MARKET SURVEILLANCE & COMPLIANCE PANEL ANNUAL REPORT 2017

nems National Electricity Market of Singapore

IN MEMORIAM

JOSEPH GRIMBERG SC

It is with great sadness that we mark the passing of Mr Joseph Grimberg on 17 August 2017.

Mr Joe Grimberg was the first Chairman of the Market Surveillance and Compliance Panel (MSCP). He took office on 1 January 2003, right at the beginning when the Singapore wholesale electricity market was inaugurated. He served for five years until 31 December 2007, at a time when the fledgling market was just taking off. The role of the Chairman was crucial in those days when there were no established procedures and precedents for the MSCP. In effect, they made things up as they went along. When he stepped down at the end of 2007, his colleagues fondly remembered the skillful way he steered the proceedings of the MSCP with both wit and eloquence.

Joe (as he was known to all) was a man without pretensions. He was unfailingly courteous both in court and out of it, even to lowly pupils in his firm. Having graduated from Cambridge University in 1955, at the fag end of Empire, he was called to the Bar in England in 1956 as a barrister of the Middle Temple. Joe retained the graciousness and bearing of the best English barristers all his life. He spoke with a refined and cultured English accent – a natural one, not an artificial snobby stage accent put on to impress others. He was also a keen sportsman who played rugby and cricket for the Singapore Cricket Club, a reflection perhaps of his anglophile character.

In 1956, Joe returned to Singapore where he joined the firm in which he spent the bulk of his professional life, Drew & Napier. He was the first Singaporean to be hired by the firm. Starting on the bottom rung as a legal assistant, he rose to the position of Senior Partner in 1967. This position he held for twenty years, until 1987.

In that year, he became a Judicial Commissioner of the Supreme Court. He returned to Drew & Napier as a consultant in 1989, having declined a permanent appointment as a judge. It was a loss to the Bench. When then President Ong Teng Cheong decided in 1995 to refer a question of law to the Constitutional Tribunal, Joe was approached to represent the Presidency. He accepted the brief with reluctance, claiming that he had lost his nerve. His performance in court belied his modesty; those who had the privilege of watching him in action can testify to the elegant eloquence with which he presented the case for the Presidency.

Joe was undoubtedly one of the very best advocates to grace our courts. His leading role in the legal profession was recognised when he was appointed Senior Counsel in 1997, one of the first batch of local ‘silks’. In 2007, the Law Society of Singapore honoured him with the C C Tan Award for outstanding contributions to the Bar. When he passed in August 2017, tributes were paid to him by the Chief Justice and the Minister for Law, among many others.

Joe Grimberg was indeed one of a kind; a gentleman maintaining the highest standards of decorum, courtesy and honour whether in or out of court. The legal profession is greatly diminished by his passing.

Requiescat in pace.

CONTENTS

EXECUTIVE SUMMARY

This annual report by the Market Surveillance and Compliance Panel (MSCP) covers the period 1 January to 31 December 2017. 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 2017 relative to 2016:

Supply Indices

- The average supply cushion[1] decreased 0.6 percentage point from 29.5 percent in 2016 to 28.9 percent in 2017, showing a tightening of supply conditions relative to that of demand.
- The average capacity ratio[2] of Combined Cycle Gas Turbine (CCGT) units was 0.23[3] percentage point higher in 2017 at 61.05 percent. The capacity ratio for Steam Turbine (ST) units dropped 0.3 percentage point to 0.1 percent.
- The generation market share of CCGT units remained at the same level as 2016 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 2.3 percentage points from 2016 to 55.5 percent.
- The average total generation outage per period in 2017 increased for the fourth consecutive year by 2.3 percent to 1,134MW. The average forced outage level per period dipped from 35MW in 2016 to 14MW in 2017.

Demand Indices

- The average demand growth in 2017 decreased to 1.9 percent, down from 2.6 percent in 2016.
- The average demand in 2017 was about 5,668MW, compared to 5,563MW in 2016. The average monthly electricity demand peaked in August at 5,856MW.
- The accuracy of real-time load forecast in 2017 improved further with an average forecast error of 2.26 percent, the best result in the history of the National Electricity Market of Singapore.

Market Prices

- The average Wholesale Electricity Price (WEP) increased 27.5 percent to $81.19/MWh – the first increase since 2012 – along with the rebound in fuel prices.
- The average price of the benchmark 180-centistoke high sulphur fuel oil (180-CST HSFO) surged 45.7 percent to US$55.64/bbl in 2017.
- The total reserve payment in 2017 increased 26.9 percent from $29.3 million to $37.2 million.

[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.

[3] Due to a technical error, the capacity ratio for CCGT in 2016 has been revised to 60.82 percent from 65.63 percent published in the 2016 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 sixteenth 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 2017. 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[4] it acquires and a catalogue of the monitoring indices[5] 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.

[4] 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.

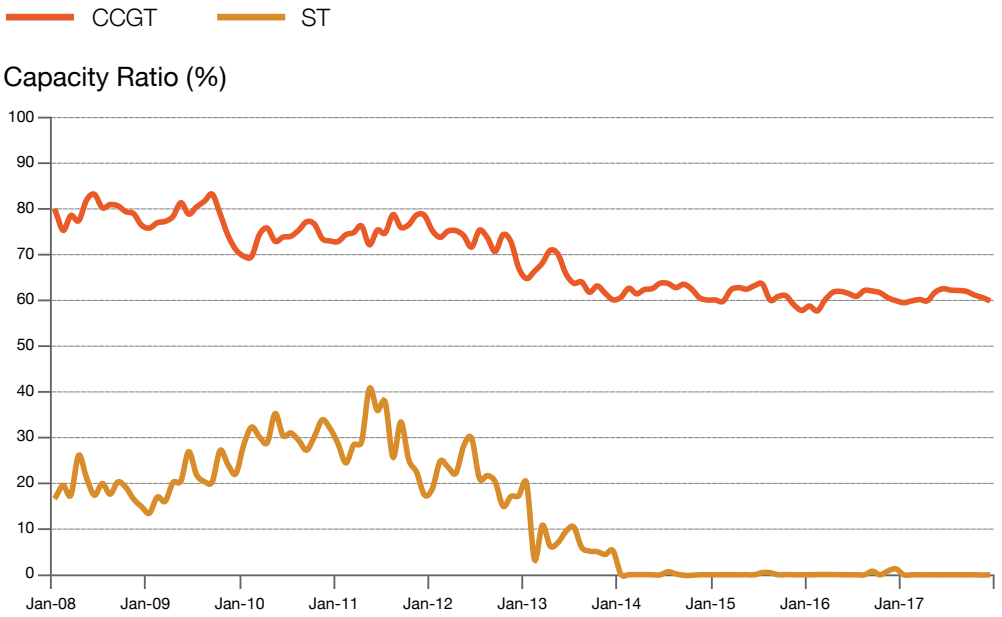
[5] On 29 July 2004, a catalogue of monitoring indices was adopted by the MSCP after public consultation. It took effect from 1 August 2004. The catalogue of monitoring indices is used to evaluate the market data collected.

Table 1: Capacity Ratio (in %) 2017

Month	CCGT	ST	OT	OCGT
Jan 17	59.57	0.11	48.96	0.02
Feb 17	59.94	0.11	45.51	0.00
Mar 17	60.25	0.12	47.58	0.00
Apr 17	59.99	0.13	49.50	0.09
May 17	61.87	0.12	47.84	0.00
Jun 17	62.61	0.11	48.75	0.00
Jul 17	62.30	0.12	45.74	0.00
Aug 17	62.23	0.12	50.94	0.00
Sep 17	62.02	0.11	49.11	0.00
Oct 17	61.23	0.12	47.22	0.00
Nov 17	60.69	0.06	48.83	0.00
Dec 17	59.95	0.12	54.76	0.00
Average	61.05	0.11	48.73	0.01

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 2017. The average capacity ratio for all generation types except Combined Cycle Gas Turbine (CCGT) units decreased in 2017.

The average capacity ratio for CCGT units rose 0.23 percentage point to 61.05 percent in 2017. Variations in the average capacity ratio for the other generation types were minimal – the average capacity ratio for Steam Turbine (ST) units, Open Cycle Gas Turbine (OCGT) units and other facilities (OT) decreased 0.3, 0.1 and 0.04 percentage point respectively.

Capacity ratio represents the utilisation level of a generation type. Chart 1 shows the capacity ratios for CCGT and ST units for the past ten years.

From 2008 to 2010, the capacity ratios for the two generation types moved in opposite directions. The capacity ratio for CCGT units fell as a result of an increase in generation capacity of CCGT units, whereas the capacity ratio for ST units rose due to lower generation capacity and higher scheduled output of ST units.

Both indices fell between 2011 and 2014. This was largely brought about by the growing generation capacity of CCGT units and declining scheduled output of ST units. The generation capacity of CCGT units increased 59.7 percent from 2011 to 2014, while the scheduled output of ST units decreased 99.5 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.

From 2015 to 2017, the capacity ratio of CCGT units hovered around 60 percent as changes in the generation capacity were matched by changes in the scheduled output of CCGT units. The low scheduled output of ST units kept the capacity ratio for ST units below 1.0 percent.

Chart 2: Relationship between Supply Cushion and USEP

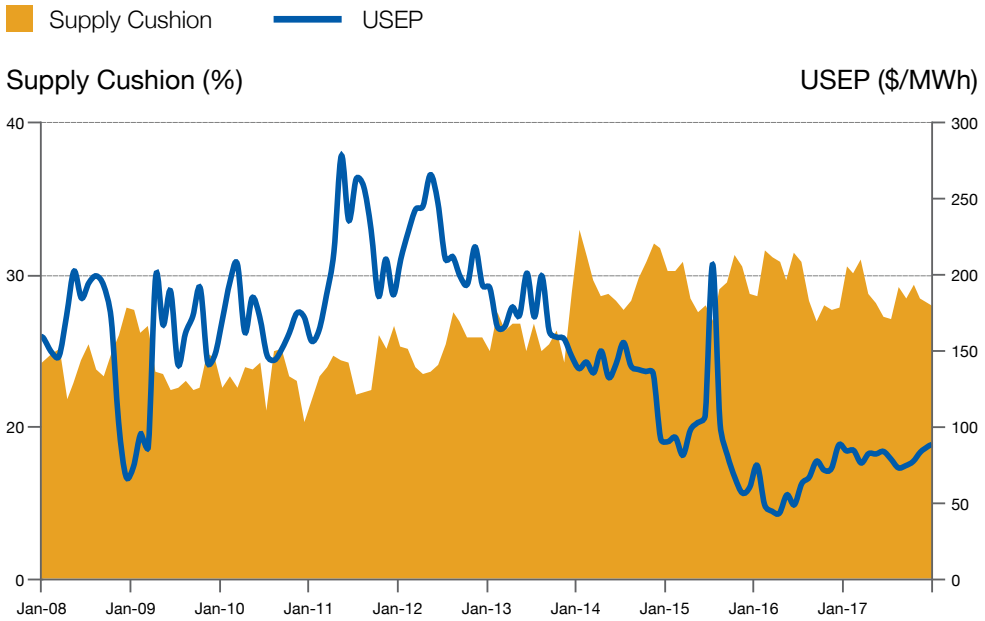


Chart 2 illustrates the relationship between the Uniform Singapore Energy Price (USEP) and the supply cushion, which measures the level of spare capacity available after dispatch.

The rise in average forecasted demand in 2017 was 1.0 percent, which outpaced the 0.1 percent rise in average supply. The supply cushion thus deflated 0.6 percentage point from 29.5 percent in 2016 to 28.9 percent in 2017. The USEP increased 27.9 percent from $63.28/MWh in 2016 to $80.91/MWh in 2017, the first increase in the USEP since 2012. The changes in the USEP corresponded with movements in the fuel price, which also increased for the first time in five years.

Chart 3: Relationship between Supply Cushion and USEP in 2017

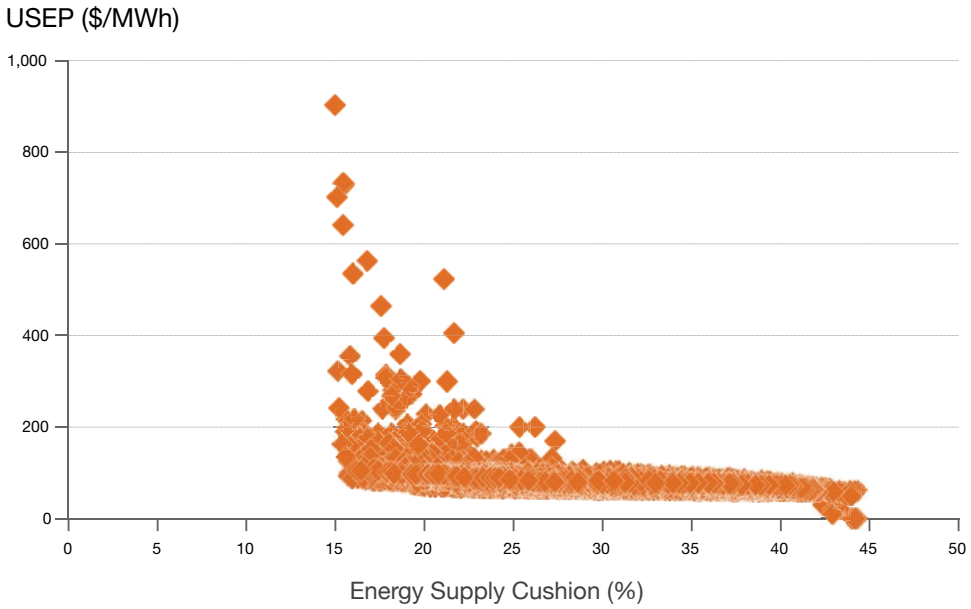


Chart 3 shows the relationship between the USEP and the supply cushion in 2017. The total number of instances of the USEP being above $500/MWh decreased from 33 in 2016 to eight in 2017, the lowest frequency since the market started in 2003.

Historically, high prices were mostly observed when the supply cushion was below 15 percent. However, only one out of the eight occurrences of high prices in 2017 was observed when the supply cushion was below 15 percent. The supply cushion was between 15 and 21 percent in the remaining seven 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)
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
2017	1	902.94	902.94	17,519	80.87	732.52

Table 2 summarises the yearly USEP movements under two supply cushion scenarios.

The number of periods with the supply cushion below 15 percent declined from 13 in 2016 to one in 2017. For periods when the supply cushion was 15 percent or above, the average USEP climbed 28.2 percent from $63.08/MWh in 2016 to $80.87/MWh in 2017.

The highest USEPs recorded under both supply cushion scenarios were lower in 2017 than those recorded in 2016. When the supply cushion was below 15 percent, the highest USEP recorded in 2017 was $902.94/MWh, compared to $1,252.59/MWh in 2016. When the supply cushion was 15 percent or above, the highest USEP recorded in 2017 was $732.52/MWh, slipping from $1,053.62/MWh in 2016.

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

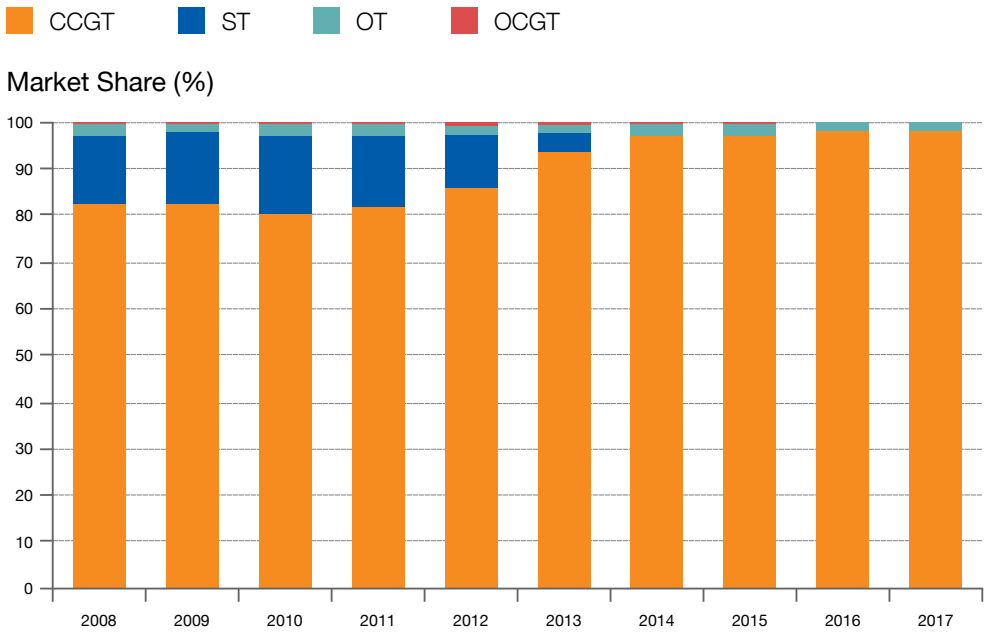
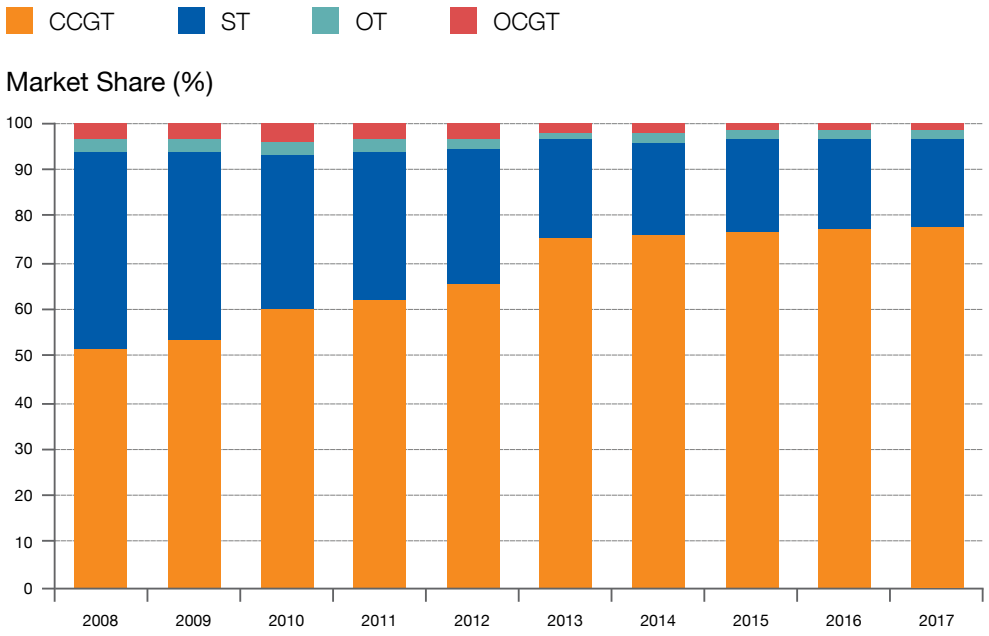


Chart 5: Market Share Based on Maximum Capacity by Generation Type



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 both CCGT units and OT units remained unchanged in 2017, at 98.1 percent and 1.9 percent respectively. The market shares of ST units and OCGT units stayed at 0 percent in 2017.

Based on maximum capacity, the market share of CCGT units grew 0.1 percentage point to 77.6 percent and that of ST units fell 0.1 percentage point to 19.1 percent in 2017. The market shares of OT and OCGT units remained relatively constant in 2017.

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

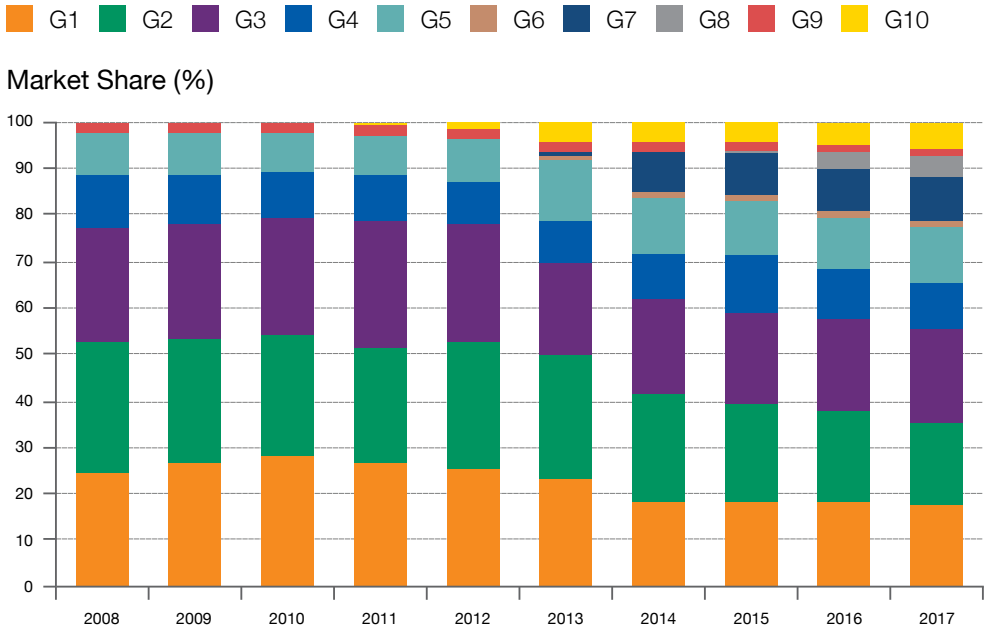
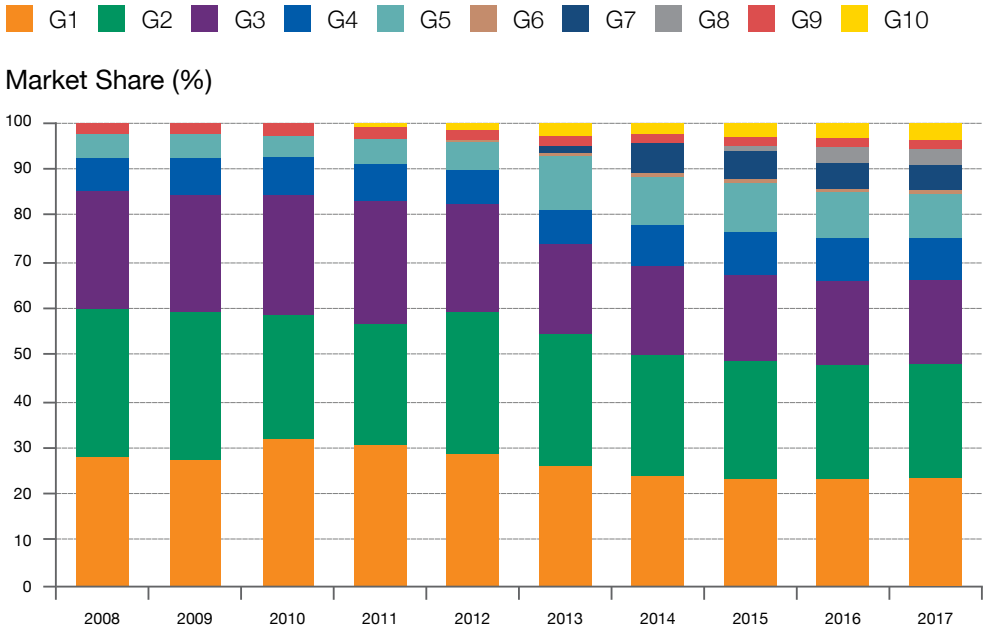


Chart 7: Market Share Based on Maximum Capacity by Generation Company



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

With the addition of four embedded generation facilities in 2017, the market share of embedded generators based on metered energy quantity grew 1.1 percentage points to 5.8 percent, and that based on maximum capacity grew 0.5 percentage point to 3.3 percent.

The combined market share of the three largest generation companies based on metered energy quantity shrank 2.3 percentage points from 57.8 percent in 2016 to 55.5 percent in 2017. In terms of maximum capacity, the three largest generation companies held 66.5 percent of the market in 2016 and 66.1 percent in 2017.

[6] 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 2.3 percent from 1,109MW in 2016 to 1,134MW in 2017. This outage level translated to 8.4 percent of the total installed capacity. The rise in total outages was mainly led by a higher level of anticipated outages from ST units.

Average forced outages reduced from 35MW per period in 2016 to 14MW per period in 2017. This was the second lowest level of average forced outages seen in the market; the lowest level was 12MW per period in 2008.

Chart 8 shows the yearly percentage breakdown of the three types of plant outages. In 2017, planned outages accounted for 98.8 percent of total outages, while forced outages made up 1.2 percent. In comparison, the distribution of total outages between planned and forced outages in 2016 were 96.8 percent and 3.2 percent respectively.

Chart 8: Composition of Total Plant Outages

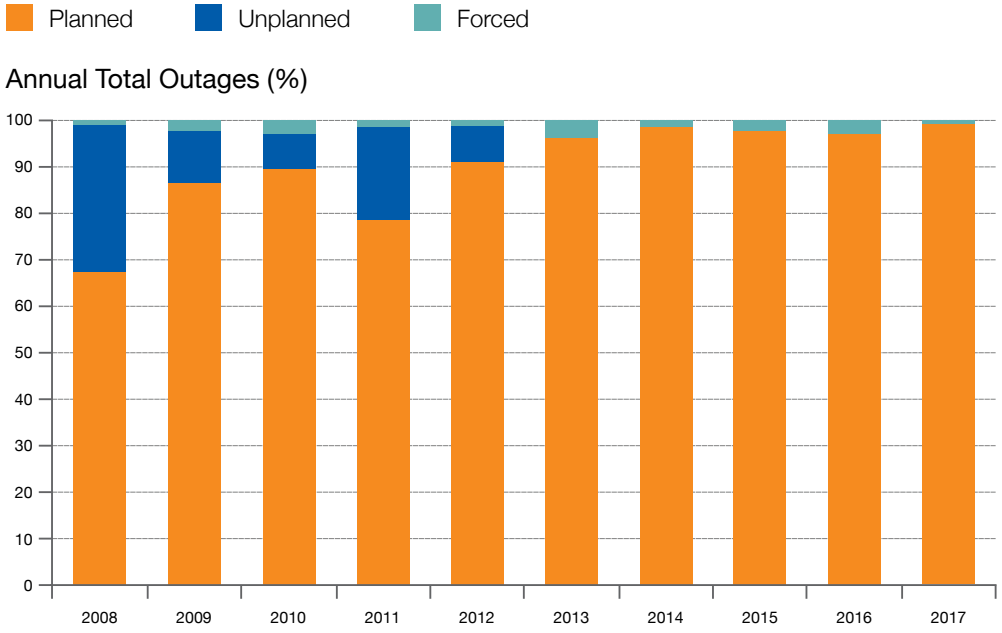
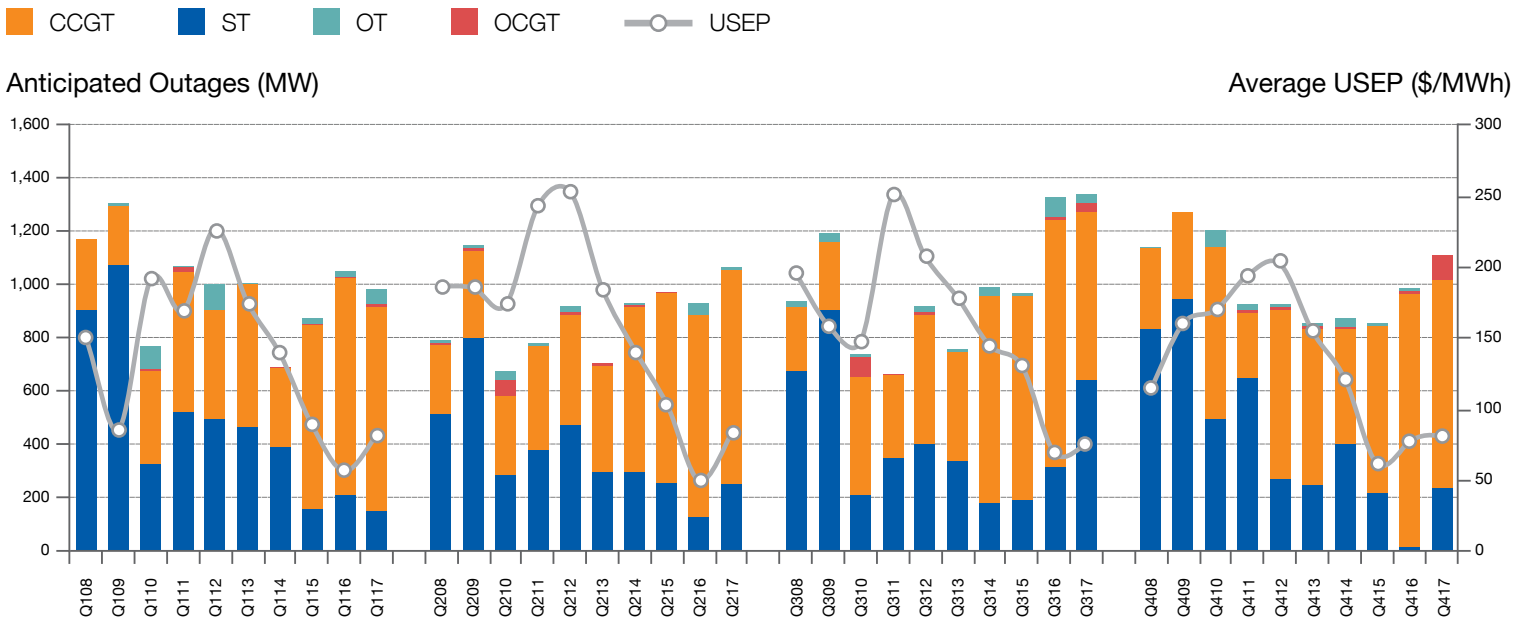


Table 3: Average Outages by Generation Type and Technology in MW (per period)

	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	
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	2	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
2017	322	744	33	22	0	0	0	0	0	14	0	0	1,134

Chart 9: Average Quarterly Anticipated Outages vs Average USEP



[7] 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.

Chart 9 compares the average anticipated outages[7] with the average USEP on a quarterly basis.

Intuitively, a higher level of anticipated outages coincides with a higher USEP because of a contraction in supply. The average level of anticipated outages for Q2 2017 was 14.6 percent higher than that for Q2 2016; correspondingly, the average USEP for Q2 2017 was 68.2 percent higher than that for Q2 2016.

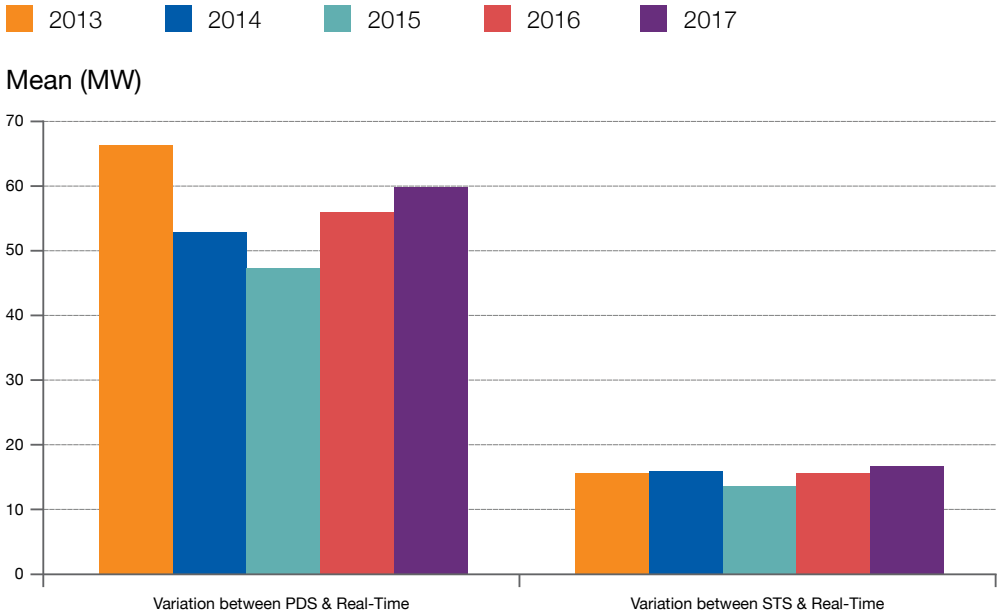
This relationship was also noted in the last two quarters of the year. The average level of anticipated outages for Q3 2017 was 0.7 percent higher than that for Q3 2016, while the average USEP for Q3 2017 was 9.4 percent higher than that for Q3 2016. Similarly, the average level of anticipated outages for Q4 2017 was 12.6 percent higher than that for Q4 2016, and the average USEP for Q4 2017 was 6.6 percent higher than that for Q4 2016.

Even though the average level of anticipated outages for Q1 2017 was 7.1 percent lower than that for Q1 2016, the average USEP for Q1 2017 was 45.7 percent higher than that for Q1 2016. The higher average USEP was primarily driven by higher fuel oil price, which almost doubled from US$97.48/bbl in Q1 2016 to US$192.40/bbl in Q1 2017.

Table 4: Variation in Load Forecasts

Year 2017				
	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	93.18	52.33	25.58	14.04
Feb	62.61	44.89	17.30	12.34
Mar	51.64	37.04	14.54	10.45
Apr	51.28	30.94	14.46	8.62
May	67.74	42.98	19.00	11.53
Jun	77.43	52.09	21.33	14.28
Jul	80.13	45.38	22.41	12.79
Aug	43.64	30.81	12.29	8.54
Sep	48.46	40.73	13.54	11.35
Oct	44.80	32.81	12.48	9.09
Nov	37.08	26.50	10.48	7.49
Dec	60.72	34.61	16.97	9.69
Average	59.89	39.26	16.70	10.85

Chart 10: Average Mean Load Forecast Variations between Forecast and Real-Time Schedules



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 and real-time schedules. 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 and 36 hours, compared to STS forecasts which are updated every half hour, with a forecast horizon of up to six hours.

Chart 10 compares the PDS and STS forecasts to the real-time load forecast, based on the mean of the variations for the past five years. The average difference between PDS forecast and real-time load forecast in 2017 was 7.7 percent greater than that in 2016. The average difference between STS forecast and real-time load forecast increased 7.4 percent in 2017.

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

Month	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Jan	3.93	3.46	3.18	3.24	2.73	3.00	3.46	3.23	2.57	2.53
Feb	4.01	3.48	3.74	2.93	2.82	2.83	3.28	3.19	3.05	2.58
Mar	3.77	3.40	3.64	2.95	2.93	2.75	3.00	2.97	2.65	2.20
Apr	3.97	3.50	3.74	3.13	3.01	2.34	3.20	2.67	2.52	2.43
May	3.89	3.41	3.83	1.96	2.76	2.77	3.27	2.76	2.64	2.06
Jun	3.76	3.93	3.15	2.65	2.61	3.00	3.10	2.67	2.92	2.31
Jul	3.96	3.45	3.17	3.36	2.75	3.04	3.30	2.40	2.71	2.09
Aug	3.68	3.54	3.54	3.14	2.86	2.90	3.70	2.63	2.31	2.18
Sep	3.70	3.34	3.42	3.20	2.93	3.24	3.29	2.58	2.89	2.09
Oct	3.74	3.54	3.56	3.01	2.81	3.28	3.26	2.60	2.88	1.85
Nov	3.40	3.28	3.62	2.94	3.05	3.23	3.82	2.57	2.71	2.12
Dec	3.60	3.24	3.64	2.88	3.17	3.46	3.35	2.62	2.49	2.68
Average	3.78	3.46	3.52	2.95	2.87	2.99	3.34	2.74	2.70	2.26

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.

In 2017, the accuracy of the real-time load forecast improved. As seen in Table 5, the average load forecast error reduced 0.44 percentage point to 2.26 percent which is the lowest level since the market started in 2003.

Chart 11: Monthly Volume-Weighted Average VCHP vs WEP

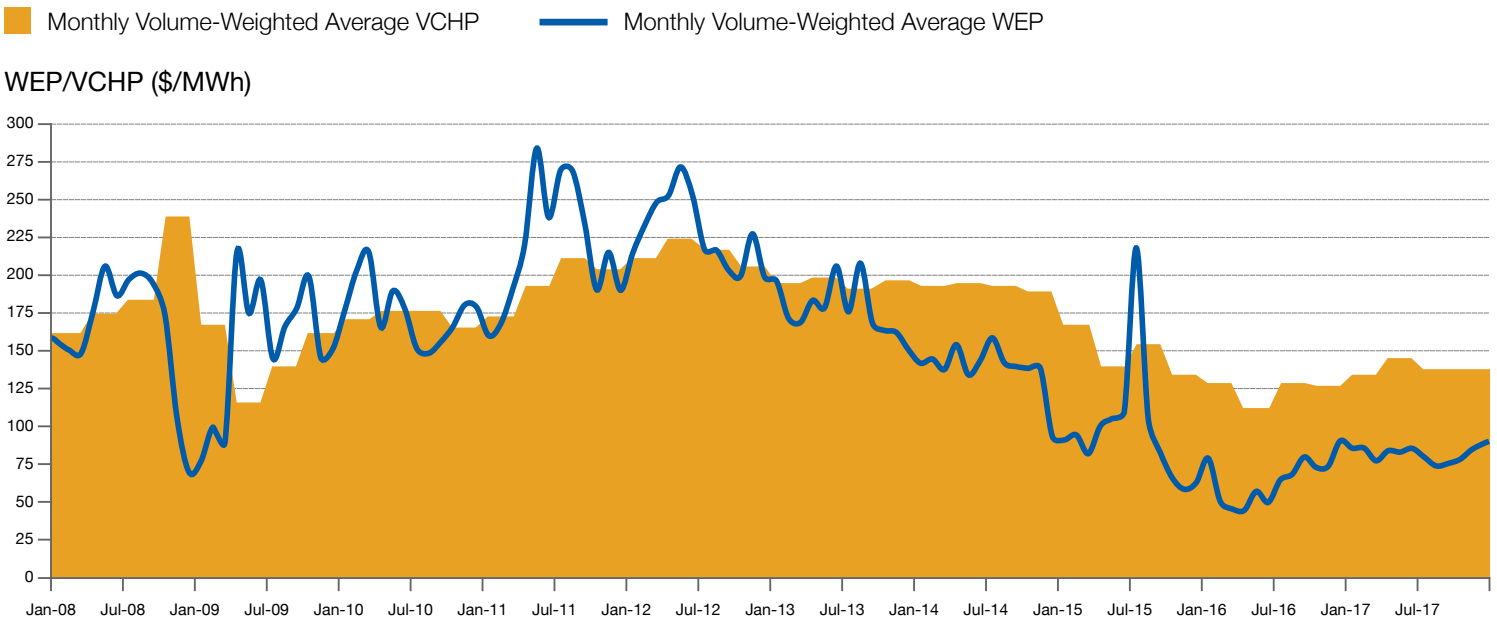


Chart 11 tracks the movements of the volume-weighted averages of the Wholesale Electricity Price (WEP) and Vesting Contract Hedge Price[8] (VCHP).

Both metrics increased in 2017. The volume-weighted average WEP rose 26.0 percent from $64.93/MWh in 2016 to $81.82/MWh in 2017, while the volume-weighted average VCHP increased 12.4 percent from $123.69/MWh in 2016 to $138.97/MWh in 2017.

In 2017, the volume-weighted average WEP was 41.1 percent lower than the volume-weighted average VCHP.

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

Chart 12: Comparisons of Actual Demand

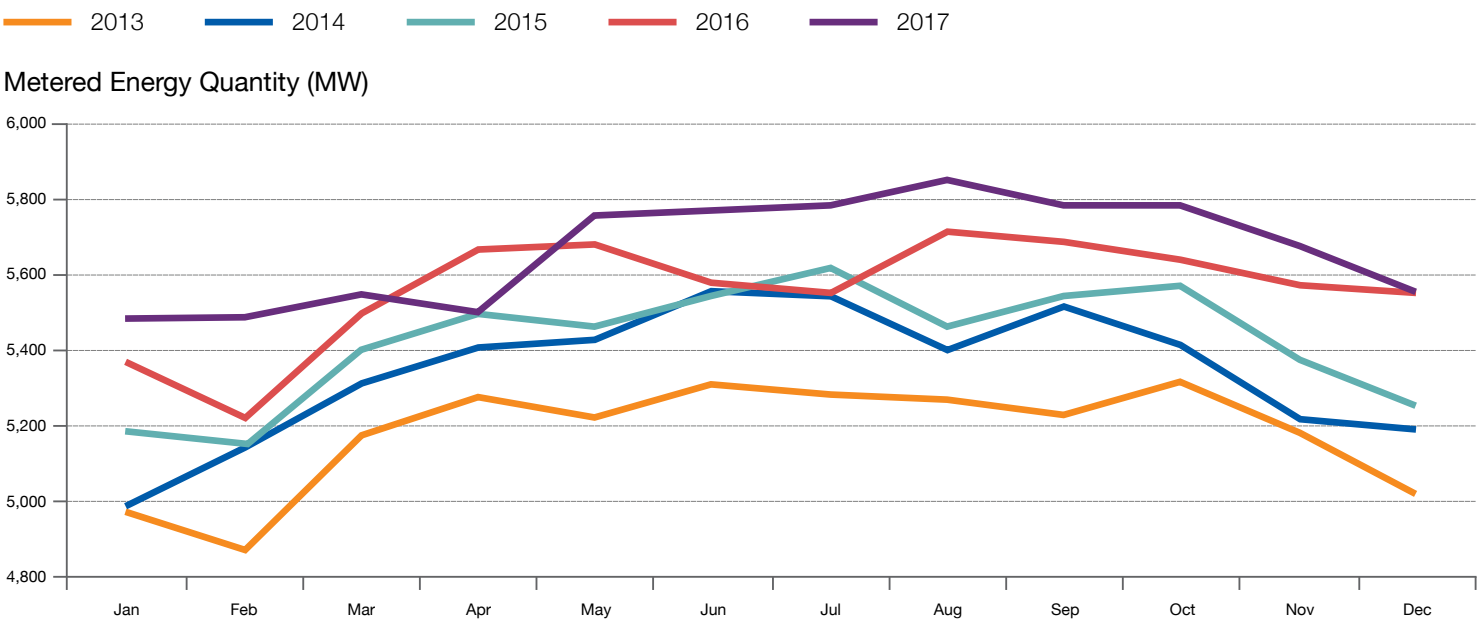


Chart 12 compares the actual demand (computed from metered energy quantity) from 2013 to 2017. Apart from April, all other months in 2017 displayed a higher demand than in 2016. Overall, demand grew 1.9 percent from 2016 to 2017.

New records were set in 2017. The average demand of 5,668MW and the peak average monthly demand of 5,856MW were higher than the previous record levels registered in 2016. The average monthly demand was the highest in August 2017.

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

	2016			2017		
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	0.72	0.52	28	0.79	0.62	28
Feb	0.63	0.39	21	0.66	0.43	21
Mar	0.57	0.32	22	0.78	0.61	29
Apr	0.66	0.44	25	0.74	0.55	29
May	0.57	0.32	20	0.63	0.40	21
Jun	0.55	0.30	20	0.52	0.27	16
Jul	0.49	0.24	16	0.55	0.30	20
Aug	0.40	0.16	13	0.67	0.45	26
Sep	0.53	0.28	20	0.62	0.38	21
Oct	0.53	0.28	18	0.74	0.55	30
Nov	0.52	0.27	20	0.89	0.80	28
Dec	0.56	0.32	17	0.87	0.76	28
Average	0.56	0.32	240	0.70	0.51	297

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 2017, the highest *r* value of 0.89 was observed in November and there were 297 days when *r* was greater than 0.5. These statistics imply a stronger connection between demand and prices in 2017 compared to 2016, when the highest *r* value was 0.72 and there were only 240 days when *r* was greater than 0.5.

Chart 13: Correlation between WEP and Metered Energy Quantity in 2017

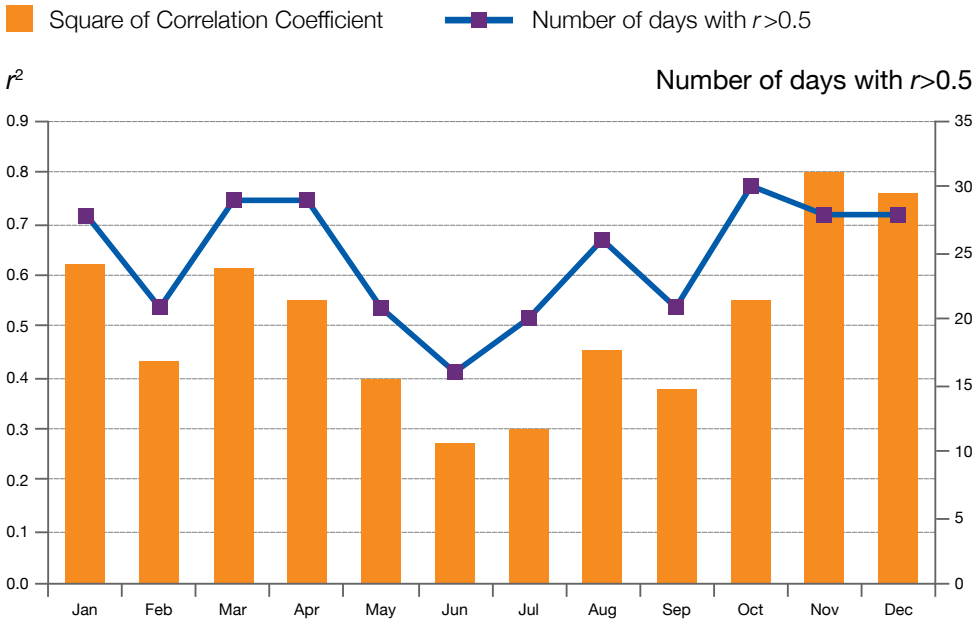


Chart 13 illustrates the correlation between the WEP and metered energy quantity in 2017. The highest r^2 value recorded during the year was 0.80 in November, when there were 28 days when r was greater than 0.5. The lowest r^2 value of 0.27 occurred in June, when there were 16 days with r greater than 0.5.

Chart 14: Correlation between WEP and Metered Energy Quantity

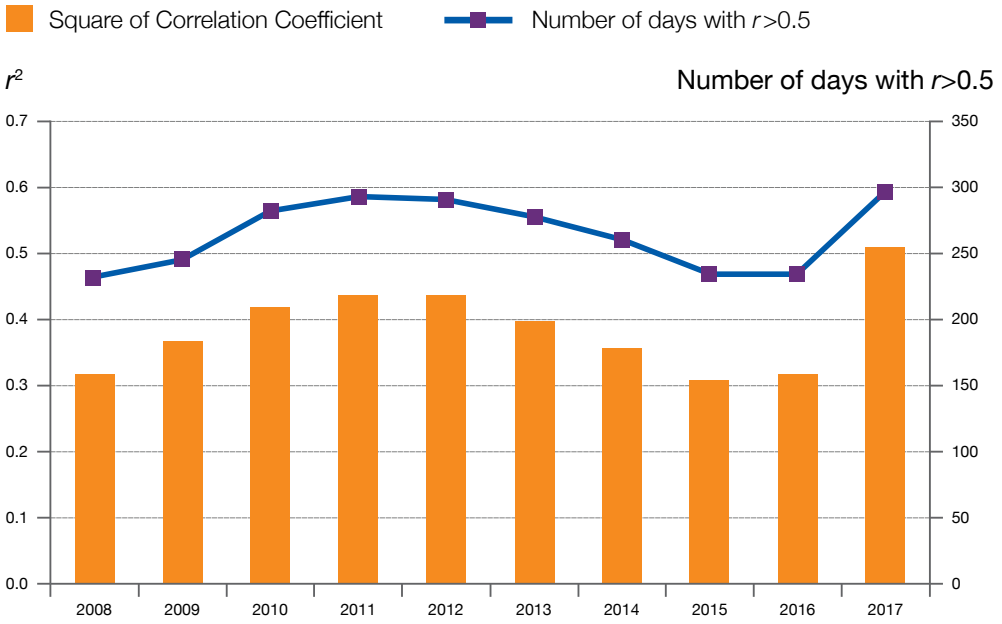


Chart 14 shows the correlation between the WEP and metered energy quantity from 2008 to 2017.

There was no major fluctuation in either index from 2008 to 2016. Significant changes were seen in 2017 – the r^2 value rose to 0.51 and the number of days with r greater than 0.5 increased to 297. These figures were the highest recorded since the market started, suggesting the growing influence of demand on energy prices.

Chart 15: Percentage of Hours when WEP Falls into a Particular Price Range

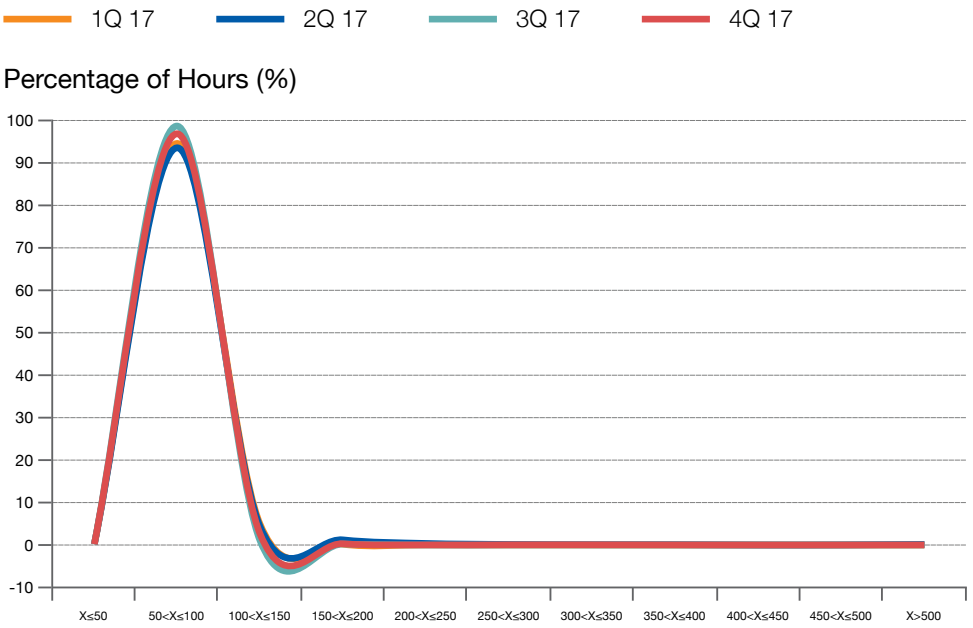


Chart 15 illustrates the distribution of the WEP based on percentage of hours of occurrence in 2017. Prices for all four quarters mostly settled in the $50/MWh to $100/MWh tranche.

Chart 16: Percentage of Energy Quantity when WEP Falls into a Particular Price Range

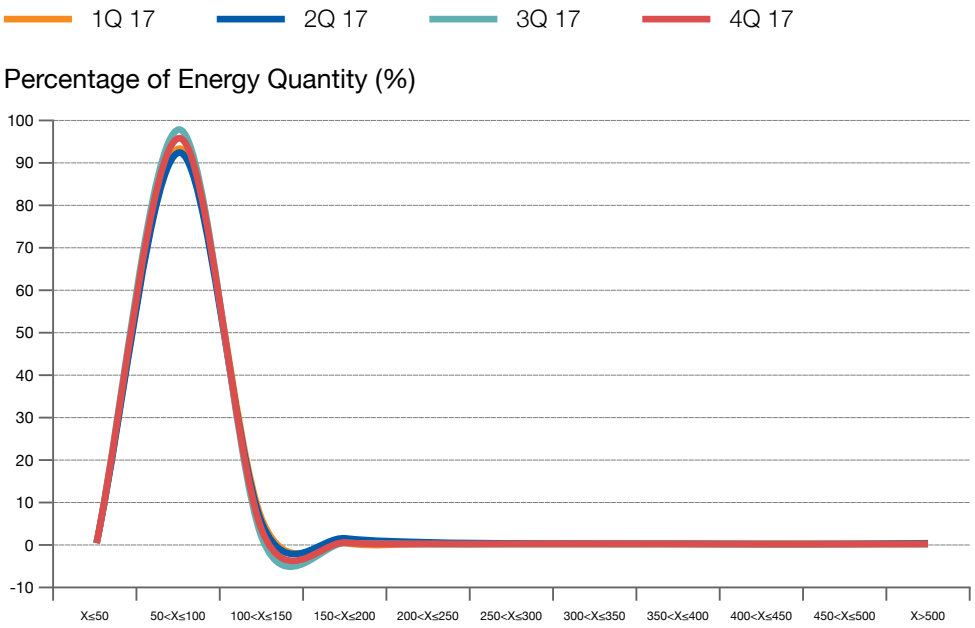


Chart 16 illustrates the distribution of the WEP based on percentage of energy quantity. The distribution is similar to that of the WEP by percentage of hours of occurrence (Chart 15).

Chart 17: Percentage of Hours when WEP Falls into a Particular Price Range

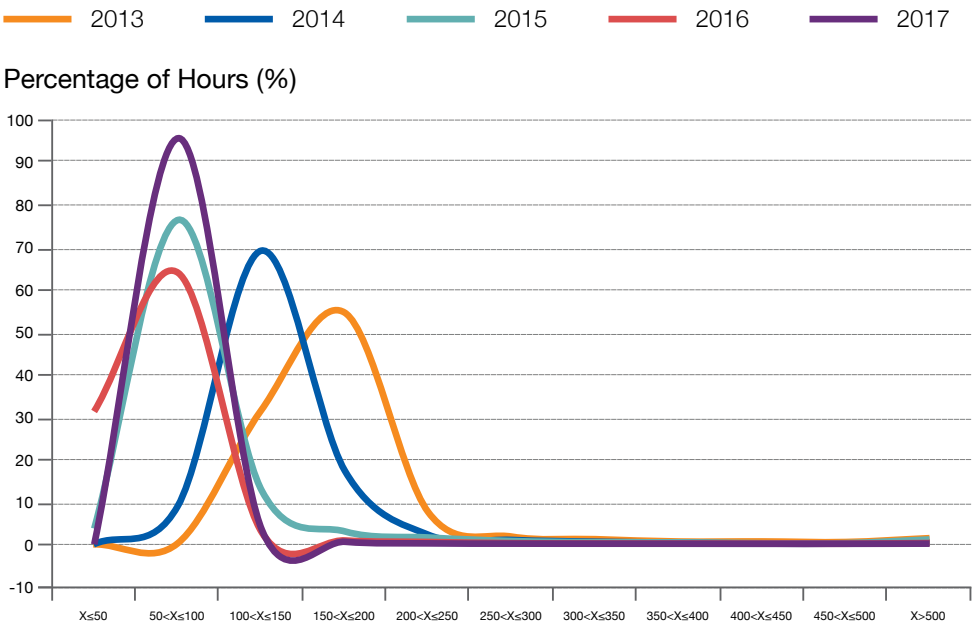


Chart 17 juxtaposes the historical price distribution curves with the price distribution curve of 2017, allowing us to examine longer-term trends. From 2013 to 2016, the percentage of hours of WEP distribution gradually shifted to a lower price range, reaching the lowest level in 2016. 2017 saw a reversing trend – more than 95 percent of the time, the WEP fell at the high end of the price tranche of between $50/MWh to $100/MWh, settling slightly above $80/MWh.

Chart 18: Percentage of Energy Quantity when WEP Falls into a Particular Price Range

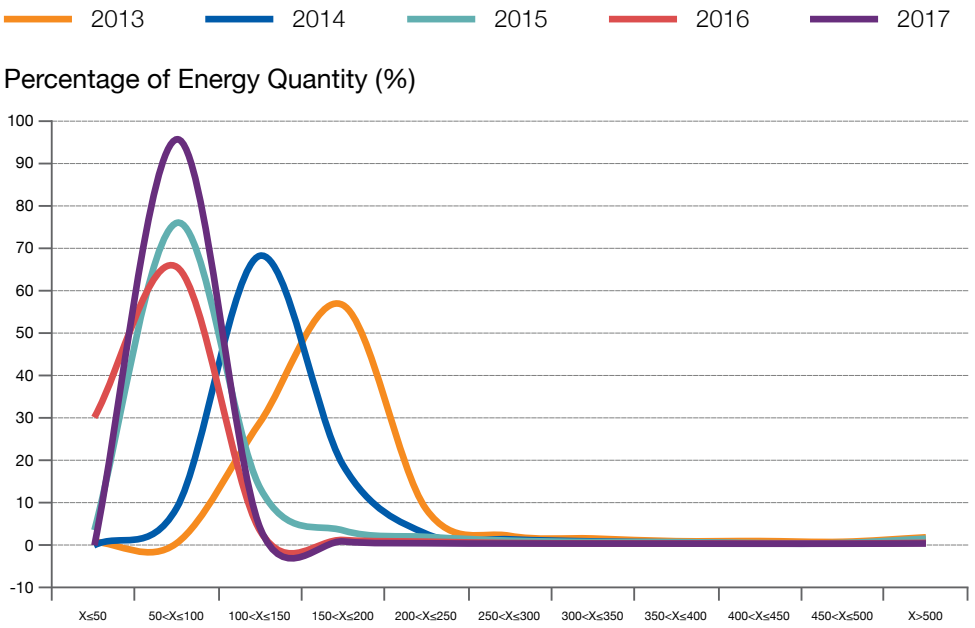


Chart 18 shows the long-term trend in the distribution of the WEP from 2013 to 2017 based on percentage of energy quantity, permitting the same observations as Chart 17.

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

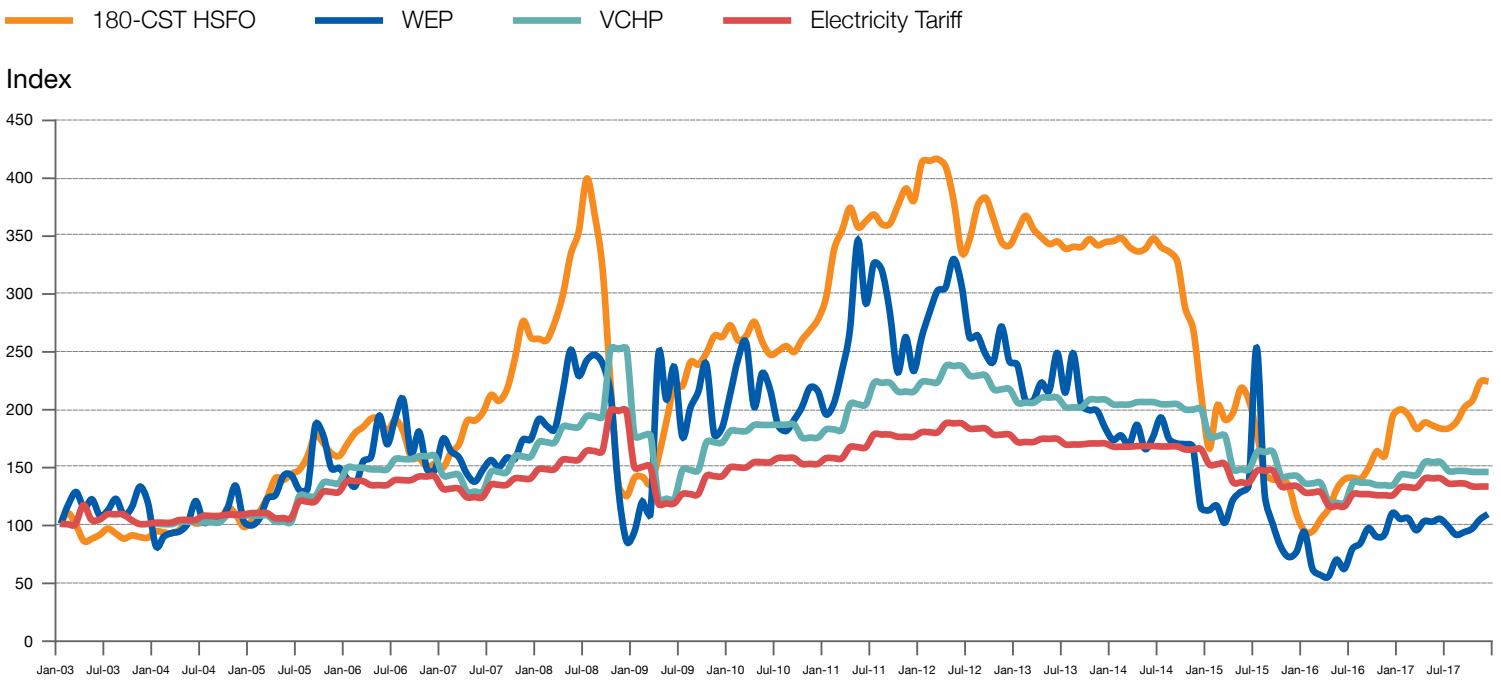


Chart 19 shows the correlation between the high sulphur fuel oil (180-CST HSFO) price, the VCHP, the WEP and electricity tariff. In 2017, the fuel oil price traded at an average of US$55.64/bbl, an increase of 45.7 percent from 2016. This is the first year that the fuel oil price increased after four consecutive years of decline since 2012. The WEP rose 27.5 percent to reach $81.19/MWh in 2017. Despite the increase, this was still the second lowest price since the market started. The monthly average WEP ranged from $73.49/MWh to $87.97/MWh. The peak monthly average WEP of $87.97/MWh was recorded in December 2017.

Chart 20: Average Reserve Prices

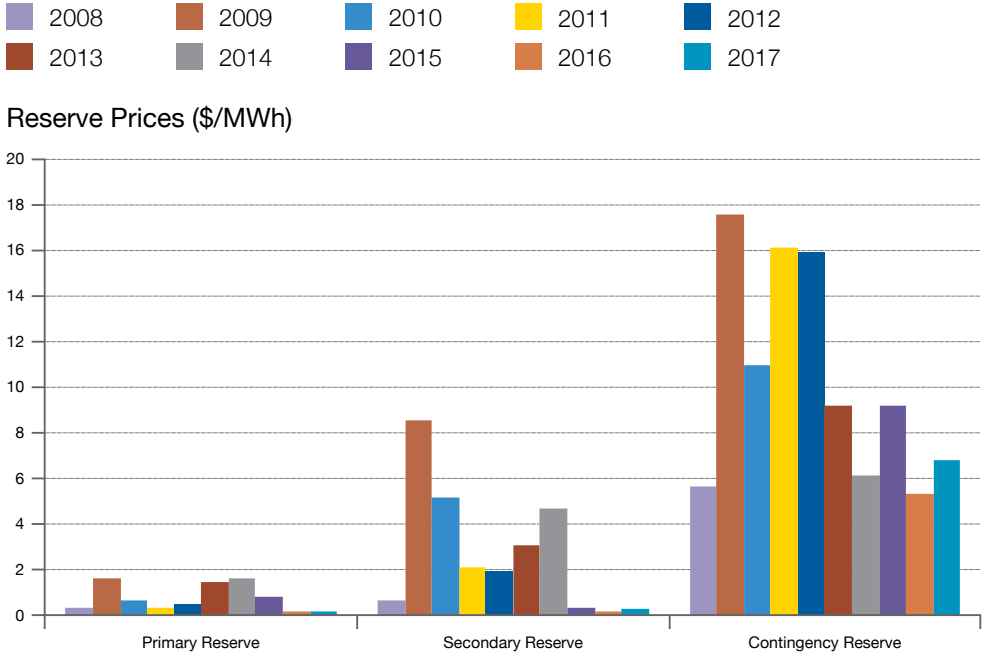
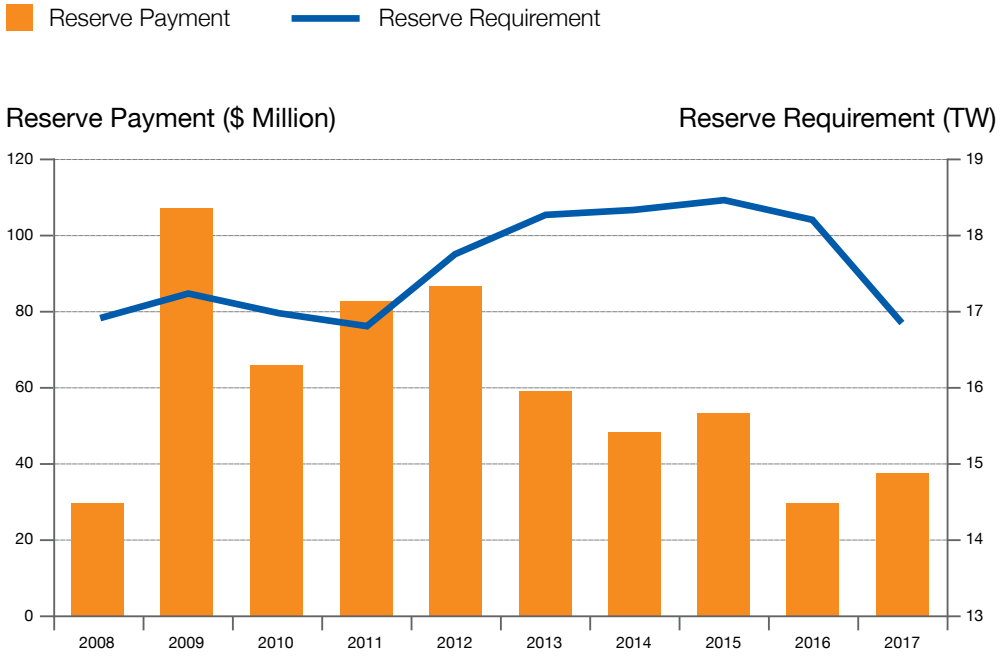


Chart 21: Annual Reserve Payment and Requirement

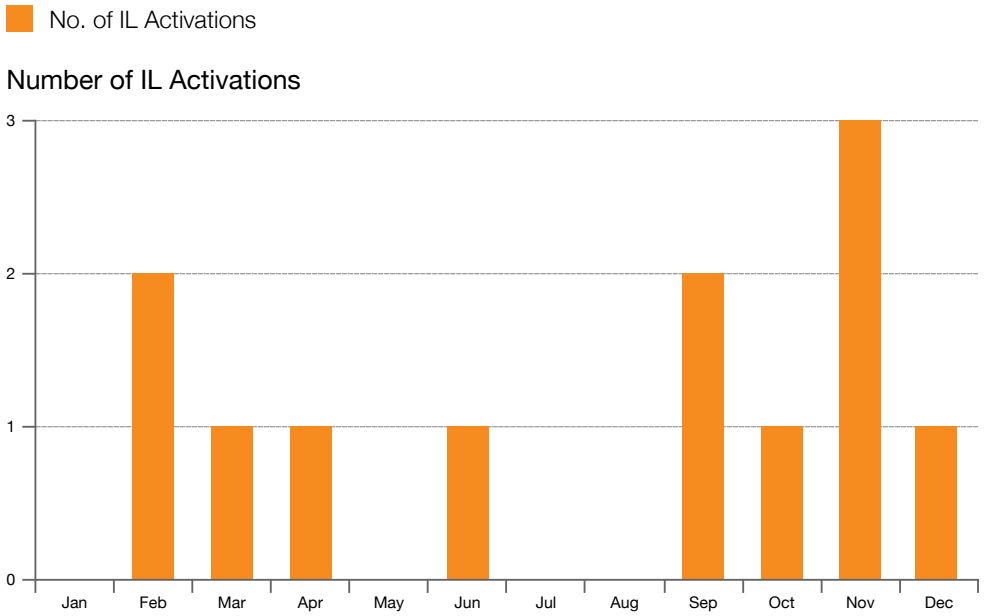


With effect from 1 October 2017, the primary and secondary reserve classes were combined into a single primary reserve class. Hence, the secondary reserve price discussed in this report is only for January to September 2017.

From Chart 20, it can be seen that the average price for primary, secondary and contingency reserves increased 42.4 percent, 89.2 percent and 27.9 percent in 2017, to reach $0.19/MWh, $0.48/MWh and $6.74/MWh respectively. The average prices for both primary and secondary reserves recorded the second lowest levels since the market started.

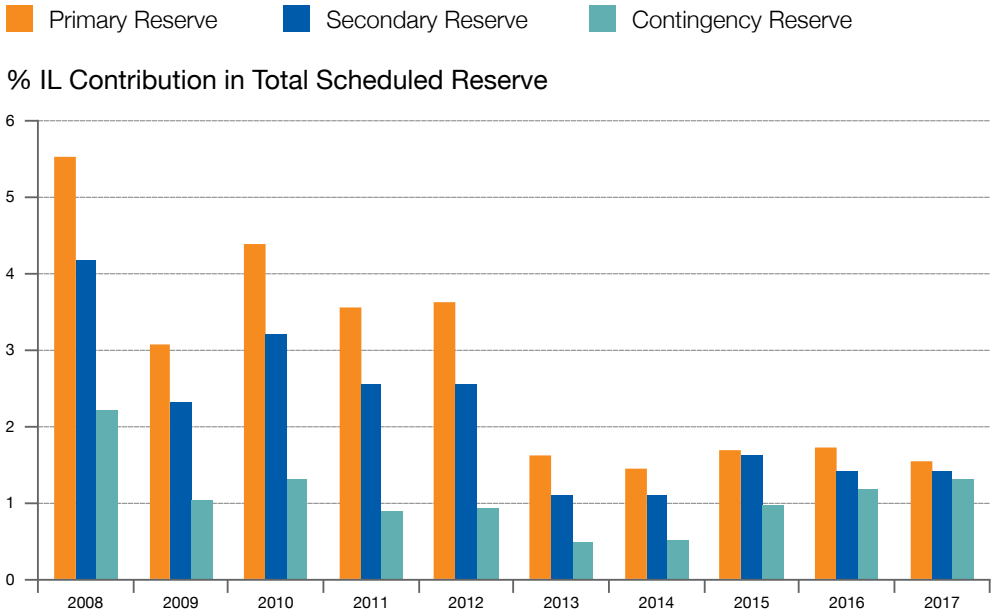
The total reserve payment increased 26.9 percent from $29.3 million in 2016 to $37.2 million in 2017, as seen in Chart 21. This is the third lowest level since the market started. The lowest and the second lowest levels were seen in year 2016 and 2008 respectively.

Chart 22: Number of IL Activations in 2017



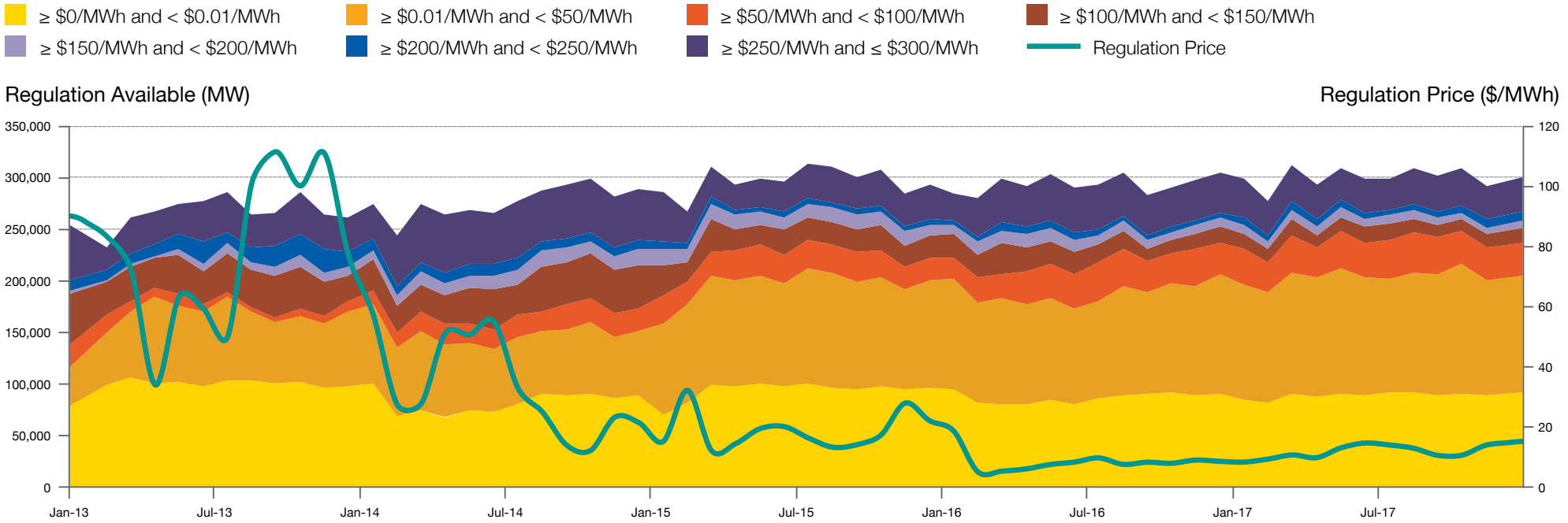
From Chart 22, it can be seen that in 2017, Interruptible Load (IL) was activated on 12 occasions to provide reserve, compared to 11 occasions in 2016. IL was activated on three occasions in the month of November, twice each in February and September, and once each in March, April, June, October and December.

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



The percentage contribution from IL in the contingency reserve class in 2017 was higher than that in 2016, as seen in Chart 23. There was a drop in the percentage contribution from IL in both primary and secondary reserves.

Chart 24: Regulation Availability vs Regulation Price



The average regulation price increased 42.4 percent from $8.06/MWh in 2016 to $11.48/MWh in 2017. Despite the increase, this was still the second lowest yearly regulation price since the market started. The 2017 peak monthly regulation price of $14.44/MWh was observed in December.

Chart 24 shows the regulation offer patterns in various offer tranches. The biggest change can be observed in the "≥$0.01/MWh and <$50/MWh" offer tranche, where the proportion of offers increased 3.8 percentage points to reach 38.5 percent in 2017. The biggest decrease of 2.3 percentage points can be observed in the "≥$250/MWh and ≤$300/MWh" offer tranche.

ECONOMETRIC MODEL AND OUTLIER PRICES

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[9]. 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 81 percent. The three variables selected were: lagged fuel oil price, supply cushion and CCGT supply.

[9] 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 2017

Variable	Coefficient	P-value
Constant	8.42	0
LOG (Lagged Fuel Oil Price)	0.88	0
LOG (Supply Cushion)	-0.81	0
LOG (CCGT Supply)	-0.53	0

Model Diagnostics	
R-squared	0.81
Adjusted R-squared	0.81
Number of observations	5,449

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 0.88 unit increase in the logarithm of the USEP;
- a one unit increase in the logarithm of the supply cushion will bring about a 0.81 unit decrease in the logarithm of the USEP; and
- a one unit increase in the logarithm of the CCGT supply will bring about a 0.53 unit decrease in the logarithm of the USEP.

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

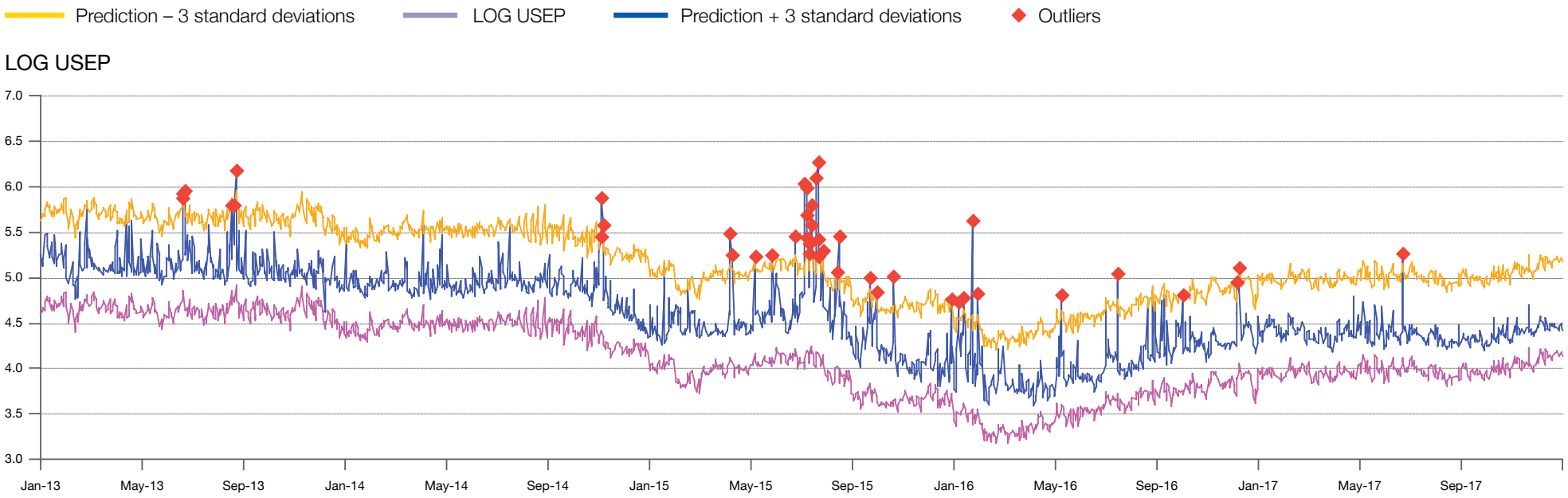
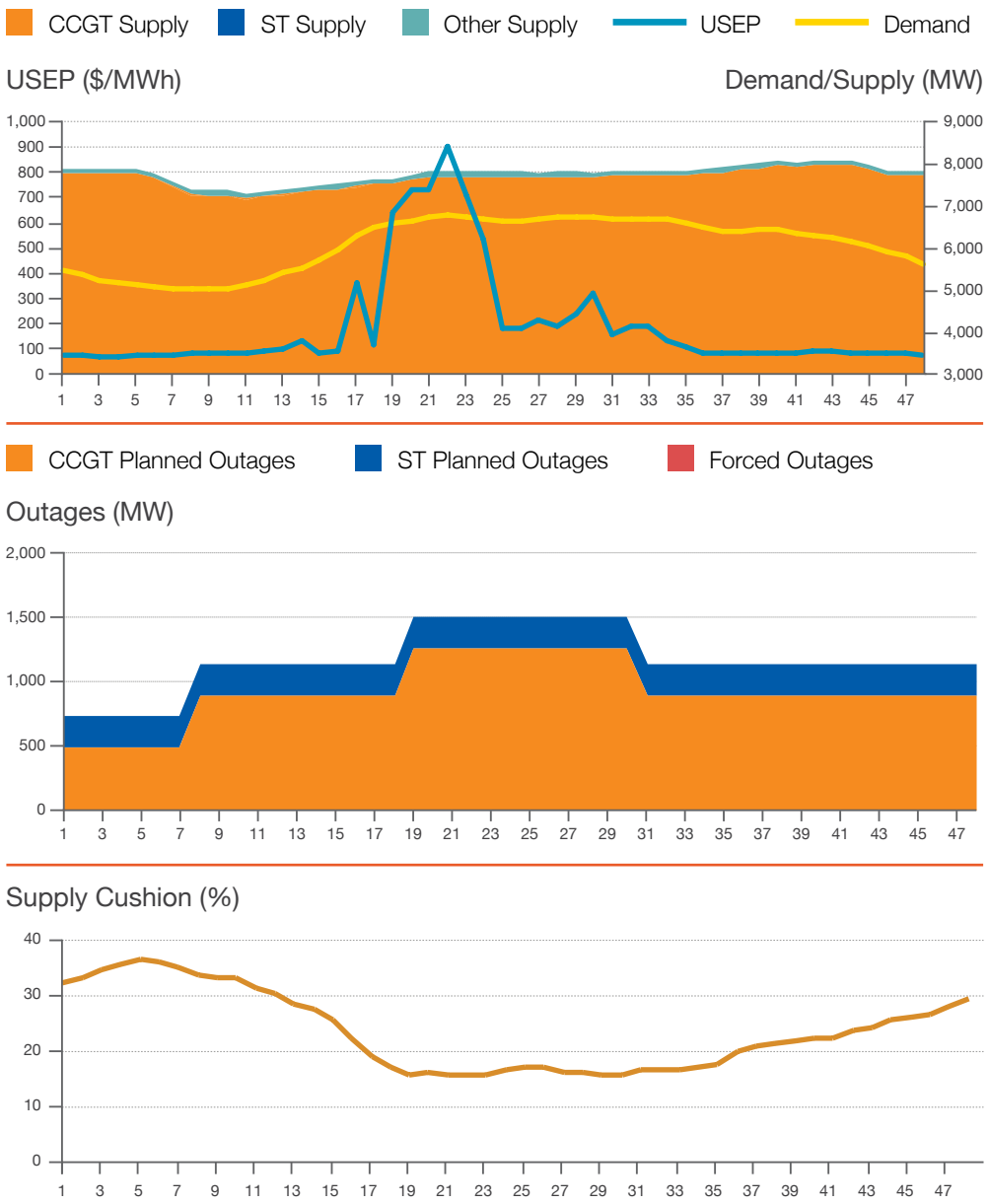


Chart 25 illustrates the actual daily average USEP, the upper and lower bands of the estimated USEP, and the outliers identified by the econometric model, from January 2013 to December 2017. In 2017, there was only one day in which outlier prices were detected by the model and it will be discussed in this report.

Chart 26: Demand and Supply Conditions — 22 June 2017



Date	Thursday 22 Jun 2017	All Thursdays in Jun 2017
Daily USEP ($/MWh)	193.23	102.11
Max USEP ($/MWh)	902.94	902.94
No. of USEP ≥ $1,000/MWh	0	0
Demand (MW)	6,071.69	6,019.89
Supply Cushion (in %)	23.34	26.17
Offers ≤ $100/MWh (in %)	78.40	78.57

Summary

On Thursday, 22 June 2017, there were six periods during which the USEP rose above $500/MWh, reaching as high as $902.94/MWh.

The high prices were largely due to a lower supply cushion caused by high demand and a high level of planned outage (1,136MW), with four CCGT units and one ST unit being taken out of the grid. An additional forced outage of 365MW of a CCGT unit during the affected periods exacerbated the situation.

During the periods of high USEP, the supply cushion averaged 15.4 percent, providing upward price pressure for the affected periods, which in turn brought up the daily USEP. Contingency reserve shortfalls were reported for four out of the six periods, with the lowest supply cushion of 15.0 percent registered for the peak USEP period.

INVESTIGATIONS

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 2017, 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.

Table 8: Investigation and Enforcement Statistics

	Rule Breaches	1 Jan 2003 to 31 Dec 2017	1 Jan to 31 Dec 2017
(A)	**Total number of offer variations after gate closure received**	36,279	719
	Total number of cases closed	36,200	743
	- cases in which the MSCP determined a breach	136	2
	- cases in which the MSCP determined no breach	16,387	730
	- cases in which the MSCP took no further action	19,677	11
(B)	**Origin of cases (excluding offer variations after gate closure)**	183	3
	- self-reports	158	3
	- referrals or complaints	18	0
	- initiated by the MSCP	7	0
	Total number of cases closed	183	3
	- cases in which the MSCP determined a breach	126	2
	- cases in which the MSCP determined no breach	13	1
	- cases in which the MSCP took no further action	43	0
	- cases in which the MSCP issued suspension order	1	0
(C)	**Number of formal MSCP hearings**	7	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	$1,126,861	$5,000
(E)	**Costs**		
	- highest award of costs imposed on a party in breach	$43,750	$1,500
	- total costs imposed on parties in breach	$238,675	$4,500

Market Efficiency and Fairness	1 Jan 2003 to 31 Dec 2017	1 Jan to 31 Dec 2017
Total number of cases	7	0
- referrals or complaints	2	0
- initiated by MSCP	5	0
Total number of cases closed	7	0

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 2017, 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 2017 is as follows:

Market Structure and Competition

Entry of new market participants

Nine new market participants (MPs) joined the National Electricity Market of Singapore (NEMS) in 2017 as shown in the table on the right.

There has been a steady influx of independent electricity retailers joining the NEMS over the last few years. In 2017, six new electricity retailers registered in the NEMS. This brings the total number of electricity retailers in the NEMS to 22.

New facilities in the market

Eight new generating facilities were introduced in the NEMS in 2017.

Of these, four are generation settlement facilities from Changi Mega Solar Pte Ltd, Cleantech Solar Singapore Assets Pte Ltd, LYS Genco Beta Pte Ltd and Public Utilities Board as shown in the table on the right.

Singapore Refining Company Pte Ltd registered two embedded facilities in May and June with generating capabilities of 37.5MW and 39.45MW respectively. ExxonMobil Asia Pte Ltd increased its existing embedded generation and added two more embedded facilities of 40.39MW each. With these additions, the total registered capacity of embedded facilities in the NEMS is 614.89MW.

In addition, on 23 October 2017, Diamond Energy Merchants Pte Ltd registered the first load facility of 7.20MW under the demand response programme in the NEMS.

New market participants

	Name of MP	Date Joined NEMS
Retailers	Union Power Pte Ltd	17 February 2017
	Cleantech Solar Singapore Assets Pte Ltd[10]	5 April 2017
	Just Electric Pte Ltd	5 April 2017
	Energy Supply Solutions Pte Ltd	9 May 2017
	SilverCloud Energy Pte Ltd	30 August 2017
	SmartCity Energy Pte Ltd	3 October 2017
Wholesale Market Traders	Changi Mega Solar Pte Ltd	28 February 2017
	Public Utilities Board	9 November 2017
	Sunseap Leasing Beta Pte Ltd	9 November 2017

[10] Previously known as Cleantech Solar Management Company Pte Ltd

New generation settlement facilities

Name of MP	Registered Capacity
Changi Mega Solar Pte Ltd	2.844MW
Cleantech Solar Singapore Assets Pte Ltd	1.26MW
LYS Genco Beta Pte Ltd	1.86MW
Public Utilities Board	0.803MW

Deregistration of facilities

Three facilities deregistered from the NEMS in 2017. Diamond Energy Merchants deregistered one of its interruptible load units on 1 January 2017. A 1.48MW unit from ECO Special Waste Management Pte Ltd was deregistered from the market on 17 May 2017. Banyan Utilities Pte Ltd also deregistered its 5MW unit from the market on the same date.

Withdrawal of market participant

Following the deregistration of its unit in May, ECO Special Waste Management Pte Ltd withdrew its market participant registration from the market on 7 December 2017.

Market Price Behaviour

Rebound in USEP in 2017

This year saw an increase of 27.9 percent in the average Uniform Singapore Energy Price (USEP) from $63.28/MWh in 2016 to $80.91/MWh. The Wholesale Electricity Price increased 27.5 percent from $63.69/MWh to $81.19/MWh.

The higher energy prices coincided with higher fuel oil prices across all four quarters of 2017. In 2017, there was a 45.7 percent increase in the fuel oil prices on a year-on-year basis to US$55.64/bbl.

Another driver of the higher energy prices was the increase in system demand from 5,688MW to 5,748MW in 2017. This was attributed to a higher month-on-month demand in 2017 for all months in the year, except for April.

Efficiency of the Electricity Markets

Productive efficiency

The market shares of Combined Cycle Gas Turbine (CCGT) units and other facilities (OT) based on metered energy quantity remained the same at 98.1 percent and 1.9 percent respectively this year.

In terms of maximum capacity, there was a slight increase of 0.1 percentage point in the market share of CCGT units to 77.6 percent in 2017. The market share of Steam Turbine (ST) units decreased 0.1 percentage point. The market share of OT and Open Cycle Gas Turbine (OCGT) units remained relatively constant in 2017.

The high market share of CCGT units supports the view that productive efficiency continues to exist in the market in 2017.

Pricing efficiency

While the average USEP climbed in 2017, prices generally reflected relative supply and demand conditions. Higher demand in 2017 resulted in the prices being cleared at the higher price-offer tranches.

Looking Ahead

Review of mechanisms to mitigate credit default

A review was conducted in 2017 on the mechanisms to mitigate credit defaults in the wholesale electricity market. On 1 April 2018, a rule change will be implemented to revise the formula calculating the prudential requirements of new MPs and to bring forward the deadline for the submission of bilateral contract quantities from T+4 business days to T-10 calendar days.

Move towards full retail competition in the electricity market

Starting in April 2018, households and businesses in Jurong can choose to buy electricity from a retailer of their choice, instead of buying electricity from SP Group at the regulated tariff. This is in tandem with the Energy Market Authority's (EMA) move towards full retail competition in the electricity market in the second half of 2018.

Launch of Singapore's first utility-scale energy storage system

The EMA and SP Group have awarded CW Group Pte Ltd and Red Dot Power Pte Ltd a grant for the initiative to build the test-bed for Singapore's first utility-scale Energy Storage System. The test-bed is expected to be operational for three years at two substation locations, with an aggregated capacity of 4.4MWh. Energy storage is expected to facilitate greater deployment of solar.

Development of solar forecasting capabilities

A research consortium led by the National University of Singapore has received a grant from the EMA to look into improving the accuracy of solar photovoltaic output forecasts and grid management using techniques in weather prediction, remote sensing, machine learning and grid modelling. The aim of the research is to enable the Power System Operator to know the solar photovoltaic power output ahead of time in order to take appropriate actions to balance the grid.

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 2017 and the previous year.

There were 719 cases of offer variations made after gate closure in 2017. This was 18.65 percent higher than in 2016. The increase was mainly due to a new MP entering the market. The number of offer variations after gate closure from this new MP accounted for 59.3 percent of the total increase in the number of offer variations after gate closure in 2017.

Table 9: Offer Variations After Gate Closure

Number of offer variations made after gate closure from 1 January 2016 to 31 December 2016	606
Number of offer variations made after gate closure from 1 January 2017 to 31 December 2017	719
Increase in number of offer variations made after gate closure for year 2017 from previous year	18.65%

Rule Breaches

For the period 1 January to 31 December 2017, the MSCP made three determinations regarding rule breaches. The determinations were made against Senoko Energy Pte Ltd and Energy Market Company Pte Ltd (EMC).

The rule breach determinations were as follows:

- Senoko Energy Pte Ltd's failure to comply with gate closure rules on 23 January 2017.
- EMC permitting access to confidential information on EMC's website on 19 April 2017.
- EMC's incorrect offer submission on 9 June 2017.

Overall, there were no major compliance issues arising within the wholesale electricity markets in 2017.

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 2017, it was observed that 13 generation companies were issued with automatic financial penalties for a total sum of $530,283.45 by the NEMS.

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 2017. Over the year, the MSCP determined three cases of rule breaches. The number of offer changes made after gate closure picked up from 606 to 719, largely driven by violations from a new market participant (MP). In all, rule breaches and gate closure violations were found not to have had any significant impact on the NEMS.

After four consecutive years of decline, the average Wholesale Electricity Price in 2017 rebounded 27.5 percent over the previous year to $81.19/MWh. Outlier prices were extremely rare. They were observed only for one day, significantly down from nine a year ago. Generally, wholesale energy prices have responded reasonably to changes in fundamental demand and supply drivers.

There has been significant structural improvement in the market. The concentration level in the generation sector diluted further as the combined market share of the three largest generation companies fell 2.3 percentage points to 55.5 percent. On the retail front, a total of six new participants entered the market. With a total of nine new participants across all classes and only one withdrawal, the level of competition in the NEMS has risen further.

Significant momentum has gathered in the past year in new areas such as intermittent generation and large capacity energy storage systems. Going forward, 2018 is set to be yet another year of major development for the NEMS with full retail contestability set to be implemented in the form of the Open Electricity Market. The MSCP looks forward to the integration of new technologies from both demand and supply sides into the NEMS to realise more efficiency gains for the Singapore electricity industry.

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.

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