nems National Electricity Market of Singapore

MARKET SURVEILLANCE & COMPLIANCE PANEL

ANNUAL REPORT

2019

CONTENTS

EXECUTIVE SUMMARY

The Market Surveillance and Compliance Panel (MSCP) Annual Report collects data and information to cover the period from 1 January to 31 December 2019. It is based on analyses of data and monitoring indices compiled by the Market Assessment Unit to assess the performance of the wholesale electricity market on an annual basis. This report is reviewed and approved by the MSCP and highlights key observations for 2019 relative to 2018 regarding a set of supply, demand and price indices.

Supply Indices

- On the supply side, the average supply cushion[1] remained basically unchanged, recording spare capacity available after dispatch from a level of 25.41% in 2018 to 25.46% in 2019.

- In line with the above, 2019 observed a slight increment in the capacity ratio[2] of the Combined Cycle Gas Turbine (CCGT) units (1.39 percentage points) averaging 63.31%, as well as in the capacity ratio of the Steam Turbine (ST) units, which increased from an annual average of 0.12% in 2018 to 0.16% in 2019.

- The concentration level in the generation sector increased slightly, with the combined market share of the three largest generation companies rising 0.12 percentage point from 2018 to a level of 53.31% based on metered energy quantity.

- The generation market share of CCGT units continues to be the highest by technology type in Singapore at 98.20% based on metered energy quantity and 80.03% based on maximum capacity. In particular, the market saw the de-registration of five ST units, a less efficient generation technology type, with a total of 1,191MW installed capacity.

- The marginal increment in the supply indices, despite an upward trend in generation, is explained by a 15.13% increase in the average total generation outage per period in 2019, to 1,355MW. This was driven by a higher average forced outage level per period, from 14MW in 2018 to 74MW in 2019.

Demand Indices

- On the demand side, the average actual demand in 2019 was about 5,890MW, compared to 5,750MW in 2018. This represents a year-on-year growth of 2.44%, a higher annual increase from the 1.45% annual actual demand growth registered in 2018. The monthly average electricity actual demand peaked in September 2019 at 6,098MW, compared to the 5,928MW monthly average peak actual demand recorded in May 2018.

- The accuracy of real-time load forecast in 2019 improved slightly. The average forecast error decreased by 0.12 percentage point to 2.46% and represents the second lowest forecast error level recorded in the history of the National Electricity Market of Singapore.

Market Prices

- The Wholesale Electricity Price in 2019 averaged below the $100/MWh level, at $98.63/MWh, which was 10.74% lower than the average observed in 2018. The price movement was primarily driven by a 5.96% reduction in the annual average price of fuel oil, from US$73.09/bbl in 2018 to US$68.73/bbl in 2019.

- The total reserve payment rose 8.81% from $77.29 million in 2018, to $84.10 million in 2019. This increment responded to the provision of contingency reserve services cleared at higher prices during 2019.

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

INTRODUCTION

The Market Surveillance and Compliance Panel (MSCP) is an independent body established under the Singapore Electricity Market Rules (Market Rules). The work of the MSCP is guided by the functions and duties assigned to it under the Market Rules, namely the monitoring, surveillance, and investigation responsibilities, in the National Electricity Market of Singapore (NEMS).

The Market Rules establish that the MSCP monitors and investigates the conduct of market participants, the Market Support Services Licensee, the Power System Operator (PSO) and the Energy Market Company Pte Ltd (EMC), as well as the structure and performance of, and activities in, the wholesale electricity market that could provide indications of the following phenomena:

- breaches of the Market Rules, the market manuals, or the System Operation Manual;

- actual or potential design or other flaws and inefficiencies in the Market Rules, market manuals, System Operation Manual, and other rules and procedures of EMC or the PSO. This includes an assessment on whether the underlying structure of the wholesale electricity market is consistent with the efficient and fair operation of a competitive market; and

- actual or potential design or other flaws in the overall structure of the wholesale electricity market.

When appropriate, the MSCP may exercise the enforcement powers conferred to it under the Market Rules and recommend remedial actions to mitigate the conduct and inefficiencies referred to above. This includes, but is not limited to, the imposition of financial penalties and the issuance of non-compliance letters, suspension orders, termination orders, and revocation orders. All enforcement actions are administered by EMC at the direction of the MSCP.

Additionally, the MSCP assists the Energy Market Authority (EMA) to fulfil its obligations with respect to competition and abuse of a dominant position under sections 50 and 51 of the Electricity Act, Chapter 89A.

Structure and Composition of the MSCP

Appointments to the MSCP are made by the EMC Board for a three-year term of office, subject to reappointment. The appointed Panel members are specially selected to ensure that the MSCP has combined extensive experience covering the areas of competitive wholesale electricity market or financial or commodity markets, Singapore laws and/or electricity regulations, competition laws and policies, power system operation, and/or economics.

The current composition of the MSCP reflects an appropriate mix of skill sets, experience, and qualifications that are relevant to assess and safeguard the governance of the market. In exercising its fiduciary duties, the MSCP is supported by the Market Assessment Unit (MAU).

Mr. T P B Menon, MSCP Chair

Mr. Menon is currently a Consultant with Wee Swee Teow LLP. Mr. Menon was admitted to the Bar on 26 January 1962. He practised with Oehlers & Choa from 1962 to 1988, becoming a Senior Partner in 1980. Following the merger of Wee Swee Teow & Co with Oehlers & Choa in 1989, Mr. Menon took on the role of Senior Partner at Wee Swee Teow & Co., retiring in 2002 and then acting as a consultant to the firm.

Mr. Menon was President of the Law Society from 1980 to 1983 and President of the ASEAN Law Association from 1984 to 1986. He was a member of the Military Court of Appeal from 1980 to 1990 and President of the Strata Titles Boards from 1990 to 1993. He also served as Deputy Chairman of the Board of Legal Education from 1978 to 2001.

Mr. Menon was Chairman of the Disciplinary Committee of the Law Society appointed by the Chief Justice from 1991 to 2004 and a member of the Advisory Editorial Board of Halsbury's Laws of Singapore. He has published several articles and delivered papers at international conferences. Mr. Menon was awarded a PBM (Pingat Bakti Masyarakat - Public Service Medal) in 1993.

Er. Lee Keh Sai

Er. Lee Keh Sai is a registered Professional Electrical Engineer (PEng) and a Chartered Engineer (CEng). He specialises in electrical power engineering, energy management and power quality solutions and is the Principal of K. S. Lee & Associates, which he established in 1970.

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Er. Lee was the Chairman of the Professional Interviewing Panel for the Professional Engineers Board. He has also served in many professional associations, government agencies, and technical educational institutions (e.g. Deputy Chairman of the Singapore Polytechnic Board of Governors and board member of the Institute of Technical Education). He is also an accredited Arbitrator and an Engineering Expert Member of the Institution of Engineers, Singapore (IES). He has been serving as a member of the Strata Titles Board and as an engineering expert on the Market Surveillance and Compliance Panel of EMC.

Er. Lee has regularly published technical papers in the IES Journal on topics such as energy efficiency and electrical protection systems and has been teaching Singapore Certified Energy Manager (SCEM) courses on "Motor Driven Systems" since 2010. He is also a certified trainer for the preparatory course for the registration examination of the Professional Engineer Board, Part II "Practice of Professional Engineering" in Electrical Engineering.

Mr. Philip Chua

Mr. Philip Chua is a Consultant in the financial industry. Prior to this, he was the Senior Country Executive of American Express Bank Singapore. As the bank's Chief Executive, he drove local integration of global strategic directions, and was also responsible for the bank's governance. Concurrently, Mr. Chua was the Head of Global Financial Markets South East Asia, Global Product Head of the Collateralized Trading Program, and Regional Treasurer for Asia, positions which he assumed progressively after joining the bank. He also served as a Council Member of the Association of Banks in Singapore and was a lecturer with the Institute of Banking & Finance.

Mr. Chua's vast experience in financial markets began with his banking career at Chase Manhattan Bank, where he was Second Vice President and Senior Dealer, Money Market, before joining American Express Bank.

Mr. Chua holds a Master's in Business Administration from the Kelley School of Business at Indiana University, Bloomington, Indiana, U.S.A., and a Bachelor of Science in Business Administration, Summa Cum Laude, from the University of Oregon, Eugene, Oregon, U.S.A.

Professor Euston Quah

Professor Euston Quah is Albert Winsemius Chair Professor and Head of Economics at the Nanyang Technological University (NTU) of Singapore. He is a member of the Social Science Research Council of Singapore and a Board Member of the Competition and Consumer Commission of Singapore. Professor Quah is also the President of the Economic Society of Singapore.

His academic career in NTU has included several senior administrative positions over the years, including Chair of the School of Humanities and Social Sciences, Vice-Chair of the Sustainable Earth Office, Chair of the Senate Committee on University Policies, and Member of the University Teaching Council.

Prior to joining NTU, Professor Quah was Vice-Dean of the Faculty of Arts and Social Sciences, Deputy Director of the Centre for Advanced Studies, Deputy Director of the Public Policy Program (now called the Lee Kuan Yew School of Public Policy), and Head of the Department of Economics at the National University of Singapore (NUS).

In his continuing career as an economic advisor, Professor Quah has been advisor to many government ministries and statutory boards in Singapore as well as to overseas organisations including the Asian Development Bank and the World Bank. He is a member of the Panel for the Bill and Melinda Gates Foundation, for the Overseas Development Institute of London and has served as a Board of Trustees member of the Institute of Southeast Asian Studies, the Energy Market Authority, and the Energy Studies Institute at NUS.

Professor Quah is also a prolific and well-cited writer, having published over 100 articles in academic journals and lead opinion pieces in the media. He is also the author of the bestselling "Principles of Economics" textbook with Gregory Mankiw, an Asian edition (now into its third edition in 2020), and the "Cost-Benefit Analysis" book, which is well-known internationally (into its sixth edition in 2020).

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Professor Walter Woon, Senior Counsel

Professor Woon, Senior Counsel, is the Chairman of RHTLaw Asia. He is currently David Marshall Professor at the Law Faculty of the National University of Singapore and concurrently Dean of the Singapore Institute of Legal Education.

In addition, Professor Woon is Chairman of the Society of International Law Singapore. He is also a member of the Films Appeal Committee, the Criminal Practice Committee of the Law Society of Singapore and the Chancery Bar Association of England and Wales.

Professor Woon has held many prominent appointments in the past, including Attorney-General (2008 to 2010), Solicitor-General (2006 to 2008), Ambassador (1997 to 2006), Legal Adviser to the President and Council of

Presidential Advisers (1995 to 1997) and Nominated Member of Parliament (1992 to 1996).

Professor Woon's main areas of interest are company law, criminal law and international law. He has published many articles, and also written law books and novels.

Decisions of the MSCP

The decisions made by the MSCP lie fundamentally upon the monitoring, evaluations and analyses undertaken by the MAU, which are regularly reported to the MSCP. Under the Market Rules, the quorum for the transaction of any business at a meeting of the MSCP is a simple majority of the appointed members, and all decisions of the MSCP are made by a majority of the votes cast, with each MSCP member eligible to cast one vote unless there exists a conflict of interest that requires the member(s) to abstain from voting on the given matter.

Where the MSCP concludes that a breach has occurred, a report recording the facts and circumstances of the breach and details of any sanctions imposed will be published on EMC's website under Panel Determinations.

Market Assessment Unit

The MAU manages the market surveillance, compliance and dispute resolution processes. It advises and supports three external and independent governance bodies: namely the MSCP, the Dispute Resolution Counsellor (DRC) and the Dispute Resolution and Compensation Panel (DRCP).

The MAU enforces compliance with the Market Rules through its surveillance activities, investigations of alleged rule breaches, and supporting and advising the independent MSCP on enforcement actions. It monitors the outcomes of the wholesale electricity market as well as the behaviour of market participants to ensure that the market is functioning efficiently, and identifies areas of inefficiency. It provides market training to and advises the MSCP on the state of competition and efficiency of the wholesale market for the Panel to recommend changes or remedial actions to the Authority to address areas of inefficiency. The MAU also acts as the key point of communication between the market players and the MSCP.

The MAU assists the DRC to set up and maintain dispute management systems among market participants. It provides market training and operational support to the DRC and the DRCP members on all dispute-related matters.

While the Market Rules provide for employees of the MAU to report and be administratively managed by EMC, the MAU also reports to and takes direction from the Chair of the MSCP on all matters related to the market monitoring and investigation duties contained in the Market Rules.

MSCP Annual Reporting

In accordance with section 4.4.6 of the Market Rules, the MSCP is required to prepare an annual report on the conduct of its monitoring activities and investigations for submission to EMC and its subsequent provision to the EMA.

The annual report includes a summary of routine reports on the MSCP's monitoring and investigation activities, and a summary of any report 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 contains a summary of all complaints or referrals filed and investigations commenced and concluded, a summary of all investigations conducted by the MSCP concerning offer variations after gate closure reported by EMC, and a general assessment by the MSCP of the state of competition and compliance within, and the efficiency of, the wholesale electricity market.

The 2019 Market Surveillance and Compliance Panel Annual Report covers the period 1 January to 31 December 2019. This review provides the MSCP with the opportunity to highlight significant observations.

This is the 18th report issued and published by the MSCP since 2003 on the wholesale electricity market of the NEMS. All annual reports by the MSCP are publicly available on EMC's website under Panel Reports.

MARKET MONITORING

MARKET MONITORING: Catalogue of Data and Catalogue of Monitoring Indices/ Indicators of Market Performance

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.

The Catalogue of Data and Catalogue of Monitoring Indices are publicly available on Energy Market Company Pte Ltd's (EMC) website.

Catalogue of Data

The information contained under the Catalogue of Data is collected by the MAU on a pre-determined frequency from different sources (including EMC, the Power System Operator (PSO) and market participants) and is broadly categorised as follows:

- Generation registered facility characteristics data;
- Transmission system data;
- Supply data;
- Demand data;
- Pricing data; and
- Other data.

Catalogue of Monitoring Indices

The catalogue of monitoring indices adopted by the MSCP include supply indices, demand indices, and price indices, as listed below:

| Type of Indices	Description of Indices
Supply Indices	Capacity ratio of a generation registered facility – Ratio of a generation registered facility's (a) scheduled generation output to (b) maximum generation capacity
	Supply cushion - Ratio of (a) the difference between total offered volume and system demand to (b) total offered volume
	Outage frequency
	Market share by (a) generation licensee and (b) generation registered facility
	Comparison of metered generation quantity with scheduled dispatch quantity by generation registered facility/generation licensee
	Frequency of issuance by the PSO of dispatch instructions deviating from real-time dispatch schedule
	Frequency of offer variations or revisions to standing offers exceeding offer change limits
Demand Indices	Comparison of latest available very short-term load forecast with real-time load forecast
	Comparison of real-time load forecast with metered generation quantity
Price Indices	Trend of the Uniform Singapore Energy Price (USEP), reserve prices and regulation price, and comparison of trends
	Percentage of hours and quantity of load when the Wholesale Electricity Price (WEP) falls into a particular price range
	Correlation between the WEP and system demand
	Correlation between the WEP and fuel price
	Comparison of latest available short-term schedule projected prices with real-time prices

Indicators of Market Performance

The MAU submits regular market performance monitoring updates to the MSCP. These updates include observations of several market performance indicators which are broadly classified into supply, demand, price, energy and ancillary services indices. The MSCP reports its observations from these indices for the year under review in its MSCP Annual Report.

[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.

MARKET MONITORING: Market Share

Chart 1: Market Share Based on Metered Energy Quantity by Generation Company and Generation Type
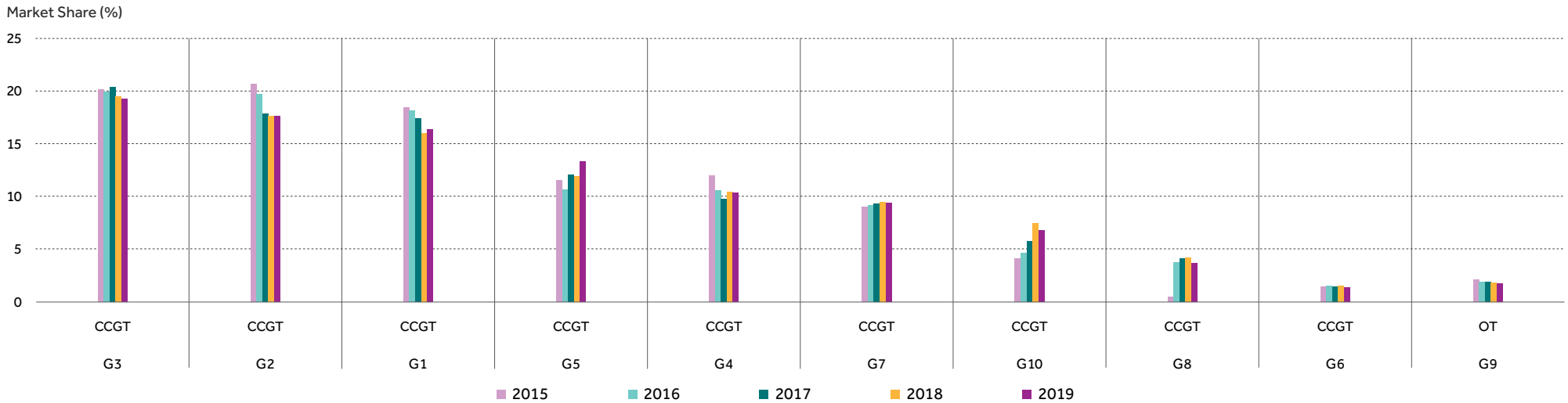
Market Share (%)

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

Chart 1 compares the yearly market share of all generation companies by generation type based on metered energy quantity from 2015 to 2019. It is arranged in descending order according to the Combined Cycle Gas Turbine (CCGT) market share of each generation company in 2019.

The market share for all generation companies is dominated by CCGT units, other than G9, which represents the waste-to-energy generation under the Other Facilities (OT) type. The metered quantities for the market share of Steam Turbine (ST) and Open Cycle Gas Turbine (OCGT) generation units were not significant enough to be shown in Chart 1 as these units barely ran during 2019. This pattern has been observed since the more efficient CCGT units were able to fully serve the system demand.

The total CCGT market share of all generation companies has been gradually expanding by a marginal percentage point since 2015, gained from the declining market share of OT type.

On a year-on-year comparison, based on metered energy quantity, the market share of CCGT units and OT units remained relatively unchanged at 98.20% and 1.74% respectively in 2019. This was reflected by an increment of 0.02 percentage point in the CCGT units' market share and a decrease of 0.03 percentage point in the OT units' market share. The market share of ST units increased by 0.01 percentage point to 0.06% and OCGT units remained close to 0% in 2019.

MARKET MONITORING: Market Share

Table 1: Market Share Based on Metered Energy Quantity by Generation Company (%)

Year	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
2015	18.46	20.65	20.18	11.96	11.51	1.44	9.02	0.51	2.08	4.19
2016	18.14	19.69	19.97	10.57	10.68	1.47	9.14	3.72	1.88	4.74
2017	17.40	17.84	20.37	9.77	12.04	1.46	9.31	4.11	1.86	5.83
2018	16.03	17.64	19.52	10.45	11.91	1.51	9.47	4.21	1.77	7.48
2019	16.36	17.66	19.29	10.35	13.36	1.38	9.41	3.64	1.74	6.81

**Note:** The percentages in this table may not add up to 100% due to rounding.

Table 1 shows the yearly market share of all generation companies in terms of metered energy quantity.

Over the years, generation companies that started with a small market share have been expanding gradually, while the combined market share of the three largest generation companies, G1, G2 and G3, by metered energy quantity has been on a downward trend between 2015 and 2018. However, there is still dominance by the three biggest generation companies with a 0.12 percentage point increase in market share to 53.31% in 2019. The market share of the other generation companies mostly declined.

The market share of the two largest generation companies, G2 and G3, remained relatively unchanged compared to 2018. However, the market share of the next two generation companies in descending order, G1 and G5, showed an increase, which suggests that the market could be moving towards a more balanced share. Apart from G1 and G2, the market share of G5 increased the most in 2019, by 1.45 percentage points.

MARKET MONITORING: Market Share

Chart 2: Market Share Based on Maximum Capacity by Generation Company and Generation Type

Market Share (%)

Legend: 2015, 2016, 2017, 2018, 2019
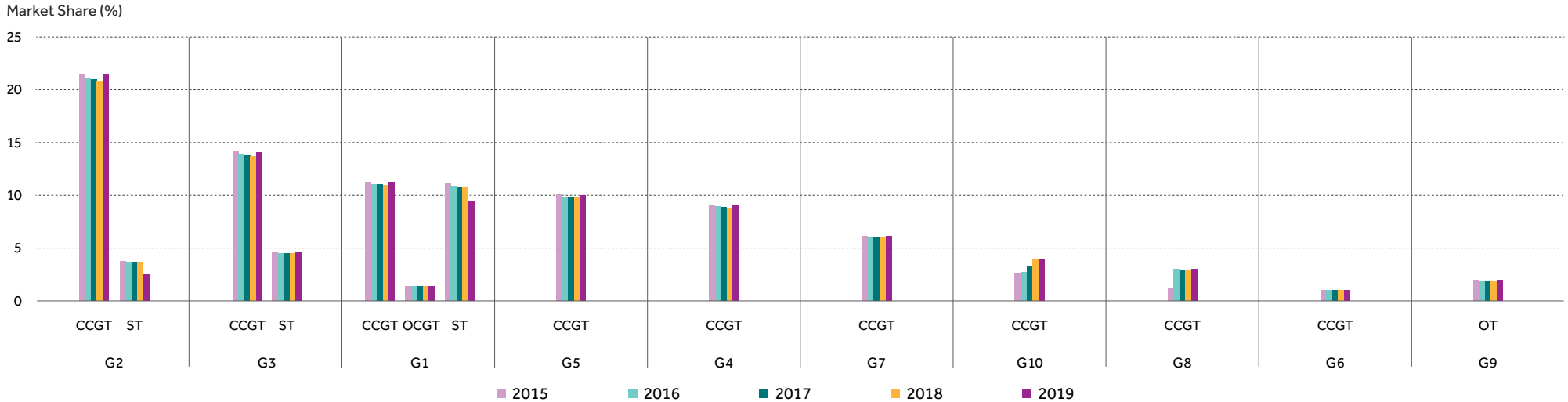
The yearly market share of all generation companies by generation type based on maximum capacity for the past five years is presented in Chart 2, in descending order according to the CCGT market share in 2019.

The total market share of the CCGT unit type has been consistently growing at a slow pace between 2015 and 2019, based on maximum capacity. The latest CCGT unit entered the market in August 2015 with an additional 400MW of capacity, bringing the total market share of CCGT units to 77.09%.

The total market share of the CCGT unit type was at 77.52% in 2016 without new units entering the market and increased by 0.12 percentage point in 2017 with the registration of four new Embedded Generator (EG) units (two in May and the other two in August and October, respectively). The new EG units added a total of 158MW in capacity to the CCGT generation type and contributed to a 0.14 percentage point increase in CCGT market share in 2018.

In 2019, the total market share of the CCGT unit type grew 2.25 percentage points to 80.03% due to the de-registration of two ST units in August and three ST units in September. Correspondingly, the market share of the ST unit type fell 2.34 percentage points to 16.63%.

As observed in Chart 2, based on maximum capacity, the total market share of the CCGT unit type for all generation companies increased across the board in 2019, while the market share of the ST units decreased for generation companies G1 and G2.

MARKET MONITORING: Market Share

Table 2: Market Share Based on Maximum Capacity by Generation Company (%)

Year	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
2015	23.74	25.27	18.73	9.10	10.03	1.02	6.13	1.24	1.97	2.76
2016	23.29	24.80	18.38	8.93	9.84	1.00	6.01	2.97	1.93	2.84
2017	23.17	24.67	18.28	8.89	9.79	1.00	5.98	2.96	1.92	3.35
2018	23.02	24.51	18.16	8.83	9.73	0.99	5.94	2.94	1.91	3.97
2019	22.08	23.94	18.69	9.08	10.01	1.02	6.11	3.02	1.96	4.08

Note: The percentages in this table may not add up to 100% due to rounding.

Table 2 consolidates the yearly market share of all generation companies in terms of maximum capacity.

In terms of maximum capacity, the combined market share of the three largest generation companies shrank by 0.99 percentage point to 64.70% in 2019. This decline was due to the lower market share of ST units of G1 and G2.

There is, however, no change in the position of the generation companies in their yearly market share. Generation company G2 retained the biggest market share based on maximum capacity, followed by generation companies G1 and G3, as seen in Table 2.

MARKET MONITORING: Supply Indices: Capacity Ratio

Table 3: Capacity Ratio by Generation Type (%)

Year	CCGT	ST	OT	OCGT
2018	61.92	0.12	47.60	0.06
2019	63.31	0.16	47.79	0.27
YOY Change	1.39	0.05	0.19	0.21

Note: The capacity ratio of generation registered facilities refers to the ratio of scheduled generation output to maximum generation capacity of generation registered facilities.

Capacity ratio represents the utilisation level of a generation type. Table 3 compares the yearly capacity ratio of the four generation types currently available in the National Electricity Market of Singapore (NEMS) between 2018 and 2019.

In 2019, the capacity ratio improved for all generation types, with CCGT units registering the largest increase of 1.39 percentage points to 63.31%. This was because the increase in the scheduled output of CCGT units outpaced the increase in generation capacity.

The changes in the capacity ratio for the other generation types were lacklustre – the capacity ratio of OCGT units rose 0.21 percentage point to 0.27%, and that of OT units grew 0.19 percentage point to 47.79%. The changes resulted from the higher scheduled output of OCGT and OT units in 2019, while their respective generation capacity remained unchanged.

The uptick of 0.05 percentage point in the capacity ratio of ST units was mainly brought about by the overall low utilisation rate of ST units with a large generation capacity, against a small scheduled output.

The higher capacity ratio observed in 2019 indicates an improved utilisation rate for all generation types and responds to the growth in demand during the year, as all types of units generated more to meet the higher demand. In particular, the capacity ratio for CCGT units registered the highest incremental rate as it dominated the market in terms of market share.


A monthly basis comparison of the past two years for the capacity ratio of CCGT units is shown in Chart 3. The pattern observed in the monthly CCGT capacity ratio corresponds to the movements in demand as shown in Chart 7.

The monthly capacity ratio of CCGT units was mostly higher in 2019. The largest year-on-year monthly increase of

3.12 percentage points was observed between January 2018 and January 2019. January 2019 registered the highest demand growth with the scheduled output rising by 5.38% during the month.

Overall, the capacity ratio for CCGT units increased by 1.39 percentage points to 63.31% in 2019, indicating an improved utilisation rate for the CCGT generation type compared to 2018.

Chart 3: Comparison of Capacity Ratio of CCGT Units

Capacity Ratio (%)
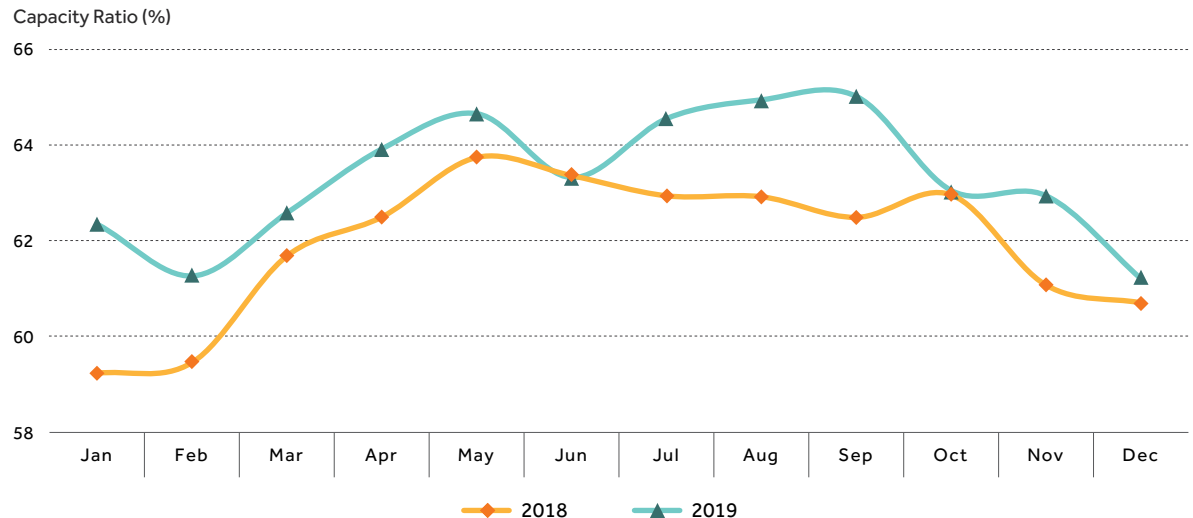
MARKET MONITORING: Supply Indices: Outages

Table 4: Average Outages by Generation Type (MW)

Year	Planned Outages						Forced Outages						Total Outages	YOY Change (%)
	ST	CCGT	OCGT	OT	Sum	%	ST	CCGT	OCGT	OT	Sum	%		
2015	206	701	1	11	919	97.41	0	24	0	0	24	2.59	944	-
2016	169	864	3	38	1,074	96.81	0	35	0	0	35	3.19	1,109	17.51
2017	322	744	33	22	1,120	98.76	0	14	0	0	14	1.24	1,134	2.25
2018	242	875	32	14	1,163	98.81	0	14	0	0	14	1.19	1,177	3.76
2019	299	962	14	6	1,281	94.57	0	74	0	0	74	5.43	1,355	15.13

Table 4 provides an overview of the outage levels by generation type from 2015 to 2019. Total outages per period increased 15.13% to 1,355MW in 2019. This outage level represents 10.88% of the total installed capacity in 2019 and reflects the highest level recorded in the past five years.

The rise in total outages in 2019 was led mainly by a higher level of planned outages from CCGT and ST units, together with a higher level of forced outages from CCGT units.

In terms of the percentage breakdown of the two types of outage, the planned outages in 2019 constituted 94.57%, down by 4.24 percentage points from 98.81% in 2018. This was, however, still the highest in MW value for the past five years. On the other hand, the average forced outages per period increased to the highest level in the past five years at 74MW in 2019, accounting for 5.43% of the total outages per period.

MARKET MONITORING: Supply Indices: Outages

Chart 4: Average Quarterly Planned Outages vs Average USEP

Planned Outages (MW)

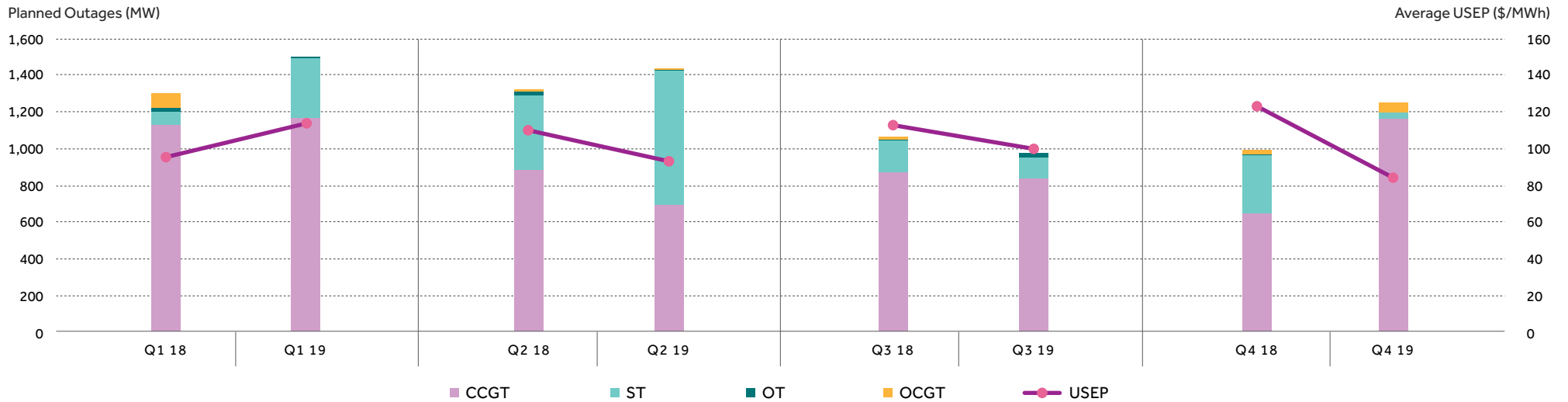Average USEP ($/MWh)

Legend: CCGT | ST | OT | OCGT | USEP

Chart 4 compares the average planned outages against the average Uniform Singapore Energy Price (USEP) on a quarterly basis between 2018 and 2019. A higher level of planned outages should intuitively coincide with a higher USEP due to the contraction in supply.

When compared with Q1 2018, the average level of planned outages was 14.48% higher in Q1 2019 and, correspondingly, the average USEP was higher by 18.09%. Apart from the contraction in supply, higher fuel oil prices were also a contributing factor, rising from US$64.36/bbl in Q1 2018 to US$70.19/bbl in Q1 2019.

The same relationship was noted in Q3 2019. The average level of planned outages declined 8.51% and correspondingly, the average USEP fell by 10.73% against Q3 2018. It was also observed that the fuel oil prices decreased by 5.98% to US$73.91/bbl in Q3 2019.

The expected correlation between planned outages and the USEP was not consistent for Q2 and Q4 2019. Even though the average level of planned outages in Q2 2019 was 7.96% higher than that in Q2 2018, the average USEP was 13.43% lower. This lower USEP was the result of a decrease in fuel oil prices by 2.25% to US$71.14/bbl. Additionally, prices in Q2 2019 were less volatile with the highest periodic USEP at $284.22/MWh, as opposed to $963.02/MWh in Q2 2018. There were no periods of high USEP at or above $400/MWh in Q2 2019, against 20 periods in Q2 2018.

Similarly, for Q4 2019, the average level of planned outages increased by 26.45% while the average USEP declined by 30.99% when compared to Q4 2018. The main reason for the lower USEP was lower fuel oil prices, which slid 21.82% to US$59.70/bbl in Q4 2019, resulting in less volatile prices as compared to Q4 2018. There were only nine periods of high USEP observed at or above $400/MWh in Q4 2019, against 81 periods in Q4 2018.

MARKET MONITORING: Supply Indices: Supply Cushion

Chart 5: Relationship between Supply Cushion and USEP

Supply Cushion (%)   USEP ($/MWh)

■ Supply Cushion   —— USEP
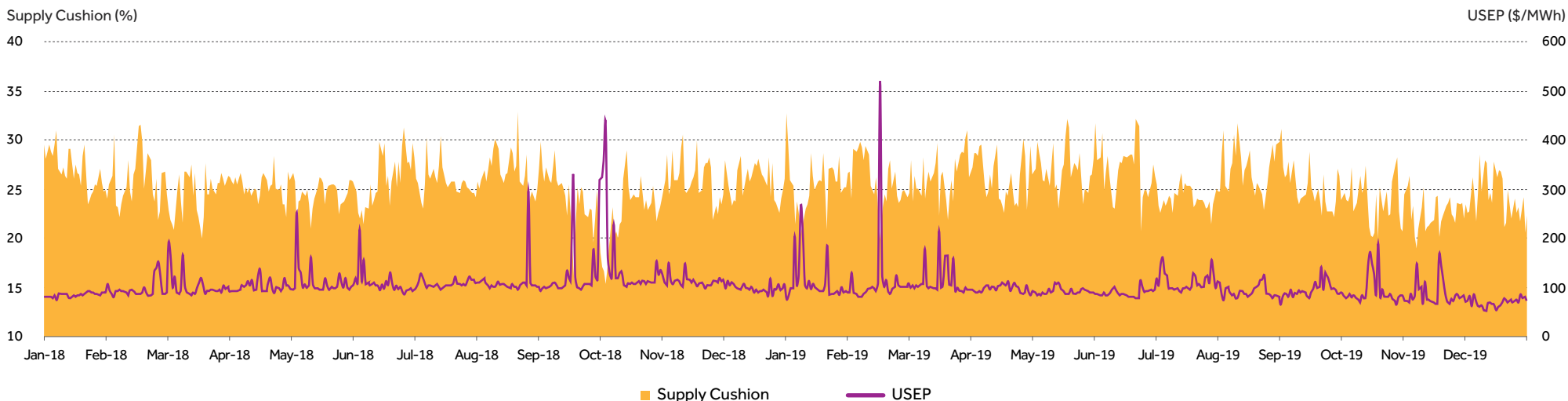
Supply cushion measures the level of spare capacity available after dispatch. Generally, the USEP and the supply cushion are highly negatively correlated. A lower supply cushion usually results in a higher USEP, due to the tight supply condition when more expensive supply is dispatched to meet the demand.

Chart 5 illustrates the relationship between the USEP and the supply cushion for 2018 and 2019. It was observed that days with a high USEP mostly correlated with a low supply cushion: for example, the price spikes observed in January, February, March, October and November 2019 correlate to lower levels of supply cushion. In particular, on days when the daily average USEP cleared between $149.02/MWh and $520.58/MWh, the daily supply cushion ranged from 18.79% to 24.10%.

For a yearly comparison, the average supply cushion rose marginally by 0.05 percentage point from 25.41% in 2018, to 25.46% in 2019. This resulted from an increase in average supply of 2.60% which outpaced the increase in average forecasted demand of 2.45%. The USEP declined 10.89% from $110.29/MWh in 2018 to $98.28/MWh in 2019.

The decrease in the USEP was attributed to a combination of factors including the slightly improved supply cushion and a decrease in fuel oil prices by 5.96% from US$73.09/bbl in 2018 to US$68.73/bbl in 2019. Fuel oil prices were higher at the beginning of the year from January to April before declining thereafter.

This downward trend in fuel oil prices was manifested towards the end of 2019, particularly in November and December when the prices fell below US$60/bbl. Correspondingly, the monthly USEP cleared at $88.79/MWh and $71.24/MWh for the two months, respectively, with December recording the lowest monthly level seen in 2019.

MARKET MONITORING: Supply Indices: Supply Cushion

Chart 6: Relationship between Supply Cushion and USEP in 2019
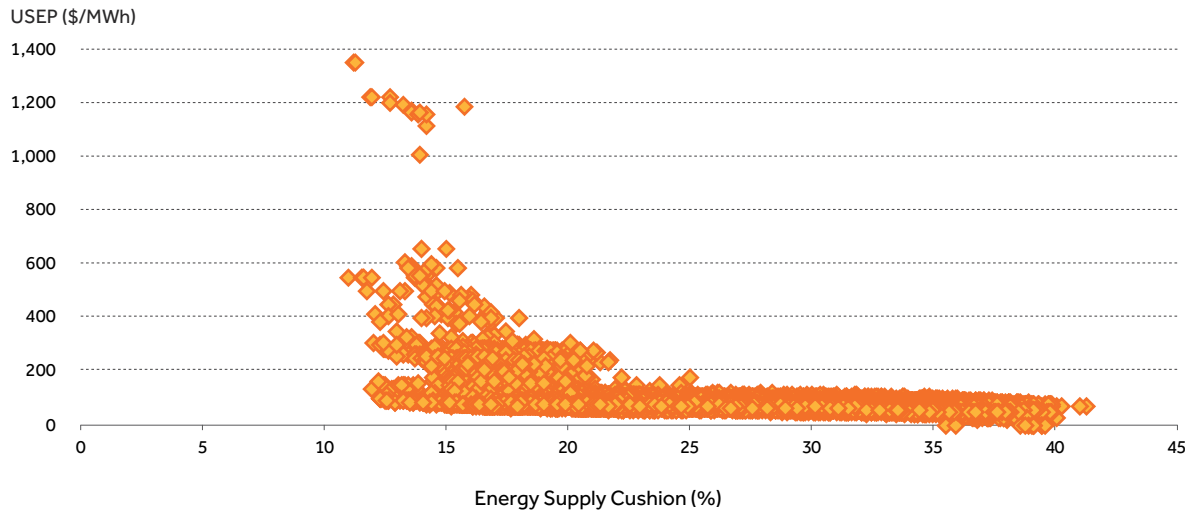
The relationship between the USEP and the supply cushion in 2019 was further analysed based on all dispatch periods, as shown in Chart 6. In comparison, the total number of instances with the USEP registering levels above $400/MWh decreased to 80 in 2019 from 150 in 2018.

Based on historical data, high prices usually occur when the supply cushion falls below 15.00%. In 2019, 59 occurrences of high prices were observed when the supply cushion was below 15.00%, as opposed to 102 occurrences in 2018. The lowest periodic supply cushion among the 59 occurrences was 10.95%. For the remaining 21 occurrences of high prices, the supply cushion ranged from 15.01% to 17.05%.

Table 5 summarises the yearly USEP movements under two supply cushion scenarios for the past five years.

The number of periods with the supply cushion below 15.00% decreased for two consecutive years from 2015 to 2017. A reverse change was observed in 2018 and 2019, with the number of periods with the supply cushion below 15.00% rising to 216 in 2018 and 222 in 2019.

The changes in the average USEP under both supply cushion scenarios were mixed for the past five years and it was counter-intuitive between 2018 and 2019. During the periods when the supply cushion was below 15.00%, the average USEP in 2019 was $306.18/MWh, which was 32.52% lower than the average USEP of $453.73/MWh in 2018. Similarly, for the periods when the supply cushion was at least 15.00%, the average USEP also decreased 9.81% from $106.01/MWh in 2018 to $95.61/MWh in 2019.

The lower USEP in 2019 was due to the improved supply cushion and lower fuel oil prices, which implied lower generation costs of generation companies, and therefore, a lower cost of supply to the market.

The maximum USEP of $1,354.86/MWh recorded in 2019 was around the same level as the highest USEP of $1,354.60/MWh recorded in 2018 when the supply cushion was below 15.00%. When the supply cushion was at least 15.00%, the peak USEP in 2019 was $1,187.31/MWh, versus $924.33/MWh in 2018.

Table 5: Relationship between Supply Cushion and USEP ($/MWh)

Year	Supply Cushion < 15%			Supply Cushion ≥ 15%		
	No. of Periods	Average USEP	Max USEP	No. of Periods	Average USEP	Max USEP
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
2018	216	453.73	1,354.60	17,304	106.01	924.33
2019	222	306.18	1,354.86	17,298	95.61	1,187.31

MARKET MONITORING: Demand Indices: Metered Energy Quantity

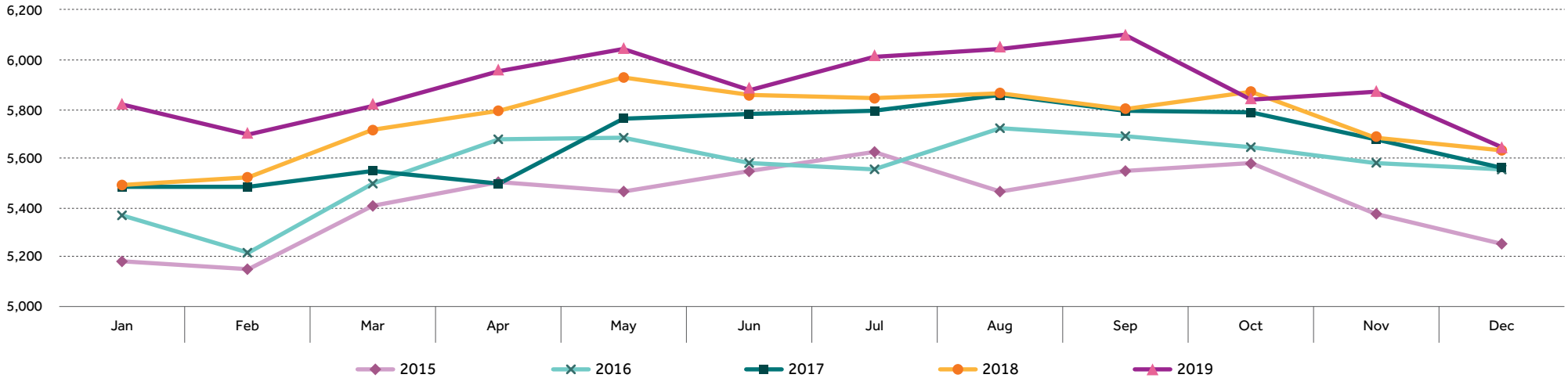## Chart 7: Comparison of Actual Demand

Metered Energy Quantity (MW)

Chart 7 compares the actual demand (computed from metered energy quantity) between 2015 and 2019. The average demand has recorded higher levels every year. Overall, the actual demand grew 2.44% from 5,750MW in 2018 to 5,890MW in 2019.

The average monthly demand was higher throughout 2019 except for October. The highest growth rate of 5.92% was recorded in January, followed by 5.17% in September. There were four months, May, July, August and September, when the actual demand crossed above the 6,000MW mark. These four months registered the highest monthly demand since the market started.

The average actual demand of 6,098MW in September was the highest monthly level ever. This represents a 2.87% increase from the peak average monthly demand of 5,928MW registered in May 2018.

MARKET MONITORING: Demand Indices: Accuracy of Pre-Dispatch and Short-Term Load Forecasts

Table 6: Variation in Load Forecast (MW)

Year	Variation between PDS & Real-Time		Variation between STS & Real-Time	
	Mean	Standard Deviation	Mean	Standard Deviation
2015	47.11	32.60	13.64	9.36
2016	55.62	38.12	15.55	10.68
2017	59.89	39.26	16.70	10.85
2018	57.97	40.67	16.82	14.31
2019	55.78	40.42	15.58	11.30

Three forecast schedules with different time horizons are made available to market participants in the NEMS. The accuracy of the load forecast is crucial to the accuracy of forecast schedules and is relevant for the efficient operation of the market, as it determines the responsiveness of generation facilities to real-time demand conditions.

The accuracy of the load forecast is measured by the mean and standard deviation of the variations between forecast schedules with different time horizons: namely Pre-dispatch Schedule (PDS) and Short-term Schedule (STS), and real-time schedules. PDS load forecasts tend to be less accurate than STS load forecasts – PDS forecasts are updated every two hours, with a forecast horizon from 12 to 36 hours, compared to STS forecasts, which are updated every half hour with a forecast horizon of up to six hours.

As shown in Table 6, the mean of the variation between PDS and real-time load forecast in 2019 was 55.78MW. This was 3.58 times as large as that between STS and real-time load forecast. A similar pattern was observed for the standard deviation of the variation.

Looking at the past five years, the mean of the variation in 2015 recorded the lowest levels for both the PDS versus the real-time load forecast, and the STS versus the real-time load forecast. This implies that the forecast schedules were the closest to the real-time schedules in 2015.

Since then, the mean of the variation between the PDS and the real-time load forecast started to increase in 2016 and peaked in 2017 before declining, whereas that between the STS forecast and the real-time load forecast increased for three consecutive years and peaked in 2018.

In 2019, the mean of the variation between the PDS and the real-time load forecast was 3.77% lower than that in 2018, indicating an improved accuracy in the PDS schedules. The mean of variation between the STS forecast and the real-time load forecast also decreased 7.36% to 15.58MW in 2019, an accuracy level similar to that in 2016.

MARKET MONITORING: Demand Indices: Accuracy of Real-Time Load Forecast

Table 7: Variation in Real-Time Load Forecast (%)

Year	Variation between Real-Time Load Forecast & Actual Demand	YOY Change
2015	2.74	-
2016	2.70	-0.04
2017	2.26	-0.44
2018	2.58	0.32
2019	2.46	-0.12

For real-time schedules, the accuracy of the load forecast is equally important as it is used to generate the real-time dispatch schedules and discover market prices. The more accurate the load forecast is, the more reflective the dispatch schedules and market prices are of the actual system conditions. Therefore, it is important to maintain a high standard of accuracy of the load forecast in order to achieve efficient pricing outcomes and system stability.

A small variation between the real-time load forecast and the actual demand is expected. There are a few factors contributing to this variation. For example, the real-time load forecast contains the station load and the 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.

Table 7 presents the percentage of variation between the real-time load forecast and the actual demand, which indicates the average load forecast error. This error has remained below 3.00% for the past five years, from its lowest level at 2.26% in 2017 to its highest at 2.74% in 2015.

In 2019, the percentage of variation between the real-time load forecast and the actual demand remained relatively low – it decreased 0.12 percentage point to 2.46% from 2.58% in 2018, implying an improvement in the accuracy of the real-time load forecast.

MARKET MONITORING: Price Indices: Volume-Weighted Vesting Contract Hedge Price and Wholesale Electricity Price
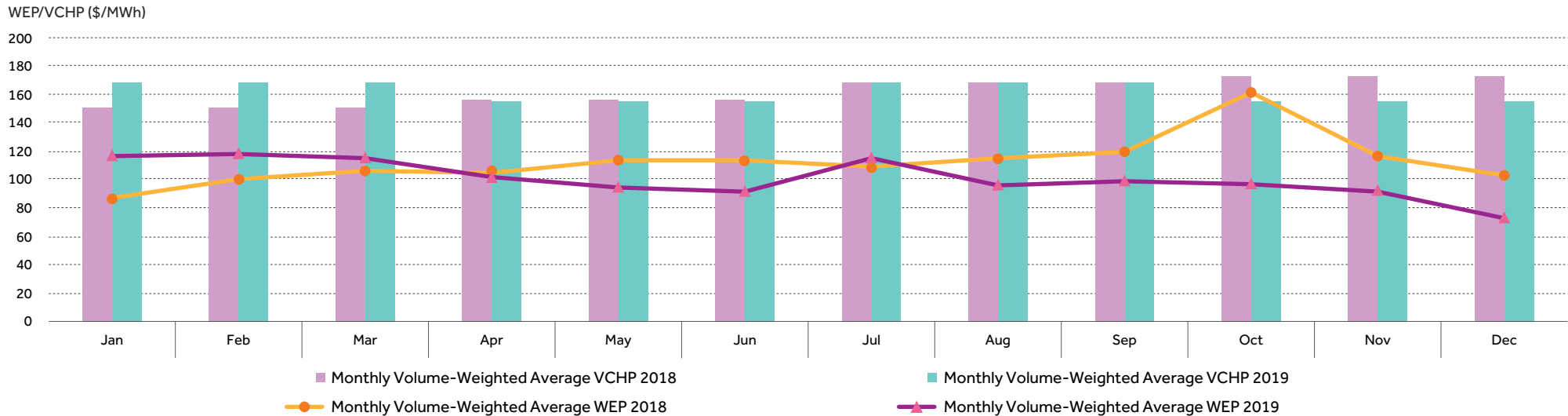
Chart 8: Volume-Weighted Average VCHP vs WEP

WEP/VCHP ($/MWh)

- Monthly Volume-Weighted Average VCHP 2018
- Monthly Volume-Weighted Average VCHP 2019
- Monthly Volume-Weighted Average WEP 2018
- Monthly Volume-Weighted Average WEP 2019

Chart 8 displays the volume-weighted averages of the Wholesale Electricity Price (WEP) and the Vesting Contract Hedge Price[5] (VCHP) on a monthly basis for 2018 and 2019.

The monthly volume-weighted average WEP in 2019 showed a downward trend. It started high at the beginning of the year with the volume-weighted WEP of January, February and March increasing by 32.59%, 17.11% and 9.30% respectively compared to 2018. The prices for the three months were among the highest monthly levels seen in 2019. The volume-weighted VCHP in Q1 2019 also registered the highest level for the year, increasing by 11.78% over Q1 2018. This was caused by higher fuel oil prices observed in Q1 2019 with an increase of 9.07% from Q1 2018.

Subsequently, the monthly volume-weighted average WEP moved downwards for the rest of the year in line with a decline in fuel oil prices. In total, there were eight months in 2019 when the volume-weighted average WEP cleared lower than that in 2018. The largest drop year-on-year of 39.94% was observed between October 2018[6] and October 2019, while April saw the lowest decrease of 3.75%. The volume-weighted VCHP was lower in Q2 and Q4 2019, and slightly higher in Q3 in comparison to that of the respective quarters in 2018.

The monthly volume-weighted average WEP in July 2019 was higher due to the tight supply conditions when the third lowest monthly supply cushion for the year was observed. Additionally, the high prices that usually occur under tight supply conditions are sometimes coupled with contingency reserve shortfall in the market. There were 55 instances of contingency reserve shortfall in July 2019 against three instances in July 2018. The WEP of the 55 instances ranged from $275.10/MWh to $313.08/MWh. As a result, the monthly volume-weighted average WEP in July 2019 increased by 5.60% to $115.04/MWh from July 2018.

For a year-on-year comparison, the annual volume-weighted average WEP declined 10.92% from $112.35/MWh in 2018 to $100.08/MWh in 2019 due to the lower fuel oil prices observed in 2019. The volume-weighted average VCHP increased slightly by 0.11% from $161.00/MWh in 2018 to $161.18/MWh in 2019.

In 2019, the volume-weighted average WEP was 37.91% lower than the volume-weighted average VCHP.

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[5]   The volume-weighted VCHP considers the LNG and balance vesting prices after volume adjustment. The balance vesting prices were phased out effective 1 July 2019.

[6]   High prices in October 2018 were observed due to the price spikes recorded during 1 – 4 October under tight supply conditions.

MARKET MONITORING: Price Indices: Correlation between VCHP, WEP, Fuel Oil Prices and Electricity Tariff

Chart 9: Index of VCHP, WEP, Fuel Oil Price and Electricity Tariff

Index

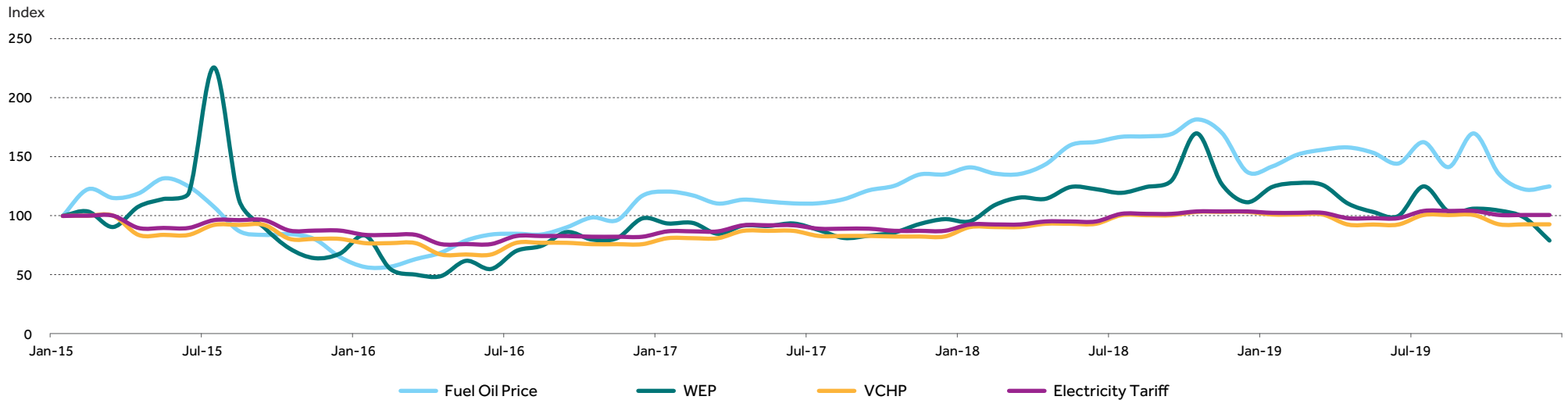Legend: Fuel Oil Price — WEP — VCHP — Electricity Tariff

Chart 9 plots the index of fuel oil price, VCHP, WEP and electricity tariff for the past five years, using 2015 as the base year. It graphically shows the correlation between the four prices as the indices measure the relative changes in these four prices over the five years.

Continuing the trend observed in 2018, the WEP closely followed the changes in fuel oil prices over the year 2019, which implies that fuel oil price is a driver that closely explains the changes in the WEP. The VCHP and electricity tariff mostly moved in tandem.

For a yearly comparison, fuel oil prices traded at an average of US$68.73/bbl in 2019, a decrease of 5.96% from 2018. The WEP also dropped 10.74% to reach $98.63/MWh in 2019. The monthly average WEP ranged from $71.51/MWh (in December 2019) to $115.71/MWh (in February 2019), a narrowed spread compared to 2018.

MARKET MONITORING: Price Indices: Correlation between WEP and Metered Energy Quantity

Table 8: Average Correlation Coefficient of WEP and Metered Energy Quantity

Month	2018			2019		
	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	0.79	0.62	27	0.72	0.52	25
Feb	0.58	0.34	21	0.64	0.41	23
Mar	0.41	0.17	17	0.65	0.42	21
Apr	0.55	0.30	18	0.67	0.45	22
May	0.51	0.26	19	0.58	0.34	23
Jun	0.72	0.52	28	0.60	0.36	24
Jul	0.71	0.50	27	0.73	0.54	26
Aug	0.68	0.46	25	0.80	0.64	29
Sep	0.71	0.50	25	0.83	0.69	29
Oct	0.67	0.45	25	0.71	0.50	27
Nov	0.78	0.61	27	0.70	0.49	24
Dec	0.80	0.65	28	0.83	0.68	29
Average/Sum	0.66	0.45	287	0.70	0.50	302

The correlation coefficient, r, in Table 8 measures the strength of the relationship between the WEP and the metered energy quantity. A positive correlation indicates that as demand increases, energy price also increases 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.

The monthly r value in 2019 was between 0.58 and 0.83, which implies an overall improvement of the strength of the relationship between the WEP and the metered energy quantity when compared to 2018, which recorded a range of 0.41 to 0.80. The r value was higher than in 2018 for nine months, resulting in a higher yearly average r value of 0.70 compared to 2018. This

indicated a stronger relationship between changes in the WEP in relation to changes in the metered energy quantity in 2019. There were 302 days in 2019 when r was greater than 0.5, 15 days more than the 287 days in 2018. This implies that there were more instances in 2019 of the WEP and the metered energy quantity moving in tandem.

The value of r^2 increased from 0.45 in 2018 to 0.50 in 2019, expanding the proportion of variance in prices which can be explained by variations in demand from 45.00% to 50.00% of the time.

# MARKET MONITORING: Price Indices: Correlation between WEP and Metered Energy Quantity

Chart 10: Correlation between WEP and Metered Energy Quantity in 2019
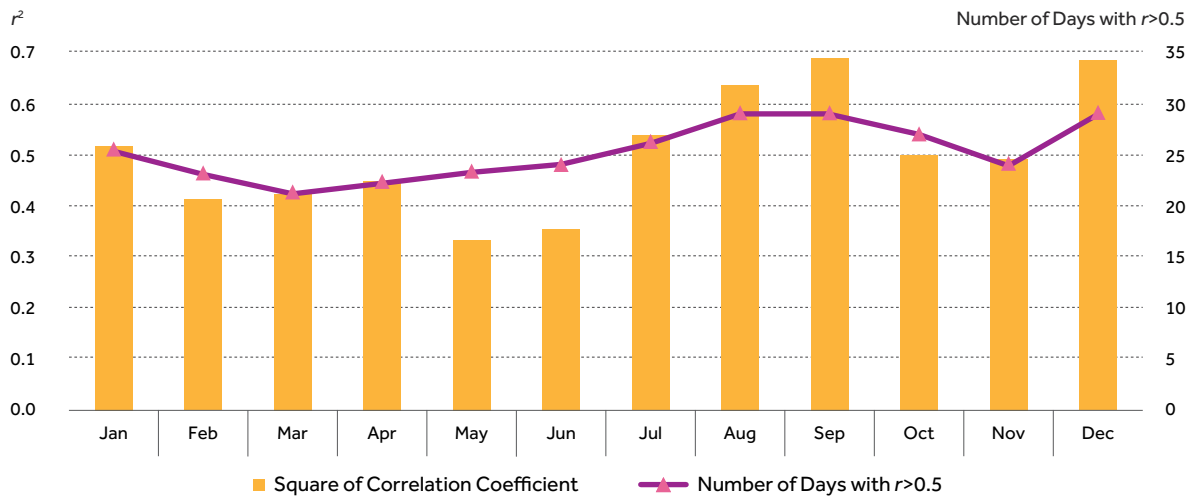
The correlation between the WEP and the metered energy quantity in 2019 is illustrated in Chart 10. Generally, the r^2 value positively correlates to the number of days when the r value is greater than 0.50. The highest r^2 value recorded during the year was 0.69 in September, which registered the highest number of days (29 days) when the r value was greater than 0.50. This implies that the WEP observed during most of the days of September 2019 was regularly driven by the metered energy quantity. The lowest r^2 value of 0.34 was in May, when there were 23 days with the r value greater than 0.50.

In 2019, there were more than 20 days every month with r value greater than 0.50. In contrast, in March, April and May of 2018, there were less than 20 days with r value greater than 0.50. In 2018, the lowest r^2 value of 0.17 was observed in March which registered the least number of days (17 days) when the r value was greater than 0.50. This implies that only 17.00% of the variance in prices could be explained by variations in demand, so demand was not a main driver to the prices in March 2018.

Chart 11: Correlation between WEP and Metered Energy Quantity for 2015 - 2019
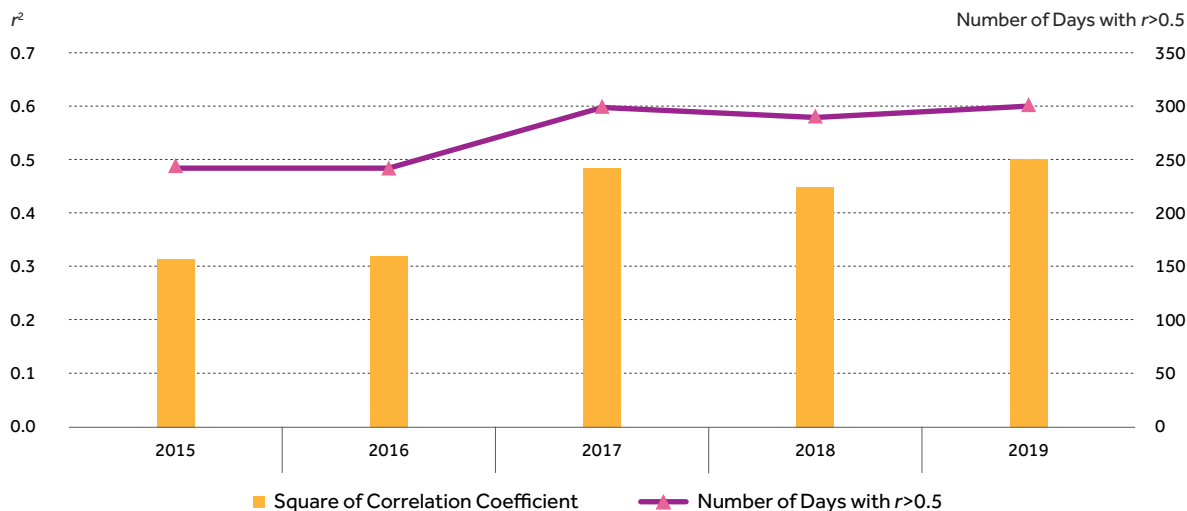
The correlation between the WEP and the metered energy quantity for the past five years is shown in Chart 11. From 2015 to 2019, the r^2 value and the number of days with r value greater than 0.50 moved in tandem without major fluctuations in either indicator.

Significant changes were observed in the past three years, between 2017 and 2019, when the r^2 value rose above the 0.40 mark and the number of days with r value greater than 0.50 were all close to 300. In 2019, both the r^2 value and the number of days with r value greater than 0.50 were the highest in the past five years, at 0.50 and 302 respectively. This reflects the growing influence of demand on energy prices.

MARKET MONITORING: Price Indices: Frequency Distribution of WEP by (a) Percentage of Hours of Occurrence and (b) Percentage of Energy Quantity Affected

Chart 12: Percentage of Hours when the WEP Falls into a Particular Price Range

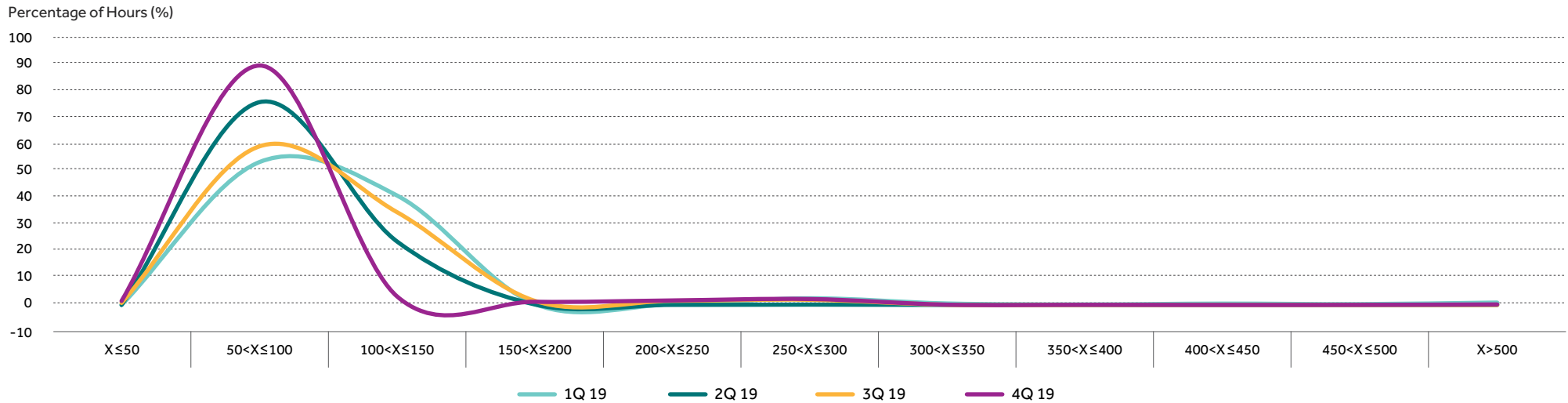Percentage of Hours (%)

Legend: 1Q 19 — 2Q 19 — 3Q 19 — 4Q 19

Chart 12 illustrates the distribution of the WEP in various price ranges, based on the percentage of hours of occurrence in 2019. A downward trend in prices was observed over the year with the quarterly prices gradually moving leftward from Q1 to Q4 2019.

Prices for the first quarter settled in the $50/MWh to $100/MWh tranche for 53.54% of the time, and in the $100/MWh to $150/MWh tranche for 40.95% of the time. There were periods with the WEP clearing at the remaining price tranches except the lowest tranche of below $50/MWh. The WEP cleared above $500/MWh for 38 periods that largely occurred on 8 January, 9 January and 16 February 2019. The peak periodic WEP of $1,351.27/MWh was recorded on 16 February. As a result, the WEP for Q1 2019 settled at $114.22/MWh, the highest quarterly price in 2019.

In the second quarter, the WEP shifted leftward. Prices fell into the $50/MWh to $100/MWh tranche 75.96% of the time, an increase of 22.42% from Q1 2019. All prices cleared below $300/MWh in Q2 2019, and the average quarterly price settled at $94.61/MWh.

Prices for the third quarter moved rightward. Q3 2019 registered a higher quarterly price of $100.96/MWh but it was still lower than that of the first quarter. This was due to a 34.71% increase in the percentage of the WEP clearing in the $100/MWh to $150/MWh tranche, whereas the percentage of the WEP clearing in the $50/MWh to $100/MWh tranche dropped to 59.42%. All prices in Q3 2019 cleared below $350/MWh with 0.82% clearing below $50/MWh.

The lowest quarterly average price of $85.08/MWh was recorded in Q4 2019. Most prices in Q4 2019, as many as 89.67%, fell into the $50/MWh to $100/MWh tranche. The proportion of prices that settled below $50/MWh increased to 1.77% when compared to Q3 2019.

MARKET MONITORING: Price Indices: Frequency Distribution of WEP by (a) Percentage of Hours of Occurrence and (b) Percentage of Energy Quantity Affected

Chart 13: Percentage of Energy Quantity when the WEP Falls into a Particular Price Range

Percentage of Energy Quantity (%)

Legend: 1Q 19 — 2Q 19 — 3Q 19 — 4Q 19
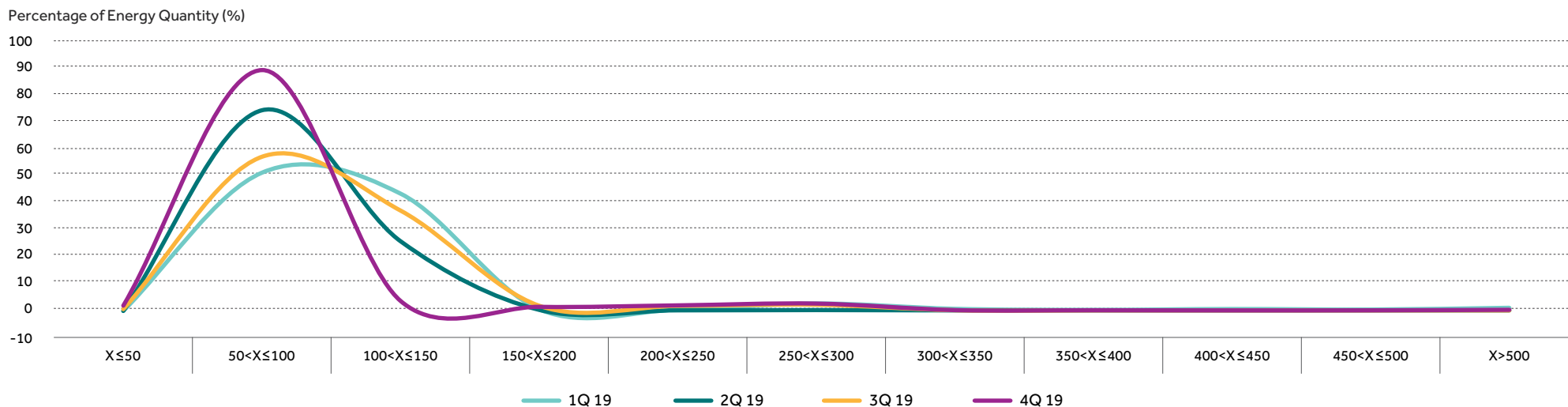
The distribution of the WEP based on percentage of energy quantity is presented in Chart 13. The movement observed in the WEP corresponds to the movement in the percentage of energy quantity cleared at various price ranges.

In Q2 2019, the percentage of energy quantity that cleared at a WEP in the $50/MWh to $100/MWh tranche was 74.08%, 23.10% higher than that in Q1 2019. Correspondingly, the WEP decreased in Q2 2019 as greater quantities of electricity were cleared within a lower price range.

Similarly, the energy quantity that cleared at a WEP in the $50/MWh to $100/MWh tranche increased 32.07% from 56.87% in Q3 2019 to 88.94% in Q4 2019, implying more periods and larger quantities of electricity being cleared within a lower price range. As a result, the WEP in Q4 2019 was also lower than that in Q3 2019.

MARKET MONITORING: Price Indices: Frequency Distribution of WEP by (a) Percentage of Hours of Occurrence and (b) Percentage of Energy Quantity Affected

Chart 14: Percentage of Hours when the WEP Falls into a Particular Price Range
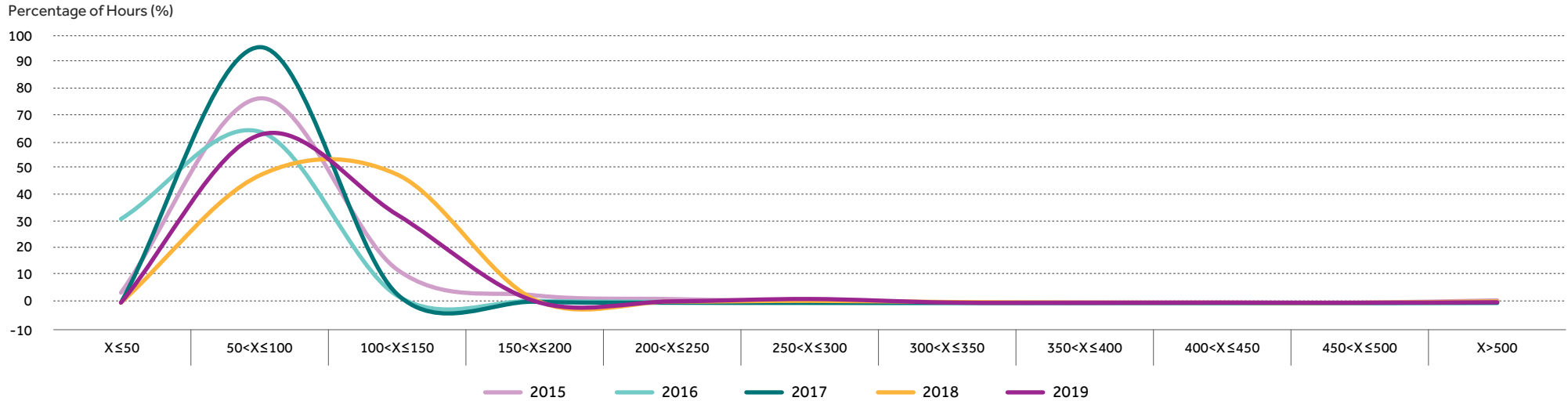
Percentage of Hours (%)

Chart 14 juxtaposes the historical price distribution curves from 2015 to 2019, allowing us to examine longer-term trends.

From 2015 to 2016 the percentage of hours of the WEP distribution shifted leftward to a lower price range. With this shift, prices in 2016 mostly cleared below $50/MWh for 31.30% of the time and cleared in the $50/MWh to $100/MWh price tranche for 64.21% of the time. This was an increase of 14.98% from 80.53% in 2015 (3.84% of the time below $50/MWh, and 76.69% of the time in the $50/MWh to $100/MWh price tranche) when the WEP settled below $100/MWh. The yearly average WEP in 2016 registered the lowest level at $63.69/MWh since the market started.

In 2017 and 2018, the trend reversed. The percentage of hours of WEP distribution shifted rightward to reflect an expansion of 31.69% when the WEP cleared at the price tranche between $50/MWh and $100/MWh, from 64.21% in 2016 to 95.90% in 2017.

In 2018, the percentage of hours of WEP distribution moved further rightward. Instances of the WEP falling within the price tranche of $50/MWh to $100/MWh reduced to 47.82%, and the percentage of the WEP settling in the $100/MWh to $150/MWh price tranche increased to 48.16%. As a result, the yearly average WEP increased from $81.19/MWh in 2017 to $110.50/MWh in 2018.

In 2019, the percentage of hours of the WEP distribution shifted leftward. Instances of the WEP falling within the price tranche of $50/MWh to $100/MWh expanded by 21.90% from 2018 to 69.72% in 2019, whereas the percentage of hours of the WEP settling in the $100/MWh to $150/MWh tranche decreased to 25.55%. Consequently, the yearly average WEP dropped to $98.63/MWh.

MARKET MONITORING: Price Indices: Frequency Distribution of WEP by (a) Percentage of Hours of Occurrence and (b) Percentage of Energy Quantity Affected

Chart 15: Percentage of Energy Quantity when the WEP Falls into a Particular Price Range

Percentage of Energy Quantity (%)

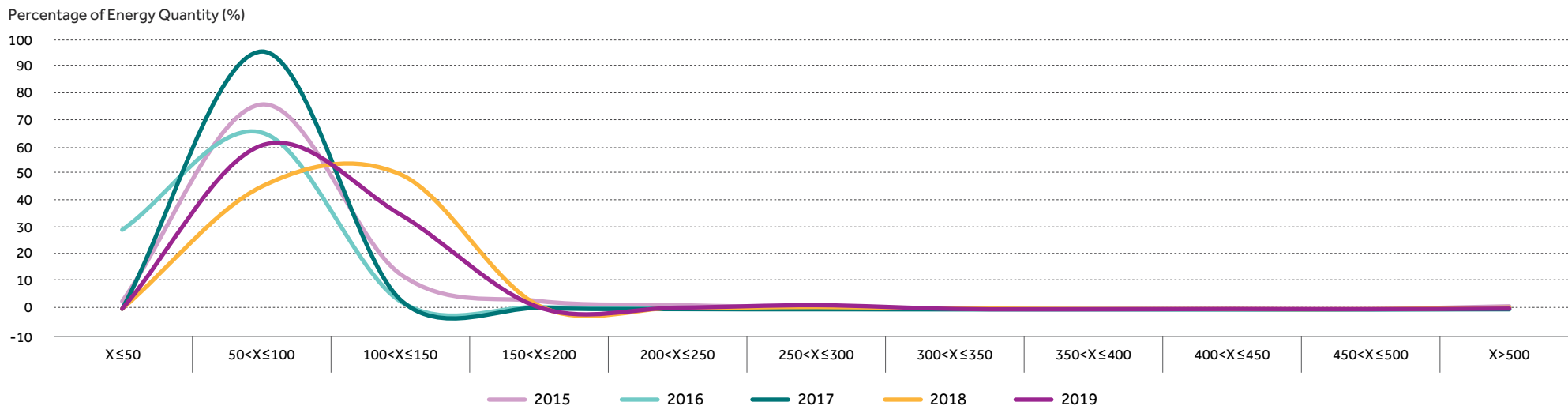2015   2016   2017   2018   2019

Chart 15 shows the long-term trend in the distribution of the WEP between 2015 and 2019 based on percentage of energy quantity.

In 2016, the total energy quantity that cleared at a WEP falling below $100/MWh was 95.00% (with 29.51% below $50/MWh and 65.49% in the $50/MWh to $100/MWh tranche), an increase of 15.77% from 79.23% in 2015. Correspondingly, the WEP in 2016 was 33.55% lower than that in 2015 since a higher volume of electricity was cleared within lower price ranges.

The change was reversed from 2017 to 2018, when the percentage of energy quantity that cleared at a WEP falling in the $100/MWh to $150/MWh tranche increased by 46.44% from 3.61% in 2017 to 50.05% in 2018. As a result, the WEP in 2018 was 36.09% higher than that in 2017, reflecting the observation of larger quantities of electricity being cleared within a higher price range.

Finally, the yearly average WEP in 2019 decreased from 2018. This was due to more energy quantity being cleared at a WEP falling in the $50/MWh to $100/MWh tranche, an increment of 22.20% from 45.52% in 2018 to 67.72% in 2019.

MARKET MONITORING: Ancillary Service Indices: Reserve Prices

Chart 16: Average Reserve Prices

Reserve Prices ($/MWh)

Legend: 2015 | 2016 | 2017 | 2018 | 2019
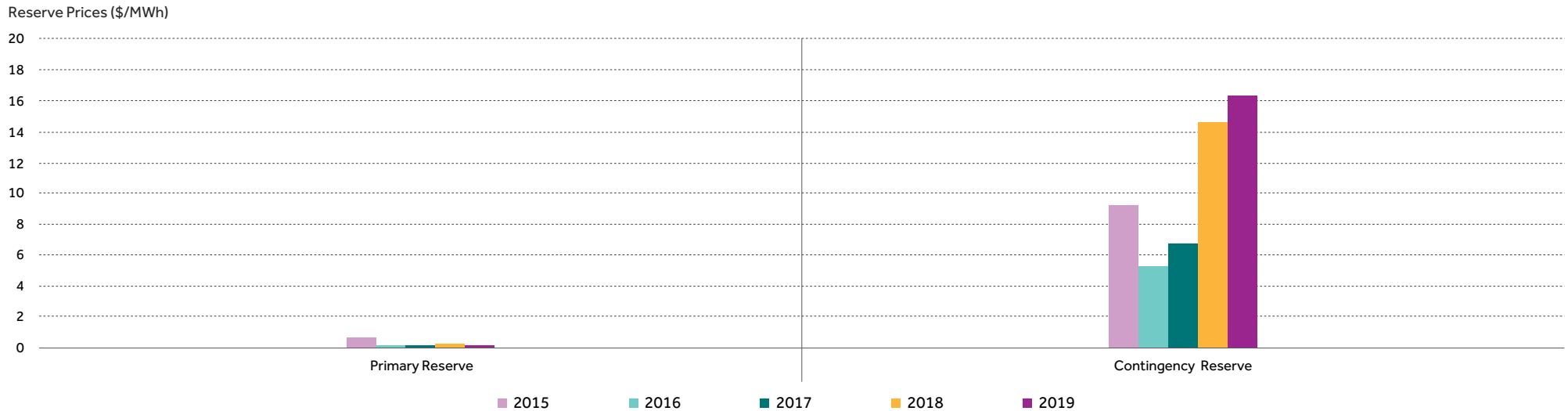
Two classes[7] of reserves, namely primary and contingency reserve, are traded in the NEMS. Prices of the two reserve classes are compared from 2015 to 2019 in Chart 16.

The annual average primary reserve price has remained below $1/MWh throughout the past five years with the highest price at $0.78/MWh in 2015. It dropped to the lowest level at $0.13/MWh in 2016 before picking up slowly to $0.19/MWh in 2017 and $0.38/MWh in 2018. In 2019, the annual average price for primary reserve declined 42.94% to $0.22/MWh. This decrease in the annual average primary reserve price was supported by the lower primary reserve requirement, which retreated by 5.23% in 2019.

A similar trend was observed in the annual average contingency reserve price from 2015 to 2018, with the annual average contingency reserve price clearing at $9.23/MWh in 2015, then slipping to $5.27/MWh in 2016. It recovered to $6.74/MWh in 2017 and $14.60/MWh in 2018. In contrast to what was observed in the annual average primary reserve price, the annual average contingency reserve price increased by 11.65% to $16.30/MWh in 2019, the highest level seen in the past five years and the third highest level since the market started.

The higher annual average contingency reserve price was coupled with price spikes in the USEP under tight supply conditions over the year, as shown in Chart 5. Additionally, there were 368 instances of contingency reserve shortfall in 2019, an increase of 109 instances from the 259 instances in 2018. The contingency reserve prices during these instances ranged from $185.00/MWh to $1,037.97/MWh with the corresponding supply cushion between 10.95% to 21.20%.

Notably, the highest level in 2019 was registered on 16 February, when 30 periods of contingency reserve shortfall were observed, and the daily average contingency reserve price rose to $396.46/MWh.

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[7] With effect from 1 October 2017, the primary and secondary reserve classes were combined into a single primary reserve class. Hence, secondary reserve was excluded here.

MARKET MONITORING: Ancillary Service Indices: Reserve Prices

Chart 17: Annual Reserve Payment and Requirement

Reserve Payment ($ Million)

Reserve Requirement (TW)

■ Reserve Payment —▲— Reserve Requirement
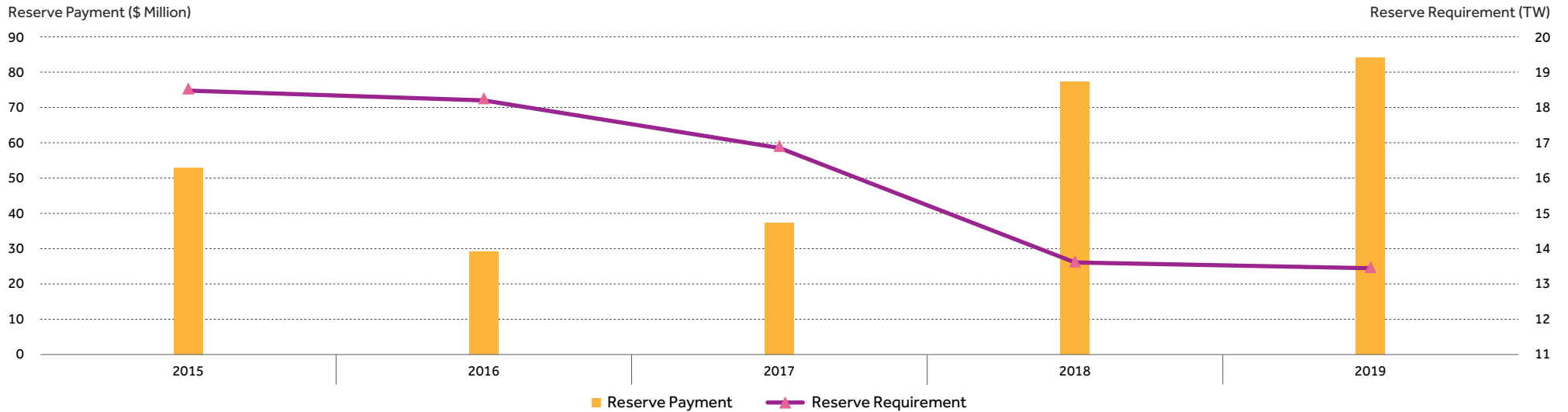
The total reserve payment rose 8.81% from $77.29 million in 2018 to $84.10 million in 2019, reaching its highest level in the past five years as seen in Chart 17. This was the third consecutive year that the market observed an increase in the reserve payment.

The increase in the total reserve payment was mainly attributed to the higher contingency reserve price observed in 2019, as discussed in Chart 16.

The reserve requirement moved in the opposite direction of the reserve payment and has been on a downward trend since 2015. The biggest drop of the reserve requirement, recorded in 2018, was largely due to the removal of the secondary reserve class. In 2019, it declined for the fourth consecutive year by 1.21% to 13.4TW.

The decrease in the reserve requirement was due to the lower primary reserve requirement seen in 2019, as the contingency reserve requirement remained unchanged.

MARKET MONITORING: Ancillary Service Indices: Reserve Prices

Chart 18: Monthly Average Reserve Payment and Contingency Reserve Prices

Reserve Payment ($ Million)

Reserve Prices ($/MWh)

Legend: ■ Reserve Payment 2018   ■ Reserve Payment 2019   —●— Contingency Reserve Price 2018   —▲— Contingency Reserve Price 2019
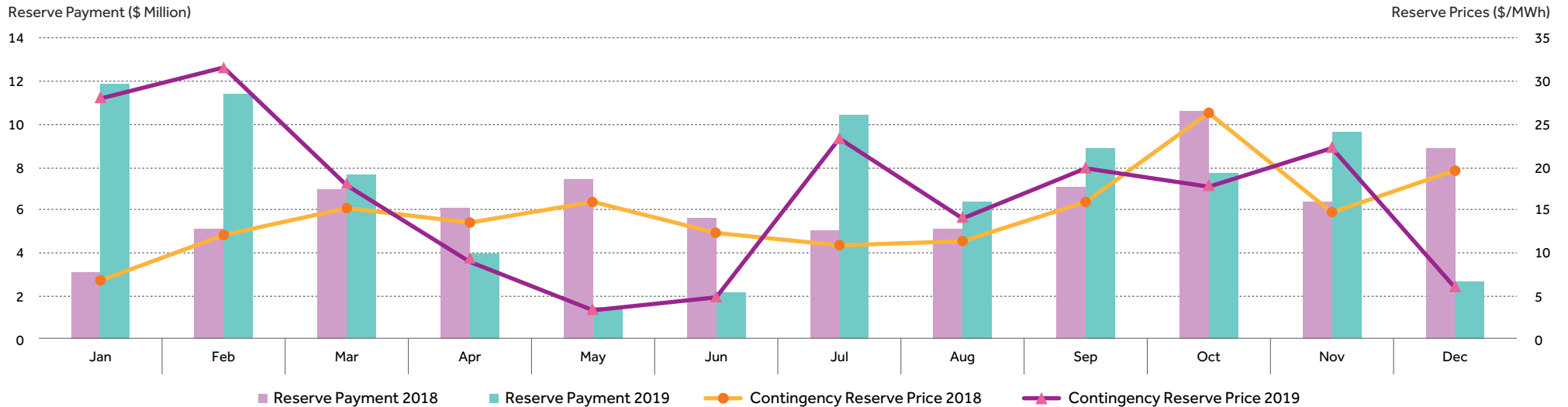
Chart 18 compares the reserve payment against the contingency reserve price between 2018 and 2019 on a monthly basis.

The contingency reserve payment was the main contributor to the total reserve payment. Hence, the changes in the monthly reserve payment are highly correlated to the movements in the contingency reserve price.

There were seven months in 2019 when the contingency reserve price was higher than that in 2018. Correspondingly, a higher total reserve payment was reported for all the seven months in 2019. The reserve payment almost tripled in January 2019 compared to January 2018, due to the higher contingency reserve price, which more than tripled from $6.91/MWh to $27.96/MWh. This was due to volatile prices in the energy market observed in January 2019. There were 87 instances of contingency reserve shortfall in January 2019 versus none in January 2018.

The remaining five months of 2019 recorded a lower reserve payment due to a lower contingency reserve price in comparison with 2018. The largest decrease of 79.62% in reserve payment was recorded in May 2019, in line with the largest drop in the contingency reserve price by 79.62% to $3.26/MWh from $15.99/MWh in May 2018. A contingency reserve shortfall was reported for 30 instances in May 2018 versus none in May 2019.

For a month-on-month comparison, the reserve payment moved in tandem with the contingency reserve price across 2019, except in February when the reserve payment was 3.80% lower than that in January despite a higher contingency reserve price. This was due to a combination of factors, including an 8.86% lower reserve requirement in February for both primary and contingency reserve, and the fact that there were only 28 days in February versus 31 days in January.

MARKET MONITORING: Ancillary Service Indices: Interruptible Load

Table 9: IL Activations for Contingency Reserve Market

Month	2018		2019	
	Instances of IL Activation	No. of Periods of IL Activation	Instances of IL Activation	No. of Periods of IL Activation
Jan	2	5	4	19
Feb	2	5	0	0
Mar	1	2	1	3
Apr	0	0	0	0
May	1	2	1	1
Jun	1	2	1	1
Jul	1	3	1	2
Aug	0	0	0	0
Sep	1	1	1	1
Oct	2	9	0	0
Nov	0	0	1	2
Dec	0	0	1	2
Sum	11	29	11	31

Table 9 compares the Interruptible Load (IL) activations for contingency reserve in terms of instances of IL activation and duration of the activation between 2018 and 2019.

IL was activated on 11 occasions to provide contingency reserve in 2019. Coincidentally, this was the same number of instances in which IL was activated during 2018.

However, the duration of the activation, measured by the number of periods of IL activation, increased to 31 in 2019. The IL activation lasted for the longest duration of 14 periods on 5 January when there was a forced outage of a CCGT unit and contingency reserve shortfall for 23 periods. The IL activations lasted three periods on 20 March, two periods each on 14 January, 25 January, 7 July, 7 November and 27 December, and one period each for the remaining four instances.

The percentage of contributions of IL in both the primary and the contingency reserve classes for the past five years are shown in Chart 19.

In 2015 and 2016, the percentage contribution of IL in the primary reserve class was at the highest level among the five years at around 1.70%. It then dropped to 1.52% in 2017, 0.62% in 2018, and nearly 0.01% in 2019. The decrease observed since 2017 was due to a reduction in the number of IL facilities that were eligible to provide primary reserve, from two to one. In 2019, the remaining IL

facility did not submit offers into the market for most of the year and eventually de-registered from the NEMS on 5 October 2019.

The percentage contribution of IL in the contingency reserve class was on an upward trend between 2015 and 2017 when it reached a peak at 1.32%. Thereafter, it moved downward in 2018 and 2019. The reason for the decrease observed in 2018 was the lower scheduled quantity for contingency reserve from IL, with an increased total scheduled quantity for contingency reserve.
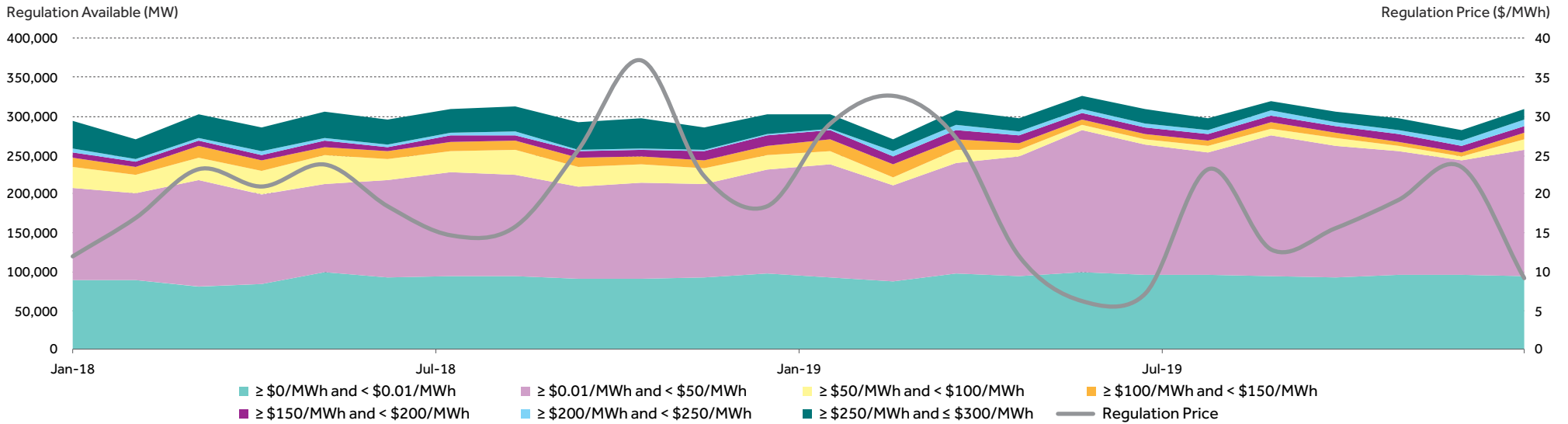
There was no change in the total scheduled quantity for contingency reserve from 2018 to 2019. However, the percentage of contribution of the scheduled quantity for contingency reserve from IL dropped by 18.60%, which was partially attributed to the de-registration of two IL facilities with the capability of providing contingency reserve, effective from 1 October and 5 October 2019 respectively.

Chart 19: Total Percentage Contribution from IL for the Two Classes of Scheduled Reserve

IL Contribution in Total Scheduled Reserve (%)

Primary Reserve ■ Contingency Reserve
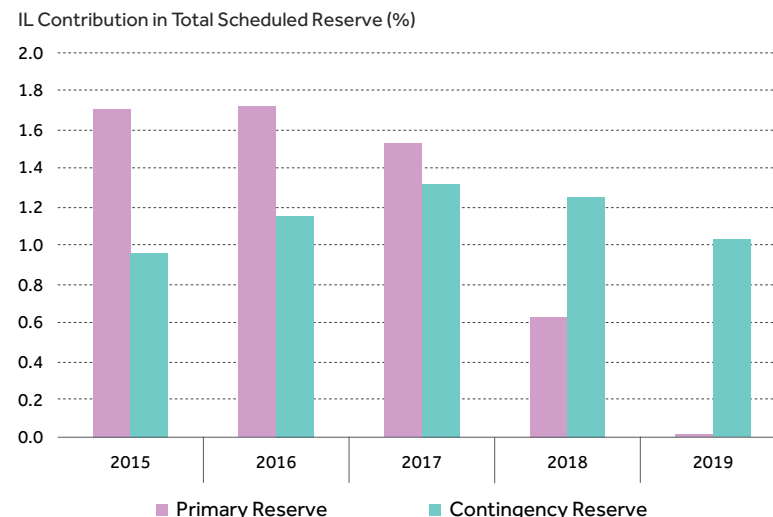
MARKET MONITORING: Ancillary Service Indices: Regulation Prices

Chart 20: Regulation Availability vs Regulation Price

Regulation Available (MW)   Regulation Price ($/MWh)

Legend: ≥ $0/MWh and < $0.01/MWh | ≥ $0.01/MWh and < $50/MWh | ≥ $50/MWh and < $100/MWh | ≥ $100/MWh and < $150/MWh | ≥ $150/MWh and < $200/MWh | ≥ $200/MWh and < $250/MWh | ≥ $250/MWh and ≤ $300/MWh | Regulation Price

As shown in Chart 20, regulation prices moved downward in 2019. Both the maximum ($32.62/MWh) and minimum ($6.17/MWh) monthly average regulation prices were lower than those recorded in 2018. However, regulation prices displayed a wider spread of $26.45/MWh in 2019 against $25.25/MWh in 2018.

The yearly average regulation price declined by 13.42% from $20.76/MWh in 2018 to $17.98/MWh in 2019, a reverse trend after two consecutive years of increase from 2016 to 2018. This was explained by the expanded regulation availability, which moved up by 2.06% in 2019.

The biggest increase was observed in the "≥$0.01/MWh and <$50/MWh" offer tranche, where the proportion of offers was 14.25 percentage points higher than in 2018, to reach 52.19% of the total regulation supply in 2019.

On a month-on-month comparison, the movement in the average regulation price recorded an opposite direction to the changes in the regulation availability in 2019.

The lowest monthly regulation price at $6.17/MWh corresponded to the highest regulation availability observed in May, whilst the monthly regulation price peaked in February when the regulation availability was at the lowest level.

ECONOMETRIC MODEL
AND OUTLIER PRICES

ECONOMETRIC MODEL AND OUTLIER PRICES

Since 2007, the Market Surveillance and Compliance Panel (MSCP) Annual Report has incorporated an econometric model analysis 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, an issue of multicollinearity between variables within the model was addressed. 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 this multicollinearity issue in the model, a stepwise regression technique was implemented. 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 the variables with the highest R-squared value were lagged fuel oil price, supply cushion and CCGT supply. Therefore, those variables were selected.

The regression analysis conducted by using the model is intended to determine how changes in independent variables are associated with changes in the dependent variable. A positive coefficient indicates that the mean of the dependent variable tends to increase as the value of the independent variable also increases. On the contrary, a negative coefficient suggests that the dependent variable tends to decrease as the independent variable increases.

The changes in the mean of the dependent variable with a one-unit shift in the independent variable, while holding other variables in the model constant, is represented by the coefficient value.

Out of the three selected variables, the lagged fuel oil price is a positive coefficient as it has been tagged to the cost of production of electricity in the National Electricity Market of Singapore (NEMS).

Table 10 shows the estimation results for the significance of the variables considered, as well as the model diagnostics in terms of R-squared and Adjusted R-squared. The R-squared value measures the proportion of the variation in the dependent variable (USEP) explained by the independent variables (lagged fuel oil price, supply cushion and CCGT supply). The Adjusted R-squared alters the statistic based on the number of independent variables in the model.

As presented in Table 10, a one-unit increase in the logarithm of the lagged fuel oil prices brought about a 0.90-unit increase in the logarithm of the USEP. This was about the same level as 2018.

The other two variables, the supply cushion and the CCGT supply, showed negative coefficients indicating an inverse relationship between the supply level of the market and the USEP. The tighter the supply condition is, the higher the price pressure is on the USEP.

Table 10: Estimation Results – January 2003 to December 2019

Variable	Coefficient
Constant	8.86
LOG (Lagged Fuel Oil Price)	0.90
LOG (Supply Cushion)	-0.63
LOG (CCGT Supply)	-0.70

Model Diagnostics	
R-squared	0.78
Adjusted R-squared	0.78
Number of Observations	6,179

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[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.

ECONOMETRIC MODEL AND OUTLIER PRICES

Table 10 provides the following observations:

- a one-unit increase in the logarithm of the supply cushion brought about a 0.63-unit decrease in the logarithm of the USEP. This value was 0.09 unit lower than the 0.72 recorded in 2018. This explains that in 2019, changes in the USEP were less sensitive to changes in the supply cushion variable compared to 2018; and

- a one-unit increase in the logarithm of the CCGT supply brought about a 0.70-unit decrease in the logarithm of the USEP, versus 0.58 unit observed in 2018. This implies that during 2019, changes in the USEP followed changes in the supply from CCGT units more closely than in 2018.

With regard to the model diagnostics, the R-squared value was 78.00% in 2019. This level implies that 78.00% of the changes in the USEP were explained by changes in the lagged fuel oil price, the supply cushion and the CCGT supply. This value was down by 5 percentage points from 2018, which implies that, with the addition of a greater number of observations in 2019 (other factors can be related to the reduction as well), the fraction of the variation of the USEP that can be explained by the selected three variables decreased when compared to 2018.

Finally, an additional variable relevant to note as part of the estimation results is the statistical significance of the model, measured by the P-value. The P-value is the level of statistical significance within a hypothesis. The P-value for the three selected variables is less than 0.05, indicating that the selected three variables play a significant role in explaining variations in the USEP.

ECONOMETRIC MODEL AND OUTLIER PRICES: Identification of Outlier Prices

Chart 21: Actual vs Predicted LOG USEP within Three Standard Deviations
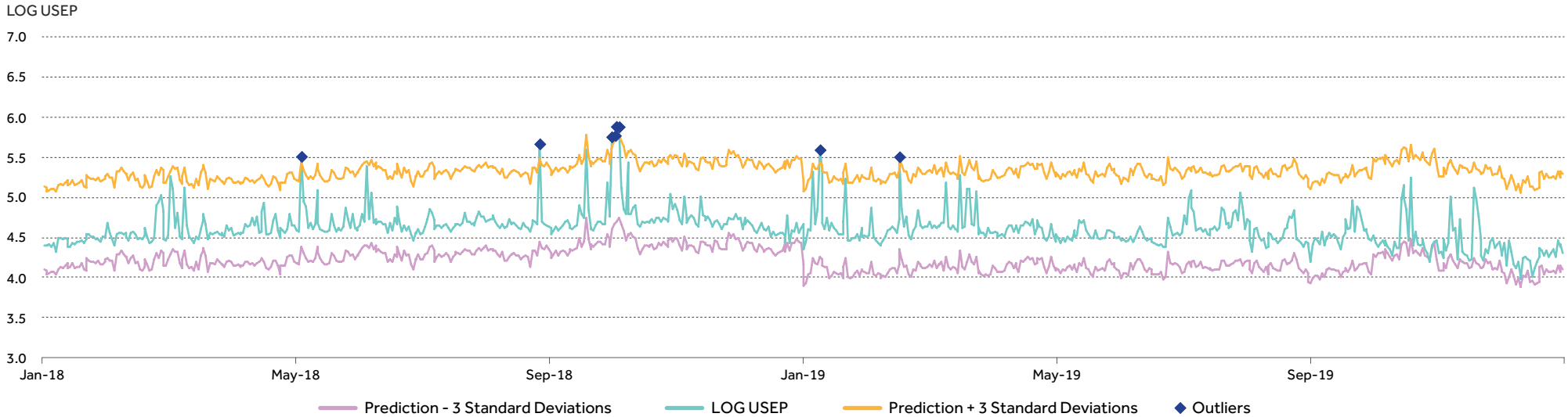

Chart 21 illustrates the logarithm of the actual daily average USEP, the upper and lower bands of the estimated USEP, and the outlier prices identified by the econometric model, from January 2018 to December 2019.
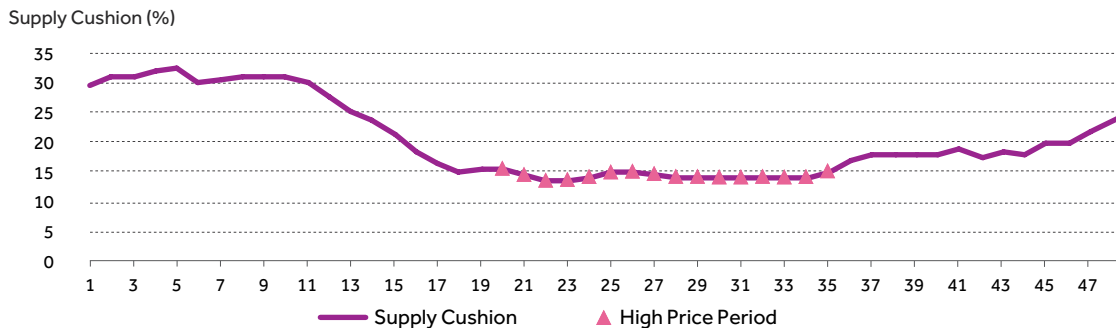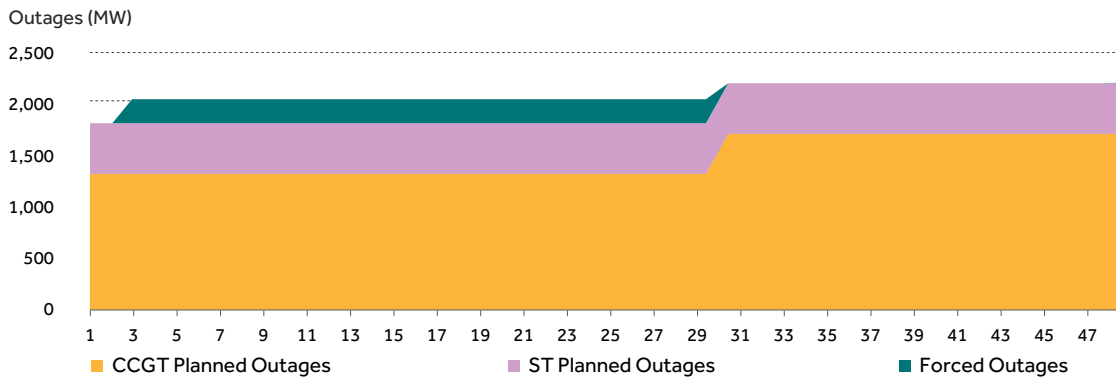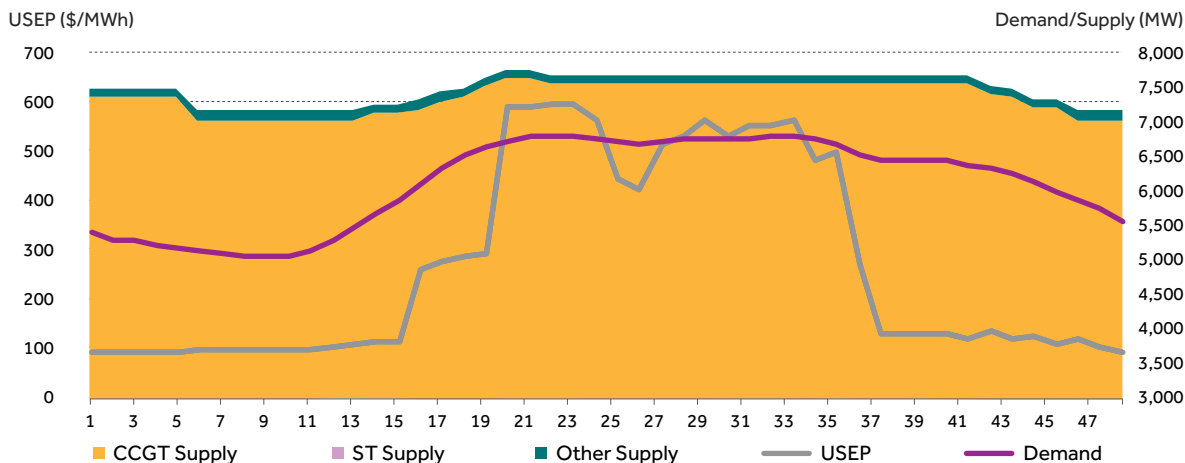
The upper and lower bands were calculated using three standard deviations above and below the logarithm of the forecast daily average USEP respectively, and the outlier prices were identified as the ones with an error of more than three standard deviations outside the upper band.

2018 showed six days during which outlier prices were detected by the model. Three of those days were articulated in the 2018 MSCP Annual Report.

In 2019, there were two days during which outlier prices were detected by the model. Both days were analysed in detail and explained in this report.

ECONOMETRIC MODEL AND OUTLIER PRICES: Identification of Outlier Prices

Chart 22: Demand and Supply Conditions – 8 January 2019

USEP ($/MWh) / Demand/Supply (MW)

Legend: CCGT Supply, ST Supply, Other Supply, USEP, Demand

Outages (MW)

Legend: CCGT Planned Outages, ST Planned Outages, Forced Outages

Supply Cushion (%)

Legend: Supply Cushion, High Price Period

Date	Tuesday 8 Jan 2019	All Tuesdays in Jan 2019
Daily USEP ($/MWh)	266.91	124.72
Max USEP ($/MWh)	592.70	592.70
No. of USEP ≥ $1,000/MWh	0	0
Demand (MW)	6,098	5,922
Supply Cushion (%)	20.41	26.13
Offers ≤ $100 /MWh (%)	78.94	77.78

Summary

On Tuesday, 8 January 2019, the USEP rose above $400/MWh for 16 periods, ranging from $422.17/MWh to $592.70/MWh.

The high prices were largely due to high demand and a contracted total supply, resulting in a lower supply cushion. Four CCGT units and two ST units were taken out of the grid, due to planned outages that totalled 2,170MW and a forced outage of 240MW from a CCGT unit.

During the periods of high USEP, the supply cushion averaged 14.28%, providing an upward price pressure to the affected periods as more expensive offers were scheduled to meet the demand, which in turn brought up the daily USEP.

Contingency reserve shortfalls were reported for 21 periods including the 16 periods with high prices.

ECONOMETRIC MODEL AND OUTLIER PRICES: Identification of Outlier Prices

Chart 23: Demand and Supply Conditions – 16 February 2019
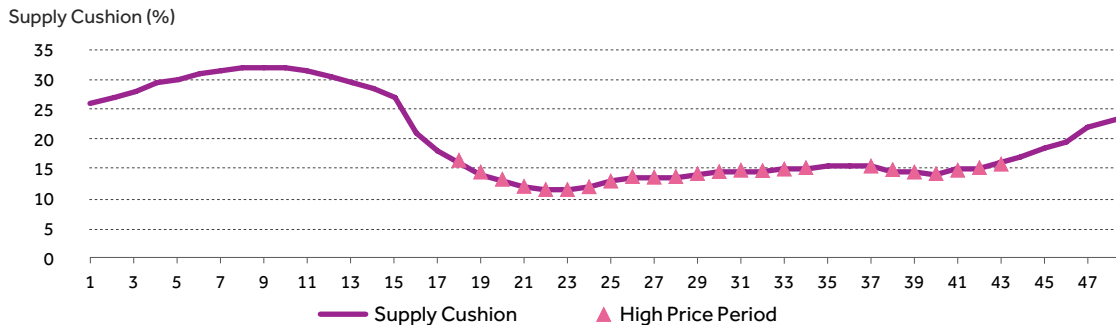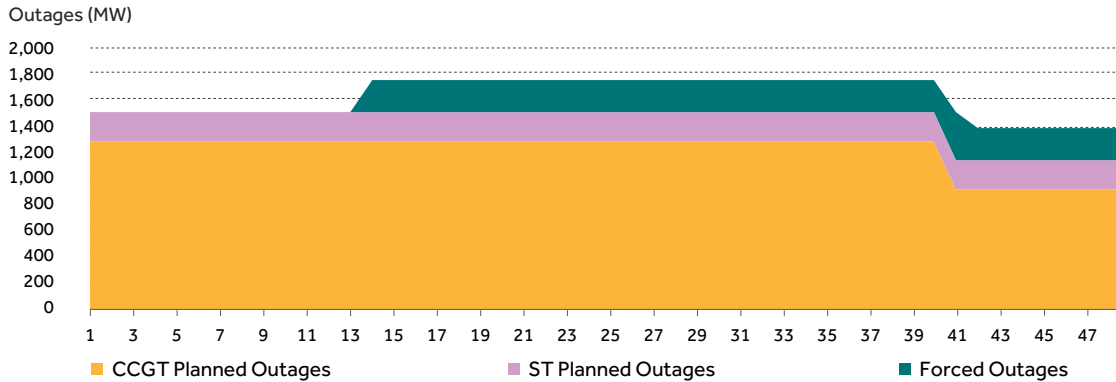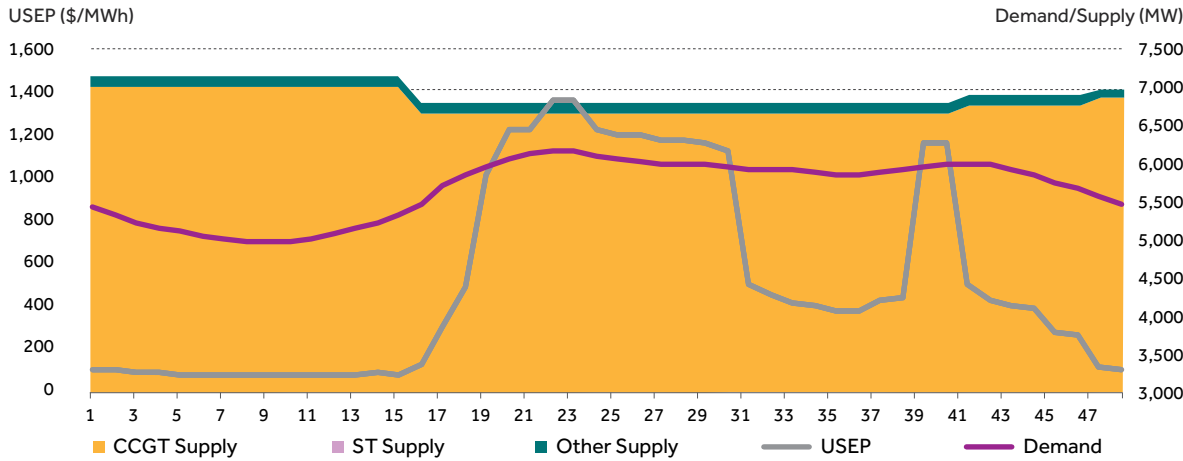
Date	Saturday 16 Feb 2019	All Saturdays in Feb 2019
Daily USEP ($/MWh)	520.58	211.37
Max USEP ($/MWh)	1,354.86	1,354.86
No. of USEP ≥ $1,000/MWh	14	14
Demand (MW)	5,664	5,647
Supply Cushion (%)	19.72	25.04
Offers ≤ $100 /MWh (%)	77.55	76.67

Summary

On Saturday, 16 February 2019, the USEP cleared above $400/MWh for 24 periods, including 14 periods when the price spiked above $1,000/MWh. The peak USEP at $1,354.86/MWh in Period 23 was the highest price recorded for the year.

The high prices were mainly due to a lower supply cushion caused by a high level of planned outages. The total supply saw a reduction of 1,913MW, with four CCGT units and one ST unit being taken out of the grid for maintenance. A forced outage of 236MW of a CCGT unit during the affected periods triggered even tighter supply conditions.

The average supply cushion during the affected periods was as low as 13.87%, sinking to a record low of 11.22% during Period 23, when the USEP was at its peak.

Contingency reserve shortfalls were reported for 30 periods and regulation shortfall occurred at the same time for 27 out of the 30 periods, coinciding with the periods of high prices.

INVESTIGATIONS

INVESTIGATIONS: Summary of Investigation Activities

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

Any investigation initiated by the MSCP is undertaken by the Market Assessment Unit at the direction of the MSCP, in accordance with the investigation process outlined in the Market Rules.

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 market, or within the jurisdiction of another party.

Table 11 reflects the position regarding investigation and enforcement activities from the start of the market on 1 January 2003 to 31 December 2019, 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 11: Investigation and Enforcement Statistics

Rule Breaches	1 January 2003 to 31 December 2019	1 January to 31 December 2019
(A) Total number of offer variations after gate closure received	37,118	342
Total number of cases closed	37,056	381
• cases in which the MSCP determined a breach	154	8
• cases in which the MSCP determined no breach	17,222	373
• cases in which the MSCP took no further action	19,680	0
(B) Origin of cases (excluding offer variations after gate closure)	198	8
• self-reports	169	7
• referrals or complaints	22	1
• initiated by the MSCP	7	0
Total number of cases closed	195	7
• cases in which the MSCP determined a breach	134	7
• cases in which the MSCP determined no breach	13	0
• cases in which the MSCP took no further action	44	0
• cases in which the MSCP issued suspension order	3	0
• cases in which the MSCP issued other order	1	0
(C) Number of formal MSCP hearings	11	1
(D) Enforcement action		
• highest financial penalty imposed on a party in breach	$842,861	$10,000
• total financial penalties imposed on parties in breach	$1,189,861	$43,000
(E) Costs		
• highest award of costs imposed on a party in breach	$43,750	$3,050
• total costs imposed on parties in breach	$270,725	$15,050
Market Efficiency and Fairness	**1 January 2003 to 31 December 2019**	**1 January to 31 December 2019**
Total number of cases	7	0
• referrals or complaints	2	0
• initiated by MSCP	5	0
Total number of cases closed	7	0

2019 Determination Highlights

- Eight offer variations after gate closure were determined to be in breach of the Market Rules. The remaining 373 cases were assessed by the MSCP to be not in breach.

- With regard to other cases, the MSCP closed seven investigation files and determined that all constituted a breach of the relevant rules.

- There was one request from EMC to have a hearing before the MSCP in relation to its breach of the Market Rules.[9]

- The MSCP's enforcement actions resulted in a total of $43,000 in financial penalties[10] imposed across six cases, with $10,000 being the highest financial penalty imposed on a party in breach. A non-compliance letter from the MSCP was issued for the remaining three cases.

- The total costs imposed on the parties in breach was $15,050.

- There were no cases referred to, or initiated by, the MSCP in relation to market efficiency and fairness.

9   This is in accordance with the investigation process outlined in the Market Rules.

10 Financial penalties imposed by the MSCP are returned to the market as a component of the monthly energy uplift charge.

SECTIONS 50 & 51
OF THE ELECTRICITY ACT

SECTIONS 50 AND 51 OF THE ELECTRICITY ACT

Competition-Related Provisions in the Electricity Act

The Energy Market Authority (EMA) is responsible for enforcing the electricity sector-specific anti-competitive agreements and abuse of dominance provisions contained in sections 50 and 51 of the Electricity Act, Chapter 89A.

Section 50 of the Electricity Act prohibits agreements, decisions, or concerted practices by persons, which have as their object or effect the prevention, restriction, or distortion of competition in any wholesale electricity market or the retail electricity market in Singapore.

The prohibition applies, in particular, to agreements, decisions, or concerted practices which:

- directly or indirectly fix purchase or selling prices or any other trading conditions of electricity in Singapore;

- limit or control generation of electricity, any wholesale electricity market, the retail electricity market, technical development or investment in the electricity industry in Singapore;

- share markets or sources of supply of electricity in Singapore;

- apply dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage;

- make the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts; or

- provide for the acquisition, directly or indirectly, of shares in or the assets of an electricity licensee.

Section 51 of the Electricity Act prohibits any conduct on the part of one or more persons, which amounts to the abuse of a dominant position in any wholesale electricity market or the retail electricity market in Singapore, if it may affect trade within Singapore.

Conduct constitutes an abuse if it consists of:

- directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions of electricity in Singapore;

- limiting generation of electricity, any wholesale electricity market, the retail electricity market or technical development in the electricity industry in Singapore to the prejudice of consumers;

- applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage; or

- making the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts.

SECTIONS 50 AND 51 OF THE ELECTRICITY ACT

Information Requirements to Assist the EMA

The Market Rules[11] 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 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.

Reports to the EMA

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.

The MAU, on behalf of the MSCP, also develops ad-hoc reports on any abnormal trends identified in the Uniform Singapore Energy Price, including a comprehensive analysis of the market drivers and other factors that may have contributed to the movements.

The MSCP and the MAU did not submit any report to the EMA in the course of monitoring and investigative activities carried out from January to December 2019.

The MAU regularly provides data to the EMA according to the information requirements, as shown in the table below.

Table 12: Information Requirements to Assist the Authority to Fulfil its Obligations with Respect to Competition and Abuse of a Dominant Position under Sections 50 and 51 of the Electricity Act

No.	Description	Frequency of Collection
1	Maximum installed capacity of each registered facility	Once and upon change
2	Maximum capacity for primary reserve, secondary reserve, contingency reserve, regulation, generation and load curtailment of each registered facility	Once and upon change
3	Maximum combined generation capacity and reserve capacity of each registered facility	Once and upon change
4	Maximum ramp-up and/or ramp-down rate of each registered facility	Once and upon change
5	Offers and bids for energy, primary reserve, secondary reserve, contingency reserve and regulation (prices and quantities) submitted by all market participants that are used in each dispatch run	Every two hours
6	All offer and bid variations and revisions to standing offers and bids for energy, primary reserve, secondary reserve, contingency reserve and regulation	Every two hours
7	Scheduled dispatch and load curtailment volumes by registered facility/market participants for all dispatch schedules, scenarios and re-runs	Every two hours
8	Half-hourly market energy price (MEP) at all market network nodes (MNN) for all dispatch schedules, scenarios and re-runs	Every two hours
9	Half-hourly prices and requirements for energy, primary reserve, secondary reserve, contingency reserve, regulation and load curtailment for all dispatch schedules, scenarios and re-runs	Every two hours
10	Metered injection and withdrawal quantities by registered facility/market participants, date and period	Daily
11	Uplift charges by date and period	Daily
12	Advisory notices reported by time, day and type	Daily
13	Intertie quantities and prices by date and period	Daily
14	Vesting contract reference prices by market participants, date and period	Monthly

[11] Section 4.3.10 of Chapter 3 of the Singapore Electricity Market Rules.

ASSESSMENT OF THE WHOLESALE ELECTRICITY MARKET

ASSESSMENT OF THE WHOLESALE ELECTRICITY MARKET: State of Competition and Efficiency of the Wholesale Electricity Market

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 market. The MSCP's assessment for 2019 is as follows:

Market Structure and Competition

Entry of New Market Participants

Two new market participants (MPs) were registered in the National Electricity Market of Singapore (NEMS) during 2019 under the wholesale market trader MP class:

- Terrenus Energy Pte. Ltd. joined the market on 9 May 2019, and
- Enel X Singapore Pte. Ltd. (Demand Side Participation) registered on 13 December 2019.

New Facilities in the Market

In 2019, 23 new intermittent generation sources (IGS) were registered in the NEMS, as shown in Table 13.

There were also revisions to the generation capacities of the two IGS facilities from SP Services

Table 13: New IGS Facilities

Name of MP	Number of New Facilities in 2019	Total Registered Capacity in 2019 (MW)
Cleantech Solar Singapore Assets Pte. Ltd.	2	0.650
Sembcorp Solar Singapore Pte. Ltd.	18	26.837
Sun Electric Energy Assets Pte. Ltd.	1	0.242
Sunseap Leasing Pte. Ltd.	1	1.219
Terrenus Energy Pte. Ltd.	1	4.650

Note: The registered IGS generation facilities[12] do not include the registration of new embedded non-exporting intermittent generation facilities.

Limited, which collectively added 43.266MW of generation capacity to the market in 2019.

The total number of registered IGS facilities in the NEMS increased to 52 units at the end of 2019, with a combined generation capacity of 127.347MW.

Just Electric Pte. Ltd. also registered its first load registered facility in the NEMS on 5 December 2019. The facility has a maximum load curtailment capacity of 35MW.

Withdrawal of Market Participants

In 2019, five MPs withdrew their participation in the NEMS.

Wholesale market trader
- Diamond Energy Managers Pte. Ltd.

Retail electricity licensee
- Charis Electric Pte. Ltd.
- Environmental Solutions (Asia) Pte Ltd
- SingNet Pte Ltd
- Peerer Energy Pte. Ltd.

De-Registration of Facilities in the Market

Five generation facilities were de-registered from the market during 2019. These were steam turbine units with a total of 1,191MW installed capacity.

Senoko Energy Pte Ltd (Senoko Energy) de-registered two units with 493MW on 30 August 2019. The remaining 698MW corresponded to three steam turbine units from YTL PowerSeraya Pte. Limited (YTL PowerSeraya) that were de-registered on 13 September 2019.

In October 2019, two interruptible load (IL) facilities from Diamond Energy Merchants Pte. Ltd. were de-registered from the market. This was a 15.4MW loss of contingency reserve provision to the market.

Market Price Behaviour

Drop in USEP in 2019

The Uniform Singapore Energy Price (USEP) declined 10.89% from an annual average of $110.29/MWh in 2018 to $98.28/MWh in 2019, while the Wholesale Electricity Price decreased 10.74% from an annual average of $110.50/MWh to $98.63/MWh.

The lower energy prices were in line with a higher supply cushion in 2019. Although forecasted demand rose 2.45% from 5,874MW in 2018 to 6,018MW in 2019, there was a 2.60% increase in supply from 7,864MW to

8,069MW, which outpaced the rise in forecasted demand.

The lower energy prices coincided with lower fuel oil prices. On a year-on-year basis, fuel oil prices dropped from an annual average of US$73.09/bbl in 2018 to US$68.73/bbl in 2019.

Efficiency of the Electricity Markets

Market Concentration

Market concentration measures the intensity of competition in the market by looking at the level of market share between market players. The less concentrated a market is, the more competitive it is.

The concentration level in the generator sector has remained fairly stable in recent years. In 2019, the top three market players accounted for 64.70% in market share based on maximum capacity. This was a 0.99 percentage point drop from 65.69% in 2018.

In terms of metered energy quantity, the market shares held by the three largest players in the NEMS rose 0.12 percentage point from 53.19% in 2018 to 53.31% in 2019.

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[12] This information can be obtained from the Market Data Download for Capacity for Registered Facilities on www.emcsg.com/MarketData/PriceInformation.

ASSESSMENT OF THE WHOLESALE ELECTRICITY MARKET: State of Competition and Efficiency of the Wholesale Electricity Market

While there were no new conventional plant installations in the NEMS in the reporting year, the development of a competitive fringe, particularly from the rising entry of intermittent generators (i.e. solar), may add to the level of competitiveness in the market.

Productive Efficiency

The year saw improvements in productive efficiency with the increase in the market share of the most efficient generation technology, the Combined Cycle Gas Turbine (CCGT) units, in terms of both energy quantity generated and maximum capacity.

The market share of CCGT units and other facilities (OT) based on metered energy quantity remained relatively unchanged in 2019 at 98.20% and 1.74% respectively. The market share of Steam Turbine (ST) units increased by 0.01 percentage point to 0.06% and Open Cycle Gas Turbine (OCGT) units stayed close to 0% in 2019.

In terms of maximum capacity, the market share of CCGT units increased 2.25 percentage points to 80.03% in 2019. Also, five of the less efficient ST units from Senoko Energy and YTL PowerSeraya exited the market in 2019, reducing the market share of ST units by

2.34 percentage points in 2019 to 16.63%. The market share of OT and OCGT units recorded 1.96% and 1.38% respectively.

Pricing Efficiency

Price spikes in the NEMS have been historically attributed to low supply cushion caused by sudden unavailability in supply resulting from forced outages by generators. These are assessed as part of the MSCP's review of offer variations which generators submit after gate closure following a forced outage.

In the Panel's assessment of the cases of offer variations after gate closure, the MSCP did not make any determination on abnormal behaviour from the forced outages. Prices in the NEMS generally reflected the supply and demand conditions in 2019.

Looking Ahead

Review of the Prudential Requirements Regime

EMC conducted a review of the credit support requirements imposed on MPs in the NEMS. The review was undertaken to address the gaps or inadequacy in the current credit support requirements arising from the liberalisation of the retail electricity market, particularly

Table 14: Risk Exposure Thresholds

Risk Exposure Threshold	MP	MSSL
First Notification Trigger	From 60% to 45%	From 60% to 50%
Margin Call Trigger	From 70% to 55%	From 70% to 60%

that of the market's risk exposure associated with a retailer's default.

Under the previous prudential requirements regime, the credit support requirement was based on an MP's expected average trading exposure over a 30-day period, which covered the 20-day settlement cycle and a 10-day default remediation and suspension process. There was no credit support coverage for the time customers are transferred to another retailer (i.e. the Market Services Support Licensee (MSSL) in this case) after the retailer exits the market (also known as the Retailer of Last Resort event).

Following the review, credit support requirements will now be increased to cover 38 days' exposure for MPs and 33 days' exposure for the MSSL. Additionally, the risk exposure thresholds that would trigger a margin call will now be lowered in accordance with Table 14.

These changes went into effect from 8 January 2020.

Review of Default Levy Arrangements

EMC, in its review of the arrangements on the imposition of default levy in the NEMS, proposed that the following changes be made to the existing default levy arrangements:

1. allocate the default levy to net creditors only;

2. allow monthly energy uplift charges as well as EMC and the PSO's fees to be recovered in full upfront in the event of a settlement shortfall;

3. correct the erroneous default levy calculations; and

4. elucidate definitions and timelines in the Market Rules.

Proposals 3 and 4 were supported by the Rules Change Panel (RCP) by majority vote.

The new rules arising from these two proposals will be made effective from 15 May 2020.

In contrast, proposals 1 and 2 did not receive support from the RCP. The EMC Board referred proposal 2 back to the RCP for re-consideration. The RCP agreed to reassess proposal 2 as a separate rule change proposal from the current rule modification paper.

Increased Installed Solar Capacity in the Market

The Minister for Trade and Industry announced plans for Singapore to increase the installed solar capacity in the market to reach 2 Gigawatt-peak by 2030. This is expected to account for about four percent of Singapore's total electricity demand today.

To achieve the target, solar panels will be adopted on a larger scale on increased available surfaces. There are pilot projects to deploy floating solar panels on water reservoirs and harvest solar energy from vertical building surfaces. Investments will also be made in energy storage systems so that energy can be stored for later use, thus alleviating peak demand power consumption.

ASSESSMENT OF THE WHOLESALE ELECTRICITY MARKET: State of Compliance within the Wholesale Electricity Market

Ensuring compliance is important in the operation of a competitive and reliable electricity market. Market participants 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 market is set out below.

Offer Variations After Gate Closure

Currently, the Singapore wholesale electricity market has a gate closure period of 65 minutes. Any offer variation data that is submitted within 65 minutes of the beginning of a dispatch period will be reported by EMC to the MSCP for investigation.

However, not all offer variations after gate closure are prohibited under the Market Rules. Specified circumstances are provided for in the Market Rules as exceptions that allow offer variations to be submitted after gate closure.

Chart 24 compares the number of offer variations after gate closure submitted by MPs in 2019 with the previous years.

Chart 24: Offer Variations Made After Gate Closure

Number of Offer Variations Made After Gate Closure
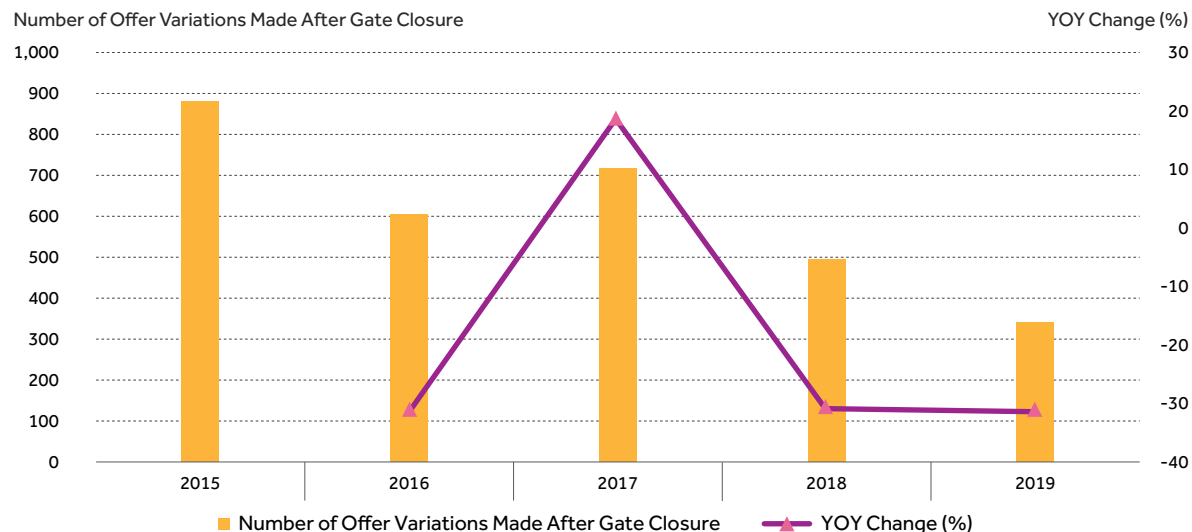
YOY Change (%)

Year	Number of Offer Variations After Gate Closure	YOY Change (%)
2015	884	–
2016	606	–31.45
2017	719	18.65
2018	497	–30.88
2019	342	–31.19

The number of offer variations after gate closure has significantly reduced at an annual average of 18.72% for the last five years, with a decrease of approximately 31.03% year-on-year over the last two years. 2019 recorded the lowest number of offer variations after gate closure since the market started. This reduction reflects the MAU assessment and recommendations put forward to the MSCP, and the Panel's assertive determinations and enforcement actions on errant market participants.

The MSCP has completed and issued determinations against 280 cases of the 342 offer variations made after gate closure. All 280 cases were found to be not in breach of the Market Rules. The remaining 62 cases are scheduled to be discussed for the MSCP's determination in 2020.

Rule Breach Determinations Issued

For the period 1 January to 31 December 2019, the MSCP issued nine determinations regarding rule breaches.

The determinations issued by the MSCP are a result of the MAU investigation and examination for the MSCP's deliberation. The MSCP's determinations are listed by breach type under the following subheadings:

ASSESSMENT OF THE WHOLESALE ELECTRICITY MARKET: State of Compliance within the Wholesale Electricity Market

Failure to Comply with Gate Closure

Two MSCP rule breach determinations were issued in 2019 in relation to eight offer variations after gate closure events identified in 2018 by Shell Eastern Petroleum (Pte) Ltd and ExxonMobil Asia Pacific Pte. Ltd.

- Shell Eastern Petroleum (Pte) Ltd's offer variations after gate closure on 6 October 2018.

- ExxonMobil Asia Pacific Pte. Ltd.'s offer variations after gate closure on 8 December 2018.

Failure to Comply with the Declared Quantities

The MSCP also issued two determinations against Singapore Refining Company Private Limited and TP Utilities Pte. Ltd. with regard to the non-compliance of their declared quantity (i.e. the energy offer quantity in the first price-quantity pair) with the Market Rules.

- Singapore Refining Company Private Limited's declared quantities in September and November 2018.

- TP Utilities Pte. Ltd.'s declared quantities on 22 April 2019.

Failure to Comply with the System Operation Manual During the PSO's Contingency Reserve Activation

Two rule breach determinations were issued against Red Dot Power Pte. Ltd., an interruptible load service provider, for its breach of the System Operation Manual. These were in relation to its non-compliance events during the PSO's contingency reserve activation.

- Red Dot Power Pte. Ltd.'s restoration of interrupted load before the PSO gave clearance on 5 January 2019.

- Red Dot Power Pte. Ltd.'s failure to comply with the PSO's direction on 20 March 2019.

Failure of Associated Load of an Embedded Generation Facility (EGF) Group to Comply with a Minimum Consumption of at Least Half of the Generation of That EGF Group in a Successive 12-Month Period

The MSCP also made its first determination on the market rule concerning the associated load of the embedded generation facility (EGF) group, which failed to consume at least half of the generation of that EGF group in a successive 12-month period by TP Utilities Pte. Ltd.

- TP Utilities Pte. Ltd.'s associated load of the EGF group failed to consume at least half of the generation of that EGF group in a successive 12-month period.

Failure to Comply with the Market Operation Responsibilities Under the Market Rules

EMC was also served two rule breach determinations from the MSCP, one for its breach occurring in October 2018 and another in January 2019.

- Energy Market Company Pte Ltd's failure to determine, release and publish real-time dispatch schedule, short-term schedule and pre-dispatch schedule on 2 October 2018.

- Energy Market Company Pte Ltd's failure to use the most current valid information on the dispatch related data received from the PSO from 1 January to 7 January 2019.

The number of rule breach determinations issued in 2019 increased to nine, compared to three in the previous year. However, the MSCP recognises that some of the rule breach determinations made in 2019 were in relation to incidents occurring in the year before.

Of note, the 280 cases of offer variations after gate closure which the MSCP has completed in its review this year, were all determined to be not in breach of the Market Rules. This is an improvement compared to the nine cases[13] in 2018 that were determined by the MSCP to be in breach. The improved gate closure statistics are evidence of the MSCP's reinforcement efforts in ensuring that market participants comply with the Market Rules, and the effectiveness of the implementation of the remedial actions by the relevant market participants to minimise recurrence.

No suspension order was issued to any market participants this year, in contrast to two suspension orders that were issued in 2018.

Automatic Financial Penalty Scheme

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

In 2019, it was observed that 14 generation companies were issued with automatic financial penalties for a total sum of $338,636.02.

Since the inception of the scheme, there has been a decrease in the penalty collected from the AFPS. This reflects an improvement in the generators' compliance with dispatch schedules.

In 2019, the market also saw the first penalty imposed on a load registered facility under the AFPS, for a sum of $5,000.00.

Table 15: Financial Penalties Imposed Under the AFPS ($)

Year	Amount of Financial Penalties Imposed Under the AFPS
2015 (from 17 November)	82,262.00
2016	544,846.25
2017	530,283.45
2018	401,146.29
2019	338,636.02

[13] This includes eight cases from Shell Eastern Petroleum (Pte) Ltd and ExxonMobil Asia Pacific Pte. Ltd. and one case from Sembcorp Cogen Pte Ltd on 25 January 2018 (the determination was issued in 2018).

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 2019. The MSCP determined nine cases of rule breaches over the year. The number of offer changes made after gate closure declined from 497 to 342. The improved gate closure statistics reflect the MSCP's reinforcement efforts in ensuring that market participants are compliant with the Market Rules and the effectiveness of the implementation of the remedial actions by the relevant market participants to minimise recurrence.

In all, rule breaches and gate closure violations were found not to have had significant impact on the NEMS as the Market Assessment Unit (MAU) worked in coordination with the Power System Operator to analyse relevant information about breaches to the Market Rules potentially leading to any effect on the system security and reliability of supply, as well as to any price distortion that could have had an impact on the market conditions or the financial integrity of the market.

The MSCP considers it relevant to highlight the significant fall in the number of default notices issued to market participants, compared to 2018. No suspension orders were issued to any market participants this year, in contrast to two suspension orders issued to two retail licensees following their respective unremedied defaults in 2018.

With regard to prices, after a volatile 2018, 2019 was a year of lower Wholesale Electricity Prices, recording a 10.74% lower annual average price, in line with reduced fuel oil prices. This framework led to fewer instances of outlier prices, of only two days, down from six high price events identified a year ago.

Regarding market share, the top three-firm concentration ratio by capacity has remained fairly similar in recent years. In 2019, the top three market players accounted for a 64.70% share of the market based on maximum capacity. While there were no new conventional plant installations in the NEMS this year, the development of a competitive fringe, particularly from the rising entry of intermittent generators (i.e. solar) may add to the level of competitiveness in the market.

The structural improvement in the market observed in 2018, in both the generation and retail sectors, has remained solid, after the launch of the Open Electricity Market for household consumers in November 2018 and the full roll-out of the Energy Market Authority initiative in 2019, incentivising the entrance of new participants.

In line with the above-mentioned initiatives, two new market participants joined the NEMS in 2019 under the wholesale market trader market participant class. New intermittent generation facilities continue to enter the market, bringing the total to 52 units with a collective capacity of 127.347MW. In contrast to past years, the retail front did not see any entry of new participants in 2019.

New rule modifications were also introduced to review and improve the existing processes established in the NEMS. In all, these developments together bring about a more competitive and dynamic electricity industry for the years to come.

The MSCP looks forward to the continuous evolution of the industry to greater heights and will persist with its commitment to enforce compliance with the Market Rules, supported by the MAU's monitoring and surveillance activities, investigations of alleged rule breaches and advisory functions to the Panel on enforcement actions to make sure that the market consolidates its path towards a more efficient and effective operation.

Mr. T P B Menon
Chairman
Market Surveillance and
Compliance Panel

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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 Limited (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.

Table 16: 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: https://www.openelectricitymarket.sg/business/resources/vesting-contracts/vesting-data

- Due to rounding, numbers presented throughout this report may not add up precisely to the totals indicated, and percentages may not precisely reflect the absolute figures for the same reason.

- References to 2018 figures in this year's report may slightly differ from last year's report due to rounding to two decimal points for all figures.

- All companies mentioned in this report are referred to by their legal entity name in line with their registered entity name under the Accounting and Corporate Regulatory Authority.

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:

  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.

Price Indices

The Wholesale Electricity Price (WEP) is the net purchase price paid by retailers, inclusive of all administrative costs incurred in the wholesale market. This price consists of the following cost components: Uniform Singapore Electricity Price (USEP), allocated regulation price (AFP), hourly energy uplift charge (HEUC), monthly energy uplift charge (MEUC), EMC fees and PSO fees.

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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.

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