-Time Energy Market. During on-peak hours, the standard deviation in the Real-Time Energy Market was about 32 percent higher than in the Day-Ahead Energy Market, while it was 26 percent higher during off-peak hours.

Table C-6, Figure C-17 and Figure C-18 show the difference between real-time and day-ahead LMP during calendar year 2004 during the on-peak and off-peak hours, respectively. The difference between real-time and day-ahead average LMP during on-peak hours was only $0.32 per MWh. (Day-ahead LMP was lower than real-time LMP.) During the off-peak hours, the difference between real-time and day-ahead average LMP was $1.55 per MWh. (Day-ahead LMP was lower than real-time LMP.)

Table C-6 - Off-peak and on-peak hourly LMP (Dollars per MWh): Calendar year 2004

	Day-Ahead			Real-Time			Change in Real-Time Relative to Day-Ahead	
	Off Peak	On Peak	On Peak/ Off Peak	Off Peak	On Peak	On Peak/ Off Peak	Off Peak	On Peak
Average LMP	$32.53	$51.54	1.58	$34.08	$51.86	1.52	4.8%	0.6%
Median LMP	$29.84	$49.85	1.67	$29.20	$47.70	1.63	-2.1%	-4.3%
Standard deviation	$14.08	$13.08	0.93	$19.04	$19.31	1.01	35.3%	47.6%

Figure C-17 - Hourly real-time LMP minus day-ahead LMP (On-peak hours): Calendar year 2004

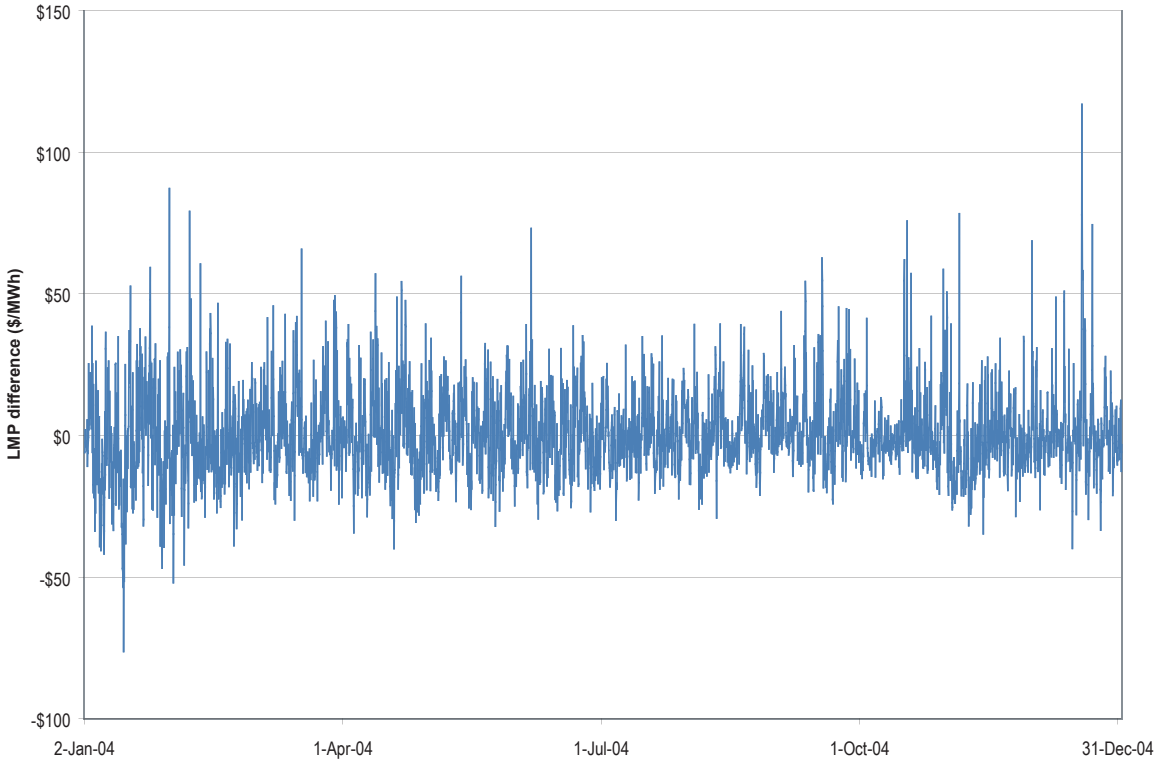
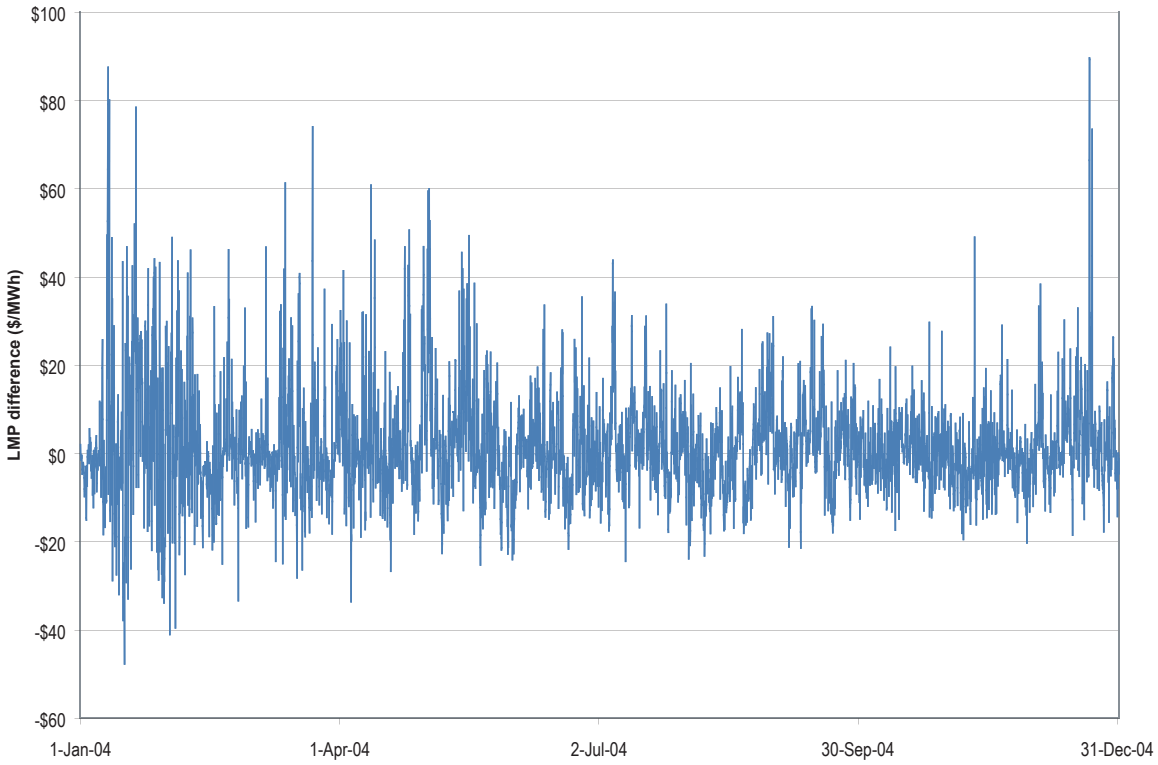


Figure C-18 - Hourly real-time LMP minus day-ahead LMP (Off-peak hours): Calendar year 2004



LMP during Constrained Hours: Day-Ahead and Real-Time Energy Markets

Figure C-19 shows the number of constrained hours in each month for the Day-Ahead and Real-Time Energy Markets and the average number of constrained hours for 2004. Overall, there were 5,721 constrained hours in the Real-Time Energy Market and 8,158 constrained hours in the Day-Ahead Energy Market. Figure C-19 shows that in every month of calendar year 2004 the number of constrained hours in the Day-Ahead Energy Market exceeded those in the Real-Time Energy Market. On average for the year, the Day-Ahead Energy Market had 43 percent more constrained hours than the Real-Time Energy Market.

Figure C-19 - Real-time and day-ahead, market-constrained hours: Calendar year 2004

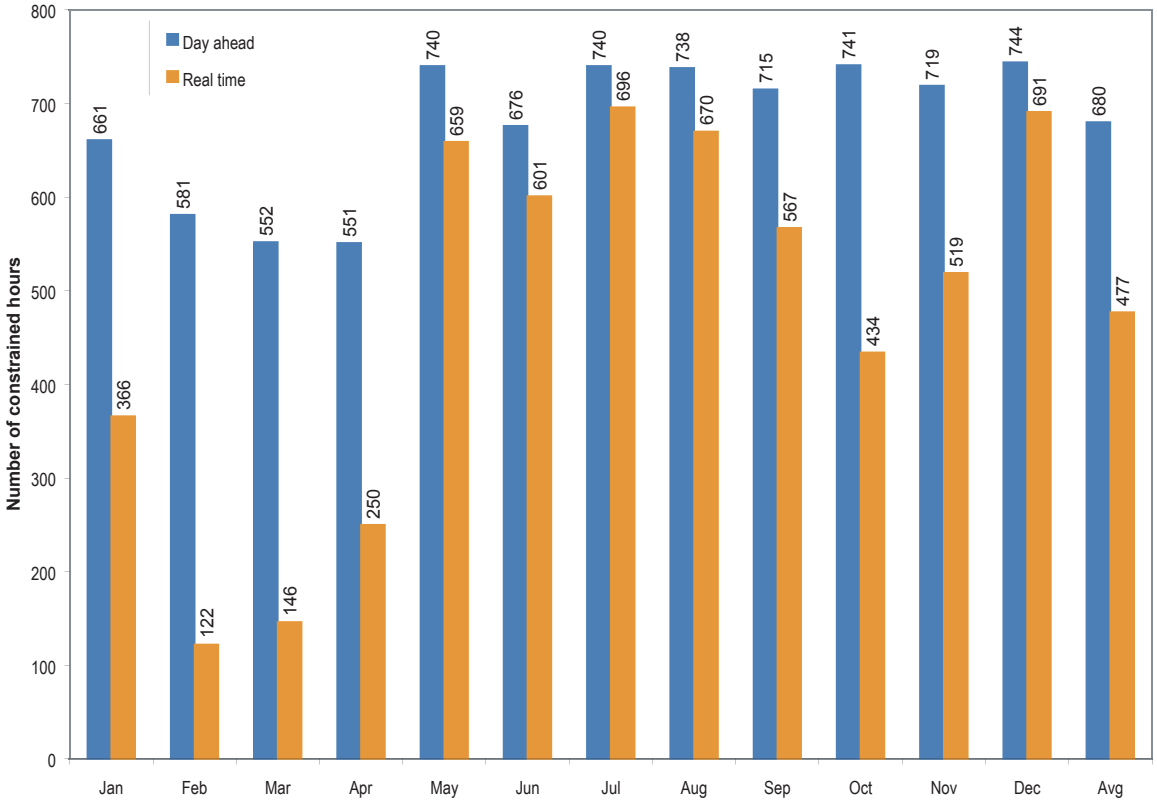


Table C-7 shows average LMP during constrained and unconstrained hours in the Day-Ahead and Real-Time Energy Markets. In the Day-Ahead Energy Market, average LMP during constrained hours was 21.5 percent higher than average LMP during unconstrained hours. In the Real-Time Energy Market, average LMP during constrained hours was 12.6 percent higher than average LMP during unconstrained hours. Average LMP during constrained hours was 5.2 percent higher in the Real-Time Energy Market than in the Day-Ahead Energy Market.

Table C-7 - LMP during constrained and unconstrained hours (Dollars per MWh): Calendar year 2004

	Day Ahead			Real Time		
	Unconstrained Hours	Constrained Hours	Percent Difference	Unconstrained Hours	Constrained Hours	Percent Difference
Average LMP	$34.53	$41.96	21.5%	$39.18	$44.13	12.6%
Median LMP	$32.29	$40.94	26.8%	$34.94	$40.09	14.7%
Standard deviation	$14.97	$16.60	10.8%	$21.81	$20.54	-5.8%

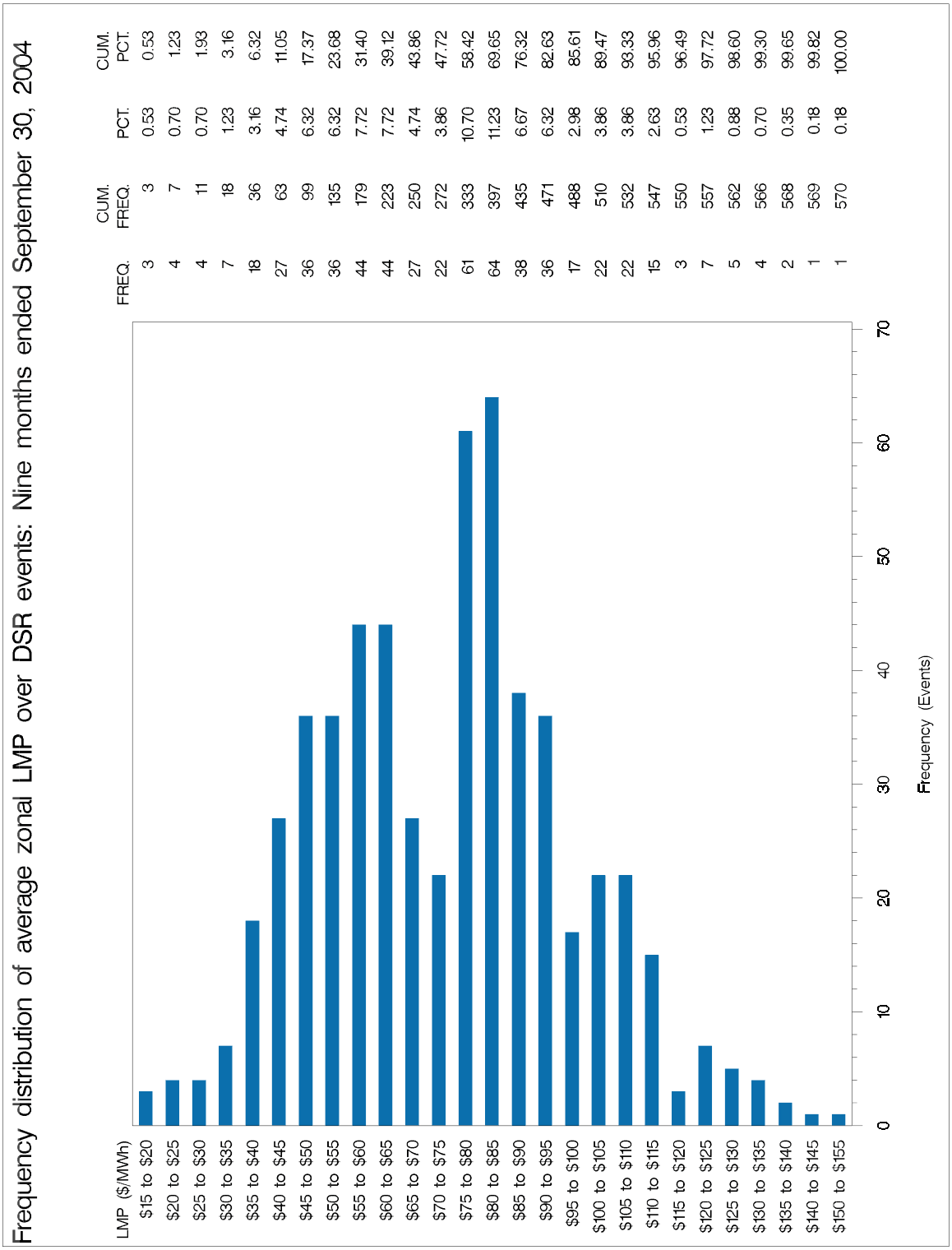
Taken together, the data shows that average LMP in the Day-Ahead Energy Market during constrained hours was 1.3 percent higher than the overall average LMP for the Day-Ahead Energy Market, while average LMP during unconstrained hours was 16.7 percent lower.[6] In the Real-Time Energy Market, average LMP during constrained hours was 4.1 percent higher than the overall average LMP for the Real-Time Energy Market, while average LMP during unconstrained hours was 7.6 percent lower.

Frequency of Demand-Side Response (DSR) Events under the Economic Program Options

Figure C-20 shows the number of demand-side response (DSR) events (frequency), the cumulative number of DSR events (cumulative frequency), the percent of DSR events (percent) and the cumulative percent of DSR events (cumulative percent) that average zonal LMP was within a given $5 per MWh price range.[7] This figure includes the nine months of available data, ended September 30, 2004. The DSR business rules provide for larger payments when LMP is above $75 per MWh than when LMP is below $75 per MWh. A DSR event is the range of hours in a day when participants in one of the zones reduce their load under one of the DSR Economic Program options. Participants in multiple zones can reduce their load during a specific DSR event simultaneously. If the zonal prices vary, this DSR event will appear in more than one of the $5 price increments of Figure C-20.

6 See Section 2, "Energy Market" for this table.
7 Average zonal LMP is calculated for every option of the Economic Program by averaging preliminary, posted real-time zonal LMP over the hours of a DSR event. For example, if a particular zone participated in multiple options of the Economic Program during a specific DSR event, then there would be average zonal LMP for each of the Economic Program's options.

Figure C-20 - Frequency distribution of average zonal LMP over DSR events: Nine months ended September 30, 2004



LMP ($/MWh)	FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
$15 to $20	3	3	0.53	0.53
$20 to $25	4	7	0.70	1.23
$25 to $30	4	11	0.70	1.93
$30 to $35	7	18	1.23	3.16
$35 to $40	18	36	3.16	6.32
$40 to $45	27	63	4.74	11.05
$45 to $50	36	99	6.32	17.37
$50 to $55	36	135	6.32	23.68
$55 to $60	44	179	7.72	31.40
$60 to $65	44	223	7.72	39.12
$65 to $70	27	250	4.74	43.86
$70 to $75	22	272	3.86	47.72
$75 to $80	61	333	10.70	58.42
$80 to $85	64	397	11.23	69.65
$85 to $90	38	435	6.67	76.32
$90 to $95	36	471	6.32	82.63
$95 to $100	17	488	2.98	85.61
$100 to $105	22	510	3.86	89.47
$105 to $110	22	532	3.86	93.33
$110 to $115	15	547	2.63	95.96
$115 to $120	3	550	0.53	96.49
$120 to $125	7	557	1.23	97.72
$125 to $130	5	562	0.88	98.60
$130 to $135	4	566	0.70	99.30
$135 to $140	2	568	0.35	99.65
$140 to $145	1	569	0.18	99.82
$150 to $155	1	570	0.18	100.00

As Figure C-20 indicates, during the nine months ended September 30, 2004, DSR events when prices were below $75 per MWh increased in frequency in the $35 to $40 per MWh price range and were concentrated in the $45 to $65 per MWh range. The same figure shows that DSR events when prices were greater than $75 per MWh were concentrated in the $75 to $95 per MWh range. A majority, 52 percent, of all DSR events took place when average zonal LMP during the DSR event was equal to, or greater than, $75 per MWh.