National Electricity Market of Singapore

MARKET SURVEILLANCE & COMPLIANCE PANEL 2016 ANNUAL REPORT

CONTENTS

EXECUTIVE SUMMARY

This annual report by the Market Surveillance and Compliance Panel (MSCP) covers the period 1 January to 31 December 2016. It is based on analyses of data and monitoring indices compiled by the MSCP to assess the performance of the wholesale electricity markets. The MSCP highlights the following observations for 2016 relative to 2015:

Supply Indices

- The average supply cushion[1] increased 0.2 percentage point from 29.3 percent in 2015 to 29.5 percent in 2016, showing an improvement of supply conditions relative to that of demand.
- The average capacity ratio[2] of Combined Cycle Gas Turbine (CCGT) units was 3.3 percentage points higher in 2016 at 65.6 percent. The capacity ratio for Steam Turbine (ST) units gained 0.2 percentage point to 0.4 percent.
- The generation market share of CCGT units remained at almost the same level as 2015 at 98.1 percent.
- The concentration level in the generation sector continued to fall with the combined market share of the three largest generation companies declining 1.4 percentage points from 2015, to 57.8 percent.
- The average total generation outage per period in 2016 increased by 17.5 percent to 1,109MW. The average forced outage level per period rose from 24MW in 2015 to 35MW in 2016.

Demand Indices

- The average demand growth in 2016 increased to 2.6 percent, up from 1.5 percent in 2015.
- The average monthly electricity demand in 2016 was about 5,563MW, compared to 5,424MW in 2015. The average monthly electricity demand peaked in August at 5,719MW.
- The accuracy of real-time load forecast in 2016 improved further with an average forecast error of 2.7 percent, the best result in the history of the National Electricity Market of Singapore.

Market Prices

- The average Wholesale Electricity Price (WEP) fell 33.6 percent to $63.69/MWh – the lowest level since the market started – along with sharp declines in fuel prices.
- The average price of the benchmark 180-centistoke high sulphur fuel oil (180-CST HSFO) fell 19.8 percent to US$38.19/bbl in 2016.
- The total reserve payment in 2016 dropped 44.4 percent from $52.8 million to $29.3 million. This is the lowest level since the market started.

[1] Supply cushion measures the percentage of total supply available after matching off demand. Details can be found in the USER GUIDE of this report.

[2] Capacity ratio measures the ratio of scheduled output to a generation registered facility's maximum generation capacity. Details can be found in the USER GUIDE of this report.

INTRODUCTION

The Market Rules provide for the Market Surveillance and Compliance Panel (MSCP) to prepare and submit to Energy Market Company Pte Ltd (EMC) an annual report on the conduct of its monitoring and investigation activities. The report is submitted to the Energy Market Authority by EMC. This is the fifteenth report by the MSCP since 2003 on the wholesale electricity markets of the National Electricity Market of Singapore.

The current report covers the period 1 January to 31 December 2016. This review provides the MSCP with the opportunity to highlight significant observations.

The current MSCP members are:

- T P B Menon, Chair;
- Lee Keh Sai;
- Philip Chua;
- Professor Euston Quah; and
- Professor Walter Woon

Supported by the Market Assessment Unit of EMC, the role of the MSCP is to monitor and investigate activities in the wholesale electricity markets and the conduct of market participants, the Market Support Services Licensee, the Power System Operator and EMC to:

- identify breaches of the Market Rules, market manual or system operation manual;
- assess whether the underlying structure of the wholesale electricity markets is consistent with the efficient and fair operation of a competitive market; and
- recommend remedial actions to mitigate the conduct and inefficiencies referred to above.

The Market Rules require this annual report to include a summary of routine reports on the MSCP's monitoring and investigation activities, and a summary of any reports regarding the possibility of anti-competitive agreements or the abuse of a dominant position contrary to sections 50 or 51 of the Electricity Act. The report also includes a summary of all complaints or referrals filed and investigations commenced and concluded, and a summary of all investigations conducted by the MSCP concerning offer variations after gate closure reported by EMC. The Market Rules require the report to contain the general assessment by the MSCP of the state of competition and compliance within, and the efficiency of, the wholesale electricity markets.

MARKET MONITORING

Catalogue of Data and Catalogue of Monitoring Indices

To carry out monitoring effectively, the Market Rules provide for the Market Assessment Unit (MAU), under the supervision and direction of the Market Surveillance and Compliance Panel (MSCP), to develop a catalogue of the data[3] it acquires and a catalogue of the monitoring indices[4] that it uses to evaluate the acquired data.

Indicators of Market Performance

The MAU submits regular monitoring updates to the MSCP. These updates include observations of several indicators of market performance which can be broadly classified into supply, demand and price indices. In the following sections, the MSCP reports its observations from these indices for the year under review.

[3] On 29 August 2003, a catalogue of data was adopted by the MSCP after public consultation. It took effect from 1 October 2003. Data is collected according to this catalogue, with the assistance of market entities.

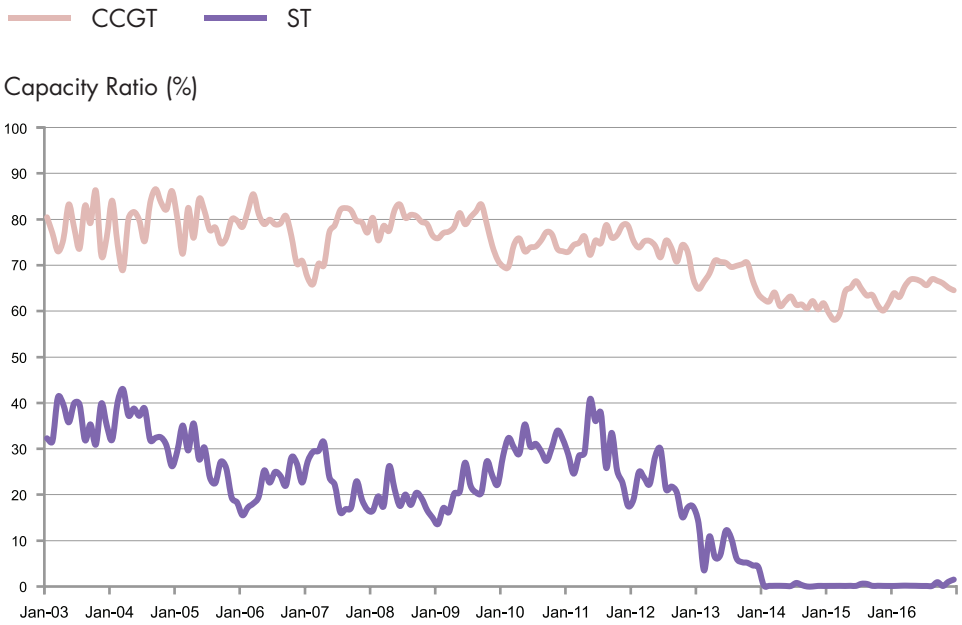
[4] On 29 July 2004, a catalogue of monitoring indices was adopted by the MSCP after public consultation. It took effect from 1 August 2004. The catalogue of monitoring indices is used to evaluate the market data collected.

Table 1: Capacity Ratio (in %) 2016

Month	CCGT	ST	OT	OCGT
Jan 16	63.93	0.12	54.87	0.08
Feb 16	63.05	0.16	51.16	0.00
Mar 16	65.45	0.19	50.39	0.00
Apr 16	66.87	0.16	47.91	0.00
May 16	66.92	0.15	50.31	0.25
Jun 16	66.44	0.12	48.05	0.00
Jul 16	65.64	0.12	44.91	0.06
Aug 16	66.98	0.12	45.08	0.03
Sep 16	66.60	0.94	49.52	0.38
Oct 16	66.08	0.12	48.45	0.00
Nov16	65.12	1.01	47.16	0.00
Dec 16	64.53	1.51	47.46	0.25
Average	65.63	0.39	48.77	0.09

OT = other facilities, i.e., incineration plants that convert energy from incinerated refuse

Chart 1: Comparison of Capacity Ratio for CCGT and ST



The capacity ratio of generation registered facilities, i.e., the ratio of scheduled generation output to maximum generation capacity of generation registered facilities

Table 1 shows the monthly capacity ratio of the four generation types for 2016. The average capacity ratio for Combined Cycle Gas Turbine (CCGT) units was 65.6 percent in 2016, an increase of 3.3 percentage points over 2015. The average capacity ratio for other facilities (OT) fell 3.2 percentage points to 48.8 percent and the average capacity ratio for Open Cycle Gas Turbine (OCGT) units fell 0.2 percentage point to 0.1 percent in 2016.

The average capacity ratio for Steam Turbine (ST) units increased 0.2 percentage point to 0.4 percent in 2016. The significant rise in the scheduled output of ST units, especially in September, November and December, led to the increase in the average capacity ratio for ST units.

Chart 1 shows the capacity ratios for CCGT and ST units since the market started in 2003. Both indices were generally on the decline from 2011 to 2016, largely due to the growing generation capacity of CCGT units and declining scheduled output of ST units. The maximum generation capacity of CCGT units increased 69.2 percent from 2011 to 2016, while the scheduled output of ST units decreased 98.9 percent in the same period. The significant drop in the scheduled output of ST units caused the capacity ratio for ST units to fall from 29.2 percent in 2011 to below 1.0 percent in 2014 and the years thereafter.

Chart 2: Relationship between Supply Cushion and USEP

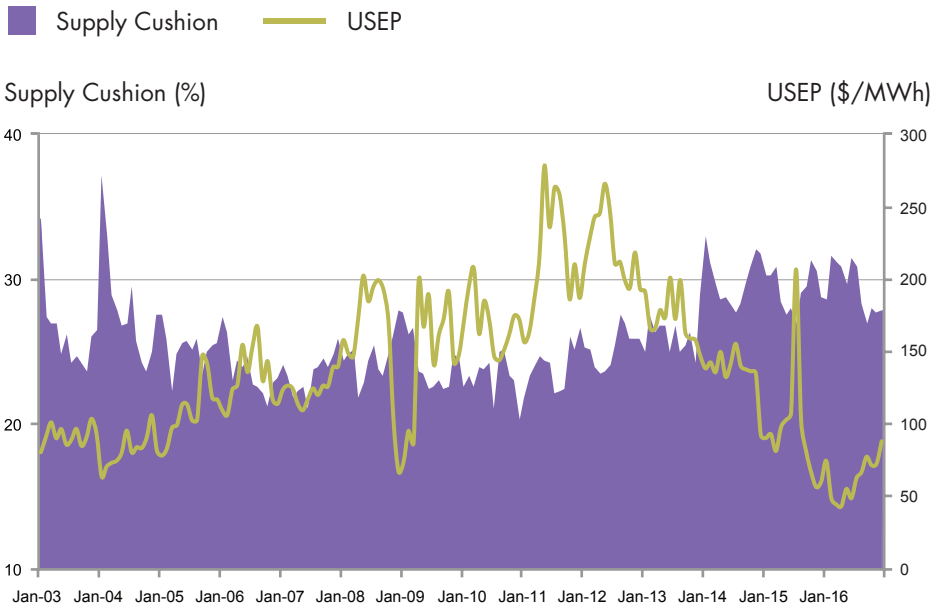


Chart 3: Relationship between Supply Cushion and USEP in 2016

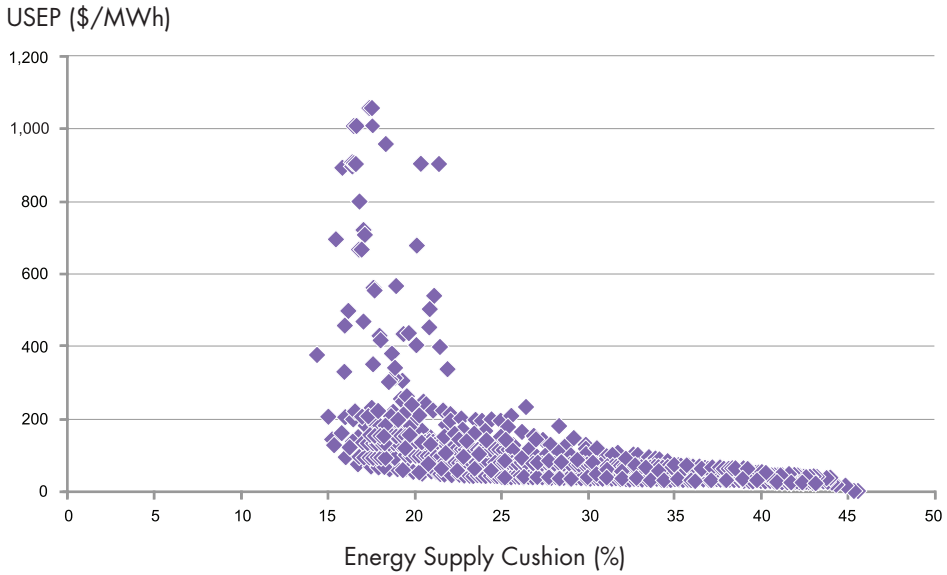


Chart 2 illustrates the relationship between the Uniform Singapore Energy Price (USEP) and the supply cushion, which measures the level of spare capacity available after dispatch.

In 2016, the average supply rose 2.9 percent whereas the average demand rose 2.5 percent. Hence, the supply cushion strengthened 0.2 percentage point from 29.3 percent in 2015 to 29.5 percent in 2016. The USEP dropped 34.1 percent from $95.97/MWh in 2015 to $63.28/MWh in 2016, which is the lowest level since the National Electricity Market of Singapore (NEMS) started in 2003. This drop in the USEP coincided with falling fuel prices.

Chart 3 shows the relationship between the USEP and the supply cushion in 2016. The total number of instances of the USEP being above $500/MWh decreased from 180 in 2015 to 33 in 2016.

Historically, more occurrences of high prices were observed when the supply cushion was below 15 percent. In 2016, however, only one out of the 33 occurrences of high prices was observed when the supply cushion was below 15 percent. The supply cushion was between 15 and 20 percent in the remaining 32 occurrences.

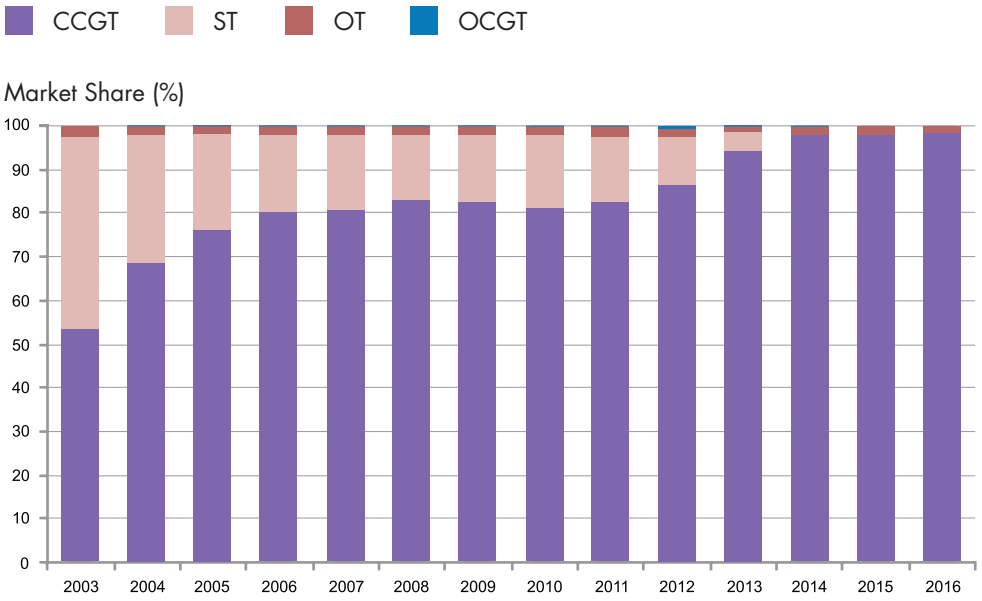
Table 2: Relationship between Supply Cushion and USEP

	Supply Cushion < 15%			Supply Cushion ≥ 15%		
Year	No. of periods	Average USEP ($/MWh)	Max USEP ($/MWh)	No. of periods	Average USEP ($/MWh)	Max USEP ($/MWh)
2003	319	272.91	4,500.00	17,201	89.00	1,904.56
2004	74	339.50	4,500.00	17,494	81.26	1,624.68
2005	109	607.48	4,430.65	17,411	106.79	2,229.61
2006	191	477.21	4,500.00	17,329	128.62	930.77
2007	278	332.54	4,500.00	17,242	121.22	988.06
2008	127	391.43	1,126.03	17,441	160.59	955.52
2009	268	599.42	4,499.41	17,252	140.73	1,572.58
2010	498	310.67	3,234.93	17,022	166.41	910.94
2011	289	505.36	4,500.00	17,231	209.96	693.45
2012	82	925.72	4,500.00	17,486	219.19	805.13
2013	128	525.74	2,787.87	17,392	170.64	785.50
2014	12	589.54	936.81	17,508	136.36	857.78
2015	21	1,052.29	1,328.06	17,499	94.82	1,231.40
2016	13	329.55	1,252.59	17,555	63.08	1,053.62

Table 2 summarises the yearly USEP movements under two supply cushion scenarios. When the supply cushion was below 15 percent, the average USEP in 2016 was less volatile at $329.55/MWh, compared to $1,052.29/MWh in 2015. When the supply cushion was 15 percent or above, the average USEP in 2016 was $63.08/MWh. This was a noticeable decline of 33.5 percent from $94.82/MWh in 2015.

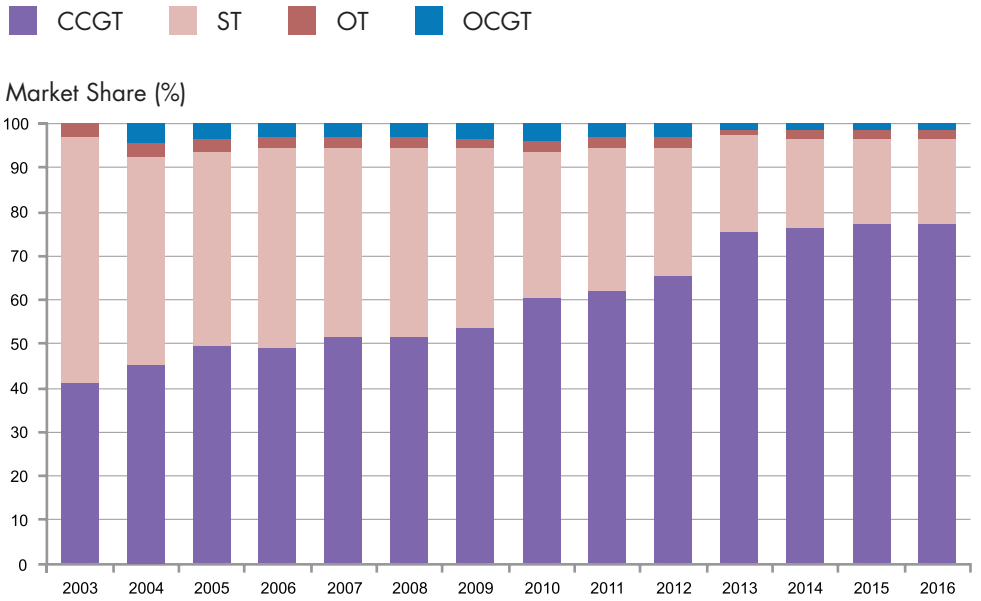
The highest USEP observed when the supply cushion was below 15 percent was $1,252.59/MWh in 2016, a slight decrease from $1,328.06/MWh in 2015. The highest USEP observed when the supply cushion was 15 percent or above slipped from $1,231.40/MWh in 2015 to $1,053.62/MWh in 2016.

Chart 4: Market Share Based on Metered Energy Quantity by Generation Type



Charts 4 and 5 present the yearly market shares by generation types based on metered energy quantity and maximum capacity respectively. Based on metered energy quantity, the market shares of the four generation types saw minimal changes in 2016. The market share of CCGT units rose 0.1 percentage point to 98.1 percent, and that of OT units decreased 0.2 percentage point to 1.9 percent in 2016.

Chart 5: Market Share Based on Maximum Capacity by Generation Type



Based on maximum capacity, the market share of CCGT units grew 0.4 percentage point to 77.5 percent and that of ST units shrank 0.4 percentage point to 19.2 percent in 2016. The market shares of OT and OCGT units remained relatively constant in 2016.

Chart 6: Market Share Based on Metered Energy Quantity by Generation Company

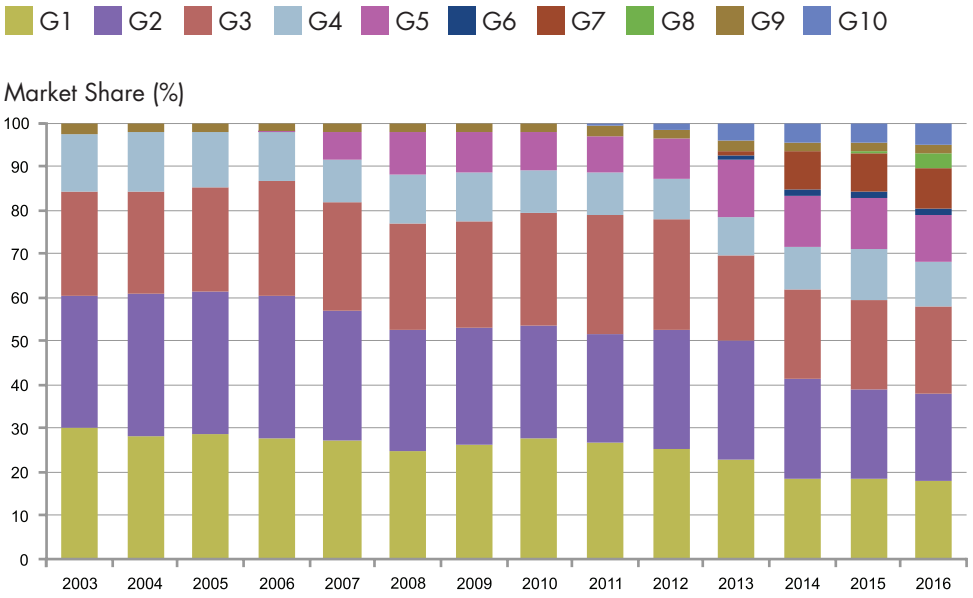
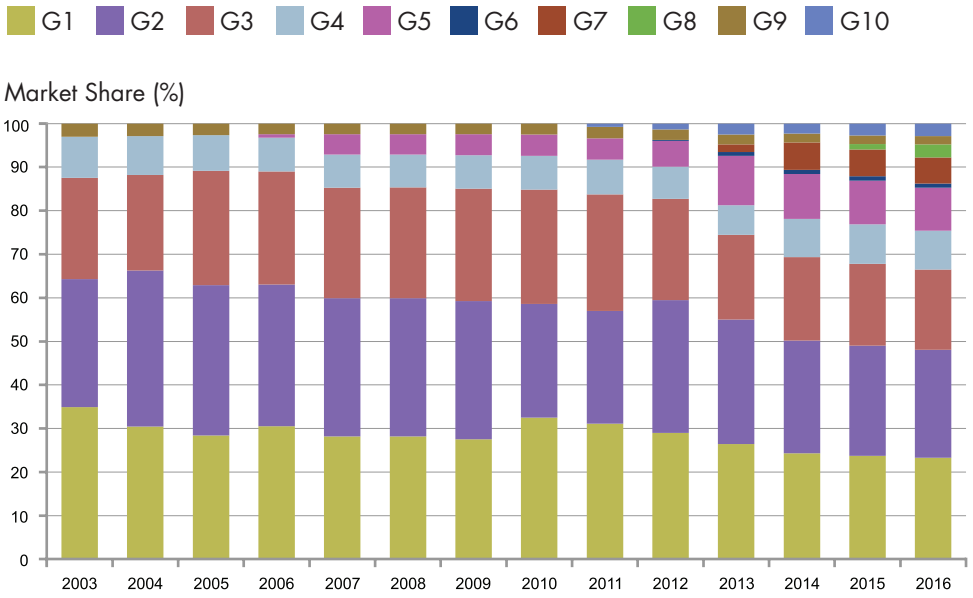


Chart 7: Market Share Based on Maximum Capacity by Generation Company



Charts 6 and 7 show the yearly market shares[5] of all generation companies based on metered energy quantity and maximum capacity respectively.

Embedded generators held 4.7 percent of the market share based on metered energy quantity and 2.8 percent of the market share based on maximum capacity.

The combined market share of the three largest generation companies based on metered energy quantity declined 1.4 percentage points, from 59.2 percent in 2015 to 57.8 percent in 2016.

[5] The yearly market shares exclude generators operating below 10MW.

Table 3 provides an overview of the outage levels by generation type and year. Total outages per period increased 17.5 percent from 944MW in 2015 to 1,109MW in 2016. This outage level translated to 8.3 percent of the total installed capacity. The rise in total outages was mainly led by a higher level of anticipated outages of CCGT units.

Average forced outages rose as well, from 24MW per period in 2015 to 35MW per period in 2016.

Chart 8 shows the yearly percentage breakdown of the three types of plant outages. In 2016, planned outages accounted for 96.8 percent of total outages, while forced outages formed 3.2 percent. This was in contrast to 2015, when planned and forced outages made up 97.4 percent and 2.6 percent respectively.

Chart 8: Composition of Total Plant Outages

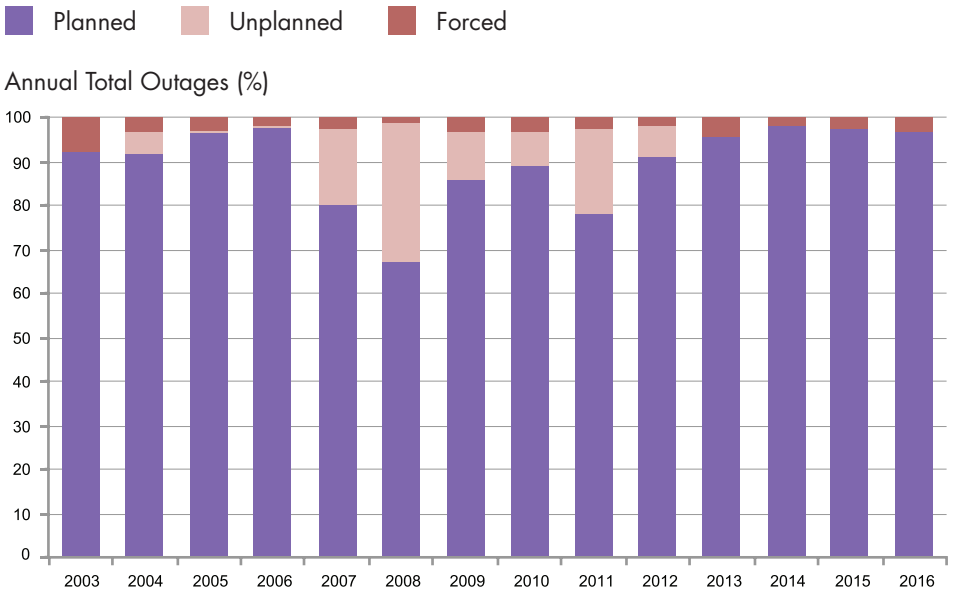


Table 3: Average Outages by Generation Type and Technology in MW (per period)

	Anticipated Outages (MW)								Forced Outages (MW)				Total Outages (MW)
	Planned Outages				Unplanned Outages								
Year	ST	CCGT	OCGT	OT	ST	CCGT	OCGT	OT	ST	CCGT	OCGT	OT	
2003	425	167	5	30	0	0	0	0	4	45	0	1	677
2004	982	204	14	3	64	2	2	0	2	37	0	0	1,309
2005	915	363	22	26	0	1	1	0	7	35	0	0	1,370
2006	854	283	51	17	0	2	1	0	4	21	1	0	1,234
2007	761	348	28	32	159	94	1	7	6	27	0	0	1,464
2008	439	236	1	6	298	26	0	2	2	10	0	0	1,020
2009	826	250	2	13	108	29	0	2	20	7	10	1	1,266
2010	312	391	38	45	22	40	2	1	5	24	0	0	880
2011	387	281	7	10	85	87	1	0	7	11	1	0	878
2012	392	436	5	36	21	51	0	0	1	12	1	0	956
2013	335	483	3	4	0	0	0	0	3	35	0	0	863
2014	316	536	3	17	0	0	0	0	0	18	0	0	890
2015	206	701	1	11	0	0	0	0	0	24	0	0	944
2016	169	864	3	38	0	0	0	0	0	35	0	0	1,109

Chart 9: Average Quarterly Anticipated Outages vs Average USEP

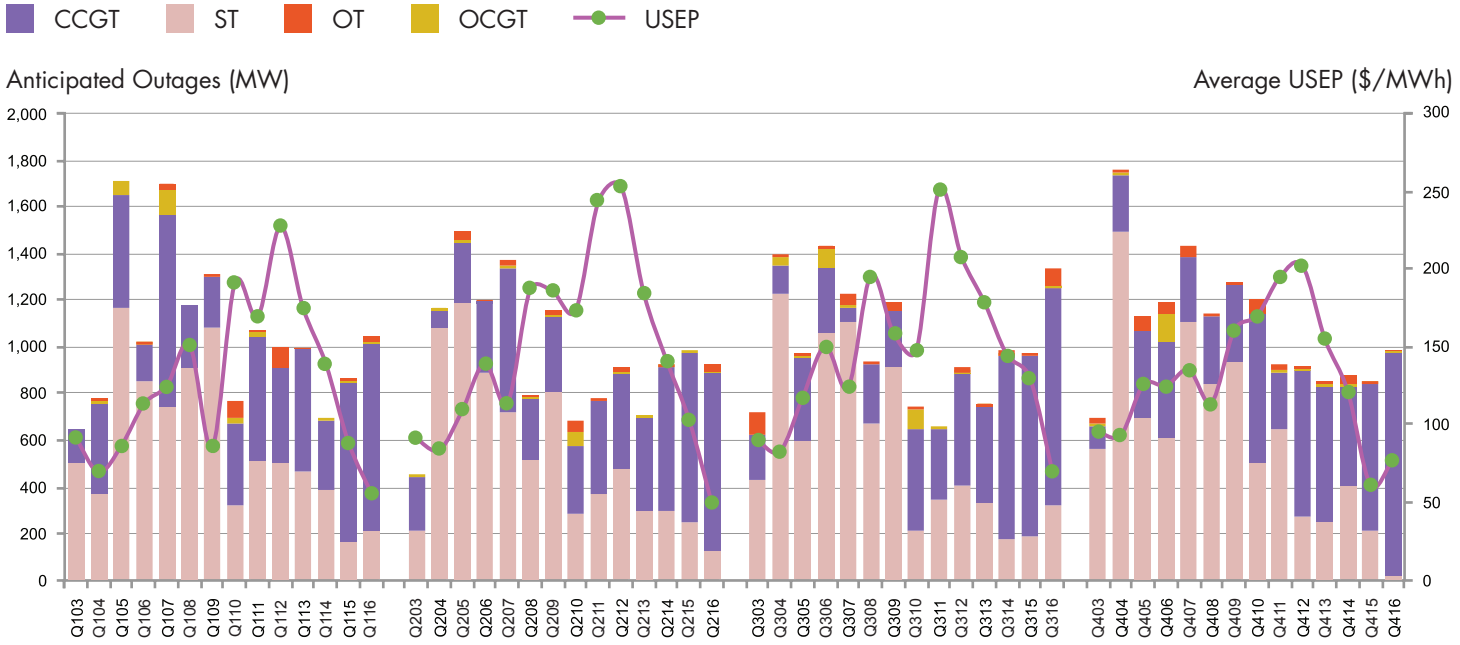


Chart 9 compares the average anticipated outages[6] with the average USEP on a quarterly basis.

Intuitively, a higher level of anticipated outages coincides with a higher USEP because the former leads to a contraction in supply. The average level of anticipated outages for Q2 2016 was 5.0 percent lower than that for Q2 2015; the average USEP for Q2 2016 was 52.0 percent lower than that for Q2 2015.

This relationship was also seen in Q4 2016. The average level of anticipated outages for Q4 2016 was 15.2 percent higher than that for Q4 2015; the average USEP for Q4 2016 was 26.6 percent higher than that for Q4 2015.

Even though the average level of anticipated outages for Q1 2016 was 20.4 percent higher than that for Q1 2015, the average USEP for Q1 2016 was 36.5 percent lower than that for Q1 2015. The lower average USEP was primarily driven by the lower fuel oil price, which fell 47.8 percent from US$186.57/bbl in Q1 2015 to US$97.48/bbl in Q1 2016.

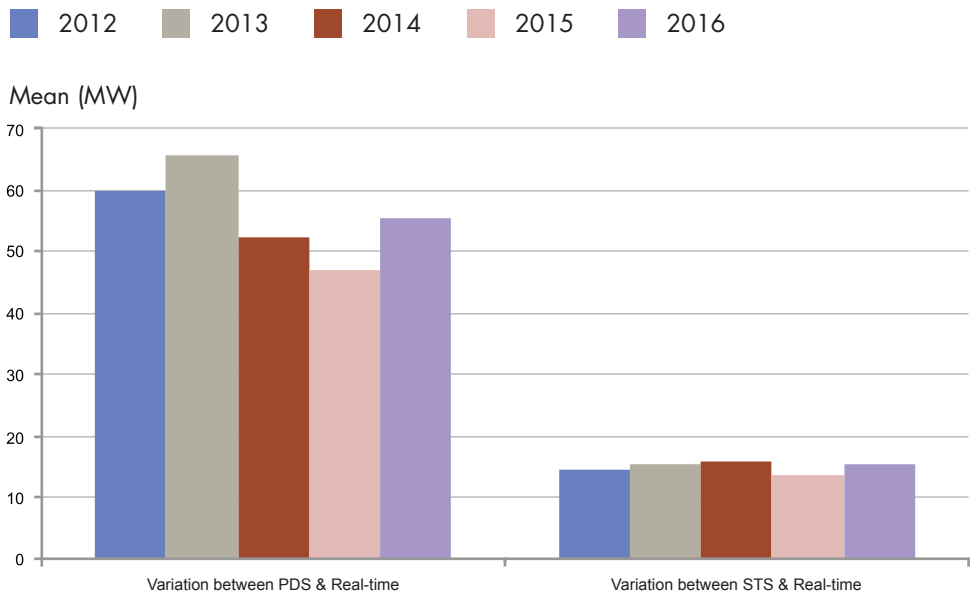
For Q3 2016, the average level of anticipated outages was 37.4 percent higher than that for Q3 2015, but the average USEP was 46.9 percent lower than that for Q3 2015. One of the reasons was the lower fuel oil price observed in Q3 2016, which was down by 6.9 percent. The multiple periods of high USEP in July 2015 also contributed to the difference in average USEP for Q3 2016 and Q3 2015.

[6] Anticipated outages refer to the sum of planned and unplanned outages. From 1 June 2012, the category of "unplanned outages" was removed. Outages previously classified under unplanned were subsumed under planned or forced outages, depending on the time and duration of occurrence.

Table 4: Variation in Load Forecasts

Year 2016				
	Variation between PDS & Real-time		Variation between STS & Real-time	
Month	Mean (in MW)	Standard Deviation (in MW)	Mean (in MW)	Standard Deviation (in MW)
Jan	50.43	39.97	14.13	11.27
Feb	77.75	50.95	21.47	13.94
Mar	23.18	20.91	6.56	6.04
Apr	33.92	25.37	9.56	7.24
May	43.69	28.85	12.21	7.95
Jun	95.50	56.55	26.76	15.87
Jul	95.74	59.83	26.60	16.78
Aug	59.61	41.34	16.54	11.76
Sep	47.55	29.95	13.45	8.32
Oct	52.42	40.69	14.79	11.28
Nov	30.94	23.01	8.73	6.60
Dec	56.74	40.03	15.82	11.13
Average	55.62	38.12	15.55	10.68

Chart 10: Average Mean Variation between PDS and Real-time Load Forecast



In the NEMS, three forecast schedules with different time horizons are made available to market participants (MPs). The accuracy of forecast schedules is important for the efficient operation of the market, as it determines how well generation facilities can respond to real-time demand conditions.

Table 4 shows the accuracy of the load forecast as measured by the mean and standard deviation of the variations between forecast schedules with different time horizons. The variation between the Pre-Dispatch Schedule (PDS) forecast and real-time load forecast was 3.6 times as large as the variation between the Short Term Schedule (STS) forecast and real-time load forecast. PDS forecasts tend to be less accurate than STS forecasts – PDS forecasts are updated every two hours, with a forecast horizon of between 12 to 36 hours, compared to STS forecasts which are updated every half hour, with a forecast horizon of up to six hours.

In Chart 10, the average difference between PDS forecast and real-time load forecast in 2016 was 18.1 percent greater than that in 2015. The average difference between STS forecast and real-time load forecast increased 14.0 percent in 2016.

The accuracy of the load forecast used in generating real-time dispatch and pricing schedules is important for efficient pricing outcomes and system stability.

A small variation between real-time load forecast and actual demand (metered energy quantity) is expected. There are a number of factors contributing to this variation. For example, the real-time load forecast contains the station load and auxiliary load consumption, while the metered energy quantity which is based on settlement data furnished by the Market Support Services Licensee (MSSL) omits these components. Other factors include loss factors and metering errors.

The accuracy of the real-time load forecast improved in 2016. As seen in Table 5, the average load forecast error reduced 0.04 percentage point to 2.7 percent.

Table 5: Percentage of Variation in Real-time Load Forecast

Month	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Jan	4.29	3.93	3.46	3.18	3.24	2.73	3.00	3.46	3.23	2.57
Feb	4.52	4.01	3.48	3.74	2.93	2.82	2.83	3.28	3.19	3.05
Mar	4.25	3.77	3.40	3.64	2.95	2.93	2.75	3.00	2.97	2.65
Apr	4.40	3.97	3.50	3.74	3.13	3.01	2.34	3.20	2.67	2.52
May	4.20	3.89	3.41	3.83	1.96	2.76	2.77	3.27	2.76	2.64
Jun	4.11	3.76	3.93	3.15	2.65	2.61	3.00	3.10	2.67	2.92
Jul	4.05	3.96	3.45	3.17	3.36	2.75	3.04	3.30	2.40	2.71
Aug	3.94	3.68	3.54	3.54	3.14	2.86	2.90	3.70	2.63	2.31
Sep	3.94	3.70	3.34	3.42	3.20	2.93	3.24	3.29	2.58	2.89
Oct	4.21	3.74	3.54	3.56	3.01	2.81	3.28	3.26	2.60	2.88
Nov	3.88	3.40	3.28	3.62	2.94	3.05	3.23	3.82	2.57	2.71
Dec	3.74	3.60	3.24	3.64	2.88	3.17	3.46	3.35	2.62	2.49
Average	4.13	3.78	3.46	3.52	2.95	2.87	2.99	3.34	2.74	2.70

Chart 11: Monthly Volume-weighted Average VCHP vs WEP

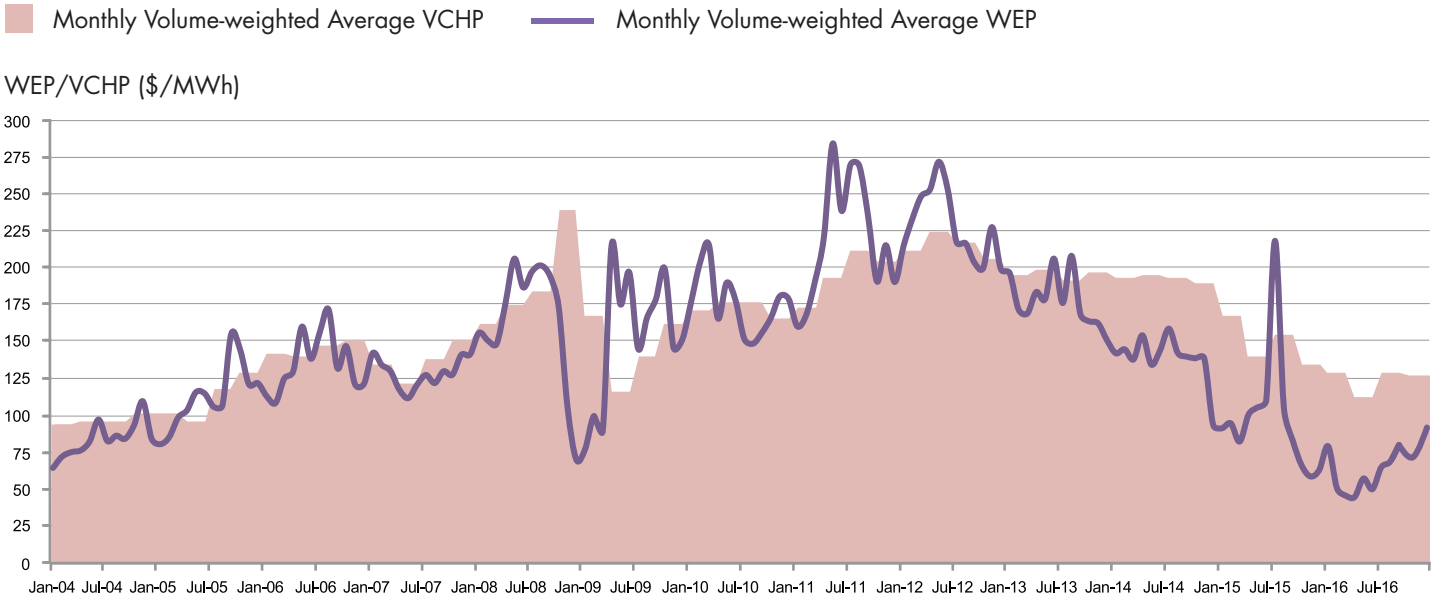


Chart 11 tracks the movements of the volume-weighted averages of the Wholesale Electricity Price (WEP) and Vesting Contract Hedge Price[7](VCHP). The average VCHP fell 17.0 percent from $149.04/MWh in 2015 to $123.69/MWh in 2016.

In 2016, the volume-weighted average WEP was 47.5 percent lower than the volume-weighted average VCHP. The volume-weighted average WEP decreased 34.2 percent from $98.67/MWh in 2015 to $64.93/MWh in 2016.

[7] The volume-weighted VCHP takes into account the LNG, balance and tendered vesting prices after considering volume adjustment.

Chart 12: Comparisons of Actual Demand

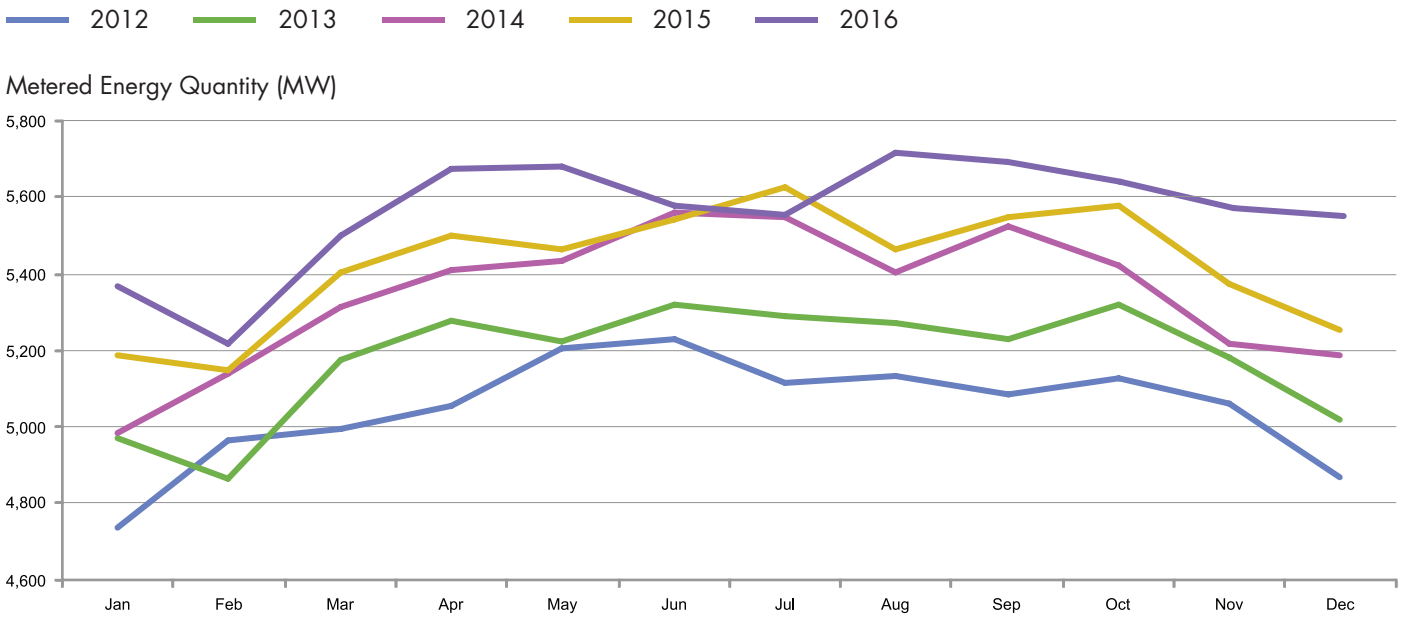


Chart 12 compares the actual demand (computed from the metered energy quantity) from 2012 to 2016. Apart from July, all other months in 2016 displayed a higher demand than in 2015. In 2016, the average demand grew 2.6 percent from the year before.

The average system demand for the year was 5,563MW. The peak average monthly system demand was 5,719MW in August 2016. Both figures are the highest since the market was established in 2003.

Table 6: Monthly Average Correlation Coefficient of WEP and Metered Energy Quantity

	2015			2016		
Month	Correlation Coefficient, r	r^2	Number of days with r > 0.5	Correlation Coefficient, r	r^2	Number of days with r > 0.5
Jan	0.46	0.21	16	0.72	0.52	28
Feb	0.31	0.10	9	0.63	0.39	21
Mar	0.46	0.21	16	0.57	0.32	22
Apr	0.54	0.29	23	0.66	0.44	25
May	0.45	0.20	16	0.57	0.32	20
Jun	0.34	0.11	10	0.55	0.30	20
Jul	0.72	0.52	30	0.49	0.24	16
Aug	0.54	0.29	22	0.40	0.16	13
Sep	0.67	0.45	26	0.53	0.28	20
Oct	0.62	0.38	21	0.53	0.28	18
Nov	0.73	0.53	26	0.52	0.27	20
Dec	0.65	0.42	24	0.56	0.32	17
Average	0.54	0.31	239	0.56	0.32	240

The correlation coefficient r in Table 6 measures the strength of the relationship between the WEP and metered energy quantity. A positive correlation indicates that as demand increases, energy price follows and vice versa. The square of the correlation coefficient r^2 can be interpreted as the proportion of variance in prices which can be explained by variations in demand.

In 2016, the highest r value of 0.72 was observed in January and there were 240 days when r was greater than 0.5. The statistics were similar to those in 2015, when the highest r value was 0.73 and there were 239 days when r was greater than 0.5.

Chart 13: Correlation between WEP & Metered Energy Quantity in 2016

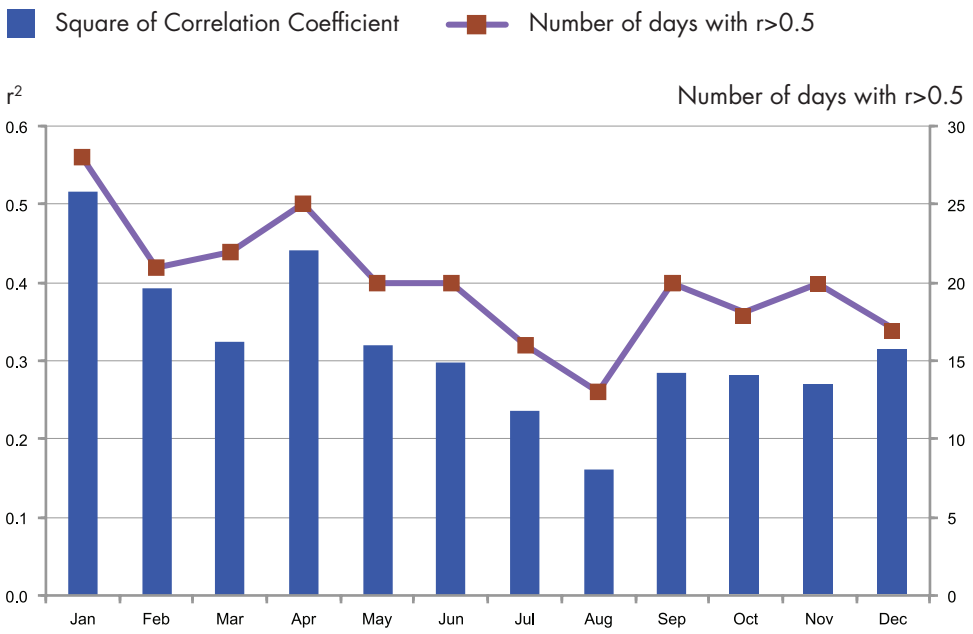


Chart 13 illustrates the correlation between the WEP and metered energy quantity in 2016. The highest r^2 value during the year was recorded at 0.52 in January, during which there were 28 days when r was greater than 0.5. The lowest r^2 value of 0.16 occurred in August, when there were 13 days with r greater than 0.5.

Chart 14: Correlation between WEP & Metered Energy Quantity

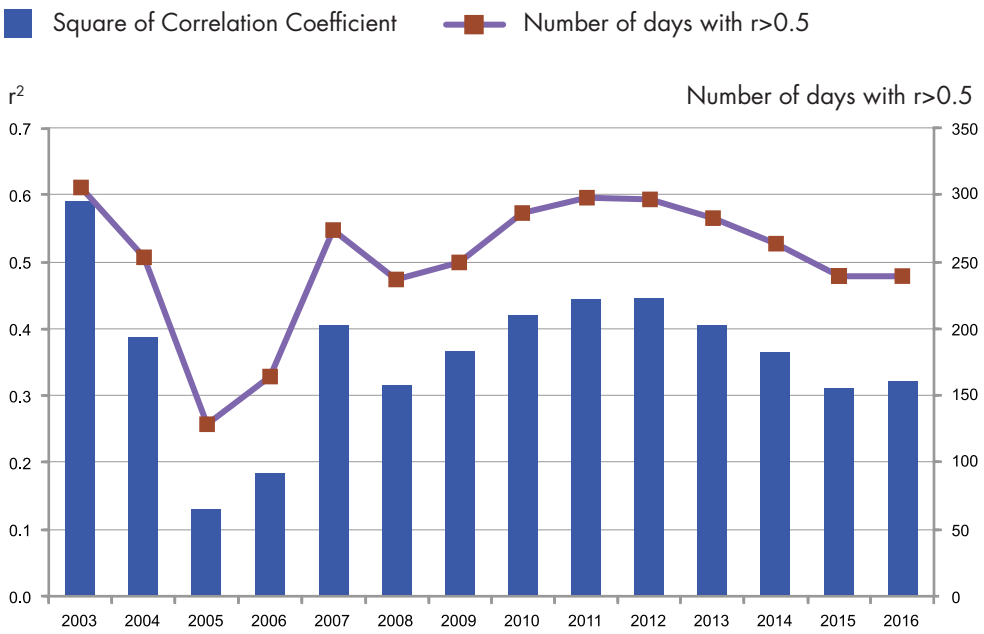


Chart 14 shows the correlation between the WEP and metered energy quantity between 2003 and 2016. Except for the steep decline and subsequent increase between 2004 and 2007, there was no major fluctuation in either index.

Since 2011, the square of the correlation coefficient and the number of days with r greater than 0.5 have been decreasing, implying that non-demand factors have a growing influence on energy prices. The changes observed in 2016 were minimal – as shown in Table 6, the square of the correlation coefficient increased by 0.01 and the number of days with r greater than 0.5 increased by one.

Chart 15: Percentage of Hours When WEP Falls Into a Particular Price Range

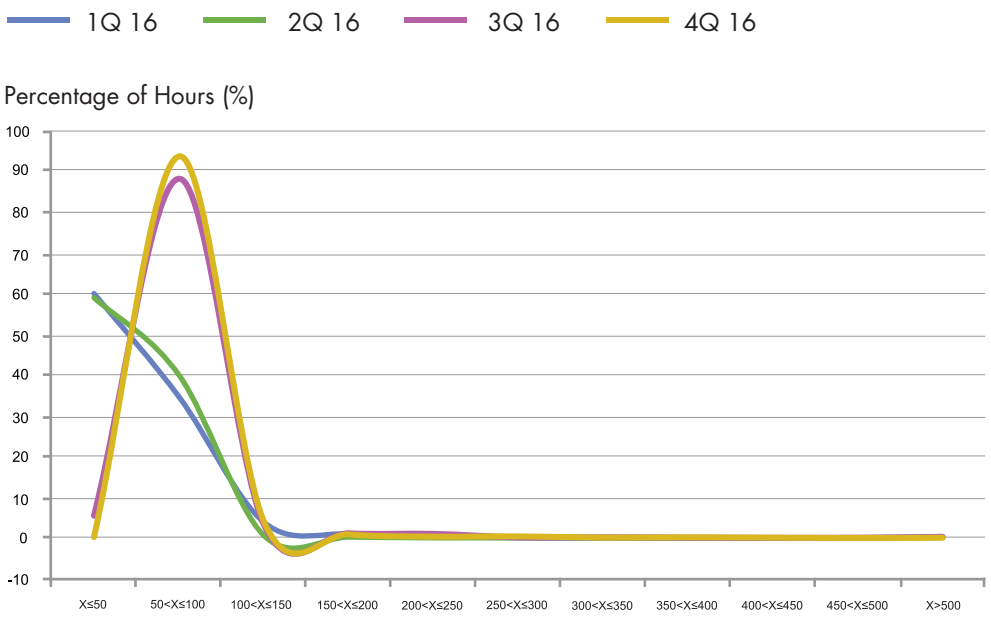


Chart 15 illustrates the distribution of the WEP based on percentage of hours of occurrence in 2016. Prices for the first and second quarters settled below $50/MWh more than half of the time, while prices for the third and fourth quarters mostly settled in the $50/MWh to $100/MWh tranche.

Chart 16: Percentage of Energy Quantity When WEP Falls Into a Particular Price Range

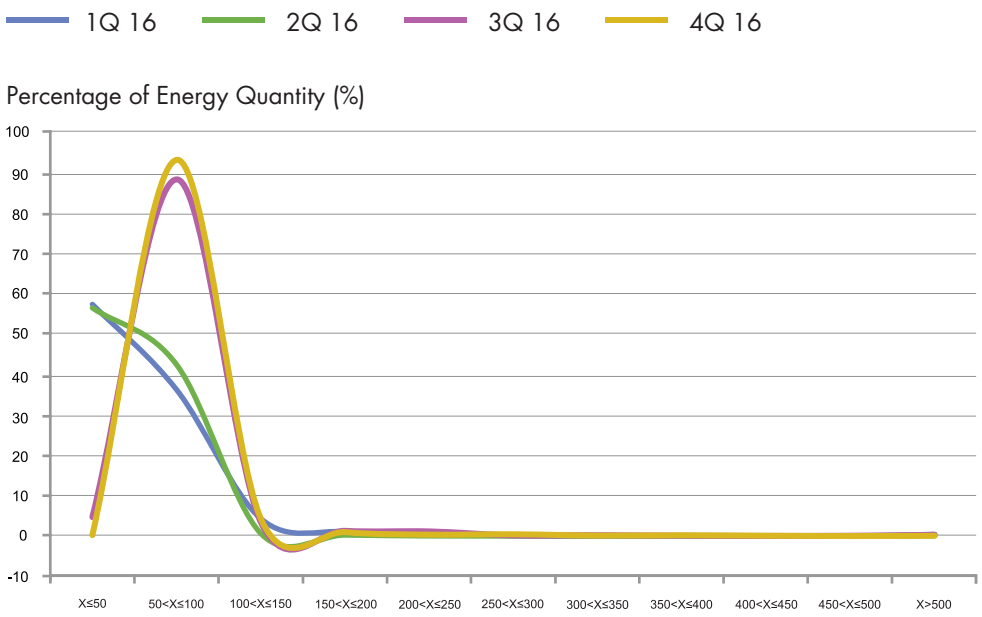


Chart 16 illustrates the distribution of the WEP based on percentage of energy quantity. The distribution is similar to that of the WEP by percentage of hours of occurrence (Chart 15).

Chart 17: Percentage of Hours When WEP Falls Into a Particular Price Range

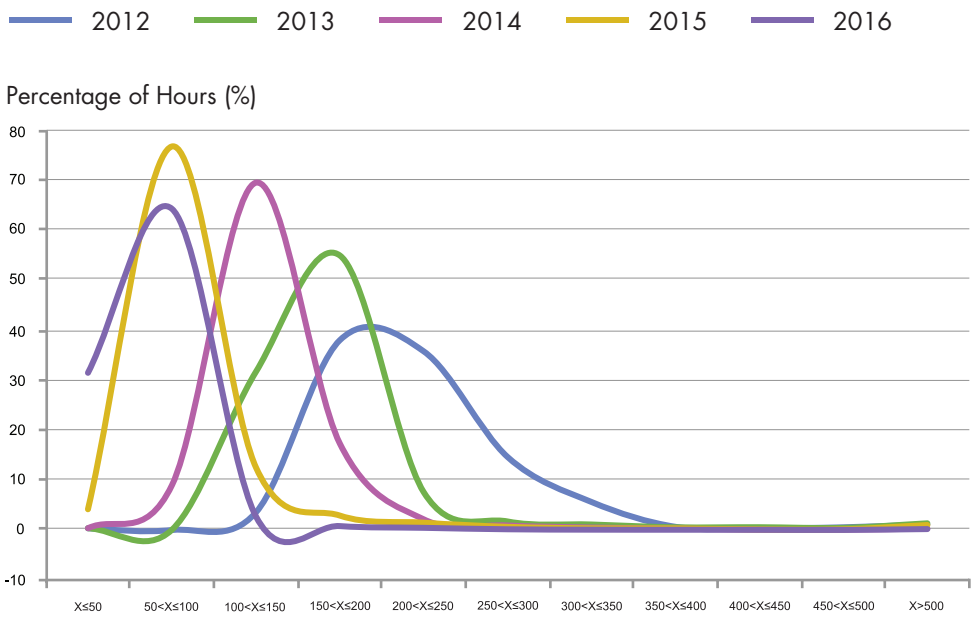


Chart 17 juxtaposes the historical price distribution curves with the price distribution curve of 2016, allowing us to examine longer-term trends. From 2012 to 2015, the percentage of hours of WEP distribution gradually shifted to a lower price range. In 2016, the WEP reached the lowest level of the past five years, settling slightly above $60/MWh.

Chart 18: Percentage of Energy Quantity When WEP Falls Into a Particular Price Range

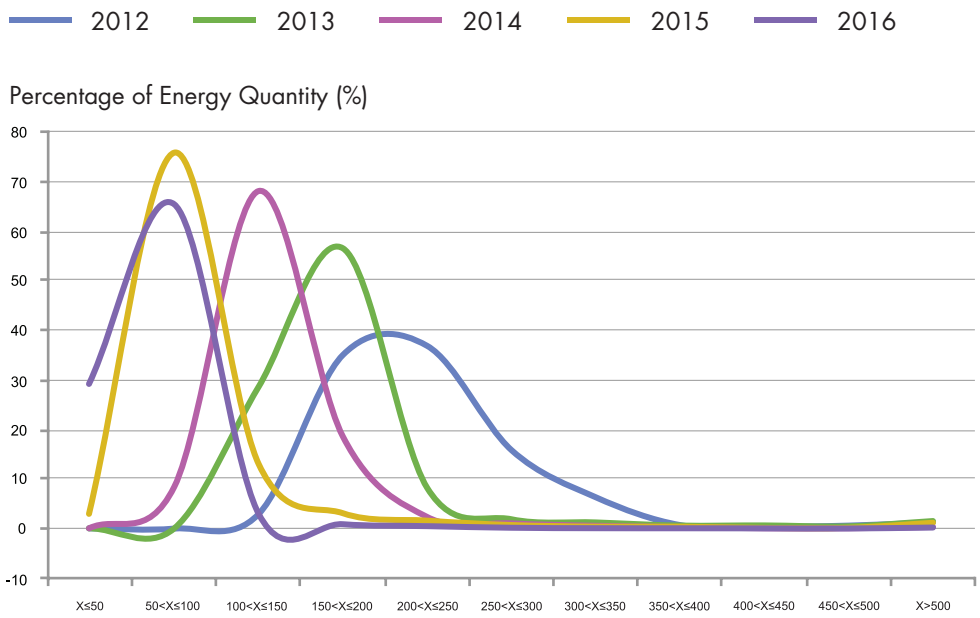


Chart 18 shows the long-term trend in the distribution of the WEP from 2012 to 2016 based on percentage of energy quantity, permitting the same observations as Chart 17.

Chart 19: Index of VCHP, WEP, Fuel Oil (180-CST HSFO), Electricity Tariff

Chart 19 shows the correlation between the high sulphur fuel oil (180-CST HSFO) price, the VCHP, the WEP and electricity tariff. In 2016, the fuel oil price traded at an average of US$38.19/bbl, a drop of 19.8 percent from 2015. This is the lowest level since 2005. The WEP declined by 33.6 percent to reach $63.69/MWh in 2016, recording the lowest price since the market started. The peak monthly average WEP of $88.53/MWh was recorded in December 2016.

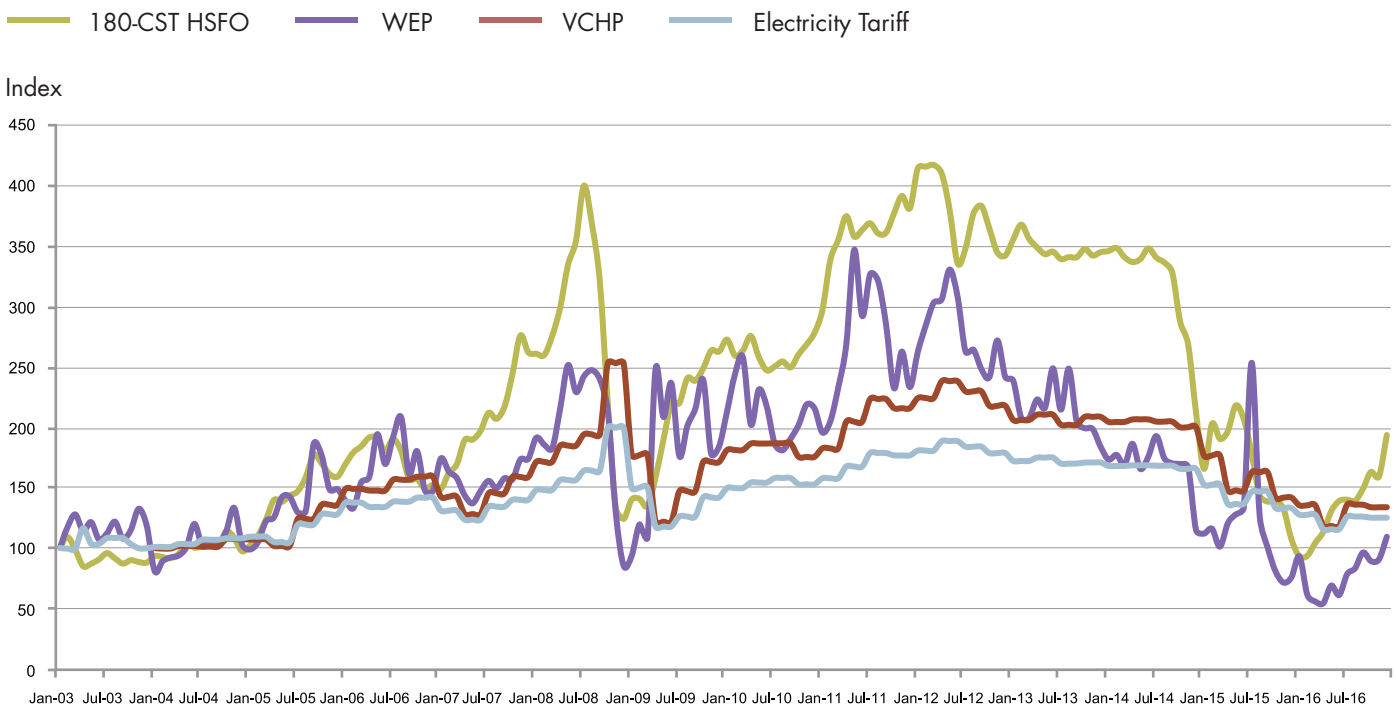
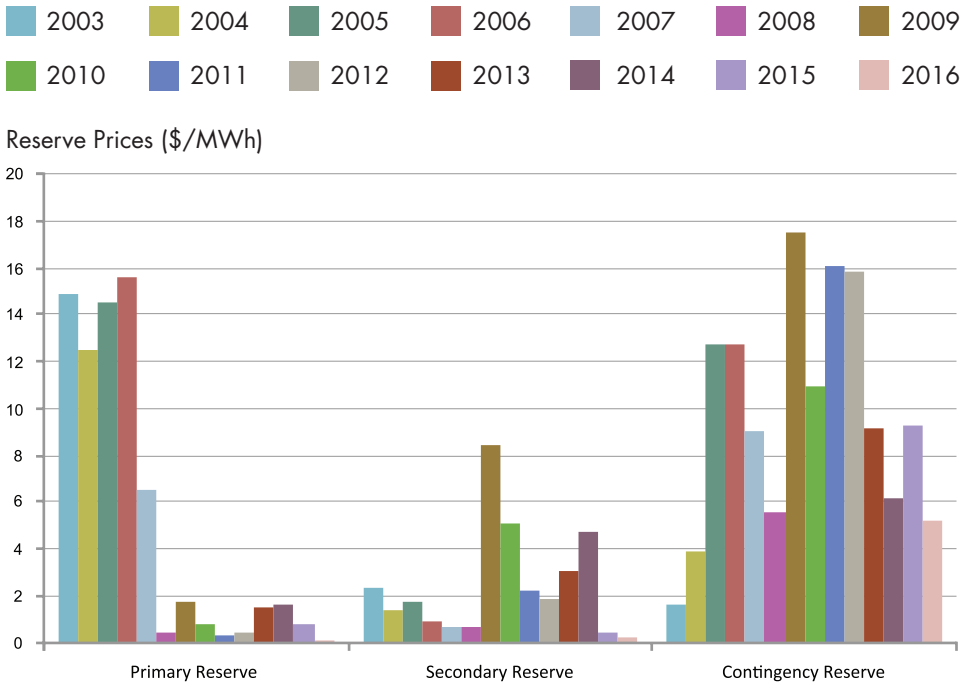
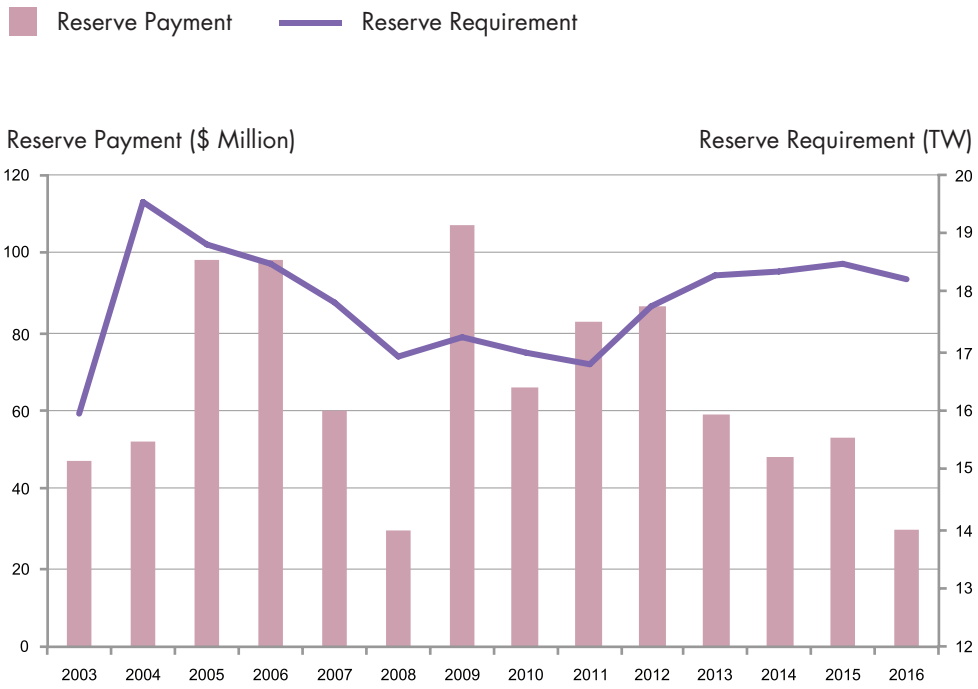


Chart 20: Average Reserve Prices



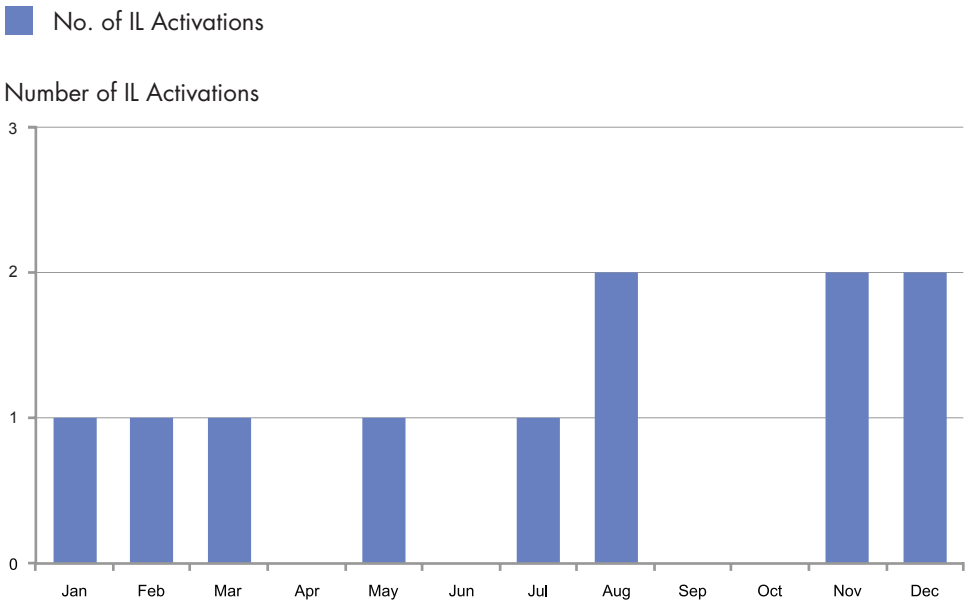
From Chart 20, it can be seen that the average price for primary, secondary and contingency reserves decreased by 83.2 percent, 36.1 percent and 42.9 percent in 2016 to reach $0.13/MWh, $0.26/MWh and $5.27/MWh respectively. The average prices for both primary and secondary reserves recorded the lowest levels since the market started.

Chart 21: Annual Reserve Payment and Requirement



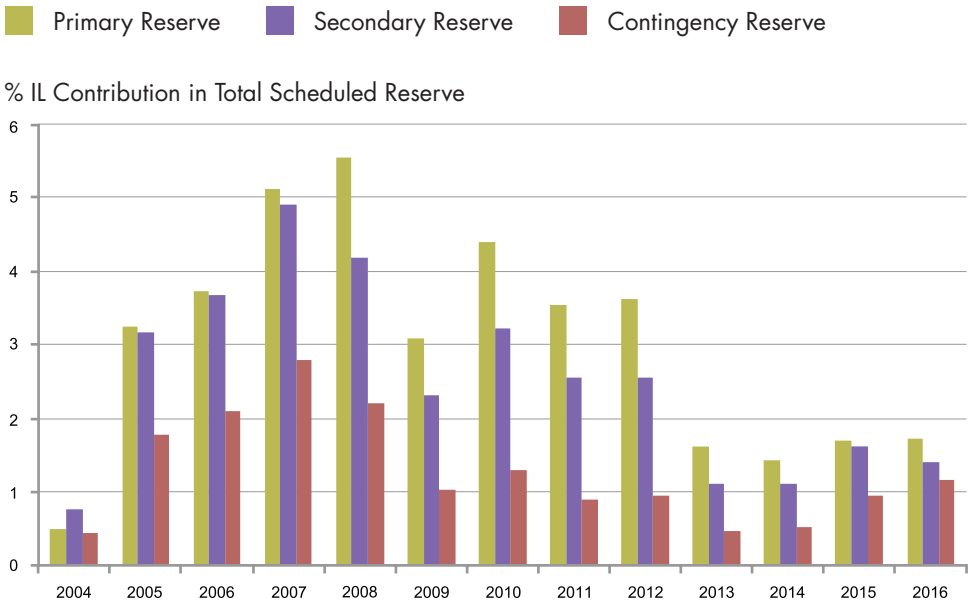
The total reserve payment decreased 44.4 percent from $52.8 million in 2015 to $29.3 million in 2016, as seen in Chart 21. This is the lowest level since the market started.

Chart 22: Number of IL Activations in 2016



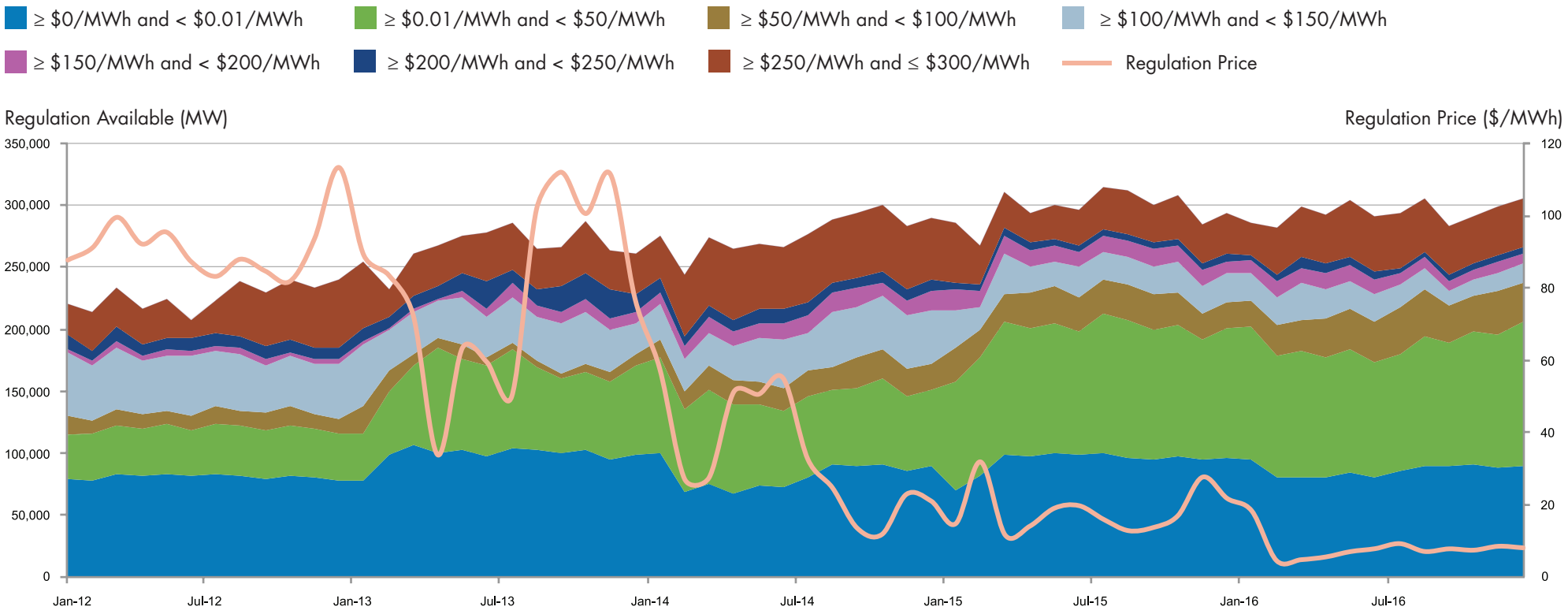
From Chart 22, it can be seen that in 2016, Interruptible Load (IL) was activated on 11 occasions to provide reserve, compared to six occasions in 2015. IL was activated on two occasions each for the months of August, November and December, and one occasion each in January, February, March, May and July.

Chart 23: Total Percentage Contribution from IL in Three Classes of Scheduled Reserve



With the rise in IL activations, the percentage contributions from IL in the primary and contingency reserve classes in 2016 were higher than that in 2015, as seen in Chart 23. There was a slight drop in the percentage contribution from IL in secondary reserve.

Chart 24: Regulation Availability vs Regulation Price



The average regulation price decreased 55.8 percent from $18.23/MWh in 2015 to $8.06/MWh in 2016. This was the lowest yearly regulation price since the market started. The 2016 peak monthly regulation price of $18.29/MWh was observed in January.

Chart 24 shows the regulation offer patterns in various offer tranches. The biggest change can be observed in the "≥$250/MWh and ≤$300/MWh" offer tranche, where the proportion of offers increased by 2.7 percentage points to reach 13.5 percent in 2016. The biggest decrease of 2.2 percentage points can be observed in the "≥$0/MWh and <$0.01/MWh" offer tranche.

ECONOMETRIC MODEL AND OUTLIER PRICES

In 2007, the Market Surveillance and Compliance Panel (MSCP) started using an econometric model to identify and analyse high price incidents[8]. The model provides a means of estimating the average Uniform Singapore Energy Price (USEP) through the use of independent variables, including the Combined Cycle Gas Turbine (CCGT) supply, Steam Turbine (ST) supply, energy supply cushion, offers lower than $100/MWh, energy demand, reserve cushion and lagging fuel oil prices. The model is also adjusted to differentiate planned outages from generation companies with different portfolios, and forced outages by month, day-of-week, and year via the use of dummy variables.

As part of the effort to review and enhance the model, following the publication of the 2008 MSCP Annual Report, the issue of multicollinearity between variables within the model was tackled. While multicollinearity does not affect the predictive and detection powers of the model, it may misrepresent the explanatory power of the variables in the model. In particular, the coefficients of the independent variables may be distorted to some degree. In addition, some variables may be statistically insignificant.

To reduce multicollinearity in the model, stepwise regression was used. Stepwise regression is a statistical technique in which variables are added to a model in a forward selection or backward elimination procedure to determine their contribution to the regression model. The statistical significance of the variable is measured by its additional contribution to the residual sum of squares (RSS). If the RSS is not improved significantly by the addition of a variable, the variable is left out of the final model.

By employing stepwise regression, it was found that selecting three variables would create a model with an R-squared value of 84 percent. The three variables selected were: lagged fuel oil price, supply cushion and CCGT supply.

[8] Details of the model and its methodology can be found in the paper, "How Market Fundamental Factors Affect Energy Prices in the NEMS — An Econometric Model", available on www.emcsg.com.

Table 7: Estimation Results – January 2003 to December 2016

Variable	Coefficient	P-value
Constant	7.98	0.08
LOG (Lagged Fuel Oil Price)	0.87	0.01
LOG (Supply Cushion)	-0.77	0.02
LOG (CCGT Supply)	-0.49	0.01
Model Diagnostics		
R-squared	0.84	
Adjusted R-squared	0.84	
Number of observations	5,084	

Table 7 provides the following observations, which are in line with expectations:

- a one unit increase in the logarithm of the lagged fuel oil price will bring about a 0.87 unit increase in the logarithm of the USEP;
- a one unit increase in the logarithm of the supply cushion will bring about a 0.77 unit decrease in the logarithm of the USEP; and
- a one unit increase in the logarithm of the CCGT supply will bring about a 0.49 unit decrease in the logarithm of the USEP.

Chart 25: Actual vs Predicted LOG USEP Within Three Standard Error Bands

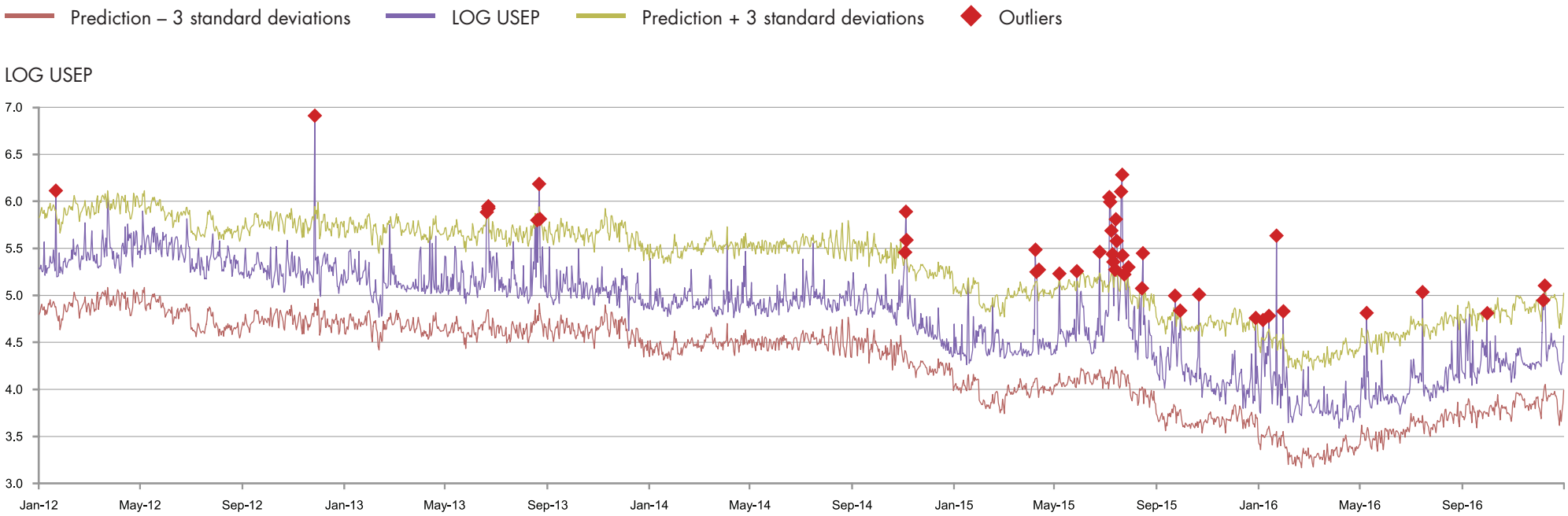
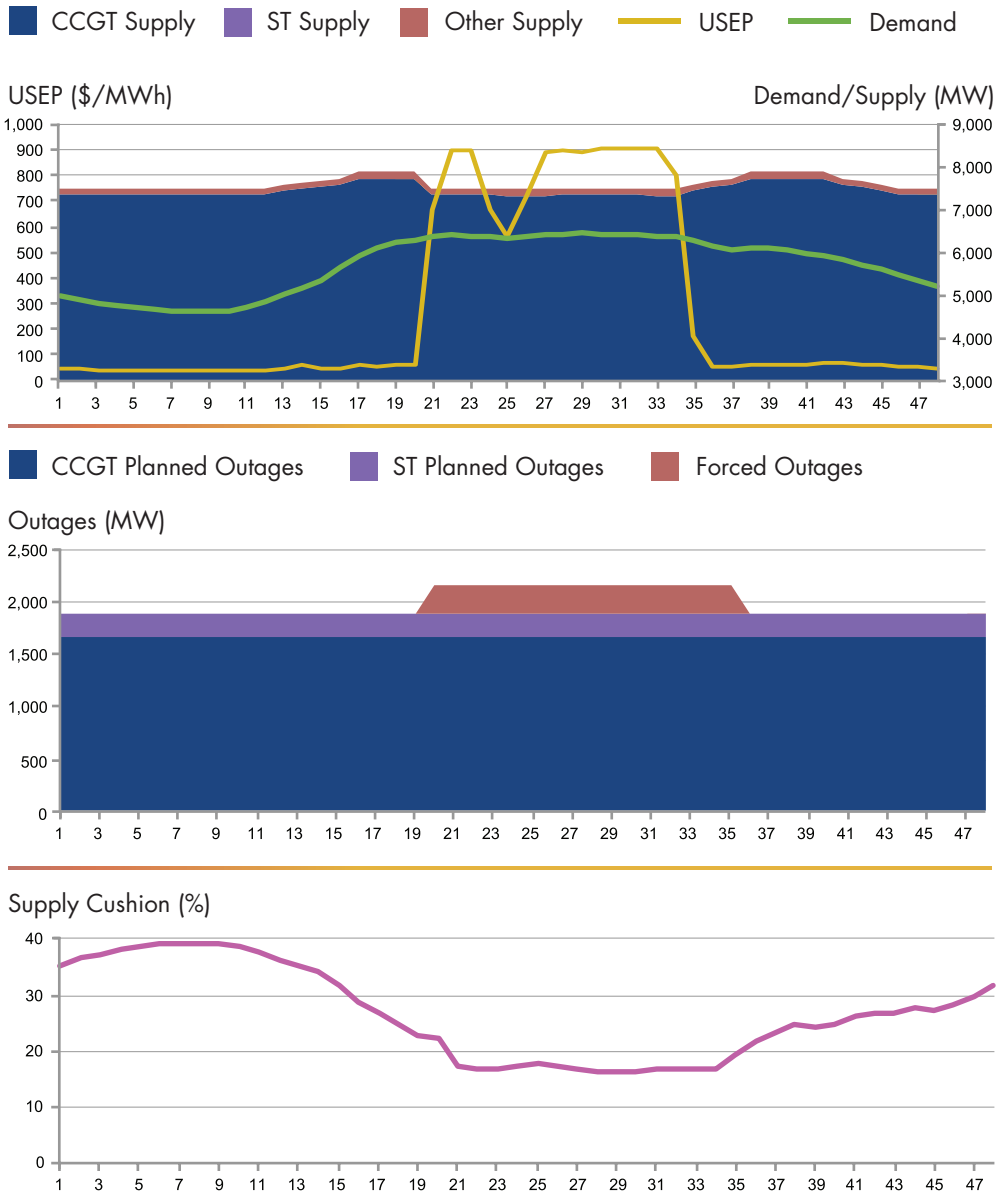


Chart 25 illustrates the actual daily average USEP, the upper and lower bands of the estimated USEP, and the outliers identified by the econometric model, from January 2012 to December 2016. In 2016, there were nine days in which outlier prices were detected by the model. Four of these days will be discussed in this report as the rest of the cases were small-scale recurrences of similar phenomena.

Chart 26: Demand and Supply Conditions — 22 January 2016



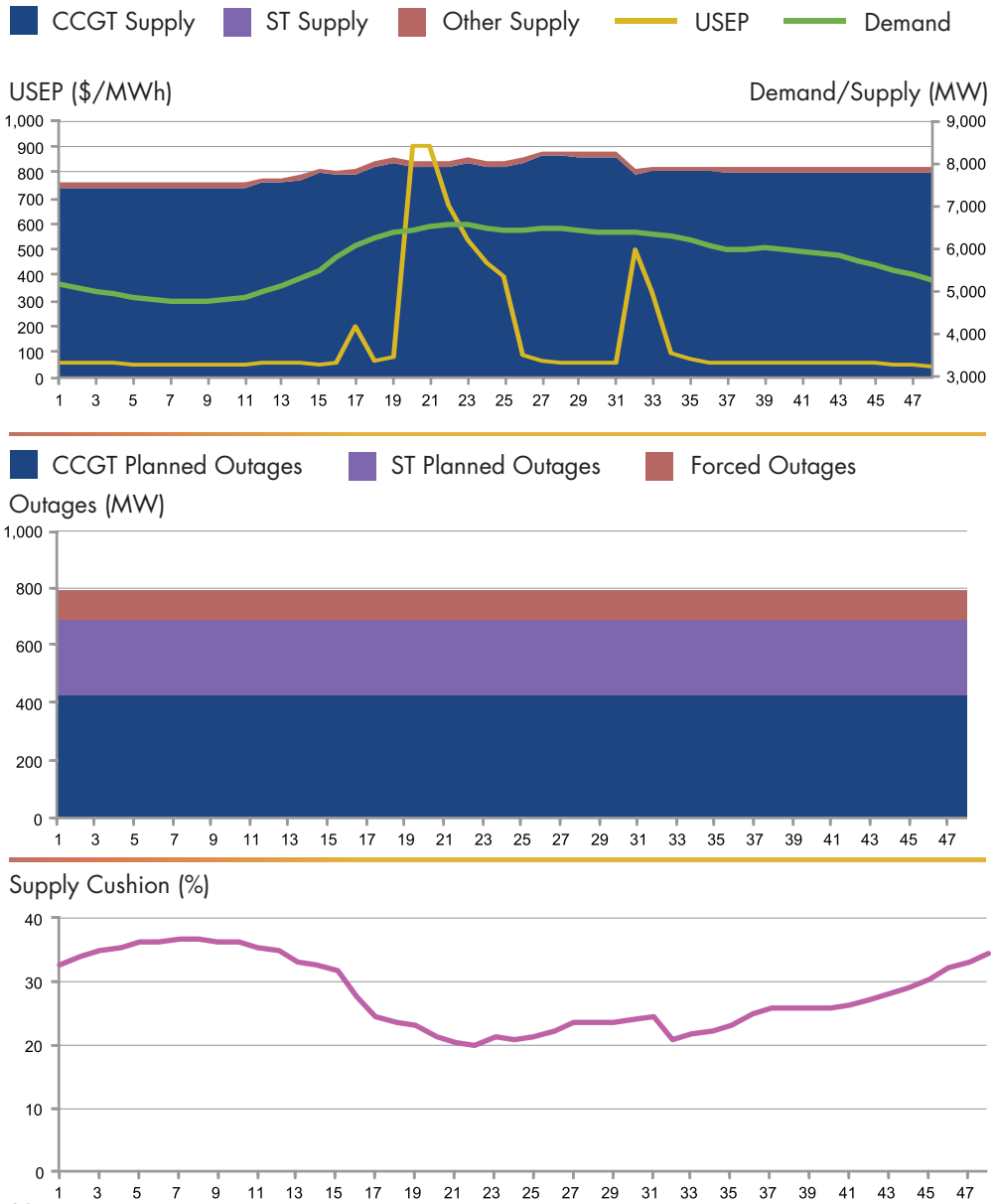
Date	Friday 22 Jan 2016	All Fridays in Jan 2016
Daily USEP ($/MWh)	279.21	101.67
Max USEP ($/MWh)	903.66	903.66
No. of USEP ≥ $1,000/MWh	0	0
Demand (MW)	5,706.02	5,529.05
Supply Cushion (in %)	26.48	28.82
Offers ≤ $100/MWh (in %)	75.86	75.49

Summary

On Friday, 22 January 2016, there were 14 periods during which the USEP rose above $400/MWh, reaching as high as $903.66/MWh.

The high prices were largely due to a lower supply cushion caused by high demand and a very high level of planned outage (1,991MW), with five CCGT units and one ST unit being taken out of the grid. An additional forced outage of 271MW of a CCGT unit during the affected periods exacerbated the situation, pushing the supply cushion even lower to 16.6 percent which resulted in the high prices for these periods.

Chart 27: Demand and Supply Conditions — 15 July 2016



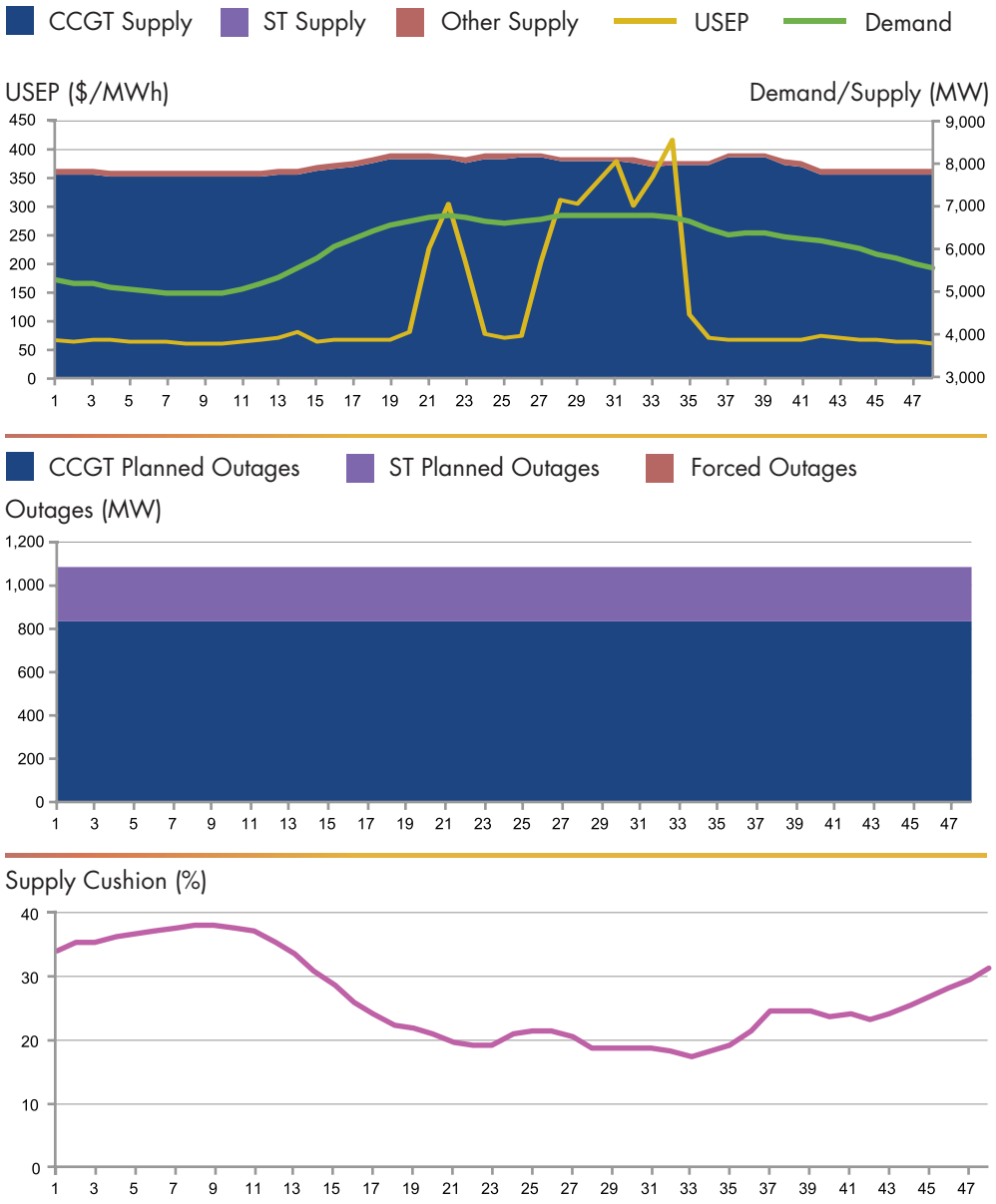
Date	Friday 15 Jul 2016	All Fridays in Jul 2016
Daily USEP ($/MWh)	153.60	88.58
Max USEP ($/MWh)	902.77	1,053.02
No. of USEP ≥ $1,000/MWh	0	2
Demand (MW)	5,811.54	5,847.94
Supply Cushion (in %)	28.04	29.35
Offers ≤ $100/MWh (in %)	74.84	74.65

Summary

On Friday, 15 July 2016, the USEP went above $400/MWh for six periods, hitting $902.77/MWh at its peak.

The high prices were mainly due to a lower supply cushion caused by a contracted total supply resulting from a planned outage of 815MW and a forced outage of 109MW. During the periods of high USEP, the supply cushion averaged 20.8 percent, providing upward price pressure for these affected periods, which in turn brought up the daily USEP.

Chart 28: Demand and Supply Conditions — 30 September 2016



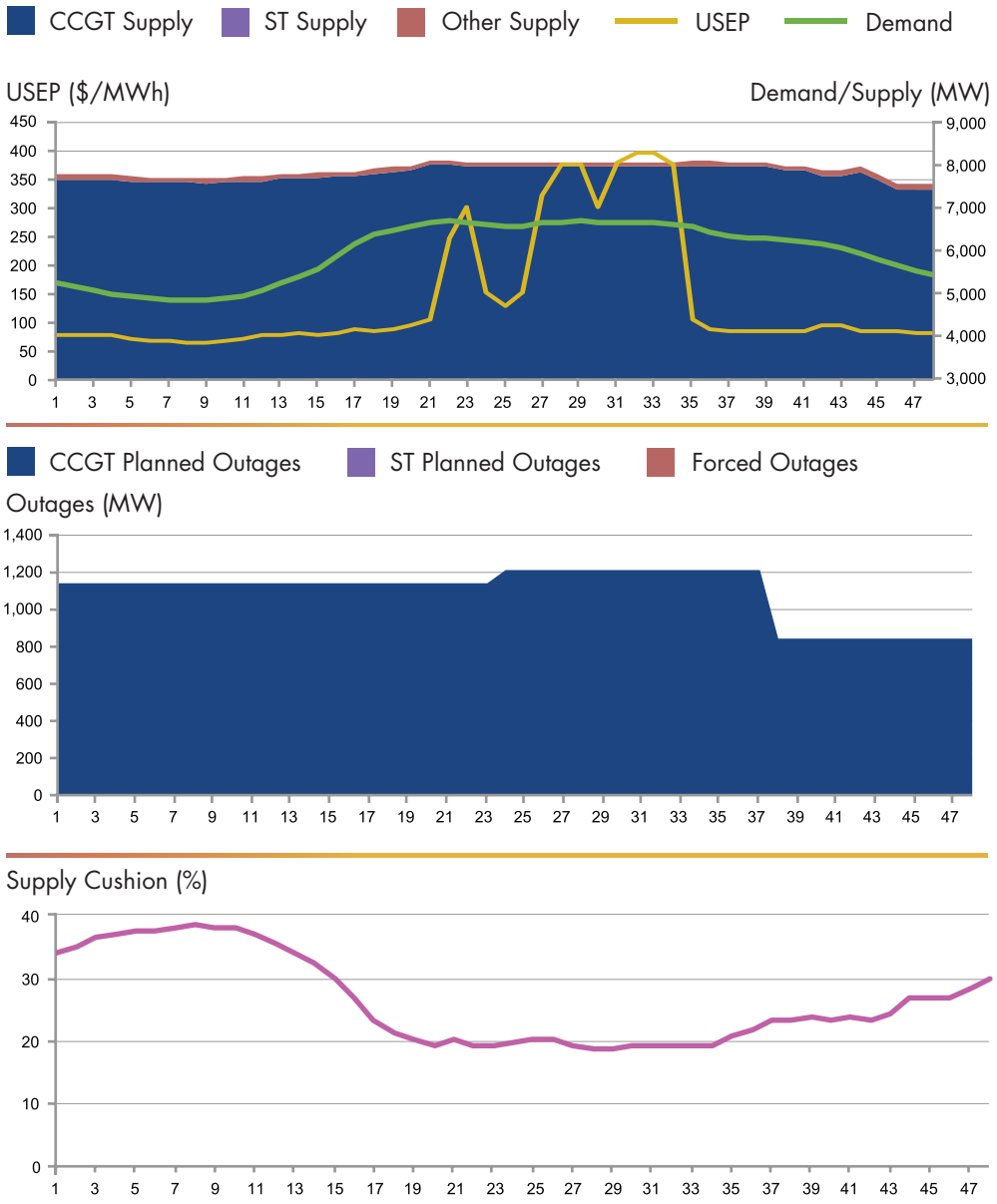
Date	Friday 30 Sep 2016	All Fridays in Sep 2016
Daily USEP ($/MWh)	122.21	88.82
Max USEP ($/MWh)	414.75	414.75
No. of USEP ≥ $1,000/MWh	0	0
Demand (MW)	6,040.52	5,987.26
Supply Cushion (in %)	26.46	26.16
Offers ≤ $100/MWh (in %)	75.91	77.15

Summary

On Friday, 30 September 2016, there were some high prices during the peak demand periods. The highest USEP of $414.75/MWh was registered at Period 34.

The high prices were mainly due to a lower supply cushion caused by high demand and a high level of planned outage (1,085MW) when three CCGT units and one ST unit were out for maintenance. The average supply cushion for the periods of high prices was 18.9 percent. Contingency reserve shortfall was reported for one period with the lowest supply cushion at 17.6 percent.

Chart 29: Demand and Supply Conditions — 6 December 2016



Date	Tuesday 6 Dec 2016	All Tuesdays in Dec 2016
Daily USEP ($/MWh)	140.63	96.39
Max USEP ($/MWh)	397.17	397.17
No. of USEP ≥ $1,000/MWh	0	0
Demand (MW)	5,942.95	5,833.34
Supply Cushion (in %)	26.55	26.55
Offers ≤ $100/MWh (in %)	75.77	77.02

Summary

On Tuesday, 6 December 2016, there were some high prices during the peak demand periods. The highest USEP of $397.17/MWh was reached at Period 33.

The high prices were mainly due to a lower supply cushion caused by high demand and a high level of planned outage. During the periods of high prices, planned outage was at the highest level of 1,209MW for the day, dragging the average supply cushion to a low level of 19.2 percent.

INVESTIGATIONS

Table 8: Investigation and Enforcement Statistics

Rule Breaches	1 Jan 2003 to 31 Dec 2016	1 Jan to 31 Dec 2016
(A) Total number of offer variations after gate closure received	35,560	606
Total number of cases closed	35,457	610
- cases in which the MSCP determined a breach	134	6
- cases in which the MSCP determined no breach	15,657	591
- cases in which the MSCP took no further action	19,666	13
(B) Origin of cases (excluding offer variations after gate closure)	180	5
- self-reports	155	5
- referrals or complaints	18	0
- initiated by the MSCP	7	0
Total number of cases closed	180	6
- cases in which the MSCP determined a breach	124	5
- cases in which the MSCP determined no breach	12	0
- cases in which the MSCP took no further action	43	1
- cases in which the MSCP issued suspension order	1	0
(C) Number of formal MSCP hearings	6	1
(D) Enforcement action		
- highest financial penalty imposed on a party in breach	$842,861	$5,000
- total financial penalties imposed on parties in breach	$1,121,861	$13,000
(E) Costs		
- highest award of costs imposed on a party in breach	$43,750	$7,600
- total costs imposed on parties in breach	$234,175	$22,100

Market Efficiency and Fairness	1 Jan 2003 to 31 Dec 2016	1 Jan to 31 Dec 2016
Total number of cases	7	0
- referrals or complaints	2	0
- initiated by MSCP	5	0
Total number of cases closed	7	0

Under the Market Rules, the Market Surveillance and Compliance Panel (MSCP) may initiate an investigation into any activity in the wholesale electricity markets or into the conduct of a market participant, the Market Support Services Licensee, Energy Market Company or the Power System Operator that is brought to its attention by way of a referral or complaint from any source, or that the MSCP of its own volition determines as warranting an investigation.

The MSCP may refuse to commence or may terminate an investigation when it is of the view that a complaint, referral or investigation is frivolous, vexatious, immaterial or unjustifiable, not directly related to the operation of the wholesale electricity markets, or within the jurisdiction of another party.

Table 8 reflects the position with regard to investigation and enforcement activities from the start of the market on 1 January 2003 to 31 December 2016, with the last column focusing on the period under review.

Reports of determinations of breach made by the MSCP are published in accordance with the Market Rules.

SECTIONS 50 AND 51 OF THE ELECTRICITY ACT

Information Requirements to Assist the Authority

The Market Rules provide for the Market Assessment Unit (MAU), under the supervision and direction of the Market Surveillance and Compliance Panel (MSCP), to develop a set of information requirements to assist the Energy Market Authority (EMA) to fulfil its obligations with respect to prohibiting anti-competitive agreements and abuse of a dominant position under sections 50 and 51 of the Electricity Act.

The first set of information requirements was finalised in consultation with the EMA and published on 27 March 2003. As the market evolved, modifications to the information requirements were published on 18 August 2003, 28 January 2004 and 3 April 2012, with the latest modification made and published on 22 August 2016.

The MAU regularly provides data to the EMA according to the information requirements.

Reports to the Authority

The Market Rules provide for the MSCP to include in its report a summary of reports that have been made to the EMA regarding any complaint that may have been received or any information that may have been uncovered, that may indicate the possibility of anti-competitive agreements, or the abuse of a dominant position, contrary to sections 50 or 51 of the Electricity Act.

In the course of monitoring and investigative activities carried out from January to December 2016, the MSCP and MAU did not make any report to the EMA.

ASSESSMENT OF THE WHOLESALE ELECTRICITY MARKETS

Under the Market Rules, the Market Surveillance and Compliance Panel (MSCP) is required to provide a general assessment of the state of competition and compliance within, and the efficiency of, the wholesale electricity markets. The MSCP's assessment for 2016 is as follows:

Market Structure and Competition

Entry of new market participants and new facilities

In 2016, nine new market participants (MPs) joined the National Electricity Market of Singapore (NEMS) as shown in the table on the right.

Eight new facilities were introduced in the NEMS in 2016.

Of the eight facilities, seven were registered as generation settlement facilities (GSF) in the NEMS. SP Services Ltd registered in April 2016 with an aggregated capacity of 0.224MW. In June 2016, Sun Electric Energy Assets Pte Ltd registered two GSFs with generating capability of 0.082MW each. Sunseap Leasing Pte Ltd registered two GSFs with generating capability of 1.518MW and 9.131MW in July 2016 and August 2016 respectively. In September 2016, Solar C&I Holdings Pte Ltd registered its 1.56MW GSF in the NEMS. In December 2016, Nanyang Technological University registered its 4.971MW GSF in the market.

Singapore District Cooling Pte Ltd registered its 6MW load facility on 4 November 2016.

Name of MP	Electricity Licence	Date Joined NEMS
Solar C&I Holdings Pte Ltd	Wholesaler (Generation)	1 January 2016
Singapore Refining Company Pte Ltd	Generation	14 April 2016
Singapore District Cooling Pte Ltd	Wholesaler (Demand Side Participation)	11 May 2016
I Switch Pte Ltd	Retailer	18 May 2016
Sun Electric Energy Assets Pte Ltd	Wholesaler (Generation)	10 June 2016
Charis Electric Pte Ltd	Retailer	9 September 2016
Environmental Solutions (Asia) Pte Ltd	Retailer	8 November 2016
Nanyang Technological University	Wholesaler (Generation)	8 November 2016
GreenSync Holdings Pte Ltd	Wholesaler (Demand Side Participation)	22 November 2016

Deregistration of facilities

One Steam Turbine (ST) facility[9] from Air Liquide Singapore Pte Ltd deregistered from the market on 25 November 2016.

Withdrawal by market participants

Two market participants exited from the NEMS in 2016. KiWi Power Singapore Pte Ltd deregistered on 11 May 2016 and Air Products Pte Ltd deregistered on 23 December 2016.

[9] Air Liquide Singapore Pte Ltd consolidated its two ST facilities into one.

Market Price Behaviour

Further energy price decrease in 2016

Energy prices have been on a downward trend since 2013. In 2016, the average Uniform Singapore Energy Price dropped 34.1 percent from $95.97/MWh in 2015 to $63.28/MWh while the Wholesale Electricity Price decreased 33.6 percent from $95.85/MWh to $63.69/MWh. Energy prices were below the vesting contract prices for over 95.5 percent of the time in 2016.

The decrease in energy prices in 2016 was largely due to falling fuel oil prices and greater supply capacity available in the market.

Efficiency of the Electricity Markets

Productive efficiency

At 98.1 percent, the market share of Combined Cycle Gas Turbine (CCGT) units based on injection quantity was at a similarly high level as 2015. Based on maximum capacity, there was a 0.4 percentage point increase in the market share of CCGT units in 2016. There was a corresponding decrease in the market share of the remaining generation types based on maximum capacity – the largest decrease was observed for Steam Turbine units at 0.4 percentage point.

Overall, this represented an improvement in productive efficiency in 2016.

Pricing efficiency

Prices generally reflected relative supply and demand conditions in 2016.

Looking Ahead

Further demand-side management initiatives

Over the years, the Energy Market Authority (EMA) has been gradually introducing demand-side management initiatives to enhance competition in the wholesale electricity market. In 2016, it was announced that the EMA will be collaborating with Professor Frank Wolak of Stanford University to measure consumer responsiveness to incentives and evaluate business models for their sustainability.

The electricity grid operator, Singapore Power, will also be studying how demand-side management technologies and initiatives can be incorporated in the grid network planning process to bring benefits to consumers and the power system.

Move towards smart metering

Together with the Public Utilities Board and Singapore Power, the EMA is launching a Call for Proposals to develop and test-bed integrated advanced metering solutions to consumers in the various utility sectors. The result of the test-bed is expected to help assess whether and how advanced metering solutions can be deployed nationwide, dovetailing the EMA's plans to achieve full retail contestability in the electricity market by 2018.

Ensuring compliance with the Market Rules is important in the operation of a competitive and reliable electricity market. MPs that breach the rules may be subject to sanctions if the MSCP considers it appropriate.

The assessment as to the state of compliance within the wholesale electricity markets is set out below.

Offer Variations After Gate Closure

Table 9 compares the number of offer variations after gate closure submitted by MPs in 2016 and the previous year.

There were 606 cases of offer variations made after gate closure in 2016. This was 31.45 percent lower than in 2015. The decrease was mainly due to an interruptible load provider submitting fewer offer variations after gate closure in 2016.

The MSCP was also satisfied that the offer variations made after gate closure did not give rise to any significant concern.

Table 9: Offer Variations After Gate Closure

Number of offer variations made after gate closure from 1 January 2015 to 31 December 2015	884
Number of offer variations made after gate closure from 1 January 2016 to 31 December 2016	606
Decrease in number of offer variations made after gate closure for year 2016 from previous year	31.45%

Rule Breaches

For the period 1 January to 31 December 2016, the MSCP made seven determinations regarding rule breaches. The determinations were made against Energy Market Company Pte Ltd (EMC), Senoko Energy Pte Ltd, Tuas Power Generation Pte Ltd, ExxonMobil Asia Pacific Pte Ltd and Shell Eastern Petroleum (Pte) Ltd.

The rule breach determinations were as follows:

- EMC's late validation of offer on 20 August 2015.
- EMC's failure to release real-time dispatch schedule and short-term schedule to the PSO on 25 January 2016.
- EMC's failure to release real-time dispatch schedule and short-term schedule to the PSO on 22 August 2016.
- Senoko Energy Pte Ltd's failure to comply with gate closure rules on 22 May 2016.
- Tuas Power Generation Pte Ltd's failure to comply with gate closure rules on 28 June 2016.
- ExxonMobil Asia Pacific Pte Ltd's failure to comply with the declared quantity rules.
- Shell Eastern Petroleum (Pte) Ltd's failure to comply with the declared quantity rules and submit offer variations to reflect generation capability and non-cooperation during initial stage of investigation.

Overall, there were no major compliance issues arising within the wholesale electricity markets in 2016.

Automatic Financial Penalty Scheme

The Automatic Financial Penalty Scheme for generation registered facilities that deviate from their dispatch schedule came into effect on 17 November 2015.

In 2016, it was observed that nine generation companies were issued with automatic financial penalties for a total sum of $544,846.25 by NEMS.

The MSCP dismissed two appeals over penalties imposed under the Automatic Financial Penalty Scheme.

CONCLUSION

CONCLUSION

The Market Surveillance and Compliance Panel (MSCP) is generally satisfied with the state of compliance in the National Electricity Market of Singapore (NEMS) in 2016. Over the year, the MSCP determined seven cases of rule breaches which did not result in any significant impact on the market. The number of offer changes made after gate closure continued to decline significantly from 884 to 606. These violations were also found not to have any significant market impact. Additionally, the MSCP assessed and dismissed the first two appeals[10] for refund of penalties imposed under the Automatic Financial Penalty Scheme. It determined that non-compliance with dispatch instructions may only be excusable under exceptional circumstances.

On the pricing front, wholesale electricity prices in 2016 fell by over a third over the previous year to $63.69/MWh. This is the fourth year in a row that wholesale prices have declined significantly and coincided with the slide in global fuel prices that began in late 2014. Outlier prices were observed on nine days, significantly down from 26 a year ago. Nevertheless, these have largely occurred during periods of high levels of equipment outages. Otherwise, the movements of wholesale energy prices have responded to changes in underlying demand and supply drivers, and were within reasonable expectation.

The market improved structurally. The concentration level in the generation sector diluted further as the combined market share of the three largest generation companies fell 1.4 percentage points to 57.8 percent. The market share of the most efficient Combined Cycle Gas Turbine (CCGT) units (based on injection quantities) was maintained at a very high level of 98.1 percent. Declining market concentration in generation and continued dominance of efficient generation reflect keener competition and high levels of efficiency in the wholesale electricity markets.

Despite the withdrawal of two market participants in 2016, a significant total of nine new market participants joined the NEMS. The new additions consisted of a good mix of participants across different licensee classes. More buyers and sellers in the market place are again positive for competition. Going forward, the MSCP looks forward to these developments dove-tailing with a pick-up in demand-side activities to unlock more efficiency gains for the electricity sector.

[10] The MSCP determination papers can be found on EMC's website:www.emcsg.com/aboutthemarket/paneldeterminations.

USER GUIDE

Data

- All real-time and forecast prices and settlement data are provided by Energy Market Company Pte Ltd (EMC).
- Vesting Contract Hedge Prices (VCHP) are computed by SP Services Ltd (SP Services) based on a formula set by the Energy Market Authority.
- Data for forecast demand and outages is compiled from reports prepared by the Power System Operator (PSO), including advisory notices.
- Metered energy quantities are supplied by SP Services as the Market Support Services Licensee (MSSL). All metered data used in this report is final data, derived after any settlement reruns.
- Throughout this document, demand figures are based on the forecast demand supplied by the PSO, except where metered energy quantities are indicated.
- Combined Cycle Gas Turbine (CCGT) units refer to all generating units clustered under the CCGT/COGEN/TRIGEN umbrella.

Supply Indices

- Capacity ratio measures the scheduled (by the Market Clearing Engine) output of energy, reserve and regulation as a ratio of a generation registered facility's maximum generation capacity at a given time.
- Supply cushion is the ratio between (a) the supply and demand gap (i.e., the difference between total offered volume and demand) and (b) supply. This index measures supply adequacy. It indicates the level of unused capacity that was offered but not scheduled, and could be called up if required. The total offered volume refers to the total amount of energy offered by all generation registered facilities. Demand refers to the demand forecast by the PSO used to determine the real-time dispatch schedule for energy.
- Market share is computed based on the generation output of each company. The maximum capacity for each generation company is the registered maximum capacity in the standing data.
- Under the Market Rules and System Operation Manual (SOM), outages of generation registered facilities are defined as follows:

Table 10: Definition of Peak, Shoulder and Off-peak Periods*

	Sunday/Public Holiday	Weekday	Saturday
Peak	-	Periods 18-41	-
Shoulder	Periods 22-46	Periods 15-17 Periods 42-48	Periods 18-47
Off-peak	Periods 1-21 Periods 47-48	Periods 1-14	Periods 1-17 Period 48

*Source: MSSL

a. planned outage is defined in the SOM to "include both the Annual Outage plan for overhaul, retrofitting or inspection and the Short-term Outage Plan for urgent repair or maintenance"; and

b. forced outage is defined in the Market Rules as "an unanticipated intentional or automatic removal from service of equipment or the temporary de-rating of, restriction of use or reduction in performance of equipment".

There may be slight differences in the calculation of outages in the Annual Report of the MSCP and the NEMS Market Report due to differing methodologies.

Vesting Contracts

The VCHP is calculated by the MSSL every three months. It is determined using the long-run marginal cost of the most efficient technology in the Singapore power system, i.e., the Combined Cycle Gas Turbine. EMC's settlement system uses the VCHP to settle the vesting quantity between the MSSL and the generation companies.

Periods

Each day is divided into 48 half-hour periods. Period 1 is from 0000 to 0029 and Period 48 is from 2330 to 2359.

Important Notice

This publication is meant only for general information and nothing in it may be construed as advice. Whilst the Market Surveillance and Compliance Panel (MSCP) has taken reasonable care in the preparation of this publication, the MSCP does not warrant its suitability for any purpose. You should always consult your professional advisors before relying on this publication to make any decision.

If you have any specific queries about this publication, you can write to mau@emcsg.com.

Energy Market Company

Market Assessment Unit
4 Shenton Way
#03-01 SGX Centre 2
Singapore 068807
T: +65 6779 3000
F: +65 6533 0340
www.emcsg.com
mau@emcsg.com