Consultation on automation of negative residue management for the implementation of transmission loops

Consultation paper - Standard consultation for the National Electricity Market

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Australian Energy Market Operator Ltd ABN 94 072 010 327

Executive summary

This consultation paper commences the consultation process conducted by AEMO to amend the Automation of Negative Residue Management document[1] to include a process that is appropriate for transmission loops (proposal) in preparation for the inclusion of the Project EnergyConnect (PEC) interconnector in AEMO's dispatch processes. Negative residue management (NRM) is the process used by AEMO to manage negative settlements residue and is applied under National Electricity Rules (NER) 3.8.1(b)(11). AEMO publishes its policy in respect of the management of negative settlements residue in accordance with NER 3.8.10(c)(5)[2].

At this stage PEC is due to be completed by October 2026, with inter-network testing due to commence in late 2026. From early next year AEMO will begin work towards implementation of PEC as a transmission loop in dispatch processes, in preparation for October 2026. AEMO may need to make complementary changes in other documents for the implementation of a transmission loop and will initiate further consultations as appropriate.

The current rule change proposal *Inter-regional settlement residue arrangements for transmission loops*[3] being considered by the AEMC is focused on allocation of negative settlement residues. The AEMC has confirmed in their Draft Determination[4] that they intend to support AEMO's approach to clamping in transmission loops where counter-price flows would only be clamped if the net inter-regional settlement residue (IRSR) for the loop is negative. Therefore this consultation is focused on the process of managing these negative IRSR around the loop. Note that the threshold for NRM (currently set at -$100,000) does not form part of the scope of this consultation.

In summary, AEMO is consulting on the following elements:

- The treatment of transmission loops, as arises from the implementation of the PEC interconnector.
- 'Cycling' issue in the existing clamping process.
- Other possible enhancements or changes to the existing NRM process and design.

AEMO is now consulting on this proposal and invites written submissions from interested persons on the issues identified in this paper to NEMReform@aemo.com.au by **5:00pm (Melbourne time) on Friday 11 July 2025.**

AEMO invites stakeholders to:

- Provide feedback and comments on this consultation paper.
- Identify any unintended adverse consequences of the proposal.

[1] The Automation of Negative Residue Management document describes how AEMO's policy in respect of the management of negative settlements residue (contained in SO_OP_3705 Dispatch Procedure) is applied as an automated process in dispatch: https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/2018/brief-on-automation-of-negative-residue-management.pdf?la=en

[2] AEMO, *SO_OP_3705 Dispatch Procedure,* Section 17: https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power_system_ops/procedures/so_op_3705-dispatch.pdf?la=en

[3] AEMC*, Inter-regional settlements residue arrangements for transmission loops*, https://www.aemc.gov.au/rule-changes/inter-regional-settlements-residue-arrangements-transmission-loops

[4] AEMC*, Inter-regional settlements residue arrangements for transmission loops*, https://www.aemc.gov.au/rule-changes/inter-regional-settlements-residue-arrangements-transmission-loops, Draft Determination, page iii

An optional consultation response template is available to help stakeholders give feedback about the proposal, and is available on the consultation page.

Before making a submission, please read and take note of AEMO's consultation submission guidelines, which can be found at https://aemo.com.au/consultations. Subject to those guidelines, submissions will be published on AEMO's website.

Please identify any parts of your submission that you wish to remain confidential, and explain why. AEMO may still publish that information if it does not consider it to be confidential, but will consult with you before doing so. Material identified as confidential may be given less weight in the decision-making process than material that is published.

AEMO is not obliged to consider submissions received after the closing date and time. Any late submissions should explain the reason for lateness and the detriment to you if AEMO does not consider your submission.

Interested persons can request a meeting with AEMO to discuss any particularly complex, sensitive or confidential matters relating to the proposal. Meeting requests must be received by the end of the submission period and include reasons for the request. AEMO will try to accommodate reasonable meeting requests but, where appropriate, may hold joint meetings with other stakeholders or convene a meeting with a broader industry group. Subject to confidentiality restrictions, AEMO will publish a summary of matters discussed at stakeholder meetings.

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1. Stakeholder consultation process

AEMO is consulting on amendments to the Automation of Negative Residue Management document to include a process that is appropriate for the implementation of transmission loops (proposal), in preparation for the inclusion of the Project EnergyConnect (PEC) interconnector in AEMO's dispatch processes.

AEMO has established a comprehensive stakeholder engagement program for the implementation of PEC and has included the PEC-Market Integration (PEC-MI)[5] project as a NEM Reform Program Initiative[6] to ensure the effectiveness of consultations for changes to AEMO procedures and other documents. AEMO has also included in this consultation certain considerations relating to the NRM process generated through the draft High Level Impact Assessment (HLIA)[7]. Any complimentary changes to other AEMO procedures from this consultation will follow the appropriate consultation process.

Note that this document uses terms defined in the NER, which are intended to have the same meanings. There is a glossary of additional terms and abbreviations in Appendix A.

AEMO's indicative process and timeline for this consultation are outlined below. Future dates may be adjusted and additional steps may be included if necessary, as the consultation progresses.

Consultation steps	Dates
Draft High Level Impact Assessment (HLIA) published with consultation considerations for NRM	15 December 2024
Consultation paper published	13 June 2025
Submissions due on consultation paper	11 July 2025
Draft report published	Expected 11 August 2025
Submissions due on draft report	Expected 8 September 2025
Final report published	Expected 6 October 2025

2. Background

2.1. Context for this consultation

A transmission loop will be formed in the NEM when PEC is included as an interconnector in AEMO's dispatch processes. PEC will be a new 330 kilovolts (kV) electricity interconnector between Robertstown in South Australia and Wagga Wagga in New South Wales, with a short 220 kV spur from Buronga in New South Wales to Red Cliffs in north-west Victoria. At completion, the project will provide approximately 800 megawatts (MW) of additional transmission capacity between New South Wales and South Australia.

[5] Project Energy Connect Market Integration https://aemo.com.au/initiatives/major-programs/nem-reform-program/nem-reform-program-initiatives/project-energyconnect-market-integration-project

[6] https://aemo.com.au/initiatives/major-programs/nem-reform-program/nem-reform-program-initiatives

[7] PEC-MI Draft HLIA https://aemo.com.au/-/media/files/initiatives/project-energyconnect/pec-mi--hlia_draft-v1.pdf?la=en

This new transmission configuration is expected to cause more frequent accrual of negative inter-regional settlement residues (IRSR) than across 'radial' interconnectors (that is, the current regulated interconnectors that link two regions without forming part of an inter-regional transmission loop).[8] This is due to the way power flows in a transmission loop, and how this interacts with the NEM's regional pricing model.

The costs of negative IRSR are passed on to consumers via transmission use of system (TUOS) charges, and AEMO currently limits the accumulation of negative IRSR through a process of 'clamping' counter-price flows described in Sections 2.2 and 2.3.1 below. However there are also benefits to consumers in efficient dispatch and inter-regional trade and competition[9]. To ensure benefits flow to consumers from constructing and energising transmission loops and related transmission infrastructure, AEMO proposed it would not 'clamp' looped interconnectors to limit negative IRSR when 'net' loop IRSR is positive. Additionally, clamping would reduce the overall benefits of PEC by restricting the flow of electricity over the interconnector until negative IRSR is below the predefined threshold set by AEMO[10]. However, AEMO needs to amend the existing automation of negative residue management (NRM) process to allow for the introduction of a transmission loop.

AEMO also conducted its own analysis and has identified a series of issues with the current application of automated NRM. These issues are largely separate from the transmission loop requirements discussed above.

This paper proposes options for addressing these issues as they will continue to impact the effectiveness of the automated NRM process both before and after the commencement of transmission loops, including on interconnectors which are not part of the transmission loop.

One issue AEMO is aware of is repeated turning on and off (or 'cycling'), of the 'clamp'. In this, 'cycling' refers to multiple successive NRM management periods occurring on a directional interconnector, separated only by short intervening time intervals. These cycles typically involve negative residues continuously accumulating very soon after NRM constraint deactivation at the end of a management period, resulting in a buildup of negative residues over the duration of the overall cycling episode amounts in excess of the -$100,000 threshold.

While AEMO has sought to expand this consultation to issues beyond those associated with the introduction of a transmission loop, due to time limitations placed by the expected completion of PEC, AEMO proposes to prioritise the issues and related changes to NRM process for transmission loop integration for this consultation.

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[8] Modelling the settlement effects of PEC transmission loop discussed in AEMO's directions paper - https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/directions-paper-for-consultation/pec-market-integration---directions-paper-for-consultation.pdf?la=en and ACIL market modelling report - https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/directions-paper-for-consultation/modelling-the-settlement-effects-of-pec---final-report.pdf?la=en

[9] AEMC, *Inter-regional settlements residue arrangements for transmission loops*, https://www.aemc.gov.au/rule-changes/inter-regional-settlements-residue-arrangements-transmission-loops

[10] For more background on loop flow IRSR, see https://aemo.com.au/consultations/current-and-closed-consultations/project-energy-connect-market-integration-paper.

2.2. NER requirements

Under NER 3.8.10(c), AEMO must, in accordance with the Rules consultation procedures, maintain the network constraint formulation guidelines to address certain aspects of AEMO's use of network constraints. AEMO has published most of this guidance in the Constraint Formulation Guidelines.

Under NER 3.8.10(c)(5), the network constraint formulation guidelines are required to contain AEMO's policy in respect of the management of negative settlements residue, by intervening in the central dispatch process under clause 3.8.1 through the use of fully co-optimised network constraint formulations, including in respect of the process to be undertaken by AEMO to manage negative settlements residue.

AEMO publishes this policy, and the process used to manage negative settlements residue through the policy, in the SO_OP_3705 Dispatch Procedure[11]. The Automation of Negative Residue Management[12] process document describes how the policy is applied as an automated process in dispatch.

2.3. The national electricity objective

Within the specific requirements of the NER applicable to this proposal, AEMO will seek to make a determination that is consistent with the national electricity objective (NEO) and, where considering options, to select the one best aligned with the NEO.

The NEO is expressed in section 7 of the National Electricity Law as:

> to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system; and
>
> (c) the achievement of targets set by a participating jurisdiction—
>
> (i) for reducing Australia's greenhouse gas emissions; or
>
> (ii) that are likely to contribute to reducing Australia's greenhouse gas emissions.

2.3.1. Automated negative residue management process

AEMO uses automated constraints to limit the further growth of negative IRSR on a directional interconnector when this reaches or exceeds the negative residue accumulation threshold of -$100,000. AEMO is not consulting on this threshold as part of this consultation.

These constraints are controlled by an automated NRM process that has been adapted since 2010. This process activates the relevant NRM constraint equation when the threshold has been reached, and deactivates the constraint when negative residues cease accumulating and there are no further extensions to the management period. The aim of NRM constraint equations is to limit further

[11] AEMO, *SO_OP_3705 Dispatch Procedure*, Section 17: https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power_system_ops/procedures/so_op_3705-dispatch.pdf?la=en

[12] AEMO, *Automation of Negative Residue Management* https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/2018/brief-on-automation-of-negative-residue-management.pdf?la=en

accumulation of negative residues by reducing the counter-price flow on the relevant directional interconnector in real time (also referred to as ‘clamping’).

This consultation also covers a number of existing aspects of the NRM process that AEMO is looking to address, in response to questions and issues raised by participants in the context of other reviews or forums.

3. Consultation summary of issues

3.1. Transmission loops in the NEM

AEMO is consulting on the NRM process once a transmission loop is formed following implementation of PEC as an interconnector between New South Wales (NSW) and South Australia (SA) in the dispatch process.

As outlined in the draft PEC-MI High Level Impact Assessment (HLIA)[13] modification of the NRM process will include the following elements:

- Introduction of logic to permit the accumulation of negative inter-regional settlement residues in the Vic-SA, SA-Vic, SA-NSW, NSW-SA, NSW-Vic and Vic-NSW directional interconnectors when the net total of these residues remains positive.
- Changes to the NRM constraints used to limit the accumulation of negative inter-regional settlement residues when this reaches or exceeds the negative residue accumulation threshold.
- Possible changes to publication for the estimate of negative residues in real time.
- New NRM data items and new referenced relevant field names.
- Addition of NRM constraint equations covering PEC.
- Any other information, change or addition that AEMO considers reasonably necessary.

For the avoidance of doubt, the loop flow logic does not apply to the Queensland – New South Wales or New South Wales – Queensland directional interconnectors.

As Basslink is a Market Network Service Provider (MNSP), the Victoria – Tasmania and Tasmania – Victoria directional interconnectors are not covered by this procedure. Should Basslink and/or a future Marinus Link become regulated, it would need to be considered by the procedure, however would not be part of the loop flow logic.

3.1.1. Including the new transmission loop within the NRM process

AEMO proposes to introduce logic that permits the accumulation of negative inter-regional settlement residues on the Vic-SA, SA-Vic, SA-NSW, NSW-SA, NSW-Vic and Vic-NSW directional interconnectors while the net total of these residues (‘loop-aggregate residue’) remains positive. Measurement of negative residues on individual directional interconnectors for assessment against the threshold and potential clamping would only commence from the time that loop-aggregate residue became negative.

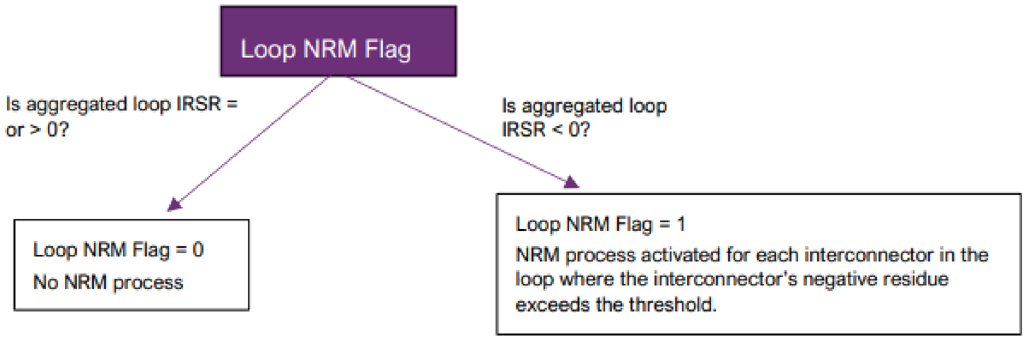
[13] At https://www.aemo.com.au/initiatives/major-programs/nem-reform-program/nem-reform-program-initiatives/project-energyconnect-market-integration-project.

To implement this, a new Loop NRM Flag field is proposed to record the status of this aggregate residue, with a value of either 0 or 1 (see Figure 1).

Where loop-aggregate residue remains zero or positive, the Loop NRM Flag will have a value of zero and no NRM process will apply to any of the directional interconnectors that comprise the loop even if the accumulation of negative IRSR on a particular directional interconnector exceeds the threshold. But if the loop-aggregate residue becomes negative then the Loop NRM Flag will be set to 1 ('active') and negative residue accumulation and monitoring would commence for all directional interconnectors in the loop. The NRM process would be applied to any directional interconnector(s) recording an accumulation of negative IRSR exceeding the threshold while the Loop NRM Flag remained active[14].

Restricting the clamping of loop interconnectors only to periods where loop-aggregate residue is negative recognises that around a transmission loop, negative residues on individual interconnectors may arise as a normal consequence of economic dispatch due to the 'spring-washer' effect[15]. The proposed modification to the automated NRM process seeks to prevent interconnector clamping affecting dispatch outcomes under these circumstances.

Figure 1 New Loop NRM process



Questions for stakeholders – treatment of transmission loops in NRM process

Question 1: When considering AEMO's proposed approach to the inclusion of transmission loops within the automated NRM process, what do stakeholders consider are the main challenges? Why?

3.1.2. Automated NRM process changes for transmission loops

At high level, implementing the Loop NRM Flag control in the automated NRM process involves modifications to:

- test for presence of an operating loop
- disregard negative residues on loop directional interconnectors unless and until loop-aggregate residue is negative, and

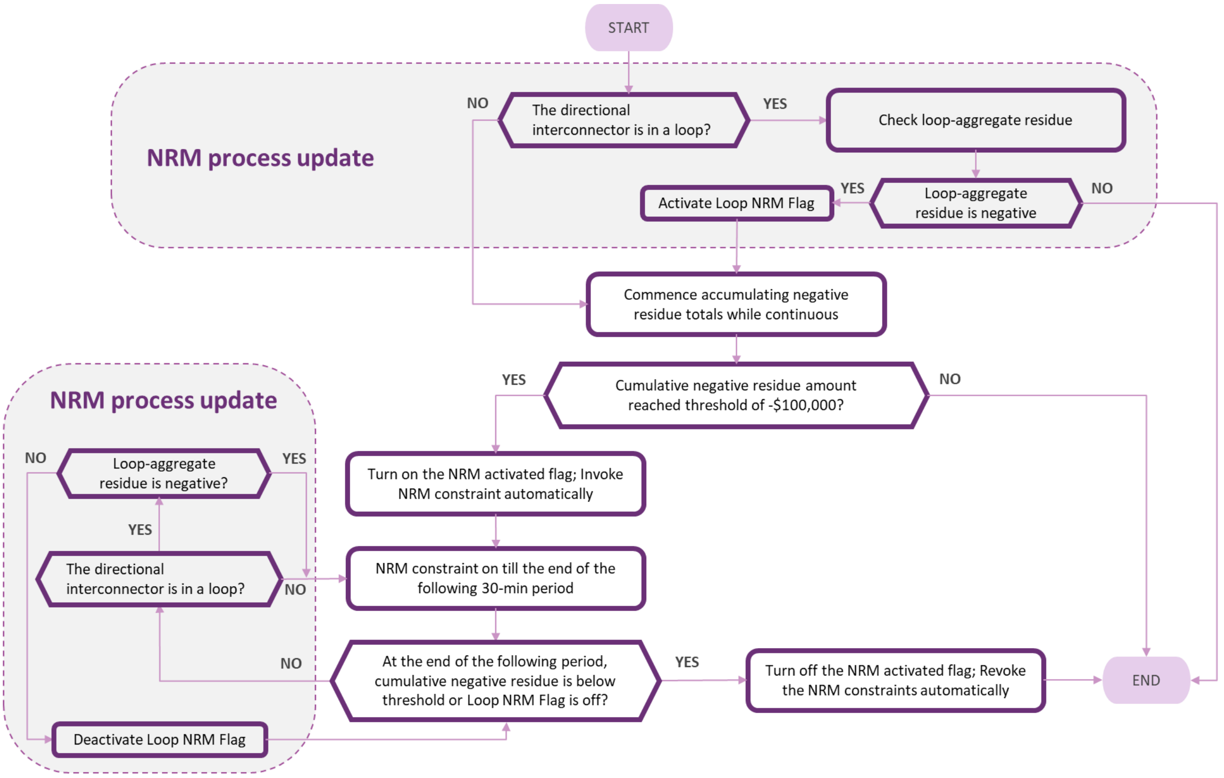
[14] For the avoidance of doubt, negative residues would only be accumulated, from an initial value of zero, from the dispatch interval in which the Loop NRM Flag became active. Any negative residues incurred prior to this time would be disregarded.

[15] Section A1 of the Project Energy Connect Market Integration Paper includes background reference material explaining the 'spring washer' effect. The Paper is at https://aemo.com.au/consultations/current-and-closed-consultations/project-energy-connect-market-integration-paper.

- trigger exit from an NRM management period if loop-aggregate residue becomes positive, as an additional alternative to the usual exit process triggered when accumulation of negative residue ceases on a clamped directional interconnector.

The additional logic required in the automated NRM process is shown in Figure 2 below.

Figure 2 Proposed NRM process updates



A question for stakeholder consideration is the period(s) over which loop-aggregate residue is measured in determining whether to apply and exit from management of negative residues on directional interconnectors in the loop. The automated NRM process currently operates[16] on the basis that:

- An NRM management period and interconnector clamping can begin from the first Dispatch Interval in which the process detects that accumulated negative residue has reached the -$100,000 threshold.
- Exit from a management period occurs at the end of a half-hour period following the process determining that accumulation of negative residues on the directional interconnector has ceased.

AEMO proposes to follow a similar approach to measurement of loop-aggregate residue, with Loop NRM Flag activation triggered after any Dispatch Interval in which loop-aggregate residue is negative, while exit from a management period would occur at the end of a half-hour in which loop-aggregate residue returned to a zero or positive value.

[16] Refer to Appendix B for a detailed description of the current NRM automation process.

The process is only to be applied when a loop is physically operating. If there is a complete outage of one of the alternating current (AC) interconnectors[17], then the NRM Loop Flag will not be activated. AEMO proposes to implement a step to determine if the transmission loop is in effect, to determine when all AC interconnectors are operational..

Questions for stakeholders – Automated process changes for transmission loop interconnectors

Question 2: Do stakeholders agree that AEMO's proposed NRM process updates have been appropriately specified?

Question 3: Do stakeholders consider the proposed measurement periods for loop-aggregate residues prior to commencement of, and exit from, a NRM management period are appropriate? Why?

3.1.3. NRM constraint step sizes for the PEC directional interconnectors

When negative residues reach the threshold trigger, the NRM automated management process uses an NRM constraint equation to progressively constrain off counter-price flow in pre-defined steps every dispatch interval, with the size of the step dependent on the amount, and sign, of the most recent estimated residue, labelled 'NRM_DI_AMT'. Step sizes for the existing directional interconnector constraints are given in Table 1.

Table 1 NRM constraint equation step sizes

NRM_DI_AMT (NR$) Interconnector constraint	NR$ < -5000	-5000 <= NR$ < -1000	-1000 <= NR$ < 1000	NR$ >= 1000
NRM_NSW1_QLD1	-100 MW	-50 MW	0 MW	30 MW
NRM_QLD1_NSW1	-100 MW	-50 MW	0 MW	30 MW
NRM_NSW1_VIC1	-100 MW	-50 MW	0 MW	30 MW
NRM_VIC1_NSW1	-100 MW	-50 MW	0 MW	30 MW
NRM_VIC1_SA1	-50 MW	-30 MW	0 MW	30 MW
NRM_SA1_VIC1	-30 MW	-25 MW	0 MW	25 MW

These step sizes either tighten, maintain, or relax flow limits on the relevant directional interconnector in each active dispatch interval, depending on estimated residue amounts.

For the new PEC directional interconnectors, NSW1_SA1 and SA1_NSW1, AEMO proposes to use values intermediate to the existing step sizes for VIC1_NSW1 and VIC1_SA1. These proposed values are shown in Table 2.

[17] Murraylink, being a controllable dirct current (DC) interconnector is not considered as part of the AC transmission loop.,.

Table 2 Proposed NRM constraint equation step sizes for PEC

Interconnector Constraint NRM_DI_AMT (NR$)	NR$ < -5000	-5000 <= NR$ < -1000	-1000 <= NR$ < 1000	NR$ >= 1000
NRM_NSW1_SA1	-75MW	-40MW	0	30MW
NRM_SA1_NSW1	-75MW	-40MW	0	30MW

Questions for stakeholders – NRM constraint equation step sizes

Question 4: Do stakeholders consider that the proposed NRM constraint equation step sizes for PEC are appropriate in the current market?

3.2. Issues with the current automated NRM process - cycling

Initial stakeholder feedback and AEMO's own analysis has identified a series of issues with the current implementation of automated NRM. These issues are largely separate from the transmission loop-specific integration requirements discussed above. However, if not addressed they will continue to impact the effectiveness of the automated NRM process both before and after a transmission loop is integrated into the NEM, including on interconnectors which are not part of the transmission loop.

This section focuses on the key issue identified with the current process, known as 'cycling', in response to which AEMO is proposing an immediate modification. The following section then summarises the remaining issues, AEMO's analysis of their impacts and likely causes, and potential changes to address them. To assist stakeholders, Appendix B provides an outline of key features of the existing NRM process, in particular the methods and criteria it uses to determine when NRM management periods start and end, and its methodology for estimating IRSR.

3.2.1. 'Cycling' of automated NRM management

'Cycling' refers to multiple successive NRM management periods occurring on a directional interconnector, separated only by short intervening time intervals. Typically these episodes involve negative residues continuously accumulating very soon after NRM constraint deactivation at the end of a management period, until the -$100,000 threshold is once again reached and a new NRM management period begins.

This allows the buildup of negative residues over the duration of the overall cycling episode to multiples of the -$100,000 threshold, as each new NRM management period begins only when the negative residues accumulated since conclusion of the prior period again reach that threshold.

Example of NRM cycling

A recent example is illustrated for the directional interconnector NSW1_VIC1 on 6 February 2025. As shown in Table 3 below, there were 4 separate NRM management periods on this day.

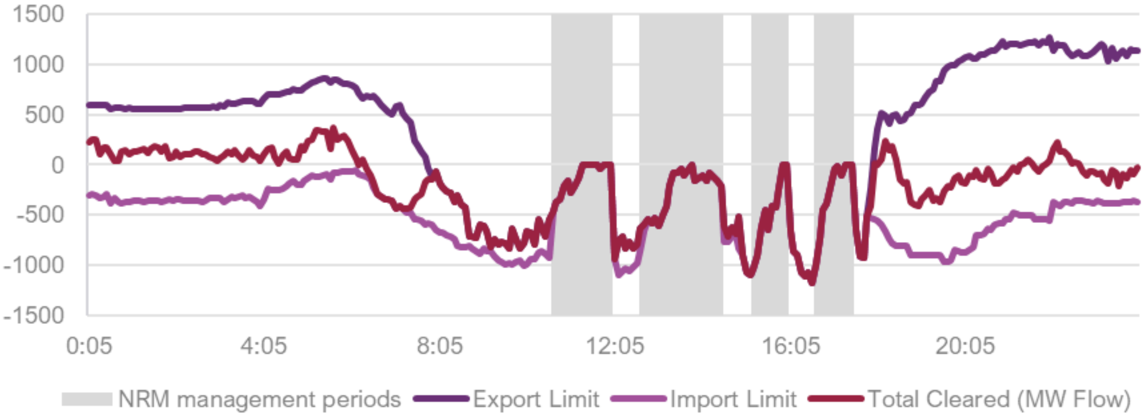
Table 3 NRM management periods for NSW1_VIC1 on 6 February 2025

Start Time	End Time	Accumulated Negative Residue from earlier half-hours (continuous)	Estimated Negative Residue for current half-hour	Total Negative Residue triggering management period start
6/02/2025 10:40	6/02/2025 12:00	-$83,981.08	-$16,299.12	-$100,280.20
6/02/2025 12:40	6/02/2025 14:30	-$68,813.84	-$48,262.79	-$117,076.63

Start Time	End Time	Accumulated Negative Residue from earlier half-hours (continuous)	Estimated Negative Residue for current half-hour	Total Negative Residue triggering management period start
6/02/2025 15:15	6/02/2025 16:00	-$21,040.36	-$89,171.61	-$110,211.97
6/02/2025 16:40	6/02/2025 17:30	-$60,621.68	-$80,936.97	-$141,558.65

These repeated applications of automated NRM clamping arose from counter-price flows from New South Wales into Victoria on the VIC1-NSW1 interconnector (VNI) driven by a binding transmission constraint in New South Wales. Figure 3 charts these power flows, which reflect a continuous underlying event forcing counter-price flows, with the NRM process activating and deactivating NRM constraints over four separate management periods during this event.

Figure 3 Limits and target flows for VNI on 6 February 2025



Analysis of cycling episodes

AEMO has analysed the incidence of NRM management periods on the three directional interconnectors which have been most frequently subject to NRM constraints since January 2022: NSW1_VIC1, QLD1_NSW1, and VIC1_SA1.

Table 4 below shows the number of NRM activations (individual management periods) on each of these directional interconnectors, the number of days on which these occurred, and the incidence of multiple NRM activations, comprising a significant proportion (30-60%) of days where automated NRM management was required on these directional interconnectors.

Table 4 NRM activation statistics 2022 – 2025

Directional Interconnector	Measure	2022	2023	2024	2025	Total
QLD1_NSW1	Total NRM activations	26	18	38	2	84
	Days with NRM activations	23	11	27	1	62
	Single activation	20	5	18	0	43
	Two or more activations	3	6	9	1	19
	% multiple activations	**13%**	**55%**	**33%**	**100%**	**31%**
NSW1_VIC1	Total NRM activations	63	174	233	82	552
	Days with NRM activations	49	89	124	51	313
	Single activation	38	43	56	30	167

Directional Interconnector	Measure	2022	2023	2024	2025	Total
	Two or more activations	11	46	68	21	146
	% multiple activations	**22%**	**52%**	**55%**	**41%**	**47%**
VIC1_SA1	Total NRM activations	4	-	17	48	69
	Days with NRM activations	3	-	8	23	34
	Single activation	2	-	4	8	14
	Two or more activations	1	-	4	15	20
	% multiple activations	**33%**	**-**	**50%**	**65%**	**59%**

While not all multiple activation episodes represent cycling, further analysis shows that for around 65-90% of activations which ended but were followed by another management period on the same day, accumulation of negative residues recommenced immediately or almost immediately (within six dispatch intervals) from unclamping. This is highly indicative of an underlying event driving counter-price flows having persisted throughout a management period, but the NRM process exiting prematurely.

Causes and potential solutions

AEMO has identified that the predominant cause for premature exit from NRM management is the cessation of negative residue accumulation once clamping reduces physical flow limits on a directional interconnector to zero. A half-hour without negative residues satisfies the automated process's criterion for deactivation[18] and very frequently leads to unclamping regardless of underlying market conditions.

Based on this analysis, AEMO has identified two potential modifications to NRM process and NRM constraints to reduce the frequency of cycling:

1. A change to NRM constraints so that minimum flow limits on a directional interconnector will not be reduced to zero but to a small non-zero value such as 20 MW. This would allow limited accumulation of small negative residues to continue throughout a management period if the underlying market conditions for counter-price flows persist. The NRM process would detect this ongoing negative residue buildup and extend the management period accordingly.
2. The introduction of a 'graduated release' stage before exit from any NRM management period. During graduated release, NRM constraint limits would be progressively relaxed in successive dispatch intervals by predefined amounts, allowing market outcomes at successively higher flow limits to be assessed prior to the end of the management period. This would allow deferral of exit if negative residues persist or reappear during the relaxation process.

These possible modifications are not mutually exclusive.

Assessment

The first option is a straightforward change requiring no modification to the NRM process logic, only to NRM constraint formulations. The analysis above indicates that this change should generally prevent premature unclamping in cases where underlying pressure for counter-price flows persists through a management period. AEMO does not consider there are any associated risks with targeting a non-zero

[18] Refer to Appendix B for details.

minimum NRM constraint limit, apart from a small additional accumulation of negative residue during a management period.

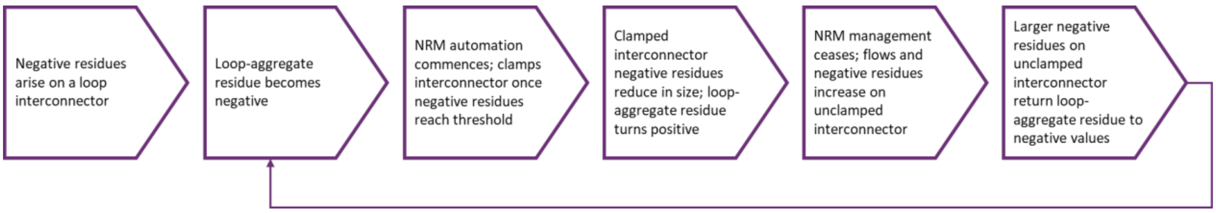
The simplicity and potential effectiveness of this option is such that AEMO proposes to initiate this change in the near term, since it will mitigate the ongoing and frequent cycling episodes that are already occurring on some directional interconnectors. Initially a minimum flow limit of 20 MW would be implemented in NRM constraints for all directional interconnectors, but the effectiveness of this threshold would be monitored, with adjustments made if experience shows a different value might be more effective in preventing cycling. This change will be applied in AEMO's pre-production environment for testing purposes, during this consultation period, to enable stakeholders to assess this change prior to a final decision to proceed.

The second option would require substantial changes to the NRM process to implement a graduated release stage, including the development and implementation of criteria and processes for commencement, monitoring, and conclusion of graduated constraint release, as well as changes to NRM constraint formulation. Further detail on these requirements as well as possible criteria and parameters are set out in Appendix C.

Despite its additional complexity, in the context of loop interconnections there are reasons for developing the second option as a potential addition to automated NRM management.

This is because the loop-aggregate negative residue criterion for NRM management allows the possibility of a new form of cycling, illustrated in Figure 4 below.

Figure 4 Possible loop-level NRM cycling



Even with a change to NRM constraints to allow small negative residues to accumulate while a loop interconnector is clamped, the reduced size of these residues may return loop-aggregate residue to positive values, triggering the end of NRM management on the loop, as described in Section 3.1.1.

Introduction of a graduated release stage prior to exit from NRM management periods would allow loop-aggregate residue to be assessed at progressively higher flow levels on the clamped interconnector, potentially avoiding a premature release of NRM constraints in these circumstances.

Questions for stakeholders – cycling

Question 5: Has AEMO correctly identified the causes of cycling observed under the existing NRM process?

Question 6: Is AEMO's proposed modification to minimum flow limits for NRM constraints an appropriate solution to reduce cycling? Are there any unintended consequences?

Question 7: Is the proposed minimum flow limit of 20MW an appropriate value? AEMO has implemented this release in AEMO's pre-production environment and is seeking feedback on whether there are any unintentional consequences arising from such changes.

Question 8: Describe whether AEMO should or should not also pursue the addition of a graduated release stage to NRM management periods to reduce the possibility of loop-level cycling?

Question 9: Are the process criteria and parameters outlined in Appendix C appropriate for a graduated release stage being added to the NRM process?

3.3. Other issues identified

As stated previously, AEMO is working on prioritising solutions to issues with the highest impact and which will provide a more robust and reliable NRM process. The following issues have all been assessed, and AEMO seeks feedback from stakeholders on which ones they consider may have the highest benefit for the market (refer Table 5). However, in light of AEMO's congested workflow over the next 18 months, AEMO will consider all feedback as part of the PEC construction timeline, implementation effort, AEMO resourcing availability and delivery requirements.

3.3.1. IRSR calculations for NRM process

As explained in Appendix B, the NRM process estimates IRSR on a 30-minute settlement basis (30MS) using average, or running average, price and flow values for each half-hour period. This can lead to material differences in the process's assessment of negative residue amounts against the -$100,000 threshold, relative to the 5-minute calculation basis (5MS) on which IRSR is actually settled.

Assessment

At times the approach currently implemented can lead to clamping being initiated some dispatch intervals before accumulated negative residues calculated on a 5MS basis reach the -$100,000 threshold. During an NRM management period, material negative residues may have continued to accrue for some dispatch intervals in a half-hour, but the 30MS calculation can yield a zero or positive residue estimate for the half-hour as a whole, leading to premature unclamping.

AEMO considers from its analysis that the impact of some of the discrepancies created by 30MS residue estimation, particularly those related to early unclamping, will be mitigated by the proposed changes to address cycling. Nevertheless, aligning the automated process's basis for residue estimation with 5MS market calculations would further reduce the risks of cycling.

Modification of the automated process's calculations to reflect the actual 5-minute settlement basis for IRSR would be conceptually straightforward, requiring no additional data to be accessed by the process, but would involve recoding and testing of the revised calculations.

Prioritisation of a change in the automated process's calculations will be assessed in the context of other changes required for PEC integration and mitigation of NRM cycling which are the issues with highest impact. AEMO's initial assessment is that a change to use of 5MS residue calculations involves relatively little additional effort, and therefore AEMO proposes to include this change as part of these priority items.

Questions for stakeholders – IRSR estimation

Question 10: Do stakeholders consider it appropriate to use 5MS calculations in the NRM process?

3.3.2. Use of pre-dispatch estimates in NRM process

In the final dispatch interval of each half-hour, the latest available pre-dispatch (PD) data (projections of prices and flows for future 30-minute periods) are used by the automated process to calculate a 30-minute IRSR estimate for the following half-hour. If this PD estimate yields negative IRSR for a given directional interconnector, it is added to any accumulated negative residue value and the total is assessed against the -$100,000 threshold in determining whether to commence or exit from an NRM management period.

Unavoidable differences between PD projections and actual dispatch outcomes (including constraint representations, participant rebidding, and forecast uncertainties), as well as the 30MS calculation basis of the PD estimate, mean that negative residue estimates using PD data have relatively low accuracy in predicting actual outcomes. At times, PD estimates can lead to unwarranted activation of NRM management periods which have unintended consequences, with an example of this documented in Appendix D.

Assessment

Use of PD estimates in assessing the exit criterion from a NRM management period is an attempt to address the problem of interconnector clamping reducing actual negative residues to zero, potentially leading to premature unclamping.

However the high observed prevalence of cycling shows that inclusion of PD estimates is not in itself an effective tool to prevent early unclamping. Since AEMO intends to proceed with changes to NRM constraint limits which will allow the observed buildup of actual negative residues to prevent early unclamping, this weakens the rationale for using PD estimates for this purpose.

Including a PD estimate in the entry criterion to an NRM management period can trigger clamping before actual residues reach the -$100,000 threshold. Since commencement of NRM management can occur immediately after any dispatch interval in which the threshold is actually reached, it is not clear that consideration of a PD estimate is justified prior to that point.

For these reasons, AEMO considers that use of PD estimates in the NRM process could cease when other changes to mitigate cycling behaviour have been implemented.

However, before moving forward with any changes to remove PD estimates, which would involve material effort in recoding and testing changes to the NRM process, AEMO will consider the overall prioritisation of changes to the process and welcomes stakeholder feedback on the desirability and any consequences of removing PD estimation from the NRM process's entry and exit assessments.

Questions for stakeholders – use of Predispatch estimates

Question 11: Should the use of Predispatch estimates of future IRSR be removed from the NRM process, wholly or selectively (for example, only for entry to/exit from a NRM management period)?

Question 12: Are there any pre-conditions for, or possible unintended consequences of this change?

3.3.3. Other possible adjustments to NRM processes

In reviewing the NRM process, AEMO has identified two issues which relate to the **purpose** of negative residue management and its application in certain circumstances, rather than the specific details of its implementation. These are:

- The treatment of NRM constraints as 'hard' constraints with violation penalty costs currently set at twice the Market Price Cap (MPC) of $17,500/megawatt hour (MWh). This means that in addition to limiting counter-price flows, activated NRM constraints will also limit economic 'pro-price' flows even if the price difference from the physically exporting region to the importing region reaches the maximum possible $18,500/MWh. Examples of relevant instances are provided in Appendix D.
- Where an interconnector is involved in one or more frequently control ancillary services (FCAS) co-optimisation constraints which balance the level of interconnector transfer against regional FCAS requirements, an active NRM constraint can effectively force one or two FCAS prices to the MPC to avoid counter-price flows against a modest energy price differential. In these co-optimisation cases, negative settlement residues on the interconnector may be a normal economic outcome which avoids much higher cost consequences for the FCAS markets. By analogy with not clamping loop interconnectors unless overall loop-aggregate residues are negative, there is an economic argument for not clamping directional interconnectors when negative residues result from energy-FCAS co-optimisation.

Preliminary analysis indicates that a lower, 'soft' Constraint Violation Penalty (CVP) cost[19] of the order of $1,500-$2,000/MWh for NRM constraints would still be sufficient to prevent almost all instances of counter-price flow, but would partially mitigate both of the adverse impacts described above. However additional analysis and testing would be required before recommending and implementing such a change.

Considerably more analysis and process modification would be required to identify and enable instances of FCAS-energy co-optimisation to be fully quarantined from application of the NRM process. AEMO does not intend to undertake this as part of the transmission loop-related changes to NRM process. but is interested in stakeholder feedback on the materiality and importance of addressing this issue in more depth in a separate process.

Questions for Stakeholders – NRM constraint CVP and FCAS co-optimisation

Question 13: Do stakeholders consider this to be sufficiently material for AEMO to consider in the future? If yes, please provide justification.

Question 14: Are there alternative approaches to dealing with the issues described?

4. Prioritisation of potential changes

Table 5 below sets out AEMO's proposed prioritisation of changes to the automated NRM management process for implementation of PEC as well as possible changes to address other issues identified. These priorities reflect initial assessments of the market benefits and implementation complexity associated with these changes, and the need to have the loop-related set of changes in place prior to PEC operation.

[19] Refer to the schedule of Constraint Violation Penalty factors at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/congestion-information/2024/schedule-of-constraint-violation-penalty-factors.pdf.

AEMO intends to focus initially on the Mandatory and High priority items while further assessing the feasibility and desirability of delivering additional modifications within the timeline for PEC implementation. Feedback from stakeholders will be valuable in refining these priorities.

Table 5 Automated NRM management process – change priority ranking

Item	Section ref.	Description	Benefit	Implementation complexity (AEMO System impact)	Priority
PEC-related changes	3.1	NRM Loop Flag and incorporation into NRM process. Addition of NRM constraint equations and step sizes for PEC directional interconnectors.	High	High	**Mandatory**
Cycling (1)	3.2.1	Modification of NRM constraint limits to set non-zero minimum flow.	High	Low	**High**
NRM IRSR estimation	3.3.1	Replacement of 30MS residue estimation with 5MS calculations.	Moderate	Low to Moderate	**Moderate to High**
Cycling (2)	3.2.1	Addition of Graduated Release stage to NRM management periods.	Moderate to High	High	**Moderate**
Use of predispatch estimates	3.3.2	Remove use of predispatch negative residue estimates in NRM process.	Low	Moderate	**Low**
NRM constraint CVP value	3.3.3	'Soften' NRM constraints to mitigate unintended consequences, by reducing CVP below Market Price Cap.	Low	Moderate	**Low**
FCAS co-optimisation	3.3.3	Exclusion from NRM automated process of NRM events driven by FCAS-energy co-optimisation constraints.	Low to Moderate	High	**Low**

Questions for stakeholders – change prioritisation

Question 15: Do stakeholders agree with the priorities assigned to these items?

Appendix A. Glossary

Term or acronym	Meaning
AC	alternating current
CVP	Constraint Violation Penalty
DC	direct current
DI	dispatch interval
FCAS	frequency control ancillary service/s
5MS or 30MS	Five or 30 minute settlement
IRSR	inter-regional settlements residue
MNSP	Market Network Service Provider
MPC	market price cap
MW	megawatt/s
NER	National Electricity Rules
NRM	negative residue management
NRM management period	A continuous sequence of dispatch intervals in which the automated NRM process is using NRM constraints on a directional interconnector to limit the accumulation of negative IRSR.
NSW	New South Wales
PD	pre-dispatch
PEC	Project EnergyConnect
QLD	Queensland
RRP	regional reference point
SA	South Australia
Transmission loop	interconnectors between three adjacent regions.
TI	trading interval – a 5-minute period ending on the hour (EST) and each continuous period of 5 minutes thereafter and, where identified by a time, the 5-minute period ending at that time.
VIC	Victoria

Appendix B. NRM process description

This Appendix draws from and should be read in conjunction with the document *Automation of Negative Residue Management*[20] which describes AEMO's NRM process in detail.

Overview

The NRM process operates to restrict the continuous accumulation of negative residues driven by counter-price flows on a directional interconnector[21]. When its estimate[22] of these residues on any directional interconnector, accumulated over a period of continuous growth, has reached or exceeded a threshold of -$100,000, the automated process activates an NRM constraint to progressively reduce ("clamp") flows on the relevant physical interconnector(s) to slow and ultimately stop the growth of negative residues. The process deactivates this NRM constraint following a period where negative residues have ceased or their estimated accumulated value has fallen below the threshold.

Key features

Key features of the automated process are as follows:

- It operates every 5 minutes, immediately following publication of market data (prices, flows and targets) for the current Dispatch Interval (DI). The process calculates and accumulates estimates of negative IRSR for each directional interconnector as half-hourly quantities, continuously recalculating its estimates for the current half-hour as DIs within that half-hour proceed.
- In addition to residues estimated from current and past dispatch data, in the final DI of each half-hour, the process uses the most recent pre-dispatch (PD) projections to estimate residue for the following half-hour, and adds this estimate to its accumulated total.
- An "NRM management period" for a directional interconnector commences when a continuous series of half-hourly negative residue estimates (including the current half-hour and, at the last DI of every half-hour, the PD estimate for the following half hour) reaches or exceeds the -$100,000 threshold.
- Once the process has determined that negative residues, measured as above, have reached or will reach the threshold, an NRM management period commences in the next DI. For example, if in monitoring outcomes for the 14:40 DI – an evaluation undertaken at the start of that interval just after 14:35 NEM time – the process detects that the threshold has been reached, a management period will be initiated from the 14:45 DI inclusive.
- Accumulation of past negative residues ceases once a half-hourly estimate of negative residue is zero. The -$100,000 threshold operates strictly as a per-application parameter, rather than an

[20] At https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/2018/brief-on-automation-of-negative-residue-management.pdf?la=en.

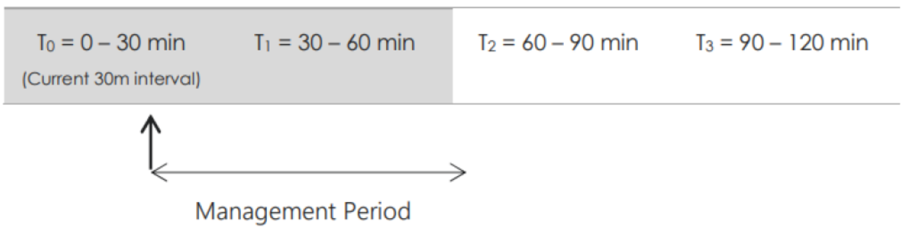
[21] A directional interconnector represents net energy transfer in a specific direction, and associated inter-regional settlement residues, aggregated over one or more physical interconnectors between two regions. For example, the QLD1_NSW1 directional interconnector represents aggregate transfers from the Queensland region to the New South Wales region when net flows across the NSW1-QLD1 (QNI) and N-Q-MNSP1 (Directlink) interconnectors are in a southward direction.

[22] Estimation of residues is necessary because their final settlement value depends on energy metering data which is not available in real time. Residue estimates are based on beginning-of-interval SCADA snapshot values for interconnector power transfers.

aggregate over discontinuous periods of negative residue accumulation such as the morning and evening periods of a day.

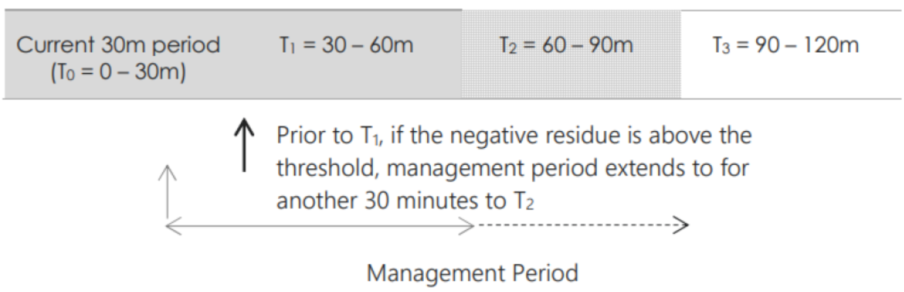
- When an NRM management period begins, the relevant NRM constraint is activated by "unswamping" its Right Hand Side (RHS) value in the first DI of the period, to start controlling counter-price flow on the relevant physical interconnector(s).
- During an NRM management period, flow limits for NRM constraints are progressively tightened or eased according to a schedule of step sizes linked to the rate at which estimated negative residues are accumulating. The purpose of this schedule is to balance objectives of slowing negative residue buildup, while ramping interconnector flow limits between DIs at rates that will not compromise system security.
- The process continues to estimate and accumulate negative residue during an NRM management period, and either:
  - schedules exit from the event at the end of the half-hour following the first half-hour in which its estimate of accumulated residues falls below the threshold, or
  - extends the scheduled end time of the management period by half an hour if:
    - negative residue remains above the threshold in the final DI before the currently-scheduled final half hour, or
    - estimated negative residue during the currently-scheduled final half hour again exceeds the threshold.
- The excerpt below from the automated process documentation illustrates this process of assessment and management period extension.

Figure 1: Negative residue management period



If the accumulated negative residue before the start of a new 30-minute period[3] remains above the threshold, the management period is extended for another 30-minute period.

Figure 2: Negative residue management period extension



- Analysis of NRM events shows that most management periods end due to completion of a half-hour period in which no estimated negative residue occurs. This resets the automated process's value for past accumulated negative residue to zero, and the management period will end at conclusion of the following half hour unless negative residue exceeding the threshold is incurred within that final half-hour[23].

Estimation of half-hourly residue amounts

Calculation of IRSR amounts in the NRM process mirrors the logic formerly used to settle IRSR under 30MS. Settlement of IRSR has since moved to 5MS, with IRSR values calculated and assigned to the appropriate directional interconnector, depending on net flow direction, for each of the six dispatch intervals in a half-hour. However the NRM process calculates a single IRSR estimate per half-hour, assigned to just one member of each directional interconnector pair.

Ignoring interconnector losses for simplicity (although these are included in the NRM process's calculations), the process's estimate of half-hourly IRSR on a physical interconnector is:

*avg(RRP diff) * avg(I/C flow) * 0.5* **(30MS calculation)**

where **RRP diff** is the relevant regional price difference and **I/C flow** is the SCADA metered start-of-interval boundary flow on the interconnector. The averages of prices and flows are taken across the six dispatch intervals comprising the half-hour.

For the current, incomplete half-hour, the price and flow averages used are simply the running averages for those DIs dispatched so far – meaning that the current half-hourly estimate is recalculated as additional DIs progress and their price and flow data is incorporated in these running averages.

This approach means that within the current half-hour, the automated process's estimate is effectively a forecast extrapolated from partial data, namely those DIs dispatched to date.

Assignment of this IRSR estimate – whether negative or positive – to the relevant directional interconnector depends on the direction of average flow over the half-hour (aggregated across physical interconnectors where multiple links serve the adjoining regions).

Settlement IRSR calculation

Contrasting this approach, the settlement calculation of IRSR on a physical interconnector for each 5-minute DI (again ignoring losses for simplicity) is

*RRP diff * I/C flow * (1/12)* **(5MS calculation)**

Summed across a half-hour, these values may differ materially from the 30MS calculation because of joint variation in prices and flows. Furthermore, assignment of these 5MS amounts to directional interconnectors is based on the direction of 5-minute flow (aggregated across physical interconnectors). This means that for adjoining regions, both directional interconnector pairs (for example, NSW1_VIC1 and VIC1_NSW1) can accumulate IRSR within a single half-hour under 5MS. By contrast, in the case of the 30MS estimate, IRSR is assigned to a single directional interconnector based on the direction of net flow when averaged for the half-hour.

[23] In the final DI of each half-hour this test also includes the PD estimate of negative residue for the succeeding half-hour.

Impacts of 30MS versus 5MS approach

These basis differences in the automated process's calculations can lead to timing and quantum differences in the process's assessment of negative IRSR against the -$100,000 threshold, relative to 5MS calculations.

For example, if prices and flows in the first dispatch interval of a half-hour lead to a 5MS IRSR value of -$17,000, the automated process's initial estimate for the full half-hour will be six times larger at -$102,000, triggering or extending a management period, as the 30MS calculation effectively extrapolates those price and flow values over the full half-hour.

For a half-hour during which flow directions change between DIs, these differences can lead the process to conclude, based on the direction of **average** flow, that no negative residue has occurred (and also discarding accumulation of prior negative residue amounts) for a specific directional interconnector, whereas at 5MS granularity significant negative residues may still have accrued in one or more DIs.

Appendix C. Graduated release process requirements

As explained in Appendix B, the NRM process typically schedules exit from a management period for the end of the half-hour following a half-hour in which its estimate of accumulated residues falls inside the -$100,000 threshold. On exit, active NRM constraints are immediately and fully unclamped (swamped out) in the first dispatch interval after the management period ends, potentially leading to large changes in dispatch outcomes and interconnector flows.

Graduated release of NRM constraints could be used in the final scheduled half-hour to allow a more controlled exit from a management period and enable the automated process to more effectively test market conditions at higher flow limits on the directional interconnector before fully unclamping.

This would involve progressively increasing the relevant NRM constraint limits by significant step sizes in each of the six dispatch intervals over the release period, with the process monitoring dispatch outcomes at each step, and either:

- observing no return to negative residue buildup (at directional interconnector level in the case of a non-loop link, as well as loop-aggregate level in the case of a link within a loop) – in this case, release would continue through the period with full unclamping at the start of the next half hour; or
- observing a return to negative link- or aggregate loop-level residue, indicating that market pressures for counter-price flows remain, and that exit from the NRM management period should be deferred.

Step sizes for NRM constraint relaxation at each of the six DIs within a graduated release period could be constant, yielding a linear increase pattern, or begin with relatively smaller increments (resulting in lower negative residue amounts if these resume early in the release period), increasing to progressively larger steps – for example:

DI number in release period	Constant ramp flow limit MW	Progressive ramp flow limit MW
1	50	20
2	100	45
3	150	80
4	200	130
5	250	200
6	300	300

Different step sizes might apply to different directional interconnectors, depending on their notional capacity.

Commencement of a graduated release period would be based on testing a set of criteria in the last DI of each half-hour, each of which can individually signal that conditions may be appropriate for conclusion of an NRM management period. AEMO's suggested criteria for this purpose and their rationale are set out below:

Test criterion	Rationale
Loop-aggregate IRSR > 0 **(only where directional interconnector is part of a transmission loop)**	This criterion reflects the design intention of not clamping individual links, regardless of negative residue buildup, when loop-aggregate residue is positive. Entry into graduated release under this condition would enable retesting of loop-aggregate residue under controlled conditions as flow limits on the directional interconnector were relaxed. This would assist in prevention of 'loop-level cycling' where loop-aggregate residue might become positive during a management period but rapidly return to negative values as flows were unclamped.
NRM constraint not binding (marginal value = 0)	Testing shows that an NRM constraint not binding towards the end of a management period is a generally reliable indicator of negative residue buildup ending.
Importing region RRP > Exporting region RRP	With these Regional Reference Point (RRP) relativities, increased flow on the clamped directional interconnector is likely to generate positive not negative residues, at least initially. However, in this situation the NRM constraint may remain binding, meaning this additional test on RRP relativities is required.
Zero negative residue observed over current half-hour	While the NRM constraint marginal value and RRP relativity conditions are generally good tests of whether conditions for counter-price flows have subsided, testing shows they are not perfect predictors. Commencement of graduated release after 6 dispatch intervals with no IRSR recorded will allow controlled observation of market outcomes at higher flow limits.
Directional interconnector accumulated negative residue within -$100,000 threshold	Current design of the NRM process can trigger clamping based on estimates of 30-minute IRSR extrapolated from data from a single DI, or a half-hourly pre-dispatch estimate. If actual accumulated negative residues at the end of a half-hour are inside the threshold, this may mean that the NRM management period has been commenced too early. If evaluation of IRSR in the automated process was changed to simply sum values calculated at 5MS granularity, and remove predispatch estimates from the process, then this condition would not be necessary.

During each DI within the graduated release half-hour, IRSR values could be monitored, with the automated process either continuing to relax constraint limits according to the specified step size schedule, or in the event of negative residue resumption at link- or loop-aggregate level as appropriate, the relaxation process would be suspended, the management period extended for a further half-hour, and NRM constraint operation as per the current process be reinstated.

The overall graduated release process is illustrated schematically in the following diagram:

Graduated release: detailed entry and exit criteria

Test in final DI of each half-hour:

- IF
  - |Accumulated neg residue| < $100k **OR**
  - Neg residue for current half hour = 0 **OR**
  - NRM constraint not binding (MV=0) **OR**
  - Importing rgn RRP > Exporting rgn RRP **OR**
  - Loop-aggregate residue > 0
- THEN
  - Commence graduated release from next DI
- ELSE
  - Extend NRM management period 30 mins
  - Continue clamping per current NRM process
  - Retest in final DI of next half hour

Graduated release:

- Relax NRM constraint by X MW each DI
- Continue relaxing WHILE
  - Neg residue over buffer period = 0 **OR**
  - Loop-aggregate residue over buffer period > 0
- ELSE
  - Extend NRM management period 30 mins
  - Revert to clamping per current NRM process

At last DI of relaxation period:

- IF not extended, exit NRM
- ELSE retest graduated release criteria

Appendix D. Unintended consequences of NRM clamping – examples

This Appendix presents two examples of NRM management being activated or continued in circumstances where:

- the commencement or continuation of interconnector clamping was not actually required to manage negative residues, and/or
- the clamping constraints had unintended and undesirable impacts on market dispatch outcomes.

The purpose of documenting these examples is to assist in assessment of potential modifications to the NRM automated process or NRM constraints that might avoid or mitigate these and similar unintended consequences.

Activation of NRM management triggered solely by predispatch estimates

At DI 1800 on 15 August 2024, the NRM constraint on QLD1_NSW1 was activated solely on the basis of a PD estimate of negative residue in the next half hour breaching the -$100,000 threshold, while no material negative residues had been recorded to that point. However, subsequently there were no negative residues and New South Wales spot prices unexpectedly jumped to over $10,000/MWh in two dispatch intervals, with the NRM constraint unnecessarily and heavily restricting flows into the higher price region.

Measure	Dispatch interval ending							
	17:55	18:00	18:05	18:10	18:15	18:20	18:25	18:30
Queensland RRP ($/MWh)	$499.70	$264.01	$228.01	$228.01	$237.73	$249.89	$249.89	$249.89
New South Wales RRP ($/MWh)	$493.23	$249.89	$11,730.45	$223.92	$10,058.38	$249.89	$249.89	$246.59
Qld to NSW metered flow (MW)	288	308	243	237	113	166	256	272
Qld to NSW flow limit (MW)	1,269	1,267	143	267	143	196	286	302
Qld to NSW flow target (MW)	279	240	173	226	153	196	286	294
Estimated 5-minute IRSR	$271	-$159	$237,459	$91	$95,428	$179	$216	$144
NRM automated PD IRSR estimate (next half hour)	-	-$143,428	-	-	-	-	-	-
NRM activation flag (1=activated)	0	0	1	1	1	1	1	1

NRM constraints amplifying price volatility

Rapidly changing market conditions can lead to reversal of pressures for counter-price flows on a clamped directional interconnector such that prices in the physically importing region rise well above those in the exporting region. This means that flows on the interconnector would be ‘pro-price’, or in the expected economic direction, but are restricted by an NRM constraint intended to prevent counter-price flows.

This outcome was evident in the example above for the QLD1_NSW1 directional interconnector, while the table below shows another example which occurred on 1 February 2025 on the VIC1_SA1 directional interconnector.

Unlike the previous example, this was not due to triggering of an NRM management period based only on PD estimates, but by a rapid change in underlying market conditions leading to volatility in the importing region – in this case South Australia. Prior to this period negative residues on flows into South Australia had accumulated beyond -$100,000, with an NRM management period triggered from DI 17:05 onwards and scheduled to conclude at DI 18:30.

However the South Australian price rose to extreme levels in the 17:50 DI and then again from 18:00 onwards, and persisted at these levels until 18:30 when the management period ended (only DIs up to 18:10 are shown below). Over this period, the NRM constraint held the flow limit from Victoria to levels generally below 150 MW into the high-priced South Australian region. Even at these limited levels large positive IRSR amounts accrued on the directional interconnector.

Measure	Dispatch interval ending						
	17:40	17:45	17:50	17:55	18:00	18:05	18:10
Victoria RRP ($/MWh)	$223.55	$198.04	$239.01	$299.29	$301.03	$172.49	$299.29
South Australia RRP ($/MWh)	$138.00	$224.71	$9,551.00	$230.00	$17,411.99	$15,103.24	$17,407.99
Vic to SA metered flow (MW)	369	326	213	200	117	120	19
Vic to SA flow limit (MW)	339	276	163	230	147	150	49
Vic to SA flow target (MW)	339	276	163	230	147	150	49
Estimated 5-minute IRSR	-$2,862	$509	$163,099	-$1,408	$165,112	$148,579	$26,002
NRM activation flag (1=activated)	1	1	1	1	1	1	1

The extreme prices in South Australia and foregone opportunity to import more energy from Victoria during this period were effectively a cost to the market imposed by the NRM constraint. However, its CVP of $35,000/MWh rendered this the optimal outcome for the market dispatch process rather than breaching the NRM constraint.

Had the NRM constraint been formulated as a ‘soft’ constraint with a CVP below the MPC, South Australian energy prices would almost certainly have been less extreme, as the dispatch process would have chosen on economic grounds to breach the NRM constraint’s flow limit to allow higher imports into South Australia.