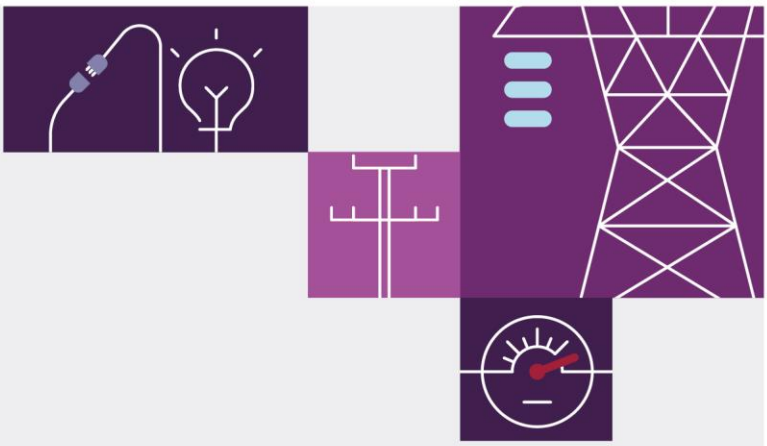
AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Scheduling Error Report

October 2022

NEM Dispatch Engine – Constraint Calculation Error – 10 August 2022

A report for the National Electricity Market



Important notice

Purpose

This report describes the circumstances surrounding a scheduling error identified by AEMO under NER 3.8.24(a)(2). AEMO has prepared this report using information available as 18 October 2022, unless otherwise specified.

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Abbreviations

Abbreviation	Term
AER	Australian Energy Regulator
FCAS	Frequency control ancillary service
GW	gigawatt
MCC	Marginal Cost of Congestion
MII	Manifestly incorrect input
MW	megawatt
MWh	megawatt hour
NEMDE	National Electricity Market Dispatch Engine
OCD	Over Constrained Dispatch
R6, R60, R5	Fast (5 second), slow (60 second) and delayed (5 minute) FCAS raise services respectively
L6, L60, L5	Fast (5 second), slow (60 second) and delayed (5 minute) FCAS lower services respectively
LREG, RREG	Lower and raise FCAS regulation services respectively
RHS	Right-hand side (of a constraint equation)
LHS	Left-hand side (of a constraint equation)
PCF	Participant compensation fund
DRP	Dispute resolution panel
MNSP	Market Network Service Provider

Glossary

Term	Definition
Non-functional change	A software change that does not affect inputs, calculations or outputs from an application. For example, a change that addresses a solution time only is considered non-functional.
System strength	A characteristic of the power system relating to its ability to maintain a stable voltage waveform following a fault or disturbance
Voltage stability	The ability of a power system to maintain steady voltages after a disturbance
Resolved/unresolved	The result of an OCD rerun to determine a valid price. If a case is unresolved, AEMO manually reruns the case to find a valid price.

Executive summary

AEMO has determined that it failed to follow the central dispatch process set out in National Electricity Rules (NER) 3.8 from trading interval 1135 hrs to trading interval 1235 hrs on 10 August 2022, constituting a scheduling error under NER 3.8.24.

The error resulted in the National Electricity Market (NEM) dispatch engine (NEMDE) determining incorrect requirements for several market ancillary services (FCAS) in all regions, and incorrectly calculating several other constraint equations. These artificial requirements significantly exceeded the quantities of FCAS available, resulting in prices for those services at or near the market price cap in all regions. The electricity spot price in Tasmania was also at or near the market price cap.

AEMO identified that the issue commenced after an IT change to NEMDE. AEMO reversed the software change, which resolved the issue from trading interval 1240 hrs. AEMO declared this incident as a scheduling error on 12 August 2022.

Planned NEMDE change

NEMDE is used online for dispatch and pre-dispatch, and for offline marginal cost of congestion (MCC) analysis for the Australian Energy Regulator (AER). In early 2022, AEMO observed an MCC case that did not solve. Following an investigation, AEMO concluded that a similar result could occur in dispatch and that a change was needed to address the potential performance issue.

A non-functional change[1] was developed, tested and placed into pre-production in March 2022 using AEMO's internal change control procedures. Following independent certification, the new version of NEMDE was scheduled for implementation in the production system on 10 August 2022.

Error and initial impacts

The NEMDE change introduced a defect in NEMDE that had not been detected in testing. The defect affected calculation of the right-hand side (RHS) of affected constraints, causing constraint default values to be used for several calculations. In particular, the error affected calculation of FCAS requirements and the number of synchronous generating units in service in north Queensland system strength constraints.

There were no threats to system security as a result of the error. The direct impacts of the error on central dispatch were:

- Violation of FCAS requirements for the services mentioned above. Of the 13 intervals affected, seven were automatically resolved under AEMOs' over-constrained dispatch (OCD) rerun process[2] before the end of the relevant trading interval. The other six remained unresolved.
- Pricing of several services at or near the market price cap of $15,500. Energy prices and other FCAS prices in all regions were also affected to varying degrees, with Tasmania's energy price at or near the market price cap.
- Energy dispatch errors due to co-optimisation of energy and FCAS to maximise the amount of FCAS dispatch.

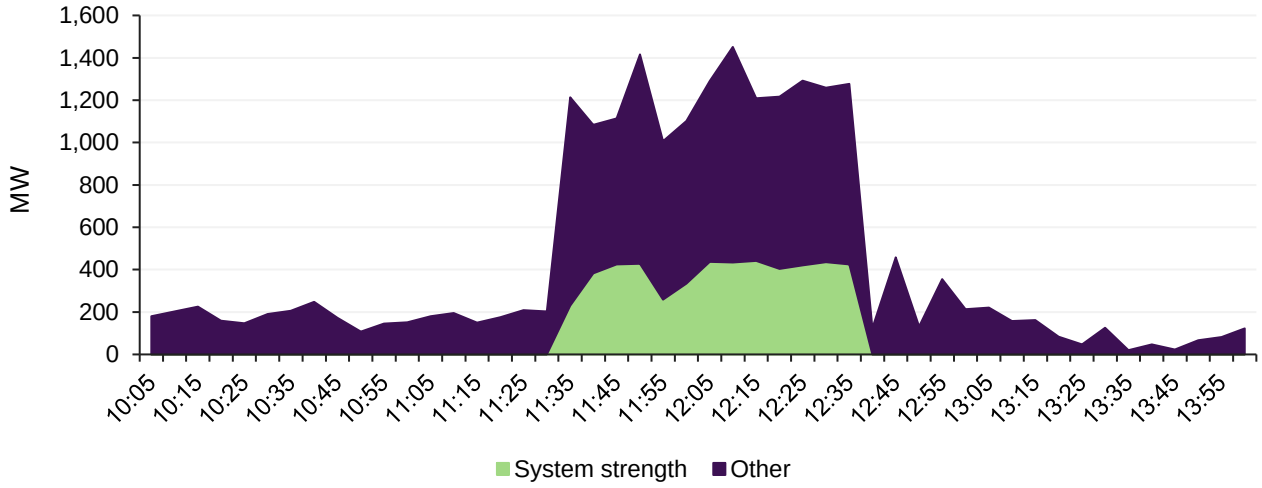
[1] That is, a change that does not change the inputs, calculations or outputs of NEMDE.

[2] See Over-Constrained Dispatch Rerun Process, at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/2016/Over-Constrained-Dispatch-Rerun-Process.pdf.

- Around 1,000 megawatts (MW) of generation was constrained-off by network constraints that bound because of the error.
- Flows on interconnectors and Basslink were changed due to changes in dispatch of generation.

The reduction in dispatched solar and wind generation resulting from the scheduling error across the NEM is shown in Figure 1. “System strength” refers to constraints on renewables in North Queensland due to system strength and voltage collapse limits. “Other” refers to differences in dispatch of variable renewables that have not been directly attributed to system strength or a market response. They are likely due to the co-optimisation of energy and FCAS by NEMDE for other generators.

Figure 1 Reduction in dispatched solar and wind during the scheduling error.



Several market generators, mainly semi-scheduled generators, rebid to reduce their generation, citing the high FCAS contingency prices in rebid reasons. Figure 1 does not show changes in generation due to rebidding.

Subsequent actions

Pricing and dispatch

The dispatch outcomes resulting from the scheduling error did not trigger the automated procedures for determining trading intervals subject to price review (NER 3.9.2B), and AEMO did not determine at the time that the affected intervals were likely to be subject to a manifestly incorrect input.

All affected intervals were over-constrained dispatch (OCD) runs. As noted above, seven were resolved by the automated rerun process with the ‘resolved’ prices published by NEMDE. For the remaining six affected intervals, the defect in NEMDE that caused the dispatch error also resulted in pricing errors in the automated rerun process, and these prices were flagged by automated market notices as subject to review.

All energy and FCAS prices for these trading intervals were subsequently recalculated offline using the reinstated version of NEMDE. The energy and FCAS prices of the six unresolved OCD intervals were revised on 10 August. As a result of the extreme impacts of this scheduling error, AEMO made a decision to also revise the prices for the seven automatically ‘resolved’ intervals the next day. All prices were revised using the reinstated version of NEMDE by the end of 11 August 2022 (the next business day, aligning with the timeframe in AEMO’s OCD price revision process).

The recalculated dispatch runs include information that can be used to estimate dispatch instructions had the error not occurred.

Market notification

The categorisation of the software change as non-functional meant there was no broad internal communication in AEMO prior to its implementation. As a result, in the period after constraints began violating after 1130 hrs, AEMO operational staff could not immediately identify the reason for those outcomes. It took around 40 minutes before the probable cause was identified as software-related, and for the software change to be established as coincident with the dispatch issues. Work to reverse the change then began immediately.

AEMO's first market notice to inform the market was issued after the software change had been reversed, at 1311 hrs on 10 August[3].

Scheduling error compensation

Under the NER, a participant compensation fund has been established to fund compensation to scheduled and semi-scheduled generators and scheduled network service providers who incur spot market losses arising from specified dispatch outcomes resulting from the scheduling error. Compensation is limited to the specified participants and outcomes, and by the amount in the fund. Any compensation claims must be determined by a dispute resolution panel. AEMO is working with the NEM Dispute Resolution Adviser to facilitate the compensation claims process.

Recommendations

While it is not feasible to eliminate the risk of errors being introduced into software logic in NEMDE upgrades, AEMO has identified the following process improvements to further mitigate that risk:

- Additional cases to be used in testing and certification that include examples of the constraints that were affected by the error.
- Constraint default values to be revised to reflect reasonable worst-case values (completed).
- Internal notification processes for software change implementation involving NEMDE and other critical business systems to be reviewed and expanded, to heighten vigilance when implementing changes into production, regardless of their nature. This includes having key business and IT staff on standby to confirm satisfactory operation of systems functions.

AEMO acknowledges that the delay in providing any information to the market about the incident was not acceptable. AEMO will improve its external notification alert procedures to provide timely notification to market participants of major dispatch-related software incidents under investigation, regardless of whether the cause is yet identified.

AEMO is also continuing its work to identify potential options to incorporate FCAS-related triggers into the automated procedures to review dispatch intervals for manifestly incorrect inputs under NER 3.9.2B.

[3] See MN 100839 at https://aemo.com.au/market-notices?marketNoticeQuery=100839&marketNoticeFacets= .

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1 Summary

AEMO has determined that it failed to follow the central dispatch process set out in National Electricity Rules (NER) 3.8 from trading interval 1135 hrs to trading interval 1235 hrs on 10 August 2022.

The error resulted in high market ancillary services (FCAS) requirements for the fast raise (R6), fast lower (L6), slow raise (R60) and slow lower (L60) services in all regions, and incorrect calculations of several other constraint equations. The FCAS requirements were unable to be supplied, violating the requirements and resulting in prices at or near the market price cap of $15,500/megawatt hour (MWh) for each of these services. The electricity spot price in Tasmania was also at or near the market price cap.

AEMO identified that the issue commenced after a change to the National Electricity Market (NEM) dispatch engine (NEMDE). AEMO reversed the software change, which resolved the issue from trading interval 1240 hrs.

All intervals were over-constrained dispatch (OCD) intervals, with seven intervals being resolved through automated processes, and six remaining unresolved. AEMO subsequently performed reruns for all affected intervals using the same dispatch inputs and the reinstated version of NEMDE. All prices from the OCD reruns were republished by the end of the following day (11 August 2022).

2 Description of the error

2.1 Planned change to NEMDE

NEMDE is the algorithm that is used by AEMO to dispatch energy and FCAS and solves for the regional prices for each dispatch interval. While NEMDE's primary function is for dispatch and pricing in the spot market, it is also used for pre-dispatch schedules, and for offline marginal cost of congestion (MCC) analysis for the AER. In early 2022, AEMO observed an MCC case that did not solve. Following an investigation, AEMO concluded that a similar result could occur in dispatch and that a change was needed to address the potential performance issues.

A NEMDE IT update was developed to avoid the risk of unacceptably long solution times. That is, its purpose was to improve performance, not to change the mathematical functionality of NEMDE. The change was not intended to impact on the inputs, calculations or outputs of NEMDE and was therefore categorised as 'non-functional'.

The change was developed, tested and placed into pre-production in March 2022 using AEMO's change control procedures. Following independent certification, the update was scheduled for implementation in production system on 10 August 2022.

At 1130 hrs on 10 August 2022, the update was implemented. This had an immediate impact on dispatch and prices. After AEMO had identified that the issue was due to the IT change, the software change was reversed by 1235 hrs – hence the affected trading intervals were 1135 hrs to 1235 hrs inclusive.

2.2 Constraints affected

NEMDE's primary functions are to dispatch energy and FCAS at the lowest cost, while considering the physical limitations of the power system, and to determine prices for energy and FCAS. To produce an outcome that

operates the power system within its technical envelope, constraint equations are used in NEMDE to ensure the network limit and ancillary service requirements of the power system are satisfied in the dispatch solution.

The requirements of the power system are typically set on the right-hand side (RHS) of constraint equations and are factors that NEMDE cannot change in dispatch – for example, the amount of FCAS required for a contingency event. The left-hand side (LHS) of constraint equations contains dispatchable factors such as generator outputs, which NEMDE is able to determine and optimise.

On the RHS, some power system requirements may be shared across multiple constraint equations. Generic equations are formulas or variables used to represent these common terms with either a dynamically computed value or a generic default value assigned to them. All constraints make use of default values to cover the possibility of missing data.

Subsequent investigation found the update introduced an error into the calculation of the RHS terms. For constraints with more than one generic equation, the calculation logic only evaluated the first generic equation in the constraint, with subsequent terms being set to their default values.

This caused several constraint equations to produce unreasonable RHS values, in particular:

- FCAS constraints:
  - FCAS constraints calculate the amount of required FCAS within the power system for a credible contingency event.
  - The use of default values for the generic equation terms of FCAS constraints resulted in artificially high RHS calculations and subsequently high FCAS requirements for multiple markets.
- System strength constraints:
  - In far north Queensland, due to the high number of inverter-based resources (IBR), there are constraints used to manage system strength (the ability of the power system to maintain and control the voltage waveform).
  - Queensland system strength constraints use generic equations to count the number of synchronous generators online in the Queensland region. With a default value of 0 used for each equation after the first, the system strength requirements could not be met, and some Queensland semi-scheduled generators were constrained down as a result.
- Voltage stability constraints:
  - Voltage stability is the ability of a power system to maintain steady voltages after a disturbance.
  - The constraint equations Q^FNQ_MEWF_-70_-120 and Q^FNQ_MEWF_-60_-100 used a default value of 0 for their second generic equation, indicating an outage of either the 7139 or 7301 transmission lines in far north Queensland. The requirement to dispatch additional North Queensland synchronous generation to increase the LHS of the equation had a very high associated marginal value at the time of the incident.

2.3 FCAS impacts

FCAS constraints calculate the amount of FCAS required in the power system, either across the NEM, or within individual regions if they are at risk of separation or islanding. Due to the similarity in their requirements, the FCAS 6-second and 60-second constraints are built with a similar structure and contain the same generic equations.

Taking the FCAS constraint, “F_I+BIP_ML_L6” as an example:

DISPATCH RHS = Max

(Boyne Island potline 3 load,

Max **(**

Boyne Island potline 2 load,

Boyne Island potline 1 load

)

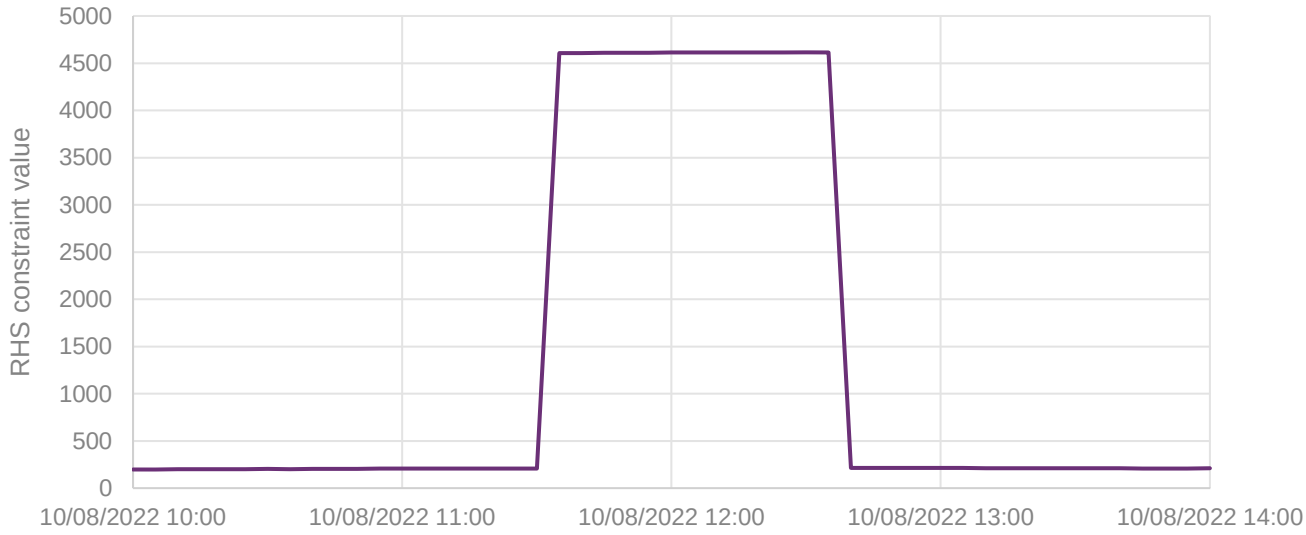
)

+ *Generic Equation:* X_MAIN_LOAD_RELIEF (Default value = 0)

+ 4 x [*Generic Equation:* X_TAS_LOAD_RELIEF_DS (Default value = 1100)

The calculation error arises with the second generic equation (X_TAS_LOAD_RELIEF_DS). When evaluated, it is normally in the order of -1e-6*TAS_GEN+NON_SCHED (close to 0, with a multiplier of 4). However, the default value for those equations was 1,100. The four times multiplier increased the overall value of the RHS to above 4,500, as seen in Figure 2 of the RHS output during the affected intervals.

Figure 2 RHS output of FCAS constraint



This occurred over multiple FCAS constraints, and due to the artificially high RHS requirement, NEMDE could not obtain enough FCAS and violated these constraints.

2.4 System strength constraints impact

System strength is a characteristic of the power system relating to its ability to maintain a stable voltage waveform following a fault or disturbance. Historically power system operators did not need to manage system strength due to its inherent provision by synchronous generators. However, in areas with an increasing number of inverter-based generators, including far north Queensland and South Australia, AEMO uses constraints to manage system strength.

For each inverter-based facility in Queensland, a corresponding constraint exists with the general naming convention:

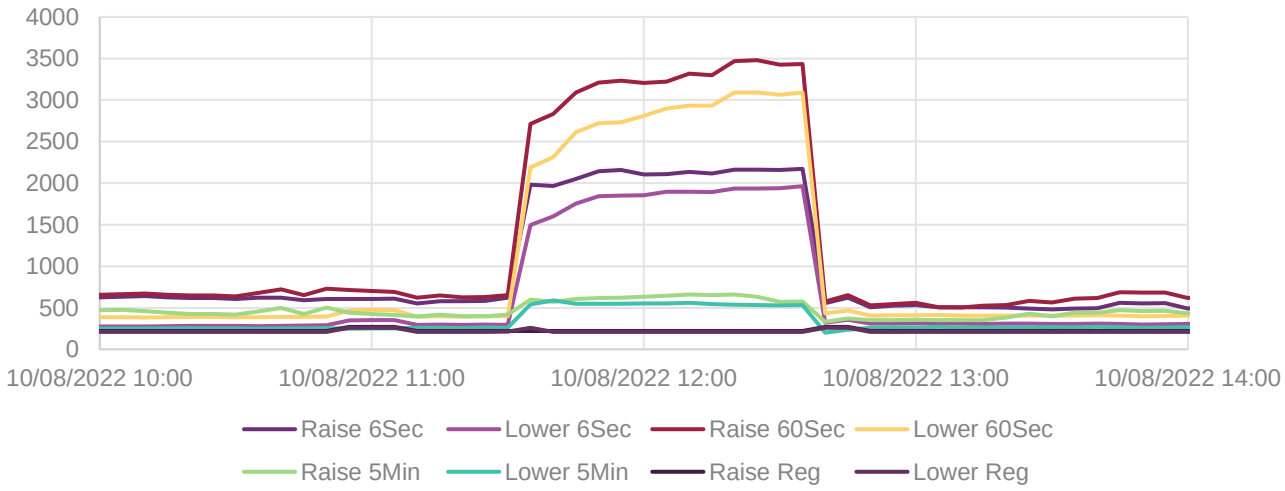
Q_NIL_STRGTH_<facility> or Q_STR_7C2K_<facility>

These constraints have generic equations that count the number of synchronous generators online in Queensland. With the default value of the generic equations assuming none of the synchronous generators were online, the system strength constraints were binding during the incident and semi-scheduled generators in far north Queensland were constrained down as a result.

2.5 Changes to dispatch outcomes

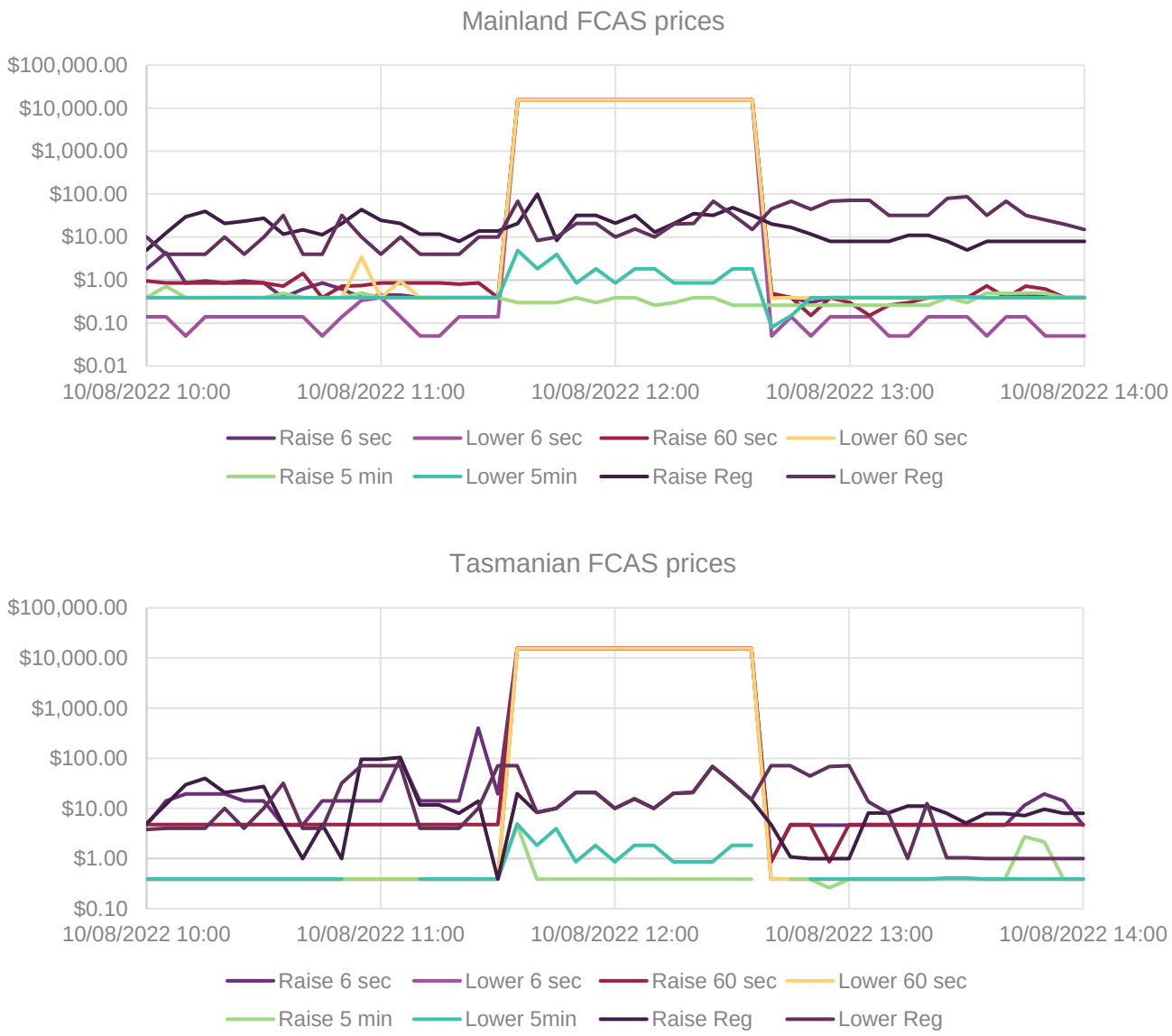
To meet the artificially high RHS requirements, NEMDE dispatched almost five times the normal amount of FCAS in the L6, R6, L60 and R60 markets (see Figure 3).

Figure 3 Dispatched FCAS from 10:00 to 14:00 on 10 August 2022



Due to the high procurement of FCAS, prices for the L6, L60, R6 and R60 markets were at the price cap of $15,500 for all regions (see Figure 4). The price for energy in Tasmania was also at the price cap. Prices for all other energy and FCAS markets were also impacted.

Figure 4 Mainland and Tasmanian FCAS prices (log scale)



Many constraints were violated over the 13 dispatch intervals. Of the 13 intervals affected, seven were automatically resolved before or within the trading interval under AEMOs' OCD rerun process, described in Section 3.3. The other six remained unresolved.

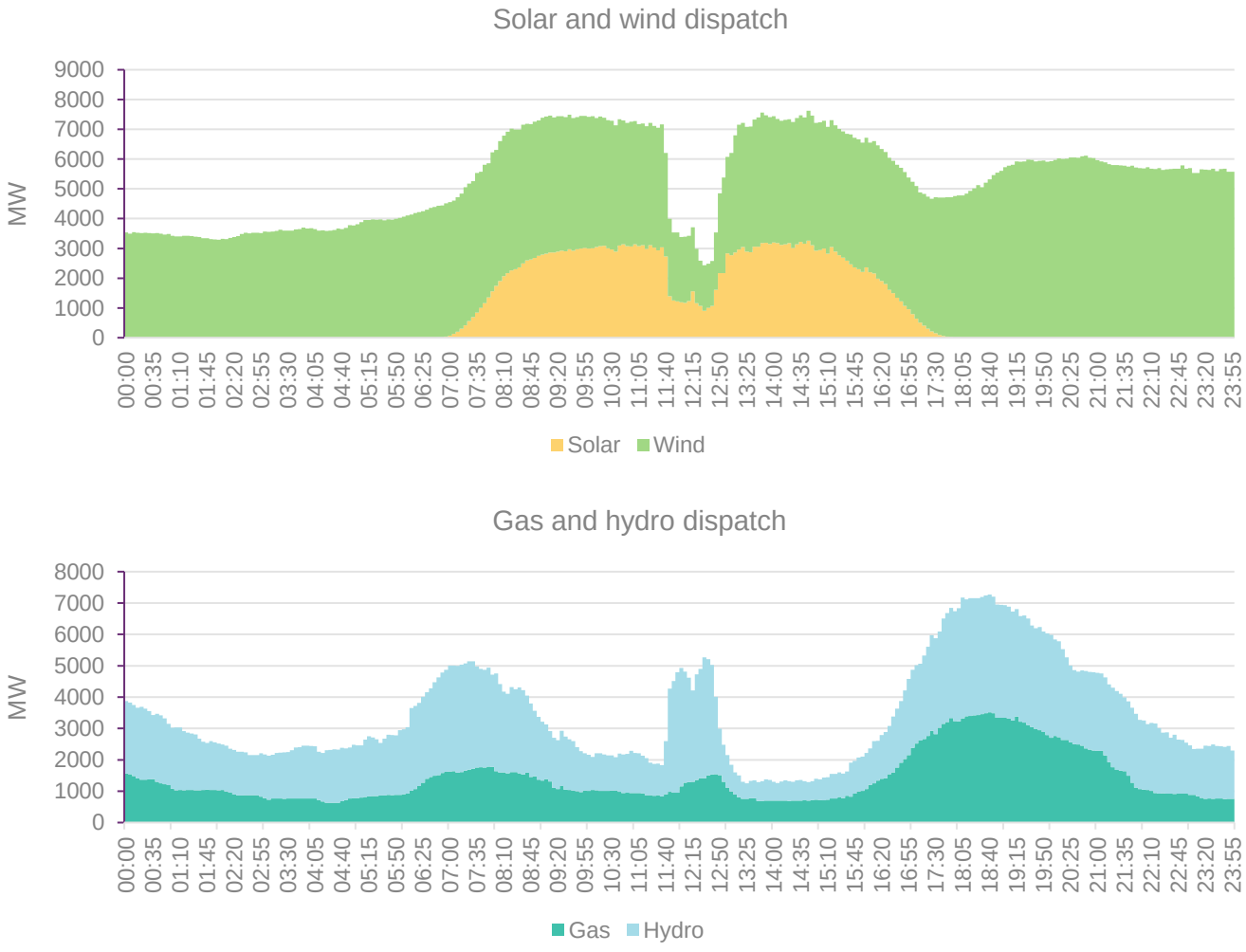
Table 1 Automatically resolved trading intervals

Trading interval	OCD rerun	Market notice
10/08/2022 11:35	Resolved (inline rerun)	
10/08/2022 11:40	Resolved (inline rerun)	
10/08/2022 11:45	Resolved (inline rerun)	
10/08/2022 11:50	Resolved (inline rerun)	
10/08/2022 11:55	Unresolved	100827
10/08/2022 12:00	Unresolved	100829
10/08/2022 12:05	Unresolved	100830

Trading interval	OCD rerun	Market notice
10/08/2022 12:10	Unresolved	100831
10/08/2022 12:15	Resolved (automated offline rerun)	100832 & 100833
10/08/2022 12:20	Resolved (inline rerun)	
10/08/2022 12:25	Unresolved	100834
10/08/2022 12:30	Unresolved	100835
10/08/2022 12:35	Unresolved	100836

Several market generators, mainly semi-scheduled generators, rebid to reduce their generation, citing the high FCAS contingency prices in rebid reasons. There was a reduction of 1,750 megawatts (MW) of solar generation and almost 2 gigawatts (GW) of wind generation in the affected trading intervals, with most of this generation being replaced by hydro and gas, as shown in Figure 5.

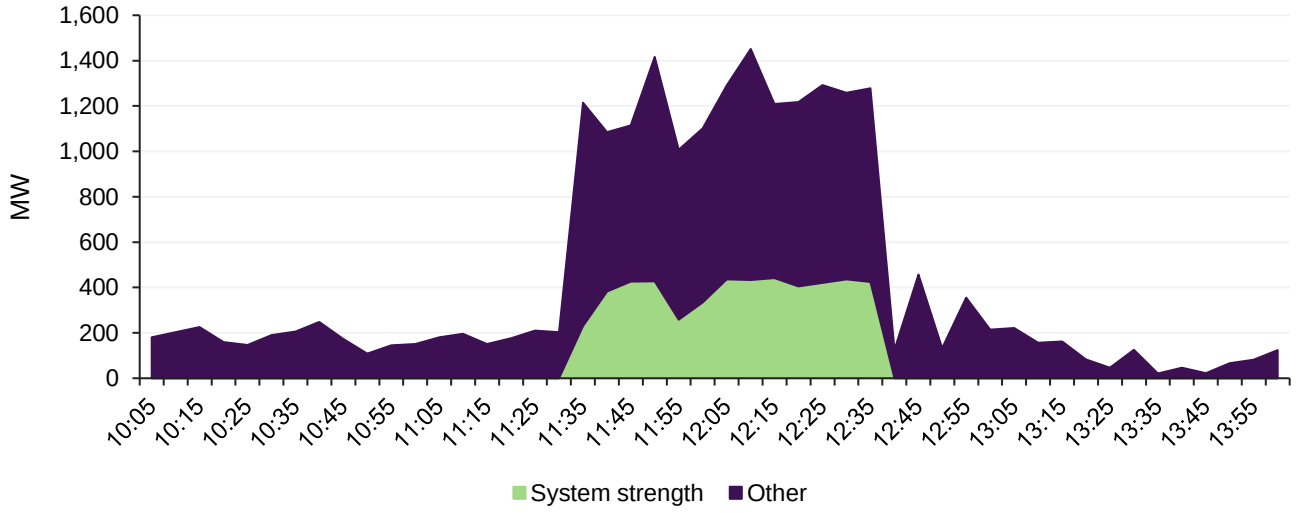
Figure 5 Generation fuel mix over 10 August 2022



Some intermittent generators were subject to a semi-dispatch cap by system strength and voltage collapse constraints. Figure 6 shows the total amount of constrained megawatts for variable renewable energy (VRE) sources that were subject to a semi-dispatch cap during the scheduling error period. Factors such as co-optimisation of FCAS and energy markets have been separated from the system strength constraints in the

'Other' category. Approximately 1,000 MW of semi-scheduled generation was dispatched lower as a direct result of the error.

Figure 6 Constrained off variable renewable energy (MW)



3 Assessment of the error and response

3.1 Change control and communications

Changes to NEMDE are subject to independent certification by an external provider. There are two types of certifications, depending on the nature of the change:

- Certification of the mathematical formulation against the requirements of the NER.
- Certification of the software implementation against the mathematical formulation.

As this change was not intended to change the mathematical formulation and had therefore been categorised as non-functional, only the software implementation was certified.

The software certification was undertaken using a set of test cases developed by AEMO and verified for suitability with the external certifier. These cases did not incorporate a constraint RHS where multiple generic equations are used, so could not have identified the error. The other testing undertaken concentrated on confirming there were no unacceptable issues with solution time – effectively testing that the change had met its intended purpose without degrading solution time performance in other respects. With this confirmed, the change to NEMDE was implemented in pre-production.

Pre-production is an environment that simulates the production environment for performance testing and testing participant interfaces. As with software certification, the pre-production run verified that the change would not impact on solution times. The NEMDE error was not identified during pre-production testing.

The change was then scheduled to be placed into production.

The categorisation of the software change as non-functional meant there was no broad internal communication in AEMO prior to its implementation. As a result, in the period after constraints began violating after 1130 hrs, AEMO operational staff did not immediately identify the source as a NEMDE issue. It took around 40 minutes before the probable cause was identified as software-related, and to establish that the software change was coincident with the dispatch issues arising. Work to reverse the change then began immediately.

The previous version of NEMDE was placed into production with effect from trading interval 1240 hrs (after 13 trading intervals). During this period, AEMO's focus was on identifying and resolving the issue, and the market was not notified until after the software change had been reversed.

A market notice (MN 100839[4]) was issued at 1311 hrs on 10 August informing participants of the large changes in contingency FCAS requirements, violation of FCAS constraints, and market price caps for those services in all regions and for energy in Tasmania. The notice indicated that dispatch appeared to have been running normally from the trading interval ending 1240 hrs, after reversing a software change.

3.2 Automated procedures for determining manifestly incorrect inputs

Under NER 3.9.2B(a), software setup is considered to be an input for the purpose of determining whether there has been an incorrect input used by the dispatch algorithm. NER 3.9.2B(h) requires AEMO to develop procedures for the automatic identification of trading intervals subject to review for a manifestly incorrect input (MII), and AEMO may use those procedures to identify a trading interval as subject to review[5].

The automated procedures will trigger when there has been a sufficiently large change in a regional price and an interconnector flow. However, they will not trigger solely due to an FCAS change, so in this case, the MII process did not trigger. NER 3.9.2B(c) allows AEMO to determine that a trading interval is subject to review if AEMO considers that it is likely to be subject to a MII, but this discretion only applies if the immediately preceding trading interval has already been identified as subject to review (that is, there must have been an initial trigger under the automated procedures in a prior interval). AEMO therefore did not determine that any of the affected trading intervals was subject to a MII.

An unrelated scheduling error occurred in April 2022 when an incorrect input to an FCAS constraint caused a large dispatch and price error in Tasmania. Prior to the 10 August event, AEMO had commenced preliminary investigation of potential options for an automated FCAS trigger for a MII. This assessment is ongoing, and any feasible identified options will be subject to consultation before implementation. A successful FCAS incorrect input trigger would allow automatic detection, notification, and (in theory) correction of FCAS prices affected by a MII. It would not, however, prevent the same dispatch outcomes from continuing until the software issue could be corrected, noting that NER 3.9.2B requires confirmation of prices for intervals flagged for MII review within 30 minutes after initial publication.

[4] See MN 100839 at https://aemo.com.au/market-notices?marketNoticeQuery=100839&marketNoticeFacets=.

[5] AEMO Dispatch SP_OP_3705. Current version 89.0, published 1 July 2022, available at https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power_system_ops/procedures/so_op_3705-dispatch.pdf?la=en.

3.3 Price revisions

All affected intervals (trading intervals from 1135 hrs to 1235 hrs inclusive) were OCD runs, with the FCAS prices of fast raise and lower (R6/L6), and slow raise and lower (R60/L60) contingency services at the market price cap of $15,500.

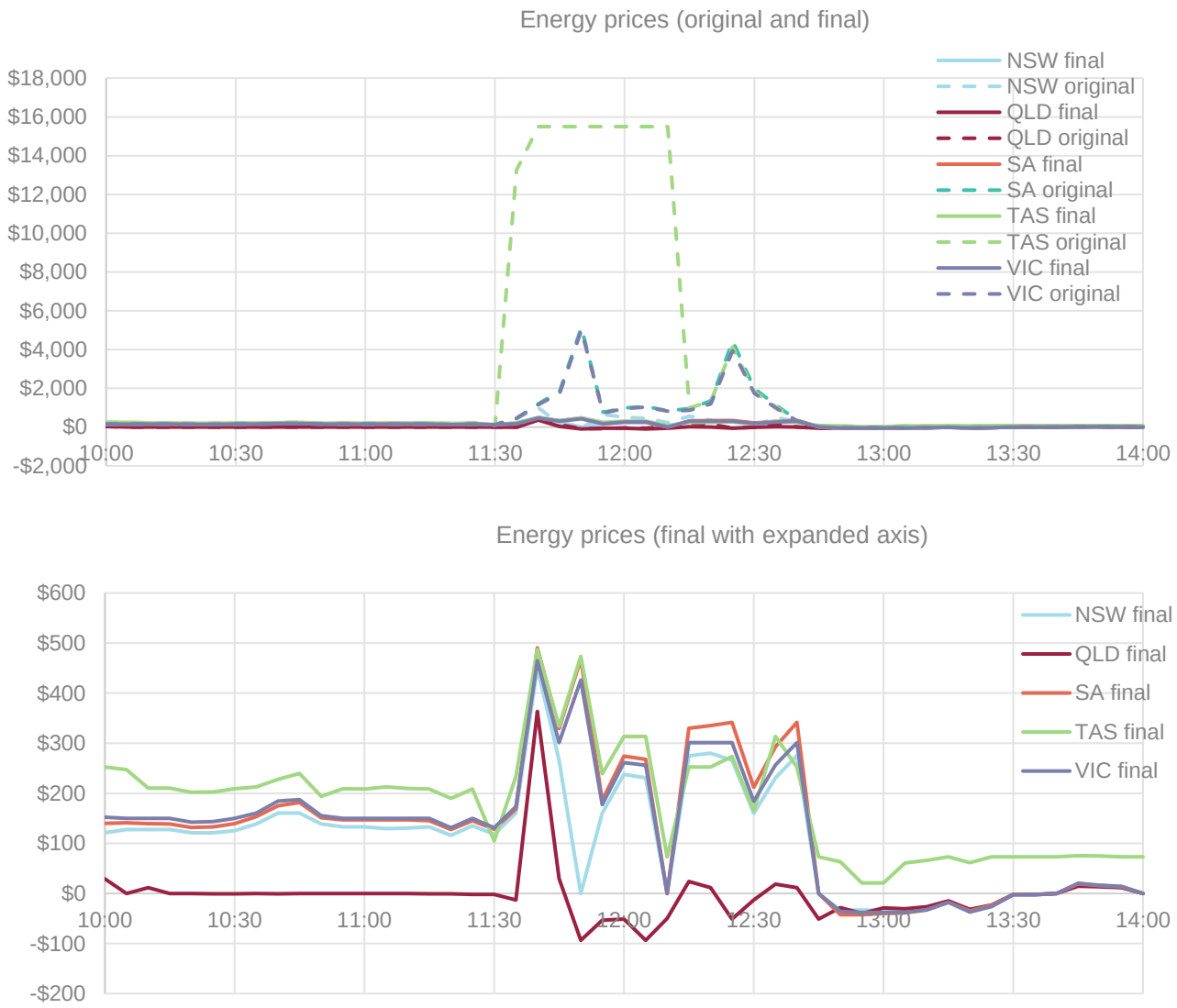
As noted above in Table 1, seven of these OCD intervals were resolved by the automated rerun process set out in AEMO's Over-constrained Dispatch Rerun Process Document[6], with the 'resolved' prices published by NEMDE. Of these seven, all but one was resolved in the 'inline' OCD rerun. The 1215 hrs trading interval was not resolved by the start of the interval and re-run using the automatic offline process, with prices confirmed within the same trading interval. For the remaining six affected intervals, the defect in NEMDE that caused the dispatch error also resulted in pricing errors in the automated rerun process, and these prices were flagged by automated market notices as subject to review. According to section 3.2.1 of the OCD rerun process document, offline OCD reruns are to be undertaken by the end of the next business day.

All energy and FCAS prices for the six unresolved OCD intervals were recalculated offline using the reinstated version of NEMDE. The OCD process document specifies that reruns are to be undertaken by relaxing violating constraints. However, this would not been effective given the constraint relaxation process would still have contained the fundamental software error that caused the OCD interval. The process document simply does not contemplate a gross error caused by a software failure within NEMDE. The only feasible option available to AEMO was to use the reinstated version of NEMDE in the rerun process.

All prices, in all regions, for these six intervals were revised later on 10 August. These updated prices are shown in Figure 7.

[6] AEMO Over-Constrained Dispatch Rerun Process. Current version 1.2, published 16 June 2011, available at https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/2016/Over-Constrained-Dispatch-Rerun-Process.pdf.

Figure 7 Energy price revisions



Although not contemplated by the NER, as a result of the extreme market impacts of this scheduling error,[7] AEMO made the exceptional decision to also revise the prices for the other seven previously 'resolved' intervals the next day. All prices were revised using the same dispatch inputs, applied to the reinstated version of NEMDE (as described above), by the end of 11 August 2022 (the next business day).

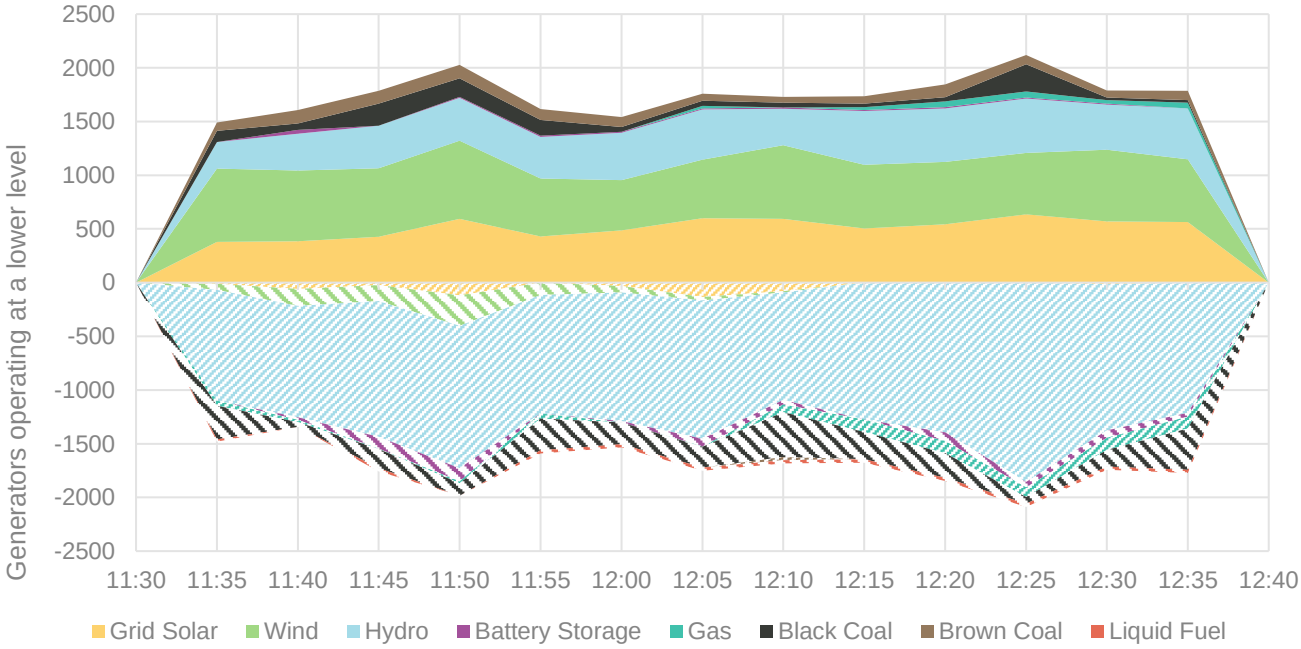
The recalculated dispatch runs that determined the revised prices also includes information that can be used to estimate dispatch instructions had the error not occurred.

Figure 8Figure 8 shows the difference between the actual dispatch targets of generating units and the dispatch targets in the OCD rerun. Generation that would have been dispatched higher had the dispatch error not occurred is shown above the zero axis, and generation that would have been dispatched lower is shown below the zero axis.

[7] AEMO estimated that the settlement cost of the additional FCAS and energy dispatched as a result of the error would have been approximately $200 million

Figure 8 shows the first order effects on solar and wind generation of the scheduling error to be approximately 1,000 MW. The NEMDE rerun did not reverse rebidding responses to the FCAS prices or any other second order impacts.

Figure 8 MW displaced from scheduled or semi-scheduled generating unit operating at a lower level



4 Scheduling error compensation

On 12 August 2022, AEMO declared a scheduling error due to a failure by AEMO to follow the central dispatch process under rule 3.8. Under the NER, a participant compensation fund (PCF) has been established to fund compensation to scheduled and semi-scheduled generators and scheduled network service providers who incur spot market losses arising from specified dispatch outcomes due to the scheduling error.

Any compensation claims must be determined by a dispute resolution panel (DRP). AEMO is working with the NEM Dispute Resolution Adviser to facilitate the compensation claims process[8].

Note that compensation from the PCF is limited in three ways (see NER 3.16.2):

- By amount – the DRP cannot award compensation exceeding the balance of the PCF at the time of award. Their determination will also take account of expected claims known at the time of any award. The current balance of the PCF is just over $5 million.
- By participant type – only scheduled and semi-scheduled generators and market network service providers (MNSPs) contribute to the PCF, and they are the only market participants eligible for compensation.

[8] Guidelines and application for compensation for a scheduling error, available at https://www.aer.gov.au/node/40426.

- By nature of impact – the error must have given rise to one of the central dispatch outcomes described in NER 3.16.2(d) to (g) for a relevant participant. Relevant for this event, these include receiving a dispatch instruction to operate at a lower level of generation or power transfer than would have been the case without the error.

For compensation purposes, AEMO is able to determine the target instructions that would have been determined using the reinstated version of NEMDE without the error.

5 Recommendations

While it is not feasible to eliminate the risk of errors being introduced into software logic in NEMDE upgrades, AEMO has identified the following process improvements to further mitigate that risk:

- Additional cases to be used in testing and certification that include examples of the constraints that were affected by the error.
- Constraint default values to be revised to reflect reasonable worst-case values (completed).
- Internal notification processes for software change implementation involving NEMDE and other critical business systems to be reviewed and expanded, to heighten vigilance when implementing changes into production, regardless of their nature. This includes having key business and IT staff on standby to confirm satisfactory operation of systems functions.

AEMO acknowledges that the delay in providing any information to the market about the incident was not acceptable. AEMO will improve its external notification alert procedures to provide timely notification to market participants of major dispatch-related software incidents under investigation, regardless of whether the cause is yet identified

AEMO is also continuing its work to identify potential options to incorporate FCAS-related triggers into the automated procedures to review dispatch intervals for manifestly incorrect inputs under NER 3.9.2B.