Automation of Negative Residue Management

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Current version release details

Version	Effective date	Summary of changes
3.0	1 July 2021	Updated for 5MS. New template.

Note: There is a full version history at the end of this document.

1. Introduction

AEMO uses automated constraints to limit the accumulation of negative inter-regional settlement residues in the NEM when this accumulation reaches or exceeds the negative residue accumulation threshold of -$100,000 (as of 1 July 2010).

To ensure limitation measures are initiated once the accumulated negative residue has, or is expected to, reach or exceed the threshold, AEMO has implemented an automated negative residue management process. This process activates or deactivates relevant Negative Residue Management (NRM) constraint equations as soon as the threshold is reached or positive residues start accumulating. The aim of the NRM constraint equations is to prevent further accumulation of negative residues by reducing the counter-price flow on the relevant directional interconnector in real time. NRM constraint equations may also be used in the pre-dispatch time frame for up to the next two 30-minute periods.

The automatic NRM constraint equations will use the latest accumulation values available from dispatch. The accumulation amount, relevant to the affected directional interconnector, is based on residues in the previous 30-minute period and an estimate of current 30-minute period residue. Estimates of the current 30-minute period residue are based on an average of the available trading intervals (TIs) in the current 30-minute period. At the last TI of the 30-minute period (e.g. 1225-1230 for the 1200-1230 period), or when TI results are not available, pre-dispatch residues for the next 30-minute period are assessed using 30-minute pre-dispatch and included in the accumulation amount.

AEMO publishes the estimate of negative residues in real-time.

This document provides an overview of the process and the NRM data that is published. In this document, NRM data items are referenced to the relevant field name in the DISPATCH.NEGATIVE_RESIDUE table, shown in italics.

Note that this document uses many terms that are defined in the National Electricity Rules, which are intended to have the same meaning here.

2. Accumulation of negative residue

The accumulation of negative residue for a directional interconnector commences from the first TI that residues across the directional interconnector become negative (*NEGRESIDUE_CURRENT_TI*).

At any TI when the accumulated negative residue (*CUMUL_NEGRESIDUE_AMOUNT*) reaches or exceeds the threshold of -$100,000, AEMO's automated process will start managing to reduce the negative residue (unless the underlying dispatch prices are subject to review[1]).

The accumulated negative residue will be reset to zero when the residue for the current 30-minute period is either zero or positive.

[1] *Automated procedures to identify intervals subject to review* is available at AEMO | Policy and process documentation.

3. Negative residue management process

3.1. Negative residue management constraint equations

The NRM process involves a permanently invoked set of constraint equations to manage flow on each directional interconnector, where the NRM constraint equation is named 'NRM_<Directional Interconnector ID>' as shown in Table 1.

For example, constraint equation 'NRM_NSW1_QLD1' manages the net flow from New South Wales to Queensland over the 'NSW1-QLD1' and 'N-Q-MNSP1' interconnectors.

Table 1: NRM constraint equations

Constraint Equation	Interconnector flow direction
NRM_NSW1_QLD1	New South Wales to Queensland
NRM_QLD1_NSW1	Queensland to New South Wales
NRM_NSW1_VIC1	New South Wales to Victoria
NRM_VIC1_NSW1	Victoria to New South Wales
NRM_SA1_VIC1	South Australia to Victoria
NRM_VIC1_SA1	Victoria to South Australia

These constraint equations have the form Left Hand Side (LHS) ≤ RHS where the directional interconnectors are the controllable variables on the LHS. The constraint violation penalty (CVP) factor for each of these equations is set to 2[2]. AEMO's control room will block the relevant constraint equation and manually set the CVP if a different factor is required.

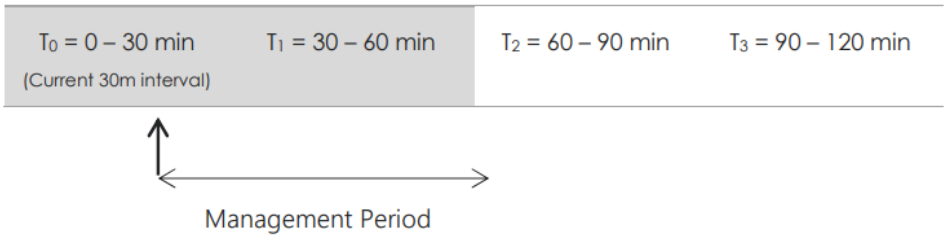
Typically, NRM constraint equations are not active in the system by being swamped out with a large Right Hand Side (RHS) value.

[2] *Schedule of Constraint Violation Penalty Factors* is available at AEMO | Policy and process documentation.

3.2. Negative residue management period

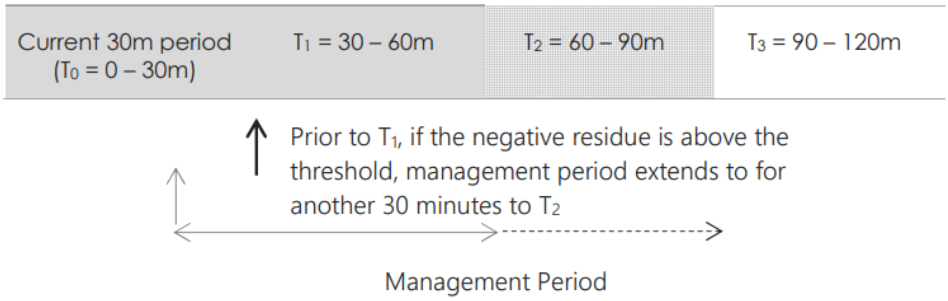
When the threshold is reached or exceeded the relevant NRM constraint equations will be automatically activated to manage the accumulated negative residue from the next trading interval to the end of the following 30-minute period. Within this management period, NRM constraint equations can be temporarily activated and de-activated when certain conditions are met, as discussed in section 3.3.

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



3.3. Management of directional interconnector flow

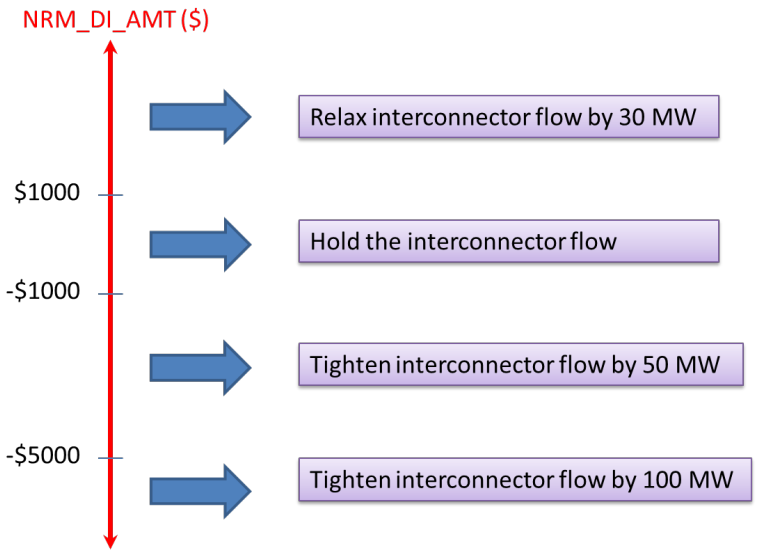
The management process uses a NRM constraint equation to progressively constrain off counter-priced flow in pre-defined steps, with the size of the step dependent on the amount, and sign, of the estimated residue for the current TI, defined as 'NRM_DI_AMT' (*NEGRESIDUE_CURRENT_TI*).

Depending on the negative value of 'NRM_DI_AMT' the constraint equation will constrain the directional interconnector with either a more aggressive or a more conservative step. If the 'NRM_DI_AMT' is positive, beyond a defined positive limit, the NRM constraint equation will relax the directional interconnector flow by another pre-defined step. These step adjustments are automatically carried out while ensuring that the directional flow does not reverse.

[3] This is determined after the dispatch run for the last TI of the current 30 minute period, and based on the actual accumulated negative residue plus the estimated residue for the next 30 minute period of the latest pre-dispatch run.

Figure 3 shows a typical example of the different thresholds of NRM_DI_AMT and the corresponding actions taken by the NRM constraint equation with the different steps sizes (MW).

Figure 3: Example of negative residue management process



The current step sizes and thresholds for 'NRM_DI_AMT' (NR$) for each directional interconnector are listed in Table 2 and will be continually reviewed on a half-yearly basis in order to improve the NRM process.

Table 2: NRM constraint equation - RHS step change design

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

Asymmetrical step sizes - where larger steps are applied for negative residues and smaller steps are applied for positive residues - were introduced to minimise the negative residue accumulation and to avoid oscillations of the target interconnector flow over consecutive TIs. If the relaxation and tightening introduced by the NRM constraint equations were applied symmetrically, the target interconnector flow can oscillate over a series of consecutive TIs. When oscillations occur, it will be difficult to return the target interconnector flow to a stable state where there will be zero residues.

3.4. Temporary suspension of negative residue management within the management period

Within a management period, the NRM constraint equation will continue to manage the accumulation of negative residue until one of the following conditions is met:

- For the last three TIs, the NRM constraint equation has not bound (DI_NOTBINDING_COUNT) and non-negative NRM_DI_AMT (that is, *NEGRESIDUE_CURRENT_TI* = 0) were occurring.
- For the last three TIs, the NRM constraint equation has violated (*DI_VIOLATED_COUNT*) and non-negative NRM_DI_AMT (that is, *NEGRESIDUE_CURRENT_TI* = 0) were occurring.
- AEMO's control room manually intervenes in the process by blocking the NRM constraint equation (*NRMCONSTRAINT_BLOCKED_FLAG*).

Temporary suspension of the NRM within a management period will cease when NRM_DI_AMT (*NEGRESIDUE_CURRENT_TI*) exceeds -$1,000.

3.5. End of management period

The management of negative residues ceases at the end of the management period for a directional interconnector when its accumulated negative residue is below the threshold of -$100,000 and there are no further extensions to the management period.

3.6. Notices to Participants

The NRM process automatically issues Market Notices when an NRM constraint equation becomes active to inform participants that NRM is active. This will be followed by another Market Notice to inform participants when the management period has ended.

4. Publication of inputs for negative residue management

The publication of inputs for NRM constraint equations are available from:

- Data Interchange in the DISPATCH_NEGATIVE_RESIDUE table, and
- AEMO's website:
  - http://nemweb.com.au/Reports/CURRENT/DISPATCH_NEGATIVE_RESIDUE/ (Current month, one file per TI)
  - http://nemweb.com.au/Reports/ARCHIVE/Dispatch_Negative_Residue/ (Previous months, one file per day)

The table / file is populated for each 5-minute trading interval, displaying only residues that are negative for each directional interconnector. It provides several key pieces of information including:

- Active management period (*NRM_ACTIVATED_FLAG*)
- Negative residue amounts (*CUMUL_NEGRESIDUE_AMOUNT*, *CUMUL_NEGRESIDUE_PREV_TI*, *NEGRESIDUE_CURRENT_TI* and *NEGRESIDUE_PD_NEXT_TI*)
- Trading interval when the management will cease (*EVENT_DEACTIVATED_DI*)

Appendix A describes the data in the DISPATCH_NEGATIVERESIDUE table.

Appendix A.

Table 3: Dispatch

Name	DISPATCH
Comment	Results from a published Dispatch Run

Table 4: Negative_Residue

Name	NEGATIVE_RESIDUE
Comment	Shows the inputs provided to the Negative Residue Constraints in the Dispatch horizon
Visibility	Public

Table 5: Field names

Field Name	Data type	Mandatory	Comment
SETTLEMENTDATE	DATE	Yes	Dispatch Interval to which the results from the NRM apply in Dispatch
NRM_DATETIME	DATE	Yes	The time that the NRM process determines residues
DIRECTIONAL_INTERCONNECTORID	VARCHAR2(30)	Yes	Directional interconnector ID (see table 2)
NRM_ACTIVATED_FLAG	NUMBER(1,0)	No	1 if NRM constraint applies for SettlementDate, else 0
CUMUL_NEGRESIDUE_AMOUNT	NUMBER(15,5)	No	Accumulated negative residue amount used to trigger an NRM event and apply an NRM constraint
CUMUL_NEGRESIDUE_PREV_TI	NUMBER(15,5)	No	Accumulated negative residue amount for the previous trading interval
NEGRESIDUE_CURRENT_TI	NUMBER(15,5)	No	Negative residue amount for the current trading interval
NEGRESIDUE_PD_NEXT_TI	NUMBER(15,5)	No	Negative residue amount for the next trading interval of the latest pre-dispatch
PRICE_REVISION	VARCHAR2(30)	No	Subject To Review, Indeterminate, Accepted or Rejected
PREDISPATCHSEQNO	VARCHAR2(20)	No	Pre-dispatch sequence number
EVENT_ACTIVATED_DI	DATE	No	The starting DI when NRM event is active
EVENT_DEACTIVATED_DI	DATE	No	The finishing DI when NRM event stops being active.
DI_NOTBINDING_COUNT	NUMBER(2,0)	No	Count of the number of consecutive DIs that the relevant NRM constraint is not binding (0-3)
DI_VIOLATED_COUNT	NUMBER(2,0)	No	Count of the number of consecutive DIs that the NRM constraint is violated (0-3)
NRMCONSTRAINT_BLOCKED_FLAG	NUMBER(1,0)	No	1 if NRM constraint is blocked, else 0

Version release history

Version	Effective Date	Summary of Changes
3.0	1 July 2021	Updated for 5MS. New template.
2.0	1 February 2018	Publication of NRM inputs.
1.1	9 July 2014	New template.
1.0	1 May 2012	Initial draft.